Reverse Osmosis and Nanofiltration

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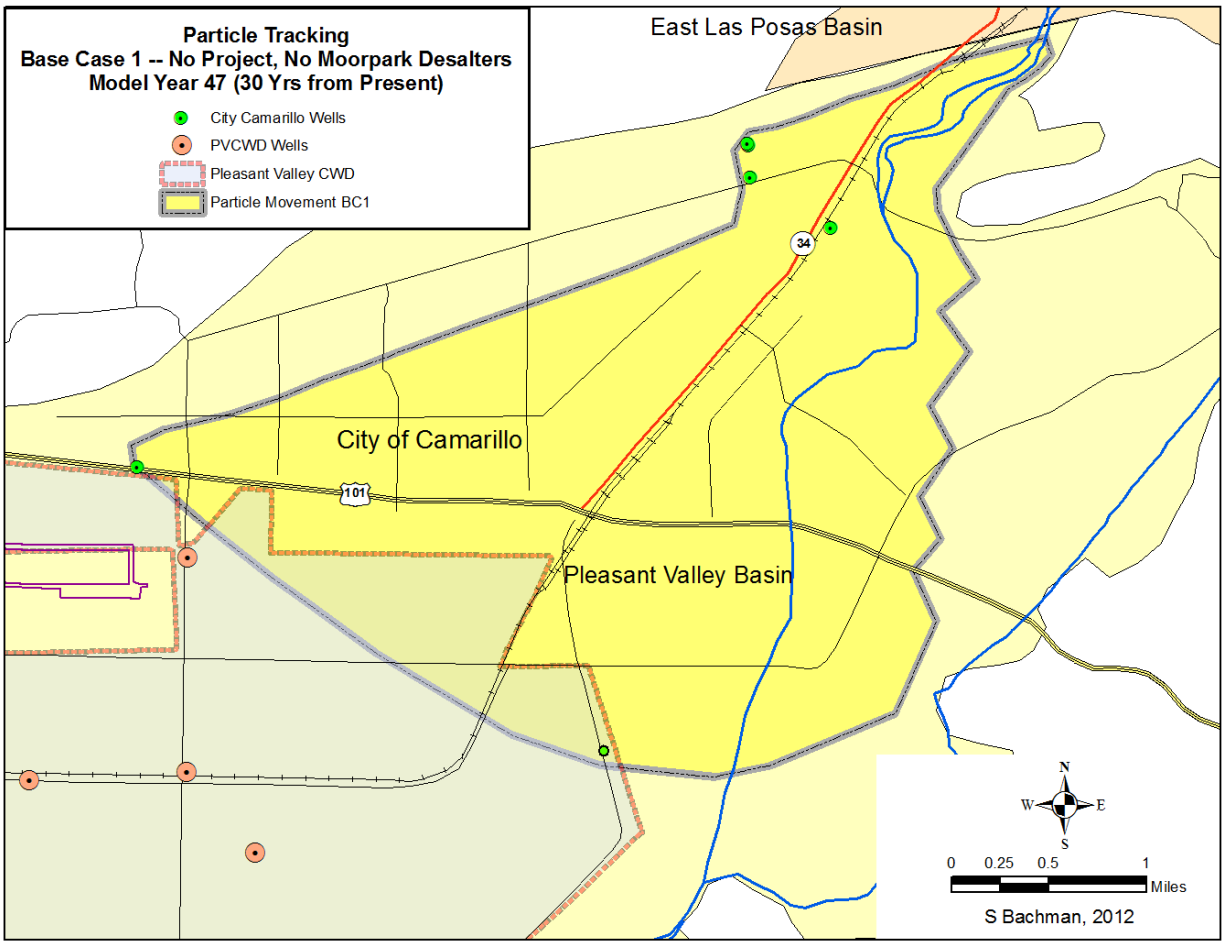
Northern Pleasant Valley Desalter Groundwater Analysis and Modeling

Report to Desalter Working Group



November, 2012

Prepared by Steven Bachman, PhD

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1 Introduction

Poor-quality brackish water from upstream discharges has infiltrated into the northern Pleasant Valley basin (NPV) since 1994. This infiltration has caused a large mound of poor-quality groundwater in NPV that has both raised groundwater elevations almost 200 ft within the mound and deteriorated groundwater quality for both agricultural and municipal pumpers. The proposed NPV Desalter project aims to reverse the water quality degradation by pumping poor-quality groundwater from the mound and treating it to drinking water standards. The timing of the proposed project is dependent upon the arrival of the Salinity Management Pipeline (SMP) into the Camarillo area near the location of the proposed project because brine from the reverse osmosis treatment process must be discharged to the SMP.

This study included constructing a groundwater flow model to simulate a range of scenarios to help answer several questions:

- Groundwater elevations – would the NPV Desalter pumping effectively reduce the mound of poor quality groundwater and prevent its migration into the main portion of the Pleasant Valley basin? Could the pumping occur without adversely affecting the basin and other pumpers?
- Water quality – how far has the poor-quality water spread into the basin[1]? Could the project pull this water back effectively? What duration of desalting project would the re-captured water sustain? Would all the poor-quality water be extracted?
- Project Capacity – how many wells would be required, what capacity could be pumped and treated, what would pumping rates be, and where would the desalter wells be located?

The study consisted of collecting and analyzing surface water and groundwater data, constructing and calibrating a groundwater flow model, simulating salt migration through particle tracking modeling, and analyzing a number of model scenarios to test capacity and location of desalter wells, and the groundwater response to this pumping.

2 Hydrogeology of Northern Pleasant Valley Basin

NPV is the northern extension of the main Pleasant Valley basin, an important source of groundwater for both urban use and the irrigation of the extensive crops of the Oxnard Plain. The discussion of the hydrogeology of the NPV is organized from the general to the specific, with general geology followed by aquifer testing and aquifer properties.

[1] Poor quality water defined as exceeding Los Angeles Regional Water Quality Control Board, Basin Plan Objectives, TDS 700 mg/L, sulfate 300 mg/L, chloride 150 mg/L (*http://www.waterboards.ca.gov/losangeles/water_issues/programs/basin_plan/electronics_documents/bp3_water_quality_objectives.pdf*)

2.1 General Geology

Historical interest in NPV has largely focused on structural geology, with a number of faults identified over the years. Because some of these faults are considered active, evaluating these faults in terms of geologic hazards has been a priority. Some of these faults have surface expression, whereas others are buried in the alluvium (Figure 1 indicates faults as they are depicted by the U.S. Geological Survey in their latest GIS coverage[2]). Whether any of these faults impede groundwater movement is discussed in the next section.

Faulting and accompanying folding in NPV is largely controlled by regional stresses associated with the rotation and movement of the Transverse Ranges. Compressional forces dominate, with the major faults in the area having a significant component of north-south thrusting. The Simi-Santa Rosa Fault Zone (Figure 1) is associated with anticlinal folding, both along the Camarillo Hills and as shown crossing Section A-A' just south of the Reunion Beryl #2 well. NPV is located in a syncline that trends south-southwest through the approximate location of the Pitts #1 well.

Two cross sections were constructed approximately orthogonally through the center of NPV (Figure 1). Stratigraphic correlations along the section lines were made primarily using oil well geophysical logs, supplemented by water well drillers logs. Section A-A' was tied on both ends to Turner and Mukae's (1975) regional cross sections B-B' and D-D'. The sections were also tied to cross sections being constructed by United Water Conservation District as part of the effort to revise the Ventura Regional Groundwater Model. The interpreted geophysical log for the Pitts #1 well is shown in Figure 2.

The water-bearing units of the Lower (LAS) and Upper (UAS) Aquifer Systems rest on both older sedimentary units and Conejo Volcanics. The UAS and LAS together reach a thickness of as much as 1,500 ft in NPV (Figure 3, Figure 4). The basal LAS consist of the Grimes Canyon Aquifer overlain by the Fox Canyon Aquifer. The Fox Canyon is now the primary water-producing unit in NPV. The LAS is folded and partially truncated at the north end of NPV (Figure 3). This truncation is evident where the LAS is exposed in the hills on the west and east sides of northernmost NPV (Figure 1). Along Arroyo Las Posas, this truncation surface is unconformably overlain by the sediments deposited by the arroyo (description in following paragraph). The UAS is present in NPV but is not a major water-producing unit. It is entirely truncated in the northern portion of NPV (Figure 3).

Unconformably overlying the UAS and LAS is an alluvial unit deposited along the Arroyo Las Posas. Drillers' logs indicate that this alluvial unit, herein designated as the Shallow Aquifer, consists of sand and gravel, with finer-grained units in overbank locations (e.g., Figure 4). The maximum thickness of the unit in NPV is about 200 ft. Where the sand and gravel facies of the Shallow Aquifer overlies the Fox Canyon Aquifer, there is a ready conduit for recharge from the arroyo to the Fox Canyon (e.g., Figure 3). This occurs in a limited area within NPV, but apparently is the main recharge area for NPV. The limits of this recharge area are discussed in the next chapter.

[2] USGS, 2003, *Simulation of Groundwater/Surface Water Flow in the Santa Clara-Calleguas Basin, Ventura County, California*, WRIR 02-4136, 157 p.

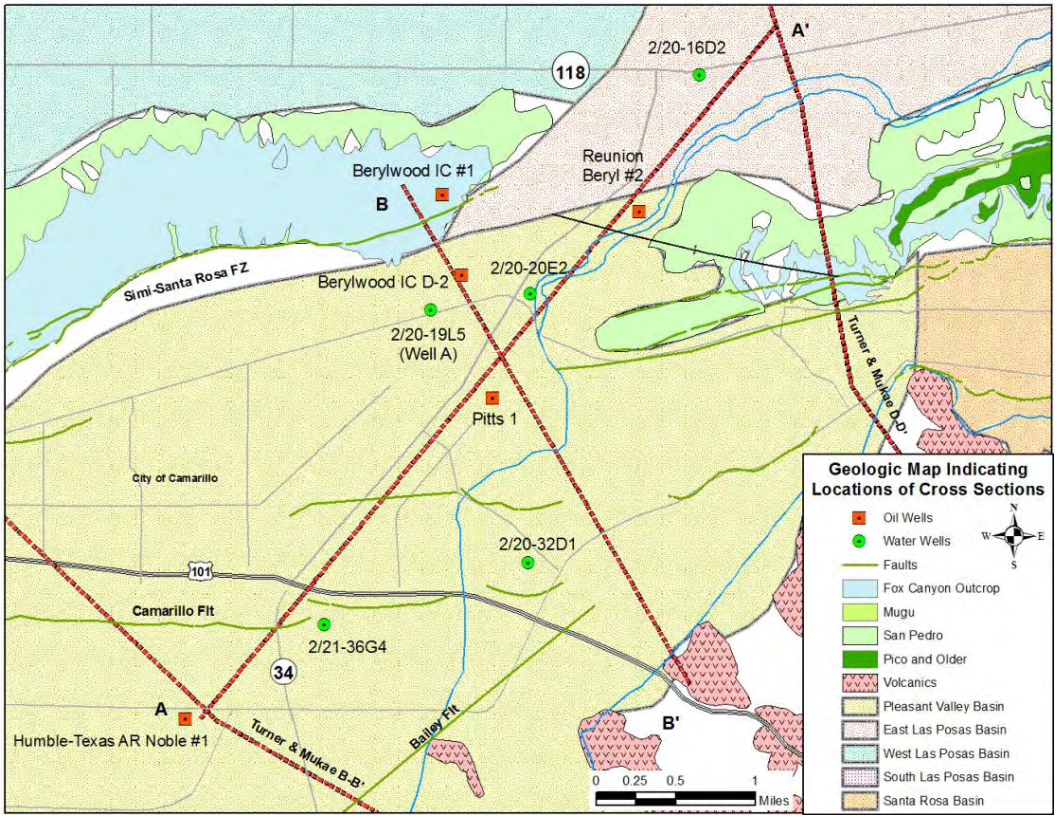


Figure 1. Geologic map of NPV indicating location of cross sections in following figures.

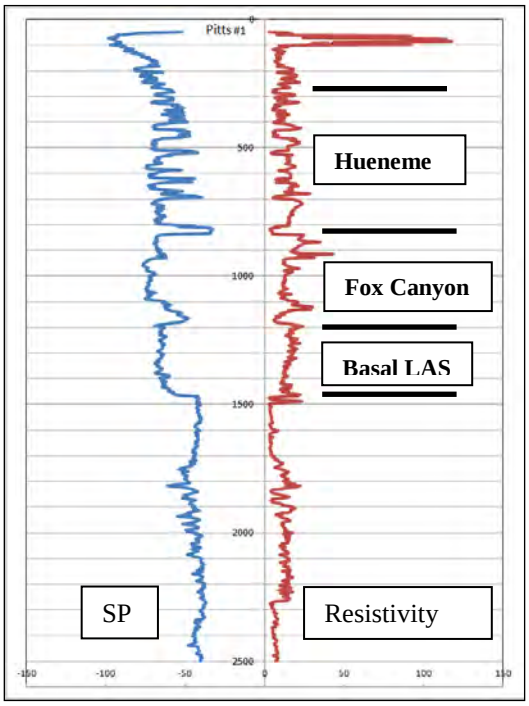


Figure 2. Geophysical log from Pitts #1 oil well (see location map). SP (spontaneous potential) is measured in millivolts; resistivity is measured in ohms m^2/m.

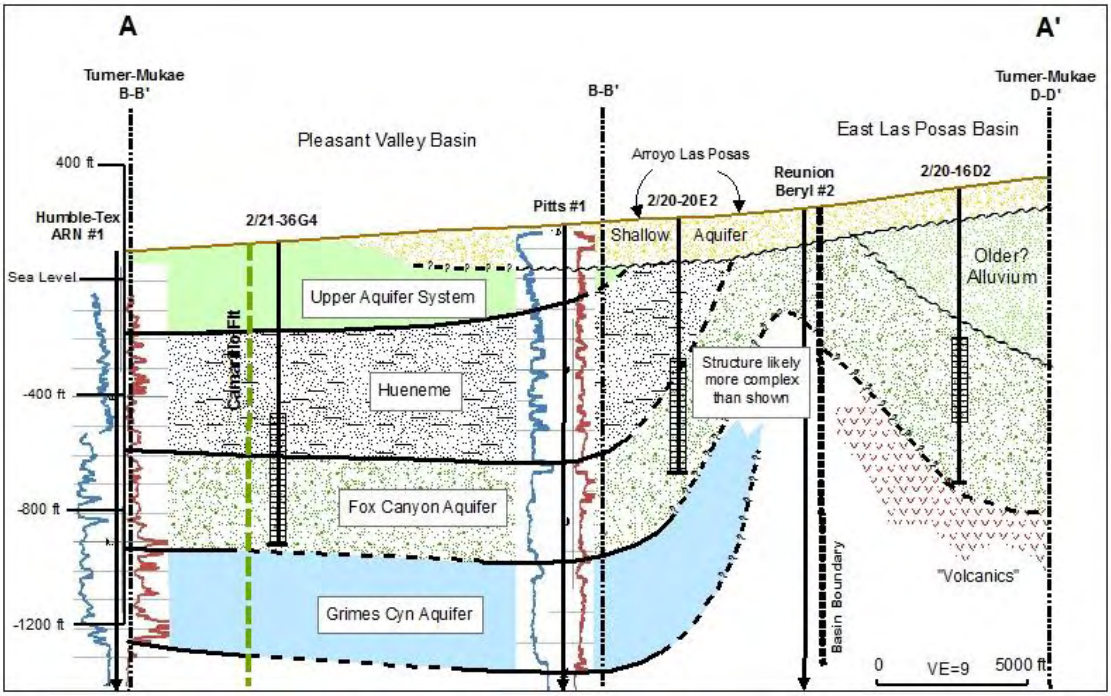


Figure 3. Section A-A' that crosses the project area from southwest (A) to northeast (A') (see location map). The southern end of the section ties to Turner-Mukae's section B-B' and United Water's regional cross sections and the northern end of the section ties to Turner-Mukae's section D-D'. The northern end of the project area is located at the basin boundary, where an anticline (and likely at least one fault structure) forms the boundary between NPV and the East Las Posas basin. Note that the Fox Canyon Aquifer is truncated by the Shallow Aquifer near the basin boundary; where this relationship occurs, water from the arroyo can percolate through the Shallow Aquifer into the Fox Canyon Aquifer, providing a conduit for movement of brackish water from the arroyo into the Fox Canyon. Perforations in water wells are indicated by hachured areas.

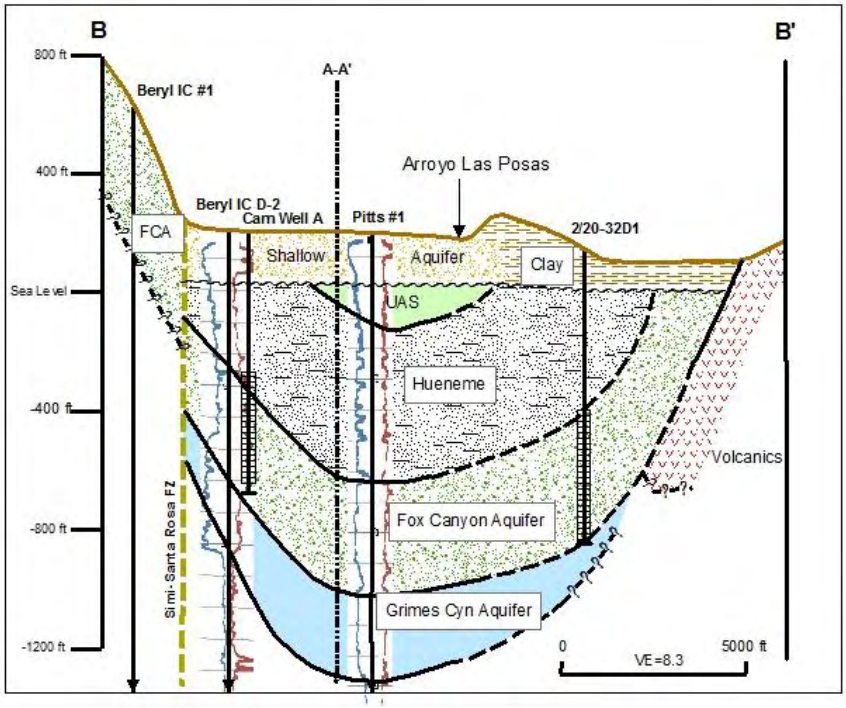


Figure 4. Section B-B' that crosses the project area from northwest (B) to southeast (B') (see location map). Although this section indicates the same relationships between geologic units as Section A-A', the Fox Canyon Aquifer in Section B-B' is overlain by clay-rich alluvium and does not present a ready path for movement of surface water into the Fox Canyon Aquifer.

2.2 Hydrogeology

NPV has seen rapid changes in both water levels and water quality over a two-decade period. The trigger for these changes appears to be the advent of overflow of dry-weather flow from the Las Posas basin, with the dual effect of rapidly raising groundwater elevations from this new source of recharge and deterioration of water quality from the poorer-quality baseflow in the arroyo.

Trends in Groundwater Elevations

Hydrographs constructed in the northern portion of NPV (Figure 5) exhibit the rapid rise (over 200 ft) in groundwater elevations that began in the early 1990s (Figure 6). In the portions of NPV closest to the Santa Rosa basin (and away from the recharge area in NPV), groundwater elevations had risen by about 50 ft by 2005 (Figure 7); there are no data available for later time periods in that area. South across Highway 101, there was a less substantial rise in groundwater elevations (Figure 8, Figure 9, Figure 10), with water level trends complicated by recovery from drought pumping in the late 1980s and early 1990s, increased in-lieu surface water deliveries by United Water Conservation District, and the beginning of the Conejo Creek Project.

Groundwater elevation maps were constructed for Spring of 1994 (Figure 11) and 2011 (Figure 12). There was a significant pumping depression in NPV (groundwater elevations as low as 120 feet below sea level) in 1994 (Figure 11). The additional percolation from the dry-weather flow (base flow) of Arroyo Las Posas had sufficiently recharged the Lower Aquifer System of NPV that by 2011 the pumping depression was eradicated and a recharge mound

created (Figure 12). At its northern edge, this recharge mound creates heads that are near ground surface. Figure 13 indicates that groundwater elevations increased by as much as 225 ft from 1980 to 2011. As discussed previously, some of this rise in groundwater elevations south of Highway 101 is likely caused by increased in-lieu surface water deliveries by United Water Conservation District and the Conejo Creek Project to the area.

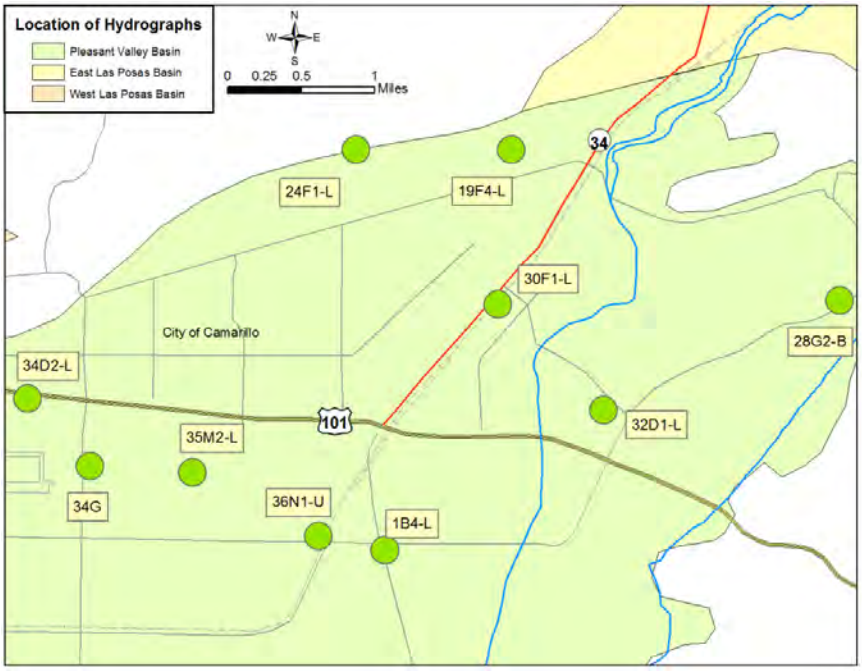


Figure 5. Location of hydrographs in following figures. In well designation, L=Lower Aquifer, U=Upper Aquifer, B=Both aquifers.

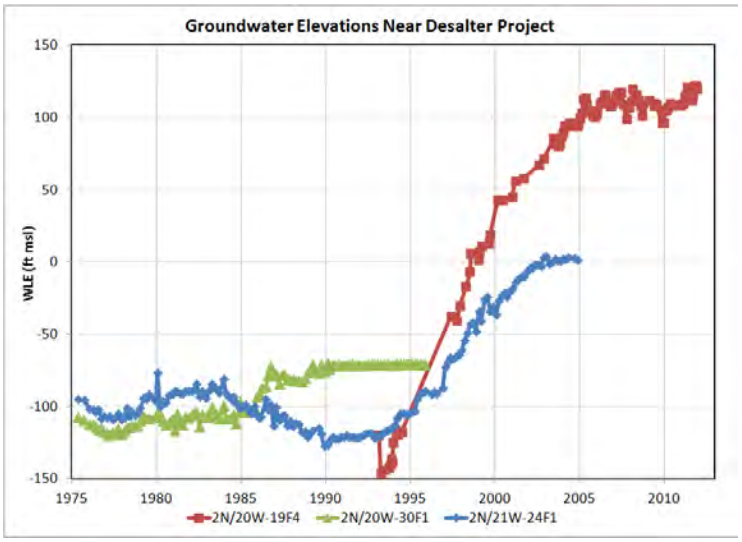


Figure 6. Hydrographs for wells near Desalter Project. See map for well locations.

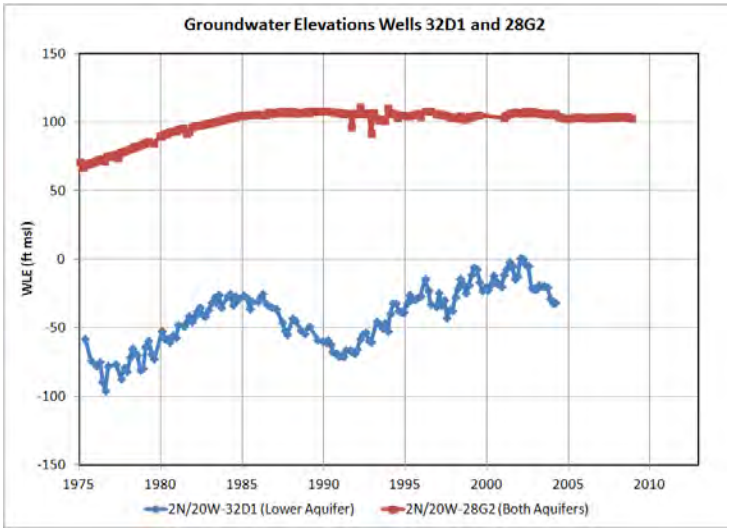


Figure 7. Hydrographs for wells 32D1 and 28G2. See map for well locations.

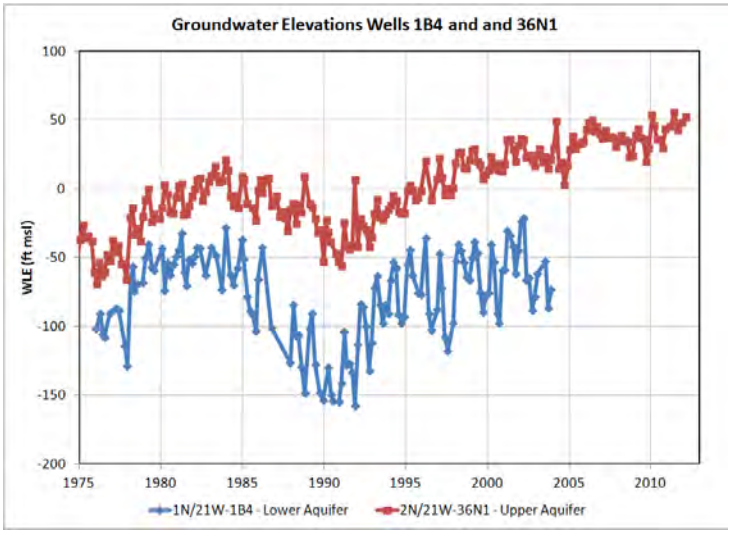


Figure 8. Hydrographs for wells 1B4 and 36N1. See map for well locations.

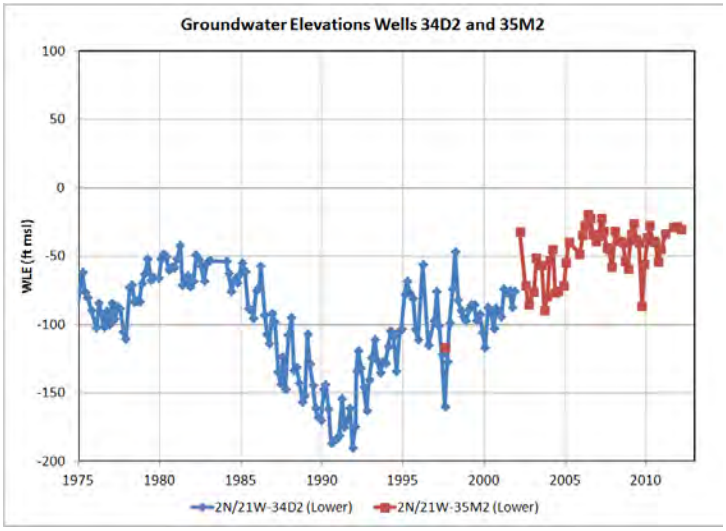


Figure 9. Hydrographs for wells 34D2 and 35M2. See map for well locations.

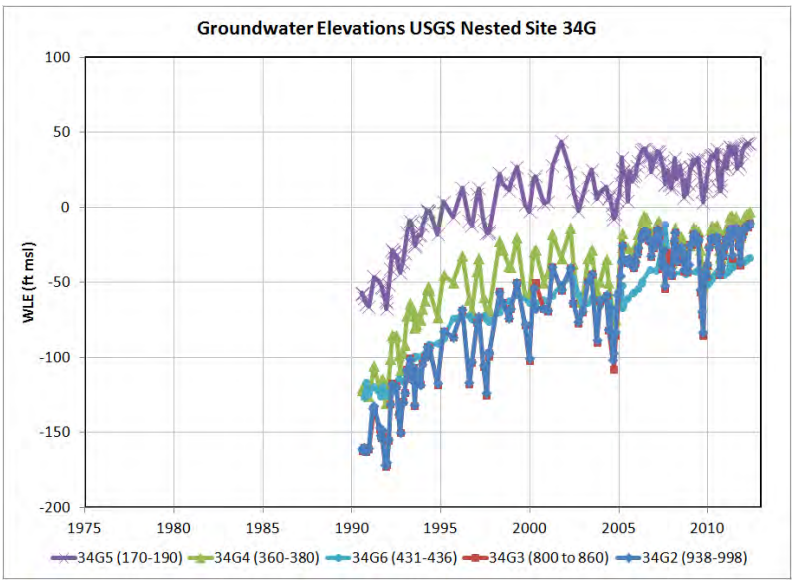


Figure 10. Hydrographs for USGS nested site 34G. See map for well locations.

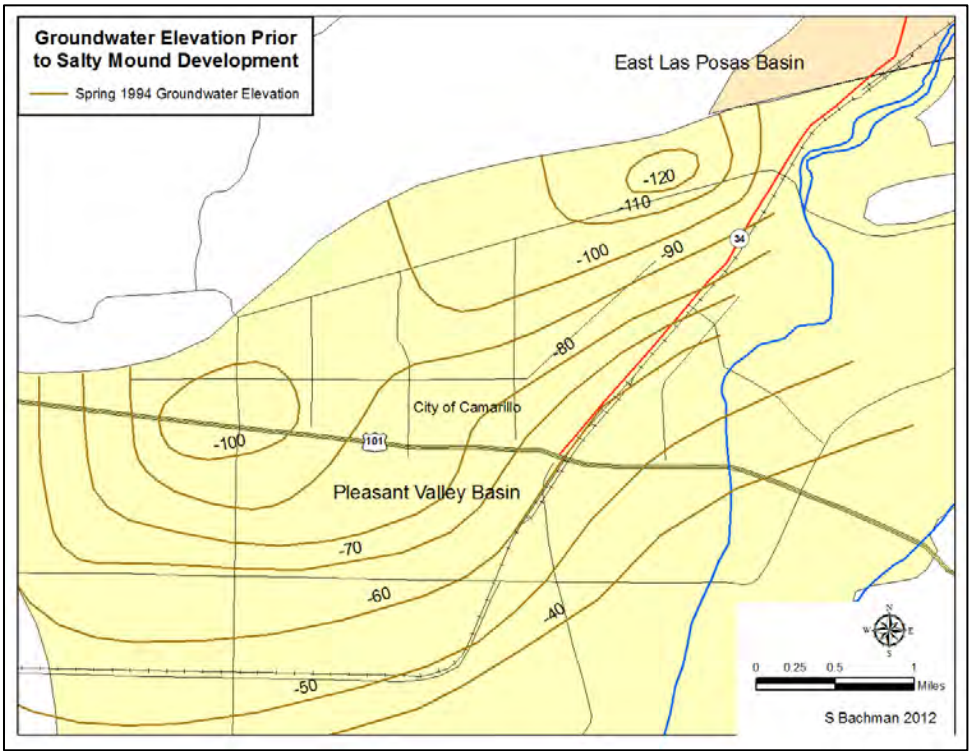


Figure 11. Groundwater elevation map for Spring 1994.

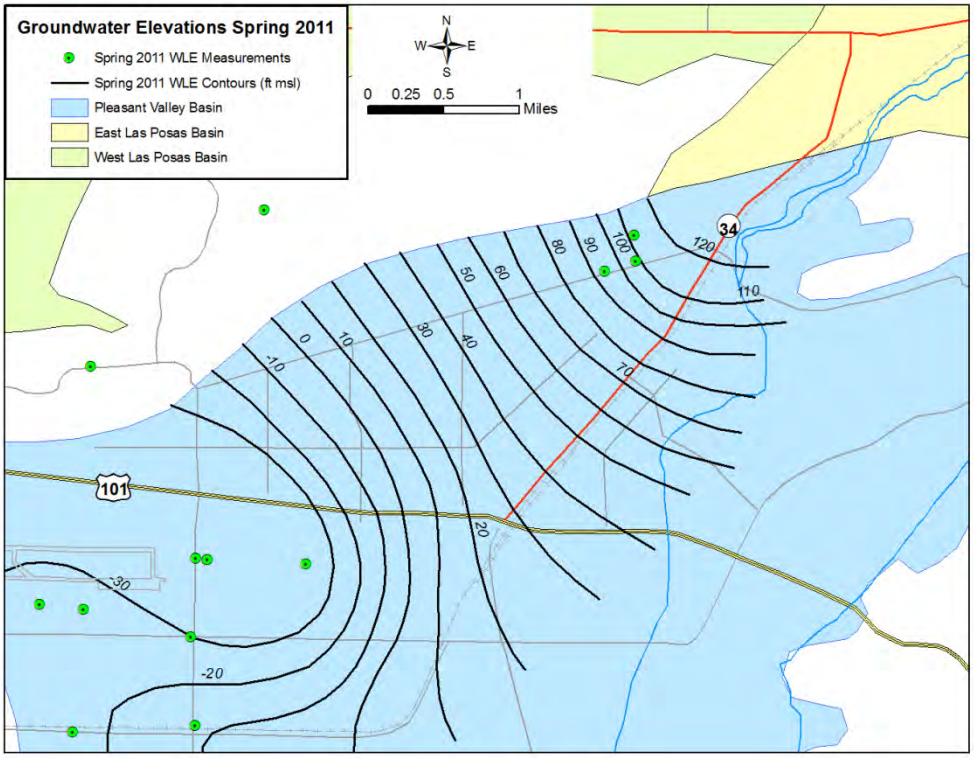


Figure 12. Groundwater elevation map for Spring 2011.

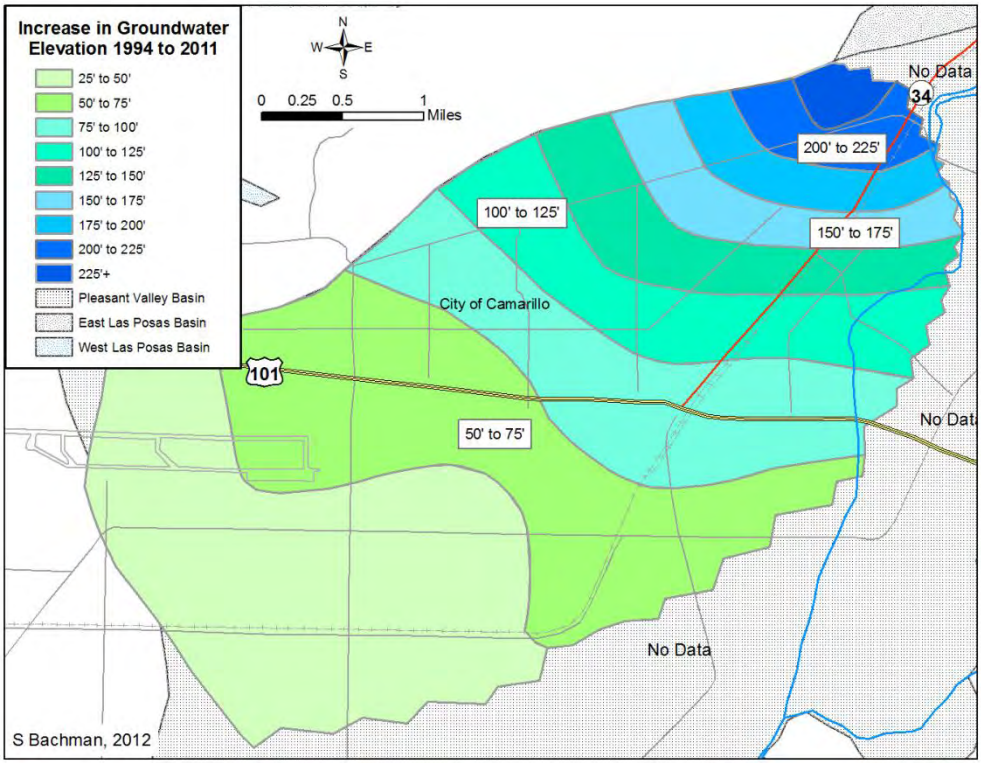


Figure 13. Increase in groundwater elevation from 1994 to 2011.

Groundwater Quality

The effect of the recharge of the poorer-quality base flow of Arroyo Las Posas is evident in the wells closest to the area of recharge in the northernmost wells in NPV. Figure 15 and Figure 16 show increases in sulfate, chloride, and TDS starting in the 1990s; Figure 15 shows the most distinct change in water quality sometime after year 1995. For context, groundwater elevations started to rise in about 1992 in these wells – a lag time between a rise in groundwater elevation and actual movement of the poor-quality out into the aquifer would be expected. The observed lag time was used to help calibrate the groundwater model.

PV wells located towards the center of the basin have not yet detected the water quality changes seen in the wells located in northern PV (Figure 17 to Figure 22). There is a data gap in recent sampling in much of NPV because the wells that provided earlier data have been destroyed as urban growth occurred. Thus, it is not known how much further the poor quality water has migrated southward in PV. The particle tracking analysis discussed in a later chapter models the possibilities for this migration.

Two additional water quality analyses were performed in NPV. Stiff diagrams (charting milliequivalents of major cations and anions) for the 1980s and in 2010-11 were constructed to examine differences in water quality with time and space (Figure 23 and Figure 24). There is a variety of water quality types shown in Figure 23, indicating different sources of water and/or different histories of migration of the waters. From the 1980s to 2010-11, the only evident change in water quality occurs in the northernmost wells, where sulfate and chloride now dominate the major ions. This is consistent with the determination of water quality documented in preceding paragraphs in this northern portion of NPV. The gap in recent data in NPV is also documented in Figure 24.

A series of graduated-dot maps were constructed for groundwater quality in NPV in 2010-11. Although chloride concentrations have increased in NPV, levels are below drinking water standards. In the main Pleasant Valley basin, chloride concentrations above 200 mg/L are problematic for irrigation of many crops (Figure 25) and are not related to the baseflow recharge in NPV. Increased TDS and sulfate concentrations in NPV are higher than drinking water standards (Figure 26 and Figure 27), one of the main reasons the NPV Desalter Project was conceived to remove the excess salts that have infiltrated into NPV.

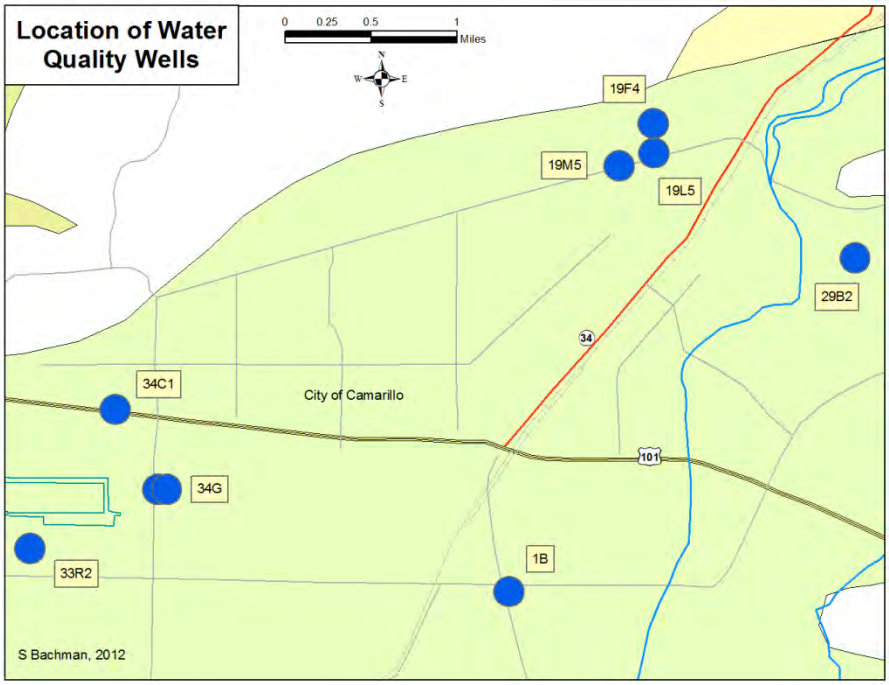


Figure 14. Location of wells with water quality graphs. Some of the graphs are in the Appendix.

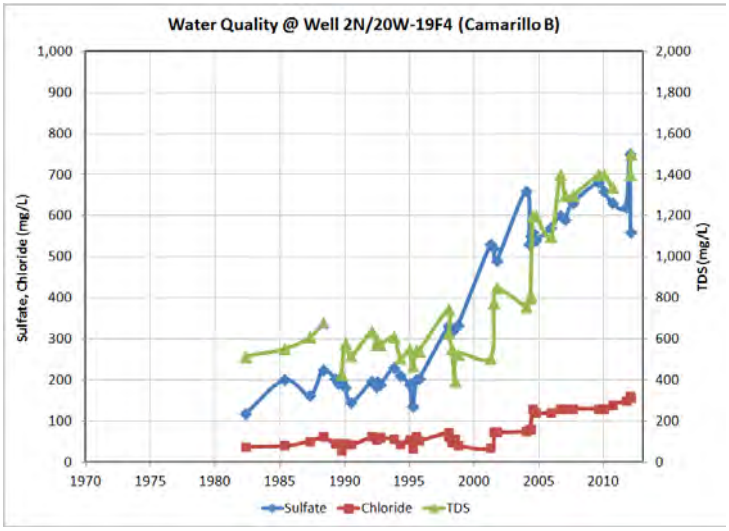


Figure 15. Water quality in well 19F4. See map for location.

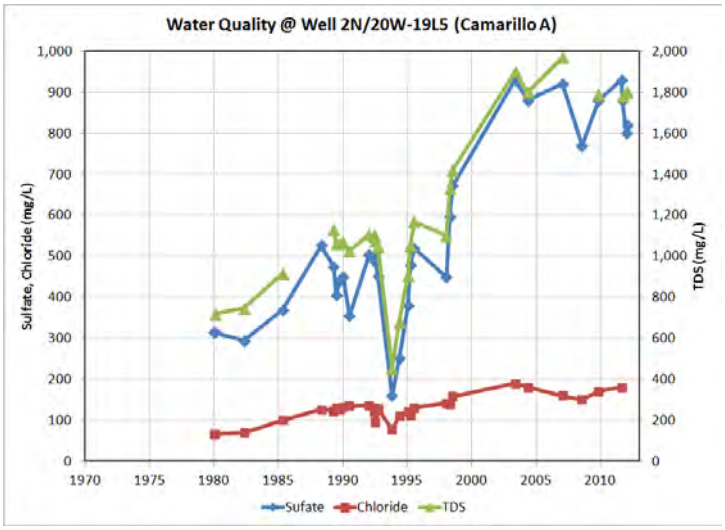


Figure 16. Water quality in well 19L5. See map for location.

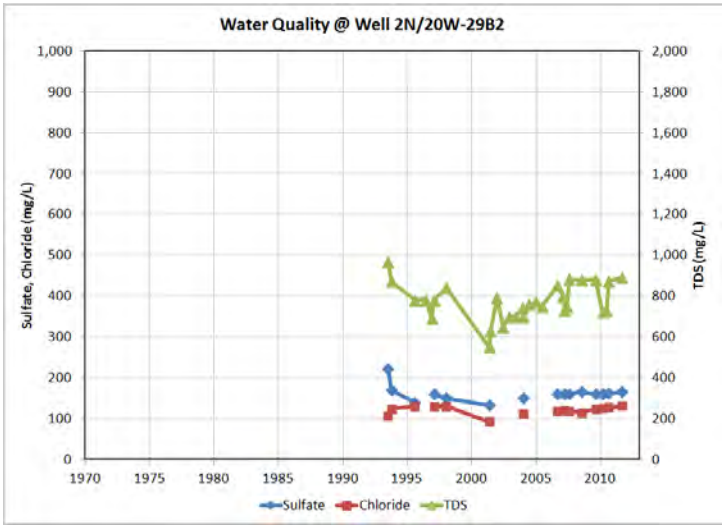


Figure 17. Water quality in well 29B2 (Camrosa WD Woodcreek well). See map for location.

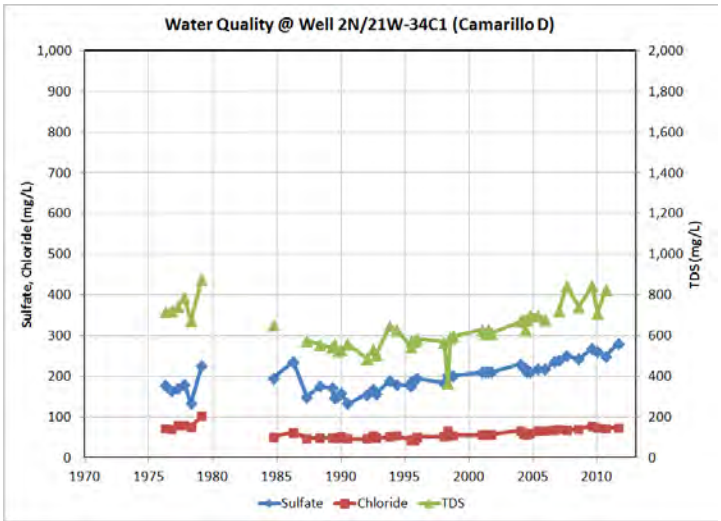


Figure 18. Water quality in well 34C1. See map for location.

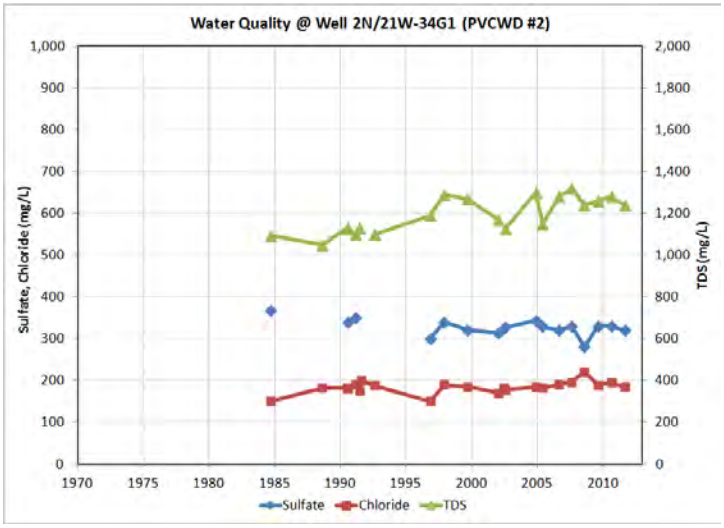


Figure 19. Water quality in well 34G1. See map for location.

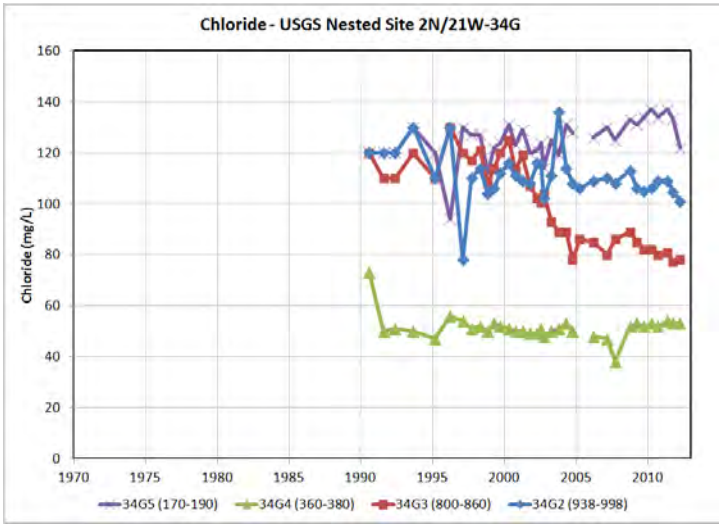


Figure 20. Chloride in wells 34G. See map for location.

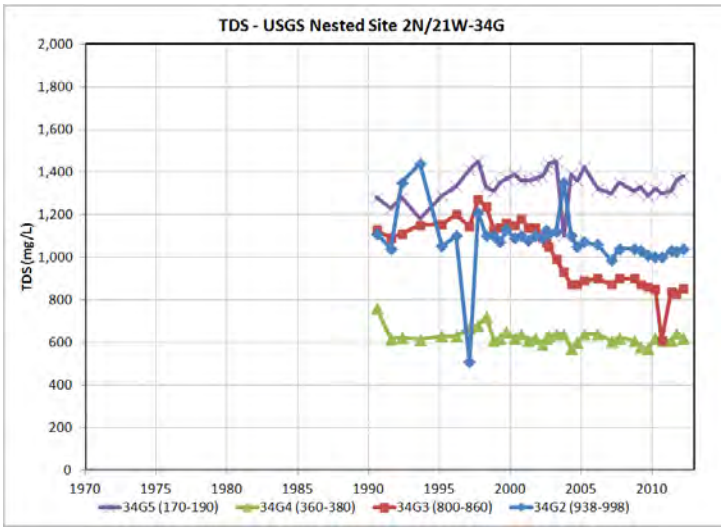


Figure 21. TDS in wells 34G. See map for location.

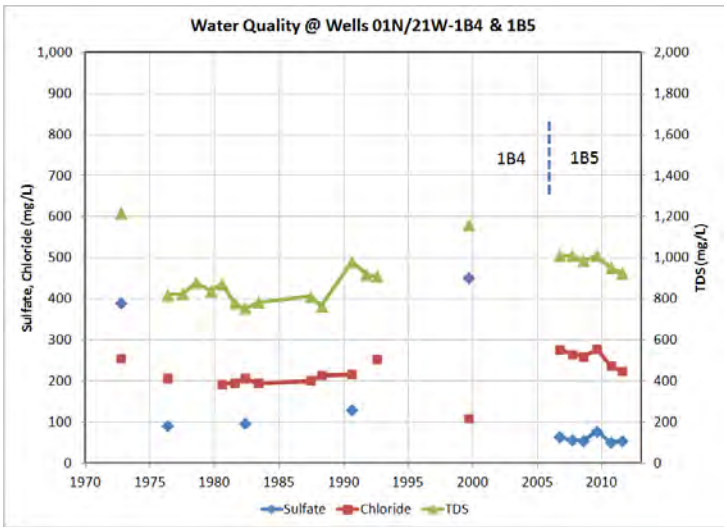


Figure 22. Water quality in wells 1B. See map for location.

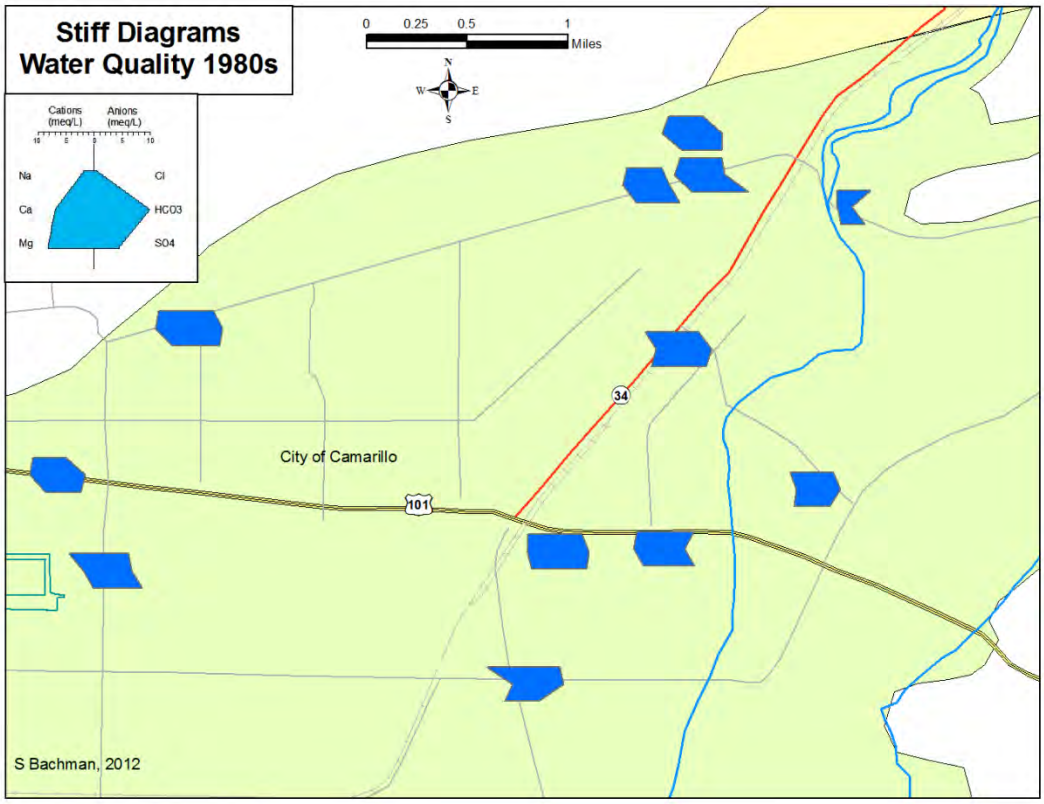


Figure 23. Stiff water quality diagrams for NPV groundwater in the 1980s.

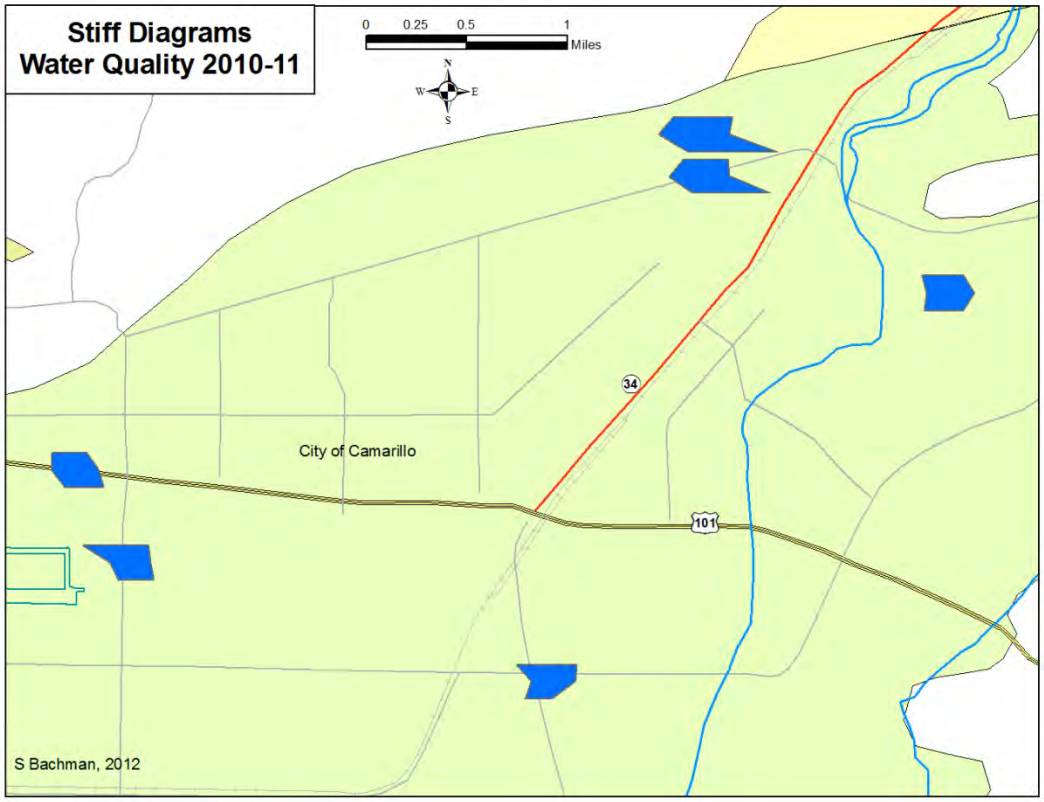


Figure 24. Stiff water quality diagrams for NPV groundwater 2010-11. See previous figure for Stiff legend.

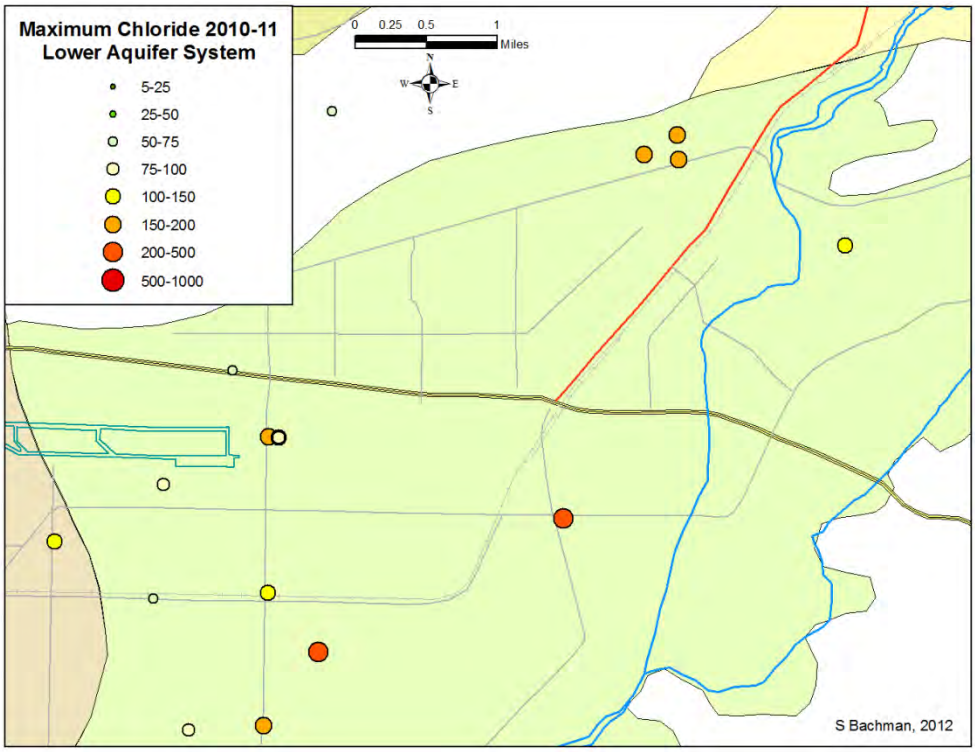


Figure 25. Maximum chloride concentrations (mg/L) measured in Lower Aquifer System wells during 2010 and 2011.

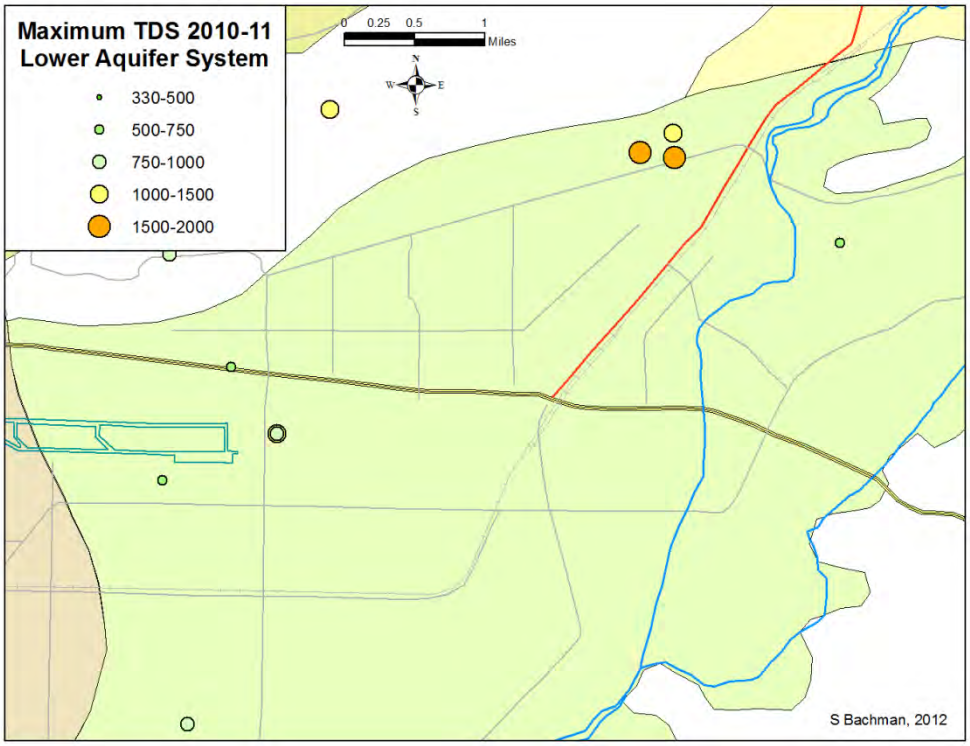


Figure 26. Maximum TDS concentrations (mg/L) measured in Lower Aquifer System wells during 2010 and 2011.

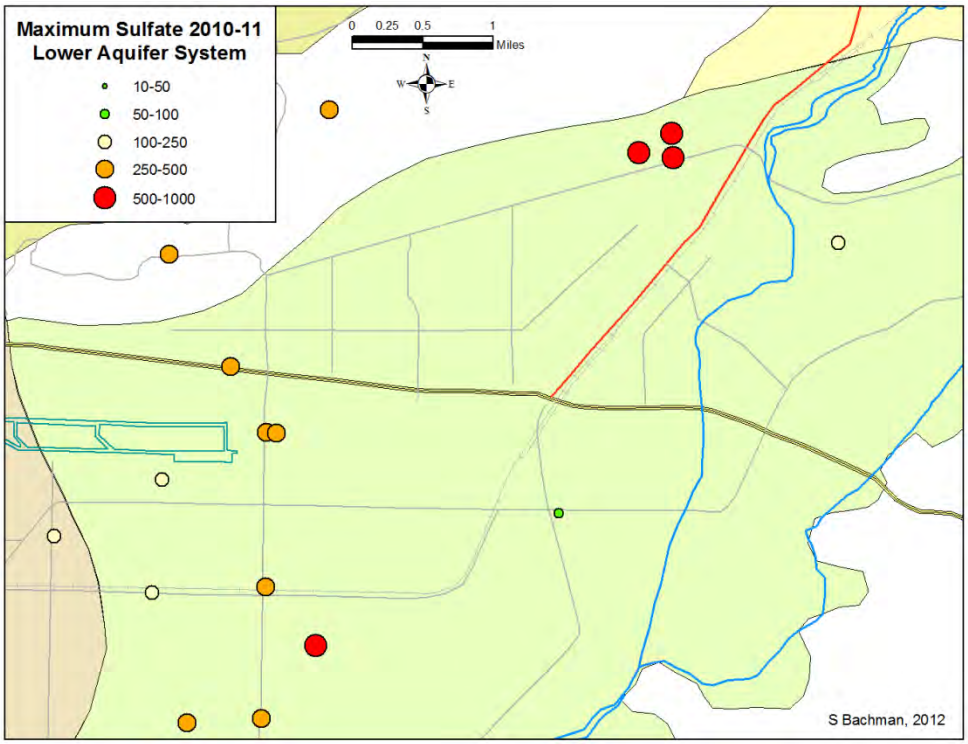


Figure 27. Maximum sulfate concentrations (mg/L) measured in Lower Aquifer System wells during 2010 and 2011.

Aquifer Properties

A series of aquifer tests, dynamic spinner logs, and vertical chemical profiles were conducted in 2011 for the City of Camarillo (contracted by TMR Geological Consulting Services). Two of Camarillo's production wells (A and B) and two other nearby wells were used as pumping and observation wells for the aquifer tests. The details of the results are included in the Appendix and on the attached CD. Ranges of results included:

Transmissivity: 4,000 to 10,300 ft^2/day

Storativity: 3.1E-06 to 4.5 E-04

Horizontal Hydraulic Conductivity: 11 to 30 ft/day

3 Analysis of Flow – Arroyo Las Posas

The flow of Arroyo Las Posas as it crosses the boundary between the Las Posas basin (LPB) and NPV is one of the most important components of the water balance for the NPV Desalter. There is no permanent gage at the basin boundary, so gages upstream and downstream of the project area must be used in flow analysis. Additional information was provided by a two-month long dry-weather flow study conducted in late 2011 in the LPB[3].

The two permanent gage sites of interest (Figure 28) are upstream in the LPB at Hitch Blvd (Gages #841, 841a) and downstream near Highway 101 (Gages #806, 806a). The gages have overlapping but not completely coincident periods of record (Table 1). A number of analyses were conducted to understand baseflow and stormflow relationships between the gage sites. An examination of historical aerial photos also provided insight into the downstream progression of baseflow percolation as the Shallow Aquifer in the LPB filled.

Baseflow in Arroyo Las Posas is a mixture of natural dry-weather flows, discharges from wastewater treatment plants, discharge from dewatering wells in Simi Valley, and agricultural tail waters. The terminus of the baseflow has moved downstream over the past decades as basins adjacent to the arroyo have filled, with spillage across the LPB-NPV boundary occurring in the early 1990s. Since that time, baseflow has entirely percolated into groundwater in the upstream quarter-mile or so of the arroyo as it flows into NPV (Figure 29).

In contrast, stormflows percolate into a longer reach of the arroyo than baseflow (Figure 29). The extent of stormflow percolation in NPV is not known with certainty. Aquifer testing in City of Camarillo wells A and B indicate that confined aquifer conditions exist at those locations, somewhat limiting the potential extent of percolation of stormflow into the Fox Canyon Aquifer. The possible downstream limit of significant percolation may occur where the arroyo changes from a wider braided stream to a narrow channel (Figure 29).

[3] Larry Walker and Assoc., 2012, *Phase I Study: Surface Flow and Groundwater Recharge in Arroyo Las Posas*, report to Calleguas Municipal Water District.

There are a number of inputs and outputs to streamflow between the Hitch and 101 gage sites. These include:

a) Tributaries within LPB (flow gain);
b) Percolation into groundwater as the arroyo flows over the LPB (flow lost);
c) Rising groundwater as the arroyo flows over the LPB (flow gain),
d) Percolation into groundwater as the arroyo flows over the NPV (flow lost); and
e) Tributaries and stormwater channels within NPV (flow gain).

There is only a loose correlation between daily flows gaged at the Hitch and 101 sites (Figure 30). The main reason for this poor correlation of daily flows is that baseflow is included in the comparison, and baseflow at Hitch never reaches the 101 gage site (it completely percolates along the route). However, if stormflow totals (the total flows from individual storm events) are compared, there is a good correlation between the two gage sites (Figure 31). Stormflow totals are somewhat higher at the 101 gage site, indicating that storm runoff between the two gages is higher than percolation from the arroyo.

It is important to separate infiltration of baseflow from infiltration of stormflow because baseflow is the source of poor-quality water in the aquifers. To estimate the amount of baseflow infiltration into NPV, the fate of baseflow between the Hitch gage site and the NPV basin boundary must be determined. The two-month long dry-weather study of the arroyo in LPB by Larry Walker Associates characterized flow at a number of sites in the reach between the Hitch gage and the LPB/NPV boundary. Net dry-weather loss along this reach averaged 10.6 acre-feet per day (Table 2). This net loss includes all additions and subtractions of water along the reach from the Hitch gage to the NPV boundary – water flowing in from upstream of the gage, water from tributaries and treatment plants along the reach, infiltration into the groundwater basin, and evapotranspiration losses. There were some uncertainties that will be addressed in a follow-up study during the 2012 dry season.

By subtracting the daily losses from the daily baseflow at Hitch, the baseflow reaching NPV can be estimated for the period 1994-2010 (baseflow first reached NPV about 1994). Within rounding errors, the baseflow reaching NPV is 3,851 acre-feet per year (10.55 acre-feet per day loss multiplied by 365 days) less than the baseflow at the Hitch gage. The summation of these daily estimates is shown in Table 4. Note that all baseflow entering NPV is percolated, which has been established by visual and aerial photography evidence. In addition, there is little or no recorded baseflow at the 101 gage site.

Stormflow percolation in NPV must be calculated using a different technique. Because there is currently little infiltration of stormflow in the Las Posas basin (infiltration of baseflow keeps groundwater elevations at stream level), it was assumed that stormflow gaged at the Hitch site reached the Las Posas basin/NPV boundary (plus additional tributary flows that are ungaged). The stormflow likely bypassed the first quarter-mile of the NPV reach because this reach has perennial flow and percolation of baseflow. Thus, infiltration of stormflow likely occurs downstream of the first quarter-mile of the arroyo, with the downstream limit of percolation indicated in Figure 29 and discussed earlier.

There is no direct measurement of percolation rates in the area of stormflow percolation. However, percolation rates can be estimated from baseflow percolation (Table 3). Baseflow percolates about 23 acre-feet per day (8,300 acre-feet per year divided by 365 days/year) over the measured length of the streambed where percolation occurs (1,400 ft). This equates to an infiltration rate of about 0.02 acre-feet per day per foot of arroyo length. If the same infiltration rate (0.02 acre-feet per day per foot) is used over the 5,500 ft reach where storm flow can infiltrate, a maximum of 89 acre-feet per day of storm water can be infiltrated. When this infiltration rate is applied during days when stormflow reaches NPV (averages 54 days/year), percolated stormflow can be estimated (Table 4). It should be noted that ungaged tributary flows between the Hitch gage and NPV are not included in this estimate. Infiltration of baseflow into NPV averages about 8,300 acre-feet per year and infiltration of stormflow averages at least 2,200 acre-feet per year (Table 4).

These estimated recharge rates are based on current data and studies, and likely have an error range of tens of percent. Potential errors in percolation amounts are integrated into the groundwater modeling for this study; amounts of percolation are varied to determine the sensitivity of percolation amounts to project modeling results.

Gage	Period of Record	Missing Yrs since 1990
Gage #841,a (Hitch)	1990 to present	WY 1996
Gage #806,a (101)	1968 to present	WY 2008

Table 1. Period of record of gages used in this study.

Reach between Gage Sites	Reach Gain (Loss) (CFD)	Reach Gain (Loss) (AFD)
Portion of 5 to 6 below Hitch	78,577	1.80
6 to 7	(5,967)	(0.14)
7 to 8	193,226	4.43
8 to 9	(480,211)	(11.0)
9 to 10	Unknown	
10 to 11 at NPV Boundary	(245,806)	(5.64)
Total Gain (Loss)	**(460,181)**	**(10.6)**

Table 2. Calculations of dry-weather stream gains and losses in Las Posas basin between the Hitch gage and the NPV border, based on Table 3 of the Larry Walker Assoc. study.

Recharge Area	Reach Length (ft)	Annual Recharge (AFY)	Daily Recharge (AFD)	Unit Recharge Rate (AFD/ft)
Baseflow	1,400	8,307	23	0.02
Stormflow	5,500		89	0.02

Table 3. Calculation of recharge rate for stormflows in NPV. The average annual recharge for baseflow was based on daily and annual calculations (see Table 4). The average recharge of 8,307 AFY equates to a daily recharge rate of 23 AFD, or 0.02 AFD for each foot of reach length. Using this unit recharge rate over the 5,500 feet of stormflow reach yields a potential of 89 AFD of stormflow recharge. 89 AFD was then applied in the daily stormflow calculations as the upper limit on daily infiltration.

	Hitch Gage		NPV Infiltration	
Calendar Year	**Storm Flow (AF)**	**Base Flow (AF)**	**Storm Flow (AF)**	**Base Flow (AF)**
1994	3,229	9,663	1,528	5,812
1995	27,621	10,980	4,229	7,129
1996	8,628	11,139	1,475	7,278
1997	7,206	10,313	1,308	6,462
1998	39,138	10,252	5,258	6,402
1999	1,783	14,879	739	11,028
2000	5,794	13,516	1,216	9,654
2001	17,206	12,465	1,891	8,614
2002	5,458	11,686	1,450	7,835
2003	10,763	12,110	1,296	8,260
2004	14,552	14,532	2,425	10,670
2005	50,615	11,639	4,166	7,788
2006	5,974	13,104	1,581	9,253
2007	3,092	13,404	1,844	9,554
2008	13,131	11,536	3,891	7,675
2009	6,098	12,514	2,103	8,663
2010	12,140	12,776	1,884	9,147
Avg	**13,672**	**12,147**	**2,252**	**8,307**

Table 4. Estimated baseflow and stormflow percolating into NPV. All of the Arroyo Las Posas baseflow crossing into NPV percolates into NPV. A portion of the stormflow crossing into NPV percolates into NPV. Totals are summations of daily flows. Significant figures are to nearest thousand at best. The sensitivity of modeling results to streamflow was tested and is described in the section "Using Model Results".

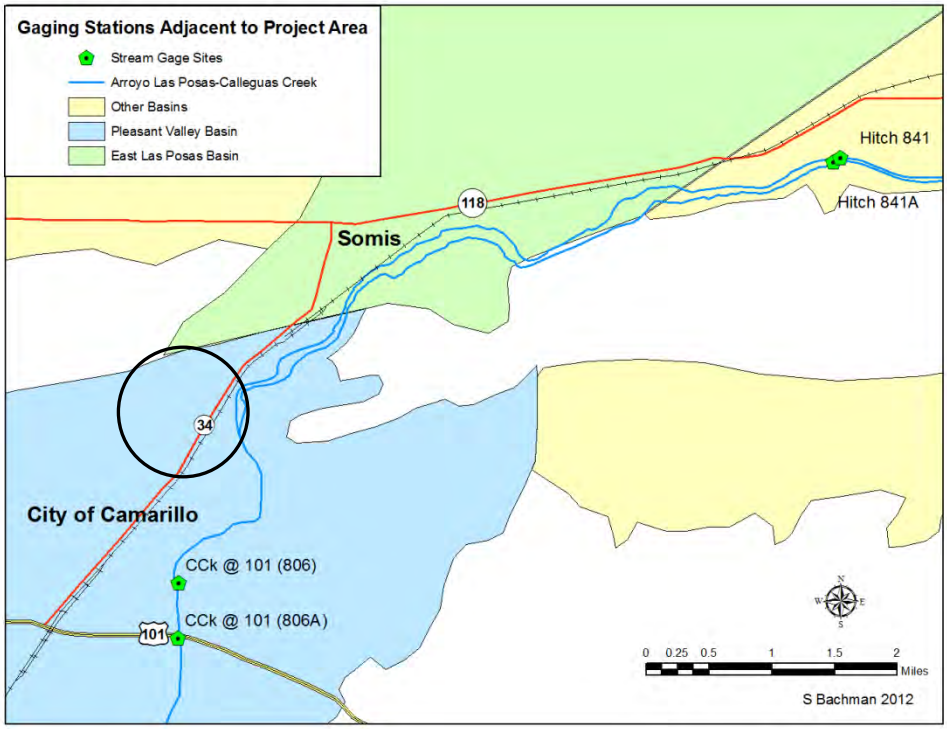


Figure 28. Gages on Arroyo Las Posas/Calleguas Creek used in this study. Circle is location of project.

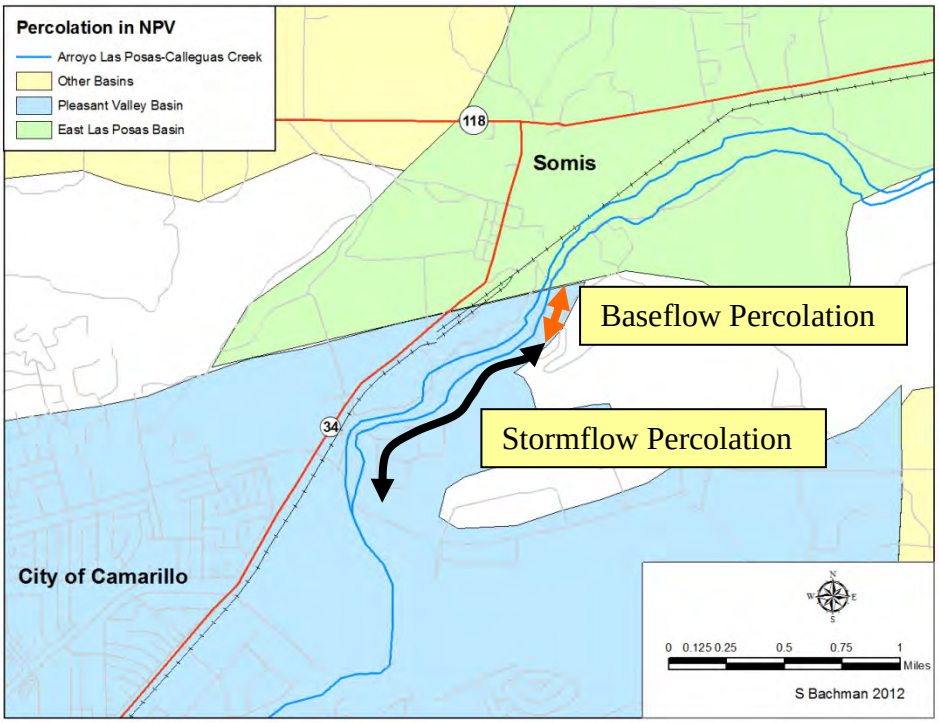


Figure 29. Location of percolation of baseflow and stormflow of Arroyo Las Posas into groundwater.

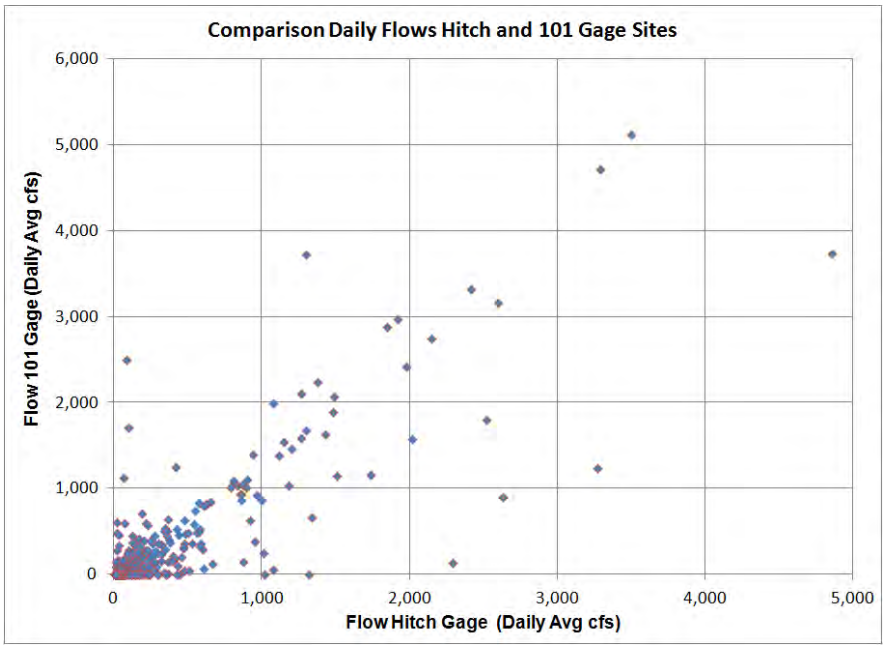


Figure 30. Comparison of daily flows at Hitch and 101 gage sites.

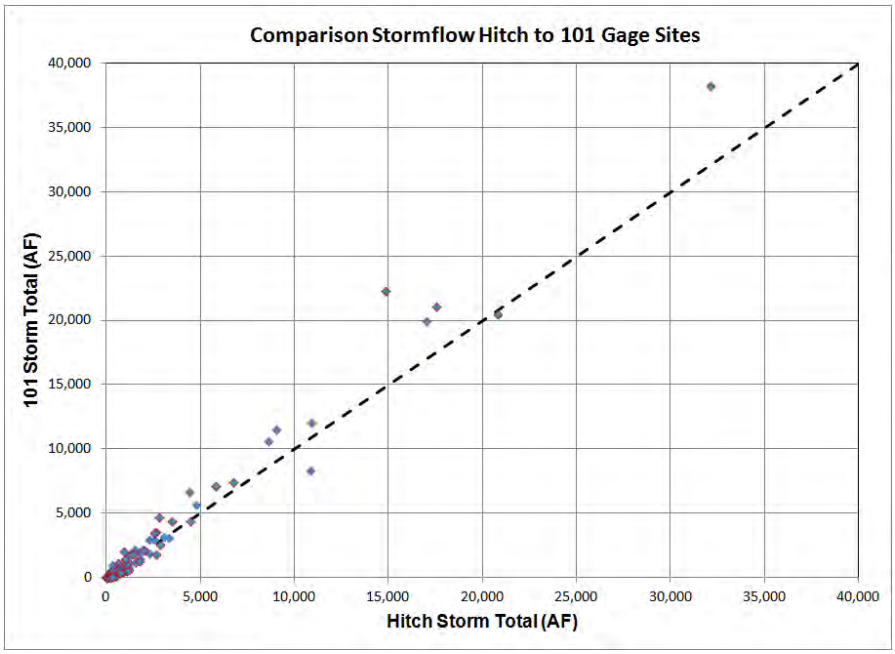


Figure 31. Comparison of storm total flows at Hitch and 101 gage sites.

4 Model Setup

The MODFLOW 2000 interface Groundwater Vistas version 6 was used for the modeling. Grid spacing is variable, with the smallest cells (200 ft by 200 ft) located in the project area to accommodate particle tracking. The model has two layers, Shallow Aquifer and Fox Canyon Aquifer, with the Fox Canyon Aquifer extending to the coast (Figure 32) and the Shallow Aquifer restricted in areal extent to the most upstream (northern) portion of NPV (Figure 33). The unconfined Shallow Aquifer accommodates all the percolation from Arroyo Las Posas-Calleguas Creek and moves the percolated groundwater vertically into the Fox Canyon Aquifer. The location of the Shallow Aquifer is estimated based on historical aerial photos showing the location of stream percolation, aquifer testing (City of Camarillo wells are in the confined portion of aquifer), the cross sections discussed earlier, and stream morphology.

Layer 1 is defined as the alluvial sediments located between the surface and the top of Layer 2 and thus varies in thickness laterally. The thickness of Layer 2 within the project area varies laterally somewhat, based on perforated intervals and well logs. South of US 101, the aquifer thickness used was that defined by the US Geological Survey in their groundwater model. In all cases within the project area and within a mile or so south of Highway 101, the thickness of Layer 2 was between 300 ft and 340 ft. Layer 2 aquifer properties were based on the recent aquifer testing of City of Camarillo's and nearby wells (discussed in an earlier section), where the effects of constant rate pumping on nearby wells were measured (Table 5). Layer 1 aquifer properties were initially estimated and then refined during the model calibration process.

The model boundaries were defined by basin edges (no-flow) and a set of constant-head cells located near the coastline and at a distance sufficient from the project area not to cause unwanted boundary effects. The values of the constant-head cells were based on sets of historical groundwater elevations measured during the calibration period. The model edge at the Pleasant Valley/Santa Rosa basin boundary was considered a no-flow boundary for model simplification. Because there is likely some movement of groundwater across this basin boundary, groundwater elevations in NPV are likely higher than modeled and the effects of pumping are likely overstated.

The model has annual stress periods, with 25 time steps each. Pumping for the appropriate model period was assigned to each well location based on historical pumping reported semi-annually to the FCGMA. Streamflow percolation was simulated by a set of cells with a specified flux located along the arroyo between the northern edge of the Pleasant Valley basin and the southern edge of Layer 1. Water was added to Layer 1 based on the estimated streamflow percolation of Table 4.

There were three types of modeling runs performed:

1. Steady State – Model was run in steady-state mode (inputs and outputs are constant) during an historical period when there was little change in groundwater elevations. Used to test the overall water balance, conceptual geometry, and aquifer properties for stability.
2. Transient Calibration – Model was run in transient mode (input and outputs change with time) using historical data. Groundwater elevations predicted by the model

should match measured historical water levels during the calibration period. Selected parameters (hydraulic properties of layers) were varied until there was a reasonable match.

3. Project Modeling – Project scenarios were simulated for a future period given specific inputs and outputs to the calibrated transient model.

	Kx (ft/day)	Kz (ft/day)	S
Model – Layer 1	40	20	0.15
Model – Layer 2	18	10	2E-04
Aquifer Tests Fox Canyon (Layer 2)	11-30	2-4	3E-06 to 5E-04

Table 5. Aquifer properties from aquifer tests on Camarillo wells A & B and adjacent wells compared to calibrated aquifer properties in model. Kx = horizontal conductivity, Kz = vertical conductivity, S = storativity. The modeled value for Kz in layer 2 is a calibrated value, which can vary from aquifer tests at a specific well because it applies to a large area of the model.

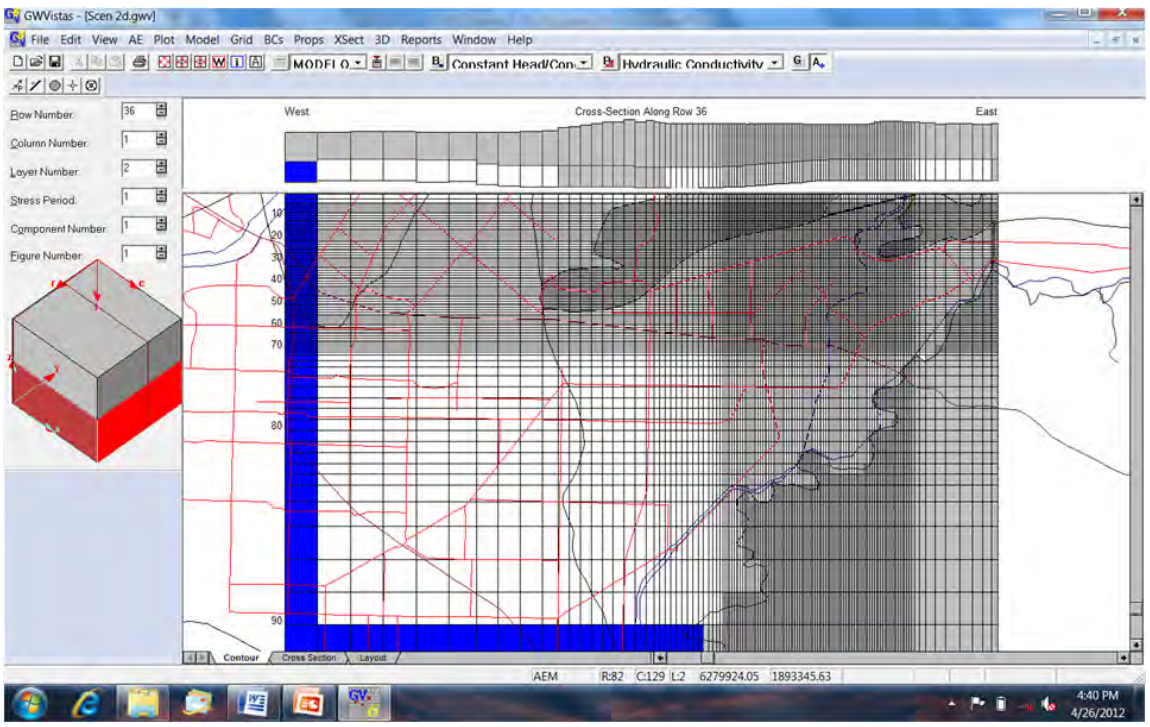


Figure 32. Model grid for layer 2. Model cell size was significantly decreased in the project area to accommodate particle tracking. Shaded areas are no-flow boundaries coinciding with the edges of the groundwater basins; blue model cells are constant head boundaries near the coastline.

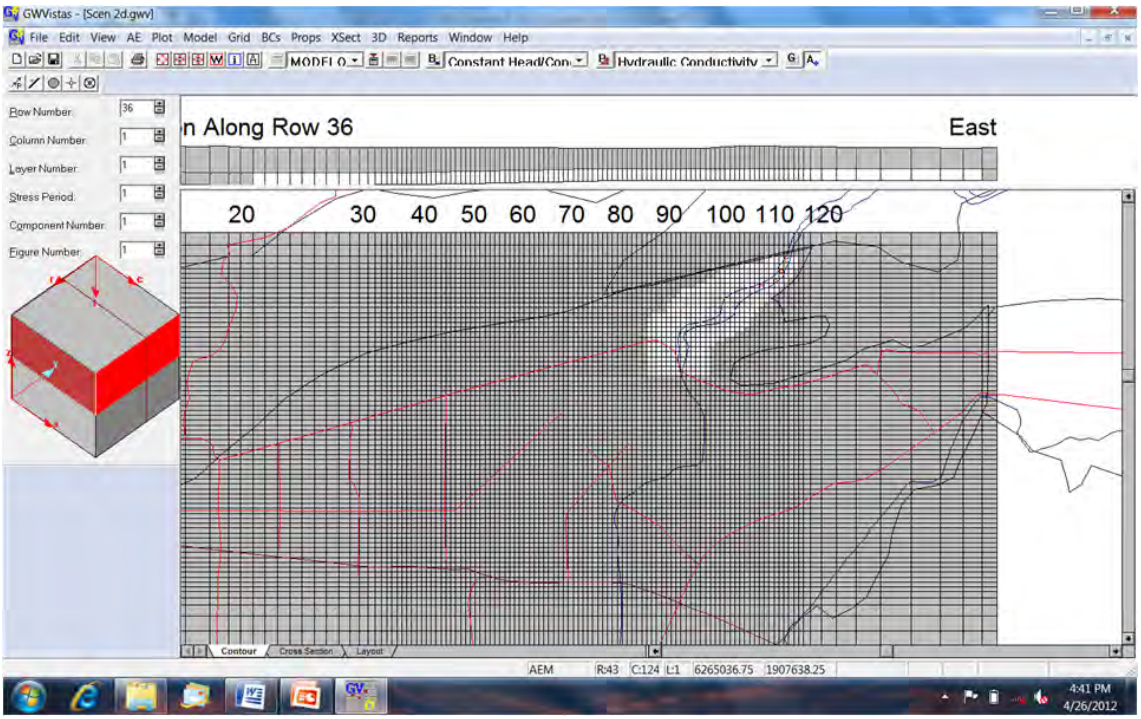


Figure 33. Model grid for layer 1. Model cell size was significantly decreased in the project area to accommodate particle tracking. Shaded areas are no-flow boundaries coinciding with the modeled extent of the Shallow Aquifer.

4.1 Steady-State Model

The model was run in steady-state mode for the period 1983 through 1986 to test the stability of the model. This period was chosen because there was little change in groundwater elevations and there was little baseflow yet reaching NPV from the Las Posas basin. Average stormflow and reported pumping for the period were used as inputs and outputs. Results simulated by the model indicated that water levels did not change during the period, verifying that the model was stable and ready for transient calibration (Figure 34).

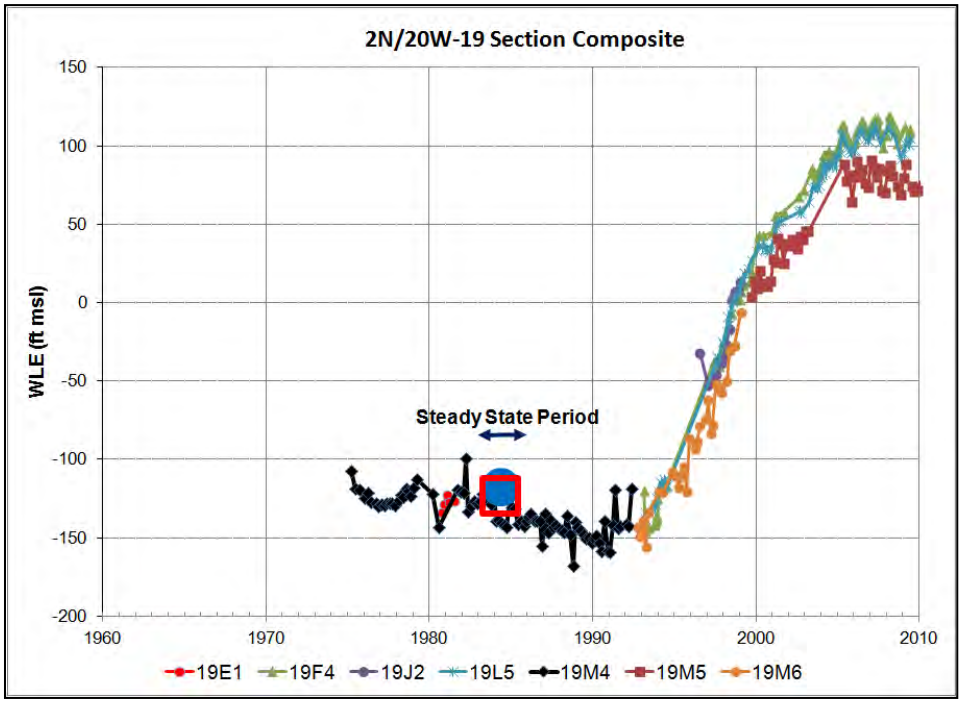


Figure 34. Composite groundwater elevations in area of Camarillo's wells A and B (2N/20W-19 location shown on Figure 35). Symbols are initial heads (blue circle) and final heads (red box) in the steady-state model.

4.2 Transient Calibration of Model

The model was then run in transient mode. Annual stress periods with 25 time steps each were prepared for the time interval 1994 through 2010. This period coincided with the beginning of spillage of brackish arroyo baseflow into NPV and the rapid rise in groundwater elevations caused by percolation of this brackish water. Streamflow percolation was simulated by introducing water into Layer 1 in the annual quantities indicated in Table 4. Baseflow was added in the first quarter-mile of the arroyo south of the boundary with the Las Posas basin and stormflow was added in the remainder of the arroyo within the extent of Layer 1. Production wells were pumped with the annual volume reported by well operators to the FCGMA (varied by year).

A set of wells with measured historical groundwater elevations was selected as "target" wells for the calibration period (Figure 35). The measured groundwater elevations for the target wells were input into the model for comparison with modeled values. The model then compared target

to simulated groundwater elevations in these wells. The calibration process is iterative, with changes made to the model following one calibration run and then the model is run again. There were approximately 25 calibration runs for this study. Contours of measured groundwater elevations at the beginning and the end of the calibration period are indicated in Figure 36 and Figure 37.

Although Groundwater Vistas has various methods of auto-calibration, the only automated tool used in this calibration was doing a sensitivity analysis of single model parameters. Because there were measured constraints on many of the model parameters, the only parameters that were allowed to be varied in the calibration process were Layer 1 hydraulic conductivity (horizontal and vertical), Layer 1 storage coefficient, and Layer 2 vertical conductivity.

The results of the calibration process are indicated in Figure 38 and Figure 39, with additional targets in the Appendix. Annual discrepancies seen in the comparison of modeled to actual water levels are partially created by the frequency of the measured water levels. Well measurements in this area are rarely performed on an annual basis, so that the "measured" curve is an average curve fit by Groundwater Vistas, whereas the "modeled" value reflects annual changes in recharge and pumping. The most important parameters in model verification are the timing and magnitude of change of groundwater elevations. In addition, calibration error is calculated by Groundwater Vistas – the scaled root mean squared (RMS) error of this model is 4.5%, well within the recommended error range of 10%[4].

The rise in groundwater elevations during the calibration period was significant, so the model is calibrated over a range of groundwater elevations; this is important in simulating project effects because pumping down the mound of brackish water would also occur over this same range of groundwater elevations.

[4] Zheng, C., and C. Neville, 1994, Practical Modeling of Pump-and-Treat Systems Using MODFLOW, PATH3d and MT3D, Short Course Notes.

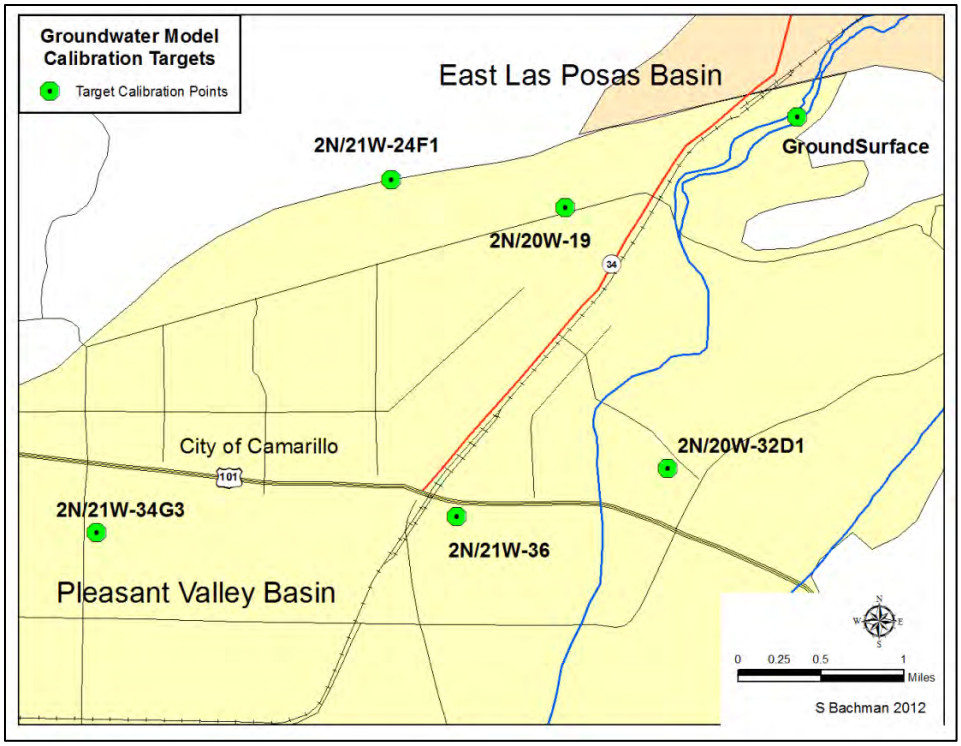


Figure 35. Calibration targets. In addition to wells with measured groundwater elevations, a calibration target was chosen in the area of the groundwater mounding to ensure that groundwater elevations did not exceed ground surface (MODFLOW allows this to occur in unconfined aquifers).

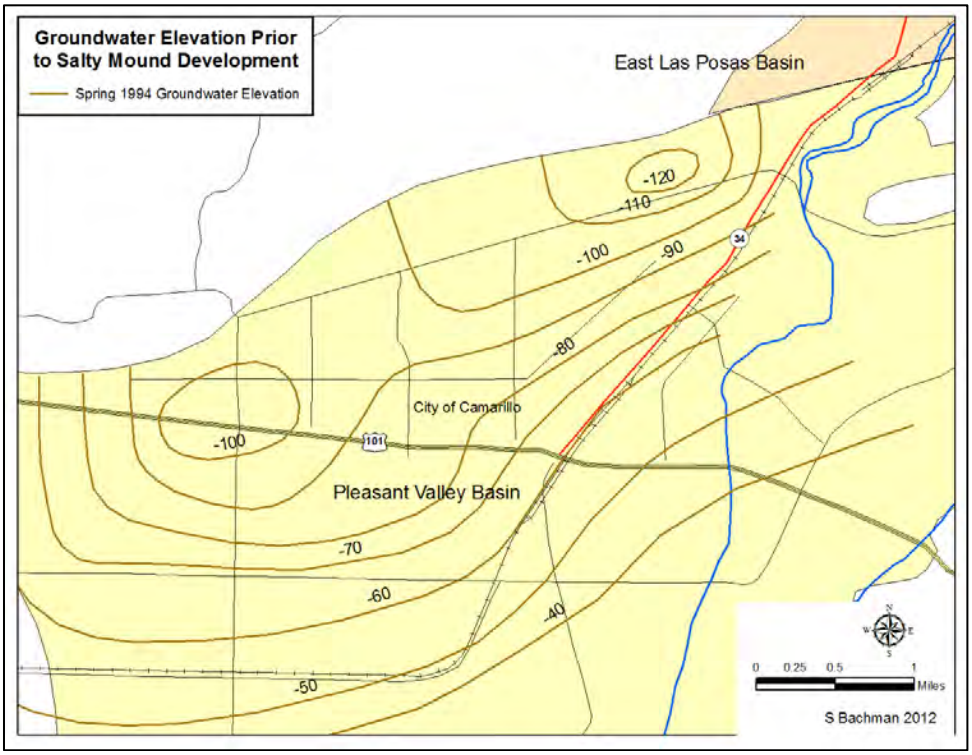


Figure 36. Groundwater elevations in spring 1994, just prior to the beginning of growth of the brackish mound beneath NPV.

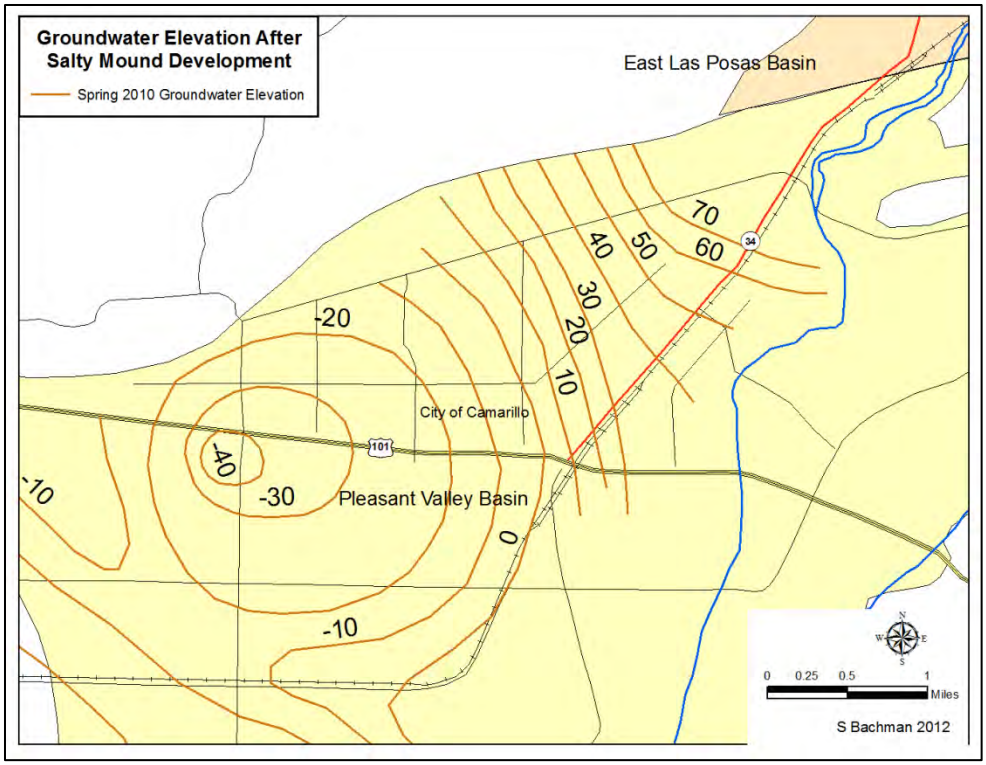


Figure 37. Groundwater elevations in spring 2010, after development of the brackish mound beneath NPV.

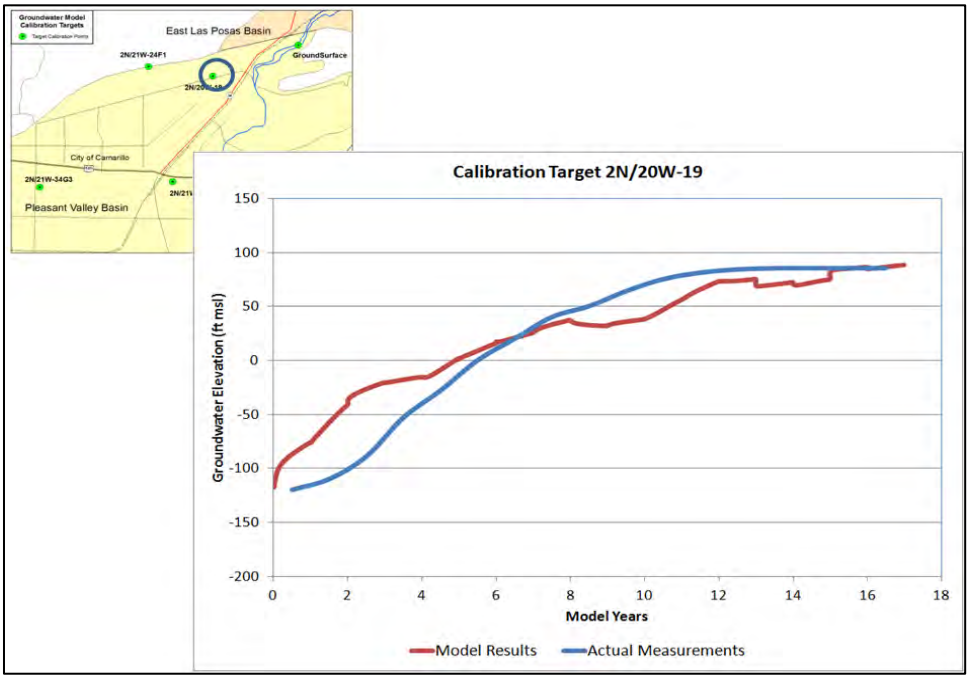


Figure 38. Calibration target 2N/20W-19.

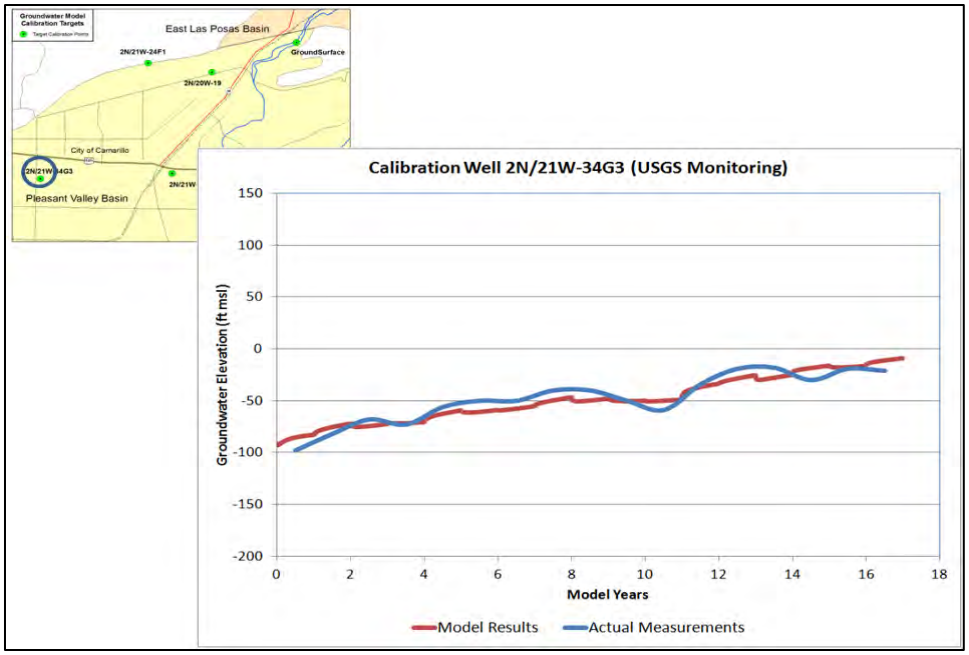


Figure 39. Calibration target 2N/21W-34G3.

4.3 Project Modeling

To model the effects of the project, both background hydrology (streamflow) and project yield/locations were varied. So that the potential path of brackish water could be modeled since brackish water first entered NPV, the model period started with the 17 years of the calibration period (1994-2010) and added 30 project years for a total model period of 47 years.

Modeling Inputs

Streamflow for model years 1 to 17 were the same as for model calibration. For the next 30 years, streamflow varied in two overall scenarios:

Scenario #1 – Annual streamflow (including baseflow and stormflow) was the average of the calibration period 1994-2010 (see average in Table 4). This assumes that no desalters (with their accompanying shallow pumping) were built and operated in Las Posas basin. This is a best-case scenario for source water for the NPV Desalter project.

Scenario #2 – Baseflow percolating into NPV is identical to Scenario #1 until the beginning of model year 23, when 5,000 AFY of baseflow is removed from NPV as a Las Posas desalter comes on line[5]. At the beginning of model year 28, the rest of the baseflow is removed by Las Posas desalting, leaving only stormflow entering NPV (as was the case prior to 1994). As baseflow is removed, the length of the streambed available for percolation of stormflow is increased, so stormflow percolation is increased proportionally. This is a worse-case scenario for source water for the NPV Desalter.

Groundwater pumping at individual wells for model years 1 to 17 was from FCGMA reported pumping. For model years 18 to 47 under all scenarios, groundwater pumping at each well was

[5] This desalter is likely to be the Moorpark Desalter, but any desalter project along the arroyo in Las Posas will yield the same effect in NPV.

the average of the past five years of pumping reported to the FCGMA. The only exception to the five-year average was for City of Camarillo wells (existing and new desalter wells) that varied with each scenario as to location and amounts of pumping.

Base Cases

The base case for the modeling analysis is that no desalting project would be built. All other inputs and outputs remain the same except that there is no project pumping. There is one change, however – City of Camarillo moves pumping of its 4,500 AFY FCGMA allocation to Well D and the Airport Well because the brackish water at its wells A and B make those wells unusable for potable supply.

In Base Case #1, the mound of poor-quality water continued to grow, extending into the main portion of the Pleasant Valley basin (Figure 40). Particle tracking for this scenario indicates that salts would affect a wide area of the basin, causing a potential new threat to aquifers within the FCGMA (see section Particle Tracking).

In Base Case #2 where desalters in the Las Posas basin eventually remove brackish baseflow from the arroyo, the recharge mound at the northern edge of NPV remained, but was less pronounced (Figure 41). The main reason for any mound remaining in Base Case #2 is that the City of Camarillo has moved its pumping away from NPV towards the Highway 101/Camarillo Airport area, reducing pumping of the mound.

Project Scenarios

A number of project scenarios were run with the model against the backdrop of Scenarios #1 and #2 changes in baseflow in the arroyo. In some of the project scenarios, the City of Camarillo's pumping is moved entirely to the desalter wells, eliminating pumping of Well D and the Airport Well (all scenarios except those with "-AP" at the end of scenario number). In other scenarios, there continues to be some pumping near the airport (scenarios with "-AP" at end of scenario number). As modeling results were discussed periodically among the desalter participants, the focus of later model runs was on using Scenario #2 arroyo flows because they represented a worse-case track for project longevity and effects, as well as a best-case for removing salts from the aquifer. Two scenarios also tested the sensitivity of varying the amount of baseflow in the arroyo that percolates into NPV (increase/decrease by 20%). Well locations used in the modeling are indicated on Figure 42. The project scenarios are summarized below:

Scenarios #1a and #2a – 4,500 AFY of desalter pumping (equivalent to Camarillo's FCGMA allocation) from two wells (existing wells A and B).

Scenarios #1b and #2b – 9,000 AFY of desalter pumping from four wells (wells A and B plus two nearby new wells).

Scenarios #1c and #2c – 9,000 AFY of desalter pumping from four wells (wells A and B plus two new wells extending northeast in a line from the existing wells). The only different between #b and #c is the location of the two new wells.

Scenario #2c-AP – Same as Scenario #2c except 2,000 AFY are pumped from Well D and the Airport Well during the project.

Scenarios #1d and #2d – 11,800 AFY of desalter pumping (the highest customer demand from desalter group) from five wells (wells A and B plus three new wells extending northeast in a line from the existing wells).

Scenario #2e – Scenario #2c (9,000 AFY of desalter pumping from four wells) with baseflow infiltration increased to 120% of calculated 8,300 AFY.

Scenario #2e-AP – Same as Scenario #2e except 2,000 AFY are pumped from Well D and the Airport Well during the project.

Scenario #2f – Scenario #2c (9,000 AFY of desalter pumping from four wells) with baseflow infiltration decreased to 80% of calculated 8,300 AFY.

Scenario #2f-AP – Same as Scenario #2f except 2,000 AFY are pumped from Well D and the Airport Well during the project.

Scenario #2g – 7,500 AFY of desalter pumping from four wells (wells A and B plus two new wells, one to the northeast of the existing wells and one to the south of the existing wells that would target "stranded brackish water" indentified during particle tracking).

Scenario #2h – 9,000 AFY of desalter pumping from four wells (same as Scenario #2c with further optimization of well locations).

Scenario #2h-AP – Same as Scenario #2h except 2,000 AFY are pumped from Well D and the Airport Well during the project.

Scenario #2h – 9,000 AFY of desalter pumping from four wells (same as Scenario #2c with further optimization of well locations).

Scenario #2i – 11,800 AFY of desalter pumping from five wells over 25 years (rather than 30 yrs).

Modeling results were analyzed several ways. The modeled change in groundwater elevations at several monitoring points within and adjacent to NPV were plotted and scenarios were compared. Groundwater elevation contour maps were also compared among scenarios. Particle tracking provided a technique to evaluate the potential movement of salts from their site of infiltration, their potential path of migration into NPV, and their movement after desalter pumping began.

The monitoring points that were used for evaluating model results included a combination of calibration wells, wells at the northern edge of agricultural production in the Pleasant Valley basin, and monitoring points located within the model at strategic positions within NPV. The locations of these monitoring points are shown in Figure 43.

Model Results in Groundwater Mound

The mound of poor-quality water is only pumped down at higher desalter pumping rates in Scenario #1 options (Figure 44), whereas the mound is dissipated to a larger degree at lower pumping rates in Scenario #2 options (Figure 45). Without desalter pumping in Base Cases #1 and #2, the mound of poor-quality water would remain as a prominent feature.

Model Results within City of Camarillo

None of the pumping options in Scenario #1 would reduce the mound of poor-quality water to historical 1994 levels (Figure 46, Figure 48). In contrast, the higher pumping-rate options of Scenario #2 eliminate the mound completely, in some cases lowering water levels below 1994 measurements (Figure 47, Figure 49).

Model Results at Southern Edge of City of Camarillo

Model results at three locations south of the City of Camarillo were analyzed: the USGS monitoring well at the PVCWD office and the two active agricultural wells closest to the southern boundary of the City of Camarillo (Figure 43). All Scenario #1 pumping options failed to reduce the effect of the mounding of the poor-quality groundwater at the USGS monitoring well site (Figure 50). In contrast, the higher pumping-rate options of Scenario #2 essentially eliminated the post-1994 groundwater mounding (Figure 51, Figure 52, Figure 53). At the higher pumping rates, drawdown at the southern edge of the City would need to be monitored and managed.

Further Optimizing of Desalter Wells Locations

To further optimize the location of the desalter wells, two additional scenarios (Scenarios #2h and #2h-AP) were added that mimicked Scenarios #2c and #2c-AP (9.000 AFY, 4 wells) except that the well farthest to the northeast was moved within the area of the other three desalter wells (location shown in Particle Tracking section, Figure 69). There were some decided advantages to this move, which are discussed in the Particle Tracking section. The potential disadvantage was that drawdown could be increased at the southern edge of Camarillo; however, as indicated in Figure 54, there is no discernible extra drawdown along the southern edge of the City.

25-Year Project

Following discussions with the NPV Desalter group, the option of a 25-year project (instead of 30 years) was modeled at a project pumping rate of 11,800 AFY (Scenario #2i). Several iterations with differing well locations were simulated to determine least impact on surrounding pumpers and maximum potential recovery of brackish water. The iterations were combined with particle tracking described in the next section to determine when project wells would no longer pump brackish water and would therefore be turned off. Five wells were used in the simulation (Figure 55) and an additional monitoring point was added (Pleasant Valley Mutual Water Company well 19E1).

Simulated hydrographs at monitoring points indicate that the 25-year project has initial drawdown similar to the 11,800 AFY 30-year project, but that later drawdown is muted by wells turning off as brackish water is recovered (Figure 56 to Figure 58).

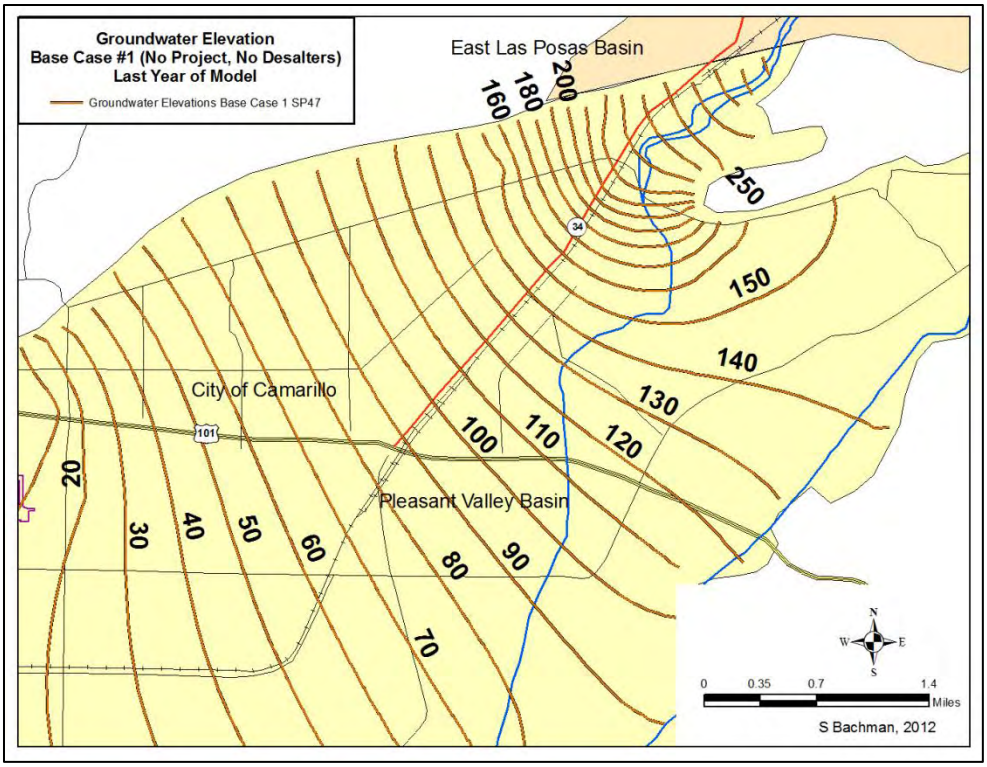


Figure 40. Scenario #1 Base Case groundwater elevations at end of 47-year modeling period. No project, no Las Posas basin desalters upstream (i.e., no pumping of shallow, brackish groundwater anywhere along Arroyo Las Posas and Calleguas Creek).

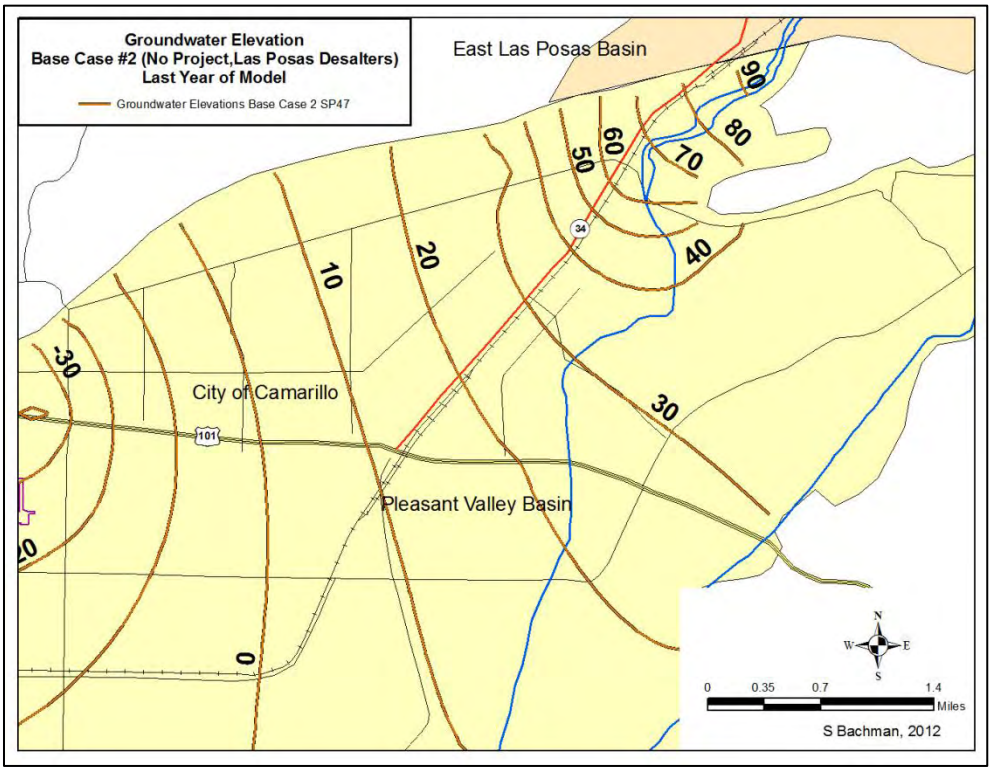


Figure 41. Scenario #2 Base Case groundwater elevations at end of 47-year modeling period. No project, but progressive reduction in brackish baseflow as Las Posas desalters comes on line.

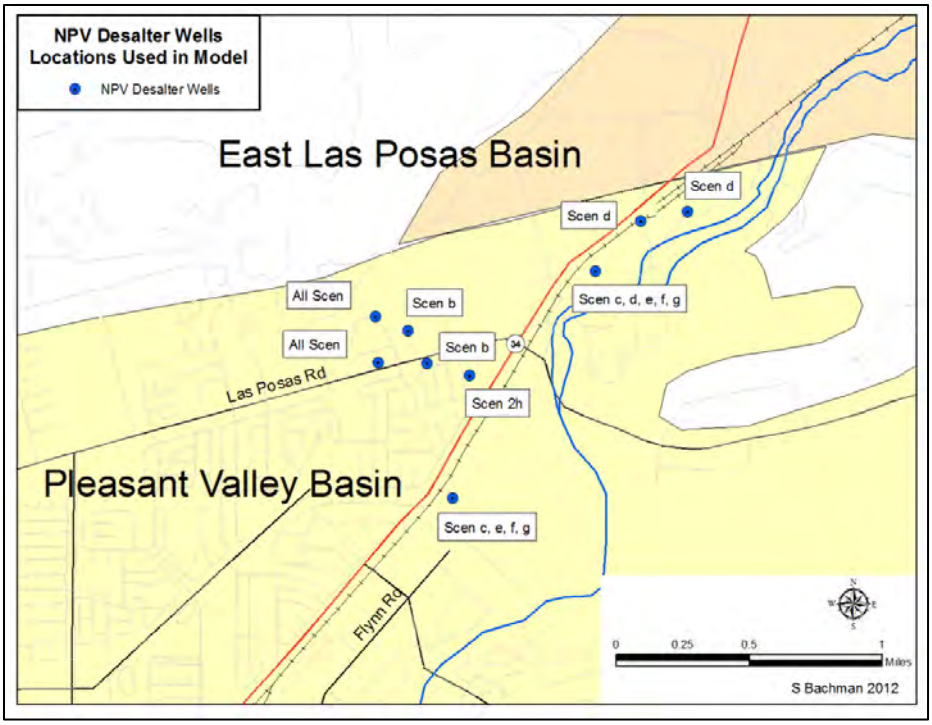


Figure 42. Location of wells used in desalter model runs. Label next to well indicates which scenario(s) the well was used for.

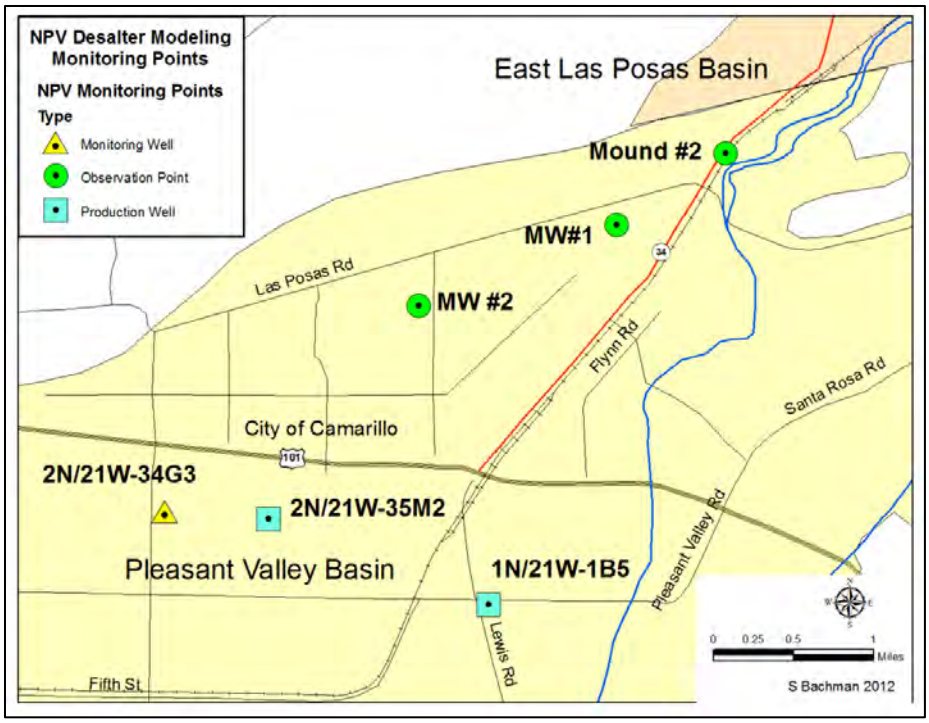


Figure 43. Location of monitoring points in model used for evaluation of the varying project scenarios. Monitoring wells and production wells are actual wells; observation points are selected in the model to simulate what a monitoring well would observe at that location. Mound #2 is a Shallow Aquifer (model Layer 1) monitoring point whereas the other monitoring points are in the Fox Canyon Aquifer (model Layer 2).

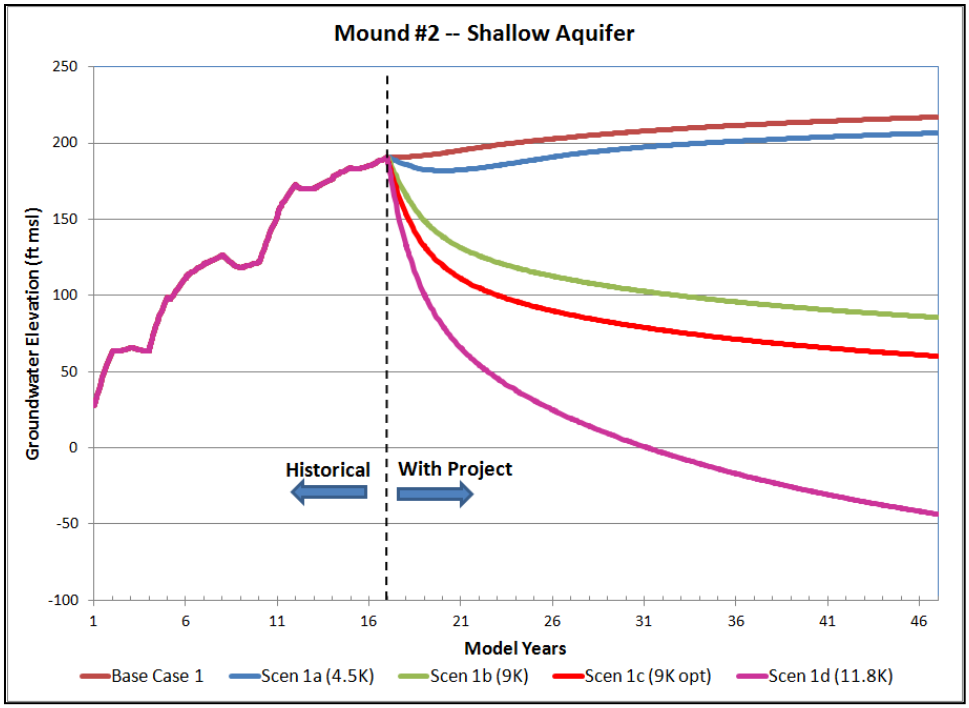


Figure 44. Hydrograph of Scenario #1 options at Mound #2 observation point. See previous map for location.

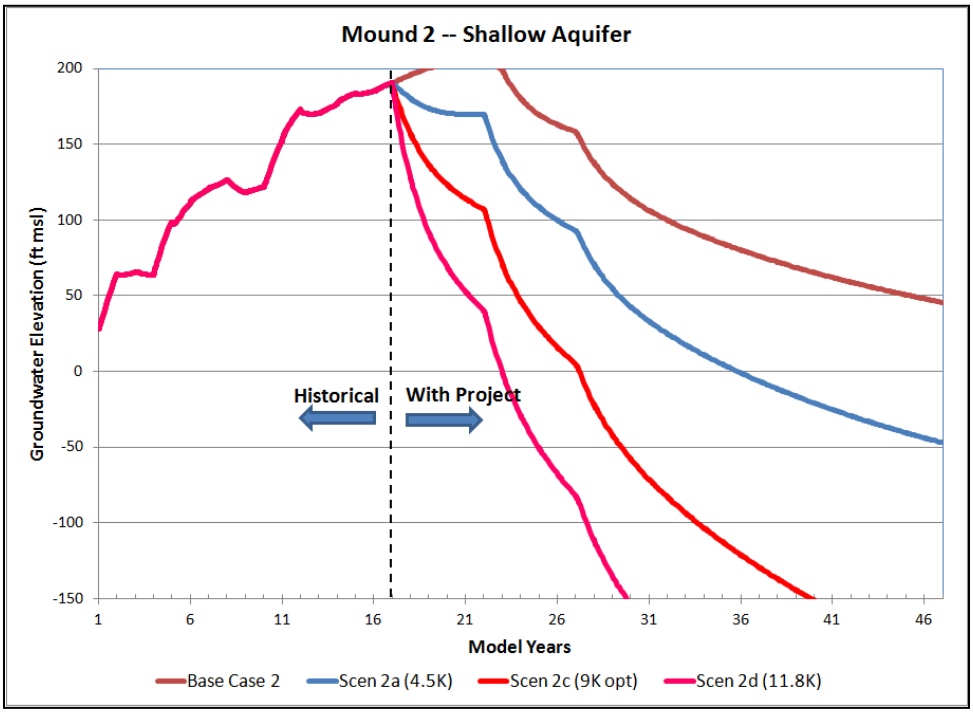


Figure 45. Hydrograph of Scenario #2 options at Mound #2 observation point. See previous map for location.

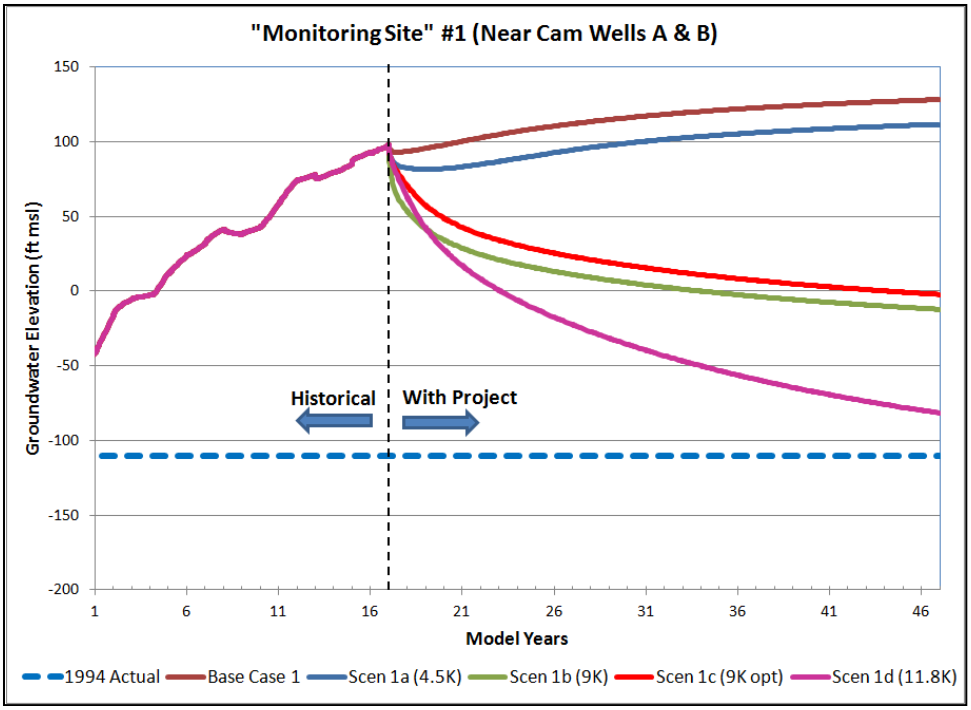


Figure 46. Hydrograph of Scenario #1 options near City of Camarillo's well #A and #B. See previous map for location.

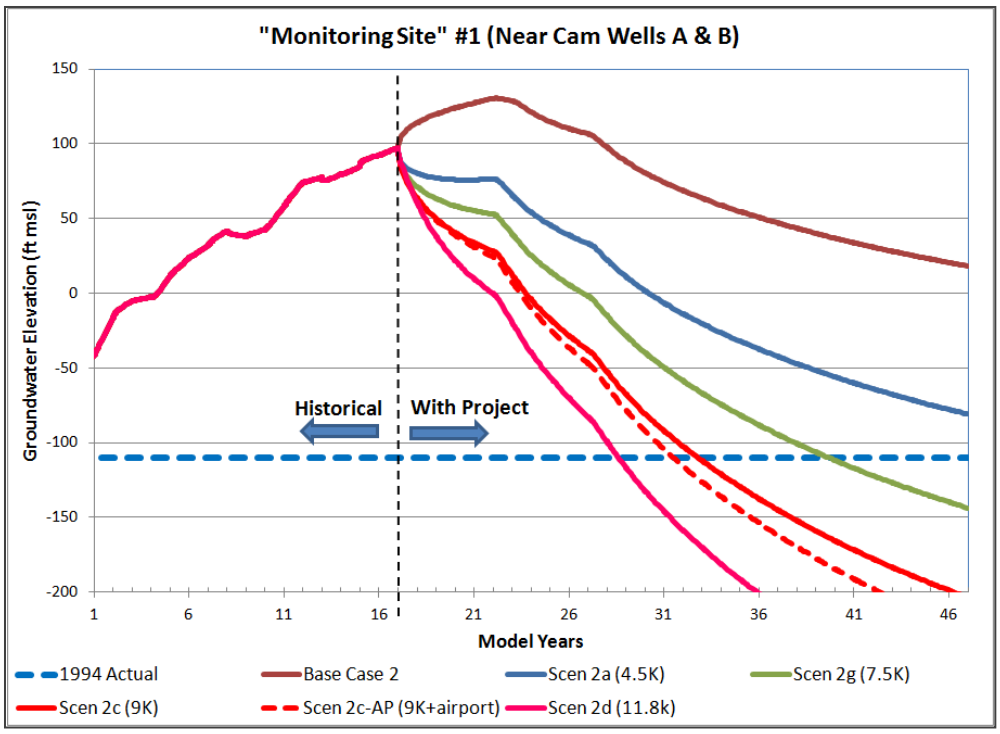


Figure 47. Hydrograph of Scenario #2 options near City of Camarillo's well #A and #B. See previous map for location.

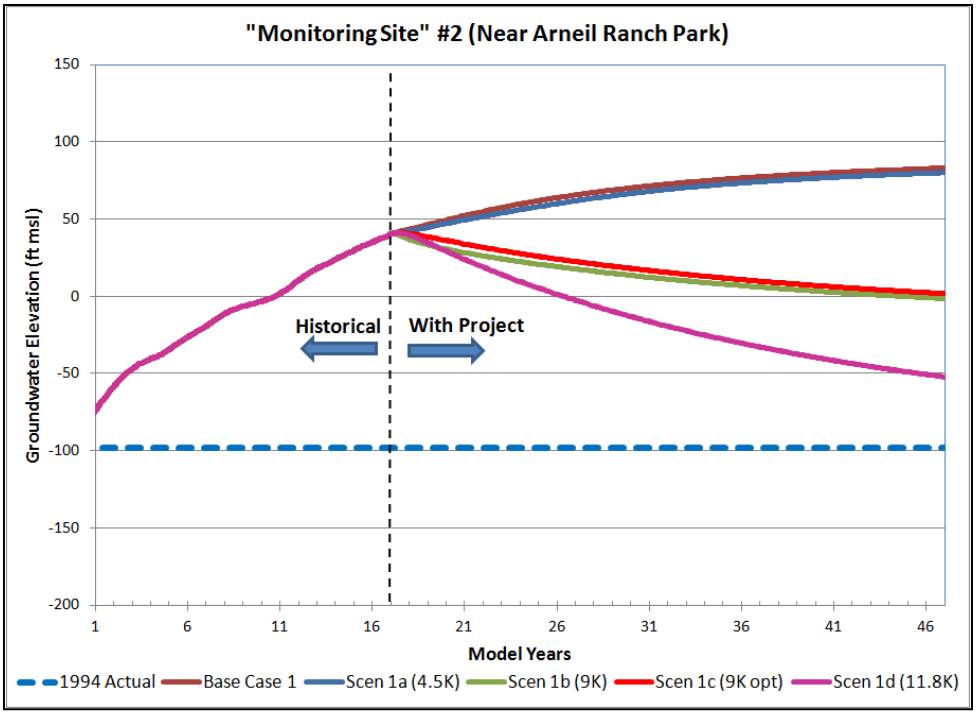


Figure 48. Hydrograph of Scenario #1 options near middle of City of Camarillo. See previous map for location.

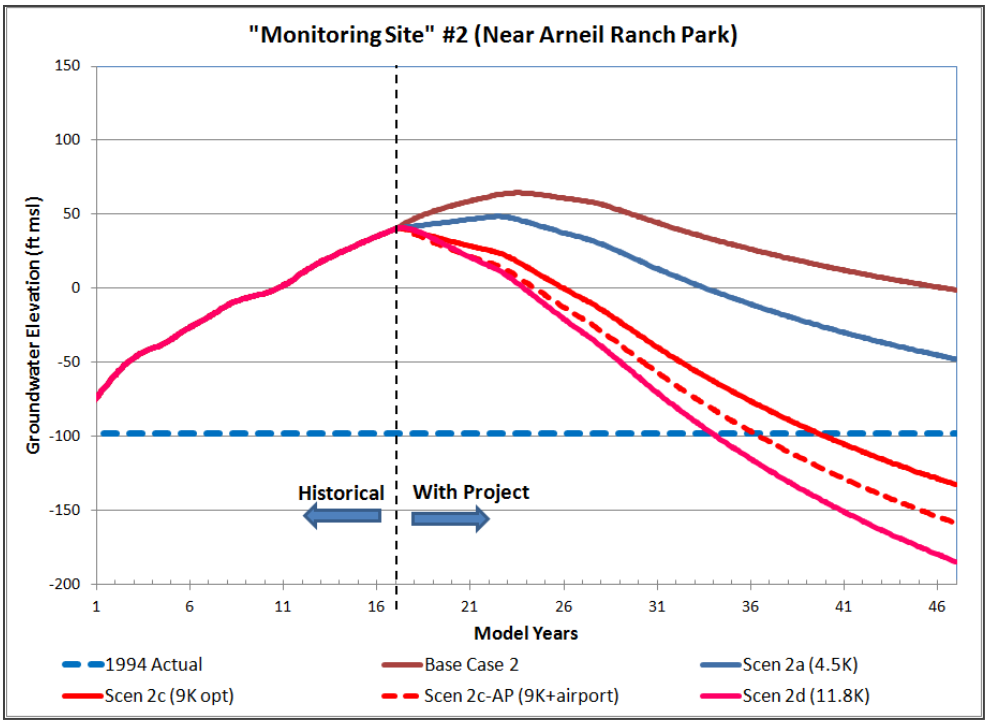


Figure 49. Hydrograph of Scenario #2 options near middle of City of Camarillo. See previous map for location.

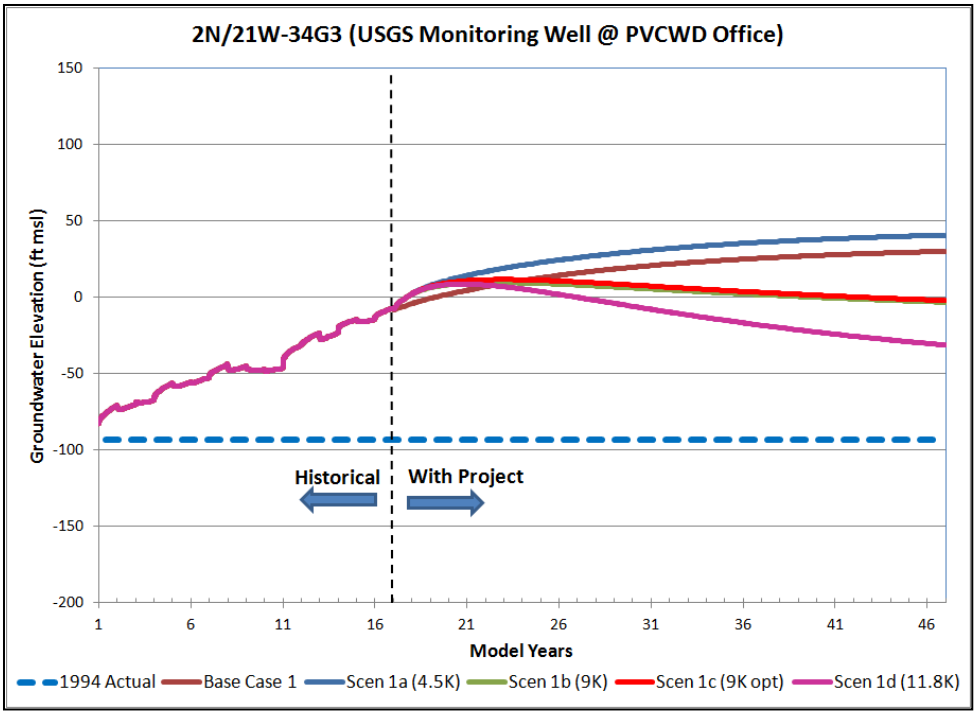


Figure 50. Hydrograph of Scenario #1 options at USGS monitoring site at PVCWD office. See previous map for location.

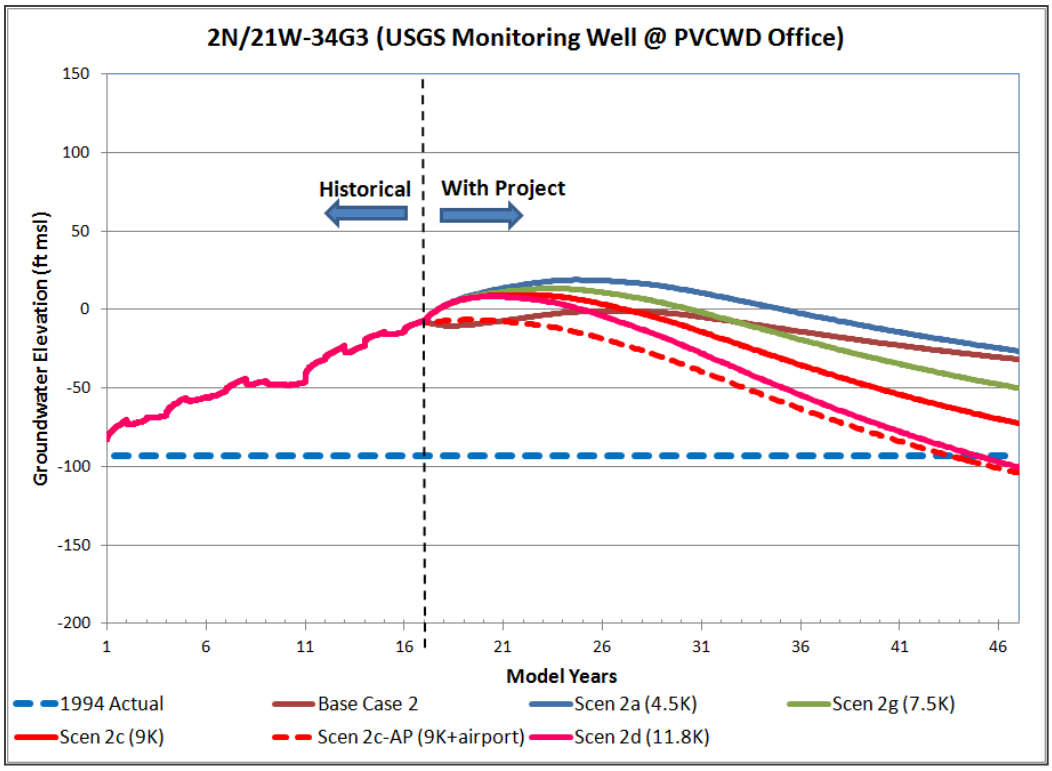


Figure 51. Hydrograph of Scenario #2 options at USGS monitoring site at PVCWD office. See previous map for location.

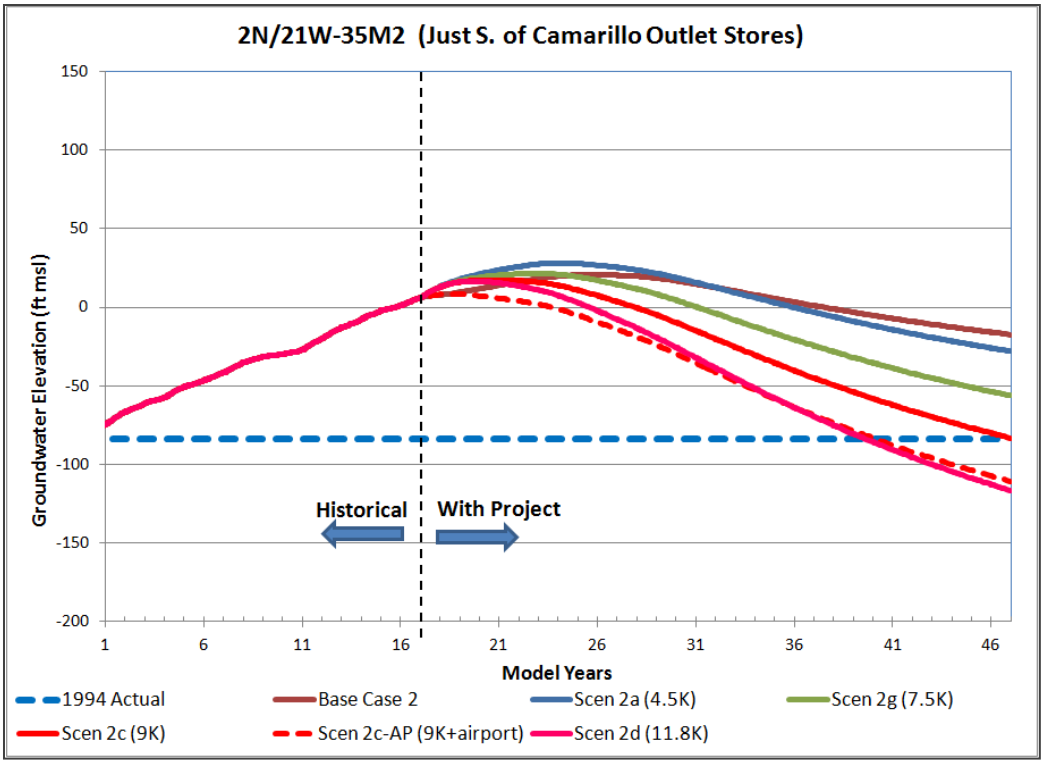


Figure 52. Hydrograph of Scenario #2 options at well 35M2, south of Camarillo Outlet stores (farthest north pumping in that area). See previous map for location.

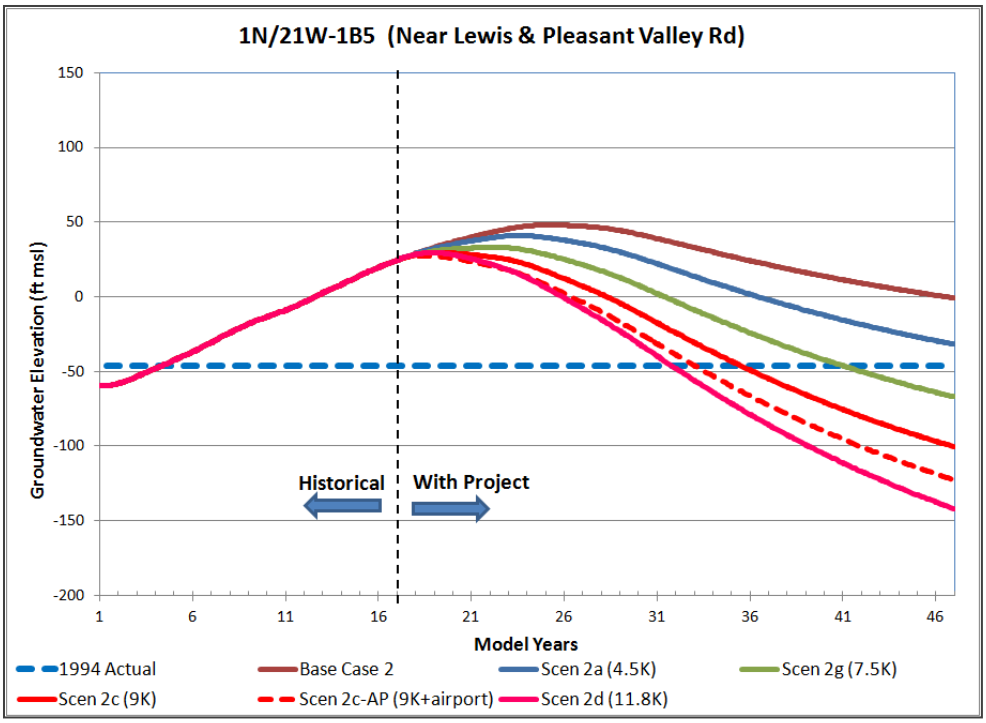


Figure 53. Hydrograph of Scenario #2 options at well 1B5, near the intersection of Lewis and Pleasant Valley roads. This well represents the farthest north pumping in that area. See previous map for location.

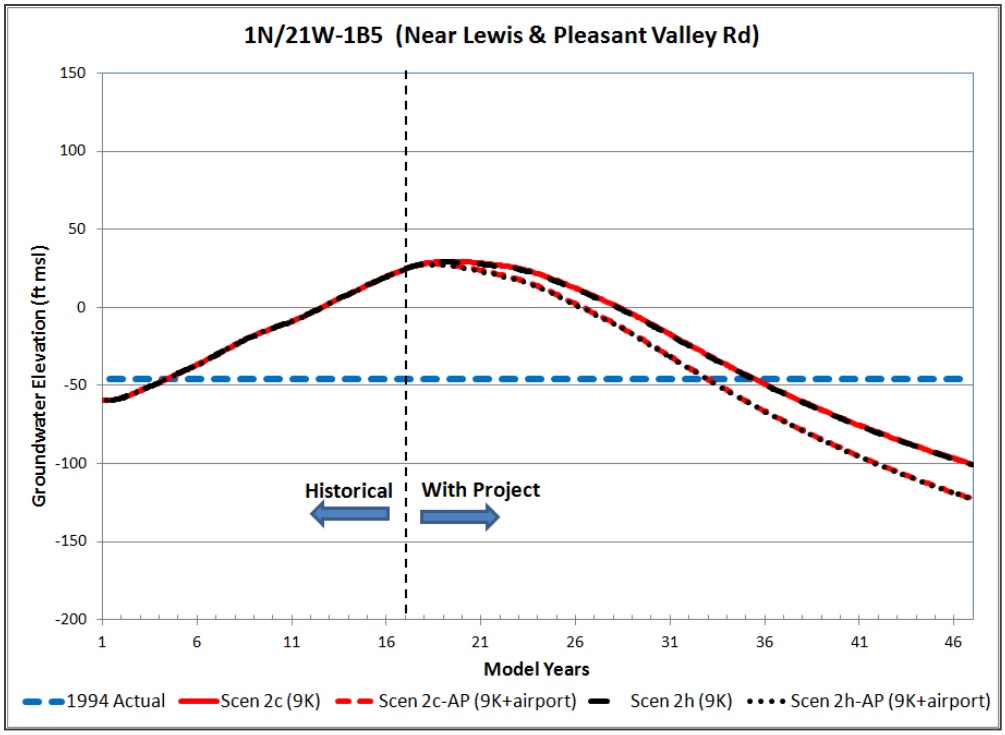


Figure 54. There is no discernible effect at well 1B5 near the City of Camarillo's southern border from moving the farthest-northeast well in Scenario #2c (9,000 AFY, 4 wells) back into the area of the other three desalter wells (Scenario #2h, 9,000 AFY, 4 wells). Location of moved well indicated in Figure 69.

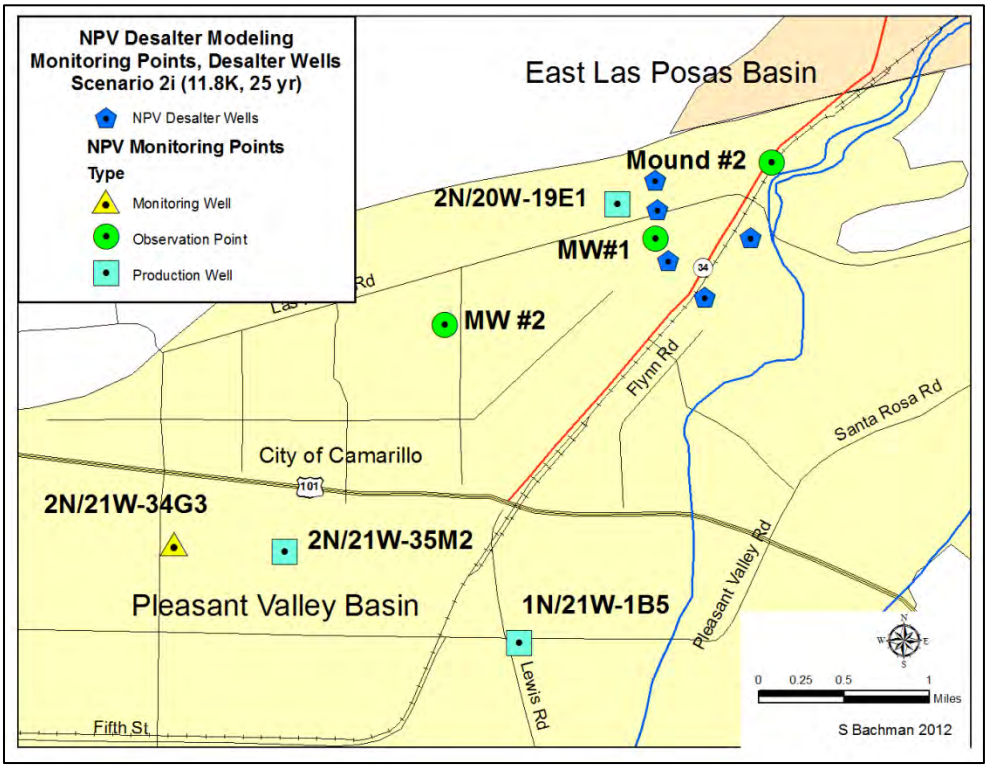


Figure 55. Location of desalter and monitoring wells for Scenario #2i (11,800 AFY, 5 wells, 25 years).

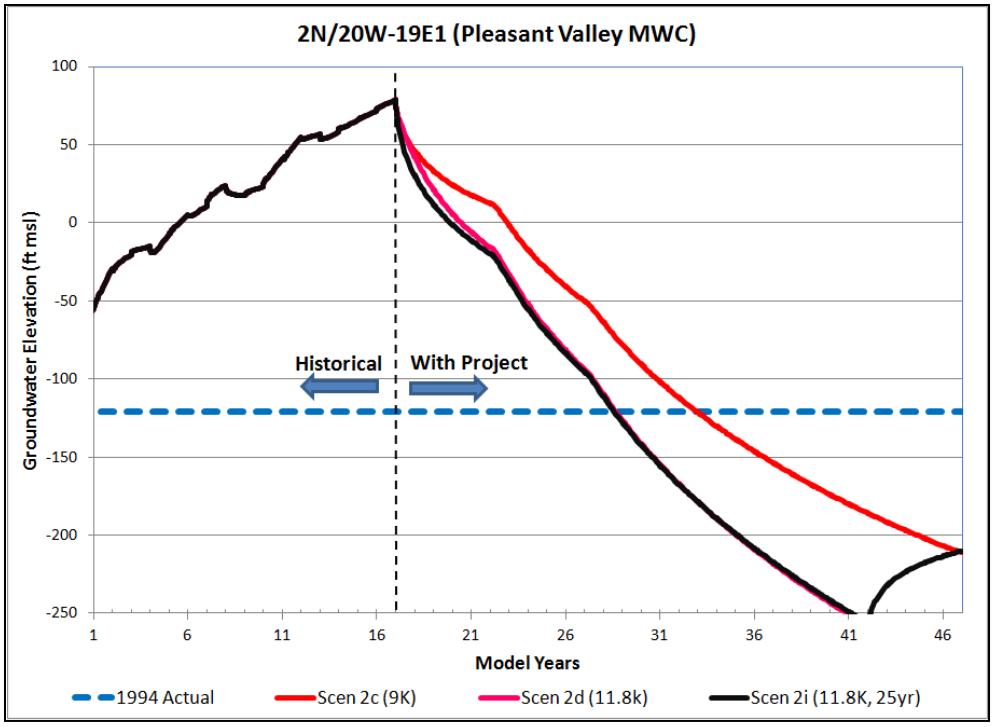


Figure 56. Simulated hydrograph at 19E1 well for 25-year project (Scenario #2i, 11,800 AFY, 5 wells).

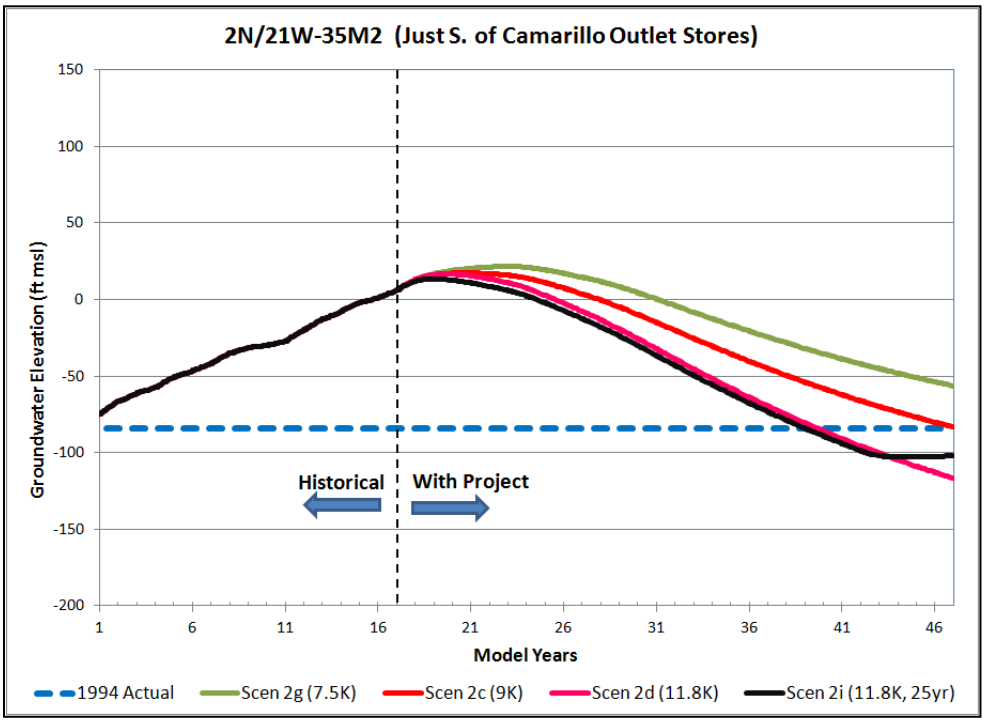


Figure 57. Simulated hydrograph at well 35M2 at southwestern edge of City of Camarillo for 25-year project (Scenario #2i, 11,800 AFY, 5 wells).

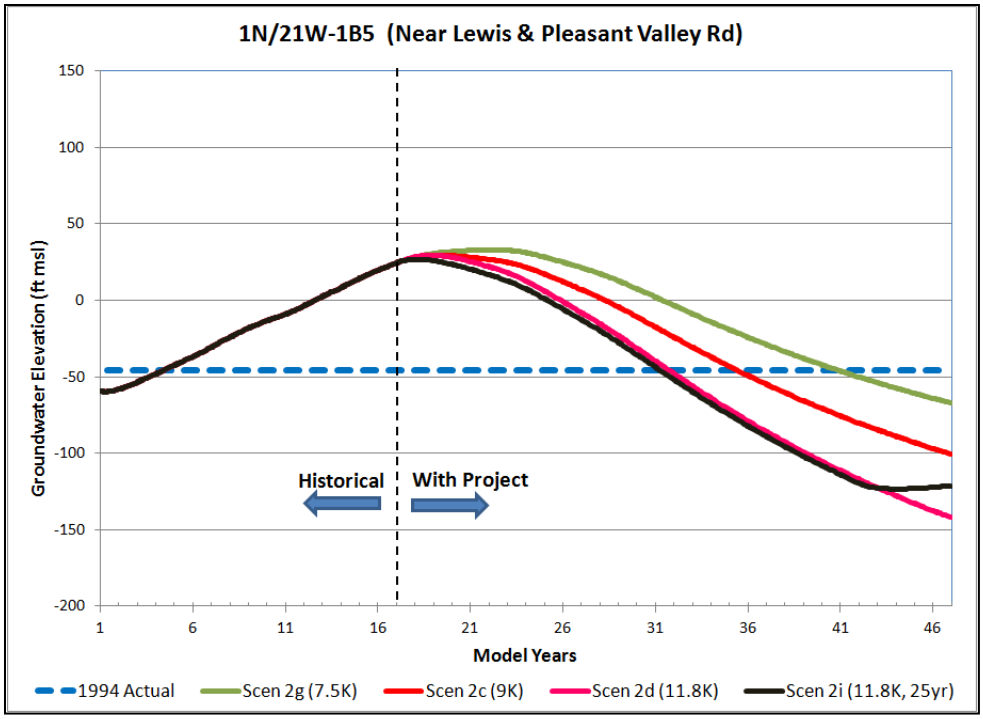


Figure 58. Simulated hydrograph at well 1B5 at southern boundary of City of Camarillo for 25-year project (Scenario #2i, 11,800 AFY, 5 wells).

5 Particle Tracking

Particle tracking is an especially useful tool for analyzing projects such as the NPV Desalter. The particle tracking component of MODFLOW, called MODPATH, uses the MODFLOW grid and cell-by-cell model results to simulate the movement of a particle within the groundwater flow path. A starting time and location of a particle is designated, and the path of the particle is then traced during any portion of the model period. The particle moves both horizontally and vertically (potentially from one model layer to another) depending upon the groundwater gradient in each cell of the model for each time step of the model. Because this model used 25 time steps in each of 47 annual stress periods, a particle could be tracked over as many as 1,175 time steps.

In this study, particles were used to simulate plug-flow in the aquifer. In other words, the poor-quality groundwater was assumed to move as a mass through the aquifer and mixing with other waters was assumed negligible. In less stratified units such as the Fox Canyon Aquifer, this assumption does not likely lead to large error.

The results of one set of particle tracks are indicated in Figure 59. A set of these particle tracking results was generated for each scenario, with the set containing tracks of particles at different starting times. In all Scenario #2 options, one set of particle tracks was timed to coincide with the end of baseflow percolation into NPV (when upstream desalters had removed all baseflow from the arroyo). This set of particles represented the beginning of movement of better-quality stormflow, so the location of the tail-end of the brackish water could be tracked.

By combining the results of the set of particle tracks for each scenario, an approximation of the location of the brackish water at any time could be determined. For the Base Case scenarios, the furthest travel of the particles at the end of the 47 years of the model is indicated. For all other scenarios, the progressive movement of the particles is indicated.

Results for Base Cases – For Base Case #1 (no desalters in either Las Posas basin or NPV), particles track across Highway 101 and beneath the agricultural fields of Pleasant Valley (Figure 60). The potential of salts reaching that far south is a new threat to the water resources of the Pleasant Valley basin. If desalters are built in Las Posas and baseflow into NPV is eliminated (Base Case #2), brackish water that entered the aquifer prior to reduction of baseflow would continue to move southward towards the main Pleasant Valley basin, but at a slower rate (Figure 61).

Results with NPV Desalter Pumping – Particle movement with NPV desalters operating (starting in model year 18) is largely dependent upon the location of the desalter wells and the rate of pumping. The locations of desalter wells were optimized iteratively by examining both water level drawdown and particle tracking. Thus, the scenarios in this evaluation are largely dependent upon pumping rate. As pumping rates were increased (4,500-7,500-9,000 AFY), the period and extent of migration was shortened.

In Scenario #2a (4,500 AFY, 2 wells, Figure 62, Figure 63) particles just cross beneath Highway 101 before they are reversed. Most importantly, there is a relatively large area of potential brackish water that remains stranded at model year 47. When pumping rates are increased to 7,500 AFY (Scenario #2g, 4 wells – Figure 64, Figure 65) and 9,000 AFY (Scenario

#2c, 4 wells – Figure 66, Figure 67) the southward extent and the area of potential stranded salts are decreased. When the airport wells are pumped during the model simulation (Figure 68), brackish water migrates farther to the southwest, but is effectively recovered before model year 47. The effectiveness of the recovery may be caused by better alignment of the brackish water with the recovery wells.

Scenario #2h (9,000 AFY, 4 wells) was constructed to extend the period during which the desalter wells were potentially pumping brackish water. As indicated in Figure 69, moving the northeastern well resulted in desalter wells pumping potentially brackish water over a longer period of time.

Simulation of the 25-year, 11,800 AFY project (Scenario #2i) indicates that there is complete recapture of particles prior to the end of model year 47 (Figure 70). In the scenario, two wells were shut off near the end of the model period as particles were recaptured (i.e., "brackish water" was completely recaptured at that site).

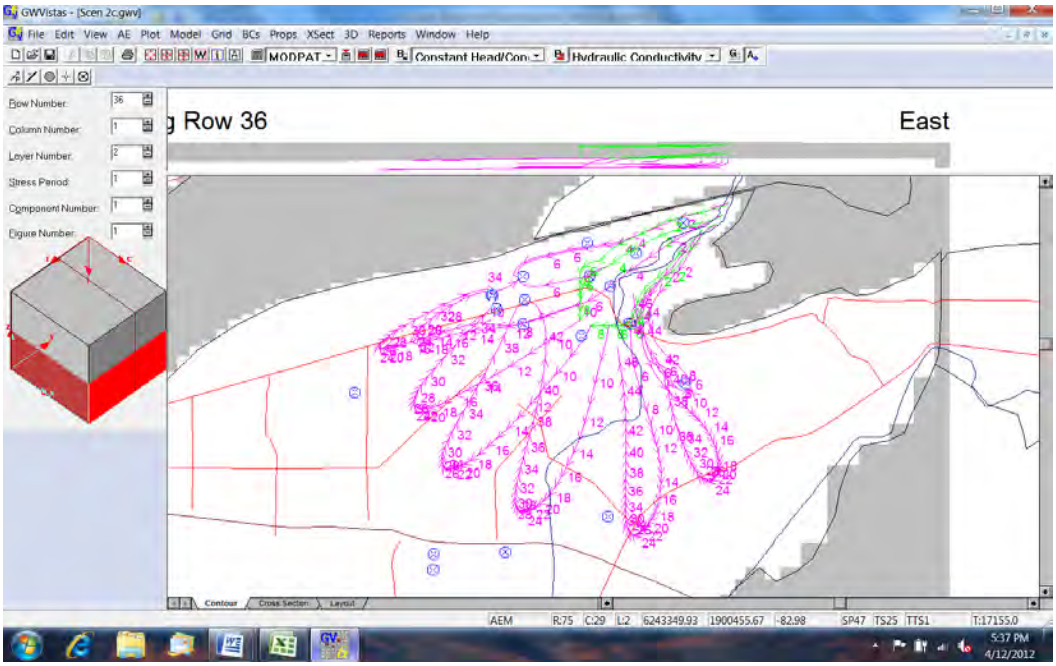


Figure 59. Particle tracking results for Scenario #2c (9,000 AFY, 4 wells) with a set of particles released at the baseflow recharge area at the beginning of year 1 of the model. Years are shown for each particle track; the light green tracks are when the particle is in Layer 1, whereas the purple tracks are when the particle is in Layer 2. Particles reverse direction following the beginning of desalter pumping in year 18.

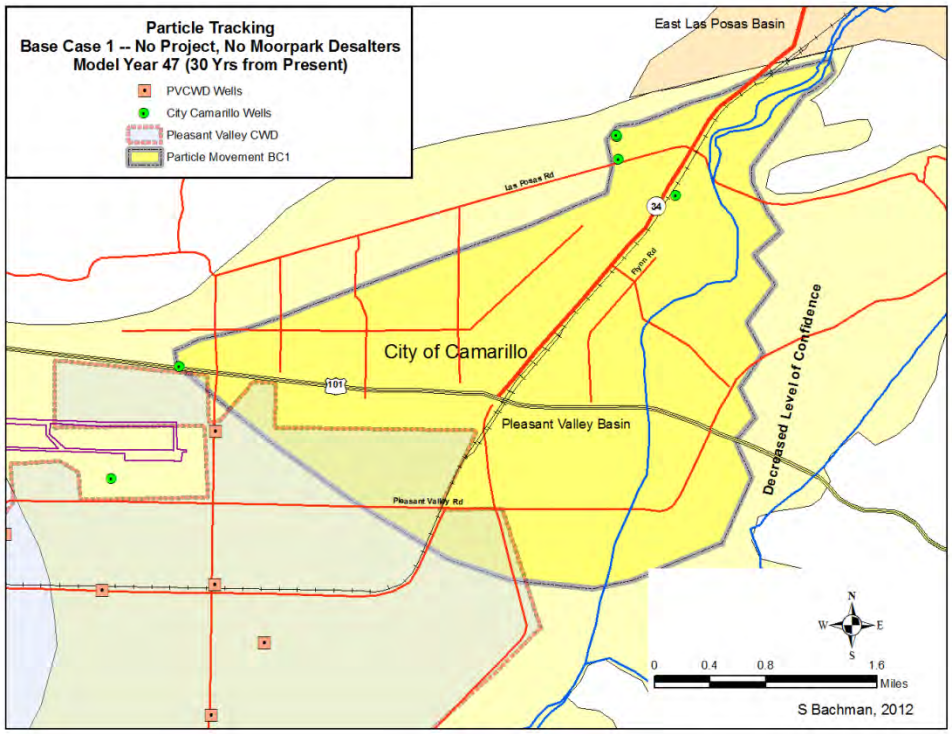


Figure 60. Particle tracking results for Base Case #1, indicating that by the end of model year 47 (30 years from now), the poor-quality water could migrate beneath the agricultural fields of the Pleasant Valley County Water District.

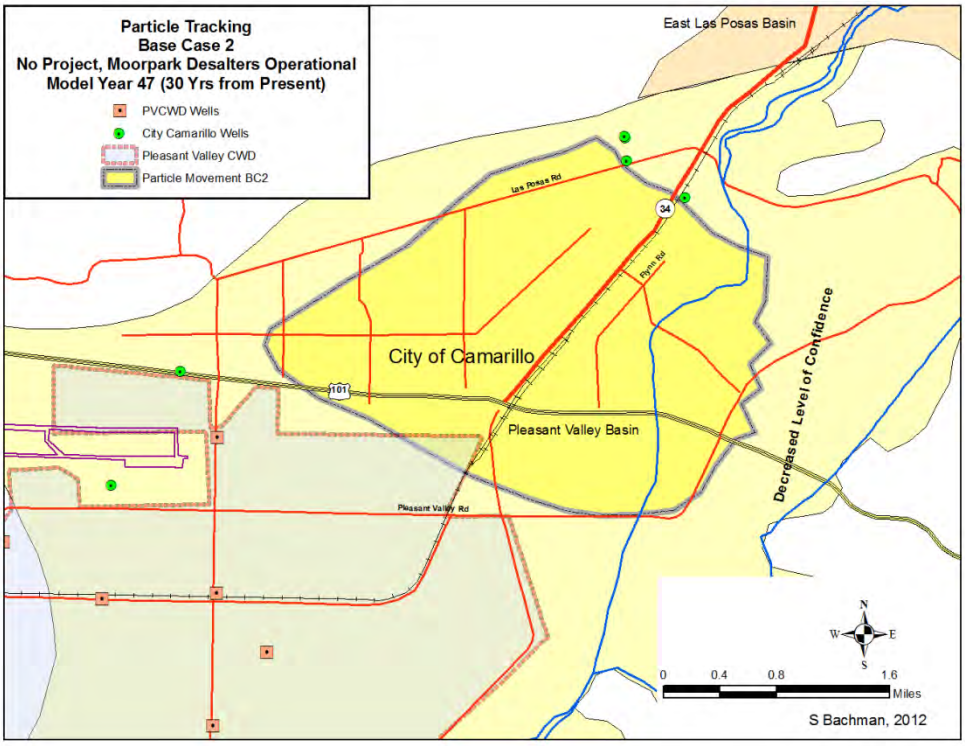


Figure 61. Particle tracking results for Base Case #2, indicating that by the end of model year 47 (30 years from now), the poor-quality water could migrate south of Highway 101 even with Las Posas desalters operating.

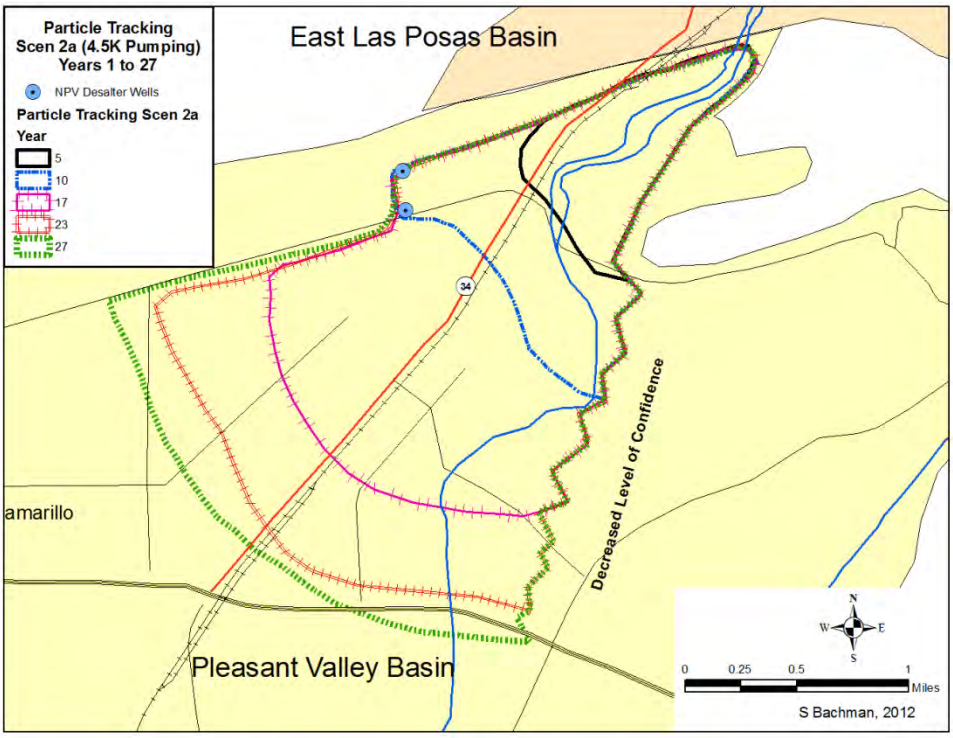


Figure 62. Particle tracking for Scenario #2a (4,500 AFY, 2 wells), model years 1 to 27. Particle movement slowed down somewhat after the beginning of desalter pumping in year 18.

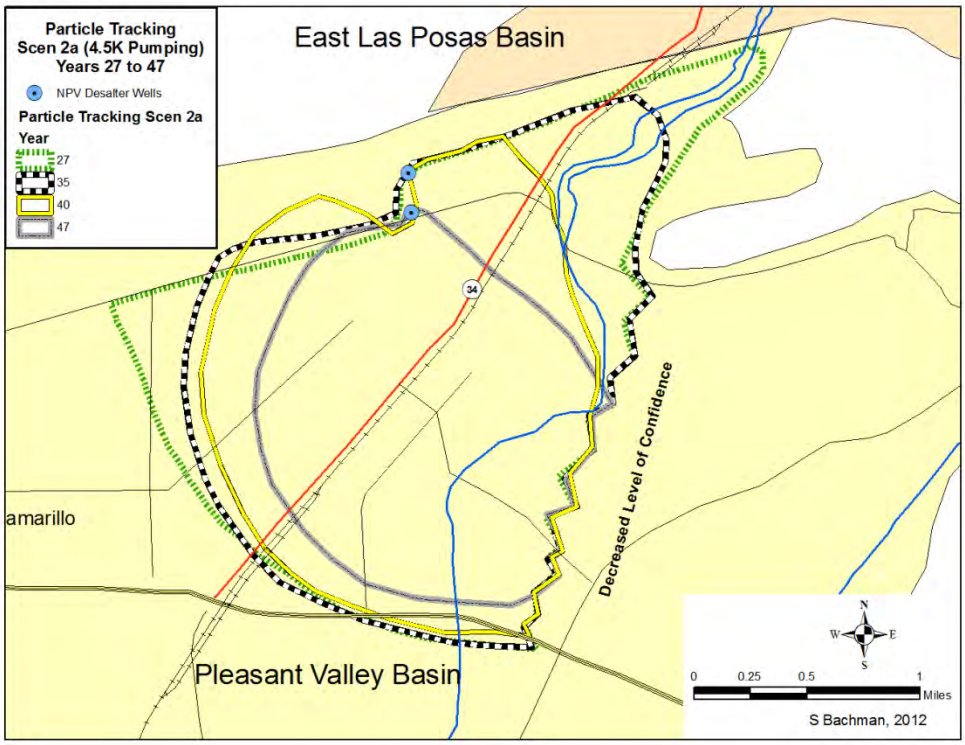


Figure 63. Particle tracking for Scenario #2a (4,500 AFY, 2 wells), model years 27 to 47. After model year 27, particles reverse direction and the area of potential brackish water decreases somewhat. There is a significant area of potentially stranded salts (inside year 47 boundary).

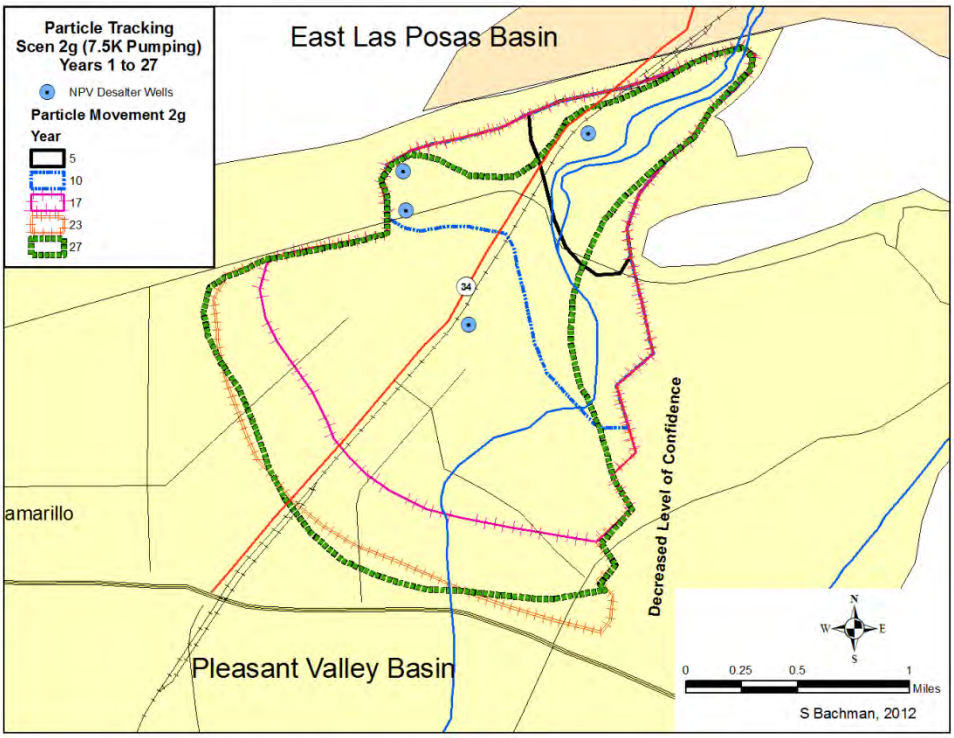


Figure 64. Particle tracking for Scenario #2g (7,500 AFY, 4 wells), model years 1 to 27. Particles stop migrating to southwest by model year 23.

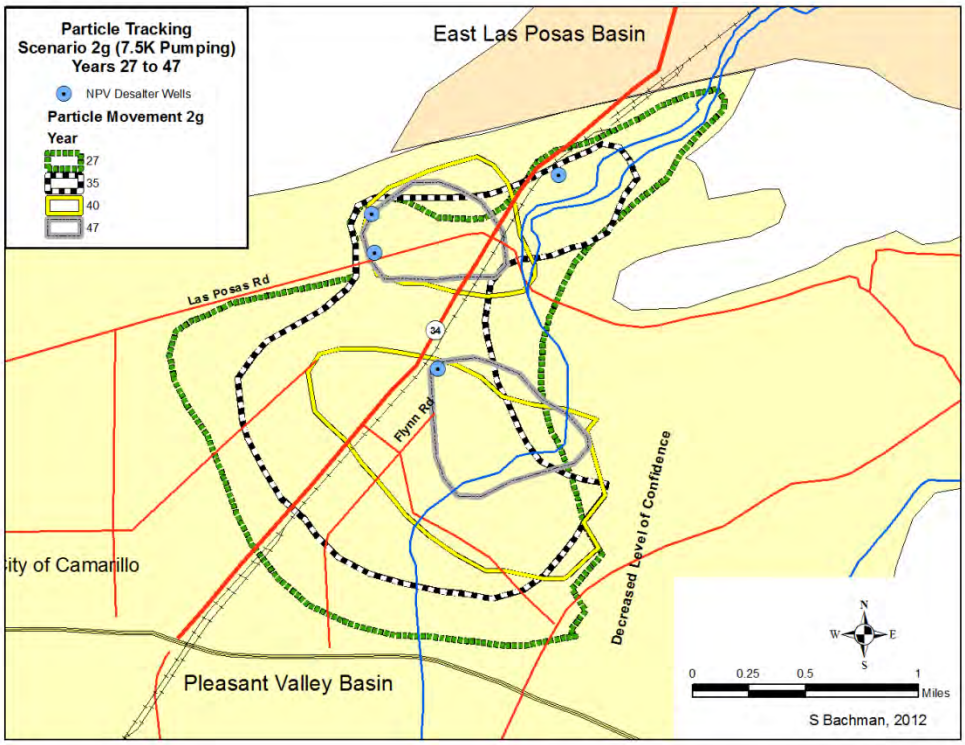


Figure 65. Particle tracking for Scenario# 2g (7,500 AFY, 4 wells), model years 27 to 47. Potential areas with brackish water in model year 47 are significantly reduced from Scenario #2a (4,500 AFY, 2 wells).

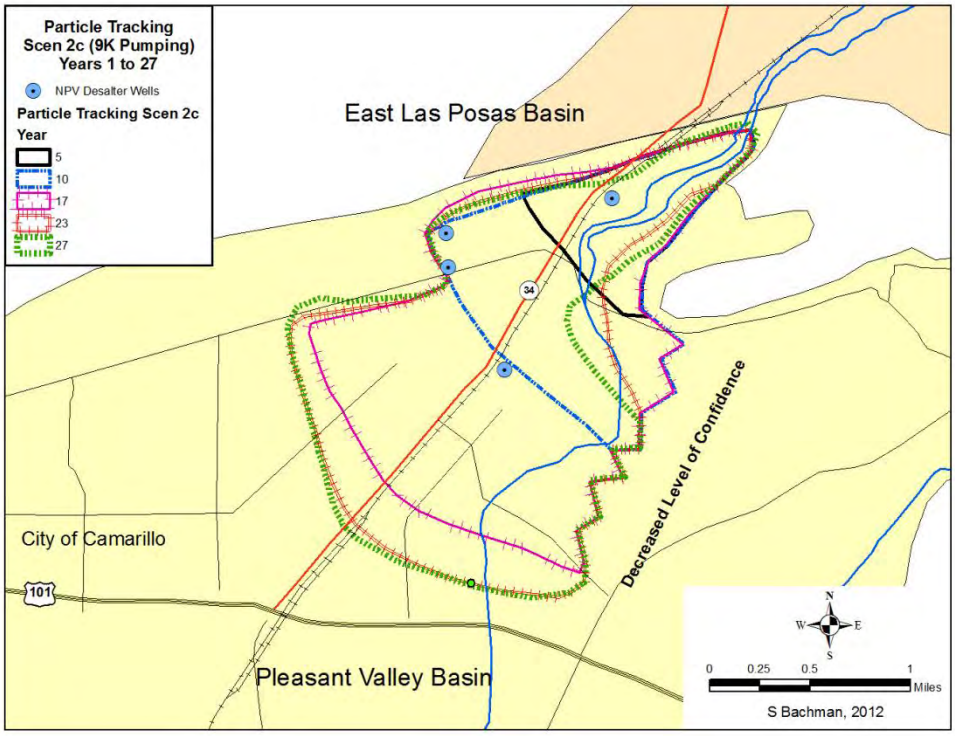


Figure 66. Particle tracking for Scenario #2c (9,000 AFY, 4 wells), model years 1 to 27. Particles stop migrating to southwest by model year 23.

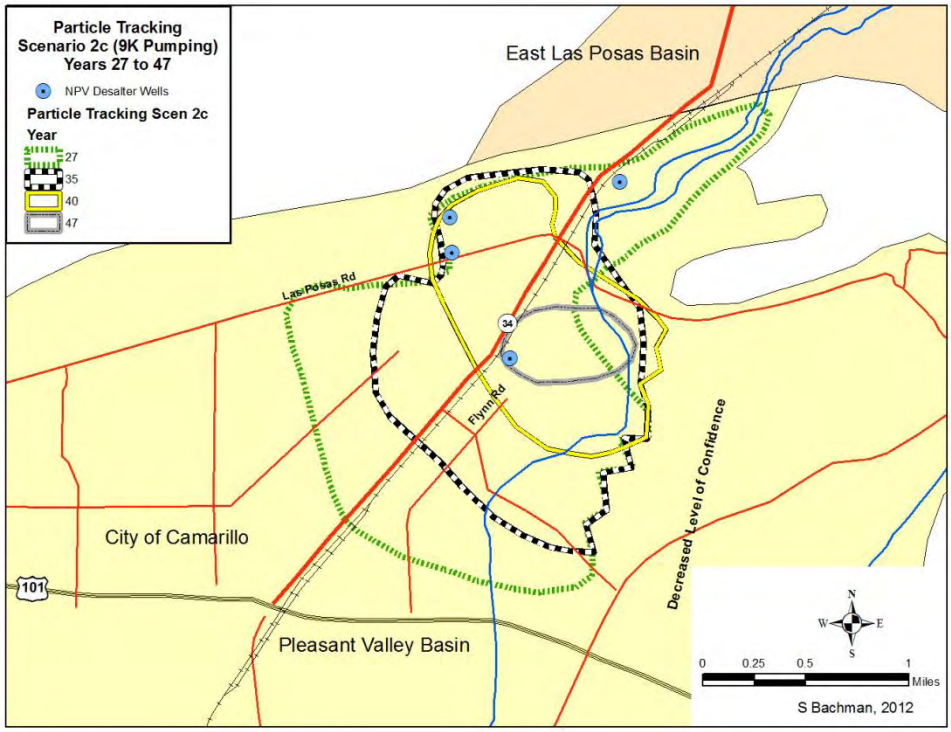


Figure 67. Particle tracking for Scenario #2c (9,000 AFY, 4 wells), model years 27 to 47. Potential areas of brackish water are almost eliminated by model year 47.

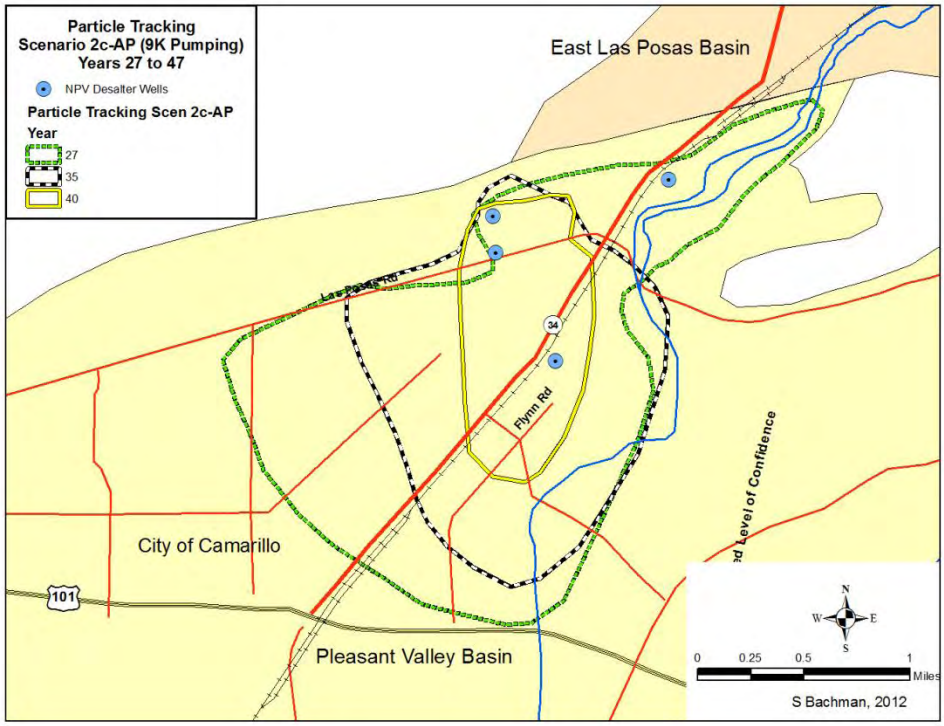


Figure 68. Particle tracking for Scenario #2c-AP (9,000 AFY, 4 wells, pumping of Airport wells), model years 27 to 47. Comparison to the previous figure indicates that the pumping at the airport wells tends to migrate the brackish water farther southwest by year 27, but results in elimination of the brackish water before model year 47.

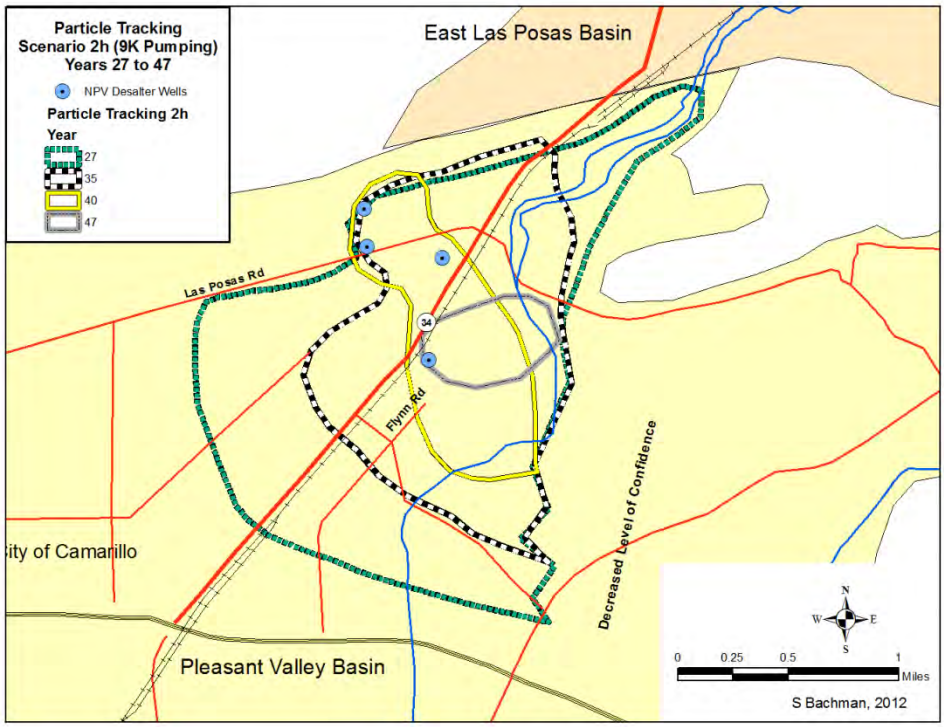


Figure 69. Particle tracking for Scenario #2h (9,000 AFY, 4 wells), which mimics Scenario #2c except that farthest northeast desalter well was moved closer to the other desalter wells.

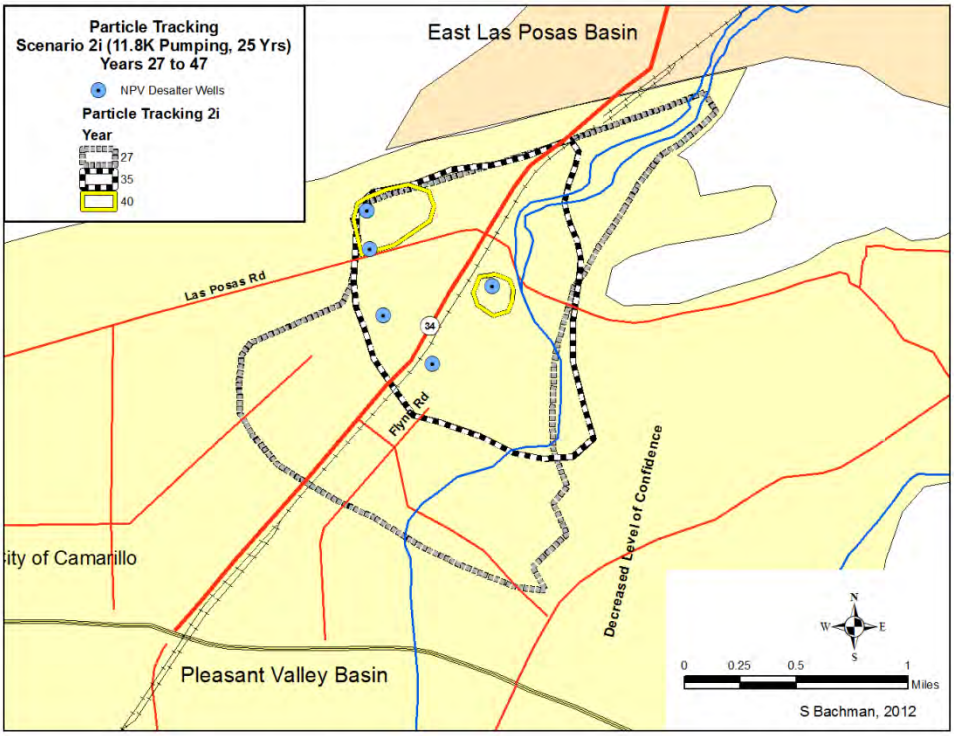


Figure 70. Particle tracking results for Scenario #2i, the 11,800 AFY project that was shortened to 25 years. All particles are recovered by model year 47, suggesting a successful recapture of brackish water.

6 Using Model Results

Modeling is used to simulate actual behavior in the aquifer. When interpreting model results, it is important to determine how well the model does represent aquifer responses. Three methods were used to determine the accuracy of the modeling and how sensitive model results are to inputs such as streamflow.

Water Level Comparisons – this was the model calibration process discussed earlier in the report. Because calibration took place during the building of the mound, the model is well suited for simulating depletion of the mound over the same water level range (i.e., the model is operated within its calibrated range).

Water Quality Comparisons – water quality measured in wells can be compared to the results of the particle tracking analysis. In theory, you could compare water quality changes throughout the historical period. In practice, there were few wells within the city limits of Camarillo during the 17-year period when model results could be compared to measured results. There is the opportunity to do this with Camarillo's wells A and B – they are within the mound of poor-quality water and there are abundant water level and water quality data during this period. In these wells, there is a lag time of 5 to 10 years between when water levels started to rise and when increased salts reached the wells. MODFLOW and MODPATH model results predict that particles released in the area of baseflow infiltration along the arroyo would reach wells A and B in a similar time frame. Thus, there is agreement between observed and modeled results.

Sensitivity Analysis – the sensitivity of model parameters such as aquifer properties was part of the model calibration – the model parameters were optimized for calibration to measured groundwater elevations. The sensitivity of the model to major input and outputs such as pumping and recharge need to be addressed separately for this model. Groundwater pumping in the model is from data reported by pumpers to the FCGMA. Although there has been long discussion on the accuracy of this self-reporting, the amount of pumping in the model does not vary between scenarios except for City of Camarillo and desalter pumping. Thus, the changes in aquifer response between the various scenarios, where only desalter pumping is varied, are likely to be fairly representative of actual changes.

The significant input to the model is percolation from streamflow. In particular, the amount of baseflow (brackish water) is important in determining both groundwater elevations and particle tracking. To test the sensitivity of the model to variations in the amount of baseflow, baseflow was varied by ± 20% for Scenario #2c (9,000 AFY, 4 wells). The largest effect in groundwater elevations in the sensitivity analysis is in the area where baseflow percolation occurs (Figure 71). Farther from the area of percolation, the effects of changing baseflow become more muted (Figure 72 and Figure 73). At reduced baseflow, particles do not extend as far southwest as in Scenario #2c and the area of "stranded brackish water" at model year 47 is eliminated (Figure 74). With increased baseflow, particles extend farther southwest and the area of "stranded brackish water" at model year 47 is larger (Figure 75). This information is integrated into the analysis of the project in the following chapter.

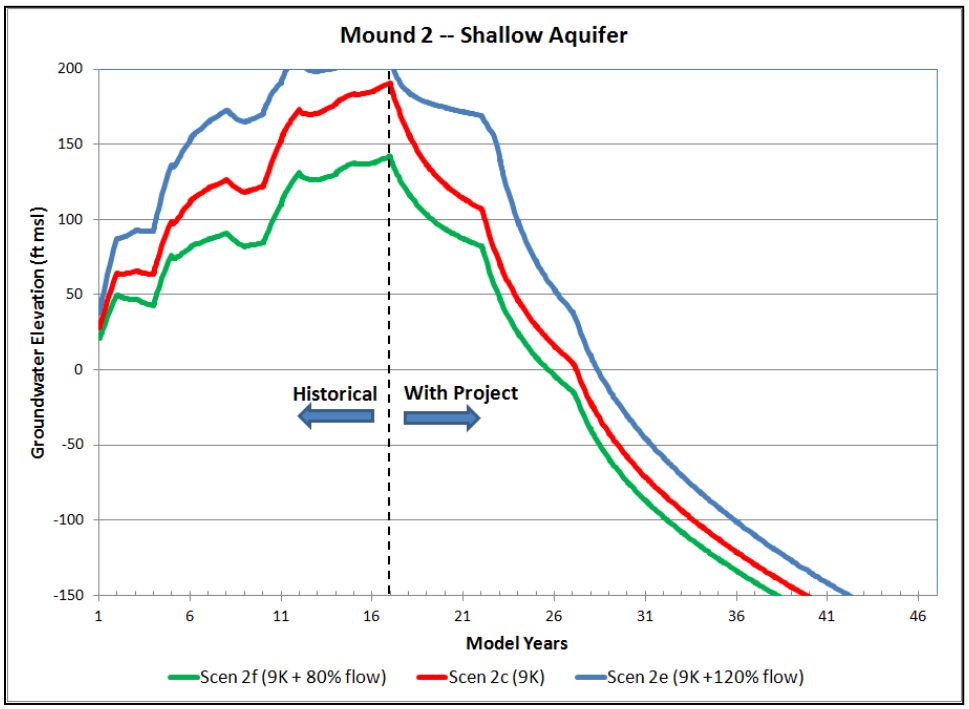


Figure 71. Sensitivity analysis at observation point Mound #2 (Figure 43) by changing baseflow by ± 20% for Scenario #2c (9,000 AFY, 4 wells).

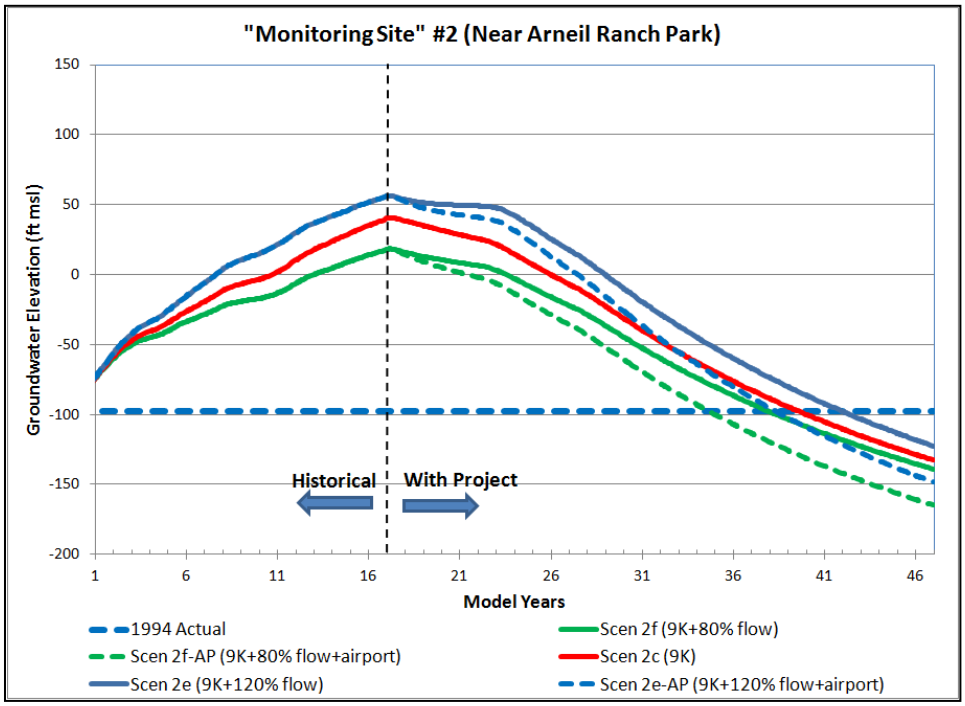


Figure 72. Sensitivity analysis at observation point MW #2 (Figure 43) by changing baseflow by ± 20% for Scenario #2c (9,000 AFY, 4 wells).

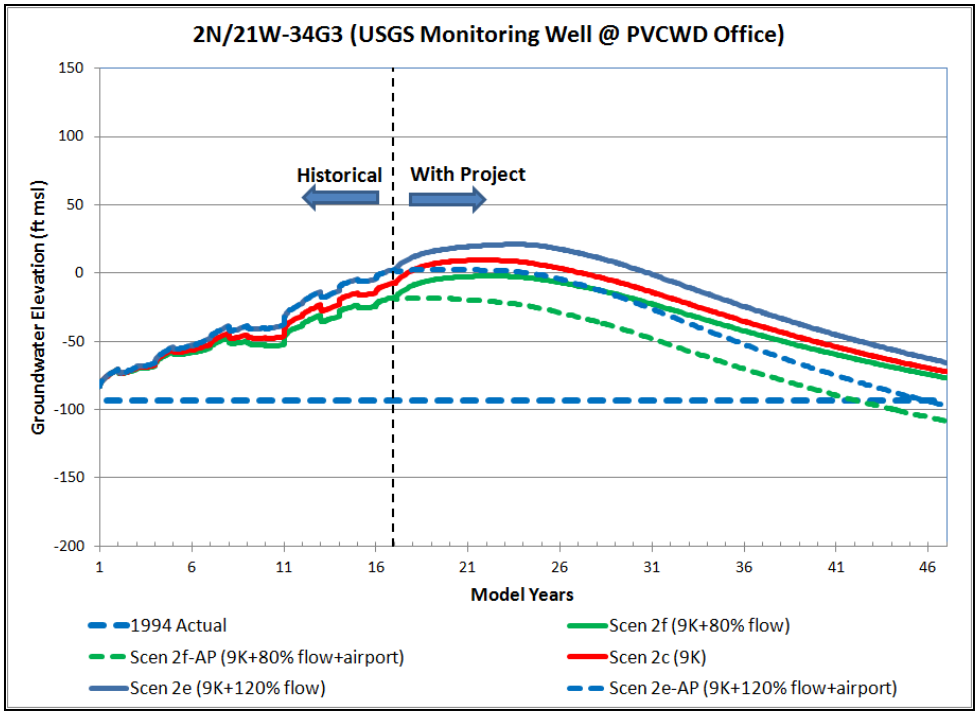


Figure 73. Sensitivity analysis at monitoring well 34G3 by changing baseflow by ± 20% for Scenario #2c (9,000 AFY, 4 wells).

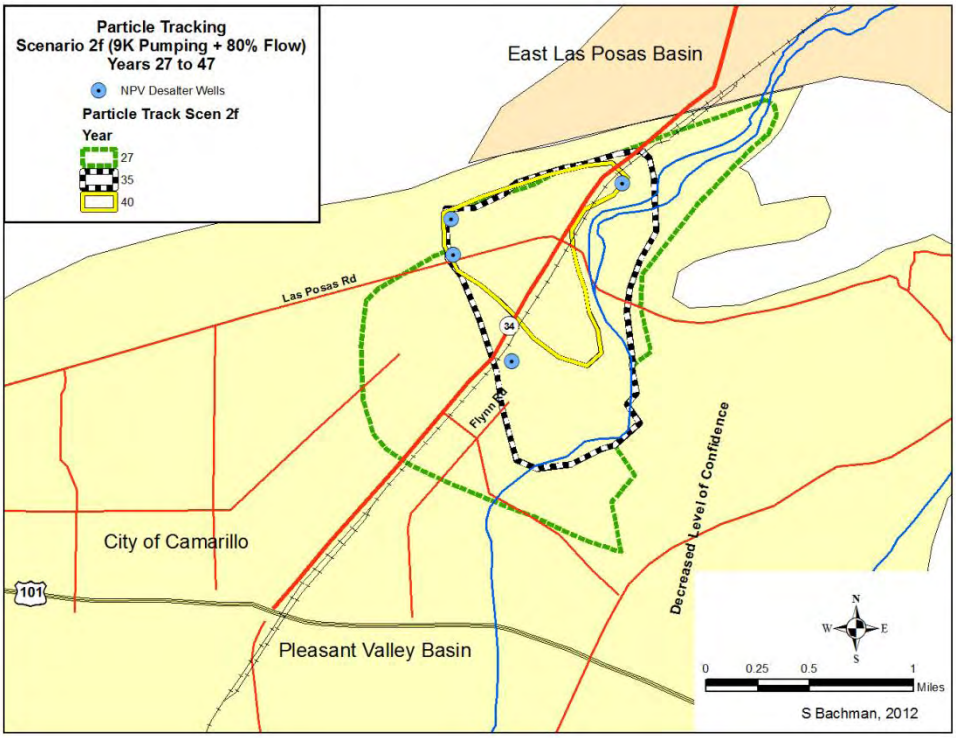


Figure 74. Sensitivity analysis for particle tracking for Scenario #2f (Scenario #2c with 80% baseflow infiltration). Compare results to those shown on Figure 67 for Scenario #2c (9,000 AFY, 4 wells).

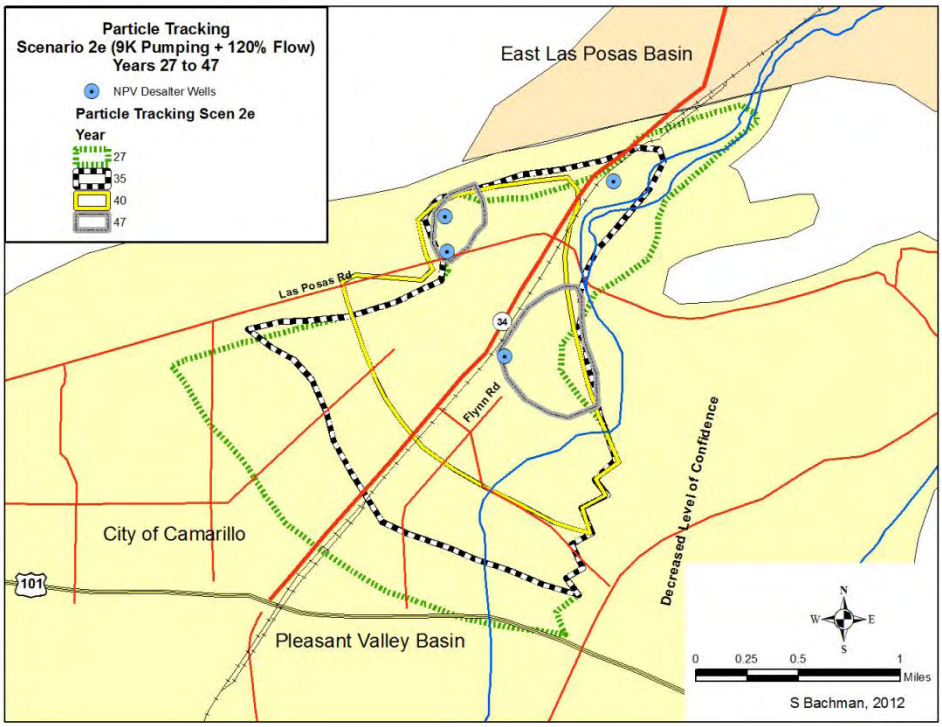


Figure 75. Sensitivity analysis for particle tracking for Scenario# 2e (9,000 AFY, 4 wells, baseflow 120%). Compare results to those shown on Figure 67 for Scenario #2c (9,000 AFY, 4 wells, 100% baseflow.

7 Analysis of Results

Modeling results indicate that with no desalter pumping in NPV and/or the Las Posas basin, poor-quality water could continue its migration towards and into the agricultural areas of the main Pleasant Valley basin. NPV desalter pumping largely eliminates that threat to the aquifers. Although Scenario #1 options (no desalter pumping in the Las Posas basin) were evaluated in this study, the concentration was on the effects of the NPV desalter with Las Posas basin desalters operating (Scenario #2). Scenario #2 is a worse-case situation for the NPV desalter project, but it is also a more likely situation. The remainder of the discussion will use results from Scenario #2 desalter options.

At lowered rates of desalter pumping (e.g., 4,500 AFY), the mound of brackish water in NPV would be reduced but not eliminated. Likewise, there would likely be "stranded brackish water" under the City of Camarillo at these lower pumping rates that would continue moving southward into the basin. At higher rates of desalter pumping, there becomes a trade-off between salt removal and lowered groundwater elevations. The 1994 groundwater elevations are indicated on the hydrographs in this report because they were the groundwater levels prior to build-up of the mound of brackish water.

It is appropriate that water levels could be pumped back to the 1994 elevation during the project. Groundwater elevations could also be safely pumped below that level under the City of Camarillo as long as the needs of the other pumpers adjacent to that area are met. Active wells in the vicinity of the NPV Desalter project are shown on Figure 76. The closest well is operated by the Pleasant Valley Mutual Water Company (19E1). Model results for Scenario #2i (11,800 AFY, 5 wells, 25-year period) indicate that water levels would drop below 1994 levels, but then recover somewhat after project pumping (Figure 77). Other nearby wells would likely see a similar pattern in groundwater elevations. The Bell Ranch well is shown on Figure 76. It is not clear at this time which basin the well is in; if in the Pleasant Valley basin, the well would also likely see drawdown from the NPV Desalter project.

Another potential effect of NPV desalter pumping would be on the largely agricultural pumpers south of the Camarillo city limits. Wells along this southern boundary were used to estimate project effects. Modeled groundwater elevations at the USGS monitoring well at PVCWD's office (Figure 51) indicate that groundwater elevations would remain above 1994 levels at even the highest pumping rates (11,800 AFY), but wells to the east of that location indicate drawdown below that elevation at higher pumping rates (Figure 52, Figure 53). Because these wells are at a significant distance from NPV desalter wells and because the modeled elevations below 1994 levels occur near the end of the model period, there is more uncertainty as to the amount and timing of drawdown at this southern edge of Camarillo's city limits.

Particle tracking results suggest that much of the poor-quality water that has infiltrated into NPV can be recaptured by NPV Desalter pumping. By careful examination of the set of particle traces that were initiated at different times during the model period, the period during which brackish water could potentially be pumped by the desalter wells can be estimated (Table 6). Three aspects are evident in the table:

- Moving the northeastern desalter well of Scenario #2c (9,000 AFY, 4 wells) increased substantially the period during which all four project wells could potentially operate as desalter wells (Scenario #2h, 9,000 AFY, 4 wells);
- The amount of brackish baseflow infiltrating into NPV is an important factor in project longevity; and
- A 25-year project could potentially recapture most of the "brackish" water (Scenario 2i, 11,800 AFY, 5 wells, 25 years).

It is important to note that particle tracking has its limitations and that conclusions based on the particle tracking should be tempered by these limitations. The limitations are that particle tracking inherits any errors from the main MODFLOW results, particle movement is plug flow and has no components of mixing processes, the brackish baseflow could be stratified in the aquifer and groundwater pumped could be a mix of brackish water and ambient better-quality groundwater, and individual wells could be pulling in brackish water from one direction and better-quality well from another direction. Thus, the actual water quality pumped by any desalter well may vary in salt concentration. This variation in concentration may be more pronounced in later stages of the project, when the brackish water may have taken complex travel paths from infiltration to extraction.

Scenario	5 wells	4 wells	3 wells	2 wells	1 well
2a (4.5K Pumping)				23 to 29	30+
2g (7.5K Pumping)		19 to 22	19 to 30+	30+	30+
2c (9K Pumping)		11 to 17	24 to 29	24 to 29	30+
2c-AP (9K Pumping)		11 to 17	24 to 29	24 to 29	24 to 29
2f (9K w/80% flow)		19 to 22	24 to 29	24 to 29	24 to 29
2f-AP (9K w/80% flow)		24 to 29	24 to 29	24 to 29	24 to 29
2e (9K w/120% flow)		19 to 22	30+	30+	30+
2e-AP (9K w/120% flow		19 to 22	30+	30+	30+
2h (9K optimized)		24 to 29	24 to 29	24 to 29	30+
2h-AP (9K optimized)		19 to 22	24 to 29	24 to 29	24 to 29
2i (11.8K, 25-yr)	19 to 22	19 to 22	24+		

Table 6. Results of particle tracking, indicating the number of years wells would pump "brackish" water for each Scenario #2 pumping option. For example, under Scenario #2g four wells would be within the area of "brackish" particles for at least 19 years but perhaps for as long as 22 years; three wells would be within the area of "brackish" particles for at least 19 years, but perhaps as long as 30+ years. In Scenario #2i, there is nearly complete recapture of "brackish" water by the end of the project.

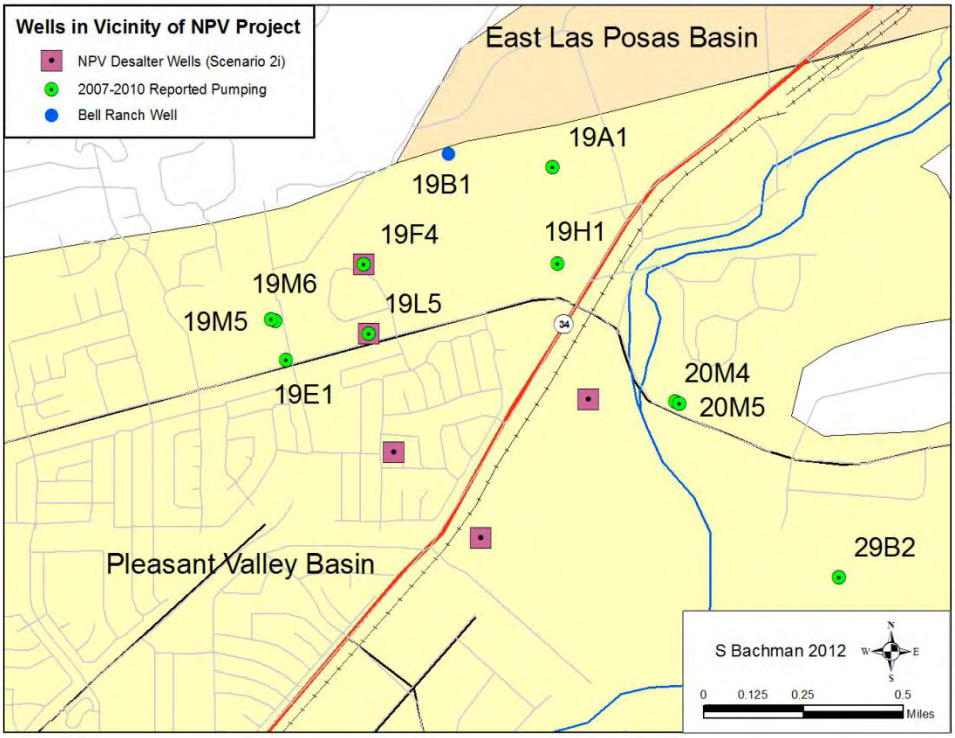


Figure 76. Wells in vicinity of proposed NPV Desalter project.

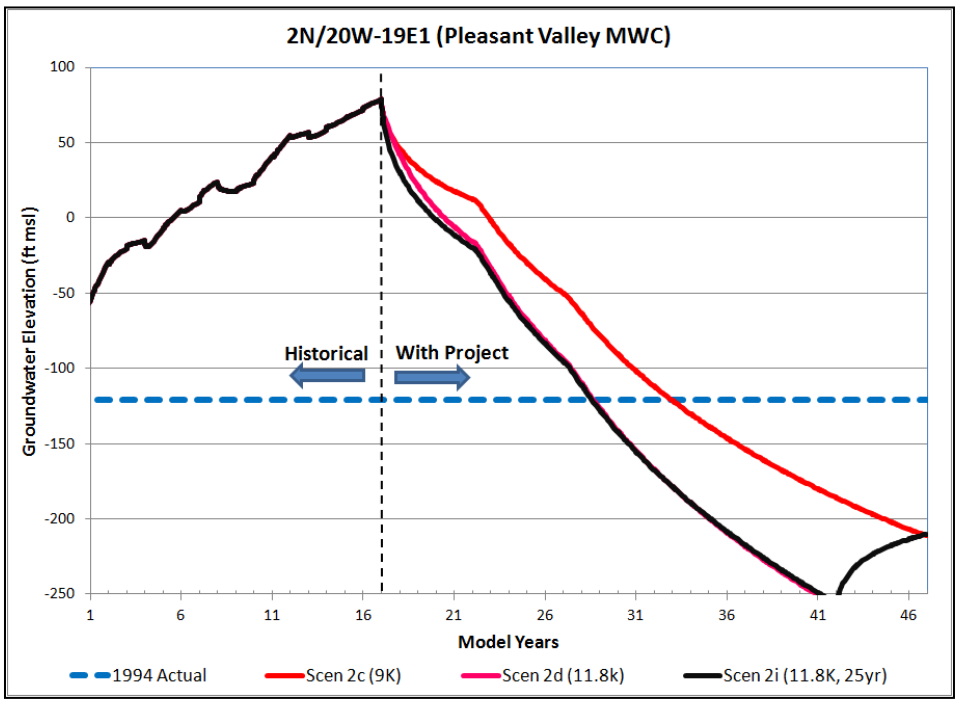


Figure 77. Effect of Scenario #2i (11,800 AFY, 5 wells, 25-yr project) on closest well.

8 Potential for Land Subsidence During Project

Land subsidence can occur when pumping causes groundwater elevations to drop sufficiently to dewater sediments in the basin or to create pressure gradients where water flows out of the sediments. It is the fine-grained sediments (e.g., mudstone) which may be present both within the aquifers and as low-permeability layers between the aquifers that cause land subsidence – water lost from these sediments is permanent and causes compaction of the material. In contrast, water lost from coarser-grained sediments (e.g., sand and gravel) causes minimal compaction and water can re-enter the pore spaces when water levels rise.

Repeated cycling of groundwater elevations caused by drought/wet periods or pumping/recharge periods is less likely to cause further subsidence as long as groundwater elevations remain above historical lows. In NPV, groundwater elevations reached their lowest level prior to 1994, then rose substantially after that time (e.g., Figure 78). Thus, the potential for land subsidence is significantly reduced if project groundwater elevations remain above historical low elevations. If groundwater elevations drop below historical lows, then the land surface elevation in the area of the low groundwater elevations should be monitored regularly to detect any subsidence.

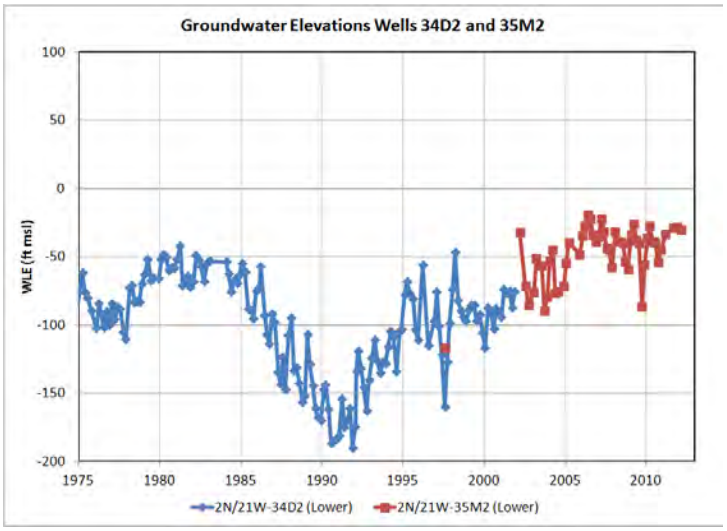


Figure 78. Example of historical low groundwater elevation prior to 1994.

9 Monitoring and Contingency Plan

A Monitoring and Contingency Plan serves the multiple purposes of assisting Project operators in fine-tuning operation of the Project, providing a basis for compliance with FCGMA requirements, and providing a level of comfort for other pumpers in the NPV. The Plan is discussed in two parts in the following sections.

9.1 Monitoring Plan

The recommended monitoring plan for the desalter project includes drilling new monitoring wells, monitoring water levels and water quality in several existing wells, monitoring water quality and flow at one stream location, and analyzing/reporting results annually.

Wells as Monitoring Points

Dedicated Monitoring Wells – It is recommended that three new monitoring wells be installed in NPV. The purpose of the monitoring wells is two-fold: establishing baseline information and tracking the progress of the desalter project as it pulls salts from the basin. The recommended approximate locations of the new monitoring wells are indicated in Figure 79. They are spaced on either side of the calculated particle track boundary for 17 years of groundwater movement since brackish water first reached NPV (approximates today's conditions).

It is recommended that the monitoring wells be completed at multiple depths (e.g., typical U.S. Geological Survey monitoring well), with each sampled zone sealed from the rest of the well (e.g., Figure 80). The approximate depth and screened intervals at each well location as indicated in Table 7; the actual screened intervals will have to be determined after a geophysical log is run between the time the well is drilled and it is cased. Each screened interval is continuously gravel-packed from 10 to 20 feet below the screen to 10 to 20 feet above the screen. A bentonite seal is placed at the bottom of the hole and between each screened interval (Figure 80).

The screen length in a monitoring well can vary from tens of feet (targeting a specific zone within an aquifer) up to hundreds of feet (targeting most or all of an aquifer's thickness). Each end member has its own advantages and disadvantages. The purpose of the recommended monitoring wells is to determine the salt content in each of the major units and how they change with time. Thus, a relatively thick interval is sampled in each recommended screen interval (particularly in the Fox Canyon Aquifer, which is the primary water-producing zone in NPV and is the target of the desalter project). Thus, sampling results should be similar to what would be detected in a typical Fox Canyon production well and in desalter project extraction wells.

The monitoring wells should be designed such that a transducer can be installed and a submersible pump temporarily lowered in each well for sampling. A 2-inch PVC casing and screen are generally used for each screened interval. This allows multiple screened intervals to be completed in each well bore. However, if depth to groundwater is expected to exceed 200 ft, the casing size should be increased to 4-inch to accommodate a larger sampling pump that can adequately lift water to the surface. If 4-inch wells are required, it may be more practical to drill each well separately rather than nesting the wells.

A transducer/data logger should be installed in each screened casing, with data downloaded periodically. It might be advantageous for the transducers to measure both water levels and electrical conductivity – the movement of brackish groundwater may be more complex than periodic water quality sampling can detect. Recommended sampling intervals are shown in Table 8.

There is an existing USGS monitoring well cluster located near Highway 101 and Las Posas Rd (2N/21W-34G). The cluster has screened intervals appropriate to this project and is already being monitored by United Water Conservation District for both water levels and water quality. These data should be included and analyzed in the Annual Monitoring Report.

Existing Production Wells – Three areas of existing production wells have been identified as monitoring sites (Figure 81). The actual number of wells used as monitoring sites will depend upon the willingness of well owners to have their wells monitored. A minimum of five production wells are recommended to be monitored. If allowed by the well owner, a transducer/data logger should be installed in each production well. Recommended sampling intervals are shown in Table 8.

In Monitoring Area #1 (Figure 81), it is recommended that three wells be monitored. One of Pleasant Valley Mutual Water Company's wells (19M5 or 19E1) and the Bell Ranch well (19B1) are the closest to the likely desalter wells, and will indicate localized effects of pumping for the desalter. An additional well is recommended to be chosen among the six wells farther to the east.

In Monitoring Area #2 (Figure 81), one well is recommended to be monitored among the six indicated. The 1B4 well has a long record of measured groundwater elevations (Figure 8), although there is a gap in the record after 2005.

In Monitoring Area #3, the USGS nested well site (wells 34G2 to 34G5) is already monitored regularly for groundwater elevation and less regularly for water quality. Although the record only begins in 1990 following installation of the wells (Figure 10), it is the only existing site that monitors discrete depths in the aquifers; it is recommended as the monitoring site for this area.

Desalter Extraction Wells – Extraction wells used in the desalter project should be equipped with transducers/data loggers unless SCADA hardware already measure water levels. Electrical conductivity should be automatically measured on an interval recommended in Table 8.

Baseline Monitoring Wells for Regional Groundwater Trend Evaluation – Baseline regional monitoring is important so that regional trends (e.g., drought conditions, regional water quality changes) can be identified and accounted for in project monitoring. To factor these regional effects, a set of monitoring wells that are far enough away to be unaffected by the project should be utilized. It is recommended that the set of wells that are regularly monitored in the Pleasant Valley basin by United Water be used for this background monitoring; results of this monitoring should be used for identifying both regional water level and water quality trends.

Surface Water Monitoring

Dry-weather base flow into NPV along Arroyo Las Posas should be sampled regularly to determine the quality of this source of recharge to NPV. An appropriate site should be

determined that is very close to the NPV-East Las Posas basin boundary (blue arrow in Figure 81) and is currently perennially wet. Dry-weather sampling will detect the quality of the brackish recharge water that is currently recharging NPV. As desalters are built in the Las Posas basin, base flow should diminish with time.

It is recommended that base flow water quality be sampled monthly during the months of May through October. If rainfall occurs that brings storm water into NPV during the sampling season, it is still appropriate to collect a sample from the arroyo for comparison to the quality of base flow. Such storm events prior to sampling should be noted in the Annual Report. Recommended sampling is shown in Table 8.

The quantity of baseflow into NPV is not currently monitored systematically, and must be estimated as discussed in an earlier chapter. Knowing this flow (and how it changes with time in the future) with more accuracy is important for both the NPV Desalter Project and similar desalter projects in the upstream Las Posas basin. It is recommended that a recording gauge be installed at the site to measure daily flows during dry-weather (base flow) conditions. The cost of this monitoring can likely be shared with Las Posas basin desalter project(s).

Monitoring Data Analysis

Transducer data should be downloaded quarterly and examined for overall trends and potential trigger values. When water quality analyses are received, a similar examination is warranted. Water level, streamflow, and quality data should be maintained in digital form for annual analyses and determination of trends and trigger values.

Reporting

An Annual Report is recommended to be prepared by July following the end of the calendar year. The Annual Report should show a summary of desalter operations, data analyses and graphs, conclusions formed from the analyses, and recommendations for future operations and monitoring. The Annual Report may be submitted to regulatory agencies as required.

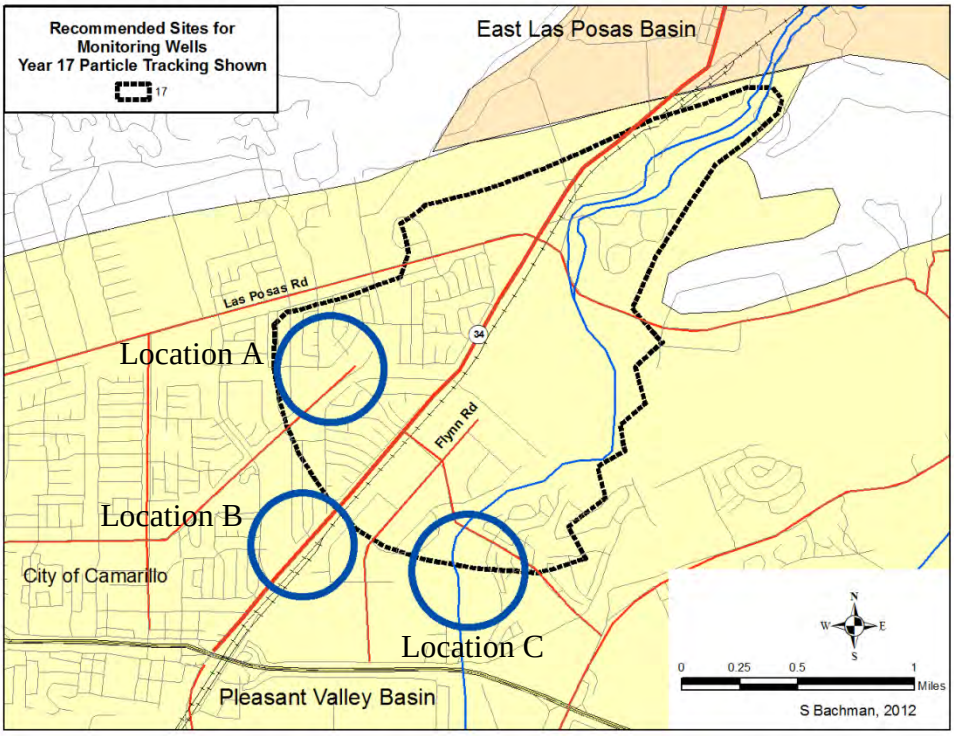


Figure 79. Recommended sites (circles) for installation of new monitoring wells. It is recommended that wells be installed with at least one well one either side of the particle tracking boundary of 17 years (approximates today's condition).

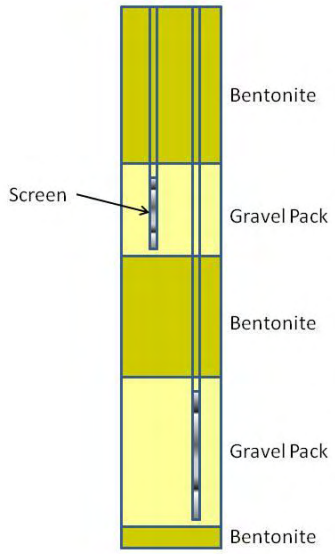


Figure 80. Monitoring well completion schematic. Each screened interval is isolated above and below by a bentonite seal. Gravel pack extends 10 to 20 feet above and below screen.

Well Location	Total Depth	Shallow Aquifer Screen	Hueneme Screen	Fox Canyon Screen
A	1050’	60-170’	430-640’	680-1030’
B	1100’	60-110’	620-740’	830-1080’
C*	1100’	60-140’	none	660-1080’

Table 7. Approximate depth and screened intervals for recommended monitoring wells. Actual screened intervals would be based on electric logs run prior to casing the holes. *May be less expensive to drill two separate smaller-diameter wells.

	Dedicated Monitoring Wells	Monitored Production Wells	Desalter Extraction Wells	Surface Water
Groundwater Elevation	Transdcr-3 hr	Transdcr-3 hr	Transdcr-3 hr	
Electrical Conductivity	Transdcr-3 hr	Transdcr-3 hr	Transdcr-3 hr	
General Minerals	Quarterly	Quarterly	Monthly	Monthly dry season

Table 8. Recommended sampling for desalter project.

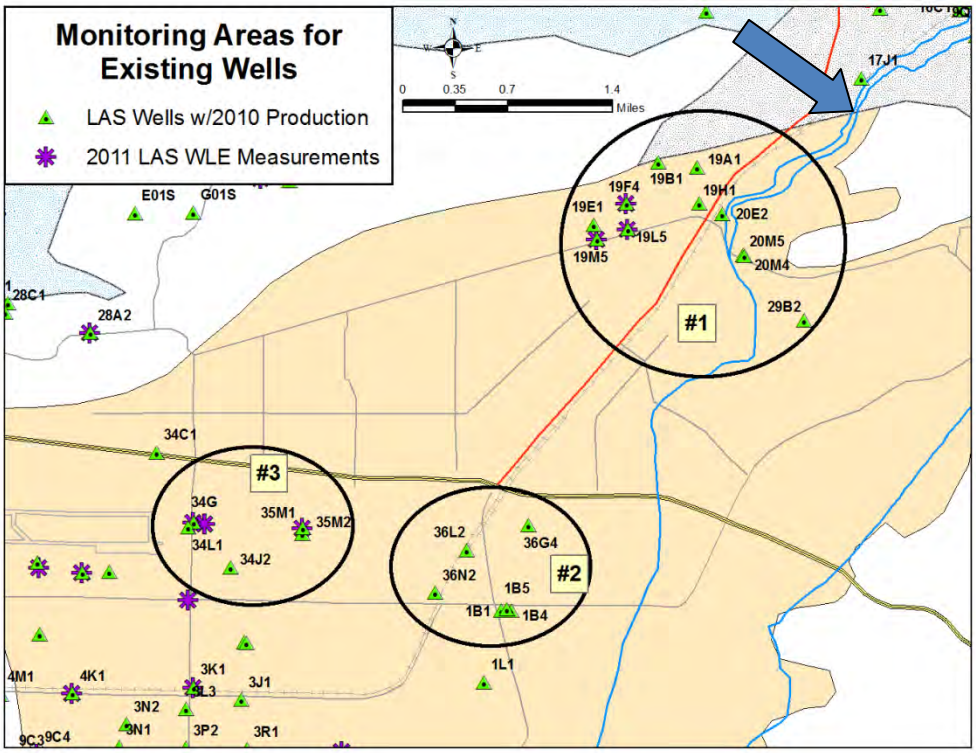


Figure 81. Three recommended areas for monitoring existing production wells. Blue arrow indicates potential site for surface water monitoring.

Contingency Plan

A Contingency Plan deals with issues that may arise during operation of the project, including unexpected water level declines or unexpected changes in water quality.

Contingency Plan for Groundwater Elevations

Predicted changes in groundwater elevations caused by pumping for the desalter can be addressed prior to commencement of the Project by agreements with affected parties. It is recommended that such an understanding be arranged with Pleasant Valley Mutual Water Company, which may be affected by increased pumping if new desalter wells are constructed. Likewise, discussions may be prudent with other pumpers within Monitoring Area #1 in Figure 81.

Depending upon the actual Scenario implemented, pumpers outside of Monitoring Area #1 may not see effects of the desalter pumping for several years. The long-term contingencies for these areas are discussed in the following sections.

Contingency Triggers for Groundwater Elevations

Contingency triggers are numerical values for groundwater elevations /water quality concentrations beyond which a contingency plan is implemented. These triggers vary by area. There are several factors that must be considered in devising triggers for the desalter project that would result in implementing project contingencies.

- Groundwater elevations rose for decades in the project area as the aquifers were filled with non-native brackish water (discharge from wastewater treatment plants, dewatering of shallow aquifers) that spilled over from the Las Posas basin. Without this recharge, groundwater elevations in the project areas would currently be much lower (e.g., Figure 6 prior to 1994). Recovery of this brackish water would be expected to lower groundwater elevations back to pre-1994 levels.
- There is a water quality benefit to all pumpers who would potentially be affected by future movement of the brackish water if the desalter project is not built. This benefit must be balanced against lower groundwater elevations that the pumpers may experience. The benefit applies to both municipal pumpers (sulfates exceeding drinking water standards) and agricultural pumpers (chlorides exceeding tolerance levels in salt-sensitive crops).
- Groundwater elevations in the project area may be lower in the future from causes unrelated to desalter pumping – such as current overdraft of the basin and/or increased pumping related to crop changes.

Given these factors, it is reasonable to set groundwater elevation triggers somewhat lower than the 1994 measured groundwater elevations. Table 9 indicates the proposed groundwater elevation triggers in each Monitoring Area designated on Figure 81; the trigger value is the minimum 1994 measured groundwater elevation in the Lower Aquifer System less 10 feet. If groundwater elevations were to drop below these designated values, a set of Contingency Actions would take place.

Contingency Actions for Groundwater Elevations

Contingency actions are taken when groundwater elevations measured in the Monitoring Plan approach or are deeper than the trigger in that Monitoring Area and project pumping is found to be the primary cause. The actions are progressive, from informational/planning to modifying project operations.

Groundwater Elevation within 10 ft of Trigger – When any measured groundwater elevation within the Monitoring Area drops to within 10 ft of the trigger elevations, the project operator should review the monitoring data to determine the reason(s) for the drop. The project operator should also commence monthly downloads of the transducers installed in that monitoring area to determine if groundwater elevations are expected to drop below the trigger level. The owner/operator of the monitored well and the FCGMA will be informed of the findings. Potential mitigation of the effects of water levels dropping below the trigger value will be discussed with the well owner/operator if project pumping is determined to be the primary cause of the drop. Mitigation could include reimbursement for increased pumping lifts, reimbursement for required well modifications, and/or modifying project pumping patterns.

Groundwater Elevation Deeper than Trigger – If measured groundwater elevations in the Monitoring Area are deeper than the trigger value consecutively for more than six months of measurements, and project pumping is determined to be the primary cause of the drop, the mitigation discussed in the previous paragraph will be implemented. The owner/operator of the monitored well and the FCGMA will be informed of the trigger exceedance. If these actions do not mitigate the problem within a six-month period (i.e., prevent further drops in groundwater elevations or mitigate the effects of the drop in groundwater elevation), further mitigation may be required. This mitigation could include reimbursement for required well modifications and/or modifying project pumping patterns. This additional mitigation will be discussed with the well owner/operator and reported to the FCGMA. If no satisfactory agreement on mitigation can be resolved with the well owner/operator, mitigation measures will be proposed by the project operator and submitted to the FCGMA for discussion, modification, and approval.

Monitoring Area	Trigger WLE (ft msl)	Based on Well
#1	-135	2N/20W-19F4
#2	-107	1N/21W-1B4
#3	-128	USGS 2N/21W-34G3

Table 9. Trigger groundwater elevations for Contingency Plan.

Contingency Plan for Groundwater Quality

The purpose of the Desalter Project is to pump brackish water, treat it to remove salts, and discharge the salts from the watershed. It is an expectation of the Project that the FCGMA will extend its policy from the Las Posas basin that allows pumping and treating of this brackish without the use of FCGMA allocations or credits. The movement of salts can be more complex than modeled for this Project – particle tracking assumes plug flow (no dispersion or dilution) – and the aquifer is very likely to be more complex in its geometry and internal bedding than can be modeled. In reality, the water extracted for desalting may vary in salt content from day-to-

day and month-to-month. Such variation is expected, cannot be avoided, and does not detract from the goals of the Project or the benefits of the Project to the aquifer.

As the Project matures and the travel paths of brackish water become more complex as the salts are recovered from aquifer areas further away from Project pumping, there are likely to be episodic periods when individual wells pump fresh water. Although this cannot be avoided when attempting to clean up the entire area of brackish groundwater, a contingency plan for FCGMA allocations and credits is prudent. The purpose of the contingency plan is to differentiate between extended pumping of fresh groundwater (which would require the use of FCGMA allocations and/or credits) and pumping of primarily brackish groundwater (which would fit under the FCGMA policy related to pumping and treating brackish groundwater).

Analytical test results can be variable, and single water quality test results cannot characterize the duration, magnitude, or frequency of the measured quality. Therefore, it is recommended that single water quality test results should be used as triggers to initiate a response, rather than only as a means to determine whether brackish water is being pumped.

Pumping of Primarily Brackish Groundwater – As discussed previously, the salt content of brackish groundwater pumped by the Project is likely to vary episodically with time. Thus, the determination of primarily brackish groundwater must take this into account. For purposes of defining primarily brackish groundwater, three components were examined – chloride, sulfate, and electrical conductivity. The examination concentrated on Monitoring Area #1 (shown on Figure 81) where the degradation of water quality has occurred.

When comparing measurements from the 1980s (prior to degradation) to those from the 2000s (following degradation), wells that were measured in both periods show varying amounts of degradation (Appendix section 13.5) caused by varying time length of degradation and other factors. Sulfate, which has been the largest problem for the City of Camarillo's groundwater pumping, is shown in Figure 82 prior to and after degradation. The figure also shows the measurements within the Regional Board's Basin Plan Objectives of 300 mg/L for sulfate.

It is recommended that the criteria for brackish water be a threshold of 300 mg/L of chloride to reflect historical concentrations and the Basin Plan Objective. Using this threshold, pumped groundwater with sulfate concentrations above 300 mg/L would be considered brackish water and its removal beneficial to the aquifers.

Extended Pumping of Fresh Groundwater – At some time in the future, Project wells will likely start pumping a mixture of brackish and ambient groundwater as the brackish water is removed. It is unlikely that the transition from brackish to ambient groundwater will be a sharp break – it is most likely to be transitional, with periods of pumping brackish and fresher water. Given this scenario, there must be criteria for determining how this transition is considered. It is recommended that when sulfate concentrations drop below 300 mg/L in any Project well, a verification period would begin to ensure that brackish water has indeed been removed from the portion of the aquifer supplying water to the well. This verification period would be one year in duration, with water quality testing

increased to monthly during the period. If, after one year, sulfate concentrations remained below 300 mg/L, then subsequent pumping would be considered as pumping fresh groundwater subject to the FCGMA allocation system.

If future pumping of water from a Project well that has transitioned from brackish to fresh water returns to a brackish water condition, then the verification period would be reversed – it would require one year of verified pumping of groundwater above 300 mg/L sulfate to return the well to a brackish water status. These criteria are summarized in the table below. This information would be provided to the FCGMA in the Annual Report.

Contingency	Project well pumping brackish water has sulfate drop below 300 mg/L	Project well pumping fresh water has sulfate increase to above 300 mg/L
Action	Begin one year verification period	Begin one year verification period
Considered Fresh Water	Monthly testing remains below 300 mg/L for verification period	Any monthly test is below 300 mg/L
Addt'l Evaluation	Evaluate whether regional conditions contributed to drop	Evaluate whether regional conditions contributed to increase
Considered Brackish Water	Any monthly test exceeds 300 mg/L	Monthly tests remain above 300 mg/L for verification period
Termination of Action	One year of pumping below 300 mg/l (reverts to fresh water) or any monthly test greater than 300 mg/L (remains brackish water)	One year of pumping above 300 mg/L (reverts to brackish water) or any test less than 300 mg/L (remains fresh water)
FCGMA Allocation	No allocation required	Prorated use of allocation*
Sunset Provision	If well pumps fresh water for 36 consecutive months, well permanently reverts to fresh water status	

Table 10. Contingency actions for water quality. * If any monthly measurement is greater than 300 mg/L sulfate, then allocation is prorated across reporting year (e.g., if sulfate is greater than 300 mg/L for two of the twelve months, then pumping for those two months does not require an allocation).

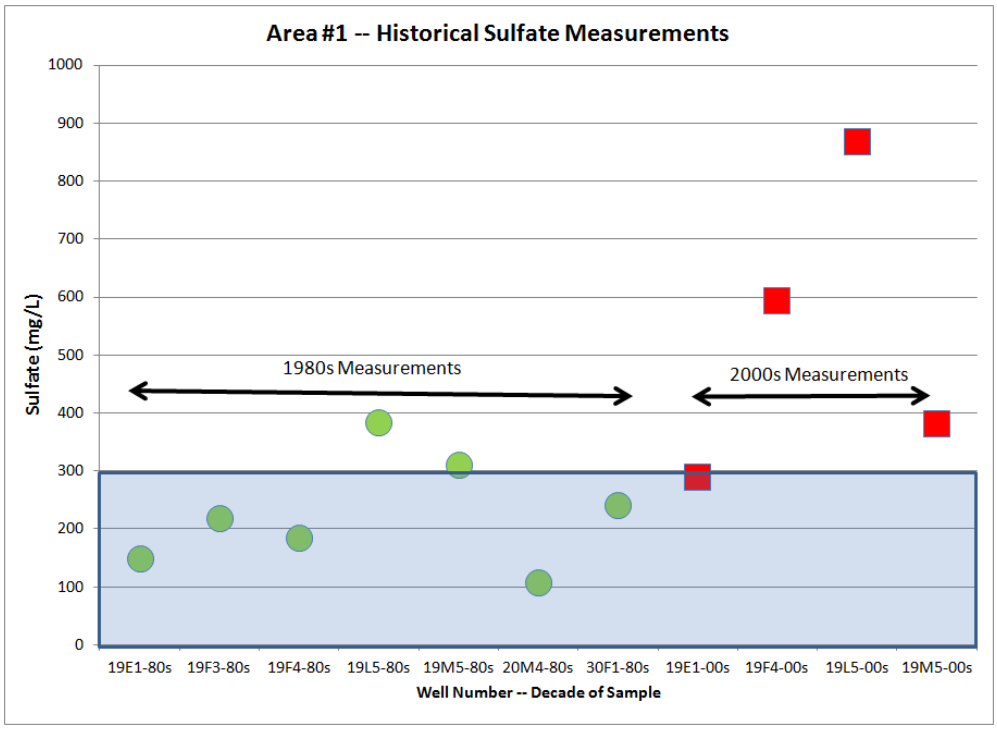


Figure 82. Historical sulfate concentrations in Monitoring Area #1 (near future desalter pumping). Green circles are data from the 1980s, red squares are from 2000s (through 2011). Shaded area denotes concentrations that are within Basin Plan Objective of 300 mg/L sulfate.

10 Recommendations

Analyses and modeling using current data have largely reached the limit of our understanding of the brackish water problem. Recommendations are therefore centered on obtaining additional information for design and subsequent monitoring of the Project. There is sparse measured information outside of the location of Camarillo's production wells on the current location and concentration of the poor-quality baseflow that has infiltrated into NPV. It is recommended that three monitoring wells with pressure and electrical conductivity sensors be installed downstream of the NPV area within the City of Camarillo to measure both groundwater elevations and salt content. Installing these wells prior to design of the desalting project would help verify the accuracy of the modeling and particle tracking and allow any necessary adjustments to be made in modeling conclusions. The general locations of recommended monitoring wells are indicated in Figure 79 with wells located on either side of the 17-year particle boundary that approximates today's condition. These wells would help verify both current water quality and water level predictions from the model and would be used to track these parameters as the project progresses.

A comprehensive Monitoring Plan should be implemented, as discussed in section 9.1. Besides monitoring the three new monitoring wells, at least five existing production wells are recommended to be instrumented and monitored in three identified areas. In addition, a surface water monitoring point is recommended to be installed along Arroyo Las Posas where it crosses

the basin boundary into NPV. The data collected for the Monitoring Plan should be analyzed regularly and presented in an Annual Report.

It is also recommended that a Contingency Plan be implemented as discussed in section 0. The Contingency Plan identifies groundwater elevations in several areas that would trigger a Project response. It also recommends water quality criteria to determine when Project wells are pumping brackish or fresh water.

An additional recommendation relates to pumpers near the NPV Desalter pumping area. Predicted changes in groundwater elevations caused by pumping for the desalter can be addressed prior to commencement of the Project by agreements with affected parties. It is recommended that such an understanding be arranged with Pleasant Valley Mutual Water Company, which may be affected by increased pumping if new desalter wells are constructed. Likewise, discussions may be prudent with other pumpers within the area of pumping for the desalter.

11 Conclusions

The MODFLOW model successfully simulated the historical buildup of the mound of poor quality beneath NPV, so it appears to be an appropriate tool to test various configurations of the NPV Desalter pumping. An unexpected result of the modeling of base case conditions (without project) was the potential threat of migration of poor-quality water into the agricultural areas of the Pleasant Valley basin. This result reinforces the need for desalter projects to prevent further groundwater contamination.

All modeled pumping scenarios indicate that there will be reduction of the mound of poor-quality groundwater, with a resulting decrease in groundwater elevations in NPV and bordering areas. This decrease in groundwater elevations is necessary – there can't be cleanup without it. The extent of the drawdown varies by pumping scenario, but modeling of the 25-year project scenario suggests that there will be recovery of a portion of the drawdown at the conclusion of the project. In many cases, pre-contamination groundwater elevations are reached, whereas in other cases groundwater elevations remain above these 1994 groundwater elevations throughout the project. Nearby wells are likely to be affected and the recommended Monitoring and Contingency Plans should be employed.

Both changes in groundwater elevations and particle tracking simulated by the model suggest that the NPV Desalter project would work as planned – the mound of poor-quality water would be pumped down, there would be a significant amount of water available for desalting, and much of the brackish water that has infiltrated into the aquifer would be recovered. Modeling of the 11,800 AFY, 25-year project suggests that such a project is feasible and would recover most if not all of the "brackish water."

Groundwater modeling and particle tracking are robust tools to predict the effects of desalter pumping, but their limitations and the limitations of the streamflow data indicate that the results should be used cautiously. Monitoring of groundwater elevations and quality is the best method of verifying the results of this model. Monitoring and Contingency Plans recommended here should be implemented. Dedicated monitoring wells recommended as part of the Monitoring

Plan should be installed prior to desalter design to verify model results and to analyze the progress of the project.

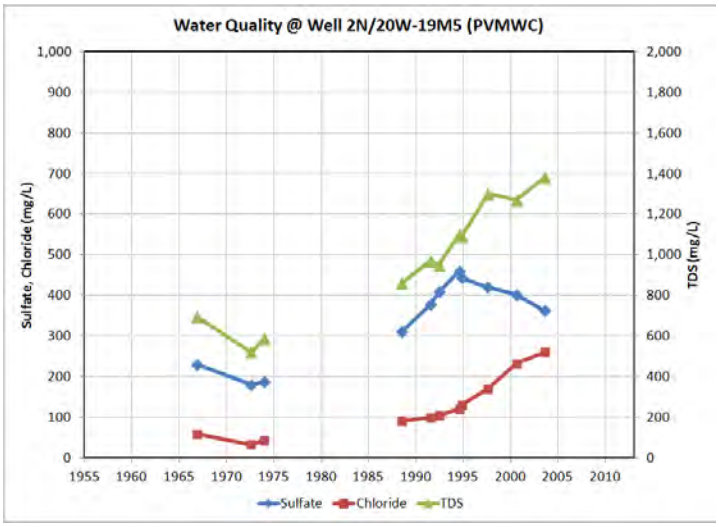
12 Limitations

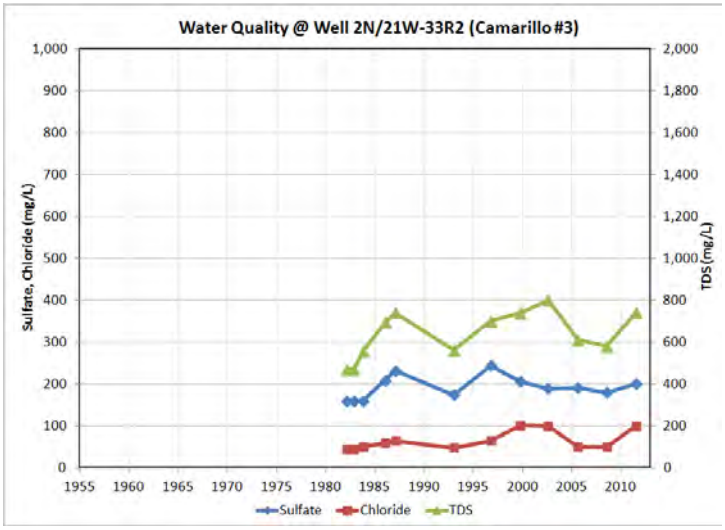
Many of the conclusions in this report are based on groundwater modeling results. It is important to note that modeling of complex hydrogeologic conditions requires simplification of these complex conditions and, thus, modeling results are a simplified approximation of future groundwater conditions. Measurement of actual future conditions utilizing the recommended Monitoring Plan should be the primary guide to the efficacy of the project, and adaptive management based on these monitoring results will be required to ensure that the project meets its objectives.

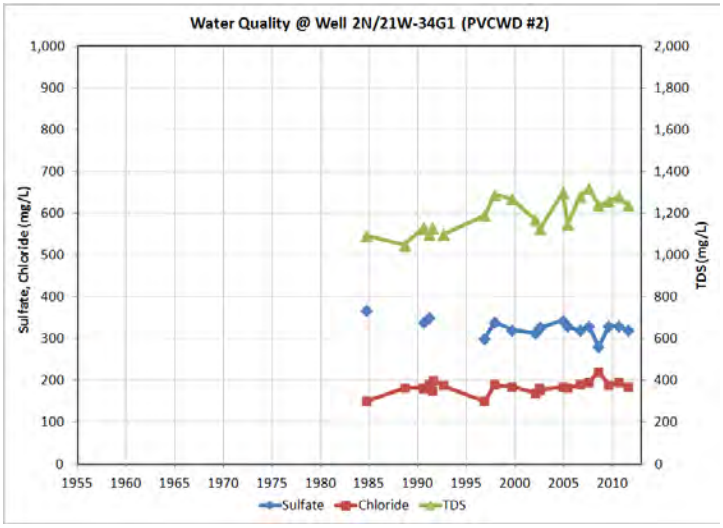
13 Appendix

13.1 Water Quality Graphs

Additional graphs are shown here. See location map Figure 14.







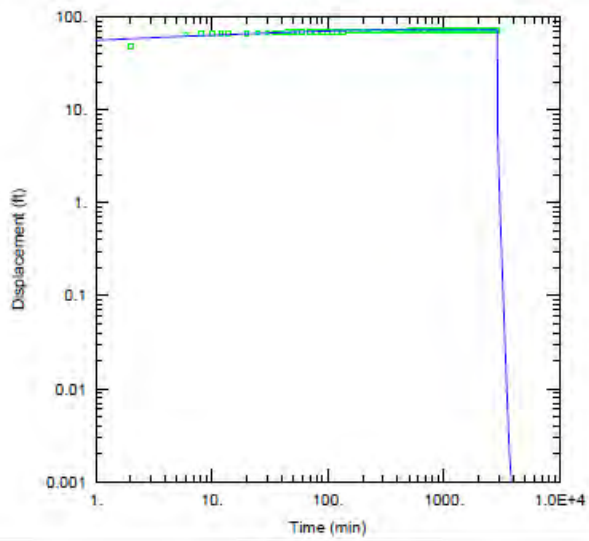
13.2 Aquifer Testing

Aquifer testing results contracted by TMR Geological Consulting Services for City of Camarillo. A summary of those results are shown below, with more-detailed results shown in this section and on the attached CD.

Date	Length of Test	Pumping Well	Pumping Rate gpm	Observation Wells	Distance to Pumping Well (feet)
6/1/2011	48 hr	Camarillo Well A	1840	Camarillo Well A	0
				Camarillo Well B	909
				PVMWC Well 10	1265
				PVMWC Well 11	1162
6/6/2011	48 hr	Camarillo Well B	1534	Camarillo Well B	0
				Camarillo Well A	909
				PVMWC Well 10	1299
				PVMWC Well 11	1429

Well ID	Total Depth (ft)	Depth To Top of Screen (ft)	Aquitard Thickness
Well A	875	467	307
Well B	779	459	315
Well 10	920	564	404
Well 11	816	540	293
Average	847.5	507.5	
	Aquifer Thickness	**340**	**329.75**

		Aquifer Properties			Aquitard Properties	
Pumping Well	Observation Wells	Transmissivity	Storativity	Horizontal Hydraulic Conductivity	Vertical Hydraulic Conductivity	Leakage Coefficient
		ft^2/day		ft/day	ft/day	min^{-1}
Camarillo Well A	Camarillo Well A	4700	-	-	-	--
	Camarillo Well B	5772	1.1E-04	17.0	3.3	6.9E-06
	PVMWC Well 10	10340	5.0E-05	30.4	3.9	8.3E-06
	PVMWC Well 11	6864	4.5E-04	20.2	4.1	8.6E-06
Camarillo Well B	Camarillo Well B	7052	-	-	-	--
	Camarillo Well A	3929	3.1E-06	11.6	1.7	3.6E-06
	PVMWC Well 10	5821	8.8E-06	17.1	2.5	5.2E-06
	PVMWC Well 11	5424	5.0E-06	16.0	2.1	4.4E-06



WELL TEST ANALYSIS

PROJECT INFORMATION

Client: City of Camarillo
Location: Camarillo
Test Well: Camarillo Well A
Test Date: 6/1/11

AQUIFER DATA

Saturated Thickness: 340 ft
Aquitard Thickness (b'): 330 ft

Anisotropy Ratio (Kz/Kr): 1
Aquitard Thickness (b"): 1 ft

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
Camarillo Well A	6253885	1911929

Observation Wells

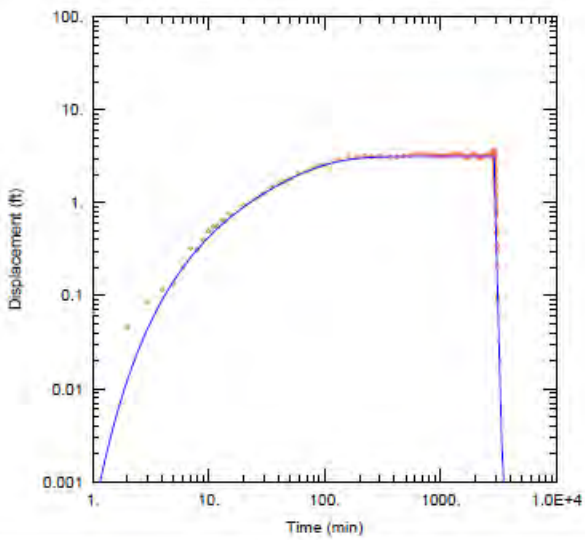
Well Name	X (ft)	Y (ft)
Camarillo Well A	6253885	1911929

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 4700.4 ft^2/day
1/B' = 0.003242 ft^{-1}
1/B" = 0 ft^{-1}

S = 9.791E-5
ß'/r = 0.003998 ft^{-1}
ß"/r = 0 ft^{-1}



WELL TEST ANALYSIS

PROJECT INFORMATION

Client: City of Camarillo
Location: Camarillo
Test Well: Camarillo Well A
Test Date: 6/1/11

AQUIFER DATA

Saturated Thickness: 340 ft
Aquitard Thickness (b'): 330 ft

Anisotropy Ratio (Kz/Kr): 1.
Aquitard Thickness (b"): 1 ft

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
Camarillo Well A	6253885	1911929

Observation Wells

Well Name	X (ft)	Y (ft)
Camarillo Well B	6253824	1912836

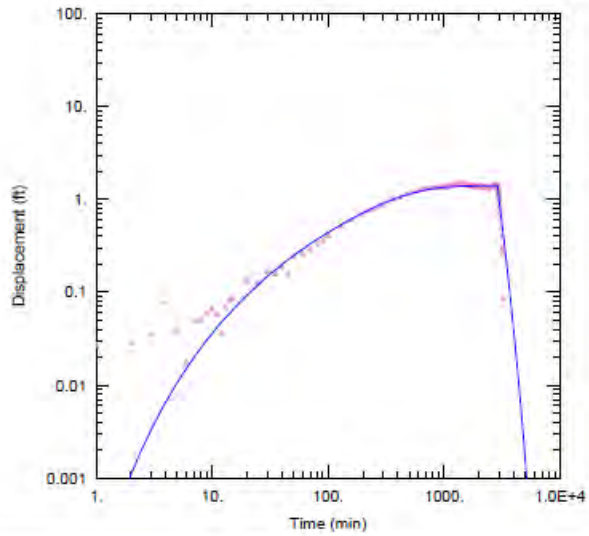
SOLUTION

Aquifer Model: Leaky

T = 5771.8 ft^2/day
1/B' = 0.001312 ft^{-1}
1/B" = 0. ft^{-1}

Solution Method: Hantush

S = 0.0001085
ß'/r = 0.001102 ft^{-1}
ß"/r = 0. ft^{-1}



WELL TEST ANALYSIS

PROJECT INFORMATION

Client: City of Camarillo
Location: Camarillo
Test Well: Camarillo Well A
Test Date: 6/1/11

AQUIFER DATA

Saturated Thickness: 340. ft
Aquitard Thickness (b'): 330. ft

Anisotropy Ratio (Kz/Kr): 1.
Aquitard Thickness (b"): 1. ft

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
Camarillo Well A	6253685	1911929

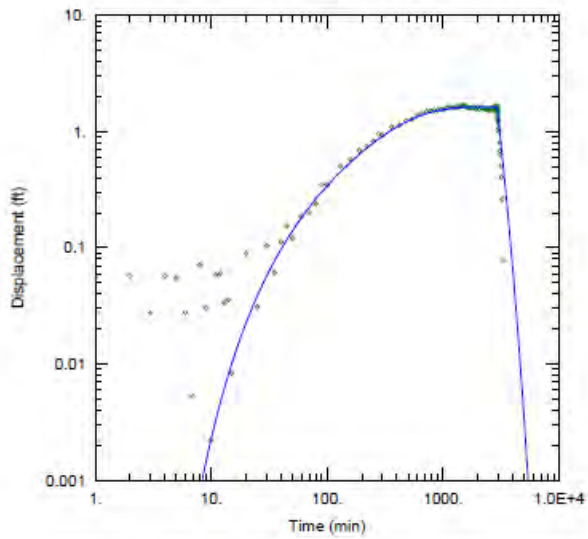
Observation Wells

Well Name	X (ft)	Y (ft)
PVMWC Well 10	6252463	1912256

SOLUTION

Aquifer Model: Leaky
T = 1.034E+4 ft^2/day
1/B' = 0.001073 ft^{-1}
1/B" = 0. ft^{-1}

Solution Method: Hantush
S = 5.0E-5
ß'/r = 0.003375 ft^{-1}
ß"/r = 0. ft^{-1}



WELL TEST ANALYSIS

Data Set: C:\...\PVMWC_Pumping Well A_Obs Well Drawdown Data.aqt
Date: 12/03/11 Time: 10:14:23

PROJECT INFORMATION

Client: City of Camarillo
Location: Camarillo
Test Well: Camarillo Well A
Test Date: 6/1/11

AQUIFER DATA

Saturated Thickness: 340 ft
Aquitard Thickness (b'): 330 ft
Anisotropy Ratio (Kz/Kr): 1.
Aquitard Thickness (b''): 1 ft

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
Camarillo Well A	6253685	1911929

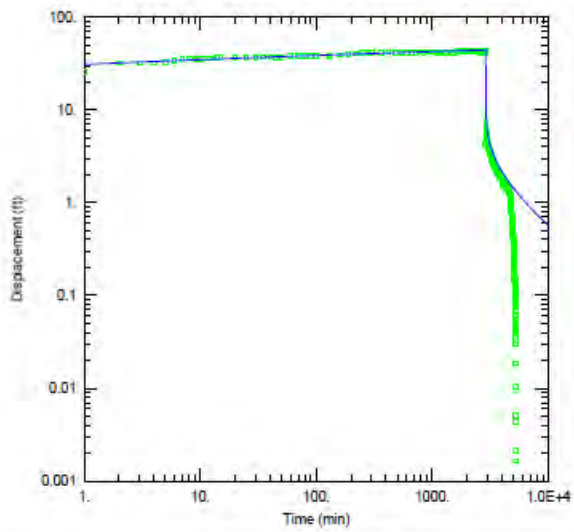
Observation Wells

Well Name	X (ft)	Y (ft)
PVMWC Well 11	6252523	1911925

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 6864.2 ft^2/day
1/B' = 0.00134 ft^{-1}
1/B'' = 0. ft^{-1}
S = 0.0004509
δ'/r = 0.001398 ft^{-1}
δ''/r = 0. ft^{-1}



WELL TEST ANALYSIS

PROJECT INFORMATION

Client: City of Camarillo
Location: Camarillo
Test Well: Camarillo Well B
Test Date: 6/6/11

AQUIFER DATA

Saturated Thickness: 340. ft
Aquitard Thickness (b'): 330. ft

Anisotropy Ratio (Kz/Kr): 1.
Aquitard Thickness (b"): 1. ft

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
Camarillo Well B	6253624	1912836

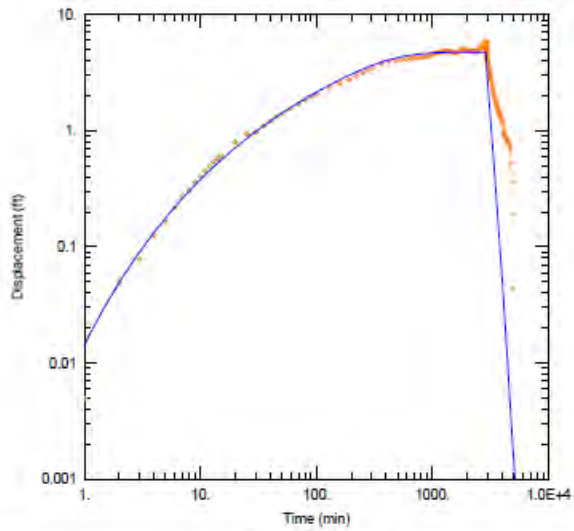
Observation Wells

Well Name	X (ft)	Y (ft)
▫ Camarillo Well B	6253624	1912836

SOLUTION

Aquifer Model: Leaky
T = 7051.7 ft^2/day
1/B' = 8.547E-6 ft^{-1}
1/B" = 0. ft^{-1}

Solution Method: Hantush
S = 2.308E-5
G'/r = 0.01213 ft^{-1}
G"/r = 0. ft^{-1}



WELL TEST ANALYSIS

Data Set: C:\...\PVMWC Pumping Well B_Observation Wells.aqt
Date: 12/02/11 Time: 22:22:25

PROJECT INFORMATION

Client: City of Camarillo
Location: Camarillo
Test Well: Camarillo Well B
Test Date: 6/6/11

AQUIFER DATA

Saturated Thickness: 340. ft
Aquitard Thickness (b'): 330. ft
Anisotropy Ratio (Kz/Kr): 1.
Aquitard Thickness (b"): 1. ft

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
Camarillo Well B	6253624	1912836

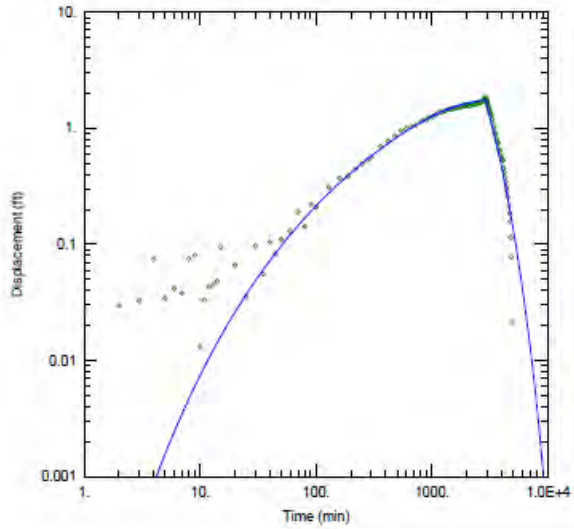
Observation Wells

Well Name	X (ft)	Y (ft)
+ Camarillo Well A	6253885	1911929

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 3928.6 ft^2/day
1/B' = 0.001146 ft^{-1}
1/B" = 0. ft^{-1}
S = 3.137E-6
ß'/r = 0.008851 ft^{-1}
ß"/r = 0. ft^{-1}



WELL TEST ANALYSIS

Data Set: C:\...\PVMWC Pumping Well B_Observation Wells.agt
Date: 12/02/11 Time: 18:09:26

PROJECT INFORMATION

Client: City of Camarillo
Location: Camarillo
Test Well: Camarillo Well B
Test Date: 6/6/11

AQUIFER DATA

Saturated Thickness: 340. ft
Aquitard Thickness (b'): 330. ft
Anisotropy Ratio (Kz/Kr): 1.
Aquitard Thickness (b"): 1. ft

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
Camarillo Well B	6253624	1912836

Observation Wells

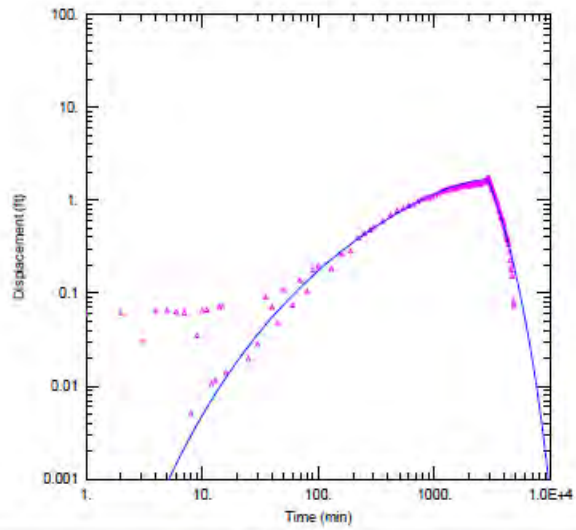
Well Name	X (ft)	Y (ft)
+ PVMWC Well 10	6252463	1912256

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 5821.4 ft^2/day
1/B' = 0.00113 ft^{-1}
1/B" = 0. ft^{-1}

S = 8.761E-6
ß'/r = 0.011 ft^{-1}
ß"/r = 0. ft^{-1}



WELL TEST ANALYSIS

PROJECT INFORMATION

Client: City of Camarillo
Location: Camarillo
Test Well: Camarillo Well B
Test Date: 6/6/11

AQUIFER DATA

Saturated Thickness: 340. ft
Aquitard Thickness (b'): 330. ft

Anisotropy Ratio (Kz/Kr): 1.
Aquitard Thickness (b"): 1. ft

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
Camarillo Well B	6253624	1912836

Observation Wells

Well Name	X (ft)	Y (ft)
+ PVMWC Well 11	6252523	1911925

SOLUTION

Aquifer Model: Leaky
T = 5423.6 ft^2/day
1/B' = 0.001076 ft^{-1}
1/B" = 0. ft^{-1}

Solution Method: Hantush
S = 5.034E-6
B'/r = 0.01313 ft^{-1}
B"/r = 0. ft^{-1}

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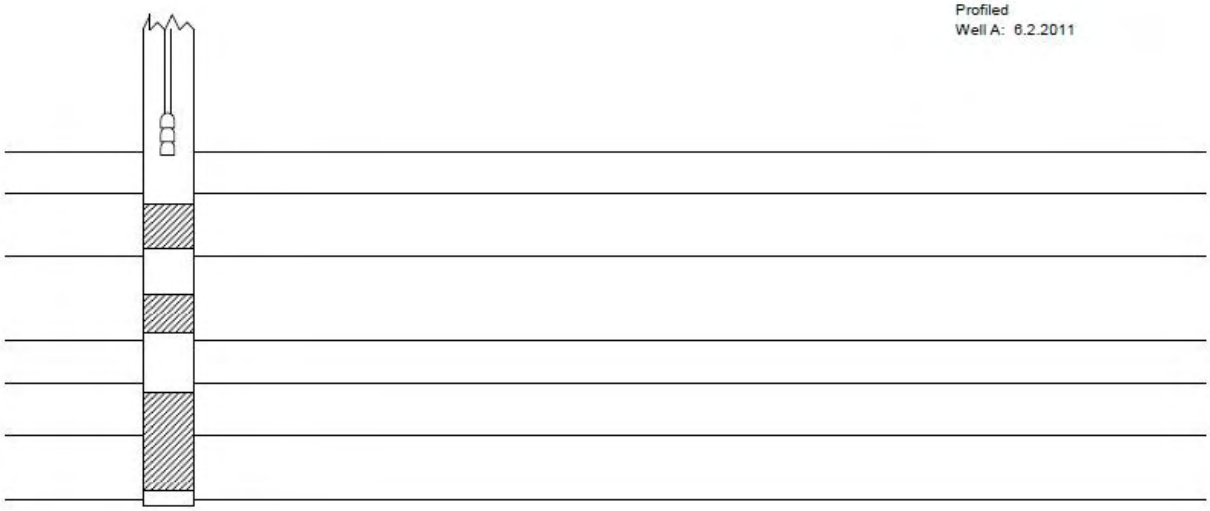
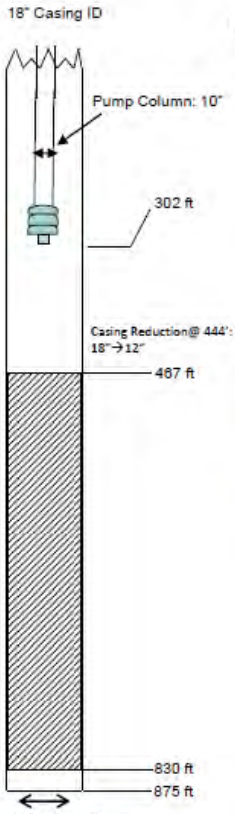
50 Tiburon Street Suite 7
San Rafael , CA 94901
Toll Free.866.298.8701
Phone.415.453.2501
Fax.415.453.2509

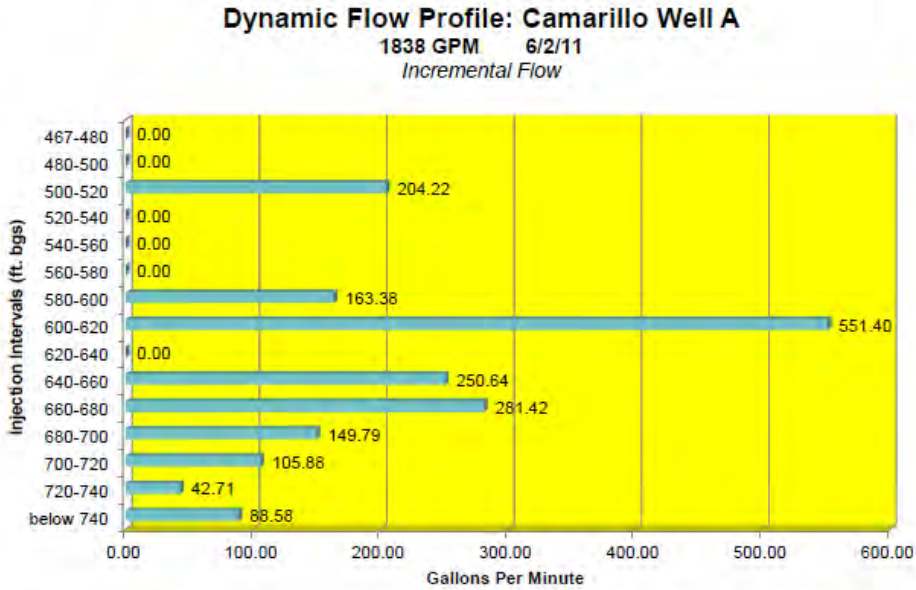
Final Report: Dynamic Flow and Chemistry Profile
City of Camarillo Well A

Profiled
Well A: 6.2.2011





Dynamic Flow Contribution (GPM) By Depth and Screen Intervals



The graph shows dynamic flow contribution vs. the injection depth intervals (ft. bgs). There is one screen interval in Well A. The screened interval is between 467'-830' and produces a cumulative flow of 1838 GPM. This test was conducted under steady state conditions and pumping water level was 160 ft below ground surface. During the descent down the well, our tubing became blocked between 760'-770' bgs. The dye tracer tubing would not continue any deeper inside the well and we assumed the bottom of the well within this interval. Our last viable dye injection was conducted at 760' bgs. This information may be verified by conducting a video survey of the well casing. The graph above shows a breakdown of Incremental Flow in relation to the Dye Injection Intervals.

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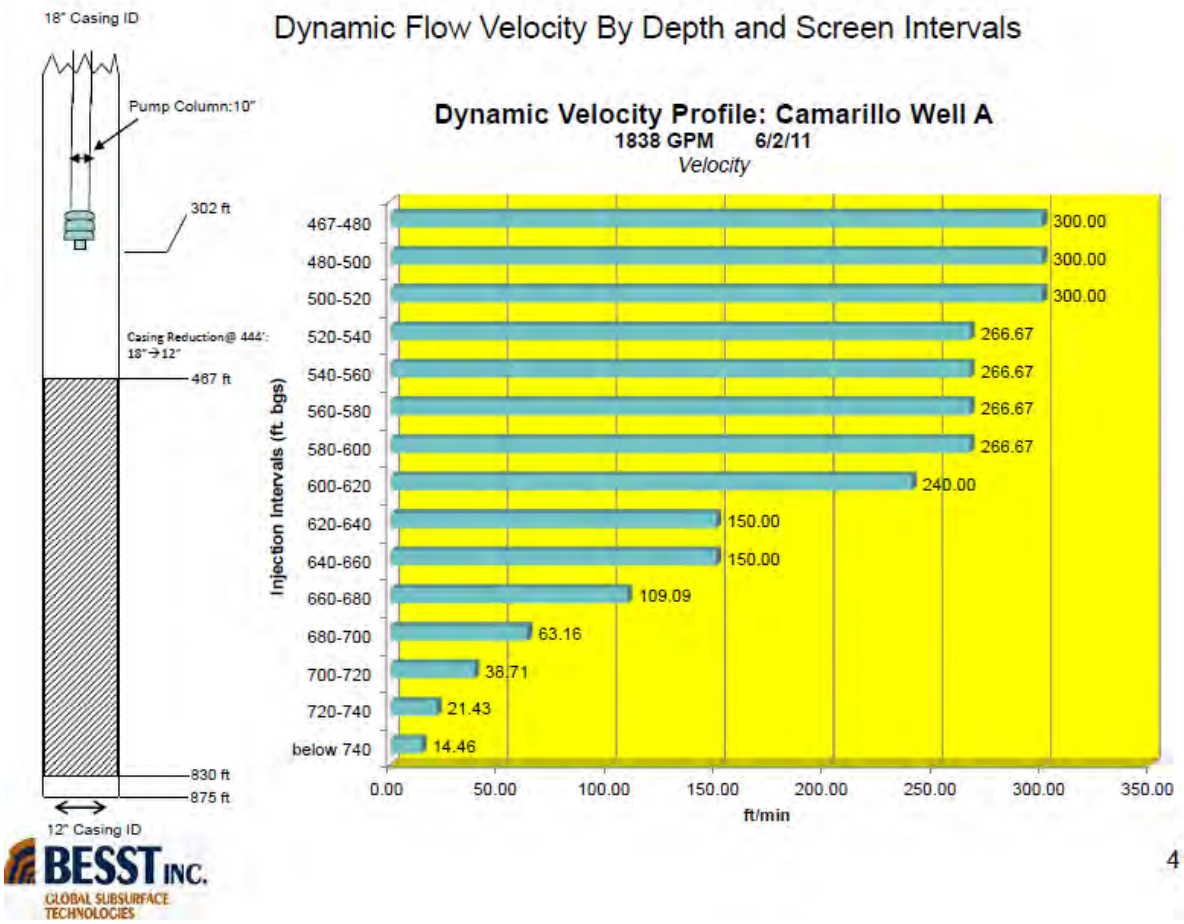
Dynamic Flow Velocity By Depth and Screen Intervals
18" Casing ID
Pump Column:10"
302 ft
Casing Reduction@ 444': 18"→12"
467 ft
830 ft
875 ft
12" Casing ID
Dynamic Velocity Profile: Camarillo Well A
1838 GPM 6/2/11
Velocity
Injection Intervals (ft. bgs)
467-480
480-500
500-520
520-540
540-560
560-580
580-600
600-620
620-640
640-660
660-680
680-700
700-720
720-740
below 740
300.00
300.00
300.00
266.67
266.67
266.67
266.67
240.00
150.00
150.00
109.09
63.16
38.71
21.43
14.46
0.00
50.00
100.00
150.00
200.00
250.00
300.00
350.00
ft/min
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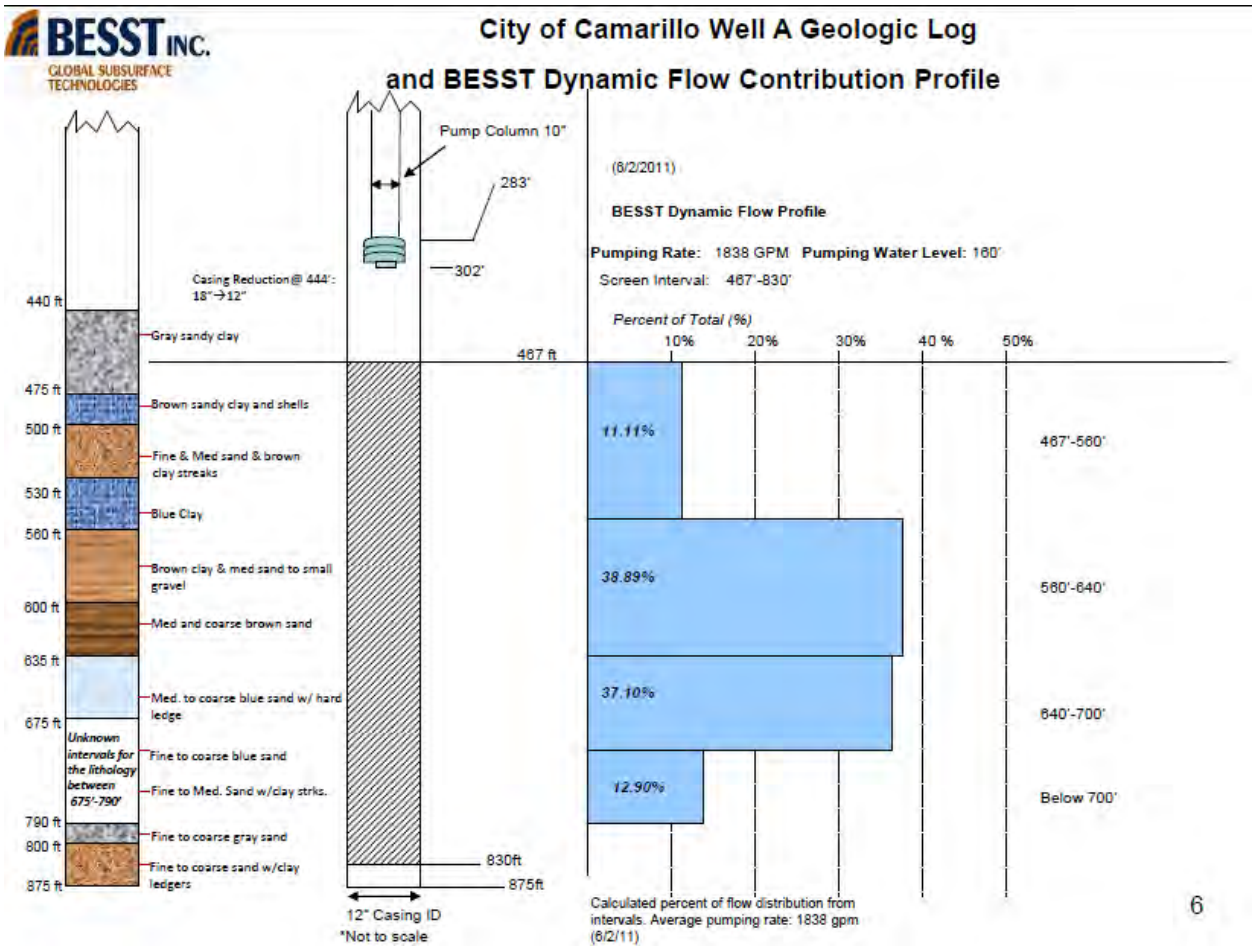
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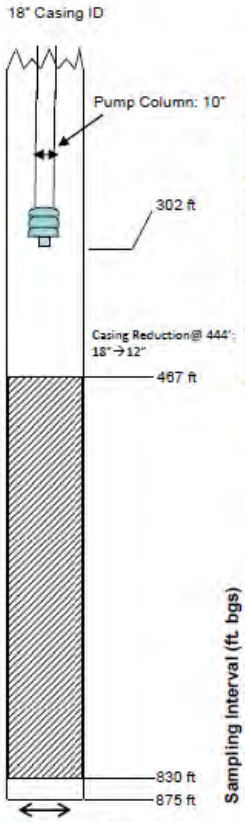
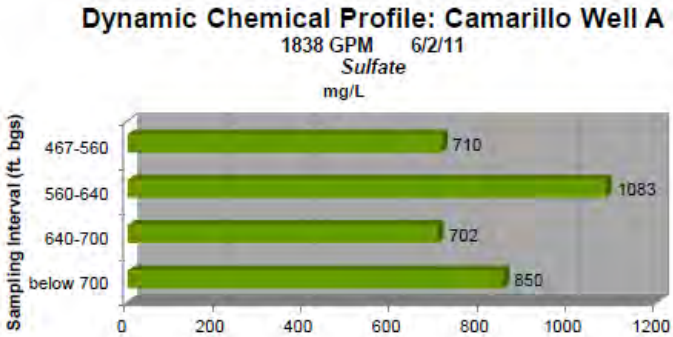
City of Camarillo Well A Geologic Log
and BESST Dynamic Flow Contribution Profile
Pump Column 10"
283'
302'
(6/2/2011)
BESST Dynamic Flow Profile
Pumping Rate: 1838 GPM Pumping Water Level: 160'
Screen Interval: 467'-830'
Casing Reduction@ 444': 18"→12"
Percent of Total (%)
10%
20%
30%
40 %
50%
440 ft
475 ft
500 ft
530 ft
560 ft
600 ft
635 ft
675 ft
790 ft
800 ft
875 ft
467 ft
Gray sandy clay
Brown sandy clay and shells
Fine & Med sand & brown clay streaks
Blue Clay
Brown clay & med sand to small gravel
Med and coarse brown sand
Med. to coarse blue sand w/ hard ledge
Unknown intervals for the lithology between 675'-790'
Fine to coarse blue sand
Fine to Med. Sand w/clay strks.
Fine to coarse gray sand
Fine to coarse sand w/clay ledgers
830ft
875ft
11.11%
38.89%
37.10%
12.90%
467'-560'
560'-640'
640'-700'
Below 700'
12" Casing ID
*Not to scale
Calculated percent of flow distribution from intervals. Average pumping rate: 1838 gpm (6/2/11)
6

Chemical Mass Balance Analysis: Sulfate



Sulfate	ft. bgs	ft. bgs	GPM	mg/L	GPM	mg/L	
	Depth	Interval	Cumulative Flow	Measured Concentration	Incremental Flow	Incremental Concentration	Mass Balance Check
	Tap	467-560	1838.00	870	204.22	710	144998
	560	560-640	1633.78	890	714.78	1083	774002
	640	640-700	919.00	740	681.84	702	478473
	700	below 700	237.16	850	237.16	850	201587
							1599060	870



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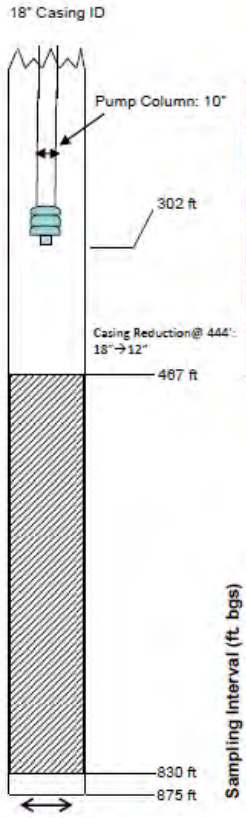
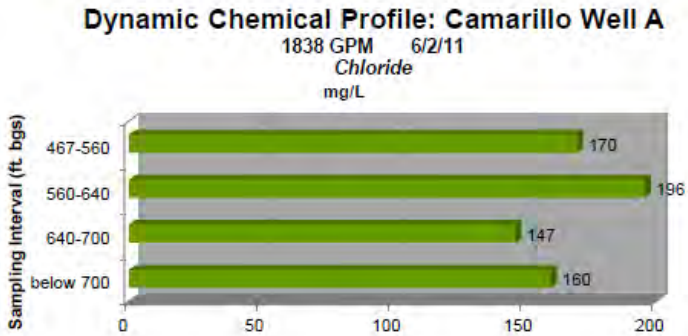


Chemical Mass Balance Analysis: Chloride

Chloride	ft. bgs	ft. bgs	GPM	mg/L	GPM	mg/L	
	Depth	Interval	Cumulative Flow	Measured Concentration	Incremental Flow	Incremental Concentration	Mass Balance Check
	Tap	467-560	1838.00	170	204.22	170	34718
	560	560-640	1633.78	170	714.78	196	139892
	640	640-700	919.00	150	681.84	147	99904
	700	below 700	237.16	160	237.16	160	37946
							312460	170



The laboratory has reported a chloride concentration of 540 mg/L for the water sample taken at 560' which appears to be aberrant, evidenced by the cation:anion imbalance reported at this depth. With Tom Regan's consent, we've adjusted the measured concentrations to 170 mg/L to match what we agree is likely the case down hole. Confirmation is found in the agreement with the zonal concentrations seen in the Specific Conductance analysis on the next page.

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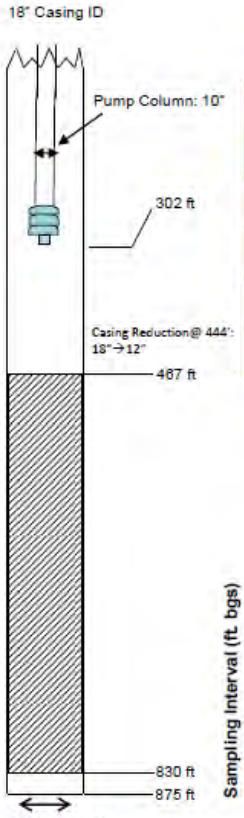
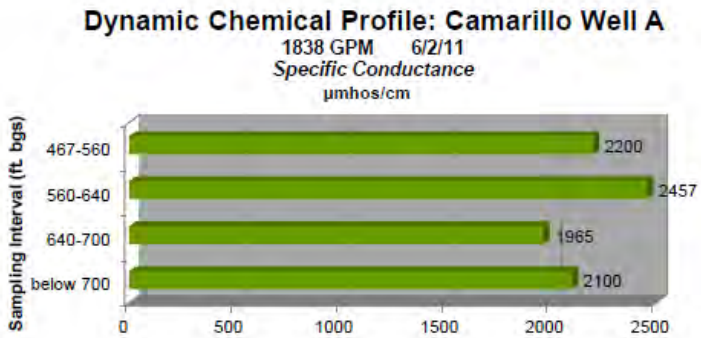
Chemical Mass Balance Analysis: Specific Conductance



Specific Conductance	ft. bgs	ft. bgs	GPM	µmhos/cm	GPM	µmhos/cm	
	Depth	Interval	Cumulative Flow	Measured Concentration	Incremental Flow	Incremental Concentration	Mass Balance Check
	Tap	467-560	1838.00	2,200	204.22	2200	449289
	560	560-640	1633.78	2,200	714.78	2457	1756311
	640	640-700	919.00	2,000	681.84	1965	1339961
	700	below 700	237.16	2,100	237.16	2100	498039
							4043600	2200



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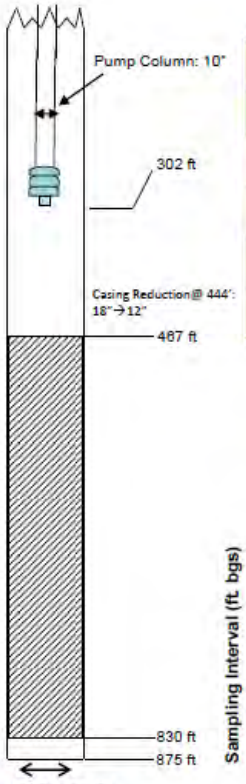
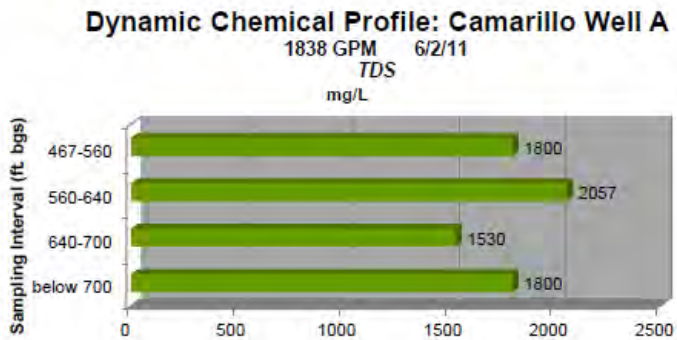
Chemical Mass Balance Analysis: Total Dissolved Solids



TDS	ft. bgs	ft. bgs	GPM	mg/L	GPM	mg/L	
	Depth	Interval	Cumulative Flow	Measured Concentration	Incremental Flow	Incremental Concentration	Mass Balance Check
	Tap	467-560	1838.00	1,800	204.22	1800	367600
	560	560-640	1633.78	1,800	714.78	2057	1470400
	640	640-700	919.00	1,600	681.84	1530	1043510
	700	below 700	237.16	1,800	237.16	1800	426890
							3308400	1800



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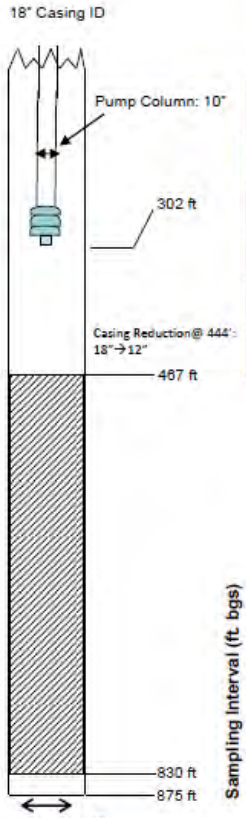
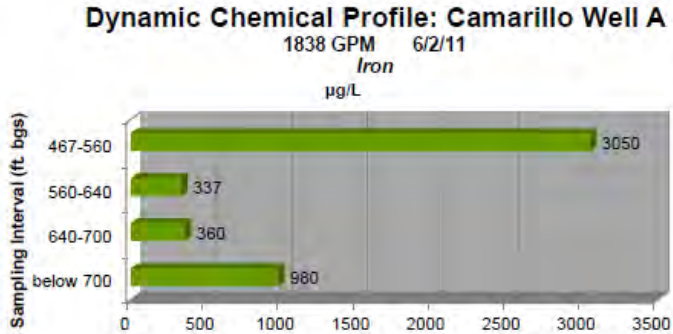
Chemical Mass Balance Analysis: Iron



Iron	ft. bgs	ft. bgs	GPM	µg/L	GPM	µg/L	
	Depth	Interval	Cumulative Flow	Measured Concentration	Incremental Flow	Incremental Concentration	Mass Balance Check
	Tap	467-560	1838.00	730	204.22	3050	622878
	560	560-640	1633.78	440	714.78	337	240982
	640	640-700	919.00	520	681.84	360	245462
	700	below 700	237.16	980	237.16	980	232418
							1341740	730



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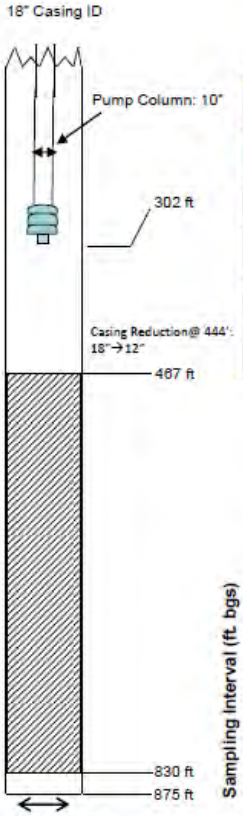
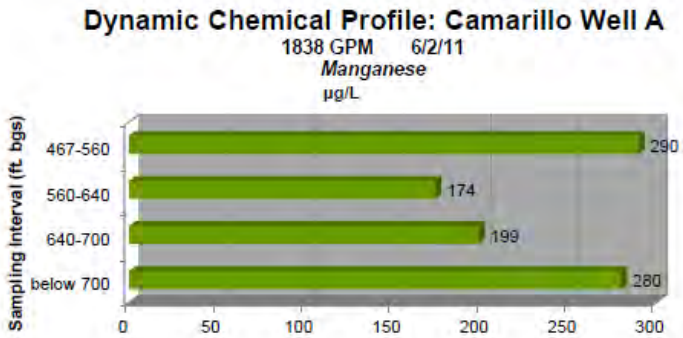
Chemical Mass Balance Analysis: Manganese



Manganese	ft. bgs	ft. bgs	GPM	µg/L	GPM	µg/L	
	Depth	Interval	Cumulative Flow	Measured Concentration	Incremental Flow	Incremental Concentration	Mass Balance Check
	Tap	467-560	1838.00	210	204.22	290	59224
	560	560-640	1633.78	200	714.78	174	124576
	640	640-700	919.00	220	681.84	199	135775
	700	below 700	237.16	280	237.16	280	66405
							385980	210



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San Rafael , CA 94901
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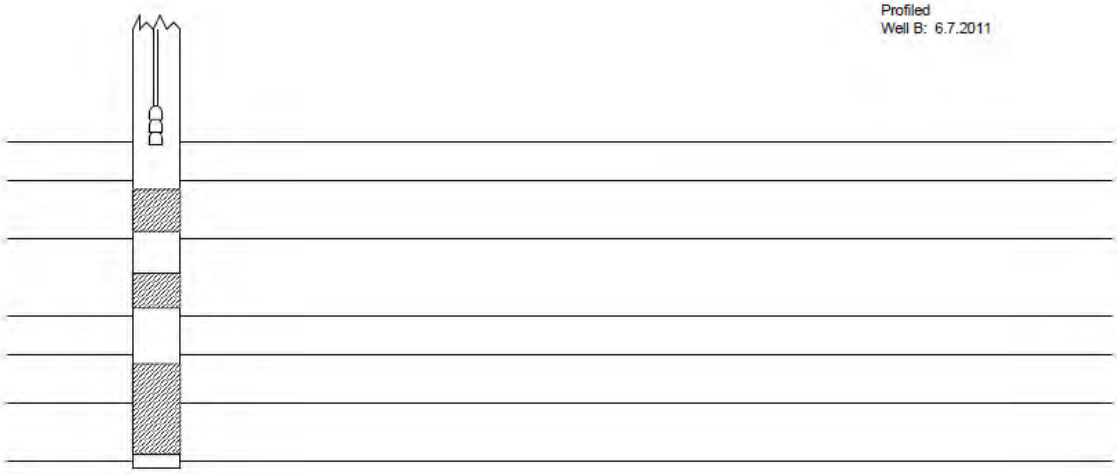
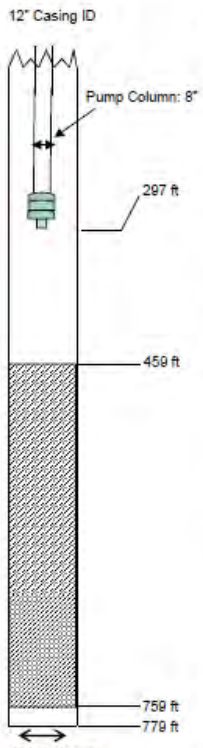
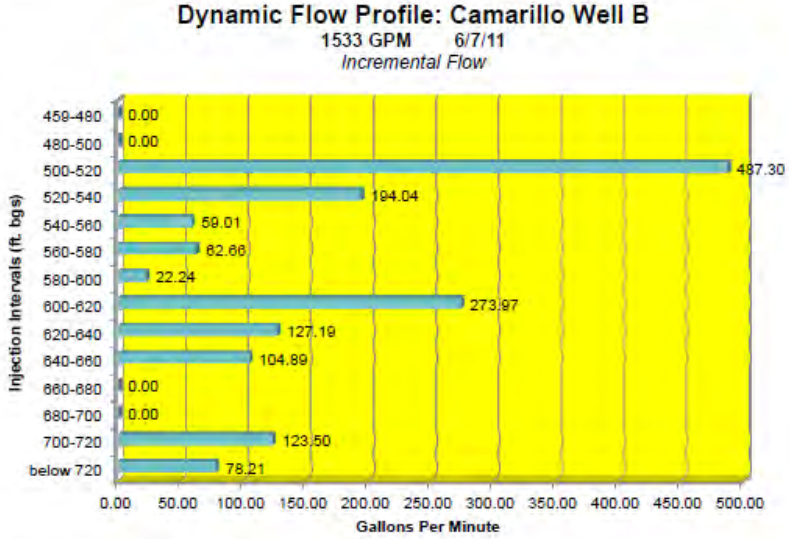
Final Report: Dynamic Flow and Chemistry Profile
City of Camarillo Well B

Profiled
Well B: 6.7.2011





Dynamic Flow Contribution (GPM) By Depth and Screen Intervals



The graph shows dynamic flow contribution vs. the injection depth intervals (ft. bgs). There is one screen interval in Well B. The screened interval is between 459'-759' and produces a cumulative flow of 1533 GPM. This test was conducted under steady state conditions and pumping water level was between 63.1 and 63.6 ft below the top of the access pipe. The graph above shows a breakdown of Incremental Flow in relation to the Dye Injection Intervals.

Note: There was no dye return at the surface when it was injected at or below 480 ft. bgs. This indicates that the vertical flow boundary layer is between 470 and 480 ft. bgs. There is no vertical/upward flow below 480 ft. bgs.

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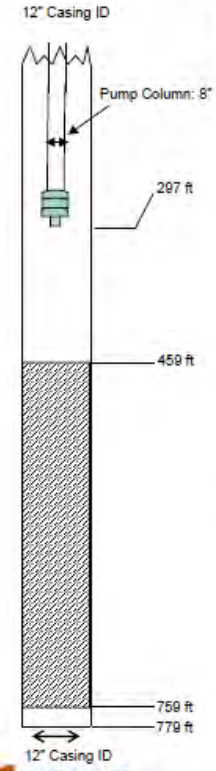
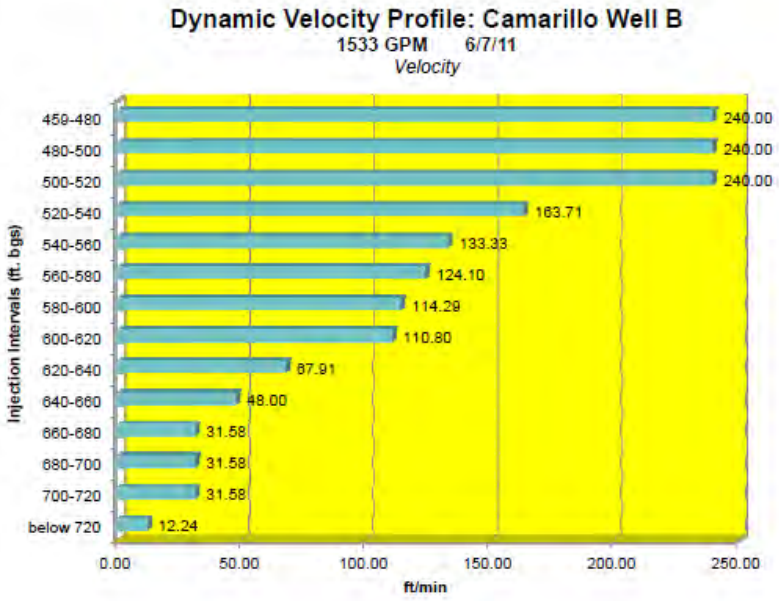


Dynamic Flow Velocity By Depth and Screen Intervals



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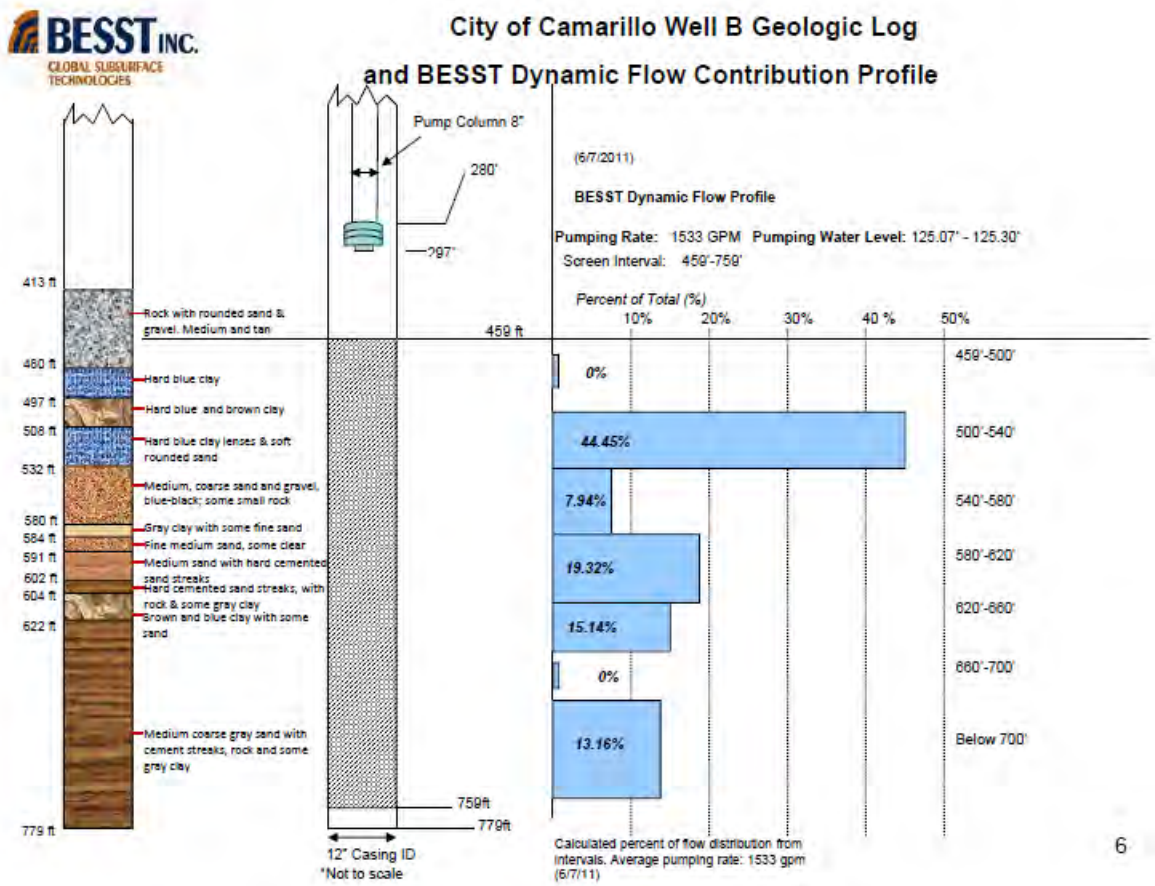
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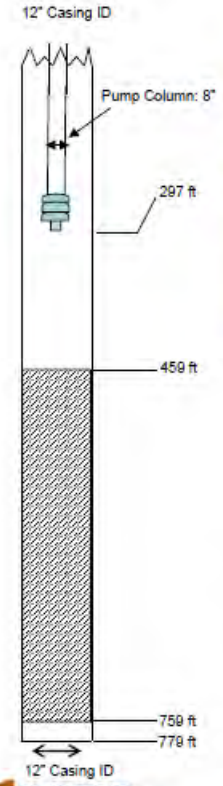
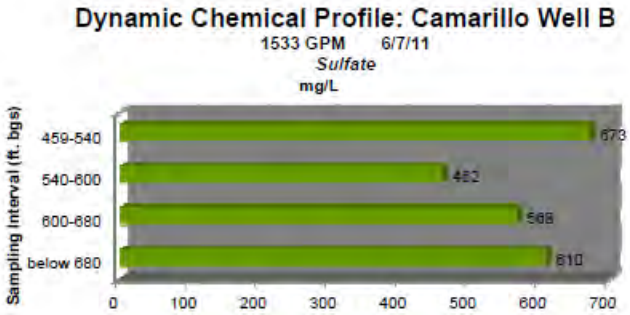
City of Camarillo Well B Geologic Log
and BESST Dynamic Flow Contribution Profile
Pump Column 8"
280'
?97'
(6/7/2011)
BESST Dynamic Flow Profile
Pumping Rate: 1533 GPM Pumping Water Level: 125.07' - 125.30'
Screen Interval: 459'-759'
Percent of Total (%)
10%
20%
30%
40 %
50%
413 ft
460 ft
497 ft
508 ft
532 ft
580 ft
584 ft
591 ft
602 ft
604 ft
622 ft
779 ft
Rock with rounded sand & gravel. Medium and tan
Hard blue clay
Hard blue and brown clay
Hard blue clay lenses & soft rounded sand
Medium, coarse sand and gravel, blue-black; some small rock
Gray clay with some fine sand
Fine medium sand, some clear
Medium sand with hard cemented sand streaks
Hard cemented sand streaks, with rock & some gray clay
Brown and blue clay with some sand
Medium coarse gray sand with cement streaks, rock and some gray clay
459 ft
759ft
779ft
12" Casing ID
*Not to scale
0%
44.45%
7.94%
19.32%
15.14%
0%
13.16%
459'-500'
500'-540'
540'-580'
580'-620'
620'-660'
660'-700'
Below 700'
Calculated percent of flow distribution from intervals. Average pumping rate: 1533 gpm (6/7/11)
6



Chemical Mass Balance Analysis: Sulfate

Sulfate	ft. bgs	ft. bgs	GPM	mg/L	GPM	mg/L	
	Depth	Interval	Cumulative Flow	Measured Concentration	Incremental Flow	Incremental Concentration	Mass Balance Check
	Tap	459-540	1533.00	610	681.33	673	458197
	540	540-600	851.67	560	143.91	462	66435
	600	600-680	707.76	580	506.05	568	287455
	680	below 680	201.71	610	201.71	610	123043
							935130	610



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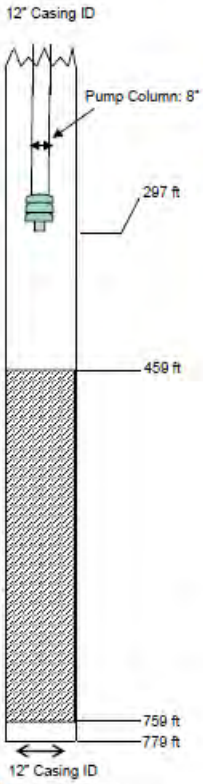
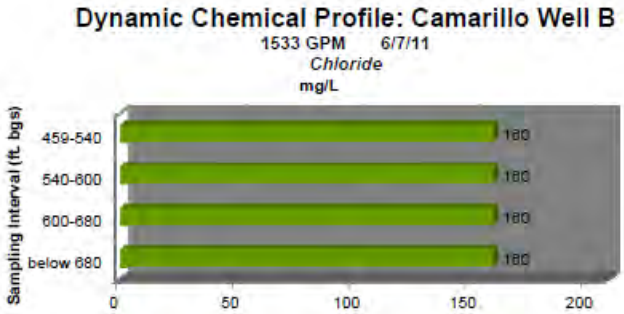


Chemical Mass Balance Analysis: Chloride

Chloride	ft. bgs	ft. bgs	GPM	mg/L	GPM	mg/L	
	Depth	Interval	Cumulative Flow	Measured Concentration	Incremental Flow	Incremental Concentration	Mass Balance Check
	Tap	459-540	1533.00	160	681.33	160	109013
	540	540-600	851.67	160	143.91	160	23026
	600	600-680	707.76	160	506.05	160	80967
	680	below 680	201.71	160	201.71	160	32274
							245280	160



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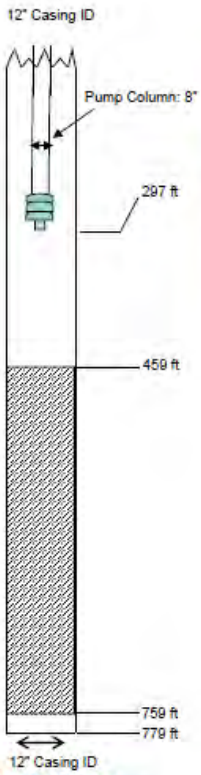
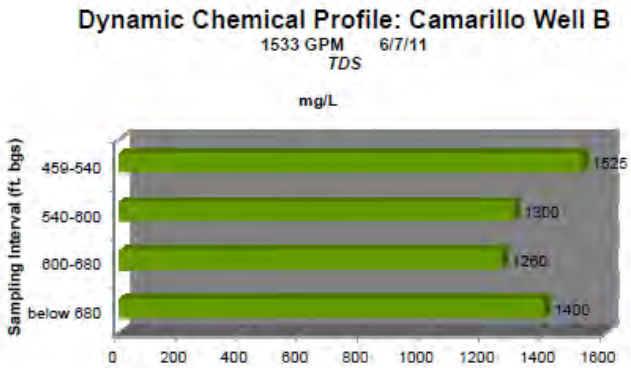


Chemical Mass Balance Analysis: Total Dissolved Solids

TDS	ft. bgs	ft. bgs	GPM	mg/L	GPM	mg/L	
	Depth	Interval	Cumulative Flow	Measured Concentration	Incremental Flow	Incremental Concentration	Mass Balance Check
	Tap	459-540	1533.00	1,400	681.33	1525	1039033
	540	540-600	851.67	1,300	143.91	1300	187084
	600	600-680	707.76	1,300	506.05	1260	637668
	680	below 680	201.71	1,400	201.71	1400	282395
							2146200	1400



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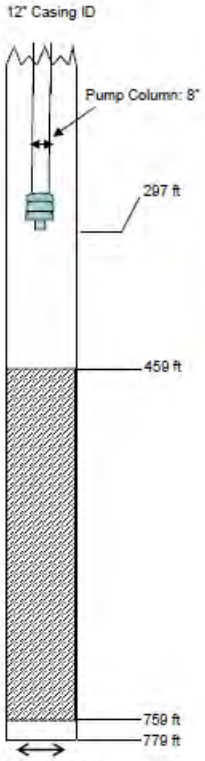
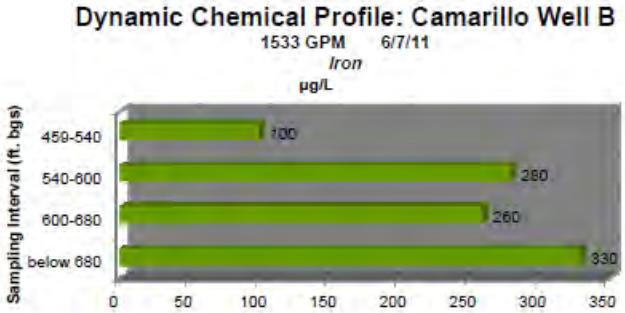


Chemical Mass Balance Analysis: Iron

Iron	ft. bgs	ft. bgs	GPM	µg/L	GPM	µg/L	
	Depth	Interval	Cumulative Flow	Measured Concentration	Incremental Flow	Incremental Concentration	Mass Balance Check
	Tap	459-540	1533.00	200	681.33	100	68133
	540	540-600	851.67	280	143.91	280	40295
	600	600-680	707.76	280	506.05	260	131607
	680	below 680	201.71	330	201.71	330	66564
							306600	200



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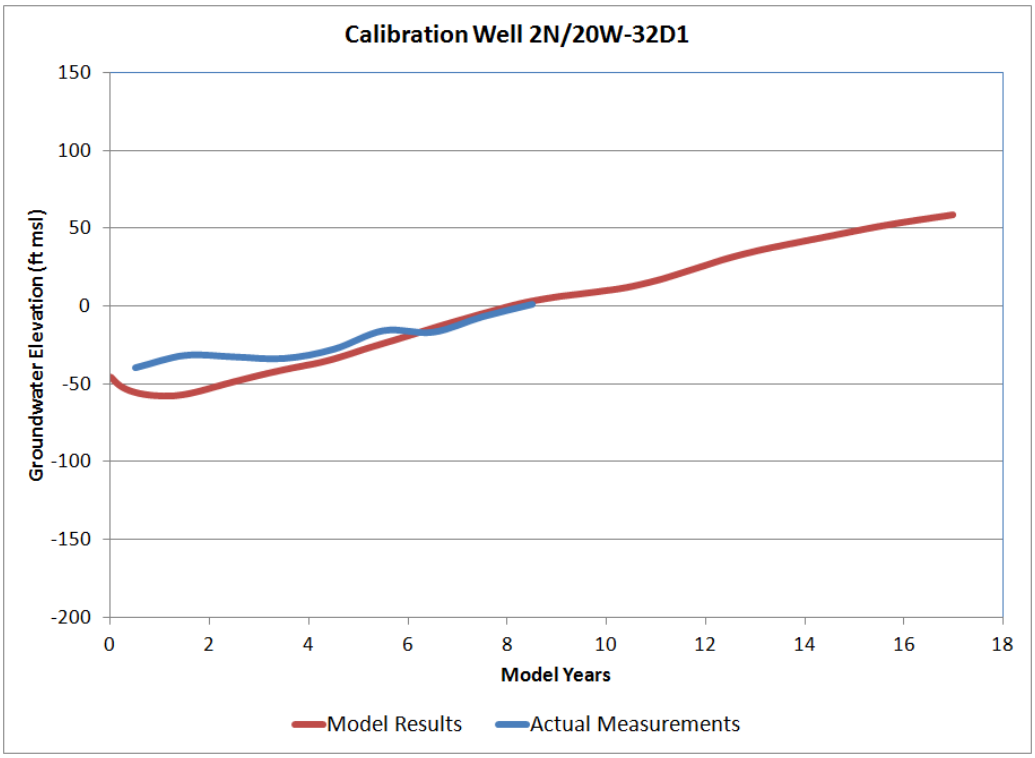
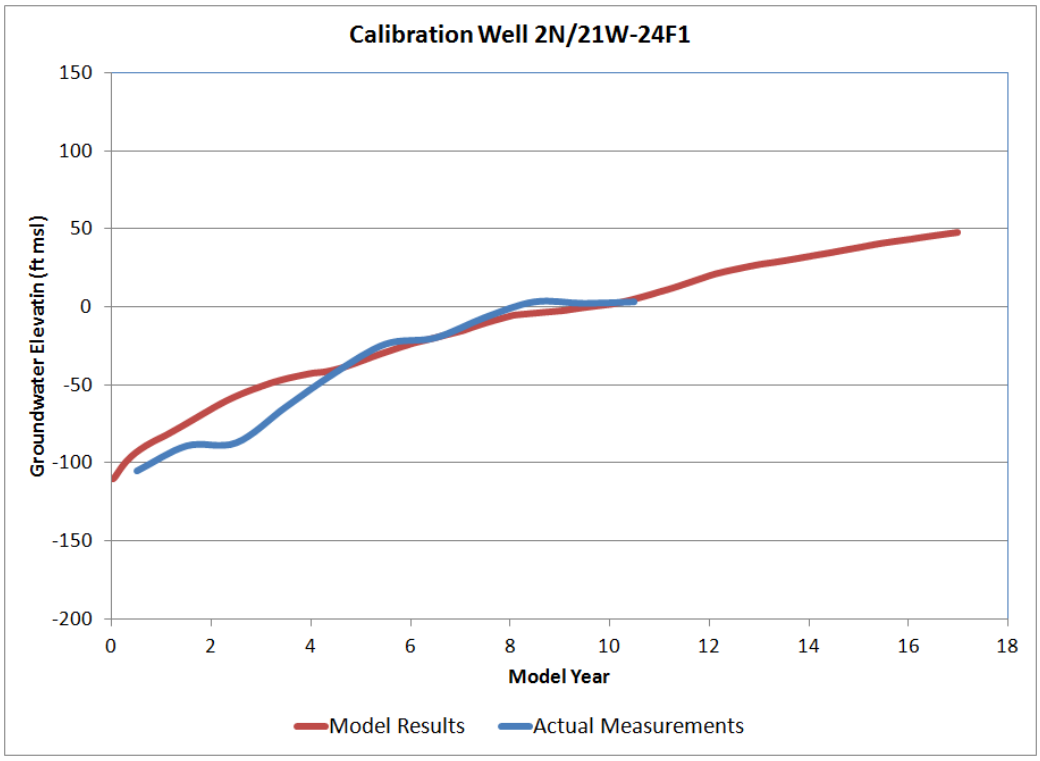
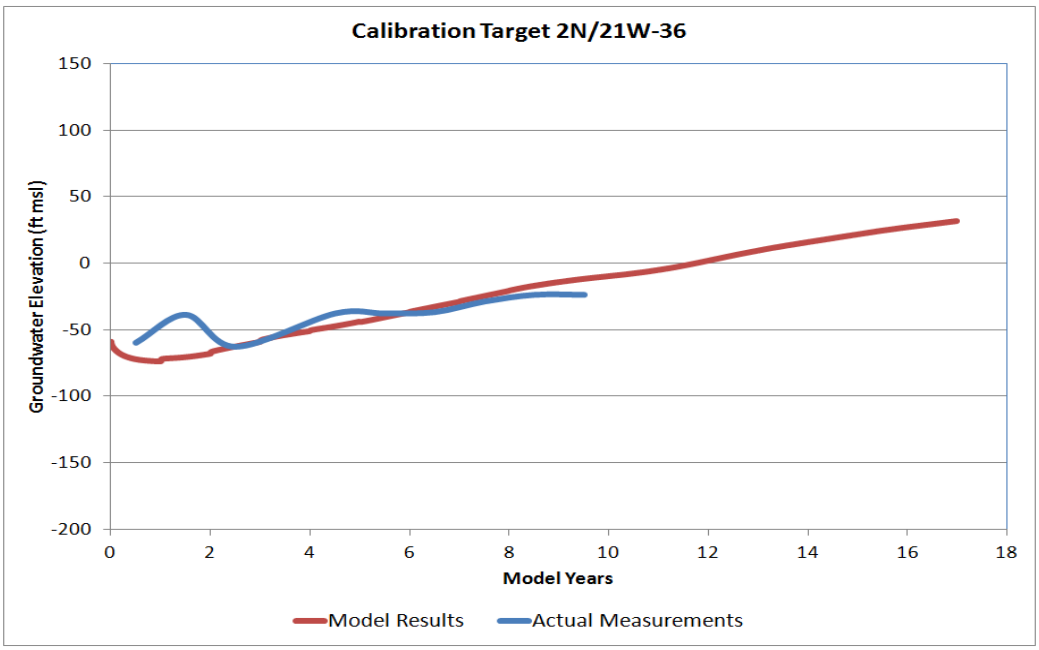
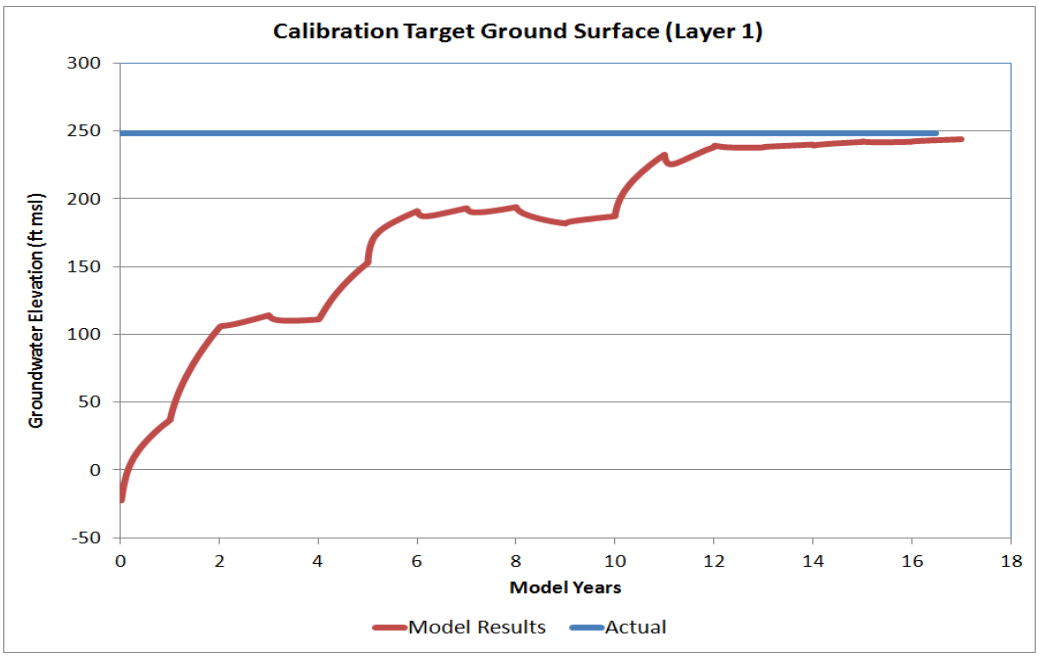
13.3 Additional Calibration Wells

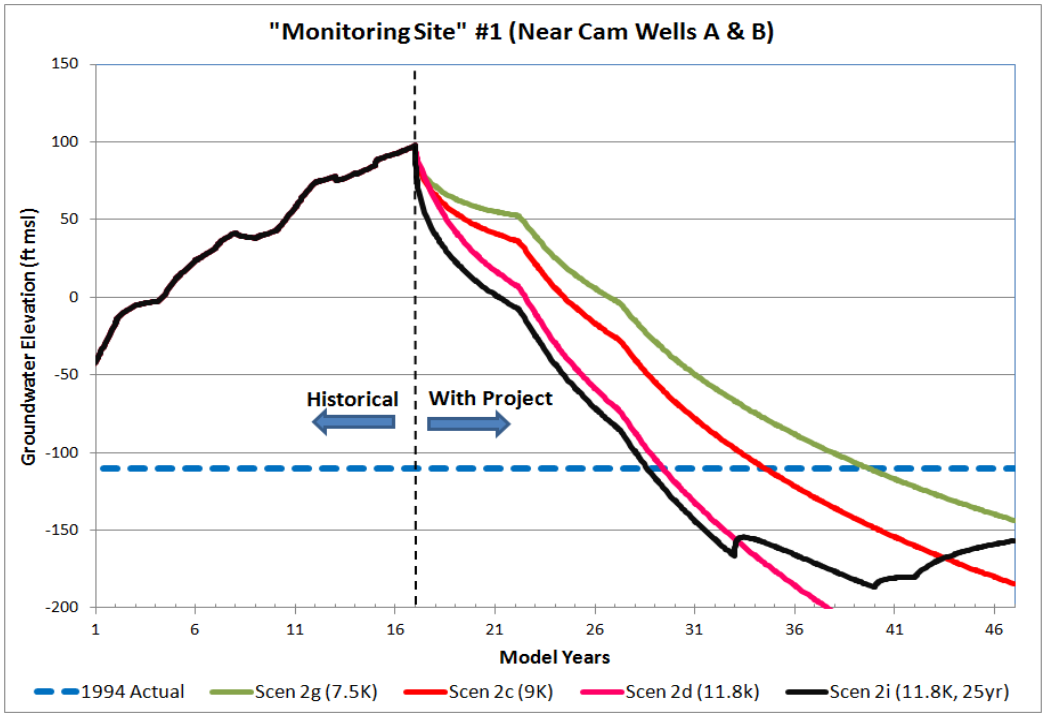


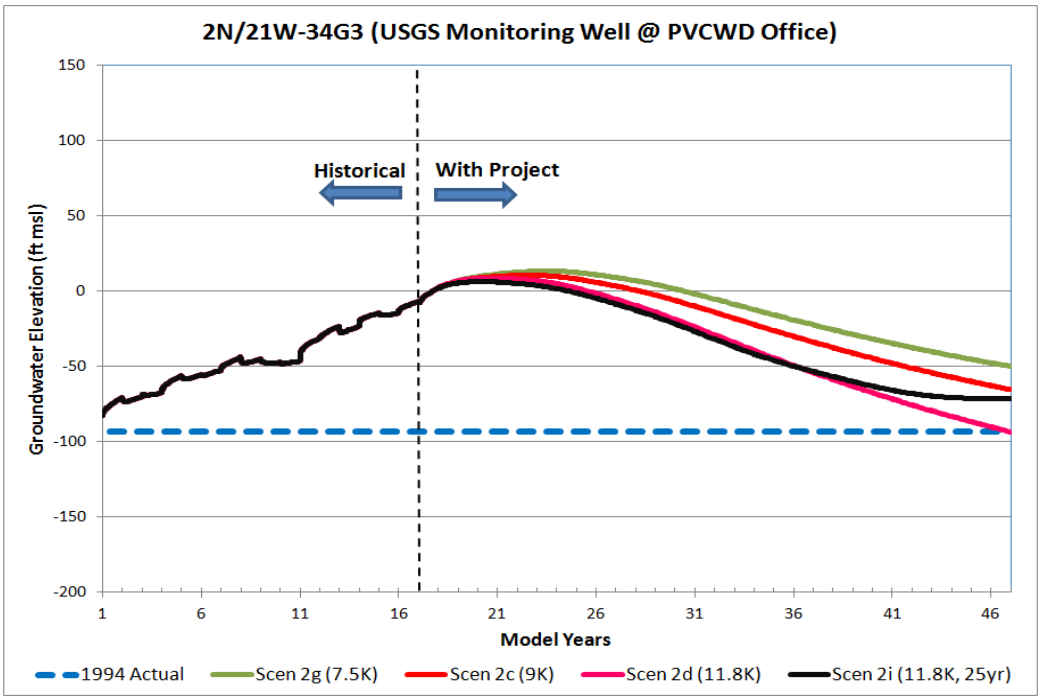



Calibration Target 2N/21W-36
Groundwater Elevation (ft msl)
150
100
50
0
-50
-100
-150
-200
0
2
4
6
8
10
12
14
16
18
Model Years
Model Results
Actual Measurements

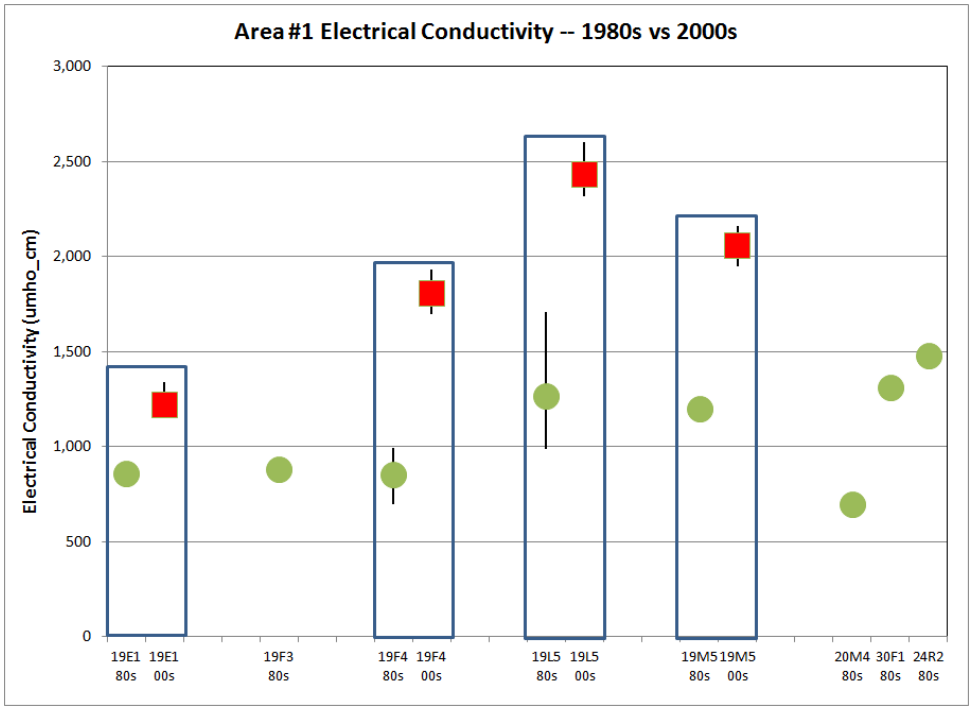

Calibration Target Ground Surface (Layer 1)
Groundwater Elevation (ft msl)
300
250
200
150
100
50
0
-50
0
2
4
6
8
10
12
14
16
18
Model Years
Model Results
Actual

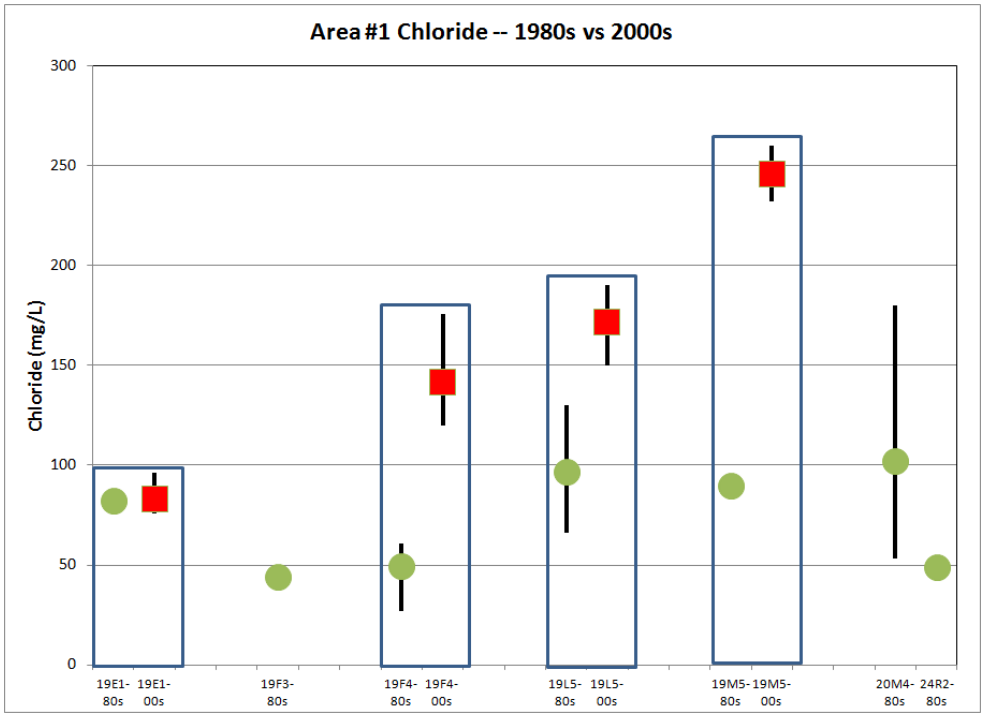
13.4 Additional Project Results

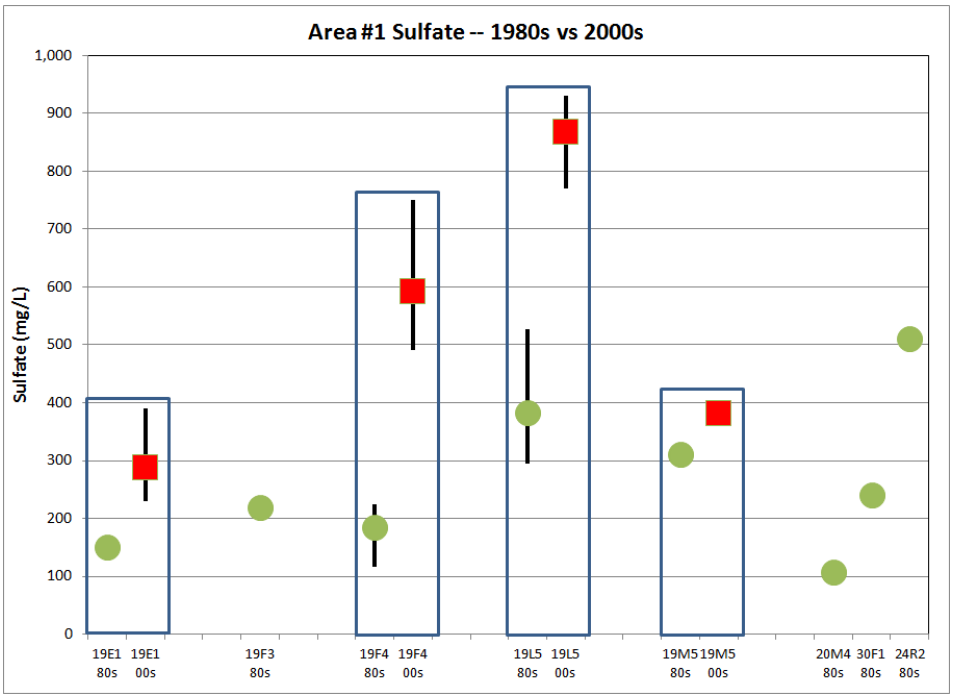




13.5 Additional Monitoring/Contingency Plan Graphs






Area #1 Sulfate -- 1980s vs 2000s
Sulfate (mg/L)
1,000
900
800
700
600
500
400
300
200
100
0
19E1 80s
19E1 00s
19F3 80s
19F4 80s
19F4 00s
19L5 80s
19L5 00s
19M5 80s
19M5 00s
20M4 80s
30F1 80s
24R2 80s

TED GRANDSEN
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GAIL L. PRINGLE, DIRECTOR
DIVISION 4

JEFFREY A. BORENSTEIN, TREASURER
DIVISION 2

CALLEGUAS MUNICIPAL WATER DISTRICT

WILLIAM R. SEAVER, VICE PRESIDENT
DIVISION 5

DONALD G. HAUSER, SECRETARY
DIVISION 3

DONALD R. KENDALL, Ph.D., P.E.
GENERAL MANAGER

web site: www.calleguas.com

2100 OLSEN ROAD • THOUSAND OAKS, CALIFORNIA 91360-6800 805/526-9323 • FAX: 805/522-5730 • FAX: 805/526-3675

To: Board of Directors
From: General Manager
Date: January 25th, 2007

Subject: **CO_2 Emissions and Imported State Project Water to Ventura County**

For the past decade, much attention has been given to so-called greenhouse gases and their role in altering the earth's climate. Greenhouse gases include water vapor, nitrous oxide, methane, tropospheric ozone and carbon dioxide (CO_2).

In 2006, Governor Schwarzenegger called for a reduction in anthropogenic contributions to greenhouse gases, with a focus on CO_2. Because of the sizable power requirements to convey State Project water to Southern California, the potable community began to assess its own "carbon footprint", and ask just how much CO_2 is produced for every acre foot of water conveyed. What are the comparisons with locally produced potable water? This memorandum summarizes the author's approach to answer those questions.

Power Requirements

Pumping plant design information for the State Water Project (SWP) system is well documented [1]. Pumping plants utilized in moving water to Ventura County, and the power requirements needed in calendar year 2004 are listed below in Table 1. [2]

Table 1: CY 2004 SWP MWH AND AF BY PUMPING PLANT

PLANT	MWh	AF	kWh/AF	Normal Static Head (feet)
Banks	892,609	3,104,770	287	236 – 252
Dos Amigos	397,117	2,861,029	139	107 - 125
Buena Vista	516,766	2,147,650	241	205
Wheeler Ridge	563,529	2,158,235	261	233
Wind Gap	1,249,417	2,056,919	607	518
Edmonston	4,580,994	2,032,080	2254	1926
Oso	231,378	877,066	264	231

Additionally, imported water is treated at Metropolitan's Joseph Jensen Filtration Plant. Ozonation is used as a primary disinfectant, and is power intensive.

Sources of Power

The State's major sources of electricity are shown below in Table 2. Electricity utilized to convey water to Southern California is seen to emanate from three different sub-regions, namely CAL, PNW and DSW. Almost 80% of California's electricity is generated within the state (CAL) [3]. That number includes two coal plants which are considered in-state, since they are in California specific control areas. The other 20% is imported from energy grids cited as the Pacific Northwest (PNW) and the Desert Southwest (DSW).

Table 2. California's Major Sources of Electricity (2005)

In-State	**78.33%**
Natural Gas	37.71%
Nuclear	14.47%
Large Hydro	17.03%
Coal*	20.07%
Renewable	10.73%
Imports	**21.67%**
PNW	7.04%
DSW	14.63%

**Intermountain and Mohave coal plants are considered in-state, since they are in California control areas.*

Typically, each sub-region has the ability to generate electricity utilizing different sources. This discussion will focus on those sources which produce significant carbon dioxide emissions, namely, natural gas and coal.

Approach

Estimates of CO_2 emissions per acre foot of water conveyed were made two different ways. The most straightforward approach was to utilize published emission rate data [4]. The California Climate Action Registry (the Registry) has published data in pounds emitted per megawatt hour generated (lbs/MWh) for each sub region (e Grid). Data available for year 2000 are shown below in Table 3. The data represent an annual average, and account for electrical transmission and distribution losses.

Table 3
eGRID Subregion Annual Average CO_2 Output-Based Emission Rates
(Year 2000 – Total Energy)

eGRID Subregion Name	eGRID Subregion Acronym	Percent of Total	CO_2 Output Emission Rate (lbs/MWh)
WECC California	CAL	0.7833	804.54
WECC Pacific Northwest	PNW	0.0704	671.04
WECC Southwest	DSW	0.1463	1,423.95

All of Calleguas' supply is treated at Jensen. Power data for Jensen is shown below in Table 4. [5] The data show an increase in power requirements when ozone disinfection came on-line in June, 2005.

Table 4
2005 Power Requirements at Jensen

Month	kWH	Bill	AF
January	700,000	$57,888.92	42,131
February	428,000	$45,280.43	25,037
March	428,000	$45,280.43	24,567
April	428,000	$45,280.43	32,841
May	428,000	$45,280.43	14,601
June	1,165,000	$100,393.17	36,168
July	1,330,000	$113,355.17	41,685
August	1,636,000	$132,770.12	43,196
September	1,596,000	$128,510.56	37,193
October	1,660,000	$133,792.33	41,361
November	1,362,000	$110,339.87	38,201
December	1,434,000	$114,398.19	38,933

Since the numbers in Table 1 are from actual data, the inherent pump and motor inefficiencies will have already been accounted for. Summing the energy requirements, we arrive at 4.053 MWh/AF for the State Water Project. Including energy requirements at the Jensen Filtration Plant with ozone disinfection of 0.037 MWh/AF, a total of 4.090 MWh of energy are required for every acre foot of water delivered to Ventura County.

The calculated weighted average of carbon dioxide emissions shown in Table 3 is 0.443 tons of CO_2 emitted per megawatt hour. Thus, we see that 1.81 tons of CO_2 are produced for every acre foot of water delivered to the Calleguas service area. In a typical year of 120,000 acre feet or more of imported water demand, approximately 217,000 tons of carbon dioxide will have been produced.

Alternative Calculation

Let's start the calculation over, but this time we will start with the ideal power equation, or

$$P = \gamma Q h$$

where: $\gamma =$ the specific weight of water *[W/L^3]*
$Q =$ the volumetric flow rate *[L^3/time]*
$h =$ total static head lift *[L]*

Summing the last column of Table 1, we see that $h =$ 3,473 feet. From the above equation, we get an ideal power requirement of 3,555 KWh/AF. We can compute actual power requirements by dividing by the pump and motor efficiency η_p and electrical transmission and distribution efficiency η_D, which is equal to $1-\eta_{losses}$. In the United States, losses have been referenced on the order of 7%. [6]

$$P_{actual} = \frac{P_{ideal}}{\eta_p \eta_D}$$

Relying on data provided in Table 1, compared to the ideal power requirement, we compute the pump and motor efficiency to be 0.88. That is,

$$\eta_P = \frac{3555}{4053} = 0.88$$

This is a reasonable number. Assuming T&D losses of 7%, and still including power requirements for Jensen, we get an actual energy requirement of 4.344 MWh/AF.

Now we must focus our attention on the electrical grids, and utilize other independent sources of data with respect to CO_2 emissions per Mwh. The California Energy Commission reports [7] that the In-State CO_2 emission rate is 0.4 tons/MWh, while the Out-of-State emission rate is 0.55 tons/MWh. Taking a weighted average based on the proportion of electricity which comes from within or out of the State, (Table 3), yields 0.43 tons/MWh. Multiplying this result by our calculated energy requirement of 4.344 MWh/AF, yields a result of 1.87 tons of carbon dioxide produced for every acre foot of water delivered. This compares favorably with our first calculation (within 5%).

Carbon Footprint for Local Groundwater Pumping and Desalting Facilities

Power requirements for a low pressure membrane, reverse osmosis groundwater pumping and treatment facility are on the order of 1.64 MWh/AF, including pump, motor and transmission losses [8]. CO_2 production was calculated to be 0.70 tons/AF of water produced. Feedwater TDS was assumed to be 2000 mg/liter. Groundwater pumping lift was assumed to be 200 feet, with $\eta_P = 0.88$, and $\eta_D = 0.93$. A comparison is shown below in Table 5.

Table 5. Ventura County Potable Water Carbon Footprint

	MWh/AF	CO_2 (tons/AF)
Imported	4.09	1.84
GW Pumping and Desal	1.64	0.70

Conclusions

Importing water to Ventura County is clearly an energy intensive operation, which is almost three times higher than local supply development. It is interesting to see how the carbon footprint for water compares with that of a standard automobile. A typical car emits 22 pounds of CO_2 per gallon of gas consumed. On average, Americans travel 240 miles per week in their car, getting 22.40 miles per gallon [9], [10], [11]. This translates to 5.4 tons of CO_2 generated per year on average for every car. This number does not include additional generation due to the transportation of crude oil to a refinery, or the processing of gasoline itself. Assuming that an average family of four uses about 1 acre foot per year we can make a brief comparison on a per capita basis shown in Table 6.

Table 6. Carbon Footprint on per Capita Basis

Source	CO_2 (tons/yr/capita)
Imported Water	0.460
Local Desalinated Groundwater	0.175
Automobile	2.7 – 5.4
1997 Kyoto (Carbon Allowance)	5.4

References:

1. Department of Water Resources, Division of Operations and Maintenance, “Data Handbook, State Water Project”, 1992.

2. Data provided by Metropolitan Water District of Southern California.

3. California Energy Commission, Website, www.energy.ca.gov, 2005.

4. California Climate Action Registry, Appendix to the General Reporting Protocol, Power/Utility Reporting Protocol, April 2005.

5. Data provided by Metropolitan Water District.

6. U.S. Climate Change Technology Program, Technology Options for the Near and Long Term, page 34, November, 2003.

7. California Energy Commission, “A Preliminary Environmental Profile of California’s Imported Electricity”, CEC-700-2005-017, June 2005.

8. American Water Works Association, Manual of Water Supply Practices, “Reverse Osmosis and Nanofiltration”, Denver, Colorado, 1999.

9. Earth Institute, www.vtearthinstitute.org

10. Yes Magazine, Winter 1999-2000, American Forests, www.americanforests.org

11. Acterra, 3 Phases Energy, Sierra Club, www.cool-it.us

Don Kendall

CALLEGUAS

MUNICIPAL WATER DISTRICT

Annual Water Quality Report

July 2011

Este informe contiene información muy importante sobre su agua potable. Tradúzcalo o hable con alguien que lo entienda bien.

Water Quality as Our Priority

Water quality continues to be a priority for the Calleguas Municipal Water District. Our mission since the 1950s has been to provide our service area with a reliable supply of high quality, imported drinking water. A team of highly trained professionals works hard to ensure that Calleguas' water supply meets all state and federal water quality standards. This brochure provides information about the sources and quality of the water delivered by Calleguas in 2010. Included are details about where your water comes from, what it contains, and how it compares to state and federal standards.

During the year, multiple tests for over 150 drinking water contaminants were performed on Calleguas' water supply to determine concentrations of mineral, physical, bacteriological, inorganic, organic, and radioactive constituents. Once again, we are proud to report that our system did not violate any water quality standards. For additional information on the quality of water delivered by Calleguas, please contact Tony Goff at (805) 579-7138 or visit our website at www.calleguas.com.

Drinking water, including bottled water, may reasonably be expected to contain at least small amounts of some contaminants. The presence of contaminants does not necessarily indicate that water poses a health risk. More information about contaminants and potential health effects can be obtained by calling the USEPA's Safe Drinking Water Hotline (1-800-426-4791).

Our Mission

. . . is to provide our service area with a reliable and adequate supply of quality supplemental water through the acquisition and distribution of both regional and locally-developed water in an environmentally and economically responsible manner.

Our Source Water

Originating in northern California, Calleguas' drinking water supply is conveyed over five hundred miles through the State Water Project's network of reservoirs, aqueducts, and pump stations. Metropolitan Water District of Southern California completed a source water assessment of its State Water Project supply. This source is considered to be most vulnerable to urban and storm water runoff, wildlife, agriculture, recreation, and wastewater. A copy of the assessment can be obtained by contacting Metropolitan by phone at (213) 217-6850. The State Water Project supply is filtered and disinfected at Metropolitan's Joseph Jensen Filtration Plant in Granada Hills. Following treatment, water is conveyed by pipeline through the San Fernando Valley to Calleguas' mile-long tunnel in the Santa Susana Mountains. The water is then distributed by Calleguas and its purveyors to over one-half million Ventura County residents, representing 80% of the County's population. Surplus supplies of imported water are stored in Lake Bard, the District's surface water reservoir near the city of Thousand Oaks, and the Las Posas groundwater basin underlying the city of Moorpark and surrounding area.

Through the Las Posas Aquifer Storage and Recovery (ASR) project, Calleguas stores water for later use during summer peak demand periods, droughts and emergencies. To date, 18 ASR wells are operational. Additional wells are under consideration to further increase the program's injection and extraction capacity. Visit www.calleguas.com for more information on the Las Posas ASR project and other Calleguas water supply reliability programs.

General Information About Source Water

The sources of drinking water (both tap water and bottled water) include rivers, lakes, streams, ponds, reservoirs, springs, and wells. As water travels over the surface of the land or through the ground, it dissolves naturally-occurring minerals and, in some cases, radioactive material, and can pick up substances resulting from the presence of animals or from human activity.

Contaminants that may be present in source water before we treat it include:

- *Microbial contaminants*, such as viruses and bacteria, that may come from sewage treatment plants, septic systems, agricultural livestock operations, and wildlife.
- *Inorganic contaminants*, such as salts and metals, that can be naturally-occurring or result from urban stormwater runoff, industrial or domestic wastewater discharges, oil and gas production, mining, or farming.
- *Pesticides and herbicides*, that may come from a variety of sources such as agriculture, urban stormwater runoff, and residential uses.
- *Organic chemical contaminants*, including synthetic and volatile organic chemicals, that are by-products of industrial processes and petroleum production, and can also come from gas stations, urban stormwater runoff, agricultural application, and septic systems.
- *Radioactive contaminants* that can be naturally-occurring or be the result of oil and gas production and mining activities.

Our Treated Water

In order to ensure that tap water is safe to drink, the U.S. Environmental Protection Agency (USEPA) and the State Department of Public Health (Department) prescribe regulations that limit the amount of certain contaminants in water provided by public water systems. Department regulations also establish limits for contaminants in bottled water that must provide the same protection for public health.

Calleguas achieves these standards through vigilant watershed protection and treatment techniques used at Metropolitan's Jensen Plant as well as Calleguas' Lake Bard Water Filtration Plant. A good indicator of the effectiveness of our filtration system is the measurement of turbidity. Turbidity, or the cloudiness of water, is listed in the tables included in this report.

Water Quality Data

The tables below list all the drinking water contaminants that we detected during the 2010 calendar year. The presence of these contaminants in the water does not necessarily indicate that the water poses a health risk. Unless otherwise noted, the data presented in these tables is from testing done January 1 through December 31, 2010. The State requires that we monitor for certain contaminants less than once per year because the concentrations of these contaminants are not expected to vary significantly from year to year. Some of the data, though representative of water quality, is more than one year old.

CALLEGUAS MUNICIPAL WATER DISTRICT

Summary of Water Quality Results For 2010

			Imported Surface Water Treated by Metropolitan		Locally Stored Surface Water Treated by Calleguas		Las Posas Aquifer Storage and Recovery Program		
			Percent of Supply		*89%*		*1%*		*10%*		
Parameter	MCL [MRDL]	PHG (MCLG) [MRDLG]	Average	Range	Average	Range	Average	Range	**Major Sources in Drinking Water**
PRIMARY DRINKING WATER STANDARDS - Mandatory Health-Related Standards									
CLARITY (a)									
Turbidity (NTU) (TT)	Highest Single Value		0.05		0.06		(a)		Soil runoff
	% of samples <0.3		100%		100%		(a)		
MICROBIOLOGICAL									
Total Coliform Bacteria	2	(0)	System-Wide Average = ND, Range = ND - 1						Naturally present in the environment
DISINFECTION BY-PRODUCTS AND DISINFECTANT RESIDUALS									
Bromate (ppb) (b)	10	0.1	7	ND - 11	6	ND - 12	(b)	(b)	By-product of drinking water disinfection
Haloacetic Acids (ppb) (c)	60	n/a	Highest Running Annual Average = 5, Range = ND - 10						By-product of drinking water disinfection
Total Chlorine Residual (ppm)	[4]	[4]	Highest Running Annual Average = 1.9, Range = 1.7 - 2.0						Drinking water disinfectant added for treatment
Total Trihalomethanes (ppb) (c)	80	n/a	Highest Running Annual Average = 23, Range = 15 - 45						By-product of drinking water chlorination
INORGANIC CHEMICALS									
Aluminum (ppb)	1,000	600	81	56 - 100	ND	ND	ND	ND	Erosion of natural deposits, residual from water treatment process
Arsenic (ppb)	10	0.004	3	3	3	3	3	3	Erosion of natural deposits, runoff from orchards
Fluoride - Distribution System (ppm) (d)	2.0	1	Highest Running Annual Average = 0.8, Range = 0.7 - 0.8						Water additive that promotes strong teeth
Nickel (ppb)	100	12	ND	ND	ND	ND	ND	ND - 13	Erosion of natural deposits
Nitrate (as N) (ppm)	10	10	0.6	0.5 - 0.7	ND	ND	ND	ND - 0.5	Runoff and leaching from fertilizer use, erosion of natural deposits
RADIOLOGICALS (e)									
Gross Alpha Particle Activity (pCi/L)	15	(0)	3.4	ND - 7.3	ND	ND	ND	ND - 6.7	Erosion of natural deposits
Gross Beta Particle Activity (pCi/L)	50	(0)	ND	ND - 5.2	ND	ND	ND	ND	Decay of natural and manmade deposits
Uranium (pCi/L)	20	0.43	1.8	1.6 - 2.0	1.8	1.4 - 2.4	4.2	ND - 16.2	Erosion of natural deposits

ABBREVIATIONS, DEFINITIONS, and NOTES

n/a = not applicable
ND = None Detected
NTU = Nephelometric Turbidity Units
ppm = parts per million, or milligrams per liter (mg/L)
ppb = parts per billion, or micrograms per liter (µg/L)
pCi/L = PicoCuries per Liter

Maximum Contaminant Level (MCL) = The highest level of a contaminant that is allowed in drinking water. Primary MCLs are set as close to the PHGs (or MCLGs) as is economically and technologically feasible.

Maximum Contaminant Level Goal (MCLG) = The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs are set by the U.S. Environmental Protection Agency.

Maximum Residual Disinfectant Level (MRDL) = The highest level of a disinfectant allowed in drinking water. There is convincing evidence that addition of a disinfectant is necessary for control of microbial pathogens.

Maximum Residual Disinfectant Level Goal (MRDLG) = The level of a drinking water disinfectant below which there is no known or expected risk to health. MRDLGs do not reflect the benefits of the use of disinfectants to control microbial contaminants.

Public Health Goal (PHG) = The level of a contaminant in drinking water below which there is no known or expected risk to health. PHGs are set by the California Environmental Protection Agency.

Primary Drinking Water Standard = MCLs and MRDLs for contaminants that affect health along with their monitoring and reporting requirements, and water treatment requirements.

Treatment Technique (TT) = A required process intended to reduce the level of a contaminant in drinking water.

(a) The turbidity level of filtered water shall be less than or equal to 0.3 NTU in 95% of the measurements taken each month and shall not exceed 1.0 NTU. ASR water is not subject to these requirements.

(b) Compliance for treatment plants that use ozone is based on a running annual average of monthly samples. ASR water is not subject to these requirements.

(c) Compliance is based on a running annual average of quarterly distribution system samples. Values reported reflect the highest and lowest single value in the distribution system (range) and the highest running annual average.

(d) The Metropolitan Water District treats their water by adding fluoride to the naturally occurring level in order to help prevent dental caries in consumers. Fluoride level in the treated water is maintained within a range of 0.7 - 1.3 ppm, as required by CDPH regulations.

(e) Metropolitan results were taken from 2008 monitoring. Calleguas Las Posas ASR results were taken from 2008, 2009 and 2010 monitoring.

Summary of Water Quality Results For 2010

CALLEGUAS MUNICIPAL WATER DISTRICT

Parameter	Secondary MCL	Notification Level	Imported Surface Water Treated by Metropolitan		Locally Stored Surface Water Treated by Calleguas		Las Posas Aquifer Storage and Recovery Program		Major Sources in Drinking Water
		Percent of Supply	*89%*		*1%*		*10%*		
			Average	Range	Average	Range	Average	Range	
SECONDARY DRINKING WATER STANDARDS – Aesthetic Standards									
Aluminum (ppb) (a)	200		81	56 - 100	ND	ND	ND	ND	Erosion of natural deposits, residual from water treatment process
Chloride (ppm)	500		74	67 - 80	86	86	56	47 - 70	Runoff and leaching from natural deposits, seawater influence
Color (Units)	15		1	1 - 2	ND	ND	8	ND - 15	Naturally-occurring organic materials
Iron (ppb)	300		ND	ND	ND	ND	ND	ND - 110	Leaching from natural deposits
Manganese (ppb)	50		ND	ND	ND	ND	31	ND - 61	Leaching from natural deposits
Odor Threshold (Units)	3		3	3	ND	ND	ND	ND	Naturally-occurring organic materials
Specific Conductance (µS/cm)	1,600		560	500 - 570	637	632 - 641	622	526 - 731	Substances that form ions when in water, seawater influence
Sulfate (ppm)	500		60	55 - 65	71	71	108	76 - 138	Runoff and leaching from natural deposits
Total Dissolved Solids (ppm)	1,000		310	290 - 320	345	330 - 360	386	330 - 500	Runoff and leaching from natural deposits
Turbidity (NTU) (b)	5		0.04	0.03 - 0.08	0.04	0.04 - 0.05	0.2	ND - 0.6	Soil runoff
ADDITIONAL PARAMETERS (Unregulated)									
Alkalinity (ppm)	NS	NS	87	81 - 99	105	100 - 110	114	100 - 150	
Boron (ppb)	NS	1,000	210	200 - 220	200	200	210	100 - 300	
Calcium (ppm)	NS	NS	28	26 - 31	30	30	49	37 - 58	
Chlorate (ppb)	NS	800	20	20	ND	ND	ND	ND	
Corrosivity (AI) (c)	NS	NS	12.0	12.0 - 12.1	11.7	11.7	11.8	11.6 - 11.9	
Hardness (Total Hardness) (ppm)	NS	NS	118	86 - 130	132	132	180	142 - 211	
Magnesium (ppm)	NS	NS	12	11 - 12	14	14	14	12 - 16	
N-Nitrosodimethylamine (ppt)	NS	10	System-Wide Average = 5, Range = ND - 9						
pH (pH Units)	NS	NS	8.2	8.1 - 8.4	8.1	7.8 - 8.5	7.6	7.4 - 7.8	
Potassium (ppm)	NS	NS	3	3	3	3	3	3 - 4	
Radon (pCi/L) (d)	NS	NS	ND	ND	ND	ND	569	244-1087	
Sodium (ppm)	NS	NS	63	58 - 65	67	67	56	49 - 65	
Total Organic Carbon (ppm)	NS	NS	1.5	1.3 - 1.8	1.9	1.4 - 2.3	1.2	1.2	
Vanadium (ppb)	NS	50	5	5 - 6	ND	ND	3	3 - 4	

ABBREVIATIONS, DEFINITIONS, and NOTES

ND = None Detected NS = No Standard
NTU = Nephelometric Turbidity Units
ppm = parts per million, or milligrams per liter (mg/L)
ppb = parts per billion, or micrograms per liter (µg/L)
ppt = parts per trillion, or nanograms per liter (ng/L)
pCi/L = PicoCuries per Liter
µS/cm = microSiemen per Centimeter

Maximum Contaminant Level (MCL) = Secondary MCLs are set to protect the odor, taste, and appearance of drinking water.
Notification Level = The level at which notification of the public water system's governing body is required.
(a) Aluminum has both primary and secondary standards.
(b) The monthly averages and ranges of turbidity shown in the Secondary Standards section are based on source effluents.
(c) AI measures the aggressiveness of water transported through pipes. Water with AI <10.0 is highly aggressive and would be very corrosive to almost all materials found in a typical water system. AI ≥12.0 indicates non-aggressive water. AI between 10.0 and 11.9 indicates moderately aggressive water.
(d) Radon results were taken from 2008, 2009 and 2010 monitoring.

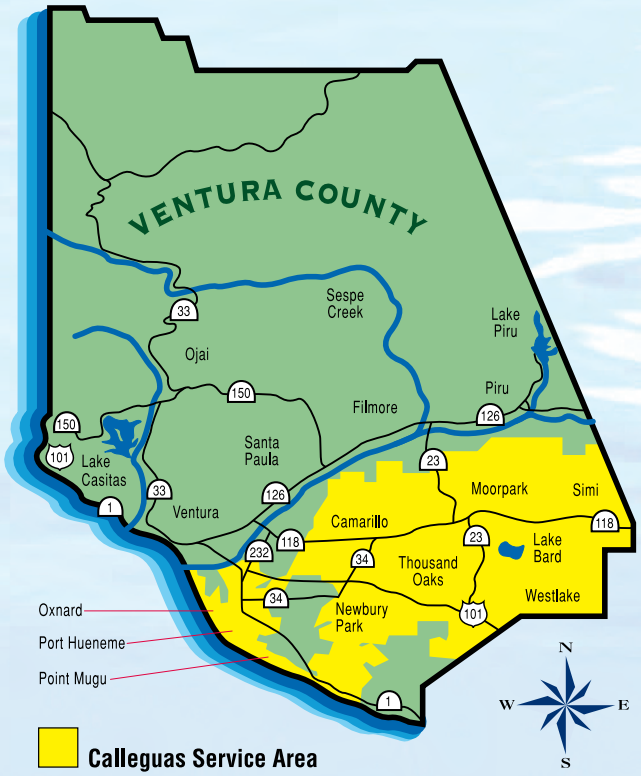
Information for Customers with Special Water Needs

Some people may be more vulnerable to contaminants in drinking water than the general population. Immuno-compromised persons such as persons with cancer undergoing chemotherapy, persons who have undergone organ transplants, people with HIV/AIDS or other immune system disorders, some elderly, and infants can be particularly at risk from infections. These people should seek advice about drinking water from their health care providers. USEPA/Centers for Disease Control guidelines on appropriate means to lessen the risk of infection by *Cryptosporidium* and other microbial contaminants are available from the Safe Drinking Water Hotline (1-800-426-4791).

Constituents Tested For and Not Detected

In addition to the information provided in the Summary of Water Quality Results, Calleguas also monitored for, but did not detect, the following contaminants during 2010:

Antimony	Cyanide	Perchlorate	Total Chromium
Asbestos	Foaming Agents	Pesticides	Tritium
Barium	Herbicides	Radium 226	Volatile Organic Chemicals (VOCs)
Beryllium	Lead	Radium 228	Zinc
Cadmium	Mercury	Silver	
Chromium 6	MTBE	Strontium-90	
Copper	Nitrite	Thallium	



Information on Lead in Household Plumbing

If present, elevated levels of lead can cause serious health problems, especially for pregnant women and young children. Lead in drinking water is primarily from materials and components associated with service lines and home plumbing. Your local utility is responsible for providing high quality drinking water, but cannot control the variety of materials used in plumbing components. When your water has been sitting for several hours, you can minimize the potential for lead exposure by flushing your tap for 30 seconds to 2 minutes before using water for drinking or cooking. If you are concerned about lead in your water, you may wish to have your water tested. Information on lead in drinking water, testing methods, and steps you can take to minimize exposure is available from the Safe Drinking Water Hotline or at http://www.epa.gov/safewater/lead.

Drinking Water Fluoridation

In 2007, Calleguas' wholesale water provider, the Metropolitan Water District of Southern California, joined a majority of the nation's public water suppliers in systematically adding fluoride to drinking water at each of five water treatment plants in order to help prevent tooth decay.

In line with recommendations from the California Department of Public Health, as well as the U.S. Centers for Disease Control and Prevention, Metropolitan adjusted the natural fluoride level in the water, which ranges from 0.1 to 0.4 parts per million, to the optimal range for dental health of 0.7 to 0.8 parts per million.

Fluoride levels in drinking water are limited under California state regulations at a maximum dosage of 2 parts per million.

Fluoride has been added to U.S. drinking water supplies since 1945. Of the 50 largest cities in the U.S, 43 fluoridate their drinking water.

For more information about the benefits of drinking water fluoridation, please visit the following web sites:

The American Dental Association
http://www.ada.org/fluoride.aspx

U.S. Centers for Disease Control and Prevention
http://www.cdc.gov/fluoridation/fact_sheets/cwf_qa.htm

Information on Radon

Water suppliers are required to provide information on the presence of radon in water sources. A known human carcinogen, radon is a radioactive gas that one cannot see, taste, or smell. Commonly found in soils throughout the United States, breathing air containing radon may lead to lung cancer. Drinking water containing radon may also cause increased risk of stomach cancer. Radon can seep up through the ground and into homes and other structures through cracks and holes in foundations. Over time, concentrations of the gas can increase to high levels potentially exposing inhabitants to greater health risks. It is possible that radon can also be released from tap water when used for showering, washing dishes, and other household activities. However, the concentration of radon released through tap water is in most cases assumed to be considerably lower than concentrations entering a home from underlying ground. If you are concerned about radon, you are advised to test the air in your home. Testing is inexpensive and easy. The EPA recommends taking measures to reduce radon levels in your home if concentrations are 4 PicoCuries per liter of air (pCi/L) or higher. For additional information, call your State radon program (1-800-745-7236), the EPA Safe Drinking Water Hotline at (1-800-426-4791), or call the National Safe Council Radon Hotline (1-800-SOS-RADON).

More Information on Water Quality

Calleguas Municipal Water District
2100 Olsen Road • Thousand Oaks, CA 91360-6800
(805) 526-9323
http://www.calleguas.com

Metropolitan Water District of Southern California
Public Affairs • P.O. Box 54153 • Los Angeles, CA 90054-0153
(800) CALL MWD
www.mwdh2o.com/

State of California Department of Public Health
Office of Drinking Water • 601 North 7th Street • Sacramento, CA 94234-7320
http://www.cdph.ca.gov/programs/Pages/DDWEM.aspx

U.S. Environmental Protection Agency (WH-550)
Office of Ground Water & Drinking Water
401 M. Street, S.W. • Washington, D.C. 20460
Safe Drinking Water Hotline (800) 426-4791
http://water.epa.gov/drink/index.cfm

The Calleguas Municipal Water District Board of Directors meets on the first and third Wednesday of each month at 5:00 pm at the District's administration building, 2100 Olsen Road in Thousand Oaks. The public is welcome to attend these meetings.

CALLEGUAS
MUNICIPAL WATER DISTRICT

Ted Grandsen - President
William R. Seaver - Vice President
Donald G. Hauser - Secretary
Gail L. Pringle - Treasurer
Scott H. Quady - Director
Susan B. Mulligan - General Manager

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• *Pesticides* and herbicides, that may come from a variety of sources such as agriculture, urban stormwater runoff, and residential uses.

• *Organic* chemical contaminants, including synthetic and volatile organic chemicals, that are by-products of industrial processes and petroleum production, and can also come from gas stations, urban stormwater runoff, agricultural application, and septic systems.

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CALLEGUAS MUNICIPAL WATER DISTRICT

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		Percent of Supply	*95%*		*4%*		*1%*		
			Average	Range	Average	Range	Average	Range	
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CLARITY (a)									
Turbidity (NTU) (TT)	Highest Single Value		0.05		0.08		(a)		Soil runoff
	% of samples <0.3		100%		100%		(a)		
DISINFECTION BY-PRODUCTS AND DISINFECTANT RESIDUALS									
Bromate (ppb) (b)	10	0.1	5.9	ND - 8.8	ND	ND - 7.1	(b)	(b)	By-product of drinking water disinfection
Haloacetic Acids (ppb) (c)	60	n/a	System Wide Range: 4 - 9, Highest RAA: 6						By-product of drinking water disinfection
Total Chlorine Residual (ppm)	[4]	[4]	System Wide Range: 1.8 - 2.0, Highest RAA: 1.9						Drinking water disinfectant added for treatment
Total Trihalomethanes (ppb) (c)	80	n/a	System Wide Range: 15 - 44, Highest RAA: 24						By-product of drinking water chlorination
INORGANIC CHEMICALS									
Aluminum (ppb)	1,000	600	82	61 - 99	ND	ND	60	60	Erosion of natural deposits, residual from water treatment process
Arsenic (ppb)	10	0.004	2.3	2.3	ND	ND	3.0	3.0	Erosion of natural deposits, runoff from orchards
Fluoride - Distribution System (ppm) (d)	2.0	1	System Wide Range: 0.7 - 0.9, Highest RAA: 0.8						Water additive that promotes strong teeth
Nitrate (as NO_3) (ppm)	45	45	1.8	1.8 - 2.2	ND	ND	ND	ND - 2.2	Runoff and leaching from fertilizer use, erosion of natural deposits
Selenium (ppb)	50	30	ND	ND	ND	ND	5	5	Runoff and leaching from fertilizer use, erosion of natural deposits
RADIOLOGICALS (e)									
Gross Alpha Particle Activity (pCi/L)	15	(0)	ND	ND	ND	ND	5	ND - 7	Erosion of natural deposits
Gross Beta Particle Activity (pCi/L)	50	(0)	ND	ND - 4	ND	ND	ND	ND	Decay of natural and manmade deposits
Uranium (pCi/L)	20	0.43	1	ND - 2	2	1 - 2	8	ND - 16	Erosion of natural deposits

ABBREVIATIONS, DEFINITIONS, and NOTES

n/a = not applicable
ND = None Detected
NTU = Nephelometric Turbidity Units
ppm = parts per million, or milligrams per liter (mg/L)
ppb = parts per billion, or micrograms per liter (µg/L)
pCi/L = PicoCuries per Liter

Maximum Contaminant Level (MCL) = The highest level of a contaminant that is allowed in drinking water. Primary MCLs are set as close to the PHGs (or MCLGs) as is economically and technologically feasible.

Maximum Contaminant Level Goal (MCLG) = The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs are set by the U.S. Environmental Protection Agency.

Maximum Residual Disinfectant Level (MRDL) = The highest level of a disinfectant allowed in drinking water. There is convincing evidence that addition of a disinfectant is necessary for control of microbial pathogens.

Maximum Residual Disinfectant Level Goal (MRDLG) = The level of a drinking water disinfectant below which there is no known or expected risk to health. MRDLGs do not reflect the benefits of the use of disinfectants to control microbial contaminants.

Public Health Goal (PHG) = The level of a contaminant in drinking water below which there is no known or expected risk to health. PHGs are set by the California Environmental Protection Agency.

Primary Drinking Water Standard = MCLs and MRDLs for contaminants that affect health along with their monitoring and reporting requirements, and water treatment requirements.

Treatment Technique (TT) = A required process intended to reduce the level of a contaminant in drinking water.

Running Annual Average (RAA) = The average of all the samples taken for the year.

(a) The turbidity level of filtered water shall be less than or equal to 0.3 NTU in 95% of the measurements taken each month and shall not exceed 1.0 NTU. ASR water is not subject to these requirements.

(b) Compliance for treatment plants that use ozone is based on a running annual average of monthly samples. ASR water is not subject to these requirements.

(c) Compliance is based on a running annual average of quarterly distribution system samples. Values reported reflect the highest and lowest single value in the distribution system (range) and the highest running annual average.

(d) The Metropolitan Water District treats their water by adding fluoride to the naturally occurring level in order to help prevent dental caries in consumers. Fluoride level in the treated water is maintained within a range of 0.7 - 1.3 ppm, as required by CDPH regulations.

(e) Metropolitan results were taken from 2011 monitoring. Calleguas Las Posas ASR results were taken from 2009, 2010 and 2011 monitoring.

Summary of Water Quality Results For 2011

CALLEGUAS MUNICIPAL WATER DISTRICT

Parameter	Secondary MCL	Notification Level	Imported Surface Water Treated by Metropolitan		Locally Stored Surface Water Treated by Calleguas		Las Posas Aquifer Storage and Recovery Program		Major Sources in Drinking Water
		Percent of Supply	*95%*		*4%*		*1%*		
			Average	Range	Average	Range	Average	Range	
SECONDARY DRINKING WATER STANDARDS – Aesthetic Standards									
Aluminum (ppb) (a)	200		82	61 - 99	ND	ND	60	60	Erosion of natural deposits, residual from water treatment process
Chloride (ppm)	500		64	59 - 69	89	87 - 90	68	59 - 75	Runoff and leaching from natural deposits, seawater influence
Color (Units)	15		1	1	6	ND - 15	8	ND - 14	Naturally-occurring organic materials
Manganese (ppb)	50		ND	ND	ND	ND	ND	ND - 70	Leaching from natural deposits
Odor Threshold (Units)	3		2	2	ND	ND	ND	ND	Naturally-occurring organic materials
Specific Conductance (µS/cm)	1,600		500	420 - 530	638	633 - 644	602	515 - 754	Substances that form ions when in water, seawater influence
Sulfate (ppm)	500		56	54 - 58	70	70	90	56 - 147	Runoff and leaching from natural deposits
Total Dissolved Solids (ppm)	1,000		280	280 - 290	360	350 - 380	352	280 - 460	Runoff and leaching from natural deposits
Turbidity (NTU) (b)	5		0.03	0.03 - 0.09	0.04	0.04	0.3	ND - 0.6	Soil runoff
ADDITIONAL PARAMETERS (Unregulated)									
Alkalinity (ppm)	NS	NS	85	76 - 93	93	90 - 100	92	80 - 110	
Boron (ppb)	NS	1,000	190	190	200	200	200	200	
Calcium (ppm)	NS	NS	27	26 - 28	29	29	40	27 - 62	
Chlorate (ppb)	NS	800	26	26	ND	ND	ND	ND	
Corrosivity (AI) (c)	NS	NS	12.0	12.0	12.1	12.1	11.9	11.5 - 12.1	
Hardness (Total Hardness) (ppm)	NS	NS	110	110 - 120	130	130	159	117 - 229	
Magnesium (ppm)	NS	NS	12	12	14	14	14	12 - 18	
N-Nitrosodimethylamine (ppt)	NS	10	System-Wide Average = 5, Range = ND - 9						
pH (pH Units)	NS	NS	8.2	8.1 - 8.4	8.1	7.9 - 8.3	8.0	7.4 - 8.4	
Potassium (ppm)	NS	NS	3	3	3	3	3	3 - 4	
Radon (pCi/L) (d)	NS	NS	ND	ND	ND	ND	761	244 - 1087	
Sodium (ppm)	NS	NS	54	52 - 57	71	71	57	53 - 64	
Total Organic Carbon (ppm)	NS	NS	1.9	1.6 - 2.1	2.4	1.9 - 2.6	0.6	0.6	
Vanadium (ppb)	NS	50	3	3	ND	ND	3	3	

ABBREVIATIONS, DEFINITIONS, and NOTES

ND = None Detected NS = No Standard
NTU = Nephelometric Turbidity Units
ppm = parts per million, or milligrams per liter (mg/L)
ppb = parts per billion, or micrograms per liter (µg/L)
ppt = parts per trillion, or nanograms per liter (ng/L)
pCi/L = PicoCuries per Liter
µS/cm = microSiemen per Centimeter

Maximum Contaminant Level (MCL) = Secondary MCLs are set to protect the odor, taste, and appearance of drinking water.
Notification Level = The level at which notification of the public water system's governing body is required.
(a) Aluminum has both primary and secondary standards.
(b) The monthly averages and ranges of turbidity shown in the Secondary Standards section are based on source effluents.
(c) AI measures the aggressiveness of water transported through pipes. Water with AI <10.0 is highly aggressive and would be very corrosive to almost all materials found in a typical water system. AI ≥12.0 indicates non-aggressive water. AI between 10.0 and 11.9 indicates moderately aggressive water.
(d) Radon results were taken from 2009, 2010 and 2011 monitoring.

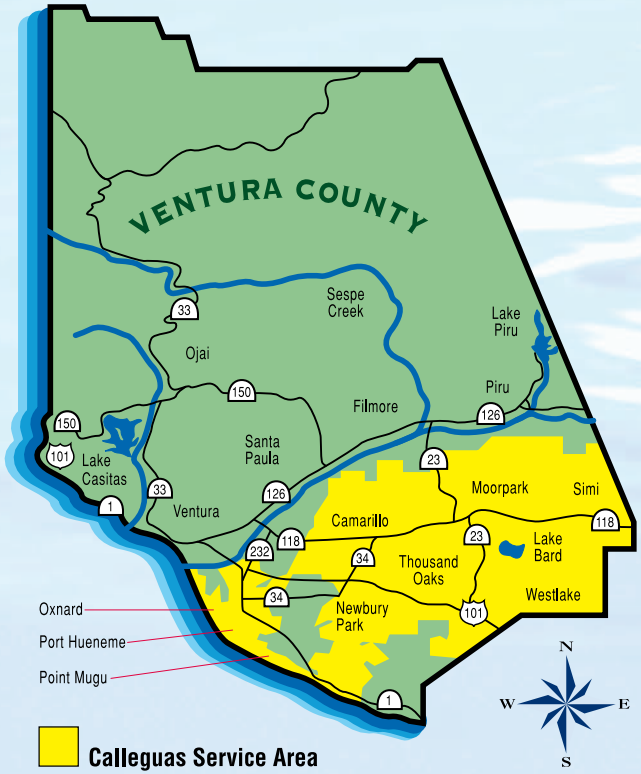
Information for Customers with Special Water Needs

Some people may be more vulnerable to contaminants in drinking water than the general population. Immuno-compromised persons such as persons with cancer undergoing chemotherapy, persons who have undergone organ transplants, people with HIV/AIDS or other immune system disorders, some elderly, and infants can be particularly at risk from infections. These people should seek advice about drinking water from their health care providers. USEPA/Centers for Disease Control guidelines on appropriate means to lessen the risk of infection by *Cryptosporidium* and other microbial contaminants are available from the Safe Drinking Water Hotline (1-800-426-4791).

Constituents Tested For and Not Detected

In addition to the information provided in the Summary of Water Quality Results, Calleguas also monitored for, but did not detect, the following contaminants during 2011:

Antimony	Cyanide	Perchlorate	Total Chromium
Asbestos	Foaming Agents	Pesticides	Tritium
Barium	Herbicides	Radium 226	Volatile Organic Chemicals (VOCs)
Beryllium	Lead	Radium 228	Zinc
Cadmium	Mercury	Silver	
Chromium 6	MTBE	Strontium-90	
Copper	Nitrite	Thallium	



Information on Lead in Household Plumbing

If present, elevated levels of lead can cause serious health problems, especially for pregnant women and young children. Lead in drinking water is primarily from materials and components associated with service lines and home plumbing. Your local utility is responsible for providing high quality drinking water, but cannot control the variety of materials used in plumbing components. When your water has been sitting for several hours, you can minimize the potential for lead exposure by flushing your tap for 30 seconds to 2 minutes before using water for drinking or cooking. If you are concerned about lead in your water, you may wish to have your water tested. Information on lead in drinking water, testing methods, and steps you can take to minimize exposure is available from the Safe Drinking Water Hotline or at http://www.epa.gov/safewater/lead.

Drinking Water Fluoridation

In 2007, Calleguas' wholesale water provider, the Metropolitan Water District of Southern California, joined a majority of the nation's public water suppliers in systematically adding fluoride to drinking water at each of five water treatment plants in order to help prevent tooth decay.

In line with recommendations from the California Department of Public Health, as well as the U.S. Centers for Disease Control and Prevention, Metropolitan adjusted the natural fluoride level in the water, which ranges from 0.1 to 0.4 parts per million, to the optimal range for dental health of 0.7 to 0.8 parts per million.

Fluoride levels in drinking water are limited under California state regulations at a maximum dosage of 2 parts per million.

Fluoride has been added to U.S. drinking water supplies since 1945. Of the 50 largest cities in the U.S, 43 fluoridate their drinking water.

For more information about the benefits of drinking water fluoridation, please visit the following web sites:

The American Dental Association
http://www.ada.org/fluoride.aspx

U.S. Centers for Disease Control and Prevention
http://www.cdc.gov/fluoridation/fact_sheets/cwf_qa.htm

Information on Radon

Water suppliers are required to provide information on the presence of radon in water sources. A known human carcinogen, radon is a radioactive gas that one cannot see, taste, or smell. Commonly found in soils throughout the United States, breathing air containing radon may lead to lung cancer. Drinking water containing radon may also cause increased risk of stomach cancer. Radon can seep up through the ground and into homes and other structures through cracks and holes in foundations. Over time, concentrations of the gas can increase to high levels potentially exposing inhabitants to greater health risks. It is possible that radon can also be released from tap water when used for showering, washing dishes, and other household activities. However, the concentration of radon released through tap water is in most cases assumed to be considerably lower than concentrations entering a home from underlying ground. If you are concerned about radon, you are advised to test the air in your home. Testing is inexpensive and easy. The EPA recommends taking measures to reduce radon levels in your home if concentrations are 4 PicoCuries per liter of air (pCi/L) or higher. For additional information, call your State radon program (1-800-745-7236), the EPA Safe Drinking Water Act Hotline at (1-800-426-4791), or call the National Safe Council Radon Hotline (1-800-SOS-RADON).

More Information on Water Quality

Calleguas Municipal Water District
2100 Olsen Road • Thousand Oaks, CA 91360-6800
(805) 526-9323
http://www.calleguas.com

Metropolitan Water District of Southern California
Public Affairs • P.O. Box 54153 • Los Angeles, CA 90054-0153
(800) CALL MWD
www.mwdh2o.com/

State of California Department of Public Health
Office of Drinking Water • 601 North 7th Street • Sacramento, CA 94234-7320
http://www.cdph.ca.gov/programs/Pages/DDWEM.aspx

U.S. Environmental Protection Agency (WH-550)
Office of Ground Water & Drinking Water
401 M. Street, S.W. • Washington, D.C. 20460
Safe Drinking Water Hotline (800) 426-4791
http://water.epa.gov/drink/index.cfm

The Calleguas Municipal Water District Board of Directors meets on the first and third Wednesday of each month at 5:00 pm at the District's administration building, 2100 Olsen Road in Thousand Oaks. The public is welcome to attend these meetings.

CALLEGUAS
MUNICIPAL WATER DISTRICT

Ted Grandsen - President
William R. Seaver - Vice President
Donald G. Hauser - Secretary
Gail L. Pringle - Treasurer
Scott H. Quady - Director
Susan B. Mulligan - General Manager

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ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

CAMARILLO
GROUNDWATER TREATMENT FACILITY
DRAFT INITIAL STUDY

SCH No. _____

Lead Agency:

City of Camarillo
601 Carmen Drive
Camarillo, California 93010
Contact: Ms. Lucia McGovern
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April 2008

Project No. 0702-2781

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1.0 INTRODUCTION

1.1 PURPOSE AND LEGAL AUTHORITY

An Initial Study has been prepared for the Camarillo Groundwater Treatment Facility Project, which has been proposed by the City of Camarillo (City), the project proponent. Section 2.0 of this document provides a description of the proposed project. The City is also the "lead agency" for the proposed project. As defined by Section 15367 of the California Environmental Quality Act (CEQA) Guidelines, the lead agency is "the public agency which has the principal responsibility for carrying out or approving a project which may have a significant impact on the environment."

Seven of the eight alternative sites under consideration are located outside the City boundary and the City's ~~and City Water District's~~ Sphere of Influence, but within the City's Area of Interest ~~and City Water District Special Study Area~~. ~~Selection of one of these seven sites would require annexation by the City and adjustment of the City's Sphere of Influence boundary. A lot line adjustment may also be required. The annexation would be subject to approval by the Ventura County Local Agency Formation Commission (LAFCO). The lot line adjustment would be subject to the approval of Ventura County. Both LAFCO and Ventura County are considered responsible agencies.~~

Should the City select a site outside the City's municipal boundaries, the City would request approval from the Ventura County Local Agency Formation Commission (LAFCO) for a reorganization. The reorganization proposal would include:

- An amendment to the City's Sphere of Influence boundary to include the project site;
- Annexation of the site to the City;
- An amendment to the Camarillo Sanitary District's Sphere of Influence boundary to include the project site;
- Annexation of the site to the Camarillo Sanitary District; and
- Detachment of the project site from the Ventura County Resource Conservation District.

Should the City select a site outside the City's municipal boundaries, the City would also pre-zone the site to R-E (Rural Exclusive) and amend the General Plan. A lot line adjustment for the affected parcel would be requested from the Ventura County Resource Management Agency. LAFCO, the Camarillo Sanitary District and Ventura County would be responsible agencies, if the selected project site is located outside the City's municipal boundaries.

Based on the findings of the Impact Analysis (Section 4.0 of this Initial Study), it has been determined that the project may be controversial due to agricultural conversion and annexation issues, and may have a significant impact on the environment. As such, an Environmental Impact Report will be prepared for the project in accordance with CEQA.

1.2 PROJECT PROPONENT AND LEAD AGENCY

City of Camarillo
601 Carmen Drive
Camarillo, California 93010

Contact: Lucia M. McGovern
(805) 388-5334

1.3 PROJECT LOCATION AND SITE DESCRIPTION

Eight alternative project sites located near Wells A and B have been evaluated in this Initial Study (see Figure 2). The proposed project would serve two existing water wells, one or two new wells and would discharge a waste (brine) stream to the Regional Salinity Management pipeline (under development). Therefore, each of the alternative sites are located within one mile of the well sites and the Regional Salinity Management pipeline alignment. Currently, Site 2 is considered the preferred site for the Groundwater Treatment Facility.

1.3.1 Alternative Site 1

This site is located immediately north of the City limits within the unincorporated portion of Ventura County, and is zoned AE-40 ac (Agricultural Exclusive, 40 acre minimum parcel size). Site 1 is located in the western portion of Assessor's Parcel Number (APN) 156-0-180-14 (57.57 acres), near the intersection of Ponderosa Drive and Antonio Drive. The current land use is agriculture (orchards).

1.3.2 Alternative Site 2

This site is located immediately north of the City limits within the unincorporated portion of Ventura County, and is zoned AE-40 ac. Site 2 is located in the western portion of APN 156-0-180-34 (77.30 acres), along Antonio Drive. The current land use is agriculture (row crops).

1.3.3 Alternative Site 3

This site is located immediately north of the City limits within the unincorporated portion of Ventura County, and is zoned AE-40 ac. Site 3 is located in the southwestern portion of APN 156-0-180-34 (77.30 acres), near the intersection of Antonio Drive and Villamonte Court (immediately east of Site 2). The current land use is agriculture (row crops).

1.3.4 Alternative Site 4

This site is located immediately north of the City limits within the unincorporated portion of Ventura County, and is zoned AE-40 ac. Site 4 is located in the southwestern portion of APN 156-0-180-34 (77.30 acres), near the intersection of Villamonte Court and Fieldgate Drive. The current land use is agriculture (row crops).

1.3.5 Alternative Site 5

This site is located immediately north of the City limits within the unincorporated portion of Ventura County, and is zoned AE-40 ac. Site 5 is located in the southwestern portion of APN 156-0-180-28 (40.22 acres), near the intersection of Las Posas Road and Lewis Road. The current land use is agriculture (row crops).

1.3.6 Alternative Site 6

This site is located north of the City limits within the unincorporated portion of Ventura County, and is zoned AE-40 ac. Site 6 is located in the southern portion of APN 156-0-180-28 (40.22 acres), along Somis Road (immediately east of Site 5). The current land use is agriculture (row crops).

1.3.7 Alternative Site 7

This site is located within the City limits, and is zoned RE (Rural Exclusive). Site 7 is located in the southern portion of APN 163-0-070-25 (5.77 acres), near the intersection of Upland Road and Lewis Road. The current land use is agriculture (orchards).

1.3.8 Alternative Site 8

This site is located approximately 1,000 feet north of the City limits within the unincorporated portion of Ventura County, and is zoned AE-40 ac. Site 8 is located in the eastern portion of APN 156-0-180-14 (57.57 acres). The current land use is agriculture (orchards).

1.4 PROJECT BACKGROUND

The City provides drinking water to approximately 60 percent of City residents, which is obtained from local groundwater wells and imported water. The quality of groundwater from two of the wells (Wells A and B) has deteriorated, primarily due to elevated levels of total dissolved solids (TDS), chloride, iron and manganese. Due to these water quality issues, the City has placed one of these wells (Well A) on standby, and is blending water from the second well (Well B) with imported water from the Calleguas Municipal Water District to meet drinking water quality standards.

The City is considering the construction and operation of a Groundwater Treatment Facility in the vicinity of Wells A and B to remove TDS, chloride, iron and manganese from groundwater produced by these and future well(s), and reduce reliance on imported water. A Groundwater Treatment Facility Feasibility Study, was prepared by Black & Veatch in 2005, in association with Separation Processes, Inc., to determine the appropriate technology and basic configuration of treatment processes to be used. The Feasibility Study identified target concentrations of TDS, chloride, iron and manganese to be met by the proposed Groundwater Treatment Facility. The target concentrations of TDS (330 mg/l) and chloride (80 mg/l) were set low, as these constituents would add to the mass loading in wastewater produced during use of supplied potable water. Wastewater is treated by the Camarillo Sanitary District and discharged to Conejo Creek (north of confluence with Calleguas Creek), which has strict limits on TDS and chloride. The target concentrations for iron (0.3 mg/l) and manganese (0.05 mg/l) are the Secondary Maximum Contaminant Levels set in Title 22 of the California Code of Regulations.

Based on the evaluation of four treatment processes (distillation, ion exchange, electrodialysis, reverse osmosis), the Feasibility Study determined reverse osmosis (RO) to be the most cost effective treatment process. Iron and manganese are effectively removed by the RO process. However, if iron and/or manganese are present in groundwater in oxidized forms, fouling of the RO membranes may occur. Therefore, pre-treatment of the groundwater prior to reverse osmosis would be required. A pilot study was conducted by Camp Dresser McGee to identity the appropriate pre-treatment process to supplement RO treatment of groundwater. Pre-treatment processes evaluated in the pilot study included sequestering, aeration followed by granular filtration, aeration followed by membrane filtration, chlorine dioxide (ClO2) and granular filtration, and gaseous chlorine (Cl2) followed by granular filtration. Based on the results of the pilot study, aeration followed by membrane filtration has been preliminarily selected as the pre-treatment process.

A new well(s) is also proposed at the Groundwater Treatment Facility to produce brackish groundwater for treatment at the new Facility. Overall, approximately 3,000 gallons per minute (gpm) from Wells A and B, and 3,000 gpm from new brackish groundwater wells would be treated at the Facility. A well siting study was prepared by Hopkins Groundwater Consultants in 2003, and considered 16 sites based on hydrogeologic suitability, accommodation of treatment facilities and construction suitability. These sites were further evaluated by Black & Veatch Engineers to ensure construction and operating costs could be accommodated within the available funding.

The proposed Groundwater Treatment Facility would serve existing Wells A and B as well as new brackish groundwater well(s), and discharge to the Regional Salinity Management pipeline (to be located along Lewis Road). Therefore, an economically feasible project site must be located in close proximity to these facilities. Wells A and B are located adjacent to the northern City limit, and surrounding land uses within the City are residential and commercial, which cannot accommodate the proposed Groundwater Treatment Facility. Therefore, sites selected for analysis within the document are limited to agricultural lands, mostly within adjacent Ventura County.

1.5 PREPARERS OF THE INITIAL STUDY

This document was prepared for the City by the following staff of Padre Associates, Inc.:

Matt Ingamells, Project Manager

Suzun Rasmusson, Graphics Specialist

2.0 PROJECT DESCRIPTION

2.1 PROJECT COMPONENTS

2.1.1 Groundwater Treatment Facility

Eight alternative sites were assessed for the proposed Groundwater Treatment Facility (see Figure 2). The sites considered vary from about 3 to 14 acres. However, a maximum of 3 acres would be needed for the Groundwater Treatment Facility and brackish groundwater well(s). The precise location of the 3 acre site within each area has not been determined. A conceptual layout of the Groundwater Treatment Facility is provided as Figure 3, and would be essentially the same for any of the sites. All treatment facilities and controls would be housed in a single stucco-coated masonry building (about 200 feet by 70 feet), with gabled roof covered with clay tiles. The emergency generator would be housed in a separate enclosure. A small flow equalization basin (about 1,600 square feet) would be provided immediately adjacent to the structure. Brackish groundwater wells and associated facilities would be located adjacent to the treatment components.

Pre-Treatment. Groundwater to be treated contains elevated concentrations of iron and manganese. If iron and/or manganese are present in oxidized forms, fouling of the RO membranes may occur. Therefore, pre-treatment of the groundwater prior to reverse osmosis would be required. Based on the results of a recently completed pilot study at Well A, aeration followed by membrane filtration (microfiltration/ultrafiltration) has been preliminarily selected as the pre-treatment process. The pre-treatment process to be implemented will be determined prior to preparation of the Draft EIR.

Reverse Osmosis (RO) Treatment. This process would be designed for a groundwater feed of 6,000 gpm, and produce approximately 4,700 gpm of treated water. The City's two existing wells (A & B) have capacities of 1,500 gallons per minute (gpm) each for a total combined capacity of 3,000 gpm. The additional 3,000 gpm of feed water would be produced by new brackish groundwater wells to be located at the Facility. Following RO treatment, the treated water would be decarbonated to remove CO2, and then disinfected with aqueous ammonia and sodium hypochlorite.

The resulting treated water would meet all drinking water standards, with an estimated concentration of 0.08 mg/l iron, 0.03 mg/l manganese, 224 mg/l TDS and 21 mg/l chloride. The waste stream (brine) would have a TDS concentration of about 7,000 mg/l and would be discharged to the Calleguas Municipal Water District's Regional Salinity Management pipeline, which is currently under final design and would be located along Lewis Road, near the six alternative project sites evaluated. The Regional Salinity Management pipeline would transport the brine stream to an ocean outfall to be constructed near Port Hueneme.

Chemicals associated with water treatment would be stored on-site (30 day supply) and include sulfuric acid, sodium hypochlorite, aqueous ammonia and sodium hydroxide.

2.1.2 New Well(s)

The City proposes to develop about 3,000 gpm brackish groundwater well capacity at the Groundwater Treatment Facility site. This water would be treated at the Facility, and would serve to provide an additional source of potable water, and remove chloride from the groundwater basin. It is anticipated that 1 or 2 wells would be developed and include the following components:

- Wellhead and enclosure;
- Submersible pumps; and
- Piping and electrical gear.

2.1.3 Pipelines

New pipelines would be required to:

- Connect both Wells A and B to the inlet of the proposed Groundwater Treatment Facility;
- Connect the waste (brine) stream from the RO process to the Regional Salinity Management pipeline; and
- Connect the outlet of the proposed Groundwater Treatment Facility to existing Zone 1 and Zone 2 water service pipelines.

. Table 1 provides a comparison of pipeline lengths needed for each alternative site. Note that the well feed pipelines would be pressurized and have a diameter of approximately 18 inches. The brine stream pipeline would be approximately 10 inches in diameter if pressurized, and approximately 14 inches in diameter if flow relies on gravity.

It is anticipated that the pipelines would be located within the public right-of-way along roadways, primarily Antonio Avenue, Las Posas Road and Somis Road. Table 1 indicates the selection of sites further from Wells A and B (Sites 1, 5, 6, 7 and 8) would involve substantially longer pipelines.

Table 1. Pipeline Length Comparison (feet)

Alternative Site	Well A Feed	Well B Feed	Brine Stream	Zone 1 Tie-in	Zone 2 Tie-in	Total
1	2,790	1,630	5,450	2,100	1,600	13,570
2	1,860	770	3,870	1,300	2,400	10,200
3	1,670	570	3,680	1,160	2,560	9,640
4	2,210	1,690	2,420	1,680	3,070	11,070
5	2,700	3,260	560	2,230	670	12,420
6	3,490	4,060	190	2,980	4,420	15,410
7	3,310	3,870	370	2,790	4,230	14,570
8	6,100	6,660	2,100	5,580	7,020	27,460

2.1.4 Access

An access road would be constructed between the nearest public street and the Groundwater Treatment Facility site. Table 2 provides a comparison of potential access road requirements for each alternative site.

Table 2. Access Road Summary

Alternative Site	Nearest Public Street	Approximate Access Road Length (feet)
1	Antonio Avenue	100
2	Antonio Avenue	100
3	Antonio Avenue	100
4	Fieldgate Drive	100
5	Somis Road	100
6	Somis Road	100
7	Upland Road	100
8	Somis Road	2000

2.1.5 Emergency Power

An emergency generator would be provided at the Groundwater Treatment Facility site to ensure a reliable source of power to the high pressure pumps and other water treatment equipment. The emergency generator may also be used to provide emergency power to the proposed groundwater wells. The emergency generator would only be used during power outages, and for short periods during maintenance periods. The generator would produce up to 2,000 KW and would be powered by a diesel engine.

2.1.6 Operation

The Groundwater Treatment Facility and associated wells would be operated 24 hours per day with a crew of 2 to 3, and employ 6 to 9 persons (three 8-hour shifts). The Groundwater Treatment Facility would include a restroom, and wastewater would be piped to the nearest sewer served by the Camarillo Sanitary District.

2.2 CONSTRUCTION

Construction of the proposed facilities would be coordinated with funding and would likely be initiated in 2009. Construction would last approximately 12 to 18 months, including pipeline installation.

2.2.1 Treatment and Well Facilities

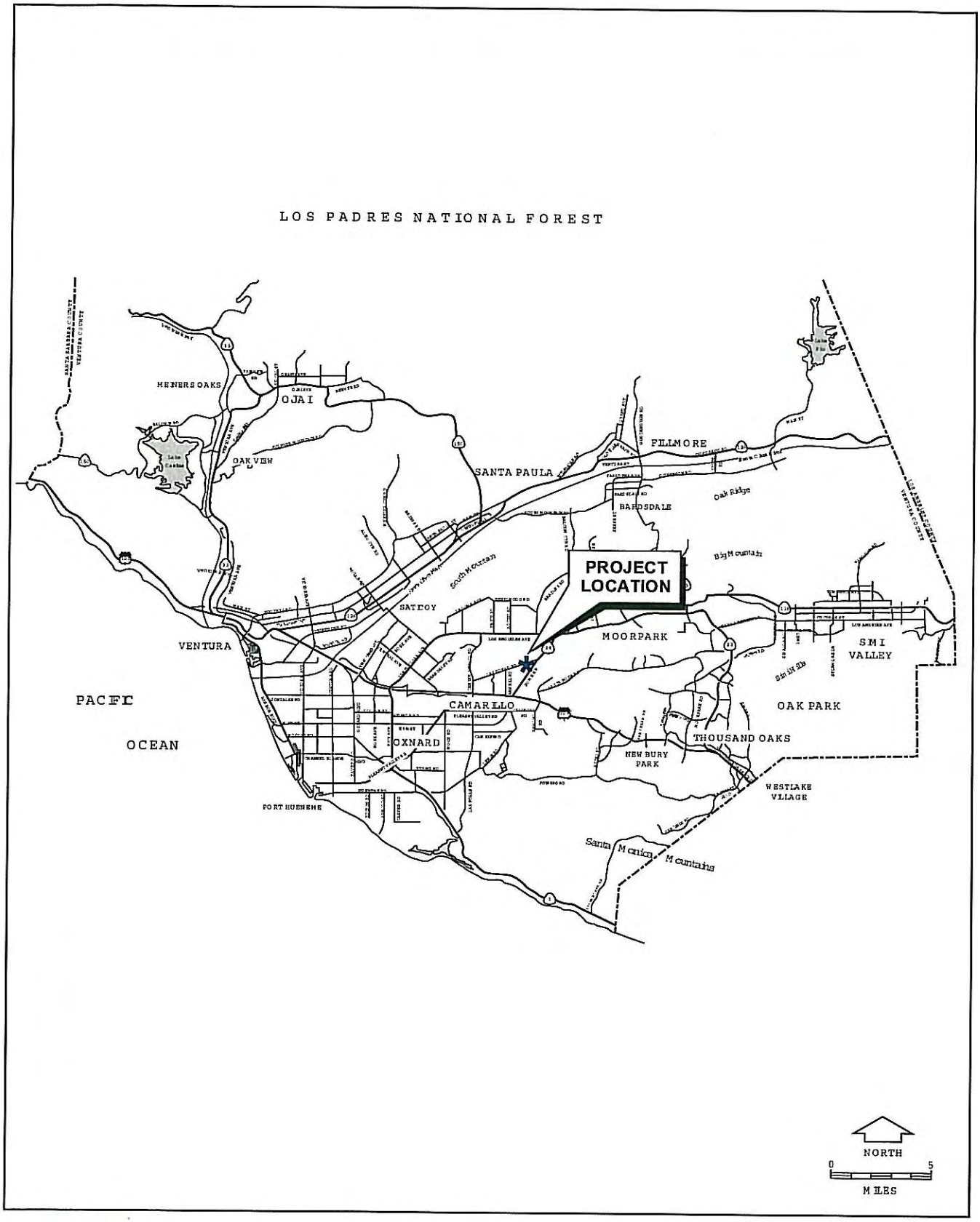
Ground disturbance associated with construction of the Groundwater Treatment Facility would be approximately one acre, including the access road. However, selection of alternative sites 5 or 8 would require a longer access road and the disturbance area would be larger.

2.2.2 Pipelines

Excluding Alternative Site 8, pipelines would be located in public roadways, and installed using conventional trenching methods. The trench would be about 3 feet wide and 5 feet deep. A concrete slurry would be used as the final backfill over the pipelines, and the pavement replaced. Pipeline installation would be coordinated with planned street repairs and pavement overlays, schedule permitting.

Pipelines associated with Alternative Site 8 would be located in farmlands, and be installed using conventional trenching methods. The pipelines would be located at least 5 feet under farmlands, to allow cultivation to occur over the buried pipelines.

March 2008
Project No. 0702-2781



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City of Camarillo Groundwater Treatment Plant

REGIONAL MAP
FIGURE 1

Project No. J702-2781

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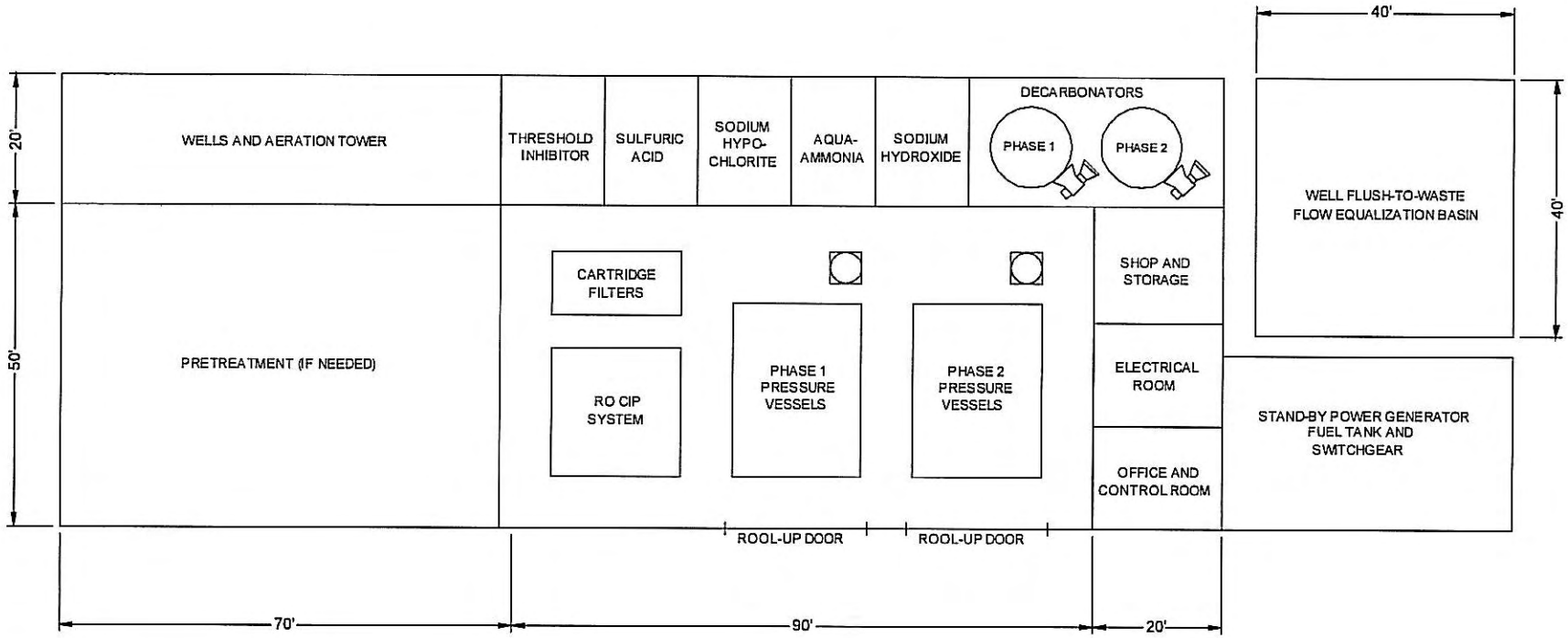
City of Camarillo Groundwater Treatment Plant

SITE LOCATION MAP
FIGURE 2



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City of Camarillo Groundwater Treatment Plant

CONCEPTUAL SITE LAYOUT
FIGURE 3

3.0 ENVIRONMENTAL IMPACT ANALYSIS

This section provides an analysis of the potential environmental impacts associated with the proposed project. The analysis is organized by environmental issue area (e.g., aesthetics, agricultural resources, air quality, etc.). Each issue area begins with a checklist, which identifies criteria that has been used to assess the significance or insignificance of each potential impact. The checklists used in this Initial Study were developed by the State of California, and are provided as Appendix G of the State CEQA Guidelines. The checklists also indicate the conclusions made regarding the potential significance of each impact. Explanations of each conclusion are provided after the checklists. Finally, any issues that are in need of further study (i.e., in an Environmental Impact Report) are identified.

Impact classifications used in the checklists are the following:

- **Potentially Significant Impact.** An impact that could be significant, and requires further study in an Environmental Impact Report (EIR).
- **Less than Significant Impact with Mitigation.** An impact that is potentially significant, but can feasibly be mitigated to a less than significant level with measures identified in the Initial Study.
- **Less than Significant Impact.** An impact that would not be significantly adverse.
- **No Impact.** Applied when the project would not result in any impact to a specific issue area

3.1 AESTHETICS

Would the project:	Potentially Significant Impact	Less than Significant Impact with Mitigation	Less than Significant Impact	No Impact
a. Have a substantial adverse effect on a scenic vista?	☐	☐	☐	☒
b. Substantially damage scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings within a state scenic highway?	☐	☐	☒	☐
c. Substantially degrade the existing visual character or quality of the site and its surroundings?	☐	☐	☒	☐
d. Create a new source of substantial light or glare which would adversely affect day or nighttime views in the area?	☐	☐	☐	☒

3.1.1 Impact Analysis

a. There are no designated scenic vistas in the project area. Most project components would be housed in a stucco-coated masonry building with clay roof tiles. This structure would be compatible with the architecture of adjacent residential and commercial land uses. As such, the project would not impact scenic views from public vistas.

b. Based on a review of the City of Camarillo General Plan, scenic corridors in the project area include Las Posas Road, Lewis Road, Ponderosa Drive and Upland Road. Alternative Site 1 would be visible from Ponderosa Drive. Alternative Site 5 may be visible from Las Posas Road. Alternative Site 7 would be visible from Upland Road. The Groundwater Treatment Facility would be compatible with the architecture of adjacent residential and commercial land uses, and would not substantially degrade views for scenic corridors.

c. The Groundwater Treatment Facility would be compatible with the architecture of adjacent residential and commercial land uses, and would not substantially degrade the visual character or quality of the site and surroundings.

d. The Groundwater Treatment Facility would include limited night lighting, consisting of spotlights directed to illuminate the entrance. At Alternative Sites 3 and 4, this lighting may be visible from nearby residences. However, such lighting is not considered a substantial increase in light or glare and would not affect day or nighttime views. Therefore, no light or glare impacts are expected.

3.1.2 Further Study

The project would not result in impacts related to aesthetics or light and glare. No further study of these issues is required.

3.2 AGRICULTURAL RESOURCES

Would the project:	Potentially Significant Impact	Less than Significant Impact with Mitigation	Less than Significant Impact	No Impact
a. Convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program of the California Resources Agency, to non-agricultural use?	☐	☐	☒	☐
b. Conflict with existing zoning for agricultural use, or a Williamson Act contract?	☐	☐	☒	☐
c. Involve other changes in the existing environment which, due to their location or nature, could result in conversion of Farmland, to non-agricultural use?	☐	☐	☐	☒

3.2.1 Impact Analysis

a. According to the State of California Department of Conservation Important Farmland Map for the Camarillo quadrangle, Alternative Sites 1, 2, 3, 4, 7 and 8 are located in areas designated as Prime farmland. Alternative Sites 5 and 6 are located in areas designated as Statewide Importance farmland. According to the impact significance criteria provided in the Ventura County Initial Study Assessment Guidelines, the project would result in a significant project-level impact if it would convert 5 acres or more of Prime or Statewide Importance farmland. The maximum project-related loss of farmland would be 4.1 acres (Alternative Site 8: 3 acre Facility site, 2000 foot access road). Therefore, farmland conversion impacts are considered less than significant.

b. The proposed project would involve annexing 3 acres of land and changing the zoning to a non-agricultural designation. Selection of Alternative Site 5 or 6 would result in a lot line adjustment and reduce the size of the remaining parcel below the 40 acre minimum required by the Ventura County zoning designation. However, the zoning of remaining portions of affected parcels would not be modified, and Williamson Act contracts would not be affected. The proposed project would not conflict with surrounding agricultural operations.

c. The 3 acre converted farmland area would be located along the margins of large parcels, and would not preclude the continuation of farming on these parcels. In addition, the Ventura County Save Open-Space Agricultural Resources (SOAR) Initiative and the Ventura County Right-to-Farm ordinance would preclude conversion of adjacent farmlands.

Projects that involve public infrastructure (e.g., roads, power, water, sewer, etc.) in a previously undeveloped area may lead to inducement of population growth and associated conversion of agricultural lands. The project would improve the quality and reliability of local potable water supplies. However, the City has an adequate allocation of imported water to augment local sources. Therefore, potable groundwater provided by the proposed project would not result in population growth and related conversion of farmland. In addition, the proposed project would make brackish groundwater available for agricultural uses.

3.2.2 Further Study

The project is unlikely to ~~would not~~ result in any significant impacts to agricultural resources. However, further study will be included in an EIR in support of LAFCO review of the proposed annexation.

3.3 AIR QUALITY

Would the project:	Potentially Significant Impact	Less than Significant Impact with Mitigation	Less than Significant Impact	No Impact
a. Conflict with or obstruct implementation of the applicable air quality plan?	☐	☐	☐	☒
b. Violate any air quality standard or contribute substantially to an existing or projected air quality violation?	☐	☐	☒	☐
c. Result in a cumulatively considerable net increase of any criteria pollutant for which the project region is non-attainment under an applicable federal or state ambient air quality standard (including releasing emissions that exceed quantitative thresholds for ozone precursors)?	☐	☐	☒	☐
d. Expose sensitive receptors to substantial pollutant concentrations?	☐	☐	☒	☐
e. Create objectionable odors affecting a substantial number of people?	☐	☐	☒	☐

3.3.1 Impact Analysis

a. Projects that cause local populations to exceed population forecasts in the Ventura County Air Quality Management Plan (AQMP) are considered inconsistent with the AQMP, as exceeding population forecasts can result in the generation of emissions beyond those which have been projected in the AQMP. The proposed project would not directly or indirectly result in population growth, and therefore would not cause population forecasts in the AQMP to be exceeded. As such, the project would be consistent with the AQMP.

b. State 1-hour ambient standards for CO are sometimes exceeded at roadway intersections during times of peak traffic congestion. These localized areas are sometimes called CO "hotspots". Due to the relatively low ambient CO levels and the lack of major intersections in the region, CO hotspots rarely occur. The project would generate only small amounts of traffic, primarily during the construction period. Considering the above, the project would not be expected to create or contribute substantially to the violation of CO standards.

Fugitive dust would be generated by the operation of earth-moving equipment and off-road use of vehicles during the construction of the project improvements. Dust generation from these activities would be considered a significant impact if APCD Rule 51 is violated. Rule 51 states "A person shall not discharge from any source whatsoever such quantities of air contaminants or other material which cause injury, detriment, nuisance, or annoyance to any considerable number of persons or the public or which endangers the comfort, repose, health or safety of any such persons or the public or which cause or have a natural tendency to cause injury or damage to business or property." Standard dust control measures would be implemented, and would reduce dust impacts to a less than significant level.

c. Emissions would be generated during the construction phase by construction equipment, heavy-duty trucks and employee passenger vehicles. Exhaust emissions during peak construction periods would exceed the 25 pounds per day threshold established by the Ventura County Air Pollution Control District (APCD). However, due to the temporary, short-term nature of construction emissions, the APCD does not apply the quantitative emissions thresholds for ROC and NO_X to construction activities. The APCD does require that emission reduction measures be implemented during construction to reduce exhaust emissions and fugitive dust generation. Applicable measures have been incorporated into the project.

d. See the discussion under part b. above regarding CO and fugitive dust.

e. Small amounts of mildly odorous compounds would be used at the Groundwater Treatment Facility, including sodium hypochlorite and aqueous ammonia. However, these compounds would be stored in sealed containers and used in small quantities. Therefore, odors are not expected to be detectable at adjacent land uses.

3.3.2 Further Study

Air quality impacts of the project would be less than significant. No further study of this issue is required.

3.4 BIOLOGICAL RESOURCES

Would the project:	Potentially Significant Impact	Less than Significant Impact with Mitigation	Less than Significant Impact	No Impact
a. Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by the California Department of Fish and Game or U.S. Fish and Wildlife Service?	☐	☐	☐	☒
b. Have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations or by the California Department of Fish and Game or US Fish and Wildlife Service?	☐	☐	☐	☒
c. Have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the Clean Water Act (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means?	☐	☐	☐	☒
d. Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites?	☐	☐	☐	☒

Would the project:	Potentially Significant Impact	Less than Significant Impact with Mitigation	Less than Significant Impact	No Impact
e. Conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance?	☐	☐	☐	☒
f. Conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan?	☐	☐	☐	☒

3.4.1 Impact Analysis

a. All sites under consideration are located in agricultural areas supporting short rotation row crops or orchards. No native vegetation or wildlife habitat would be removed or adversely affected. Therefore, special-status species would not be affected.

b. No riparian or other sensitive natural community occurs within or in close proximity to the project sites under consideration. Therefore, the project would not impact sensitive biological communities.

c. No wetlands occur within or in close proximity to the project sites under consideration. No impacts to wetlands would occur.

d. Arroyo Las Posas is located approximately 200 feet east of Alternative Site 7, and may be a local wildlife movement corridor. The project would not impede the movement of wildlife through Arroyo Las Posas, and intervening orchard trees would shield the Groundwater Treatment Facility. No impacts to wildlife migration would occur.

e. The project would not impact biological resources, and would not conflict with any tree protection ordinance, or other local policies or ordinances established to protect sensitive species or habitats.

f. There are no habitat conservation plans or natural community conservation plans that apply to the project site. Therefore, the proposed project would not conflict with such plans.

3.4.2 Further Study

Impacts of the proposed project to biological resources are expected to be less than significant. No further study of this issue is required.

3.5 CULTURAL RESOURCES

Would the project:	Potentially Significant Impact	Less Than Significant with Mitigation	Less Than Significant Impact	No Impact
a. Cause a substantial adverse change in the significance of a historical resource as defined in Section 5064.5 of the CEQA Guidelines?	☐	☐	☐	☒
b. Cause a substantial adverse change in the significance of an archaeological resource pursuant to Section 5064.5 of the CEQA Guidelines?	☒	☐	☐	☐
c. Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?	☐	☐	☐	☒
d. Disturb any human remains, including those interred outside of formal cemeteries?	☒	☐	☐	☐

3.5.1 Impact Analysis

a. The project sites under consideration are currently under cultivation as row crops or orchards, and do not contain any historical structures or resources. No impact would result.

b. An archeological survey or record search of the alternative project sites has not be conducted to date. However, the potential for intact artifacts is low, based on the current agricultural land use.

c. The project site is not designated as a paleontological resource site on the Ventura County resource maps. In addition, the project site has been the location of an extensive amount of past ground disturbance associated with agricultural operations, and project construction would be limited to previously disturbed areas. Therefore, the project is not expected to result in impacts to paleontological resources.

d. An archeological survey or record search of the alternative project sites has not be conducted to date. However, the potential for human remains to be encountered is low, based on the current agricultural land use.

3.5.2 Further Study

A archeological survey and record search will be conducted, and potential impacts of the project to cultural resources will be assessed in the EIR.

3.6 GEOLOGY AND SOILS

Would the project:	Potentially Significant Impact	Less than Significant Impact with Mitigation	Less than Significant Impact	No Impact
a. Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:				
i) Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault? Refer to Division of Mines and Geology Special Publication 42.	☐	☐	☒	☐
ii) Strong seismic ground shaking?	☐	☐	☒	☐
iii) Seismic-related ground failure, including liquefaction?	☐	☐	☒	☐
iv) Landslides?	☐	☐	☒	☐
b. Result in substantial soil erosion or the loss of topsoil?	☐	☐	☒	☐
c. Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse?	☐	☐	☐	☒
d. Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property?	☐	☐	☒	☐
e. Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of wastewater?	☐	☐	☐	☒

3.6.1 Impact Analysis

a. None of the sites under consideration are located within an Alquist-Priolo Earthquake Fault Zone. Therefore, substantial seismic-related groundshaking or ground failure are not expected. The sites under consideration are relatively level and would not be subject to landslides.

b. Project construction would require the removal of existing crops, which acts to stabilize soils. As such there is the potential for the project to result in soil erosion. However, grading would not occur on steep slopes and would affect an area of less than 3 acres. Therefore, the potential for soil erosion is considered less than significant.

c. According to the Camarillo General Plan Safety Element, the sites under consideration are not located in a subsidence or liquefaction hazard zone. As such the project site is not expected to be subject to impacts associated with land subsidence or liquefaction. See response a. for discussion of issues related to landslides.

d. Based on the Camarillo General Plan Safety Element and *Soil Survey, Ventura Area, California* (Edwards et al., 1970), the sites under consideration are located in a moderate expansive soil area. It is anticipated that the Groundwater Treatment Plant site would be excavated and backfilled with suitable soils, and damage associated with expansive soils would not occur.

e. Septic waste disposal systems are not proposed as part of this project. No impacts would result.

3.6.2 Further Study

No further study of this issue is required.

3.7 HAZARDS AND HAZARDOUS MATERIALS/RISK OF UPSET

Would the project:	Potentially Significant Impact	Less than Significant Impact with Mitigation	Less than Significant Impact	No Impact
a. Create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials?	☐	☐	☒	☐
b. Create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment?	☐	☐	☒	☐
c. Emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school?	☐	☐	☐	☒
d. Be located on a site which is included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5 and, as a result, would it create a significant hazard to the public or the environment?	☒	☐	☐	☐
e. For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project result in a safety hazard for people residing or working in the project area?	☐	☐	☐	☒
f. For a project within the vicinity of a private airstrip, would the project result in a safety hazard for people residing or working in the project area?	☐	☐	☐	☒
g. Impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan?	☐	☐	☐	☒

Would the project:	Potentially Significant Impact	Less than Significant Impact with Mitigation	Less than Significant Impact	No Impact
h. Expose people or structures to a significant risk of loss, injury or death involving wildland fires, including where wildlands are adjacent to urbanized areas or where residences are intermixed with wildlands?	☐	☐	☐	☒

3.7.1 Impact Analysis

a. The proposed project would use treatment-related chemicals, including sulfuric acid, sodium hypochlorite, aqueous ammonia and sodium hydroxide. However, these chemicals would be transported and stored according to State and Federal requirements. In addition, the City would be required to develop a Hazardous Materials Business Plan to address potential hazards and submit the Plan to the Ventura County Environmental Health Department. The transportation and use of these chemicals would not result in a hazard to the public or the environment.

b. The City would implement the Hazardous Materials Business Plan, which would minimize the potential for accidental release of treatment-related chemicals. The transportation and use of these chemicals would not result in a hazard to the public or the environment.

c. The nearest school is located approximately 1.4 miles to the west of the alternative project sites. The transportation and use of treatment-related chemicals would not result in a hazard to school children or other members of the public.

d. None of the project sites under consideration are included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5. An environmental site assessment has not been conducted to date, and the alternative sites may contain contaminated soils or other residual materials that may be considered hazardous. Each of the eight sites under consideration have a long history of agricultural cultivation and could contain historically applied pesticides.

e. The project sites under consideration are located approximately 4 miles northwest of the Camarillo Airport, and are not located within the airport land use plan. The proposed project would not result in any hazards to the operation of the Camarillo Airport.

f. The project sites under consideration are not located near a private airstrip. The proposed project would not result in any hazards to the operation of any private airstrips.

g. The project would be constructed and operated on private land, and would not interfere with the implementation of any designated emergency response plans or emergency evacuation plans. No impacts of this nature would occur.

h. The project sites under consideration are surrounded by irrigated agricultural crops, which are not susceptible to seasonal fire hazards. Project components would be constructed of non-combustible materials (masonry, concrete and steel). The proposed project does not include the construction or occupancy of any habitable structures. Therefore, the project would not subject persons or property to fire hazards.

3.7.2 Further Study

An Environmental Site Assessment will be completed for all project sites under consideration, and potential impacts associated with hazardous materials will be addressed in an EIR. A testing program for historical pesticides would be conducted if warranted based on the results of the Environmental Site Assessment.

3.8 HYDROLOGY AND WATER QUALITY

Would the project:	Potentially Significant Impact	Less than Significant Impact with Mitigation	Less than Significant Impact	No Impact
a. Violate any water quality standards or waste discharge requirements?	☐	☐	☒	☐
b. Substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g., the production rate of pre-existing nearby wells would drop to a level which would not support existing land uses or planned uses for which permits have been granted)?	☐	☐	☒	☐
c. Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner which would result in substantial erosion or siltation on- or off-site?	☐	☐	☒	☐
d. Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner which would result in flooding on- or off-site?	☐	☐	☒	☐
e. Create or contribute runoff water which would exceed the capacity of existing or planned stormwater drainage systems?	☐	☐	☐	☒
f. Otherwise substantially degrade water quality?	☐	☐	☐	☒
g. Place housing within a 100-year flood hazard area as mapped on a federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map?	☐	☐	☐	☒
h. Place within a 100-year flood hazard area structures which would impede or redirect flood flows?	☒	☐	☐	☐

Would the project:	Potentially Significant Impact	Less than Significant Impact with Mitigation	Less than Significant Impact	No Impact
i. Expose people or structures to a significant risk of loss, injury or death involving flooding, including flooding as a result of the failure of a levee or dam?	☒	☐	☐	☐
j. Inundation by seiche, tsunami, or mudflow?	☐	☐	☐	☒

3.8.1 Impact Analysis

a. The proposed project would serve to improve drinking water quality in the City of Camarillo. However, the project would generate brine as part of the reverse osmosis process, which would be discharged to the Calleguas MWD Salinity Management pipeline and would be ultimately discharged to the Pacific Ocean near Port Hueneme. Impacts to ocean water quality have been assessed in the Final Program EIR/EA for the Calleguas Regional Salinity Management Project prepared by Calleguas MWD. The Final Program EIR/EA concluded that the ammonia, copper and mercury water quality standards of the California Ocean Plan would be exceeded at the Ormond Beach outfall, under design flow rates when the power plant was not pumping cooling water through the outfall. Calleguas MWD has selected a new outfall and is currently working with the Regional Water Quality Control Board to develop dilution ratios and effluent limits that would ensure compliance with the California Ocean Plan. Project-related brine flows were included in the design flows analyzed in the Program EIR/EA for the Calleguas Regional Salinity Management Project, and impacts have been assessed and would be mitigated as part of that project.

b. Currently, the City pumps about 1,500 gallons per minute (gpm) of groundwater from the Pleasant Valley Groundwater Basin from Well B. The proposed project includes groundwater treatment and a new well(s), which would increase groundwater production up to about 6,000 gpm. Based on the Fox Canyon Groundwater Management Plan, in the northern portion of Camarillo (project area) increased surface flow in Arroyo Las Posas has raised groundwater levels to historic highs (increase of 250 feet since 1994). Therefore, the proposed increase in groundwater production is not expected to deplete groundwater supplies.

c. The proposed Groundwater Treatment Facility would not alter drainage patterns, but would be provided with storm drains as needed to ensure ponding of rain water does not occur. No erosion or siltation is anticipated.

d. The proposed Groundwater Treatment Facility would not require altering the course of any drainage. Large areas of impervious surfaces would not be created, thus major increases in surface water runoff from the site would not result.

e. The area of impervious surfaces would be less than one acre, such that the increase in run-off would be minimal. The City's existing storm drain system would be adequate to handle this increase.

f. The purpose of the project is to improve drinking water quality, and remove chloride from the Pleasant Valley Groundwater Basin. The project would not substantially degrade surface water or groundwater quality.

g. The project would not involve the construction of any housing.

h. Based on preliminary revisions to floodplain maps, Alternative Site 7 is located within a floodway and construction of the Groundwater Treatment Facility at this site may impede flood flows.

i. Based on preliminary revisions to floodplain maps, Alternative Sites 2, 3, 4, 5 and 6 are located within the 100-year floodplain, and Alternative Site 7 is located within a floodway. The proposed Groundwater Treatment Facility would be manned. The project would expose people and structures to a potentially significant flood hazard.

j. Tsunamis are large-scale sea waves produces by tectonic activities along the ocean floor. Seiches are freestanding or oscillatory waves associated with large enclosed or semi-enclosed bodies of water. As the project site is not located near the ocean or any large enclosed or semi-enclosed bodies of water, the project is not subject to any impacts of this nature. Debris and mudflows are typically a hazard experienced in the floodplains of streams that drain very steep watersheds. The project sites under consideration are located in level areas, which are not subject to mudflows/

3.8.2 Further Study

Flood-related hazards will be addressed in an EIR for all sites under consideration.

3.9 LAND USE AND PLANNING

Would the project:	Potentially Significant Impact	Less than Significant Impact with Mitigation	Less than Significant Impact	No Impact
a. Physically divide an established community?	☐	☐	☐	☒
b. Conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the project (including, but not limited to the general plan, specific plan, local coastal program, or zoning ordinance) adopted for the purpose of avoiding or mitigating an environmental effect?	☒	☐	☐	☐
c. Conflict with any applicable habitat conservation plan or natural community conservation plan?	☐	☐	☐	☒

3.9.1 Impact Analysis

a. The project sites under consideration are located in agricultural areas, and would not require the construction of any roads, barriers, or facilities that could potentially physically divide an existing community. No impact of this nature would result.

b. Depending on the site selected, the project may be considered inconsistent with the current agricultural zoning, and the Ventura County Save Open-Space Agricultural Resources (SOAR) Initiative.

c. There are no habitat conservation plans, natural community conservation plans or similar plans that apply to the project site. No impacts of this nature would result.

3.9.2 Further Study

Annexation of the project site into the City of Camarillo and Camarillo Sanitary District, consistency with SOAR and zoning changes would be addressed in an EIR.

3.10 MINERAL RESOURCES

Would the project:	Potentially Significant Impact	Less than Significant Impact with Mitigation	Less than Significant Impact	No Impact
a. Result in the loss or availability of a known mineral resource that would be of value to the region and the residents of the state?	☐	☐	☐	☒
b. Result in the loss of availability of a locally important mineral resource recovery site delineated on a local general plan, specific plan or other land use plan?	☐	☐	☐	☒

3.10.1 Impact Analysis

a. The project site is not located in a mineral resource area, and would not hamper the extraction of such resources in the region. Therefore, no impacts to such resources would occur as result of project implementation.

b. The nearest mineral resource recovery site is the Mary Smith quarry, located approximately five miles southeast of the project sites. The proposed project would not adversely affect the continued operation of this quarry.

3.10.2 Further Study

The project would not result in any impacts to mineral resources. No further study of this issue is required.

3.11 NOISE

Would the project:	Potentially Significant Impact	Less than Significant Impact with Mitigation	Less than Significant Impact	No Impact
a. Exposure of persons to or generation of noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?	☒	☐	☐	☐
b. Exposure of persons to or generation of excessive groundborne vibration or groundborne noise levels?	☐	☐	☒	☐
c. A substantial permanent increase in ambient noise levels in the project vicinity above levels existing without the project?	☐	☐	☒	☐
d. A substantial temporary or periodic increase in ambient noise levels in the project vicinity above levels existing without the project?	☒	☐	☐	☐
e. For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project expose people residing or working in the project area to excessive noise levels?	☐	☐	☐	☒
f. For a project within the vicinity of a private airstrip, would the project expose people residing or working in the project area to excessive noise levels?	☐	☐	☐	☒

3.11.1 Impact Analysis

a. The project would include 24 hour per day operation of high pressure pumps and other noise-generating equipment at the Groundwater Treatment Facility, and a pump/motor at the proposed new well(s). The high pressure pumps and associated treatment equipment would be enclosed in a masonry building, which would attenuate noise. The City's noise ordinance (Chapter 10.34 of the Municipal Code) limits nighttime noise (9 pm to 7 am) to 45 dBA at residential properties. Alternative sites 3, 4, 5, 6 and 7 are located within 350 feet of residences and may result in nighttime noise levels exceeding the noise ordinance standards.

b. Excavation and well drilling at the project site as part of construction may result in some ground-borne noise or vibration. Due to the short duration and small magnitude of these activities, these impacts are considered less than significant.

c. Alternative sites 1 through 7 are located in commercial or residential areas within the City and are exposed to traffic noise. Alternative site 8 is located in an agricultural area and is exposed to noise related to cultivation and harvesting of orchard crops. The proposed high pressure pumps and related noise-generating equipment would be housed in a masonry building, and the well pump(s) would be submersible. Therefore, project-related noise is not anticipated to substantially increase ambient noise in areas adjacent to the sites under consideration.

d. City of Camarillo Municipal Code Chapter 10.34 establishes noise standards for construction, if these activities occur in the evening or nighttime (7 pm to 7 am) or on Sunday. Excluding well drilling, project-related construction activities would be limited to daytime hours. Well drilling activities may occur at nighttime and would exceed the noise ordinance standards if conducted near residential land uses.

e. The project is not located in an area addressed in an Airport Land Use Plan, nor is it within two miles of any public or private airstrips. Therefore, no impacts are expected.

f. See the discussion of airstrip-related noise in part e. above.

3.11.2 Further Study

Depending on the site selected, the City's noise standards may be exceeded at adjacent residential areas. Further study of this issue would be conducted in an EIR.

3.12 POPULATION AND HOUSING

Would the project:	Potentially Significant Impact	Less than Significant Impact with Mitigation	Less than Significant Impact	No Impact
a. Induce substantial population growth in an area, either directly (for example, by proposing new homes and businesses) or indirectly (for example, through extension of roads or other infrastructure)?	☐	☐	☐	☒
b. Displace substantial numbers of existing housing, necessitating the construction of replacement housing elsewhere?	☐	☐	☐	☒
c. Displace substantial numbers of people, necessitating the construction of replacement housing elsewhere?	☐	☐	☐	☒

3.12.1 Impact Analysis

a. The project would increase the production rate of groundwater used as a source of drinking water for the City of Camarillo, and could be viewed as growth inducing. However, this water would be used as a replacement for more expensive imported water, and the net amount of drinking water provided would not substantially change. In addition, drinking water is not currently an impediment to population growth as the City has sufficient groundwater and imported water allocations to meet current and projected needs.

b. No housing would be displaced and construction of replacement housing would not be necessary.

c. As people would not be displaced as a result of project implementation, it would not be necessary to provide replacement housing.

3.12.2 Further Study

The project would not result in any impacts to population or housing. No further study of this issue is required.

3.13 PUBLIC SERVICES

Would the project:	Potentially Significant Impact	Less than Significant Impact with Mitigation	Less than Significant Impact	No Impact
a. Would the project result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times or other performance objectives for any of the public services?				
Fire protection?	☐	☐	☐	☒
Police protection?	☐	☐	☐	☒
Schools?	☐	☐	☐	☒
Parks?	☐	☐	☐	☒
Other public facilities?	☐	☐	☐	☒

3.13.1 Impact Analysis

a. Police protection services, fire protection services, schools, parks and other public facilities are normally required to be augmented as a result of projects that increase an area's population (e.g., new residential, commercial, and industrial development). The proposed project would not increase the local population. The proposed structures would be constructed of non-flammable materials (concrete, masonry, steel) and would not require fire protection services. The proposed facilities would be provided security services by City, such that police protection services would not be required. Therefore, no impacts to police protection services, fire protection services, schools, parks and other public facilities are expected.

3.13.2 Further Study

The project would not result in any impacts to public services. No further study of this issue is required.

3.14 RECREATION

Would the project:	Potentially Significant Impact	Less than Significant Impact with Mitigation	Less than Significant Impact	No Impact
a. Would the project increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated?	☐	☐	☐	☒
b. Does the project include recreational facilities or require the construction or expansion of recreational facilities that might have an adverse physical effect on the environment?	☐	☐	☐	☒

3.14.1 Impact Analysis

a. The project would not result in population growth, and would not increase the use of existing neighborhood or regional parks, or any other recreational facilities. As such, the project would not result in the accelerated physical deterioration of any recreational facilities. No impact would result.

b. The project would not involve the construction or expansion of any recreational facilities. Thus, the project would not have any impacts on the physical environment associated with the construction or use of recreational facilities.

3.14.2 Further Study

The project would not result in any impacts to recreational facilities, or to the physical environment through the use or construction of recreational facilities. No further study of this issue is required.

3.15 TRANSPORTATION/CIRCULATION

Would the project:	Potentially Significant Impact	Less than Significant Impact with Mitigation	Less than Significant Impact	No Impact
a. Cause an increase in traffic that is substantial in relation to the existing traffic load and capacity of the street system (i.e., result in a substantial increase in either the number of vehicle trips, the volume to capacity ratio on roads, or congestion at intersections)?	☐	☐	☒	☐
b. Exceed, either individually or cumulatively, a level of service standard established by the county congestion management agency for designated roads or highways?	☐	☐	☒	☐
c. Result in a change in air traffic patterns, including either an increase in traffic levels or a change in location that results in substantial safety risks?	☐	☐	☐	☒
d. Substantially increase hazards due to a design feature (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment)?	☐	☐	☒	☐
e. Result in inadequate emergency access?	☐	☐	☐	☒
f. Result in inadequate parking capacity?	☐	☐	☐	☒
g. Conflict with adopted policies, plans, or programs supporting alternative transportation (e.g., bus turnouts, bicycle racks)?	☐	☐	☐	☒

3.15.1 Impact Analysis

a. Construction activities may generate up to 30 round trips per day (light and heavy-duty vehicles), over the 12 to 18 month construction period. Most of these trips would utilize State Route 34 (Lewis Road/Somis Road) to access the project site. Somis Road transitions from 4 lanes to 2 lanes approximately 0.3 miles northeast of the Las Posas Road intersection. Based on 2006 data collected by Caltrans, the average annual daily trips on the 2 lane roadway segment is 16,700, which is equivalent to Level of Service E (considered unacceptable by the City of Camarillo and Ventura County). Project-related construction vehicle trips may aggravate the existing unacceptable LOS on this roadway. However, due to the short-term nature of construction activities and the small incremental increase in vehicle trips, this impact is considered less than significant.

Operation of the proposed facilities would require periodic maintenance and monitoring of site operations by employees, and deliveries of treatment supplies. It is estimated that project operations would generate approximately 10 daily vehicle round trips, and is not considered a substantial increase in traffic volumes.

b. See the discussion under part a. above.

c. Since no public airports or private airstrips are located near the project site, no impacts to such facilities would result from the project.

d. The proposed project would include the construction of an access road to the Groundwater Treatment Facility site. The access road would be constructed according to City and County safety standards. If alternative site 5, 6 or 8 was selected, the access road would intersect Somis Road near the transition from 4 to 2 lanes. During construction, heavy-duty trucks entering or exiting the access road from/to Somis Road may result in a traffic hazard. However, a traffic control plan would be developed and implemented as part of an encroachment permit required from Caltrans, and would prevent significant traffic hazards.

e. The proposed project would be manned and may require emergency services. The proposed access road would be suitable for emergency access. The project would not create conditions that would impede emergency access for adjacent land uses.

f. All short-term construction related parking and long-term project operation related parking would be accommodated onsite. Therefore no impacts to parking capacity would result.

g. As discussed in response a. above, the project would result in temporary short-term increases in traffic volumes. However, construction-related traffic would not be of significant levels that would conflict with or impede existing alternative transportation (e.g., mass transit, bicycles, etc.). In addition, the project would not result in obstruction of areas (e.g., bus turnouts, bicycle racks, bicycle lanes, etc.) that support alternative transportation plans, policies or programs. In addition, the project does not include any residential development and would not generate transportation demand.

3.15.2 Further Study

No significant impacts related to traffic/circulation would result; therefore, no further study of this issue is required.

3.16 UTILITIES AND SERVICE SYSTEMS

Would the project:	Potentially Significant Impact	Less than Significant Impact with Mitigation	Less than Significant Impact	No Impact
a. Exceed wastewater treatment requirements of the applicable Regional Water Quality Control Board?	☐	☐	☐	☒
b. Require or result in the construction of new water or wastewater treatment facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?	☐	☐	☐	☒
c. Require or result in the construction of new storm water drainage facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?	☐	☐	☐	☒
d. Have sufficient water supplies available to serve the project from existing entitlements and resources, or are new or expanded entitlements needed?	☐	☐	☐	☒
e. Result in a determination by the wastewater treatment provider which serves or may serve the project that it has adequate capacity to serve the project's projected demand in addition to the provider's existing commitments?	☐	☐	☐	☒
f. Be served by a landfill with sufficient permitted capacity to accommodate the projects solid waste disposal needs?	☐	☐	☒	☐
g. Comply with federal, state, and local statutes and regulations related to solid waste?	☐	☐	☐	☒

3.16.1 Impact Analysis

a. ~~Wastewater generation would be limited to occasional use of on-site sanitary facilities by operations and maintenance staff. This wastewater would drain to a sanitary collection tank, and would be periodically trucked offsite for disposal at an approved facility~~. Wastewater (brine) generated by groundwater treatment is addressed in Section 3.8.1.a. Proposed restroom facilities would generate small volumes of municipal wastewater, which would not exceed wastewater treatment requirements. Considering the above, the project would not result in any impacts to wastewater facilities.

b. The Groundwater Treatment Facility would be provided with a restroom, with wastewater treated at the Camarillo Sanitary District facilities. No new water or wastewater treatment facilities would be required for the proposed project.

c. The project would not require the construction or modification of public storm water drainage facilities. No impacts would result.

d. The project would result in a beneficial impact to public water supply by facilitating more effective use of State water and groundwater. Only minimal amounts of water would be used on site, as part of water quality testing. This would not require new water entitlements or sources.

e. See response b.

f. Any project that generates solid waste would have an impact on the demand for solid waste disposal capacity in Ventura County. The Countywide Siting Element approved by the California Integrated Waste Management Board on June 20, 2001 demonstrates that the approval of extension of the existing Solid Waste Facility Permit for the Simi Valley Landfill and Recycling Center, combined with the existing permitted capacity of the Toland Road Landfill would provide Ventura County with sufficient disposal capacity beyond the 15 year planning period mandated by State law. Therefore, no individual project would have a significant impact on the demand for solid waste capacity.

g. The City of Camarillo complies with all federal, state and local statutes relating to solid waste, and would continue to do so during the operation of the proposed project. As such, no impacts of this type are expected to result.

3.16.2 Further Study

The project would not result in significant impacts to utilities or services. No further study of this issue is required.

4.0 CUMULATIVE IMPACTS

Cumulative impacts are defined as two or more individual effects which, when considered together are considerable, or which compound or increase other environmental impacts. Under Section 15064 of the State CEQA Guidelines, the lead agency (City of Camarillo) must identify cumulative impacts, determine their significance and determine if the effects of the project are cumulatively considerable.

4.1 DESCRIPTION OF CUMULATIVE PROJECTS

~~To be added~~ A list of other projects proposed or recently approved in the vicinity of the selected project site will be developed as part of the EIR.

4.2 DISCUSSION OF CUMULATIVE IMPACTS

~~To be added~~ An analysis of the cumulative impacts of the proposed project in combination with other projects proposed or recently approved in the vicinity of the selected project site will be provided in the EIR.

5.0 MANDATORY FINDINGS OF SIGNIFICANCE

MANDATORY FINDINGS OF SIGNIFICANCE –	Potentially Significant Impact	Less than Significant Impact with Mitigation	Less than Significant Impact	No Impact
a. Does the project have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, reduce the number or restrict the range of a rare or endangered plant or animal or eliminate important examples of the major periods of California history or prehistory?	☒	☐	☐	☐
b. Does the project have impacts that are individually limited, but cumulatively considerable? ("Cumulatively considerable" means that the incremental effects of a project are considerable when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probable future projects)?	☐	☐	☒	☐
c. Does the project have environmental effects that will cause substantial adverse effects on human beings, either directly or indirectly?	☒	☐	☐	☐

a. Based on preliminary analysis, the project may result in significant impacts to the quality of the environment, including potential disturbance of cultural resources.

b. The project is unlikely to ~~would not~~ result in significant cumulative impacts. The significance of cumulative impacts will determined as part of the EIR.

c. The project may have substantial direct or indirect adverse effects (i.e., significant impacts) on human beings associated with hazardous materials, flooding and noise.

6.0 DETERMINATION OF ENVIRONMENTAL DOCUMENT

On the basis of this evaluation:

[ ] I find the proposed project COULD NOT have a significant effect on the environment, and a NEGATIVE DECLARATION should be prepared.

[ ] I find that although the proposed project could have a significant impact on the environment, there will not be a significant effect with the implementation of mitigation measures described in this Initial Study. A MITIGATED NEGATIVE DECLARATION should be prepared.

[X] I find the proposed project, individually and/or cumulatively, MAY have a significant effect on the environment and an ENVIRONMENTAL IMPACT REPORT is required.

Signature of Person Responsible for Administering the Project — Date: 4/10/2008

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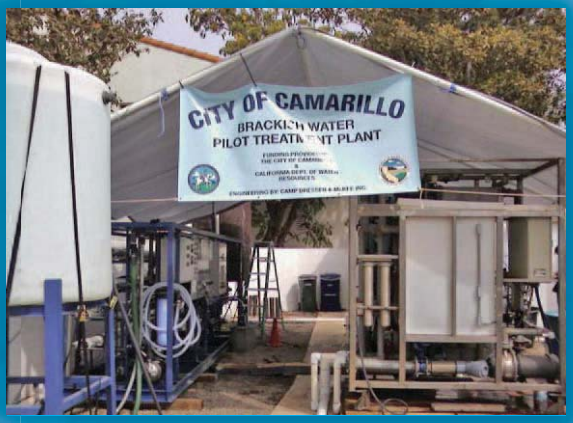
FINAL

CITY OF CAMARILLO

Brackish Water Desalination Pilot Study



CDM in association with Trussell TECHNOLOGIES INC

January 2009

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List of Acronyms and Abbreviations

Avg	Average
$CaCO_3$	Calcium Carbonate
CCL	Contaminant Candidate List
CDPH	California Department of Public Health
CF	Cartridge Filter
CIP	Clean-In-Place
Cl_2	Chlorine
ClO_2	Chlorine Dioxide
CMWD	Calleguas Municipal Water District
CT	Contact Time
CU	Color Unit
CWD	Camarillo Water Division
CWRP	Camarillo Water Reclamation Plant
DBP	Disinfection Byproduct
DHS	Department of Health Services
DLR	Detection Limit for the Purpose of Reporting
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
DPH	Department of Public Health
DWR	Department of Water Resources
EBCT	Empty Bed Contact Time
EPA	Environmental Protection Agency
EQ	Equalization
Fe	Iron
gfd	gallons per day per square foot
GMF	Granular Media Filter, Granular Media Filtration
gpd	gallons per day
gpm	gallons per minute
LR	Loading Rate
LSI	Langelier Saturation Index
LT2ESWTR	Long Term 2 Enhanced Surface Water Treatment Rule
max	maximum
MCL	Maximum Contaminant Levels
MEK	Methyl ethyl ketone
MF	Microfiltration
mg/L	milligrams per liter
mgd	million gallons per day
min	minutes, minimum
Mn	Manganese
MTC	Mass Transfer Coefficient

N/A	Not applicable
$Na_2S_2O_3$	Sodium Thiosulfate
$NaHSO_3$	Sodium Bisulfite
NaOH	Caustic Soda, Sodium Hydroxide
ND	Non-detect
NDMA	N-nitroso-dimethylamine
NF	Nanofiltration
NH_3-N	Ammonia Nitrogen
NL	Notification Level
NTU	Nephelolometric Turbidity Units
O_2	Oxygen
OEHHA	Office of Environmental Health Hazard Assessment
P&ID	Process and Instrumentation Diagram
PCA	Possible Contaminating Activity
PFD	Process FlowDiagram
PHG	Public Health Goal
psi	pounds per square inch
PT	Pretreatment
PTF	Pretreatment Feed
PTP	Pretreatment Product
PTW	Pretreatment Waste
PV	Pressure Vessel
PWS	Public Water System
PWT	Professional Water Technologies
QA/QC	Quality Assurance/Quality Control
RL	Reporting Limit
RO	Reverse Osmosis
ROF	Reverse Osmosis Feed
ROP	Reverse Osmosis Permeate, Reverse Osmosis Product
ROW	Reverse Osmosis Waste, Concentrate, Brine
RW	Raw Water
RWQCB	Regional Water Quality Control Board
SLR	Surface Loading Rate
SDI	Silt Density Index
SDS	Simulated Distribution System
SDWA	Safe Drinking Water Act
sf	square foot
Siemens	Siemens Water Technologies
TBD	To Be Determined
TDS	Total Dissolved Solids
TMDL	Total Maximum Daily Load
TMP	Transmembrane Pressure
TOC	Total Organic Carbon
TSS	Total Suspended Solids

THM	Trihalomethane
TTHM	Total Traihalomethane
UCMR 1	Unregulated Contaminant Monitoring Rule 1
UCMR 2	Unregulated Contaminant Monitoring Rule 2
UV	ultraviolet
WTP	Water Treatment Plant

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Section 1
Project Information

1.1 Overview

This section provides project information, including project type, project title, start/end dates, grantee information, contact person information, grant awarded, and total cost of the project. This section also provides the outline of the report.

1.2 Project Information

The City of Camarillo (City) and Camp Dresser and McKee Inc. (CDM) have conducted a desalination pilot study to test high-pressure membrane technologies in conjunction with various pretreatment options for treating brackish groundwater. The objective was to select a practical and cost-effective treatment technology that allows the City to treat brackish groundwater to produce a reliable high quality drinking water supply. This work was funded by the City through a grant from the California Department of Water Resources (DWR) under the Water Security, Clean Drinking Water, Coastal and Beach Protection Act of 2002, Proposition 50 – Chapter 6, 2006 Water Desalination (Prop 50 grant). The City contracted CDM to design, install, and operate the pilot plant.

Agreement Number:	4600007441
DWR ID Number:	P 2006-14
Project Title:	City of Camarillo Brackish Water Desalination Pilot Study
Grant Awarded:	Proposition 50 – Chapter 6, 2006 Water Desalination
Total Cost of the Project:	$767,744
Start Date of Contract:	April 1, 2007
End Date of Contract:	March 31, 2009
Recipient Organization:	City of Camarillo
Partners:	Camp Dresser and McKee, Inc. Trussell Technologies, Inc.

Contact Person: Lucia McGovern
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1.2 Report Outline

Section 1 of this report presents project information, including project type, title, start/end dates, grantee information, contact person information, grant awarded and the total cost of the project.

Section 2 provides an executive summary of the project, its purpose, and a short description of the main findings/accomplishments.

Section 3 summarizes the goals and objectives of the project.

Section 4 describes project tasks/activities, implementation methods, and procedures.

Section 5 presents the results of the pilot study.

Section 6 describes the outreach activities performed, including presentations of the project to the public, conferences, workshops, coordination with various stakeholders, tours, and ways used to disseminate project results and information.

Section 7 presents the list of project deliverables and materials produced during the project.

Section 8 summarizes the results of the project, challenges and the lessons learned during the project.

Section 9 presents the project budget information including level of project execution and expenditures to date

Section 2
Executive Summary

2.1 Background

In an effort to reduce dependence on imported water, the City of Camarillo (City) has embarked on a groundwater treatment program to develop a reliable, high quality, local water supply. With the State of California experiencing a severe drought and significant water restrictions imposed on imported water supplies, the City's efforts to desalinate groundwater will be a critical aspect of the City's future drinking water supply. The City has contracted with Camp Dresser & McKee, Inc. (CDM) to conduct pilot testing of various groundwater treatment alternatives. This work is a matching funds project, funded by the City and California Department of Water Resources (DWR) under the Water Security, Clean Drinking Water, Coastal and Beach Protection Act of 2002, Proposition 50 – Chapter 6, 2006 Water Desalination (Prop 50 grant).

The City's water supply currently consists of approximately 60 percent imported water, purchased through the Calleguas Municipal Water District (CMWD), and 40 percent local well water produced from two active and one stand-by well. Water quality of two of the City's wells, Well A and Well B, have been steadily deteriorating over the past 18 years. In addition to naturally-occurring high levels of manganese and iron, dramatic increases in total dissolved solids (TDS) have occurred, which are partially attributed to increases in sulfate, chloride and hardness. The increase in TDS for Wells A and B represent a general deterioration in the City's source water that needs to be addressed to comply with state regulations, specifically from the California Department of Public Health (CDPH) and the Los Angeles Regional Water Quality Control Board (RWQCB). A 2005 Groundwater Treatment Facility Feasibility Study indentified reverse osmosis (RO) membrane treatment as the only viable treatment process for this application.

2.2 Project Goals

The final treated water quality goals for this project are presented in Table 2-1, listing the most significant constituents, which exceed CDPH secondary regulations, RWQCB limits, or are significantly different from the imported water the City purchases through CMWD. If the groundwater RO facility meets these water quality objectives, the City will produce a potable water that is safely within all primary and secondary maximum contaminant levels established by CDPH.

Table 2-1
Final Product Water Quality Goals

Constituent	Units	Goal	Imported Water [(2)]
Chloride	Mg/L	65	61
Gross Alpha	pCi/L	12	< 3
Iron	Mg/L	0.2	<0.02
Manganese	Mg/L	0.025 [(1)]	<0.005
pH		> 8.0 [(3)]	8.3
Sulfate	Mg/L	70	52
Total Dissolved Solids	Mg/L	250	267
Total Hardness as $CaCO_3$	Mg/L	75 – 120	112

Notes:
(1) Established as 50% of CDPH MCL
(2) Based on CMWD 2007 Water Quality Report
(3) Final pH depends on finished water hardness and alkalinity, and compatibility with existing distribution system water.

The goal of the pilot study was to test RO and/or nanofiltration (NF) membranes for brackish water desalination in conjunction with various pretreatment options that are designed to protect these membranes from iron and manganese fouling. During the first nine months of pilot testing, the following five pretreatment options were evaluated:

Phase I — Oxygen quenching: dose sodium thiosulfate to quench dissolved oxygen (DO) and keep iron and manganese in reduced state.

Phase II — Aeration plus granular media filtration (GMF): determine if aeration plus GMF will effectively remove iron oxide through the GMF and keep manganese in the reduced state so that it is removed by the RO membranes.

Phase III — Chlorine dioxide plus GMF: determine if chlorine dioxide will oxidize both iron and manganese to allow iron and manganese oxides to be effectively removed by the GMF.

Phase IV — Chlorine plus greensand: evaluate chlorine oxidation of both iron and manganese using a catalytic media such as pure manganese dioxide (pyrolucite).

Phase V — Aeration plus microfiltration (MF): determine if aeration plus MF will effectively remove iron through MF and keep manganese in the reduced state so that it is removed by the RO.

The last three months of the pilot testing were dedicated to the desalination evaluation, in which RO and/or NF membranes were optimized using the selected most effective pretreatment process tested during the five phases of this study and design criteria was established for a full-scale treatment plant.

2.3 Pretreatment Testing

The following conclusions were drawn based on the pretreatment testing:

- Oxygen quenching successfully prevented iron oxidation and thereby prevented metal oxide fouling of the reverse osmosis (RO) membranes.

- Aeration plus media filtration effectively oxidized and removed iron when a minimum of six minutes of contact time was provided. Providing additional contact time, beyond six minutes, did not have significant impact on iron oxidation. However, aeration plus media filtration was problematic because partial manganese oxidation occurred after a certain length of time.

- Complete oxidation of iron with aeration was accomplished with nearly zero minutes of contact time, when the pH was adjusted to 8.0 through the addition of caustic soda. However, raising the pH of the Well A raw water was problematic, as it caused severe scaling in the piping, valves, the granular media filters, and the cartridge filters. This scaling could not be controlled with the addition of antiscalant upstream of the caustic soda injection point.

- Chlorine dioxide feed and media filtration effectively oxidized and removed 100 percent of iron and 70 percent of manganese and appears to have prevented metal oxide fouling of the RO membranes, however, this pretreatment method was problematic due primarily to RO membrane damage. Chlorine dioxide appears to have damaged the RO membranes, as was evident in the steadily increasing permeate conductivities and the gradually increasing membrane permeability (MTC) during the first three weeks of the Phase III testing.

- Chlorine feed with Pyrolox (greensand) media filtration pretreatment was similar in performance to the chlorine dioxide feed plus media filtration pretreatment (Phase III). Both pretreatment processes oxidized and removed 100 percent of total iron and approximately 70 percent of total manganese. The difference was that manganese oxidation occurred in the filtration stage during Phase IV, whereas manganese oxidation occurred prior to the filtration stage during Phase III.

- Chlorine feed plus Pyrolox media filtration pretreatment was partially effective, particularly during the early portion of the testing. However, the two issues of concern for this process are the risk of damaging the RO membranes with chlorine, and the difficulty in maintaining properly functioning media filters. Although the dechlorination process was successful during the pilot study and, therefore, did not cause damage to the RO membranes, the possible failure of a dechlorination

process is risky for a full-scale plant, given the capital investment required to replace damaged RO membranes. The operation of the Pyrolox media filters causes some concern, due to the high backwashing rates and possible air scour systems required to remove iron oxides from the dense media.

- With the aeration and MF pretreatment process, the iron was only partially oxidized by the DO in the contact tank within the 3 to 36 minutes of contact time tested, and additional oxidation of iron was observed within the MF basin, the break tank after the MF, and within the cartridge filters.

- The rate of iron and manganese oxidation was sensitive to the contact time and the concentration of DO in the water. For the aeration followed by MF pretreatment process to completely oxidize and remove the iron, it was determined that the pretreatment feed water must be saturated at approximately 8.7 mg/L of DO, and approximately 35 minutes of contact time must be provided. To provide 35 minutes of contact time in a full-scale plant, a 210,000 gallon capacity tank must be provided.

- Aeration followed by MF was found to be less effective than the aeration followed by media filtration pretreatment process, evaluated in Phase II. Although the MF could be considered a better filtration process than the media filtration, the media filters provide improved oxidation of iron, resulting in greater removal.

- Ultimately, the Phase I approach of oxygen quenching was selected for operation of the RO optimization testing and the future full scale facility.

2.4 RO Optimization Testing

The following conclusions were drawn based on the RO optimization testing:

- Complications were seen in the oxygen quenching pretreatment approach, first with the build-up of biological growth and iron on the cartridge filters, and second with the fouling of second stage membranes. The addition of muriatic acid (HCl) ahead of the cartridge filters, and the reduction of thiosulfate dose to less than 2 mg/L appeared to control the fouling both of the cartridge filters and the RO.

- The oxygen quenching with acid addition pretreatment maintained manganese and iron in the dissolved form and produced stable membrane permeability data for all membrane systems tested, when the feed water pH was adjusted to 6.5 by acid addition. However, when the target feed water pH was adjusted to 6.8, the RO membranes began to foul and the MTC decreased rapidly.

- The Dow RO membrane (model XLE 4040) stabilized at a membrane permeability of 0.15 gfd/psi, while the Saehan RO membrane (model RE 4040 BLR) stabilized around 0.25 gfd/psi. The quality of the Dow RO membrane permeate was superior to the Saehan RO membrane permeate.

- The permeate of the Saehan RO membranes had the highest TDS at 95 mg/L, possibly caused by damage to the RO elements during Phase III testing, when the membranes were exposed to chlorine dioxide. Nonetheless, based on the permeate mineral water quality alone, the Saehan RO membranes performed the worst of the four membranes tested, which is contrary to results of the membrane manufacturers' modeling software.

- Membranes I (Dow XLE 4040) and III (Toray TM710) showed the greatest rejection of boron (50 percent), and because no vanadium was detected in any of the membrane permeates, vanadium performance could not be compared. Regardless, all raw water and membrane permeate samples had boron and vanadium concentrations less than the CDPH notification levels. No additional treatment considerations are recommended based on this emerging contaminant analysis.

- Manganese and sulfate are the limiting constituent for blending, and only 5 to 7 percent of the total flow can be allowed to bypass the RO. Such a bypass flow will result in a blended water TDS between 150 and 200 mg/L, and a blended water hardness between 70 and 80 mg/L, without exceeding any of the finished water quality goals.

2.5 Recommendations and Conclusions

Based on the results of the pilot testing, a treatment train was recommended consisting of oxygen quenching at the wells, acid and antiscalant addition at the treatment facility, and reverse osmosis using standard rejection brackish RO elements (similar to Saehan RE 4040 BLR or Dow XLE 4040). Figure 2-1 presents a process schematic of the recommended treatment approach that was tested during the RO optimization testing. Sodium bisulfite, sodium thiosulfate, or sodium metabisulfite may be utilized for oxygen quenching, however, the most efficient and cost effective chemical should be determined based on bench-top testing with the final source water. Muriatic acid is recommended to depress the pH of the feed water to 6.5. While sulfuric acid is more commonly used at desalination facilities, the high sulfate concentrations in the City wells and concern about the saturation limits of calcium sulfate, make muriatic acid a better approach for the City. Approximately 5 to 7 percent of the well flow should be bypassed around the RO membranes and blended with the permeate to produce a blended product water that is stable, non-corrosive, and in compliance with all of the treatment goals for the facility.

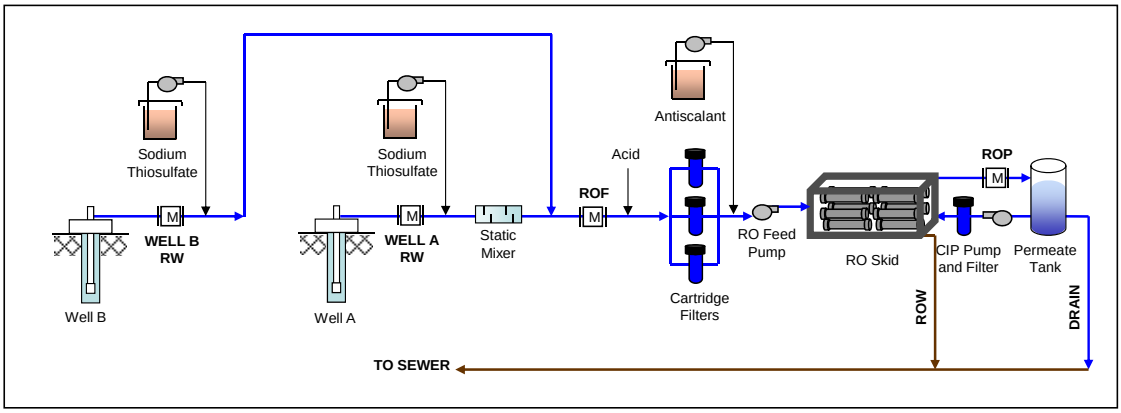


Figure 2-1.
Selected Treatment Approach Process Schematic

Table 2-2 presents the full-scale design flows for the well supplies, treatment plant flows, bypass flow, and final product water flow.

Table 2-2
Design Flows

Stream	**Flow Rate**
Well Production	8.6 mgd
RO Influent (i.e., pre-treated groundwater)	8.3 mgd
RO Permeate (i.e., desalinated groundwater)	6.2 mgd (See Note 1)
Groundwater Blending (i.e., RO bypass, blending at the facility)	0.3 mgd (See Note 2)
Total Plant Product (i.e., RO permeate + groundwater blending)	**6.5 mgd**

Note:
1) Assuming 75% RO permeate water recovery rate.
2) Assuming 5% bypass and blend.

Section 3
Goals and Objectives of the Project

3.1 Overview

This section provides background information including the source water quality, regulatory compliance, and water quality treatment goals. This section also identifies the goals and objectives of the project.

3.2 Background

In an effort to reduce dependence on imported water, the City has embarked on this groundwater treatment program to develop a reliable, high quality, local water supply. With the State of California experiencing a severe drought and significant water restrictions imposed on both major imported water supplies (State Water Project and Colorado River Water), the City's efforts to desalinate groundwater will be a critical aspect of the City's future drinking water supply. The City has contracted with Camp Dresser & McKee, Inc. (CDM) to conduct pilot testing of various groundwater treatment alternatives. This work is funded by the City through a grant from the California Department of Water Resources (DWR) under the Water Security, Clean Drinking Water, Coastal and Beach Protection Act of 2002, Proposition 50 – Chapter 6, 2006 Water Desalination (Prop 50 grant).

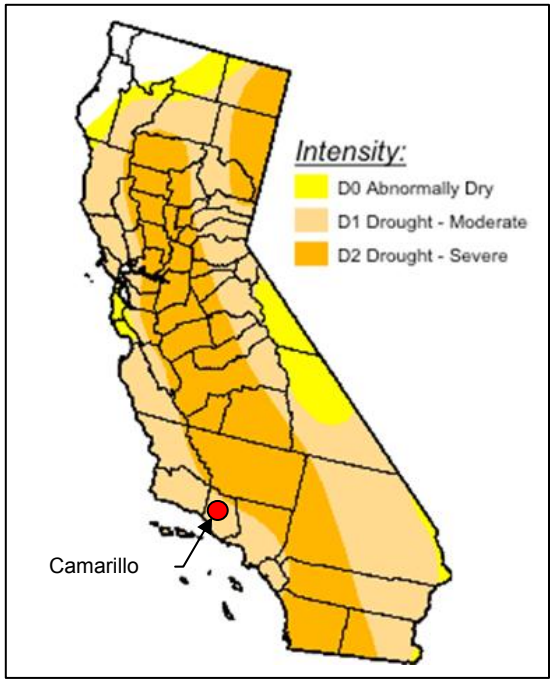


Figure 3-1.
California's Drought Conditions in November 2008
(National Oceanic and Atmospheric Administration, 2008)

3.2.1 Source Water Quality

The City's water supply currently consists of approximately 60 percent imported water, purchased through the Calleguas Municipal Water District (CMWD), and 40 percent local well water produced from two active and one stand-by well. Table 3-1 presents 2007 water quality data from the three City wells (two active and one stand-by) and the imported water supply. Two of the City's wells, Well A and Well B, have been steadily deteriorating in water quality over the past 18 years. In addition to naturally-occurring high levels of manganese and iron, dramatic increases in total dissolved solids (TDS) have occurred, which are partially attributed to increases in sulfate, chloride and hardness. From 1990 to 2008, the TDS concentration in Well A has increased 77 percent from 1000 mg/L to 1768 mg/L. Well B TDS concentrations have increased an even more dramatic 136 percent since 1990 and current TDS is 1414 mg/L. The increase in TDS for Wells A and B represent a general deterioration in the City's source water that needs to be addressed to comply with state regulations, with the only viable treatment process for this application being reverse osmosis (RO) membrane treatment.

Table 3-1.
Summary of Water Quality Data

Constituent	Unit	City of Camarillo Wells			Imported Water
		Well A (1)	Well B (2)	Well D (3)	Calleguas MWD (4)
pH		7.2	7.3	NA	NA
Calcium	mg/L	260	210	87	24
Potassium	mg/L	6.2	5.3	4.5	3
Magnesium	mg/L	80	49	24	12
Sodium	mg/L	190	140	97	50
Strontium	mg/L	1.9	1.4	NA	NA
Fluoride	mg/L	0.24	0.21	0.38	0.1
Alkalinity as $CaCO_3$	mg/L	300	240	230	82
Ammonia as N	mg/L	0.25	0.33	NA	NA
Gross Alpha	pCi/L	15	10	NA	ND
Total Hardness as $CaCO_3$	mg/L	980	730	320	110
Nitrate as NO_3^-	mg/L	0.9	ND	ND	0.6
Total Dissolved Solids	mg/L	1800	1400	700	270
Total Organic Carbon	mg/L	1.6	1.6	NA	2.2
Chloride	mg/L	170	150	60	61
Sulfate	mg/L	840	560	210	52
Total Silica	mg/L	37	36	NA	NA
Barium	mg/L	0.04	0.05	NA	NA
Boron	mg/L	0.70	0.57	NA	0.18
Total Vanadium	mg/L	ND	ND	NA	NA
Total Iron	mg/L	0.22	0.22	0.17	ND
Total Manganese	mg/L	0.22	0.16	0.05	ND

Table 3-1.
Summary of Water Quality Data

Constituent	Unit	City of Camarillo Wells			Imported Water
		Well A (1)	Well B (2)	Well D (3)	Calleguas MWD (4)

Notes:
(1) Average of water quality data from August 1998 through October 2008
(2) Average of water quality data from April 2001 through October 2008
(3) 2007 Average
(4) Based on CMWD 2007 Water Quality Report
ND: Not detectable or below detection limits
NA: Not available

3.2.2 Regulatory Compliance

Wells A and B have existing permits that allow the City to operate these wells to feed directly into the distribution system following the addition of sodium hypochlorite. However, as discussed above, the source water quality has deteriorated to the point that the water quality does not meet the concentrations established in the secondary drinking water standards. Specifically, Well A and B exceed the manganese, sulfate, and total dissolved solids concentrations that are detailed in the California Department of Public Health's (CDPH) literature on drinking water regulations. The City had decommissioned Well A prior to this study due to poor water quality, maintaining it only as an emergency water supply. Observing Table 3-1, Well A has a high enough Gross Alpha level that it is at the primary drinking water standard of 15 pCi/L. Table 3-2 presents the primary and secondary maximum contaminant levels (MCL) set by CDPH for relevant feed water contaminants.

Table 3-2.
Select CDPH Maximum Contaminant Levels

Constituent	Units	Primary MCL	Secondary MCL		
			Recommended	Upper	Short Term
Chloride	mg/L		250	500	600
Gross Alpha	pCi/L	15			
Iron	mg/L			0.3	
Manganese	mg/L			0.05	
Sulfate	mg/L		250	500	600
Total Dissolved Solids	mg/L		500	1000	1500

In addition to the CDPH regulations, the wastewater effluent from the Camarillo Water Reclamation Plant (CWRP) must comply with total maximum daily load (TMDL) limits on a number of parameters, as established by the California Regional Water Quality Control Board (RWQCB). The TMDL limits for chloride, sulfate, and TDS are particularly relevant to the City's drinking water quality, as the primary

method for controlling the CWRP effluent water quality for these parameters will be to limit the water quality in the drinking water supply. Domestic and industrial water uses in the City will add significant quantities of chloride, sulfate and TDS to the water going to the CWRP facility, with the processes in the facility itself adding further to the final concentrations. Water quality monitoring data from 2007, taken from the CWRP effluent and the City drinking water distribution system at 2159 Gorman, indicate that the domestic and industrial water uses in the City and the treatment processes at the CWRP facility add approximately 125 mg/L of chloride, 180 mg/L of sulfate, and 380 mg/L of TDS into the water before being discharged by the CWRP. These effluent TMDL limits require additional constituents to be considered when establishing the drinking water quality treatment objectives. Table 3-3 presents the TMDL limits for these parameters, the estimated incremental increase between the drinking water supply and the wastewater effluent, along with the resulting drinking water objectives.

Table 3-3.
Select CWRP Discharge Limitations

Constituent	Units	Total Maximum Daily Load Limits (1)	Typical Increase (2)	Implied Drinking Water Objective (3)
Chloride	mg/L	190	125	65
Sulfate	mg/L	250	180	70
Total Dissolved Solids	mg/L	850	380	470

Notes:
(1) Established by California Regional Water Quality Control Board, January 2004
(2) Represents the average increase in 2007 between the Camarillo drinking water distribution system measured at 2159 Gorman and the CWRP Effluent
(3) Calculated as the total maximum daily load limit minus the typical increase

3.2.3 Water Quality Treatment Goals

The final treated water quality goals in Table 3-4 were established for the most significant constituents, which exceed secondary maximum contaminant levels, CDPH regulations, TMDL limits, or are significantly different from the imported water the City purchases through CMWD. If the groundwater RO facility meets these water quality goals, the City will produce a potable water quality that is well below all primary and secondary maximum contaminant levels (MCLs) established by CDPH.

Table 3-4.
Final Product Water Quality Goals

Constituent	Units	Goal	Imported Water (2)
Chloride	mg/L	65	61
Gross Alpha	pCi/L	12	< 3
Iron	mg/L	0.2	< 0.02
Manganese	mg/L	0.025 (1)	< 0.005
pH		> 8.0 (3)	8.3
Sulfate	mg/L	70	52
Total Dissolved Solids	mg/L	≤ 250	267
Total Hardness as $CaCO_3$	mg/L	70 – 120	112

Notes:
(1) Established as 50% of CDPH MCL
(2) Based on CMWD 2007 Water Quality Report
(3) Final pH depends on design water quality, distribution system age, pipe/valve components, and composition.

The iron and manganese goals identified above were established below the required secondary MCLs to address colored water issues. It is anticipated that the water quality goal for either manganese or sulfate will control how much water can be bypassed to blend with the RO product water. Manganese, even at low concentrations (below 0.05 mg/L), can be oxidized in the distribution system and result in a fine colloidal form that adsorbs to pipes and settles out in quiescent zones in the distribution system. These "pockets" of manganese turn into pockets of colored water that can cause significant customer complaints. Ideally, the water served in the City would contain non-detect manganese concentrations (< 0.005 mg/L), however, the goal established in Table 3-3 has been set at half the secondary MCL, or 0.025 mg/L.

Goals for hardness and pH were established to produce a water quality that is considered reasonable for distribution and similar to the imported water supply. It should be noted that the final pH target should be determined after the final water quality from the ultimate groundwater RO facility design is determined. This final pH target should then be determined with significant consideration given to the distribution system components and the age of these materials. There are significant concerns that arise from corrosion of lead and copper fittings, iron from any valving or lined ductile iron pipes in the distribution system, or deterioration in the strength of cement asbestos pipes. It is important that the City incorporate a post-treatment process to ensure proper mineral content and select a final product water pH that minimizes any impacts that may occur in the transition to this new water supply while minimizing treatment costs.

3.3 Goals and Objectives of the Pilot Study

The goal of the pilot study was to test reverse osmosis (RO) and/or nanofiltration (NF) membranes for brackish water desalination in conjunction with various pretreatment options that are designed to protect these membranes from fouling. While the majority of the treatment goals for the facility are addressed through the desalination process, pretreatment is required to assure efficient, reliable operation for the downstream RO process. Specifically, many utilities have faced membrane fouling and operational problems from iron or manganese in their water supplies. Other problems have been experienced from biofouling or damage from oxidants used in their pretreatment processes. The selected pretreatment process will need to provide water of a quality acceptable to feed an RO system, and must be reliable, simple to operate, safe, and cost effective. During the first nine months of pilot testing, the following five pretreatment options were evaluated:

Alternative 1 — Oxygen quenching: dose sodium thiosulfate to quench dissolved oxygen (DO) and keep iron and manganese in reduced state (i.e., in solution, not particulate).

Alternative 2 — Aeration plus granular media filtration (GMF): determine if aeration plus GMF will effectively remove iron oxide through the GMF and keep manganese in the reduced state so that it is removed by the RO membranes.

Alternative 3 — Chlorine dioxide plus GMF: determine if chlorine dioxide will oxidize both iron and manganese to allow iron and manganese oxides to be effectively removed by the GMF.

Alternative 4 — Chlorine plus greensand: evaluate chlorine oxidation of both iron and manganese using a catalytic media such as pure manganese dioxide (pyrolucite).

Alternative 5 — Aeration plus microfiltration (MF): determine if aeration plus MF will effectively remove iron through MF and keep manganese in the reduced state so that it is removed by the RO.

The last three months of the pilot testing was dedicated to desalination evaluation, in which the RO and/or NF membranes were optimized and design criteria were established for a full-scale treatment plant. The following presents the specific evaluation criteria that were used to select the most appropriate pretreatment process.

3.3.1 Pretreatment Water Quality Goals

The water quality goals for the pretreatment system relate to the performance and efficiency of the RO system. The following water quality goals were established for the pretreatment systems:

- Particulate Iron < 0.01 mg/L
- Particulate Manganese < 0.005 mg/L
- Silt Density Index (SDI) < 2
- RO Fouling Rate < 0.5 percent per day

Particulate Iron
The particulate iron goal of 0.01 mg/L is based on the accuracy of the testing method, which typically lists the reported detection limit as 0.02 mg/L for both total and dissolved iron. Particulate iron is calculated as the difference between total and dissolved iron. Iron results in the range of 0.01 mg/L or lower cannot be accurately measured, so this treatment goal assures that detectible levels of particulate iron are not present.

Particulate Manganese
The detection limit for manganese is 0.005 mg/L. The treatment goal for particulate manganese was set at the detection limit to ensure that particulate manganese is not present in the RO feed.

Silt Density Index
The SDI test is a direct measure of the short term fouling potential of the water on a membrane disk. SDI values of 3 or lower are typically considered acceptable for RO feed. A goal of 2 has been established for this pilot to ensure that the selected treatment method produces water exceeding the quality typically recommended for RO feed.

RO Fouling Rate
The RO fouling rate is defined here as the percent change in the mass transfer coefficient (MTC) of water across the membranes. A reduced MTC represents a loss of performance (or membrane permeability), requiring more pressure to produce the same amount of water. The fouling rate should be low enough to avoid chemical cleaning of the membranes more frequently than once every 6 months, but ideally the membranes would be capable of running for a year between cleanings. The RO fouling rate goal has been set at 0.5 percent per day.

3.3.2 Reliability

Reliability of the pretreatment system represents the consistency of the water produced by the process, in terms of both quality and quantity. A reliable pretreatment system is not significantly impacted by changes in the raw quality, but produces a steady supply of water for the RO system with a consistent water. A reliable pretreatment system is essential for efficient operation of the downstream RO system. The measure of reliability is more subjective than the specific treatment goals identified above, however, it considers the ability to consistently meet treatment goals over varying operating conditions.

3.3.3 Simplicity and Ease of Operation

Simplicity and ease of operation are important for the pretreatment system, as they will impact both the cost of operating a full scale facility and the risk of unintended operational problems that impact the downstream processes. Simplicity and ease of operation are impacted by the number of unit processes, number and quantities of chemicals used, and by the number and quantity of waste flow streams created by the processes.

3.3.4 Safety

Safety will be the highest priority in operation of any plant, however, treatment processes should be selected which will minimize the risk of safety hazards for the future facility operators. Safety considerations made in evaluating the treatment processes include use of hazardous chemicals, operating pressures, and risk of health impacts to the general public.

3.3.5 Cost

While detailed cost estimates were not developed for each of the pretreatment alternatives, general cost considerations were evaluated from both a capital construction and operating cost perspective.

3.4 Definitions and Equations

The following terms are used in the discussion of the pilot study results:

- Antiscalant – a chemical used to inhibit scaling (i.e., precipitation or crystallization of salt compounds)
- Clean-in-Place (CIP) – the in-situ chemical cleaning of membranes that consists of soaking membranes in one or more chemical solutions (typically acid and caustic solutions) to remove accumulated foulants and restore permeability
- Concentrate – a continuous waste stream, typically containing concentrated dissolved solids, from the membrane process
- Element – an encased spiral-wound membrane module
- Flux – the unit rate at which water passes through the membrane expressed as flow per unit of membrane area (e.g., gallons per square foot per day (gfd))

  Flux = Flow/Membrane Area

- Fouling – the accumulation of contaminants on the membrane surface, within membrane pores, or media surface that inhibits the passage of water

- Microfiltration (MF) – a pressure-driven membrane filtration process that employs hollow-fiber membranes with a pore size range of approximately 0.1 to 0.2 µm (nominally 0.1 µm)

- Mass Transfer Coefficient (MTC) or Permeability – the ability of the membrane to allow the passage or diffusion of a substance (i.e., a gas, a liquid, or solute)

  MTC = Flux * Temperature Correction Factor (25 °C) / TMP

- Nanofiltration (NF) – a pressure-driven membrane separation process that employs the principles of reverse osmosis to remove dissolved contaminants from water

- Net Driving Pressure (NDP) – the pressure available to force water through a semi-permeable NF or RO membrane

  NDP = TMP – Osmotic Pressure

- Normalization – the process of evaluating membrane system performance at a given set of reference conditions (e.g., at standard temperature, per unit pressure, etc.) to directly compare and trend day-to-day performance independent of changes to the actual system operating conditions

- Osmotic Pressure – the amount of pressure that must be applied to stop the natural process of osmosis

- Particulate Iron = Total Iron – Dissolved Iron

- Particulate Manganese = Total Manganese – Dissolved Manganese

- Percent Oxidation = Particulate Iron/Total Iron

- Permeate – a continuous stream of water that passes through a NF or RO membrane

- Recovery – the volumetric percent of feed water that is converted to permeate

  Recovery = Permeate Flow Rate/Feed Flow Rate

- Reverse Osmosis (RO) – the pressure-driven membrane separation process that employs the principles of reverse osmosis (i.e., the passage of water through a semi-permeable membrane against the concentration gradient, achieved by applying pressure greater than the osmotic pressure) to remove dissolved contaminants from water

- Scaling – the precipitation or crystallization of salts on a surface (e.g., on the feed side of a membrane)

- Stage – a group of membrane units operating in parallel
- Transmembrane Pressure (TMP) – the difference in pressure from the feed (or feed-concentrate average) to the permeate across the membrane

  TMP for MF = Feed Pressure – Filtrate Pressure

  TMP for NF or RO = [(Feed Pressure + Concentrate Pressure)/2] – Permeate Pressure

Section 4
Project Implementation

4.1 Overview

This section describes project tasks/activities, implementation methods and procedures. In addition, the descriptions of the pilot plant configuration, equipment, testing phases and schedule are also provided in this section.

4.2 Project Tasks, Implementation Methods and Procedures

The project tasks consist of project management, pilot test preparation, pilot testing, data evaluation, and report development.

4.2.1 Task 1 Project Management

4.2.1.1 General Project Management and Administration

The City and CDM performed daily project administration and management responsibilities including resource management, contract management, monitoring and management of costs, development and submittal of invoices and monthly progress reports, and schedule management.

CDM created the overall project schedule, action item list, and contact information list and updated these as the project progressed.

4.2.1.2 Project Team Coordination and Communication

The City and CDM held monthly progress meetings to discuss recent activities and piloting results, using these discussions to adapt and refine the implementation of the project on an ongoing basis. The topics of discussion at each monthly meeting are summarized below:

- Progress Meeting #1 (April 24, 2007): The topics discussed include the pretreatment processes to be tested, use of Well A and Well B, pilot plant logistics, electrical/power needs, and lab selection for outside analytical tests.

- Progress Meeting #2 (May 15, 2007): The topics discussed include the schedule, deliverables, Well B rehabilitation, pilot plant equipment, CA Department of Water Resources (DWR) involvement, and emerging contaminants evaluation.

- Progress Meeting #3 (June 12, 2007): The topics discussed include the emerging contaminants evaluation, testing protocol, and contact list and communication.

- Progress Meeting #4 (July 10, 2007): The topics discussed include the testing protocol, emerging contaminants evaluation, health and safety (H&S) plan, and pilot plant construction schedule and logistics.

- Progress Meeting #5 (August 14, 2007): The topics discussed include the testing protocol, sulfate concerns, pilot plant installation and startup schedule and logistics, and chlorine dioxide alternatives.

- Progress Meeting #6 (September 11, 2007): The topics discussed include Phase I test operation, well operation and shutdown coordination, pilot plant weekend monitoring and remote monitoring, and sulfate concerns.

- Progress Meeting #7 (October 9, 2007): The topics discussed include the pilot plant operation, well operation and shutdown coordination, pilot plant shut-down and start-up procedures, emergency contact protocol, and aeration pretreatment option.

- Operator Training Workshop (October 9, 2007): The City and CDM also held the Operator Training Workshop on October 9, 2007. The topics covered in the workshop include: project background; pilot study objectives; technology overview of reverse osmosis (RO), aeration, and filtration; and the testing protocol. The training also included a pilot plant site visit, and on-site discussions of the pilot plant equipment and sampling protocol. Approximately 15 City staff and operators attended the workshop.

- Progress Meeting #8 (November 13, 2007): The topics discussed include the Phase I test results, dissolved iron test concerns, Phase II test progress update, and future testing plans.

- Progress Meeting #9 (December 10, 2007): The topics discussed include the emerging contaminants tests results, Phase II test results, City Council site visit, and future testing plans.

- Progress Meeting #10 (January 8, 2008): The topics discussed include the emerging contaminants sampling results, review of Phase II testing results, Phase III testing progress update, and future testing plans.

- Progress Meeting #11 (February 12, 2008): The topics discussed include the updated pilot testing schedule, minimum contact tank volume calculation, and review of Phase III testing results.

- Progress Meeting #12 (March 11, 2008): The topics discussed include the Phase IV testing results and updated pilot testing schedule.

- Progress Meeting #13 (April 8, 2008): The topics discussed include the Phase IV testing results, and future testing plans.

- Progress Meeting #14 (May 13, 2008): The topics discussed include the updated pilot testing schedule, and reviewed of Phase V testing results.

- Progress Meeting #15 (June 17, 2008): The topics discussed include the Phase V testing results, plans for Phase VI RO optimization testing, full scale water treatment plant design implications, full scale plant water quality goals, emerging contaminants sampling schedule, and final report outline.
- Progress Meeting #16 (July 8, 2008): The topics discussed include the review of Phase VI testing results.
- Progress Meeting #17 (August 12, 2008): The topics discussed include the review of Phase VI testing results.
- Progress Meeting #18 (September 11, 2008): The topics discussed include the review of Phase VI testing results.
- Progress Meeting #19 (October 14, 2008): The topics discussed include the review of Phase VI testing results.

4.2.2 Task 2 Pilot Test Preparation

4.2.2.1 Pilot Test Protocol

CDM submitted the draft Testing Protocol to the City in June 2007. The testing Protocol, which is intended to provide a detailed testing program to direct the pilot study, contained the following sections: introduction; testing phases; equipment; operations; data control and management; sampling and monitoring; quality assurance/quality control (QA/QC); schedule, staffing, and communications; and attachments. The draft Testing Protocol was submitted to DWR on June 29, 2007. The draft Testing Protocol was revised in accordance with recommendations made at the July and August progress meetings, and finalized for operation in September 2007. The Testing Protocol, final for operation, was submitted to DWR on October 30, 2007, and is included in Appendix A.

CDM prepared the Health and Safety Plan for the pilot plant site at Well A in June 2007. The Health and Safety Plan was submitted to the City and finalized in July 2007.

Table 4-1 summarizes the pilot plant operation monitoring and water quality test methods that were used during the pilot study.

Table 4-1
Pilot Plant Operation Monitoring and Water Quality Test Methods

Parameter	Sampling Location (1)	Test Method (2)
Pressure (psi)	RW, PTF, PTP, Pre-CF, Post-CF, ROF, RO Interstage, ROW, ROP, RO 1st Stage Permeate, RO 2nd Stage Permeate	Online
Flow (gpm)	PTF, PTP, ROF, RO 2nd Stage Permeate, ROP, ROW	Online

Table 4-1
Pilot Plant Operation Monitoring and Water Quality Test Methods

Parameter	Sampling Location [(1)]	Test Method [(2)]
Tank level (gal or percent full)	Contact tank, equalization tank, chemical feed tanks	Visual
Temp (deg C)	RW	HACH WQ Kit
pH	RW, PTF, PTP, ROF, ROP, ROW	HACH WQ Kit
Conductivity (uS/cm2)	RW, ROF, ROW, ROP, PV-1, PV-2, PV-3, PV-4, PV-5, PV-6	HACH WQ Kit
Dissolved Oxygen (mg/L)	RW, PTF	HACH DO probe
Free Chlorine (mg/L)	PTF, PTP, ROF	DR4000 Method 8021, DPD Method
Chlorine Dioxide (mg/L)	PTF, PTP, ROP	DR4000 Method 10126, DPD Method
Redox Potential/ORP	ROF	HACH WQ Kit
Total Iron (mg/L)	RW, PTF, PTP, ROP, ROW	DR4000 Method 8147, FerroZine Method
Dissolved (Ferrous) Iron (mg/L) [(3)]	RW, PTF, PTP, ROP, ROW	DR4000 Method 8146, 1,10 Phenanthroline Method
Particulate Iron (mg/L)	Calculated value. Particulate Iron = Total Iron – Dissolved Iron	
Total Manganese (mg/L)	RW, PTF, PTP, ROP, ROW	DR4000 Method 8149, PAN Method
Dissolved Manganese (mg/L)	Same samples as above. Measured after filtering the samples.	DR4000 Method 8149, PAN Method
Particulate Manganese (mg/L)	Calculated value. Particulate Manganese = Total Manganese – Dissolved Manganese	
UV254	RW, PTP	DR4000 Method 10054, Direct Reading Method
Apparent Color (CU)	RW, ROF, ROP	DR4000 Method 8025, Platinum-Cobalt Standard Method
Turbidity (NTU)	RW, PTP, ROW	DR4000 Method 10047, Attenuated Radiation Method (Direct Reading)
SDI	ROF	SDI Kit
Alkalinity (mg/L CaCO3)	RW, ROF, ROP, ROW	Outside Lab, SM2320B
Calcium (mg/L)	ROF, ROP, ROW	Outside Lab, EPA 200.7
Magnesium (mg/L)	ROF, ROP, ROW	Outside Lab, EPA 200.7
Total Hardness (mg/L CaCO3)	ROF, ROP, ROW	Outside Lab, EPA 200.7
Sulfate (mg/L)	RW, ROF, ROP, ROW	DR4000 Method 8051, SulfaVer 4 Method; or Outside Lab, EPA 300.0
Silica (mg/L)	ROF, ROP, ROW	DR4000 Method 8185, Silicomolybdate Method; or Outside Lab, EPA 200.7

Table 4-1
Pilot Plant Operation Monitoring and Water Quality Test Methods

Parameter	Sampling Location (1)	Test Method (2)
Chloride (mg/L)	RW, ROF, ROP	DR4000 Method 8113, Mecuric Thiocyanate Method; or Outside Lab, EPA 300.0
Sodium (mg/L)	RW, ROP, ROP	Outside Lab, EPA 200.7
Boron (mg/L)	RW, ROP	Outside Lab, EPA 200.8
Vanadium (mg/L)	RW, ROP	Outside Lab, EPA 200.8
Gross Alpha	RW, ROP	Outside Lab, EPA 900.0
NH3-N (mg/L) (Low)	RW, ROP, ROW	DR4000 Method 8038, Nessler Method; or Outside Lab, EPA 350.1
TSS (mg/L)	RW, PTW, ROF	Outside Lab, SM2540D
TOC (mg/L)	RW, PTP	Outside Lab, SM5310C
TDS (mg/L)	RW, ROP	Outside Lab, SM2540C
Strontium (mg/L)	ROF, ROP, ROW	Outside Lab, EPA 200.7
Barium (mg/L)	ROF, ROP, ROW	Outside Lab, EPA 200.7

Notes:

(1) RW = Raw water, PTF = Pretreatment Feed, PTP = Pretreatment Product, PTW = Pretreatment Waste (backwash waste), ROF = Reverse Osmosis Feed, ROP = Reverse Osmosis Product (permeate), ROW = Reverse Osmosis Waste (Concentrate), CF = cartridge filter (RO skid), PV = RO Pressure Vessel.

(2) DR4000 indicates the HACH DR4000 Spectrophotometer.

(3) The dissolved iron measured in an unfiltered sample using the ferrous iron test method (1,10 Phenanthroline Method) produced similar results as the total iron measured in a filtered sample using the Ferrozine Method, which proved that the 1,10 Phenanthroline Method was a reliable test method for measuring dissolved iron.

4.2.2.2 Emerging Contaminants Evaluation

CDM and its subconsultants submitted the draft Emerging Contaminants Evaluation memorandum to the City in May 2007. The purpose of the emerging contaminants evaluation was to identify pertinent emerging contaminants recommended for monitoring during the pilot study. The draft Emerging Contaminants Evaluation memorandum was submitted to DWR on June 29, 2007, and the final Emerging Contaminants Evaluation memorandum was submitted to DWR on October 30, 2007.

4.2.2.3 System Design and Equipment Procurement

CDM started the pilot system design in May 2007, in conjunction with the development of the Testing Protocol, to facilitate successful implementation of the project. CDM contacted reputable equipment vendors for major pieces of pilot test equipment starting in April 2007, and started procurement in June 2007. Equipment such as the multi-media filters, microfiltration (MF) systems, and RO systems were selected based on cost, availability, and compliance with the project specifications.

CDM selected Weck Laboratories Inc. as the outside laboratory to be used for the pilot sampling analysis.

CDM continued the pilot system design, equipment procurement, and off-site and on-site construction as the project progressed through each pilot testing phase. CDM also continued to procure chemicals, analytical equipment and reagents for field analysis, and sample bottles for outside laboratory analysis throughout the project.

4.2.2.4 Equipment Installation and System Construction

CDM performed equipment installation and off-site and on-site construction of the pilot plant system throughout the project through CDM's specialized pilot plant fabrication group. The pilot plant configuration is described in detail in Section 4.4. Notable events of equipment installation and system construction are listed below in chronological order.

- The City installed power and phone lines at Well A pilot plant site in May 2007, and constructed a transmission pipeline from Well B to Well A pilot plant site in June 2007. The City completed rehabilitation of Well B pump in July 2007.

- CDM completed off-site construction of RO system equipment and on-site installation of pilot plant equipment for Phase I pilot testing on August 30, 2007. CDM started the pilot plant operation on August 31, 2007.

- CDM completed off-site construction and on-site installation of granular media filters for Phase II pilot testing on October 25, 2007.

- CDM replaced the existing Hydranautics RO membranes with the new Saehan RO membranes on January 2, 2008.

- CDM installed a secondary containment pallet for bulk chemical storage and a chemical metering pump for chlorine dioxide (ClO_2) feed during Phase III testing. Two 330-gallon bulk chemical totes containing 0.3 percent chlorine dioxide were delivered separately to the pilot plant site on December 27, 2007 and on January 17, 2008 to be used for Phase III testing. CDM also installed a chemical metering pump and a chemical injection nozzle in the Well A raw water pipe upstream of the chlorine dioxide feed point to feed caustic soda in the Well A raw water for pH adjustment. CDM also changed the overflow piping arrangement on the contact tank and installed an overflow tank and sump pump assembly to use lower overflow levels and thereby test lower contact times.

- CDM removed the existing granular media from the filter vessels and loaded the filter vessels with Pyrolox media on February 18, 2008. CDM also replaced the RO boost pump and two pressure gauges on the RO skid, and installed a new chemical injection port on the pretreatment product water pipe on February 18, 2008.

- Microfiltration (MF) pilot system supplied by Siemens Water Technologies (Siemens) was delivered to the pilot plant site on April 1, 2008. CDM and Siemens completed the installation of the MF system, ancillary equipment and piping on April 4, 2008.
- CDM removed the existing Pyrolox media from the filter vessels and loaded the filter vessels with new dual media (sand and anthracite) on May 29, 2008.
- CDM replaced the existing Saehan RO membranes (model CRM) with new Dow/Filmtec RO membranes (model XLE 4040) in Train A on June 2, 2008.
- CDM installed two pressure gauges on the RO permeate side (stage-2 of both trains) on June 26, 2008.
- CDM replaced the existing Dow/Filmtec RO membranes (model XLE 4040) in Train A with Toray RO membranes (model TM710), and the existing Saehan RO membranes (model RE4040 BLR) in Train B with Dow/Filmetec NF membranes (model NF90) on August 26, 2008.
- CDM fixed the RO boost pump bypass valve and piping, and the low pressure shut-down switch on the RO feed piping on September 26, 2008.

4.2.3 Task 3 Conduct Pilot Testing

4.2.3.1 Pretreatment Evaluation

CDM conducted the five pretreatment evaluation testing from August 31, 2007 through May 23, 2008.

4.2.3.2 New Membrane Element Testing

CDM conducted Phase VI desalination process evaluation testing from June 2, 2008 through October 10, 2008.

4.2.3.3 Decommissioning

CDM removed granular media filters from the pilot plant site on September 26, 2008. CDM removed MF membrane system from the pilot plant site on May 30, 2008.

Decommissioning of the RO equipment is scheduled in December 2008.

4.2.4 Task 4 Data Evaluation

4.2.4.1 Operating Data Evaluation

CDM performed preliminary evaluation of pilot test operating data throughout all testing phases.

4.2.4.2 Water Quality Data Evaluation

CDM performed preliminary evaluation of pilot test water quality data throughout all testing phases.

4.2.5 Task 5 Report Development

4.2.5.1 Draft Report Preparation/Workshop

CDM submitted the draft report to the City on December 4, 2008. The City submitted the draft report to DWR on December 12, 2008.

4.2.5.2 Final Report Preparation

CDM will submit the final report to the City on January 15, 2009. The City will submit the final report to DWR on January 30, 2009.

4.3 Testing Phases

The pilot unit consisted of two overall processes: the pretreatment process and the desalination process. The five pretreatment processes were tested in five testing phases as summarized in Table 4-2.

Table 4-2.
Pretreatment Process Evaluation Testing Phases and Schedule

Testing Phases	Pretreatment Process	Schedule
Phase I.	Oxygen Quenching (Alternative 1)	08/31/07 – 10/23/07
Phase II.	Aeration plus Media Filtration (Alternative 2)	10/30/07 – 01/01/08 02/01/08 – 02/17/08
Phase III.	Chlorine Dioxide Feed plus Media Filtration (Alternative 3)	01/02/08 – 01/31/08
Phase IV.	Chlorine Feed plus Pyrolox Media Filtration (Alternative 4)	02/20/08 – 04/04/08
Phase V.	Aeration plus Microfiltration (Alternative 5)	04/07/08 – 05/23/08

During the last testing phase, Phase VI desalination process evaluation, new RO and NF membranes were tested using the recommended pretreatment process, as shown in Table 4-3.

Table 4-3.
Desalination Process Evaluation Testing Phases and Schedule

Testing Phase	Pretreatment Process	Membranes Tested	Schedule
Phase VI. Desalination Process Evaluation	Aeration plus Media Filtration	Train A: Saehan RO Model RE4040 BLR; Train B: Dow/Filmtec RO Model XLE	06/02/08 – 07/30/08
	Oxygen Quenching		07/31/08 – 08/26/08
		Train A: Toray RO Model TM710; Train B: Dow/Filmtec NF Model NF90	08/26/08 – 10/10/08

The recommended pretreatment process initially selected was aeration plus media filtration. However, based on deteriorating testing results from partial manganese oxidation, the recommended pretreatment process was changed to oxygen quenching.

During the first part of Phase VI testing, Saehan low-pressure brackish water RO membranes (model RE4040 BLR) and Dow/Filmtec RO membranes (model XLE) were tested. During the latter part of Phase VI testing, Toray RO membranes (model TM710) and Dow/Filmtec NF membranes (model NF90) were tested.

Each of the testing phases are described in detail below.

4.3.1 Phase I – Oxygen Quenching (Alternative 1)

The Phase I pretreatment evaluation, which consisted of oxygen quenching followed by reverse osmosis (RO) desalination, was conducted from August 31, 2007 through October 23, 2007.

4.3.1.1 Objectives

Iron and manganese in the well water are generally present in a reduced, soluble state when oxygen is not present, allowing RO membranes to remove the metals along with other dissolved compounds. However, if any oxygen is present in the well or enters the water through the wellhead or transmission line, iron and sometimes manganese may oxidize, creating the risk of excessive, and possibly irreversible fouling on the RO membranes. Because of this, steps are often taken at desalination facilities to prevent oxidation of iron or to increase solubility through pH suppression.

The purpose of the Phase I pretreatment evaluation was to determine if oxygen quenching could prevent oxidation of iron and manganese or if the iron or manganese have already been oxidized in the well or wellhead. The goal of oxygen quenching is to keep iron and manganese dissolved (in the reduced state) so they can be removed by the RO membranes without causing particulate fouling.

4.3.1.2 Description

During this phase of the pilot testing, sodium thiosulfate was introduced into the raw water at each of the wells to quench dissolved oxygen and prevent the oxidation of iron and manganese. Sodium thiosulfate may react with the oxygen by the following reaction, removing it, and preventing it from oxidizing the iron and manganese.

$$2NaOH + Na_2S_2O_3 + 2O_2 \rightarrow 2Na_2SO_4 + H_2O$$

Other oxygen quenching agents, such as sodium bisulfite or sodium metabisulfite, could also be used to prevent oxygen oxidation within transmission lines.

Should this process prove effective, it would eliminate the need to oxidize and filter these metals prior to the desalination step and would significantly decrease the solids and residuals handling needed at the treatment facility. If, however, oxidation of one or both of these metals has already occurred prior to the addition of the sodium thiosulfate, the process cannot be effectively reversed and the treatment approach would be ineffective at preventing fouling.

4.3.1.3 Configuration

Both Well A and Well B raw water (RW) were blended at the pilot plant site and tested during the first half of the Phase I testing, and only Well A water was tested in the second half. For pretreatment, sodium thiosulfate was injected to the raw water close to the wellhead for oxygen quenching. Sodium thiosulfate dose was varied to test the impact of sodium thiosulfate dose on oxygen quenching and prevention of iron oxidation. After oxygen quenching, the RO feed (ROF) water was fed to the cartridge filters, after which antiscalant was injected, and then pumped to the RO membranes. Figure 4-1 presents a simplified schematic of the Phase I treatment process.

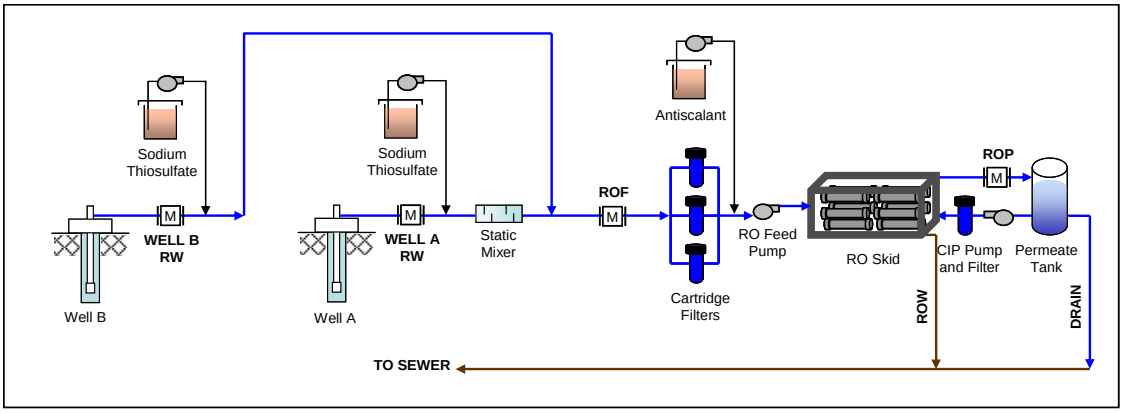


Figure 4-1.
Phase I Oxygen Quenching Process Schematic

4.3.1.4 Operating Conditions

During the Phase I pretreatment evaluation, eight operating conditions were tested, as summarized below in Table 4-4:

Table 4-4.
Phase I – Oxygen Quenching + RO: Operating Conditions

	Time Period	Operating Hours	Sodium Thiosulfate Dose (mg/L)	Well A Flow (gpm)	Well B Flow (gpm)	ROF Flow (gpm)	ROP Flow (gpm)	ROW Flow (gpm)	Recovery (%)
1A	8/31/07 – 9/9/07	~235	33	14	16	27	21	8	73
1B	9/10/07 – 9/14/07	~96	87	12	18	28	21	8	72
1C	9/15/07 – 9/21/07	151	17	14	15	27	21	8	72
1D	9/22/07 – 9/24/07	69	8	30	0	27	20	8	72
1E	9/25/07 – 10/02/07	192	0	18	12	27	20	8	71
1F	10/03/07-10/04/07	52	18	13	15	25	17	8	67
1G	10/5/07-10/19/07	285	19 to 30	20	0	15 to 25	7 to 16	8	46 to 67
1H	10/20/07-10/23/07	86	17	30	0	29	20	8	72

As indicated in Table 4-4 above, during Operating Conditions 1A through 1E, sodium thiosulfate dose was varied between the operating conditions while keeping other conditions, such as feed flow and percent recovery, relatively constant. The sodium thiosulfate feed was stopped during Operating Condition 1E, and restarted during Operating Condition 1F. Well B was taken offline and only Well A water was tested during Operating Conditions 1G and 1H.

During Operating Conditions 1F and 1G, the RO system was operated at decreasing recovery rates and flows due to membrane fouling. During Operating Condition 1G, the recovery rate was decreased to as low as 46 percent and the feed flow to 15 gpm. After the RO membranes were chemically cleaned on October 19, the RO system was restarted under Operating Condition 1H with 72 percent recovery and 30 gpm feed flow.

4.3.1.5 Testing Protocol

Flows, pressures, temperature, chemical storage tank levels, and metering pump settings were recorded daily. pH, conductivity, dissolved oxygen, and oxidation reduction potential (ORP) were measured five times a week. Total iron, dissolved iron, total manganese, UV254, and apparent color were measured for selected sample

streams three times a week. Silt density index (SDI), chloride, silica, sulfate, and ammonia nitrogen were measured once a week.

In addition, weekly samples were sent to an outside lab to test for alkalinity, total hardness, boron, calcium, magnesium, sodium, vanadium, total dissolved solids (TDS), total organic carbon (TOC), and gross alpha. Samples were also tested for iron and manganese at the outside lab to compare against data measured at the pilot plant for QA/QC.

4.3.2 Phase II – Aeration plus Media Filtration (Alternative 2)

The Phase II pretreatment evaluation consisted of aeration plus media filtration pretreatment, followed by reverse osmosis (RO) desalination. The first part of the Phase II pretreatment evaluation was conducted from October 30, 2007 through January 1, 2008, and additional Phase II pretreatment evaluation was conducted from February 1, 2008 through February 17, 2008.

4.3.2.1 Objectives

The purpose of the Phase II pretreatment evaluation was to test if i) iron could be oxidized through aeration and removed through the granular media filtration; and ii) manganese could be kept in the reduced state during the pretreatment stages so that it could be removed by the RO membranes without causing fouling of the RO elements.

The purpose of the additional Phase II pretreatment evaluation was to evaluate i) the impact of the contact time on the oxidation of iron; and ii) the impact of the pH on the oxidation of iron.

4.3.2.2 Description

During this phase of the pilot testing, aeration was used to introduce oxygen to the raw water to oxidize the iron while maintaining manganese in its dissolved state.

Once aeration oxidized the iron, the iron oxide was removed through media filtration before entering the RO process. The soluble manganese passed through the GMF to the RO process. Dual GMF, using a mix of sand and anthracite, was used with a filtration rate of approximately 5 gpm/sf.

The main benefit to aeration is that it is the least costly method of oxidizing iron and no chemicals are needed for oxidation.

The aeration plus media filtration pretreatment process takes advantage of the vast difference of oxidation rates between iron and manganese when air is used for oxidation. Oxidation of iron using oxygen can occur in a matter of seconds, but could take up to 20 minutes, depending on the pH of the aerated water. Oxidation of iron is faster at higher pH. Oxidation of manganese with oxygen will take in excess of 24 hours, and therefore should not be occurring within the pilot system or contributing to membrane fouling in the desalination process.

Dissolved Oxygen Demand

The oxidation of iron with oxygen (O_2) can be described by the following reaction (MWH, 2005):

$$4Fe^{2+} + O_2 + 10H_2O \rightarrow 4Fe(OH)_3 + 8H^+$$

The amount of oxygen required for the oxidation of iron is 0.14 mg O_2/mg Fe^{2+}. Therefore, approximately 0.03 mg/L of oxygen is required to oxidize 0.19 mg/L of iron.

The oxidation of manganese with oxygen can be described by the following reaction (MWH, 2005):

$$2Mn^{2+} + O_2 + 2H_2O \rightarrow 2MnO_2 + 4H^+$$

Although aeration can also be used for the oxidation of manganese, it has been found that the oxidation of manganese with oxygen is slow, even at elevated pH.

4.3.2.3 Configuration

Only Well A water was tested during the additional Phase II testing. Well A raw water (RW) was aerated using an eductor, upstream of the static mixer and the contact tank. Three overflows on the contact tank at different levels (full tank, 1/2 tank, and 1/3 tank) were used to vary the contact time (i.e., hydraulic residence time) for iron oxidation to occur. From the contact tank, the pretreatment feed (PTF) water was pumped and filtered through the granular media filters (GMFs) in parallel. To test close to zero minutes of contact time, the contact tank was bypassed and the pretreatment feed water was fed through the GMFs using the pressure in Well A raw water pipe. The hydraulic loading rate through the GMFs was varied by using two or three GMFs. After granular media filtration, the pretreatment product (PTP) water was fed through the cartridge filters, after which the antiscalant was injected, and the RO feed (ROF) water was then pumped to the RO membranes. Figure 4-2 presents a simplified schematic of the Phase II treatment process.

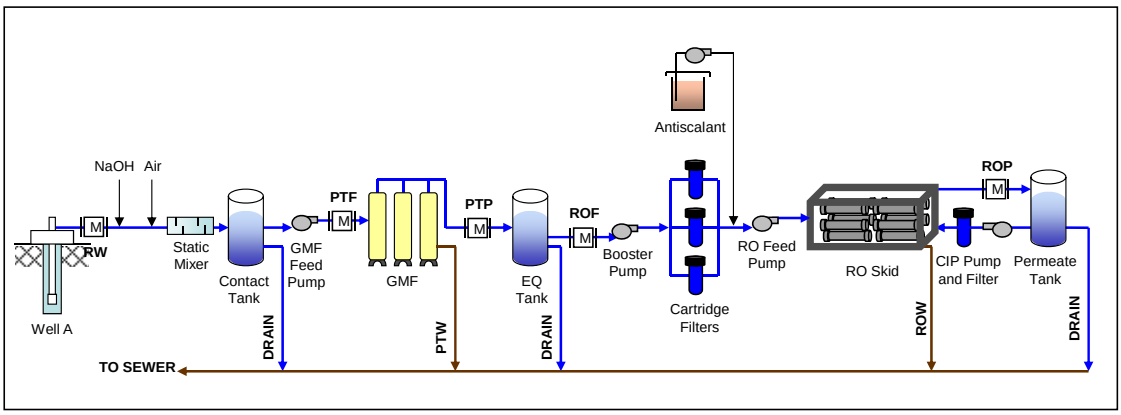


Figure 4-2.
Phase II Aeration plus Media Filtration Process Schematic

In addition, to test the impact of pH on the oxidation of iron, caustic soda (NaOH) was fed to Well A raw water, upstream of aeration.

4.3.2.4 Operating Conditions

The variables tested during the Phase II pretreatment evaluation were: Well A raw water pH, contact time, GMF loading rate, and the RO operating parameters. These variables are listed in Table 4-5, which summarizes the pilot plant operating conditions for all of Phase II pretreatment evaluation.

Table 4-5.
Phase II – Aeration + Media Filtration + RO: Operating Conditions

	Time Period	Operating Hours	NaOH Feed	PTF pH	Contact Time (min)	No. of GMF Used	GMF Loading Rate (gpm/sf)	EQ Tank Used	Antiscalant Feed Location	RW Flow (gpm)	PTF Flow (gpm)	ROF Flow (gpm)	ROP Flow (gpm)	ROW Flow (gpm)	Recovery (%)
2A	10/30/07 – 11/09/07	233	No	7.7	30	3	3.5	Yes	ROF	37	33	28	20	8	71
2B	11/10/07 – 11/20/07	261	No	7.7	29	2	5.1	No	ROF	38	32	26	18	8	69
2C	11/21/07	25	No	7.8	0	3	3.2	No	ROF	30	31	24	16	8	66
2D	11/22/07 – 11/29/07	190	No	7.7	22	3	3.4	No	ROF	51	32	24	16	8	66
2E	11/30/07 – 12/18/07	447	No	7.2	21	3	3.3	No	ROF	54	31	30	21	9	71
2F	12/19/08 – 1/1/08	291	No	7.4	21	2	4.1	No	ROF	52	26	28	20	8	71
2G	2/1/08	23	No	7.3	6	2	5.6	Yes	ROF	55	35	29	21	8	74
2H	2/2/08 – 2/5/08	92	No	7.4	10	2	5.4	Yes	ROF	36	35	28	21	8	74
2J	2/6/08 – 2/8/08	79	Yes	8.0	9	2	4.6	No	RW	38	34	28	21	8	74
2K	2/9/08 – 2/10/08	65	No	n/a	10	3	3.1	No	RW	35	29	28	21	8	74
2L	2/11/08	4	Yes	8.0	0	3	3.1	No	RW	28	29	29	21	8	74
2M	2/12/08 – 2/17/08	141	No	7.5	9	3	3.0	No	ROF	51	28	28	21	8	74

- **Adjusting the pH of Well A Raw Water and Feeding Antiscalant Upstream of Aeration –** The pH of the Well A raw water and the location of antiscalant feed were varied as summarized in Table 4-6. For most operating conditions, the pH of Well A raw water was not adjusted, and the antiscalant was fed in the RO feed water, upstream of the RO. During operating conditions 2J and 2L, caustic soda was added upstream of the aeration point to raise the pH of Well A raw water to pH 8, and the antiscalant feed location was moved to the Well A raw water. This test was designed to evaluate i) whether improved iron oxidation could be achieved at a more optimal oxidation pH, and ii) whether antiscalant has any impact on iron oxidation.

Table 4-6.
Phase II – Aeration + Media Filtration: pH Adjustment

PTF pH	NaOH Feed	Antiscalant Feed Location	Operating Conditions
7.3 to 7.5	No	ROF (Upstream of RO)	2E, 2F, 2G 2H, 2M
7.7 to 7.8	No	ROF (Upstream of RO)	2A, 2B, 2C, 2D
8.0	Yes	RW (Upstream of Aeration)	2J, 2L

- **Contact Time –** The contact time (hydraulic residence time in the contact tank located downstream of aeration and upstream of the GMFs) was varied to evaluate the impact of reaction time on iron oxidation, as summarized in Table 4-7.

Table 4-7.
Phase II – Aeration + Media Filtration: Contact Time

Contact Time (min)	Operating Conditions
29 to 30	2A, 2B
21 to 22	2D, 2E, 2F
9 to 10	2H, 2J, 2K, 2L
6	2G
0	2C, 2L

- **GMF Loading Rate –** The hydraulic loading rates for the GMFs were varied as summarized in Table 4-8.

Table 4-8.
Phase II – Aeration + Media Filtration: GMF Loading Rate

GMF Loading Rate (gpm/sf)	Operating Conditions
3.0 to 3.5	2A, 2C, 2D, 2E, 2K, 2L, 2M
4.1 to 4.6	2F, 2J
5.1 to 5.6	2B, 2G, 2H

4.3.2.5 Testing Protocol

Flows, pressures, temperature, chemical storage tank levels, and metering pump settings were recorded daily. pH, conductivity, dissolved oxygen, and turbidity were measured five times a week. Total iron, dissolved iron, total manganese, dissolved manganese, UV254, and apparent color were measured for selected sample streams three times a week.

Silt density index (SDI) was measured once a week. Chloride, silica, sulfate, and ammonia nitrogen were measured once a week until the third week of December 2007. In addition to the tests performed at the pilot plant lab, samples were sent to an outside lab to test for alkalinity, total hardness, boron, calcium, magnesium, sodium, vanadium, total dissolved solids (TDS), total organic carbon (TOC), and gross alpha. These outside lab tests were performed once a week until third week of December 2007. Starting the fourth week of December 2007, the frequency of all weekly tests, except the SDI test, was reduced to monthly.

Samples were also tested for iron and manganese at the outside lab to compare against data measured at the pilot plant for QA/QC once during Phase II testing.

4.3.3 Phase III – Chlorine Dioxide Feed plus Media Filtration (Alternative 3)

The Phase III pretreatment evaluation, which consisted of chlorine dioxide (ClO_2) injection plus media filtration pretreatment followed by reverse osmosis (RO) desalination, was conducted from January 2, 2008 through January 31, 2008.

4.3.3.1 Objectives

The purpose of this pretreatment evaluation was to test if both iron and manganese could be oxidized by adding chlorine dioxide and removed through the granular media filtration while preventing fouling or damage to the desalination process.

4.3.3.2 Description

Chlorine dioxide is a strong oxidant that quickly oxidizes both iron and manganese. Oxidized iron and manganese are removed by the granular media filters (GMFs), preventing fouling on the RO elements. While RO elements are generally reported to be resistant to damage from chlorine dioxide, ultra-pure solutions are required to prevent damage caused by residual levels of free chlorine or other oxidants. Chlorine dioxide was delivered in bulk at 0.3 percent concentration and 99.7 percent pure chlorine-free chlorine dioxide.

Chlorine Dioxide Dose and Demand

The oxidation of iron and manganese with chlorine dioxide can be described by the following reactions:

$$ClO_2 + Fe^{2+} \rightarrow ClO_2^- + Fe^{3+}$$

$$2ClO_2 + Mn^{2+} \rightarrow 2ClO_2^- + Mn^{4+}$$

The typical chlorine dioxide doses that have been reported for the oxidation of iron and manganese are 1.2 mg ClO_2/mg Fe^{2+} and 2.5 mg ClO_2/mg Mn^{2+}, respectively (MWH, 2005).

4.3.3.3 Configuration

Only Well A water was tested during Phase III testing. Chlorine dioxide was injected into Well A raw water (RW), upstream of the static mixer and the contact tank. Three overflows on the contact tank at different levels (full tank, 1/2 tank, and 1/3 tank) were used to vary the contact time (i.e., hydraulic residence time) for iron and manganese oxidations to occur. From the contact tank, the pretreatment feed (PTF) water was pumped and filtered through the GMFs operated in parallel. To test close to zero minutes of contact time, the contact tank was bypassed and the pretreatment feed water was fed through the GMFs using the pressure in Well A raw water pipe. The hydraulic loading rate through the GMFs was varied by using two or three GMFs. After granular media filtration, the pretreatment product (PTP) water was fed through the cartridge filters, after which the antiscalant was injected, and the RO feed (ROF) water was then pumped to the RO membranes. Figure 4-3 presents a simplified schematic of the Phase III treatment process.

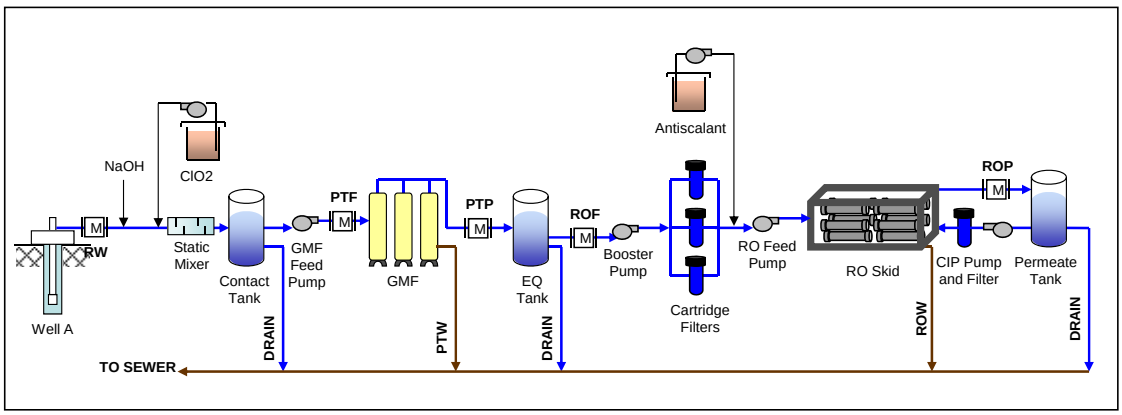


Figure 4-3.
Phase III Chlorine Dioxide Feed plus Media Filtration Process Schematic

In addition to the regular Phase III pretreatment process of chlorine dioxide injection plus media filtration, sodium thiosulfate feed upstream of the cartridge filters and caustic soda (NaOH) feed upstream of the chlorine dioxide feed point were also tested to evaluate the effects of quenching chlorine dioxide residual in the RO feed sample, and of raising the pH of Well A raw water to pH 8, respectively.

The test variables of the Phase III pretreatment evaluation were: Well A raw water pH, chlorine dioxide dose, chlorine dioxide contact time, GMF loading rate, sodium thiosulfate feed, and the RO operating parameters.

4.3.3.4 Operating Conditions

The operating conditions tested during the Phase III pretreatment evaluation are summarized in Table 4-9:

- **Chlorine Dioxide Dose –** The chlorine dioxide feed rate was adjusted on a daily basis to maintain a 1.5 mg/L concentration in the pretreatment feed water sampled downstream of the contact tank. On average, the chlorine dioxide dose was 1.7 mg/L, the chlorine dioxide level measured in the pretreatment feed sample was 1.4 mg/L, and the chlorine dioxide residual measured in the RO feed sample was 0.3 mg/L.

- **Contact Time –** During operating conditions 3A through 3G, the chlorine dioxide contact time was maintained at approximately 37 minutes. During operating conditions 3H, 3J, 3K and 3L, the contact time was reduced to 17 minutes, 15 minutes, 10 minutes and 6 minutes, respectively. During operating condition 3M, the contact time was reduced to near zero minutes by bypassing the contact tank. The contact time was varied to evaluate the impact of reaction time on manganese oxidation.

- **GMF Loading Rate –** During operating conditions 3A through 3C and 3H through 3L, two GMFs were operated at hydraulic loading rates ranging from 4.5 to 5.5 gpm/sf. During operating conditions 3D through 3G, three GMFs were operated at hydraulic loading rates ranging from 3.0 to 3.2 gpm/sf.

- **Quenching Chlorine Dioxide Residual –** During operating condition 3A, sodium thiosulfate was added upstream of the cartridge filters to quench the chlorine dioxide residual in the RO feed water. The purpose of this was to protect the membranes from potential oxidation damage during the initial stage of operation until it could be confirmed that stable operation was achieved.

- **Adjusting the Well A Raw Water pH –** During operating conditions 3D through 3F, caustic soda was added upstream of the chlorine dioxide feed point to raise the pH of Well A raw water to pH 8. This test was designed to evaluate whether improved manganese oxidation could be achieved at a more optimal oxidation pH.

Table 4-9.
Phase III – ClO2 + Media Filtration + RO: Operating Conditions

	Time Period	Operating Hours	ClO_2 Dose (mg/L)	Contact Time (min)	No. of GMF Used	GMF Loading Rate (gpm/sf)	NaOH Feed	PTF pH	Sodium Thiosulfate Feed	EQ Tank Used	RW Flow (gpm)	PTF Flow (gpm)	ROF Flow (gpm)	ROP Flow (gpm)	ROW Flow (gpm)	Recovery (%)
3A	01/02/08-01/07/08	115	1.8	36	2	4.7	No	7.3	6.8 mg/L	No	30	30	28	23	8.0	74
3B	01/08/08-01/11/08	87	1.7	38	2	4.6	No	7.3	No	No	29	29	28	22	7.8	74
3C	01/11/08-01/13/08	66	1.7	36	2	5.1	Yes	8.1	No	No	31	32	27	23	7.3	76
3D	01/14/08-01/15/08	23	1.8	38	3	3.0	Yes	8.1	No	No	29	28	27	21	7.2	75
3E	01/16/08	18	0	38	3	3.0	No	7.1	No	No	29	29	27	22	7.5	74
3F	01/17/08-01/22/08	116	2.1	38	3	3.0	No	7.3	No	No	29	29	28	21	7.6	74
3G	01/23/08	23	1.9	17	3	3.2	No	7.3	No	No	32	30	29	23	8.0	74
3H	01/24/08	20	1.8	15	2	4.5	No	7.3	No	No	36	29	29	21	7.5	74
3J	01/25/08	25	1.6	10	2	4.6	No	7.3	No	No	39	29	28	21	7.5	74
3K	01/28/08	29	1.3	6	2	5.6	No	7.4	No	Yes	62	35	28	21	7.5	74
3L	01/29/07-01/31/08	64	0.9 to 1.4	0	2	4.5	No	7.3	No	No	50 to 56	28	28	21	7.3	74

4.3.3.5 Testing Protocol

Flows, pressures, temperature, chemical storage tank levels, and metering pump settings were recorded daily. Chlorine dioxide concentrations, pH, and conductivity were measured five times a week. Also, during this phase, total iron, dissolved iron, total manganese, dissolved manganese, UV254, and apparent color were measured for selected sample streams four to five times a week.

Silt density index (SDI) was measured once a week. Chloride, silica, sulfate, and ammonia nitrogen were measured once a month. In addition to the tests performed at the pilot plant lab, samples were sent to an outside lab once a month to test for alkalinity, total hardness, boron, calcium, magnesium, sodium, vanadium, total dissolved solids (TDS), total organic carbon (TOC), and gross alpha. Also, filtered and unfiltered samples of raw water, pretreatment feed, RO feed, RO permeate and RO waste were sent to the outside lab for QA/QC of the iron and manganese tests.

4.3.4 Phase IV – Chlorine Feed plus Pyrolox Media Filtration (Alternative 4)

The Phase IV pretreatment evaluation, which consisted of chlorine (Cl_2) injection plus Pyrolox media filtration pretreatment followed by reverse osmosis (RO) desalination, was conducted from February 20, 2008 to April 4, 2008.

4.3.4.1 Objectives

The purpose of Phase IV pretreatment evaluation was to test if iron and manganese could be oxidized by adding chlorine and removed using Pyrolox media filtration while preventing fouling or damage to the desalination process.

Oxidation of both iron and manganese using chlorine and catalytic media, such as pure or partially pure manganese dioxide (pyrolucite) or greensand, is the process used most commonly for removing iron and manganese from groundwater.

Similar to Phase III, this process would remove iron and manganese prior to desalination, however, the process requires a dechlorination step, using sodium bisulfite ahead of the RO membranes, to prevent damage to the membranes. Chlorine damage is a common concern for RO membrane manufacturers, some of whom will require a warranty clause exempting them from damage caused due to the dechlorination system failure.

4.3.4.2 Description

Sodium hypochlorite is used to oxidize iron and manganese in the raw water prior to filtration. While oxidation of manganese using chlorine can take in excess of 30 minutes to occur, pyrolucite-based media have proven effective at accelerating this process to occur within seconds. This phase employed the same GMF used during the Phases II and III, with the media replaced with a pyrolucite-based media (Pyrolox).

Chlorine Dose and Demand

Iron Oxidation: The oxidation of iron with chlorine can be described by the reaction:

$$2Fe^{2+} + Cl_2 \rightarrow 2Fe^{3+} + 2Cl^-$$

The amount of chlorine required for the oxidation of iron is 0.63 mg Cl_2/mg Fe^{2+} (MWH, 2005).

Manganese Oxidation: The oxidation of manganese with chlorine enhanced by filtration through media coated with MnO_2 can be described by the following two-step reactions:

Step 1: Adsorption of Mn^{2+} on the MnO_2 surface:

$$Mn^{2+} + MnO(OH)_2 \leftrightarrow MnO_2MnO + 2H^+$$

Step 2: Oxidation of the adsorbed species by chlorine:

$$MnO_2MnO + Cl_2 + H_2O \leftrightarrow 2MnO_2 + 2HCl$$

The amount of chlorine required for the oxidation of manganese is about 1.29 mg Cl_2/mg Mn^{2+} (MWH, 2005).

Sodium Bisulfite Demand

Sodium bisulfite is added to the filtered water upstream of the equalization tank to quench the residual chlorine and prevent damage to the RO membranes. This reaction is summarized below.

$$NaHSO_3 + HOCl \rightarrow NaHSO_4 + HCl$$

4.3.4.3 Configuration

Only Well A water was tested during Phase IV testing. Chlorine was injected into Well A raw water (RW), upstream of the static mixer and the contact tank. Three overflows on the contact tank at different levels (full tank, 1/2 tank, and 1/3 tank) were used to vary the contact time (i.e., hydraulic residence time) for iron and manganese oxidations to occur. From the contact tank, the pretreatment feed (PTF) water was pumped and filtered through the granular media filters (GMFs) with Pyrolox media operated in parallel. The hydraulic loading rate through the GMFs was kept constant by using three GMFs during the whole phase. After granular media filtration, sodium thiosulfate or sodium bisulfite was fed to the pretreatment product (PTP) water to quench the residual chlorine. After dechlorination, the pretreatment product water was fed through the cartridge filters, after which the antiscalant was injected, and the RO feed (ROF) water was then pumped to the RO membranes. Figure 4-4 presents a simplified schematic of the treatment process.

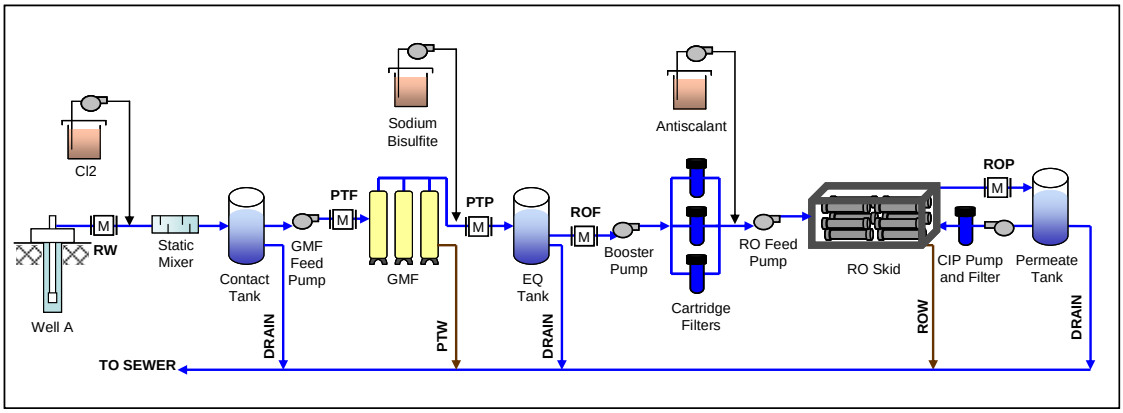


Figure 4-4.
Phase IV Chlorine Feed plus Pyrolox Media Filtration Process Schematic

The test variables of the Phase IV pretreatment evaluation are: chlorine dose, and contact time.

4.3.4.4 Operating Conditions

The operating conditions tested during Phase IV pretreatment evaluation are summarized in Table 4-10:

Table 4-10.
Phase IV – Cl2 + Pyrolox Media Filtration + RO: Operating Conditions

	Time Period	Operating Hours	Chlorine Dose (mg/L)	Contact Time (min)	No. of GMF Used	Pyrolox Media Filtration Loading Rate (gpm/sf)	Thiosulfate /Bisulfite Feed	Antiscalant Dose (mg/L)	RW Flow (gpm)	PTF Flow (gpm)	ROF Flow (gpm)	ROP Flow (gpm)	ROW Flow (gpm)	Recovery (%)
4A	2/20/08 – 3/12/08	321	1.0	15	3	3.1	Thiosulfate, 15 mg/L	1.1	37	30	27	21	8	74
4B	3/13/08-3/17/08	97	1.1	10	3	3.2	Thiosulfate, 14 mg/L	1.5	37	30	21	13	6	65
4C	3/18/08-3/19/08	38	1.2	15	3	3.2	Thiosulfate, 12 mg/L	0.9	37	30	31	20	7	74
4D	3/19/08-3/20/08	25	1.9	15	3	3.2	Thiosulfate, 24 mg/L	1.0	37	30	29	21	8	73
4E	3/21/08	19	4.4	16	3	3.2	Bisulfite, 3.3 mg/L	0.9	34	30	31	21	8	74
4F	3/24/08-3/25/08	17	2.4	15	3	3.2	Bisulfite, 6.6 mg/L	0.9	37	30	34	23	8	74
4G	3/26/08-3/28/08	73	1.8	15	3	3.3	Bisulfite, 1.7 mg/L	0.9	36	31	32	22	8	74
4H	3/29/08-3/30/08	45	1.5	15	3	3.3	Bisulfite, 1.7 mg/L	0.9	38	31	32	21	7	74
4J	3/31/08-4/2/08	72	1.5	10	3	3.4	Bisulfite, 1.7 mg/L	0.9	36	32	33	23	8	74
4K	4/3/08-4/4/08	49	1.8	7	3	3.5	Bisulfite, 1.7 mg/L	1.3	60	33	31	22	8	75

- **Chlorine Dose –** Chlorine was dosed at 1.0 to 4.4 mg/L as shown below:

Table 4-11.
Phase IV – Cl2 + Pyrolox Media Filtration: Average Chlorine Dose

Chlorine Dose (mg/L)	Operating Conditions
1.0 to 1.2	4A, 4B, 4C
1.5	4H, 4J
1.8 to 1.9	4D, 4G, 4K
2.4	4F
4.4	4E

- **Contact Time –** The contact time (hydraulic residence time in the contact tank located downstream of chlorine injection and upstream of the Pyrolox media filters) was varied to evaluate the impact of reaction time on manganese oxidation, as summarized in Table 4-12.

Table 4-12.
Phase IV – Cl2 + Pyrolox Media Filtration: Contact Time

Contact Time (min)	Operating Conditions
7	4K
10	4B, 4J
15 to 16	4A, 4C, 4D, 4E, 4F, 4G, 4H

- **Pyrolox Media Filter Loading Rate –** During this phase, all three Pyrolox media filters were operated at hydraulic loading rates ranging from 3.0 to 3.5 gpm/sf. The filters were backwashed weekly at a rate of 15 gpm/sf.

- **Dechlorination –** During operating conditions 4A through 4D, sodium thiosulfate was fed upstream of the cartridge filters to quench the residual chlorine in the pretreatment product water. During operating conditions 4E through 4K, sodium bisulfite was used to quench the residual chlorine in the pretreatment product water.

4.3.4.5 Testing Protocol

Flows, pressures, temperature, chemical storage tank levels, and metering pump settings were recorded daily. Free chlorine concentrations, pH, and conductivity were measured five times a week. Total iron, dissolved iron, total manganese, dissolved manganese, UV254, and apparent color were measured for selected sample streams three times a week.

Silt density index (SDI) was measured once a week. Chloride, silica, sulfate, and ammonia nitrogen were measured once a month. In addition to the tests performed at the pilot plant lab, samples were sent to an outside lab once a month to test for

alkalinity, total hardness, boron, calcium, magnesium, sodium, vanadium, total dissolved solids (TDS), total organic carbon (TOC), and gross alpha. Also, filtered and unfiltered samples of raw water, pretreatment feed, RO feed, RO permeate and RO waste were sent to the outside lab for QA/QC of the iron and manganese tests. The monthly tests for March were performed on March 12, 2008.

4.3.5 Phase V – Aeration plus Microfiltration (Alternative 5)

The Phase V pretreatment evaluation, which consisted of aeration plus microfiltration (MF) pretreatment followed by reverse osmosis (RO) desalination, was conducted from April 7 through May 23, 2008.

4.3.5.1 Objectives

The purpose of the Phase III pretreatment evaluation was to test if 1) iron could be oxidized through aeration and removed through the MF membranes; and 2) manganese could be kept in the reduced state during the pretreatment stages to be removed by the RO membranes without causing fouling of the RO membranes.

4.3.5.2 Description

The process for Phase V is the same as for Phase II, except that microfiltration is used instead of media filtration to filter the iron as a pretreatment to RO. Microfiltration should be capable of removing a higher percentage of the iron oxide, due to the small pore size in the membranes, however, process optimization would be needed for both microfiltration and media filtration to determine which will be more cost effective in a full-scale facility.

4.3.5.3 Configuration

Only Well A water was tested during Phase V testing. Well A raw water (RW) was aerated using an eductor (Mazzei air injector model 1584) or an air compressor upstream of the static mixer and the contact tank. Three overflows on the contact tank at different levels (full tank, 1/2 tank, and 1/3 tank) were used to vary the contact time (i.e., hydraulic residence time) for iron oxidation to occur. From the contact tank, the pretreatment feed (PTF) water was pumped and filtered through the MF membranes. After filtration, the pretreatment product water was fed through the cartridge filters, after which the antiscalant was injected, and the RO feed (ROF) water was then pumped to the RO membranes. Figure 4-5 presents a simplified schematic of the treatment process.

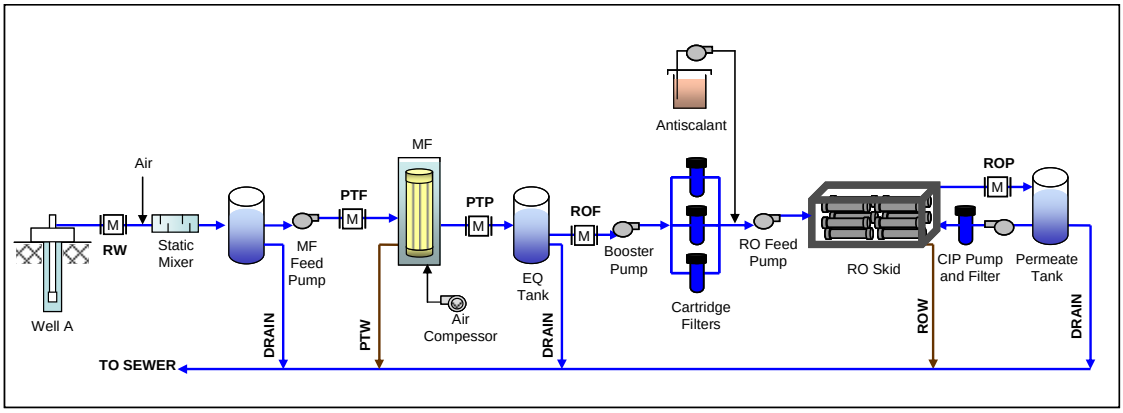


Figure 4-5.
Phase V Aeration plus Microfiltration Process Schematic

The test variables of the Phase V pretreatment evaluation were: dissolved oxygen (DO) concentration, and contact time.

4.3.5.4 Operating Conditions

The operating conditions tested during Phase V pretreatment evaluation are summarized in Table 4-13:

Table 4-13.
Phase V – Aeration + Microfiltration + RO: Operating Conditions

	Time Period	Operating Hours	Aeration Method	PTF DO (mg/L)	Contact Time (min)	MF Flux (gfd)	Antiscalant Feed	RW Flow (gpm)	PTF Flow (gpm)	ROF Flow (gpm)	ROP Flow (gpm)	ROW Flow (gpm)	Recovery (%)
5A	4/7/08	2	Eductor	5.5	3	31	Yes	41	33	29	21	8	74
5B	4/8/08	40	Eductor	7.7	19	31	Yes	37	32	13	8	5	62
5C	4/10/08	14	Eductor	5.6	45	16	Yes	28	17	14	9	5	64
5D	4/11/08 – 4/22/08	264	Eductor	4.1 to 5.9 (Avg 5.3)	31 to 34 (Avg 33)	34 to 36 (Avg 35)	Yes	36 to 40 (Avg 38)	36 to 38 (Avg 37)	14 to 29 (Avg 27)	11 to 21 (Avg 20)	4 to 8 (Avg 7)	71 to 74 (Avg 73)
5E	4/23/08 – 4/25/08	58	Air Compressor	8.1 to 8.8 (Avg 8.4)	33 to 36 (Avg 34)	33 to 36 (Avg 34)	Yes	35 to 38 (Avg 37)	34 to 37 (Avg 36)	14 to 18 (Avg 17)	11	4 to 7 (Avg 6)	62 to 74 (Avg 66)
5F	4/28/08	~ 0	Air Compressor	8.7	32	17	Yes	39	18	--	--	--	--
5G	4/29/08 – 4/30/08	16	Air Compressor	8.3	4	29	Yes	40	30	16	11	5	69
5H	4/30/08 – 5/23/08	522	Air Compressor	8.0 to 9.1 (Avg 8.5)	4	30 to 36 (Avg 33)	Yes	33 to 39 (Avg 36)	32 to 38 (Avg 35)	26 to 29 (Avg 27)	18 to 22 (Avg 20)	7 to 8 (Avg 7)	71 to 76 (Avg 73)

- **Aeration –** Two methods of aeration were used during Phase V. Initially, an eductor was used for aeration, similar to Phase II. Starting April 24, an air compressor was used to enhance aeration and thereby increase the dissolved oxygen concentration in pretreatment feed sample to close to saturation point. Aeration methods and average dissolved oxygen concentration are summarized in Table 4-14.

Table 4-14.
Phase V – Aeration + Microfiltration: Average Dissolved Oxygen

Aeration Method	Average DO (mg/L)	Operating Conditions
Eductor	5.6	5A – 5D
Air Compressor	8.7	5E – 5H

- **Contact Time –** The contact time (hydraulic residence time in the contact tank located downstream of aeration and upstream of the MF membranes) was varied to evaluate the impact of reaction time on iron oxidation, as summarized in Table 4-15.

Table 4-15.
Phase V – Aeration + Microfiltration: Contact Time

Contact Time (min)	Operating Conditions
3 to 4 (Avg 3.5)	5A, 5G, 5H
19	5B
31 to 36 (Avg 33)	5D, 5E, 5F
45	5C

- **Microfiltration Flux –** The MF flux (measured in gfd, or million gallons per day per square foot) was varied as summarized in Table 4-16.

Table 4-16.
Phase V – Aeration + Microfiltration: Microfiltration Flux

Flux (gfd)	Operating Conditions
16 to 17	5C, 5F
30 to 36	5A, 5B, 5D, 5E, 5G, 5H

4.3.5.5 Testing Protocol

Flows, pressures, temperature, chemical storage tank levels, and metering pump settings were recorded daily. Dissolved oxygen concentrations, pH, conductivity, and turbidity were measured five times a week. Total iron, dissolved iron, total manganese, dissolved manganese, UV254, and apparent color were measured for selected sample streams three times a week.

Silt density index (SDI) was measured once a week. Chloride, silica, sulfate, and ammonia nitrogen were measured once a month. In addition to the tests performed at the pilot plant lab, samples were sent to an outside lab once a month to test for alkalinity, total hardness, boron, calcium, magnesium, sodium, vanadium, total dissolved solids (TDS), total organic carbon (TOC), and gross alpha. Also, filtered and unfiltered samples of raw water, pretreatment feed, RO feed, RO permeate and RO waste were sent to the outside lab for QA/QC of the iron and manganese tests. The monthly tests for March were performed on March 12, 2008.

4.4 Pilot Plant Configuration

4.4.1 Site Layout

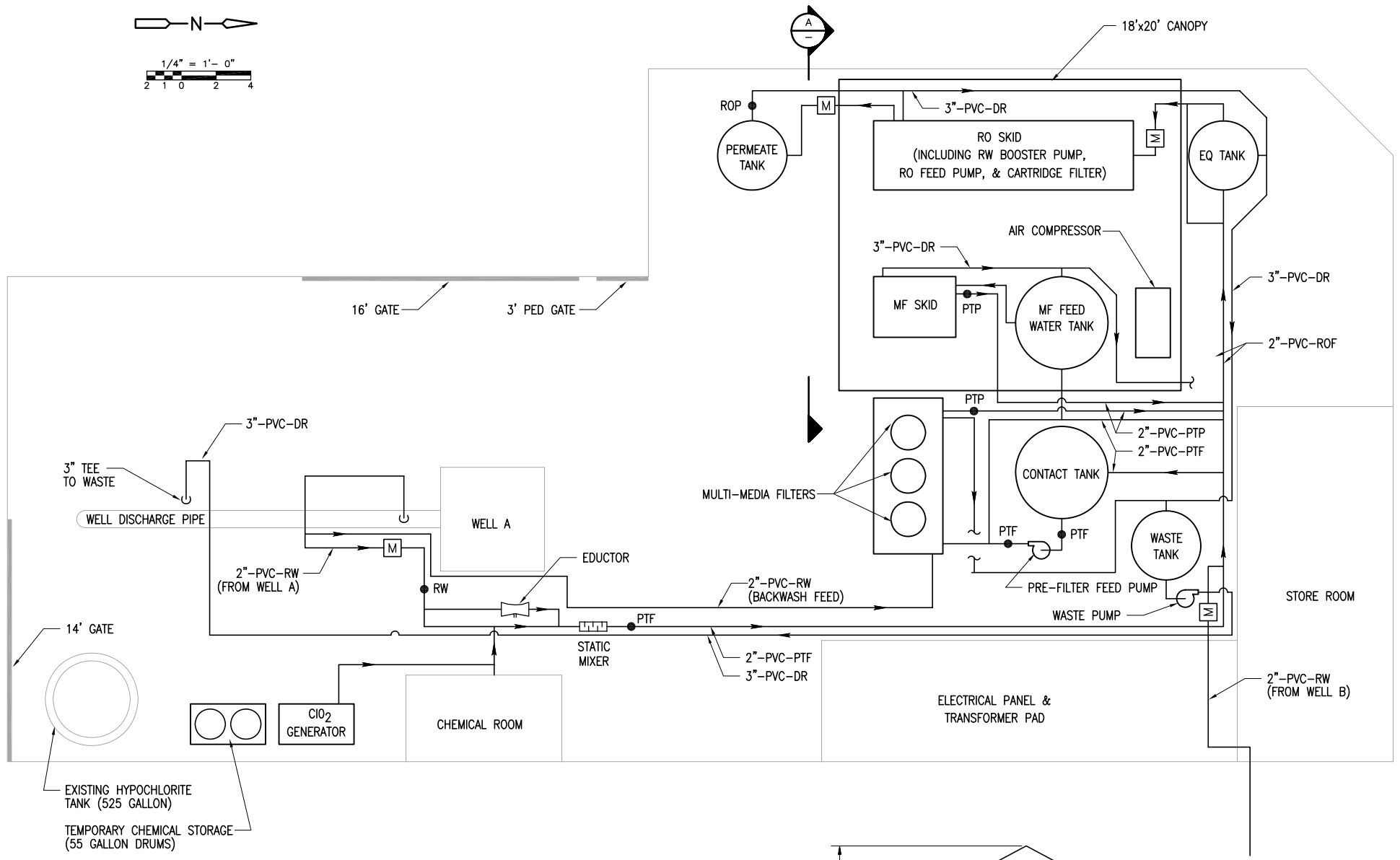
Both Well A and Well B water were tested during the pilot study, and the pilot plant was located at City Well A. Figure 4-7 shows the locations of Well A and Well B. Figure 4-8 shows the zoomed-in view of the pilot plant site at Well A, and Figure 4-9 shows a photograph of the pilot plant site.

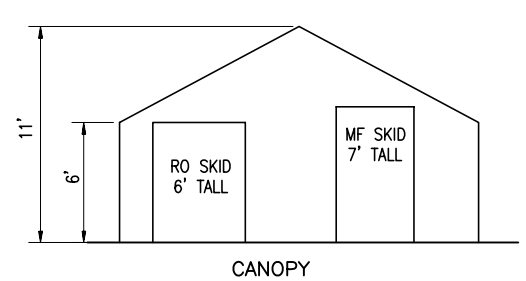
Figure 4-7.
Aerial Photo of Well A and Well B (Source: Google Map)

Figure 4-8.
Aerial Photo of Well A (Source: Google Map)

Figure 4-9.
Photo of Pilot Plant at Well A

The pilot plant tested water either from Well A or a blend of both Well A and Well B. Figure 4-10 shows the general layout of the pilot plant site. Figure 4-11 shows the process and instrumentation diagram (P&ID) for the overall pilot plant process.





SECTION A
SCALE: NTS –

LEGEND

RW	RAW WATER
PTF	PRE-TREATMENT FEED
PTP	PRE-TREATMENT PRODUCT
PTW	PRE-TREATMENT WASTE
ROF	REVERSE OSMOSIS FEED
ROP	REVERSE OSMOSIS PRODUCT
ROW	REVERSE OSMOSIS WASTE
DR	DRAIN
●	SAMPLE PORT

DRAFT

REV. NO.	DATE	DRWN	CHKD	REMARKS

DESIGNED BY: ECY
DRAWN BY: SMP
SHEET CHK'D BY: MSB
CROSS CHK'D BY:
APPROVED BY: GW
DATE: JUNE 2007

CDM Camp Dresser & McKee Inc.
consulting engineering construction operations

CITY OF CAMARILLO
601 CARMEN DRIVE
CAMARILLO, CA 93010

BRACKISH WATER DESALINATION PROJECT
PILOT STUDY

GENERAL SITE LAYOUT

PROJECT NO.
FILE NAME: C-1.dwg

SHEET NO.
FIGURE 4-10

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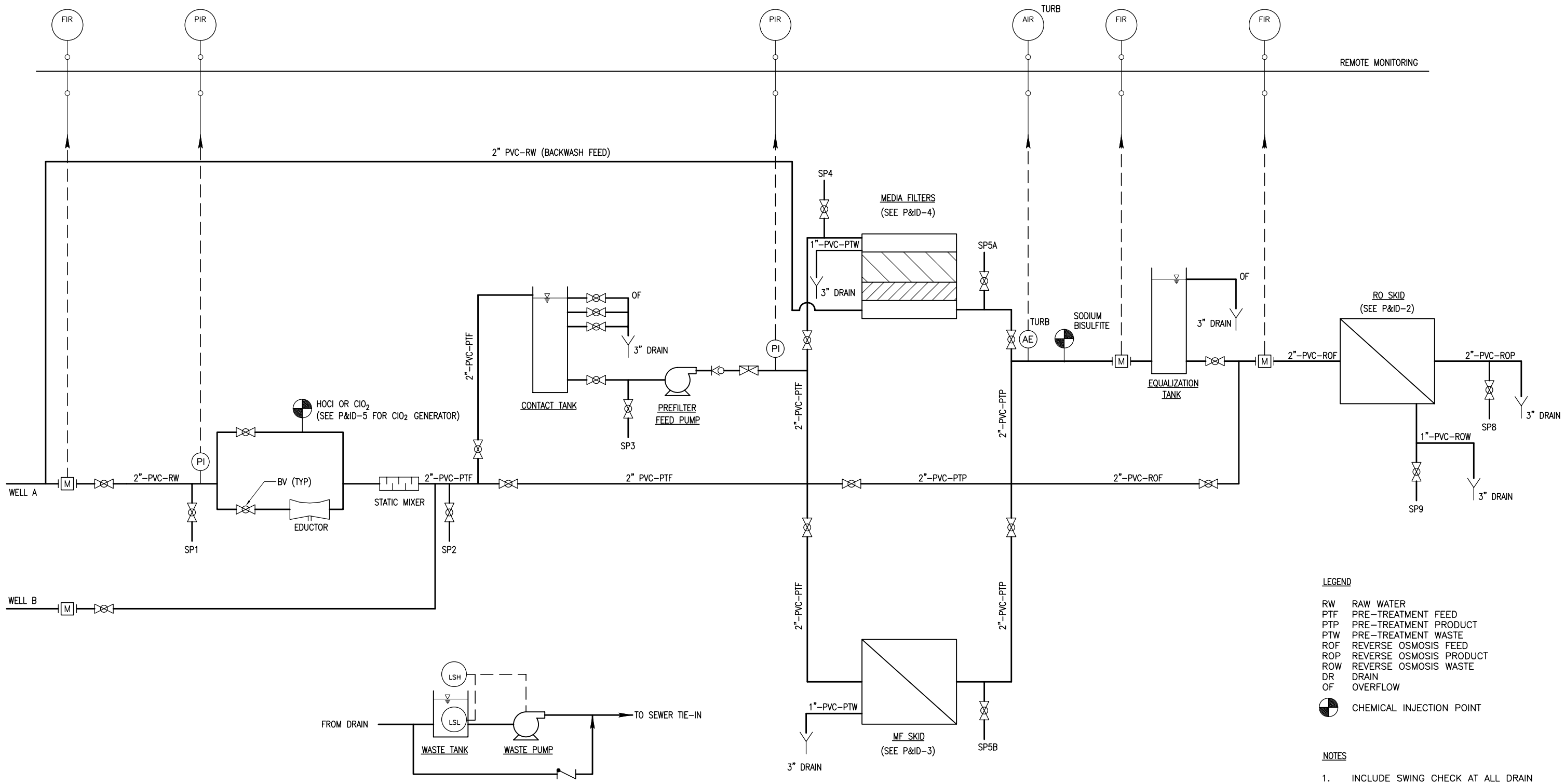
Ascession No: ASCESSION NO.



LEGEND

RW	RAW WATER
PTF	PRE-TREATMENT FEED
PTP	PRE-TREATMENT PRODUCT
PTW	PRE-TREATMENT WASTE
ROF	REVERSE OSMOSIS FEED
ROP	REVERSE OSMOSIS PRODUCT
ROW	REVERSE OSMOSIS WASTE
DR	DRAIN
OF	OVERFLOW

CHEMICAL INJECTION POINT

NOTES

1. INCLUDE SWING CHECK AT ALL DRAIN LOCATIONS.

DRAFT

REV. NO.	DATE	DRWN	CHKD	REMARKS

DESIGNED BY: ECY
DRAWN BY: MP
SHEET CHK'D BY: MSB
CROSS CHK'D BY:
APPROVED BY: GW
DATE: JUNE 2007

CDM Camp Dresser & McKee Inc.
consulting engineering construction operations

CITY OF CAMARILLO
601 CARMEN DRIVE
CAMARILLO, CA 93010

BRACKISH WATER DESALINATION PROJECT
PILOT STUDY

RO PILOT SYSTEM

PROJECT NO.
FILE NAME: P&ID-1.dwg

SHEET NO.
FIGURE 4-11

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Ascession No: ASCESSION NO.

4.4.2 Equipment

The following is a list of equipment used for the pilot plant.

4.4.2.1 Process Equipment

Major process equipment used during the pilot study are described in Table 4-17.

Table 4-17.
Process Equipment

Equipment	Description	Capacity
Eductor	Mazzei Model 1584-A supplied by Mazzei Injector Corporation	
Static Mixer	2-inch, clear PVC, in-line static mixer with standard 6-element or 12-element configurations, by Koflo	
Granular Media Filters	Three 24-inch diameter FRP pressure vessels. Dual media consisted of 11 inches of sand and 25 inches of anthracite. Pyrolox media consisted of 18 inches of 20x40 Pyrolox media with sand underbed.	Up to 15 gpm each.
Membrane Filters	Pressure microfiltration (MF) system (Memcor Model 6M10C Pilot Skid with CMF 6L10V membrane modules) by Siemens Water Technologies. Nominal pore size is 0.1 microns.	Up to 30 gpm
RO	NF/RO Pilot Skid custom-designed by CDM. Designed to test NF or RO membranes.	Up to 30 gpm at 225 psi

4.4.2.2 Chemical Addition

The chemicals used during each testing phase are summarized in Table 4-18.

Table 4-18.
Chemicals Used for Treatment Process

Chemical	Phase I	Phase II	Phase III	Phase IV	Phase V	Phase VI
Sodium Thiosulfate (Na2S2O3), 31%	Used for oxygen quenching					Used for oxygen quenching
Aeration (O2)		Used to enhance iron oxidation			Used to enhance iron oxidation	
Caustic Soda (NaOH), 10%		Used intermittently for pH adjustment				
Chlorine Dioxide (ClO2), 0.3%			Used to oxide iron and manganese			

Table 4-18. Chemicals Used for Treatment Process						
Chemical	**Phase I**	**Phase II**	**Phase III**	**Phase IV**	**Phase V**	**Phase VI**
Sodium Hypochlorite (NaOCl), 12.5%				Used to oxidize iron		
Sodium Bisulfite (NaHSO3), 36%			Used intermittently to quench residual ClO2	Used for dechlorination		
Muriatic Acid (HCl), 31%						Used to slow iron oxidation and prevent scaling
Antiscalant, 100%	SpectraGuard by Professional Water Technologies (PWT). Used to prevent scaling					

Additional chemicals used for membrane clean-in-place (CIP) are summarized in Table 4-19.

Table 4-19. Chemicals Used for Membrane Cleaning			
Chemical	**MF Maintenance Clean**	**MF CIP**	**RO CIP**
Caustic Soda (NaOH), 10% or 25%			Used for caustic clean
Citric Acid ($C_6H_8O_7$), 50%		Used for heated acid clean	Used for acid clean
Sodium Hypochlorite (NaOCl), 12.5%		Used for chlorine clean	
Phosphoric acid (H_3PO_4)	Used for weak acid clean. Weekly for 45 minutes.		

4.4.2.3 Pumps

The pumps used during the pilot study are described in Table 4-20.

Table 4-20.
Pumps

Pumps	Application	Description	Capacity
Chemical Metering Pumps	Chemical Feed	Diaphragm metering pumps (Pulsatron MP Series by Pulsafeeder).	12 gph to 24 gph
GMF Feed Pump	Pump pretreatment feed water to the media filter vessels	Horizontal end suction pump (G&L Series Model MCS by Goulds Pumps)	
MF Feed Pump	Pump pretreatment feed water to the MF membranes	Provided by Siemens Water Technologies as part of MF Skid	
RO Feed Pump	Pump RO feed water to the RO membranes	Vertical pump Provided as part of RO Skid. Variable frequency drive (VFD) controlled.	
RO Boost Pump	Boost flow through the RO membranes	Horizontal end suction pump (Model ACDU70/315TG by EBARA Pump)	

4.4.2.4 Tanks

The tanks used during the pilot study are described in Table 4-21.

Table 4-21.
Tanks

Tank	Application	Description	Capacity
Contact Tank	Provide contact time for oxidation of iron and/or manganese upstream of pretreatment filtration	HDPE tank with multiple overflow ports to facilitate testing of various contact times.	1100 gallons
Equalization Tank	Provide flow equalization between pretreatment and RO	HDPE with one overflow port and one drain port.	550 gallons
Permeate Tank	Provide storage of RO permeate and function as CIP tank during RO CIP	HDPE with one overflow port and one drain port.	550 gallons

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Section 5
Project Results

5.1 Overview

This section presents the results of the pretreatment evaluation (Section 5.2), selection of recommended pretreatment process (Section 5.3), reverse osmosis (RO) optimization test results (Section 5.4), and the emerging contaminants sampling results (Section 5.5).

5.2 Pretreatment Evaluation Results

The following presents the results of the pretreatment evaluation. The five pretreatment processes and testing phases are summarized in Table 5.2-1.

Table 5.2-1.
Pretreatment Evaluation Testing Phases

Phase	Pretreatment Process	Start Date	Finish Date
I	Alt 1: Oxygen Quenching	August 31, 2007	October 23, 2007
II	Alt 2: Aeration plus Media Filtration	October 30, 2007 February 1, 2008	January 1, 2008 February 17, 2008
III	Alt 3: Chlorine Dioxide Feed plus Media Filtration	January 2, 2008	January 31, 2008
IV	Alt 4: Chlorine Feed plus Pyrolox Media Filtration	February 20, 2008	April 4, 2008
V	Alt 5: Aeration plus Microfiltration	April 7, 2008	May 23, 3008

5.2.1 Phase I – Oxygen Quenching (Alternative 1)

The pretreatment process tested during Phase I was oxygen quenching. The objectives of this pretreatment evaluation, process description, pilot configuration, operating conditions, and testing protocol were described previously in Section 4.3.1. The primary objective was to prevent dissolved oxygen from oxidizing dissolved iron into particulate iron, which is known to foul RO membranes. A successful test would remove all dissolved oxygen, prevent particulate iron, and prevent a loss in mass transfer coefficient (MTC), or membrane permeability, across the RO membranes.

5.2.1.1 Oxygen Quenching Performance

During the Phase I pretreatment evaluation, the sodium thiosulfate dose was varied to test the impact of sodium thiosulfate dose on the dissolved oxygen (DO) and iron oxidation. Total iron, dissolved iron, and total manganese measurements are averaged for each operating condition and summarized below in Table 5.2-2. Dissolved manganese was not measured during this phase of testing. Particulate iron, not shown on this table, can be calculated from the total iron minus the dissolved iron.

Table 5.2-2.
Phase I – Oxygen Quenching + RO: Test Data per Operating Conditions

	Time Period	Sodium Thiosulfate Dose (mg/L)	WQ Parameters, Average Values	Well A Raw Water	Well B Raw Water	RO Feed	RO Permeate	RO Concentrate
1A	8/31/07 – 9/9/07	33	Total Iron, (mg/L)	0.23	0.14	0.21	0.06	0.65
			Dissolved Iron, (mg//L)	0.19	0.12	0.17	--	0.63
			Total Manganese, (mg/L)	0.24	0.18	0.22	0.05	--
1B	9/10/07 – 9/14/07	87	Total Iron, (mg/L)	0.23	0.20	0.19	0.01	0.66
			Dissolved Iron, (mg//L)	0.21	0.15	0.18	--	0.56
			Total Manganese, (mg/L)	0.30	0.20	0.24	≤ 0.005	--
1C	9/15/07 – 9/21/07	17	Total Iron, (mg/L)	0.24	0.19	0.19	≤ 0.008	0.66
			Dissolved Iron, (mg//L)	0.23	0.17	0.17	--	0.35
			Total Manganese, (mg/L)	0.32	0.23	0.25	0.01	--
1D	9/24/07	8	Total Iron, (mg/L)	0.22	--	0.21	0.03	0.74
			Dissolved Iron, (mg//L)	0.25	--	0.20	--	0.61
			Total Manganese, (mg/L)	0.25	--	0.24	≤ 0.005	--
1E	9/25/07 – 10/02/07	0	Total Iron, (mg/L)	0.25	0.18	0.22	0.03	0.56
			Dissolved Iron, (mg//L)	0.24	0.14	0.09	--	0.22
			Total Manganese, (mg/L)	0.30	0.17	0.21	≤ 0.005	--
1F	10/03/07-10/04/07	18	Total Iron, (mg/L)	0.23	0.15	0.19	0.02	0.43
			Dissolved Iron, (mg//L)	0.20	0.19	0.15	--	0.30
			Total Manganese, (mg/L)	0.18	0.21	0.22	≤ 0.005	--
1G	10/5/07-10/18/07	19 to 30	Total Iron, (mg/L)	0.22	--	0.20	0.01	0.36
			Dissolved Iron, (mg//L)	0.23	--	0.20	--	0.38
			Total Manganese, (mg/L)	0.33	--	0.29	≤ 0.005	0.61
1H	10/20/07-10/23/07	16	Total Iron, (mg/L)	0.21	--	0.22	0.01	0.70
			Dissolved Iron, (mg//L)	0.19	--	0.21	--	0.37
			Total Manganese, (mg/L)	0.27	--	0.26	0.01	0.77

-- Not tested

Dissolved Oxygen Level

Early measurements showed Well A and Well B raw water (RW) to have approximately 1 to 2 mg/L of DO. Average DO measurements in Well A raw water were 1.9 mg/L with a median value of 1.5 mg/L. Average DO measurements in Well B raw water were 1.7 mg/L with a median value of 1.3 mg/L.

Iron Oxidation

During Phase I testing, the median total iron level was approximately 0.23 mg/L in Well A raw water and 0.16 mg/L in Well B raw water, and particulate iron, calculated

from the total and dissolved iron, was below the reporting level of 0.02 mg/L (the median concentration was calculated as 0.01 mg/L). The RO feed (ROF) was a blend of 50 percent Well A raw water and 50 percent Well B raw water, sampled downstream of the cartridge filters and upstream of RO. The average total iron in the RO feed was 0.19 mg/L, and particulate iron in the RO feed was also below reporting level.

The effectiveness of oxygen quenching on preventing iron oxidation can be seen by comparing the particulate iron levels in the RO feed when sodium thiosulfate was fed at each well pump discharge (see Figure 5.2-1) against the particulate iron levels in the RO feed when sodium thiosulfate was not fed (see Figure 5.2-2).

When sodium thiosulfate was fed at each well pump discharge to quench DO, the total iron level in the RO feed was approximately the average of the iron levels in Well A raw water and Well B raw water, and the particulate iron level in the RO feed was below the detection level, as shown in Figure 5.2-1. This indicates that there was no measurable amount of iron oxidation when sodium thiosulfate was used for oxygen quenching.

However, when sodium thiosulfate feed was stopped, particulate iron levels in Well A raw water, Well B raw water and the RO feed increased, which indicates that unquenched DO oxidized iron within minutes of contact. The calculated particulate iron level in the RO feed represented more than 50 percent of the total iron, while substantial particulate fouling in the RO began to be observed, as discussed in Section 5.2.1.2.

It should be noted that wells A and B operations were stopped and restarted periodically throughout the testing period to simulate conditions in full scale operation, which may have contributedto air introduction into the raw water supplies.

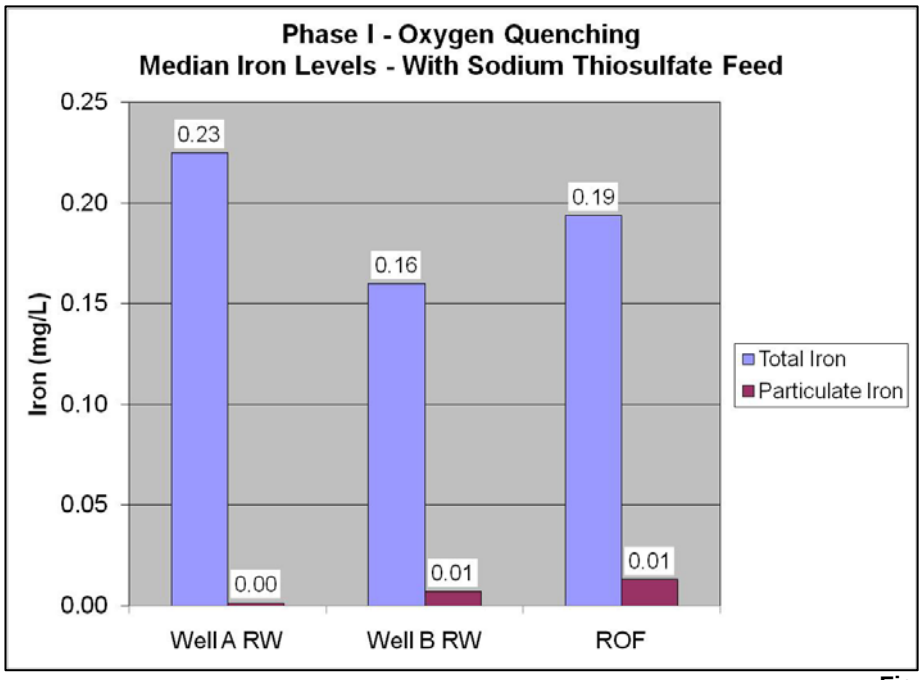

Figure 5.2-1.
Phase I – Median Iron Levels with Sodium Thiosulfate Feed

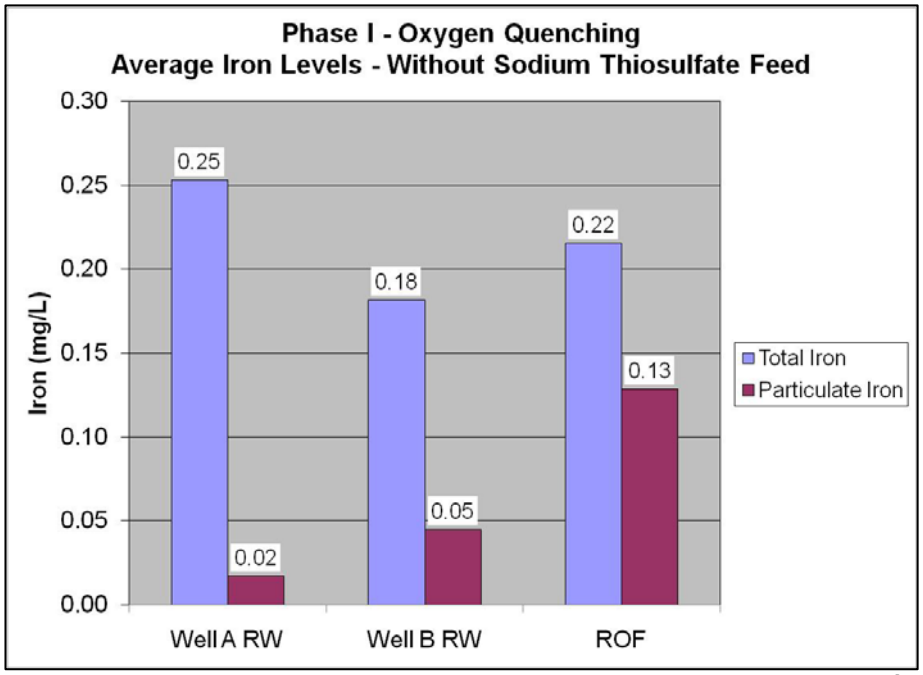

Figure 5.2-2.
Phase I – Average Iron Levels without Sodium Thiosulfate Feed

Manganese Oxidation

It appears that manganese was unaffected by the amount of DO in the raw water. The average total manganese level in the RO feed was approximately 0.25 mg/L, as

shown in Figure 5.2-3, representing the average of the Well A and Well B raw water. Dissolved manganese was not measured during this phase of the testing, preventing the calculation of particulate manganese, however, the lack of a decrease in total manganese between the raw water and the RO feed indicates that no manganese was oxidized or removed by the cartridge filters.

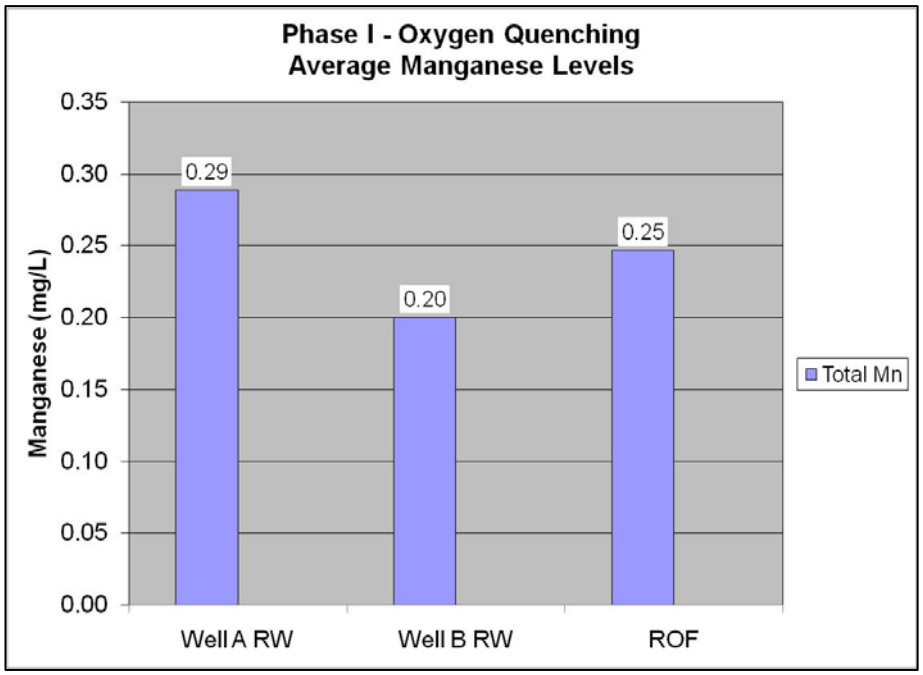

Figure 5.2-3.
Phase I – Average Manganese Levels

5.2.1.2 RO Membrane Performance

The first stage and second stage MTC (also referred to as membrane permeability), shown in Figure 5.2-4, remained approximately constant in Operating Conditions 1A through 1C, indicating that the membranes were not fouled when sodium thiosulfate was fed to quench oxygen in the raw water.

When sodium thiosulfate feed was stopped temporarily during part of Operating Condition 1D and all of Operating Condition 1E, the first stage MTC decreased rapidly due to membrane fouling, while the second stage MTC decreased more slowly. This data suggests that the membrane fouling was mainly caused by particulates, such as the oxidized iron particles, that would foul the first stage membranes more than the second stage membranes.

Restarting the sodium thiosulfate feed in Operating Condition 1F slightly slowed the membrane fouling but did not stop it, as shown in Figure 5.2-4. After the CIP on October 19, the MTCs were increased to approximately the same values as before the membrane fouling in Operating Condition 1E. This indicates that the CIP was successful, and the membranes were not irreversibly fouled.

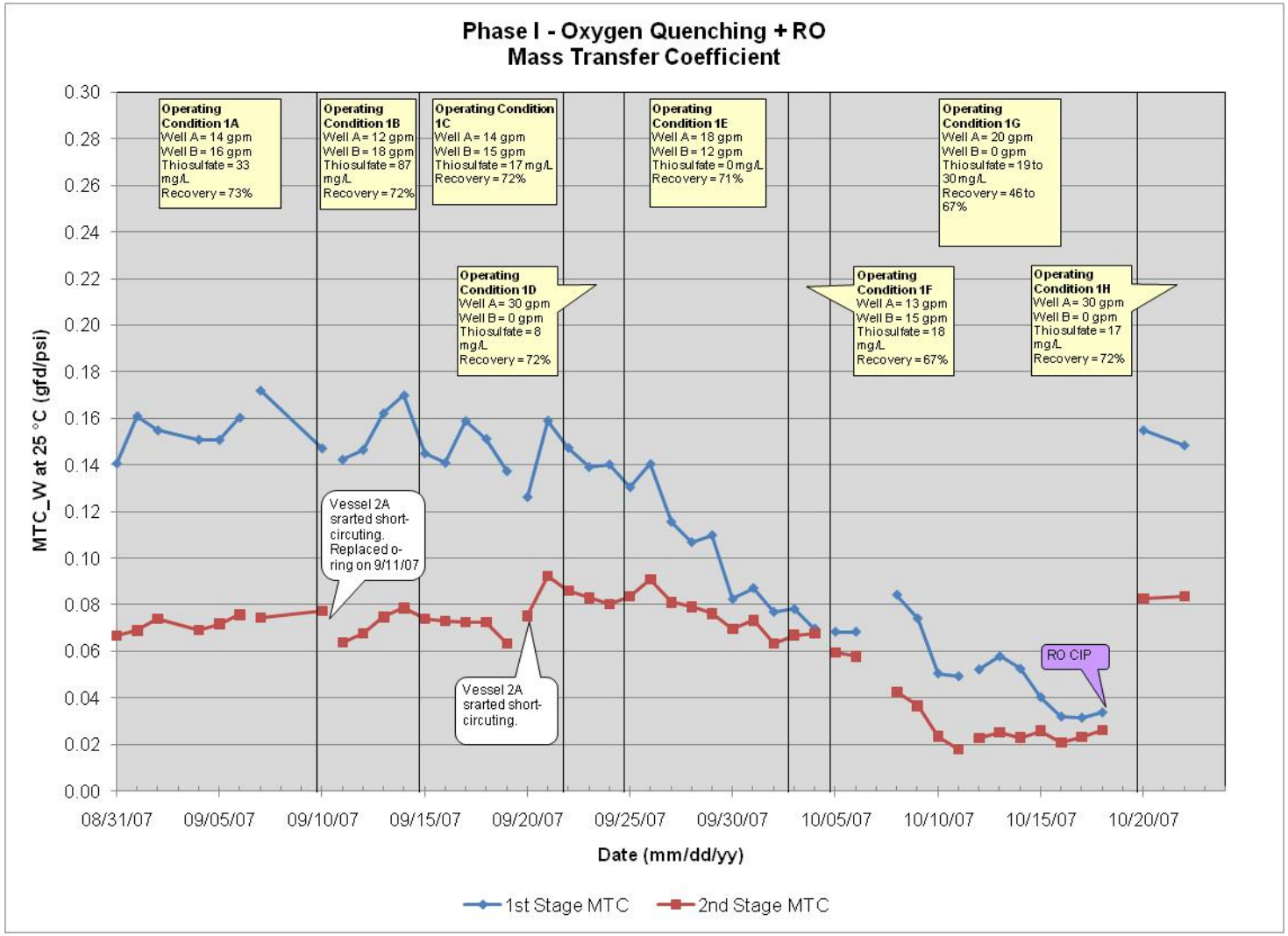

Figure 5.2-4.
Phase I – MTC_W at 25 °C

5.2.1.3 Water Quality

The water quality parameters tested during Phase I are summarized in Table 5.2-3.

Table 5.2-3.
Phase I – Oxygen Quenching + RO: Water Quality

Parameter	Detection Limit	Water Quality Goals: Regulatory Requirement or Reporting Limit	Water Quality Goals: City's Goals	Water Quality Values, Median: Well A Raw Water	Well B Raw Water	RO Feed	RO Permeate	RO Waste
Temperature (°C)				--	--	22	--	--
pH		6.5 – 8.5	6.5 – 8.5	7.7	7.9	7.0	6.6	8.0
Conductivity (uS/cm^2)		900	900	2960	2260	2840	135	7175
UV254 (cm^{-1})				--	--	0.05	--	--
Color (C.U)	2	15	2	--	--	10	< 2	--
Total Iron (mg/L)	0.02	0.3	0.2	0.23	0.16	0.20	< 0.02	0.64
Total Manganese (mg/L)	0.005	0.05	0.02	0.28	0.20	0.25	< 0.005	0.63
Alkalinity as $CaCO_3$ (mg/L)	2.0			300	240	265	10	940
Total Hardness as $CaCO_3$ (mg/L)	0.66		120	--	--	890	3	3200
TDS (mg/L)	10	500	300	2000	1350	--	44	--
TSS (mg/L)	5			< 5	< 5	< 5	--	--
TOC (mg/L)	0.60			1.7	1.6	--	--	--
Ammonia (NH3-N, mg/L)	0.017			0.81	0.32	--	0.03	1.15
Total Barium (mg/L)	0.0020			--	--	0.062	< 0.002	0.220
Total Boron (mg/L)	0.010	1	1	0.74	0.60	0.64	0.61	--
Calcium (mg/L)	0.10			--	--	250	0.83	910
Chloride (mg/L)	0.24	250	80	104	183	85	9.4	--
Magnesium (mg/L)	0.10			--	--	64	0.20	220
Silica (mg/L)	0.3			--	--	30.8	1.3	100.2
Sodium (mg/L)	0.50			210	140	170	10	--
Sulfate (mg/L)		250		1430	985	1195	5	2868
Total Strontium (mg/L)	0.0050			--	--	1.8	0.0089	6.6
Total Vanadium (mg/L)	0.0050			< 0.005	< 0.005	< 0.005	< 0.005	--
Gross Alpha (pCi/L)		15	15	15.1	7.65	--	0.48	--

Note:
-- Not measured.

Table 5.2-3 shows acceptable water quality for the RO permeate (ROP) for all parameters, including iron, manganese, TDS, chloride and sulfate.

5.2.1.4 Phase I Summary (Alternative 1)

Overall, oxygen quenching using sodium thiosulfate feed at the well pump discharges proved to be a successful pretreatment process to prevent metal oxide fouling of the RO membranes. However, when the sodium thiosulfate feed was stopped, iron oxidation immediately occurred and particulate fouling of the RO membranes started immediately. Particulate fouling of the membranes continued even when the sodium thiosulfate feed was resumed, and was stopped only when the membranes were cleaned with high concentrations of acid and caustic soda. Therefore, oxygen quenching pretreatment process must be carefully designed to safeguard against failure of the oxygen quenching agent.

5.2.2 Phase II – Aeration plus Media Filtration (Alternative 2)

The pretreatment process tested during Phase II was aeration plus media filtration. The objectives of this pretreatment evaluation, process description, pilot configuration, operating conditions, and testing protocol were detailed in Section 4.3.2. The primary objective was to oxidize dissolved iron into particulate iron and remove it with the media filters, while preventing the oxidation of manganese. A successful test would remove all iron in the media filters, prevent formation of particulate manganese, and prevent a loss in MTC across the RO membranes.

5.2.2.1 Oxidation Performance

Total iron, dissolved iron, total manganese, and dissolved manganese measurements are averaged for each operating condition of Phase II testing and summarized in Table 5.2-4.

Table 5.2-4.
Phase II – Aeration + Media Filtration + RO: Test Data per Operating Conditions

	Time Period	WQ Parameters, Average Values	Well A Raw Water	Pre-treatment Feed (1)	Pre-treatment Product	RO Feed	RO Permeate	RO Waste
2A	10/30/07 - 11/09/07	Total Iron, (mg/L)	0.207	0.210	--	0.013	0.011	0.016
		Dissolved Iron, (mg//L)	0.182	0.158	--	0.008	≤ 0.008	0.010
		Total Manganese, (mg/L)	0.279	0.277	--	0.270	≤ 0.005	0.905
		Dissolved Manganese (mg/L)	--	0.278	--	0.268	--	--
2B	11/10/07 - 11/20/07	Total Iron, (mg/L)	0.196	0.193	--	≤ 0.008	≤ 0.008	0.013
		Dissolved Iron, (mg//L)	0.156	0.158	--	0.008	≤ 0.008	0.010
		Total Manganese, (mg/L)	0.259	0.255	--	0.256	≤ 0.005	0.788
		Dissolved Manganese (mg/L)	--	0.254	--	0.253	--	--
2C	11/21/07 - 11/21/07	Total Iron, (mg/L)	0.209	0.224	--	0.082	0.039	0.130
		Dissolved Iron, (mg//L)	0.087	0.109	--	0.017	≤ 0.008	0.010
		Total Manganese, (mg/L)	0.257	0.259	--	0.247	≤ 0.005	0.860
		Dissolved Manganese (mg/L)	--	0.288	--	0.276	--	--
2D	11/22/07 - 11/29/07	Total Iron, (mg/L)	0.208	0.211	--	≤ 0.008	≤ 0.008	0.013
		Dissolved Iron, (mg//L)	0.150	0.137	--	0.014	≤ 0.008	≤ 0.008
		Total Manganese, (mg/L)	0.275	0.254	--	0.272	0.009	0.730
		Dissolved Manganese (mg/L)	--	0.253	--	0.273	--	--
2E	11/30/07 - 12/18/07	Total Iron, (mg/L)	0.189	0.168	--	0.009	≤ 0.008	0.008
		Dissolved Iron, (mg//L)	0.184	0.158	--	0.010	≤ 0.008	≤ 0.008
		Total Manganese, (mg/L)	0.258	0.255	--	0.252	≤ 0.005	0.687
		Dissolved Manganese (mg/L)	--	0.253	--	0.252	--	--
2F	12/19/07 - 01/01/08	Total Iron, (mg/L)	0.188	0.175	--	0.008	≤ 0.008	≤ 0.008
		Dissolved Iron, (mg//L)	0.184	0.147	--	≤ 0.008	≤ 0.008	≤ 0.008
		Total Manganese, (mg/L)	0.257	0.245	--	0.247	≤ 0.005	0.670

Table 5.2-4.
Phase II – Aeration + Media Filtration + RO: Test Data per Operating Conditions

	Time Period	WQ Parameters, Average Values	Well A Raw Water	Pre-treatment Feed (1)	Pre-treatment Product	RO Feed	RO Permeate	RO Waste
		Dissolved Manganese (mg/L)	--	0.243	--	0.242	--	--
2G	2/1/08	Total Iron, (mg/L)	0.166	0.166	--	≤ 0.008	≤ 0.008	≤ 0.008
		Dissolved Iron, (mg//L)	0.170	0.149	--	≤ 0.008	≤ 0.008	≤ 0.008
2H	2/2/08 - 2/5/08	Total Iron, (mg/L)	0.179	0.151	--	≤ 0.008	≤ 0.008	≤ 0.008
		Dissolved Iron, (mg//L)	0.175	0.166	--	≤ 0.008	≤ 0.008	≤ 0.008
2J	2/6/08 - 2/8/08	pH	7.5	8.0 (2)	--	7.9	7.0	8.0
		Total Iron, (mg/L)	0.179	0.162	--	≤ 0.008	≤ 0.008	≤ 0.008
		Dissolved Iron, (mg//L)	0.174	0.115	--	≤ 0.008	≤ 0.008	0.008
2L	2/11/08	pH	7.5	8.0 (2)	--	7.9	6.8	8.0
		Total Iron, (mg/L)	0.176	0.167	--	≤ 0.008	≤ 0.008	≤ 0.008
		Dissolved Iron, (mg//L)	0.171	0.148	--	≤ 0.008	≤ 0.008	≤ 0.008
2M	2/12/08 – 2/17/08	Total Iron, (mg/L)	0.169	0.163	≤ 0.008	≤ 0.008	≤ 0.008	≤ 0.008
		Dissolved Iron, (mg//L)	0.166	0.150	≤ 0.008	≤ 0.008	≤ 0.008	≤ 0.008

(1) The pretreatment feed samples were grabbed from upstream of the contact tank from 10/30/07 through 12/11/07, and from downstream of the contact tank starting 12/12/07.
(2) pH of the pretreatment feed was raised to 8.0 by adding NaOH to Well A raw water. pH of the pretreatment feed was measured from samples grabbed from upstream of the contact tank.
-- Not measured.
NOTE: Iron and manganese levels were not measured during operating condition 2K, and manganese levels were not measured during operating conditions 2G through 2L.

Aeration

Phase I testing demonstrated that normal operation of Wells A and B entrained sufficient amounts of DO to oxidize some portion of dissolved iron if the DO was not quenched. The DO in the blended raw water requires either i) oxygen quenching to completely remove the DO to prevent iron oxidation, or ii) sufficient aeration to saturate the water with DO promoting complete iron oxidation.

Iron Oxidation

The average total iron concentration in Well A raw water was 0.20 mg/L, and the particulate iron was below the detection level (< 0.01 mg/L), as shown in Figure 5.2-5.

Aeration using an eductor increased the DO concentrations in the pretreatment feed (PTF) water to oxidize and remove iron. Approximately 95 percent of the total iron was oxidized and removed by the granular media filters (GMFs) when 6 minutes or more of contact time was provided (all operating conditions except Operating Condition 2C), as shown in Figure 5.2-5.

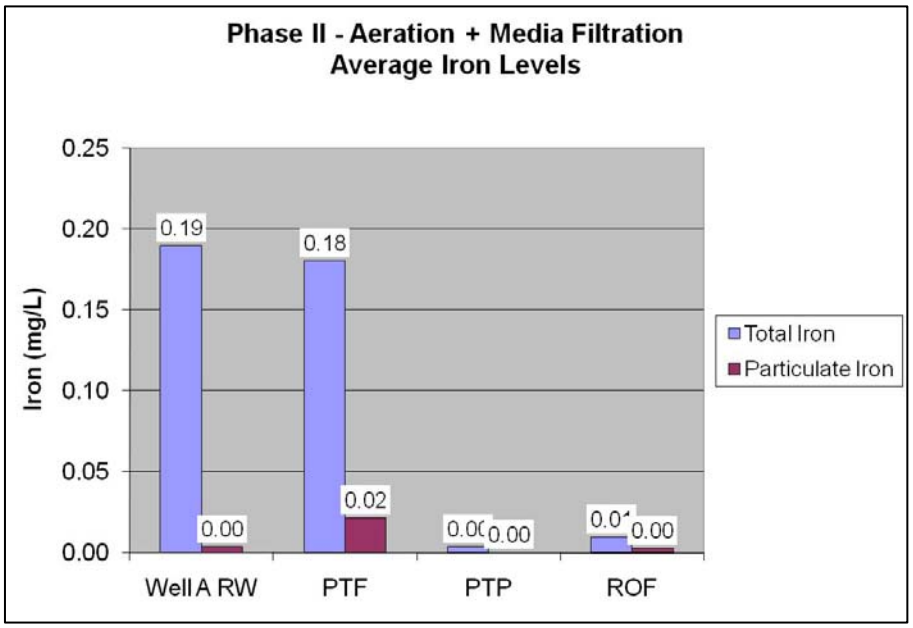

Figure 5.2-5.
Phase II – Average Iron Levels for Contact Time Greater than 6 Minutes

When the Contact Tank was bypassed during Operating Condition 2C, the effectiveness of the pretreatment process decreased. During Operating Condition 2C, about 60 percent of the total iron was oxidized and removed by the GMFs and about 40 percent passed through the GMFs as dissolved iron, providing a significant solids load onto the cartridge filters and RO membranes.

Iron Oxidation vs. Contact Time

The aeration plus media filtration pretreatment was effective at oxidizing and removing iron when a minimum of six minutes of contact time was provided. Figure 5.2-6 shows that the concentrations of total iron in the RO feed and the RO waste (ROW) were close to or below the detection level when the contact time was 6 minutes or more. Figure 5.2-6 also shows that aeration plus media filtration pretreatment was ineffective when the contact time was close to zero minutes. Note that concentrations below the detection level of 0.02 mg/L can be recorded by the testing method, however, the accuracy of these low values is uncertain. This can be noted in the fact that the RO waste often recorded identical iron concentrations to the RO feed when less than 0.02 mg/L was measured in the feed, but recorded significantly higher concentrations when greater than 0.02 mg/L were present in the feed.

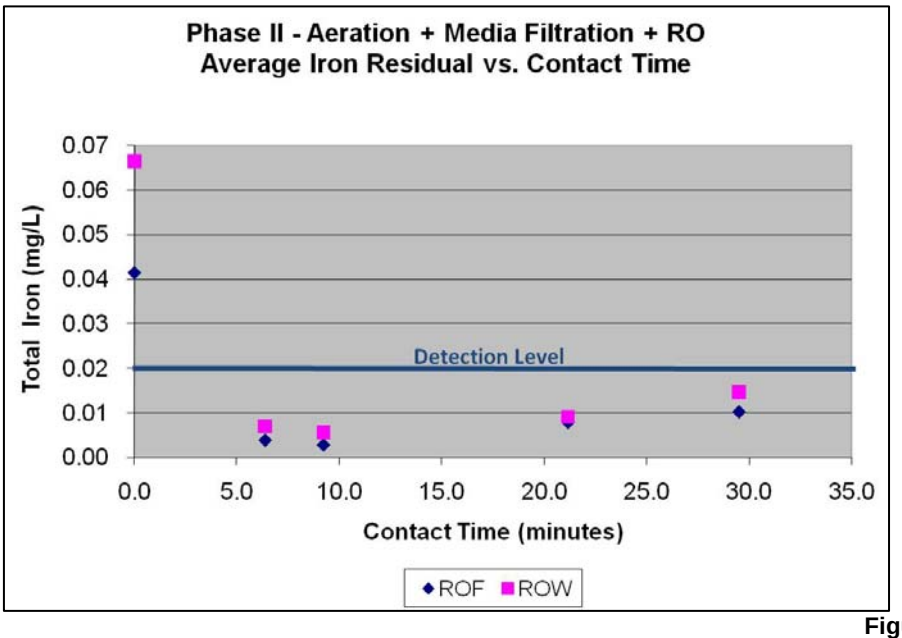

Figure 5.2-6.
Phase II – Average Total Iron Residual in ROF and ROW vs. Contact Time

Iron Oxidation vs. pH

pH adjustments of the raw water was conducted to determine whether increased pH could reduce the contact time required to oxidize the dissolved iron. While testing without pH adjustment had indicated that a minimum of 6 minutes of contact time were required for complete oxidation of iron, adjusting the pH to 8.0 allowed complete oxidation with nearly zero minutes of contact time. These results are presented in Figure 5.2-7. While this would indicate that pH adjustment was successful at accelerating iron oxidation, raising the pH with caustic soda also caused severe scaling in the piping, valves, media filters, and cartridge filters. The scaled media filters were cleaned with acid solution on February 13, 2008, and the cartridge filters were replaced as often as twice a day when the pH was raised. The antiscalant injection point was moved ahead of the aeration eductor in an attempt to reduce this scaling, however, this was not successful and the media filters, piping, valves, and cartridge filters continued to scale. Increasing the pH did not appear to be a feasible alternative for the Well A supply.

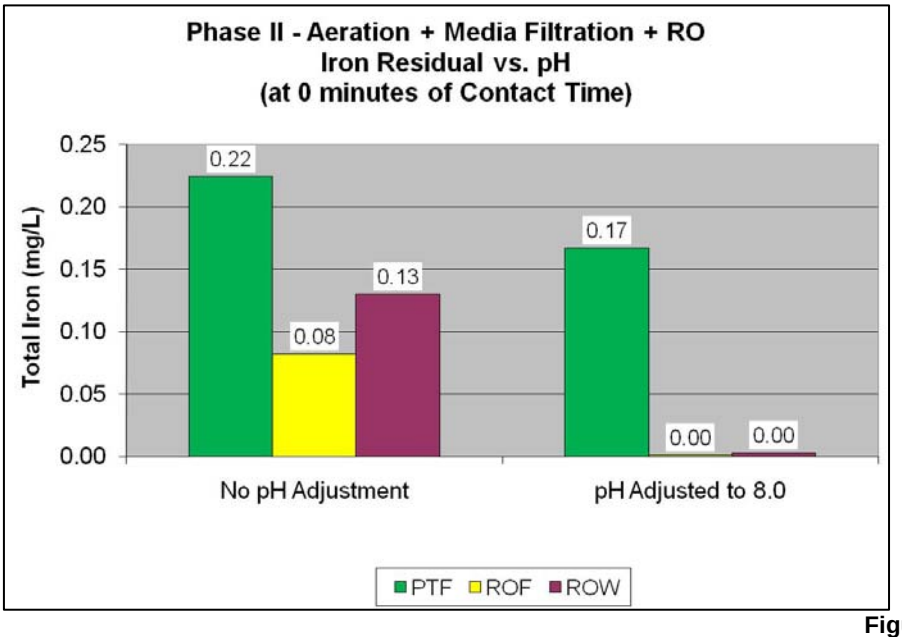

Figure 5.2-7.
Phase II –Total Iron Residual in PTF, ROF, and ROW vs. pH at Zero Minute Contact Time

Manganese Oxidation

Manganese appears to have been kept in the reduced state through the pretreatment processes, unaffected by aeration. Almost all of the total manganese in Well A raw water was fed to the RO membranes, all of it dissolved (in the reduced state) as shown in Figure 5.2-8. Also, the RO membranes effectively removed almost all of the dissolved manganese, as shown in Table 5.2-4.

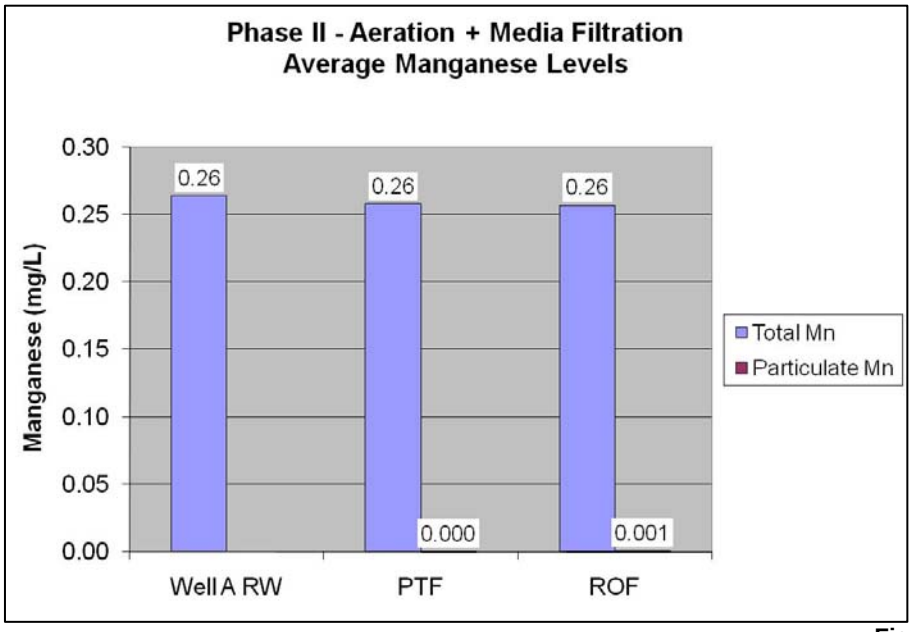

Figure 5.2-8.
Phase II – Average Manganese Levels (All Operating Conditions)

5.2.2.2 RO Performance

Phase II pretreatment method appears to be providing acceptable quality water for the RO, based on the low silt density index (SDI) numbers, typically less than 2, and the low iron in the RO feed, typically less than 0.01 mg/L.

A steady decline in MTC in the first stage, however, indicates that particulate fouling was occurring during Operating Conditions 2A through 2D, as shown on Figure 5.2-9. This fouling could be from particulate iron, or could be a result of algal growth observed in the equalization tank and cartridge filters prior to bypassing the equalization tank. It is because of this fouling, and the uncertainty of its cause, that a CIP was conducted on November 30, 2007. Phase II testing was therefore continued through the month of December 2007 to confirm whether the treatment process could be effective at preventing fouling on the RO.

The first stage MTC was more stable in December, but there was a slight decline in the first stage MTC toward the end of Operating Condition 2F that indicates particulate fouling. It appears that the GMF was more prone to iron breakthrough when the GMF loading rates was higher than 3.5 gpm/sf (e.g., Operating Conditions 2B and 2F). However, it is possible that a different media (lower effective size), deeper bed, or more aggressive backwashing approach could have allowed for a higher loading rate without breakthrough.

The first stage MTC and the second stage MTC for the additional Phase II pretreatment evaluation during January and February 2008 (e.g., Operating Conditions 2G through 2E) are also shown in Figure 5.2-9. Both the first stage and second stage MTC are relatively flat indicating that particulate fouling did not occur during this time.

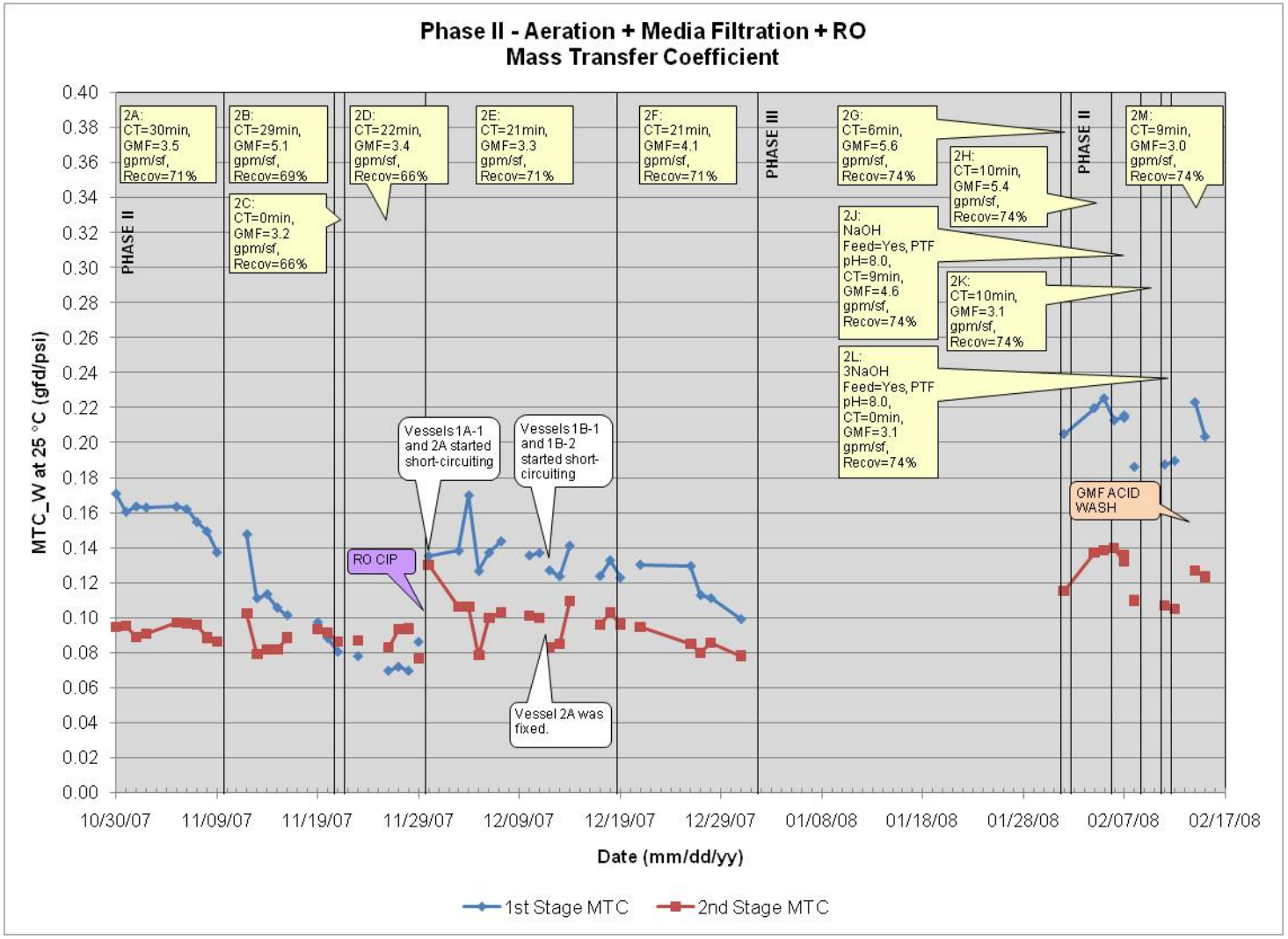

Figure 5.2-9.
Phase II – MTC_W at 25 °C

5.2.2.3 Water Quality

The water quality parameters tested during Phase II are summarized in Table 5.2-5.

Table 5.2-5.
Phase II – Aeration + Media Filtration + RO: Water Quality

Parameter	Detection Limit	Water Quality Goals		Water Quality			
		Regulatory Requirement or Reporting Limit	City's Goal	Well A Raw Water	RO Feed	RO Permeate	RO Waste
Temperature (°C)				--	21	--	--
pH		6.5 – 8.5	6.5 – 8.5	7.5	7.6	6.6	7.9
Conductivity (uS/cm^2)		900	900	2885	2930	148	7445
UV254 (cm^{-1})				0.04	0.03	--	--
Color (C.U)	2	15	2	5	3	< 2	--
Total Iron (mg/L)	0.02	0.3	0.2	0.19	0.01	< 0.001	0.01
Total Manganese (mg/L)	0.005	0.05	0.02	0.26	0.26	< 0.005	0.76
Alkalinity as $CaCO_3$ (mg/L)	2.0			300	300	14	920
Total Hardness as $CaCO_3$ (mg/L)	0.66		120	1000	980	4	3400
TDS (mg/L)	10	500	300	1850	1800	63	--
TSS (mg/L)	5			< 5	5	--	7
TOC (mg/L)	0.60			1.7	2.0	--	--
Ammonia (NH3-N, mg/L)	0.017			0.25	--	< 0.017	0.19
Total Barium (mg/L)	0.0020			--	0.056	< 0.002	0.170
Total Boron (mg/L)	0.010	1	1	0.75	--	0.65	--
Calcium (mg/L)	0.10			--	270	1.0	955
Chloride (mg/L)	0.24	250	80	92	--	10	--
Magnesium (mg/L)	0.10			--	74	0.24	235
Silica (mg/L)	0.3			31	--	2.6	78
Sodium (mg/L)	0.50			--	205	13	--
Sulfate (mg/L)		250		1320	--	1.1	3040
Total Strontium (mg/L)	0.0050			--	2.1	0.0051	6.3
Total Vanadium (mg/L)	0.0050			< 0.005	--	< 0.005	--
Gross Alpha (pCi/L)		15	15	8.9	--	1.7	--

Note:
-- Not measured.

Table 5.2-5 shows acceptable water quality for the RO permeate for all parameters, including iron, manganese, TDS, chloride and sulfate. In particular, the TDS level in the RO permeate was 63 mg/L, much lower than the City's goal of 300 mg/L.

However, boron concentrations in Well A raw water have been measured at 0.75 mg/L, approximately twice their historic levels, as shown in Table 5.2-5. While this level is still lower than the California Department of Public Health (CDPH) notification level of 1 mg/L, the measured concentrations could create toxicity concerns for certain plants, such as roses and citrus, among others. Boron is difficult to remove with brackish RO elements, and is present in the RO permeate at concentrations only 10 to 20 percent lower than in the feed water, as shown in Table 5.2-5.

5.2.2.4 Phase II Summary (Alternative 2)

The aeration plus media filtration pretreatment was effective at oxidizing and removing iron when a minimum of six minutes of contact time was provided. Providing additional contact time, beyond six minutes, did not have significant impact on iron oxidation. Complete iron oxidation was achieved with zero minute contact time when the pH was elevated to 8.0 standard units using caustic soda, however, pH adjustment was found to cause severe scaling in the piping, valves, the granular media filters, and the cartridge filters.

Although the particulate iron levels did not indicate iron breakthrough at any point in the testing, an observed decrease in first stage MTC suggests that the GMFs are more prone to solids breakthrough when the GMF loading rates are higher than 3.5 gpm/sf. Higher loading rates may be sustainable, however, if utilizing media with greater depth, smaller effective size, or a more aggressive backwashing approach than utilized in the pilot.

5.2.3 Phase III – Chlorine Dioxide Feed plus Media Filtration (Alternative 3)

The pretreatment process tested during Phase III was chlorine dioxide (ClO_2) feed plus media filtration. The objectives of this pretreatment evaluation, process description, pilot configuration, operating conditions, and testing protocol were described previously in Section 4.3.3. The primary objective was to oxidize both dissolved iron and dissolved manganese into particulate iron and manganese, removing both with the media filters. A successful test would remove all iron and manganese in the media filters and prevent a loss in MTC across the RO membranes.

5.2.3.1 Oxidation Performance

Chlorine dioxide, total iron, dissolved iron, total manganese, and dissolved manganese measurements are averaged for each operating condition of Phase III testing and summarized in Table 5.2-6.

Table 5.2-6.
Phase III – Chlorine Dioxide Feed + Media Filtration + RO: Test Data per Operating Conditions

	Time Period	WQ Parameters, Average Values	Well A Raw Water	Pre-treatment Feed [(2)]	RO Feed	RO Permeate	RO Waste
3A	01/02/08-01/07/08	pH	7.3	7.3	7.3	6.3	7.8
		Chlorine Dioxide, (mg/L)	1.6 [(1)]	1.65	0.30	0.23	--
		Total Iron, (mg/L)	0.177	0.166	≤ 0.008	≤ 0.008	≤ 0.008
		Dissolved Iron, (mg//L)	0.181	0.012	≤ 0.008	≤ 0.008	0.009
		Total Manganese, (mg/L)	0.238	0.214	0.059	≤ 0.005	0.230
		Dissolved Manganese (mg/L)	0.215	0.059	0.057	0.006	0.015
3B	01/08/08-01/11/08	pH	7.3	7.3	7.3	6.4	7.7
		Chlorine Dioxide, (mg/L)	1.7 [(1)]	1.61	0.56	0.56	--
		Total Iron, (mg/L)	0.174	0.168	0.009	≤ 0.008	≤ 0.008
		Dissolved Iron, (mg//L)	0.171	≤ 0.008	≤ 0.008	≤ 0.008	0.009
		Total Manganese, (mg/L)	0.245	0.208	0.063	≤ 0.005	--
		Dissolved Manganese (mg/L)	0.222	0.066	0.065	0.007	--
3D	01/14/08-01/15/08	pH	7.3	8.1 [(4)]	7.7	6.8	7.8
		Chlorine Dioxide, (mg/L)	1.8 [(1)]	1.02	0.13	0.10	--
		Total Iron, (mg/L)	0.182	0.167	0.054	≤ 0.008	0.165
		Dissolved Iron, (mg//L)	0.181	≤ 0.008	≤ 0.008	≤ 0.008	0.008
		Total Manganese, (mg/L)	0.243	0.219	0.083	≤ 0.005	--
		Dissolved Manganese (mg/L)	0.230	0.062	0.061	≤ 0.005	--
3E	01/16/08	pH	7.3	7.1	7.3	6.5	7.8
		Chlorine Dioxide, (mg/L)	0.0 [(1)]	≤ 0.04	--	--	--
		Total Iron, (mg/L)	--	--	--	--	--
		Dissolved Iron, (mg//L)	0.176	0.120	0.010	≤ 0.008	0.015
		Total Manganese, (mg/L)	0.255	0.280	0.096	≤ 0.005	--

Table 5.2-6.
Phase III – Chlorine Dioxide Feed + Media Filtration + RO: Test Data per Operating Conditions

	Time Period	WQ Parameters, Average Values	Well A Raw Water	Pre-treatment Feed (2)	RO Feed	RO Permeate	RO Waste
		Dissolved Manganese (mg/L)	0.254	0.251	0.114	0.006	--
3F	01/17/08-01/22/08	pH	7.3	7.3	7.2	6.4	7.7
		Chlorine Dioxide, (mg/L)	2.1 (1)	1.54 (3)	0.17	--	--
		Total Iron, (mg/L)	0.170	0.172	≤ 0.008	≤ 0.008	0.008
		Dissolved Iron, (mg//L)	0.171	0.011	≤ 0.008	≤ 0.008	≤ 0.008
		Total Manganese, (mg/L)	0.240	0.228	0.061	≤ 0.005	0.315
		Dissolved Manganese (mg/L)	0.238	0.075	0.069	0.011	0.344
3G	01/23/08	pH	7.4	7.3	7.3	6.7	7.7
		Chlorine Dioxide, (mg/L)	1.9 (1)	1.40 (3)	0.26	0.28	--
		Total Iron, (mg/L)	0.175	0.169	≤ 0.008	≤ 0.008	≤ 0.008
		Dissolved Iron, (mg//L)	0.176	≤ 0.008	≤ 0.008	≤ 0.008	≤ 0.008
		Total Manganese, (mg/L)	0.257	0.230	0.075	≤ 0.005	0.230
		Dissolved Manganese (mg/L)	0.253	0.085	0.088	≤ 0.005	0.300
3H	01/24/08	pH	7.4	7.3	7.4	6.6	7.8
		Chlorine Dioxide, (mg/L)	1.8 (1)	1.47 (3)	0.29	0.22	--
		Total Iron, (mg/L)	0.176	0.165	≤ 0.008	0.009	≤ 0.008
		Dissolved Iron, (mg//L)	0.167	≤ 0.008	≤ 0.008	≤ 0.008	≤ 0.008
		Total Manganese, (mg/L)	0.247	0.214	0.065	≤ 0.005	0.250
		Dissolved Manganese (mg/L)	0.220	0.084	0.080	0.014	0.300
3J	01/25/08	pH	7.4	7.3	7.5	6.6	7.8
		Chlorine Dioxide, (mg/L)	1.6 (1)	1.47 (3)	0.47	0.50	--
		Total Iron, (mg/L)	0.174	0.165	≤ 0.008	≤ 0.008	≤ 0.008
		Dissolved Iron, (mg//L)	0.170	≤ 0.008	≤ 0.008	≤ 0.008	≤ 0.008
		Total Manganese, (mg/L)	0.259	0.230	0.081	≤ 0.005	0.250
		Dissolved Manganese (mg/L)	0.247	0.091	0.069	0.005	0.230
3K	01/28/08	pH	7.5	7.4	7.4	6.6	7.8
		Chlorine Dioxide, (mg/L)	1.3 (1)	0.82 (3)	0.15	0.06	--
		Total Iron, (mg/L)	0.169	0.171	≤ 0.008	≤ 0.008	≤ 0.008
		Dissolved Iron, (mg//L)	0.173	≤ 0.008	≤ 0.008	≤ 0.008	≤ 0.008
		Total Manganese, (mg/L)	0.240	0.212	0.137	≤ 0.005	0.400
		Dissolved Manganese (mg/L)	0.227	0.119	0.067	≤ 0.005	0.350
3L	01/29/07-01/31/08	pH	7.4	7.3 (3)	7.4	6.6	7.8
		Chlorine Dioxide, (mg/L)	1.1 (1)	0.90 (3)	0.06	0.06	--
		Total Iron, (mg/L)	0.167	0.177	0.012	≤ 0.008	0.015
		Dissolved Iron, (mg//L)	0.163	≤ 0.008	≤ 0.008	≤ 0.008	≤ 0.008
		Total Manganese, (mg/L)	0.241	0.231	0.087	≤ 0.005	0.297
		Dissolved Manganese (mg/L)	0.234	0.077	0.083	0.009	0.275

(1) Chlorine dioxide dose injected to Well A raw water.

Table 5.2-6.
Phase III – Chlorine Dioxide Feed + Media Filtration + RO: Test Data per Operating Conditions

	Time Period	WQ Parameters, Average Values	Well A Raw Water	Pre-treatment Feed (2)	RO Feed	RO Permeate	RO Waste

(2) All pretreatment feed samples were grabbed from downstream of the contact tank, unless otherwise noted.

(3) Measured in the pretreatment feed sample grabbed upstream of the contact tank.

(4) pH raised to 8.1 by adding NaOH to Well A raw water.

-- Not measured.

NOTE: Iron and manganese levels were not measured during operating condition 3C.

Chlorine Dioxide Dose and Demand

The chlorine dioxide dose fed to Well A raw water, and the chlorine dioxide levels in the pretreatment feed and the RO feed are shown in Figure 5.2-10. On average, chlorine dioxide was dosed at approximately 1.7 mg/L, and the chlorine dioxide residual measured in the RO feed sample was 0.29 mg/L. The chlorine dioxide demand fluctuated from 0.8 to 2.1 mg/L, with an average of 1.4 mg/L.

The chlorine dioxide test, USEPA accepted DPD Method, was tested for interferences from oxidized manganese in the water samples, starting January 24, 2008. On average, the chlorine dioxide test interference due to oxidized manganese was 0.4 mg/L in the pretreatment feed, and 0.05 mg/L in the RO feed. The chlorine dioxide test interference was greater in the pretreatment feed sample because the pretreatment feed sample had higher concentrations of oxidized manganese than the RO feed sample. Correcting the chlorine dioxide measurements for oxidized manganese interferences, the average chlorine dioxide residual measured in the RO feed sample was 0.24 mg/L, and the average chlorine dioxide demand was 1.5 mg/L.

Based on the typical chlorine dioxide dosages needed to oxidize iron and manganese, it appears 0.6 mg/L of the 1.5 mg/L chlorine dioxide demand was used for oxidizing these minerals. Other oxidant demanding substances, such as organics, appear to have contributed to the remaining 0.9 mg/L demand. In addition, these other demands competed for the chlorine dioxide available to complete the oxidization of dissolved manganese, leaving a fraction of the manganese in a reduced (non-oxidized) state.

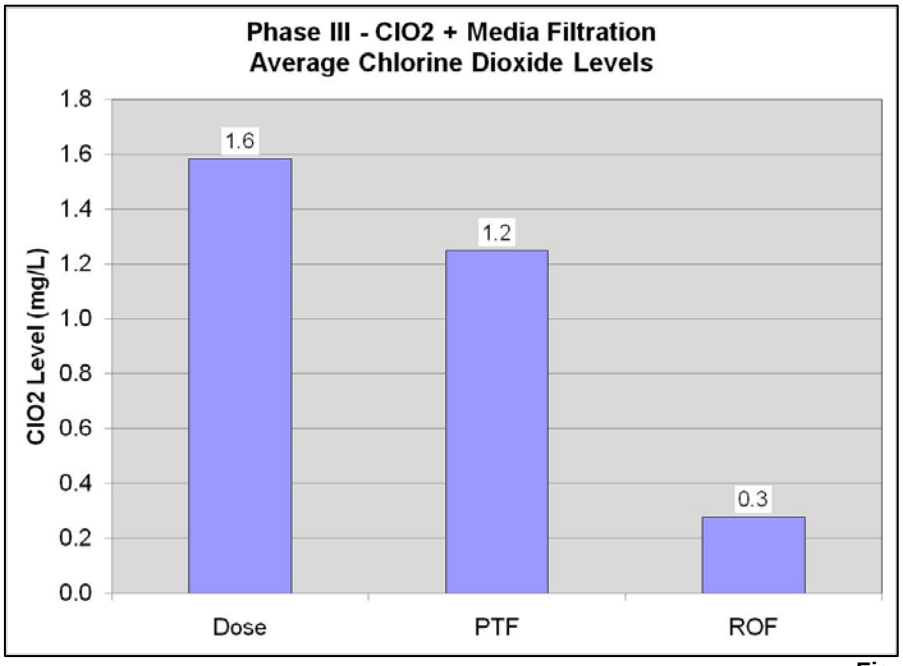

Figure 5.2-10.
Phase III – Average Chlorine Dioxide Levels

Iron Oxidation

The total and dissolved iron data shows that the chlorine dioxide feed plus media filtration is an effective pretreatment process for removing iron by oxidation and filtration. Figure 5.2-11 summarizes the average total iron and particulate iron levels in the Well A raw water, the pretreatment feed and the RO feed.

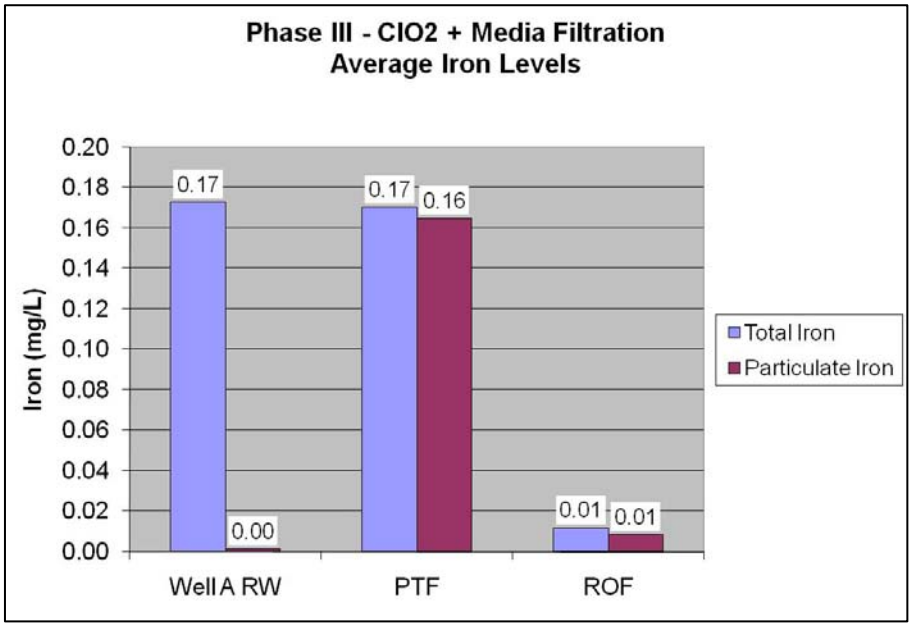

Figure 5.2-11.
Phase III – Average Iron Levels

The total and particulate iron data for Well A raw water and the pretreatment feed shows that chlorine dioxide oxidized nearly 100 percent of iron when chlorine dioxide was dosed. The only time iron was not fully oxidized was on January 16, 2008, when chlorine dioxide feed was stopped.

The contact time had no effect on iron oxidation because chlorine dioxide reacts with iron nearly instantaneously. Although the contact time was reduced to nearly zero minutes by bypassing the contact tank during Operating Condition 3K, nearly 100 percent of iron was oxidized. The pH adjustment also had no effect on iron oxidation.

On all days except January 14, 2008, the total iron concentrations were nearly non-detect in the RO feed, which indicates that the iron was nearly 100 percent oxidized and removed by the granular media filters and/or the cartridge filters.

On January 14, 2008, on the sixth day after the last change-out of the cartridge filters, the cartridge filters were heavily fouled (see Figure 5.2-12) and particulate iron was evidently breaking through to the RO membranes. After the cartridge filters were replaced on January 15, 2008, the total and dissolved iron in the RO feed was nearly non-detect on all days including January 16, 2008, when the chlorine dioxide dose was zero.

Figure 5.2-12.
Phase III - Heavily Fouled Cartridge Filters

The presence of oxidized iron on the cartridge filters, in spite of the high rate of oxidation ahead of the media filters is indication that the media filters were only partially effective at removing oxidized iron, even at the low filtration rates utilized during this testing (averaging between 3 to 5 gpm/sf). It is likely that the accumulation of oxidized iron in the media was not being fully removed through the backwashing approach, and more aggressive backwashing, perhaps with the addition of air scour, may have been required. Such capabilities were not available for the pilot unit, with backwashing limited to 15 gpm/sf.

Manganese Oxidation

The total and particulate manganese data shows that chlorine dioxide feed plus media filtration pretreatment removed 55 percent to 80 percent of total manganese. On average, 70 percent of total manganese was oxidized and removed by pretreatment. Figure 5.2-13 summarizes the average total and particulate manganese levels in the Well A raw water, the pretreatment feed and the RO feed.

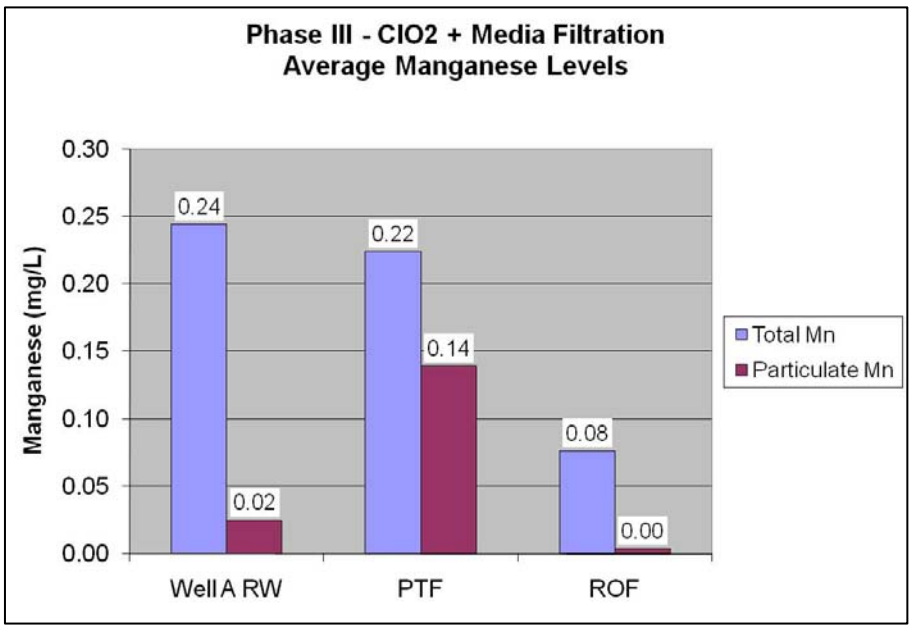

Figure 5.2-13.
Phase III – Average Manganese Levels

The total and dissolved manganese data for the RO feed shows that 0.08 mg/L of total manganese in the RO feed was nearly all in the dissolved stage. Further, it should be noted that these manganese levels were nearly equivalent to the dissolved manganese levels upstream of the media filters (e.g., total manganese in the pretreatment feed – particulate manganese in the pretreatment feed). The data indicates that approximately 0.08 mg/L of dissolved manganese that was not oxidized during the pretreatment stage did not get oxidized in the RO, even in the presence of residual chlorine dioxide in the RO feed. Although the chlorine dioxide oxidized only 70 percent of total manganese, the remaining 30 percent of total manganese that was dissolved in the RO feed water remained dissolved and was removed by desalination process without causing particulate fouling of the RO.

Manganese Oxidation vs. Dose

Manganese oxidation was slightly improved with increased chlorine dioxide dose as shown in Figure 5.2-14. Up to 80 percent of manganese oxidation was achieved with chlorine dioxide dose between 1.5 mg/L and 2.2 mg/L. Higher doses were not tested, and it is unclear whether complete oxidation of manganese could have been achieved with substantially higher doses than those employed.

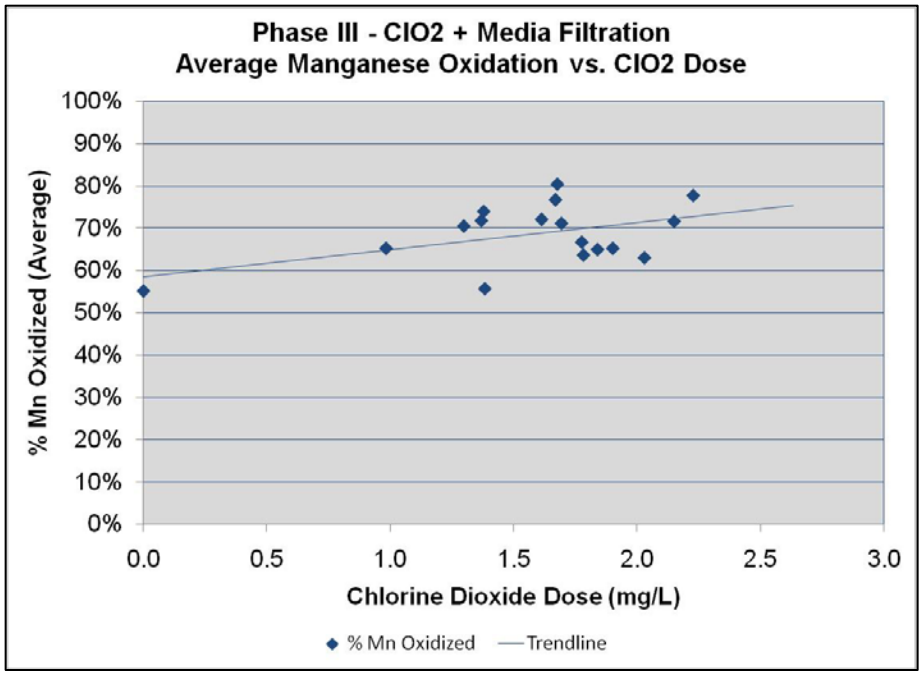

Figure 5.2-14.
Phase III – Average Manganese Oxidation vs. Chlorine Dioxide Dose

Manganese Oxidation vs. Contact Time

The contact time had no apparent impact on manganese oxidation. On average, the same amount of manganese was oxidized with nearly zero minutes of contact time as with 37 minutes of contact time. Figure 5.2-15 shows the average manganese oxidation rates per contact time.

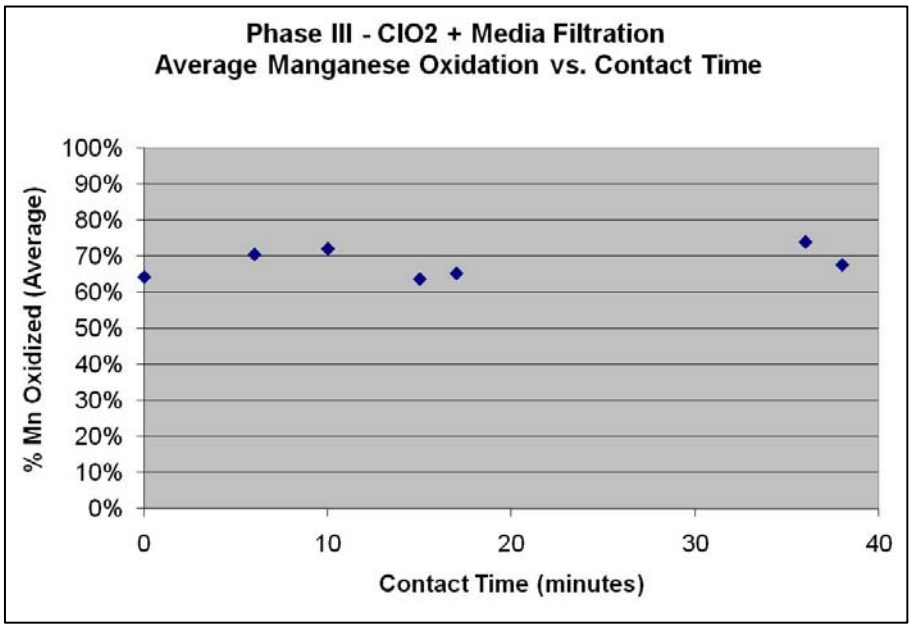

Figure 5.2-15.
Phase III – Average Manganese Oxidation vs. Contact Time

Manganese Oxidation vs. pH
It appears that raising the Well A raw water pH from 7.3 to 8.1 also did not improve manganese oxidation rate significantly (see Figure 5.2-16), however, elevating the pH was found during Phase II testing to cause considerable scaling from calcium carbonate in the piping, valves, and media filters.

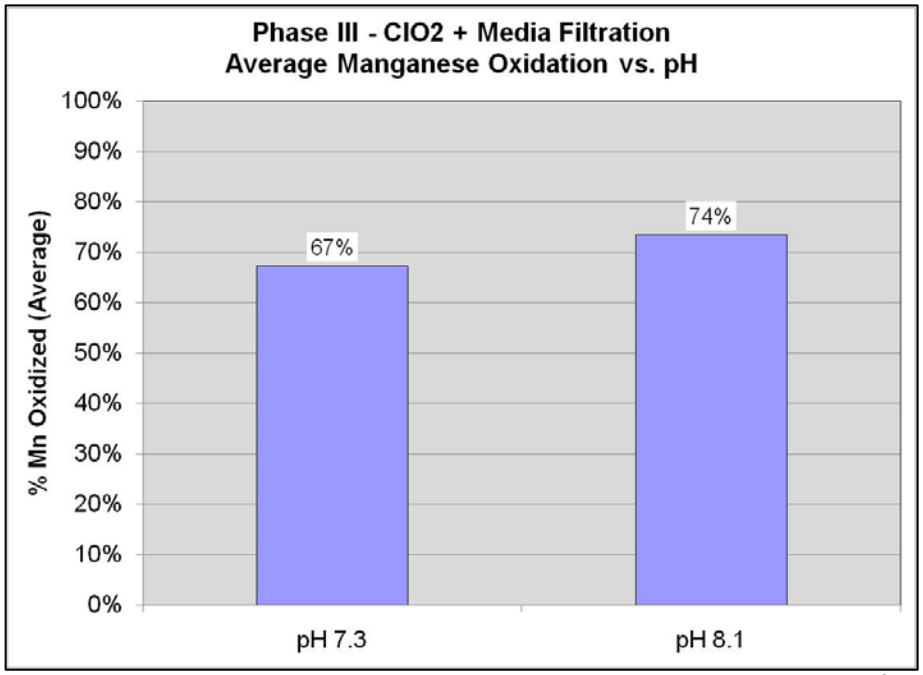

Figure 5.2-16.
Phase III - Average Manganese Oxidation vs. pH

5.2.3.2 Filtration Performance

Granular Media Filters Performance
The GMFs were fouled at a much faster rate during this phase than during Phase II, with the GMFs removing both oxidized iron and oxidized manganese. Table 5.2-7 summarizes the estimated fouling rates of the GMFs. The differential pressure across the GMFs increased by 1.5 psi/day at the hydraulic loading rate of 3.0 gpm/sf, and 3.6 psi/day at the hydraulic rate of 4.5 to 4.7 gpm/sf. The higher fouling rates require more frequent backwashes.

When caustic soda was used to raise the pH of Well A raw water from 7.3 to 8.1, the GMFs were fouled at a much faster rate due to added fouling from scale build-up. The differential pressure across the GMFs increased by as much as 13 psi/day at the hydraulic loading rate of 5.1 gpm/sf. Consequently, an acid soak and backwash was required to fully remove the scale which had built up on the GMFs.

Table 5.2-7.
Phase III – Chlorine Dioxide Feed + Media Filtration: GMF Fouling Rate

GMF Loading Rate (gpm/sf)	Without pH Adjustment (pH 7.3) Average GMF Fouling Rate (psi/day)	With pH Adjustment (pH 8.1) Average GMF Fouling Rate (psi/day)
3.0	1.5	4.8
4.5 to 4.7	3.6	--
5.1	--	13

Cartridge Filters Performance

It was evident that the GMFs did not remove all oxidized iron or manganese based on the heavy fouling rate of the cartridge filters, which were replaced weekly. High total iron level in the RO feed on January 14, 2008, was evidence of particulate iron break-through. Also, the high SDI numbers measured on January 10 and January 29, 2008, two or more days after the cartridge filters replacement, as opposed to a low SDI number measured on January 23, less than a day after the cartridge filters change-out, may be evidence of particulate break-through.

Table 5.2-8 summarizes the estimated fouling rates of the cartridge filters. On average, the differential pressure across the cartridge filters increased by more than 1.2 psi/day when caustic soda was not used for pH adjustment. However, the fouling rate of the cartridge filters approximately doubled due to scale build-up when caustic soda was used to raise the pH of the Well A water.

Table 5.2-8.
Phase III – Chlorine Dioxide Feed + Media Filtration: Cartridge Filter Fouling Rate

Sets	Date	No. of Hours Used	NaOH Used for pH Adjustment	Initial Differential Pressure (psi)	Final Differential Pressure (psi)	Fouling rate (psi/day)
1	1/2/08 -1/8/08	137	No	--	--	--
2	1/8/08 - 1/15/08	151	Yes	~ 5	≥ 20	≥ 2.4
3	1/15/08 - 1/22/08	137	No	4	≥ 10.5	≥ 1.2
4	1/22/08 - 1/31/08	204	No	5	≥ 18	≥ 1.5

While iron was clearly evident in the fouled cartridge filters, black manganese colored foulant was also observed on the cartridge filters during Phase III. The fouled cartridge filters were dark brown in color while they were wet, but patches of black manganese were clearly visible when they were dry. This indicates that the media filters were only partially effective at removing the oxidized manganese, even at the low filtration rates, averaging between 3 to 5 gpm/sf, tested during Phase III. As stated previously, a more aggressive backwashing approach, utilizing an air scour,

may be required to prevent breakthrough of this type, however, it may also be necessary to utilize filters with smaller effective size media or a deeper bed depth.

The spent cartridge filters from Phase III (ClO_2 + GMF), were dark brown overall with patches of black manganese (see Figure 5.2-17). This compares against the fouled cartridge filters from Phase II (aeration + GMF), which were uniformly rust colored without black manganese fouling (see Figure 5.2-18).

Figure 5.2-17.
Fouled Cartridge Filters from Phase III (ClO2 + Media Filtration)

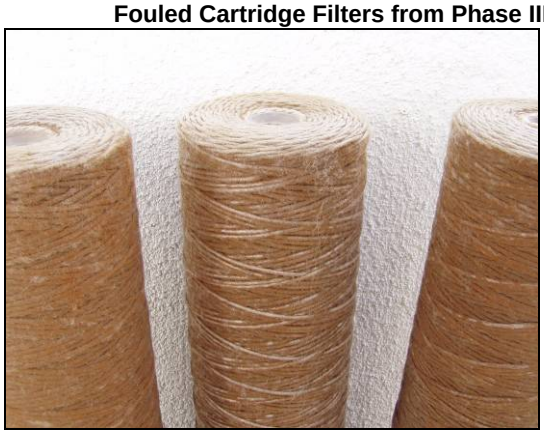

Figure 5.2-18.
Fouled Cartridge Filters from Phase II (Aeration + Media Filtration)

5.2.3.3 RO Performance

The first stage MTC and the second stage MTC are shown in Figure 5.2-19, respectively. MTC is a measure of membrane performance, with fouled membranes demonstrating a drop or reduction in MTC. The first stage MTC shows a slight upward trend during most operating conditions, with a slight downward trend during the latter stages of testing. Overall, the first stage MTC looks relatively flat, indicating that particulate fouling was not a significant concern during this stage of testing. The slight rise in MTC during the first 3 weeks of Phase III testing, however, is a concern, as it indicates that membrane damage was occurring from chlorine dioxide or hypochlorite residuals in the chlorine dioxide. It should be noted that ultra-pure chlorine dioxide from CDG Research Corporation was used for this pilot

testing to avoid the risk of membrane damage from residual hypochlorite, chlorite, or chlorate byproducts. The CDG product is reported to be greater than 99.8 percent pure in chlorine dioxide, without significant residual concentrations of byproducts known to damage RO membranes. Our data suggests, however, that either the purity of chlorine dioxide was less than anticipated, or the chlorine dioxide itself caused significant damage to the membranes.

RO membrane damage is also evident in permeate conductivities shown in Figures 5.2-20 and 5.2-21. Standard brackish water membranes (Saehan BLR), used in Vessels 1B-1, 1B-2 and 2B, show evidence of damage with a steadily increasing permeate conductivity in all three vessels (see Figure 5.2-21). The chlorine resistant membranes (Saehan CRM), used in Vessels 1A-1, 1A-2 and 2A, did not show consistent evidence of membrane damage during the testing period (see Figure 5.2-20).

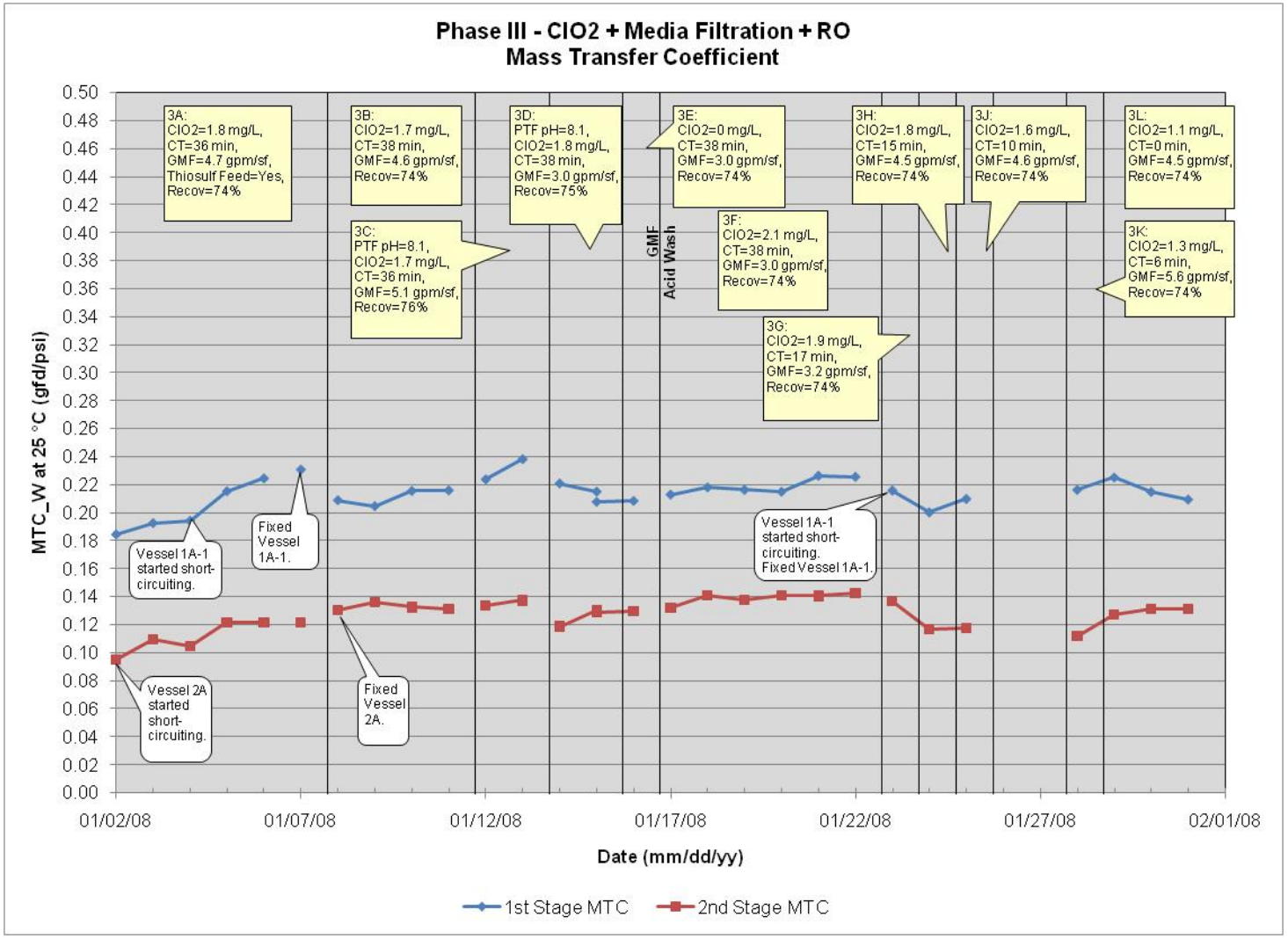

Figure 5.2-19.
Phase III – MTC_W at 25 °C

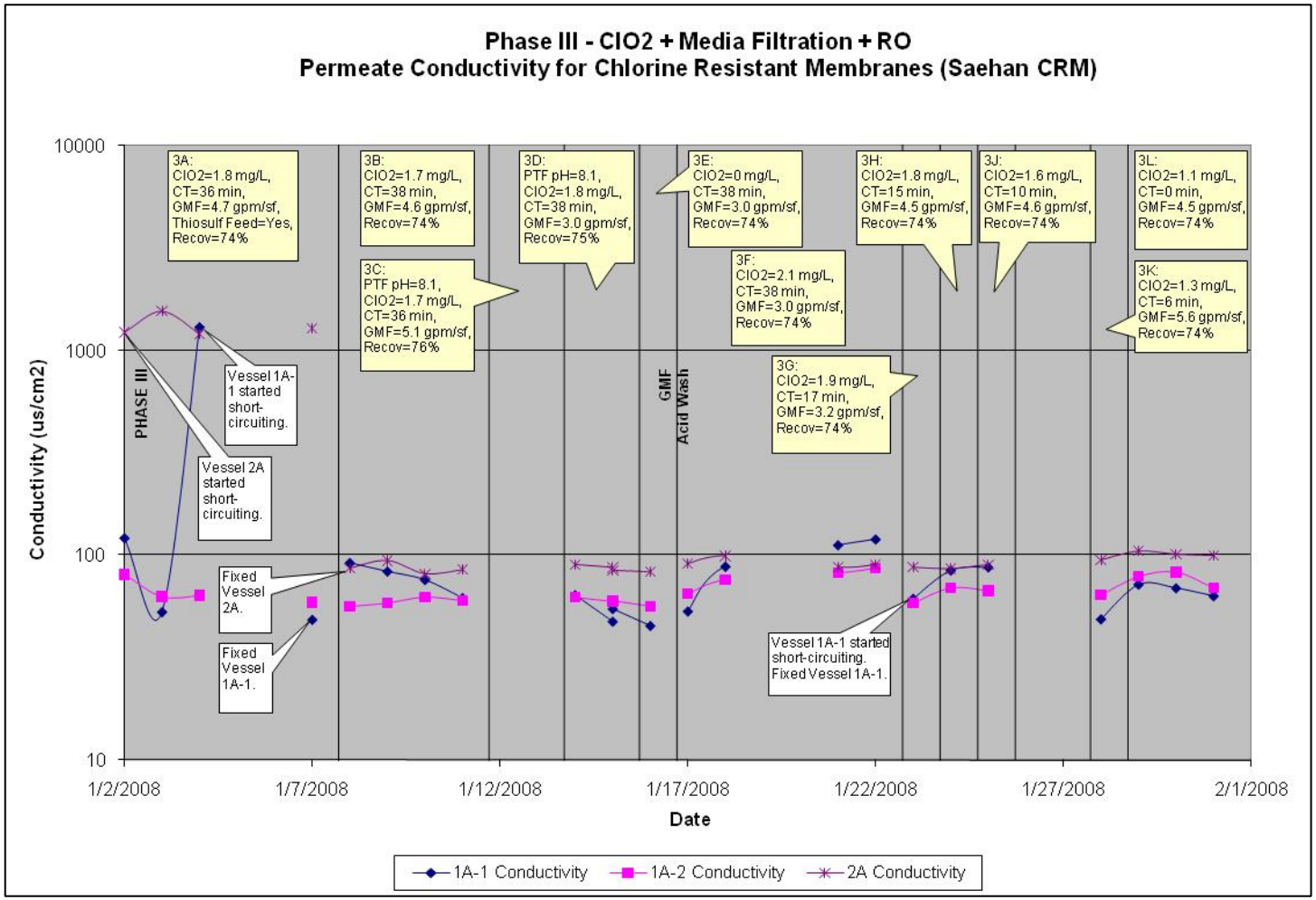

Figure 5.2-20.
Phase III – Permeate Conductivity for Chlorine Resistant Membranes (Saehan CRM)

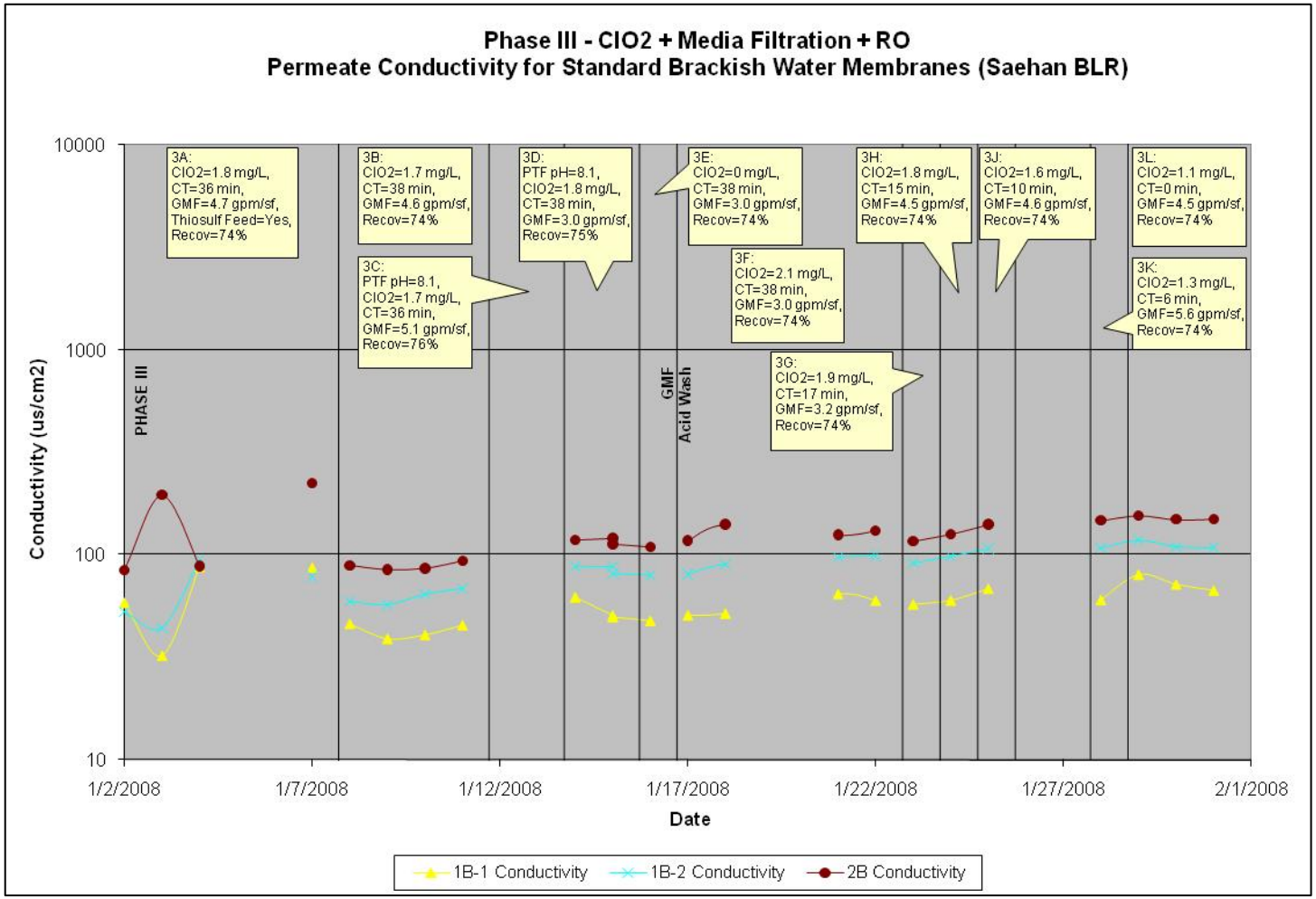

Figure 5.2-21.
Phase III – Permeate Conductivity for Standard Brackish Water Membranes (Saehan BLR)

5.2.3.4 Water Quality

The water quality parameters tested during Phase III are summarized in Table 5.2-9.

Table 5.2-9.
Phase III – Chlorine Dioxide Feed + Media Filtration + RO: Water Quality

Parameter	Detection Limit	Water Quality Goals: Regulatory Requirements or Reporting Limit	Water Quality Goals: City's Goal	Water Quality: Well A Raw Water	Water Quality: RO Feed	Water Quality: RO Permeate	Water Quality: RO Waste
Temperature (°C)				--	21	--	--
pH		6.5 – 8.5	6.5 – 8.5	7.3	7.3	6.4	7.8
Conductivity (uS/cm^2)		900	900	2630	2790	272	8970
UV254 (cm^{-1})				0.04	0.03	--	--
Color (C.U)	2	15	2	6	3	< 2	--
Total Iron (mg/L)	0.02	0.3	0.2	0.174	0.003	0.002	0.006
Total Manganese (mg/L)	0.005	0.05	0.02	0.245	0.073	0.001	0.250
Alkalinity as $CaCO_3$ (mg/L)	2.0			300	300	25	1100
Total Hardness as $CaCO_3$ (mg/L)	0.66		120	970	970	4	3500
TDS (mg/L)	10	500	300	1500	1600	78	--
TSS (mg/L)	5			< 5	< 5	--	< 5
TOC (mg/L)	0.60			1.6	1.8	--	--
Ammonia (NH3-N, mg/L)	0.017			0.30	--	0.03	1.04
Total Barium (mg/L)	0.0020			--	0.054	< 0.002	0.180
Total Boron (mg/L)	0.010	1	1	0.70	--	0.68	--
Calcium (mg/L)	0.10			--	260	1.0	970
Chloride (mg/L)	0.24	250	80	101	--	18	--
Magnesium (mg/L)	0.10			--	76	0.29	270
Silica (mg/L)	0.3			29		5.1	87
Sodium (mg/L)	0.50			--	200	21	--
Sulfate (mg/L)		250		1125	--	0.10	3520
Total Strontium (mg/L)	0.0050			--	2.1	0.0071	7.1
Total Vanadium (mg/L)	0.0050			< 0.005	--	< 0.005	--
Gross Alpha (pCi/L)		15	15	18.8	--	2.9	--

Notes:
-- Not measured.

Table 5.2-9 shows acceptable water quality for the RO permeate for all parameters, including iron, manganese, TDS, chloride and sulfate. In particular, the TDS level in the RO permeate was 78 mg/L, much lower than the City's goal of 300 mg/L.

5.2.3.5 Phase III Summary (Alternative 3)

The estimated chlorine dioxide demand in Well A raw water ranged from 0.8 to 2.1 mg/L, with an average of 1.5 mg/L. Chlorine dioxide oxidized approximately 100 percent of iron and 70 percent of manganese. The ability of chlorine dioxide to oxidize iron and manganese was not affected by contact time or raw water pH. The same quantities of iron and manganese were oxidized when the contact tank was bypassed as when 37 minutes of contact time was provided. Also, the same quantities of iron and manganese were oxidized at pH of 7.3 as at pH of 8.1.

Although only 70 percent of manganese was oxidized during the pretreatment stages, the remaining 30 percent did not appear to cause fouling of the RO membranes. It appears that when manganese was not oxidized at the first exposure to chlorine dioxide during the pretreatment, it did not further oxidize downstream of the pretreatment, regardless of the level of chlorine dioxide residual present in the RO feed water. All of the non-oxidized manganese remained dissolved and was successfully removed by the RO without causing particulate fouling.

Chlorine dioxide plus media filtration pretreatment appears to be problematic for several reasons. First and foremost, chlorine dioxide appears to have damaged the RO membranes, as was evident in the steadily increasing permeate conductivities and the gradually increasing MTC during the first three weeks of the Phase III testing. Although the chlorine resistant membranes (Saehan CRM) appeared to be more resistant to chlorine dioxide than the standard brackish water membranes (Saehan BLR), these membranes are a new product currently only produced by one manufacturer, and not in use in any full scale applications. For chlorine dioxide to be used in a full-scale plant with any membranes other than the CRMs, it is likely that dechlorination with sodium bisulfite or sodium thiosulfate would be required.

In addition to the RO damage, particulate iron and manganese appeared to be passing through the media filtration process and fouling the cartridge filters. The cartridge filters should not be relied on for filtration, but were heavily loaded with particulate iron and manganese during this phase. Further, the fouling rate on the media filters was high, averaging 3 to 6 psi/day at a filtration rate less than 5 gpm/sf.

5.2.4 Phase IV – Chlorine Feed plus Pyrolox Media Filtration (Alternative 4)

The pretreatment process tested during Phase IV was chlorine (Cl_2) feed plus Pyrolox media filtration, sometimes referred to as greensand. The objectives of this pretreatment evaluation, process description, pilot configuration, operating conditions, and testing protocol were described previously in Section 4.3.4. Similar to Phase III, the primary objective was to oxidize both dissolved iron and dissolved manganese into particulate iron and manganese, removing both with the Pyrolox or "greensand" filters. A successful test would remove all iron and manganese in the Pyrolox filters and prevent a loss in MTC across the RO membranes.

5.2.4.1 Oxidation Performance

Free chlorine concentration, total iron, dissolved iron, total manganese, and dissolved manganese measurements are averaged for each operating condition of Phase IV testing and summarized in Table 5.2-10.

Table 5.2-10.
Phase IV – Chlorine Feed + Pyrolox Media Filtration + RO: Test Data per Operating Conditions

	Time Period	WQ Parameters, Average Values	Well A Raw Water	Pre-treatment Feed (2)	Pre-treatment Product	RO Feed	RO Permeate	RO Waste
4A	2/20/08-3/12/08	Chlorine, (mg/L)	1.0 (1)	0.4 (3)	0.2	≤ 0.01	≤ 0.01	--
		Total Iron, (mg/L)	0.165	0.168	0.026	≤ 0.008	≤ 0.008	≤ 0.008
		Dissolved Iron, (mg//L)	0.167	≤ 0.008	--	≤ 0.008	≤ 0.008	≤ 0.008
		Total Manganese, (mg/L)	0.248	0.243	0.079	0.062	≤ 0.005	0.274
		Dissolved Manganese (mg/L)	0.236	0.186	--	0.073	≤ 0.005	0.241
4B	3/13/08-3/17/08	Chlorine, (mg/L)	1.1 (1)	0.2 (3)	0.1	≤ 0.01	≤ 0.01	--
		Total Iron, (mg/L)	0.168	0.169	0.047	0.011	≤ 0.008	≤ 0.008
		Dissolved Iron, (mg//L)	0.168	≤ 0.008	--	≤ 0.008	≤ 0.008	≤ 0.008
		Total Manganese, (mg/L)	0.235	0.229	0.095	0.061	≤ 0.005	0.225
		Dissolved Manganese (mg/L)	0.205	0.198	--	0.061	≤ 0.005	0.160
4C	3/18/08-3/19/08	Chlorine, (mg/L)	1.2 (1)	0.2 (3)	0.1	≤ 0.01	≤ 0.01	--
		Total Iron, (mg/L)	0.152	0.169	0.079	≤ 0.008	≤ 0.008	≤ 0.008
		Dissolved Iron, (mg//L)	0.168	≤ 0.008	--	≤ 0.008	≤ 0.008	≤ 0.008
		Total Manganese, (mg/L)	0.245	0.236	0.110	0.051	≤ 0.005	0.230
		Dissolved Manganese (mg/L)	--	--	--	--	--	--
4D	3/19/08-3/20/08	Chlorine, (mg/L)	1.9 (1)	0.4 (3)	0.2	≤ 0.01	≤ 0.01	--
		Total Iron, (mg/L)	0.165	0.170	0.055	≤ 0.008	≤ 0.008	≤ 0.008
		Dissolved Iron, (mg//L)	0.169	≤ 0.008	--	≤ 0.008	≤ 0.008	0.010
		Total Manganese, (mg/L)	0.248	0.266	0.133	0.080	≤ 0.005	0.290
		Dissolved Manganese (mg/L)	--	--	--	--	--	--
4E	3/21/08-3/21/08	Chlorine, (mg/L)	4.4 (1)	1.5 (3)	0.1	≤ 0.01	≤ 0.01	--
		Total Iron, (mg/L)	0.131	0.156	0.039	0.016	≤ 0.008	0.018
		Dissolved Iron, (mg//L)	0.140	0.013	--	≤ 0.008	≤ 0.008	≤ 0.008

Table 5.2-10.
Phase IV – Chlorine Feed + Pyrolox Media Filtration + RO: Test Data per Operating Conditions

	Time Period	WQ Parameters, Average Values	Well A Raw Water	Pre-treatment Feed (2)	Pre-treatment Product	RO Feed	RO Permeate	RO Waste
		Total Manganese, (mg/L)	0.230	0.238	0.095	0.061	≤ 0.005	0.330
		Dissolved Manganese (mg/L)	0.239	0.123	--	0.064	≤ 0.005	0.420
4F	3/24/08-3/25/08	Chlorine, (mg/L)	2.4 (1)	0.9 (3)	0.3	≤ 0.01	≤ 0.01	--
		Total Iron, (mg/L)	0.157	0.171	0.088	≤ 0.008	≤ 0.008	≤ 0.008
		Dissolved Iron, (mg//L)	0.172	≤ 0.008	--	≤ 0.008	≤ 0.008	≤ 0.008
		Total Manganese, (mg/L)	0.227	0.226	0.142	0.061	≤ 0.005	0.180
		Dissolved Manganese (mg/L)	0.213	0.188	--	0.073	≤ 0.005	0.240
4G	3/26/08-3/28/08	Chlorine, (mg/L)	1.8 (1)	0.5 (3)	0.2	≤ 0.01	≤ 0.01	--
		Total Iron, (mg/L)	0.165	0.167	0.067	≤ 0.008	≤ 0.008	≤ 0.008
		Dissolved Iron, (mg//L)	0.166	≤ 0.008	--	≤ 0.008	≤ 0.008	≤ 0.008
		Total Manganese, (mg/L)	0.252	0.249	0.123	0.084	0.011	0.420
		Dissolved Manganese (mg/L)	--	--	--	--	--	--
4J	3/31/08-4/02/08	Chlorine, (mg/L)	1.5 (1)	0.3 (3)	0.2	≤ 0.01	≤ 0.01	--
		Total Iron, (mg/L)	0.156	0.168	0.113	≤ 0.008	≤ 0.008	≤ 0.008
		Dissolved Iron, (mg//L)	0.171	≤ 0.008	--	≤ 0.008	≤ 0.008	≤ 0.008
		Total Manganese, (mg/L)	0.241	0.235	0.180	0.072	≤ 0.005	0.315
		Dissolved Manganese (mg/L)	0.225	0.209	--	0.081	≤ 0.005	0.310
4K	4/03/08-4/04/08	Chlorine, (mg/L)	1.8 (1)	0.3 (3)	0.2	≤ 0.01	≤ 0.01	--
		Total Iron, (mg/L)	0.157	0.164	0.078	≤ 0.008	≤ 0.008	≤ 0.008
		Dissolved Iron, (mg//L)	0.145	≤ 0.008	--	≤ 0.008	≤ 0.008	≤ 0.008
		Total Manganese, (mg/L)	0.244	0.239	0.109	0.071	≤ 0.005	0.295
		Dissolved Manganese (mg/L)	0.226	0.203	--	0.083	≤ 0.005	0.230

(1) Chlorine dose injected to Well A raw water.
(2) All pretreatment feed samples were grabbed from downstream of the contact tank, unless otherwise noted.
(3) Measured in the pretreatment feed sample grabbed upstream of the contact tank.
-- Not measured.
NOTE: Iron and manganese levels were not measured during Operating Condition 4H.

Chlorine Dose and Demand

The chlorine dose fed to Well A raw water, and the chlorine levels in the pretreatment feed and the pretreatment product (PTP) are shown in Figure 5.2-22. On average, chlorine was dosed at approximately 1.4 mg/L, and the chlorine residual measured in the PFP sample was 0.2 mg/L. Therefore, the average chlorine demand was 1.2 mg/L.

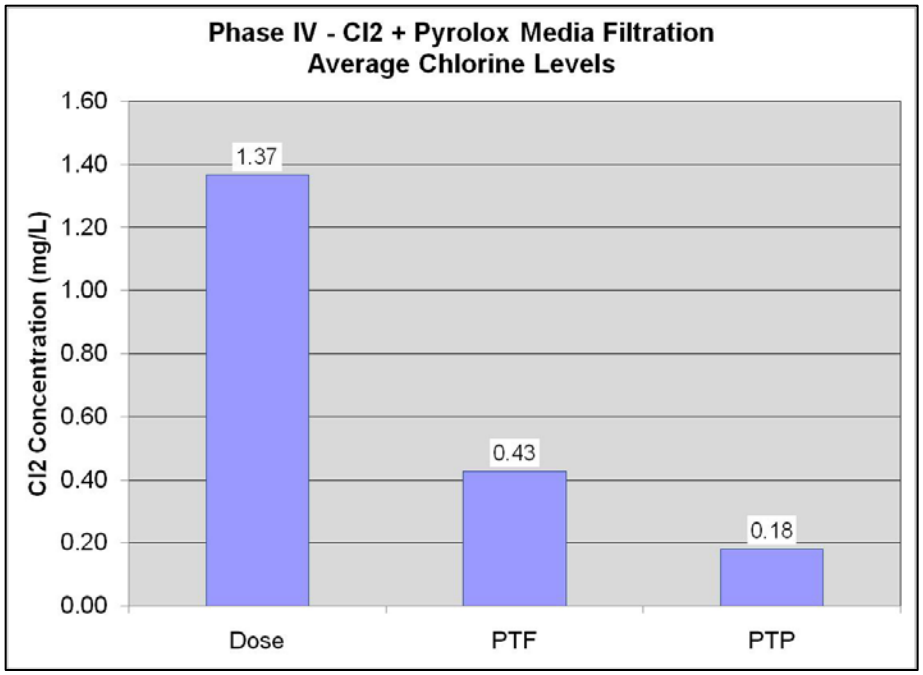

Figure 5.2-22.
Phase IV – Average Chlorine Levels

The typical chlorine dose that has been reported for the oxidation of iron and manganese are 0.63 mg Cl_2/mg Fe^{2+} and 1.29 mg Cl_2/mg Mn^{2+}, respectively (MWH, 2005). The average dissolved iron concentration in Well A raw water was 0.17 mg/L, all of which was oxidized by chlorine. The average dissolved manganese concentration in Well A raw water was 0.22 mg/L, of which 0.17 mg/L was oxidized by chlorine feed plus Pyrolox media filtration. Therefore, it can be calculated, based on the above ratios, that approximately 0.4 mg/L of chlorine was used to oxidize iron and manganese in the Well A raw water, with the remaining chlorine demand coming from other materials, such as dissolved organics.

Of the 0.24 mg/L of total manganese in the raw water, approximately 0.07 mg/L of manganese was not oxidized with chlorine during the testing, even with chlorine doses in excess of 4 mg/L.

It is important to note that the chlorine dose did not affect the amount of iron and manganese oxidized. As summarized in Table 5.2-11, 100 percent of iron oxidation and 70 percent of manganese oxidation was achieved at for all doses ranging from 1.0 mg/L to 4.4 mg/L. It is not clear whether chlorine doses significantly higher than those utilized here could have resulted in complete oxidation of the dissolved manganese.

Table 5.2-11.
Phase IV – Chlorine Feed + Pyrolox Media Filtration: Chlorine Demand and Oxidation Rates

Average Cl_2 Dose (mg/L)	Average Cl_2 Demand (mg/L)	Contact Time (min)	% Iron Oxidized	Well A Raw Water Total Manganese (mg/L)	RO Feed Dissolved Manganese (mg/L)	% Manganese Oxidized
1.0	0.8	15	100%	0.25	0.07	70%
1.1	0.9	10	100%	0.24	0.06	75%
1.5	1.3	10	100%	0.24	0.08	66%
1.8	1.6	7	100%	0.25	0.08	68%
2.4	2.1	15	100%	0.23	0.07	69%
4.4	4.3	15	100%	0.23	0.06	73%

It appears that 1.0 mg/L of chlorine dose was sufficient to achieve 100 percent of iron oxidation and approximately 70 percent of manganese oxidation, while higher doses of chlorine achieved only marginal changes in manganese oxidation.

Iron Oxidation

The total iron levels for Well A raw water, the pretreatment product, and the RO permeate samples during Phase III testing are shown in Figure 5.2-23. A sudden increase in iron levels in the pretreatment product was seen beginning March 7, 2008.

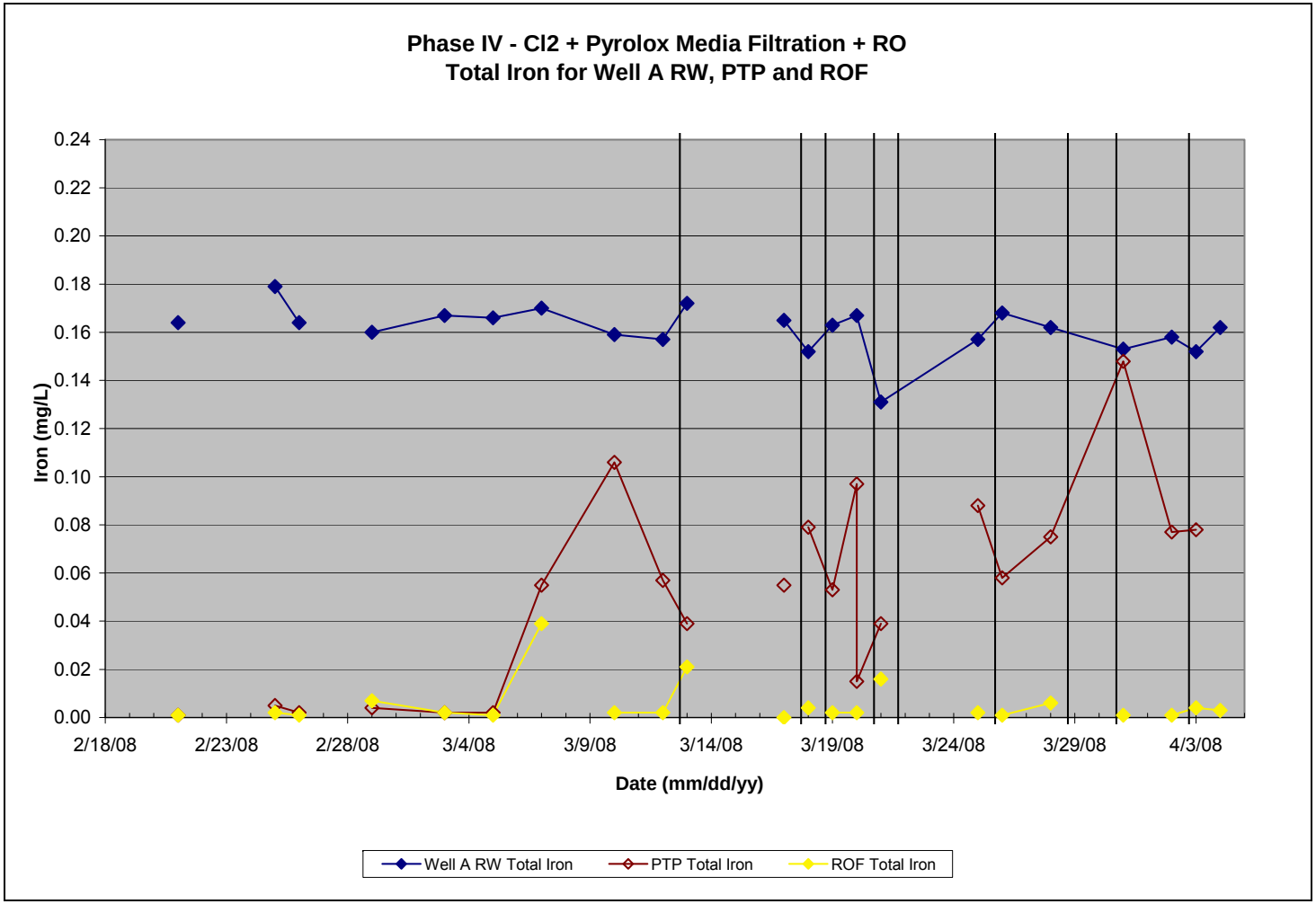

Figure 5.2-23.
Phase IV – Total Iron for Well A RW, PTP, and ROF

The average total and dissolved iron data are shown in Figures 5.2-24 and 5.2-25. Both figures show that 100 percent of total iron was oxidized in the pretreatment feed water (after the contact tank), indicating that chlorine is an effective oxidant for iron at these concentrations and contact times.

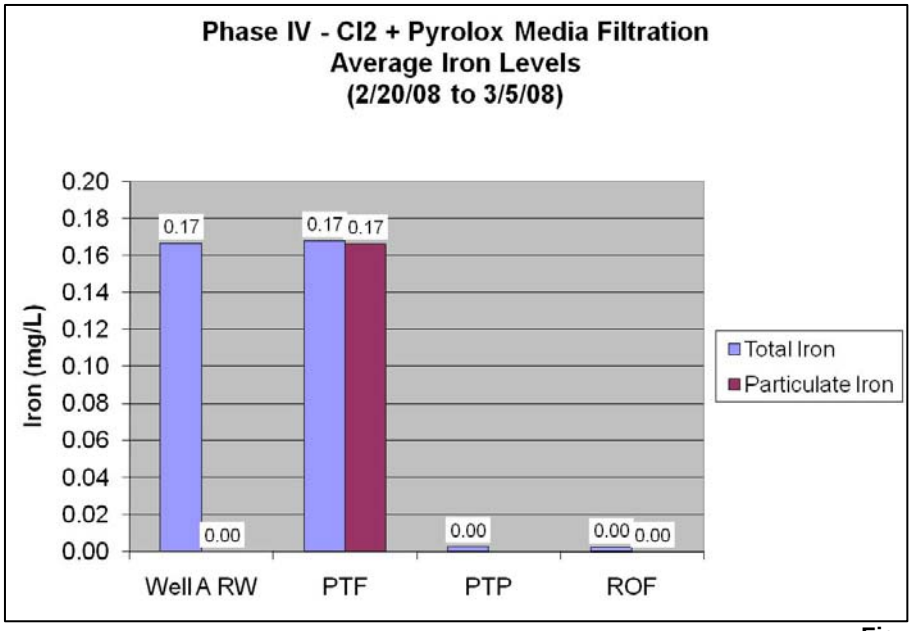

Figure 5.2-24.
Phase IV – Average Iron Levels (2/20/08 to 3/5/08)

The total and dissolved iron data from February 20, 2008 to March 5, 2008, shown in Figure 5.2-24, shows that the chlorine feed plus Pyrolox media filtration is an effective pretreatment method for removing iron by oxidation and filtration, as the iron level in the pretreatment product is below detection level.

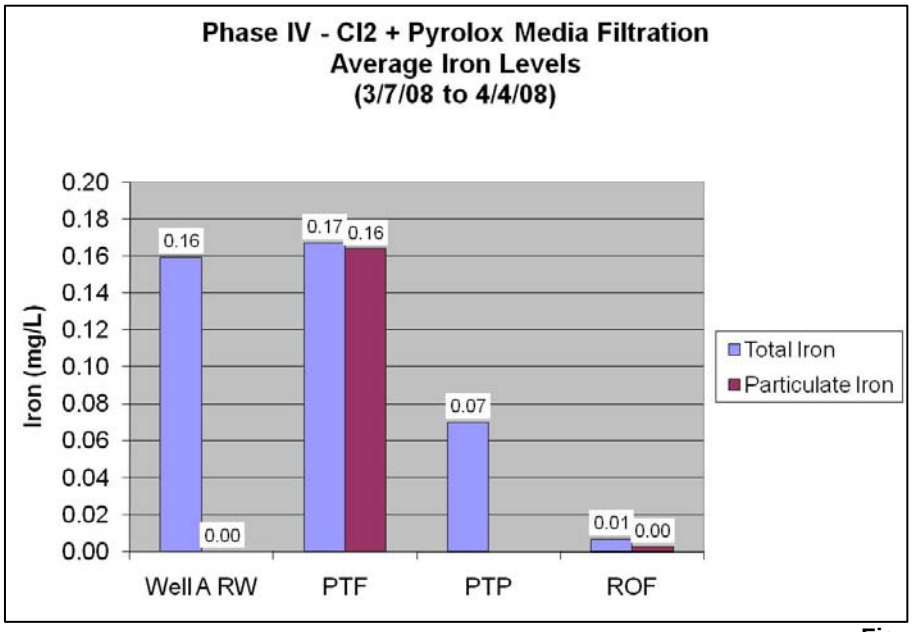

Figure 5.2-25.
Phase IV – Average Iron Levels (3/7/08 to 4/4/08)

However, the total and dissolved iron data from March 7, 2008 to April 4, 2008, shown in Figure 5.2-25 shows significant quantities of iron passing through the media filters, which appears to be the result of insufficient backwashing of the media filters. Although all of the iron in the pretreatment feed was oxidized and should have been removed by the Pyrolox media filters, approximately 40 percent of total iron passed through the Pyrolox media filters and was removed by the cartridge filters instead.

It should be noted here that operation of Pyrolox media filters often requires backwashing rates in excess of 25 to 30 gpm/sf, to achieve 40 percent filter bed expansion when significant quantities of iron are present in the water source. Such backwash rates were not feasible with the pilot unit, due to the large degree of media carryover seen when operating with high bed expansion rates. Pyrolox and greensand facilities often employ air scour in the backwash process to reduce the backwashing rates, however, such capabilities were not included in the pilot unit tested here. Backwashing rates during the pilot study did not exceed 15 gpm/sf, which is a generally a sufficient rate for typical media filters, but was not effective for the heavily fouled Pyrolox media.

Manganese Oxidation

The average total and dissolved manganese data are shown in Figures 5.2-26 and 5.2-27. Both figures show that the total and dissolved manganese levels in the Well A raw water were approximately 0.24 mg/L, and the total and dissolved manganese levels in the RO feed water was approximately 0.07 mg/L. The chlorine feed plus Pyrolox media filtration achieved approximately 70 percent of manganese oxidation, which is similar to the level of oxidation achieved with chlorine dioxide during the Phase III testing.

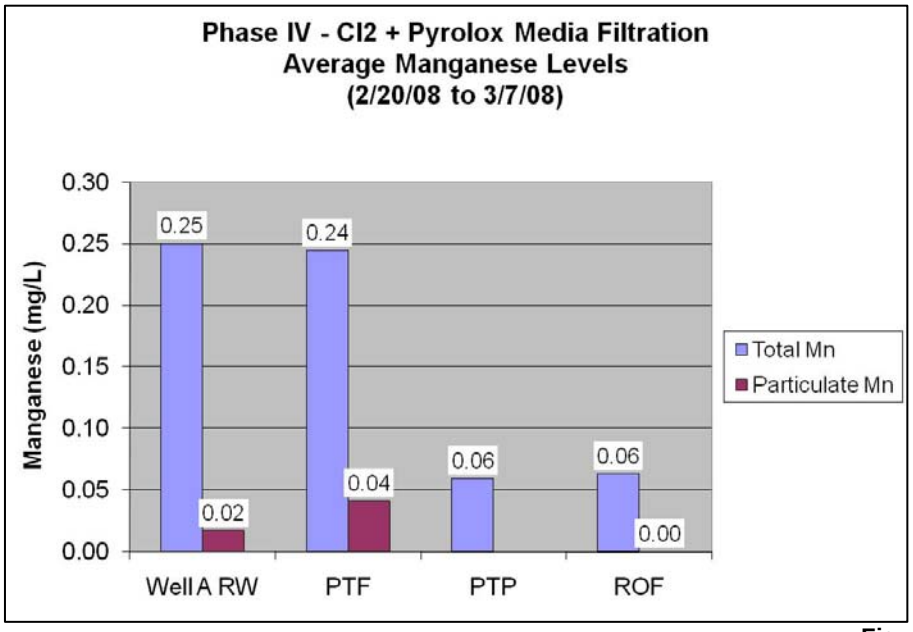

Figure 5.2-26.
Phase IV – Average Manganese Levels (2/20/08 to 3/7/08)

The total and dissolved manganese data from February 20, 2008 to March 7, 2008, shown in Figure 5.2-26, indicates that chlorine feed plus Pyrolox media filtration pretreatment oxidized and removed approximately 70 percent of total manganese. Approximately 17 percent of total manganese was oxidized by chlorine in the pretreatment feed, grabbed downstream of the contact tank and upstream of the Pyrolox media filters. An additional 53 percent of manganese was oxidized on the surface of the Pyrolox media.

It should be noted that during this period, from February 20, 2008 to March 7, 2008, the Pyrolox media removed all oxidized manganese, and all of the total manganese in the pretreatment product was dissolved.

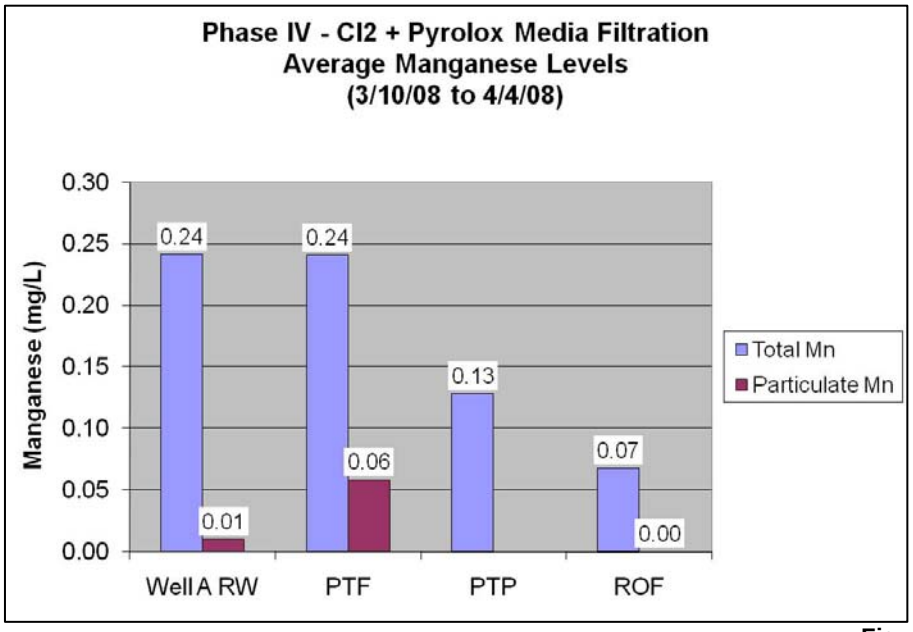

Figure 5.2-27.
Phase IV – Average Manganese Levels (3/10/08 to 4/4/08)

The total and dissolved manganese data from March 10, 2008 to April 4, 2008, shown in Figure 5.2-27, indicates manganese breakthrough similar to what was seen with the iron. Build-up of the organics and iron oxides likely occurred within the media due to the insufficient backwashing rates mentioned previously. Breakthrough for iron began on March 7. With the adsorption sites on the media reduced by the build-up of these materials, manganese oxidation began to reduce, to the point where manganese breakthrough was seen three days after the initial iron breakthrough. Figure 5.2-28 shows a sudden increase in manganese levels in the pretreatment product starting March 10, 2008.

Figure 5.2-27 shows that the total manganese level was 0.13 mg/L in the pretreatment product and 0.07 mg/L in the RO feed. This indicates that 0.06 mg/L of the total manganese in the pretreatment product had been oxidized, but was removed by the cartridge filters rather than the media filters.

The total and dissolved manganese data for the RO feed shows that the manganese in the RO feed was all in the dissolved state. The data indicates that during phase IV approximately 0.07 mg/L of dissolved manganese that was not oxidized during the pretreatment stage did not get oxidized in the RO and was removed by desalination.

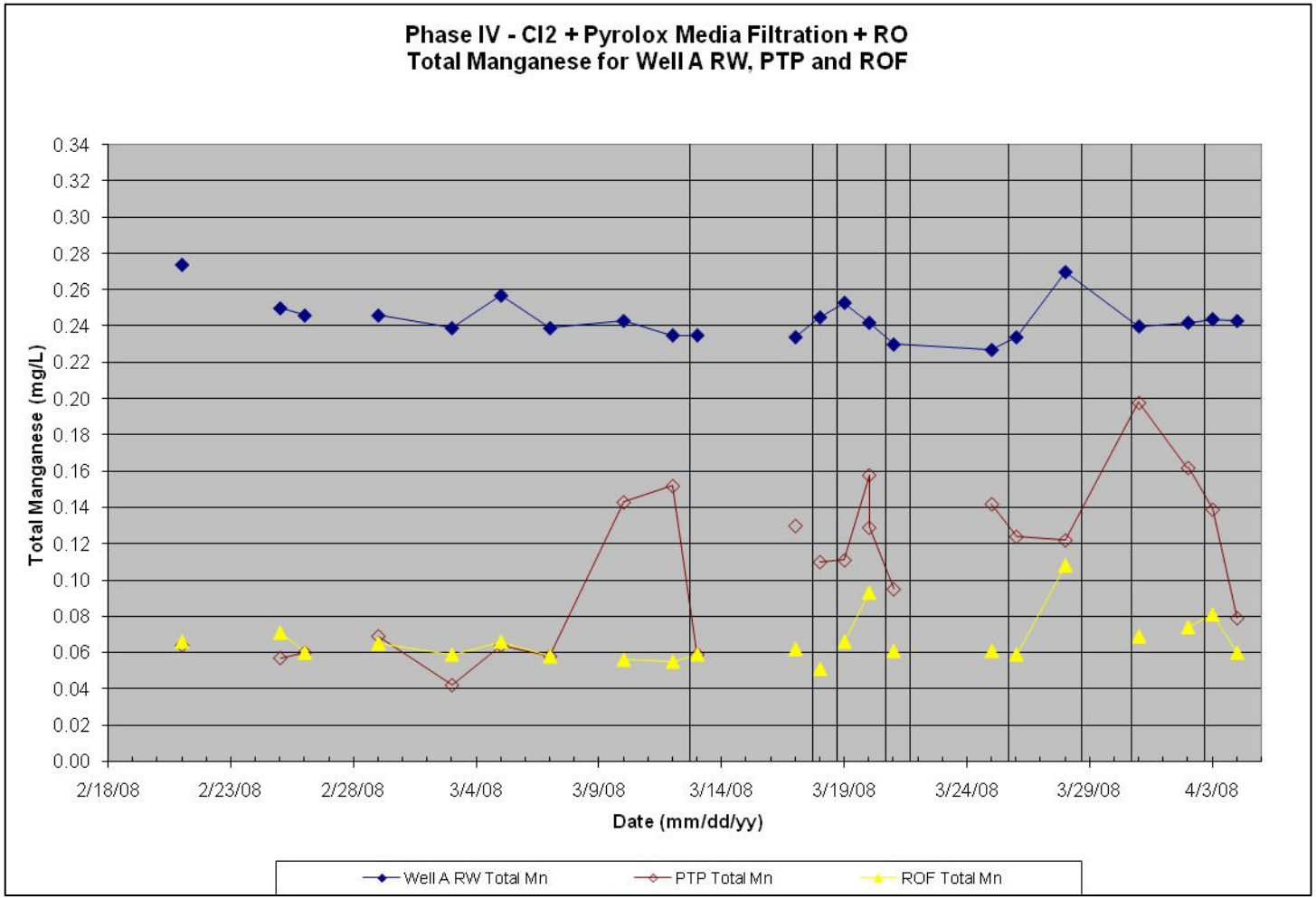

Figure 5.2-28.
Phase IV – Total Manganese for Well A RW, PTP, and ROF

Manganese Oxidation vs. Chlorine Dose

Manganese oxidation did not improve with increased chlorine dose, as shown in Figure 5.2-29. While chlorine dose of 1 mg/L to 2 mg/L achieved up to 80 percent manganese oxidation, increasing the chlorine dose to greater than 4 mg/L did not increase the manganese oxidation.

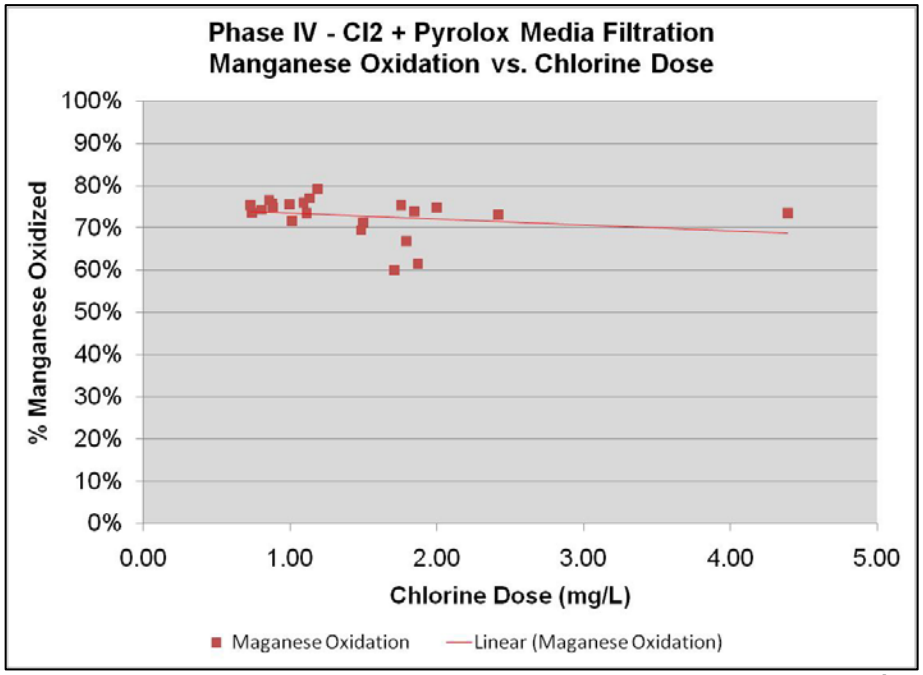

Figure 5.2-29.
Phase IV –Manganese Oxidation vs. Chlorine Dose

5.2.4.2 Filtration Performance

Pyrolox Media Filters Performance

The Pyrolox media filters were used to i) remove the oxidized iron; and ii) oxidize and remove manganese. In general, the Pyrolox media filters have been shown to work well if they are operated properly, however, high loading of iron is often problematic for these types of filters. The iron and manganese data from February 20, 2008 through March 5, 2008 show the Pyrolox media filters performing properly, and the data after March 5, 2008 show the Pyrolox media performing poorly.

The break-through of particulate iron and manganese was likely caused by the build-up of particulate iron and organic silts on the surface of the Pyrolox media, which were not completely removed by the weekly backwashes. While the build-up of oxidized manganese enhances the manganese oxidation, the build-up of oxidized iron on the surface of the media reduces the filtration capacity and interferes with manganese adsorption to the media surface. Backwashing of Pyrolox filters is also somewhat difficult, due to the high specific gravity of the media, requiring filtration rates in excess of 25-30 gpm/sf. Such filtration rates could not be achieved in the pilot without loss of media due to excessive bed expansion. Without proper backwashing,

the filters continued to accumulate iron oxides and silts, resulting in the breakthrough of both iron and manganese.

During Phase IV, the Pyrolox media filters were operated at an average loading rate of 3.2 gpm/sf, and the differential pressure across the filters increased at an average rate of 1 psi/day.

Cartridge Filters Performance

The fouling rate of the cartridge filters were in congruence with the performance of the Pyrolox media filters. Between February 20, 2008 and March 6, 2008, before the iron and manganese began breaking through the media filters, the differential pressure across the cartridge filters barely increased. However, from March 7, 2008 to April 20, 2008, the cartridge filters began getting loaded with particulate iron and manganese, and had to be replaced frequently.

The first set of cartridge filters, removed on March 10, 2008, were greenish brown with gray slime, indicating fouling from algae, iron and manganese. All other sets of cartridge filters removed afterwards were dark brown when wet, and predominantly gray when dried, indicating fouling from iron and manganese.

Figure 5.2-30 compares the clean cartridge filters against wet fouled cartridge filters immediately after removal. Figure 5.2-31 shows the fouled cartridge filters after they have dried.

Figure 5.2-30.
Phase IV – Clean and Wet Fouled Cartridge Filters

Figure 5.2-31.
Phase IV – Dry Fouled Cartridge Filters

Table 5.2-12 summarizes the estimated fouling rates of the cartridge filters. Before the Pyrolox media break-through of particulate iron and manganese, the differential pressure across the cartridge filters increased at approximately 0.27 psi/day. After the break-through, the differential pressure across the cartridge filters increased at an average of 4.3 psi/day.

Table 5.2-12.
Phase IV – Chlorine Feed + Pyrolox Media Filtration + RO: Cartridge Filter Fouling Rate

Sets	Date	No. of Hours Used	Fouling rate (psi/day)		Fouling rate (psi/day)
1a	2/20/08 – 3/6/08	181	0.27	Before Pyrolox Media Break-Through	0.27
1b	3/6/08 – 3/10/08	95	5.1	After Pyrolox Media Break-Through	4.3
2	3/10/08 – 3/13/08	70	5.1		
3	3/13/08 – 3/17/08	66	4.4		
4	3/17/08 – 3/19/08	38	12.3		
5	3/19/08 – 3/20/08	19	8.2		
6	3/20/08 – 3/28/08	90	1.9		
7	3/28/08 – 4/1/08	73	2.8		
8	4/1/08 – 4/4/08	71	2.0		

5.2.4.3 RO Performance

The first stage MTC and the second stage MTC are shown in Figure 5.2-32. MTC is a measure of membrane performance, with fouled membranes demonstrating a drop or reduction in MTC. The first stage MTC shows a slight downward trend toward the latter part of operating condition 4A, starting March 6, 2007, indicating particulate fouling due to iron and manganese break-through. Starting operating condition 4C, the first stage MTC is relatively flat. The second stage MTC is also relatively flat during this phase.

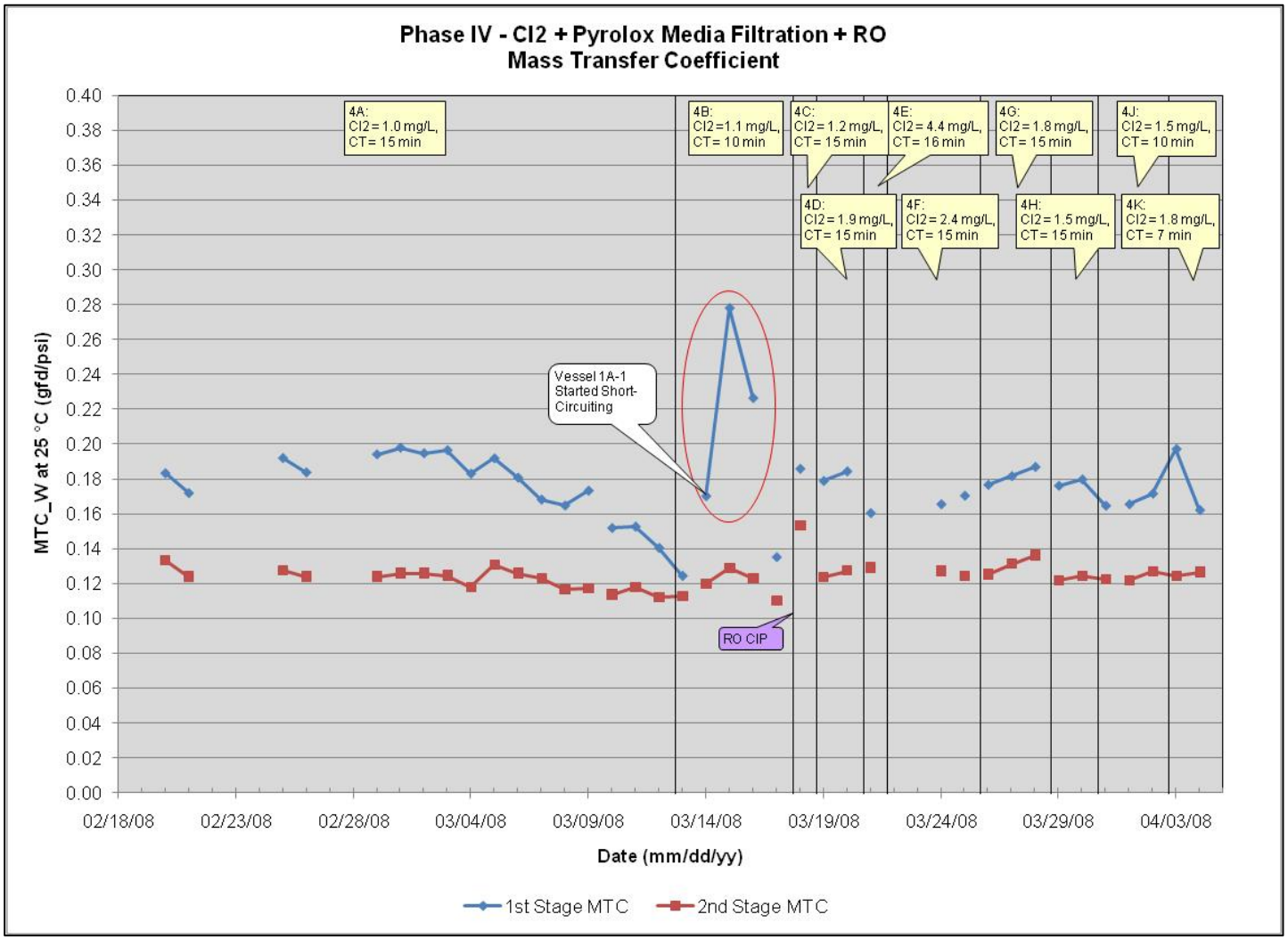

Figure 5.2-32.
Phase IV – MTC_W at 25 °C

5.2.4.4 Water Quality

The water quality parameters tested during Phase IV are summarized in Table 5.2-13.

Table 5.2-13.
Phase IV – Chlorine Feed + Pyrolox Media Filtration + RO: Water Quality

		Water Quality Goals		Water Quality			
Parameter	**Detection Limit**	**Regulatory Requirement or Reporting Limit**	**City's Goal**	**Well A Raw Water**	**RO Feed**	**RO Permeate**	**RO Waste**
Temperature (°C)				--	22	--	--
pH		6.5 – 8.5	6.5 – 8.5	7.4	7.4	6.4	7.7
Conductivity (uS/cm^2)		900	900	2333	2388	85	6815
UV254 (cm^{-1})				0.03	0.04	--	--
Color (C.U)	2	15	2	3	3	< 2	--
Total Iron (mg/L)	0.02	0.3	0.2	0.163	0.002	< 0.002	< 0.002
Total Manganese (mg/L)	0.005	0.05	0.02	0.243	0.062	< 0.005	0.250
Alkalinity as $CaCO_3$ (mg/L)	2.0			290	300	21	950
Total Hardness as $CaCO_3$ (mg/L)	0.66		120	920	940	5	3200
TDS (mg/L)	10	500	300	1300	1300	51	--
TSS (mg/L)	5			< 5	< 5	--	< 5
TOC (mg/L)	0.60			1.6	1.8	--	--
Ammonia (NH3-N, mg/L)	0.017			0.52	--	0.01	0.88
Total Barium (mg/L)	0.0020			--	0.046	< 0.002	0.180
Total Boron (mg/L)	0.010	1	1	0.69	--	0.54	--
Calcium (mg/L)	0.10			--	260	1.3	830
Chloride (mg/L)	0.24	250	80	93	--	13	--
Magnesium (mg/L)	0.10			--	71	0.36	270
Silica (mg/L)	0.3			30	--	3.8	82
Sodium (mg/L)	0.50			--	200	14	--
Sulfate (mg/L)		250		1320	--	1.6	3530
Total Strontium (mg/L)	0.0050			--	2.1	0.0099	8.3
Total Vanadium (mg/L)	0.0050			< 0.005	--	0.26	--
Gross Alpha (pCi/L)		15	15	14.5	--	0.5	--

Notes:
-- Not measured.

Table 5.2-13 shows acceptable water quality for the RO permeate for all parameters, including iron, manganese, TDS, chloride and sulfate. In particular, the TDS level in the RO permeate was 51 mg/L, much lower than the City's goal of 300 mg/L.

5.2.4.5 Phase IV Summary (Alternative 4)

The estimated chlorine demand in Well A raw water was approximately 0.8 mg/L. Chlorine demand of 1.0 mg/L was sufficient to oxidize 100 percent of iron and approximately 70 percent of manganese with the aid of the Pyrolox media filters. Although higher doses of chlorine may enhance manganese oxidation by a few percentages, the impact of higher doses was minimal.

Chlorine feed plus Pyrolox media filtration pretreatment (Phase IV) was similar in performance to the chlorine dioxide feed plus media filtration pretreatment (Phase III). Both pretreatment processes oxidized and removed 100 percent of total iron and approximately 70 percent of total manganese. The difference was that manganese oxidation occurred in the filtration stage during Phase IV, whereas manganese oxidation occurred prior to the filtration stage during Phase III.

Although only 70 percent of manganese was oxidized during the pretreatment stages, the remaining 30 percent non-oxidized manganese did not appear to impact RO performance, as it remained dissolved throughout the RO process and into the RO waste stream.

Chlorine feed plus Pyrolox media filtration pretreatment was partially effective, particularly during the early portion of the testing. However, the two issues of concern for this process are the risk of damaging the RO membranes with chlorine, and the difficulty in maintaining properly functioning media filters. Although the dechlorination process was successful during the pilot study and, therefore, did not cause damage to the RO membranes, the possible failure of a dechlorination process is risky for a full-scale plant, given the capital investment required to replace damaged RO membranes.

In addition to the dechlorination process requirement, the operation of the Pyrolox media filters causes some concern, due to the high backwashing rates and possible air scour systems required to remove iron oxides from the dense media. Pyrolox systems tend to work best in systems with high manganese levels, but low iron, and are commonly used at smaller facilities where waste washwater volumes from the high backwashing rates do not create site constraints. Based on the two primarily concerns mentioned here, and the difficult performance during the pilot testing, it is unlikely that this process will prove to be the most appropriate approach for pretreatment at the Camarillo desalination facility.

5.2.5 Phase V – Aeration plus Microfiltration (Alternative 5)

The pretreatment process tested during Phase V was aeration plus microfiltration (MF). The objectives of this pretreatment evaluation, process description, pilot configuration, operating conditions, and testing protocol were described previously in Section 4.3.5. Similar to Phase II, the primary objective was to oxidize dissolved iron into particulate iron and remove it with the membrane filters, while preventing the oxidation of manganese. A successful test would remove all iron in the membrane filters, prevent formation of particulate manganese, and prevent a loss in MTC across the RO membranes.

5.2.5.1 Oxidation Performance

DO concentration, pH, total iron, dissolved iron, total manganese, and dissolved manganese measurements are averaged for each operating condition of Phase V testing and summarized in Table 5.2-14.

Table 5.2-14.
Phase V – Aeration + Microfiltration + RO: Test Data per Operating Conditions

	Sampling Date	WQ Parameters, Average Values	Well A Raw Water	Pre-treatment Feed (2)	Pre-treatment Product	RO Feed	RO Permeate	RO Waste
5A	4/7/08	DO, (mg/L)	2.6 (1)	5.5 (3)	--	--	--	--
		pH	7.0	7.1	7.2	7.0	6.0	7.4
		Total Iron, (mg/L)	0.165	0.157	0.145	0.111	≤ 0.008	0.327
		Dissolved Iron, (mg//L)	0.165	0.158	--	0.089	≤ 0.008	0.010
		Total Manganese, (mg/L)	0.240	0.246	0.239	0.236	≤ 0.005	1.000
		Dissolved Manganese (mg/L)	--	0.234	--	0.235	--	--
5B	4/8/08	DO, (mg/L)	--	7.7 (3)	--	--	--	--
		pH	7.1	7.2	7.4	7.2	--	7.5
		Total Iron, (mg/L)	--	0.162	0.102	--	--	--
		Dissolved Iron, (mg//L)	--	0.111	0.085	--	--	--
5D	4/11/08, 4/14/08, 4/15/08, 4/16/08, 4/18/08, 4/21/08	DO, (mg/L)	1.8 (1)	5.3 (3)	--	--	--	--
		pH	7.1	7.2	7.4	7.3	6.4	7.7
		Total Iron, (mg/L)	0.162	0.150	0.076	0.047	≤ 0.008	0.161
		Dissolved Iron, (mg//L)	0.160	0.117	--	0.044	≤ 0.008	0.010
		Total Manganese, (mg/L)	0.220	0.222	0.226	0.223	≤ 0.005	0.825
		Dissolved Manganese (mg/L)	--	0.229	--	0.211	--	--
5E	4/24/08, 4/25/08	DO, (mg/L)	2.1 (1)	8.4 (3)	--	--	--	--
		pH	7.3	7.3	7.4	7.3	6.4	7.7
		Total Iron, (mg/L)	0.157	0.161	0.018	≤ 0.008	≤ 0.008	0.012
		Dissolved Iron, (mg//L)	0.157	0.059	--	≤ 0.008	≤ 0.008	0.005
		Total Manganese, (mg/L)	0.224	0.234	0.231	0.231	0.043	0.645
		Dissolved Manganese (mg/L)	--	0.218	--	0.223	--	--
5F	4/28/08	DO, (mg/L)	1.6 (1)	8.7 (3)	--	--	--	--
		pH	7.1	7.2	7.4	--	--	--

Table 5.2-14.
Phase V – Aeration + Microfiltration + RO: Test Data per Operating Conditions

	Sampling Date	WQ Parameters, Average Values	Well A Raw Water	Pre-treatment Feed (2)	Pre-treatment Product	RO Feed	RO Permeate	RO Waste
		Total Iron, (mg/L)	0.152	0.143	0.009	--	--	--
		Dissolved Iron, (mg//L)	0.155	0.093	--	--	--	--
5G	4/29/08	DO, (mg/L)	1.0 (1)	8.3 (3)	--	--	--	--
		pH	7.0	7.2	7.3	7.2	6.1	7.5
		Total Iron, (mg/L)	0.154	0.159	0.065	0.020	≤ 0.008	0.079
		Dissolved Iron, (mg//L)	0.169	0.151	--	0.022	≤ 0.008	0.013
		Total Manganese, (mg/L)	0.230	0.219	0.223	0.229	0.013	0.910
		Dissolved Manganese (mg/L)	--	0.223	--	0.221	--	--
5H	5/1/08, 5/2/08, 5/5/08, 5/7/08, 5/9/08, 5/12/08, 5/16/08, 5/20/08, 5/21/08, 5/23/08	DO, (mg/L)	2.1 (1)	8.5 (3)	--	--	--	--
		pH	7.1	7.2	7.4	7.3	6.3	7.7
		Total Iron, (mg/L)	0.163	0.156	0.080	0.039	≤ 0.008	0.125
		Dissolved Iron, (mg//L)	0.153	0.140	--	0.031	≤ 0.008	0.007
		Total Manganese, (mg/L)	0.230	0.230	0.230	0.233	≤ 0.005	0.881
		Dissolved Manganese (mg/L)	--	0.225	--	0.219	--	--

(1) Air injected to Well A raw water.
(2) All pretreatment feed samples were grabbed from downstream of the contact tank, unless otherwise noted.
(3) Measured in the pretreatment feed sample grabbed upstream of the contact tank.
-- Not measured.
NOTE: Iron and Manganese levels were not measured during operating condition 5C.

Aeration

During this phase, the aeration was accomplished using two different methods:

- **Eductor –** From April 7 through April 22, the aeration was accomplished using an eductor and one 12 element static mixer. During this testing period, the DO in the pretreatment feed ranged from 4.1 to 7.7 mg/L, with an average of 5.6 mg/L.

- **Air Compressor –** From April 23 through May 23, aeration was accomplished using an air compressor, one 12 element static mixer and two 6 element static mixers. During this testing period, the DO in the pretreatment feed ranged from 8.0 to 9.1 mg/L, with an average of 8.5 mg/L.

Iron Oxidation with Dissolved Oxygen

The amount of oxygen required for the oxidation of iron is 0.14 mg O_2/mg Fe^{2+} (MWH, 2005). As shown on Figures 5.2-33 through 5.2-35, the average dissolved iron

concentration in Well A raw water was 0.16 mg/L. Therefore, approximately 0.02 mg/L of oxygen was required to oxidize 0.16 mg/L of iron.

In general, the DO only partially oxidized the iron within the 3 to 36 minutes of contact time tested. The rate of oxidation was sensitive to the contact time and the concentration of DO in the water. Furthermore, the iron was oxidized not only in the contact tank, but also in the MF. The rate of oxidation of iron is summarized in Table 5.2-15.

Table 5.2-15.
Phase V – Aeration + Microfiltration: Dissolved Oxygen and Oxidation Rates

	Time Period	Aeration Method	Pretreatment Feed DO (mg/L)	Pretreatment Feed pH	Contact Time (min)	% Iron Oxidized in Contact Tank *	% Iron Oxidized in Contact Tank and Removed by MF **
5A	4/7	*Eductor*	5.5	7.1	3	4	12
5B	4/8	*Eductor*	7.7	7.2	19	--	37
5D	4/11 – 4/22	*Eductor*	4.1 to 5.9	7.0 to 7.3	31 to 34	25 to 32 (Avg 28)	36 to 65 (Avg 53)
5E	4/23 – 4/25	*Air Compressor*	8.1 to 8.8	7.3 to 7.5	33 to 36	49 to 76 (Avg 62)	84 to 93 (Avg 88)
5F	4/28	*Air Compressor*	8.7	7.2	32	39	94
5G	4/29 – 4/30	*Air Compressor*	8.3	7.2	4	2	58
5H	4/30 – 5/23	*Air Compressor*	8.6	7.2	4	0 to 26 (Avg 14)	23 to 68 (Avg 50)

* % Iron Oxidized = [1 – (Dissolved iron in the pretreatment feed / Total iron in raw water)]*100
** % Iron Oxidized = [1 – (Total iron in pretreatment product / Total iron in raw water)]*100

The average total and dissolved iron data are shown in Figures 5.2-33, 5.2-34, and 5.2-35. All three figures show that iron was only partially oxidized and removed during the pretreatment stages.

Figure 5.2-33 shows the average iron levels in Well A raw water, the pretreatment feed, the pretreatment product and the RO feed, between April 7 and April 22, when aeration was accomplished using the eductor. During this time, the average DO in the pretreatment feed was 5.6 mg/L, and the average pH of the pretreatment feed was 7.2. On average, 44 percent of total iron was oxidized and removed during the pretreatment processes. About 25 percent was oxidized in the contact tank, and an additional 19 percent was oxidized in the MF.

Aeration with an eductor followed by MF was ineffective, evidenced also by the cartridge filters, which were heavily loaded with oxidized iron, removing an average

of 0.03 mg/L iron that was oxidized inside the equalization tank. Also, the RO feed had an average of 0.06 mg/L of total iron, which continued to be oxidized in the RO, fouling the membranes.

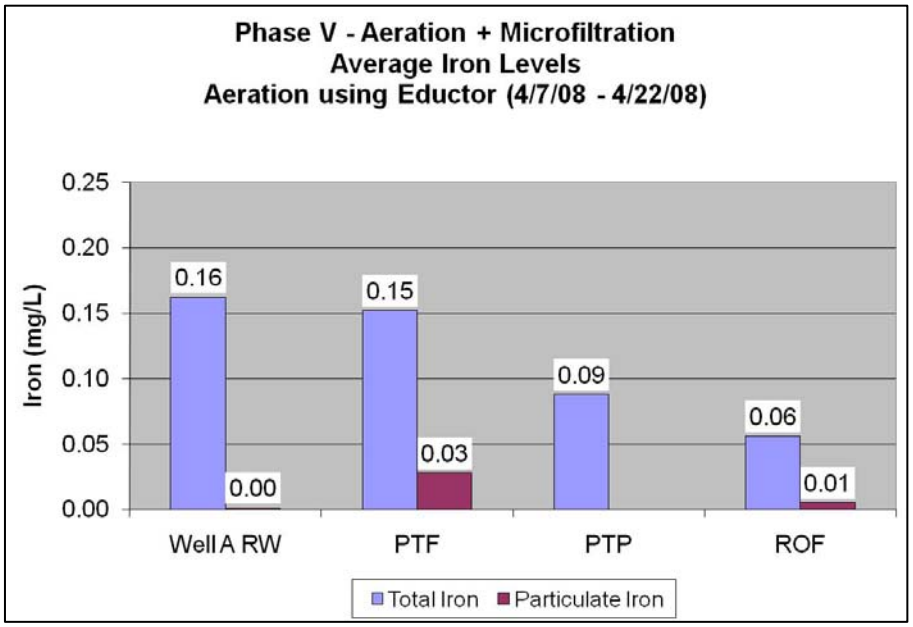

Figure 5.2-33.
Phase V – Average Iron Levels: Aeration using Eductor (4/7/08-4/22/08)

Figure 5.2-34 shows the average iron levels in Well A raw water, the pretreatment feed, the pretreatment product and the RO feed, between April 23 and April 28, when aeration was accomplished using the air compressor and 33 minutes of contact time. During this period, the average DO in the pretreatment feed was 8.5 mg/L, and the average pH of the pretreatment feed was 7.3. On average, 88 percent of total iron was oxidized and removed during the pretreatment processes. About 56 percent was oxidized in the contact tank, and additional 32 percent was oxidized in the MF. This was an improvement over conditions when an eductor was used for aeration, due to the higher DO concentrations, however, clogging of the cartridge filters from iron oxidized in the equalization tank continued.

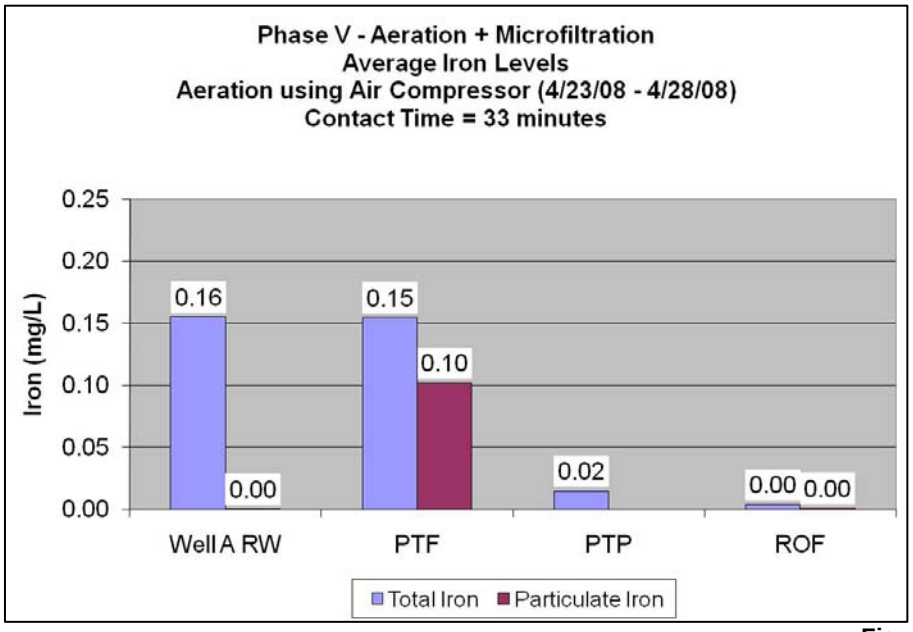

Figure 5.2-34.
Phase V – Average Iron Levels: Aeration using Air Compressor with 33 Minutes of Contact Time (4/23/08-4/28/08)

Figure 5.2-35 shows the average iron levels in Well A raw water, the pretreatment feed, the pretreatment product and the RO feed, between April 29 and May 23, when aeration was accomplished using the air compressor and 4 minutes of contact time. During this period, the average DO in the pretreatment feed was 8.5 mg/L, and the average pH of the pretreatment feed was 7.2. On average, 50 percent of total iron was oxidized and removed during the pretreatment processes. About 13 percent was oxidized in the contact tank, and an additional 37 percent was oxidized in the MF.

These results were similar to conditions when an eductor was used for aeration with lower DO concentrations. As with the other two operating conditions, problems continued to be experienced with iron oxidation in the equalization tank and clogging of the cartridge filters.

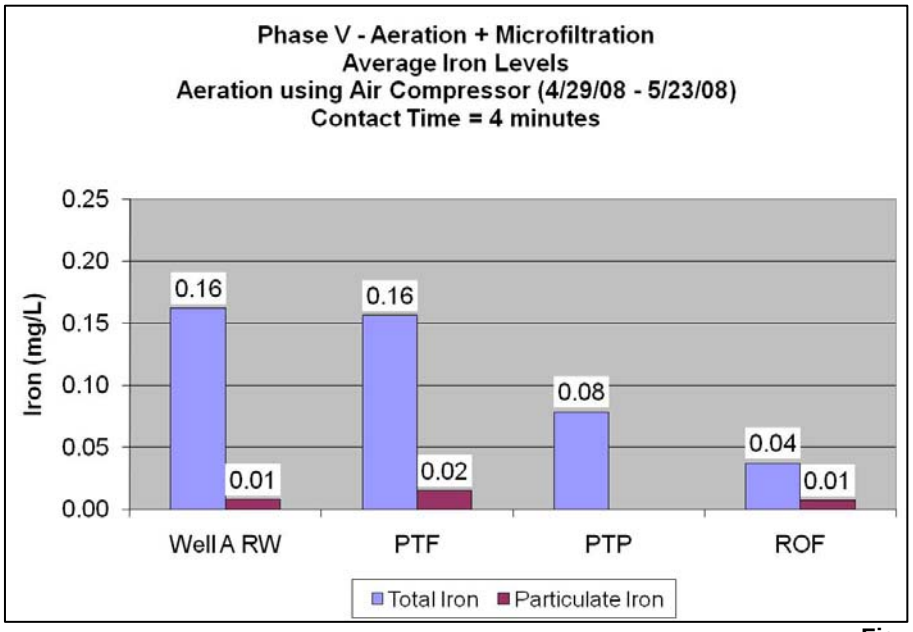

Figure 5.2-35.
Phase V – Average Iron Levels: Aeration using Air Compressor with 4 Minutes of Contact Time (4/29/08-5/23/08)

Effect of Contact Time on Iron Oxidation

Figures 5.2-36 and 5.2-37 show the dissolved iron residual in the pretreatment feed and total iron residual in the pretreatment product versus the contact time. Both figures show that more than 30 minutes of contact time is required to completely oxidize and remove iron by aeration and MF.

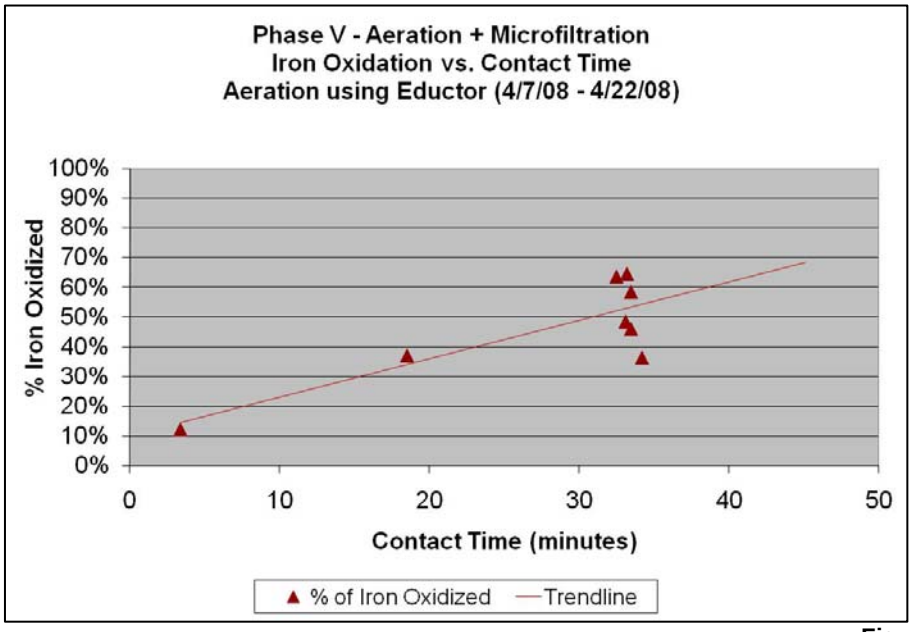

Figure 5.2-36.
Phase V – Iron Oxidation vs. Contact Time: Aeration using Eductor (4/7/08-4/22/08)

As previously presented in Figure 5.2-33 already, Figure 5.2-36 shows that aeration with an eductor followed by MF was not an effective pretreatment method, with more than 0.06 mg/L of iron remaining in the pretreatment product at approximately 33 minutes of contact time.

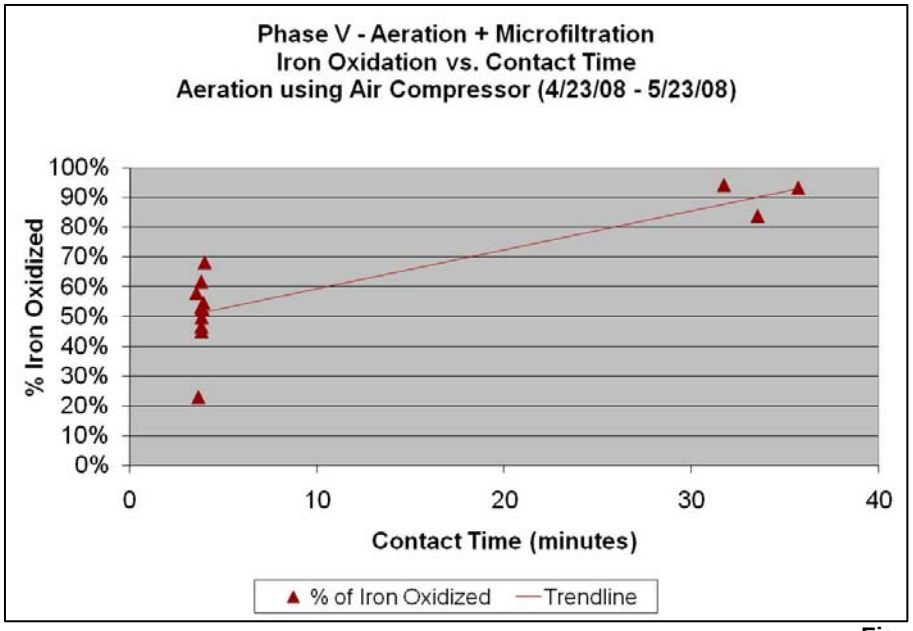

Figure 5.2-37.
Phase V – Iron Oxidation vs. Contact Time: Aeration using Air Compressor (4/23/08-5/23/08)

Figure 5.2-37 demonstrates that aeration with an air compressor followed by MF was more effective with greater than 90 percent iron oxidation when 35 minutes or more of contact time is provided. However, even with this improved oxidation, problems continued to persist with iron oxide clogging in the cartridge filters.

Effect of Dissolved Oxygen Concentration on Iron Oxidation

Figures 5.2-38 and 5.2-39 show the dissolved iron residual in the pretreatment feed and total iron residual in the pretreatment product versus the DO. Clear decreasing trends of the iron residual in the pretreatment feed and the pretreatment product with increasing DO concentration in the pretreatment feed indicate that better oxidation was achieved at higher DO concentrations.

Figure 5.2-38 shows that, at an average of 33 minutes of contact time, the DO in the pretreatment feed must be saturated at approximately 8.7 mg/L in order to achieve greater than 90 percent iron oxidation and removal.

Figure 5.2-39 confirms that 4 minutes of contact time was not sufficient to fully oxidize and remove iron, even when the water was fully saturated with DO.

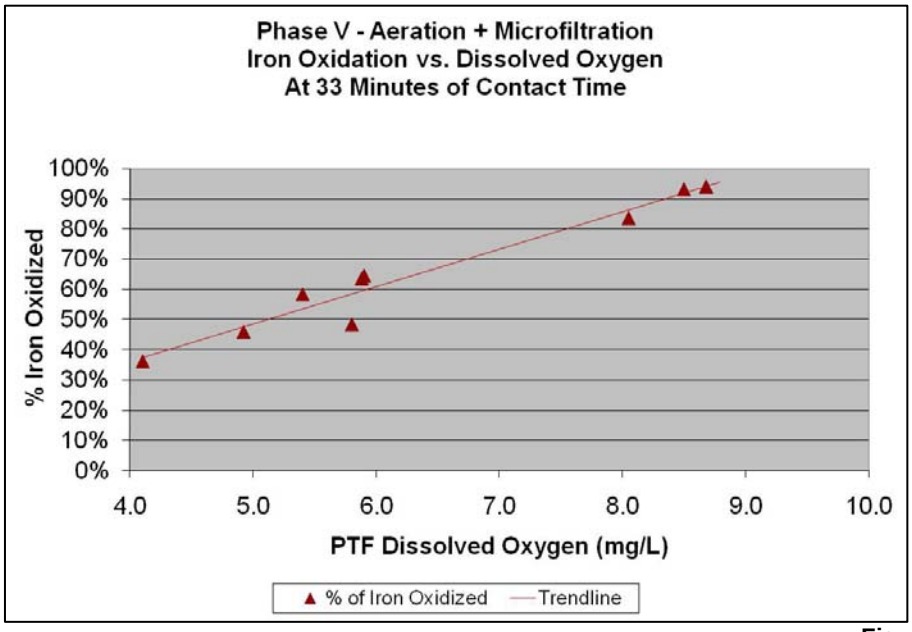

Figure 5.2-38.
Phase V –Iron Oxidation vs. Dissolved Oxygen at 33 Minutes of Contact Time

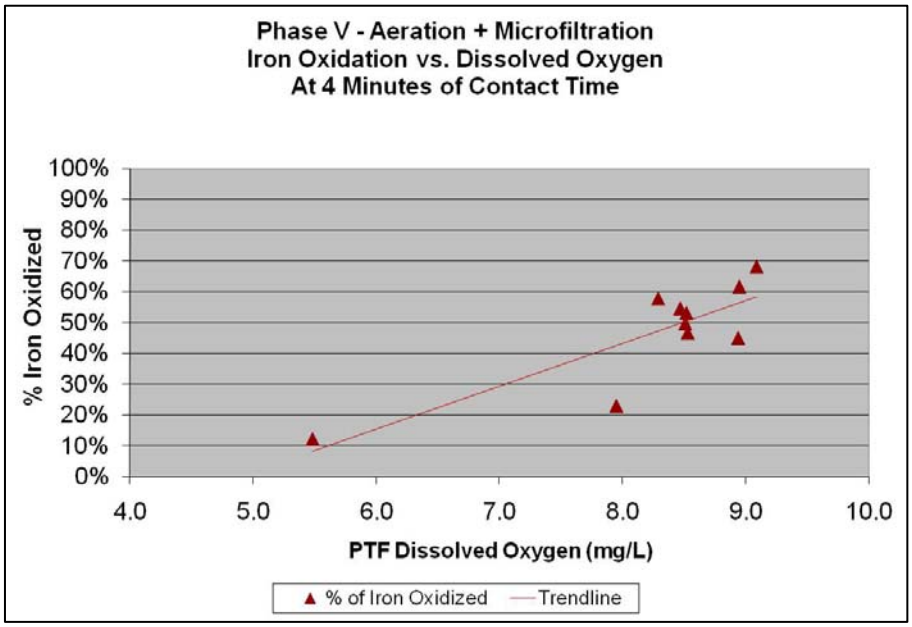

Figure 5.2-39.
Phase V – Iron Oxidation vs. Dissolved Oxygen at 4 Minutes of Contact Time

Different Rates of Oxidation with MF and Media Filters

It has long been known that the presence of oxides of manganese serve as a catalyst to accelerate the oxidation of manganese. This is often discussed in textbooks to explain the mechanism of manganese removal on acclimated filter media preceded by an oxidant residual (JMM, 1985, HDR 2001). Less well-recognized is the fact that a similar catalysis occurs in the oxidation of ferrous iron. This effect was first published

by Takai (1973) and further elucidated by Sung and Morgan (1980). Thus the presence of oxides of iron on the surface of granular media, or microfiltration membranes, can greatly accelerate the oxidation of ferrous iron to ferric iron, facilitating its removal from solution.

In a meeting with the project team, Dr. Morgan explained that this effect could easily explain why ferrous iron, which had still not been oxidized after 30 minutes was effectively removed by media filtration. The vast surface area of the ferric oxides, which accumulate in the granular media filters, serve to greatly accelerate the oxidation and removal of ferrous iron in the presence of modest levels of oxygen. Similar catalytic effect on iron oxidation could be observed by the build-up of iron oxides in microfiltration, but to a lesser extent than in media filtration, because the iron oxides can build up on the surface of microfiltration membranes only in thin layers, greatly limited by the transmembrane pressure (TMP).

5.2.5.2 Filtration Performance

During this phase, the MF was operated at an average instantaneous flux of 33 gfd, and the TMP of the MF increased at approximately 1.34 psi/day.

Table 5.2-16 summarizes the estimated fouling rates of the MF membranes between each chemical cleaning.

Table 5.2-16.
Phase V – Aeration + Microfiltration: Microfiltration Fouling Rate

Runs	Date	Average MF Flux (gfd)	No. of Operating Hours	Fouling rate (psi/day)		Fouling Rate (psi/day)
1	4/7/08 – 4/28/08	33	378	1.27	Without Maintenance Wash	1.27
2	4/29/08 – 5/7/08	35	160	0.46	With Maintenance Wash	1.40
3	5/7/08 – 5/14/08	31	157	0.85		
4	5/14/08 – 5/19/08	33	115	2.89		
5	5/19/08 – 5/21/08	33	47	2.39		
6	5/21/08 – 5/22/08	33	23	3.91		
7	5/22/08 – 5/23/08	33	22	N/A		

The MF was operated without chemical cleaning from April 7 through April 28. The MF was cleaned in place with citric acid on April 28, and with chlorine on April 29. In May, the MF was chemically cleaned with weak phosphoric acid for 45 minutes each on May 7, 14, 19, 21 and 22, 2008. The chemical maintenance washes were ineffective at cleaning the MF membranes.

Cartridge Filters Performance

The fouling of the cartridge filters was the result of incomplete iron oxidation in the pretreatment processes. Because the aeration followed by MF only partially oxidized and removed the iron, the iron residual in the pretreatment product was further oxidized in the equalization tank and cartridge filter surface, fouling the cartridge filters.

Figure 5.2-40 shows the fouled cartridge filters, which were removed on April 17. The uniform rust-color indicates fouling from iron oxides.

Figure 5.2-40.
Phase V – Fouled Cartridge Filters

Table 5.2-17 summarizes the estimated fouling rates of the cartridge filters. During this phase, the differential pressure across the cartridge filters increased at an average of 0.7 psi/day.

Table 5.2-17.
Phase V – Aeration + Microfiltration: Cartridge Filter Fouling Rate

Sets	Date	No. of Hours Used	Fouling rate (psi/day)	Average Fouling Rate (psi/day)
1	4/7/08 – 4/17/08	199	0.55	0.68
2	4/17/08 – 5/2/08	239	0.62	
3	5/2/08 – 5/9/08	158	0.52	
4	5/9/08 – 5/16/08	159	0.77	
5	5/16/08 – 5/23/08	161	1.04	

5.2.5.3 RO Performance

The first stage mass transfer coefficient (MTC) and the second stage MTC are shown in Figure 5.2-41. Due to problems with the O-rings in the RO vessels that occurred many times in April, the MTCs did not show any clear trend of RO fouling in April. However, the first stage and second stage MTC show clear downward trend in May indicating heavy particulate fouling due to iron. The second stage MTC also showed a significant decline, indicating scaling in the second stage.

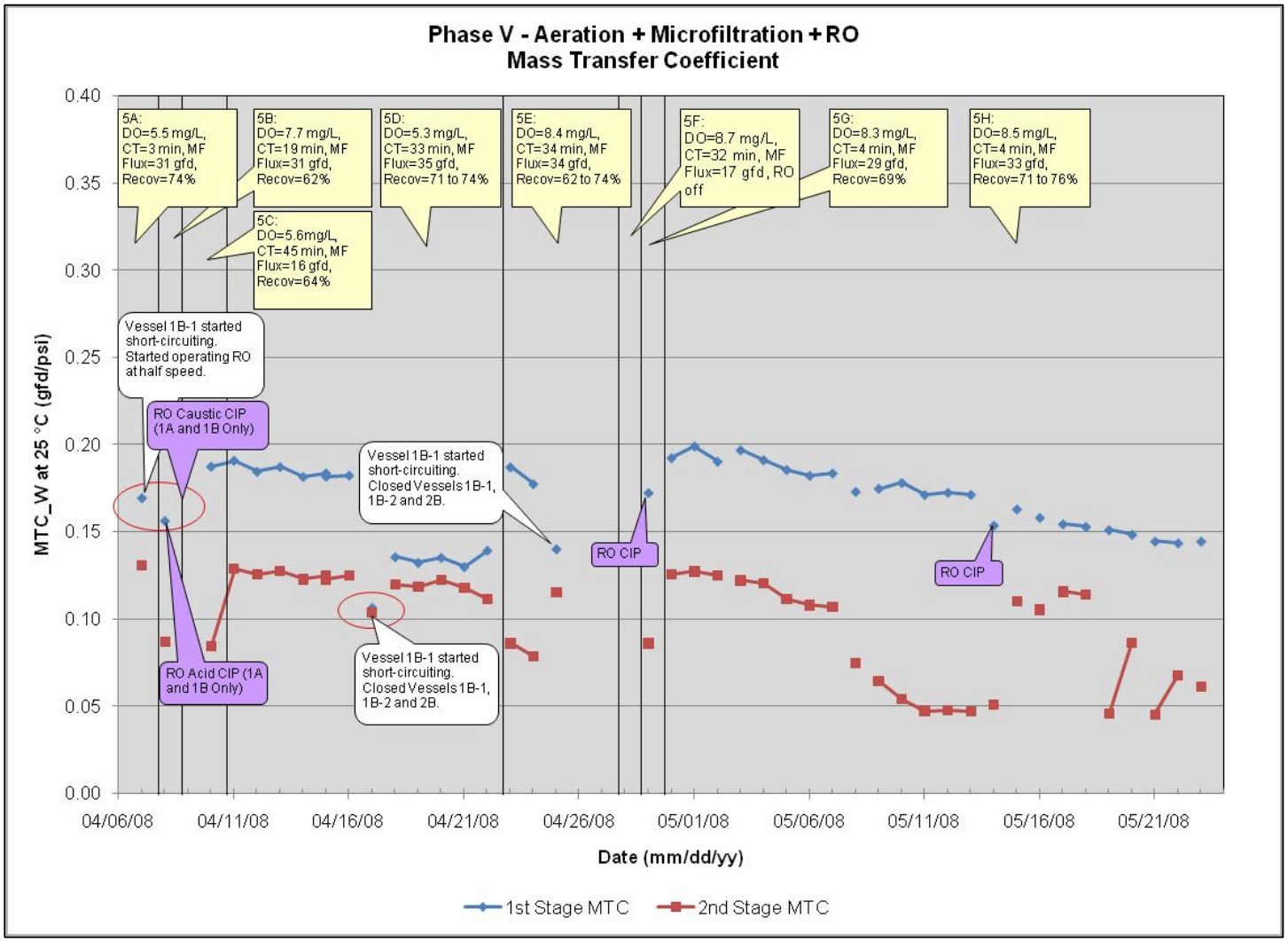

Figure 5.2-41.
Phase V – MTC_W at 25 °C

5.2.5.4 Water Quality

The water quality parameters tested during Phase V are summarized in Table 5.2-18.

Table 5.2-18.
Phase V – Aeration + Microfiltration + RO: Water Quality

Parameter	Detection Limit	Water Quality Goals: Regulatory Requirement or Reporting Limit	Water Quality Goals: City's Goal	Water Quality: Well A Raw Water	Water Quality: RO Feed	Water Quality: RO Permeate	Water Quality: RO Waste
Temperature (°C)				--	22	--	--
pH		6.5 – 8.5	6.5 – 8.5	7.1	7.3	6.3	7.7
Conductivity (uS/cm^2)		900	900	1964	2130	130	6645
UV254 (cm^{-1})				0.03	0.03	--	--
Color (C.U)	2	15	2	4	3	< 2	--
Total Iron (mg/L)	0.02	0.3	0.2	0.16	0.04	< 0.002	0.12
Total Manganese (mg/L)	0.005	0.05	0.02	0.23	0.23	< 0.005	0.88
Alkalinity as $CaCO_3$ (mg/L)	2.0			310	300	22	1400
Total Hardness as $CaCO_3$ (mg/L)	0.66		120	920	920	15	4100
TDS (mg/L)	10	500	300	1600	1700	11	--
TSS (mg/L)	5			< 5	< 5	--	< 5
TOC (mg/L)	0.60			1.9	1.9	--	--
Ammonia (NH3-N, mg/L)	0.017			0.29	--	0.02	0.98
Total Barium (mg/L)	0.0020			--	0.052	< 0.002	0.220
Total Boron (mg/L)	0.010	1	1	0.66	--	0.55	--
Calcium (mg/L)	0.10			250	250	4.1	1100
Chloride (mg/L)	0.24	250	80	94	--	16	--
Magnesium (mg/L)	0.10			69	69	1.1	300
Silica (mg/L)	0.3			30	--	3.8	--
Sodium (mg/L)	0.50			--	190	20	--
Sulfate (mg/L)		250		1245	--	13.1	3920
Total Strontium (mg/L)	0.0050			--	1.9	30	8.1
Total Vanadium (mg/L)	0.0050			0.005	--	0.075	--
Gross Alpha (pCi/L)		15	15	16.5	--	3.8	--

Notes:
-- Not measured.

Table 5.2-18 shows acceptable water quality for the RO permeate for all parameters, including iron, manganese, TDS, chloride and sulfate. In particular, the TDS level in the RO permeate was 11 mg/L, much lower than the City's goal of 300 mg/L.

5.2.5.5 Phase V Summary (Alternative 5)

The Phase V pretreatment evaluation, which consisted of aeration followed by microfiltration (MF), was tested during this period.

The pretreatment feed water had an average of 5.6 mg/L of dissolved oxygen (DO) when the eductor was used for aeration, and 8.5 mg/L of DO when an air compressor was used. Under both conditions, the iron was only partially oxidized by the DO in the contact tank within the 3 to 36 minutes of contact time tested. Additional oxidation of iron was observed in the MF.

The rate of oxidation was sensitive to the contact time and the concentration of DO in the water. For the aeration followed by MF pretreatment process to completely oxidize and remove the iron, it was determined that the pretreatment feed water must be saturated at approximately 8.7 mg/L of DO, and approximately 35 minutes of contact time must be provided. To provide 35 minutes of contact time in a full-scale plant, a 210,000 gallon capacity tank would need to be provided.

Aeration followed by MF was found to be less effective than the aeration followed by media filtration pretreatment process, evaluated in Phase II. Although the MF could be considered a better filtration process than the media filtration, the media filters provide improved oxidation of iron, resulting in greater removal.

5.3 Pretreatment Process Selection

The purpose of the pretreatment evaluation was to identify the most appropriate treatment approach to prepare the water from City wells for desalination. The following discussion explains the criteria used to evaluate the various pretreatment approaches, discusses how each process met these criteria, and makes a final recommendation for a pretreatment process used both in the final optimization stage of the pilot and in the proposed full-scale facility.

5.3.1 Evaluation Criteria

While the majority of the treatment goals for the facility are addressed through the desalination process, pretreatment is required to assure efficient, reliable operation for the downstream RO process. Specifically, many utilities have faced membrane fouling and operational problems from iron or manganese in their water supplies. Other problems have been experienced from biofouling or damage from oxidants used in their pretreatment processes. The selected pretreatment process will need to provide water of a quality acceptable to feed an RO system, and must be reliable, simple to operate, safe, and cost effective. These goals were discussed previously in Section 3.

5.3.2 Evaluation

The following includes a discussion of the rankings for each of the five pretreatment approaches based on the criteria presented above.

5.3.2.1 Water Quality Goals

Table 5.3-1 lists the water quality goals and performance results for each of the five pretreatment alternatives. Treatment Alternatives 1 and 2 (oxygen quenching and aeration plus media filtration, respectively) were the most effective at meeting all of the treatment objects. For Alternative 1 considerable fouling was experienced on the RO unit after the oxygen quenching chemical (sodium thiosulfate) was turned off for several days, with the fouling continuing after chemical feeding was restarted. However, water quality goals were consistently met when the chemical feed remained uninterrupted, and the fouling was easily reversed through chemical cleaning of the membranes. Similarly, Alternative 2 saw fouling when adequate contact time was not maintained after aeration, however, under optimized conditions, the treatment goals were met for both Alternatives 1 and 2.

While Alternative 3 (chlorine dioxide feed plus media filtration) met the treatment goals for particulate iron and manganese, considerable irreversible damage to the RO membranes was experienced from contact with chlorine dioxide. It is not clear whether the RO fouling rate would have been acceptable had the membranes not been damaged, however, the SDI for the pretreatment product water did not meet the treatment goals. It should also be noted that only 70 percent of the manganese was oxidized with this process, regardless of the contact time, pH, or chlorine dioxide dose.

Alternative 4 (chlorine feed plus greensand) met the treatment goals for RO Fouling rate, particulate iron and particulate manganese, however, the SDI goal of 2.0 was not met for this process, and considerable problems were experienced with the cartridge filters becoming clogged within days of being replaced. High breakthrough of both iron and manganese occurred with this process, due in part to the difficulty of effectively backwashing the dense media. Similar to Alternative 3, only 70 percent of the manganese was oxidized with this process.

Alternative 5 (aeration plus microfiltration) did not meet the treatment goals for RO fouling or particulate manganese. While this process resulted in the lowest SDI (0.7) of any pretreatment alternative, a significant portion of the iron remained unoxidized after the MF membranes, but was subsequently oxidized within the break tank ahead of the RO membranes. Cartridge filter replacement was high during this phase, with RO fouling rate higher than any of the other pretreatment alternatives.

Table 5.3-1.
Water Quality Goals for Pretreatment Alternatives

Criteria	Goal	Alt 1 Oxygen Quenching	Alt 2 Aeration + Media Filtration	Alt 3 ClO2 + Media Filtration	Alt 4 Cl2 + Greensand	Alt 5 Aeration + MF
RO Fouling Rate Representative Conditions	0.5%	0.07%	0.5%	Membrane Damage	0.2%	2.9%
SDI Representative conditions	< 2	0.8	0.9	3.3	2.5	0.7
Particulate Iron in RO Feed	< 0.01	0.01	< 0.01	0.01	< 0.01	0.01
Particulate Manganese in RO Feed	< 0.005		< 0.005	< 0.005	< 0.005	0.01
Treatment Goals Rating		**1**	**1**	**2**	**2**	**4**
Rating Scale: 1-Best, 2-Good, 3-Average, 4-Poor, 5-Worst						

5.3.2.2 Reliability

Table 5.3-2 presents the reliability rankings for each of the five pretreatment alternatives. Alternative 2 provided the most reliable product water quality of the pretreatment methods tested. While Alternative 1 also provided high quality product water, it was ranked lower than Alternative 2, due to the continued RO fouling experienced after the brief period in which the oxygen quenching agent was shut off. It should be noted, however, that Alternative 1 demonstrated reliable performance when the oxygen quenching agent was consistently fed at both wells and the fouling which was experienced was readily removed through chemical cleaning. Alternatives 3 and 4 both employed oxidants which were found to be damaging to the membranes

and therefore require effective and complete quenching of these oxidants prior to feeding water to the RO membranes. Alternatives 4 and 5 also saw considerably high replacement rates for the cartridge filters due to plugging from particulate iron and other particulates. Alternative 5 was ranked last from a reliability standpoint, due to its inability to meet to treatment goals under the various operating conditions tested.

Table 5.3-2.
Reliability Ratings for Pretreatment Alternatives

Criteria	Alt 1 Oxygen Quenching	Alt 2 Aeration + Media Filtration	Alt 3 ClO2 + Media Filtration	Alt 4 Cl2 + Greensand	Alt 5 Aeration + MF
Reliability Rating	3	1	3	3	4
Rating Scale: 1-Best, 2-Good, 3-Average, 4-Not Poor, 5-Worst					

5.3.2.3 Simplicity

Table 5.3-3 presents the simplicity rankings for each of the five pretreatment alternatives. Alternative 1 was ranked best, due to the overall simplicity of this pretreatment process, which involves nothing more than a chemical feed system at each of the operational wells. Alternatives 2 and 5 also offer relatively simple operation, with no chemical feed systems required for operation, however, aeration systems would be required, along with significant contact tanks, and filtration systems, making these alternatives considerably more complex than Alternative 1. Alternatives 3 and 4 were ranked last in simplicity. Chlorine dioxide generation is a complex process, requiring multiple chemicals and complex generation equipment. Both Alternatives 3 and 4 will require reliable quenching of the oxidizing agent, whether chlorine dioxide or free chlorine, to prevent damage to the RO membranes.

Table 5.3-3.
Simplicity Ratings for Pretreatment Alternatives

Criteria	Alt 1 Oxygen Quenching	Alt 2 Aeration + Media Filtration	Alt 3 ClO2 + Media Filtration	Alt 4 Cl2 + Greensand	Alt 5 Aeration + MF
Simplicity Rating	1	3	4	4	3
Rating Scale: 1-Best, 2-Good, 3-Average, 4-Poor, 5-Worst					

5.3.2.4 Safety

Table 5.3-4 presents the safety rankings for each of the five pretreatment alternatives. Alternatives 2 and 5 do not involve the use of any chemicals in every day operation, however, both make use of high pressure air, both for injection into the process stream and for control of frequently operated automated valves. The safety risks for these alternatives are low, as are the risks for Alternative 1, which involves the

injection of a non-hazardous chemical at each of the wells and no additional pumping. Safety issues for Alternative 4 are also relatively low. While this alternative involves the injection of a hazardous chemical, sodium hypochlorite, the chemical will already be in use at the treatment facility for post RO disinfection. The highest safety risks are associated with Alternative 3, which makes use of multiple hazardous chemicals and an explosive chemical product.

Table 5.3-4.
Safety Ratings for Pretreatment Alternatives

	Alt 1 Oxygen Quenching	**Alt 2 Aeration + Media Filtration**	**Alt 3 ClO2 + Media Filtration**	**Alt 4 Cl2 + Greensand**	**Alt 5 Aeration + MF**
Hazardous Chemicals	Non-hazardous	No chemicals	Multiple hazardous chemicals	Hypochlorite only	No chemicals
Operating pressures	Low	High pressure air	Low	Low	High pressure air
Risk to Public	Low	Low	Explosive chemical	Low	Low
Overall Ranking	**2**	**1**	**4**	**2**	**1**
Rating Scale: 1-Best, 2-Good, 3-Average, 4-Poor, 5-Worst					

5.3.2.5 Cost

Detailed cost estimates were not developed for each of the pretreatment alternatives, however, the alternatives were evaluated from a relative cost perspective, based on an assumption that the cost of the RO equipment would not be impacted by which of the pretreatment alternatives is selected. Table 5.3-5 presents the relative cost ratings for each alternative from a capital, operations and maintenance, and lifecycle cost perspective. Similar to the other rating categories, costs were rated from 1 to 5, with 1 being the lowest cost and 5 being the highest. The lowest capital cost alternative is Alternative 1, which includes only equipment for chemical injection at the wells. This alternative, however, has a higher O&M cost than either Alternatives 2 or 5, due to the use of chemicals, which are not required for the latter alternatives. The highest cost alternatives, from both capital and O&M perspective, are Alternatives 3 and 4, which require the capital cost of both chemical feed and filtration equipment, and also the operating costs for both.

Table 5.3-5.
Cost Ratings for Pretreatment Alternatives

Criteria	Alt 1 Oxygen Quenching	Alt 2 Aeration + Media Filtration	Alt 3 ClO2 + Media Filtration	Alt 4 Cl2 + Greensand	Alt 5 Aeration + MF
Capital Cost	1	4	5	5	4
O&M Cost	3	2	5	4	2
Lifecycle Cost	**2**	**3**	**5**	**5**	**3**
Rating Scale: 1-Lowest, 2-Low, 3-Average, 4-High, 5-Highest					

5.3.3 Recommended Pretreatment Process

Table 5.3-6 presents a summary of the process alternative rankings for each of the categories discussed above. Based on this evaluation, Alternatives 1 and 2 were identified as the most appropriate for RO pretreatment in the Phase VI pilot testing.

It was initially recommended to proceed using aeration plus media filtration, which had been shown to operate with greater reliability, when compared with the fouling observed in the oxygen quenching tests after the oxygen quenching chemical was turned off temporarily. However, after several weeks of operation, it was found that manganese oxidation was occurring within the media filters, causing significant fouling of the cartridge filters and RO membranes. The pretreatment process for Phase VI testing was therefore changed to oxygen quenching, which was ranked equally to Alternative 2 in the pretreatment evaluation. These issues will be discussed further with the Phase VI results.

Table 5.3-6.
Pretreatment Alternatives Ranking

	Alt 1 Oxygen Quenching	Alt 2 Aeration + Media Filtration	Alt 3 ClO2 + Media Filtration	Alt 4 Cl2 + Greensand	Alt 5 Aeration + MF
Water Quality Goals	1	1	2	2	4
Reliability	3	1	3	3	4
Simplicity	1	3	4	4	3
Safety	2	1	4	2	1
Cost	2	3	5	5	3
Overall Ranking	**9**	**9**	**18**	**16**	**15**
Note: Lower overall ranking number indicates more desirable pretreatment alternative.					

5.4 Reverse Osmosis (RO) Optimization Test Results

The following presents the results of the RO optimization evaluation.

5.4.1 Overview

The purpose of the Phase VI testing was to optimize the RO process for finished water quality and energy usage, and to achieve the lowest operating costs that would meet the City's water quality goals.

Four different membranes, ranging from nanofiltration (NF) to recently developed low-pressure RO membranes, were considered in this evaluation. There were two parallel RO trains treating the same feed water. Both RO trains were operated at approximately 15 gfd flux and 75 percent feed water recovery.

An overview of the Phase VI testing is provided in Table 5.4-1, including the names of the RO membranes studied and the pilot study dates.

Table 5.4-1
Phase VI – New RO Membrane Element Testing Schedule

RO Optimization Test	Membranes Tested	Pretreatment Strategies Studied	Start Date	End Date
I	I. Dow Filmtec XLE 4040 II. Saehan RE 4040 BLR	Aeration plus Media Filtration	June 2, 2008	July 28, 2008
		Oxygen Quenching Alone	July 29, 2008	Aug. 13, 2008
		Oxygen Quenching plus Acid Addition (pH ~6.4)	Aug. 14, 2008	Aug. 26, 2008
II	III. Toray TM710 IV. Dow Filmtec NF90	Oxygen Quenching plus Acid Addition (pH~6.4)	Aug. 26, 2008 Sep. 19, 2008	Sep. 11, 2008 Oct. 10, 2008
		Oxygen Quenching plus Acid Addition (pH~6.8)	Sep. 11, 2008	Sep. 18, 2008

5.4.2 Selected Pretreatment Test Results

5.4.2.1 RO Optimization Test I - Aeration plus Media Filtration

Description

Only Well A water was tested during RO Optimization Test I in the Phase VI testing in which aeration plus media filtration was studied. Well A raw water (RW) was aerated using an eductor (Mazzei air injector model 1584) upstream of the static mixer. The contact tank (following the static mixer) provided 15 min retention time for the iron oxidation. From the contact tank, the pretreatment feed (PTF) water was pumped and filtered through three granular media filters (GMFs) at 10 gpm feed flow rate per filter. After filtration, the pretreatment product (PTP) water was fed through the cartridge filters, after which the antiscalant was injected, and the RO feed (ROF) water was then pumped into the two parallel RO trains. Both RO trains were operated at approximately 15 gfd flux and 75 percent feed water recovery.

DO Concentration

Figure 5.4-1 shows the DO concentration in Well A (RW) and GMF feed (PTF). The average DO concentration in Well A raw water was 2.2 mg/L while in the GMF feed water it was 5.6 mg/L. This shows that the eductor increased the DO level in the GMF feed water by 250 percent, however, the feed water was not fully saturated with DO.

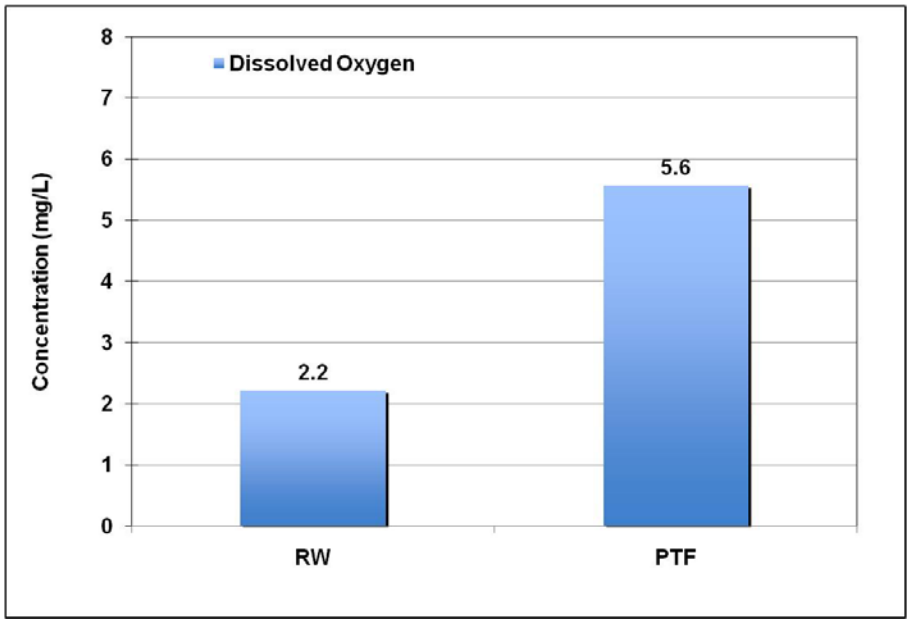

Figure 5.4-1.
Phase VI - Aeration + Media Filtration: DO Profiles in Well A RW and PTF

Iron Oxidation and Filtration

The total and particulate iron data for Well A (RW), GMF feed (PTF), GMF product (PTP), and RO feed (ROF) for the entire period of the aeration plus media filtration testing in Phase VI (July and July 2008) are depicted in Figure 5.4-2. On average, both total and particulate iron present in Well A raw water were removed by the aeration plus media filtration pretreatment process. About 95 percent of the total iron was removed by the aeration plus media filtration pretreatment. The particulate iron was increased by 120 percent in the contact tank (0.03 to 0.06 mg/L).

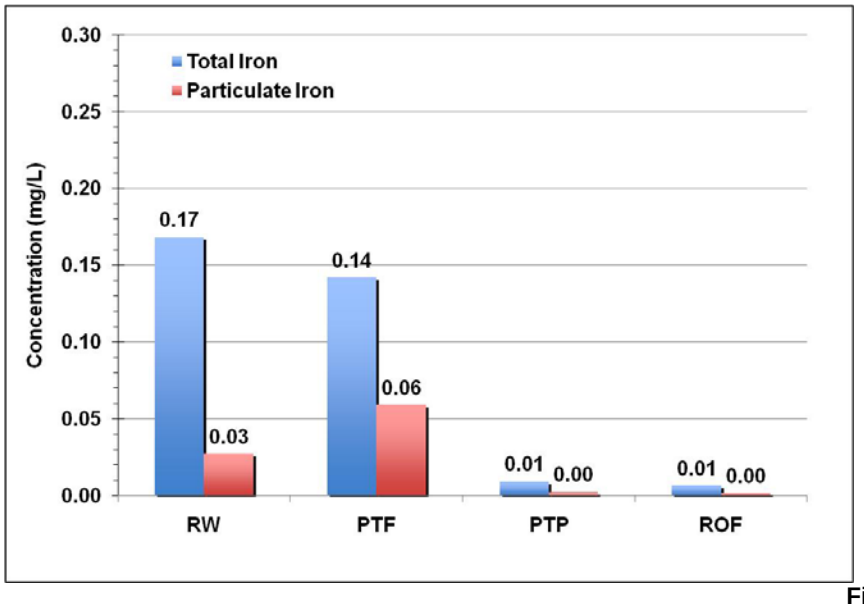

Figure 5.4-2.
Phase VI - Aeration + Media Filtration: Total Iron and Particulate Iron Profiles

Manganese Oxidation and Filtration

The total manganese data for Well A (RW), GMF feed (PTF), GMF product (PTP), and RO feed (ROF) water are depicted in Figure 5.4-3 for the entire period of aeration plus media filtration pretreatment testing in Phase VI (RO Optimization Test 1 in June and July 2008). Unlike iron, 15 minutes contact time did not change the total manganese concentration between Well A raw water and GMF feed water. However, there is a slight drop in the average manganese concentration following GMF, from 0.23 to 0.22 mg/L (about 5 percent difference). This suggests some of the manganese may unexpectedly have been oxidized and removed by the GMF.

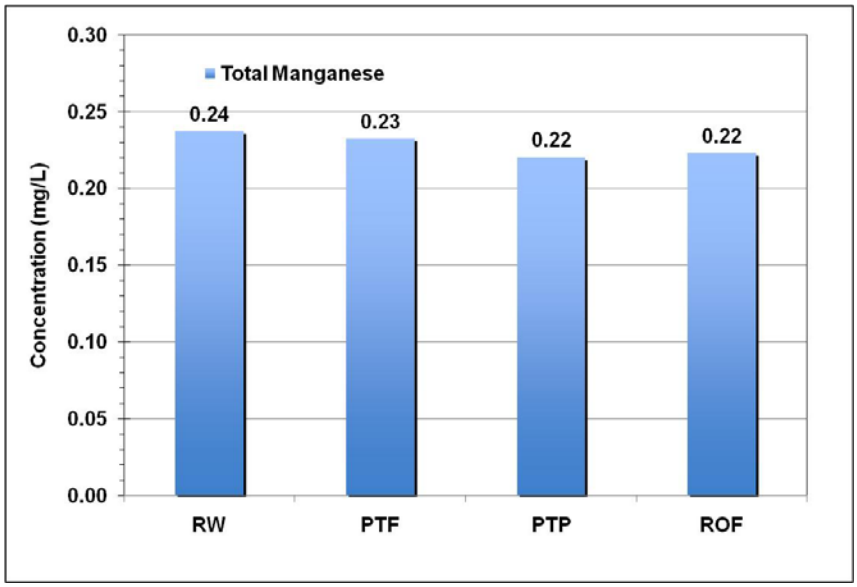

Figure 5.4-3.
Phase VI - Aeration + Media Filtration: Total Manganese Profiles

The total and dissolved manganese data for Well A (RW), GMF feed (PTF), GMF product (PTP), and RO feed (ROF) for July 2008 are depicted in Figure 5.4-4. To a much less extent than particulate iron, 15 minutes contact time changed the particulate manganese concentration between Well A raw water and GFM feed from 0.011 to 0.015 mg/L (about 36 percent difference). There is also a slight increase in the particulate manganese concentration following GMF, from 0.016 to 0.020 mg/L (about 25 percent difference). These results suggest that a small fraction of the dissolved manganese was oxidized to particulate manganese by the aeration and GMF process. This unexpected result was further verified by performing an autopsy on the cartridge filters, which is discussed next.

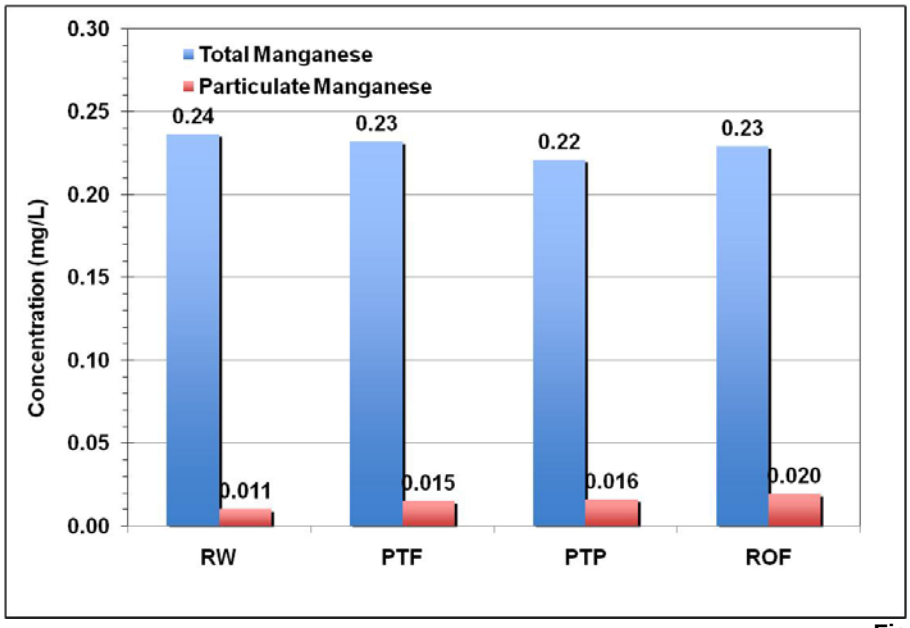

Figure 5.4-4.
Phase VI - Aeration + Media Filtration: Total Manganese and Particulate Manganese Profiles

Figure 5.4-5 shows a picture of the fouled cartridge filters. The dark brown color on the cartridge filters is indicative of the particulate manganese deposit. A detailed chemical analysis of this foulant material was performed by the Weck Lab and results are summarized in Table 5.4-2.

As shown in Table 5.4-2, the foulant deposit on the cartridge filter is primarily composed of manganese. The autopsy results confirmed that (1) dissolved manganese is being oxidized in the pretreatment process to particulate manganese, and (2) particulate manganese is not fully removed by the GMF. Such oxidation of manganese by air was both unexpected and unseen during the two months of previous pilot testing using aeration and media filtration (Phase II). Under normal conditions, the oxidation of manganese with air would take numerous hours of contact time to achieve, however, the presence of residual concentrations of

manganese dioxide on the media, perhaps a remnant of the Phase IV Pyrolox testing, may have accelerated the manganese oxidation through catalytic means. If this is the cause of the manganese oxidation, then it should be anticipated that similar results would be seen at a full scale facility, given enough time for the media to acclimate, building up its own layer of manganese dioxide. For this reason it was recommended that the pretreatment process be revised, with oxygen quenching selected to prevent oxidation of both iron and manganese for the remainder of the Phase IV testing period.

Figure 5.4-5.
Phase VI - Aeration + Media Filtration: Photo of Cartridge Filters

Table 5.4-2.
Phase VI – Aeration + Media Filtration: Cartridge Filters Autopsy Results

Analyte	mg of Analyte per kg of Cartridge Filter Fabric (1)
Iron, total	260
Manganese, total	1100
TOC	12

Note:
1) Chemical analysis was performed after acid digestion of the solid sample

5.4.2.2 RO Optimization Test I - Oxygen Quenching

Description

Only Well A water was tested during the initial period of Phase VI testing, RO Optimization Test I. Beginning July 29, use of oxygen quenching was begun, such that Well A raw water was injected with sodium thiosulfate upstream of the static mixer, with no aeration, contact tank, or filtration ahead of the cartridge filters and RO unit. After the cartridge filters, antiscalant was injected, and the RO feed water was then pumped into the two parallel RO trains. Both RO trains were operated at 15 gfd flux and 75 percent feed water recovery. On August 14, the addition of muriatic acid began upstream of the cartridge filters to reduce the pH of the RO feed in addition to oxygen quenching at the well.

During the portion of the testing with oxygen quenching alone (July 29 – August 13), the concentration of sodium thiosulfate was varied from 1 mg/L to 20 mg/L to try to improve performance, but declines in MTC were observed for the RO membranes and fouling of the cartridge filters was seen. It was also attempted to vary the antiscalant feed to improve performance. Once oxygen quenching with acid addition was in place, the antiscalant feed was leveled at the manufacturer recommended concentration of 1.5 mg/L and the sodium thiosulfate feed concentration was reduced to 4 mg/L.

DO concentration

At the end of July 2008, a new device was proposed for measuring the dissolved oxygen in the water samples to minimize the influence of atmospheric oxygen. This device, pictured in Figure 5.4-6, was used throughout the entire measuring period in August. It yielded results much lower than those seen in June and July 2008.

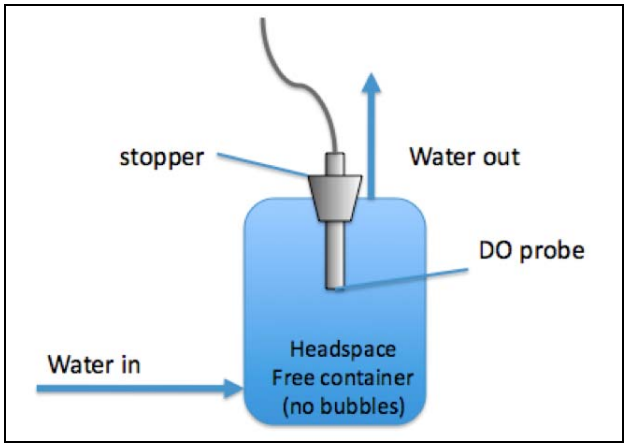

Figure 5.4-6.
Schematic of New Measuring DO Device

Figure 5.4-7 shows the DO measurements at the Well (RW) and in the RO feed (ROF) during RO Optimization Test I testing in Phase VI with oxygen quenching / oxygen quenching with acid addition pretreatment in August 2008. The DO concentrations for the raw water shown in Figure 5.4-7 are much lower than those shown in Figure 5.4-1 for June and July, demonstrating the effectiveness of the change in DO measurement protocol.

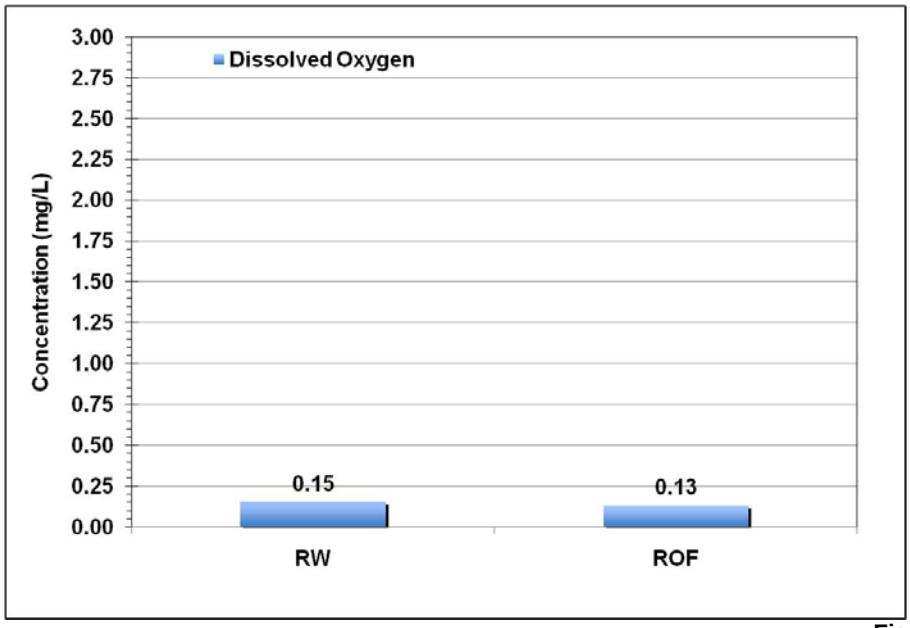

Figure 5.4-7.
Phase VI – Test I Oxygen Quenching: DO Levels

Iron oxidation and filtration

The total and particulate iron data for Well A (RW), water upstream of the RO cartridge filter (PTF), and RO feed (ROF) for August are depicted in Figure 5.4-8. At the end of July, the contact tank and the media filtration process were bypassed. The iron levels up to the RO cartridge filters were fairly consistent, but the cartridge filters seemed to be removing a significant amount of the iron as there was about a 10 percent difference in total iron between the raw water and the RO feed.

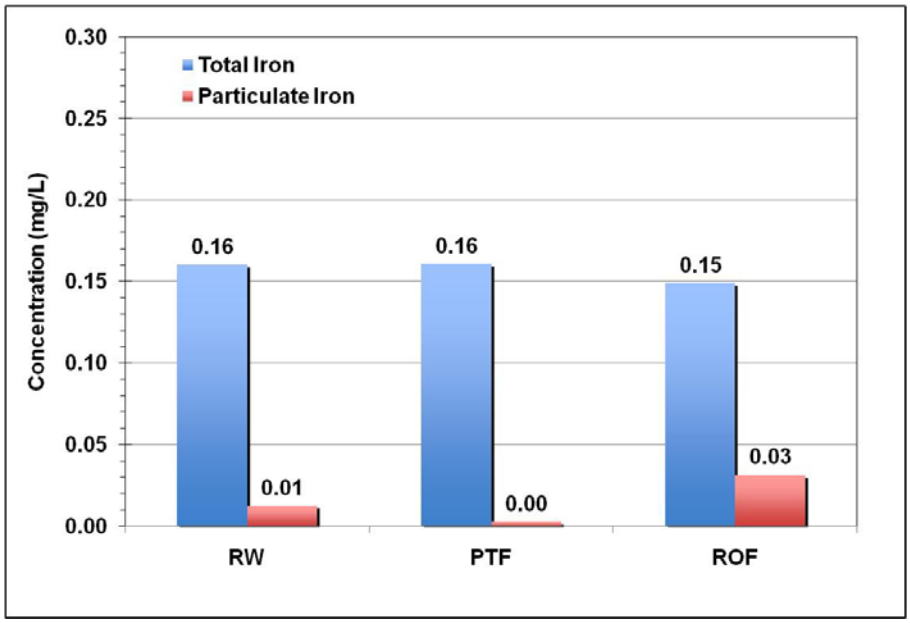

Figure 5.4-8.
Phase VI – Test I Oxygen Quenching: Total Iron and Particulate Iron Profiles

In mid-August 2008, the pretreatment strategy was refined to incorporate oxygen quenching with acid addition. On August 14, 2008, muriatic acid was fed into the system in order to slow the oxidation of iron, which was occurring to a small degree on the surface of the cartridge filters. With acid addition, an average pH of 6.4 was achieved in the RO feed for the duration of RO Optimization Test I.

The impact of acid addition on iron concentrations in the RO feed can be seen in Figure 5.4-9. Before acid addition began, the iron concentration in the RO feed was below the average concentration for Well A. After the addition of muriatic acid was initiated on August 14, 2008, the iron concentration in the RO feed was near the average concentration for Well A, which is depicted by the blue line in the figure.

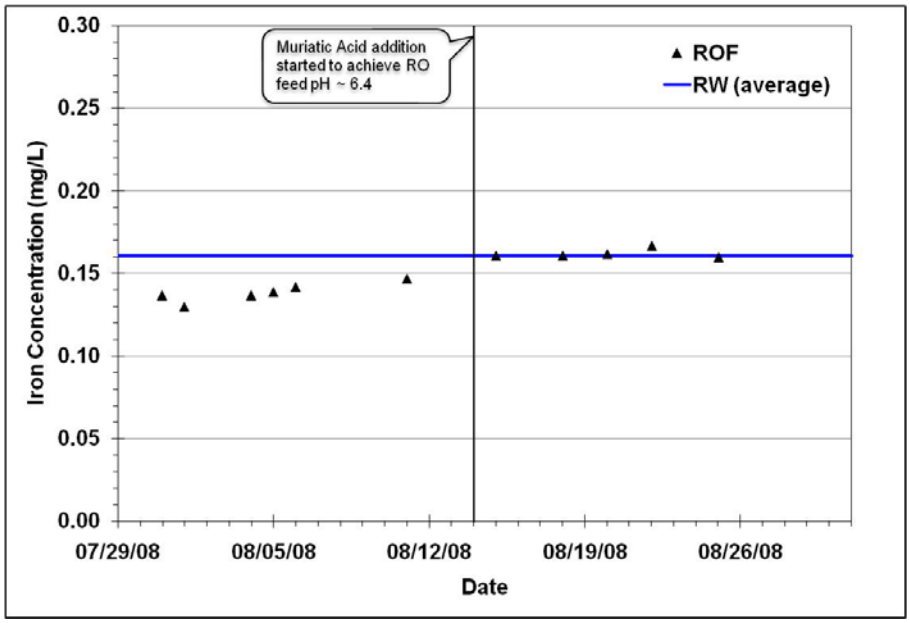

Figure 5.4-9.
Phase VI – Test I Oxygen Quenching: Summary of Iron Concentration in the ROF

Manganese Oxidation and filtration

The total and particulate manganese data for Well A (RW) and RO feed (ROF) for August is depicted in Figure 5.4-10. The cartridge filters did not do much to alter the manganese, so the total manganese concentrations from the well to the RO feed water were similar.

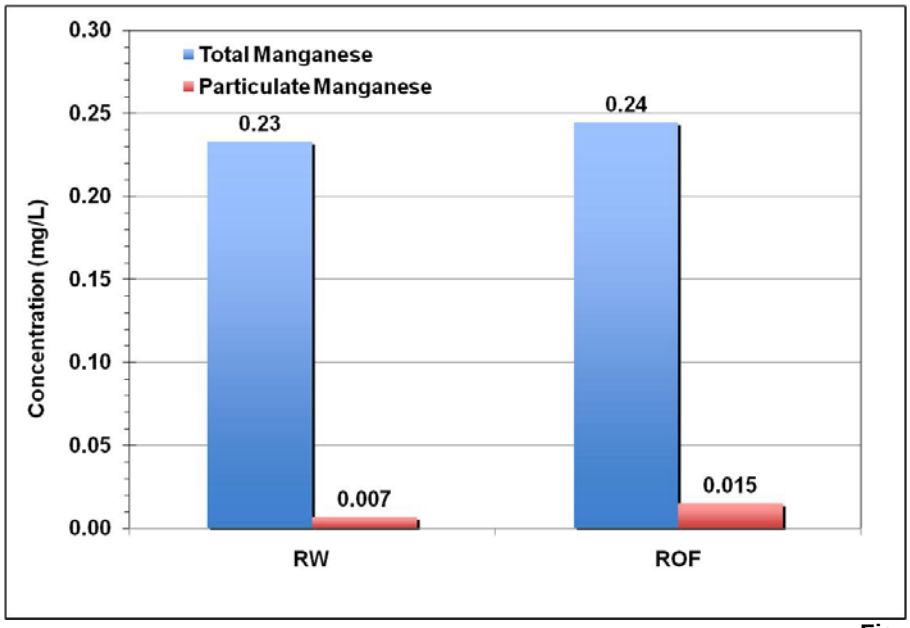

Figure 5.4-10.
Phase VI – Test I Oxygen Quenching: Total Manganese and Particulate Manganese Profiles

5.4.2.3 RO Optimization Test II - Oxygen Quenching with Well A

Description

Both Well A water and Well B water were tested during the latter period of Phase VI testing, RO Optimization Test II, which ran from August 26, 2008 to October 10, 2008. Well A feed was used from August 26 to September 19 with Well B feed thereafter. The use of oxygen quenching was continued, such that Well A raw water was injected with sodium thiosulfate upstream of the static mixer, with no aeration, contact tank, or filtration ahead of the cartridge filters and RO unit. After the cartridge filters, antiscalant was injected, and the RO feed water was then pumped into the two parallel RO trains. Both RO trains were operated at 15 gfd flux and 75 percent feed water recovery. The addition of muriatic acid was continued upstream of the cartridge filters to reduce the pH of the RO feed in addition to oxygen quenching at the well.

Well A feed was used during the initial part of RO Optimization Test II as discussed above. For most of this test period, the acid addition achieved an RO feed pH of 6.4 similar to the acid addition in RO Optimization Test I. In an attempt to test whether a lower acid dose might be possible, an RO feed pH of 6.8 was achieved during a one week portion of this part of the testing with Well A feed in RO Optimization Test II from September 11 to September 18, 2008. Late September 18, acid addition was restored to achieve the original target of RO feed pH 6.4.

DO concentration

At the end of July 2008, a new device was proposed for measuring the dissolved oxygen in the water samples to minimize the influence of atmospheric oxygen and use of this device continued in RO Optimization Test II from August through

October. On September 11, further refinements in the DO sampling protocol to further reduce the impact of ambient air on DO levels were made. This change resulted in measured DO levels even lower than those seen earlier with the new device and much lower than the DO levels measured in June and July before the new device was introduced. Figure 5.4-11 shows the DO levels measured during the portion of RO Optimization Test II with Well A feed. The results suggest a lack of DO at the Well A feed.

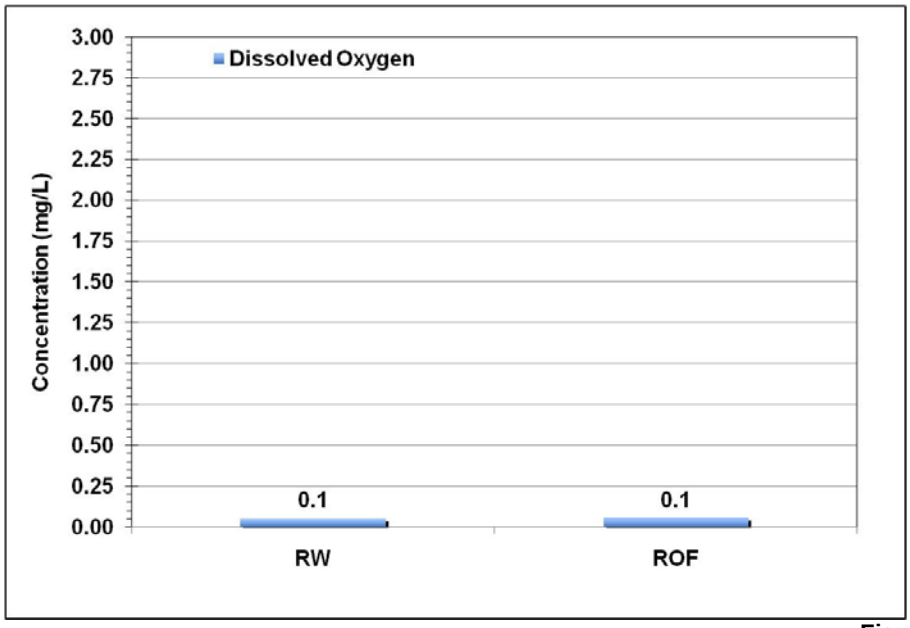

Figure 5.4-11.
Phase VI – Test II Oxygen Quenching with Well A: DO Levels

Iron Oxidation and Filtration

The total and dissolved iron data for Well A (RW), water upstream of the RO cartridge filter (PTF), and RO feed (ROF) for the portion of RO Optimization Test II with Well A feed are depicted in Figure 5.4-12. The results demonstrate that the iron concentration did not change much between the Well A raw water and the RO feed provided sufficient acid addition was achieved.

It should be noted that during the testing with lower acid dose to achieve RO feed pH 6.8, a difference in total iron between the raw water and the RO feed as high as 6 percent was observed (compared to difference in average levels of < 0.1 percent) and rapidly accelerated decline in MTC was observed during this portion of the testing, most notably for the Dow Filmtec NF90 membranes. This suggests that sufficient acid dose to achieve pH 6.4 in the RO feed is necessary to reduce problems with iron oxidation and that the lower acid dose to achieve pH 6.8 in the RO feed is not sufficient.

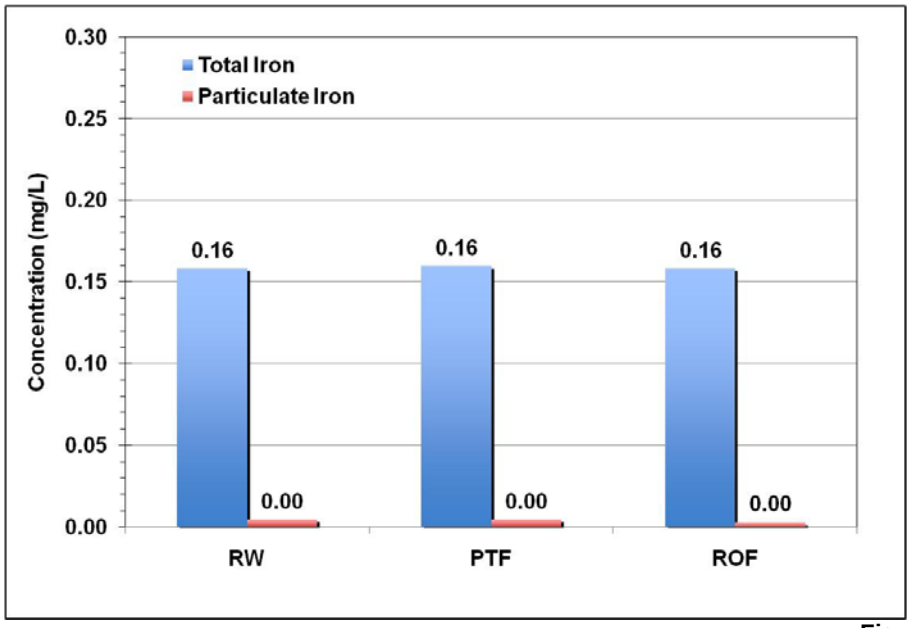

Figure 5.4-12.
Phase VI – Test II Oxygen Quenching with Well A: Total Iron and Particulate Iron Profiles

Manganese Oxidation and filtration

The total and particulate manganese data for Well A (RW) and RO feed (ROF) for the portion of RO Optimization Test II with Well A feed is depicted in Figure 5.4-13. The cartridge filters did not do much to alter the manganese, so the total manganese concentration from the well to the RO feed water were similar.

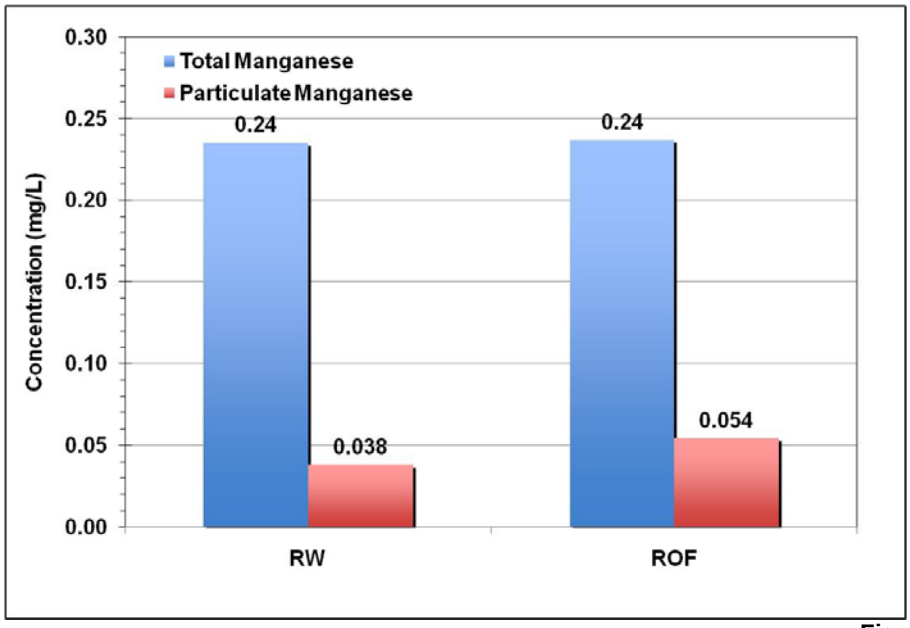

Figure 5.4-13.
Phase VI – Test II Oxygen Quenching with Well A: Total Manganese and Particulate Manganese Profiles

5.4.2.4 RO Optimization Test II - Oxygen Quenching with Well B

Description

Well B feed was used during the latter part of RO Optimization Test II as discussed above. For this portion of the testing, the acid addition achieved an RO feed pH of 6.4 similar to the acid addition in RO Optimization Test I and most of the earlier portion of RO Optimization Test II.

DO Concentration

At the end of July 2008, a new device was proposed for measuring the dissolved oxygen in the water samples to minimize the influence of atmospheric oxygen and use of this device continued in RO Optimization Test II from August through October. On September 11, further refinements in the DO sampling protocol to further reduce the impact of ambient air on DO levels were made. This change resulted in measured DO levels even lower than those seen earlier with the new device and much lower than the DO levels measured in June and July before the new device was introduced. Figure 5.4-14 shows the DO levels measured during the portion of RO Optimization Test II with Well B feed from September 19 to October 10. The results suggest a lack of DO at the Well B feed and represent the lowest DO levels observed at Well A or Well B during the Phase VI testing.

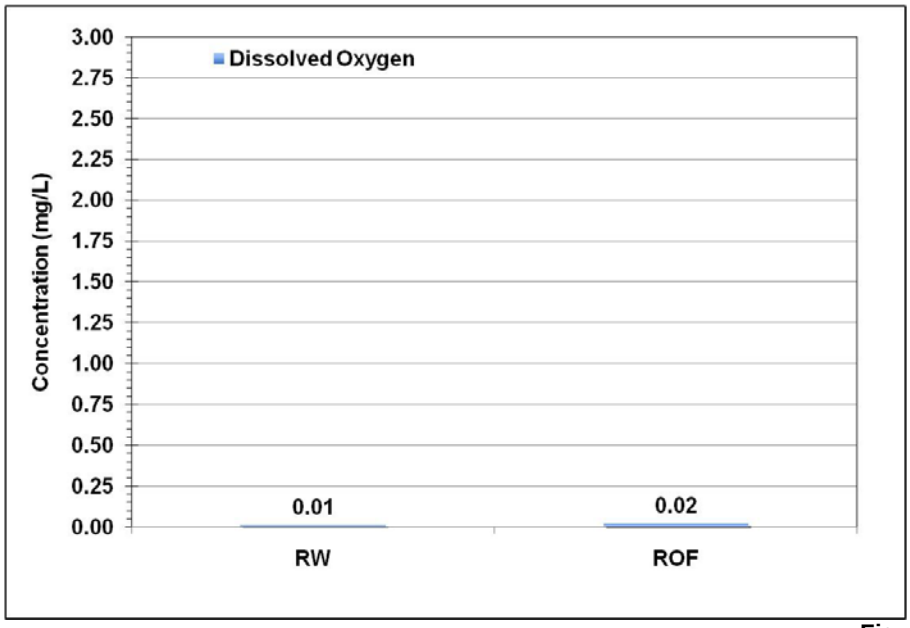

Figure 5.4-14.
Phase VI – Test II Oxygen Quenching with Well B: DO Levels

Iron Oxidation and Filtration

The total and particulate iron data for Well A (RW), water upstream of the RO cartridge filter (PTF), and RO feed (ROF) for the portion of RO Optimization Test II with Well B feed are depicted in Figure 5.4-15. The results demonstrate that the total iron concentration did not change much between the raw Well A raw water and the RO feed with acid addition to achieve RO feed pH 6.4.

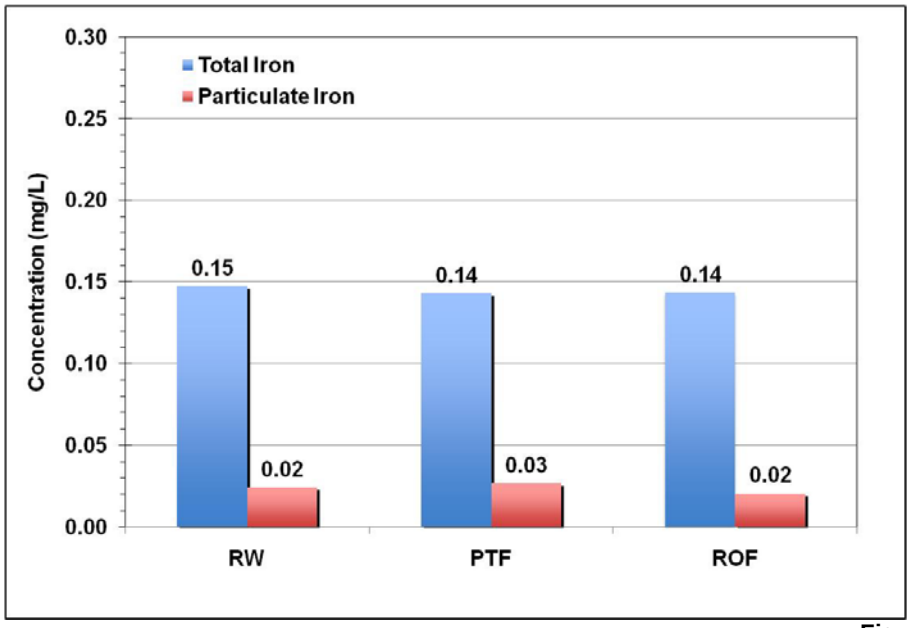

Figure 5.4-15.
Phase VI – Test II Oxygen Quenching with Well B: Total Iron and Particulate Iron Profiles

Manganese Oxidation and filtration

The total and particulate manganese data for Well A (RW) and RO feed (ROF) for the portion of RO Optimization Test II with Well B feed is depicted in Figure 5.4-16. The cartridge filters did not do much to alter the manganese, so the manganese concentration from the well to the RO feed water were similar.

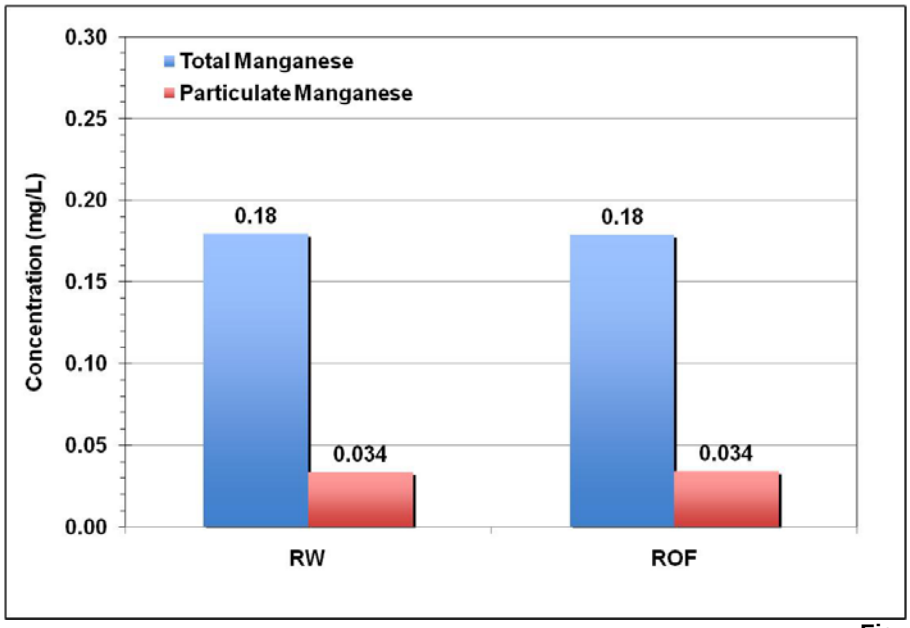

Figure 5.4-16.
Phase VI – Test II Oxygen Quenching with Well B: Total Manganese and Particulate Manganese Profiles

5.4.2.5 RO Feed Water Quality

During the course of Phase VI testing, various feed water constituents were measured. Table 5.4-3 provides a summary of various parameters measured in the lab for Well A and Well B during RO Optimization Test I and RO Optimization Test II including average concentrations for Well A over multiple days of laboratory testing. The levels of iron and manganese in the well and RO feed water were discussed in detail above.

Table 5.4-3.
Phase VI – Summary of Feed Water Quality Parameters Measured in the Lab

		RO Optimization Test I			RO Optimization Test II		Summary	
		Well A	Well A	Well A	Well A	Well B	Well A	Well B
Parameter	**Units**	**6/27/08**	**7/10/08**	**7/14/08**	**9/19/08**	**10/6/08**	**Average**	**10/6/08**
Total Barium	mg/L	0.049	0.052	0.052	0.047	0.064	**0.050**	**0.064**
Calcium	mg/L	240	250	260	230	200	**245**	**200**
Potassium	mg/L	5.3	6	5.9	5.7	5.4	**5.7**	**5.4**
Magnesium	mg/L	66	72	71	67	49	**69**	**49**
Sodium	mg/L	180	200	200	190	140	**193**	**140**
Strontium, Total	mg/L	1.8	1.9	1.9	1.9	1.4	**1.9**	**1.4**
Total Fluoride	mg/L	0.26	0.24	0.24	0.23	0.22	**0.24**	**0.22**
Alkalinity as $CaCO_3$	mg/L	290	290	280	290	230	**288**	**230**
Carbonate Alkalinity as $CaCO_3$	mg/L		ND (< 2.0)	ND (< 2.0)	ND (< 2.0)	ND (< 2.0)	**ND (< 2.0)**	**ND (< 2.0)**
Bicarbonate Alkalinity as HCO_3	mg/L		360	350	350	280	**353**	**280**
Hydroxide Alkalinity as $CaCO_3$	mg/L		ND (< 2.0)	ND (< 2.0)	ND (< 2.0)	ND (< 2.0)	**ND (< 2.0)**	**ND (< 2.0)**
Ammonia as N	mg/L	0.24	0.24	0.26	0.26	0.33	**0.25**	**0.33**
Gross Alpha	pCi/L	13.2	10.1	9.29	5.2	8	**9.4**	**8.0**
Gross Alpha counting error (+/-)	pCi/L	1.28	1.14	1.1	1.05	1.19	**1.1**	**1.2**
Gross Alpha MDA95	pCi/L	0.35	0.362	0.362	0.343	0.343	**0.35**	**0.34**
Total Hardness as $CaCO_3$	mg/L	870	930	930	850	710	**895**	**710**
Nitrate as NO_3	mg/L	0.99	0.81	1.5	0.69	ND (< 0.50)	**1.0**	**ND (< 0.50)**
Total Dissolved Solids	mg/L	1800	1700	1600	1800	1400	**1725**	**1400**

Table 5.4-3.
Phase VI – Summary of Feed Water Quality Parameters Measured in the Lab

Parameter	Units	RO Optimization Test I			RO Optimization Test II		Summary	
		Well A	Well A	Well A	Well A	Well B	Well A	Well B
		6/27/08	7/10/08	7/14/08	9/19/08	10/6/08	Average	10/6/08
Total Organic Carbon (TOC)	mg/L	1.5	1.4	1.4	1.5	1.4	**1.5**	**1.4**
Chloride	mg/L	170			170	170	**170**	**170**
Sulfate	mg/L	840			790	590	**815**	**590**
Silica as SiO_2, Total	mg/L	16			34	36	**25**	**36**

Table 5.4-4 provides a summary of feed water quality parameters in the raw water and the RO feed measured onsite during RO Optimization Test I and RO Optimization Test II including total and dissolved manganese as well as total and dissolved iron.

Table 5.4-4.
Phase VI – Summary of Feed Water Quality Parameters Measured Onsite

Parameter (1)	Units	RO Optimization Test I		RO Optimization Test II			
		6/2/08 - 8/26/08		8/26/08 - 9/19/08		9/19/08 - 10/10/08	
		Well A	RO Feed	Well A	RO Feed	Well B	RO Feed
Total Manganese	mg/L	0.236	0.230	0.235	0.237	0.180	0.180
Dissolved Manganese	mg/L	0.226	0.217	0.340	0.216	0.178	0.181
Total Iron	mg/L	0.165	0.070	0.158	0.158	0.148	0.144
Dissolved Iron	mg/L	0.1	0.053	0.155	0.155	0.13	0.13

Note:
(1) Average values

Table 5.4-5 shows an overview of total iron and total manganese during portions of RO Optimization Test I and RO Optimization Test II corresponding to the various pretreatment strategies discussed above, as well as the RO feed pH achieved during the portions of the testing when acid addition was employed as a part of the pretreatment strategy.

Table 5.4-5.
Overview of Feed Water Quality Parameters Measured Onsite during Various Parts of the Phase VI Testing

Parameter [1]	Units	RO Optimization Test I				RO Optimization Test II				
		6/2/08 – 8/26/08				8/26/08 – 9/19/08			9/19/08 – 10/10/08	
		Well A	RO Feed 6/2 – 7/28 Aeration + Media Filtration	RO Feed 7/29 – 8/13 Oxygen Quenching	RO Feed 8/14 – 8/26 Oxygen Quenching + Acid Feed (pH target ~6.5)	Well A	RO Feed 8/26 – 9/10, 9/19 Oxygen Quenching + Acid Feed (pH target ~6.5)	RO Feed 9/11 – 9/18 Oxygen Quenching + Acid Feed (pH target ~ 6.8)	Well B	RO Feed 9/19 – 10/10 Oxygen Quenching + Acid Feed (pH target ~6.5)
Total Manganese	mg/L	0.236	0.223	0.249	0.234	0.235	0.216	0.260	0.180	0.180
Total Iron	mg/L	0.165	0.007	0.139	0.162	0.158	0.160	0.155	0.148	0.144
Summary of RO Feed pH during Portions of Pilot Study involving Muriatic Acid Addition										
pH	pH units	-	-	-	6.4	-	6.4	6.8	-	6.4

Note:
(1) Average values

5.4.2.6 Phase VI Pretreatment Summary

The level of DO in the wells is an important consideration within to selection of a pretreatment strategy. The measurement of DO levels for the Camarillo wells was refined and improved over the course of the Phase VI testing. These improvements are summarized on Figure 5.4-17. By introduction of a flow through device to minimize the impact of ambient air on DO levels measured for the wells, DO levels down near zero (< 0.02 mg/L) were measured once the measurement technique was refined. It would be a prudent strategy to take steps to monitor DO at the wells during plant operation and take appropriate steps to mitigate the impact of rising DO levels promptly should they be observed.

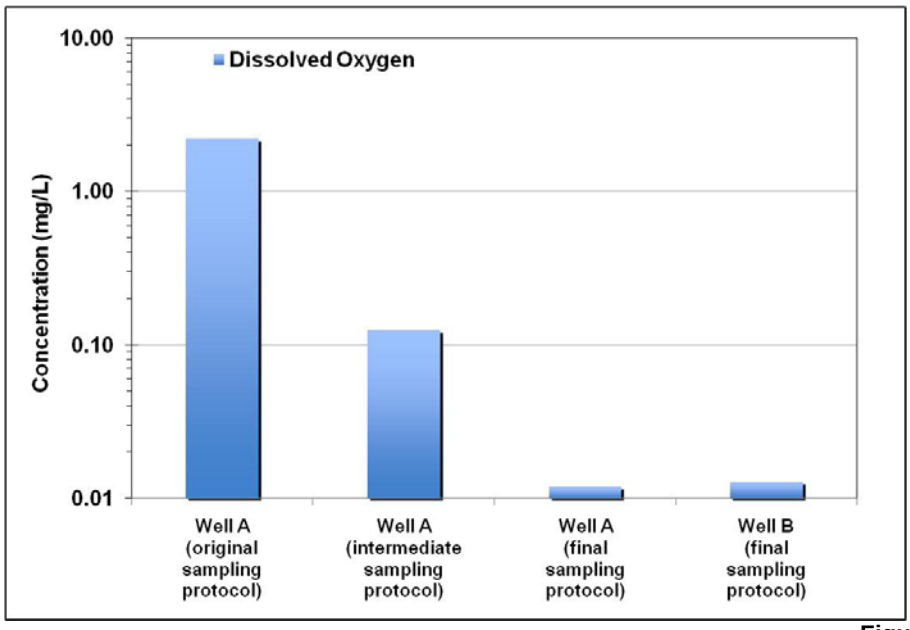

Figure 5.4-17.
Phase VI – Comparison of DO Levels

Various observations on pretreatment from the Phase VI testing are summarized in Table 5.4-6. The most promising pretreatment strategy based on the Phase VI testing appears to be oxygen quenching with acid addition. It should be noted that the oxygen levels during Phase VI testing appear to have been near zero at the wells. Because of this and because declines in MTC were observed for certain membranes even with the oxygen quenching with acid addition strategy, care must be exercised in the selection of the RO membrane for the plant and to avoid changes in DO levels in the wells to assure that the pretreatment strategy will be effective.

Table 5.4-6.
Phase VI – Observations on Pretreatment Strategies

Pretreatment Strategy		Observations based on Phase VI Results
Aeration plus Media Filtration		Appeared to result in fouling of the cartridge filters by manganese and in accelerated declines in MTC for membranes
Oxygen Quenching	No Acid Addition	Reduction in iron levels observed in cartridge filters; Accelerated decline in MTC for membranes
Oxygen Quenching with Acid Addition	Acid to pH ~ 6.4	No reduction in iron levels observed in cartridge filters; Most stable MTCs, still some declines in MTC observed for certain membranes
	Acid to pH ~ 6.8	Reduction in iron levels observed in cartridge filters; Accelerated decline in MTC for membranes

5.4.3 RO Optimization Test I Results

The following discussion will present pilot testing results for two low-pressure brackish RO membranes downstream of the selected pretreatment system (e.g., Phase II - Aeration plus Media Filtration). After completing 2 months of pilot testing, the pretreatment system was simplified to a chemical addition approach (similar to Phase I testing) to remediate undesired RO fouling that occurred during the sustained operation with the aeration plus media filtration approach.

5.4.3.1 Objectives

The objectives of RO Optimization Test I is to develop water quality and pressure information to select the optimal RO membrane, which will minimize the capital and O&M costs. The RO membranes will be evaluated based upon their ability to produce the defined water quality objectives set forth in Section 3.1.3 with the lowest total energy requirements (e.g., kWh/kgal). A secondary objective was to confirm that RO membrane fouling rates for the selected manufacturer were acceptable for the selected pretreatment process.

5.4.3.2 Description

The RO system was re-plumbed for Phase VI to allow parallel testing of two RO membranes on the same feed water. For the RO Optimization Test I, the low-pressure RO membranes offered by Saehan and Dow were evaluated for their fouling propensity, operating pressures, and product water quality. Each individual RO system was operated independently with a target feed water recovery of 75 percent and membrane flux of 15 gfd.

5.4.3.3 Membrane I Performance

Figure 5.4-18 presents the MTC for the Phase VI testing of Dow's FilmTec XLE 4040 membranes. The RO pilot was successfully operated for the three month time period without significant shutdowns, except for three CIPs (two acid and one caustic). Continuous data operation provides an excellent means to evaluate the influence of the entire treatment train on RO water quality and performance. From June 2, 2008 to

July 28, 2008, the aeration plus media filtration pretreatment produced the RO feed water. Unfortunately, unlike the testing performed in Phase II that demonstrated a moderate decline in the MTC, the RO membranes exhibited a significant decline in the MTC over the two-month testing period. In an effort to stop the decline in the MTC, an acid CIP followed by a caustic CIP was performed at the end of June, but provided little recovery of the MTC. The system continued to operate with aeration plus media filtration pretreatment until the RO membranes were acid cleaned again on July 30, 2008 to restore the MTC and begin a new operational run. Following this CIP, the pretreatment was changed significantly by eliminating the aeration plus media filtration completely. Instead of pretreatment equipment (aeration plus media filtration), chemical addition (muriatic acid and thiosulfate) was used to maintain the RO feed water iron and manganese in the dissolved form. Additional discussion on the rationale for this change in pretreatment process is provided in the upcoming section on water quality. Following these changes to the pretreatment process, the RO membranes exhibited minimal membrane fouling with the MTC declining very gradually in the second stage, but no loss in MTC was observed in the first stage (unlike the testing with the aeration plus media filtration pretreatment). The stable MTC in the first stage provides a good indication that the RO membrane was no longer fouling due to the presence of colloidal fouling components in the feed water. Once the feed water pH was reduced to 6.4 on August 14, 2008, the MTC values stabilized in the second stage.

Although the FilmTec XLE 4040 membranes initially exhibited high MTC values, they could not be restored to those initial values following the CIPs that were performed. The MTC stabilized around 0.17 gfd/psi for the first stage and 0.13 gfd/psi for the second stage.

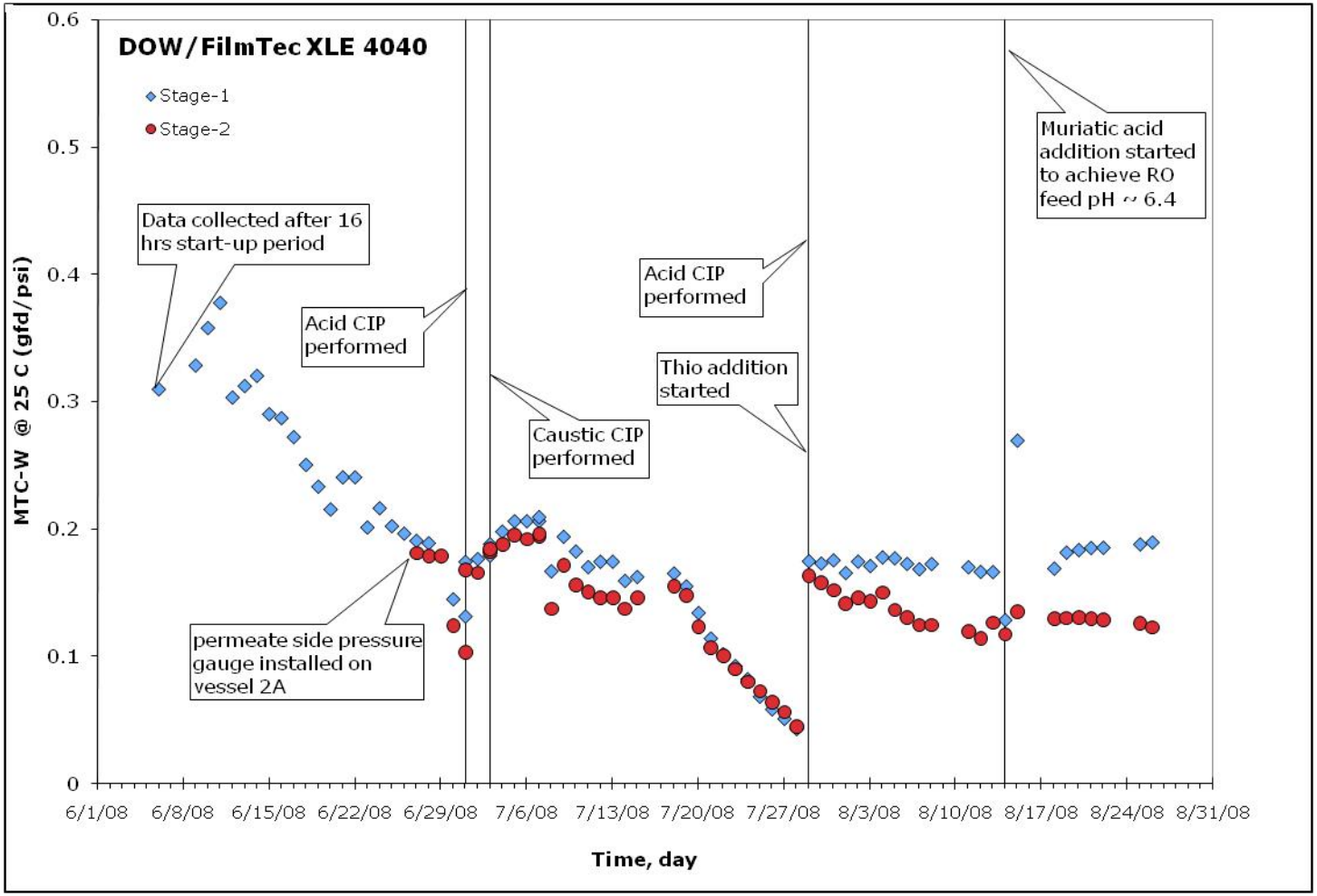

Figure 5.4-18.
Phase VI – Dow/FilmTec XLE 4040 Membrane Performance

5.4.3.4 Membrane II Performance

Figure 5.4-19 presents the MTC for the Phase VI testing of Saehan's RE4040 BLR membranes. Similar to the results presented for Dow's XLE 4040, the RO system operated continuously for three months. However, the membrane fouling observed with the RE4040 BLR membranes was more severe and five CIPs (four acid and one caustic) were performed in an attempt to restore the MTC. From June 2 to July 28, 2008, the aeration plus media filtration pretreatment produced the RO feed water and the RO membranes exhibited a significant decline in the MTC over the two-month testing period. An acid CIP was performed to begin the Phase VI operation and the MTC was relatively stable for the first couple weeks of operation. However, near the end of June, the MTC for both stages began a rapid decline and decreased from approximately 0.25 gfd/psi to less than 0.1 gfd/psi over a 2 week period. The RO membranes were acid cleaned on July 15, 2008 and the MTC was restored to approximately 0.2 gfd/psi. However, the rapid loss of MTC in both RO systems lead to the project team to conclude that a change in the pretreatment was required. Instead of pretreatment equipment (aeration plus media filtration), chemical addition (muriatic acid and thiosulfate) was used to maintain the RO feed water iron and manganese in the dissolved form. Again, additional discussion on the rationale for this change in pretreatment process is provided in the upcoming section on water quality. While these changes were being made to the pretreatment process, an acid CIP was performed. Similar to the fouling observed with the Dow XLE 4040, the first stage MTC was relatively stable, but the second stage MTC continued to decline until acid addition was implemented on August 14, 2008. The stable MTC in the first stage provides a good indication that the RO membrane was no longer fouling due to the presence of colloidal fouling components in the feed water. The muriatic acid addition appears critical to maintaining iron in a dissolved form, as it is concentrated in the second stage.

The Saehan RE4040 BLR membranes did not exhibit the same irrecoverable decline in the MTC that was observed with the XLE 4040s. The MTC initially stabilized around 0.25 to 0.3 gfd/psi for the first stage and the MTC remained stable towards the end of the testing period around 0.25 gfd/psi.

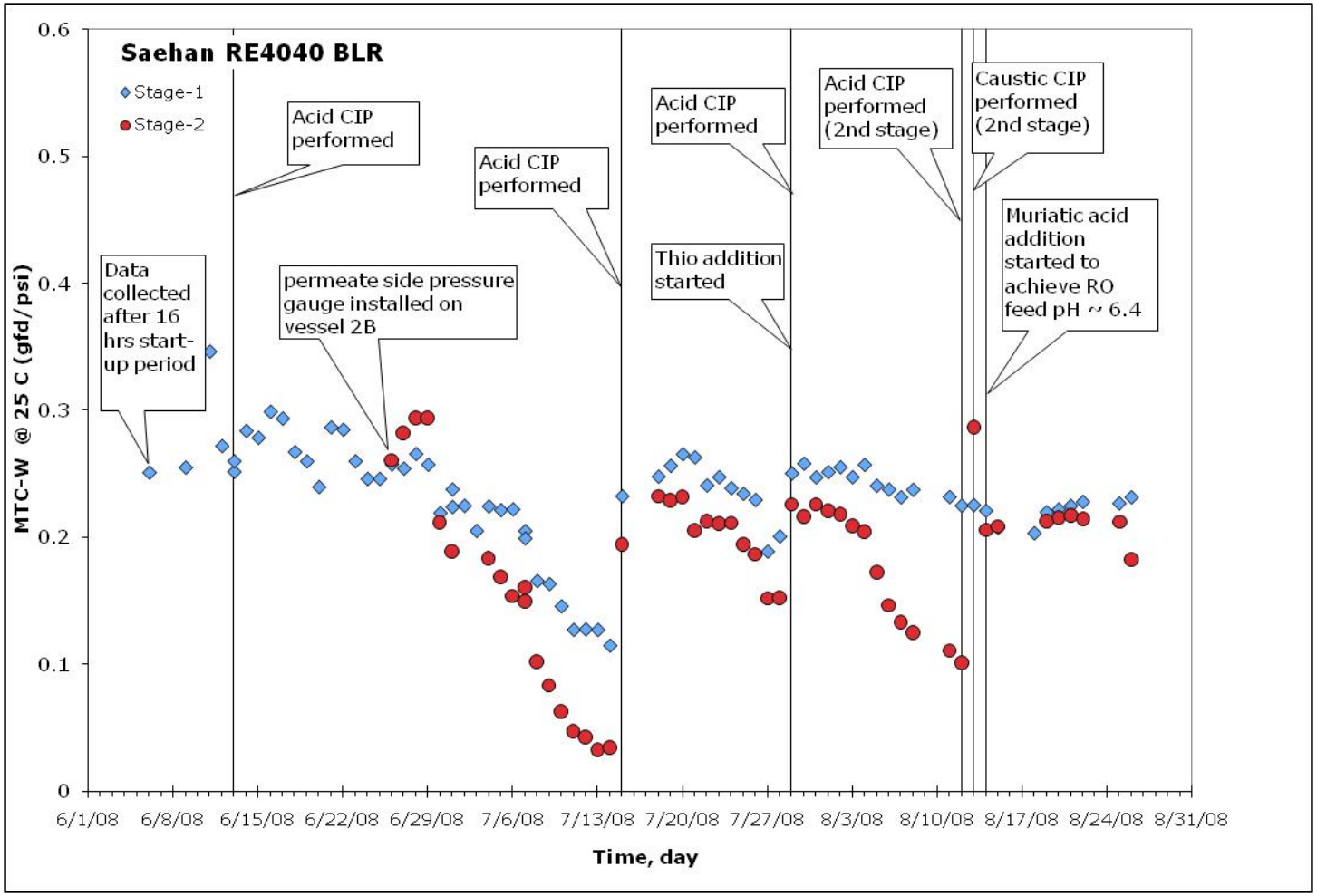

Figure 5.4-19.
Phase VI – Saehan RE4040 BLR Membrane Performance

5.4.3.5 RO Permeate Water Quality

The feed water, RO permeate, and concentrate water quality for the Dow FilmTec XLE 4040 membranes is summarized in Table 5.4-7 for the total iron and manganese concentrations. The observed concentrations in Table 5.4-7 shows that:

- ***Pretreatment (Well A and RO Feed data)***
  - Total iron was effectively removed by the aeration plus media filtration pretreatment between 6/2 and 7/28
  - Total iron was unchanged when feed water was dosed with acid and thiosulfate
  - Total manganese was slightly reduced by aeration plus media filtration pretreatment
  - Total manganese was unchanged with thiosulfate and acid addition
- ***Influence of Iron on Dow RO Membrane Fouling at 75 percent recovery (RO Feed and Concentrate data)***
  - 3.7 grams per day of iron adsorbed to the membrane with the aeration plus media filtration pretreatment (e.g., concentrate iron is 0.006 mg/L, but should be 0.028 mg/L based on 0.007 mg/L in RO feed)
  - 13.9 grams per day of iron continued to adsorb to the membrane with thiosulfate alone as pretreatment (e.g., concentrate iron is 0.473 mg/L, but should be 0.556 mg/L based on 0.139 mg/L in RO feed)
  - No iron adsorbed to the membrane when thiosulfate and acid (pH ~ 6.5) were dosed to the feed water
- ***Influence of Manganese on Dow RO Membrane Fouling at 75 percent recovery (RO Feed and Concentrate data)***
  - 27 grams per day of manganese adsorbed to the membrane with the aeration plus media filtration pretreatment (e.g., concentrate manganese is 0.731 mg/L, but should be 0.892 mg/L based on 0.223 mg/L in RO feed)
  - No manganese adsorbed to the membrane when chemical addition alone was used (July 29 to August 26, 2008)

Table 5.4-7.
Phase VI – Total Iron and Total Manganese Concentrations with Dow Filmtec XLE 4040

Dates	Location	Pretreatment	Membrane I (Dow Filmtec XLE 4040)	
			Total Manganese (mg/L)	Total Iron (mg/L)
6/2/08 – 8/26/08	Well A	All	0.236	0.165
	RO Feed		0.230	0.070
	Permeate		0.002	0.007
	Concentrate		0.818	0.264
6/2/08 – 7/28/08	Well A	Aeration + Media Filtration	0.238	0.169
	RO Feed		0.223	0.007
	Permeate		0.002	0.005
	Concentrate		0.731	0.006
7/29/08 – 8/13/08	Well A	Oxygen Quenching	0.233	0.157
	RO Feed		0.249	0.139
	Permeate		0.001	0.007
	Concentrate		1.007	0.473
8/14/08 – 8/26/08	Well A	Oxygen Quenching + Acid Feed (target pH~6.5)	0.234	0.165
	RO Feed		0.234	0.162
	Permeate		0.001	0.014
	Concentrate		0.999	0.632

The feed water, RO permeate and concentrate water quality for the Saehan RE 4040 BLR is summarized in Table 5.4-8 for total iron and manganese concentrations observed throughout the various stages of Phase VI. The iron and manganese concentrations through the treatment train show that:

- ***Pretreatment (Well A and RO Feed data)***
  - Same conclusions as from Table 5.4-7
- ***Influence of Iron on Saehan RO Membrane Fouling at 75 percent recovery (RO Feed and Concentrate data)***
  - 3.5 grams per day of iron adsorbed to the membrane with the aeration plus media filtration pretreatment (e.g., concentrate iron is 0.007 mg/L, but should be 0.028 mg/L)
  - 21 grams per day of iron adsorbed to the membrane with thiosulfate alone as pretreatment (e.g., concentrate iron is 0.431 mg/L, but should be 0.556 mg/L)
  - Unlike the Dow XLE 4040, 6 grams per day of iron continued to adsorb to the membrane when thiosulfate and acid (pH ~ 6.5) were dosed to the feed water.

- ***Influence of Manganese on Saehan RO Membrane Fouling at 75 percent recovery (RO Feed and Concentrate data)***
  - 20.5 grams per day of manganese adsorbed to the membrane with the aeration plus media filtration pretreatment (e.g., concentrate manganese is 0.770 mg/L, but should be 0.892 mg/L)
  - Unlike the Dow XLE 4040, 13.5 grams per day of manganese continued to adsorb to the membrane when dosing thiosulfate
  - When the feed water was dosed with both acid and thiosulfate, the rate of manganese deposition was reduced to 4 grams per day

Table 5.4-8.
Phase VI – Total Iron and Total Manganese Concentrations with Saehan RE 4040 BLR

Dates	Location	Pretreatment	Membrane II (Saehan RE4040 BLR)	
			Total Manganese (mg/L)	Total Iron (mg/L)
6/2/08 – 8/26/08	Well A	All	0.236	0.165
	RO Feed		0.230	0.070
	Permeate		0.005	0.008
	Concentrate		0.823	0.260
6/2/08 – 7/28/08	Well A	Aeration + Media Filtration	0.238	0.169
	RO Feed		0.223	0.007
	Permeate		0.007	0.005
	Concentrate		0.770	0.007
7/29/08 – 8/13/08	Well A	Oxygen Quenching	0.233	0.157
	RO Feed		0.249	0.139
	Permeate		0.003	0.007
	Concentrate		0.916	0.431
8/14/08 – 8/26/08	Well A	Oxygen Quenching + Acid Feed (target pH~6.5)	0.234	0.165
	RO Feed		0.234	0.162
	Permeate		0.003	0.018
	Concentrate		0.909	0.612

Tables 5.4-9 and 5.4-10 present the general mineral water quality analyses for the Dow/FilmTec XLE 4040 and Saehan RE4040 BLR membranes, respectively. The XLE 4040 membranes produced a high quality permeate with TDS ranging from non-detect (< 10 mg/L) to 11 mg/L. The Saehan membranes, which were believed to be partially oxidized from previous testing, produced TDS concentrations between 74 and 110 mg/L. Additional discussion on the importance of water quality on the membrane selection is provided in Section 5.4.5.

Table 5.4-9.
Phase VI – Mineral Water Quality Results for Dow Filmtec XLE 4040

		Membrane 1 (Dow Filmtec XLE 4040)						
		Well A	RO Permeate	RO Waste	Well A	RO Permeate	Well A	RO Permeate
Parameter	**Units**	**6/27/08**	**6/27/08**	**6/27/08**	**7/10/08**	**7/10/08**	**7/14/08**	**7/14/08**
Total Barium	mg/L	0.049	ND (< 0.0020)	0.21	0.052	ND (< 0.0020)	0.052	ND (< 0.0020)
Calcium	mg/L	240	0.4	1100	250	0.59	260	0.36
Potassium	mg/L	5.3	ND (< 0.10)	25	6	1.3	5.9	0.62
Magnesium	mg/L	66	ND (< 0.10)	290	72	0.13	71	0.11
Sodium	mg/L	180	3.8	860	200	8.9	200	3.1
Strontium, Total	mg/L	1.8	ND (< 0.0050)	8	1.9	ND (< 0.0050)	1.9	ND (< 0.0050)
Total Fluoride	mg/L	0.26	ND (< 0.10)	0.94	0.24	ND (< 0.10)	0.24	ND (< 0.10)
Alkalinity as $CaCO_3$	mg/L	290		1200	290	4.8	280	4.8
Carbonate Alkalinity as $CaCO_3$	mg/L				ND (< 2.0)	ND (< 2.0)	ND (< 2.0)	ND (< 2.0)
Bicarbonate Alkalinity as HCO_3	mg/L				360	5.9	350	5.9
Hydroxide Alkalinity as $CaCO_3$	mg/L				ND (< 2.0)	ND (< 2.0)	ND (< 2.0)	ND (< 2.0)
Ammonia as N	mg/L	0.24	ND (< 0.10)	ND (< 0.10)	0.24	ND (< 0.10)	0.26	ND (< 0.10)
Gross Alpha	pCi/L	13.2			10.1	0.72	9.29	1.2
Gross Alpha counting error (+/-)	pCi/L	1.28			1.14	0.2	1.1	0.25
Gross Alpha MDA95	pCi/L	0.35			0.362	0.038	0.362	0.037
Total Hardness as $CaCO_3$	mg/L	870	0.99	4100	930	2	930	1.3
Nitrate as NO_3	mg/L	0.99	ND (< 0.50)	7.6	0.81	ND (< 0.50)	1.5	ND (< 0.50)
Total Dissolved Solids	mg/L	1800	11	8000	1700	ND (< 10)	1600	ND (< 10)
Total Organic Carbon (TOC)	mg/L	1.5	ND (< 0.30)	7.3	1.4	ND (< 0.30)	1.4	ND (< 0.30)
Chloride	mg/L	170	3.6	740				
Sulfate	mg/L	840	1.1	3700				
Silica as SiO_2, Total	mg/L	16	0.14	71				

Table 5.4-10.
Phase VI – Mineral Water Quality Results for Saehan RE 4040 BLR

		Membrane II (Saehan RE 4040 BLR)					
		Well A	RO Permeate	Well A	RO Permeate	Well A	RO Permeate
Parameter	**Units**	**6/27/08**	**6/27/08**	**7/10/08**	**7/10/08**	**7/14/08**	**7/14/08**
Total Barium	mg/L	0.049	ND (< 0.0020)	0.052	ND (< 0.0020)	0.052	ND (< 0.0020)
Calcium	mg/L	240	2.2	250	4.1	260	4.1
Potassium	mg/L	5.3	0.6	6	1.7	5.9	1.1
Magnesium	mg/L	66	0.59	72	1.2	71	1.2
Sodium	mg/L	180	24	200	47	200	33
Strontium, Total	mg/L	1.8	0.015	1.9	0.029	1.9	0.03
Total Fluoride	mg/L	0.26	ND (< 0.10)	0.24	ND (< 0.10)	0.24	ND (< 0.10)
Alkalinity as $CaCO_3$	mg/L	290	29	290	48	280	43
Carbonate Alkalinity as $CaCO_3$	mg/L			ND (< 2.0)	ND (< 2.0)	ND (< 2.0)	ND (< 2.0)
Bicarbonate Alkalinity as HCO_3	mg/L			360	59	350	53
Hydroxide Alkalinity as $CaCO_3$	mg/L			ND (< 2.0)	ND (< 2.0)	ND (< 2.0)	ND (< 2.0)
Ammonia as N	mg/L	0.24	ND (< 0.10)	0.24	ND (< 0.10)	0.26	ND (< 0.10)
Gross Alpha	pCi/L	13.2		10.1	2.1	9.29	1
Gross Alpha counting error (+/-)	pCi/L	1.28		1.14	0.42	1.1	0.27
Gross Alpha MDA95	pCi/L	0.35		0.362	0.06	0.362	0.052
Total Hardness as $CaCO_3$	mg/L	870	7.9	930	15	930	15
Nitrate as NO_3	mg/L	0.99	1	0.81	1.2	1.5	0.76
Total Dissolved Solids	mg/L	1800	74	1700	110	1600	100
Total Organic Carbon (TOC)	mg/L	1.5	ND (< 0.30)	1.4	ND (< 0.30)	1.4	ND (< 0.30)
Chloride	mg/L	170	26				
Sulfate	mg/L	840	3.5				
Silica as SiO_2, Total	mg/L	16	3.2				

5.4.3.6 RO Optimization Test I Summary

The selected pretreatment process from Phase II (Aeration plus Media Filtration) resulted in partial oxidation removal of manganese and significant RO fouling. Acid and thiosulfate addition successfully maintained the iron and manganese in the dissolved form which dramatically reduced RO fouling rates. The Dow XLE 4040 stabilized at a 0.17 and 0.13 gfd/psi for the first and second stages while the Saehan membrane stabilized around 0.25 gfd/psi. The mineral water quality produced by the Dow membrane was superior to the Saehan membrane.

5.4.4 RO Optimization Test II Results

The following discussion will present pilot testing results for a new low-pressure brackish RO membrane and a NF membrane downstream of the modified pretreatment system (e.g., oxygen quenching plus acid addition). The testing lasted for approximately 45 days.

5.4.4.1 Objectives

The objectives of RO Optimization Test II is to develop water quality and pressure information for two different desalination membrane types to select the optimal RO membrane, which will minimize the capital and O&M costs. The membranes will be evaluated based upon their ability to produce the defined water quality objectives set forth in Section 3.1.3 with the lowest total energy requirements (e.g., kWh/kgal). A secondary objective was to confirm that RO membrane fouling rates for the selected manufacturer were acceptable for the selected pretreatment process.

5.4.4.2 Description

For the RO Optimization Test II, the low-pressure RO membrane offered by Toray was compared with Dow's NF90 membrane for their fouling propensity, operating pressures, and product water quality. Each individual desalination system was operated independently with a target feed water recovery of 75 percent and membrane flux of 15 gfd.

5.4.4.3 Membrane III Performance

Figure 5.4-20 presents the MTC for the Phase VI testing of Toray's TM710 membrane. With the new chemical pretreatment, the RO membranes maintained a stable MTC throughout the entire testing period. An attempt was made on September 11, 2008 to increase the pH target from 6.5 to 6.8 to reduce acid consumption. However, this change resulted in membrane fouling, particularly of the second stage. The membranes were cleaned with caustic and acid solutions and put back into service with a target pH of 6.5 on September 19, 2008. Additionally, all work prior to this was performed on Well A, but Well B was put in service on September 19, 2008. The Toray membrane's MTC remained stable once acid dosing was restored to achieve a target pH of 6.5.

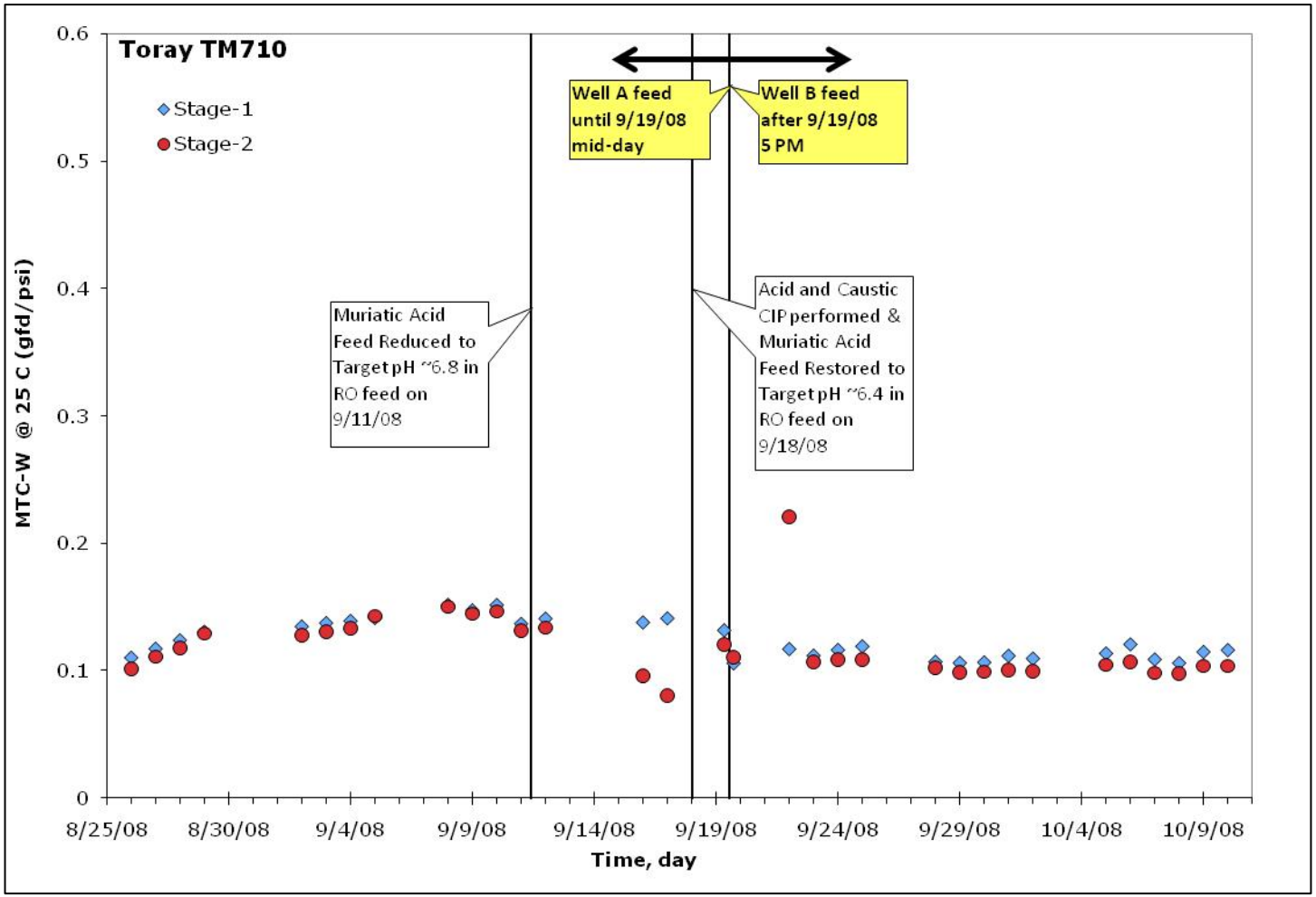

Figure 5.4-20.
Phase VI – Toray TM710 Membrane Performance

5.4.4.4 Membrane IV Performance

Figure 5.4-21 presents the MTC for the Phase VI testing of Dow's NF90 membrane. Unlike the Toray RO membranes, the NF membranes experienced a rapid decline in the MTC over the first two weeks of testing. Similar to the Toray RO membranes, the second stage of the Dow NF90 membranes was fouled significantly when an attempt was made to reduce the acid consumption on September 11, 2008. However, once the NF membranes were chemically cleaned and the pH target of 6.5 was restored, the MTC was more stable, but continued a gradual decline that indicates membrane fouling continued.

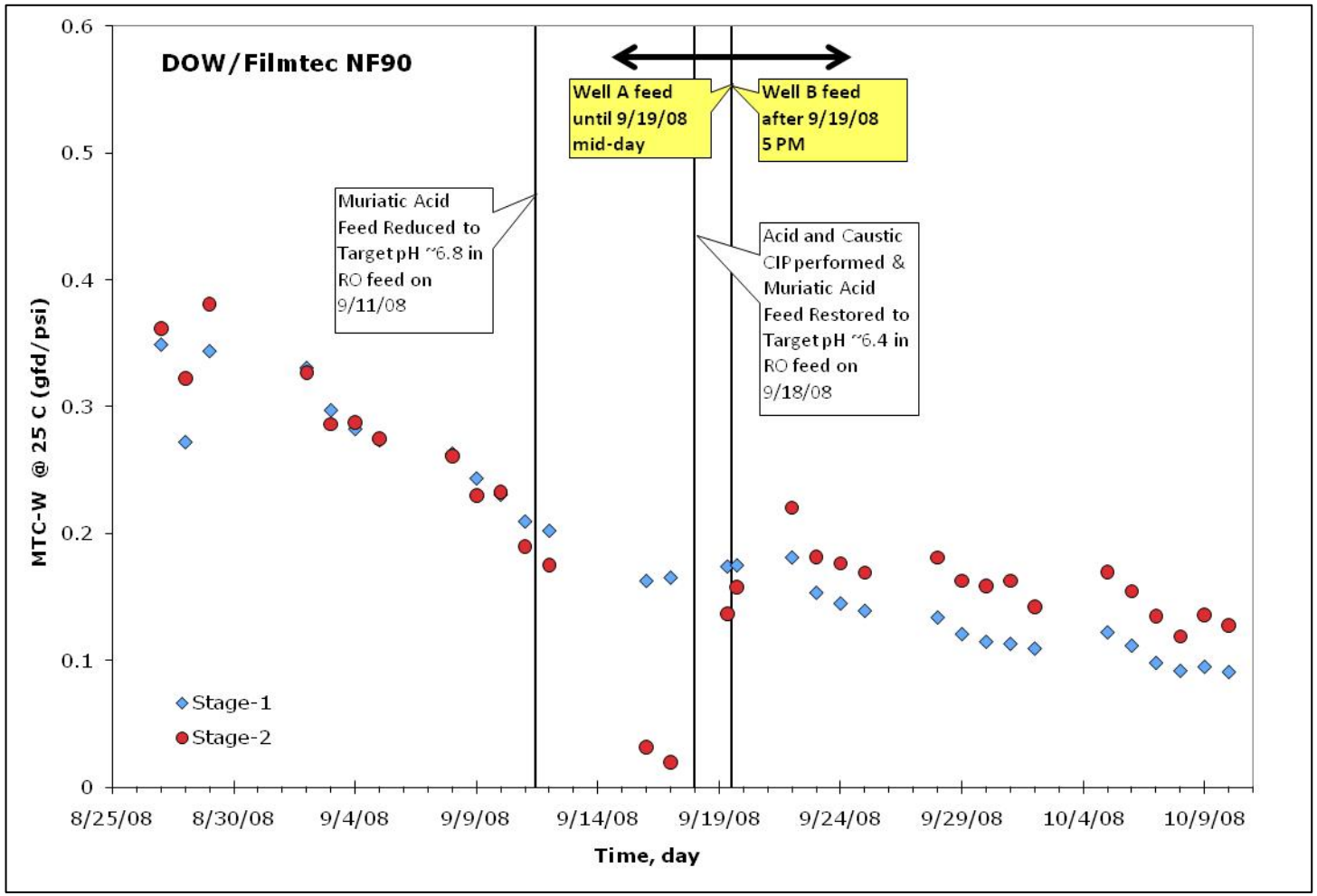

Figure 5.4-21.
Phase VI – Dow/FilmTec NF90 Membrane Performance

5.4.4.5 RO Permeate Water Quality

The feed water, RO permeate, and concentrate water quality for the Toray TM710 membranes are summarized in Table 5.4-11 for the total iron and manganese concentrations. The observed concentrations in Table 5.4-11 shows that:

- ***Pretreatment (Well A and RO Feed data)***
  - Total iron and manganese were unchanged when feed water was dosed with acid and thiosulfate
- ***Influence of Iron on Toray RO Membrane Fouling at 75 percent recovery (RO Feed and Concentrate data)***
  - Little iron was adsorbed to the membrane with a feed water pH of 6.5 and thiosulfate addition (August 26 to September 10, 2008)
  - 42.7 grams per day of iron adsorbed to the membrane when the target feed water pH was increased to 6.8
  - No iron adsorbed to the membrane when target feed water pH was returned to 6.5
- ***Influence of Manganese on Toray RO Membrane Fouling at 75 percent recovery (RO Feed and Concentrate data)***
  - No manganese adsorbed to the membrane when target feed water pH was 6.5
  - 35.7 grams per day of manganese adsorbed to the membrane when the target feed water pH was increased to 6.8

Table 5.4-11.
Phase VI – Total Iron and Total Manganese Concentrations with Toray TM710

Dates	Location	Pretreatment	Membrane III (Toray TM710) Total Manganese (mg/L)	Membrane III (Toray TM710) Total Iron (mg/L)
8/26/08 – 9/19/08	Well A	All (Well A feed)	0.235	0.158
	RO Feed		0.237	0.158
	Permeate		0.001	0.018
	Concentrate		0.910	0.554
8/26/08 – 9/10/08, 9/19/08	Well A	Oxygen Quenching + Acid Feed (target pH~6.5)	0.228	0.158
	RO Feed		0.216	0.160
	Permeate		0.001	0.020
	Concentrate		0.933	0.629

Table 5.4-11.
Phase VI – Total Iron and Total Manganese Concentrations with Toray TM710

Dates	Location	Pretreatment	Membrane III (Toray TM710) Total Manganese (mg/L)	Total Iron (mg/L)
9/11/08 – 9/18/08	Well A	Oxygen Quenching + Acid Feed (target pH~6.8)	0.250	0.159
	RO Feed		0.260	0.155
	Permeate		0.001	0.014
	Concentrate		0.828	0.366
9/19/08 – 10/10/08	Well B	Oxygen Quenching + Acid Feed (target pH~6.5)	0.180	0.148
	RO Feed		0.180	0.144
	Permeate		0.001	0.006
	Concentrate		0.773	0.614

The feed water, RO permeate and concentrate water quality for the Dow FilmTec NF90 is summarized in Table 5.4-12 for total iron and manganese concentrations observed throughout the various stages of Phase VI. The iron and manganese concentrations through the treatment train show that:

- ***Pretreatment (Well A and RO Feed data)***
  - Total iron and manganese were unchanged when feed water was dosed with acid and thiosulfate
- ***Influence of Iron on Dow NF Membrane Fouling at 75 percent recovery (RO Feed and Concentrate data)***
  - 5.7 grams per day of iron adsorbed to the membrane with a feed water pH of 6.5 and thiosulfate addition (August 26 to September 10, 2008)
  - 50.8 grams per day of iron adsorbed to the membrane when the target feed water pH was increased to 6.8
  - Minimal iron adsorbed to the membrane when target feed water pH was returned to 6.5
- ***Influence of Manganese on Dow NF Membrane Fouling at 75 percent recovery (RO Feed and Concentrate data)***
  - No manganese adsorbed to the membrane when target feed water pH was 6.5
  - 49.5 grams per day of manganese adsorbed to the membrane when the target feed water pH was increased to 6.8

5.4-12.
Phase VI – Total Iron and Total Manganese Concentrations with Dow FilmTec NF90

Dates	Location	Pretreatment	Membrane IV (Dow Filmtec NF90) Total Manganese (mg/L)	Total Iron (mg/L)
8/26-9/19	Well A	All (Well A feed)	0.235	0.158
	RO Feed		0.237	0.158
	Permeate		0.001	0.018
	Concentrate		0.878	0.524
8/26-9/10, 9/19	Well A	Oxygen Quenching + Acid Feed (target pH~6.5)	0.228	0.158
	RO Feed		0.216	0.16
	Permeate		0.001	0.022
	Concentrate		0.893	0.606
9/11-9/18	Well A	Oxygen Quenching + Acid Feed (target pH~6.8)	0.250	0.159
	RO Feed		0.260	0.155
	Permeate		0.004	0.01
	Concentrate		0.746	0.318
9/19-10/10	Well A	Oxygen Quenching + Acid Feed (target pH~6.5)	0.180	0.148
	RO Feed		0.180	0.144
	Permeate		0.001	0.005
	Concentrate		0.735	0.572

Tables 5.4-13 and 5.4-14 present the general mineral water quality analyses for the Toray TM710 and Dow/FilmTec NF90 membranes, respectively. The TM710 membranes produced a high quality permeate with TDS ranging from non-detect (< 10 mg/L) to 26 mg/L. The NF90 membranes produced TDS concentrations between 27 and 85 mg/L, which is excellent water quality for a NF membrane. Additional discussion on the importance of water quality on the membrane selection is provided in Section 5.4.5.

5.4-13.
Phase VI – Mineral Water Quality Results for Toray TM710

Parameter	Units	Membrane III (Toray TM710)					
		Well A	RO Permeate	RO Concentrate	Well B	RO Permeate	RO Concentrate
		9/19/08	9/19/08	9/19/08	10/6/08	10/6/08	10/6/08
Total Barium	mg/L	0.047	ND (< 0.0020)	0.18	0.064	ND (< 0.0020)	0.22
Calcium	mg/L	230	0.19	960	200	0.11	650
Potassium	mg/L	5.7	0.13	23	5.4	ND (< 0.10)	20
Magnesium	mg/L	67	ND (< 0.10)	260	49	ND (< 0.10)	160
Sodium	mg/L	190	4.7	770	140	2.9	560
Strontium, Total	mg/L	1.9	ND (< 0.0050)	7.3	1.4	ND (< 0.0050)	5
Total Fluoride	mg/L	0.23	ND (< 0.10)	0.63	0.22	ND (< 0.10)	0.58
Alkalinity as $CaCO_3$	mg/L	290	7.2	820	230	7.2	650
Carbonate Alkalinity as $CaCO_3$	mg/L	ND (< 2.0)	ND (< 2.0)	ND (< 2.0)	ND (< 2.0)	ND (< 2.0)	ND (< 2.0)
Bicarbonate Alkalinity as HCO_3	mg/L	350	8.8	1000	280	8.8	790
Hydroxide Alkalinity as $CaCO_3$	mg/L	ND (< 2.0)	ND (< 2.0)	ND (< 2.0)	ND (< 2.0)	ND (< 2.0)	ND (< 2.0)
Ammonia as N	mg/L	0.26	ND (< 0.10)	0.98	0.33	ND (< 0.10)	0.96
Gross Alpha	pCi/L	5.2	0.0		8	0.0	
Gross Alpha counting error (+/-)	pCi/L	1.05	1.0		1.19	0.71	
Gross Alpha MDA95	pCi/L	0.343	1.6		0.343	1.1	
Total Hardness as $CaCO_3$	mg/L	850	ND (< 0.66)	3500	710	ND (< 0.66)	2300
Nitrate as NO_3	mg/L	0.69	0.91	1.9	ND (< 0.50)	ND (< 0.50)	ND (< 0.50)
Total Dissolved Solids	mg/L	1800	26	9900	1400	ND (< 10)	4900
Total Organic Carbon (TOC)	mg/L	1.5	ND (< 0.30)	4.6	1.4	ND (< 0.30)	5.2
Chloride	mg/L	170	2.4	860	170	1.2	740
Sulfate	mg/L	790	0.52	3400	590	ND (< 0.50)	2100
Silica as SiO_2, Total	mg/L	34	0.21	130	36	0.12	120

5.4-14.
Phase VI – Mineral Water Quality Results for Dow Filmtec NF90

		Membrane IV (Dow Filmtec NF90)			
		Well A	**RO Permeate**	**Well B**	**RO Permeate**
Parameter	**Units**	**9/19/08**	**9/19/08**	**10/6/08**	**10/6/08**
Total Barium	mg/L	0.047	ND (< 0.0020)	0.064	ND (< 0.0020)
Calcium	mg/L	230	0.33	200	0.29
Potassium	mg/L	5.7	0.37	5.4	0.5
Magnesium	mg/L	67	ND (< 0.10)	49	ND (< 0.10)
Sodium	mg/L	190	13	140	8.5
Strontium, Total	mg/L	1.9	0.0024	1.4	ND (< 0.0050)
Total Fluoride	mg/L	0.23	ND (< 0.10)	0.22	ND (< 0.10)
Alkalinity as $CaCO_3$	mg/L	290	8.4	230	4.8
Carbonate Alkalinity as $CaCO_3$	mg/L	ND (< 2.0)	ND (< 2.0)	ND (< 2.0)	ND (< 2.0)
Bicarbonate Alkalinity as HCO_3	mg/L	350	10	280	5.9
Hydroxide Alkalinity as $CaCO_3$	mg/L	ND (< 2.0)	ND (< 2.0)	ND (< 2.0)	ND (< 2.0)
Ammonia as N	mg/L	0.26	ND (< 0.10)	0.33	ND (< 0.10)
Gross Alpha	pCi/L	5.2	0.0	8	0.0
Gross Alpha counting error (+/-)	pCi/L	1.05	0.85	1.19	0.98
Gross Alpha MDA95	pCi/L	0.343	1.5	0.343	1.6
Total Hardness as $CaCO_3$	mg/L	850	0.83	710	0.72
Nitrate as NO_3	mg/L	0.69	0.77	ND (< 0.50)	ND (< 0.50)
Total Dissolved Solids	mg/L	1800	85	1400	27
Total Organic Carbon (TOC)	mg/L	1.5	ND (< 0.30)	1.4	ND (< 0.30)
Chloride	mg/L	170	14	170	10
Sulfate	mg/L	790	ND (< 0.5)	590	ND (< 0.5)
Silica as SiO_2, Total	mg/L	34	1.3	36	0.95

5.4.4.6 RO Optimization Test II Summary

The change in pretreatment processes to chemical addition to maintain manganese and iron in a dissolved form (e.g., similar to Phase I pretreatment) provided stable MTC data for both membrane systems tested. During the testing of Toray's TM710 and Dow's NF90 membrane, the attempt to increase the target feed water pH from 6.5 to 6.8 resulted in a rapid loss of MTC. However, the MTC was recovered with CIPs and the MTC was stable again once the target feed water pH was returned to 6.5. During the period where the target feed water pH was increased to 6.8, both iron and manganese fouled the RO membranes. The Dow NF90 membranes experienced a rapid decline in MTC that was never recovered. However, the MTC did stabilize at around 0.1 to 0.15 psi/gfd while the Toray membrane remained relatively unchanged at 0.1 gfd/psi for the duration of testing. The mineral water quality produced by both membranes was excellent with TDS concentrations less than 100 mg/L.

5.4.5 Summary of RO Optimization Findings

The complete mineral quality attained from the four desalination membranes that were evaluated is presented in Table 5.4-15. The data in this table shows that the Saehan membrane produced the effluent with the highest TDS at 95 mg/L, which was higher than the NF membrane tested by Dow. This higher TDS concentration means that the Saehan permeate had higher concentrations of sodium, calcium, magnesium, alkalinity, chloride, sulfate and silica than any of the four membrane manufacturers tested. Some of the loss in rejection is believed to be caused by damage to the RO elements that happened during a previous phase where the Saehan membranes were exposed to chlorine dioxide. However, based on permeate mineral water quality, the Saehan membrane performed the worst. This was not anticipated based on the membrane manufacturers' modeling software. According to the membrane manufacturers' software, the Dow NF90 membrane should have produced the highest permeate TDS followed by the Dow XLE 4040.

Table 5.4-15.
Phase VI - Summary of Mineral Water Quality Results for the Four Desalination Membranes

Parameter (See Note 1)	Units	Feed	RO Permeate			
		Well A Average	Membrane I (Dow Filmtec XLE 4040)	Membrane II (Saehan RE4040 BLR)	Membrane III (Toray TM710)	Membrane IV (Dow Filmtec NF90)
Total Barium	mg/L	0.05	ND (< 0.0020)	ND (< 0.0020)	ND (< 0.0020)	ND (< 0.0020)
Calcium	mg/L	245	0.45	3.5	0.15	0.31
Potassium	mg/L	5.7	0.96	1.1	0.13	0.44
Magnesium	mg/L	69	0.12	1.0	ND (< 0.10)	ND (< 0.10)
Sodium	mg/L	193	5.3	35	3.8	11
Strontium, Total	mg/L	1.9	ND (< 0.0050)	0.025	ND (< 0.0050)	0.0024
Total Fluoride	mg/L	0.24	ND (< 0.10)	ND (< 0.10)	ND (< 0.10)	ND (< 0.10)
Alkalinity as $CaCO_3$	mg/L	288	4.8	40	7.2	6.6
Carbonate Alkalinity as $CaCO_3$	mg/L	ND (< 2.0)	ND (< 2.0)	ND (< 2.0)	ND (< 2.0)	ND (< 2.0)
Bicarbonate Alkalinity as HCO_3	mg/L	353	5.9	56	8.8	8.0
Hydroxide Alkalinity as $CaCO_3$	mg/L	ND (< 2.0)	ND (< 2.0)	ND (< 2.0)	ND (< 2.0)	ND (< 2.0)
Ammonia as N	mg/L	0.25	ND (< 0.10)	ND (< 0.10)	ND (< 0.10)	ND (< 0.10)
Gross Alpha	pCi/L	9.4	0.96	1.6	0.0	0.0
Gross Alpha counting error (+/-)	pCi/L	1.1	0.23	0.35	0.86	0.92
Gross Alpha MDA95	pCi/L	0.35	0.038	0.06	1.35	1.55
Total Hardness as $CaCO_3$	mg/L	895	1.43	12.63	ND (< 0.66)	0.78
Nitrate as NO_3	mg/L	1.00	ND (< 0.50)	0.99	0.91	0.77
Total Dissolved Solids	mg/L	1725	11	94.67	26	56
Total Organic Carbon (TOC)	mg/L	1.5	ND (< 0.30)	ND (< 0.30)	ND (< 0.30)	ND (< 0.30)
Chloride	mg/L	170	3.6	26	1.8	12
Sulfate	mg/L	815	1.1	3.5	0.52	ND (< 0.5)
Silica as SiO_2, Total	mg/L	25	0.14	3.2	0.17	1.1

Note:
1) Average values used where multiple measurements were available

Table 5.4-16 presents a comparison of actual water quality obtained during pilot testing to the projected concentrations from the RO manufacturers' model. All model runs were performed at a flux of 15 gfd with a 75 percent feed water recovery and a feed water temperature of 22°C. This table shows that Dow's modeling software is the most conservative of the three membrane manufacturers that were evaluated. All of the projected permeate concentrations were greater than those observed during actual pilot testing. Only the potassium of the XLE 4040 was greater than what the model projected. The Toray modeling software was almost as conservative, but like the Dow XLE 4040 the potassium observed during pilot testing was greater than what their model projected. In addition to potassium, Toray's software under projected the sodium and the TDS concentrations. Saehan's software was quite different from those offered by the other two manufacturers and it projected permeate concentrations that were too low for almost every component identified in Table 5.4-16. The only ionic species that were found in the RO permeate to be lower than the concentration projected by Saehan was sulfate. However, it is extremely important to note that it is believed that the Saehan membrane was damaged in a previous phase of pilot testing. As a result, it is likely that the Saehan membrane could achieve the projected by the manufacturer's software. Another important general note is that none of the membrane manufacturers include a prediction for manganese in their software and only 2 provided predictions for permeate iron concentrations.

Table 5.4-17 presents the allowable bypass flows to the blended water quality objectives established in Section 3 for each of the desalination products tested. As demonstrated in this table, sulfate and manganese are the limiting constituents and approximately 5 to 7 percent of the total flow can be a bypass stream (i.e., not treated by desalination process).

Table 5.4-16.
Phase VI – Comparison of Manufacturer Model Projections to Actual Water Quality

Parameter (See Note 1)	Units	Feed Well A Average	Membrane I (Dow Filmtec XLE 4040)			Membrane II (Saehan RE4040 BLR)			Membrane III (Toray TM710)			Membrane IV (Dow Filmtec NF90)		
			Actual	Projected	Percent Difference	Actual	Projected	Percent Difference	Actual	Projected	Percent Difference	Actual	Projected	Percent Difference
Iron	mg/L	0.16					0.0			0.0006				
Manganese	mg/L	0.23												
Calcium	mg/L	245	0.45	4.6	-1,000%	3.5	1.1	33%	0.15	0.90	-600%	0.31	4.1	-1,300%
Potassium	mg/L	5.7	0.96	0.46	48%	1.1	0.1	6%	0.13	0.085	66%	0.44	0.95	-220%
Magnesium	mg/L	69	0.12	1.3	-1,100%	1.0	0.3	32%	ND (<0.10)	0.25	-250%	ND (<0.10)	1.2	-1,200%
Sodium	mg/L	193	5.3	11.4	-220%	35	1.8	5%	3.8	2.6	67%	10.8	23.4	-220%
Alkalinity as $CaCO_3$	mg/L	288	4.8	11.7	-240%	40		NA	7.2		NA	6.6	23.4	-350%
Total Hardness as $CaCO_3$	mg/L	895	1.4	16.7	-1,200%	12.6	4.2	33%	ND (<0.66)	3.3	-500%	0.78	15.1	-1,900%
Total Dissolved Solids	mg/L	1,725	11	59.1	-540%	95	13.0	14%	26	11.8	45%	56	95.1	-170%
Chloride	mg/L	170	3.6	9.0	-250%	26	1.6	6%	1.8	3.5	-190%	12	19.3	-160%
Sulfate	mg/L	815	1.1	17.1	-1,600%	3.5	4.2	-120%	0.52	1.3	-260%	ND (< 0.5)	15.4	-3,100%

NOTES:
1) Average values used where multiple measurements were available
2) The actual value is X% more (+ sign) than the model or X% less than the model (- sign)
3) Model is reference point for calculating percent difference

Table 5.4-17.
Phase VI - Allowable Bypass Flows to Meet Blended Water Quality Goals for Each Membrane Tested

Parameter (See Note 1)	Units	Goal	Feed	Actual RO Permeate and Percent Bypass							
				Membrane I (Dow Filmtec XLE 4040)		Membrane II (Saehan RE4040 BLR)		Membrane III (Toray TM710)		Membrane IV (Dow Filmtec NF90)	
		Product	Well A Average	Actual Permeate	Percent of Plant Feed Flow Bypassing the RO	Actual Permeate	Percent of Plant Feed Flow Bypassing the RO	Actual Permeate	Percent of Plant Feed Flow Bypassing the RO	Actual Permeate	Percent of Plant Feed Flow Bypassing the RO
Iron	mg/L	0.2	0.16	0.0083	140%	0.0095	139%	0.015	140%	0.014	140%
Manganese	mg/L	0.025	0.23	0.0015	7.9%	0.0045	7.0%	0.001	8.1%	0.0018	7.8%
Total Hardness as $CaCO_3$	mg/L	70 - 120	895	1.4	10%	12.6	9.4%	ND (< 0.66)	10%	0.78	10%
Total Dissolved Solids	mg/L	250	1,725	11	11%	95	7.3%	26	10.2%	56	9.0%
Sulfate	mg/L	70	815	1.1	6.5%	5.5	6.1%	0.52	6.5%	0.5	6.5%
Chloride	mg/L	65	170	3.6	31%	26	22%	1.8	31%	12	28%

Note:
1) Average values used where multiple measurements were available

Figures 5.4-22, 5.4-23, 5.4-24, and 5.4-25 provide visual comparisons of the product water TDS concentration, chloride concentration, sulfate concentration and iron concentration that were measured during this study compared to the manufacturers' software model predictions, respectively. It is clear from these figures that Saehan's software projected lower permeate concentrations than what was actually observed while the other three manufacturers provided more conservative projections with their software. It is important to note that none of the membrane manufacturers have software that is able to accurately predict permeate iron or manganese concentrations.

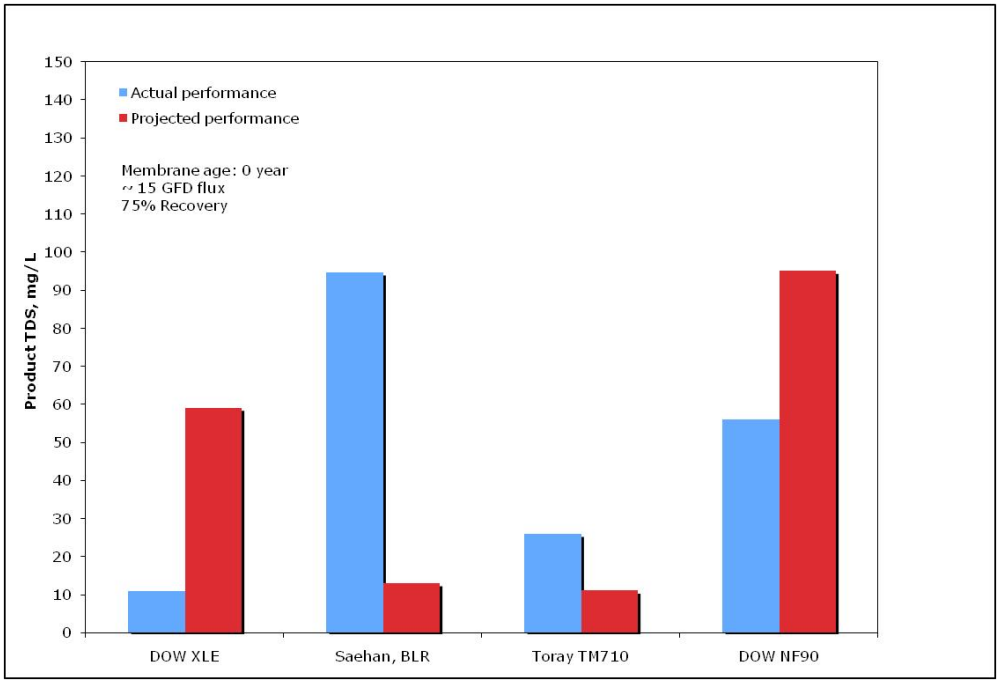

Figure 5.4-22.
Phase VI – Comparison of Observed and Projected Permeate TDS Concentrations

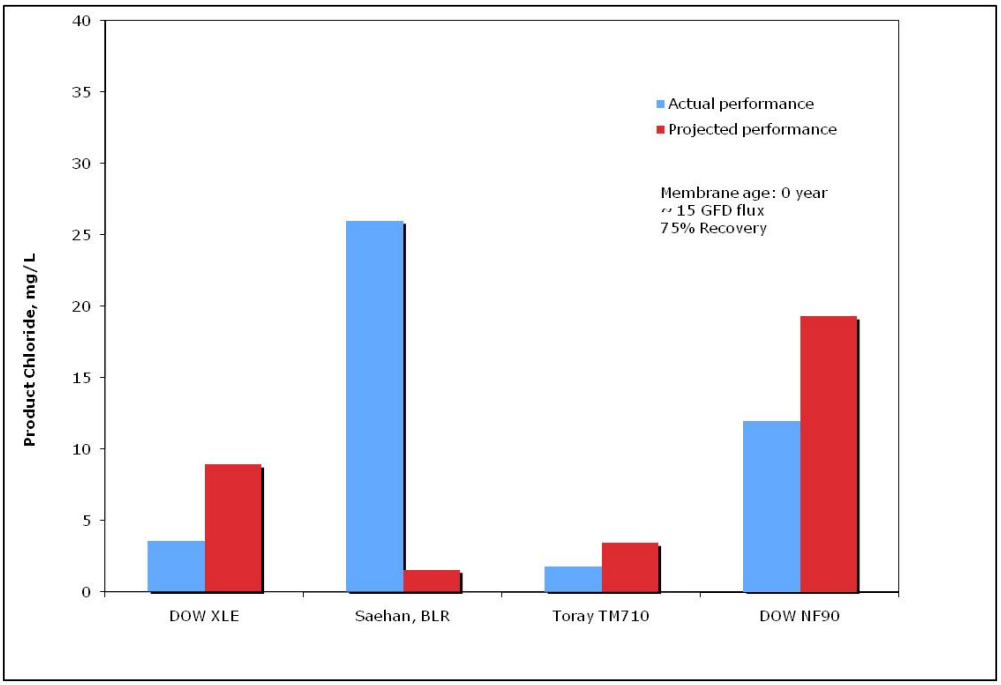

Figure 5.4-23.
Phase VI – Comparison of Observed and Projected Permeate Chloride Concentrations

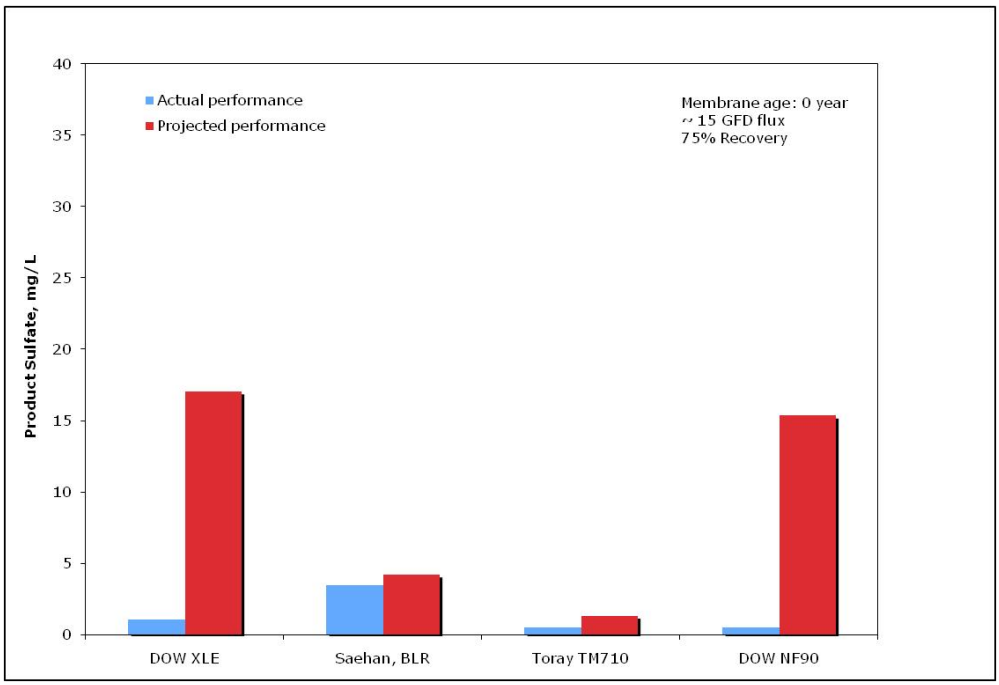

Figure 5.4-24.
Phase VI – Comparison of Observed and Projected Permeate Sulfate Concentrations

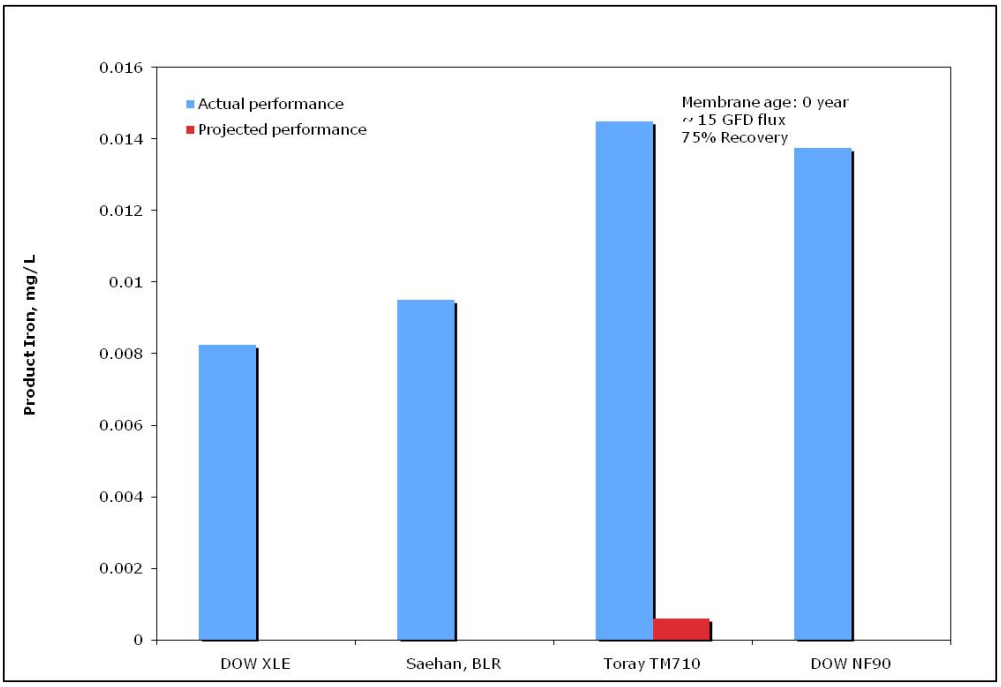

Figure 5.4-25.
Phase VI – Comparison of Observed and Projected Permeate Iron Concentrations

5.5 Emerging Contaminants Sampling Results

5.5.1 Overview

Technology advancements have made possible the detection of chemicals at increasingly lower concentrations, creating an awareness of drinking water contaminants that were previously unknown. In addition, current research suggests that some chemicals have human health effects, where previously no effects were known. These chemicals are referred to as emerging contaminants; they are chemicals not currently regulated for drinking water treatment, but that may someday have mandated removal. California is a leading state in identifying and dealing with these emerging contaminants. As part of the City of Camarillo Water Division's (CWD) pilot groundwater treatment study, Trussell Tech developed a list of emerging contaminants that were of particular interest and studied these contaminants as part of the pilot project.

Emerging contaminants identified by California Department of Public Health (CDPH) and the Environmental Protection Agency (EPA) contaminant lists were reviewed in the context of the CWD's groundwater wells. In addition, a vulnerability assessment for CWD source water was used to identify possible contaminating activities (PCAs) that may be releasing emerging contaminants that would be of interest. Seven contaminants were identified as being of particular interest to CWD and were monitored as part of this study.

5.5.2 Short List of Emerging Contaminants

Based on an analysis of existing monitoring data for emerging contaminants, with consideration of source water vulnerability to possible contaminating activities (PCAs) and new regulations recently enacted, seven emerging contaminants were selected for monitoring (Table 5.5-1).

Table 5.5.-1 **Short List of Emerging Contaminants Monitored**
Three of CDPH's 33 Unregulated Chemicals
Boron
Vanadium
Hexavalent Chromium
One of EPA's UCMR 2 Chemicals
N-nitroso-dimethylamine (NDMA)
Three Pesticides
Chloropicrin
Methyl Bromide (bromomethane)
1,3-Dichloropropene (cis and trans)

5.5.2.1 Pre-Screening Criteria

Potential contaminants of interest were chosen from the following categories: (1) unregulated chemicals for which CDPH has a monitoring requirement and/or a notification level, (2) chemicals that are listed as part of the EPA's Unregulated Contaminant Monitoring Rule 2 (UCMR 2) List 1 and List 2, as well as the Contaminant Candidate List (CCL) and (3) pesticides with significant usage in Ventura County (CWD source water area). Chemicals that CDPH and/or EPA already regulate were not considered emerging contaminants in the context of this part of the study.

The emerging contaminants monitored in this study were selected using following criteria: (1) occurrence in past monitoring efforts, (2) identification through the vulnerability assessment, and (3) likelihood of being regulated in the near future.

5.5.2.2 Pre-Screening Discussion

The following describes how the seven emerging contaminants of interest were identified.

Evaluation of CDPH's 33 Unregulated Chemicals:
Boron, Vanadium, and Hexavalent Chromium monitoring selections

There are 30 unregulated chemicals that lack Maximum Contaminant Levels (MCLs) for which CDPH has established health-based advisory levels in drinking water called *Notification Levels* (NLs). California's Title 22 regulations require monitoring of six of the unregulated chemicals with NLs, plus an additional three unregulated chemicals under certain conditions[1]. These 33 unregulated chemicals identified by CDPH were of particular interest for this project as emerging contaminants.

Based on previous chemicals detected through past monitoring efforts of Well A and Well B, boron and vanadium were chosen from the CDPH list unregulated chemicals[2] to be monitored regularly throughout the project. Both chemicals have been previously detected at concentrations less than the NL, but at concentrations exceeding the detection limit for the purpose of reporting (DLR). The complete pre-existing data set on unregulated contaminants from the CDPH database for CWD wells A and B (Smith, 2007b) is provided in Appendix C (Section C.1; Summary Tables C.25 and C.26).

In addition, monitoring of any of these 33 emerging contaminants that may be released by possible contaminating activities was also considered. Based on

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[1] The 9 unregulated chemicals requiring monitoring are listed in Title 22 California Code of Regulations (CCR) § 64450. Note that 6 of the 9 contaminants requiring monitoring have NLs.

[2] While manganese has a CDPH NL and has been detected in past monitoring at levels that exceed the DLR (but < NL), it is not classified as an *emerging* contaminant because it is regulated (secondary MCL in 22 CCR § 64449) and will be considered elsewhere in the project.

information from the CWD (Smith, 2007a; Appendix C, Section C.3) and CDPH (CDHS, 2005; Ali, 2007; Appendix C, Section C.2) regarding a vulnerability assessment identifying possible contaminating activities to which the source water (Wells A and B) was vulnerable, there were no additional unregulated chemicals subject to monitoring. Therefore, with the exception of hexavalent chromium discussed below, no additional monitoring of the 33 emerging contaminants was recommended.

There is an ongoing evaluation in California of hexavalent chromium, which is one of the three unregulated chemicals that do not have NLs, but require monitoring under certain conditions. CDPH guidance on unregulated chemical monitoring states that, "generally, all sources are considered vulnerable to hexavalent chromium unless a screening using total chromium analysis indicates by a non-detect that a source is not vulnerable" (CDHS, 2001). CWD had previously measured total chromium in Wells A and B and all results were below the detection limit for the purpose of reporting (DLR), which is 0.01 mg/L (Appendix C, Table C.33). The DLR for hexavalent chromium is 0.001 mg/L, 10 times lower than the total chromium DLR. CWD also measured hexavalent chromium in Well B in two measurements at non-detect levels in 2002, but the detection limit for hexavalent chromium was not clear from these data. CDPH states that if total chromium is used in screening for hexavalent chromium, then the analytical technique must be able to achieve a reporting limit of 0.001 mg/L (CDHS, 2001).

California's Safe Drinking Water Act of 1996 requires the Office of Environmental Health Hazard Assessment (OEHHA) to perform risk assessments and adopt public health goals (PHGs) for contaminants in drinking water based exclusively on public health considerations (CA Health and Safety Code § 116365). OEHHA is in the process of setting a PHG for hexavalent chromium. Once the PHG is specified, CDPH is mandated to set a MCL for hexavalent chromium as close as "technically and economically feasible" to the PHG by January 1, 2004 (CA Health and Safety Code, § 116365.5 and § 116365). The establishment of the MCL has been delayed because OEHHA has not set the PHG yet. A pre-release draft of the PHG from OEHHA recommended a PHG of 0.002 mg/L for hexavalent chromium, but peer review of the draft PHG by an expert panel raised questions about the draft PHG and the evaluation process is ongoing (OEHHA, 2005). The National Toxicology Program (NTP) is currently carrying out a toxicological study to ascertain if ingestion of hexavalent chromium causes cancer (OEHHA, 2005).

Because the process of establishing a PHG and a MCL for hexavalent chromium is ongoing and there is uncertainty at what levels the PHG, MCL and possibly a revised DLR might be established, monitoring of emerging contaminant hexavalent chromium once in each well (A and B) was recommended for this study.

Evaluation of EPA's Unregulated Contaminant Monitoring Rule 2 (UCMR 2) Chemicals: NDMA monitoring selection

The federal Safe Drinking Water Act (SDWA) requires monitoring of certain unregulated contaminants under the Unregulated Contaminants Monitoring Rule (UCMR), which includes three lists of contaminants (more background provided in Appendix C, Section C.4). List 1, termed Assessment Monitoring, includes chemicals for which analytical methods are available. The first round of UCMR monitoring (UCMR 1) was conducted from 2001 – 2006 and is complete. The second round of UCMR sampling (UCMR 2) was on the horizon at the outset of this project in 2007 (scheduled for Jan. 2008 – Dec. 2010). Public water systems (PWSs) that serve greater than 10,000 people (including CWD) are required to monitor for all List 1 chemicals. There are ten chemicals, including five flame retardants and three explosives on EPA's UCMR 2 List 1 (Assessment Monitoring), as shown in Appendix C, Section C.4 and Table C.32.

The vulnerability assessment showed that source water Well B is vulnerable to PCAs encompassing but not limited to irrigated crops (including orchards) and fertilizer (pesticide/herbicide application). The UCMR 2 List 1 chemical dimethoate is an insecticide used on orchard crops (EPA, 2006), but there is no reason to believe that source water Wells A or B are vulnerable to PCAs that may release dimethoate for the following reasons: (1) it is not on the list of the most widely used pesticides in Ventura County, and (2) dimethoate was also measured by CWD in Wells A and B at levels less than the reporting limit. Further, there is no reason to believe that source water Wells A and B are vulnerable to PCAs that may release any of the other contaminants on UCMR 2 List 1. Because it is believed that source water Wells A and B are not vulnerable to PCAs that may release any of the contaminants on UCMR 2 List 1 and because sampling for UCMR 2 List 1 chemicals in summer 2007 could not be applied to meet the requirements of EPA's UCMR 2 program (according to EPA Region 9's UCMR 2 coordinator; Ryan, 2007), no sampling of UCMR 2 List 1 chemicals was recommended for this project.

The second list of contaminants under UCMR includes chemicals for which analytical methods have recently been developed. Monitoring of UCMR 2 List 2 (Screening Survey) chemicals is required by 320 representative PWSs serving 10,001-100,000 people (CWD falls into this category). CWD is not among the PWSs being required by EPA to monitor for UCMR 2 List 2 chemicals.

There are fifteen chemicals including three parent acetanilides, six acetanilide degradates, and six nitrosamines on EPA's UCMR 2 List 2 (Screening Survey), as shown in Appendix C, Section C.4 and Table C.32. Based on the vulnerability assessment, it is not believed that source water wells A or B are vulnerable to PCAs that may release contaminants on EPA's UCMR 2 List 2. However, one contaminant on the list, NDMA, is a disinfection byproduct of particular interest in California (Najm and Trussell, 2001). Trussell Tech recommended monitoring NDMA, downstream of where Well B water is blended with imported water, in a simulated distribution system (SDS) test to mimic conditions in the distribution system. If

NDMA was detected in the SDS test at levels above the DLR, other sampling locations would have been recommended, but this was not the case. No other emerging contaminants on UCMR 2 List 2 (Screening Survey) were recommended for monitoring.

Pesticides with Relatively High Use in Ventura County: Chloropicrin, Methyl Bromide, and 1,3-Dichloropropene monitoring selection

As previously mentioned, well B in particular is vulnerable to PCAs encompassing but not limited to irrigated crops (including orchards) and fertilizer (pesticide/herbicide application). Three pesticides with relatively high use in Ventura County (PANNA, 2007) are chloropicrin, methyl bromide (bromomethane), and 1,3-dichloropropene (cis-1,3-dichloropropene and trans-1,3-dichloropropene). Therefore, it was recommended that these three pesticides be monitored once at each well A and B during the project, and that additional sampling be conducted for any of these chemicals measured at levels that exceed their detection limit.

Additional Chemicals Monitored

Several of the analytical methods used (EPA methods 521, 524.2, and 551.1) to measure the selected emerging contaminants are designed to quantify several chemicals at once. All additional chemicals (a total of 80) that could be measured using these methods were included at no additional cost (full list of chemicals provided in Appendix C, Table C.34). Many of these chemicals are not considered emerging contaminants, as they are currently regulated.

5.5.3 Emerging Contaminants Sampling Results

The initial monitoring effort was conducted on October 11, 2007; samples were collected from both wells (A and B) and analyzed for the selected emerging contaminants. Weck Laboratories (Industry, CA) performed the analysis using the EPA methods listed in Table 5.5-2 and following standard quality control and assurance procedures.

Table 5.5-2.
List of Analytical Methods used for Emerging Contaminant Detection

Emerging Contaminant	EPA Method
Boron	200.8
Vanadium	200.8
Hexavalent Chromium	218.6
N-nitroso-dimethylamine (NDMA)	521
Chloropicrin	551.1
Methyl Bromide (bromomethane)	524.2
1,3-Dichloropropene (cis and trans)	524.2

Of the seven emerging contaminants monitored during this initial test, only boron (both wells) and vanadium (well B only) were detected at concentrations above the

reporting limit (Table 5.5-3). Hexavalent chromium and the three pesticides (chloropicrin, methyl bromide, and1,3-dischloropropene) were not detected in samples from either well. In addition, NDMA was not present in the SDS test at detectable levels. However, of the 80 additional chemicals measured incidentally by the EPA methods, one chemical, 2-butanone (a.k.a. methyl ethyl ketone), was detected in the well water (Well B only) using EPA method 524.2.

Table 5.5-3.
Results from Initial Emerging Contaminant Monitoring of Wells A and B on October 11, 2007

Chemical	Well A	Well B	Blend of Well B and imported water [a]	Laboratory Reporting Limit
Unregulated Chemicals				
Boron	0.78 mg/L	0.66 mg/L	--	0.003 mg/L
Vanadium	0.0012 mg/L	ND	--	0.0005 mg/L
Chromium VI	ND	ND	--	0.0003 mg/L
UCMR 2 Chemical (DBP of particular interest in California)				
NDMA	--	--	ND	0.002 mg/L
Pesticides				
Chloropicrin	ND	ND	--	0.0005 mg/L
Methyl bromide	ND	ND	--	0.0005 mg/L
1,3-dichloropropene	ND	ND	--	0.0005 mg/L
Other chemicals incidentally detected using EPA methods				
Methyl ethyl ketone (MEK)	ND	0.029 mg/L	--	0.005 mg/L

[a] Simulated Distribution System (SDS) test
-- indicates sample location is not applicable for contaminate monitoring
"ND" indicates chemical not detected or concentration below reporting level

Methyl ethyl ketone (MEK) is *not* among CDPH's list of 33 unregulated chemicals with NLs or monitoring requirements. MEK is a solvent used in production of resins and vinyl surface coatings (EPA 2000). One possible source of the MEK detected was identified as possible leaching off of PVC piping used in the pilot plant. On December 18, 2007, both wells were retested for MEK (again using EPA 524.2), but this time the sampling location was at the wellhead, upstream of any PVC pipe. The repeated samples showed no detectable levels of MEK in either well.

The laboratory analysis of the December 2007 MEK sampling also measured all constituents that are detected through EPA method 524.2. All constituents were non-detect (ND) in Well A. However, the following regulated contaminants were detected in well B: THMs bromodichloromethane at 3.4 µg/L, bromoform at 6.4 µg/L, chloroform at 1.9 µg/L, dibromochloromethane at 6.8 µg/L for a TTHM concentration of 18.5 µg/L. These disinfection byproducts (DBPs) are regulated under the EPA's Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR), measured regularly in accordance with regulatory requirements, and are not considered

emerging contaminants. Two possible reasons for the detection of THMs at the levels measured include (1) sampling at a location downstream of chlorination of the water supply or (2) the influence of wastewater on the groundwater supply. It should be noted that in the initial emerging contaminant sampling in October 2007, no DBPs were detected in either Well A or in Well B.

As recommended, boron and vanadium were monitored in both the raw well water and RO membrane permeates at regular intervals throughout the pilot testing (Table 5.5-4). In addition, both chemicals were measured in the RO membrane concentrate as part of the July 11, 2008 sampling. Weck Labs performed the analysis and percent removals were calculated for each membrane (Table 5.5-4).

Boron was consistently detected in both the raw well water and the membrane permeates for all four membranes tested. The percent of boron removed varied between the membranes; RO membranes I (Dow Filmtec XLE 4040) and III (Toray TM710) had the greatest rejection (approximately 50 percent), while membrane IV (Dow Filmtec NF90) was less effective (approximately 34 percent) and membrane II (Saehan RE 4040 BLR) was ineffective. As discussed else where, it is believed that membrane II (Saehan RE 4040 BLR) was compromised due to exposure to chlorine dioxide in earlier phases of testing, before the Phase VI pilot testing. Regardless, boron concentrations in the raw water and permeate samples were all lower than the CDPH notification level (1 mg/L for boron).

Vanadium, on the other hand, was detected in all raw water samples, but was reduced to a concentration below the reporting limit by all membranes. Thus a performance comparison between membranes was not possible for vanadium. All vanadium concentrations were also less than the CDPH notification level (0.05 mg/L for vanadium).

Table 5.5-4.
Results of Boron and Vanadium Monitoring during Phase VI Testing

Sampling Date	Location	Boron Concentration (mg/L)	Boron Percent Removal	Vanadium Concentration (mg/L)*	Vanadium Percent Removal
6/27/08	Raw Water (Well A)	0.56	--	0.0012	--
	RO Membrane I Permeate (Dow Filmtec XLE 4040)	0.27	52%	ND (<0.0005)	> 58%
	RO Membrane II Permeate (Saehan RE 4040 BLR)	0.48	14%	ND (<0.0005)	> 58%
7/11/08	Raw Water (Well A)	0.56	--	0.0013	--
	RO Membrane I Permeate (Dow Filmtec XLE 4040)	0.28	50%	ND (<0.0005)	> 62%
	RO Membrane I Concentrate	1.70	--	ND (<0.01)	--
	RO Membrane II Permeate (Saehan RE 4040 BLR)	0.57	0%	ND (<0.0010)	> 23%
	RO Membrane II Concentrate	0.90	--	ND (<0.01)	--
10/6/08	Raw Water (Well B)	0.57	--	0.00052	--
	RO Membrane III Permeate (Toray TM710)	0.26	54%	ND (<0.0005)	> 4%
	RO Membrane IV Permeate (Dow Filmtec NF90)	0.37	34%	ND (<0.0005)	> 4%

*Variation in reporting limit result of different sample dilution

5.5.4 Emerging Contaminants Conclusions

Potential emerging contaminants of specific interest to CWD were identified from state and federal emerging contaminant lists, as well as from a vulnerability assessment of the City of Camarillo's source water area. Seven emerging contaminants were chosen for monitoring as part of the CWD ground water treatment pilot project. Of these chemicals, only boron and vanadium were detected in the raw well water. Boron and vanadium were monitored at regular intervals during the pilot study. Membranes I (Dow Filmtec XLE 4040) and III (Toray TM710) showed the greatest rejection of boron (approximately 50 percent), and because no vanadium was detected in any of the membrane permeates, vanadium performance could not be compared. Regardless, all raw water and membrane permeate samples had boron and vanadium concentrations less than the CDPH notification levels. No additional treatment considerations are recommended based on this emerging contaminant analysis.

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Section 6
Dissemination/Outreach Activities

6.1 Overview

This section describes the types of outreach performed, including presentations of the project to the public, conferences, workshops, coordination with various stakeholders, tours, and ways used to disseminate project results and information.

6.2 Tours

6.2.1 City Council Tours

The City and CDM provided a tour of the pilot plant site for the City of Camarillo Council on May 28, 2008 from 6 pm to 8 pm. Approximately 20 City Council members and city residents attended the tour. The City and CDM gave a brief presentation of the project, followed by a question and answer session. The following topics were covered during the pilot plant tour:

- Current drinking water sources and water quality;
- Drinking water quality regulations and goals;
- Pilot study objectives; and
- Technology overview of Reverse Osmosis technology, oxidation, and filtration.

The posters used during the tour are included in Appendix B.

6.2.2 Proposition 50 Tours

The State Water Resources Control Board (SWRCB) Proposition 50 staff also visited the pilot plant site on two separate visits. The first visit was on February 13, 2008 and the second visit was on March 20, 2008.

6.3 Training/Workshops

The City and CDM held a three-hour, Operator Training Workshop on October 9, 2007. The following topics were covered during the PowerPoint presentation:

- Project background;
- Pilot study objectives;
- Technology overview of Reverse Osmosis technology, oxidation, and filtration; and
- Testing protocol.

The training also included a pilot plant site visit, and on-site discussions of the pilot plant equipment and sampling protocol.

6.4 Website

The City constructed a webpage on the City's website <http://www.ci.camarillo.ca.us/main.aspx?q=6087&p=9201> so that the project information is available to the public. The webpage summarizes the objectives of the pilot study and the City's goals for the drinking water system. The webpage also presents a poster containing the schematic of the recommended pretreatment alternative and descriptions of each treatment process.

Section 7
Project Deliverables

7.1 Overview

This section lists deliverables and materials produced during the project.

7.2 Project Deliverables

The project deliverables included monthly progress reports, quarterly progress reports, draft and final Pilot Test Protocol, draft and final Emerging Contaminants Evaluation Summary, and draft and final Summary Report. The submittal dates of each deliverable are summarized in Table 7-1.

Table 7-1
Project Deliverables

Deliverable	Complete	Submittal Date to City	Submittal Date to DWR
Task 1.1 Quarterly Progress Reports			
Quarterly Progress Report #1	Complete	July 16, 2007	July 30, 2007
Quarterly Progress Report #2	Complete	October 26, 2007	October 30, 2007
Quarterly Progress Report #3	Complete	January 21, 2008	January 30, 2008
Quarterly Progress Report #4	Complete	April 25, 2008	April 29, 2008
Quarterly Progress Report #5	Complete	July 31, 2008	July 31, 2008
Quarterly Progress Report #6	Complete	October 21, 2008	October 30, 2008
Task 2.1			
Draft Pilot Test Protocol	Complete	June 20, 2007	June 29, 2007
Final Pilot Test Protocol	Complete	October 26, 2007	October 30, 2007
Task 2.2			
Draft Emerging Contaminants Evaluation Summary	Complete	June 22, 2007	June 29, 2007
Final Emerging Contaminants Evaluation Summary	Complete	October 26, 2007	October 30, 2007
Task 5.1 Draft Summary Report	Complete	December 4, 2008	December 12, 2008
Task 5.2 Final Summary Report		January 30, 2009	January 30, 2009

7.3 Publications

The publications on the findings from this project are listed below:

- You, E.; Wetterau, G.; Burbano, M.; and McGovern, L. 2008. "Control of Metal Oxide Fouling in Reverse Osmosis." *2008 IWA North American Membrane Research Conference*. Amherst, Massachusetts.

- Hokanson, D.; Trussell, S.; Trussell, R.; Wetterau, G.; and McGovern, L. 2009. "A Groundwater Pilot Study in Camarillo: Occurrence and Removal of PhPCPs." *Annual Conference & Exposition 2009*. San Diego, CA

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Section 8
Conclusions/Lessons Learned

8.1 Overview

This section summarizes the results of the project and recommendations for the full-scale brackish water desalination facility design. This section also describes problems encountered, lessons learned, and recommendations for future studies.

8.2 Findings

8.2.1 Pretreatment Evaluation Findings

Key findings from the pretreatment evaluation testing include the following:

8.2.1.1 Phase I Summary (Alternative 1)

- Oxygen quenching successfully prevented iron oxidation and thereby prevented metal oxide fouling of the reverse osmosis (RO) membranes.

- Periodic starting and stopping of Wells A and B, intended to simulate normal operation of a full-scale facility, may have contributed to the entrainment of air into the feed water that was not seen later during Phase VI testing where only one well at a time was utilized.

- Oxygen quenching pretreatment process must be carefully designed to safeguard against failure of the oxygen quenching agent. When oxygen quenching was stopped, iron oxidation occurred immediately and particulate fouling of the RO membranes started immediately. Particulate fouling of the membranes continued even when oxygen quenching was resumed, and was stopped only when the membranes were cleaned with high concentrations of acid and caustic soda.

8.2.1.2 Phase II Summary (Alternative 2)

- Aeration plus media filtration effectively oxidized and removed iron when a minimum of six minutes of contact time was provided. Providing additional contact time, beyond six minutes, did not have significant impact on iron oxidation.

- Complete oxidation of iron was accomplished with nearly zero minutes of contact time, when the pH was adjusted to 8.0 through the addition of caustic soda. However, raising the pH of the Well A raw water was problematic, as it caused severe scaling in the piping, valves, the granular media filters, and the cartridge filters. This scaling could not be controlled with the addition of antiscalant upstream of the caustic soda injection point.

- Although the particulate iron levels did not indicate iron breakthrough at any point in the testing, an observed decrease in first stage mass transfer coefficient (MTC), or membrane permeability, suggests that the media filters were more prone to solids breakthrough when the filter loading rates were higher than 3.5 gpm/sf. Higher

loading rates may be sustainable, however, if utilizing media with greater depth, smaller effective size, or a more aggressive backwashing approach than utilized in the pilot. Backwashing rates were limited to 15 gpm/sf in the pilot study due to the media carry-over seen with higher rates, however, more aggressive backwashing could be achieved with the use of an air scour system or with higher sidewall depths.

8.2.1.3 Phase III Summary (Alternative 3)

- The estimated chlorine dioxide demand in Well A raw water ranged from 0.8 to 2.1 mg/L, with an average of 1.5 mg/L.

- Chlorine dioxide feed and media filtration effectively oxidized and removed 100 percent of iron and 70 percent of manganese and appears to have prevented metal oxide fouling of the RO membranes.

- The ability of chlorine dioxide to oxidize iron and manganese was not affected by contact time or raw water pH. The same quantities of iron and manganese were oxidized when the contact tank was bypassed as when 37 minutes of contact time was provided. Also, the same quantities of iron and manganese were oxidized at pH of 7.3 as at pH of 8.1.

- Chlorine dioxide plus media filtration pretreatment was problematic due primarily to RO membrane damage. Chlorine dioxide appears to have damaged the RO membranes, as was evident in the steadily increasing permeate conductivities and the gradually increasing MTC during the first three weeks of the Phase III testing.

- Particulate iron and manganese appeared to be passing through the media filtration process and fouling the cartridge filters. The cartridge filters should not be relied on for filtration, but were heavily loaded with particulate iron and manganese during this phase. Further, the fouling rate on the media filters was high, averaging 3 to 6 psi/day at a filtration rate less than 5 gpm/sf.

8.2.1.4 Phase IV Summary (Alternative 4)

- The estimated chlorine demand in Well A raw water was approximately 0.8 mg/L. A chlorine dose of 1.0 mg/L was sufficient to oxidize 100 percent of iron and approximately 70 percent of manganese with the aid of the Pyrolox (greensand) media filters. Although higher doses of chlorine may be capable of enhancing manganese oxidation, the impact of higher doses seen in the piloting was minimal.

- Chlorine feed with Pyrolox media filtration pretreatment was similar in performance to the chlorine dioxide feed plus media filtration pretreatment (Phase III). Both pretreatment processes oxidized and removed 100 percent of total iron and approximately 70 percent of total manganese. The difference was that manganese oxidation occurred in the filtration stage during Phase IV, whereas manganese oxidation occurred prior to the filtration stage during Phase III.

- Although only 70 percent of manganese was oxidized during the pretreatment stages, the remaining 30 percent non-oxidized manganese did not appear to impact RO performance, as it remained dissolved throughout the RO process and into the RO waste stream.

- Chlorine feed plus Pyrolox media filtration pretreatment was partially effective, particularly during the early portion of the testing. However, the two issues of concern for this process are the risk of damaging the RO membranes with chlorine, and the difficulty in maintaining properly functioning media filters. Although the dechlorination process was successful during the pilot study and, therefore, did not cause damage to the RO membranes, the possible failure of a dechlorination process is risky for a full-scale plant, given the capital investment required to replace damaged RO membranes.

- The operation of the Pyrolox media filters causes some concern, due to the high backwashing rates and possible air scour systems required to remove iron oxides from the dense media. Pyrolox systems tend to work best in systems with high manganese levels, but low iron, and are commonly used at smaller facilities where waste washwater volumes from the high backwashing rates do not create site constraints.

8.2.1.5 Phase V Summary (Alternative 5)

- The average dissolved oxygen (DO) level in the pretreatment feed water was 5.6 mg/L of when the eductor was used for aeration, and 8.5 mg/L of DO when an air compressor was used.

- With the aeration and microfiltration (MF) pretreatment process, the iron was only partially oxidized by the DO in the contact tank within the 3 to 36 minutes of contact time tested, and additional oxidation of iron was observed within the MF, the break tank after the MF, and within the cartridge filters.

- The rate of oxidation was sensitive to the contact time and the concentration of DO in the water. For the aeration followed by MF pretreatment process to completely oxidize and remove the iron, it was determined that the pretreatment feed water must be saturated at approximately 8.7 mg/L of DO, and approximately 35 minutes of contact time must be provided. To provide 35 minutes of contact time in a full-scale plant, a 210,000 gallon capacity tank must be provided.

- Aeration followed by MF was found to be less effective than the aeration followed by media filtration pretreatment process, evaluated in Phase II. Although the MF could be considered a better filtration process than the media filtration, the media filters provide improved oxidation of iron, resulting in greater removal.

8.2.1.6 Pretreatment Process Selection

- The five pretreatment process alternatives were evaluated based on the ability to meet water quality goals, reliability, simplicity, safety, and cost. Based on this

evaluation, Alternative 1 Oxygen Quenching and Alternative 2 Aeration plus Media Filtration were identified as the most appropriate for RO pretreatment in the Phase VI pilot testing.

8.2.2 RO Optimization Findings

Key findings from the RO optimization testing include the following:

- The aeration plus media filtration pretreatment resulted in partial oxidation and removal of manganese and significant RO fouling. While this did not occur during two months of Phase II testing, using the same pretreatment approach, it is believed that the presence of previously oxidized manganese dioxide, possibly from the Pyrolox media used during Phase IV, may have catalyzed the manganese oxidation. While manganese oxidation with air normally takes several hours to occur, the presence of previously oxidized manganese dioxide may have accelerated the oxidation of a small portion of manganese, which subsequently caused operational complications with the downstream processes.

- When the pretreatment process was changed to oxygen quenching (Alternative 1), further complications were seen, first with the build-up of biological growth and iron on the cartridge filters, and second with the fouling of second stage membranes. The addition of muriatic acid (HCl) ahead of the cartridge filters, and the reduction of thiosulfate dose to less than 2 mg/L appeared to control the fouling both of the cartridge filters and the RO.

- The oxygen quenching with acid addition pretreatment maintained manganese and iron in the dissolved form and produced stable MTC data for all membrane systems tested, when the feedwater pH was adjusted to 6.5 by acid addition.

- When the target feedwater pH was adjusted to 6.8, the RO membranes began to foul and the MTC decreased rapidly.

- The Dow RO membrane (model XLE 4040) stabilized at a membrane permeability of 0.15 gfd/psi, while the Saehan RO membrane (model RE 4040 BLR) stabilized around 0.25 gfd/psi. The mineral water quality of the Dow RO membrane permeate was superior to the Saehan RO membrane permeate.

- The permeate of the Saehan RO membranes had the highest TDS at 95 mg/L, possibly caused by damage to the RO elements during Phase III testing, when the membranes were exposed to chlorine dioxide. Nonetheless, based on the permeate mineral water quality alone, the Saehan RO membranes performed the worst of the four membranes tested, which is contrary to results of the membrane manufacturers' modeling software. According to the membrane manufacturers' model projections, the Dow NF90 membrane should have produced the highest permeate TDS followed by the Dow XLE 4040.

- Dow's modeling software is the most conservative of the three membrane manufacturers' softwares that were evaluated. All of the projected permeate concentrations were greater than those observed during actual pilot testing. Only potassium was measured greater than what the model projected.

- Toray's modeling software was almost as conservative, but it underestimated the potassium, sodium and the TDS concentrations.

- Saehan's software was quite different from those offered by the other two manufacturers and it projected permeate concentrations that were too low for almost every parameter. The only ionic species that were found in the RO permeate to be lower than the projected concentration was sulfate. However, it is extremely important to note that the Saehan membrane was exposed to chlorine dioxide during Phase III testing. Therefore, it is likely that the Saehan membrane could perform as projected by the manufacturer's software.

- Manganese and sulfate are the limiting constituent for blending, and only 5 to 7 percent of the total flow can be allowed to bypass the RO. Such a bypass flow will result in a blended water TDS between 150 and 200 mg/L, and a blended water hardness between 70 and 80 mg/L, without exceeding any of the finished water quality goals.

8.2.3 Emerging Contaminants Findings

Key findings from the emerging contaminants evaluation include the following:

- Potential emerging contaminants of specific interest to CWD were identified from state and federal emerging contaminant lists, as well as from a vulnerability assessment of the City of Camarillo's source water area.

- Seven emerging contaminants were chosen for monitoring as part of the CWD ground water treatment pilot project. Of these chemicals, only boron and vanadium were detected in the raw well water. Boron and vanadium were monitored at regular intervals during the pilot study.

- Membranes I (Dow Filmtec XLE 4040) and III (Toray TM710) showed the greatest rejection of boron (50 percent), and because no vanadium was detected in any of the membrane permeates, vanadium performance could not be compared. Regardless, all raw water and membrane permeate samples had boron and vanadium concentrations less than the CDPH notification levels. No additional treatment considerations are recommended based on this emerging contaminant analysis.

8.3 Recommendations

Based on the findings from the pilot study, presented in Section 5 and summarized in Section 8.2, oxygen quenching with acid feed was selected as the optimum pretreatment process. The recommendations for pretreatment are summarized below:

- Dosing oxygen quenching chemical (sodium thiosulfate, sodium bisulfite or sodium metabisulfite) at the wellhead facilities to quench oxygen;
- Decreasing the pH to 6.5 with acid for stable RO performance;
- UV to prevent biofouling; and
- Antiscalant dose of 1.5 mg/L to prevent scaling.

Also, the following design parameters for the RO were established:

- Stable RO membrane performance can be sustained at 75 percent recovery;
- Blending is limited by manganese and sulfate goals; and
- The four membranes tested allow 5 to 7 percent blending to meet final water quality goals.

The following subsections describe the basic design parameters for the pretreatment processes, RO, and post-treatment. This section also presents projection of probably cost information, and preliminary schedule for the design and construction of the full-scale treatment plant.

8.3.1 Preliminary Design Criteria

8.3.1.1 Design Flows

Two existing wells (Well A and Well B) and one future well will be used to pump groundwater to the new brackish water desalination facility. Table 8-1 summarizes the pumping capacities of the three groundwater wells.

Table 8-1.
Total Groundwater Pumping Capacity

Well	Pumping Capacity
Well A	1,500 gpm = 2.16 mgd
Well B	1,500 gpm = 2.16 mgd
Future Well	3,000 gpm = 4.32 mgd
Total Groundwater Pumping Capacity	**6,000 gpm = 8.64 mgd**

The City's water system demand is 8.9 mgd or 10,000 ac-ft/yr. This demand will be met by treating pumped groundwater and then blending the treated water in the

distribution system with imported water. A small fraction of untreated groundwater will also be bypassed around the treatment process and blended to produce a product water that is stable, non-corrosive, and similar to the quality of imported water in the distribution system. Table 8-2 summarizes the expected design flows of the treated water and blend water.

Table 8-2.
Design Flows

Stream	Flow Rate
Water System Demand	**8.9 mgd = 10,000 ac-ft/yr**
Well Production	8.6 mgd
RO Influent (i.e., pre-treated groundwater)	8.3 mgd
RO Permeate (i.e., desalinated groundwater)	6.2 mgd (See Note 1)
Groundwater Blending (i.e., RO bypass, blending at the facility)	0.3 mgd (See Note 2)
Total Plant Product (i.e., RO permeate + groundwater blending)	**6.5 mgd**
Imported Water Required	2.4 mgd

Note:
1) Assuming 75% RO permeate water recovery rate.
2) Assuming 5% bypass and blend.

8.3.1.2 Wellhead Facilities

The recommended pretreatment process consists of oxygen quenching, which is accomplished by feeding sodium thiosulfate or sodium bisulfite to the well water. Since this pretreatment process is most effective when the chemicals are fed close to the wellheads to prevent iron oxidation as early as possible, the chemical storage and feed facilities will be located at each of the three wells. Preliminary design criteria for the wellhead facilities are summarized in Table 8-3.

Table 8-3.
Wellhead Facilities Design Criteria

	Units	Well A	Well B	Future Well
Main Process Stream		Well A Raw Water (1,500 gpm)	Well B Raw Water (1,500 gpm)	Future Well Raw Water (3,000 gpm)
Chemical		Sodium Bisulfite	Sodium Bisulfite	Sodium Bisulfite
Concentration	%	36	36	36
Dose	mg/L	2	2	2
Feed Equipment				
Pump Type		Peristaltic	Peristaltic	Peristaltic
Pump Capacity, each	gph	0.4	0.4	0.8
Number of Pumps	each	2	2	2
Wetted Materials				

Table 8-3.
Wellhead Facilities Design Criteria

	Units	Well A	Well B	Future Well
Storage System				
Tank Type		XLPE	XLPE	XLPE
Tank Capacity, each	gal	300	300	800
Storage Time, each	days	34	34	45
Number of Tanks		1	1	1
Piping Material		PVC	PVC	PVC

8.3.1.3 Desalination Facility

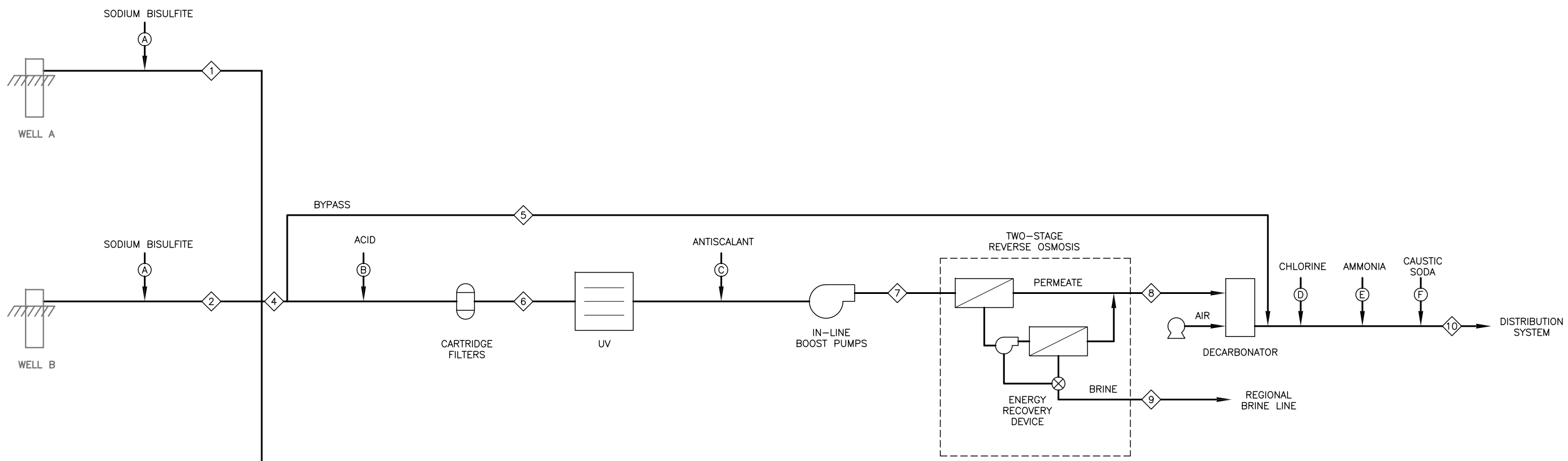
The main treatment processes at the desalination facility include the following:

- Acid feed to reduce the pH of raw water to 6.5, to slow down iron oxidation and prevent scaling;
- Cartridge filters to remove debris and suspended solids;
- Ultraviolet (UV) to prevent biological fouling;
- Antiscalant feed to prevent scaling;
- In-line boost pumps to increase the RO feed water pressure to push water through the RO;
- Two-stage RO for desalination;
- Decarbonator to remove carbon dioxide from RO permeate water and increase the pH;
- Blending of RO permeate with raw water;
- Chlorine feed for disinfection;
- Caustic soda feed for pH adjustment; and
- Finished water pumps to pump treated water to the distribution system.

Other ancillary equipment includes:

- RO membrane clean-in-place (CIP) system.

The preliminary process flow diagram for the desalination facility is show in Figure 8-1, and the preliminary site layout is presented in Figure 8-2. The preliminary design criteria for each of the main treatment processes are described below.



STREAM ID	1	2	3	4	5	6	7	8	9	10	A	B	C	D	E	F
	EXISTING WELL A	EXISTING WELL B	FUTURE WELL	COMBINED WELL SUPPLY / PLANT INFLUENT	BLEND WATER BYPASS	PRETREATMENT PRODUCT (CARTRIDGE FILTER EFFLUENT)	RO FEED (BOOST PUMP DISCHARGE)	RO PERMEATE	RO CONCENTRATE	TREATED WATER / PLANT EFFLUENT	SODIUM BISULFITE	ACID	ANTISCALANT	CHLORINE	AMMONIA	CAUSTIC SODA
DESIGN FLOW (mgd)	2.2	2.2	4.3	8.6	0.4	8.2	8.2	6.2	2.1	6.6	--	--	--	--	--	--
DESIGN FLOW (gpm)	1500	1500	3000	6000	300	5700	5700	4275	1425	4575	--	--	--	--	--	--
PRESSURE (psi)	80	80	80	80	80	65	175	10	30	NA						
CHEMICAL DOSE (mg/L)	--	--	--	--	--	--	--	--	--	--	2	70	1 to 3	0.5 to 2.5	0.1 to 0.3	3 to 5
NOTE:																
BLEND WATER BYPASS =	5%															
RO RECOVERY =	75%															

REV. NO.	DATE	DRWN	CHKD	REMARKS

DESIGNED BY:
DRAWN BY:
SHEET CHK'D BY:
CROSS CHK'D BY:
APPROVED BY:
DATE: AUGUST, 2008

CDM Camp Dresser & McKee Inc.
consulting engineering construction operations
1331 17th Street, Suite 1200
Denver, Colorado 80202
Contact: Mr. Tom Charles (303) 298-1311

CITY OF CAMARILLO
-
BRACKISH WATER DESALINATION FACILITY

PROCESS FLOW DIAGRAM

PROJECT NO. 2689-58780
FILE NAME: MROPLA03

SHEET NO.
FIGURE 8-1

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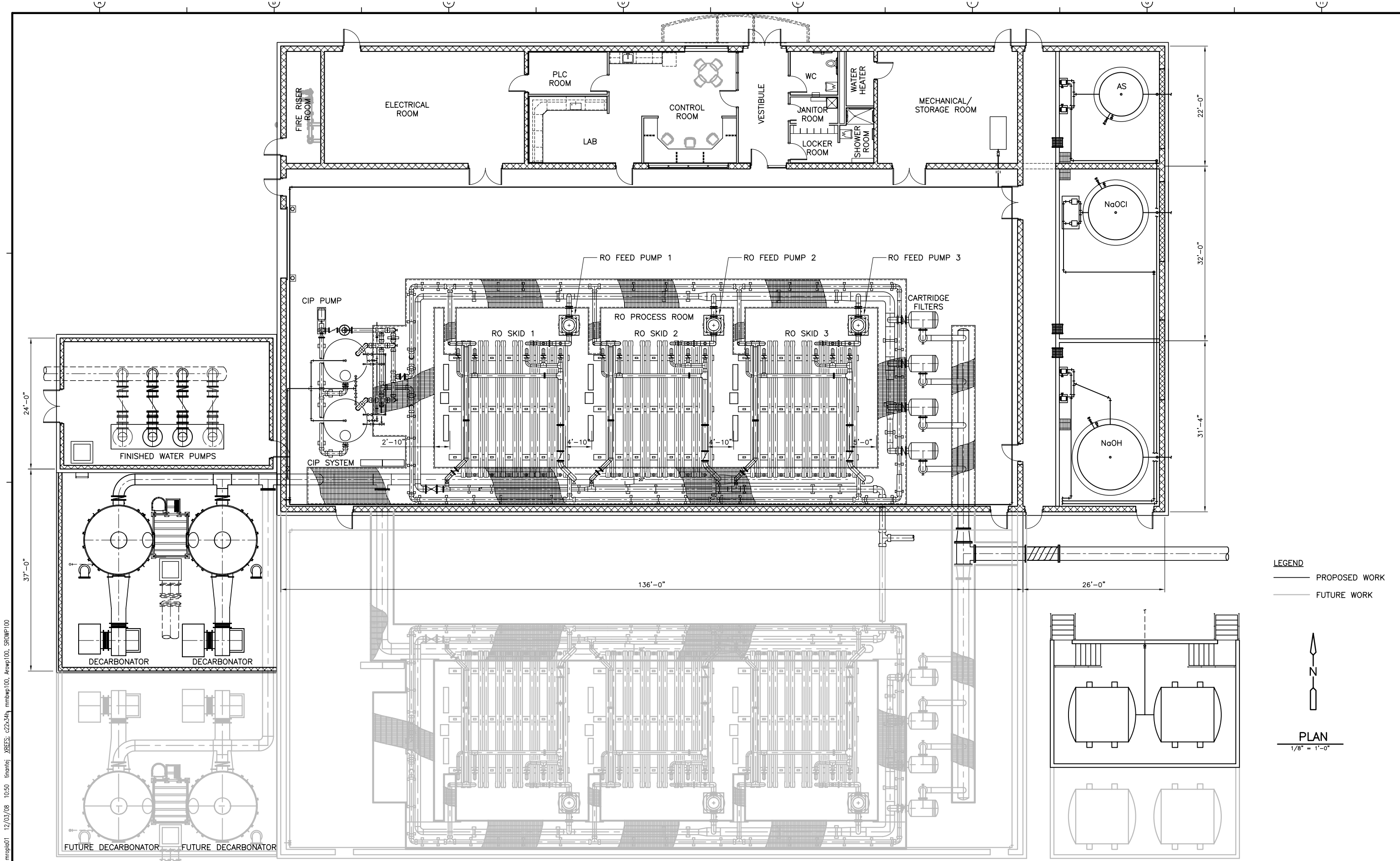

REV. NO.	DATE	DRWN	CHKD	REMARKS

DESIGNED BY:
DRAWN BY:
SHEET CHK'D BY:
CROSS CHK'D BY:
APPROVED BY:
DATE: AUGUST, 2008

CDM Camp Dresser & McKee Inc.
consulting engineering construction operations
1331 17th Street, Suite 1200
Denver, Colorado 80202
Contact: Mr. Tom Charles (303) 298-1311

CITY OF CAMARILLO
-
BRACKISH WATER DESALINATION FACILITY

PRELIMINARY SITE PLAN - ALTERNATIVE 1

PROJECT NO. 2689-58780
FILE NAME: MROPLA01

SHEET NO.
FIGURE 8-2

L:\City\Camarillo\42405\ mropla01 12/03/08 10:50 timante; XREFS: c22x34h, mmbwp100, Mrowp100, SROWP100

Acid Feed

The purpose of acid feed is to slow down iron oxidation and prevent scaling by reducing the pH of the raw water to pH 6.5. The acids that could be used for this purpose include muriatic acid and sulfuric acid, but other acids may be used. The disadvantage of using muriatic acid is that it is typically available in 31 percent concentration, and requires large storage tanks. The primary disadvantage of using sulfuric acid is that, while it is available in higher concentrations, it adds sulfate to the water, which can contribute to membrane scaling, as calcium sulfate.

Preliminary design criteria for muriatic acid and sulfuric acid feed system are summarized in Table 8-4. Other acids should be evaluated during preliminary design.

Table 8-4.
Acid Feed System Design Criteria

Parameter	Units	Design Value	Design Value
Main Process Stream		RO Feed Water (6,000 gpm)	RO Feed Water (6,000 gpm)
Chemical		Muriatic Acid (Hydrochloric Acid)	Sulfuric Acid
Concentration	%	31.45%	93.2%
Dose	mg/L	70	90
Feed Equipment			
Pump Type		Peristaltic	Peristaltic
Pump Capacity, each	gph	76	20
Number of Pumps	each	2	2
Wetted Materials			Teflon/Carpenter 20
Storage System			
Tank Type		Phenolic-coated Steel Tank	Phenolic-coated Steel Tank
Tank Capacity, each	gal	25,000	6,800
Storage Time, each	days	15	15
Number of Tanks	each	1	1
Piping Material		PVDF	PVDF

Cartridge Filters

The cartridge filters are used to protect the RO membranes by removing debris and suspended solids from the raw water. Preliminary design criteria for cartridge filters are summarized in Table 8-5.

Table 8-5.
Cartridge Filters Design Criteria

Parameter	Units	Design Value
Main Process Stream		RO Feed Water (6,000 gpm)
Number of Units		4
Design Feed Rate per Vessel	gpm	2,000
Maximum Loading Rate at Design Feed Rate	gpm	3.0
Initial Pressure Drop	psi	0.7
Cartridge Changeout Pressure Drop	psi	10
Filter Housings		
Orientation		Horizontal
Housing Material		316L Stainless Steel
Filter Cartridges		
Cartridge Element Material		Wound Polypropylene
Nominal Filter Rating	micron	5

UV

The purpose of UV is to prevent bio-fouling by disinfecting the feed stream ahead of the cartridge filters and RO membranes. Intermittent biological growth was observed on the cartridge filters during the pilot testing, introduced either from the chemical feed systems or directly from the wells. The UV system may not be required for a full scale facility, however, it provides a method to reduce the risk of biofouling and improved plant efficiency. Preliminary design criteria for a UV reactor system are summarized in Table 8-6.

Table 8-6.
UV Reactor System Design Criteria

Parameter	Units	Design Value
Main Process Stream		RO Feed Water (6,000 gpm)
Dose	mJ/cm^2	40
UV Transmittance at 253.7 nm	%	80
Number of Reactors		2
Capacity per Reactor	gpm	3,000
UV Reactor Configuration		
Number of Lamps per Reactor	Each	30
Number of Sensors per Reactor	each	3
Materials of Construction		316L Stainless Steel
Maximum Operating Pressure	psi	150
Auto-Wiper		Yes

Antiscalant Feed

The purpose of antiscalant feed is to prevent scaling of the RO membranes. Typical doses for antiscalant are 1 to 3 mg/L, and the antiscalant dose used during the pilot study was 1 to 2 mg/L. Preliminary design criteria for antiscalant feed system are summarized in Table 8-7.

Table 8-7.
Antiscalant Feed System Design Criteria

Parameter	Units	Design Value
Main Process Stream		RO Feed Water (6,000 gpm)
Chemical		Antiscalant
Concentration	%	100
Dose	mg/L	1 to 3
Manufacturers		King Lee Technologies; Professional Water Technologies; Avista Technologies
Feed Equipment		
Pump Type		Peristaltic
Pump Capacity, each	gph	0.6
Number of Pumps	each	2
Wetted Materials		CPVC/PVDF/ceramic
Storage System		
Tank Type		XLPE
Tank Capacity, each	gal	530
Storage Time, each	days	45
Number of Tanks		1
Piping Material		CPVC

In-line Boost Pumps

The in-line boost pumps will be used to increase the RO feed water pressure. Preliminary design criteria for in-line boost pumps are summarized in Table 8-8.

Table 8-8.
In-Line Boost Pumps Design Criteria

Parameter	Units	Design Value
Main Process Stream		RO Feed Water (6,000 gpm)
Number of Units		5
Type		Vertical Turbine, canned
Capacity, each	gpm	1,500
TDH	ft	TBD
Speed	rpm	1,800
Motor Size	hp	TBD
VFD		Yes
Pump Materials		316 Stainless Steel

Two-Stage RO

Two-stage RO system will be used for desalination. Preliminary design criteria for two-stage RO are summarized in Table 8-9.

Table 8-9.
RO System Design Criteria

Parameter	Units	Design Value
Number of Skids		3
Design Feed Rate per Skid	gpm	2,000
Permeate Flow per Skid	gpm	1,500
Permeate Water Recovery Rate	%	75
Number of Stages		2
Initial Feed Pressure	psi	200 psi
Energy Recovery Device (Inter-stage Boost)	gpm	1,000
Pressure Vessels (each skid)		
1st Stage		34
2nd Stage		16
Housing Material		FRP
Elements/Vessel		7
Total Elements		350
Membrane Elements		
Size		8-inch diameter x 40-inch length
Total Installed Number		1,050
Average Flux Rate		15
Material		Thin Film Composite/Polyamides (TFC / PA)

Decarbonator

The purpose of decarbonators is to remove carbon dioxide from RO permeate water and thereby increase the pH of the RO permeate to approximately pH 7.0 to 7.5. Preliminary design criteria for the decarbonators are summarized in Table 8-10.

Table 8-10.
Decarbonators Design Criteria

Parameter	Units	Design Value
Main Process Stream		RO Permeate (4,500 gpm)
Type		Packed Tower
Number of Units		2
Capacity, each	gpm	2,250
Air to Water Ratio		20:1
Target pH		7.0 to 7.5
Packed Tower		
Material		FRP

Table 8-10.
Decarbonators Design Criteria

Parameter	Units	Design Value
Blowers		
Number of Blowers per Tower	each	1
Capacity	scfm	6,000
Motor	hp	TBD

Chlorine and Ammonia Feed

Chloramination will be used for disinfection of the blended water to be consistent with the disinfection system of the imported water, which has chloramines. Since the ammonia in the City's well water will be removed by the RO, ammonia will be injected in addition to chlorine to form stable chloramines residual comparable with imported water. The chlorine to ammonia ratio will be maximum 7.5. The target total chlorine residual is 1.2 to 1.5 mg/L. Preliminary design criteria for chlorine and ammonia feed system are summarized in Tables 8-11 and 8-12.

Table 8-11.
Chlorine Feed System Design Criteria

Parameter	Units	Design Value
Main Process Stream		Blended Water (4,500 gpm)
Chemical		Sodium Hypochlorite
Concentration	%	12.5
Dose		
Average	mg/L	1.5
Minimum	mg/L	0.5
Maximum	mg/L	2.5
Feed Equipment		
Pump Type		Peristaltic
Pump Capacity, each	gph	7
Number of Pumps	each	2
Wetted Materials		PVDF/EPDM
Storage System		
Tank Type		FRP
Tank Capacity, each	gal	1,200
Storage Time, each	days	45
Number of Tanks		1
Piping Material		CPVC

Table 8-12.
Ammonia Feed System Design Criteria

Parameter	Units	Design Value
Main Process Stream		Blended Water (4,500 gpm)
Chemical		Aqua Ammonia (Ammonium Hydroxide)
Concentration	%	19
Chlorine to Ammonia Ratio		7.5:1
Dose		
Average	mg/L	0.2
Minimum	mg/L	0.07
Maximum	mg/L	0.3
Feed Equipment		
Pump Type		Peristaltic
Pump Capacity, each	gph	0.5
Number of Pumps	each	2
Wetted Materials		PVDF/EPDM
Storage System		
Tank Type		FRP
Tank Capacity, each	gal	500
Storage Time, each	days	45
Number of Tanks		1
Piping Material		CPVC

Caustic Soda Feed

Caustic soda will be used to adjust the pH of the disinfected water to pH 8.5 and Langelier Saturation Index (LSI) to greater than 0. Preliminary design criteria for caustic soda feed system are summarized in Table 8-13.

Table 8-13.
Caustic Soda Feed System Design Criteria

Parameter	Units	Design Value
Main Process Stream		Blended Water (4,500 gpm)
Chemical		Caustic Soda
Concentration	%	25
Dose	mg/L	3 to 5
Target Water Quality		pH 8.5 LSI > 0
Feed Equipment		
Pump Type		Peristaltic
Pump Capacity, each	gph	5
Number of Pumps	each	2
Wetted Materials		CPVC/viton

Table 8-13.
Caustic Soda Feed System Design Criteria

Parameter	Units	Design Value
Storage System		
Tank Type		FRP
Tank Capacity, each	gal	3,100
Storage Time, each	days	30
Number of Tanks		1
Piping Material		CPVC

RO Membrane CIP System

The purpose of RO membrane CIP system is to clean the membranes when membranes are fouled with inorganic fouling/scaling, particulate fouling, microbial fouling, and/or organic fouling. Inorganic fouling is typically cleaned with acidification (citric acid is typically used), and organic fouling is typically cleaned with caustic soda.

Preliminary design criteria for RO membrane CIP system equipment are summarized in Table 8-14.

Table 8-14.
RO Membrane CIP System Design Criteria

Parameter	Units	Design Value
CIP Tanks		
Tank Type		FRP
Tank Capacity, each	gal	TBD
Number of Tanks		2
CIP Pumps		
Pump Type		Horizontal Centrifugal
Pump Capacity, each	gph	TBD
Number of Pumps	each	1
Wetted Materials		Stainless Steel
Neutralization Pump		
Pump Type		Horizontal Centrifugal
Pump Capacity, each	gph	TBD
Number of Pumps	each	1
Wetted Materials		Stainless Steel
Piping Material		CPVC

8.3.2 Projection of Probable Cost Information

Based on the preliminary design criteria presented above in Section 8.3.1, the capital and operation and maintenance (O&M) costs have been projected. The projected

capital cost is presented in Table 8-15, the projected O&M cost is presented in Table 8-16, and the life-cycle cost is presented in Table 8-17.

Table 8-15.
Probable Capital Cost

Item	Capital Cost
New Well	$3,500,000
Raw Water Pipelines	$1,088,000
Wellhead Treatment Facilities (See Note 1)	$587,000
RO Facilities (See Note 2)	$19,851,000
Finished Water Facilities	$2,147,000
Brine Line Connection	N/A (See Note 3)
Finished Water Pipelines	$1,460,000
Subtotal	**$28,798,000**
Contingency (30%)	$8,639,000
Engineering (14%)	$5,241,000
Total	**$42,678,000**
Unit Cost ($/acre-ft) (See Note 4)	**$472**

Note:
1) The cost of the wellhead treatment facilities includes the equipment described in Section 8.3.1.2.
2) The cost of the RO Facilities includes the systems described in Section 8.3.1.3, and emergency standby power generator system.
3) The brine line connection will be installed in the future.
4) The treated water capacity is 6.5 mgd or 7,300 acre-ft/yr. The capital cost has been amortized over 20 years at 5% discount rate.

Table 8-16.
Probable O&M Cost

Item	O&M Cost
Electricity	$936,000
Chemicals	$844,000
Membrane Replacement	$150,000
Cartridge Filters	$9,000
Miscellaneous Repair and Replacement	$297,000
Well Pumping Charge	$58,000
Brine Disposal Fee	(See Note 1)
Labor	$105,000
Total	**$2,399,000**
Unit Cost ($/acre-ft) (See Note 3)	**$331**

Note:
1) The cost of brine discharge to the regional brine line is not included in this estimate.
2) The treated water capacity is 6.5 mgd or 7,300 acre-ft/yr.

Table 8-17.
Probable Life-Cycle Cost

Item	Unit Cost
Capital Cost ($/acre-ft)	$472
O&M Cost ($/acre-ft)	$331
Total Life-Cycle Cost ($/acre-ft)	**$802**

Note:
1) The treated water capacity is 6.5 mgd or 7,300 acre-ft/yr.

The basis for the life cycle economic analysis is as follows:

- Contingencies have been estimated at 30 percent of the capital cost, which is appropriate at this level of planning.
- Engineering costs have been estimated at 14 percent of the total capital cost including contingencies, and includes the design and construction services and inspection of the facilities.
- Capital cost amortization is based on a 20 year bond sale at an interest of 5 percent.
- Total costs per acre-ft is based on the total product water produced and the total annual costs of the facilities.

8.3.3 Schedule

The schedule for the design and construction of the new brackish water desalination facility is presented in Table 8-18.

Table 8-18.
Schedule for Design and Construction

Milestones	Start Date	Complete Date
Select Design-Build Firm		January 2009
Design	January 2009	July 2009
Permitting	July 2009	September 2009
Construction	September 2009	December 2010

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Section 9
Final Financial Statement

9.1 Overview

This section includes pertinent budget information including comparison of actual expenditures with the original spending plan. The expenditures from the grant funds as well as the City's share are included in the financial statement.

9.2 Progress Report

The estimated percent complete of the total project is: 92%

Table 9-1

Project Progress (April 1, 2007 through September 30, 2008)

Agreement Number:	Starting Date:	Completion Date:	Quarter - Year	Report Number
4600007441	4/1/2007	3/31/2009	3 - 2008	
Grantee Agency Name:		% Time Elapsed	Total Grant Funds Used To Date	Grant Funds Remaining
City of Camarillo		75%	$335,768.99	$48,103.01

Name of Project:
City of Camarillo Brackish Water Desalination Pilot Study

	YEAR	2007			2008				2009	Percent of Project Complete
TASKS	MONTH	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	
Task 1: Project Management										9
Task 2: Pilot Test Preparation										14
Task 3: Conduct Pilot Testing										62
Task 4: Data Evaluation										7
Task 5: Report Development										0
Show Progress by Use of Bar Chart	Scheduled =									92
	Completed =									

9.3 Expense Report

The total budget of the pilot study is $767,744. The State's share and the City's share are each 50 percent of the total cost. The expenditures for the project to date are summarized in Table 9-2.

Expense Report from April 1, 2007 to September 30, 2008.

Table 9-2.
Project Expenditure (April 1, 2007 through September 30, 2008)

Expense Items (Budget Category or Task Description)	**State's Cost Share**		**City's Cost Share**	
	Expenses to Date	**Remaining Balance**	**Expenses to Date**	**Remaining Balance**
a. Administration – Task 1.1				
Salaries	$120,715.99	$7,000.01	$15,000.00	$0.00
Travel	$26,582.13	$3,917.87	$750.00	$0.00
b. Planning/Design/Engineering – Tasks 2.1, 2.2, 2.3	$22,360.00	$0.00	$10,000.00	$0.00
c. Equipment Purchases/Rentals/Rebates/Vouchers – Task 2.3	$127,376.89	$3,623.11	$10,000.00	$0.00
d. Materials/Installation/Implementation – Task 2.4	$8,250.00	$0.00	$0.00	$0.00
i. Environmental Compliance/Mitigation/Enhancement – Task 4.2	$0.00	$0.00	$4,589.40	$410.60
j. Construction – Task 2.4	$0.00	$0.00	$60,088.00	$0.00
l. Monitoring and Assessment – Tasks 3.1, 3.2, 4.1, 4.2	$22,366.00	$0.00	$283,034.00	$0.00
m. Report Preparation – Task 1.2, 5.1, 5.2	$8,679.67	$33,562.03	$0.00	$0.00
Totals	**$335,768.99**	**$48,103.01**	**$383,461.40**	**$410.60**

Note that the expenses shown in Table 9-2 do not cover October 2008 through January 2009, during which time the report will be finalized.

Appendix A – Pilot Plant Information

A.1 Pilot Test Protocol
A.2 Photos
A.3 MSDS of Chemicals Used

A.1 Pilot Test Protocol

A.2 Photos

Overall View of Pilot Plant Equipment at Well A

Overall View of Pilot Plant Equipment at Well A

Wellhead Facilities

Chemical Injection at Well B

Well A Raw Water Sample port at well A

Sodium Thiosulfate Drum and Metering Pump at Well B

Chemical Injection Port and Air Eductor at Well A

Well A

Static Mixer

Tanks

Contact Tank

Permeate Tank

Equalization Tank

RO System Equipment

RO Skid

RO Skid

Antiscalant Storage and Metering Pump

Antiscalant Feed Port, Acid Feed Port, and Pressure Gauges

Cartridge Filters

RO Feed Pump

RO Panel

Granular Media Filters

Granular Media Filters

Granular Media Filters

Media Filters Feed Pump

A.3 MSDS of Chemicals Used

- Antiscalant
- Chlorine Dioxide

PROFESSIONAL WATER TECHNOLOGIES, Inc.
High-Performance Reverse Osmosis Chemicals

2420 Grand Avenue, Suite A Vista, CA 92083
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MSDS

Material Safety Data Sheet
August 1, 2001

Section 01: Chemical Product Identification

Domestic Trade Name: *SpectraGuard SCÔ*
Export Trade Name: *SpectraGuard SCÔ*
Chemical Type: *Water Soluble Polymer*

Section 02: Information on Hazardous Ingredients

Non Hazardous Ingredients

Section 03: Hazards Identification:

Acute Toxicity

Mutagenicity: AMES Salmonella Mutagenicity Testing Exhibits No Evidence of Mutagen Presence.
Oral Toxicity: Rat LD50>100,000 mg/kg
Dermal Toxicity: Not Absorbed Topically
Inhalation Toxicity: Exposure to Spray Will Cause Irritation to Mucous Membranes and Respiratory System.
Skin Irritation: Rabbit; No Irritation Observed.
Sensitizer: No Human Repeat Insult Patch Test; Not a Sensitizer.
DOT Corrosive: Not Applicable
Primary Route of Entry: Contact

Signs and Symptoms of Exposure

Symptoms of Ingestion: No Effect of Exposure Expected
Symptoms of Inhalation: If Misted, No Effects Expected
Symptoms of Skin Contact: No Effects Expected
Symptoms of Eye Contact: No Effects Expected With the Exception of Possible Irritation

Medical Conditions Aggravated by Exposure: None Known.

Other Toxicity:

Sub Chronic Oral Toxicity: None Known.
Sub Chronic Inhalation Toxicity: None Known.
Aquatic Toxicity: None Known.
Mutagenicity: AMES Salmonella Mutagenicity Testing Exhibits No Evidence of Mutagen Presence.

Section 04: First Aid Measures

First Aid For Ingestion: Do not induce vomiting, give 2 glasses of milk and several glasses of water. Never Give Anything by Mouth to an Unconscious Person. Call a Physician Immediately.
First Aid Inhalation: None Required
First Aid Eye Contact: For all Foreign Materials; Immediately Flush Eyes with Plenty of Water.
First Aid Skin Contact: For all Foreign Materials; Wash After Exposure.

Section 05: Fire Fighting Measures

Autoignition Temp: N/A
Flammable Limits: LEL (Lower Explosive Limits) N/A
Fire Fighting Media: Use Media Appropriate to Primary Cause of Fire.
Special Fire Fighting Procedures: None Known.
Fire/Explosion Hazards: None Known.
NFPA Hazard Codes - Health/Flammability/Reactivity; 0,0,0.
HMIS Hazard Codes - Health/Flammability/Reactivity; 0,0,0.

Section 06: Accidental Release Measures

Spill/Leak Clean-Up Procedures: If Possible, Neutralize with Alkaline Soap.
Absorb with approved liquid spill absorbent. Dispose of with Solid Waste According to Federal, State, and Local Regulations. Flush Spill with Water.
***CAUTION**: Floor will be Slippery.

Section 07: Handling and Storage

Precautionary Measures: Avoid Breathing Spray.
Disposal Method: Dispose of with Solid Waste According to Federal, State and Local Regulations.
RCRA Class: Not Regulated.

Section 08: Exposure Control/Personal Protection

Ventilation: Use with Normal Adequate Ventilation.
Respiratory Protection: Dust Masks Where Spraying cannot be Avoided.
Eye Protection: Safety Glasses.
Skin Protection: Use OSHA Approved Neoprene Gloves, Boots, and Apron.
Personal Hygiene: Observe Ordinary Measures of Personal Hygiene.

Section 09: Physical and Chemical Properties

Boiling Point: That of Water.
Vapor Pressure: That of Water.
Vapor Density: That of Water.
Water Solubility: Complete.
Melting/Freezing Point: 32 °F
Appearance: Clear to light amber.
Specific Gravity: 1.0 – 1.2 g/ml
Percentage Volatile: 50 - 60%
Evaporation Rate: That of Water.
pH of Solution: 3 – 7.5 (5% Solution).
Odor: Mild.

Section 10: Stability and Reactivity

Stability: Stable.
Hazardous Polymerization: Will not Occur.
Conditions to Avoid: None Known.
Incompatible Materials: Strong Oxidizing or Reducing Agents.
Hazardous Decomposition Products: None Known.

Section 11: Transport Information

Domestic Data

Dot Shipping Name: Not Regulated.
Dot Hazard Class: Not Regulated.
Hazardous Ingredients: None.

Export Data

Export Shipping Name: Not Regulated.
Export Hazard Class: Not Regulated.
Hazardous Ingredients: None.
UN Number: None.

This material safety data sheet reflects information provided by raw material suppliers and other reliable sources.

Material Safety Data Sheet

Material:	Chlorine Dioxide ≤0.3% Aqueous Solution
Company:	CDG Research Corporation
MSDS No.	CD-003
Date of Preparation:	April 4, 2007
Revision:	002

Section 1 – Chemical Product and Company Identification

Chemical Name:	Chlorine Dioxide Aqueous Solution
General Class:	Corrosive Liquid
General Purpose:	Biocide
Synonyms:	Chlorine Oxide Solution Chlorine Peroxide Solution Chlorine (IV) Oxide Solution Chloroperoxyl Solution
UN ID:	1760
Company Name & Address:	CDG Research Corporation 759 Roble Road Allentown, PA 18109
Emergency Telephone Number:	**800-424-9300** 24 hours, 7 days/week

Section 2 – Composition / Information on Ingredients

Hazardous component(s):

Chemical name	Chlorine Dioxide
Molecular formula	ClO_2
Concentration	$\leq$ 0.3% ($\leq$ 3,000 ppm)

Non-hazardous component(s):

Chemical name	Water
Molecular formula	H_2O
Concentration	$\geq$ 99.7% ($\geq$ 997.000 ppm)

Section 3 – Hazard Identification

Potential Health Effects – General:

Chlorine dioxide gas is a mucous membrane and respiratory tract irritant.

Swallowing large amounts of this material may be harmful.

Respiration/protection should be worn if concentrations exceed applicable standards.

Primary Route(s) of Exposure:

The primary routes of exposure to this material are ingestion; inhalation; and eye and skin contact

Signs and Symptoms of Exposure

Ingestion

Signs and symptoms of exposure to this material through swallowing include stomach or intestinal upset (nausea, vomiting, diarrhea)

Inhalation

Signs and symptoms of exposure to this material through inhalation of its vapors include coughing, sore throat, breathing difficulty

Eye and Skin contact

Signs and symptoms of exposure to this material through skin contact include skin irritation and redness. Signs and symptoms of exposure to this material through eye contact include eye irritation, tearing and redness.

Section 4 – First Aid Measures

Eyes

If symptoms develop, move patient away from the source of exposure and into fresh air. Flush eyes gently with large amounts of water while holding eyelids apart. If symptoms persist or there is any visual difficulty, seek medical attention.

Skin

First aid is not normally required. However, concentrated solutions of the material (> 1000 ppm) may be highly irritating, especially on prolonged contact. Remove contaminated clothing immediately. Immediately flush exposed skin with large amounts of water. Wash thoroughly with mild soap. Consult a physician if irritation or burning persists. Contaminated clothing must be laundered before re-use. Lower concentrations (<1000) ppm may cause some irritation with very-prolonged exposure.

Swallowing

First aid is not normally required when small amounts of the material are ingested. If symptoms develop or if large amounts of material have been ingested, DO NOT induce vomiting. DO NOT give anything by mouth if the patient is unconscious. Drink large quantities of water. Consult a physician immediately. Neutralization and use of activated charcoal are not recommended.

Inhalation

If symptoms develop, immediately move individual away from exposure and into fresh air. Seek immediate medical attention; keep person warm and quiet. If person is not breathing, begin artificial respiration. If breathing is difficult, administer oxygen. Monitor the patient closely for delayed development of pulmonary edema, which may occur up to 72 hours after inhalation.

Notes to Physicians

No data

Section 5 – Fire-Fighting Measures

NFPA Rating

Health – 1
Flammability – 0
Reactivity – 1

Flash Point

Not applicable

Auto-ignition Temperature

Not applicable

Explosive Limit

Chlorine dioxide solution is not explosive. Chlorine dioxide gas, which may evolve from chlorine dioxide solution, may spontaneously decompose with a mild energy release at concentrations of 10% in air or greater at standard temperature and pressure (i.e., 76 mm Hg partial pressure).

Chlorine dioxide gas may explode with violent force at concentrations of 30% or greater in air at standard temperature and pressure (i.e., 228 mm Hg partial pressure)

Hazardous Products of Combustion

May form chlorine, hydrochloric acid gas, oxygen on combustion or decomposition

Fire and Explosion Hazards

There are no special fire hazards known to be associated with the material.

Extinguishing Media

Water

Fire Fighting Instructions

Wear a self-contained breathing apparatus (SCBA) with a full face piece operated in the "positive pressure demand" setting. Use SCBA in conjunction with appropriate chemically resistant personal protective gear. Refer also to the personal protective equipment section of this MSDS.

Section 6 – Accidental Release Measures

Large Spill

In the event of a large spill of the material, prevent runoff to sewers, streams, lakes or other bodies of water. If run-off occurs, notify proper authorities of any runoff, as required, Persons not wearing protective equipment should be excluded from area of spill until clean-up has been completed. Stop spill at source, dike area around spill to prevent spreading, and pump liquid to salvage tank. Remaining liquid may be taken up on sand, clay, earth, vermiculite, floor absorbent, or other absorbent material and shoveled into containers. Flush with water the area from which the bulk of the spill has been removed.

Small Spill

Absorb liquid on vermiculite, floor absorbent or other absorbent material. Flush area with water.

Section 7 – Handling and Storage

Handling

In order to prevent the evolution of chlorine dioxide gas into the breathing zones of workers, agitation of the material should be minimized, and the material should not be stirred, mixed turbulently, sprayed or splashed.

Storage

The material should be stored indoors, only in the containers in which it is shipped, or in containers authorized by the manufacturer for such storage. Storage temperatures should be maintained above 50°F and below 110°F. The material should not be stored outside or exposed to freezing temperatures (below 32°F). The material should not be heated to temperatures in excess of 140°F. At temperatures above 140°F, the gas concentration in the headspace of the container may reach high, energetically unstable concentrations.

Section 8 – Exposure Controls / Personal Protection

The OSHA permissible exposure limit (PEL) for ClO_2 gas in air is 0.1 ppm (0.3 mg/m^3) as an 8-hour time weighted average. NIOSH recommended exposure limits (REL) and ACGIH threshold limit values (TLV) are also 0.1 ppm.

NIOSH and ACGIH short-term exposure limits (STEL) are 0.3 ppm (0.83 mg/m^3) for periods not to exceed 15 minutes. The STEL concentration should not be repeated more than 4 times per day and should be separated by intervals of at least 60 minutes.

Exposure Guidelines (vapor)

OSHA PEL	0.100 ppm – TWA
ACGIH TLV	0.100 ppm – TWA
ACGIH TLV	0.300 ppm - STEL

Eye Protection

Wear splash-proof face and eye protection (PVC is preferred) where chlorine dioxide solution may splash or spray. Safety glasses should be in compliance with OSHA regulations.

Skin Protection

Wear waterproof protective clothing (PVC is preferred) where chlorine dioxide solution may splash or spray. Wear resistant gloves, such as Neoprene, to prevent skin contact, wear impervious clothing and boots. Other protective equipment: eyewash station, emergency shower.

Respiratory Protection

Exposures in the workplace should be monitored to determine if worker exposure exceeds the facility-specified exposure "action level" or the use of the material produces adverse health effects or symptoms of exposure. Provide adequate ventilation to maintain all work areas at concentrations below 0.1 ppm chlorine dioxide concentration. If the generation of vapors or mists is possible, use local ventilation. Where gas concentration may exceed 0.1 ppm, only a NIOSH/MSHA approved full-face acid gas respirator should be used. Monitoring results must be used to assess the proper level or respiratory protection necessary. Proper engineering and/or administrative controls should be used to reduce worker exposure. The facility's respiratory protection program must meet the requirements established in 29 CFR 1910.134, which includes a program for medical evaluation. A NIOSH/MSHA approved self-contained breathing apparatus, with full face piece, is required for leaks and emergencies where the concentration may exceed 5 ppm.

Engineering Controls

Provide sufficient mechanical ventilation-- general and/or local exhaust-- to maintain exposure below allowable limits.

Section 9 – Physical and Chemical Properties

Appearance and odor

Yellow-green liquid, with sharp, pungent odor

Liquid specific gravity

1.0 at 0° C

Boiling Point

100° C (212° F)

Odor threshold of gas

0.1 ppm

Section 10 – Stability and Reactivity

Hazardous Polymerization

Material does not undergo hazardous polymerization.

Hazardous Decomposition

Gas-phase vapors that evolve from the material may decompose on exposure to light, on contact with incompatible materials (see below), or spontaneously at concentrations above 10% in air at standard temperature and pressure (76mm Hg). On decomposition, material may form: Chlorine, hydrochloric acid gas and oxygen.

Chemical stability

The material, as solution, is stable in the dark. On exposure to light, the solution may decompose to an aqueous solution of chloride and chlorate ions. In regard to vapor (gas) that may evolve from the material, see "Hazardous Decomposition" above.

Incompatibility

Avoid exposure to light. Avoid contact with: metals, reducing agents, strong oxidizing agents, sulfur compounds or sulfur-containing components, carbon monoxide, excessive heat, mercury, organic materials, phosphorus.

Section 11 – Toxicological Information

Chlorine dioxide gas is a mucous membrane and respiratory tract irritant. Primary routes of exposure include ingestion, skin and eye contact and inhalation of vapors which may evolve from the material.

Target Organ Effects

This material may cause mild eye irritation; it is unlikely to cause serious eye irritation or injury

This material may cause mild skin irritation; it is unlikely to cause serious skin irritation or injury

Digestive Tract

This material may cause nausea, vomiting and diarrhea; it is unlikely to cause serious digestive tract injury. Chlorine dioxide given daily in drinking water at 1-100 ppm caused a decrease in blood glutathione, altered the morphology of erythrocytes, and caused osmotic fragility in laboratory animals.

Respiratory Tract

The fumes from this material may cause respiratory tract irritation, wheezing and difficulty breathing. In extreme cases, it may cause pulmonary damage and death.

Developmental/Reproductive Effects

Available information is insufficient to assess risk to the fetus from maternal exposure to this material during pregnancy. Chlorine dioxide did not cause birth defects in laboratory animals even at very high exposure levels.

Cancer Effects

Available information is insufficient to assess cancer risk (i.e., carcinogenicity) associated with exposure to this material. This material is not listed as a carcinogen by the International Agency for Research on Cancer (IARC), the National Toxicology Program (NTP), or the Occupational Safety and Health Administration (OSHA) United States Environmental Protection Agency (EPA) or American Conference of Industrial Hygienists (ACGIH).

Other Health Effects

No data available on other possible health effects

Section 12 – Ecological Information

No data available.

Section 13 – Disposal Considerations

Disposal of this material should be in accordance with all applicable Federal, State and local rules, regulations and requirements.

Section 14 – Transport Information

Transport of this material should be in accordance with all applicable Federal, State and local rules, regulations and requirements, including, without limitation, the rules and regulations of the US Department of Transportation, including all applicable packaging and labeling requirements.

DOT Information:

Proper shipping name:	chlorine dioxide solution ($\leq$0.3)
Class:	N/A (Exempt under CFR 173.154(d)
Packing group:	None, but must not ship or store in metal Containers
Hazard label:	None Required

Section 15 – Regulatory Information

US Federal Regulations

TSCA (Toxic Substances Control Act) Status - United States

The intentional ingredients of this material are listed.

CERCLA RQ- 40 CFR 302.4(a)

None listed

SARA 302 Components - 40 CFR 355 Appendix A

None

Section 311/312 Hazard Class-40 CFR 370.2

Immediate ( )
Delayed ( )
Fire ( )
Reactive ( )
Sudden Release of Pressure ( )

SAARA 313 Components - 40 CFR 372.65

Section 313 Components	CAS Number	Percent (%)
Chlorine dioxide	1004-04-4	0.03

OSHA Process Safety Management 29 CFR 1910

PSM Component(s)	Condition	TQ (lbs)
CHLORINE DIOXIDE		100

EPA Accidental Release Prevention 40 CFR 68

PSM Component(s)	Condition	TQ (lbs)
CHLORINE DIOXIDE Chlorine Oxide (ClO2)		100

International Regulations

Not determined

State and Local Regulations

California Proposition 65

None

Section 16 – Other Information

The information set forth herein is believed to be accurate. However, NO WARRANTY IS GIVEN AS TO THE ACCURACY OF ANY OF THE INFORMATION, WHETHER ORIGINATED BY THE COMPANY OR BY OTHERS. Recipients of this MSDS are advised to confirm, in advance of any need, that the information is current, applicable, and suitable to their circumstances.

- END -

Appendix B – Dissemination and Outreach Materials

B.1 Posters Used at Pilot Plant Site Tour

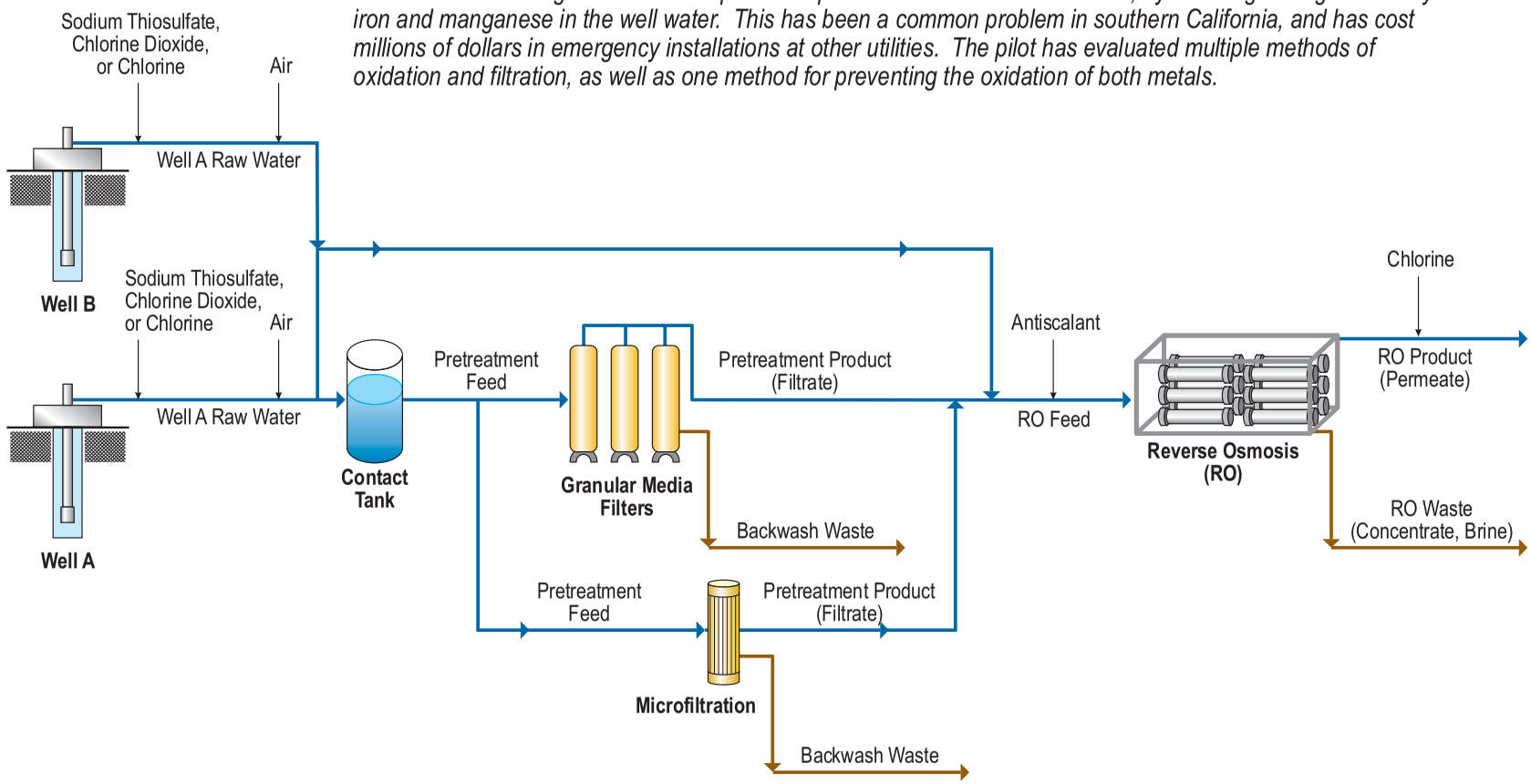
B.2 Operator Training Workshop Presentation

B.1 Posters Used at Pilot Plant Site Tour

City of Camarillo

Brackish Water Desalination Pilot Study

Alternatives are being evaluated to improve the performance of reverse osmosis, by reducing fouling caused by iron and manganese in the well water. This has been a common problem in southern California, and has cost millions of dollars in emergency installations at other utilities. The pilot has evaluated multiple methods of oxidation and filtration, as well as one method for preventing the oxidation of both metals.



Oxidation Alternatives

Aeration	*Oxidizes iron only. Manganese will remain dissolved*
Chlorine Dioxide (ClO_2)	*Oxidizes both iron and manganese*
Chlorine (Cl_2)	*Oxidizes iron and manganese when used in conjunction with pyrolusite (greensand) media*

Filtration Alternatives

Granular Media Filtration	*Removes oxidized iron and manganese*
Pyrolusite Media Filtration	*Enhances oxidation of manganese, and removes oxidized iron and manganese*
Microfiltration (MF)	*Removes oxidized iron and manganese*

Sequestering

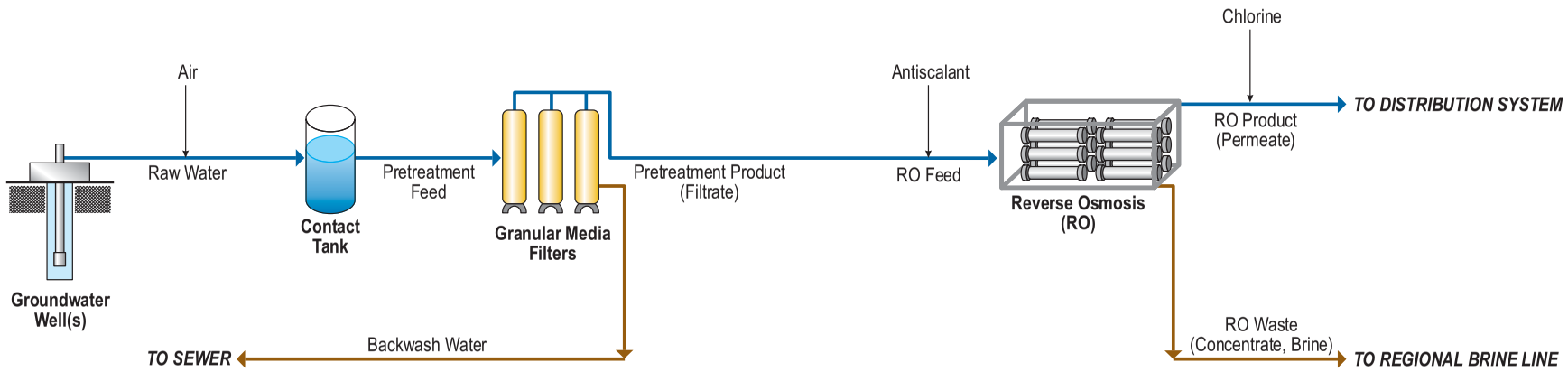
Sodium Thiosulfate or Sodium Bisulfite	*Prevents oxidation*

CDM

Overall Pilot Plant Process Flow Diagram

City of Camarillo

Brackish Water Desalination Pilot Study



Aeration

- *Add air to increase dissolved oxygen (DO) level in water to saturation (8 to 9 mg/L)*
- *Oxidizes iron but not manganese*

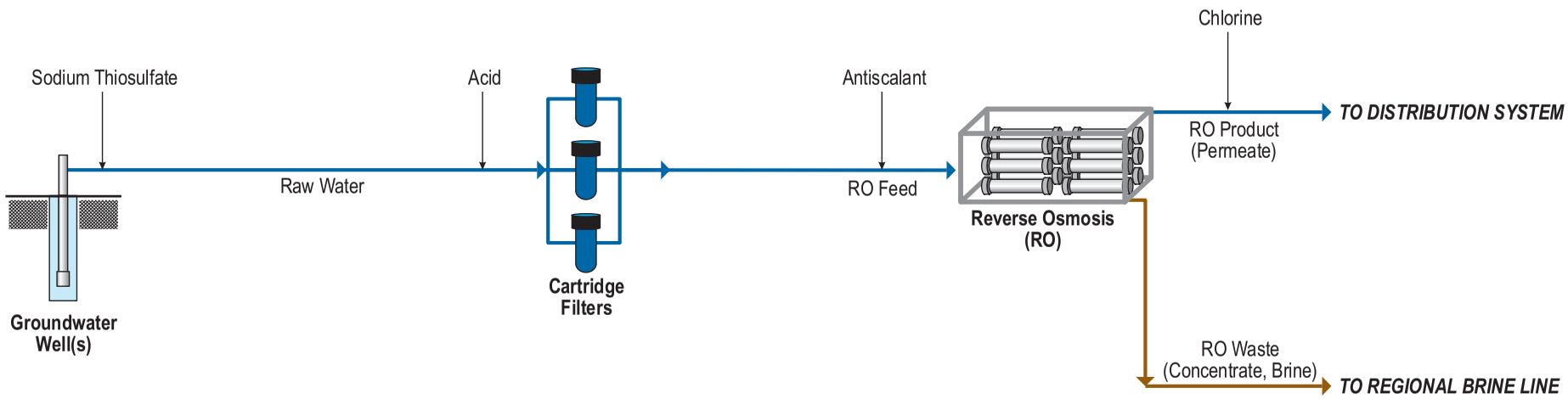
Granular Media Filtration

- *Dual media filters using sand and anthracite media*
- *Depth filtration was found to accelerate iron oxidation, removing nearly 100% of the iron from the feed water*
- *Non-oxidized manganese remains dissolved, passing through the media filters*
- *Backwash waste from the granular media filters will be directed to the sewer system*

Reverse Osmosis

- *Reverse osmosis is used to remove salinity and sulfates from the water, allowing the city to meet drinking water standards*
- *Lower salinity and sulfate in the drinking water will also improve wastewater plant effluent, helping to meet current and anticipated TMDLs*
- *Non-oxidized manganese in the water will be removed, along with other salts, without causing fouling*
- *A concentrate stream from the reverse osmosis system will be disposed of in the future brine line.*

Recommended Pretreatment Alternative: ***Aeration with Granular Media Filtration***



Sequestering

- *Sodium thiosulfate is added to quench dissolved oxygen (DO) in the raw water to slow down oxidation of iron and manganese.*

pH Adjustment

- *Acid is added to reduce the pH of RO Feed water to pH 6.5 to slow down oxidation of iron, and prevent scaling in the RO membranes.*

Reverse Osmosis

- *Reverse osmosis is used to remove salts, metals, and organic compounds from the water, allowing the city to meet drinking water standards.*
- *Lower salinity and sulfate in the drinking water will also improve wastewater plant effluent, helping to meet current and anticipated TMDLs.*
- *Non-oxidized iron and manganese in the water will be removed, along with other salts, without causing fouling*
- *A concentrate stream from the reverse osmosis system will be disposed of in the future brine line.*

Recommended Pretreatment Alternative: ***Sequestering***

B.2 Operator Training Workshop Presentation

City of Camarillo Brackish Water Desalination Pilot Study

Operator Training Workshop

October 9, 2007

CDM

Introductions

- Greg Wetterau, Project Manager
  WetterauGD@cdm.com
- Marie Burbano, Project Engineer
  BurbanoMS@cdm.com
- Evelyn You, Task Leader
  YouEC@cdm.com
- Chris Wessel, Field Engineer
  WesselCJ@cdm.com
- Stephanie Roberts, Field Engineer
  RobertsSC@cdm.com

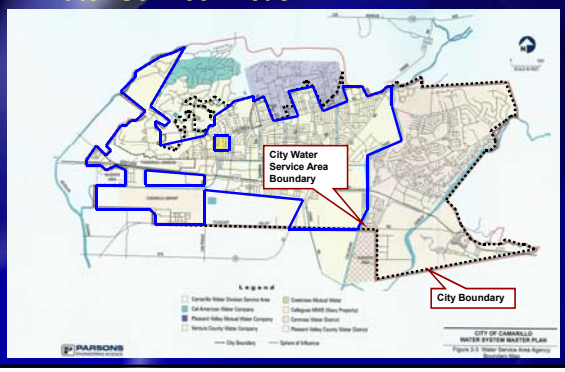
Outline

- Background
- Project Objectives
- Technology Overview
- Pilot Study Description and Testing Protocol
- Phase I Testing Preliminary Results
- Q&A

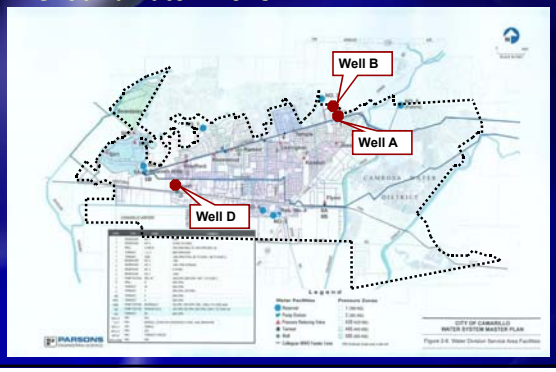
Background

- City provides water to 60% of City residents
- City obtains water from two sources:
  - Local groundwater wells
  - Imported water from Calleguas Municipal Water District

Water Service Areas



Groundwater Wells



Well A and Well B

- Groundwater quality from two wells (Wells A and B) have deteriorated:
  - High Total Dissolved Solids (TDS)
  - High Chloride (Cl)
  - High Sulfate (SO_4)
  - High Iron (Fe)
  - High Manganese (Mn)
- City normally operates by blending Well B water with the imported water to meet drinking water standards, and operates Well A on standby mode.

Capital Improvement Plan

- City's Goal:
  - Supply high quality water cost-effectively
  - Maximize the use of local water resources
- City's Plan:
  - Construct a groundwater treatment plant for Wells A and B, and a future well
  - Improve water supply reliability
  - Deliver high quality water from local groundwater resources

Current Water Quality & Goals

Parameter	Existing Water Quality* (mg/L)	Secondary or Recommended MCL (mg/L)	City's Water Quality Goal (mg/L)
TDS	~1700	500	300
Chloride	~160	250	80
Iron	~0.55	0.3	≤0.01**
Manganese	~0.18	0.05	≤0.01**

* Average of Well A and Well B data from Jan 2007.
** Water quality goals set based on removal method (i.e., RO)

Current Water Quality & Goals

Parameter	Existing Water Quality* (mg/L)	Secondary or Recommended MCL (mg/L)	City's Water Quality Goal (mg/L)
Calcium (mg/L)	~260	n/a	Varies – goal to prevent fouling
Sulfate (mg/L)	~755	250	
Silica (mg/L)	~39	n/a	
pH	7.2 – 7.8	n/a	

* Average of Well A and Well B data from Jan 2007. Silica was measured from Well A only in May 2004.

Project Objectives

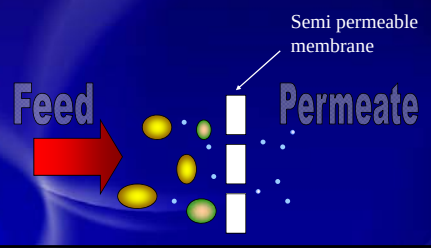
- Develop design criteria for a treatment process that supplies high quality water cost effectively
  - Evaluate water treatment technologies to reduce high levels of iron, manganese, chloride, TDS, and sulfate
  - Demonstrate the feasibility and effectiveness of the selected treatment scheme
  - Comply with water quality goals
  - Optimize the operation of the treatment processes for full-scale design criteria
  - Minimize chemical usage, process waste streams, and life-cycle cost

Technology Overview

- All contaminants of concern can be removed through desalination
- Oxidation and filtration may be required to increase reliability of desalination process
- Testing will focus on multiple oxidation/filtration approaches

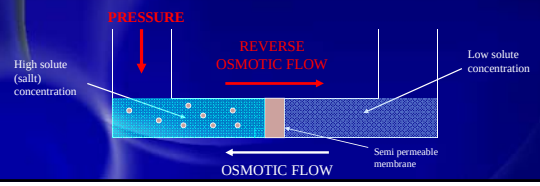
Desalination will be done by Reverse Osmosis (RO)

- Membrane is semi permeable: it only allows water to pass through it

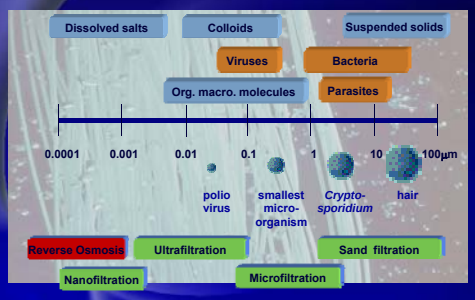


Why is it called reverse osmosis?

- Osmosis is the natural movement across membrane from low to higher solute concentration side
- Applied pressure reverses flow of osmosis by overcoming osmotic pressure



Reverse Osmosis (RO)



Membrane type defined by pore size

Reverse Osmosis (RO) Definitions

- Flux (Filtration Rate): Unit rate at which water passes through the membrane
  - $J = Q/A$
    - J = flux, gfd
    - Q = flow, gpd
    - A = membrane area, sf
- Transmembrane Pressure (TMP): Average pressure across the membrane
  - $TMP = (P_f + P_c)/2 - P_p$
    - P_f = feed pressure, psi
    - P_c = concentrate pressure, psi
    - P_p = permeate pressure, psi

Reverse Osmosis (RO) Definitions

- Osmotic pressure: Pressure induced by concentration difference across a membrane
  - $P_o = RT\ln(Xi)/V_w = (zRT/M)C$

    (Gibbs) (Van't Hoff)

    where: P_o = osmotic pressure;
    z = # of ions;
    C = mass concentration (g/L);
    M = molecular weight (g/mol);
    T = temperature (K);
    R = ideal gas law constant = 8.314 Pa-m^3/mol-K; and
    V_w = water molar volume = 0.018 L/mol
- Net driving pressure (NDP)
  - $NDP = TMP - P_o$

Reverse Osmosis (RO) Definitions

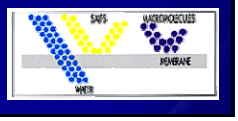
- Mass Transfer Coefficient (MTC) – Membrane resistance
  - Normalize rate at which water passes through the membrane
  - Commonly used to characterize membrane fouling, since it accounts for changes in concentration, filtration rate, and temperature
  - MTC = J / NDP

    where J = volumetric flux of water

    NDP = Net Driving Pressure

Reverse Osmosis (RO)

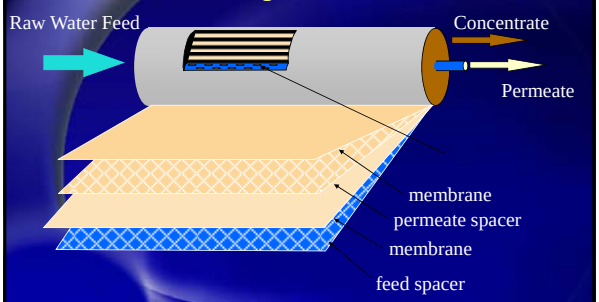
- Retains virtually all ions at > 98%
- Dissolved gases will pass (O_2, CO_2, H_2S)
- Typical Pressures
  - Brackish water RO: 150-600 psi
  - Seawater RO: 800-1,250 psi
- Typical Flux:
  - Brackish water RO: 10-20 gfd
  - Seawater RO: 10-15 gfd
- Recovery:
  - Brackish water RO: 60-90%
  - Seawater RO: 30-50%



Reverse Osmosis (RO) Membrane Materials

- Thin Film Composite (TFC)
  - Polysulfone support layer with polyamide membrane skin
  - Benefits
    - High porosity, high uniformity
    - Good pH range
  - Drawbacks
    - Low chlorine tolerance (no free chlorine)
    - Suffer from compaction

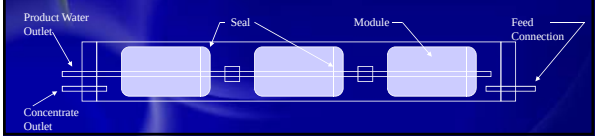
Reverse Osmosis (RO) Membrane Configuration



Spiral wound configuration

Reverse Osmosis (RO) Membrane Configuration

- Spiral wound:
  - Employ multiple elements in series
  - Last elements see highest concentrations
  - Cannot be backwashed
  - Do not reject at 100%



Reverse Osmosis (RO)

Membrane Fouling

- Fouling is the deposition of material onto the membrane surface, which impedes the production of water. The nature of the foulant can vary, as will methods of prevention and cleaning

Types of Fouling

- Scaling
  - Inorganic scale from calcium, silica, or magnesium
  - Easily controlled, but very bad for membrane if some scales form
- Biofouling
  - organic
  - Not easily controlled, can be difficult to clean
- Particulate
  - Can be organic or inorganic
  - Not easily controlled, can be difficult to clean

Particulate Fouling

- Main forms
  - Organic carbon
  - Iron, manganese, aluminum
  - Hydrogen sulfide
  - Sand and silt
- Can be prevented by either removing foulants, or preventing them from entering feed
- Many cause by air entrainment

Particulate Fouling - Oxidation of Iron, Sulfide, and Manganese

$$4Fe^{2+} + O_2 + 10\ H_20 \text{ -----> } 4Fe(OH)_3 + 8H^+$$

Ferrous Ion, Oxygen, Water, Ferric Hydroxide (precipitate)

$$2H_2S + O_2 \text{ -----> } 2S + 2H_2O$$

Hydrogen Sulfide, Oxygen, Sulfur (precipitate), Water

$$2Mn^{2+} + O_2 + 2\ H_20 \text{ -----> } 2MnO_2 + 4H^+$$

Manganese Ion, Oxygen, Water, Manganese Dioxide (precipitate)

Methods for Dealing With Fouling

- Preventative
  - Pretreatment (cartridge filters, acid, antiscalant, thiosulfate)
  - Reduce recovery
  - Careful monitoring of operations
- Restorative
  - Boost feed pressure
  - Chemical cleaning
  - Membrane replacement

Chemical Clean-in-Place

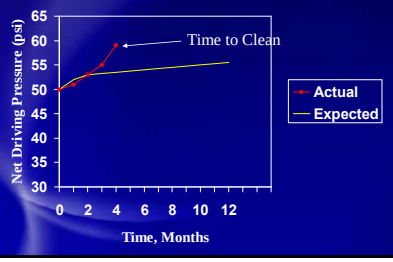
- Improves performance by eliminate scaling and fouling
- Prevent irreversible fouling and damage, which can be caused by excessive scaling or fouling
- Eliminate biological build-up, which can damage membranes and membrane performance

Cleaning Method

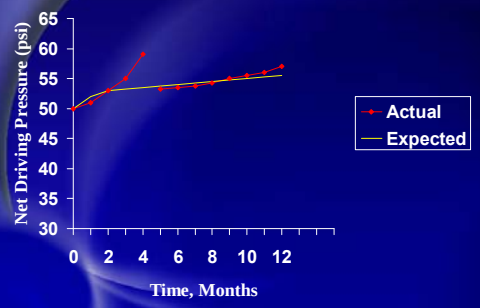
- Low pH solution for metallic scales/foulants
- High pH solution for biological, organic, and silica fouling
- High flow with low pressure
- Use warm water when possible
- Always follow guidelines of membrane manufacturer
- Improper cleaning can void warranty

When to Clean - Net Driving Pressure

- Whenever the net driving pressure increases 10-15% above expected, it is time to chemically clean the unit
- May also clean on increased TDS or pressure drop



Successful Cleaning



Chemical Pretreatment

- Antiscalant added to prevent silica and calcium scaling
- Sodium thiosulfate used at wells to remove oxygen and prevent oxidation of iron and manganese:

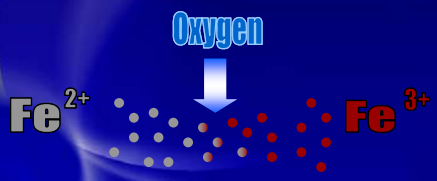
  $2NaHSO_3 + O_2 \rightarrow 2NaHSO_4$
- Chemical usage may be costly
- Will only be effective when iron oxidation has not already occurred

Oxidation Alternatives

- Oxidation will be used in pilot to aid in removal of iron and manganese upstream of RO
- Oxidized metals insoluble and relatively easy to filter out of the water
- Oxidizing agents include:
  - Aeration
  - Chlorine Dioxide
  - Chlorine

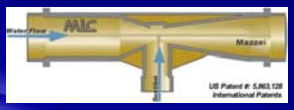
Oxidation using Aeration

- Oxygen introduced to the feed water to oxidize iron and keep manganese in its dissolved state.
- Oxidation of iron using oxygen is fast (seconds)
- Oxidation of manganese with oxygen is slow (more than 24 hours) so it should not occur within the pilot system



Oxidation using Aeration

- Oxygen added to the water through a Mazzei Model 1584-A Injector provided by the Mazzei Injector Corporation (MIC) located in Bakersfield, California
- It operates in-line with a suction port to pull air into the line, dissolving oxygen into solution
- No chemical addition required
- Oxidized iron will foul RO membranes, if not removed



Mazzei Model 1584-A Injector

Oxidation using Chlorine Dioxide

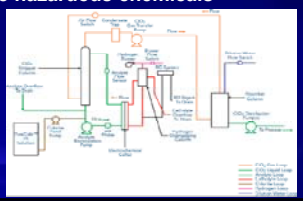
- Strong oxidant that quickly oxidizes both iron and manganese
- Unlike chlorine and ozone, will not damage RO elements
- No disinfection byproducts
- Most effective method for oxidizing both iron and manganese

Oxidation using Chlorine Dioxide

- Requires ultra-pure system (>99% pure) to prevent damage to RO membranes
- Generated onsite by a Pureline 3 lb/day generator
- Can be costly, complex, and often requires handling of multiple hazardous chemicals

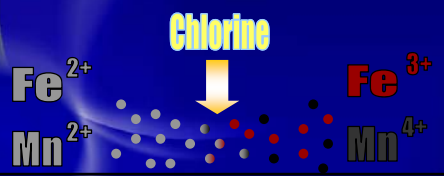
Process flow diagram

Source: Pureline



Oxidation using Chlorine (Hypochlorite)

- Oxidizes both iron and manganese
- Manganese oxidation can be slow, taking up to 30 minutes to complete
- Use pyrolusite as a catalyst to accelerate oxidation of manganese using chlorine



Oxidation using Chlorine

Disadvantages

- Can cause disinfection byproducts
- Will destroy RO membranes, requiring dechlorination ahead of RO

Advantages

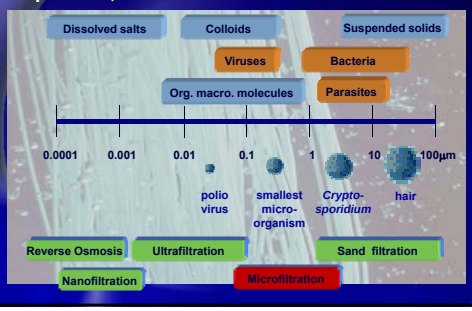
- Inexpensive
- Already in use at all well sites
- Most common method

Filtration

- Filtration removes oxidized iron and manganese ahead of reverse osmosis
- Pilot will look at:
  - Membrane filtration (microfiltration)
  - Granular media filtration
  - Catalyzing media filtration

Microfiltration (MF)

- Pressure driven membrane separation process, similar to RO

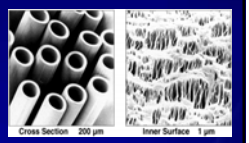


Microfiltration (MF)

- Filtration process
- Removes suspended solids, bacteria, and some viruses.
- Operating Pressure: Typically 10-30 psi
- Typical Flux: 30-40 gfd
- 90-98% Recovery, backwashing once every 30-40 minutes
- MF skid used: Siemens Memcor CMF L20 skid employing a low pressure microfiltration with a nominal pore size of 0.04 microns

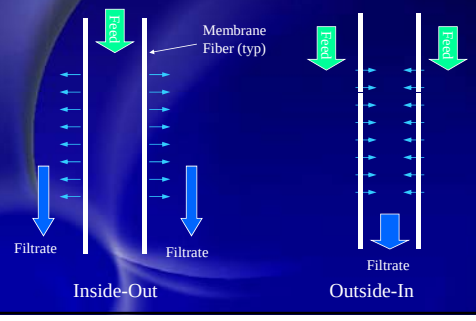
Microfiltration (MF)

- Polyvinyl Difluoride (PVDF)
  - MF/UF only
  - Benefits: - Chlorine tolerant
    - Low fouling from organics
- Hollow fiber membranes
  - Can be backwashed
  - Highest area/volume ratio
  - 100% rejection common
  - Generally limited to MF/UF



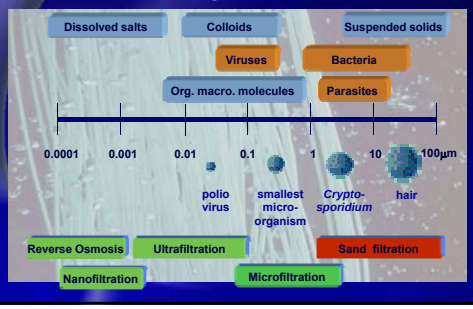
Microfiltration (MF)

- Hollow fiber membranes



Granular Media Filtration

- Removal highly dependent on filtration rate and other operating conditions



Granular Media Filtration

- Dual media filters using sand/anthracite
- Removal highly impacted by operating conditions
- Breakthrough can occur from high flowrates, dirty filters, or changes in feed water quality
- Operating Pressure: Typically 10-15 psi
- 97-99% Recovery, backwashing once every several days

Granular Media Filtration

- Multimedia Filters
  - Number: 3 vessels
  - Flowrate: 20 to 30 gpm
  - Filtration Rate: 5 gpm/sf
  - PVC pressure vessels
  - Media:
    - 18-inch anthracite
    - 18-inch silica sand

Catalyzing Media

- Manganese dioxide (pyrolucite) is a high-rate, granular filter media that operates both as a classical filter and as a catalyzing media
- Accelerates oxidation of manganese using chlorine within seconds in lieu of 30 minutes in general
- Regenerates as it is used
- Most common method for removing iron and manganese from well water

Pyrolucite

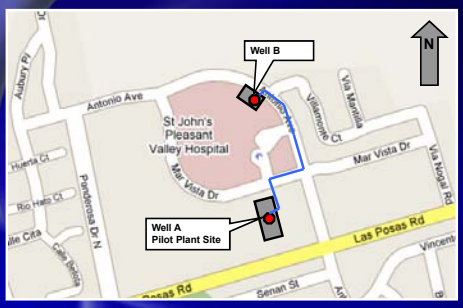
Catalyzing Media

- Most common form is greensand
  - Manganese dioxide coated silica
  - Requires conditioning with permanganate
- Pure pyrolucite available as
  - Laynox
  - Pyrolox
- Backwash to remove dirt, debris, and iron oxide
- Dense media can be difficult to backwash

Pilot Study Description and Testing Protocol

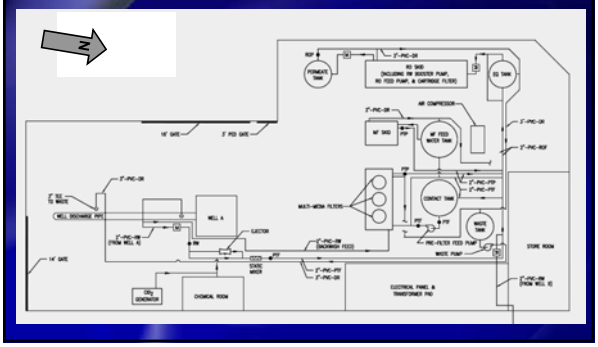
- Location
- Site Layout
- Pilot Study Schedule
- Testing Phases and Sampling Protocol

Pilot Plant Location

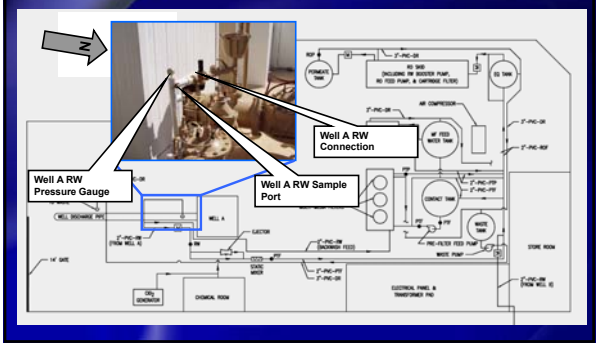


Well B Connection

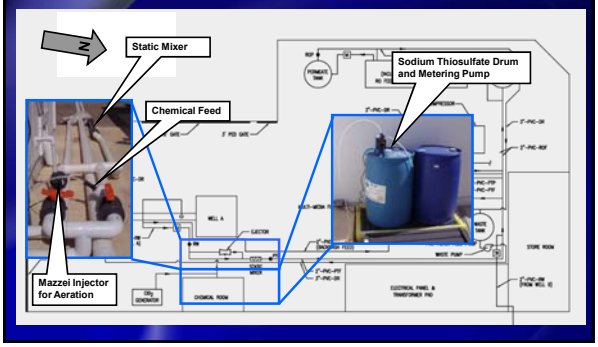
Well A Pilot Plant Site Layout



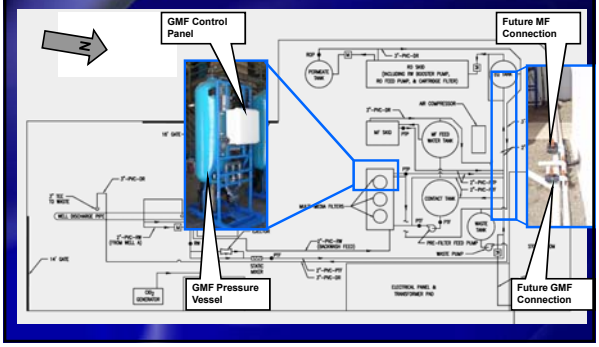
Well A Connection



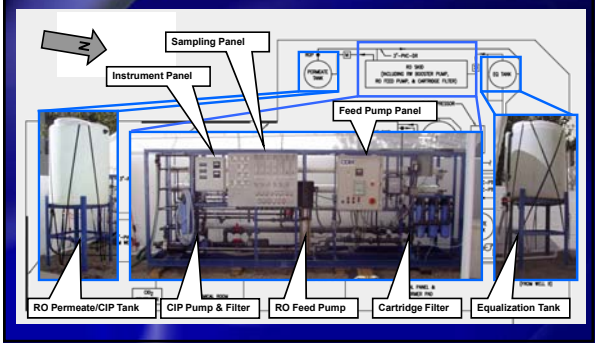
Oxidation



Pretreatment



Reverse Osmosis (RO)



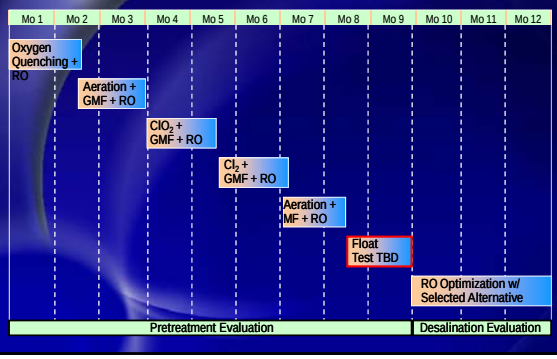
Reverse Osmosis (RO)

- RO skid used for the pilot plant study:
- CDM's NF/RO Pilot Skid No.1 designed to test nanofiltration or reverse osmosis membranes
- Skid-mounted and can treat feed water of up to a total dissolved solids (TDS) level of 5000 mg/L
- Can conduct tests on membrane softening at recovery rates up to 92 percent
- Can operate up to 30-gpm and 280-psi

Reverse Osmosis (RO)

- Two stages of pressure vessels in a 2:1 array with four elements per vessel
- First stage = four 4-inch diameter vessels containing four membrane elements each connected => two parallel 8-element vessels
- Second stage = two 4-inch diameter vessels each connected => one 8-element vessel

Pilot Study Schedule



Sample Streams

- RW – Raw Water (i.e., untreated well water)
- PTF – Pretreatment Feed
- PTP – Pretreatment Product
- PTW – Pretreatment Waste (i.e., GMF or MF backwash water)
- ROF – RO Feed
- ROP – RO Product (i.e., RO Permeate)
- ROW – RO Waste (i.e., RO Concentrate)

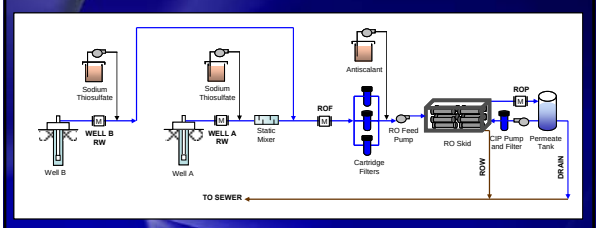
Phase I
Oxygen Quenching + RO

- Purpose:
  - Determine if iron and/or manganese oxidation could be prevented if sodium thiosulfate is added at the wellhead to consume dissolved oxygen
- Note:
  - If oxygen is present, iron and/or manganese may oxidize and cause excessive RO membrane fouling

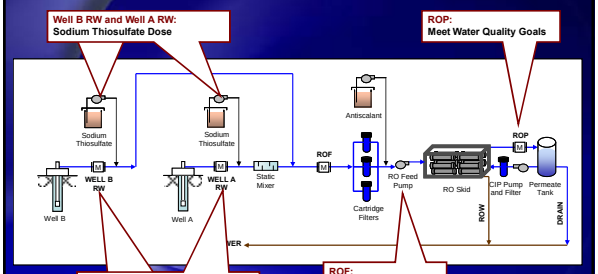
Phase I
Oxygen Quenching + RO

- Dose sodium thiosulfate to quench DO and keep Fe and Mn in reduced state
- Monitor DO, Total Fe, Dissolved Fe, and Total Mn in ROF
  - Want to see:
    - DO ≈ 0
    - Particulate Fe = Total Fe – Dissolved Fe ≈ 0
- Monitor RO feed pressure to check RO fouling

Phase I
Oxygen Quenching + RO



Phase I
Oxygen Quenching + RO



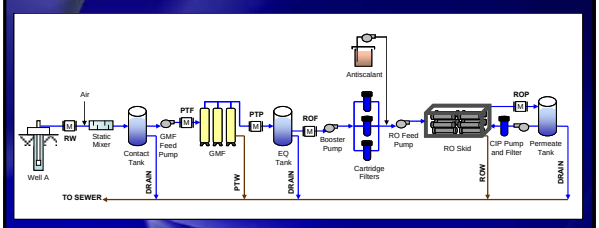
Phase II
Aeration + GMF + RO

- Purpose:
  - Determine if aeration plus GMF will effectively remove iron oxide through the GMF and keep manganese in the reduced state so that it is removed by the RO
- Notes:
  - Aeration will provide O2 to oxidize iron while keeping manganese in a reduced state (reaction is slower)
  - Aeration is the least costly method with no need of chemical oxidation

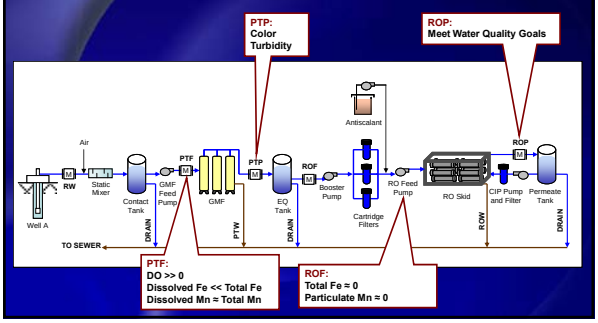
Phase II
Aeration + GMF + RO

- Introduce air into RW using Mazzei injector to oxidize Fe while keeping Mn in reduced state
- Remove all iron oxides using GMF
- Check Color and Turbidity in PTP for breakthrough
- Monitor Fe and Mn in PTF and ROF
  - In PTF, want to see:
    - Dissolved Fe << Total Iron
    - Dissolved Mn ≈ Total Mn
  - In ROF, want to see:
    - Total Fe ≈ 0
    - Particulate Mn ≈ 0

Phase II
Aeration + GMF + RO



Phase II
Aeration + GMF + RO



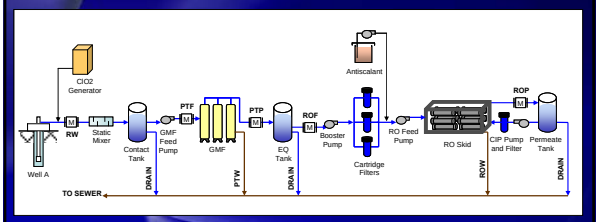
Phase III
Chlorine Dioxide (ClO_2) + GMF + RO

- Purpose:
  - Determine if chlorine dioxide will oxidize both iron and manganese to allow iron and manganese oxides to be effectively removed through GMF
- Note:
  - ClO_2 strong oxidant that quickly oxidizes both iron and manganese so that they could be removed by the GMF
  - ClO_2 will be generated onsite and needs to be as pure as possible. This method may be the most costly

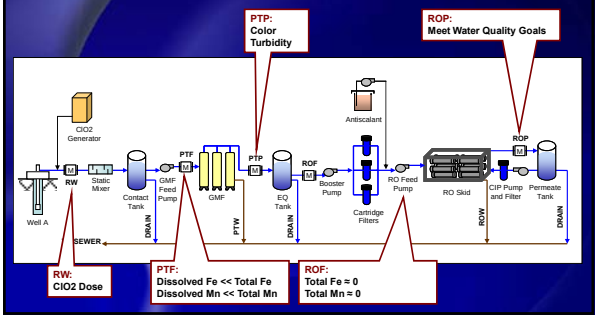
Phase III
Chlorine Dioxide (ClO_2) + GMF + RO

- Feed ClO_2 in RW to oxidize Fe and Mn
- Remove iron and manganese oxides using GMF
- Check Color and Turbidity in PTP for breakthrough
- Monitor Fe and Mn in PTF and ROF
  - In PTF, want to see:
    - Dissolved Fe << Total Iron
    - Dissolved Mn << Total Mn
  - In ROF, want to see:
    - Total Fe ≈ 0
    - Total Mn ≈ 0

Phase III
Chlorine dioxide (ClO_2) + GMF + RO



Phase III
Chlorine Dioxide (ClO_2) + GMF + RO



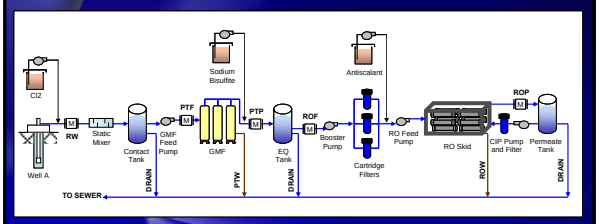
Phase IV
Cl_2 + Catalyzing Media Filters + RO

- Purpose:
  - Evaluate chlorine oxidation of both iron and manganese using a catalytic media such as pure or partially pure manganese dioxide (pyrolucite)
- Note:
  - Sodium thiosulfate will be used ahead of RO to prevent damages to the elements by residual chlorine
  - Process most commonly used to remove iron and manganese from groundwater

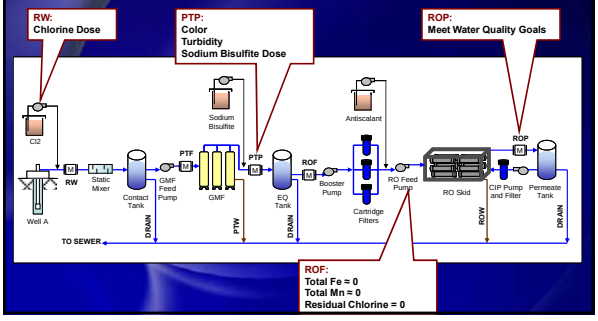
Phase IV
Cl_2 + Catalyzing Media Filters + RO

- Feed chlorine in RW to oxidize Fe
- Pyrolucite to catalyze Mn oxidation and remove iron and manganese oxides
- Check Color and Turbidity in PTP for breakthrough
- Monitor Fe, Mn, and Residual Chlorine in ROF. Want to see:
  - Total Fe ≈ 0
  - Total Mn ≈ 0
  - Residual Chlorine = 0

Phase IV
Cl_2 + Catalyzing Media Filters + RO



Phase IV
Cl_2 + Catalyzing Media Filters + RO



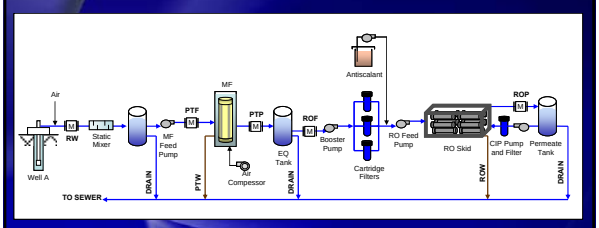
Phase V
Aeration + MF + RO

- Purpose:
  - Determine if aeration plus MF will effectively remove iron through MF and keep manganese in the reduced state so that it is removed by the RO
- Note:
  - Similar to Phase II testing
  - MF should remove more iron oxide than GMF due to smaller pore size
  - Process optimization is required to determine which of MF and GMF will be more cost effective in a full-scale facility

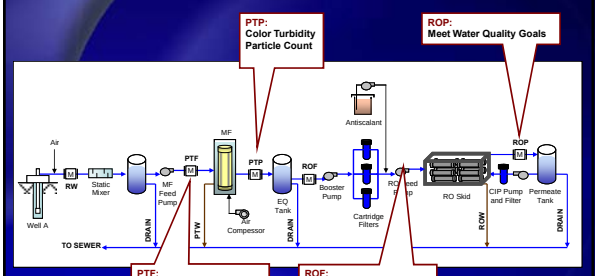
Phase V
Aeration + MF + RO

- Introduce air into RW using eductor to oxidize Fe while keeping Mn in reduced state
- Remove all iron oxides using GMF
- Check Color, Turbidity, and Particle Count in PTP for breakthrough
- Monitor Fe and Mn in PTF and ROF
  - In PTF, want to see:
    - Dissolved Fe << Total Iron
    - Dissolved Mn ≈ Total Mn
  - In ROF, want to see:
    - Total Fe ≈ 0
    - Particulate Mn ≈ 0

Phase V
Aeration + MF + RO



Phase V
Aeration + MF + RO



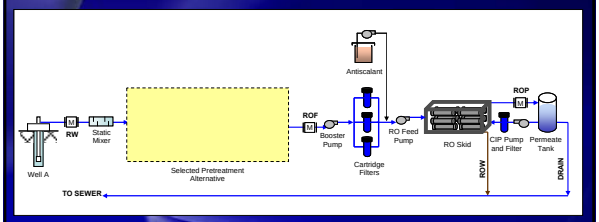
Phase VI
RO Optimization w/ Selected Pretreatment

- Purpose:
  - Optimize the RO process for recovery, finished water quality and energy usage and achieve the lowest operating costs
- Notes:
  - Will use selected pretreatment process and RO membranes from a various list including brackish RO and nanofiltration membranes
  - Will run two parallel desalination trains

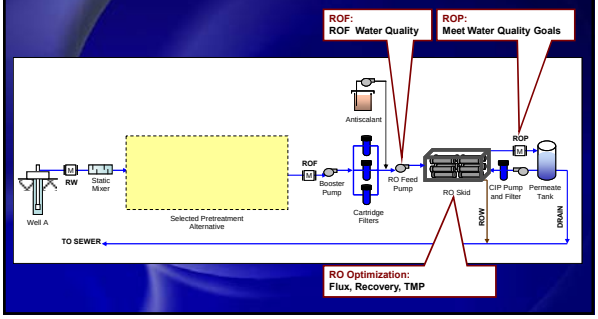
Phase VI
RO Optimization w/ Selected Pretreatment

- Use selected pretreatment alternative
- Test different membrane types and configuration
- Monitor:
  - Flux, recovery, and transmembrane pressure (TMP)
  - Finished water quality
  - Energy usage
  - Operating costs

Phase VI
RO Optimization w/ Selected Pretreatment



Phase VI
RO Optimization w/ Selected Pretreatment



Equipment Performance Indicators

- Flow rate and pressure are good indicators of fouling
  - Differential Pressure
    - GMF
    - Cartridge Filters
  - Transmembrane Pressure of MF
  - Feed Pressure of RO
- Conductivity is a good indicator of RO membrane short-circuit

Water Quality Parameters of Interest

- Parameters measured 3 to 7 days/week:
  - Temperature & pH
  - Conductivity
  - Dissolved Oxygen (DO)
  - Redox Potential (ORP)
  - Total Iron & Dissolved Iron
  - Total Manganese
  - UV254
  - Apparent Color
  - Turbidity

Weekly Sampling

- Silt Density Index (SDI)
- Alkalinity, Total Hardness, TSS, TDS
- Metals
  - Fe, Mn, Ca, Mg, Na, B, V
- Sulfate
- Silica
- Chloride
- Ammonia Nitrogen
- TOC
- Gross Alpha

Monthly Sampling

- Barium
- Strontium

Emerging Contaminants

- Detection of new contaminants at very low levels now possible
- State of California is a leader in the domain of emerging contaminants regulations
- Evaluated data from wells A and B to identify which emerging contaminants will need to be monitored

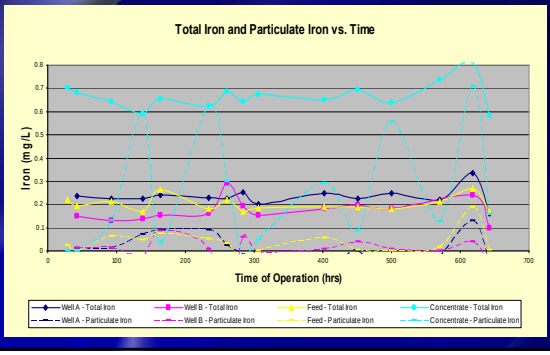
Emerging Contaminants

- 33 unregulated chemicals have notification levels (NLs) and/or monitoring requirements established by the California Department of Public Health (CDPH)
- 10 chemicals appear on List 1 (Assessment Monitoring) for EPA's Unregulated Contaminant Monitoring Rule 2 (UCMR 2) and 15 chemicals appear on List 2 (Screening survey) for EPA's UCMR 2
- Pesticides of relatively high use in Ventura County

Emerging Contaminants Sampling Plan

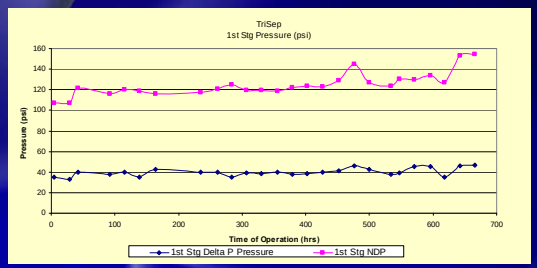
- Three of CDHS's 33 Unregulated Chemicals
  - Boron, Vanadium, Hexavalent Chromium
- Three Pesticides commonly used in Ventura County
  - Chloropicrin
  - Methyl Bromide (bromomethane)
  - 1,3-Dichloropropene (cis and trans)
- One of EPA's UCMR2 Chemicals
  - N-nitroso-dimethylamine (NDMA)

Phase I Testing Preliminary Results



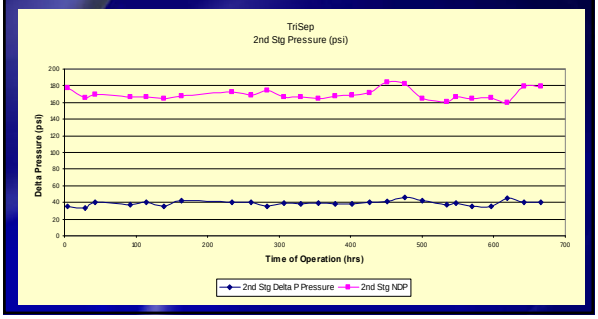
Phase I Testing Preliminary Results

- Pressure
  - First stage



Phase I Testing Preliminary Results

- Second stage



Topics Covered

- Background
- Project Objectives
- Technology Overview
- Pilot Study Description and Testing Protocol
- Phase I Testing Preliminary Results

City of Camarillo
Brackish Water Desalination
Pilot Study

Q & A

Operator Training Workshop
October 9, 2007

CDM

Appendix C – Final Emerging Contaminant Evaluation

C.1 Pre-existing monitoring data on unregulated chemicals

The following tables present the pre-existing monitoring data for unregulated chemicals[1] in the City of Camarillo's Wells A1 and B2, summarized from data provided by the City of Camarillo (Smith, 2007b). The raw data were provided by CDPH (Mike Ali, CDHS-DWFOB-Santa Barbara) to the City of Camarillo.

The data are for Public Water System (PWS) Number 5610019, Camarillo Water Division. Data are provided for the following groundwater sources:

Source No. 005 with Name: WELL A 1 – STANDBY

Source No. 007 with Name: WELL B-2

C.1.1 Available Data for Chemicals with CDPH Notification Levels (NLs)

Table C.1 – Boron Data

Chemical	Date	Result	NL*	DLR**	Unit
Well A 1-Standby					
Boron	5/29/2003	0.48	1	0.1	mg/l
Boron	5/13/2004	0.54	1	0.1	mg/l
Boron	1/31/2007	0.65	1	0.1	mg/l
Well B2					
Boron	1/20/1998	< DL	1	0.1	mg/l
Boron	4/11/2001	0.36	1	0.1	mg/l
Boron	7/11/2001	0.32	1	0.1	mg/l
Boron	10/3/2001	0.37	1	0.1	mg/l
Boron	1/24/2002	0.27	1	0.1	mg/l
Boron	7/24/2002	0.38	1	0.1	mg/l
Boron	1/21/2004	0.5	1	0.1	mg/l
Boron	4/7/2004	0.43	1	0.1	mg/l
Boron	5/13/2004	0.46	1	0.1	mg/l

* NL = CDHS Notification Level

** DLR = Detection Limit for the Purpose of Reporting

> DLR

[1] Unregulated chemicals with notification levels and/or unregulated chemicals requiring monitoring under Title 22 CCR and available data for chemicals listed in the EPA UCMR 2

Table C.2 - n-Butylbenzene Data

Chemical	Date	Result	NL*	DLR**	Unit
Well A 1-Standby					
n-Butylbenzene	5/23/1994	< DL	0.26	0.0005	mg/l
n-Butylbenzene	5/16/1996	< DL	0.26	0.0005	mg/l
Well B2					
n-Butylbenzene	4/27/1994	< DL	0.26	0.0005	mg/l
n-Butylbenzene	5/15/1996	< DL	0.26	0.0005	mg/l
n-Butylbenzene	5/11/1999	< DL	0.26	0.0005	mg/l
n-Butylbenzene	5/22/2002	< DL	0.26	0.0005	mg/l

* NL = CDHS Notification Level
** DLR = Detection Limit for the Purpose of Reporting

Table C.3 - sec-Butylbenzene Data

Chemical	Date	Result	NL*	DLR**	Unit
Well A 1-Standby					
sec-Butylbenzene	5/23/1994	< DL	0.26	0.0005	mg/l
sec-Butylbenzene	5/16/1996	< DL	0.26	0.0005	mg/l
Well B2					
sec-Butylbenzene	4/27/1994	< DL	0.26	0.0005	mg/l
sec-Butylbenzene	5/15/1996	< DL	0.26	0.0005	mg/l
sec-Butylbenzene	5/11/1999	< DL	0.26	0.0005	mg/l
sec-Butylbenzene	5/22/2002	< DL	0.26	0.0005	mg/l

* NL = CDHS Notification Level
** DLR = Detection Limit for the Purpose of Reporting

Table C.4 - tert-Butylbenzene Data

Chemical	Date	Result	NL*	DLR**	Unit
Well A 1-Standby					
tert-Butylbenzene	5/23/1994	< DL	0.26	0.0005	mg/l
tert-Butylbenzene	5/16/1996	< DL	0.26	0.0005	mg/l
Well B2					
tert-Butylbenzene	4/27/1994	< DL	0.26	0.0005	mg/l
tert-Butylbenzene	5/15/1996	< DL	0.26	0.0005	mg/l
tert-Butylbenzene	5/11/1999	< DL	0.26	0.0005	mg/l
tert-Butylbenzene	5/22/2002	< DL	0.26	0.0005	mg/l

* NL = CDHS Notification Level
** DLR = Detection Limit for the Purpose of Reporting

Table C.5 - 2-Chlorotoluene Data

Chemical	Date	Result	NL*	DLR**	Unit
Well A 1-Standby					
2-Chlorotoluene	5/23/1994	< DL	0.14	0.0005	mg/l
2-Chlorotoluene	5/16/1996	< DL	0.14	0.0005	mg/l
Well B2					
2-Chlorotoluene	4/27/1994	< DL	0.14	0.0005	mg/l
2-Chlorotoluene	5/15/1996	< DL	0.14	0.0005	mg/l
2-Chlorotoluene	5/11/1999	< DL	0.14	0.0005	mg/l
2-Chlorotoluene	5/22/2002	< DL	0.14	0.0005	mg/l

* NL = CDHS Notification Level

** DLR = Detection Limit for the Purpose of Reporting

Table C.6 - 4-Chlorotoluene Data

Chemical	Date	Result	NL*	DLR**	Unit
Well A 1-Standby					
4-Chlorotoluene	5/23/1994	< DL	0.14	0.0005	mg/l
4-Chlorotoluene	5/16/1996	< DL	0.14	0.0005	mg/l
Well B2					
4-Chlorotoluene	4/27/1994	< DL	0.14	0.0005	mg/l
4-Chlorotoluene	5/15/1996	< DL	0.14	0.0005	mg/l
4-Chlorotoluene	5/11/1999	< DL	0.14	0.0005	mg/l
4-Chlorotoluene	5/22/2002	< DL	0.14	0.0005	mg/l

* NL = CDHS Notification Level

** DLR = Detection Limit for the Purpose of Reporting

Table C.7 - Dichlorodifluoromethane (Freon 12) Data

Chemical	Date	Result	NL*	DLR**	Unit
Well A 1-Standby					
Dichlorodifluoromethane (Freon 12)	5/23/1994	< DL	1	0.001	mg/l
Dichlorodifluoromethane (Freon 12)	5/16/1996	< DL	1	0.001	mg/l
Well B2					
Dichlorodifluoromethane (Freon 12)	4/27/1994	< DL	1	0.001	mg/l
Dichlorodifluoromethane (Freon 12)	5/15/1996	< DL	1	0.001	mg/l
Dichlorodifluoromethane (Freon 12)	5/11/1999	< DL	1	0.001	mg/l
Dichlorodifluoromethane (Freon 12)	1/24/2002	< DL	1	0.0005	mg/l
Dichlorodifluoromethane (Freon 12)	5/22/2002	< DL	1	0.0005	mg/l
Dichlorodifluoromethane (Freon 12)	7/24/2002	< DL	1	0.0005	mg/l

* NL = CDHS Notification Level

** DLR = Detection Limit for the Purpose of Reporting

Table C.8 – Isopropylbenzene Data

Chemical	Date	Result	NL*	DLR**	Unit
Well A 1-Standby					
Isopropylbenzene	5/23/1994	< DL	0.77	0.0005	mg/l
Isopropylbenzene	5/16/1996	< DL	0.77	0.0005	mg/l
Well B2					
Isopropylbenzene	4/27/1994	< DL	0.77	0.0005	mg/l
Isopropylbenzene	5/15/1996	< DL	0.77	0.0005	mg/l
Isopropylbenzene	5/11/1999	< DL	0.77	0.0005	mg/l
Isopropylbenzene	5/22/2002	< DL	0.77	0.0005	mg/l

* NL = CDHS Notification Level
** DLR = Detection Limit for the Purpose of Reporting

Table C.9 – Manganese Data

Chemical	Date	Result	NL*	DLR**	Unit
Well A 1-Standby					
Manganese	1/14/1994	0.064	0.5	0.01	mg/l
Manganese	5/23/1994	0.09	0.5	0.01	mg/l
Manganese	5/23/1994	0.095	0.5	0.01	mg/l
Manganese	1/26/1995	0.121	0.5	0.01	mg/l
Manganese	4/3/1995	0.122	0.5	0.01	mg/l
Manganese	7/19/1995	0.178	0.5	0.01	mg/l
Manganese	10/3/1995	0.213	0.5	0.01	mg/l
Manganese	1/9/1996	0.245	0.5	0.01	mg/l
Manganese	7/15/1996	0.22	0.5	0.01	mg/l
Manganese	10/9/1996	0.205	0.5	0.01	mg/l
Manganese	1/29/1997	0.189	0.5	0.01	mg/l
Manganese	4/29/1997	0.163	0.5	0.01	mg/l
Manganese	7/16/1997	0.18	0.5	0.01	mg/l
Manganese	10/22/1997	0.186	0.5	0.01	mg/l
Manganese	1/14/1998	<0.03	0.5	0.01	mg/l
Manganese	4/22/1998	0.197	0.5	0.01	mg/l
Manganese	7/16/1998	0.162	0.5	0.01	mg/l
Manganese	8/11/1999	0.15	0.5	0.01	mg/l
Manganese	9/8/1999	0.179	0.5	0.01	mg/l
Manganese	5/29/2003	0.17	0.5	0.01	mg/l
Manganese	5/13/2004	0.24	0.5	0.01	mg/l
Manganese	1/31/2007	0.19	0.5	0.01	mg/l

Table C.9 – Manganese Data (continued)

Chemical	Date	Result	NL*	DLR**	Unit
Well B2					
Manganese	3/3/1994	0.059	0.5	0.01	mg/l
Manganese	4/20/1994	0.063	0.5	0.01	mg/l
Manganese	4/27/1994	0.06	0.5	0.01	mg/l
Manganese	1/1/1995	0.059	0.5	0.01	mg/l
Manganese	4/4/1995	<0.03	0.5	0.01	mg/l
Manganese	7/18/1995	0.06	0.5	0.01	mg/l
Manganese	10/4/1995	0.079	0.5	0.01	mg/l
Manganese	1/9/1996	0.082	0.5	0.01	mg/l
Manganese	7/15/1996	0.065	0.5	0.01	mg/l
Manganese	10/9/1996	0.106	0.5	0.01	mg/l
Manganese	1/17/1997	0.093	0.5	0.01	mg/l
Manganese	4/16/1997	0.065	0.5	0.01	mg/l
Manganese	7/15/1997	0.07	0.5	0.01	mg/l
Manganese	10/14/1997	0.08	0.5	0.01	mg/l
Manganese	1/13/1998	0.08	0.5	0.01	mg/l
Manganese	1/20/1998	0.08	0.5	0.01	mg/l
Manganese	4/15/1998	0.072	0.5	0.01	mg/l
Manganese	7/8/1998	0.0733	0.5	0.01	mg/l
Manganese	8/12/1998	0.0472	0.5	0.01	mg/l
Manganese	9/9/1998	0.08	0.5	0.01	mg/l
Manganese	10/7/1998	0.108	0.5	0.02	mg/l
Manganese	12/9/1998	0.086	0.5	0.02	mg/l
Manganese	1/13/1999	0.08	0.5	0.02	mg/l
Manganese	2/10/1999	0.038	0.5	0.02	mg/l
Manganese	3/2/1999	0.076	0.5	0.02	mg/l
Manganese	4/14/1999	0.086	0.5	0.02	mg/l
Manganese	5/12/1999	0.079	0.5	0.02	mg/l
Manganese	6/9/1999	0.073	0.5	0.02	mg/l
Manganese	7/7/1999	0.282	0.5	0.02	mg/l
Manganese	12/8/1999	0.1	0.5	0.02	mg/l
Manganese	1/12/2000	0.084	0.5	0.02	mg/l
Manganese	2/9/2000	0.096	0.5	0.02	mg/l
Manganese	3/8/2000	0.108	0.5	0.02	mg/l
Manganese	4/13/2000	0.074	0.5	0.02	mg/l
Manganese	6/14/2000	0.0883	0.5	0.02	mg/l
Manganese	7/5/2000	0.079	0.5	0.02	mg/l
Manganese	9/13/2000	0.082	0.5	0.02	mg/l
Manganese	10/11/2000	0.096	0.5	0.02	mg/l
Manganese	12/6/2000	0.101	0.5	0.02	mg/l
Manganese	4/11/2001	0.11	0.5	0.02	mg/l
Manganese	5/9/2001	0.08	0.5	0.02	mg/l
Manganese	6/7/2001	0.082	0.5	0.02	mg/l
Manganese	7/11/2001	0.15	0.5	0.02	mg/l

Table C.9 – Manganese Data (continued)

Chemical	Date	Result	NL*	DLR**	Unit
Well B2					
Manganese	8/8/2001	0.1	0.5	0.02	mg/l
Manganese	9/5/2001	0.098	0.5	0.02	mg/l
Manganese	10/3/2001	0.089	0.5	0.02	mg/l
Manganese	11/7/2001	0.13	0.5	0.02	mg/l
Manganese	12/5/2001	0.12	0.5	0.02	mg/l
Manganese	1/7/2002	0.14	0.5	0.02	mg/l
Manganese	3/20/2002	0.069	0.5	0.02	mg/l
Manganese	4/3/2002	0.1	0.5	0.02	mg/l
Manganese	4/24/2002	0.1	0.5	0.02	mg/l
Manganese	5/1/2002	0.12	0.5	0.02	mg/l
Manganese	6/5/2002	0.11	0.5	0.02	mg/l
Manganese	7/3/2002	0.12	0.5	0.02	mg/l
Manganese	8/7/2002	0.11	0.5	0.02	mg/l
Manganese	9/4/2002	0.13	0.5	0.02	mg/l
Manganese	10/2/2002	0.11	0.5	0.02	mg/l
Manganese	11/6/2002	0.14	0.5	0.02	mg/l
Manganese	12/4/2002	0.1	0.5	0.02	mg/l
Manganese	2/5/2003	0.12	0.5	0.02	mg/l
Manganese	3/4/2003	0.18	0.5	0.02	mg/l
Manganese	4/2/2003	0.17	0.5	0.02	mg/l
Manganese	5/7/2003	0.15	0.5	0.02	mg/l
Manganese	6/4/2003	0.13	0.5	0.02	mg/l
Manganese	7/2/2003	0.13	0.5	0.02	mg/l
Manganese	8/7/2003	0.13	0.5	0.02	mg/l
Manganese	9/3/2003	0.12	0.5	0.02	mg/l
Manganese	10/1/2003	0.1	0.5	0.02	mg/l
Manganese	11/5/2003	0.16	0.5	0.02	mg/l
Manganese	12/2/2003	0.16	0.5	0.02	mg/l
Manganese	1/6/2004	0.18	0.5	0.02	mg/l
Manganese	1/21/2004	0.17	0.5	0.02	mg/l
Manganese	2/3/2004	0.16	0.5	0.02	mg/l
Manganese	3/2/2004	0.14	0.5	0.02	mg/l
Manganese	4/7/2004	0.15	0.5	0.02	mg/l
Manganese	4/7/2004	0.13	0.5	0.02	mg/l
Manganese	5/5/2004	0.18	0.5	0.02	mg/l
Manganese	5/13/2004	0.2	0.5	0.02	mg/l
Manganese	6/2/2004	0.16	0.5	0.02	mg/l
Manganese	7/14/2004	0.17	0.5	0.02	mg/l
Manganese	7/15/2004	0.15	0.5	0.02	mg/l
Manganese	8/4/2004	0.16	0.5	0.02	mg/l
Manganese	9/15/2004	0.14	0.5	0.02	mg/l
Manganese	10/7/2004	0.15	0.5	0.02	mg/l
Manganese	11/3/2004	0.14	0.5	0.02	mg/l

Table C.9 – Manganese Data (continued)

Chemical	Date	Result	NL*	DLR**	Unit
Well B2					
Manganese	1/5/2005	0.14	0.5	0.02	mg/l
Manganese	2/1/2005	0.15	0.5	0.02	mg/l
Manganese	3/10/2005	0.15	0.5	0.02	mg/l
Manganese	8/17/2005	0.15	0.5	0.02	mg/l
Manganese	9/7/2005	0.15	0.5	0.02	mg/l
Manganese	10/10/2005	0.14	0.5	0.02	mg/l
Manganese	11/9/2005	0.16	0.5	0.02	mg/l
Manganese	12/6/2005	0.15	0.5	0.02	mg/l
Manganese	1/9/2006	0.15	0.5	0.02	mg/l
Manganese	2/6/2006	0.16	0.5	0.02	mg/l
Manganese	3/9/2006	0.15	0.5	0.02	mg/l
Manganese	4/3/2006	0.15	0.5	0.02	mg/l
Manganese	5/8/2006	0.16	0.5	0.02	mg/l
Manganese	6/6/2006	0.17	0.5	0.02	mg/l
Manganese	7/12/2006	0.15	0.5	0.02	mg/l
Manganese	10/10/2006	0.16	0.5	0.02	mg/l
Manganese	11/8/2006	0.15	0.5	0.02	mg/l
Manganese	12/4/2006	0.14	0.5	0.02	mg/l
Manganese	2/13/2007	0.16	0.5	0.02	mg/l
Manganese	3/12/2007	0.15	0.5	0.02	mg/l
Manganese	4/3/2007	0.16	0.5	0.02	mg/l

Table C.10 - Methyl isobutyl ketone (MIBK) (4-Methyl-2-pentanone) Data

Chemical	Date	Result	NL*	DLR**	Unit
Well A 1-Standby					
Methyl isobutyl ketone (MIBK) (4-Methyl-2-pentanone)	5/23/1994	< DL	0.12	0.005	mg/l
Well B2					
Methyl isobutyl ketone (MIBK) (4-Methyl-2-pentanone)	4/27/1994	<DL	0.12	0.005	mg/l

* NL = CDHS Notification Level
** DLR = Detection Limit for the Purpose of Reporting

Table C.11 – Naphthalene Data

Chemical	Date	Result	NL*	DLR**	Unit
Well A 1-Standby					
Naphthalene	5/23/1994	< DL	0.017	0.0005	mg/l
Naphthalene	5/16/1996	< DL	0.017	0.0005	mg/l
Well B2					
Naphthalene	4/27/1994	< DL	0.017	0.0005	mg/l
Naphthalene	5/15/1996	< DL	0.017	0.0005	mg/l
Naphthalene	5/11/1999	< DL	0.017	0.0005	mg/l
Naphthalene	5/22/2002	< DL	0.017	0.0005	mg/l

* NL = CDHS Notification Level
** DLR = Detection Limit for the Purpose of Reporting

Table C.12 – Perchlorate Data

Chemical	Date	Result	NL*	DLR**	Unit
Well B2					
Perchlorate	1/24/2002	< DL	0.006	0.004	mg/l
Perchlorate	7/24/2002	< DL	0.006	0.004	mg/l
Perchlorate	12/11/2002	< DL	0.006	0.004	mg/l

* NL = CDHS Notification Level
** DLR = Detection Limit for the Purpose of Reporting

Table C.13 – Propachlor Data

Chemical	Date	Result	NL*	DLR**	Unit
Well A 1-Standby					
Propachlor	6/7/1994	< DL	0.09	0.0005	mg/l
Well B2					
Propachlor	4/27/1994	< DL	0.09	0.0005	mg/l

* NL = CDHS Notification Level
** DLR = Detection Limit for the Purpose of Reporting

Table C.14 - n-Propylbenzene Data

Chemical	Date	Result	NL*	DLR**	Unit
Well A 1-Standby					
n-Propylbenzene	5/23/1994	< DL	0.26	0.0005	mg/l
n-Propylbenzene	5/16/1996	< DL	0.26	0.0005	mg/l
Well B2					
n-Propylbenzene	4/27/1994	< DL	0.26	0.0005	mg/l
n-Propylbenzene	5/15/1996	< DL	0.26	0.0005	mg/l
n-Propylbenzene	5/11/1999	< DL	0.26	0.0005	mg/l
n-Propylbenzene	5/22/2002	< DL	0.26	0.0005	mg/l

* NL = CDHS Notification Level
** DLR = Detection Limit for the Purpose of Reporting

Table C.15 - 1,2,3-Trichloropropane (1,2,3-TCP) Data

Chemical	Date	Result	NL*	DLR**	Unit
Well A 1-Standby					
1,2,3-Trichloropropane (1,2,3-TCP)*	5/23/1994	<NL	5E-06	5.E-04	mg/l
1,2,3-Trichloropropane (1,2,3-TCP)*	5/16/1996	<NL	5E-06	5.E-04	mg/l
Well B2					
1,2,3-Trichloropropane (1,2,3-TCP)*	4/27/1994	<NL	5E-06	5.E-04	mg/l
1,2,3-Trichloropropane (1,2,3-TCP)*	5/15/1996	<NL	5E-06	5.E-04	mg/l
1,2,3-Trichloropropane (1,2,3-TCP)*	5/11/1999	<NL	5E-06	5.E-04	mg/l
1,2,3-Trichloropropane (1,2,3-TCP)*	1/24/2002	<NL	5E-06	5.E-04	mg/l
1,2,3-Trichloropropane (1,2,3-TCP)*	7/24/2002	<NL	5E-06	5E-06	mg/l

* NL = CDHS Notification Level
** DLR = Detection Limit for the Purpose of Reporting

Table C.16 – 1,2,4-Trimethylbenzene Data

Chemical	Date	Result	NL*	DLR**	Unit
Well A 1-Standby					
1,2,4-Trimethylbenzene	5/23/1994	< DL	0.33	0.0005	mg/l
1,2,4-Trimethylbenzene	5/16/1996	< DL	0.33	0.0005	mg/l
Well B2					
1,2,4-Trimethylbenzene	4/27/1994	< DL	0.33	0.0005	mg/l
1,2,4-Trimethylbenzene	5/15/1996	< DL	0.33	0.0005	mg/l
1,2,4-Trimethylbenzene	5/11/1999	< DL	0.33	0.0005	mg/l
1,2,4-Trimethylbenzene	5/22/2002	< DL	0.33	0.0005	mg/l

* NL = CDHS Notification Level
** DLR = Detection Limit for the Purpose of Reporting

Table C.17 - 1,3,5-Trimethylbenzene Data

Chemical	Date	Result	NL*	DLR**	Unit
Well A 1-Standby					
1,3,5-Trimethylbenzene	5/23/1994	< DL	0.33	0.0005	mg/l
1,3,5-Trimethylbenzene	5/16/1996	< DL	0.33	0.0005	mg/l
Well B2					
1,3,5-Trimethylbenzene	4/27/1994	< DL	0.33	0.0005	mg/l
1,3,5-Trimethylbenzene	5/15/1996	< DL	0.33	0.0005	mg/l
1,3,5-Trimethylbenzene	5/11/1999	< DL	0.33	0.0005	mg/l
1,3,5-Trimethylbenzene	5/22/2002	< DL	0.33	0.0005	mg/l

* NL = CDHS Notification Level
** DLR = Detection Limit for the Purpose of Reporting

Table C.18 - Vanadium Data

Chemical	Date	Result	NL*	DLR**	Unit
Well A 1-Standby					
Vanadium	5/29/2003	<DL	0.05	0.003	mg/l
Vanadium	1/31/2007	< 0.002	0.05	0.003	mg/l
Well B2					
Vanadium	4/11/2001	<DL	0.05	0.003	mg/l
Vanadium	1/24/2002	<DL	0.05	0.003	mg/l
Vanadium	7/24/2002	<DL	0.05	0.003	mg/l
Vanadium	1/21/2004	0.02	0.05	0.003	mg/l

* NL = CDHS Notification Level
** DLR = Detection Limit for the Purpose of Reporting

> DLR

C.1.2 Unregulated Chemicals Requiring Monitoring in Title 22 CCR § 64450

For the following unregulated chemicals requiring monitoring in Title 22 CCR, available data is presented above: boron; dichlorodifluoromethane (Freon 12); perchlorate; 1,2,3-trichloropropane (1,2,3-TCP); vanadium. Available data for other chemicals in this category is shown below.

Table C.19 – Chromium (VI) Data

Chemical	Date	Result	NL*	DLR**	Unit
Well B2					
Chromium (VI)*	1/24/2002	< DL	Not Applicable	----	mg/l
Chromium (VI)*	7/25/2002	< DL	Not Applicable	----	mg/l

* NL = CDHS Notification Level
** DLR = Detection Limit for the Purpose of Reporting

Table C.20 – Ethyl tertiary butyl ether Data

Chemical	Date	Result	NL*	DLR**	Unit
Well B2					
Ethyl tertiary butyl ether	5/11/1999	< DL	Not Applicable	0.003	mg/l
Ethyl tertiary butyl ether	5/22/2002	< DL	Not Applicable	0.003	mg/l
Ethyl tertiary butyl ether	7/24/2002	< DL	Not Applicable	0.003	mg/l

* NL = CDHS Notification Level
** DLR = Detection Limit for the Purpose of Reporting

Table C.21 – Tertiary amyl methyl ether Data

Chemical	Date	Result	NL*	DLR**	Unit
Well B2					
Tertiary amyl methyl ether*	5/11/1999	< DL	Not Applicable	0.003	mg/l
Tertiary amyl methyl ether*	5/22/2002	< DL	Not Applicable	0.003	mg/l
Tertiary amyl methyl ether*	7/24/2002	< DL	Not Applicable	0.003	mg/l

* NL = CDHS Notification Level
** DLR = Detection Limit for the Purpose of Reporting

C.1.3 Available Data for Unregulated Contaminant Monitoring Rule 2 (UCMR2) Chemicals

Table C.22 – Dimethoate Data

Chemical	Date	Result	NL*	DLR**	Unit
Well A 1-Standby					
Dimethoate	6/7/1994	< DL	Not Applicable	0.01	mg/l
Well B2					
Dimethoate	4/27/1994	< DL	Not Applicable	0.01	mg/l
Dimethoate	5/25/2000	< DL	Not Applicable	0.01	mg/l
Dimethoate	4/24/2003	< DL	Not Applicable	0.01	mg/l

* NL = CDHS Notification Level
** DLR = Detection Limit for the Purpose of Reporting

Table C.23 – Alachlor Data

Chemical	Date	Result	NL*	DLR**	Unit
Well A 1-Standby					
Alachlor	6/7/1994	< DL	No Applicable	0.001	mg/l
Well B2					
Alachlor	4/27/1994	< DL	No Applicable	0.001	mg/l
Alachlor	5/25/2000	< DL	No Applicable	0.001	mg/l
Alachlor	4/24/2003	< DL	No Applicable	0.001	mg/l

* NL = CDHS Notification Level
** DLR = Detection Limit for the Purpose of Reporting

Table C.24 – Metolachlor Data

Chemical	Date	Result	NL*	DLR**	Unit
Well A 1-Standby					
Metolachlor	6/7/1994	<DL	Not Applicable	----	mg/l
Well B2					
Metolachlor	4/27/1994	<DL	Not Applicable	----	mg/l
Metolachlor	5/25/2000	<DL	Not Applicable	----	mg/l
Metolachlor	4/24/2003	<DL	Not Applicable	----	mg/l

* NL = CDHS Notification Level
** DLR = Detection Limit for the Purpose of Reporting

Table C.25 Summary of Monitoring Results for Well A1

Chemical	Mean	Standard Deviation	Median	Minimum	Maximum	No. of Observations	Date of First Sample	Date of Most Recent Sample	Units	NL	MRL
Chemicals with Notification Levels (NLs)											
Boron	0.56	0.09	0.54	0.48	0.65	3	5/28/1999	1/30/2003	mg/L	1	0.1
n-Butylbenzene	All measurements < 0.0005 (< MRL)					2	5/22/1990	5/15/1992	mg/L	0.26	0.0005
sec-Butylbenzene	All measurements < 0.0005 (< MRL)					2	5/22/1990	5/15/1992	mg/L	0.26	0.0005
tert-Butylbenzene	All measurements < 0.0005 (< MRL)					2	5/22/1990	5/15/1992	mg/L	0.26	0.0005
2-Chlorotoluene	All measurements < 0.0005 (< MRL)					2	5/22/1990	5/15/1992	mg/L	0.14	0.0005
4-Chlorotoluene	All measurements < 0.0005 (< MRL)					2	5/22/1990	5/15/1992	mg/L	0.14	0.0005
Dichlorodifluoromethane (Freon 12)	All measurements < 0.001 (< MRL)					2	5/22/1990	5/15/1992	mg/L	1	0.001
Isopropylbenzene	All measurements < 0.0005 (< MRL)					2	5/22/1990	5/15/1992	mg/L	0.77	0.0005
Manganese	0.169	0.048	0.179	0.064	0.245	22	1/13/1990	1/30/2003	mg/L	0.5	0.01
Methyl isobutyl ketone (MIBK) (4-Methyl-2-pentanone)	All measurements < 0.005 (< MRL)					1	5/22/1990	NA	mg/L	0.12	0.005
Naphthalene	All measurements < 0.0005 (< MRL)					2	5/22/1990	5/15/1992	mg/L	0.017	0.0005
Propachlor	All measurements < 0.0005 (< MRL)					1	6/6/1990	NA	mg/L	0.09	0.0005
n-Propylbenzene	All measurements < 0.0005 (< MRL)					2	5/22/1990	5/15/1992	mg/L	0.26	0.0005
1,2,3-Trichloropropane (1,2,3-TCP)	All measurements < 0.0005 (< MRL)					2	5/22/1990	5/15/1992	mg/L	0.000005	0.0005
1,2,4-Trimethylbenzene	All measurements < 0.0005 (< MRL)					2	5/22/1990	5/15/1992	mg/L	0.33	0.0005
1,3,5-Trimethylbenzene	All measurements < 0.0005 (< MRL)					3	5/22/1990	5/15/1992	mg/L	0.33	0.0005
Vanadium	All measurements < 0.003 (< MRL)					2	5/29/2003	1/31/2007	mg/L	0.05	0.003
Unregulated Chemicals Requiring Monitoring in Title 22 CCR											
Boron	0.56	0.09	0.54	0.48	0.65	3	5/28/1999	1/30/2003	mg/L	1	0.1
Dichlorodifluoromethane	All measurements < 0.001 (< MRL)					2	5/22/1990	5/15/1992	mg/L	1	0.001
Ethyl-tert-butyl ether	All measurements < 0.003 (< MRL)					3	5/10/1995	7/23/1998	mg/L	NA	0.003
tert-Amyl-methyl ether	All measurements < 0.003 (< MRL)					3	5/10/1995	7/23/1998	mg/L	NA	0.003
1,2,3-Trichloropropane	All measurements < 0.0005 (< MRL)					2	5/22/1990	5/15/1992	mg/L	0.000005	0.0005
Vanadium	All measurements < 0.003 (< MRL)					2	5/29/2003	1/31/2007	mg/L	0.05	0.003
Unregulated Contaminant Monitoring Rule 2 (UCMR 2) Chemicals											
Dimethoate	All measurements < 0.01 (< MRL)					1		6/6/1990	mg/L	NA	0.01
Alachlor	All measurements < 0.001 (< MRL)					1		6/6/1990	mg/L	NA	0.001
Metolachlor	All measurements < MRL					1		6/6/1990	mg/L	NA	-

Table C.26 Summary of Monitoring Results for Well B2

Chemical	Mean	Standard Deviation	Median	Minimum	Maximum	No. of Observations	Date of First Sample	Date of Most Recent Sample	Units	NL	MRL
Chemicals with Notification Levels (NLs)											
Boron	0.39	0.075	0.38	0.27	0.5	9	1/20/1998	5/13/2004	mg/L	1	0.1
n-Butylbenzene	All measurements < 0.0005 (< MRL)					4	4/27/1994	5/22/2002	mg/L	0.26	0.0005
sec-Butylbenzene	All measurements < 0.0005 (< MRL)					4	4/27/1994	5/22/2002	mg/L	0.26	0.0005
tert-Butylbenzene	All measurements < 0.0005 (< MRL)					4	4/27/1994	5/22/2002	mg/L	0.26	0.0005
2-Chlorotoluene	All measurements < 0.0005 (< MRL)					4	4/27/1994	5/22/2002	mg/L	0.14	0.0005
4-Chlorotoluene	All measurements < 0.0005 (< MRL)					4	4/27/1994	5/22/2002	mg/L	0.14	0.0005
Dichlorodifluoromethane (Freon 12)	All measurements < 0.0005-0.001 (< MRL)					6	4/27/1994	7/24/2002	mg/L	1	0.0005 - 0.001
Isopropylbenzene	All measurements < 0.0005 (< MRL)					4	4/27/1994	5/22/2002	mg/L	0.77	0.0005
Manganese	0.12	0.04	0.12	0.038	0.282	107	3/3/1994	4/3/2007	mg/L	0.5	0.01 - 0.02
Methyl isobutyl ketone (MIBK) (4-Methyl-2-pentanone)	All measurements < 0.005 (< MRL)					1		4/27/1994	mg/L	0.12	0.005
Naphthalene	All measurements < 0.0005 (< MRL)					4	4/27/1994	5/22/2002	mg/L	0.017	0.0005
Perchlorate	All measurements < 0.004 (< MRL)					3	1/24/2002	12/11/2002	mg/L	0.006	0.004
Propachlor	All measurements < 0.0005 (< MRL)					1		4/27/1994	mg/L	0.09	0.0005
n-Propylbenzene	All measurements < 0.0005 (< MRL)					4	4/27/1994	5/22/2002	mg/L	0.26	0.0005
1,2,3-Trichloropropane (1,2,3-TCP)	All measurements < 0.000005-0.0005 (< MRL)					5	4/27/1994	7/24/2002	mg/L	0.000005	0.0005 - 0.000005
1,2,4-Trimethylbenzene	All measurements < 0.0005 (< MRL)					4	4/27/1994	5/22/2002	mg/L	0.33	0.0005
1,3,5-Trimethylbenzene	All measurements < 0.0005 (< MRL)					4	4/27/1994	5/22/2002	mg/L	0.33	0.0005
Vanadium	-	-	-	<0.003 (<MRL)	0.02	4	4/11/2001	1/21/2004	mg/L	0.05	0.003
Unregulated Chemicals Requiring Monitoring in Title 22 CCR											
Boron	0.38625	0.074821215	0.375	0.27	0.5	9	35815	38120	mg/L	1	0.1
Chromium VI	All measurements < MRL					2	1/24/2002	7/25/2002	mg/L	NA	-
Dichlorodifluoromethane	All measurements < 0.0005-0.001 (< MRL)					6	34451	37461	mg/L	1	0.0005 - 0.001
Ethyl-tert-butyl ether	All measurements < 0.003 (< MRL)					3	5/11/1999	7/24/2002	mg/L	NA	0.003
Perchlorate	All measurements < 0.004 (< MRL)					3	37280	37601	mg/L	0.006	0.004
tert-Amyl-methyl ether	All measurements < 0.003 (< MRL)					3	5/11/1999	5/11/1999	mg/L	NA	0.003
1,2,3-Trichloropropane	All measurements < 0.000005-0.0005 (< MRL)					5	34451	37461	mg/L	0.000005	0.0005 - 0.000005
Vanadium	-	-	-	<0.003 (<MRL)	0.02	4	36992	38007	mg/L	0.05	0.003
Unregulated Contaminant Monitoring Rule 2 (UCMR 2) Chemicals											
Dimethoate	All measurements < 0.01 (< MRL)					3	4/27/1994	4/24/2003	mg/L	NA	0.01
Alachlor	All measurements < 0.001 (< MRL)					3	4/27/1994	4/24/2003	mg/L	NA	0.001
Metolachlor	All measurements < MRL					3	4/27/1994	4/24/2003		NA	-

C.2 Background Information on CDPH's Drinking Water Source Assessment Program (DWSAP)

C.2.1 Source Water Assessment

The 1996 reauthorization of the federal Safe Drinking Water Act requires states to establish programs to assess source waters and encourages states to establish protection programs (CDHS, 1999). This sub-section discussing Source Water Assessment (SWA) requirements was prepared based on the Drinking Water Source Assessment Program (DWSAP) document (CDHS, 1999).

It should be noted that when a public water system completes an evaluation of a source water through another program that is the "functional equivalent of a portion or all of the drinking water source assessment," the results of the evaluation from the other program may be submitted to meet the source assessment requirements. One example is the Watershed Sanitary Survey (WSS) required for surface water sources (see discussion of the WSS in the next sub-section), which is likely to satisfy most SWA requirements except for the vulnerability assessment.

CDPH procedures for Source Water Assessments include the following:

Location of drinking water source

Delineation of source areas and protection zones for both surface waters and ground waters

Identification of possible contaminating activities (PCAs)

Determination of PCAs to which the source water is most vulnerable

Assessments of new drinking water sources by public water systems

These CDPH procedures will be discussed in more detail below.

C.2.2 Location of drinking water source

The location of ground water sources (wells) and surface water intakes (latitude and longitude) will be determined by CDPH using GPS. The CWD wells A1 and B2 represent groundwater that has NOT been classified as groundwater under the direct influence of surface water.

C.2.3Delineation of source areas and protection zones for ground waters

For ground waters, CDPH will delineate as the source area the recharge area and protection zones.

The CDPH assumes ground water sources are from two aquifer types: porous media and fractured rock. The recharge area should be identified as much as possible based on the topography, hydrogeology, and other information for the area. For the SWA under the DWSAP, source areas to be assessed for ground water include a group of protection zones "at the land surface adjacent to and surrounding the well." There are several methods that CDPH recommends for defining the zones, based on a primary criterion of time-of-travel (time for ground water to travel from a location in an aquifer to the well). The methods include arbitrary fixed radius (not allowed for community water systems), calculated fixed radius, modified calculated fixed radius, estimation of the direction of ground water flow, analytical methods, detailed hydrogeologic mapping, and numeric flow/transport models. CDPH will typically use the simpler approach, such as the calculated fixed radius method, to delineate the source area. At the same time, CDPH recognizes the value of more complex methods and is open to application of more complex methods by a water system if sufficient information is available to use them.

All ground water sources should have zones defined and CDPH recommends the following approach of four zones plus an optional fifth zone: Well Site Control Zone (wellhead), Zone A – Microbial/Direct Chemical Contamination Zone (defined by surface area overlying aquifer contributing water to well within a two-year travel time); Zone B5 – Chemical Contamination Zone (area between two- and five-year travel time); Zone B10 – Chemical Contamination Zone (area between five- and ten-year travel time); Optional Buffer Zone (for added protection of drinking water sources). The two-year time-of-travel for Zone A is based on EPA's proposed Groundwater Rule (discussed in a later sub-section) in recognition of existing research showing bacteria and viruses survive less than two years in ground water and soil. Zones B5 and B10 are intended to prevent chemical contamination, focusing on contamination that could exist near the well but farther away than Zone A. CDPH recommends the following minimum radii for zones A, B5, and B10:

Table C.27 – CDPH Recommended Minimum Radius Based on Zone and Type of Aquifer

Zone	Porous Media	Fractured Rock
Zone A	600 ft	900 ft
Zone B5	1,000 ft	1,500 ft
Zone B10	1,500 ft	2,250 ft

C.2.4 Identification of possible contaminating activities (PCAs)

A possible contaminating activity (PCA) is a potential origin of contamination in source areas and protection zones. If any of the contaminants of concern are associated with an activity, then the activity needs to be included in the inventory of PCAs required in a SWA:

Microorganisms of drinking water importance (fecal coliform bacteria, E. coli, viruses, Giardia lambia, Cryptosporidium)

Chemicals for which MCLs or California drinking water notification levels have been established and unregulated chemicals in drinking water that require monitoring – See section below on *MCLs and Notification Levels* for the list.

Turbidity

Total Organic Carbon (TOC)

The PCA inventory focuses on determining if a type of activity exists in a source area or protection zone. The exact location and number of sites are not needed, nor is the specific identification of a PCA in terms of name and address. The steps in a PCA inventory are listed below.

a. Develop initial list of Types of PCAs of Concern that May Exist within or Near Source Area or Protection Zone. Assemble all resources that may help locate activities.

b. Prepare a PCA inventory form – activities ranked from very high to low risk for use in vulnerability assessment. Some rankings vary by protection zone. CDPH has developed inventory forms for surface water and ground water sources.

c. Conduct PCA Inventory

d. Attach a list of PCAs to Assessment Map

C.2.5 Determination of PCAs to which the source water is most vulnerable

The vulnerability assessment prioritizes the list of PCAs in the PCA inventory by identifying the activities to which the drinking water source is most vulnerable. The steps in a vulnerability assessment are:

a. Determine the physical barrier effectiveness (PBE), a measure of the ability of the geology, hydraulics, and construction features of well or intake, to prevent contaminant migration to the drinking water source. CDPH provides approaches to determining PBE for surface and ground water sources. The PBE is ranked as either low, moderate, or high.

b. Determination of vulnerability. The PCA inventory and PBE evaluation are used to prioritize the list of PCAs to determine the activities to which the source is most vulnerable based on analysis methods shown in the DWSAP document (CDHS, 1999; see pp. 103-105). The drinking water source is vulnerable to all PCA types above the cutoff. The drinking water source is most vulnerable to PCAs with the highest vulnerability points AND to those types of PCAs associated with a contaminant detected in the drinking water source, irrespective of the amount of vulnerability points. In addition to its role in the SWA, the CDPH will use the vulnerability assessment results to determine if a source is eligible for chemical monitoring relief.

C.3 Information provided by CWD Regarding Vulnerability Assessments of Wells A1 and B2

The following information associated with the source water assessment for wells A1 and B2 were provided by CWD (Smith, 2007a).

C.3.1 Location of drinking water source (Appendix H in DWSAP program document)

Well A1

Public Water System: City of Camarillo

ID No.: 5610019

Name of Source: Well A-1

ID No. of Source: 5610019005

Location Date: 5/30/01

Source Located by: Tom P. Smith

Method of Determining Location:

USGS Quad Map (7.5 minute series, 1:24,000 scale), hand calculated

Location of Well (decimal degrees):

Latitude: 341430.9

Longitude: 1190109.5

Well B2

Public Water System: City of Camarillo

ID No.: 5610019

Name of Source: Well B-2

ID No. of Source: 5610019007

Location Date: 5/30/01

Source Located by: Tom P. Smith

Method of Determining Location:

USGS Quad Map (7.5 minute series, 1:24,000 scale), hand calculated

Location of Well (decimal degrees):

Latitude: 341436.1

Longitude: 1190104..0

C.3.2 Delineation of source areas and protection zones for ground waters (Appendix I in DWSAP program document)

Method Used to Delineate the Zones:

Calculated Fixed Radius (Default)

Well A1

Porous Media Aquifer

Zone A: Radius = 801 ft

Zone B5: Radius = 1267 ft

Zone B10: Radius = 1792 ft

Well B2

Porous Media Aquifer

Zone A: Radius = 1003 ft

Zone B5: Radius = 1586 ft

Zone B10: Radius = 2243 ft

C.3.3 Determination of Physical Barrier Effectiveness (PBE) of Source Water (Appendix J in DWSAP program document)

Well A1

Physical Barrier Effectiveness (PBE) Score Interpretation = High

Well B2

Physical Barrier Effectiveness (PBE) Score Interpretation = High

C.3.4 Possible Contaminating Activity (PCA) Inventory Form (Appendix K in DWSAP program document)

The following PCAs were listed in the inventory form. This list does NOT represent the list of PCAs to which the source was determined vulnerable.

Table C.28 PCA inventory Form for Well A1

Zone	Type of PCA	Zone	Type of PCA
COMMERCIAL/INDUSTRIAL		AGRICULTURAL/RURAL	
A	Sewer collection systems	A	Septic systems - low density (<1/acre)
B5	Sewer collection systems	B5	Septic systems - low density (<1/acre)
B10	Sewer collection systems	B10	Septic systems - low density (<1/acre)
A	Parking lots/malls (>50 spaces)	A	Agricultural Drainage
B5	Parking lots/malls (>50 spaces)	B5	Agricultural Drainage
A	Office buildings/complexes	B10	Agricultural Drainage
B5	Office buildings/complexes	B5	Crops, irrigated (Berries, hops, mint, orchards, sod, greenhouses, vineyards, nurseries, vegetables)
RESIDENTIAL/MUNICIPAL		B10	Crops, irrigated (Berries, hops, mint, orchards, sod, greenhouses, vineyards, nurseries, vegetables)
A	Septic systems - high density (>1/acre)	B5	Fertilizer, Pesticide/Herbicide Application
B5	Septic systems - high density (>1/acre)	B10	Fertilizer, Pesticide/Herbicide Application
B10	Septic systems - high density (>1/acre)	B5	Crops, nonirrigated (e.g., Christmas trees, grains, grass seeds, hay, pasture) (includes drip-irrigated crops)
A	Sewer collection systems	B10	Crops, nonirrigated (e.g., Christmas trees, grains, grass seeds, hay, pasture) (includes drip-irrigated crops)
B5	Sewer collection systems	OTHER ACTIVITIES	
B10	Sewer collection systems	A	NPDES/WDR permitted discharges
A	Housing - high density (>1 house/0.5 acres)	A	Wells - Water supply
B5	Housing - high density (>1 house/0.5 acres)	B5	Wells - Water supply
B10	Housing - high density (>1 house/0.5 acres)	A	Road Right-of-ways (herbicide use areas)
A	Parks	B5	Road Right-of-ways (herbicide use areas)
B5	Parks	B10	Road Right-of-ways (herbicide use areas)
B10	Apartments and condominiums	A	Roads/Streets
B10	Schools	B5	Roads/Streets
		B10	Roads/Streets
		A	Hospitals
		A	Storm Water Detention Facilities
		A	Medical/dental offices/clinics
		B5	Medical/dental offices/clinics
		B5	Veterinary offices/clinics

Table C.29 PCA inventory Form for Well B2

Zone	Type of PCA	Zone	Type of PCA
COMMERCIAL/INDUSTRIAL		AGRICULTURAL/RURAL	
A	Sewer collection systems	A	Septic systems - low density (<1/acre)
B5	Sewer collection systems	B5	Septic systems - low density (<1/acre)
A	Parking Lots/Malls (>50 spaces)	B10	Septic systems - low density (<1/acre)
B5	Parking Lots/Malls (>50 spaces)	A	Agricultural Drainage
A	Office buildings/complexes	B5	Agricultural Drainage
B5	Office buildings/complexes	B10	Agricultural Drainage
RESIDENTIAL/MUNICIPAL		A	Crops, irrigated (Berries, hops, mint, orchards, sod, greenhouses, vineyards, nurseries, vegetables)
A	Septic systems - high density (>1/acre)	B5	Crops, irrigated (Berries, hops, mint, orchards, sod, greenhouses, vineyards, nurseries, vegetables)
B5	Septic systems - high density (>1/acre)	B10	Crops, irrigated (Berries, hops, mint, orchards, sod, greenhouses, vineyards, nurseries, vegetables)
B10	Septic systems - high density (>1/acre)	A	Fertilizer, Pesticide/Herbicide Application
A	Sewer Collection Systems	B5	Fertilizer, Pesticide/Herbicide Application
B5	Sewer Collection Systems	B10	Fertilizer, Pesticide/Herbicide Application
B10	Sewer Collection Systems	OTHER ACTIVITIES	
A	Housing - high density (>1 house/0.5 acres)	A	NPDES/WDR permitted discharges
B5	Housing - high density (>1 house/0.5 acres)	A	Wells - Water supply
B10	Housing - high density (>1 house/0.5 acres)	B5	Wells - Water supply
B5	Parks	A	Road Right-of-ways (herbicide use areas)
B10	Parks	B5	Road Right-of-ways (herbicide use areas)
B5	Apartments and condominium	B10	Road Right-of-ways (herbicide use areas)
B10	Schools	A	Roads/Streets
		B5	Roads/Streets
		B10	Roads/Streets
		A	Hospitals
		A	Storm Water Detention Facilities
		A	Medical/dental offices/clinics
		B5	Medical/dental offices/clinics
		B5	Veterinary offices/clinics

C.3.5 Determination of PCAs to which the source water is most vulnerable (Appendix M in DWSAP program document)

The Vulnerability Ranking was provided for Wells A1 and B2 (Smith, 2007a). A groundwater source is vulnerable to all types of PCAs with a Vulnerability Score greater than or equal to 8. The source is most vulnerable to the types of PCAs with the highest score (CDHS, 1999). The Vulnerability Rankings for Wells A1 and B2 are shown below. The tables show all types of PCAs to which Wells A1 and B2 are vulnerable.

Table C.30 List of the types of PCAs to which Well A1 –Standby is vulnerable

Zone	Type of PCA	PCA Points VH=7 H=5 M=3 L=1	Zone Points A=5 B5=3 B10=1 Unknown=0	PBE Points	Vulnerability Score PCA Points + Zone Points + PBE Points
COMMERCIAL/INDUSTRIAL					
A	Sewer collection systems (H if in Zone A, otherwise L)	5	5	1	11
A	Parking lots/malls (>50 spaces) (M)	3	5	1	9
RESIDENTIAL/MUNICIPAL					
A	Septic systems - high density (>1/acre) (VH if in Zone A, otherwise M)	7	0	1	8
A	Sewer collection systems (H if in Zone A, otherwise L)	5	5	1	11
A	Housing - high density (>1 house/0.5 acres) (M)	3	5	1	9
A	Parks (M)	3	5	1	9
AGRICULTURAL/RURAL					
A	Agricultural Drainage (H in Zone A, otherwise M)	5	5	1	11
OTHER ACTIVITIES					
A	NPDES/WDR permitted discharges (H)	5	5	1	11
A	Wells - Water supply (M)	3	5	1	9
A	Transportation corridors - Road Right-of-ways (herbicide use areas) (M)	3	5	1	9
A	Hospitals (M)	3	5	1	9
A	Storm Water Detention Facilities (M)	3	5	1	9

Table C.31 List of the types of PCAs to which Well B2 is vulnerable

Zone	Type of PCA	PCA Points VH=7 H=5 M=3 L=1	Zone Points A=5 B5=3 B10=1 Unknown=0	PBE Points	Vulnerability Score PCA Points + Zone Points + PBE Points
COMMERCIAL/INDUSTRIAL					
A	Sewer collection systems (H if in Zone A, otherwise L)	5	5	1	11
A	Parking Lots/Malls (>50 spaces) (M)	3	5	1	9
RESIDENTIAL/MUNICIPAL					
A	Septic systems - high density (>1/acre) (VH if in Zone A, otherwise M)	7	0	1	8
A	Sewer Collection Systems (H if in Zone A, otherwise L)	5	5	1	11
A	Housing - high density (>1 house/0.5 acres) (M)	3	5	1	9
AGRICULTURAL/RURAL					
A	Agricultural Drainage (H in Zone A, otherwise M)	5	5	1	11
A	Crops, irrigated (Berries, hops, mint, orchards, sod, greenhouses, vineyards, nurseries, vegetables) (M)	3	5	1	9
A	Fertilizer, Pesticide/Herbicide Application (M)	3	5	1	9
OTHER ACTIVITIES					
A	NPDES/WDR permitted discharges (H)	5	5	1	11
A	Wells - Water supply (M)	3	5	1	9
A	Transportation corridors - Road Right-of-ways (herbicide use areas) (M)	3	5	1	9
A	Hospitals (M)	3	5	1	9
A	Storm Water Detention Facilities (M)	3	5	1	9

C.4 EPA's Contaminant Candidate List (CCL) and Unregulated Contaminant Monitoring Rule (UCMR)

The Safe Drinking Water Act (SDWA) includes a mechanism by which EPA must identify and list unregulated contaminants that may require a National Primary Drinking Water Regulation (NPDWR) in the future. EPA must periodically publish the list, which is called the Contaminant Candidate List (CCL). The EPA must issue "regulatory determinations" that decide whether or not to regulate 5 or more candidates on the list at least every 5 years. The SDWA also requires monitoring of certain unregulated contaminants under the Unregulated Contaminants Monitoring Rule (UCMR), which includes three lists of contaminants:

List 1 – contaminants requiring monitoring for which analytical methods are available;

List 2 – screening survey of contaminants for which methods are just developed;

List 3 – pre-screen testing of contaminants that require research on methods) and must be issued every 5 years.

As shown on Figure C.1, the EPA published the first CCL (CCL1) in March 1998 with 60 contaminants and made regulatory determinations that 9 of the contaminants required no regulatory action in July 2003. In February 2005, EPA published the second CCL (CCL2), which carried over 51 contaminants from CCL1 and regulatory determinations of contaminants on CCL2 were not issued until July 2008. The third CCL (CCL3) was not published until February 2008. The selection of emerging contaminants for this study was completed prior to the most recent CCL updates. In the CCL2 regulatory determinations, the EPA decided not to set a national primary drinking water regulation (NPDWR) for boron, based on limited occurrence in surface and ground water sources (4.3% of ground water sources had >0.7 mg/L). The EPA did suggest that for states with localized occurrence, "State-level guidance (or some other type of action) may be appropriate" (EPA 2008).

UCMR1 includes 34 contaminants on CCL1 and 2 radionuclides that emerged during development of the regulation. UCMR2 includes some contaminants on CCL2 but also includes contaminants that have not been listed on the CCL including flame retardants and explosives on List 1 and nitrosamines on List 2. Emerging contaminants that appear on the UCMR but not on the CCL are likely a long way from being regulated (e.g., NDMA). On the other hand, emerging contaminants that appear on the CCL may be regulated in a shorter time frame.

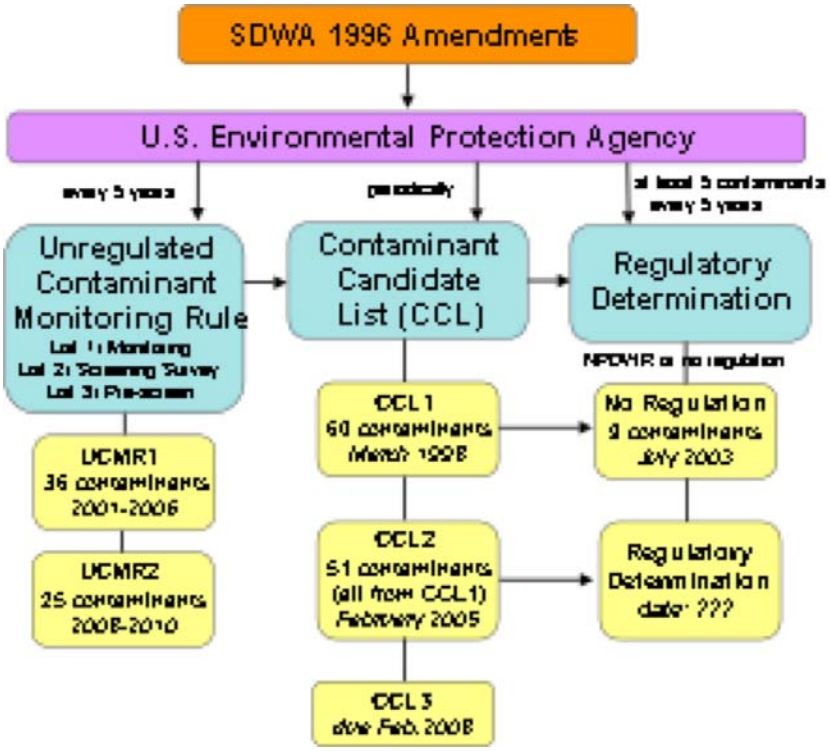


Figure C.1 – Status of Unregulated Contaminants

UCMR1 data was collected nationally over 2001-2006 and is complete. The UCMR2 List 1 and List 2 contaminants are listed in Table D.1.

Table C.32 – UCMR 2 Chemicals

UCMR 2 List 1 (Assessment Monitoring) Chemicals	
Dimethoate	***Five Flame Retardants***
Terbufos Sulfone	2,2',4,4'-tetrabromodiphenyl ether (BDE-47)
Three Explosives:	2,2',4,4',5-pentabromodiphenyl ether (BDE-99)
1,3-dinitrobenzene	2,2',4,4',5,5'-hexabromobiphenyl (HBB)
2,4,6-Trinitrotoluene (TNT)	2,2',4,4',5,5'-hexabromodiphenyl ether (BDE-153)
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	2,2',4,4',6-pentabromodiphenyl ether (BDE-100)

UCMR 2 List 2 (Screening Survey) Chemicals	
Six Nitrosamines	***Three Parent Acetanilides***
N-nitroso-diethylamine (NDEA)	Acetochlor
N-nitroso-dimethylamine (NDMA)	Alachlor
N-nitroso-di-n-butylamine (NDBA)	Metolachlor
N-nitroso-di-n-propylamine (NDPA)	***Six Acetanilides Degradates***
N-nitroso-methylethylamine (NMEA)	Acetochlor ethane sulfonic acid (ESA)
N-nitroso-pyrrolidine (NPYR)	Acetochlor oxanilic acid (OA)
	Alachlor ethane sulfonic acid (ESA)
	Alachlor oxanilic acid (OA)
	Metolachlor ethane sulfonic acid (ESA)
	Metolachlor oxanilic acid (OA)

Table C.33 Regulated Chemical Monitoring Data for Total Chromium

Chemical	Date	Result	MCL*	DLR**	Unit
Well A-1 Standby					
Chromium (total)	1/26/95	< DLR	0.05	0.010	mg/l
Chromium (total)	4/3/95	< DLR	0.05	0.010	mg/l
Chromium (total)	7/19/95	< DLR	0.05	0.010	mg/l
Chromium (total)	10/3/95	< DLR	0.05	0.010	mg/l
Chromium (total)	1/14/98	< DLR	0.05	0.010	mg/l
Chromium (total)	5/29/03	< DLR	0.05	0.010	mg/l
Chromium (total)	5/13/04	< DLR	0.05	0.010	mg/l
Chromium (total)	1/31/07	< DLR	0.05	0.010	mg/l
Well B-2					
Chromium (total)	4/27/94	< DLR	0.05	0.010	mg/l
Chromium (total)	1/1/95	< DLR	0.05	0.010	mg/l
Chromium (total)	4/4/95	< DLR	0.05	0.010	mg/l
Chromium (total)	7/18/95	< DLR	0.05	0.010	mg/l
Chromium (total)	10/4/95	< DLR	0.05	0.010	mg/l
Chromium (total)	1/13/98	< DLR	0.05	0.010	mg/l
Chromium (total)	1/20/98	< DLR	0.05	0.010	mg/l
Chromium (total)	4/11/01	< DLR	0.05	0.010	mg/l
Chromium (total)	1/21/04	< DLR	0.05	0.010	mg/l
Chromium (total)	5/13/04	< DLR	0.05	0.010	mg/l

* MCL = maximum contaminant level (Title 22 CCR § 64431)
** DLR = detection limit for the purpose of reporting (Title 22 CCR § 64432)

Table C.34 Complete results of emerging contaminant monitoring. Compounds marked in red were recommended for monitoring; all other compounds were measured incidentally using the same method at no additional cost.

(Table continues for a total of 5 parts)

Chemical	October 11, 2007 Sampling			December 18, 2007 Sampling		Laboratory Reporting Limit (mg/L)
	Well A Concentration (mg/L)	Well B Concentration (mg/L)	Well B/ Import Water Blend (mg/L)	Well A Concentration (mg/L)	Well B Concentration (mg/L)	
EPA Method 200.8						
Total Boron	**0.78**	**0.66**	--	--	--	**0.003**
Total Vanadium	**0.0012**	**ND**	--	--	--	**0.0005**
EPA Method 218.6						
Hexavalent Chromium (Chromium VI)	**ND**	**ND**	--	--	--	**0.0003**
EPA Method 521						
N-Nitrosodimethylamine (NDMA)	**--**	**--**	**ND**	**--**	**--**	**0.002**
N-Nitrosodiethylamine (NDEA)	--	--	ND	--	--	0.002
N-Nitrosodi-n-butylamine (NDBA)	--	--	ND	--	--	0.002
N-Nitrosodi-n-propylamine (NDPA)	--	--	ND	--	--	0.002
N-Nitrosomethylethylamine (NMEA)	--	--	ND	--	--	0.002
N-Nitrosopyrrolidine (NPYR)	--	--	ND	--	--	0.002
N-Nitrosomorpholine	--	--	ND	--	--	0.002
N-Nitrosopiperidine	--	--	ND	--	--	0.002

Table C.34 Continued (Part 2)

Chemical	October 11, 2007 Sampling			December 18, 2007 Sampling		Laboratory Reporting Limit (mg/L)
	Well A Concentration (mg/L)	Well B Concentration (mg/L)	Well B/ Import Water Blend (mg/L)	Well A Concentration (mg/L)	Well B Concentration (mg/L)	
Chloropicrin	**ND**	**ND**	--	--	--	**0.0005**
1,1,1-trichloro-2-propanone	ND	ND	--	--	--	0.0005
1,1-Dichloro-2-propanone	ND	ND	--	--	--	0.0005
Bromochloroacetonitrile	ND	ND	--	--	--	0.0005
Chloral hydrate	ND	ND	--	--	--	0.0005
Dibromoacetonitrile	ND	ND	--	--	--	0.0005
Dichloroacetonitrile	ND	ND	--	--	--	0.0005
Trichloroacetonitrile	ND	ND	--	--	--	0.0005
EPA 524.2						
Methyl Bromide (Bromomethane)	**ND**	**ND**	--	**ND**	**ND**	**0.0005**
1,3 Dichloropropene (total)	**ND**	**ND**	--	**ND**	**ND**	**0.0005**
cis-1,3-Dichloropropene	**ND**	**ND**	--	**ND**	**ND**	**0.0005**
trans-1,3-Dichloropropene	**ND**	**ND**	--	**ND**	**ND**	**0.0005**
1,1,1,2-Tetrachloroethane	ND	ND	--	ND	ND	0.0005
1,1,1-Trichloroethane	ND	ND	--	ND	ND	0.0005
1,1,2,2-Tetrachloroethane	ND	ND	--	ND	ND	0.0005
1,1,2-Trichloroethane	ND	ND	--	ND	ND	0.0005
1,1-Dichloroethane	ND	ND	--	ND	ND	0.0005
1,1-Dichloroethene	ND	ND	--	ND	ND	0.0005
1,1-Dichloropropene	ND	ND	--	ND	ND	0.0005
1,2,3-Trichlorobenzene	ND	ND	--	ND	ND	0.0005
1,2,3-Trichloropropane	ND	ND	--	ND	ND	0.0005

Table C.34 Continued (Part 3)

Chemical	October 11, 2007 Sampling			December 18, 2007 Sampling		Reporting Limit (mg/L)
	Well A Concentration (mg/L)	Well B Concentration (mg/L)	Well B/ Import Blend (mg/L)	Well A Concentration (mg/L)	Well B Concentration (mg/L)	
EPA 524.2						
1,2,4-Trichlorobenzene	ND	ND	--	ND	ND	0.0005
1,2,4-Trimethylbenzene	ND	ND	--	ND	ND	0.0005
1,2-Dichloroethane	ND	ND	--	ND	ND	0.0005
1,2-Dichloropropane	ND	ND	--	ND	ND	0.0005
1,3,5-Trimethylbenzene	ND	ND	--	ND	ND	0.0005
1,3-Dichloropropane	ND	ND	--	ND	ND	0.0005
2,2-Dichloropropane	ND	ND	--	ND	ND	0.0005
2-Butanone (Methyl Ethyl Ketone)	ND	**0.029**	--	ND	ND	0.005
2-Chloroethyl vinyl ether	ND	ND	--	ND	ND	0.001
2-Chlorotoluene	ND	ND	--	ND	ND	0.0005
2-Hexanone	ND	ND	--	ND	ND	0.005
4-Chlorotoluene	ND	ND	--	ND	ND	0.0005
4-Methyl-2-pentanone	ND	ND	--	ND	ND	0.005
Benzene	ND	ND	--	ND	ND	0.0005
Bromobenzene	ND	ND	--	ND	ND	0.0005
Bromochloromethane	ND	ND	--	ND	ND	0.0005
Bromodichloromethane	ND	ND	--	ND	**0.0034**	0.0005
Bromoform	ND	ND	--	ND	**0.0064**	0.0005
Carbon tetrachloride	ND	ND	--	ND	ND	0.0005

Table C.34 Continued (Part 4)

Chemical	October 11, 2007 Sampling			December 18, 2007 Sampling		Laboratory Reporting Limit (mg/L)
	Well A Concentration (mg/L)	Well B Concentration (mg/L)	Well B/ Import Blend (mg/L)	Well A Concentration (mg/L)	Well B Concentration (mg/L)	
EPA 524.2 (continued)						
Chlorobenzene	ND	ND	--	ND	ND	0.0005
Chloroethane	ND	ND	--	ND	ND	0.0005
Chloroform	ND	ND	--	ND	**0.0019**	0.0005
Chloromethane	ND	ND	--	ND	ND	0.0005
cis-1,2-Dichloroethene	ND	ND	--	ND	ND	0.0005
Dibromochloromethane	ND	ND	--	ND	**0.0068**	0.0005
Dibromomethane	ND	ND	--	ND	ND	0.0005
Dichlorodifluoromethane (Freon 12)	ND	ND	--	ND	ND	0.0005
Di-isopropyl ether	ND	ND	--	ND	ND	0.003
Ethyl tert-butyl ether	ND	ND	--	ND	ND	0.003
Ethylbenzene	ND	ND	--	ND	ND	0.0005
Freon 113	ND	ND	--	ND	ND	0.005
Hexachlorobutadiene	ND	ND	--	ND	ND	0.0005
Isopropylbenzene	ND	ND	--	ND	ND	0.0005
m,p-Xylene	ND	ND	--	ND	ND	0.001
m-Dichlorobenzene	ND	ND	--	ND	ND	0.0005
Methyl tert-butyl ether (MTBE)	ND	ND	--	ND	ND	0.003
Methylene chloride	ND	ND	--	ND	ND	0.0005
Naphthalene	ND	ND	--	ND	ND	0.0005
n-Butylbenzene	ND	ND	--	ND	ND	0.0005

Table C.34 Continued (Part 5)

Chemical	October 11, 2007 Sampling			December 18, 2007 Sampling		Laboratory Reporting Limit (mg/L)
	Well A Concentration (mg/L)	Well B Concentration (mg/L)	Well B/ Import Blend (mg/L)	Well A Concentration (mg/L)	Well B Concentration (mg/L)	
EPA 524.2 (continued)						
m-Dichlorobenzene	ND	ND	--	ND	ND	0.0005
Methyl tert-butyl ether (MTBE)	ND	ND	--	ND	ND	0.003
Methylene chloride	ND	ND	--	ND	ND	0.0005
Naphthalene	ND	ND	--	ND	ND	0.0005
n-Butylbenzene	ND	ND	--	ND	ND	0.0005
n-Propylbenzene	ND	ND	--	ND	ND	0.0005
o-Dichlorobenzene	ND	ND	--	ND	ND	0.0005
o-Xylene	ND	ND	--	ND	ND	0.0005
p-Dichlorobenzene	ND	ND	--	ND	ND	0.0005
p-Isopropyltoluene	ND	ND	--	ND	ND	0.0005
sec-Butylbenzene	ND	ND	--	ND	ND	0.0005
Styrene	ND	ND	--	ND	ND	0.0005
Tert-amyl methyl ether	ND	ND	--	ND	ND	0.003
tert-Butylbenzene	ND	ND	--	ND	ND	0.0005
Tetrachloroethene	ND	ND	--	ND	ND	0.0005
Toluene	ND	ND	--	ND	ND	0.0005
trans-1,2-Dichloroethene	ND	ND	--	ND	ND	0.0005
Trichloroethene	ND	ND	--	ND	ND	0.0005
Trichlorofluoromethane	ND	ND	--	ND	ND	0.005
Vinyl chloride	ND	ND	--	ND	ND	0.0005
Xylenes (total)	ND	ND	--	ND	ND	0.0005

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City of Camarillo

FINAL DRAFT
UWMP

2010 Urban Water Management Plan

May 2011

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City of Camarillo
2010 Urban Water Management Plan

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The Water supplier is a: **Municipality**

The Water supplier is a: **Retailer**

Utility services provided by the water supplier include: **Water**

Is This Agency a Bureau of Reclamation Contractor? **No**

Is This Agency a State Water Project Contractor? **No**

City of Camarillo

URBAN WATER MANAGEMENT PLAN

FINAL DRAFT
May 2011

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City of Camarillo

Urban Water Management Plan

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LIST OF ABBREVIATIONS

Abbreviation	Description
AB	Assembly Bill
ADD	Average Day Demand
af	Acre Feet
afy	Acre Feet per Year
BMP	Best Management Practices
BPS	Booster Pumping Station
CDR	Center for Demographic Research
CIMIS	California Irrigation Management Information System
CRWQCB	California Regional Water Quality Control Board
DMMs	Demand Management Measures
DOF	Department of Finance
DPH	Department of Public Health
du/ac	Dwelling Units per Acre
DWR	Department of Water Resources
EPA	Environmental Protection Agency
ETo	Evapotranspiration
FAR	Floor Area Ratio
ft-MSL	Feet above Mean Sea Level
FY	Fiscal Year
gpcd	Gallons per Capita per Day
gpm	Gallons per Minute
GWMP	Groundwater Management Plan
HGL	Hydraulic Grade Line
HOA	Home Owners' Association
IRP	Integrated Resource Plan
MAF	Million Acre Feet
MCL	Maximum Contaminant Level
MFR	Multi-Family Residential
MG	Million Gallons
mgd	Million Gallons per Day
mg/l	Milligrams per Liter
MOU	Memorandum of Understanding
MWDSC	Metropolitan Water District of Southern California
RUWMP	Regional Urban Water Management Plan
RW	Recycled Water
RWMP	Recycled Water Master Plan
RWQCB	Regional Water Quality Control Board
SAWPA	Santa Ana Watershed Project Authority
SB	Senate Bill
SCAG	Southern California Association of Governments
SDP	Seawater Desalination Project
SFR	Single Family Residential
SOI	Sphere of Influence
SWP	State Water Project
TDS	Total Dissolved Solids
ULF	Ultra Low Flush
UWMP	Urban Water Management Plan
UWMPA	Urban Water Management Planning Act

Abbreviation	Description
WCS	Water Code Section
WMP	Water Master Plan
WRF	Water Reclamation Facility
WRCC	Western Regional Climate Center
WSA	Water Supply Assessment
WSDM	Water Surplus and Drought Management
WSRP	Water Shortage Response Plan

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Table I-2 Urban Water Management Plan checklist, organized by subject

No.	UWMP requirement [a]	Calif. Water Code reference	Additional clarification	UWMP location
PLAN PREPARATION				
4	Coordinate the preparation of its plan with other appropriate agencies in the area, including other water suppliers that share a common source, water management agencies, and relevant public agencies, to the extent practicable.	10620(d)(2)		Section 1.3 Appendix B
6	Notify, at least 60 days prior to the public hearing on the plan required by Section 10642, any city or county within which the supplier provides water that the urban water supplier will be reviewing the plan and considering amendments or changes to the plan. Any city or county receiving the notice may be consulted and provide comments.	10621(b)		Section 1.4 Appendix B
7	Provide supporting documentation that the UWMP or any amendments to, or changes in, have been adopted as described in Section 10640 et seq.	10621(c)		Appendix B
54	Provide supporting documentation that the urban water management plan has been or will be provided to any city or county within which it provides water, no later than 60 days after the submission of this urban water management plan.	10635(b)		Section 1.3 Appendix B
55	Provide supporting documentation that the water supplier has encouraged active involvement of diverse social, cultural, and economic elements of the population within the service area prior to and during the preparation of the plan.	10642		Appendix B
56	Provide supporting documentation that the urban water supplier made the plan available for public inspection and held a public hearing about the plan. For public agencies, the hearing notice is to be provided pursuant to Section 6066 of the Government Code. The water supplier is to provide the time and place of the hearing to any city or county within which the supplier provides water. Privately-owned water suppliers shall provide an equivalent notice within its service area.	10642		Section 1.4 Appendix B
57	Provide supporting documentation that the plan has been adopted as prepared or modified.	10642		Appendix B
58	Provide supporting documentation as to how the water supplier plans to implement its plan.	10643		Section 6.3

No.	UWMP requirement [a]	Calif. Water Code reference	Additional clarification	UWMP location
59	Provide supporting documentation that, in addition to submittal to DWR, the urban water supplier has submitted this UWMP to the California State Library and any city or county within which the supplier provides water supplies a copy of its plan no later than 30 days after adoption. This also includes amendments or changes.	10644(a)		Section 1.3 Appendix B
60	Provide supporting documentation that, not later than 30 days after filing a copy of its plan with the department, the urban water supplier has or will make the plan available for public review during normal business hours	10645		Section 1.3 Appendix B
SYSTEM DESCRIPTION				
8	Describe the water supplier service area.	10631(a)		Chapter 2 Figure 2.1
9	Describe the climate and other demographic factors of the service area of the supplier	10631(a)		Sections 2.3 and 2.4
10	Indicate the current population of the service area	10631(a)	Provide the most recent population data possible. Use the method described in "Baseline Daily Per Capita Water Use." See Section M.	Section 2.3
11	Provide population projections for 2015, 2020, 2025, and 2030, based on data from State, regional, or local service area population projections.	10631(a)	2035 and 2040 can also be provided to support consistency with Water Supply Assessments and Written Verification of Water Supply documents.	Section 2.3
12	Describe other demographic factors affecting the supplier's water management planning.	10631(a)		Section 2.2
SYSTEM DEMANDS				
1	Provide baseline daily per capita water use, urban water use target, interim urban water use target, and compliance daily per capita water use, along with the bases for determining those estimates, including references to supporting data.	10608.20(e)		Section 6.1 Section 5.1 Tables 6.1 to 6.4
2	*Wholesalers:* Include an assessment of present and proposed future measures, programs, and policies to help achieve the water use reductions. *Retailers:* Conduct at least one public hearing that includes general discussion of the urban retail water supplier's implementation plan for complying with the Water Conservation Bill of 2009.	10608.36 10608.26(a)	Retailers and wholesalers have slightly different requirements	Section 1.4

No.	UWMP requirement [a]	Calif. Water Code reference	Additional clarification	UWMP location
3	Report progress in meeting urban water use targets using the standardized form.	10608.40		Not Applicable Until 2015
25	Quantify past, current, and projected water use, identifying the uses among water use sectors, for the following: (A) single-family residential, (B) multifamily, (C) commercial, (D) industrial, (E) institutional and governmental, (F) landscape, (G) sales to other agencies, (H) saline water intrusion barriers, groundwater recharge, conjunctive use, and (I) agriculture.	10631(e)(1)	Consider 'past' to be 2005, present to be 2010, and projected to be 2015, 2020, 2025, and 2030. Provide numbers for each category for each of these years.	Section 5.2 Table 5.3
33	Provide documentation that either the retail agency provided the wholesale agency with water use projections for at least 20 years, if the UWMP agency is a retail agency, OR, if a wholesale agency, it provided its urban retail customers with future planned and existing water source available to it from the wholesale agency during the required water-year types	10631(k)	Average year, single dry year, multiple dry years for 2015, 2020, 2025, and 2030.	[Need to Obtain]
34	Include projected water use for single-family and multifamily residential housing needed for lower income households, as identified in the housing element of any city, county, or city and county in the service area of the supplier.	10631.1(a)		Table 5.4
SYSTEM SUPPLIES				
13	Identify and quantify the existing and planned sources of water available for 2015, 2020, 2025, and 2030.	10631(b)	The 'existing' water sources should be for the same year as the "current population" in line 10. 2035 and 2040 can also be provided.	Section 3.1 Table 3.1
14	Indicate whether groundwater is an existing or planned source of water available to the supplier. If yes, then complete 15 through 21 of the UWMP Checklist. If no, then indicate "not applicable" in lines 15 through 21 under the UWMP location column.	10631(b)	Source classifications are: surface water, groundwater, recycled water, storm water, desalinated sea water, desalinated brackish groundwater, and other.	Section 3.5
15	Indicate whether a groundwater management plan been adopted by the water supplier or if there is any other specific authorization for groundwater management. Include a copy of the plan or authorization.	10631(b)(1)		Section 3.5
16	Describe the groundwater basin.	10631(b)(2)		Section 3.5
17	Indicate whether the groundwater basin is adjudicated? Include a copy of the court order or decree.	10631(b)(2)		Section 3.5

No.	UWMP requirement [a]	Calif. Water Code reference	Additional clarification	UWMP location
18	Describe the amount of groundwater the urban water supplier has the legal right to pump under the order or decree. If the basin is not adjudicated, indicate “not applicable” in the UWMP location column.	10631(b)(2)		Section 3.5 Appendix C
19	For groundwater basins that are not adjudicated, provide information as to whether DWR has identified the basin or basins as overdrafted or has projected that the basin will become overdrafted if present management conditions continue, in the most current official departmental bulletin that characterizes the condition of the groundwater basin, and a detailed description of the efforts being undertaken by the urban water supplier to eliminate the long-term overdraft condition. If the basin is adjudicated, indicate “not applicable” in the UWMP location column.	10631(b)(2)		Section 3.5
20	Provide a detailed description and analysis of the location, amount, and sufficiency of groundwater pumped by the urban water supplier for the past five years	10631(b)(3)		Section 3.5
21	Provide a detailed description and analysis of the amount and location of groundwater that is projected to be pumped.	10631(b)(4)	Provide projections for 2015, 2020, 2025, and 2030.	Section 3.5
24	Describe the opportunities for exchanges or transfers of water on a short-term or long-term basis.	10631(d)		Section 7.6
30	Include a detailed description of all water supply projects and programs that may be undertaken by the water supplier to address water supply reliability in average, single-dry, and multiple-dry years, excluding demand management programs addressed in (f)(1). Include specific projects, describe water supply impacts, and provide a timeline for each project.	10631(h)		Section 7.2
31	Describe desalinated water project opportunities for long-term supply, including, but not limited to, ocean water, brackish water, and groundwater.	10631(i)		Section 3.6 Section 7.7
44	Provide information on recycled water and its potential for use as a water source in the service area of the urban water supplier. Coordinate with local water, wastewater, groundwater, and planning agencies that operate within the supplier's service area.	10633		Chapter 4
45	Describe the wastewater collection and treatment systems in the supplier's service area, including a quantification of the amount of wastewater collected and treated and the methods of wastewater disposal.	10633(a)		Section 4.1

No.	UWMP requirement [a]	Calif. Water Code reference	Additional clarification	UWMP location
46	Describe the quantity of treated wastewater that meets recycled water standards, is being discharged, and is otherwise available for use in a recycled water project.	10633(b)		Section 4.1
47	Describe the recycled water currently being used in the supplier's service area, including, but not limited to, the type, place, and quantity of use.	10633(c)		Section 4.2
48	Describe and quantify the potential uses of recycled water, including, but not limited to, agricultural irrigation, landscape irrigation, wildlife habitat enhancement, wetlands, industrial reuse, groundwater recharge, indirect potable reuse, and other appropriate uses, and a determination with regard to the technical and economic feasibility of serving those uses.	10633(d)		Section 4.3
49	The projected use of recycled water within the supplier's service area at the end of 5, 10, 15, and 20 years, and a description of the actual use of recycled water in comparison to uses previously projected.	10633(e)		Sections 4.2 and 4.3
50	Describe the actions, including financial incentives, which may be taken to encourage the use of recycled water, and the projected results of these actions in terms of acre-feet of recycled water used per year.	10633(f)		Section 4.4
51	Provide a plan for optimizing the use of recycled water in the supplier's service area, including actions to facilitate the installation of dual distribution systems, to promote recirculating uses, to facilitate the increased use of treated wastewater that meets recycled water standards, and to overcome any obstacles to achieving that increased use.	10633(g)		Not Applicable
WATER SHORTAGE RELIABILITY AND WATER SHORTAGE CONTINGENCY PLANNING [b]				
5	Describe water management tools and options to maximize resources and minimize the need to import water from other regions.	10620(f)		Section 3.5 and 3.6
22	Describe the reliability of the water supply and vulnerability to seasonal or climatic shortage and provide data for (A) an average water year, (B) a single dry water year, and (C) multiple dry water years.	10631(c)(1)		Sections 7.4 and 7.5
23	For any water source that may not be available at a consistent level of use - given specific legal, environmental, water quality, or climatic factors - describe plans to supplement or replace that source with alternative sources or water demand management measures, to the extent practicable.	10631(c)(2)		Section 7.3
35	Provide an urban water shortage contingency analysis that specifies stages of action, including up to a 50-percent water supply reduction, and an outline of specific water supply conditions at each stage	10632(a)		Chapter 8

No.	UWMP requirement [a]	Calif. Water Code reference	Additional clarification	UWMP location
36	Provide an estimate of the minimum water supply available during each of the next three water years based on the driest three-year historic sequence for the agency's water supply.	10632(b)		[Not Included]
37	Identify actions to be undertaken by the urban water supplier to prepare for, and implement during, a catastrophic interruption of water supplies including, but not limited to, a regional power outage, an earthquake, or other disaster.	10632(c)		Sections 8.1 and 8.2
38	Identify additional, mandatory prohibitions against specific water use practices during water shortages, including, but not limited to, prohibiting the use of potable water for street cleaning.	10632(d)		Section 8.2.1
39	Specify consumption reduction methods in the most restrictive stages. Each urban water supplier may use any type of consumption reduction methods in its water shortage contingency analysis that would reduce water use, are appropriate for its area, and have the ability to achieve a water use reduction consistent with up to a 50 percent reduction in water supply.	10632(e)		Section 8.2
40	Indicated penalties or charges for excessive use, where applicable.	10632(f)		Section 8.2.3
41	Provide an analysis of the impacts of each of the actions and conditions described in subdivisions (a) to (f), inclusive, on the revenues and expenditures of the urban water supplier, and proposed measures to overcome those impacts, such as the development of reserves and rate adjustments.	10632(g)		Section 8.4
42	Provide a draft water shortage contingency resolution or ordinance.	10632(h)		Section 8.3 Appendix E
43	Indicate a mechanism for determining actual reductions in water use pursuant to the urban water shortage contingency analysis.	10632(i)		Section 8.6
52	Provide information, to the extent practicable, relating to the quality of existing sources of water available to the supplier over the same five-year increments, and the manner in which water quality affects water management strategies and supply reliability	10634	For years 2010, 2015, 2020, 2025, and 2030	Section 7.7

No.	UWMP requirement [a]	Calif. Water Code reference	Additional clarification	UWMP location
53	Assess the water supply reliability during normal, dry, and multiple dry water years by comparing the total water supply sources available to the water supplier with the total projected water use over the next 20 years, in five-year increments, for a normal water year, a single dry water year, and multiple dry water years. Base the assessment on the information compiled under Section 10631, including available data from state, regional, or local agency population projections within the service area of the urban water supplier.	10635(a)		Section 7.4 and 7.5
DEMAND MANAGEMENT MEASURES				
26	Describe how each water demand management measures is being implemented or scheduled for implementation. Use the list provided.	10631(f)(1)	Discuss each DMM, even if it is not currently or planned for implementation. Provide any appropriate schedules.	Section 6.2
27	Describe the methods the supplier uses to evaluate the effectiveness of DMMs implemented or described in the UWMP.	10631(f)(3)		Section 6.2
28	Provide an estimate, if available, of existing conservation savings on water use within the supplier's service area, and the effect of the savings on the ability to further reduce demand.	10631(f)(4)		Section 6.2
29	Evaluate each water demand management measure that is not currently being implemented or scheduled for implementation. The evaluation should include economic and non-economic factors, cost-benefit analysis, available funding, and the water suppliers' legal authority to implement the work.	10631(g)	See 10631(g) for additional wording.	Not Applicable
32	Include the annual reports submitted to meet the Section 6.2 requirements, if a member of the CUWCC and signer of the December 10, 2008 MOU.	10631(j)	Signers of the MOU that submit the annual reports are deemed compliant with Items 28 and 29.	Appendix F

a The UWMP Requirement descriptions are general summaries of what is provided in the legislation. Urban water suppliers should review the exact legislative wording prior to submitting its UWMP.

b The Subject classification is provided for clarification only. It is aligned with the organization presented in Part I of this guidebook. A water supplier is free to address the UWMP Requirement anywhere with its UWMP, but is urged to provide clarification to DWR to facilitate review.

Chapter 1

INTRODUCTION

1.1 PURPOSE

The California Water Code requires urban water suppliers within the state to prepare and adopt Urban Water Management Plans (UWMPs) for submission to the California Department of Water Resources (DWR). The UWMPs, which must be filed every five years, must satisfy the requirements of the Urban Water Management Planning Act (UWMPA) of 1983 including amendments that have been made to the Act. The UWMPA requires urban water suppliers servicing 3,000 or more connections, or supplying more than 3,000 acre-feet (af) of water annually, to prepare an UWMP.

The purpose of the UWMP is to maintain efficient use of urban water supplies, continue to promote conservation programs and policies, ensure that sufficient water supplies are available for future beneficial use, and provide a mechanism for response during water drought conditions. This report, which was prepared in compliance with the California Water Code, and as set forth in the guidelines and format established by the DWR, constitutes the City of Camarillo (City) 2010 UWMP.

1.2 BACKGROUND

1.2.1 Urban Water Management Planning Act

In 1983, State Assembly Bill (AB) 797 modified the California Water Code Division 6, by creating the UWMPA. Several amendments to the original UWMPA, which were introduced since 1983, have increased the data requirements and planning elements to be included in the 2005 and 2010 UWMPs.

Initial amendments to the UWMPA required that total projected water use be compared to water supply sources over the next 20 years, in 5-year increments. Recent DWR guidelines also suggest projecting through a 25-year planning horizon to maintain a 20-year timeframe until the next UWMP update has been completed and for use in developing Water Supply Assessments.

Other amendments require that UWMPs include provisions for recycled water use, demand management measures, and a water shortage contingency plan, set forth therein. Recycled water was added in the reporting requirements for water usage and figures prominently in the requirements for evaluation of alternative water supplies, when future projections predict the need for additional water supplies. Each urban water purveyor must coordinate the preparation of the water shortage contingency plan with other urban water purveyors in the area, to the extent practicable. Each water supplier must also describe their water demand management measures that are being implemented, or scheduled for implementation.

In addition to the UWMPA and its amendments, there are several other regulations that are related to the content of the UWMP. In summary, the key relevant regulations are:

- AB 1420: Requires implementation of demand management measures (DMMs)/best management practices (BMPs) and meeting the 20 percent reduction by 2020 targets to qualify for water management grants or loans.
- AB 1465: Requires water suppliers to describe opportunities related to recycled water use and stormwater recapture to offset potable water use.
- Amendments Senate Bill (SB) 610 (Costa, 2001), and SB 221 (Daucher, 2001), which became effective beginning January 1, 2002, require counties and cities to consider information relating to the availability of water to supply new large developments by mandating the preparation of further water supply planning (Daucher) and Water Supply Assessments (Costa).
- SB 1087: Requires water suppliers to report single family residential (SFR) and multi-family residential (MFR) projected water use for planned lower income units separately.
- Amendment SB 318 (Alpert, 2004) requires the UWMP to describe the opportunities for development of desalinated water, including but not limited to, ocean water, brackish water, and groundwater, as long-term supply.
- AB 105 (Wiggins, 2004) requires urban water suppliers to submit their UWMPs to the California State Library.
- SBx7-7: Requires development and use of new methodologies for reporting population growth estimates, base per capita use, and water conservation. This water bill also extended the 2010 UWMP adoption deadline for retail agencies to July 1, 2011.
- SB 1478: This bill was signed on September 23, 2010and extends the 2010 UWMP deadline for wholesale agencies, such as the Metropolitan Water District of Southern California (MWDSC), to July 1, 2011, as SBx7-7 did for retail agencies.

The UWMPA is included for reference in Appendix C.

1.2.2 Previous Urban Water Management Plan

Pursuant to the UWMPA, the City previously prepared an UWMP in 2005, which was approved and adopted on December 14, 2005. Following initial adoption, the 2005 UWMP was amended, presented at a public hearing, and adopted as amended on May 10, 2006. This 2010 UWMP report serves as an update to the 2005 UWMP and pulls extensively from that report.

1.3 COORDINATION WITH APPROPRIATE AGENCIES

The UWMPA requires that the UWMP identify the water agency's coordination with appropriate nearby agencies.

> *10620 (d) (2) Each urban water supplier shall coordinate the preparation of its plan with other appropriate agencies in the area, including other water suppliers that share a common source, water management agencies, and relevant public agencies, to the extent practicable.*

The City is the sole water supplier and water management agency for the area. While preparing the 2010 UWMP, the City coordinated its efforts with relevant agencies to ensure that the data and issues discussed in the plan were presented accurately. Table 1.1 summarizes how the UWMP preparation was coordinated with different agencies in area.

Table 1.1 Coordination with Appropriate Agencies (Guidebook Table 1)

Check at least one box on each row	Participated in Developing the Plan	Commented on the Draft	Attended Public Meetings	Was Contacted for Assistance	Was Sent a Copy of the Draft Plan	Was Sent a Notice of Intention to Adopt	Not Involved/ Not Informed
Camarillo Sanitary District							
Fox Canyon Groundwater Management Agency							
Camrosa Water District						✓	
Cal-American Water Company						✓	
Calleguas Municipal Water District						✓	
Pleasant Valley Mutual Water Company						✓	
Ventura County Water Company						✓	
Pleasant Valley Company Water District						✓	
Crestview Mutual Water Company						✓	

1.4 PUBLIC PARTICIPATION AND PLAN ADOPTION

The UWMPA requires that the UWMP show the water agency solicited public participation.

> 10642. Each urban water supplier shall encourage the active involvement of diverse social, cultural, and economic elements of the population within the service area prior to and during the preparation of the plan. Prior to adopting a plan, the urban water supplier shall make the plan available for public inspection and shall hold a public hearing thereon. Prior to the hearing, notice of the time and place of hearing shall be published … After the hearing, the plan shall be adopted as prepared or as modified after the hearing.

In accordance with the UWMPA, the City held a public hearing and adopted the 2010 UWMP on [June 8, 2011]. A copy of the adopting resolution and resolution of intent to adopt are included in Appendix B. The hearing provided an opportunity for the City's customers, residents, and employees to learn and ask questions about the current and future water supply of the City.

A notice of the public hearing was published in the local newspaper on February 27, 2011, notifying interested parties that the draft 2010 UWMP was under preparation. Pursuant to California Code Section 6066, a notification of the time and place of the public hearing was published in the local newspaper on May 15 and 22, 2011. A copy of these notifications is included in Appendix B.

1.5 REPORT ORGANIZATION

The UWMP contains eight chapters, followed by appendices that provide supporting documentation for the information presented in the report. The chapters are briefly described below:

Executive Summary

Chapter 1 - Introduction. This chapter presents the purpose of this UWMP, describes the efforts of the City to coordinate the preparation of the UWMP with appropriate nearby agencies, and discusses the measures used to solicit public participation in the UWMP.

Chapter 2 - Service Area. This chapter presents a description of the City's water service area and various characteristics of the area served including climate, population, and other demographic factors.

Chapter 3 – Water Sources. This chapter presets a description of the agency's existing and future water supply sources for the next 25 years. The description of water supplies includes information on the groundwater usage such as water rights, determination if the basin is in overdraft, and other relevant information.

Chapter 4 – Water Reclamation. This chapter includes information on the City's existing recycled water system and usage, as well as the projected expansion of recycled water use per the recent Recycled Water Master Plan prepared in 2010.

Chapter 5 – Water Use. This chapter presents the quantity of water supplied to the agency's customers including a breakdown by user classification.

Chapter 6 – Water Conservation. This chapter is broken into two parts:

Part I addresses the requirements of the Water Conservation Act of 2009

Part II includes a description of the City's Best Management Practices (BMPs). This includes programs which are currently implemented or scheduled for implementation.

Chapter 7 – Reliability of Supply. In this chapter, the UWMP addresses the reliability of the agency's water supplies. This includes supplies that are vulnerable to seasonal or climatic variations. In addition, there is an analysis of supply availability in a single dry year and in multiple dry years.

Chapter 8 – Water Shortage Contingency Plan. This chapter includes an urban water shortage contingency analysis that includes stages of action to be undertaken in the event of water supply shortages; a water shortage contingency ordinance; prohibitions, consumption reduction methods and penalties; an analysis of revenue and expenditure impacts and measures to overcome these impacts; actions to be taken during a catastrophic interruption; and a mechanism for measuring water use reduction.

1.6 ACKNOWLEDGEMENTS

Carollo Engineers wishes to acknowledge and thank the following City staff:

Lucie McGovern	Water Superintendent
Tom Smith	Deputy Director of Public Works

Their cooperation and courtesy in obtaining a variety of necessary information were valuable components in completing and producing this report.

The following staff of Carollo Engineers was involved in the preparation of this plan:

Patrick White, P.E.	Principal-in-Charge
Inge Wiersema, P.E.	Project Manager
Brian Brenhaug, P.E.	Project Engineer
John Meyerhofer	Staff Engineer
Li-Chen Wang	GIS and graphics

Chapter 2

SERVICE AREA AND POPULATION

The UWMPA requires that the UWMP include a description of the water purveyor's service area and various characteristics of the area served including climate, population, and other demographic factors.

> *10631. A plan shall be adopted in accordance with this chapter and shall do all of the following:*
>
> *10631. (a) Describe the service area of the supplier, including current and projected population, climate, and other demographic factors affecting the supplier's water management planning. The projected population estimates shall be based upon data from the state, regional, or local service agency population projections within the service area of the urban water supplier and shall be in five-year increments to 20 years or as far as data is available.*

2.1 LOCATION

Camarillo is located on Highway 101 in the Pleasant Valley portion of the Oxnard Plain, 9 miles inland from the Pacific Ocean, and 45 miles northwest of the City of Los Angeles. Camarillo is situated in the southern portion of Ventura County and is surrounded by open hills, mountains, and agricultural lands. The majority of the City is approximately 150 feet above mean sea level (ft-msl) while the northern foothill regions are as high as 360 ft-msl. The City's location is shown in Figure 2.1.

2.2 SERVICE AREA

The City's water service area consists of approximately 9,100 acres, about 75 percent of the City's total incorporated area of 12,186 acres. Figure 2.1 shows the City's water service area in relation to the City boundary. The Camrosa Water District, Pleasant Valley County Water District, Pleasant Valley Mutual Water Company, and Crestview Mutual Water Company serve the remaining 3,100 acres. As shown on Figure 2.1, the City's water service area extends outside the City boundary to serve some small areas to the west and north of the City.

Since the City's 2005 UWMP, the City's water service has annexed the airport water system, referred to as the Camarillo Utility Enterprise or the Ventura County Water Company. This annexation was completed in August 2006.

2.3 LAND USE

Land use within the service area is primarily residential, with some elements of commercial, industrial, and irrigated cropland. The City is approximately 50 percent residential, 5 percent commercial, 10 percent industrial, 10 percent agriculture, 15 percent public, and the remainder is parks and other uses. Table 2.1 summarizes the General Plan land use categories.

Table 2.1 Land Use Categories
2010 Urban Water Management Plan
City of Camarillo

Land Use	Area[1] (acres)	Percentage of Total
Residential - Rural Density	1,848	17.3%
Residential - Low Density	2194	20.5%
Residential - Low-Medium Density	971	9.1%
Residential - Medium Density	176	1.6%
Residential - High Density	250	2.3%
Residential - Mobile Home	127	1.2%
Commercial - General Commercial	472	4.4%
Commercial - Office	112	1.0%
Industrial - Industrial	869	8.1%
Industrial - Industrial/Commercial	7	0.1%
Industrial - Research and Development	188	1.8%
Conservation - Agriculture	1225	11.4%
Conservation - Natural Open Space	458	4.3%
Conservation - Urban Reserve	0	0.0%
Public - Public	748	7.0%
Public - Mini Park	1	0.0%
Public - Neighborhood Park	74	0.7%
Public - Community Park	95	0.9%
Public - City-Wide Park	73	0.7%
Public - Schools, Elementary	102	1.0%
Public - Schools, Middle School	39	0.4%
Public - Schools, High	69	0.6%
Public - Quasi-Public/Utility	261	2.4%
Public - Historic Site	6	0.1%
Public - Waterway Linkage	334	3.1%
Total	**10,699**	**100.0%**

Table 2.1 Land Use Categories
2010 Urban Water Management Plan
City of Camarillo

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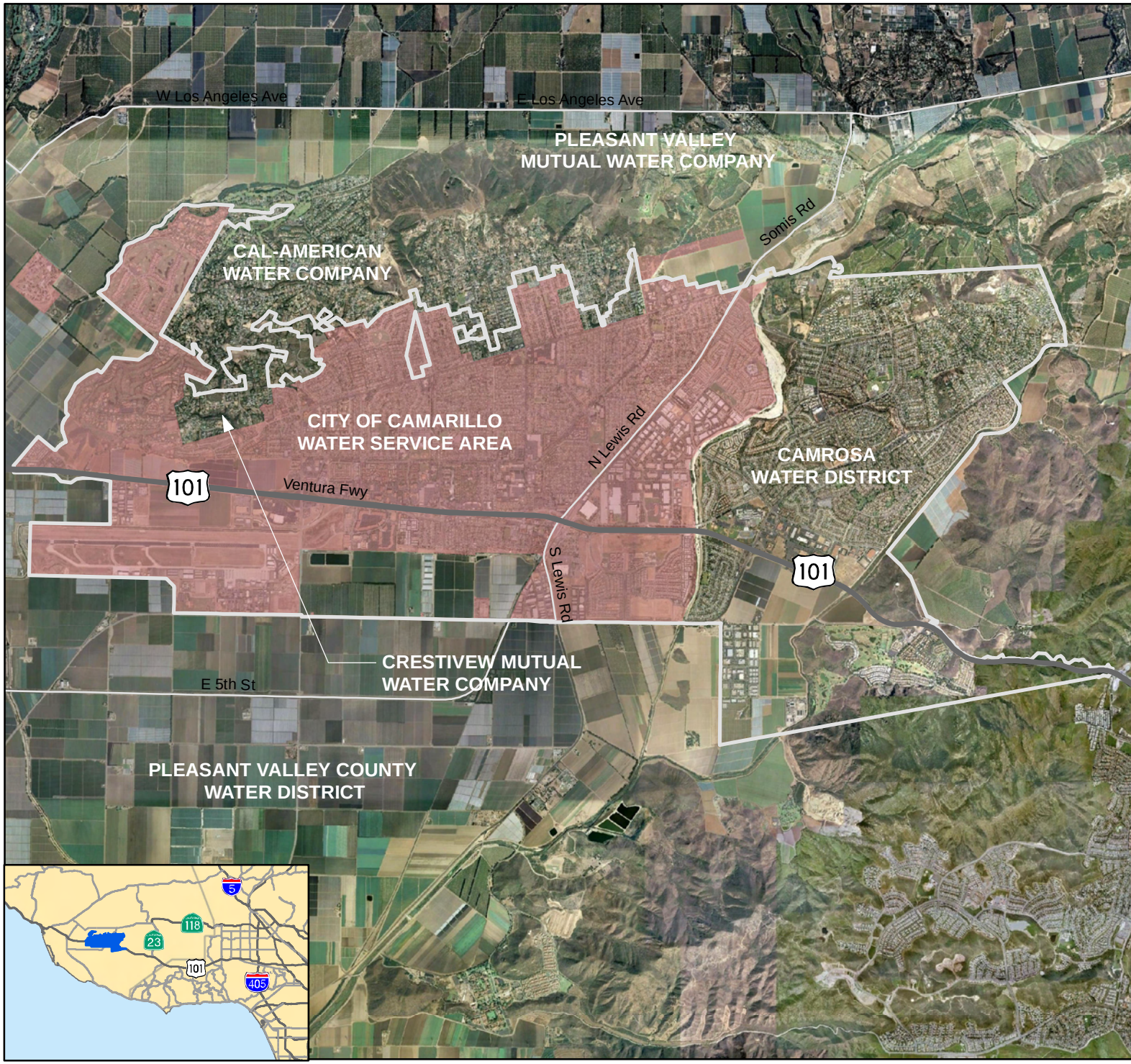
Public - Historic Site	6	0.1%
Public - Waterway Linkage	334	3.1%
Total	**10,699**	**100.0%**

Notes:
(1) Areas do not include street.



Legend

- Freeway
- Major Roads
- City Limits
- Water Service Boundary

N

0 2,500 5,000 10,000 Feet

Figure 2.1
2010 Urban Water
Management Plan
City of Camarillo

carollo

2.4 POPULATION

Population projections, shown in Table 2.2 and Figure 2.2, were used to forecast water requirements for the City. Since the City's water service area does not coincide with the City boundary, percentage growth from population projections from the SCAG Integrated Forecast (SCAG, 2010) for the City of Camarillo was adapted to the historical population within the City's water service area.

Table 2.2 Projected Population

2010 UWMP Projection Years	2015	2020	2025	2030	2035
Service Area Population(1)	46,902	48,213	49,323	50,293	50,918

Notes:
(1) Source: SCAG growth trends applied to historical service area population (SCAG, 2010)

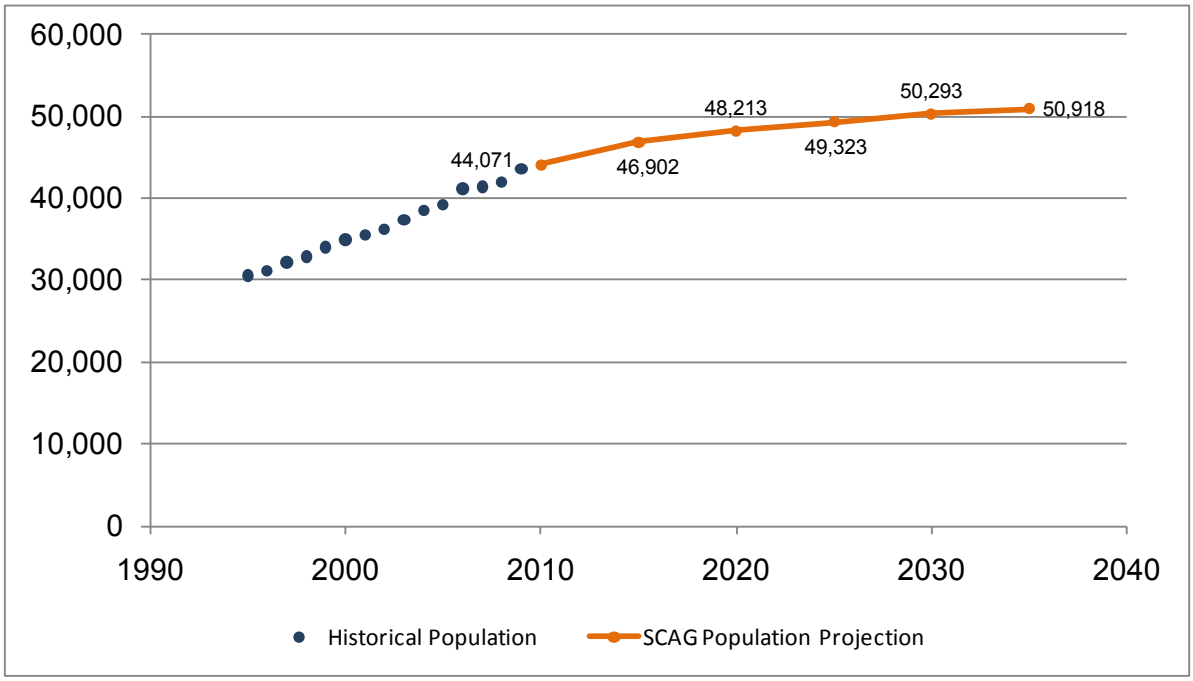


Figure 2.2 Historical and Projected Population

Since the City's water service area does not coincide with the City's boundaries, historical population shown in Figure 2.2 was calculated according to DWR methodologies, based on the number of service connections each year. The population within the water service area in 2000 was established through census data from the 2000 census (USCB, 2000). The population within the water service area was then compared with the number of service connections in 2000 to establish a population-to-account ratio, which could then be applied to the remaining years between 1995 and 2009. This method incorporated both single and multi-family population-to- account ratios through the number of single family and multi-family connections.

2.5 CLIMATE

The City's service area climate is a semi-arid environment with mild winters, warm summers and moderate rainfall, consistent with coastal Southern California. The climate is mild, tempered by cool sea breezes. The usually mild climatological pattern is interrupted infrequently by periods of extremely hot weather, winter storms, or dry hot Santa Ana winds. Table 2.3 summarizes the standard monthly average evapotranspiration (ETo) rates, rainfall, and temperature. The City's average monthly temperature ranges from 51.6 to 70.6 degrees Fahrenheit (°F), with an annual average temperature of 61.1°F. The daily extreme low and high temperatures have been measured to be 31°F and 100°F, respectively. ETo averages a total of 46.43 inches. The average annual temperature is 61.1°F.

Table 2.3 Climate Characteristics

Month	Standard Monthly Average ETo[1] (inches)	Monthly Average Rainfall[2] (inches)	Monthly Average Temperature[2] (°F)		
			Average	Minimum	Maximum
January	1.83	3.17	56.30	45.7	66.9
February	2.20	3.79	55.80	45.7	65.9
March	3.42	1.63	56.95	47.0	66.9
April	4.49	1.24	57.85	57.9	67.6
May	5.25	0.44	61.40	52.8	70.0
June	5.67	0.03	64.45	56.4	72.5
July	5.86	0.01	67.65	59.5	75.8
August	5.61	0.00	67.60	59.2	76.0
September	4.49	0.01	66.65	58.1	75.2
October	3.42	0.70	63.8	53.8	73.5
November	2.36	1.09	59.6	48.7	70.5
December	1.83	1.68	55.55	44.8	66.3
Annual	**46.43**	**13.86**	**61.10**	**51.6**	**70.6**

Notes:
(1) Source: California Irrigation Management Information System (CIMIS) Station 152 – Camarillo (CIMIS, 2010). Represents monthly average ETo from January 2000 to November 2010.
(2) Source: Western Regional Climate Center (WRCC) Station 046572 – Oxnard WSFO, California (WRCC, 2010). Represents monthly average data from May 1998 to July 2010.

As shown in Table 2.3, the historical annual average precipitation is approximately 13.9 inches. Records show that the monthly precipitation has been as high as 9.56 inches and as low as 0.0 inches. Most of the rainfall occurs during the period of November through April.

Chapter 3

WATER SUPPLY

The UWMPA requires that the UWMP include a description of the agency's existing and future water supply sources for the next 25 years. This section includes an overview of the City's supplies along with projections of usage of each source of supply followed by a detailed discussion on each supply source. This detailed discussion includes information on imported water supplies, recycled water supplies, groundwater supply facilities, and the groundwater basin such as water rights, determination of whether the basin is in overdraft, and other information from the groundwater management plan, which can be found in Appendix C.

> *10631. A plan shall be adopted in accordance with this chapter and shall do all of the following:*
>
> *10631 (b) Identify and quantify, to the extent practicable, the existing and planned sources of water available to the supplier over the same five-year increments described in subdivision (a) [to 20 years or as far as data is available]. If groundwater is identified as an existing or planned source of water available to the supplier, all of the following information shall be included in the plan:*
>
> *10631 (b) (1) A copy of any groundwater management plan adopted by the urban water supplier…*
>
> *10631 (b) (2) A description of any groundwater basin or basins from which the urban water supplier pumps groundwater. For those basins for which a court or board has adjudicated the rights to pump groundwater…For basins that have not been adjudicated, information as to whether the department has identified the basin or basins as overdrafted…*
>
> *10631 (b) (3) A detailed description and analysis of the location, amount, and sufficiency of groundwater pumped by the urban water supplier for the past five years. The description and analysis shall be based on information that is reasonably available, including, but not limited to, historic records.*
>
> *10631 (b) (4) A detailed description and analysis of the amount and location of groundwater that is projected to be pumped by the urban water supplier. The description and analysis shall be based on information that is reasonable available, including, but not limited to, historic use records.*

3.1 SUPPLY OVERVIEW

The City's water system supplies water from two sources, groundwater and imported water. The City pumps groundwater from the Fox Canyon Aquifer. The City's imported water supplier is Calleguas Municipal Water District (CMWD), a member of the Metropolitan Water District of Southern California (MWDSC). MWDSC's imported water originates from the Colorado River Aqueduct and the State Water Project (SWP); however, the City's imported supply from MWDSC has historically been from the SWP due to its location in the MWDSC supply system.

Total demands for the City from 2005 to 2009 averaged 9,863 acre-feet per year (afy). In 2009, 4,019 afy came from groundwater sources (i.e., Fox Canyon Aquifer) and 5,586 afy from imported water supplies (i.e., MWDSC's SWP supply via CMWD). Figure 3.1 shows the breakdown in deliveries in 2009.

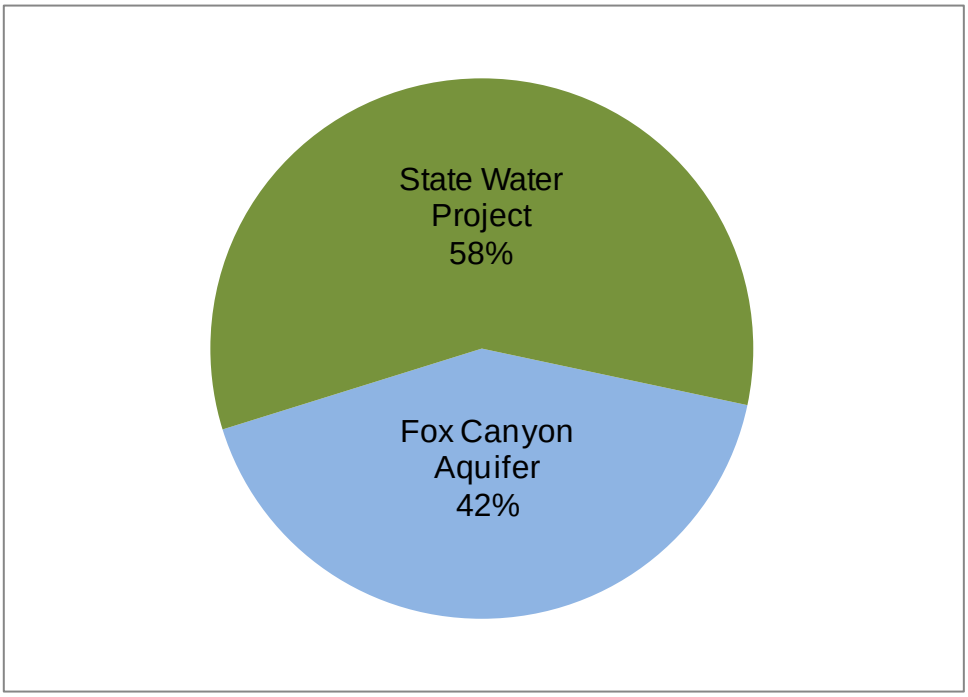


Figure 3.1 City Water Supplies for 2009

Between 1995 and 2009, the City's local groundwater supply, on average, met about 39 percent of the overall demand with the remaining 61 percent met by imported water. These numbers vary from year to year depending upon weather conditions, groundwater recharge rates, and groundwater blending requirements due to groundwater quality. Future demand projections assume that the City will continue to pump similar volumes of groundwater as the past five years until the completion of the Camarillo Regional Groundwater Desalter (Desalter). With the construction of the Desalter, the City's allocation will increase and the City will use groundwater to satisfy the most of its annual demand. Groundwater pumping is currently kept below the City's current Fox Canyon Groundwater Management Agency (FCGMA) groundwater allocation of 4,279 afy. The anticipated sources of water supply through the planning horizon of 2035 are shown in Table 3.1.

Table 3.1 Current and Projected Water Supply

Supply Source	Annual Supply (afy)					
	2010[(1)]	2015	2020[(2)]	2025	2030	2035
Imported Water (CMWD/MWDSC)[(2)]	4,550	6,344	153	375	570	695
Groundwater[(3)]	4,036	4,000	9,279	9,279	9,279	9,279
Recycled Water[(4)]	0	220	220	220	220	220
Total	**8,586**	**10,564**	**9,652**	**9,875**	**10,069**	**10,194**

Notes:
(1) 2010 represents actual historical data, all future values are based in population and gpcd projections
(2) The amount of imported water from year 2020 onward is determined as the balance between projected demand, and groundwater and recycled water production.
(3) The Camarillo Regional Groundwater Desalter is anticipated to complete in 2016/2017 and will increase the City's groundwater by 5,000 afy, increasing the groundwater pumping allotment from approx. 4,279 afy to 9,279 afy.
(4) The Village at the Park development is planned to use approx. 220 afy of recycled water. Recycled water is further discussed in Chapter 4.

The ability of the supplies to meet future growth in demands is discussed in Chapter 5. As shown in Table 3.1, groundwater pumping undergoes a dramatic increase in 2020 due to the implementation of the regional groundwater desalter. Recycled water is projected to be utilized at the new Village at the Park, increasing recycled water use within the City's service area to 220 afy. Imported water is used to meet additional demands and is anticipated to decline between 2010 and 2020 in order for the City to reach the Water Conservation Act of 2009 target for 2020. The imported supply then increases slightly along with normal population growth.

3.2 DISTRIBUTION SYSTEM AND STORAGE

The City's existing water distribution system consists of approximately 190 miles of 6-inch through 20-inch diameter pipelines, which include eight (US 101) freeway crossings. Other components of the City's water distribution system include: six reservoirs (four above ground and two underground) with a total combined capacity of 13.4 million gallons (MG), four groundwater wells, eight connections for importing water from CMWD, three pumping stations, and 11 pressure reducing valve locations.

3.3 IMPORTED WATER

10631 (k). Urban water suppliers that rely upon a wholesale agency for a source of water, shall provide the wholesale agency with water use projections from that agency for that source of water in five-year increments to 20 years or as far as data is available. The wholesale agency shall provide information to the urban water supplier for inclusion in the urban water supplier's plan that indentifies and quantifies, to the extent practicable, the existing and planned sources of water as required by subdivision (b), available from the wholesale agency to the urban water supplier over the same 5 year increments, and during various water year types in accordance with subdivision (c). An urban water supplier may rely upon water supply information provided by the wholesale agency in fulfilling the plan information requirements of subdivisions (b) and (c), including, but not limited to, ocean water, brackish water, and groundwater, as a long-term supply.

The City has purchased imported water from CMWD since April of 1966. CMWD receives treated SWP supplies from MWDSC's Jensen Treatment Plant located in Granada Hills, and supplies the City through eight turnouts from its Oxnard-Santa Rosa Feeder and Camarillo Feeder. Each of the City's turnouts has a rated capacity of 2,000 gpm.

In 1960, CMWD became a member agency of MWDSC. MWDSC is comprised of 26 member agencies; CMWD is the fifth largest member agency in terms of average annual water deliveries.

CMWD distributes potable water on a wholesale basis to 19 local purveyors, who deliver water to area residents, businesses, and agricultural customers. The water supplied by CMWD currently represents approximately 73 percent of the total municipal and industrial water supply within its service area. CMWD's service area encompasses approximately 375 square miles. Land use in the area is primarily residential, commercial, industrial, and irrigated cropland (BV, 2010).

The treated imported water is delivered to CMWD through MWDSC's West Valley Feeder No. 2 Pipeline. The water is then conveyed to Simi Valley, where the majority is distributed to CMWD's customers through their transmission system. The remainder is injected into the Las Posas aquifer or stored in Lake Bard. Water stored at Lake Bard, also called Wood Ranch Reservoir, is treated through CMWD's Lake Bard Water Filtration Plant, which has a capacity of 65 million gallons per day (mgd) (BV, 2010). This increases the supply reliability of the CMWD system and all of its customers.

3.4 SURFACE WATER

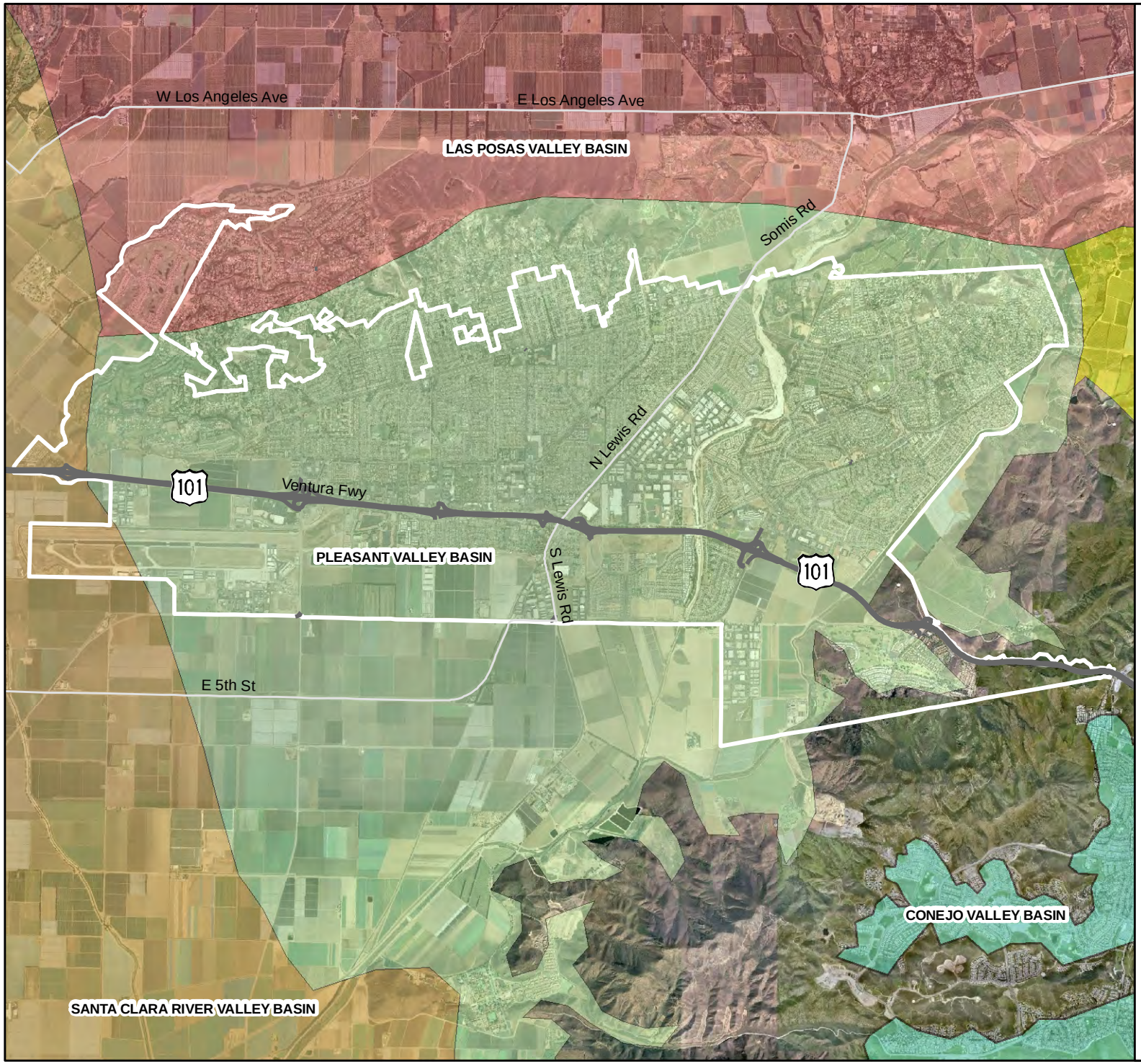
The City does not utilize local surface water supplies.

3.5 GROUNDWATER

The City and the surrounding area rest on an alluvial deposit approximately 1,000 feet thick, which is comprised of several aquifers interbedded with gravel, sand, and clay lenses. The

clay lenses preclude any significant groundwater movement from one aquifer to the next. The City's water service area lies almost entirely in the Pleasant Valley Basin, but there are also several separate groundwater basins in the area, separated by a series of faults or folds, which also reduce groundwater movement from one basin to another. Groundwater in the region generally flows southwest.

The Pleasant Valley Basin historically has been replenished by subsurface inflows from the Oxnard Plain Basin, East and West Las Posas Basins, and the Santa Rosa Basin. Subsurface inflow over the past several years has been limited to only the Oxnard Plain and the East Las Posas Basins. Over pumping in the other basins has lowered water tables and prevented subsurface inflows into the Pleasant Valley Basin.



Legend

Groundwater Basins

- Arroyo Santa Rosa Valley
- Conejo Valley
- Pleasant Valley
- Santa Clara River Valley
- Las Posas Valley

N

0 2,500 5,000 10,000 Feet

Figure 3.2
Groundwater Basins Map
2010 Urban Water
Management Plan
City of Camarillo

carollo

Most of the groundwater within the basin is contained within alluvial deposits and within the Fox Canyon and Grimes Canyon aquifers. The Fox Canyon Aquifer is the major water bearing unit in the Pleasant Valley Basin. The upper strata of the basin are alluvial deposits, which average 400 feet in thickness and consist of water bearing sands and gravels separated by clay lenses. The Fox Canyon aquifer is within the bottom of the San Pedro formation, which underlies the alluvial deposits. It varies in thickness from 400 feet to 1,500 feet and is effectively sealed from percolation of water from above by impervious materials located at the bottom of the alluvial deposits. Beneath the San Pedro formation lies the Santa Barbara formation containing the Grimes Canyon aquifer.

3.5.1 Groundwater Quality

The lower part of the area's aquifer system is generally considered to contain the better quality water with total dissolved solids (TDS) as low as 250 mg/L, although in some areas the TDS levels are in excess of 2,000 mg/L. TDS concentrations in excess of 1,000 mg/L are not uncommon in the upper aquifer system. The large number of well operators and continued pumping has created a severe overdraft of the Fox Canyon Aquifer. Saline intrusion from the coast and salinity associated with low groundwater levels are the primary water quality concern in the Pleasant Valley basin. Low groundwater levels extend from underneath the City to the ocean.

Other regional groundwater quality issues involve high TDS and occasionally high nitrate concentrations. Seawater intrusion has long been a concern and was the issue that precipitated the creation of the FCGMA. The intrusion occurs exclusively along the coastline in the Oxnard Plain and Pleasant Valley Basins.

Chloride as a particular constituent of concern in the East and South Las Posas basins, recently affecting the City's wells (CMWD, 2011). High nitrate concentrations in the groundwater is a problem localized in the Oxnard Plain and Forebay basins. Drinking water wells in the impacted areas are often affected during and following dry periods. The primary sources of nitrate are septic systems and agricultural fertilizer. To address the problem, septic systems are now prohibited in the Oxnard Plain Forebay and BMPs are being implemented to limit agricultural contributions (BV, 2010).

3.5.2 Groundwater Levels and Historical Trends

Historically, it was assumed that the lower aquifer system of the Pleasant Valley Basin was confined and received little overall recharge across the fault that extends from the Camarillo Hills to Port Hueneme. However, since the early 1990s, water levels began to rise in the northern adjacent basins. The City has two existing wells in the northeast portion of the Pleasant Valley Basin and these wells confirm that rising water levels in the northern adjacent basins directly impact recharge rates, water quality, and water levels in the Pleasant Valley Basin area. Recharge in the area may be the result of uplift and folding of lower aquifer units that allow rapid stream flow percolation.

The portion of the Pleasant Valley Basin east of the City is not well understood because there are not very many wells. Along Calleguas Creek near California State University Channel Islands, water has been produced historically from aquifer depths that are shallower than the typical lower aquifer well, suggesting that water bearing strata are not limited to the lower aquifers in that area (FCGMA, 2007).

3.5.3 Sources of Recharge and Discharge

As mentioned in Section 3.5.1, much of Pleasant Valley Basin's recharge originates with the Las Posas Basin to the north. As water makes its way southwest through the watershed, Las Posas Basin, as well as Pleasant Valley Basin, receive recharge water. CMWD supplements natural groundwater recharge in the area through the use of groundwater injection. Some of the water imported by CMWD is stored in the Las Posas Groundwater Basin.

3.5.4 Groundwater Pumping

The annual amount of groundwater pumped since the 2005 UWMP is presented in Table 3.2.

Table 3.2 Amount of Groundwater Pumped

	Historical Groundwater Pumped from Basin (afy)				
Basin Name	**2006**	**2007**	**2008**	**2009**	**2010**
Pleasant Valley Basin	3,890	4,070	3,943	4,019	4,036
% of Total Water Supply(1)	**40.66%**	**39.03%**	**38.44%**	**41.84%**	**47.01%**

Notes:
(1) Camarillo Public Water System Statistics

As shown in Table 3.2, the amount of groundwater pumped in the Pleasant Valley Basin has gone up slightly, but remained fairly consistent over the last five years.

Table 3.3 groundwater supply projections are consistent with those presented in Table 3.1.

Table 3.3 Amount of Groundwater to be Pumped

	Annual Groundwater Pumped from Basin (afy)					
Basin Name	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**
Pleasant Valley Basin	4,000	4,000	9,279	9,279	9,279	9,279
Total	**4,000**	**4,000**	**9,279**	**9,279**	**9,279**	**9,279**

Notes:
(1) Assumes the City will pump recent historical volumes prior to the completion of the desalination plant, and will fully utilize its basin allocation after the desalter's completion

As shown in Table 3.3, the amount of groundwater pumped is anticipated to remain constant until the construction of the Camarillo Regional Groundwater Desalter. These estimates are based on the assumption that the City will pump a volume similar to what was pumped between 2005 and 2009 until the construction of a groundwater desalination plant is completed. The groundwater desalination plant will enable the City to utilize 5,000 afy of additional groundwater, resulting in a new basin allocation of 9,279 afy. It is anticipated that the desalter will be completed by 2016/2017. Hence, the amount of groundwater produced is increased in planning year 2020. The City's adjusted allocation of 9,279 afy is assumed to remain consistent through the planning horizon. Further details on the City's groundwater are available in the FCGMA Groundwater Management Plan, available in Appendix C. Also, basin information, such as California Groundwater Bulletin 118, is also presented in Appendix C.

It was assumed that the City will maximize groundwater first and then fulfill remaining demand with imported water, meaning that imported water, rather that groundwater, will decrease to meet conservation targets.

3.5.5 Basin Overdraft

Oxnard Plain, the hydrologic region just south of the City, began experiencing saltwater intrusion into its groundwater supply as early as 1930. In the Port Hueneme area, seawater in the aquifer system reached its farthest point inland in the early 1980s. Following the high rainfall in year 1983, chloride levels began to decrease in many of the area's wells. This improving trend was accelerated in the 1990s as aquifer pressures were restored and seawater was pushed back towards the coast.

The lower aquifer system, of which the Fox Canyon Aquifer is a part of, did not drop below sea level until the late 1950s. The over pumping of the aquifers that led to seawater intrusion also led to land subsidence of up to 2.2 feet in the Pleasant Valley area as dewatered clay layers between aquifer zones collapsed from reduced hydrostatic pressures. This subsidence is permanent, as refilling the sand and gravel aquifers does not force water back into the dry clay layers.

The FCGMA was created to moderate the use of groundwater within the area. In 1985, the FCGMA summed all water inputs and outputs to determine how much could be extracted from the basins in the region. Since that initial analysis, basin yield in the area has been recalculated several times. It has been found that many of the inland basins which do not abut the coastline are hydrologically connected to the coastal basins, evidenced by the continuity of groundwater elevation contours across their boundaries (FCGMA, 2007).

Although the Pleasant Valley Basin, the basin which the City overlies and from which the City draws from, is in a state of overdraft, the basin is not adjudicated. The FCGMA Ordinance established reductions in extraction allocations as a method to reduce overdraft of the groundwater basin. The reductions were scheduled to reduce groundwater pumping

by 25 percent over a 15 year period. In 2010, the reduction was set to 75 percent of historical allocation. The City's historical allocation is 4,082 afy. After including transfers and the 25 percent reduction, the City's "adjusted allocation" for 2010 was 4,279 afy. Pending approval by the FCGMA, the introduction of the Desalter will increase the City's groundwater allocation by 5,000 afy to 9,279 afy. This will significantly decrease reliance on imported water and allow the City to meet the majority of its demands with groundwater pumped from the Pleasant Valley Basin. Further information on the FCGMA's overdraft reduction can be found in the FCGMA Ordinance Code and the Groundwater Management Plan included in Appendix C.

To combat basin saline intrusion, land subsidence, and groundwater quality degradation, FCGMA instituted an ordinance prohibiting the drilling of new wells in the lower aquifer system within the region, instead requiring that wells be drilled into the more easily replenishable upper aquifer system. Further plans to address basin overdraft include additional storage projects and utilization of groundwater injection.

3.6 DESALINATED WATER

10631. A plan shall be adopted in accordance with this chapter and shall do all of the following:

10631 (i) Describe the opportunities for development of desalinated water, including, but not limited to, ocean water, brackish water, and groundwater, as a long term supply.

The UWMPA requires that the UWMP address the opportunities for development of desalinated water, including ocean water, brackish water, and groundwater. Table 3.4 summarizes the City's opportunities for the various types of desalinated water supply.

Table 3.4 Opportunities for Desalinated Water

Sources of Water	Existing Desalinated Water	Opportunities for Desalinated Water
Ocean Water	None	None
Brackish Ocean Water	None	None
Brackish Groundwater	None	Camarillo Regional Groundwater Desalter
Other	None	None

As summarized in Table 3.4, for the City is not pursuing ocean water desalination, but is in the planning stages of developing a groundwater desalination plant, as discussed below.

3.6.1 Brackish Water and/or Groundwater Desalination

Currently, high TDS levels are found within the groundwater basin underlying the City's water service area. This necessitates the blending of pumped groundwater with imported water to lower the TDS prior to introduction to the potable water system. This has limited

the amount of groundwater the City is able to pump, and increases dependence on imported water for blending.

The planned groundwater desalination plant will allow the City to increase its groundwater allocation and use, consequently lowering the amount of imported water required for blending. Desalinated water from the Camarillo Regional Groundwater Desalter is anticipated to be supplied directly to the City's distribution system as well as to CMWD feeders for supply to other CMWD members (BV, 2010). As previously discussed, if the groundwater desalination plant is operational by 2016/2017, the City will then be able to pump approximately 9,200 afy of groundwater.

3.6.2 Seawater Desalination

At this time it is neither practical nor economically feasible for the City to implement a seawater desalination program. However, the City's could provide financial assistance to other purveyors in exchange for water supplies. A discussion of MWDSC's regional efforts to support desalinated water is included in the Chapter 7 with the discussion of supply reliability.

3.7 RECYCLED WATER

A portion of the treated effluent from the Camarillo Sanitary District's Camarillo Water Reclamation Plant (WRP) is currently supplied local recycled water users. In addition, CSD has agreements with the Camrosa Water District that allow for delivery of tertiary treated recycled water to Camrosa. Additional details about Camarillo Sanitary District's recycled water system can be found in Chapter 4.

Chapter 4

RECYCLED WATER

This chapter includes information on water recycling and its potential for use as a water source for the City in accordance with the UWMPA.

> *10633. The plan shall provide, to the extent available, information on recycled water and its potential for use as a water source in the service area of the urban water supplier. To the extent practicable, the preparation of the plan shall be coordinated with local water, wastewater, groundwater, and planning agencies and shall include all of the following:*
>
> *10633 (a) A description of the wastewater collection and treatment systems in the supplier's service area, including a quantification of the amount of wastewater collected and treated and the methods of wastewater disposal.*
>
> *10633 (b) A description of the recycled water currently being used in the supplier's service area, including but not limited to, the type, place and quantity of use.*
>
> *10633 (c) A description and quantification of the potential uses of recycled water, including, but not limited to, agricultural irrigation, landscape irrigation, wildlife habitat enhancement, wetlands, industrial reuse determination with regard to the technical and economic feasibility of serving those uses, groundwater recharge, and other appropriate uses, and a determination with regard to the technical and economic feasibility of serving those uses.*
>
> *10633 (d) The projected use of recycled water within the supplier's service area at the end of 5, 10, 15, and 20 years.*
>
> *10633 (e) A description of actions, including financial incentives, which may be taken to encourage the use of recycled water, and the projected results of these actions in terms of acre-feet of recycled water used per year.*
>
> *10633 (f) A plan for optimizing the use of recycled water in the supplier's service area, including actions to facilitate the installation of dual distribution systems and to promote recirculating uses.*

4.1 COLLECTION AND TREATMENT SYSTEMS

The Camarillo Sanitary District (CSD) provides wastewater collection and treatment for the City's water service area. CSD also treats wastewater for areas within the City boundary but outside the water service area and areas north of the City served by Cal American Water Company, Pleasant Valley Mutual Water Company, Crestview Mutual Water Company, and Pleasant Valley County Water District.

CSD treats the wastewater collected within its service area at the Camarillo Water Reclamation Plant (Camarillo WRP), which is located in the southeast portion of the City adjacent to Conejo Creek. Camarillo WRP was initially designed with a capacity of 2.75 mgd and currently treats an average of 4.0 mgd or 4,480 afy of wastewater and has a peak capacity of 7.25 mgd (Camarillo, 2010). Tertiary treatment processes were added as a part of Camarillo WRP's most recent expansion in 2005.

CSD also maintains approximately 158 miles of underground sewer lines and four lift stations as a part of its wastewater collection system. Historically, CSD has recycled wastewater through agricultural irrigation of nearby farmlands and landscape irrigation in the vicinity of Camarillo WRP. Disposal of non-recycled wastewater is accomplished through discharge into Conejo Creek.

Recycled water is supplied to a local farmer, Smith Ranch, who apportions water among various fields adjacent and near to Camarillo WRP. Depending on the location of the field, water is either pumped directly to the fields from Camarillo WRP or to storage for distribution to fields farther from Camarillo WRP. Recycled water is supplied to agricultural users in the daytime and to non-agricultural irrigation users during the night. CSD also supplies tertiary treated recycled water to the Village at the Park Community which uses the water to irrigate landscaping and a 54 acre sports park.

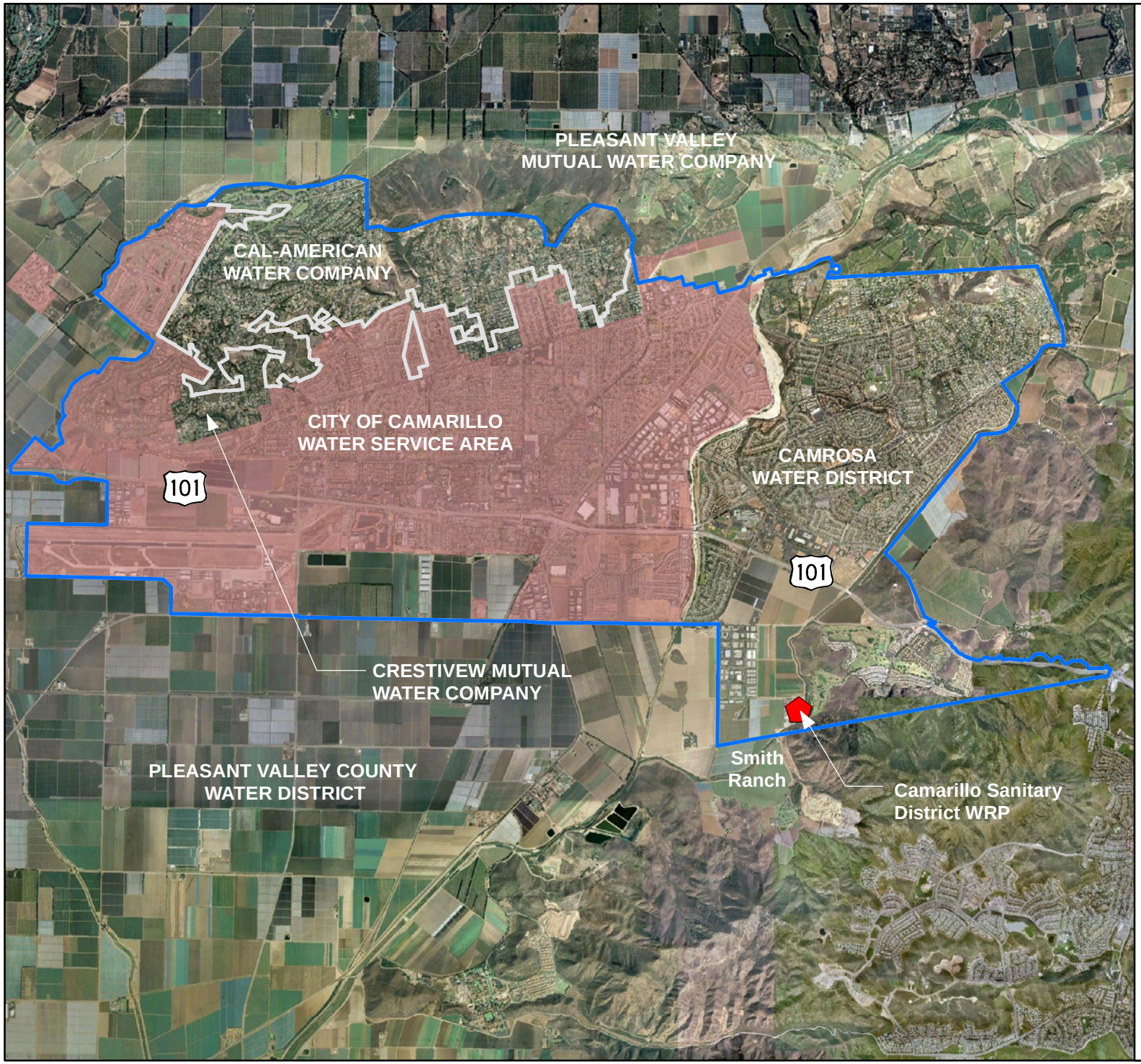
CSD's existing recycled water distribution system consists of about 4,200 feet of 8-inch pipeline from Camarillo WRP south across Conejo Creek to a storage pond at the Smith Ranch and west from Camarillo WRP to adjacent fields. CSD is planning to construct a 24-inch diameter pipeline to Camrosa Water District's recycled water distribution system. This pipeline is sized to facilitate the transfer of the entire effluent flow from Camarillo WRP.

Table 4.1 presents the current and projected wastewater collected from the City's water service area along with current and projected wastewater collected from CSD's entire service area. Table 4.1 demonstrates that all of the treated wastewater from CSD is and will continue to be treated to recycled water quality standards. CSD has recently added tertiary treatment to its entire WRP, and the volumes shown in Table 4.1 reflect this. While the entire volume treated at the WRP currently meets tertiary treatment requirements, not all water is used in recycled water applications.

Table 4.1 Wastewater Collection and Treatment

	Projected Annual Flow (afy)					
Type of Wastewater	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**
Estimated Wastewater Collected and Treated in Service Area(1)	3,309	3,521	3,620	3,703	3,776	3,823
Wastewater Collected and Treated in Camarillo Sanitary District(2)	4,223	4,368	4,368	4,368	4,368	4,368
CSD Volume that Meets Recycled Water Standard(2)	4,223	4,368	4,368	4,368	4,368	4,368

Notes:
(1) This table assumes a 30% return to sewer ratio for wastewater collected and treated in service area
(2) Historical 2010 flow data obtained from Engineer Compliance Report (Carollo, 2010). Flow projections for 2015 through 2035 for CSD and recycled water projections are from the 2010 Calleguas MWD UWMP (BV, 2010).
(3) The entire volume treated at the WRP currently meets tertiary treatment requirements, but not all water is used in recycled water applications.



Legend

- CSD Service Area Boundary
- City Limits
- City Water Service Boundary

N

0 2,500 5,000 10,000 Feet

Figure 4.1
CSD Service Area
2010 Urban Water
Management Plan
City of Camarillo

carollo

Since the wastewater flow from the City's water service area is collected along with wastewater flow from CSD's entire service area, actual wastewater flow data from the City's water service area was not available. The projected wastewater flow for the City's water service area in Table 4.1 is instead estimated based on an assumed return-to-sewer ratio of 30 percent. The collection and treatment for CSD's entire service area is based on the data presented in the Calleguas 2010 UWMP (BV, 2010).

Based on the Calleguas 2010 UWMP, recycled water is anticipated to be delivered to Pleasant Valley County Water District and Camrosa Water District (CWD) in the future. An exception of approximately 500 afy will be delivered to Smith Ranch, and over 220 afy will be delivered to the Village at the Park Community, eliminating all discharge to Conejo Creek by 2015.

Other uses of recycled water include irrigation of non-food crops, such as fodder fiber and seed crops, and processed foods, and landscape irrigation at the Conejo Mountain Memorial Cemetery. Each of these uses are outside the City's water service area. The City has determined that establishing recycled water service within its water service area beyond the future deliveries to Smith Ranch and Village at the Park would not be economically viable.

As discussed above, CSD currently discharges excess wastewater (treated to tertiary standards) to Conejo Creek. Table 4.2 lists the current and projected disposal method for this flow of discharging to Conejo Creek.

Table 4.2 Disposal of Non-Used Recycled Wastewater

Method of Disposal	Treatment Level	Annual Discharge Flow (afy)					
		2010	2015	2020	2025	2030	2035
Discharge to Conejo Creek	Tertiary	2,755	-	-	-	-	-
Total		**2,755**	**-**	**-**	**-**	**-**	**-**

Notes:
(1) The annual discharge flow to Conejo Creek of 0 is based on Engineering Compliance Report (Carollo, 2010). Flows for 2015 through 2035 are based on 100% usage of all recycled water. The exact quantity to be taken is unknown at this time.

As shown in Table 4.2, it is anticipated that once CSD is able to connect to CWD's recycled water distribution system, the entire flow from Camarillo WRP will be used for recycled water purposes. However, the amount of recycled water which CWD will be able to use is not known at this time and may increase the amount of non-recycled wastewater to be discharged to Conejo Creek from 0 at 2015 to something greater but less than current discharge of 2,755 afy.

4.2 RECYCLED WATER USES

Table 4.3 presents a comparison of anticipated 2010 recycled water use of the City's wastewater by others as presented in the City's 2005 UWMP to the actual recycled water use by the City's in 2010.

Table 4.3 2005 UWMP Projected 2010 Recycled Water Use Compared to 2010

Type of Use	Treatment Level	Projected[1] 2010 Recycled Water Use (afy)	Actual Recycled Water Use[2] 2010 (afy)
Agriculture and Landscape	Tertiary	4,368	1,468
Total		**4,368**	**1,468**

Notes:
(1) From City's 2005 UWMP (UWMP, 2005)
(2) From 2010 usage listed in Appendix E of the Engineering Compliance Report (Carollo, 2010)
(3) User Types which are not included in this table (e.g., Groundwater Recharge, Indirect Potable Reuse) have no existing or projected demands within the City's water service area or in CSD's service area and the associated rows were removed for clarity. The breakdown of demands between agricultural and landscape irrigation uses was not available.

As shown in Table 4.3, the projected recycled water demand for 2010 in the City's 2005 UWMP was 4,368 acre-feet (af). This value was derived by assuming the first 850 af of recycled water supply would continue to be delivered to Smith Ranch, and that the remainder would be delivered to Pleasant Valley County Water District and CWD as tertiary treated recycled water. Because the Camarillo WRP has yet to be connected to CWD's recycled water distribution system, the portion of wastewater anticipated for delivery to Pleasant Valley County WD and CWD in the City's 2005 UWMP instead has continued to be discharged to Conejo Creek.

4.3 POTENTIAL USES AND PROJECTED DEMAND

As outlined above, recycled water generated within the City service area, but not utilized by the City is anticipated to see two potential uses. A portion will continue to be utilized for agricultural irrigation and landscaping purposes near the Camarillo WRP while the remainder is anticipated to be supplied to recycled water distribution systems within the water service areas of Pleasant Valley County Water District and CWD. It should be noted that the recycled water supplied to agricultural irrigation uses near Camarillo WRP as well as potential supplies to these neighboring agencies does not lead to recycled water offsets within the City and therefore does not affect future demand projections for the City.

Projected recycled water supplied from Camarillo WRP is presented in Table 4.4. The Calleguas 2010 UWMP describes how Pleasant Valley County Water District and CWD

intend to use the purchased recycled water for landscape irrigation, which coupled with Smith Ranch, makes the recycled water from Camarillo WRP solely intended for this one type of use.

Table 4.4 Camarillo WRP Recycled Water Uses – Actual and Potential

User Type	Treatment Level	Projected Recycled Water Demand[3] (afy)					
		2010	2015	2020	2025	2030	2035
Agricultural Irrigation	Tertiary	1,342	2,401	2,401	2,401	2,401	2,401
Landscape Irrigation	Tertiary	71	292	292	292	292	292
Industrial Reuse[1]	Tertiary	55	55	55	55	55	55
Unspecified[2]	Tertiary	0	1,620	1,620	1,620	1,620	1,620
Total		**1,468**	**4,368**	**4,368**	**4,368**	**4,368**	**4,368**
Use within City Service Area[6]	Tertiary	0	220	220	220	220	220

Notes:
(1) Camarillo WRP plant process use.
(2) Anticipated to be supplied to CWD and Pleasant Valley County Water District but use is currently unknown.
(3) Demands from Appendix E of the Engineering Compliance Report (Carollo, 2010)
(4) User Types which are not included in this table (e.g., Groundwater Recharge, Indirect Potable Reuse) have no existing or projected demands within the City's water service area or in CSD's service area and the associated rows were removed for clarity.
(5) Actual current and projected recycled water use for the City is 0. While service area water is used for tertiary treatment, usage of this recycled water is within CSD service area, but not that of the City.
(6) Recycled water used within the City service area for landscape irrigation, causing the 2015 increase in total landscape irrigation from Camarillo WRP. Use occurring in the Village at the Park Community.

As shown in Table 4.4, recycled water is projected for primarily agricultural and landscape irrigation uses, as well as some usage at the Camarillo WRP. Since usage for the recycled water supplied to CWD and Pleasant Valley County Water District is unknown at this time, this is provided separately in Table 4.4 under Unspecified.

4.4 INCENTIVES AND PLANNING

While the City is not anticipating the development of a recycled water distribution system within its water service area, the City will continue to support the use of recycled water from the wastewater generated within the City water service area to be put to use in areas outside the City's water service area. If development of CWD's recycled water system and agricultural irrigation uses associated with Smith Ranch do not fully utilize the tertiary treated wastewater supplied by Camarillo WRP, and the increasing cost of imported water changes the economic viability of recycled water, the City may consider development of a recycled water system within its water service area.

Chapter 5

WATER DEMAND

The UWMPA requires that the UWMP identify the quantity of water supplied to the agency's customers including a breakdown of demands and demand projections by user classification.

> 10631. A plan shall be adopted in accordance with this chapter and shall do all of the following:
>
> 10631 (e) (1) Quantify, to the extent records are available, past and current water use, over the same five-year increments described in subdivision (a), and projected water use, identifying the uses among water use sectors including, but not necessarily limited to, all of the- following uses:
>
> (A) Single-family residential; (B) Multifamily; (C) Commercial; (D) Industrial; (E) Institutional and governmental; (F) Landscape; (G) Sales to other agencies; (H) Saline water intrusion barriers, groundwater recharge, or conjunctive use, or any combination thereof; and (I) Agricultural.
>
> (2) The water use projections shall be in the same 5-year increments to 20 years or as far as data is available.

5.1 PAST, CURRENT, AND PROJECTED WATER USE

This section describes the historical, current, and projected water use through year 2035. It also describes the types of customer accounts in the City and the breakdown of accounts throughout the system.

5.1.1 Historical Water Use

Water demands (or water use) represent water that leaves the distribution system through metered or unmetered connections or at pipe joints (leaks) or breaks. Water demands occur throughout the distribution system based on the number and type of consumers in each location. Annual historical water demands within the City's service area between 1995 and 2009 are presented in Table 5.1 along with population and per capita demand.

Water demands shown in Table 5.1 are based on calendar year consumption figures provided by the City. Population is included for the same time period, estimated based on DWR calculations from the number of service connections installed each year.

Table 5.1 Historical Water Use

Year	Demand[1] (afy)	Population[2]	Per Capita Consumption (gpcd)
1995	6,871	30,580	201
1996	7,166	31,097	206
1997	7,936	32,170	220
1998	7,338	32,887	199
1999	8,762	34,031	230
2000	9,326	34,939	238
2001	8,756	35,451	220
2002	9,885	36,156	244
2003	8,888	37,340	212
2004	9,646	38,514	224
2005	9,457	39,283	215
2006	9,567	41,174	207
2007	10,429	41,416	225
2008	10,258	41,973	218
2009	9,605	43,672	196
2010	8,585	46,694	164
Average	**8,905**	**37,336**	**214**

Notes:
(1) Demands obtained from Public Water System Statistics Sheets
(2) Historic population estimates were calculated from the number of service connections installed each year between 1990 and 2010. A benchmark of the year 2010 was used based on census data (USCB, 2000).

As shown in Table 5.1, City demands increased over the last 16 years, growing from 6,871 afy to more than 10,000 afy and recently declined to about 8,500 afy. In the same period, the population has increased to nearly 47,000.

5.1.2 Per-Capita Consumption

Per capita demands are calculated by dividing the total system demands by the City's population. The resulting number is the average number of gallons consumed, per person, per day for that year. Annual per capita demands are included in Table 5.1. Over the last 15 years, the per capita consumption has ranged between 164 and 230 gpcd. As shown, the City's average per capita demand over the last 16 years was 214 gpcd.

5.1.3 Projected Water Use

Based on the future trends in population obtained from the Southern California Association of Governments (SCAG) and established per capita water consumption rates, the City's future water requirements were estimated and summarized in Table 5.2. The per capita water consumption factors were determined by establishing consumption targets to meet

future water conservation requirements throughout the state (as discussed in more detail in Chapter 6). The City's average gpcd from 1999 to 2008, 223 gpcd, was used as the baseline consumption and applied to the projection for 2010. The baseline was reduced by 10 percent to 201 gpcd for the 2015 projection, and by the full 20 percent, 179 gpcd, required by the water conservation act of 2009 for year 2020 and onward.

Table 5.2 Demand Projections

Year	Per Capita Consumption (gpcd)(2)	Population(1)	Demand (afy)
2010	223	44,071	11,029
2015	201	46,902	10,564
2020	179	48,213	9,652
2025	179	49,323	9,875
2030	179	50,293	10,069
2035	179	50,918	10,194

Notes:

(1) Population Projections from Table 2.2 for the City service area.

(2) Per capita consumption based on baseline period for 2010 and SBx7-7 targets for 2015 and 2020 through 1035

As shown in Table 5.2, the City's demands are anticipated to decrease from 11,029 afy to 10,194 afy in 2035. Over this same time period, the population of the City is anticipated to grow by over 5,000 to approximately 50,918. This demand projection is based on per capita consumption rates which have been specifically calculated to satisfy the water conservation targets laid out in the Water Conservation Act of 2009. Put simply, the listed per capita consumption values will allow the City to realize a 20 percent reduction in water use in 2020. More details regarding the per capita consumption rates presented in Table 5.2 can be found in Chapter 6.

5.2 WATER USAGE BY CLASSIFICATION

The current and projected water deliveries by sector are summarized in Table 5.3 along with those for 2005. As shown, the City does not have any unmetered accounts and is planning to continue installing meters for all future accounts.

The water loss calculations for calendar year 2005 showed an estimated water loss of five percent. As this water loss is low compared to the typical water loss range of 5 to 10 percent, it is assumed that this is the minimum amount of water loss that can realistically be achieved. The water loss for future planning years is therefore also estimated at five percent.

Table 5.3 Water Demand Projections by Sector

Use	2005[1]		2010[1]		2015		2020		2025		2030		2035	
	# of accounts[2]	Demand (afy)	# of accounts[2]	Demand (afy)	# of accounts[2]	Demand (afy)	# of accounts[2]	Demand (afy)	# of accounts[2]	Demand (afy)	# of accounts[2]	Demand (afy)	# of accounts[2]	Demand (afy)
SFR	11,147	4,632	11,211	4,213	13,984	5,204	14,374	4,755	14,705	4,864	14,995	4,960	15,181	5,021
MFR	187	594	379	660	308	676	316	618	323	632	330	645	334	653
Comm./Inst.	757	1,137	889	1,133	1,000	1,248	1,028	1,140	1,051	1,167	1,072	1,190	1,086	1,204
Ind.	7	163	18	59	11	134	12	123	12	126	12	128	12	2,111
Land./Irr.	528	1,959	623	1,791	705	2,188	724	1,999	741	2,045	755	2,085	765	130
Other	19	39	15	14	26	43	27	40	28	40	28	41	29	42
Ag.	11	485	11	337	13	542	13	495	13	507	14	516	14	523
Unmetered System Losses (5%)[3]		473		377		528		483		494		503		510
Total	12,928	9,457	11,736	8,585	16,046	10,564	16,495	9,652	16,875	9,875	17,206	10,069	17,420	10,194

Notes:

(1) Years 2005 and 2010 based in actual historical data, 2015 to 2035 based on projections incorporating water conservation targets

(2) Number of accounts shown are based on average account type breakdown from 2005 to 2009 for non-conservation water use projections

(3) Assumes 5% water loss

(4) Demands by each account type based on average usage breakdown by account type from 2005 to 2009 for conservation water use projections (see Figure 5.1)

(5) Water uses which are not included in this table (e.g., Groundwater Recharge and Conjunctive Use) have no existing or projected demands within the City's water service area and the associated rows were removed for clarity.

As shown in Table 5.3, projected water usage is slated to decrease in order to meet 2020 conservation targets. The decrease in demand takes future conservation goals into account. The number of projected accounts is based on the historic account-to-demand ratios from 2005 through 2009 (average of 1.37 afy per account) multiplied by non-conservation demand projections. The reason for basing account numbers on non-conservation projections is that, while water use will diminish, the number of accounts will not. In other words, the City will meet its reduction goals by having every account use 20 percent less water, rather than removing 20 percent of all accounts. The projections in Table 5.3 account for this fact by basing account growth on non-conservation projections, but assuming that conservation goals will still be met.

The average breakdown of the number of accounts by account type between 2005 and 2009 is depicted graphically on Figure 5.1.

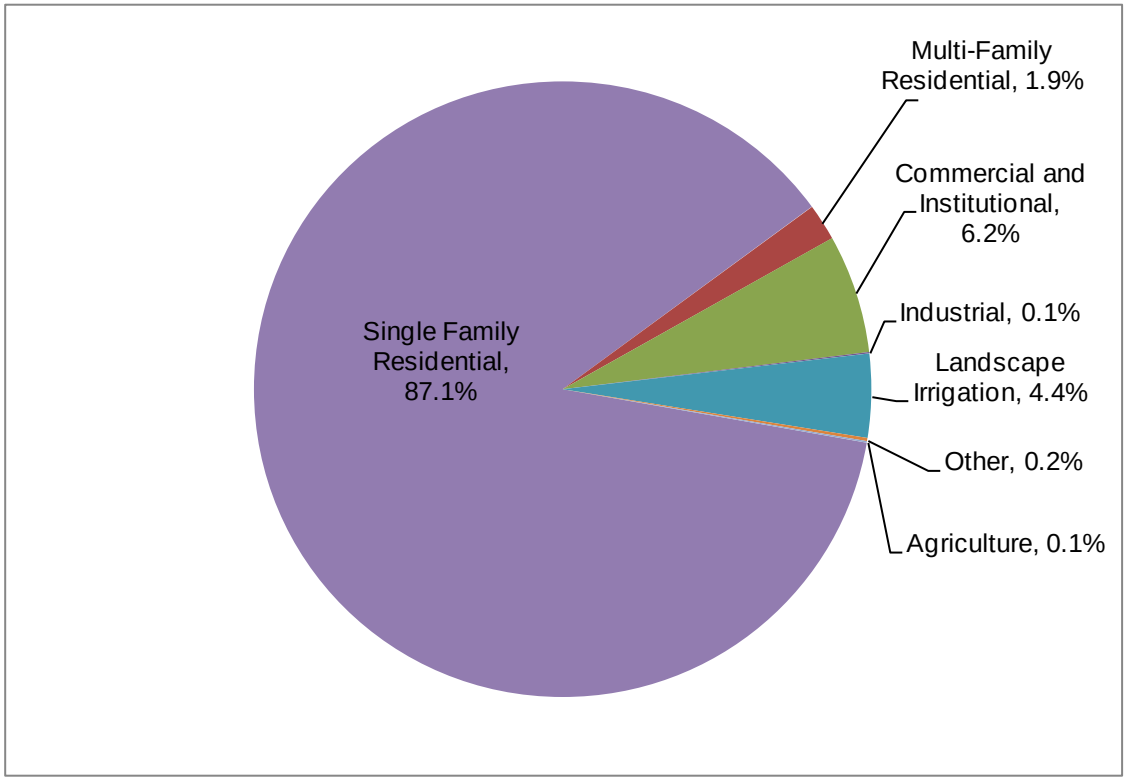


Figure 5.1 Breakdown of Average Number of Accounts by Account Type (2005-09)

Water demands met by the City are primarily from residential uses. From year 2005 to 2009, residential uses (single family and multi-family) accounted for 59 percent of water consumption and 87percent of the City's accounts. During the same period, landscape irrigation accounted for 22 percent of water consumption but only 4.4 percent of the City's accounts. The remaining water use was divided between commercial, industrial, institutional, and agricultural uses.

5.3 PROPOSED DEVELOPMENTS

The UWMPA requires that the UWMP identify the major developments within the agency's service area that would require water supply planning.

> 10910. (a) Any city or county that determines that a project, as defined in section 10912, is subject to the California Environmental Quality Act (Division 13 (commencing with Section 21000) of the Public Resources Code) under Section 21080 of the Public Resources Code shall comply with this part.
>
> 10912. For the purpose of this part, the following terms have the following meanings:
>
> 10912 (a) "Project" means any of the following:
> (1) A proposed residential development of more than 500 dwelling units.
> (2) A proposed shopping center or business establishment employing more than 1,000 persons or having more than 500,000 square feet of floor space.
> (3) A proposed commercial office building employing more than 1,000 persons or having more than 250,000 square feet of floor space.
> (4) A proposed hotel or motel, or both, having more than 500 rooms.
> (5) A proposed industrial, manufacturing or processing plant, or industrial park planned to house more than 1,000 persons, occupying more than 40 acres of land, or having more than 650,000 square feet of floor area.
> (6) A mixed-use project that includes one or more of the projects specified in this subdivision.
> (7) A project that would demand an amount of water equivalent to, or greater than, the amount of water required by a 500 dwelling unit project.

City staff identified one major development planned within its service area, the Springville Specific Plan. This development is anticipated to be constructed by 2015.

The Springville Specific Plan proposes a mix of residential densities and types, as well as a Village Center with mixed use development, featuring local serving specialty retail, commercial and residential uses. The emphasis of the development plan is a gateway to the retail village, the village square, and the specific plan residential community, featuring increased pedestrian activity, landscaped parkways, parks, open space, and an enhanced circulation system. The land use summary indicates 173.5 acres of total development, with 1,350 residential units (EIP, 2008). As the Springville Specific Plan falls within the City's water service area, the City will supply water service. Water demands associated with this development are accounted for in the demand projections.

5.4 LOW INCOME HOUSING

The UWMPA requires that the UWMP identify low income housing developments within the agency's service area and develop demand projections for those units.

> 10631.1(a). The water use projections required by Section 10631 shall include projected water use for single-family and multifamily residential housing needed for lower income households, as defined in Section 50079.5 of the Health and Safety Code, as identified in the housing element of any city, county, or city and county in the service area of the supplier

The City's 2009 General Plan Update (Camarillo, 2009) provides information on Regional Housing Needs Allocation Progress (RHNA). This element of the update contains plans to construct low and very low income housing units between January 1, 2006 and June 30, 2014. A total of 1318 of these low income dwelling units are in construction or remain to be built before the 2014 deadline.

Assuming the 1318 dwelling units reflect the SCAG defined average of 3.19 people per dwelling unit, the projected 2020 per capita water usage of 179 gpcd, would result in a total of 843 afy of low income housing water consumption in the year 2020.

Table 5.4 Low Income Projected Water Demands

	Demand (afy)				
	2015	**2020**	**2025**	**2030**	**2035**
Low Income Housing	-	843	843	843	843

Notes:
(1) Based on planned low income housing development as described in the City's General Plan (Camarillo, 2009). The General Plan projects housing needs through 2014.

As shown in Table 5.4, water demands for planned low income housing units are 843 afy. This value is assumed for all years beyond 2015. The 2009 General Plan Update does not provide information on single family versus multi-family low income dwelling units, so the total average number of people per dwelling unit (3.19) for the entire City was used.

Chapter 6

WATER CONSERVATION

The UWMPA requires the UWMP involve a discussion of the agency's water conservation measures. This includes an overview of the supplier's Best Management Practices (BMPs) as well as a discussion of how the supplier intends to meet the water conservation targets established by SBx7-7.

> 10608.20. (a) (1) Each urban retail water supplier shall develop urban water use targets and an interim urban water use target by July 1, 2011. Urban retail water suppliers may elect to determine and report progress toward achieving these targets on an individual or regional basis, as provided in subdivision (a) of Section 10608.28, and may determine the targets on a fiscal year or calendar year basis. (2) It is the intent of the Legislature that the urban water use targets described in subdivision (a) cumulatively result in a 20-percent reduction from the baseline daily per capita water use by December 31, 2020

6.1 WATER CONSERVATION

6.1.1 Water Conservation Target Methods per SBx7-7

The Water Conservation Act of 2009 (SBx7-7) is the new law governing water conservation in California that was enacted November 2009. This law requires that all water suppliers increase water use efficiency with the overall goal to decrease per capita consumption within the state by 20 percent by year 2020. DWR provided four different methods to establish water conservation targets. These four methods can be summarized as follows.

- **Method 1 – Baseline Reduction Method.** The 2020 water conservation target of this method is defined as a 20 percent reduction of average per capita demand during a 10-year continuous baseline period that should end between 2004 and 2010.
- **Method 2 – Efficiency Standard Method.** The 2020 water conservation target of this method is based on calculating efficiency standards for indoor use separately from outdoor use for residential sectors and an overall reduction of 10 percent for commercial, industrial, and institutional (CII) sectors. The aggregated total of the efficiency standards in each area is then used to create a conservation target.
- **Method 3 – Hydrologic Region Method.** This method uses the ten regional urban water use targets for the state. Based on the water supplier's location within one of these regions, a static water use conservation target for both 2015 and 2020 is assigned.
- **Method 4 – BMP-based Method.** This method uses previous BMPs of a supplier in order to establish a conservation target for 2020. Depending on how aggressively the water supplier has pursued water reduction and conservation in the past, a new conservation target for 2020 will be assigned.

6.1.2 City's Water Conservation Targets

Method 1 establishes baseline water consumption in gpcd based on historical population and historical demand numbers. Any 10-year consecutive period between 1995 and 2010 can be selected to establish the baseline per capita demand for the water supplier using the average per capita consumption in gpcd from that 10-year period. If an agency uses 10 percent or more recycled water in year 2008, the baseline value can also be determined with a 15-year consecutive period between 1990 and 2010. Since the City does not utilize recycled water within its water service area, the baseline period must be 10 years in length and end between 2004 and 2010.

The baseline value is then reduced by twenty percent to determine the year 2020 conservation target. The intermediate target for year 2015 is the mid-point value between the baseline and year 2020 target values.

In addition to the 10-year baseline period, a 5-year period needs to be selected in any year ending no earlier than 2007 to determine the minimum required reduction in water use. The selected 10-year and 5-year base period ranges are summarized in Table 6.1.

Table 6.1 Base Period Ranges

Base	Parameter	Value	Units
Water Deliveries	2008 total water deliveries	10,258	af
	2008 total volume of delivered recycled water	0	af
	2008 recycled water as a percent of total deliveries	0	%
10-year Base Period	Number of years in base period	10	years
	Year beginning base period range	1999	
	Year ending base period range	2008	
5-year Base Period	Number of years in base period	5	years
	Year beginning base period range	2004	
	Year ending base period range	2008	

Table 6.1 shows the characteristics of the 10 and 5 year period selected as the baselines for the City in meeting the Water Conservation Act of 2009. The City's historical water consumption for the period 1995 through 2010 is shown in Figure 6.1. This figure also depicts the minimum, average, and maximum 10-year baseline values. As shown, the 10-year period with the highest baseline consumption starts in 1999 and ends in 2008.

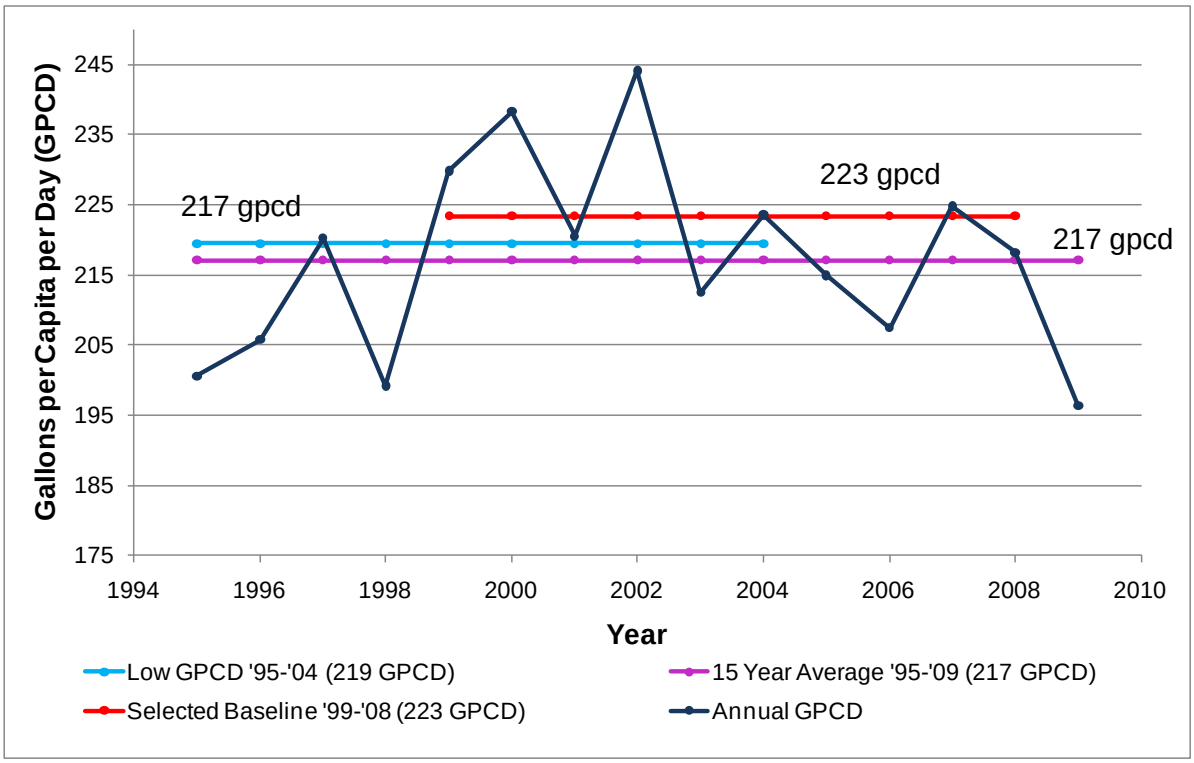


Figure 6.1 Historical Consumption

As shown in Figure 6.1, although the yearly per capita demand varies significantly over a 15-year period between 1995 and 2009, the high average, low average, and 15-year average are all relatively close in value. Although more recent per capita demand values show a decline compared to previous years, this is partly due to the recent drought reflecting more aggressive conservation outreach efforts by the City.

Table 6.2 Base Daily Per Capita Water Use – 10 Year Range

Base Period Year		Distribution System Population[1]	Daily System Gross Water Use (mgd)	Annual Daily Per Capita Water Use (gpcd)
Sequence Year	**Calendar Year**			
Year 1	1999	34,031	7.8	230
Year 2	2000	34,939	8.3	238
Year 3	2001	35,451	7.8	220
Year 4	2002	36,156	8.8	244
Year 5	2003	37,340	7.9	212
Year 6	2004	38,514	8.6	224
Year 7	2005	39,283	8.4	215
Year 8	2006	41,174	8.5	207
Year 9	2007	41,416	9.3	225
Year 10	2008	41,973	9.2	218
Average	**n/a**	**38,028**	**8.5**	**223**

Notes:
1) Estimated from the number of service connection and year 2000 census data as shown in Figure 2.2 and described in Chapter 2

Table 6.2 shows City population, total volume of consumption, and per capita consumption of the selected 10-year baseline period. The average per capita consumption during this period was 223 gpcd. Based on Method 1, a twenty percent reduction from this baseline period determines the City's 2020 conservation target at 179 gpcd.

Table 6.3 shows the population, total volume of consumption, and the per capita consumption of a five year baseline period. The five-year baseline value is used to determine the minimum required reduction in water use.

Table 6.3 Base Daily Per Capita Water Use – 5 Year Range

Base Period Year		Distribution System Population[1]	Daily System Gross Water Use (mgd)	Annual Daily Per Capita Water Use (gpcd)
Sequence Year	**Calendar Year**			
Year 1	2004	38,514	8.6	224
Year 2	2005	39,283	8.4	215
Year 3	2006	41,174	8.5	207
Year 4	2007	41,416	9.3	225
Year 5	2008	41,973	9.2	218
Average	**n/a**	**40,472**	**8.8**	**218**

Notes:
1) Estimated from the number of service connection and year 2000 census data as shown in Figure 2.2 and described in Chapter 2

As shown in Table 6.3, the average consumption in the period 2004-2008 was 218 gpcd. The minimum per capita consumption for year 2020 is defined as 95 percent of this value, reflecting a minimum water conservation of five percent. This equates to a minimum water conservation target of 207 gpcd.

As the water conservation target from the 10-year baseline period (179 gpcd) is lower than the minimum water conservation target (207 gpcd), the City's water conservation targets are as follows:

- Year 2015 Target: 201 gpcd (10 percent reduction)
- Year 2020 Target: 179 gpcd (20 percent reduction)

6.1.3 Method 2

Method 2 uses performance standards for both indoor and outdoor usage to establish the supplier's 2020 water conservation target. Method 2 consists of a series of four steps and utilizes actual water use data and estimates from the water supplier. First, the method assumes a standard statewide indoor use target of 55 gpcd. Then, the landscaped area for the supplier's entire service area is determined. Commercial, institutional, and industrial water use is accounted for separately using historical billing data. The performance standards for outdoor landscape irrigation, based on acreage, and commercial, institution, and industrial use, based on demands, are then applied to those totals. Finally, the performance standards for all three sectors are added together to determine the Method 2 2020 conservation target.

There is insufficient data to calculate Method 2 for the City. Principally, the effort associated with digitizing or surveying the amount of irrigated landscape within the City's service area would be a significant effort.

6.1.4 Method 3

The State's 20 by 2020 water conservation plan has identified specific urban water use targets for 2015 and 2020 for each of the ten hydrologic regions shown in Figure 6.2. The City falls in Hydrologic Region 4 (South Coast) which has a target use of 142 gpcd for year 2020.

The City's water conservation targets using Method 3 are as follows:

- Year 2015 Target: 183 gpcd (18 percent reduction)
- Year 2020 Target: 142 gpcd (36 percent reduction)

6.1.5 Method 4

Method 4 uses the supplier's BMP reports as a guide to set the 2020 conservation target. The intent behind Method 4 is to use the BMP reports to account for what water conserving measures the supplier has already taken in order to set a more accurate and realistic target for the future and take into consideration the supplier's previous water conservation efforts.

Provisional Method 4

Method 4 is based on the City's BMP efforts and has been released as a provisional method, subject to later revisions during the 2015 UWMP cycle.

The methodology for the provisional method relies on the base daily per capita use in 2000 and reduction in the three urban use sectors:

- Residential indoor;

- Commercial, industrial, and institutional (CII); and
- Landscape use and water loss.

A discussion of each of these components, and the calculated savings in each of these sectors is included below.

Residential Indoor Savings

Since indoor and outdoor water use is delivered through a single meter, an assumption of 70 gpcd has been provided by DWR for standard residential indoor water use.

To determine indoor residential savings, Method 4 outlines two methodologies. First, a (BMP) calculator has been developed to sum the savings for four conservation elements including single and multi-family residential housing toilets, residential washers, and showerheads. Due to insufficient data on the water savings associated with these measures, the City will use what has been termed the “default option” to determine these savings. Based on the draft provisional method, this default value is 15 gpcd.

Commercial, Industrial, and Institutional Savings

Baseline CII water can be easily established for the City since all commercial, industrial, and institutional connections were metered in 2000. The calculated baseline CII use for the baseline period 1999 through 2008 was 31 gpcd. The CII gpcd is determined using the population for the service area.

The provisional method estimates a default value for CII savings of 10 percent of the per capita CII demand. The CII water savings are therefore 3.1 gpcd.

Landscape and Water Loss Savings

The landscape and water loss water use is determined by subtracting the default indoor water use of 70 gpcd and CII water use of 31 gpcd from the calculated baseline per capita use of 223. Based on calculated baseline per capita water use, the landscape and water loss use is 122 gpcd.

The draft provisional method estimates a default value for landscape and water loss savings of 21.6 percent. The landscape and water loss savings are therefore 26.4 gpcd.

Metered Savings

Since all connections within the City are currently metered, no water savings are associated with metering unmetered accounts.

Summary

Based on the steps above, the total water savings is estimated at 44 gpcd. When compared with the baseline demand of 223 gpcd, this would result in a water conservation target of

179 gpcd. A summary of baseline water use by sector and individual savings calculated using Method 4 is included in Table 6.4.

Table 6.4 Method 4 Target Determination Summary

Baseline Water Use (gpcd)				Water Savings (gpcd)				
Residential Indoor(1)	CII(2)	Landscape/ Water Loss	Total	Residential /Indoor(3)	CII(4)	Landscape Water	Metered	Total
70	31	122	223	-15.0	-3.1	-26.4	0.0	179

Notes:
(1) Assumed value based on guidelines in provisional Method 4.
(2) Source: DWR Public Water System Statistics and additional sources as described in Section 6.1.1.
(3) Default savings based on guidelines in provisional Method 4.
(4) CII water savings of 10 percent based on guidelines in provisional Method 4.
(5) Landscape and water loss savings of 21.6 percent based on guidelines in provisional Method 4.

6.1.6 Recommended Method

The water conservation targets per method as developed with data provided by the City are summarized in Table 6.5. As shown, Method 1 and Method 4 result in the same targets. However, Method 1 will allow the City the greatest freedom in reaching these targets.

Table 6.5 Conservation Method Overview

	Conservation Target (gpcd)		Reduction by 2020 (%)	
Supply Source	Year 2015	Year 2020	From Baseline(1)	From 2009 Usage(2)
Method 1	201	179	20%	9%
Method 2	n/a	n/a	n/a	n/a
Method 3	183	142	36%	28%
Method 4	201	179	20%	9%

Notes:
1) Baseline consumption is 223 gpcd
2) 2009 consumption is 196 gpcd

Based on an evaluation of each method as described above and discussions with City staff, it was decided to use Method 1 for the 2010 UWMP. The following section discusses the various BMPs available to the City to achieve this reduction in water use.

6.1.7 Demand Projections with Water Conservation

Table 6.6 presents City demand projections with and without water conservation targets in accordance with the Water Conservation Act of 2009. The demand projections in afy were derived from the population projections presented in Chapter 2 and the per capita consumption targets described above. Demands shown for the year 2010 were based on a per capita consumption of 223 gpcd which reflect historic trends over the last several years. The actual water demand in 2010 was 8,586 af due to water conservation as well as weather and economic factors.

Year 2015 serves as an interim point, with projected per capita consumption reduced to meet the 2015 target.

Table 6.6 Demand Projections

Year	Projected Water Demand without Conservation (afy)	Projected Water Demand with Target Conservation (afy)
2010	11,029	11,029
2015	11,737	10,564
2020	12,065	9,652
2025	12,343	9,875
2030	12,586	10,069
2035	12,742	10,194

Notes:

(1) Population Projections are taken from Table 2.2.

(2) Non-conservation projections are based on population growth combined with baseline consumption of 223 gpcd, whereas conservation projections are based on 2020 conservation target consumption of 179 gpcd

As shown in Table 6.6 and graphically in Figure 6.3, water conservation requirements of SBx7-7 reduce projected water demand for year 2020 from 12,065 afy to 9,652 afy. The following section discusses the various BMPs available for the City to achieve this reduction in water use.

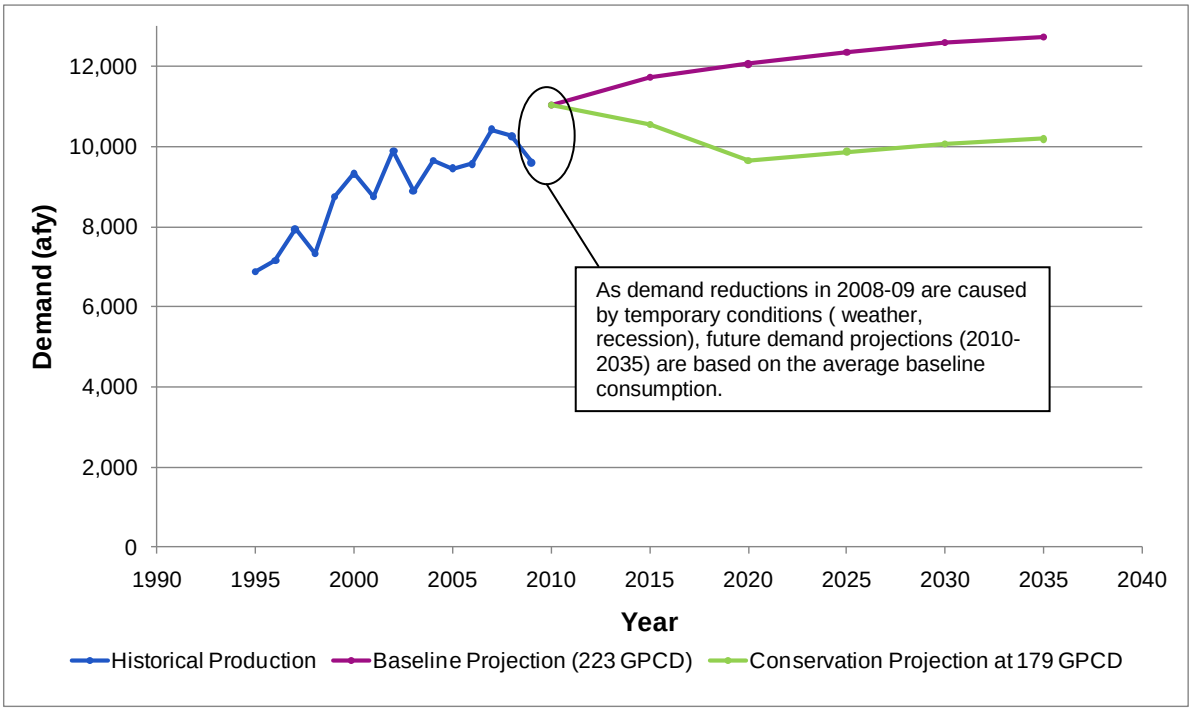


Figure 6.3 Projected Water Demands with and without Conservation

6.2 BEST MANAGEMENT PRACTICES

The City is a signatory to the Memorandum of Understanding regarding Urban Water Conservation in California (MOU) and is therefore a member of the California Urban Water Conservation Council (CUWCC). The City became a signatory to the MOU in 1991 and submits annual reports outlining progress towards implementing the 14 BMPs in the MOU. BMPs are conservation practices that have been identified by the CUWWC: conferences, BMP workshops, free publications, research regarding water management practices, leadership on water legislation and networking with other agencies and special interest groups, for example.

The City has, in good faith, tried to address, or plans to address, all of the BMP targets listed in the CUWCC MOU except where mentioned below. BMP Number 10 applies only to wholesale agencies and is not reported in this plan.

BMP signatories can submit their most recent BMP Report with their UWMP to address the urban water conservation requirements specified in the UWMPA. As a member of CUWCC and signatory of its MOU, the City realizes the importance of the BMPs to ensure a reliable future water supply. The City is committed to implementing water conservation and water recycling programs to maximize sustainability in meeting future water needs for its customers.

The City's previous UWMP provided information regarding the City's conservation measures already in place and those that would improve the efficiency of water use within the City.

> 10631 (f) Provide a description of the supplier's water demand management measures. This description shall include all of the following:
>
> (1) A description of each water demand management measure that is currently being implemented, or scheduled for implementation, including the steps necessary to implement any proposed measures, including, but not limited to, all of the following:
>
> (A) Water survey programs for single-family residential and multifamily residential customers.
>
> (B) Residential plumbing retrofit.
>
> (C) System water audits, leak detection, and repair.
>
> (D) Metering with commodity rates for all new connections and retrofit of existing connections.
>
> (E) Large landscape conservation programs and incentives.
>
> (F) High-efficiency washing machine rebate programs.
>
> (G) Public information programs.
>
> (H) School education programs.
>
> (I) Conservation programs for commercial, industrial, and institutional accounts.
>
> (J) Wholesale agency programs.
>
> (K) Conservation pricing.
>
> (L) Water conservation coordinator.
>
> (M) Water waste prohibitions.
>
> (N) Residential ultra-low-flush toilet replacement programs.

While the CUWCC has re-classified the BMPs, the numbered classification system will be used in this discussion since the City's efforts have been categorized accordingly.

Table 6.7 Best Management Practices

Best Management	Implemented	Planned for Implementation	Not Applicable
BMP 1 - Water Survey Programs	✓		
BMP 2 - Residential Plumbing Retrofit	✓		
BMP 3 - Water System Audits			✓
BMP 4 - Metering with Commodity Rates	✓		
BMP 5 - Landscape Irrigation Programs	✓		
BMP 6 - Washing Machine Rebate Program	✓		
BMP 7 - Public Information Program	✓		
BMP 8 - School Education Program	✓		
BMP 9 - Commercial, Industrial, and Institutional Conservation Programs	✓		
BMP 10 - Wholesale Agency Programs			✓
BMP 11 - Conservation Pricing	✓		
BMP 12 - Water Conservation Coordinator	✓		
BMP 13 - Water Waste Prohibition	✓		
BMP 14 - Ultra Low Flush Toilet Replacement	✓		

6.2.1 BMP 1 - WATER SURVEY PROGRAMS

This program consists of offering water audits to single family and multi-family residential customers. Audits include reviewing water usage history with the customer, identifying leaks inside and outside the home, and recommending improvements.

Upon request, City personnel will perform on-site inspection of residences and businesses for potential internal leaks. Leak detection kits are available and are provided to residents free of charge, upon request. As an incentive to complete the audit, the City provides free low-flow showerheads and kitchen/bathroom shut-off nozzles. Also, the City provides exterior audits for residence with landscape irrigation systems.

6.2.2 BMP 2 - RESIDENTIAL PLUMBING RETROFIT

This program consists of installing physical devices to reduce the amount of water used or to limit the amount of water that can be served to the customer. In accordance with State law, low-flow fixtures have been required on all new construction since 1978. In addition, State legislation enacted in 1990 requires all new buildings after January 1, 1992 to install Ultra-Low-Flush Toilets (ULFT).

Several studies suggest that water use savings resulting from miscellaneous interior retrofit fixtures can range between 25 and 65 gpd per housing unit. The studies also suggest that installation of retrofit fixtures in older single-family homes tend to produce more savings, while newer multi-family homes tend to produce fewer saving per housing unit.

Assuming approximately 50 percent saturation for both single and multi-family accounts, one would estimate current water savings within the City at 368 afy from single family conservation, and 8 afy from multi-family conservation, yielding a total of 376 afy for BMP 2. If the City were to increase total residential account saturation to 80 percent, further water conservation could be achieved. Retrofitting an additional 3,942 single family accounts and 88 multi-family accounts would likely decrease use by approximately 226 afy. 80 percent saturation of the residential sector would entail a water savings of 602 afy, or 25 percent of the 2,413 af reduction in 2020.

6.2.3 BMP 3 - SYSTEM WATER AUDITS, LEAK DETECTION, AND REPAIR

A water audit is a process of accounting for water use throughout a water system in order to quantify unmetered water usage. Unaccounted-for water is the difference between metered production and metered usage on a system-wide basis.

2010 public water system statistics records show approximately 4 percent unaccounted-for water loss of the City's water production. This is relatively low compared to the typical range of 5 to 10 percent experienced by most agencies in Southern California. For this reason, the City does not provide a comprehensive system leak detection program. The City is conscientious about locating and repairing main and service connection leaks when they occur. The Water Conservation Program provides assistance in locating leaks on private property and City Municipal Code Chapter 14.12 prohibits leak durations of more than 72 hours.

6.2.4 BMP 4 - METERING WITH COMMODITY RATES FOR ALL NEW CONNECTIONS AND RETROFIT OF EXISTING CONNECTIONS

This BMP requires water meters for all new connections and billing by volume of use, as well as establishment of a program for retrofitting any existing unmetered connections. All connections within the City are metered and customers are billed according to the amount of water used. As the City continues to install meters at all its new connections, this program will not provide foreseeable water conservation opportunities.

6.2.5 BMP 5 - LARGE LANDSCAPE CONSERVATION PROGRAMS AND INCENTIVES

This BMP calls for agencies to start assigning reference ETo based water budgets to accounts with dedicated irrigation meters and to provide water use audits to accounts with mixed use meters.

Based on the historical billing records of 2009, the City currently serves approximately 611 accounts with dedicated irrigation meters that have a combined annual water demand of 2,118 afy. This equates to an average water use of 3.5 afy per landscape meter. Assuming that these landscape customers could save 30 percent of their water use, or 1 afy, through more efficient watering techniques and ETo sensors, the City could potentially save approximately 300 afy by implementing landscape conservation programs with 50 percent of landscaping customers. This would result in 12 percent of the 2,413 af reduction needed in 2020.

Although a detailed water conservation analysis would be required to obtain a more accurate savings estimate, it can be concluded that this BMP has the potential to contribute significantly towards achieving the City's water conservation goals. Financial incentives, including regional funding from MWDSC, are also available to improve landscape water use efficiency.

6.2.6 BMP 6 - HIGH-EFFICIENCY WASHING MACHINE REBATE PROGRAM

This program generally provides financial incentives (rebate offers) to qualifying customers who install high-efficiency washing machines in their homes.

These machines typically use 15 to 25 gallons less water per load than typical washers. If the City were to achieve 60 percent saturation of the single family residential customers, the City would potentially add approximately 6,728 HECWs. At an average of 1 load per day and 20 gallons of water savings per load, this program could potentially contribute over 150 afy of conservation, or 6 percent of the 2,413 af reduction in 2020.

6.2.7 BMP 7 - PUBLIC INFORMATION PROGRAMS

This program consists of distributing information to the public through a variety of methods including brochures, radio, television, school presentations and videos, and websites. The City maintains a newsletter which is distributed regularly and often touches on water issues. The City has also distributed water information in its monthly bills, at special events, and on its homepage.

6.2.8 BMP 8 - SCHOOL EDUCATION PROGRAM

This BMP requires water suppliers to implement a school education program that includes providing educational materials and instructional assistance. Brochures are distributed on various water issues, and the City participates in MWDSC programs to promote student Water Awareness. A number of teachers have included water conservation classes as part of their curriculum.

6.2.9 BMP 9 - CONSERVATION PROGRAMS FOR COMMERCIAL, INDUSTRIAL, AND INSTITUTIONAL ACCOUNTS

The City targets commercial, industrial, and institutional water accounts with a monthly consumption of 200 hcf or more for water audits. Such programs typically involve turf fields, smart irrigation timers, and industrial process water use reductions. Currently, the City has approximately 900 CII accounts. Assuming that the City has the potential to implement 100 new CII programs by year 2020 and that each program would, on average, save 0.5 afy per program, the total savings of the CII program would generate approximately 50 afy of water conservation, which is about 2 percent of the 2,413 afy water conservation goal for year 2020.

6.2.10 BMP 10 - WHOLESALE AGENCY PROGRAMS

This BMP applies to wholesale agencies and defines a wholesaler's role in terms of financial, technical, and programmatic assistance to its retail agencies implementing BMPs.The City is not a wholesale agency, so this BMP does not apply.

6.2.11 BMP 11 - CONSERVATION PRICING

Camarillo implements a tiered rate structure which applies a uniform standby rate on most of the fixed costs of supplying water, which does not vary with the amount of water used. Most of the variable costs are applied as the commodity portion of the rate, which is proportional to the amount of water used and purchased from MWDSC.

6.2.12 BMP 12 - WATER CONSERVATION COORDINATOR

The City employs one full time Water Conservation Technician and a Water Conservation Coordinator; it budgets for an annual Water Conservation Program.

6.2.13 BMP 13 - WATER WASTE PROHIBITION

The City has implemented municipal code specifically to address water waste. These prohibitions are part of the water shortage contingency plan, and are further discussed in Chapter 8.

6.2.14 BMP 14 - RESIDENTIAL ULTRA-LOW-FLUSH TOILET REPLACEMENT PROGRAMS

State legislation requires the installation of efficient plumbing in new construction and, effective in 1994, requires that only ULFTs be sold in California. There have been over 4,000 ULFTs installed through this program in the City since the program began. Assuming three people per household, five flushes per person per day, and one gallon savings per flush, this has resulted in a water savings of approximately 15 gpd for each household.

Over time, this program, combined with the natural replacement of toilets with ULFTs, could increase the City's water savings substantially. Upon reaching a theoretical residential

market saturation of 50 percent, the City would save approximately 110 afy which is about 4.5 percent of the 2,413 afy water conservation goal for year 2020.

6.3 WATER CONSERVATION IMPLEMENTATION PLAN

The BMP's currently implemented by the City have been effective in reducing water consumption, but further efforts will need to be made to reach the 2020 water conservation target. The City's historic per capita and future projections are shown in Figure 6.4.

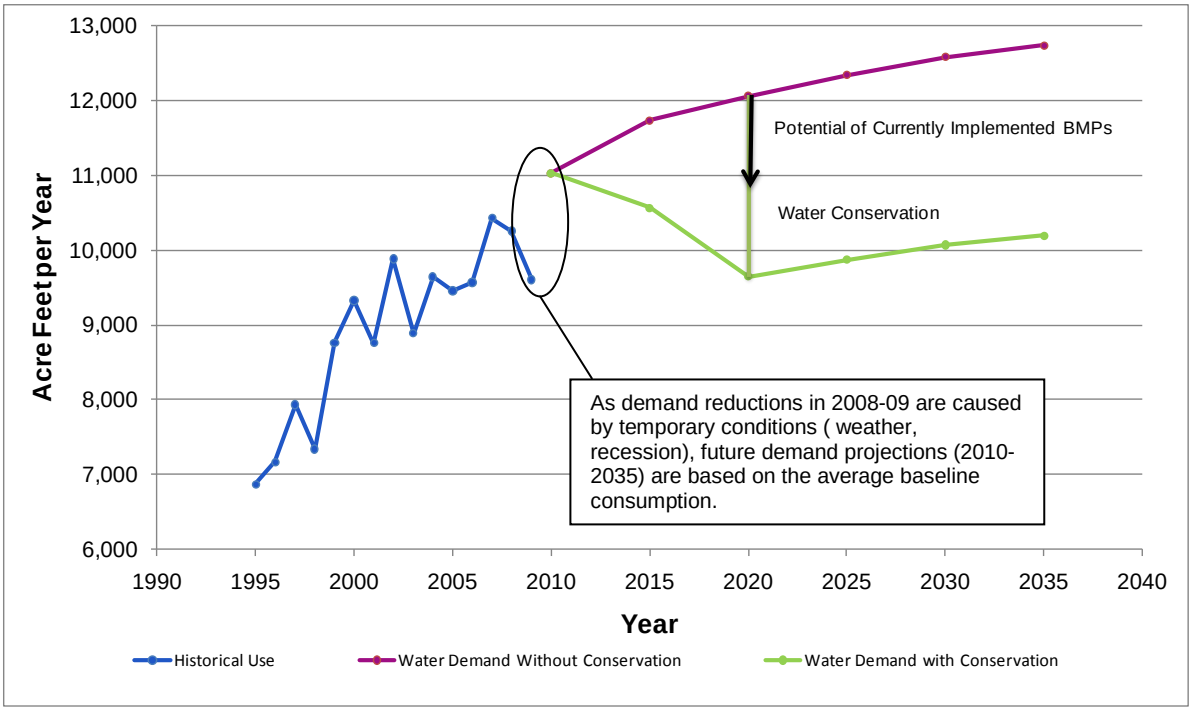


Figure 6.4 Projected Water Demands with and without Conservation

The conservation and non-conservation projections diverge rapidly after 2010, revealing conservation savings the City will need to implement by year 2020. The potential effect of current BMP programs by 2020 is shown in Figure 6.4. This value is listed as potential because it is based on the assumption that currently implemented BMPs will continue to be practiced and will have an affect on the City's water consumption. A breakdown of the potential water conservation amounts by BMP as described in the previous sections is graphically presented in Figure 6.5.

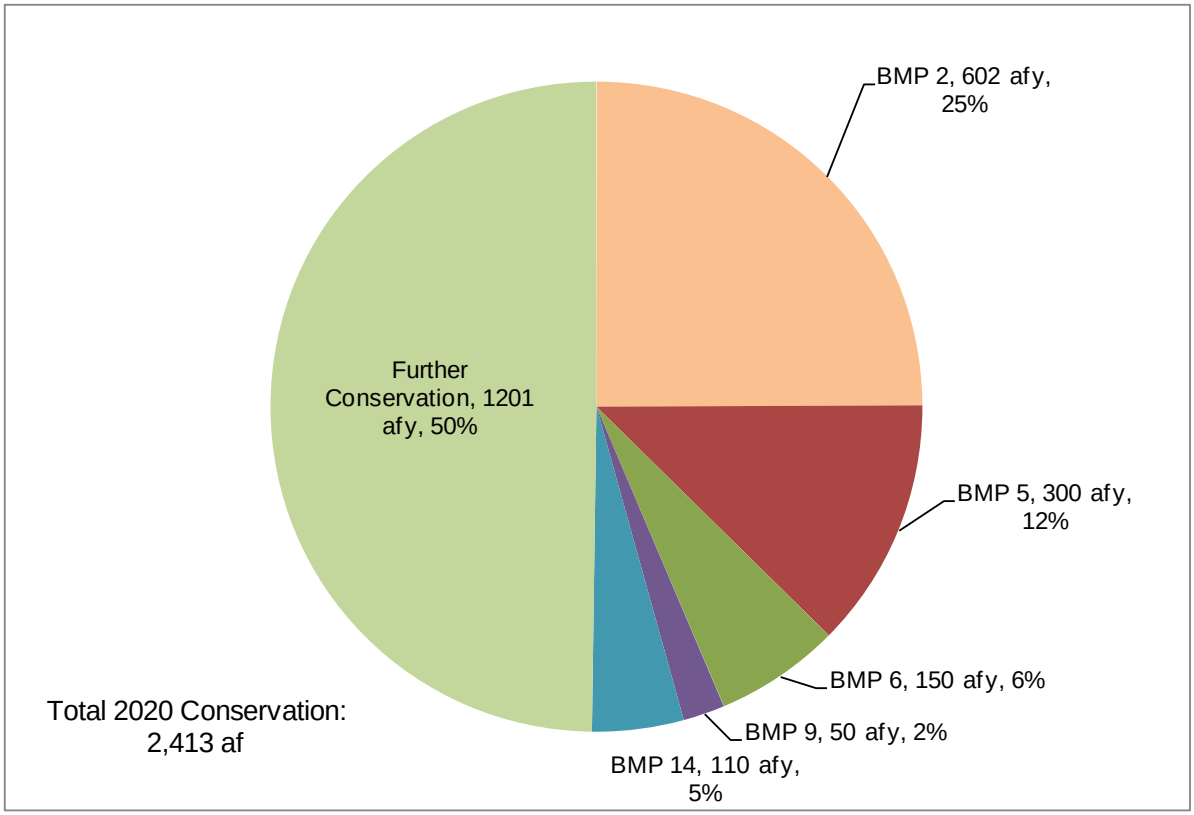


Figure 6.5 Water Conservation Savings by Method

As shown in Figure 6.5, current BMP programs will only account for 1,212 af of the 2,413 afy of conservation needed to reach the 9,652 af target in 2020, which equates to about 50 percent of the total water conservation goal. This figure, however, only accounts for 5 of the 13 BMP's (discounting BMP 10) which the City can use to reduce water consumption. BMP's such as school education, water surveying, and other such methods remain viable strategies to reduce consumption by an additional 1,201 af.

To achieve the necessary amount of water conservation, the City should prioritize its efforts towards expanding its large scale BMP programs to result in large conservation gains. Continued support of residential retrofits is also essential because of the City's largely residential customer base. Finally, although some BMP's do not result in tangible conservation savings, such as school and public education programs, these efforts provide much needed support as the City strives to meet its 2020 conservation target.

Chapter 7

WATER RELIABILITY PLANNING

The UWMPA requires that the UWMP address the reliability of the agency's water supplies. This includes supplies that are vulnerable to seasonal or climatic variations. In addition, an analysis must be included to address supply availability in a single dry year and in multiple dry years.

> *10631. A plan shall be adopted in accordance with this chapter and shall do all of the following:*
>
> *10631 (c) Describe the reliability of the water supply and vulnerability to seasonal or climatic shortage, to the extent practicable.*
>
> *10631 (c) For any water source that may not be available at a consistent level of use, given specific legal, environmental, water quality, or climatic factors, describe plans to replace that source with alternative sources or water demand management measures, to the extent practicable.*
>
> *10631 (c) Provide data for each of the following: (1) An average water year, (2) A single dry water year, (3) Multiple dry water years.*
>
> *10632. The plan shall provide an urban water shortage contingency analysis which includes each of the following elements which are within the authority of the urban water supplier:*
>
> *10632 (b) An estimate of the minimum water supply available during each of the next three-water years based on the driest three-year historic sequence for the agency's water supply.*

The UWMPA also requires that the UWMP include information on the quality of water supplies and how this affects management strategies and supply reliability.

> 10634. The plan shall include information, to the extent practicable, relating to the quality of existing sources of water available to the supplier over the same five-year increments as described in subdivision (a) of Section 10631 and the manner in which water quality affects management strategies and supply reliability.

Finally, the UWMPA lays out an approximate methodology for how suppliers should make the dry year supply and demand comparisons, and what information needs to be presented.

> *10635 (a) Every urban water supplier shall include, as part of its urban water management plan, an assessment of the reliability of its water service to its customers during normal, dry, and multiple dry water years. This water supply and demand assessment shall compare the total water supply sources available to the water supplier with the total projected water use over the next 20 years, in five-year increments, for a normal water year, a single dry water year, and multiple dry water years. The water service reliability assessment shall be based upon the information compiled pursuant to Section 10631, including available data from the state, regional, or local agency population projections within the service area of the urban water supplier.*

7.1 OVERVIEW OF WATER SUPPLY RELIABILITY

The City faces many of the same water supply issues as other water purveyors in Southern California. Drought, climatic challenges, water conveyance, environmental regulation, and competition for water from outside the region all force changes in water deliveries and the timing of those deliveries.

As discussed in Chapter 3, the City's water supply consists of two sources: imported water and groundwater. In 2009, the City received approximately 42 percent of its total water from local groundwater sources and 58 percent imported, although this breakdown will change with the implementation of the regional groundwater desalter. The following sections outline and summarize the supply reliability of these two sources. Reliability is described first in a general, conceptual sense, and then projected demands for the two sources are compared against supply projections, to numerically estimate and determine the City's total supply reliability.

7.1.1 Imported Water Supply Reliability

Although the City purchases its water from CMWD, the water is imported to the region by MWDSC. For this reason, when examining imported water supply reliability it is most important to consider the reliability estimates given by MWDSC. Moreover, at the time of the writing of this report, MWDSC offers the most comprehensive and up-to-date estimates of imported water supply reliability.

Because of competing needs and uses associated with water resources, and because of concerns related to the regional water operations, MWDSC has undertaken a number of planning efforts during the past fifteen years. Some of the most recent documents include the 2010 Integrated Water Resources Plan Update, Water Surplus and Drought Management Plan, Water Supply Allocation Plan, and Long-term Conservation Plan. These documents were reviewed for the purpose of preparing the City's 2010 UWMP.

MWDSC's customers receive water from three different sources. The first is from the customer's own local resources (such as ground or surface water) while the remaining is imported from two sources: the Colorado River (via the CRA), and the Sacramento-San Joaquin River Delta via the SWP. The City receives imported water only from the SWP at this time.

7.1.2 Groundwater Supply Reliability

The City historically receives approximately 40 percent of its total water supply from groundwater. The City has made efforts in the past to decrease its reliance on imported water by additional pumping and development of its groundwater resources. Overdraft and subsidence in the Pleasant Valley basin has caused FCGMA to restrict pumping. This has resulting in the City using a greater percentage of imported water. As mentioned above and

in Chapter 3, the implementation of the regional desalter will increase the City's groundwater supply.

7.2 FUTURE SUPPLY PROJECTS AND PROGRAMS

The three agencies who bear primary responsibility for providing water supplies to the City are MWDSC, CMWD, and the City itself. This section outlines the future supply projects and programs planned by these three agencies.

7.2.1 Projects Planned by MWDSC

As described in its Regional UWMP, MWDSC plans to meet its supply reliability goal through the following programs.

- Surface water storage programs related to the SWP and Colorado River
- Colorado River water management programs
- SWP management programs
- Central Valley/SWP storage and transfer programs
- Water conservation
- Development of local supplies
- Water recycling projects
- Ocean desalination programs
- Groundwater banking programs in Southern California region

The implementation approach and the achievements to-date for each of these programs are discussed in detail in Chapter 3 of MWDSC's Regional UWMP. The projected increase in supply availability due to these programs under average year conditions is summarized in Table 7.1.

Table 7.1 MWDSC's Current and Planned Supply Programs

Program Description	2015 (afy)	2020 (afy)	2025 (afy)	2030 (afy)	2035 (afy)
Current Programs					
In-Region Storage and Programs	685,000	931,000	1,076,000	964,000	830,000
California Aqueduct	1,550,000	1,629,000	1,763,000	1,733,000	1,734,000
Colorado River Aqueduct	1,250,000	1,250,000	1,250,000	1,250,000	1,250,000
Capability of Current Programs	**3,485,000**	**3,810,000**	**4,089,000**	**3,947,000**	**3,814,000**
Under Development					
In-Region Storage and Programs	206,000	306,000	336,000	336,000	336,000
California Aqueduct	382,000	383,000	715,000	715,000	715,000
Colorado River Aqueduct	187,000	187,000	187,000	182,000	182,000
Capability of Planned Programs	**588,000**	**689,000**	**1,051,000**	**1,051,000**	**1,051,000**
Supply Increase					
Total (afy)	4,073,000	4,499,000	5,140,000	4,998,000	4,865,000
Total (%)	+17%	+18%	+26%	+27%	+28%

Notes:
Source: Table 2-11 from MWDSC RUWMP (MWDSC, 2010).

7.2.2 Projects Planned by CMWD

At this time, CMWD has outlined plans various projects which range in scale from regional to local, but all of which provide some benefit to the City. A few of these projects are listed below.

- Los Posas Aquifer Storage and Recovery
- Lake Bard and Lake Bard Water Treatment Plant
- Salinity Management Project
- Transfer Opportunities

A more complete list and description of future projects can be found in CMWD's 2010 UWMP.

7.2.3 Projects Planned by the City

The following projects were listed as planned in the 2005 UWMP in order to enhance the operations and reliability of the City's water infrastructure. However, these projects will increase reliability not supplies.

- Airport Water System Improvements
- Pleasant Valley Rd Reclaimed Water Main
- Develop New Wells

In addition to these projects, which were slated for completion by 2010, the City also has plans to implement its groundwater desalination facility in 2016 and 2017 in order to use its groundwater supply without blending.

- Groundwater Desalination Program

7.3 FACTORS RESULTING IN INCONSISTENCY OF SUPPLY

There are a variety of factors that can impact water supply reliability. Factors impacting the City's supply sources are indicated with an "X" in Table 7.2. A brief discussion on each of these factors is provided below.

Table 7.2 Factors Resulting in Inconsistency of Supply

Water Supply Sources	Specific Source Name	Limitation Quantification	Legal	Environmental	Water Quality	Climatic	Additional Information
Imported	MWDSC/CMWD	-	-	X	-	X	-
Groundwater	Pleasant Valley Basin	-	-	-	X	-	-

7.3.1 Environmental

Given the fragile state of many of California's ecosystems, environmental concerns inevitably arise during the water planning process. The delicacy of these systems can, in turn, reduce the availability of water supply due to the enforcement of environmental legislation. The recent legal actions involving the Endangered Species Act in the Delta are an example of the competition between environmental concerns and water users over water supply. The environmental issues which impact supply reliability for the City are primarily dealt with by MWDSC. In June 2007, MWDSC's Board approved a Delta Action Plan that provides a framework for staff to pursue actions with other agencies and

stakeholders to build a sustainable Delta and reduce conflicts between water supply conveyance and the environment. MWDSC continues to develop principles to help achieve its mission to provide adequate and reliable supplies of high quality water in an environmentally and economically responsible way.

7.3.2 Water Quality

Water quality impacts on the groundwater supply are discussed below in Section 7.7. The overdrafted basin contributes to its water quality problems.

7.3.3 Climatic

MWDSC's service area encompasses three major climate zones, while MWDSC's water sources are drawn from an immense area. The Colorado River watershed is over 246,000 square miles while the SWP draws from about 32,000 square miles. Due to these geographic considerations, a reduction in supply in one watershed due to climatic variability can be extreme and may be balanced by availability in the other watershed. However, with the long term drought in the Colorado River watershed, this supply has not been able to compensate for the dry climatic conditions in the Feather River watershed of the SWP.

In addition, climate change will add many new uncertainties to the challenges of planning, and irrespective of the debate associated with the sources and cause of increasing concentrations of greenhouse gasses, changes in weather will significantly affect water supply planning. MWDSC intends to explore opportunities to continually increase efficiency, join the California Climate Action Registry, support environmental practices, develop solar power at some of their water treatment facilities, and pursue renewable water and energy programs that promote sustainability. Given that climatic pressures will unarguably affect supply reliability, continual attention to this issue will be necessary on the part of MWDSC.

7.4 SUPPLY RELIABILITY

There are two aspects of supply reliability that can be considered. The first relates to immediate service needs and is primarily a function of the availability and adequacy of the supply facilities. The second aspect is climate-related, and involves the availability of water during mild or severe drought periods. This section compares water supplies and demands during three water scenarios: normal water year, single dry water year, and multiple dry water years. These scenarios are defined as follows.

- **Normal Year**:
  The normal year is a year in the historical sequence that most closely represents median runoff levels and patterns. The supply quantities for this condition are derived from historical average yields.
- **Single Dry Year**:
  This is defined as the year with the minimum useable supply. The supply quantities

for this condition are derived from the minimum historical annual yield.

- **Multiple Dry Years**:
  This is defined as the three consecutive years with the minimum useable supply. Water systems are more vulnerable to these droughts of long duration, because they deplete water storage reserves in local and state reservoirs and in groundwater basins. The supply quantities for this condition are derived from the minimum historical three consecutive years' annual average yields.

In identifying historical supply reliability conditions throughout dry year and multiple dry year events, the chosen years are consistent with the years in MWDSC's 2010 RUWMP. As summarized in Table 7.3, MWDSC has identified 1977 as the single driest year since 1922 and the years 1990 through1992 as the driest multiple years over that same period. These years represent the years in which the least amount of imported water was available from MWDSC.

Table 7.3 Basis of Water Year Data

Water Year Type	Base Year(s)
Average Water Year	2008
Single Dry Water Year	1977
Multiple Dry Water Years	1990-1992

Sources:
Regional UWMP (MWDSC, 2010) for single and multiple dry years, and historical consumption and population data provided by City for average year.

MWDSC's RUWMP does not identify a particular year that would represent average water year conditions. To determine the average water year, the City's historical per capita water usage was evaluated. By normalizing water consumption with population and thus expressing consumption in gpcd, the increase in demands due to growth is eliminated. The historical per capita consumption in the period 1995-2009 is shown in Figure 7.1. As shown, the average consumption in the period was 217 gpcd. As the per capita consumption in 2008 was 218 gpcd and the closest to the 15 year average of 217 gpcd, this year was selected to represent average year conditions.

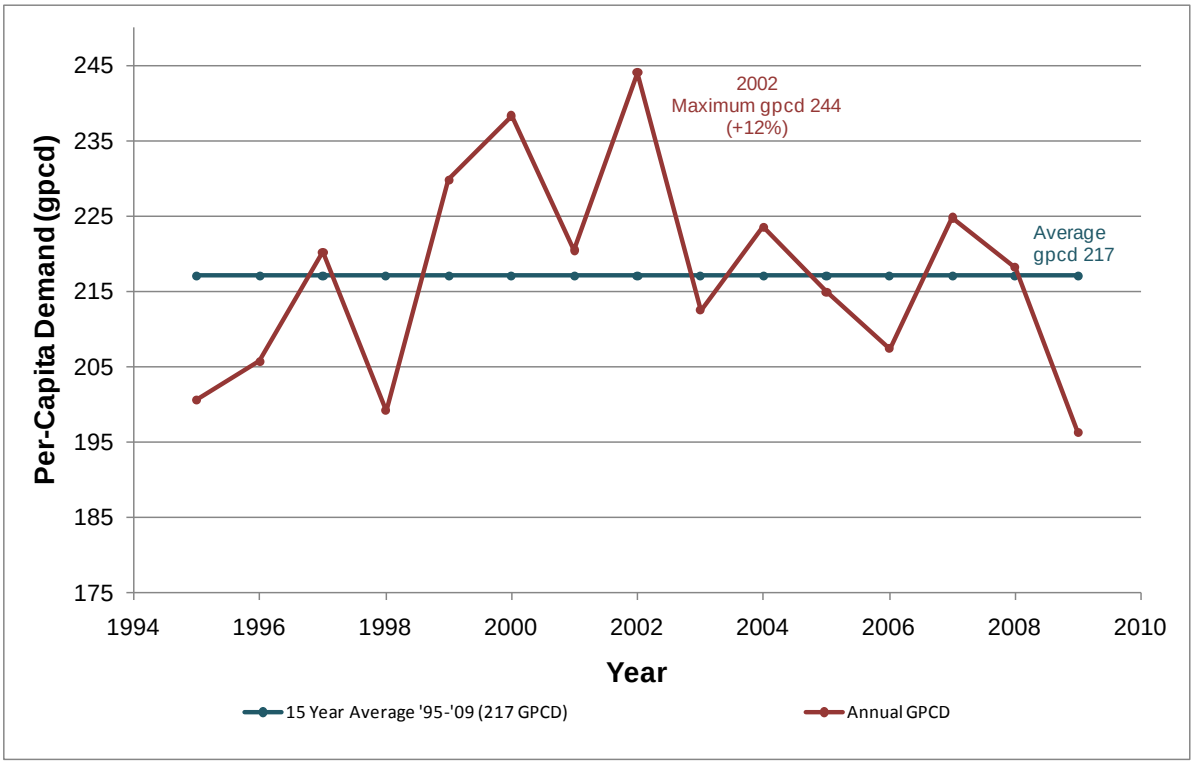


Figure 7.1 Historical Per Capita Consumption Variation

Supply reliability for these historical conditions is presented in Table 7.4. The total amount of available imported water in MWDSC's multiple dry years is less than during average year conditions.

Table 7.4 Supply Reliability – Historical Conditions

Water Supply Source	Average Year (2008)	Single Dry Year (2002)	Multiple Dry Years		
			2000	2001	2002
Imported (afy)	6,315	n/a	n/a	n/a	n/a
% of Normal	100%	n/a	n/a	n/a	n/a
Groundwater (afy)	3,943	n/a	n/a	n/a	n/a
% of Normal	100%	n/a	n/a	n/a	n/a
Total (afy)	10,258	n/a	n/a	n/a	n/a
% of Normal	100%	n/a	n/a	n/a	n/a

Notes:
Source:

Because the City relies on imported water and groundwater, comparing average year conditions to historical drought events doesn't provide a good indication of supply availability. Furthermore, while the source of MWDSC's water might change and fluctuate during drought periods (between groundwater banking, SWP, CRA, etc), imported water as a source for the City would remain both constant and unchanged under MWDSC's RUWMP conclusions of 100 percent supply reliability to meet demands during dry years.

Because of this aspect of the City's water sources, it was not considered realistic to use a historical condition based approach for future dry year planning. Instead the year with the maximum relative per capita usage was selected to project future demands during single and multiple dry years. Using a per capita comparison provided a single factor with which to simulate the effects of a dry year on demand. As shown in Figure 7.1, the maximum per capita use in the 15-year period was 244 gpcd in 2002, which is 12 percent higher than the average consumption of 217 gpcd.

This method differs from the single and multiple dry year demand projections presented in MWDSC's 2010 Regional UWMP, but provides a more conservative planning basis.

7.4.1 Demand Variations

The demand projections shown in Table 7.5 were obtained from the MWD-MAIN Water Use Forecasting System (MWD-Main), which is based on forecasts taken from the SCAG 2007 Regional Transportation Plan and the SANDAG Series 12: 2050 Regional Growth Forecast.

Table 7.5 MWDSC Retail Demands for Average, Single, and Multiple Dry Years

Retail Municipal and Industrial Demand	2015 (afy)	2020 (afy)	2025 (afy)	2030 (afy)	2035 (afy)
Average Year (afy)	4,978,000	5,170,000	5,330,000	5,491,000	5,627,000
Single Dry Year (afy)	5,000,000	5,194,000	5,354,000	5,515,000	5,653,000
Multiple Dry Year (afy)	5,004,000	5,232,000	5,409,000	5,572,000	5,715,000
Single Dry Year Increase(1)	0.4%	0.5%	0.5%	0.4%	0.5%
Multiple Dry Year Increase(1)	0.5%	1.2%	1.5%	1.5%	1.6%

Notes:
(1) As percentage of Average Year Conditions
(2) Source: Tables 2-6, 2-7, and 2-8 of Regional UWMP (MWDSC, 2010)

As shown in Table 7.5, the MWDSC's RUWMP shows that the single and multiple dry year retail municipal and industrial demands only increased between 0.4 and 1.6 percent. This is a very low estimate of demand increases, which typically involve a projected increase of at least 5 percent. Demand variations due to dry year conditions are anticipated to be less noticeable in the much larger service area of MWDSC than in the City's service area because:

- MWDSC's customers may experience different levels of extreme dry weather within different portions of its large service area,
- MWDSC's service area includes many urban regions with very limited outdoor demands, making those areas less sensitive to weather variations, and
- MWDSC's service area includes more industrial and other non-residential demands that are not sensitive to weather.

The City's demands are expected to increase more during hydrological dry years than MWDSC's demand as the entire area would experience extreme dry weather conditions at the same time and because the primarily residential character with plentiful outdoor usage makes demands more weather dependent. This added further reason to use the City's historical demands normalized for population (per capita consumption) as shown in Figure 7.1 as a basis for projecting the demand increase during single and multiple dry years. This means that 2008 was chosen as the base year for average year conditions and the supplies available for the single dry and multiple dry years were increased by 12 percent.

7.5 SUPPLY AND DEMAND COMPARISON

The UWMPA requires that the UWMP demonstrate that sufficient water supplies be available to meet the next 25 years of projected water demands under different water year types in five year increments.

7.5.1 Average Year

The projected average year demands and supplies compared in five year increments are presented in Table 7.6 through Table 7.10. This comparison consists of a number of steps described below.

First, the projected average year demands for 2015 through 2020 were compared with the year 2010 demands. As shown, the projected demands for the entire planning period are projected to remain below the year 2010 demand. This decrease reflects the SB7X-7 water conservation targets combined with limited growth potential within the City. This trend is discussed in more detail later.

Table 7.6 City Projected Average Year Water Demands

Description	2015	2020	2025	2030	2035
Projected Average Year Demand (afy)	10,564	9,652	9,875	10,069	10,194
Increase Compared to 2010[(1)] (afy)	(465)	(1,377)	(1,154)	(960)	(835)
Increase Compared to 2010 (%)	-4%	-12%	-10%	-9%	-8%
Demand as % of 2010 Demand	96%	88%	90%	91%	92%

Notes:
1) Based on a 2010 Average Year Demand of 11,029 afy.

Secondly, the average year supplies from MWDSC for 2015 through 2020 are compared with the year 2010 supplies. This comparison only includes the current supply programs operated by MWDSC, such as the existing in-region storage programs, the SWP via the California Aqueduct, and the Colorado River Aqueduct. For conservative planning purposes, the capacities of the new programs that are under development are not included in the summary presented in Table 7.7. It should be noted that the average year supply for 2010 was obtained from the 2005 RUWMP as this information was not presented in the 2010 Plan. As shown, there has been a significant increase in the estimated supply capacity between year 2010: 2.7 million acre feet (maf)) and 2015 (3.5 maf).

Table 7.7 MWDSC Projected Average Year Supplies

Description	2015	2020	2025	2030	2035
Average Year Supply(1) (afy)	3,485,000	3,810,000	4,089,000	3,947,000	3,814,000
Increase Compared to 2010(2) (afy)	817,000	1,142,000	1,421,000	1,279,000	1,146,000
Increase Compared to 2010	31%	43%	53%	48%	43%
Supply as % of 2010 Supply	131%	143%	153%	148%	143%

Notes:
1) Based on the current supply programs as listed in Table 2-11 from the 2010 Regional UWMP.
2) Based on the projected supply capacity of 2,668,000 afy obtained from 2005 Regional UWMP.

Subsequently, projected MWDSC supplies and demands were compared under average year conditions. As shown in Table 7.8, the projected supplies are substantially greater (174 to 181 percent) than the projected demands through the planning horizon of 2035. This reflects a combination of increased water conservation efforts by the member agencies as well an increase in supplies.

Table 7.8 MWDSC Projected Average Year Supply as Percentage of Demand

Description	2015	2020	2025	2030	2035
Average Year Supply(1) (afy)	3,485,000	3,810,000	4,089,000	3,947,000	3,814,000
Average Year Demand(2) (afy)	2,006,000	1,933,000	1,985,000	2,049,000	2,106,000
MWDSC Supply as % of Demand	174%	197%	206%	193%	181%

Notes:
1) Based on the current supply programs as listed in Table 2-11 from the 2005 Regional UWMP.
2) Based on total demands on Metropolitan as listed in Table 2-11 from the 2010 Regional UWMP.

The last step to determine imported water supply and demand involves the comparison of the relative increase in the City's demand with the relative increase in MWDSC supplies. This comparison is presented in Table 7.9. As shown, the imported water supplies are projected to increase proportionately more (46-60 percent) than the City's demands. This difference indicates that it is reasonable to expect that MWDSC would have sufficient supplies available to accommodate the City's projected demands under average year conditions as CMWD would get its proportional share of the increased supplies as one of MWDSC's 26 member agencies.

Groundwater supply and demand projections are based on simpler assumptions. Through 2015, groundwater supply and demand are both held at current FCGMA allocations. In 2015, it is assumed that the City will utilize only 4,000 af. This value is a reflection of historical trends which accommodate blending proportions that the City must utilize to compensate for certain groundwater quality considerations. It was assumed that the City will have constructed its groundwater desalter by 2020. This project will allow the City to pump its 9,279 af; this quantity is used for 2020 through 2035 groundwater supply and demand values.

Although groundwater supply could potentially decrease during single or multiple dry year events due to a reduction in recharge quantities, it was assumed here that the City will

continue to pump its full allocation and allow the basin to recover during wetter years. In the event of an extended drought where groundwater levels become a concern, the FCGMA may establish new or temporary allocations at that time. As such, groundwater supply is assumed to remain equal to demand over the projected timeframe.

Table 7.9 Comparison of Supply and Demands under a Normal Year

Row	Description	2015	2020	2025	2030	2035
1	City Demand Increase as % of 2010 Demand (from Table 7.6)	96%	88%	90%	91%	92%
2	MWDSC Supply Increase as % of 2010 Supply (from Table 7.7)	131%	143%	153%	148%	143%
3	MWDSC Supply as % of Demand (from Table 7.8)	174%	197%	206%	193%	181%
4	**Difference MWD Supply Increase and City Demand Increase (Row 3 – Row 1)**	**46%**	**54%**	**60%**	**53%**	**47%**

The ratios presented in Table 7.9 were used to project the imported water supply availability for each planning year. By combining the imported water supplies with the other supply sources, the total available supply capacity is calculated. The available supplies were then compared with projected demands to determine if the City has sufficient water supplies available to meet future demand under average year conditions. This summary is presented in Table 7.10.

Table 7.10 Supply and Demand Comparison – Normal Year

Water Sources	2015	2020	2025	2030	2035
Supply					
Projected Supply as a % of Demand During a Normal Year(1)	174%	197%	206%	193%	181%
Imported Water Supply(2)	11,021	302	773	1,097	1,258
Groundwater Supply	4,000	9,279	9,279	9,279	9,279
Recycled Water Supply	220	220	220	220	220
Total Supply	**15,241**	**9,801**	**10,273**	**10,596**	**10,757**
% of Normal Year	100%	100%	100%	100%	100%
Demands					
Imported Water	6,344	153	375	570	695
Groundwater(3)	4,000	9,279	9,279	9,279	9,279
Recycled Water Supply	220	220	220	220	220
Total Demand	**10,564**	**9,652**	**9,875**	**10,069**	**10,194**
% of Year 2010(4)	96%	88%	90%	91%	92%
Difference Supply - Demand	**4,677**	**149**	**398**	**528**	**563**
Difference as % of Supply	**31%**	**2%**	**4%**	**5%**	**5%**
Difference as % of Demand	**44%**	**2%**	**4%**	**5%**	**6%**

Notes:
1) From Table 7.8.
2) Calculated by multiplying the imported water demand with the imported water supply (%) from Row 1.
3) Groundwater demands are assumed to be identical to groundwater supply
4) Year 2010 deliveries were 11,029 afy.

As shown in Table 7.10, it is projected that the City has sufficient supplies available to meet water demands through 2035 under average year conditions with a supply surplus ranging from 44 to 2 percent of the projected demands. The reason for this wide range of supply surplus is the City's substantial change in supply composition. Starting in 2020, the City will meet most of its demand with groundwater. Because of groundwater's unique supply profile (a large underground aquifer which is depleted and recharged only on a long timescale) the supply is assumed to equal demand.

The decrease in available supply should not be taken to imply reduced reliability. Rather, the reduced imported water supply implies a proportionately smaller share of MWDSC's supply surplus.

7.5.2 Single Dry Year

As described in the previous section, the projected average year water demands were increased by 12 percent to estimate water demands during dry years. The projected imported water supplies were obtained from MWDSC's R2010 UWMP. The projected single dry year demands and supplies compared in five year increments are presented in Table 7.11 and Table 7.12. Details on the calculations of the values presented in this table are included in Appendix H.

Table 7.11 Comparison of Supply and Demands Under a Single Dry Year

Row	Description	2015	2020	2025	2030	2035
1	City of Camarillo Demand Increase as % of 2010 Demand	108%	98%	101%	103%	104%
2	MWDSC Supply Increase as % of 2010 Supply	86%	98%	105%	99%	95%
3	MWDSC Supply as % of Demand	113%	129%	135%	125%	116%
4	**Difference MWD Supply Increase and City of Camarillo Demand Increase (Row 3 – Row 1)**	**5%**	**30%**	**35%**	**23%**	**12%**

Notes:
Details on the calculations in each row are included in Appendix H.

As shown in Table 7.11, imported water supply availability is projected to increase more (5 to 35 percent) than City demands. This difference indicates that, similar to average year conditions, it is reasonable to expect that MWDSC would have sufficient supplies available to accommodate projected demands under single dry year conditions as the City would receive its proportional share of increased supplies.

The ratios presented in Table 7.11 were used to project imported water supply availability for each planning year. By combining imported water supplies with groundwater supply sources, total available supply availability was calculated. The available supplies were then compared with projected demands to determine if the City has sufficient water supplies available to meet future demands under single dry year conditions. This summary is presented in Table 7.12.

Table 7.12 Supply and Demand Comparison – Single Dry Year

Water Sources	2015	2020	2025	2030	2035
Supply					
Projected Supply as a % of Demand During a Single Dry Year(1)	113%	129%	135%	125%	116%
Imported Water Supply(2)	8,636	1,707	2,132	2,248	2,245
Groundwater Supply(3)	4,000	9,279	9,279	9,279	9,279
Recycled Water Supply	247	247	247	247	247
Total Supply	**12,883**	**11,234**	**11,659**	**11,774**	**11,772**
% of Normal Year	85%	115%	113%	111%	109%
Demands					
Imported Water	7,630	1,327	1,577	1,795	1,936
Groundwater(3)	4,000	9,279	9,279	9,279	9,279
Recycled Water Supply	247	247	247	247	247
Total Demand	**11,878**	**10,853**	**11,103**	**11,321**	**11,462**
% of Year 2010(4)	108%	98%	101%	103%	104%
Difference Supply - Demand	**1,005**	**380**	**556**	**453**	**310**
Difference as % of Supply	**8%**	**3%**	**5%**	**4%**	**3%**
Difference as % of Demand	**8%**	**4%**	**5%**	**4%**	**3%**

Notes:
1) From Table 7.11.
2) Calculated by multiplying the imported water demand with the imported water supply (%) from Row 1.
3) Groundwater demands are assumed to be identical to groundwater supply
4) Year 2010 deliveries were 11,029 afy.

As shown in Table 7.12, it is projected that the City has sufficient supplies available to meet water demands through 2035 under single dry year condition with a total supply surplus ranging from 8 to 3 percent of the projected demands. Once again, the drop in surplus does not imply reduced supply reliability, but as explained in Section 7.5.1, results from a dramatic increase in utilization of regional groundwater supplies.

7.5.3 Multiple Dry Year

The projected average year water demands were increased by 12 percent to estimate water demands during both single and multiple dry years. Projected imported water supplies were obtained from MWDSC's 2010 RUWMP. The projected multiple dry year demands and supplies were compared in five year increments in Table 7.13 through Table 7.16. Details on the calculations of the values presented in this table are included in Appendix H.

Table 7.13 Comparison of Supply and Demands under Multiple Dry Years

Row	Description	2015	2020	2025	2030	2035
1	City of Camarillo Demand Increase as % of 2010 Demand	108%	98%	101%	103%	104%
2	MWDSC Supply Increase as % of 2010 Supply	86%	92%	96%	94%	92%
3	MWDSC Supply as % of Demand	101%	110%	110%	105%	101%
4	**Difference MWD Supply Increase and City Demand Increase (Row 3 – Row 1)**	**-7%**	**12%**	**10%**	**2%**	**-3%**

Notes:
Details on the calculations in each row are included in Appendix H.

The data in Table 7.13 shows an important change in supply values. As a percent of demand, the imported water supplies are projected to increase less (-7 to +10 percent) than City demands. This difference indicates that City demands on imported water in a multiple dry year scenario might outpace MWDSC's growth in supply. It's important to note that this increase in demand means that, although MWDSC has established that it will have sufficient supplies to meet demand, the rate at which MWDSC's supply is growing is frequently less than the rate at which individual agency demand is growing. As this difference is based on percentage growth however, it is important to consider the absolute values presented in the tables below. Furthermore, the City is projected to use such a smaller percentage of imported water as compared to groundwater, that it's unlikely that an imported water shortage would result in MWDSC and CMWD being unable to meet the City's imported water demands.

The ratios presented in Table 7.13 were used to project the imported water supply availability for each planning year. By combining the imported water supplies with the other supply sources, the total available supply capacity is calculated. The available supplies are then compared with the projected demands to determine if the City has sufficient water

supplies available to meet future demand under multiple dry year conditions. This summary is presented in Table 7.14 (Dry Year 1), Table 7.15 (Dry Year 2), and Table 7.16 (Dry Year 3).

Table 7.14 Supply and Demand Comparison – Multiple Dry Year No. 1

Water Sources	2015	2020	2025	2030	2035
Supply					
Projected Supply as a % of Demand During Multiple Dry Years(1)	101%	110%	110%	105%	101%
Imported Water Supply(2)	7,671	1,466	1,740	1,887	1,949
Groundwater Supply(3)	4,000	9,279	9,279	9,279	9,279
Recycled Water Supply	247	247	247	247	247
Total Supply	**11,919**	**10,992**	**11,267**	**11,413**	**11,475**
% of Normal Year	78%	112%	110%	108%	107%
Demands					
Imported Water	7,630	1,327	1,577	1,795	1,936
Groundwater(3)	4,000	9,279	9,279	9,279	9,279
Recycled Water Supply	247	247	247	247	247
Total Demand	**11,878**	**10,853**	**11,103**	**11,321**	**11,462**
% of Year 2010(4)	108%	98%	101%	103%	104%
Difference Supply - Demand	**41**	**139**	**164**	**92**	**13**
Difference as % of Supply	**0.3%**	**1%**	**1%**	**1%**	**0.1%**
Difference as % of Demand	**0.3%**	**1%**	**1%**	**1%**	**0.1%**

Notes:
1) From Table 7.13.
2) Calculated by multiplying the imported water demand with the imported water supply (%) from Row 1.
3) Groundwater demands are assumed to be identical to groundwater supply
4) Year 2010 deliveries were 11,029 afy.

Table 7.15 Supply and Demand Comparison – Multiple Dry Year No. 2

Water Sources	2016	2021	2026	2031	2036
Supply					
Projected Supply as a % of Demand During Multiple Dry Years[1]	101%	110%	110%	105%	101%
Imported Water Supply[2]	7,465	1,521	1,788	1,917	1,977
Groundwater Supply[3]	4,000	9,279	9,279	9,279	9,279
Recycled Water Supply	247	247	247	247	247
Total Supply	**11,713**	**11,047**	**11,315**	**11,443**	**11,503**
% of Normal Year	77%	113%	110%	108%	107%
Demands					
Imported Water	7,425	1,377	1,620	1,823	1,964
Groundwater[3]	4,000	9,279	9,279	9,279	9,279
Recycled Water Supply	247	247	247	247	247
Total Demand	**11,673**	**10,903**	**11,147**	**11,350**	**11,490**
% of Year 2010[4]	106%	99%	101%	103%	104%
Difference Supply - Demand	**40**	**144**	**168**	**94**	**13**
Difference as % of Supply	**0.3%**	**1%**	**1%**	**1%**	**0.1%**
Difference as % of Demand	**0.3%**	**1%**	**2%**	**1%**	**0.1%**

Notes:
See footnotes listed in Table 7.14.

Table 7.16 Supply and Demand Comparison – Multiple Dry Year No. 3

Water Sources	2017	2022	2027	2032	2037
Supply					
Projected Supply as a % of Demand During Multiple Dry Years[1]	101%	110%	110%	105%	101%
Imported Water Supply[2]	7,259	1,576	1,837	1,946	2,005
Groundwater Supply[3]	4,000	9,279	9,279	9,279	9,279
Recycled Water Supply	247	247	247	247	247
Total Supply	**11,507**	**11,102**	**11,363**	**11,473**	**11,532**
% of Normal Year	75%	113%	111%	108%	107%
Demands					
Imported Water	7,221	1,427	1,664	1,851	1,992
Groundwater[3]	4,000	9,279	9,279	9,279	9,279
Recycled Water Supply	247	247	247	247	247
Total Demand	**11,468**	**10,953**	**11,190**	**11,378**	**11,518**
% of Year 2010[5]	104%	99%	101%	103%	104%
Difference Supply - Demand	**39**	**149**	**173**	**95**	**13**
Difference as % of Supply	**0.3%**	**1%**	**2%**	**1%**	**0.1%**
Difference as % of Demand	**0.3%**	**1%**	**2%**	**1%**	**0.1%**

Notes:
1) See footnotes listed in Table 7.14.

As shown in Table 7.14 through Table 7.16, the projected demands for each source are lower than the projected supplies in each year of a three-year multiple dry year period.

Although the increase in demands outstrips MWDSC's growth in supply as a percentage, MWDSC is still projected as being able to meet the total volume of imported water needed by the City. In several of the multiple dry year scenarios, supply capability is projected to fall within a few hundred acre-feet of its availability, but in all cases demands will be met. It should be noted that these dry year demand summaries assume that the projected available supply from MWDSC only includes the existing supply programs and does not include the programs that are currently under development which are estimated to increase the imported water supplies by 17 to 39 percent, depending on the planning year and hydrologic conditions (see Table 7.1). It should be noted that these planned programs increase the total available imported water supply relatively more during single and multiple dry years than during average years. The underlying assumption that groundwater supply will equal groundwater demand also contributes to the supply reliability in multi year drought conditions.

Based on the positive supply surplus shown in this section and the two conservative planning assumptions listed above, it can be concluded that the City has sufficient supplies available to meet water demands through 2035 under average, single dry year, and multiple dry year conditions.

7.6 TRANSFER AND EXCHANGE OPPORTUNITIES

Water exchange and transfers are primarily taking place at the importer and wholesale supplier level. MWDSC's Central Valley and SWP storage and transfer program are an example of such an opportunity. The City does not, at this time, pursue separate water transfer or exchange opportunities with other agencies or suppliers. Such an arrangement could occur in the future.

7.7 WATER QUALITY IMPACTS ON SUPPLY

10634. The plan shall include information, to the extent practicable, relating to the quality of existing sources of water available to the supplier over the same five-year increments as described in subdivision (a) of Section 10631 and the manner in which water quality affects management strategies and supply reliability.

7.7.1 Groundwater Quality

Groundwater quality has historically proved problematic for the City, and has had adverse effects on their water supply. High levels of TDS and chloride have resulted in the City needing to blend their groundwater with imported water in order to achieve water quality standards. Since 2005, this has resulted in the City typically pumping 200 af less than their current groundwater allocation.

As mentioned in Chapter 3, The City of Camarillo has assessed the feasibility of constructing a groundwater treatment and desalination facility that would be located in the Somis Gap area of the Pleasant Valley Basin. This project would allow the City to stop pumping the groundwater aquifer in areas where the groundwater level is decreasing, and instead take water from areas where the groundwater is of poor quality, but increasing in quantity.

7.7.2 Imported Water Quality

The City's imported water is supplied by MWDSC through CMWD. Details of MWDSC's water quality can be found in its 2010 RUWMP.

7.7.3 Seawater Desalination

It is neither practical nor economically feasible to implement a seawater desalination program at this time. Due to geographic placement of the City's service area, it would not be cost effective to develop desalinated water from the ocean.

7.7.4 MWDSC's Desalination Program

Although, the City has not identified any specific project opportunities for desalination of seawater at this time, other desalination projects developed by MWDSC within the region indirectly benefit the City. The recent efforts to develop and implement desalination by MWDSC as described in its 2010 RUWMP are summarized in Table 7.17. The potential capacity of all these combined project ranges from 270,000 to 422,000 afy. Although the projects would not benefit the City directly, new supplies contribute to increasing the reliability of Southern California water supplies.

Table 7.17 MWDSC Desalination Project Opportunities

Project Name	Member Agency	Capacity (afy)	Status n/a
Long Beach Seawater Desalination Project(1)	LBWD	10,000	Pilot Study
South Orange Coastal Ocean Desalination Project(1)	MWDOC	16,000-28,000	Pilot Study
Carlsbad Seawater Desalination Project(1)	SDCWA	56,000	Permitting
West Basin Seawater Desalination Project(1)	WBMWD	20,000	Pilot Study
LADWP Seawater Desalination Project	LADWP	28,000	Unknown
Huntington Beach Seawater Desalination Project	MWDOC	56,000	Permitting
Camp Pendleton Seawater Desalination Project	SDCWA	56,000-168,000	Planning
Rosarito Beach Seawater Desalination Feasibility Study	SDCWA	28,000-56,000	Feasibility Study

Notes:
1) These SDPs have executed incentive agreements with MWDSC.

MWDSC's Seawater Desalination Program (SDP) was created in 2001 to encourage the development of seawater desalination by local agencies and was modeled after the Local Resources Program (LRP). To promote the development of local seawater desalination projects, MWDSC provides regional facilitation by supporting member agency projects during permit hearings and other proceedings, coordinating responses to potential legislation and regulations, and working with the member agencies to resolve related issues, such as greenhouse gas emission standards and seawater intake regulations. As seawater desalination continues to develop through the Southern California region, the City stands to benefit from such programs.

Chapter 8

WATER SHORTAGE CONTINGENCY PLAN

The UWMPA requires that the UWMP include an urban water shortage contingency analysis that includes stages of action to be undertaken in the event of water supply shortages; a draft water shortage contingency resolution or ordinance; prohibitions, consumption reduction methods and penalties; an analysis of revenue and expenditure impacts and measures to overcome these impacts; actions to be taken during a catastrophic interruption; and a mechanism for measuring water use reduction.

8.1 STAGES OF ACTIONS

The UWMPA requires that the UWMP include an urban water shortage contingency analysis that addresses specified issues.

> 10632. The plan shall provide an urban water shortage contingency analysis, which includes each of the following elements, which are within the authority of the urban water supplier:
>
> 10632 (a) Stages of action to be undertaken by the urban water supplier in response to water supply shortages, including up to a 50 percent reduction in water supply and an outline of specific water supply conditions which are applicable to each stage.

The City implemented its current Water Shortage Contingency Plan (WSCP) in July 2009. The plan, included in Appendix E, was developed as a tool for the City to manage its water supplies in event of prolonged drought, natural disaster, or water failures.

Currently, Chapter 14.12 of the Camarillo Municipal Code, as amended by Urgency Ordinance 1039 (Ordinance), included in Appendix E, details the City's water conservation rules and water shortage contingency plan. The stages and their objectives are presented in Table 8.1.

Table 8.1 Water Shortage Stages and Reduction Objectives

Stage	Title	Supply Conditions (% of Normal)	Percentage Reduction of Demands
Permanent Restrictions			-
Stage 1 Shortage	Water Supply Alert	85 – 95%	15%
Stage 2 Shortage	Water Supply Shortage	70 – 84%	30%
Stage 3 Shortage	Critical Water Supply Shortage	60 – 69%	40%
Stage 4 Shortage	Severe Water Supply Shortage	50 – 59%	50%

As shown in Table 8.1, the water shortage stages include consideration of water shortages up to a Stage 4 Shortage, a Severe Water Supply Shortage, which includes reductions in water consumption by 50 percent.

8.2 PROHIBITIONS, CONSUMPTION REDUCTION METHODS, AND PENALTIES

The UWMPA requires that the UWMP include an urban water shortage contingency analysis that addresses methods to reduce consumption.

> 10632. The plan shall provide an urban water shortage contingency analysis, which includes each of the following elements, which are within the authority of the urban water supplier:
>
> 10632 (d) Additional, mandatory prohibitions against specific water use practices during water shortages, including, but not limited to, prohibiting the use of potable water for street cleaning.
>
> 10632 (e) Consumption reduction methods in the most restrictive stages. Each urban water supplier may use any type of consumption reduction methods in its water shortage contingency analysis that would reduce water use, are appropriate for its area, and have the ability to achieve a water use reduction consistent with up to a 50 percent reduction in water supply.
>
> 10632 (f) Penalties or charges for excessive use, where applicable.

8.2.1 Mandatory Prohibitions on Water Wasting

The City's Ordinance includes several permanent restrictions in force under all stages including normal use, with prohibitions listed as follows:

- Irrigating during daytime hours and longer than 15 minutes
- Excessive flow or runoff
- Washing outdoor surfaces
- Leaks in distribution, irrigation, or plumbing systems
- Non-recirculating water fountains
- Washing vehicles without a self-closing nozzle
- Restaurants providing water without request
- Not providing guests the option to avoid laundering towels daily
- Single pass cooling systems
- Water conserving nozzles in restaurants
- Restrictions on commercial car wash facilities

Under conservation stages, the City's Ordinance includes the following additional water conservation measures, listed by stage (note that each stage includes the restrictions from prior stages).

- Stage 1 Shortage
  - Irrigation limited to four days a week
  - Water Impact Study for new service connections showing the project will not increase the City's demands
- Stage 2 Shortage
  - Irrigation limited to three days a week
  - Obligation to fix leaks reduced to 48 hours
  - Filling ponds or ornamental lakes restricted to sustaining aquatic life
  - Limited filling of pools and spas
  - Agricultural irrigation limited to three days per week
  - Construction water must use recycled water if available
- Stage 3 Shortage
  - Irrigation limited to two days a week
  - Agricultural irrigation prohibited unless recycled water is available
- Stage 4 Shortage
  - Watering is prohibited except with recycled water under restricted conditions
  - Obligation to fix leaks reduced to 24 hours
  - Washing of vehicles is prohibited
  - Limited filling of pools and spas
  - No new potable water service connections, except under restricted conditions
  - No building permits that increase water demands
  - No new annexations

8.2.2 Water Reduction Stage Triggering Mechanisms

The City's water conservation stages are determined by resolution of the City Council at a public meeting. Such resolution will be based on the current drought situation and the amount of imported water available from CMWD and MWDSC. Some of the specific reasons cited in the WSCP as potential reasons to change stages are listed as follows:

- Advancement to subsequent stage

  - Emergency condition, such as failure of pumping equipment, etc., that requires a percentage of water consumption reduction greater than that of the current stage.
  - Regulatory action that requires more than that stage's percentage reduction in water consumption.
  - Failure to maintain target water consumption reduction goal of that particular stage.
- Withdrawal to previous stage
  - Emergency condition has been decreased in severity or resolved, so that the previous target goal may be utilized.
  - Regulatory action has been resolved or modified.
  - Water consumption reductions have been above that necessary to meet target goals of the current stage.

When a resolution of the City Council has been issued to change the water stage, the public will be notified through publication of the resolution in the local newspaper, on the City's website, and in the billing statement.

8.2.3 Excessive Use Penalties

The City's WSCP lists the penalties for violating the conservation measures as follows (violations must be within a year of each other to count as a subsequent violation).

- First Violation: written warning
- Second Violation: fine not to exceed $100
- Third Violation: fine not to exceed $500
- Fourth and Subsequent Violations: fine not to exceed $1,000 and installation of a flow restriction device

The City also includes termination of service as a penalty for willful violation of the Ordinance.

8.2.4 Review Process

The WSCP includes an appeal process by which administrative review can be requested of a penalty. Once an administrative review has been completed, an appeal hearing can be requested. The decision of the appointed hearing officer will be final.

8.3 WATER SHORTAGE CONTINGENCY ORDINANCE/ RESOLUTION

According to the UWMPA, the UWMP is required to include an urban water shortage contingency analysis that includes a draft water shortage contingency resolution or ordinance.

> 10632. The plan shall provide an urban water shortage contingency analysis, which includes each of the following elements, which are within the authority of the urban water supplier:
>
> 10632 (h) A draft water shortage contingency resolution or ordinance.

The City established its WSCP through Urgency Ordinance 1039 (Ordinance), which is included in Appendix E along with the WSCP.

8.4 REVENUE AND EXPENDITURE IMPACTS/MEASURES TO OVERCOME IMPACTS

According to the UWMPA, the UWMP is required to include an urban water shortage contingency analysis that addresses the financial impacts from reduced water sales.

> 10632. The plan shall provide an urban water shortage contingency analysis, which includes each of the following elements, which are within the authority of the urban water supplier:
>
> 10632 (g) An analysis of the impacts of each of the actions and conditions described in subdivisions (a) to (f), inclusive, on the revenues and expenditures of the urban water supplier, and proposed measures to overcome those impacts, such as the development of reserves and rate adjustments.
>
> 10632 (g) An analysis of the impacts of each of the proposed measures to overcome those revenue and expenditure impacts, such as the development of reserves and rate adjustments.

Since the City meters all accounts and charges based on actual water usage, it is anticipated that water shortages would result in a reduction in revenue. Since exact information on the duration of a water shortage cannot be predicted, the City would determine the extent of any revenue and expenditure imbalance as well as proposed measures to overcome impacts to City revenues and expenditure imbalances at the time the water shortage has started.

Some actions the City may choose to consider include temporarily increasing water rates or delaying capital improvements until the shortage has ended.

8.5 ACTIONS DURING A CATASTROPHIC INTERRUPTION

The UWMPA requires that the UWMP include an urban water shortage contingency analysis that addresses a catastrophic interruption of water supplies.

> 10632. The plan shall provide an urban water shortage contingency analysis, which includes each of the following elements, which are within the authority of the urban water supplier:
>
> 10632 (c) Actions to be undertaken by the urban water supplier to prepare for, and implement during, a catastrophic interruption of water supplies including, but not limited to, a regional power outage, an earthquake, or other disaster.

The City has included emergency conditions as a triggering action for advancement to a subsequent stage. Ostensibly, a catastrophic interruption could be considered an emergency condition.

8.6 REDUCTION MEASURING MECHANISM

> 10632. The plan shall provide an urban water shortage contingency analysis, which includes each of the following elements, which are within the authority of the urban water supplier:
>
> 10632 (i) A mechanism for determining actual reductions in water use pursuant to the urban water shortage contingency analysis.

The City's water system currently has water meters on all production sources and customer connections. These meters record the amount of water consumed at each location. Customer consumption totals are tallied on monthly basis for billing purposes. The City's WSCP states that the Water Superintendent will inform the Public Works Director of any increase to water consumed or decrease to water supplies. The Public Works Director will then make recommendations to the City Manager on whether to change water shortage stages and will provide supporting reports of consumption or supply as required.

2010
Urban Water Management Plan

Prepared for

CALLEGUAS
MUNICIPAL WATER DISTRICT

FINAL
May 2011

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Building a world of difference.

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Abbreviations and Acronyms

°F	degrees Fahrenheit
ac-ft	acre feet
ASR	aquifer storage and recovery
AWPF	advanced water purification facility
Bay-Delta	San Francisco Bay/Sacramento-San Joaquin Bay Delta
BDCP	Bay-Delta Conservation Plan
BMP	best management practice
CCDP	Conejo Creek Diversion Project
cfs	cubic feet per second
CII	commercial, industrial and institutional
CIMIS	California Irrigation Management Information System
CMWD	Calleguas Municipal Water District
CRA	Colorado River Aqueduct
CSUCI	California State University Channel Islands
CUWCC	California Urban Water Conservation Council
CVP	Central Valley Project
DWR	California Department of Water Resources
EIR	environmental impact report
EIS	environmental impact statement
FCGMA	Fox Canyon Groundwater Management Agency
GIS	geographic information system
GREAT Program	Groundwater Recovery Enhancement and Treatment Program
GSP	Groundwater Storage Program
IAWP	Interim Agricultural Water Program
IRAMP	Integrated Resource Adaptive Management Plan
IRP	Integrated Resources Plan
LAS	Lower Aquifer System
LRP	Local Resources Program
mdg	million gallons per day
mg/L	milligrams per liter
MOU	Memorandum of Understanding
MWD	Metropolitan Water District of Southern California
RUWMP	Regional Urban Water Management Plan
SB 7	Senate Bill No. 7

SCAG	Southern California Association of Governments
SMP	Salinity Management Pipeline
SDP	Seawater Desalination Program
SWP	State Water Project
TAZ	traffic analysis zone
TDS	total dissolved solids
TOC	total organic carbon
UAS	Upper Aquifer System
ULFT	ultra low flush toilet
UWCD	United Water Conservation District
UWMP	Urban Water Management Plan
UWMP Act	Urban Water Management Plan Act
VCOG	Ventura Council of Regional Governments
VCWWD	Ventura County Waterworks District
WRF	water reclamation facility
WRP	water reclamation plant
WSAP	water shortage allocation plan
WSDM Plan	Water Surplus and Drought Management Plan
WTP	water treatment plant
WWTP	wastewater treatment plant

Foreword

This Urban Water Management Plan (UWMP) has been prepared by the Calleguas Municipal Water District (CMWD) in compliance with the Urban Water Management Plan Act (UWMP Act) defined in Division 6 Part 2.6 of the California Water Code §§10610 - 10656. This act requires municipal water suppliers that serve more than 3,000 customers, or provide more than 3,000 acre feet (ac-ft) of water annually, to prepare UWMPs every five years with the specific deadline of December 31st of years ending in zero or five. These plans must be submitted to and reviewed by the California Department of Water Resources (DWR). In the past, DWR has issued a guidebook outlining the specific information required by the UWMP Act, as well as the criteria used by DWR staff in reviewing the UWMP for completeness.

On November 10, 2009 Senate Bill No. 7 (SB 7) was approved by the Governor and filed with the Security of State. SB 7, also known as the Water Conservation Bill, mandates that the State of California achieve a 20 percent reduction in urban per capita water use by December 31, 2020. SB 7 requires each urban retail water supplier to develop water use targets and agricultural water suppliers to implement efficient water management practices. Consequently, beginning in 2010, retail water suppliers must document historical per capita water use in their UWMPs and identify the means and methods for reducing per capita consumption 20 percent by 2020.

Requirements associated with SB 7 for urban wholesale water suppliers are different than those for urban retail water suppliers. Most notably, since target per capita water use rates will be measured for compliance at the retail level, wholesale water suppliers are not specifically required to identify the per capita water use rates for each of their purveyors. However, wholesale water suppliers are expected to include an assessment of how water conservation programs and policies implemented by the wholesale water agency will help achieve SB 7 requirements. A discussion on preliminary assessments performed for the CMWD service area is included in Chapter 4 of this UWMP.

The timing of SB 7 delayed the issuance of DWR's 2010 UWMP Guidebook until early 2011, and as a result, the submittal deadline for 2010 UWMPs has been pushed back to July 1, 2011. To meet the July 1, 2011 deadline, activities related to the CMWD 2010 UWMP were performed according to the following schedule.

Timeframe	Task
January 2010 – September 2010	Compile information.
September 2010	Develop draft report.
September 2010 – November 2010	Review of draft report by CMWD.
January 2011	Purveyor review.
February 2011	Address CMWD and purveyor comments and issue draft final report.
February 2011	60 day notification of public hearing.
Mid-May 2011	Adoption hearing by CMWD.
Prior to July 1, 2011	Submission to DWR.

By following this schedule the target July 1, 2011 adoption date will be met by CMWD.

Chapter 1
Plan Preparation and System Description

This UWMP has been prepared for CMWD to meet requirements of the UWMP Act defined in Division 6 Part 2.6 of the California Water Code §§10610 – 10656. The intent of this plan is to provide information regarding CMWD's current and future water supplies and water resource needs. Specifically, the UWMP presents water supply planning associated with a 20-year planning period (in 5-year increments), identifies and quantifies adequate water supplies for existing and future demands during normal, dry and drought years, and demonstrates conservation methods and efficient use of urban water supplies.

The following summarizes some of the more notable changes made to UWMP reporting requirements since the last issuance in 2005:

- Retail water suppliers are required to include water use projections for single- and multi-family residential low-income housing. This requirement stems from Section 65589.7 of the Government Code, which requires suppliers to prioritize providing service to housing units that are affordable to lower income households (Water Code §10631.1).

- Assembly Bill 1420 (AB 1420) was enacted, which requires DWR and other State agencies to condition water management grants and loans to urban water suppliers based on implementation of demand management measures, and specifically requires urban water suppliers to submit self-certification statements.

- SB 7 was enacted, which seeks to reduce state-wide water use by 20 percent by year 2020, specifically requires retail water providers to include the following information in their 2010 UWMPs: 1) baseline daily per capita water use; 2) urban water use targets; 3) interim water use targets; and 4) compliance daily per capita water use.

Retail and wholesale urban water suppliers must comply with AB 1420 if they intend to pursue grants or loans from State agencies. Retail water agencies have primary responsibility for meeting SB 7 and the new low-income housing requirements. Present and future measures that can be implemented by CMWD to assist its purveyors in meeting these objectives are identified in this UWMP.

CMWD has coordinated its UWMP planning efforts with a number of agencies to ensure that the information presented herein is accurate. Table 1-1 lists the agencies that have provided coordination with the development of this UWMP.

Table 1-1
Agency Coordination

Agency	Participated in UWMP Development	Received Draft Report and Public Hearing Notice	Attended Public Meetings	Received Final Report(1)
Berylwood Heights Mutual Water Company	X	X		X
Brandeis Mutual Water Company	X	X		X
Butler Ranch Mutual Water Company		X		X
California American Water Company	X	X		X
California DWR		X		X
California Water Service Company	X	X		X
Camrosa Water District	X+	X		X
Camarillo Library		X		X
City of Camarillo	X	X		X
City of Moorpark		X		X
City of Oxnard	X	X	X	X
City of Simi Valley (VCWWD No. 8)	X	X		X
City of Thousand Oaks	X	X		X
Crestview Mutual Water Company	X	X		X
Farm Bureau of Ventura County		X		X
Fox Canyon Groundwater Management Agency	X+	X		X
Lake Sherwood Community Services District	X	X		X
Metropolitan Water District of Southern California	X	X		X
Moorpark Library		X		X
Oxnard Library		X		X
Port Hueneme Library		X		X
Pleasant Valley Mutual Water Company	X	X		X
Simi Valley Library		X		X
Solano Verde Mutual Water Company	X	X		X
Southern California Association of Governments	X	X		X
Golden State Water Company	X	X		X
Thousand Oaks Library		X		X
United Water Conservation District		X		X
Ventura County Watershed Protection District		X		X
Ventura County Waterworks Districts Nos. 1 and 19 (VCWWD No. 1 and VCWWD No. 19)	X	X		X
Ventura County Regional Sanitation District (Oak Park Water/Triunfo Sanitation District)	X	X		X
Zone Mutual Water Company	X	X		X

(1) Identifies those that will receive either a hard copy or electronic copy of the report directly from CMWD after Board Adoption.
X + Identifies those that both participated in the UWMP development and provided comments on the Draft Report.

To improve the readability of this UWMP, the document has been organized differently than the structure laid out in DWR's 2010 UWMP Guidebook. Appendix A lists the required elements as defined in DWR's guidance manual and references the section where that topic can be found within this report. To minimize reporting redundancy, water management activities undertaken by CMWD's purveyors are not discussed in detail in this document, as they are addressed in the individual UWMPs of those purveyors.

A. Background

CMWD is an enterprise special district that was formed by the voters of southern Ventura County in 1953 for the purpose of providing a safe, reliable water supply. Named for the watershed in which it is located, the district is a public agency established under the Municipal Water District Act of 1911. It is governed by a five-member board of directors elected by voters to represent each of the five geographic divisions within the District.

In 1960, CMWD became a member agency of MWD, which provides wholesale water from the Colorado River via the Colorado Aqueduct and from northern California via the State Water Project (SWP). MWD is comprised of 26 member agencies, and CMWD is the fifth largest member agency in terms of average annual water deliveries.

CMWD distributes high quality drinking water on a wholesale basis to 19 local purveyors, who in turn deliver water to area residents, businesses, and agricultural customers. These purveyors are listed in Table 1-2. Approximately three-quarters of Ventura County residents (roughly 630,000 people) depend on CMWD for all or part of their water, and the water supplied by CMWD currently represents approximately 73 percent of the total municipal and industrial water demand within its service area. It is important to note that a large portion of the water use in Ventura County is for agricultural purposes. Agricultural demands are generally met by other agencies or private entities using untreated surface water, recycled wastewater, and groundwater from various basins underlying the area.

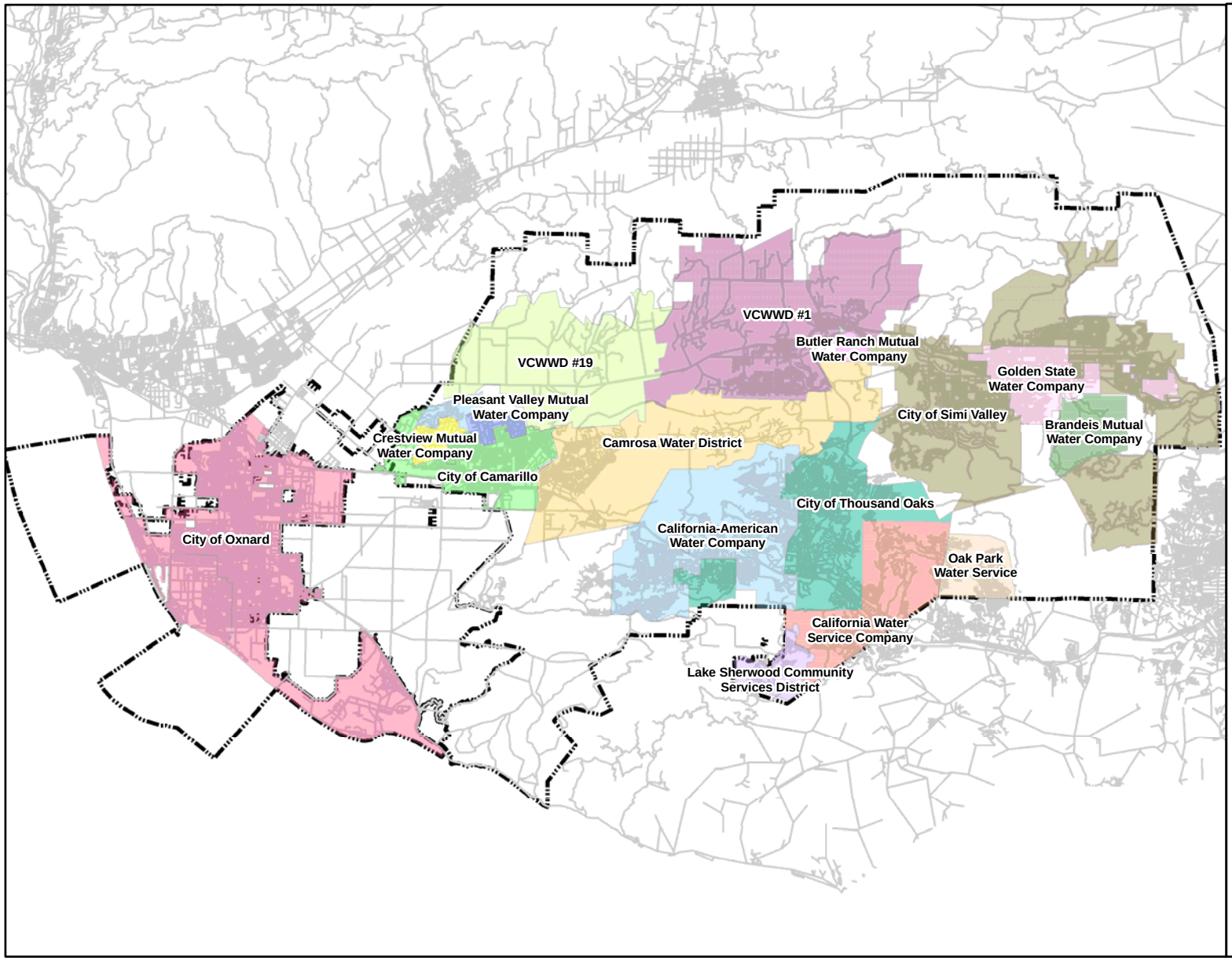
Table 1-2
CMWD Purveyors

Berylwood Heights Mutual Water Company	Crestview Mutual Water Company
Brandeis Mutual Water Company	Golden State Water Company
Butler Ranch Mutual Water Company	Lake Sherwood Community Services District
California Water Service Company	Oak Park Water Service
California-American Water Company	Pleasant Valley Mutual Water Company
Camrosa Water District	Solano Verde Mutual Water Company
City of Camarillo	VCWWD No. 1
City of Oxnard	VCWWD No. 19
City of Simi Valley (VCWWD No. 8)	Zone Mutual Water Company
City of Thousand Oaks	

Since the 2005 UWMP, there have been some changes with respect to the purveyors served by CMWD, as discussed below.

- In 2008, Newbury Park Academy Water Company was absorbed by California American Water Company.
- Capehart Housing has transitioned service to the City of Camarillo. Therefore, water demands for Capehart Housing were incorporated into Camarillo's projections for this 2010 UWMP.
- The Solano Verde Mutual Water Company became a CMWD purveyor in 2006.
- Southern California Water Company changed its name to Golden State Water Company.

Figure 1-1 shows CMWD's service area and purveyor boundaries. CMWD's service area encompasses approximately 375 square miles. Land use in the area is primarily residential, commercial, industrial, and irrigated cropland. Note that the City of Oxnard provides water to the Port Hueneme Water Agency (PHWA), which provides water to the City of Port Hueneme, Naval Base Ventura County Port Hueneme and Point Mugu, and the Channel Islands Beach Community Services District.



LEGEND

CMWD Purveyors

- Brandeis Mutual Water Company
- Butler Ranch Mutual Water Company
- California Water Service Company
- California-American Water Company
- Camrosa Water District
- City of Camarillo
- City of Oxnard *
- City of Simi Valley (VCWWD #8)
- City of Thousand Oaks
- Crestview Mutual Water Company
- Golden State Water Company
- Lake Sherwood Community Services District
- Oak Park Water Service
- Pleasant Valley Mutual Water Company
- Ventura County Water Works District #1
- Ventura County Water Works District #19
- CMWD Service Boundary

Note: Service area boundaries for Berylwood Heights Mutual Water Company and Zone Mutual Water Company generally overlie the service area of VCWWD # 19 and are not shown on this figure. Service area boundaires of Solano Verde Mutual Water Company were not available and are not shown on this figure.

* City of Oxnard supplies Port Hueneme Water Agency and Point Mugu Naval Base Ventura County

N

0 1.25 2.5 5 Miles

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CMWD Service Area and Purveyors

Figure 1-1

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B. Demographics

Two data sources were utilized to develop population, dwelling unit and employment projections for CMWD's service area. These sources include:

- Southern California Association of Governments (SCAG), 2007.
- Ventura Council of Regional Governments (VCOG), 2000.

Demographic projections through 2035 were developed by SCAG in 2007. This data is available in geographic information system (GIS) format with information distributed by traffic analysis zones (TAZs). This information was utilized by MWD to develop demographic projections for CMWD's service area.

The most recent demographic projections available from VCOG were developed in 2000. VCOG projections for the CMWD service area were estimated as the sum of the growth and non-growth portions of the following areas: Camarillo, Las Posas, Moorpark, Oak Park, Oxnard, Port Hueneme (including Channel Islands Beach and the Naval Base), Simi Valley, and Thousand Oaks. These areas are located within CMWD's service area.

The following sections summarize the demographic projections from each of these sources.

1. Population Projections

Table 1-3 lists population projections for the CMWD service area through the year 2035. Projections are also shown graphically on Figure 1-2.

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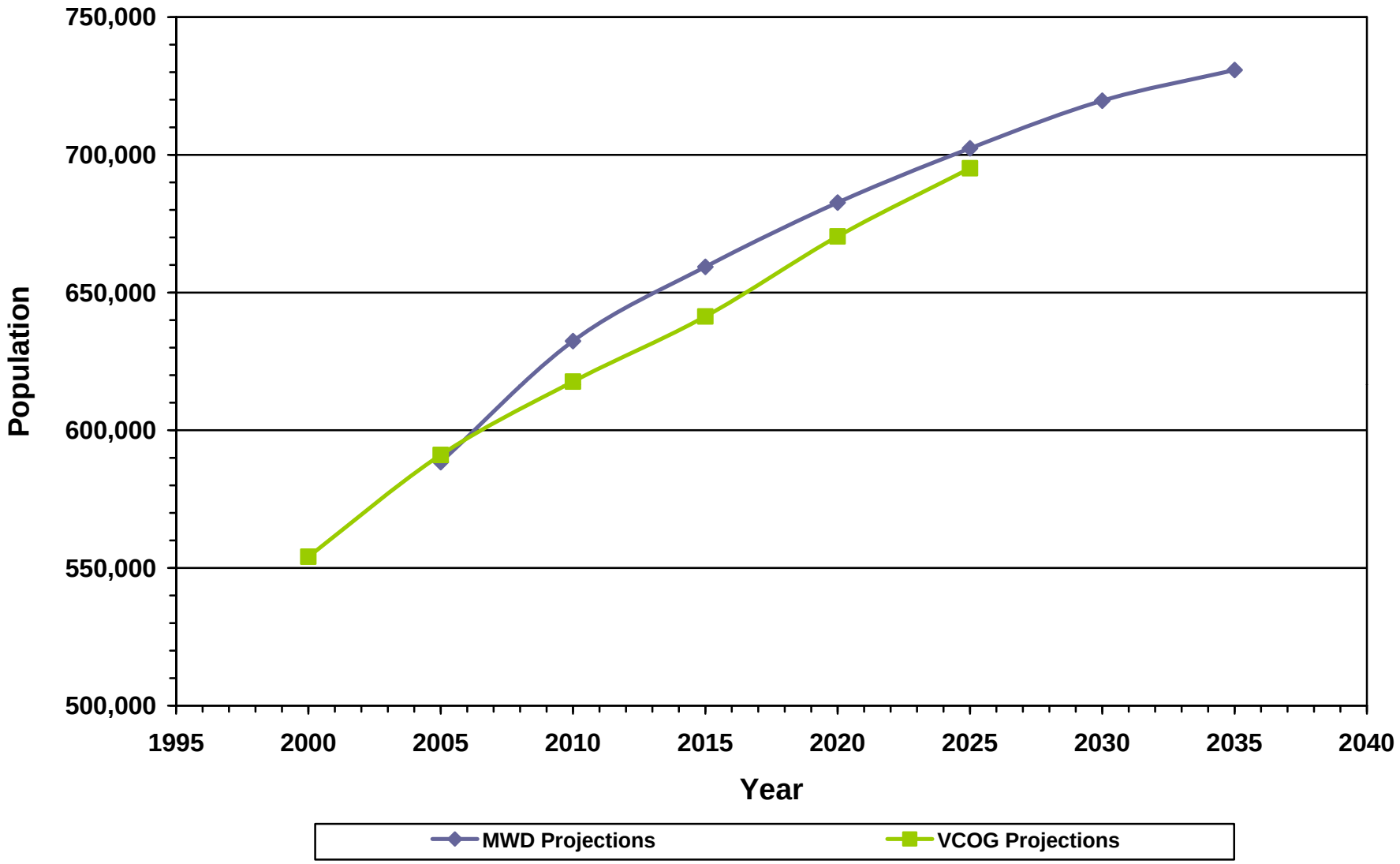

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Population Projections

Figure 1-2

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Table 1-3
CMWD Service Area Population Projections

Year	MWD Projections [1]	VCOG Projections [2]
2005	588,435	591,030
2010	632,399	617,662
2015	659,330	641,329
2020	682,651	670,358
2025	702,386	695,141
2030	719,655	-
2035	730,788	-
Average Annual Increase	0.7%	0.9%

[1] Based on SCAG RPT07 data by TAZ. Special consideration was given to allocate population in TAZ polygons that are partially within the CMWD service area.

[2] Based on the sum of the growth and non-growth area projections for Camarillo, Las Posas, Moorpark, Oak Park, Oxnard, Port Hueneme, Simi Valley, and Thousand Oaks. Projections for 2030 and 2035 were not available.

2. Dwelling Unit Projections

Dwelling unit projections for the CMWD service area through 2035 are listed in Table 1-4 and shown graphically on Figure 1-3.

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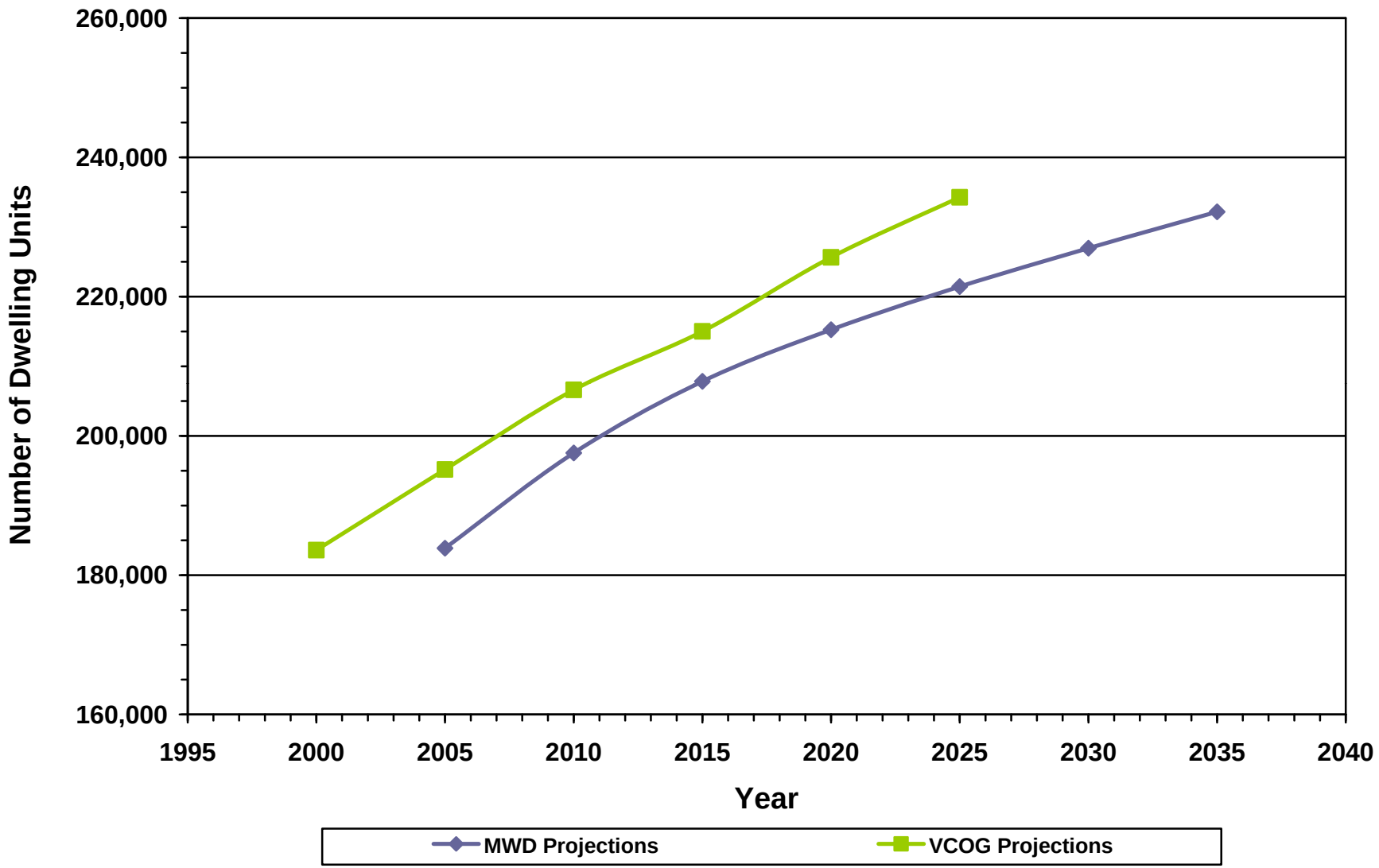

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Dwelling Unit Projections

Figure 1-3

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Table 1-4
CMWD Service Area Dwelling Unit Projections

Year	MWD Projections [1]	VCOG Projections [2]
2005	183,867	195,180
2010	197,544	206,610
2015	207,832	215,019
2020	215,258	225,642
2025	221,449	234,273
2030	226,953	-
2035	232,176	-
Average Annual Increase	0.8%	0.9%

[1] Based on SCAG RPT07 data by TAZ. Special consideration was given to allocate dwelling units in TAZ polygons that are partially within the CMWD service area.

[2] Based on the sum of the growth and non-growth area projections for Camarillo, Las Posas, Moorpark, Oak Park, Oxnard, Port Hueneme, Simi Valley, and Thousand Oaks. Projections for 2030 and 2035 were not available.

3. Employment Projections

Ventura County maintains a skilled labor force. Major industries within the County include agriculture, oil, aerospace, pharmaceutical, tourism, automotive, and military testing and development. Table 1-5 lists the employment projections for the CMWD service area through 2035. These projections are also shown graphically on Figure 1-4.

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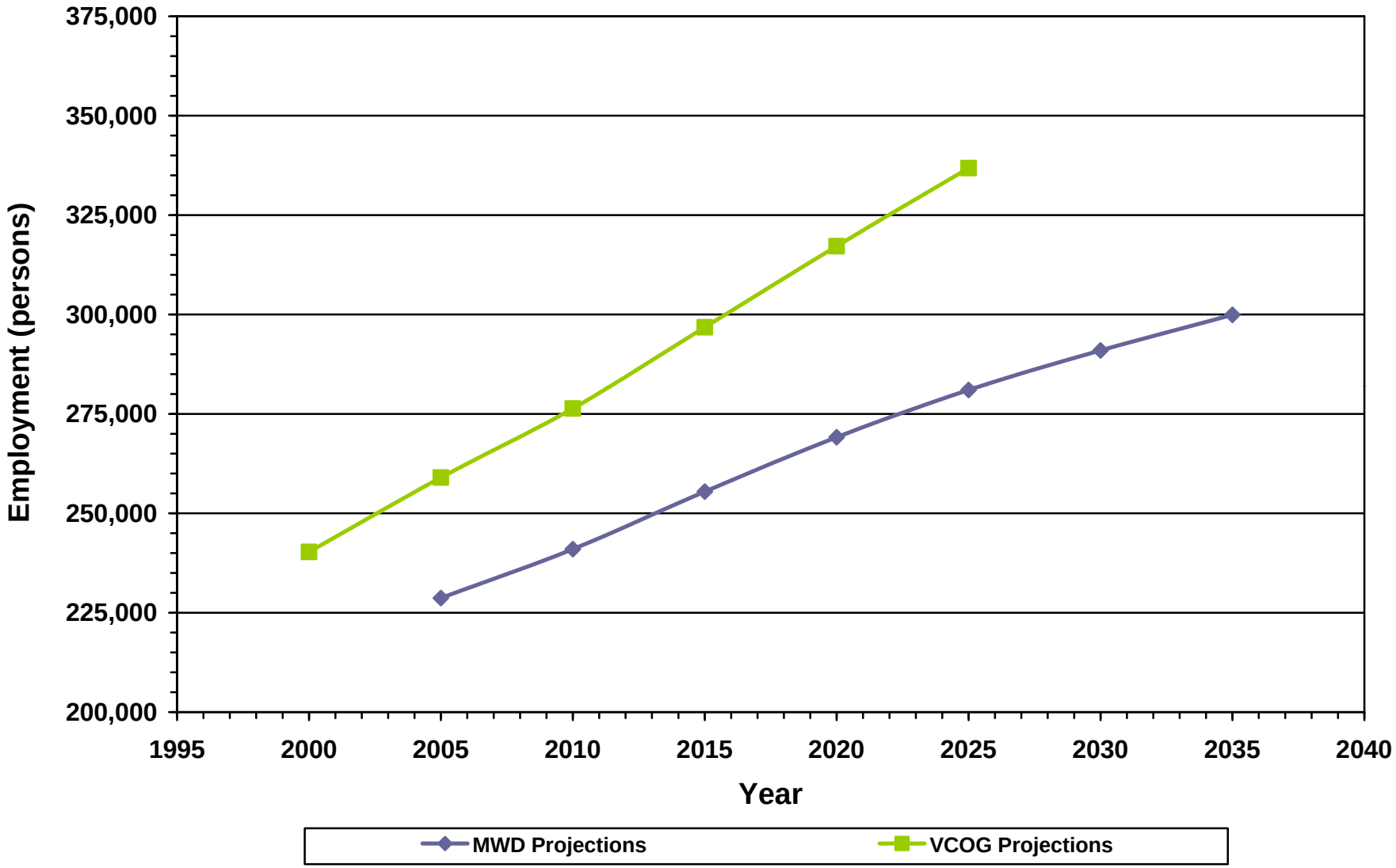

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CMWD 2010 Urban Water Management Plan

Employment Projections

Figure 1-4

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Table 1-5
CMWD Service Area Employment Projections

Year	MWD Projections [1]	VCOG Projections [2]
2005	228,673	258,987
2010	240,986	276,369
2015	255,445	296,789
2020	269,123	317,199
2025	281,002	336,814
2030	290,973	-
2035	299,921	-
Average Annual Increase	0.9%	1.4%

[1] Based on SCAG RPT07 data by TAZ. Special consideration was given to allocate dwelling units in TAZ polygons that are partially within the CMWD service area.

[2] Based on the sum of the growth and non-growth area projections for Camarillo, Las Posas, Moorpark, Oak Park, Oxnard, Port Hueneme, Simi Valley, and Thousand Oaks. Projections for 2030 and 2035 were not available.

MWD's employment projections shown in Table 1-5 are on average approximately 10.5 percent less than those projected in the 2005 UWMP. Based on discussions with MWD, the 2010 UWMP projections assume less growth in manufacturing type businesses and a shift towards businesses in the service industry. As discussed in more detail in Chapter 3, these two changes in employment projections have impacts on MWD's projections for water demands in the CMWD service area.

C. Climate

Like many regions in coastal southern California, the climate in Ventura County varies based on proximity to the ocean. Areas closest to the coast experience mild summers and winters, while inland areas experience similar winters but warmer summers. In the summer, high temperatures average 75 degrees Fahrenheit (°F) along the coast and 84 degrees further inland. Average winter low temperatures are fairly consistent across the region at 44 to 45 degrees °F. CMWD's service area receives an average of 10 to 14 inches of precipitation annually with the majority of this rainfall occurring during the winter

months. Tables 1-6 and 1-7 present monthly average climatic data for coastal and inland areas respectively.

Table 1-6
Monthly Average Climatic Data – Coastal (Western) Ventura County

Month	Average Evapotranspiration Rate [1] (inches per month)	Average Maximum Temperature [2] (°F)	Average Minimum Temperature [2] (°F)	Average Total Precipitation [2] (inches)
January	1.83	66.8	45.6	2.91
February	2.2	65.9	45.7	3.76
March	3.42	66.9	47	1.75
April	4.49	67.6	48.1	1.24
May	5.25	70	52.8	0.44
June	5.67	72.5	56.4	0.03
July	5.86	75.8	59.5	0
August	5.61	76	59.2	0
September	4.49	74.8	57.7	0.1
October	3.42	73.7	53.7	0.63
November	2.36	70.3	48.8	1.19
December	1.83	66.4	44.8	1.6
Total	**46.43**	**N/A**	**N/A**	**13.64**

[1] From the California Irrigation Management Information System (CIMIS) website http://wwwcimis.water.ca.gov. Data shown is for the Oxnard 156 station from October 2001 – January 2010.

[2] From the Western Regional Climate Center website www.wrcc.dri.edu. Data shown is for the Oxnard WFSO 046572 station from May 1998 – January 2010.

Table 1-7
Monthly Average Climatic Data - Inland (Eastern) Ventura County

Month	Average Evapotranspiration Rate [1] (inches per month)	Average Maximum Temperature [2] (°F)	Average Minimum Temperature [2] (°F)	Average Total Precipitation [2] (inches)
January	2.2	61.7	43.2	2.94
February	2.6	65	45	3.41
March	3.4	67.9	45.4	0.99
April	4.5	71.8	47.2	0.33
May	5.4	73.7	51.5	0.33
June	5.9	80.9	55	0
July	6.7	85.9	60	0
August	6.4	84.5	58.9	0.01
September	5.4	81.3	55.1	0.07
October	3.9	74.7	52.4	1.52
November	2.6	71.3	48	0.21
December	2.0	65.2	43.9	0.67
Total	**51.0**	**N/A**	**N/A**	**10.48**

[1] From the Cooperative Extension UC Division of Agriculture and Natural Resources, Leaflet 21426 for the Thousand Oaks Region.

[2] From the Western Regional Climate Center website www.wrcc.dri.edu. Data shown is for the Thousand Oaks 1 SW 048904 station from Oct 2001 through Aug 2008.

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Chapter 2
Water Supplies and Quality

Southern California's water supply is subject to natural and man-made forces, ranging from drought and earthquakes to environmental regulations and water rights determinations. Some of the challenges facing Southern California with respect to water include:

- Population and resulting urban water demands are increasing.
- A major earthquake could damage the California Aqueduct or the Colorado River Aqueduct (CRA), or both, interrupting water supply to the region for up to six months.
- Water demands associated with environmental causes are increasing, especially in the San Francisco Bay/Sacramento-San Joaquin Bay Delta (Bay-Delta), thus reducing the availability of water for Southern California.
- New and increasingly stringent drinking water standards are being promulgated and could further impact the use of local surface and groundwater supplies.
- California, like much of the west, is susceptible to long periods of drought.
- Recent climate change studies indicate that Bay-Delta and Colorado River supplies could be even more variable than that of the historical record, further stressing California water supplies.
- Several of the groundwater basins within CMWD's service area are in an overdraft condition.

The economic vitality of Ventura County is contingent upon a dependable water supply. Therefore, it is imperative that a strategy be developed to ensure reliable sources of water supply, including using existing supplies efficiently. This chapter discusses both imported and local supplies of water available to CMWD, as well as the water quality associated with each type of supply.

A. Imported Water

Due to the geographic location of its service area, CMWD receives SWP water exclusively under normal MWD operating conditions. The SWP is a 600 mile network of reservoirs, aqueducts, and pumping facilities that convey water from the northern Sierra Nevada Mountain Range to Southern California. Water is treated by MWD at the Joseph Jensen Filtration Plant in Granada Hills and is delivered to CMWD through MWD's West Valley Feeder No. 2 Pipeline. CMWD's sole connection to MWD is located in the City of Chatsworth at CMWD's East Portal Facility. From this point, water is conveyed 1.39 miles through the Perliter Tunnel into Simi Valley, where it is distributed through CMWD's transmission system, injected into the Las Posas aquifer, or stored in Lake Bard.

Water stored in Lake Bard is treated at the Lake Bard Water Treatment Plant (WTP), which has a treatment capacity of 65 million gallons per day (mgd), (100 cubic feet per second [cfs]). The WTP is used during the summer months to supplement imported MWD deliveries to the western part of CMWD's service area, and can supply the entire system for short durations if service from MWD is interrupted or reduced due to routine maintenance or emergency.

1. Water Quantity Challenges

The original SWP facilities, completed in the early 1970s, were designed to meet the needs of the SWP contractors established at that time. It was anticipated that additional SWP facilities would be constructed over time to meet increases in contractor delivery needs. However, these additional facilities were repeatedly deferred and public attitudes and environmental regulations have changed. As a result, the SWP is not capable of delivering full contractor entitlements every year.

The focal point of SWP supplies is the Bay-Delta; the largest estuary on the west coast through which 60 percent of the freshwater used in the State must pass. Years of environmental neglect to this area and political gridlock has resulted in significant environmental damage. In recent years, the Delta smelt, winter-run Chinook salmon, spring-run Chinook salmon, and splittail were added as threatened or endangered species under the federal Endangered Species Act (ESA). Resulting actions taken to protect the ecosystem of the Bay-Delta have placed additional restrictions on SWP operations.

As mentioned previously, CMWD's sole connection to MWD is the West Valley Feeder No. 2 Pipeline. The West Valley Feeder No. 2 Pipeline is capable of delivering up to 300 cfs of water to the East Portal of the Perliter Tunnel. The reliability of MWD's supply is evaluated in Chapter 5 and contingency planning is discussed in Chapter 6.

2. Water Quality Challenges

SWP water is generally of high quality. Total dissolved solids (TDS) concentrations range between 250 and 350 milligrams per liter (mg/L). The quality of SWP water as a drinking water source is affected by a number of factors, most notably seawater intrusion and agricultural drainage from peat soil islands in the Bay-Delta. The water quality parameters of most concern are total organic carbon (TOC), bromide, and salinity. Levels of TOC and bromide in the water increase significantly as it moves through the Bay-Delta. These constituents can combine with chemicals used in the water treatment process to form disinfection byproducts that are carcinogenic. Treated wastewater discharged from cities and towns surrounding the Bay-Delta also add salts and pathogens to the water, which affect its suitability for drinking and recycling.

Moreover, actions to protect Bay-Delta fisheries have exacerbated existing water quality problems by forcing SWP diversions to shift from the spring to the fall, when salinity and bromide levels are highest. Closure of the Delta Cross Channel gates to protect migrating fish has also degraded the quality of SWP supplies by reducing the flow of higher quality Sacramento River water.

B. Groundwater

Groundwater has been used in Ventura County for many years, primarily for irrigation, but also for municipal and industrial water supply. Historically, the aquifer system in southern Ventura County has been in a state of overdraft, mostly in the Lower Aquifer System (LAS), which has led to seawater intrusion. The non-consumptive portion of imported water utilized by the majority of CMWD purveyor customers is treated at local wastewater treatment facilities and discharged to the Calleguas Creek watershed. This water ultimately percolates into the Upper Aquifer System (UAS), increasing groundwater levels in the region. Unfortunately, water in the UAS can have elevated levels of chlorides and TDS. As described in more detail in subsequent sections of this chapter, CMWD

is an active participant in regional efforts to put some of this water to beneficial use by advancing groundwater desalter projects (groundwater recovery).

1. Fox Canyon Groundwater Management Agency

The Fox Canyon Groundwater Management Agency (FCGMA) is an independent special agency created in 1983 to oversee Ventura County's groundwater resources. The primary objective of the FCGMA is to preserve groundwater resources for agricultural, municipal and industrial uses in the best interests of the public and for the common benefit of all water users. Protection of water quality and quantity, along with maintenance of long-term water supply, is part of that objective (FCGMA, 2007 Update to the FCGMA Groundwater Management Plan, 2007).

FCGMA's boundary is located partially within CMWD's service area and overlies approximately 118,000 acres. The FCGMA boundary encompasses the coastal basins that underlie the cities of Oxnard, Port Hueneme, Camarillo and Moorpark. Private groundwater pumping (by non-CMWD purveyors) that occurs within CMWD's service area but outside of FCGMA's boundary is not monitored by a management agency, and therefore, pumping records are not available.

There are seven major groundwater basins within FCGMA's jurisdiction. These include the Oxnard Plain, the Oxnard Plain Forebay, the Pleasant Valley, the portion of the Santa Rosa basin west of the Bailey fault and the East, West and South Las Posas Basins. These basins generally contain two major aquifer systems, the UAS and LAS. The aquifers are recharged by infiltration of streamflow and precipitation, artificial and mountain-front recharge, return flow from agricultural and residential irrigation, and in varying degrees by groundwater underflow from adjacent basins.

Table 2-1 lists the pumping allocations associated with each of the basins managed by FCGMA. It is important to note that actual pumping can vary from allocation amounts because agricultural users are not governed by allocations if they can demonstrate that they are irrigating efficiently. It is also important to note that not all of the allocations shown in Table 2-1 are allocated to CMWD purveyors. In fact, a majority of the allocations listed in Table 2-1 are owned by agricultural water users (and to a lesser extent municipal and industrial water users) that are outside the CMWD service area. A more detailed accounting of groundwater supplies available to CMWD purveyors is included in the UWMPs for each purveyor.

Table 2-1
FCGMA Pumping Allocations [1]

Basin	Number of Wells	Historical Allocation [2] (ac-ft per year)	Baseline Allocation [3] (ac-ft per year)	Total Allocation (ac-ft per year)
Arroyo Santa Rosa	18	846	-	846
Oxnard Plain Forebay	150	29,661	216	29,877
Oxnard Plain	597	74,444	2,250	76,693
Pleasant Valley	144	21,425	1,409	22,834
East Las Posas	199	17,450	393	17,843
West Las Posas	48	13,680	504	14,185
South Las Posas	40	2,064	42	2,106
Total	1,196	159,571	4,814	164,385

[1] Information provided by FCGMA, 2010. Allocations are for all wells in FCGMA including destroyed wells and monitoring wells. Note that not all of the presented allocations are available to CMWD's purveyors. Refer to individual purveyor UWMPs for specific purveyor allocations.

[2] Allocation established as the average pumping that occurred at the well from 1985 through 1989.

[3] If no historical extraction data exists (i.e. new wells), a baseline extraction of 1 ac-ft per acre per year may be granted pending compliance with the FCGMA Ordinance Code.

FCGMA's goal is to balance the groundwater supply and demand within its jurisdiction by 2010. To achieve this goal, FCGMA has adopted a number of ordinances in an effort to eliminate groundwater overdraft, and to combat the ongoing threat of seawater intrusion in both the UAS and LAS. These ordinances and resolutions help to regulate, conserve, and manage the use and extraction of groundwater within the region. The most recent relevant FCGMA ordinances are provided in Appendix B.

2. Groundwater Storage Strategies and Transfer Agreements

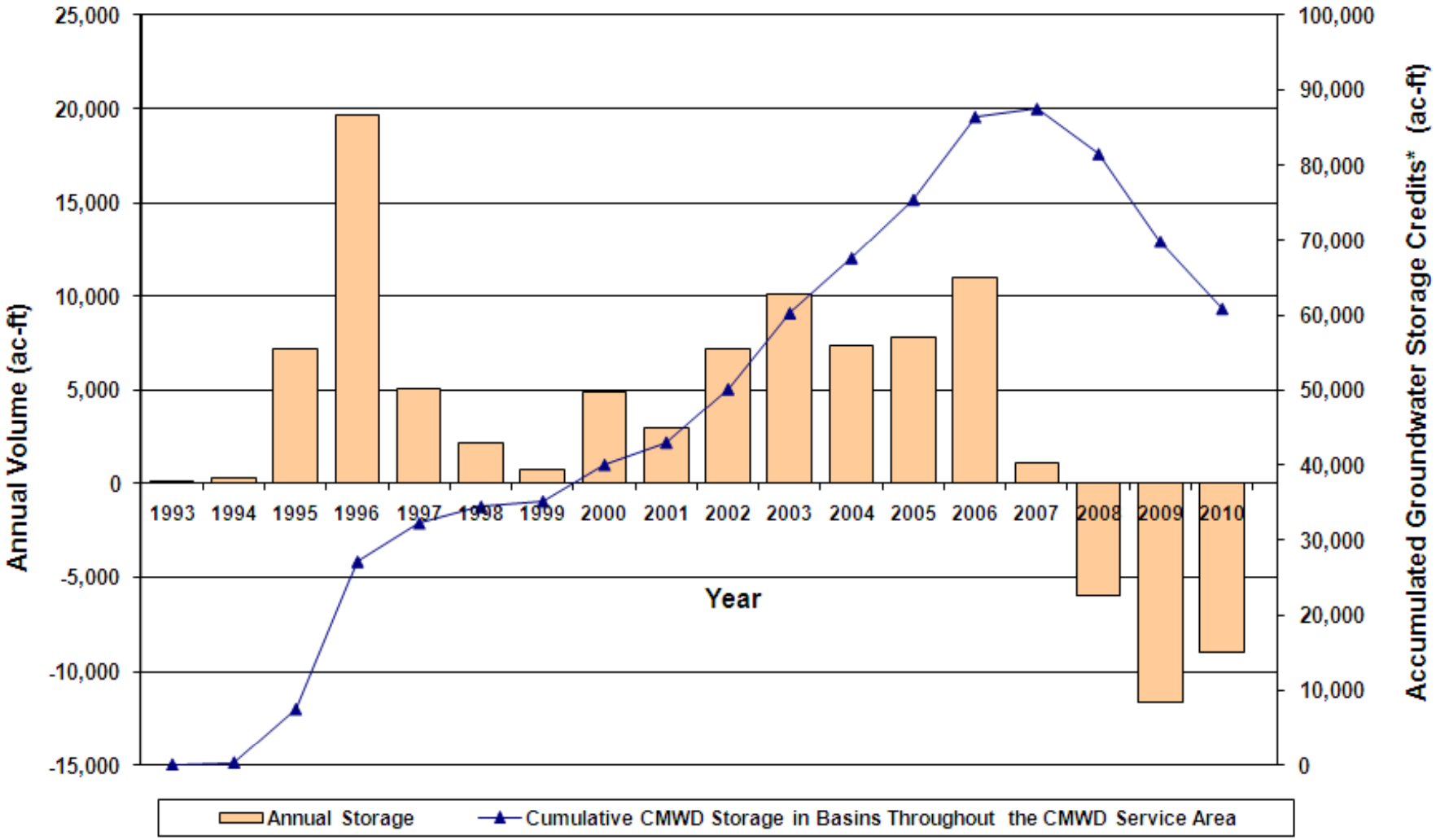
In addition to local groundwater supplies used directly by CMWD purveyors, CMWD has incorporated groundwater storage strategies and transfer agreements into its water resources portfolio..

Beginning in the early 1990s, CMWD has periodically stored water through in-lieu means. Under this storage method, CMWD has supplied imported water to well operators which, in turn, reduce groundwater pumping. The reduction in pumping results in the creation of storage credits. Such storage credits are then transferred to CMWD. In this way, groundwater can be stored and subsequently pumped during periods when imported supplies are curtailed.

In addition to storing water via in-lieu deliveries, CMWD operates the Las Posas ASR facilities. The project includes dual-purpose extraction and injection wells in two well fields in the Las Posas groundwater basin. CMWD can store water in this basin for use during scheduled shutdowns or emergencies..

Moreover, CMWD has accumulated additional groundwater storage credits through the Conejo Creek Diversion Project (CCDP). The CCDP consists of a diversion structure and pipelines that were jointly constructed by CMWD and the Camrosa Water District. The facilities are owned and operated by CMWD and Camrosa Water District. Recycled wastewater from the City of Thousand Oaks is diverted from Conejo Creek and used for agricultural and landscape irrigation within Camrosa Water District's service area. Water that is not used within the Camrosa Water District is provided to the Pleasant Valley County Water District for agricultural irrigation in-lieu of groundwater pumping. In return, CMWD receives groundwater credits from FCGMA equal to the amount of water delivered. By agreement, those credits are pumped from wells operated by the United Water Conservation District (UWCD) to meet demands in the Cities of Oxnard and Port Hueneme.

Figure 2-1 shows CMWD's Accumulated Groundwater Storage Credits in FCGMA-approved programs stored in basins throughout the CMWD service area since 1993. Some of this water was directly injected into the Las Posas Well Field. However, the majority represents credits gained from in-lieu deliveries. As illustrated on Figure 2-1, CMWD's groundwater storage steadily increased through 2007. However, as a result of drought conditions, CMWD extracted stored water to help meet regional water demands from 2008 through 2010.



* Accumulated groundwater storage credits in FCGMA Approved Programs. Extraction of credits is subject to FCGMA's policies and conditions of adopted storage programs.

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		Historical CMWD Groundwater Storage Data	

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A copy of the approval letter from FCGMA for the CMWD's groundwater storage program is included in Appendix B.

3. Groundwater Quality

Table 2-2 summarizes the groundwater quality for the basins that underlie CMWD's service area. Groundwater in CMWD's service area is generally high in TDS and occasionally high in nitrate concentrations. It is important to note that water quality within the basins can vary based on the location of the sample well, condition of the sample well, and groundwater conditions on the day the sample is taken.

Table 2-2
Groundwater Basin Water Quality Summary

Groundwater Basin	Average/ Maximum TDS Level (mg/L)	Average/ Maximum Nitrate Level (mg/L)
Arroyo Santa Rosa	965 / 1130	65 / 113
Simi Valley	1,659 / 2,050	30 54
South Las Posas	1,390 / 1,520	21 / 54
North (East/West) Las Posas	825 / 1,400	29 / 152
Pleasant Valley	1,590 / 4,890	14 / 121
Oxnard Forebay	1,150 / 1,210	22 / 48
Oxnard Plain	1,344 / 2,710	31 / 152

Source: Ventura County Watershed Protection District 2010 Annual Report

Data not available for Conejo Valley.

Seawater intrusion has long been a concern and was the issue that precipitated the creation of the FCGMA. The intrusion occurs exclusively along the coastline in the Oxnard Plain Basin.

Chloride has also become a problem in the East and South Las Posas basins and groundwater from these basins must be blended with lower-chloride water to be suitable for irrigation. This problem appears to have migrated

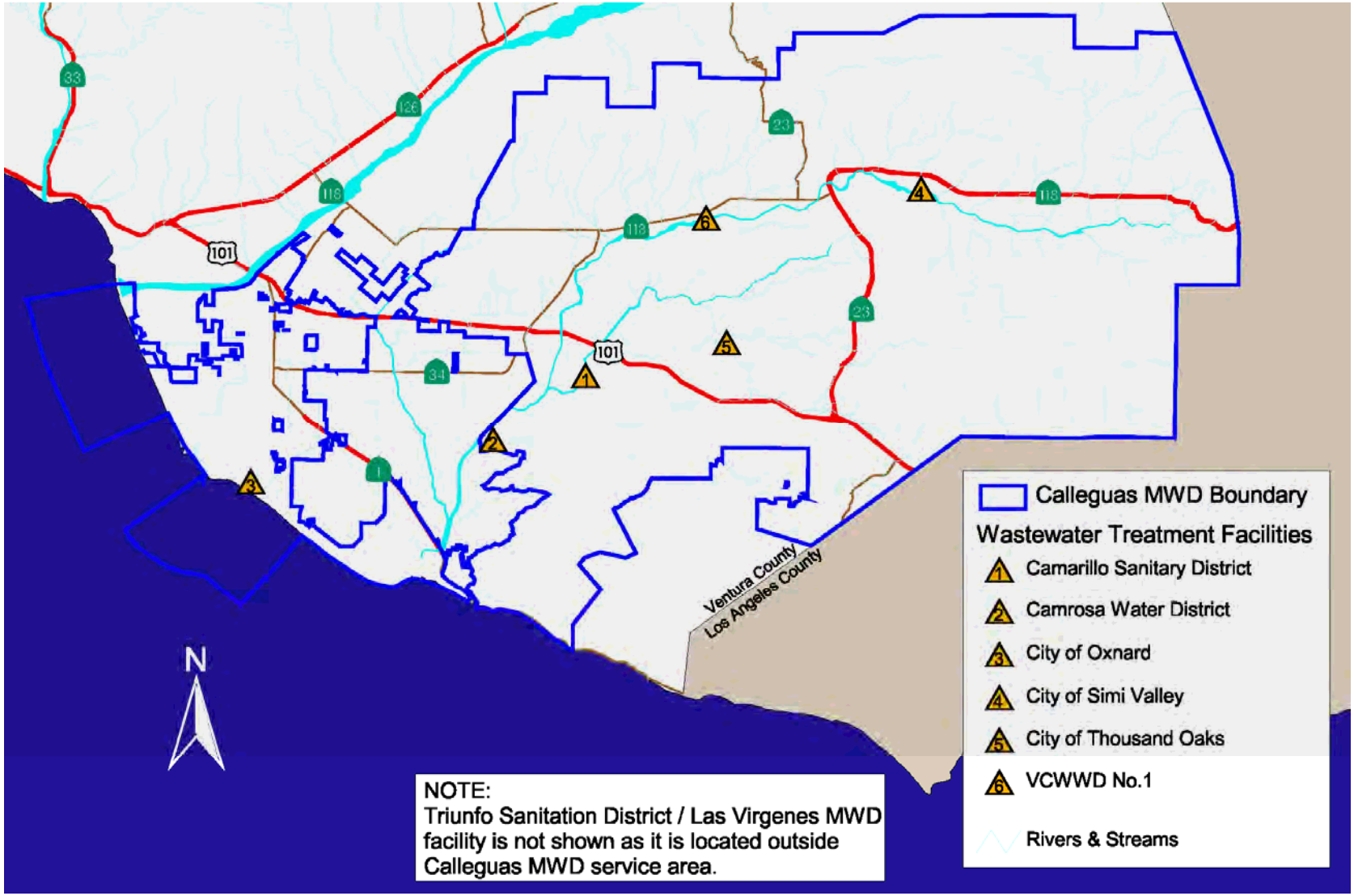
downstream, with some of the City of Camarillo's wells now affected (FCGMA, 2007 Update to the FCGMA Groundwater Management Plan, 2007).

High nitrate concentrations in the groundwater is a problem localized in the Oxnard Plain and Forebay basins. Drinking water wells in the impacted areas are often affected during and following dry periods. The primary sources of nitrate are septic systems and agricultural fertilizer. To address the problem, septic systems are now prohibited in the Oxnard Plain Forebay and best management practices (BMPs) are being implemented to limit agricultural contributions.

C. Recycled Wastewater

CMWD does not treat any wastewater. However, seven service providers treat wastewater that originates within CMWD's service area, as shown on Figure 2-2. These service providers are independent of CMWD and therefore, the entire service area of each provider may or may not be within CMWD's service area boundary. Many of these service providers treat wastewater so that it can be recycled for non-potable uses such as irrigation of golf courses, street medians, and school athletic fields, and dust abatement. Table 2-3 summarizes the recycling efforts of these wastewater service providers, including level of treatment provided, disposal method for non-recycled wastewater effluent, uses of recycled wastewater, and methods currently utilized to encourage recycled wastewater use. Details regarding local recycled water projects within the CMWD service area are provided in Section F of this chapter.

Although CMWD does not operate any wastewater treatment facilities, it does own and operate some recycled water pipelines and pumping facilities. CMWD purchases recycled water from Triunfo Sanitation District and the City of Simi Valley and delivers the water to a limited number of customers for irrigation. Additionally, CMWD supports the use of recycled wastewater as a financial participant in the CCDP.



CALLEGUAS MUNICIPAL WATER DISTRICT

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CMWD 2010 Urban Water Management Plan

Wastewater Service Providers in CMWD's Service Area

Figure 2-2

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Table 2-3
Recycled Wastewater in CMWD's Service Area

Wastewater Service Provider	Treatment Level	Method of Disposal for Non-Recycled Wastewater	Uses of Recycled Wastewater	Methods to Encourage Use
Camarillo Sanitary District (Camarillo Water Reclamation Plant [WRP])	Tertiary	Conejo Creek	Irrigation	Not applicable
Camrosa Water District (Camrosa Water Reclamation Facility [WRF])	Tertiary	Calleguas Creek (1)	Irrigation	Recycled water priced lower
City of Oxnard Advanced Water Purification Facility (AWPF) (2)	Secondary (tertiary with advanced oxidation and reverse osmosis in 2011)	Ocean	Industrial, irrigation, sea water barrier (3)	Mandatory use, recycled water priced lower
City of Simi Valley (VCWWD No. 8)	Tertiary	Arroyo Simi	Irrigation, wash water, dust abatement	Recycled water priced lower
City of Thousand Oaks (Hill Canyon Wastewater Treatment Plant [WWTP])	Tertiary	North Fork of Arroyo Conejo	Irrigation	Recycled water priced lower
Triunfo Sanitation District/ Las Virgenes Municipal Water District (Tapia WRF)	Tertiary	Los Angeles River or Malibu Creek (4)	Irrigation	Recycled water priced lower
VCWWD No. 1 (Moorpark WWTP)	Tertiary	Percolation ponds	Irrigation	Recycled water priced lower

(1) Treated effluent is normally discharged to storage ponds and used for irrigation. Discharge to Calleguas Creek is rare and generally only occurs during wet-weather events.

(2) The AWPF is not currently operational, but expected to be producing recycled water before 2015.

(3) Highly treated recycled water is expected to be used for groundwater injection, which will provide a hydrologic gradient creating a barrier between sea water and fresh groundwater. Through two resolutions (Resolutions 03-04 and 03-05 dated 12/17/2003) adopted by FCGMA, Oxnard expects to receive groundwater credits allowing Oxnard to pump groundwater from other regions of the aquifer.

(4) Tapia WRF is not permitted to discharge into Malibu Creek between April 15th and November 15th.

Table 2-4 lists the historic and projected wastewater flows through 2035, as provided by each service provider. Note that the wastewater flows presented in Table 2-4 may include flows generated outside the CMWD service area.

Table 2-4
Wastewater Treatment in CMWD's Service Area [1]

Wastewater Service Provider	Annual Average Wastewater Flows (ac-ft)						
	2005	2010	2015	2020	2025	2030	2035
Camarillo Sanitary District (Camarillo WRP)	4,368	4,368	4,369	4,369	4,369	4,369	4,369
Camrosa Water District (Camrosa WRF)	1,650	1,522	1,696	1,870	2,044	2,044	2,044
City of Oxnard (GREAT Program)	26,879	25,199	27,887	30,799	32,367	33,935	35,839
City of Simi Valley (VCWWD No. 8)	9,856	10,864	11,872	12,880	13,888	14,000	14,728
City of Thousand Oaks (Hill Canyon WWTP)	10,667	10,667	10,667	10,667	10,667	10,667	10,667
Triunfo Sanitation District/ Las Virgenes Municipal Water District (Tapia WRF)	1,444	1,444	1,444	1,444	1,444	1,444	1,444
VCWWD No. 1 (Moorpark WWTP)	1,059	1,190	1,351	1,507	1,657	1,825	1,971
Total	55,922	55,254	59,285	63,536	66,435	68,283	71,061

[1] Data obtained through correspondence with each agency.

Table 2-5 lists the historical and projected recycled water use for each service provider through the year 2035. Quantities of recycled water by use type are provided in individual purveyor's UWMPs.

Table 2-5
Available Recycled Wastewater in CMWD's Service Area

Recycled Water Service Provider	Approximate Annual Recycled Water (ac-ft)					
	2010	2015	2020	2025	2030	2035
California Water Service [1]	425	429	433	437	441	445
Camarillo Sanitary District	0	500	500	500	500	500
Camrosa Water District	4,924	6,110	6,990	8,170	8,800	8,880
Triunfo Sanitation District (Lake Sherwood Community) [1],[2]	300	300	300	300	300	300
Triunfo Sanitation District (Oak Park Water Service)[1]	790	790	790	790	790	790
City of Oxnard [3]	0	2,700	7,050	7,050	7,050	7,050
City of Simi Valley (VCWWD No. 8)	60	80	110	110	110	110
City of Thousand Oaks [4]	-	-	-	-	-	-
Triunfo Sanitation District/Las Virgenes Municipal Water District [5]	-	-	-	-	-	-
VCWWD No. 1	448	1,100	1,100	1,100	1,100	1,100
Total	6,947	12,009	17,273	18,457	19,091	19,175

[1] Imported from Triunfo Sanitation District/Las Virgenes Municipal Water District.

[2] Estimated by CMWD.

[3] Per material published by City of Oxnard for its AWPF.

[4] Hill Canyon WWTP discharges effluent into Conejo Creek. The effluent is picked up further downstream as part of the CCDP and is accounted for by other purveyors in their recycled water estimates.

[5] Recycled water from Tapia Water Reclamation Facility is delivered through CMWD facilities to California Water Service and Triunfo Sanitation District (Oak Park and Lake Sherwood) and is accounted for by those purveyors in their recycled water estimates.

Figure 2-3 graphically presents the beneficial uses for wastewater effluent and recycled water in the CMWD service area. In addition to the direct use of recycled water, agreements that allow the exchange of recycled water supplies for groundwater credits, such as the CCDP, further increase the effective use of recycled water in CMWD's service area.

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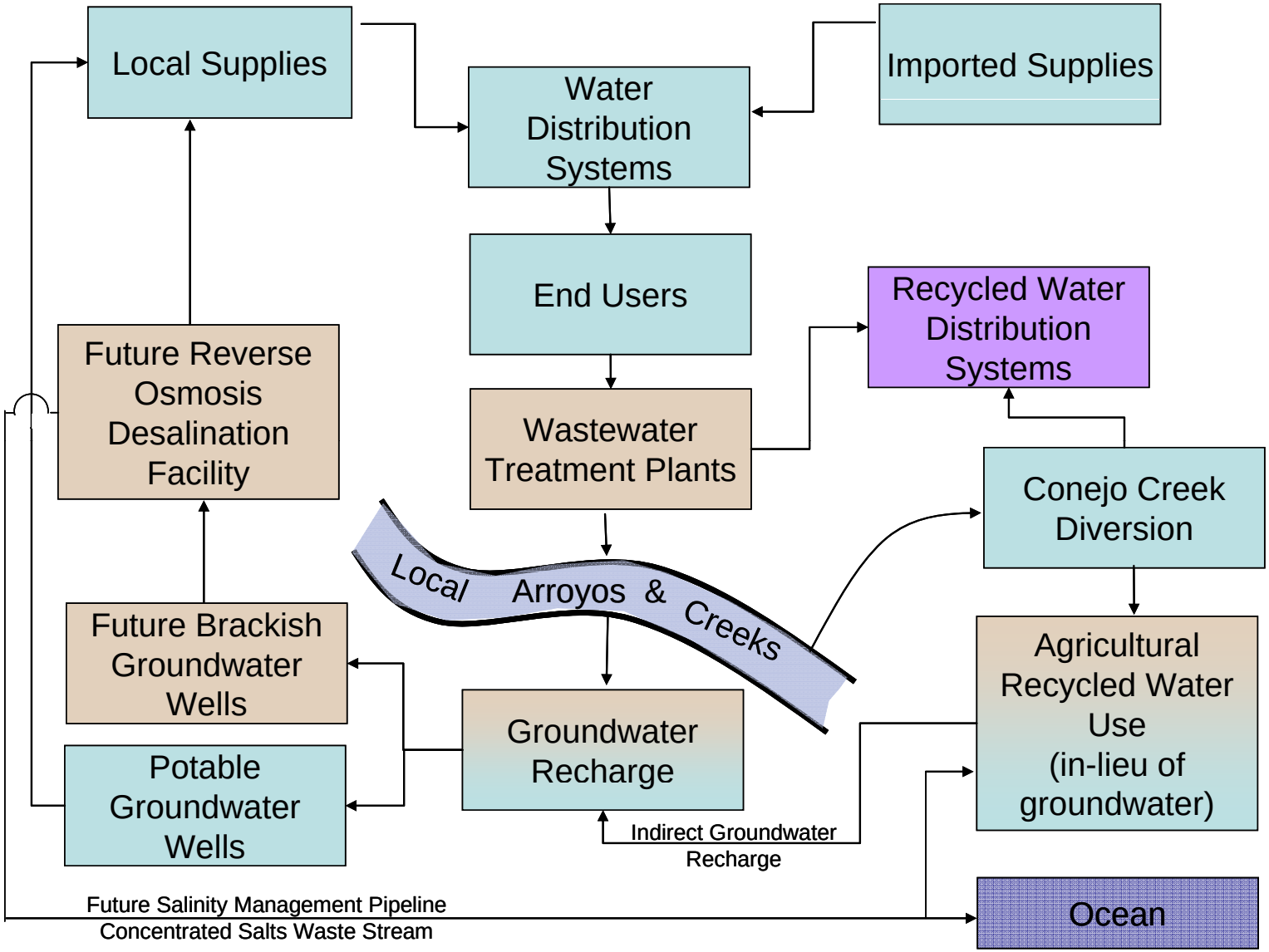

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CMWD 2010 Urban Water Management Plan

Water Cycle for CMWD's Service Area

Figure 2-3

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D. Projected Water Supplies

Water supply projections were developed for both imported water and local supplies. Local supplies include untreated surface water, groundwater and recycled wastewater. Water supply projections were projected for three hydrologic scenarios; average year, dry year, and multiple dry years. The average year is the expected demand under average hydrologic conditions (based on historic average year conditions from 1922 through 2008); the dry year is the expected demand under the single driest hydrologic year (based on conditions experienced in 1977); and the multiple dry year is the expected demand during a period of three consecutive dry years (based on conditions experienced from 1990 through 1992).

1. Imported Supply Projections

MWD utilizes a custom computer program called MWD-MAIN to forecast demand conditions throughout the MWD service area. MWD projects the need for imported supplies as a function of the demand forecasts and local supplies available to its member agencies. Table 2-6 lists the quantity of water that MWD estimates will be available to CMWD during average, dry and multiple dry year scenarios. Potential quantities of reserves are discussed in more detail in Chapter 5.

Table 2-6
MWD's Imported Supply Projections for the CMWD Service Area

Hydrologic Condition	Volume (ac-ft per year)					
	2010	2015	2020	2025	2030	2035
Average Year	118,546	129,004	136,966	140,753	142,365	143,777
Dry Year	121,313	131,876	139,975	143,819	145,534	147,013
Multiple Dry Years	-	131,104	139,985	145,255	148,545	149,548

2. Local Supply Projections

Table 2-7 presents local supply projections estimated by MWD for the CMWD service area. MWD projections are based on computer modeling that considers the reliability of both existing and potential future local supplies. Also, when estimating future local water supplies, MWD considers that not all water

supply projects being considered will become an actual water source and the projections take into account variables such as allocated funding, engineering status, and environmental documentation.

Table 2-7
MWD's Local Supply Projections for the CMWD Service Area [(1),(2)]

Hydrologic Condition	Volume (ac-ft per year)					
	2010	2015	2020	2025	2030	2035
Average Year	50,095	48,640	47,617	47,743	50,256	51,612
Dry Year	49,940	48,457	47,372	47,493	49,973	51,325
Multiple Dry Years	-	49,974	48,649	48,038	48,950	51,093

(1) MWD does not include future local supply projects in their projections until funding allocations, engineering, environmental approvals and permitting requirements are substantially complete.

(2) CMWD local supply projections differ to MWD projections because CMWD purveyors typically include future local supplies in their projections upon completion of feasibility studies.

CMWD also develops local supply projections for its service area. Although MWD and CMWD share information related to existing and future local supply projections, the two projections make different assumptions related to local supply reliability and the likelihood of reality of future supplies. Tables 2-8 through 2-10 list CMWD's local supply projections by source for each hydrologic condition. The CMWD projections are an aggregate of information prepared by CMWD purveyors and consider historic yield of existing local supplies and the anticipated yield of future local supplies.

Table 2-8
CMWD's Local Supply Projections for Average Year Conditions [1]

Source	Volume (ac-ft per year)					
	2010	2015	2020	2025	2030	2035
Potable Groundwater	40,094	33,595	31,365	30,345	31,485	31,495
Desalinated Brackish Groundwater	800	13,499	14,032	14,040	14,048	14,057
Recycled Wastewater [2]	6,947	12,009	17,273	18,457	19,091	19,175
Non-Potable Groundwater	7,068	7,331	7,734	8,132	8,730	9,328
Total	54,909	66,434	70,404	70,974	73,354	74,055

[1] Includes reclaimed wastewater and groundwater pumping associated with the CCDP.

[2] Includes reclaimed wastewater purchased from Triunfo and Simi Valley and delivered for irrigation.

Table 2-9
CMWD's Local Supply Projections for Dry Year Conditions [1]

Source	Volume (ac-ft per year)					
	2010	2015	2020	2025	2030	2035
Potable Groundwater	40,084	33,615	31,385	30,365	31,505	31,515
Recovered Groundwater	800	13,515	14,065	14,090	14,116	14,143
Recycled Wastewater [2]	7,212	12,275	17,531	18,716	19,351	19,437
Non-Potable Groundwater	7,615	7,928	8,530	8,925	9,620	10,215
Total	55,711	67,333	71,511	72,096	74,592	75,310

[1] Includes recycled wastewater and groundwater pumping associated with the CCDP.

[2] Recycled wastewater purchased from Triunfo and Simi Valley and delivered for irrigation.

Table 2-10
CMWD's Local Supply Projections for Multiple Dry Year Conditions [1]

Source	Volume (ac-ft per year)					
	2010	2015	2020	2025	2030	2035
Potable Groundwater	38,974	26,920	25,400	25,660	25,880	25,890
Desalinated Brackish Groundwater	800	13,406	14,098	14,142	14,188	14,237
Recycled Wastewater [2]	7,242	12,305	16,720	17,326	17,411	17,497
Non-Potable Groundwater	7,360	7,670	8,270	8,665	9,355	9,950
Total	54,376	60,301	64,489	65,793	66,834	67,574

[1] Includes recycled wastewater and groundwater pumping associated with the CCDP.

[2] Recycled wastewater purchased from Triunfo and Simi Valley and delivered for irrigation.

CMWD's local supply projections are substantially higher than MWD's. However, both MWD and CWMD project an increase in imported and local supplies through the planning period. The lower local supply projections by MWD are related to MWD's policy not to include future local supply projects until funding allocations, engineering, environmental approvals, and permitting requirements are substantially complete. CMWD purveyors, however, typically include future local supplies in their projections upon completion of feasibility studies.

The following sections provide information on regional and local supply programs.

E. Regional Water Supply Programs

MWD adopted its first Integrated Resources Plan (IRP) in 1996, as a result of the 1987-1992 drought. The 1996 IRP focused on increasing regional supply reliability by implementation of a diverse portfolio of resource investments and conservation measures The 1996 IRP objective was to balance demand management and supply augmentation as well as local resources and imported supplies.

Approximately every five years, MWD updates their IRP, which presents in detail the most recent supply augmentation and demand management programs being considered or implemented by MWD. The most current IRP was published

in the fall of 2010. The 2010 IRP focuses on adaptive management planning recognizing there is significant uncertainty in long-term water supply planning. A summary of MWD's efforts to develop new and alternative regional water supplies is provided below. For more detailed information on MWD water supply planning see the MWD 2010 IRP and MWD 2010 RUWMP.

1. Recycling

MWD and its member agencies are widely recognized as leaders in water recycling. It is estimated that over 1 million ac-ft of recycled water was beneficially used within the MWD service area between 1985 and July 2009. As part of the 2010 IRP efforts, MWD assembled a technical workgroup focused on evaluating the potential for additional recycled water use. Although the workgroup noted several technical, financial, regulatory and public acceptance challenges associated with significant expansions of recycled water programs, numerous concepts to overcome these challenges were also identified. For the 2010 IRP planning period, recycled water supplies are anticipated to increase in the MWD service area from 353,000 to 430,000 ac-ft per year between 2010 and 2035.

2. Seawater Desalination

MWD created the Seawater Desalination Program (SDP) in 2000, which included a target of 150,000 ac-ft per year of seawater desalination by 2020. A technical committee was formed as part of the MWD 2010 IRP to assess the current status of the SDP and refine seawater desalination supply projections. As stated in the 2010 IRP technical issues paper on seawater desalination, four seawater desalination projects are either currently operating pilot studies or under construction of the full scale facilities. At full scale, these four projects could produce between 130,000 and 143,000 ac-ft per year of renewable supplies. Three additional projects that are not part of the SDP but are within the MWD service area are also in various stages of study or permitting.

3. Competitive Local Resources Program

The primary goal of MWD's Competitive Local Resources Program (LRP) is to financially support the development of cost-effective water recycling and groundwater recovery projects that reduce demand for imported supplies. Specifically, for projects that meet the selection criteria, incentives of up to $250

per acre-foot per year are possible for up to 25 years. In 2009, LRP water projects produced about 155,000 ac-ft per year. The MWD 2010 IRP indicates a goal of expanding LRP supplies by an additional 174,000 ac-ft per year by 2025.

4. Surface and Groundwater Storage Programs

Diamond Valley Lake was constructed in 1999 and holds 800,000 ac-ft of water. This water is stored for use during dry year and emergency conditions. In addition, MWD has operational control of approximately 219,000 ac-ft of water in reservoirs at the southern terminals of the California Aqueduct, which provide greater flexibility in handling supply shortages.

MWD also delivers replenishment water to member agencies. The member agency in turn delivers this water in-lieu of utilizing water from local sources. The deferred local production allows water to be left in local storage for future use. MWD also delivers water to spreading sites and injection wells for groundwater replenishment. These programs increase supply availability and improve MWD's operational flexibility, thus allowing it to better manage out-of-region supply and storage programs to meet dry year needs.

MWD has an agreement with CMWD to store up to 210,000 ac-ft of water in the North Las Posas Groundwater Basin for ASR. MWD manages other conjunctive use projects that further increase MWD's supply reliability.

5. Central Valley Transfer and Storage Programs

MWD has several Central Valley Project (CVP) and SWP transfer and storage programs in place or under development. The agencies involved in these programs include (but may not limited to) Semitropic Water Storage District, Arvin-Edison Water Storage District, San Bernardino Valley Municipal Water District, Kern-Delta Water District, and Mojave Storage Program. These programs are expected to provide approximately 396,000 ac-ft of dry-year water supply.

6. Colorado River Aqueduct

MWD is in the planning process or has implemented several programs related to the CRA with the primary objective of having a "full" CRA during dry years. Some of these programs include:

- A conservation agreement between MWD and the Imperial Irrigation District, which guarantees MWD at least 85,000 ac-ft of water per year.

- The Coachella and All-American Canal Lining Projects, which are expected to conserve 26,000 and 67,700 ac-ft of water per year, respectively.

- A 35-year land management, crop rotation, and water supply program with the Palo Verde Irrigation District that is estimated to conserve up to 111,000 ac-ft of water per year, when the program is fully implemented.

- Groundwater storage programs along the CRA that could eventually allow approximately 400,000 ac-ft of CRA water to be stored in adjacent groundwater basins for future withdrawal.

- Collaborative projects with other Colorado River water users such as the Lake Mead Intentionally Created Surplus Storage Program, Drop 2 Storage and Reservoir Project, and the Lower Colorado Supply Project.

7. State Water Project

MWD is committed to restoring traditional supply from the SWP through short, mid, and long-term action plans. A summary of these actions are provided below.

Short-Term Actions

- Secure ESA take authorizations.
- Enhance Delta Smelt habitat.
- Complete the Bay-Delta Conservation Plan (BDCP) Environmental Impact Statement (EIS).
- Restore ecosystems.
- Complete the Two-Gates Project.

Mid-Term Actions

- Implement the BDCP.
- Implement flood control protection.

Long-Term Actions

- Restore ecosystems.
- Implement water supply conveyance improvement projections.
- Develop storage.

Additional information on the status of these actions can be found on MWD and DWR websites.

F. Local Supply Programs

CMWD has focused its planning efforts on using existing supplies more efficiently and maximizing local water resources. Working cooperatively with local agencies, CMWD supports a number of local recycling and groundwater recovery projects to offset increasing imported water demands. The projects described below and summarized in Table 2-11 include a combination of wastewater reclamation, brackish groundwater recovery, and regional salinity management programs. It is important to note that the effect of each of these projects on groundwater resources and environmental compliance must be evaluated and approved before they can be implemented.

Table 2-11
Summary of Future Local Supply Projects [1]

Project	Impact to Supplies	Project Timing
Camarillo Recycled Water	Additional 500 ac-ft per year by 2015	Near-term
Camrosa Water District Recycled Water	Additional 1,020 ac-ft per year by 2015	Near-term
Oxnard GREAT Program	Additional 2,700 ac-ft per year in 2015 increasing to 7,000 ac-ft per year in 2035	Near-term and long-term
VCWWD No. 1 Reclaimed Water Distribution System Expansion	Additional 600 ac-ft per year by 2015	Near-term
Round Mountain Groundwater Desalter	1,000 ac-ft per year	Near-term
Camarillo Groundwater Desalter	7,000 ac-ft per year	Near to mid-term
Moorpark Groundwater Desalter	5,000 ac-ft per year	Mid- to long-term

[1] See MWD RUWMP for summary of future regional supply projects.

1. Regional Recycling Projects

CMWD is working with local agencies to implement various water recycling projects. As discussed previously, recycled wastewater is used for beneficial use applications including agricultural and non-agricultural irrigation, industrial use, and groundwater recharge.

a. Camarillo Recycled Water

A portion of the treated effluent from the Camarillo WRP is pumped to Smith Ranch for irrigation of non-food crops. Approximately 500 ac-ft per year of recycled water are projected to be beneficially used in 2015 and beyond. In addition, the Camarillo Sanitary District has agreements with the Camrosa Water District that allow for delivery of tertiary treated recycled water to Camrosa.

b. Camrosa Water District Recycled Water

The Camrosa Water District is involved in three recycled water projects: the Camrosa WRF, the Camarillo Water Reclamation Plant and the CCDP. The Camrosa WRF treats wastewater to tertiary levels and then distributes it through a recycled water distribution system for use in landscape irrigation. Approximately 980 ac-ft per year of recycled water are projected to be beneficially used from the CWRF in 2010 with that amount increasing to 2,000 ac-ft per year by 2015.

The Camrosa Water District and the Camarillo Sanitary District have entered into an agreement to allow for delivery of tertiary treated wastewater to Camrosa from Camarillo. As previously explained, Camrosa also receives recycled water from the CCDP. When Camrosa cannot use all of the CCDP water, it is delivered to Pleasant Valley County Water District in exchange for groundwater credits. The groundwater is pumped by United Water Conservation District for use by Oxnard and Port Hueneme as a local supply.

c. Lake Sherwood / Oak Park Recycled Water

The Triunfo Sanitation District/Las Virgenes Municipal Water District jointly own and operate the Tapia WRF. Approximately 1,450 ac-ft per year of recycled water produced from this facility is imported into the CMWD service area and distributed to recycled water customers in Lake Sherwood, Oak Park and North Ranch through agreements between CMWD, Triunfo and Las Virgenes.

d. Oxnard GREAT Program

The City of Oxnard is implementing the GREAT Program, which includes an AWPF consisting of reverse osmosis and advanced oxidation. A portion of the flow from the AWPF will be distributed to meet water demands for irrigation and industrial processes. Approximately 2,700 ac-ft per year of recycled water from the GREAT Program is projected to be directly used as recycled water by 2015, with that amount increasing to approximately 7,000 ac-ft per year by 2035.

e. Simi Valley Water Quality Control Plant

The Simi Valley Water Quality Control Plant treats wastewater to tertiary standards. The majority of the water is discharged to the Arroyo Simi, however between 60 and 100 ac-ft per year is used for dust control and irrigation at the Simi Valley landfill. The water discharged to the Arroyo Simi ultimately recharges downstream groundwater basins. Pending regulatory approvals, this water could be available to other downstream CMWD purveyors who could capture the water with groundwater extraction and treatment systems.

f. VCWWD No. 1 Reclaimed Water Distribution System Expansion

The Moorpark WWTP is operated by VCWWD No. 1. Effluent from this facility is treated to secondary standards and discharged to percolation ponds, the Arroyo Las Posas, or treated to tertiary levels and used for reclaimed purposes. Recycled water is currently delivered to the Moorpark Country Club Estate for golf course irrigation and to local agricultural interests. Approximately 500 ac-ft per year of recycled water are projected to be beneficially used in 2010 with that amount increasing to 1,100 ac-ft per year by 2015.

2. Calleguas Salinity Management Pipeline

CMWD, working with other agencies and stakeholders, initiated the Salinity Management Pipeline (SMP). Currently under construction, the SMP consists of a pipeline system to collect treated wastewater and brine concentrates from municipal WWTPs, groundwater treatment facilities (both municipal and agricultural), and industrial operations located within the Calleguas Creek watershed. Water discharged into the SMP will be conveyed to other areas where is can be utilized by agricultural users and possibly for wetland applications. Any remaining water will be discharged into the ocean through an ocean outfall. Operation of the facilities will allow for the use of poor quality

water that was previously underutilized and will substantially reduce the amount of salts released into the watershed. Over time, this will reduce salt concentrations in surface water and groundwater within the watershed.

The alignment of the SMP has been strategically located so that it can receive reverse osmosis concentrate from future brackish groundwater recovery facilities as well as effluent from wastewater treatment facilities. Providing a means for disposal of brine waste from the proposed groundwater recovery facilities allows for increased use of a previously underutilized water supply and could ultimately remove an estimated 42,300 tons per year of salt from the watershed. The following sections provide descriptions of anticipated future brackish groundwater recovery projects.

3. Brackish Groundwater Recovery Projects

Water imported by CMWD and delivered to CMWD purveyors that is not fully consumed is collected in local sanitary systems and treated at the local wastewater treatment facilities listed in Table 2-4. There are numerous locations within the Calleguas Creek watershed where discharged treated wastewater recharges the local groundwater basins. Much of this groundwater has relatively high dissolved solids and chloride concentrations, which requires that the water be treated with reverse osmosis. The primary purpose of the brackish groundwater recovery projects is to recover this groundwater of poor water quality, thereby increasing the availability and reliability of the region's local water supply.

a. Round Mountain Desalter

Groundwater levels in a local perched aquifer near CSUCI, east of the Bailey fault in have been rising for decades and Camrosa Water District plans to construct the Round Mountain Desalter to treat local brackish groundwater using reverse osmosis. Groundwater to be treated at the Round Mountain Desalter will be pumped from an existing well on California State University Channel Islands (CSUCI) property in Camarillo. The Round Mountain Desalter will produce about 1,000 ac-ft per year of potable water.

b. Camarillo Desalter

Similar to the Moorpark Desalter, the Camarillo Desalter would pump and treat brackish groundwater for potable water use and discharge reverse osmosis

concentrate to the SMP. A Pilot Study Report prepared by CDM Consultants dated January 2009 indicates that up to 7,000 ac-ft per year of high quality potable water could be produced at this location on a sustainable basis. Water produced from this facility would be conveyed to nearby City of Camarillo distribution pipelines and also to nearby CMWD transmission pipelines for delivery to other CWMD purveyors.

c. Moorpark Desalter

Groundwater levels in the Moorpark region of the Calleguas Creek watershed have been rising for decades and it is estimated that a brackish groundwater recovery facility at this location could reliably produce up to 5,000 ac-ft per year of high quality potable water. Reverse osmosis concentrate from this proposed desalter would be discharged to the SMP and the potable water produced from this facility would be distributed by VCWWD No. 1.

d. Other Potential Regional Desalters

Other regional desalters are being considered and are in various stages of investigation, including desalters owned and operated by the agricultural community. Because these desalters are in the preliminary stages of investigation, potential local supplies produced from these facilities are not included in the local supply projections. However, as the projects become better defined, supplies from these facilities will be included.

4. Watershed Management Plans

There are numerous on-going efforts to protect and improve the water quality within the Calleguas Creek watershed and enhance local water supplies. Information on water projects under consideration by the region, but not specifically discussed herein, can be found in the following two documents:

- Calleguas Creek Watershed Management Plan, 2004
- Integrated Regional Water Management Plan for the Watershed Coalition of Ventura County, 2006

Projects presented in these two documents may yield new local supplies to CMWD purveyors. As these projects are further advanced, local supply projections within the CMWD service area will be updated appropriately.

Chapter 3
Water Use and Demands

This chapter addresses water use characteristics and projected imported water demands on CMWD. Unless stated otherwise, demands are based on fiscal year (July 1 to June 30) projections.

A. Past Water Use

In 2005, the amount of water imported by CMWD from MWD was 116,432 ac-ft and the amount of local supplies utilized was 39,605 ac-ft. In total, 156,037 ac-ft of water was used in the CMWD service area in 2005, broken down by the following sectors:

- Single family 56.6 percent
- Multi-family 7.9 percent
- Non-residential 27.7 percent
- Unmetered and system losses 7.8 percent

B. Water Use

Figure 3-1 shows the distribution of average water deliveries by CMWD to its purveyors. As illustrated on Figure 3-1, CMWD's largest customer is the City of Simi Valley, which accounts for approximately one-fifth of the water distributed by CMWD.

Water use by sector within CMWD's service area as estimated by MWD is listed in Table 3-1. MWD estimates system losses for CMWD's service area to be around 8 percent. CMWD records indicate losses within its distribution system of 0.34 percent and purveyor data indicate that combined system losses (CMWD and purveyor distribution systems) average 5 percent.

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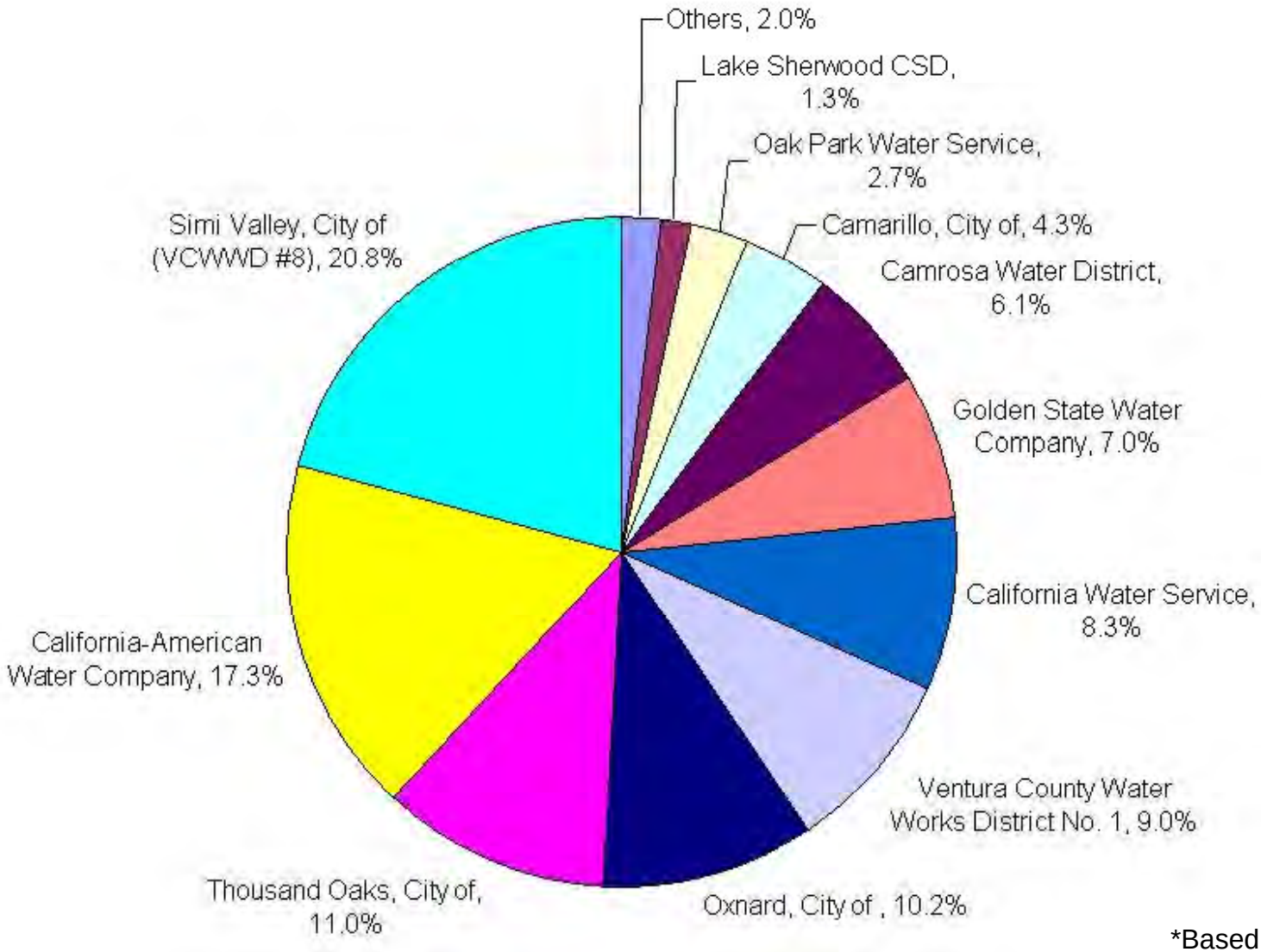

*Based on 2010 Data

CALLEGUAS MUNICIPAL WATER DISTRICT	BLACK & VEATCH building a world of difference™	**CMWD 2010 Urban Water Management Plan**	**Figure 3-1**
		Distribution of CMWD Imported Water Deliveries	

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Table 3-1
CMWD's Water Use by Sector [(1),(2)]

Sector	Percentage					
	2010	2015	2020	2025	2030	2035
Single Family	63	63	62	62	62	62
Multi-Family	8	8	9	9	9	9
Non-Residential	21	21	21	21	21	21
Unmetered and System Losses [(3)]	8 [(4)]	8	8	8	8	8

[(1)] Estimated by MWD.

[(2)] A detailed breakdown of water use by sector is provided in individual purveyor UWMPs.

[(3)] Includes system losses in both CMWD's and its purveyor's systems.

[(4)] CMWD records show the historical average is closer to 5 percent.

Municipal and industrial uses are expected to account for approximately 90 percent of the water distributed by CMWD's purveyors through the planning period. Agricultural uses are expected to account for the remaining 10 percent. These proportions are forecasted to remain constant throughout the planning period.

C. Demand Projections

Similar to the supply projections, water demands for the CMWD service area were projected for three hydrologic scenarios: average year, dry year, and multiple dry years. It is worth noting that actual 2010 conditions did not fall into any of these categories as the weather in Ventura County was cooler than normal. As described below, both MWD and CMWD developed independent demand forecasts for the CMWD service area. MWD utilizes a top-down approach to demand projections based on output from the MWD-MAIN software model. CMWD demand projections are developed using a bottom-up approach based on demand projections developed by each CMWD member purveyor.

1. Total Demand Projections

MWD projections are shown in Table 3-2 and were developed using the MWD-MAIN Water Use Forecasting System. This model incorporates demographic and economic projections from regional planning agencies, and considers conservation and end uses.

Table 3-2
MWD's Total Demand Projections for CMWD's Service Area [1]

Hydrologic Condition	Volume (ac-ft per year)					
	2010 [2]	2015	2020	2025	2030	2035
Average Year	168,641	177,644	184,583	188,496	192,621	195,389
Dry Year	171,253	180,333	187,347	191,312	195,507	198,338
Multiple Dry Year	-	181,078	188,634	193,293	197,495	200,641

[1] Considers demand reductions due to conservation measures put into place through 2008. Does not consider future conservation measures related to SB 7 requirements.

[2] MWD Main demand projections for 2010. Actual water usage was 138,954 ac-ft. Lower usage was due to implementation of the water supply allocation program (which was triggered because of reduced availability of SWP supplies due to ongoing drought conditions) and because the CMWD service area experienced cooler than normal weather in 2010.

A summary of CMWD's demand projections is provided in Table 3-3. These projections are an aggregate of forecasts by individual member purveyors and consider expected population growth, planned land use and water use trends. Individual purveyor projections are listed in Appendix C. Purveyor projections include an allocation for water losses within their respective systems.

Table 3-3
CMWD's Total Demand Projections [1]

Hydrologic Condition	Volume (ac-ft per year)					
	2010 [2]	2015	2020	2025	2030	2035
Average Year	171,776	179,818	188,687	192,121	198,164	202,160
Dry Year	176,548	185,960	194,699	198,843	206,556	211,547
Multiple Dry Years	176,728	185,654	194,330	198,448	205,556	210,205

[1] Considers demand reduction due to conservation measures currently in place. Assumes normal weather conditions and typical supply allocations from MWD.

[2] Actual water usage was 138,954 ac-ft. Lower usage was due to implementation of the water supply allocation program (which was triggered because of reduced availability of SWP supplies due to ongoing drought conditions) and because the CMWD service area experienced cooler than normal weather in 2010.

The projected demands presented in Tables 3-2 and 3-3 consider the on-going and future benefits from water conservation-related programs. CMWD is a member of the California Urban Water Conservation Council (CUWCC) and has been implementing water conservation BMPs since the early 1990s. These BMPs are discussed in more detail in Chapter 4.

As expected, demands increase slightly during drier years. Comparing Tables 3-2 and 3-3, MWD's total demand projections for the CMWD service area are less than CMWD's projections. However, as discussed below, this is offset by the fact that MWD local supply projections for the CMWD service area are also less than CMWD's projections.

2. Imported Demand Projections

Both MWD and CMWD estimated CMWD's imported water demand using the following formula:

CMWD Imported Demand = Total CMWD Demands – Local Supplies

Imported water demands are calculated as the total demands for the CMWD service area less local supplies. Tables 3-4 and 3-5 present MWD's and

CMWD's imported water demand projections for the CMWD service area for average year conditions, respectively.

Table 3-4
MWD's Imported Demand Projections for Average Year Conditions

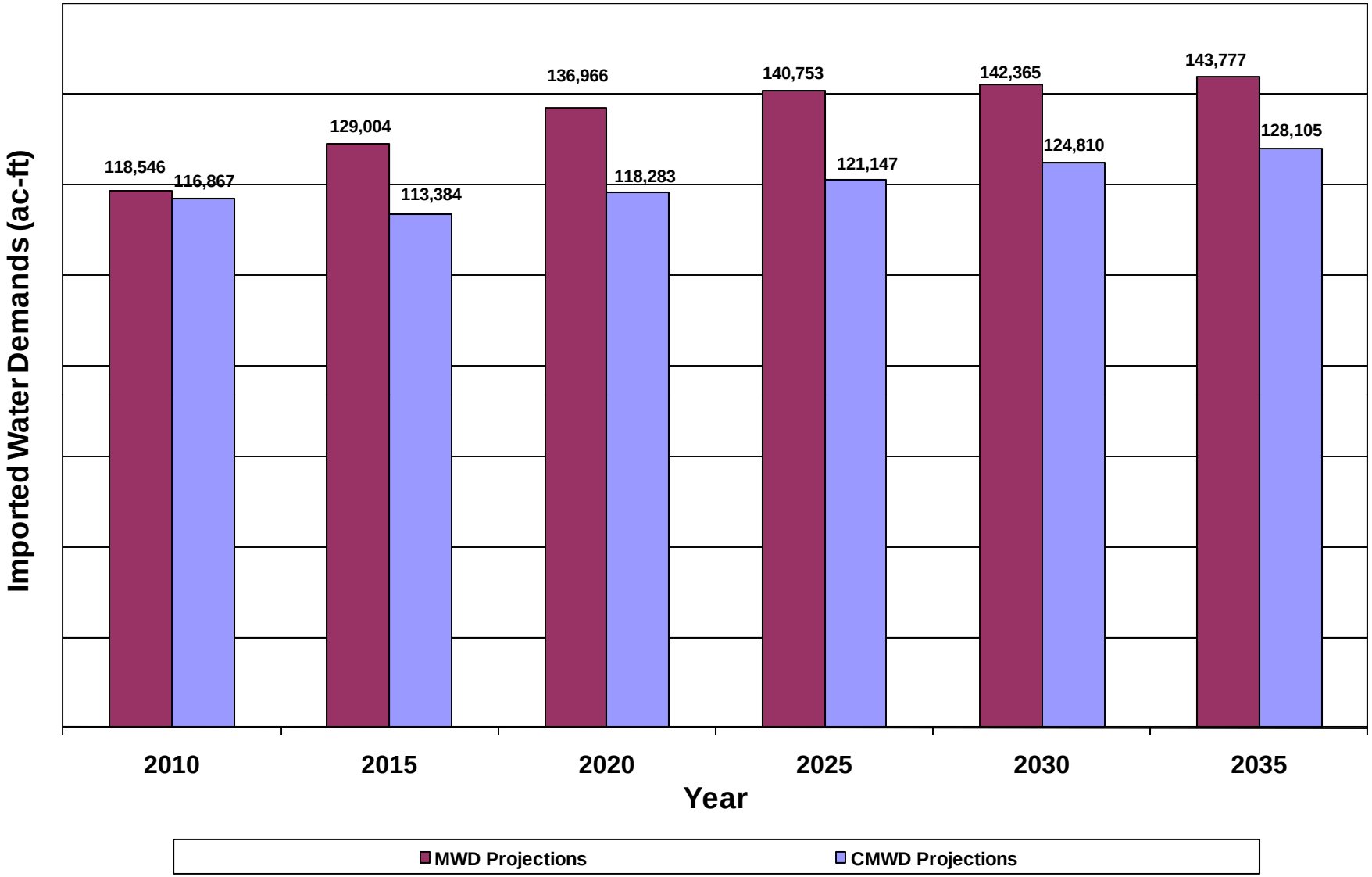
Parameter	Volume (ac-ft per year)					
	2010	2015	2020	2025	2030	2035
Total Demand	168,641	177,644	184,583	188,496	192,621	195,389
Local Supply	50,095	48,640	47,617	47,743	50,256	51,612
Imported Demand	118,546	129,004	136,966	140,753	142,365	143,777

Table 3-5
CMWD's Imported Demand Projections for Average Year Conditions

Parameter	Volume (ac-ft per year)					
	2010	2015	2020	2025	2030	2035
Total Demand	171,776	179,818	188,687	192,121	198,164	202,160
Local Supply	54,909	66,434	70,404	70,974	73,354	74,055
Imported Demand	116,867	113,384	118,283	121,147	124,810	128,105

As shown in Tables 3-4 and 3-5, the higher CMWD demand projections are off-set by greater local supply projections. Therefore, although MWD and CMWD utilize different methods to forecast total demands and local supplies, imported water demands predicted by both agencies are similar. A comparison of imported demand projections is shown graphically on Figure 3-2.

Tables 3-6 through 3-9 show MWD's and CMWD's imported demand projections for single dry and multiple dry year conditions.



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CMWD 2010 Urban Water Management Plan

Imported Water Demand Projections for Average Year Conditions

Figure 3-2

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Table 3-6
MWD's Imported Demand Projections for Dry Year Conditions

Parameter	Volume (ac-ft per year)					
	2010 [1]	2015	2020	2025	2030	2035
Total Demand	171,253	180,333	187,347	191,312	195,507	198,338
Local Supply	49,940	48,457	47,372	47,493	49,973	51,325
Imported Demand	121,313	131,876	139,975	143,819	145,534	147,013

[1] Actual total usage in 2010 was 138,954 ac-ft and actual imported water was 100,769 ac-feet. Lower usage was due to implementation of the water supply allocation program (which was triggered because of reduced availability of SWP supplies due to ongoing drought conditions) and because the CMWD service area experienced cooler than normal weather in 2010.

Table 3-7
CMWD's Imported Demand Projections for Dry Year Conditions

Parameter	Volume (ac-ft per year)					
	2010 [1]	2015	2020	2025	2030	2035
Total Demand	176,548	185,960	194,699	198,843	206,556	211,547
Local Supply	55,711	67,333	71,511	72,096	74,592	75,310
Imported Demand	120,837	118,627	123,188	126,747	131,964	136,237

[1] Actual total usage in 2010 was 138,954 ac-ft and actual imported water was 100,769 ac-feet. Lower usage was due to implementation of the water supply allocation program (which was triggered because of reduced availability of SWP supplies due to ongoing drought conditions) and because the CMWD service area experienced cooler than normal weather in 2010.

Table 3-8
MWD's Imported Demand Projections for Multiple Dry Year Conditions

Parameter	Volume (ac-ft per year)					
	2010	2015	2020	2025	2030	2035
Total Demand	-	181,078	188,634	193,293	197,495	200,641
Local Supply	-	49,974	48,649	48,038	48,950	51,093
Imported Demand	-	131,104	139,985	145,255	148,545	149,548

Table 3-9
CMWD's Imported Demand Projections for Multiple Dry Year Conditions

Parameter	Volume (ac-ft per year)					
	2010	2015	2020	2025	2030	2035
Total Demand	-	185,654	194,330	198,448	205,556	210,205
Local Supply	-	60,301	64,489	65,793	66,834	67,574
Imported Demand	-	125,353	129,841	132,655	138,722	142,631

3. Comparison of Imported Demand Projections

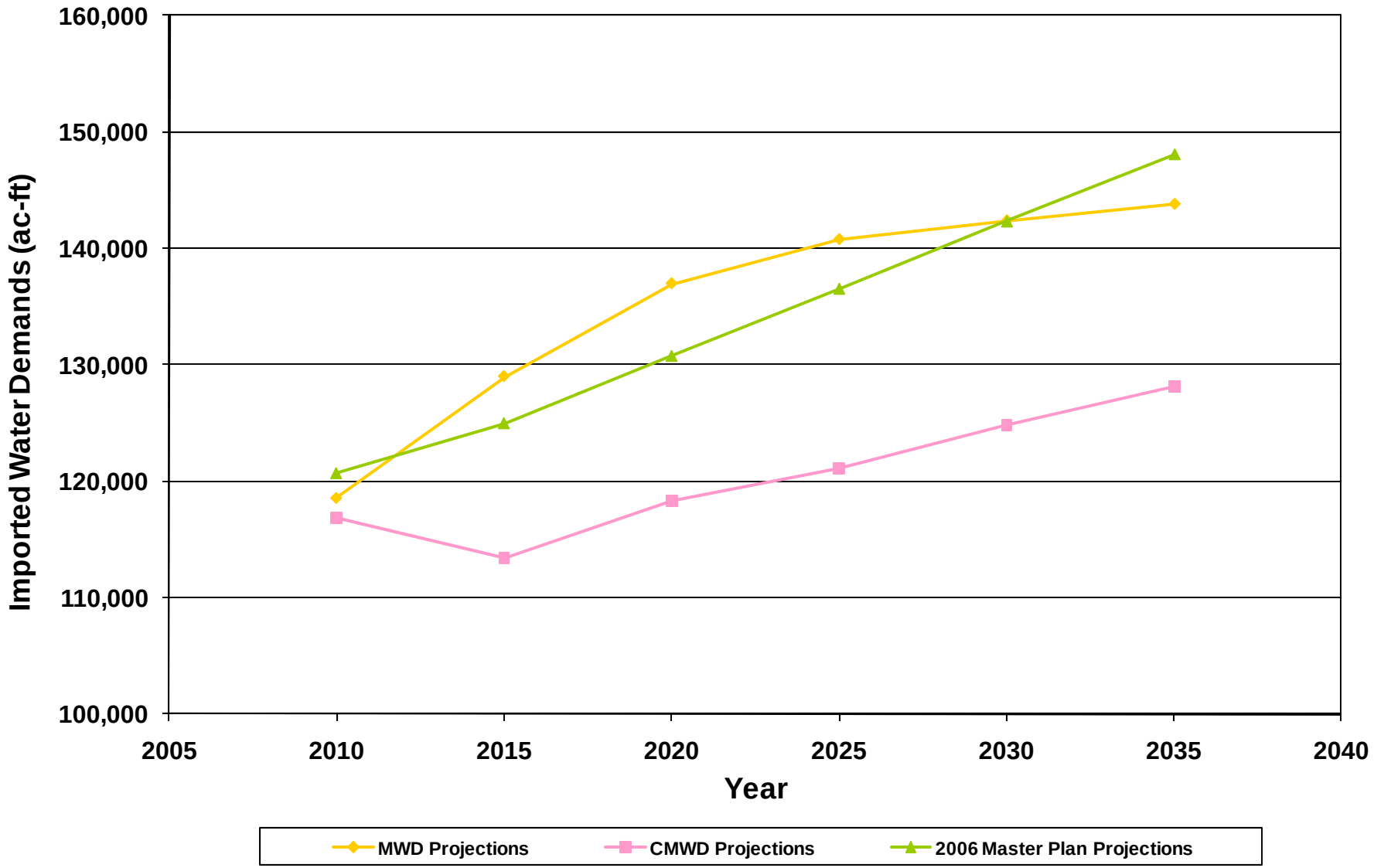
As discussed previously, MWD demand projections are based on its MWD-MAIN model that considers population and employment forecasts plus social and economic data. CMWD demand projections are based on information directly from its member purveyors. Table 3-10 shows how these projections for imported water compare to previous CMWD demand projections as presented in CMWD's 2006 Master Plan. These projections are also shown graphically on Figure 3-3.

Table 3-10
Comparison of Imported Water Demand Projections for Average Year Conditions

Year	MWD	CMWD	2006 Master Plan [(1)]
2010	118,546	116,867	120,723
2015	129,004	113,384	125,014
2020	136,966	118,283	130,783
2025	140,753	121,147	136,552
2030	142,365	124,810	142,321
2035	143,777	128,105	148,090

[(1)] Based on extrapolation.

Both the current MWD and CMWD projections consider the recent economic downturn that has resulted in lower demand projections. However, the MWD projections show a more rapid increase in the need for imported water than



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Comparison of CMWD Imported Water Demand Projections for Average Year Conditions

Figure 3-3

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projected by CMWD. It should be noted that the imported demands calculated by MWD for all hydrologic conditions (average year, single dry year, and multiple dry year) exceed the projected imported water need by CMWD. This provides a small contingency for CMWD as MWD will be prepared to supply slightly more water than what CMWD forecasts will be necessary.

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Chapter 4
Water Demand Management

This section evaluates the current demand management measures that CMWD employs to reduce the demand for imported water.

A. Demand Management Measures

In the early 1990s, the CUWCC developed a Memorandum of Understanding (MOU) to provide guidance for implementing conservation measures as a way to manage water demands. CMWD is a member of the CUWCC and was a signatory of the MOU. The MOU originally included a list of 14 BMPs that define industry standards for implementing demand management measures. Most recently, these BMPs were organized into five categories:

- Utility Operations Foundational BMPs
  - Utility Operations
  - Education

- Programmatic BMPs
  - Residential
  - Commercial, Industrial and Institutional (CII)
  - Landscape

Table 4-1 lists the old BMP names and numbers along with the new BMP category.

Table 4-1
CUWCC Demand Management Program BMP Naming Changes

Old BMP Names and Number	New BMP Category
1. Residential Water Surveys	Programmatic: Residential
2. Residential Plumbing Fixture Retrofits	Programmatic: Residential
3. System Water Audits, Leak Detection, and Repair	Foundational: Utility Operations
4. Metering and Commodity Rates	Foundational: Utility Operations
5. Large Landscape Audits	Programmatic: Landscape
6. High Efficiency Washing Machine Rebates	Programmatic: Residential
7. Public Information Programs	Foundational: Education
8. School Education Programs	Foundational: Education
9. CII Conservation Programs	Programmatic: CII
10. Wholesale Agency Assistance	Foundational: Utility Operations
11. Retail Conservation Pricing	Foundational: Utility Operations
12. Conservation Coordinator	Foundational: Utility Operations
13. Water Waste Prohibition	Foundational: Utility Operations
14. Residential Ultra Low Flush Toilet (ULFT) Replacement	Programmatic: Residential

B. CMWD Conservation Programs

CMWD has worked closely with its purveyors and MWD to implement BMP programs, even though many of the BMPs listed in Table 4-1 are not directly applicable to wholesale agencies. CMWD submits annual reports that summarize the status regarding implementation of BMP measures. Copies of the most recent annual reports submitted to the CUWCC are included in Appendix D and a description of each of CMWD's specific conservation programs is given below.

1. Water Loss Control (Formerly BMP-03)

Every water agency has some degree of water loss, which can include system leaks, unmetered deliveries, or unmetered usage in locations such as water treatment plants. CMWD performs water audits and balances to monitor the amount of unaccounted water use. Average water loss in the CMWD distribution system is consistently less than 1 percent of the total water delivered.

2. Public Information Programs (Formerly BMP-07)

CMWD promotes conservation, education, and public awareness programs through its website, tours, and speaking engagements. In 2008, CMWD increased the public awareness campaign in response to drought conditions. Advertisements were run in newspapers, movie theaters and on a billboard. In addition, as part of water rates paid to MWD, CMWD contributes to a Water Stewardship fund allowing MWD to continue such programs on behalf of their member agencies. Approximately $62,000 was spent on public information efforts in 2008.

3. School Education Programs (Formerly BMP-08)

CMWD has work closely within the state recommended framework to implement a school information program. These programs include free teacher inservice workshops, and tours and classroom presentations for grades kindergarten through 6. The primary focus of the various programs is to educate children on water resource issues including available water sources, water use and conservation. In 2008, CMWD allocated $6,000 for school education programs.

4. Wholesale Agency Assistance Programs (Formerly BMP-10)

CMWD has worked closely with its purveyors and provided financial assistance in the implementation of several BMPs. CMWD sets aside $1 for every acre-foot of water sold, which has resulted in $100,000 to $120,000 per year of funds set aside to support implementation of BMPs. Any unspent monies roll over from year to year to support additional programs. Programs that typically receive such funds include:

- High efficiency washing machine rebates
- Public information programs
- School education programs
- Conservation coordinator programs
- Residential ULFT replacement assistance

5. Conservation Coordinator (Formerly BMP-12)

CMWD has staff designated to the oversight and implementation of the conservation BMPs and the promotion of water conservation.

C. Effectiveness of Conservation Measures

The implementation of cost-effective BMPs provides mechanisms for both active conservation and financial incentives for reducing discretionary consumption. CMWD will continue to work with MWD and regional purveyors to identify new ways to control water consumption in a cost effective manner and will continue to measure and evaluate the effectiveness of the current conservation activities.

Figure 4-1 presents historical water sales by CMWD and shows the effectiveness of the BMPs since they were implemented in the early 1990s. It is important to note that California experienced a severe extended drought from 1987 through 1992. Many water providers were forced to increase their water rates, which resulted in decreased water sales. This impact is illustrated on Figure 4-1 by the significant drop in water sales between 1990 and 1991 and certainly helped contribute to conservation, in addition to the implementation of BMPs.

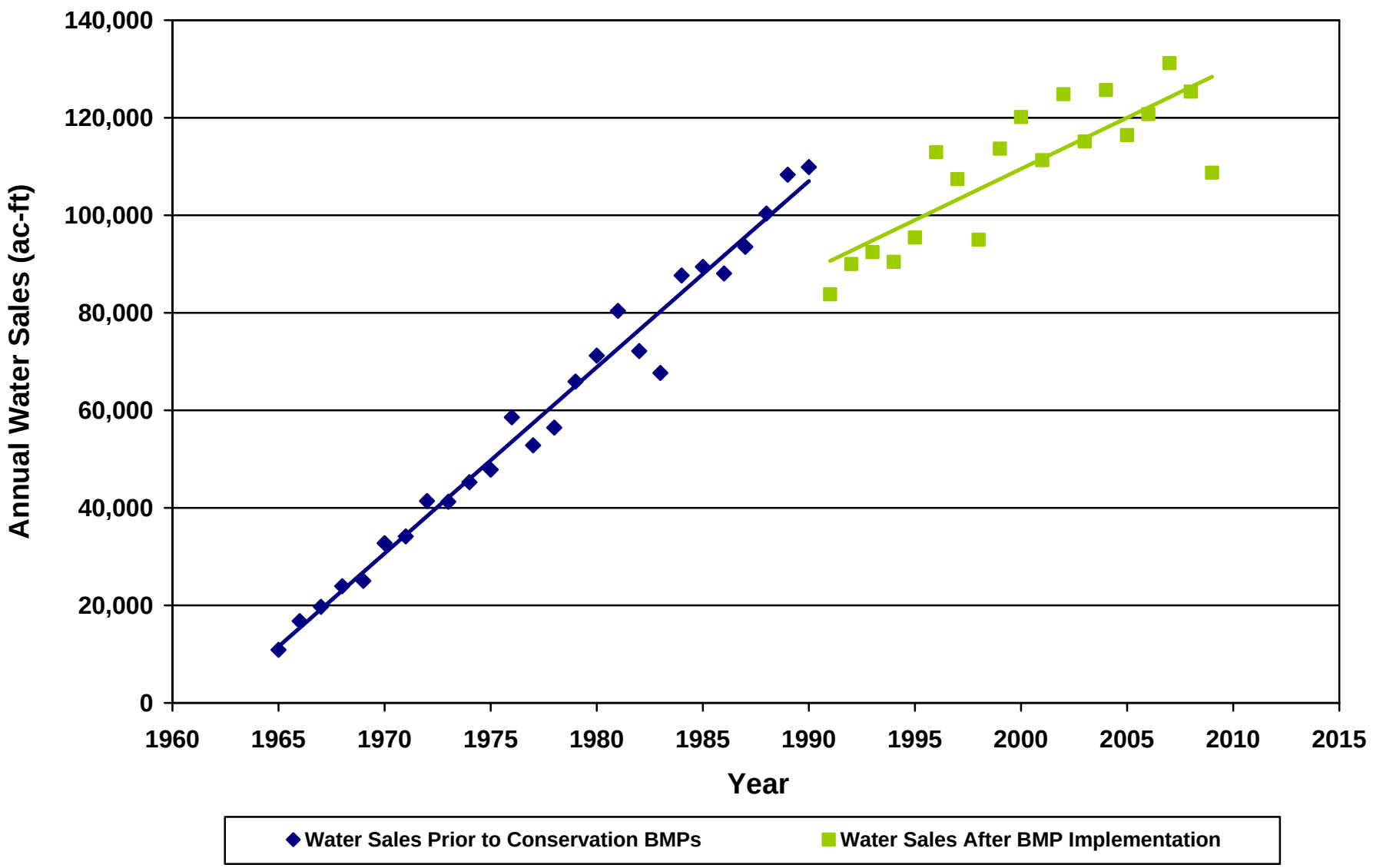
D. Water Reduction Target

As discussed previously, SB 7 requires urban retail water supplies to reduce per capita water use 20 percent by 2020. Retail water providers can choose from four compliance methods, which are summarized as follows:

- **Method 1.** Determine baseline gallon per capita per day (gpcd) water use and reduce that amount by 20 percent. Baseline is defined as the average gross water use divided by the number of people in the service area, for a ten-year period ending no earlier than December 31, 2004. Gross water use is defined as the total volume of water, whether treated or untreated, entering the distribution system of an urban retail water supplier excluding recycled water and water used for agriculture.

- **Method 2.** Achieve all three of the following performance standards: residential indoor water use of no more than 55 gpcd, landscape water use commiserate with DWR's Model Water Efficient Landscape Ordinance, and a 10 percent reduction in baseline commercial, industrial, and institutional water use.

- **Method 3.** Achieve 95 percent of the DWR defined per capita water use target for the applicable hydrologic region. MWD and CMWD service areas are in the South Coast region, which has a baseline



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CMWD 2010 Urban Water Management Plan

CMWD Historical Water Sales

Figure 4-1

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target of 149 gpcd. Therefore, under this method, CMWD would have a 2020 target of 141 gpcd for its service area.

- **Method 4.** The fourth method is not yet adopted by DWR. Preliminary indications are that this method will include an aggregate of unique targets for residential, outdoor, and industrial type use.

In November 2009, MWD prepared a paper titled *Estimating the Water Savings Achieved with 20 percent by 2020 Compliance at the Member Agency Level*. This preliminary assessment estimated a baseline per capita water use for the CMWD service area of roughly 209 gpcd, based on the 10-year period from 1995 to 2005. Using Method 1, the 20 percent reduction target would be approximately 167 gpcd. It is important to note that the purpose of the MWD analysis was to provide a high-level analysis. Compliance estimates were done at the Member Agency level, but the law will be applied at the retail service level. Therefore, actual targets for each CMWD purveyor could vary significantly from the value estimated for CMWD's entire service area.

The reduced per capita target estimated by MWD was compared to CMWD's projected water supplies and uses for 2020. As shown in Table 4-2, a combination of additional recycled water projects or conservation beyond that included in the current projections will be required to meet the 2020 targets. CMWD and MWD intend to provide support for retail agencies efforts through technical assistance and continued financial assistance through the CMWD wholesale agency assistance program.

Table 4-2
High-Level Analysis of 20x2020 Compliance in CMWD Service Area [1]

Compliance Component	Value
2020 Projected Total Water Use	188,687 ac-ft
2020 Projected Agricultural Water Use	21,070 ac-ft
2020 Projected Recycled Water Supply	17,273 ac-ft
2020 Gross Water Use	150,344 ac-ft
2020 Projected Population	682,651
2020 Per Capita Estimate (Method 1)	196 gpcd
2020 Reduction Target (from MWD)	167 gpcd
Additional Reduction Required to Meet 2020 Target	29 gpcd
Additional Reduction of Gross Water Use	14.8%

[1] Analysis performed for CMWD service area. Compliance will be measured at the retail level. Therefore, this analysis provides only a general understanding of the amount of recycled water and conservation projects that may be required in the CMWD service area.

Chapter 5
Reliability Planning

This chapter evaluates the reliability of available supplies to meet demands and discusses MWD and CMWD strategies to maintain reliable water deliveries during single dry year and multiple dry year conditions.

A. Supply versus Demand Evaluation

This section evaluates MWD's and CMWD's reliability to meet demands during each of the hydrologic conditions.

1. Average Year Hydrologic Conditions

As shown in Table 5-1, sufficient supplies are available to meet demands for average year conditions. On average, there is projected to be a water supply surplus of approximately eight percent annually through 2035.

Table 5-1
CMWD Supply versus Demand for Average Year Conditions

Parameter	Volume (ac-ft per year)					
	2010	2015	2020	2025	2030	2035
Average Year Demand	171,776	179,818	188,687	192,121	198,164	202,160
Average Year Local Supply	54,909	66,434	70,404	70,974	73,354	74,055
Imported Demand on MWD	116,867	113,384	118,283	121,147	124,810	128,105
MWD Available Supplies	118,546	129,004	136,966	140,753	142,365	143,777
Surplus/Deficit	1%	14%	16%	16%	14%	12%

2. Single Dry Year Hydrologic Conditions

As shown in Table 5-2, the estimated allocation of water from MWD during a dry year is sufficient to meet the CMWD's projected dry year imported water demands from 2015 through 2035.

Table 5-2
CMWD Supply versus Demand for Dry Year Conditions

Parameter	Volume (ac-ft per year)					
	2010	2015	2020	2025	2030	2035
Dry Year Demand	176,548	185,960	194,699	198,843	206,556	211,547
Dry Year Local Supply	55,711	67,333	71,511	72,096	74,592	75,310
Imported Demand on MWD	120,837	118,627	123,188	126,747	131,964	136,237
MWD Dry Year Allocation	112,042 (1)	131,876	139,975	143,819	145,534	147,013
Surplus/Deficit	-7% (2)	11%	14%	13%	10%	8%

(1) MWD's projected 2010 dry-year allocation for CMWD in a non-shortage condition was 121,313 ac-ft. Actual allocation for 2010 was 112,042 ac-ft due to ongoing drought conditions and Bay-Delta issues.

(2) Demand management measures and cooler than normal weather helped CMWD purveyors accommodate the reduced MWD allocation.

For perspective, CMWD purveyors purchased 125,300 ac-ft of water from CMWD in 2008, 108,720 ac-ft in 2009, and 100,769 ac-ft in 2010. The reduction in 2009 and 2010 was due to implementation of both voluntary and mandatory restrictions imposed on the region due to ongoing drought conditions and reductions in available supplies from the Bay-Delta. Demand management measures and cooler than normal weather helped CMWD purveyors accommodate the reduced MWD allocation in 2010.

Values presented in Table 5-2 for future years take into account the Bay-Delta Conservation Plan, which is anticipated to relieve several of the current Bay-Delta constraints. However, it is anticipated that restrictions will remain in place as long as the drought persists and as a result, a supply deficit of between 5 and 10 percent could occur in the near term.

Chapter 6 provides additional details on how CMWD's water shortage contingency plans can be implemented to provide flexibility in meeting potential short-term supply shortfalls.

3. Multiple Dry Year Hydrologic Conditions

Table 5-3 shows the water supply versus demand evaluation under multiple dry year hydrologic conditions. Sufficient imported water is projected to be available for the years 2015 through 2035.

Table 5-3
CMWD Supply versus Demand for Multiple Dry Year Conditions

Parameter	Volume (ac-ft per year)					
	2010	2015	2020	2025	2030	2035
Multiple Dry Year Demand	176,728	185,654	194,330	198,448	205,556	210,205
Multiple Dry Year Local Supply	54,376	60,301	64,489	65,793	66,834	67,574
Imported Demand on MWD	122,352	125,353	129,841	132,655	138,722	142,631
MWD Available Supplies (1)	-	131,104	139,985	145,255	148,545	149,548
Surplus/Deficit	-	5%	8%	9%	7%	5%

(1) MWD does not project multiple dry year supplies for the current year. For 2010 conditions, refer to the single dry year supply versus demand analysis.

B. Supply Reliability Strategies

This section discusses water supply reliability strategies being implemented by DWR, MWD and CMWD. As a result of investments made in conservation, water recycling, transfer agreements, storage, and supply, MWD expects to be able to meet forecasted CMWD demands. Therefore, CMWD also expects to be able to meet the forecasted purveyor demands.

1. DWR Strategies

Water for Southern California is pumped from the Bay-Delta into the SWP system. This pumping can create conflicts with natural flow patterns that stress the native habitat. In response to this stress, DWR has curtailed pumping from the Bay-Delta until some of these issues can be resolved. In addition to habitat concerns, the Bay-Delta relies on hundreds of miles of levees to separate seawater from the fresh water in the Bay-Delta. Levee assessments have shown that the levees are vulnerable to failure due to a seismic event.

To address these and other related issues, DWR and the U.S. Bureau of Reclamation, in collaboration with California water agencies, environmental organizations, and the California Farm Bureau began work on the Bay-Delta Conservation Plan (BDCP) in 2006. The primary objective of the BDCP is to restore the Bay-Delta in a manner that results in both a more resilient ecosystem and more reliable water supplies. Alternatives for resolving the Bay-Delta issues have been identified and these alternatives are currently being evaluated as part of an environmental impact report (EIR) / environmental impact statement (EIS).

As of December 2010, the Draft EIR/EIS is anticipated to be available for public review by mid-2011. The final decision (Record of Decision) on the alternative(s) to be used in the Bay-Delta is expected late 2012 to mid-2013. Once a record of decision has been issued, final permits must be secured before construction of the required facilities can proceed. Upon completion of these facilities, diversions from the Bay-Delta are anticipated to return to more historic and reliable levels. Additional information on Bay-Delta issues and the status of the BDCP can be found on the DWR website.

2. MWD Strategies

MWD is implementing transfer agreements and storage strategies to increase the reliability of both SWP and Colorado River supplies. In addition to utilizing Diamond Valley Lake and shared portions of Lake Perris and Castaic Lake, MWD plans to develop off-stream storage facilities along the SWP California Aqueduct and the CRA. More detail on all of MWD's strategies for providing water supply reliability can be found in MWD's 2010 RUWMP.

3. CMWD Strategies

CMWD operates several facilities that increase the reliability of the CMWD's supply to its purveyors. These facilities are discussed below.

a. CMWD Stored Groundwater

As shown on Figure 2-1, CMWD has stored a significant amount of water under FCGMA-approved storage programs in groundwater basins throughout the CMWD service area. This water can be extracted during times when imported supplies are curtailed.

b. Lake Bard and Lake Bard Water Treatment Plant

Lake Bard is located in the center of the CMWD service area and can store approximately 8,000 ac-ft of water. CMWD operates the Lake Bard WTP, which is adjacent to the lake and has a treatment capacity of 100 cfs. Supplies stored in Lake Bard can be used during times when imported supplies are curtailed.

c. Salinity Management Project

As described in Chapter 2, the SMP will facilitate treatment of local groundwater that is currently too saline for potable use. These desalters will improve overall regional supply reliability.

d. Transfer Opportunities

Water transfer agreements between agricultural and municipal water users are another method for increasing supply reliability. As a member agency to MWD, CMWD benefits from transfer agreements made through MWD. Therefore, CMWD does not currently pursue independent transfer agreements.

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Chapter 6
Contingency Planning

CMWD has developed water shortage contingency plans in the event that MWD significantly reduces deliveries to its member agencies due to severe water shortage conditions or in the event that a catastrophe interrupts water deliveries. This chapter summarizes CMWD's water shortage contingency measures.

A. Severe Drought Planning

In 1999, MWD developed a Water Surplus and Drought Management Plan (WSDM Plan) that included guidelines for implementing water supply restrictions in the event of a water shortage. The WSDM Plan does not outline specific criteria for how water would be distributed among the MWD member agencies during water shortage conditions, but states that the methods to be used for determining reduction in supplies to each member agency would be developed in a manner that was equitable and minimized hardship to retail water customers.

In 2007, MWD began to update their plans for addressing water shortage conditions. The impetus for this was a combination of on-going dry conditions and reduced deliveries from the SWP. In February 2008, the MWD Board adopted the Water Supply Allocation Plan. This plan is an extension of the WSDM Plan and includes specific formula for allocating available supplies among MWD member agencies. Table 6-1 summarizes the surplus and shortage actions to be taken by MWD as defined in the WSDM Plan. As shown, water shortage stage 7 is where the Water Supply Allocation Plan is implemented. In April 2009 and again in April 2010, MWD concluded that water shortage stage 7 conditions existed and the Water Supply Allocation Plan was implemented, resulting in reduced deliveries to all MWD member agencies.

Table 6-1
MWD Resource Conditions and Action Stages

Resource Stage	Action
Surplus 5	Make cyclic deliveries.
Surplus 4	Fill central valley groundwater basins.
Surplus 3	Store supplies in SWP carryover.
Surplus 2	Fill conjunctive use basins.
Surplus 1	Fill DWR and Diamond Valley Reservoirs.
Supplies = Demands	Conduct public affairs program.
Shortage 1	Utilize Diamond Valley Reservoir.
Shortage 2	Utilize central valley groundwater storage.
Shortage 3	Interrupt long-term seasonal and replenishment deliveries.
Shortage 4	Take from conjunctive use and DWR storage.
Shortage 5	Call for extraordinary conservation / reduce Interim Agricultural Water Program (IAWP) deliveries.
Shortage 6	Call options contracts / buy spot water.
Shortage 7	Implement Water Supply Allocation Plan.

1. CMWD Water Shortage Stages of Action

Table 6-2 presents water management actions that could be implemented by CMWD during both surplus and shortage conditions. CMWD's surplus and shortage stages of actions are intended to be consistent with the stages defined in MWD's WSDM Plan. It is important to note that the CMWD system is complex and the ultimate actions taken by CMWD will depend on the unique issues of each particular condition.

In addition, CMWD's Ordinance No. 12 gives the Board of Directors authority to take actions necessary to manage available supplies, including passing through to member agencies allocations and penalties for exceeding allocated deliveries.

Table 6-2
CMWD Water Shortage Stages of Action Guidelines

Resource Stage	Actions [1]
Surplus	Store water in groundwater basins throughout CMWD service area.
Supply = Demand	No actions required.[2]
Stage 1 Shortage	Call on purveyors to maximize local supplies, promote voluntary conservation.
Stage 2 Shortage	Begin withdrawals from CMWD stored groundwater.
Stage 3 Shortage	Call for extraordinary conservation efforts.
Stage 4 Shortage	Implement allocation program.[3]

[1] Actions are additive as shortage conditions progress.

[2] Deliveries will consist of purveyor demands and filling of Lake Bard.

[3] CMWD will monitor consumption and asses penalties for excessive use.

2. Three-Year Minimum Supply Evaluation

The UWMP Act requires that the minimum water supply be quantified based on the driest three-year historic sequence for each of the five year planning increments. The following tables evaluate the reliability of CMWD to meet demands assuming a linear increase between the two five year planning increments, linear increase in supply from MWD and no increase in local supplies. As shown on Tables 6-3 through 6-7, CMWD has developed water supply strategies to meet potential future multiple dry year events.

Table 6-3 presents a three year minimum supply versus demand analysis for years 2010 through 2015. For comparative purposes, the 2010 average year supply and demand balance is also shown. An average shortfall of 10 percent is shown for 2011 through 2013. If this shortfall were to become a reality, CMWD could supplement with groundwater reserves and Lake Bard reserves, as well as implement short-term conservation measures.

Table 6-3
Estimated Three-Year Minimum Supply (2010 – 2015)

Parameter	Volume (ac-ft per year)			
	2010 Average Year	2011 Multiple-Dry Year	2012 Multiple Dry Year	2013 Multiple-Dry Year
MWD Imported Supplies [1]	118,546	108,700	108,700	108,700
CMWD Local Supplies [2]	54,909	54,376	54,376	54,376
Total Supplies to CMWD	173,455	163,076	163,076	163,076
Total Demand	171,776	178,513	180,298	182,084
Surplus/Deficit	1%	-9%	-10%	-10%

[1] Assumes that Bay-Delta issues and current drought persists through 2013, resulting in similar MWD import allocations as those in 2009.

[2] Assumes no new local supply projects are brought online between 2011 and 2013.

Table 6-4 presents a three-year supply and demand analysis for 2015 through 2020. For comparative purposes, the 2015 average year supply and demand balance is also shown. As shown, the system is more reliable in this timeframe as compared to the 2010 through 2015 analysis. Available supplies are projected to exceed demands for all conditions

Table 6-4
Estimated Three-Year Minimum Supply (2015 – 2020)

Parameter	Volume (ac-ft per year)			
	2015 Average Year	2016 Multiple Dry Year	2017 Multiple Dry Year	2018 Multiple Dry Year
MWD Imported Supplies [1]	129,004	132,880	134,656	136,433
CMWD Local Supplies [2]	66,434	60,301	60,301	60,301
Total Supplies to CMWD	195,438	193,181	194,957	196,734
Total Demand	179,818	187,389	189,125	190,860
Surplus/Deficit	9%	3%	3%	3%

[1] Linearly interpolated from 2015 and 2020 data set.

[2] Assumes no new local supply projects are brought online between 2016 and 2018.

Tables 6-5 through 6-7 show similar evaluations for the multiple dry year scenario for 2020 through 2025, 2025 through 2030, and 2030 through 2035. As shown on these tables, available supplies are projected to exceed demands for all conditions.

Table 6-5
Estimated Three-Year Minimum Supply (2020 – 2025)

Parameter	Volume (ac-ft per year)			
	2020 Average Year	2021 Multiple Dry Year	2022 Multiple-Dry Year	2023 Multiple-Dry Year
MWD Imported Supplies [1]	136,966	141,039	142,093	143,147
CMWD Local Supplies [2]	70,404	64,489	64,489	64,489
Total Supplies to CMWD	207,370	205,528	206,582	207,636
Total Demand	188,687	195,154	195,977	196,801
Surplus/Deficit	10%	5%	5%	6%

[1] Linearly interpolated from 2020 and 2025 data set.

[2] Assumes no new local supply projects are brought online between 2021 and 2023.

Table 6-6
Estimated Three-Year Minimum Supply (2025 – 2030)

Parameter	Volume (ac-ft per year)			
	2025 Average Year	2026 Multiple Dry Year	2027 Multiple Dry Year	2028 Multiple Dry Year
MWD Imported Supplies [1]	140,753	145,913	146,571	147,229
CMWD Local Supplies [2]	70,974	65,793	65,793	65,793
Total Supplies to CMWD	211,727	211,706	212,364	213,022
Total Demand	192,121	199,869	201,291	202,712
Surplus/Deficit	10%	6%	6%	5%

[1] Linearly interpolated from 2025 and 2030 data set.

[2] Assumes no new local supply projects are brought online between 2026 and 2028.

Table 6-7
Estimated Three-Year Minimum Supply (2030 – 2035)

Parameter	Volume (ac-ft per year)			
	2030 Average Year	2031 Multiple Dry Year	2032 Multiple Dry Year	2033 Multiple Dry Year
MWD Imported Supplies [1]	142,365	148,746	148,946	149,147
CMWD Local Supplies [2]	73,354	66,834	66,834	66,834
Total Supplies to CMWD	215,719	215,580	215,780	215,981
Total Demand	198,164	206,485	207,415	208,345
Surplus/Deficit	9%	4%	4%	4%

[1] Linearly interpolated from 2030 and 2035 data set.

[2] Assumes no new local supply projects are brought online between 2031 and 2033.

B. Catastrophe Planning

Although MWD's and CMWD's water delivery systems are robust, these systems are still vulnerable. A natural event, such as an earthquake, could cause the complete and sudden failure of the facilities used by MWD to import water into the region. Similarly, the facilities used to import water from MWD to the CMWD service area are susceptible to these same threats.

1. MWD Catastrophe Plan

The majority of Southern California's water is imported via three facilities, the California Aqueduct, Los Angeles Aqueduct, and the CRA. All three sources cross the San Andreas Fault. A catastrophic event that resulted in an unplanned interruption in supply from any of these facilities would have a significant impact on the ability to supply water. Consequently, MWD has invested heavily in emergency storage facilities located both in and out of the region. MWD anticipates that approximately 75 percent of average year demands could be delivered to its member agencies even if there was a disruption of service from one of these facilities.

2. CMWD Catastrophe Strategies

CMWD is one of only a few MWD member agencies with only one connection for receiving imported supplies. In the event that service from this supply is disrupted, CMWD would be required to meet purveyor demands from water stored in Lake Bard and the local groundwater basins. Providing CMWD with a second water source was one of the primary reasons for development of the Las Posas groundwater basin.

Lake Bard has a total storage capacity of 10,000 ac-ft; however, only 8,000 ac-ft are quantified as usable storage. The Lake Bard WTP extracts water stored in Lake Bard and can produce 100 cfs of potable water for a short period of time. Additionally, CMWD has accumulated on the order of 60,000 acre feet of groundwater storage credits under FCGMA-approved programs in basins within the CMWD service area. It should also be noted that CMWD can receive emergency supplies from the Los Angeles Department of Water and Power if there is a disruption in service from the MWD operated Jensen WTP.

Utilizing a combination of Lake Bard and CMWD stored groundwater, CMWD can endure an extended disruption in service from MWD. Table 6-8

shows example strategies for meeting 2015 water demands during conditions of reduced deliveries from MWD.

Table 6-8
Strategies for Meeting 2015 Average Year Demands
During Interruptions of MWD Deliveries

Source of Supply	Short-Term MWD Interruption [1] (cfs)	Long-Term MWD Interruption [2] (ac-ft per year)
MWD	0	0
Lake Bard [3]	100	8,000
CMWD Stored Groundwater [4]	60	60,000
Additional Local Supply [5]	0	10,860
Total	160	78,860
Imported Demand	160	113,384
Conservation Required	0%	30%

[1] Defined as an interruption of less than 30 days.

[2] Defined as an interruption of 12 months.

[3] Lake Bard facilities can supply 100 cfs for between 10 and 35 days, depending on initial lake levels.

[4] Approximate amount of CMWD's accumulated groundwater storage credits under FCGMA-approved programs.

[5] During an extended MWD outage, CMWD would request local purveyors to maximize local supplies

3. CMWD Emergency Pipeline Repair Protocol

The CMWD distribution system has proven highly reliable for over 40 years. However, its potential vulnerability was demonstrated by the 1994 Northridge Earthquake, which resulted in numerous pipeline separations and cracked joints, and again in 1997 by an intense pressure surge that lead to the rupture of a 20 linear-foot section of a 66-inch diameter pre-stressed concrete pipe in Simi Valley.

Recognizing the inherent vulnerability of water transmission systems, the CMWD Board of Directors adopted an Emergency Pipeline Repair Protocol in

1998. The intent of this protocol is to establish a state of preparedness and an organized, planned procedure to mobilize and begin work.

The plan facilitates timely emergency response and assures that repairs will be performed in the most efficient manner. Large diameter pipeline failures, if not addressed promptly and properly, can inconvenience thousands of customers and cause considerable property damage. Facility failures may be caused by construction activity, earthquakes, power failures, or other conditions such as pressure surges (i.e., water hammer). While failures can be expected, their locations are unknown until they occur, which dictates that a repair protocol be applicable to a broad range of situations and locations. Furthermore, the more quickly the failure can be repaired, the less likely it will cause debilitating damage or service outages.

In preparing the protocol, CMWD identified factors that could enhance the efficiency with which emergency repairs are performed, and developed specific actions to improve emergency repair procedures. In an effort to learn from the experiences of others in the water industry, meetings and discussions were held with pipeline suppliers and other vendors as well as with other large water providers including MWD and the San Diego County Water Authority.

The findings indicated that the key to efficient repair procedures is a structured approach, in which specific procedures, responsible personnel and necessary equipment are identified and secured ahead of time. With this in mind, CMWD developed a protocol that includes a step-by-step procedure for responding to an emergency. The key elements of the protocol are:

- Establishment of an emergency repair organizational structure.
- Redevelopment of a spare pipe and fittings inventory and management of inventory records.
- Identification of emergency contacts.
- Damage assessment.
- Comprehensive repair drawings, specifications, and procedures for various facility types.
- Ongoing maintenance of the protocol.

Rapid mobilization of repair crews is dependent upon having equipment and replacement pipe and appurtenances at the ready. CMWD's plan contains recommendations for the stockpiling of a total of seven sizes of replacement pipe, in diameters ranging from 24 to 78 inches. This pipe has been purchased and is stored at CMWD's Lake Bard and well field properties. Having this inventory available gives CMWD the ability to quickly repair up to 98 percent of the pipelines in its distribution system in a timely manner.

C. Water Quality Contingency Planning

Changes in drinking water regulations, environmental litigation, or identification of a new contaminant could result in the loss of an existing water supply source. This section discusses how water quality concerns could impact the reliability of the regional water systems.

1. MWD Water Quality Contingency Planning

To reduce the potential impact from a decrease in water supply due to water quality, MWD has instituted a 10 percent planning buffer requirement. This buffer requires the identification of contingency supplies equal to 10 percent above that needed to meet 2025 demands. These supplies allow for a more speedy response and are to be used only if existing supplies become unavailable.

2. CMWD Water Quality Contingency Planning

CMWD manages two major local storage facilities, Lake Bard and the Las Posas ASR Facilities. Lake Bard is relatively small and is primarily intended to provide operational flexibility to CMWD rather than to serve as a consistent water supply. Contamination of the lake is an unlikely event as the lake and its watershed are owned by CMWD and access is restricted. However, if the lake was deemed unusable due to water quality, only approximately 5 percent of CMWD's total annual demands would be affected. It is anticipated that this lost supply could be supplemented with additional imported water from MWD or by extracting water from CMWD stored groundwater.

Stored groundwater is also an important part of CMWD's water resource mix and potential water quality related issues with groundwater would have an impact on the ability to meet demands.

If a water quality issue occurred in the Las Posas or other local basins, it would likely be resolved with treatment upon extraction. In the event that the existing treatment facilities were not capable of removing the contaminant, CMWD would rely on MWD to deliver additional imported water until the facilities could be upgraded to remove the contaminant.

D. Provisions to Reduce Water Consumption

Under the most severe drought conditions and under almost any catastrophe condition, CMWD may call for mandatory reduction in water consumption. This section presents guidelines to reduce water consumption and identifies measures that could be utilized by CMWD to monitor and enforce reduced water consumption.

1. Guidelines for Meeting Reduced Consumption Mandates

In the event that a mandatory reduction in water consumption is required, one or all the following guidelines can be implemented to meet the water consumption goals:

- Disallow non-essential irrigation and limit water use for essential irrigation.
- Restrict irrigation to evening and early morning hours.
- Restrict or disallow the use of sprinklers during all hours.
- Limit or disallow the use of potable water for golf course and park irrigation.
- Disallow the use of water to fill ornamental lakes, ponds, pools, and fountains.
- Limit or disallow the washing of vehicles.
- Disallow the spraying of outdoor paved surfaces and using potable water for street cleaning.
- Request that restaurants not serve water to customers unless specifically requested.
- Restrict the use of water from fire hydrants for construction purposes.

- Develop a rate structure for charges and penalties for water use restriction violations.

2. Monitoring and Enforcing Reduced Consumption Mandates

California Water Code Section 10632-f allows urban water suppliers to charge penalties for excessive water use in order to encourage consumption reduction during a water shortage. Under the current Water Shortage Allocation Plan adopted by MWD, any time a member agency takes 102 percent of their reduced allotment under a declared Stage 7 shortage condition, they will be assessed a surcharge equal to three times the MWD full service rate. To meet MWD reduced allotments during water shortages, CMWD may be required to reduce allotments in-kind.

CMWD can monitor daily water consumption and issue penalties for excessive use during declared shortage conditions using existing water metering facilities. Additionally, CMWD is currently in the design phase of the Turnout Automation Project. When complete, the system will provide monitoring of flow conditions at all turnouts and will provide real time flow data to both CMWD and its purveyors. The Turnout Automation Project will assist in more efficient operations during both water shortage conditions and normal operating conditions.

3. Fiscal Impacts from Reduced Water Deliveries

During periods of reduced consumption, revenue from water sales will decline while expenses remain relatively constant. A natural disaster may also entail unpredicted expenditures for repairs. Therefore, it is imperative that CMWD have adequate reserves to cover operating and emergency repair expenses during these periods. Historically CMWD has budgeted conservatively and in so doing, it has built up substantial reserves. CMWD can operate several months without revenue from water sales while at the same time paying for significant repairs to its system due to an unexpected event. If periods of reduced consumption are prolonged, CMWD may be required to adjust rates to remain financially stable.

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Appendix A
UWMP Checklist

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Urban Water Management Plan Checklist				
No.	**UWMP Requirement**	**California Water Code Reference**	**UWMP Location**	**Additional Comments**
1	Provide baseline daily per capita water use, urban water use target, interim urban water use target, and compliance daily per capita water use, along with the bases for determining those estimates, including references to supporting data.	10608.20(e)	Chapter 4,	Section D Baseline Usage – Section D Target Usage – Table 4-2
2	Include an assessment of present and proposed future measures, programs, and policies to help achieve the water use reductions.	10608.36	Chapter 4	Section B CMWD is a wholesale water supplier. Refer to purveyor UWMPs.
3	Report progress in meeting urban water use targets using the standardized form.	10608.4	Not applicable	CMWD is a wholesale water supplier. Refer to purveyor UWMPs.
4	Each urban water supplier shall coordinate the preparation of its plan with other appropriate agencies in the area, including other water suppliers that share a common source, water management agencies, and relevant public agencies, to the extent practicable.	10620(d)(2)	Chapter 1	Table 1-1
5	An urban water supplier shall describe in the plan water management tools and options used by that entity that will maximize resources and minimize the need to import water from other regions.	10620(f)	Chapter 2	Sections B.2, D.2, E and F
6	Every urban water supplier required to prepare a plan pursuant to this part shall, at least 60 days prior to the public hearing on the plan required by Section 10642, notify any city or county within which the supplier provides water supplies that the urban water supplier will be reviewing the plan and considering amendments or changes to the plan. The urban water supplier may consult with, and obtain comments from, any city or county that receives notice pursuant to this subdivision.	10621(b)	Appendix E	
7	The amendments to, or changes in, the plan shall be adopted and filed in the manner set forth in Article 3 (commencing with Section 10640).	10621(c)	Appendix E	
8	Describe the service area of the supplier.	10631(a)	Chapter 1	Section A

Urban Water Management Plan Checklist				
No.	**UWMP Requirement**	**California Water Code Reference**	**UWMP Location**	**Additional Comments**
9	(Describe the service area) climate.	10631(a)	Chapter 1	Section C
10	(Describe the service area) current and projected population... The projected population estimates shall be based upon data from the state, regional, or local service agency population projections within the service area of the urban water supplier…	10631(a)	Chapter 1	Section B
11	(population projections) shall be in five-year increments to 20 years or as far as data is available.	10631(a)	Chapter 1	Table 1-3
12	Describe... other demographic factors affecting the supplier's water management planning.	10631(a)	Chapter 1	Section B; Table 1-4, Table 1-5
13	Identify and quantify, to the extent practicable, the existing and planned sources of water available to the supplier over the same five-year increments described in subdivision (a).	10631(b)	Chapter 2	Sections D & E
14	(Is) groundwater... identified as an existing or planned source of water available to the supplier...?	10631(b)	Chapter 2	Section B
15	(Provide a) copy of any groundwater management plan adopted by the urban water supplier, including plans adopted pursuant to Part 2.75 (commencing with Section 10750), or any other specific authorization for groundwater management. Indicate whether a groundwater management plan been adopted by the water supplier or if there is any other specific authorization for groundwater management. Include a copy of the plan or authorization.	10631(b)(1)	Appendix B	
16	(Provide a) description of any groundwater basin or basins from which the urban water supplier pumps groundwater.	10631(b)(2)	Chapter 2	Section B.1
17	For those basins for which a court or the board has adjudicated the rights to pump groundwater, (provide) a copy of the order or decree adopted by the court or the board.	10631(b)(2)	Appendix B	FCGMA has management jurisdiction over a portion of the groundwater basins in Ventura County.
18	(Provide) a description of the amount of groundwater the urban water supplier has the legal right to pump under the order or decree.	10631(b)(2)	Chapter 2	Section B

Urban Water Management Plan Checklist				
No.	**UWMP Requirement**	**California Water Code Reference**	**UWMP Location**	**Additional Comments**
19	For basins that have not been adjudicated, (provide) information as to whether the department has identified the basin or basins as overdrafted or has projected that the basin will become overdrafted if present management conditions continue, in the most current official departmental bulletin that characterizes the condition of the groundwater basin, and a detailed description of the efforts being undertaken by the urban water supplier to eliminate the long-term overdraft condition.	10631(b)(2)	Chapter 2	Section B
20	(Provide a) detailed description and analysis of the location, amount, and sufficiency of groundwater pumped by the urban water supplier for the past five years. The description and analysis shall be based on information that is reasonably available, including, but not limited to, historic use records.	10631(b)(3)	Chapter 2	Section B.2
21	(Provide a) detailed description and analysis of the amount and location of groundwater that is projected to be pumped by the urban water supplier. The description and analysis shall be based on information that is reasonably available, including, but not limited to, historic use records.	10631(b)(4)	Chapter 2	Section B.2
22	Describe the reliability of the water supply and vulnerability to seasonal or climatic shortage, to the extent practicable, and provide data for each of the following: (A) An average water year, (B) A single dry water year, (C) Multiple dry water years.	10631(c)(1)	Chapter 5	Section B
23	For any water source that may not be available at a consistent level of use - given specific legal, environmental, water quality, or climatic factors - describe plans to supplement or replace that source with alternative sources or water demand management measures, to the extent practicable.	10631(c)(2)	Chapter 4 Chapter 6	
24	Describe the opportunities for exchanges or transfers of water on a short-term or long-term basis.	10631(d)	Chapter 5 Chapter 6	Chapter 5, Section B.3.d

Urban Water Management Plan Checklist				
No.	**UWMP Requirement**	**California Water Code Reference**	**UWMP Location**	**Additional Comments**
25	Quantify, to the extent records are available, past and current water use, and projected water use (over the same five-year increments described in subdivision (a)), identifying the uses among water use sectors, including, but not necessarily limited to, all of the following uses: (A) Single-family residential; (B) Multifamily; (C) Commercial; (D) Industrial; (E) Institutional and governmental; (F) Landscape; (G) Sales to other agencies; (H) Saline water intrusion barriers, groundwater recharge, or conjunctive use, or any combination thereof;(I) Agricultural.	10631(e)(1)	Chapter 3	
26	(Describe and provide a schedule of implementation for) each water demand management measure that is currently being implemented, or scheduled for implementation, including the steps necessary to implement any proposed measures, including, but not limited to, all of the following: (A) Water survey programs for single-family residential and multifamily residential customers; (B) Residential plumbing retrofit; (C) System water audits, leak detection, and repair; (D) Metering with commodity rates for all new connections and retrofit of existing connections; (E) Large landscape conservation programs and incentives; (F) High-efficiency washing machine rebate programs; (G) Public information programs; (H) School education programs; (I) Conservation programs for commercial, industrial, and institutional accounts; (J) Wholesale agency programs; (K) Conservation pricing; (L) Water conservation coordinator; (M) Water waste prohibition;(N) Residential ultra-low-flush toilet replacement programs.	10631(f)(1)	Chapter 4 Appendix D	
27	A description of the methods, if any, that the supplier will use to evaluate the effectiveness of water demand management measures implemented or described under the plan.	10631(f)(3)	Not applicable	CMWD is a wholesale water supplier. Refer to purveyor UWMPs.

Urban Water Management Plan Checklist				
No.	**UWMP Requirement**	**California Water Code Reference**	**UWMP Location**	**Additional Comments**
28	An estimate, if available, of existing conservation savings on water use within the supplier's service area, and the effect of water use within the supplier's service area, and the effect of the savings on the supplier's ability to further reduce demand.	10631(f)(4)	Chapter 4 Appendix D	Figure 4-1
29	An evaluation of each water demand management measure listed in paragraph (1) of subdivision (f) that is not currently being implemented or scheduled for implementation. In the course of the evaluation, first consideration shall be given to water demand management measures, or combination of measures, that offer lower incremental costs than expanded or additional water supplies. This evaluation shall do all of the following: (1) Take into account economic and noneconomic factors, including environmental, social, health, customer impact, and technological factors; (2) Include a cost-benefit analysis, identifying total benefits and total costs; (3) Include a description of funding available to implement any planned water supply project that would provide water at a higher unit cost; (4) Include a description of the water supplier's legal authority to implement the measure and efforts to work with other relevant agencies to ensure the implementation of the measure and to share the cost of implementation.	10631(g)	Chapter 4 Appendix D	CMWD has implemented all DMMs that are applicable to wholesale urban water suppliers
30	(Describe) all water supply projects and water supply programs that may be undertaken by the urban water supplier to meet the total projected water use as established pursuant to subdivision (a) of Section 10635. The urban water supplier shall include a detailed description of expected future projects and programs, other than the demand management programs identified pursuant to paragraph (1) of subdivision (f), that the urban water supplier may implement to increase the amount of the water supply available to the urban water supplier in average, single-dry, and multiple-dry water years. The description shall identify	10631(h)	Chapter 2 Chapter 5	Chapter 2, Section B.3 Chapter 5, Sections D & E

Urban Water Management Plan Checklist				
No.	**UWMP Requirement**	**California Water Code Reference**	**UWMP Location**	**Additional Comments**
	specific projects and include a description of the increase in water supply that is expected to be available from each project. The description shall include an estimate with regard to the implementation timeline for each project or program.			
31	Describe the opportunities for development of desalinated water, including, but not limited to, ocean water, brackish water, and groundwater, as a long-term supply.	10631(i)	Chapter 2	Section E.2
32	Include the annual reports submitted to meet the Section 6.2 requirement (of the MOU), if a member of the CUWCC and signer of the December 10, 2008 MOU.	10631(j)	Appendix D	
33	Urban water suppliers that rely upon a wholesale agency for a source of water shall provide the wholesale agency with water use projections from that agency for that source of water in five-year increments to 20 years or as far as data is available. The wholesale agency shall provide information to the urban water supplier for inclusion in the urban water supplier's plan that identifies and quantifies, to the extent practicable, the existing and planned sources of water as required by subdivision (b), available from the wholesale agency to the urban water supplier over the same five-year increments, and during various water-year types in accordance with subdivision (c). An urban water supplier may rely upon water supply information provided by the wholesale agency in fulfilling the plan informational requirements of subdivisions (b) and (c).	10631(k)	Appendix C	
34	The water use projections required by Section 10631 shall include projected water use for single-family and multifamily residential housing needed for lower income households, as defined in Section 50079.5 of the Health and Safety Code, as identified in the housing element of any city, county, or city and county in the service area of the supplier.	10631.1(a)	Not applicable	Per California Code 65589.7, these requirements are not applicable to a water supplier that sells water to another water supplier for resale. Refer to purveyor UWMPs.

Urban Water Management Plan Checklist				
No.	**UWMP Requirement**	**California Water Code Reference**	**UWMP Location**	**Additional Comments**
35	Stages of action to be undertaken by the urban water supplier in response to water supply shortages, including up to a 50 percent reduction in water supply, and an outline of specific water supply conditions which are applicable to each stage.	10632(a)	Chapter 6	Section 4 Table 6-1; Table 6-2
36	Provide an estimate of the minimum water supply available during each of the next three water years based on the driest three-year historic sequence for the agency's water supply.	10632(b)	Chapter 6	Table 6-3 through Table 6-7
37	(Identify) actions to be undertaken by the urban water supplier to prepare for, and implement during, a catastrophic interruption of water supplies including, but not limited to, a regional power outage, an earthquake, or other disaster.	10632(c)	Chapter 6	Section B
38	(Identify) additional, mandatory prohibitions against specific water use practices during water shortages, including, but not limited to, prohibiting the use of potable water for street cleaning.	10632(d)	Chapter 6	Section D
39	(Specify) consumption reduction methods in the most restrictive stages. Each urban water supplier may use any type of consumption reduction methods in its water shortage contingency analysis that would reduce water use, are appropriate for its area, and have the ability to achieve a water use reduction consistent with up to a 50 percent reduction in water supply.	10632(e)	Chapter 6	Section D
40	(Indicate) penalties or charges for excessive use, where applicable.	10632(f)	Chapter 6	Section D.2
41	An analysis of the impacts of each of the actions and conditions described in subdivisions (a) to (f), inclusive, on the revenues and expenditures of the urban water supplier, and proposed measures to overcome those impacts, such as the development of reserves and rate adjustments.	10632(g)	Chapter 6	Section D.3

Urban Water Management Plan Checklist				
No.	**UWMP Requirement**	**California Water Code Reference**	**UWMP Location**	**Additional Comments**
42	(Provide) a draft water shortage contingency resolution or ordinance.	10632(h)	Appendix E	CMWD's Resolution No. 1636 outlines water shortage allocations consistent with MWD's Water Shortage Allocation Plan (WSAP). See MWD's WSAP for more details.
43	(Indicate) a mechanism for determining actual reductions in water use pursuant to the urban water shortage contingency analysis.	10632(i)		
44	Provide, to the extent available, information on recycled water and its potential for use as a water source in the service area of the urban water supplier. The preparation of the plan shall be coordinated with local water, wastewater, groundwater, and planning agencies that operate within the supplier's service area	10633	Chapter 2	Section C
45	(Describe) the wastewater collection and treatment systems in the supplier's service area, including a quantification of the amount of wastewater collected and treated and the methods of wastewater disposal.	10633(a)	Chapter 2	Section C Table 2-3, Table 2-4
46	(Describe) the quantity of treated wastewater that meets recycled water standards, is being discharged, and is otherwise available for use in a recycled water project.	10633(b)	Chapter 2	Section C Table 2-4
47	(Describe) the recycled water currently being used in the supplier's service area, including, but not limited to, the type, place, and quantity of use.	10633(c)	Chapter 2	Section C Table 2-5
48	(Describe and quantify) the potential uses of recycled water, including, but not limited to, agricultural irrigation, landscape irrigation, wildlife habitat enhancement, wetlands, industrial reuse, groundwater recharge, indirect potable reuse, and other appropriate uses, and a determination with regard to the technical and economic feasibility of serving those uses.	10633(d)	Chapter 2	Section C Potential uses of recycled water are quantified by purveyor, as provided by the purveyors. Refer to purveyor UWMPs for breakdown by use and feasibility of specific recycled water use locations.
49	(Describe) the projected use of recycled water within the	10633(e)	Chapter 2	Section C

Urban Water Management Plan Checklist				
No.	**UWMP Requirement**	**California Water Code Reference**	**UWMP Location**	**Additional Comments**
	supplier's service area at the end of 5, 10, 15, and 20 years, and a description of the actual use of recycled water in comparison to uses previously projected pursuant to this subdivision.			Table 2-3, Table 2-5
50	(Describe the) actions, including financial incentives, which may be taken to encourage the use of recycled water, and the projected results of these actions in terms of acre-feet of recycled water used per year.	10633(f)	Chapter 2	Section C Table 2-3 Refer to purveyor UWMPs for more specific information.
51	(Provide a) plan for optimizing the use of recycled water in the supplier's service area, including actions to facilitate the installation of dual distribution systems, to promote recirculating uses, to facilitate the increased use of treated wastewater that meets recycled water standards, and to overcome any obstacles to achieving that increased use.	10633(g)	Not applicable	Refer to purveyor UWMPs.
52	The plan shall include information, to the extent practicable, relating to the quality of existing sources of water available to the supplier over the same five-year increments as described in subdivision (a) of Section 10631, and the manner in which water quality affects water management strategies and supply reliability.	10634	Chapter 2	Sections A.1, A.2 and B.3
53	Every urban water supplier shall include, as part of its urban water management plan, an assessment of the reliability of its water service to its customers during normal, dry, and multiple dry water years. This water supply and demand assessment shall compare the total water supply sources available to the water supplier with the total projected water use over the next 20 years, in five-year increments, for a normal water year, a single dry water year, and multiple dry water years. The water service reliability assessment shall be based upon the information compiled pursuant to Section 10631, including available data from state, regional, or local agency population projections within the service area of the	10635(a)	Chapter 5	Section A Table 5-1, Table 5-2 and Table 5-3

Urban Water Management Plan Checklist				
No.	**UWMP Requirement**	**California Water Code Reference**	**UWMP Location**	**Additional Comments**
	urban water supplier.			
54	The urban water supplier shall provide that portion of its urban water management plan prepared pursuant to this article to any city or county within which it provides water supplies no later than 60 days after the submission of its urban water management plan.	10635(b)	Appendix F	
55	Each urban water supplier shall encourage the active involvement of diverse social, cultural, and economic elements of the population within the service area prior to and during the preparation of the plan.	10642	Appendix F	
56	Prior to adopting a plan, the urban water supplier shall make the plan available for public inspection and shall hold a public hearing thereon. Prior to the hearing, notice of the time and place of hearing shall be published within the jurisdiction of the publicly owned water supplier pursuant to Section 6066 of the Government Code. The urban water supplier shall provide notice of the time and place of hearing to any city or county within which the supplier provides water supplies. A privately owned water supplier shall provide an equivalent notice within its service area.	10642	Appendix F	
57	After the hearing, the plan shall be adopted as prepared or as modified after the hearing.	10642	Appendix F	
58	An urban water supplier shall implement its plan adopted pursuant to this chapter in accordance with the schedule set forth in its plan.	10643	Foreword	
59	An urban water supplier shall submit to the department, the California State Library, and any city or county within which the supplier provides water supplies a copy of its plan no later than 30 days after adoption. Copies of amendments or changes to the plans shall be submitted to the department, the California State Library, and any city or county within which the supplier provides water supplies within 30 days	10644(a)	Appendix F	

Urban Water Management Plan Checklist				
No.	**UWMP Requirement**	**California Water Code Reference**	**UWMP Location**	**Additional Comments**
	after adoption.			
60	Not later than 30 days after filing a copy of its plan with the department, the urban water supplier and the department shall make the plan available for public review during normal business hours.	10645		The final UWMP will be available on the CMWD website and at CMWD's main office.

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Appendix B
FCGMA Documentation

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Fox Canyon Groundwater Management Agency
Ordinance Code

Adopted July 27, 2005
Amended July 28, 2010

CHAPTER 1.0
Definitions

As used in this code, the following terms shall have the meanings stated below:

1.1. **"Actual Applied Water"** – means the total water applied by the grower to the crop over the course of a calendar year without regard to the water source. Examples of actual applied water include the sum of well water, water delivered from a water supplier, and or from surface water diversions. Total applied water does not include precipitation.

1.2. **"Agency"** means the Fox Canyon Groundwater Management Agency.

1.3. **"Agency Boundary"** shall be as depicted on the map adopted by the Board and recorded as an official record with the County Recorder's Office on January 14, 2002 (Document No. 2002-0009215), and as may be adjusted as provided in the Agency's enabling legislation.

1.4. **"Agricultural Extraction Facility"** means a facility from which the groundwater produced is used on lands in the production of plant crops or livestock for market, and uses incidental thereto.

1.5. **"Annual"** means the calendar year January 1 through December 31.

1.6. **"Aquifer"** means a geologic formation or structure that yields water in sufficient quantities to supply pumping wells or springs. A confined aquifer is an aquifer with an overlying less permeable or impermeable layer.

1.7. **"Board"** means the Board of Directors of the Fox Canyon Groundwater Management Agency.

1.8. **"County"** means the County of Ventura.

1.9. **"Developed Acreage"** means that portion of a parcel within the Agency Boundary that is receiving water for reasonable and beneficial agricultural, domestic or municipal and industrial (M & I) use.

1.10. **"East Las Posas Basin"** That part of the former North Las Posas Basin that is east of the subsurface anomaly described by significant changes in groundwater levels, as described in the Groundwater Management Plan and located for record purposes on maps as provided in Section 1.20.

1.11. **"Excess Extraction"** means those extractions in excess of an operator's extraction allocation or adjusted extraction allocation.

1.12. **"Executive Officer"** means the individual appointed by the Board to administer Agency functions, or his/her designee.

1.13. **"Exempt Well Operators"** means all well operators operating extraction facilities supplying a single family dwelling on one acre or less, with no income producing operations and those operators granted an exemption by the Board.

1.14. **"Expansion Area"** means that portion of land beyond the outer limits of the Agency Boundary in the West, East, and South Las Posas Basins that lies between the Agency Boundary and the crest of the hill or 1.5 miles beyond the Agency Boundary as defined by Map Number Two, entitled Fox Canyon Outcrop, Las Posas Basin, 1995. .

1.15. **"Extraction"** means the act of obtaining groundwater by pumping or other controlled means.

1.16. **"Extraction Allocation"** means the amount of groundwater that may be obtained from an extraction facility during a given calendar year, before a surcharge is imposed.

1.17. **"Extraction Facility"** means any device or method (e.g. water well) for extraction of groundwater within a groundwater basin or aquifer.

1.18. **"Foreign Water"** means water imported to the County through the State Water Project facilities or other newly available water as approved by the Board, such as recycled water that would otherwise be lost to the Ocean.

1.19. **"Groundwater"** means water beneath the surface of the earth within the zone below the water table in which the soil is completely saturated with water.

1.20. **"Groundwater Basin"** means a geologically and hydrologically defined area containing one or more aquifers, which store and transmit water yielding significant quantities of water to wells. For the purposes of this Ordinance Code, groundwater basins that of which either all or a portion or portions thereof are located within the Agency Boundary include, but are not limited to the Oxnard Plain Forebay Basin, Oxnard Plain Pressure Basin, Pleasant Valley Basin, East Las Posas Basin, West Las Posas Basin, South Las Posas Basin and the Arroyo Santa Rosa Basin, as described in the Groundwater Management Plan. The boundaries of these basins are shown on maps that shall be adopted by a Resolution. Groundwater basin boundaries may be modified by a Resolution.

1.21. **"Groundwater Management Plan"** means the 2007 Update to the Fox Canyon Groundwater Management Plan or Board-adopted updates to this plan.

1.22. **"Historical Extraction"** means the average annual groundwater extraction based on the five (5) calendar years of reported extractions from 1985 through 1989 within the Agency Boundary. This average will be expressed in acre-feet per year. All historical extraction allocations became effective on January 1, 1991.

1.23. **"Inactive Well"** An inactive well is a well that conforms to the County Water Well Ordinance requirements for an active well, but is being held in an idle status in case of future need. Idle status means the well is pumped no more than 8 hours during any 12-month period. Inactive wells are not required to have a flowmeter. Pumping to maintain status as an active well under the County Water Well Ordinance shall not exceed 8 hours in a 12 month period, shall be for beneficial use, and shall be estimated and reported to the Agency. Prior to removing a well from idle status, the operator shall install a flowmeter in accordance with the requirements in Chapter 3 of the Ordinance Code.

1.24. **"Injection/Storage Program"** means any device or method for injection/storage of water into a groundwater basin or aquifer within the Agency Boundary, including a program to supply foreign water in lieu of pumping.

1.25. **"Las Posas Outcrop"** or **"Outcrop"** means the area of Lower Aquifer System surface exposure as defined by Map Number One, Fox Canyon Outcrop, Las Posas Basin, 1982.

1.26. **"May"** as used in this Ordinance Code, permits action but does not require it.

1.27. **"Flowmeter"** means a manufactured instrument for accurately measuring and recording the flow of water in a pipeline.

1.28. **"Municipal and Industrial (M & I) Provider"** means person who provides water for domestic, industrial, commercial, or fire protection purposes within the Agency Boundary.

1.29. **"Municipal and Industrial (M & I) Operator"** An owner or operator that supplied groundwater for M & I use during the historical allocation period and did not supply a significant amount of agricultural irrigation during the historical period."

1.30. **"Municipal and Industrial (M & I) User"** means a person or other entity that used or uses water for any purpose other than agricultural irrigation.

1.31. **"Municipal and Industrial (M & I) Use"** means any use other than agricultural irrigation.

1.32. **"Non-Operating Flowmeter"** – A non-operating flowmeter includes a flowmeter that is out of calibration by plus or minus 5%, and/or a flowmeter that has not been calibrated within the flowmeter calibration schedule adopted by the Board.

1.33. **"Operator"** means a person who operates a groundwater extraction facility. In the event the Agency is unable to determine who operates a particular extraction facility, then "operator" shall mean the person to whom the extraction facility is assessed by the County Assessor, or, if not separately assessed, the person who owns the land upon which the extraction facility is located.

1.34. **"Ordinance Code"** means the Fox Canyon Groundwater Management Agency Ordinance Code.

1.35. **"Overdraft"** means the condition of a groundwater basin or aquifer where the average annual amount of water extracted exceeds the average annual supply of water to a basin or aquifer.

1.36. **"Owner"** means a person who owns a groundwater extraction facility. Ownership shall be determined by reference to whom the extraction facility is assessed by the County Assessor, or if not separately assessed, the person who owns the land upon which the extraction facility is located.

1.37. **"Perched"** or **"Semi-Perched Aquifer"** means the shallow, unconfined aquifer that overlies the Oxnard Aquifer in Sealing Zone III, as described in the California Department of Water Resources Bulletin No. 74-9.

1.38. **"Person"** includes any state or local governmental agency, private corporation, firm, partnership, individual, group of individuals, or, to the extent authorized by law, any federal agency.

1.39. **"Recharge"** means natural or artificial replenishment of groundwater in storage by percolation or injection of one or more sources of water.

1.40. **"Resolution"** means a formal statement of a decision adopted by the Board.

1.41. **"Safe Yield"** means the condition of groundwater basin when the total average annual groundwater extractions are equal to or less than total average annual groundwater recharge, either naturally or artificially.

1.42. **"Section"** as used in this Ordinance Code, is a numbered paragraph of a chapter.

1.43. **"Semi-Annual Groundwater Extraction Statement"** is a form filed by each operator containing the information required by Section 2.2 and 2.3.1 and shall cover the periods from January 1 to June 30 and from July 1 to December 31 annually.

1.44. **"Shall"** as used in this Ordinance Code, is an imperative requirement.

1.45. **"Well Flushing"** means the act of temporarily discharging extracted groundwater through a connection located upstream of the water distribution system at the beginning of an extraction cycle. Well flushing is typically performed until the quality of the extracted water is suitable for beneficial use and/or will not damage the distribution system. In some cases, the flushing flows may be discharged upstream of the distribution system, including the flowmeter. Flushing flows discharged upstream of the flowmeter shall be estimated and reported to the Agency in accordance with the requirements accordance with the requirements in Chapter 2 of the Ordinance Code.

1.46. **"Well Rehabilitation"** means the act of restoring a well to its most efficient condition by various treatments, development, or reconstruction methods. In most cases, groundwater extracted during well rehabilitation is not discharged through the extraction facility piping and, consequently, is not flowmetered. In these cases, the volume of water extracted shall be estimated and reported to the Agency in accordance with the requirements accordance in Chapter 2 of the Ordinance Code.

1.47. **"West Las Posas Basin"** is that part of the former North Las Posas Basin that is west of the subsurface anomaly described by significant changes in groundwater levels, as

described in the Groundwater Management Plan and located for record purposes on maps as provided in Section 1.20.

CHAPTER 2.0
Registration of Wells and Levying of Charges

2.1. Registration of Wells

2.1.1. Agency Water Well Permit Requirement (No-Fee Permit) – All new extraction facilities constructed within the Agency Boundary shall obtain a no-fee permit from the Agency prior to the issuance of a well permit by the County.

2.1.2. Registration Requirement – All groundwater extraction facilities within the boundaries of the Agency shall be registered with the Agency within 30 days of the completion of drilling activities or within 30 days after notice is given to the operator of such facility. No extraction facility may be operated or otherwise utilized so as to extract groundwater within the Agency Boundary unless that facility is registered with the Agency, flowmetered and permitted, if required, and all extractions reported to the Agency as required. The operator of an extraction facility shall register his extraction facility and provide in full, the information required to complete the form provided by the Agency that includes the following:

2.1.2.1. Name and address of the operator(s).

2.1.2.2. Name and address of the owner(s) of the land upon which the extraction facility is located.

2.1.2.3. A description of the equipment associated with the extraction facility.

2.1.2.4. Location, parcel number and state well number of the water extraction facility.

2.2. **Change in Owner or Operator** - The name of the owner of each extraction facility, the parcel number on which the well is located along with the names of all operators for each extraction facility shall be reported to the Agency within 30 days upon any change of ownership or operators, together with such other information required by the Executive Officer.

2.3. **Reporting Extractions** - All extractions shall be reported to the Agency. All extractions shall be flowmetered in accordance with the requirements and methods for flowmetering extractions as specified by Chapter 3. In cases where flowmetering is not required, the volume of water extracted shall be estimated and reported to Agency. The Agency shall send a “Semi-Annual Groundwater Extraction Statement” form to each well operator on or about the first week of January and the first week of July each year. Each operator of a registered extraction facility shall enter the necessary information and return the “Semi-Annual Groundwater Extraction Statement” covering all wells they operate on or before the due date. Statements are due on or before February 1st or August 1st annually or thirty days after the date of the letter requesting submittal of the Semi-Annual Statement

for the given period. Statements shall contain the following information on forms provided by the Agency:

2.3.1. The information required under Section 2.1.2 above.

2.3.2. The method of measuring or computing groundwater extractions.

2.3.3. The crop types or other uses and the acreage served by the extraction facility.

2.3.4. Total extractions from each extraction facility in acre-feet for the proceeding six (6) month period.

2.4. **Groundwater Extraction Charges**

2.4.1. All persons operating groundwater extraction facilities shall pay a groundwater extraction charge for all groundwater extracted after July 1, 1993, in the amount as established by Resolution. Payments are due semi-annually, and shall accompany the statement required pursuant to Section 2.3.

2.4.2. Payments are due forty-five (45) days after the billing date, and payments not received or postmarked by such date due shall be charged interest from and after such date due until payment thereof at the rate of 1.5 percent per month, or part of month that the charge remains unpaid. Late Penalty. The operator shall pay a late penalty for any extraction charge not satisfied by the due and payable date. The late penalty shall be 1½ percent per month, or any portion thereof, of the amount of the unsatisfied extraction charge. The late penalty shall not exceed 100% of the original charge, provided the penalty is paid within 60 days of the due date. If the fee is not paid within the 60 days, the penalty will continue to accrue at 1.5 percent per month with a final maximum of 200% of the original penalty due.

2.4.3. Owners of extraction facilities are ultimately responsible for payment of pumping charges and penalties should an operator not pay. Consequently, owners are charged with providing for this liability in agreements entered into with well operators and water users.

2.5. **Collection of Delinquent Extraction Charges and Late Penalties** - The Board may order that any given extraction charge and/or late penalty shall be a personal obligation of the operator or shall be an assessment against the property on which the extraction facility is located. Such assessment constitutes a lien upon the property, which lien attaches upon recordation in the office of the County Recorder. The assessment may be collected at the same time and in the same manner as ordinary ad valorem taxes are collected, and shall be subject to the same penalties and the same procedure and sale, in case of delinquency as provided for such taxes. All laws applicable to the levy, collection and enforcement of ad valorem taxes shall be applicable to such assessment, except that if any real property to which such lien would attach has been transferred or conveyed to a bona fide purchaser for value, or if a lien of a bona fide encumbrance for value has been created and attaches thereon, prior to the date on which the first installment of such taxes would become delinquent, then the lien which would otherwise

be imposed by this section shall not attach to such real property and an assessment relating to such property shall be transferred to the unsecured roll for collection.

2.6. **Use of Extraction Charges and Late Penalties** - Revenues generated from extraction charges and late penalties shall be used exclusively for authorized Agency purposes, including financial assistance to support Board approved water supply, conservation, monitoring programs and water reclamation projects that demonstrate significant reductions in overdraft.

CHAPTER 3.0
Installation and Use of Flowmeters for Groundwater Extraction Facilities

3.1. Installation and Use of Flowmeters

3.1.1. Installation Requirement - Prior to extracting groundwater, the operator shall install a flowmeter. With the exception of connections used for well flushing and extraction facilities used by multiple operators, flowmeters shall be installed upstream of all connections to the main discharge line. Flowmetering is not required during well flushing and well rehabilitation; however, the volume of water extracted shall be estimated and reported to the Agency. Flowmeters are not required on inactive wells as defined in this Ordinance Code, nor are flowmeters required for extraction facilities supplying a single family dwelling on one acre or less, with no income producing operations. If more than one operator uses the same extraction facility, flowmeters shall be installed to record the water use of each operator. Well operators were required to install flowmeters on wells by July 1, 1994.

3.1.2. Flowmeter Failure and Back-up Measurement Requirements - Flowmeters occasionally fail, losing periods of record before the disabled or inaccurate meter is either replaced or repaired. When a flowmeter fails, the operator shall repair or replace the flowmeter within the timeframe specified in a separate Resolution. Flowmeter failures and associated repairs or replacements shall be reported to the Agency together with any other information required by the Executive Officer on or before the due date of the next Semi-Annual Groundwater Extraction Statement. Well operators shall be prepared to provide another acceptable method of computing extractions during these periods of flowmeter failure to avoid the loss of record on wells that require flowmetering under this Ordinance Code.

3.1.3. Back-up Methods - It is the operator's responsibility to maintain the flowmeter. Any allowable or acceptable backup measurement methods will be specified in a separate Resolution and may be changed as technology improves or changes.

3.1.4. Flowmeter Readings - Functional flowmeters shall be read and the readings reported semi-annually on the extraction statements required under Section 2.3 above.

3.1.5. Inspection of Flowmeters - The Agency may inspect flowmeter installations for compliance with this Ordinance Code at any reasonable time.

3.2. **Flowmeter Testing and Calibration** - All flowmeters shall be tested for accuracy at a frequency interval determined by the Board to meet specific measurement standards. Calibration methods and procedures approved by the Board shall be detailed in an adopted Resolution.

3.3. **Altering Flowmeters** - Any person who alters, removes, resets, adjusts, manipulates, obstructs, or in any manner interferes or tampers with any flowmeter affixed to any groundwater extraction facility required by this Ordinance Code, resulting in said flowmeter to improperly or inaccurately measure and record groundwater extractions, is guilty of an intentional violation of this Ordinance Code and will be subject to any and all penalties as described in Chapter 8.

3.4. **Costs of Testing and Calibration** - All costs incurred with flowmeter testing or calibration shall be the personal obligation of the well owner. Non-compliance with any provision of the flowmeter calibration requirements will subject the owner to financial penalties and/or liens as described below or in Chapter 8 of the Ordinance Code.

3.5. **Fees and Enforcement** - If any water production facility within the Agency's boundaries is used to produce water without a flowmeter or with a non-operating flowmeter in excess of the allowable timeframe specified in a separate Resolution, the Agency shall assess a Non-Metered Water Use Fee against the water production facility owner. The amount of the fee shall be calculated as follows:

3.5.1 Groundwater extraction facilities - The fee shall be equal to double the current groundwater extraction charge for all estimated water used. Estimates of water used shall be calculated by the operator and approved by the Executive Officer. Any delinquent extraction charge obligations shall also be charged interest at the rate of 1.5 percent per month on any unpaid balances.

3.6. Upon violation of any flowmeter provision, the Agency may, as allowed by law, petition the Superior Court of the County for a temporary restraining order or preliminary or permanent injunction prohibiting the well owner from operating the facility or for such other injunctive relief as may be appropriate.

CHAPTER 4.0
Protection of the Las Posas Basins

4.1. **This chapter has the following purpose and intent:**

4.1.1. To eliminate overdraft from the aquifer systems within the boundary of the East and West Las Posas basins and bring these basins to a “safe yield” condition by the year 2010.

4.1.2. To protect the Las Posas outcrop as a source of groundwater recharge into the East and West Las Posas basins.

4.1.3. To prevent groundwater quality degradation of the East and West Las Posas basins by influence from the Expansion area.

4.1.4. This Ordinance Code is only one means by which these goals will be met.

4.2. Anti-degradation and Extraction Prohibition

4.2.1. Extraction Facility Permits.

4.2.1.1. Permit Required - Prior to: (a) initiating any new or increased use of groundwater in the Expansion area, obtained from any source within the Agency including the Expansion area; or (b) constructing a new or replacement extraction facility in the East or West Las Posas basins, or the Expansion area, a permit must be obtained from the Agency as provided in this Chapter. For the purpose of this Chapter, a new or increased use is that which did not exist or occur before June 30, 1988.

4.2.1.2. Permit Application - Application shall be made to the Agency on the approved County Water Well Ordinance form available from the County Public Works Agency and shall include all information required by the County Well Ordinance and the following:

4.2.1.2.1. Location of each water well to be used, along with the associated state well number.

4.2.1.2.2. Location(s) of groundwater use, including acreage accurately plotted on copy of the County Assessor's Parcel Map.

4.2.1.2.3. The proposed crop type(s) or Municipal and Industrial use(s) at each location.

4.2.1.2.4. A brief description of the type of irrigation or distribution system and flowmeter to be used.

4.2.1.2.5. The estimated average annual quantity of water use proposed for each location of use.

4.2.1.2.6. An identification of the source of historical allocation to supply the proposed water use by the well.

4.2.1.2.7. An analysis of the potential impacts on the water balance in the Las Posas Basins resulting from the proposed use(s).

4.2.1.3. Findings - A permit may only be granted if the Executive Officer finds that the proposed groundwater use will result in no net detriment to the East or West Las Posas Basins by determining that:

4.2.1.3.1. The Las Posas outcrop is not exposed to potential degradation of water quality of any type, and

4.2.1.3.2. Recharge to the East and West Las Posas Basins from the Las Posas outcrop is not diminished, and

4.2.1.3.3. Neither baseline nor efficiency allocation will be used, directly or indirectly, to support groundwater use on the Expansion Area, and (an example of indirect use is using efficiency to supply a demand inside the Agency and using the replaced historical allocation on the outcrop)

4.2.1.3.4. No increased or new uses of groundwater from inside the Agency Boundary will be applied on any area outside the Expansion area (or outside the East or West Las Posas boundary).

4.2.1.4. Permit Conditions. The Executive Officer may include in the permit granted, any conditions consistent with the purpose of this Chapter, including:

4.2.1.4.1. Any proposed agricultural use shall include the installation of irrigation systems that employ irrigation best management practices consistent with then current industry standards.

4.2.1.4.2. Any proposed municipal or industrial use shall include the installation of systems that employ municipal and industrial best management practices consistent with the then current industry standards.

4.2.1.4.3. A permit term, not to exceed 10 years from the date of issuance.

4.2.1.4.4. Mitigation, monitoring, and periodic reporting, as may be appropriate given the proposed use.

4.2.2. Permit Renewal - Permits may be renewed pursuant to the requirements of Section 4.2.1.

4.3. **Registration of Existing Uses** - The owners of groundwater wells located within the East or West Las Posas basins shall register their wells with the Agency no later than January 1, 2006, through the following procedure:

4.3.1. Registration Form - The Agency shall make available a registration form which shall be completed, and filed with the Agency for each well, which shall include the following:

4.3.1.1. Location(s) of all water well(s), along with the associated state well number(s) including offsite well(s) serving the proposed use. Information concerning wells shall also include any other use for the water well.

4.3.1.2. Location(s) of groundwater use for the well including acreage accurately plotted on a copy of the County Assessor's Parcel Map.

4.3.1.3. The proposed crop type(s) or Municipal and Industrial use(s) at each location.

4.3.1.4. A brief description of the type of irrigation or distribution system and flowmeter in use.

4.3.1.5. The estimated average annual quantity of water use at each location and for each well.

4.4. **Monitoring** - The Agency shall monitor compliance with this Chapter by reviewing County well permit applications and reported groundwater extractions and by conducting field surveys as may be necessary.

4.5 **Unreasonable Uses** - The Agency may commence and prosecute legal actions to enjoin unreasonable uses or methods of use of water within or without the Agency Boundary to the extent those uses or methods of use adversely affect the groundwater supply within the Agency Boundary.

CHAPTER 5.0
Reduction of Groundwater Extractions

5.1. **Purpose** - The purpose of this Chapter is to eliminate overdraft from the aquifer systems within the boundaries of the Agency and bring the groundwater basins to safe yield by the year 2010. It is not the purpose of this Chapter to determine or allocate water right entitlements, including those, which may be asserted pursuant to California Water Code sections 1005.1, 1005.2 or 1005.4.

5.2. **Extraction Allocations**

5.2.1. General Limitations

5.2.1.1. The Executive Officer shall establish an operator's extraction allocation for each extraction facility located within the Agency Boundary. The extraction allocation shall be the historical extraction as reported to the United Water Conservation District and/or to the Agency pursuant to Chapter 2 (or its successor), reduced as provided by Section 5.4, or as otherwise provided for in Section 5.6 of this Ordinance Code. An alternative allocation, either baseline or efficiency, may also be approved as explained in Sections 5.6.1.1 and 5.6.1.2. All extraction facilities have an allocation of zero unless the Executive Officer

determines otherwise. The operator may determine whether the annual allocation used shall be either a combination of baseline and historical allocation, or based on an efficiency allocation. All wells used by an operator in any given basin shall be operated on either a combination of historical and baseline or an efficiency allocation except water purveyors as approved by the Executive Officer. As explained by Section 5.6.1.2, an efficiency allocation may not be combined with either a baseline or a historical allocation. Extraction allocations may be adjusted or transferred only as provided in Section 5.3.

5.2.1.2. Regardless of allocation, the total water use for agricultural purposes must be at least 60 percent efficient as determined by the formula described in Section 5.6.1.2.4. This 60 percent irrigation efficiency is totally unrelated to the 80 percent efficiency described in Section 5.6.1.2, “Annual Efficiency Extraction Allocation”.

5.2.1.3. Where an operator operates more than one extraction facility in the same basin, the extraction allocations for the individual facilities may be combined.

5.2.1.4. Where there is more than one operator for any agricultural extraction facility, each operator shall be entitled to a pro rata share of the facility's historical allocation based on either usage or acreage irrigated during the historical extraction period. Such pro rata shares shall be determined by the owner of the extraction facility, and this determination shall be subject to the approval of the Executive Officer.

5.2.1.5. When an operator is no longer entitled to use an extraction facility, that operator is no longer entitled to any portion of the extraction allocation attributed to that extraction facility.

5.2.1.6. A historical allocation is assigned to an extraction facility and a baseline allocation is assigned to the land, both may be used, but neither is owned by the operator.

5.2.1.7. Where there is a sale or transfer of a part of the acreage served by any extraction facility, the extraction allocation for that facility shall be equitably apportioned between the real property retained and the real property transferred by the owner of the extraction facility, This apportionment shall be approved by the Executive Officer who may modify the apportionment to assure equity.

5.2.1.8. The name of the owner of each extraction facility, the parcel number on which the well is located along with the names of all operators for each extraction facility shall be reported to the Agency with each semi-annual statement and within 30 days of any change of ownership or operators, together with such other information required by the Executive Officer.

5.2.1.9. The Executive Officer may, on written request from a land owner or well operator, waive allocation requirements for the extraction of groundwater from the Perched or Semi-perched aquifer of Sealing Zone III when the pumping of that groundwater is specifically for the purpose of lowering the water table to reduce the high water table threat to property, including the root zone of crops, or for dewatering construction sites. The Executive Officer shall require that the groundwater extraction facility used for this purpose be perforated only in the Perched or Semi-perched zone, and shall also require the landowner and/or the operator to protect the Agency from damage potentially caused by transferring water to another location.

5.2.2. General Limitations: Special Board Approval Requirements - Notwithstanding any other provisions of this Ordinance Code, the following uses of water resources associated with the aquifers within the Agency may only be undertaken with prior Board approval of and subject to the conditions and restrictions established by the Board.

5.2.2.1. Direct or indirect export of groundwater extracted from within the Agency Boundary for use outside the Agency Boundary.

5.2.2.2. The direct or indirect use of surface water or Foreign Water from within the Agency outside the Agency in a manner that may adversely affect the groundwater supply within the Agency.

5.2.2.3. Application to the Board - To obtain the approval of the Board for any use provided in Sections 5.2.2.1 and 5.2.2.2, application shall be made to the Agency describing the details of the proposed use, including all the following information:

5.2.2.3.1. The location of each water well to be used, along with the associated state well number, and/or the location of each surface diversion and a description of the associated water right.

5.2.2.3.2. Location(s) of groundwater use, including acreage, accurately plotted on copy of the County Assessor's Parcel Map.

5.2.2.3.3. The proposed crop type(s) or Municipal and Industrial use(s) at each location.

5.2.2.3.4. A brief description of the type of irrigation or distribution system and flowmeter to be used.

5.2.2.3.5. The estimated average annual quantity of water use proposed for each location of use.

5.2.2.3.6. An identification of the source of historical allocation, if any, to supply the proposed water use by the well.

5.2.2.3.7. An analysis of the potential impacts on the water balance in any Basin or Subbasin within the Agency Boundaries resulting from the proposed use(s).

5.2.2.4. Findings - The Board may approve the proposed use if, after a public hearing, it finds that the proposed use will result in no net detriment to the Basin, or any subbasin, or aquifer associated with the use, by determining that:

5.2.2.4.1. The proposed use does not result in the material degradation of water quality of any type, or

5.2.2.4.2. Recharge to any aquifer within the Agency is not materially diminished.

5.2.2.4.3. In granting approval to projects subject to this subsection, the Board may impose any conditions as may be appropriate, including limitations on the quantity of water use, term of the approval, and periodic reporting to the Agency.

5.2.3. An operator shall comply with all provisions of this Ordinance Code and Resolutions prior to receiving an extraction allocation.

5.3. Adjustments to Extraction Allocations

5.3.1. Adjustments to extraction allocations may be necessary to provide some flexibility, while still maintaining the goal of reaching a safe yield condition by the year 2010. Adjustments may be accomplished by a transfer, an assignment of historical extraction allocation, or a demonstration of a new water source.

5.3.2. Subject to the provisions in this Section 5.3, transfers of extraction allocation are authorized provided they result in no net detriment to the Basins within the Agency. In making this determination, consideration shall be given to the location of extraction facilities, the aquifer systems being used, potential groundwater quality impacts, and the overall assessment of the cumulative impacts of transfers of extraction allocation.

5.3.3. Types of Transfers of Allocation. When irrigated agricultural land(s) changes to M & I use, a basic extraction allocation of 2 acre-feet per acre shall be transferred. In addition, a historical extraction allocation shall be transferred from the agricultural extraction facility(s) operators to the M & I provider in accordance with the following conditions:

5.3.3.1. When the extraction facility is located on the land transitioning and did not serve other land during the historical allocation determination period, the M & I Operator shall receive a historical extraction allocation of 2 acre-feet per acre per year for the acreage transitioning to M & I use. Any historical allocation in excess of 2 acre-feet per acre for the land transitioning to M & I use shall be eliminated.

5.3.3.2. When the extraction facility is located on the land transitioning and served other land during the historical allocation determination period, the historical allocation associated with the transitioning property shall be allocated on a pro rata basis by acreage to the total property served. The pro rata share for the property transitioning shall be eliminated. Two acre-feet per acre per year, based upon the acreage being transferred, shall be provided to the M & I provider.

5.3.3.3. When the extraction facility serving the lands transitioning is not located on the land transitioning, the Executive Officer shall determine the allocation on an equitable basis for the remaining properties not transitioning to M & I. Two acre-feet per acre per year, based upon the acreage being transferred, shall be provided to the M & I provider.

5.3.3.4. The transfer shall be effective upon the approval of the Executive Officer, taking into account the ongoing use of the property.

5.3.3.5. Allocation originating from an agricultural extraction facility shall not be transferred to an M & I use except as provided in this Section 5.3.3.

5.3.4. Allocation may be transferred between M & I extraction facilities provided there is no net detriment to the aquifer system. In making this determination, the Executive Officer shall, at a minimum, consider the location of extraction facilities, the aquifer system being used and groundwater quality impacts of the transfer.

5.3.5. Transfer of Allocation - Upon request, the Executive Officer may transfer allocation from one agricultural operator to another agricultural operator or from one M & I operator to another M & I operator provided there is no net detriment to the basins and the transfer is equitable. The transfer of allocation will be of indefinite duration, approved on a "case-by-case" basis, and the Executive Officer shall determine the rate of extraction and the point or points of extraction. Requests for the transfer of allocations shall be submitted jointly by the parties involved and shall include the specific details of their proposal. To ensure that there is no net detriment to the aquifer systems, transfers of allocation shall be subject to other conditions as approved by the Board. Transfers of allocation from Agricultural use to M & I use shall only be approved as provided by Section 5.3.3.

5.3.6. The Executive Officer may approve a temporary assignment of allocation from one operator to another operator when there is no net detriment to the aquifer system. The temporary assignment shall not exceed one year.

5.3.7. Adjustments to M & I Allocations - The Board may adjust the historical allocation of an M & I operator when that operator has supplied groundwater to either an agricultural or M & I user during the historical allocation period and discontinues service to that user. This adjustment may be made by transferring the supplied portion of the historical allocation from the M & I operator to the new user. This adjustment will avoid increased pumping due to windfall allocations that could

otherwise result when the M & I operator discontinues service. To avoid retroactive inequities, where an M & I operator has discontinued service to a user prior to July 1, 2005, the amount of the supplied portion of the historical allocation may be allocated to both the M & I operator and the user.

5.3.8. Historical allocation is subject to adjustment as provided in Section 5.4 below.

5.3.9. Procedures for Adjustment

5.3.9.1. It shall be necessary for the operator of the extraction facility to file a verified Application for Adjustment with the Executive Officer.

5.3.9.2. Adjustments of extraction allocations, pursuant to the Applications for Adjustment, shall be considered for approval by the Board after reviewing the findings and recommendations of the Executive Officer and, if approved, shall be effective for the remainder of the calendar year and for all subsequent calendar years until modified by a subsequent Board approved adjustment.

5.4. Reduction of Extraction Allocations

5.4.1. Historical extraction allocations, adjusted or otherwise, shall be reduced in order to eliminate overdraft from the aquifer systems within the boundaries of the Agency for agricultural and M & I uses. The reductions shall be as set forth below:

1992 - 1994 extraction allocation = 95% of historical extraction, as adjusted.
1995 - 1999 extraction allocation = 90% of historical extraction, as adjusted.
2000 - 2004 extraction allocation = 85% of historical extraction, as adjusted.
2005 - 2009 extraction allocation = 80% of historical extraction, as adjusted.
After 2009 extraction allocation = 75% of historical extraction, as adjusted.

5.4.2. Following the appropriate public review, the Board may exempt historical extraction allocations from these adjustments on a basin-by-basin basis.

5.5. Exemptions from Reductions

5.5.1. The following types of extraction allocations are exempt from the reductions set forth in Section 5.4.1:

5.5.1.1. Baseline Extraction Allocations as set forth in 5.6.1.1.

5.5.1.2. Annual Efficiency Extraction Allocations as set forth in 5.6.1.2.

5.5.1.3. Non-metered Extraction Facilities. Reductions in extraction allocations shall not apply to those extraction facilities as identified in Chapter 3 that do not require flowmeters. Neither retroactive adjustments nor refunds will be made, except that any outstanding surcharges for non-metered extractions that existed prior to June 26, 2002 will be waived.

5.6. **Alternative Extraction Allocations**

5.6.1. As an alternative to historical extractions, the Executive Officer may establish a Baseline or an Annual Efficiency extraction allocation for an operator, as follows:

5.6.1.1. Baseline Extraction Allocations. If no historical extraction exists, or the historical allocation is less than one acre-foot per acre per year, a Baseline extraction allocation may be established by the Executive Officer at one acre-foot per acre per year.

5.6.1.1.1. A Baseline Extraction Allocation specifically applies to undeveloped acreage that is being developed and once approved shall remain with that developed acreage. A Baseline allocation may be combined with a historical allocation for commonly operated facilities in the same basin. A baseline allocation shall not be used with an efficiency allocation.

5.6.1.1.2. To obtain a Baseline Extraction Allocation, a detailed report must be submitted to the Executive Officer. The report shall describe the historical extraction of groundwater use, if any, during the period between the end of calendar year 1984 and the end of calendar year 1989, the type (crop type or M & I) and the amount of water use and acreage involved. The report shall include copies of Assessor's maps identifying the parcels where groundwater is presently being used. For the purpose of this ordinance, one (1) acre-foot per acre per year represents a reasonable use of water for a Baseline extraction allocation.

5.6.1.1.3. Application for the initial Baseline Extraction Allocation must be submitted prior to submission of the annual report of pumping. If approved, the Baseline Extraction Allocation shall apply beginning with the current calendar year.

5.6.1.1.4. To facilitate accounting procedures, an operator shall use Baseline Extraction Allocation before using Historical Allocation.

5.6.1.2. Annual Efficiency Extraction Allocation - If an operator can demonstrate to the Executive Officer that water used for agriculturally developed land is at least 80 percent overall irrigation efficient, based on evapotranspiration requirements, an Annual Efficiency extraction allocation shall be established for one calendar year. An 80 percent overall irrigation efficiency has been determined by the Agency to be reasonable on agricultural lands within the Agency's boundaries.

5.6.1.2.1. An Efficiency Allocation may be used when no historical allocation exists or when the historical allocation is not

sufficient for the crop being grown. A historical allocation shall not be used in conjunction with an efficiency allocation.

5.6.1.2.2. To prove that irrigation efficiency is at least 80 percent, the operator must submit a detailed report covering a minimum period of the immediately preceding calendar year. This report shall be submitted to the Executive Officer no later than February 1st of the following year unless otherwise extended by the Board. The report shall include a complete crop and irrigation history for the extraction facility and actual acreage irrigated. The report shall include the reference evapotranspiration (ETo) rates and crop factors (Kc) for the calendar year period similar to that provided by the California Irrigation Management Information System (CIMIS) as developed and modified by the California Department of Water Resources. The report shall include a summary sheet that compares the water use to the evapotranspiration requirements for each crop and the corresponding acreage covered in the calendar year. The Board may extend the time to apply for an efficiency allocation for any year.

5.6.1.2.3. Irrigation efficiency will include an appropriate amount of water necessary to avoid salt build-up based on the quality of irrigation water used.

5.6.1.2.4. Irrigation Efficiency (I.E.) will be calculated using the following formula:

$$\text{I.E.} = \frac{[\text{ETo} \times \text{Kc}] - \text{ER} \times 100}{\text{Actual Water Applied (inches)}}$$

Where:

ETo is the reference evapotranspiration measured in inches.

Kc is a crop factor, which is a dimensionless number that relates water use by a given plant in comparison to ETo.

ER is the effective rainfall measured in inches as determined by the Executive Officer.

5.6.2. Exceptions - The Board may grant exceptions to Sections 5.6.1.1 and 5.6.1.2 on a case-by-case basis. However, individual exceptions shall not become the norm. Where agricultural efficiency cannot be measured as set forth in Section 5.6.1.2, then the most efficient practices of record for the type of agricultural use shall be the measurement of efficiency utilized by the Board in its deliberations.

5.7. **Credits**

5.7.1. Credits can be obtained by operators, but are not considered as extraction allocations or adjustments to extraction allocations. Credits are not subject to any reductions as set forth in Section 5.4.1. Credits, if available, shall be used to avoid paying extraction surcharges. Credits shall be accounted for through the normal reporting and accounting procedure and are carried forward from year to year. Except as provided below, credits may be transferred between commonly operated extraction facilities and within the basin where the credits were earned.

5.7.2. The Board may transfer credits between facilities that are not commonly operated within a basin or beyond the basin where such credits were earned, provided that there is no net detriment to the aquifers within the Agency. In determining whether there is no net detriment, the Board may, among other things, consider whether the transfer will help bring the aquifers within the Agency into equilibrium or whether the transfer is a part of an Agency or inter-Agency management plan or program to bring the aquifers of the Agency into balance. Also, in making this determination of no net detriment the Board may consider quality of water as well as the quantity. The transfer of credits will be of indefinite duration, approved on a "case-by-case" basis, and the Executive Officer shall determine the rate of extraction and the point or points of extraction.

5.7.2.1. Requests for the transfer of credits shall be submitted jointly by the parties involved and shall include the specific details of their proposal. To ensure that there is no net detriment to the aquifer systems, transfers of credits shall be subject to other conditions as approved by the Board. Under no circumstances shall credits earned as a result of agricultural use be transferred to an M & I Provider, M & I Operator or an M & I User unless the transfer is specifically approved by the Board and no net detriment to the aquifer systems involved can be shown. Credits earned by an M & I facility shall remain with that facility unless transferred by the Board or transferred as part of a program such as an Agency or inter-Agency management plan or program approved by the Board. The types of credits are:

5.7.2.1.1. Conservation credits - An operator can obtain conservation credits by extracting less groundwater than the historical extraction allocation. Annual Efficiency, Baseline, or an allocation assigned to an extraction facility that is not required to have a flowmeter shall not earn credits. Credits shall be determined by the Executive Officer after receipt of annual extraction data. Subsequent to determining the amount of credits earned, a confirmation shall be mailed to the operator indicating the current allocation, the groundwater extracted during the previous calendar year, and the credits or surcharges for the previous year.

5.7.2.1.2. Storage credits - An operator may obtain storage credits for water that has been determined by the Board to qualify for

credits or foreign water stored, injected or spread and percolated or delivered in lieu of pumping in a Board approved injection/storage program used within the Agency Boundary. A written application for approval of a program or an injection/storage facility shall include:

5.7.2.1.2.1. Operator of proposed injection/storage program.

5.7.2.1.2.2. Purpose of proposed injection/storage program.

5.7.2.1.2.3. Location, depth, casing diameter, perforated interval and other information regarding proposed injection/extraction facilities, if applicable.

5.7.2.1.2.4. Method of operation including source, quantity and quality of water, planned scheduling of storage, injection/extraction, delivery or percolation operations and proposed use of extracted water.

5.7.2.1.2.5. Any other information deemed necessary by the Executive Officer.

5.7.3. Following Board approval of the application, successful storage, delivery or injection of water and reporting of results, an operator will obtain credit as determined by the Executive Officer.

5.8. Extraction Surcharges and Late Penalty

5.8.1. Necessity for Surcharges

5.8.1.1. Extraction surcharges are necessary to achieve safe yield from the groundwater basins within the Agency and shall be assessed annually when annual extractions exceed the historical and/or baseline allocation for a given extraction facility or the combined sum of historical allocation and baseline allocation for combined facilities. The extraction surcharge shall be fixed by the Board and shall be based upon (1) the cost to import potable water from the Metropolitan Water District of Southern California, or other equivalent water sources that can or do provide non-native water within the Agency jurisdiction; and (2) the current groundwater conditions within the Agency jurisdiction.

5.8.2. At the discretion of the Board, the extraction surcharge may be structured, tiered, and varied between basins and or aquifers.

5.8.3. The Board shall fix the surcharge by Resolution at a cost sufficiently high to discourage extraction of groundwater in excess of the approved allocation when that extraction will adversely affect achieving safe yield of any basin within the

Agency and may adjust the surcharge by Resolution; provided however, that the then existing extraction surcharge shall remain in effect until adjusted by the Board.

5.8.4. Surcharge for No Allocation - In circumstances where an individual or entity extracts groundwater from a facility(s) having no valid extraction allocation, the extraction surcharge shall be applied to the entire quantity of water extracted. Imposition and acceptance of payment of the surcharge imposed on an individual or entity that extracts water from a facility(s) that holds no extraction allocation shall not be deemed a waiver of the Agency's authority to limit or enjoin the unauthorized extractions.

5.8.5. Efficiency Surcharge Facilities relying on the annual efficiency allocation shall also be subject to surcharge for inefficient use. The extraction allocation for efficiency is the amount of water used at 80% efficiency as defined in 5.6.1.2 of this ordinance. Extraction surcharges will be applied to the difference between the water extracted which correlates with the actual efficiency achieved and the water that would have been extracted to attain the 80% efficiency allocation. For example, an actual efficiency of 70% would be subject to surcharges on the difference between the amount of water used at 70% efficiency and the amount of water that would have been used at 80% efficiency. If an efficiency of less than 60% is achieved, no efficiency allocation will be available, and the operator shall revert to a historical, baseline or to no allocation whichever applies to that facility. Extraction surcharges would then apply to the difference between actual water used and the applicable allocation, if any. For example, a facility operating at an actual efficiency of 59% with no historical or baseline allocation, would be subject to surcharges on all water used.

5.8.6. Payment of Extraction Surcharges

5.8.6.1. Surcharges are assessed annually with respect to the annual allocation and shall become due and payable by the owner/operator on February 1st each year or 30 days after the date shown on the "Semi-Annual Groundwater Extraction Statement." Payments shall be made with credits, if available. The Board may extend the 30-day time allowed to pay surcharges for a period of up to twelve months when circumstances exist that in the opinion of the Board warrant such extension. The Board may also approve the payment of surcharges in installments of up to 24 months with terms suitable to the Board.

5.8.6.2. Late Penalty - The operator shall pay a late penalty for any extraction surcharge not satisfied by the due and payable date. The late penalty shall be 1.5 percent per month, or any portion thereof, of the amount of the unsatisfied extraction surcharge. The late penalty shall not exceed 100% of the original surcharge, provided the penalty is paid within 60 days of billing. If the fee is not paid within the 60 days, the penalty will continue to accrue at 1.5 percent per month with a final maximum of 200% of the original penalty due.

5.8.6.3. Collection of Delinquent Extraction Surcharges and Late Penalties - The Board may order that any given extraction surcharge and/or late penalty shall be a personal obligation of the operator or shall be an assessment against the property on which the extraction facility is located. Such assessment constitutes a lien upon the property, which lien attaches upon recordation in the office of the County Recorder. The assessment may be collected at the same time and in the same manner as ordinary ad valorem taxes are collected, and shall be subject to the same penalties and the same procedure and sale, in case of delinquency as provided for such taxes. All laws applicable to the levy, collection and enforcement of ad valorem taxes shall be applicable to such assessment, except that if any real property to which such lien would attach has been transferred or conveyed to a bona fide purchaser for value, or if a lien of a bona fide encumbrance for value has been created and attaches thereon, prior to the date on which the first installment of such taxes would become delinquent, then the lien which would otherwise be imposed by this section shall not attach to such real property and an assessment relating to such property shall be transferred to the unsecured roll for collection.

5.8.6.4. Use of Extraction Surcharges and Late Penalties - Revenues generated from extraction surcharges and late penalties shall be used exclusively for authorized Agency purposes, including financial assistance to support Board approved water supply, conservation, monitoring programs and water reclamation projects that demonstrate significant reductions in overdraft.

CHAPTER 6.0
Appeals

6.1. Any person aggrieved by a decision or determination made by the Executive Officer may appeal to the Board within forty-five (45) calendar days thereof by filing with the Clerk, or Deputy Clerk, of the Board a written request that the Board review the decision of the Executive Officer. The Board shall equitably act on the appeal within 120 days after all relevant information has been provided by the appellant.

CHAPTER 7.0
Severability

7.1. If any section, part, clause or phrase in this Ordinance Code is for any reason held invalid or unconstitutional, the remaining portion of this Ordinance Code shall not be affected but shall remain in full force and effect.

CHAPTER 8.0
Penalties

8.1. Any operator or other person who violates the provisions of this Ordinance Code is subject to the criminal and civil sanctions set forth in the Agency's enabling act and its Ordinances.

8.2. Any person who intentionally violates any provision of this Ordinance Code shall be guilty of an infraction and may be required to pay a fine to the Agency in an amount not to exceed five hundred dollars ($500).

8.3. Any person who negligently or intentionally violates any provision of this Ordinance Code may also be liable civilly to the Agency for a sum not to exceed one thousand dollars ($1,000) per day for each day of such violation, in addition to any other penalties that may be prescribed by law.

8.4. Upon the failure of any person to comply with any provision of this Ordinance Code, the Agency may petition the Superior Court for a temporary restraining order, preliminary or permanent injunction, or such other equitable relief as may be appropriate. The right to petition for injunctive relief is an additional right to those, which may be provided elsewhere in this Ordinance Code or otherwise allowed by law. The Agency may petition the Superior Court of the County to recover any sums due the Agency.

This Ordinance Code and amendments hereof shall become effective on the thirty-first day after adoption.

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ORDINANCE NO. 8.3

An Ordinance to Amend the Fox Canyon Groundwater Management Agency Code

The Board of Directors of the Fox Canyon Groundwater Management Agency ordains as follows:

SECTION ONE: Section 1.27 of Chapter 1.0, Definitions, is hereby repealed and reenacted as follows:

1.27. "Flowmeter" means a manufactured instrument for accurately measuring and recording the flow of water in a pipeline.

SECTION TWO: Section 1.45 of Chapter 1.0, Definitions, is hereby repealed and reenacted as follows:

1.45. "Well Flushing" means the act of temporarily discharging extracted groundwater through a connection located upstream of the water distribution system at the beginning of an extraction cycle. Well flushing is typically performed until the quality of the extracted water is suitable for beneficial use and/or will not damage the distribution system. In some cases, the flushing flows may be discharged upstream of the distribution system, including the flowmeter. Flushing flows discharged upstream of the flowmeter shall be estimated and reported to the Agency in accordance with the requirements accordance with the requirements in Chapter 2 of the Ordinance Code.

SECTION THREE: Section 1.46 of Chapter 1.0, Definitions, is hereby added to the Ordinance Code as follows:

1.46. "Well Rehabilitation" means the act of restoring a well to its most efficient condition by various treatments, development, or reconstruction methods. In most cases, groundwater extracted during well rehabilitation is not discharged through the extraction facility piping and, consequently, is not flowmetered. In these cases, the volume of water extracted shall be estimated and reported to the Agency in accordance with the requirements accordance in Chapter 2 of the Ordinance Code.

SECTION FOUR: Section 1.47 of Chapter 1.0, Definitions, is hereby added to the Ordinance Code as follows:

1.47. "West Las Posas Basin" is that part of the former North Las Posas Basin that is west of the subsurface anomaly described by significant changes in groundwater levels as described in the Groundwater Management Plan and located for record purposes on maps as provided in Section 1.20.

SECTION FIVE: Section 2.3 of Chapter 2.0, Registration of Wells and Levying of Charges, is hereby repealed and reenacted as follows:

2.3. **Reporting Extractions -** All extractions shall be reported to the Agency. All extractions shall be flowmetered in accordance with the requirements and methods for flowmetering extractions as specified by Chapter 3. In cases where flowmetering is not required, the volume of water extracted shall be estimated and reported to Agency. The Agency shall send a "Semi-Annual Groundwater Extraction Statement" form to each well operator on or about the first week of January and the first week of July each year. Each operator of a registered extraction facility shall enter the necessary information and return the "Semi-Annual Groundwater Extraction Statement" covering all wells they operate on or before the due date. Statements are due on or before February 1st or August 1st annually or thirty days after the date of the letter requesting submittal of the Semi-Annual Statement for the given period. Statements shall contain the following information on forms provided by the Agency:

2.3.1. The information required under Section 2.1.2 above.

2.3.2. The method of measuring or computing groundwater extractions.

2.3.3. The crop types or other uses and the acreage served by the extraction facility.

2.3.4. Total extractions from each extraction facility in acre-feet for the proceeding six (6) month period.

SECTION SIX: Chapter 3.0, Installation of Metering Equipment for Groundwater Extraction Facilities, is hereby repealed and reenacted as follows:

CHAPTER 3.0
Installation and Use of Flowmeters for Groundwater Extraction Facilities

3.1. Installation and Use of Flowmeters

3.1.1. Installation Requirement - Prior to extracting groundwater, the operator shall install a flowmeter. With the exception of connections used for well flushing and extraction facilities used by multiple operators, flowmeters shall be installed upstream of all connections to the main discharge line. Flowmetering is not required during well flushing and well rehabilitation; however, the volume of water extracted shall be estimated and reported to the Agency. Flowmeters are not required on inactive wells as defined in this Ordinance Code, nor are flowmeters required for extraction facilities supplying a single family dwelling on one acre or less, with no income producing operations. If more than one operator uses the same extraction facility, flowmeters shall be installed to record the water use of each operator. Well operators were required to install flowmeters on wells by July 1, 1994.

3.1.2. Flowmeter Failure and Back-up Measurement Requirements - Flowmeters occasionally fail, losing periods of record before the disabled or inaccurate meter is either replaced or repaired. When a flowmeter fails, the operator shall repair or replace the flowmeter within the timeframe specified in a separate Resolution. Flowmeter failures and associated repairs or replacements shall be reported to the another acceptable method of computing extractions during these periods of flowmeter failure to avoid the loss of record on wells that require flowmetering under this Ordinance Code Agency together with any other information required by the Executive Officer on or before the due date of the next Semi-Annual Groundwater Extraction Statement. Well operators shall be prepared to provide.

3.1.3. Back-up Methods - It is the operator's responsibility to maintain the flowmeter. Any allowable or acceptable backup measurement methods will be specified in a separate Resolution and may be changed as technology improves or changes.

3.1.4. Flowmeter Readings - Functional flowmeters shall be read and the readings reported semi-annually on the extraction statements required under Section 2.3 above.

3.1.5. Inspection of Flowmeters - The Agency may inspect flowmeter installations for compliance with this Ordinance Code at any reasonable time.

3.2. **Flowmeter Testing and Calibration** - All flowmeters shall be tested for accuracy at a frequency interval determined by the Board to meet specific measurement standards. Calibration methods and procedures approved by the Board shall be detailed in an adopted Resolution.

3.3. **Altering Flowmeters** - Any person who alters, removes, resets, adjusts, manipulates, obstructs, or in any manner interferes or tampers with any flowmeter affixed to any groundwater extraction facility required by this Ordinance Code, resulting in said flowmeter to improperly or inaccurately measure and record groundwater extractions, is guilty of an intentional violation of this Ordinance Code and will be subject to any and all penalties as described in Chapter 8.

3.4. **Costs of Testing and Calibration** - All costs incurred with flowmeter testing or calibration shall be the personal obligation of the well owner. Non-compliance with any provision of the flowmeter calibration requirements will subject the owner to financial penalties and/or liens as described below or in Chapter 8 of the Ordinance Code.

3.5. **Fees and Enforcement** - If any water production facility within the Agency's boundaries is used to produce water without a flowmeter or with a non-operating flowmeter in excess of the allowable timeframe specified in a separate Resolution, the Agency shall assess a Non-Metered Water Use Fee against the water production facility owner. The amount of the fee shall be calculated as follows:

3.5.1 Groundwater extraction facilities - The fee shall be equal to double the current groundwater extraction charge for all estimated water used. Estimates of water used shall be calculated by the operator and approved by the Executive Officer. Any delinquent extraction charge obligations shall also be charged interest at the rate of 1.5 percent per month on any unpaid balances.

3.6. Upon violation of any flowmeter provision, the Agency may, as allowed by law, petition the Superior Court of the County for a temporary restraining order or preliminary or permanent injunction prohibiting the well owner from operating the facility or for such other injunctive relief as may be appropriate.

SECTION SEVEN: The Ordinance Code is amended so that the terms "Metering Equipment" and "Meter" shall be replaced with "Flowmeter."

This Ordinance shall become effective on the thirty-first day after adoption.

ADOPTED this 28th day of July 2010 by the following vote:

AYES: Directors Maulhardt, Craven, Bennett, Kelley, and Borchard
NOES: None
ABSENT: None

Lynn Maulhardt, Chair, Board of Directors
Fox Canyon Groundwater Management Agency

ATTEST: I hereby certify that the above is a true and correct copy of Ordinance No. 8.3

Tammy Butterworth, Deputy Clerk of the Board

FOX CANYON GROUNDWATER MANAGEMENT AGENCY

BOARD OF DIRECTORS
Lynn E. Maulhardt, Chair
John K. Flynn
Sam McIntyre
James Daniels
Michael Conroy

AGENCY COORDINATOR
Lowell Preston, Ph.D.

July 12, 1994

Eric Berg, Projects Administrator
Calleguas Municipal Water District
2100 Olsen Road
Thousand Oaks, CA 91360-6800

SUBJECT: BOARD APPROVAL OF CMWD APPLICATION FOR INJECTION/STORAGE FACILITIES IN NORTH LAS POSAS GROUNDWATER BASIN

Dear Mr. Berg:

At the Board of Directors meeting on February 23, 1994, the Board approved the CMWD application for injection/storage facilities in the North Las Posas Basin. The approval of this application, as provided for under Ordinance 5.3, was subject to the conditions that follow. These conditions include several changes and additions requested by the Board of Directors.

NORTH LAS POSAS BASIN INJECTION/STORAGE FACILITIES CONDITIONS

1. *The identification, size, depth, well logs and location of wells used for injection/extraction will be registered with the GMA. A maximum of twenty (20) wells all to be permitted by the County of Ventura, Public Works Agency, and registered with the GMA.*

2. *Calleguas will inject/extract on a schedule determined by availability of water to inject and the needs of their customers. The number of acre-feet injected/extracted from each well shall be reported to the GMA monthly. The monthly report shall also include a water quality analysis for the injected water that covers and conforms to the limits listed for the following items:*

a.	*Sodium Adsorption Ratio (SAR) calculated in meq/l as* $SAR=NA/((CA + Mg)/2)^{.5}$	$\geq 1 \leq 4$	
b.	*Total Dissolved Solids (TDS)* *Electrical conductivity (EC)*	$\geq 100 \leq 800$ <1100	*mg/l* *uMHO*
c.	*Chloride (Cl)*	<120	*mg/l*
d.	*Boron* (H_3Bo_3)	<1	*mg/l*
e.	*Nitrates*	<45	*mg/l*

(NOTE: These limits are based on University of California research. Should the University reverse these limits, the recommended changes will be incorporated into these conditions.)

800 South Victoria Avenue, Ventura, CA 93009
(805) 654-2088 FAX:(805) 654-3951

Testing shall be conducted monthly during periods of continuous injection, prior to beginning an injection of more than one hundred (100) acre-feet (but no more frequently than monthly), and as frequently as necessary when a change in water quality is suspected or known to exist.

3. *The total water in storage at any one time shall not exceed three hundred thousand (300,000) acre-feet (AF) unless approved by the GMA Board of Directors.*

4. *The point of extraction shall be the same as the point of injection or in the near vicinity. Extraction from points other than that of injection may be desirable and shall be coordinated with, and approved by the GMA.*

5. *Water stored by the facility shall be used in Ventura County.*

6. *Calleguas shall periodically review the effects of the injection on surrounding basins to ensure no detrimental effects result from the injection alone or in combination with natural recharge. Should negative effects exist, Calleguas shall take action to mitigate those effects caused by the injection program.*

7. *Should the injected water or conditions deviate from these standards, injection will stop, or not be started until the condition has been corrected.*

If you have any questions regarding this Agency's approval of your project facilities, please call Rick Farnsworth at 654-2327 or myself at 648-9204.

Very truly yours,

Lowell Preston, Ph.D.
Agency Coordinator

RF:vg

JGG/berg

Appendix C
Purveyor Projections

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CMWD 2010 UWMP - PURVEYOR FORECAST SUMMARY (AC-FT)

NORMAL YEAR SCENARIO

1 Berylwood Heights Mutual Water Company

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	-	-	-	-	-	-
Agricultural	1,550	1,800	2,200	2,600	3,200	3,800
Total Retail Demand	1,550	1,800	2,200	2,600	3,200	3,800
Local Supplies						
Recycled Water	-	-	-	-	-	-
Non-Potable GW	1,548	1,796	2,194	2,592	3,190	3,788
Total Non-Potable	1,548	1,796	2,194	2,592	3,190	3,788
Recovered GW	-	-	-	-	-	-
Potable GW	-	-	-	-	-	-
Total Potable	-	-	-	-	-	-
Total Local Supplies	1,548	1,796	2,194	2,592	3,190	3,788
IMPORTED WATER DEMAND	2	4	6	8	10	12

2 Brandeis Mutual Water Company

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	84	86	88	90	91	92
Agricultural	-	-	-	-	-	-
Total Retail Demand	84	86	88	90	91	92
Local Supplies						
Recycled Water	-	-	-	-	-	-
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	-	-	-	-	-	-
Recovered GW	-	-	-	-	-	-
Potable GW	-	-	-	-	-	-
Total Potable	-	-	-	-	-	-
Total Local Supplies	-	-	-	-	-	-
IMPORTED WATER DEMAND	84	86	88	90	91	92

CMWD 2010 UWMP - PURVEYOR FORECAST SUMMARY (AC-FT)

NORMAL YEAR SCENARIO

3 Butler Ranch Mutual Water Company ***(No information provided)***

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	-	-	-	-	-	-
Agricultural	-	-	-	-	-	-
Total Retail Demand	-	-	-	-	-	-
Local Supplies						
Recycled Water	-	-	-	-	-	-
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	-	-	-	-	-	-
Recovered GW	-	-	-	-	-	-
Potable GW	-	-	-	-	-	-
Total Potable	-	-	-	-	-	-
Total Local Supplies	-	-	-	-	-	-
IMPORTED WATER DEMAND	-	-	-	-	-	-

4 California-American Water Company

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	20,062	20,458	20,885	21,249	21,737	22,280
Agricultural	-	-	-	-	-	-
Total Retail Demand	20,062	20,458	20,885	21,249	21,737	22,280
Local Supplies						
Recycled Water	-	-	-	-	-	-
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	-	-	-	-	-	-
Recovered GW	-	-	-	-	-	-
Potable GW	-	-	-	-	-	-
Total Potable	-	-	-	-	-	-
Total Local Supplies	-	-	-	-	-	-
IMPORTED WATER DEMAND	20,062	20,458	20,885	21,249	21,737	22,280

CMWD 2010 UWMP - PURVEYOR FORECAST SUMMARY (AC-FT)

NORMAL YEAR SCENARIO

5 California Water Service

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	10,045	10,112	10,180	10,248	10,317	10,387
Agricultural	-	-	-	-	-	-
Total Retail Demand	10,045	10,112	10,180	10,248	10,317	10,387
Local Supplies						
Recycled Water	425	429	433	437	441	445
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	425	429	433	437	441	445
Recovered GW	-	-	-	-	-	-
Potable GW	-	-	-	-	-	-
Total Potable	-	-	-	-	-	-
Total Local Supplies	425	429	433	437	441	445
IMPORTED WATER DEMAND	9,620	9,683	9,747	9,811	9,876	9,942

6 City of Camarillo

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	9,900	10,463	11,025	11,538	12,050	12,563
Agricultural	350	300	250	250	250	250
Total Retail Demand	10,250	10,763	11,275	11,788	12,300	12,813
Local Supplies						
Recycled Water	-	500	500	500	500	500
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	-	500	500	500	500	500
Recovered GW	-	7,266	7,266	7,266	7,266	7,266
Potable GW	4,000	-	-	-	-	-
Total Potable	4,000	7,266	7,266	7,266	7,266	7,266
Total Local Supplies	4,000	7,766	7,766	7,766	7,766	7,766
IMPORTED WATER DEMAND	6,250	2,997	3,509	4,022	4,534	5,047

CMWD 2010 UWMP - PURVEYOR FORECAST SUMMARY (AC-FT)

NORMAL YEAR SCENARIO

7 Camrosa Water District

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	9,025	10,470	12,025	12,950	13,970	13,970
Agricultural	7,600	7,600	7,600	7,600	7,600	7,600
Total Retail Demand	16,625	18,070	19,625	20,550	21,570	21,570
Local Supplies						
Recycled Water	4,924	6,110	6,990	8,170	8,800	8,880
Non-Potable GW	1,000	1,000	1,000	1,000	1,000	1,000
Total Non-Potable	5,924	7,110	7,990	9,170	9,800	9,880
Recovered GW	-	425	950	950	950	950
Potable GW	3,600	3,600	3,600	3,600	3,600	3,600
Total Potable	3,600	4,025	4,550	4,550	4,550	4,550
Total Local Supplies	9,524	11,135	12,540	13,720	14,350	14,430
IMPORTED WATER DEMAND	7,101	6,935	7,085	6,830	7,220	7,140

8 Crestview Mutual Water Company

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	1,128	1,150	1,175	1,200	1,200	1,200
Agricultural	-	-	-	-	-	-
Total Retail Demand	1,128	1,150	1,175	1,200	1,200	1,200
Local Supplies						
Recycled Water	-	-	-	-	-	-
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	-	-	-	-	-	-
Recovered GW	-	-	-	-	-	-
Potable GW	772	770	770	770	770	770
Total Potable	772	770	770	770	770	770
Total Local Supplies	772	770	770	770	770	770
IMPORTED WATER DEMAND	356	380	405	430	430	430

CMWD 2010 UWMP - PURVEYOR FORECAST SUMMARY (AC-FT)

NORMAL YEAR SCENARIO

9 Golden State Water Company

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	9,072	9,399	9,962	10,514	11,055	11,555
Agricultural	-	-	-	-	-	-
Total Retail Demand	9,072	9,399	9,962	10,514	11,055	11,555
Local Supplies						
Recycled Water	-	-	-	-	-	-
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	-	-	-	-	-	-
Recovered GW	-	-	-	-	-	-
Potable GW	1,000	1,000	1,000	1,000	1,000	1,000
Total Potable	1,000	1,000	1,000	1,000	1,000	1,000
Total Local Supplies	1,000	1,000	1,000	1,000	1,000	1,000
IMPORTED WATER DEMAND	8,072	8,399	8,962	9,514	10,055	10,555

10 Lake Sherwood CSD

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	1,503	1,687	1,870	1,870	1,870	1,870
Agricultural	-	-	-	-	-	-
Total Retail Demand	1,503	1,687	1,870	1,870	1,870	1,870
Local Supplies						
Recycled Water	300	300	300	300	300	300
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	300	300	300	300	300	300
Recovered GW	-	-	-	-	-	-
Potable GW	-	-	-	-	-	-
Total Potable	-	-	-	-	-	-
Total Local Supplies	300	300	300	300	300	300
IMPORTED WATER DEMAND	1,203	1,387	1,570	1,570	1,570	1,570

CMWD 2010 UWMP - PURVEYOR FORECAST SUMMARY (AC-FT)

NORMAL YEAR SCENARIO

11 Oak Park Water Service

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	3,890	3,890	3,890	3,890	3,890	3,890
Agricultural	-	-	-	-	-	-
Total Retail Demand	3,890	3,890	3,890	3,890	3,890	3,890
Local Supplies						
Recycled Water	790	790	790	790	790	790
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	790	790	790	790	790	790
Recovered GW	-	-	-	-	-	-
Potable GW	-	-	-	-	-	-
Total Potable	-	-	-	-	-	-
Total Local Supplies	790	790	790	790	790	790
IMPORTED WATER DEMAND	3,100	3,100	3,100	3,100	3,100	3,100

12 City of Oxnard

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	36,700	38,770	40,880	39,850	40,980	40,980
Agricultural	-	-	-	-	-	-
Total Retail Demand	36,700	38,770	40,880	39,850	40,980	40,980
Local Supplies						
Recycled Water	-	2,700	7,050	7,050	7,050	7,050
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	-	2,700	7,050	7,050	7,050	7,050
Recovered GW	-	-	-	-	-	-
Potable GW	24,932	22,425	20,185	19,155	20,285	20,285
Total Potable	24,932	22,425	20,185	19,155	20,285	20,285
Total Local Supplies	24,932	25,125	27,235	26,205	27,335	27,335
IMPORTED WATER DEMAND	11,768	13,645	13,645	13,645	13,645	13,645

CMWD 2010 UWMP - PURVEYOR FORECAST SUMMARY (AC-FT)

NORMAL YEAR SCENARIO

13 Pleasant Valley Mutual Water Company

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	1,020	1,066	1,124	1,158	1,204	1,250
Agricultural	-	-	-	-	-	-
Total Retail Demand	1,020	1,066	1,124	1,158	1,204	1,250
Local Supplies						
Recycled Water	-	-	-	-	-	-
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	-	-	-	-	-	-
Recovered GW	-	-	-	-	-	-
Potable GW	720	730	740	750	760	770
Total Potable	720	730	740	750	760	770
Total Local Supplies	720	730	740	750	760	770
IMPORTED WATER DEMAND	300	336	384	408	444	480

14 City of Simi Valley

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	24,861	25,607	26,375	27,166	27,981	28,821
Agricultural	100	101	102	103	104	105
Total Retail Demand	24,961	25,708	26,477	27,269	28,085	28,926
Local Supplies						
Recycled Water	60	80	110	110	110	110
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	60	80	110	110	110	110
Recovered GW	800	808	816	824	832	841
Potable GW	-	-	-	-	-	-
Total Potable	800	808	816	824	832	841
Total Local Supplies	860	888	926	934	942	951
IMPORTED WATER DEMAND	24,101	24,820	25,551	26,335	27,143	27,975

CMWD 2010 UWMP - PURVEYOR FORECAST SUMMARY (AC-FT)

NORMAL YEAR SCENARIO

15 Solano Verde Mutual Water Company

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	50	55	60	60	60	60
Agricultural	260	285	325	325	325	325
Total Retail Demand	310	340	385	385	385	385
Local Supplies						
Recycled Water	-	-	-	-	-	-
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	-	-	-	-	-	-
Recovered GW	-	-	-	-	-	-
Potable GW	-	-	-	-	-	-
Total Potable	-	-	-	-	-	-
Total Local Supplies	-	-	-	-	-	-
IMPORTED WATER DEMAND	310	340	385	385	385	385

16 City of Thousand Oaks

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	12,800	14,000	15,400	15,400	15,400	15,400
Agricultural	-	-	-	-	-	-
Total Retail Demand	12,800	14,000	15,400	15,400	15,400	15,400
Local Supplies						
Recycled Water	-	-	-	-	-	-
Non-Potable GW	20	35	40	40	40	40
Total Non-Potable	20	35	40	40	40	40
Recovered GW	-	-	-	-	-	-
Potable GW	-	-	-	-	-	-
Total Potable	-	-	-	-	-	-
Total Local Supplies	20	35	40	40	40	40
IMPORTED WATER DEMAND	12,780	13,965	15,360	15,360	15,360	15,360

CMWD 2010 UWMP - PURVEYOR FORECAST SUMMARY (AC-FT)

NORMAL YEAR SCENARIO

17 VCWWD No. 1

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	10,300	11,015	11,738	12,497	13,295	14,134
Agricultural	3,147	3,147	3,147	3,147	3,147	3,147
Total Retail Demand	13,447	14,162	14,885	15,644	16,442	17,281
Local Supplies						
Recycled Water	448	1,100	1,100	1,100	1,100	1,100
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	448	1,100	1,100	1,100	1,100	1,100
Recovered GW	-	5,000	5,000	5,000	5,000	5,000
Potable GW	2,547	2,547	2,547	2,547	2,547	2,547
Total Potable	2,547	7,547	7,547	7,547	7,547	7,547
Total Local Supplies	2,995	8,647	8,647	8,647	8,647	8,647
IMPORTED WATER DEMAND	10,452	5,515	6,238	6,997	7,795	8,634

18 VCWWD No. 19

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	1,033	1,061	1,090	1,120	1,142	1,185
Agricultural	2,296	2,296	2,296	2,296	2,296	2,296
Total Retail Demand	3,329	3,357	3,386	3,416	3,438	3,481
Local Supplies						
Recycled Water	-	-	-	-	-	-
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	-	-	-	-	-	-
Recovered GW	-	-	-	-	-	-
Potable GW	2,523	2,523	2,523	2,523	2,523	2,523
Total Potable	2,523	2,523	2,523	2,523	2,523	2,523
Total Local Supplies	2,523	2,523	2,523	2,523	2,523	2,523
IMPORTED WATER DEMAND	806	834	863	893	915	958

CMWD 2010 UWMP - PURVEYOR FORECAST SUMMARY (AC-FT)

NORMAL YEAR SCENARIO

19 Zone Mutual Water Company

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	-	-	-	-	-	-
Agricultural	5,000	5,000	5,000	5,000	5,000	5,000
Total Retail Demand	5,000	5,000	5,000	5,000	5,000	5,000
Local Supplies						
Recycled Water	-	-	-	-	-	-
Non-Potable GW	4,500	4,500	4,500	4,500	4,500	4,500
Total Non-Potable	4,500	4,500	4,500	4,500	4,500	4,500
Recovered GW	-	-	-	-	-	-
Potable GW	-	-	-	-	-	-
Total Potable	-	-	-	-	-	-
Total Local Supplies	4,500	4,500	4,500	4,500	4,500	4,500
IMPORTED WATER DEMAND	500	500	500	500	500	500

CMWD 2010 UWMP - PURVEYOR FORECAST SUMMARY (AC-FT)

DRY YEAR SCENARIO

1 Berylwood Heights Mutual Water Company

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	-	-	-	-	-	-
Agricultural	1,600	1,900	2,500	2,900	3,600	4,200
Total Retail Demand	1,600	1,900	2,500	2,900	3,600	4,200
Local Supplies						
Recycled Water	-	-	-	-	-	-
Non-Potable GW	1,595	1,893	2,490	2,885	3,580	4,175
Total Non-Potable	1,595	1,893	2,490	2,885	3,580	4,175
Recovered GW	-	-	-	-	-	-
Potable GW	-	-	-	-	-	-
Total Potable	-	-	-	-	-	-
Total Local Supplies	1,595	1,893	2,490	2,885	3,580	4,175
IMPORTED WATER DEMAND	5	7	10	15	20	25

2 Brandeis Mutual Water Company

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	84	86	88	90	91	92
Agricultural	-	-	-	-	-	-
Total Retail Demand	84	86	88	90	91	92
Local Supplies						
Recycled Water	-	-	-	-	-	-
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	-	-	-	-	-	-
Recovered GW	-	-	-	-	-	-
Potable GW	-	-	-	-	-	-
Total Potable	-	-	-	-	-	-
Total Local Supplies	-	-	-	-	-	-
IMPORTED WATER DEMAND	84	86	88	90	91	92

CMWD 2010 UWMP - PURVEYOR FORECAST SUMMARY (AC-FT)

DRY YEAR SCENARIO

3 Butler Ranch Mutual Water Company ***(No information provided)***

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	-	-	-	-	-	-
Agricultural	-	-	-	-	-	-
Total Retail Demand	-	-	-	-	-	-
Local Supplies						
Recycled Water	-	-	-	-	-	-
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	-	-	-	-	-	-
Recovered GW	-	-	-	-	-	-
Potable GW	-	-	-	-	-	-
Total Potable	-	-	-	-	-	-
Total Local Supplies	-	-	-	-	-	-
IMPORTED WATER DEMAND	-	-	-	-	-	-

4 California-American Water Company

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	20,062	20,458	20,885	21,249	21,737	22,280
Agricultural	-	-	-	-	-	-
Total Retail Demand	20,062	20,458	20,885	21,249	21,737	22,280
Local Supplies						
Recycled Water	-	-	-	-	-	-
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	-	-	-	-	-	-
Recovered GW	-	-	-	-	-	-
Potable GW	-	-	-	-	-	-
Total Potable	-	-	-	-	-	-
Total Local Supplies	-	-	-	-	-	-
IMPORTED WATER DEMAND	20,062	20,458	20,885	21,249	21,737	22,280

CMWD 2010 UWMP - PURVEYOR FORECAST SUMMARY (AC-FT)

DRY YEAR SCENARIO

5 California Water Service

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	10,000	10,568	11,135	11,653	12,170	12,688
Agricultural	-	-	-	-	-	-
Total Retail Demand	10,000	10,568	11,135	11,653	12,170	12,688
Local Supplies						
Recycled Water	560	565	571	576	581	587
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	560	565	571	576	581	587
Recovered GW	-	-	-	-	-	-
Potable GW	-	-	-	-	-	-
Total Potable	-	-	-	-	-	-
Total Local Supplies	560	565	571	576	581	587
IMPORTED WATER DEMAND	9,440	10,003	10,564	11,077	11,589	12,101

6 City of Camarillo

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	9,490	10,107	10,763	11,248	11,529	11,817
Agricultural	350	300	250	250	250	250
Total Retail Demand	9,840	10,407	11,013	11,498	11,779	12,067
Local Supplies						
Recycled Water	-	500	500	500	500	500
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	-	500	500	500	500	500
Recovered GW	-	7,266	7,266	7,266	7,266	7,266
Potable GW	4,000	-	-	-	-	-
Total Potable	4,000	7,266	7,266	7,266	7,266	7,266
Total Local Supplies	4,000	7,766	7,766	7,766	7,766	7,766
IMPORTED WATER DEMAND	5,840	2,641	3,247	3,732	4,013	4,301

CMWD 2010 UWMP - PURVEYOR FORECAST SUMMARY (AC-FT)

DRY YEAR SCENARIO

7 Camrosa Water District

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	9,500	11,020	12,660	13,630	14,700	14,700
Agricultural	8,000	8,000	8,000	8,000	8,000	8,000
Total Retail Demand	17,500	19,020	20,660	21,630	22,700	22,700
Local Supplies						
Recycled Water	4,924	6,110	6,990	8,170	8,800	8,880
Non-Potable GW	1,000	1,000	1,000	1,000	1,000	1,000
Total Non-Potable	5,924	7,110	7,990	9,170	9,800	9,880
Recovered GW	-	425	950	950	950	950
Potable GW	3,600	3,600	3,600	3,600	3,600	3,600
Total Potable	3,600	4,025	4,550	4,550	4,550	4,550
Total Local Supplies	9,524	11,135	12,540	13,720	14,350	14,430
IMPORTED WATER DEMAND	7,976	7,885	8,120	7,910	8,350	8,270

8 Crestview Mutual Water Company

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	1,128	1,150	1,175	1,200	1,200	1,200
Agricultural	-	-	-	-	-	-
Total Retail Demand	1,128	1,150	1,175	1,200	1,200	1,200
Local Supplies						
Recycled Water	-	-	-	-	-	-
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	-	-	-	-	-	-
Recovered GW	-	-	-	-	-	-
Potable GW	772	800	800	800	800	800
Total Potable	772	800	800	800	800	800
Total Local Supplies	772	800	800	800	800	800
IMPORTED WATER DEMAND	356	350	375	400	400	400

CMWD 2010 UWMP - PURVEYOR FORECAST SUMMARY (AC-FT)

DRY YEAR SCENARIO

9 Golden State Water Company

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	9,072	9,399	9,962	10,514	11,055	11,555
Agricultural	-	-	-	-	-	-
Total Retail Demand	9,072	9,399	9,962	10,514	11,055	11,555
Local Supplies						
Recycled Water	-	-	-	-	-	-
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	-	-	-	-	-	-
Recovered GW	-	-	-	-	-	-
Potable GW	1,000	1,000	1,000	1,000	1,000	1,000
Total Potable	1,000	1,000	1,000	1,000	1,000	1,000
Total Local Supplies	1,000	1,000	1,000	1,000	1,000	1,000
IMPORTED WATER DEMAND	8,072	8,399	8,962	9,514	10,055	10,555

10 Lake Sherwood CSD

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	1,697	1,905	2,111	2,111	2,111	2,111
Agricultural	-	-	-	-	-	-
Total Retail Demand	1,697	1,905	2,111	2,111	2,111	2,111
Local Supplies						
Recycled Water	360	360	360	360	360	360
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	360	360	360	360	360	360
Recovered GW	-	-	-	-	-	-
Potable GW	-	-	-	-	-	-
Total Potable	-	-	-	-	-	-
Total Local Supplies	360	360	360	360	360	360
IMPORTED WATER DEMAND	1,337	1,545	1,751	1,751	1,751	1,751

CMWD 2010 UWMP - PURVEYOR FORECAST SUMMARY (AC-FT)

DRY YEAR SCENARIO

11 Oak Park Water Service

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	4,050	4,050	4,050	4,050	4,050	4,050
Agricultural	-	-	-	-	-	-
Total Retail Demand	4,050	4,050	4,050	4,050	4,050	4,050
Local Supplies						
Recycled Water	850	850	850	850	850	850
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	850	850	850	850	850	850
Recovered GW	-	-	-	-	-	-
Potable GW	-	-	-	-	-	-
Total Potable	-	-	-	-	-	-
Total Local Supplies	850	850	850	850	850	850
IMPORTED WATER DEMAND	3,200	3,200	3,200	3,200	3,200	3,200

12 City of Oxnard

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	36,700	38,770	40,880	39,850	40,980	40,980
Agricultural	-	-	-	-	-	-
Total Retail Demand	36,700	38,770	40,880	39,850	40,980	40,980
Local Supplies						
Recycled Water	-	2,700	7,050	7,050	7,050	7,050
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	-	2,700	7,050	7,050	7,050	7,050
Recovered GW	-	-	-	-	-	-
Potable GW	24,932	22,425	20,185	19,155	20,285	20,285
Total Potable	24,932	22,425	20,185	19,155	20,285	20,285
Total Local Supplies	24,932	25,125	27,235	26,205	27,335	27,335
IMPORTED WATER DEMAND	11,768	13,645	13,645	13,645	13,645	13,645

CMWD 2010 UWMP - PURVEYOR FORECAST SUMMARY (AC-FT)

DRY YEAR SCENARIO

13 Pleasant Valley Mutual Water Company

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	974	1,020	1,066	1,124	1,170	1,204
Agricultural	-	-	-	-	-	-
Total Retail Demand	974	1,020	1,066	1,124	1,170	1,204
Local Supplies						
Recycled Water	-	-	-	-	-	-
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	-	-	-	-	-	-
Recovered GW	-	-	-	-	-	-
Potable GW	710	720	730	740	750	760
Total Potable	710	720	730	740	750	760
Total Local Supplies	710	720	730	740	750	760
IMPORTED WATER DEMAND	264	300	336	384	420	444

14 City of Simi Valley

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	24,861	26,104	27,409	28,780	30,219	31,730
Agricultural	100	101	102	103	104	105
Total Retail Demand	24,961	26,205	27,511	28,883	30,323	31,835
Local Supplies						
Recycled Water	70	90	110	110	110	110
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	70	90	110	110	110	110
Recovered GW	800	824	849	874	900	927
Potable GW	-	-	-	-	-	-
Total Potable	800	824	849	874	900	927
Total Local Supplies	870	914	959	984	1,010	1,037
IMPORTED WATER DEMAND	24,091	25,291	26,552	27,899	29,313	30,798

CMWD 2010 UWMP - PURVEYOR FORECAST SUMMARY (AC-FT)

DRY YEAR SCENARIO

15 Solano Verde Mutual Water Company

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	50	55	60	60	60	60
Agricultural	260	265	265	285	285	285
Total Retail Demand	310	320	325	345	345	345
Local Supplies						
Recycled Water	-	-	-	-	-	-
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	-	-	-	-	-	-
Recovered GW	-	-	-	-	-	-
Potable GW	-	-	-	-	-	-
Total Potable	-	-	-	-	-	-
Total Local Supplies	-	-	-	-	-	-
IMPORTED WATER DEMAND	310	320	325	345	345	345

16 City of Thousand Oaks

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	14,100	15,300	15,300	15,300	15,300	15,300
Agricultural	-	-	-	-	-	-
Total Retail Demand	14,100	15,300	15,300	15,300	15,300	15,300
Local Supplies						
Recycled Water	-	-	-	-	-	-
Non-Potable GW	20	35	40	40	40	40
Total Non-Potable	20	35	40	40	40	40
Recovered GW	-	-	-	-	-	-
Potable GW	-	-	-	-	-	-
Total Potable	-	-	-	-	-	-
Total Local Supplies	20	35	40	40	40	40
IMPORTED WATER DEMAND	14,080	15,265	15,260	15,260	15,260	15,260

CMWD 2010 UWMP - PURVEYOR FORECAST SUMMARY (AC-FT)

DRY YEAR SCENARIO

17 VCWWD No. 1

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	12,065	12,965	13,568	13,942	15,416	16,363
Agricultural	3,147	3,147	3,147	3,147	3,147	3,147
Total Retail Demand	15,212	16,112	16,715	17,089	18,563	19,510
Local Supplies						
Recycled Water	448	1,100	1,100	1,100	1,100	1,100
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	448	1,100	1,100	1,100	1,100	1,100
Recovered GW	-	5,000	5,000	5,000	5,000	5,000
Potable GW	2,547	2,547	2,547	2,547	2,547	2,547
Total Potable	2,547	7,547	7,547	7,547	7,547	7,547
Total Local Supplies	2,995	8,647	8,647	8,647	8,647	8,647
IMPORTED WATER DEMAND	12,217	7,465	8,068	8,442	9,916	10,863

18 VCWWD No. 19

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	1,462	1,494	1,527	1,561	1,586	1,634
Agricultural	2,296	2,296	2,296	2,296	2,296	2,296
Total Retail Demand	3,758	3,790	3,823	3,857	3,882	3,930
Local Supplies						
Recycled Water	-	-	-	-	-	-
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	-	-	-	-	-	-
Recovered GW	-	-	-	-	-	-
Potable GW	2,523	2,523	2,523	2,523	2,523	2,523
Total Potable	2,523	2,523	2,523	2,523	2,523	2,523
Total Local Supplies	2,523	2,523	2,523	2,523	2,523	2,523
IMPORTED WATER DEMAND	1,235	1,267	1,300	1,334	1,359	1,407

CMWD 2010 UWMP - PURVEYOR FORECAST SUMMARY (AC-FT)

DRY YEAR SCENARIO

19 Zone Mutual Water Company

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	-	-	-	-	-	-
Agricultural	5,500	5,500	5,500	5,500	5,500	5,500
Total Retail Demand	5,500	5,500	5,500	5,500	5,500	5,500
Local Supplies						
Recycled Water	-	-	-	-	-	-
Non-Potable GW	5,000	5,000	5,000	5,000	5,000	5,000
Total Non-Potable	5,000	5,000	5,000	5,000	5,000	5,000
Recovered GW	-	-	-	-	-	-
Potable GW	-	-	-	-	-	-
Total Potable	-	-	-	-	-	-
Total Local Supplies	5,000	5,000	5,000	5,000	5,000	5,000
IMPORTED WATER DEMAND	500	500	500	500	500	500

CMWD 2010 UWMP - PURVEYOR FORECAST SUMMARY (AC-FT)

MULTIPLE DRY YEAR SCENARIO

1 Berylwood Heights Mutual Water Company

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	-	-	-	-	-	-
Agricultural	1,650	1,950	2,550	2,950	3,650	4,250
Total Retail Demand	1,650	1,950	2,550	2,950	3,650	4,250
Local Supplies						
Recycled Water	-	-	-	-	-	-
Non-Potable GW	1,640	1,935	2,530	2,925	3,615	4,210
Total Non-Potable	1,640	1,935	2,530	2,925	3,615	4,210
Recovered GW	-	-	-	-	-	-
Potable GW	-	-	-	-	-	-
Total Potable	-	-	-	-	-	-
Total Local Supplies	1,640	1,935	2,530	2,925	3,615	4,210
IMPORTED WATER DEMAND	10	15	20	25	35	40

2 Brandeis Mutual Water Company

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	84	86	88	90	91	92
Agricultural	-	-	-	-	-	-
Total Retail Demand	84	86	88	90	91	92
Local Supplies						
Recycled Water	-	-	-	-	-	-
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	-	-	-	-	-	-
Recovered GW	-	-	-	-	-	-
Potable GW	-	-	-	-	-	-
Total Potable	-	-	-	-	-	-
Total Local Supplies	-	-	-	-	-	-
IMPORTED WATER DEMAND	84	86	88	90	91	92

CMWD 2010 UWMP - PURVEYOR FORECAST SUMMARY (AC-FT)

MULTIPLE DRY YEAR SCENARIO

3 Butler Ranch Mutual Water Company ***(No information provided)***

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	-	-	-	-	-	-
Agricultural	-	-	-	-	-	-
Total Retail Demand	-	-	-	-	-	-
Local Supplies						
Recycled Water	-	-	-	-	-	-
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	-	-	-	-	-	-
Recovered GW	-	-	-	-	-	-
Potable GW	-	-	-	-	-	-
Total Potable	-	-	-	-	-	-
Total Local Supplies	-	-	-	-	-	-
IMPORTED WATER DEMAND	-	-	-	-	-	-

4 California-American Water Company

	2010	2015	2020	2025	2030	2035
Retail Wate Municipal and Industrial	20,062	20,458	20,885	21,249	21,737	22,280
Agricultural	-	-	-	-	-	-
Total Retail Demand	20,062	20,458	20,885	21,249	21,737	22,280
Local Supplies						
Recycled Water	-	-	-	-	-	-
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	-	-	-	-	-	-
Recovered GW	-	-	-	-	-	-
Potable GW	-	-	-	-	-	-
Total Potable	-	-	-	-	-	-
Total Local Supplies	-	-	-	-	-	-
IMPORTED WATER DEMAND	20,062	20,458	20,885	21,249	21,737	22,280

CMWD 2010 UWMP - PURVEYOR FORECAST SUMMARY (AC-FT)

MULTIPLE DRY YEAR SCENARIO

5 California Water Service

		2010	2015	2020	2025	2030	2035
Retail Wate	Municipal and Industrial	8,737	8,796	8,856	8,915	8,976	9,038
	Agricultural	-	-	-	-	-	-
	Total Retail Demand	8,737	8,796	8,856	8,915	8,976	9,038
Local Supplies							
	Recycled Water	560	565	571	576	581	587
	Non-Potable GW	-	-	-	-	-	-
	Total Non-Potable	560	565	571	576	581	587
	Recovered GW	-	-	-	-	-	-
	Potable GW	-	-	-	-	-	-
	Total Potable	-	-	-	-	-	-
	Total Local Supplies	560	565	571	576	581	587
IMPORTED WATER DEMAND		8,177	8,231	8,285	8,339	8,395	8,451

6 City of Camarillo

Retail Water Demand		2010	2015	2020	2025	2030	2035
	Municipal and Industrial	8,362	8,848	9,333	9,769	10,204	10,640
	Agricultural	350	300	250	250	250	250
	Total Retail Demand	8,712	9,148	9,583	10,019	10,454	10,890
Local Supplies							
	Recycled Water	-	500	500	500	500	500
	Non-Potable GW	-	-	-	-	-	-
	Total Non-Potable	-	500	500	500	500	500
	Recovered GW	-	7,266	7,266	7,266	7,266	7,266
	Potable GW	4,000	-	-	-	-	-
	Total Potable	4,000	7,266	7,266	7,266	7,266	7,266
	Total Local Supplies	4,000	7,766	7,766	7,766	7,766	7,766
IMPORTED WATER DEMAND		4,712	1,382	1,817	2,253	2,688	3,124

CMWD 2010 UWMP - PURVEYOR FORECAST SUMMARY (AC-FT)

MULTIPLE DRY YEAR SCENARIO

7 Camrosa Water District

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	11,210	13,000	15,000	16,000	17,350	17,350
Agricultural	9,440	9,440	9,440	9,440	9,440	9,440
Total Retail Demand	20,650	22,440	24,440	25,440	26,790	26,790
Local Supplies						
Recycled Water	4,924	6,110	6,160	6,760	6,840	6,920
Non-Potable GW	700	700	700	700	700	700
Total Non-Potable	5,624	6,810	6,860	7,460	7,540	7,620
Recovered GW	-	300	950	950	950	950
Potable GW	2,500	2,500	2,500	2,500	2,500	2,500
Total Potable	2,500	2,800	3,450	3,450	3,450	3,450
Total Local Supplies	8,124	9,610	10,310	10,910	10,990	11,070
IMPORTED WATER DEMAND	12,526	12,830	14,130	14,530	15,800	15,720

8 Crestview Mutual Water Company

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	1,128	1,150	1,175	1,200	1,200	1,200
Agricultural	-	-	-	-	-	-
Total Retail Demand	1,128	1,150	1,175	1,200	1,200	1,200
Local Supplies						
Recycled Water	-	-	-	-	-	-
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	-	-	-	-	-	-
Recovered GW	-	-	-	-	-	-
Potable GW	772	900	900	900	900	900
Total Potable	772	900	900	900	900	900
Total Local Supplies	772	900	900	900	900	900
IMPORTED WATER DEMAND	356	250	275	300	300	300

CMWD 2010 UWMP - PURVEYOR FORECAST SUMMARY (AC-FT)

MULTIPLE DRY YEAR SCENARIO

9 Golden State Water Company

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	8,165	8,459	8,966	9,463	9,950	10,400
Agricultural	-	-	-	-	-	-
Total Retail Demand	8,165	8,459	8,966	9,463	9,950	10,400
Local Supplies						
Recycled Water	-	-	-	-	-	-
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	-	-	-	-	-	-
Recovered GW	-	-	-	-	-	-
Potable GW	1,000	1,000	1,000	1,000	1,000	1,000
Total Potable	1,000	1,000	1,000	1,000	1,000	1,000
Total Local Supplies	1,000	1,000	1,000	1,000	1,000	1,000
IMPORTED WATER DEMAND	7,165	7,459	7,966	8,463	8,950	9,400

10 Lake Sherwood CSD

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	1,725	1,937	2,147	2,147	2,147	2,147
Agricultural	-	-	-	-	-	-
Total Retail Demand	1,725	1,937	2,147	2,147	2,147	2,147
Local Supplies						
Recycled Water	390	390	390	390	390	390
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	390	390	390	390	390	390
Recovered GW	-	-	-	-	-	-
Potable GW	-	-	-	-	-	-
Total Potable	-	-	-	-	-	-
Total Local Supplies	390	390	390	390	390	390
IMPORTED WATER DEMAND	1,335	1,547	1,757	1,757	1,757	1,757

CMWD 2010 UWMP - PURVEYOR FORECAST SUMMARY (AC-FT)

MULTIPLE DRY YEAR SCENARIO

11 Oak Park Water Service

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	3,940	3,940	3,940	3,940	3,940	3,940
Agricultural	-	-	-	-	-	-
Total Retail Demand	3,940	3,940	3,940	3,940	3,940	3,940
Local Supplies						
Recycled Water	840	840	840	840	840	840
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	840	840	840	840	840	840
Recovered GW	-	-	-	-	-	-
Potable GW	-	-	-	-	-	-
Total Potable	-	-	-	-	-	-
Total Local Supplies	840	840	840	840	840	840
IMPORTED WATER DEMAND	3,100	3,100	3,100	3,100	3,100	3,100

12 City of Oxnard

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	36,700	38,770	40,920	39,920	41,080	41,080
Agricultural	-	-	-	-	-	-
Total Retail Demand	36,700	38,770	40,920	39,920	41,080	41,080
Local Supplies						
Recycled Water	-	2,700	7,050	7,050	7,050	7,050
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	-	2,700	7,050	7,050	7,050	7,050
Recovered GW	-	-	-	-	-	-
Potable GW	24,932	16,740	15,210	15,460	15,670	15,670
Total Potable	24,932	16,740	15,210	15,460	15,670	15,670
Total Local Supplies	24,932	19,440	22,260	22,510	22,720	22,720
IMPORTED WATER DEMAND	11,768	19,330	18,660	17,410	18,360	18,360

CMWD 2010 UWMP - PURVEYOR FORECAST SUMMARY (AC-FT)

MULTIPLE DRY YEAR SCENARIO

13 Pleasant Valley Mutual Water Company

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	952	998	1,044	1,102	1,148	1,182
Agricultural	-	-	-	-	-	-
Total Retail Demand	952	998	1,044	1,102	1,148	1,182
Local Supplies						
Recycled Water	-	-	-	-	-	-
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	-	-	-	-	-	-
Recovered GW	-	-	-	-	-	-
Potable GW	700	710	720	730	740	750
Total Potable	700	710	720	730	740	750
Total Local Supplies	700	710	720	730	740	750
IMPORTED WATER DEMAND	252	288	324	372	408	432

14 City of Simi Valley

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	24,861	26,104	27,409	28,780	30,219	31,730
Agricultural	100	100	100	100	100	100
Total Retail Demand	24,961	26,204	27,509	28,880	30,319	31,830
Local Supplies						
Recycled Water	80	100	110	110	110	110
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	80	100	110	110	110	110
Recovered GW	800	840	882	926	972	1,021
Potable GW	-	-	-	-	-	-
Total Potable	800	840	882	926	972	1,021
Total Local Supplies	880	940	992	1,036	1,082	1,131
IMPORTED WATER DEMAND	24,081	25,264	26,517	27,844	29,237	30,699

CMWD 2010 UWMP - PURVEYOR FORECAST SUMMARY (AC-FT)

MULTIPLE DRY YEAR SCENARIO

15 Solano Verde Mutual Water Company

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	55	60	65	65	65	65
Agricultural	290	320	360	360	360	360
Total Retail Demand	345	380	425	425	425	425
Local Supplies						
Recycled Water	-	-	-	-	-	-
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	-	-	-	-	-	-
Recovered GW	-	-	-	-	-	-
Potable GW	-	-	-	-	-	-
Total Potable	-	-	-	-	-	-
Total Local Supplies	-	-	-	-	-	-
IMPORTED WATER DEMAND	345	380	425	425	425	425

16 City of Thousand Oaks

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	14,100	15,300	15,300	15,300	15,300	15,300
Agricultural	-	-	-	-	-	-
Total Retail Demand	14,100	15,300	15,300	15,300	15,300	15,300
Local Supplies						
Recycled Water	-	-	-	-	-	-
Non-Potable GW	20	35	40	40	40	40
Total Non-Potable	20	35	40	40	40	40
Recovered GW	-	-	-	-	-	-
Potable GW	-	-	-	-	-	-
Total Potable	-	-	-	-	-	-
Total Local Supplies	20	35	40	40	40	40
IMPORTED WATER DEMAND	14,080	15,265	15,260	15,260	15,260	15,260

CMWD 2010 UWMP - PURVEYOR FORECAST SUMMARY (AC-FT)

MULTIPLE DRY YEAR SCENARIO

17 VCWWD No. 1

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	12,321	13,111	13,941	14,812	15,728	16,692
Agricultural	3,174	3,174	3,174	3,174	3,174	3,174
Total Retail Demand	15,495	16,285	17,115	17,986	18,902	19,866
Local Supplies						
Recycled Water	448	1,100	1,100	1,100	1,100	1,100
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	448	1,100	1,100	1,100	1,100	1,100
Recovered GW	-	5,000	5,000	5,000	5,000	5,000
Potable GW	2,547	2,547	2,547	2,547	2,547	2,547
Total Potable	2,547	7,547	7,547	7,547	7,547	7,547
Total Local Supplies	2,995	8,647	8,647	8,647	8,647	8,647
IMPORTED WATER DEMAND	12,500	7,638	8,468	9,339	10,255	11,219

18 VCWWD No. 19

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	1,526	1,558	1,591	1,626	1,651	1,700
Agricultural	2,296	2,296	2,296	2,296	2,296	2,296
Total Retail Demand	3,822	3,854	3,887	3,922	3,947	3,996
Local Supplies						
Recycled Water	-	-	-	-	-	-
Non-Potable GW	-	-	-	-	-	-
Total Non-Potable	-	-	-	-	-	-
Recovered GW	-	-	-	-	-	-
Potable GW	2,523	2,523	2,523	2,523	2,523	2,523
Total Potable	2,523	2,523	2,523	2,523	2,523	2,523
Total Local Supplies	2,523	2,523	2,523	2,523	2,523	2,523
IMPORTED WATER DEMAND	1,299	1,331	1,364	1,399	1,424	1,473

CMWD 2010 UWMP - PURVEYOR FORECAST SUMMARY (AC-FT)

MULTIPLE DRY YEAR SCENARIO

19 Zone Mutual Water Company

Retail Water Demand	2010	2015	2020	2025	2030	2035
Municipal and Industrial	-	-	-	-	-	-
Agricultural	5,500	5,500	5,500	5,500	5,500	5,500
Total Retail Demand	5,500	5,500	5,500	5,500	5,500	5,500
Local Supplies						
Recycled Water	-	-	-	-	-	-
Non-Potable GW	5,000	5,000	5,000	5,000	5,000	5,000
Total Non-Potable	5,000	5,000	5,000	5,000	5,000	5,000
Recovered GW	-	-	-	-	-	-
Potable GW	-	-	-	-	-	-
Total Potable	-	-	-	-	-	-
Total Local Supplies	5,000	5,000	5,000	5,000	5,000	5,000
IMPORTED WATER DEMAND	500	500	500	500	500	500

Appendix D
CUWCC Annual Reports

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BMP 03: System Water Audits, Leak Detection and Repair

Reporting Unit:	BMP Form Status:	Year:
Calleguas Municipal Water District	**100% Complete**	**2005**

A. Implementation

1. Does your agency own or operate a water distribution system?	yes
2. Has your agency completed a pre-screening system audit for this reporting year?	yes
3. If YES, enter the values (AF/Year) used to calculate verifiable use as a percent of total production:	
a. Determine metered sales (AF)	116770
b. Determine other system verifiable uses (AF)	1784.6
c. Determine total supply into the system (AF)	120057.4
d. Using the numbers above, if (Metered Sales + Other Verifiable Uses) / Total Supply is < 0.9 then a full-scale system audit is required.	0.99
4. Does your agency keep necessary data on file to verify the values entered in question 3?	yes
5. Did your agency complete a full-scale audit during this report year?	yes
6. Does your agency maintain in-house records of audit results or completed AWWA M36 audit worksheets for the completed audit which could be forwarded to CUWCC?	yes
7. Does your agency operate a system leak detection program?	yes

a. If yes, describe the leak detection program:

The transmission system is continually audited by District operations and maintenance staff.

B. Survey Data

1. Total number of miles of distribution system line.	149.5
2. Number of miles of distribution system line surveyed.	149.5

C. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP?	No

a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

D. Comments

Voluntary Questions (Not used to calculate compliance)

E. Volumes

	Estimated	Verified
1. Volume of raw water supplied to the system:		
2. Volume treated water supplied into the system:		

3. Volume of water exported from the system:

4. Volume of billed authorized metered consumption:

5. Volume of billed authorized unmetered consumption:

6. Volume of unbilled authorized metered consumption:

7. Volume of unbilled authorized unmetered consumption:

F. Infrastructure and Hydraulics

1. System input (source or master meter) volumes metered at the entry to the:

2. How frequently are they tested and calibrated?

3. Length of mains:

4. What % of distribution mains are rigid pipes (metal, ac, concrete)?

5. Number of service connections:

6. What % of service connections are rigid pipes (metal)?

7. Are residential properties fully metered?

8. Are non-residential properties fully metered?

9. Provide an estimate of customer meter under-registration:

10. Average length of customer service line from the main to the point of the meter:

11. Average system pressure:

12. Range of system pressures: From to

13. What percentage of the system is fed from gravity feed?

14. What percentage of the system is fed by pumping and re-pumping?

G. Maintenance Questions

1. Who is responsible for providing, testing, repairing and replacing customer meters?

2. Does your agency test, repair and replace your meters on a regular timed schedule?

a. If yes, does your agency test by meter size or customer category?:

b. If yes to meter size, please provide the frequency of testing by meter size:

Less than or equal to 1"

1.5" to 2"

3" and Larger

c. If yes to customer category, provide the frequency of testing by customer category:

SF residential

MF residential

Commercial

Industrial & Institutional

3. Who is responsible for repairs to the customer lateral or customer service line?

4. Who is responsible for service line repairs downstream of the customer meter?

5. Does your agency proactively search for leaks using leak survey techniques or does your utility reactively repair leaks which are called in, or both?

6. What is the utility budget breakdown for:

Leak Detection	$
Leak Repair	$
Auditing and Water Loss Evaluation	$
Meter Testing	$

H. Comments

Reported as of 6/

BMP 07: Public Information Programs

Reporting Unit:
Calleguas Municipal Water District

BMP Form Status:
100% Complete

Year:
2005

A. Implementation

1. How is your public information program implemented?
Wholesaler implements program (none or minimal retailer participation)

2. Describe the program and how it's organized:
District promotes conservation programs through it's website, tours, speaking engagements and class presentations.

3. Indicate which and how many of the following activities are included in your public information program:

Region-Wide Public Information Program Activity	Yes/No	Number of Events
a. Paid Advertising	no	
b. Public Service Announcement	no	
c. Bill Inserts / Newsletters / Brochures	yes	10
d. Bill showing water usage in comparison to previous year's usage	no	
e. Demonstration Gardens	yes	2
f. Special Events, Media Events	yes	1
g. Speaker's Bureau	yes	23
h. Program to coordinate with other government agencies, industry and public interest groups and media	yes	

B. Conservation Information Program Expenditures

1. Annual Expenditures (Excluding Staffing) 13807.5

C. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP? No

a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

D. Comments

Reported as of 6/

BMP 08: School Education Programs

Reporting Unit:
Calleguas Municipal Water District

BMP Form Status:
100% Complete

Year:
2005

A. Implementation

1. How is your public information program implemented?
Wholesaler and retailer both participate in program

2. Please provide information on your region-wide school programs (by grade level):

Grade	Are grade-appropriate materials distributed?	No. of class presentations	No. of students reached	No. of teachers' workshops
Grades K-3rd	yes	15	300	3
Grades 4th-6th	yes	12	240	3
Grades 7th-8th	yes	0	0	2
High School	yes	0	0	3

4. Did your Agency's materials meet state education framework requirements? yes

5. When did your Agency begin implementing this program? 06/03/1991

B. School Education Program Expenditures

1. Annual Expenditures (Excluding Staffing) 6000

C. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP? No

a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

D. Comments

Calleguas Partners with Metropolitan Water district of Southern California (MWD) to implement education programs. MWD provide inservices to teachers who with to participate in their programs. All inservices and materials are free.

Reported as of 6/

BMP 10: Wholesale Agency Assistance Programs

Reporting Unit:
Calleguas Municipal Water District

BMP Form Status:
100% Complete

Year:
2005

A. Implementation

1. Financial Support by BMP

BMP	Financial Incentives Offered?	Budgeted Amount	Amount Awarded	BMP	Financial Incentives Offered?	Budgeted Amount	Amount Awarded
1	No	0	0	**8**	yes	2815	6000
2	No	0	0	**9**	No	0	0
3	No	0	0	**10**	No	0	0
4	No	0	0	**11**	No	0	0
5	yes	5000	0	**12**	yes	46370	46370
6	yes	10000	91710	**13**	No	0	0
7	yes	2815	3818	**14**	yes	30000	30940

2. Technical Support

a. Has your agency conducted or funded workshops addressing CUWCC procedures for calculating program savings, costs and cost-effectiveness?	No
b. Has your agency conducted or funded workshops addressing retail agencies' BMP implementation reporting requirements?	No
c. Has your agency conducted or funded workshops addressing:	
1) ULFT replacement	No
2) Residential retrofits	No
3) Commercial, industrial, and institutional surveys	No
4) Residential and large turf irrigation	No
5) Conservation-related rates and pricing	No

3. Staff Resources by BMP

Qualified	No. FTE	Qualified	No. FTE

BMP	Staff Available for BMP?	Staff Assigned to BMP	BMP	Staff Available for BMP?	Staff Assigned to BMP
1	yes	1	**8**	yes	1
2	yes	1	**9**	yes	1
3	yes	1	**10**	yes	1
4	yes	1	**11**	yes	1
5	yes	1	**12**	yes	1
6	yes	1	**13**	yes	1
7	yes	1	**14**	yes	1

4. Regional Programs by BMP

BMP	Implementation/ Management Program?	BMP	Implementation/ Management Program?
1	No	**8**	No
2	No	**9**	yes
3	No	**10**	No
4	No	**11**	No
5	No	**12**	No
6	No	**13**	No
7	No	**14**	No

B. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP? No

a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

C. Comments

Metropolitan Water District of Southern California (MWD) offers multiple conservation programs available to Calleguas and in turn is also offered to all Calleguas sub agencies. MWD money for their programs is provided by member agencies of whiich Calleguas is one. While Calleguas may not budget for a particular BMP directly, it may be indirectly providing funding via MWD. CUWCC workshops were available to Calleguas sub agencies through MWD.

BMP 12: Conservation Coordinator

Reporting Unit:	BMP Form Status:	Year:
Calleguas Municipal Water District	**100% Complete**	**2005**

A. Implementation

1. Does your Agency have a conservation coordinator?	yes
2. Is this a full-time position?	
3. If no, is the coordinator supplied by another agency with which you cooperate in a regional conservation program ?	no
4. Partner agency's name:	
5. If your agency supplies the conservation coordinator:	
a. What percent is this conservation coordinator's position?	50%
b. Coordinator's Name	Steven Sabbe
c. Coordinator's Title	Resource Specialist
d. Coordinator's Experience and Number of Years	7 years
e. Date Coordinator's position was created (mm/dd/yyyy)	6/3/1991
6. Number of conservation staff, including Conservation Coordinator.	1

B. Conservation Staff Program Expenditures

	This Year	Next Year
1. Budgeted Expenditures		
2. Actual Expenditures		

C. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP?	no

a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

D. Comments

50% of Resource Specialist position salary and benefits comes from conservation budget.

Reported as of 6/

BMP 03: System Water Audits, Leak Detection and Repair

Reporting Unit:	BMP Form Status:	Year:
Calleguas Municipal Water District	**100% Complete**	**2006**

A. Implementation

1. Does your agency own or operate a water distribution system?	yes
2. Has your agency completed a pre-screening system audit for this reporting year?	yes
3. If YES, enter the values (AF/Year) used to calculate verifiable use as a percent of total production:	
a. Determine metered sales (AF)	116774.1
b. Determine other system verifiable uses (AF)	1821.2
c. Determine total supply into the system (AF)	121118
d. Using the numbers above, if (Metered Sales + Other Verifiable Uses) / Total Supply is < 0.9 then a full-scale system audit is required.	0.98
4. Does your agency keep necessary data on file to verify the values entered in question 3?	yes
5. Did your agency complete a full-scale audit during this report year?	yes
6. Does your agency maintain in-house records of audit results or completed AWWA M36 audit worksheets for the completed audit which could be forwarded to CUWCC?	yes
7. Does your agency operate a system leak detection program?	yes

a. If yes, describe the leak detection program:

The transmission system is continually audited by District operations and maintenance staff.

B. Survey Data

1. Total number of miles of distribution system line.	149.5
2. Number of miles of distribution system line surveyed.	149.5

C. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP?	No

a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

D. Comments

Voluntary Questions (Not used to calculate compliance)

E. Volumes

	Estimated	Verified
1. Volume of raw water supplied to the system:		
2. Volume treated water supplied into the system:		

3. Volume of water exported from the system:

4. Volume of billed authorized metered consumption:

5. Volume of billed authorized unmetered consumption:

6. Volume of unbilled authorized metered consumption:

7. Volume of unbilled authorized unmetered consumption:

F. Infrastructure and Hydraulics

1. System input (source or master meter) volumes metered at the entry to the:

2. How frequently are they tested and calibrated?

3. Length of mains:

4. What % of distribution mains are rigid pipes (metal, ac, concrete)?

5. Number of service connections:

6. What % of service connections are rigid pipes (metal)?

7. Are residential properties fully metered?

8. Are non-residential properties fully metered?

9. Provide an estimate of customer meter under-registration:

10. Average length of customer service line from the main to the point of the meter:

11. Average system pressure:

12. Range of system pressures: From to

13. What percentage of the system is fed from gravity feed?

14. What percentage of the system is fed by pumping and re-pumping?

G. Maintenance Questions

1. Who is responsible for providing, testing, repairing and replacing customer meters?

2. Does your agency test, repair and replace your meters on a regular timed schedule?

a. If yes, does your agency test by meter size or customer category?:

b. If yes to meter size, please provide the frequency of testing by meter size:

Less than or equal to 1"

1.5" to 2"

3" and Larger

c. If yes to customer category, provide the frequency of testing by customer category:

SF residential

MF residential

Commercial

Industrial & Institutional

3. Who is responsible for repairs to the customer lateral or customer service line?

4. Who is responsible for service line repairs downstream of the customer meter?

5. Does your agency proactively search for leaks using leak survey techniques or does your utility reactively repair leaks which are called in, or both?

6. What is the utility budget breakdown for:

Leak Detection	$
Leak Repair	$
Auditing and Water Loss Evaluation	$
Meter Testing	$

H. Comments

Reported as of 6/

BMP 07: Public Information Programs

Reporting Unit:
Calleguas Municipal Water District

BMP Form Status:
100% Complete

Year:
2006

A. Implementation

1. How is your public information program implemented?
Wholesaler implements program (none or minimal retailer participation)

2. Describe the program and how it's organized:
District promotes conservation programs through it's website, tours, speaking engagements and class presentations.

3. Indicate which and how many of the following activities are included in your public information program:

Region-Wide Public Information Program Activity	Yes/No	Number of Events
a. Paid Advertising	no	
b. Public Service Announcement	no	
c. Bill Inserts / Newsletters / Brochures	yes	5
d. Bill showing water usage in comparison to previous year's usage	no	
e. Demonstration Gardens	no	
f. Special Events, Media Events	yes	1
g. Speaker's Bureau	yes	32
h. Program to coordinate with other government agencies, industry and public interest groups and media	yes	

B. Conservation Information Program Expenditures

1. Annual Expenditures (Excluding Staffing) 7699.43

C. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP? No

a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

D. Comments

Reported as of 6/

BMP 08: School Education Programs

Reporting Unit:
Calleguas Municipal Water District

BMP Form Status:
100% Complete

Year:
2006

A. Implementation

1. How is your public information program implemented?
Wholesaler and retailer both participate in program

2. Please provide information on your region-wide school programs (by grade level):

Grade	Are grade-appropriate materials distributed?	No. of class presentations	No. of students reached	No. of teachers' workshops
Grades K-3rd	yes	28	560	1
Grades 4th-6th	yes	12	240	1
Grades 7th-8th	yes	0	0	3
High School	yes	0	0	2

4. Did your Agency's materials meet state education framework requirements? yes

5. When did your Agency begin implementing this program? 06/03/1991

B. School Education Program Expenditures

1. Annual Expenditures (Excluding Staffing) 3000

C. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP? No

a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

D. Comments

Calleguas Partners with Metropolitan Water district of Southern California (MWD) to implement education programs. MWD provide inservices to teachers who with to participate in their programs. All inservices and materials are free.

Reported as of 6/

BMP 10: Wholesale Agency Assistance Programs

Reporting Unit:
Calleguas Municipal Water District

BMP Form Status:
100% Complete

Year:
2006

A. Implementation

1. Financial Support by BMP

BMP	Financial Incentives Offered?	Budgeted Amount	Amount Awarded	BMP	Financial Incentives Offered?	Budgeted Amount	Amount Awarded
1	No	0	0	**8**	yes	6596	3000
2	No	0	0	**9**	No	0	0
3	No	0	0	**10**	No	0	0
4	No	0	0	**11**	No	0	0
5	yes	10000	0	**12**	yes	31808	31808
6	yes	12500	41295	**13**	No	0	0
7	yes	6596	7699	**14**	yes	20000	5160

2. Technical Support

a. Has your agency conducted or funded workshops addressing CUWCC procedures for calculating program savings, costs and cost-effectiveness?	No
b. Has your agency conducted or funded workshops addressing retail agencies' BMP implementation reporting requirements?	No
c. Has your agency conducted or funded workshops addressing:	
1) ULFT replacement	No
2) Residential retrofits	No
3) Commercial, industrial, and institutional surveys	No
4) Residential and large turf irrigation	No
5) Conservation-related rates and pricing	No

3. Staff Resources by BMP

Qualified	No. FTE	Qualified	No. FTE

BMP	Staff Available for BMP?	Staff Assigned to BMP	BMP	Staff Available for BMP?	Staff Assigned to BMP
1	yes	1	**8**	yes	1
2	yes	1	**9**	yes	1
3	yes	1	**10**	yes	1
4	yes	1	**11**	yes	1
5	yes	1	**12**	yes	1
6	yes	1	**13**	yes	1
7	yes	1	**14**	yes	1

4. Regional Programs by BMP

BMP	Implementation/ Management Program?	BMP	Implementation/ Management Program?
1	No	**8**	No
2	No	**9**	yes
3	No	**10**	No
4	No	**11**	No
5	No	**12**	No
6	No	**13**	No
7	No	**14**	No

B. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP? No

a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

C. Comments

Metropolitan Water District of Southern California (MWD) offers multiple conservation programs available to Calleguas and in turn is also offered to all Calleguas sub agencies. MWD money for their programs is provided by member agencies of whiich Calleguas is one. While Calleguas may not budget for a particular BMP directly, it may be indirectly providing funding via MWD. Some CUWCC workshops were available to Calleguas sub agencies through MWD.

BMP 12: Conservation Coordinator

Reporting Unit:	BMP Form Status:	Year:
Calleguas Municipal Water District	**100% Complete**	**2006**

A. Implementation

1. Does your Agency have a conservation coordinator?	yes
2. Is this a full-time position?	
3. If no, is the coordinator supplied by another agency with which you cooperate in a regional conservation program ?	no
4. Partner agency's name:	
5. If your agency supplies the conservation coordinator:	
a. What percent is this conservation coordinator's position?	50%
b. Coordinator's Name	Steven Sabbe
c. Coordinator's Title	Resource Specialist
d. Coordinator's Experience and Number of Years	8 years
e. Date Coordinator's position was created (mm/dd/yyyy)	6/3/1991
6. Number of conservation staff, including Conservation Coordinator.	1

B. Conservation Staff Program Expenditures

	This Year	Next Year
1. Budgeted Expenditures		
2. Actual Expenditures		

C. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP?	no
a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."	

D. Comments

Reported as of 6/

BMP 03: System Water Audits, Leak Detection and Repair

Reporting Unit:	BMP Form Status:	Year:
Calleguas Municipal Water District	**100% Complete**	**2007**

A. Implementation

1. Does your agency own or operate a water distribution system?	yes
2. Has your agency completed a pre-screening system audit for this reporting year?	yes
3. If YES, enter the values (AF/Year) used to calculate verifiable use as a percent of total production:	
a. Determine metered sales (AF)	132916.6
b. Determine other system verifiable uses (AF)	0
c. Determine total supply into the system (AF)	133224.19
d. Using the numbers above, if (Metered Sales + Other Verifiable Uses) / Total Supply is < 0.9 then a full-scale system audit is required.	1.00
4. Does your agency keep necessary data on file to verify the values entered in question 3?	yes
5. Did your agency complete a full-scale audit during this report year?	no
6. Does your agency maintain in-house records of audit results or completed AWWA M36 audit worksheets for the completed audit which could be forwarded to CUWCC?	yes
7. Does your agency operate a system leak detection program?	yes

a. If yes, describe the leak detection program:

The transmission system is continually audited by District operations and maintenance staff.

B. Survey Data

1. Total number of miles of distribution system line.	150
2. Number of miles of distribution system line surveyed.	150

C. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP?	No

a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

D. Comments

Percentage of loss was .997%.

Voluntary Questions (Not used to calculate compliance)

E. Volumes

	Estimated	Verified
1. Volume of raw water supplied to the system:		
2. Volume treated water supplied into the system:		

3. Volume of water exported from the system:

4. Volume of billed authorized metered consumption:

5. Volume of billed authorized unmetered consumption:

6. Volume of unbilled authorized metered consumption:

7. Volume of unbilled authorized unmetered consumption:

F. Infrastructure and Hydraulics

1. System input (source or master meter) volumes metered at the entry to the:

2. How frequently are they tested and calibrated?

3. Length of mains:

4. What % of distribution mains are rigid pipes (metal, ac, concrete)?

5. Number of service connections:

6. What % of service connections are rigid pipes (metal)?

7. Are residential properties fully metered?

8. Are non-residential properties fully metered?

9. Provide an estimate of customer meter under-registration:

10. Average length of customer service line from the main to the point of the meter:

11. Average system pressure:

12. Range of system pressures: From to

13. What percentage of the system is fed from gravity feed?

14. What percentage of the system is fed by pumping and re-pumping?

G. Maintenance Questions

1. Who is responsible for providing, testing, repairing and replacing customer meters?

2. Does your agency test, repair and replace your meters on a regular timed schedule?

a. If yes, does your agency test by meter size or customer category?:

b. If yes to meter size, please provide the frequency of testing by meter size:

Less than or equal to 1"

1.5" to 2"

3" and Larger

c. If yes to customer category, provide the frequency of testing by customer category:

SF residential

MF residential

Commercial

Industrial & Institutional

3. Who is responsible for repairs to the customer lateral or customer service line?

4. Who is responsible for service line repairs downstream of the customer meter?

5. Does your agency proactively search for leaks using leak survey techniques or does your utility reactively repair leaks which are called in, or both?

6. What is the utility budget breakdown for:

Leak Detection	$
Leak Repair	$
Auditing and Water Loss Evaluation	$
Meter Testing	$

H. Comments

Reported as of 6/

BMP 07: Public Information Programs

Reporting Unit:	BMP Form Status:	Year:
Calleguas Municipal Water District	**100% Complete**	**2007**

A. Implementation

1. How is your public information program implemented?
   Wholesaler and retailer both materially participate in program

2. Describe the program and how it's organized:
   District promotes conservation, education, and public awareness programs through it's website, tours, speaking engagements and class room presentations.

3. Indicate which and how many of the following activities are included in your public information program:

Region-Wide Public Information Program Activity	Yes/No	Number of Events
a. Paid Advertising	no	
b. Public Service Announcement	no	
c. Bill Inserts / Newsletters / Brochures	no	
d. Bill showing water usage in comparison to previous year's usage	no	
e. Demonstration Gardens	yes	5500
f. Special Events, Media Events	yes	2500
g. Speaker's Bureau	yes	0
h. Program to coordinate with other government agencies, industry and public interest groups and media	yes	

B. Conservation Information Program Expenditures

1. Annual Expenditures (Excluding Staffing) 8000

C. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP? No

   a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

D. Comments

Money was given to a purveyor for installation of Cal Friendly Garden. Money also given to local Rescource Conseravtion District for Native Garden. These and the above efforts in addition to the efforts by Metropolitan Water District of Southern California (MWD) in both advertising and public outreach events make up our public information programs. Calleguas MWD contributes to a "Water Stewardship" fund in the rates we pay to MWD to continue such programs on behalf of their member agencies.

Reported as of 6/

BMP 08: School Education Programs

Reporting Unit:
Calleguas Municipal Water District

BMP Form Status:
100% Complete

Year:
2007

A. Implementation

1. How is your public information program implemented?
Wholesaler and retailer both participate in program

2. Please provide information on your region-wide school programs (by grade level):

Grade	Are grade-appropriate materials distributed?	No. of class presentations	No. of students reached	No. of teachers' workshops
Grades K-3rd	yes	12	240	1
Grades 4th-6th	yes	10	300	1
Grades 7th-8th	no	0	0	0
High School	no	0	0	0

4. Did your Agency's materials meet state education framework requirements? yes

5. When did your Agency begin implementing this program? 06/03/1991

B. School Education Program Expenditures

1. Annual Expenditures (Excluding Staffing) 5000

C. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP? No

a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

D. Comments

Calleguas MWD offers and provides tours of facilities to schools throughout the service area as well as offering in class presentations to EVERY elementary school in the service area. In addition, Calleguas Partners with Metropolitan Water district of Southern California (MWD) to implement education programs. MWD provide inservices to teachers who with to participate in their programs. All inservices and materials are free.

Reported as of 6/

BMP 10: Wholesale Agency Assistance Programs

Reporting Unit:
Calleguas Municipal Water District

BMP Form Status:
100% Complete

Year:
2007

A. Implementation

1. Financial Support by BMP

BMP	Financial Incentives Offered?	Budgeted Amount	Amount Awarded	BMP	Financial Incentives Offered?	Budgeted Amount	Amount Awarded
1	No			**8**	yes	5000	5000
2	No			**9**	No		
3	No			**10**	No		
4	No			**11**	No		
5	No			**12**	yes	23330	23330
6	yes	12500	12500	**13**	No		
7	yes	27500	27500	**14**	yes	34500	34500

2. Technical Support

a. Has your agency conducted or funded workshops addressing CUWCC procedures for calculating program savings, costs and cost-effectiveness?	No
b. Has your agency conducted or funded workshops addressing retail agencies' BMP implementation reporting requirements?	No
c. Has your agency conducted or funded workshops addressing:	
1) ULFT replacement	No
2) Residential retrofits	No
3) Commercial, industrial, and institutional surveys	No
4) Residential and large turf irrigation	No
5) Conservation-related rates and pricing	No

3. Staff Resources by BMP

Qualified	No. FTE	Qualified	No. FTE

BMP	Staff Available for BMP?	Staff Assigned to BMP	BMP	Staff Available for BMP?	Staff Assigned to BMP
1	yes	1	**8**	yes	1
2	yes	1	**9**	yes	1
3	yes	1	**10**	yes	1
4	yes	1	**11**	yes	1
5	yes	1	**12**	yes	1
6	yes	1	**13**	yes	1
7	yes	1	**14**	yes	1

4. Regional Programs by BMP

BMP	Implementation/ Management Program?	BMP	Implementation/ Management Program?
1	No	**8**	No
2	No	**9**	yes
3	No	**10**	No
4	No	**11**	No
5	No	**12**	No
6	No	**13**	No
7	No	**14**	No

B. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP? No

a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

C. Comments

Metropolitan Water District of Southern California (MWD) offers multiple conservation programs available to Calleguas and in turn is also offered to all Calleguas sub agencies. MWD money for their programs is provided by member agencies of whiich Calleguas is one. While Calleguas may not budget for a particular BMP directly, it may be indirectly providing funding via MWD. CUWCC workshops were available to Calleguas sub agencies through MWD.

BMP 12: Conservation Coordinator

Reporting Unit:	BMP Form Status:	Year:
Calleguas Municipal Water District	**100% Complete**	**2007**

A. Implementation

1. Does your Agency have a conservation coordinator?	yes
2. Is this a full-time position?	
3. If no, is the coordinator supplied by another agency with which you cooperate in a regional conservation program ?	no
4. Partner agency's name:	
5. If your agency supplies the conservation coordinator:	
a. What percent is this conservation coordinator's position?	75%
b. Coordinator's Name	Steven Sabbe
c. Coordinator's Title	Resource Specialist
d. Coordinator's Experience and Number of Years	9 years
e. Date Coordinator's position was created (mm/dd/yyyy)	06/03/1991
6. Number of conservation staff, including Conservation Coordinator.	1

B. Conservation Staff Program Expenditures

	This Year	Next Year
1. Budgeted Expenditures		
2. Actual Expenditures		

C. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP?	no

a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

D. Comments

Reported as of 6/

BMP 03: System Water Audits, Leak Detection and Repair

Reporting Unit:	BMP Form Status:	Year:
Calleguas Municipal Water District	**100% Complete**	**2008**

A. Implementation

1. Does your agency own or operate a water distribution system?	yes
2. Has your agency completed a pre-screening system audit for this reporting year?	yes
3. If YES, enter the values (AF/Year) used to calculate verifiable use as a percent of total production:	
a. Determine metered sales (AF)	121449.5
b. Determine other system verifiable uses (AF)	0
c. Determine total supply into the system (AF)	121593.9
d. Using the numbers above, if (Metered Sales + Other Verifiable Uses) / Total Supply is < 0.9 then a full-scale system audit is required.	1.00
4. Does your agency keep necessary data on file to verify the values entered in question 3?	yes
5. Did your agency complete a full-scale audit during this report year?	no
6. Does your agency maintain in-house records of audit results or completed AWWA M36 audit worksheets for the completed audit which could be forwarded to CUWCC?	yes
7. Does your agency operate a system leak detection program?	yes

a. If yes, describe the leak detection program:

The transmission system is continually audited by District operations and maintenance staff.

B. Survey Data

1. Total number of miles of distribution system line.	149.5
2. Number of miles of distribution system line surveyed.	149.5

C. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP?	No

a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

D. Comments

Percentage of loss was .998%. This was based on a calendar year and the month of December was not included. The system audit data is on calendar. year.

Voluntary Questions (Not used to calculate compliance)

E. Volumes

	Estimated	Verified
1. Volume of raw water supplied to the system:		
2. Volume treated water supplied into the system:		
3. Volume of water exported from the system:		
4. Volume of billed authorized metered consumption:		

5. Volume of billed authorized unmetered consumption:

6. Volume of unbilled authorized metered consumption:

7. Volume of unbilled authorized unmetered consumption:

F. Infrastructure and Hydraulics

1. System input (source or master meter) volumes metered at the entry to the:

2. How frequently are they tested and calibrated?

3. Length of mains:

4. What % of distribution mains are rigid pipes (metal, ac, concrete)?

5. Number of service connections:

6. What % of service connections are rigid pipes (metal)?

7. Are residential properties fully metered?

8. Are non-residential properties fully metered?

9. Provide an estimate of customer meter under-registration:

10. Average length of customer service line from the main to the point of the meter:

11. Average system pressure:

12. Range of system pressures: From to

13. What percentage of the system is fed from gravity feed?

14. What percentage of the system is fed by pumping and re-pumping?

G. Maintenance Questions

1. Who is responsible for providing, testing, repairing and replacing customer meters?

2. Does your agency test, repair and replace your meters on a regular timed schedule?

a. If yes, does your agency test by meter size or customer category?:

b. If yes to meter size, please provide the frequency of testing by meter size:

Less than or equal to 1"

1.5" to 2"

3" and Larger

c. If yes to customer category, provide the frequency of testing by customer category:

SF residential

MF residential

Commercial

Industrial & Institutional

3. Who is responsible for repairs to the customer lateral or customer service line?

4. Who is responsible for service line repairs downstream of the customer meter?

5. Does your agency proactively search for leaks using leak survey techniques or does your utility reactively repair leaks which are called in, or both?

6. What is the utility budget breakdown for:

Leak Detection	$
Leak Repair	$
Auditing and Water Loss Evaluation	$
Meter Testing	$

H. Comments

Reported as of 3/9/10

BMP 07: Public Information Programs

Reporting Unit:	BMP Form Status:	Year:
Calleguas Municipal Water District	**100% Complete**	**2008**

A. Implementation

1. How is your public information program implemented?
   Wholesaler and retailer both materially participate in program
2. Describe the program and how it's organized:
   District promotes conservation, education, and public awareness programs through it's website, tours, speaking engagements and class room presentations. Additional efforts were made in response to drought conditions.
3. Indicate which and how many of the following activities are included in your public information program:

Region-Wide Public Information Program Activity	Yes/No	Number of Events
a. Paid Advertising	yes	43000
b. Public Service Announcement	yes	18000
c. Bill Inserts / Newsletters / Brochures	no	
d. Bill showing water usage in comparison to previous year's usage	no	
e. Demonstration Gardens	no	
f. Special Events, Media Events	yes	0
g. Speaker's Bureau	yes	0
h. Program to coordinate with other government agencies, industry and public interest groups and media	yes	

B. Conservation Information Program Expenditures

1. Annual Expenditures (Excluding Staffing) 61000

C. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP? No
   a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

D. Comments

Calleguas increased the public awareness campaign in response to drought conditions. Movie Theater ads were running in several theaters and news paper adds were placed. A large billboard was placed in a high traffic area at a local shopping mall. These and the above efforts in addition to the efforts by Metropolitan Water District of Southern California (MWD) in both advertising and public outreach events make up our public information programs. Calleguas MWD contributes to a "Water Stewardship" fund in the rates we pay to MWD to continue such

programs on behalf of their member agencies.

Reported as of 3/9/10

BMP 08: School Education Programs

Reporting Unit:
Calleguas Municipal Water District

BMP Form Status:
100% Complete

Year:
2008

A. Implementation

1. How is your public information program implemented?
   Wholesaler and retailer both participate in program

2. Please provide information on your region-wide school programs (by grade level):

Grade	Are grade-appropriate materials distributed?	No. of class presentations	No. of students reached	No. of teachers' workshops
Grades K-3rd	yes	17	340	0
Grades 4th-6th	yes	8	240	0
Grades 7th-8th	no	0	0	0
High School	no	0	0	0

4. Did your Agency's materials meet state education framework requirements? yes

5. When did your Agency begin implementing this program? 06/03/1991

B. School Education Program Expenditures

1. Annual Expenditures (Excluding Staffing) 3000

C. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP? No

   a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

D. Comments

Calleguas MWD offers and provides tours of facilities to schools throughout the service area as well as offering in class presentations to EVERY elementary school in the service area. In addition, Calleguas Partners with Metropolitan Water district of Southern California (MWD) to implement education programs. MWD provide inservices to teachers who with to participate in their programs. All inservices and materials are free.

Reported as of 3/9/10

BMP 10: Wholesale Agency Assistance Programs

Reporting Unit:
Calleguas Municipal Water District

BMP Form Status:
100% Complete

Year:
2008

A. Implementation

1. Financial Support by BMP

Financial Incentives	Budgeted	Amount	Financial Incentives	Budgeted	Amount

BMP	Offered?	Amount	Awarded	BMP	Offered?	Amount	Awarded
1	No			**8**	yes	3000	3000
2	No			**9**	No		
3	No			**10**	No		
4	No			**11**	No		
5	No			**12**	yes	24660	24660
6	yes	10000	10000	**13**	No		
7	yes	8000	8000	**14**	yes	10000	3000

2. Technical Support

a. Has your agency conducted or funded workshops addressing CUWCC procedures for calculating program savings, costs and cost-effectiveness?	No
b. Has your agency conducted or funded workshops addressing retail agencies' BMP implementation reporting requirements?	No
c. Has your agency conducted or funded workshops addressing:	
1) ULFT replacement	No
2) Residential retrofits	No
3) Commercial, industrial, and institutional surveys	No
4) Residential and large turf irrigation	No
5) Conservation-related rates and pricing	No

3. Staff Resources by BMP

BMP	Qualified Staff Available for BMP?	No. FTE Staff Assigned to BMP	BMP	Qualified Staff Available for BMP?	No. FTE Staff Assigned to BMP
1	yes	1	**8**	yes	1
2	yes	1	**9**	yes	1
3	yes	1	**10**	yes	1
4	yes	1	**11**	yes	1

5	yes	1	**12**	yes	1
6	yes	1	**13**	yes	1
7	yes	1	**14**	yes	1

4. Regional Programs by BMP

BMP	Implementation/ Management Program?	BMP	Implementation/ Management Program?
1	No	**8**	No
2	No	**9**	yes
3	No	**10**	No
4	No	**11**	No
5	No	**12**	No
6	No	**13**	No
7	No	**14**	No

B. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP? No

a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

C. Comments

Metropolitan Water District of Southern California (MWD) offers multiple conservation programs available to Calleguas and in turn is also offered to all Calleguas sub agencies. MWD money for their programs is provided by member agencies of whiich Calleguas is one. While Calleguas may not budget for a particular BMP directly, it may be indirectly providing funding via MWD. CUWCC workshops were available to Calleguas sub agencies through MWD.

BMP 12: Conservation Coordinator

Reporting Unit:	BMP Form Status:	Year:
Calleguas Municipal Water District	**100% Complete**	**2008**

A. Implementation

1. Does your Agency have a conservation coordinator?	yes
2. Is this a full-time position?	
3. If no, is the coordinator supplied by another agency with which you cooperate in a regional conservation program ?	no
4. Partner agency's name:	
5. If your agency supplies the conservation coordinator:	
a. What percent is this conservation coordinator's position?	75%
b. Coordinator's Name	Steven Sabbe
c. Coordinator's Title	Resource Specialist
d. Coordinator's Experience and Number of Years	10 years
e. Date Coordinator's position was created (mm/dd/yyyy)	06/03/1991
6. Number of conservation staff, including Conservation Coordinator.	1

B. Conservation Staff Program Expenditures

	This Year	Next Year
1. Budgeted Expenditures		
2. Actual Expenditures		

C. "At Least As Effective As"

1. Is your AGENCY implementing an "at least as effective as" variant of this BMP?	no

a. If YES, please explain in detail how your implementation of this BMP differs from Exhibit 1 and why you consider it to be "at least as effective as."

D. Comments

Reported as of 3/9/10

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Appendix E
CMWD Adoption Letters

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RESOLUTION NO. 1636

RESOLUTION OF THE BOARD OF DIRECTORS
OF CALLEGUAS MUNICIPAL WATER DISTRICT
IMPLEMENTING A WATER SUPPLY
ALLOCATION PROGRAM

WHEREAS, the Board of Directors Calleguas Municipal Water District (District) adopted an Urban Water Management Plan (the Plan) in 1995 in accordance with the requirements of the California Urban Water Management Planning Act (Water Code Sections 10610 et seq; the Act); and the plan was updated in accordance with applicable law and adopted by the Board in 2000; and further updated and adopted on October 5th, 2005;

WHEREAS, the Plan describes actions the District may follow to manage demand and, if necessary, allocate water in response to reductions in available water supplies;

WHEREAS, the State of California is now in its third consecutive year of drought and in each year of the current drought, annual rainfall and the water content in the Sierra snowpack have been significantly below the amounts needed to fill California's reservoir system;

WHEREAS, on February 27th, 2009, Governor Schwarzenegger declared a state of emergency regarding ongoing drought conditions and ordered immediate action to manage the State's dwindling supplies;

WHEREAS, on April 14th, 2009, the Metropolitan Water District of Southern California (Metropolitan) declared that a regional water shortage exists and implemented its Water Supply Allocation Plan (WSAP) at a Regional Shortage Level 2, effective July 1st, 2009, including penalty rates for water use in excess of a member agency's annual allocation; and

WHEREAS, Ordinance No. 12 authorizes the Board of Directors to pass through to member agencies of the District any allocations or penalties for use exceeding allocations the Metropolitan Water District of Southern California may impose or that the Board of Directors might independently judge to be necessary.

NOW, THEREFORE, THE BOARD OF DIRECTORS OF CALLEGUAS MUNICIPAL WATER DISTRICT RESOLVES AS FOLLOWS:

1. The General Manager is directed to develop and apply supply allocations for each District purveyor consistent with Metropolitan's WSAP; and

2. While the WSAP is in effect, the General Manager shall monitor implementation of WSAP requirements and provide monthly reports to the Board which compare actual purveyor demand with monthly allocation targets.

ADOPTED, SIGNED AND APPROVED this 27th day of May, 2009.

Ted Grandsen

Ted Grandsen, President
Board of Directors

ATTEST:

Donald G. Hauser

Donald G. Hauser, Secretary
Board of Directors

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Appendix F
Public Notices and Return Receipts

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TED GRANDSEN
DIVISION 1

GAIL L. PRINGLE, TREASURER
DIVISION 4

SCOTT H. QUADY, DIRECTOR
DIVISION 2

WILLIAM R. SEAVER, VICE PRESIDENT
DIVISION 5

DONALD G. HAUSER, SECRETARY
DIVISION 3

SUSAN B. MULLIGAN
GENERAL MANAGER

web site: www.calleguas.com

2100 OLSEN ROAD • THOUSAND OAKS, CALIFORNIA 91360-6800 805/526-9323 • FAX: 805/522-5730 • FAX: 805/526-3675

February 11, 2011

Notice of Availability of the
Calleguas Municipal Water District

Draft 2010 Urban Water Management Plan for Public Review

Calleguas Municipal Water District's (Calleguas) Draft 2010 Urban Water Management Plan (Plan) is available for public review and comment. The Plan was prepared in compliance with the Urban Water Management Planning Act (Division 6, Part 2.6 of the California Water Code).

The Plan describes and evaluates projected water demands, water supplies, water resource development programs and conservation measures in Calleguas' service area. Following adoption by Calleguas' Board of Directors, the Plan will be submitted to the California Department of Water Resources by July 1, 2011.

Hard copies of the Plan are available for review at Calleguas' Administrative Office located at 2100 Olsen Road, Thousand Oaks, California and public libraries within the district's service area. An electronic copy is available for download on Calleguas' web site at www.calleguas.com/CMWDDraft2010UWMP.pdf.

Public comments on the plan must be submitted to Calleguas MWD, 2100 Olsen Road, Thousand Oaks, CA 91360, Attn: Cy Johnson by May 4, 2011. A public hearing on the Plan will be held during Calleguas' regularly scheduled Board of Directors meeting on May 4, 2011 at 5:00 p.m. at the location noted above.

For further information, please call 805-526-9323 or send email to UWMP@calleguas.com.

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Distribution List
Draft 2010 Urban Water Management Plan
Calleguas Municipal Water District

Bob Butler
Butler Ranch
27756 Ave Mentry
Valencia, CA 91355

Norma Camacho
Director
Ventura County Watershed Protection District
800 S. Victoria Avenue
Ventura, CA 93009-1610

Ann DeMartini
General Manager
Solano Verde Mutual Water Company
P.O. Box 1248
Somis, CA 93066

Jerry Doran
Water Superintendent
Pleasant Valley Mutual Water Company
1863 Las Posas Road
Camarillo, CA 93010

Anthony Emmert
Water Resources Manager
City of Oxnard
251 Hayes
Oxnard, CA 93010

Robert Eranio
General Manager
Crestview Mutual Water Company
328 Valley Vista Drive
Camarillo, CA 93010

Skip Faria
District Superintendent
Southern California Water Company
4680 Los Angeles Ave., Unit H
Simi Valley, CA 93065

Ron Fuchiwaki
Director of Public Works
City of Simi Valley
2929 Tapo Canyon Road
Simi Valley, CA 93063

Michael Hurley
Resource Specialist
MWD of Southern California
700 N. Alameda Street
Los Angeles, CA 90012

Don Jensen
General Manager
California Water Service
2524 Townsgate, Suite A
Westlake Village, CA 911361

Susan Kirkpatrick
Berylwood Heights Mutual Water Company
1852 Harvest Lane
Camarillo, CA 93012

John Krist
Chief Executive Officer
Farm Bureau of Ventura County
5166 McGrath Street
Ventura, CA 93003

Director of Public Works
City of Moorpark
799 Moorpark Avenue
Moorpark, CA 93021

Mark Lawler
General Manager
Ventura County Regional Sanitation District
1001 Partridge Drive, Suite 150
Ventura, CA 93003-5562

Lucie McGovern
Deputy Director of Public Works
City of Camarillo
601 Carmen Drive
Camarillo, CA 93010

Reddy Pakala
General Manager
Ventura County Water Works District 1, 19 & LSCSD
6767 Spring Road
Moorpark, CA 93020

Marty Robinson
County Executive Officer
County of Ventura
800 S. Victoria Ave.
Ventura, CA 93009

Frank Royer
General Manager
Camrosa Water District
7385 Santa Rosa Road
Camarillo, CA 93012-8298

Carol Schoen
General Manager
Zone Mutual Water Company
P.O. Box 239
Somis, CA 93066

Peter Shen
Sr. Project Manager
California-American Water Company
1033 B Aveneue, Suite 200
Coronado, CA 92118

E. Michael Solomon
General Manager
United Water Conservation District
106 North 8th St.
Santa Paula, CA 93060

John Varble
Brandeis Mutual Water Company
1101 Pepper Tree Lane
Simi Valley, CA 93064

Mark Watkins
Public Works Director
City of Thousand Oaks
2100 Thousand Oaks Blvd.
Thousand Oaks, CA 91362

Alfred Yanez
California-American Water Company Village District
2439 W. Hillcrest Drive
Newbury Park, CA 91320

Camarillo Library
4101 Las Posas Road
Camarillo, CA 93010

Thousand Oaks Library
1401 E. Janss Rd.
Thousand Oaks, CA 91362

Douglas Williford
Deputy Executive Director
Southern California Association of Governments
950 County Square
Ventura, CA 93004

Moorpark Library
699 Moorpark Avenue
Moorpark, CA 93021

Oxnard Library
251 South A Street
Oxnard, CA 93030

Port Hueneme Library
510 Park Avenue
Port Hueneme, CA 93041

Simi Valley Library
2969 Tapo Canyon Road
Simi Valley, CA 93063

7010 1060 0000 1514 6798

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OFFICIAL USE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To: BOB BUTLER
Street, Apt. No.; or PO Box No.: BUTLER RANCH
City, State, ZIP+4

PS Form 3800, August 2006 — See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:
BOB BUTLER
BUTLER RANCH
24756 AVE MENTRY
VALENCIA, CA. 91355

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X Savannah ☐ Agent ☐ Addressee

B. Received by (Printed Name) Savanna Hi
C. Date of Delivery 2-14-11

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☑ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 6798

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

7010 1060 0000 1514 6804

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Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To: NORMA CAMACHO
Street, Apt. No.; or PO Box No.: VENTURA COUNTY WATERSHED PROTECTION DISTRICT
City, State, ZIP+4

PS Form 3800, August 2006 — See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:
NORMA CAMACHO
DIRECTOR
VENTURA COUNTY WATERSHED
PROTECTION DISTRICT
800 S. VICTORIA AVE.
VENTURA CA. 93009-1610

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X ☐ Agent ☐ Addressee

B. Received by (Printed Name) ROGER BOULEY
C. Date of Delivery FEB 14 2011

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

RECEIVED FEB 17 2011 CHIEF'S OFFICE

3. Service Type
☑ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 6804

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

7010 1060 0000 1514 7030

U.S. Postal Service™
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OFFICIAL USE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To CAMARILLO LIBRARY
Street, Apt. No.; or PO Box No.
City, State, ZIP+4

PS Form 3800, August 2006 — See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:
CAMARILLO LIBRARY
4101 LOS POSAS ROAD
CAMARILLO Ca
93010

COMPLETE THIS SECTION ON DELIVERY

A. Signature
x S Wenger ☐ Agent ☐ Addressee

B. Received by (Printed Name) Sherry Wenger
C. Date of Delivery 2/12/11

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 7030

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

7010 1060 0000 1514 6910

U.S. Postal Service™
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OFFICIAL USE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To DIRECTOR OF PUBLIC WORKS CITY OF MOORPARK
Street, Apt. No.; or PO Box No.
City, State, ZIP+4

PS Form 3800, August 2006 — See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:
DIRECTOR OF PUBLIC WORKS CITY OF MOORPARK
799 MOORPARK AVE
MOORPARK Ca. 93021

COMPLETE THIS SECTION ON DELIVERY

A. Signature
x ☒ Agent ☐ Addressee

B. Received by (Printed Name)
C. Date of Delivery 2/14/8

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 6910

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

7010 1060 0000 1514 6811

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Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To ANN DEMARTINI
Street, Apt. No.; or PO Box No. GEN MGR MANAGER
City, State, ZIP+4

PS Form 3800, August 2006 — See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

ANN DEMARTINI
GENERAL MANAGER
SOLANO VERDE MUTUAL
WATER CO.
P.O. BOX 1248
SAMIS CA. 93066

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X [signature] ☐ Agent ☒ Addressee

B. Received by (Printed Name) C. Date of Delivery 2/14/11

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 6811

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

7010 1060 0000 1514 6828

U.S. Postal Service™
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OFFICIAL USE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To JERRY DORAN
Street, Apt. No.; or PO Box No. WATER SUPERINTENDENT
City, State, ZIP+4

PS Form 3800, August 2006 — See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

JERRY DORAN
WATER SUPERINTENDENT
PLEASANT VALLEY
MUTUAL WATER CO.
1863 LAS POSAS RD
CAMARILLO CA 93010

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X [signature] ☐ Agent ☐ Addressee

B. Received by (Printed Name) C. Date of Delivery 2/14

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 6828

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

7010 1060 0000 1514 6835

U.S. Postal Service™
CERTIFIED MAIL™ RECEIPT
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OFFICIAL USE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To ANTHONY EMMERT
Street, Apt. No.; or PO Box No. CITY OF OXNARD
City, State, ZIP+4

PS Form 3800, August 2006 See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:
ANTHONY EMMERT
CITY OF OXNARD
251 HAYES
OXNARD CA 93010

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X Sandra Vars ☐ Agent ☐ Addressee

B. Received by (Printed Name) SANDRA VARS
C. Date of Delivery 2/14/2011

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☒ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 6835

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

7010 1060 0000 1514 6842

U.S. Postal Service™
CERTIFIED MAIL™ RECEIPT
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OFFICIAL USE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To ROBERT ERANIO
Street, Apt. No.; or PO Box No. GENERAL MANAGER
City, State, ZIP+4

PS Form 3800, August 2006 See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:
ROBERT ERANIO
GENERAL MANAGER
CRESTVIEW MUTUAL
WATER CO.
328 VALLEY VISTA DR.
CAMARILLO CA 93010

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X Lauri Marino ☐ Agent ☐ Addressee

B. Received by (Printed Name) LAURI MARINO
C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

USPS CAMARILLO CA 93010 FEB 17 2011 RECEIVED

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 6842

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

7010 1060 0000 1514 6859

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OFFICIAL USE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To: SKIP FARIA
Street, Apt. No.; or PO Box No.: DISTRICT SUPERINTENDENT
City, State, ZIP+4

PS Form 3800, August 2006 — See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:
SKIP FARIA
DISTRICT SUPERINTENDENT
SOUTHERN CALIFORNIA
WATER CO.
4680 LOS ANGELES AVE
UNITH SIMI VALLEY Ca
93065

2. Article Number (Transfer from service label): 7010 1060 0000 1514 6859

COMPLETE THIS SECTION ON DELIVERY

A. Signature: X Skip Faria — ☐ Agent ☐ Addressee

B. Received by (Printed Name) — C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

RECEIVED FEB 14 CALLUDUS/LWD

3. Service Type
☑ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

PS Form 3811, February 2004 — Domestic Return Receipt — 102595-02-M-1540

7010 1060 0000 1514 6866

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OFFICIAL USE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To: RON FUCHIWAKI
Street, Apt. No.; or PO Box No.:
City, State, ZIP+4

PS Form 3800, August 2006 — See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:
RON FUCHIWAKI
DIRECTOR OF PUBLIC WORKS
CITY OF SIMI VALLEY
2929 TAPO CANYON Rd
SIMI VALLEY Ca. 93063

2. Article Number (Transfer from service label): 7010 1060 0000 1514 6866

COMPLETE THIS SECTION ON DELIVERY

A. Signature: X Joe Collis — ☐ Agent ☒ Addressee

B. Received by (Printed Name): JOE CARILES — C. Date of Delivery: 2-14-11

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

RECEIVED FEB 14 2011

3. Service Type
☑ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

PS Form 3811, February 2004 — Domestic Return Receipt — 102595-02-M-1540

7010 1060 0000 1514 6880

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OFFICIAL USE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To: DON JENSEN
Street, Apt. No.; or PO Box No.: GENERAL MANAGER
City, State, ZIP+4:

PS Form 3800, August 2006 — See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:
DON JENSEN
GENERAL MANAGER
CALIFORNIA WATER
SERVICE 2524
TOWNSGATE SUITE A
WESTLAKE VILLAGE
CA. 91361

COMPLETE THIS SECTION ON DELIVERY

A. Signature: X ☐ Agent ☐ Addressee
B. Received by (Printed Name) | C. Date of Delivery
D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

FEB 14 2011 CALLEGUAS MWD

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 6880

PS Form 3811, February 2004 — Domestic Return Receipt — 102595-02-M-1540

7010 1060 0000 1514 6897

U.S. Postal Service™
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OFFICIAL USE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To: SUSAN KIRKPATRICK
Street, Apt. No.; or PO Box No.: BERYLWOOD HEIGHTS
City, State, ZIP+4:

PS Form 3800, August 2006 — See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:
SUSAN KIRKPATRICK
BERYLWOOD HEIGHTS
MUTUAL WATER CO.
P.O. BOX 2555
CAMARILLO, CA.
93011

COMPLETE THIS SECTION ON DELIVERY

A. Signature: X ☐ Agent ☐ Addressee
B. Received by (Printed Name): SUSAN KIRKPATRICK | C. Date of Delivery
D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

FEB

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 6897

PS Form 3811, February 2004 — Domestic Return Receipt — 102595-02-M-1540

7010 1060 0000 1514 6903

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OFFICIAL USE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To JOHN KRIST
Street, Apt. No.; or PO Box No. CHIEF EXECUTIVE
City, State, ZIP+4

PS Form 3800, August 2006 See Reverse for Instructions

SENDER: *COMPLETE THIS SECTION*

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:
JOHN KRIST
CHIEF EXECUTIVE
OFFICER FARM
BUREAU OF VENTURA
COUNTY 5166 MCGRATH
STREET VENTURA CA.
93001

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X ☐ Agent ☐ Addressee

B. Received by (Printed Name) RAFAEL M. WOODFORK
C. Date of Delivery FEB 15 2011

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

FEB 15 2011
CALEGUAR

3. Service Type
☐ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? *(Extra Fee)* ☐ Yes

2. Article Number
(Transfer from service label) 7010 1060 0000 1514 6903

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

7010 1060 0000 1514 6934

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OFFICIAL USE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To LUCIE MCGOVERN
Street, Apt. No.; or PO Box No.
City, State, ZIP+4

PS Form 3800, August 2006 See Reverse for Instructions

SENDER: *COMPLETE THIS SECTION*

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:
LUCIE MCGOVERN
DEPUTY DIRECTOR OF
PUBLIC WORKS
CITY OF CAMARILLO
601 CARMEN DRIVE
CAMARILLO CA 93010

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X ☐ Agent ☐ Addressee

B. Received by (Printed Name) J Starr
C. Date of Delivery 2-14-11

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☐ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? *(Extra Fee)* ☐ Yes

2. Article Number
(Transfer from service label) 7010 1060 0000 1514 6934

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

7010 1060 0000 1514 6927

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Postage $
Certified Fee
Return Receipt Fee (Endorsement Required)
Restricted Delivery Fee (Endorsement Required)
Total Postage & Fees $

Postmark Here

Sent To MARK LAWLER
Street, Apt. No.; or PO Box No. GENERAL MANAGER
City, State, ZIP+4

PS Form 3800, August 2006 See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

MARK LAWLER
GENERAL MANAGER
VENTURA COUNTY REG.
SANITATION DISTRICT
1001 PARTRIDGE DR
STE #150 VENTURA CA 93003

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X [signature] ☐ Agent ☐ Addressee

B. Received by (Printed Name) D. Rodriguez
C. Date of Delivery FEB 14 2011

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 6927

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

7010 1060 0000 1514 7047

U.S. Postal Service™
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OFFICIAL USE

Postage $
Certified Fee
Return Receipt Fee (Endorsement Required)
Restricted Delivery Fee (Endorsement Required)
Total Postage & Fees $

Postmark Here

Sent To MOORPARK LIBRARY
Street, Apt. No.; or PO Box No.
City, State, ZIP+4

PS Form 3800, August 2006 See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

MOORPARK LIBRARY
699 MOORPARK AVE.
MOORPARK CA 93021

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X [signature] ☒ Agent ☐ Addressee

B. Received by (Printed Name)
C. Date of Delivery 2/2

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 7047

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

7010 1060 0000 1514 7054

U.S. Postal Service™
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OFFICIAL USE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To: OXNARD LIBRARY

Street, Apt. No.; or PO Box No.

City, State, ZIP+4

PS Form 3800, August 2006 — See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

OXNARD LIBRARY
251 SOUTH A STREET
OXNARD CA 93030

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X DL
☐ Agent
☐ Addressee

B. Received by (Printed Name) | C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

RECEIVED FEB 19 2011

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 7054

PS Form 3811, February 2004 — Domestic Return Receipt — 102595-02-M-1540

7010 1060 0000 1514 6941

U.S. Postal Service™
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OFFICIAL USE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To: Reddy PAKALA

Street, Apt. No.; or PO Box No.

City, State, ZIP+4

PS Form 3800, August 2006 — See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

Reddy PAKALA
GENERAL MANAGER
VENTURA COUNTY WATER
WORKS 6767 SPRING
Rd. MOORPARK CA
93020

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X
☐ Agent
☐ Addressee

B. Received by (Printed Name) Kevin Ricart | C. Date of Delivery 2/14/

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 6941

PS Form 3811, February 2004 — Domestic Return Receipt — 102595-02-M-1540

7010 1060 0000 1514 7061

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OFFICIAL USE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To: PORT HUENEME LIBRARY
Street, Apt. No.; or PO Box No.
City, State, ZIP+4

PS Form 3800, August 2006 — See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:
PORT HUENEME LIBRARY
510 PARK AVE.
PORT HUENEME
CA 93041

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X [signature] ☐ Agent ☐ Addressee

B. Received by (Printed Name) | C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☑ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 7061

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

7010 1060 0000 1514 6972

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Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To: CAROL SCHOEN
Street, Apt. No.; or PO Box No. GENERAL MANAGER
City, State, ZIP+4

PS Form 3800, August 2006 — See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:
CAROL SCHOEN
GENERAL MANAGER
ZONE MUTUAL
WATER CO.
P.O. BOX 239
SOMIS CA
93066

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X [signature] ☐ Agent ☐ Addressee

B. Received by (Printed Name) Carol Schoen | C. Date of Delivery 2-17-4

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☑ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 6972

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

7010 1060 0000 1514 6989

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OFFICIAL USE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To PETER SHEW
Street, Apt. No.; or PO Box No. PROJECT MANAGER
City, State, ZIP+4

PS Form 3800, August 2006 See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

PETER SHEW
SR. PROJECT MANAGER
CAL-AMERICAN
WATER CO.
1033 B. AVE. STE #200
CORONADO CA
92118

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X [signature] ☒ Agent ☐ Addressee

B. Received by (Printed Name) Matt Warner
C. Date of Delivery 02/14/11

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

RECEIVED FEB 16 2011 CALLEGUAS MWD

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 6989

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

7010 1060 0000 1514 7078

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OFFICIAL USE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To SIMI VALLEY LIBRARY
Street, Apt. No.; or PO Box No.
City, State, ZIP+4

PS Form 3800, August 2006 See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

SIMI VALLEY LIBRARY
2969 TAPO CANYON RD
SIMI VALLEY CA
93063

RECEIVED FEB 1 2011

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X [signature] ☐ Agent ☐ Addressee

B. Received by (Printed Name)
C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

FEB 14 2011

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 7078

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

7010 1060 0000 1514 6965

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OFFICIAL USE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To MARTY ROBINSON
Street, Apt. No.; or PO Box No.
City, State, ZIP+4

PS Form 3800, August 2006 See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:
MARTY ROBINSON
COUNTY EXCUTIVE
OFFICER COUNTY
OF VENTURA
800 S. VICTORIA AVE
VENTURA CA 93009

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X [signature] ☐ Agent ☐ Addressee

B. Received by (Printed Name) ROGER BOULEY C. Date of Delivery FEB 14 2011

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

RECEIVED FEB 14 2011

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 6965

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

7010 1060 0000 1514 6996

U.S. Postal Service™
CERTIFIED MAIL™ RECEIPT
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For delivery information visit our website at www.usps.com

OFFICIAL USE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To E. MICHAEL SOLOMON
Street, Apt. No.; or PO Box No. GENERAL MANAGER
City, State, ZIP+4

PS Form 3800, August 2006 See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:
E. MICHAEL SOLOMON
GENERAL MANAGER
UNITED WATER CONSERVATION
DISTRICT 106 W. 8TH
ST. SANTA PAULA
CA. 93060

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X [signature] ☒ Agent ☐ Addressee

B. Received by (Printed Name) Michele K Cockrell C. Date of Delivery 2-17-11

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

RECEIVED FEB 22 2011

SANTA PAULA CA 93060 FEB 22 2011 USPS

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 6996

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

7010 1060 0000 1514 7085

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Postage $
Certified Fee
Return Receipt Fee (Endorsement Required)
Restricted Delivery Fee (Endorsement Required)
Total Postage & Fees $

Postmark Here

Sent To THOUSAND OAKS LIBRARY
Street, Apt. No.; or PO Box No.
City, State, ZIP+4

PS Form 3800, August 2006 See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:
THOUSAND OAKS LIBRARY
1401 E. JANSS Rd.
THOUSAND OAKS Ca
91362

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X [signature] ☐ Agent ☐ Addressee

B. Received by (Printed Name) SUSAN ELIAS
C. Date of Delivery 2-14-11

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

RECEIVED FEB 14 2011 THOUSAND OAKS M.W.D.

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 7085

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

7010 1060 0000 1514 7016

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OFFICIAL USE

Postage $
Certified Fee
Return Receipt Fee (Endorsement Required)
Restricted Delivery Fee (Endorsement Required)
Total Postage & Fees $

Postmark Here

Sent To MARK WATKINS
Street, Apt. No.; or PO Box No. PUBLIC WORKS director
City, State, ZIP+4

PS Form 3800, August 2006 See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:
MARK WATKINS
PUBLIC WORKS DIRECTOR
CITY OF THOUSAND OAKS
2100 THOUSAND OAKS
BLVd. THOUSAND OAKS, Ca
91362

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X [signature] ☐ Agent ☐ Addressee

B. Received by (Printed Name)
C. Date of Delivery 2-14-11

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 7016

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

7010 1060 0000 1514 7092

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OFFICIAL USE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To DOUGLAS WILLIFORD
Street, Apt. No.; or PO Box No. DEPUTY EXECUTIVE
City, State, ZIP+4

PS Form 3800, August 2006 See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:
DOUGLAS WILLIFORD
DEPUTY EXECUTIVE
DIRECTOR SOUTHER
CAL. ASSOC. OF GOV.
950 COUNTY SQUARE
VENTURA CA. 93009

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X [signature] ☐ Agent ☐ Addressee

B. Received by (Printed Name) C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

RECEIVED
FEB 15 2011

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 7092

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

7010 1060 0000 1514 7023

U.S. Postal Service™
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OFFICIAL USE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To ALFRED YAPEZ
Street, Apt. No.; or PO Box No. CAL-AMERICAN WATER
City, State, ZIP+4

PS Form 3800, August 2006 See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:
ALFRED YAPEZ
CAL AMERICAN WATER CO.
VILLAGE DISTRICT
2439 W. HILLCREST DR.
NEWBURY PARK CA 91320

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X [signature] ☐ Agent ☐ Addressee

B. Received by (Printed Name) C. Date of Delivery 2-17-11

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 7023

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

UNITED STATES POSTAL SERVICE

Home | Help | Sign In

Track & Confirm FAQs

Track & Confirm

Search Results

Label/Receipt Number: **7010 1060 0000 1514 6958**
Service(s): **Certified Mail™**
Status: **Delivered**

Your item was delivered at 12:24 pm on February 14, 2011 in CAMARILLO, CA 93012.

Track & Confirm
Enter Label/Receipt Number.
Go >

Detailed Results:

- **Delivered, February 14, 2011, 12:24 pm, CAMARILLO, CA 93012**
- **Notice Left, February 12, 2011, 9:39 am, CAMARILLO, CA 93010**
- **Arrival at Unit, February 12, 2011, 8:03 am, CAMARILLO, CA 93010**

Notification Options

Track & Confirm by email

Get current event information or updates for your item sent to you or others by email. Go >

7010 1060 0000 1514 6958

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OFFICIAL USE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To FRANK KOVER
Street, Apt. No.; or PO Box No. & RACHEL WAMPLER
City, State, ZIP+4

PS Form 3800, August 2006 See Reverse for Instructions

UNITED STATES POSTAL SERVICE

Home | Help | Sign In

Track & Confirm FAQs

Track & Confirm

Search Results

Label/Receipt Number: **7010 1060 0000 1514 7009**
Service(s): **Certified Mail™**
Status: **Delivered**

Your item was delivered at 8:33 am on February 15, 2011 in BRANDEIS, CA 93064.

Track & Confirm
Enter Label/Receipt Number
Go >

Detailed Results:

- **Delivered, February 15, 2011, 8:33 am, BRANDEIS, CA 93064**
- **Arrival at Unit, February 12, 2011, 4:29 am, SIMI VALLEY, CA 93063**

Notification Options

Track & Confirm by email

Get current event information or updates for your item sent to you or others by email. Go >

7010 1060 0000 1514 7009

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OFFICIAL USE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To JUNO VARDL
Street, Apt. No.; or PO Box No. BRANDEIS TRUVAL
City, State, ZIP+4 WATT

PS Form 3800, August 2006 See Reverse for Instructions

This Page Intentionally Left Blank and Unnumbered
For Double Sided Printing

TED GRANDSEN
DIVISION 1

GAIL L. PRINGLE, TREASURER
DIVISION 4

SCOTT H. QUADY, DIRECTOR
DIVISION 2

WILLIAM R. SEAVER, VICE PRESIDENT
DIVISION 5

DONALD G. HAUSER, SECRETARY
DIVISION 3

SUSAN B. MULLIGAN
GENERAL MANAGER

web site: www.calleguas.com

2100 OLSEN ROAD • THOUSAND OAKS, CALIFORNIA 91360-6800 805/526-9323 • FAX: 805/522-5730 • FAX: 805/526-3675

May 24, 2011

Notice of Adoption of the
Calleguas Municipal Water District

2010 Urban Water Management Plan

Calleguas Municipal Water District's (Calleguas) 2010 Urban Water Management Plan (Plan) was adopted by the Calleguas Board of Directors on May 18th, 2011. The Plan was prepared in compliance with the Urban Water Management Planning Act (Division 6, Part 2.6 of the California Water Code).

The Plan describes and evaluates projected water demands, water supplies, water resource development programs and conservation measures in Calleguas' service area. It addresses comments received during the public review period. Following the required distribution of the Plan to the County, to Cities within the Calleguas service area and other required agencies, the plan will be submitted to the California Department of Water Resources by July 1, 2011.

Hard copies of the Plan are available for review at Calleguas' Administrative Office located at 2100 Olsen Road, Thousand Oaks, California and public libraries within the District's service area. An electronic copy is available for download on Calleguas' web site at www.calleguas.com/cmwd2010uwmpfinal.pdf. Upon request, Calleguas will provide a hard copy or an electronic copy on compact disc via U.S. Mail. Please direct your request to Cy Johnson at 805-579-7129.

For further information, please call 805-526-9323 or send email to UWMP@calleguas.com.

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Distribution List
Draft 2010 Urban Water Management Plan
Calleguas Municipal Water District

Bob Butler
Butler Ranch
27756 Ave Mentry
Valencia, CA 91355

Norma Camacho
Director
Ventura County Watershed Protection District
800 S. Victoria Avenue
Ventura, CA 93009-1610

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General Manager
Solano Verde Mutual Water Company
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Somis, CA 93066

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Pleasant Valley Mutual Water Company
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City of Oxnard
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General Manager
California Water Service
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Camarillo, CA 93012

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5166 McGrath Street
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Somis, CA 93066

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California-American Water Company
1033 B Aveneue, Suite 200
Coronado, CA 92118

E. Michael Solomon
General Manager
United Water Conservation District
106 North 8th St.
Santa Paula, CA 93060

John Varble
Brandeis Mutual Water Company
1101 Pepper Tree Lane
Simi Valley, CA 93064

Mark Watkins
Public Works Director
City of Thousand Oaks
2100 Thousand Oaks Blvd.
Thousand Oaks, CA 91362

Alfred Yanez
California-American Water Company Village District
2439 W. Hillcrest Drive
Newbury Park, CA 91320

Camarillo Library
4101 Las Posas Road
Camarillo, CA 93010

Thousand Oaks Library
1401 E. Janss Rd.
Thousand Oaks, CA 91362

Douglas Williford
Deputy Executive Director
Southern California Association of Governments
950 County Square
Ventura, CA 93004

Moorpark Library
699 Moorpark Avenue
Moorpark, CA 93021

Oxnard Library
251 South A Street
Oxnard, CA 93030

Port Hueneme Library
510 Park Avenue
Port Hueneme, CA 93041

Simi Valley Library
2969 Tapo Canyon Road
Simi Valley, CA 93063

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- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
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1. Article Addressed to:
BOB BUTLER
27756 AVE. MENTRY
VALENCIA CA. 91355

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X [signature] ☐ Agent ☐ Addressee

B. Received by (Printed Name) Susanna Ali C. Date of Delivery 5/26/11

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 7221

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7010 1060 0000 1514 7229

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1. Article Addressed to:
CALIFORNIA STATE LIBRARY P.O. BOX 942837 SACRAMENTO CA. 94237-0001

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A. Signature
X [signature] ☐ Agent ☐ Addressee

B. Received by (Printed Name) CARLO MONTILLA C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

MAY 27 2011

3. Service Type
☐ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article N
(Transfer

PS Form 3

102595-02-M-1540

7010 1060 0000 1514 7214

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Street, Apt. No.; or PO Box No.

City, State, ZIP+4

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- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:
NORMA CAMACHO
DIRECTOR VENTURA
COUNTY WATERSHED
PROTECTION DISTRICT
800 S. VICTORIA AVE.
VENTURA CA. 93009-
1610

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X [signature] ☐ Agent ☐ Addressee

B. Received by (Printed Name) ROGER BOULEY
C. Date of Delivery MAY 26 2011

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 7214

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1. Article Addressed to:
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4101 LAS POSAS
Rd. CAMARILLO
CA. 93010

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A. Signature
X [signature] ☐ Agent ☐ Addressee

B. Received by (Printed Name)
C. Date of Delivery 5/26

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 7504

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Sent To: ANN DEMARTINI

Street, Apt. No.; or PO Box No.

City, State, ZIP+4

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- Print your name and address on the reverse so that we can return the card to you.
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1. Article Addressed to:

ANN DeMARTINI
GENERAL MANAGER
SOLANO VERDE MUTUAL
WATER CO
PO BOX 1248
SOMIS CA. 93066

COMPLETE THIS SECTION ON DELIVERY

A. Signature: X [signature] ☐ Agent ☐ Addressee

B. Received by (Printed Name): ANN DEMARTINI — C. Date of Delivery: 5-26-11

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label): 7010 1060 0000 1514 7238

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7010 1060 0000 1514 7245

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LEFT notice 6/4
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Sent To: JERRY DORAN

Street, Apt. No.; or PO Box No.

City, State, ZIP+4

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SENDER: COMPLETE THIS SECTION

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- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

JERRY DORAN
WATER SUPERINTENDENT
PLEASANT VALLEY
MUTUAL WATER CO
1863 LAS POSA Rd.
CAMARILLO, CA. 93010

COMPLETE THIS SECTION ON DELIVERY

A. Signature: X Beth Wood ☐ Agent ☐ Addressee

B. Received by (Printed Name): Beth Wood — C. Date of Delivery: 6-7-11

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

JUN 08 2011

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label): 7010 1060 0000 1514 7245

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7010 1060 0000 1514 7252

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Sent To ANTHONY EMMERT
Street, Apt. No.; or PO Box No.
City, State, ZIP+4

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- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:
ANTHONY EMMERT
WATER RESOURCES
MANAGER CITY OF OXNARD
251 HAYES
OXNARD CA. 93010

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X Richard Cortez ☐ Agent ☐ Addressee

B. Received by (Printed Name) Richard Cortez
C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

MAY 27 2011 USPS-ACCTG

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 7252

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

7010 1060 0000 1514 7269

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Sent To ROBERT ERANIO
Street, Apt. No.; or PO Box No.
City, State, ZIP+4

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SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:
ROBERT ERANIO
GENERAL MANAGER
CRESTVIEW MUTUAL
WATER CO.
328 VALLEY VISTA
DR. CAMARILLO CA
93010

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X Robert Eranio ☐ Agent ☐ Addressee

B. Received by (Printed Name) ERANIO
C. Date of Delivery 3-JUN-11

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

JUN 0 - 2011

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 7269

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

7010 1060 0000 1514 7436

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Sent To: Edgar FANDALIAN
Street, Apt. No.; or PO Box No.: MetroWater
City, State, ZIP+4:

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- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:
Edgar FANDALIAN
Metropolitan
Water District
of S.C.
P.O. BOX 54153
L.A. Ca. 90054-
0153

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X
☐ Agent
☐ Addressee

B. Received by (Printed Name) JUN
C. Date of Delivery 0 1 2011

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 7436

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Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

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Sent To: SKIP FARIA
Street, Apt. No.; or PO Box No.:
City, State, ZIP+4:

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- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:
SKIP FARIA
District Superintendent
Southern California
Water Co.
4680 Los Angeles Ave.
Unit H Simi Valley Ca
93065

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X
☐ Agent
☐ Addressee

B. Received by (Printed Name)
C. Date of Delivery 5/27

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

MAY 27 2011

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 7276

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Sent To: SUSAN KIRKPATRICK
Street, Apt. No.; or PO Box No.
City, State, ZIP+4

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mplete items 1, 2, and 3. Also complete
m 4 if Restricted Delivery is desired.
Print your name and address on the reverse
so that we can return the card to you.
Attach this card to the back of the mailpiece,
or on the front if space permits.

1. Article Addressed to:
SUSAN KIRKPATRICK
BERYLWOOD HEIGHTS
MUTUAL WATER CO.
1852 HARVEST LANE
CAMARILLO CA. 93012

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X
☐ Agent
☐ Addressee

B. Received by (Printed Name) C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

JUN 0 8 2011

3. Service Type
☒ Certified Mail ☐ Express Mail
☒ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 7306

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Restricted Delivery Fee (Endorsement Required)
Total Postage & Fees $

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Sent To: RON FUCHIWAKI
Street, Apt. No.; or PO Box No.
City, State, ZIP+4

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SENDER: COMPLETE THIS SECTION

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- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:
RON FUCHIWAKI,
DIRECTOR OF PUBLIC
WORKS CITY OF SIMI
VALLEY 2929 TAPO
CANYON ROAD SIMI VALLEY
CA. 93063

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X Joe Cavillo
☐ Agent
☒ Addressee

B. Received by (Printed Name) C. Date of Delivery
JOE CAVILLO 5-26-11

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

SIMI VALLEY CA MAY 27 2011

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 7283

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Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

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Sent To: DAVE KLOTZLE
Street, Apt. No.; or PO Box No.
City, State, ZIP+4

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SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:
DAVE KLOTZLE
DIRECTOR OF PUBLIC
WORKS CITY OF
MOORPARK 799
MOORPARK AVE.
MOORPARK CA. 93021

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X [signature] ☐ Agent ☐ Addressee

B. Received by (Printed Name) | C. Date of Delivery 5/26

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

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Street, Apt. No.; or PO Box No.
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PS Form 3800, August 2006 — See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:
JOHN KRIST
CHIEF EXECUTIVE
OFFICER FARM
BUREAU OF VENTURA
COUNTY 5166 MCGRATH ST.
VENTURA CA 93003

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X [signature] ☐ Agent ☐ Addressee

B. Received by (Printed Name) | C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 7313

PS Form 3811, February 2004 — Domestic Return Receipt — 102595-02-M-1540

7008 1830 0003 5700 4547

U.S. Postal Service™
CERTIFIED MAIL™ RECEIPT
(Domestic Mail Only; No Insurance Coverage Provided)

For delivery information visit our website at www.usps.com®

OFFICIAL USE

Postage $
Certified Fee
Return Receipt Fee (Endorsement Required)
Restricted Delivery Fee (Endorsement Required)
Total Postage & Fees $

Postmark Here

Sent To MARK LAWLER
Street, Apt. No.; or PO Box No.
City, State, ZIP+4

PS Form 3800, August 2006 See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:
MARK LAWLER
GENERAL MANAGER
VENTURA COUNTY
REGIONAL SANITATION
DISTRICT 1001 PARTRIDGE
DR. STE. #150 VENTURA
CA. 93003

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X Eli Rodriguez ☐ Agent ☐ Addressee

B. Received by (Printed Name) D. Rodriguez
C. Date of Delivery MAY 26 2011

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7008 1830 0003 5700 4547

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

7010 1060 0000 1514 7139

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OFFICIAL USE

Postage $
Certified Fee
Return Receipt Fee (Endorsement Required)
Restricted Delivery Fee (Endorsement Required)
Total Postage & Fees $

Postmark Here

Delivered 6/6 9:23 AM 2011 left notice 6/4

Sent To Lucie McGovern
Street, Apt. No.; or PO Box No.
City, State, ZIP+4

PS Form 3800, August 2006 See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:
Lucie McGovern
Deputy Director
of Public Works
City of Camarillo
601 Carmen Drive
Camarillo Ca.
93010

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X J. Starr ☒ Agent ☐ Addressee

B. Received by (Printed Name) J. STARR
C. Date of Delivery 6-6-11

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 7139

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

7010 1060 0000 1514 7481

U.S. Postal Service™
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OFFICIAL USE

Postage $
Certified Fee
Return Receipt Fee (Endorsement Required)
Restricted Delivery Fee (Endorsement Required)
Total Postage & Fees $

Postmark Here

Sent To MOORPARK LIBRARY
Street, Apt. No.; or PO Box No.
City, State, ZIP+4

PS Form 3800, August 2006 See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:
MOORPARK LIBRARY 699 MOORPARK AVE MOORPARK CA 93021

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X [signature] ☐ Agent ☐ Addressee

B. Received by (Printed Name) C. Date of Delivery 7/26

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☐ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 7481

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

7010 1060 0000 1514 7474

U.S. Postal Service™
CERTIFIED MAIL™ RECEIPT
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OFFICIAL USE

Postage $
Certified Fee
Return Receipt Fee (Endorsement Required)
Restricted Delivery Fee (Endorsement Required)
Total Postage & Fees $

Postmark Here

Sent To OXNARD LIBRARY
Street, Apt. No.; or PO Box No.
City, State, ZIP+4

PS Form 3800, August 2006 See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:
OXNARD LIBRARY 251 SOUTH A STREET OXNARD CA 93030

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X [signature] ☐ Agent ☐ Addressee

B. Received by (Printed Name) C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

MAY 26 2011

3. Service Type
☐ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 7474

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

7010 1060 0000 1514 7405

U.S. Postal Service™
CERTIFIED MAIL™ RECEIPT
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OFFICIAL USE

Postage $
Certified Fee
Return Receipt Fee (Endorsement Required)
Restricted Delivery Fee (Endorsement Required)
Total Postage & Fees $

Postmark Here

Sent To Port Hueneme Library
Street, Apt. No.; or PO Box No.
City, State, ZIP+4

PS Form 3800, August 2006 See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

PORT HUENEME
LIBRARY 510
PARK AVE.
PORT HUENEME
CA. 93041

COMPLETE THIS SECTION ON DELIVERY

A. Signature X ☐ Agent ☐ Addressee

B. Received by (Printed Name) C. Date of Delivery 5-28

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☐ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 7467

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

7010 1060 0000 1514 7146

U.S. Postal Service™
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OFFICIAL USE

Postage $
Certified Fee
Return Receipt Fee (Endorsement Required)
Restricted Delivery Fee (Endorsement Required)
Total Postage & Fees $

Postmark Here

Sent To Reddy PAKALA
Street, Apt. No.; or PO Box No.
City, State, ZIP+4

PS Form 3800, August 2006 See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

Reddy PAKALA
GENERAL MANAGER
VENTURA COUNTY
WATER WORK DISTRICT
1, 19 & LSCSD
6767 Spring Rd.
MOORPARK CA 93020

COMPLETE THIS SECTION ON DELIVERY

A. Signature X ☐ Agent ☐ Addressee

B. Received by (Printed Name) Kevin Rickard C. Date of Delivery 5/20/1

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 7146

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

7010 1060 0000 1514 7153

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OFFICIAL USE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To: MICHAEL POWERS
Street, Apt. No.; or PO Box No.
City, State, ZIP+4

PS Form 3800, August 2006 — See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:
MICHAEL POWERS
COUNTY OF VENTURA
800 S. VICTORIA
AVE. VENTURA
CA. 93009

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X [signature] ☐ Agent ☐ Addressee

B. Received by (Printed Name): ROGER BOULEY
C. Date of Delivery: MAY 26 2011

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label): 7010 1060 0000 1514 7153

PS Form 3811, February 2004 — Domestic Return Receipt — 102595-02-M-1540

7010 1060 0000 1514 7160

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OFFICIAL USE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Delivered June 6th 2011 1:10 pm

Sent To: FRANK ROYER
Street, Apt. No.; or PO Box No.
City, State, ZIP+4

PS Form 3800, August 2006 — See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:
FRANK ROYER
GENERAL MANAGER
CAMROSA WATER
DISTRICT 7385
SANTA ROSA ROAD
CAMARILLO CA. 93012-
8298

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X [signature] ☐ Agent ☐ Addressee

B. Received by (Printed Name)
C. Date of Delivery: 6-10-11

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

JUN 08 2011

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label): 7010 1060 0000 1514 7160

PS Form 3811, February 2004 — Domestic Return Receipt — 102595-02-M-1540

7010 1060 0000 1514 7177

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OFFICIAL USE

Postage $
Certified Fee
Return Receipt Fee (Endorsement Required)
Restricted Delivery Fee (Endorsement Required)
Total Postage & Fees $

Postmark Here

Sent To CAROL SCHOER
Street, Apt. No.; or PO Box No.
City, State, ZIP+4

PS Form 3800, August 2006 See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:
CAROL SCHOER
GENERAL MANAGER
ZONE MUTUAL
WATER CO.
P.O. BOX 239
SOMIS, CA. 93066

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X Carol Schoer ☐ Agent ☒ Addressee

B. Received by (Printed Name) Carol Schoer
C. Date of Delivery 5/26/11

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 7177

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

7010 1060 0000 1514 7184

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OFFICIAL USE

Postage $
Certified Fee
Return Receipt Fee (Endorsement Required)
Restricted Delivery Fee (Endorsement Required)
Total Postage & Fees $

Postmark Here

Sent To Peter Sher
Street, Apt. No.; or PO Box No.
City, State, ZIP+4

PS Form 3800, August 2006 See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:
Peter Sher
SR. PROJECT MANAGER
CALIFORNIA - AMERICAN WATER CO
1033 B AVE. STE. #200
CORONADO CA. 92118

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X Matthew Warren ☒ Agent ☐ Addressee

B. Received by (Printed Name) Matthew Warren
C. Date of Delivery 5/27/11

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 7184

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

7010 1060 0000 1514 7450

U.S. Postal Service™
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OFFICIAL USE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To SIMI VALLEY LIBRARY

Street, Apt. No.; or PO Box No.

City, State, ZIP+4

PS Form 3800, August 2006 — See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

SIMI VALLEY LIBRARY 2969 TAPO CANYON Rd. SIMI VALLEY CA 93063

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X Hazel Dunlap ☐ Agent ☐ Addressee

B. Received by (Printed Name) HAZEL DUNLAP C. Date of Delivery 5-26-11

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 7450

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

7010 1060 0000 1514 7191

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Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To MICHAEL SOLOMAN

Street, Apt. No.; or PO Box No.

City, State, ZIP+4

PS Form 3800, August 2006 — See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

E. MICHAEL SOLOMON
GENERAL MANAGER
UNITED WATER CONSERVATION DISTRICT
106 NORTH 8TH ST.
SANTA PAULA, CA 93060

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X M. Kinnun ☐ Agent ☐ Addressee

B. Received by (Printed Name) M Kinnun C. Date of Delivery 5-26-11

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 7191

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

7010 1060 0000 1514 7290

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Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To CARMELO SORCE
Street, Apt. No.; or PO Box No.
City, State, ZIP+4

PS Form 3800, August 2006 — See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:
CARMELO SORCE
DISTRICT MANAGER
CALIFORNIA WATER SERVICE
2524 TOWNSGATE STE A
WESTLAKE VILLAGE CA.
91361

2. Article Number (Transfer from service label) 7010 1060 0000 1514 7290

COMPLETE THIS SECTION ON DELIVERY

A. Signature X ☐ Agent ☐ Addressee

B. Received by (Printed Name) Cathy Sorce C. Date of Delivery 5/26

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☐ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

7010 1060 0000 1514 7498

U.S. Postal Service™
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For delivery information visit our website at www.usps.com®

OFFICIAL USE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To THOUSAND OAKS LIBRARY
Street, Apt. No.; or PO Box No.
City, State, ZIP+4

PS Form 3800, August 2006 — See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:
THOUSAND OAKS
LIBRARY
1401 E. JANSS RD
THOUSAND OAKS
CA 91362

2. Article Number (Transfer from service label) 7010 1060 0000 1514 7368

COMPLETE THIS SECTION ON DELIVERY

A. Signature X ☐ Agent ☐ Addressee

B. Received by (Printed Name) C. Date of Delivery 5/26

D. Is delivery address different from item 1? ☑ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☑ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

7010 1060 0000 1514 7337

U.S. Postal Service™
CERTIFIED MAIL™ RECEIPT
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OFFICIAL USE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To MARK WATKINS
Street, Apt. No.; or PO Box No.
City, State, ZIP+4

PS Form 3800, August 2006 — See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:
MARK WATKINS
PUBLIC WORKS
DIRECTOR CITY OF
THOUSAND OAKS
2100 THOUSAND OAKS
BLVD THOUSAND OAKS
CA 91362

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X [signature] ☐ Agent ☐ Addressee

B. Received by (Printed Name) Thomas Brigulz
C. Date of Delivery

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☑ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 7337

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

7010 1060 0000 1514 7375

U.S. Postal Service™
CERTIFIED MAIL™ RECEIPT
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For delivery information visit our website at www.usps.com®

OFFICIAL USE

Postage	$
Certified Fee	
Return Receipt Fee (Endorsement Required)	
Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

Postmark Here

Sent To DOUGLAS WILLIFORD
Street, Apt. No.; or PO Box No.
City, State, ZIP+4

PS Form 3800, August 2006 — See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:
DOUGLAS WILLIFORD
DEPUTY EXECUTIVE
DIRECTOR S.C.A.G.
950 COUNTY SQUARE
VENTURA CA 93004

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X [signature] ☐ Agent ☐ Addressee

B. Received by (Printed Name) John T. Procter
C. Date of Delivery JUN 0 2 2011

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No
Ste. 101

3. Service Type
☑ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 7375

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

7010 1060 0000 1514 7344

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Restricted Delivery Fee (Endorsement Required)	
Total Postage & Fees	$

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Sent To ALFRED YAPEZ

Street, Apt. No.; or PO Box No.

City, State, ZIP+4

PS Form 3800, August 2006 See Reverse for Instructions

SENDER: COMPLETE THIS SECTION

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

ALFRED YAPEZ
CALIFORNIA-
AMERICAN
WATER CO.
VILLAGE DIST.
2439 W. HILLCREST DR.
NEWBURY PARK 91320

COMPLETE THIS SECTION ON DELIVERY

A. Signature
X [signature] ☐ Agent ☐ Addressee

B. Received by (Printed Name) Jenny M. Sepulveda
C. Date of Delivery 5-27-11

D. Is delivery address different from item 1? ☐ Yes
If YES, enter delivery address below: ☐ No

3. Service Type
☒ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for Merchandise
☐ Insured Mail ☐ C.O.D.

4. Restricted Delivery? (Extra Fee) ☐ Yes

2. Article Number (Transfer from service label) 7010 1060 0000 1514 7344

PS Form 3811, February 2004 Domestic Return Receipt 102595-02-M-1540

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Sent To TONOVAKDE
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City, State, ZIP+4

PS Form 3800, August 2006 See Reverse for Instructions

City of Camarillo

Department of Public Works – Water Division
601 Carmen Drive • P.O. Box 248 • Camarillo, CA 93011-0248

Phone: (805) 388-5373 • Fax: (805) 389-9524 • e-mail: waterdiv@ci.camarillo.ca.us

May 1, 2012

Kurt Souza, Regional Chief
California Department of Public Health
Drinking Water Field Operations Branch, Santa Barbara District
1180 Eugenia Place, Suite 200
Carpinteria, CA 93013-2000

Subject: **CAMARILLO WATER QUALITY AND REGIONAL DESALTER**

Dear Mr. Souza:

Pursuant to our phone conversation on April 18, 2012, you requested additional information regarding the City of Camarillo's intentions with regard to addressing exceedance of secondary water quality standards for salts, iron & manganese.

In 2007, the City conducted a pilot treatment plant study at Well A to determine the appropriate process to treat local brackish groundwater. The study concluded that reverse osmosis (RO) is the optimal treatment process to reduce the salts and remove secondary contaminants. Concurrent with the pilot plant study, City staff submitted a proposal to the Fox Canyon Groundwater Management Agency (FCGMA) requesting authorization to annually pump 5,000 acre-feet of brackish groundwater, in addition to the City's 4,200 acre-feet of groundwater allocation, from the north/east portion of the Pleasant Valley Basin. The entire 9,200 acre-feet would be treated at the City's proposed RO treatment facility. Subsequently, the City's request was put on hold until a regional solution to the salts accumulation problem in the groundwater was part of an overall groundwater management strategy.

Since the pilot study, the City's of Camarillo and Thousand Oaks, Camrosa Water District and Calleguas Municipal Water District (Calleguas) have begun the planning efforts of a joint desalter project. The regional project is an RO groundwater treatment facility known as the North Pleasant Valley Desalter (NPVD). The NPVD, when constructed, will convert 9,000 acre-feet per year of brackish groundwater into 7,300 acre-feet of municipal potable water supply.

Hydrologists hired by the regional desalter agencies are currently conducting a study to determine if the local groundwater basin in the north/eastern portion of the City can produce the additional groundwater necessary to support the NPVD.

If the study concludes that the basin can support the desalter, the City and the regional desalter agencies will once again submit a request to FCGMA to pump groundwater in excess of the City's annual groundwater allocation.

Once the City has obtained authorization from the FCGMA to pump the additional groundwater, agreements with partnering agencies will be executed and the design process will begin. It is anticipated that the plant will be operational in mid-to-late 2016. Enclosed is a North Pleasant Valley Desalter Fact Sheet and a Supplemental Environmental Project description, both of which should provide you with additional information regarding the plans for a regional desalter.

The import water delivered to the City from turnout 1-A, which is used for blending with wells A and B, cannot exceed 2,000 gpm without incurring a high-flow penalty from Calleguas. Because the groundwater quality from these wells has degraded over the years, 2,000 gpm of imported water can no longer provide enough blend to meet secondary water quality standards. To address the immediate water quality concerns, the City is working with Calleguas to increase the amount of imported water purchased at the turnout for blending from the current 2,000 to 4,000 gpm. At this time I do not have an anticipated completion date for the turnout upgrade, but will keep you posted as the project progresses.

During our phone conversation, we discussed the operation of well A. As background, well A historically was reserved as a stand-by well. However, in 2009 $230,000 was spent to rehabilitate the well. Shortly after that, Metropolitan Water District of Southern California reduced our imported water deliveries by fifteen percent (15%) as a conservation measure. As a result of the money spent and the need for reliable local supplies, we have operated well A on a regular basis to maintain its integrity.

You requested that we only operate well A for one week out of each month and increase the monthly blending monitoring reports at wells A and B to three times per month for a period of two months. We will begin the modified operation of well A and increased blended water monitoring during the first week of May.

Hopefully, I have addressed your immediate concerns and questions. I will keep you posted on the progress of the NPVD and our plans to increase blending water from Calleguas. In the mean time, if you have any further questions, please don't hesitate to call me at 805-388-5376

Sincerely,

Tom P. Smith
Water Superintendent

Enclosures

cc: Lucie McGovern
Rick Dierksen
Rich Romero

State of California | DEPARTMENT OF WATER RESOURCES | California Natural Resources Agency

PUBLIC WATER SYSTEM STATISTICS

Calendar Year **2012**

Camarillo, City of
Rick Dierksen Water Superintendent
P.O. Box 248
Camarillo, CA 93010
PWS #561019 SD

1. General Information

Please follow the provided instructions.

Contact : Rick Dierksen
Title: Water Superintendent
Phone: 805-388-5373
Fax: 805-419-7818
E-mail: rdierksen@ci.camarillo.ca.us
Website: www.ci.camarillo.ca.us
County: **Ventura**
Population served: **45500 (11/2012)**
Names of communities served: City of Camarillo

2. Active Service Connections

Customer Class	Potable Water		Recycled Water	
	Metered	Unmetered	Metered	Unmetered
Single Family Residential	11178			
Multi-family Residential	374			
Commercial/Institutional	880			
Industrial	15			
Landscape Irrigation	620			
Other	16			
Agricultural Irrigation	10			
TOTAL	13093	Dec-12		

3. Total Water Into the System - Units of production: **AF** (Select: **AF**=acre-feet; **MG**=million gallons; **CCF**=hundred cubic feet)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Potable	*Wells*	316.4	326.4	307.6	290.4	407.0	467.7	379.4	361.6	343.0	336.9	275.1	193.3	4004.8
	Surface													
	Purchased 1/	346.6	340.7	351.6	317.1	462.4	469.0	604.2	679.8	602.1	598.9	427.6	257.9	5457.9
	Total Potable	663.0	667.1	659.2	607.5	869.4	936.7	983.6	1041.4	945.1	935.8	702.7	451.2	9462.7
Untreated Water														
Recycled 2/														

1/ Potable wholesale supplier(s): _____

2/ Recycled wholesale supplier(s): _____
Level of treatment: _____

4. Metered Water Deliveries - Units of delivery: **AF** (Select: **AF**=acre-feet; **MG**=million gallons; **CCF**=hundred cubic feet)

If recycled is included, X box ↓		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
A.SingleFamilyResidential		364.36	274.67	345.23	286.57	322.77	429.00	467.49	453.08	459.00	402.94	375.98	250.40	4431.49
B.Multi-family Residential		64.08	50.02	58.44	57.20	55.05	58.84	65.20	60.07	64.27	59.10	60.22	55.35	707.84
C.Commercial/Institutional		105.18	78.68	94.69	87.23	88.64	101.04	112.80	106.67	108.10	99.57	100.18	85.34	1168.12
D.Industrial		3.98	3.40	3.88	3.58	3.46	6.24	1.29	3.82	4.53	4.49	4.10	3.27	46.04
E.Landscape Irrigation		129.72	95.19	138.48	90.88	124.15	219.81	269.07	255.33	263.24	236.61	202.75	84.91	2110.14
F.Other		5.23	3.57	2.60	1.04	2.14	2.62	2.49	3.55	12.83	4.91	1.75	0.98	43.71
Total Urban Retail (A thru F)		672.55	505.53	643.32	526.50	596.21	817.55	918.34	882.52	911.97	807.62	744.98	480.25	8507.34
Agricultural Irrigation		45.18	40.81	54.30	63.15	82.93	69.41	55.49	87.80	50.62	83.11	77.68	33.84	744.32
Wholesale(*to other agencies*)														

California Electrical Energy Generation

California Electrical Energy Generation, 1997 to 2011*
Total Production, by Resource Type
(Gigawatt Hours)

	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997
California Generation plus Net Imports:	284,953	290,519	298,827	307,183	304,517	298,096	289,086	289,979	279,774	274,290	266,582	246,876	243,077	244,576	230,243
Hydroelectric	42,727	34,308	29,196	24,446	27,094	48,535	40,240	34,448	36,327	31,318	24,909	42,053	41,627	48,757	41,400
Nuclear	36,666	32,214	31,509	32,482	35,698	32,036	36,155	30,241	35,594	34,353	33,294	43,533	40,419	41,715	37,267
In-State Coal	3,120	3,406	3,735	3,977	4,217	4,190	4,283	4,086	4,269	4,275	4,041	3,183	3,602	2,701	2,276
Oil	36	52	67	92	103	134	148	127	103	81	379	449	55	123	143
Natural Gas	90,751	109,752	117,208	122,906	120,265	109,141	97,103	105,183	94,522	92,658	115,695	106,878	84,703	82,052	74,341
Geothermal	12,685	12,740	12,907	12,907	13,029	13,093	13,292	13,494	13,329	13,396	13,525	13,456	13,251	12,554	11,950
Biomass	5,777	5,798	5,968	5,819	5,658	5,716	6,027	6,074	6,060	6,192	5,701	6,086	5,663	5,266	5,701
Wind	7,594	6,172	6,249	5,724	5,570	4,902	4,084	4,258	3,316	3,546	3,242	3,604	3,433	2,776	2,739
Solar	1,058	908	850	733	668	616	660	741	759	851	836	860	838	839	810
Other	0	0	7	25	0	19	12	39	95	25	26	0	0	230	896
Direct Coal Imports**	13,032	13,119	13,556	14,463	14,417	14,452	24,114	24,504	23,148	23,653	23,699	23,877	22,802	22,570	22,411
Other Imports***	71,508	72,050	77,575	83,608	77,799	65,263	62,967	66,785	62,253	63,941	41,235	2,897	26,685	24,993	30,310
Governmental and Utility-Owned In-State Generation:	93,912	86,355	81,877	79,354	83,015	91,756	83,252	71,210	76,391	70,455	67,045	99,733	97,688	121,955	119,961

Hydroelectric	34,427	28,256	24,345	20,666	23,194	39,969	33,200	28,956	29,970	26,366	21,432	41,001	40,593	47,326	40,122
Nuclear	36,666	32,214	31,509	32,482	35,698	32,036	36,155	30,241	35,594	34,353	33,294	43,533	40,419	41,715	37,267
In-State Coal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oil	30	35	45	53	53	51	58	51	41	43	123	157	55	123	143
Natural Gas	21,848	24,954	25,052	25,175	23,092	18,727	12,837	10,814	9,591	8,537	11,198	13,747	14,995	27,699	37,048
Geothermal	858	846	903	947	975	970	997	1,140	1,190	1,150	996	1,252	1,543	5,009	5,302
Biomass	37	38	18	28	-	-	2	6	4	4	-	34	73	80	71
Wind	-	-	-	-	-	-	-	-	-	-	-	7	7	3	6
Solar	45	10	5	3	2	2	2	2	2	2	3	3	3	2	2
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Commercial In-State Generation:	106,503	118,996	125,819	129,758	129,286	126,626	118,754	127,480	117,982	116,240	134,603	120,369	95,903	75,058	57,561
Hydroelectric	8,300	6,052	4,851	3,780	3,899	8,566	7,040	5,492	6,357	4,952	3,477	1,052	1,035	1,430	1,277
Nuclear	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
In-State Coal	3,120	3,406	3,735	3,977	4,217	4,190	4,283	4,086	4,269	4,275	4,041	3,183	3,602	2,701	2,276
Oil	6	17	22	39	51	83	90	76	62	38	256	293	-	-	-
Natural Gas	68,903	84,798	92,157	97,731	97,172	90,415	84,266	94,368	84,931	84,121	104,497	93,130	69,708	54,354	37,292
Geothermal	11,826	11,894	12,004	11,960	12,054	12,123	12,295	12,354	12,139	12,246	12,528	12,204	11,708	7,546	6,648
Biomass	5,740	5,760	5,950	5,792	5,658	5,716	6,025	6,068	6,057	6,188	5,701	6,052	5,590	5,186	5,630
Wind	7,594	6,172	6,249	5,724	5,570	4,902	4,084	4,258	3,316	3,546	3,242	3,597	3,426	2,773	2,733
Solar	1,013	898	845	730	666	614	658	739	757	848	834	857	835	837	808
Other	0	0	7	25	-	19	12	39	95	25	26	-	-	230	896
Energy Exports:	5,146	5,054	4,629	5,064	5,586	5,056	5,685	4,825	6,026	6,534	14,854	N/A	N/A	N/A	N/A
Pacific Northwest	1,133	1,809	1,871	2,242	2,620	2,518	2,061	1,532	1,471	1,020	5,846	N/A	N/A	N/A	N/A
Pacific Southwest	4,013	3,245	2,759	2,822	2,966	2,539	3,623	3,292	4,555	5,514	9,007	N/A	N/A	N/A	N/A
Energy Imports:	89,686	90,223	95,760	103,136	97,802	84,771	92,766	96,113	91,427	94,128	79,787	N/A	N/A	N/A	N/A
Pacific Northwest	28,851	26,486	21,800	26,201	27,289	22,321	22,347	22,363	23,775	28,206	12,672	N/A	N/A	N/A	N/A

Pacific Southwest	60,835	63,737	73,960	76,935	70,514	62,450	70,419	73,750	67,652	65,921	67,114	N/A	N/A	N/A	N/A
Net Energy Imports (Imports less Exports):	84,539	85,169	91,131	98,072	92,217	79,714	87,081	91,289	85,401	87,594	64,933	26,774	49,487	47,563	52,720
Pacific Northwest	27,718	24,677	19,929	23,959	24,669	19,803	20,286	20,831	22,303	27,186	6,826	18,777	26,051	19,428	25,204
Pacific Southwest	56,821	60,492	71,201	74,113	67,547	59,911	66,795	70,458	63,097	60,408	58,107	7,997	23,436	28,135	27,517

*** Note:** The data in this table is based on corrections and updates as of August 1, 2012.

**** Note:** The "Direct Coal Imports" category is based on reported ownership shares and contractual arrangements for power purchases by California utilities. Due to legislative changes required by Assembly Bill 162 (2009) and to simplify the characterization of coal power generation, only Utah's Intermountain Power Project and Nevada's Mohave Generation Station (closed as of 2006) are included in the reported "Direct Coal Imports" for 1997 through 2011 on this table. A more detailed analysis of the role of coal-based power generation within California is outside the scope of this table. The California Air Resources Board is currently undertaking the task of identifying the fuel source of all imported power into California. When comparing coal and other power imports over time, the best approach is to compare the combined value of both "Direct Coal Imports" and "Other Imports."

***** Note:** In this tabulation, generation located physically out-of-state is included in the energy imports category. The energy imports and exports include all electricity flows in and out of the state as reported by four California Balancing Authorities: California Indendent System Operator, Los Angeles Department of Water and Power, Imperial Irrigation District, and Sacramento Municipal Utility District plus generation at five out-of-state power plants that are within one or more of these Balancing Authorities' control areas but are physically located outside California. These plants include Intermountain Power Plant in Utah, Mohave Generation Station in Nevada (now closed), Caithness Dixie Valley Valley Plant in Nevada, Termoelectrica de Mexicali Plant and InterGen's La Rosita Plant both of which are in Mexico. Power generated by these plants are not typically reported on Balancing Authorities control area imports and exports categories, hence their inclusion in this methodology.

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From: Meredith Clement
To: Lucie McGovern; Kristine McCaffrey (kmccaffrey@calleguas.com); Bryan.Bondy@ventura.org; Jim Henderson; Tim Meernik; Catrina Paez; Sachi Itagaki;
Subject: 1389001 SECOND Followup C/B Call North Pleasant Valley GW Desalter
Date: Wednesday, February 13, 2013 6:22:18 PM

Hello:

I wanted to close the loop on the North Pleasant Valley Cost/Benefit call we had on January 29. Below is the list of action items and their status.

1. Lucie to provide information on groundwater pumping cost for different groundwater users (e.g., ag, municipal). Plan is to look at recent cost of service study.
   - DONE, backup in City of Camarillo Water Rate Study on webportal*: Ref-Cost of Service by Customer Class*. I did some calculations for the major customer categories and found the following.

Category	Base Cost	Base plus max hour capacity, meters, billing staff
Single Family	$437	$1090
Multi-Family	$436	$843
Commercial	$436	$851
Industrial	$438	$736
Landscape	$437	$978
Ag	$437	$942

2. Lucie to provide actual water demands by different customer categories
   - DONE, see materials on webportal: *Ref Camarillo Public Water System Statistics 2008*, *Ref Camarillo Public Water System Statistics 2009, Ref Camarillo Public Water System Statistics 2010, Ref Camarillo Public Water System Statistics 2011*
3. Lucie to provide CPH memorandum directing City to replace existing groundwater wells
   - DONE, see materials on webportal: *Ref CDPH memo directing City to replace existing GW wells*
4. Lucie to provide information on how cost of new wells derived (~ $10Million) **(still needed, I apologize if you sent this already, I can't seem to locate it)**
5. Lucie to provide spreadsheet showing Capital, O&M cost breakdown
   - DONE, see materials on webportal: *Ref-Reverse Osmosis Desalter*

Cost

6. Lucie to provide Pilot Study (for use in determining/backup for membrane replacement schedule)) **(still needed, it looks like we have the proposal for the Pilot Study, but not the Pilot Study itself)**
7. Lucie to provide GIS data of service area to Bryan
    - DONE, see Item 9
8. Kristine to gather estimate of how often pump motors need to be replaced
    - DONE, Kristine made some inquiries but we never were able to get a solid number. K/J reviewed some industry publications and the best reference we found for a general reference was the California State Controller's Office Guide, "Suggested Useful Life for Fixed Assets". This has a specific section on water utilities and recommends a useful pump motor life of 25 years.
9. Bryan to quantify estimates of water quality improvement based on aquifer refill of higher quality water **(still needed, I apologize if you sent this already, I can't seem to locate it)**
10. Bryan to review GIS provided by Lucie an determine potential change in water use given higher quality water
    - DONE, see Bryan's email on the webportal: *Ref-email B Bondy re North Pleasant Valley Econ Analysis 2-1-13*
11. Meredith/KJ to estimate energy use desalter
    - DONE, based on the O&M Electircal Costs provided by Lucie we estimate the desalter (pumping and treatment) will use 7,862,400kWh annually

I am also looking to get Attachment 9 (Program Preferences) from the City of Camarillo.

Thanks,

--Meredith

From: Meredith Clement
Sent: Tuesday, January 29, 2013 12:35 PM
To: 'Lucie McGovern'; Kristine McCaffrey (kmccaffrey@calleguas.com); 'Bryan.Bondy@ventura.org'; 'Jim Henderson'; Tim Meernik; Catrina Paez; Sachi Itagaki
Subject: 1389001 Followup C/B Call North Pleasant Valley GW Desalter

Hello:

These are the action items from today's call:

12. Lucie to provide information on groundwater pumping cost for different groundwater users (e.g., ag, municipal). Plan is to look at recent cost of service study.
13. Lucie to provide actual water demands by different customer categories
14. Lucie to provide CPH memorandum directing City to replace existing groundwater wells
15. Lucie to provide information on how cost of new wells derived (~ $10Million)
16. Lucie to provide spreadsheet showing Capital, O&M cost breakdown
17. Lucie to provide Pilot Study (for use in determining/backup for membrane replacement schedule)
18. Lucie to provide GIS data of service area to Bryan
19. Kristine to gather estimate of how often pump motors need to be replaced
20. Bryan to quantify estimates of water quality improvement based on aquifer refill of higher quality water
21. Bryn to review GIS provided by Lucie an determine potential change in water use given higher quality water
22. Meredith/KJ to estimate energy use desalter

--Meredith

Meredith Clement | Water Resources Project Manager
Kennedy/Jenks Consultants
2775 N. Ventura Road, Suite 100 | Oxnard, CA, 93036
P: 805.973.5700 | F: 805.973.1440

Attachment A to Resolution No. R4-2007-016

Proposed Amendment to the Water Quality Control Plan – Los Angeles Region

to Incorporate the

Total Maximum Daily Load for Boron, Chloride, Sulfate, and TDS (Salts) in the Calleguas Creek Watershed

Adopted by the California Regional Water Quality Control Board, Los Angeles Region on October 4, 2007

Amendments

Table of Contents
Add:

Chapter 7. Total Maximum Daily Loads (TMDLs)

7- 22 Calleguas Creek Watershed Salts TMDL

List of Figures, Tables, and Inserts
Add:

Chapter 7. Total Maximum Daily Loads (TMDLs)
Tables

7-22 Calleguas Creek Watershed Salts TMDL
7-22.1. Calleguas Creek Watershed Salts TMDL: Elements
7-22.2. Calleguas Creek Watershed Salts TMDL: Implementation Schedule

Chapter 7. Total Maximum Daily Loads (TMDLs)
Calleguas Creek Watershed Salts TMDL

This TMDL was adopted by:

The Regional Water Quality Control Board on October 4, 2007.

This TMDL was approved by:

The State Water Resources Control Board on May 20, 2008.
The Office of Administrative Law on November 6, 2008.
The U.S. Environmental Protection Agency on December 2, 2008.

This TMDL is effective on December 2, 2008.

The elements of the TMDL are presented in Table 7-22.1 and the Implementation Plan in Table 7-22.2

Table 7-22.1. Calleguas Creek Watershed Salts TMDL: Elements

<table>
<tr><th>TMDL Element</th><th>Key Findings and Regulatory Provisions</th></tr>
<tr><td>Problem Statement</td><td>Eleven of fourteen reaches in the Calleguas Creek Watershed (CCW) are identified on the 2002 Clean Water Act Section 303(d) list of water-quality limited segments as impaired due to elevated levels of boron, chloride, sulfate, or total dissolved solids (TDS) (these constitutions are commonly referred to as salts). Salts primarily impact two beneficial uses: agricultural supply and groundwater recharge. Below is 2002 303(d) list of water quality limited segments of the Calleguas Creek watershed:
<table>
<tr><th>Reach Name</th><th>Pollutant/Stressor</th></tr>
<tr><td>▪ Calleguas Creek Reach 3</td><td>Chloride, TDS</td></tr>
<tr><td>▪ Calleguas Creek Reach 6</td><td>Chloride, Sulfate, TDS</td></tr>
<tr><td>▪ Calleguas Creek Reach 7</td><td>Boron, Chloride, Sulfate, TDS</td></tr>
<tr><td>▪ Calleguas Creek Reach 8</td><td>Boron, Chloride, Sulfate, TDS</td></tr>
<tr><td>▪ Calleguas creek Reach 9A</td><td>Sulfate, TDS</td></tr>
<tr><td>▪ Calleguas Creek Reach 9B</td><td>Chloride, Sulfate, TDS</td></tr>
<tr><td>▪ Calleguas Creek Reach 10</td><td>Chloride, Sulfate, TDS</td></tr>
<tr><td>▪ Calleguas Creek Reach 11</td><td>Sulfate, TDS</td></tr>
<tr><td>▪ Calleguas Creek Reach 12</td><td>Sulfate, TDS</td></tr>
<tr><td>▪ Calleguas Creek Reach 13</td><td>Chloride, Sulfate, TDS</td></tr>
</table>
The list of impaired segments of the Calleguas Creek watershed in the 2002 303(d) list was maintained in the 2006 303(d) list.

The segment of Reach 4 below Laguna Road is tidally influenced and therefore not impaired for chloride, boron, sulfate, and TDS. Consequently, the waste load and load allocations developed for Reach 4 in this TMDL do not apply below Laguna Road.

The goal of this TMDL is to protect and restore the water quality in the Calleguas Creek watershed by controlling the loading and accumulation of salts.</td></tr>
<tr><td>Numeric Targets</td><td>Numeric targets are based on the site-specific numeric water quality objectives (WQOs) provided in the Basin Plan.

1. <u>Surface Water Quality Objectives</u>

Site-specific surface water quality objectives for the Calleguas Creek watershed are applicable upstream of Potrero Road. Site specific objectives have not been determined for Calleguas Creek below Potrero Road because the reach is tidally influenced. Below are WQOs for Calleguas Creek upstream of Potrero Road.</td></tr>
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TMDL Element	Key Findings and Regulatory Provisions

Constituent	Water Quality Objective Upstream Potrero Road (mg/L)
Boron	1
Chloride	150
Sulfate	250
TDS	850

2. Groundwater Quality Objectives

Groundwater Basin[1]			Boron (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	TDS (mg/L)
DWR Basin No.	**Groundwater Basin as Listed in the 1994 Basin Plan**	**Implementation Areas for Salts TMDL**				
4-6	Pleasant Valley	Conejo and Calleguas/Pleasant Valley	1.0	150	300	700
4-7	Arroyo Santa Rosa	Arroyo Santa Rosa and Conejo/Arroyo Santa Rosa	1.0	150	300	900
4-8	Las Posas Valley – East of Grimes Canyon and Hitch Blvd	Arroyo Simi/South Las Posas	3.0	400	1200	2500
4-8	Las Posas Valley – South of LA Ave between Somis Rd & Hitch Blvd	Arroyo Las Posas/South Las Posas	1.0	250	700	1500
4-8	Las Posas Valley – North Las Posas Area	Arroyo Las Posas/North Las Posas	1.0	150	250	500
4-9	Simi Valley	Arroyo Simi/Simi Valley	1.0	150	600	1200
4-10	Conejo Valley	Arroyo Conejo/Conejo Valley	1.0	150	250	800
4-15	Tierra Rejada	Arroyo Santa Rosa/Tierra Rejada	0.5	100	250	700
4-19	Thousand Oaks	Arroyo Conejo/Thousand Oaks	1.0	150	700	1400

[1] The groundwater quality objectives specified in this table are equivalent to the groundwater quality objectives in the 1994 Basin Plan. Groundwater basins are numbered in the first column according to Bulletin 118-80 (Department of Water Resources, 1980). Designated groundwater basins in the 1994 Basin Plan are specified in the second column and groundwater basin descriptions of Calleguas Creek used in this TMDL are listed in the third column of the table.

Source Analysis

Sources of salts in the watershed include water supply (water imported from the State Water Project or Freeman Diversion and deep aquifer groundwater pumping), water softeners that discharge to publicly owned treatment works (POTWs), POTW treatment chemicals, atmospheric deposition, pesticides and fertilizers, and indoor water use (chemicals, cleansers, food, etc.). These salts are then transported through POTW discharges and runoff to surface water, shallow groundwater, and/or stranded on the watershed in the soils. Salts transported in the surface water to the ocean are currently the only salts

TMDL Element	Key Findings and Regulatory Provisions
	that are exported from the watershed. While the concentration of salts in the introduced water is usually below the Basin Plan Objectives, the quantity of water brought into the watershed is sufficient to rank introduced water as the greatest source of salts to the watershed. Salts that are transported during dry weather to the surface water are quantified via the following mechanisms: groundwater pumping, groundwater exfiltration, POTWs, dry weather urban and agricultural runoff. Wet weather loadings from each of these sources have the potential to be significant, but tend to be lower in concentration and do not occur during the critical conditions for salts. Wet weather loads are significant from the perspective of transporting stranded salts off the watershed.
Linkage Analysis	The linkage analysis for salts focuses on the surface water concentrations of salts. However, surface water concentrations are only one component of the watershed salts issue. Because it is difficult to model other aspects of the salt problem (i.e. surface water and groundwater interactions, stranded salts), two simplified approaches have been used to demonstrate that salts will be removed from the watershed, which should have a correspondingly positive impact on surface water and groundwater salts concentrations. First, a surface water model was developed to provide a linkage between sources and surface water quality and to demonstrate the impact of projects on receiving water quality in the watershed. Second, a salt balance was developed to quantify the removal of salts from the watershed with the goal of achieving a mass balance in which the mass of boron, sulfate, TDS and chloride imported into Calleguas Creek subwatersheds is no more than the mass of boron, sulfate, TDS and chloride exported from the Calleguas Creek subwatershed. Achieving a salt balance in the watershed will prevent additional build-up of salts in any medium in the watershed and protect ground water supplies from increasing in salt concentrations. The Calleguas Creek Modeling System is a mass balance based model that was developed for the surface water to provide a linkage between sources and surface water quality. To estimate the salts balance in the watershed, a simple chloride mass balance was developed by the Camrosa Water District (Hajas, 2003a) and modified to address the other salts.

TMDL Element	Key Findings and Regulatory Provisions
Waste Load Allocations	**<u>A. POTWs</u>** The TMDL includes waste load allocations (WLAs) for five POTWs in the Calleguas Creek watershed: Simi Valley Water Quality Control Plant (WQCP), Hill Canyon Wastewater Treatment Plan (WWTP), Moorpark WWTP, Camarillo Water Reclamation Plant (WRP), and Camrosa Water Reclamation Facility (WRF). At the end of the implementation period, only Simi Valley WQCP and the Hill Canyon WWTP are expected to discharge to surface waters. Moorpark WWTP and Camrosa WRF currently discharge directly to ponds under dry weather conditions. As part of the TMDL implementation, the Renewable Water Resources Management Program (RWRMP) will introduce treated wastewater from the Camarillo WRP into the Camrosa recycled water storage and distribution system. Surplus treated wastewater from Camarillo WRP and Camrosa WRF will be discharged at a point downstream of Potrero Road Bridge to Calleguas Creek. Dry weather WLAs are included for the case when Camarillo WRP, Camrosa WRF, and Moorpark WWTP need to discharge to the stream (for example, if there is insufficient recycled water demand during the wet season). Including WLAs for these POTWs ensures that water quality objectives are not exceeded as a result of their discharge. POTW mass-based WLAs are calculated as the POTW effluent flow rate multiplied by the water quality objective and include a mass-based adjustment factor (AF) that is subtracted from the product of the flow-rate and the water quality objective. The adjustment factor is used to link POTW allocations to the required reductions in background loads. The adjustment factors are implemented through mechanisms that export salts out of the subwatershed, such as groundwater pumping, to meet the salt balance requirements. To ensure that the loading capacity is achieved in surface water and the reductions in background loads are achieved, minimum salt exports shown below are required for POTWs and are included in WLAs as a component of the adjustment factors. If the background load reductions are not achieved, POTWs shall be responsible for providing additional load reductions to achieve water quality standards. The AF is set equal to the difference between the minimum salts export requirement to attain a salt balance in the subject reaches and the actual salts export. If the calculated annual dry weather salt exports from the subwatershed to which the POTW discharges are less than the minimum required exports for the previous year and the annual average receiving water concentration at the base of the subwatershed to which the POTW discharges exceeds water quality objectives for the previous year, the POTW allocations will be reduced using the adjustment factor.

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	The adjustment factors are also used to address unusual conditions in which the inputs to the POTWs from the water supply may challenge the POTWs ability to meet the assigned WLAs. The adjustment factor allows for the additional POTW loading only when the water quality objectives are met in the receiving waters. POTW allocations can be adjusted upwards when imported water supply chloride concentrations exceed 80 mg/L and discharges from the POTW exceed the WLA. In order to apply the AF to the assigned WLAs, the POTW is required to submit documentation of the water supply chloride concentrations, receiving water chloride concentration, the effluent mass, and evidence of increased salt exports to offset the increased discharges from the POTW to the RWQCB for approval. WLAs shown in table below apply to POTWS during dry weather when the flows in the receiving water are below the 86th percentile flow. During wet weather, the loading capacity of the stream is significantly increased by stormwater flows with very low salt concentrations. Any discharges from the POTWs during wet weather would be assimilated by these large storm flows and would not cause exceedances of water quality objectives. Boron is only listed in the Simi and Pleasant Valley (Revolon) subwatersheds and exceedances of boron do not occur in other portions of the watershed. Therefore, boron allocations are only included for the Simi Valley WQCP. Interim limits are included to allow time for dischargers to put in place implementation measures necessary to achieve final waste load allocations. The monthly average interim limits are set equal to the 95th percentile of available discharge data. **1. Minimum Salt Export Requirements for Adjustment Factor [a]** POTW: Minimum Chloride Export (lb/day); Minimum TDS Export (lb/day); Minimum Sulfate Export (lb/day); Minimum Boron Export (lb/day) Simi Valley WQCP: 460; 3220; 9120; 3.3 Moorpark WWTP: 460; 3220; 9120; 3.3 Hill Canyon WWTP: 1060; 7920; 4610; 0 Camrosa WRF: 1060; 7920; 4610; 0 Camarillo WRP: 1060; 7920; 4610; 0 [a] Minimum export requirements include a 10% Margin of Safety.

TMDL Element	Key Findings and Regulatory Provisions

2. Interim Monthly Average WLAs for POTWs

POTW	Chloride (mg/L)	TDS (mg/L)	Sulfate (mg/L)	Boron (mg/L)
Simi Valley WQCP	183	955	298	N/A
Hill Canyon WWTP	189	N/A	N/A	N/A
Moorpark WWTP	171	N/A	267	N/A
Camarillo WRP	216	1012	283	N/A
Camrosa WRF*	N/A	N/A	N/A	N/A

* Camrosa WRF has not discharged to surface water during the period under which interim limits were calculated. When effluent data are available, the Regional Board may adopt interim WLAs for Camrosa WRF.
N/A: The 95th percentile concentration is below the Basin Plan objective so interim limits are not necessary.

3. Final WLAs for POTWs[a,d]

POTW	Chloride (lb/day) [c]	TDS (lb/day) [c]	Sulfate (lb/day) [c]	Boron (lb/day) [c]
Simi Valley WQCP	150*Q-AF	850*Q-AF	250*Q-AF	1.0*Q-AF
Hill Canyon WWTP	150*Q-AF	850*Q-AF	250*Q-AF	N/A
Moorpark WWTP[b]	150*Q-AF	850*Q-AF	250*Q-AF	N/A
Camarillo WRP[b]	150*Q-AF	850*Q-AF	250*Q-AF	N/A
Camrosa WRF[b]	150*Q-AF	850*Q-AF	250*Q-AF	N/A

a. The allocations shown only apply during dry weather (as defined in this TMDL). During wet weather discharges from the POTWs do not cause exceedances of water quality objectives.
b. These POTWs are not expected to discharge after the end of the implementation period.
c. AF is the adjustment factor and equals the difference between the minimum salts export requirement and the actual salts export.
d. Q represents the POTW flow at the time the water quality measurement is collected and a conversion factor to lb/day based on the units of measurement for the flow.

N/A Boron is not listed in the reaches to which the POTW discharges. No WLA is required.

B. Urban Runoff

Permitted stormwater dischargers that are responsible parties to this TMDL include the Municipal Stormwater Dischargers (MS4s) of the Cities of Camarillo, Moorpark, Thousand Oaks, County of Ventura, Ventura County Watershed Protection District, and general industrial and construction permittees. Permitted stormwater dischargers are assigned a dry weather wasteload allocation equal to the average dry weather critical condition flow rate multiplied by the numeric target for each constituent. Waste load allocations apply in the receiving water at the base of each subwatershed. Because wet weather flows transport a large mass of salts at low concentrations, these dischargers meet water

TMDL Element	Key Findings and Regulatory Provisions

quality objectives during wet weather. Dry weather allocations apply when instream flow rates are below the 86th percentile flow and there has been no measurable precipitation in the previous 24 hours.

Interim limits are assigned for dry weather discharges from areas covered by NPDES stormwater permits to allow time to implement appropriate actions. The interim limits are assigned as concentration based receiving water limits set to the 95th percentile of the discharger data as a monthly average limit except for chloride. The 95th percentile for chloride was 267 mg/L which is higher than the recommended criteria set forth in the Basin Plan for protection of sensitive beneficial uses including aquatic life. Therefore, the interim limit for chloride for Permitted Stormwater Dischargers is set equal to 230 mg/L to ensure protection of sensitive beneficial uses in the Calleguas Creek watershed.

1. Interim Dry Weather WLAs for Permitted Stormwater Dischargers

Constituent	Interim Limit (mg/L)
Boron Total	1.3
Chloride Total	230
Sulfate Total	1289
TDS Total	1720

2. Final Dry Weather WLAs for Permitted Stormwater Dischargers

Subwatershed	Critical Condition Flow Rate (mgd)	Chloride Allocation (lb/day)	TDS Allocation (lb/day)	Sulfate Allocation (lb/day)	Boron Allocation (lb/day)
Simi	1.39	1,738	9,849	2,897	12
Las Posas	0.13	157	887	261	N/A
Conejo	1.26	1,576	8,931	2,627	N/A
Camarillo	0.06	72	406	119	N/A
Pleasant Valley (Calleguas)	0.12	150	850	250	N/A
Pleasant Valley (Revolon)	0.25	314	1,778	523	2

<table>
<tr><th>TMDL Element</th><th>Key Findings and Regulatory Provisions</th></tr>
<tr><td></td><td>

C. Final WLAs for Other NPDES Dischargers

Concentration-based WLAs are assigned at the Basin Plan objectives for other NPDES dischargers.

<table>
<tr><th>Constituent</th><th>Allocation (mg/L)</th></tr>
<tr><td>Chloride</td><td>150</td></tr>
<tr><td>TDS</td><td>850</td></tr>
<tr><td>Sulfate</td><td>250</td></tr>
<tr><td>Boron[a]</td><td>1.0</td></tr>
</table>

Other NPDES dischargers include, but are not limited to, permitted groundwater cleanup projects that could have significant salt concentrations as a result of the stranded salts in the shallow groundwater basins being treated. To facilitate the cleanup of the basins prior to alternative discharge methods (such as the brine line) being available, interim limits for other NPDES dischargers will be developed on a case-by-case basis and calculated as a monthly average using the 95th percentile of available discharge data.

</td></tr>
<tr><td>**Load Allocations**</td><td>

Dry weather load allocations are assigned as a group allocation to irrigated agricultural discharges. The load allocation (LA) is equal to the average dry weather critical condition flow rate multiplied by the numeric target for each constituent. Load allocations apply in the receiving water at the base of each subwatershed. Because wet weather flows transport a large mass of salts at a typically low concentration, these dischargers should meet water quality objectives during wet weather. Dry weather allocations apply when instream flow rates are below the 86th percentile flow and there has been no measurable precipitation in the previous 24 hours.

Interim limits are assigned for dry weather discharges from irrigated agricultural areas to allow time to implement appropriate actions. The interim limits are assigned as concentration based receiving water limits set to the 95th percentile of the discharger data as a monthly average limit except for chloride. The 95th percentile for chloride was 499 mg/L which is higher than the recommended criteria set forth in the Basin Plan for protection of sensitive beneficial uses including aquatic life. Therefore, the interim limit for chloride for Irrigated Agricultural Dischargers is set equal to 230 mg/L to ensure protection of sensitive beneficial uses in the Calleguas Creek watershed.

</td></tr>
</table>

TMDL Element	Key Findings and Regulatory Provisions

I. Interims Load Allocations for Irrigated Agricultural Dischargers

Constituent	Interim Limit (mg/L)
Boron Total	1.8
Chloride Total	230
Sulfate Total	1962
TDS Total	3995

II. Final Load Allocations for Irrigated Agricultural Dischargers

Subwatershed	Chloride Allocation (lb/day)	TDS Allocation (lb/day)	Sulfate Allocation (lb/day)	Boron Allocation (lb/day)
Simi	641	3,631	1,068	4
Las Posas	2,109	11,952	3,515	N/A
Conejo	743	4,212	1,239	N/A
Camarillo	59	336	99	N/A
Pleasant Valley	305	1,730	509	N/A
Revolon	7,238	41,015	12,063	48

Margin of Safety

A margin of safety (MOS) for the TMDL is designed to address uncertainties in the analysis that could result in targets not being achieved in the waterbodies. The primary uncertainties associated with this TMDL include the impact of implementing a salt balance on receiving water quality. The effect of the salt balance is estimated by the mass-balance and subject to the following uncertainties: 1) the flow rates used to determine the loading capacity may change due to TMDL implementation, 2) the use of a daily load for determining allocations and an annual mass balance to attain water quality objectives, and 3) the sources of salts may not be completely known. Both implicit and explicit MOS are included for this TMDL. The implicit MOS stems from the use of conservative assumptions made during development of the TMDL. The mass of salts transported out of the watershed during wet weather is on average over 15% of the annual mass of salts introduced to the watershed for all constituents. The salt export during wet weather ranges from 7% to 41% for TDS, 9% to 48% for chloride, and 13% to 89% for sulfate of the export required to meet a salt balance in the watershed. This mass is not used to determine compliance with the salt balance and represents a significant implicit margin of safety. The model also contains a component that serves to model the impact of "stranded" salts in the watershed. The component assumes low irrigation efficiencies and the ability of all salts applied as irrigation water anywhere in the watershed to be discharged to receiving water in

TMDL Element	Key Findings and Regulatory Provisions
	critical years. This likely overestimates the impact of "stranded" salts and results in a higher concentration of salts due to irrigation in the receiving water. An explicit MOS of 10% is applied to the adjustment factors for the POTWs to account for the uncertainties in the TMDL analysis. By applying the margin of safety to the adjustment factor, more salts are required to be exported than are necessary to offset the background loads in the watershed. This additional salt export provides a margin of safety on the salt balance to address uncertainties that the salt balance will result in compliance with water quality objectives. The 10% explicit MOS is determined sufficient to address the uncertainties associated with the estimated impact of the salt balance on receiving water loadings.
Future Growth	Ventura County accounts for slightly more than 2% of the state's residents with a population of 753,197 (US Census Bureau, 2000). GIS analysis of the 2000 census data yields a population estimate of 334,000 for the CCW, which equals about 44% of the county population. According to the Southern California Association of Governments (SCAG), growth in Ventura County averaged about 51% per decade from 1900-2000; with growth exceeding 70% in the 1920s, 1950s, and 1960s. Significant population growth is expected to occur within and near present city limits until at least 2020. Increased growth requires additional water. Therefore, future growth could result in increased loads of salts being imported into the watershed. However, the TMDL implementation plan is designed to maintain a salts balance in the watershed. If additional salts are imported into the watershed, a larger volume of salts will also be exported out of the watershed to maintain the balance. Consequently, increased imports from future growth are not expected to result in higher concentrations in receiving waters.
Seasonal Variations and Critical Conditions	The critical condition for salts is during dry weather periods. During wet weather, stormwater flows dilute the salt discharges and receiving water concentrations are significantly lower than water quality objectives. Dry weather, defined as days with flows lower than the 86th percentile flow and no measurable precipitation, is a critical condition regardless of the dry weather flows in the stream. The driving conditions for exceedances of water quality objectives are the concentrations in the water supply (which is driven by surface water concentrations in Northern California) and the previous year's annual precipitation and corresponding flows. Elevated salts concentrations during dry weather occur when stranded salts are discharged into the surface water after higher than average rainfall years. The elevated concentrations occur during years when the previous annual flow is

TMDL Element	Key Findings and Regulatory Provisions
	greater than the 75th percentile of the annual flows for the watershed (critical year). The higher concentrations occur during the dry periods of critical years regardless of whether the annual flow for the critical year is an average flow year, higher than average year, or lower than average year. The key parameter determining a critical year is the total annual flow volume for the previous year. Based on model results, four critical years were defined based on modeled results that resulted in receiving water concentrations greater than the 99th percentile concentration during at least 10% of the dry period. The critical years identified from the model occur with conditions similar to what occurred in 1978, 1979, 1983 and 1998.
Special Studies and Monitoring Plan	**<u>Special Studies</u>** Several special studies are planned to improve understanding of key aspects related to achievement of WLAs and LAs for the Salts TMDL. ***1. Special Study #1 (Optional) – Develop Averaging Periods and Compliance Points*** The TMDL technical report has provided information that shows instantaneous salts objectives may not be required to protect groundwater recharge and agricultural beneficial uses. It is possible that the beneficial uses will be protected and a salt balance achieved without achieving instantaneous water quality objectives in all reaches of the watershed. This optional special study is included to allow an investigation of averaging periods for the salts objectives in the CCW. Additionally, this study will investigate the locations of beneficial uses and the possibility of identifying compliance points for the salts objectives at the point of beneficial use impacts. The use of compliance points would alleviate the need to develop site-specific objectives for the reaches of the watershed upstream of the POTW discharges (described in Special Study #3) while still ensuring the protection of beneficial uses. Sensitive beneficial uses are not present in the upper reaches and POTW discharges dilute the salts from the upper reaches and may allow compliance with the objectives at the point of groundwater recharge downstream. This is an optional special study to be conducted if desired by the stakeholders or determined necessary or appropriate by the Executive Officer. ***2. Special Study #2 (Optional) – Develop Natural Background Exclusion*** Discharges of groundwater from upstream of the Simi Valley WQCP (Reaches 7 and 8) and Hill Canyon WWTP (Reaches 12 and 13) and

TMDL Element	Key Findings and Regulatory Provisions
	downstream of the Camrosa WRF (Reach 3) contain high salts concentrations. Natural marine sediments may contribute to the high concentrations in those discharges. This special study would evaluate whether or not the groundwater discharges in these areas would qualify for a natural sources exclusion. The special study could follow a 'reference system/anti-degradation approach' and/or a 'natural sources exclusion approach' for any allocations included in this TMDL that are proven unattainable due to the magnitude of natural sources. The purpose of a 'reference system/anti-degradation approach' is to ensure water quality is at least as good as an appropriate reference site and no degradation of existing water quality occurs where existing water quality is better than that of a reference site. The intention of a 'natural sources exclusion approach' is to ensure that all anthropogenic sources of salts are controlled such that they do not cause exceedances of water quality objectives. These approaches are consistent with state and federal anti-degradation policies (State Board Resolution No. 68-16 and 40 C.F.R. 131.12). This is an optional special study to be conducted if desired by the stakeholders or determined necessary for establishing a natural sources exclusion by the Executive Officer. ***3. Special Study #3 (Optional) – Develop Site-Specific Objectives*** The TMDL implementation plan provides for actions to protect the agricultural and groundwater recharge beneficial uses in the CCW. As shown in the linkage analysis, some downstream reaches may not achieve the water quality objectives through implementation of this TMDL because of the transport of salts out of the watershed through those reaches. Consequently, an optional special study is included to allow the CCW stakeholders to pursue development of site-specific objectives for salts for reaches upstream of the Hill Canyon WWTP and Simi Valley WQCP (Reaches 7, 8, 12, and 13), Calleguas Creek Reach 3, Revolon Slough (Reach 4) and Beardsley Wash (Reach 5). These alternative numeric water quality objectives would be developed based on the beneficial uses to be protected in a reach and the attainability of the current water quality objectives. This is an optional special study to be conducted if desired by the stakeholders or determined necessary or appropriate by the Executive Officer. ***4. Special Study #4 (Optional) – Develop Site-Specific Objectives for Drought Conditions*** During drought conditions, the load of salts into the watershed increases as a result of increasing concentrations in imported water. Stakeholders in the CCW cannot control the increased mass entering the watershed from the water supply. However, the stakeholders do have the ability to

TMDL Element	Key Findings and Regulatory Provisions
	manage the salts within the watershed to protect beneficial uses and export the additional mass of salts out of the watershed. If necessary, site-specific objectives may be developed to address situations that result in higher imported water salt concentrations to allow management of the salts and protection of beneficial uses. This special study may be combined with Special Study #3 if desired. This is an optional special study to be conducted if desired by the stakeholders or determined necessary or appropriate by the Executive Officer of the Regional Board. ***5. Special Study #5 (Optional) – Develop Site-Specific Objectives for Sulfate*** Sulfate is a necessary nutrient for plant growth and sulfate containing products are often applied to agriculture as fertilizers and pesticides. Therefore, site-specific objectives may be investigated and developed for sulfate that more accurately protects agricultural supply beneficial uses. Additionally, this study could evaluate whether or not a sulfate balance is necessary to maintain in the watershed. This special study may be combined with Special Study #3 and/or #4 if desired. This is an optional special study to be conducted if desired by the stakeholders or determined necessary or appropriate by the Executive Officer of the Regional Board. **<u>Monitoring Plan</u>** To ensure that the goal of a salts balance in the watershed is being achieved and water quality objectives are being met, a comprehensive method of tracking inputs and outputs to the watershed will be developed. A monitoring plan will be submitted to the RWQCB for Executive Officer approval within six months of the effective date of the CCW Salts TMDL. Monitoring will begin one year after Executive Officer approval of the monitoring plan to allow time for the installation of automated monitoring equipment. ***1. Input Tracking*** Inputs to the watershed are tracked through four mechanisms:1) Information on the import of State Water Project water is readily available and provides information on the mass of salts brought into the watershed; 2) Groundwater pumping records provide information on the mass of salts imported into the watershed from deep aquifer pumping; 3) Import records of water supply form the Santa Clara River can be obtained to determine the mass of salts imported through this source; 4) Monitoring data on imported water quality can be compared to

TMDL Element	Key Findings and Regulatory Provisions
	monitoring of effluent quality to estimate the amount of salts added through human use of the water. ***2. Output Tracking and Determining Compliance with Water Quality Objectives*** Outputs from the watershed will be tracked through surface water monitoring at key locations in the watershed and monitoring of discharges to the brine line. Monitoring will include both flow and quality. Compliance with water quality objectives will be determined at key locations where beneficial uses occur in the watershed. The stations used for output tracking will also be used to determine compliance with water quality objectives. The monitoring program will determine if the TMDL compliance points are protective of the beneficial uses for the subwatershed. If the monitoring determines that the compliance points are not protective of beneficial uses, an alternative compliance point will be selected. The Executive Officer may revise the TMDL compliance point based on the result of the monitoring. Additionally, if other places in the watershed are identified where sensitive beneficial uses occur, water quality monitoring stations can be added to determine compliance with water quality objectives. For the RWRMP, three new or upgraded automated flow measuring and sample collection stations will be installed at three points on the stream system to continuously record flow and various water quality parameters during dry weather. Preliminary monitoring locations include Arroyo Conejo in Hill Canyon, Conejo Creek at Baron Brothers Nursery and Calleguas Creek at University Drive. For the NRRWMP, one new or upgraded automated flow measuring and sample collection station will be added downstream of Simi Valley at the point at which groundwater recharge begins. A preliminary monitoring location is at Hitch Blvd. where an existing flow gauging station exists. However, the amount of groundwater recharge upstream of this site will need to be evaluated to determine the exact monitoring location. For Revolon Slough, the existing monitoring station at Wood Road. will be used to monitor quality and flow on Revolon Slough to determine the outputs from the Revolon portion of the Pleasant Valley subwatershed. Additional land use monitoring will be conducted concurrently at representative agricultural and urban runoff discharge sites as well as at POTWs in each of the subwatersheds and analyzed for chloride, TDS, sulfate, and boron. The location of the land use stations will be determined before initiation of the Calleguas Creek Watershed TMDL Monitoring Program (CCWTMP). All efforts will be made to include at least two wet weather sampling events during the wet season (October through April) during a targeted storm event.

TMDL Element	Key Findings and Regulatory Provisions
	3. Reporting and Modification of the Calleguas Creek Watershed TMDL Monitoring Program A monitoring report will be prepared annually within six months after completion of the final event of the sampling year. An adaptive management approach to the CCWTMP will be adopted as it may be necessary to modify aspects of the CCWTMP. Results of sampling carried out through the CCWTMP and other programs within the CCW may be used to modify this plan, as appropriate. These modifications will be summarized in the annual report. Possible modifications could include, but are not limited to the, following: ▪ The inclusion of additional land use stations to accurately characterize loadings; ▪ The removal of land use stations if it is determined they are duplicative (*i.e.*, a land use site in one subwatershed accurately characterize the land use in other subwatersheds); ▪ The inclusion of additional in-stream sampling stations; and ▪ The elimination of analysis for constituents no longer identified in land use and/or instream samples. If a coordinated and comprehensive monitoring plan is developed and meets the goals of this monitoring plan that plan should be considered as a replacement for the CCWTMP. ***4. Other Monitoring*** Other surface water and groundwater monitoring will be implemented as necessary to assess the impacts of the implementation actions and adjust the activities as necessary to protect beneficial uses and achieve the salts balance. Examples of additional monitoring that may be conducted include: ▪ Monitoring under Phase 2 and 3 of the RWRMP to evaluate the effects of replenishment water releases and groundwater treatment and releases. ▪ Monitoring to assess the impacts of management of the Simi Basin groundwater dewatering wells under Phase 1 of the NRRWMP.
Implementation Plan	The identified implementation actions provided in this TMDL will result in a salt balance in the stream and are expected to result in compliance with the allocations. The implementation plan is comprised of actions that directly impact discharges to the receiving water and actions that will indirectly impact discharges to receiving water. Responsible agencies and jurisdictions shall consider minimum flow

TMDL Element	Key Findings and Regulatory Provisions
	requirements that may be imposed by federal or state regulatory agencies when implementing actions to comply with this TMDL. Should the proposed implementation actions not result in compliance with objectives and site-specific objective are not adopted, additional implementation actions may be required to achieve the water quality objectives. Any plans or programs for implementation of the TMDL for the Southern Reaches of the CCW upstream of the Conejo Creek Diversion and the Northern Reaches of the CCW, that would result in significant reduction in instream flow, including but not limited to, an application for Water Reclamation Requirements (WRRs) shall include an analysis of potential impacts to instream beneficial uses that could result from the reclamation of wastewater or extracted groundwater. For Phase 1 of the Southern Reaches of the CCW Renewable Water Resource Management Program (RWRMP), Water Rights Decision 1638 from SWRCB satisfies these requirements and establishes the minimum flow requirements for Conejo and Calleguas Creek downstream of the Conejo Creek Diversion Project. Any WRRs shall require that timely written notice be given to the Regional Board, and to any regulatory agency whose instream flow is at issue, if diversion or reclamation of waste water or extraction of groundwater results or threatens to result in (or contributes to) insufficient flows to maintain beneficial uses. The Executive Officer shall issue an order pursuant to Water Code section 13267, which requires responsible agencies and jurisdictions to file a technical report if reclamation of waste water or extraction of groundwater results or threatens to result in (or contributes to) insufficient flows to maintain beneficial uses. The order shall require that the technical report identify the causes of the impairments or threatened impairments, and identifies options to abate the conditions. The Regional Board shall reconsider this TMDL if adequate flows to protect instream beneficial uses are not maintained. The implementation actions described in the TMDL represent a range of activities that could be conducted to achieve a salts balance in the watershed. Future considerations may result in other actions being implemented rather than the options presented. However, any proposed actions will be reviewed using the salt balance model to ensure the action does not adversely impact other implementation actions in the watershed or the salt balance of a downstream subwatershed. Currently, the implementation plan is presented in phases with a tentative schedule for each phase. The implementation of projects may occur earlier than planned or begin during an earlier phase. Additionally, many of the implementation actions require the use of the Regional Salinity Management Conveyance (RSMC or brine line). As such, the implementation schedule for those actions will be linked the

TMDL Element	Key Findings and Regulatory Provisions
	construction schedule for the RSMC. The implementation plan for the Salts TMDL includes regional and subwatershed specific implementation actions. There are four key structural elements to the regional implementation: Regional Salinity Management Conveyance (RSMC), Water Conservation, Water Softeners, and Best Management Practices for Irrigated Agriculture. Subwatershed implementation includes Renewable Water Resource Management Program (RWRMP) for the Southern Reaches and Northern Reach Renewable Water Management Plan (NRRWMP). Detailed discussion for each implementation element including description of the action, status and schedule for implementing the action, and a summary of the expected contribution to achievement of the salts balance are provided in the Staff Report and Technical Report for this TMDL. Proposed implementation actions in the watershed, responsible agencies, and the estimated completion date based on the effective date of the TMDL are summarized below.

Summary of Proposed Implementation Actions

Action	Responsible Agency/ies	Schedule for Completion
Water Conservation	POTWs, Permitted Stormwater Dischargers, and Other NPDES Permittees	3 years
Water Softeners	POTWs and Permitted Stormwater Dischargers	10 years
Best Management Practice for Agricultural Dischargers	Agricultural Dischargers	2 years
RMSC Phase 1	Calleguas Municipal Water District	2 year
RMSC Phase 2	Calleguas Municipal Water District	5 year
RMSC Phase 3	Calleguas Municipal Water District	10 years
RWRMP Phase 1	CamrosaWater District, Camarillo Sanitation District	3 years
RWRMP Phase 2	Camrosa Water District, City of Thousand Oaks	6 years
RWRMP Phase 3	Camrosa Water District, City of Thousand Oaks	10 years
RWRMP Phase 4	To Be Determined	15 years
NRRWMP Phase 1	Calleguas Municipal Water District, City of Simi Valley, Ventura County Water Work-District No.1	3 years
NRRWMP Phase 2	Calleguas Municipal Water District, Ventura County Water Work-District No.1, City of Camarillo	7 years
NRRWMP Phase 3	City of Camarillo, City of Simi Valley	10 years
NRRWMP Phase 4	To Be Determined	15 years
Final Completion Date		15 years

TMDL Element	Key Findings and Regulatory Provisions
	The sections below provide discussion of the application of the final WLAs for POTWs, specific permitted stormwater discharges, other NPDES dischargers, and agricultural dischargers. **I. POTWs, permitted stormwater discharges, and other NPDES discharges** The final WLAs will be included for permitted stormwater discharges, POTWs, and other NPDES discharges in accordance with the compliance schedules provided in Table 7-22.2. The Regional Board may revise these WLAs based on additional information developed through special studies and/or monitoring conducted as part of this TMDL. ▪ **POTWs** WLAs established for the POTWs in this TMDL will be implemented through NPDES permit limits. Compliance will be determined through monitoring of final effluent discharge as defined in the NPDES permit. The proposed permit limits will be applied as end-of-pipe mass-based monthly average effluent limits. Daily maximum effluent limit is not required because chloride is not expected to have an immediate or acute effect on the beneficial uses. Compliance with the minimum salt export requirements for POTWs will be based on the salt export from the subwatershed to which they discharge. The mechanisms for meeting the minimum salt export requirements and for monitoring progress towards meeting those requirements will be included in the monitoring program work plan and approved by the Executive Officer. At the end of each year, the amount of salt exported will be compared to the minimum required salt export. POTW allocations will be reduced using the adjustment factor if both of the following conditions occur: • The annual dry weather salt exports from the subwatershed to which the POTW discharges are below the minimum required exports for the previous year; and • The water quality objectives were exceeded in the receiving water at the base of the subwatershed The POTW allocations will be reduced for the following year by

TMDL Element	Key Findings and Regulatory Provisions
	the difference between the minimum required salt export and the actual amount exported. The discharger shall be notified by the Regional Board that the assigned WLAs are reduced and the reduced effluent limits shall be applied for the next year. If the POTW allocations are reduced, the POTW will need to increase the amount of salt export or reduce the mass of salts discharged from the POTW before the end of the following year when the adjustment will be evaluated again. POTWs can only request to adjust the assigned WLAs upwards using the adjustment factor under limited conditions provided below: • Water quality objectives are met in the receiving waters; • Imported water supply chloride concentrations exceed 80 mg/L; and • Discharges from the POTW exceed the allocation. When imported water supply chloride concentrations exceed 80 mg/L, the POTW will monitor the effluent to determine if the wasteload allocation is exceeded. If the wasteload allocation is exceeded and the POTW desires an adjustment to the allocation, the POTW will submit documentation of the water supply chloride concentrations, the receiving water chloride concentration, the effluent mass, and the evidence of increased salt exports to offset the increased discharges from the POTW to the Regional Board for approval. The adjustment factor will apply for three months and the POTW must submit the evidence outlined above every three months to keep the adjustment factor active. As long as the required information is submitted, the adjustment factor will be in effect upon notification in writing from the RWQCB. ▪ **Urban Stormwater Discharger** A group mass-based dry weather WLA has been developed for all permitted stormwater discharges, including municipal separate storm sewer systems (MS4s), and general industrial and construction stormwater permits. USEPA regulation allows allocations for NPDES-regulated stormwater discharges from multiple point sources to be expressed as a single categorical WLA when the data and information are insufficient to assign each source or outfall individual WLAs (40 CFR 130). The grouped allocation will apply to all NPDES-regulated municipal stormwater discharges in the CCW. MS4 WLAs will be incorporated into the NPDES

TMDL Element	Key Findings and Regulatory Provisions
	permit as receiving water limits measured in-stream at the base of each subwatershed. ▪ **Other NPDES Dischargers** WLAs established for other NPDES permitted dischargers in this TMDL, including minor non-stormwater permittees (other than Camrosa WRP) and general non-stormwater permittees, will be implemented through NPDES permit limits. The proposed permit limits will be applied as end-of-pipe concentration-based effluent limits, and compliance determined through monitoring of final effluent discharge as defined in the NPDES permit. **II. Agriculture** Load allocations for salts will be implemented through Conditional Waiver of Discharges from Irrigated Lands (Conditional Waiver Program) adopted by the LARWQCB on November 3, 2005. Compliance with LAs will be measured in-stream at the base of the subwatersheds and will be achieved through the implementation of Best Management Practices (BMPs) consistent with the Conditional Waiver Program. The Conditional Waiver Program requires the development of an agricultural water quality management plan (AWQMP) to address pollutants that are exceeding receiving water quality objectives as a result of agricultural discharges. Therefore, implementation of the load allocations will be through the development of an agricultural management plan for salts. Implementation of the load allocations will also include the coordination of BMPs being implemented under other required programs to ensure salts discharges are considered in the implementation. Additionally, agricultural dischargers will participate in educational seminars on the implementation of BMPs as required under the Conditional Program. Studies are currently being conducted to assess the extent of BMP implementation and provide information on the effectiveness of BMPs for agriculture. This information will be integrated into the AWQMP that will guide the implementation of agricultural BMPs in the Calleguas Creek watershed. After implementation of these actions, compliance with the allocations and TMDL will be evaluated and the allocations reconsidered if necessary based on the special studies and monitoring plan section of the implementation plan. As shown in Table 7-22.2, implementation of LAs will be conducted over a period of time to allow for implementation of the BMPs, as well as coordination with special studies and

TMDL Element	Key Findings and Regulatory Provisions
	implementation actions resulting from other TMDL Implementation Plans (Nutrient, Historic Pesticides and PCBs, Sediment, Metals, Bacteria, etc.).

Table 7-22.2 Calleguas Creek Watershed Salts TMDL: Implementation Schedule

Item	Implementation Action	Responsible Party	Completion Date
1	Effective date of interim Salts TMDL waste load allocations (WLAs)	POTWs, Permitted Stormwater Dischargers[1] (PSD), and Other NPDES Permittees	Effective date of the amendment
2	Effective date of interim Salts TMDL load allocations (LAs)	Agricultural Dischargers	Effective date of the amendment
3	Responsible jurisdictions and agencies shall submit compliance monitoring plan to the Los Angeles Regional Board for Executive Officer approval.	POTWs, PSD, Other NPDES Permittees, and Agricultural Dischargers	6 months after effective date of the TMDL
4	Responsible jurisdictions and agencies shall begin monitoring as outlined in the approved monitoring plan.	POTWs, PSD, Other NPDES Permittees, and Agricultural Dischargers	1 year after monitoring plan approval by Executive Officer
5	Responsible jurisdictions and agencies shall submit workplans for the optional special studies.	POTWs, PSD, Other NPDES Permittees, and Agricultural Dischargers	Within 10 years of effective date of the TMDL
6	Responsible jurisdictions and agencies shall submit results of the special studies.	POTWs, PSD, Other NPDES Permittees, and Agricultural Dischargers	2 years after workplan approval by Executive Officer
7	Re-evaluation of the interim WLAs and interim LAs for boron, chloride, sulfate, and TDS based on new data. Responsible jurisdictions and agencies shall demonstrate that implementation actions have reduced the boron, sulfate, TDS, and chloride imbalance by 20%.	POTWs, PSD, Other NPDES Permittees, and Agricultural Dischargers	3 years after effective date of the TMDL
8	Re-evaluation of the interim WLAs and interim LAs for boron, chloride, sulfate, and TDS based on new data. Responsible jurisdictions and agencies shall demonstrate that implementation actions have reduced the boron, sulfate, TDS and chloride imbalance by 40%.	POTWs, PSD, Other NPDES Permittees, and Agricultural Dischargers	7 years after effective date of the TMDL
9	Re-evaluation of the interim WLAs and interim LAs for boron, chloride, sulfate, and TDS based on new data. Responsible jurisdictions and agencies shall demonstrate that implementation actions have reduced the boron, sulfate, TDS, and chloride imbalance by 70%.	POTWs, Permitted Stormwater Dischargers (PSD), Other NPDES Permittees, and Agricultural Dischargers	10 years after effective date of the TMDL
10	The Los Angeles Regional Board shall reconsider this TMDL to re-evaluate numeric targets, WLAs, LAs and the implementation schedule based on the results of the special studies and/or compliance monitoring.	The Regional Board	12 years after effective date of the TMDL
11	Responsible jurisdictions and agencies shall demonstrate that the watershed has achieved an annual boron, sulfate, TDS, and chloride balance.	POTWs, PSD, Other NPDES Permittees, and Agricultural Dischargers	15 years after effective date of the TMDL
12	The POTWs and non-storm water NPDES permits shall achieve WLAs, which shall be expressed as NPDES mass-based effluent limitation specified in accordance with federal regulations and state policy on water quality control.	POTWs and Other NPDES Permittees	15 years after effective date of the TMDL

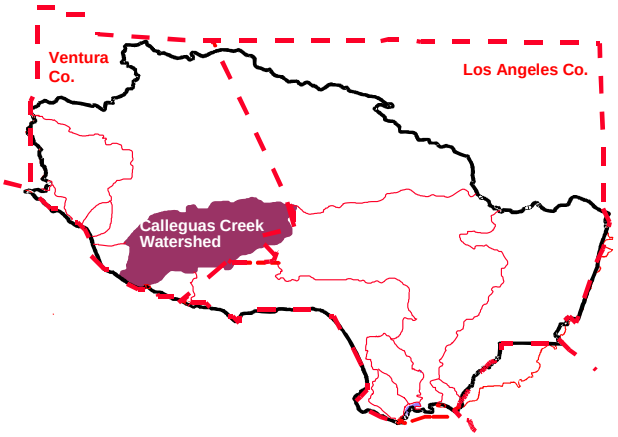
[1] Permitted stormwater dischargers that are responsible parties to this TMDL include the Municipal Stormwater Dischargers (MS4s) of the Cities of Camarillo, Moorpark, Thousand Oaks, County of Ventura, Ventura County Watershed Protection District, and general industrial and construction permittees.

Item	Implementation Action	Responsible Party	Completion Date
13	Irrigated agriculture shall achieve LAs, which will be implemented through the Conditional Waiver for Irrigated Lands as mass-based receiving water limits.	Agricultural Dischargers	15 years after effective date of the TMDL
14	The permitted stormwater dischargers shall achieve WLAs, which shall be expressed as NPDES mass-based limits specified in accordance with federal regulations and state policy on water quality control.	Permitted Stormwater Dischargers	15 years after effective date of the TMDL
15	Water quality objectives will be achieved at the base of the subwatersheds designated in the TMDL.	POTWs, PSD, Other NPDES Permittees, and Agricultural Dischargers	15 years after effective date of the TMDL

2.10 CALLEGUAS CREEK WATERSHED

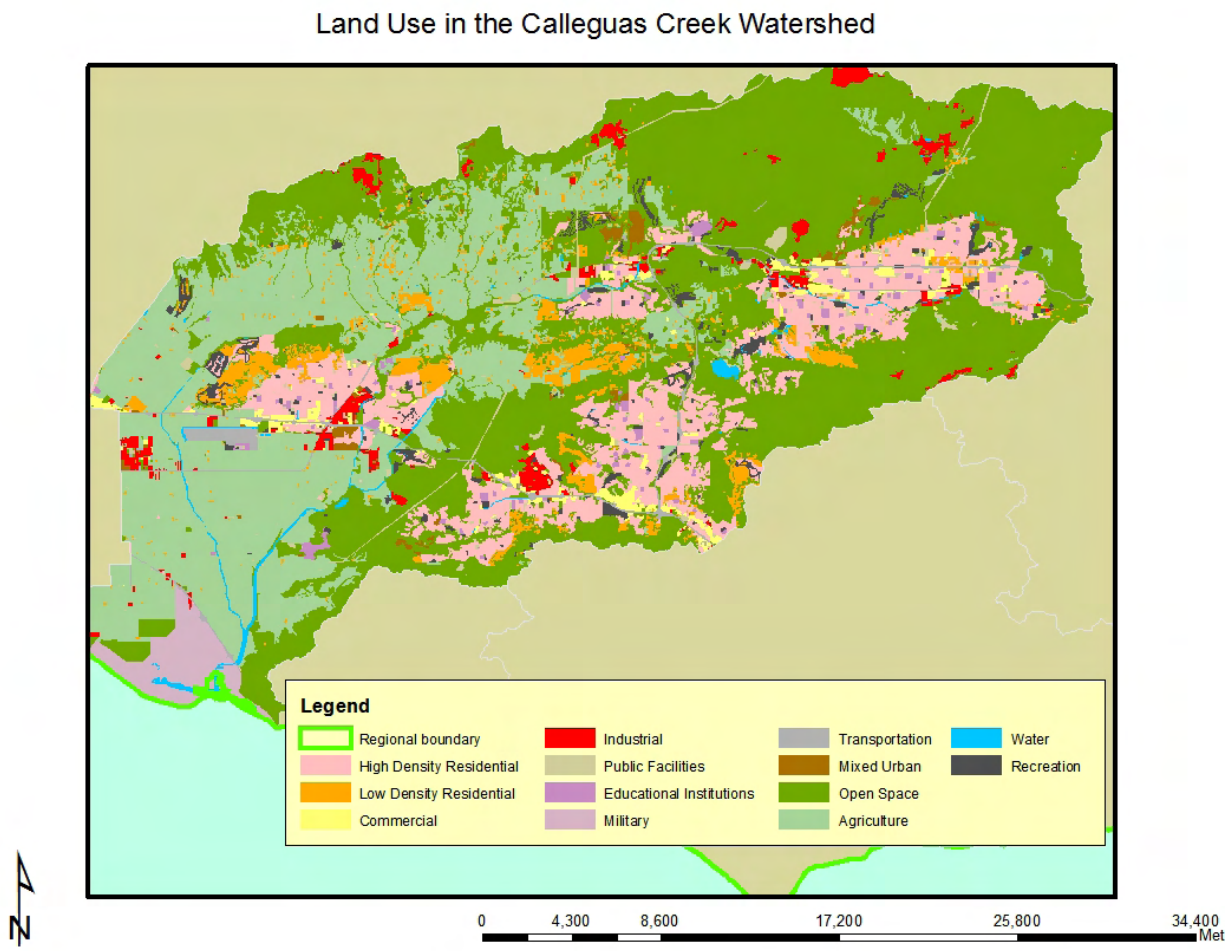
This watershed will be targeted in FY2011/2012.

Overview of Watershed



Calleguas Creek and its major tributaries, Revolon Slough, Conejo Creek, Arroyo Conejo, Arroyo Santa Rosa, and Arroyo Simi drain an area of 343 square miles in southern Ventura County and a small portion of western Los Angeles County. This watershed, which is elongated along an east-west axis, is about 30 miles long and 14 miles wide. The northern boundary of the watershed is formed by the Santa Susana Mountains, South Mountain, and Oak Ridge; the southern boundary is formed by the Simi Hills and Santa Monica Mountains.

Land uses vary throughout the watershed. Urban developments are generally restricted to the city limits of Simi Valley, Moorpark, Thousand Oaks, and Camarillo. Although some residential development has occurred along the slopes of the watershed, most upland areas are still open space; however, golf courses are becoming increasingly popular to locate in these open areas. Agricultural activities, primarily cultivation of orchards and row crops, are spread out along valleys and on the Oxnard Plain as shown in the figure below.



Mugu Lagoon, located at the mouth of the watershed, is one of the few remaining significant saltwater wetland habitats in southern California. The Point Mugu Naval Air Base is located in the immediate area and the surrounding Oxnard Plain supports a large variety of agricultural crops. These fields drain into ditches which either enter the lagoon directly or through Calleguas Creek and its tributaries. Other fields drain into tile drain systems which discharge to drains or creeks. Also in the area of the base are freshwater wetlands created on a seasonal basis to support duck hunting clubs. The lagoon borders on an Area of Special Biological Significance (ASBS) and supports a great diversity of wildlife including several endangered birds and one endangered plant species. Except for the military base, the lagoon area is relatively undeveloped.

Beneficial Uses in watershed:

Estuary	*Above Estuary*
Wildlife habitat	Wildlife habitat
Contact & noncontact water recreation	Contact & noncontact water recreation
Estuarine habitat	Industrial service supply
Marine habitat	Industrial process supply
Preservation of rare & endangered species	Preservation of rare & endangered species
Navigation	Agricultural supply
Preservation of biological habitats	Groundwater recharge
Wetlands habitat	Wetlands habitat
Migratory & spawning habitat	Freshwater replenishment
Shellfish harvesting	Warmwater habitat

Supplies of ground water are critical to agricultural operations and industry (sand and gravel mining) in this watershed. Moreover, much of the population in the watershed relies upon ground water for drinking.

Water Quality Problems and Issues

Aquatic life in both Mugu Lagoon and the inland streams of this watershed has been impacted by pollutants from nonpoint sources. DDT, PCBs, other pesticides, and some metals have been detected in both sediment and biota collected from surface waterbodies of this watershed. Additionally, ambient toxicity has been revealed in several studies from periodic toxicity testing in the watershed (ammonia from POTWs and pesticides such as diazinon and chlorpyrifos are implicated). Fish collected from Calleguas Creek and Revolon Slough exhibit skin lesions and have been found to have other histopathologic abnormalities. High levels of minerals and nitrates are common in the water column as well as in the groundwater. Sediment toxicity is also elevated in some parts of the lagoon. Reproduction is impaired in the resident endangered species, the light-footed clapper rail due to elevated levels of DDT and PCBs. Overall, this is a very impaired watershed. It appears that the sources of many of these pollutants are agricultural activities (mostly through continued disturbance and erosion of historically contaminated soils), which cover approximately 25% of the watershed along the inland valleys and coastal plain, although the nearby naval facility has also been a contributor. Other nonpoint sources include residential and urban activities, which are present over approximately 25% of the watershed. The remaining 50% of the watershed is still open space although there is a severe lack of benthic and riparian habitat.

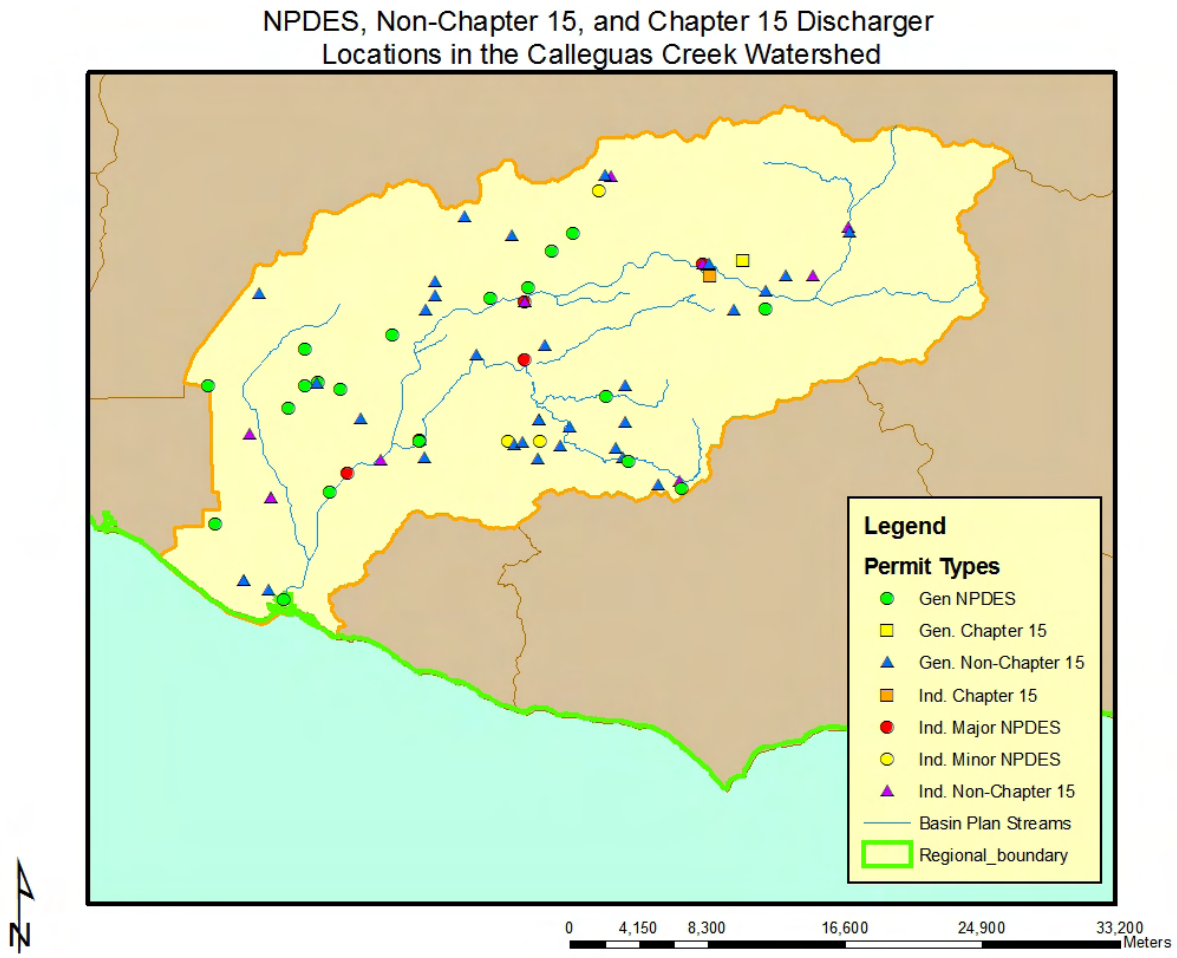
Permitted discharges:

- 26 NPDES discharges; five major discharges (POTWs); three minor discharges; eighteen discharges covered by general permits
- 73 dischargers covered under the industrial storm water permit
- 292 dischargers covered under the construction storm water permit
- Municipal storm water permit

Mugu Lagoon as well as the Calleguas Creek Estuary is considered a toxic hot spot under the Bay Protection and Toxic Cleanup Program (BPTCP) due to reproductive impairment (the endangered clapper rail), exceedance of the state Office of Environmental and Health Hazard Assessment (OEHHA) advisory level for mercury in fish, and exceedance of the NAS guideline level for DDT in fish, sediment concentrations of DDT, PCB, chlordane, chlorpyrifos, sediment toxicity and degraded benthic infaunal community.

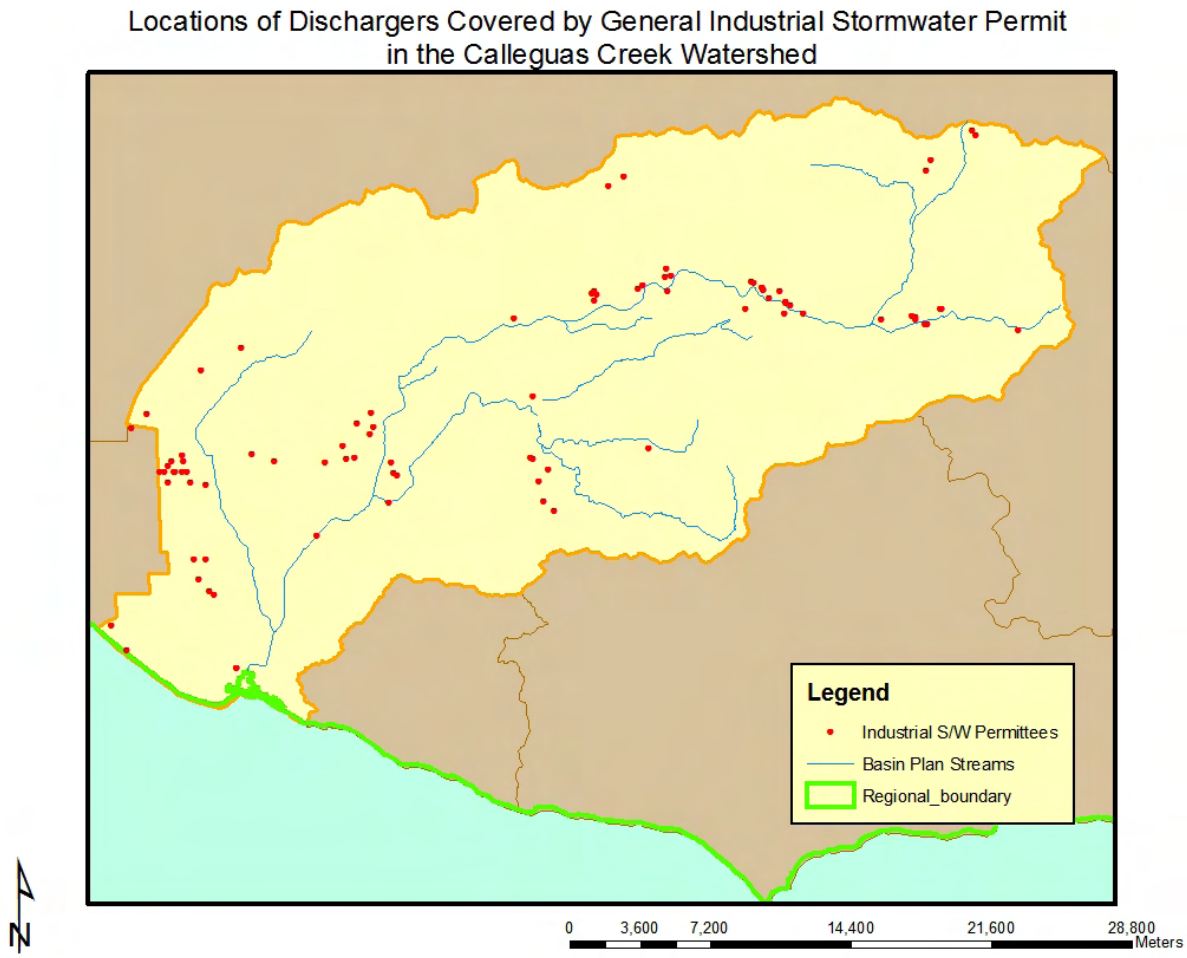
Primary issues related to POTW discharges include ammonia toxicity and high mineral content (i.e., salinity), the latter, in part, due to imported water supplies.

The locations of facilities with discharges to surface water or to the ground (other than those covered by general industrial or construction stormwater permits) are shown in the following figure. Major NPDES discharges are from either POTWs with a yearly average flow of over 0.5 MGD, from an industrial source with a yearly average flow of over 0.1 MGD, or are those discharges with lesser flows but with potential acute or adverse environmental impacts to surface waters. Minor NPDES discharges are all other discharges to surface waters that are not categorized as a Major. Minor discharges may be covered by general NPDES permits, which are issued administratively, for those that meet the conditions specified by the particular general permit. Non-Chapter 15 discharges are those to land or groundwater such as commercial septic systems or percolation ponds that are covered by Waste Discharge Requirements, a State permitting activity. Chapter 15 discharges generally relate to land disposal (landfills) under Chapter 15 of the California Code of Regulations, again an exclusively State permitting activity.



Discharges are fairly evenly spread around the watershed; four of the 26 NPDES discharges go to the Arroyo Conejo, while six discharge to Revolon Slough and twelve discharge to the Creek's various reaches.

Of the 90 dischargers enrolled under the general industrial storm water permit in the watershed, the largest numbers are located in the cities of Simi Valley and Camarillo. There is a diverse mix of industries represented including electric, gas and sanitary services; local and interurban passenger transit; electric and electronic equipment; and stone, clay and glass products based on their Standard Industrial Classification (SIC) codes. The locations of facilities with discharges covered by the general industrial stormwater permit are shown in the following figure.



There are 292 construction sites enrolled under the general construction storm water permit. About one-half of the sites are residential and about one-half are five acres or larger in size; one site is about 1,000 acres. Most of the sites are located in Camarillo, Simi Valley, and Thousand Oaks.

The table below gives the impairments for the watershed from the 2006 303(d) list:

Water Quality Limited Segment Name	Pollutant
Calleguas Creek Reach 1 (was Mugu Lagoon on 1998 303(d) list)	Chlordane (tissue)[1] Copper[2] DDT (tissue & sediment)[1] Endosulfan (tissue)[1] Mercury[2] Nickel[2] Nitrogen[3] PCBs (tissue)[1] Sediment Toxicity[1]

	Sedimentation/Siltation[1]
Calleguas Creek Reach 2 (estuary to Potrero Rd- was Calleguas Creek Reaches 1 and 2 on 1998 303d list)	Ammonia[3] ChemA (tissue)[1*] Chlordane (tissue)[1] Copper, Dissolved[2] DDT (tissue & sediment)[1] DDT[1] Endosulfan (tissue)[1] Fecal Coliform Nitrogen[3] PCBs (tissue)[1] Sediment Toxicity[1] Sedimentation/Siltation[1] Toxaphene (tissue & sediment)[1]
Calleguas Creek Reach 3 (Potrero Road upstream to confluence with Conejo Creek on 1998 303d list)	Chlordane Chloride DDT[1] Dieldrin[1] Nitrate and Nitrite[3] Sedimentation/Siltation[1] Total Dissolved Solids Toxaphene[1]
Calleguas Creek Reach 4 (was Revolon Slough Main Branch: Mugu Lagoon to Central Avenue on 1998 303d list)	Boron ChemA (tissue)[1*] Chlordane (tissue & sediment)[1] Chlorpyrifos (tissue)[1] DDT (tissue & sediment)[1] Dieldrin (tissue)[1] Endosulfan (tissue & sediment)[1] Fecal Coliform Nitrate as Nitrate (NO3)[3] Nitrogen[3] PCBs (tissue)[1] Sedimentation/Siltation[1] Selenium[2] Sulfates Total Dissolved Solids

	Toxaphene (tissue & sediment)[1] Toxicity[4] Trash
Calleguas Creek Reach 5 (was Beardsley Channel on 1998 303d list)	ChemA (tissue)[1*] Chlordane (tissue & sediment) Chlorpyrifos (tissue)[1] Dacthal (sediment)[1] DDT (tissue & sediment)[1] Dieldrin (tissue)[1] Endosulfan (tissue & sediment)[1] Nitrogen[3] PCBs (tissue)[1] Sedimentation/Siltation[1] Toxaphene (tissue & sediment)[1] Toxicity[4] Trash
Calleguas Creek Reach 6 (was Arroyo Las Posas Reaches 1 and 2 on 1998 303d list)	Ammonia[3] Chloride DDT (sediment)[1] Fecal Coliform Nitrate and Nitrite[3] Nitrate as Nitrate (NO3)[3] Sedimentation/Siltation[1] Sulfates Total Dissolved Solids
Calleguas Creek Reach 7 (was Arroyo Simi Reaches 1 and 2 on 1998 303d list)	Ammonia[3] Boron Chloride Fecal Coliform Organophosphorus Pesticides[4] Sedimentation/Siltation[1] Sulfates Total Dissolved Solids
Calleguas Creek Reach 8 (was Tapo Canyon Reach 1)	Boron Chloride Sedimentation/Siltation[1] Sulfates Total Dissolved Solids

Calleguas Creek Reach 9A (was lower part of Conejo Creek Reach 1 on 1998 303d list)	ChemA (tissue)[1*] Chlordane (tissue)[1] DDT (tissue)[1] Dieldrin (tissue)[1] Endosulfan (tissue)[1] Fecal Coliform Lindane/HCH (tissue)[1] Nitrate as Nitrate (NO3)[3] Nitrogen, Nitrate[3] PCBs (tissue)[1] Sulfates Total Dissolved Solids Toxaphene (tissue & sediment)[1]
Calleguas Creek Reach 9B (was part of Conejo Creek Reaches 1 and 2 on 1998 303d list)	Ammonia[3] ChemA (tissue)[1*] Chloride DDT (tissue)[1] Endosulfan (tissue)[1] Fecal Coliform Sulfates Total Dissolved Solids Toxaphene (tissue & sediment)[1] Toxicity[4]
Calleguas Creek Reach 10 (Conejo Creek (Hill Canyon)-was part of Conejo Ck Reaches 2 & 3, and lower Conejo Ck/Arroyo Conejo N Fk on 1998 303d list)	Ammonia[3] ChemA (tissue)[1*] Chloride DDT (tissue)[1] Endosulfan (tissue)[1] Fecal Coliform Nitrogen, Nitrite[3] Sulfates Total Dissolved Solids Toxaphene (tissue & sediment)[1] Toxicity[4]
Calleguas Creek Reach 11 (Arroyo Santa Rosa, was part of Conejo Creek Reach 3 on 1998 303d list)	Ammonia[3] ChemA (tissue)[1*] DDT (tissue)[1]

	Endosulfan (tissue)[1] Fecal Coliform Sedimentation/Siltation[1] Sulfates Total Dissolved Solids Toxaphene (tissue & sediment)[1] Toxicity[4]
Calleguas Creek Reach 12 (was Conejo Creek/Arroyo Conejo North Fork on 1998 303d list)	Ammonia[3] Chlordane (tissue)[1] DDT (tissue)[1] Sulfates Total Dissolved Solids
Calleguas Creek Reach 13 (Conejo Creek South Fork, was Conejo Cr Reach 4 and part of Reach 3 on 1998 303d list)	Ammonia[3] ChemA (tissue)[1*] Chloride DDT (tissue)[1] Endosulfan (tissue)[1] Sulfates Total Dissolved Solids Toxaphene (tissue & sediment)[1] Toxicity[4]
Duck Pond Agricultural Drains/Mugu Drain/Oxnard Drain No 2	ChemA (tissue)[1*] Chlordane (tissue)[1] DDT (tissue & sediment)[1] Nitrogen[3] Sediment Toxicity[1] Toxaphene (tissue)[1] Toxicity[4]
Fox Barranca (tributary to Calleguas Creek Reach 6)	Boron Sulfates Total Dissolved Solids
Rio De Santa Clara/Oxnard Drain No. 3	ChemA (tissue)* Chlordane (tissue) DDT (tissue) Nitrogen PCBs (tissue) Sediment Toxicity Toxaphene (tissue)

* ChemA refers to the sum of the chemicals aldrin, dieldrin. chlordane, endrin, heptachlor, heptachlor epoxide, HCH (including lindane), endosulfan, and toxaphene

[1]Calleguas Creek, its Tributaries, and Mugu Lagoon OC Pesticides, PCBs, and Siltation TMDL, 2005

[2]Calleguas Creek, its Tributaries, and Mugu Lagoon Metals and Selenium TMDL, 2007
[3]Calleguas Creek Nitrogen TMDL, 2003
[4]Calleguas Creek Toxicity TMDL, 2005

CURRENTLY SCHEDULED TMDLS:

- salts
- trash

Stakeholder Groups

Calleguas Creek Watershed Management Committee and Technical Subcommittees: Recognizing that many of the water quality problems in the lagoon stem from land use practices and pollutant sources above the lagoon, members of these committees meet regularly to exchange data and discuss coordinated approaches to solving the many problems in this watershed, including development of a watershed management plan. The watershed group consists of about 130 stakeholders who have been meeting since November 1996 with the purpose of developing a watershed management plan. As we expect that much effort will need to be focused on resolving agricultural and flood control issues, a concerted effort to include appropriate stakeholders. Besides the main management committee of stakeholders, five technical subcommittees deal with more specific issues such as water quality, flood protection/ sediment management, habitat/open space/recreation, public outreach, and land use. A Steering Committee attends to the details of management plan development. The full Management Plan Committee meets on a quarterly basis, generally conducting business in a half-day session. Staff have been and will continue to work with these committees. For further information concerning this group, please visit their website at http://www.calleguas.com/cc.htm.

A number of the above committee members were also on the *Mugu Lagoon Task Force* which was formed in 1990 in response to concerns about sedimentation filling in Mugu Lagoon which is at the mouth of the Calleguas Creek Watershed. A major focus of the early meetings was exchange of information on the extent of sedimentation with related concerns such as pesticide transfer. A sediment and erosion control plan was prepared for the Ventura County RCD by the U.S. Natural Resource Conservation Service (USNRCS) using Coastal Conservancy funds ("Calleguas Creek Watershed Erosion and Sediment Control Plan for Mugu Lagoon", May 1995). This group no longer meets; however, information gained from this effort continues to be used by the other Calleguas Watershed Committees.

Significant Past Activities

CORE REGULATORY

The majority of Calleguas Creek Watershed permits were revised in June 1996. This watershed, as well as the Ventura River Watershed, were pilot watersheds in our implementation of the watershed management approach. The Ventura County Municipal Stormwater NPDES Permit had most recently been adopted in 2000. The watershed was targeted again for NPDES permit renewals in FY01/02.

MONITORING AND ASSESSMENT

As the first integrated watershed monitoring program in the Region, the six POTWs in the watershed each implemented a portion (Characterization Study) in 2000 which also included other agencies in the effort. In conjunction with the receiving water monitoring, land-use based monitoring was done as a part of the Ventura County Municipal Storm Water Program. The monitoring supported compliance valuation, nonpoint source identification, and potential TMDL development. The expanded monitoring by the dischargers also served to evaluate beneficial uses.

Calleguas Creek was a focus for SWAMP monitoring in FY00/01 as the watershed was targeted in the rotating watershed cycle. Since extensive monitoring has already occurred here, particularly in the lower watershed, a more directed approach to sampling site selection was taken. A short-term watershed-wide regional monitoring program was created to fill in data gaps and eliminate duplicative and unnecessary monitoring. A total of thirteen sites were sampled once by SWAMP in the Calleguas Creek Watershed. Twelve directed sites were sampled for toxicity, bioassessment, conventional water chemistry and organophosphate chemistry in the water column. One estuary station was sampled for bioaccumulation in addition to abovementioned analyses. POTWs contributed significant resources to do a surface and ground water characterization study. It also served to assess nonpoint source pollution from a variety of land uses.

UCLA was under contract with the State Board to provide data needed for establishment of nutrient TMDLs in several watersheds within the Region including Calleguas Creek, Santa Clara River, and Malibu Creek. By understanding the inter-relationships between water quality and habitat condition and the resulting effects that these interactions have on the biological communities of coastal watersheds, this research was intended to further our understanding of the ecology of southern California watersheds. Besides providing information supporting the establishment of nutrient TMDLs for these three impaired coastal watersheds, the data collected would provide insight into how these TMDLs might be complied with in the future. Three specific objectives of this project were: 1) investigate the relationships between water quality (e.g. nutrients), habitat quality, and the biological community, 2) investigate how water quality and biological communities change throughout particular target reaches representing different land uses, and 3) compare the relationships between water quality, habitat quality, and biological communities among different watersheds. The work was a continuation and extension of a Regional Environmental Monitoring and Assessment Program (R-EMAP) project in the watershed. R-EMAP us part of a larger national effort by the USEPA to assess the condition of the nation's ecological resources.

BASIN PLANNING

In 1990, the Regional Board adopted Resolution No. 90-004 (**Drought Policy**) which had a term of three years and provided interim relief to dischargers who experienced difficulty meeting chloride objectives because of a state-wide drought. The policy adjusted effluent limits to the lesser of 1) 250 mg/l or 2) the chloride concentration in the water supply plus 85 mg/l. In 1995, the Regional Board extended the interim limits for three years and directed staff to develop a long-term solution to deal with the impact of changing water supply, especially during droughts. In 1997, the Regional Board adopted Resolution No. 97-002 (**Chloride Policy**) which set the chloride objective at 190 mg/l except in the Calleguas Creek and Santa Clara River Watersheds where, due to the great concern for protection of agriculture, staff were directed to determine the chloride concentrations sufficient to protect agricultural beneficial uses.

WETLANDS PROTECTION AND MANAGEMENT

The Wetlands Recovery Project funded a restoration project in the watershed, the Grimes Canyon Stream Restoration Project.

NONPOINT SOURCE PROGRAM

Work on nonpoint source problems in the watershed has been a long-term effort, initiated in 1990, with the support of 319(h) funds and other funding from, and support by, stakeholders. The 319(h) grant projects, special studies, and other activities that have been completed to date include:

- ***Irrigation Demonstration Project***: In 1994, the Ventura County Resource Conservation District successfully completed an irrigation project that demonstrated the water quality and conservation benefits of drip irrigation. This project was funded through a 319(h) grant.

- ***Toxicity Testing***: In order to detect sources of toxicity, we had collected water samples under three sequential studies (toxicity testing by UC Davis). Results of this sampling indicated sporadic toxicity, generally during wet weather seasons, with strong implication of organophosphate pesticides. A peer-reviewed paper on the results is pending.

- ***Calleguas Creek Watershed Treatment – Phases I and II***: The Ventura County Resource Conservation District served as contractor for this project which focused on Best Management Practices that involved small, individual landowners/ farmers. This demonstration project was designed to implement streambed protection practices. The two phases were funded through 319(h) grants.

Current Activities

The following is a summary of current regional board activities and strategies for dealing with point and nonpoint source pollution as well as other issues of concern in the Calleguas Creek Watershed.

CORE REGULATORY

Current regulatory activities include compliance inspections, review of monitoring reports, response to complaints, and enforcement actions, as needed.

Most urban areas in Ventura County, including this watershed, are implementing Best Management Practices (BMPs) under the Municipal Storm Water Permit (revised in 2000). The "Discharger" consists of the co-permittees Ventura County Flood Control District, the County of Ventura, and the Cities of Camarillo, Fillmore, Moorpark, Ojai, Oxnard, Port Hueneme, San Buenaventura, Santa Paula, Simi Valley, and Thousand Oaks. The Discharger is required to implement the Ventura Countywide Stormwater Quality Urban Impact Mitigation Plan (SQUIMP), which requires the implementation of BMPs to reduce the discharge of pollutants in storm water from new development and significant redevelopment. Other requirements of the Municipal Storm Water Permit include a public education program, an educational site inspection program for industrial and commercial facilities, program for construction sites, public agency activities, and a storm water monitoring program.

The Calleguas Creek receives municipal storm drain discharges from the City of Camarillo, City of Moorpark, City of Simi Valley, City of Thousand Oaks (part), and unincorporated Ventura County (part).

The storm water monitoring program has consisted of land-use based monitoring, receiving water and mass emission station monitoring, and bioassessment. The Discharger also participates in regional monitoring activities, such as the Storm Water Monitoring Coalition, organized by the Southern California Coastal Water Research Project. Furthermore, the Discharger participates in the development and implementation of volunteer monitoring programs in the Ventura Coastal watersheds.

Regulation of groundwater protection activities is intended to eventually become fully integrated into the watershed management approach; currently, groundwater monitoring (for POTWs using ponds) is being coordinated with surface water monitoring.

MONITORING AND ASSESSMENT

The BPTCP has identified the lagoon and tidal prism as "toxic hot spots" based on sediment contamination. Staff have completed a preliminary cleanup plan for the areas which was adopted as part of a statewide consolidated plan by the State Board in June 1999. Cleanup/remediation alternatives identified include dredging, in-situ capping, and treatment; however, dedicated funding for cleanup activities has not been provided by the state. Continuing Regional Board activities include working with stakeholders to further characterize historical sources of pollution as well as the extent of existing contributions. While remediation of the lagoon (as part of a military facility) may proceed on its own timeline, in general, there is a concerted effort by all stakeholders to prepare a comprehensive watershed management plan to address all problems in the watershed.

The Calleguas Creek Watershed Management Plan Habitat/Recreation and Land Use Subcommittees are jointly working on aspects of a Watershed Evaluation Study that is scheduled to be finished in 2002. This is a GIS-based effort with the goals of identifying high quality habitat and those areas that would help link them, the current level of protection, land ownership, and information from local entities land use plans. Another goal is to make the information available via the Internet.

NONPOINT SOURCE PROGRAM

We expect that stakeholders will continue work on developing a watershed management plan, which will include measures for reducing pollutants from nonpoint sources. Accordingly, our efforts in the Calleguas Creek watershed will focus on continuing the nonpoint source phase of the watershed cycle, including integrating results of our on-going nonpoint source efforts. The 319(h) grant projects, special studies, and other activities that are currently on-going include:

319(h) Grants

Calleguas Creek Water Quality Monitoring Program: The Wishtoyo Foundation received 319(h) grant funds in 2001 to educate and train volunteers to conduct a citizen monitoring program in the watershed. The goal is to measure the effectiveness of BMPs created to manage the flow of nutrients, pesticides, and sediments. Bioassessments will also be conducted.

We continue to support as high priorities for grant funding projects relating to implementation of TMDLs, habitat enhancement/restoration, and reduction of pollutants from agricultural activities.

Other NPS Activities

Our efforts to involve stakeholders also shall include exploration of funding options (especially for implementation of nonpoint source measures) and continuation of other outreach activities, such as speeches, meetings, and participation in environmental events.

Mugu Lagoon/Revolon Slough is identified as Critical Coastal Area (CCA) #58 in the State Water Resources Control Board's and California Coastal Commission's Critical Coastal Area Draft Strategic Plan. It has been identified as such in 1995 as an impaired water body and one of the few remaining saltwater wetland habitats remaining in Southern California. The major efforts listed to implement NPS management measures include: activities of Wishtoyo Foundation and Ventura CoastKeeper; streambank restoration projects conducted by Ventura County Resources Conservation District for growers; the Calleguas Municipal Water District's Regional Salinity Management Project; work conducted by the Calleguas Creek Watershed Management Plan Committee; the Erosion and Sediment Control Plan prepared in 1995 by the Ventura County Resources Conservation District; the watershed-wide monitoring program; BMPs implemented under the Ventura County municipal stormwater permit; and implementation of various TMDLs.

Laguna Point to Latigo Point is identified as CCA #59 in the CCA Draft Strategic Plan. It has been identified as such since the watersheds drain into a Marine Protected Area. This CCA covers parts of both Los Angeles and Ventura Counties from Calleguas Creek to Malibu. The major efforts listed to implement NPS management measures include: activities of the Malibu Creek Watershed Council and construction of Calleguas Municipal Water District's Regional Salinity Management Project.

BASIN PLANNING

Several high priority issues were identified in the 2005 - 2007 Triennial Review which affect this watershed management area and will require Basin Planning resources. As in all watersheds, adopting TMDLs as Basin Plan amendments is required under the Consent Decree with an estimated resource need of 0.5 PY/TMDL. This is considered a currently funded activity. The ongoing Tiered Aquatic Life Uses Pilot Project may affect many watersheds in the Region. The purpose of tiered aquatic life uses (TALUs) is to have more appropriate goals for protecting

aquatic life that account for these inherent physical limitations. The purpose of this pilot project is to develop more tailored water quality standards (through beneficial use designations and associated biocriteria) to protect the biological communities of semi-arid urban coastal streams and, If deemed appropriate, recommend appropriate tiered aquatic life uses for these semi-arid urban coastal streams. Other high priority issues identified by the Triennial Review common to multiple watersheds may be found in the Region-wide Section.

Review and comment on EIRs for the highest priority projects within the watershed will continue; however, there is currently no funding for this program.

WETLANDS PROTECTION AND MANAGEMENT

The Wetlands Recovery Project has listed the Lower Conejo Creek Acquisition as a priority project on the current workplan. Being listed on the workplan is not a guarantee of funding however. More information about the workplan may be found at http://www.scwrp.org.

A wetlands restoration plan for the watershed has been prepared (with Coastal Conservancy and USEPA funding) by a local consultant through the Habitat Subcommittee of the Calleguas Creek Watershed Plan Committee. This document is available on the Calleguas Creek Watershed Management Plan website at http://www.calleguas.com/ccbrochure/cc.htm. The next step in the process, completion of a Wetlands Restoration Feasibility Study, is ongoing.

The Santa Monica Mountains Conservancy is a state agency created by the Legislature in 1979 charged with primary responsibility for acquiring property with statewide and regional significance, and making those properties accessible to the general public. The Conservancy manages parkland in the Santa Monica Mountains, Santa Susana Mountains, the Simi Hills, the Santa Clarita Woodlands, the Whittier-Puente Hills, the Sierra Pelona, the Los Angeles River Greenway, the Rio Hondo, the Verdugo Mountains, the San Gabriel Mountains, and the San Rafael Hills. The agency's goals are to: 1) implement the Santa Monica Mountains Comprehensive Plan, 2) implement the Rim of the Valley Trails Corridor Master Plan, 3) implement the Los Angeles County River Master Plan, 4) further cooperation with local governments in the region to secure open space and parkland, and 5) expand education, public access, and resource stewardship components in a manner that best serves the public, protects habitat, and provides recreational opportunities. Additional information on their priorities may be found at http://www.smmc.ca.gov/.

DOD SITE CLEANUP PROGRAM

The Regional Board is working with the Department of Toxic Substances Control (DTSC) to investigate soil and groundwater quality at Department of Defense (DoD) facilities. Sites currently under assessment/remediation include Mugu Lagoon, a former landfill, the Naval Exchange gas station, two Installation Restoration Program (IRP) sites, numerous underground storage tanks, and the former oxidation sewage ponds.

The Navy disposed of inert, contaminated and hazardous wastes to an unlined unpermitted landfill constructed by depositing and compacting wastes into Calleguas Creek. An erosion berm was installed as an interim remedial measure to prevent further erosion of the former landfill by storm water flowing through the creek during storm events. Long-term groundwater monitoring will be required for this site. Sediments and surface water at IRP Site 5 are contaminated with chrome. An initial emergency removal action (sediment excavation) failed to adequately

remediate all impacted sediments and additional sediment remediation and surface water monitoring is ongoing.

Soil and groundwater at IRP Site 24 is contaminated with chlorinated solvents. Groundwater is being treated by implementation of a new biodegradation technology. It is not yet determined to what extent groundwater remediation or monitoring will be required to restore this site.

It is anticipated the Navy will implement a base-wide groundwater/surface water investigation to evaluate the overall groundwater and surface water quality, evaluate the interactions of surface water and groundwater, and determine the cumulative risk of multiple groundwater-surface water contamination sites on the overall water quality of the area and the risk to human health and the environment.

Prior to 1979, the Navy was allowed to discharge partially treated wastewater to surface water oxidation ponds that were constructed in the Calleguas Creek tidal prism. The ponds were unlined and allowed to percolate unevaporated water to the underlying groundwater, which is located about four feet below grade. The Regional Board rescinded the Navy's discharge permit in 1979 and required the Navy to pump all wastewater to the Oxnard POTW. However, periodic unpermitted discharges of wastewater continued to the ponds during planned repairs of the wastewater discharge line and wastewater overflow conditions, which occurred during heavy rains.

To prevent additional wastewater discharges to the ponds, the Regional Board issued a Cleanup and Abatement Order to the Navy in 1998 directing the Navy to cease all unpermitted discharges, construct a lined emergency wastewater retention basin, upgrade the wastewater discharge line, and remove the sludge that has accumulated in the ponds.

Current funding for the investigation and remediation of contaminated solids, surface water and groundwater at the base is through the DoD/CalEPA funding agreement; however, this funding is not satisfactory for the investigation or control of contaminants from upstream sources for the protection of Mugu Lagoon and continued funding cuts have had significant impacts on the level of oversight by Regional Board staff on these areas.

Near-term Activities

Specific resource needs are described in the Region-wide Section of this document.

NPDES Permits in the watershed will come up for renewal in FY 2003/04. In the meantime, core regulatory activities will focus on permit compliance, monitoring report review, and enforcement as needed. In addition, integration of stormwater and nonpoint source issues will continue. Members of the watershed team will be involved with periodic updates of the State of the Watershed Report. Additionally, there will be on-going interaction with stakeholders and followup on goals established during the permit renewal phase. Pending results from the discharger pollutant characterization study, a decision on waste load and load allocations will be pursued.

A review of resources for core regulatory activities against cost factors has determined that our region is seriously underfunded for our baseline program. We will be seeking more funding for our core program activities.

We shall have made significant progress later in this watershed's first cycle, toward identifying and assessing problems (through the characterization study) and involving stakeholders. At that point we (and the stakeholders) may also enough information to get a headstart on establishing load allocations for certain pollutants of concern.

Additional monitoring and assessment tasks include continued involvement in updates to the baseline State of the Watershed Report, focusing on filling data gaps and evaluating cumulative impacts as monitoring data become available from dischargers, evaluating the results of the SWAMP monitoring, follow-up on pollutants identified through toxicity identification evaluations, implement TMDLs to actually begin to solve problems found through monitoring, and implementing the municipal storm water program.

Our efforts to involve stakeholders shall also include exploration of funding options (especially for implementation of nonpoint source measures) and continuation of other outreach activities, such as speeches, meetings, and participation in environmental events. We shall continue our involvement in the watershed group's efforts to develop and implement a watershed management plan.

We will maintain involvement with stakeholder activities and pursue funding options, especially those involving implementation of nonpoint source measures (coordinate grant activities) as well as other outreach activities such as speeches, meetings, and participation in environmental events. As resources permit, we will also work with stakeholders to implement provisions of the Coastal Zone Act Reauthorization Amendments.

Potential Mid- to Long-term Activities

In the long-term, activities will include continued participation in both internal and external watershed planning efforts and further implementation of watershed-specific solutions. Several Basin Planning issues will be addressed through the Characterization Study and watershed planning efforts. More resources are needed for these activities.

Other mid- to long-term issues include:

- Beneficial uses: Studies to evaluate beneficial use issues.
- Site specific objectives: Review studies conducted by dischargers or other watershed interests.
- Land use planning: Integrate water supply and quality issues with local land use planning and management.
- Groundwater: Integrate inter-related ground and surface waters--optimizing protection for both.
- Flood control: Institute better coordination of multi-agency reviews of environmental impacts for flood control and development projects, including the consideration of regional mitigation programs. Optimize the use of environmentally-friendly flood control facilities.
- Implementation of watershed-wide biological monitoring is a long-term goal for all of our watersheds.

Review and comment on watershed issues in CEQA documents (for the highest priority projects) will also continue; however, this is currently an unfunded program.

Under the BPTCP, we estimated that about 20% of the Western Arm and 10% of the Eastern Arm of Mugu Lagoon contain contaminated sediments (about 725,000 cubic yards). We estimate that about 3 miles of Calleguas Creek contains 50,000 to 100,000 cubic yards of contaminated sediments. We want to work with local groups to develop remediation plans. Due to sensitive nature of Mugu Lagoon, we would suggest no action or in-situ treatment, rather than dredging, as remediation options. Treatment is expensive (probably would exceed $100 per cubic yard). Dredging could be used to remediate Calleguas Creek, although finding a suitable disposal site could be difficult; it would cost $1 to 5 million.

June 30, 2004

Progress Report on Efforts to Address Salts on the Calleguas Creek Watershed

Submitted to:
Calleguas Creek Watershed Management Plan

LARRY WALKER ASSOCIATES

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List of Acronyms

CCMS Calleguas Creek Modeling System
CCW Calleguas Creek Watershed
CMWD Calleguas Municipal Water District
CWA Clean Water Act
LA Load Allocation
POTW Publicly Owned Treatment Works
SSO Site-Specific Objective
TMDL Total Maximum Daily Load
USEPA United States Environmental Protection Agency
WLA Wasteload Allocation
WQCP Water Quality Control Plant
WQO Water Quality Objective
WRP Water Reclamation Plant
WTP Wastewater Treatment Plant

Executive Summary

The purpose of this document is to summarize work performed under the *Calleguas Creek Watershed Salts TMDL Work Plan* (Work Plan). Water quality objectives and beneficial uses are discussed, and an implementation plan for salts in the Calleguas Creek Watershed (CCW) is proposed. Regulatory issues related to surface water concentrations of salts (objectives, beneficial uses, and 303(d) listings) and broader salt management issues in the watershed are addressed. Additionally, the report provides an update on the analysis of options to address salts in the CCW.

Salts management problems in the CCW can be placed in two issue categories: regulatory issues related to 303(d) listings, and issues related to a salts imbalance. Although linked, these issues require different approaches in order to be satisfactorily addressed. Consequently, watershed sources were identified and water quality objectives and beneficial uses were reviewed. An assessment of identified projects was conducted to determine their ability to meet water quality objectives, improve the salts balance in the watershed, and increase local water resources.

Watershed Loadings

Six possible sources of salts to the watershed exist: water supply (water imported from the State Water Project or Freeman Diversion and deep aquifer groundwater pumping), water softeners, Publicly Owned Treatment Wks (POTW) treatment chemicals, atmospheric deposition, pesticides and fertilizers, and indoor water use (chemicals, cleansers, food, etc.). The use of pesticides and fertilizers may add some salts to the watershed, but the loads were not evaluated because there is insufficient information to determine the quantities added. These salts are then transported through POTW discharges and dry weather runoff to three possible endpoints: surface water, shallow groundwater, and/or stranded on the watershed in the soils. The salts stranded in the soils are eventually transported to surface water when precipitation mobilizes them and carries them to the creek system. Groundwater pumping and exfiltration moves salts from groundwater to surface water and surface water infiltration transports salts from the surface water to groundwater. Additionally, groundwater saturation of historic marine sediments can mobilize existing background salts from previously dry soil and transport them to the groundwater. However, none of these transport mechanisms add salts, they just move salts from one endpoint to another. Salts transported in the surface water to the ocean are currently the only salts that are exported from the watershed.

In the source analysis, the sources of salts to the watershed were quantified (Table ES-1). Then, the transport mechanisms were utilized to quantify the portion of salts transported to surface waters during typical dry weather conditions (Table ES-2). The salts that are not transported to surface waters are stranded in the watershed in soils and shallow, unconfined groundwater areas. These salts can be transported to the surface waters during large precipitation events, but are not mobilized during typical dry weather conditions. Consequently, the dry weather source analysis does not quantify the amount of salts that are mobilized and transported to surface waters during precipitation events.

Table ES-1. Summary of Salts Loads to Watershed

Source	Chloride (lbs/day)	TDS (lbs/day)	Sulfate (lbs/day)	Boron (lbs/day)
Water Supply [1]	75445	578182	192504	319
Residential, Industrial, Commercial Uses	11638	77911	14405	
Water Softeners	8855	14148		
Treatment Chemicals	700	700		
Atmospheric Deposition	40	340	91	0.13
Total	96678	671281	206999	319

1 Water supply includes imported State Water Project water, water imported through the Freeman Diversion from the Santa Clara River, and deep aquifer groundwater that is pumped for use in irrigation and municipal supply.

The primary source of salts to the watershed is the water supply. Water imported into the watershed from the State Water Project comes from the Sacramento/San Joaquin Delta. Consequently, chloride and TDS can vary significantly as a result of Northern California hydrology. During the drought, chloride concentrations neared 120 mg/L, but fell to 45 mg/L after El Nino. Therefore, the amount of salts entering the watershed from imported SWP water is strongly linked to hydrology in Northern California and the volume of water imported into the watershed and can vary significantly over time.

Table ES-2. Summary of Loadings to Surface Waters

Source	Chloride Load (lb/day)	% Total Chloride Load	TDS Load (lb/day)	% Total TDS Load	Sulfate Load (lb/day)	% Total Sulfate Load	Boron Load (lb/day)	% of Total Boron Load
POTWs	28,660	44%	140,259	26%	32,986	23%	126	59%
Groundwater pumping	2,750	4%	29,592	5%	22,974	16%	16.9	8%
Groundwater exfiltration	3,492	5%	14,456	3%	12,415	9%	4.43	2%
Urban Dry Weather	9,492	14%	89,675	16%	2,625	2%	9.19	4%
Agriculture Dry Weather	11,237	17%	166,634	30%	53,332	37%	47.7	22%
Total	55,632	100%	440,617	100%	124,332	100%	205	100%

Based on the information presented above, approximately 60% of the total watershed salts loads are transported to the surface waters on a daily basis. Because some of the surface water is diverted for irrigation in the lower watershed through the Conejo Creek Diversion Project, and all of the surface water in the upper watershed enters the ground water, only about 10% of the watershed salts load is exported out of the watershed to the ocean during dry weather. The remaining salts are left “stranded” in the soils or shallow groundwater basins in the watershed until large amounts of precipitation mobilize the salts and transport them off the watershed. The following table summarizes the ultimate fate of the imported salts during dry weather.

Table ES-3. Fate of Salts in Calleguas Creek Watershed during Dry Weather

Constituent	Salts Load To Watershed (lb/day)	Exported to Ocean (lb/day)	"Stranded" in Watershed (lb/day)
Chloride	96,700	10,400	86,300
TDS	671,200	49,500	621,700
Sulfate	207,000	13,600	193,400

Assessment of Water Quality Objectives and Beneficial Uses

In order to assess the need for and basis of site-specific objectives (SSOs) for the CCW, a review of the existing water quality objectives and beneficial uses was conducted. Agriculture and groundwater recharge are the beneficial uses potentially impacted by the development of SSOs and were the primary uses examined. The analysis of these beneficial uses resulted in the following conclusions that will be used to guide the development of SSOs:

1. Instantaneous objectives as contained in the Basin Plan are not necessary to protect beneficial uses.

2. Agriculture and groundwater recharge beneficial uses are not present in all areas of the watershed.

3. Water quality improvements in the surface water do not necessarily translate into protection of agriculture and groundwater recharge beneficial uses. Agriculture uses groundwater as its primary irrigation source and groundwater does not appear to be adversely impacted by surface water quality (Bachman, 2002).

Based on these conclusions, adjustments to the water quality objectives are recommended. For some reaches, the development of averaging periods for the numeric values found in the *Water Quality Control Plan:* Los Angeles Region (Basin Plan) will likely be the only recommended change to the objectives. For these reaches, it is proposed that the appropriate averaging period be determined based on additional analysis and the performance of the projects on the watershed. For other reaches, SSOs that include an adjustment to the numeric Basin Plan value may be recommended. These reaches include areas where agriculture and groundwater recharge beneficial uses are not present or not impacted by surface water salt concentrations (Reaches 11, 12, 13, 7, 8, 3, 4 and 5) and where natural background conditions make the achievement of the Basin Plan objectives not feasible and not necessary to protect beneficial uses (Reaches 6 and 7).

Analysis of Proposed Projects

Projects to address water resources and salts impairments in the upper and lower watershed have been developed. In the lower watershed, the projects involve removing Hill Canyon Wastewater Treatment Plant (WTP) and Camarillo Sanitary District Water Reclamation Plant (Camarillo WRP) effluent from the stream for reuse and the introduction of higher quality water into the upper reaches of the watershed to protect in stream beneficial uses. In the upper watershed, a groundwater desalter will be installed to treat poor quality groundwater and reduce the groundwater levels in the South Las Posas Basin. This will create storage for natural recharge from storm events, thus improving groundwater quality. Additionally, source control programs will be instituted to reduce water softener contributions of salts to the Simi Valley Water

Quality Control Plant (WQCP). Discharge from groundwater dewatering wells to surface water may be discontinued.

Models were used to assess the impacts of these projects on surface water salts concentrations, the watershed salts balance, improvement of local water resources, and the ability to comply with the EPA Chloride TMDL. Impacts of the proposed projects were also compared to the impacts of installing reverse osmosis treatment at the three wastewater treatment plants that discharge to the stream (Simi Valley WQCP, Hill Canyon WTP, and Camarillo WRP) at the levels necessary to comply with the EPA Chloride TMDL waste load allocations.

Model output was compared to the current, instantaneous Basin Plan objectives, 12 month rolling average objectives, and flow-weighted annual average objectives. For chloride, the results were also compared to the aquatic life criteria. The following tables summarize the locations in the watershed where model output predicts that the objectives would be exceeded less than one time in three years.

Table ES-4. Objective Status at Locations in the CCW for Current Conditions.[1]

Location	TMDL Reach	Chloride[2]				Sulfate[3]			TDS[4]			Boron[5]		
		D	12	W	C	D	12	W	D	12	W	D	12	W
Upper Watershed														
Arroyo Simi at Madera Rd.	Upper 7	×	×	✓	✓	×	×	×	×	×	×	×	✓	✓
Arroyo Simi below Highway 118	Mid 7	×	×	✓	✓	×	×	×	×	×	×	✓	✓	✓
Arroyo Las Posas at Hitch Blvd.	Border 6/7	×	×	✓	✓	×	×	×	×	×	×	✓	✓	✓
Arroyo Las Posas at Somis	Mid 6	×	×	✓	✓	×	×	✓	×	×	×	✓	✓	✓
Arroyo Las Posas at Seminary Rd.	Lower 6	×	×	✓	✓	×	×	✓	×	×	×	×	×	✓
Lower Watershed														
South Fork Arroyo Conejo	13	×	×	✓	×	×	×	✓	×	×	×	✓	✓	✓
Conejo Creek Below Hill Canyon	10	×	×	×	✓	×	✓	✓	✓	✓	✓	✓	✓	✓
Arroyo Santa Rosa	11	×	×	✓	✓	×	×	✓	×	×	×	×	×	✓
Conejo Creek @ Diversion	9B	×	×	✓	✓	×	✓	✓	×	✓	✓	✓	✓	✓
Conejo Creek at Howard Rd.	9A	×	×	×	✓	×	✓	✓	×	✓	✓	✓	✓	✓
Calleguas Creek above Potrero Rd	3	×	×	✓	✓	×	×	×	×	×	✓	✓	✓	✓
Oxnard Plain														
Revolon Slough	4	×	×	✓	✓	×	×	×	×	×	×	×	×	×

[1] Check indicates reaches meeting the objective, and "x" indicates reaches failing to meet objective.

[2] D = daily concentrations < 150 mg/L, 12 = 12 month rolling average < 150 mg/L, W = 12 month flow weighted average concentrations < 150 mg/L, and C = CCC concentration < 230 mg/L.

[3] D = daily concentrations < 250 mg/L, 12 = 12 month rolling average < 250 mg/L, and W = 12 month flow weighted average concentrations < 250 mg/L.

[4] D = daily concentrations < 850 mg/L, 12 = 12 month rolling average < 850 mg/L, and W = 12 month flow weighted average concentrations < 850 mg/L.

[5] D = daily concentrations < 1.0 mg/L, 12 = 12 month rolling average < 1.0 mg/L, and W = 12 month flow weighted average concentrations < 1.0 mg/L.

Under current conditions, the entire watershed meets the flow-weighted annual average objectives for boron and the Arroyo Simi/Las Posas meets the flow-weighted annual average objective for chloride. None

of the reaches meets the instantaneous maximum objectives for chloride and sulfate and only one reach meets the instantaneous maximum objective for TDS.

Table ES-5. Objective Status at Locations in the CCW after Banning Future Self-Regenerating Water Softeners and Providing Incentives/Disincentives to Reduce Water Softener Use.[1]

Upper Watershed Location	TMDL Reach	Chloride[2]				Sulfate[3]			TDS[4]			Boron[5]		
		D	12	W	C	D	12	W	D	12	W	D	12	W
Arroyo Simi at Madera Rd.	Upper 7	×	×	✓	✓	×	×	×	×	×	×	×	✓	✓
Arroyo Simi below Highway 118	Mid 7	×	✓	✓	✓	×	×	×	×	×	×	✓	✓	✓
Arroyo Las Posas at Hitch Blvd.	Border 6/7	×	✓	✓	✓	×	×	×	×	×	×	✓	✓	✓
Arroyo Las Posas at Somis	Mid 6	×	✓	✓	✓	×	×	✓	×	×	✓	✓	✓	✓
Arroyo Las Posas at Seminary Rd.	Lower 6	×	×	✓	✓	×	×	✓	×	×	✓	×	✓	✓

1 Check indicates reaches meeting the objective, and "x" indicates reaches failing to meet objective.
2 D = daily concentrations < 150 mg/L, 12 = 12 month rolling average < 150 mg/L, W = 12 month flow weighted average concentrations < 150 mg/L, and C = CCC concentration < 230 mg/L.
3 D = daily concentrations < 250 mg/L, 12 = 12 month rolling average < 250 mg/L, and W = 12 month flow weighted average concentrations < 250 mg/L.
4 D = daily concentrations < 850 mg/L, 12 = 12 month rolling average < 850 mg/L, and W = 12 month flow weighted average concentrations < 850 mg/L.
5 D = daily concentrations < 1.0 mg/L, 12 = 12 month rolling average < 1.0 mg/L, and W = 12 month flow weighted average concentrations < 1.0 mg/L.

Table ES-6. Objective Status at Locations in the CCW for Phase 3 (removal of Hill Canyon WTP and Camarillo WRP effluent) with 4 cfs CMWD Imported Water Released to the North Fork and 3 cfs Released to the South Fork of the Arroyo Conejo.[1]

Lower Watershed Location	TMDL Reach	Chloride[2]				Sulfate[3]			TDS[4]			Boron[5]		
		D	12	W	C	D	12	W	D	12	W	D	12	W
South Fork Arroyo Conejo	13	×	×	✓	✓	×	×	✓	×	×	✓	✓	✓	✓
Conejo Creek Below Hill Canyon	10	×	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓
Arroyo Santa Rosa	11	×	×	✓	✓	×	×	✓	×	×	×	×	×	✓
Conejo Creek @ Diversion	9B	×	✓	✓	✓	×	✓	✓	×	✓	✓	✓	✓	✓
Conejo Creek at Howard Rd.	9A	×	✓	✓	✓	×	✓	✓	×	✓	✓	✓	✓	✓
Calleguas Creek above Potrero Rd	3	×	×	✓	✓	×	×	×	×	×	✓	✓	×	✓

1 Check indicates reaches meeting the objective, and "x" indicates reaches failing to meet objective.
2 D = daily concentrations < 150 mg/L, 12 = 12 month rolling average < 150 mg/L, W = 12 month flow weighted average concentrations < 150 mg/L, and C = CCC concentration < 230 mg/L.
3 D = daily concentrations < 250 mg/L, 12 = 12 month rolling average < 250 mg/L, and W = 12 month flow weighted average concentrations < 250 mg/L.
4 D = daily concentrations < 850 mg/L, 12 = 12 month rolling average < 850 mg/L, and W = 12 month flow weighted average concentrations < 850 mg/L.
5 D = daily concentrations < 1.0 mg/L, 12 = 12 month rolling average < 1.0 mg/L, and W = 12 month flow weighted average concentrations < 1.0 mg/L.

Table ES-7. Objective Status at Locations in the CCW Based on Reverse Osmosis Treatment Plan[1]

Location	TMDL Reach	Chloride[2]				Sulfate[3]			TDS[4]			Boron[5]		
		D	12	W	C	D	12	W	D	12	W	D	12	W
Upper Watershed														
Arroyo Simi at Madera Rd.	Upper 7	×	×	✓	✓	×	×	×	×	×	×	×	✓	✓
Arroyo Simi below Highway 118	Mid 7	✓	✓	✓	✓	×	×	×	×	×	×	✓	✓	✓
Arroyo Las Posas at Hitch Blvd.	Border 6/7	✓	✓	✓	✓	×	×	×	×	×	×	✓	✓	✓
Arroyo Las Posas at Somis	Mid 6	×	✓	✓	✓	×	×	✓	×	×	×	✓	✓	✓
Arroyo Las Posas at Seminary Rd.	Lower 6	×	×	✓	✓	×	×	✓	×	×	×	×	×	✓
Lower Watershed														
South Fork Arroyo Conejo	13	×	×	✓	×	×	×	✓	×	×	×	✓	✓	✓
Conejo Creek Below Hill Canyon	10	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Arroyo Santa Rosa	11	×	×	✓	✓	×	×	✓	×	×	×	×	×	✓
Conejo Creek @ Diversion	9B	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Conejo Creek at Howard Rd.	9A	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Calleguas Creek above Potrero Rd	3	×	×	✓	✓	×	×	×	✓	✓	✓	×	✓	✓
Oxnard Plain														
Revolon Slough	4	×	×	✓	✓	×	×	×	×	×	×	×	×	×

[1] Check indicates reaches meeting the objective, and "x" indicates reaches failing to meet objective.
[2] D = daily concentrations < 150 mg/L, 12 = 12 month rolling average < 150 mg/L, W = 12 month flow weighted average concentrations < 150 mg/L, and C = CCC concentration < 230 mg/L.
[3] D = daily concentrations < 250 mg/L, 12 = 12 month rolling average < 250 mg/L, and W = 12 month flow weighted average concentrations < 250 mg/L.
[4] D = daily concentrations < 850 mg/L, 12 = 12 month rolling average < 850 mg/L, and W = 12 month flow weighted average concentrations < 850 mg/L.
[5] D = daily concentrations < 1.0 mg/L, 12 = 12 month rolling average < 1.0 mg/L, and W = 12 month flow weighted average concentrations < 1.0 mg/L.

As shown in the tables, very few reaches consistently meet the current Basin Plan objectives with these proposed projects or reverse osmosis treatment. However for these proposed projects, the 12 month rolling average is more consistently met for chloride in most reaches, and sulfate and TDS in some reaches. The reverse osmosis treatment plan generally results in similar compliance with chloride objectives as these proposed projects downstream of the POTWs. However, the reverse osmosis plan results in more compliance with TDS and sulfate objectives downstream of the POTWs. Upstream of the Hill Canyon WTP, these projects result in improved water quality whereas the reverse osmosis treatment plan does not impact water quality in the reaches upstream of POTWs. Arroyo Santa Rosa and Revolon Slough consistently do not meet any of the possible objectives because the projects and reverse osmosis treatment do not address those reaches. However, the discontinuation of the Olsen Rd. WTP discharge to the Arroyo Santa Rosa has resulted in minimal if any flows in the reach, and may have resolved the salts impairment for the Arroyo Santa Rosa.

Although reverse osmosis treatment of wastewater effluent provides some water quality improvements, it will not result in compliance with all salts objectives, does not provide the additional benefits of these

proposed projects (such as improvements in local supply), and does not address all of the impacts of salts on beneficial uses. Additionally, reverse osmosis results in significantly less salt removal from the watershed, and requires significant energy resource consumption. The following table compares these additional impacts for these projects and reverse osmosis treatment.

Table ES-8. Summary of Impacts of Proposed Projects as Compared to Reverse Osmosis Treatment

Impact	Proposed Projects	Reverse Osmosis Treatment
Additional Local Water Resources	30 mgd	None
Pounds of Salt Removed from Watershed (Salt Balance)	370,000 lbs/day	55,000 lbs/day
Ability to Protect Beneficial Uses	Targets the beneficial use impacts	May not address all of the impacts on beneficial uses
Ability to Meet Current Water Quality Objectives in Stream	Will not meet the current objectives in all reaches	Will not meet the current objectives in all reaches
Other Impacts	Requires SSOs	SSOs may be required; Requires large amounts of energy

In conclusion, implementation of the proposed projects in combination with the recommended revisions to the water quality objectives listed above are likely to resolve the salts impairments in the watershed and provide significant water resource benefits to the CCW.

1. Introduction

The purpose of this document is to summarize work performed under the *Calleguas Creek Watershed Salts TMDL Work Plan* (Work Plan). Water quality objectives and beneficial uses are discussed, and an implementation plan for salts in the Calleguas Creek Watershed (CCW) is proposed. Regulatory issues related to surface water concentrations of salts (objectives, beneficial uses, and 303(d) listings) and broader salt management issues in the watershed are addressed. Additionally, the report provides an update on the analysis of options to address salts in the CCW. This document is not intended to be a Total Maximum Daily Load (TMDL) nor provide all technical information necessary for developing a TMDL.

The report is organized into six major sections. The introductory section of the report (Section 1) describes the watershed. Then, the problem statement (Section 2) lays out both the regulatory and water resource issues with salts. Watershed sources, fate, and transport of salts are included to help understand the approach being taken to address salts (Section 3). Water quality objectives and beneficial uses are reviewed to examine the need for developing site-specific objectives (SSOs) (Section 4). Proposed projects are analyzed and compared to reverse osmosis treatment, as recommended by the EPA Chloride TMDL, to determine the impacts on water quality, water supply, the watershed salt balance and beneficial uses (Sections 5, 6, and 7). Finally, the document identifies the next steps to be taken in the process (Sections 8 and 9).s

1.1. Environmental Setting

Calleguas Creek and its tributaries are located in southeast Ventura County and a small portion of western Los Angeles County. Calleguas Creek drains an area of approximately 343 square miles from the Santa Susana Pass in the east to Mugu Lagoon in the southwest. The main surface water system drains from the mountains in the northeast part of the watershed toward the southwest where it flows through the Oxnard Plain before emptying into the Pacific Ocean through Mugu Lagoon. The watershed, which is elongated along an east-west axis, is about thirty miles long and fourteen miles wide. The Santa Susana Mountains, South Mountain, and Oak Ridge form the northern boundary of the watershed; the southern boundary is formed by the Simi Hills and Santa Monica Mountains.

Land uses in the CCW include agriculture, high and low density residential, commercial, industrial, open space and a Naval Air Base located adjacent to Mugu Lagoon. The watershed includes the cities of Simi Valley, Moorpark, Thousand Oaks, and Camarillo. Most of the agriculture is located in the middle and lower watershed with the major urban areas (Thousand Oaks and Simi Valley) located in the upper watershed. The current land use in the watershed is approximately 26% agriculture, 24% urban, and 50% open space. Patches of high quality riparian habitat are present along the length of Calleguas Creek and its tributaries.

The watershed is characterized by three major sub watersheds: the Arroyo Simi/Las Posas in the north, Conejo Creek in the south and Revolon Slough in the west. Additionally, the lower watershed is also drained by several minor agricultural drains in the Oxnard plain. The following sections describe the sub watersheds in more detail. Figure 1 depicts Calleguas Creek with reach names and designations used in this report.

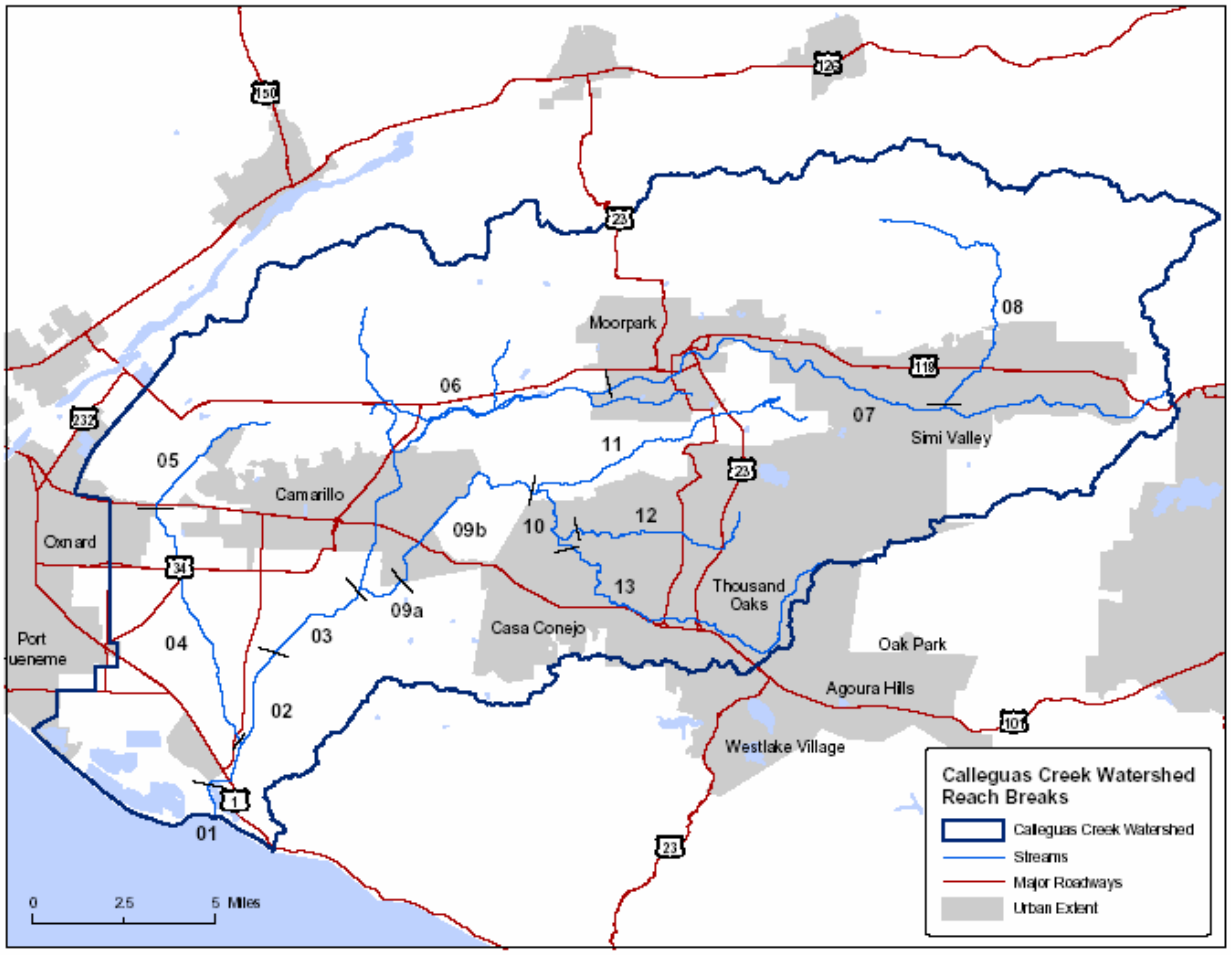

Figure 1. Calleguas Creek Watershed Reaches

1.1.1. Arroyo Simi/Las Posas

The upper portion of the watershed is drained by the Arroyo Las Posas and the Arroyo Simi, which is tributary to the Arroyo Las Posas. The upper part of the watershed system originates in the Simi Valley and surrounding foothills. The surface flow comes from the headwaters of the Arroyo Simi at Santa Susanna pass (upper parts of Reach 7) and Tapo Canyon (Reach 8). Arroyo Simi and Arroyo Las Posas flow through the cities of Simi Valley and Moorpark and join with Calleguas Creek near Camarillo.

Upstream of Simi Valley, the creek is unlined and passes through open space and recreational areas. Through the city of Simi Valley, the Arroyo Simi flows through concrete lined or rip-rapped channels. Between Simi Valley and Moorpark, a distance of approximately 7 miles, the creek is unlined and without rip-rap. From the edge of Moorpark to Hitch Boulevard, the creek is once again rip-rapped on the sides with a soft bottom throughout most of the channel, but in some areas, such as under bridges, the bottom is covered with concrete and rip rap.

The Arroyo Simi flows into the Arroyo Las Posas at Hitch Blvd. Downstream of Hitch Boulevard, Arroyo Las Posas passes through agricultural fields and orchards in a primarily natural channel. Although the Arroyo Las Posas channel joins with Calleguas Creek near Camarillo, surface flow is typically not present in this portion of the channel due to evaporation and groundwater recharge upstream of Seminary Road.

Two POTWs are located in this sub watershed. The Simi Valley Water Quality Control Plant (WQCP) discharges to the Arroyo Simi on the western edge of the City of Simi Valley. The Moorpark Wastewater Treatment Plant (WTP) discharges primarily to percolation ponds near the Arroyo Las Posas downstream of Hitch Boulevard. Direct discharges to the Arroyo Las Posas from the Moorpark WTP only occur during extremely wet periods.

1.1.2. Arroyo Conejo/Conejo Creek

Conejo Creek and its tributaries (Arroyo Conejo and Arroyo Santa Rosa) drain the lower portion of the watershed. Flow in the lower portion of the watershed originates in the City of Thousand Oaks and flows through the City of Camarillo before joining Calleguas Creek upstream of the California State University Channel Islands. This area supports significant residential and agricultural land uses. The following sections describe Conejo Creek and its tributaries.

1.1.2.1. Arroyo Conejo

The Arroyo Conejo runs through Thousand Oaks and has three branches, the main fork, the north fork, and the south fork. The main fork of the Arroyo Conejo runs underground for most of its length. The portions that are above ground are concrete lined until the creek enters Hill Canyon on the western side of the city and converges with the south fork. The south fork runs through the southern and western portions of Thousand Oaks. For most of its length, the south fork flows underground or through concrete lined channels. The Hill Canyon Wastewater Treatment Plant (WTP) discharges to the north fork of the Arroyo Conejo on the western edge of the City of Thousand Oaks. The north fork runs through Thousand Oaks upstream of the Hill Canyon WTP. The channel is concrete lined for the portion that runs through the city, but becomes unlined when it nears the treatment plant. The main fork and the south fork join together about a mile upstream of the treatment plant. The joined flow (usually called the south fork at this point) and the north fork converges approximately 0.4 miles downstream of the Hill Canyon WTP. The Arroyo Conejo then flows in a natural channel through a primarily open space area until it merges with the Arroyo Santa Rosa to form Conejo Creek at the base of the canyon.

Arroyo Santa Rosa

Arroyo Santa Rosa runs on the northern edge of the City of Thousand Oaks and through agricultural land in the Santa Rosa Valley. Arroyo Santa Rosa is a natural channel for most of its length with portions of riprap and concrete lining along the sides and bottom of the channel in the vicinity of homes (such as near Las Posas Road). Prior to 1999, a wastewater treatment plant (Olsen Rd.) discharged to Arroyo Santa Rosa and maintained a constant surface flow in the reach. Since 1999, the POTW has not discharged and much of the channel is dry during non-storm events.

1.1.2.2. Conejo and Calleguas Creek

Arroyo Conejo and Arroyo Santa Rosa converge at the base of Hill Canyon to form Conejo Creek. Conejo Creek flows downstream approximately 7.5 miles, through the City of Camarillo, to its confluence with

Calleguas Creek. Just downstream of the city, the Camarillo WRP discharges to Conejo Creek. Because the Arroyo Las Posas does not generally provide surface flow to Calleguas Creek during dry periods, Conejo Creek provides the majority of the flow in Calleguas Creek. For most of the length of the Conejo and Calleguas Creeks, the sides of the channel are rip rapped and the bottom is unlined.

1.1.3. Revolon Slough

Revolon Slough drains the agricultural land in the western portion of the watershed (Oxnard Plain). The slough does not pass through any urban areas, but does receive drainage from tributaries that drain urban areas. Revolon Slough starts as Beardsley Wash in the hills north of the City of Camarillo. The wash is a rip rapped channel for most of its length and combines with Revolon Slough at Central Avenue in Camarillo. The slough is concrete lined just upstream of Central Avenue and remains lined for approximately 4 miles to Wood Road. From there, the slough is soft bottomed with rip-rapped sides. The lower mile and a half or so of the slough to above Las Posas Road appears to be tidally influenced by inflows from Mugu Lagoon. Revolon Slough flows into Mugu Lagoon in a channel that runs parallel to Calleguas Creek. The flows from Revolon Slough and Calleguas Creek only converge in the lagoon.

In addition to Revolon Slough, a number of agricultural drains (Oxnard Drain, Mugu Drain, and Duck Pond Drain) serve as conveyances for agricultural and industrial drainage water to the Calleguas Creek estuary and Mugu Lagoon.

1.1.4. Mugu Lagoon

Mugu Lagoon, an estuary at the mouth of Calleguas Creek, supports a diverse wildlife population including migratory birds and endangered species. This area is affected by military land uses of the Point Mugu Naval Air Weapons Station and substantial agricultural activities in the Oxnard Plain. The lagoon consists of approximately 287 acres of open water, 128 acres of tidal flats, 40 acres of tidal creeks, 944 acres of tidal marsh and 77 acres of salt pan (California Resources Agency, 1997). It is comprised of a central basin into which flows from Revolon Slough and Calleguas Creek enter and two arms (eastern and western) that receives some drainage from agricultural and industrial drains. The salinity in the lagoon is generally between 31 and 33 parts per thousand (ppt) (Granade, 2001). The central basin of the lagoon has a maximum tidal range of approximately -1.1 to 7 feet (as compared to mean sea level) with smaller ranges in the two arms. The western arm of the lagoon receives less tidal volume because of a bridge culvert that restricts the flows in that area. The velocity of water traveling through the mouth of the lagoon is approximately 5-6 knots, which is a high velocity for a lagoon (Grigorian, 2001). The mouth of the lagoon never closes, apparently as a result of a large canyon present at the mouth of Calleguas Creek. The canyon prevents ocean sand from building up to a high enough level to close the mouth and likely accounts for the high velocities in the lagoon (Grigorian, 2001).

1.1.5. Climate and Hydrology

The climate in the watershed is typical of the southern California coastal region. Summers are relatively warm and dry and winters are mild and wet. Eighty-five percent of the rainfall occurs between November and March with most of the precipitation occurring during just a few major storms. Annual rainfall in Ventura County averages 15 inches and varies from 13 inches on the Oxnard Plain to a maximum of 20 inches in the higher elevations (USDA, 1995). About 15 to 20 discrete storm events occur per year concentrated in the wet-weather months, producing runoff of duration from one-half day to several days (USGS, 2000).

Discharge during runoff from storm events is commonly 10 to 100 times greater than at other times. Storm events and the resulting high stream flows are highly seasonal, grouped heavily in the months of November through February, with an occasional major storm as early as September and as late as April. Rainfall is rare in other months, and major storm flows historically have not been observed outside the wet-weather season.

1.1.6. Surface Waters

Dry weather surface water flow in the Calleguas Creek watershed is primarily composed of groundwater (pumped and exfiltration), municipal wastewater, urban non-storm water discharges, and agricultural runoff. In the upper reaches of the watershed, upstream of any wastewater discharges, groundwater discharge from shallow surface aquifers provides a constant base flow. Additionally, urban non-storm water runoff and groundwater extraction for construction dewatering or remediation of contaminated aquifers contribute to the base flow. Stream flow in the upper portion of the watershed is minimal, except during and immediately after rainfall. Flow in Calleguas Creek is described as storm peaking and is typical of smaller watersheds in coastal southern California.

In the Arroyo Simi/Las Posas sub watershed, additional flow is contributed by groundwater pumped for dewatering and discharged under permit to the Arroyo Simi upstream of Madera Road. The Simi Valley WQCP discharges downstream of the City of Simi Valley and provides much of the flow in the Arroyo Simi during dry weather. During most of the year, at the point where the channel reaches Seminary Road, the surface water flow has been lost to groundwater percolation and evaporation. During and immediately following significant rains, surface flows in the Arroyo Las Posas discharge to Calleguas Creek. In the Conejo Creek sub watershed, the Hill Canyon WTP provides the majority of the surface water flow. Additionally, the Camarillo WRP provides some flow in the lower portion of Conejo Creek. Revolon Slough receives all of its flow from agricultural discharges, groundwater exfiltration, and some urban non-storm water flow.

1.1.7. Groundwater

Groundwater features of the watershed are dominated by the Fox Canyon Aquifer System, which is linked to the neighboring Santa Clara River Watershed. The Fox Canyon Aquifer System is a series of deep, confined aquifers. These aquifers today receive little or no recharge from the watershed. The water quality in these aquifers is very high. However, because there is little recharge to these aquifers they suffer from overdraft. Major groundwater basins within the watershed include the Simi Basin, East Las Posas, West Las Posas, South Las Posas, Pleasant Valley, and Arroyo Santa Rosa Basins. Significant aquifers within the watershed include the Epworth Gravels, the Fox Canyon aquifer, and the Grimes Canyon aquifer in order from shallowest to deepest. In addition, the top 350 feet of sediments within the Pleasant Valley (PV) Basin are often referred to as the "Upper Zone", and are thought by some to be equivalent to the Hueneme aquifer zone that is a more well-defined and recognized layer to the west of the PV Basin.

Shallower, unconfined aquifers are located in the valleys of the watershed. In the upper sub-watersheds of Simi Valley and Conejo Valley, groundwater collects in the lower areas and overflows into the down-gradient valleys. The Tierra Rejada, Santa Rosa and South Las Posas valley basins are larger than the upper valley basins and are the most significant unconfined basins on the watershed. Areas of perched and unconfined groundwater are also present along the base of the Santa Monica Mountains, and overlying areas of the southeastern Oxnard Plain in the Pleasant Valley.

Water rights have not been adjudicated in many of these basins, and groundwater production is not comprehensively controlled or maintained. However, groundwater extractions are regulated in the Oxnard Plain, Pleasant Valley Basin and the Las Posas Basin by the Fox Canyon Groundwater Management Agency. In some basins, groundwater is being over-drafted and as a result Pleasant Valley has experienced subsidence. In other basins, such as the South Las Posas Basin, groundwater levels have increased significantly in the last several decades.

1.1.8. Anthropogenic Alterations

Historically, the Oxnard Plain served as the flood plain for Calleguas Creek. Starting in the 1850's, agriculture began to be practiced extensively in the watershed. By 1889, a straight channel from the area near the present day location of Highway 101 to the Conejo Creek confluence had been created for Calleguas Creek. In the 1920's, levees were built to channelize flow directly into Mugu Lagoon (USDA, 1995). Increased agricultural and urban land uses in the watershed resulted in continued channelization of the creek to the current channel system. Historically, Calleguas Creek was an ephemeral creek flowing only during the wet season. The cities of Simi Valley, Moorpark, Camarillo, and Thousand Oaks experienced rapid residential and commercial development beginning in the 1960s. In the early 70's, State Water Project supplies began being delivered to the watershed. In 1957, the Camarillo WRP came online, followed by the Hill Canyon WTP in Thousand Oaks in 1961. Increasing volumes of discharges from these POTWs eventually caused the Conejo/Calleguas system to become a perennial stream by 1972 (SWRCB, 1997). When the Simi Valley WQCP began discharging in the early 1970's, the Arroyo Simi/Arroyo Las Posas became a perennial stream that gradually flowed further downstream and currently reaches Seminary Road in Camarillo.

1.1.9. Flow Diversion Project

The Conejo Creek Diversion project in the Calleguas Creek watershed diverts the majority of flow in Conejo Creek to agricultural uses in the Pleasant Valley area. The diversion project is located approximately 7 miles downstream from the Hill Canyon WTP. The water rights application allows the diversion of an amount equal to the Hill Canyon WTP's effluent minus 4 cfs for in stream uses and channel losses. An additional amount of water equal to the flow contributed by use of imported water in the region (estimated at 4 cfs) may be diverted when at least 6 cfs of water will remain in the stream downstream of the diversion point (SWRCB, 1997). As a result of this project, flows in the lower reach of Conejo Creek have been reduced to less than half of the previous creek flows.

1.1.10. Reach Designations

Table 1 summarizes the reach descriptions of Calleguas Creek used in this TMDL and the correlation between these reaches and the 303(d) and consent decree listed reaches. These reach designations provide greater detail than the designations in the current *Water Quality Control Plan: Los Angeles Regional Water Quality Control Plan* (Basin Plan). The reach revisions may provide an appropriate analytical tool for future analyses in the watershed. At this time, though, the reach revisions are not regulatory and do not alter water quality objectives for the reaches in the existing Basin Plan.

Table 1. Description of Calleguas Creek Reaches

Assigned Reach No.	Reach Name Reach as Listed in 303(d) List and Consent Decree	Geographic Description
1 Mugu Lagoon	Mugu Lagoon	Lagoon fed by Calleguas Creek
2 Calleguas Creek South	Calleguas Creek Reach 1 and Reach 2 (Estuary to Potrero Rd.)	Downstream (south) of Potrero Rd
3 Calleguas Creek North	Calleguas Creek Reach 3 (Potrero to Somis Rd.)	Potrero Rd. upstream to confluence Conejo Creek
4 Revolon Slough	Revolon Slough Main Branch	Revolon Slough from Mugu Lagoon to Central Ave
5 Beardsley Channel	Beardsley Channel	Revolon Slough upstream of Central Ave.
6 Arroyo Las Posas	Arroyo Las Posas Reach 1 and part of Reach 2 (Lewis Somis Rd. to Moorpark Fwy (23))	Confluence with Calleguas Creek to Hitch Road
7 Arroyo Simi	Arroyo Simi Reach 1 and Reach 2 (Moorpark Fwy (23) to Headwaters) part of Arroyo Las Posas Reach 2	End of Arroyo Las Posas (Hitch Rd) to headwaters in Simi Valley.
8 Tapo Canyon	Tapo Canyon Reach 1 and Reach 2	Confluence w/ Arroyo Simi up Tapo Cyn to headwaters
9A Conejo Creek Diversion	Conejo Creek Reach 1 (Conflict with Calleguas Creek to Santa Rosa Rd.)	Extends from Camrosa Diversion to confluence with Calleguas Creek.
9B Conejo Creek Main Stem	Conejo Creek Reach 2 (Santa Rosa Rd. to Tho. Oaks city limit)	Extends from the confluence with Arroyo Santa Rosa downstream to the Camrosa Diversion
10 Hill Canyon reach of Conejo Creek	Part of Conejo Creek Reach 2 and Reach 3 (Santa Rosa Rd. to Lynn Rd.)	Confluence w/ Arroyo Santa Rosa to confluence w/ N. Fork; and N. Fork to just above Hill Canyon WTP
11 Arroyo Santa Rosa	Arroyo Santa Rosa	Confluence w/ Conejo Creek to headwaters
12 North Fork Conejo Creek	North Fork Conejo Creek	N. Fork just above Hill Canyon WTP to headwaters
13 Arroyo Conejo (South Fork Conejo Creek)	Conejo Creek Reach 4 (Above Lynn Rd.)	Confluence w/ N. Fork to headwaters —two channels

2. Problem Statement

Since 1999, ongoing discussions about the best mechanisms for managing chlorides in the CCW have clearly demonstrated that two distinct problems exist related to salts. The first is the regulatory defined problems based on the 303(d) list. This problem definition relies solely on the ability of the surface waters to meet Basin Plan water quality objectives to protect beneficial uses. However, the issues with salts are much broader than just surface water concentrations. Therefore, two problem statements were developed. The first deals with the regulatory requirements resulting from the 303(d) listings of salts in the CCW. The second deals with the broader impacts from salts in the CCW. The projects described in this report focus on addressing both components of the problem statement.

2.1. Regulatory Problem Statement

2.1.1. Regulatory Background

Section 303(d) of the Clean Water Act (CWA) requires that "Each State shall identify those waters within its boundaries for which the effluent limitations are not stringent enough to implement any water quality standard applicable to such waters." The CWA also requires states to establish a priority ranking for waters on the 303(d) list of impaired waters and establish TMDLs for such waters.

The Los Angeles Regional Water Quality Control Board (Regional Board) identified over 700 water body-pollutant combinations in the Los Angeles Region where TMDLs are required (SWRCB, 1999). A schedule for development of TMDLs in the Los Angeles Region was established in a consent decree (Heal the Bay Inc., et al. v. Browner C 98-4825 SBA) approved on March 22, 1999. The consent decree combined water body pollutant combinations in the Los Angeles Region into 92 TMDL analytical units. Based on the consent decree schedule, a TMDL for chloride was adopted by USEPA in March 2002. According to the consent decree, the remaining salts (TDS, sulfate, and boron) TMDLs must be approved or established by United States Environmental Protection Agency (USEPA) by March 2012.

In addition to the 303(d) listings for salts, a number of other regulatory activities have been ongoing in the watershed to address chloride surface water concentrations and objectives. The following section summarizes the other regulatory activities related to chloride that are relevant to the development of this report.

2.1.1.1. Chloride Regulatory History

During the drought that began in the 1980s and continued through the early 1990s, many dischargers in the Los Angeles Region had difficulty meeting the chloride discharge limits based on the Basin Plan objectives. Although, chloride levels were expected to subside after the drought, many water bodies continued to exceed the chloride objective.

In 1997, the Regional Board adopted Resolution 97-02 (the Chloride Policy) that revised the chloride water quality objectives (WQOs) upward to 190 mg/L for specified reaches of the Los Angeles River and 180 mg/L in the San Gabriel River. However, the chloride objectives were not revised in the Calleguas Creek and Santa Clara River watersheds due to concerns for agricultural beneficial uses, which are sensitive to chloride levels. Rather, the Regional Board extended the interim limits in these watersheds and directed staff to carefully determine the chloride WQO that would fully support the agricultural beneficial use (See Table 2). The Regional Board determined that the interim limits expired on March 29, 2002.

Table 2. Interim Chloride Limits for Specified Stream Segments

Calleguas Creek watershed segments for which existing dischargers are subject to Interim Chloride Limits	Interim Chloride Limit
Arroyo Simi and tributaries-upstream of Madera Road	160 mg/L
Arroyo Simi- downstream of Madera Road, Arroyo Las Posas, and tributaries	190 mg/L
Calleguas Creek and tributaries-between Potrero Road and Arroyo Las Posas (including Conejo Creek, Arroyo Conejo, and Arroyo Santa Rosa)	190 mg/L

After the expiration of the interim limits on March 29, 2002, the dischargers in the watershed worked with the State Water Resources Control Board (State Board) to develop a stay that would extend the interim limits for up to three years to allow them to pursue "a watershed planning effort to support determinations of beneficial uses, water quality objectives, and development of total maximum daily loads as necessary" (WQO 2002-0017). The State Board approved the stay in October 2002. The stay requires that a work plan be developed to "re-evaluate water quality objectives for chloride in the Calleguas Creek watershed and/or the beneficial uses currently associated with chloride objectives in the Calleguas Creek watershed (Work Plan)." The Regional Board must then ensure that the work plan provides "an adequate approach to determining appropriate water quality standards and implementation with respect to chloride in the Calleguas Creek watershed."

The Calleguas Creek Watershed Management Plan submitted a work plan to meet the requirements of the stay agreement in January 2003 (*Calleguas Creek Watershed Salts TMDL Work Plan*). The work plan was approved by the Regional Board in July 2003, thereby fulfilling the requirements of the stay agreement.

Concurrently with the activity surrounding the Chloride Policy, a chloride TMDL was being developed. In December 2001, the Regional Board developed a draft chloride TMDL (Draft Chloride TMDL) for the CCW. Although the proposed TMDL was never adopted by the Regional Board, the USEPA used it as a basis for developing a chloride TMDL for the CCW to meet the consent decree requirements. The USEPA developed chloride TMDL (EPA Chloride TMDL) was adopted by USEPA on March 2, 2002.

When the discharge permits for three of the POTWs in the watershed were renewed in 2003, the interim limits were placed in the NPDES discharge permits in accordance with the stay agreement. The USEPA objected to the draft orders that were consistent with the stay. USEPA contended that the final orders must include effluent limitations for chloride consistent with waste load allocations (WLA) contained in the EPA Chloride TMDL. As a result, the Regional Board adopted the orders with new chloride effluent limitations and accompanying time schedule orders based upon the EPA Chloride TMDL.

In response, the dischargers appealed their permits to the State Board. Another stay agreement was adopted in October 2003 to address the concerns outlined in the appeal. This agreement stayed the final chloride effluent limitations and time schedule orders associated with the limitations for all of the appealed permits. The stay acknowledged that a work plan has been approved by the Regional Board and activities related to the work plan were in progress. In December 2003, the Regional Board adopted orders for the remaining two POTWs that included effluent limitations for chloride consistent with WLAs contained in the EPA Chloride TMDL. These permits were also appealed to the State Board and a similar stay of the final chloride effluent limitations is pending. This document is a summary of work conducted under the approved work plan.

2.1.1.2. Water Quality Standards

Federal water quality standards consist of the following elements: 1) designated beneficial uses and 2) narrative and/or numeric water quality criteria. State water quality objectives, which parallel, federal criteria, are numeric values or narrative statements which are intended to provide reasonable protection of designated beneficial uses. For inland surface waters in the Los Angeles Region, beneficial uses, numeric and narrative objectives are identified in the Basin Plan. The State water quality objectives and Federal criteria applicable to salts are addressed in this section.

2.1.1.2.1. Beneficial Uses

Salts primarily impact two beneficial uses: agriculture irrigation and groundwater recharge. In addition, chloride has the potential to impact aquatic life, there are secondary drinking water standards for some salts, and industrial processing can be impacted by high salts concentrations. The following table summarizes the locations of these beneficial uses as listed in the Basin Plan.

Table 3. Beneficial Uses Potentially Impacted by Salts in Calleguas Watershed

Reach	Reach No.	Hydro Unit	WARM	MUN	IND	PROC	AGR	GWR
Mugu Lagoon	1	403.11						
Calleguas Creek Estuary	2	403.11						
Calleguas Creek	2, 3	403.11	E	P*			E	E
Calleguas Creek	3, 9A	403.12	E	P*	E	E	E	E
Revolon Slough	4	403.11	E	P*	P		E	E
Beardsley Wash	5	403.61	E	P*				
Conejo Creek	3, 9A	403.12	E	P*	E	E	E	E
Conejo Creek	9B	403.63	I	P*				I
Arroyo Conejo	9A, 9B,10	403.64	I	P*				I
Arroyo Conejo	13	403.68	I	P*				I
Arroyo Santa Rosa	11	403.63	I	P*				I
Arroyo Santa Rosa	11	403.65	I	P*				I
North Fork Arroyo Conejo	12	403.64	E	P*			E	E
Arroyo Las Posas	6	403.12	E	P*	P	P	P	E
Arroyo Las Posas	6	403.62	E	P*	P	P	P	E
Arroyo Simi	7	403.62	I	P*	I			I
Arroyo Simi	7	403.67	I	I*	I			I
Tapo Canyon Creek	8	403.66	I	I*		P	P	I
Tapo Canyon Creek	8	403.67	I	I*		P	P	I
Gillibrand Canyon Creek		403.66	I	P*				I
Gillibrand Canyon Creek		403.67	I	P*				I
Lake Bard		403.67	E	E	E	E	E	P

E-Existing Beneficial Use, P-Potential Beneficial Use, I-Intermittent Beneficial Use

* Asterixed MUN designations are not to be put into effect until a study has been done to confirm the presence of the beneficial use.

2.1.1.2.2. Water Quality Objectives

2.1.1.2.2.1. Surface Water Objectives

The Basin Plan contains water body specific numeric water quality objectives for salts in Table 4-2. The objectives for the CCW are applicable upstream of Potrero Road and are shown in Table 4. The objectives are currently applied as instantaneous maximum concentrations.

Table 4. Basin Plan Objectives for Salts

Constituent	Objective Upstream Potrero Road (mg/L)
TDS	850
Chloride	150
Sulfate	250
Boron	1.0
SAR	Not enough data

The objectives in Table 4 are water body specific and only apply upstream of Potrero Road. It is unclear based on the reach definitions in Table 3-8 of the Basin Plan whether or not the water body specific values apply to Revolon Slough and Beardsley Wash. Because Revolon Slough enters Calleguas Creek downstream of Potrero Road, it does not appear that the objectives apply to these reaches. However, in the 2002 listing process, USEPA determined that an interpretation of the narrative standards in the Basin Plan results in the application of the objectives to Revolon Slough.

In addition to the existing Basin Plan objectives, Federal advisory criteria are numeric for the protection of aquatic life and municipal drinking water exist for several salts as shown in Table 5.

Table 5. Federal Advisory Criteria for Salts

	MUN (mg/L)	AQ Life Chronic 4 day average (mg/L)	AQ Life Acute 1 hour average (mg/L)
TDS	500 (USEPA secondary MCL)		
Chloride	250 (USEPA secondary MCL)	230	860
Sulfate	400-500 (USEPA proposed MCL)		

Finally, California has secondary Maximum Contaminant Level (MCL) ranges for TDS, chloride and sulfate in drinking water.

Table 6. California Secondary Maximum Contaminant Levels - Ranges

Constituent, Units	Recommended	Upper	Short Term
Total Dissolved Solids, mg/L	500	1,000	1,500
Chloride, mg/L	250	500	600
Sulfate, mg/L	250		

2.1.1.2.2.2. Groundwater Objectives

The Basin Plan also includes objectives for groundwater basins as shown in Table 7.

Table 7. Groundwater Objectives in Calleguas Creek Watershed

	GWR Arroyo Simi/Simi Valley Basin	GWR Arroyo Simi/ South Las Posas	GWR Arroyo Las Posas/ South Las Posas	GWR Arroyo Las Posas/ North Las Posas	GWR Arroyo Santa Rosa and Conejo/ Arroyo Santa Rosa Basin	GWR Arroyo Santa Rosa/ Tierra Rejada Basin	GWR Arroyo Conejo/ Thousand Oaks area	GWR Arroyo Conejo/ Conejo Valley	GWR Conejo and Calleguas/ Pleasant Valley
TDS	1200	2500	1500	500	900	700	1400	800	700
Chloride	150	400	250	150	150	100	150	150	150
Sulfate	600	1200	700	250	300	250	700	250	300
Boron	1.0	3.0	1.0	1.0	1.0	0.5	1.0	1.0	1.0

2.1.1.2.2.3. Antidegradation

"State Board Resolution 68-16, Statement of Policy with Respect to Maintaining High Quality Water in California, known as the "Antidegradation Policy," protects surface and ground waters from degradation. According to the Antidegradation Policy, any actions that can adversely affect water quality in all surface and ground waters must be consistent with the maximum benefit of the people of the state, must not unreasonably affect present and anticipated beneficial use of such water, and must not result in water quality less than that prescribed in water quality plans and policies. Furthermore, any actions that can adversely affect surface waters are also subject to the federal Antidegradation Policy (40 CFR 131.12)." (LARWQCB, 2002b)

2.1.1.3. Other Relevant Policies

In addition to the Federal and State regulations described above, the Regional Board enacted Resolution No. 97-10, *Support for Watershed Management in the Calleguas Creek Watershed* on April 7, 1997. Resolution 97-10 recognized watershed management as an innovative, cost-effective strategy for the protection of water quality. Resolution 97-10 also recognized that the Calleguas Creek Municipal Water District and the POTWs in the Calleguas Creek watershed had worked cooperatively with the Regional Board to develop an integrated watershed-wide monitoring program. The Calleguas Watershed Management Plan has been active since 1996 in the development of a watershed management plan for the Calleguas Creek watershed and has proactively worked with the Regional Board and EPA to develop TMDLs in the watershed.

Another important component of addressing salts impacts and the watershed salt balance is water reclamation. Several portions of the California Water Code establish goals and guidelines supporting water reclamation that should be considered as part of the analysis of projects to address salts. The Legislature has established a goal of recycling 1 million acre feet of water by 2010. (Water Code §13577.) The Legislature has declared that the people of the State have a "primary interest" in the development of recycled water facilities, and that the State should "take all possible steps" to encourage the development of such facilities in order to meet the State's water needs. (Water Code §§13510, 13512.) The Water Code defines recycled water not as a waste but as "water, which, as a result of treatment, is suitable for a

direct beneficial use or a controlled use that would not otherwise occur and is therefore considered a valuable resource." (Water Code §13050(n).)

2.1.2. 303(d) Listings

As discussed previously, the CWA requires that water bodies that do not meet water quality standards be listed on the 303(d) list. The Basin Plan water quality objectives listed above were used to assess the surface water bodies in Calleguas Creek for listing on the 303(d) list. Ten out of fourteen reaches in the CCW are identified on the 2002 Clean Water Act Section 303(d) list of water-quality limited segments as impaired due to elevated levels of salts (Table 8).

Table 8. 2002 303(d) Listings

Reach No.	Reach Name	Boron	Chloride	Sulfates	TDS
7	Arroyo Simi	X	X	X	X
6	Arroyo Las Posas		X	X	X
8	Tribs to Arroyo Simi	X	X	X	X
13	South Fork Conejo Creek		X	X	X
12	North Fork Conejo Creek			X	X
10	Conejo Creek Hill Canyon		X	X	X
11	Arroyo Santa Rosa			X	X
9B	Conejo Creek Main Stem		X	X	X
9A	Camrosa Diversion			X	X
3	Calleguas Creek Upper Main Stem		X		X
2	Calleguas Creek Lower Main Stem				
4	Revolon Slough	X		X	X
5	Beardsley Wash				
1	Mugu Lagoon				

Blank cells indicate no listings for that constituent in the reach.

2.1.3. Basis of 303(d) listings

This section presents the data used for comparison to the water quality objectives that resulted in the 303(d) listings for salts. Regional Board staff conducted water quality assessments in 1996, 1998 and 2002, with the majority of salts listings first appearing on the 1998 303(d) list. This section discusses the data reviewed for the Water Quality Assessments and the application of the data that resulted in the 1998 303(d) listings. In 2002, changes were made to the 303(d) list based on the changes to the reach designations. Additionally, USEPA added listings on Revolon Slough for TDS, sulfate and boron. The available information on the basis for the 1998 listings is summarized in Table 9. The information used for the 2002 listings is not included in the table.

Table 9. Basis of 1998 303(d) Listings

Reach No.	2002 Reach Name	1998 Reach Name	TDS			Chloride			Sulfate			Boron		
			Max	Avg.	% Exceed	Max	Avg.	% Exceed	Max	Avg.	% Exceed	Max	Avg.	% Exceed
8	Tapo Canyon	Tapo Canyon	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
7	Arroyo Simi	Arroyo Simi R2	2380	1654	86	180	130	57	1040	800	86	1.5	0.9	57
		Arroyo Simi R1	2600	1751	100	1190	277	90	1000	842	86	1.4	1.1	60
6	Arroyo Las Posas	Arroyo Las Posas R2	1280	1194	100	190	171	75	500	438	100	0.91	0.84	0
11	Arroyo Santa Rosa	Arroyo Santa Rosa	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
12	North Fork Conejo Creek	Arroyo Conejo North Fork	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
13	South Fork Conejo Creek	Conejo R4	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
10	Conejo Creek Hill Canyon	Conejo R3	1240	888	52	242	172	80	571	286	63	0.5	0.46	0
9B	Conejo Creek Main Stem	Conejo R2	1210	819	35	230	173	84	386	264	56	0.5	0.38	0
9A	Camrosa Diversion	Conejo R1	1210	625	33	236	181	87	414	261	52	0.5	0.38	0
3	Calleguas Creek Upper Main Stem	Calleguas R3	1340	860	54	264	185	92	550	372	59	0.6	0.42	0
2	Calleguas Creek Lower Main Stem	Calleguas R2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Calleguas R1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5	Beardsley Wash	Beardsley	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4	Revolon Slough	Revolon	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1	Mugu Lagoon	Mugu	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

N.D. indicates that no data were available for the constituent for the reach.
N/A indicates that objectives were not considered applicable to the reach so no listings were made.

As shown in the table above, surface water concentrations of salts exceed the Basin Plan water quality objectives for most reaches in the CCW.

2.2. Water Resources Problem Statement

The regulatory problem statement summarizes the necessary information for the development of a TMDL to address surface water concentrations of salts. However, salts impacts are broader and not completely addressed through the 303(d) listing process. Therefore, this additional problem statement was developed to highlight the additional issues surrounding salts management in the CCW.

Large volumes of salts are imported into the watershed to support development in the semi-arid climate of the watershed. The salts are imported from State Water Project imported water, Santa Clara River through the Freeman Diversion, and the pumping of deep aquifers, not directly recharged by surface water or irrigation, within the watershed. Additionally, the watershed contains naturally occurring or background concentrations of salts due to the fact that many of the soils are marine sediments. The watershed's stream systems do not have the capacity to effectively transport these salts off of the watershed and existing transportation processes do not effectively transport the salts to the surface waters on a daily basis. Consequently, salts are stranded on the watershed and build-up over time. The result is a general salt imbalance on the watershed that manifests itself in higher surface water and groundwater concentrations of salts. The concentrations can increase significantly for prolonged periods following extreme wet periods on the watershed as years of stranded salts that have built-up on the watershed are flushed into the surface waters.

As will be discussed in this report, the impacts on beneficial uses from the salt imbalance and watershed flushing have been minimal to date. However, there is concern that if the salt imbalance continues unmanaged, there could be impacts to groundwater and general soil conditions. Therefore, alternative mechanisms for addressing the salt imbalance and potential beneficial use impacts need to be developed.

3. Source Assessment

In this section, estimated dry weather loadings from sources of salts to the watershed are examined and the fate and transport of the salts in the watershed are discussed.

3.1. Conceptual Model

A conceptual model is designed to show how the pollutant and water flow through the watershed system. A conceptual model of salts sources and transport is presented diagrammatically in Figure 2. This diagram is meant to provide a generalized conceptual overview of the salts sources and related processes occurring throughout the watershed. Figure 2 is not spatially specific, in that some of the sources and processes may predominate in certain areas of the watershed and be absent from other areas. The squares represent sources of salts to the watershed, the arrows represent the transport of salts, and the diamonds represent the ultimate fate of salts in the CCW.

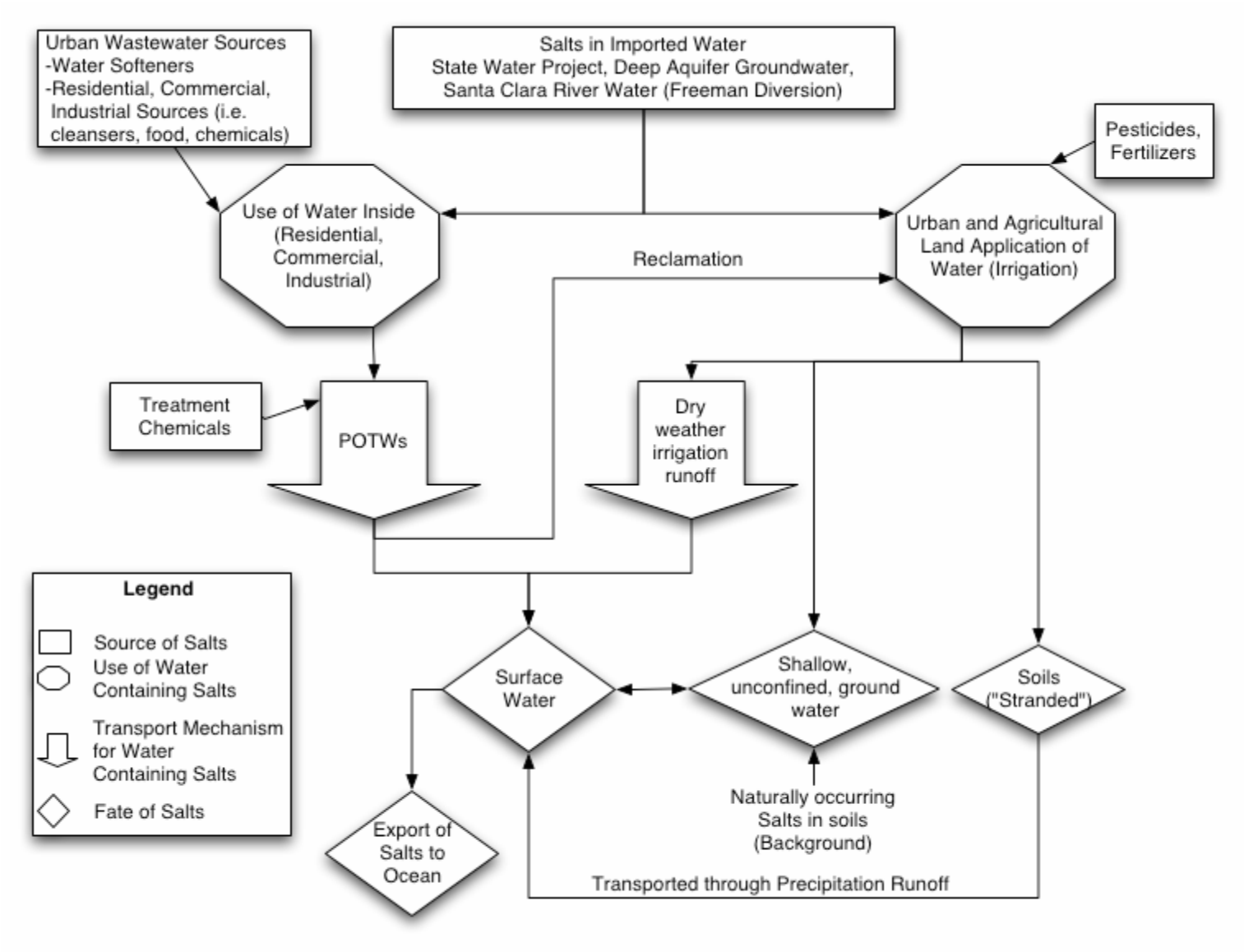

Figure 2: A Generalized Conceptual Model of salts flow for the Calleguas Creek Watershed.

3.2. Source Analysis

As shown in the conceptual model, six possible sources of salts to the watershed exist: water supply (water imported from the State Water Project or Freeman Diversion and deep aquifer groundwater pumping), water softeners, POTW treatment chemicals, atmospheric deposition, pesticides and fertilizers, and indoor water use (chemicals, cleansers, food, etc.). The use of pesticides and fertilizers may add some salts to the watershed, but the loads were not evaluated because there is insufficient information to determine the quantities added. These salts are then transported through POTW discharges and dry weather runoff to three possible endpoints: surface water, shallow groundwater, and/or stranded on the watershed in the soils. The salts stranded in the soils are eventually transported to surface water when precipitation mobilizes them and carries them to the creek system. Groundwater pumping and exfiltration moves salts from groundwater to surface water and surface water infiltration transports salts from the surface water to groundwater. Additionally, groundwater saturation of historic marine sediments can mobilize existing background salts from previously dry soil and transport them to the groundwater. However, none of these transport mechanisms add salts, they just move salts from one endpoint to another. Salts transported in the surface water to the ocean are currently the only salts that are exported from the watershed.

In the source analysis, the sources of salts to the watershed were quantified. Then, the transport mechanisms were utilized to quantify the portion of salts transported to surface waters during typical dry weather conditions. The salts that are not transported to surface waters are stranded in the watershed in soils and shallow, unconfined groundwater areas. These salts can be transported to the surface waters during large precipitation events, but are not mobilized during typical dry weather conditions. Consequently, the dry weather source analysis does not quantify the amount of salts that are mobilized and transported to surface waters during precipitation events.

3.2.1. Sources of Salts to Watershed

3.2.1.1. Water Supply

A major source of salts to the watershed is the load associated with introduced water sources. For the purposes of this report, introduced water includes water imported from the State Water Project, water produced from the watershed's deep confined aquifer system (Las Posas and Pleasant Valley groundwater basins), and Santa Clara River water (Freeman Diversion). While the concentration of salts in the introduced water is low relative to Basin Plan Objectives, the quantity of water brought into the watershed is sufficient to rate introduced water as the number one source of salts to the watershed.

Water supply for all cities except Thousand Oaks is composed of a combination of local groundwater and imported water. Thousand Oaks is supplied exclusively by State Water Project (SWP). Agricultural supply is primarily composed of local groundwater or reclaimed water that is supplemented with imported water from the SWP and Santa Clara River.

The introduced water supply load is estimated based on 1993 to 2003 water quality data and 2003 introduced water quantities. All local groundwater pumping was assumed to be from deep aquifers; essentially resulting in salts added to the system. Although some shallow groundwater pumping occurs that could be salts that entered the groundwater from introduced water, the assumption that all groundwater pumping is from deep aquifers results in a higher estimated load and is conservative. Reclaimed water used for irrigation purposes is not considered as part of the water supply load.

Table 10. Average Introduced Water Volumes and Quality Used for Loadings[1]

Water Source	Volume (MGD)	Chloride (mg/L)	TDS (mg/L)	Sulfate (mg/L)	Boron (mg/L)
State Water Project	70	64	332	86	0.27
Santa Clara River (Freeman Diversion)	10	56	1080	490	0.70
Groundwater from Las Posas Basin	20	56	631	219	0.12
Groundwater from Pleasant Valley Basin	25	119	910	312	0.40

1 Concentrations are average values from available data from 1993 to 2003. Volumes are from Hajas, 2004.

The following table summarizes the total water supply loads to the watershed for each of the constituents based on the concentrations and volumes in Table 10.

Table 11. Total Water Supply Loads

Constituent	Load (lb/day)
Chloride	75,450
TDS	578,200
Sulfate	192,500
Boron	320
Volume (MGD)	125

The primary source of salts to the watershed is the water supply. Water introduced into the watershed from the State Water Project comes from the Sacramento/San Joaquin Delta. Consequently, chloride and TDS can vary significantly as a result of Northern California hydrology. During the drought, chloride concentrations neared 120 mg/L, but fell to 45 mg/L after El Nino (See Figure 3). Therefore, the amount of salts entering the watershed from imported SWP water is strongly linked to hydrology in Northern California and the volume of water imported into the watershed and can vary significantly over time.

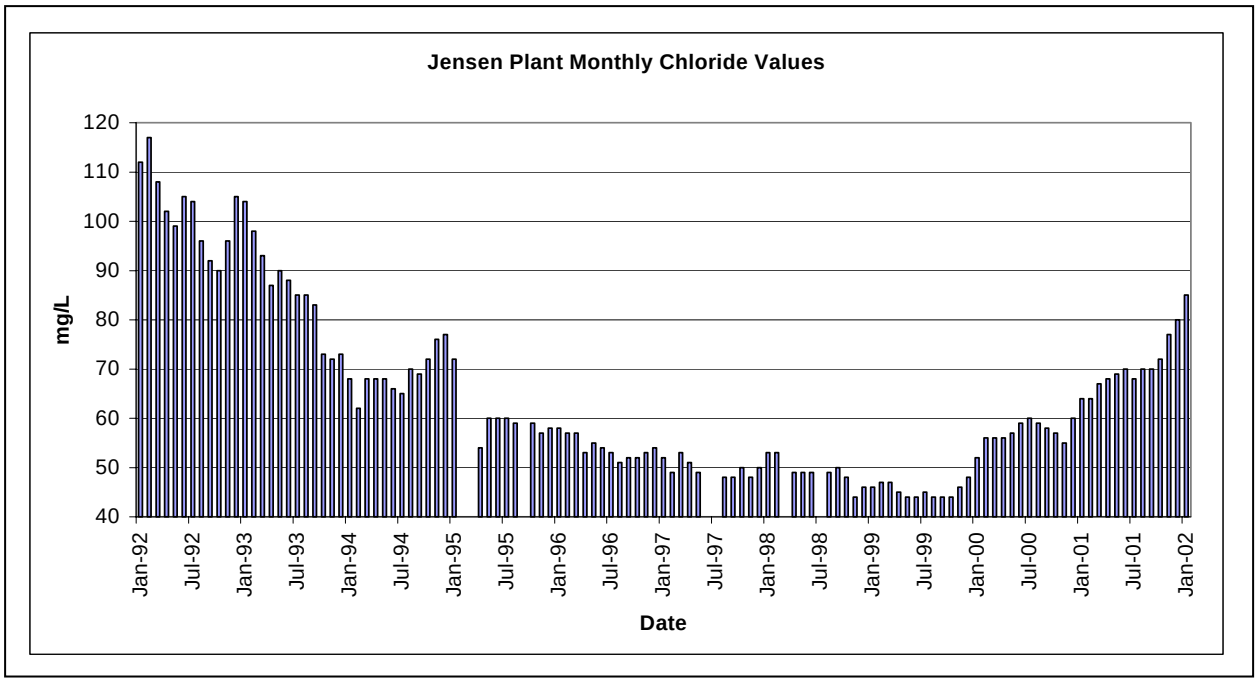

Figure 3. Imported Water Chloride History

3.2.1.2. Urban Wastewater Sources

Water supply and treatment plant effluent were compared to assess the overall amount of salts contributed to the watershed through industrial, commercial and residential activities and water softeners. Estimated loadings to the watershed were developed based on information for the urban areas served by wastewater treatment facilities.

Detailed source analyses were developed for TDS, chloride, and sulfate based on information from Simi Valley, Thousand Oaks, and Camarillo. This analysis was extrapolated to account for loadings from urban sources in Moorpark. Unsewered areas were assumed to be all residential sources with the same contribution of salts due to normal use as sewered areas and with the same percentage of water softener use. Population estimates for unsewered areas were estimated based on census data for unincorporated Ventura County in the CCW. Sufficient data were not available to allow an assessment of boron loadings from urban wastewater sources.

3.2.1.2.1. Residential, Commercial, and Industrial Activities

A planning level analysis of sources of salts from residential, commercial, and industrial activities was conducted for TDS, chloride, and sulfate. Insufficient data were available to conduct a similar analysis for boron. For TDS, chloride, and sulfate, data on industrial, commercial and residential activities were available. Industrial chloride and TDS data were available for Simi Valley, Thousand Oaks, and Camarillo. In addition, Simi Valley had conducted some chloride and TDS monitoring for commercial businesses. Simi Valley has also conducted some commercial and industrial sampling for sulfate, but data are not available for Camarillo and Thousand Oaks for sulfate. Commercial chloride sampling has also been conducted by the Sanitation Districts of Los

Angeles County (LACSD) and the City of Burbank. Simi Valley's commercial data was used to estimate their commercial loadings. For Camarillo and Thousand Oaks, commercial data from the other communities was corrected for water supply, averaged together where applicable, and adjusted for the number of businesses or business flow in Camarillo and Thousand Oaks. These adjusted values were used to estimate commercial loadings. Other community data were used because the Simi Valley commercial data included information that was very specific to the City of Simi Valley and the other community data were more appropriate for extrapolation to other areas. Loadings from normal residential use were based on literature values. The details of the values used and the calculations are included in Appendix B.

The source analysis presented below was developed for planning and informational purposes and should not be considered an exact quantification and determination of sources

3.2.1.2.2. Water Softeners

Information on contributions from water softeners was available based on work conducted in other nearby communities. LACSD has recently completed a survey in the Santa Clarita Valley to evaluate self-regenerating water softener usage (LACSD, 2002). The percentage of water softener use in this study was used as the basis for determining water softener contributions in the CCW. The contributions from water softeners were estimated based on the water supply hardness for each area of the watershed (See Appendix B for example calculation).

3.2.1.2.3. Summary of Urban Wastewater Loads

The following table summarizes the loads to the watershed from water softeners, residential, commercial and industrial activities.

Table 12. Summary of Urban Wastewater Loads to CCW

Source	Chloride Load (lb/day)	TDS Load (lb/day)	Sulfate Load (lb/day)
Water Softeners	8,855	14,148	N/A
Residential Use	7,480	54,109	4809
Commercial Use	3,109	18,913	5379
Industrial Use	1,048	4,889	4217
Total	20,493	92,059	14405

Details of the loading calculations for each of the three major wastewater treatment plants (Hill Canyon WTP, Simi Valley WQCP, and Camarillo WRP) and the assumptions used to estimate loadings for Moorpark, Camrosa, and unsewered areas are presented in Appendix B.

3.2.1.3. Treatment Chemicals

Another source of salts to treatment plant discharges is chemicals used in treatment plant operations. The most likely sources of salts are sodium hypochlorite that is used for disinfection and ferric chloride and aluminum sulfate (alum) that are used as coagulants. Camarillo estimated that approximately 2.5 mg/L of chloride are added to the effluent as a result of disinfection. Simi Valley estimates that approximately 553 lb/day of sodium hypochlorite are added per day for treatment plant disinfection or approximately 261 lb/day of chlorine. Based on these values,

approximately 700 lbs/day of chloride and TDS are added to the watershed as a result of treatment chemicals. No information is readily available on the impact of ferric chloride or alum used in the treatment plants on salt levels in the effluent.

3.2.1.4. Atmospheric Deposition

Salts may be deposited onto the earth's surface under either dry or wet (precipitation) conditions. Dry deposition occurs as particles settle out of the atmosphere and as gaseous pollutants adsorb onto the earth's surface. Wet deposition occurs when rain falls through contaminated air, scavenging pollutants by impaction and interception of particulate matter and by dissolving gaseous pollutants. Wet and dry deposition occurs directly onto receiving waters, or indirectly by depositing onto the watershed surface and subsequently transported to the surface water in runoff. To quantify the deposition contribution of pollutants to the Calleguas Watershed, available precipitation and deposition monitoring data were used to estimate loadings.

Data from national and local air quality monitoring networks were evaluated to estimate the salts loading to the watershed from atmospheric deposition. For wet deposition, data from the National Atmospheric Deposition Program (NADP) sites were used to determine the typical range of salts concentrations present in precipitation. Dry deposition was estimated from the Clean Air Status and Trends Network (CAST NET) and the Air Resources Board. A detailed discussion of the calculations is included in Appendix A.

Average chloride concentrations in precipitation along the California coastline are below 1 mg/L. Results for other constituents are similar. Because of the low average concentration and annual precipitation, the average annual wet deposition loading of chloride is approximately 3 kg/ha. Given that the watershed is some 88,800 ha (343 square miles), wet deposition accounts for approximately 1,610 lbs/day for the entire watershed.

Average depositional velocity for particulate matter (PM) in the Southern California area is 0.175 cm/sec. The average particulate chloride concentration measured in Simi Valley is 0.135ug/m^3. Multiplying the deposition rate by the concentration and watershed area, and using the proper unit conversions, leads to calculation of an average 40 lb/day dry deposition over the entire watershed.

Wet and dry deposition of chloride is representative of other salts and the magnitude of loads is similar. Dry deposition of TDS is estimated to be 340 lbs/day, and the sulfate load is approximately 90 lbs/day.

3.2.1.5. Total Estimated Salts Loads to the CCW

The total estimated salts loading to the CCW from water supply; residential, commercial, and industrial activities; water softeners; treatment chemicals; and atmospheric deposition are summarized in Figures 4 through 6.

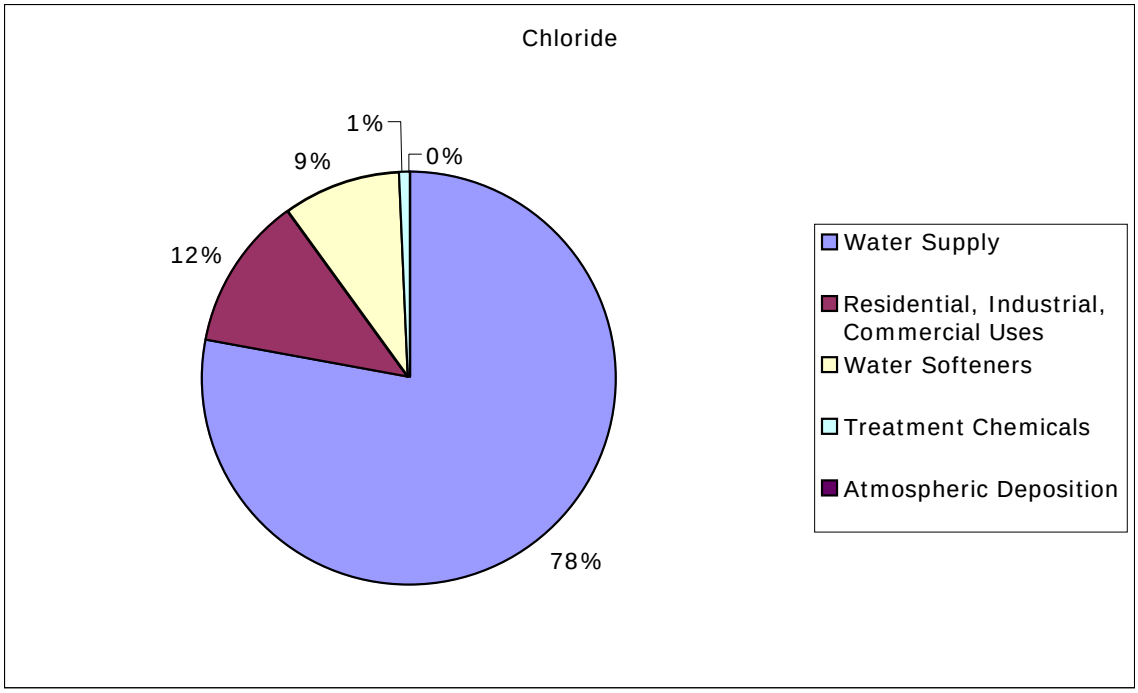

Figure 4. Sources of Total Chloride Load to Watershed of 97,000 lbs/day

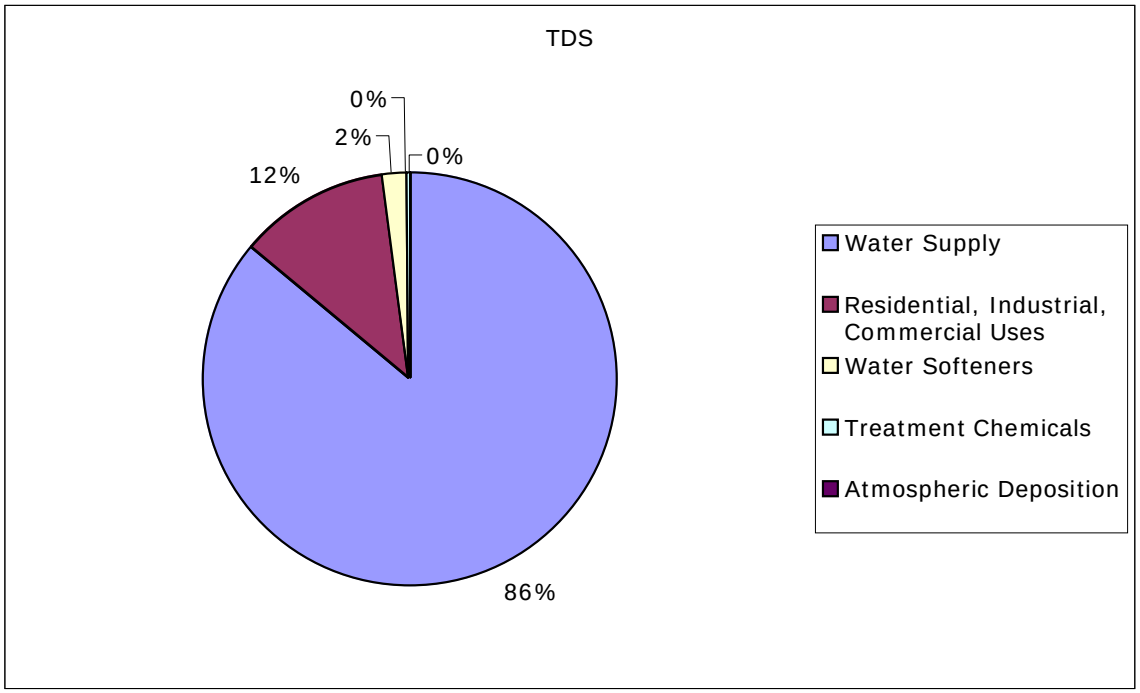

Figure 5. Sources of Total TDS Load to Watershed of 670,000 lbs/day

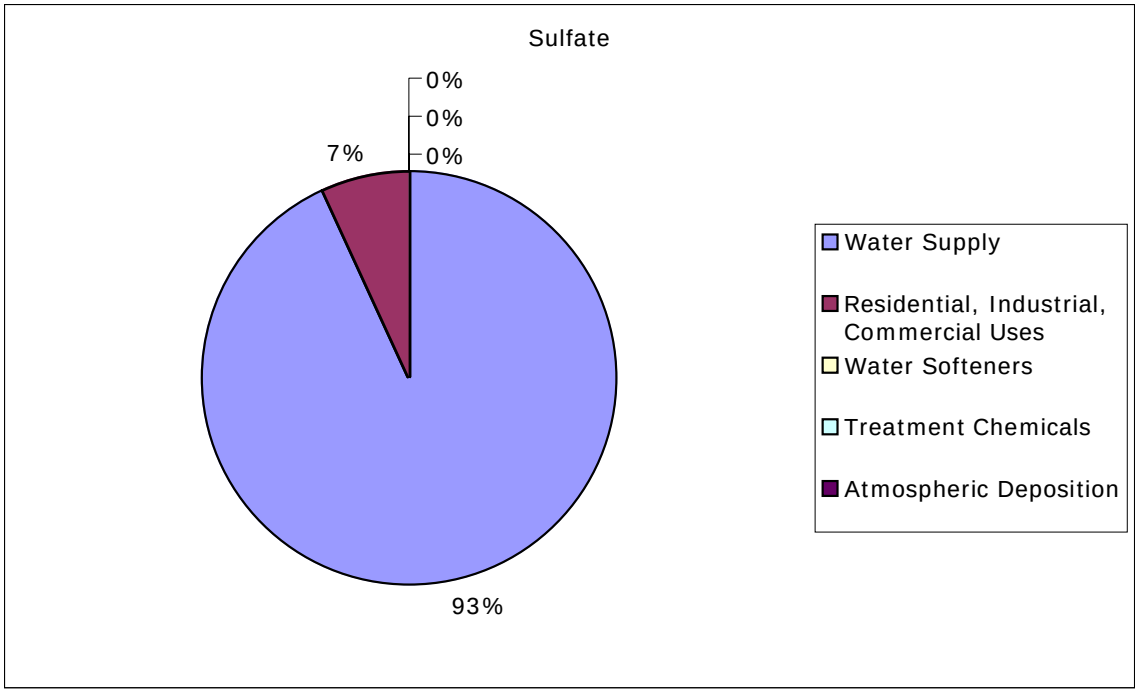

Figure 6. Sources of Total Sulfate Load to Watershed of 207,000 lbs/day

As shown in the figures above, the introduced water supply is the single largest source of salts to the watershed. Depending on the constituent, the introduced water supply is at least 78% of the overall salt load to the watershed.

3.2.2. Transportation of Salts to Surface Waters

Once the salts have been imported with and added to the water used in the watershed, they are transported through the watershed to one of three endpoints: surface water, groundwater, or the land surface/soils. The salts can also be transferred between these three endpoints when water flows mobilize the salts (i.e. precipitation events mobilize salts in the soils and transport them to the surface water). This section identifies the mechanisms that transport salts to the surface water from the original use of the water (i.e. POTWs) or between the endpoints (i.e. groundwater exfiltration). The quantities of salts transported during dry weather to the surface water are quantified for the following mechanisms.

- Groundwater Pumping
- Groundwater Exfiltration
- POTWs
- Dry weather urban and agricultural runoff

3.2.2.1. Groundwater Pumping

In the upper Arroyo Simi and the City of Thousand Oaks, groundwater is pumped and directly discharged to the creek system. High groundwater levels in Simi Valley require dewatering to prevent seepage into developed areas. Dewatering flows are typically discharged to the Arroyo Simi via the City's drainage system. In the City of Thousand Oaks, a number of treatment operations pump groundwater, treat it, and discharge it to the Arroyo Conejo under NPDES discharge permits. The following table summarizes the estimated loads from the groundwater pumping.

Table 13. Estimated Salts Loads from Groundwater Pumping

Source	Flow (cfs)	Chloride (mg/L)	Chloride Load (lb/day)	TDS (mg/L)	TDS Load (lb/day)	Sulfate (mg/L)	Sulfate Load (lb/day)	Boron (mg/L)	Boron Load (lb/day)
Simi Dewatering Wells	3.1	133	2224	1637	27,379	1302	21,774	0.98	16
Permitted Groundwater Discharge (Thousand Oaks)	0.5	195	526	820	2212	445	1200	0.2	0.54

3.2.2.2. Groundwater Exfiltration

Groundwater is a major source of salts to the surface water upstream of the upper POTWs (Simi Valley WQCP and Hill Canyon WTP). Groundwater exfiltration results in a continuous baseflow upstream of both POTWs. The flow rate of the baseflow depends on dry- or wet-year conditions. While the quantity and quality of the pumped groundwater has been measured, it is difficult to accurately measure groundwater baseflow in the stream because it is mixed with other discharges. The methods used to estimate the baseflow quantity and concentration are as follows:

1. Calculate the mean summer flows at the gaging stations in the watershed.
2. Subtract the known POTW discharges and estimates for urban and agricultural discharges.
3. Develop a relationship for baseflow quantities based on the precipitation during the previous winter.
4. Examine the salts concentrations from groundwater wells in the vicinity of the surface waters.
5. Compare the average well concentrations to estimates of concentrations based on surface water measurements.
6. Calculate an average baseflow concentration for chloride, sulfate and TDS.

Based on this procedure, average baseflow concentrations for salts were calculated and equations were developed to estimate baseflow quantities based on the previous winter's precipitation. A detailed discussion of the analysis is included in Appendix A. The average loadings estimated based on the analysis of concentrations for groundwater base flow were based on the analysis conducted for the development of the CCMS model and are shown in Table 14. Flow estimates were based on the critical condition precipitation year defined in the EPA chloride TMDL (12.2 inches annual precipitation).

Table 14. Average Loadings by Reach from Groundwater Exfiltration

Reach	Flow (cfs)	Chloride (mg/L)	Chloride Load (lb/day)	TDS (mg/L)	TDS Load (lb/day)	Sulfate (mg/L)	Sulfate Load (lb/day)	Boron (mg/L)	Boron Load (lb/day)
3	2.37	227	2907	907	11,614	801	10,256	0.2	2.56
7	0.098	199	105	1197	633	1232	651	1.4	0.74
8	0.098	199	105	1197	633	1232	651	1.4	0.74
10	0.010	195	11	820	45	445	25	0.2	0.01
11	0.090	195	94	820	397	445	215	0.2	0.10
12	0.092	195	97	820	408	445	221	0.2	0.10
13	0.16	195	173	820	727	445	395	0.2	0.18

Reaches not shown in the table do not receive significant loads from groundwater exfiltration..

3.2.2.3. POTWs

For the three POTWs that discharge to surface waters, estimates of the chloride, TDS, sulfate, and boron loadings to surface waters were estimated. The total loads from each of the POTWs are shown in Table 15. The loadings were estimated based on the concentration and flow analysis conducted for the development of the CCMS model (See Appendix A).

Table 15. POTW Salts Loads

POTW	Flow (cfs)	Chloride (mg/L)	Chloride Load (lb/day)	TDS (mg/L)	TDS Load (lb/day)	Sulfate (mg/L)	Sulfate Load (lb/day)	Boron (mg/L)	Boron Load (lb/day)
Simi Valley WQCP	14.3	139	10752	713	55151	139	10752	0.6	46
Camarillo WRP (1)	6.1	169	5604	863	28619	183	6069	0.65	22
Hill Canyon WTP	16.6	137	12304	629	56489	180	16165	0.65	58

(1) The loadings for Camarillo represent the total loadings from the POTW. However, some of the water is reclaimed for irrigation purposes during dry weather so the entire load may not be discharged to the surface water.

3.2.2.4. Land Use Runoff

Estimates of dry weather runoff from urban, agricultural, and open space lands were estimated using information developed for the Calleguas Creek Modeling System (CCMS) model. A

discussion of the model is discussed in the Linkage Analysis section and the details of the calculations are included in Appendix A. The loadings presented below represent average daily loadings to the reach from land use runoff. In reality, these loads would occur intermittently and in different locations at different times. However, information is not currently available to accurately account for the intermittent nature of these discharges.

3.2.2.4.1. Urban Runoff

Salts are applied to urban areas through irrigation water and fertilizers and pesticides. Runoff to surface waters occurs during dry weather as a result of over irrigation or applying irrigation water to impervious surfaces. During wet weather, precipitation transports salts that are stranded in the soils from previous irrigation water, fertilizer, and pesticide applications to the surface water. Irrigation water and precipitation have the potential to transport salts into shallow groundwater as well.

The following table summarizes the estimated urban runoff loads in each reach.

Table 16. Estimated Dry Weather Urban Loads

Reach	Flow (cfs)	Chloride (mg/L)	Chloride Load (lb/day)	TDS (mg/L)	TDS Load (lb/day)	Sulfate (mg/L)	Sulfate Load (lb/day)	Boron (mg/L)	Boron Load (lb/day)
1	0.275	217	322	2050	3045	60	89	0.21	0.31
2	0.000	217	0	2050	0	60	0	0.21	0.00
3	0.259	217	303	2050	2861	60	84	0.21	0.29
4	1.050	217	1230	2050	11,617	60	340	0.21	1.19
5	0.326	217	381	2050	3603	60	105	0.21	0.37
6	0.278	217	325	2050	3070	60	90	0.21	0.31
7	2.576	217	3016	2050	28,488	60	834	0.21	2.92
8	0.416	217	487	2050	4599	60	135	0.21	0.47
9A	0.126	217	147	2050	1393	60	41	0.21	0.14
9B	0.375	217	439	2050	4144	60	121	0.21	0.42
10	0.000	217	0	2050	0	60	0	0.21	0.00
11	0.171	217	200	2050	1894	60	55	0.21	0.19
12	0.582	217	681	2050	6432	60	188	0.21	0.66
13	1.675	217	1961	2050	18,529	60	542	0.21	1.90

3.2.2.4.2. Agricultural Runoff

Irrigation water, fertilizers and pesticides are also sources of salts to agricultural areas. The volume of runoff to surface waters from agricultural areas depends on the crop type being irrigated and the irrigation practices. Runoff from agricultural fields has been observed in varying quantities during all times of the year. During wet weather, precipitation transports salts that are stranded in the soils from previous irrigation water, fertilizer, and pesticide applications to the surface water. Irrigation water and precipitation have the potential to transport salts into shallow groundwater as well.

The following table summarizes the estimated dry weather agricultural runoff loads in each reach.

Table 17. Estimated Dry Weather Agricultural Loads

Reach	Flow (cfs)	Chloride (mg/L)	Chloride Load (lb/day)	TDS (mg/L)	TDS Load (lb/day)	Sulfate (mg/L)	Sulfate Load (lb/day)	Boron (mg/L)	Boron Load (lb/day)
1	0.768	193	800	2862	11,859	916	3796	0.82	3.40
2	2.177	193	2267	2862	33,619	916	10,760	0.82	9.63
3	0.304	193	317	2862	4698	916	1504	0.82	1.35
4	2.205	193	2297	2862	34,055	916	10,899	0.82	9.76
5	1.675	193	1744	2862	25,869	916	8279	0.82	7.41
6	2.176	193	2265	2862	33,593	916	10,752	0.82	9.62
7	0.630	193	656	2862	9723	916	3112	0.82	2.79
8	0.029	193	30	2862	441	916	141	0.82	0.13
9A	0.061	193	63	2862	935	916	299	0.82	0.27
9B	0.478	193	498	2862	7382	916	2363	0.82	2.11
10	0.011	193	12	2862	173	916	55	0.82	0.05
11	0.131	193	136	2862	2016	916	645	0.82	0.58
12	0.000	193	0	2862	0	916	0	0.82	0.00
13	0.147	193	153	2862	2271	916	727	0.82	0.65

3.2.2.5. Surface Water Loading Summary

The following table summarizes the dry weather loads to surface water from all of the sources listed above for each of the constituents.

Table 18. Summary of Loadings to Surface Waters

Source	Chloride Load (lb/day)	% Total Chloride Load	TDS Load (lb/day)	% Total TDS Load	Sulfate Load (lb/day)	% Total Sulfate Load	Boron Load (lb/day)	% of Total Boron Load
POTWs	28,660	44%	140,259	26%	32,986	23%	126.3	59%
Groundwater pumping	2750	4%	29,592	5%	22,974	16%	16.9	8%
Groundwater exfiltration	3492	5%	14,456	3%	12,415	9%	4.43	2%
Urban Dry Weather	9492	14%	89,675	16%	2625	2%	9.19	4%
Agriculture Dry Weather	11,237	17%	166,634	30%	53,332	37%	47.7	22%
Total	55,632	100%	440,617	100%	124,332	100%	205	100%

Wet weather loadings from each of these sources has the potential to be significant, but tend to be lower in concentration and do not occur during the critical conditions for salts. Wet weather loads are significant from the perspective of transporting stranded salts off the watershed and have been included in the modeling and linkage analysis.

3.3. Fate and Transport of Salts

Based on the information presented above, approximately 60% of the total watershed salts loads are transported to the surface waters on a daily basis. Because some of the surface water is diverted for irrigation in the lower watershed through the Conejo Creek Diversion Project, and all of

the surface water in the upper watershed enters the ground water, only about 10% of the watershed salts load is exported out of the watershed to the ocean during dry weather. The remaining salts are left "stranded" in the soils or shallow groundwater basins in the watershed until large amounts of precipitation mobilize the salts and transport them off the watershed. The following table summarizes the ultimate fate of the imported salts during dry weather.

Table 19. Fate of Salts in Calleguas Creek Watershed during Dry Weather

Constituent	Salts Load To Watershed (lb/day)	Exported to Ocean (lb/day)	"Stranded" in Watershed (lb/day)
Chloride	96,700	10,400	86,300
TDS	671,200	49,500	621,700
Sulfate	207,000	13,600	193,400

Dry season stranded salts are a temporary condition that is remedied by cyclical patterns of wet weather, which washes stranded salts out to the ocean. The cyclical patterns of drought followed by extreme periods of heavy rainfall produce high stream flows on the watershed. These infrequent yet routine wet periods create high stream flows that extend well into the summer and fall seasons carrying large volumes of salts off the watershed. It is this feature of the watershed that has prevented the daily importation of chlorides and other salts to the watershed from accumulating in ever increasing concentrations (Hajas, 2004). Salts accumulate even with average and slightly above average rain years and extreme wet years are needed to flush the stranded salts from the watershed.

4. Review of Water Quality Standards and Uses

As discussed above, the Basin Plan includes water quality standards for salts for the CCW. This section provides a review of the beneficial uses and water quality objectives and recommendations for objective changes based on the review.

4.1. Beneficial Uses

In order to assess the need for and basis of site-specific objectives (SSOs) for the CCW, a review of the existing water quality objectives and beneficial uses was conducted. Agriculture, aquatic life, and groundwater recharge are the beneficial uses potentially impacted by the development of SSOs and were the primary uses examined. Unless required under the SSO development process, use attainability analyses (UAAs) will not be pursued based on this work.

4.1.1. Aquatic Life

Chloride is the only constituent for which an aquatic life criterion exists. Chloride can be toxic to freshwater aquatic organisms by impacting the ionic balance in the water necessary to support freshwater aquatic life (USEPA, 1988). According to the USEPA criteria document, the most chloride sensitive organisms are fathead minnows and daphnids. Because these are common species, they are likely to be present throughout the CCW. Therefore, the aquatic life impacts from chloride could occur throughout the watershed.

Based on the objectives and a review of the USEPA criteria document, it is clear that aquatic life is not the most sensitive beneficial use in the watershed. However, it is the only beneficial use that is an in stream use. Therefore, there are not any alternative mechanisms for protecting the aquatic life beneficial use.

4.1.2. Agriculture

Agriculture is the most salt sensitive beneficial use in the CCW. This section discusses the most salt sensitive crops, the locations of the crops in the watershed, and the options for protecting this beneficial use from the impact of salts.

4.1.2.1. Crops Grown in the Calleguas Creek Watershed

Crops are grown in several areas of the watershed including the Oxnard Plain, the Pleasant Valley Plain, the Las Posas Valley (East and West) and the Santa Rosa Valley. Specific crops grown in the areas are shown in Figure 7. Of the crops shown in the figure, avocado, berry, citrus, strawberry, and, to some extent, nurseries are the most adversely impacted by high salinity and high chloride irrigation water. In general, avocados and citrus are grown in the northern part of the watershed, specifically the Las Posas Valley. Strawberries and row crops are grown in the Oxnard and Pleasant Valley Plains. Some avocado and citrus are grown in the lower portion of the Pleasant Valley Plain. In the Santa Rosa Valley, crops are avocados, row crops and citrus.

Agriculture is limited or not existent in the upper portions of the watershed because urban land uses have replaced agricultural fields in those areas. Agriculture is not likely to return to those areas.

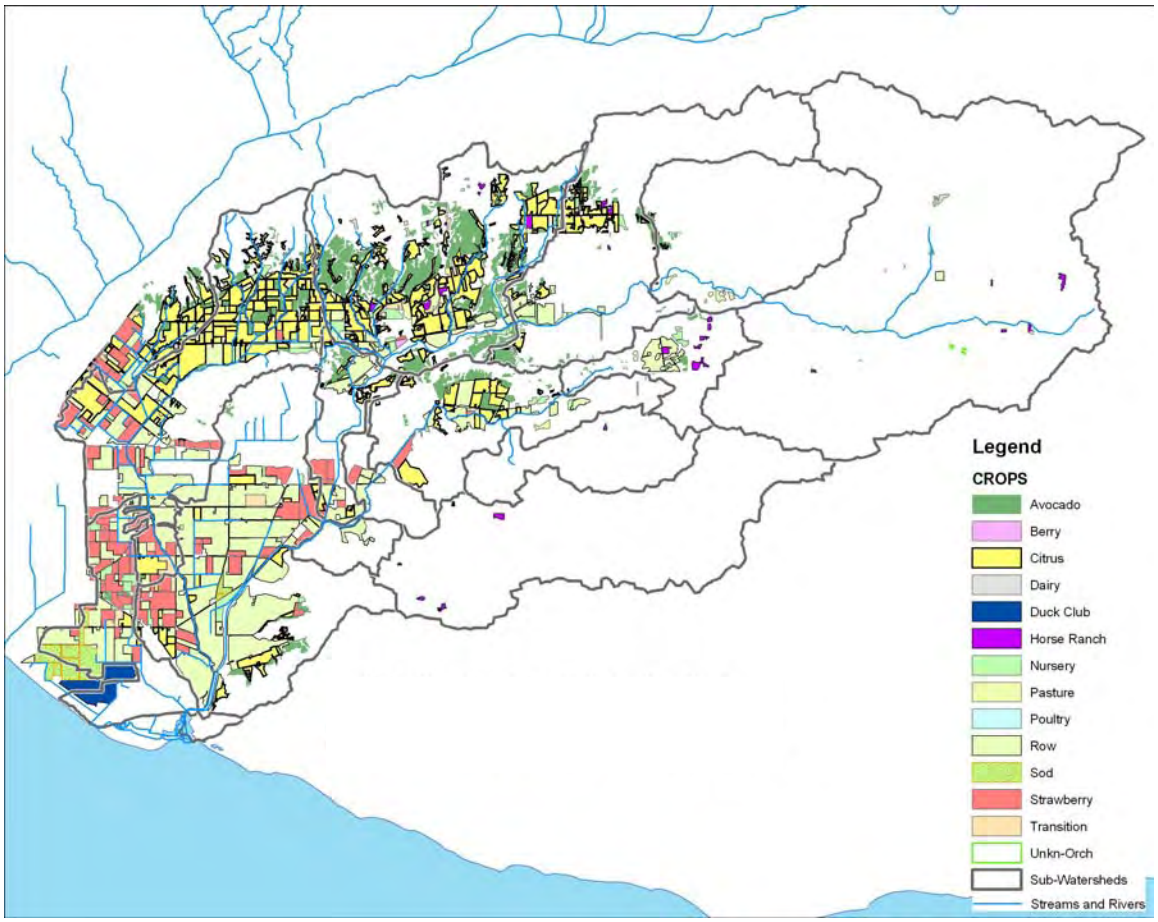

Figure 7. Crops Grown in Calleguas Creek Watershed

4.1.2.2. Impacts of High Salts on Crops

Determining the impact of salts on crops is difficult because of all of the factors that can influence the growth and yield of crops. The salinity of the irrigation water is only one factor in the equation. Numerous studies have been done to try to assess the impact of salinity and chloride in particular on crops and have come up with varying results depending on the conditions during the testing (Oster and Arpaia, 2002). An in-depth analysis of the impact of chloride on avocados would take a multi-year study using several acres of trees.

Rather than conduct this type of analysis to try to determine an independent quality objective for irrigation water, an assessment of the influences that impact the salinity sensitivities of crops was developed and the situations in which the quality of the irrigation water limits the ability to grow crops in the CCW was determined.

All crops have some sensitivity to salinity in irrigation water. The sensitivity is dependent on a number of factors including the type of crop, the precipitation received during the year, the irrigation practices, the type of soils, the amount of irrigation water applied, and the quality of the irrigation water. All of these factors need to be taken into account when considering the impacts of salts on

crop growth and yield. For example, providing extremely high quality water would potentially not result in a higher yield if sufficient water is not applied. Whereas, larger quantities of poorer quality water may result in better growth and yields (Oster and Arpaia, 2002).

No matter how pure the irrigation water, salts build up in the soils in the root zone over time. Typical irrigation practices are to flush (or leach) the salts from the root zone on a regular basis. The quality of the irrigation water impacts the frequency and quantity of water needed to flush the salts from the field. At some point, the salinity will be too high to allow the growth of salt sensitive crops (Oster and Arpaia, 2002). Therefore, the quality of the irrigation water needs to be high enough to allow the growth of salt sensitive crops and allow cost effective flushing of the root zone (i.e. allows sufficient time between flushings).

The importance of the quality of the irrigation water is also impacted by the quantity of water available. The ultimate limitation on crop production is the cost. Irrigation water accounts for approximately 10% of the total cost to produce avocados in Ventura County. So growers try to balance the quantity of water used to provide sufficient water for optimal growth without having too much runoff.

Additionally, the impacts on agriculture are not instantaneous. The total quality of the water over the course of the growing season impacts the growth and production of the crop. As shown in Figure 8, precipitation appears to be significantly correlated to production, at least for avocados. Total annual precipitation influences both the cumulative quantity and quality of water crops are exposed to. Irrigation is essentially designed to create artificial precipitation. Precipitation is an extremely low salt form of irrigation for the crops. Therefore, the higher the quantity of precipitation, the larger the quantity of effective irrigation water applied for the year. Additionally, the overall quality of the irrigation water applied for the year is higher. The strong correlation between total annual precipitation and production clearly demonstrates that the impacts of salts are not instantaneous.

Of the crops mentioned earlier as being salt-sensitive, avocados are the primary concern in the watershed. High chloride irrigation water is reported to cause leaf burn in avocados as an initial symptom with reduction in tree growth and fruit size the ultimate concern. The adverse effects may take up to three years of poor quality water before appearing. Growers in the South Las Posas Basin report that after El Nino (1998) productivity increased for a few years. However, they report that using irrigation water in the range of 150 mg/L – 180 mg/L over a three year period since then has resulted in greater than 50% reduction in tree growth and fruit size (Macintyre, 2004). Figure 8 shows an initial drop in productivity in 1999 with productivity increasing over the next two years along with increasing annual rainfall.

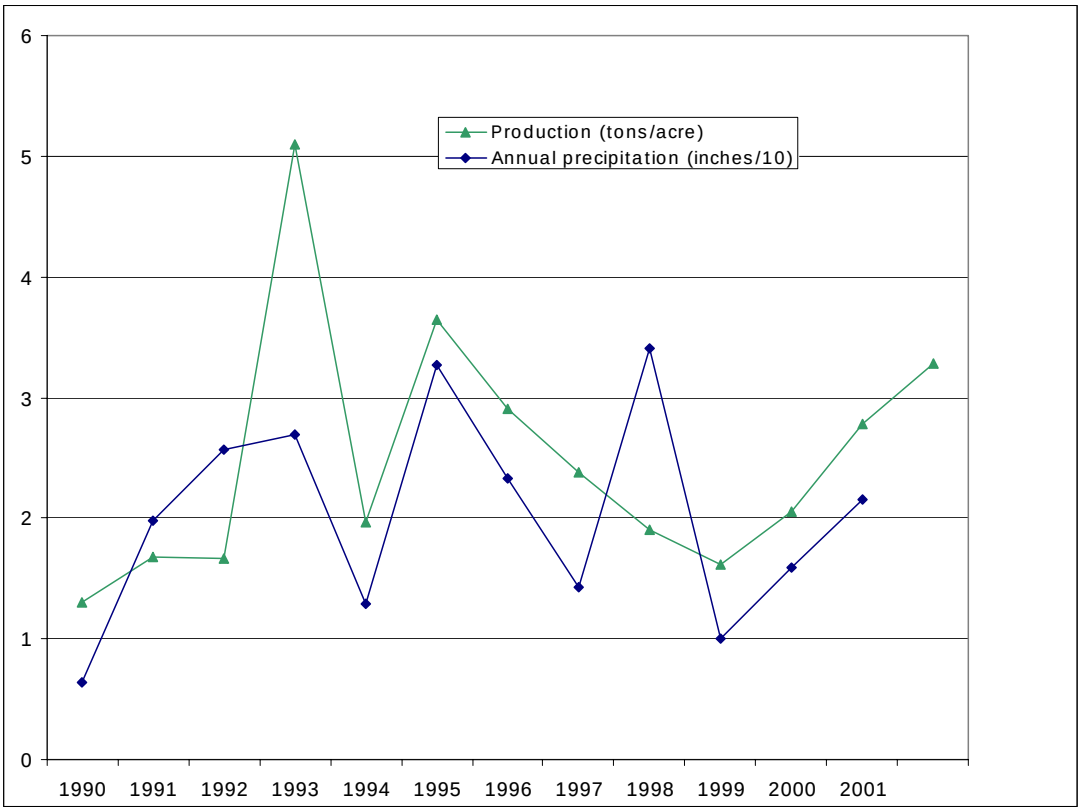

Figure 8. Ventura County Avocado Production and Annual Precipitation

The two key points demonstrated from the information and figures above is that precipitation (and potentially other factors) appears to have a significant impact on production and the impacts on agriculture from salts occur over long periods of time, not instantaneously.

4.1.2.3. Current Sources of Water for Crops

Most growers in the Calleguas Creek Watershed rely on groundwater delivered through local mutual water companies as their primary water supply. Growers in the Arroyo Simi/Las Posas and Conejo Valleys also utilize imported water supplied by Calleguas Municipal Water District through a variety of purveyors including Ventura Water Works District and Camrosa Water District or. United Water supplies growers in the Oxnard and Pleasant Valley Plains through the Pleasant Valley Water District (PVWD) or the Pumping Trough Pipeline (PTP). United water is a combination of local groundwater and water imported from the Santa Clara River at the Freeman Diversion. Growers in this area also receive water from the Conejo Creek Diversion Project. Growers in the Santa Rosa Valley receive water from Camrosa Water District. Water sources include local groundwater, Conejo Creek water and imported water from Calleguas Municipal Water District. These water supplies are blended to provide a consistent water quality to meet the grower's needs. In the Las Posas Valley, water sources include imported water or groundwater supplied through Ventura Waterworks Districts #1 and #19 and local groundwater supplied by Arroyo Las Posas

Mutual Water Company, Zone Mutual Water Company and Beryl wood Heights Mutual Water Company. Many growers also have private wells on their property.

Surface water is not diverted for use on salt sensitive crops in the watershed except for the Conejo Creek Diversion Project in Camrosa. In the Conejo and Calleguas Creeks, water right appropriations prevent the diversion of water in the stream for uses other than the Conejo Creek Diversion Project.

The quality of groundwater used as irrigation supply in the Calleguas Creek Watershed is shown in Figure 9 (chloride) and Figure 10 (TDS). In the figures, wells are only shown if data are available for the constituent. In addition, water quality for both groundwater and imported water is summarized in Table 20. In general, the water quality data is from between 1990 and 2003. In some cases, very little data were available during that time frame, so data collected from 1970 were also used.

Table 20. Calleguas Creek Watershed Water Quality

Water source	Average Chloride (mg/L)	Average TDS (mg/L)	Average Sulfate (mg/L)	Average Boron (mg/L)	Time Frame	Number of Samples
Oxnard, Pleasant Valley						
UWCD(Freeman Diversion - Imported Water)	57	880	495	0.71	1990-2003	433
CMWD(Jensen plant- Imported Water)	64	332	86	0.27	1993-2003	130
Pumping Trough Pipeline groundwater (Oxnard)	44	871	306	0.42	1990-2003	60
Pleasant Valley Water Conservation District groundwater	119	910	312	0.40	1990-2002	49
Camrosa Water District Conejo Creek Project	159	822*	n/a	n/a	0.27	86
Las Posas Valley (North)						
CMWD(Jensen plant- Imported Water)	64	870	86	0.27	1993-2003	130
Ventura County Waterworks District #19	48	589	193	0.08	1990-2002	16
Ventura County Waterworks District #1	25	452	129	0.13	1990-2002	27
North Las Posas basin (miscellaneous wells)	56	631	219	0.12	1990-2003	50
South Las Posas Basin						
CMWD(Jensen plant- Imported Water)	64	870	86	0.27	1993-2003	130
Ventura County Waterworks District #19	48	589	193	0.08	1990-2002	16
Beryl wood MWC	23	420	n/a	n/a	1993-2003	1
Zone MWC Location 1	14	535	89	0.06	1990-1999	4
Zone MWC Location 2	200	1544	649	0.64	1971-2000	19
Arroyo Las Posas MWC	345	1950	890	1.1	1991	2
Miscellaneous wells	213	1600	581	0.58	1975-1999	10
Santa Rosa Valley						
CMWD(Jensen plant- Imported Water)	64	870	86	0.27	1993-2003	130
Camrosa Water District Well #3	135	918	229	0.41	1991-2000	108
Camrosa Water District Wood creek Well	119	753	162	0.25	1993-2001	6
Camrosa Water District Conejo Creek Project	159	822*	n/a	n/a	1996-2003	90

* TDS average for Conejo Creek based on 12 data points in 2003

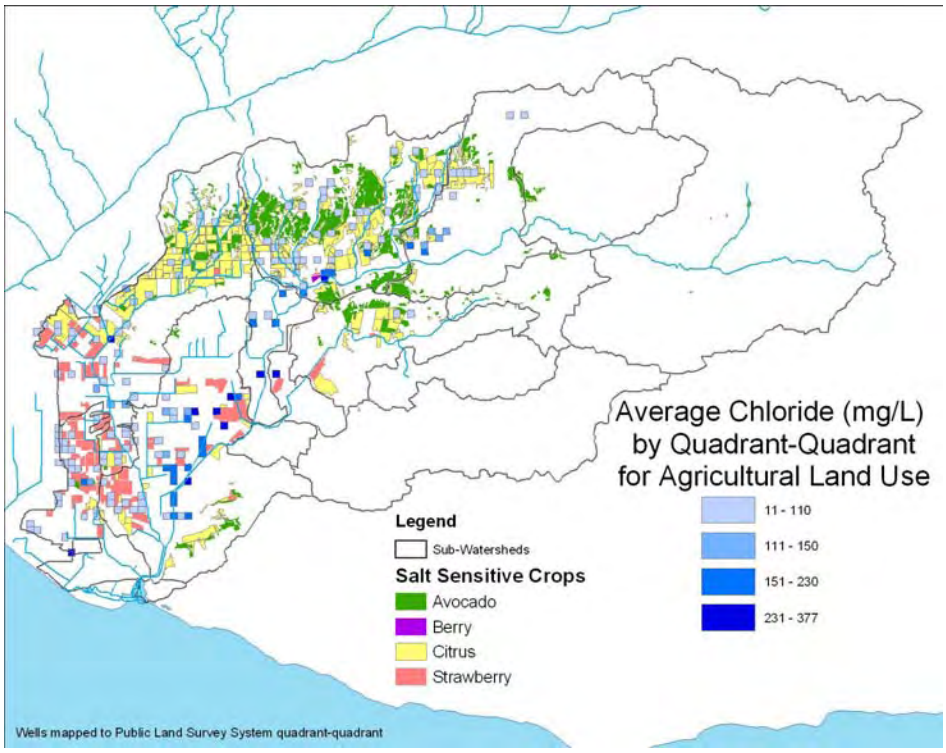

Figure 9. Average groundwater chloride levels in Calleguas Creek Watershed

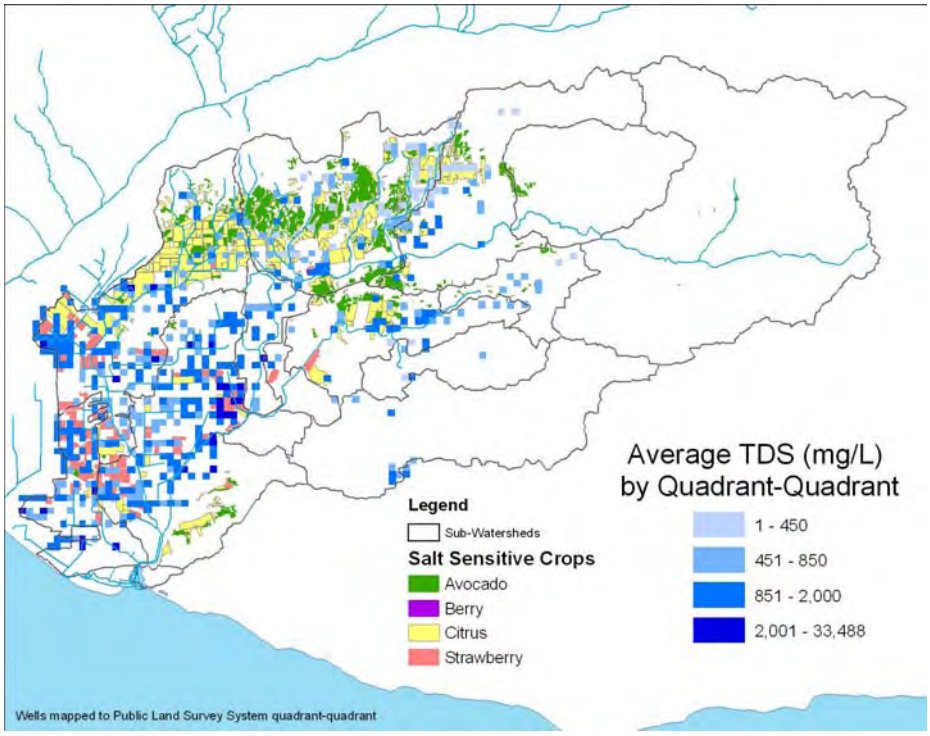

Figure 10.Average groundwater TDS levels in Calleguas Creek Watershed

The information presented above demonstrates that irrigation water supplies are well below surface water and groundwater objectives in most areas.

4.1.2.4. Assessment of Agricultural Beneficial Use Protection

Because surface water is not used as a primary irrigation source for any sensitive crops in the CCW, the quality of surface water is not critical to the protection of the agricultural beneficial use. In the Conejo Creek, water rights prevent anyone other than the Camrosa Water District from taking water out of the stream. Therefore, the only mechanism through which surface water could impact agriculture is through impacts due to groundwater recharge of basins used for agricultural supply. Consequently, regulating surface water quality to directly protect agriculture is not necessary.

For most of the watershed, chloride and TDS levels in the water supplied to agriculture is within the acceptable range even for salt sensitive crops. Two areas that may be impacted by high salt concentrations with respect to growing salt sensitive crops are the Santa Rosa Valley and the South Las Posas Basin. However, it is possible to supply these areas with alternative sources. Camrosa Water District manages the water made available to growers in the Santa Rosa Valley to deliver water with chloride levels of 110 mg/L. This is accomplished by blending imported water from CMWD with the groundwater from Well #3 and/or Conejo Creek water via the diversion facilities. Growers in the South Las Posas Basin receive ground water from Zone MWC, Arroyo Las Posas and Beryl wood Heights MWC. Average chloride concentrations in groundwater from the South Las Posas Basin are reported to be approximately 180 mg/L. As shown in Table 3, this is consistent with the values reported for groundwater wells in the basin. Growers report that irrigation water is alternated between Zone or Beryl wood Heights and Ventura Waterworks District #19 to achieve an acceptable level of chloride. Additionally, imported water from CMWD is available to growers in this area for blending or leaching.

Although two areas may have higher salts concentrations in groundwater, the link between surface water concentrations and groundwater concentrations is unclear (see Groundwater Recharge section 4.13). Therefore, the best mechanism for protecting agriculture is by managing the salts in the water supplied to the growers. In non-drought years, adequate quantities of source water is available to meet all the growers needs in the watershed, and alternative water supplies are available for growing salt sensitive crops if local irrigation supplies are not acceptable.

One of the concerns is the protection of future agricultural beneficial uses based on changing conditions in the watershed. As discussed previously, irrigation water is available to most of the watershed with salt levels that are acceptable for salt sensitive crops. In areas where higher salts concentrations exist, alternative water supplies are available should a grower choose to use them. The decision as to which crops to grow in the future are made based on a number of factors: soil conditions, irrigation water quality, market conditions, etc. As long as high quality irrigation water is available, a grower can choose the crops to grow on the land based on the factors and economics that make the most sense for the farming operation.

4.1.3. Groundwater Recharge

As discussed above, groundwater is the primary water supply for agriculture in the CCW. Additionally, groundwater is used as a municipal supply in several areas of the watershed. Finally,

the Calleguas Municipal Water District (CMWD) stores imported water in the North Las Posas groundwater basin. To prevent these uses from being impacted by poor quality groundwater, the groundwater recharge beneficial use needs to be protected.

Impacts on groundwater occur through infiltration of surface water and potentially through irrigation in the watershed. The beneficial use of groundwater recharge only addresses the surface water infiltration component of the impacts of salts on groundwater. As a result, this is the only impact discussed here.

4.1.3.1. Locations of Groundwater Recharge

Groundwater infiltration primarily occurs in the South Las Posas and Santa Rosa Basin. Although most reaches of the watershed have the GWR beneficial use, the only areas where significant recharge occurs are these two reaches and upper Revolon Slough/lower Beardsley Wash. This is clearly demonstrated by the fact that groundwater exfiltration occurs in most other reaches in the watershed.

The amount of recharge is predicated on the depth and width of the underlying stream channel deposits, the nature of the geologic materials comprising the stream channel deposits, the depth and nature of the geologic materials underlying the stream channel deposits, the depth to groundwater and the quantity and timing of water flowing into the streams.

Recharge to the shallowest aquifers occurs by subsurface infiltration through streambed deposits. Soil surveys conducted by the USDA / NRCS show permeability of streambed deposits within the Watershed to be greater than 20 inches/hour. Based on this number, water can easily percolate through the streambed deposits and recharge the shallow aquifers.

In some areas of the Watershed (Pleasant Valley and the Oxnard Plain), recharge beneath streams is limited due to a shallow perching layer. The perching layer is of low permeability and severely limits the amount of recharge passing through it. As a result, the shallow soils above the perching layer become saturated, thus preventing more water from percolating through them. Drainage in the southern portion of the Watershed is a large enough problem that local farmers have been forced to install drains to prevent problems such as root rot and to keep salts from accumulating in the groundwater.

4.1.3.2. Impacts from Surface Water Recharge of Groundwater

The impacts of surface water quality recharge on groundwater basins occur over time and are not instantaneous. Although localized impacts can occur over a few months to years, widespread impacts on groundwater basins take many years to occur. Groundwater mixing occurs very slowly as groundwater gradually moves through the basins.

The impacts of surface water recharge on groundwater basins were clearly demonstrated with the beginning of importation of State Water Project water into the basin. Salts concentrations in groundwater were impacted by the importation of water and development of the watershed beginning in the 1970's. However, since the beginning of importation of State Water Project water, the groundwater salt concentrations have remained relatively stable in most areas of the watershed (Hajas, 2004). The most notable exception is the South Las Posas Basin, where salts

concentrations have been increasing over time. It is also noteworthy, however, that long-term decreases in chloride concentrations have been observed in a few Santa Rosa Basin wells along Lower Conejo Creek.

Because all water discharged to the Arroyo Simi during dry weather infiltrates into the South Las Posas groundwater basin, this basin is the most significantly impacted by surface water recharge. A number of studies have been conducted to examine the quality of the groundwater and the impacts of surface water recharge on this basin. A significant amount of the analysis is presented in *Water Quality in the East and South Las Posas Basin: Problems and Solutions* (Bachman, 2002).

As described in this report, the South Las Posas Basin is completely full as a result of constant discharges to the Arroyo Simi/Las Posas. This "topping off" of the shallow aquifer occurred during the 1980's along the Arroyo Simi, and during the 1990's along the Arroyo Las Posas. The fact that the basin is full prevents recharge of higher quality storm water flows. Additionally, the higher water levels appear to be impacting the quality of water in the basin. The increase in water levels is strongly correlated with an increase in salts concentrations in many of the wells near the Arroyo Las Posas. The salts concentrations in those wells are higher than the concentrations in the surface water. Therefore, mechanisms other than changes in surface water quality appear to be contributing to the increasing salts levels in the groundwater.

Salts on the watershed have a number of geological origins. The watershed has remnants of significant volcanic activity, large multi-layered sediment deposits and evidence of ancient marine influence. All of these geologic characteristics indicate the presence of salts that dissolve into solution following rain events and remain dissolved in the watershed's groundwater and surface waters. It is widely believed that these salts have been a natural part of the watershed for thousands of years (Hajas, 2004). Increases in groundwater levels may cause saturation of soil previously above the water table, allowing additional salts to dissolve into the groundwater.

The combination of increased groundwater levels that leach background salts from the soils and surface water concentrations is the likely cause of the increased groundwater salts concentrations in the South Las Posas Basin. Consequently, protection of the groundwater recharge beneficial use is linked to both the quality and quantity of the water in the stream and natural background conditions.

In contrast to the South Las Posas Basin, groundwater quality in the Santa Rosa Basin has remained stable or improved over the past 15 years. Figure 11 shows groundwater quality data from 1 well near Hill Canyon WTP, 2 wells along Lower Conejo Creek, and 1 well along Lower Calleguas Creek. The data show a gradually decreasing trend in groundwater chloride concentrations at all 4 wells. While the TDS concentrations near the wells are subject to greater variability, they appear to remain relatively constant or only slightly increase. Screening levels for the wells are currently not available. However, if it is determined that the data in the figure represent the quality of the shallow Santa Rosa basin, then the analysis will suggest surface water recharge at the existing water quality is not adversely impacting the groundwater basins and may be improving the basins for some constituents.

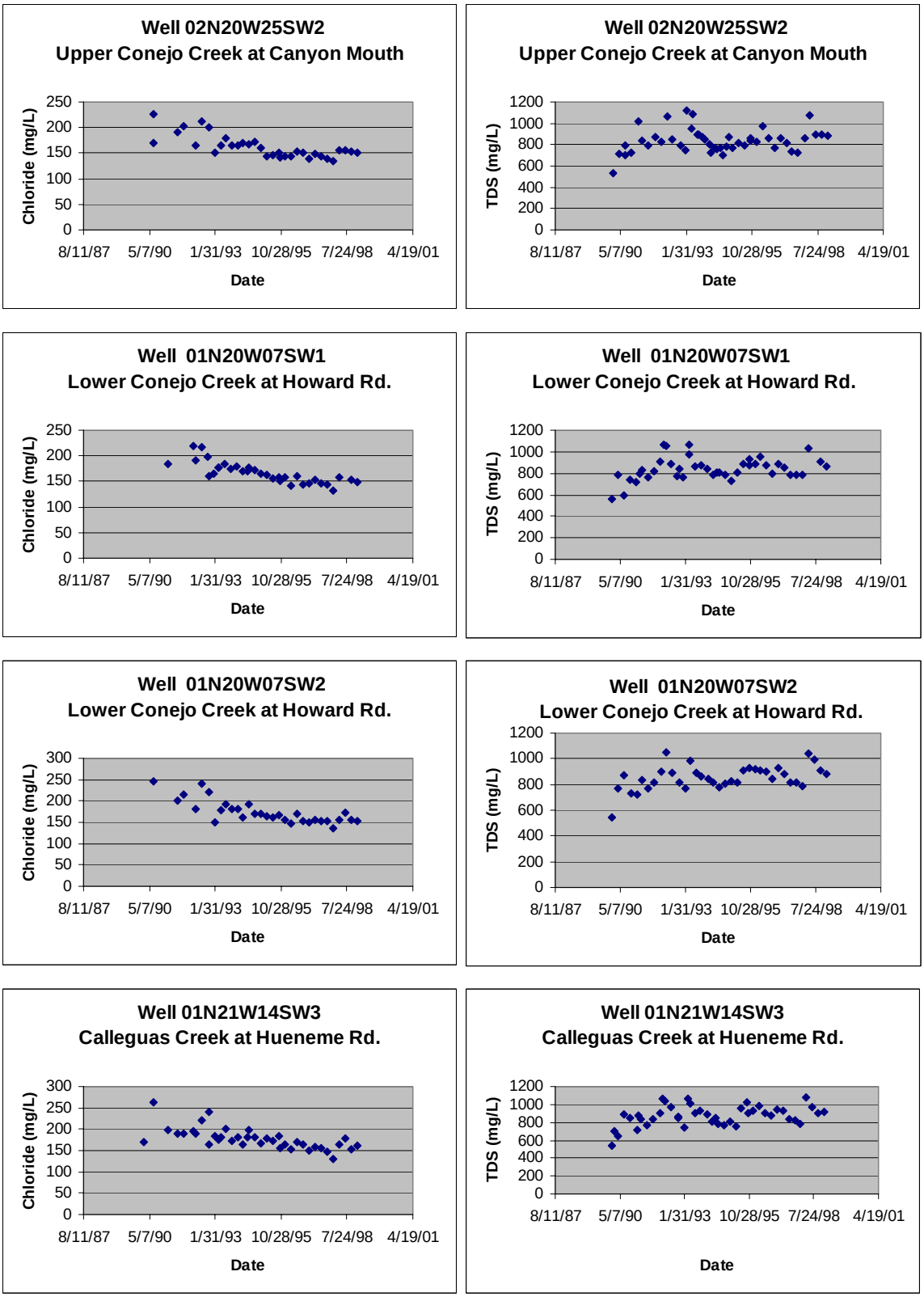

Figure 11. Groundwater quality data from wells near Conejo Creek and Lower Calleguas Creek

Another key aspect of the protection of the groundwater recharge beneficial use is that the protection of the groundwater itself is not inherently necessary. Instead, groundwater recharge must be protected to allow use of the water for agricultural and municipal purposes. No crops are grown in the groundwater basins and no aquatic life is present in the basins that are impacted by salts. Instead, impacts occur once groundwater is pumped for use. Therefore, the protection of the groundwater recharge beneficial use does not need to occur in basin. Alternative mechanisms for protecting the beneficial use could be implemented (such as point of use treatment) and may be necessary to address naturally occurring sources of salts.

4.2. Water Quality Objectives

As discussed in the problem statement section and throughout this report, surface water concentrations of salt are only one element of the salt impairment in the watershed. Therefore, the water quality objectives need to be designed to facilitate the protection of beneficial uses and the correction of the salts impairment in the watershed. To determine the best mechanism for protecting beneficial uses and mitigating salt impacts, a number of objective alternatives were considered.

- Current Basin Plan Objectives (Instantaneous Maximums)
- Numeric Values of Basin Plan Objectives with an averaging period applied instead of instantaneous maximums
- Aquatic life objectives
- Site-specific objectives
- Mass balance objectives

The criteria used to evaluate the alternatives included:

- consistency with State and federal water quality initiatives policies;
- level of beneficial use protection;
- consistency with the current science regarding water quality necessary to reasonably protect the beneficial uses; and
- applicability to existing condition of Calleguas Creek.

To help in the assessment of the water quality objectives and determine the potential for developing site-specific objectives (SSOs), the information gathered about the uses was compiled. This information was used to help determine the feasibility of developing SSOs that adequately protect the existing beneficial uses in the watershed. Following are the key points from the analysis to help in the development of SSOs.

1. Impacts to agriculture do not occur on an instantaneous basis. As discussed in the agricultural beneficial use section, impacts can take years to occur.

2. Annual precipitation plays a significant role in the yield of salt sensitive crops in the watershed.

3. Sensitive crops are only grown in certain areas of the watershed and the ability to grow sensitive crops is limited in other areas.

4. Irrigation water quality is only one of the factors that impacts crop yield and growth.

5. Irrigation water quality is only one of the factors that impact the choice of crops to grow in a particular area.

6. Impacts on groundwater basins are not instantaneous.

7. Impacts from surface waters on groundwater basins appear to be linked more to the quantity of water rather than the quality of the water in the creeks. In the lower watershed, salts concentrations in groundwater basins do not appear to have changed significantly and may have decreased for some constituents since equilibrium was reached after importation of State Water Project water began. In the upper watershed, higher groundwater levels appear to be leaching salts out of marine sediments in the upper watershed, thereby adding more salts to the groundwater.

8. Groundwater recharge only occurs in certain areas of the watershed.

9. Significant rain years flush salts stranded in soils and groundwater basins and result in higher surface water concentrations of salts for months to years after the high precipitation year. However, the flushing of the salts is critical for helping to maintain a salt balance in the watershed and results in lower surface water and groundwater concentrations after the flushing has been completed.

10. Control of surface water concentrations does not necessarily link to beneficial use protection. The primary source of irrigation water is groundwater and surface water quality does not appear to have a significant impact on groundwater quality.

Based on this information, a number of factors for assessing the appropriate water quality objectives are clear.

- Instantaneous objectives as contained in the Basin Plan are not necessary to protect beneficial uses.

- Agriculture and groundwater recharge beneficial uses are not present in all areas of the watershed.

- Water quality improvements in the surface water do not necessarily translate into protection of agriculture and groundwater recharge beneficial uses.

These factors were used to help assess the water quality objective options for the watershed.

4.2.1. Current Basin Plan Objectives (Instantaneous Maximums)

The current Basin Plan objectives for salts (Table 4) are instantaneous maximums. These objectives are applied equally throughout the watershed. The issues with these objectives are:

- Agriculture and groundwater recharge are not impacted instantaneously.
- The objectives are applied to all areas of the watershed even those that do not contain the sensitive beneficial uses.
- The administrative record for the development of these objectives is unclear as to the link between the numeric values and the protection of agriculture and groundwater recharge beneficial uses.

The positive aspects of these objectives are as follows:

- Because they are instantaneous maximums, they provide a very conservative approach to protecting beneficial uses in the watershed.
- Because the Basin Plan objectives are already on the books, Regional Board resources do not have to be expended on amending the Basin Plan.

4.2.2. Averaging Periods

Because the beneficial uses are not impacted instantaneously by salts concentrations, defining appropriate averaging periods for the objectives would be a possible mechanism for addressing one of the issues with the current Basin Plan objectives and protecting beneficial uses. The issues with this approach are:

- The development of the appropriate averaging period is challenging.
- The use of existing basin plan numeric values may not be protective of beneficial uses because the link between the numeric values and beneficial use protection is unclear.

The benefits of this approach are:

- An averaging period can more directly address the time frames over which beneficial use impacts occur.
- An averaging period would allow for more flexibility in managing salts and water resources in the watershed.
- The averaging period could take into account the benefits of watershed flushing of salts after wet years.

4.2.3. Aquatic Life Criteria

Aquatic life criteria are only available for chloride. Although these criteria are the most directly applicable to the stream system, they are not necessarily protective of all of the beneficial uses in the water body. Additionally, criteria have not been established for TDS, sulfate or boron so the impacts from these pollutants would not be addressed by using these criteria.

The EPA criteria are based on tests with common test species (fathead minnow and daphnids) that are likely to be present in the CCW. The criteria were developed in 1988 and only included three chronic test species. The chronic criterion was based on acute-to-chronic ratios rather than a calculation based on a calculation using a sufficient number of chronic tests. Therefore, it is possible that a site-specific objective could be developed for chloride. However, short of conducting studies with a sufficient number of species to replace the acute to chronic ratio approach in the criteria document, a SSO would likely not be successful. Therefore, the aquatic life beneficial use is likely to be best protected using the EPA criteria.

The aquatic life criteria represent the upper bound of chloride levels that can be present in the stream for shorter periods of time than needed to protect the other beneficial uses. Therefore, the aquatic life criteria for chloride are proposed as the upper limits as shown below:

> The four-day average does not exceed 230 mg/L more than once every three years on the average and the one-hour average concentration does not exceed 860 mg/L more than once every three years on the average.

4.2.4. Mass Balance Based Objectives

As discussed in the water resources problem statement, a salt imbalance exists in the watershed. Under the assumption that improving the salt imbalance in the watershed will improve water quality, objectives that are linked to the mass entering and leaving the watershed could be developed. This approach addresses the fundamental problem with salts and prevents an accumulation of salts in the watershed. However, the link between the mass removal and protection of water resources and beneficial uses would have to be demonstrated on a regular basis to ensure that beneficial uses were being protected. Additionally, the use of mass balance objectives would potentially involve the need to regulate areas other than surface water quality.

4.2.5. Site-Specific Objectives

This approach involves a careful evaluation of the location of beneficial uses impacted by salts in the watershed and identification of appropriate objectives to protect those beneficial uses. It also includes an analysis of areas in the watershed for which Basin Plan objectives cannot be achieved as a result of natural background conditions. The benefit of this approach is the direct link between beneficial uses and objectives. The challenge is selecting the appropriate objectives to protect the beneficial uses.

Certain areas of the watershed clearly do not have any of the sensitive beneficial uses and alternative objectives may be considered for these areas. These areas include the North and South Fork of the Arroyo Conejo (Reaches 12 and 13), the upper portion of the Arroyo Simi (Reach 7), Tapo Canyon (Reach 8), and the lower portion of Calleguas Creek above Potrero Road (Reach

3). Reaches 12, 13, 8 and the upper portion of 7 are all located in urban areas in which no agricultural areas exist or likely will exist in the future. Additionally, all of these areas are places where groundwater exfiltration occurs. Consequently, groundwater recharge would not be impacted in these reaches.

Reach 3 is the farthest downstream reach to which objectives apply. Concentrations in this reach tend to be higher because salts are transported out of the watershed through this reach. Sensitive beneficial uses do not exist in this reach and the transport of salts out of the watershed through this reach is a critical component of maintaining a salts balance in the watershed.

Although Reach 6 (Arroyo Las Posas) and the lower Reach 7 (Arroyo Simi) have the potential to contain beneficial uses impact salts, SSOs may be required as a result of the natural background conditions in those reaches. The natural background concentrations of salts in groundwater infiltration into the stream may result in the current Basin Plan objectives (even with an averaging period applied) being exceeded. Since the agricultural and groundwater recharge beneficial uses can be protected through other mechanisms than controlling surface water concentrations and surface water concentrations may not be directly linked to protection of the beneficial uses, site-specific objectives resulting from the natural background conditions may be appropriate and necessary for managing salts for these reaches.

Finally, site-specific objectives need to be considered for Revolon Slough/Beardsley Wash. As discussed in the problem statement, the numeric Basin Plan objectives do not apply to Revolon Slough/Beardsley Wash. However, USEPA used the numeric values in the Basin Plan as an interpretation of the narrative standards that do apply to Revolon Slough. Appropriate numeric objectives need to be developed for Revolon Slough/Beardsley Wash to protect beneficial uses in those reaches.

4.2.6. Recommended Objective Changes

The use of an averaging period is essential to protecting the beneficial uses. An averaging period more accurately reflects the impacts of salts on the beneficial uses and allows for management of the watershed to provide protection of the agricultural beneficial use. Therefore, a revision to the Basin Plan objectives to include an averaging period is recommended.

Site-specific objectives may be necessary for some reaches in the watershed where sensitive beneficial uses are not impacted and/or natural back ground conditions make SSOs necessary.

In conclusion, for some reaches, the development of averaging periods for the numeric values found in the Basin Plan will likely be the only recommended change to the objectives. For these reaches, it is proposed that the appropriate averaging period be determined based on additional analysis and the performance of the projects on the watershed. For other reaches, SSOs that include an adjustment to the numeric Basin Plan value may be recommended. These reaches include areas where agriculture and groundwater recharge beneficial uses are not present or not impacted by surface water salt concentrations (Reaches 11, 12, 13, 7, 8, 3, 4 and 5) and where natural background conditions make the achievement of the Basin Plan objectives not feasible and not necessary to protect beneficial uses (Reaches 6 and 7).

5. Linkage Analysis

The linkage analysis for salts focuses on the surface water concentrations of salts. However, as discussed previously, surface water concentrations are only one component of the watershed salt issue. Because it is difficult SP model other aspects of the salt problem (i.e. surface water and groundwater interactions, stranded salts), two simplified approaches have been used to demonstrate that salts will be removed from the watershed and that should have a correspondingly positive impact on surface water and groundwater salts concentrations. First, two surface water models were used to demonstrate the impact of projects on receiving water quality in the watershed. Secondly, a salt balance was developed to quantify the removal of salts from the watershed with the goal of achieving a salt balance. Achieving a salt balance in the watershed will prevent additional build-up of salts in any medium in the watershed and protect water supplies from increasing in salt concentrations.

For the surface water modeling, two different approaches were taken. The first is described in detail in Appendix A. The second is a modification to the chloride model developed by the Regional Board and modified by USEPA for the EPA Chloride TMDL. To estimate the salts balance in the watershed, a simple chloride mass balance was developed by the Camrosa Water District (Hajas, 2003a) and modified to address the other salts. The following section describes the various models and their uses.

5.1. Model Descriptions

5.1.1. Calleguas Creek Modeling System (CCMS)

The framework for the salts modeling effort is a numerical mass balance water quality model originally developed for use in the Calleguas Creek nutrient TMDL effort. The spreadsheet-based mass balance model was accepted by State and Federal regulatory authorities for use in the Nutrient TMDL process for the Calleguas Creek Watershed (CCW).

The water quality simulation component of the CCMS is built on a spreadsheet mass-balance model. To model the CCW, the entire watershed is divided into 15 sub watersheds based on drainages to sampling locations and significant tributaries. A computational element is assigned to each sub watershed for calculating the changes in stream flow and water quality due to processes present along stream reaches circumscribed by the sub-watersheds. The model was expanded to accommodate stochastic input, which allows calculation of the likely distribution of in-stream salts concentrations.

5.2. Computational Element

Each computational element balances the inflow and outflow of water and mass with conservation equations to calculate changes in in-stream flow and concentration across a sub watershed. Over each time step, the stream reach within any sub watershed is assumed to behave as a steady-state complete-mix reactor. Because of the relatively short reach length, stream geometry, and daily time step; flows can be considered in equilibrium on a daily basis, so long as the routing of peak flows is not of critical importance. Assuming that each sub watershed behaves as a complete-mix reactor implies that the in-stream concentration is constant at all locations within a

sub watershed (Tchobanoglous and Schroeder, 1985). Because the concentration is modeled as constant for the entire reach, all withdrawals from the reach, including the discharge to the downstream reach will have the same concentration by definition. A schematic of the computational element is displayed in Figure 12. Each input and output considered in the CCMS is represented in Figure 12 with an arrow pointing into the reach for additions, and pointing out from the reach to represent withdrawals. In Figure 12, flows from upstream reaches enter from the right and flow to downstream reaches exit to the left.

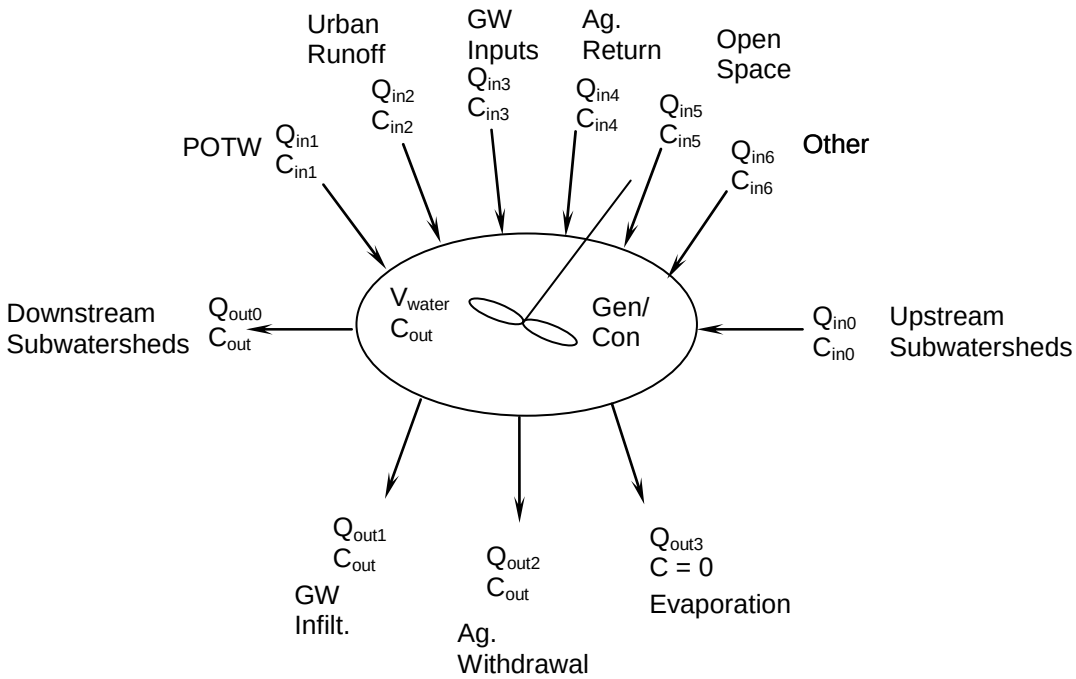

Figure 12: Schematic of Inputs and Outputs for a General Computational Element used in the CCMS Mass Balance Model to Estimate Water Flow and Quality within Surface Water Reaches.

5.2.1. Mass Balance Calculations

To calculate the stream discharge flow and in-stream concentration for a computational element, all inflow rates and concentrations must be specified along with all of the outflow rates (Tchobanoglous and Schroeder, 1985). Normally, the outflow to the downstream reach will be calculated with the conservation of flow equation. If all inflow rates and concentrations, and outflow rates are known, the in-stream concentration may be calculated. Because of the complete-mix assumption, the concentration in the outflows will equal the in-stream concentration, except in the case of evaporation (Tchobanoglous and Schroeder, 1985), where only water is assumed to be removed from the system by evaporation implying that the concentration of salts in evaporated water is equal to zero. The general conservation law is captured in Equation (1).

$$\text{accumulation} = \text{in} - \text{out} + \text{generation} \tag{1}$$

Each of the daily time steps is assumed to be in steady-state. By making the steady-state assumption the ability to model peak flood routing is lost; however because of the relatively small size of the CCW, a smaller time step than one day would be required to capture a flood wave moving through the watershed. The steady assumption specifies no accumulation of flow or mass in the surface water within a sub watershed, simplifying the mass balance equation by setting the left hand side of Equation (1) to zero, in effect requiring the sum of the inputs to equal the sum of the outputs plus and generation within the sub watersheds (Tchobanoglous and Schroeder, 1985). However, for the case of salts, the assumption is made that no generation or consumption occurs in any of the sub watersheds, further simplifying (1) to Equation (2).

$$\text{in} = \text{out} \tag{2}$$

5.2.2. Upstream Sub watersheds

Inflow and mass loading from the upstream sub watershed are added as inputs to the computational element. If the sub-watershed is located at the top of a stream's drainage, there will be no upstream sub watershed and the CCMS will assign a 0.0 for the flow and mass loading. If multiple upstream sub watersheds contribute to the computational element, the sum of the upstream outflows and sum of the mass loadings are inserted in Q_{in0} and $C_{in0}Q_{in0}$.

5.2.3. Sub watershed Inflows

Possible inflows include: publicly owned treatment works (POTWs), urban runoff, groundwater exfiltration, agriculture returns, open space runoff, and any other flows. Each computational element includes provisions to include a generation component, which would be necessary if the constituents were being generated chemio-physio-biologically in the reach. In the case of salts, the generation component is set to zero as no reactions producing salts are assumed to occur in the CCW surface waters.

5.2.4. Sub watershed Outflows

Possible withdrawals or outflows from the CCW reaches include groundwater infiltration, diversions, agricultural use, and evaporation. No processes are included in the model that consumes salts. Because of the complete-mix assumption, the concentration in each of the outflows is equal to the concentration calculated in the reach that is discharged to downstream sub watersheds.

5.2.5. Chloride TMDL Model

For the development of the Draft Chloride TMDL, the Regional Board developed a mass balance model for chloride in the CCW. When the USEPA prepared the TMDL that was adopted for the CCW, they used this model as the starting point and made some modifications based on additional information about the watershed. For the purposes of this analysis, the RWQCB model (which was the only one available in electronic format) was updated to match the USEPA model used for development of the EPA Chloride TMDL. The model was then modified to provide results for TDS, sulfate, and boron as well as chloride. Additionally, the chloride concentrations used as inputs to the model were updated based on the source analysis presented above.

The Chloride TMDL Model described four different conditions in the CCW and identified two of the conditions as critical conditions for the TMDL. For this analysis, only the two critical conditions (non-storm maximum flow and post-drought) were updated and used for the linkage analysis.

5.2.5.1. Input Concentrations

In the original model, input concentrations for POTWs were based on one year of monitoring data and assumptions were made to estimate the concentrations from POTWs during different conditions (i.e. drought and post—drought). For this analysis, the POTW concentrations were calculated as an average value of available data for years meeting the definition of the critical conditions. The groundwater exfiltration concentrations were calculated based on the analysis presented above and in Appendix A. Flow rates were not changed for any of the inputs or outputs and no changes were made to the number or types of inputs and outputs. The model is included as Appendix C.

The model with the updated concentrations did a relatively good job of predicting in stream water quality for chloride. However, for TDS, sulfate and boron, the model did not do as well at predicting the in-stream water quality. As shown in the loads above, agricultural loads of TDS and sulfate make up a higher proportion of the load to the watershed than for chloride. Since agricultural loads are not included in the chloride TMDL model, this may be one reason for the discrepancy between the model and real world conditions.

5.2.6. Salts Balance Model

Camrosa Water District developed a simple mass balance model that calculates the chloride loading to the watershed from introduced water and water use. Chloride outputs in dry weather surface water flow are compared to the chloride inputs and an estimate of the pounds of salt "stranded' in the watershed is determined. The details of the model are discussed in the technical memorandum "Salts Loading in the Calleguas Creek Watershed" (Hajas, 2003a).

This model was updated to include inputs and outputs of TDS and sulfate based on the loading information presented in the Source Assessment section.

All of the models discussed above were used to assess the impacts of the proposed projects on water quality and the watersheds salts balance and compare the benefits to alternative methods for addressing salts, such as reverse osmosis treatment.

6. Project Descriptions

To manage salts in the CCW, a number of projects have been developed to address all components of the salts problem in the watershed. These projects were developed as alternatives to treating the inputs to the stream system (through reverse osmosis) to protect beneficial uses. As discussed in the previous sections, salts management is more complex than just the concentrations of salts in the surface water. Focusing on surface water concentrations may not result in significant reductions of the overall salt load to the watershed or in the protection of all beneficial uses. Therefore, the following projects were developed to manage salts in the watershed and provide additional water resources to reduce the major source of salts to the watershed, the introduced water supply.

6.1. Regional Salinity Management Conveyance (Brine line)

The project consists of a pipeline system to collect treated wastewater and brine concentrations from treatment facilities and industrial operations in the CCW and convey the effluent to other areas for direct use or to an existing ocean outfall. The brine line forms the backbone of all the proposed projects by providing a mechanism for discharging salts to the ocean other than through the surface water system.

Calleguas Municipal Water District is working with other public water and wastewater agencies to construct the Calleguas Regional Salinity Management Project, which is designed to help manage high salinity water use and disposal. The project consists of a pipeline system that would collect treated wastewater and brine concentrates from wastewater treatment plants, groundwater wells (both municipal and agricultural), and industrial operations located within the Calleguas Creek watershed, and convey the effluent to other areas for direct use or to an existing ocean outfall.

The project is divided into two distinct phases. Phase I is comprised of the pipeline from the Camrosa Water District Wastewater Treatment Plant to an existing ocean outfall in the City of Oxnard. The remaining portions of the pipeline system extend north and east from the Camrosa plant to the City of Simi Valley. Phase II segments would provide for connections to other municipal wastewater and groundwater treatment facilities in the watershed.

Construction of the $64 million project began in 2003 and is expected to continue over a seven year period. A program environmental impact report was certified by Calleguas MWD in September 2002. Design specifications for the first segment of Phase I have been approved, and construction began in February 2003. Phase II components will be designed and constructed incrementally in coordination with POTWs and other potential dischargers.

The need to permit the ocean discharge is a critical component of the development of the project. Because the discharge from the project incorporates both brines and the disposal of poor quality groundwater and/or excess tertiary treated effluent, it is possible to manage the project to meet the permit limits assigned to the discharge to meet Ocean Plan requirements. In the future as different discharges are added to the project, it may become necessary to look at alternative outfall options. These options include modifying the existing outfall with a diffuser, extending the outfall deeper into the ocean, and/or building a new outfall for the discharge. The implementation of the Calleguas Salinity Management Project is essential to any solutions for addressing salts in the Calleguas Creek watershed. Consequently, alternative options will be evaluated in the future if necessary. However, in the short term, existing ocean outfalls will need to be used and managed to meet permit limits in order to facilitate the implementation of projects to address salts in the watershed in the near term.

6.2. Renewable Water Resource Management Program (RWRMP) for the Southern Reaches of the Calleguas Creek Watershed (SCCW)

For the lower reaches of the CCW (Conejo Creek and lower Calleguas Creek), the proposed project contains four phases as discussed below. The following discussion is taken from the Notice of Preparation for a Draft EIR for the project and describes the current information available

on the project. For the portions of the project after Phase 1, some information will need to be determined as more information is gathered through implementation of earlier phases (i.e. what facilities will be needed to discharge imported water supplies). The CEQA process will be used as the mechanism for obtaining input on the project. The information is presented here for clarity in the analysis of the projects. However, the CEQA documentation represents the official project description and the mechanism for commenting on the details of the projects.

The overall goal of the project is to provide an adaptive management plan and the facilities to improve the reliability of local water resources and reduce dependence on imported water. Objectives of the project include:

- Recycle and reuse wastewater to the greatest extent possible;
- Reclaim abandoned unconfined groundwater resources;
- Provide a reliable, high-quality, water supply to support the existing environmental value of the riparian corridor;
- Increase agricultural water quality options to promote agricultural sustainability
- Achieve a salts balance within each sub-watershed;
- Reduce the salt load to surface waters; and
- Manage recycled and reclamation projects in a manner that achieves and maintains a salt balance.

6.2.1. Project Components

The proposed project is an integrated set of facilities to reduce reliance on imported water supplies while improving water quality through the managed transport of salts out of the watershed. There are three major elements to the project: water resource reclamation, salts management, and adaptive management. While either water resource reclamation or salts management could be optimized without reference to the other, this project seeks to increase water resources while moving toward a net daily salts balance.

6.2.1.1. Water Resource Reclamation

The project reduces reliance on imported water and over drafted confined groundwater aquifers by expanding water recycling and reclaiming poor quality, unconfined groundwater supplies. The project facilities also improve the quality of water supporting the riparian environment and groundwater recharge. The project facilities increase the water quality options for agricultural users.

The general plan for water resource reclamation includes direct recycling of tertiary-treated wastewater that is currently discharged to the creek by the Camarillo WRP and, in later phases, by the Hill Canyon WTP. This recycled water would be delivered through a common transmission pipeline system operated by Camrosa Water District for beneficial reuse in the Camrosa, Pleasant Valley County Water District and portions of the City of Camarillo. Existing recycled water distribution systems would be expanded in the Santa Rosa Valley, along Conejo and Calleguas

Creeks below Highway 101, and east of Calleguas Creek below Potrero Road. When recycled water supplies exceed available demands and storage, the recycled water would be discharged either to a proposed new discharge point on Calleguas Creek below the Potrero Road bridge, or into the Calleguas Regional Salinity Management Project brine pipeline for ocean discharge.

Unconfined groundwater, high in salts, in the Santa Rosa Basin and the perched zone of the eastern Pleasant Valley Basin would be blended and/or treated for use. Existing wells in the Santa Rosa Basin would be used to increase the transport of groundwater down gradient through existing facilities and blending operations. Santa Rosa Basin water would also be treated by a new reverse osmosis (RO) treatment facility. A pipeline from the new RO plant would be connected to Calleguas MWD brine line for waste disposal. Existing wells in the perched zone of the eastern Pleasant Valley basin would be renovated or new wells constructed. RO treatment would also be applied to this water.

The management plan would result in improved surface water quality and improved water quality for consumptive beneficial uses. The management plan would result in the removal of treated wastewaters from the stream system, which would significantly reduce the average daily salt load to the surface waters. In turn replenishment water (imported water or other sources of high quality water) would be released to the stream system as necessary to preserve in stream environmental values and functions, including recharge of groundwater in the Santa Rosa Basin.

The plan would continue the current practice of providing water with lower concentrations of chloride to the avocado growers in the Santa Rosa Valley through a controlled blending operation. Blending operations at the existing Camrosa storage ponds and other locations on the watershed would be developed as needed to improve overall irrigation water quality. Reverse osmosis treatment of groundwater would improve drinking water quality, reduce hardness and result in improved recycled water quality in the Camrosa recycled water.

6.2.1.2. Salts Management

More salts enter the watershed on a daily basis through introduced water than are transported out in surface water flowing to the ocean. From time to time, this salt imbalance is expressed in surface water concentrations that exceed water quality standards, but the problem is larger than surface water quality. Unless salts are actively managed, stranded salts will continue to accumulate and periodically impair surface waters. They also have the potential to further degrade groundwater sources. Since the watershed is already impaired for salts, any project to reduce reliance on introduced water sources must address how it will affect watershed water quality and the current salt imbalance.

The proposed project seeks to manage salts through a systems approach. To the extent possible, the proposed project proposes to address the salt imbalance by reducing salts introduced into the watershed system, removing salts currently disposed into the creek system, distributing water so as to move salts down-gradient and off of the watershed, introducing high quality water into the creek system to increase its capacity to carry salts that cannot otherwise be intercepted, and finally capturing and disposing of concentrated salts that would not otherwise move off the watershed.

Reducing the introduction of salts would be accomplished by new programs and enhancements to existing programs for water conservation in both urban landscape and agricultural irrigation. The programs would target reductions in imported water and groundwater pumping from the Fox Canyon system to reduce salt loading to the watershed. A minimum goal of a 2 percent reduction in outdoor water would help meet the projected salt balance requirements. Programs would also be implemented providing incentives and/or disincentives to reduce the use of self-regenerative water softeners in the watershed with a goal of reducing the overall load to the sewer system by 10 percent.

The proposed facilities to capture and distribute recycled water will assist in the managed transport of salts down and out of the watershed. By transporting unconfined groundwater down gradient for beneficial uses and/or transporting brine streams from the treatment of this groundwater off of the watershed, salt loads to each sub-watershed would be controlled. Shallow groundwater with very high salts would be pumped directly to the brine line for disposal if necessary to achieve a salt balance in the lower sub-watershed. This active management of shallow, unconfined groundwater will also enhance recharge by higher quality replenishment water or from rain events.

6.2.1.3. Adaptive Management

The watershed's hydrology is complex and dynamic. In order to evaluate the project's ongoing effect on sub-watershed salt balances, the project includes a monitoring and adaptive management element. The initial phase includes the establishment of automated monitoring points on the creek to measure flow and salt concentrations. By collecting data on an ongoing basis, the agencies can track and evaluate how best to move additional salts down the watershed. Collected data would be analyzed regularly for comparison to water quality objectives and project-specific improvement criteria. Data, analysis results and conclusions would be shared with watershed stakeholders through the Calleguas Creek Watershed planning process. A continuous inventory of the inputs and outputs of salts to each sub-watershed would be maintained to document the relative success in transporting salts out of the watershed. The overall project is designed to be implemented incrementally so that water quality impacts and future actions can be evaluated at each phase.

The project phasing and specific facilities are described in more detail in the following sections.

6.2.2. Project Facilities and Phasing

The proposed project includes four phases, with a focus on Phase 1 as it is critical to address the immediate water quality problems of the lower Calleguas Creek watershed. Phase 1 would be implemented over a one- to three-year period following completion of environmental compliance. Other phases would be implemented later and may require additional CEQA review.

6.2.2.1. Phase 1

This phase focuses on increasing recycled/reclaimed water use, reducing salt inputs to surface waters and construction of facilities to transport salts out of the watershed. Components of Phase 1 include:

Expansion of Recycled Water Transmission and Distribution System. A pipeline and pumping facility would be constructed to deliver recycled water from the Camarillo WRP into the existing

Camrosa recycled water system approximately 1.2 miles west of the treatment plant. A replacement pipeline (36 inches in diameter) would be constructed from the Camrosa water storage ponds to a point south of the Potrero Road Bridge and with an inter-connection to the Calleguas MWD brine disposal system (approximately 2.8 miles). The pipeline alignment would follow the existing pipe corridor. Additional small diameter pipelines would be installed to distribute recycled and non-potable water to western Santa Rosa Valley, eastern portion of the City of Camarillo (immediately west of Calleguas Creek and south of U.S. 101), and in the eastern and southwestern portions of Pleasant Valley. These pipelines would be primarily located along agricultural access roads.

Groundwater Reclamation. A portion of the water produced from the southern Pleasant Valley Basin unconfined aquifer system would be treated for salt removal to produce potable water to supplement the Camrosa's potable water deliveries. The treatment plant would be located at the existing well facility near California State University Channel Islands and treat approximately one to two million gallons per day. The treatment process would employ either reverse osmosis or electro dialysis reversal technology. The brine waste streams from well treatment would be discharged to the Calleguas MWD brine disposal system for ocean disposal. A 0.4 mile-long small diameter pipeline would be constructed to transport the brine to the southwest to connect with the Calleguas MWD brine disposal system.

Water Conservation and Source Control. Incentives/disincentives to reduce salt-based water softener use would be implemented within the Camrosa, Camarillo and Thousand Oaks service areas. An outdoor water conservation program would be developed and implemented throughout the lower watershed.

Water Blending Facilities. Existing blending facilities and new facilities would be used to meet the water quality needs for salt concentrations of various users. The existing facilities in the Santa Rosa Valley would be expanded and new facilities in the eastern portion of the Pleasant Valley and at the Wood creek well in Camarillo would be added. Major new components would include:

- Expansion of the existing blending capacity for the agricultural irrigation system in the Santa Rosa Basin;
- New blending facility at the Wood creek Well Facility; and
- New blending facility at Camrosa's water storage ponds.

Relocation of Wastewater Discharge Point. Surplus treated wastewater from the Camarillo WRP, Camrosa WRF, and in a later phase the Hill Canyon WTP; would no longer be discharged at their current discharge locations. The combined wastewaters would be discharged to a point downstream of the Potrero Road Bridge on the Calleguas Creek when there is surplus wastewater in the water recycling system. This discharge location would also be used when the Calleguas MWD brine disposal system may be unable to receive such waters because of temporary operational interruptions. New major facilities would include a discharge structure with a capacity of 25 million gallons per day located downstream of the Potrero Road Bridge for release to the Calleguas Creek.

Monitoring. The program would include three new or upgraded automated flow measuring and sample collection stations at three points on the stream system to record flow and various water quality parameters. Preliminary monitoring locations include Arroyo Conejo in Hill Canyon, Conejo Creek at Baron Brothers Nursery and Calleguas Creek at University Drive.

6.2.2.2. Phase 2

Phase 2 would expand groundwater treatment, expand recycled water distribution facilities and initiate water releases to the Arroyo Conejo creek system in anticipation of termination of discharge of the Hill Canyon WTP to North Fork Arroyo Conejo (Phase 3). Phase 2 components would include:

Groundwater Reclamation. A portion of the water produced from the Santa Rosa Basin would be treated for salt removal to produce potable water to supplement the Camrosa's potable water deliveries. A treatment plant would be constructed at the Camrosa Water District headquarters to treat Santa Rosa Basin water (5.0 million gallons per day). The treatment process would employ either reverse osmosis or electro dialysis reversal technology. The brine waste streams from the treatment plant would be discharged to the Calleguas MWD brine disposal system for ocean disposal. A 2.7 mile-long small diameter brine disposal pipeline would be installed along Upland Road to connect to the Calleguas MWD brine disposal system near Arroyo Las Posas.

Initiate Replenishment Water Releases. Small amounts of imported water would be discharged to Arroyo Conejo from the Calleguas MWD distribution system. Water would be released in the City of Thousand Oaks from about 3 to 5 discharge locations. These water releases would be experimental to determine the feasibility to maintain in stream beneficial uses following the termination of discharge of Hill Canyon WTP effluent (see Phase 3). The facilities and permits necessary to release the water will be determined during the planning for the initiation of Phase 2. It is likely that dechlorination facilities will be necessary and an NPDES permit will need to be obtained for the releases.

Monitoring. Additional monitoring (beyond Phase 1) may be implemented to determine the effects of replenishment water releases.

6.2.2.3. Phase 3

This Phase focuses on terminating discharge of effluent from the Hill Canyon WTP into Arroyo Conejo and introducing it directly into the Camrosa recycled/non-potable water distribution system for agricultural irrigation purposes. Phase 3 components include:

Thousand Oaks – Camrosa Recycled Water Interconnect. A new 3.6 mile-long pipeline (30-36 inches in diameter) would be constructed to transport tertiary-treated wastewater from the Hill Canyon WTP to Interconnect with Camrosa's recycled water distribution system near Camrosa's Reservoir 1-A. The pipeline alignment would be located along Hill Canyon Road immediately west of the roadway pavement. The pipeline would likely be placed above-ground and covered with fill. In the Santa Rosa Valley, the pipeline would be located within agricultural fields. A new pump station at the City of Thousand Oaks Hill Canyon WTP would lift the water to Camrosa Reservoir 1-A.

Monitoring. Continued monitoring would be necessary to adjust the replenishment water to meet water quality and in-stream objectives. Based on this monitoring, the staging of the final project phase would be evaluated.

6.2.2.4. Phase 4

This Phase focuses on pumping brackish groundwater to transport salts. Components of Phase 4 include:

Conejo Groundwater Basin. Wells would be installed to pump groundwater from the Conejo Valley Basin and discharge into the stream system in coordination with replenishment releases to assure compliance with surface water quality standards. Major new components would include several shallow groundwater wells (3-5) located near the South Fork of the Arroyo Conejo with metering facilities and diffusers for release into the creek. Well locations have not been identified to date, but would likely be within the northern and western portion of Thousand Oaks.

Lower Watershed. In the lower areas of the watershed where salts may accumulate, shallow dewatering wells would be constructed and operated to 1) Blend with other waters for irrigation uses, 2) discharged to the Calleguas MWD brine disposal system, or 3) treated for use and the brine stream discharged to the Calleguas MWD brine disposal system. Disposal of these waters on an as-needed-basis would prevent continued salt accumulation and excess salt loading to the surface water system. Major components would include new shallow wells (number and location to be determined) and pipelines to pump and transport water to the Calleguas MWD brine disposal system, or for blending with the Camrosa recycled system.

Monitoring Ongoing monitoring would focus on long-term patterns and management of salt transport.

6.3. Upper Calleguas Creek Watershed Plan

The Upper Calleguas Creek Watershed Plan consists of a phased approach to determine the best mechanisms for protecting beneficial uses. Phase 1 will be implemented over the short term and consists of source control at the Simi Valley WQCP, the provision of alternative water supplies to the growers in the South Las Posas Basin, and monitoring. Phase 2 will be the evaluation of a groundwater recovery and recharge program and the development of site-specific objectives.

6.3.1. Source Control Program

A source control program, focused on incentives/disincentives to reduce the use of self-regenerative water softeners, will be implemented. The first phase will be a ban of future water softeners to the extent allowed under the law. The implementation of additional incentives/disincentives to reduce water softener use will be evaluated in the second phase.

6.3.2. Provision of Lower Salinity Water to Agricultural Users

The Calleguas Municipal Water District is working with Zone Mutual to provide imported State Project Water to agricultural users so that they can blend the lower salt concentration water with poorer quality groundwater from the shallow South Las Posas Basin aquifer to obtain water of sufficient quality for agricultural use. In return, Zone Mutual will pump higher volumes of water from the South Las Posas to remove the poorer quality water and allow recharge by higher quality surface water into the basin. The resulting project will reduce demands on the lower Las Posas Basin, which has higher quality water, and improve the quality of the water in the shallow portions of the South Las Posas Basin.

6.3.3. Monitoring Program

A monitoring program will be implemented to measure the groundwater and surface water concentrations in the upper watershed, the volume of brine discharged to the brine line from the desalter and the amount of potable water produced from the treatment.

6.3.4. Groundwater Recovery and Recharge

The Calleguas Municipal Water District, Ventura County Water Works District #19 and other interested parties are evaluating the construction of a groundwater desalter facility near Moorpark to pump and treat poor quality groundwater. The pumping of poor quality groundwater will supplement imported water supplies and reduce the groundwater levels in the shallow groundwater. By lowering groundwater levels, higher quality storm water flows can recharge the groundwater basin and improve the quality in the basin.

In addition, following the completion of the construction of the proposed brine line in Simi Valley, the dewatering wells that currently discharge to the upper Arroyo Simi maybe reclaimed and the water may no longer be discharged to the stream.

6.3.5. Site Specific Objectives

As discussed previously, natural background conditions in the Arroyo Simi may make the Basin Plan objectives unachievable. Should that be the case, the development of site-specific objectives will be pursued for the Arroyo Simi/Las Posas in addition to the recommended averaging period changes.

6.4. Other Alternatives

An alternative approach to water quality regulation is to treat the inputs to the surface water in order to achieve surface water quality objectives. An example of this approach is the use of reverse osmosis to treat POTW effluent as discussed in the EPA Chloride TMDL. For the purposes of this analysis, the effluent from the three POTWs that currently discharge to the stream was treated with reverse osmosis at the levels required to meet the drought WLAs in the EPA Chloride TMDL. The percent reductions used in the model were based on an analysis of the maximum dry weather chloride loads from each of the dischargers and the reductions required for the maximum discharge loads to be equal to or less than the WLAs. All of that water was then discharged to the stream. Although this approach may meet water quality objectives, in this case it

does not provide the best mechanism for protecting the beneficial uses. For this reason, the projects listed above were developed to provide protection of beneficial uses, improvements in surface water quality, and supplementation of potable water supplies. The alternative approach (Reverse Osmosis Treatment) is presented in the comparison to evaluate the ability of the plan to meet water quality objectives and protect beneficial uses and to demonstrate the added benefits of the proposed projects.

Additionally, the removal and reclamation of the effluent from the Simi Valley WQCP was evaluated as a potential alternative to the proposed upper watershed project. Only the impacts on water quality were assessed for this alternative.

7. Evaluation of Projects

To assess the impact of the proposed projects and the alternative projects, four criteria were addressed: impacts on water supply, impacts on the watershed salt balance, impacts on surface water quality, and the ability to meet the EPA chloride TMDL waste load and load allocations. The following sections discuss how each of these impacts were evaluated.

7.1. Water Supply Impacts

The lower watershed project (RWRMP) will significantly increase the local water supply and reduce imported water demand. The net impact of the RWRMP on the watershed would be to reduce the use of imported or pumped deep aquifer water by up to 22.5 million gallons per day.

The upper watershed project will also significantly increase the local water supply and reduce imported water demand. Additionally, the project will help protect the imported water stored in the North Las Posas Basin. When implemented, the project would reduce imported water and groundwater pumping demand by up to 9 million gallons per day.

The reverse osmosis treatment approach would not provide any increase in the local water supply. The treated water would need to be discharged back to the stream in order to meet the water quality objectives.

7.2. Watershed Salt Balance Impacts

Both of the projects and the reverse osmosis treatment plan improve the salt balance in the watershed. As discussed above, the watershed was divided into five sub watersheds and a salts balance was developed for each of them.

The lower watershed project will result in an approximate salts balance under average conditions once Phase 4 has been implemented. In the lower watershed, up to 300,000 lbs/day of salts (TDS) will be removed as a result of the projects. The upper watershed project will result in approximately 70,000 pounds/day of salts being removed from the upper watershed. Of the 70,000 lbs/day removed, approximately 55,000 lbs/day are stranded salts and 15,000 lbs/day are salts prevented from entering the watershed from water softeners. The Reverse Osmosis Treatment plan would result in approximately 70,000 lbs/day of salts removed from the watershed.

Therefore, the proposed projects will remove five times more salt mass from the watershed than the reverse osmosis treatment plan.

7.3. Surface Water Quality Impacts

The CCMS and the Chloride TMDL model were used to project the water quality resulting from the projects. The resulting water quality was then compared to current conditions and water quality objectives.

7.3.1. CCMS Evaluation

As discussed previously, the CCMS model has the capability to predict water quality on a daily basis or with any chosen averaging period. Because the impacts on agriculture and groundwater recharge occur over longer periods of time than a day and the variability in daily concentrations is significant because of rain events, the 12 month rolling average was used to assess the impacts of the projects.

Time series graphs and probability plots were developed for the upper watershed project and the phases of the lower watershed based on the project descriptions. Because a number of the elements proposed in the projects involve elements that do not have direct impacts on surface water quality, not all of the elements presented above were analyzed in the surface water modeling. Elements such as groundwater pumping and treatment are likely to have a positive impact on surface water quality, but it is difficult to estimate the impacts at this time. Consequently, the modeled results provide a conservative estimate of the impacts on surface water quality from the proposed projects. The elements of the projects that were included in the modeling and the changes to the model used to describe these project elements are listed in Table 21.

Table 21: Modeled Scenarios for Salts Control in the Calleguas Creek Watershed.

Name	Description	Model Input Changes
Entire Watershed		
Current Conditions	Current Watershed Conditions, Conejo Creek Diversion Operated According to Records [1].	None
Upper Watershed [6]		
Ban Future SRW and Provide Incentives/Disincentives to Discontinue SRW use	A 25% reduction in the chloride and TDS concentrations from Simi Valley WQCP due to banning future SRW installations and providing incentives for discontinuing SRW use.	Chloride and TDS set to 75% of the current value in Simi Valley WQCP effluent.
Lower Watershed [6]		
Phase 1	Expansion of the Recycled Water Transmission and Distribution System to allow reclamation of all Camarillo WRP effluent.	Camarillo WRP effluent flow rate set to zero. Conejo Creek Diversion operated to allow 6 cfs bypass and capture of balance.
Phase 2, 1.5 cfs CMWD to both NF and SF Conejo	As above, with the Initiation of Replenishment Water Releases. 1.5 cfs imported water from the CMWD discharged to both the NF and SF of the Arroyo Conejo were the volumes assumed for the releases.	As in Phase 1. 1.5 cfs flow rate added to NF and SF Arroyo Conejo with modeled concentrations of CMWD water.
Phase 3, 3 cfs CMWD to both NF and SF Conejo	As in Phase 1 with the Thousand Oaks-Camrosa Recycled Water Interconnect and continuation of replenishment water releases. Hill Canyon WTP effluent fully reclaimed after the connection and 3 cfs imported water from the CMWD discharged to both the NF and SF of the Arroyo Conejo as the assumed volumes for the releases.	As in Phase 1. Hill Canyon WTP effluent flow rate set to zero. 3 cfs flow rate added to NF and SF Arroyo Conejo with modeled concentrations of CMWD water.
Phase 3, 4 cfs CMWD to NF and 2 cfs to SF Conejo	As above with alterations to the amount of replenishment water releases to assess the impacts of different volumes and different release locations. As in Phase 1 with Hill Canyon WTP effluent fully reclaimed and 4 cfs imported water from the CMWD discharged to NF and 2 cfs discharged to the SF of the Arroyo Conejo as the assumed discharge volumes.	As in Phase 1. Hill Canyon WTP effluent flow rate set to zero. 4 cfs flow rate added to NF and 2 cfs added to SF Arroyo Conejo with modeled concentrations of CMWD water.
Phase 3, 2 cfs CMWD to NF and 4 cfs to SF Conejo	As above with alterations to the amount of replenishment water releases to assess the impacts of different volumes and different release locations. As in Phase 1 with Hill Canyon WTP effluent fully reclaimed and 2 cfs imported water from the CMWD discharged to NF and 4 cfs discharged to the SF of	As in Phase 1. Hill Canyon WTP effluent flow rate set to zero. 2 cfs flow rate added to NF and 4 cfs added to SF Arroyo Conejo with modeled concentrations of CMWD water.

Name	Description	Model Input Changes
	the Arroyo Conejo as the assumed discharge volumes.	
Phase 3, 4 cfs CMWD to NF and 3 cfs to SF Conejo	As above with alterations to the amount of replenishment water releases to assess the impacts of different volumes and different release locations. As in Phase 1 with Hill Canyon WTP effluent fully reclaimed and 4 cfs imported water from the CMWD discharged to NF and 3 cfs discharged to the SF of the Arroyo Conejo as the assumed discharge volumes.	As in Phase 1. Hill Canyon WTP effluent flow rate set to zero. 4 cfs flow rate added to NF and 3 cfs added to SF Arroyo Conejo with modeled concentrations of CMWD water.
Phase 3, 4 cfs CMWD to both NF and SF Conejo	As above with alterations to the amount of replenishment water releases to assess the impacts of different volumes and different release locations. As in Phase 1 with Hill Canyon WTP effluent fully reclaimed and 4 cfs imported water from the CMWD discharged to both the NF and SF of the Arroyo Conejo as the assumed discharge volumes.	As in Phase 1. Hill Canyon WTP effluent flow rate set to zero. 4 cfs flow rate added to NF and SF Arroyo Conejo with modeled concentrations of CMWD water.
Reverse Osmosis Treatment Plan	Implementation of Reverse Osmosis Treatment at Hill Canyon WTP, Simi Valley WQCP, and Camarillo WRP to meet the drought WLAs in EPA Chloride TMDL. Percent reductions were estimated using the maximum dry weather (June to September) chloride loads from each facility as predicted by the conditions in the model.	Chloride, sulfate, TDS, and boron (Salts) concentrations set to 68% of the current value of Simi Valley WQCP effluent and flow rate reduced to 93.2% of current flow. Salts concentrations set to 57.3% of the current value of Hill Canyon WTP effluent and flow rate reduced to 91% of current flow. Salts concentrations set to 40.1% of the current value of Camarillo WRP effluent and flow rate reduced to 87.4% of current flow.

[1] See Appendix A for Details
[2] Groundwater
[3] Self regenerating water softener
[4] Reverse osmosis or other desalination treatment.
[5] Assuming 80% of water desalinated and 20% discharged to brine line.
[6] Improvements to dry-weather runoff and POTW effluent quality due to higher quality source water from desalinating groundwater unaccounted for in current model runs.

For six key points in the watershed, time series graphs and probability plots were developed for each of the scenarios to demonstrate how the water quality changes through implementation of the project. The following figures show the comparison between current conditions prior to implementation of the projects and the final scenarios in the table above that demonstrate the best water quality achievable through the projects. Appendix D contains the figures showing the impacts of the other scenarios modeled. For all scenarios, the solid line in the figures is the Basin Plan objective.

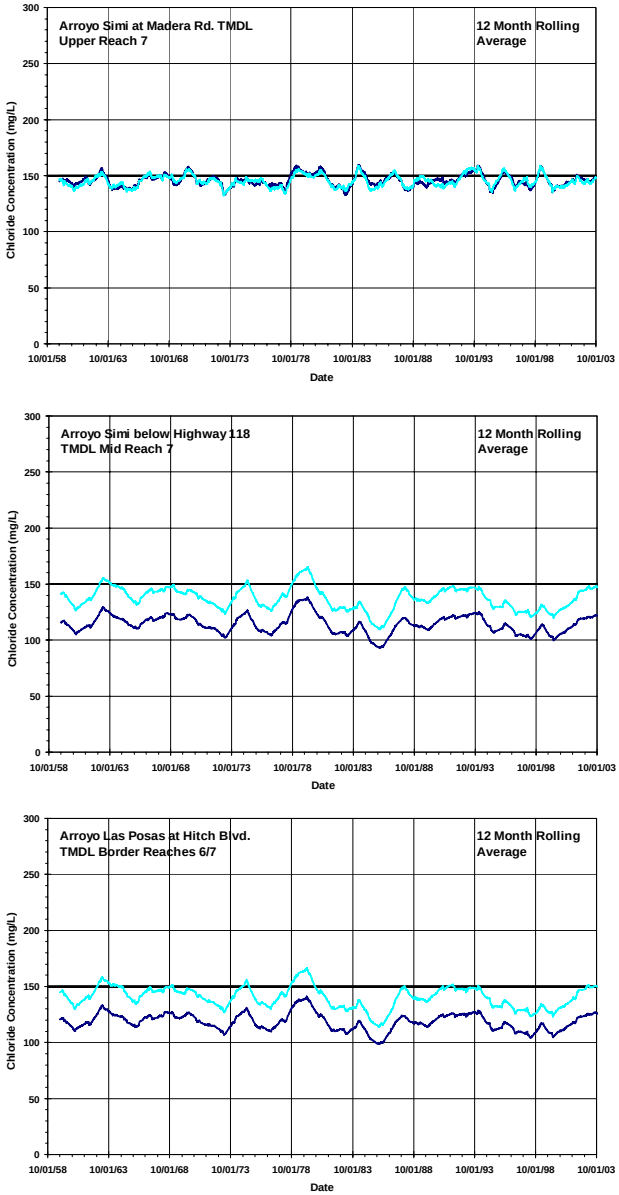

Figure 13: Current (light line) and Estimated (dark line) Chloride 12-month Rolling Average Concentrations in Arroyo Simi/Las Posas With No Future SRW and Incentives/Disincentives to Reduce SRW Use.

After implementation of the upper watershed projects, the chloride concentrations consistently meet the 12 month rolling average downstream of the Simi Valley WQCP, but not upstream. Concentrations in the surface water upstream of the Simi Valley WQCP are not addressed by these projects.

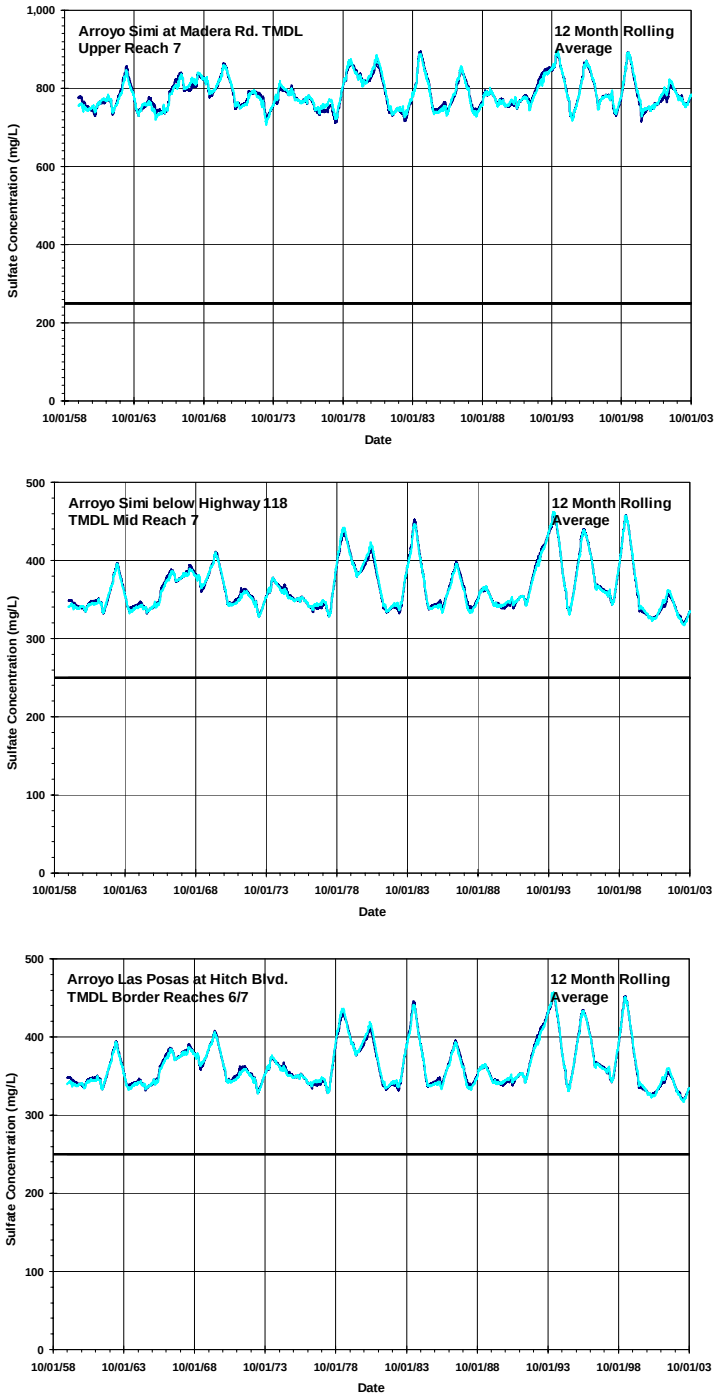

Figure 14: Current (light line) and Estimated (dark line) Sulfate 12-month Rolling Average Concentrations in Arroyo Simi/Las Posas With No Future SRW and Incentives/Disincentives to Reduce SRW Use.

Sulfate concentrations are not impacted by the modeled components of the project. It is possible that the groundwater desalting in the South Las Posas basin will have an impact on surface water sulfate concentrations, but the impacts cannot be determined at this time.

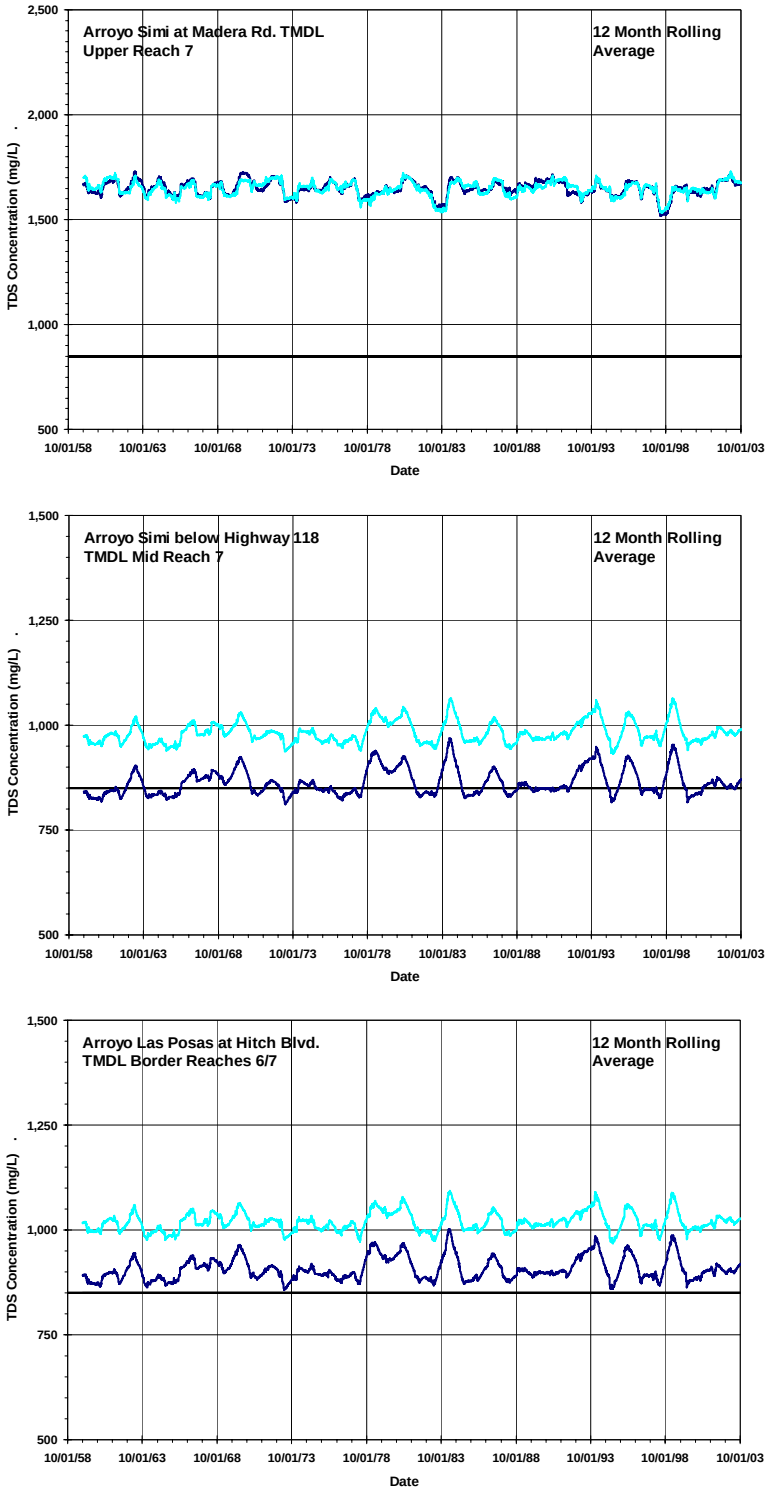

Figure 15: Current (light line) and Estimated (dark line) TDS 12-month Rolling Average Concentrations in Arroyo Simi/Las Posas With No Future SRW, and Incentives/Disincentives to Reduce SRW Use.

The projects result in a significant decrease in TDS concentrations (approximately 100 mg/L) and result in the surface water concentrations falling below the objectives under certain conditions. However, the 12 month rolling average would not consistently meet objectives.

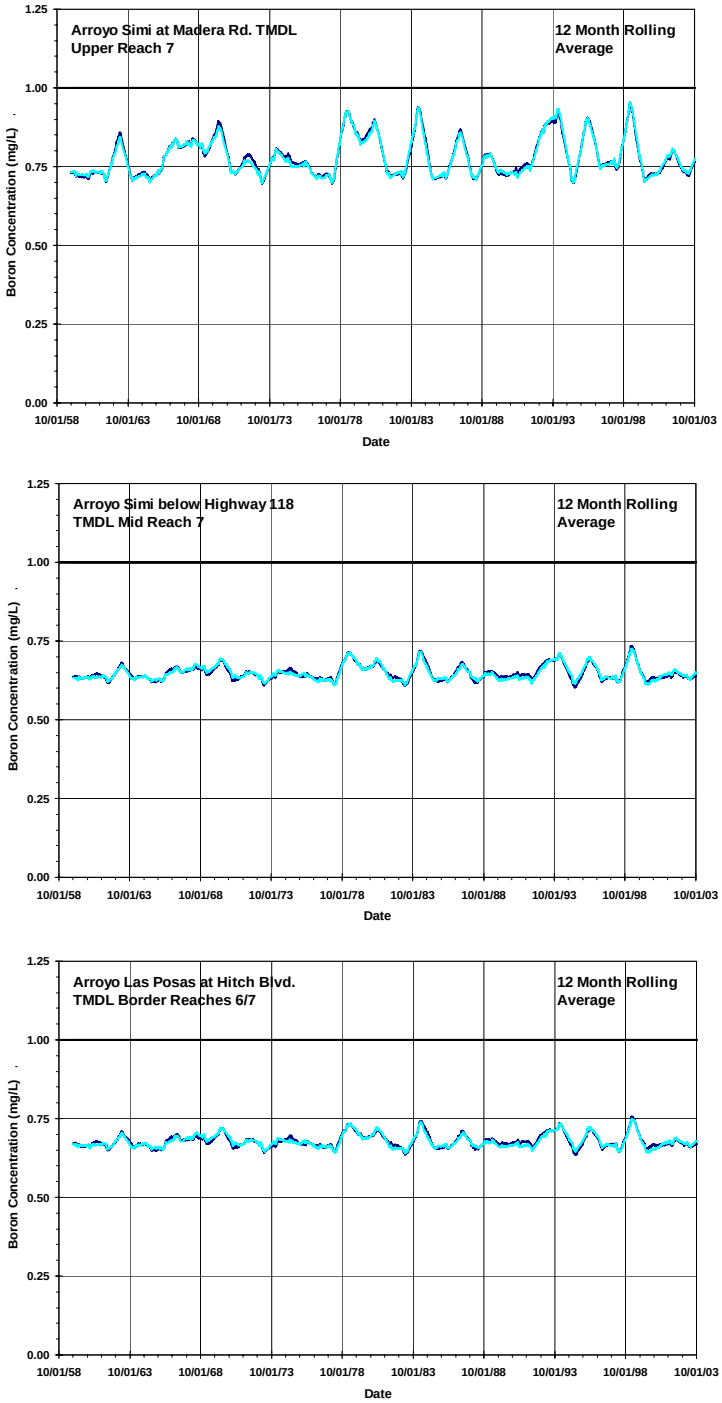

Figure 16: Current (light line) and Estimated (dark line) Boron 12-month Rolling Average Concentrations in Arroyo Simi/Las Posas With No Future SRW, and Incentives/Disincentives to Reduce SRW Use.

Boron consistently meets the 12 month rolling average objective even without implementation of the projects. The projects have no significant impact on boron concentrations.

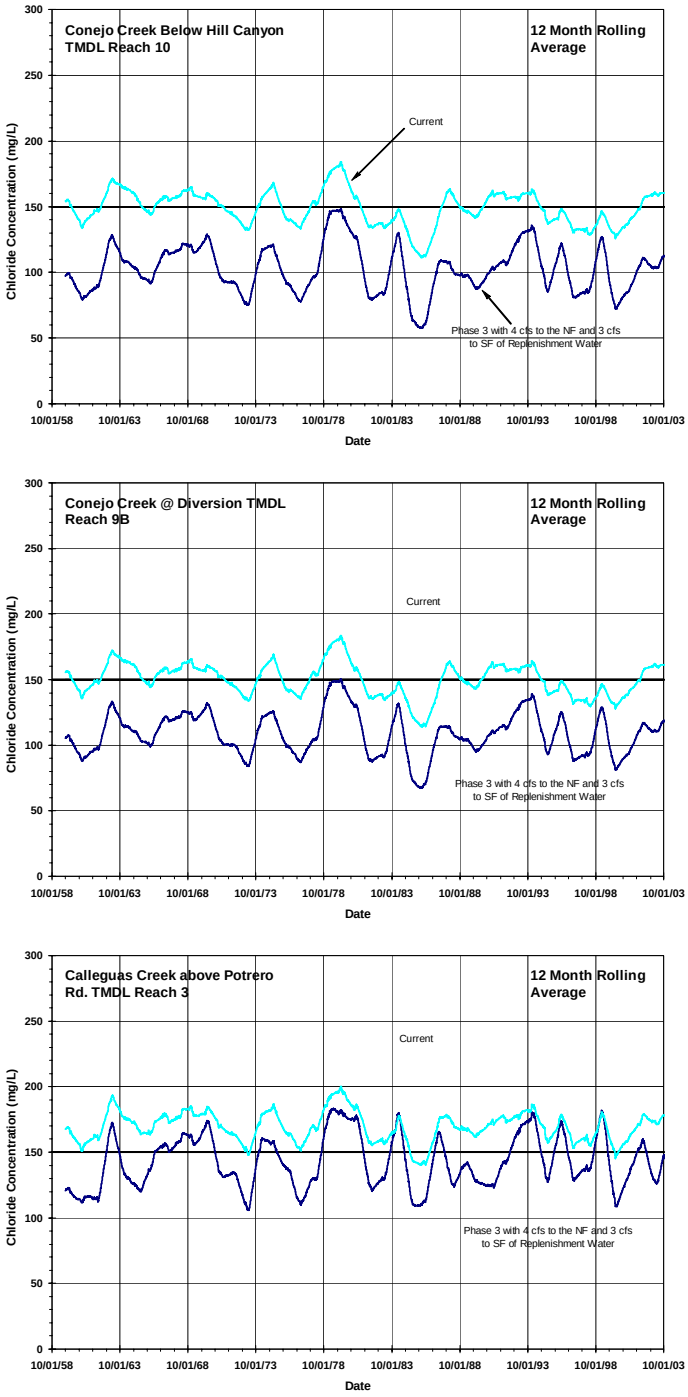

Figure 17: Current and Estimated Chloride 12-month Rolling Average Concentrations in Lower Watershed After Implementing Phase 3 of the RWRMP and supplying 4 cfs to the NF and 3 cfs to the SF Arroyo Conejo of Replenishment Water.

Concentrations of chloride decrease significantly after implementation of the lower watershed projects. In Conejo, concentrations are reduced by approximately 50 mg/L and the surface water would meet the 12 month rolling average objectives the majority of the time. Calleguas Creek would not consistently meet the 12 month rolling average objectives, but chloride concentrations are reduced through implementation of the projects.

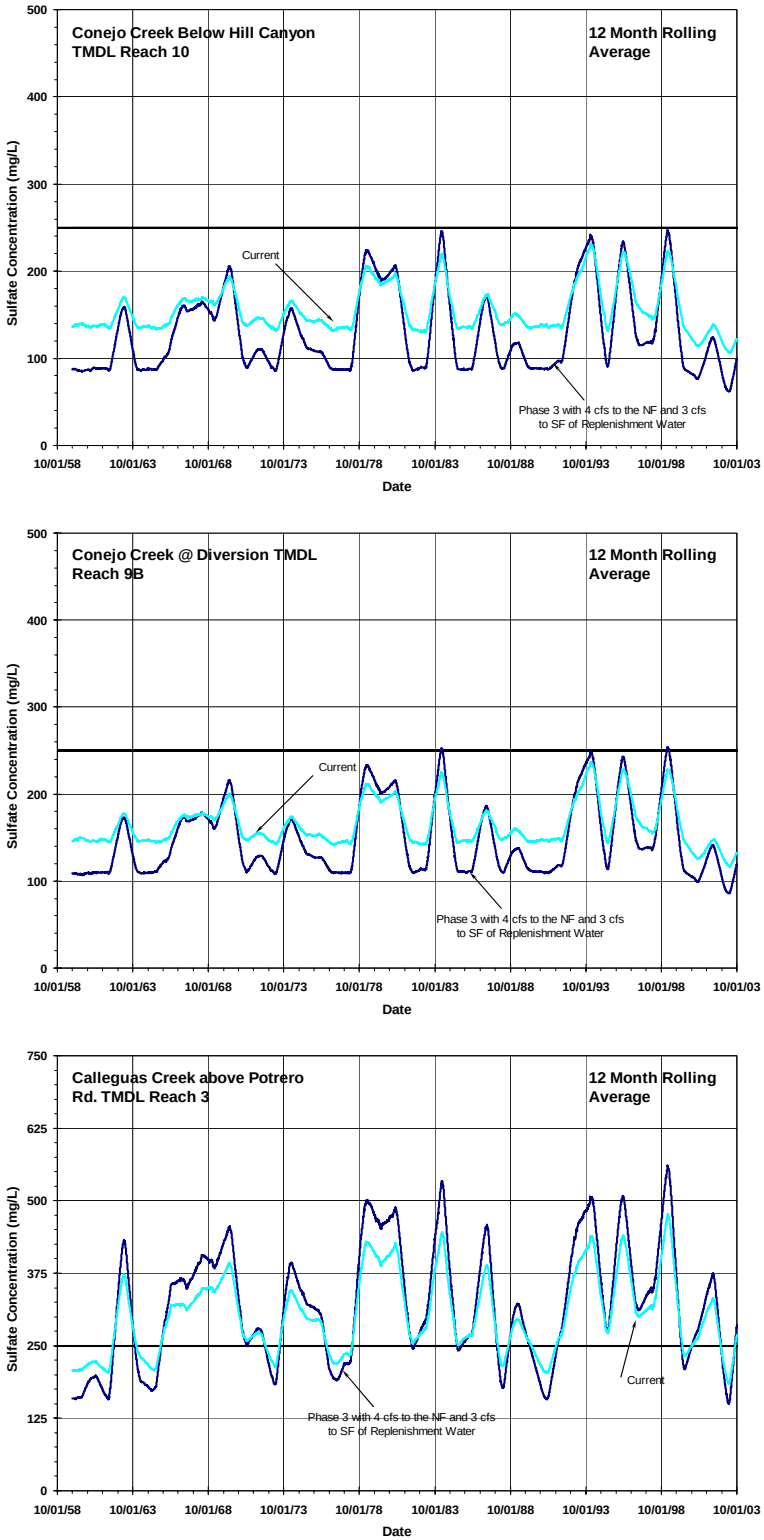

Figure 18: Current and Estimated Sulfate 12-month Rolling Average Concentrations in Lower Watershed After Implementing Phase 3 of the RWRMP and supplying 4 cfs to the NF and 3 cfs to the SF Arroyo Conejo of Replenishment Water.

Modeled sulfate concentrations are more variable than other constituents because there are fewer data available for this constituent and the available data are more variable. Consequently, the equations used to represent conditions in the watershed include more variability. Concentrations increase at Potrero Rd. because groundwater exfiltration containing high sulfate concentrations occurs in this reach. The projects reduce the amount of flow in the reach available to dilute the groundwater concentrations. However, the implementation of Phase 4 of the lower watershed project includes pumping of groundwater in this reach that should reduce the exfiltration. This should reduce sulfate concentrations in the surface water, but the impacts cannot be modeled until the project has been implemented.

The increase in sulfate concentrations at Potrero Road is not a problematic situation because it will not have an impact on beneficial uses. The reach is at the lower end of a reach of rising groundwater so no groundwater recharge occurs in this area. Additionally, the water rights are fully appropriated in this reach so no diversions for agriculture are permitted. Finally, the lower reach is the conduit by which salts are exported from the watershed. Higher concentrations in this reach are inevitable if additional salts are being exported from the upper reaches of the watershed to protect the beneficial uses present in those areas.

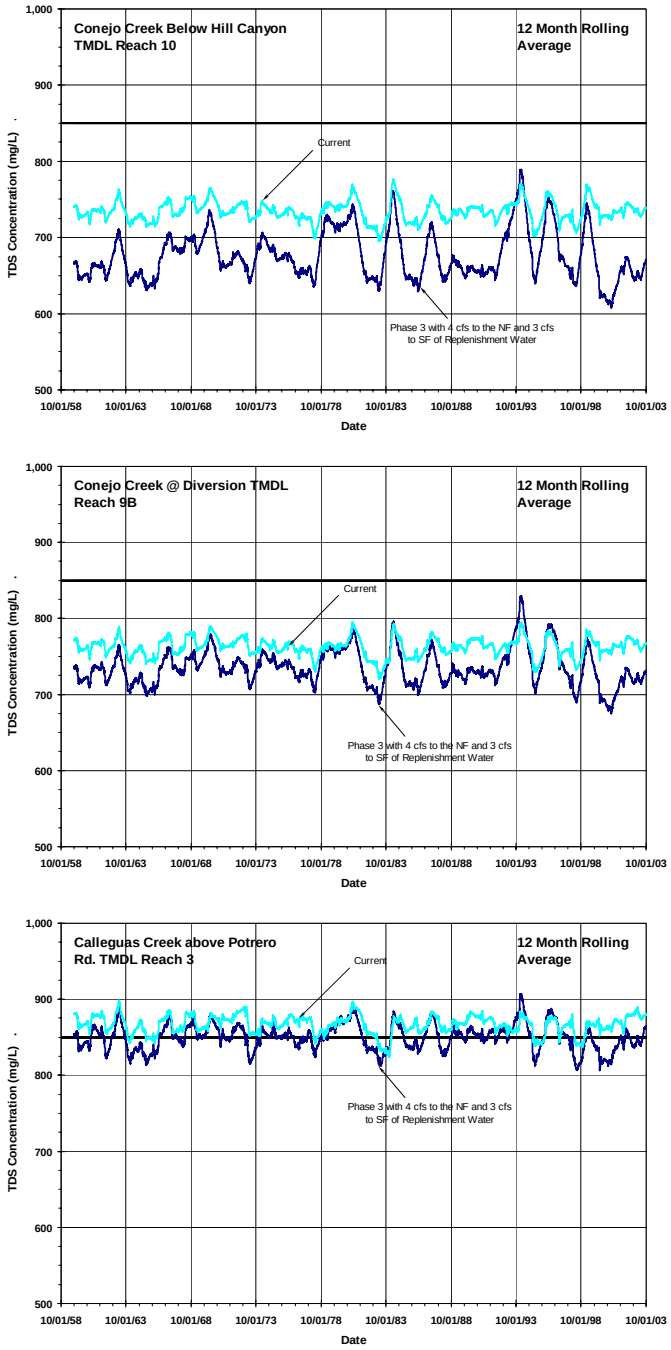

Figure 19: Current and Estimated TDS 12-month Rolling Average Concentrations in Lower Watershed After Implementing Phase 3 of the RWRMP and supplying 4 cfs to the NF and 3 cfs to the SF Arroyo Conejo of Replenishment Water.

TDS concentrations are reduced by approximately 50 mg/l in Conejo Creek, but remain approximately the same in Calleguas Creek. The TDS concentrations in the groundwater base flow are very high. Once the effluent is removed from the stream, the base flow makes up a much larger portion of the flow in the stream. Dilution is provided by the replenishment water releases, but it is not of the magnitude that was provided by the effluent. Like sulfate, any groundwater pumping and treatment that is implemented as part of the projects will likely reduce the surface water concentrations of TDS as well. However, the impacts could not be assessed at this time.

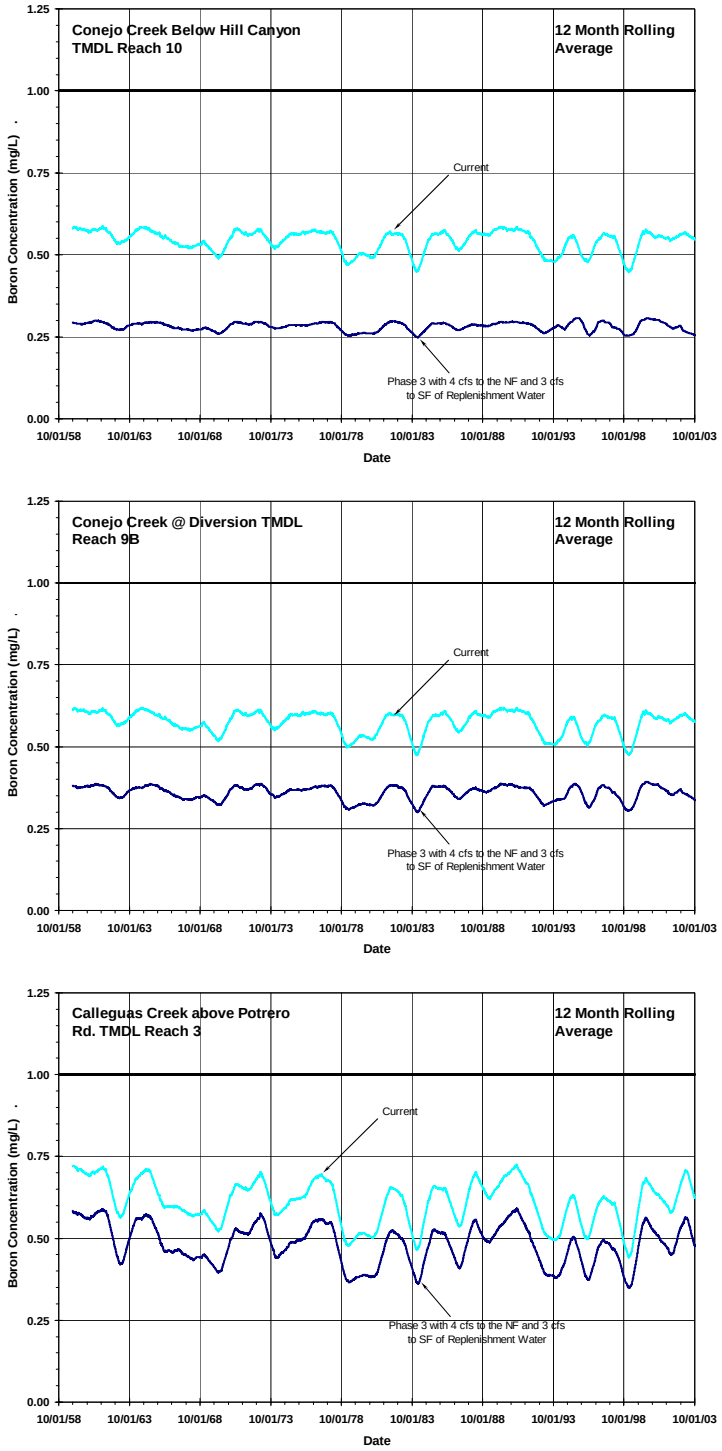

Figure 20: Current and Estimated Boron 12-month Rolling Average Concentrations in Lower Watershed After Implementing Phase 3 of the RWRMP and supplying 4 cfs to the NF and 3 cfs to the SF Arroyo Conejo of Replenishment Water.

Boron is not on the 303(d) list for these reaches. The current conditions shown in the graphs clearly demonstrate that boron concentrations are below the objective of 1.0 mg/L at all times.

The following series of plots show the probability of a given concentration occurring on any given day at the designated location in the watershed. The current conditions and the conditions present after implementation of the projects are presented in the plots.

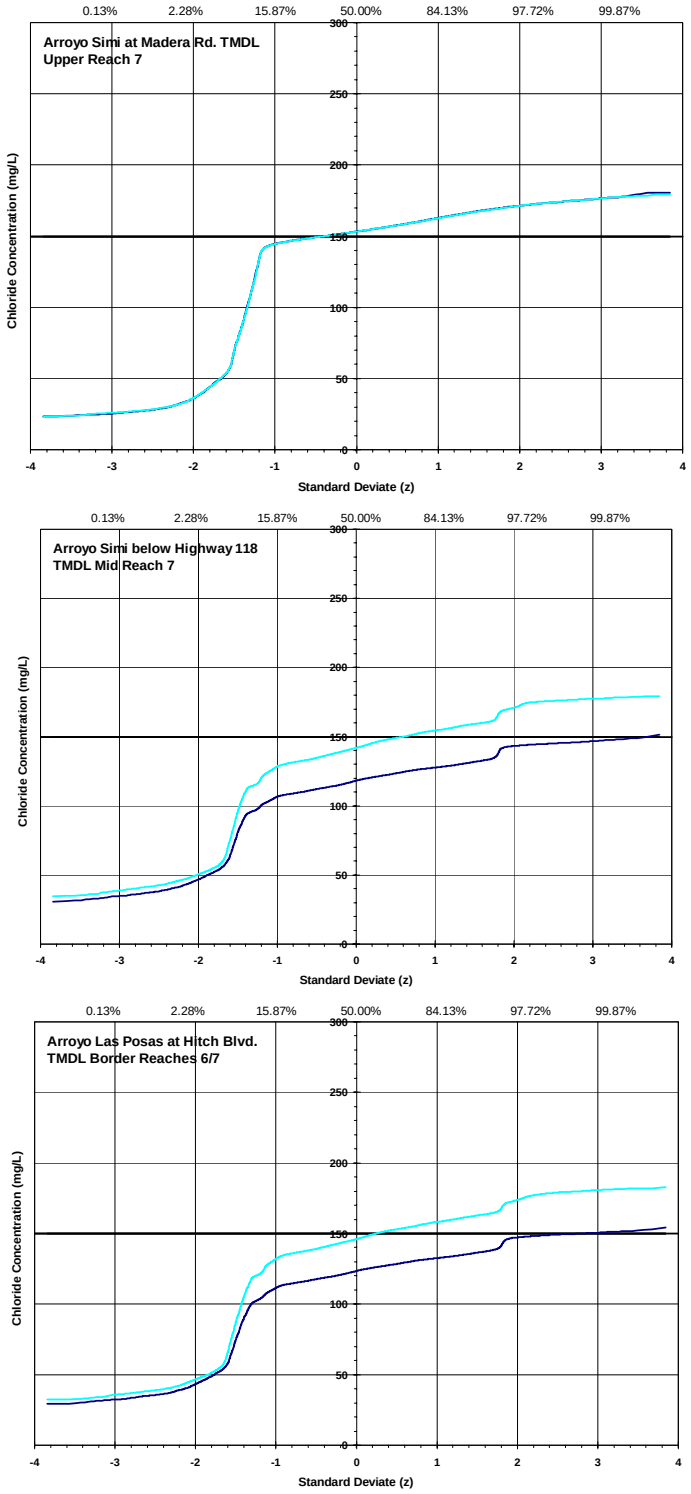

Figure 21: Current (light line) and Estimated (dark line) Probability Distributions of Daily Average Chloride Concentrations in Arroyo Simi/Las Posas with No Future SRW, and Incentives/Disincentives to Reduce SRW Use.

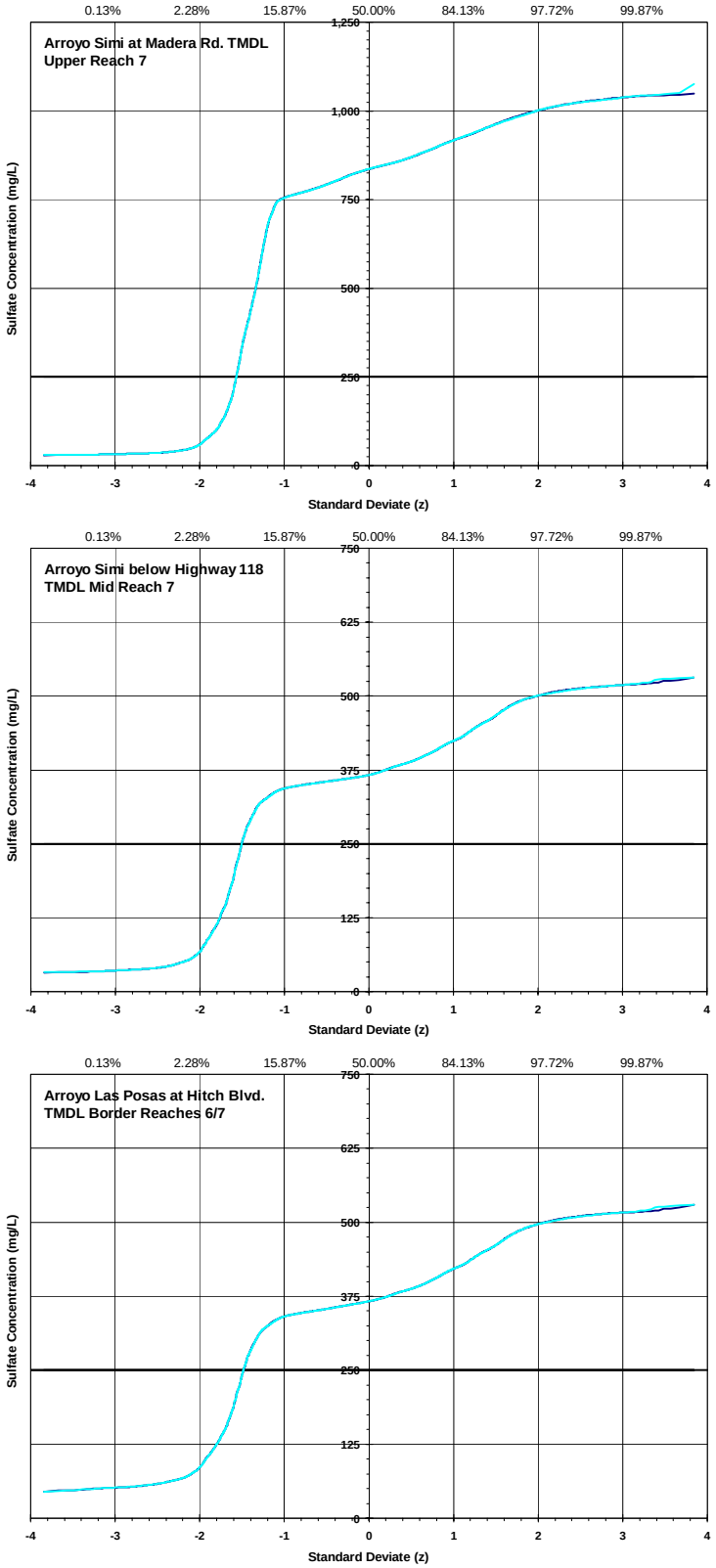

Figure 22: Current (light line) and Estimated (dark line) Probability Distributions of Daily Average Sulfate Concentrations in Arroyo Simi/Las Posas with No Future SRW and Incentives/Disincentives to Reduce SRW Use.

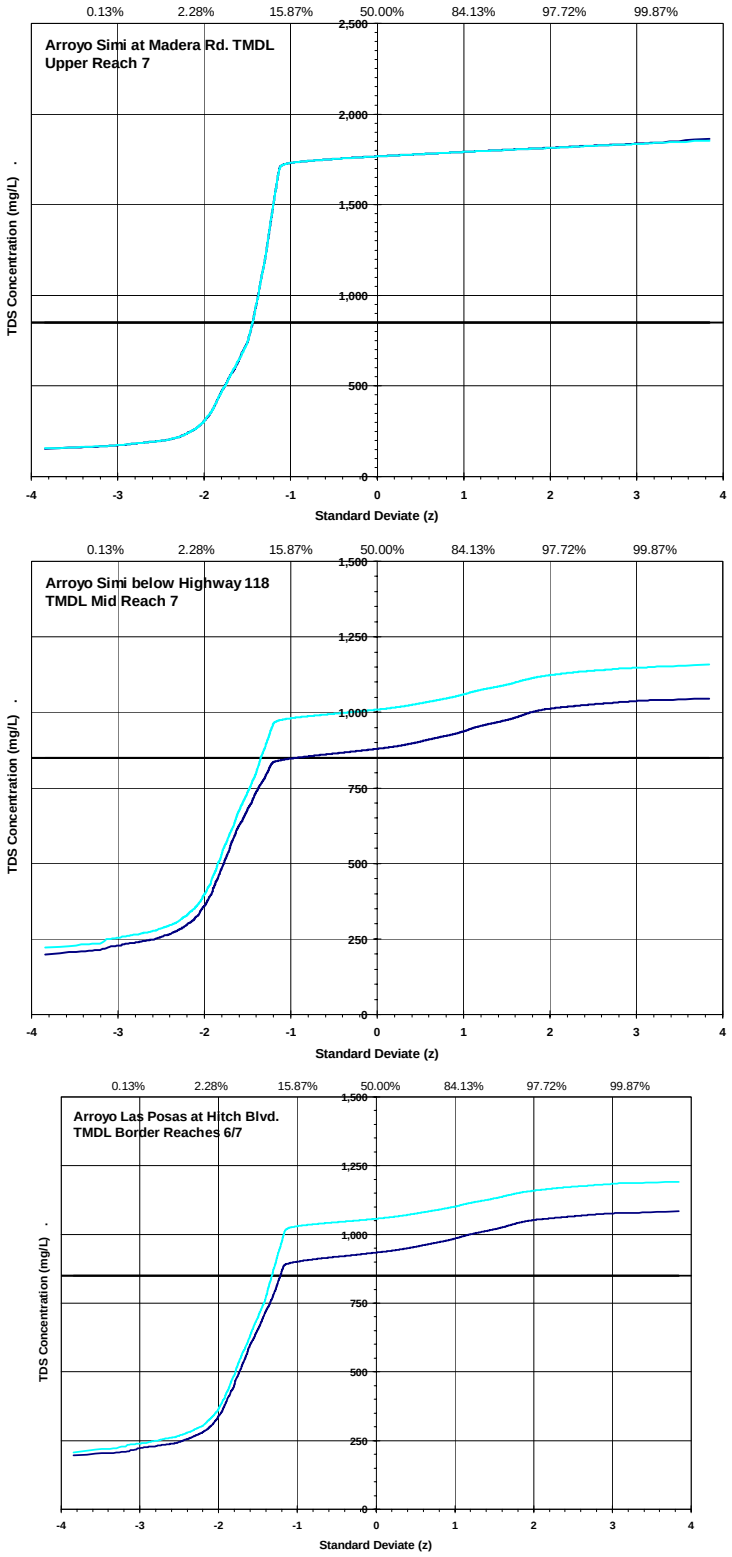

Figure 23: Current (light line) and Estimated (dark line) Probability Distributions of Daily Average TDS Concentrations in Arroyo Simi/Las Posas with No Future SRW and Incentives/Disincentives to Reduce SRW Use.

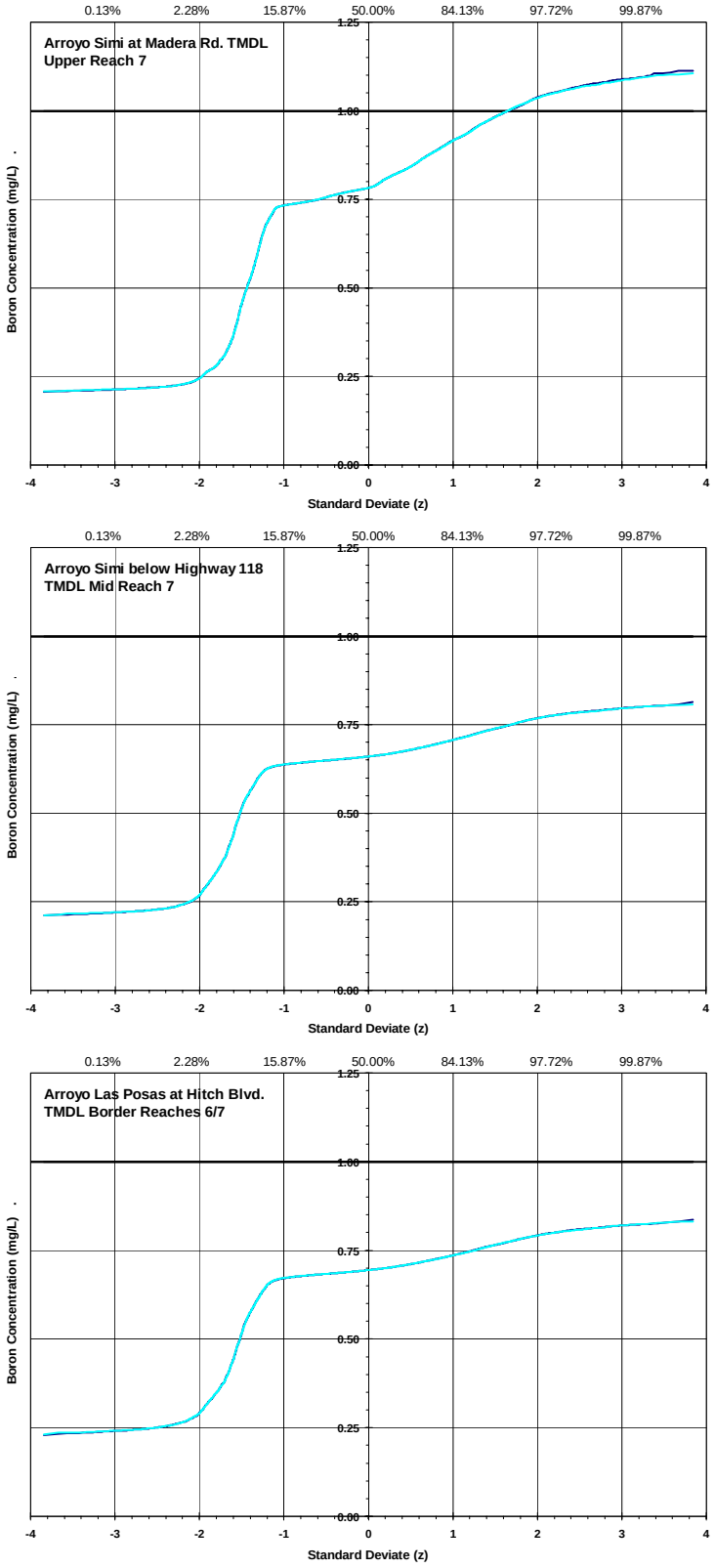

Figure 24: Current (light line) and Estimated (dark line) Probability Distributions of Daily Average Boron Concentrations in Arroyo Simi/Las Posas with No Future SRW and Incentives/Disincentives to Reduce SRW Use.

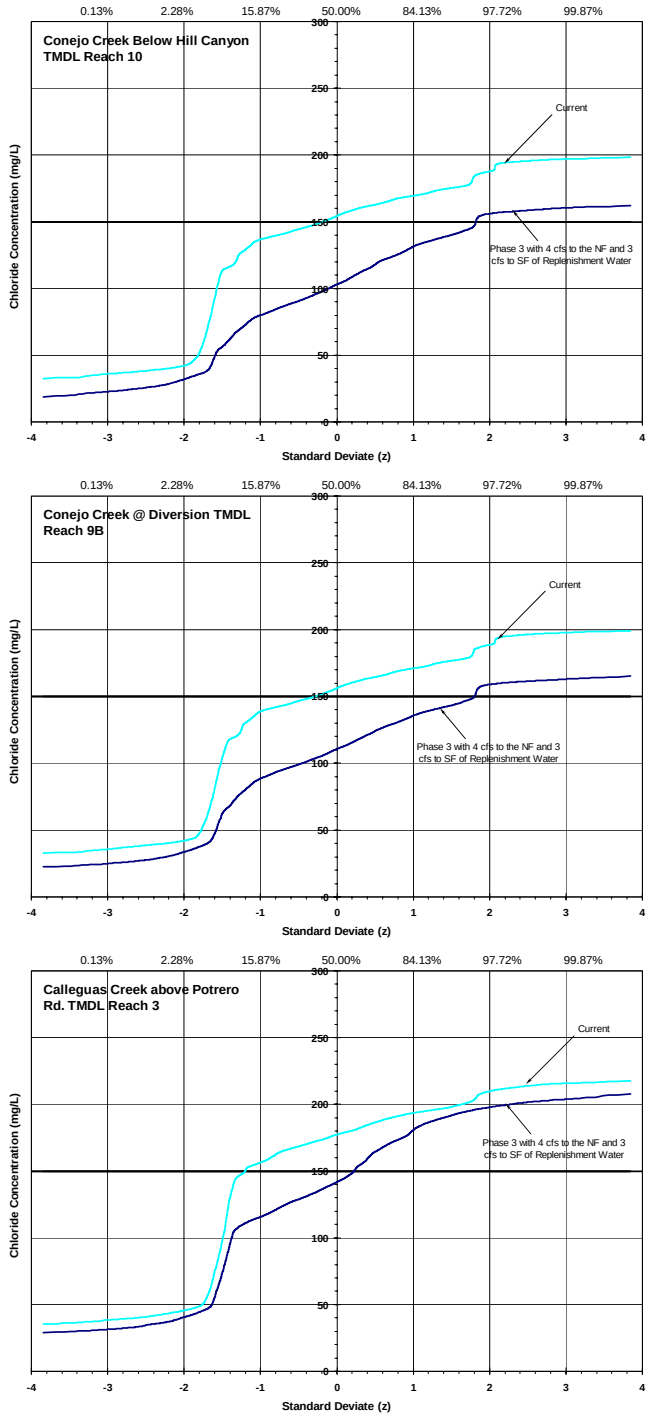

Figure 25: Current and Estimated Chloride Probability Distribution of Daily Average Concentrations in Lower Watershed After Implementing Phase 3 of the RWRMP and supplying 4 cfs to the NF and 3 cfs to the SF Arroyo Conejo of Replenishment Water.

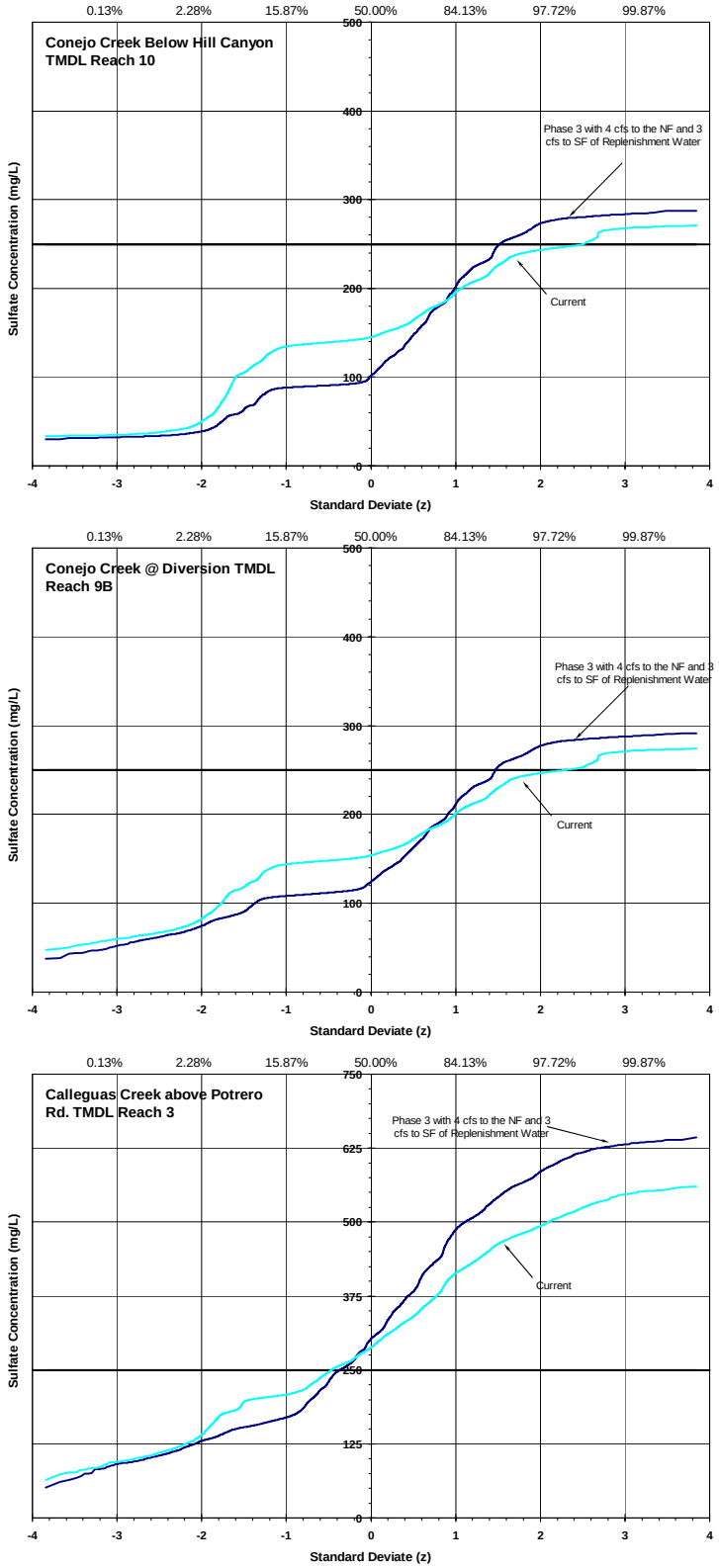

Figure 26: Current and Estimated Sulfate Probability Distribution of Daily Average Concentrations in Lower Watershed After Implementing Phase 3 of the RWRMP and supplying 4 cfs to the NF and 3 cfs to the SF Arroyo Conejo of Replenishment Water.

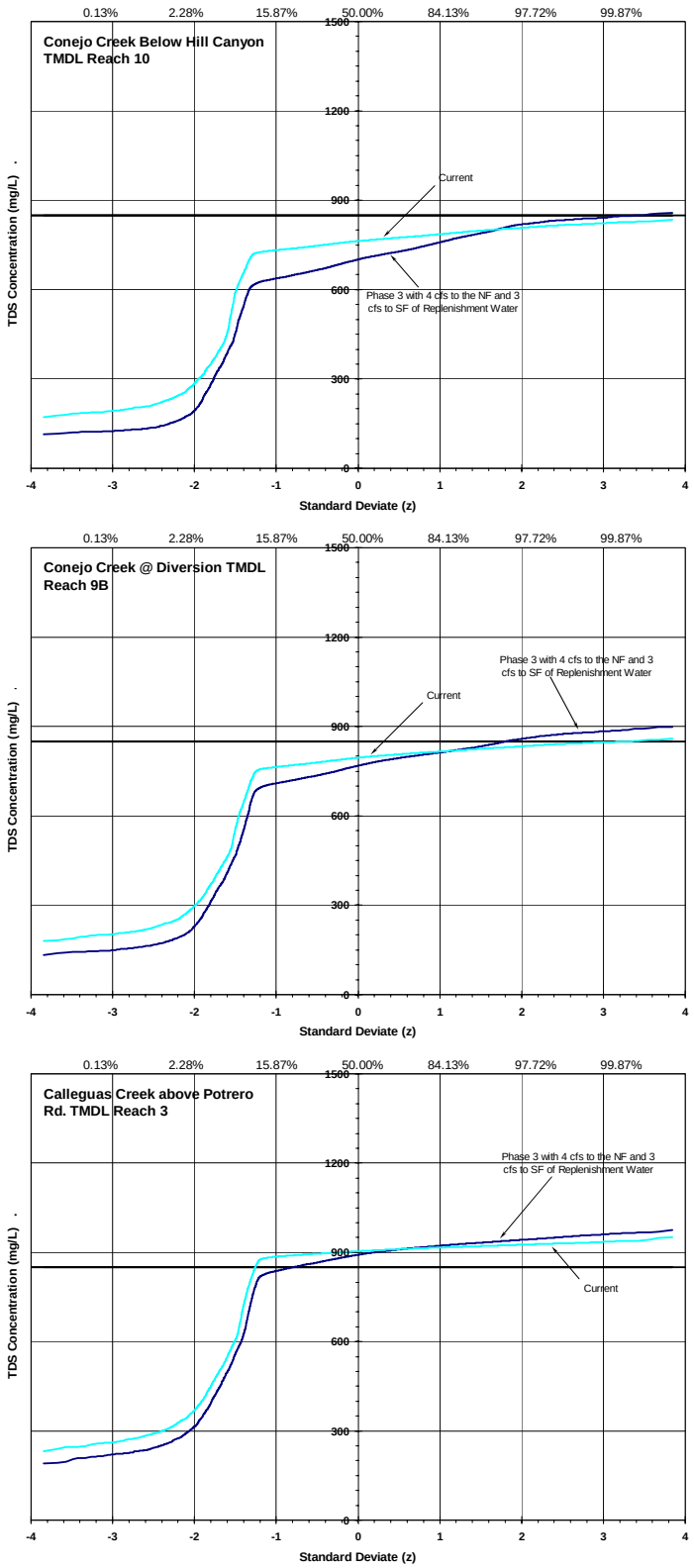

Figure 27: Current and Estimated TDS Probability Distribution of Daily Average Concentrations in Lower Watershed After Implementing Phase 3 of the RWRMP and supplying 4 cfs to the NF and 3 cfs to the SF Arroyo Conejo of Replenishment Water.

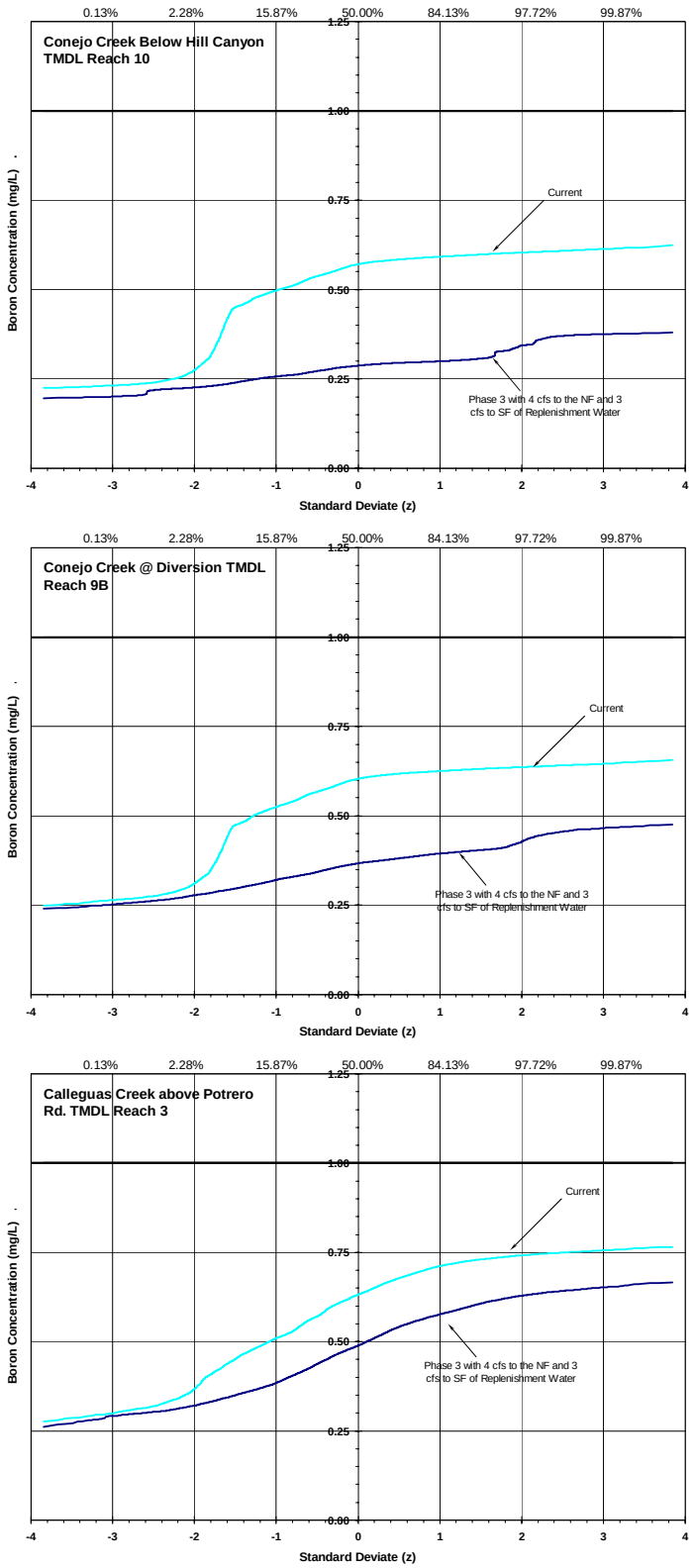

Figure 28: Current and Estimated Boron Probability Distribution of Daily Average Concentrations in Lower Watershed After Implementing Phase 3 of the RWRMP and supplying 4 cfs to the NF and 3 cfs to the SF Arroyo Conejo of Replenishment Water.

For most areas of the watershed, the projects result in compliance with the objectives at least 95% of the time. However, the five percent of the time that the objectives are exceeded tend to be for extended periods of time as a result of drought or large precipitation events rather than spread evenly over time. The exceptions are TDS and sulfate in Arroyo Simi/Las Posas and TDS, chloride, and sulfate above Potrero Rd.

The same analysis was conducted for the Reverse Osmosis Treatment Plan to provide a comparison with the proposed projects. Additionally, the impact of removing the Simi Valley WQCP effluent from the stream was evaluated.

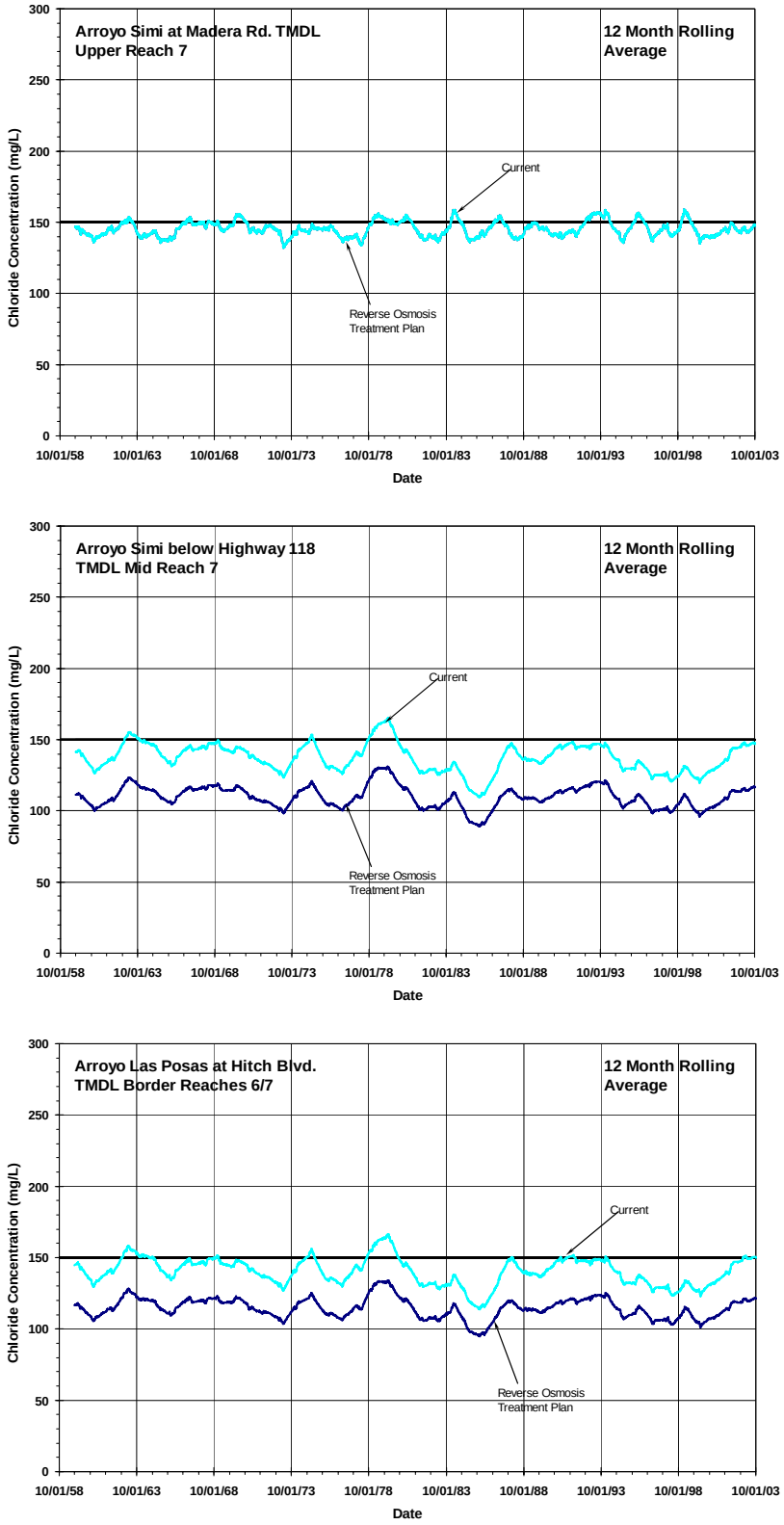

Figure 29: Current and Estimated 12-month Rolling Average Chloride Concentrations in Arroyo Simi for the Reverse Osmosis Treatment Plan.

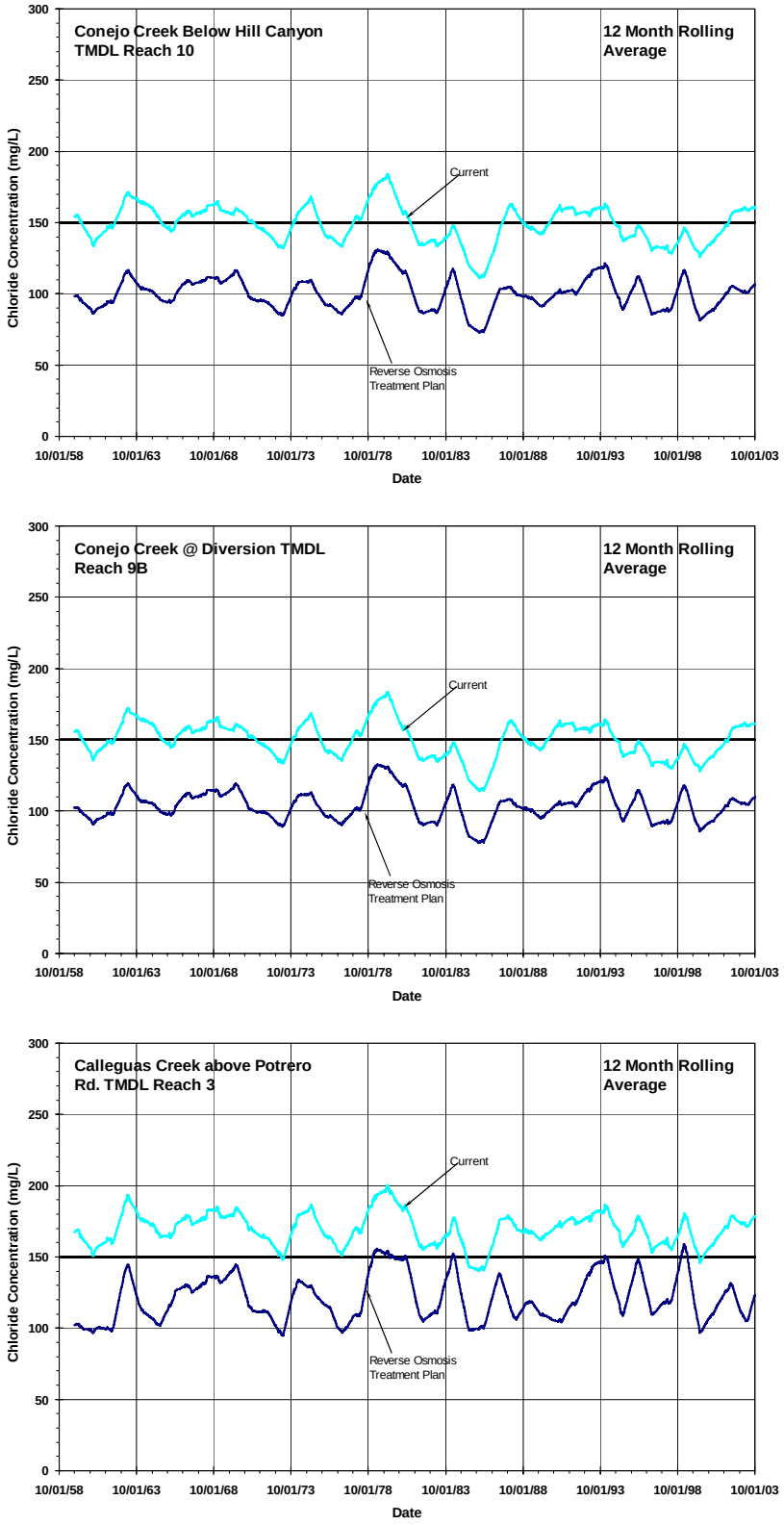

Figure 30: Current and Estimated 12-month Rolling Average Chloride Concentrations in the Lower CCW Reaches for the Reverse Osmosis Treatment Plan.

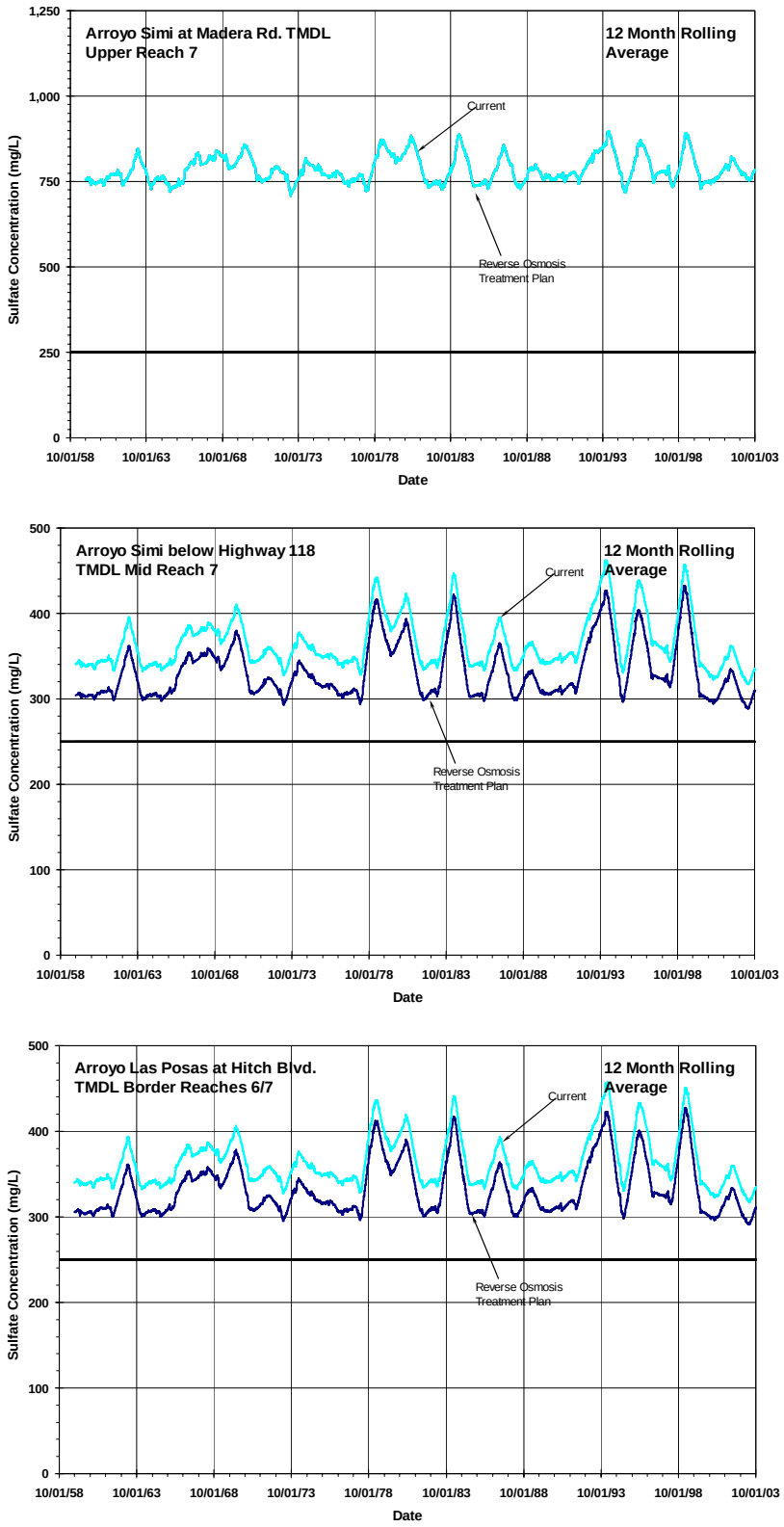

Figure 31: Current and Estimated 12-month Rolling Average Sulfate Concentrations in Arroyo Simi for the Reverse Osmosis Treatment Plan.

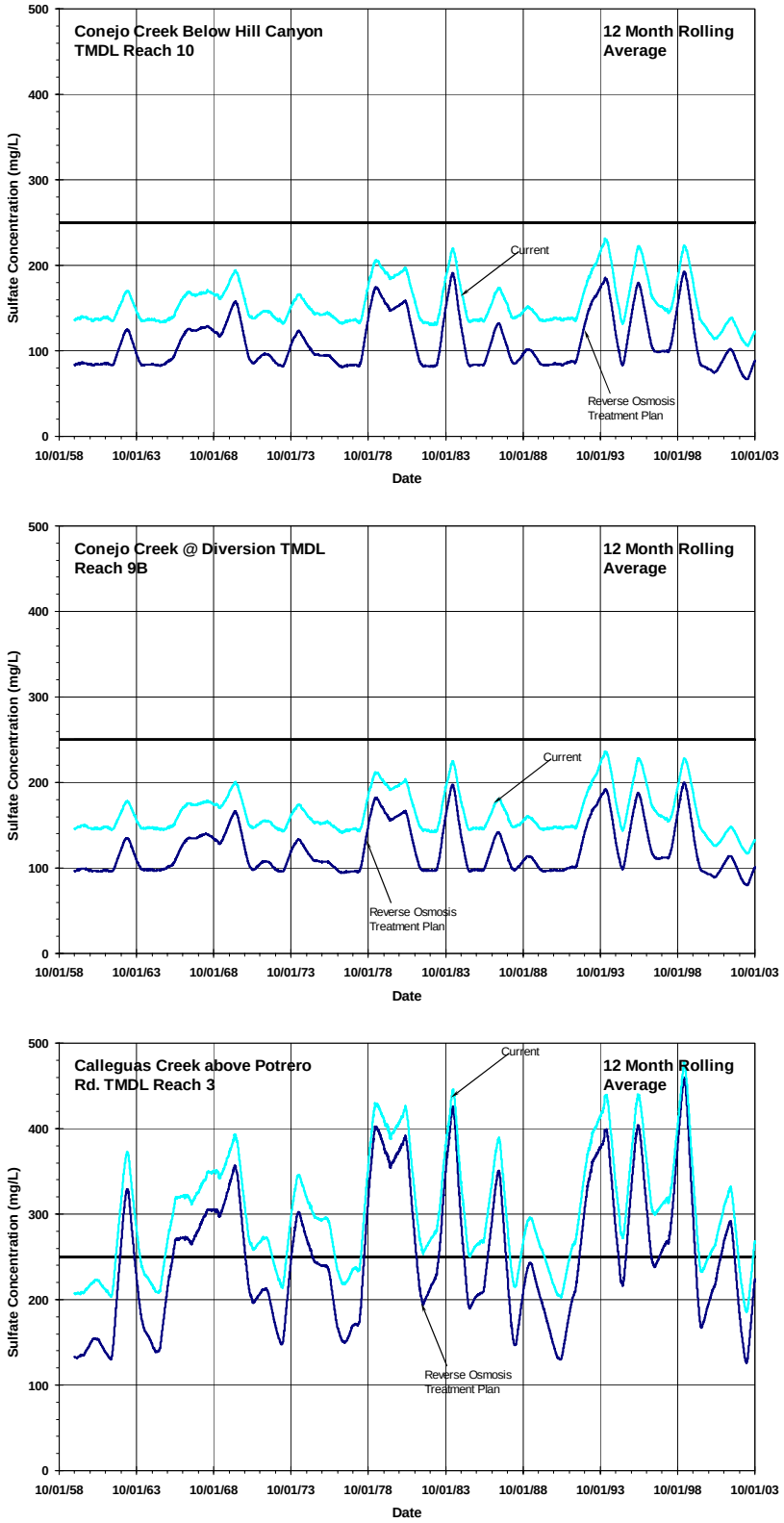

Figure 32: Current and Estimated 12-month Rolling Average Sulfate Concentrations in the Lower CCW Reaches for the Reverse Osmosis Treatment Plan.

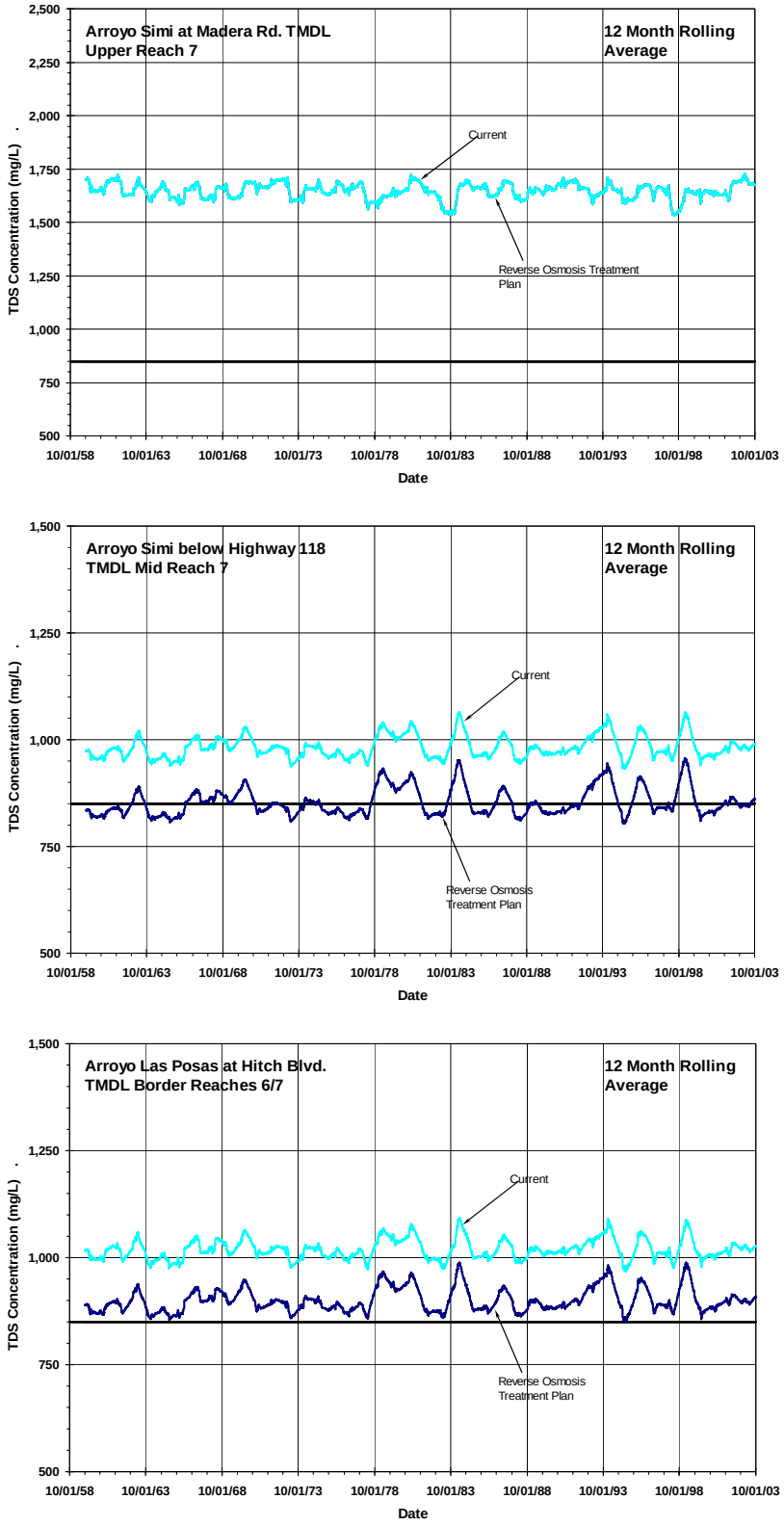

Figure 33: Current and Estimated 12-month Rolling Average TDS Concentrations in Arroyo Simi for the Reverse Osmosis Treatment Plan.

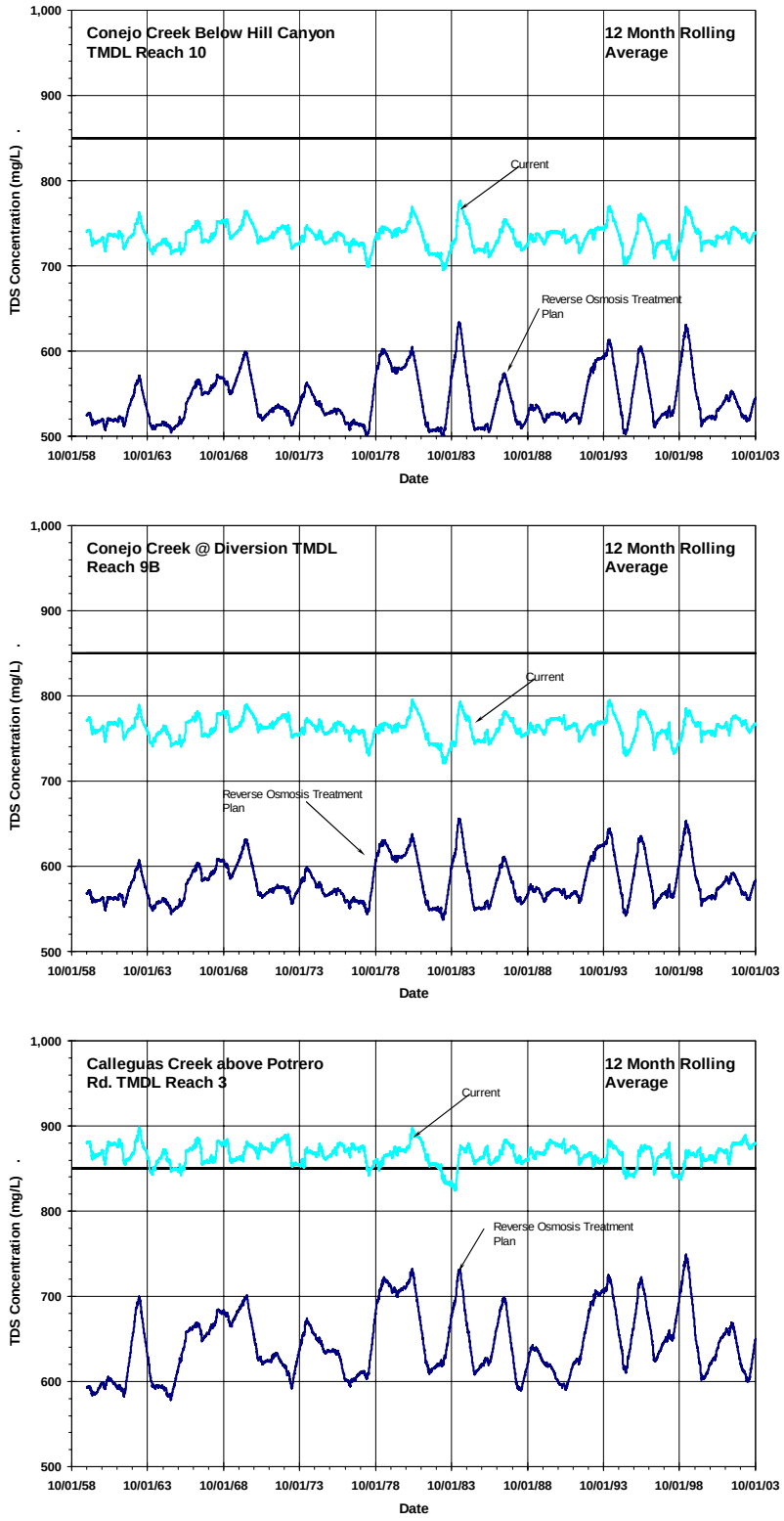

Figure 34: Current and Estimated 12-month Rolling Average TDS Concentrations in the Lower CCW Reaches for the Reverse Osmosis Treatment Plan.

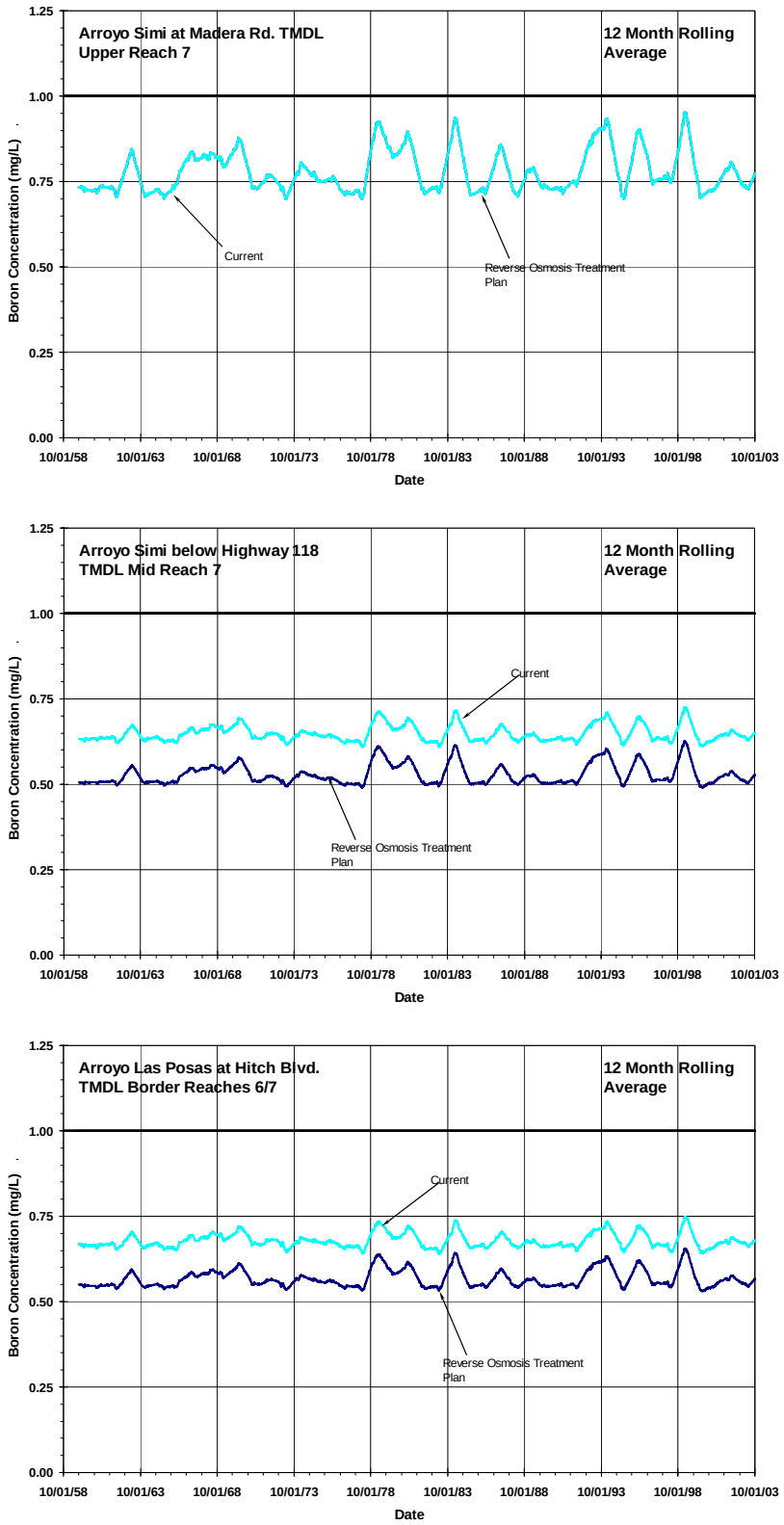

Figure 35: Current and Estimated 12-month Rolling Average Boron Concentrations in Arroyo Simi for the Reverse Osmosis Treatment Plan.

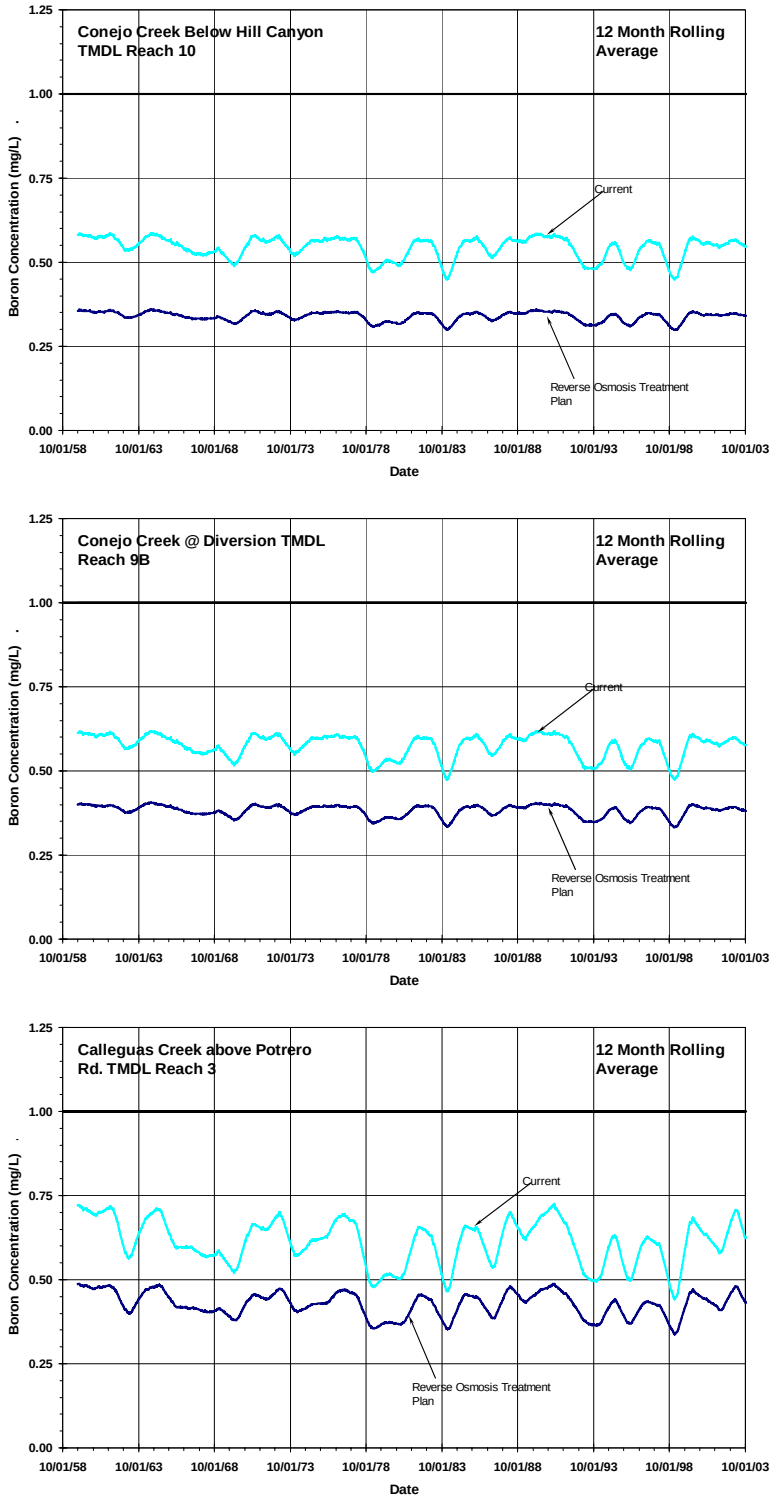

Figure 36: Current and Estimated 12-month Rolling Average Boron Concentrations in the Lower CCW Reaches for the Reverse Osmosis Treatment Plan.

The Reverse Osmosis Treatment Plan reduces surface water concentrations of salts. However, the plan does not result in compliance with the 12 month rolling average under all conditions for all reaches.

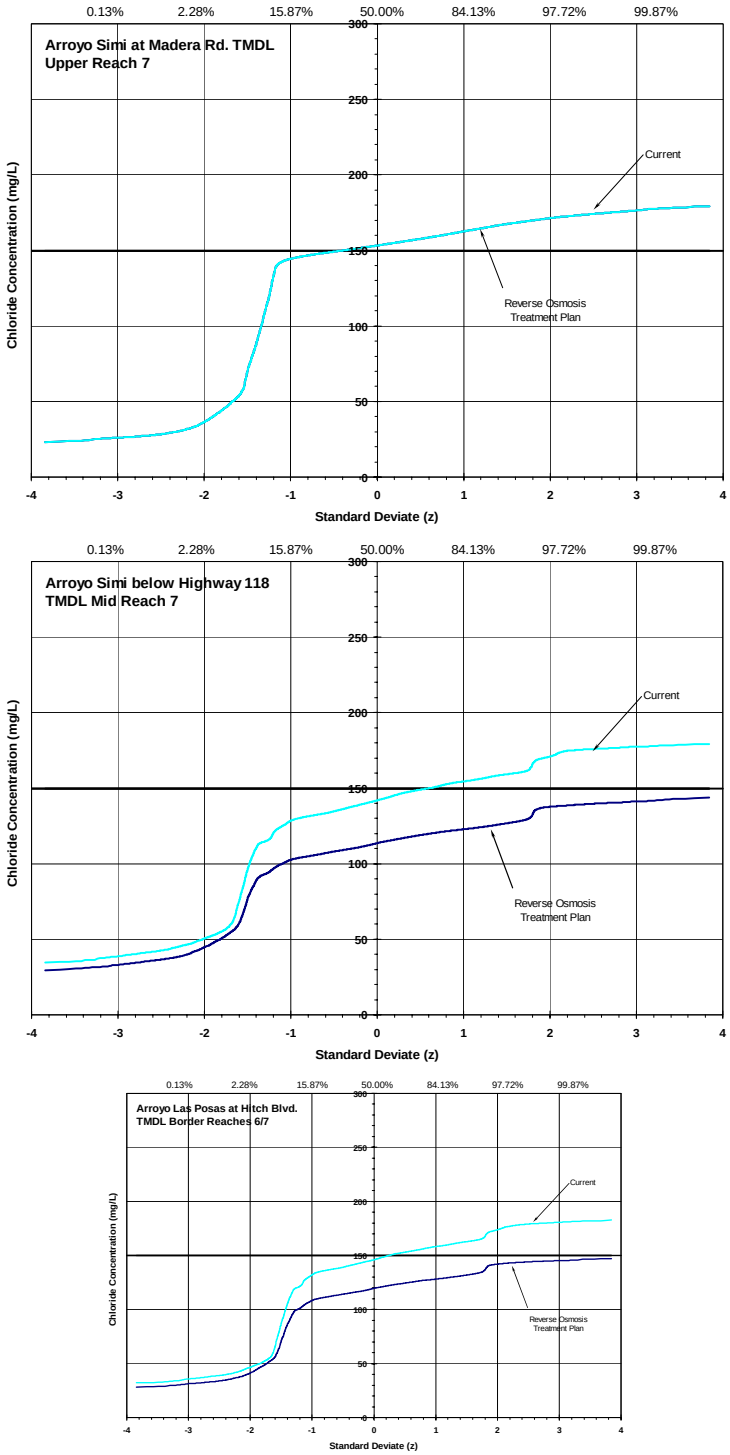

Figure 37: Current and Estimated Probability Distributions of Average Daily Chloride Concentrations in Arroyo Simi for the Reverse Osmosis Treatment Plan.

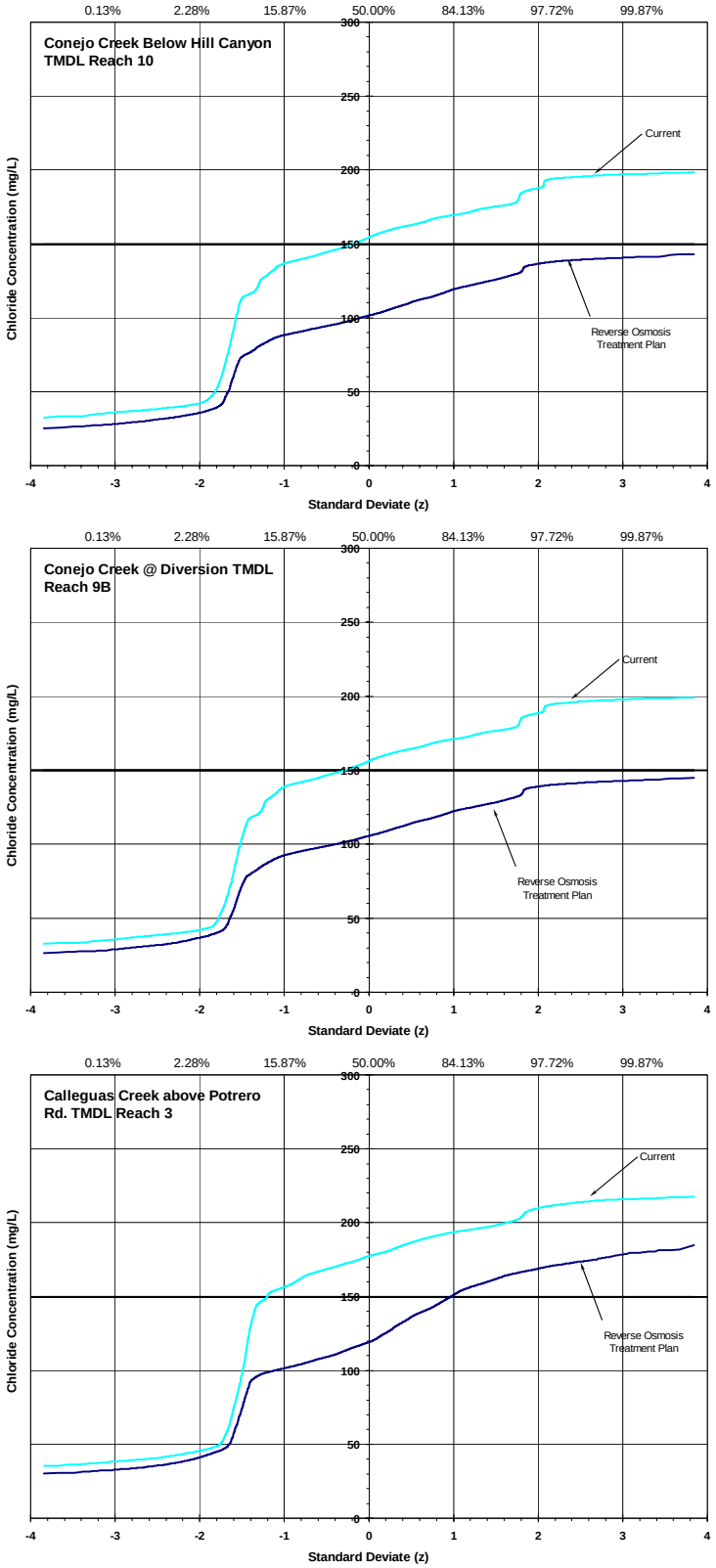

Figure 38: Current and Estimated Probability Distributions of Average Daily Chloride Concentrations in the Lower CCW Reaches for the Reverse Osmosis Treatment Plan.

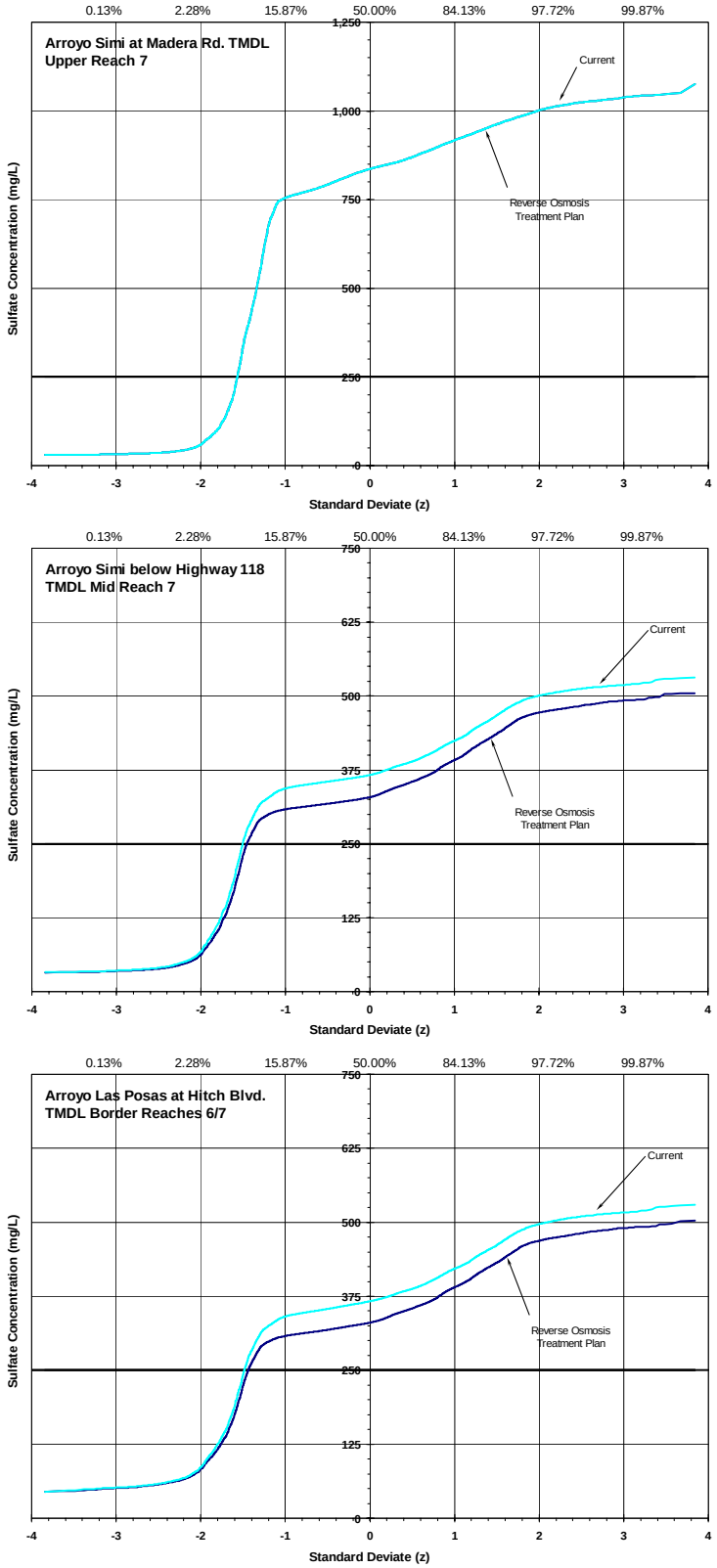

Figure 39: Current and Estimated Probability Distributions of Average Daily Sulfate Concentrations in Arroyo Simi for the Reverse Osmosis Treatment Plan.

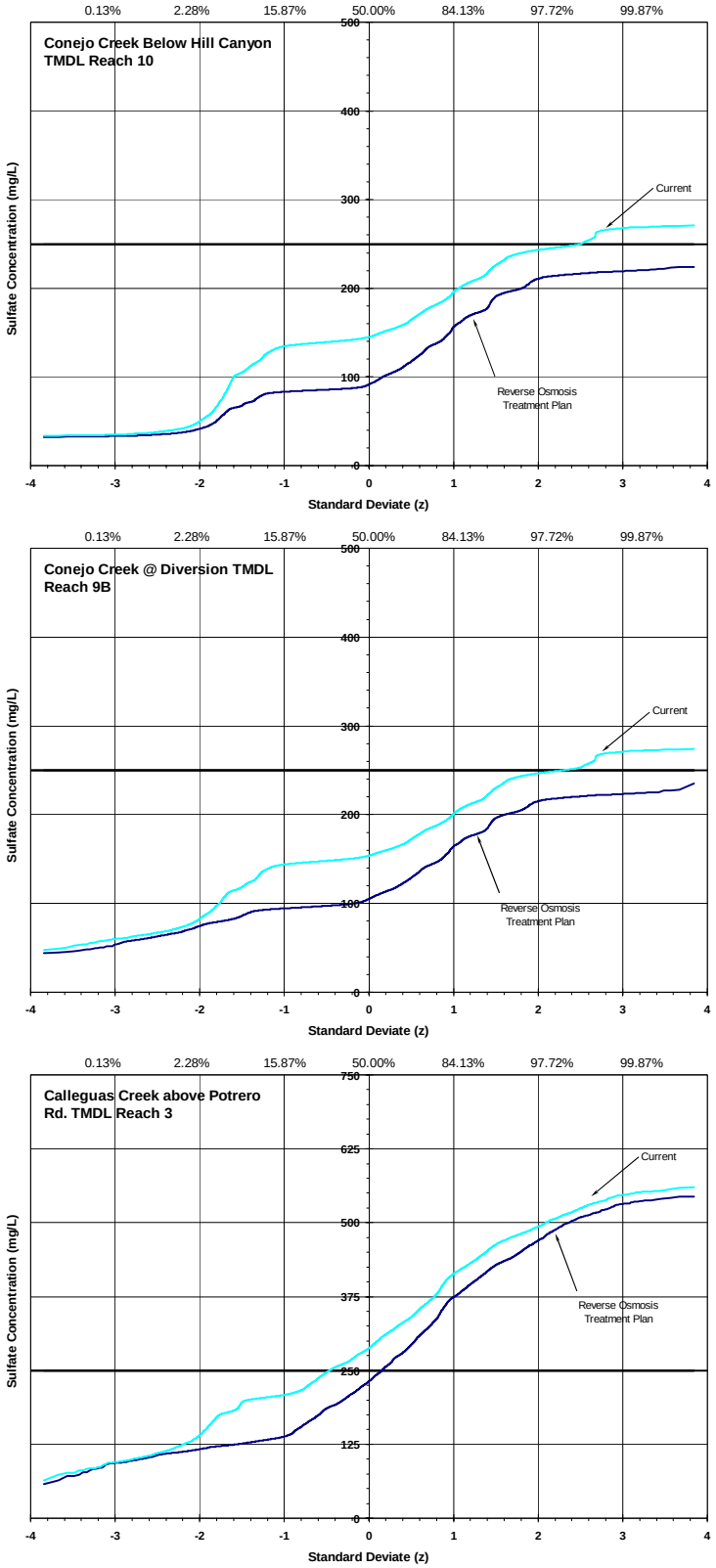

Figure 40: Current and Estimated Probability Distributions of Average Daily Sulfate Concentrations in the Lower CCW Reaches for the Reverse Osmosis Treatment Plan.

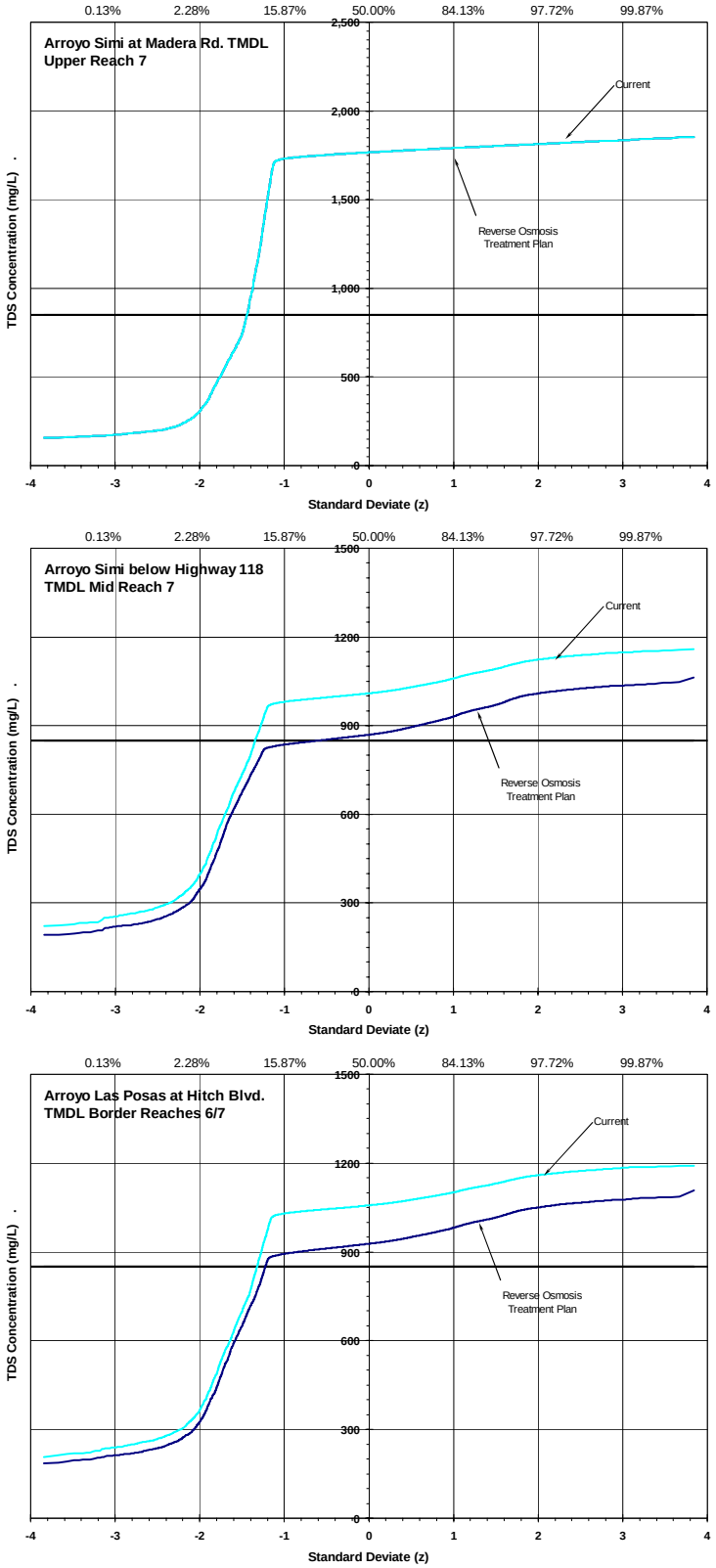

Figure 41: Current and Estimated Probability Distributions of Average Daily TDS Concentrations in Arroyo Simi for the Reverse Osmosis Treatment Plan.

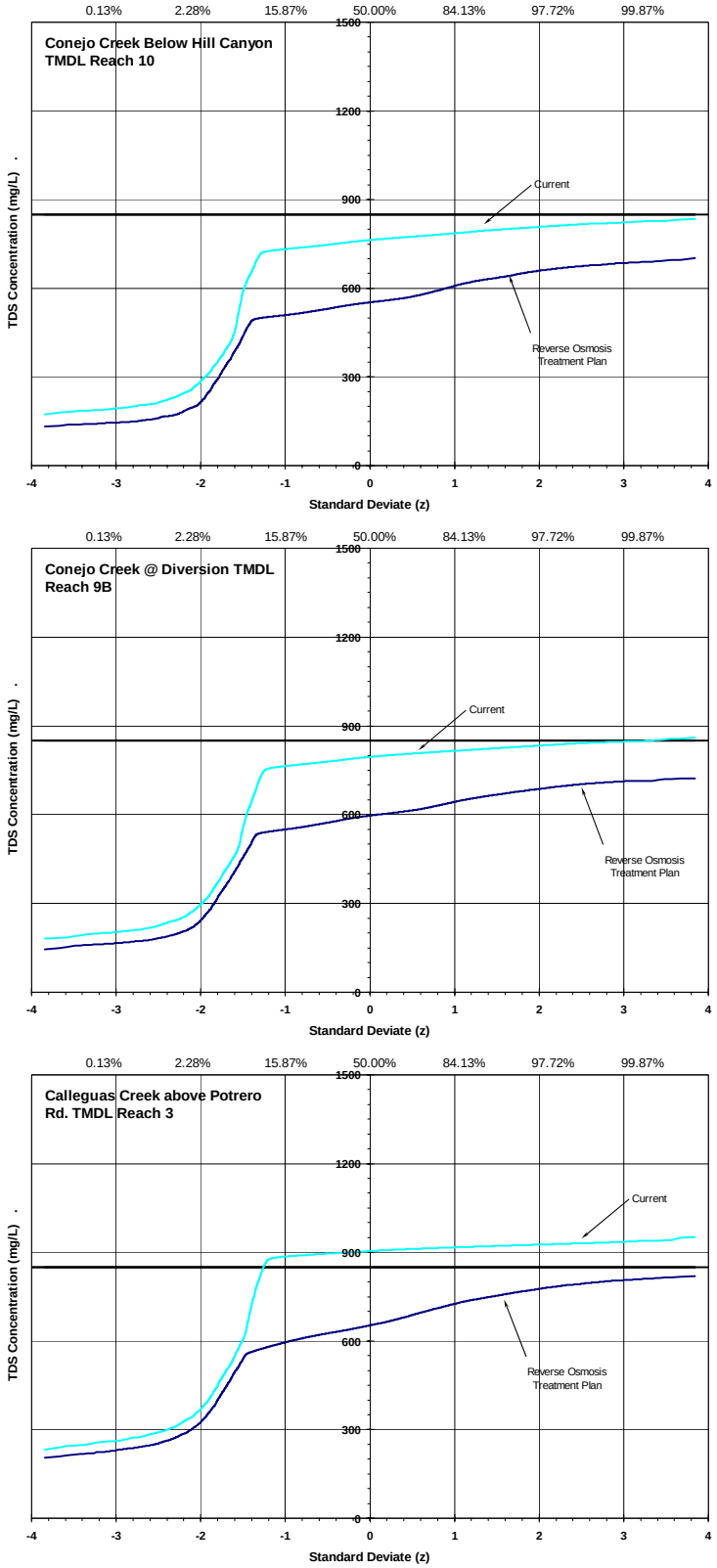

Figure 42: Current and Estimated Probability Distributions of Average Daily TDS Concentrations in the Lower CCW Reaches for the Reverse Osmosis Treatment Plan.

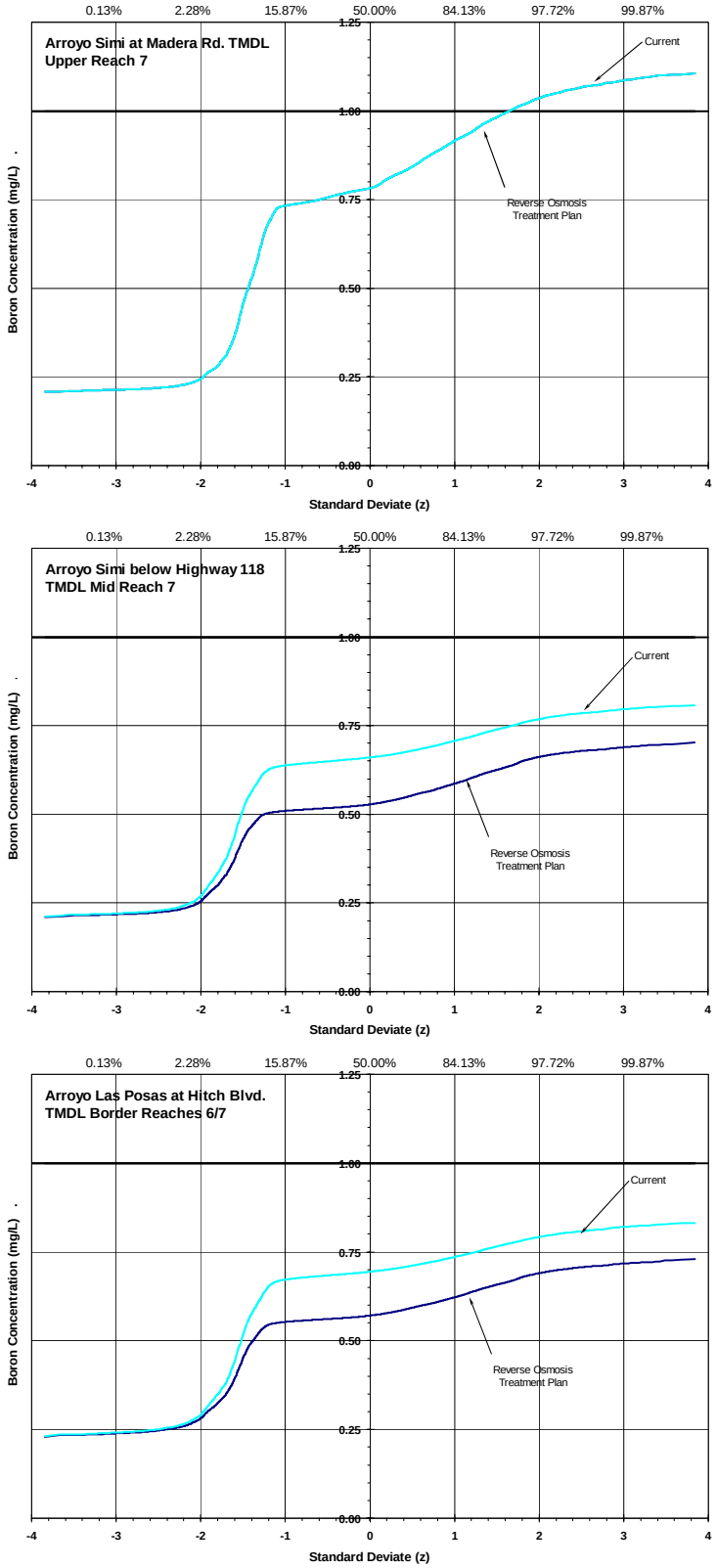

Figure 43: Current and Estimated Probability Distributions of Average Daily Boron Concentrations in Arroyo Simi for the Reverse Osmosis Treatment Plan.

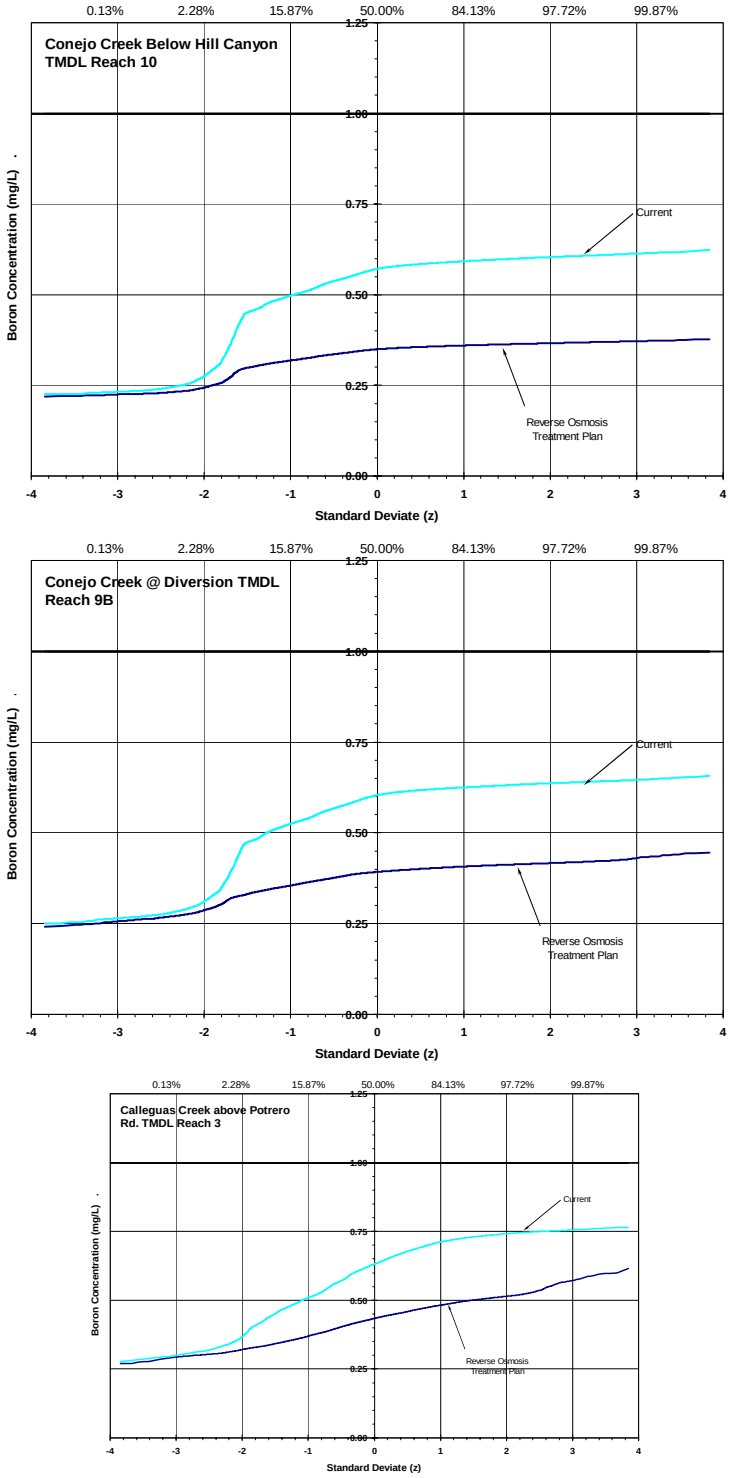

Figure 44: Current and Estimated Probability Distributions of Average Daily Boron Concentrations in the Lower CCW Reaches for the Reverse Osmosis Treatment Plan.

The probability distributions demonstrate that the Reverse Osmosis Treatment Plan will result in compliance with the objectives over 90% of the time for most reaches. However, like the projects, sulfate and TDS will not be in compliance in the Arroyo Simi/Las Posas and chloride, TDS, and sulfate meet objectives much less frequently above Potrero Rd.

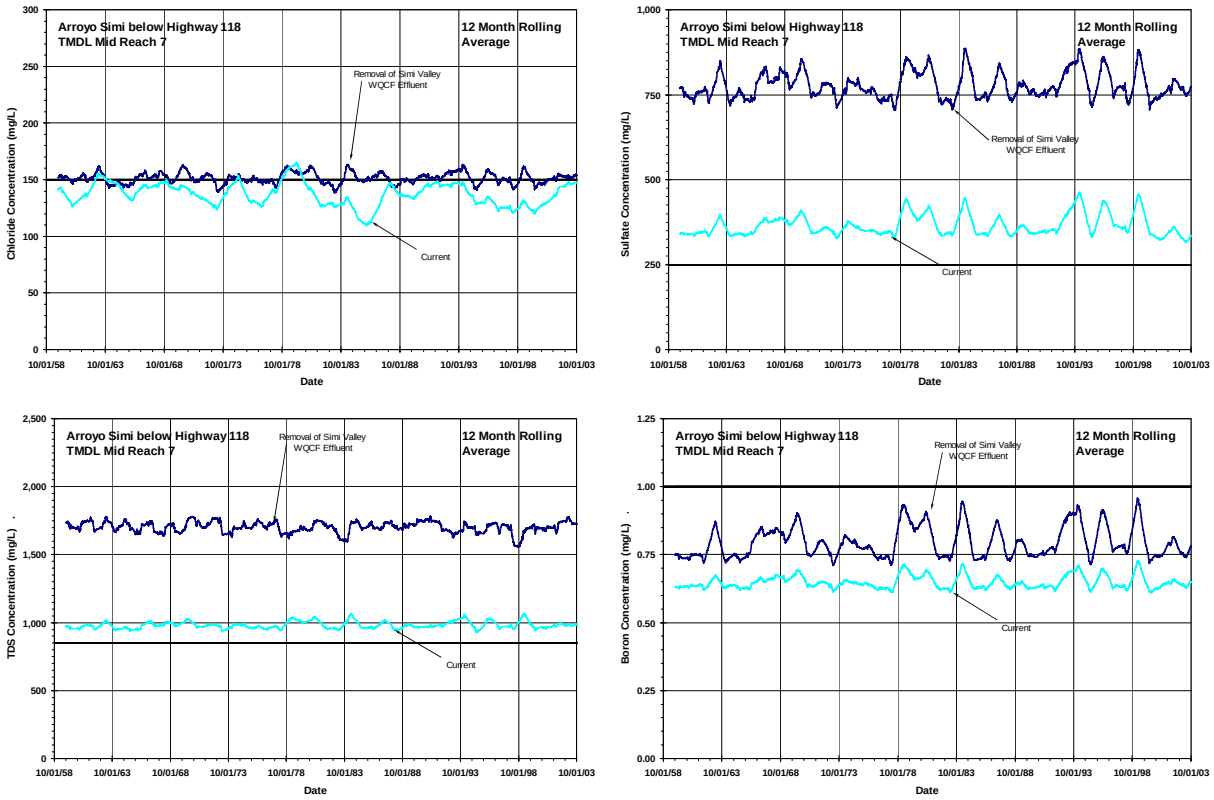

Figure 45. Salts Concentrations in Arroyo Simi at Hwy 118 after Removal of Simi Valley WQCP effluent

The removal of Simi's effluent results in significantly higher concentrations of all salts in the stream downstream of the discharge point. For this reason, this alternative will not be considered in any further analysis of alternatives.

Based on the results of the model, summary tables were developed to show where in the watershed the key objective options are met and exceeded in the watershed after implementation of the projects and the reverse osmosis treatment plan.

Table 22: Objective Status at Locations in the CCW for Current Conditions.[1]

Location	TMDL Reach	Chloride[2]				Sulfate[3]			TDS[4]			Boron[5]		
		D	12	W	C	D	12	W	D	12	W	D	12	W
Upper Watershed														
Arroyo Simi at Madera Rd.	Upper 7	×	×	✓	✓	×	×	×	×	×	×	×	✓	✓
Arroyo Simi below Highway 118	Mid 7	×	×	✓	✓	×	×	×	×	×	×	✓	✓	✓
Arroyo Las Posas at Hitch Blvd.	Border 6/7	×	×	✓	✓	×	×	×	×	×	×	✓	✓	✓
Arroyo Las Posas at Somis	Mid 6	×	×	✓	✓	×	×	✓	×	×	×	✓	✓	✓
Arroyo Las Posas at Seminary Rd.	Lower 6	×	×	✓	✓	×	×	✓	×	×	×	×	×	✓
Lower Watershed														
South Fork Arroyo Conejo	13	×	×	✓	×	×	×	✓	×	×	×	✓	✓	✓
Conejo Creek Below Hill Canyon	10	×	×	×	✓	×	✓	✓	✓	✓	✓	✓	✓	✓
Arroyo Santa Rosa	11	×	×	✓	✓	×	×	✓	×	×	×	×	×	✓
Conejo Creek @ Diversion	9B	×	×	✓	✓	×	✓	✓	×	✓	✓	✓	✓	✓
Conejo Creek at Howard Rd.	9A	×	×	×	✓	×	✓	✓	×	✓	✓	✓	✓	✓
Calleguas Creek above Potrero Rd	3	×	×	✓	✓	×	×	×	×	×	✓	✓	✓	✓
Oxnard Plain														
Revolon Slough	4	×	×	✓	✓	×	×	×	×	×	×	×	×	×

[1] Check indicates reaches meeting the objective, and "x" indicates reaches failing to meet objective.

[2] D = daily concentrations < 150 mg/L, 12 = 12 month rolling average < 150 mg/L, W = 12 month flow weighted average concentrations < 150 mg/L, and C = CCC concentration < 230 mg/L.

[3] D = daily concentrations < 250 mg/L, 12 = 12 month rolling average < 250 mg/L, and W = 12 month flow weighted average concentrations < 250 mg/L.

[4] D = daily concentrations < 850 mg/L, 12 = 12 month rolling average < 850 mg/L, and W = 12 month flow weighted average concentrations < 850 mg/L.

[5] D = daily concentrations < 1.0 mg/L, 12 = 12 month rolling average < 1.0 mg/L, and W = 12 month flow weighted average concentrations < 1.0 mg/L.

Table 23: Objective Status at Locations in the CCW for Banning Future Self-Regenerating Water Softeners and Providing Incentives/Disincentives to Reduce Use of Self-Regenerating Water Softeners.[1]

Upper Watershed Location	TMDL Reach	Chloride[2]				Sulfate[3]			TDS[4]			Boron[5]		
		D	12	W	C	D	12	W	D	12	W	D	12	W
Arroyo Simi at Madera Rd.	Upper 7	×	×	✓	✓	×	×	×	×	×	×	×	✓	✓
Arroyo Simi below Highway 118	Mid 7	×	✓	✓	✓	×	×	×	×	×	×	✓	✓	✓
Arroyo Las Posas at Hitch Blvd.	Border 6/7	×	✓	✓	✓	×	×	×	×	×	×	✓	✓	✓
Arroyo Las Posas at Somis	Mid 6	×	✓	✓	✓	×	×	✓	×	×	✓	✓	✓	✓
Arroyo Las Posas at Seminary Rd.	Lower 6	×	×	✓	✓	×	×	✓	×	×	✓	×	✓	✓

1 Check indicates reaches meeting the objective, and "x" indicates reaches failing to meet objective.
2 D = daily concentrations < 150 mg/L, 12 = 12 month rolling average < 150 mg/L, W = 12 month flow weighted average concentrations < 150 mg/L, and C = CCC concentration < 230 mg/L.
3 D = daily concentrations < 250 mg/L, 12 = 12 month rolling average < 250 mg/L, and W = 12 month flow weighted average concentrations < 250 mg/L.
4 D = daily concentrations < 850 mg/L, 12 = 12 month rolling average < 850 mg/L, and W = 12 month flow weighted average concentrations < 850 mg/L.
5 D = daily concentrations < 1.0 mg/L, 12 = 12 month rolling average < 1.0 mg/L, and W = 12 month flow weighted average concentrations < 1.0 mg/L.

Table 24: Objective Status at Locations in the CCW for Phase 3 with 4 cfs CMWD Imported Water Released to the North Fork and 3 cfs Released to the South Fork of the Arroyo Conejo.[1]

Lower Watershed Location	TMDL Reach	Chloride[2]				Sulfate[3]			TDS[4]			Boron[5]		
		D	12	W	C	D	12	W	D	12	W	D	12	W
South Fork Arroyo Conejo	13	×	×	✓	✓	×	×	✓	×	×	✓	✓	✓	✓
Conejo Creek Below Hill Canyon	10	×	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓
Arroyo Santa Rosa	11	×	×	✓	✓	×	×	✓	×	×	×	×	×	✓
Conejo Creek @ Diversion	9B	×	✓	✓	✓	×	✓	✓	×	✓	✓	✓	✓	✓
Conejo Creek at Howard Rd.	9A	×	✓	✓	✓	×	✓	✓	×	✓	✓	✓	✓	✓
Calleguas Creek above Potrero Rd	3	×	×	✓	✓	×	×	×	×	×	✓	✓	×	✓

1 Check indicates reaches meeting the objective, and "x" indicates reaches failing to meet objective.
2 D = daily concentrations < 150 mg/L, 12 = 12 month rolling average < 150 mg/L, W = 12 month flow weighted average concentrations < 150 mg/L, and C = CCC concentration < 230 mg/L.
3 D = daily concentrations < 250 mg/L, 12 = 12 month rolling average < 250 mg/L, and W = 12 month flow weighted average concentrations < 250 mg/L.
4 D = daily concentrations < 850 mg/L, 12 = 12 month rolling average < 850 mg/L, and W = 12 month flow weighted average concentrations < 850 mg/L.
5 D = daily concentrations < 1.0 mg/L, 12 = 12 month rolling average < 1.0 mg/L, and W = 12 month flow weighted average concentrations < 1.0 mg/L.

Table 25: Objective Status at Locations in the CCW for the Reverse Osmosis Treatment Plan.[1]

Location	TMDL Reach	Chloride[2]				Sulfate[3]			TDS[4]			Boron[5]		
		D	12	W	C	D	12	W	D	12	W	D	12	W
Upper Watershed														
Arroyo Simi at Madera Rd.	Upper 7	×	×	✓	✓	×	×	×	×	×	×	×	✓	✓
Arroyo Simi below Highway 118	Mid 7	✓	✓	✓	✓	×	×	×	×	×	×	✓	✓	✓
Arroyo Las Posas at Hitch Blvd.	Border 6/7	✓	✓	✓	✓	×	×	×	×	×	×	✓	✓	✓
Arroyo Las Posas at Somis	Mid 6	×	✓	✓	✓	×	×	✓	×	×	×	✓	✓	✓
Arroyo Las Posas at Seminary Rd.	Lower 6	×	×	✓	✓	×	×	✓	×	×	×	×	×	✓
Lower Watershed														
South Fork Arroyo Conejo	13	×	×	✓	×	×	×	✓	×	×	×	✓	✓	✓
Conejo Creek Below Hill Canyon	10	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Arroyo Santa Rosa	11	×	×	✓	✓	×	×	✓	×	×	×	×	×	✓
Conejo Creek @ Diversion	9B	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Conejo Creek at Howard Rd.	9A	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Calleguas Creek above Potrero Rd	3	×	×	✓	✓	×	×	×	✓	✓	✓	×	✓	✓
Oxnard Plain														
Revolon Slough	4	×	×	✓	✓	×	×	×	×	×	×	×	×	×

[1] Check indicates reaches meeting the objective, and "x" indicates reaches failing to meet objective.

[2] D = daily concentrations < 150 mg/L, 12 = 12 month rolling average < 150 mg/L, W = 12 month flow weighted average concentrations < 150 mg/L, and C = CCC concentration < 230 mg/L.

[3] D = daily concentrations < 250 mg/L, 12 = 12 month rolling average < 250 mg/L, and W = 12 month flow weighted average concentrations < 250 mg/L.

[4] D = daily concentrations < 850 mg/L, 12 = 12 month rolling average < 850 mg/L, and W = 12 month flow weighted average concentrations < 850 mg/L.

[5] D = daily concentrations < 1.0 mg/L, 12 = 12 month rolling average < 1.0 mg/L, and W = 12 month flow weighted average concentrations < 1.0 mg/L.

As shown in the tables, very few reaches consistently meet the current Basin Plan objectives with these proposed projects or reverse osmosis treatment. However for these proposed projects, the 12 month rolling average is more consistently met for chloride in most reaches, and sulfate and TDS in some reaches. The reverse osmosis treatment plan generally results in similar compliance with chloride objectives as these proposed projects downstream of the POTWs. However, the reverse osmosis plan results in more compliance with TDS and sulfate objectives downstream of the POTWs. Upstream of the Hill Canyon WTP, these projects result in improved water quality whereas the reverse osmosis treatment plan does not impact water quality in the reaches upstream of POTWs. Arroyo Santa Rosa and Revolon Slough consistently do not meet any of the possible objectives because the projects and reverse osmosis treatment do not address those reaches. However, the discontinuation of the Olsen Rd. WTP discharge to the Arroyo Santa Rosa has resulted in minimal if any flows in the reach, and may have resolved the salts impairment for the Arroyo Santa Rosa.

7.3.1.1. Chloride TMDL Model

The Chloride TMDL Model was also used to assess the scenarios shown in Table 21. The following tables summarize the locations in the stream where water quality is modeled and where the instantaneous objectives are met. Because the model is static, 12 month rolling averages and flow-weighted averages cannot be calculated.

Table 26. Reaches Meeting Basin Plan Objective Based on Chloride TMDL Model After Implementation of Final Phase of Projects

	Routine Critical				Long Term Critical			
	Chloride	TDS	Sulfate	Boron	Chloride	TDS	Sulfate	Boron
Conditions, USGS gauge Arroyo Simi	×	×	×	✓	×	×	×	✓
Conditions, outflow to Reach 6	✓	×	×	✓	✓	✓	×	✓
Conditions, USGS gauge Conejo Ck.	✓	✓	✓	✓	✓	✓	✓	✓
Conditions at proposed diversion	✓	✓	✓	✓	✓	✓	✓	✓
Conditions, outflow to Reach 3	✓	✓	✓	✓	✓	✓	✓	✓
Conditions, USGS gauge Potrero Rd.	×	×	×	✓	×	×	×	✓

Table 27. Reaches Meeting Basin Plan Objective Based on Chloride TMDL Model After Implementation of Reverse Osmosis Treatment Plan

	Routine Critical				Long Term Critical			
	Chloride	TDS	Sulfate	Boron	Chloride	TDS	Sulfate	Boron
Conditions, USGS gauge Arroyo Simi	×	×	×	✓	×	×	×	✓
Conditions, outflow to Reach 6	✓	✓	×	✓	✓	✓	×	✓
Conditions, USGS gauge Conejo Ck.	✓	✓	✓	✓	✓	✓	✓	✓
Conditions at proposed diversion	✓	✓	✓	✓	✓	✓	✓	✓
Conditions, outflow to Reach 3	✓	✓	✓	✓	✓	✓	✓	✓
Conditions, USGS gauge Potrero Rd.	×	×	×	✓	×	×	×	✓

Based on the tables above, neither the proposed projects nor the reverse osmosis treatment plan would result in all reaches meeting the Basin Plan objectives under the two defined critical conditions. The proposed projects result in more reaches meeting the chloride and sulfate objectives and fewer reaches meeting the TDS objectives under all conditions. The purpose of using the TMDL Model was to evaluate the results of the CCMS as compared to the model that had been used to adopt the EPA Chloride TMDL. As shown above, the CCMS allows a more detailed analysis of watershed conditions. The CCMS provides information on how often different types of objectives are exceeded in the watershed and how long exceedances last. Also, different averaging periods for the objectives and receiving water concentrations can be examined.

The CCMS model appears to be more conservative than the TMDL model. The TMDL model predicted more reaches would meet the Basin Plan objectives than the CCMS model.

7.3.1.2. Protection of Beneficial Uses

The projects contain provisions for providing alternative water supplies to sensitive agricultural uses as necessary. Additionally, the majority of agriculture uses groundwater as the primary irrigation source. Both projects will be improving the quality of the groundwater basins through pumping and treating poorer quality groundwater and creating room for higher quality storm water flows to recharge the basins.

The Reverse Osmosis Treatment plan protects agriculture that uses irrigation water directly from the stream system. However, it does not address agriculture that uses groundwater as an irrigation source and does not have provisions for providing alternative water supplies. Although groundwater recharge from surface waters would be of higher quality, because the basins are currently full, the recharge would have little impact on the groundwater basins.

7.3.1.3. Ability to Meet EPA Chloride TMDL WLAs

The final analysis of the proposed projects was the ability of the projects to meet the proposed waste load (WLA) and load allocations (LA). For the purpose of this analysis, the only WLA and LAs examined were those that required a reduction in loadings in the TMDL. The WLAs and LAs examined (for drought conditions) are included in the following table along with a summary of those met by the proposed projects.

Table 28. Summary of Project's Ability to Meet the EPA Chloride TMDL WLAs and LAs

Discharge	WLA or LA (lb/day)	Project Meet WLA/LA?	Notes
Simi Dewatering Wells	1200	Yes	The groundwater may be removed from the stream so the WLA would be met if that occurs.
Simi Valley WQCP	9200	Possibly	The estimated reductions in loads from water softener controls have the possibility to result in compliance with the WLAs if they are completely successful.
Moorpark WRP	1600	Yes	Moorpark does not regularly discharge to the stream so the WLA would be met.
Conejo pumped gw	330	No	The projects do not address this source so it is unlikely the WLAs would be met.
Hill Canyon WTP	9700	Yes	Hill Canyon WTP's effluent will be removed from the stream so the WLA will be met.
Camarillo WRP	2200	Yes	Camarillo WRP's effluent will be removed from the stream so the WLA will be met.
Groundwater discharge near Conejo	1000	Unknown	Groundwater in this area will be pumped and treated. If this pumping reduces discharge of groundwater to the stream, then the LA may be met.
Agricultural discharge	1300	No	The projects may improve the quality and reduce the quantity of the water supplied to agriculture in this area, but it is unlikely this will reduce the discharges sufficiently to meet the proposed reductions.
Camrosa WRP	1500	Yes	Camrosa will not discharge to the stream so the WLA will be met.
Groundwater discharge near Camrosa	1500	Unknown	Groundwater in this area will be pumped and treated. If this pumping reduces discharge of groundwater to the stream, then the LA may be met.

7.4. Summary of Project Analysis

Based on the two models examined, the proposed projects will result in an improvement in water quality over current conditions for all reaches influenced by the projects. Upstream of the introduction of higher quality water to the stream in Arroyo Conejo and the Simi Valley WQCP, improvements in water quality will not likely be seen. Additionally, the projects will not significantly impact water quality in Revolon Slough or Arroyo Santa Rosa.

The modeling demonstrates that the projects will not result in compliance with the Basin Plan objectives at all times, but may result in compliance with a 12 month rolling average objective, except for TDS and sulfate in Arroyo Simi and on Calleguas Creek at Potrero Rd. Additionally, the projects will result in significant improvements in local water resources and will improve the salt balance in the watershed.

Although reverse osmosis treatment of wastewater effluent provides some water quality improvements, it will not result in compliance with all salts objectives, does not provide the additional benefits of these proposed projects (such as improvements in local supply), and does not address all of the impacts of salts on beneficial uses. Additionally, reverse osmosis results in significantly less salt removal from the watershed, and requires significant energy resource consumption. The following table compares these additional impacts for these projects and reverse osmosis treatment.

Table 29. Summary of Impacts of Proposed Projects as Compared to Reverse Osmosis Treatment

Impact	Proposed Projects	Reverse Osmosis Treatment
Additional Local Water Resources	30 mgd	None
Pounds of Salt Removed from Watershed (Salt Balance)	370,000 lbs/day	55,000 lbs/day
Ability to Protect Beneficial Uses	Targets the beneficial use impacts	May not address all of the impacts on beneficial uses
Ability to Meet Current Water Quality Objectives in Stream	Will not meet the current objectives in all reaches	Will not meet the current objectives in all reaches
Other Impacts	Requires SSOs	SSOs may be required; Requires large amounts of energy

8. Conclusions

Based on the analysis presented above, the following conclusions and recommendations are made for the water quality objectives, beneficial uses, and implementation projects.

1. The current instantaneous maximum objectives in the Basin Plan are not appropriate for protection of the beneficial uses. It is recommended that analysis be conducted to determine an appropriate averaging period for the Basin Plan objectives.

2. The most sensitive aspects of the beneficial uses (i.e. avocado agriculture) do not occur in all areas of the watershed. It is recommended that the objectives take into account the varying sensitivities of the beneficial uses and naturally occurring conditions in the watershed and site-specific objectives be defined for some reaches in the watershed (specifically Reaches 3,4,5,6, 7, 8,12, and 13 and the upper portions of Reach 7).

3. The proposed projects provide water quality improvement, water resource benefits, and a flexible management approach to allow protection of beneficial uses. Implementation of the proposed projects in combination with the revisions to the water quality objectives listed above are likely to resolve the salts impairments in the watershed.

4. The proposed projects have significant benefits over Reverse Osmosis Treatment including increased local water supplies, higher watershed salt load removal, and more effective mechanisms for protecting beneficial uses.

5. The management plan is consistent with the EPA's chloride implementation plan criteria.

6. The monitoring plan data and the modeling tools that have been developed for the watershed will aid in developing recommendations for site-specific WQ standards where necessary and the criteria for any recommended averaging periods for the concentrations of various salts.

9. Next Steps

Following are the proposed next steps:

1. The CEQA process to implement the management plan for the lower reaches of the CCW has begun and is scheduled for completion early next year.
2. Necessary permit applications will be submitted following completion of CEQA.
3. Implementation of Phase 1 of the lower CCW plan is anticipated to be complete within 3 years.
4. Much of the monitoring portion of Phase1 of the lower CCW plan will be implemented within one year.
5. A SSO Work plan will be developed and submitted to the Regional Board for review and approval. Following approval, work will begin on the development of SSOs for the CCW.
6. The plan anticipates that as phases are implemented and data gathered, it may not be a necessary to develop TMDLs for TDS, sulfates, and boron. However, sufficient data should be available to develop TMDLs if necessary in a timely manner.
7. A second progress report will be provided to the EPA and the LARWQCB in June 2005 that will include the following:
    - Results of additional data gathering and modeling on all salts of concern
    - Detailed schedule for implementation of Phase1 of the lower CCW plan
    - Schedule of tasks related to implementation of Phases 2 and 3 of the lower CCW plan
    - A working watershed salts balance model for the lower reaches to be used as the key salt management tool on the lower watershed.
    - Summary of progress towards developing SSOs
    - Summary of outstanding issues, new developments and recommendations for additional actions.

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Appendix A

Description of CCMS

Technical Memorandum

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SUBJECT: CCMS Computational Element

DRAFT

Introduction

The framework for the salts modeling effort is a numerical mass balance water quality model originally developed for use in the Calleguas Creek nutrient TMDL effort. The spreadsheet-based mass balance model was accepted by State and Federal regulatory authorities for use in the nutrient TMDL process for the Calleguas Creek Watershed (CCW). Recently, the model has been linked to a water quality database and to extensive GIS-based information via a graphical user interface (GUI). The resulting decision support system is called the *Calleguas Creek Modeling System* (CCMS). The GUI permits access to the model, database, and GIS information via on-screen menu selection or mouse clicks on map features, allowing interactive model manipulation, querying of water quality data, and display of numerous layers of geo-referenced data. The GUI allows the user to interactively modify model parameters, evaluate pollution control scenarios, and display results in tabular and graphical form. Data queried from the database may be displayed in tabular or graphical form, or exported to a spreadsheet for manipulation and analysis.

The water quality simulation component of the CCMS is built on a spreadsheet mass balance model. To model the CCW, the entire watershed is divided into 15 subwatersheds based on drainages to sampling locations and significant tributaries. A computational element is assigned to each subwatershed for calculating the changes in stream flow and water quality due to processes present along stream reaches circumscribed by the sub-watersheds. To further facilitate the decision support capabilities of the CCMS, the model is being expanded to accommodate stochastic input, which will allow calculation of the likely distribution of in-stream salts concentrations and allow the CCMS to function in a dynamic modeling capacity. For the remainder of the discussion, dynamic modeling is used in the sense of continuous simulation/Monte Carlo modeling as discussed in the *Technical Support Document for Water Quality-based Toxic Control* commonly referred to as the TSD (EPA, 1991). Calculation procedures used in the dynamic modeling aspect of the CCMS are the focus of the following discussion. Specifically, the CCMS is being

expanded to allow statistical calculation of salts through out the CCW. Salts of interest include: chloride, total dissolved solids (TDS), sulfate, and boron. Hardness is included in the static CCMS, however the limited hardness data available preclude performing dynamic calculations for hardness. The details of both calculation procedures for modeling water flows and salts concentrations as used in both the original static and newly extended dynamic versions of the CCMS are discussed below.

Water Sources and Salts Loading to the Watershed

Precipitation, deep aquifer transfers, and imported water are all major sources of water to the watershed. Because precipitation carries negligible salts (LWA, 2003), deep aquifer and imported water are the major source of salts loading to the watershed (LWA, 2004a). Deep aquifer transfer and use in the CCW are currently addressed in the model as part of the urban and agriculture runoff. Incorporation of precipitation and imported water within the CCMS is discussed below.

Precipitation

Historical records for precipitation are used as input to the CCMS that serve to drive the continuous simulation. Precipitation stations located in the CCW are displayed in Figure 46. General statistics for the stations are listed in Table 30. Polygons are included in Figure 46 representing the area of influence for each station. The CCMS subwatersheds are overlaid on the Figure and the fractions of the total subwatershed area covered by each precipitation station are listed in Table 31. The arithmetic-mean method is used in the model for determining the areal precipitation for each subwatershed (Chow et al., 1988). Areal precipitation values for a subwatershed are calculated by using the percent of subwatershed area listed in Table 31 to form a weighted average of the precipitation measurements recorded at the local gages. As an example, the calculation to determine precipitation for subwatershed 8, corresponding to the Arroyo Santa Rosa, is calculated as Equation (3).

$$\text{precip.subwatershed } 8 = \text{gage}_{141} \cdot 0.0419 + \text{gage}_{192} \cdot 0.6262 + \text{gage}_{227} \cdot 0.2749 + \text{gage}_{49} \cdot 0.0568 \qquad (3)$$

Precipitation driven flows are calculated in the CCMS by the rational method (Chow et al., 1988). Combining the calculated precipitation with the runoff coefficient listed in Table 36, the estimated wet weather runoff from the various land use types in a watershed may be calculated. The fraction of the total subwatershed area comprising the various land use types listed in Table 40 are used to form a weighted average precipitation driven runoff. Runoff from urban, agricultural, and open space land-use areas are calculated separately. Details of the calculations for each land-use type are presented in subsequent sections corresponding to each considered land-use.

For each daily time step, the daily precipitation is calculated and stored using the above procedure for each of the CCMS subwatersheds based on the historic rainfall records. Summaries of available data for each precipitation station are presented in Table 30. The number of consecutive rain days and number of antecedent dry days are calculated and stored for each subwatershed depending on whether there was or was not rain during the previous time step, respectively. Calculation of the consecutive days of rain and antecedent dry days allow for modification of runoff parameters. Details of runoff calculations are provided in the subsequent sections.

Table 30: Precipitation Station General Statistics. See Figure 46 for Station Location within the CCW.

Station ID	Start Date	End Date	Average Annual (in) [a]	Max Daily Precip (in)
128	1/21/1943	2/26/2004	15.20	5.74
141	10/18/1948	3/2/2004	14.58	5.54
154	10/11/1947	3/2/2004	14.71	4.88
169	12/5/1956	3/2/2004	16.24	5.52
177	1/5/1957	3/2/2004	12.71	5.02
187	1/27/1956	2/26/2004	33.20	6.05
188	1/21/1956	3/2/2004	14.97	6.58
189	1/21/1956	2/3/2004	16.01	5.14
190	11/14/1955	2/3/2004	15.31	5.02
191	11/14/1955	2/3/2004	17.47	5.25
192	11/14/1955	2/4/2004	14.04	5.07
193	12/4/1980	2/4/2004	29.26	4.9
194	11/14/1955	2/3/2004	12.93	5.27
196	11/6/1977	2/4/2004	20.23	5.1
206	11/4/1960	2/6/2004	17.23	4.31
219	10/28/1964	2/26/2004	14.43	4.2
223	10/13/1946	1/28/2004	12.07	4.77
227	9/19/1966	2/4/2004	28.49	4.75
234	10/4/1968	2/4/2004	30.50	4.7
238	11/5/1970	2/3/2004	20.85	8.7
239	12/4/1972	9/29/2002	16.46	4.98
242	10/25/1971	2/3/2004	43.16	5.61
250	10/20/1976	2/3/2004	19.68	4.76
259	10/1/1981	1/3/2004	14.07	4.46
263	10/17/1984	2/3/2004	11.87	3.77
3	10/21/1902	7/12/1992	13.22	4.6
49	1/16/1929	1/28/2004	13.68	4.7

[a] Average based on annual precipitation for period of record for individual precipitation stations.

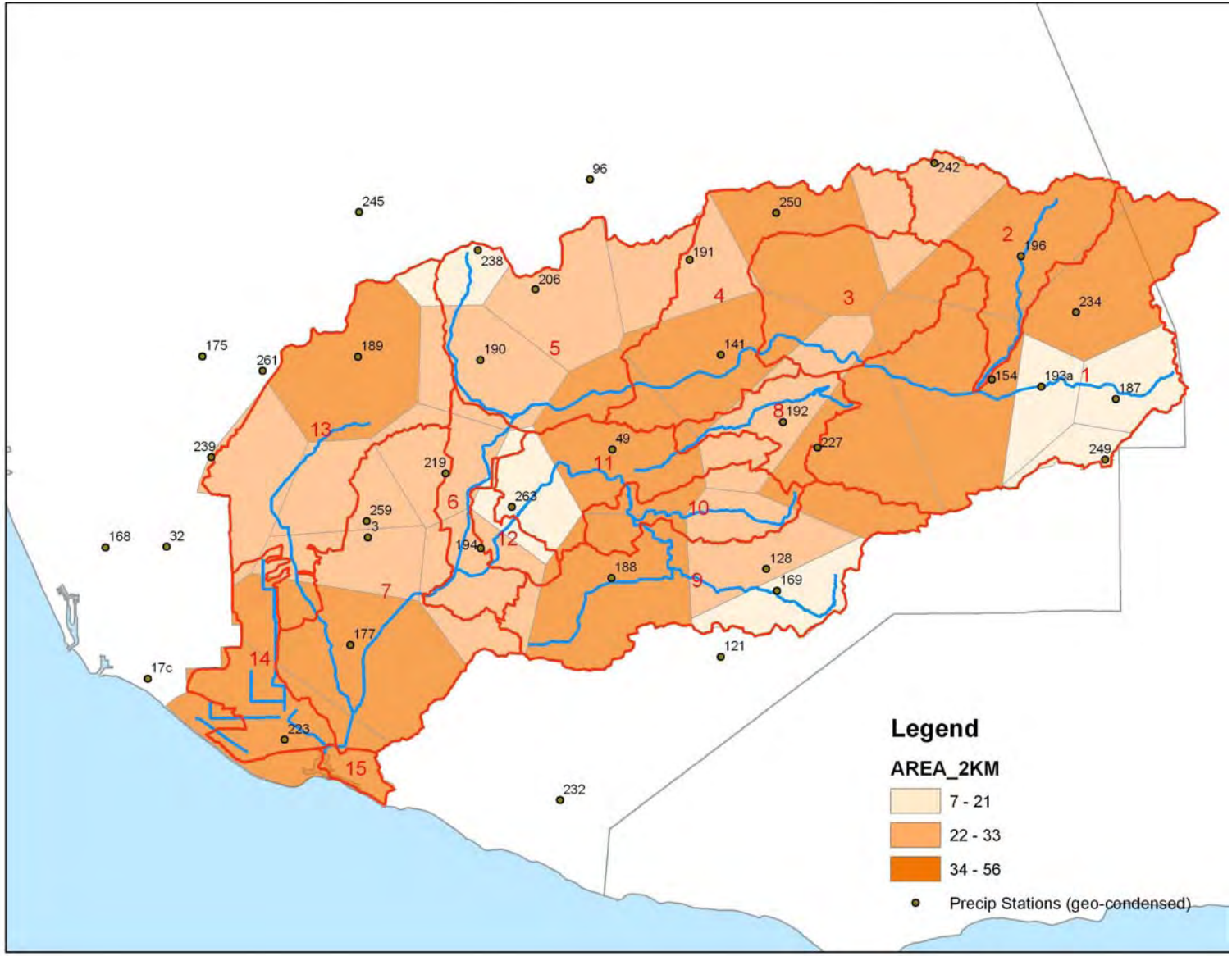

Figure 46: Precipitation Stations in the CCW with Area of Influence Superimposed on CCMS Subwatershed Boundaries.

Table 31: Precipitation Coverage of the CCW Subwatersheds.

Subwatershed [a]	Annual Average Precipitation (in)		Station ID [a]	Percent of Subwatershed
	1984 – 2002	1992 – 2002		
1	16.7	18.4	154	22.23
			187	10.99
			192	0.060
			193a	9.63
			196	18.00
			227	13.08
			234	19.05
			242	6.85
3	17.7	20.0	141	12.5
			154	12.02
			191	0.44
			192	14.71
			196	10.75
			227	1.5
			242	9.12
			250	38.96
4	17.0	19.3	141	38.67
			191	18.22
			192	2.03
			242	10.4
			250	22.9
			49	7.74
5	17.1	19.1	141	1.25
			190	27.01
			191	15.74
			206	33.34
			238	9.82
			263	0.18
			49	12.62
6	13.9	15.6	190	7.98
			194	49.05
			219	37.27
			263	5.69
7	13.7	15.6	177	45.81
			194	11.43
			219	11.45
			223	6.34
			259	24.88 [b]
			3	

continued

Table 31 continued

Subwatershed [a]	Annual Average Precipitation (in)		Station ID [a]	Percent of Subwatershed
	1984 – 2002	1992 – 2002		
8	15.1	16.8	141	4.19
			192	62.62
			227	27.49
			49	5.68
9	15.3	17.2	128	21.38
			169	19.93
			188	42.48
			194	4.05
			227	11.87
10	15.2	16.9	128	39.05
			188	22.06
			192	12.5
			227	7.13
			49	19.26
11	14.1	15.7	188	3.02
			192	11.85
			263	32.34
			49	52.78
12	13.2	14.6	188	8.08
			194	48.22
			219	1.74
			263	41.96
13	15.5	17.7	177	4.29
			189	39.15
			190	6.99
			219	2.98
			238	3.13
			239	23.13
			259	20.31 [b]
			3	
14	13.5	15.5	177	23.38
			223	69.69
			239	2.31
			259	4.61 [b]
			3	
15	13.4	15.3	223	99.72

[a] Subwatershed boundaries and precipitation stations displayed in Figure 46.
[b] Station 3 data used for dates prior to Sept. 30, 1992 and station 259 data used for all latter dates.

As is evidenced by the start dates for the precipitation stations in Table 30, several gages have limited historical records. To facilitate use of all stations in displayed in Figure 46, regressions for precipitation

amounts for stations with limited records based on adjacent stations with richer data sets are used to estimate the unknown precipitations. Developed regressions for each affected station are listed in Table 32. Using the regressions in Table 32 allows simulation of precipitation in the watershed from January 5th, 1957 to January 3rd, 2004. If all gages in one of the regressions report zero precipitation, regression not evaluated, and zero precipitation is used for the estimate.

Table 32: Regressions Estimating Precipitation at Locations Prior to Historical Data. (1)

Station ID	Historical Data Start Date	r^2	Regression(2)
193	Dec. 4, 1980	0.956	$0.6229*gage_{154} + 0.3338*gage_{187} + 0.1664*GausDev$
196	Nov. 6, 1977	0.918	$0.6959*gage_{154} – 0.0049*gage_{187} + 0.7912gage_{191} + 0.2641*GausDev$
206	Nov. 4, 1960	0.972	$0.3191*gage_{189} + 0.3709*gage_{190} + 0.3550*gage_{191} + 0.142*GausDev$
219	Oct. 28, 1964	0.937	$0.3103*gage_{190} + 0.5434*gage_{194} + 0.1357*gage_{3} + 0.176*GausDev$
227	Sep. 19, 1966	0.920	$0.4070*gage_{128} + 0.1223*gage_{169} + 0.4142*gage_{192} + 0.120*GausDev$
234	Oct. 4, 1968	0.943	$0.5325*gage_{154} + 0.3916*gage_{187} +0.1861*GausDev$
238	Nov. 5, 1970	0.874	$0.5508*gage_{189} + 0.3166*gage_{190} + 0.3735*gage_{191} + 0.364*GausDev$
239(3)	Dec. 4, 1972	0.936	$0.5294*gage_{189} + 0.2136*gage_{190} + 0.2621* gage_{3} + 0.195*GausDev$
242	Oct. 25, 1971	0.916	$0.1306*gage_{154} + 0.2758*gage_{187} + 0.7912*gage_{191} + 0.292*GausDev$
250	Oct. 20, 1976	0.965	$0.1733*gage_{141} + 0.9116*gage_{191} + 0.175*GausDev$
263	Oct. 17, 1984	0.935	$0.7422*gage_{194} + 0.1166*gage_{49} + 0.146*GausDev$

(1) Listed regressions valid from January 5, 1957 to date listed in "Historical Data Start Date".
(2) Calculation performed only if at least one station in regression listed greater than zero precipitation.
(3) Regression also used post September 29, 2002.

Imported Water Supplies

Imported water from the State Water Project and Freeman Diversion are accountable for essentially all the imported surface water. Deep groundwater wells drawing water from the lower confined aquifer underlying the CCW are producing water from the Fox Canyon Aquifer which is replenished with water from outside the watershed. Currently, only State Water Project water delivered from the Calleguas Municipal Water District is considered explicitly in the dynamic CCMS.

Water delivery rates to the subwatersheds in the CCW should influence the dry-weather urban and agricultural runoff rates. Typically, in the summer months, water deliveries far exceed the winter month deliveries. The seasonal variations will be included in future versions of the CCMS.

Water quality of the source water directly influences the water quality of POTW effluents, which are major inputs to the surface waters in the CCW. Where possible, regression relations are used in the dynamic CCMS to estimate POTW effluent salts concentrations based on Jensen Road water plant salts water quality. Direct use of historical source water quality from the Jensen Road water plant is used in the dynamic model when data are available. Monthly monitoring data for chloride, sulfate, and TDS are used as constant water quality for each month where data are available. Quarterly monitoring of boron is used as constant water quality of each quarter where data are available. Chloride and sulfate concentrations measured at the Jensen Plant are presented in Figure 47. All salts data for the Jensen Plant are displayed in Figure 48. Regressions between source water quality and POTW effluent quality for chloride and sulfate

were statistically sound and included in the dynamic CCMS. The equations used to relate imported water quality to POTW effluent are detailed in the POTW section below.

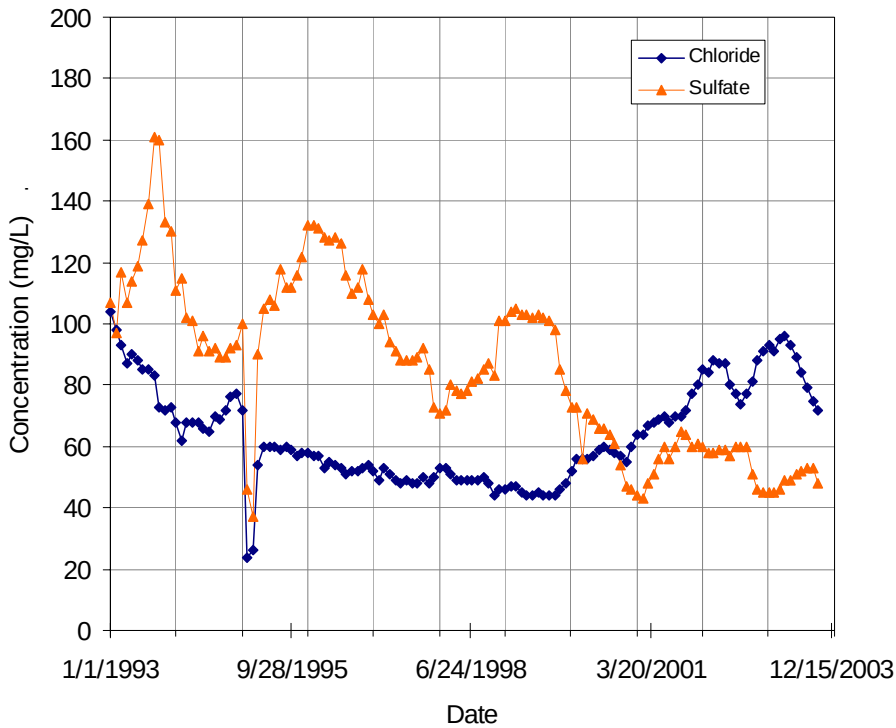

Figure 47: Chloride and Sulfate Concentrations Measured at the CMWD Jensen Plant.

Because the State Water Project water originates in the Sacramento Delta, regressions of water quality with the precipitation levels in Sacramento were investigated. Only the annual average concentration of chlorides exhibited reasonably strong correlation with Sacramento precipitation. For modeling dates prior to the range of available measured water quality, distributions are used to estimate TDS, sulfate, and Boron, Equations (4) - (6), respectively. The developed regression used to estimate chloride concentration based on the average of the second and third previous annual precipitation measurements in Sacramento, CA is presented as Equation (7).

$$\mathrm{TDS}_{\mathrm{supply}} = 328.65 \cdot exp\{0.142 \cdot \mathrm{GausDev}\} \tag{4}$$

$$\mathrm{SO}_4^{2-}{}_{\mathrm{supply}} = 81.02 \cdot exp\{0.348 \cdot \mathrm{GausDev}\} \tag{5}$$

$$\mathrm{B}^{-}_{\mathrm{supply}} = 0.263 \cdot exp\{0.246 \cdot \mathrm{GausDev}\} \tag{6}$$

$$\mathrm{Cl}^{-}_{\mathrm{supply}} = 277.92 - 71.11 \cdot ln\left(\frac{\mathrm{precip}_{\mathrm{Sac-2}} + \mathrm{precip}_{\mathrm{Sac-3}}}{2.0}\right) + 9.70 \cdot \mathrm{GausDev} \tag{7}$$

The "GausDev" is a standard normal random number used to account for the uncertainty in the regression. The relationship for chloride concentration in the State Import Water is plotted in Figure 49 for years 1950

to 2003. Determination of POTW effluent quality from the Jensen Plant water quality is discussed below in the POTW subsection. The relationships in Equations (4) - (7) are plotted in Figure 50.

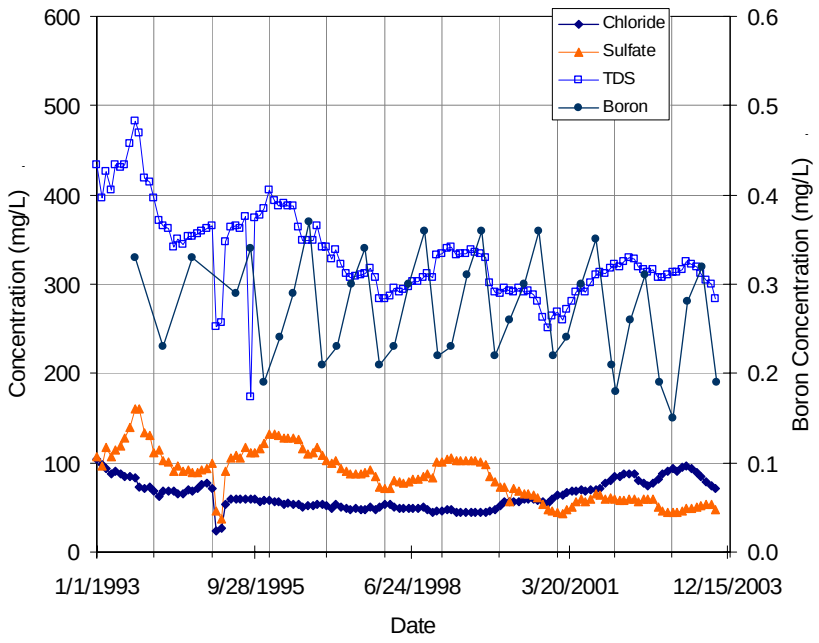

Figure 48: Concentrations of All Salts Species as Measured at the Jensen Plant.

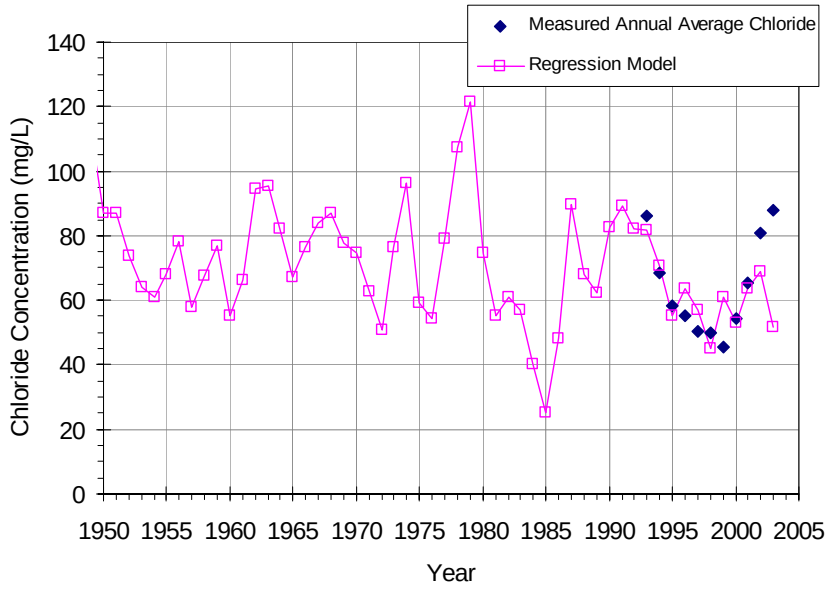

Figure 49: State Import Water Chloride Concentration Regression Based on Annual Precipitation in Sacramento, CA.

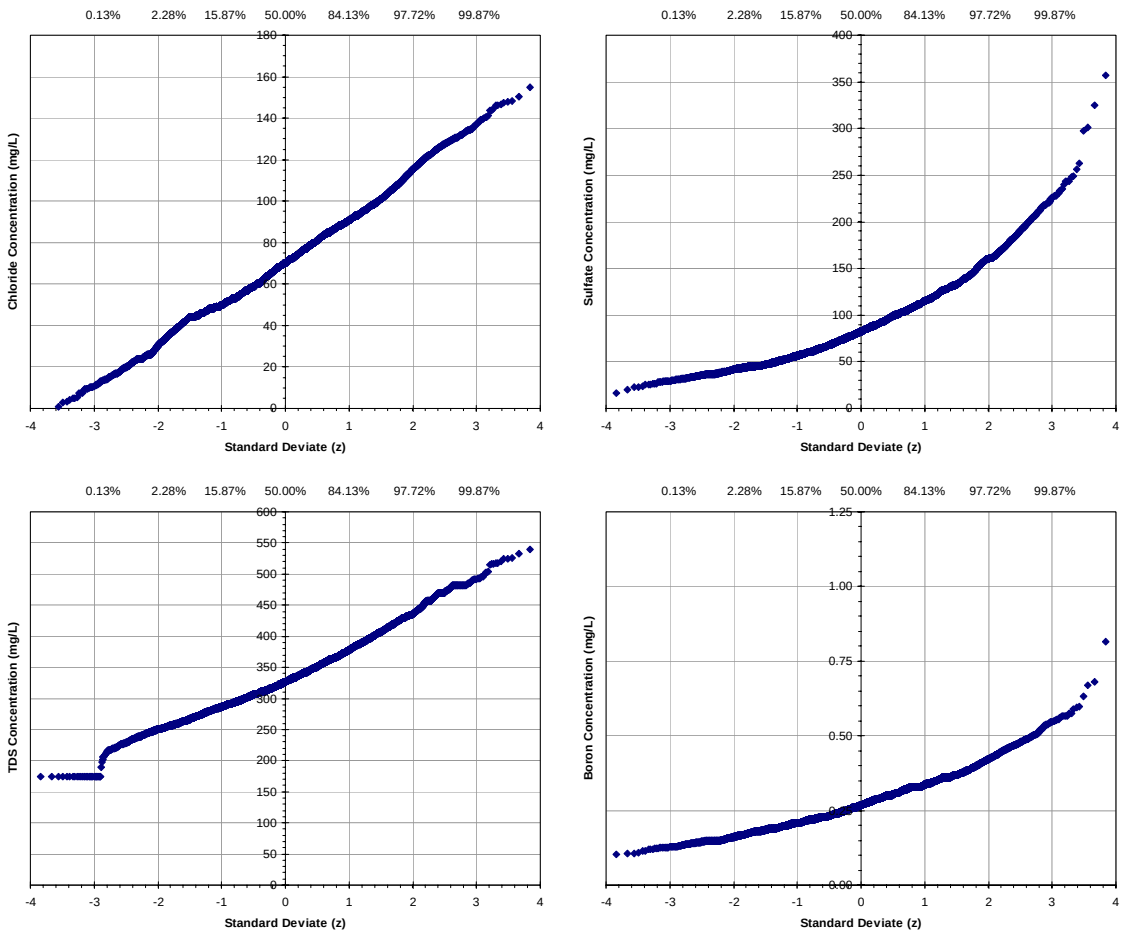

Figure 50: Probability distributions for State Import Water quality as used in the Dynamic CCMS.

Computational Element

Each computational element balances the inflow and outflow of water and mass with conservation equations to calculate changes in in-stream flow and concentration across a subwatershed. The computational elements used by the CCMS to model conditions in the CCW are displayed in Figure 46. Over each time step, the stream reach within any subwatershed is assumed to behave as a steady-state complete-mix reactor. Because of the relatively short reach length, stream geometry, and daily time step; flows can be considered in equilibrium on a daily basis, so long as the routing of peak flows is not of critical importance. Assuming that each subwatershed behaves as a complete-mix reactor implies that the in-stream concentration is constant at all locations within a subwatershed (Tchobanoglous and Schroeder, 1985). Because the concentration is modeled as constant for the entire reach, all withdrawals from the reach, including the discharge to the downstream reach will have the same concentration by definition. A schematic of the computational element is displayed in Figure 12. Each input and output considered in the CCMS is represented in Figure 12 with an arrow pointing into the reach for additions, and pointing out from the reach to represent withdrawals. In Figure 12, flows from upstream reaches enter from the right and flow to downstream reaches exit to the left. Details of the flows are discussed in subsequent subsections.

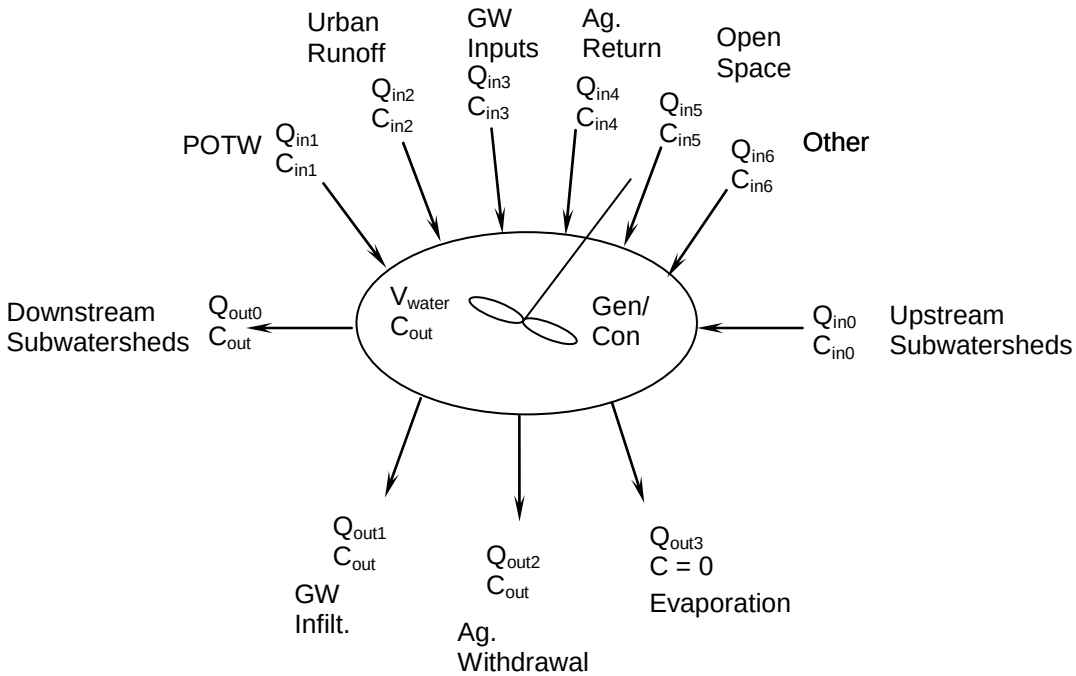

Figure 51: Schematic of Inputs and Outputs for a General Computational Element used in the CCMS Mass Balance Model to Estimate Water Flow and Quality within Surface Water Reaches.

Mass Balance Calculations

To calculate the stream discharge flow and in-stream concentration for a computational element, all inflow rates and concentrations must be specified along with all other of the outflow rates. Normally, the outflow to the downstream reach will be calculated with the conservation of flow equation. If all inflow rates and concentrations, and outflow rates are known, the in-stream concentration may be calculated. Because of the complete-mix assumption, the concentration in the outflows will equal the in-stream concentration, except in the case of evaporation (Tchobanoglous and Schroeder, 1985), where only water is assumed to be removed from the system by evaporation implying that the concentration of salts in evaporated water is equal to zero. The general conservation law is captured in Equation (1).

$$\text{accumulation} = \text{in} - \text{out} + \text{generation} \tag{8}$$

Each of the daily time steps is assumed to be in steady-state. By making the steady-state assumption the ability to model peak flood routing is lost; however because of the relatively small size of the CCW, a smaller time step than one day would be required to capture a flood wave moving through the watershed. The steady assumption specifies no accumulation of flow or mass in the surface water within a subwatershed, simplifying the mass balance equation by setting the left hand side of Equation (1) to zero, in effect requiring the sum of the inputs to equal the sum of the outputs plus and generation within the

subwatersheds (Tchobanoglous and Schroeder, 1985). However, for the case of salts, the assumption is made that no generation or consumption occurs in any of the subwatersheds, further simplifying (1) to Equation (2).

$$\text{in} = \text{out} \tag{9}$$

Referencing Figure 12, and setting the sum of all inflows equal to the sum of all outflows the flow balance for each subwatershed may be defined by Equation (10). Flows discharged downstream from the computational element may be calculated using algebra to solve Equation (10) for the flowrate leaving the subwatershed, Q_{out0}., yielding Equation (11).

$$Q_{in0} + Q_{in1} + Q_{in2} + Q_{in3} + Q_{in4} + Q_{in5} + Q_{in6} = Q_{out0} + Q_{out1} + Q_{out2} + Q_{out3} \tag{10}$$

$$Q_{out0} = Q_{in0} + Q_{in1} + Q_{in2} + Q_{in3} + Q_{in4} + Q_{in5} + Q_{in6} - Q_{out1} - Q_{out2} - Q_{out3} \tag{11}$$

The salt concentration within the subwatershed may be calculated by inserting the mass loadings indicated in Figure 12 into the conservation of mass equation, Equation (2), while recalling that the concentrations are equal for all outflows, except evaporation which by definition equals zero. The conservation of mass equation for a computational element is given by Equation (12). Rearranging Equation (12) for the outflow concentration yields Equation (13).

$$\begin{aligned} &C_{in0}Q_{in0} + C_{in1}Q_{in1} + C_{in2}Q_{in2} + C_{in3}Q_{in3} + C_{in4}Q_{in4} + C_{in5}Q_{in5} + C_{in6}Q_{in6} \\ &= C_{out}Q_{out0} + C_{out}Q_{out1} + C_{out}Q_{out2} + (0)Q_{out3} \end{aligned} \tag{12}$$

$$C_{out} = \frac{C_{in0}Q_{in0} + C_{in1}Q_{in1} + C_{in2}Q_{in2} + C_{in3}Q_{in3} + C_{in4}Q_{in4} + C_{in5}Q_{in5} + C_{in6}Q_{in6}}{Q_{out0} + Q_{out1} + Q_{out2}} \tag{13}$$

In general, the derived equations listed above will hold for each of the subwatersheds in the CCW, but not all flows will be present for each reach and if not present would be set to zero. Derivations of the individual flows are presented in the following sections.

Upstream Subwatersheds

Inflow and mass loading from the upstream subwatershed are added as inputs to the computational element. If the sub-watershed is located at the top of a stream's drainage, there will be no upstream subwatershed and the CCMS will assign a 0.0 for the flow and mass loading. If multiple upstream subwatersheds contribute to the computational element, the sum of the upstream outflows and sum of the mass loadings are inserted in Q_{in0} and $C_{in0}Q_{in0}$. A definition sketch of the case where multiple upstream reaches contribute to the computational element is displayed in Figure 52. The inflow to the computational element is a simple sum of the flowrates from the upstream reaches, as indicated in Equation (14).

$$Q_{in0} = Q_{out0\,A} + Q_{out0\,B} \tag{14}$$

The inflow of mass and concentration of the inflow are calculated in Equation (15), which may be rearranged into Equation (16) for calculating the concentration in the inflow.

$$C_{in0}Q_{in0} = C_A Q_{out0\,A} + C_B\, Q_{out0\,B} \tag{15}$$

$$C_{in0} = \frac{C_A Q_{out0\,A} + C_B\, Q_{out0\,B}}{Q_{in0}} \tag{16}$$

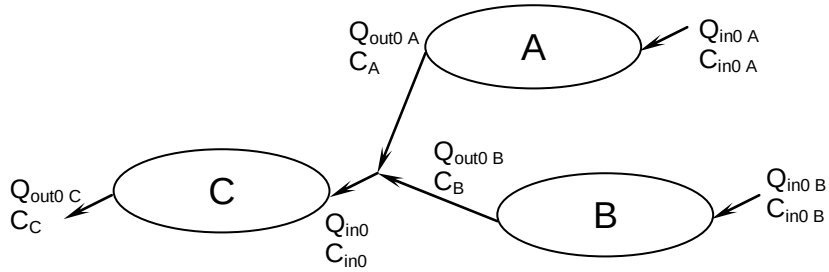

Figure 52: Schematic of Case where Two Upstream Subwatersheds, A and B, Contribute to the Inflow of a Computational Element, C.

Subwatershed Inflows

Possible inflows include: publicly owned treatment works (POTWs), urban runoff, groundwater exfiltration, agriculture returns, open space runoff, and any other flows. Each computational element includes provisions to include a generation component, which would be necessary if the constituents were being generated chemio-physio-biologically in the reach. In the case of salts, the generation component is set to zero as no reactions producing salts are assumed to occur in the CCW surface waters.

POTW Inflows to Computational Elements

Only the subwatersheds containing wastewater treatment plants that discharge to surface waters will have non-zero Q_{in1} and C_{in1}. Typical dry-weather effluent flowrate and salts concentrations for the treatment plants in the watershed used for the static CCMS are listed in Table 33. Steady dry-weather flows may be used as a check against the dynamic model calculations to verify expected behavior.

For the dynamic model, effluent monitoring data from the treatment plants are used to develop statistical descriptions of the effluent flowrate and salts concentrations. On review and analysis of flow data from the Simi Valley, Hill Canyon, and Camarillo POTWs there was an observed pattern of monthly variations in flowrates. Because the variations in flowrate could not be conclusively linked to external variables, separate distributions for flowrates from each POTW were calculated from the available data for each month of the year. Each distribution representing the expected effluent flowrate for each month are listed in Table 34 for each of the major POTWs in the CCW. Flowrates from POTWs are generally higher after precipitation. A relationship representing an incremental increase in flow due to precipitation is included in the dynamic CCMS calculations for Simi Valley, Hill Canyon, and Camarillo POTWs and each is listed in Table 34. To develop the flowrate equations all non-precipitation, daily effluent measurements for each month were grouped and analyzed separately. Each equation for the dry weather days is presented as the median flowrate of grouped data plus the standard deviation of grouped data times a normal random

number. Insufficient data from the Moorpark POTW precluded performing a similar analysis for that treatment plant. Each flowrate may be modified by a reduction factor to represent modifications due to an implementation strategy.

The full suite of calculations used to determine the effluent salts concentrations for each treatment plant is presented in Table 35. Concentrations of TDS and boron in effluents from all POTWs are calculated from distributions for each time step. Chloride and sulfate concentrations in the Simi Valley, Hill Canyon, and Camarillo POTW effluents are calculated from regression relations based on the drinking water quality from the Jensen Plant. Distributions are used to estimate the effluent quality from the Moorpark POTW for all constituents of concern. Each salt constituent for each POTW may be modified by a reduction factor to represent salt removals.

Table 33: POTW Parameters for the CCW Used in the Static CCMS.

POTW	Sub-watershed	Effluent Flow, Q_{in1} (cfs)	Salts Species Concentration, C_{in1} (mg/L)				
			Chloride	TDS	Sulfate	Boron	Hardness
Simi Valley	3	14	116	708	220	0.59	260
Moorpark	5	2	128	716	238	0.51	160
Hill Canyon	10	14	119	587	166	0.50	209
Camarillo	12	3.2	158	874	232	0.50	250

Table 34: POTW Effluent Flowrate Monthly Distributions and Increase due to Precipitation as used in the Dynamic CCMS.

Parameter	Effluent Flowrates (cfs) [a]		
	Simi Valley	Hill Canyon	Camarillo
Jan	14.27+0.481*GausDev	16.64+0.517*GausDev	4.863+0.83*GausDev
Feb	14.76+1.617*GausDev	17.22+1.839*GausDev	4.957+1.07*GausDev
Mar	14.43+1.079*GausDev	16.84+1.600*GausDev	4.365+1.17*GausDev
Apr	14.03+0.837*GausDev	16.73+0.906*GausDev	4.322+0.68*GausDev
May	13.81+0.866*GausDev	16.72+0.815*GausDev	4.598+0.83*GausDev
Jun	14.08+0.534*GausDev	16.56+1.004*GausDev	3.768+0.67*GausDev
Jul	13.85+0.424*GausDev	16.12+1.059*GausDev	3.418+0.60*GausDev
Aug	13.76+0.559*GausDev	15.99+0.967*GausDev	3.676+0.94*GausDev
Sep	13.70+0.568*GausDev	16.25+0.712*GausDev	4.614+0.70*GausDev
Oct	13.72+0.690*GausDev	16.38+0.817*GausDev	3.608+1.20*GausDev
Nov	14.21+0.687*GausDev	17.08+1.224*GausDev	4.853+1.24*GausDev
Dec	14.39+0.884*GausDev	16.91+1.407*GausDev	5.033+1.24*GausDev
Precip Days	Q_{day-1} + 1.151*$precip_{day}$	Q_{day-1} + 2.122*$precip_{day}$	Q_{day-1} + 1.025*$precip_{day}$

[a] Values rounded for display. Each monthly equation is presented in the form m+σ*GausDev, where m is the median of available data, σ is the standard deviation, and GausDev is a standard normal random number.

Urban Runoff to Computational Elements

Urban runoff is calculated in CCMS as a mix of runoff from residential, commercial, and industrial land uses. The typical percentage of imperviousness for each land use is used to estimate the runoff coefficient. Each runoff coefficient is multiplied by a water use per acre to determine a runoff rate per land use type. Watershed-wide parameters used for runoff calculations are listed in Table 36. Land use areas in each subwatershed are determined from GIS tools. To calculate the runoff by land use for each subwatershed, the total subwatershed area is multiplied by the fractional land use area. A list including subwatersheds, the total areas of each subwatershed, and the fractional areas by land use for each subwatershed is provided in Table 40.

Using the information listed in Table 36 and Table 40, the dry weather urban runoff is calculated using Equation (17).

$$Q_{in2} = \text{Total Area} \cdot \left(f_{res} \cdot runoff_{res} + f_{com} \cdot runoff_{com} + f_{ind} \cdot runoff_{ind} \right) \cdot \text{reductions}_{urban} \quad (17)$$

Where Total Area of the subwatershed in Equation (17) is from Table 40, reductions are any reductions in flows expected sue to implementation of BMPs, f_{res} represents the fractional area of the subwatershed that is residential as listed in Table 40, and $runoff_{res}$ represents the residential runoff value from Table 36. The terms corresponding to commercial and industrial areas are found in a similar fashion. Concentrations of salts in urban runoff, i.e. C_{in2}, used in the static CCMS are listed in Table 37.

Dry weather runoff is currently calculated in the dynamic model in the same manner as in the static model with the exception of allowing the runoff coefficients to vary uniformly between ±50% of the values listed in Table 36. Relating the dry weather runoff flow to the water delivery rates for each subwatershed would

allow the dynamic model to estimate seasonal and spatial changes in dry-weather runoff flows. The last runoff calculation is multiplied by an exponential decay factor to simulate tailing of stormwater runoff. The calculation is presented as Equation (18).

Wet weather runoff is calculated in the dynamic CCMS similarly to the dry-weather urban runoff, except the precipitation over the subwatershed multiplied by the runoff coefficient is used to determine the runoff flowrate and provisions are included in the model to mimic tailing of the runoff. Runoff will only occur if the precipitation is greater than a threshold value set by the user as listed in Equation (19). Wet-weather runoff flows currently do vary seasonally and spatially over the CCW in response to precipitation patterns.

$$\begin{aligned} Q_{in2} &= \text{Total Area} \cdot \left(f_{res} \cdot runoff_{res} + f_{com} \cdot runoff_{com} + f_{ind} \cdot runoff_{ind} \right) \cdot \text{reductions}_{urban} \\ &\quad + \text{Storm runoff}_{last} \cdot exp\left\{ -\left(\#\ \text{antecedent dry days} \right) \cdot \text{lag} \right\} \end{aligned} \tag{18}$$

$$\begin{aligned} \text{Storm runoff}_{day} &= \text{Total Area} \cdot \left(f_{res} \cdot C + f_{com} \cdot C_{com} + f_{ind} \cdot C_{ind} \right) \\ &\quad \cdot \left(\text{precip}_{day} - \text{threshold}_{urban} \right) \cdot \text{conversion} + \text{Storm runoff}_{day-1} \cdot exp\left\{ -\text{lag} \right\} \end{aligned} \tag{19}$$

Table 35: Calculations for Determining Salts Concentrations in POTW Effluents used in the Dynamic CCMS.

POTW	Calculation (1)
Simi Valley	
Chloride	$0.827*Cl^-_{supply} + 78.71 + 6.81*GausDev$
Sulfate	$0.926*SO_4^{2-}{}_{supply} + 126.04 + 33.09*GausDev$
TDS	706.25*exp{0.3901*GausDev}
Boron	0.60663 + 0.10971*GausDev
Hill Canyon	
Chloride	$0.911*Cl^-_{supply} + 73.11 + 8.19*GausDev$
Sulfate	$0.962*SO_4^{2-}{}_{supply} + 60.78 + 15.04*GausDev$
TDS	620.11 + 42.52*GausDev
Boron	0.61169 + 0.096495*GausDev
Camarillo	
Chloride	$0.815*Cl^-_{supply} + 121.7 + 10.30*GausDev$
Sulfate	$0.801*SO_4^{2-}{}_{supply} + 161.8 + 26.87*GausDev$
TDS	899.56+70.274*GausDev
Boron	0.62833+0.065944*GausDev
Moorpark	
Chloride	131.2*exp{0.163*GausDev}
Sulfate	200.75+54.703*GausDev
TDS	658.17*exp{0.11964*GausDev}
Boron	0.52875+0.049545*GausDev

(1) Cl^-_{supply} and $SO_4^{2-}{}_{supply}$ are concentrations of chloride and sulfate in imported water supply as measured at the CMWD Jensen Plant.

Distributions are used to estimate concentrations of all salts at each time step for both dry- and wet-weather runoff in the dynamic CCMS. Calculations used to estimate dry-weather runoff salts concentrations are listed in Table 38. Because sufficient data to develop distributions for sulfate and boron concentrations in dry-weather runoff, the static model estimates are included in the dynamic model and uniformly varied plus and minus 50% of the estimate. Distributions for wet-weather runoff salts concentrations used in the dynamic CCMS are listed in Table 39. As for dry-weather concentrations, any constituent with insufficient data to develop distributions was estimated with available data or static CCMS values and uniformly varied plus and minus 50%. Dry- and stormwater runoff rates are used in a mass balance calculation to blend the water quality from both sources. Data for developing dry- and wet-weather runoff concentrations for sulfate and boron are lacking. Use of estimates of the distributions for sulfate and boron concentrations in the CCMS would yield better estimates of the variability of the in-stream concentrations for the two species.

Table 36: Table of Parameters used in Runoff Calculations.

Land Use	Percent Impervious	Runoff Coefficient	Dry Weather Runoff (cfs/acre)
Residential	30.0%	0.425	0.00014468
Industrial	70.0%	0.725	0.00024681
Commercial	50.0%	0.575	0.00019575
Agriculture	7.5%	0.256	0.00016580
Undeveloped/Open	0.0%	0.200	0.00006809

Table 37: Static Species Concentrations for Composite Urban Runoff, C_{in2}.

	Salts Species Concentration (mg/L)				
Season	Chloride	TDS	Sulfate	Boron	Hardness
Dry	176.25	1,900	60	0.21	897
Wet	24.2	174.6	15	0.21	59.7

Table 38: Dry-weather Urban Runoff Salts Concentrations as Calculated in the Dynamic CCMS.

Species	Dry-weather Urban Runoff Concentrations (mg/L)
Chloride	156.9*exp{0.62537*GausDev}
Sulfate	60.0±50%
TDS	1,869.2*exp{0.28519*GausDev}
Boron	0.21±50%

Table 39: Wet-weather Runoff Salts Concentrations as Calculated in the Dynamic CCMS.

	Wet-weather Urban Runoff Concentrations (mg/L)		
Species	Residential	Commercial	Industrial
Chloride	18.11*exp{0.9454*GausDev}	3.0±50%	17.92*exp{1.006*GausDev}
Sulfate	15.0±50%	15.0±50%	15.0±50%
TDS	81.60*exp{0.7625*GausDev}	57.71*exp{0.4766*GausDev}	90.96*exp{0.7636*GausDev}
Boron	0.21±50%	0.21±50%	0.21±50%

Table 40: Land Use Fractional Areas by Subwatershed.

Sub-water-shed	Description	Total Area (acres)	Fractional Land Use Area					
			Residential	Industrial	Commercial	Agricultural	Open Space	Open/Water
1	Upper Arroyo Simi	50,707	0.168	0.028	0.050	0.017	0.744	0.004
3	Arroyo Simi/Arroyo Las Posas	13,944	0.026	0.028	0.052	0.028	0.879	0.000
4	Arroyo Las Posas	18,239	0.110	0.026	0.060	0.149	0.667	0.000
5	Upper Calleguas Creek	21,113	0.040	0.020	0.007	0.585	0.359	0.002
EALP	End of Arroyo Las Posas	1,055	0.050	0.026	0.038	0.730	0.156	0.000
8	Arroyo Santa Rosa	5,467	0.138	0.046	0.000	0.144	0.675	0.005
9	Upper Arroyo Conejo	22,176	0.328	0.021	0.117	0.040	0.545	0.002
10	Lower Arroyo Conejo	6,746	0.367	0.012	0.154	0.010	0.459	0.000
11	Upper Conejo Creek	11,132	0.190	0.002	0.029	0.259	0.533	0.000
12	Lower Conejo Creek	2,590	0.135	0.018	0.126	0.141	0.585	0.004
6	Central Calleguas Creek	5,578	0.112	0.077	0.057	0.329	0.432	0.007
13	Revolon Slough	25,097	0.055	0.011	0.056	0.671	0.220	0.000
7	Lower Calleguas Creek	23,702	0.118	0.009	0.081	0.554	0.248	0.001
14	Agricultural Drain	7,798	0.007	0.006	0.165	0.594	0.237	0.005
15	Mugu Lagoon	1,344	0.000	0.000	0.015	0.000	0.869	0.078

Groundwater Inputs to Computational Elements

Groundwater exfiltration and groundwater dewatering discharges are included under the general heading of groundwater inputs to computational elements. Currently, the only dewatering wells included in the model are located in the Simi Valley area of the watershed.

Concentrations utilized for the exfiltrating groundwater in the Simi and Thousand Oaks basins are listed in Table 42. Groundwater exfiltration flowrates and concentrations are constant values in the static CCMS. The exfiltration flowrates, where they exist, in the CCW are listed in Table 41. The groundwater flows in the Simi Valley are largely due to continuous pumping to lower the groundwater table. From a modeling perspective, the dewatering well discharges affect the CCW system in an equivalent manner to the natural exfiltration of groundwater providing baseflow to the stream.

Table 41: Groundwater Inputs (Q_{in3}) and Infiltration (Q_{out1}) by Subwatershed. Reach Dimensions and Evaporation (Q_{out3}) Included for Each Subwatershed.

Sub-watershed	Description	Groundwater [a]		Reach Length (mile)	Average Width (feet)	Evaporation (cfs)
		Exfiltration (cfs)	Infiltration (cfs)			

1	Upper Arroyo Simi	2.30 [e]	---	10.06	25.7	0.22
3	Arroyo Simi/Arroyo Las Posas	---	5.84 [b]	5.31	38.1	0.17
4	Arroyo Las Posas	---	3.16 [b]	2.87	93.8	0.23
5	Upper Calleguas Creek	---	5.61 [b]	5.10	29.7	0.13
EALP	End of Arroyo Las Posas	---	0.25 [b]	0.54	29.7	0.01
8	Arroyo Santa Rosa	0.90	---	6.90	6.7	0.04
9	Upper Arroyo Conejo	1.54	---	10.98	15.5	0.14
10	Lower Arroyo Conejo	0.96	---	0.63	37.1	0.02
11	Upper Conejo Creek	---	11.85 [c,d]	6.16	29.1	0.15
12	Lower Conejo Creek	---	0.57 [c]	1.89	25.0	0.04
6	Central Calleguas Creek	---	---	2.40	75.0	0.15
13	Revolon Slough	---	---	16.80	50.0	0.70
7	Lower Calleguas Creek	---	---	5.30	133.4	0.59
14	Agricultural Drain	---	---	6.50	24.2	0.13
15	Mugu Lagoon	---	---	0.78	316.0	0.21

[a] For any reach, there will either be exfiltration adding water to the reach or infiltration removing water from the reach. The flowrate may be modified with a reduction coefficient to account for implementation strategies.
[b] Corresponds to 1.1 cfs/reach mile infiltration rate.
[c] Corresponds to 0.3 cfs/reach mile infiltration rate.
[d] Includes 10 cfs Conejo Creek diversion.
[e] Average discharge flowrate from groundwater dewatering wells.

Table 42: Static Species Concentrations for Exfiltrating Groundwater, C_{in3}.

	Salts Species Concentration (mg/L)				
Season	Chloride	TDS	Sulfate	Boron	Hardness
Dry	134.4	1,639	1,500	0.80	1,230
Wet	134.4	708	739	0.20	509

Analysis of available data revealed that dry-season groundwater exfiltration rates are related to the previous wet-season total precipitation. A relationship between annual precipitation and groundwater exfiltration has been developed for the Upper Arroyo Simi, Conejo Creek, and Calleguas Creek sections of the CCW (LWA 2004b). The relationships developed in LWA (2004b) for exfiltration contribution to in-stream flowrates are listed in Table 43. For dates between April 1st and September 30th for a given water year, the cumulative precipitation for the water year is used to calculate groundwater exfiltration using the developed relationships. For dates between October 1st and March 31st, a weighted average between the total precipitation in the previous water year and the cumulative precipitation for the current water year are used in the calculations. The static model estimates of groundwater exfiltration from the Conejo system are used to apportion the calculated flow contribution to the reaches tributary to Conejo Creek.

Groundwater well water quality data were reviewed to develop updated estimates of exfiltration water quality (LWA, 2004b). Salts concentration values used in the dynamic CCMS to represent groundwater exfiltration water quality are listed in Table 44. Separate relationships are used in the dynamic CCMS to determine the

quality of exfiltrating groundwater and dewatering discharge. Estimates for groundwater exfiltration quality from LWA (2004b) are based on water quality measurements of supply wells in close proximity of the waterways in conjunction with in-stream quality measurements. Dewatering well discharge water quality measurements are used to estimate the discharge quality.

Table 43: Groundwater Exfiltration Based on Annual Precipitation.

Region	Sub-watershed	*f* (1)	Groundwater Exfiltration (2) (cfs)
Simi Valley	1	---	0.145*ann precip – 1.671 + 3.1 (3)
Conejo Creek	8 (4)	0.0	0.404*ann precip – 4.63
	9	1.54/2.5	
	10	0.96/2.5	
Calleguas Creek	6	1.0	0.406*ann precip – 2.58
	7	1.0	

(1) Fraction used to apportion calculated groundwater exfiltration to various reaches in system.
(2) Annual precipitation based calculation. Precipitation for current water year for simulation dates between April 1st and September 30th. Weighted average of previous and current water year precipitation for all other simulation dates.
(3) Simi Valley dewatering wells set to 3.1 cfs
(4) No groundwater exfiltration is assumed to exist in Arroyo Santa Rosa. Included here for comparison with Table 41.

Table 44: Calculations for Determining Salts Concentrations in Groundwater Exfiltration as used in the Dynamic CCMS.

Groundwater	Salts Calculation [a] (mg/L)	Dewatering Well Discharge [b] (mg/L)
Arroyo Simi		
Chloride	199±30%	130.91 + 2.8524*GausDev
Sulfate	1,232±30%	1,158.*exp{0.1373*GausDev}
TDS	1,197±30%	1,634 + 31.232*GausDev
Boron	1.4±50%	0.954 + 0.05888*GausDev
Conejo Creek		
Chloride	195±30%	---
Sulfate	445±30%	---
TDS	820±30%	---
Boron	0.2±50%	---
Calleguas Creek		
Chloride	227±30%	---
Sulfate	801±30%	---
TDS	907±30%	---
Boron	0.2±50%	---

[a] Chloride, Sulfate, and TDS concentrations estimated to within ±30% in LWA (2004b).
[b] Concentration distributions developed from water quality measurements from dewatering well discharge.

Agriculture Returns to Computational Elements

The runoff from agricultural returns is calculated in a manner similar to urban runoff with the appropriate values from Table 36 and Table 40 using Equation (20).

$$Q_{in4} = \text{Total Area} \cdot \left(f_{ag} \cdot runoff_{ag} \right) \cdot \text{reductions}_{ag} \tag{20}$$

Concentrations of salts in agricultural returns, i.e. C_{in4} in Figure 12, are listed in Table 45.

Table 45: Static Species Concentrations for Agricultural Runoff, C_{in4}.

	Salts Species Concentration (mg/L)				
Season	Chloride	TDS	Sulfate	Boron	Hardness
Dry	239.3	2,449	916	0.82	954
Wet	174	1,362	707	0.69	424

Wet-weather runoff flows are calculated in a similar manner to the urban runoff. Currently, the runoff threshold is set to 0.15 in of rain, and the runoff lag is set to 6.0 days. Salts concentration estimates used in the dynamic CCMS for dry- and wet-weather agricultural runoff are listed in Table 46.

Table 46: Agricultural Return Water Quality as used in the Dynamic CCMS.

Species	Runoff Quality (mg/L)	
	Dry-weather	Wet-Weather
Chloride	156.22*exp{0.391*GausDev}	23.6*exp{0.844*GausDev}
Sulfate	416±50%	407±50%
TDS	958.4*exp{0.439*GausDev}	268.4*exp{0.724*GausDev}
Boron	1.7±50%	0.69±50%

Vacant (Open Space) Runoff to Computational Elements

The runoff from vacant areas of open space is calculated in a manner similar to urban runoff with the appropriate values from Table 36 and Table 40 using Equation (21).

$$Q_{in5} = \text{Total Area} \cdot \left(f_{open} \cdot runoff_{open} \right) \cdot \text{reductions}_{open} \tag{21}$$

Concentrations of salts in agricultural runoff, i.e. C_{in5} in Figure 12, are listed in Table 47.

Table 47: Static Species Concentrations for Open Space Vacant Runoff, C_{in5}.

Season	Salts Species Concentration (mg/L)				
	Chloride	TDS	Sulfate	Boron	Hardness
Dry	170.0	1,975	500	0.178	562
Wet	59.75	481.25	17	0.178	79.25

Wet-weather runoff flows are calculated similarly to the urban runoff. Currently, the runoff threshold is set to 0.50 in of rain, and the runoff lag is set to 6.0 days. Salts concentration estimates used in the dynamic CCMS for dry- and wet-weather open space runoff are listed in Table 48.

Table 48: Open Space Runoff Water Quality as used in the Dynamic CCMS.

Salt Constituent	Runoff Quality (mg/L)	
	Dry-weather	Wet-Weather
Chloride	153.4*exp{0.513*GausDev}	76.2*exp{0.737*GausDev}
Sulfate	500±50%	17±50%
TDS	1,744*exp{0.652*GausDev}	1,427*exp{0.537*GausDev}
Boron	0.18±50%	0.18±50%

Other Inflows to Computational Elements

Other processes possibly included in the future will account for management practices and diversions resulting from the implementation of control strategies.

Other inflows are reserved for the implementation of potential control strategies.

In-stream Generation within Computational Elements

While it is possible that salts generation may exist by dissolving minerals from historic marine sediments, currently the assumption is made that surface waters have dissolved all salts easily dissolvable and the process is negligible for all reaches in the watershed. Generation is set to zero for each subwatershed in the CCW.

Subwatershed Outflows

Possible withdrawals or outflows from the CCW reaches include groundwater infiltration and diversions, agricultural use, and evaporation. No processes are included in the model that consume salts. Because of the complete-mix assumption, the concentration in each of the outflows is equal to the concentration calculated in the reach that is discharged to downstream subwatersheds.

Groundwater Infiltration from Computational Elements

Groundwater infiltration rates by subwatershed for the steady-state CCMS are listed in Table 41. In general, the infiltration rate in the Northern CCW is 1.1 cfs/reach mile, and in the Conejo Creek region the rate is 0.3 cfs/reach mile. The 10 cfs Conejo Creek Diversion is included in as a groundwater outflow in Table 41. The infiltration rate is checked internally to ensure negative flowrates are not produced if the streambed becomes dry.

The infiltration rate calculations in the dynamic CCMS are similar to the calculations in the static CCMS. However, monthly measured diverted flowrates from the Conejo Creek Diversion are used to estimate the removal flowrate in the dynamic CCMS. Groundwater infiltration rates are increased in the lower sections of the Arroyo Las Posas to calibrate the dynamic CCMS calculated flowrates to the measured flowrates at Gage 806(a).

Riparian Vegetation Demand from Computational Elements

Natural stream draw-down for riparian habitat support and agricultural withdrawals are accounted for in the Riparian Vegetation Demand. The calculated rates of riparian uptake, agricultural withdrawals, and supporting information are listed in Table 49. In the dynamic CCMS calculations, the rate of riparian vegetation consumption is modified by the ratio of the daily evaporation to the annual average evaporation, as in Equation (22).

$$\text{Riparian ET} = \text{Riparian ET}_{\text{steady}} \frac{\text{daily evap (in/d)}}{0.164\,\text{(in/d)}} \tag{22}$$

The calculated lost flow is checked against the available flow to ensure that a negative flowrate for the subwatershed does not result from including the riparian consumptive loss. Water is drawn from the streams to satisfy the evapotranspiration demand of riparian vegetation. Because the water is drawn from the stream before evaporating, salts are carried from the stream to the root-zone. Salts not may accumulate in the root zone and would be subject to leaching back into the stream with baseflow.

Evaporation from Computational Elements

Evaporation from the reaches is calculated from the evaporation rate data multiplied by the estimated water surface area, and so is strictly the evaporative loss from the stream surface. Rates of evaporation from each of the reaches in the CCW are listed in Table 41. No salts are removed from the system via evaporation. The steady version of the CCMS uses a constant evaporation rate of 60 in/yr (0.164 in/d) multiplied by the stream surface area and length. In both the steady and dynamic versions of CCMS, the calculated lost flow from evaporation is checked against the available flow in the subwatershed to ensure that a negative flowrate does not result from including the evaporation loss.

Daily evapotranspiration values for coastal and inland areas of the CCW were developed in LWA 2004c. The variability within each month of the year of available daily evaporation is used to perturb the daily evaporation values calculated in LWA 2004c. Regression of historic evaporation against daily maximum temperatures in Camarillo or Oxnard would provide a mechanism for forming a daily estimate based on daily watershed conditions rather than rely on a constant value.

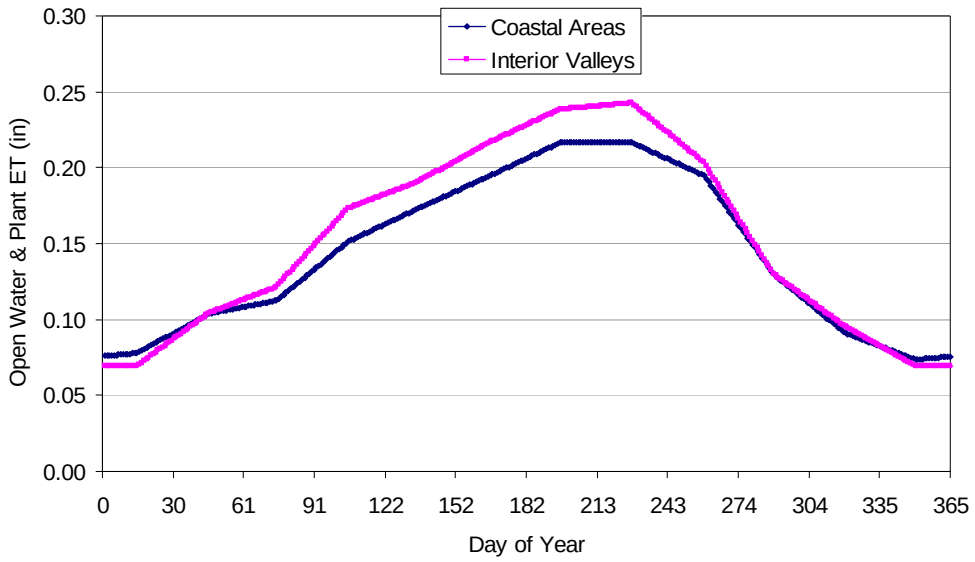

Figure 53: Base evapotranspiration from coastal and inland areas of the CCW.

Table 49: Riparian Uptake Rate (Q_{out2}) for Each Subwatershed.

Sub-watershed	Riparian Demand (cfs)	Stream-side Acreage (acres)	Riparian Vegetation Area Fraction (---)	Reach Length (miles)
1	0.00	12,877	0.017	10.06
3	0.00	6,797	0.028	5.31
4	1.89 [a]	3,674	0.149	2.87
5	11.68 [a]	6,528	0.585	5.10
EALP	0.00 [b]	691	0.730	0.54
8	0.76 [c]	2,175	0.144	6.90
9	0.00	14,054	0.040	10.98
10	0.00	806	0.010	0.63
11	7.05 [a]	7,885	0.259	6.16
12	1.18 [a]	2,419	0.141	1.89
6	3.48 [a]	3,072	0.329	2.40
13	---	21,504	0.671	16.80
7	1.38 [d]	6,784	0.554	5.30
14	---	8,320	0.594	6.50
15	0.00	998	0.000	0.78

[a] Calculated by 2.5 ft/year * Stream-side area * $f_{agriculture}$ * unit conversion.
[b] Calculated by 1.5 ft/year * (Stream-side area – 640) * $f_{agriculture}$ * unit conversion.
[c] Calculated by 2.5 ft/year * (Stream-side area – 640) * $f_{agriculture}$ * unit conversion.
[d] 0.26 cfs/reach mile * reach length.

In-stream Consumption within Computational Elements

No in-stream processes are included in the current version of the model that consumes salts from the water column. Consumption is set to zero for each subwatershed for each salt constituent.

Downstream Subwatersheds

The calculated outflow and mass load are used as input to the next most downstream computational element. As above, the reach discharge to downstream subwatersheds and outflow concentrations are calculated by Equations (23), and (24), respectively:

$$Q_{out0} = Q_{in0} + Q_{in1} + Q_{in2} + Q_{in3} + Q_{in4} + Q_{in5} + Q_{in6} - Q_{out1} - Q_{out2} - Q_{out3} \tag{23}$$

$$C = \frac{C_{in0}Q_{in0} + C_{in1}Q_{in1} + C_{in2}Q_{in2} + C_{in3}Q_{in3} + C_{in4}Q_{in4} + C_{in5}Q_{in5} + C_{in6}Q_{in6}}{Q_{out0} + Q_{out1} + Q_{out2}} \tag{24}$$

Improvements Remaining

- Obtain and analyze any additional water supply (State Import Water, Freeman Diversion, etc.) ideally including drought periods.

- Develop and implement a relationship between water delivery rates to each model subwatershed and influence on urban and agricultural dry-weather runoff.

- Determine the influence of the Freeman Diversion and deep groundwater well import water on flowrates and water quality within the CCW. Analysis of the water distribution and use throughout the watershed would be required to facilitate inclusion of the additional water sources. Reading and using the historical data from the two sources also would have to be implemented in the computer code of the CCMS.

- Determine the operational rules for the Simi Valley dewatering wells. Obtain flow data from Simi Valley. Currently, a constant pumping rate is set in the model. Variations in pumping rate could dramatically affect the local in-stream flowrate. Fluctuations in the quality of the dewatering well effluent would be beneficial to include in the dynamic model.

- Check locations and routing of urban runoff contributing to surface waters.

- Determine the quantity of groundwater dewatering in Thousand Oaks. If appreciable, include well flow and quality in a similar manner to Simi Valley dewatering wells.

- Determine estimates of distributions representing the concentrations of sulfate and boron in the various runoff streams in the CCW. Representing the sulfate and boron concentrations as uniform distributions ranging between likely maximum and minimum concentrations will provide a more robust calculation over using a simple constant value. However, estimates of the true distributions are more desirable.

- Determine relation between daily evaporation rate and daily maximum, minimum, or average temperature at an appropriate location within the watershed. Need daily temperatures at Camarillo for time period spanning April 1, 1991 to November 30, 2003.

- Use information provided from HSPF modeling to formulate better estimates of CCMS dynamic flowrate parameters.

- Align all TMDL reach end-points with CCMS subwatershed boundaries. However, results from the HSPF model would greatly facilitate the calibration of the new subwatersheds. Completing the expansion before HSPF results are available would be difficult, and should be postponed until results are available.

- Analyze HSPF output to develop estimates of groundwater infiltration rates based on in-stream flowrates. Presumably, as the flowrate in the stream increases, there will be more surface area for infiltration and the rate should increase.

- Use historical data and regressions to determine water delivery and quality to subwatersheds relating flow and quality of runoff to supplied water. Imported water, groundwater, and Freeman Diversion sources should be included in the analysis.

- Determine relationship between groundwater dewatering rates and groundwater exfiltration (baseflow) contributions to the surface waters to account for presumed reduction in exfiltration flows due to implementation of desalination of groundwater resources to augment water supply.

- Determine estimates of variability in groundwater exfiltration (baseflow) and include in as a perturbation of the baseflow calculations.

Conclusions

Conservation of mass is the basis of the CCMS water quality model. By assuming that each reach is steady for any given time step, reach outflow and concentration may be calculated from algebraic equations. The effect of using a daily time step and the steady-state assumption is to generate a series of daily average snapshots of the conditions likely to exist in the CCW. The CCMS is built on the principles of mass conservation forming a simple, robust, and defensible method of modeling constituent flows through the CCW.

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Conversions

Area

$$0.004047 \frac{km^2}{acre}$$

Volume

$$7.481 \frac{gal}{ft^3}$$

Flow

$$1.008 \frac{acre \cdot in/hr}{cfs}$$

$$0.0013813 \frac{cfs}{acre \cdot ft/yr}$$

$$0.5042 \frac{cfs}{acre \cdot ft/d}$$

$$1.547 \frac{cfs}{MGD}$$

Mass Loading

$$5.394 \frac{lb/d}{cfs \cdot mg/L}$$

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Technical Memorandum

DATE: April 21, 2004

TO: Calleguas Creek TAC and Interested Parties

CC: Salts TMDL Workgroup
TMDL Tools Workgroup

FROM: *Dustin Bambic*

SUBJECT: Surface-Groundwater Interaction

DRAFT

OVERVIEW

To develop a successful TMDL decision-support model, the interaction between ground and surface water must be quantified. However, within the Calleguas Creek watershed, many factors obscure the relationship. These factors include extreme seasonal variations in precipitation, complex hydrogeology, anthropogenic processes, and the lack of sufficient water quality data. The seasonal differences in precipitation often make it necessary to develop dry- and wet-weather regimen of water quality and quantity. However, such development can be difficult, because adequate data for each regime are not always available. The complex hydrogeology underlying the watershed further complicates the analysis due to the interaction of multiple groundwater sub-basins, which each contain a shallow unconfined aquifer, multiple levels of confined aquifer, and regional fault systems. Consequently, complicated flow paths result. Many reaches of Calleguas Creek receive groundwater inflow and are perennial, while others are ephemeral and infiltrate water into the ground at rates that often exceed the flow rate. The quality of the interacting groundwater also exhibits great seasonal and spatial variation. However, the available data on groundwater quality are of poor spatial and temporal resolution. This absence of data makes it problematic to predict changes in groundwater chemistry (based on season, precipitation, groundwater level, etc.) and the subsequent effect on surface water. Finally, anthropogenic processes further complicate the analysis by altering natural seasonal variations in hydrology. These alterations include the distribution of imported surface water, diversion of surface water to Pleasant Valley County Water District, wastewater treatment facility effluent discharges, groundwater pumping for irrigation, pumping to control high groundwater levels within the Simi Valley, and urban runoff.

Baseflow, water that is discharged to surface water from groundwater storage, is the fundamental link through which groundwater influences surface water quality. For Calleguas Creek, like many other watersheds throughout the country, the most reliable long-term data are daily precipitation and surface water discharge. Also the POTW-effluent discharges, pumped-groundwater discharges, and diversions from the Calleguas Creek system are rather constant and well-characterized. Therefore, by examining the summer flow record (when precipitation runoff is negligible), it is possible to reliably estimate the quantity of historic annual baseflow. More importantly, a relationship between that baseflow and the preceding-winter precipitation for each major segment of Calleguas Creek (Conejo Creek, Arroyo Simi/Las Posas, and Lower Calleguas Creek) was found. This correlation will allow the surface water model to predict dry-season baseflows as a function of preceding-winter precipitation. Then, using the available surface and groundwater quality data, average chloride, TDS, and sulfate concentrations will be applied to the predicted baseflow in each segment. This cycle of estimating baseflow quality and quantity defines the surface-groundwater interaction, and links the surface water model to subsurface processes.

METHODS

Baseflow Quantification and Prediction

To quantify baseflow within each major segment of Calleguas Creek, the historic daily discharge records for VCWPD flow gages 800, 803, and 805 (Figure 1) were used to calculate mean summer (June – August) flows for 1981-2000 (Figure 2). Intuitively, the long-term precipitation and discharge records suggest there is a correlation between mean summer discharge and precipitation the previous winter. Such correlations were determined for the three gages (800, 803, and 805), and results are shown graphically in Figure 3. The relationships are based on the assumption that all the precipitation for the water year (Oct. 1 – Sept. 30) fell before June. In fact, on average, 97.3% of the annual rainfall in the Calleguas Creek watershed occurs Oct 1-May 30. The observed increase in mean summer flows after wet winters is likely due to increased groundwater inputs (baseflow) to the stream system.

Because precipitation runoff during the dry-weather season of June through August is negligible, the only significant inputs to the stream are POTW effluent, urban runoff, agricultural tailwaters, and groundwater pumping from Simi Valley. Thus, by adding/subtracting the above components from the mean summer streamflow, an estimate of baseflow for each year can be calculated. The POTW effluents and Simi Valley groundwater pumping are the most significant and (fortunately) best characterized discharges. Estimates for dry-weather urban and agricultural runoff to each stream segment are also available. Finally, withdrawals from Conejo Creek for irrigation applications were included in the calculation. Knowledge of the above inputs and withdrawals makes it possible to use the mean summer discharge to derive a relationship for baseflow vs. previous-year annual precipitation (Figure 4).

In arid environments like the Calleguas Creek watershed, high precipitation winters are known to have a significant effect on water quality and quantity during the subsequent dry season. Without a specified relationship between the preceding-winter precipitation and following-year baseflow, the applied empirical model would exhibit no “memory” of high-precipitation winters. The derived regression equations in Figure 4 will be used in the mass balance model to predict higher surface water flows after wet winters, even after the precipitation-runoff has left the watershed. Consequently, the model will more accurately mimic the hydrology of the Calleguas Creek watershed, and provide more reliable results to be used during TMDL development. The baseflow

Figure 1. Calleguas Creek VCWPD Flow Gage Locations

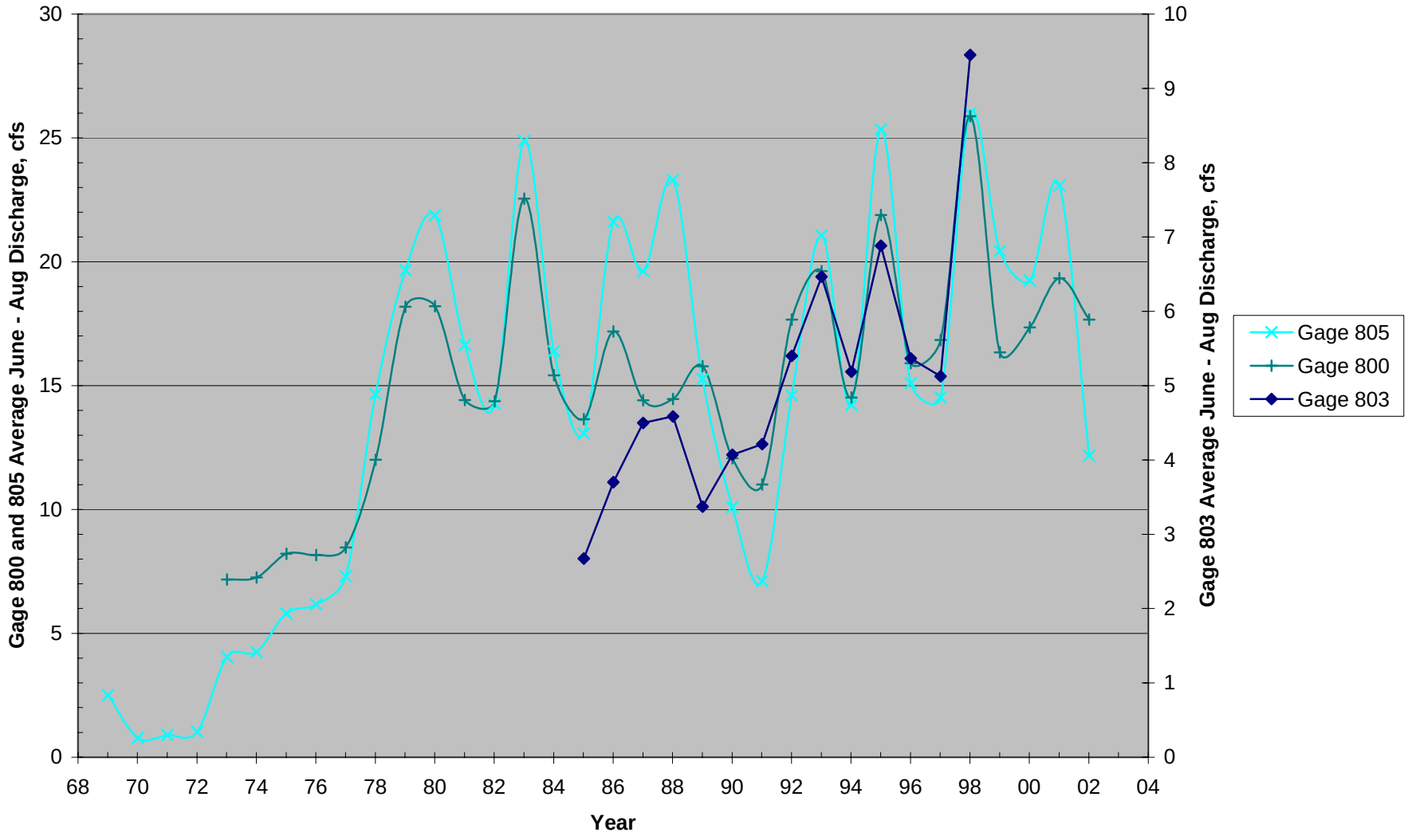

Figure 2. 1981 - 2002 Calleguas Creek Watershed Mean Summer (6/1 - 8/31) Flows

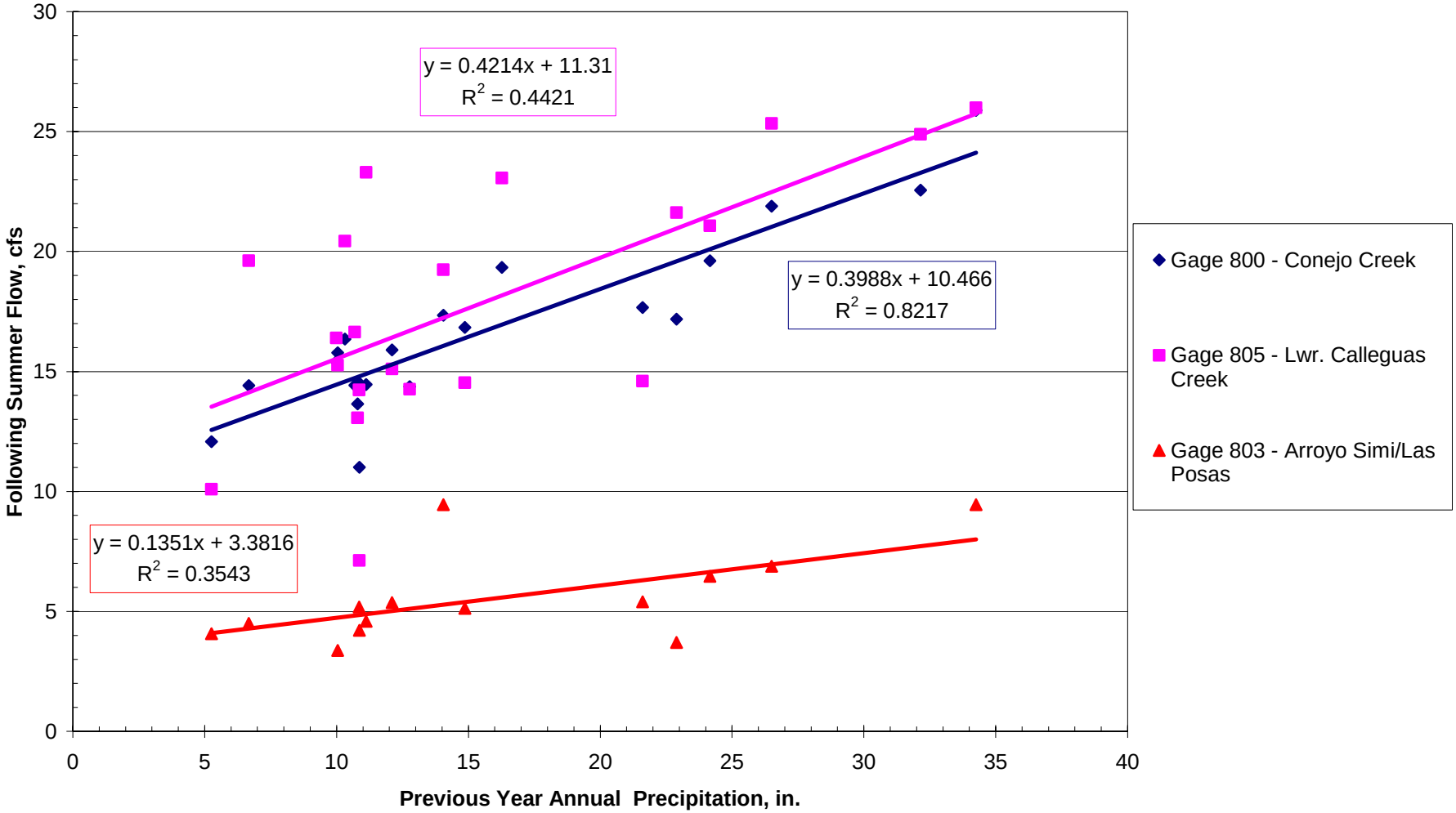

Figure 3. Calleguas Creek 1981 - 2001 Mean Summer Discharge vs. Previous-Year Annual Precipitation

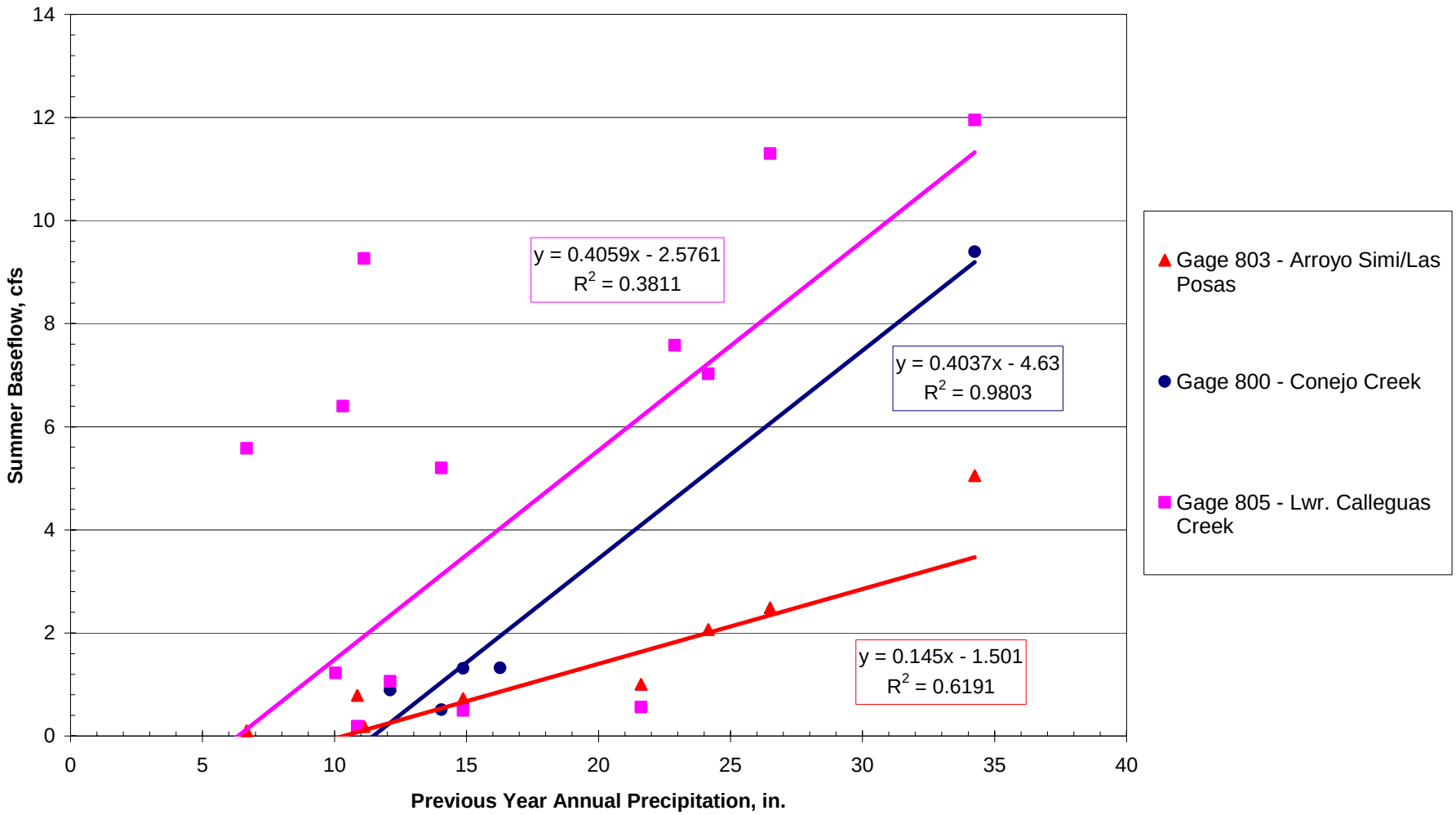

Figure 4. Calleguas Mean Summer Baseflow vs. Previous Year Annual Precipitation

calculations for the major segments (Conejo Creek, Lower Calleguas Creek, and Arroyo Simi/Las Posas) of the Calleguas Creek watershed are described in the next sub-sections.

Conejo Creek

Baseflows for the Conejo Creek segment (Gage 800) were calculated for the years 1996 through 2001 according to the following equation:

$$Q_{baseConejo} = Q_{summerConejo} - Q_{HillCanyon} - Q_{urban} - Q_{ag}$$

where:
$Q_{baseConejo}$ = 1996-2001 baseflows for the Conejo Creek segment
$Q_{summerConejo}$ = 1996-2001 mean summer discharge at Gage 800 (15.9 to 25.9 cfs)
$Q_{HillCanyon}$ = 1996-2001 Hill Canyon effluent mean summer discharge rates (13.6 to 15.4 cfs)
Q_{urban} = estimated Thousand Oaks dry-weather urban runoff (1.25 cfs)
Q_{ag} = estimated dry-weather agricultural runoff (0.16 cfs)

The baseflow calculation for Conejo Creek was limited to the years 1996-2001 because this is the period for which both discharge data from Hill Canyon (a large proportion of the flow at Gage 800) and precipitation data were available. Also, using the yearly data (as opposed to an overall average) resulted in a high r-squared value (0.98). Calculated baseflows are plotted vs. previous-year annual precipitation in Figure 4 along with the resulting regression line (blue) and corresponding regression equation. The equation will be used by the model to predict the discharge due to baseflow in all of Conejo Creek (Reaches 9A, 9B, and 10) through following winter.

Lower Calleguas

Baseflows for the Lower Calleguas Creek segment (Gage 805) were calculated for the years 1986 through 2001 according the following equation:

$$Q_{baseCall} = Q_{summerCall} - Q_{HillCanyon} - Q_{Cam} - Q_{urban} - Q_{ag} + Q_{diversion}$$

where:
$Q_{baseCall}$ = 1986-2001 baseflows for the Lower Calleguas Creek segment
$Q_{summerCall}$ = 1986-2001 summer flow at Gage 805 (7.1 to 26.0 cfs)
$Q_{HillCanyon}$ = 1996-2001 Hill Canyon effluent mean summer discharge rates (15.1 cfs)
Q_{Cam} = 1995-2003 Camarillo effluent mean summer discharge rate (3.4 cfs)
Q_{urban} = estimated Thousand Oaks and E. Camarillo dry-weather urban runoff (2.75 cfs)
Q_{ag} = estimated dry-weather agricultural runoff (0.69 cfs)
$Q_{diversion}$ = estimated lower Conejo Creek diversion rate (7.9 cfs)

The data window for Lower Calleguas Creek baseflow was chosen to be 1986 through 2000 because these years were considered to be representative of current conditions, and precipitation data was only available through 2000. Also, the effluent from the Hill Canyon and Camarillo WWTP's were not a large enough proportion of the flow at Gage 805 to limit the calculation to years for which effluent discharge data was available (like in Conejo Creek).

No direct measurement of lower Conejo Creek (below Gage 800) withdrawal rates were available for the summers of 1986 – 2001. The maximum withdrawal capacity along all of Conejo Creek during that period was

estimated to be 7.9 cfs (SWRCB, 1997). During the summer months, when irrigation rates are highest, it is likely that the maximum withdrawal rates were applied. Furthermore, nearly all agricultural/irrigated land lies downstream of Gage 800. Thus the entire Conejo Creek withdrawal capacity of 7.9 cfs was used for the Lower Calleguas Creek baseflow calculation.

Calculated baseflows are plotted vs. previous-year annual precipitation in Figure 4 along with the resulting regression line (pink) and corresponding regression equation. The equation will be used by the model to predict the discharge due to baseflow in Lower Calleguas Creek (Reaches 1, 2, and 3) through the following winter.

Arroyo Simi/Las Posas

Baseflows for the Arroyo Simi segment (Gage 803) were calculated for years 1986-1998 according to following equation:

$$Q_{baseSimi} = Q_{summerSimi} - Q_{dewatering} - Q_{urban}$$

where:

$Q_{baseSimi}$ = baseflows for the Arroyo Simi/Los Posas segment
$Q_{summerSimi}$ = 1986-1998 summer flow at Gage 803 (3.4 to 9.4 cfs)
$Q_{dewatering}$ = estimated Simi Valley groundwater dewatering rate (2.3 cfs)
Q_{urban} = estimated Simi Valley dry-weather urban runoff (2.1 cfs)

Note that no significant agricultural runoff drains to Gage 803. The data window for Arroyo Simi calculation was chosen to be 1986 through 1998 because these years were considered to be representative of current conditions, and Gage 803 data was only available through 1998. Calculated baseflows are plotted vs. previous-year annual precipitation in Figure 4 along with the resulting regression line (red) and corresponding regression equation. The equation will be used by the model to predict the discharge due to baseflow in Arroyo Simi and Arroyo Las Posas from the confluence of Tapo Canyon to the confluence of Conejo Creek (Reaches 6 and 7) through following winter.

Baseflow Chloride, TDS, and Sulfate Concentrations

Direct measurement of baseflow quality in developed watersheds is not usually feasible, because baseflow is often mixed with precipitation, effluent, agricultural runoff, and/or urban runoff. One approach to estimating baseflow quality is to investigate the water quality of wells near the surface water, because nearby wells are likely to be connected to groundwater that influences the surface water quality (i.e. groundwater that contributes to baseflow). Occasionally, however, surface water discharge and constituent concentration data are available for a site which is dominated by baseflow (i.e. an upstream location during dry-weather). In this case, the constituent concentration and discharge of the associated baseflow can be estimated by subtracting estimated discharges and concentrations of non-groundwater inputs. Such surface water quality data were available for the Conejo Creek segment.

Ideally, the surface water model would account for variations in baseflow concentration. Such a dynamic approach would require knowledge of the historical time-dependence of chloride, sulfate, and TDS concentrations in nearby groundwater. However data analysis showed that even wells that are nearby each other often display unique temporal trends, making it impossible to derive correlations between groundwater (or baseflow) concentration and precipitation, season, or groundwater level. This non-uniformity may be due to the heterogeneity of organic matter in the subsurface. The presence/absence of organic matter

enables/prevents different species of bacteria to control the oxidation-reduction state, and thus the precipitation-dissolution reaction rates (T.R. Ginn, personal communication, March 8, 2004)

Due to the "random" temporal variability of groundwater quality, the concentrations applied to baseflow will be constant. By using long-term groundwater quality data from wells that are nearby the major segments of Calleguas Creek (Arroyo Simi/Las Posas, Conejo Creek, and Lower Calleguas Creek), average concentrations of chloride, TDS, and sulfate were calculated and applied to the baseflow. Fortunately, the use of groundwater data was supported by Conejo Creek surface water data, as described in the Conejo Creek section below. In fact, the two methods resulted in identical average TDS concentrations. Furthermore, because groundwater chemistry is typically steady due to the fact that groundwater moves slowly with little mixing, exfilitrating groundwater concentrations may not vary greatly from season to season. Thus, applying a constant concentration to baseflow may be a reasonable assumption. More importantly, even though the concentration of chloride, sulfate, and TDS will be constant in the modeled baseflow, the quantity of baseflow varies with winter precipitation, allowing the groundwater to dynamically influence the surface water chemistry. Consequently, the model will predict higher surface water chloride after wet years and lower surface water chloride during storm events. Such predictions are consistent with observations by agricultural users in the watershed that yields are affected after particularly wet years due to higher surface water chloride concentrations (Hajas, personal communication), presumably as a result of higher groundwater inflows.

Conejo Creek

For Conejo Creek, both surface and groundwater quality data were used to estimate the chloride, sulfate, and TDS concentrations of the derived baseflow. Analysis of data from 30 wells in township-range sections that contain Conejo Creek resulted in the average chloride, sulfate, and TDS concentrations of 183, 239, and 820 mg/L, respectively. These averages and the associated summary statistics are listed in Table 1.

In addition, a historic record of dry-weather chloride, sulfate, and TDS concentration in Lower Calleguas and Conejo Creek are available. The chloride data are shown in Figure 5. The most upstream monitoring site was 50 ft. above the Hill Canyon WWTP discharge site. During the summer, the flow above Hill Canyon is dominated by baseflow, as seen by the much higher chloride concentrations at the site above Hill Canyon in Figure 5. Chloride concentrations are highest above Hill Canyon because baseflow concentrations are higher than downstream inputs in the Calleguas Creek watershed, as discussed in the Chloride vs. Precipitation section below.

The chloride, sulfate, and TDS data (Figure 6) for the site above Hill Canyon were used as a comparison for Conejo Creek well data displayed in Table 1. As discussed in the Baseflow Quantification and Prediction section above, one can determine average baseflow (Q_b) values in Conejo Creek. Then, applying estimates of agricultural (Q_{ag}) and urban runoff (Q_{urban}) discharge and constituent concentration (C_{ag} and C_{urban}, respectively), the baseflow constituent concentration (C_b) can be calculated using the following equation:

$$Q_tC_t = Q_bC_b + Q_{ag}C_{ag} + Q_{urban}C_{urban}, \quad \text{or}$$

$$C_b = (Q_tC_t - Q_{ag}C_{ag} - Q_{urban}C_{urban})/Q_b,$$

where:
Q_t = estimated discharge above Hill Canyon
C_t = measured constituent concentration above Hill Canyon.

The discharge at the site above Hill Canyon (Q_t) was assumed to be the average 1996-2002 discharge at Gage 800 (18.7 cfs), minus the average 1996-2002 Hill Canyon effluent discharge rate (15.1 cfs). The constituent concentrations used were the average 1987-1998 concentrations from Figure 6. The discharge and concentration values used for the calculation and the resulting calculated values for baseflow concentrations are summarized in Table 2. Solving for C_b resulted in baseflow concentrations of 248, 445, and 820 mg/L for chloride, sulfate, and TDS, respectively.

A comparison of the chloride, sulfate, and TDS concentrations derived from Conejo Creek surface and groundwater data suggests that using nearby well data for baseflow constituent determination is appropriate. In fact, the two methods derived the same value for TDS (820 mg/L) in Conejo Creek baseflow. Furthermore, the chloride values derived from the two methods (183 and 248 mg/L) were within approximately 30% of each other. The average result of the two methods (216 mg/L) will be used as the assigned chloride concentration of the baseflow in Conejo Creek. Similarly, the average sulfate concentration of 342 mg/L will be assigned to baseflow in Conejo Creek. The values that will be assigned to Conejo Creek baseflow are listed in Table 2.

Lower Calleguas

For the Arroyo Simi/Las Posas and Lower Calleguas reaches, there are insufficient surface water quality data to use for baseflow constituent estimation. Therefore, only data from wells that are the most likely to be connected to groundwater that influences surface water quality were used to estimate constituent concentrations in the groundwater inflow. Analysis of data from 34 wells in township-range sections that contain Lower Calleguas Creek resulted in the average constituent concentrations reported in Table 1. The average concentrations will be applied to the baseflow in all reaches of Lower Calleguas Creek (Reaches 1, 2, and 3). Summary statistics of well data are also presented in Table 1.

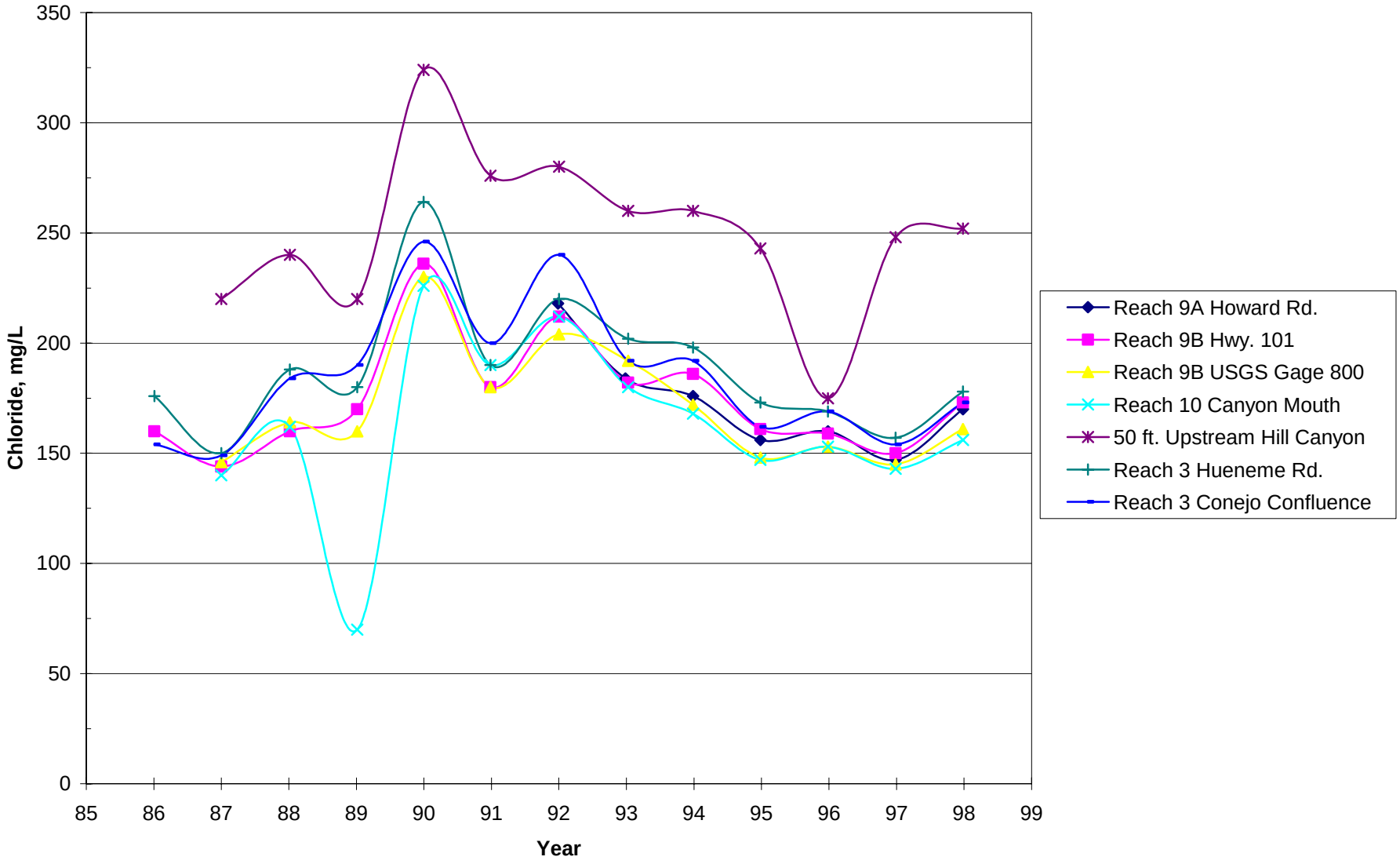

Figure 5. Calleguas and Conejo Creek Summer Recieving Water Chloride

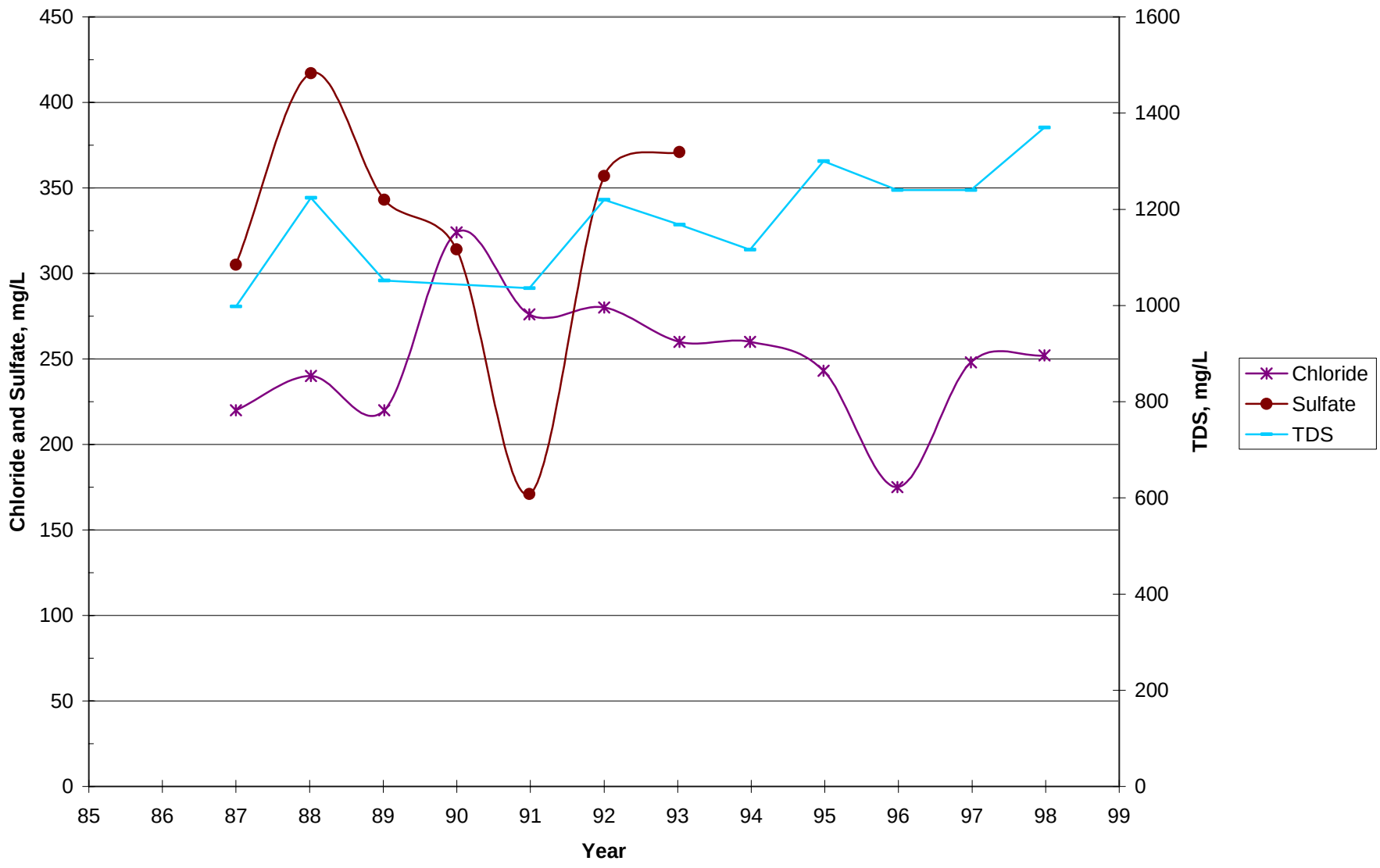

Figure 6. Conejo Creek Above Hill Canyon Summer Chloride, Sulfate, and TDS

Arroyo Simi/Las Posas

For the Arroyo Simi/Las Posas section, groundwater typically discharges from the Arroyo Simi and recharges along the Arroyo Las Posas. Therefore, Simi Valley dewatering wells near Arroyo Simi were used to estimate baseflow concentrations. Analysis of data from 5 wells resulted in the average constituent concentrations reported in Table 1. The average concentrations will be applied to the baseflow in Arroyo Simi and Arroyo Las Posas from the confluence of Tapo Canyon to the confluence of Conejo Creek (Reaches 6 and 7). Summary statistics of the well data are also presented in Table 1.

Chloride Concentration vs. Precipitation

Data compiled by the California Water Resources Board (1953) suggests that Calleguas Creek precipitation runoff exhibits chloride concentrations far below that of baseflow, resulting in low chloride concentrations during high discharge events (Figure 7). The horizontal axis of Figure 7 represents relative streamflow, with the mean annual streamflow assigned a value of one. Other Calleguas Creek surface water models have used these data exclusively for calibration (Durbin, 2002). Figure 7 shows concentrations of chloride in low relative-streamflows that are consistent with the calculated baseflow chloride concentrations in Table 1. Data from the Calleguas Creek Characterization Study also support the hypothesis of rainfall-runoff diluting baseflow chloride, as seen during the high discharge events sampled on 12/2/98 and 4/7/99 (Figure 8).

Conclusions

By calculating the quality and quantity of baseflow in the major segments of Calleguas Creek, the interaction between ground and surface water has been quantified. The correlations that define the interaction will be used in the surface water model to link surface and subsurface processes. The predicted groundwater inputs will vary spatially and temporally; a great improvement upon previous static versions of the surface water model. The quantity of groundwater inputs will be dependent on precipitation; higher after wet winters and vice-versa. The concentration of chloride, sulfate, and TDS in the baseflow will be reach-dependent to account for the spatial variation of groundwater sources within the watershed. Most significantly, the results presented here will enable the surface water model to provide more reliable estimates during the TMDL decision-making process, another step towards improving the Calleguas Creek watershed.

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State Water Resources Control Board. Proposed Decision Regarding Application 29408 and Wastewater Change Petition No. 6 for the City of Thousand Oaks and Availability of Unappropriated Water for Applications 29816, 29819, 29581, 29959, 30317, 30092, 30194 – Arroyo Conejo, Conejo Creek, and Calleguas Creek in Ventura County. Sacramento, CA. 1997.

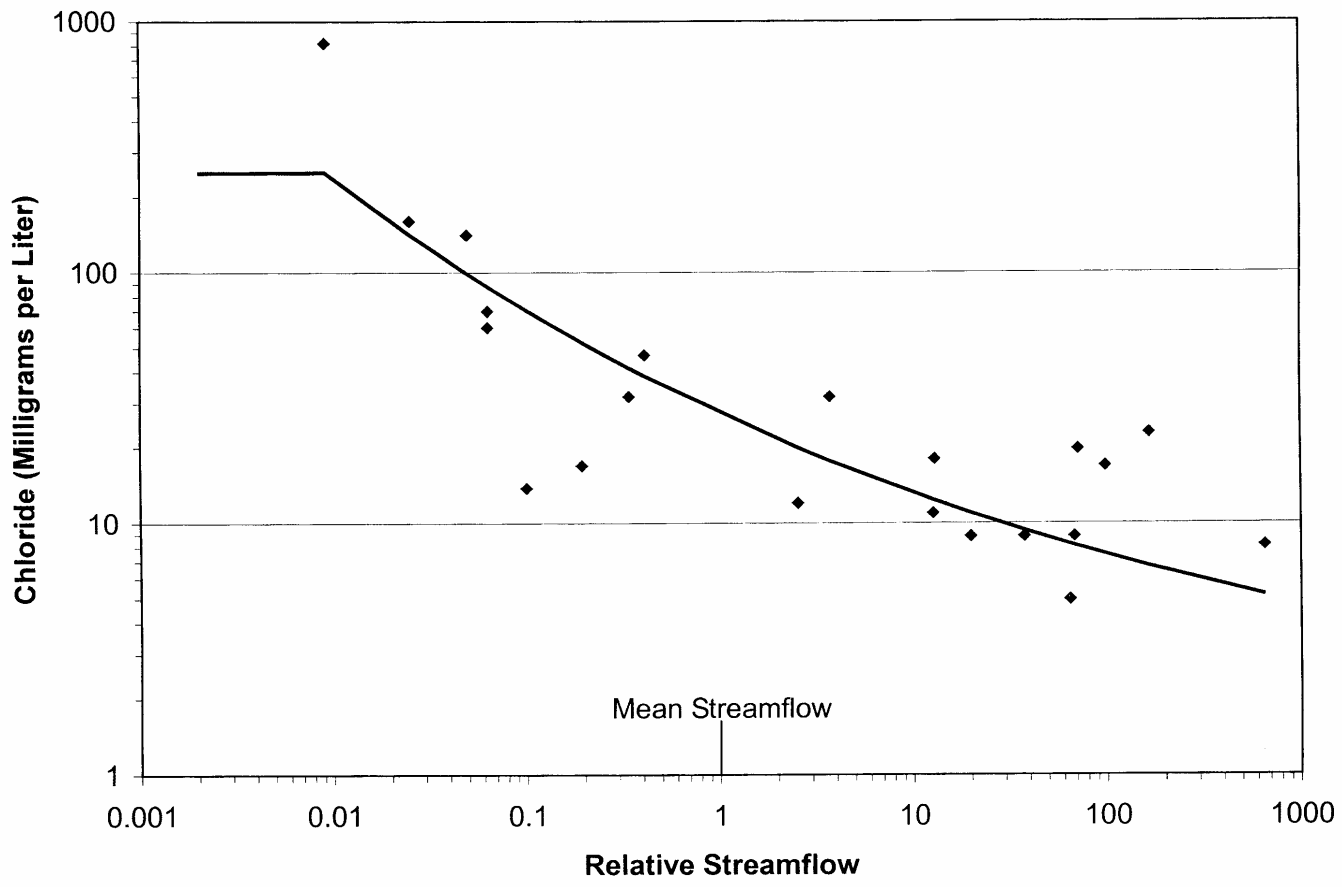


Figure 7. CC Surface Water Chloride Concentration vs. Relative Streamflow (from Durbin, 2002)

Table 1. Statistical Summary of GW Data Applied to Lower Calleguas and Arroyo Simi / Las Posas Baseflow

Parameter	Sulfate (mg/L)	Chloride (mg/L)	TDS (mg/L)
Conejo Creek			
# Samples	99	189	228
Average Concentration	**239**	**183**	**820**
Standard deviation	374	225	337
Maximum	1550	1650	1450
Minimum	0	1	0
Lower Calleguas			
# Samples	24	132	139
Average Concentration	**801**	**227**	**907**
Standard deviation	1285	332	337
Maximum	5600	2990	2770
Minimum	0	8	21
Arroyo Simi/Las Posas			
# Samples	28	28	33
Average Concentration	791	138	1741
Standard deviation	113	16	141
Maximum	1070	170	2067
Minimum	630	110	1560

Table 2. Surface Water Values Used for Conejo Creek Baseflow Estimation

Parameter	Average Flow (cfs)	Sulfate (mg/L)	Chloride (mg/L)	TDS (mg/L)
Site above Hill Canyon 1987-1998 Summer Average	3.6	325	250	1283
Estimated Dry-Weather Urban Runoff	1.2	60	185	1937
Estimated Dry-Weather Agricultural Runoff	0.1	916	163	2662
Calculated Baseflow for Conejo Creek	2.3	**445**	**248**	**820**
Average of GW and Surface Water Methods (Value assigned to Conejo Creek baseflow)	-------	**342**	**216**	**820**

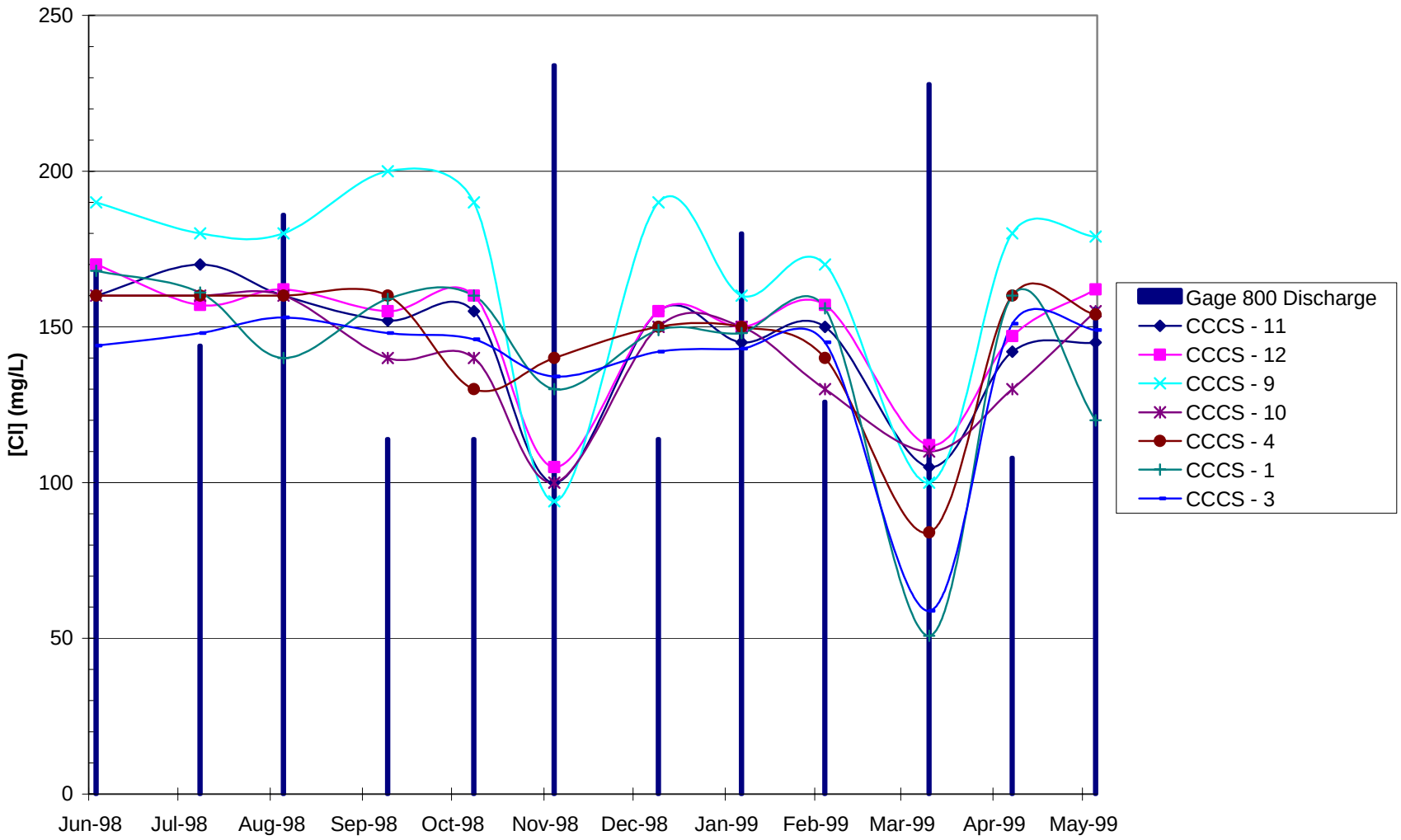


Figure 8. CCCS Receiving Water Chloride and Corresponding Gage 800 Discharge

Data Categories and Sources

Data categories analyzed to support the Calleguas Creek Dynamic Modeling System (CCDMS) included flow and quality of water inputs to the Calleguas Creek watershed and receiving waters within the watershed. Quality data considered were limited to the salt constituents, chloride, total dissolved solids (TDS), sulfate, and boron. The data categories considered in the analysis are summarized in Table 1 along with the sources from which the data were obtained.

Table 1. Summary of Data Categories Analyzed and Sources of Data

Data Category	Data Source
Flow	
POTW Effluent	
Camarillo WRP	Camarillo Wastewater Reclamation Plant
Hill Canyon WWTP	Hill Canyon Wastewater Treatment Plant
Simi Valley WQCP	Simi Valley Water Quality Control Plant
Receiving Water Gauge Stations	Ventura County Watershed Protection District
Quality	
POTW Effluent	
Camarillo WRP	Camarillo Wastewater Reclamation Plant
Hill Canyon WWTP	Hill Canyon Wastewater Treatment Plant
Simi Valley WQCP	Simi Valley Water Quality Control Plant
Imported Water	
Jensen Plant	Calleguas Municipal Water District
Freeman Diversion	United Water Conservation District
Stormwater Runoff	Ventura County Watershed Protection District; 205(j) Non-point Source Study; Calleguas Creek Characterization Study
Ag	
Open Space	

Data Category	Data Source
Industrial	
Commercial	
Residential	
Mixed Use	
Non-stormwater Runoff	Ventura County Watershed Protection District; 205(j) Non-point Source Study; Calleguas Creek Characterization Study
Ag	
Open Space	
Groundwater Discharge	Simi Valley Water Quality Control Plant; Calleguas Creek Characterization Study

Table 1. (continued)

Data Category	Data Source
Receiving water	Ventura County Watershed Protection District; 205(j) Non-point Source Study; Calleguas Creek Characterization Study; Camarillo WRP; Hill Canyon WWTP; Simi Valley WQCP
Precipitation	
Calleguas Rainfall Gauge Stations	Ventura County Watershed Protection District
Sacramento Precipitation Data	Western Regional Climatic Center
Evapotranspiration	(California SWRCB, 1984)

Data Analysis Procedures and Results

Data were analyzed for the purpose of describing the distributional characteristics of the various watershed flow and water quality parameters and, to the extent allowed by the nature of the data, to develop relationships between watershed input parameters and external variables used in the CCDMS. Such relationships, where found to be significant, are in the form of simple linear regressions. The resulting stochastic descriptions and predictive relationships are used within the CCDMS to produce internal variable values. In addition, distributional characteristics determined for watershed receiving water quality can serve as a model validation tool.

Most input parameter values were first plotted as functions of time to determine any apparent trends with time over years. In cases where time trends were apparent, selected portions of data sets were used in the analyses as necessary to best represent current conditions. Parameter values were also plotted as functions of month of the year to determine any apparent regular seasonal variability. In cases exhibiting significant seasonal variability, data were sorted and analyzed by month.

Specific analyses performed and the results obtained are presented below for the various data categories.

POTW Effluent Flow vs. Time

Effluent flow from the three POTWs that regularly discharge into the watershed, Camarillo, WRP, Hill Canyon WWTP, and Simi Valley WQCP, are plotted vs. time in Figure 1 through Figure 3, respectively. In the cases of Hill Canyon WWTP and Simi Valley WQCP, flow is tending to increase with time, most likely as a result of gradually increasing population contributing to the plants. Corresponding regression equations are displayed on each plot. The discharge pattern for Camarillo is more variable due to the variation in use of reclaimed water from the plant. To minimize the influence of time on the flow data values it was determined that subsequent stochastic descriptions of the data in all cases should be limited to the most recent 24 months of available data (October 2001 through September 2003). This time period is consistent with that used to describe effluent quality as discussed below.

POTW Effluent Flow vs. Month

Effluent flow data for Camarillo WRP, Hill Canyon WWTP, and Simi Valley WQCP were sorted by month and plotted in Figure 4 through Figure 6, respectively. Some differences in the distributions of data from month to month are apparent. Consequently, it was determined that separate frequency distributions for each month would provide a more accurate description of the flows from the various plants.

POTW Effluent Flow Frequency Distribution by Month

Monthly frequency distributions were determined for effluent flow data for non-precipitation days from each month for Camarillo WRP, Hill Canyon WWTP, and Simi Valley WQCP for the time period October 2001 through September 2003. Results are plotted for Camarillo in Figure 7 through Figure 18, for Hill Canyon in Figure 19 through Figure 30, and Simi Valley in Figure 31 through Figure 42. Each plot also displays a regression equation that describes the distributions. Regression equations are summarized in Table 2.

Table 2. Summary of Regression Equations and Statistics for POTW Effluent Flow Monthly Frequency Distributions and Δ Flow vs. Precipitation

Month	Camarillo WRP	Hill Canyon WWTP	Simi Valley WQCP
Jan	y = 4.863 + 0.82619norm(x) R= 0.97852	y = 16.642 + 0.51733norm(x) R= 0.92463	y = 14.269 + 0.48142norm(x) R= 0.98636
Feb	y = 4.9566 + 1.07norm(x) R= 0.94946	y = 17.218 + 1.8389norm(x) R= 0.88357	y = 14.764 + 1.6169norm(x) R= 0.85084
Mar	y = 4.3654 + 1.17norm(x) R= 0.97725	y = 16.842 + 1.5995norm(x) R= 0.91549	y = 14.43 + 1.0787norm(x) R= 0.91072
Apr	y = 4.3218 + 0.6838norm(x) R= 0.91311	y = 16.732 + 0.90588norm(x) R= 0.89113	y = 14.033 + 0.83749norm(x) R= 0.98076
May	y = 4.5976 + 0.8268norm(x) R= 0.95085	y = 16.724 + 0.8148norm(x) R= 0.96247	y = 13.812 + 0.86556norm(x) R= 0.93068
Jun	y = 3.7678 + 0.6655norm(x) R= 0.91555	y = 16.562 + 1.0042norm(x) R= 0.94187	y = 14.075 + 0.53396norm(x) R= 0.9697
Jul	y = 3.4175 + 0.6058norm(x) R= 0.97015	y = 16.118 + 1.0593norm(x) R= 0.92061	y = 13.847 + 0.42457norm(x) R= 0.98193
Aug	y = 3.6763 + 0.9436norm(x) R= 0.95871	y = 15.987 + 0.96662norm(x) R= 0.93561	y = 13.758 + 0.55879norm(x) R= 0.80508
Sep	y = 4.6145 + 0.6689norm(x) R= 0.96164	y = 16.253 + 0.71232norm(x) R= 0.96377	y = 13.699 + 0.56851norm(x) R= 0.98058
Oct	y = 3.6082 + 1.202norm(x) R= 0.96289	y = 16.38 + 0.81703norm(x) R= 0.85697	y = 13.723 + 0.68987norm(x) R= 0.99265
Nov	y = 4.8527 + 1.24norm(x)	y = 17.081 + 1.2237norm(x)	y = 14.212 + 0.68729norm(x)

	R= 0.98525	R= 0.88066	R= 0.98861
Dec	y = 5.0332 + 1.2383norm(x) R= 0.92881	y = 16.912 + 1.4069norm(x) R= 0.77868	y = 14.392 + 0.88446norm(x) R= 0.97912
Δ Flow vs. P	y = 0.97439x R= 0.25887	y = 2.1757x R= 0.57666	y = 1.1841x R= 0.4072

POTW Δ Effluent Flow vs. Precipitation

To quantify the effect of precipitation on effluent flow, the increases (Δ) in flows observed for days with precipitation following days without precipitation for the periods of record were plotted vs. average precipitation depths, which were determined by averaging rain gauge data from stations tributary to the POTW collection areas. Plots of Δ Effluent Flow vs. Precipitation Depth and the corresponding regression equations are presented for Camarillo WRP, Hill Canyon WWTP, and Simi Valley WQCP in Figures 43, 44, and 45, respectively. Regression equations are summarized in Table 2.

Receiving Water Flow vs. Precipitation

Receiving water flows at gauge stations 776, 800, 803, 805, 806, and 841 were plotted vs. area-weighted average precipitation depths determined from precipitation gauges tributary to the respective flow gauge stations. Plots and corresponding regression equations for gauge stations 776, 800, 803, 805, 806, and 841 are presented in Figures 46, 47, 48, 49, 50, and 51, respectively. Regression equations are summarized in Table 3.

Table 3. Summary of Regression Equations and Statistics for Gauge Flow vs. Precipitation

Gauge Station	Gauge Flow vs. Precipitation
776	y = 9.1422 + 228.02x; R= 0.62022
800	y = 17.125 + 385.92x; R= 0.68295
803	y = 7.3099 + 184.36x; R= 0.6352
805	y = 12.504 + 926.78x; R= 0.6983
806	y = 398.53x; R= 0.547
841	y = 17.445 + 396.73x; R= 0.63895

POTW Effluent Quality vs. Time

POTW effluent quality in terms of the salt constituents, chloride, total dissolve solids (TDS), sulfate, and boron, were plotted vs. time for the periods of record for the three principal treatment plants that discharge to the watershed. Results for Camarillo WRP are plotted in Figure 52 through 55 for chloride, TDS, sulfate, and boron, respectively. Chloride and TDS both clearly exhibit increasing trends over the period of record from 1998 through 2003, while sulfate and boron exhibit weak or no trends with time. The increasing trend in chloride is more dramatically illustrated in Figure 56, a plot of the 12-month running average effluent chloride vs. time. Plots for effluent quality vs. time for Hill Canyon and Simi Valley are presented in Figure 57 through Figure 60 and Figure 61 through Figure 64, respectively. Trends in chloride with time similar to those observed for Camarillo are noted for Hill Canyon and Simi Valley, although no apparent trends are exhibited with TDS, sulfate, or boron.

POTW Effluent Quality vs. Month

Effluent quality data for each salt constituent for Camarillo WRP, Hill Canyon WWTP, and Simi Valley WQCP were sorted by month and plotted in Figure 65 through Figure 68, Figure 69 through Figure 72, and Figure 73 through Figure 76, respectively. No clear differences in the distributions of data from month to month are apparent.

POTW Effluent Quality Frequency Distributions

Based on the observed relationships between effluent quality and time, and effluent quality and month of the year as described above, it was determined that frequency distributions of effluent quality in terms of the four salt constituents should be limited to the 2-year time period from October 2001 through September 2003 and that all data within the time period should be used in the analysis as opposed to separating the data by month. Resulting frequency distributions and corresponding regression equations for Camarillo WRP are plotted in Figure 77 through Figure 80, for Hill Canyon WWTP in Figure 81 through Figure 84, and for Simi Valley WQCP in Figure 85 through Figure 88. Similar plots were also prepared for the minor POTW discharges from the Camrosa and Moorpark treatment plants; results are presented in Figure 89 through Figure 92 and Figure 93 through Figure 96, respectively. Regression equations are summarized in Table 4.

Imported Water Quality vs. Time

The quality of the domestic water supply in terms of the four salt constituents of interests strongly influences the quality of POTW effluents. Imported water constitutes the major source of domestic water supply in the watershed. The principal source of imported water is State Water Project water distributed through the Jensen Water Treatment Plant (Jensen Plant). A smaller volume of water is diverted from the Santa Clara River trough the Freeman Diversion. Imported water quality data in terms of the four salt constituents of interests were analyzed with respect to variation with time. Results for the Jensen Plant are plotted in Figure 97 through Figure 100. Each of the salt constituents exhibits both short-term cyclic and long-term trends with time. The increasing trend in chloride is more dramatically illustrated in Figure 101, a plot of the 12-month running average chloride vs. time. These trends support the decision to limit POTW effluent analysis to data from the most current 2-year period.

Results for Freeman Diversion water are plotted in Figure 102 through Figure 105. No apparent time trends are exhibited in these plots.

Imported Water Quality Frequency Distributions

Frequency distributions of imported water quality in terms of the four salt constituents were determined for both the Jensen Plant and the Freeman Diversion. Plots of the distributions along with associated regression equations for the distributions are presented in Figure 106 through Figure 109 for the Jensen Plant and in Figure 110 though Figure 113 for the Freeman Diversion. Regression equations and statistics are summarized in Table 4.

Imported Water (Jensen Plant) Chloride vs. Precipitation

It was speculated that Jensen Plant chloride quality could be correlated with an external variable, such as precipitation in Northern California. To determine if such correlation exists, the Jensen Plant 12-month average chloride concentration data were plotted together with the annual precipitation depth for Sacramento vs. time. The 12-month average chloride was also plotted as a function of Sacramento Annual Precipitation. Results are presented in Figure 114 and 115, respectively. Based on the limited data set there is a weak negative correlation between Jensen Plant chloride and Sacramento Annual Precipitation, indicating that wet years in Northern California can be expected to produce lower chloride concentrations in imported water from the Jensen Plant.

POTW Effluent Quality vs. Jensen Plant Quality

In terms of direct correlation between POTW effluent salt quality and Jensen Plant quality, only chloride and sulfate exhibited significant correlations for the three principal POTWs. Plots of POTW effluent chloride and sulfate concentrations vs. Jensen Plant concentrations are presented in Figures 116 and 117, respectively for Camarillo WRP, in Figures 118 and 119 for Hill Canyon WWTP, and Figure 120 and 121 for Simi Valley WQCP. Corresponding regression equations and statistics are summarized in Table 5.

Table 4. Summary of Regression Equations and Statistics for Frequency Distributions of Quality Data from Watershed Inputs

Input Source	TDS	Chloride	Sulfate	Boron
Effluent				
Camarillo	y = 955.11 + 45.167norm(x) R= 0.97628	y = 187.85 + 9.2194norm(x) R= 0.86777	y = 216.37 + 19.632norm(x) R= 0.9759	y = 0.62741 + 0.02689norm(x) R= 0.97091
Hill Canyon	y = 640.75 + 36.932norm(x) R= 0.98374	y = 150.04 + 9.9102norm(x) R= 0.98443	y = 106.96 + 11.653norm(x) R= 0.97979	y = 0.60958 + 0.06363norm(x) R= 0.96829
Simi Valley	y = 696.56 + 55.412norm(x) R= 0.99159	y = 145.07 + 10.91norm(x) R= 0.98152	y = 170.63 + 24.261norm(x) R= 0.95165	y = 0.52963 + 0.05538norm(x) R= 0.82344
Camrosa	y = 716.55 + 146.13norm(x) R= 0.9298	y = 155.05 + 33.397norm(x) R= 0.94341	y = 133.27 + 12.608norm(x) R= 0.97092	y = 0.34338 + 0.17026norm(x) R= 0.98303
Moorpark	y = 573.67 + 8.2889norm(x) R= 0.99741	y = 140.67 + 13.469norm(x) R= 0.95492	y = 138.67 + 10.879norm(x) R= 0.90594	y = 0.55667 + 0.03108norm(x) R= 0.93326
Storm Runoff				
Ag	y = 568.37 * e^(0.72369norm(x)) R= 0.94632	y = 33.597 * e^(0.8436norm(x)) R= 0.95608	No Data	No Data
Open Space	y = 1427.3 * e^(0.53738norm(x)) R= 0.97977	y = 76.178 * e^(0.7366norm(x)) R= 0.98636	No Data	No Data
Industrial	y = 90.96 * e^(0.75636norm(x)) R= 0.96689	y = 24.25 + 16.895norm(x) R= 0.99846	No Data	No Data
Commercial	y = 57.711 * e^(0.47663norm(x)) R= 0.78019	y = 3 + 2.4605e-16norm(x) R= 0	No Data	No Data
Residential	y = 81.604 * e^(0.76254norm(x)) R= 0.97319	y = 18.11 * e^(0.94535norm(x)) R= 0.95108	No Data	No Data
Mixed Use	y = 525.25 * e^(0.90253norm(x)) R= 0.91777	y = 39.716 * e^(1.2859norm(x)) R= 0.90594	No Data	No Data

Non-storm Runoff				
Ag	y = 2662.5 + 989.56norm(x) R= 0.98538	y = 167.29 + 62.514norm(x) R= 0.95026	No Data	No Data
Open Space	y = 2078.7 + 994.16norm(x) R= 0.95134	y = 171.4 + 86.512norm(x) R= 0.9408	No Data	No Data
Mixed Use	y = 1937.5 + 502.33norm(x) R= 0.96524	y = 185.88 + 110.73norm(x) R= 0.94561	No Data	No Data
GW Discharge	y = 1633.7 + 31.232norm(x) R= 0.96421	y = 130.91 + 2.8524norm(x) R= 0.99112	y = 758.49 * e^(0.1373norm(x)) R= 0.91897	y = 0.80455 + 0.058875norm(x) R= 0.9406

Table 4. (continued)

Input Source	TDS	Chloride	Sulfate	Boron
Imported Water				
Jensen Plant	y = 328.65 * e^(0.14238norm(x)) R= 0.98771	y = 61.653 * e^(0.25203norm(x)) R= 0.97984	y = 85.731 + 27.61norm(x) R= 0.98197	y = 0.26974 + 0.059617norm(x) R= 0.97792
Freeman Diversion	y = 1105.8 + 253.35norm(x) R= 0.99483	y = 53.753 * e^(0.45105norm(x)) R= 0.98805	y = 507.08 + 139.97norm(x) R= 0.99791	y = 0.74741 + 0.19699norm(x) R= 0.983

Table 5. Summary of Regression Equations and Statistics for POTW Effluent Quality vs. Jensen Plant Quality

Salt	Camarillo WRP	Hill Canyon WWTP	Simi Valley WQCP
Chloride	y = 121.66 + 0.81487x R= 0.76842; RMS = 10.296	Y = 73.106 + 0.911x; R = 0.864; RMS = 8.189	y = 78.706 + 0.827x; R= 0.882; RMS = 6.808
Sulfate	y = 161.795 + 0.801x; R= 0.410; RMS = 26.867	Y = 60.779 + 0.962x; R = 0.695; RMS = 15.042	Y = 126.037 + 0.926x; R = 0.484; RMS = 33.092

Stormwater Runoff Quality Frequency Distributions

Only chloride and TDS data are available for stormwater runoff from different land uses. Insufficient data are available to establish relationships between stormwater runoff quality from different land uses and hydrological parameter external variables such as event rainfall amount, antecedent dry period and cumulative seasonal precipitation. Consequently, frequency distributions of chloride and TDS were developed to describe stormwater runoff quality for the following types of land use: agricultural, open space, industrial, commercial, residential, and mixed-use. Frequency distribution plots and corresponding regression equations and statistics for chloride and TDS are shown in Figures 122 and 123 for agricultural, Figures 124 and 125 for open space, Figures 126 and 127 for industrial, Figures 128 and 129 for commercial, Figures 130 and 131 for residential, and Figures 132 and 133 for mixed-use. Regression equations and statistics are summarized in Table 4.

Non-stormwater Runoff Quality Frequency Distribution

Non-stormwater (dry season) runoff data are only available for chloride and TDS from agricultural, open space and mixed-use land uses. Frequency distribution plots and corresponding regression equations and statistics are shown in Figures 134 and 135 for agricultural, Figures 136 and 137 for open space, and Figures 138 and 139 for mixed-use. Regression equations and statistics are summarized in Table 4.

Groundwater Discharge Quality Frequency Distribution

Groundwater is continuously pumped and discharged to the watershed in the Simi Valley area to control the level of the groundwater table. Frequency distributions for chloride, TDS, sulfate, and boron concentrations in pumped groundwater discharge are plotted in Figure 140 through Figure 143, respectively. Regression equations and statistics are summarized in Table 4.

Receiving Water Quality vs. Time

Concentrations of the four salt constituents observed in the various reaches of the Calleguas Creek watershed were plotted as functions of time. Plots for the various reaches are presented in the Figures listed below:

Reach	Figure No.			
	Chloride	TDS	Sulfate	Boron
2	144	145	146	147
3	148	149	150	–
4	151	152	153	154
5	155	156	–	–
6	157	158	159	160
7	161	162	163	164
9A	165	166	167	168
9B	169	170	171	172
10	173	174	175	176
11	177	178	179	180
13	181	182	183	184

In general, no consistent correlations with time were observed for any of the four salt constituents in any of the reaches.

Receiving Water Quality Frequency Distributions

Frequency distributions of salt quality data for the various reaches were prepared and are presented in the Figures listed below:

Reach	Figure No.			
	Chloride	TDS	Sulfate	Boron
2	185	186	187	188
3	189	190	191	192
4	193	194	195	–
5	196	197	198	199
6	200	201	–	–

7	202	203	204	205
9A	206	207	208	209
9B	210	211	212	213
10	214	215	216	217
11	218	219	220	221
13	222	223	224	225

These descriptions of receiving water quality may be useful during the model validation process. Regression equations and statistics associated with the frequency distributions are summarized in Table 6.

Receiving Water Gauge Flow vs. Quality

In an effort to describe receiving water salt quality as a function of stream flow, receiving water quality data were plotted vs. flow for selected stream gauges in the watershed. Not all flow gauges or constituents were analyzed in this manner, because it was discovered that quality data were only available for a small range of low flows. Consequently, any relationships developed would be valid only over a limited range of flows. Flows at Gauge 800 are plotted vs. chloride concentration in Figure 226. Flows at Gauge 803 are plotted vs. chloride, TDS, sulfate, and boron concentrations in Figures 227, 228, 229, and 230, respectively. Flows at Gauge 841 are plotted vs. chloride, TDS, and sulfate concentrations in Figures 231, 232, and 233, respectively. Regression equations and statistics are summarized in Table 7.

Daily Evapotranspiration vs. Day of Year

To develop daily values for evapotranspiration (ET) associated with water bodies and riparian vegetation that can be used as external variables in the CCDMS, monthly values of potential ET were obtain for coastal and inland areas within the Calleguas Creek watershed from a reference document (SWRCB, 1984) and daily values were calculated by interpolation between monthly values. ET for water surface and riparian vegetation were estimated by increasing the potential ET values by a factor of 1.10. Separate ET values were determined for coastal and inland areas. A plot of estimated ET versus day of year is presented in Figure 234.

references

California State Water Resource Control Board (1984), “Irrigation with Recycled Municipal Wastewater – A Guidance Manual", Report No. 84-1 wr. California. SWRCB, Sacramento, CA, July 1984.

Table 6. Summary of Regression Equations and Statistics for Frequency Distributions of Quality Data from Receiving Waters

Reach	TDS	Chloride	Sulfate	Boron
Reach 2	y = 1519.6 * e^(0.80032norm(x))	y = 378.18 * e^(1.1167norm(x))	y = 474.1 * e^(0.71844norm(x))	y = 1.5364 + 0.60691norm(x)
	R= 0.94871	R= 0.96222	R= 0.96143	R= 0.98441
Reach 3	y = 788.2 + 166.5norm(x)	y = 163.28 + 38.891norm(x)	y = 254.44 + 78.084norm(x)	No Data
	R= 0.92298	R= 0.91275	R= 0.99097	
Reach 4	y = 2200.3 + 1351.4norm(x)	y = 89.661 * e^(0.79697norm(x))	y = 1606.2 + 517.82norm(x)	y = 1.43 + 0.52767norm(x)
	R= 0.91519	R= 0.92875	R= 0.85207	R= 0.91711
Reach 5	y = 293.85 * e^(0.40701norm(x))	y = 17.549 * e^(0.52709norm(x))	No Data	No Data
	R= 0.96816	R= 0.95237		
Reach 6	y = 1187.7 + 131.07norm(x)	y = 150.45 + 18.4norm(x)	y = 459.97 + 81.622norm(x)	y = 0.73667 + 0.21298norm(x)
	R= 0.81652	R= 0.85704	R= 0.92966	R= 0.78161
Reach 7	y = 1221.6 + 674.56norm(x)	y = 142.4 + 18.917norm(x)	y = 729.92 + 243.59norm(x)	y = 1.0478 + 0.25025norm(x)
	R= 0.91798	R= 0.86582	R= 0.96237	R= 0.9643
Reach 9A	y = 832.75 + 111.4norm(x)	y = 159.95 + 19.65norm(x)	y = 248.58 + 32.006norm(x)	y = 0.37583 + 0.043026norm(x)
	R= 0.98686	R= 0.96879	R= 0.94475	R= 0.94542
Reach 9B	y = 777.52 + 143.07norm(x)	y = 159.65 * e^(0.16593norm(x))	y = 248.28 + 75.275norm(x)	y = 0.35417 + 0.052488norm(x)
	R= 0.95185	R= 0.98218	R= 0.99407	R= 0.96729
Reach 10	y = 953.73 + 232.74norm(x)	y = 168.09 * e^(0.24824norm(x))	y = 261.17 + 91.975norm(x)	y = 0.52425 + 0.1141norm(x)
	R= 0.98529	R= 0.97937	R= 0.98283	R= 0.97042

Reach 11	y = 668.33 + 94.652norm(x) R= 0.92968	y = 105.42 + 17.442norm(x) R= 0.97181	y = 150.5 + 25.916norm(x) R= 0.95627	y = 0.1875 + 0.042437norm(x) R= 0.90579
Reach 13	y = 1188.3 + 184.17norm(x) R= 0.84327	y = 167.75 + 29.957norm(x) R= 0.85555	y = 396.58 + 74.347norm(x) R= 0.89159	y = 0.17583 + 0.042261norm(x) R= 0.95017

Table 7. Summary of Regression Equations and Statistics for Gauge Flow vs. Receiving Water Quality

Gauge	TDS	Chloride	Sulfate	Boron
800		y = 163.91 – 0.1012x; R= 0.06749		
803	y = 2006.8 – 21.075x R= 0.5285	y = 164.81 – 1.7241x R= 0.6296	y = 1083.1 – 18.248x R= 0.8296	y = 1.2908 – 0.018211x R= 0.63212
841	y = 1291.2 – 4.3917x R= 0.29114	y = 170.9 – 0.88759x R= 0.43531	y = 498.05 – 1.8929x R= 0.30749	

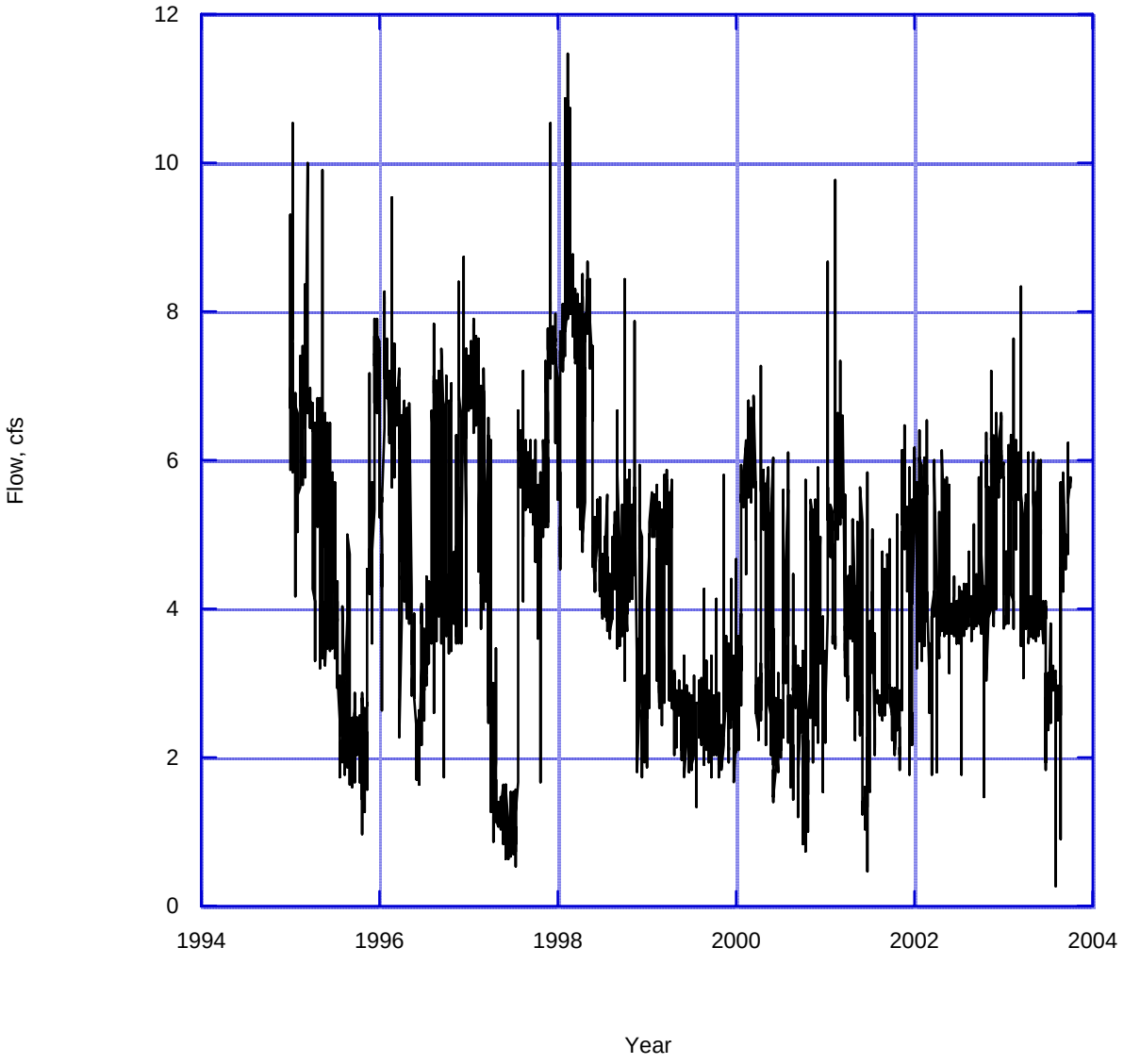


Figure 1. Camarillo Effluent Flow vs. Time

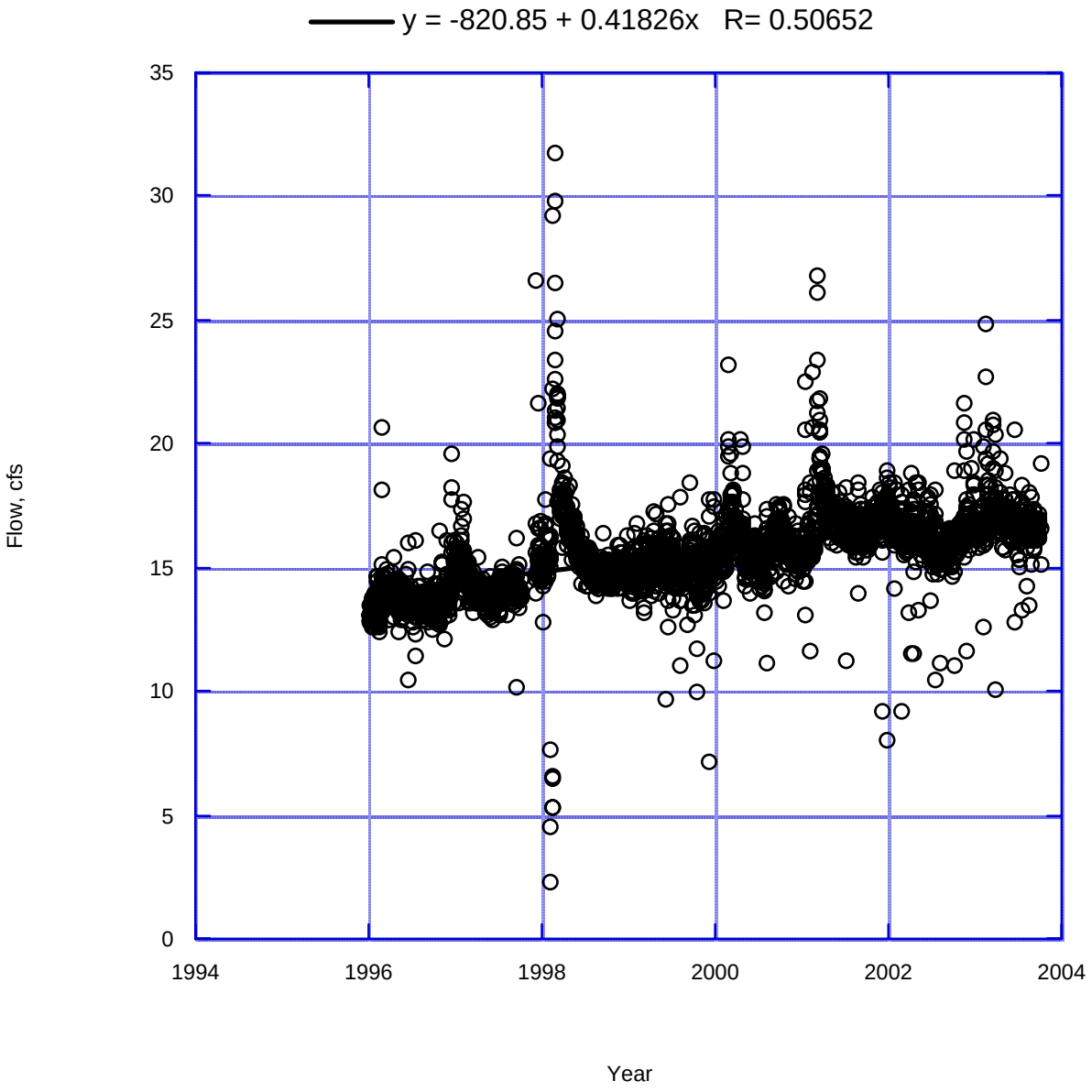


Figure 2. Hill Canyon Effluent Flow vs. Time

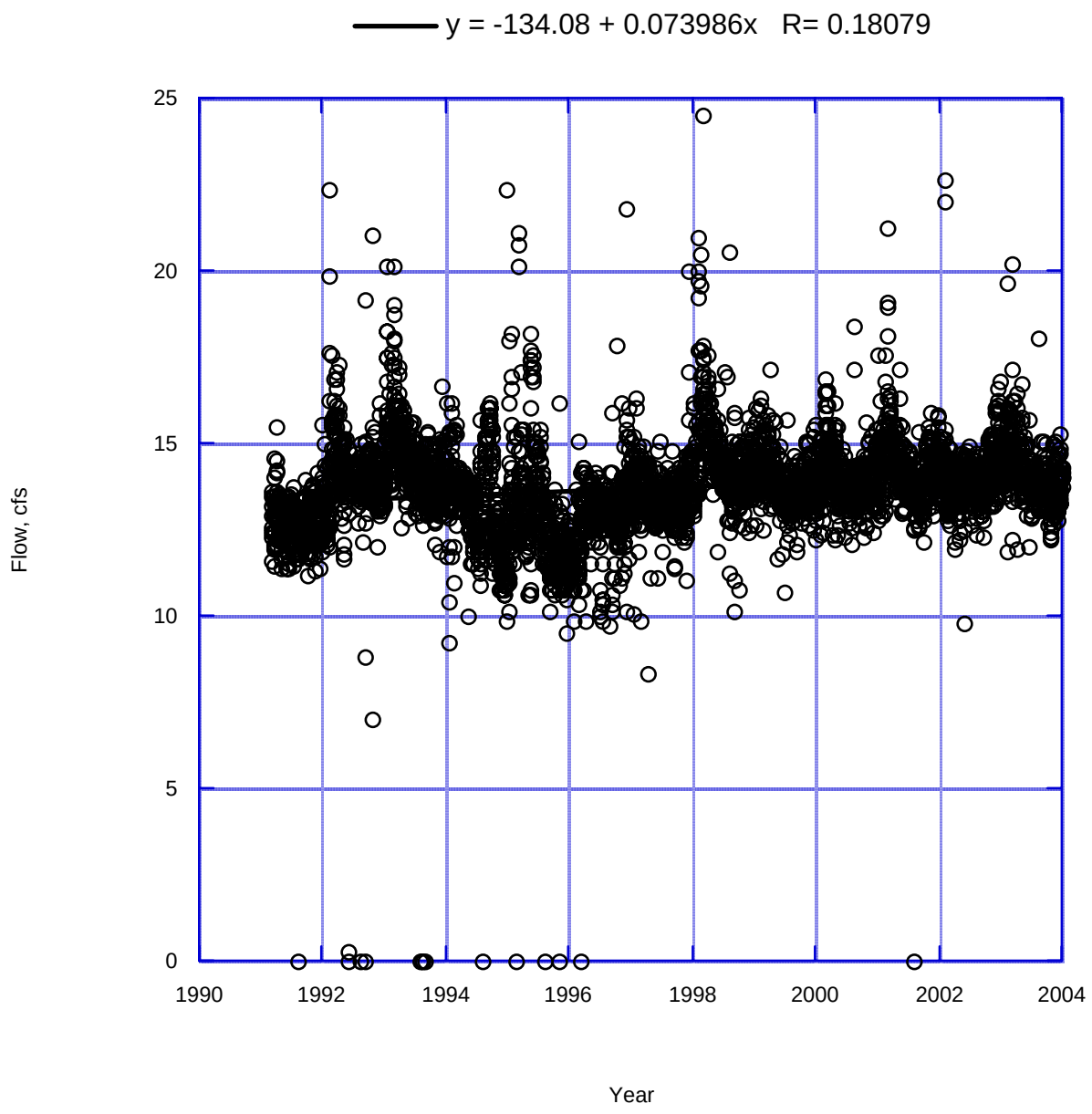


Figure 3. Simi Valley Effluent Flow vs. Time

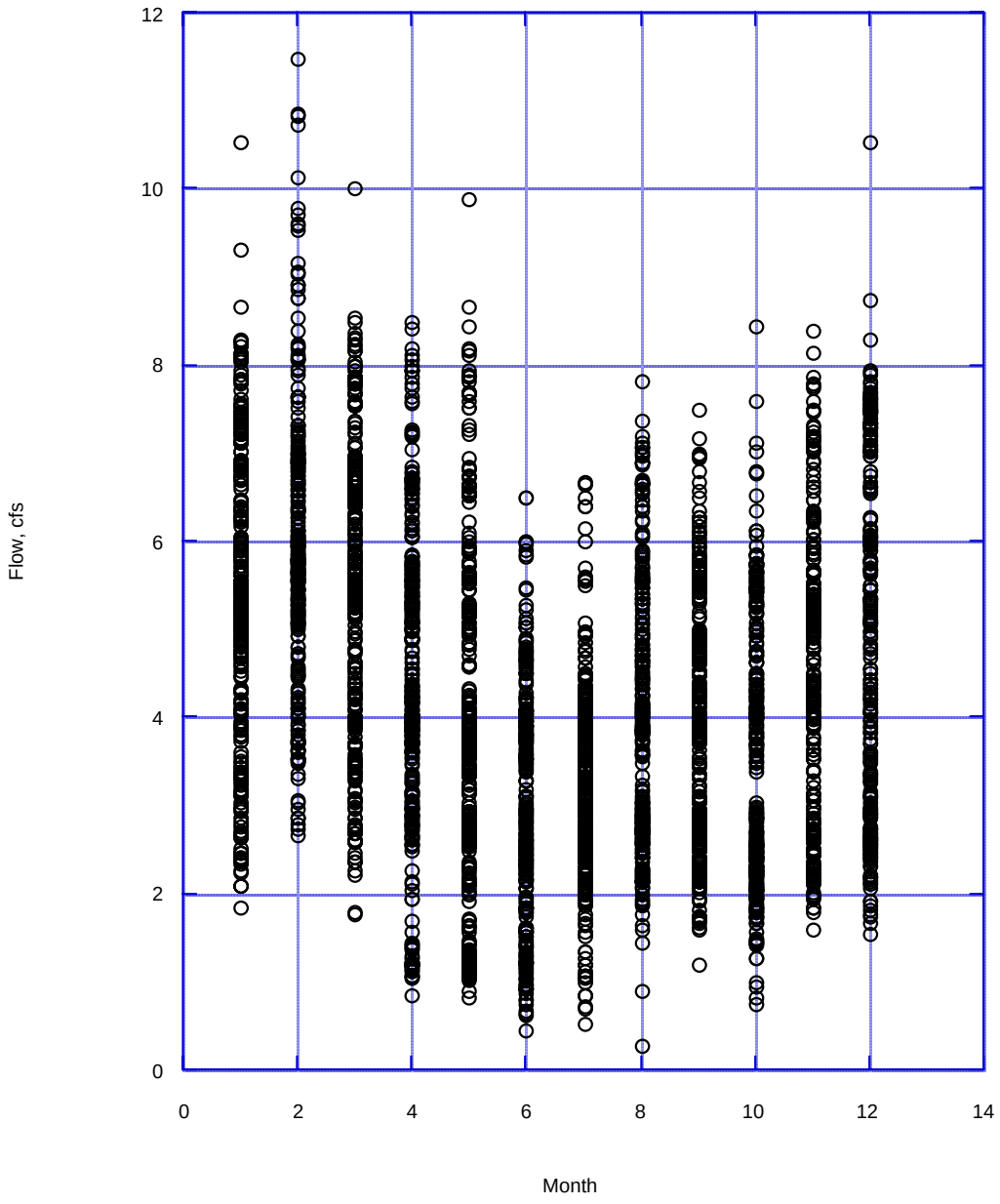


Figure 4. Camarillo Effluent Flow vs. Month

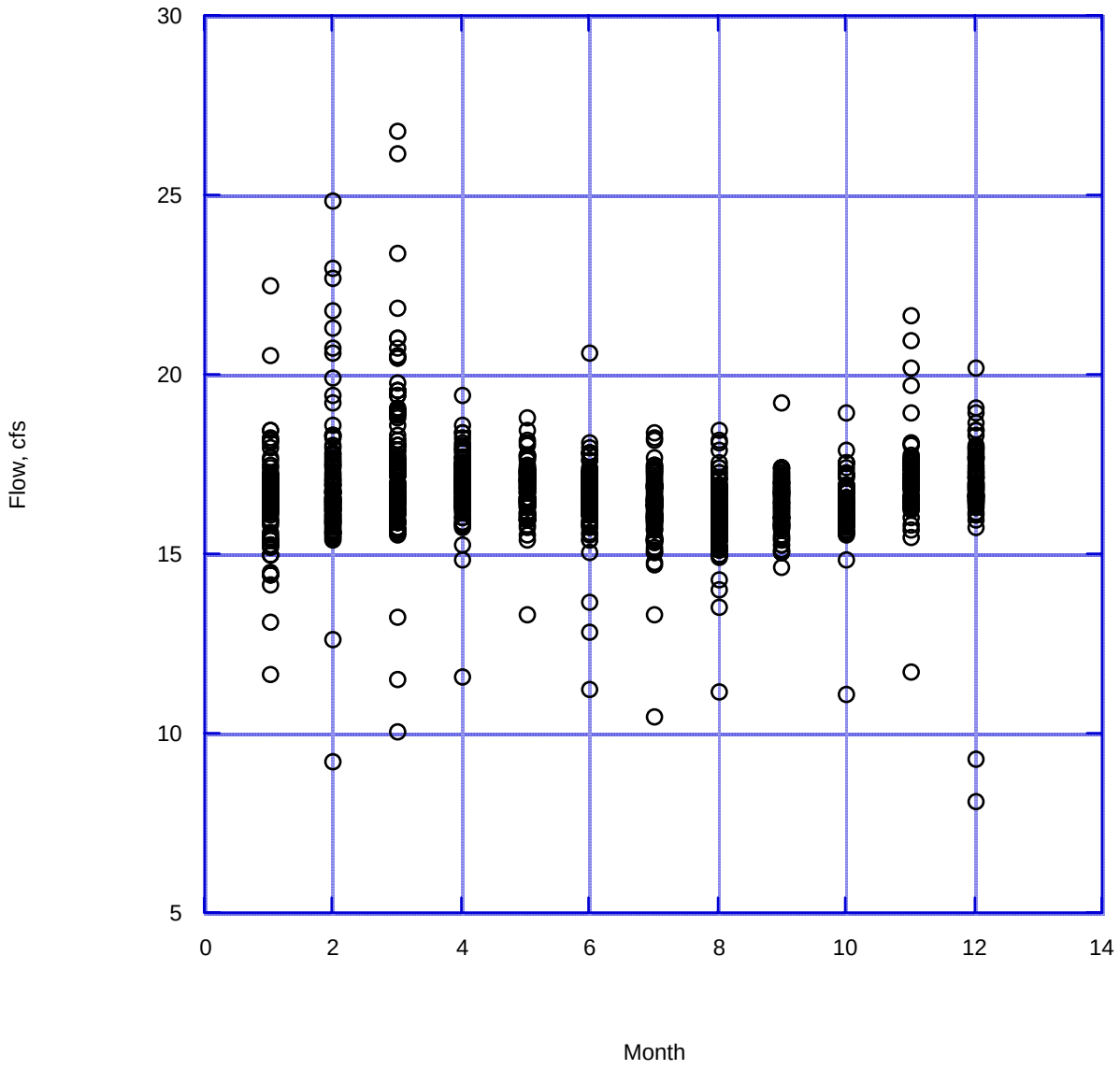


Figure 5. Hill Canyon Effluent Flow vs. Month (2001-2003)

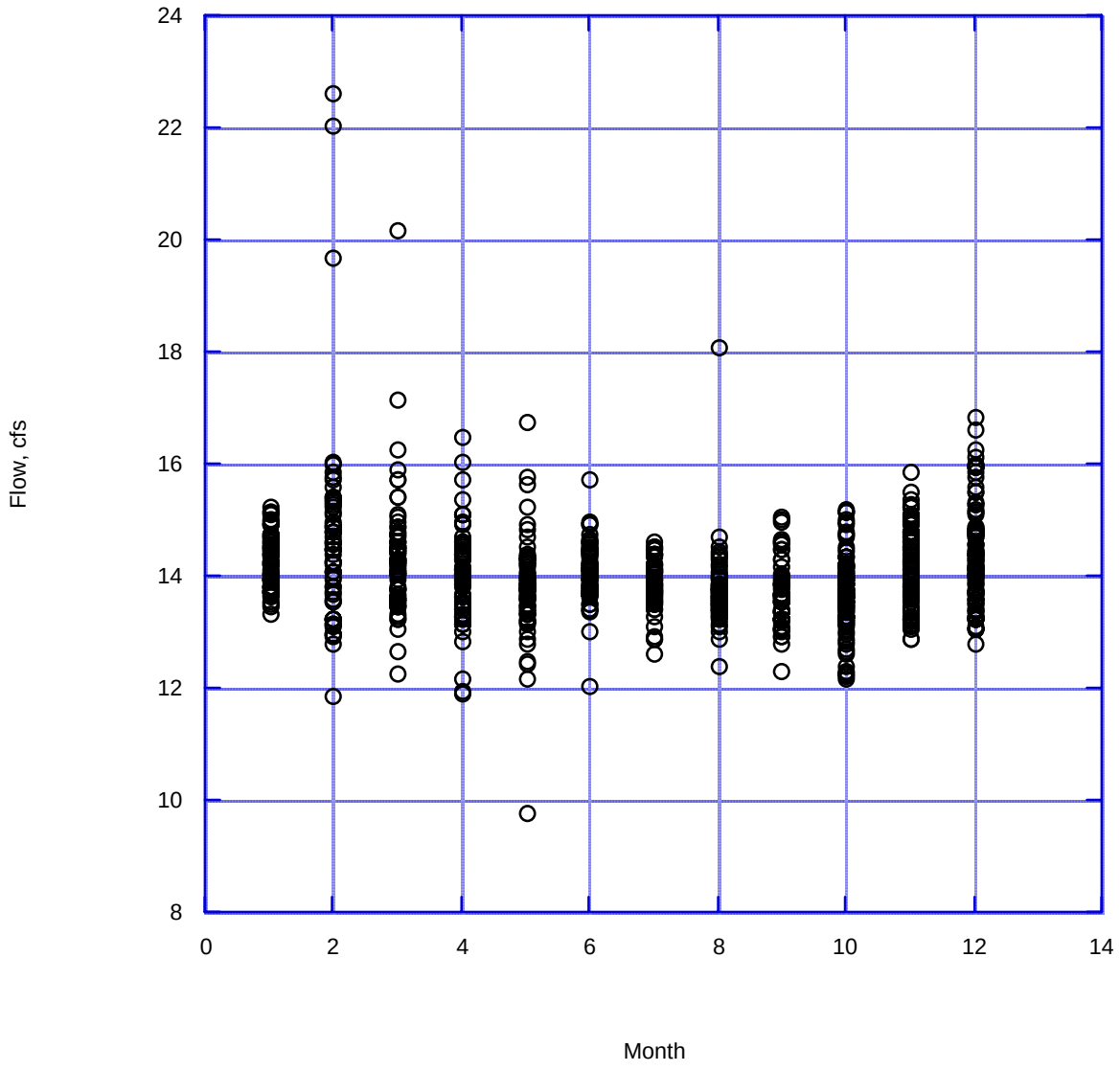


Figure 6. Simi Valley Effluent Flow vs. Month (2001-2003)

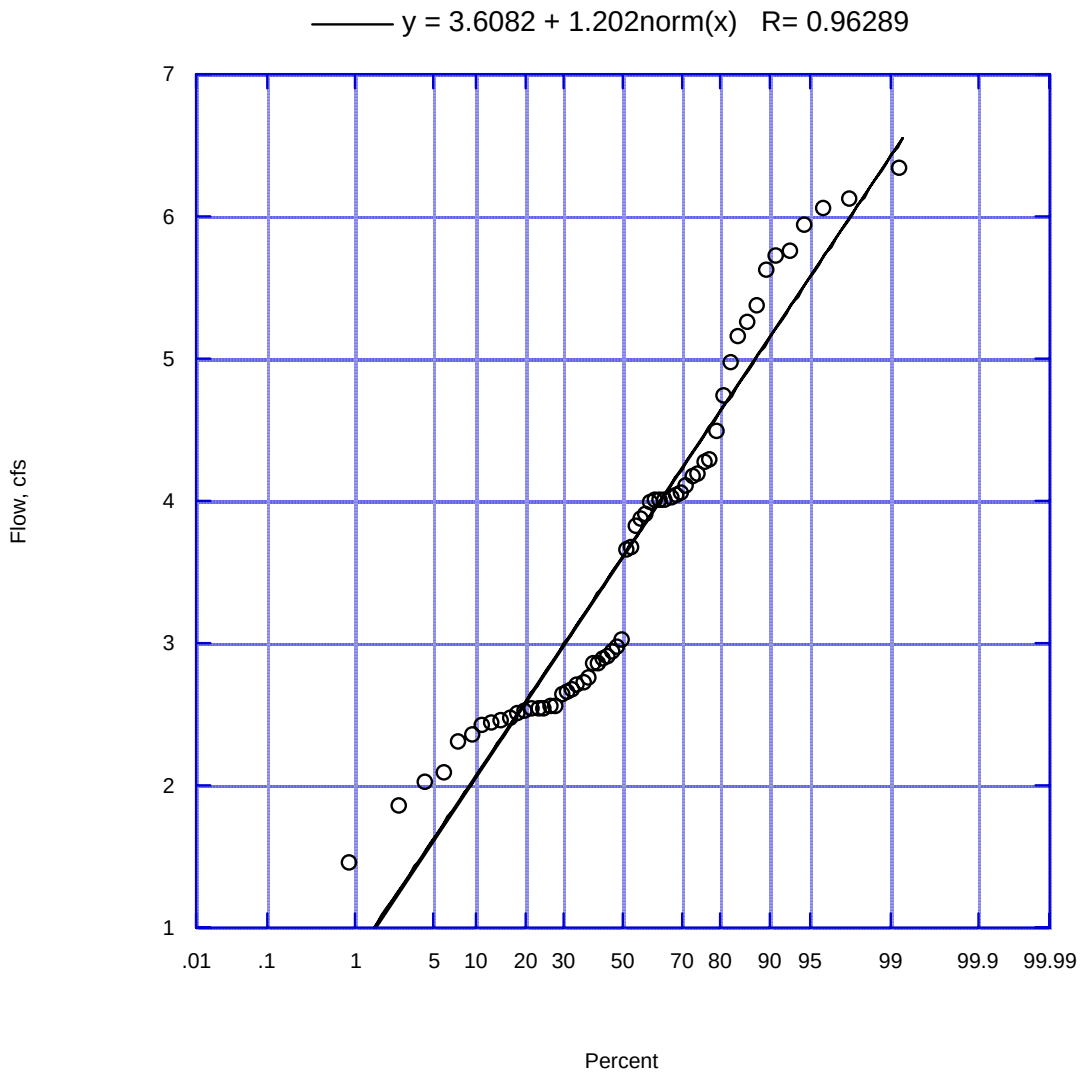


Figure 7. Camarillo Effluent Flow Frequency Distribution – Oct (01-02)

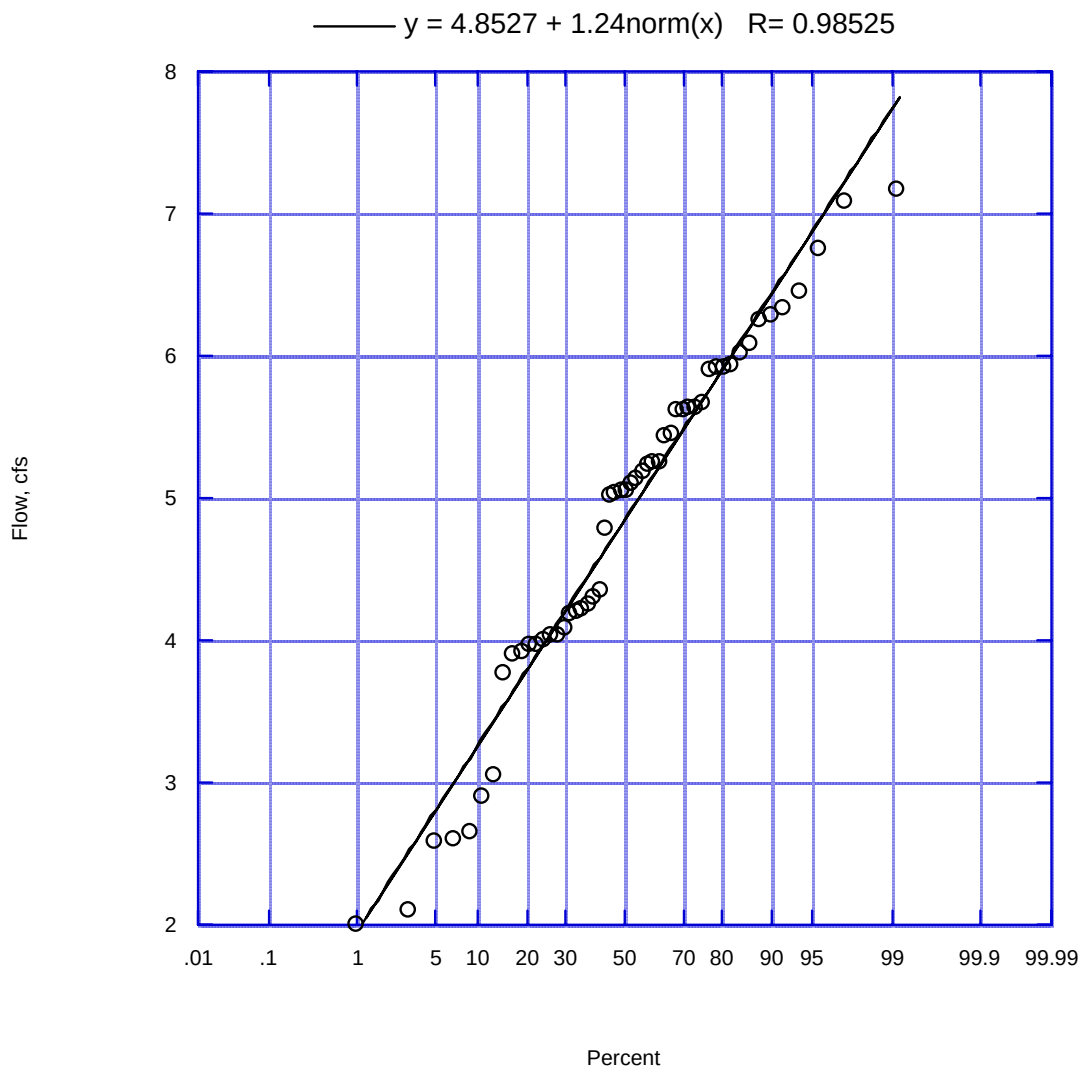


Figure 8. Camarillo Effluent Flow Frequency Distribution - Nov (01-02)

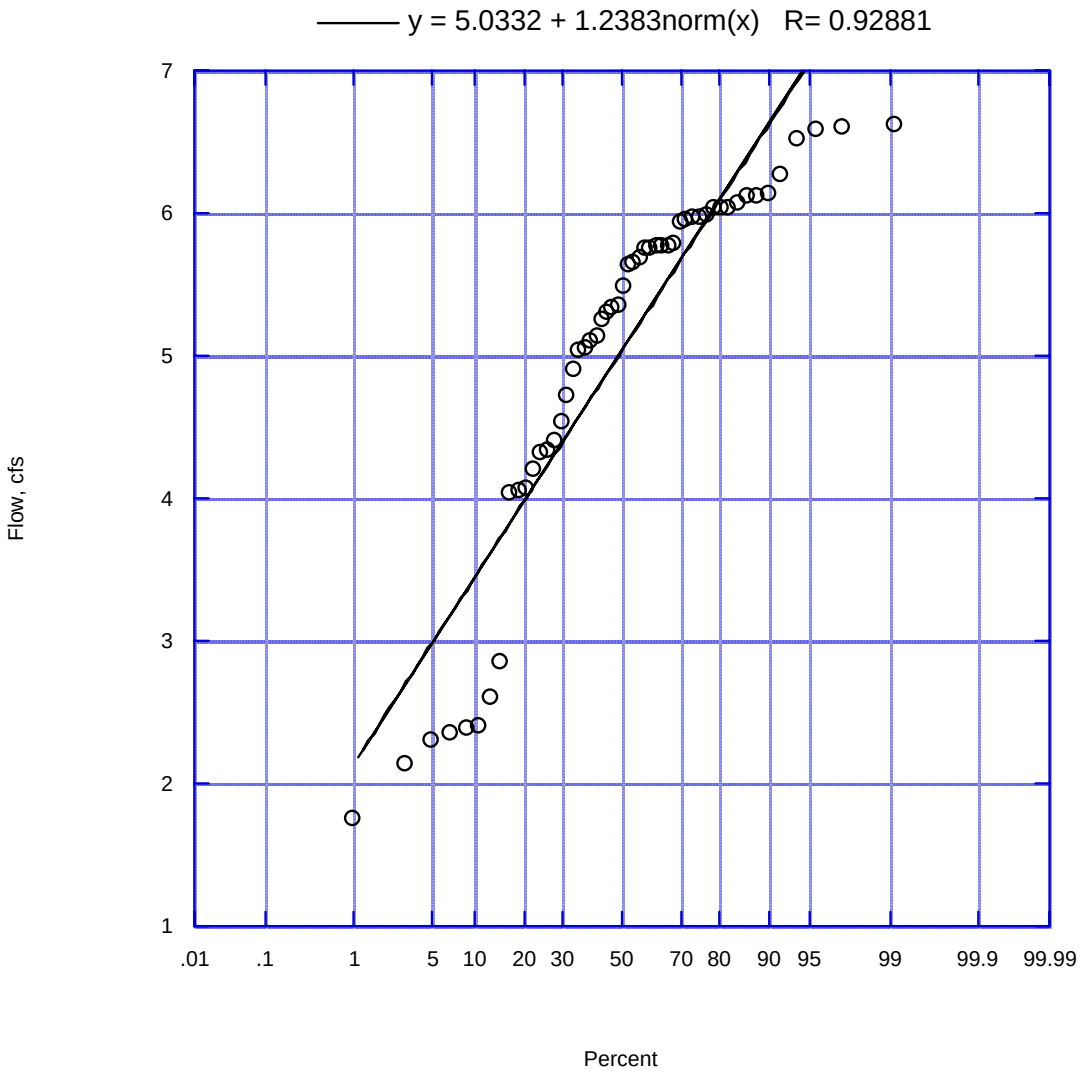


Figure 9. Camarillo Effluent Flow Frequency Distribution - Dec (01-02)

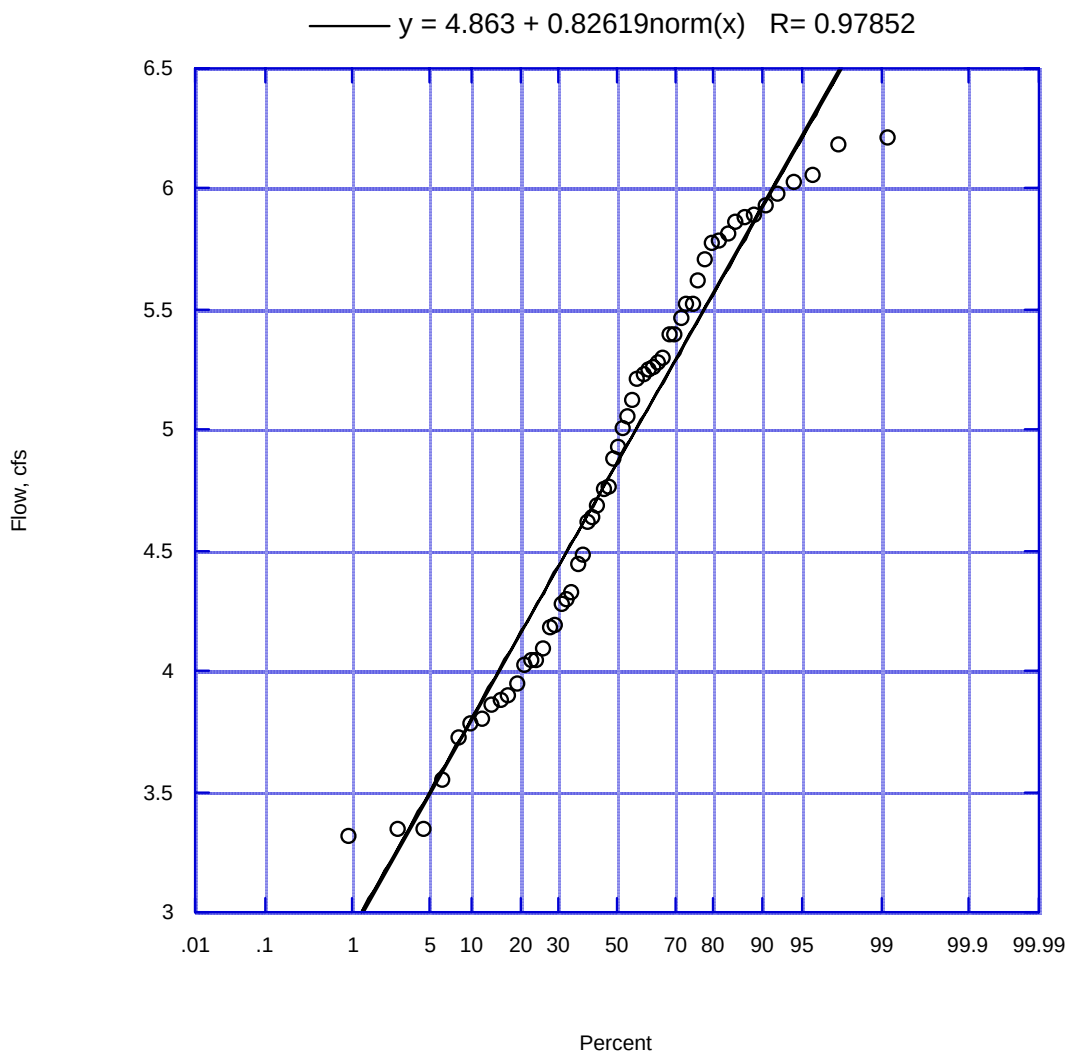


Figure 10. Camarillo Effluent Flow Frequency Distribution - Jan (02-03)

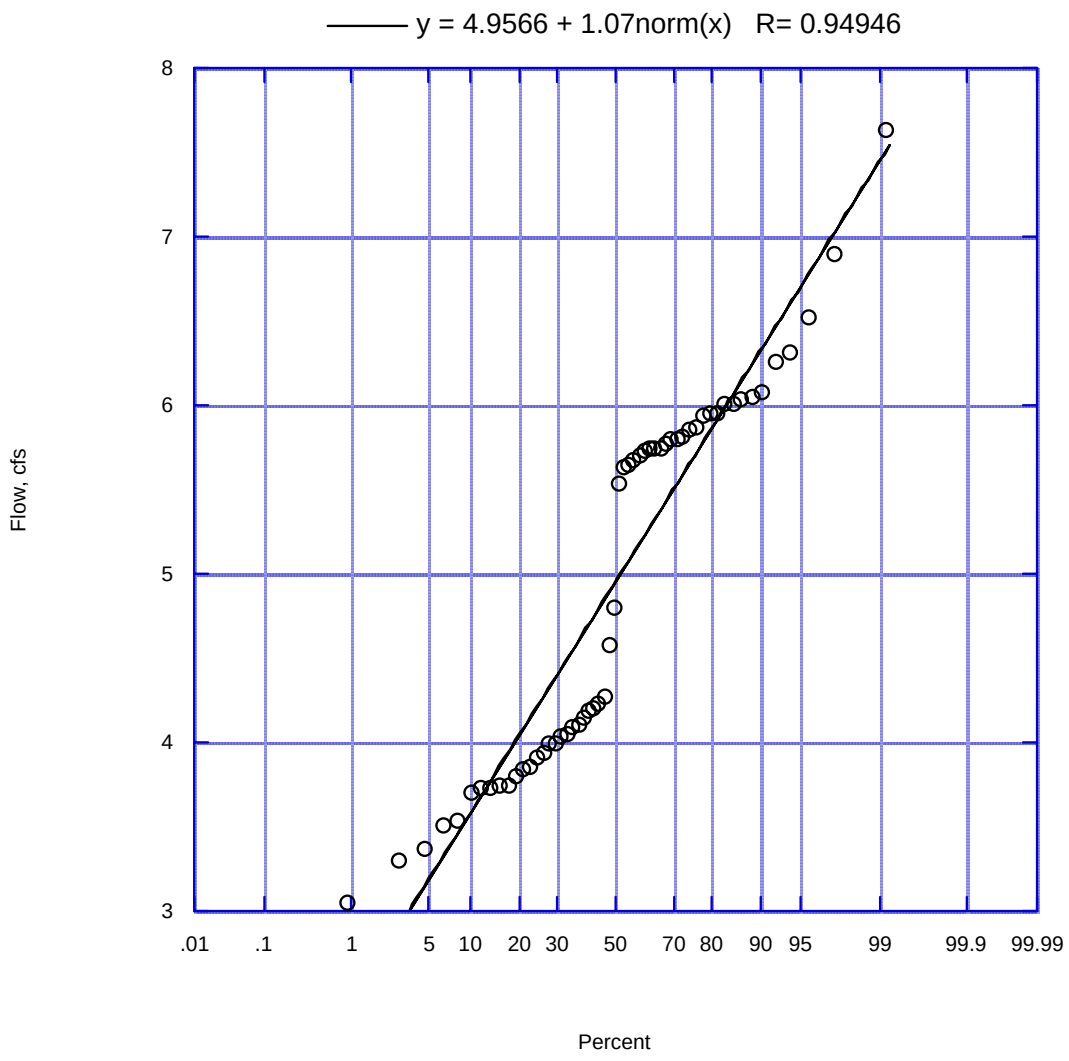


Figure 11. Camarillo Effluent Flow Frequency Distribution - Feb (02-03)

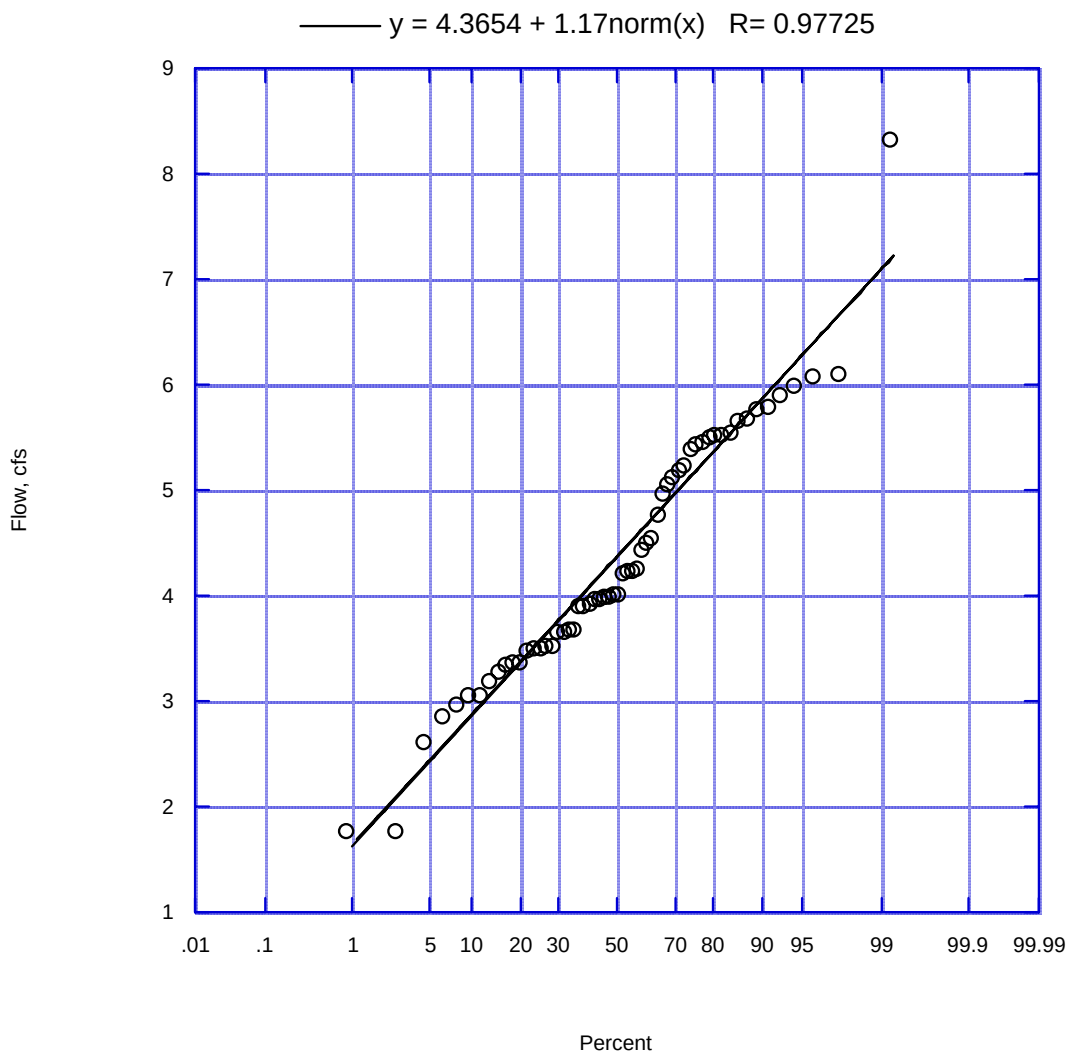


Figure 12. Camarillo Effluent Flow Frequency Distribution - Mar (02-03)

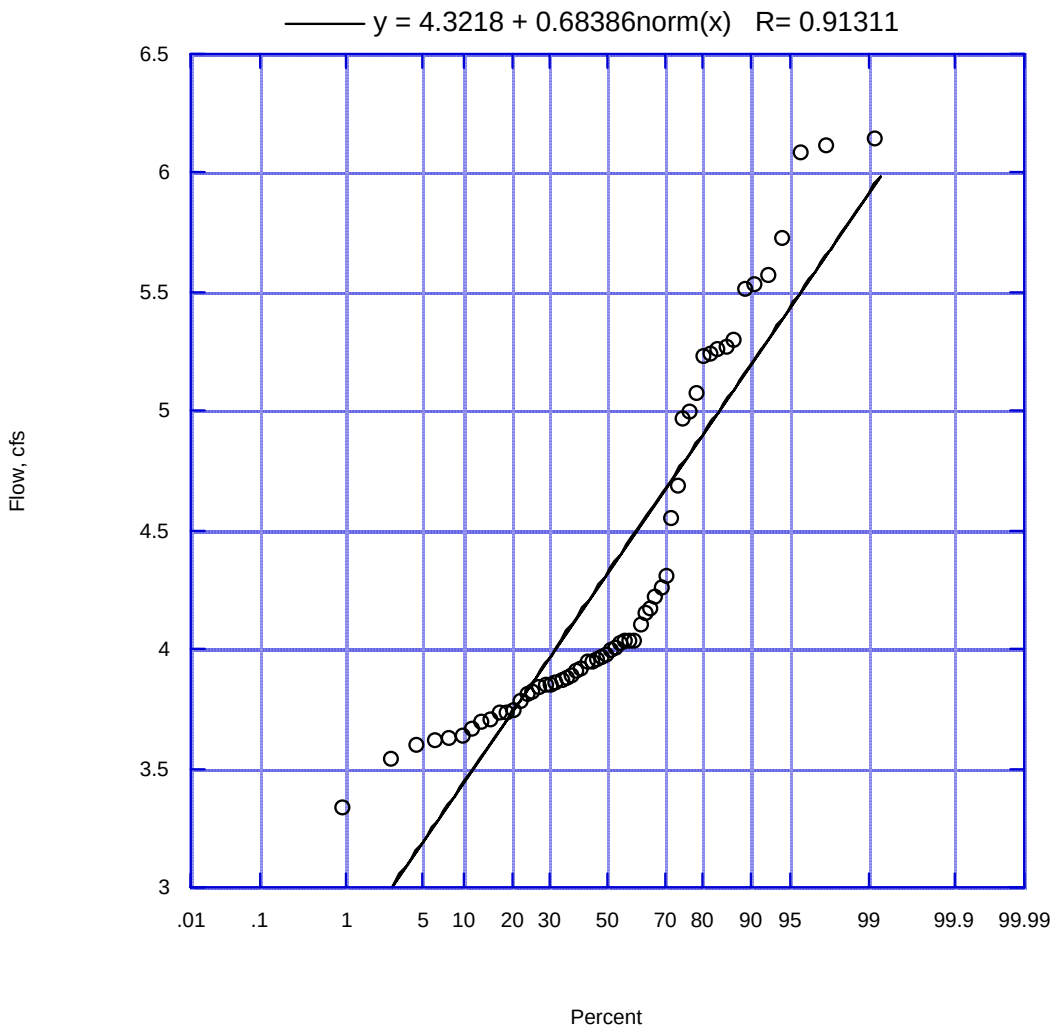


Figure 13. Camarillo Effluent Flow Frequency Distribution - April (02-03)

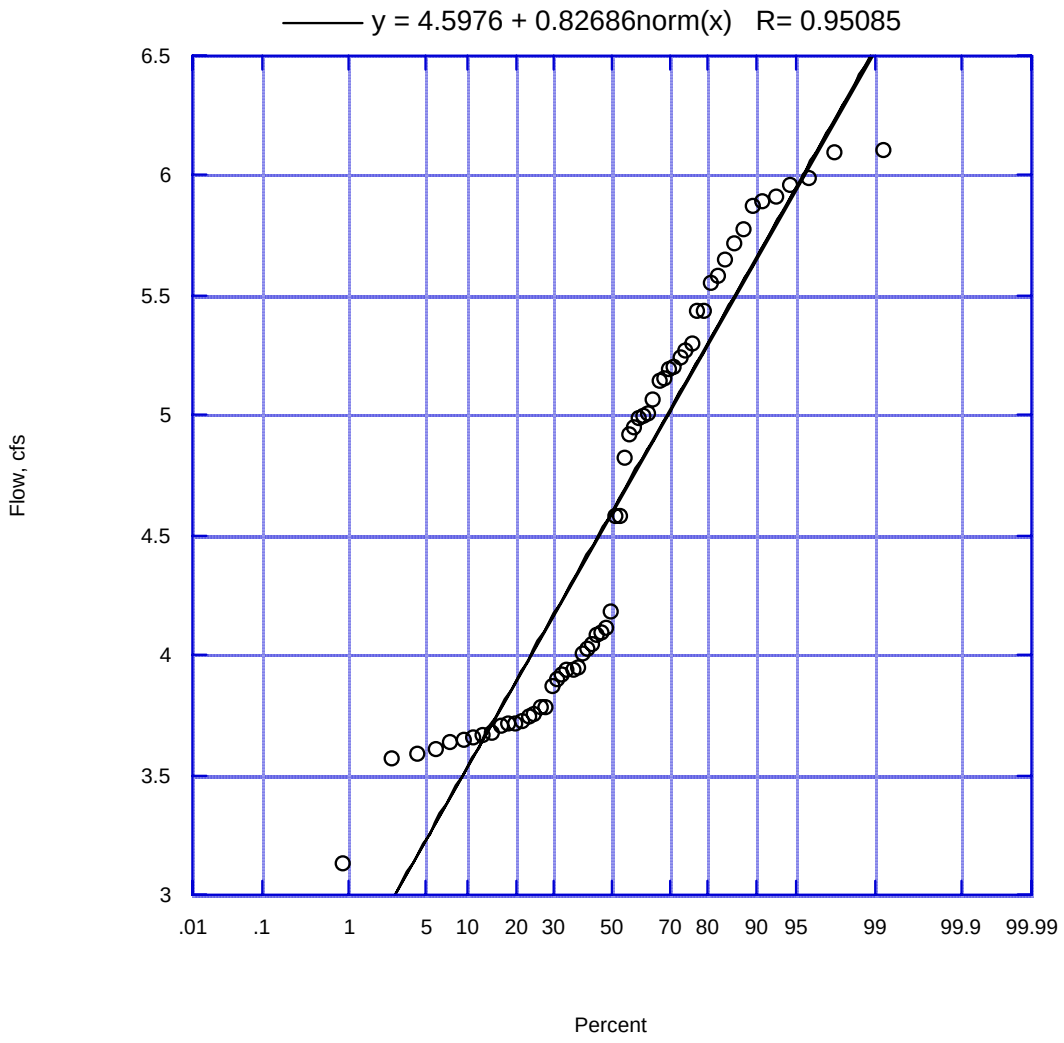


Figure 14. Camarillo Effluent Flow Frequency Distribution - May (02-03)

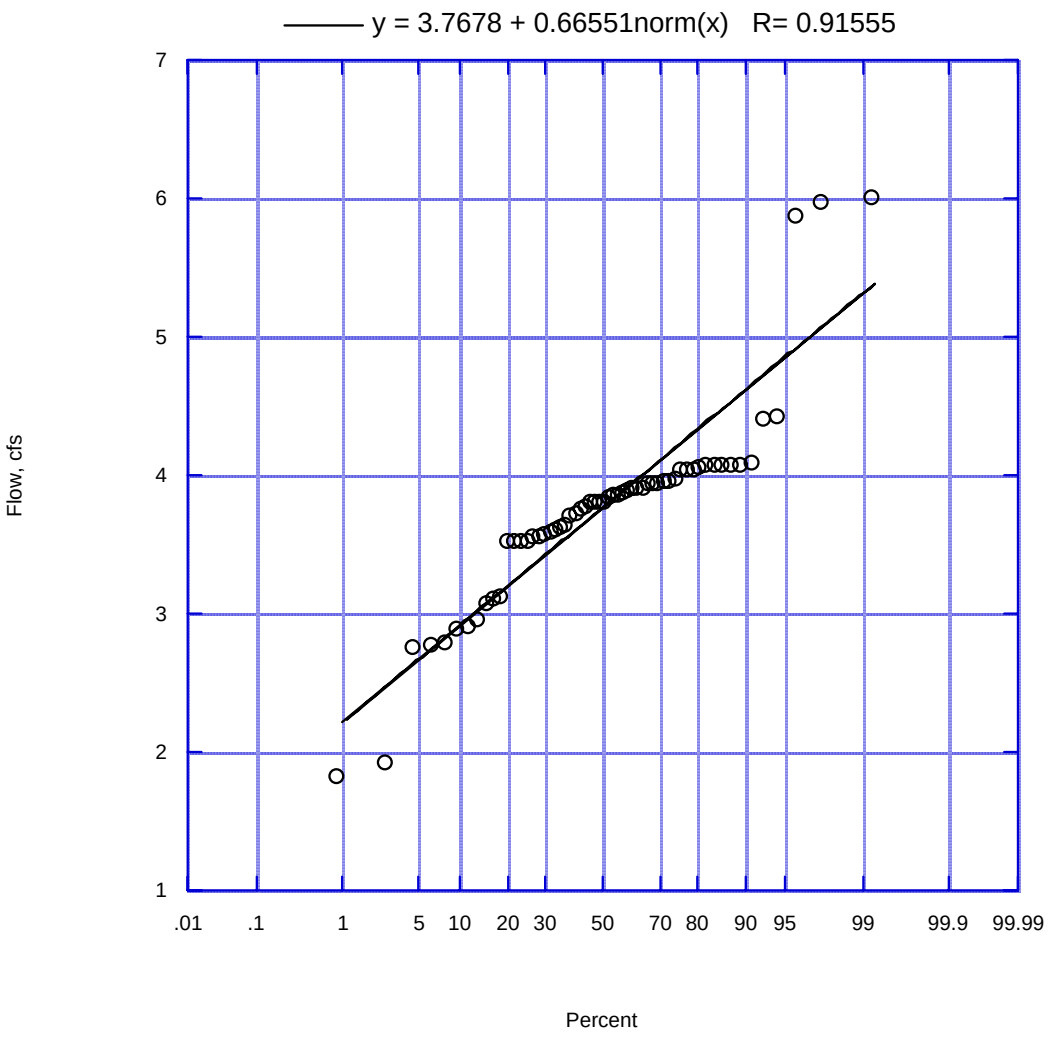


Figure 15. Camarillo Effluent Flow Frequency Distribution - June (02-03)

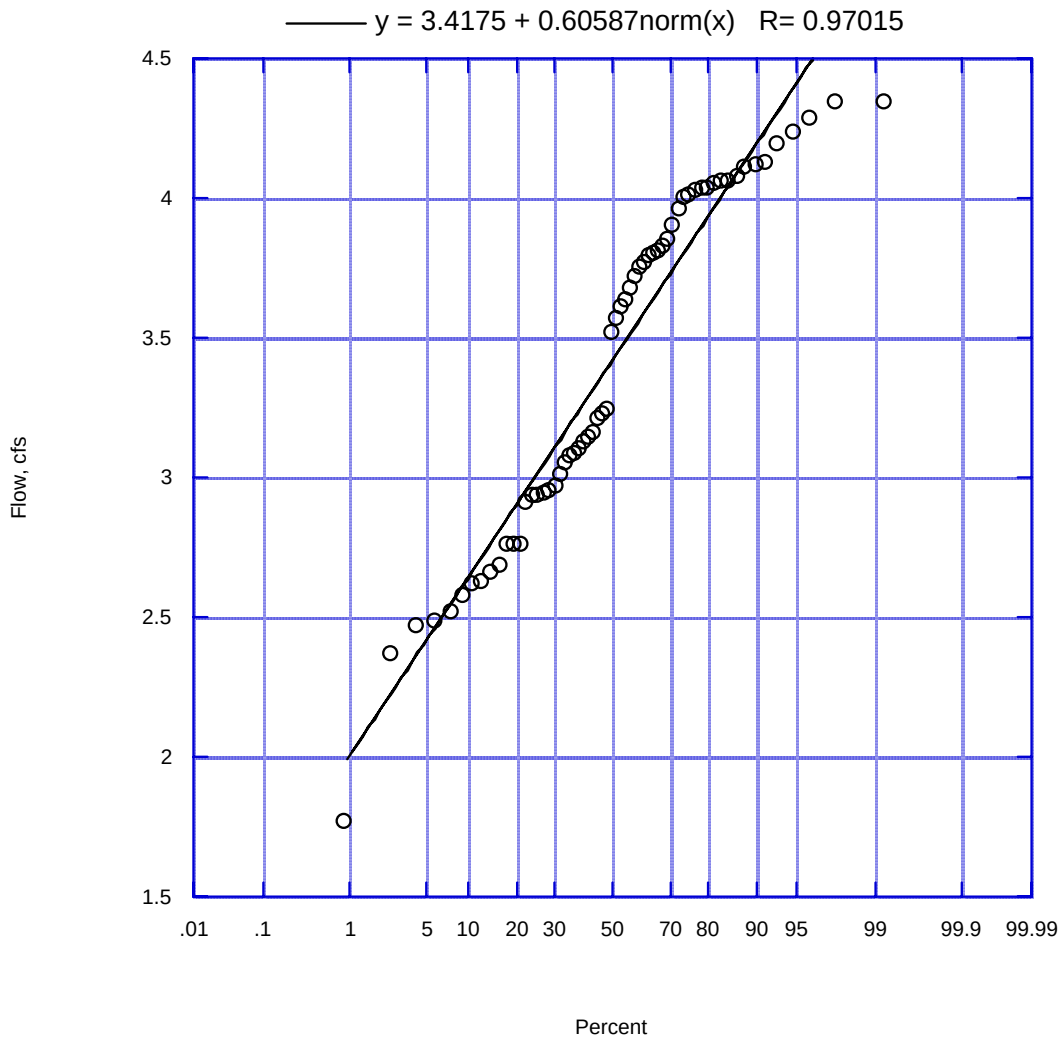


Figure 16. Camarillo Effluent Flow Frequency Distribution - July (02-03)

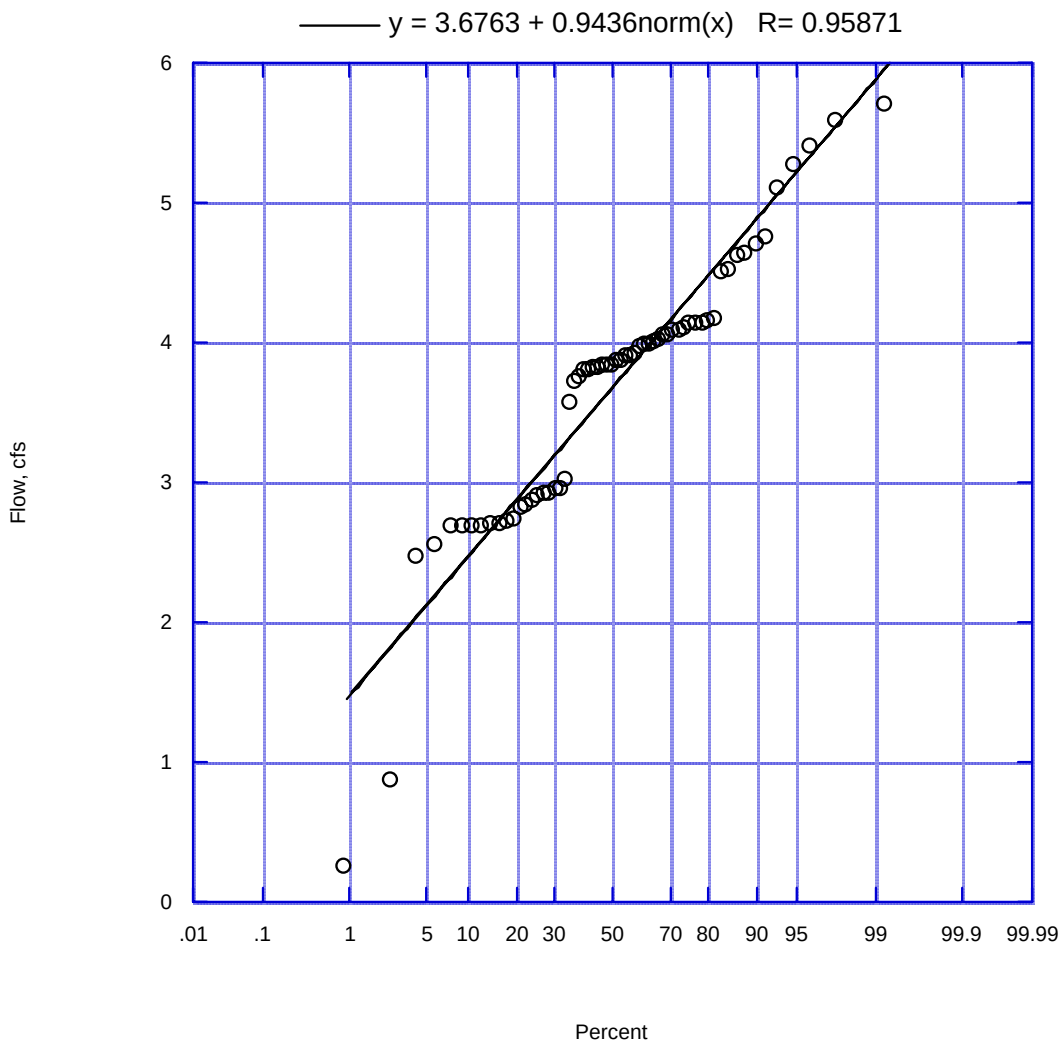


Figure 17. Camarillo Effluent Flow Frequency Distribution - Aug (02-03)

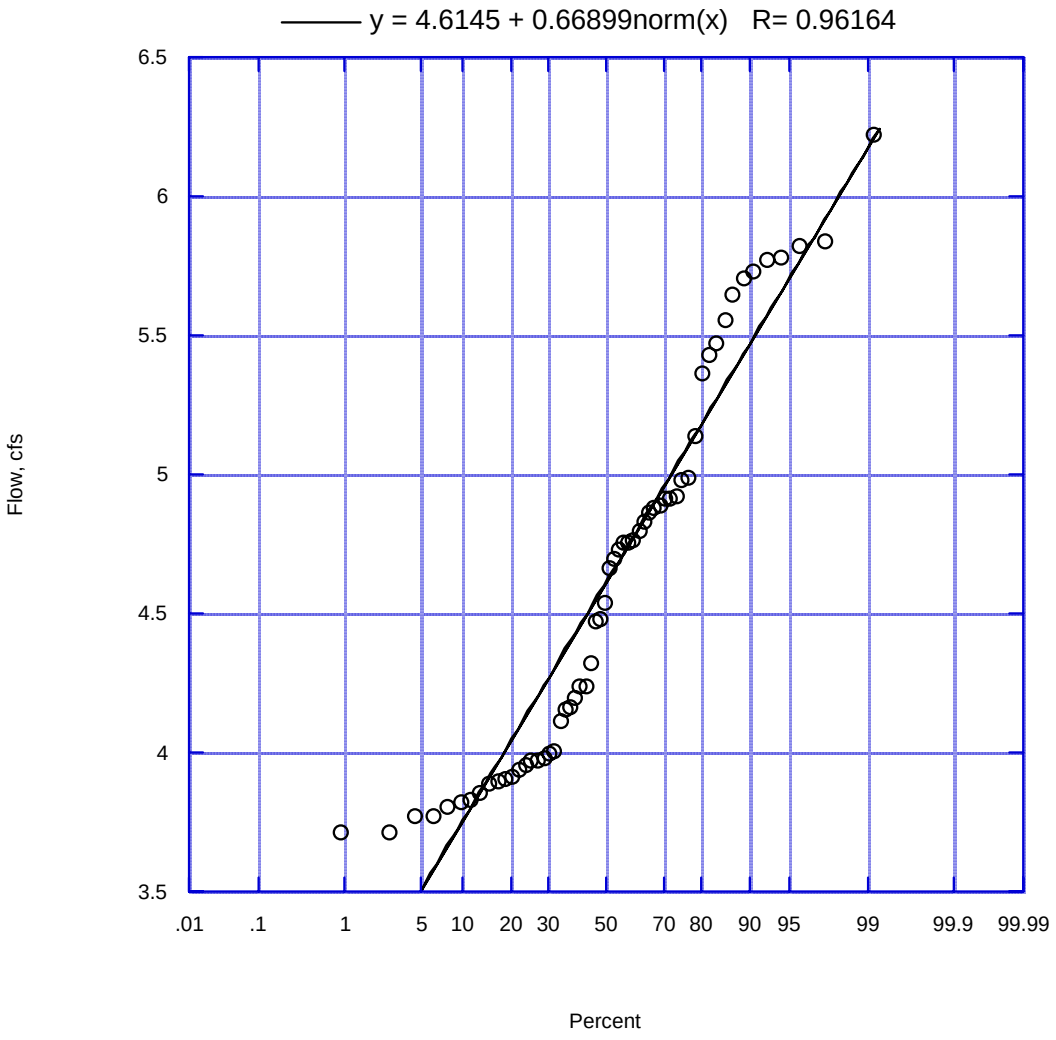


Figure 18. Camarillo Effluent Flow Frequency Distribution - Sept (02-03)

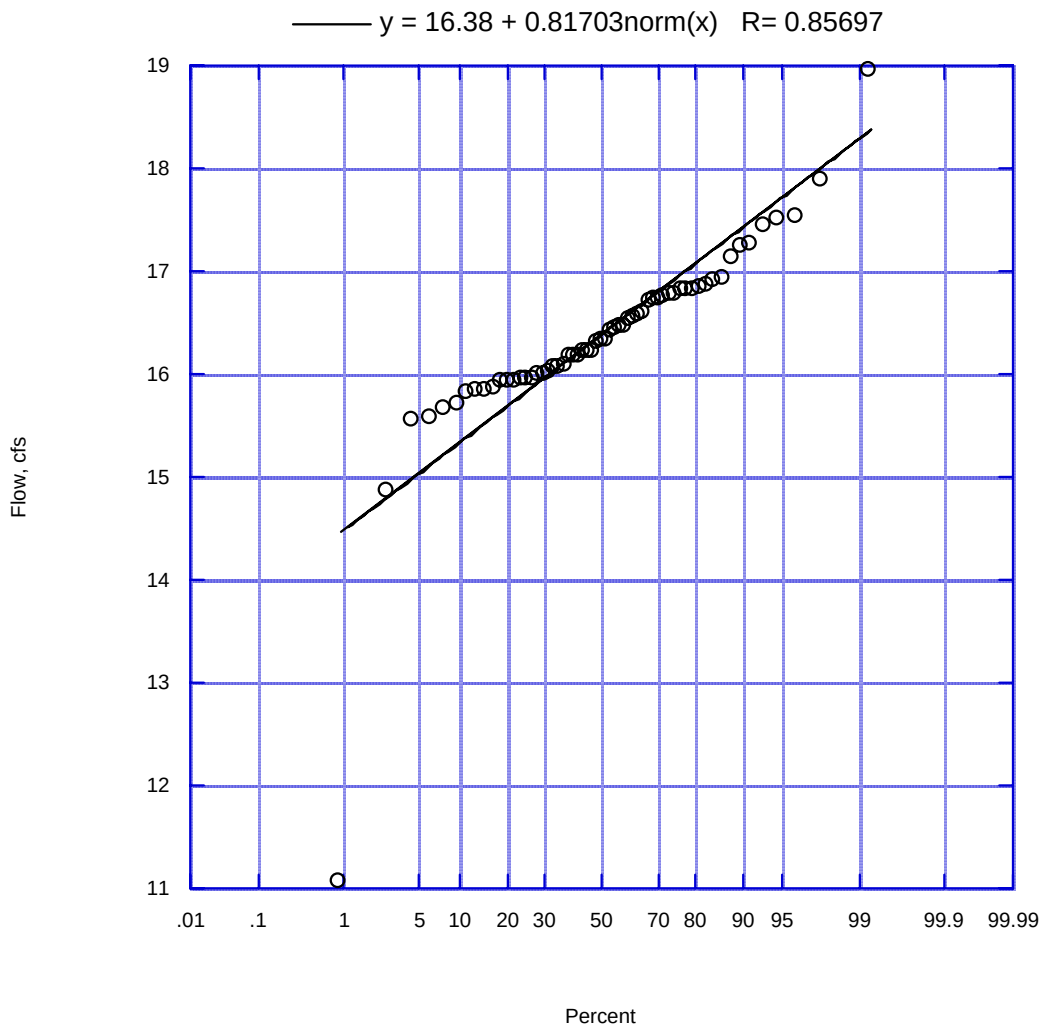


Figure 19. Hill Canyon Effluent Flow Frequency Distribution - Oct (01-02)

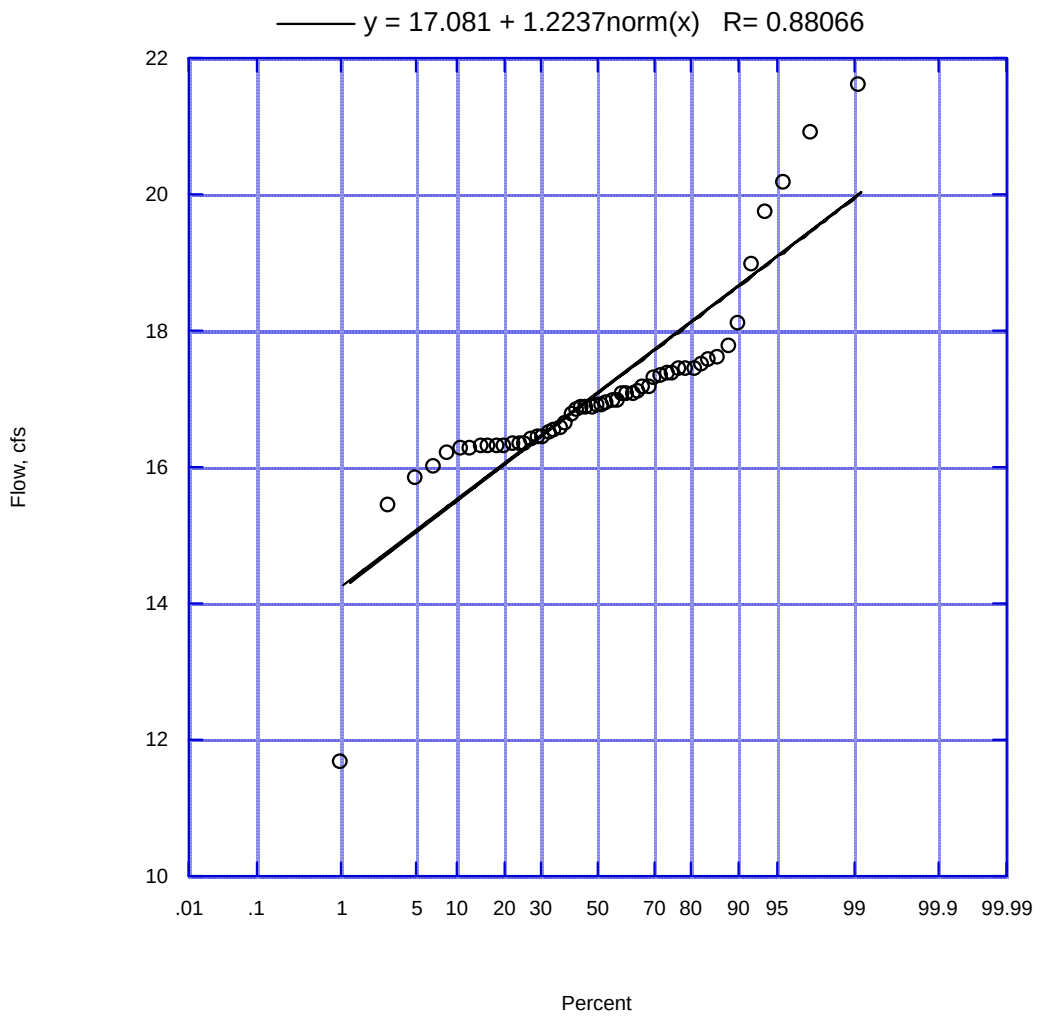


Figure 20. Hill Canyon Effluent Flow Frequency Distribution - Nov (01-02)

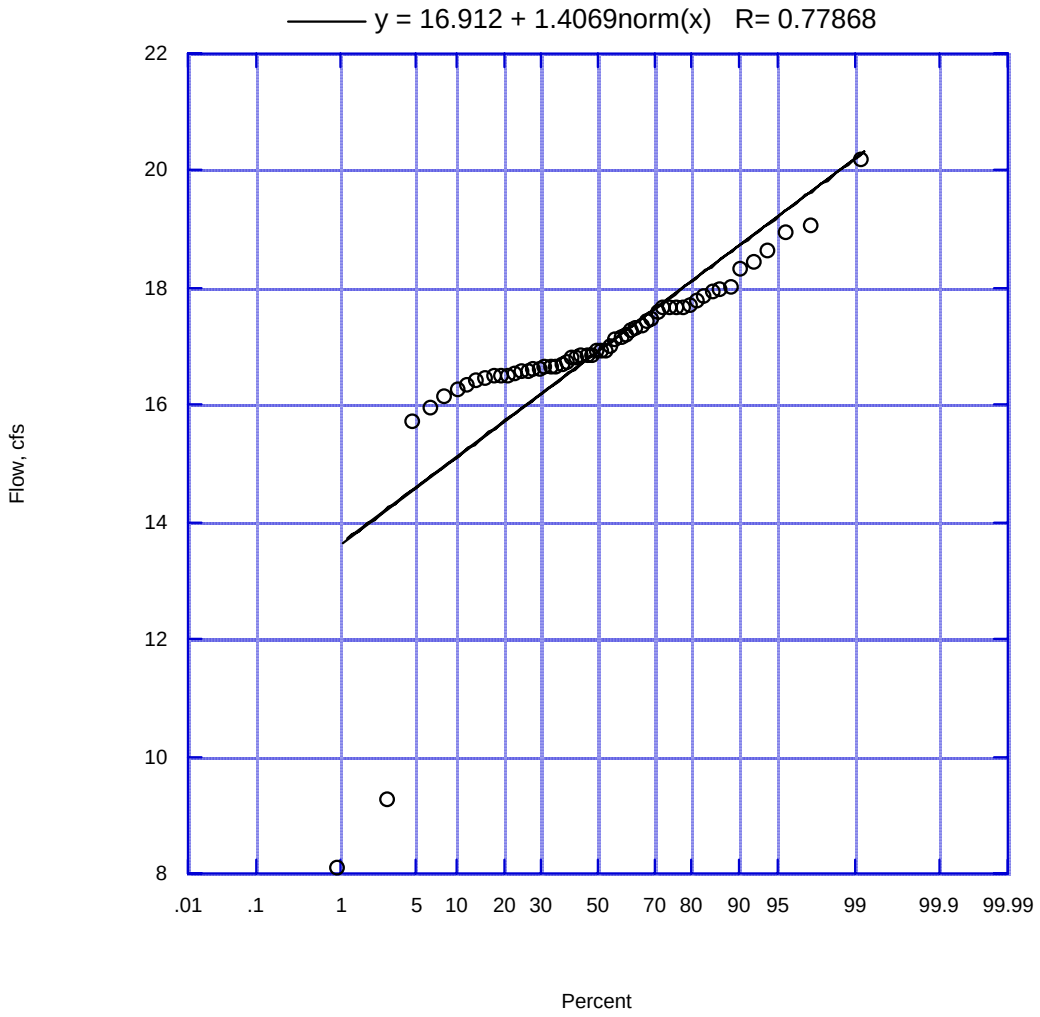


Figure 21. Hill Canyon Effluent Flow Frequency Distribution - Dec (01-02)

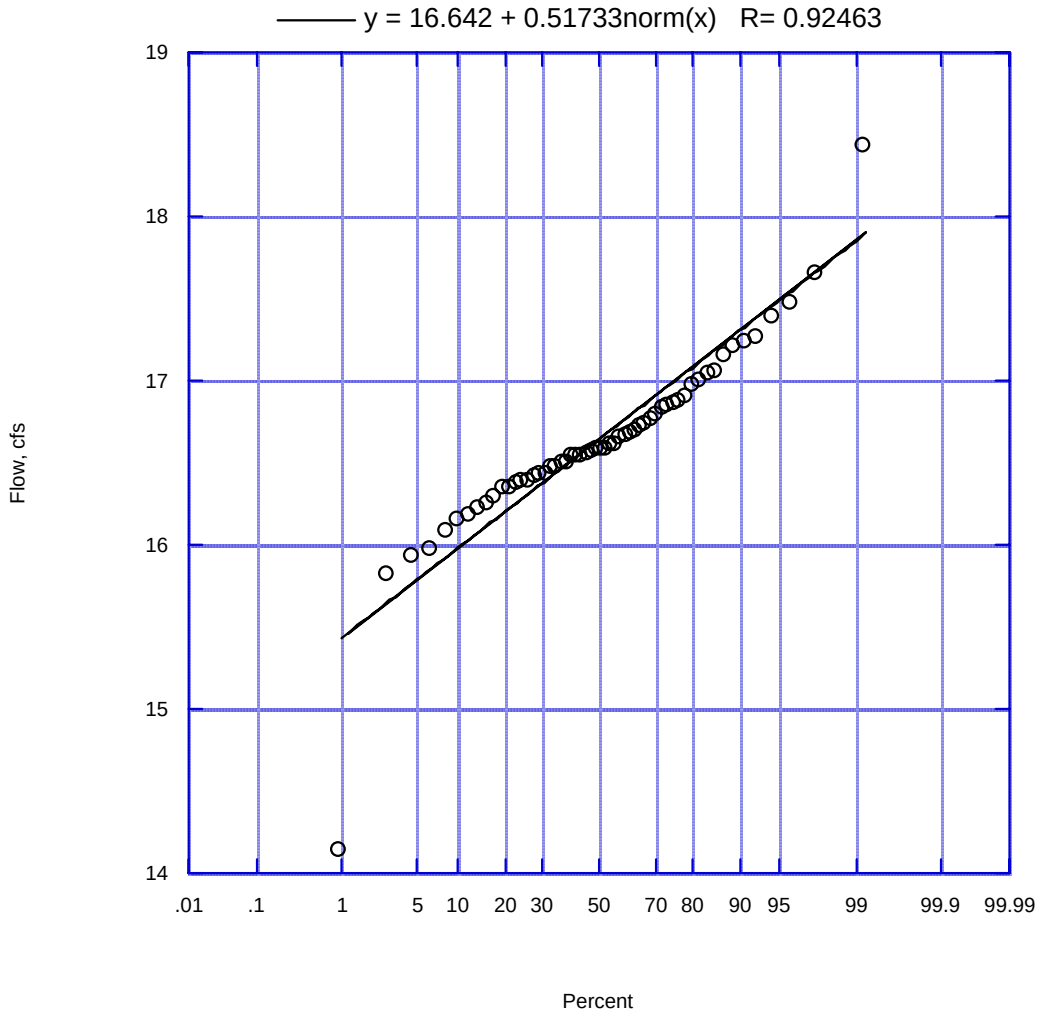


Figure 22. Hill Canyon Effluent Flow Frequency Distribution - Jan (02-03)

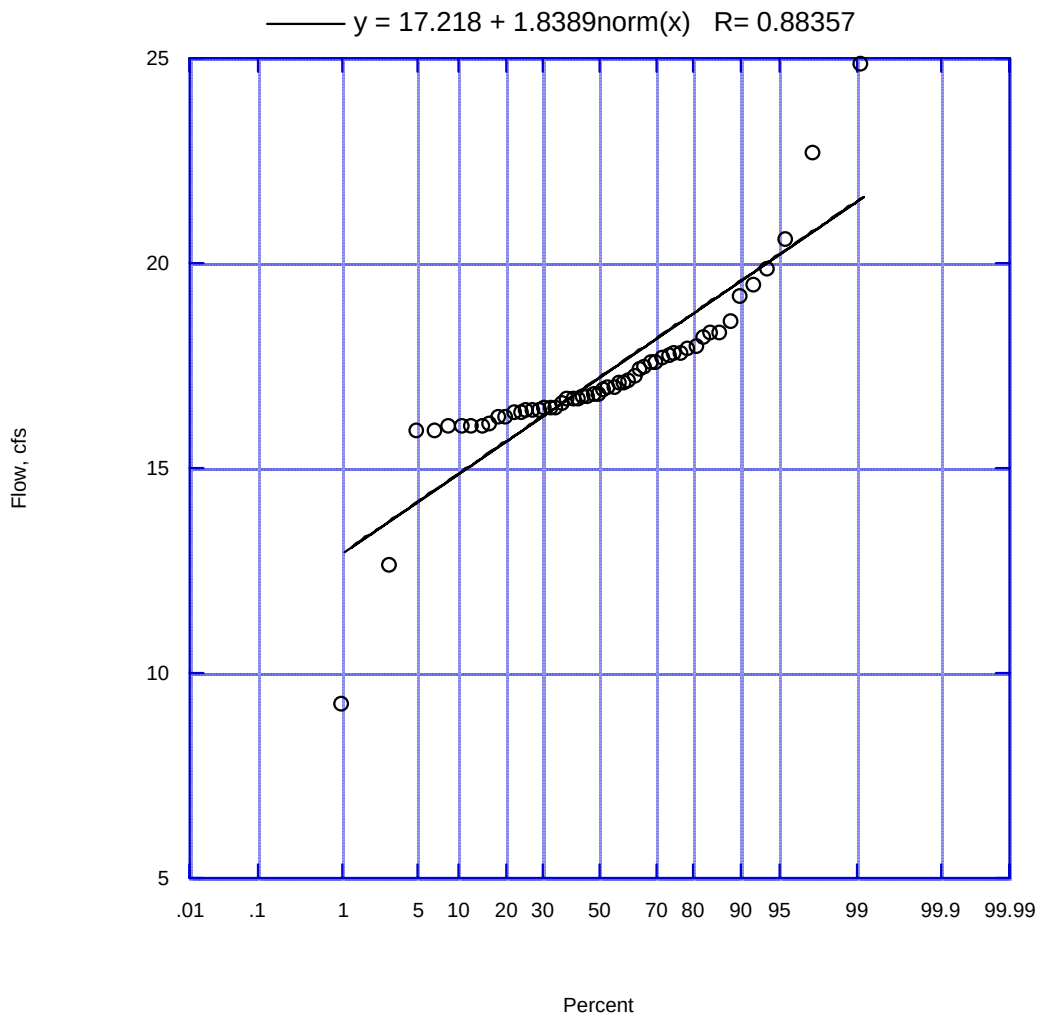


Figure 23. Hill Canyon Effluent Flow Frequency Distribution - Feb (02-03)

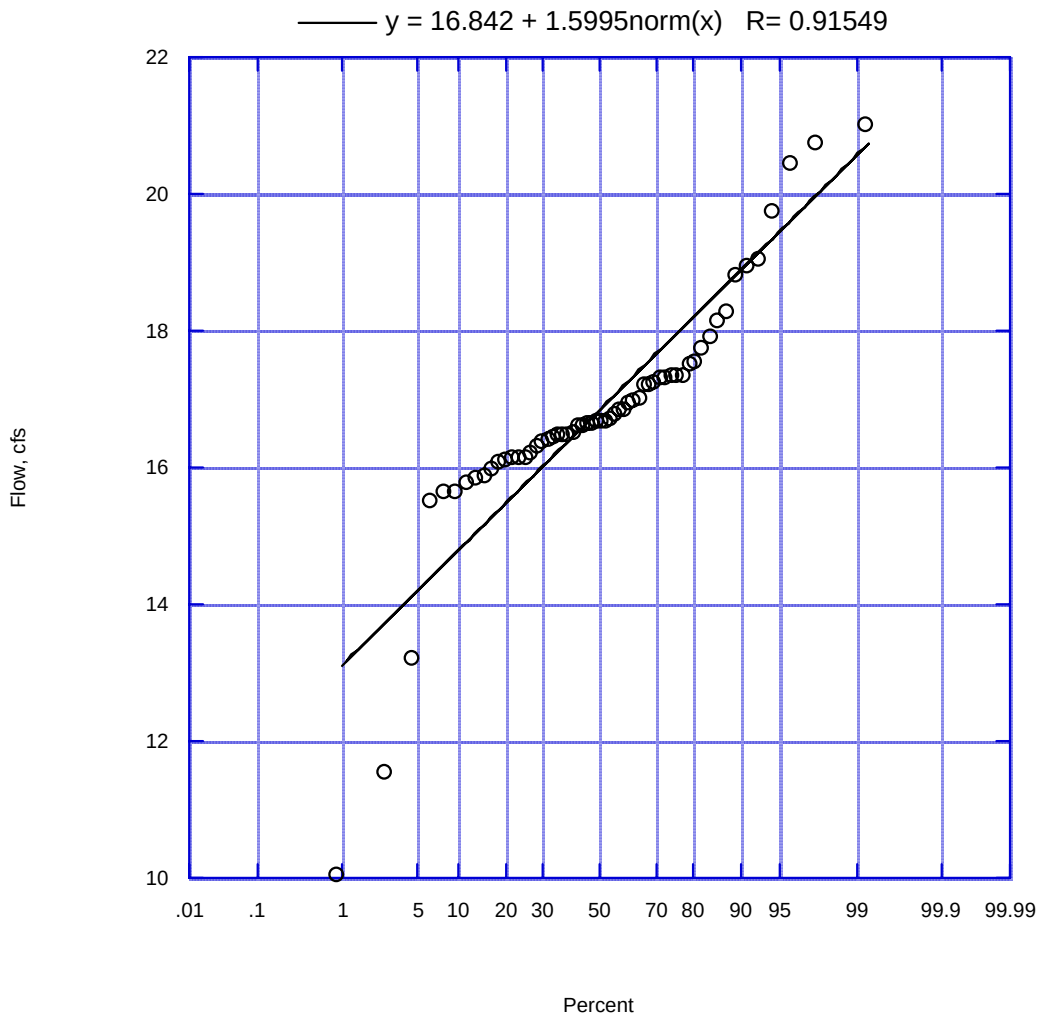


Figure 24. Hill Canyon Effluent Flow Frequency Distribution - Mar (02-03)

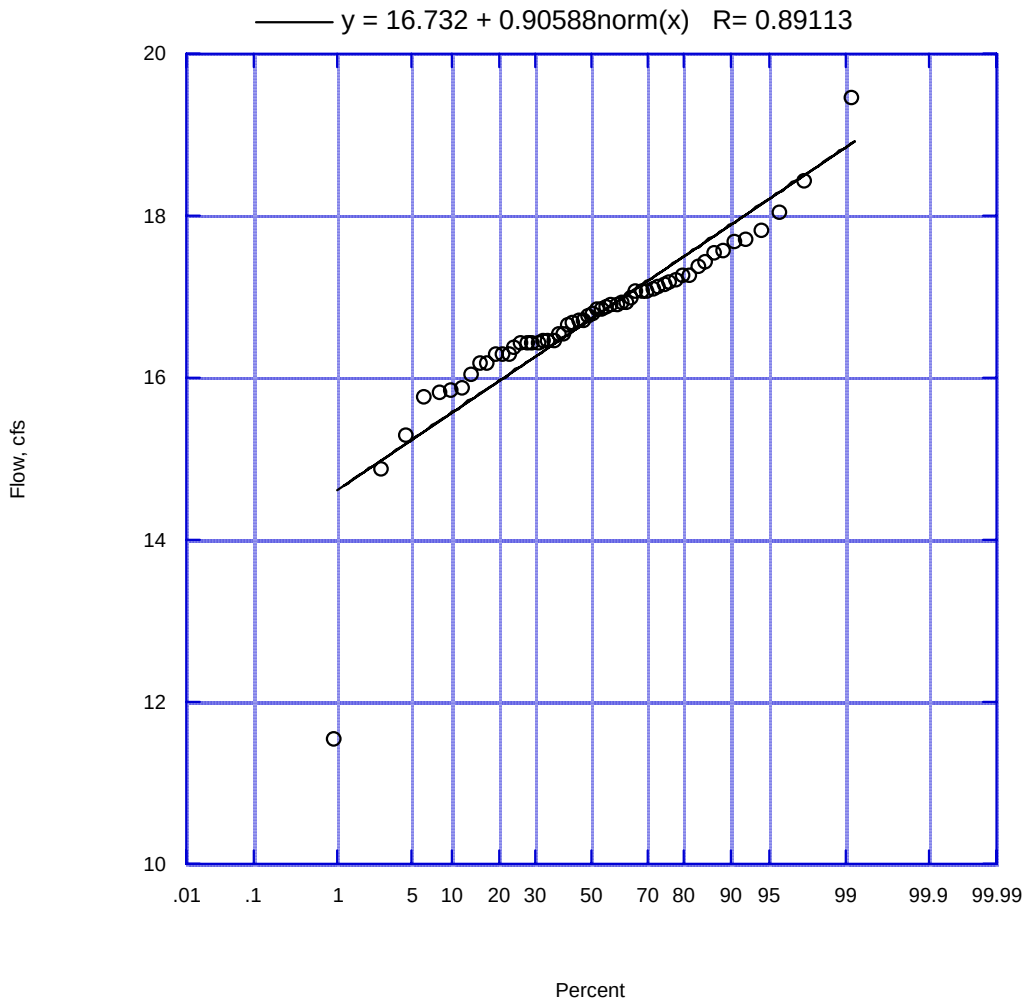


Figure 25. Hill Canyon Effluent Flow Frequency Distribution - April (02-03)

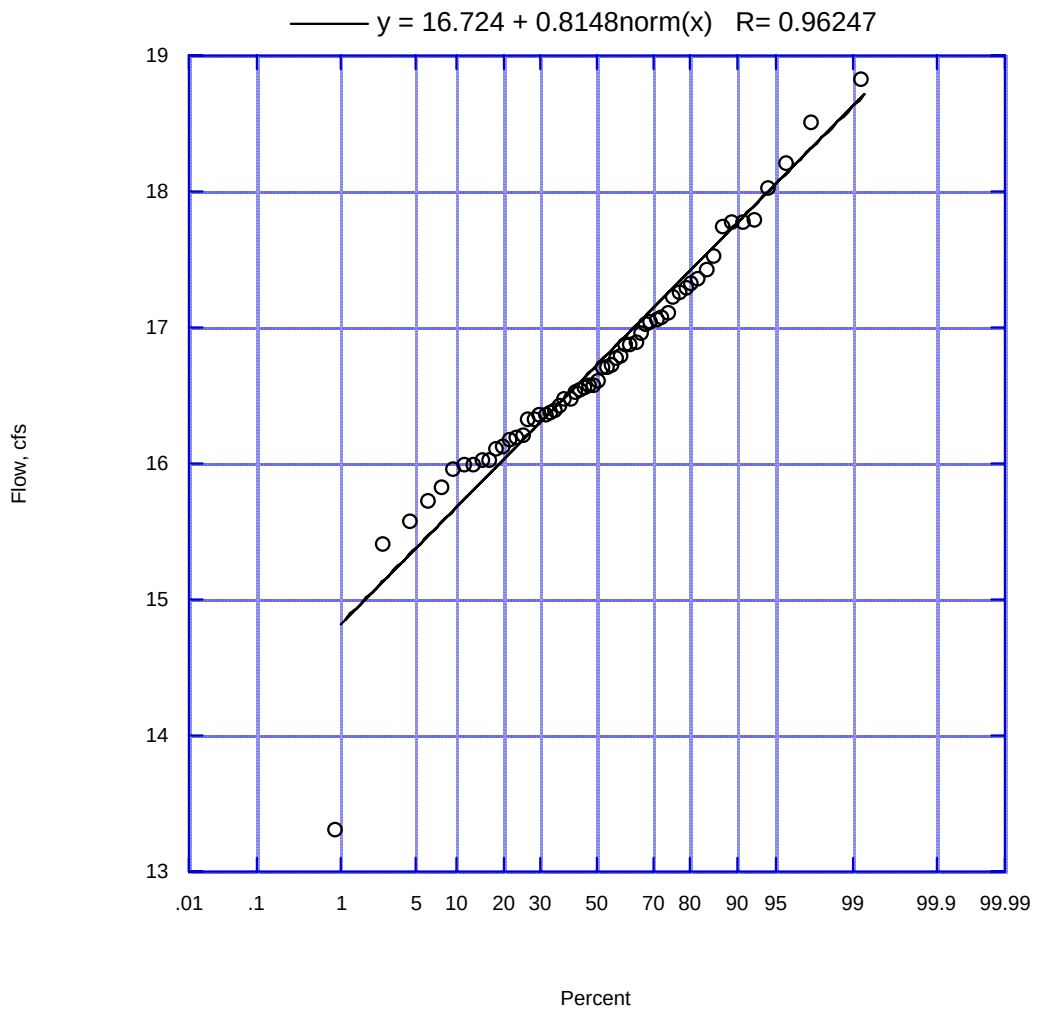


Figure 26. Hill Canyon Effluent Flow Frequency Distribution - May (02-03)

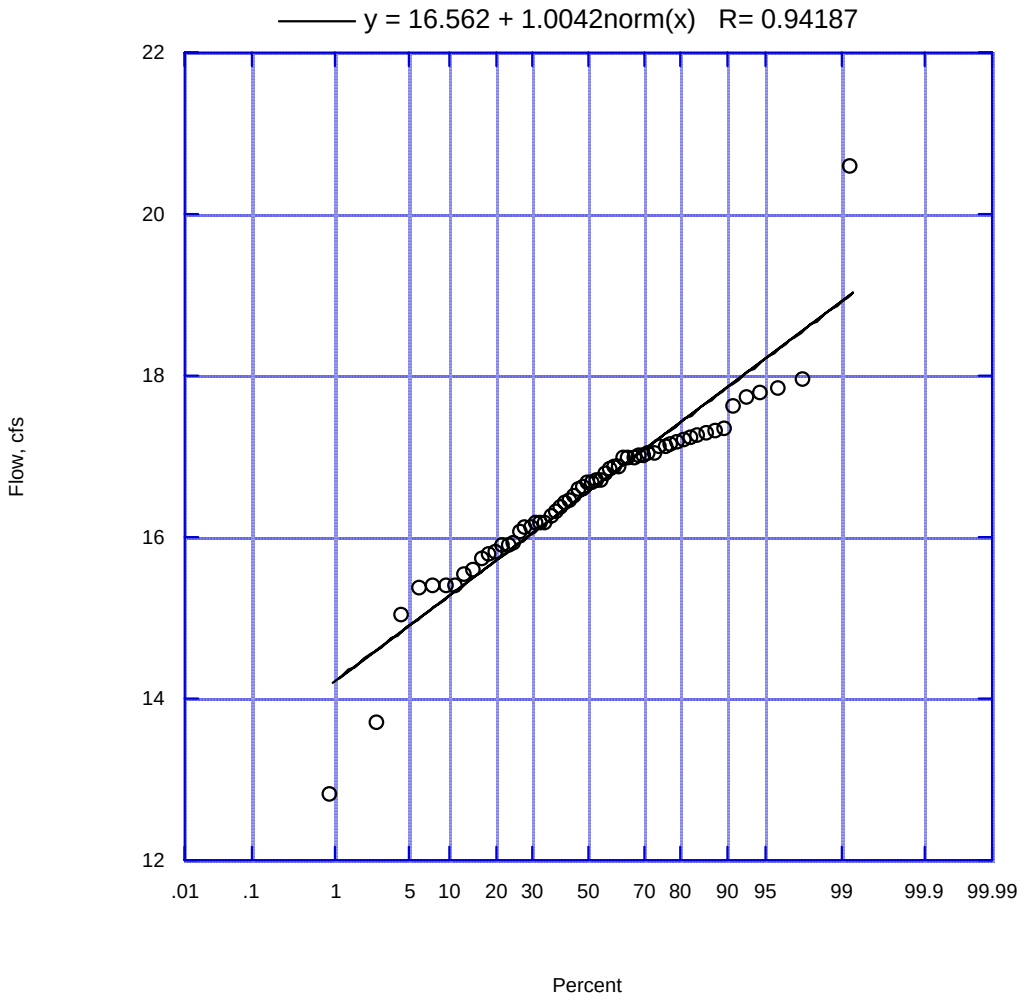


Figure 27. Hill Canyon Effluent Flow Frequency Distribution - June (02-03)

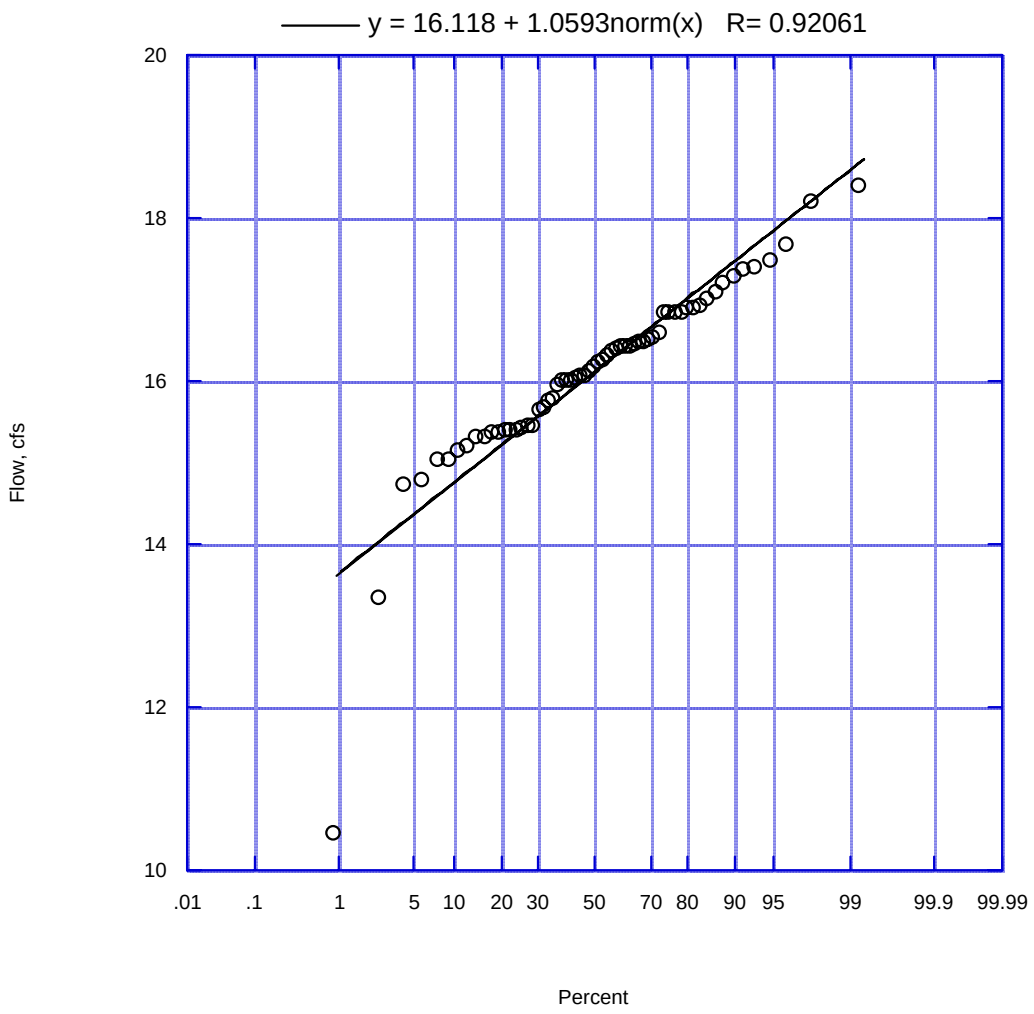


Figure 28. Hill Canyon Effluent Flow Frequency Distribution - July (02-03)

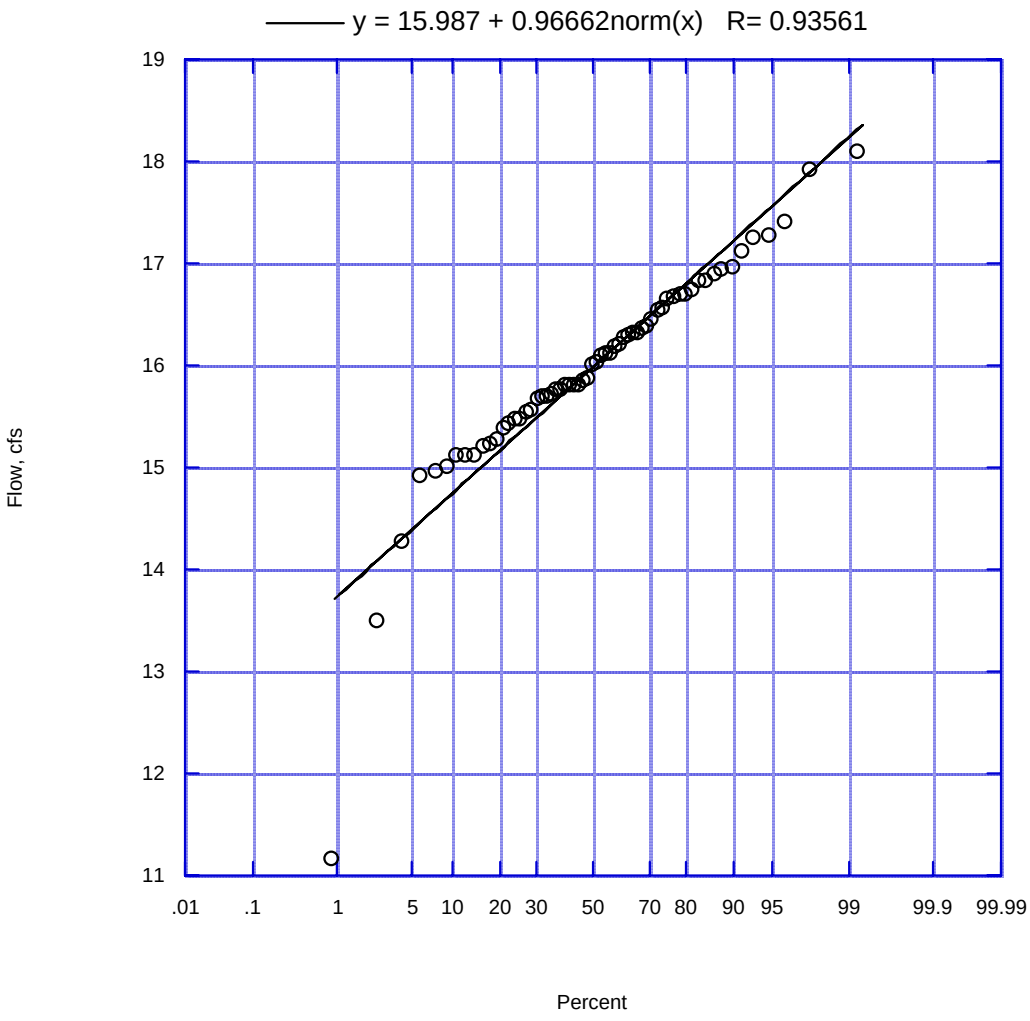


Figure 29. Hill Canyon Effluent Flow Frequency Distribution - Aug (02-03)

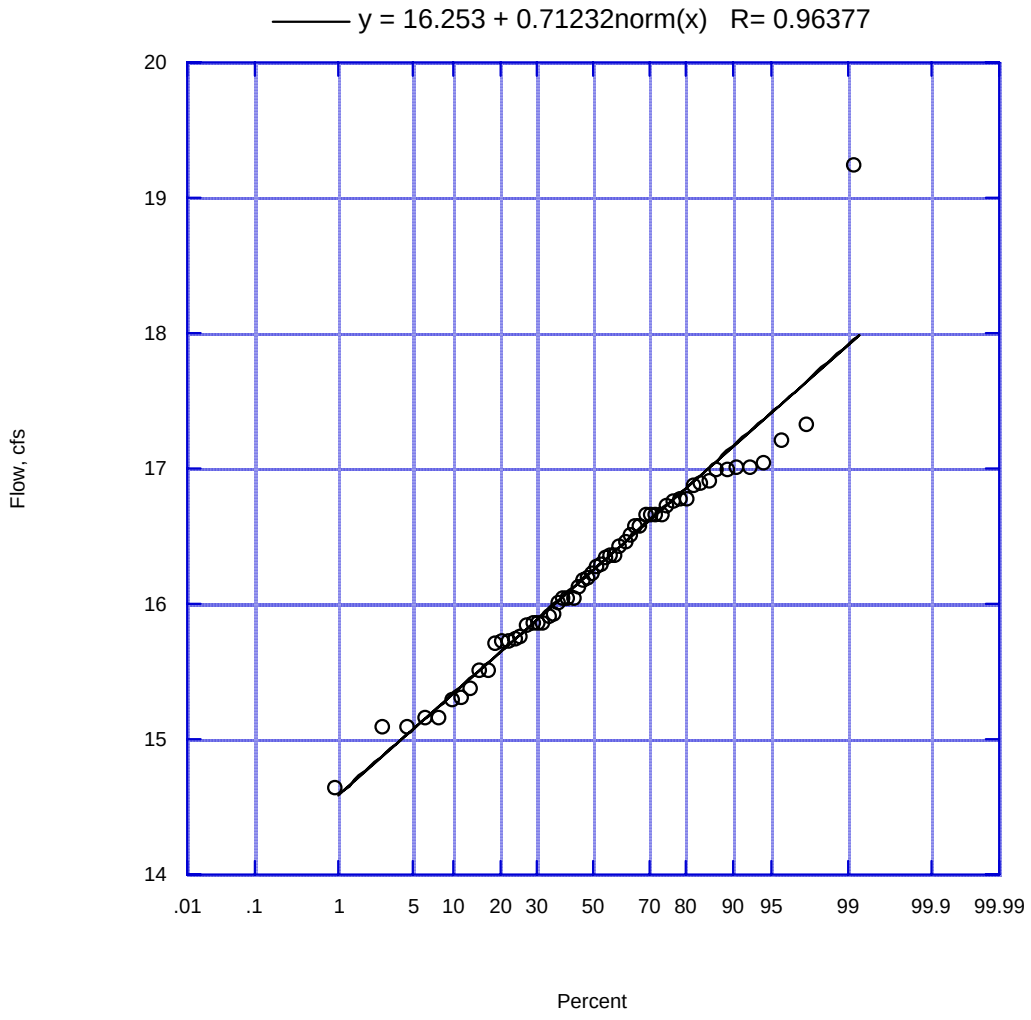


Figure 30. Hill Canyon Effluent Flow Frequency Distribution - Sept (02-03)

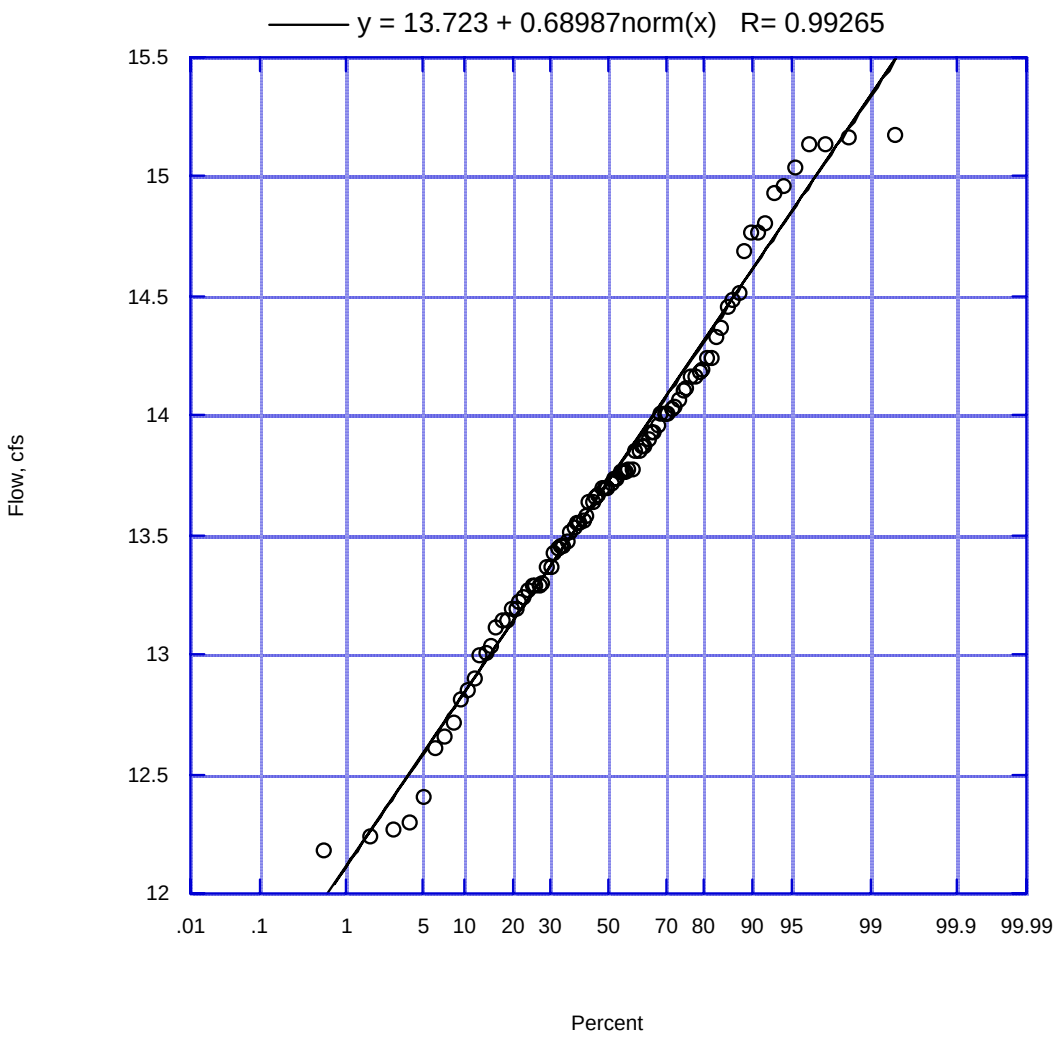


Figure 31. Simi Valley Effluent Flow Frequency Distribution - Oct (01-02)

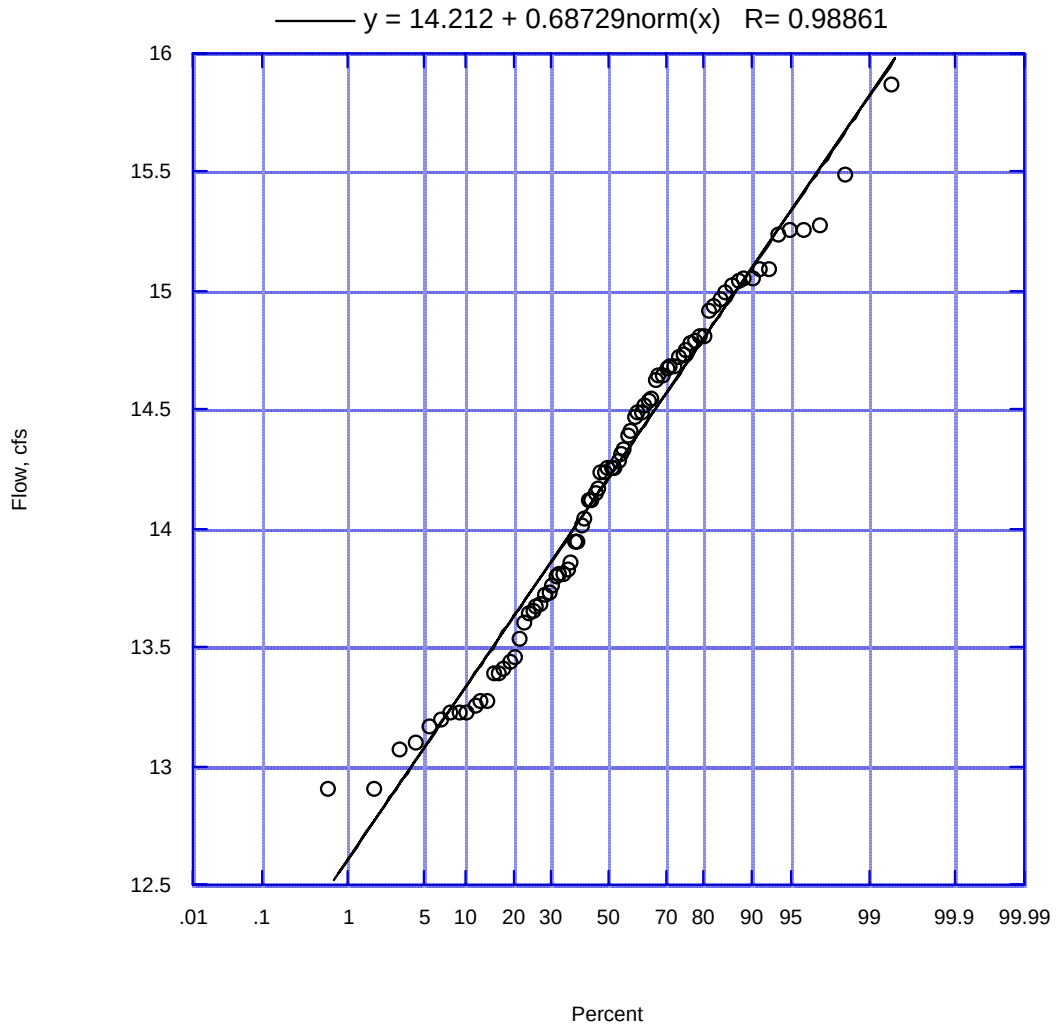


Figure 32. Simi Valley Effluent Flow Frequency Distribution - Nov (01-02)

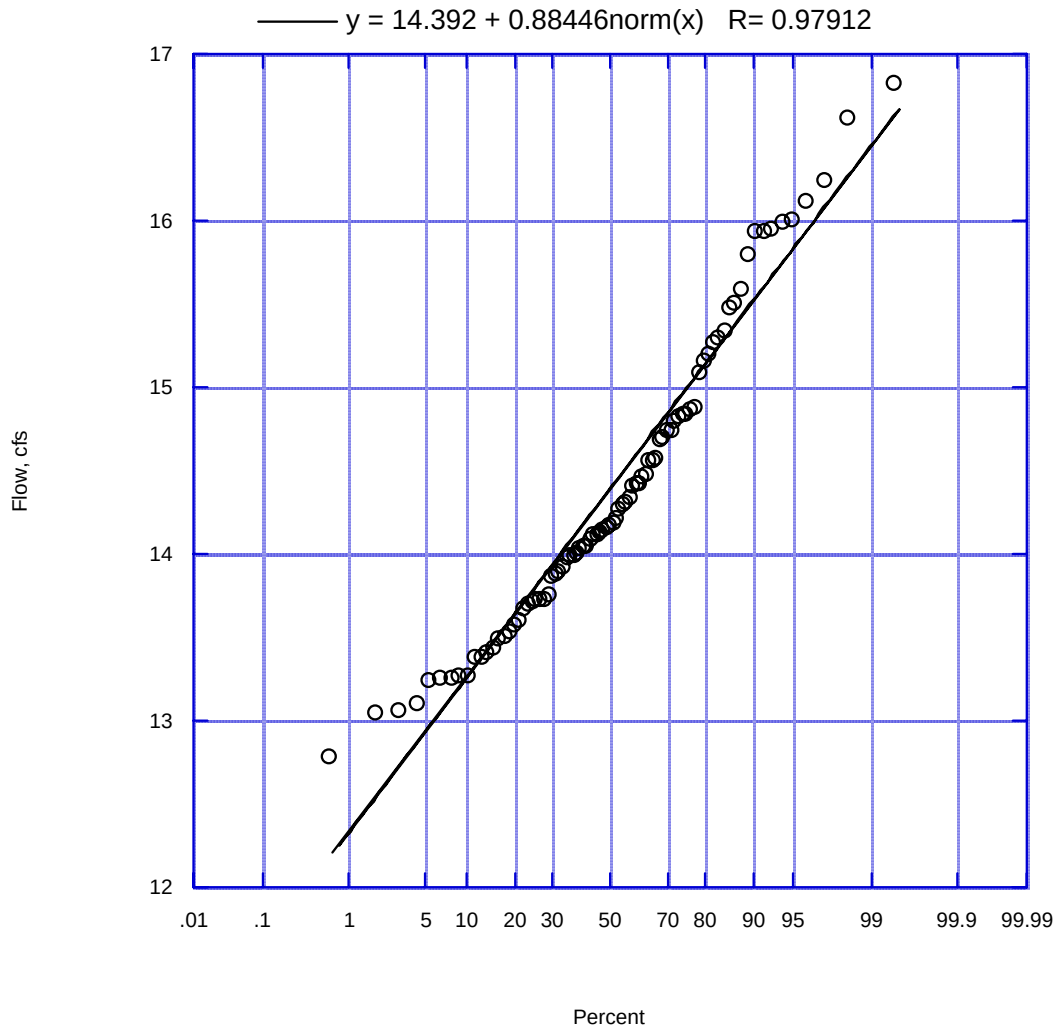


Figure 33. Simi Valley Effluent Flow Frequency Distribution - Dec (01-02)

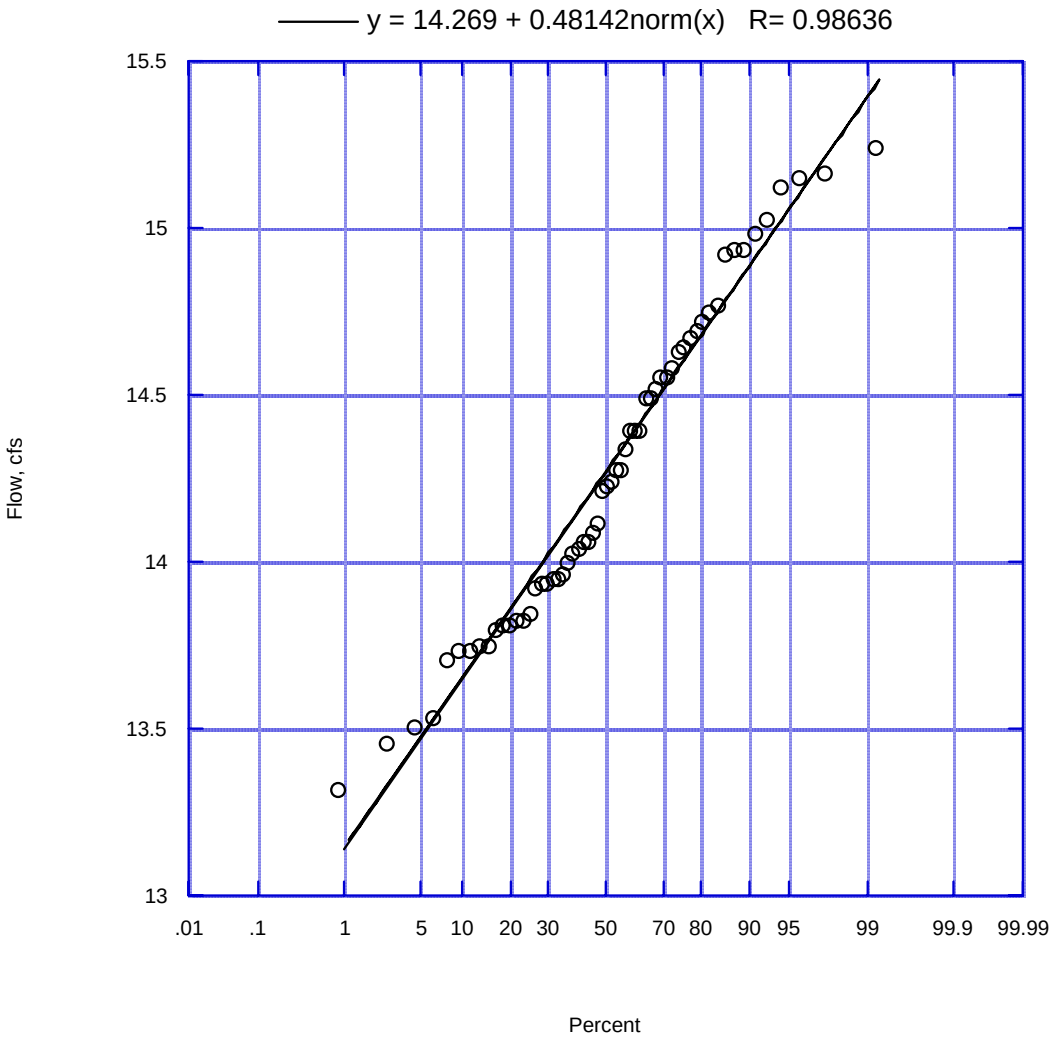


Figure 34. Simi Valley Effluent Flow Frequency Distribution - Jan (02-03)

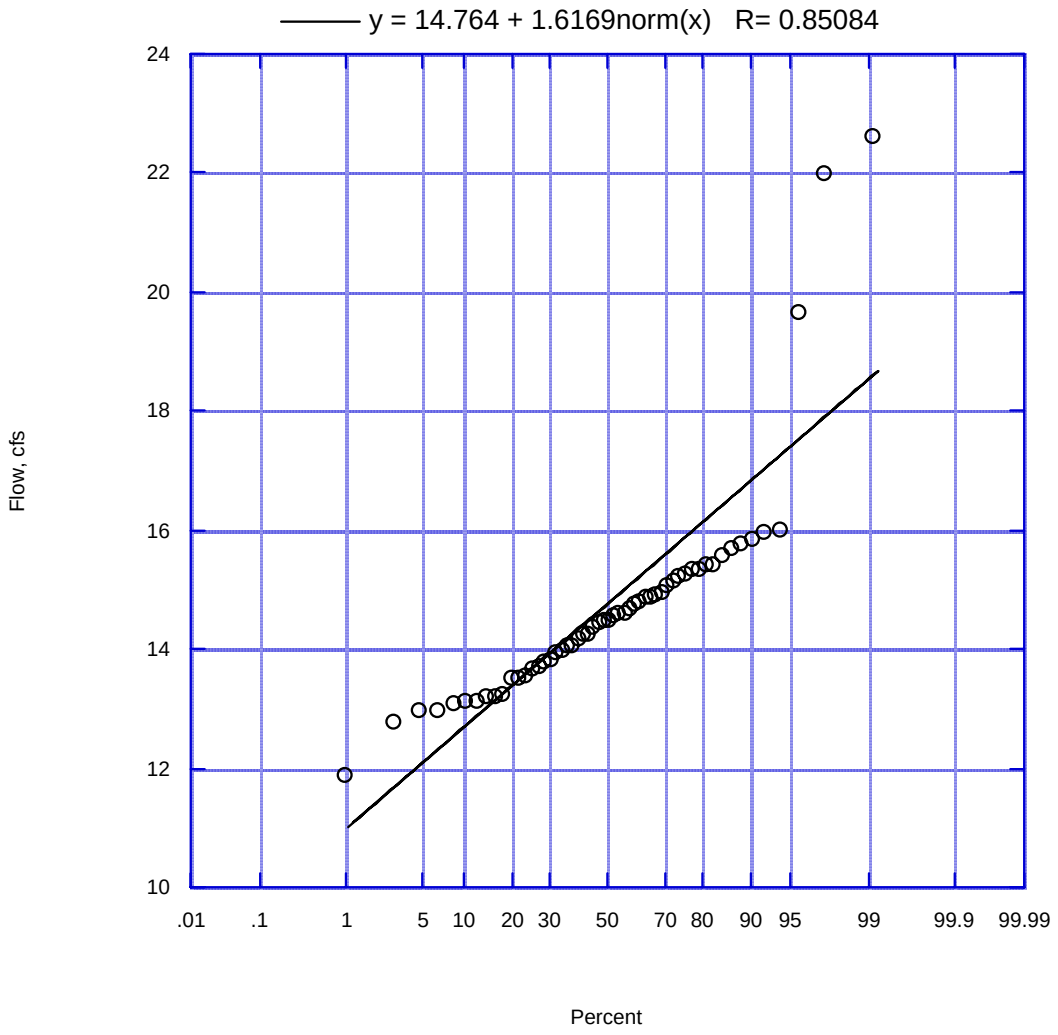


Figure 35. Simi Valley Effluent Flow Frequency Distribution - Feb (02-03)

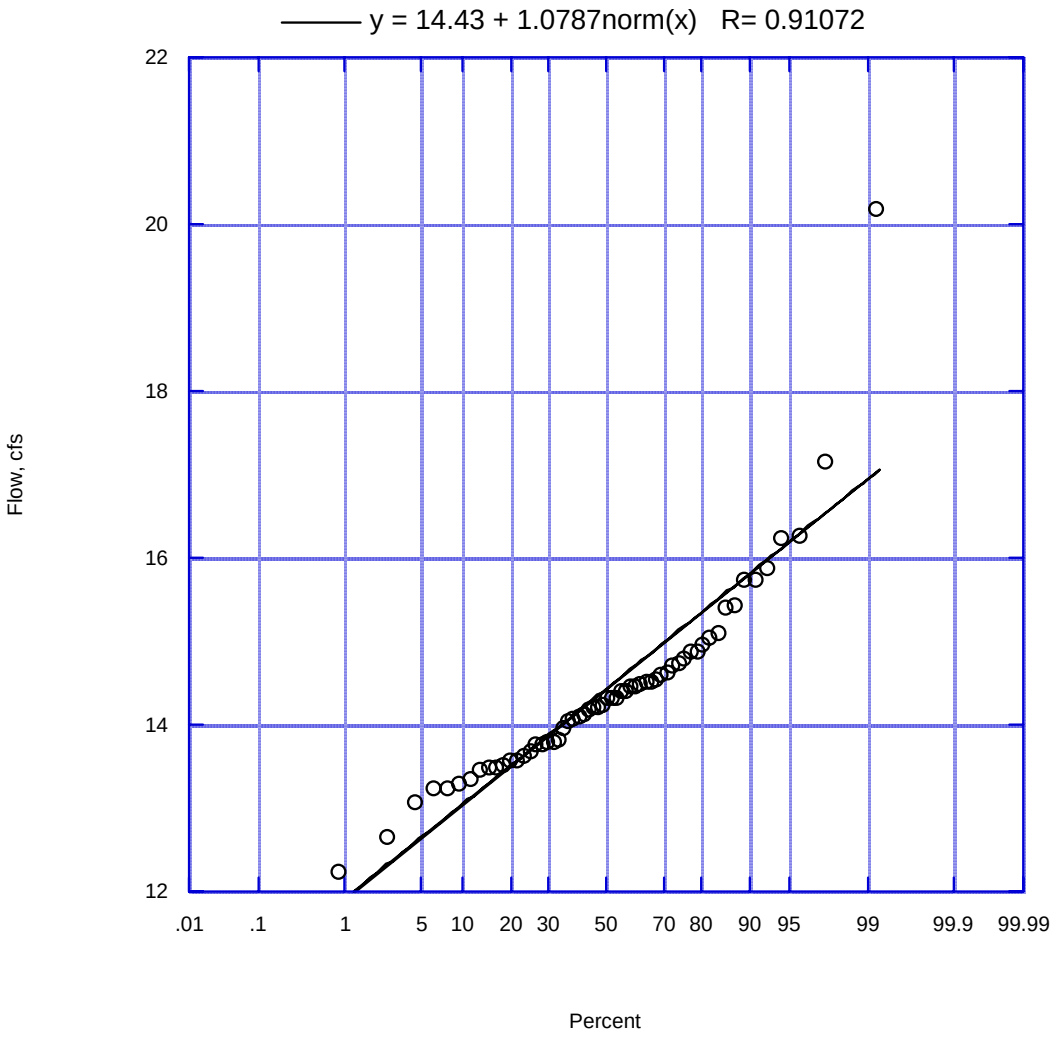


Figure 36. Simi Valley Effluent Flow Frequency Distribution - Mar (02-03)

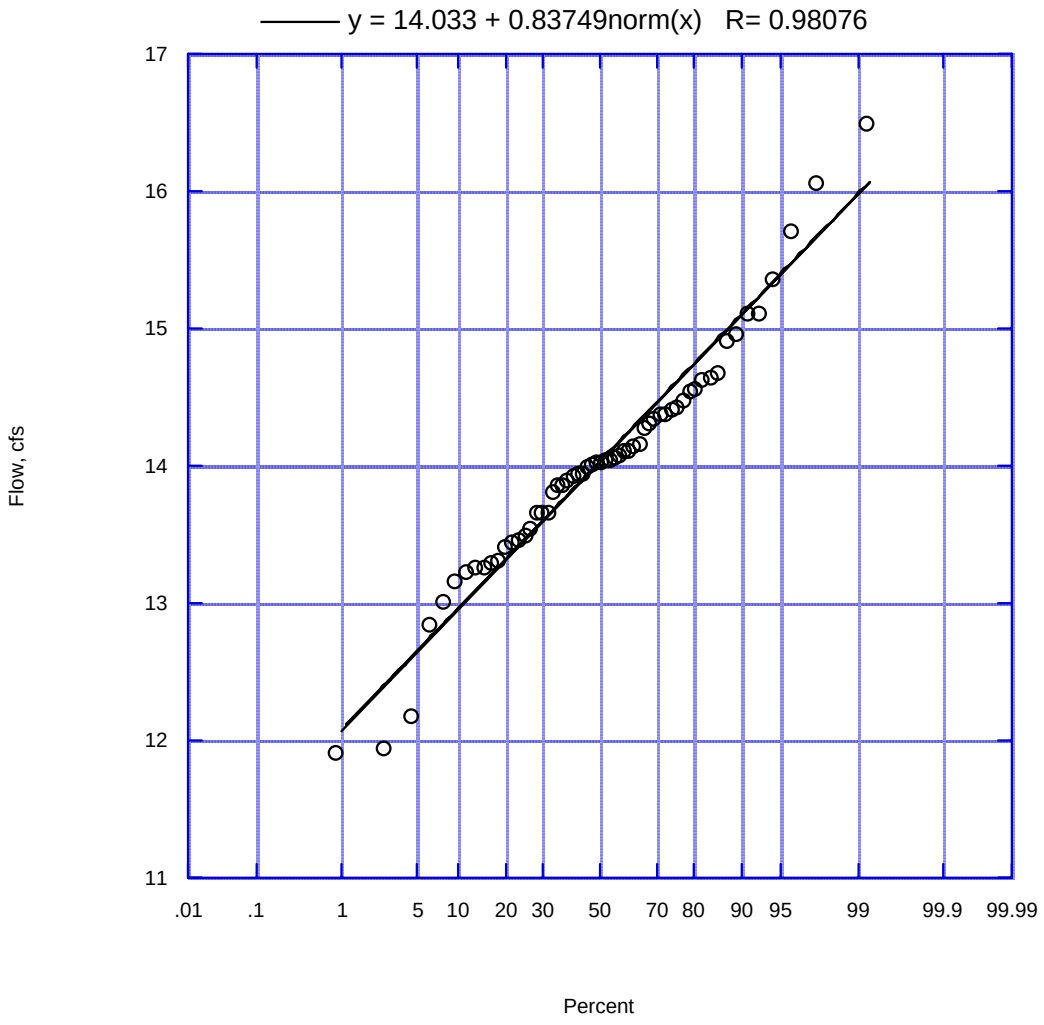


Figure 37. Simi Valley Effluent Flow Frequency Distribution - April (02-03)

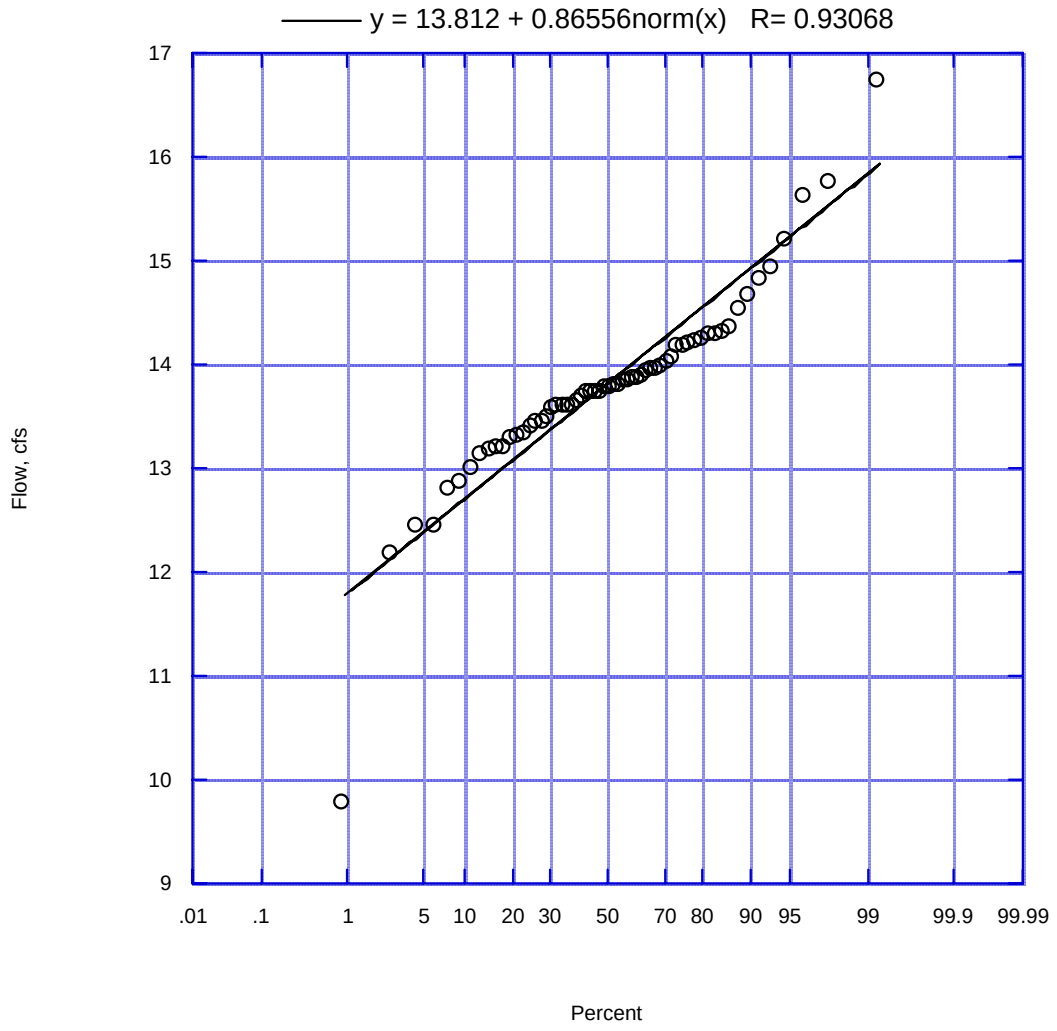


Figure 38. Simi Valley Effluent Flow Frequency Distribution - May (02-03)

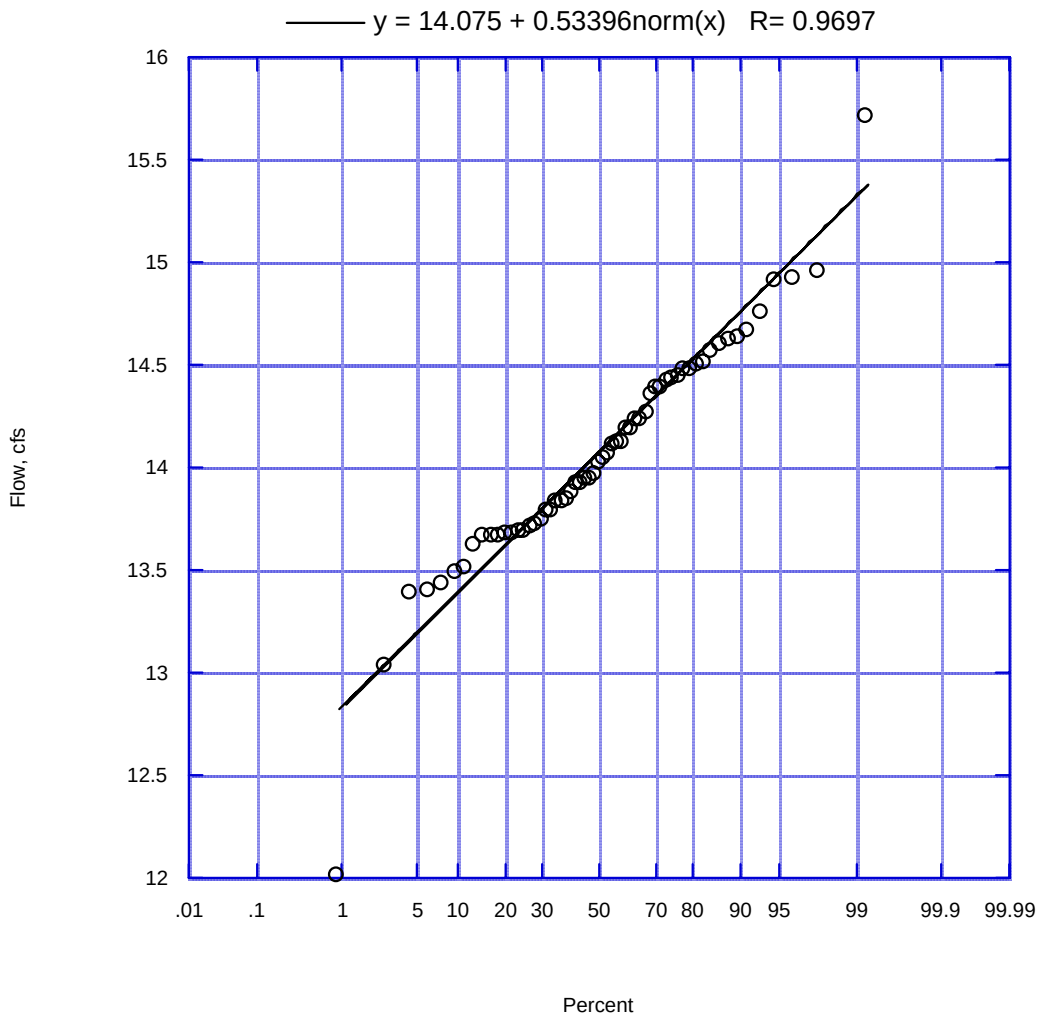


Figure 39. Simi Valley Effluent Flow Frequency Distribution - June (02-03)

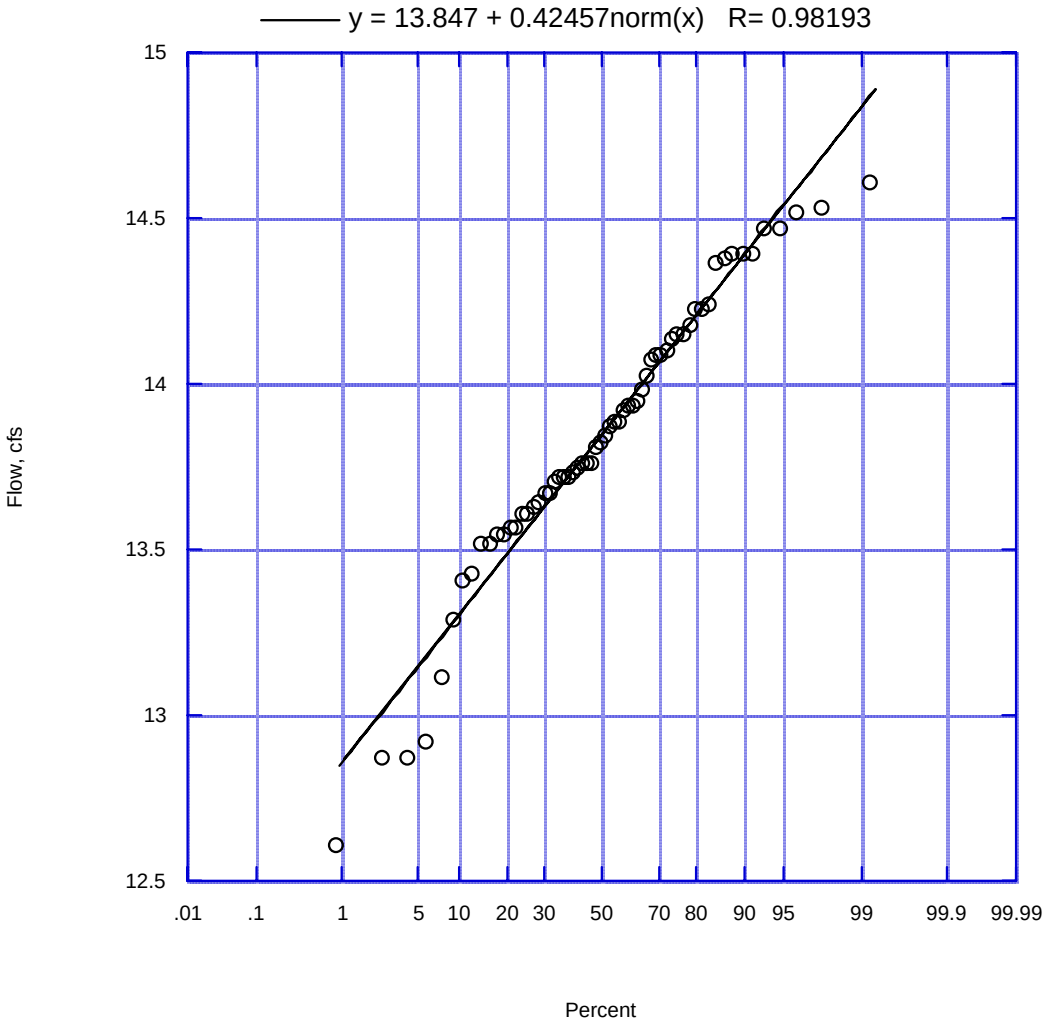


Figure 40. Simi Valley Effluent Flow Frequency Distribution - July (02-03)

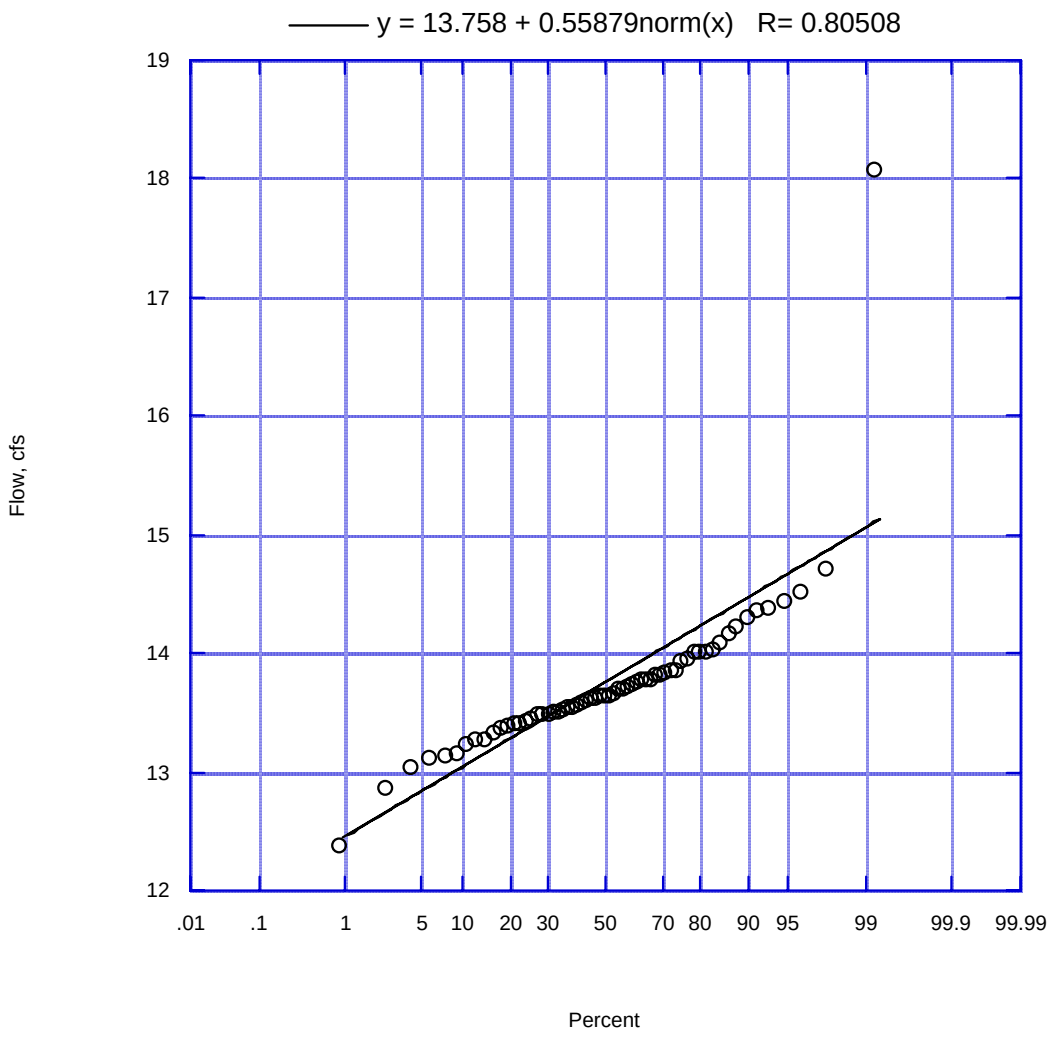


Figure 41. Simi Valley Effluent Flow Frequency Distribution - Aug (02-03)

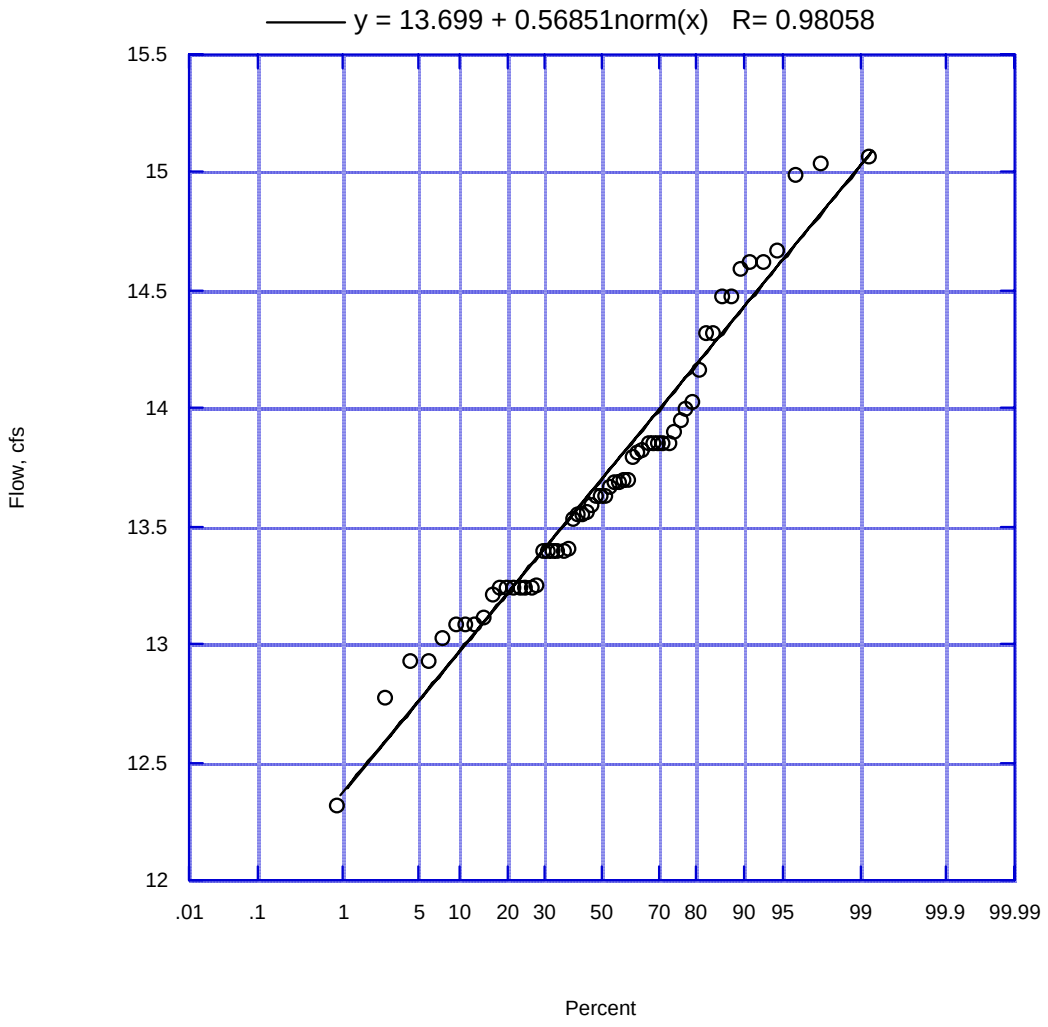


Figure 42. Simi Valley Effluent Flow Frequency Distribution - Sept (02-03)

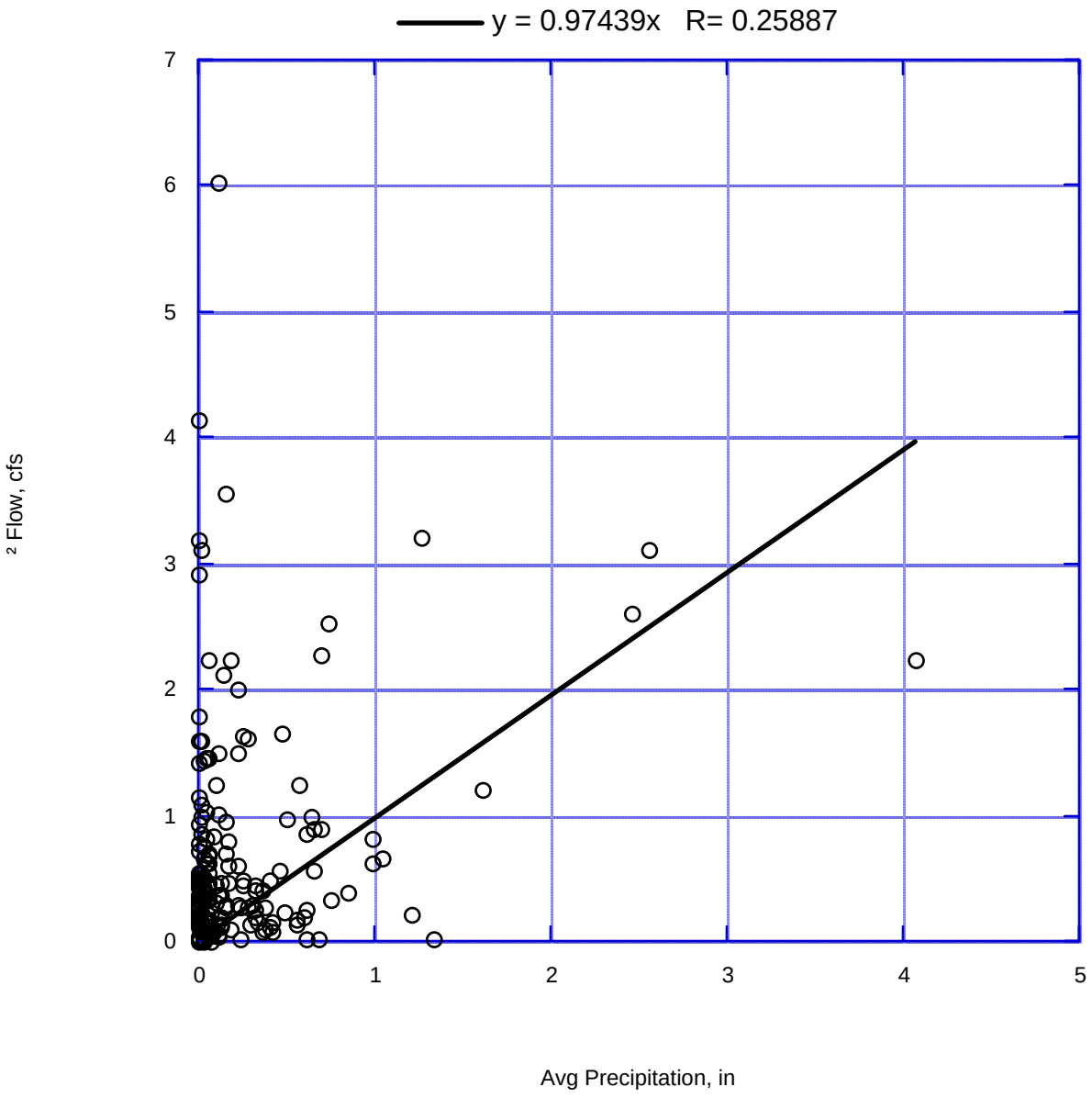


Figure 43. Camarillo ² Effluent Flow vs. Precipitation

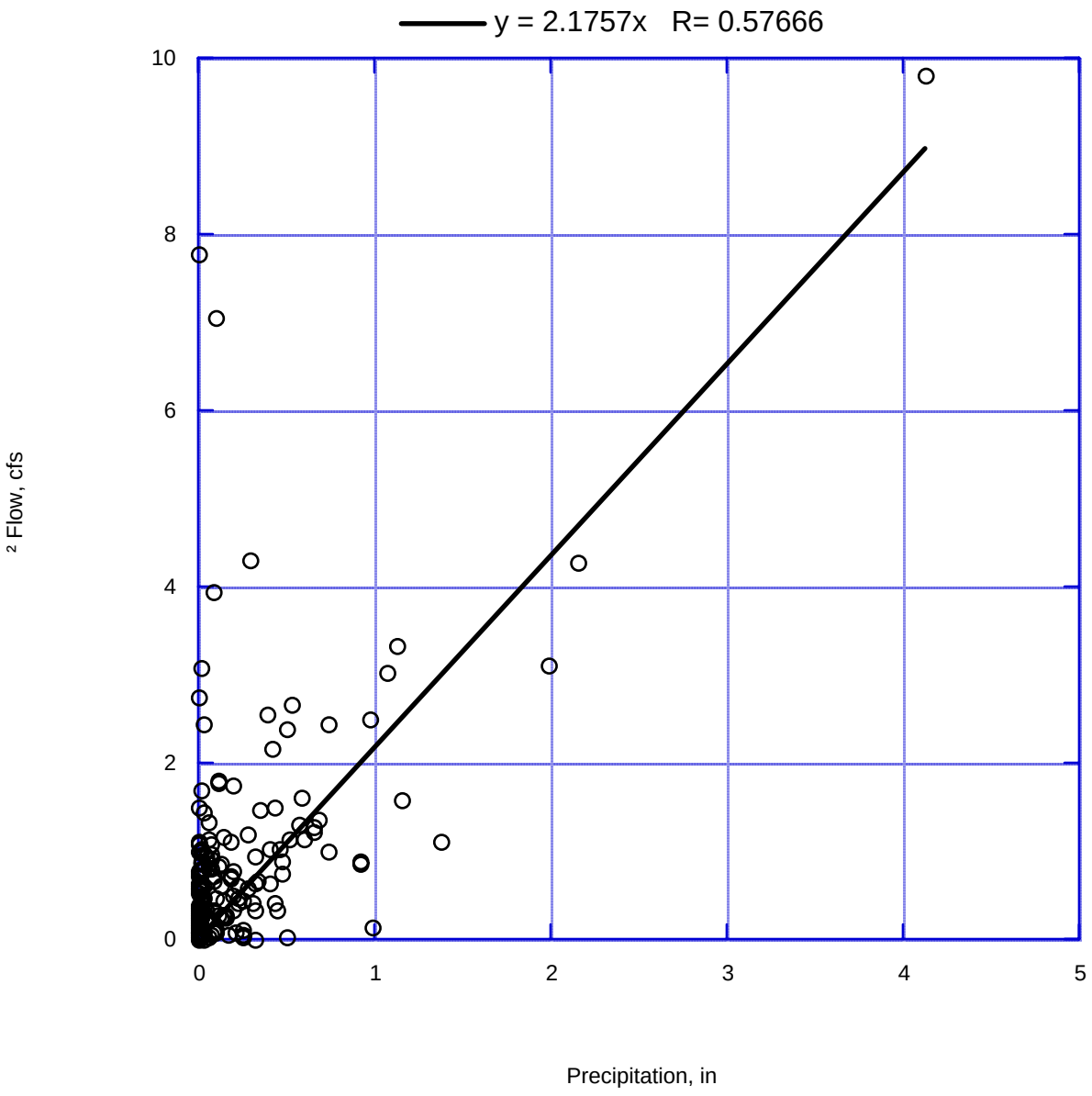


Figure 44. Hill Canyon ² Effluent Flow vs. Precipitation

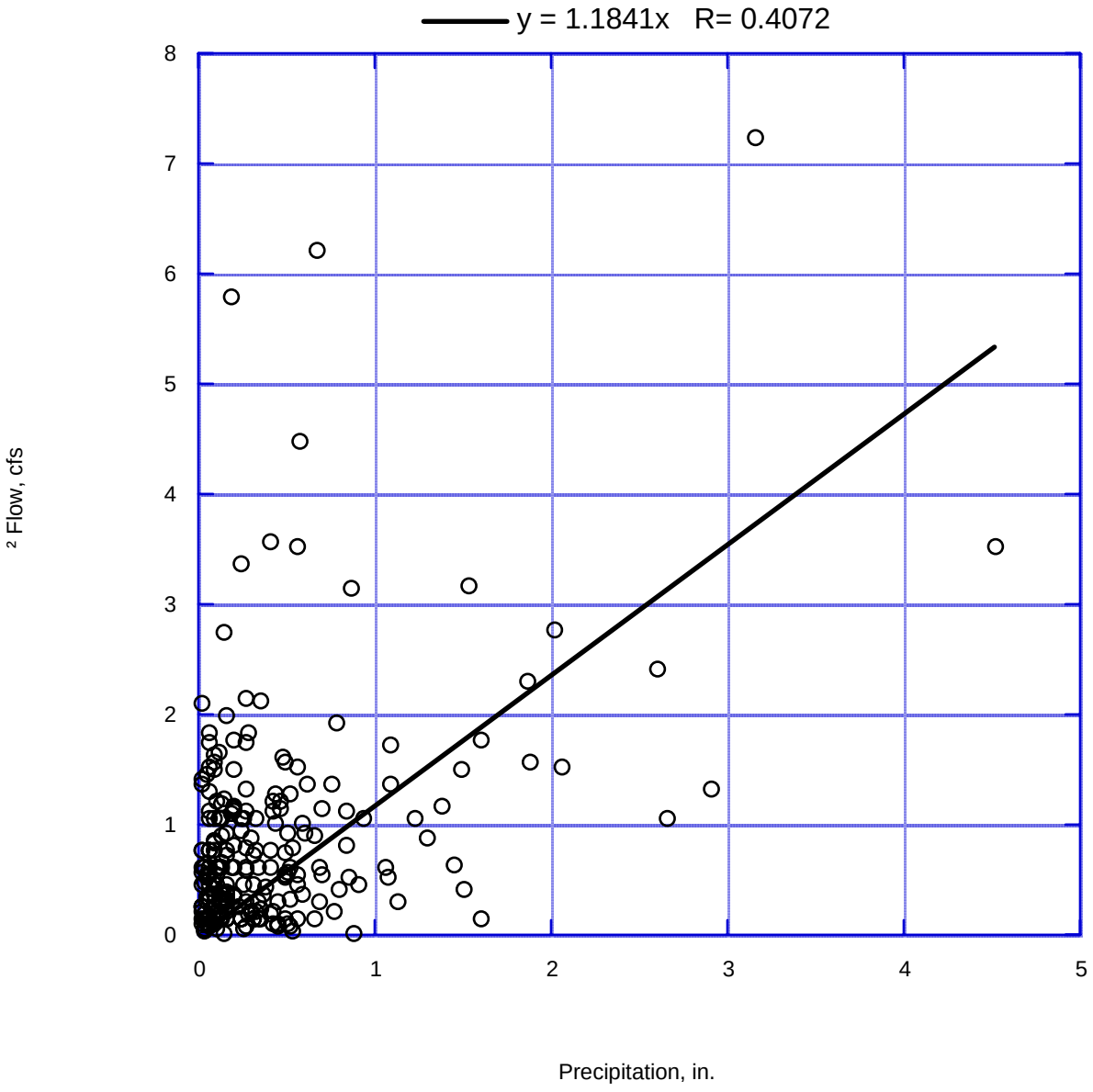


Figure 45. Simi Valley ² Effluent Flow vs. Precipitation

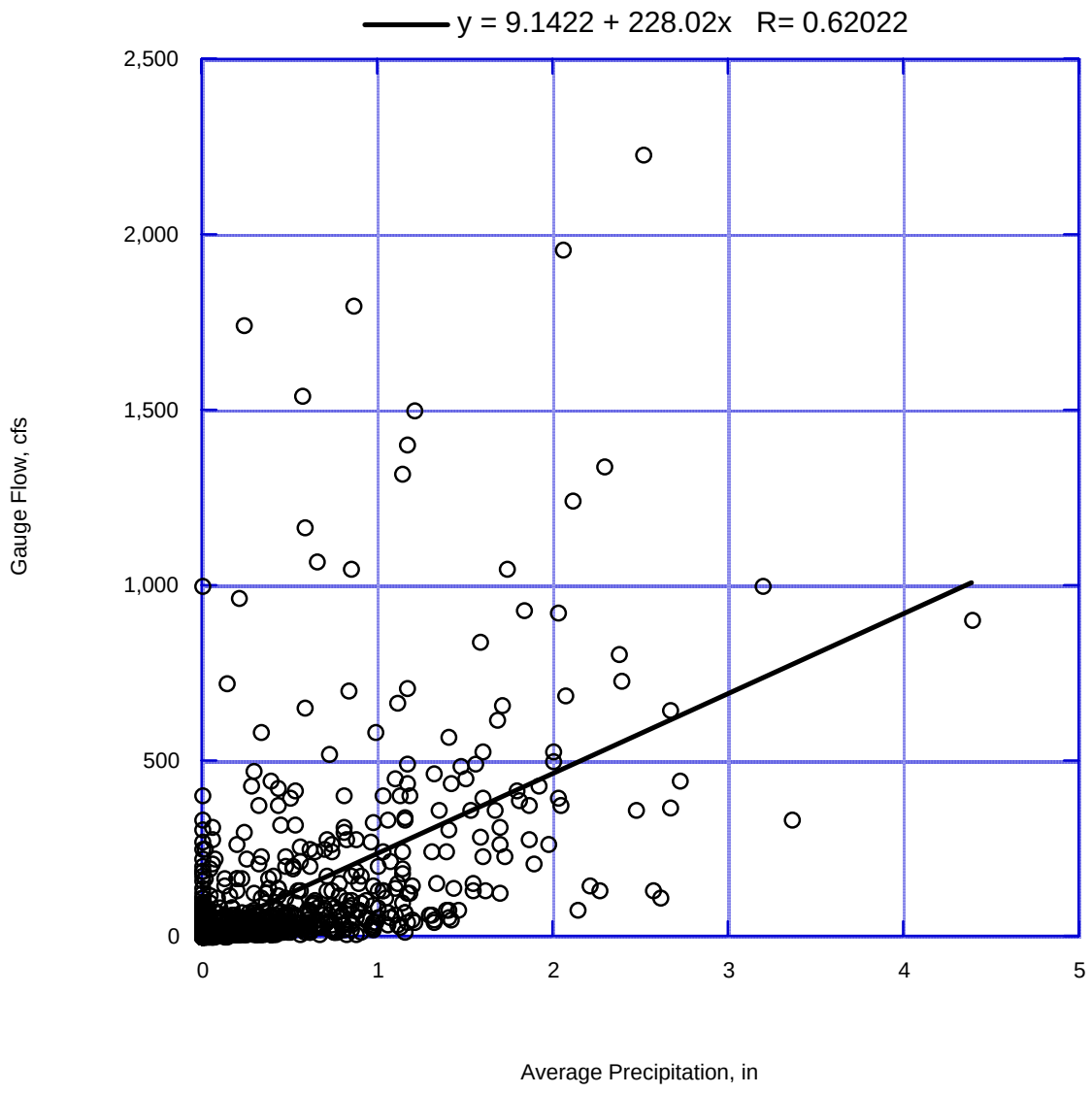


Figure 46. Gauge 776 Flow vs. Average Watershed Precipitation

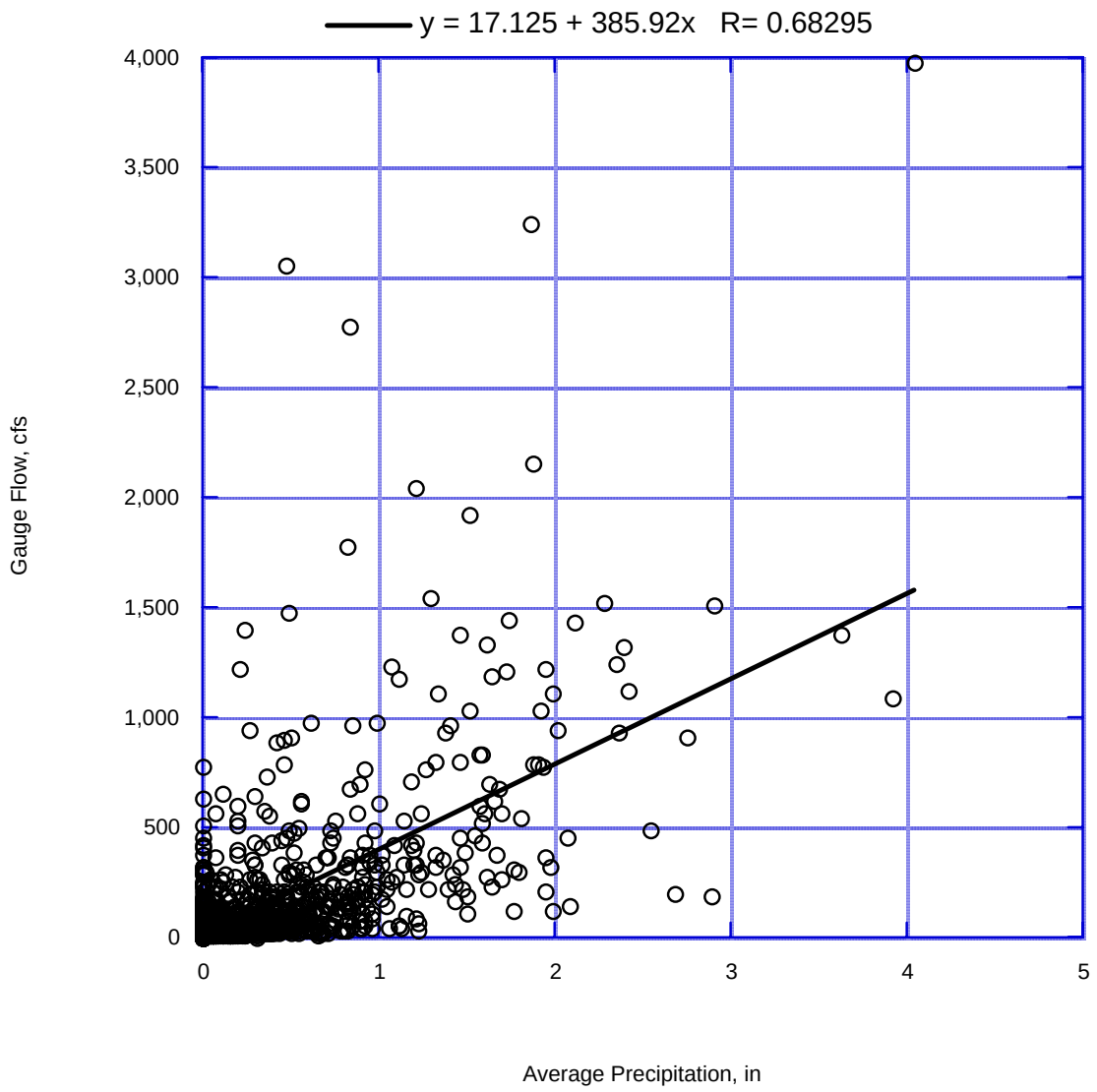


Figure 47. Gauge 800 Flow vs. Average Watershed Precipitation

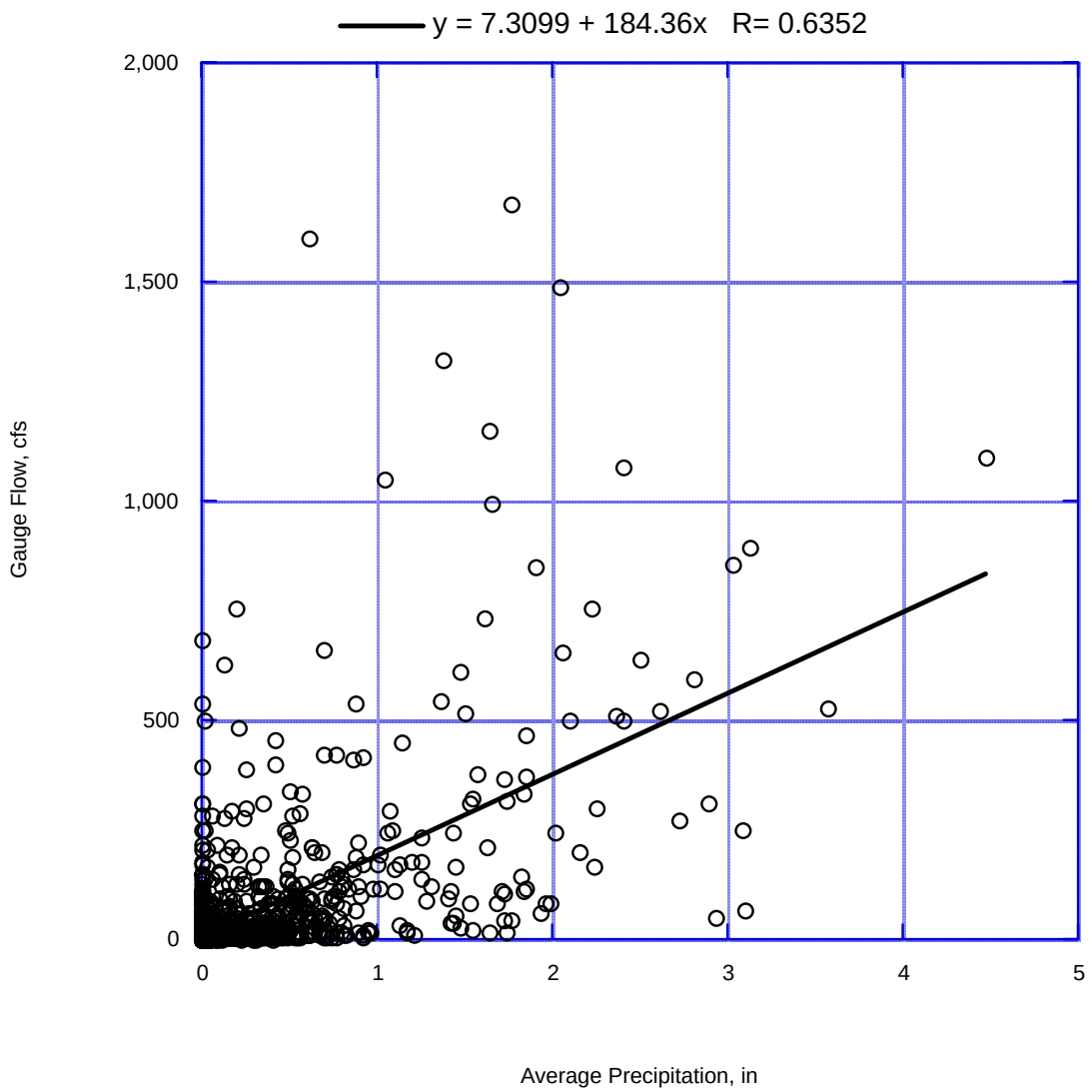


Figure 48. Gauge 803 Flow vs. Average Watershed Precipitation

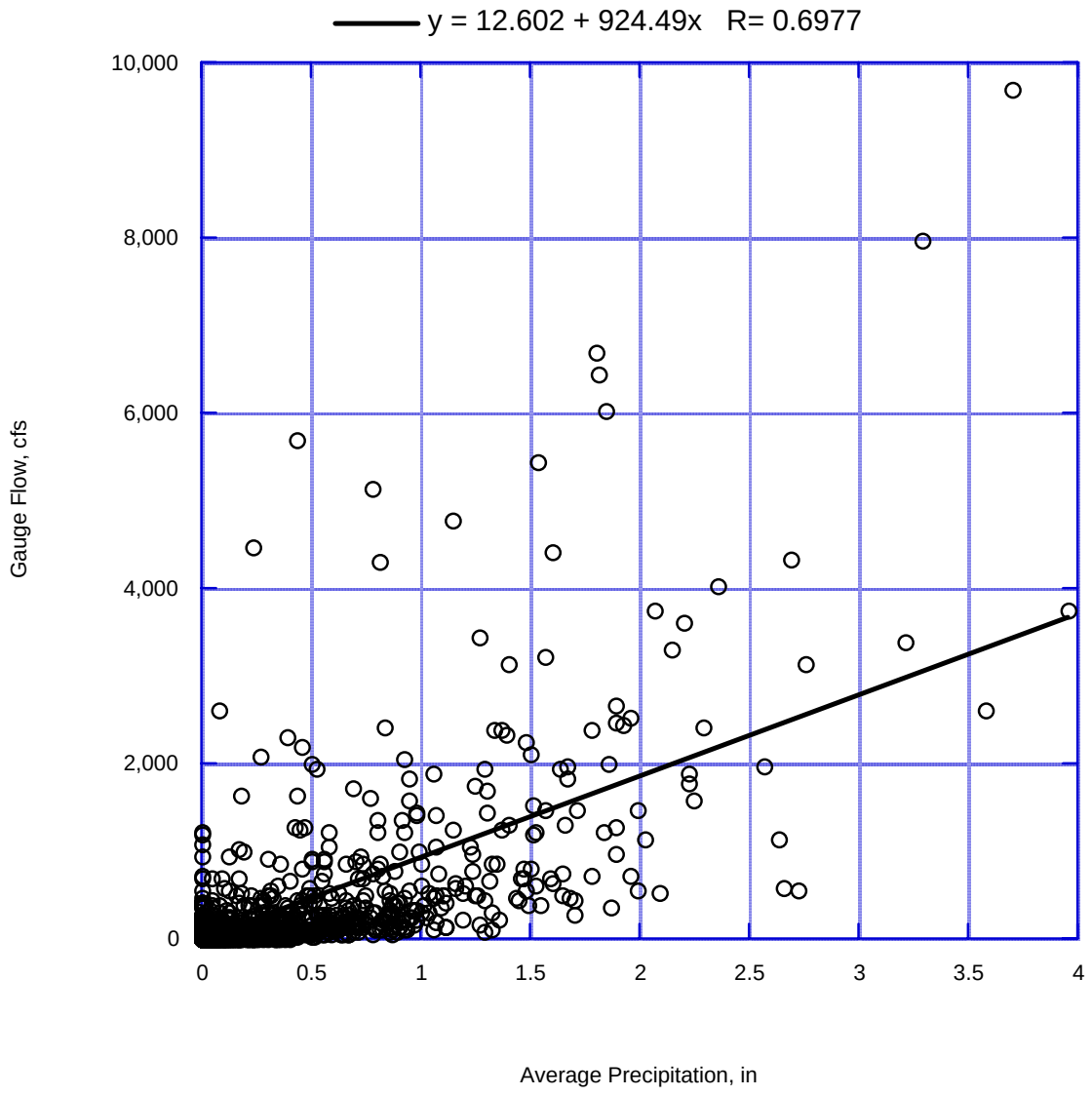


Figure 49. Gauge 805 Flow vs. Average Watershed Precipitation

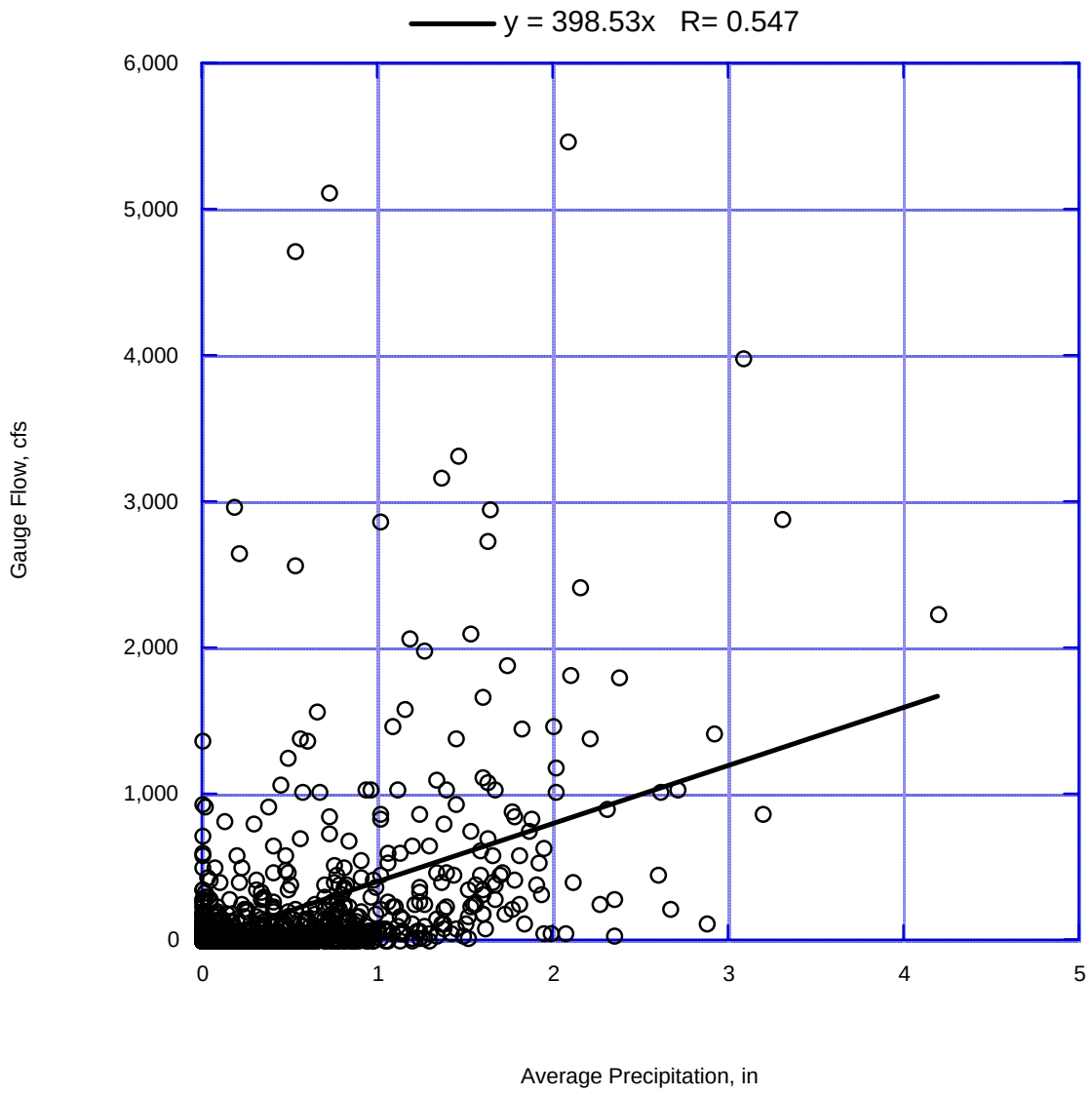


Figure 50. Gauge 806 Flow vs. Average Watershed Precipitation

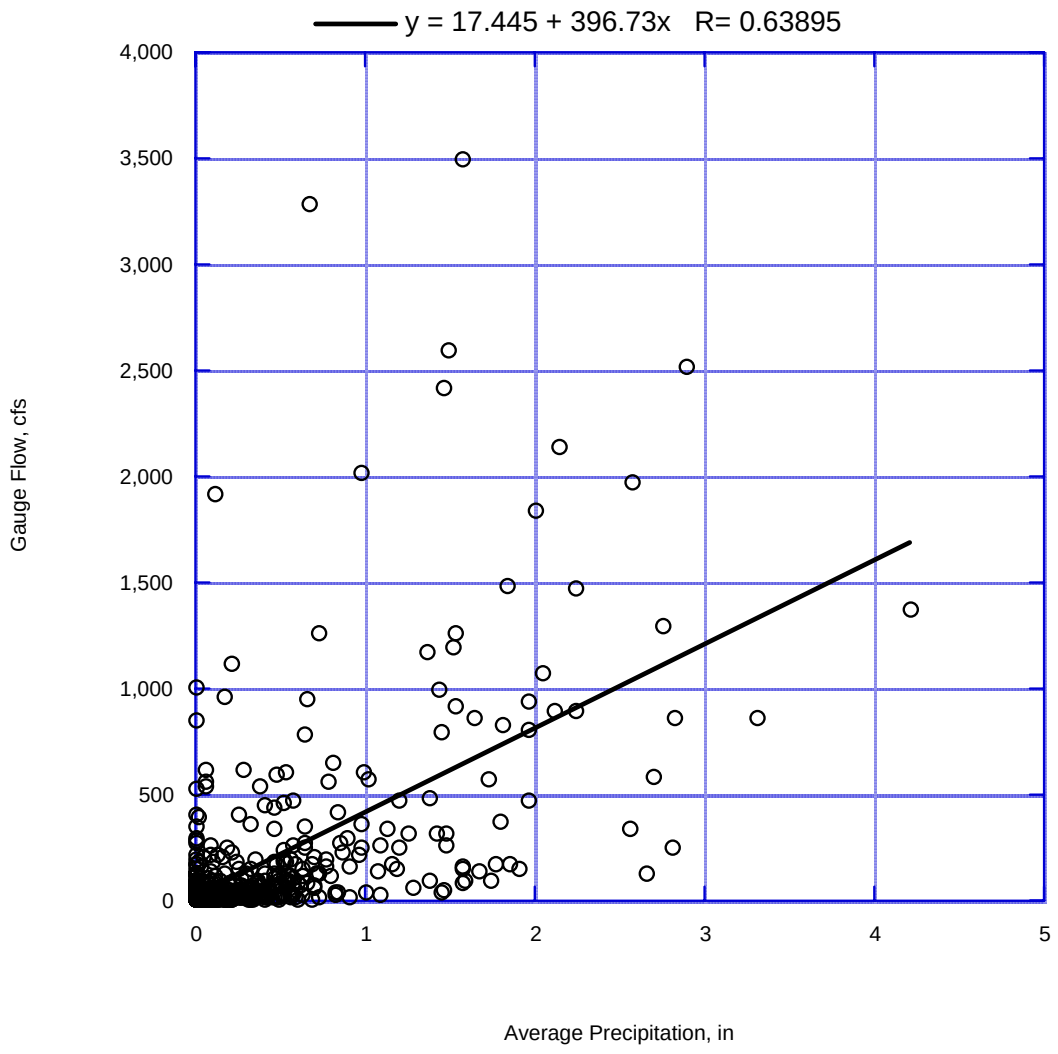


Figure 51. Gauge 841 Gauge Flow vs. Average Watershed Precipitation

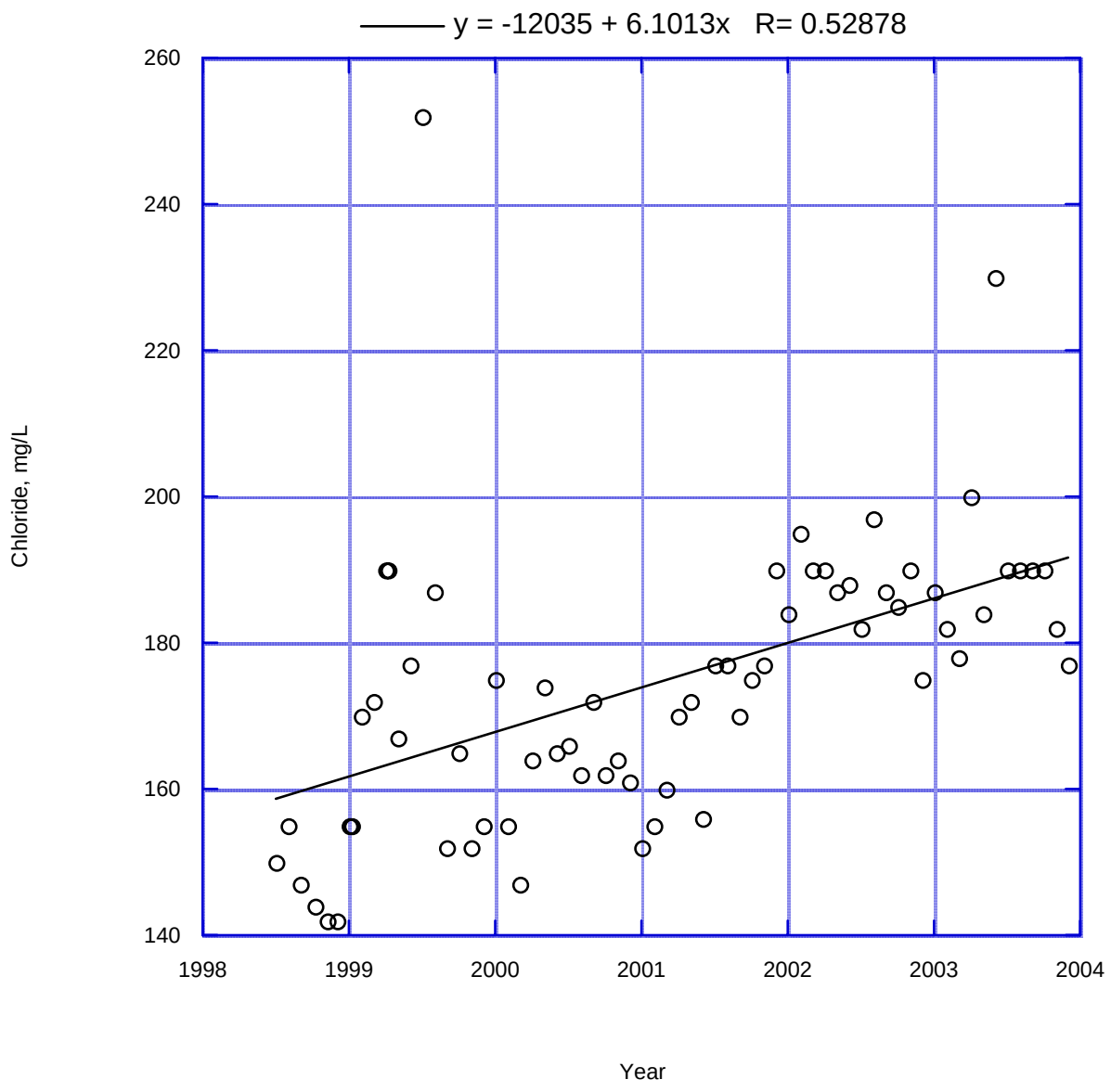


Figure 52. Camarillo Effluent Chloride vs. Time

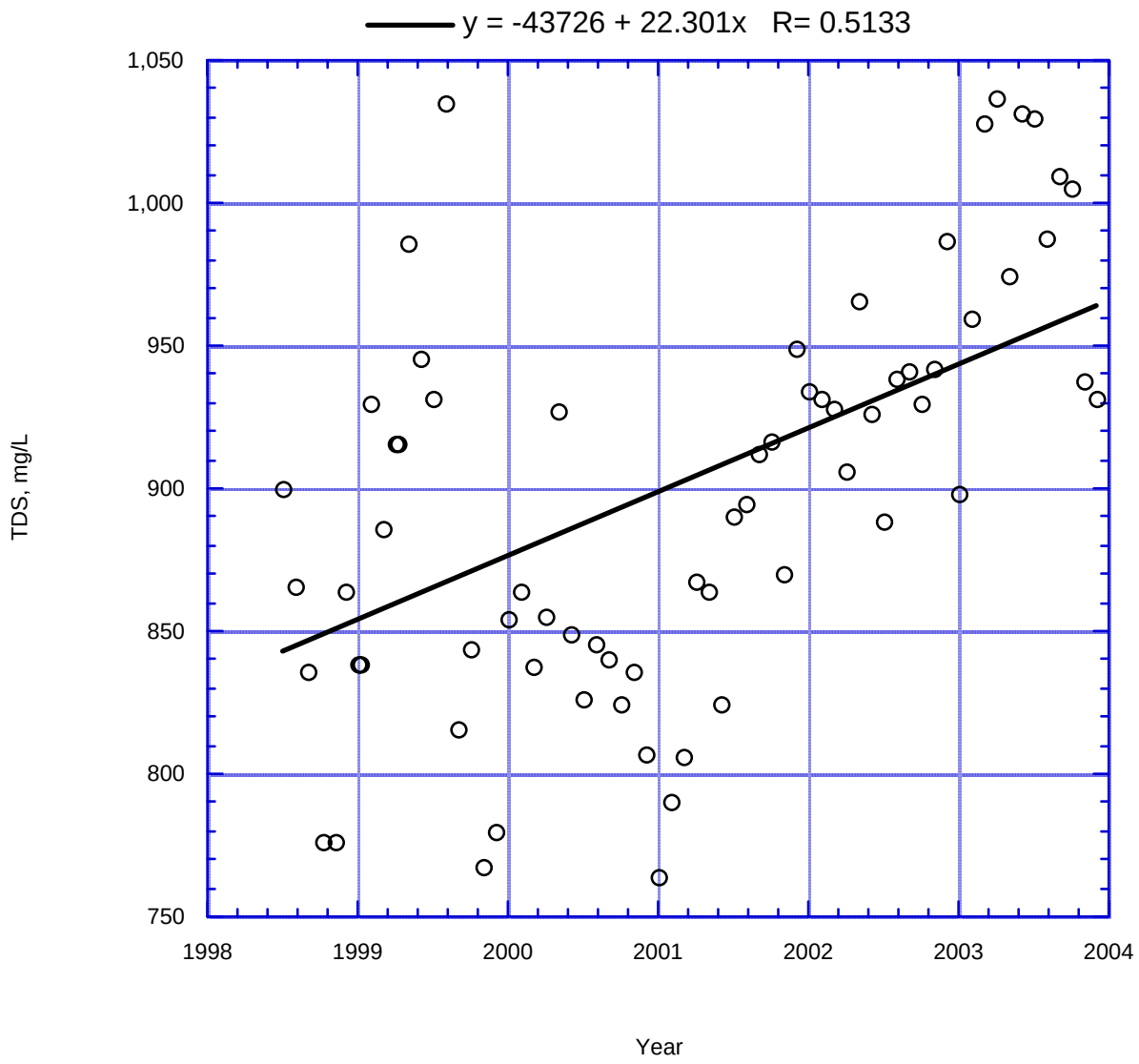


Figure 53. Camarillo Effluent TDS vs. Time

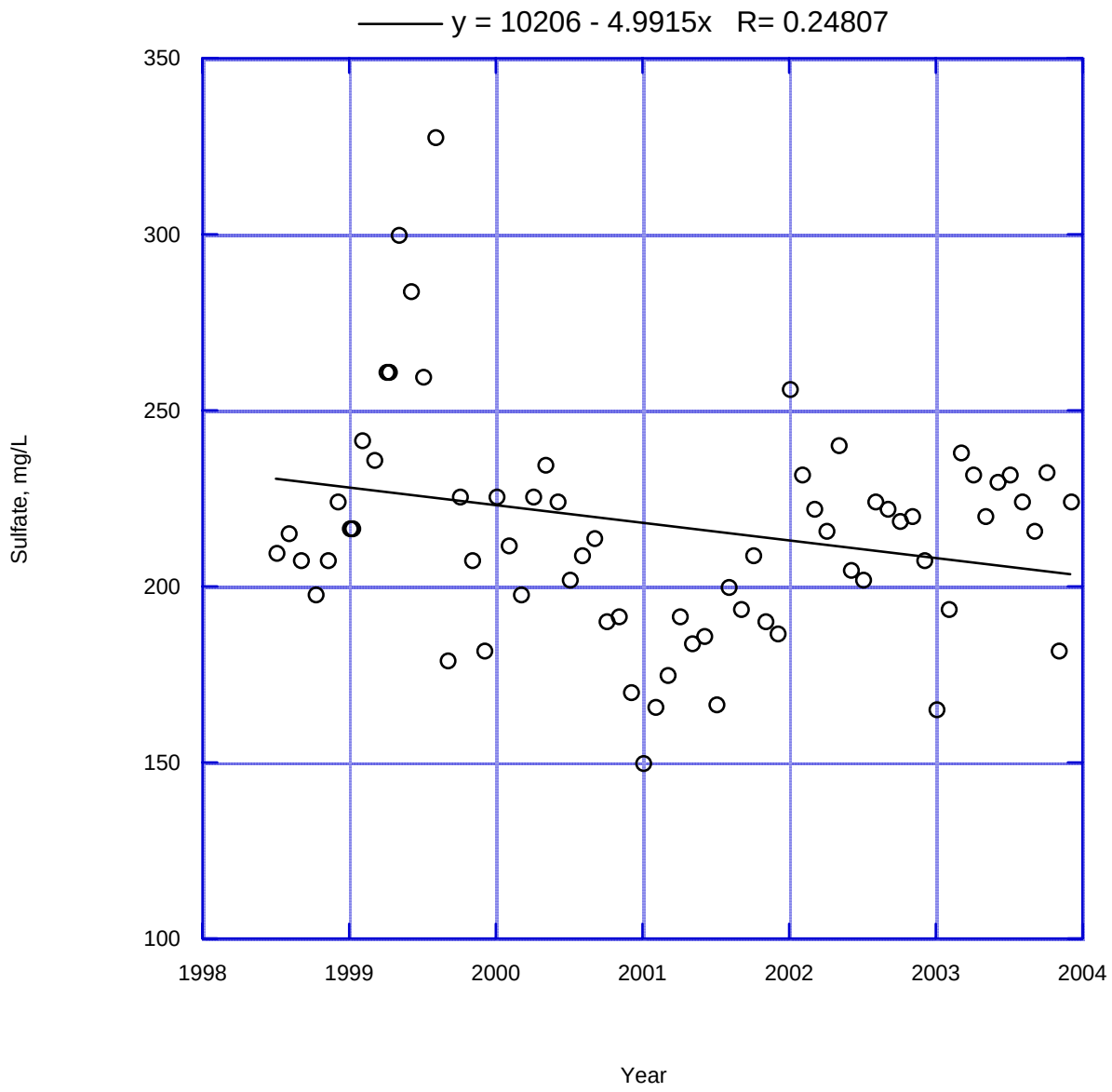


Figure 54. Camarillo Effluent Sulfate vs. Time

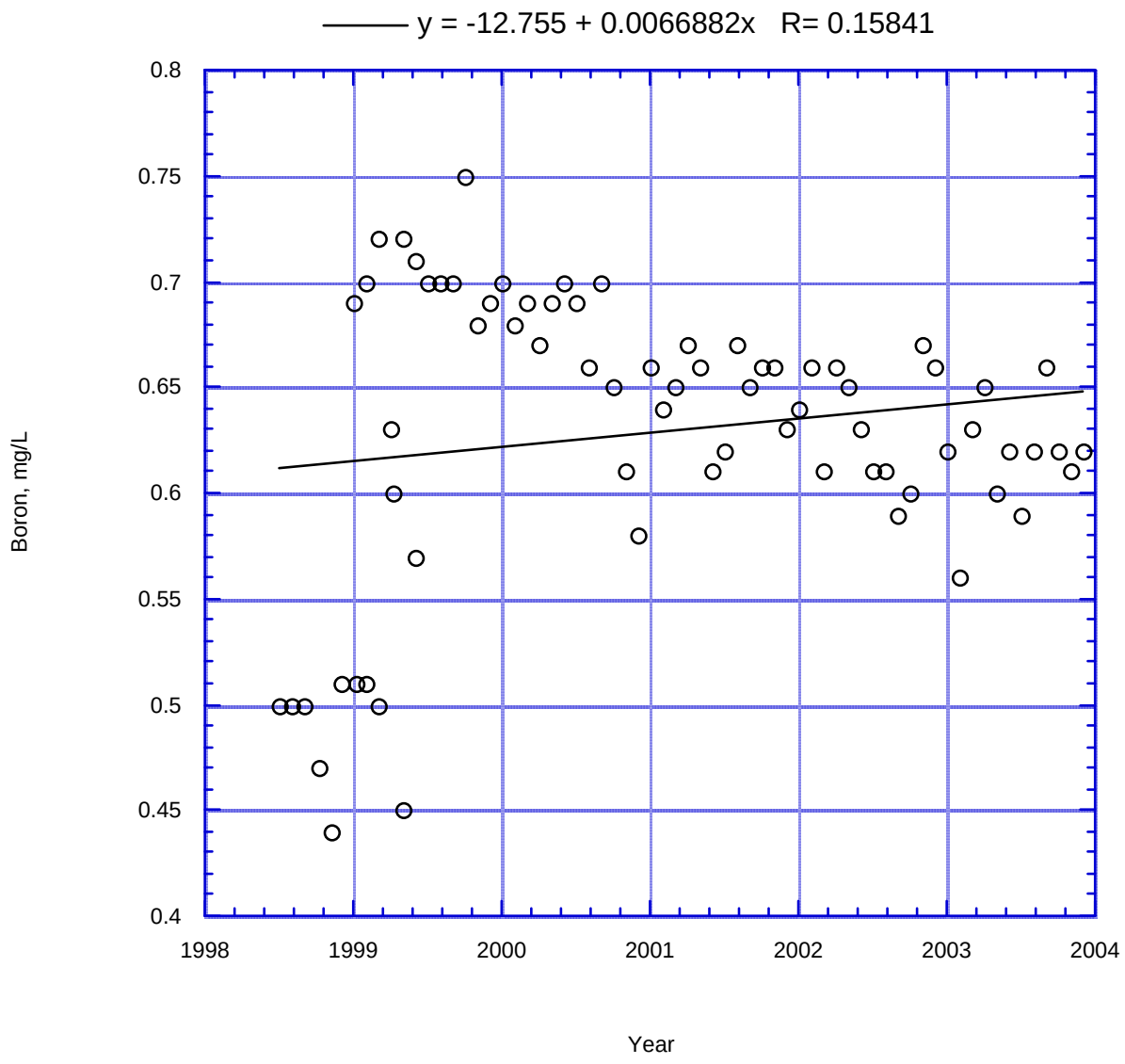


Figure 55. Camarillo Effluent Boron vs. Time

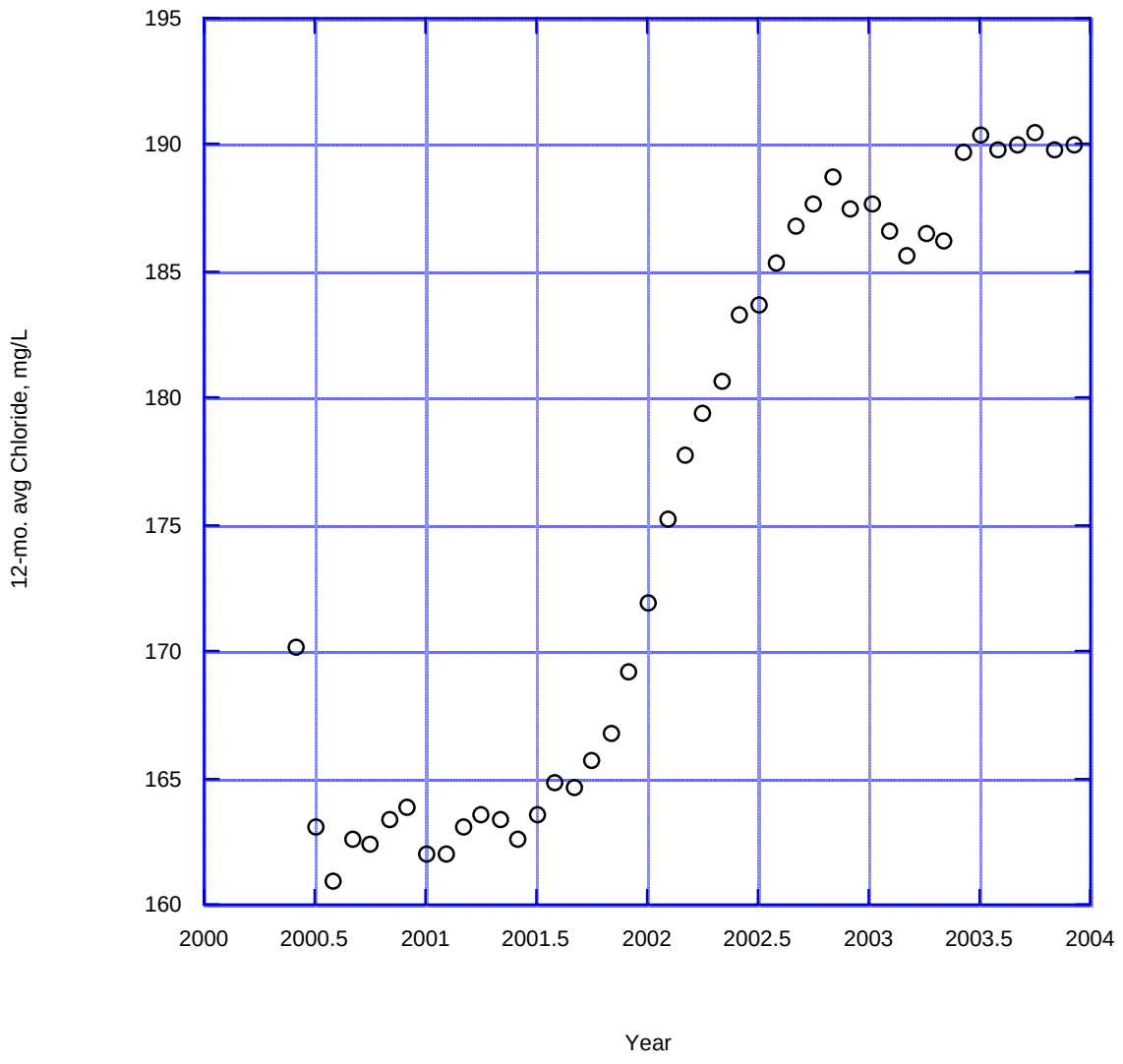


Figure 56. Camarillo Effluent 12-mo. Average Chloride vs. Time

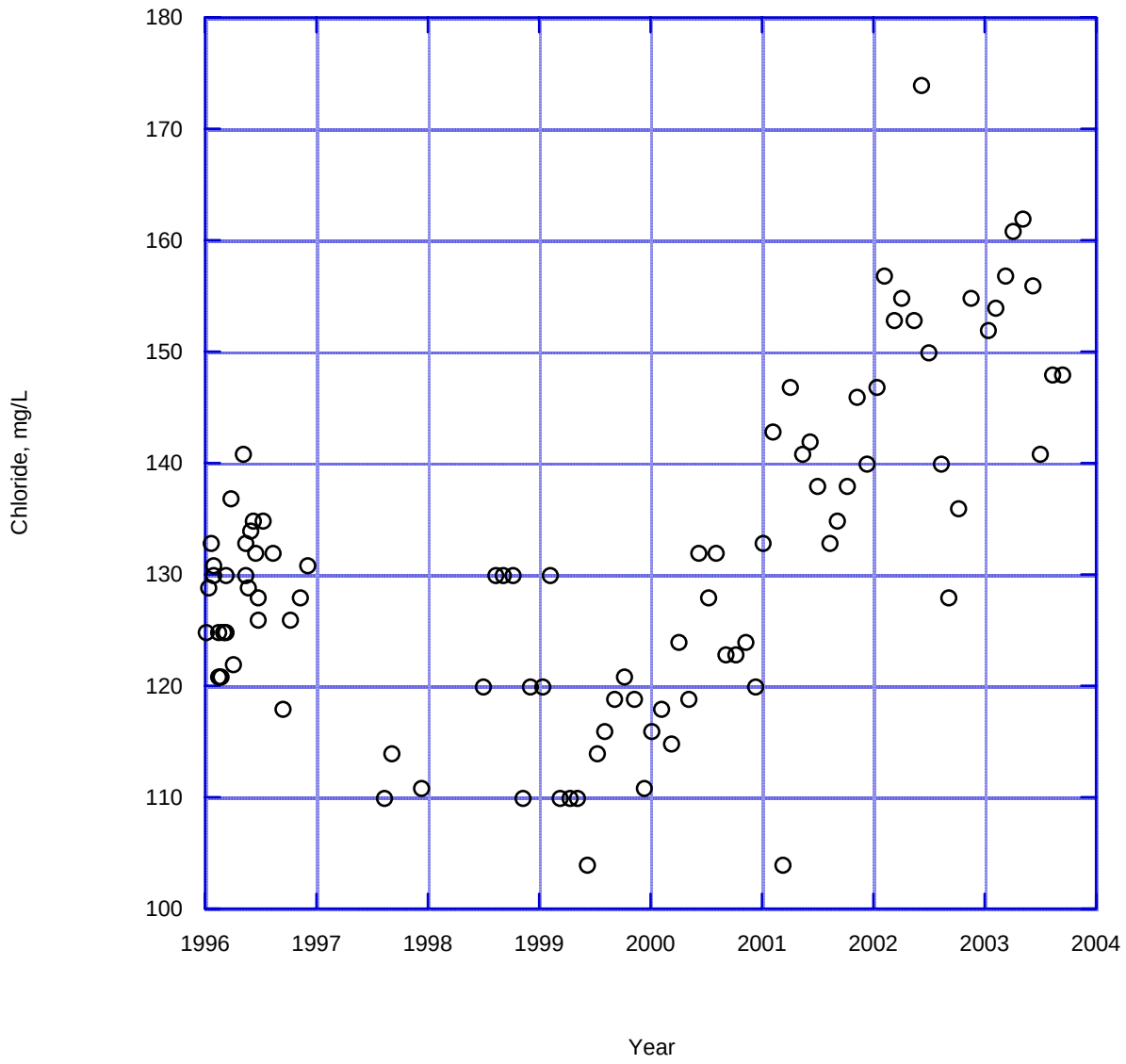


Figure 57. Hill Canyon Effluent Chloride vs. Time

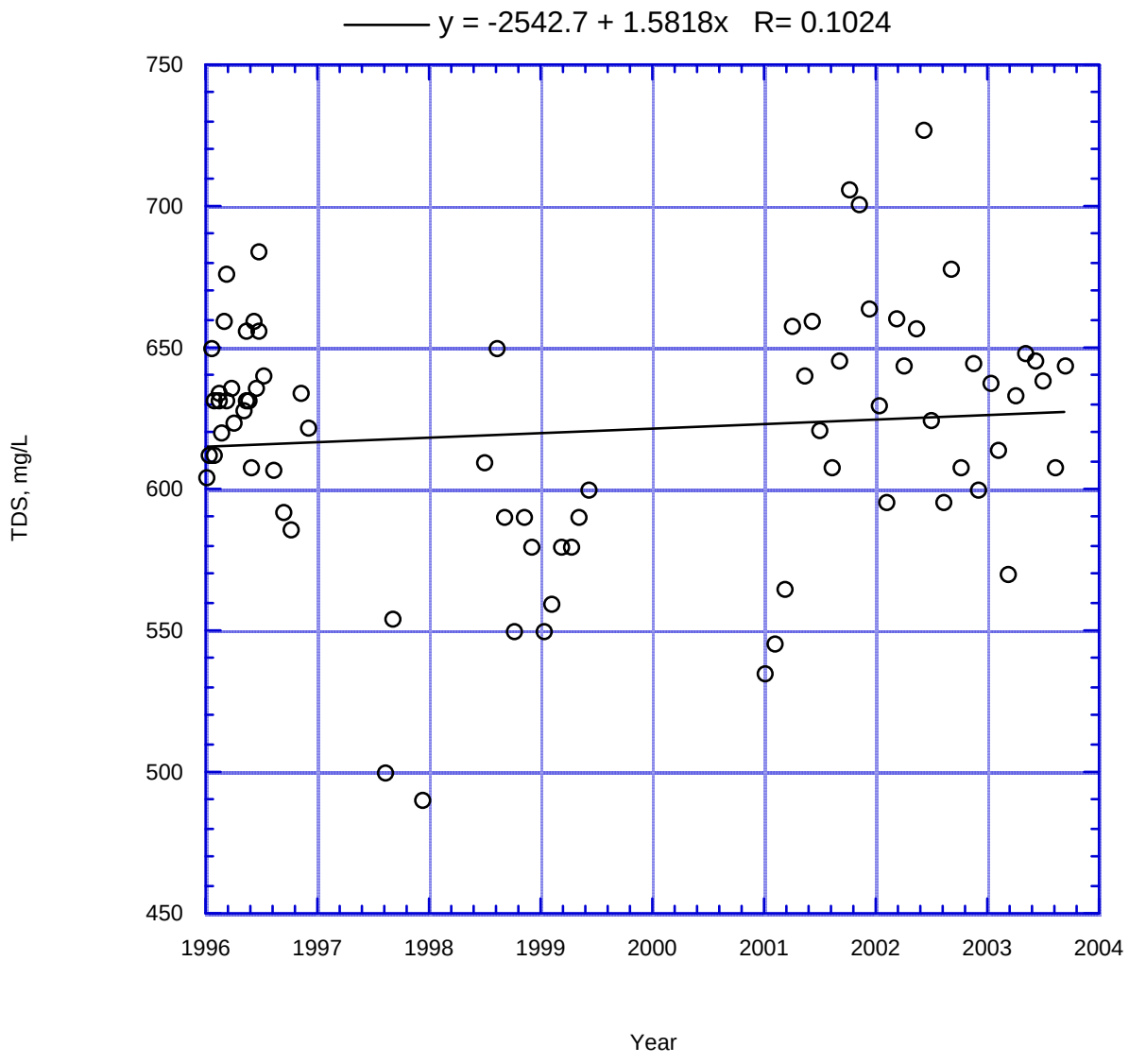


Figure 58. Hill Canyon Effluent TDS vs. Time

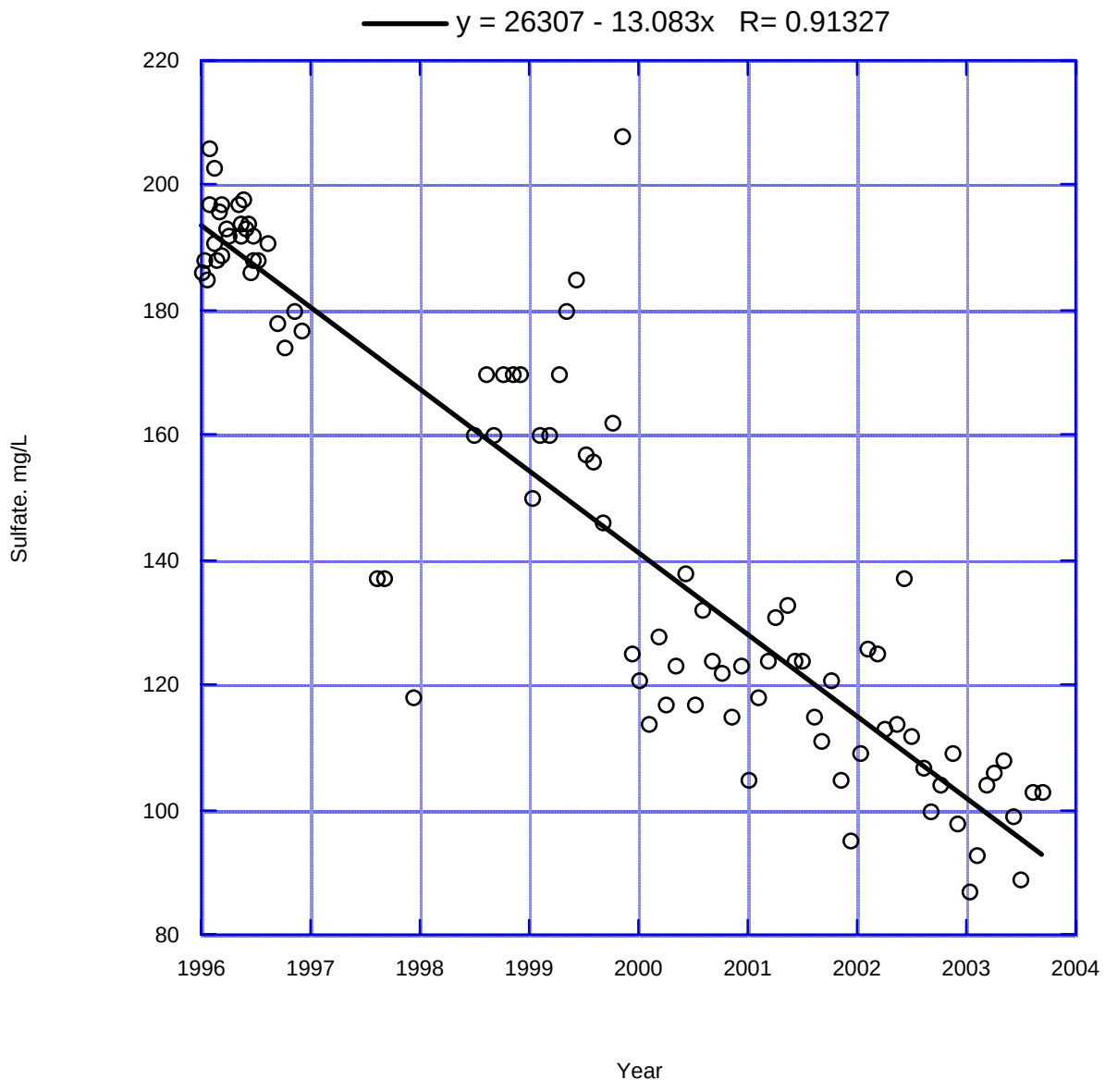


Figure 59. Hill Canyon Effluent Sulfate vs. Time

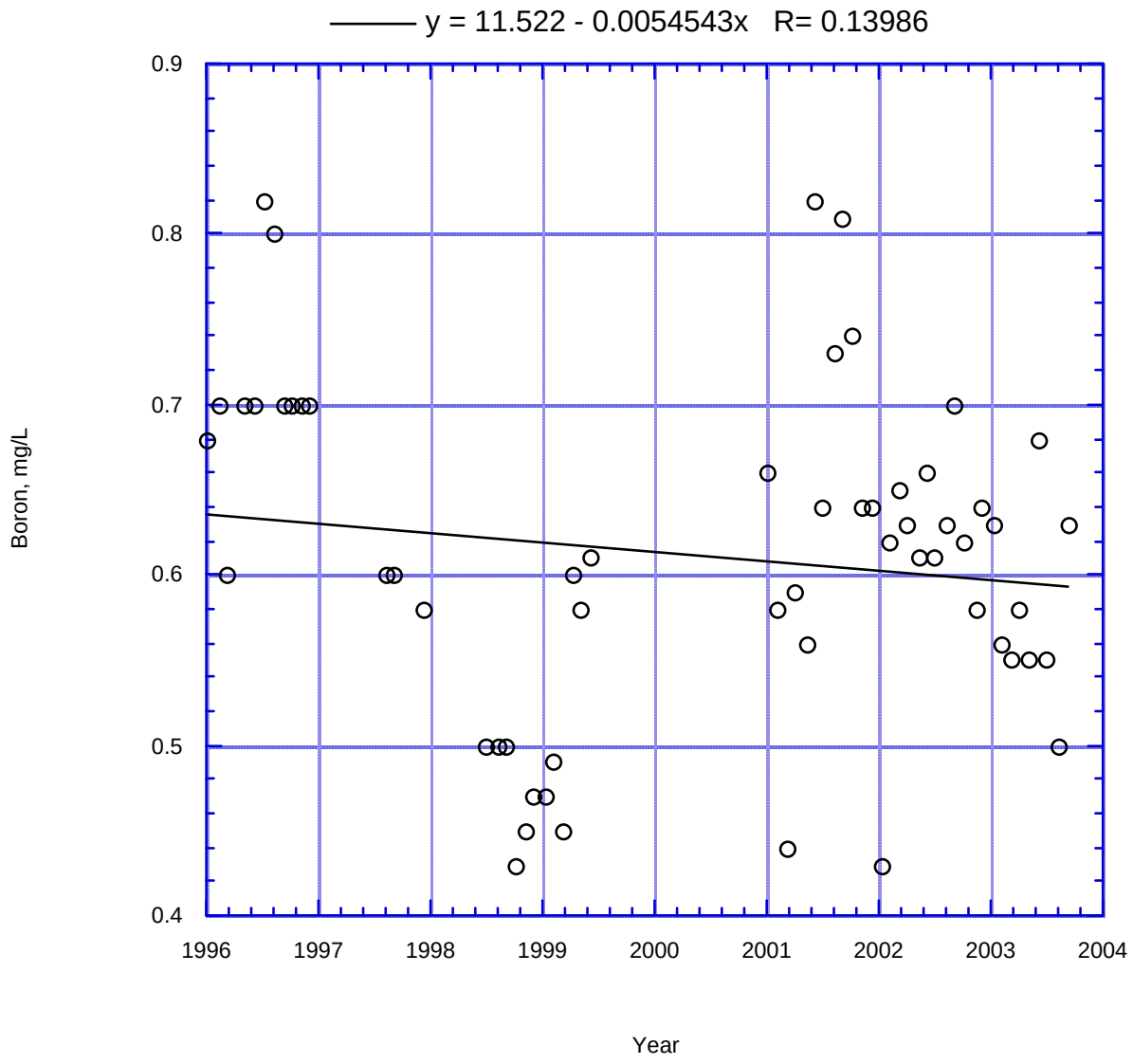


Figure 60. Hill Canyon Effluent – Boron vs. Time

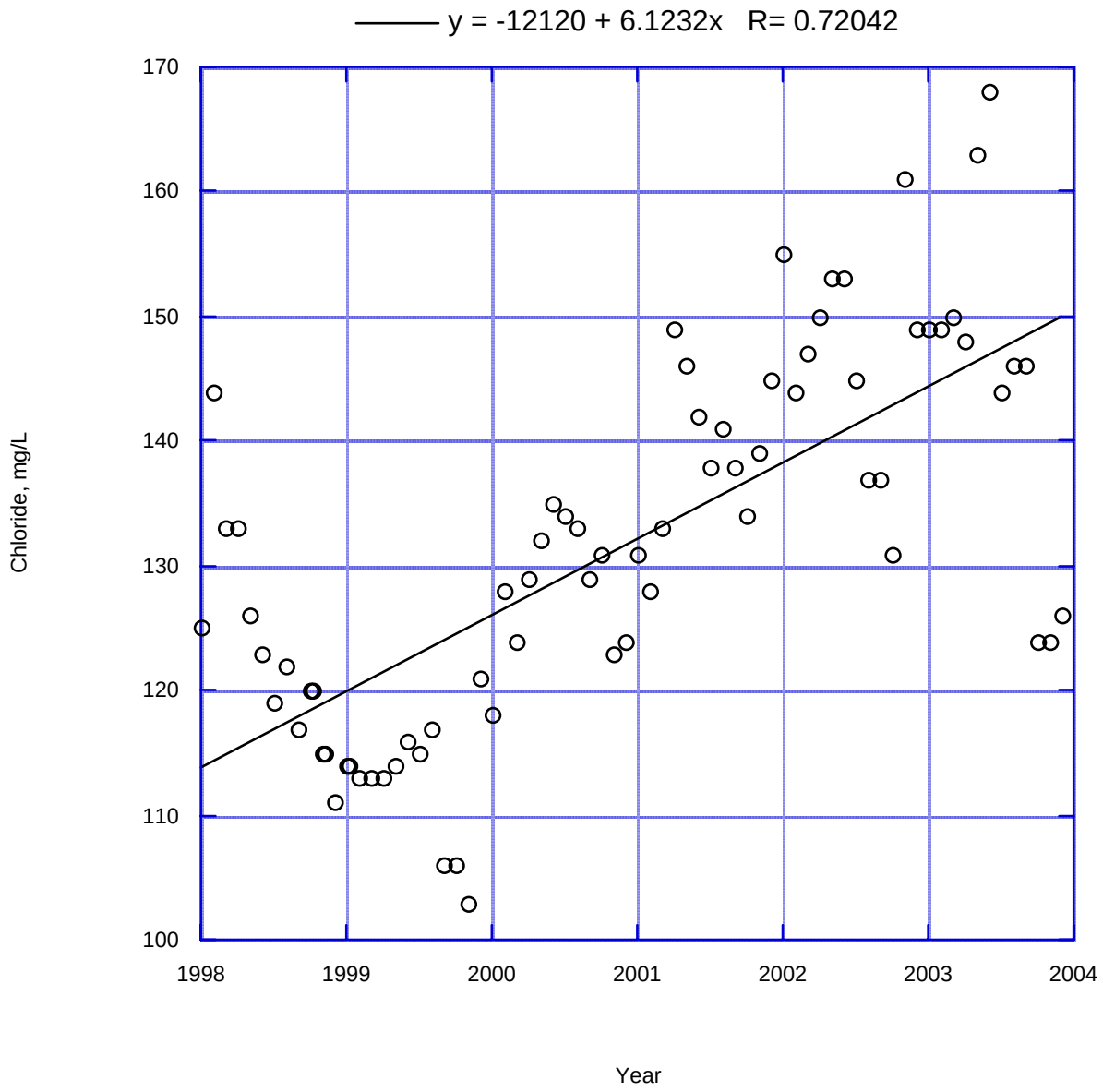


Figure 61. Simi Valley Effluent Chloride vs. Time

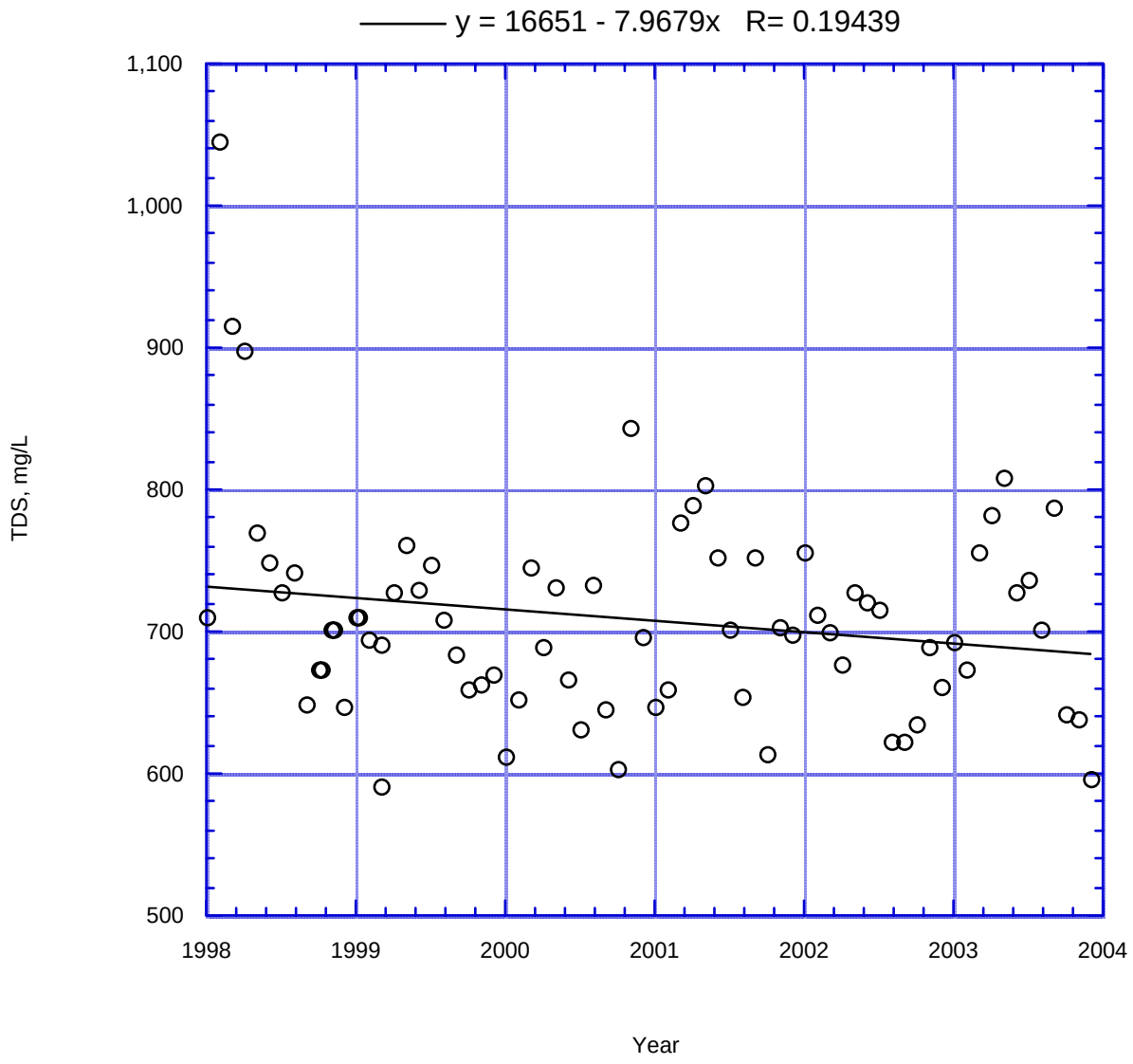


Figure 62. Simi Valley Effluent TDS vs. Time

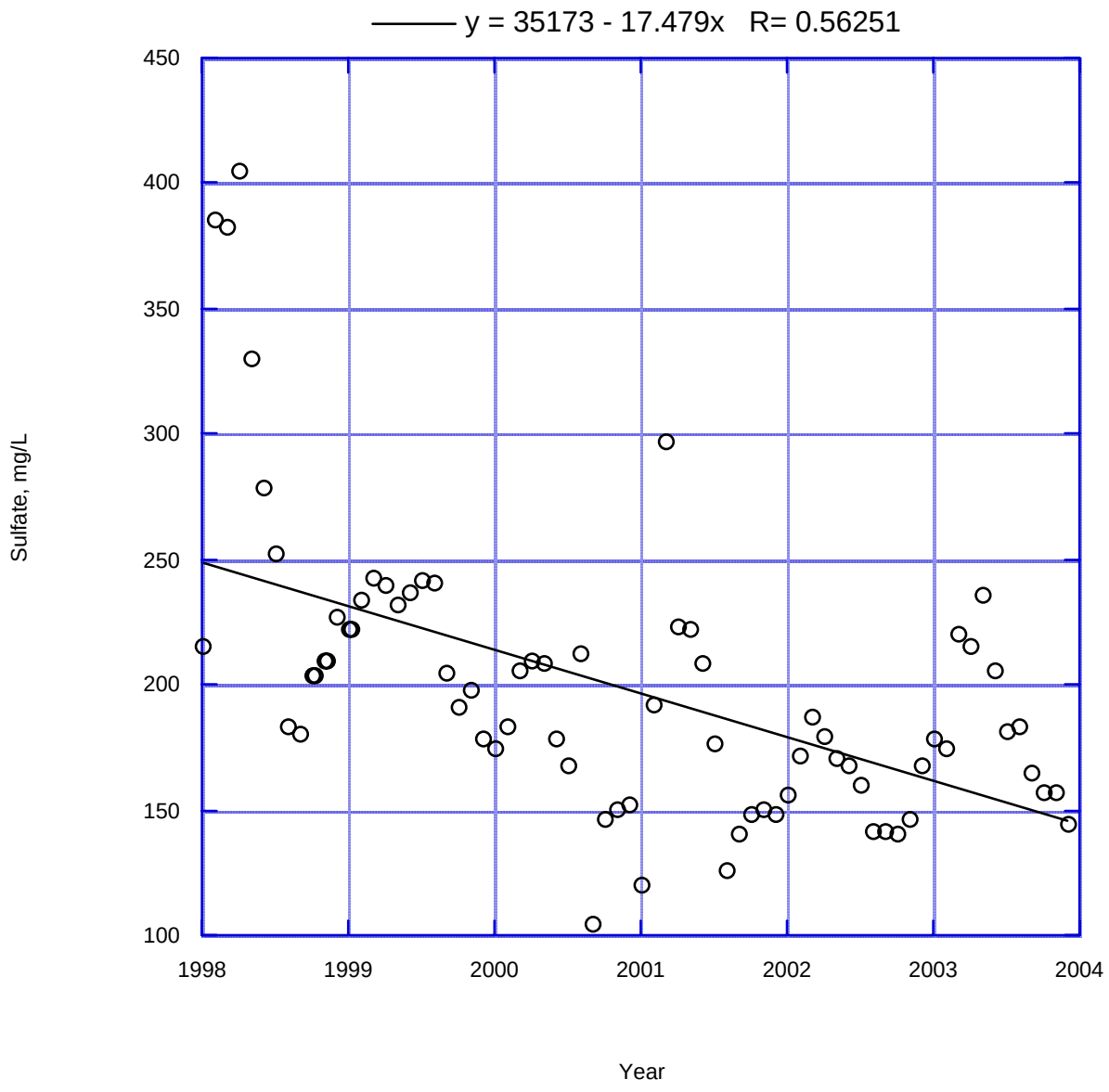


Figure 63. Simi Valley Effluent Sulfate vs. Time

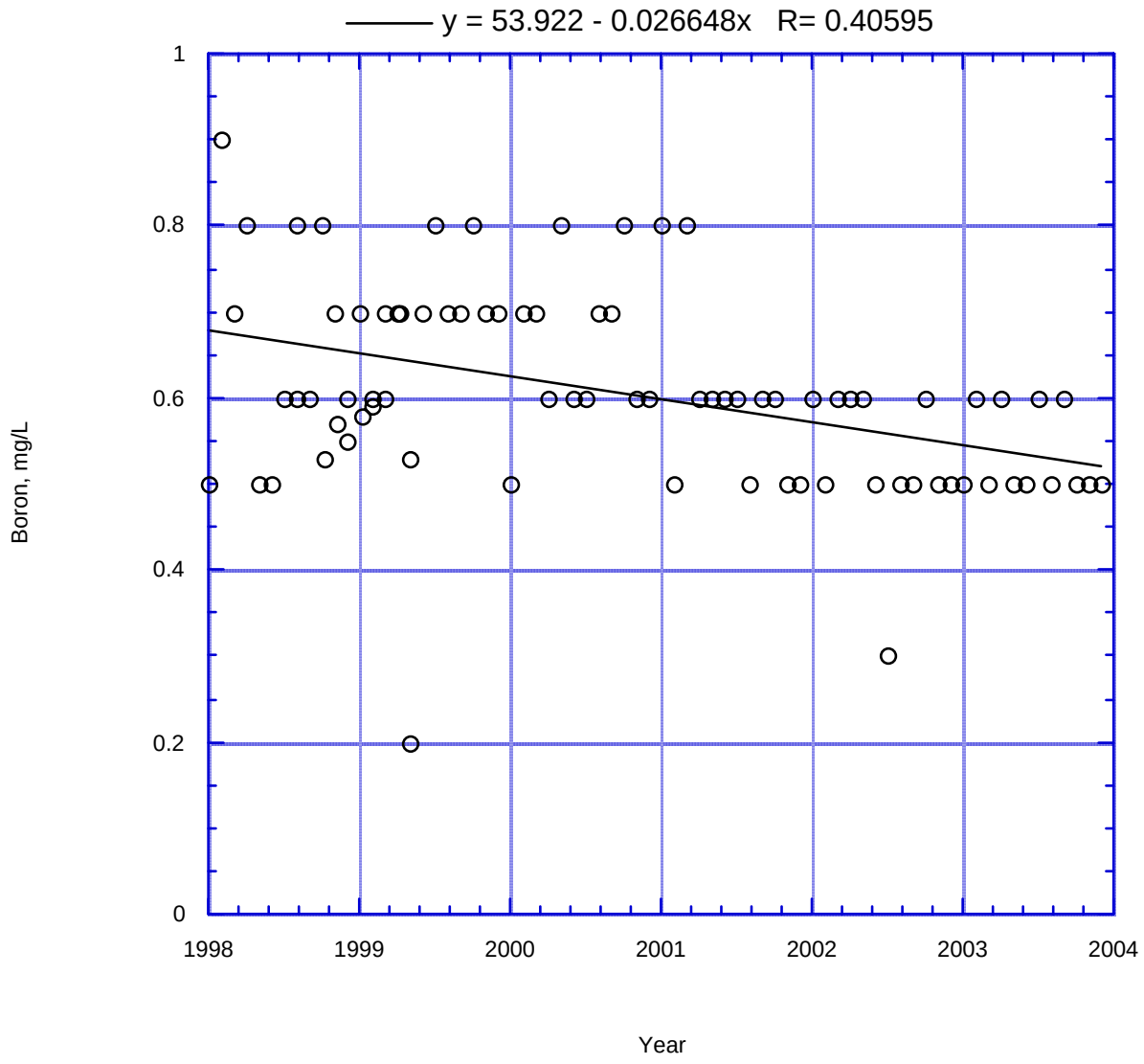


Figure 64. Simi Valley Effluent Boron vs. Time

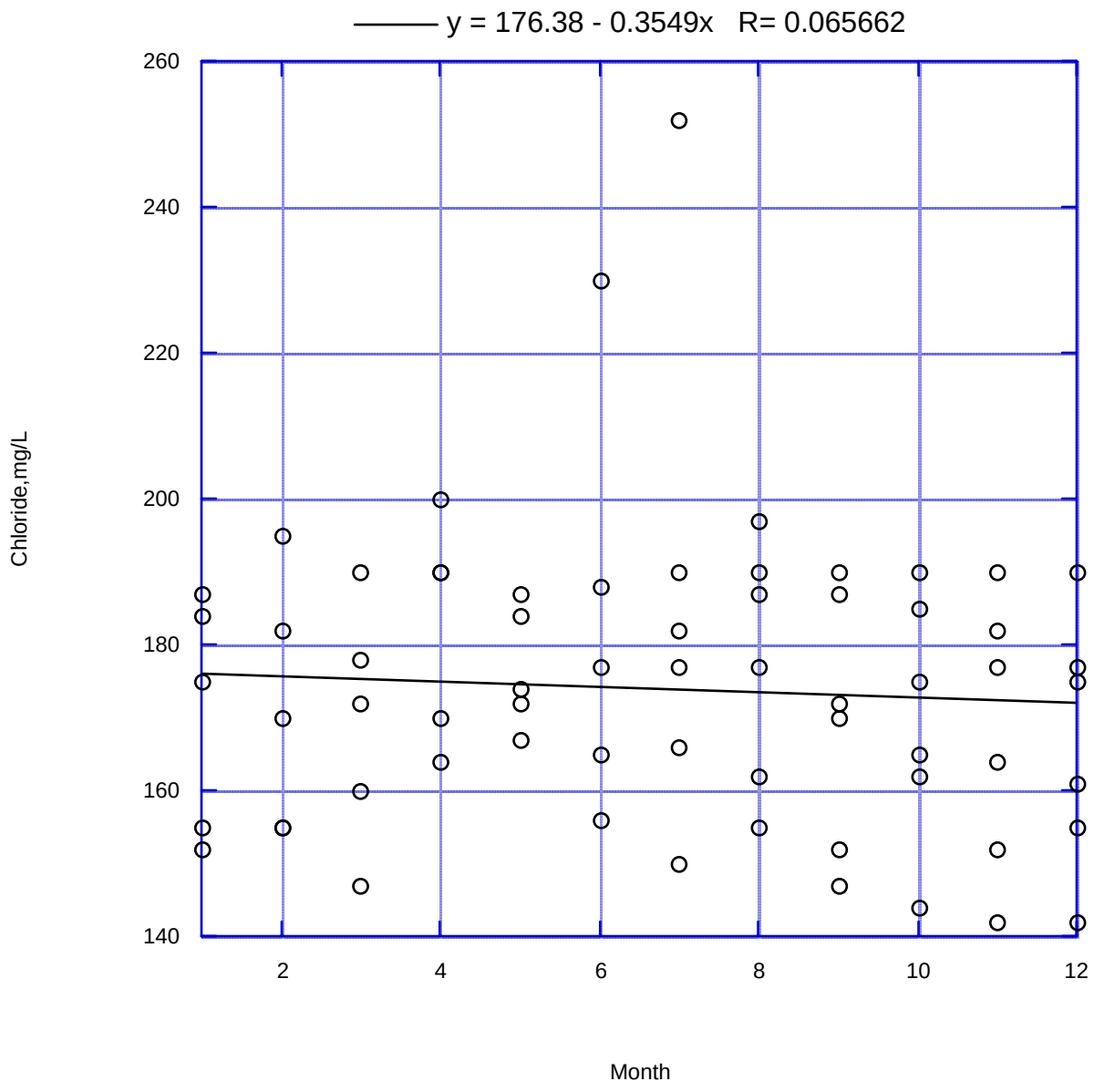


Figure 65. Camarillo Effluent Chloride v. Month

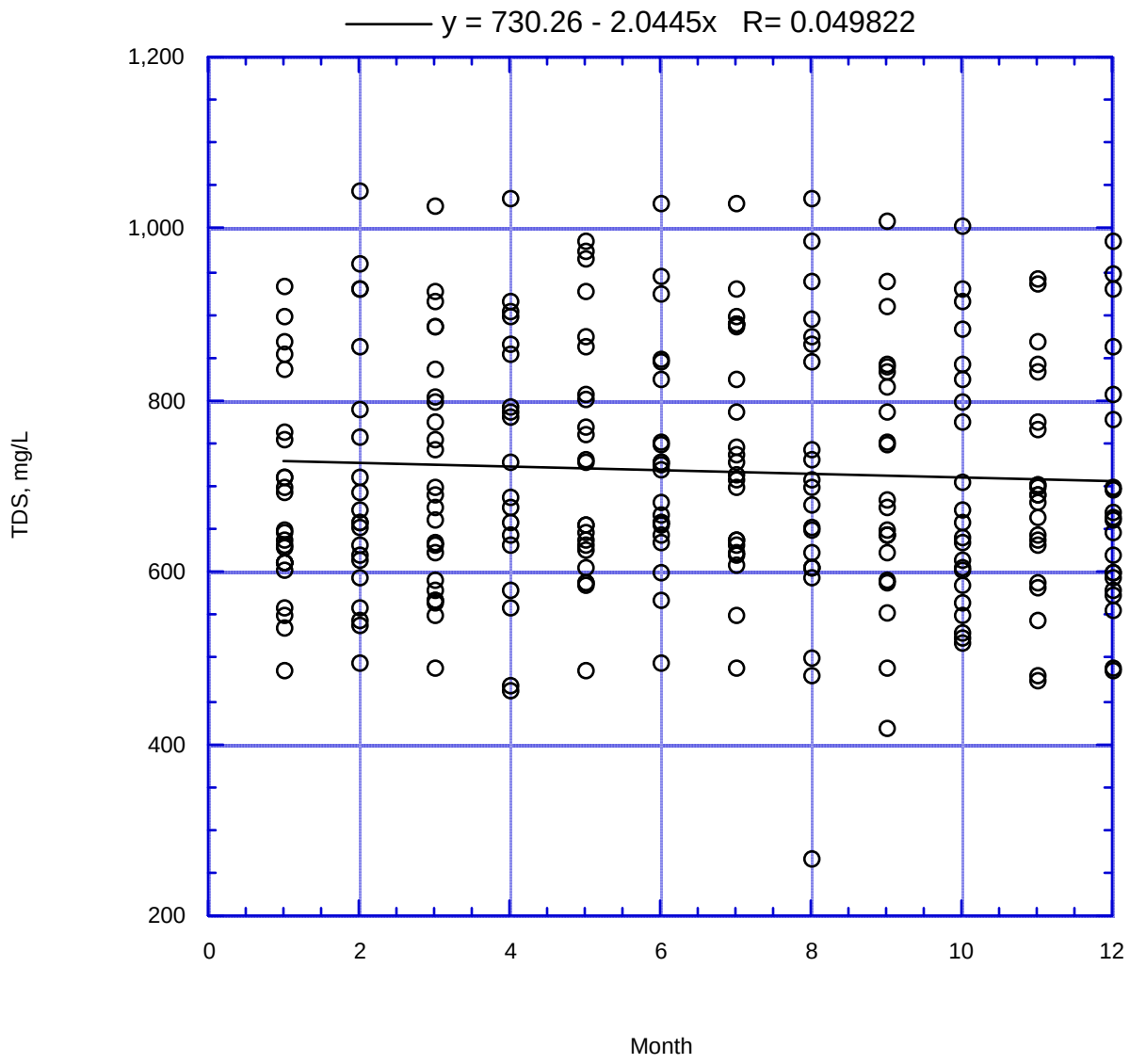


Figure 66. Camarillo Effluent TDS vs. Month

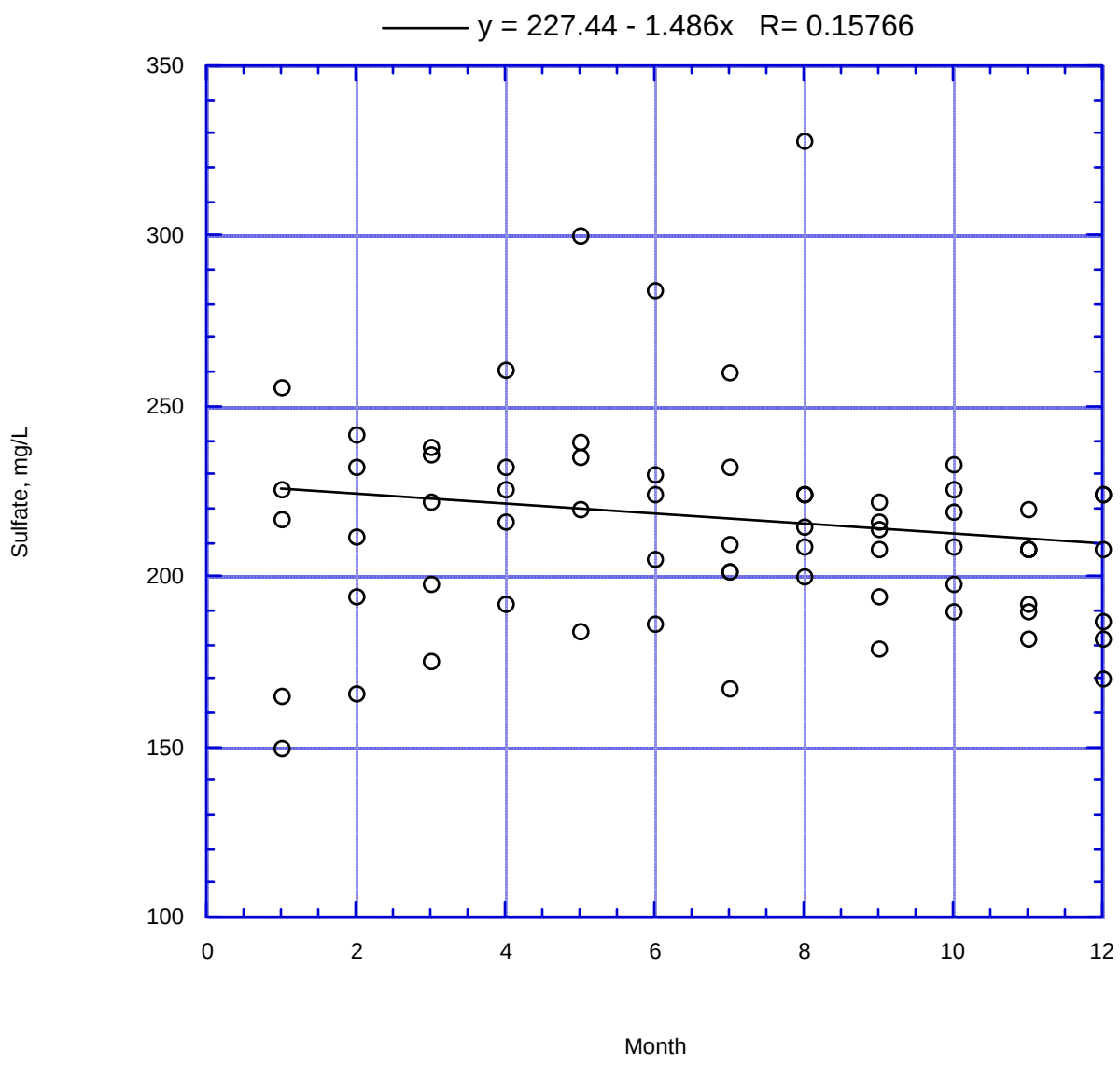


Figure 67. Camarillo Effluent Sulfate vs. Month

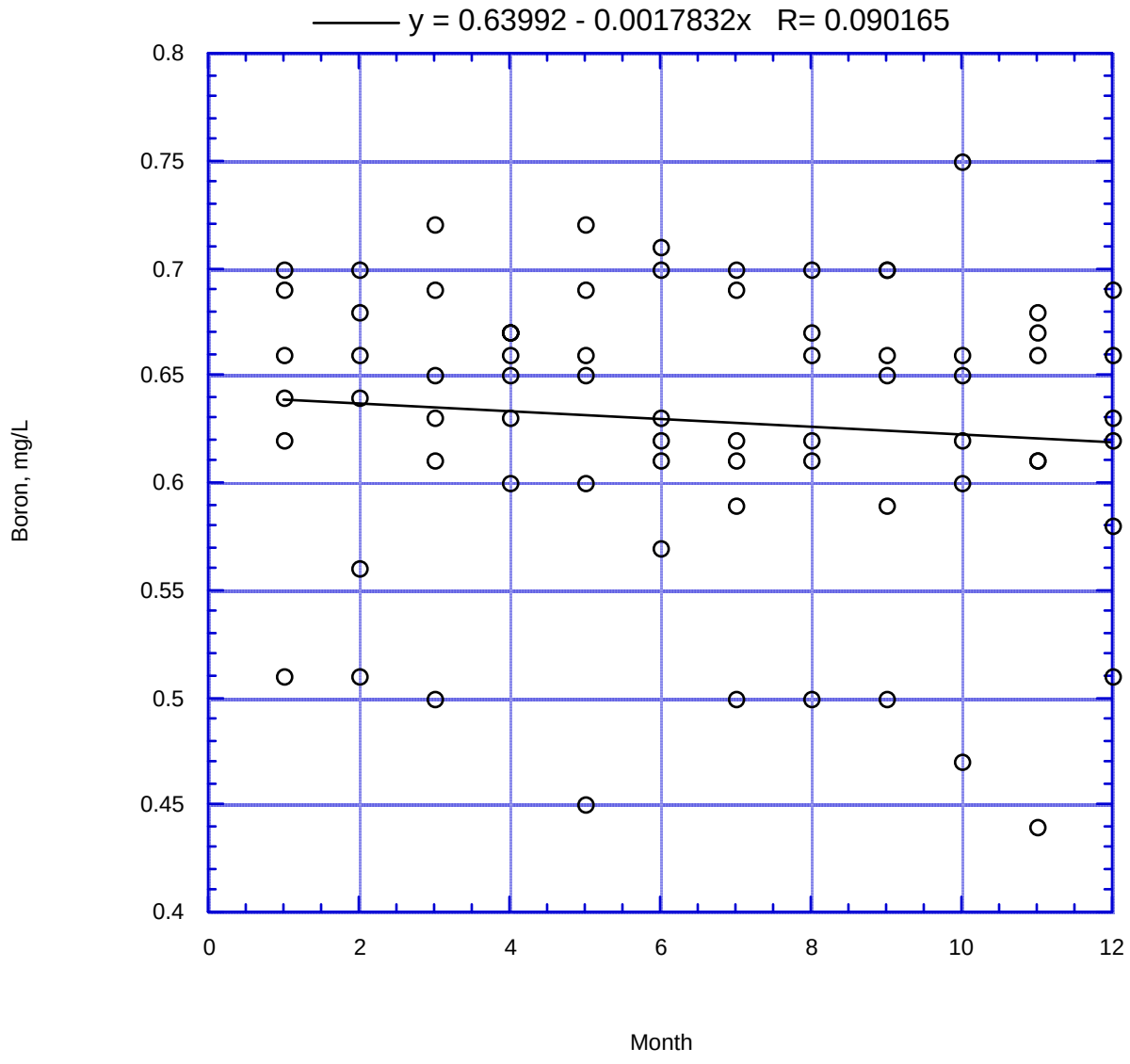


Figure 68. Camarillo Effluent Boron vs. Month

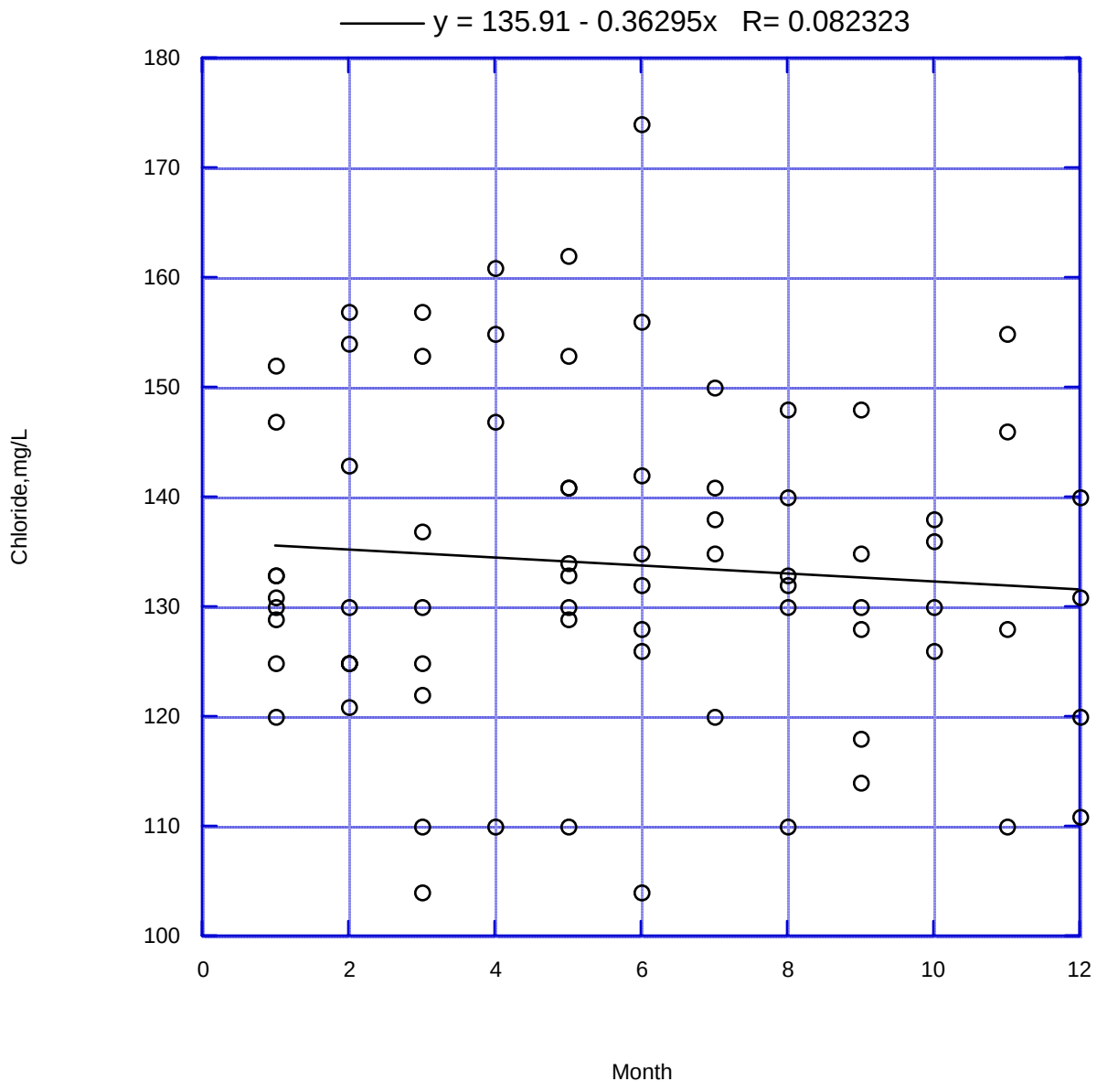


Figure 69. Hill Canyon Effluent Chloride vs. Month

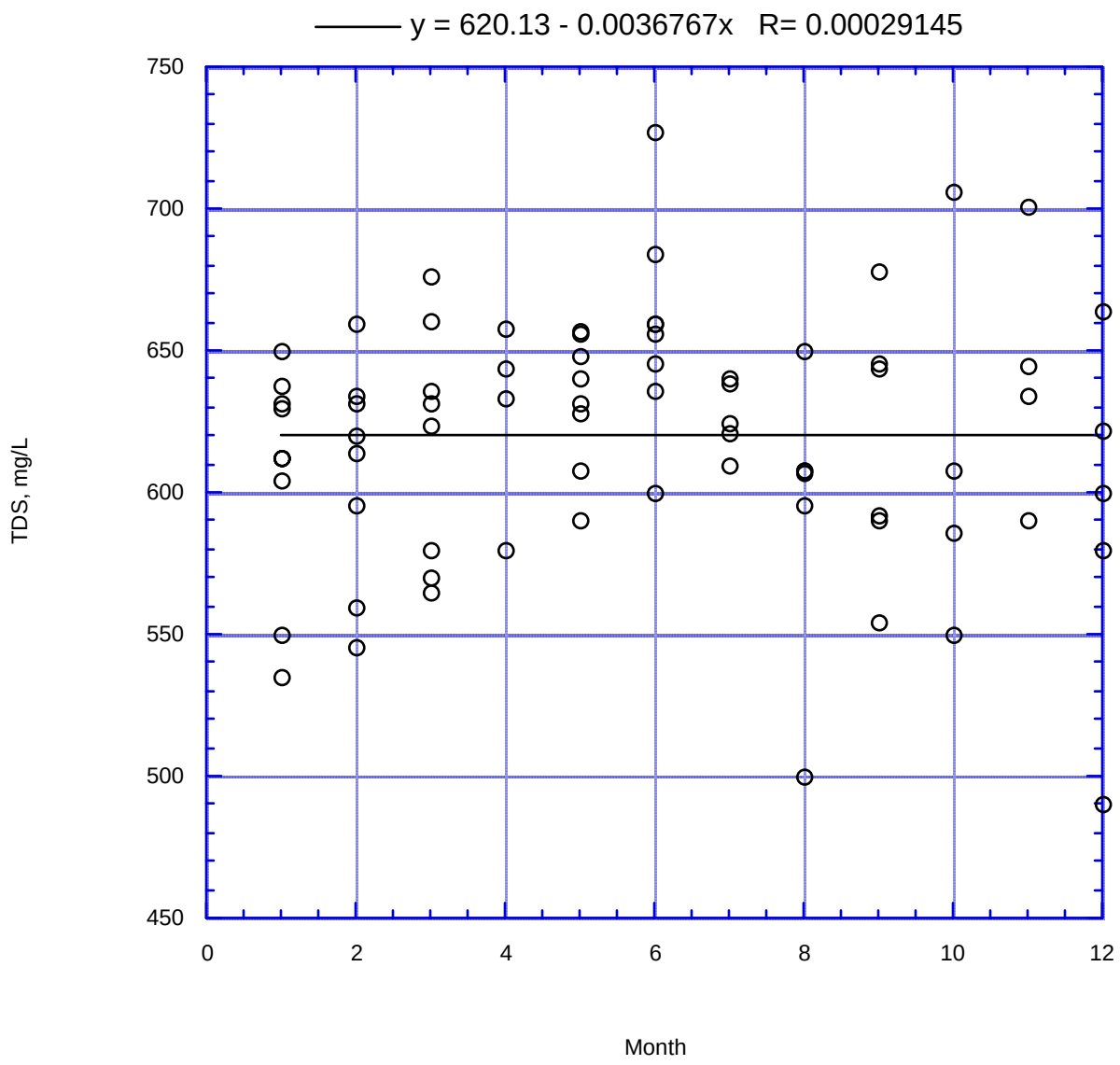


Figure 70. Hill Canyon Effluent TDS vs. Month

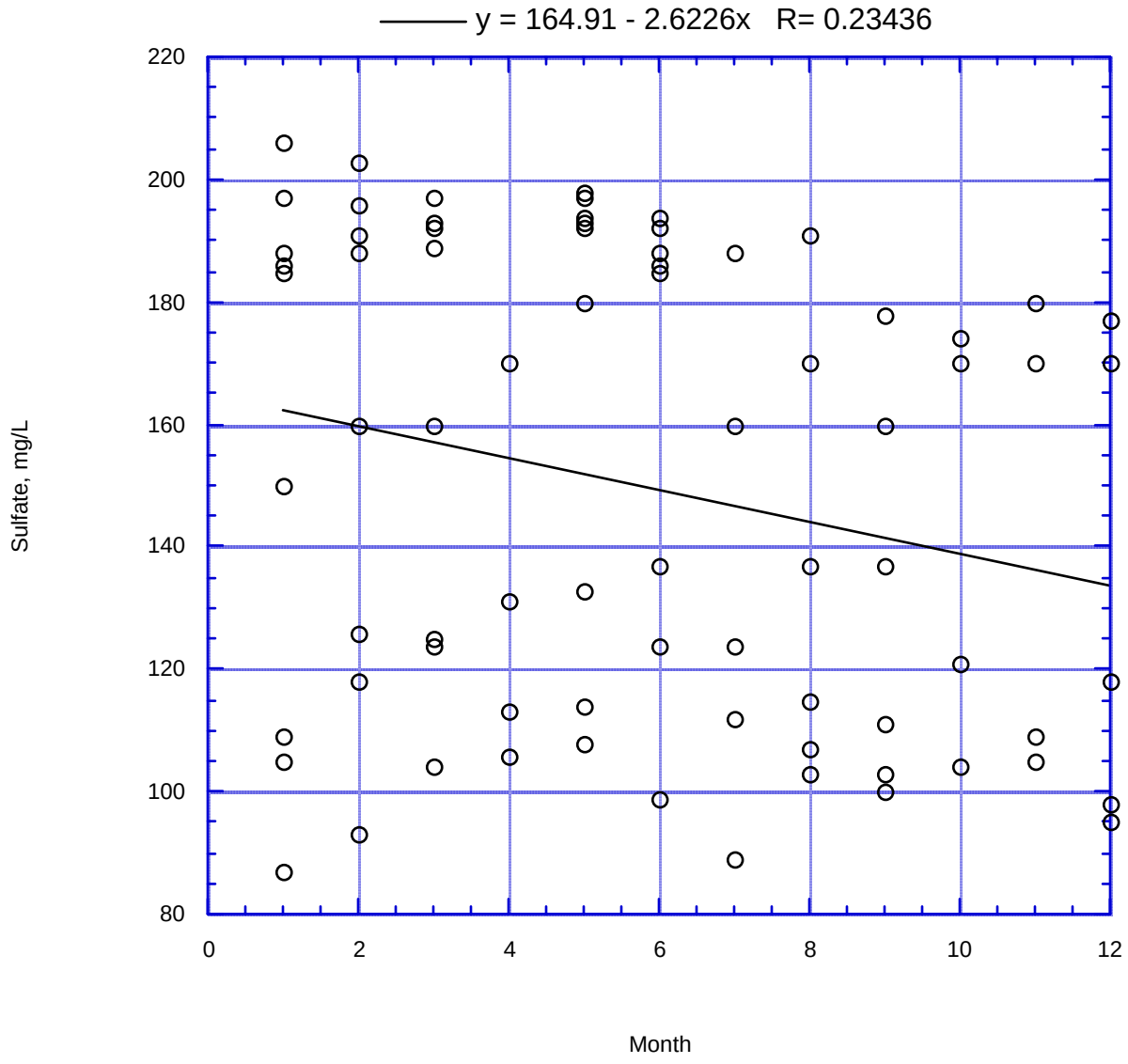


Figure 71. Hill Canyon Effluent Sulfate vs. Month

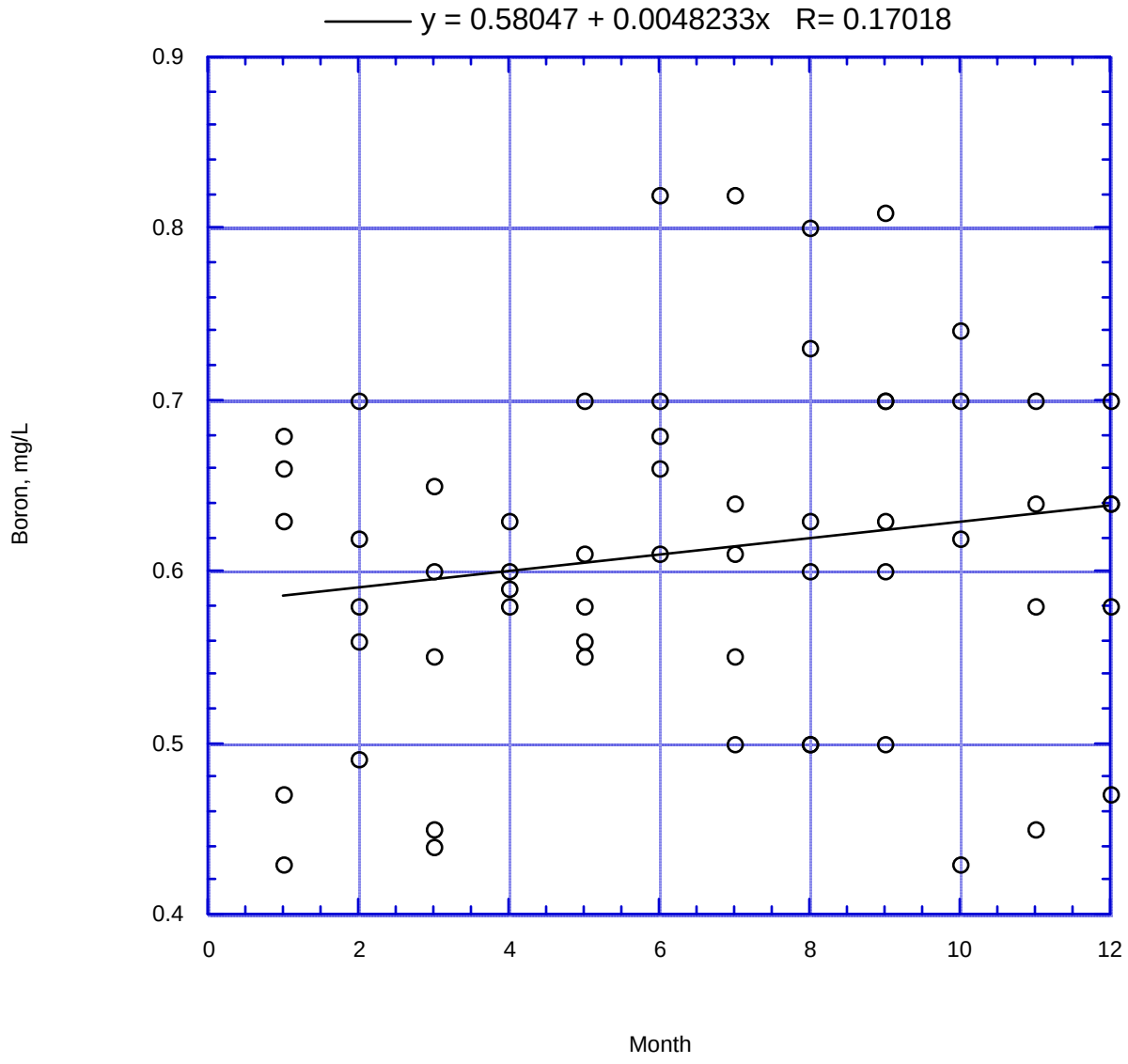


Figure 72. Hill Canyon Effluent Boron vs. Month

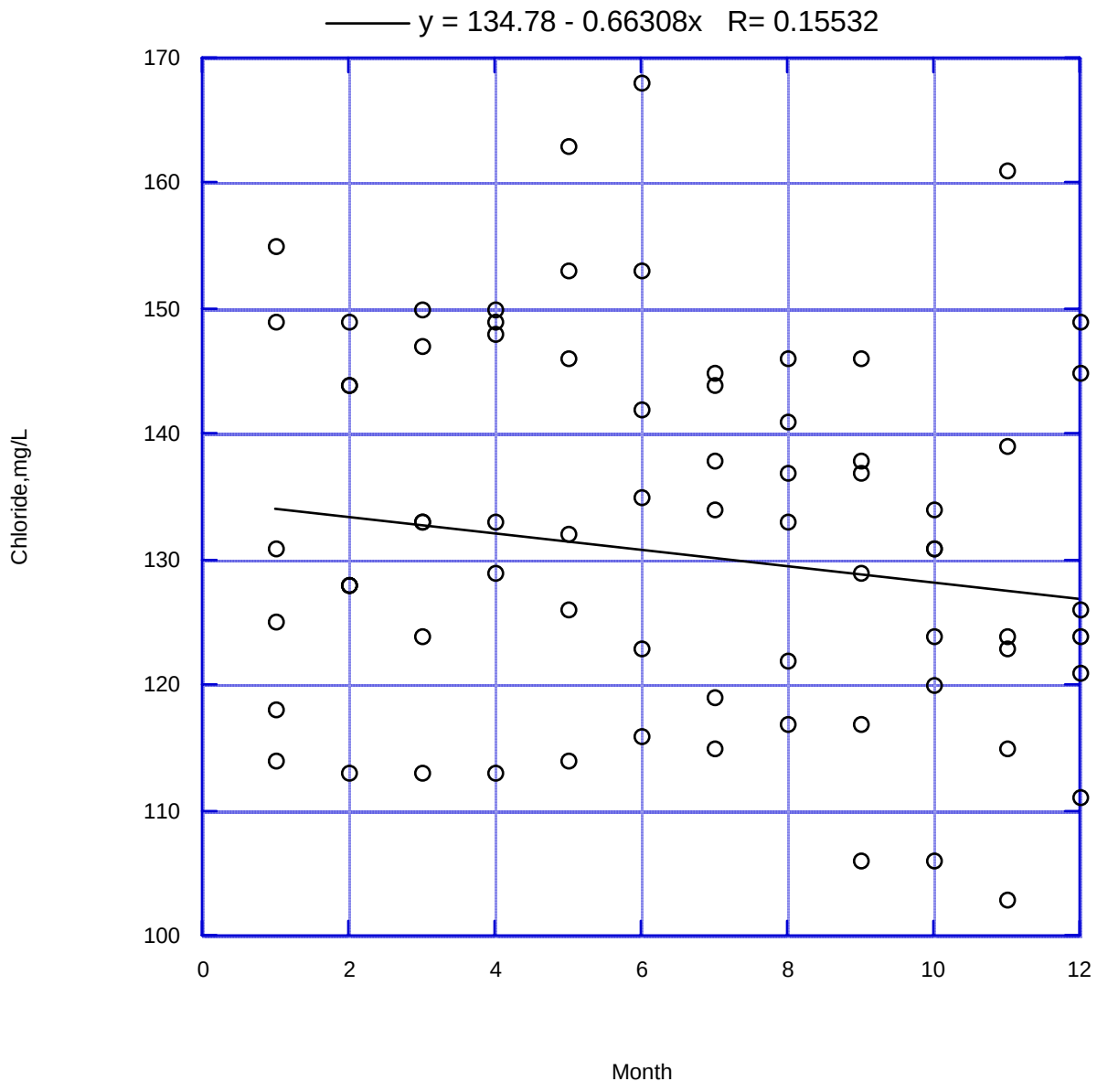


Figure 73. Simi Valley Effluent Chloride vs. Month

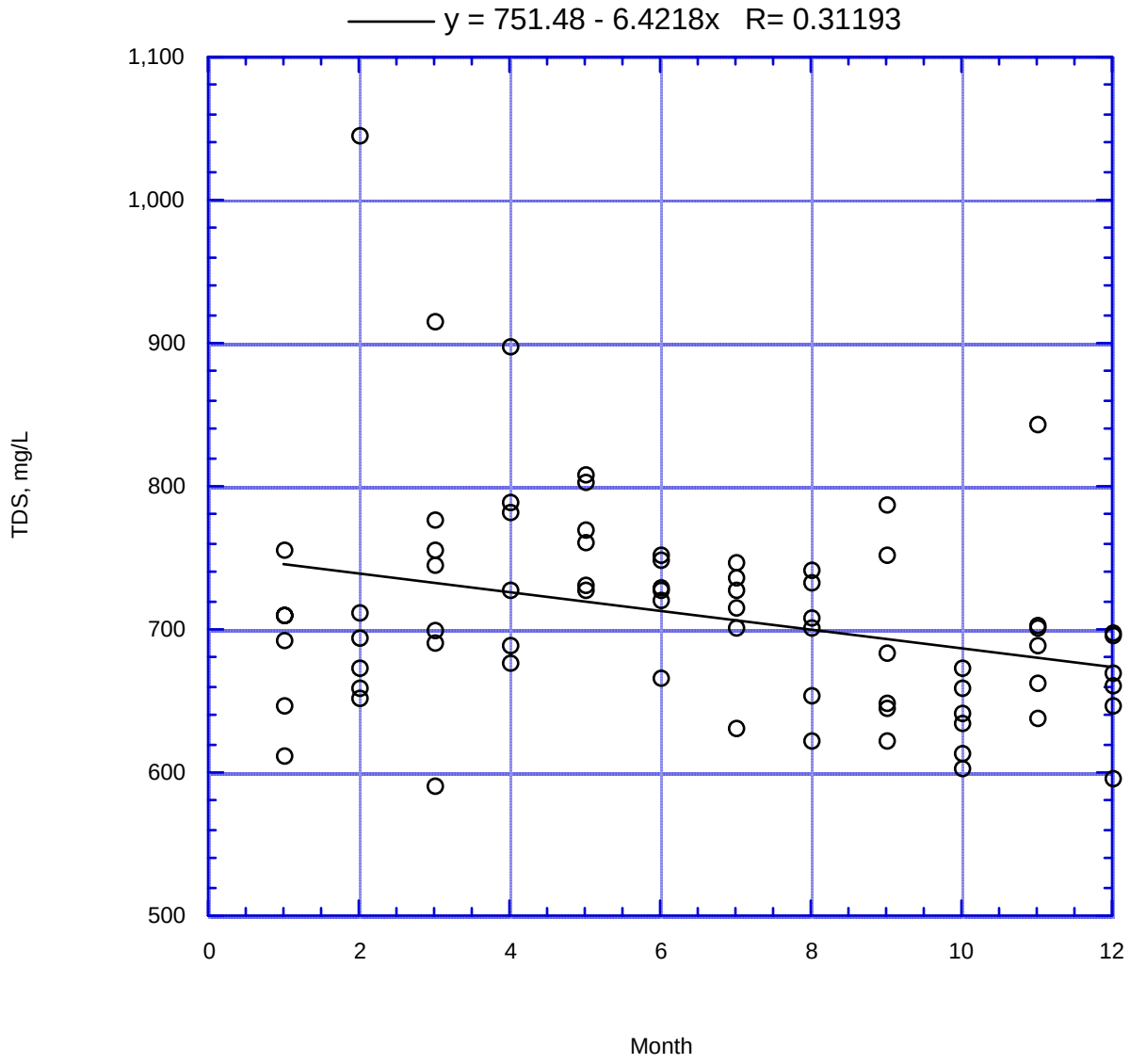


Figure 74. Simi Valley Effluent TDS vs. Month

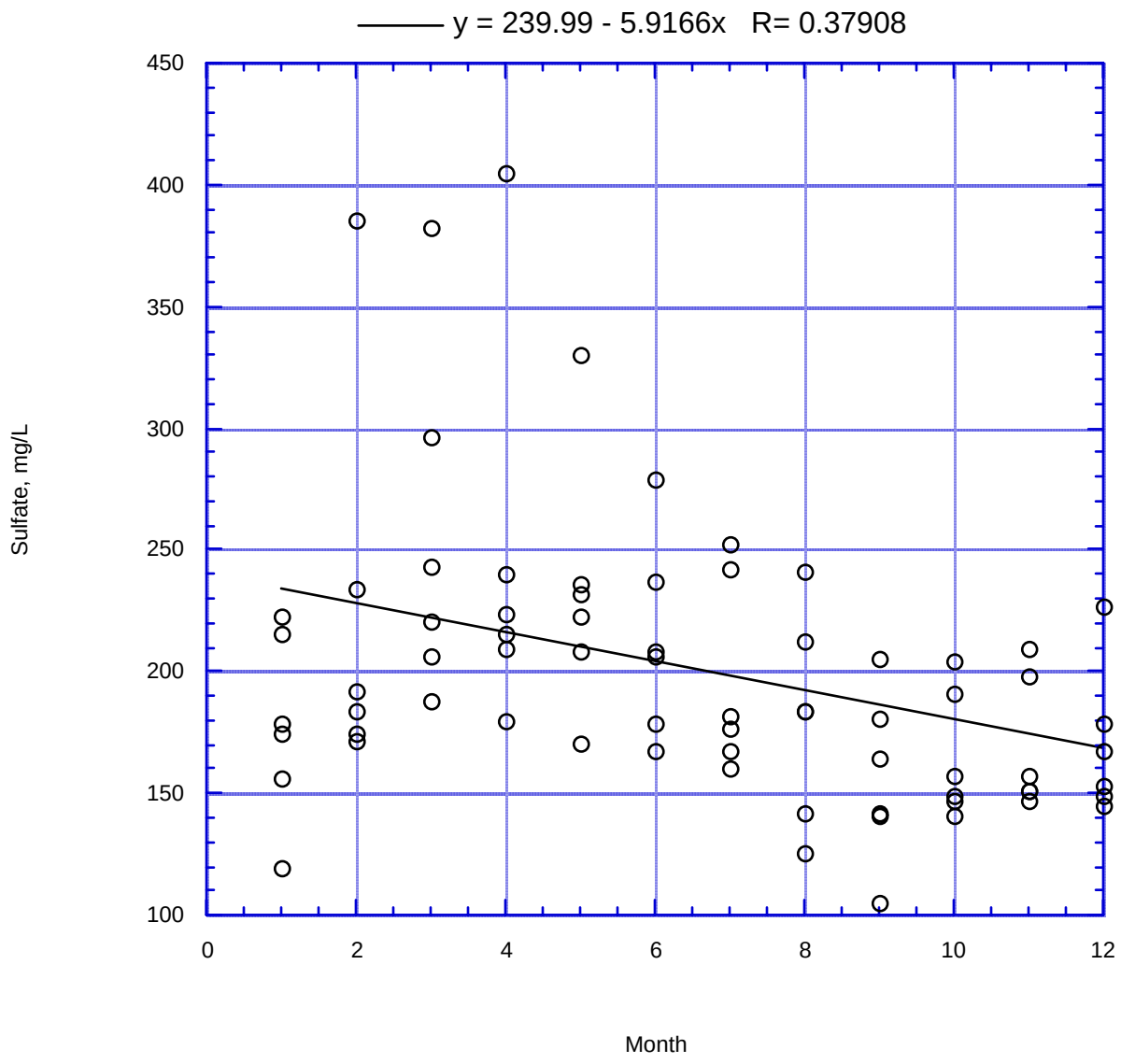


Figure 75. Simi Valley Effluent Sulfate vs. Month

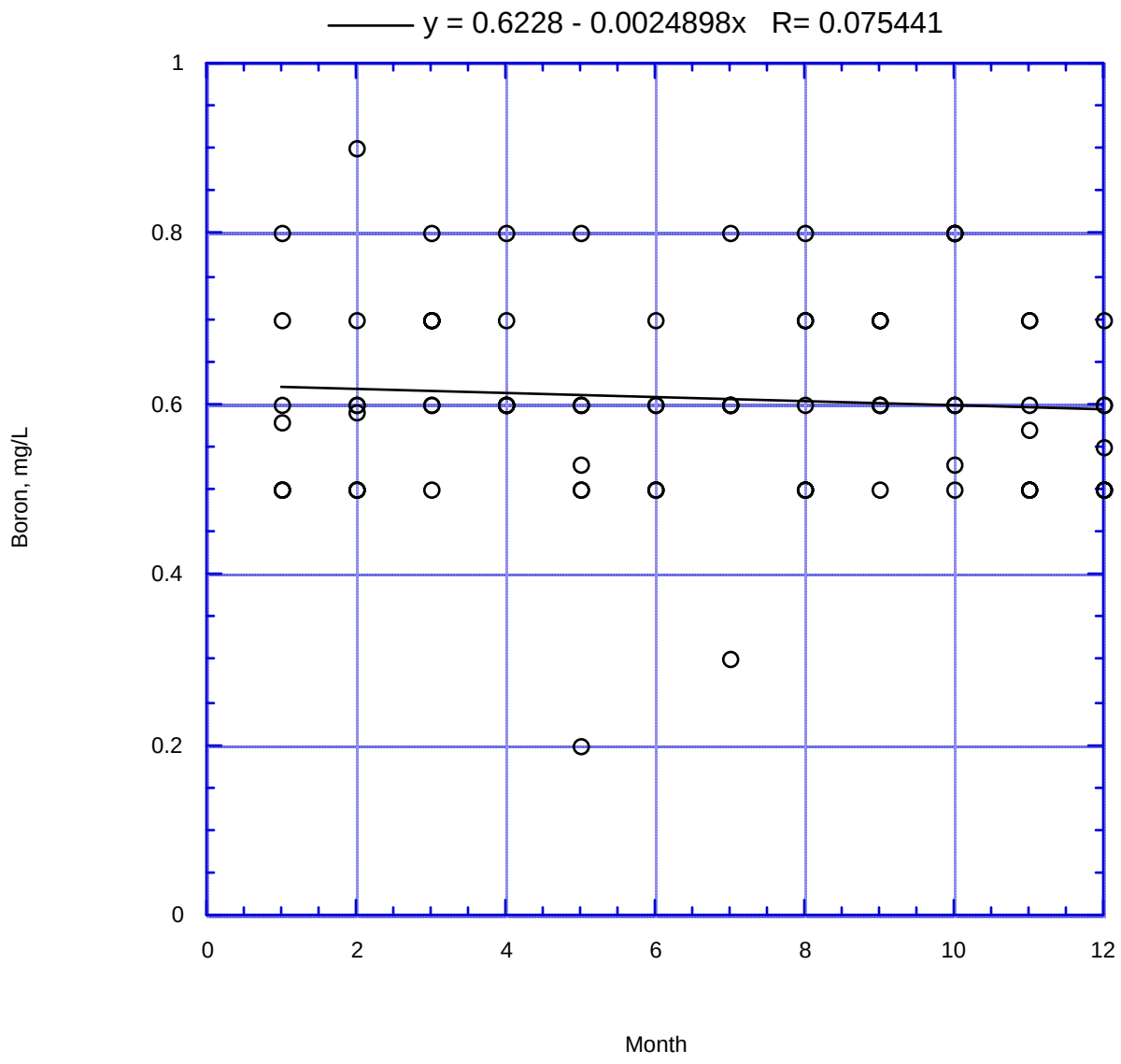


Figure 76. Simi Valley Effluent Boron vs. Month

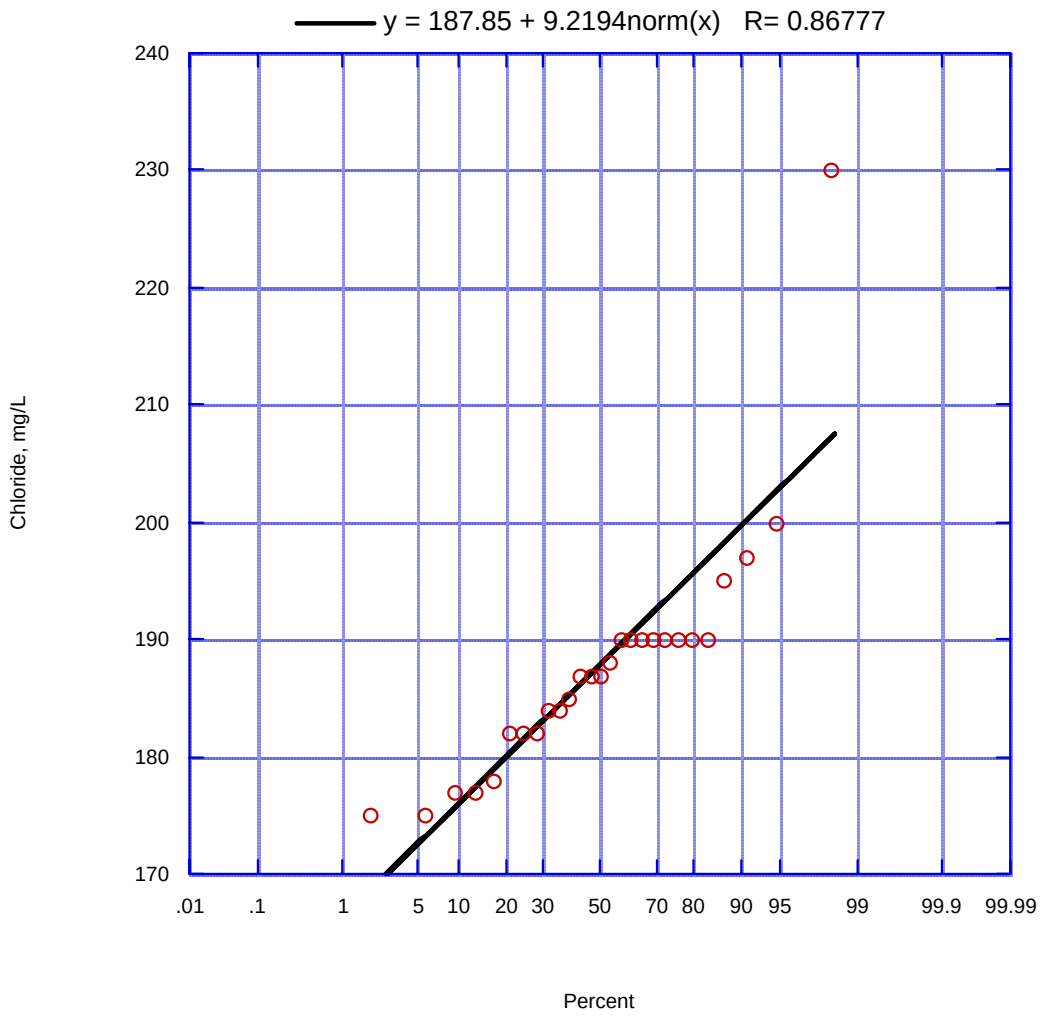


Figure 77. Camarillo Effluent Chloride Frequency Distribution (10/01-9/03)

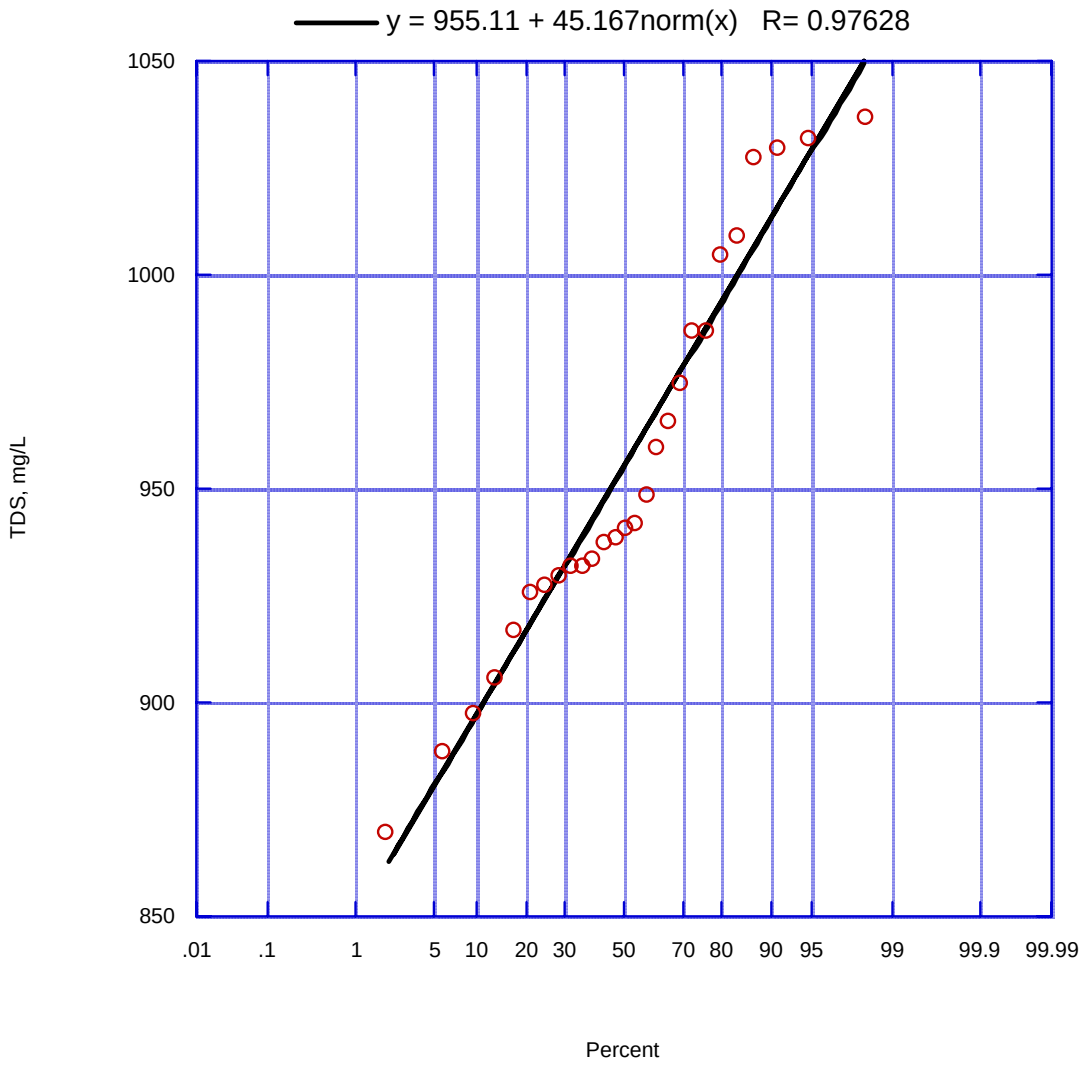


Figure 78. Camarillo Effluent TDS Frequency Distribution (10/01-12/03)

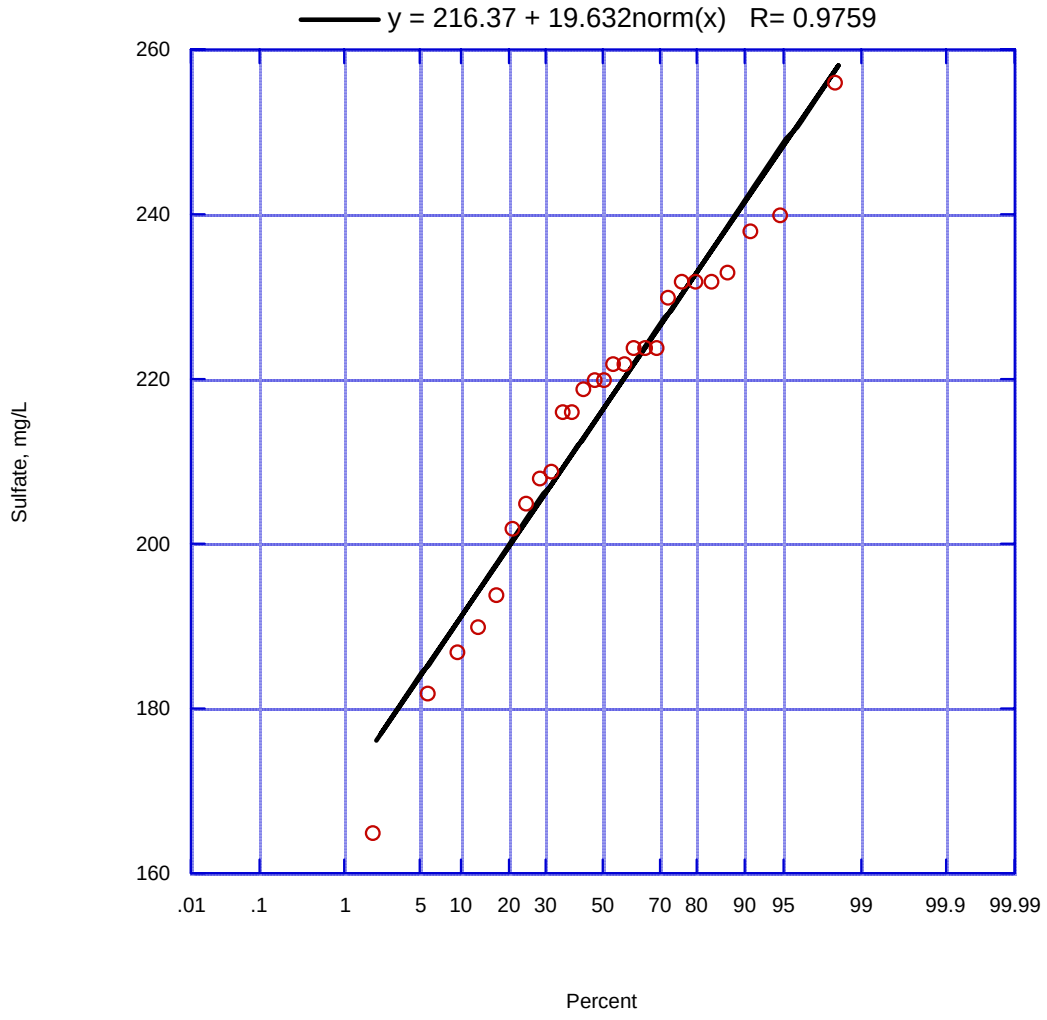


Figure 79. Camarillo Effluent Sulfate Frequency Distribution (10/01-12/03)

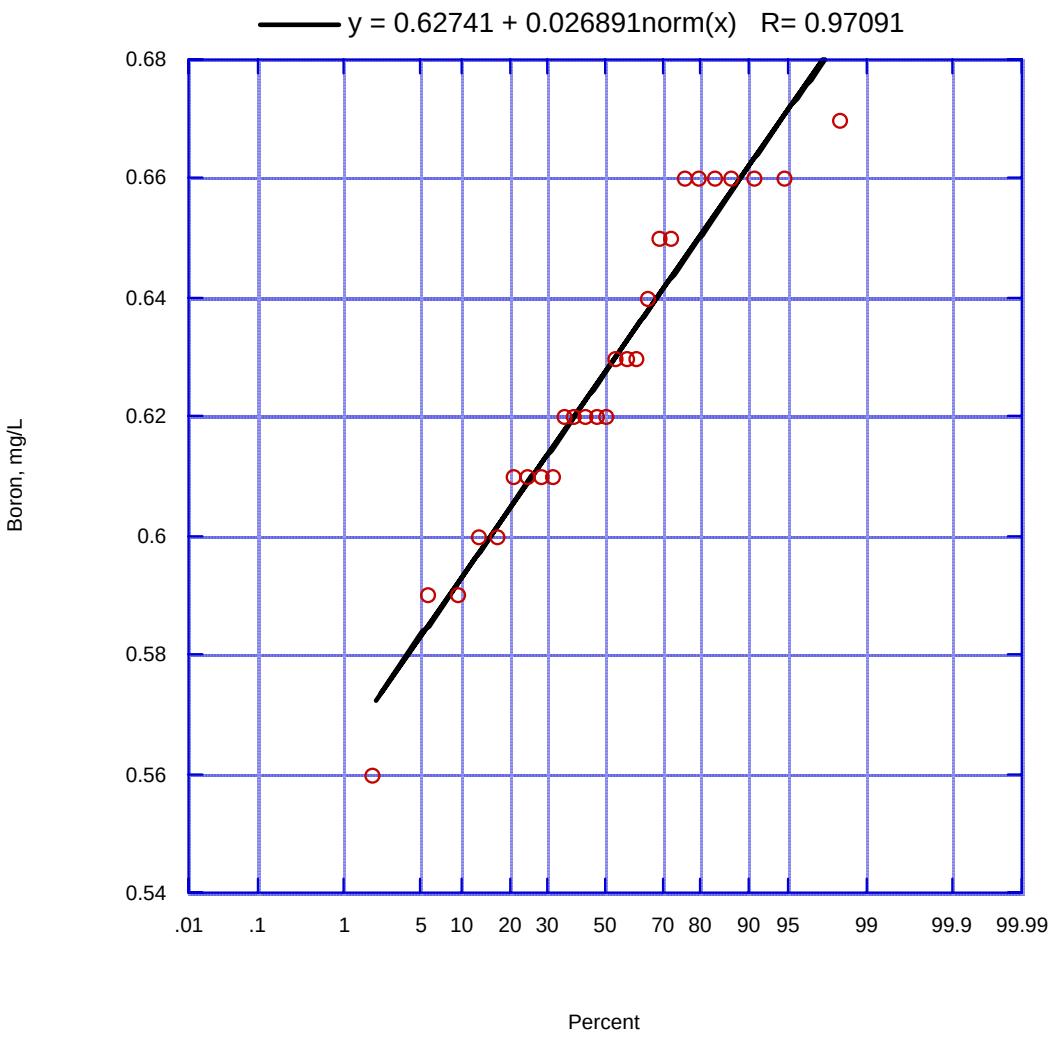


Figure 80. Camarillo Effluent Boron Frequency Distribution (10/01-12/03)

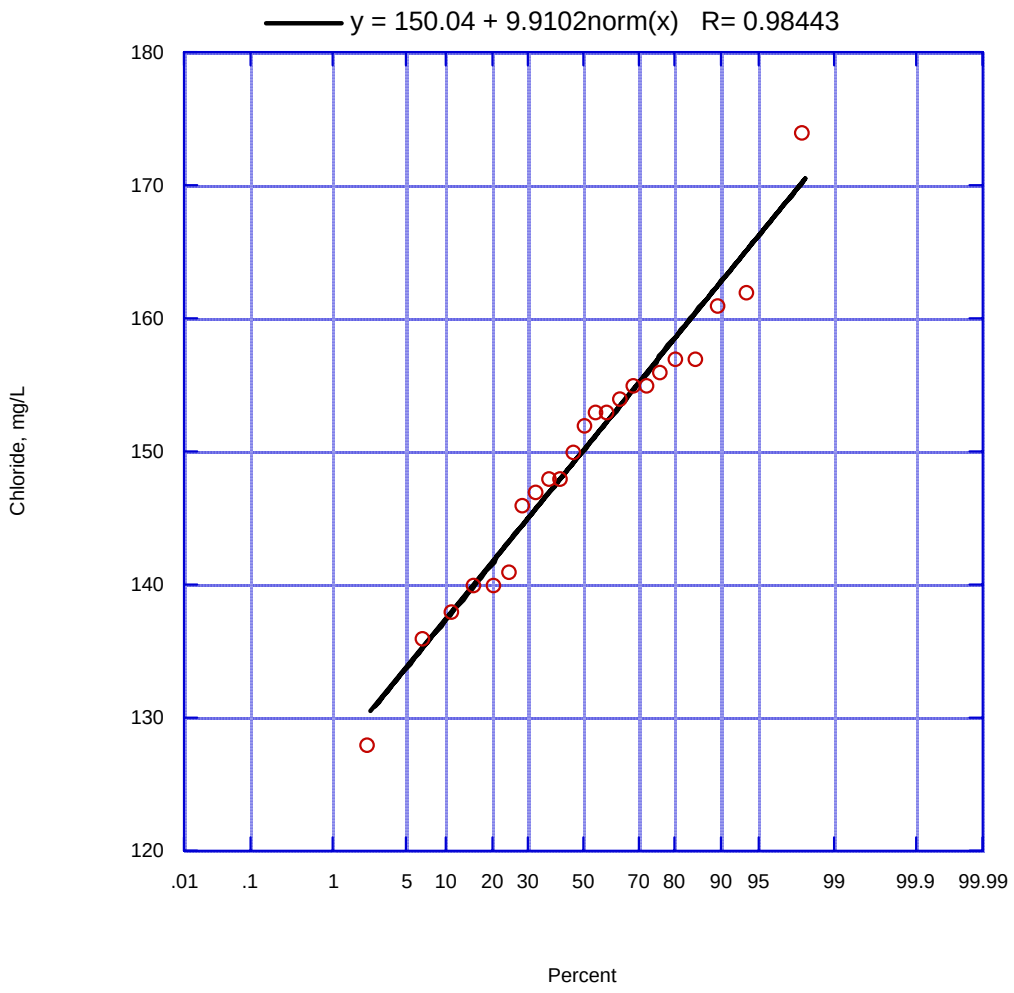


Figure 81. Hill Canyon Effluent Chloride Frequency Distribution (10/01-9/03)

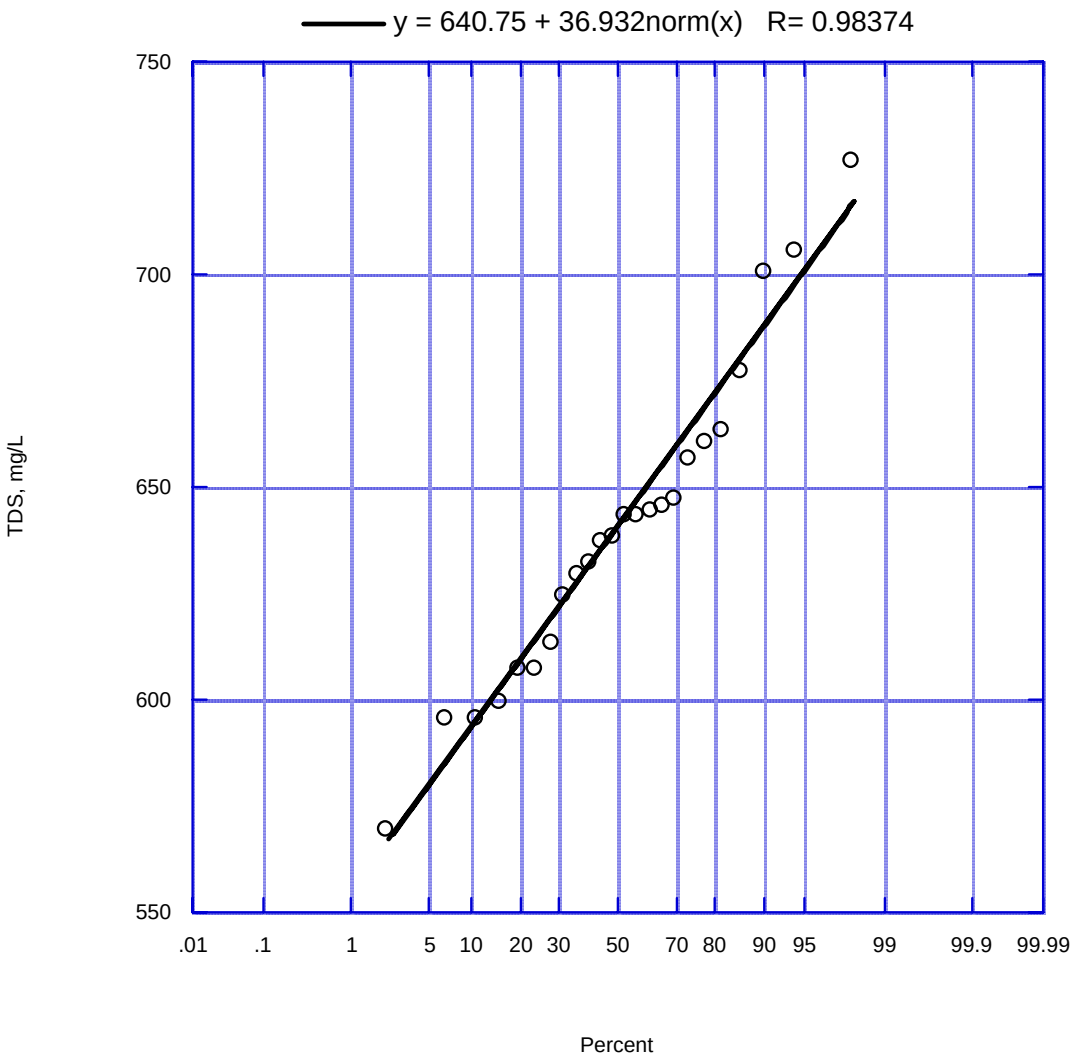


Figure 82. Hill Canyon Effluent TDS Frequency Distribution(10/01-9/03)

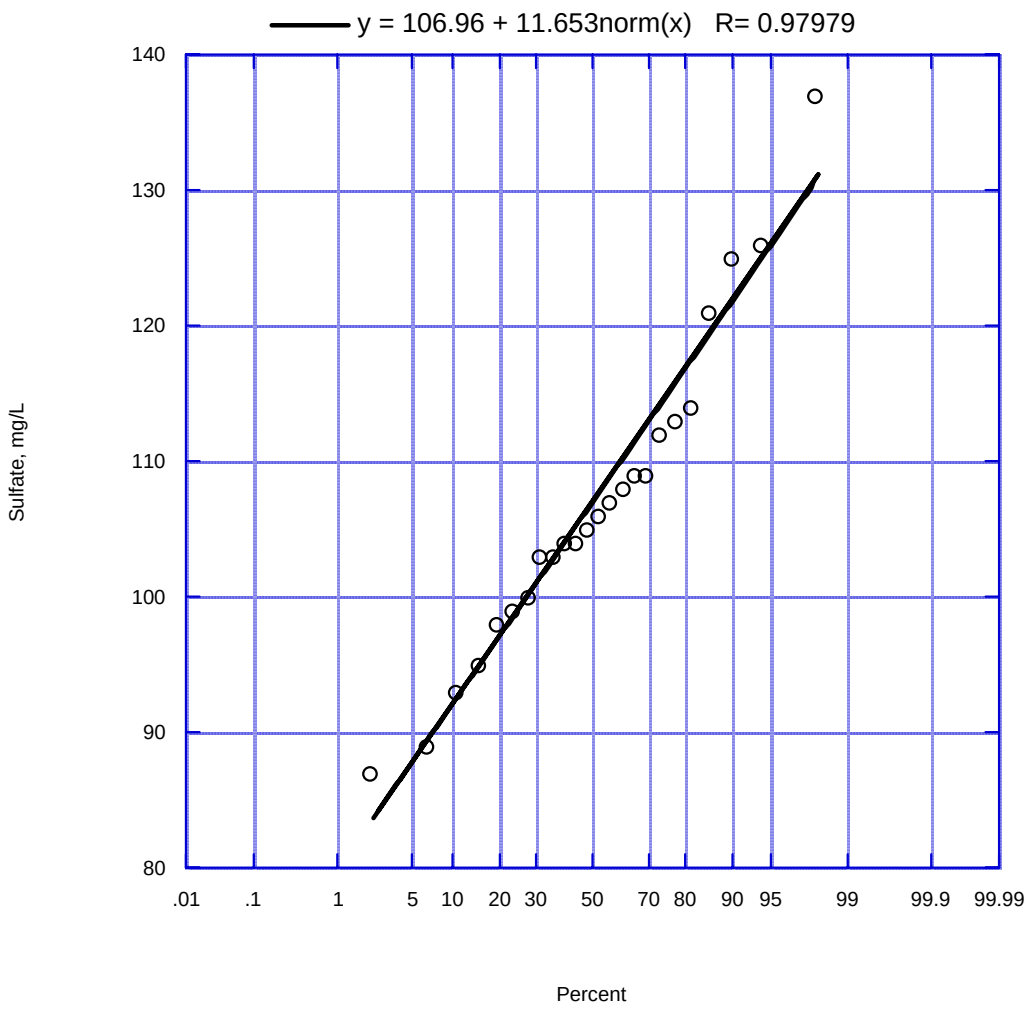


Figure 83. Hill Canyon Effluent Sulfate Frequency Distribution (10/01-9/03)

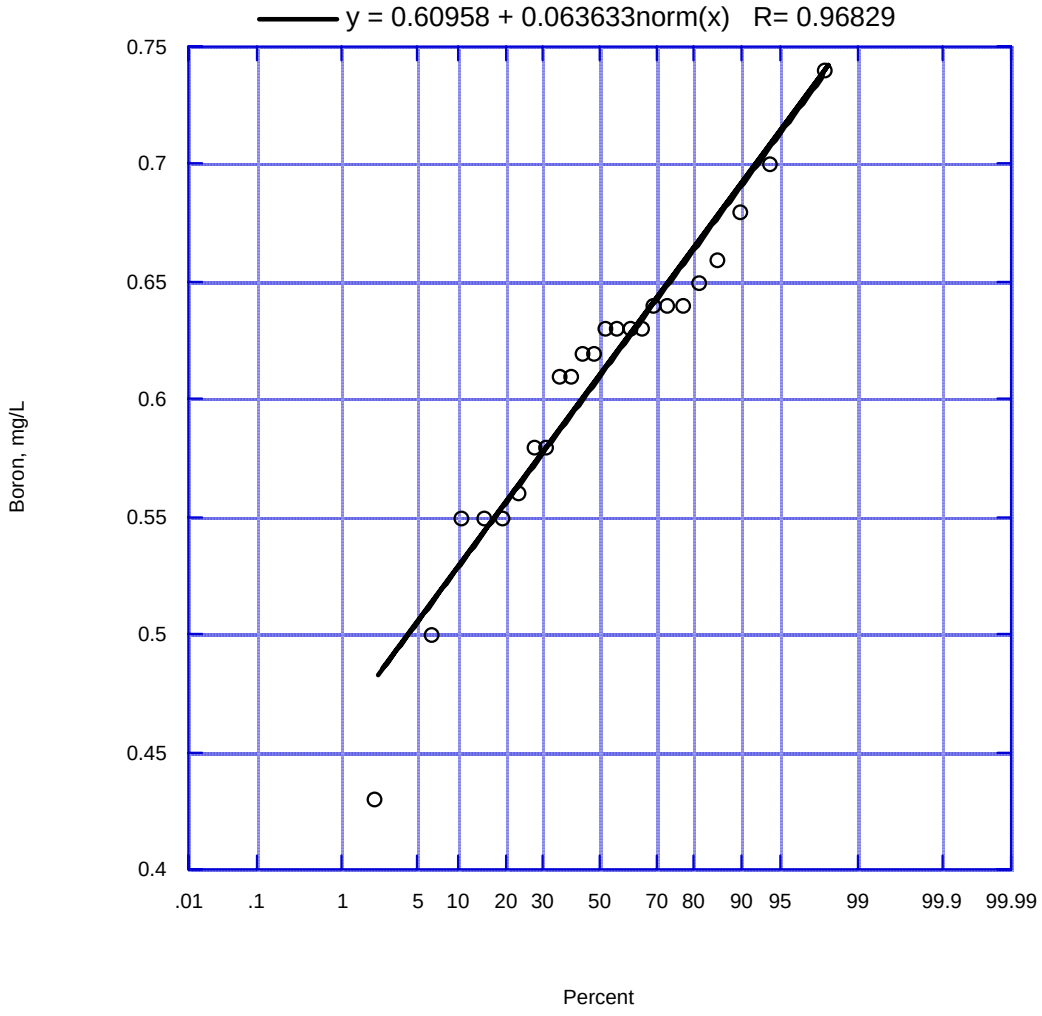


Figure 84. Hill Canyon Effluent Boron Frequency Distribution (10/01-9/03)

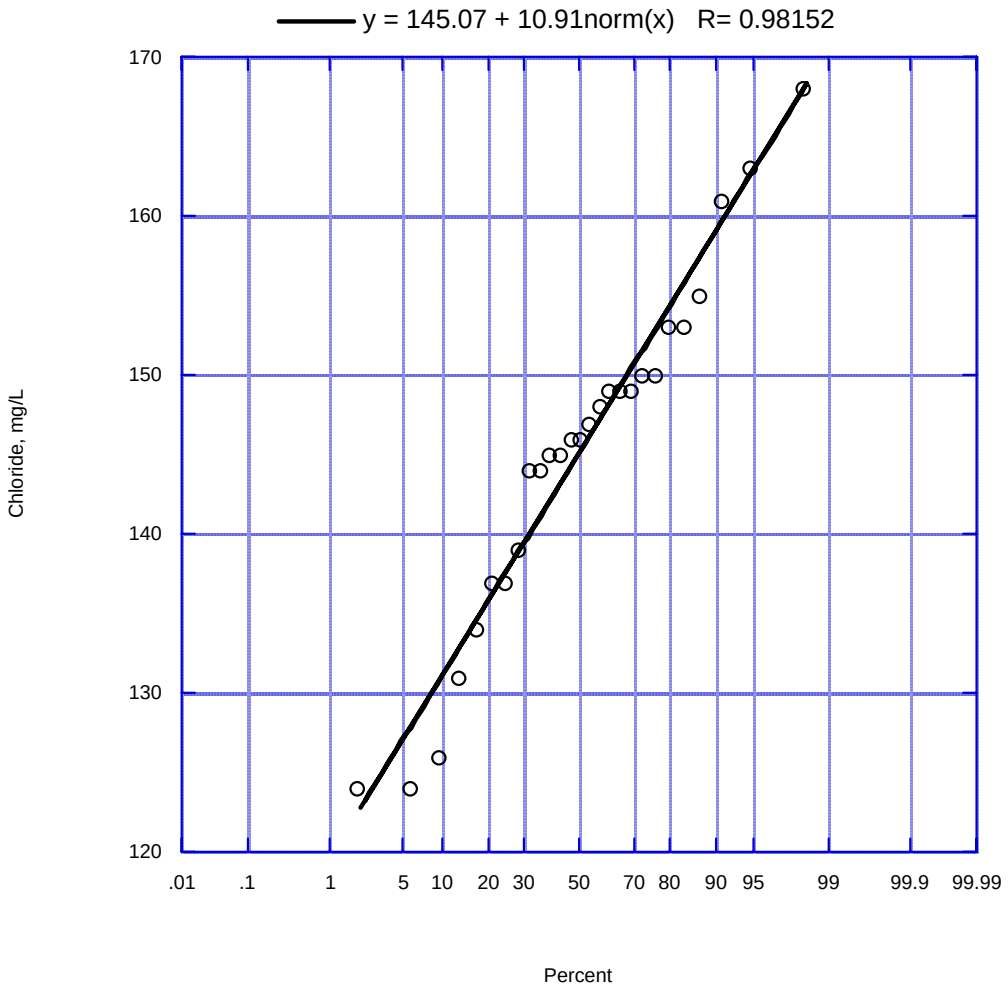


Figure 85. Simi Valley Effluent Chloride Frequency Distribution (10/01-12/03)

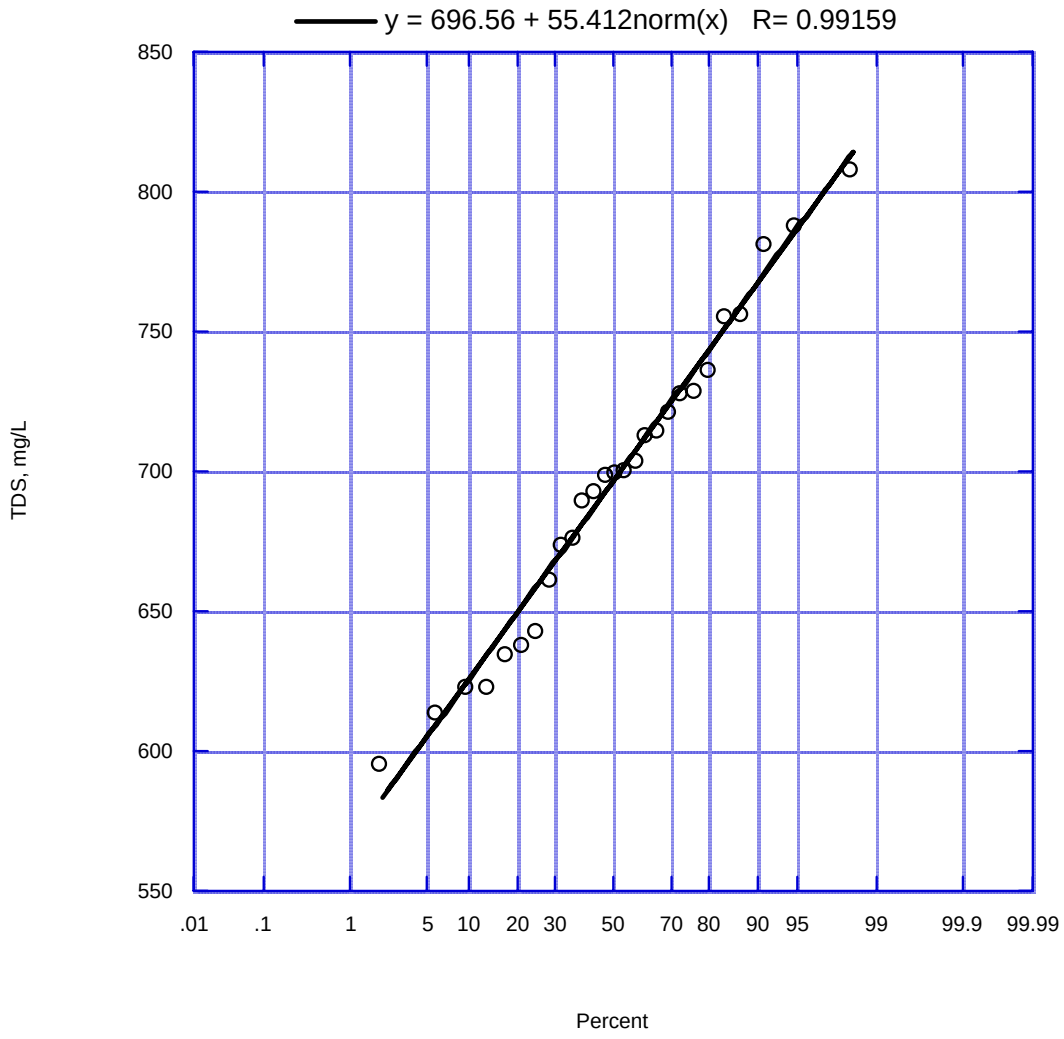


Figure 86. Simi Valley Effluent TDS Frequency Distribution (10/01-12/03)

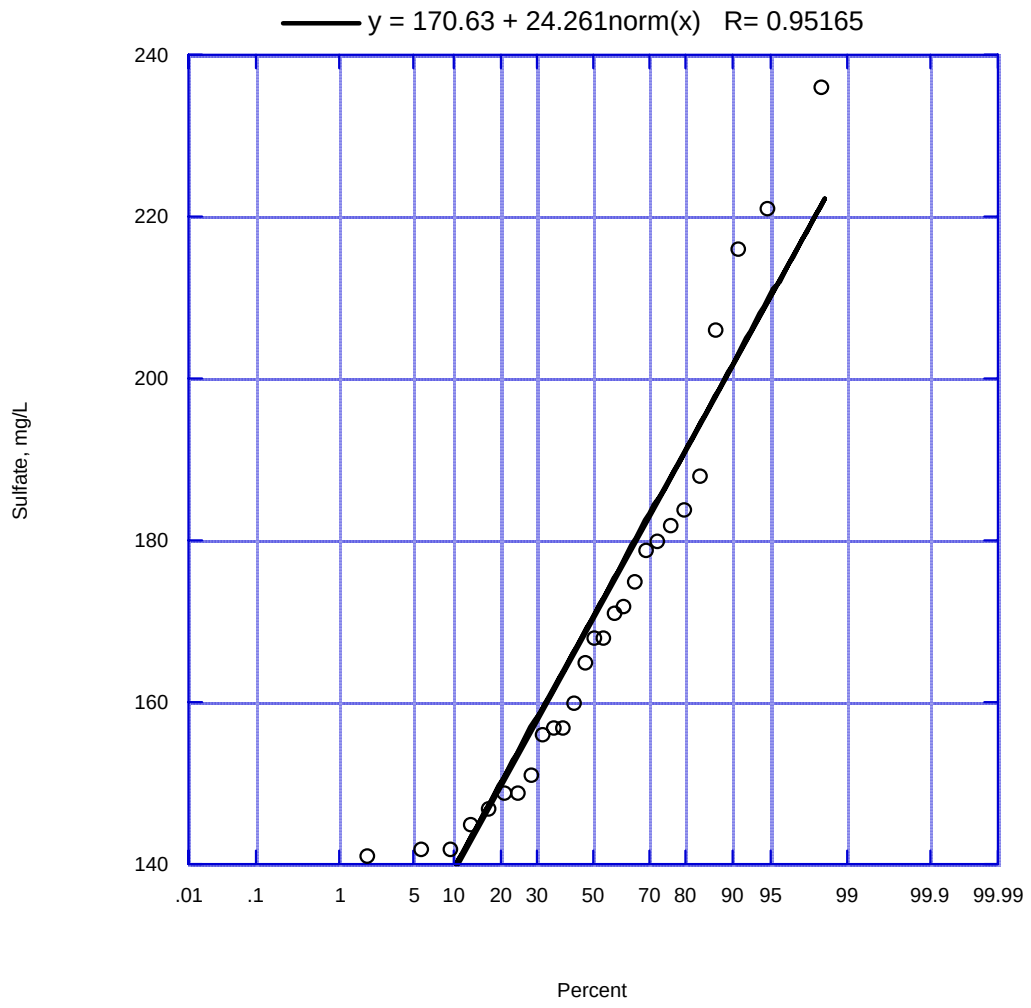


Figure 87. Simi Valley Effluent Sulfate Frequency Distribution (10/01-12/03)

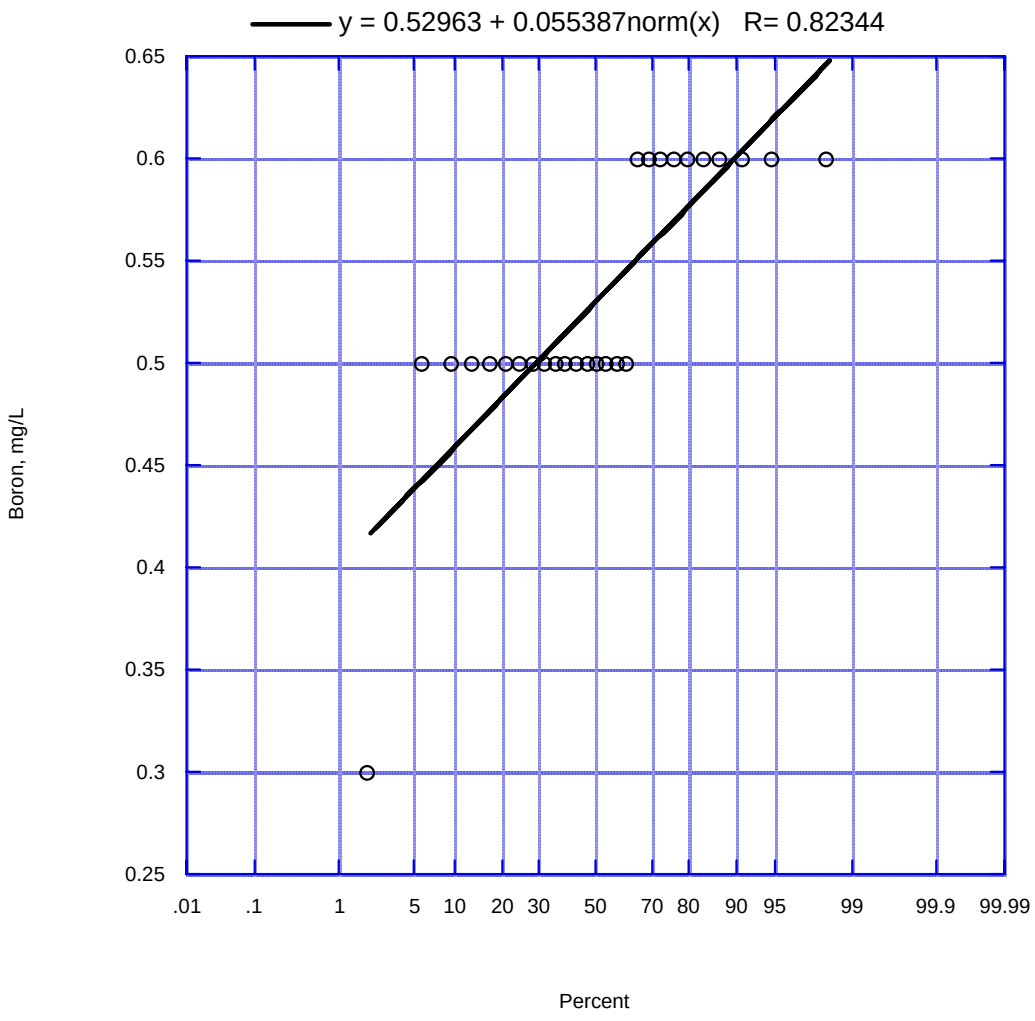


Figure 88. Simi Valley Effluent Boron Frequency Distribution (10/01-12/03)

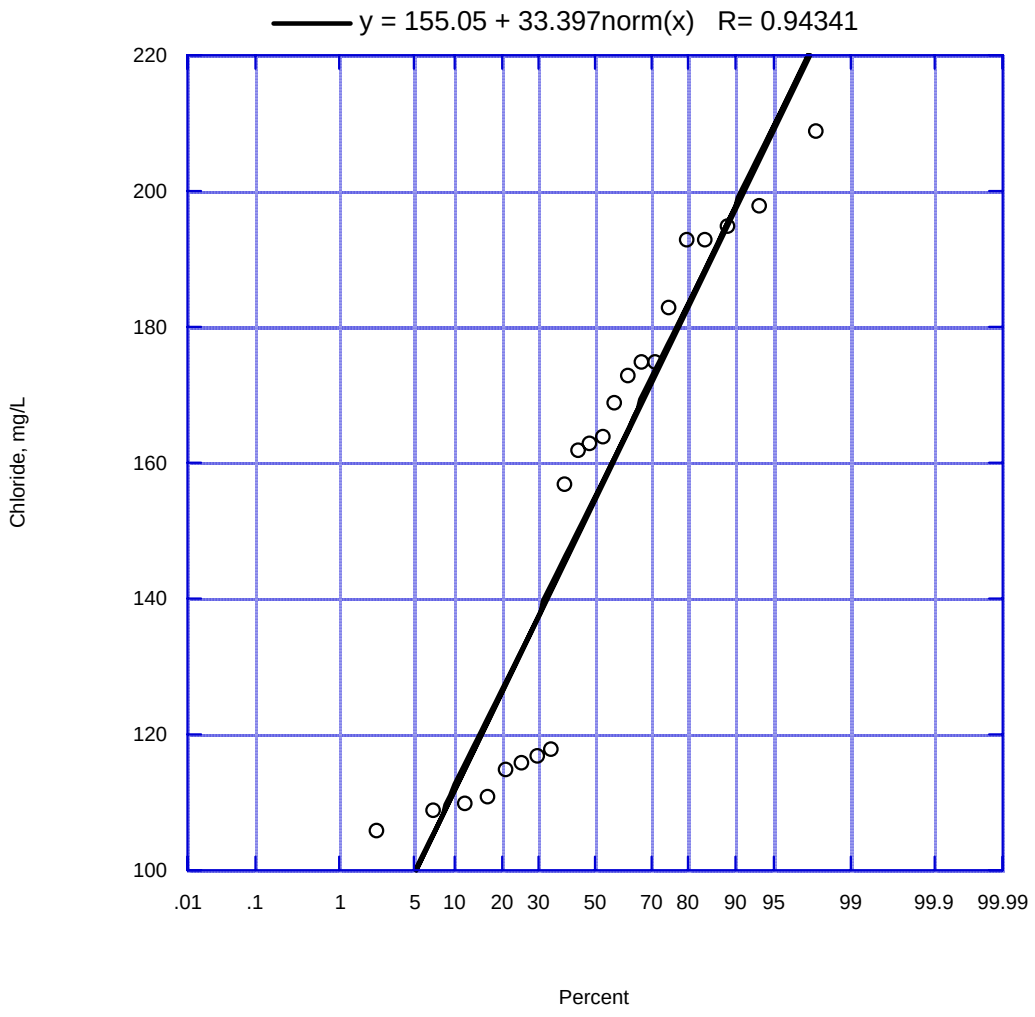


Figure 89. Camrosa Effluent Chloride Frequency Distribution (10/01-10/03)

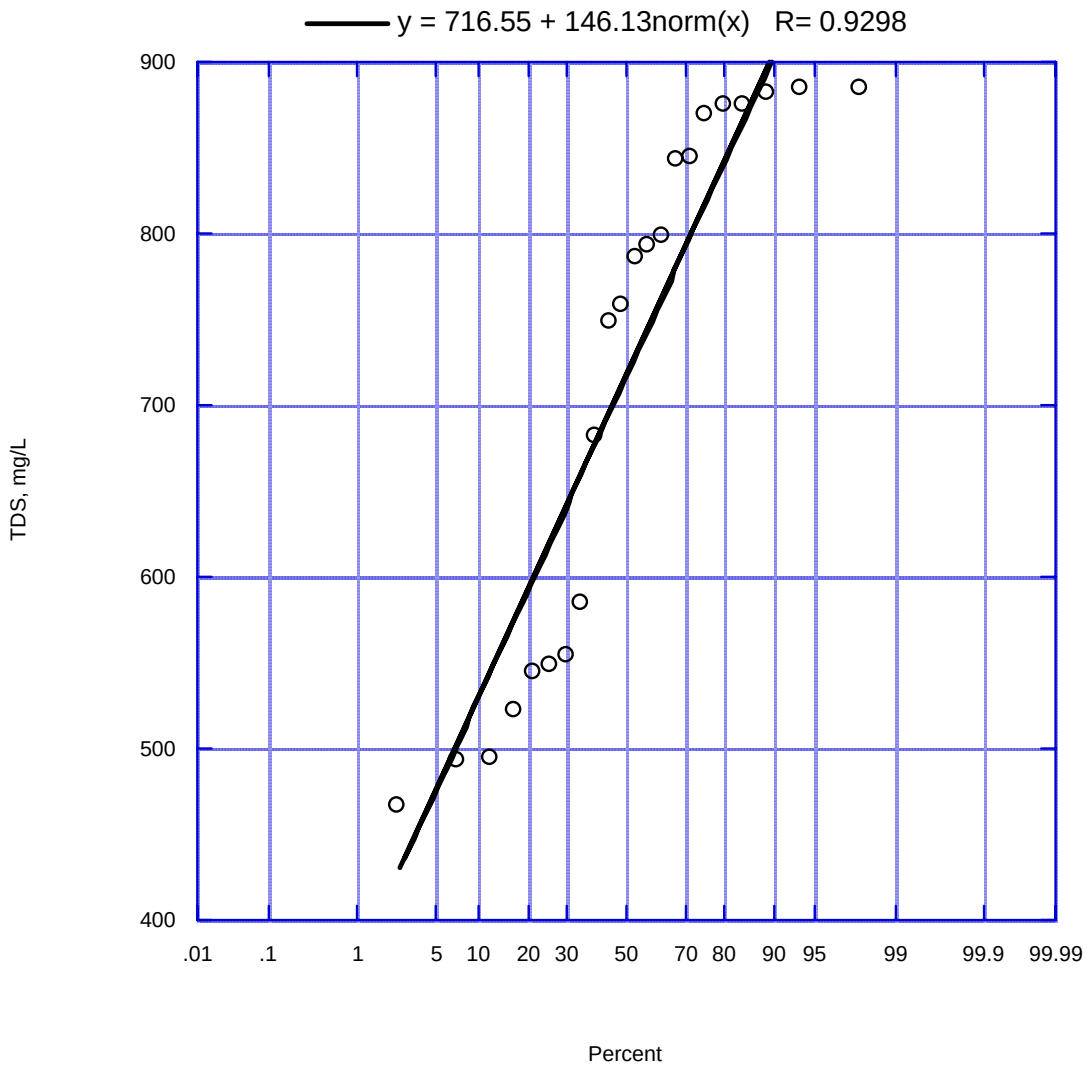


Figure 90. Camrosa Effluent TDS Frequency Distribution (10/01-10/03)

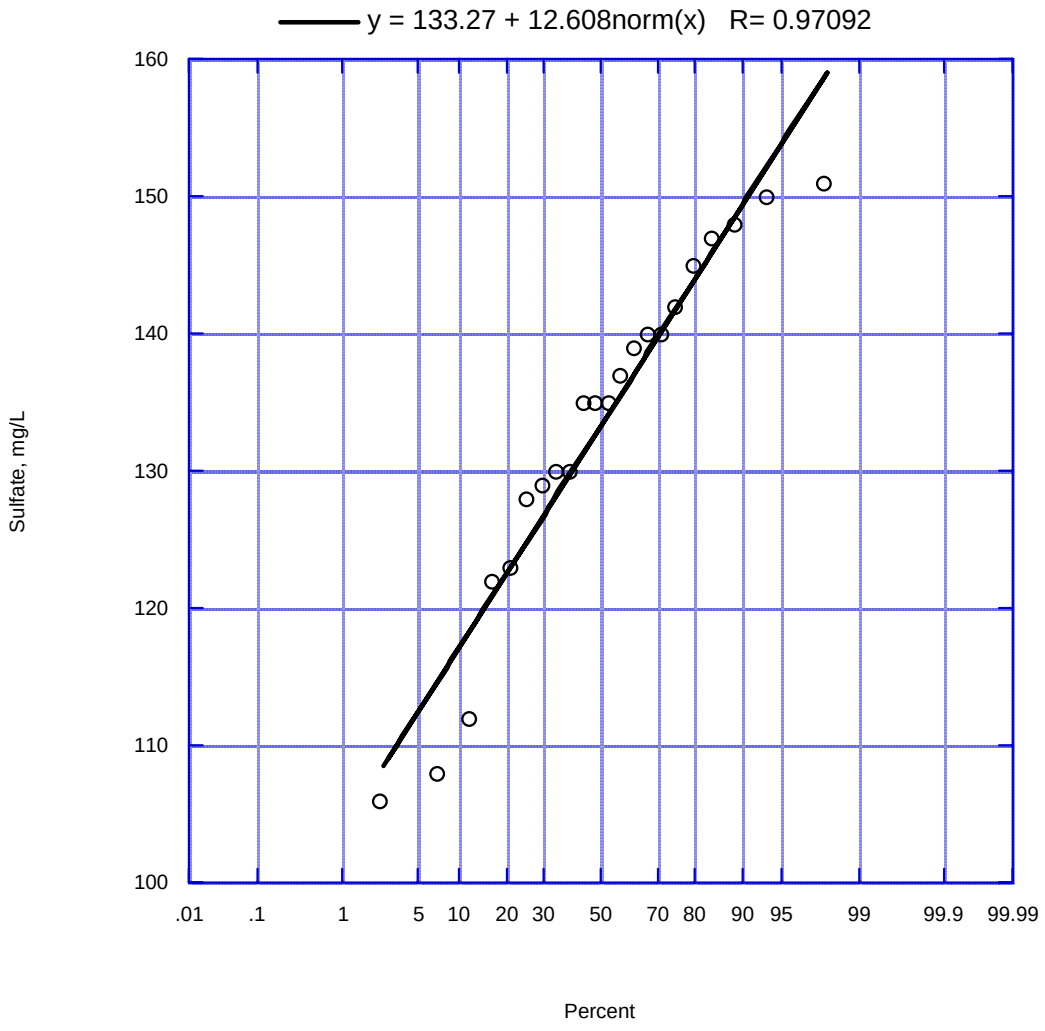


Figure 91. Camrosa Effluent Sulfate Frequency Distribution (10/01-10/03)

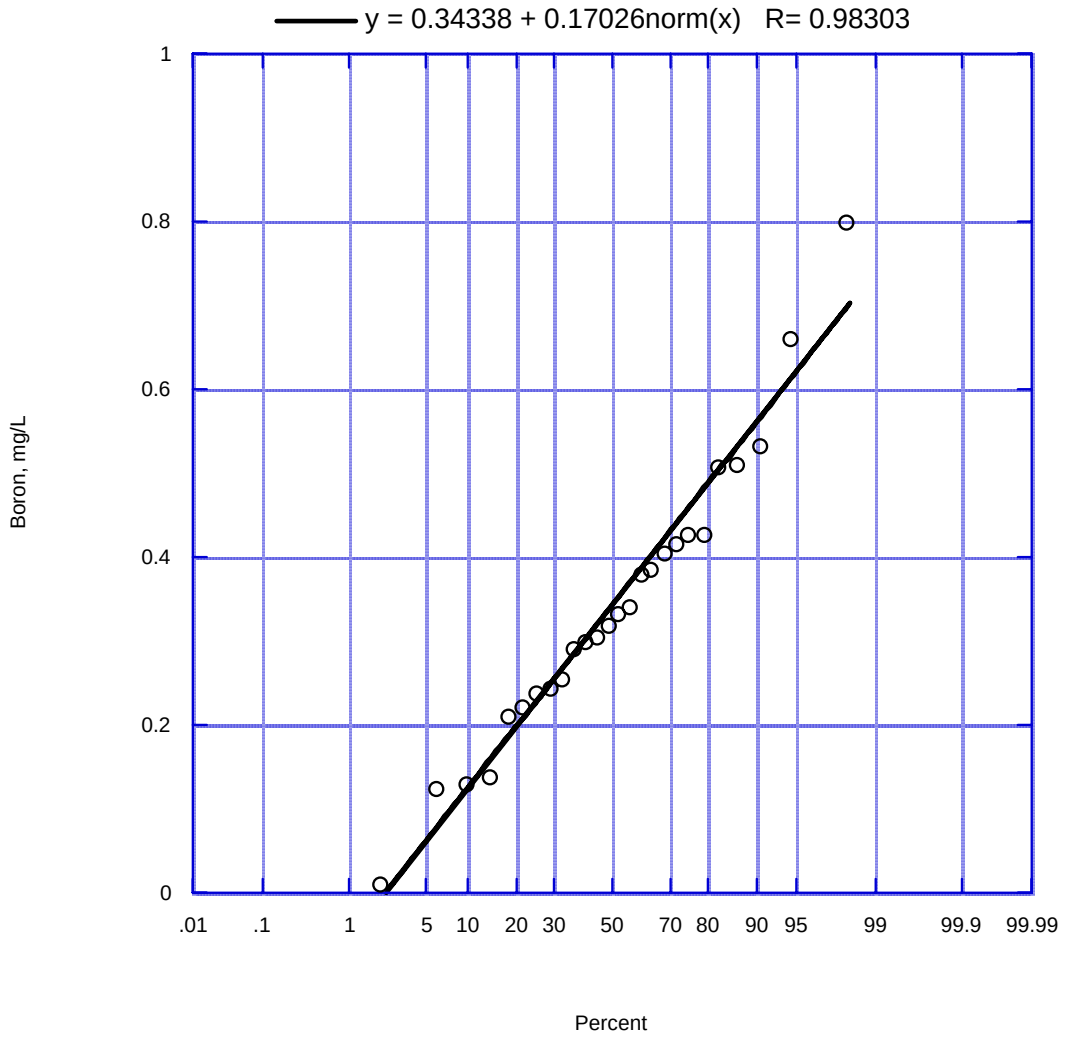


Figure 92. Camrosa Effluent Boron Frequency Distribution (10/01-11/03)

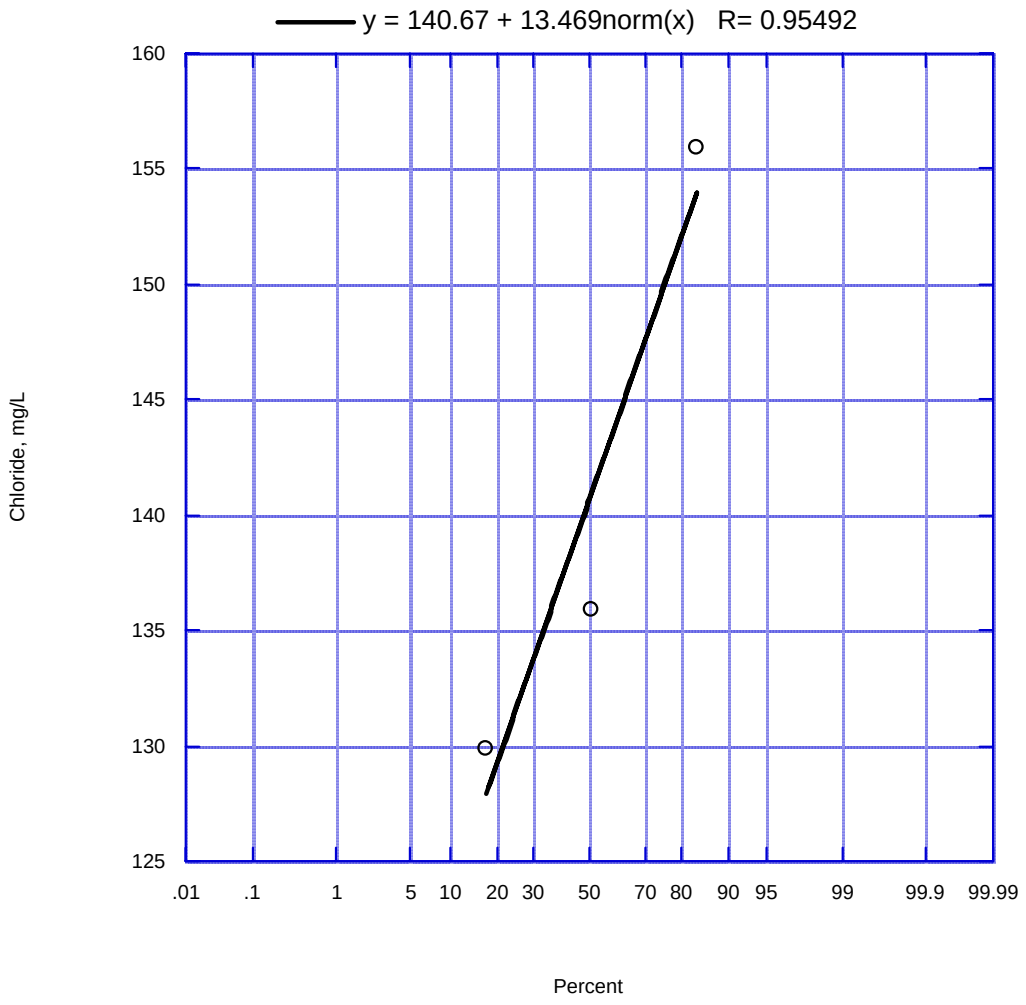


Figure 93. Moorpark Effluent Chloride Frequecny Distribution (10/01-12/01)

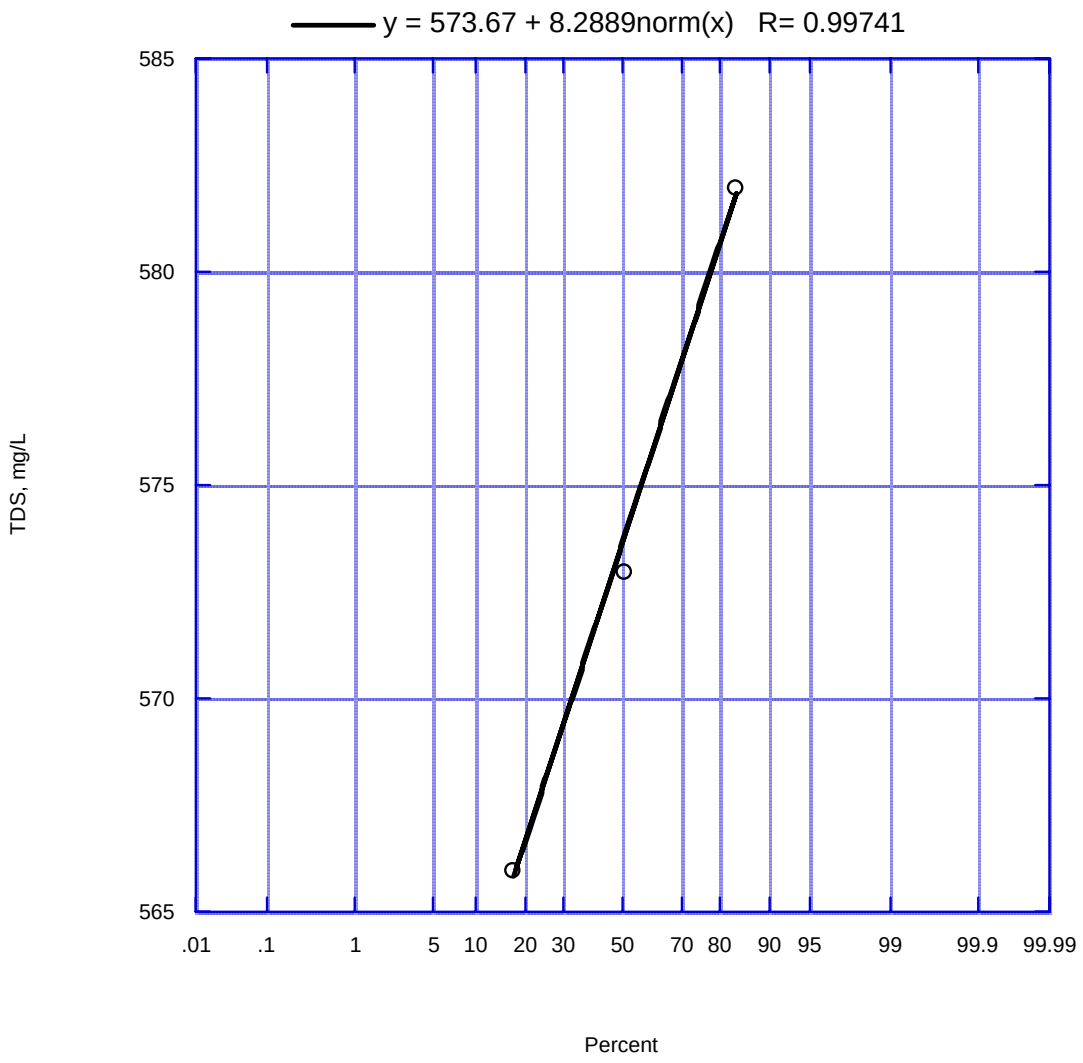


Figure 94. Moorpark Effluent TDS Frequency Distribution (10/01-12/01)

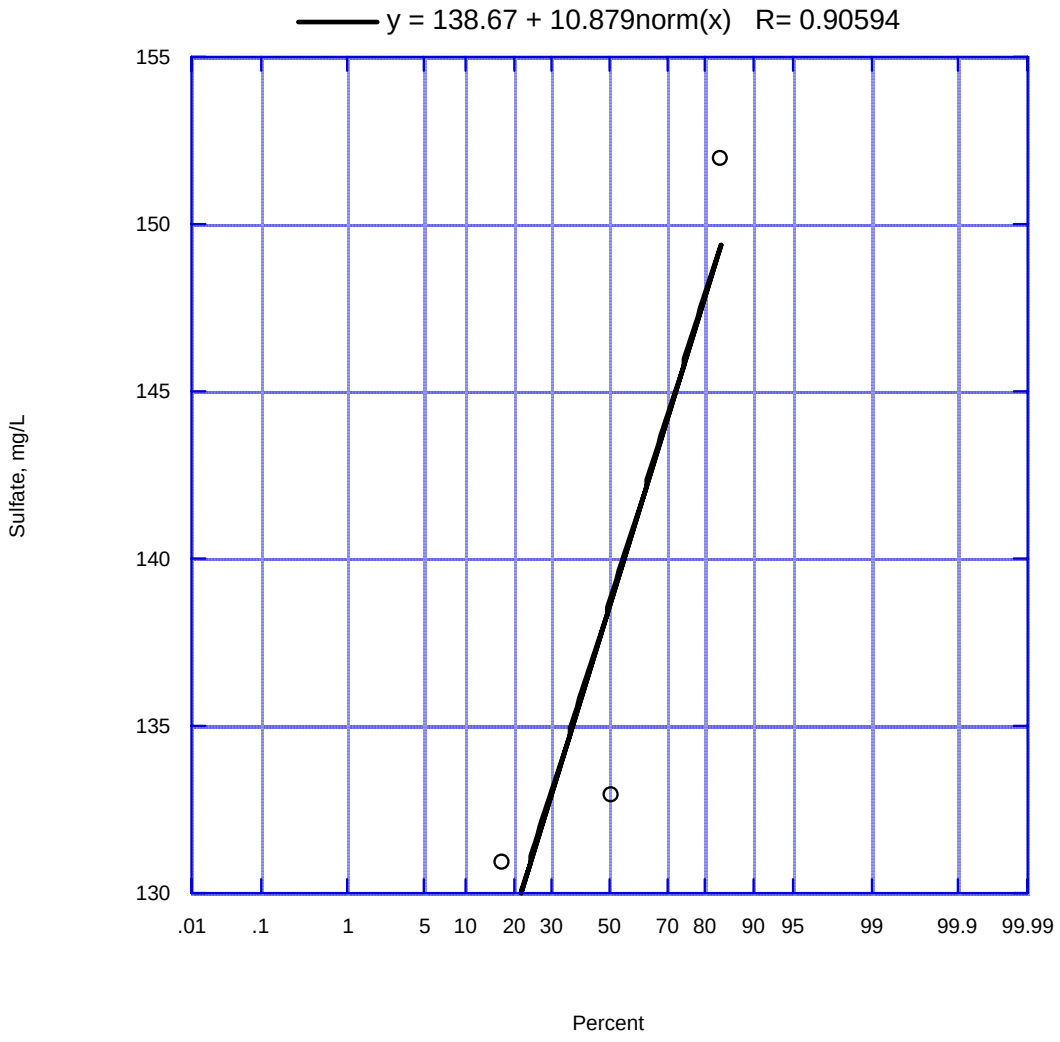


Figure 95. Moorpark Effluent Sulfate Freuency Distribution (10/01-12/01)

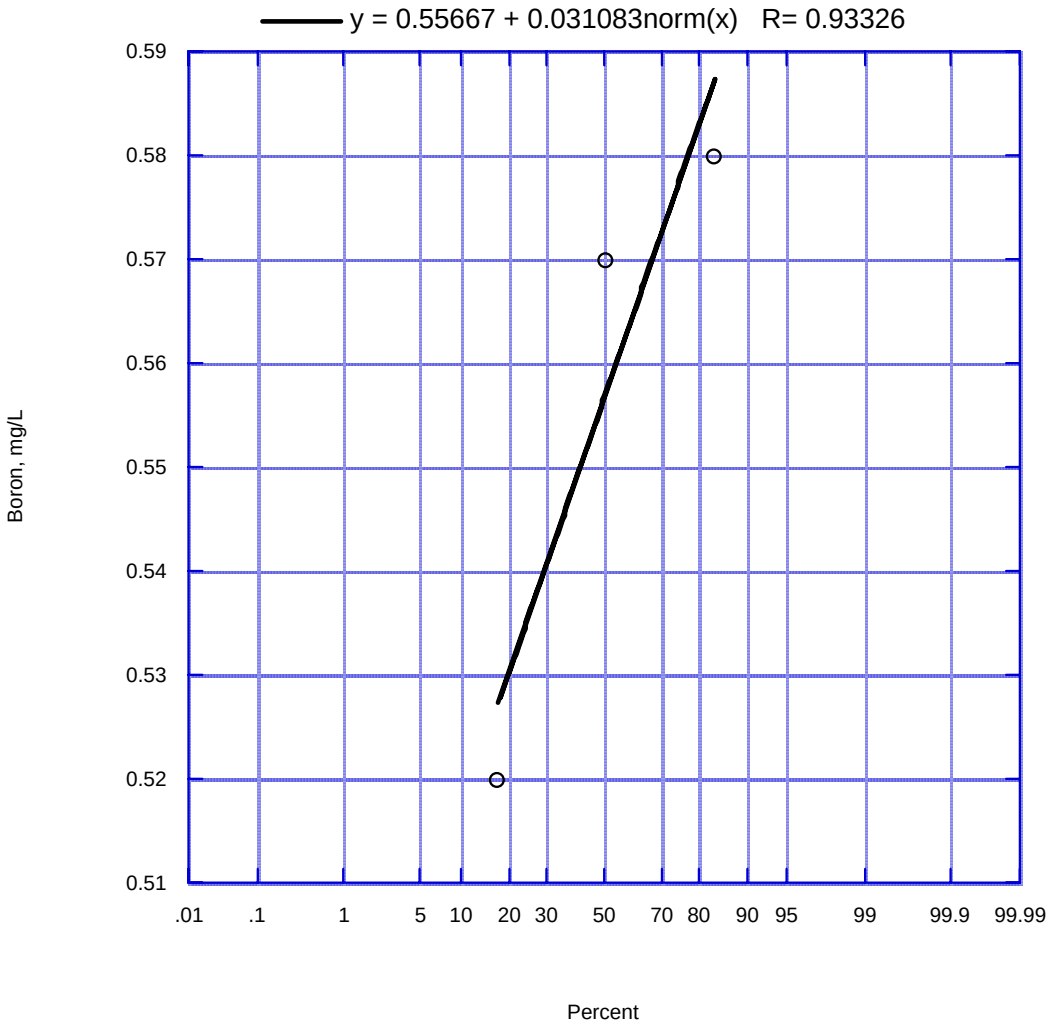


Figure 96. Moorpark Effluent Boron Frequency Distribution (10/01-12/01)

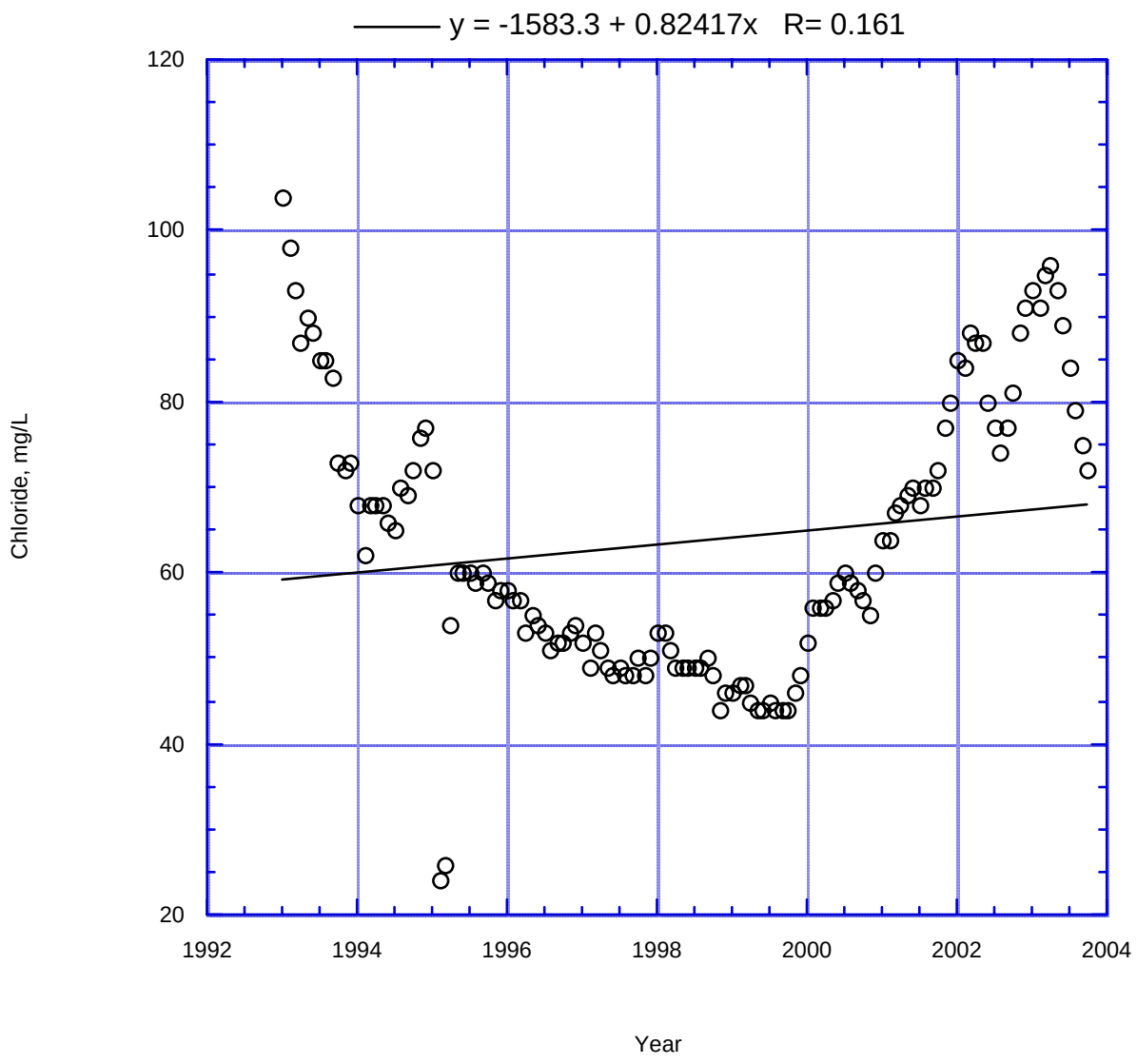


Figure 97. Jensen Plant Chloride vs. Time

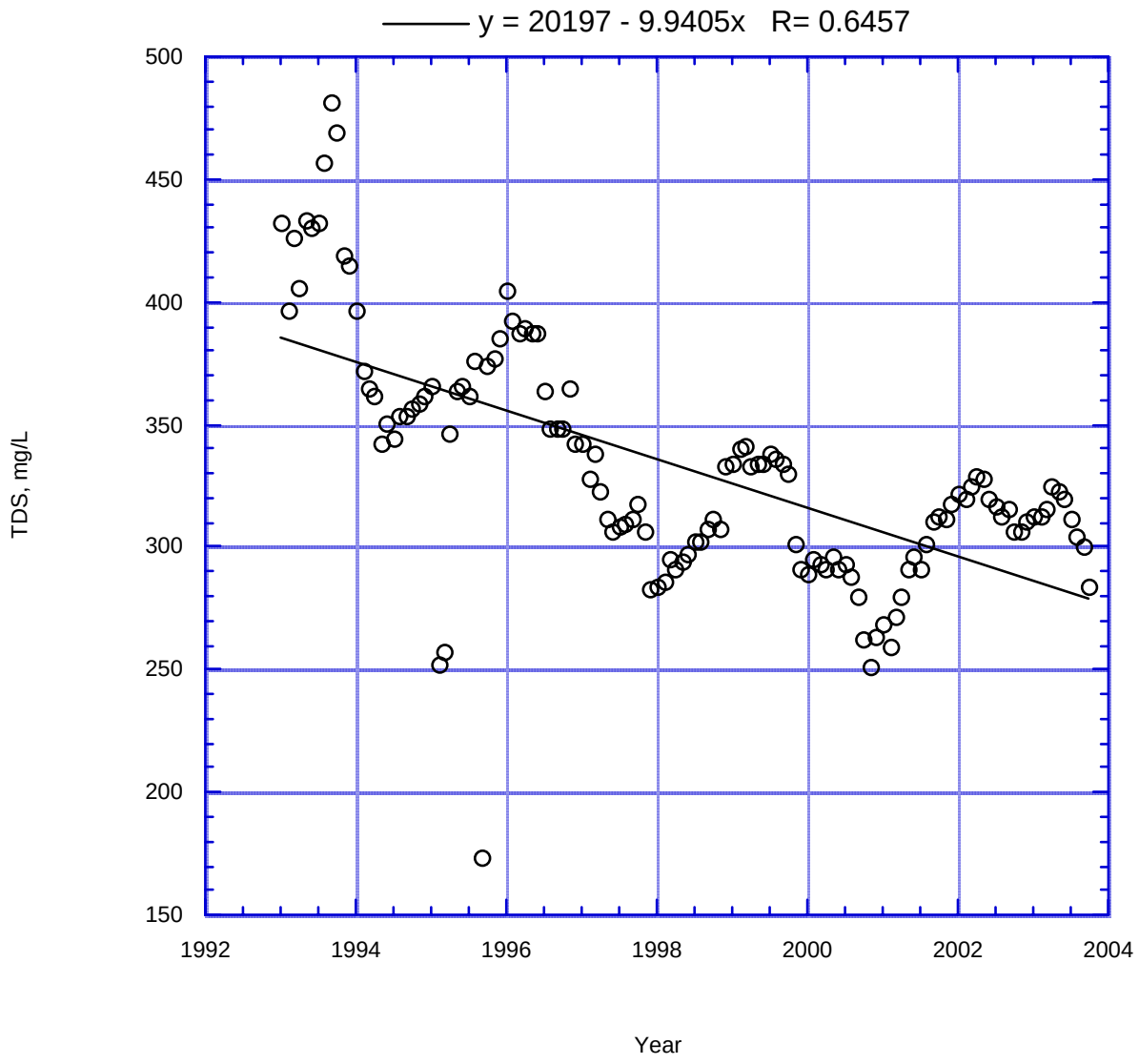


Figure 98. Jensen Plant TDS vs. Time

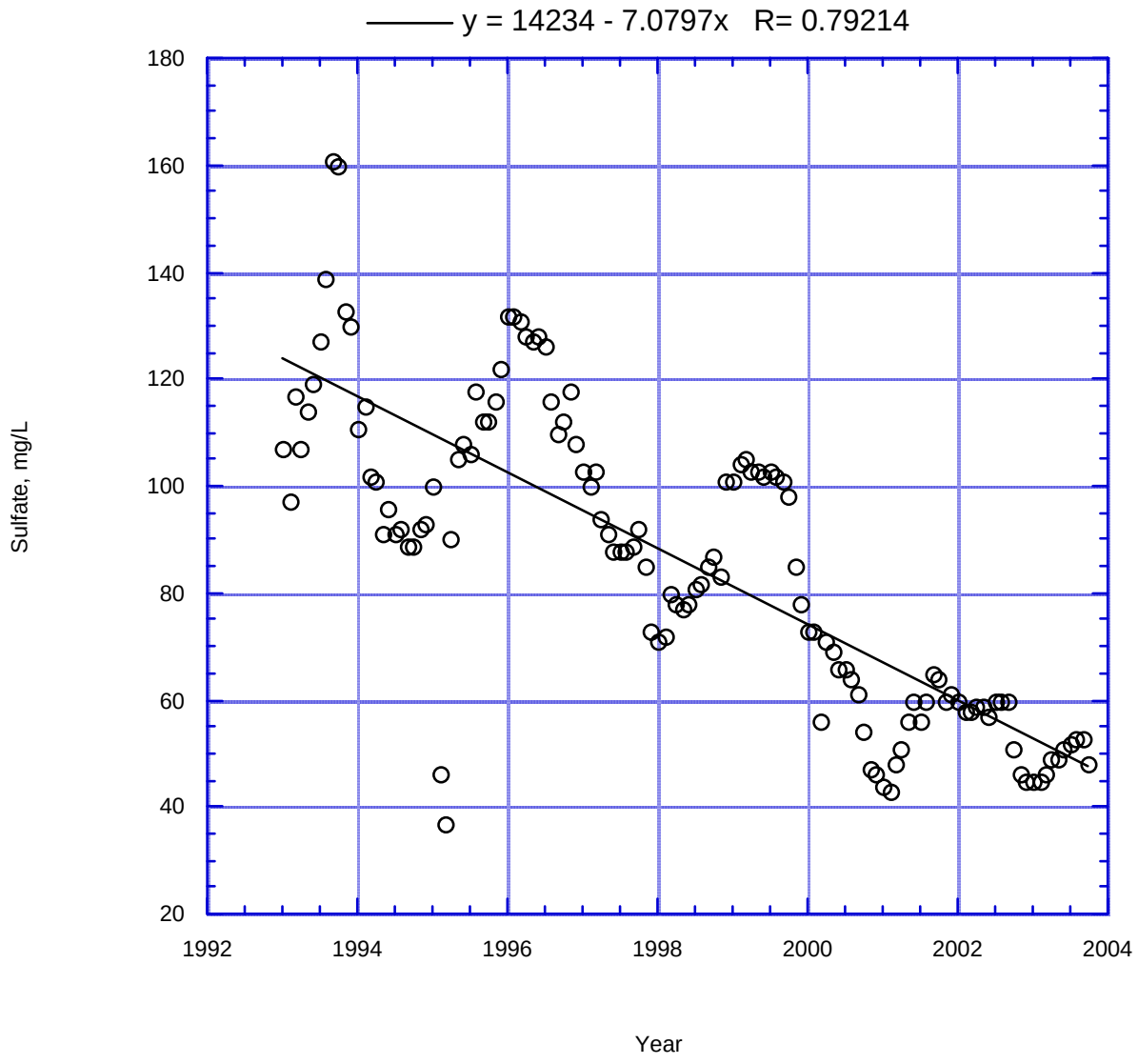


Figure 99. Jensen Plant Sulfate vs. Time

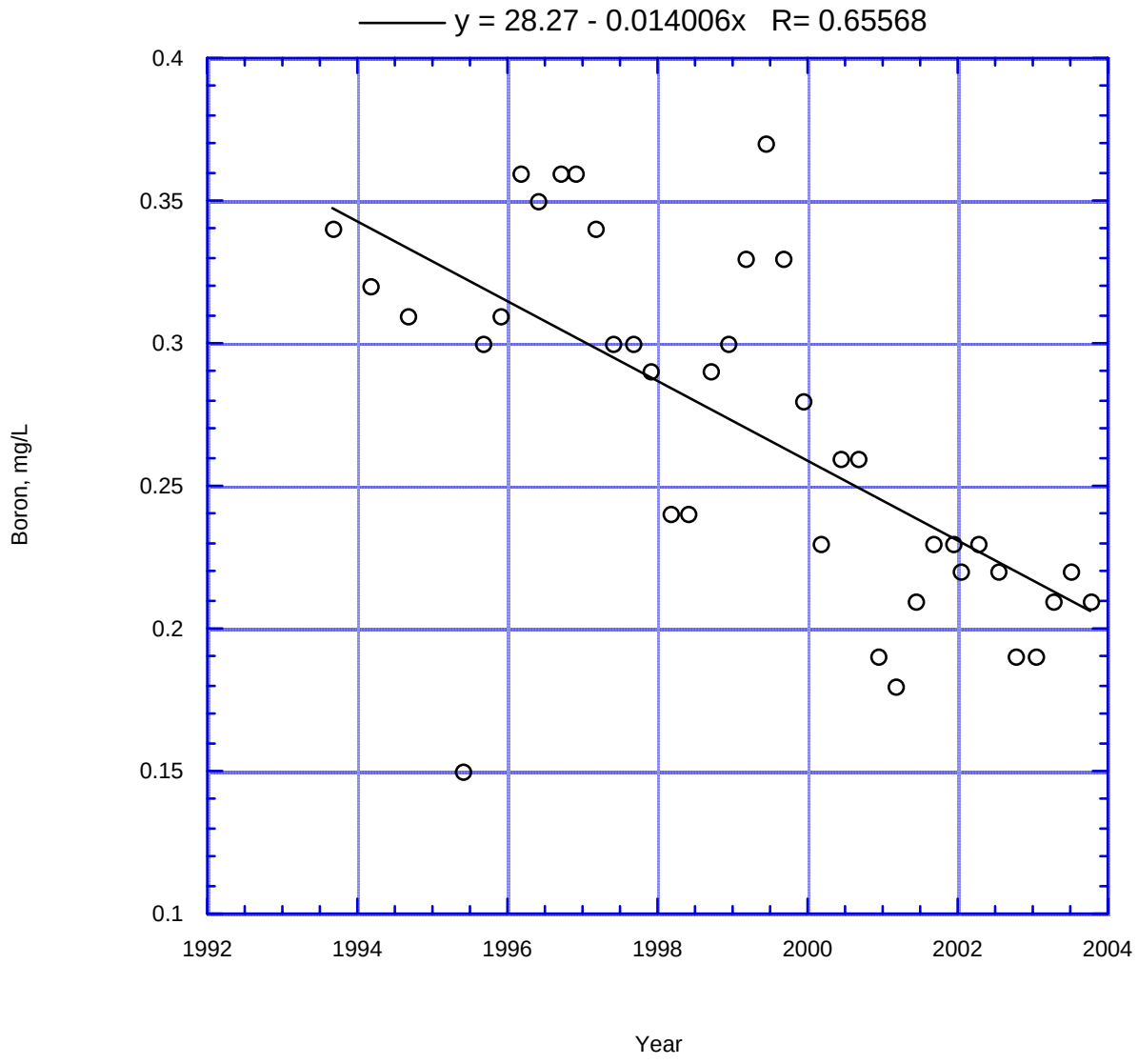


Figure 100. Jensen Plant Boron vs. Time

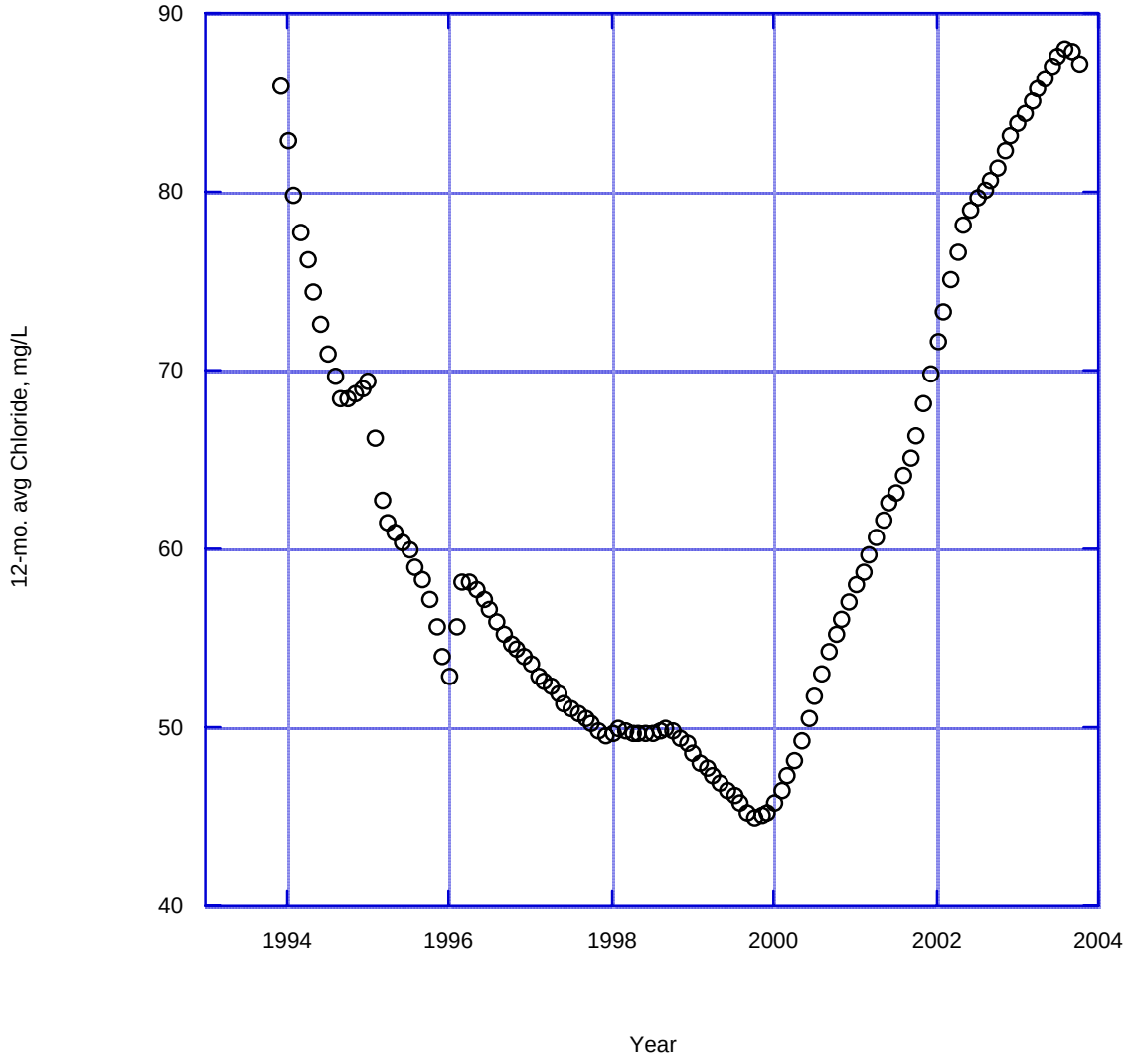


Figure 101. Jensen Plant 12-month Average Chloride vs. Time

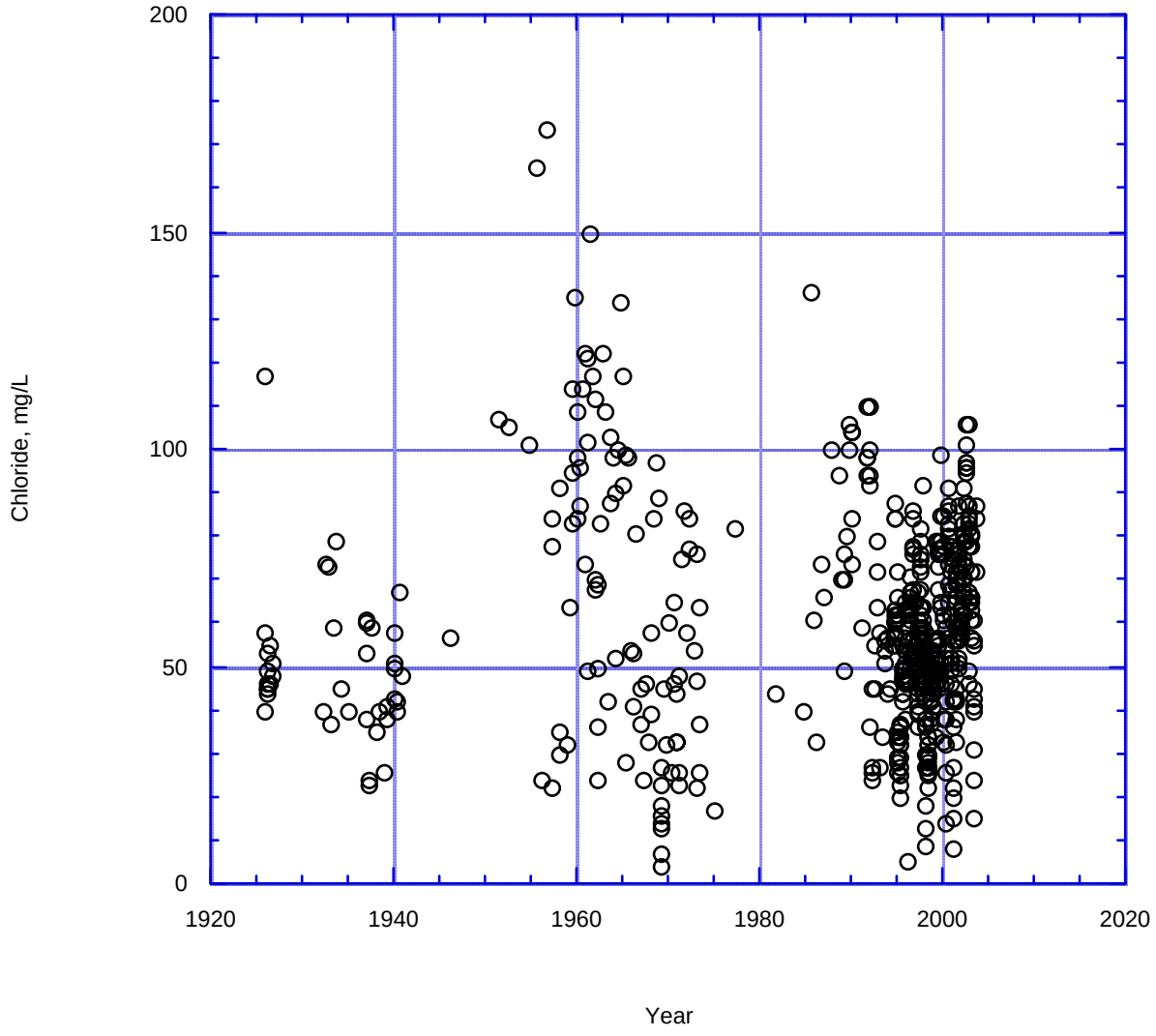


Figure 102. Freeman Diversion Chloride vs. Time

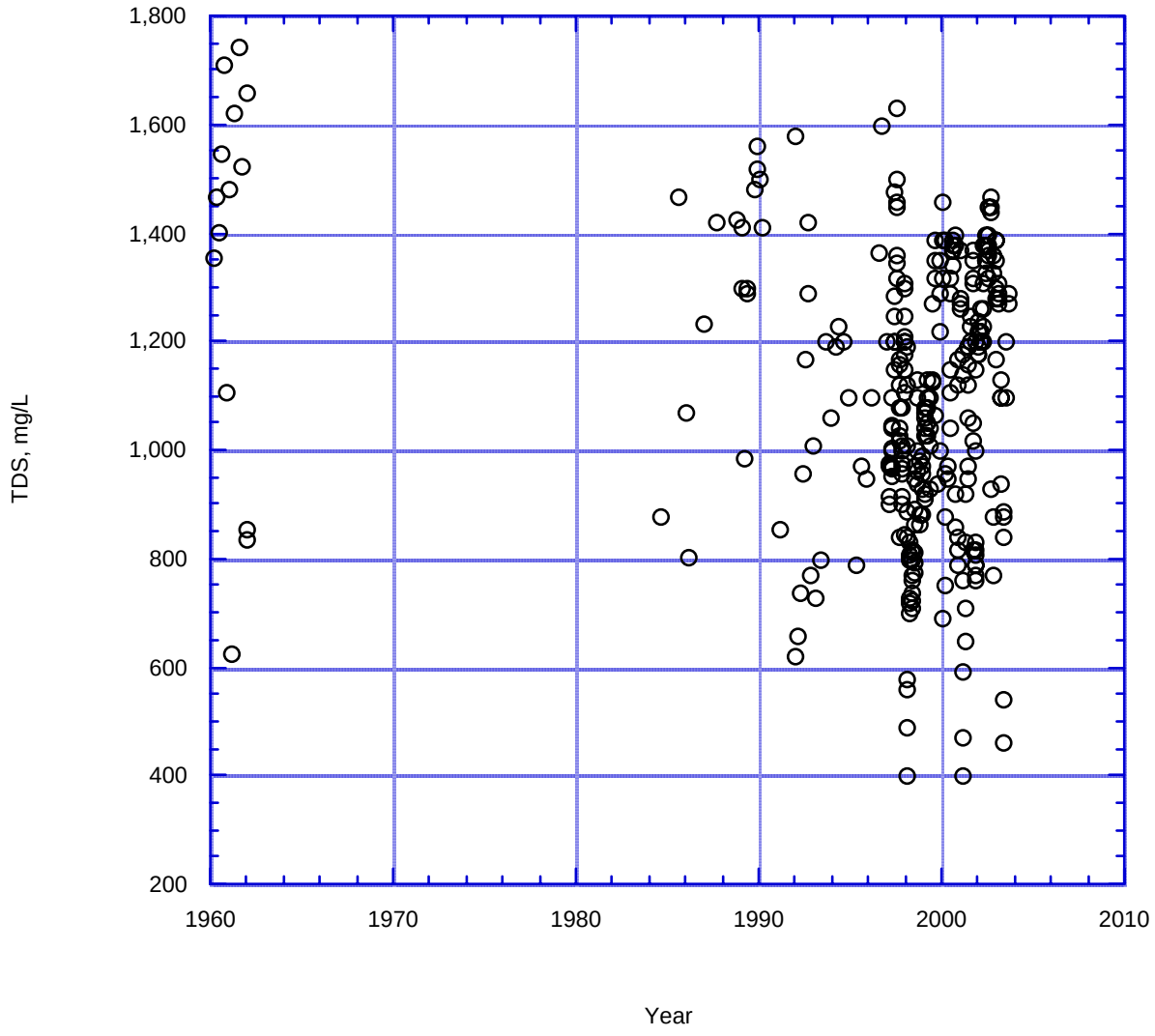


Figure 103. Freeman Diversion TDS vs. Time

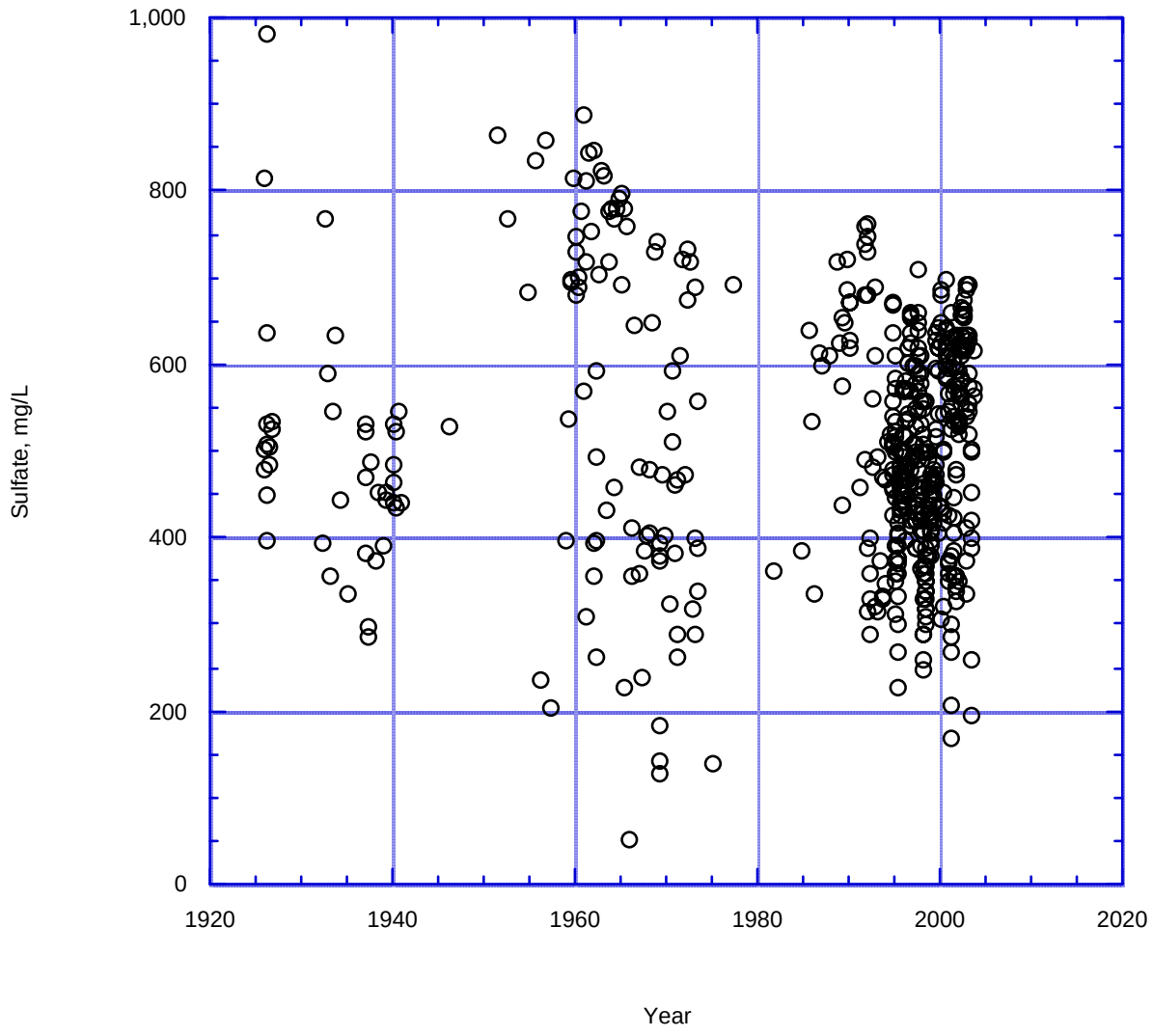


Figure 104. Freeman Diversion Sulfate vs. Time

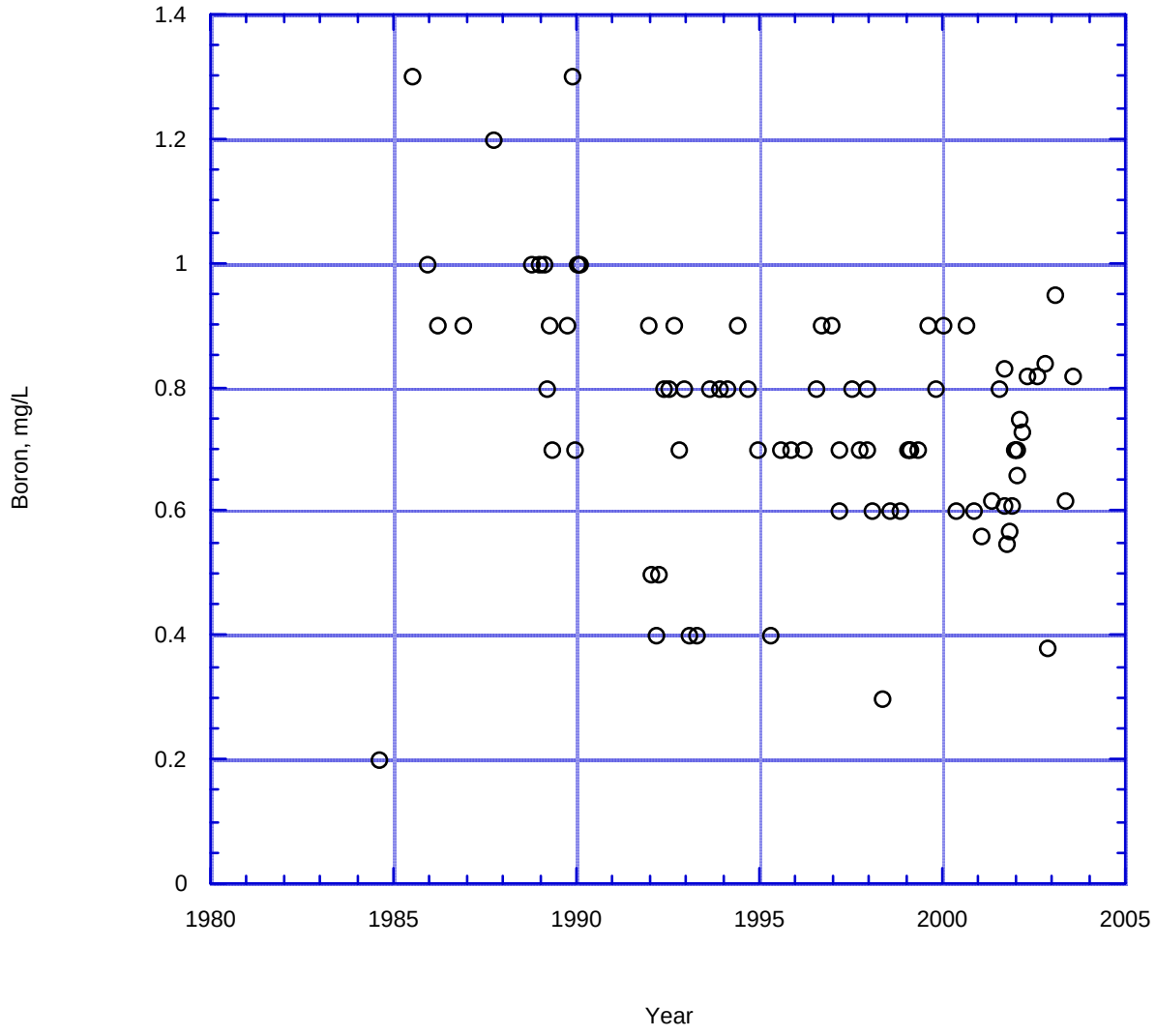


Figure 105. Freeman Diversion Boron vs. Time

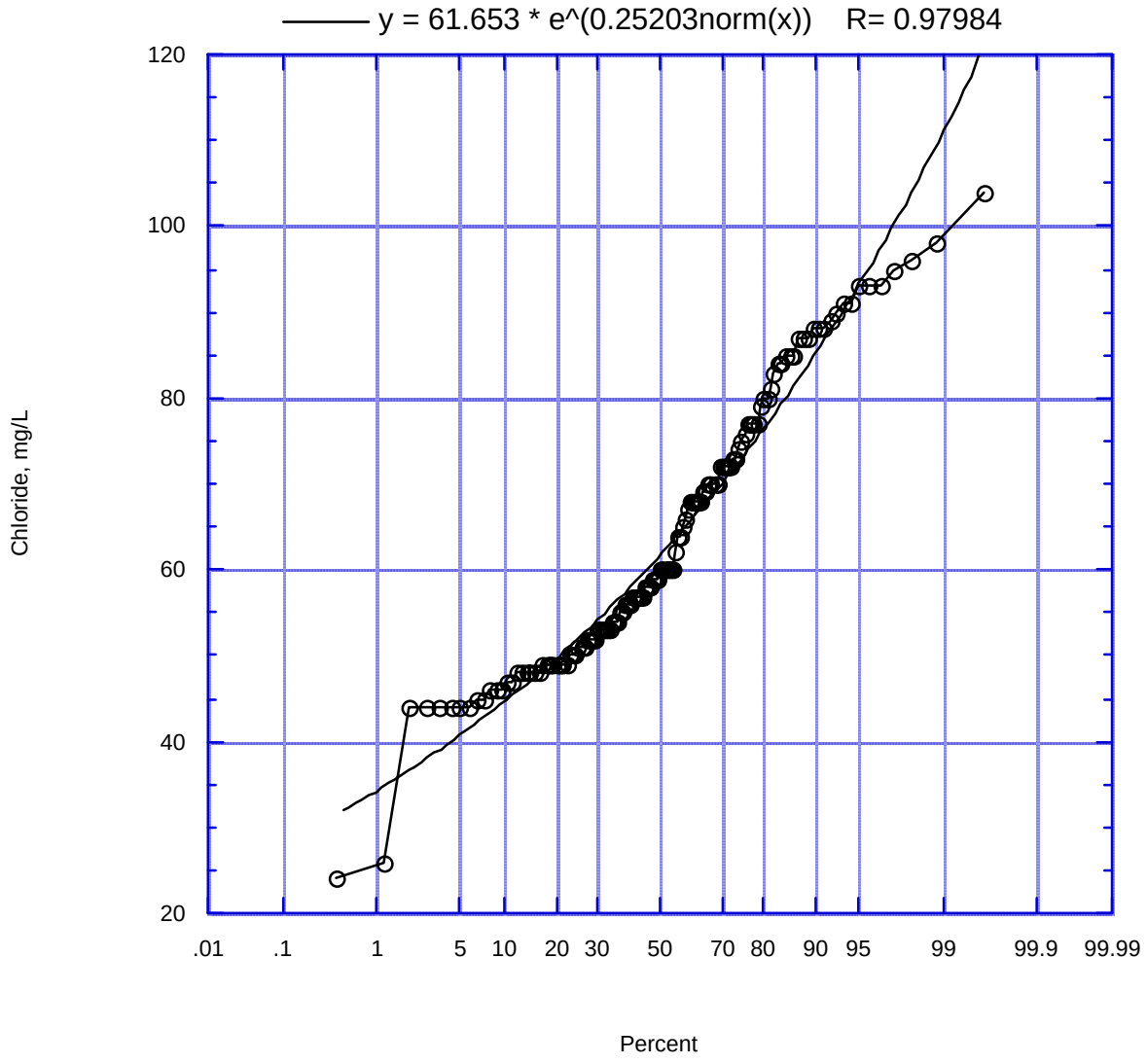


Figure 106. Jensen Plant Chloride Frequency Distribution

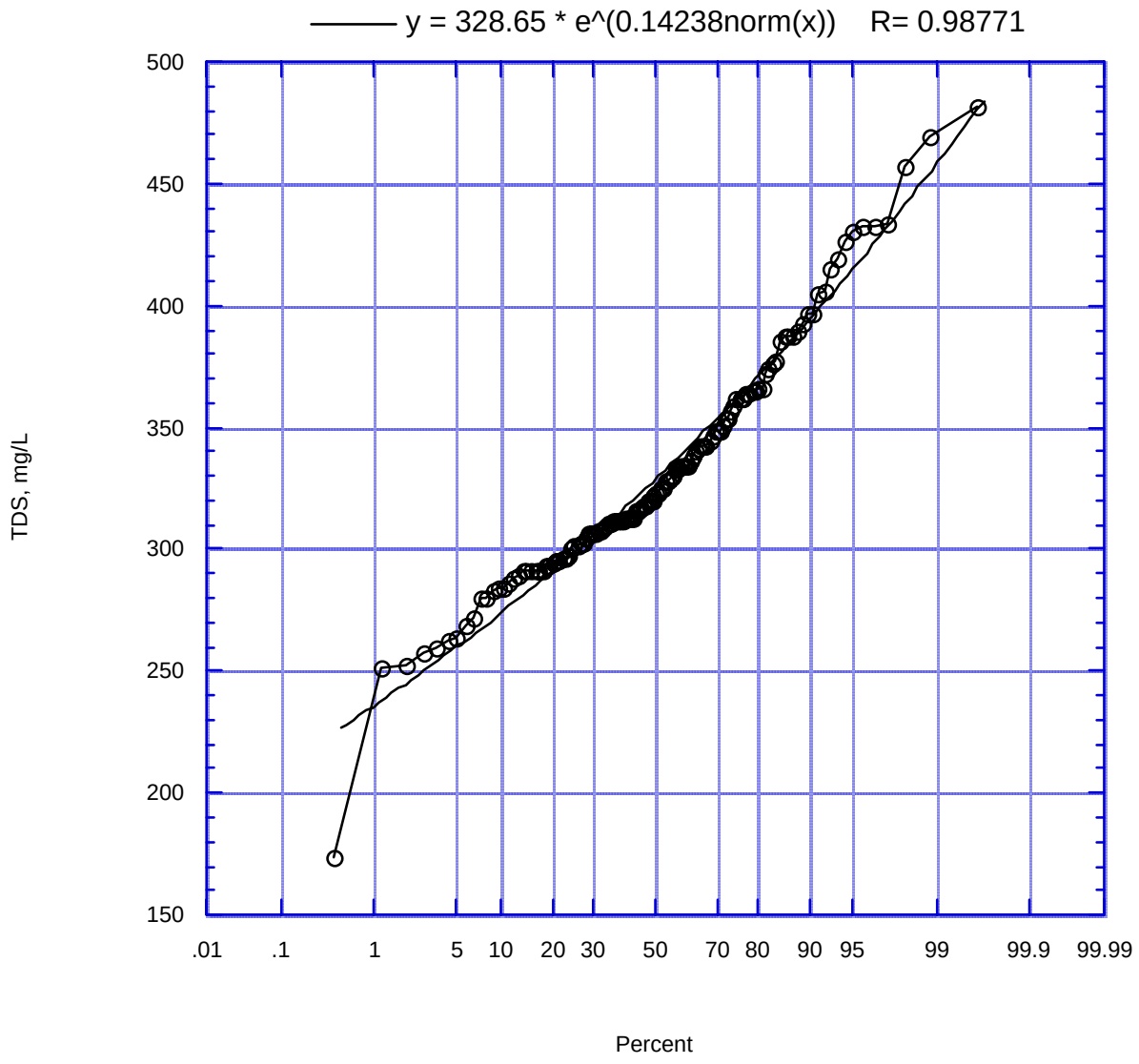


Figure 107. Jensen Plant TDS Frequency Distribution

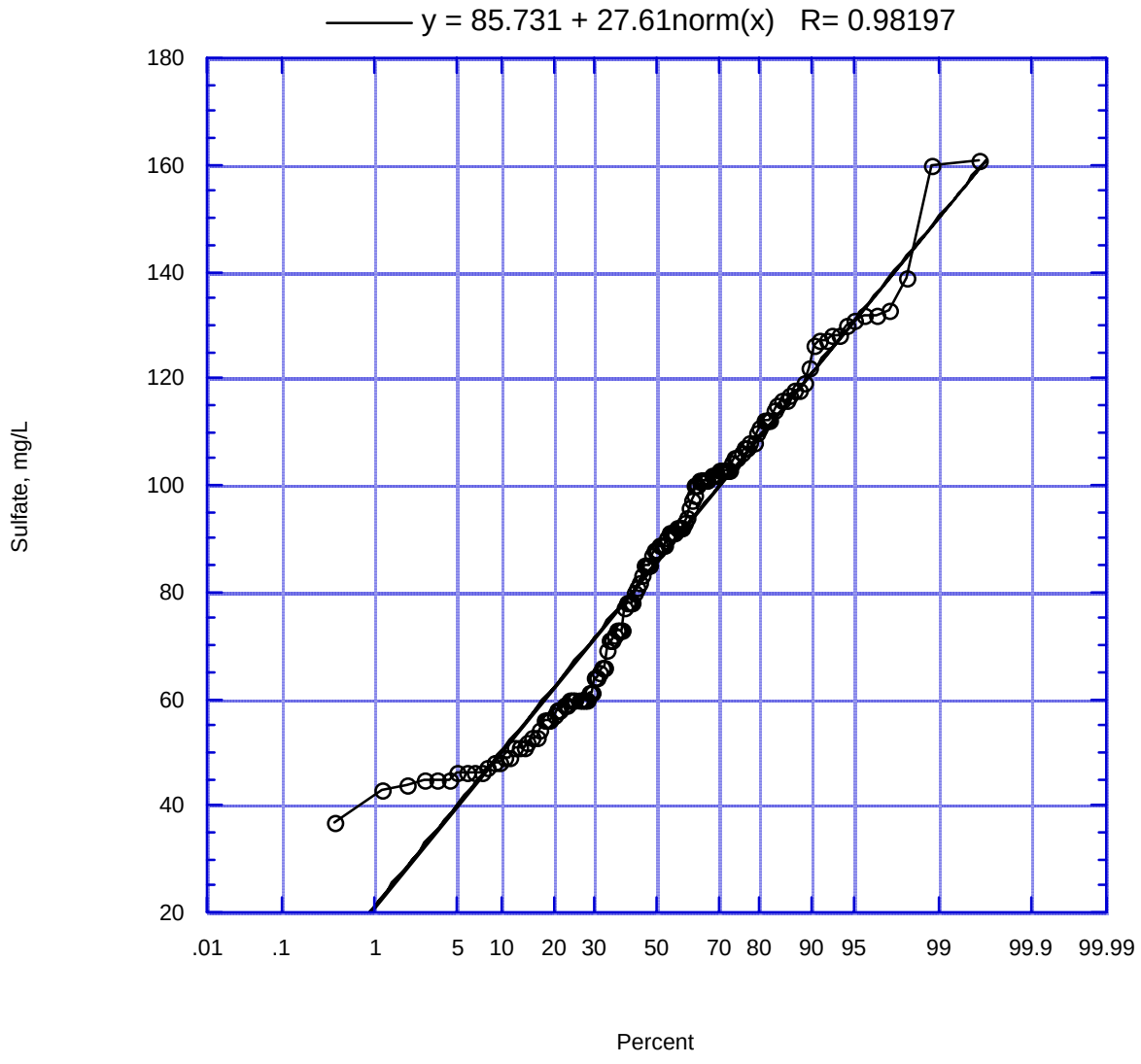


Figure 108. Jensen Plant Sulfate Frequency Distribution

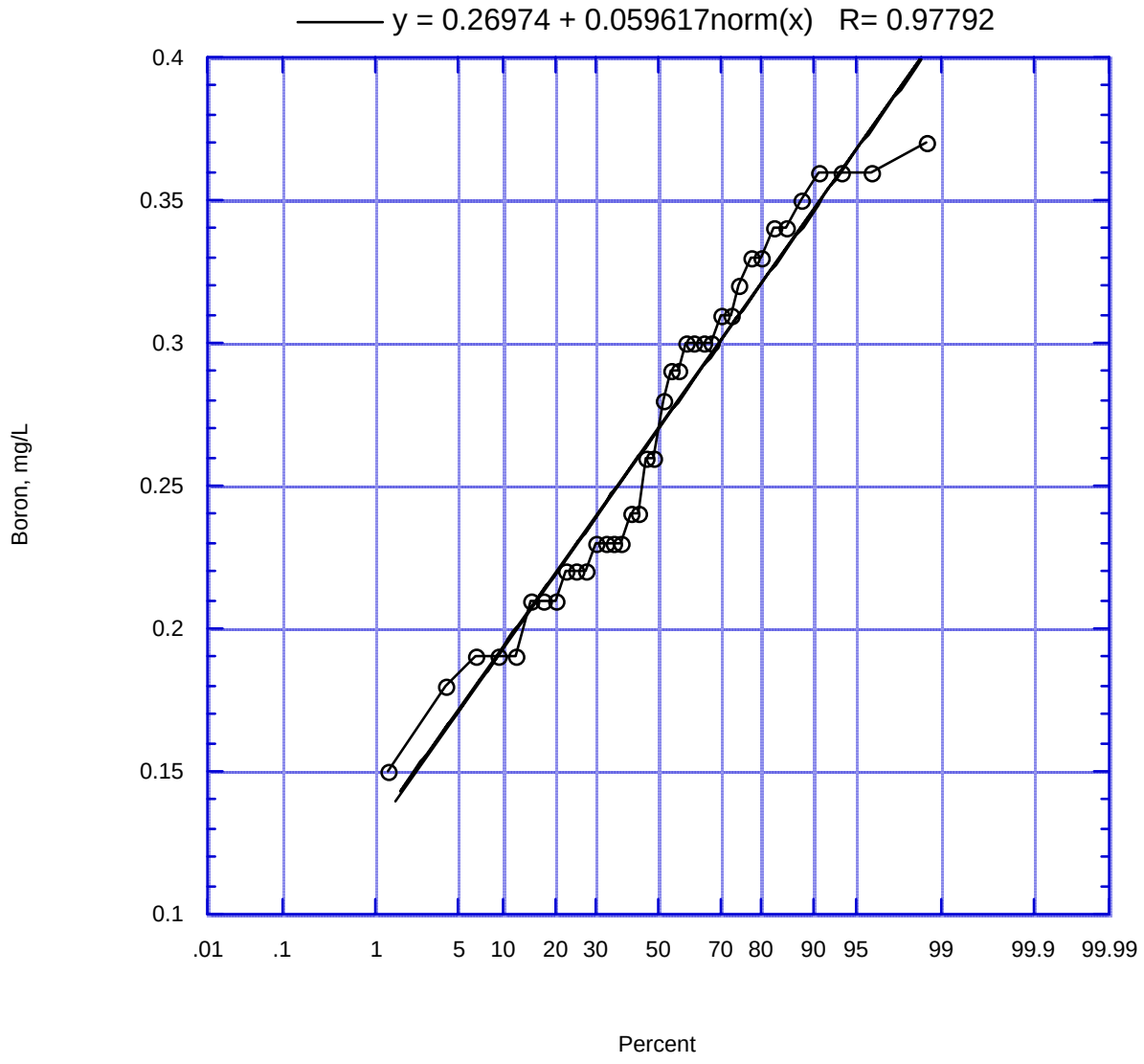


Figure 109. Jensen Plant Boron Frequency Distribution

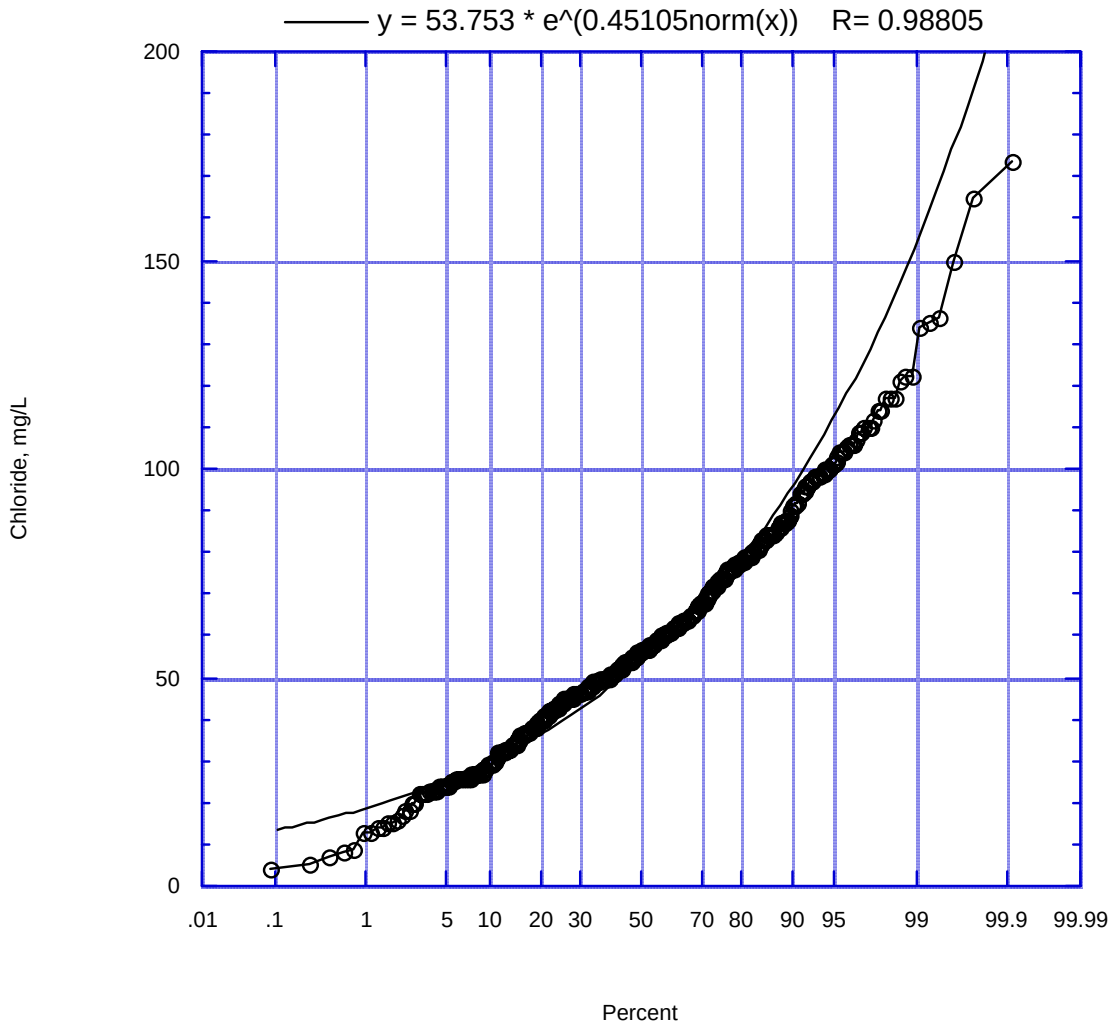


Figure 110. Freeman Diversion Chloride Frequency Distribution

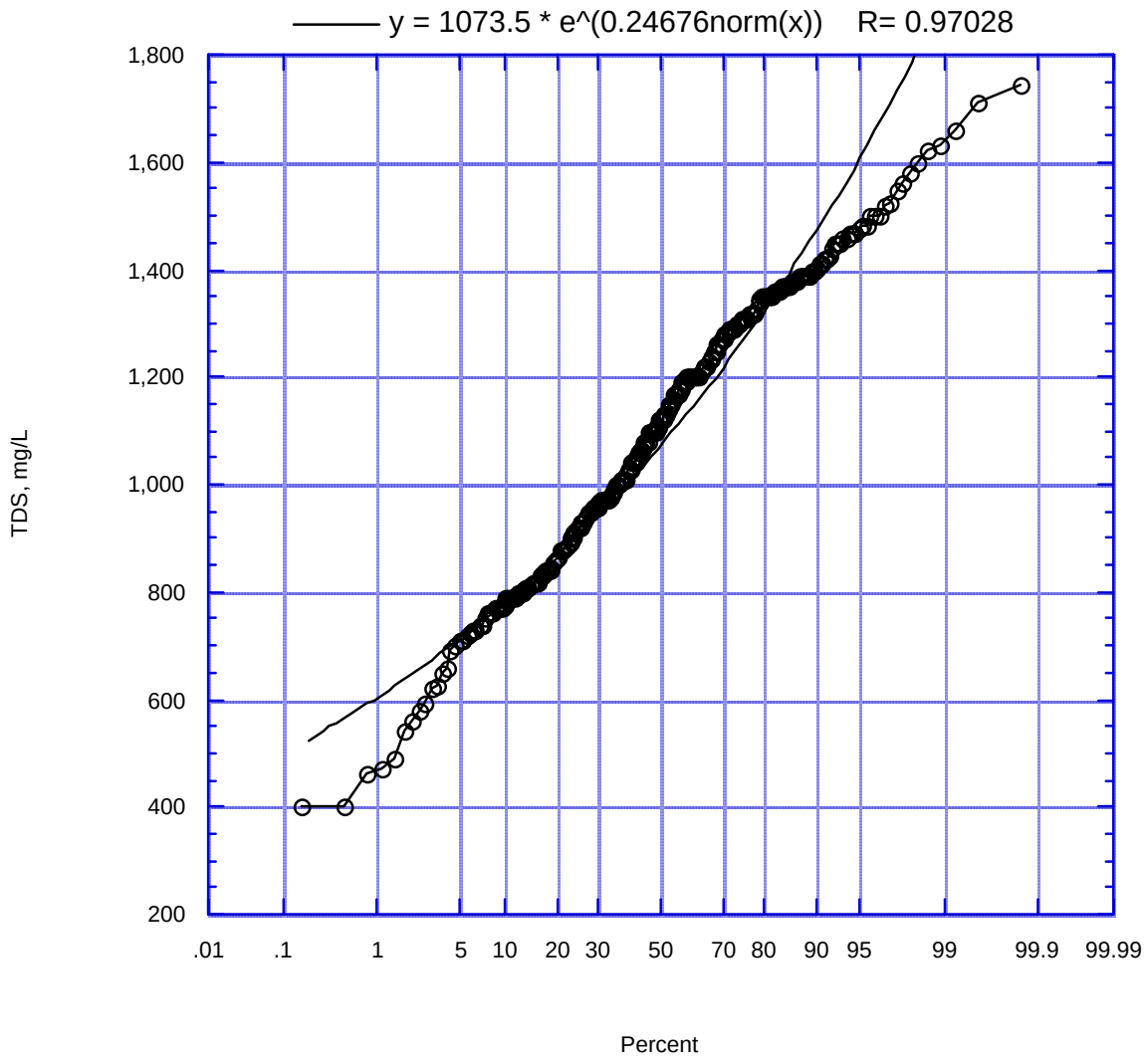


Figure 111. Freeman Diversion TDS Frequency Distribution

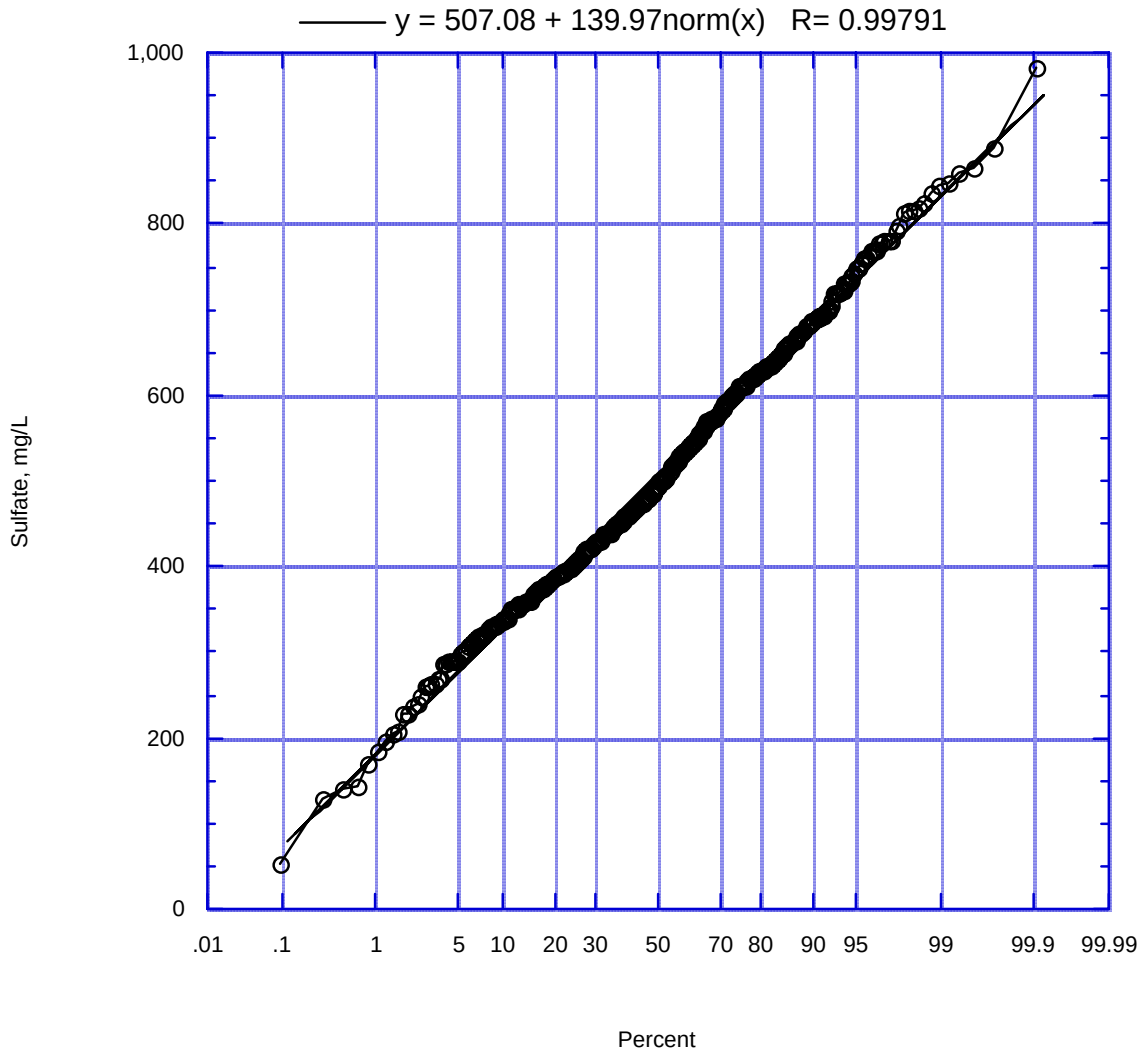


Figure 112. Freeman Diversion Sulfate Frequency Distribution

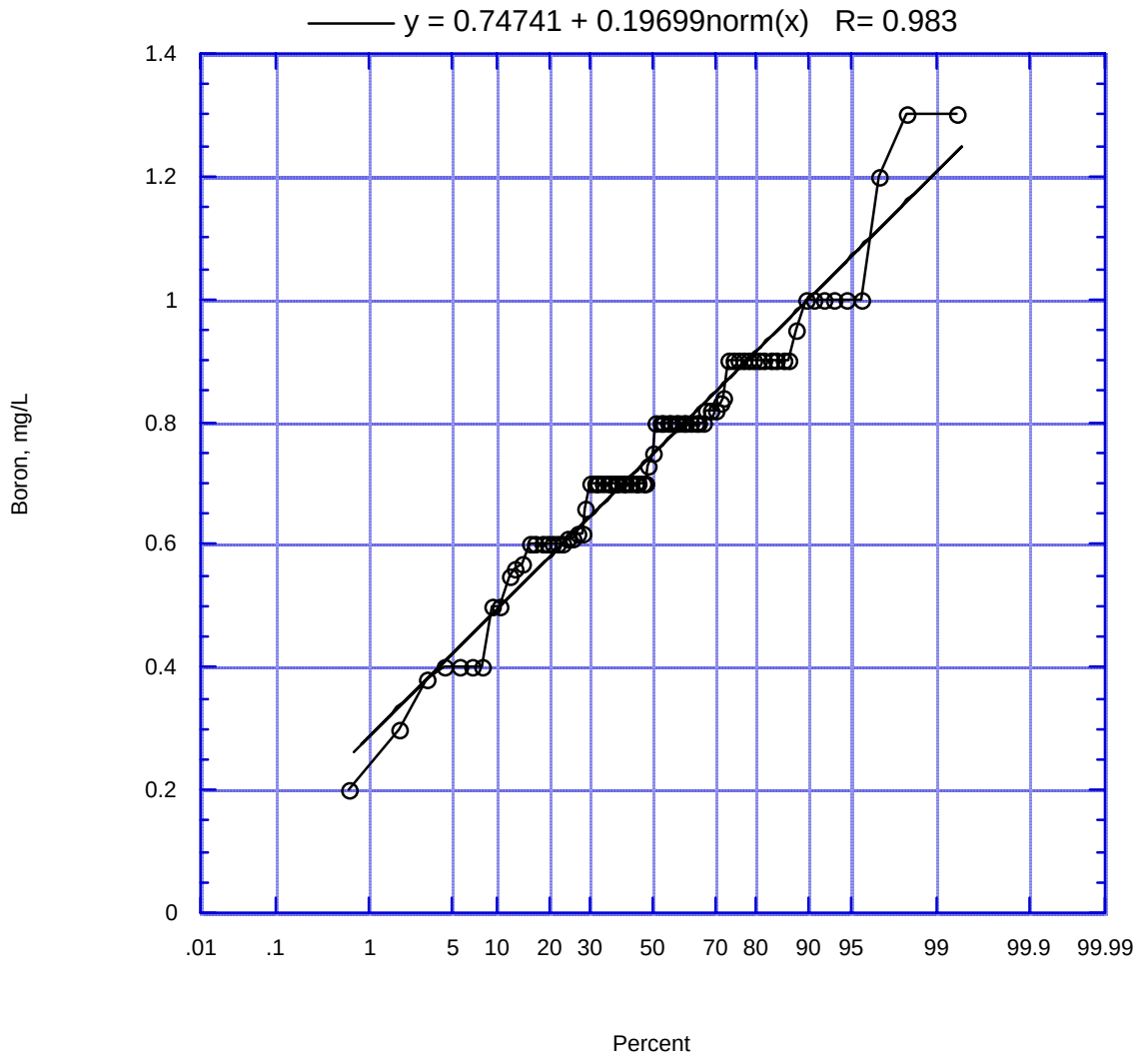


Figure 113. Freeman Diversion Boron Frequency Distribution

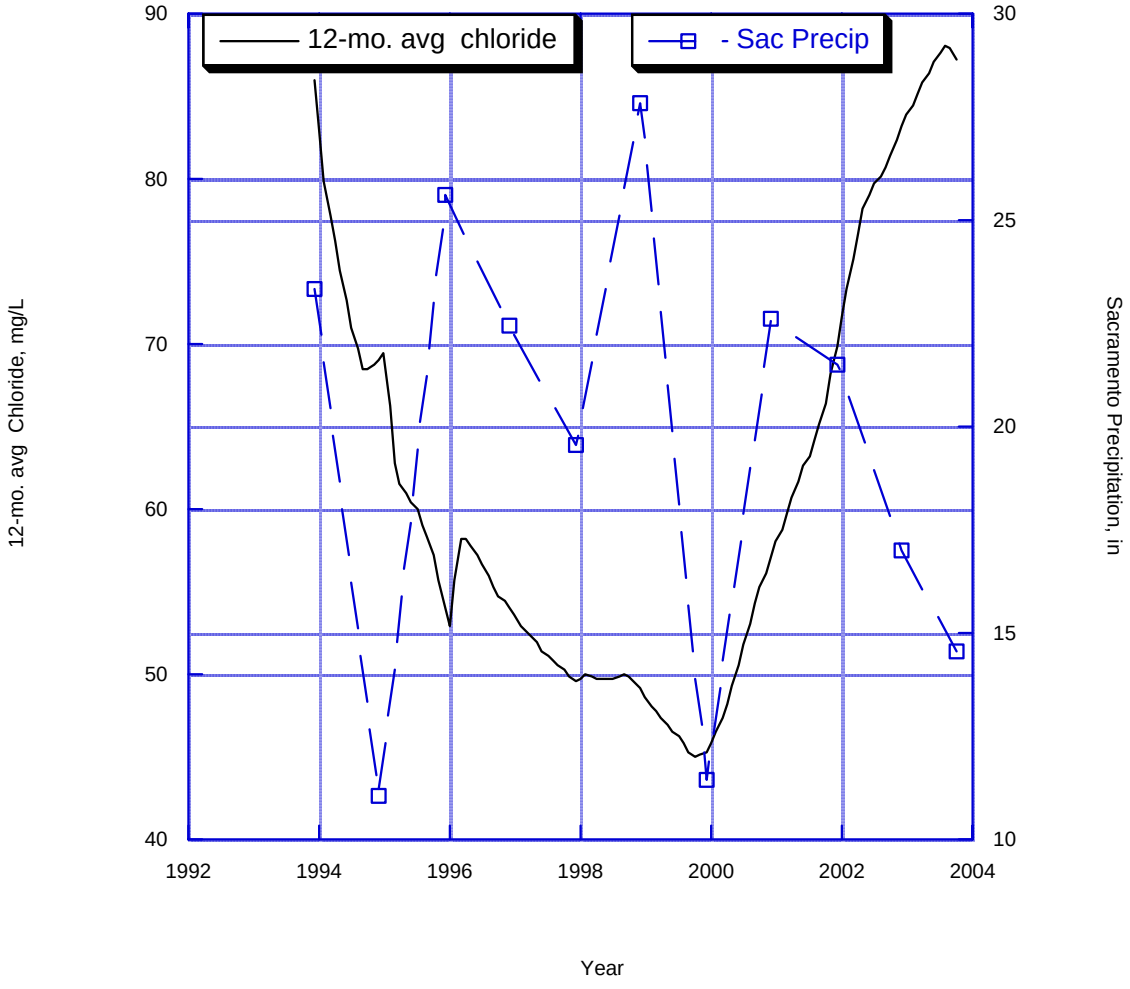


Figure 114. Jensen Plant Chloride and Sacramento Precipitation vs. Time

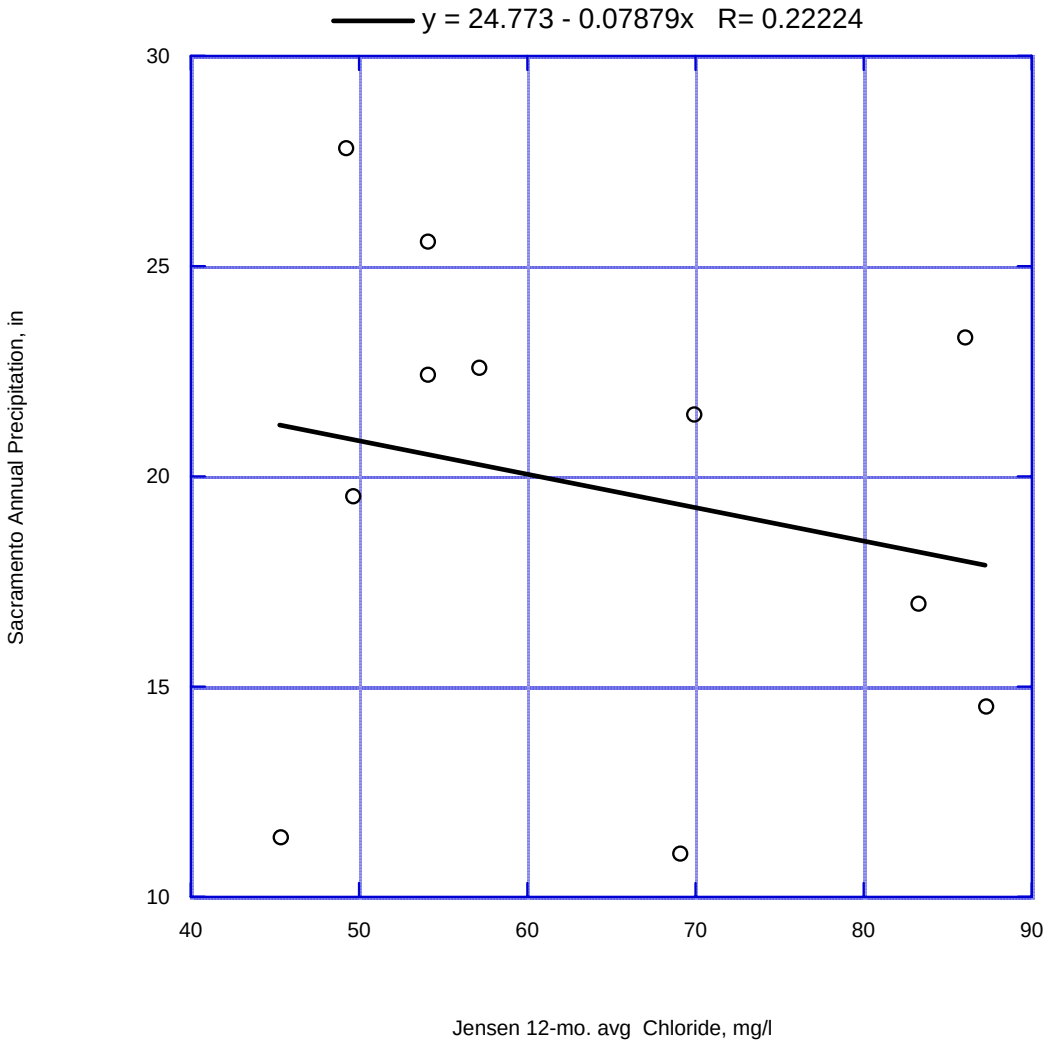


Fig 115. Jensen Plant 12-mo. avg Chloride vs. Sacramento Precipitation

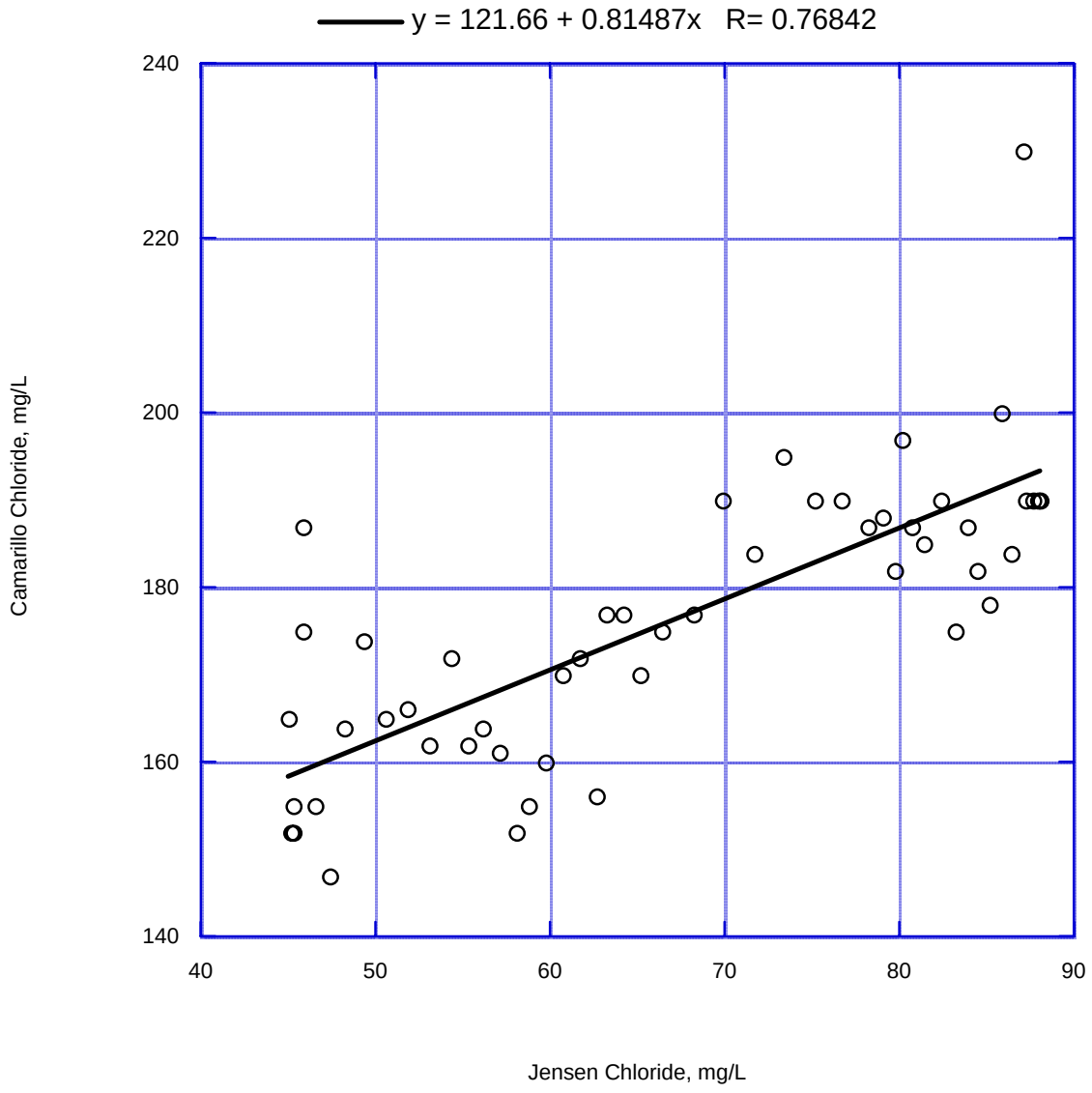


Figure 116. Camarillo Effluent Chloride vs. Jensen Plant Chloride

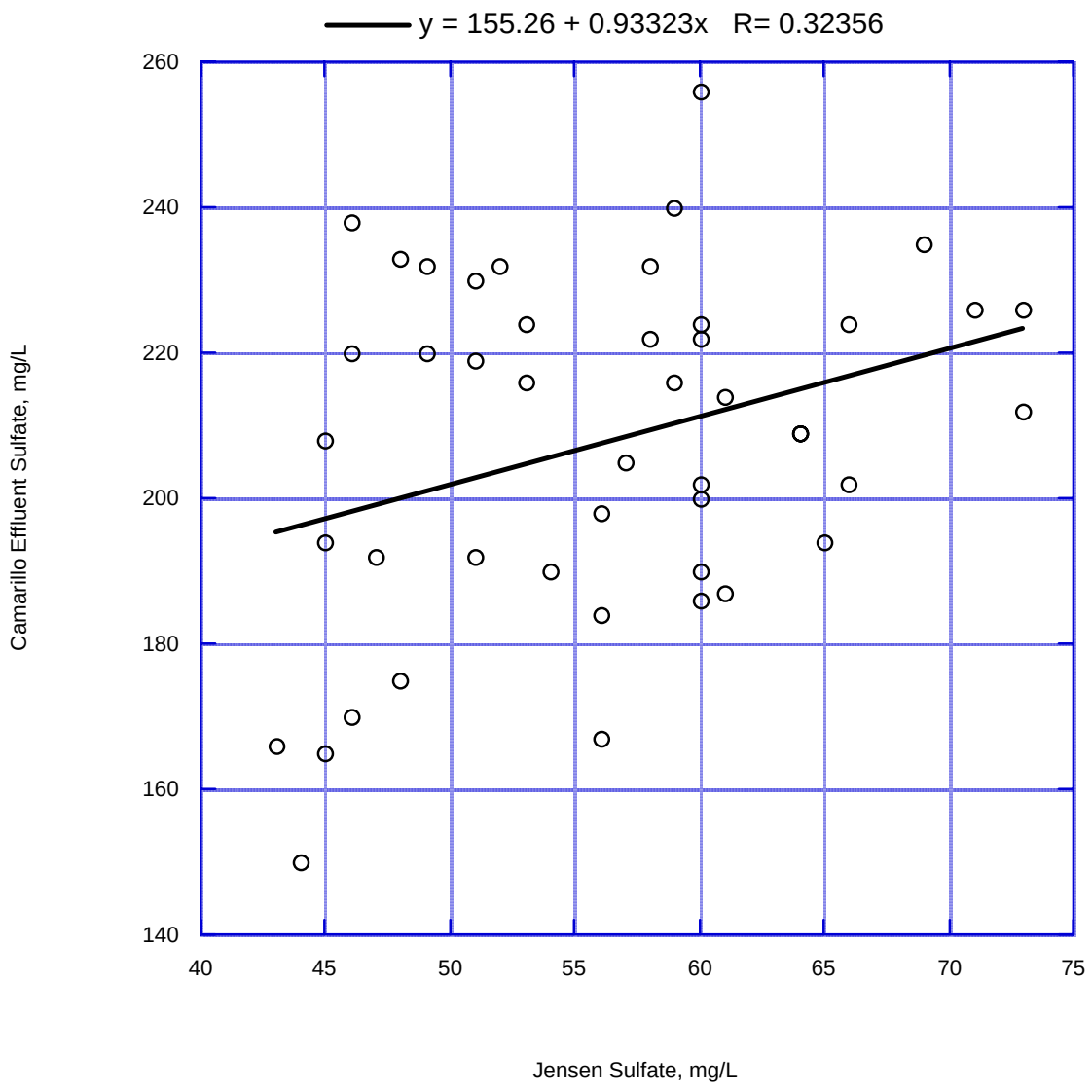


Figure 117. Camarillo Effluent Sulfate vs. Jensen Plant Sulfate

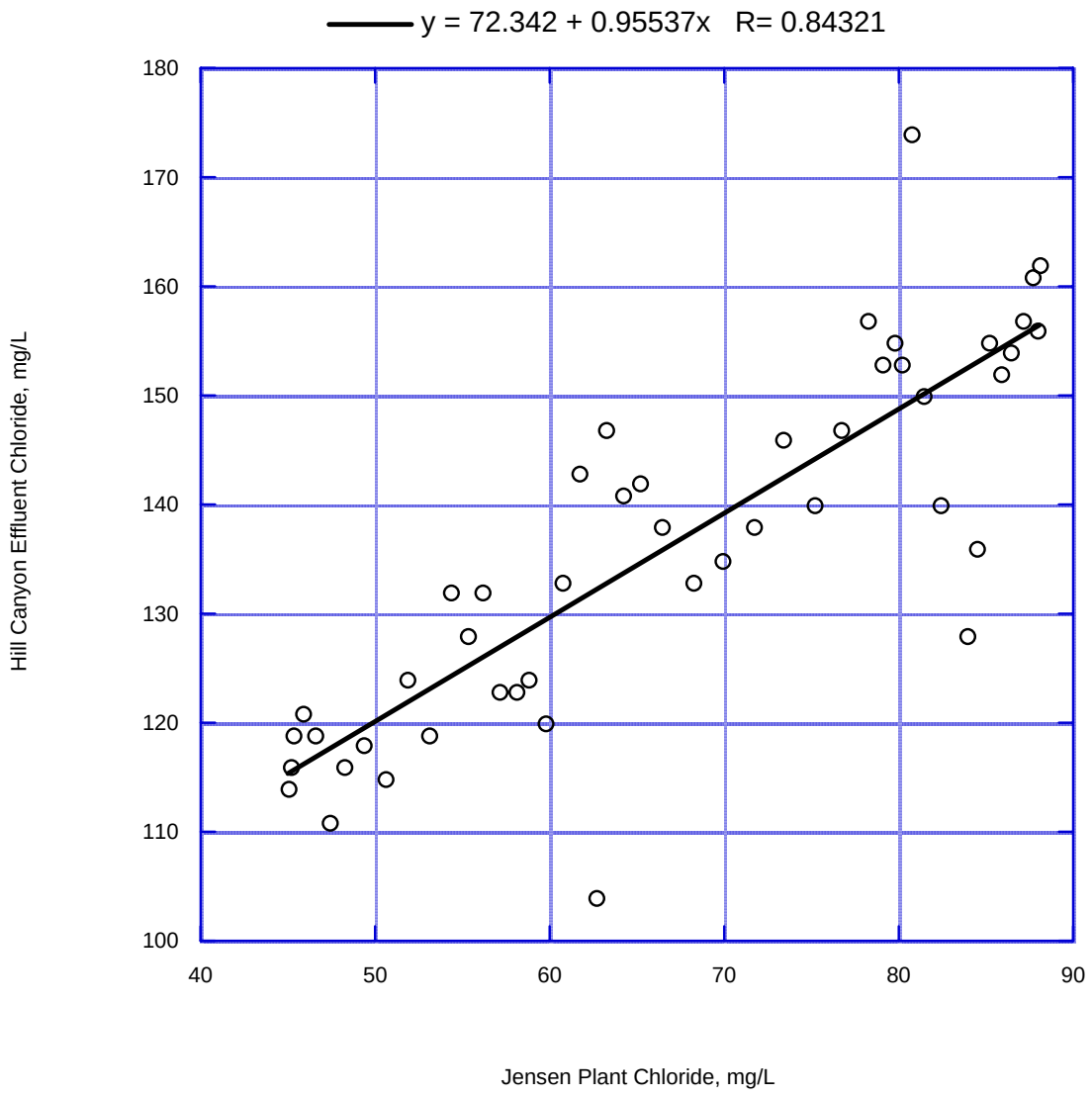


Figure 118. Hill Canyon Effluent Chloride vs. Jensen Plant Chloride

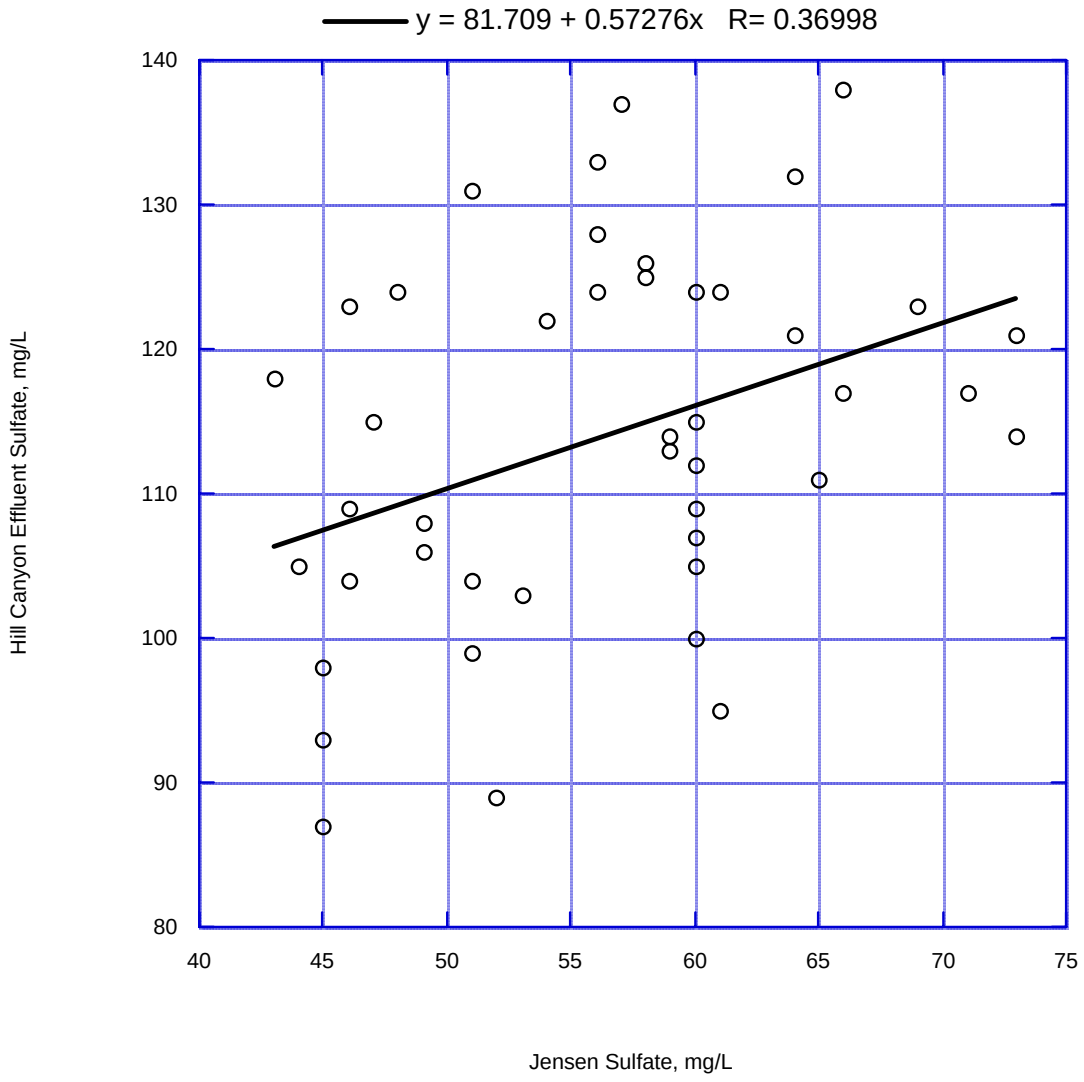


Figure 119. Hill Canyon Effluent Sulfate vs. Jensen Plant Sulfate

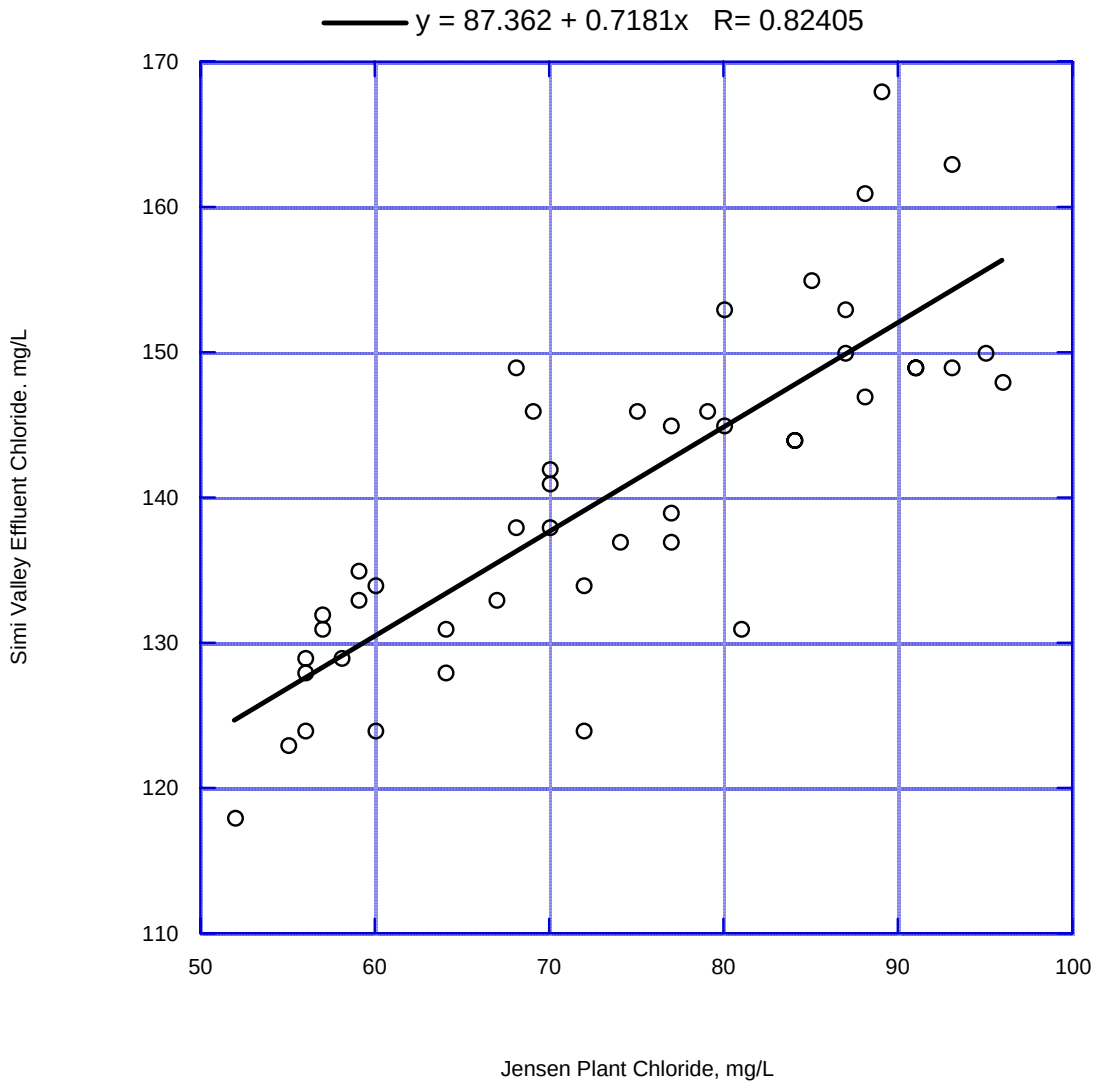


Figure 120. Simi Valley Effluent Chloride vs. Jensen Plant Chloride

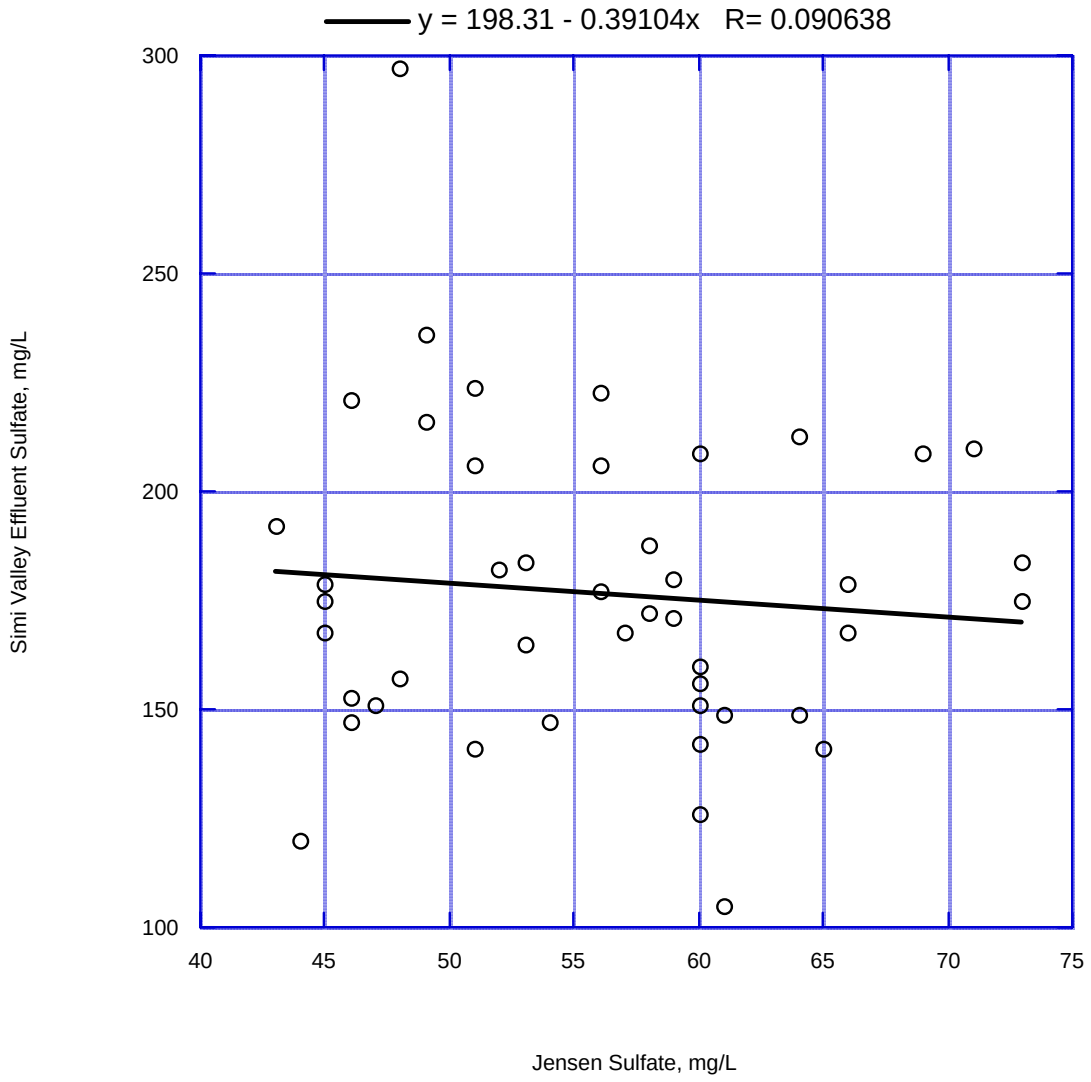


Figure 121. Simi Valley Effluent Sulfate vs. Jensen Plant Sulfate

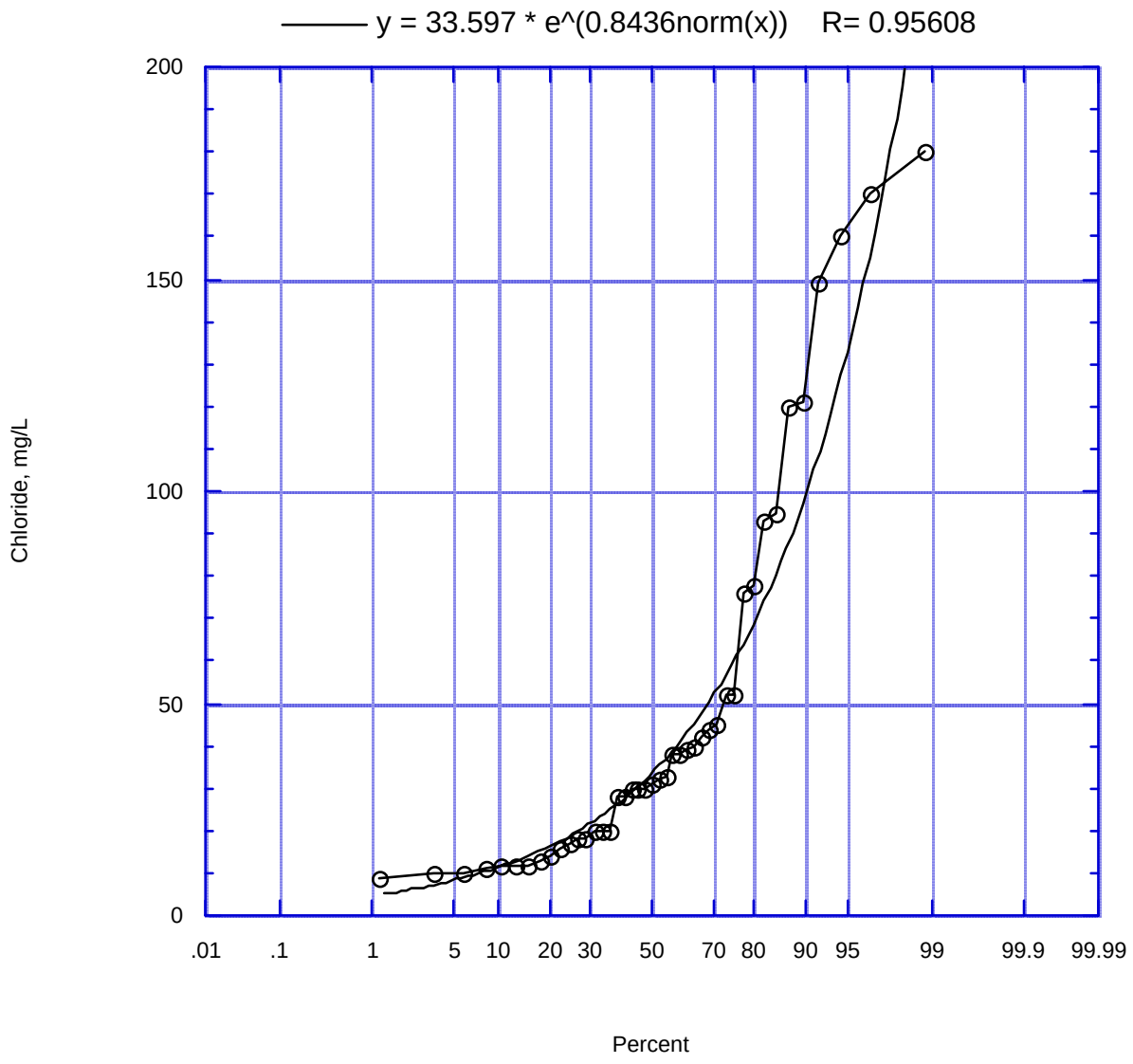


Figure 122. Frequency Distribution of Chloride in Stormwater Runoff form Agricutural Land Use

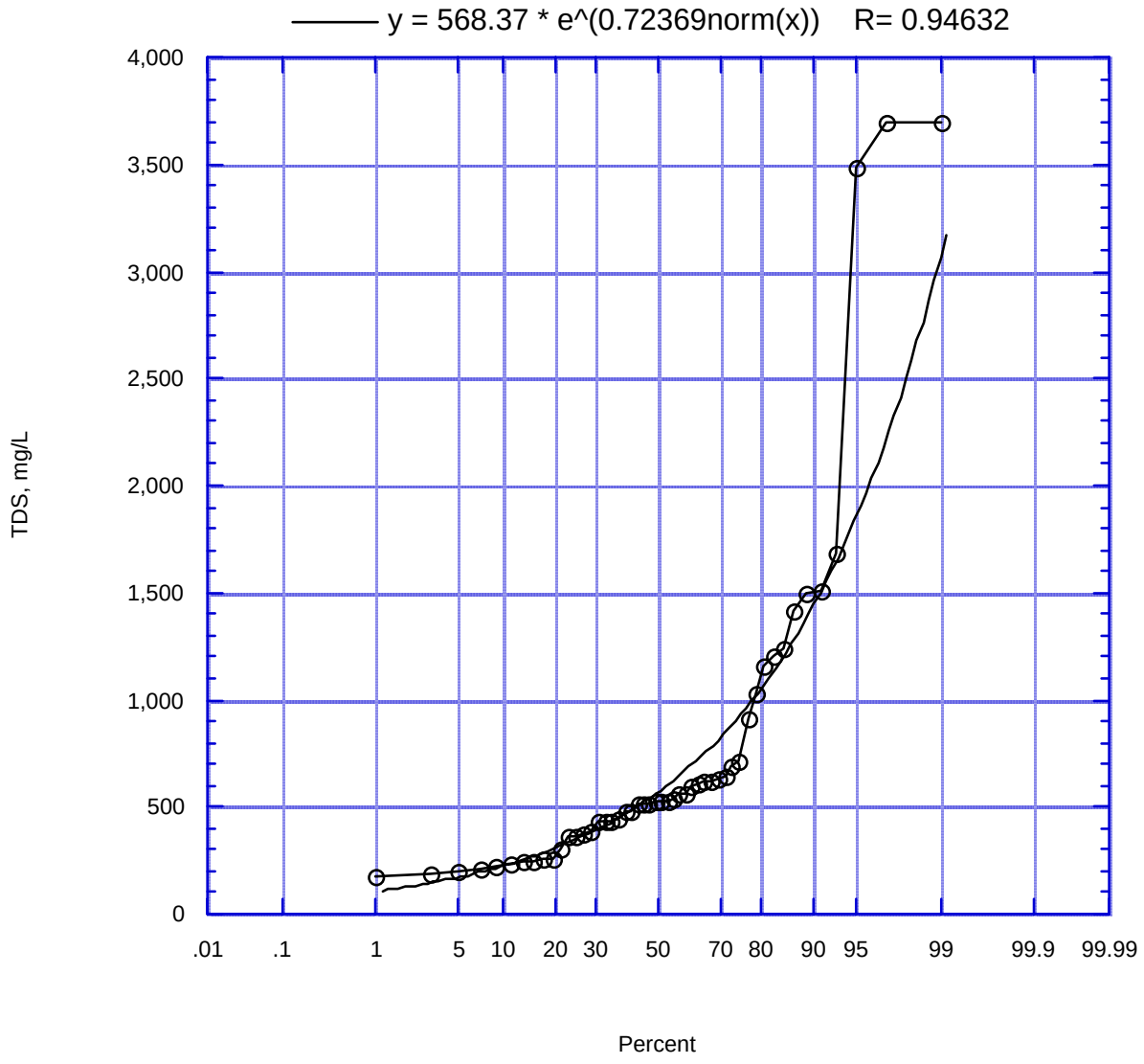


Figure 123. Frequency Distribution of TDS in Stormwater Runoff form Agricutural Land Use

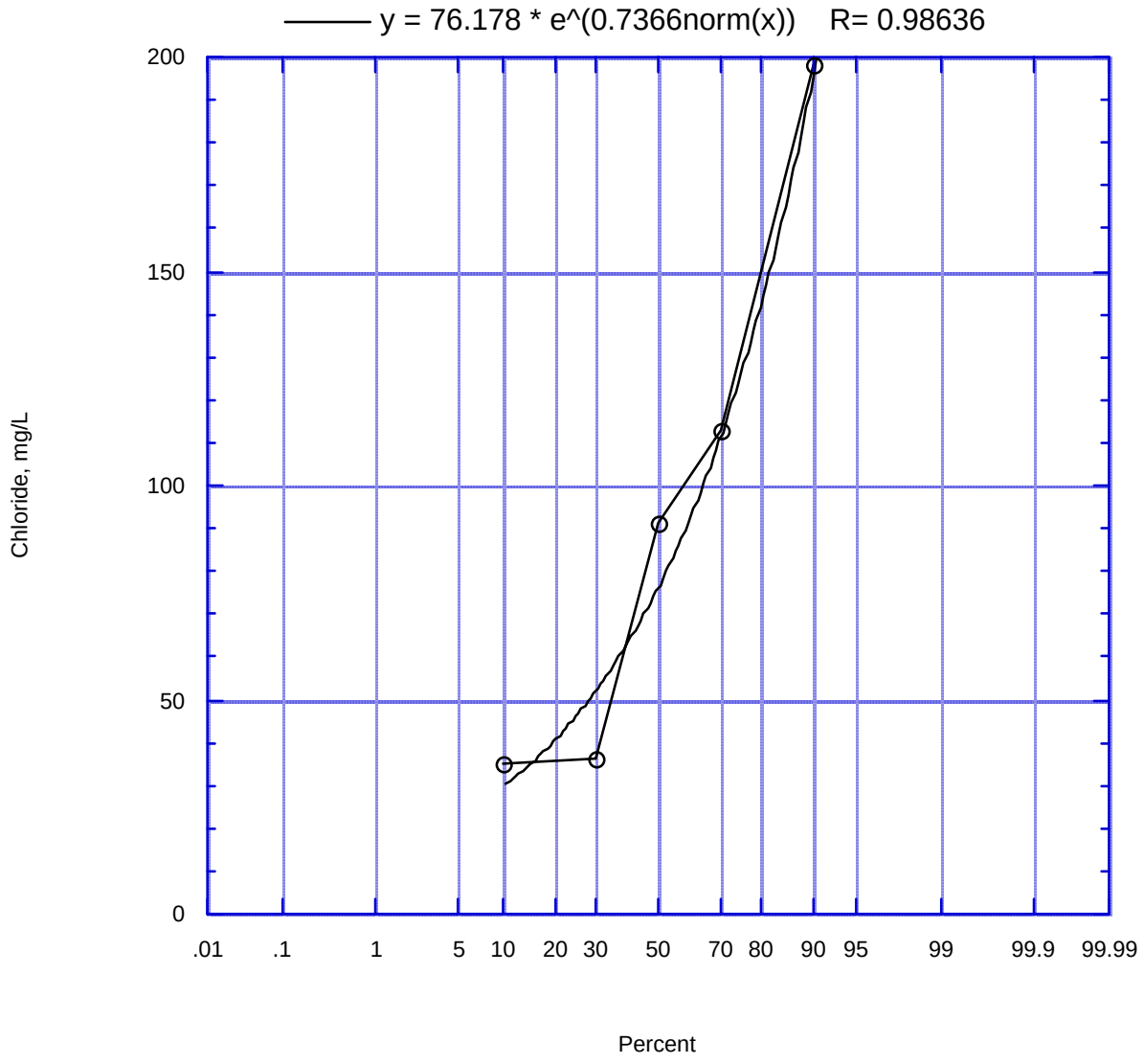


Figure 124. Frequency Distribution of Chloride in Stormwater Runoff form Open Space Land Use

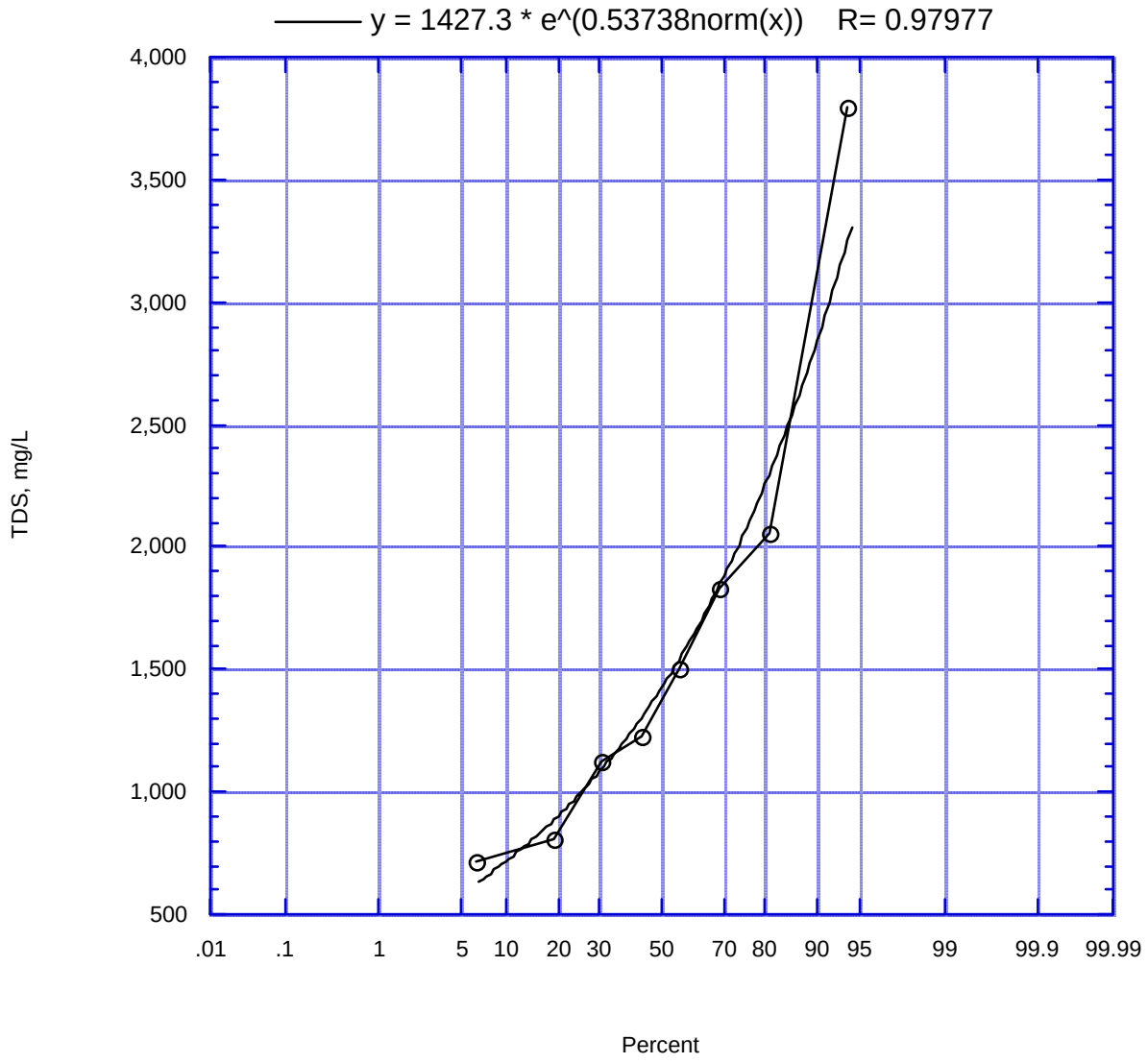


Figure 125. Frequency Distribution of TDS in Stormwater Runoff form Open Space Land Use

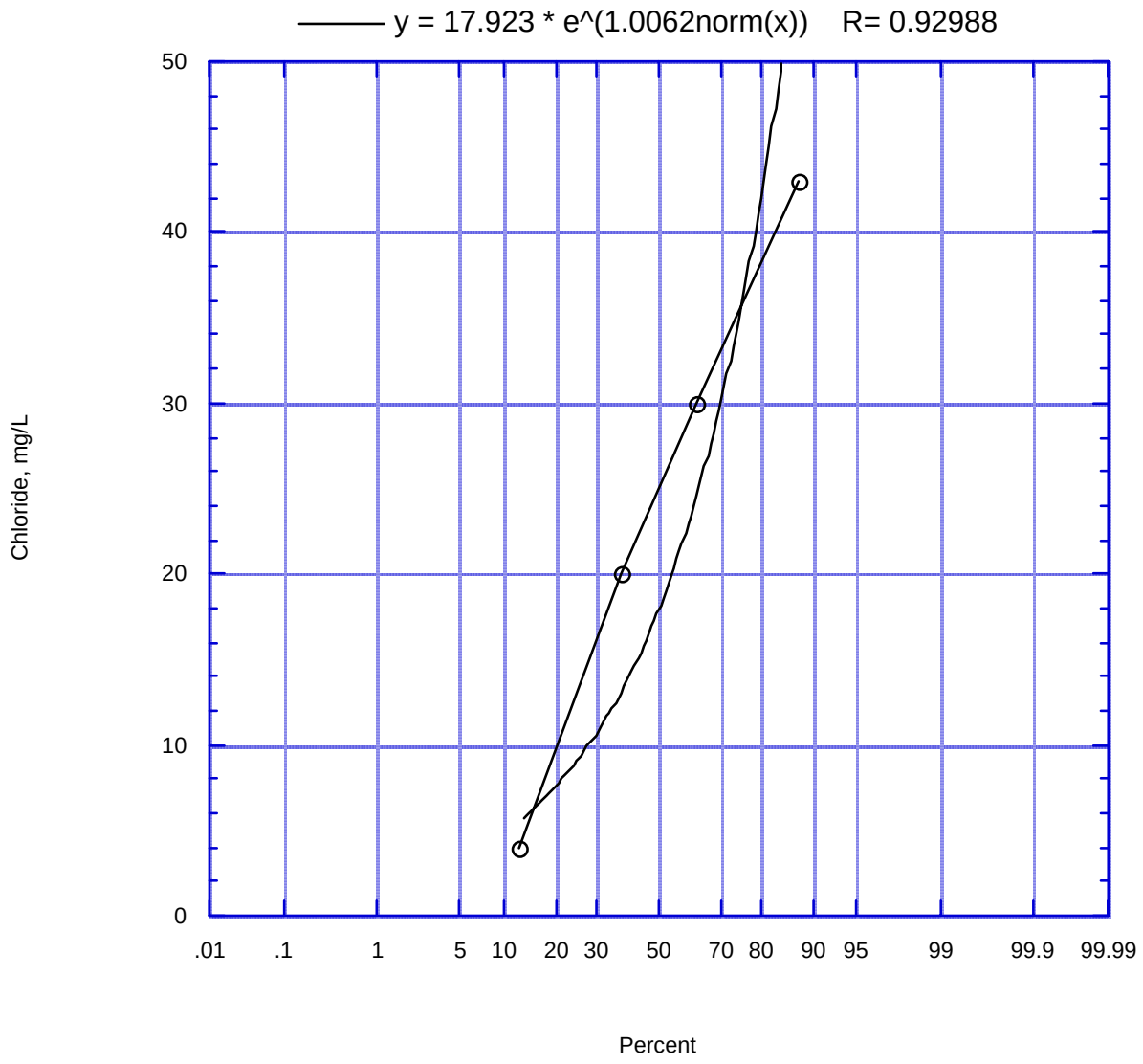


Figure 126. Frequency Distribution of Chloride in Stormwater Runoff form Industrial Land Use

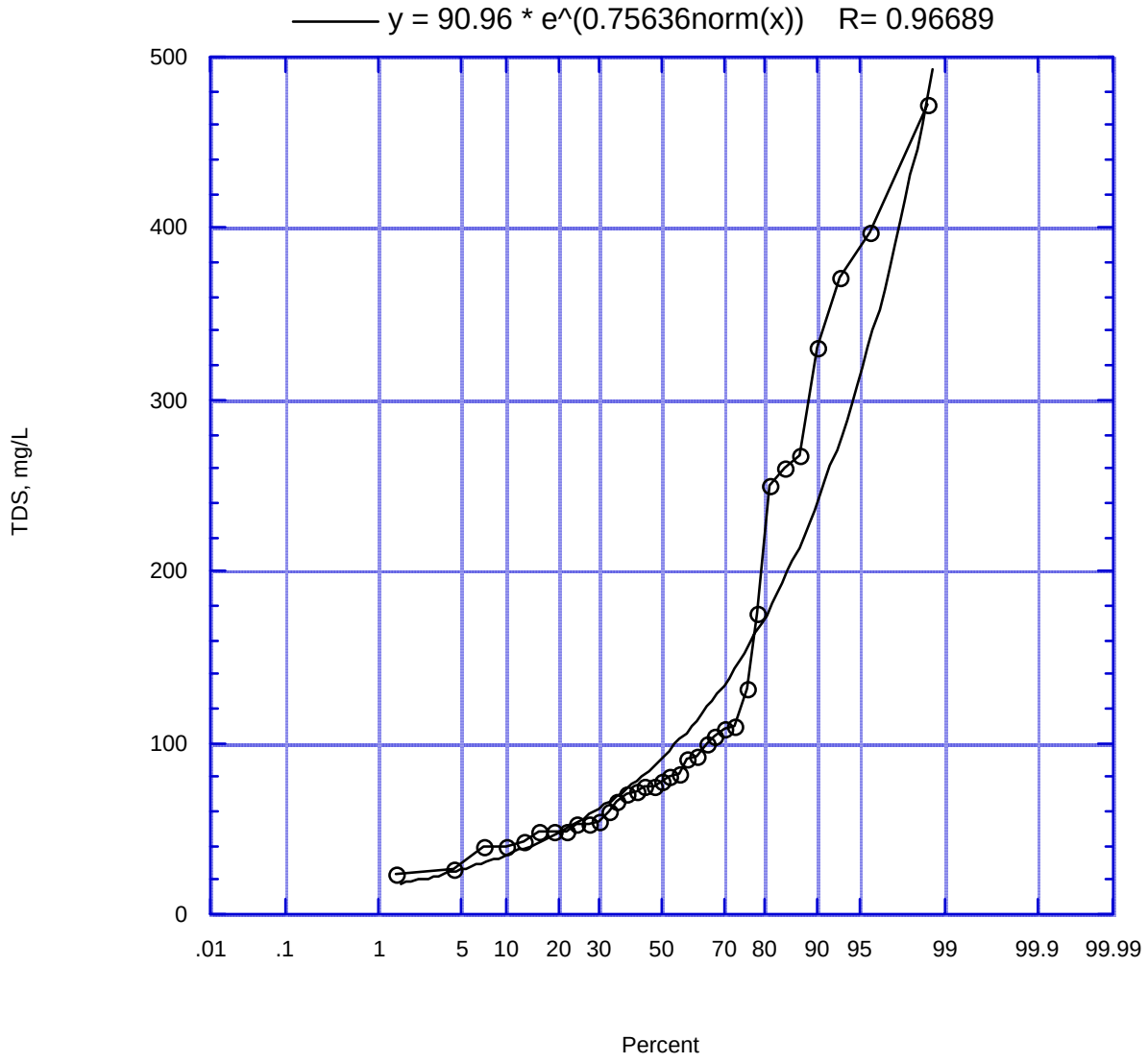


Figure 127. Frequency Distribution of TDS in Stormwater Runoff form Industrial Land Use

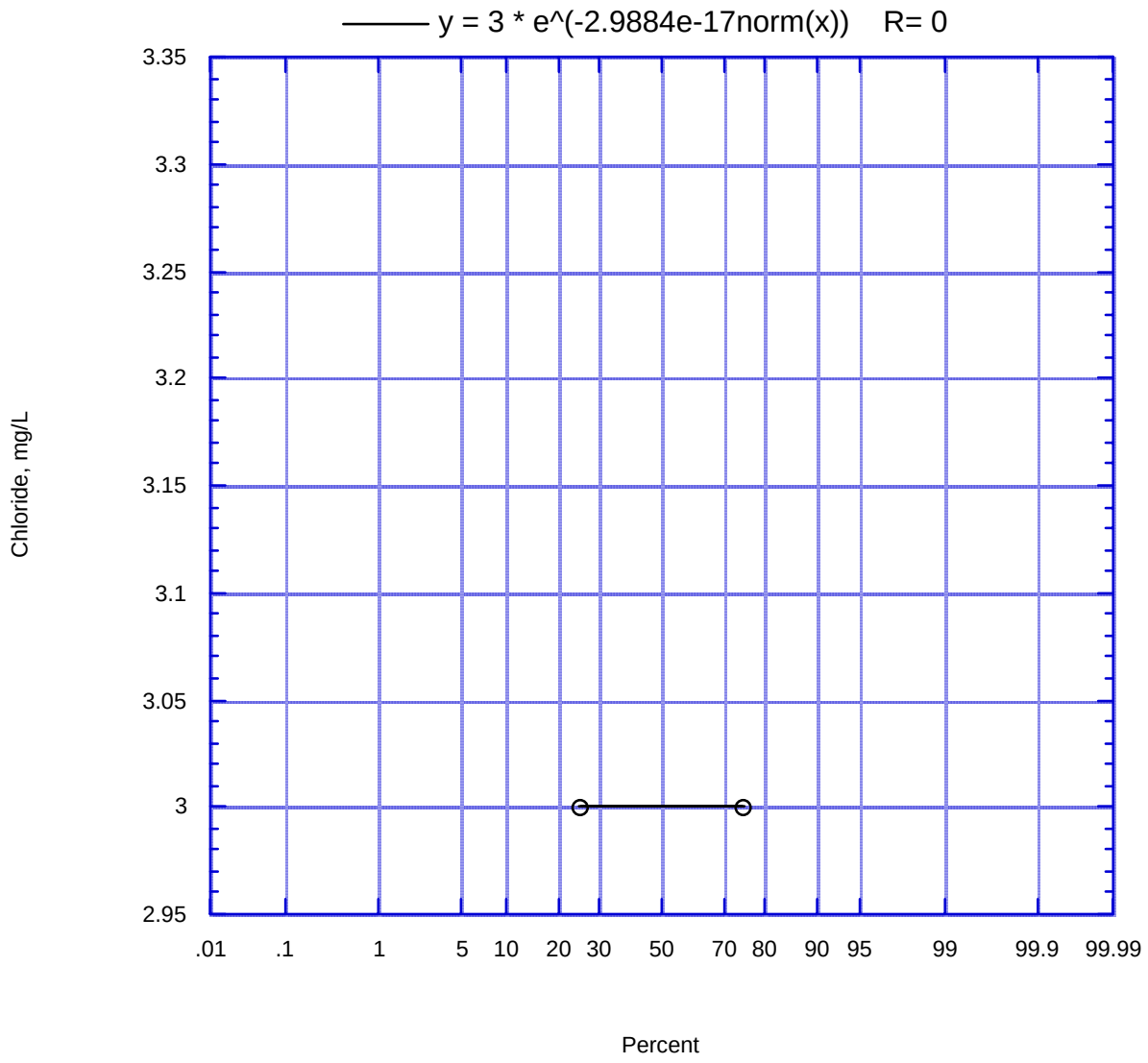


Figure 128. Frequency Distribution of Chloride in Stormwater Runoff form Commercial Land Use

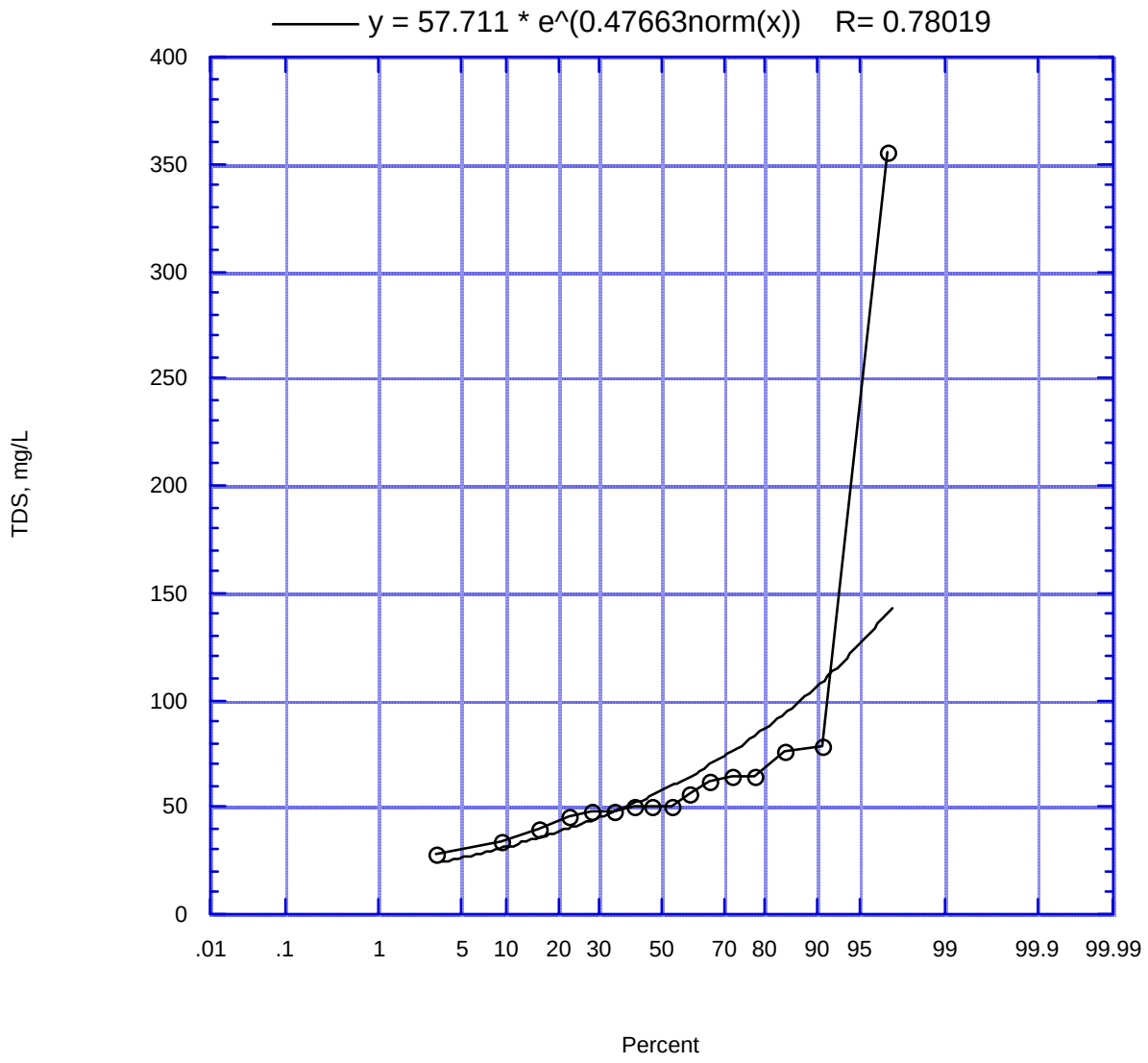


Figure 129. Frequency Distribution of TDS in Stormwater Runoff form Commercial Land Use

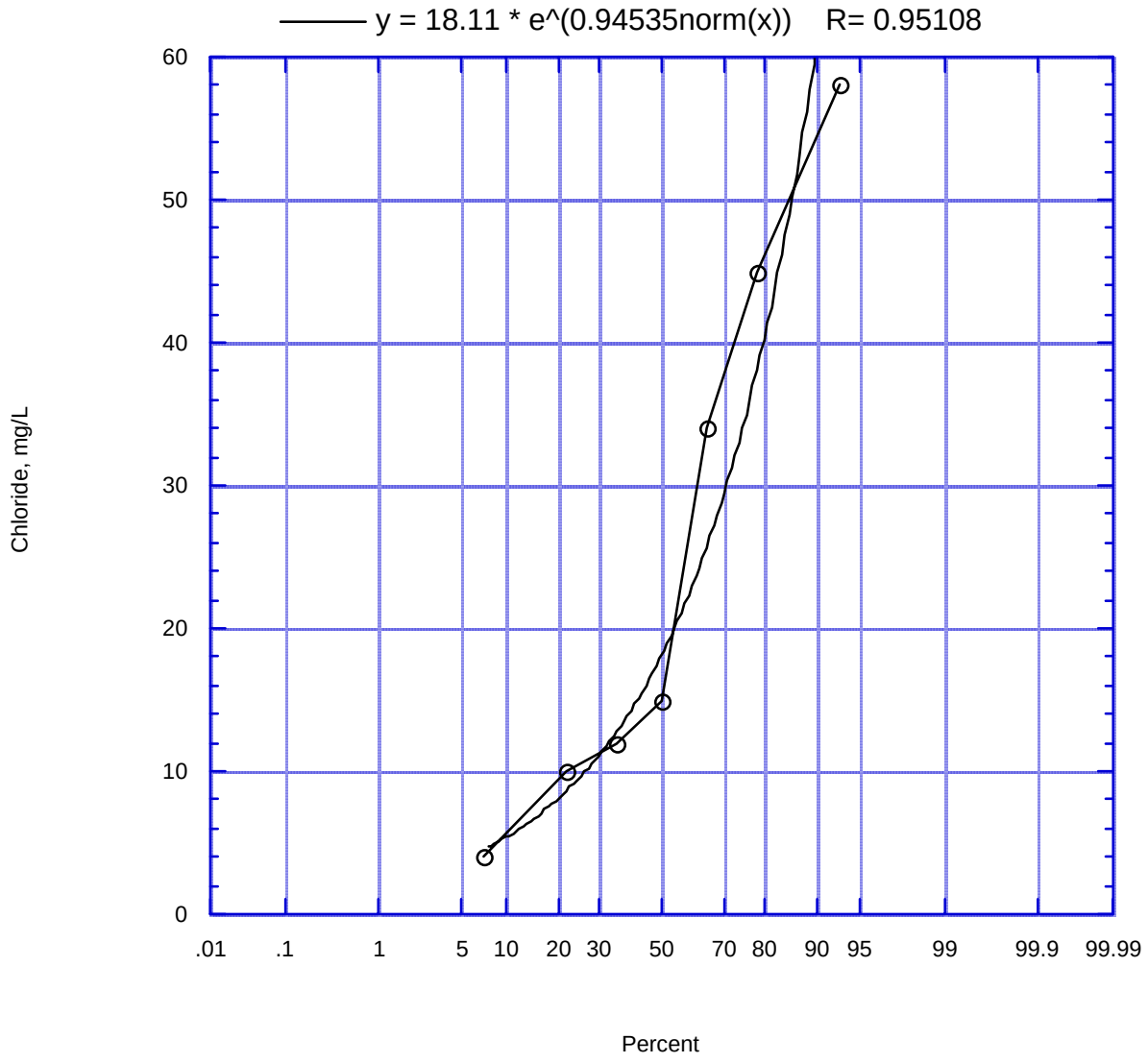


Figure 130. Frequency Distribution of Chloride in Stormwater Runoff form Residential Land Use

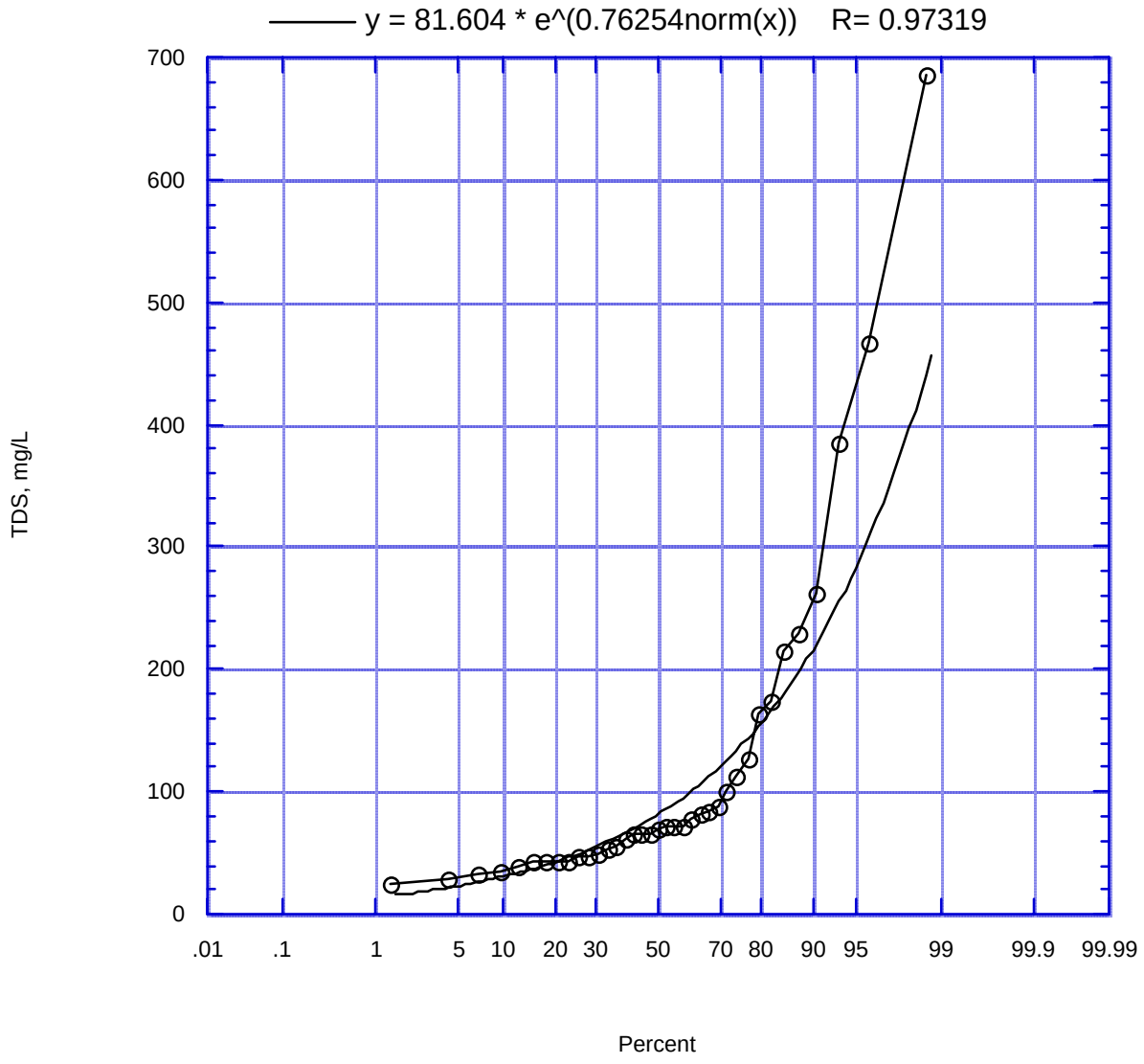


Figure 131. Frequency Distribution of TDS in Stormwater Runoff form Residential Land Use

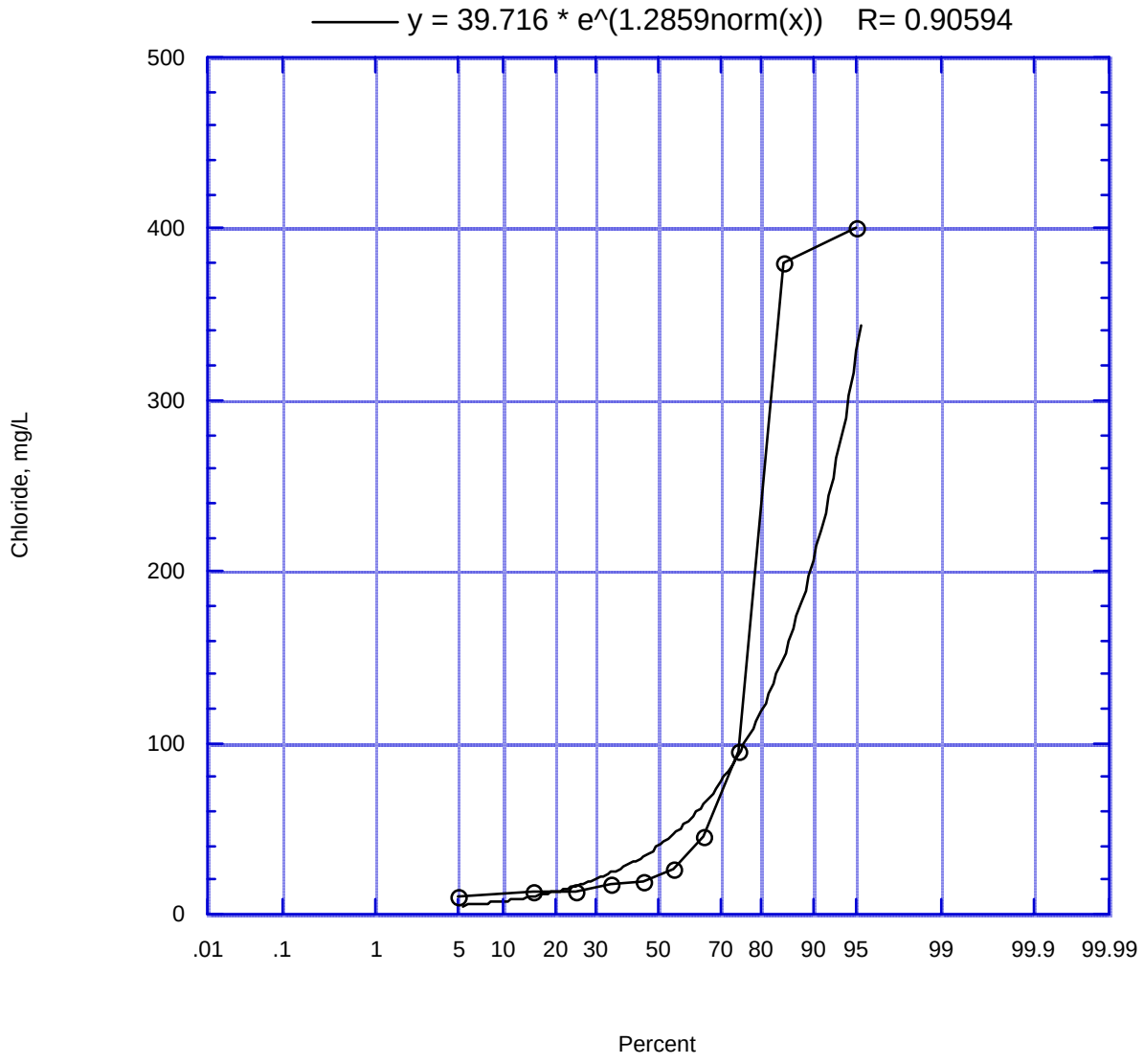


Figure 132. Frequency Distribution of Chloride in Stormwater Runoff form Mixed-use Land Use

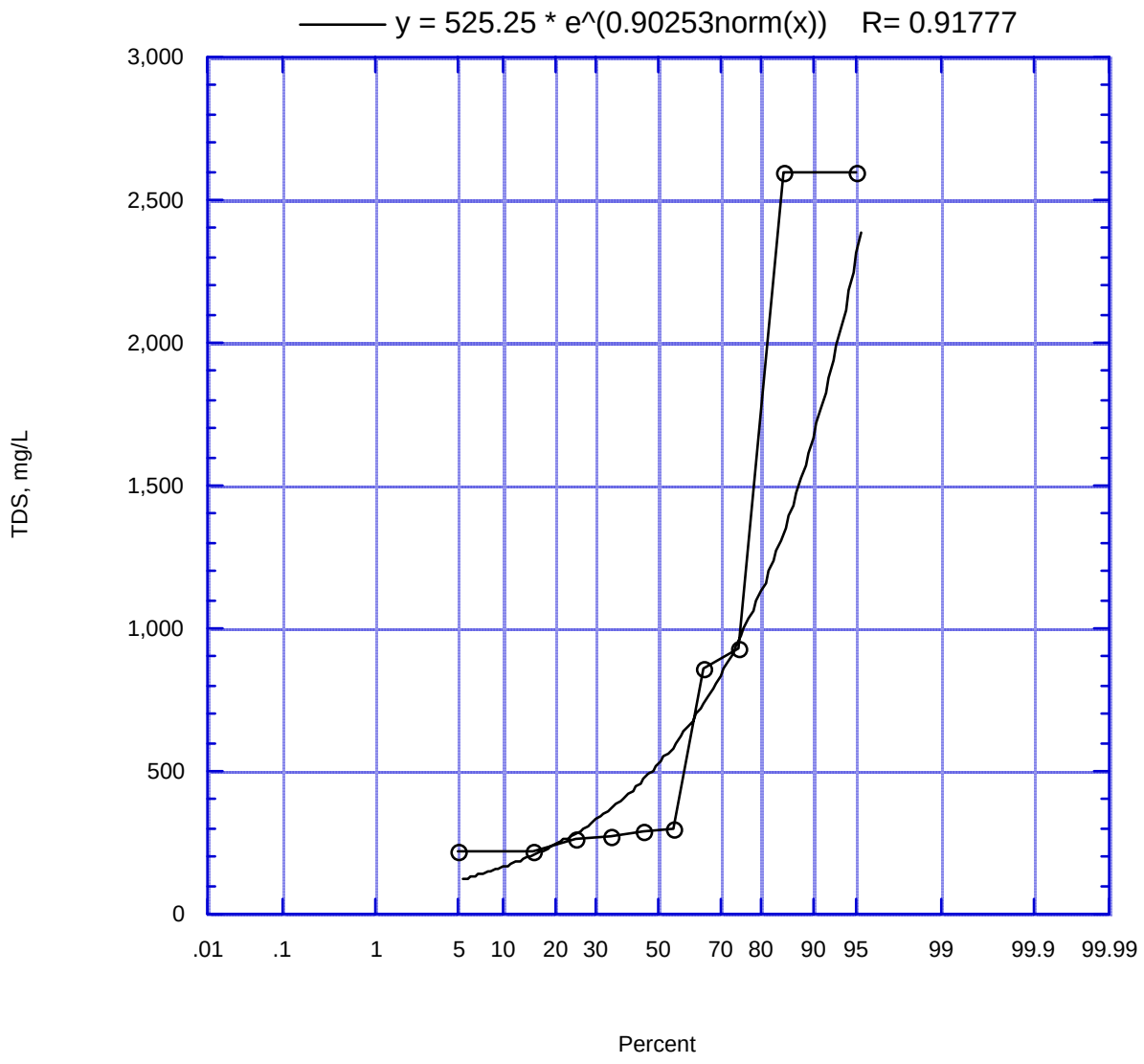


Figure 133. Frequency Distribution of TDS in Stormwater Runoff form Mixed-use Land Use

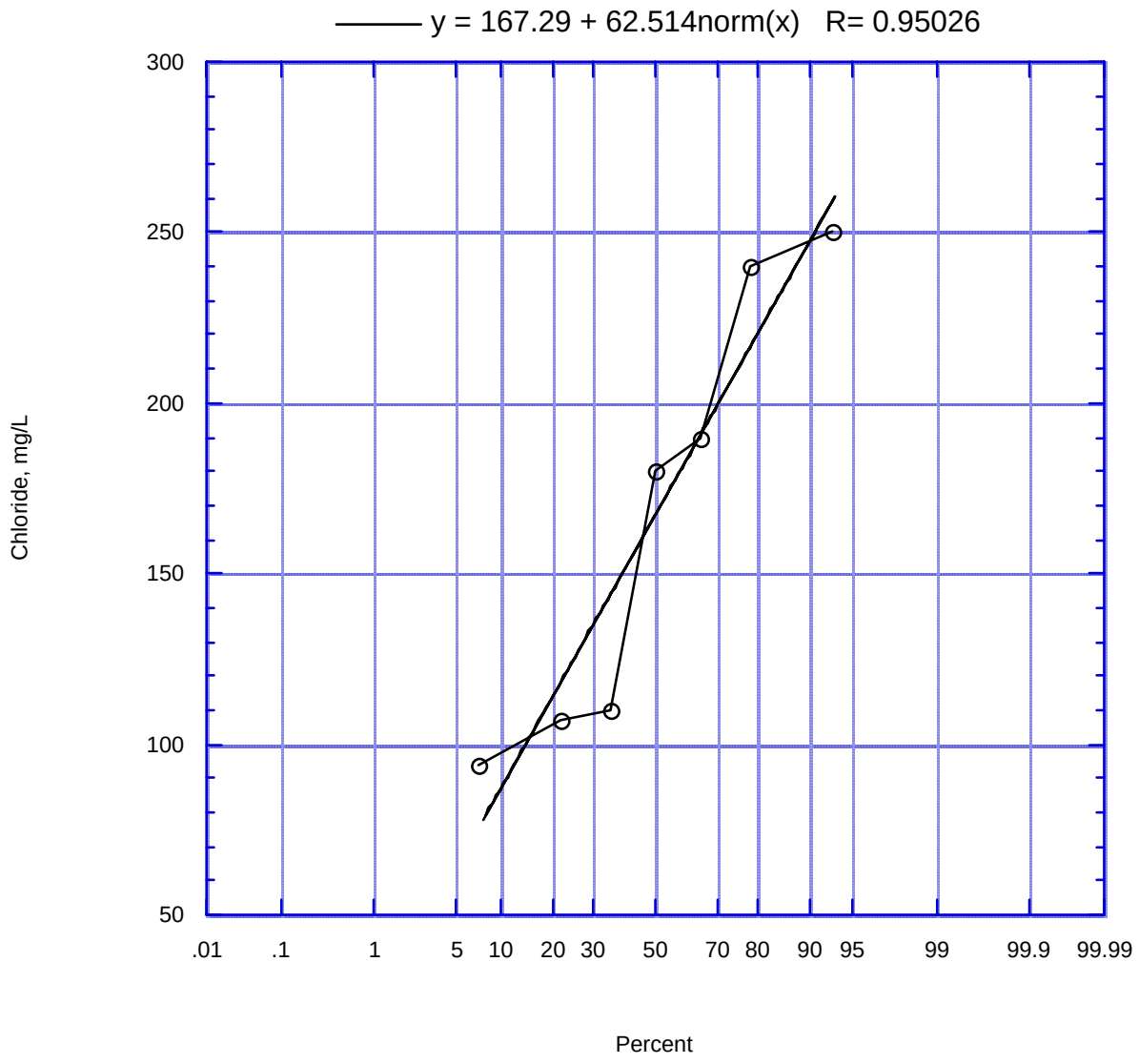


Figure 134. Frequency Distribution of Chloride in Non-stormwater Runoff form Agricutural Land Use

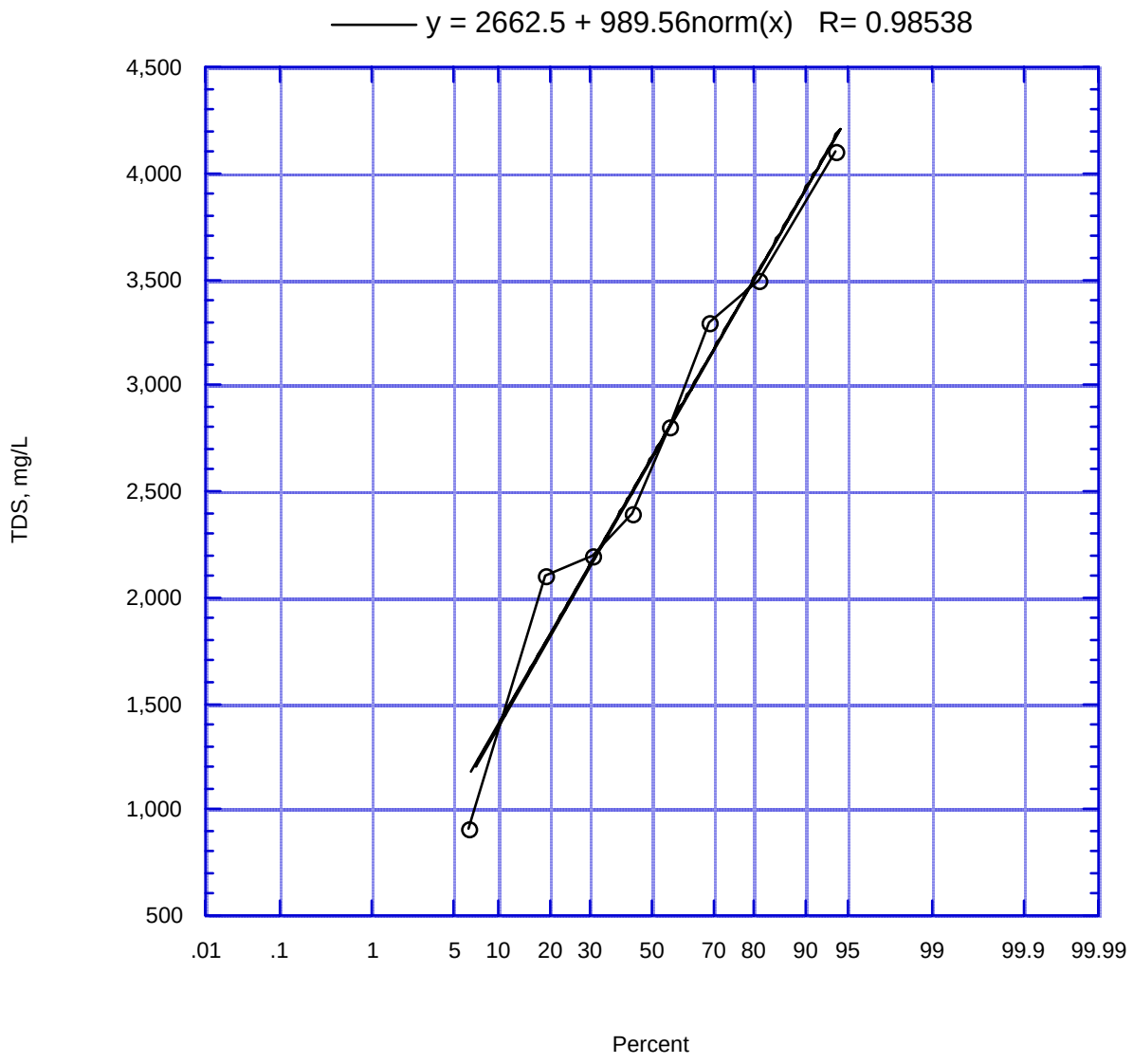


Figure 135. Frequency Distribution of TDS in Non-stormwater Runoff form Agricutural Land Use

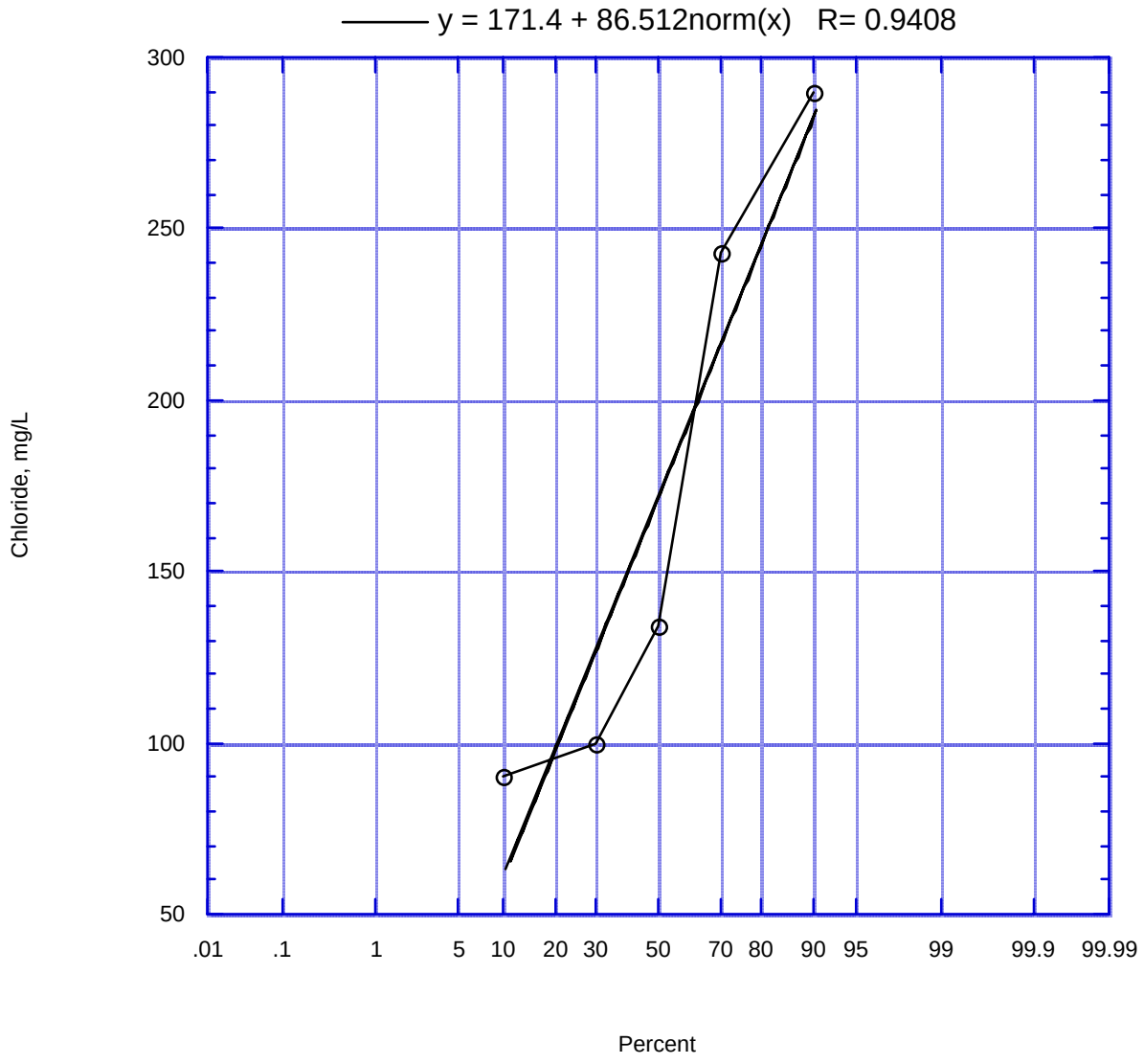


Figure 136. Frequency Distribution of Chloride in Non-stormwater Runoff form Open Space Use

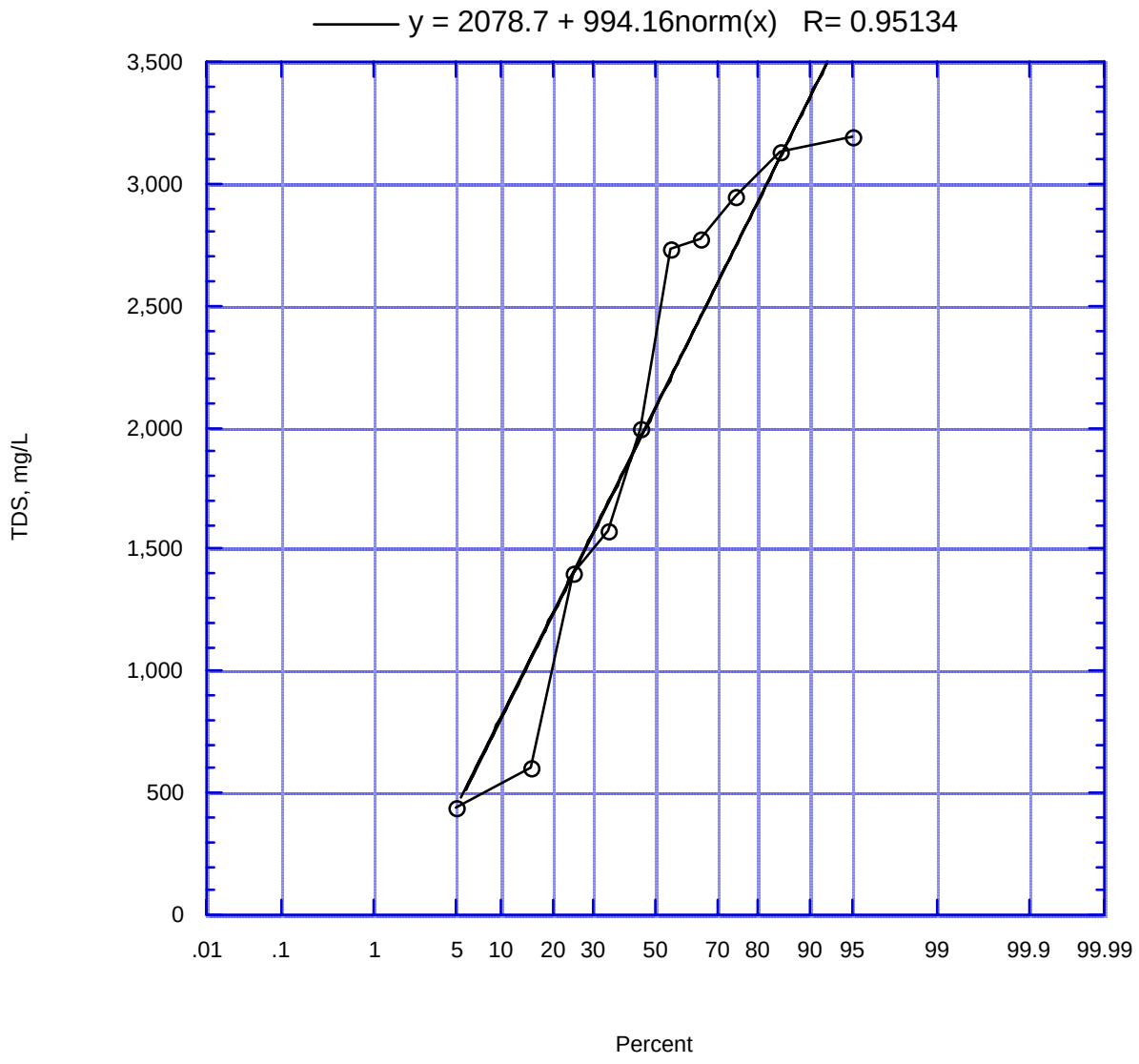


Figure 137. Frequency Distribution of TDS in Non-stormwater Runoff form Open Space Use

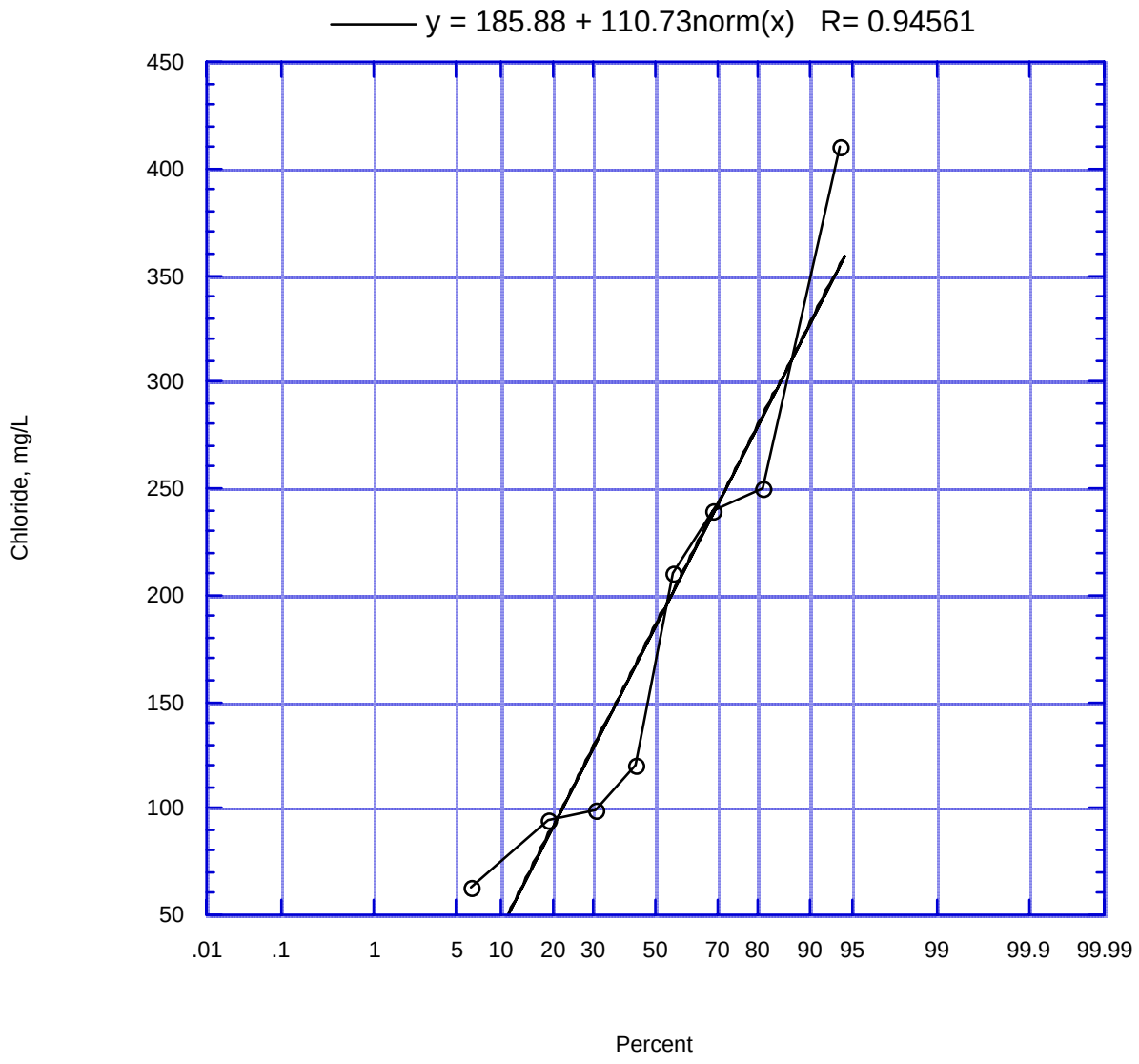


Figure 138. Frequency Distribution of Chloride in Non-stormwater Runoff form Mixed-use Use

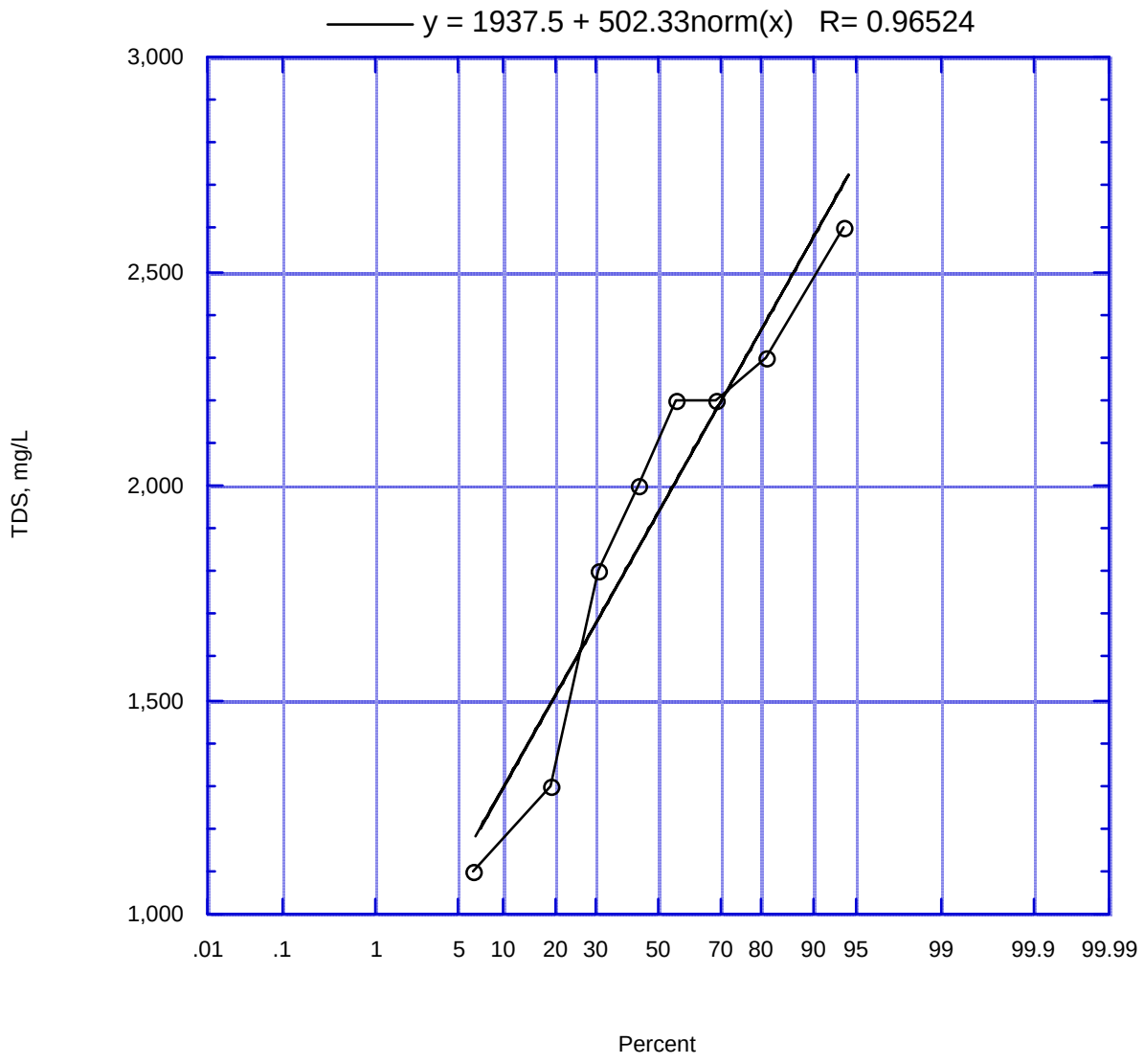


Figure 139. Frequency Distribution of TDS in Non-stormwater Runoff form Mixed-use Use

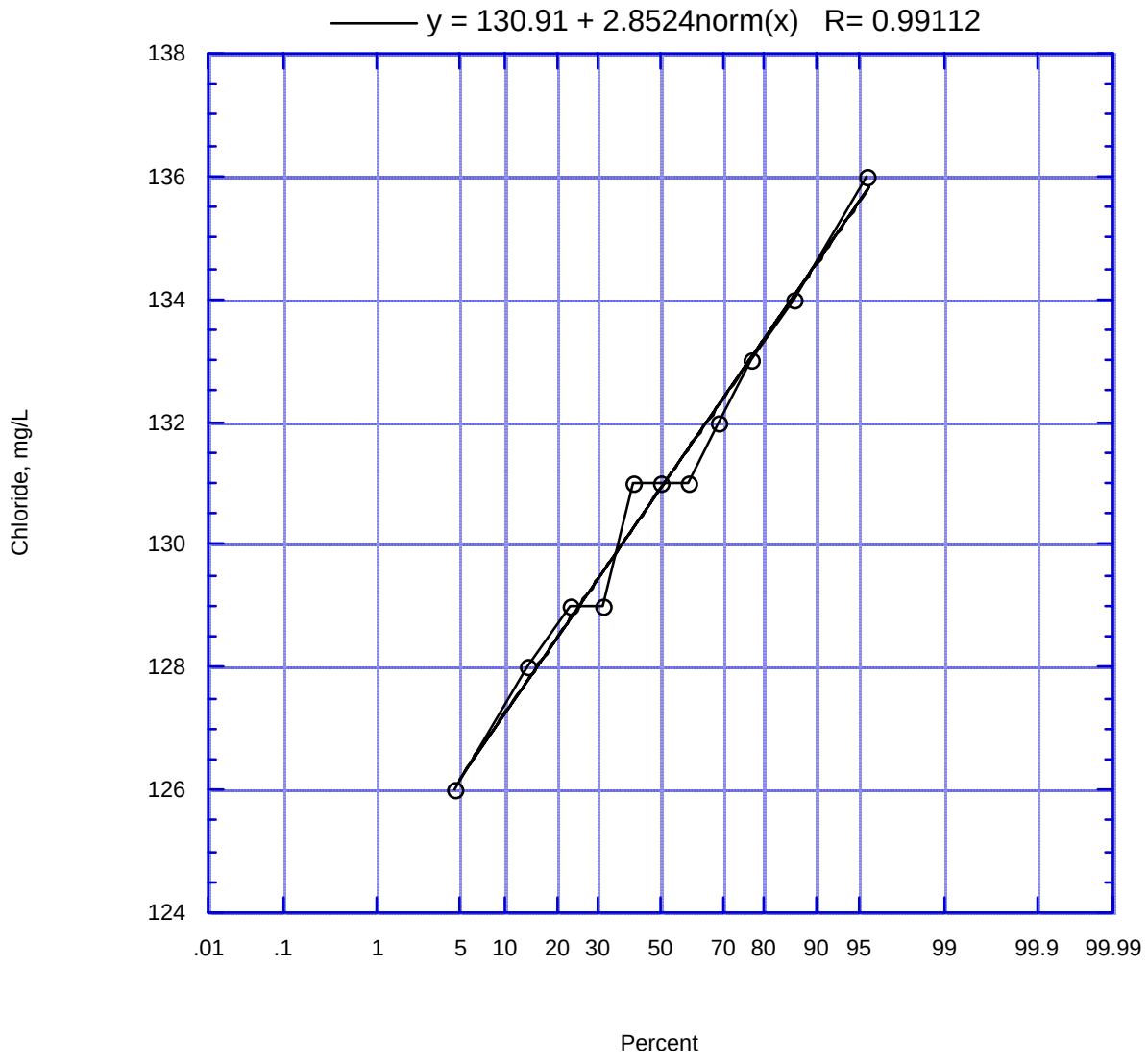


Figure 140. Frequency Distribution of Chloride in Pumped Groundwater Discharge

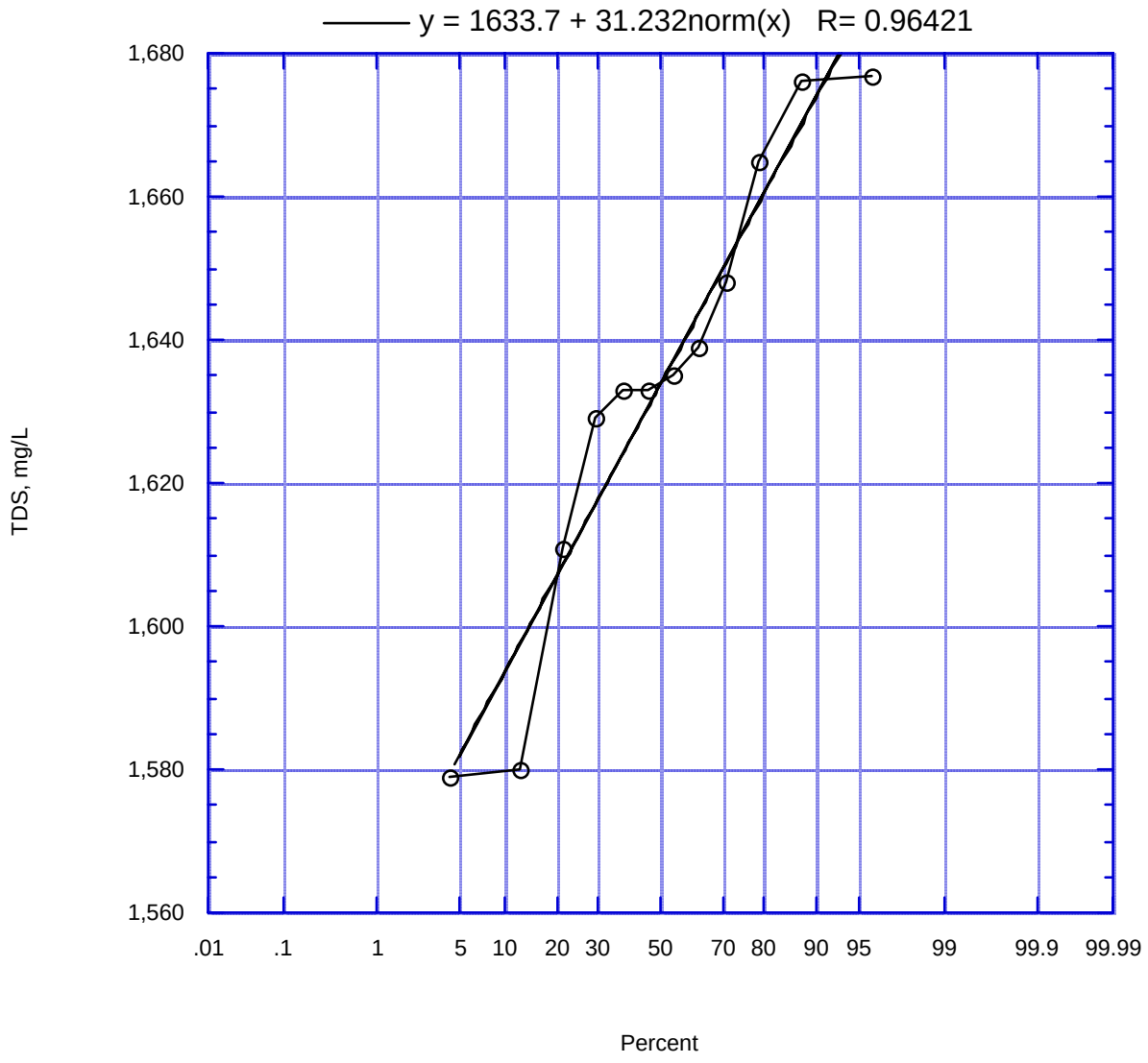


Figure 141. Frequency Distribution of TDS in Pumped Groundwater Discharge

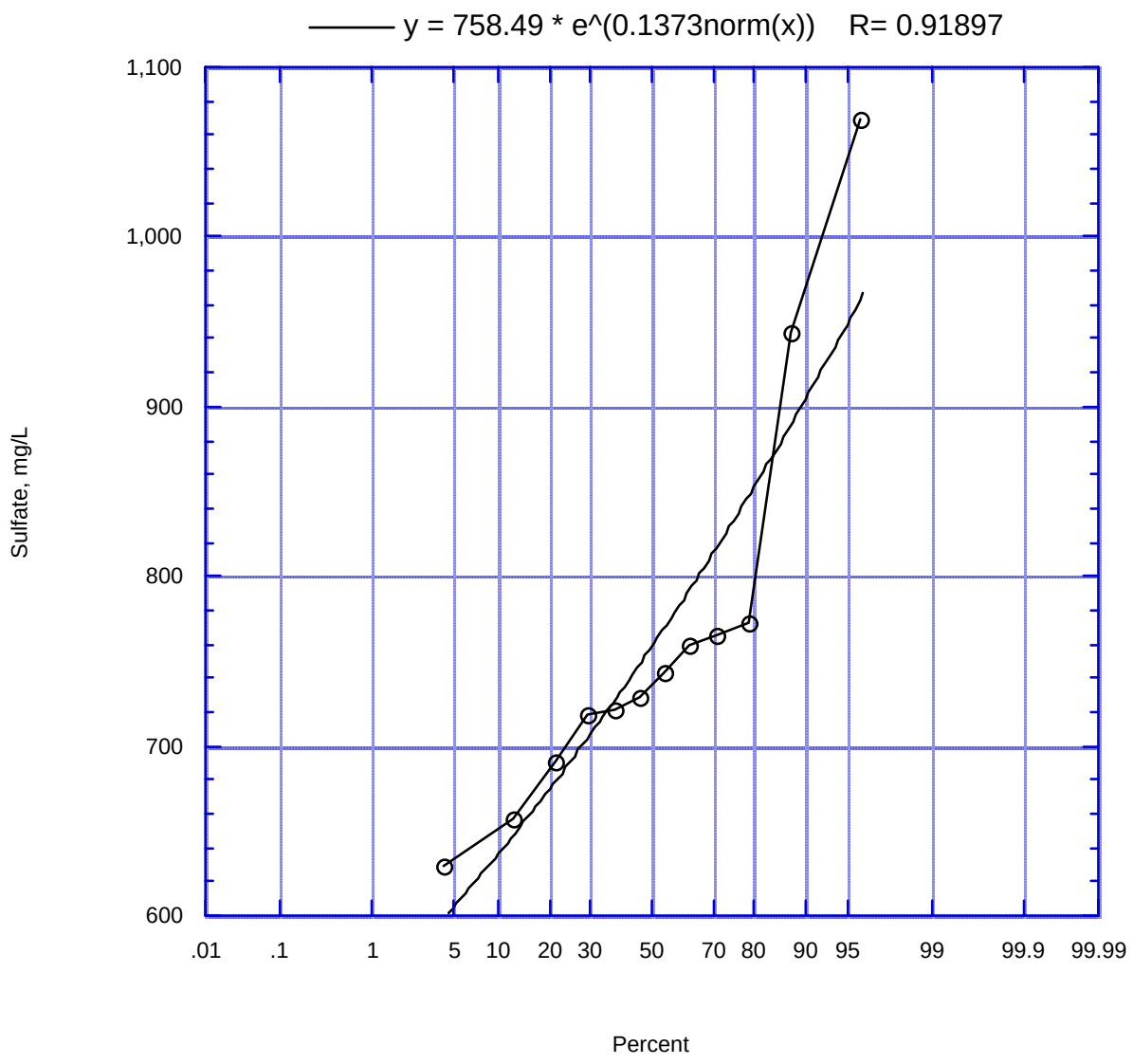


Figure 142. Frequency Distribution of Sulfate in Pumped Groundwater Discharge

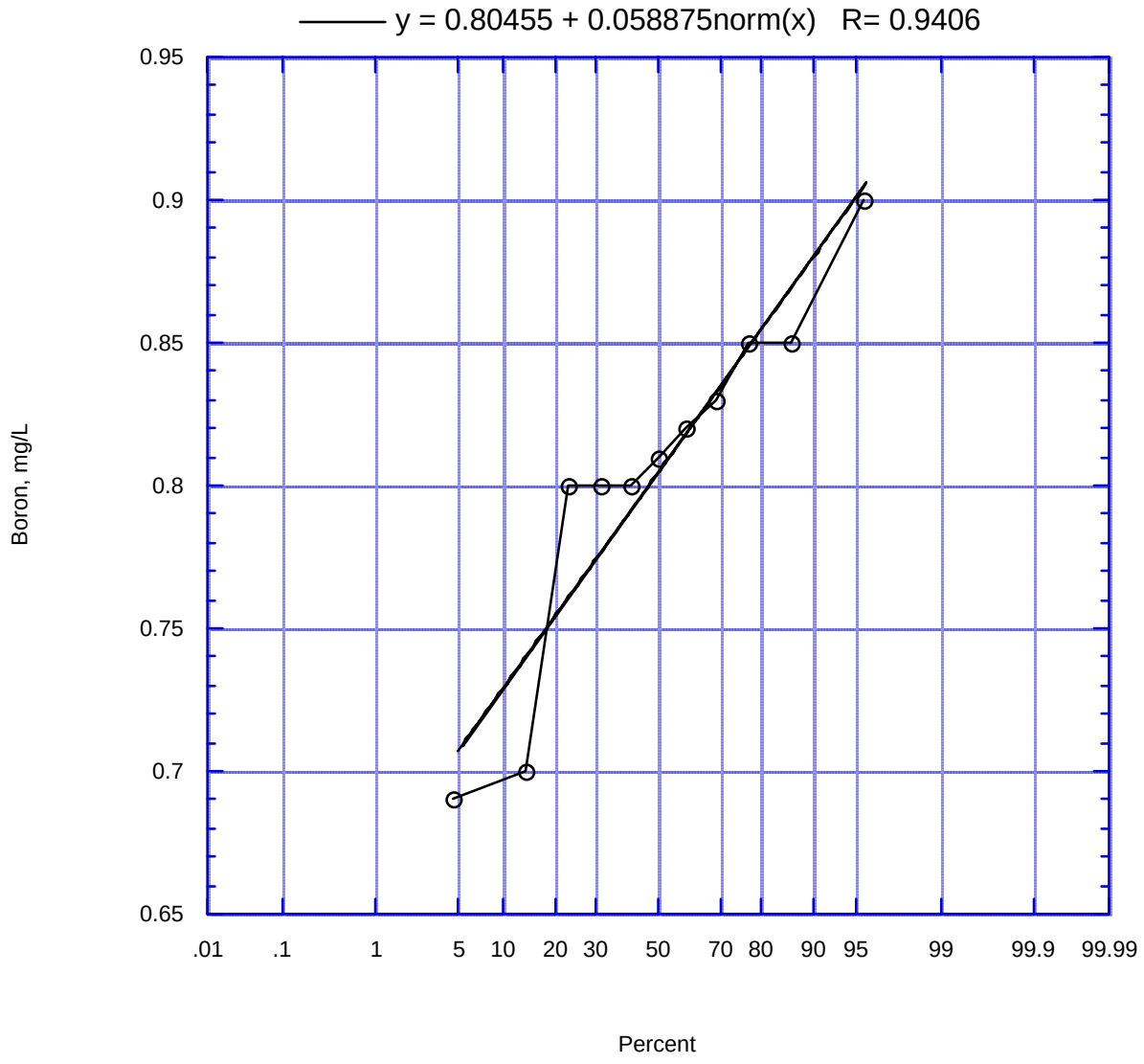


Figure 143. Frequency Distribution of Boron in Pumped Groundwater Discharge

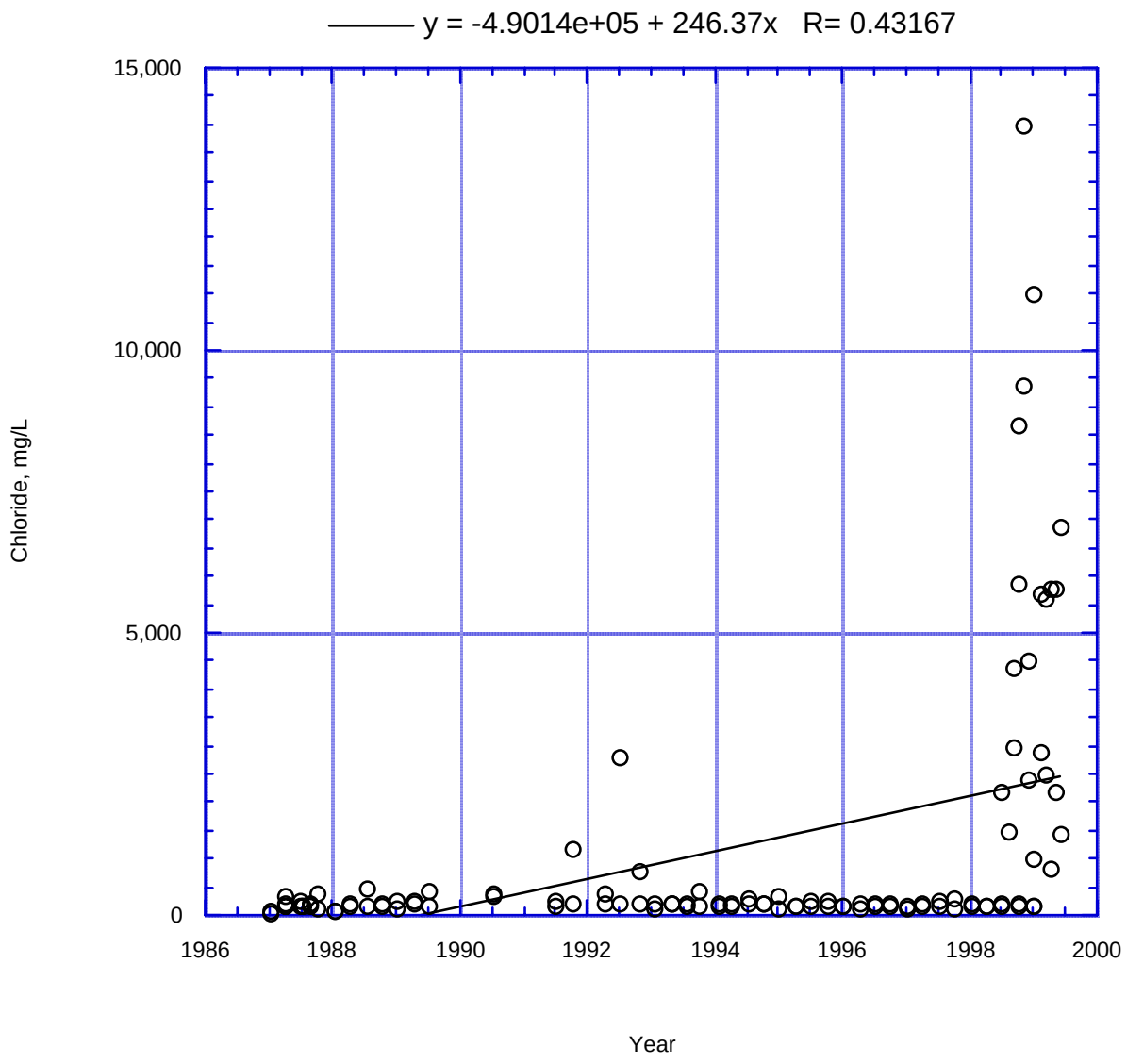


Figure 144. Reach 2 Chloride vs. Time

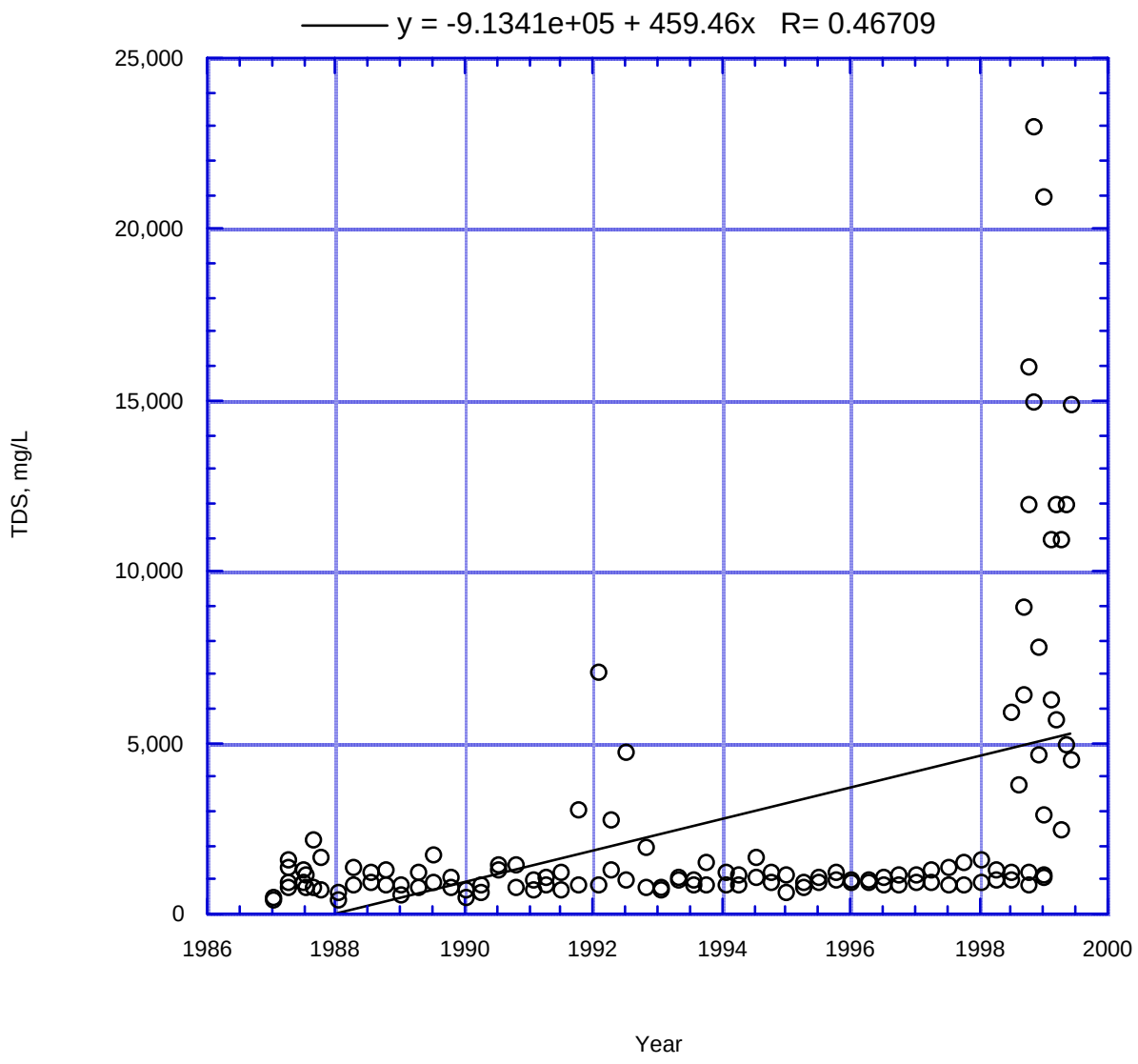


Figure 145. Reach 2 TDS vs. Time

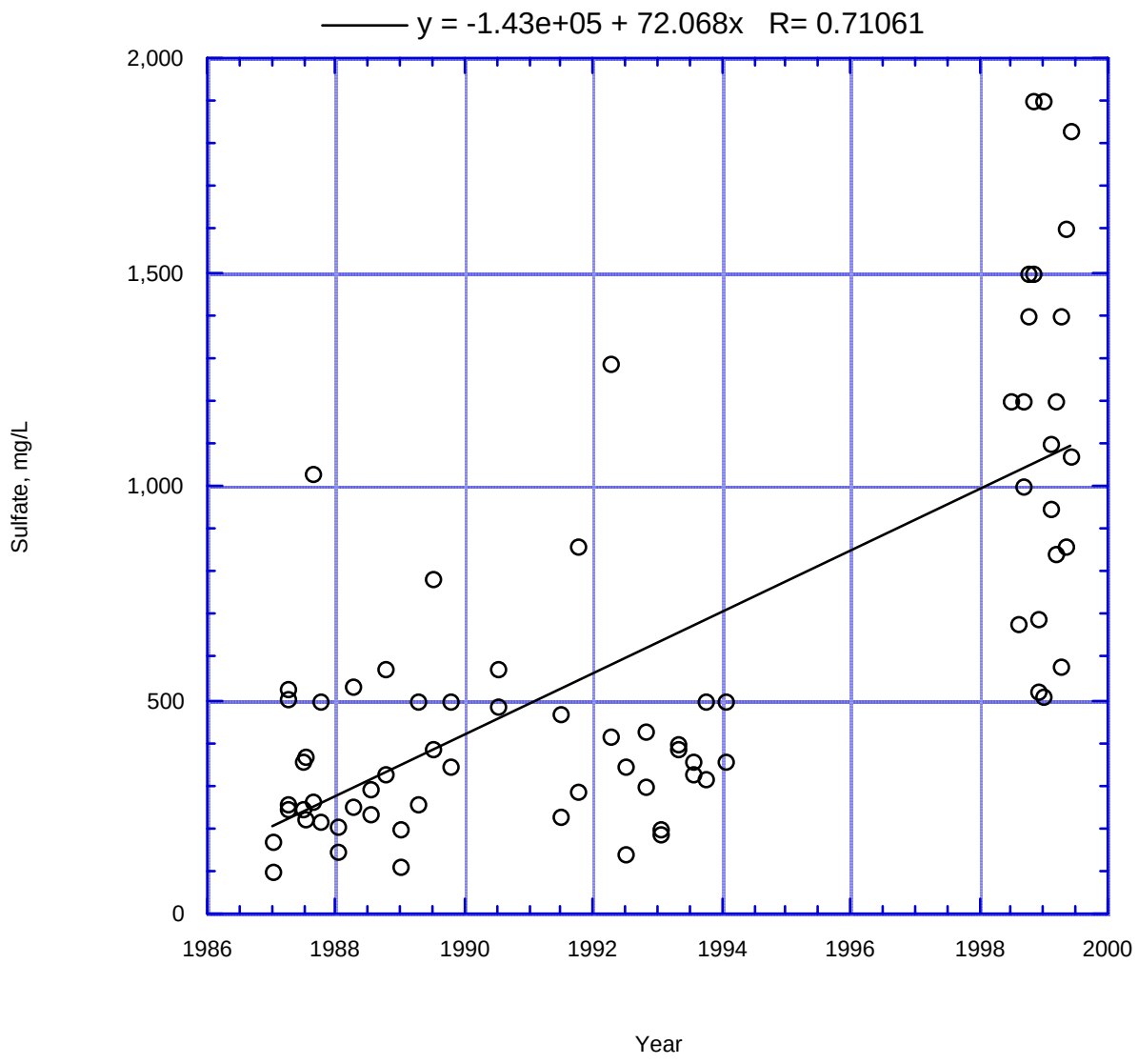


Figure 146. Reach 2 Sulfate vs. Time

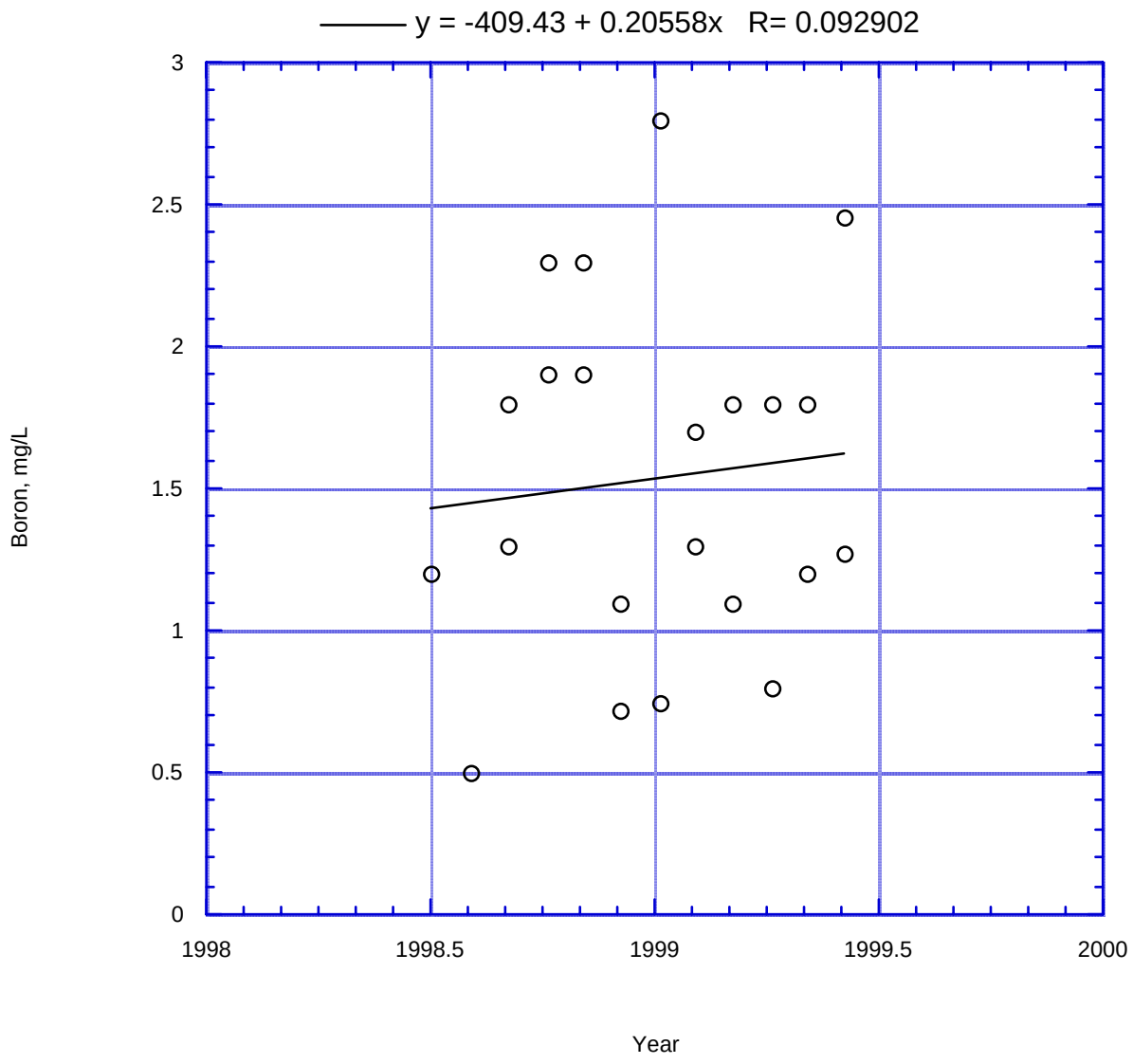


Figure 147. Reach 2 Boron vs. Time

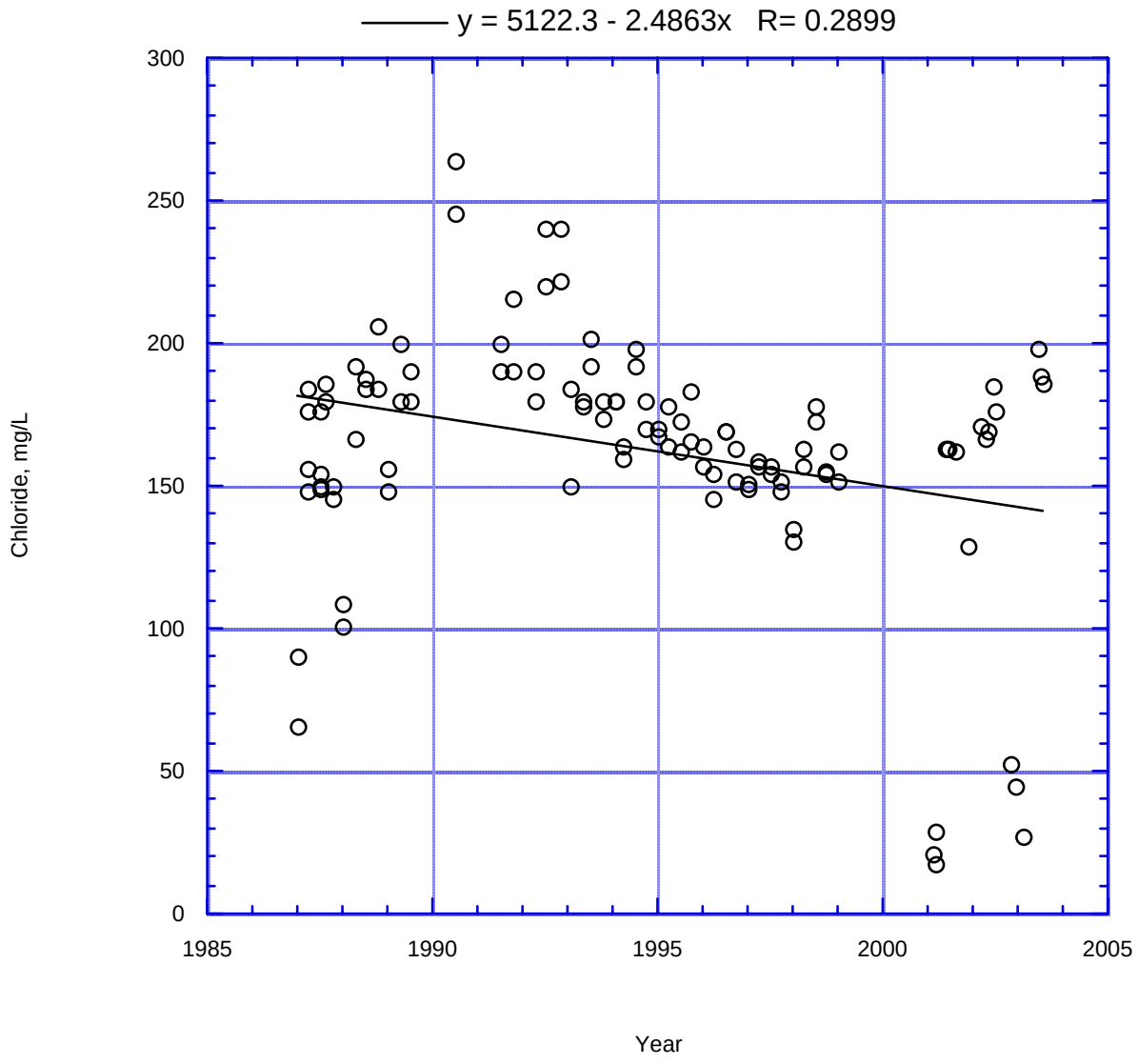


Figure 148. Reach 3 Chloride vs. Time

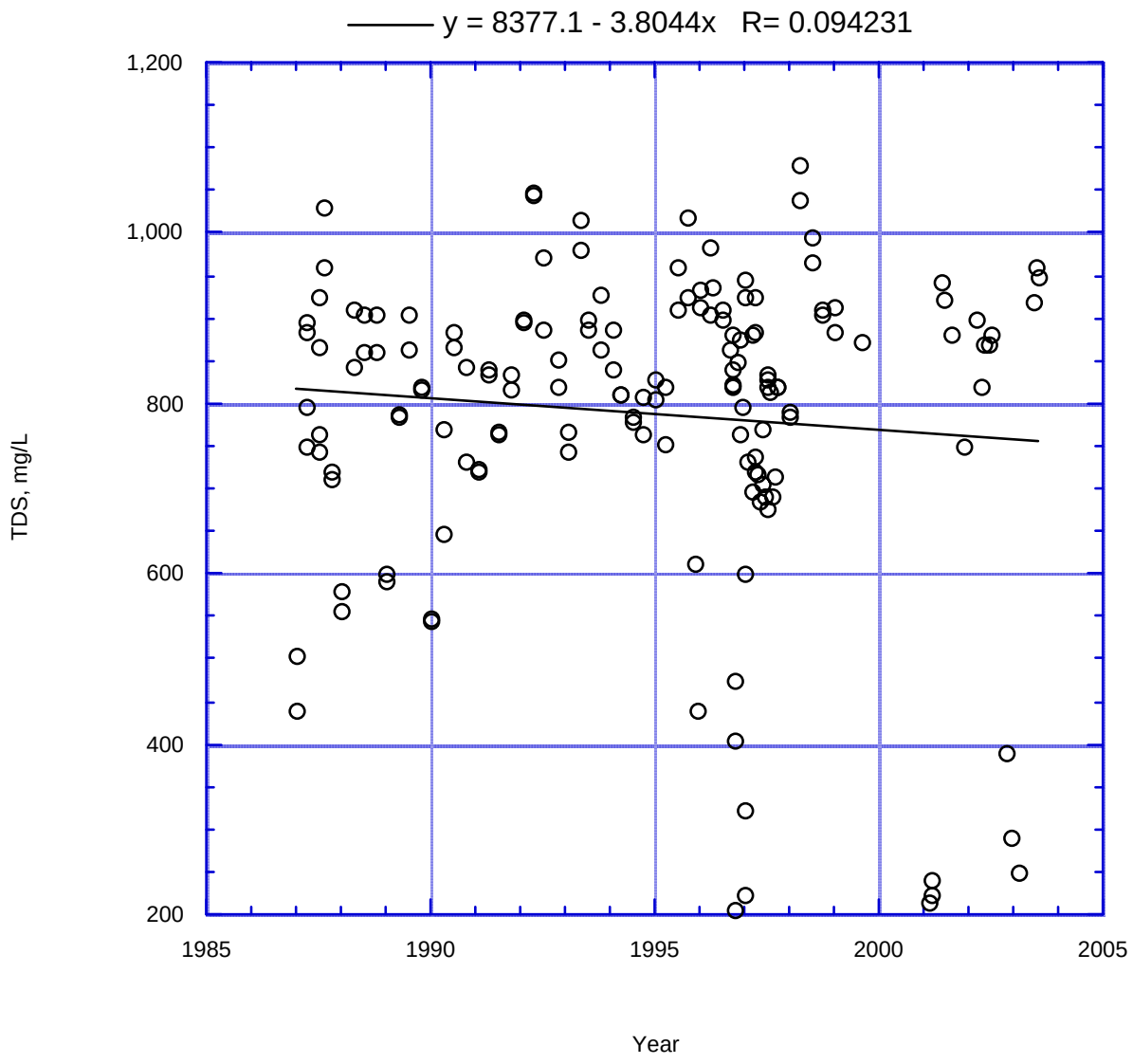


Figure 149. Reach 3 TDS vs. Time

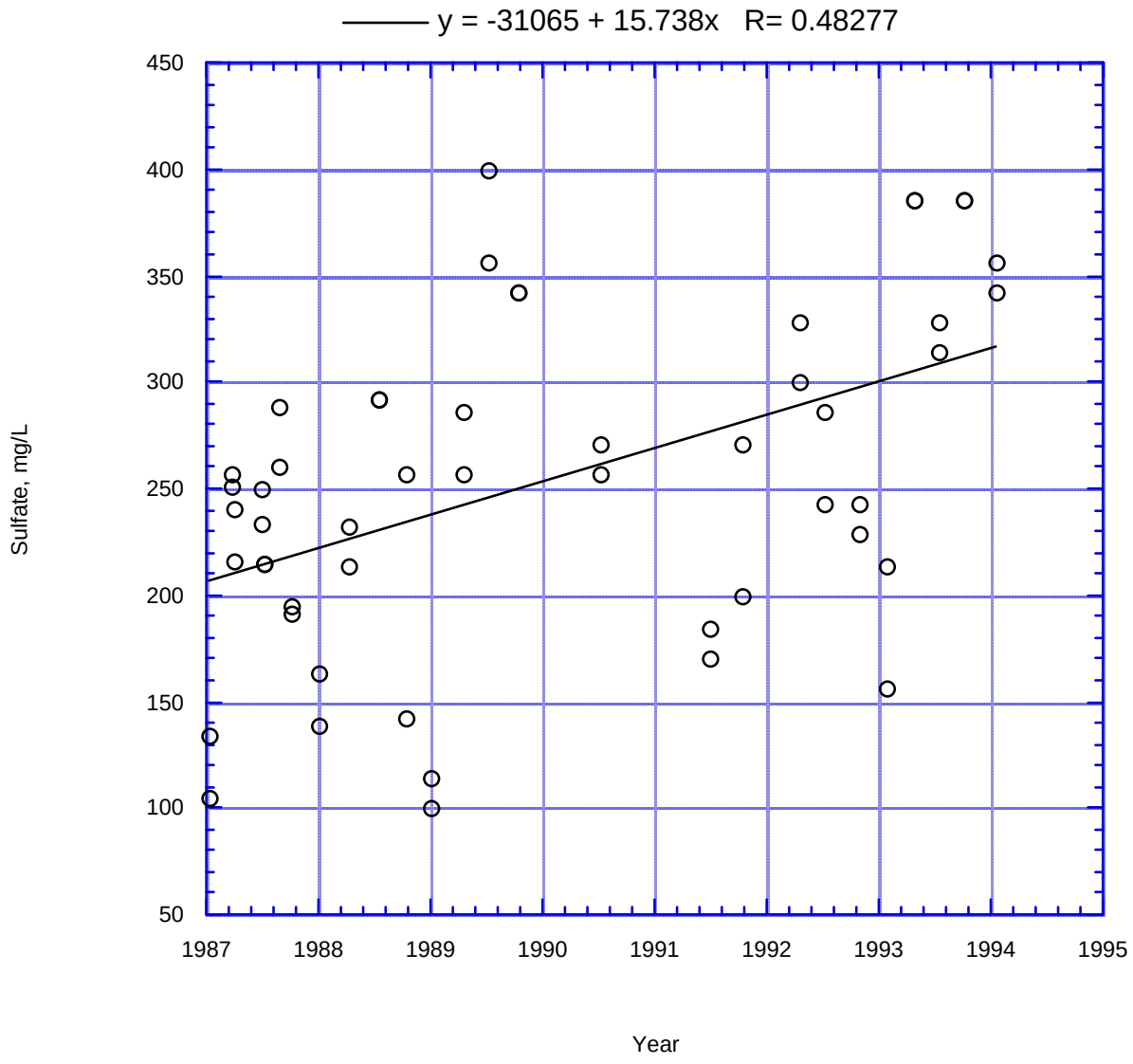


Figure 150. Reach 3 Sulfate vs. Time

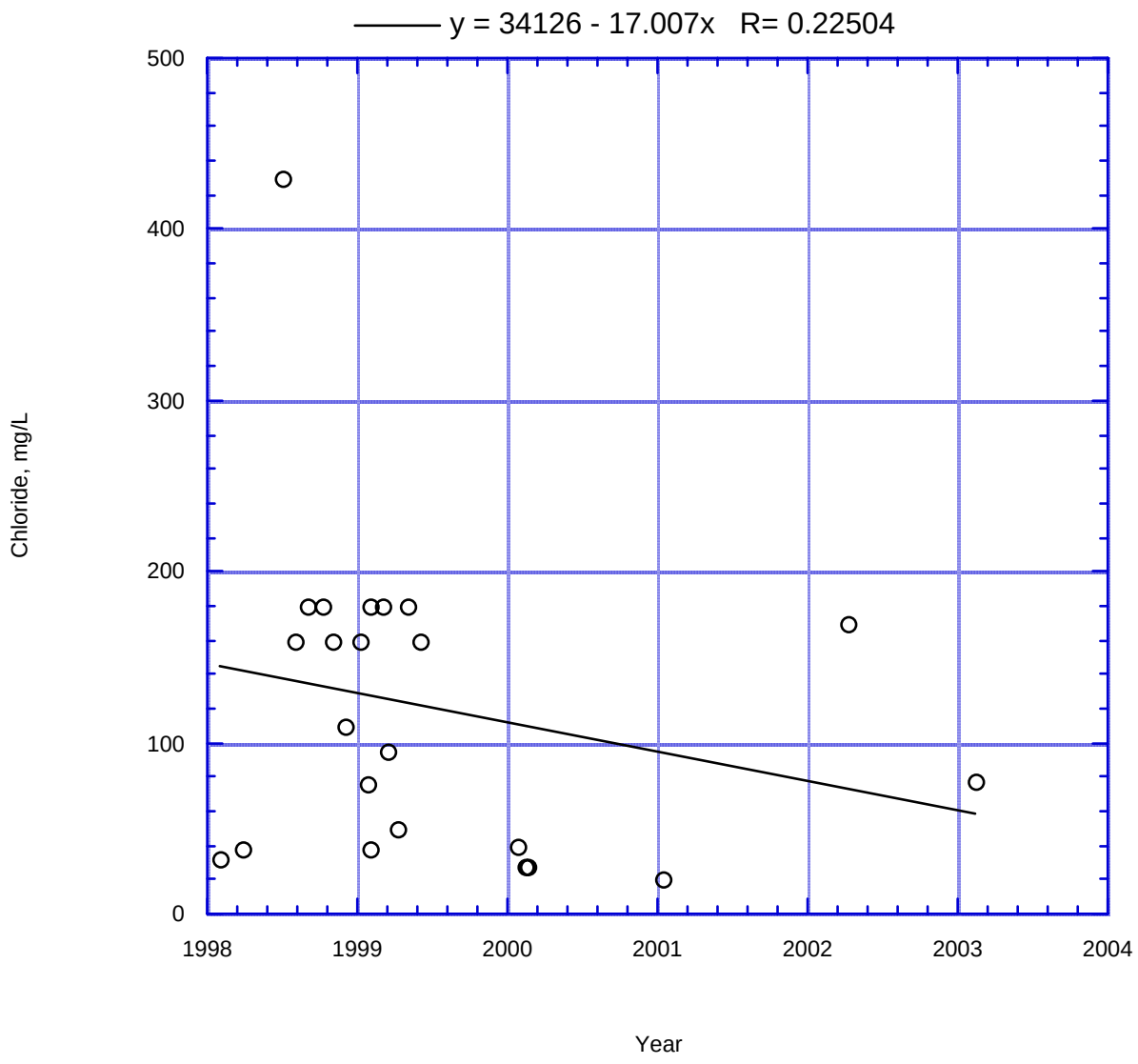


Figure 151. Reach 4 Chloride vs. Time

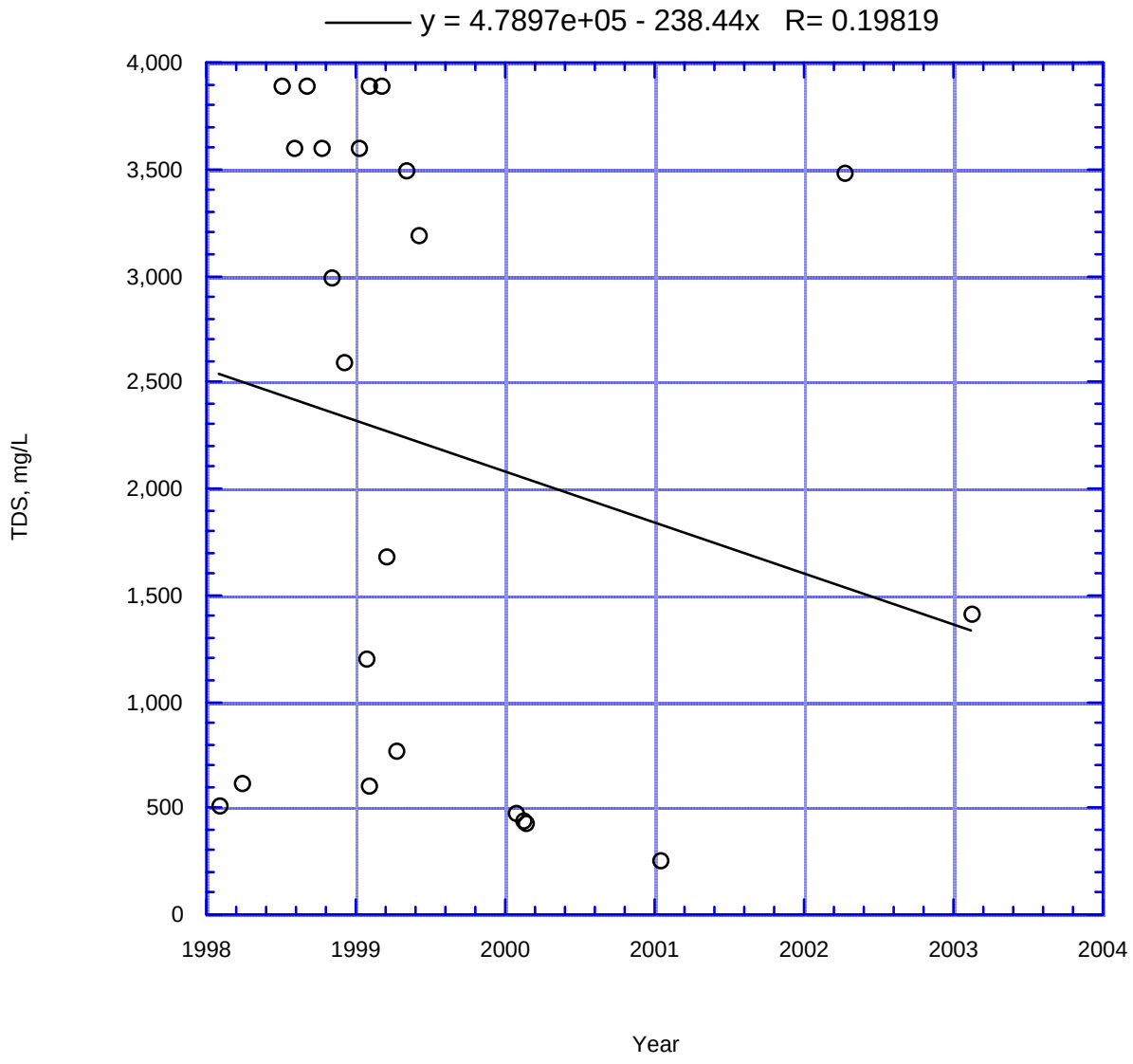


Figure 152. Reach 4 TDS vs. Time

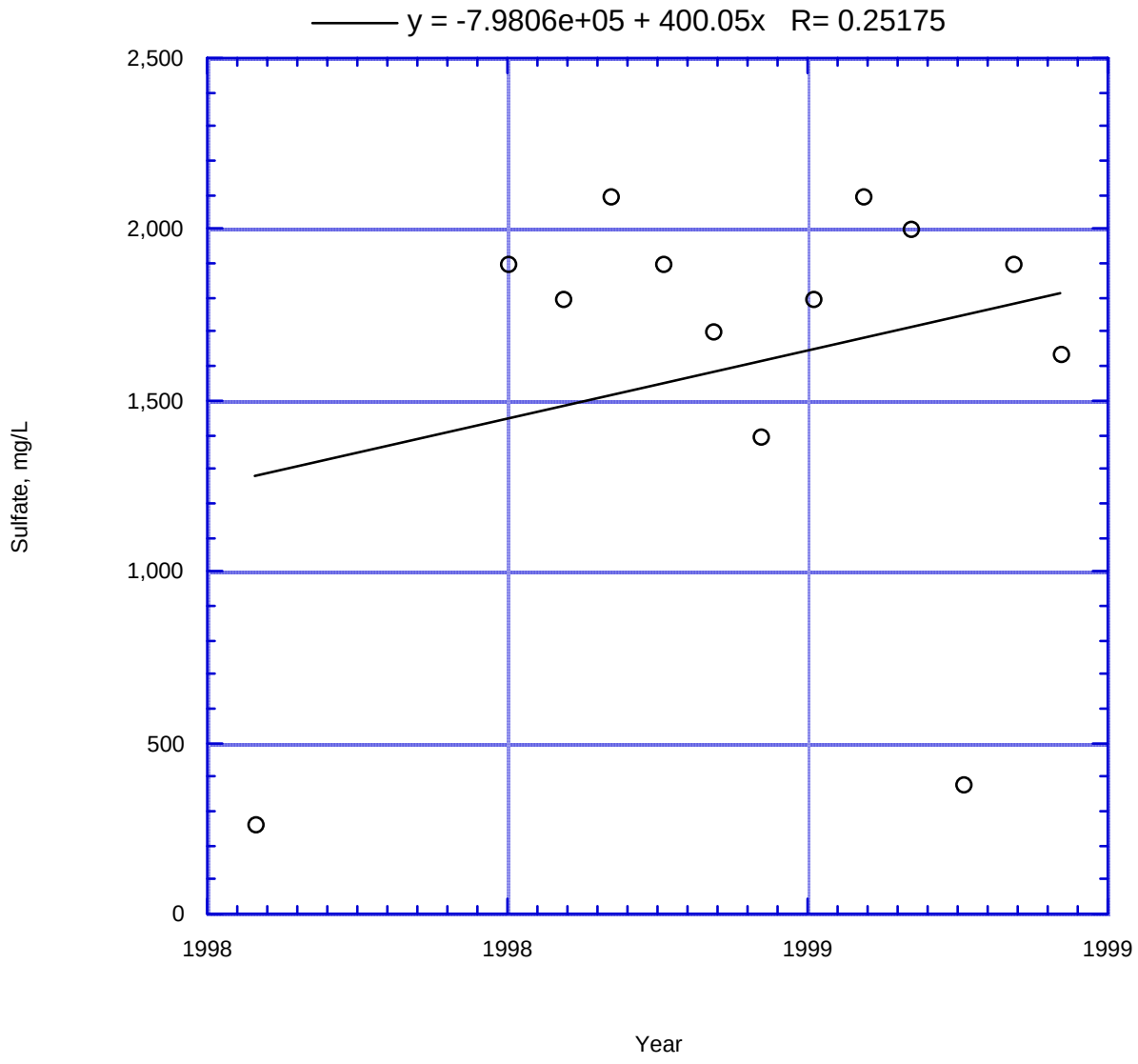


Figure 153. Reach 4 Sulfate vs. Time

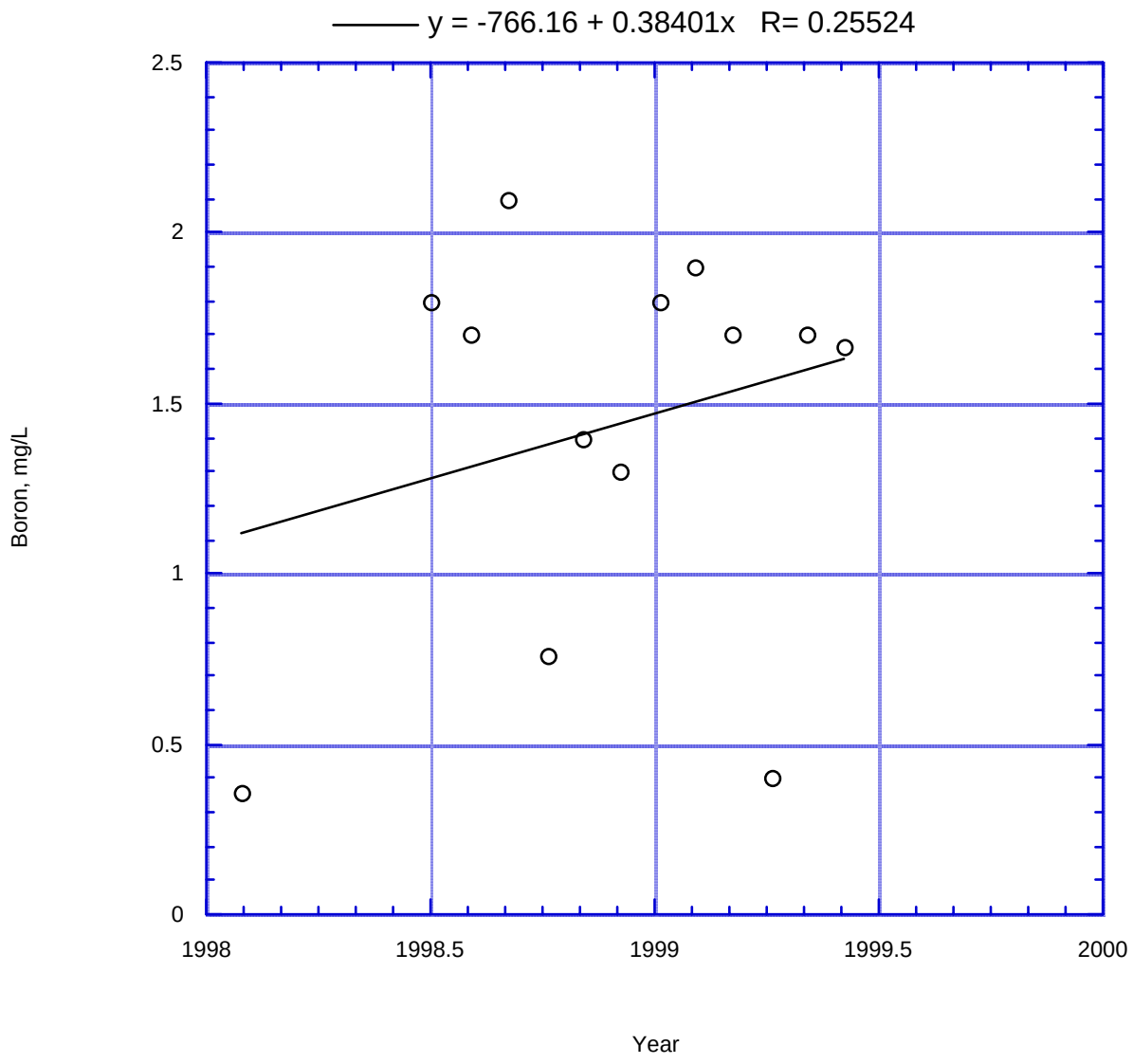


Figure 154. Reach 4 Boron vs. Time

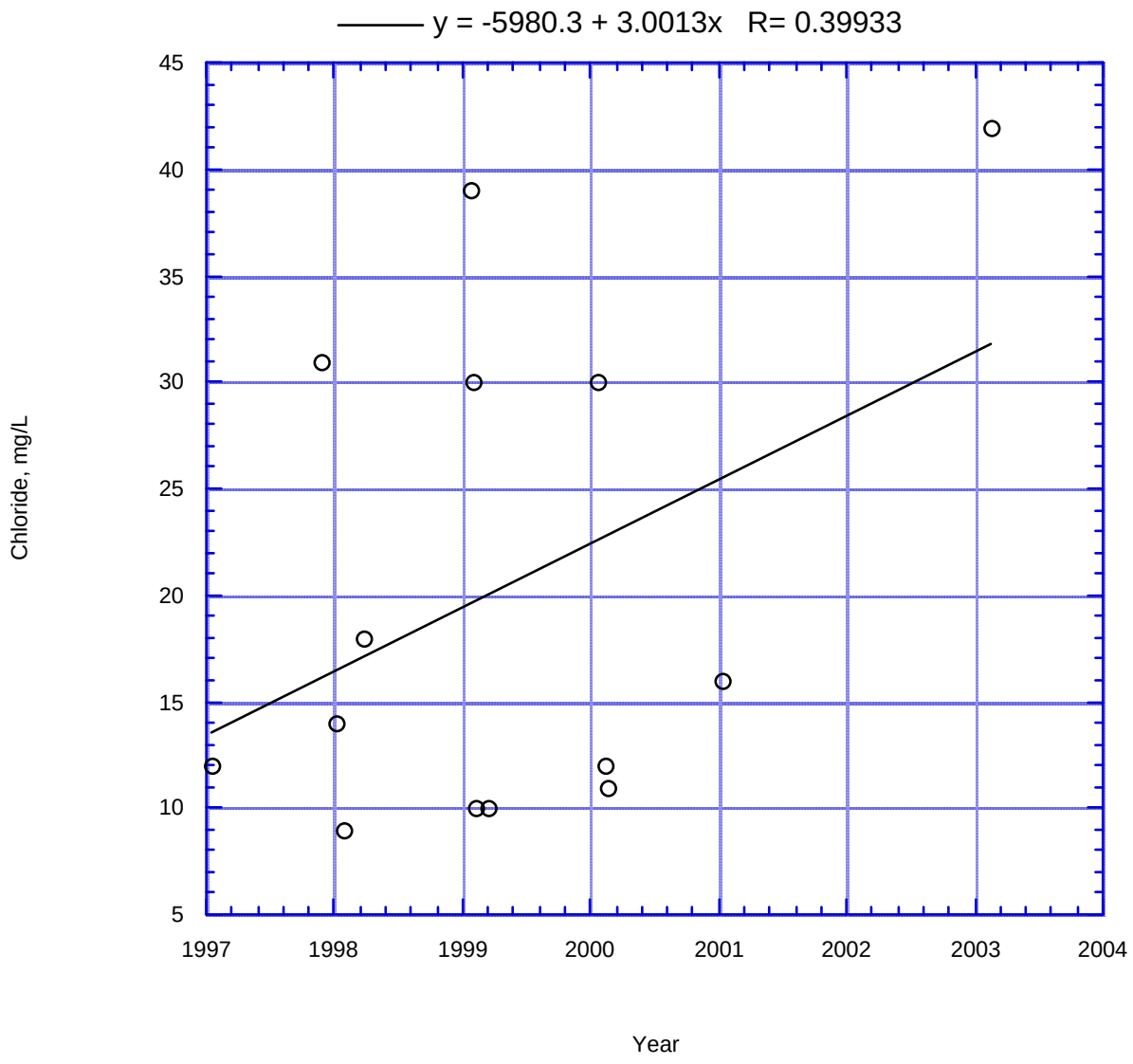


Figure 155. Reach 5 Chloride vs. Time

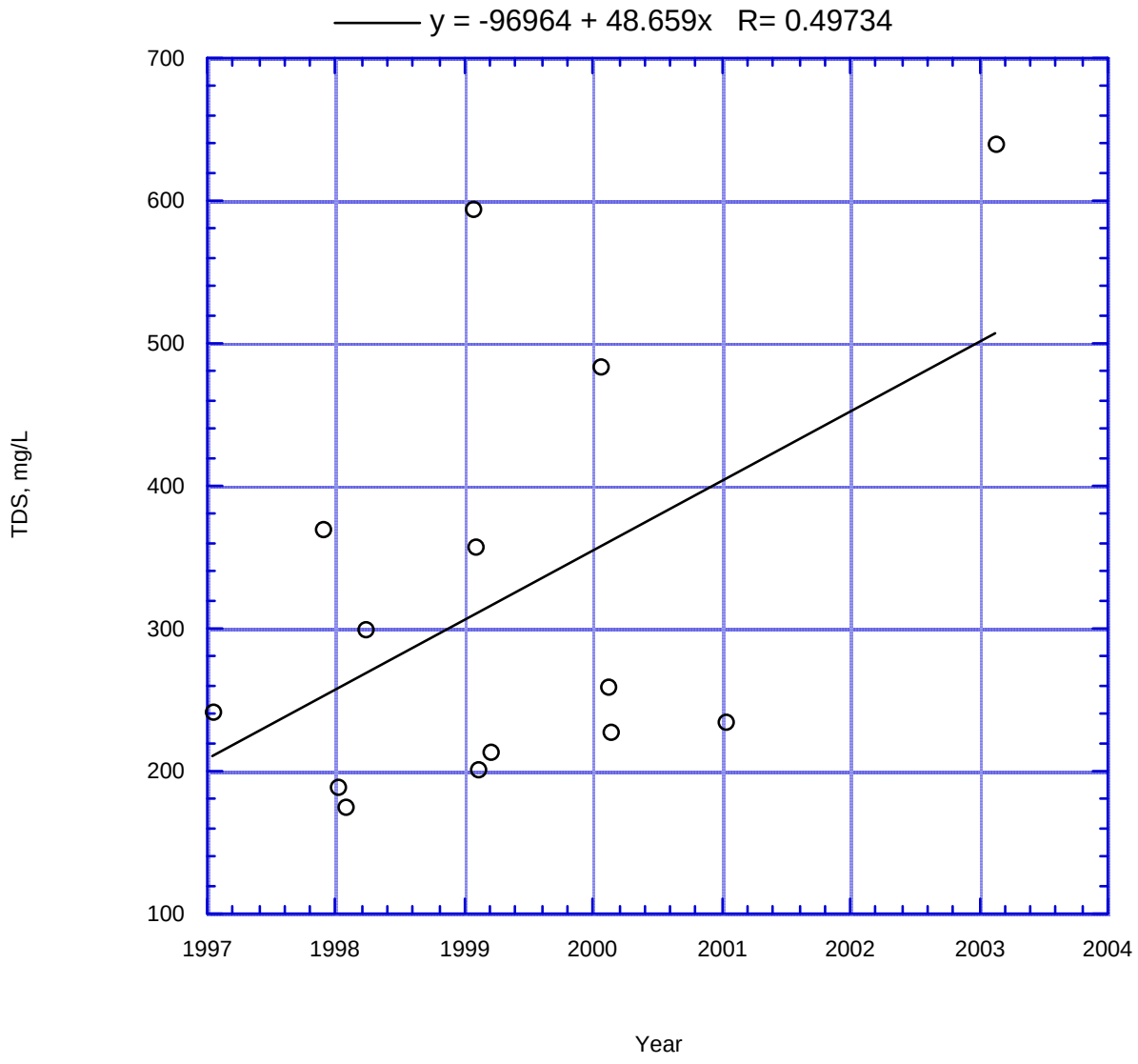


Figure 156. Reach 5 TDS vs. Time

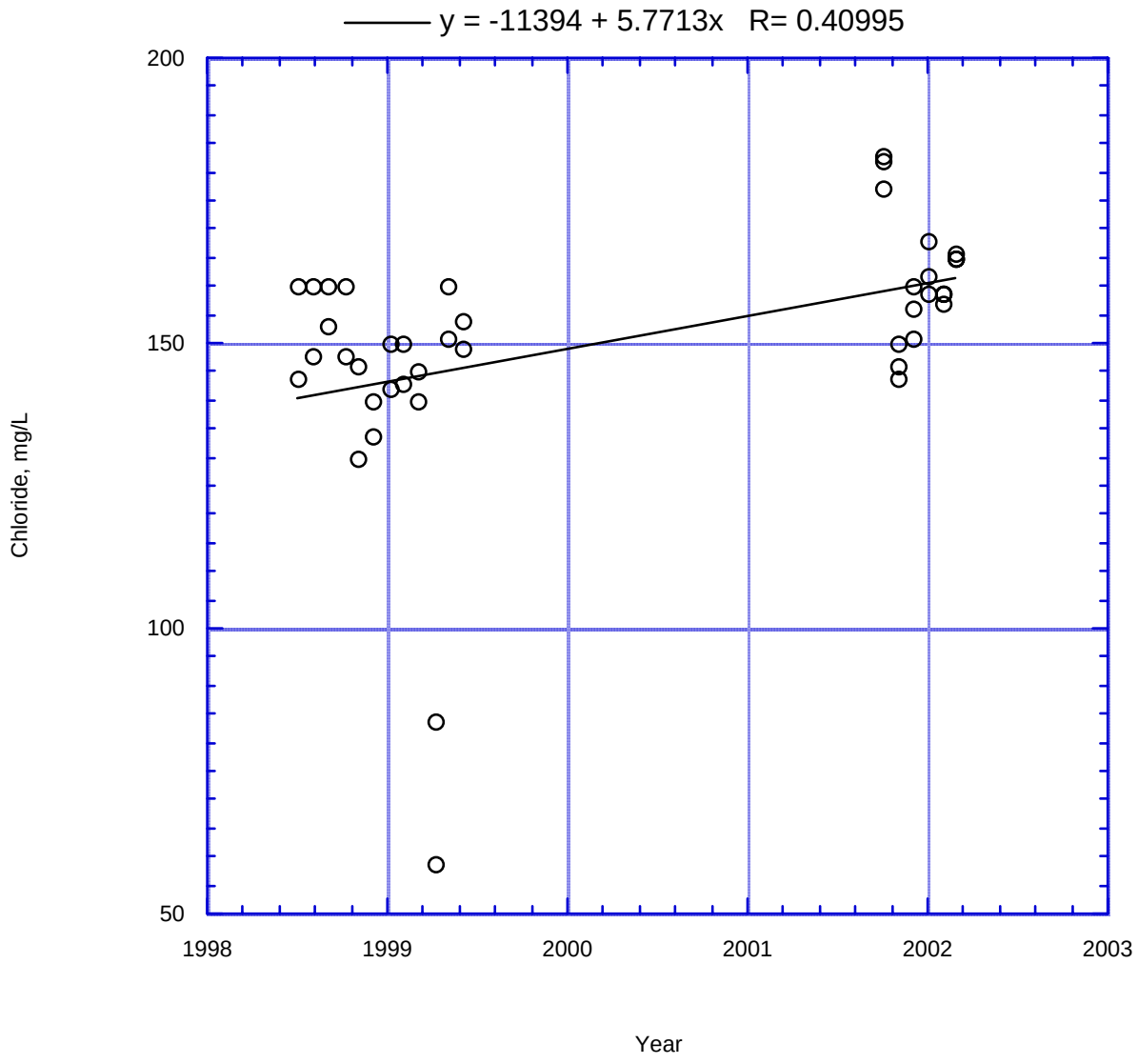


Figure 157. Reach 6 Chloride vs. Time

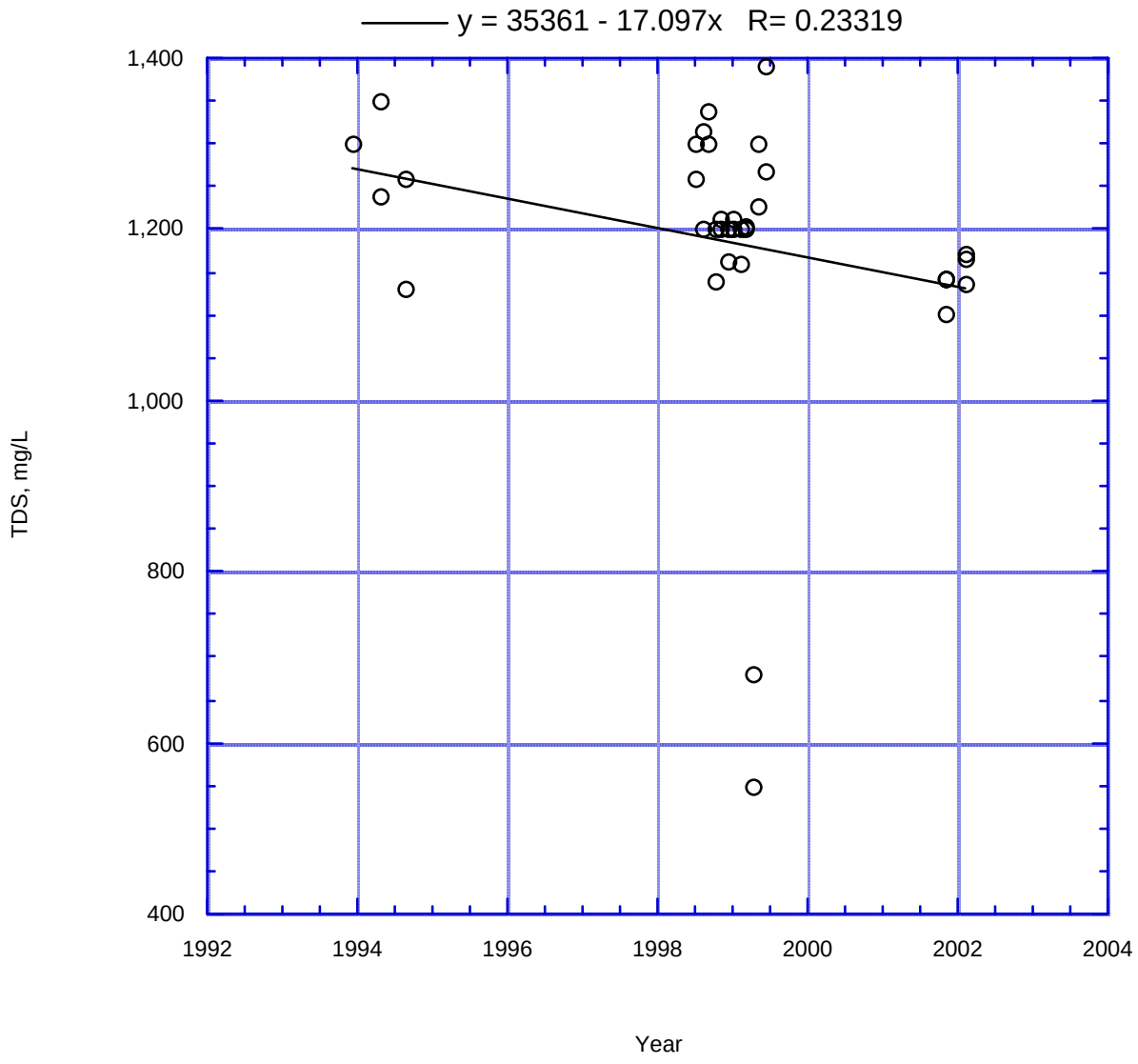


Figure 158. Reach 6 TDS vs. Time

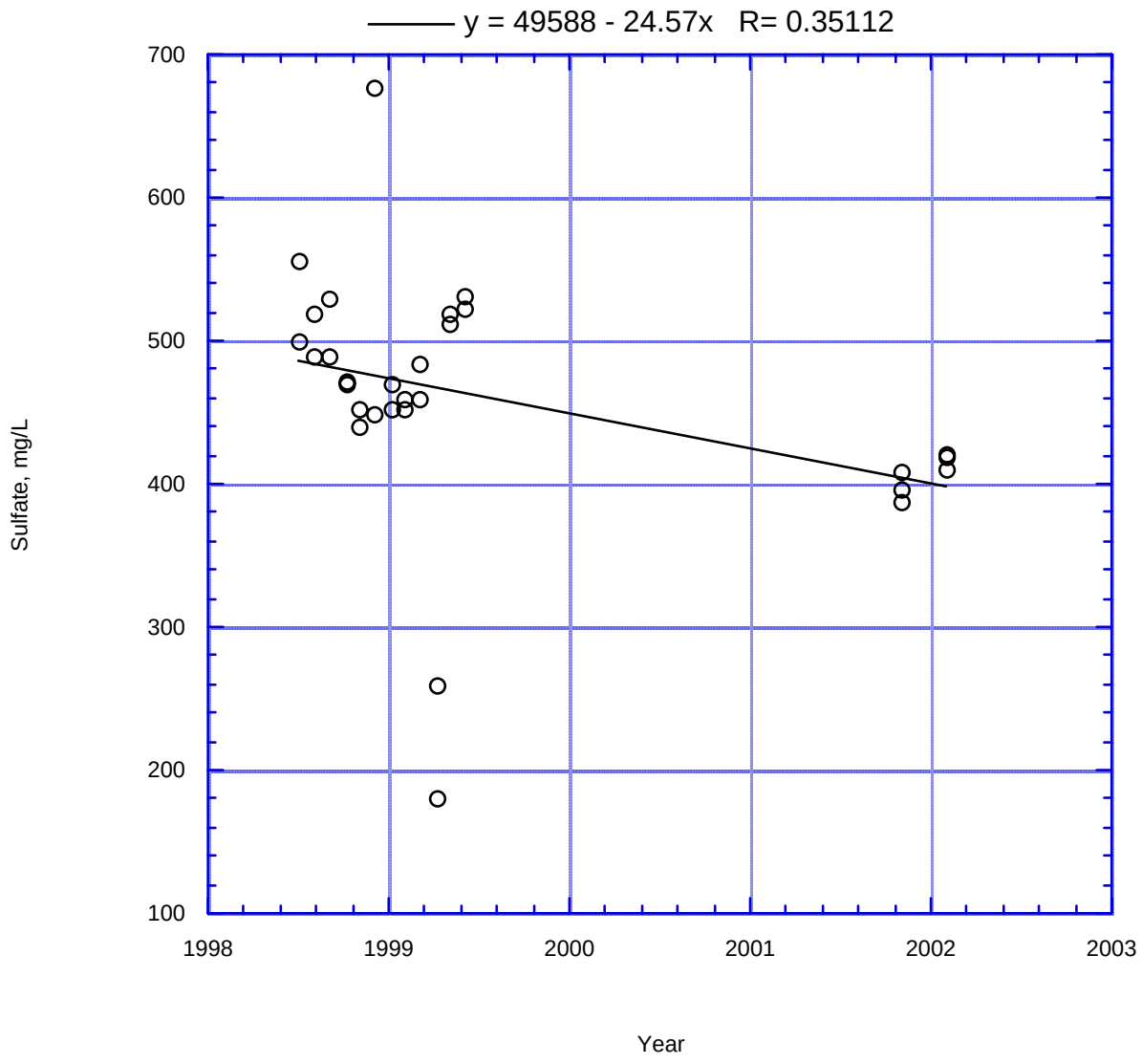


Figure 159. Reach 6 Sulfate vs. Time

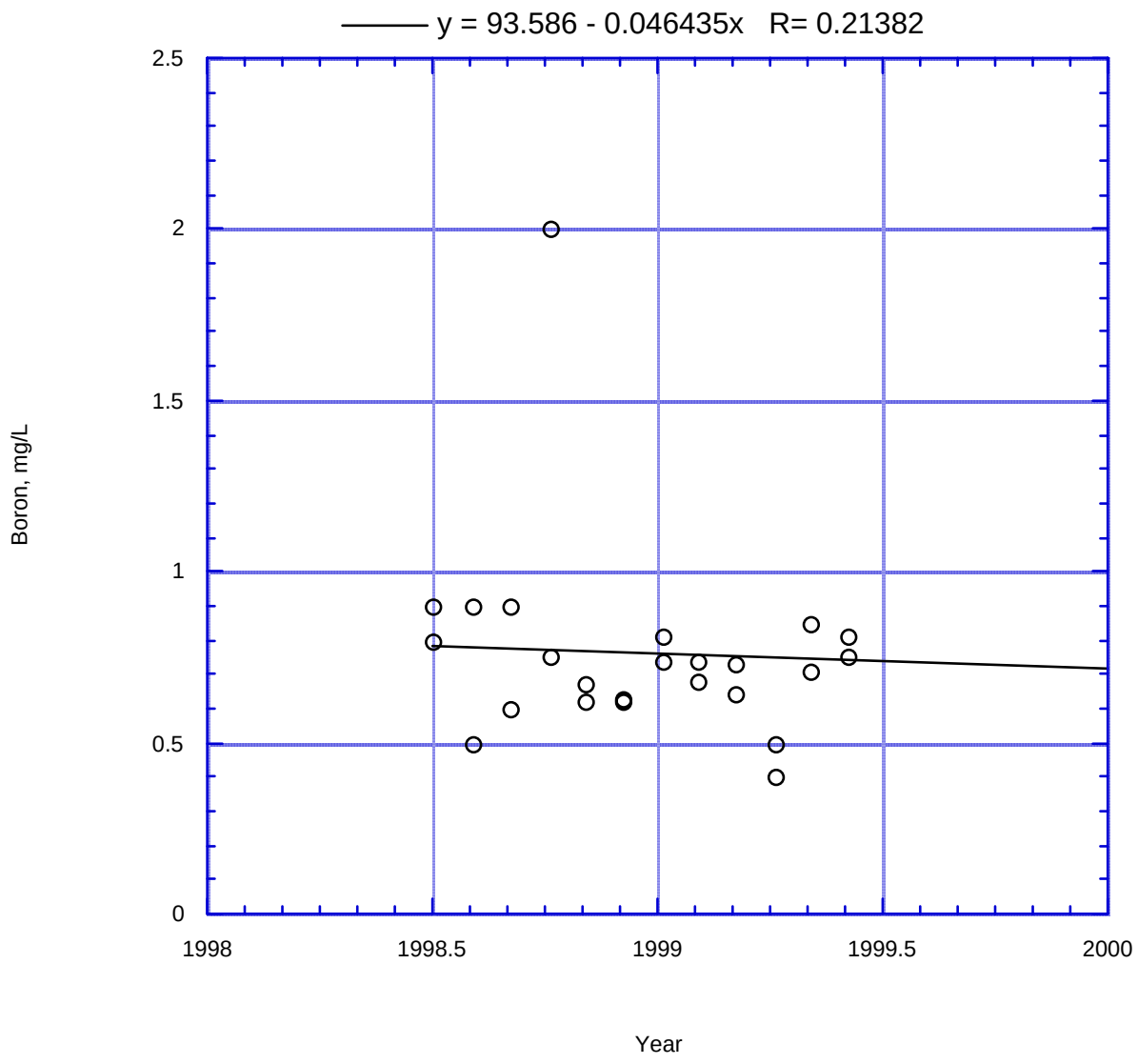


Figure 160. Reach 6 Boron vs. Time

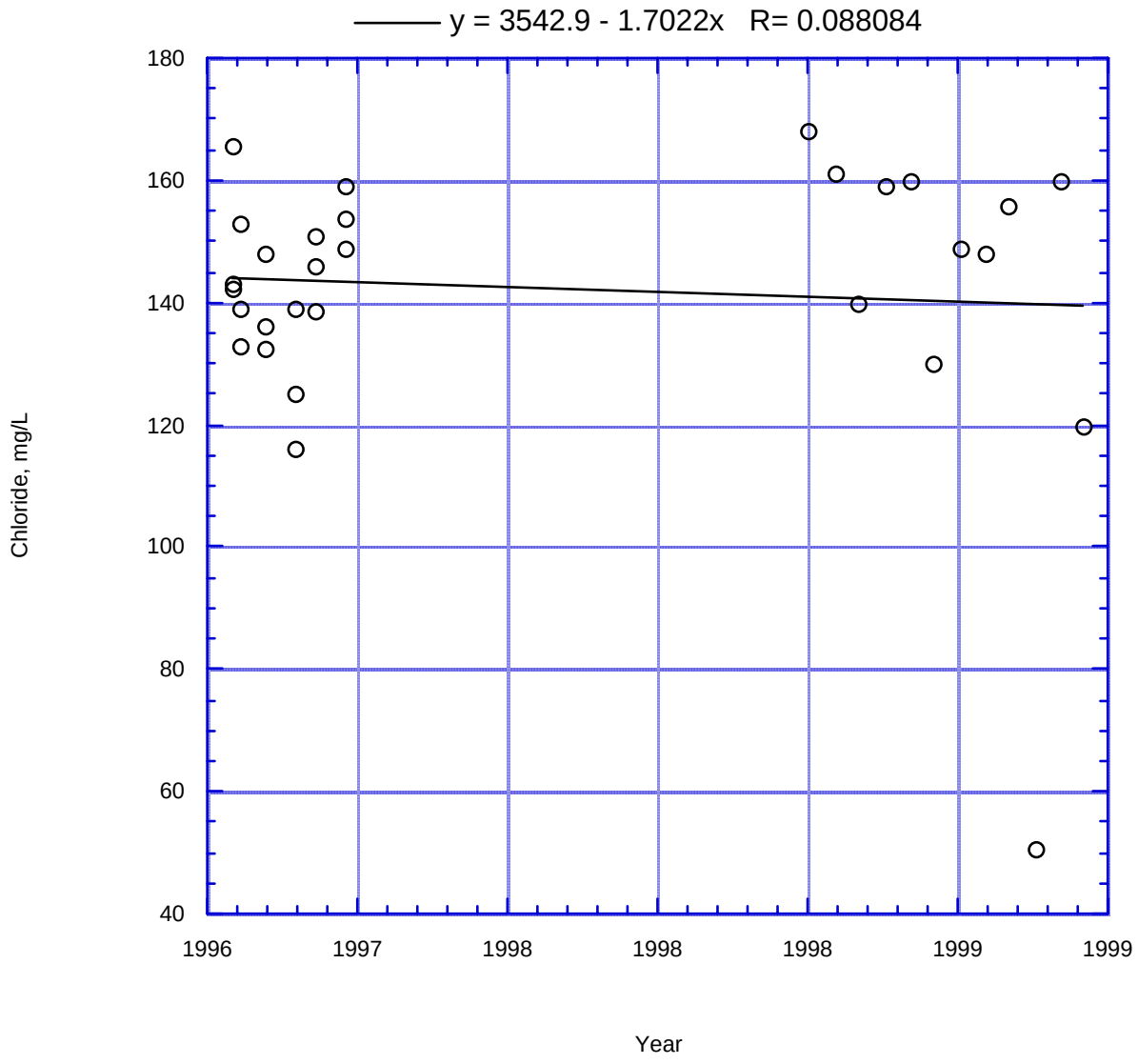


Figure 161. Reach 7 Chloride vs. Time

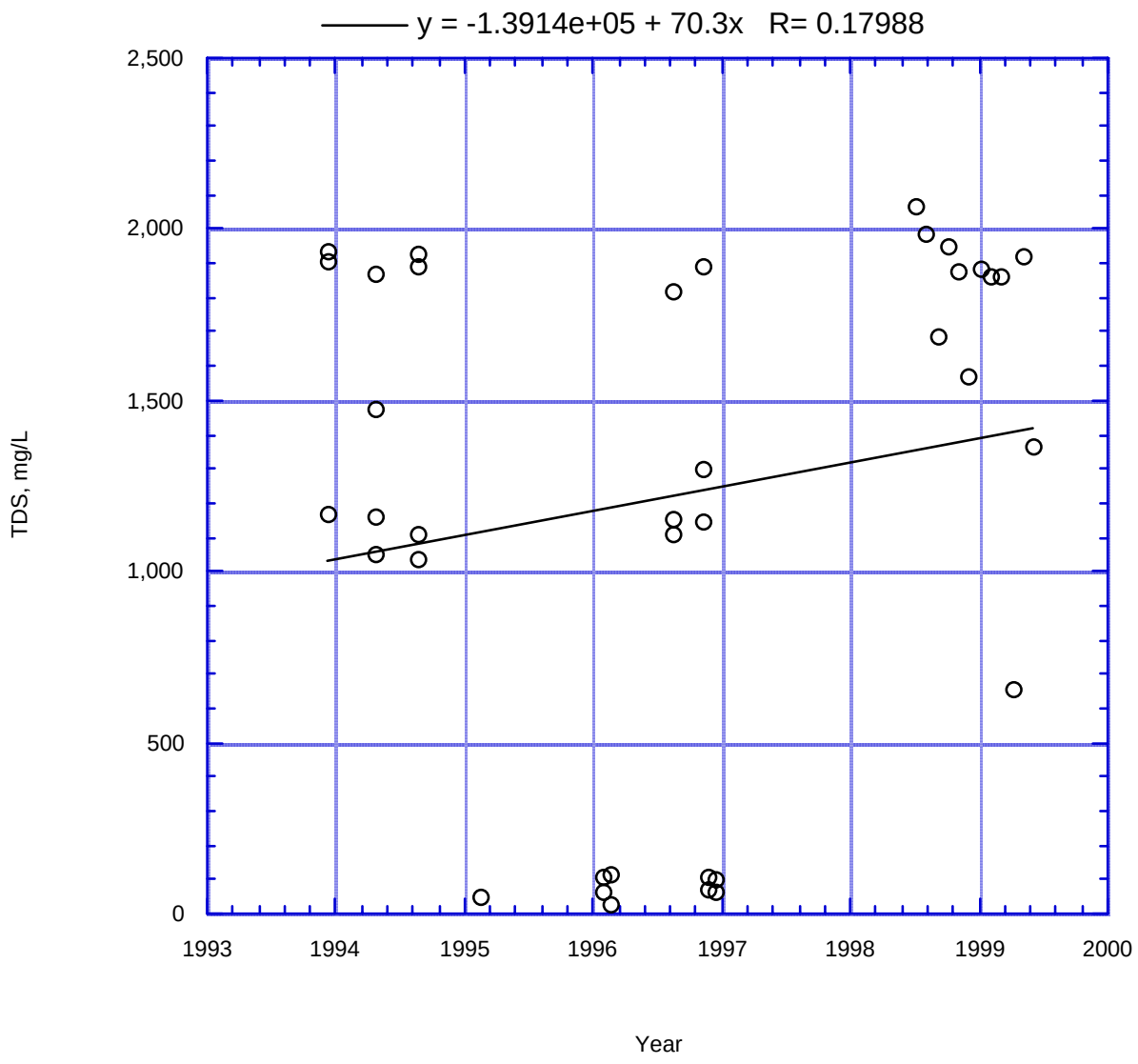


Figure 162. Reach 7 TDS vs. Time

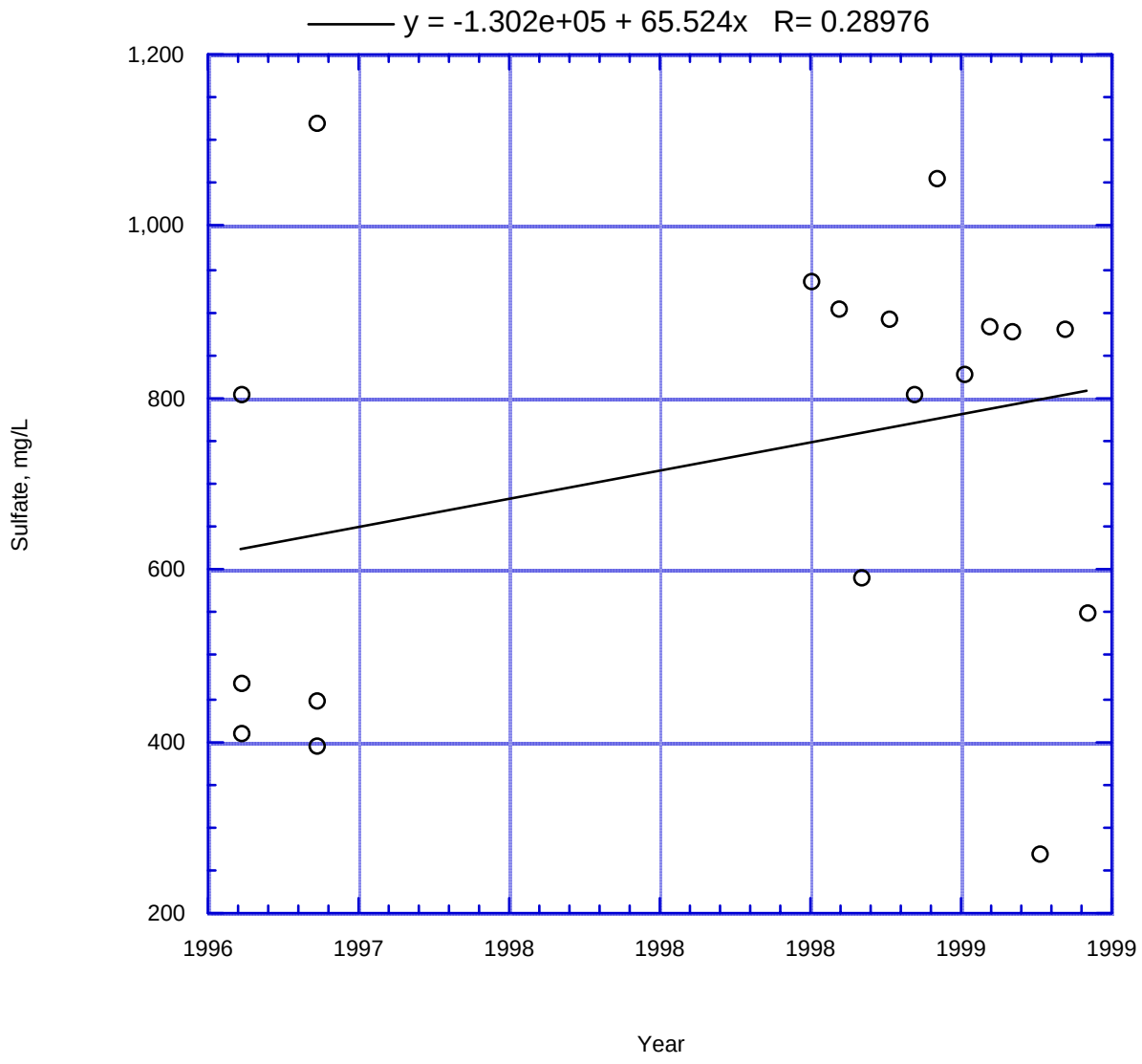


Figure 163. Reach 7 Sulfate vs. Time

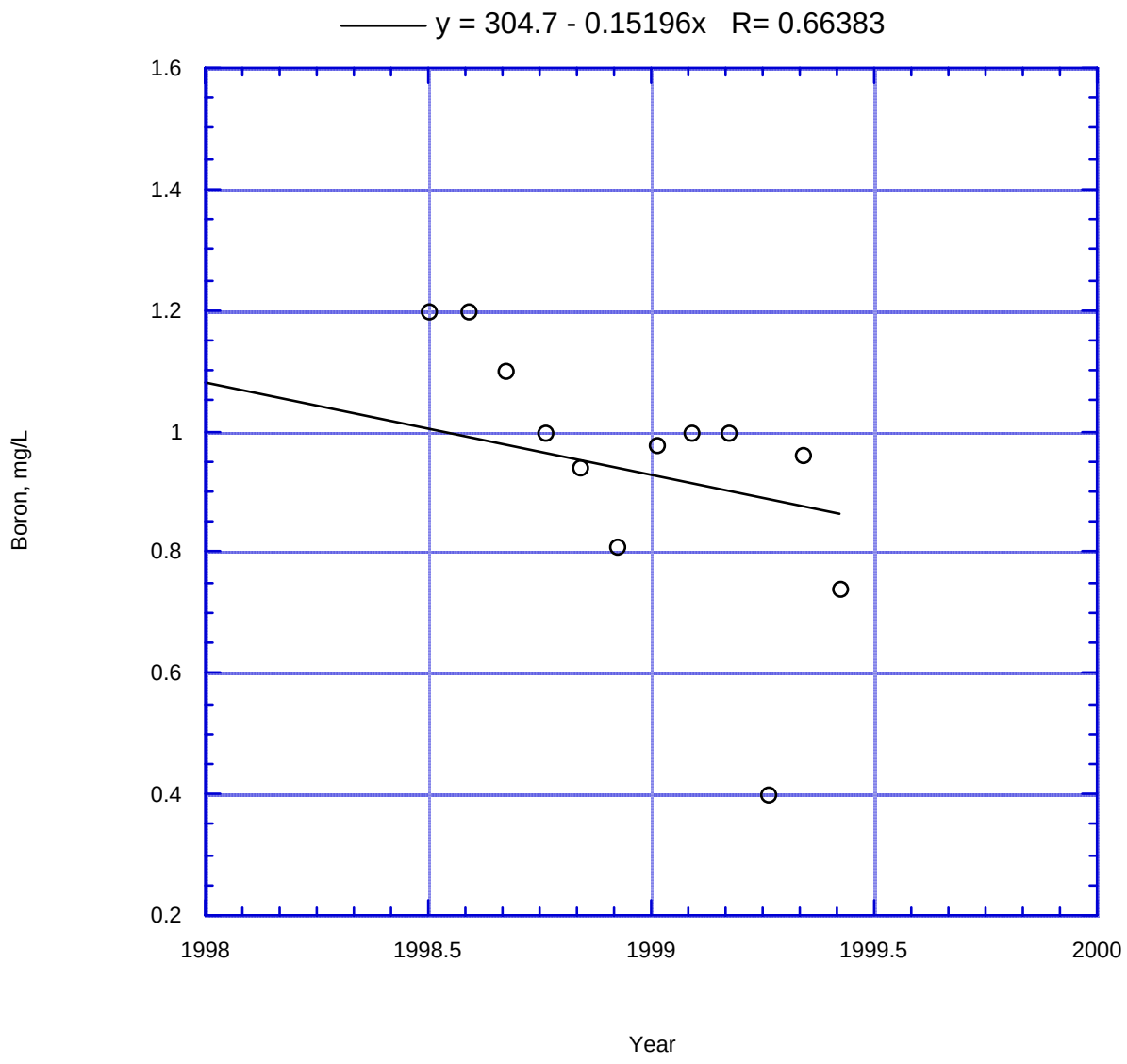


Figure 164. Reach 7 Boron vs. Time

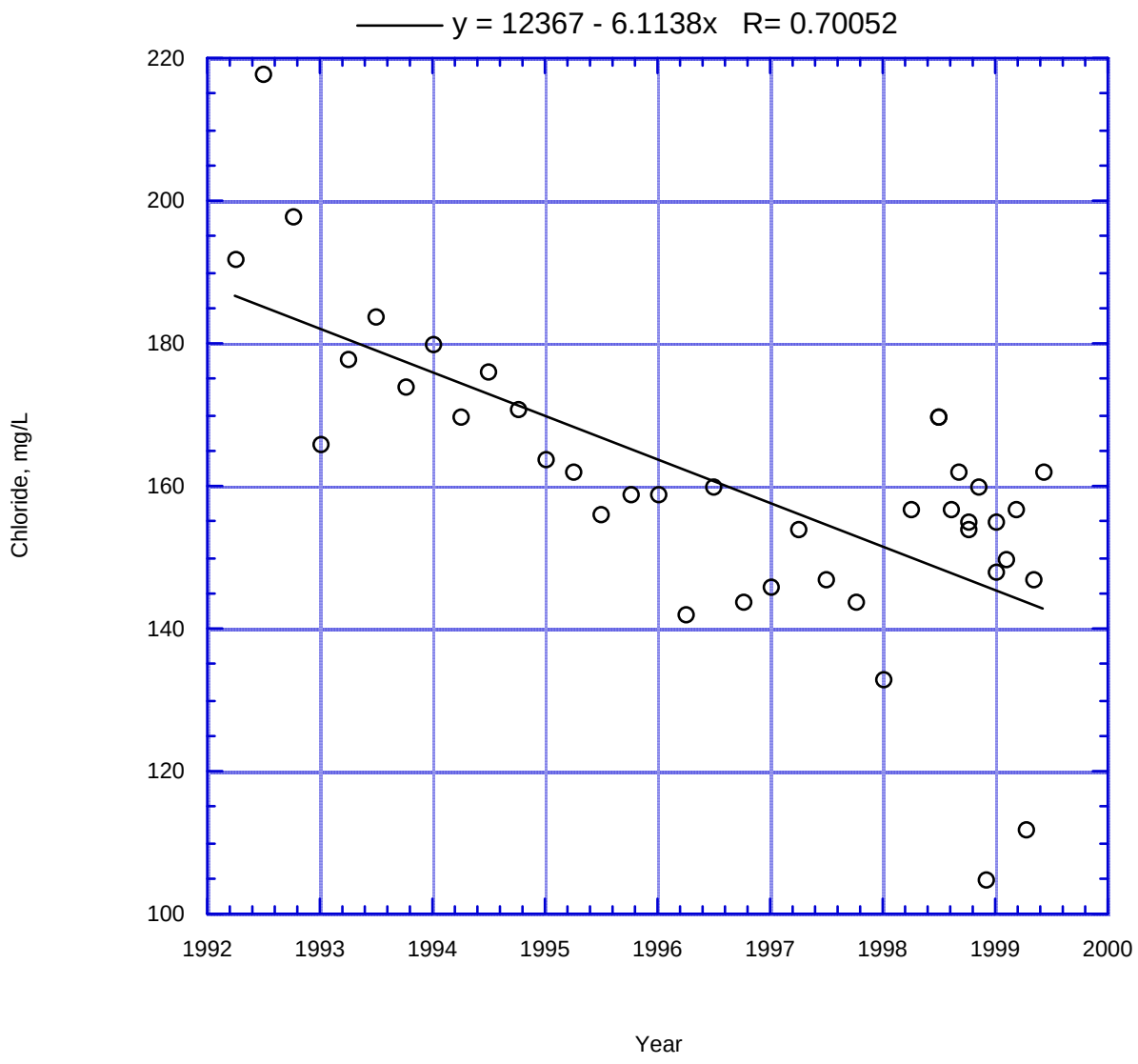


Figure 165. Reach 9A Chloride vs. Time

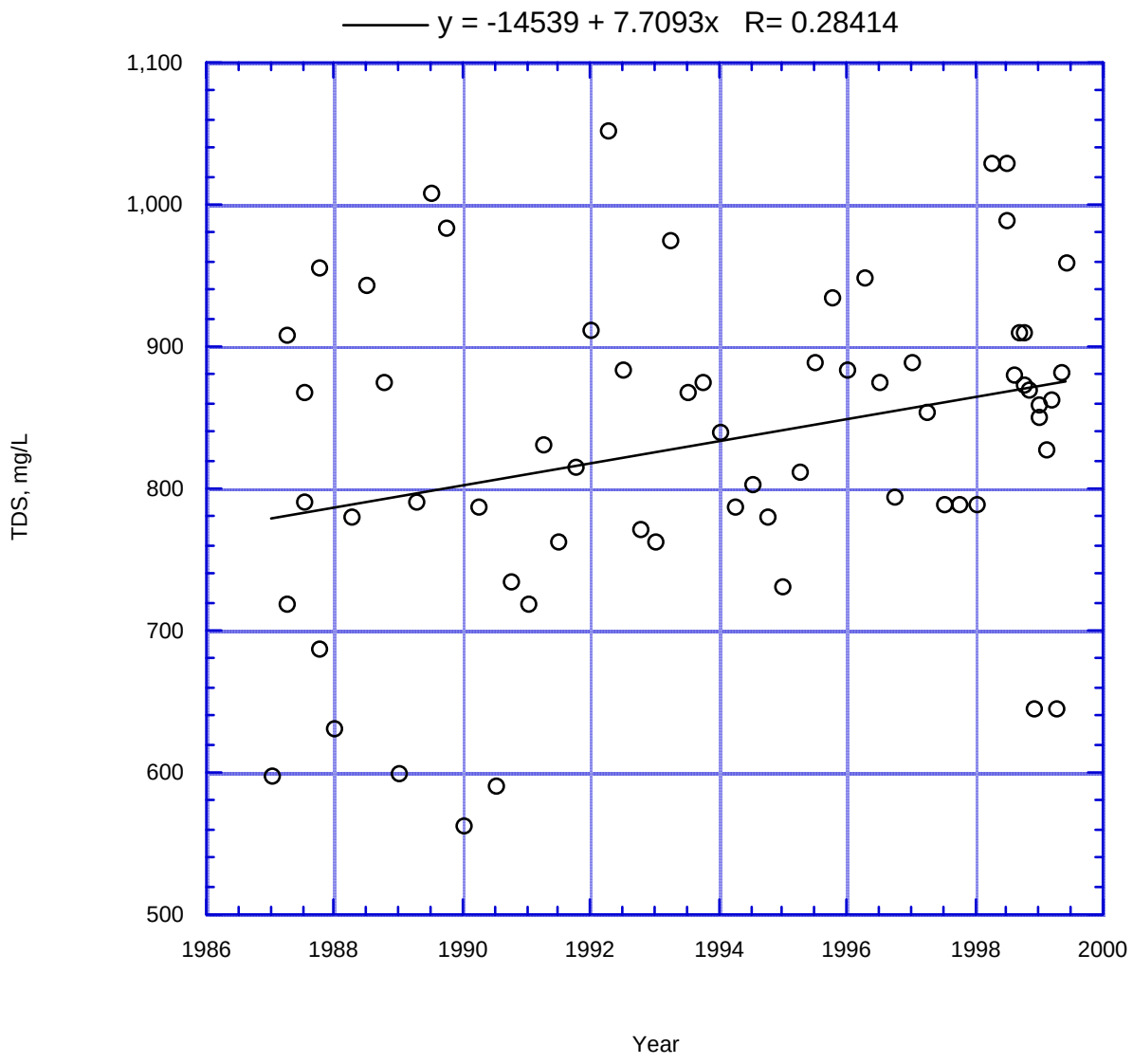


Figure 166. Reach 9A TDS vs. Time

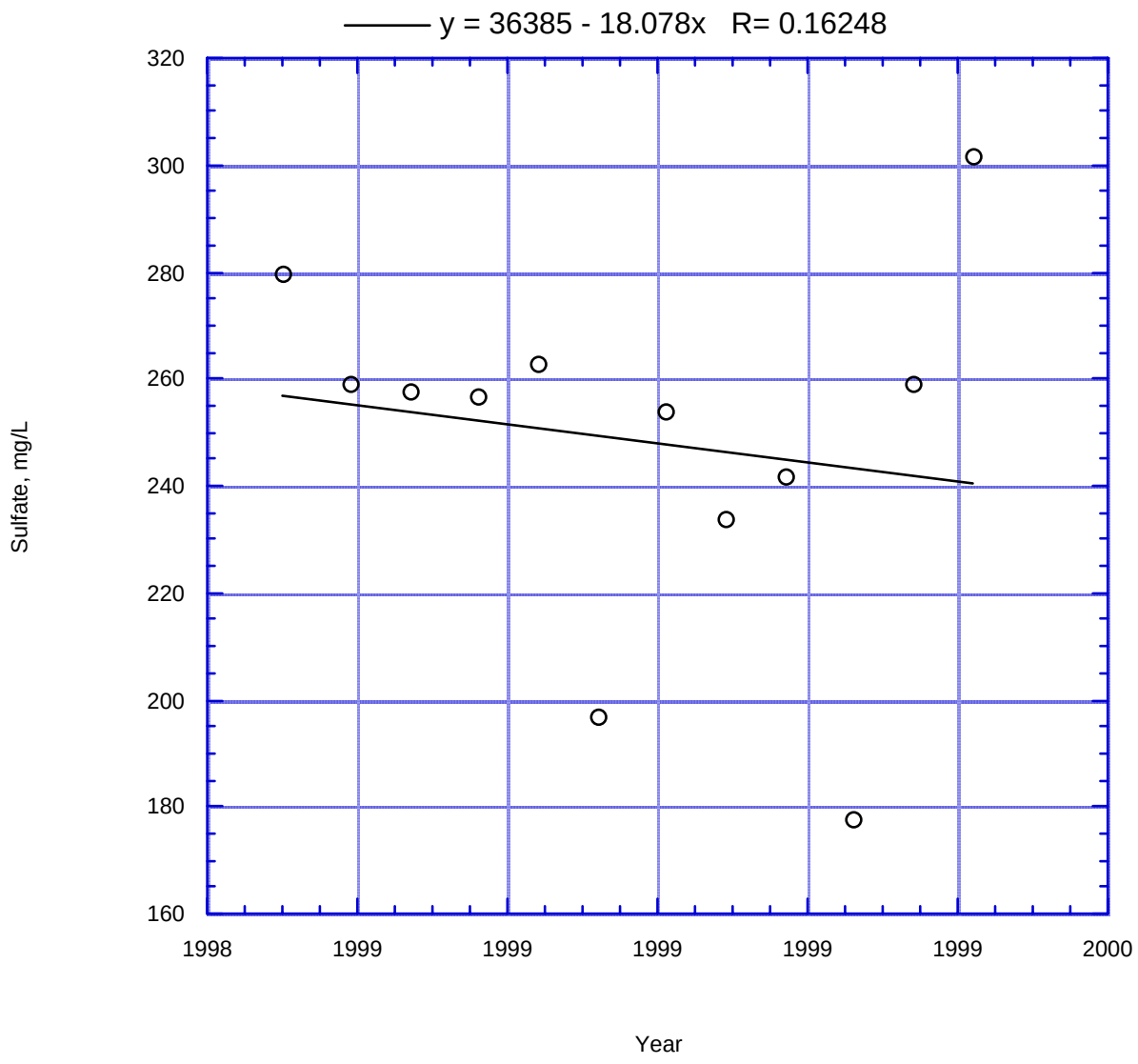


Figure 167. Reach 9A Sulfate vs. Time

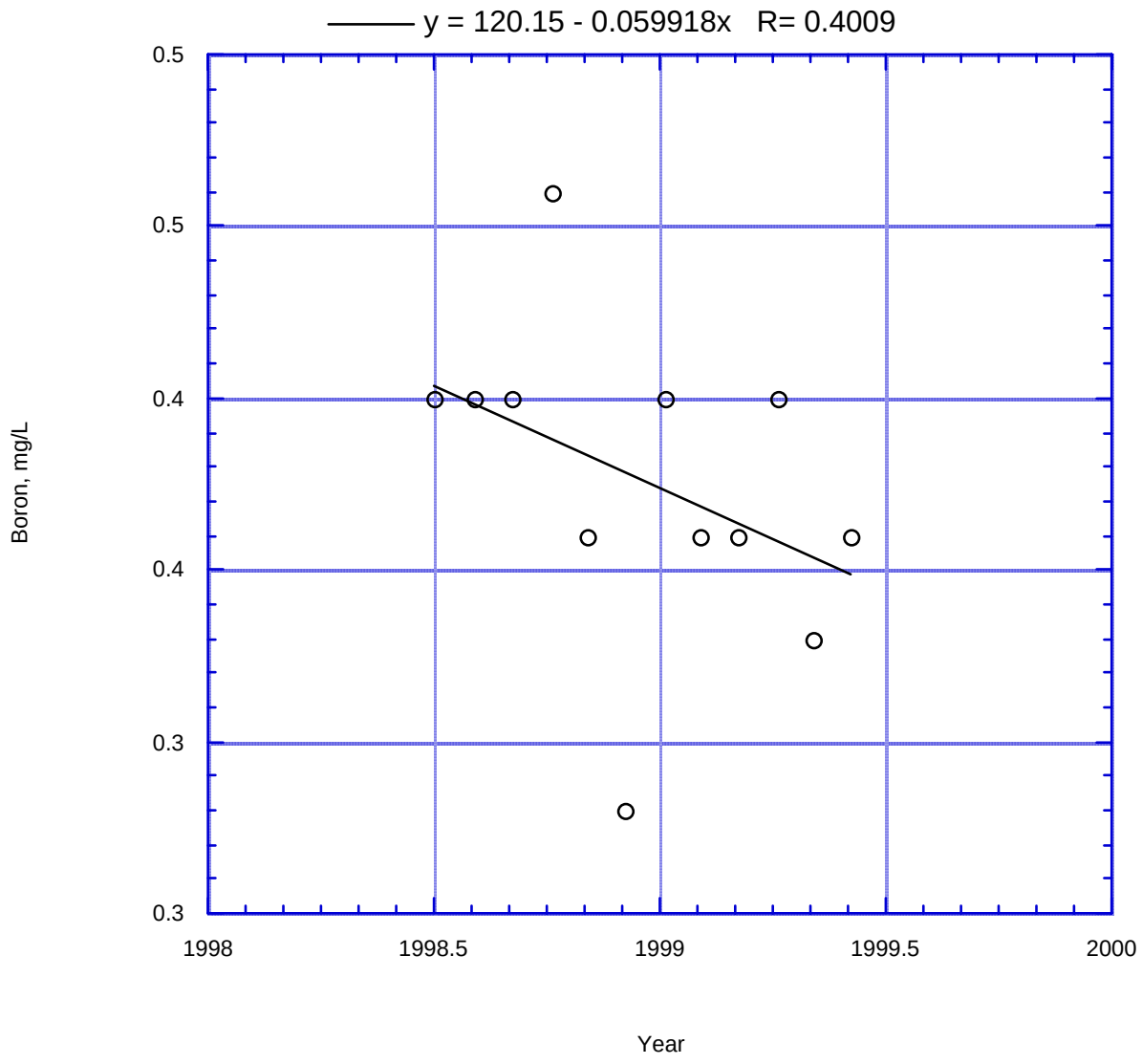


Figure 168. Reach 9A Boron vs. Time

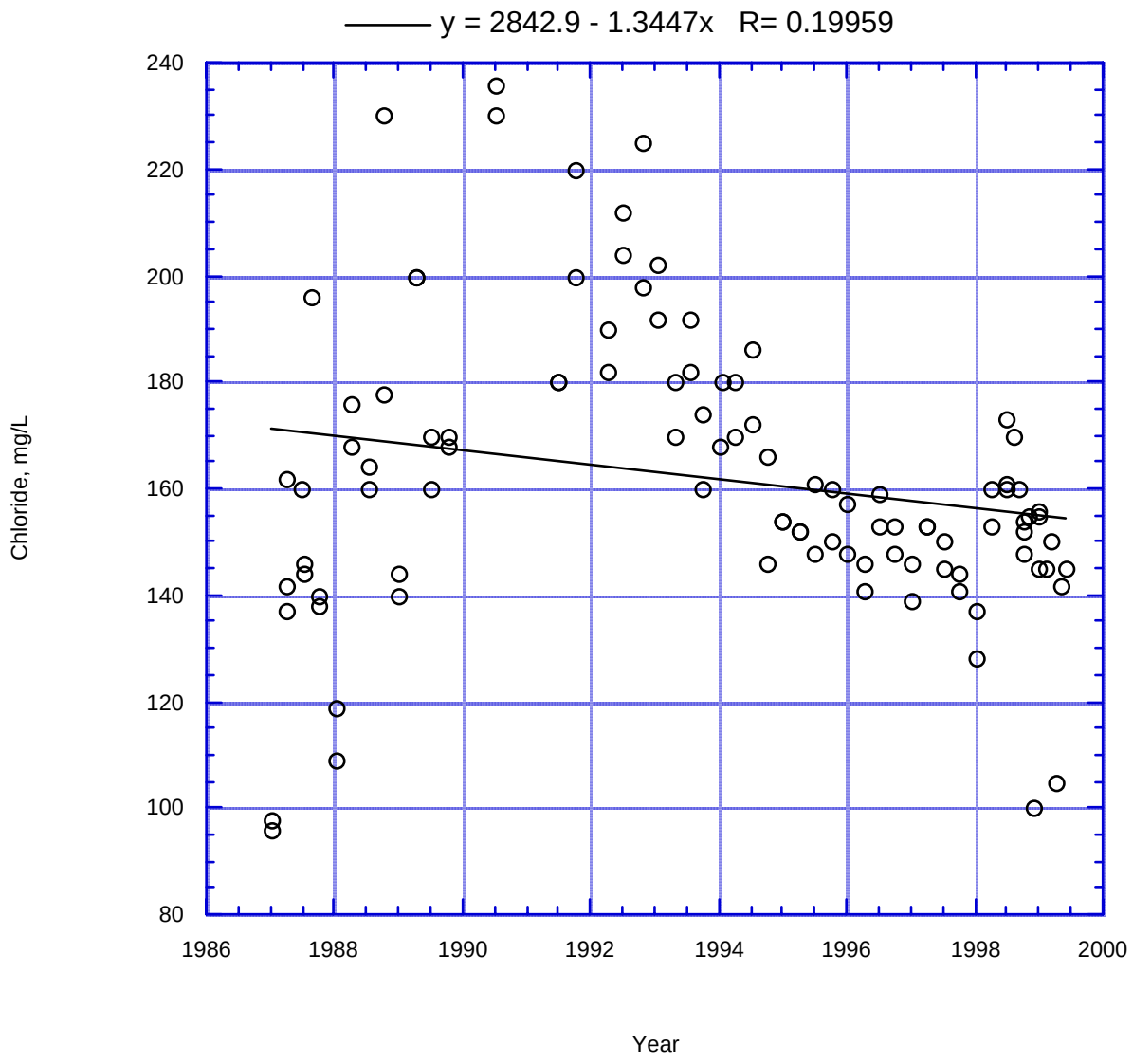


Figure 169. Reach 9B Chloride vs. Time

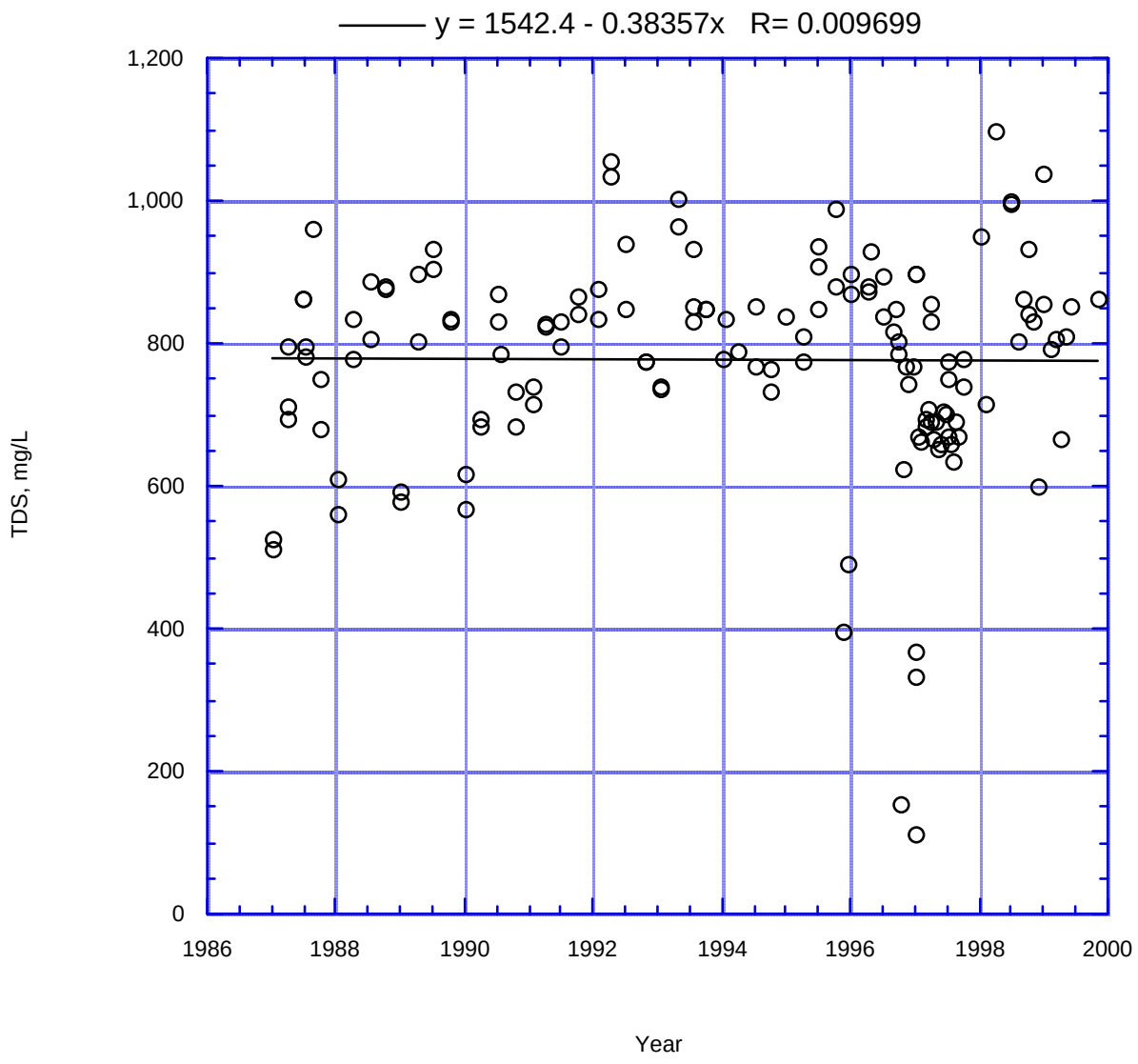


Figure 170. Reach 9B TDS vs. Time

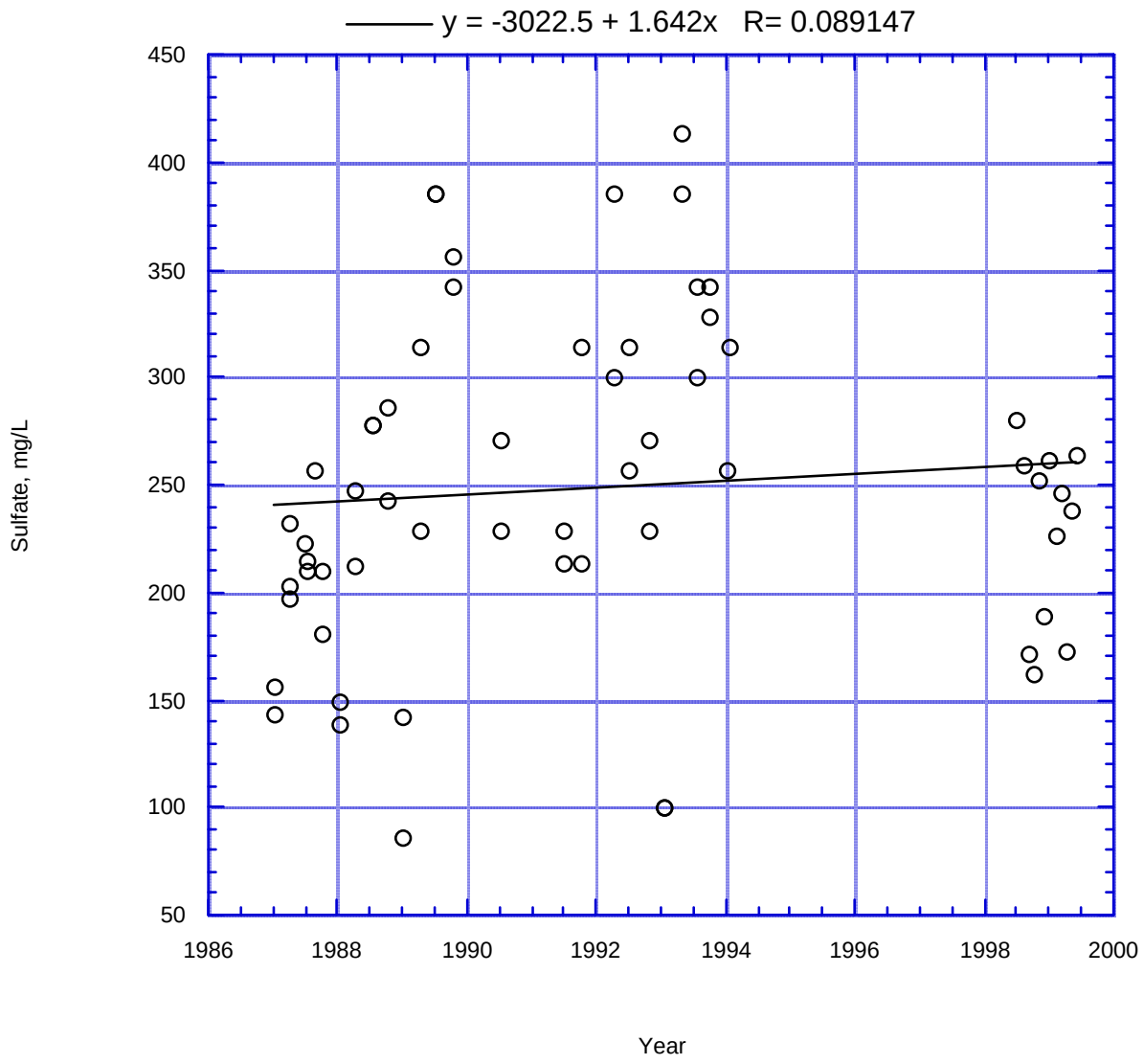


Figure 171. Reach 9B Sulfate vs. Time

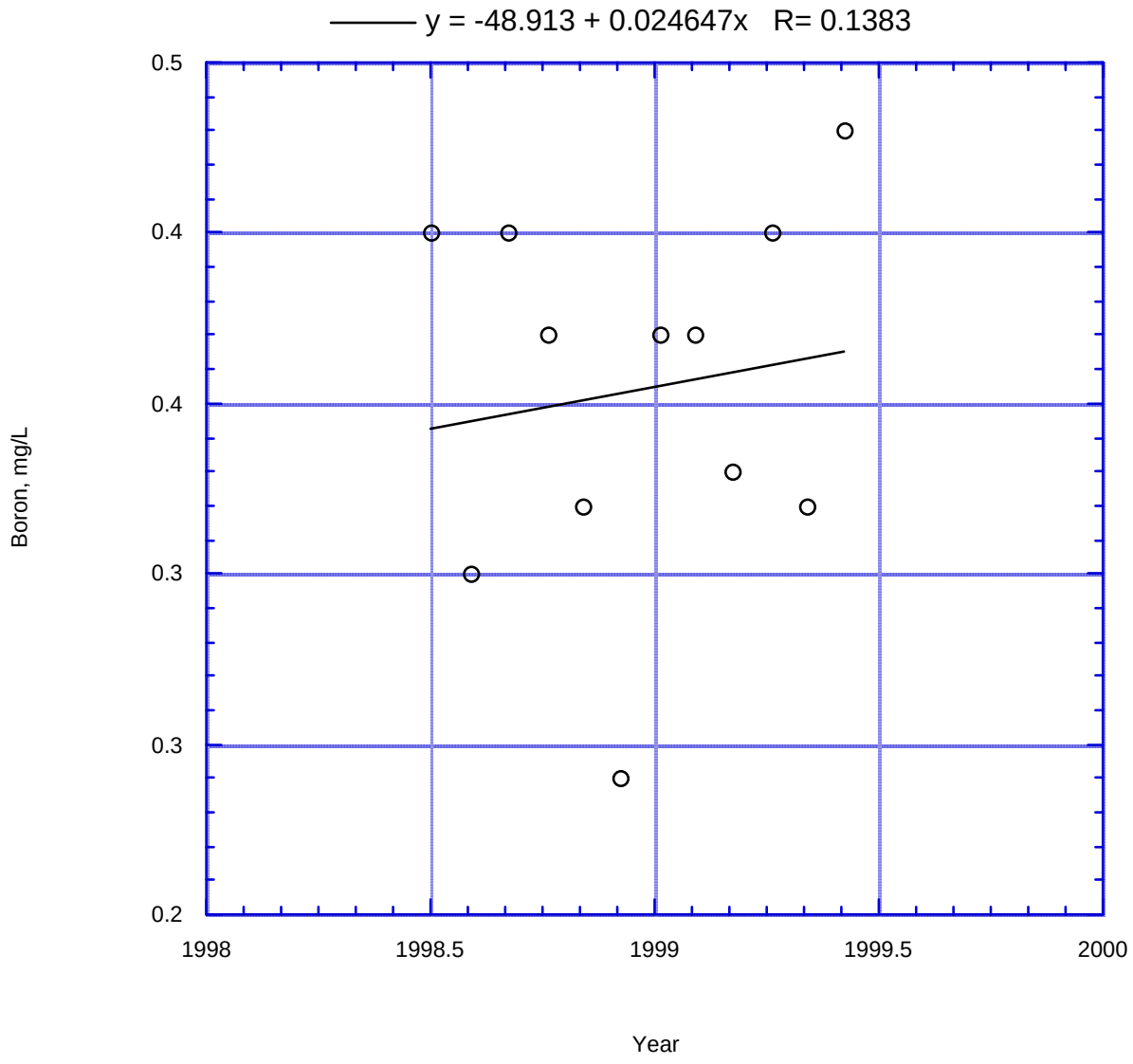


Figure 172. Reach 9B Boron vs. Time

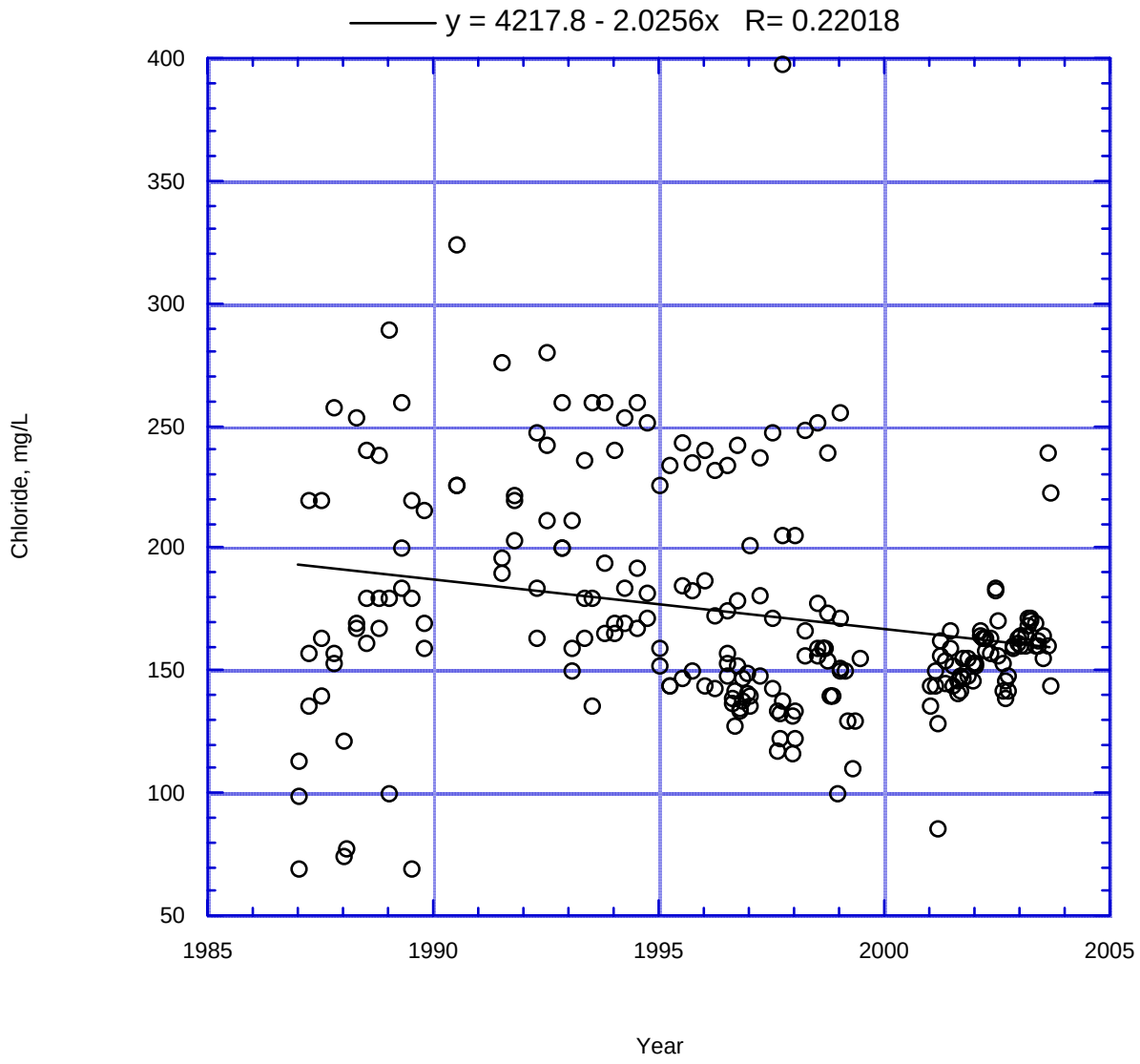


Figure 173. Reach 10 Chloride vs. Time

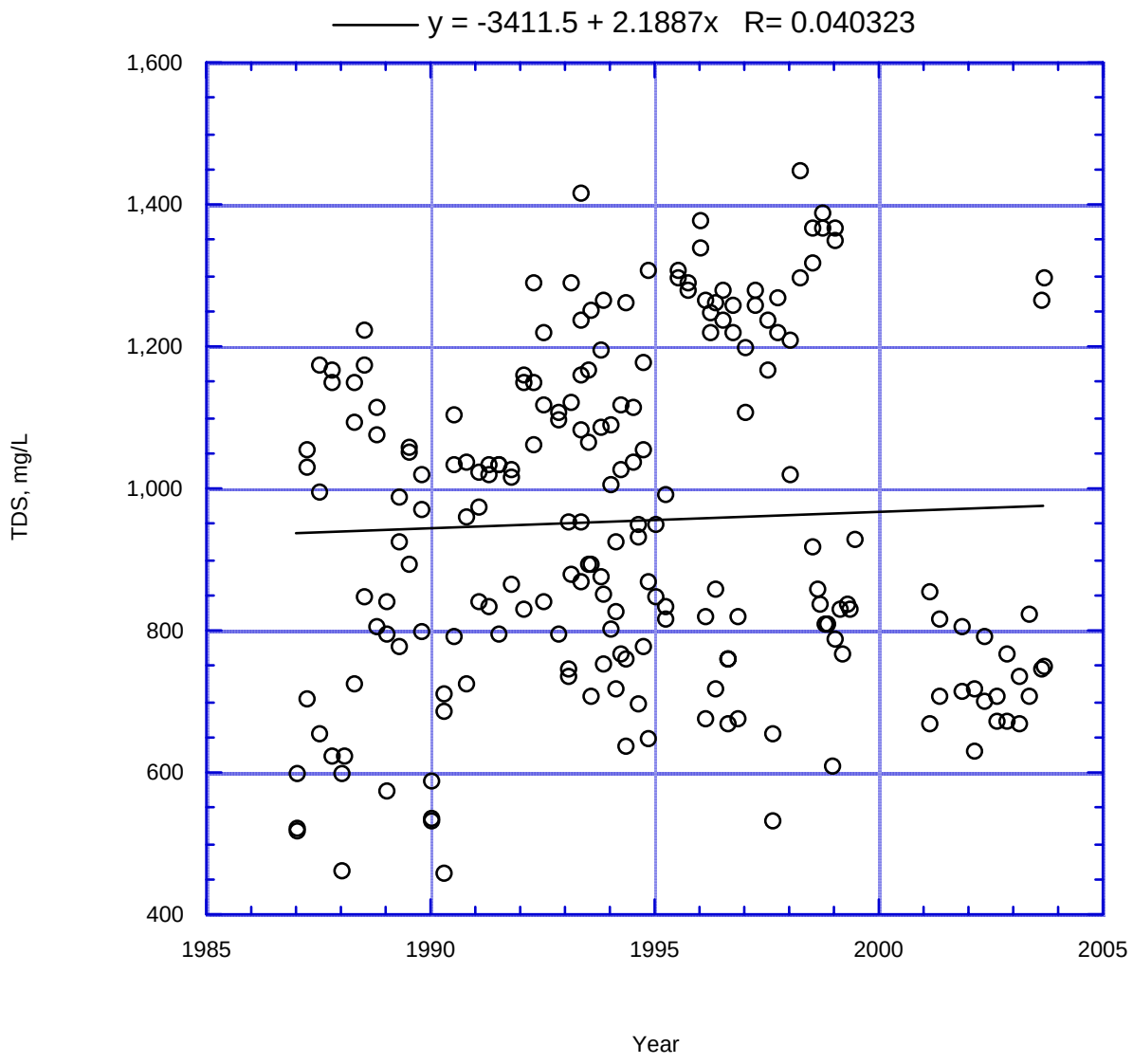


Figure 174. Reach 10 TDS vs. Time

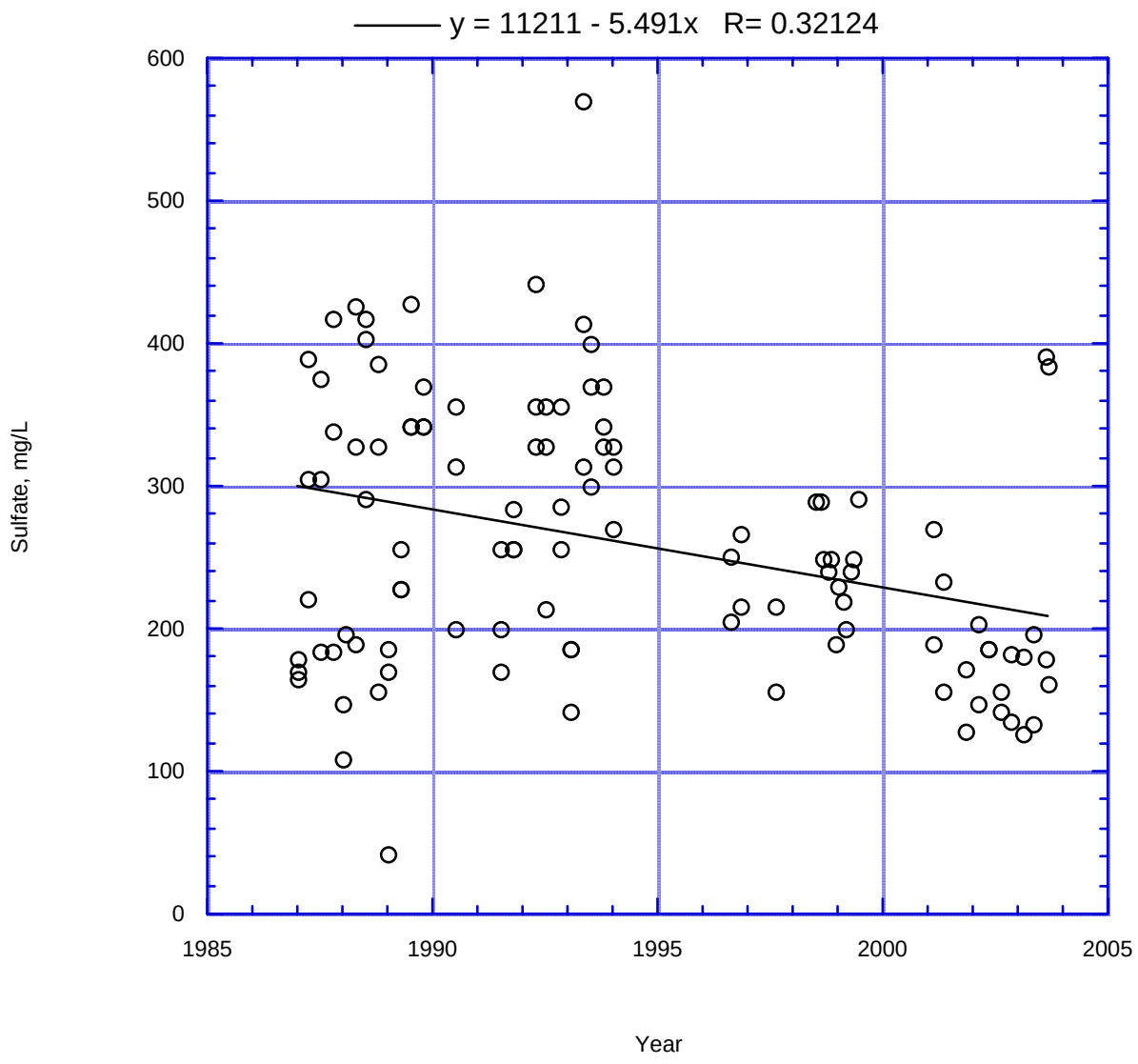


Figure 175. Reach 10 Sulfate vs. Time

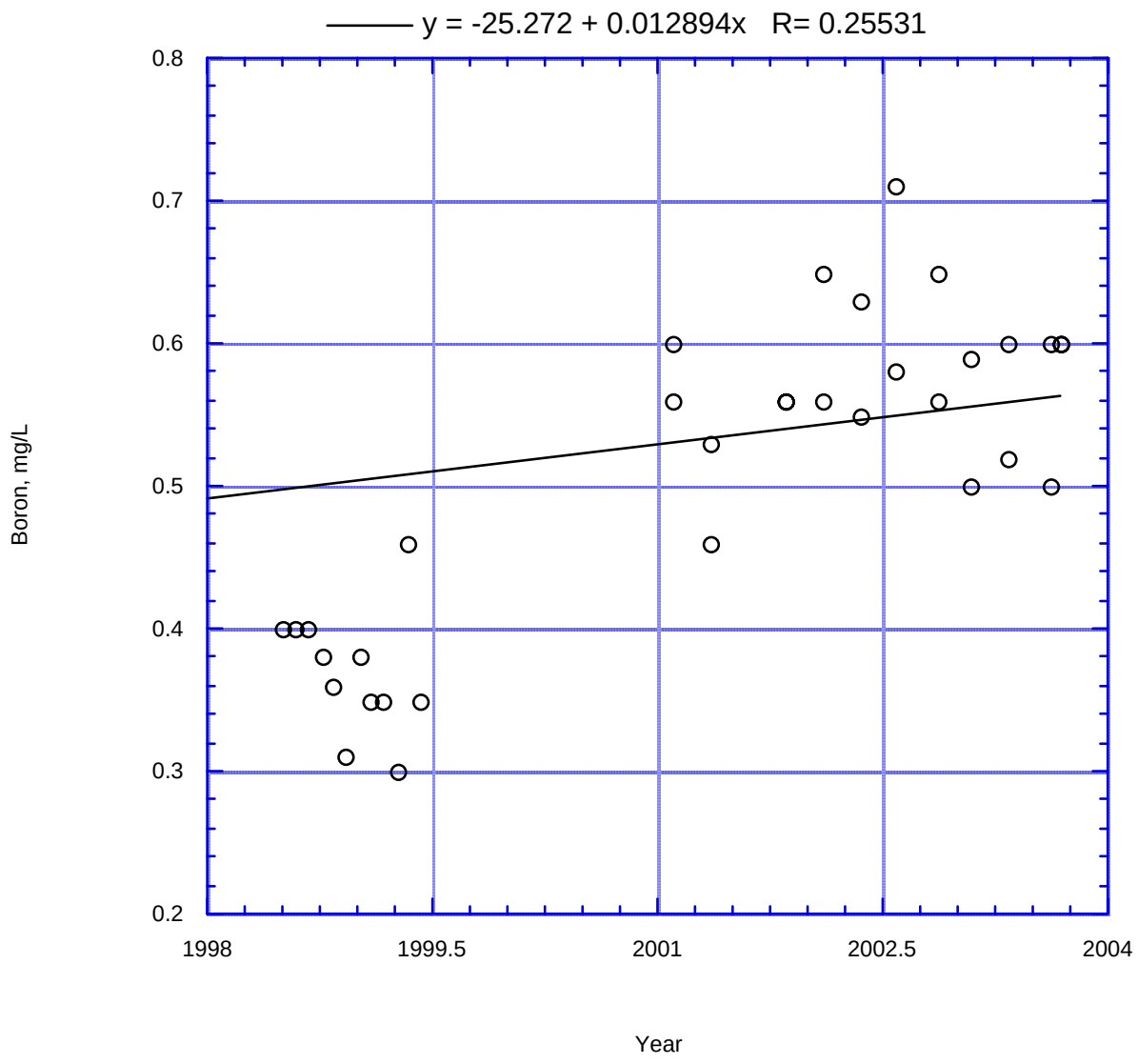


Figure 176. Reach 10 Boron vs. Time

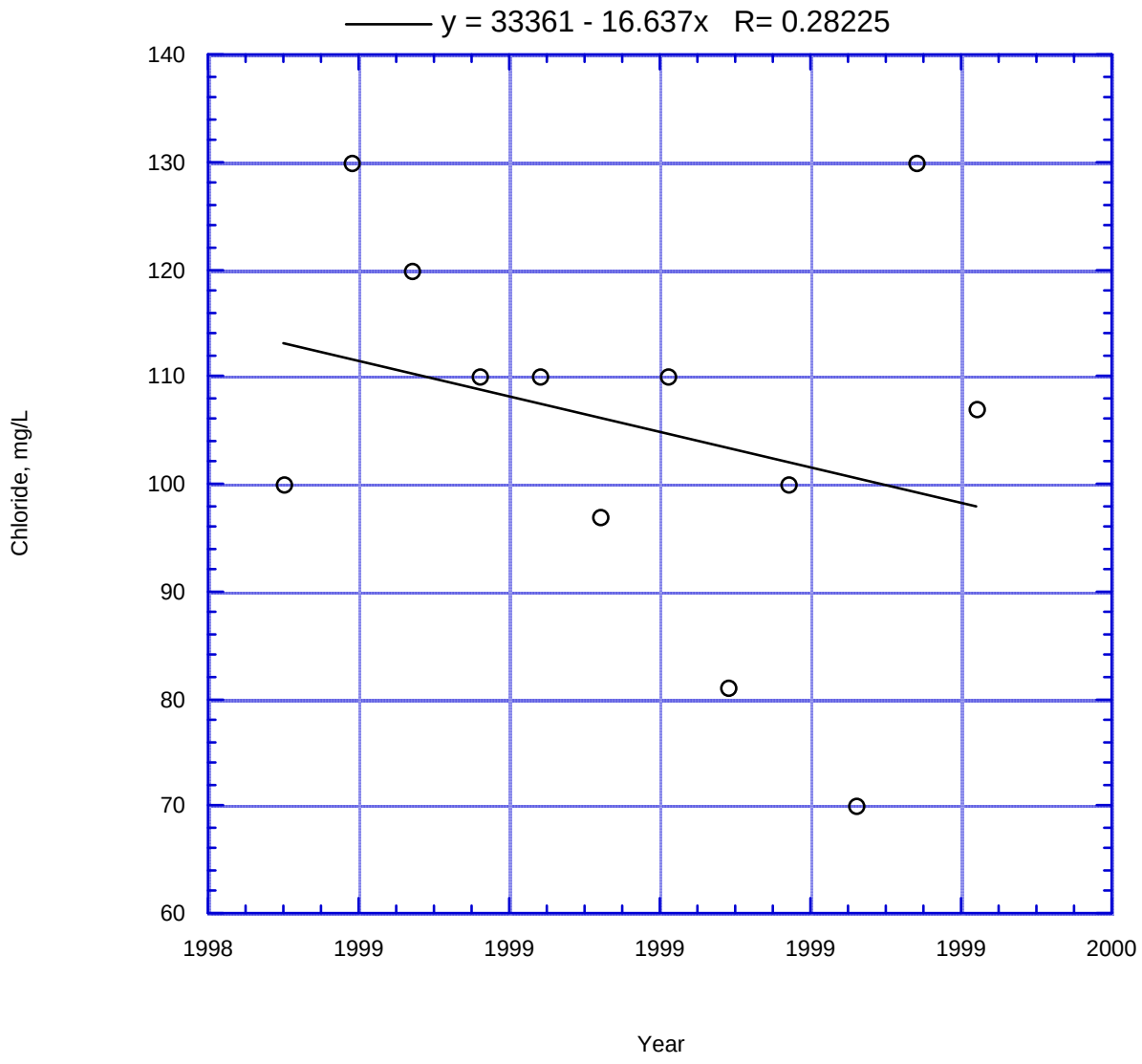


Figure 177. Reach 11 Chloride vs. Time

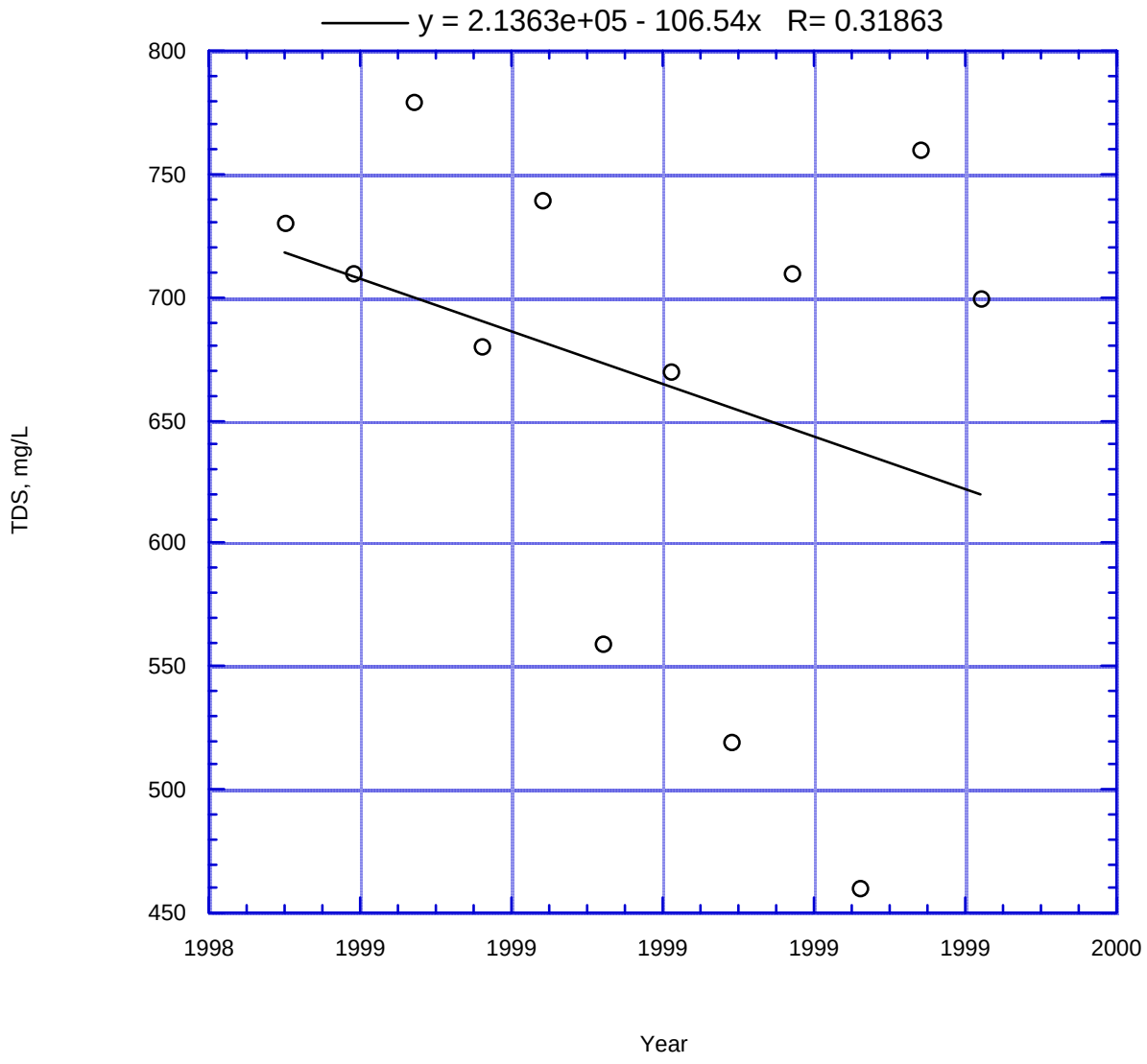


Figure 178. Reach 11 TDS vs. Time

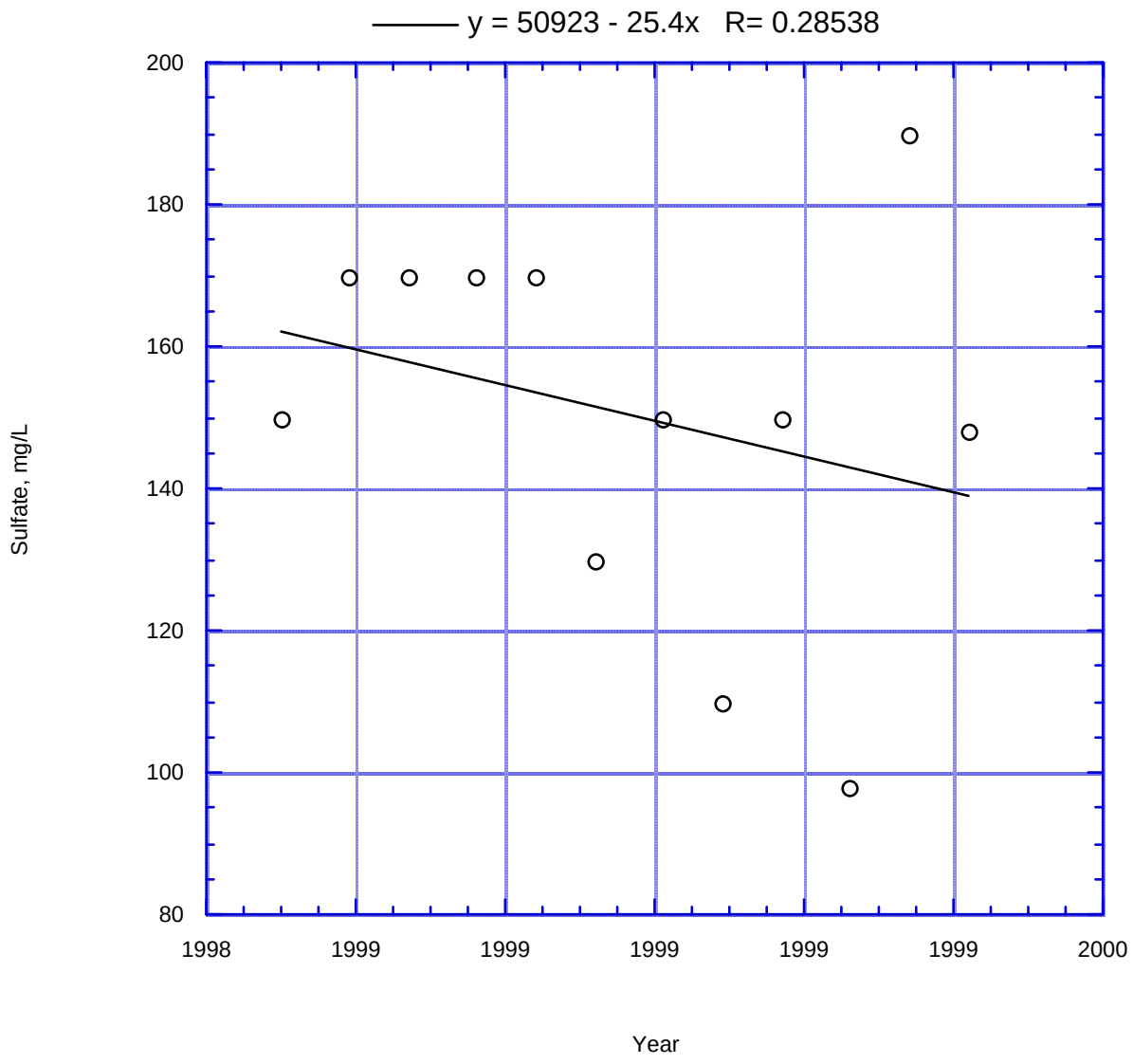


Figure 179. Reach 11 Sulfate vs. Time

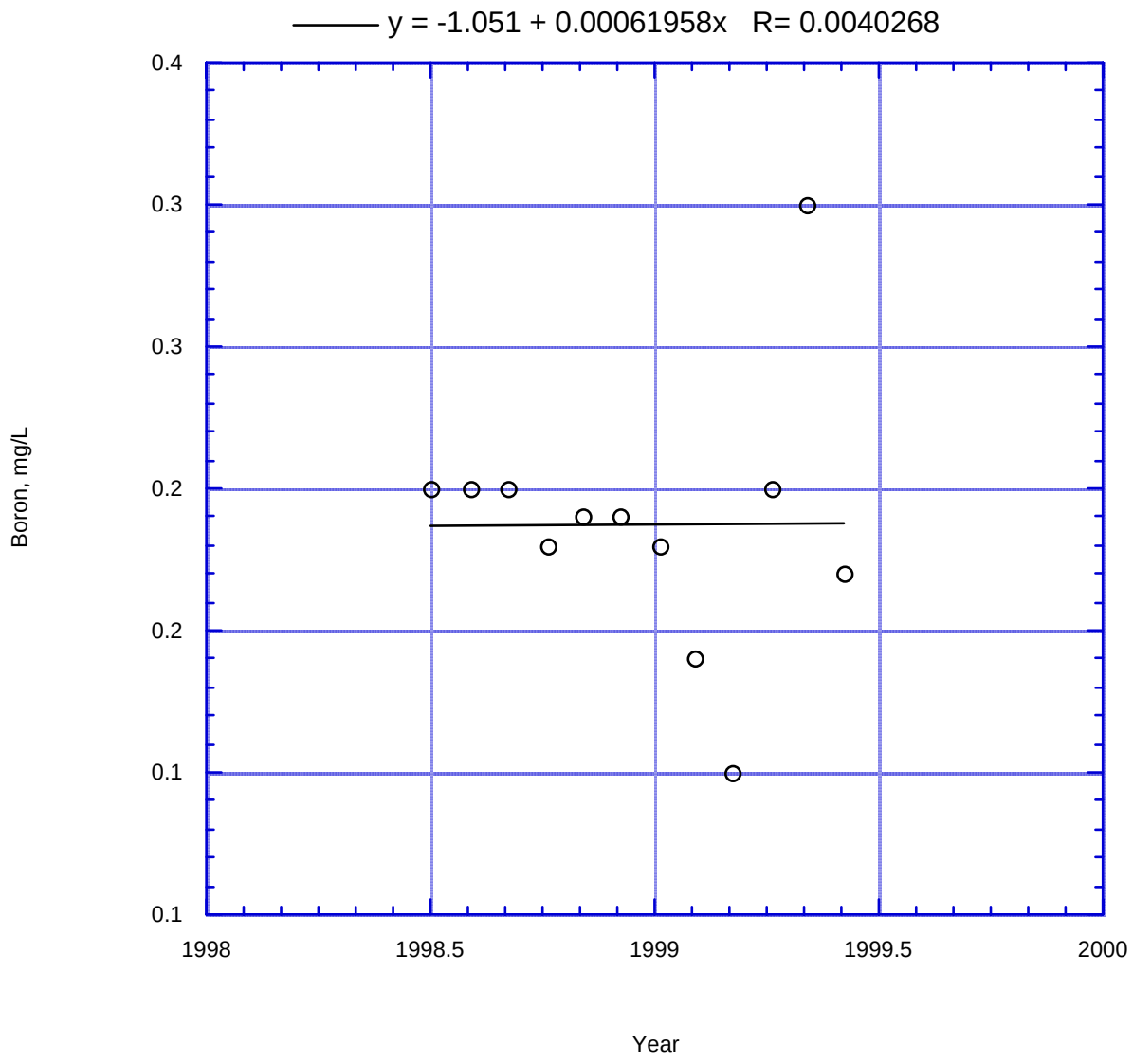


Figure 180. Reach 11 Boron vs. Time

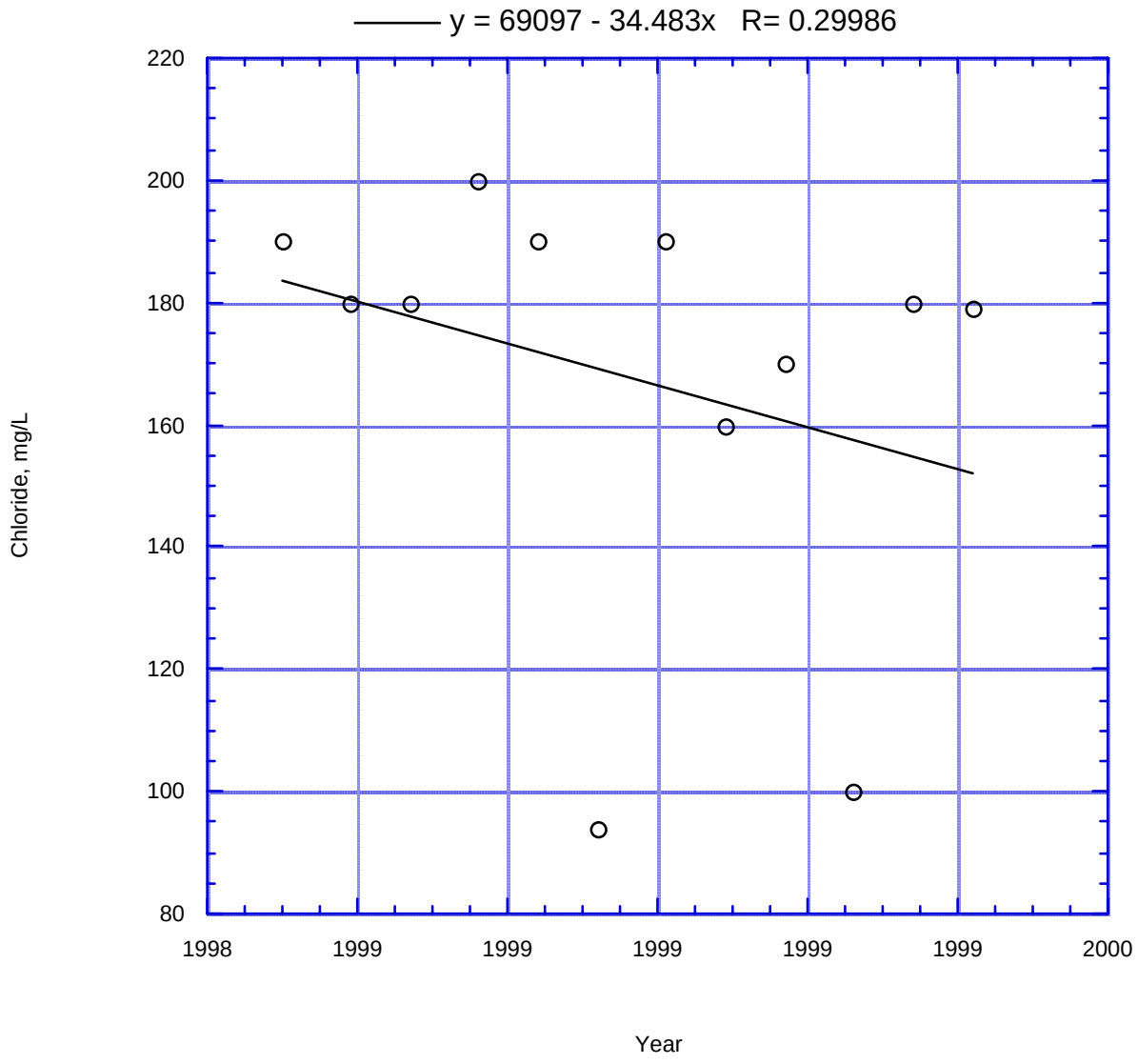


Figure 181. Reach 13 Chloride vs. Time

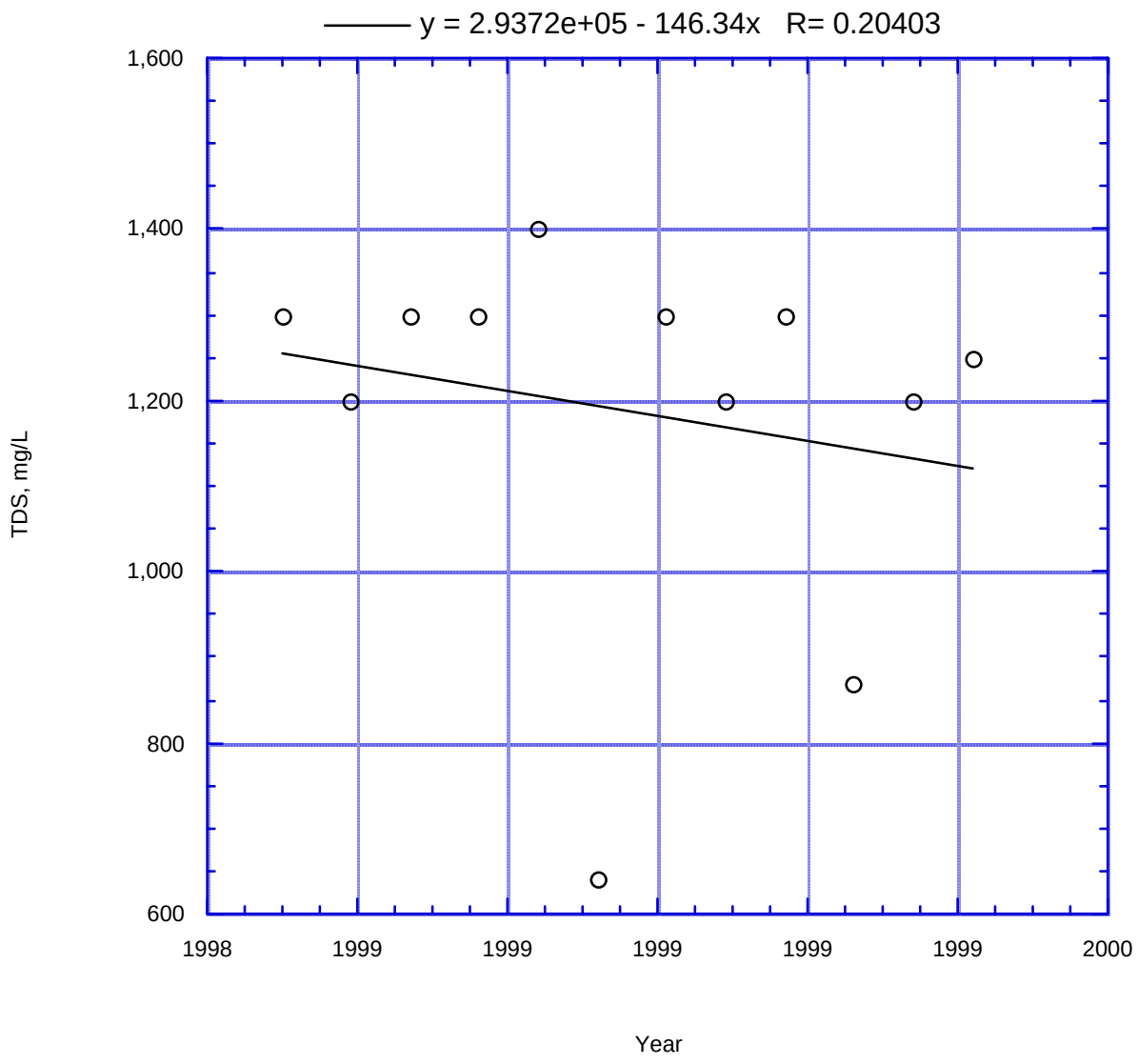


Figure 182. Reach 13 TDS vs. Time

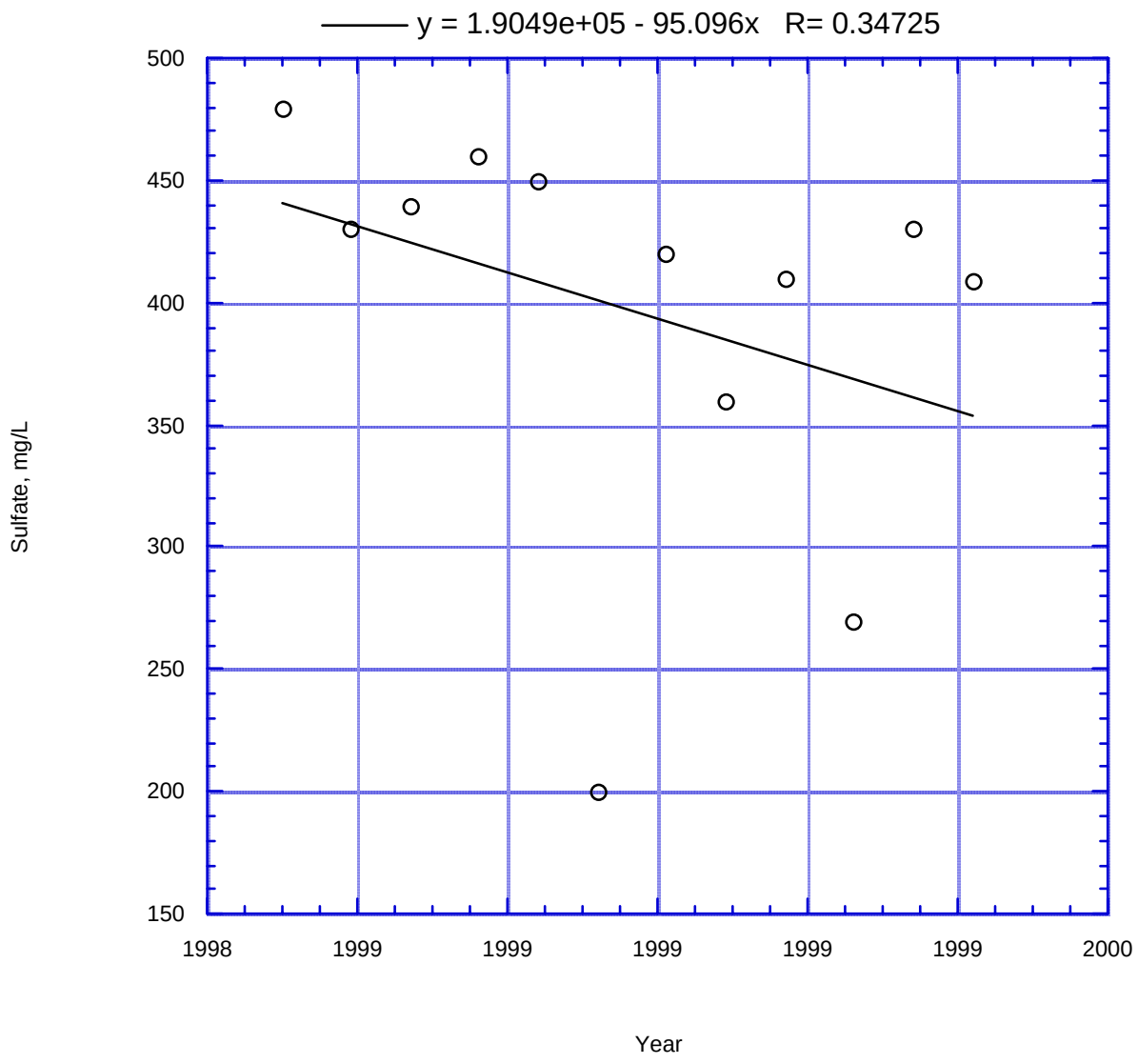


Figure 183. Reach 13 Sulfate vs. Time

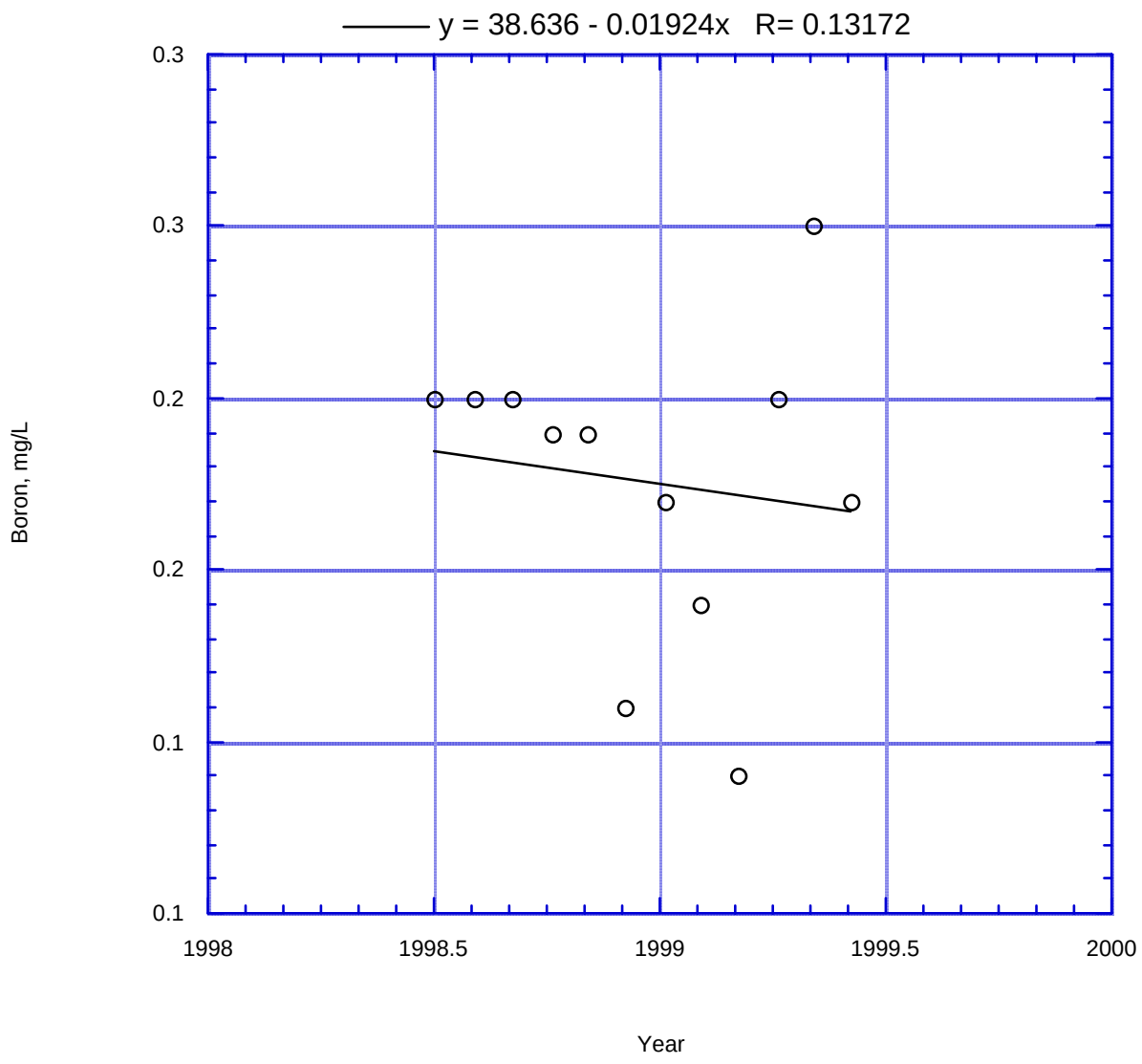


Figure 184. Reach 13 Boron vs. Time

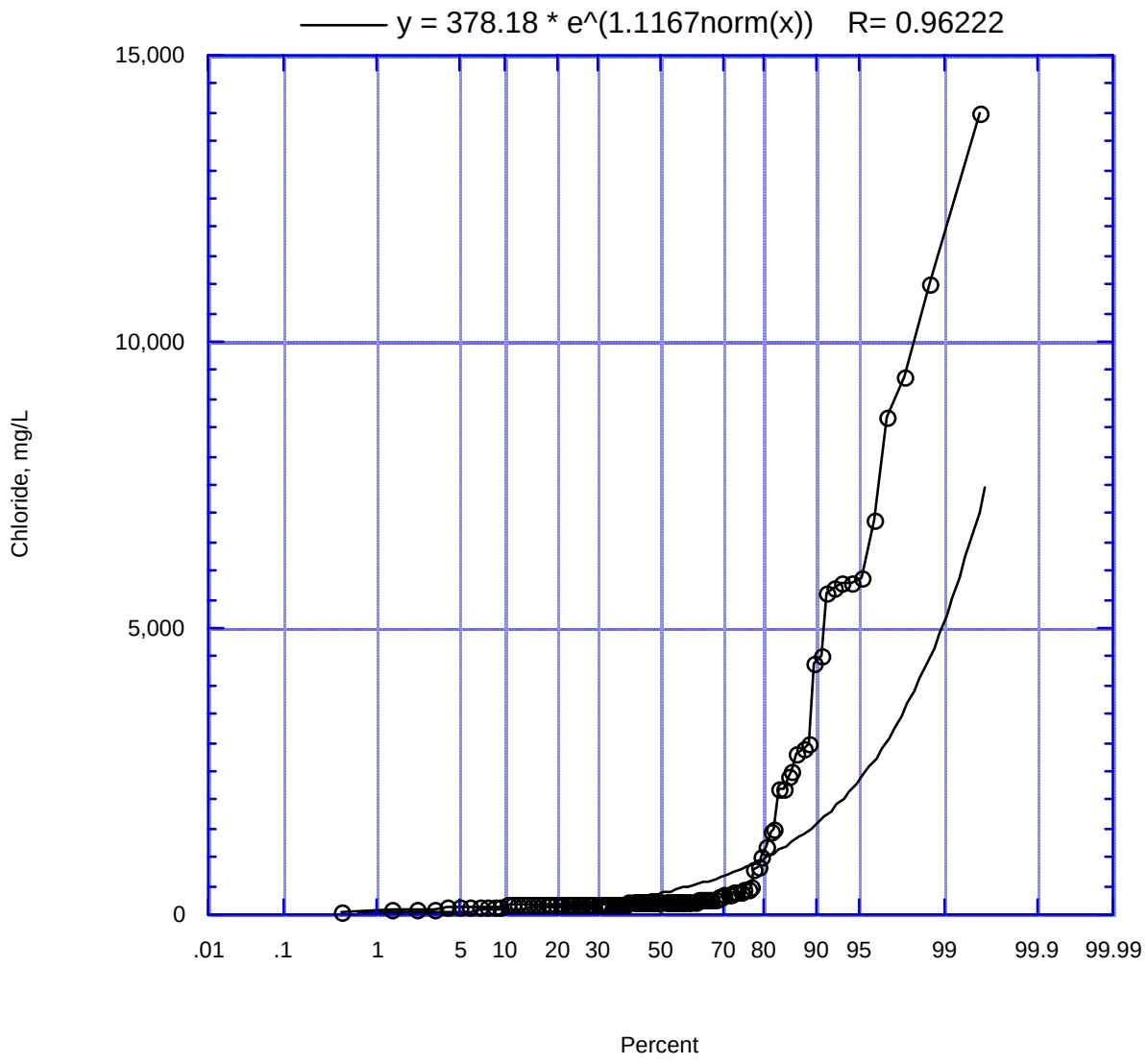


Figure 185. Reach 2 Chloride Frequency Distribution

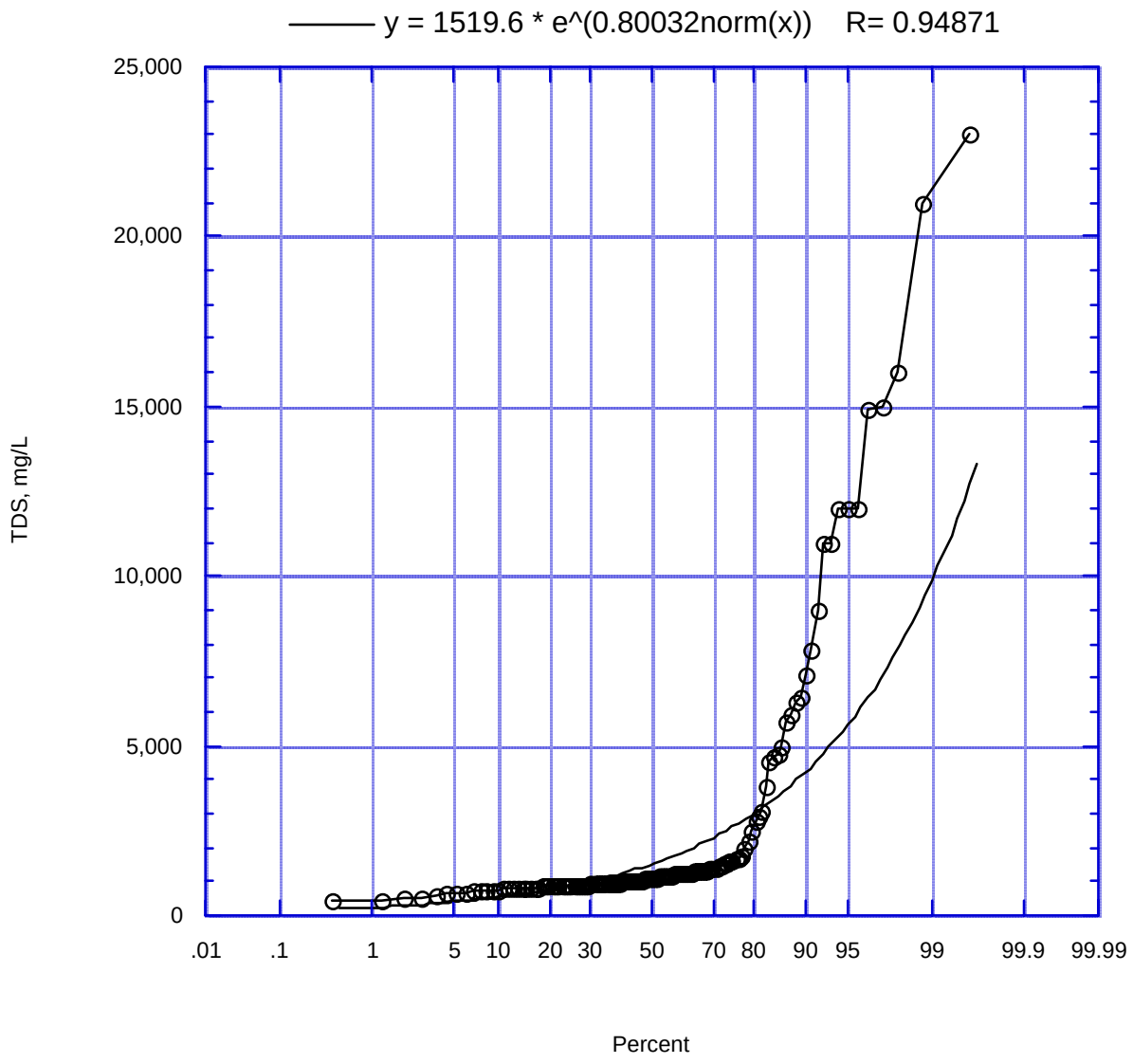


Figure 186. Reach 2 TDS Frequency Distribution

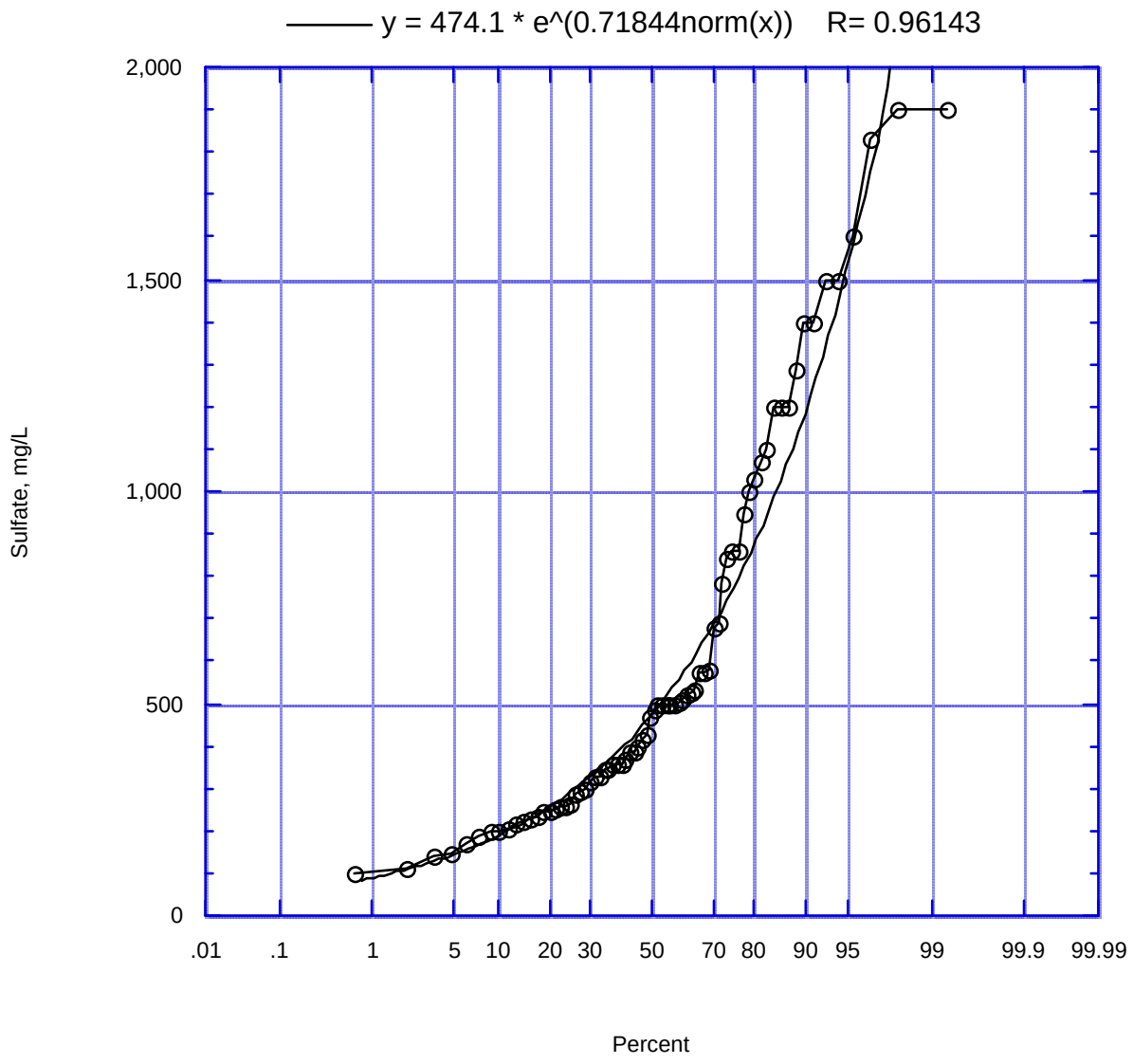


Figure 187. Reach 2 Sulfate Frequency Distribution

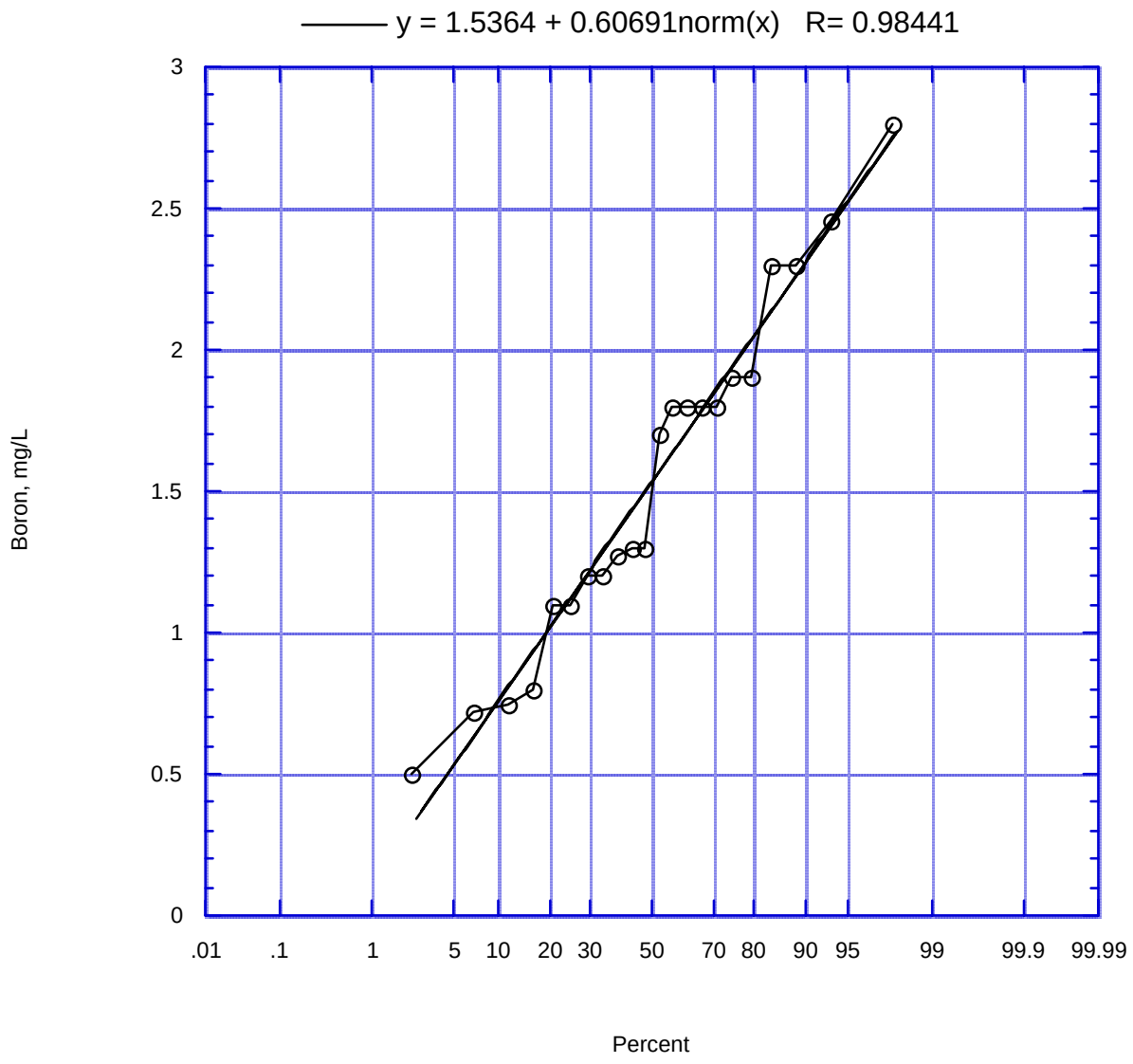


Figure 188. Reach 2 Boron Frequency Distribution

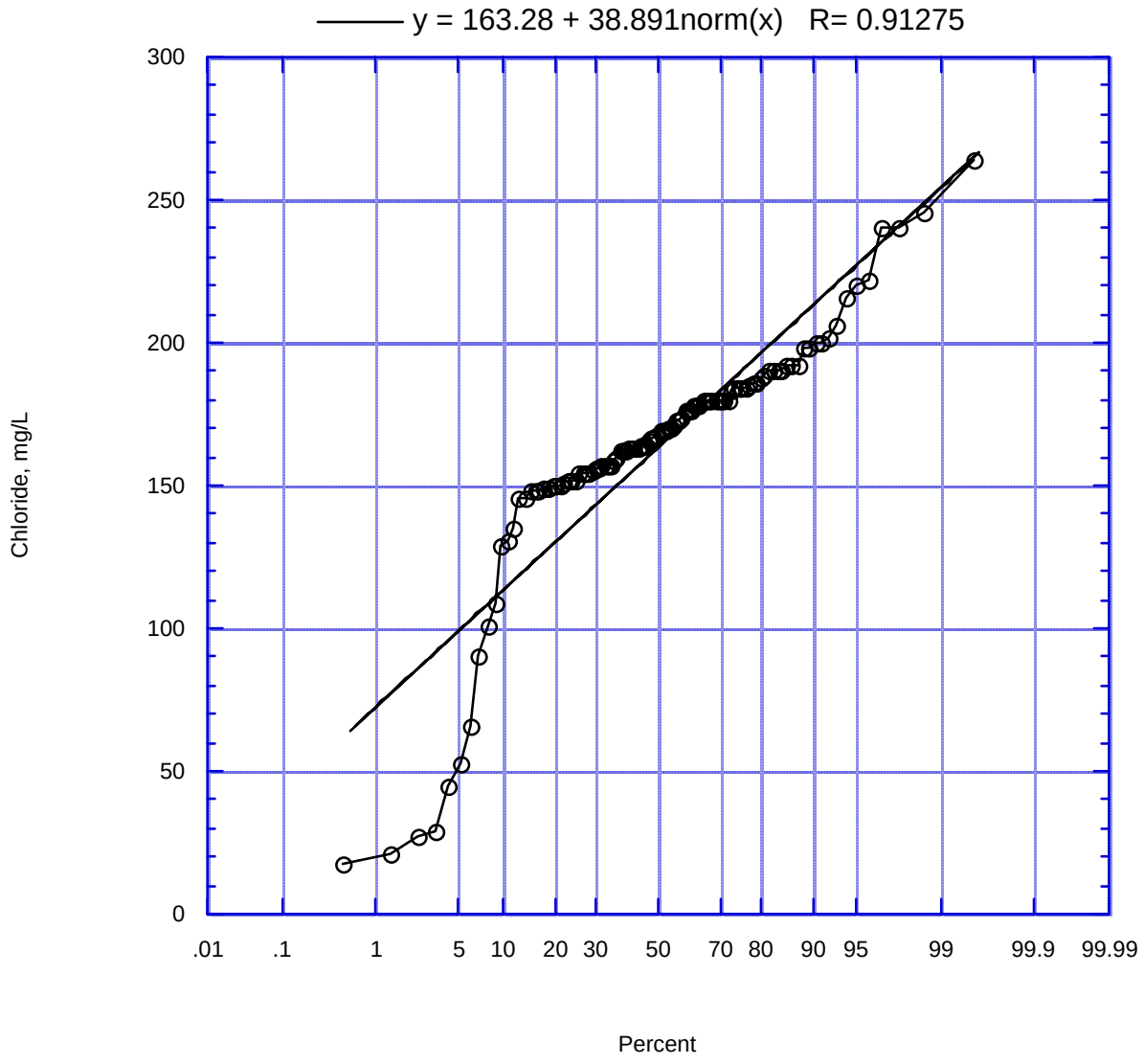


Figure 189. Reach 3 Chloride Frequency Distribution

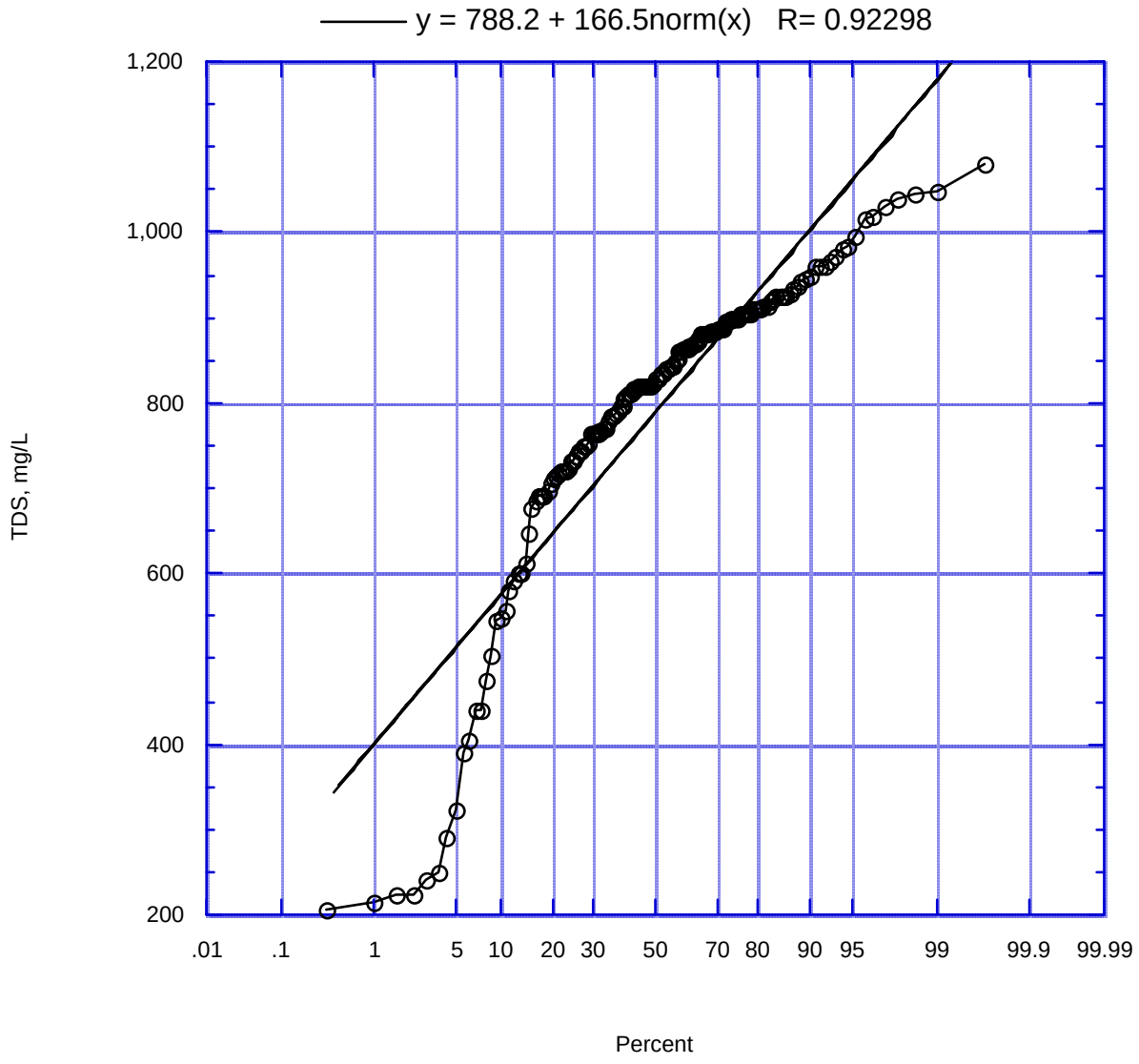


Figure 190. Reach 3 TDS Frequency Distribution

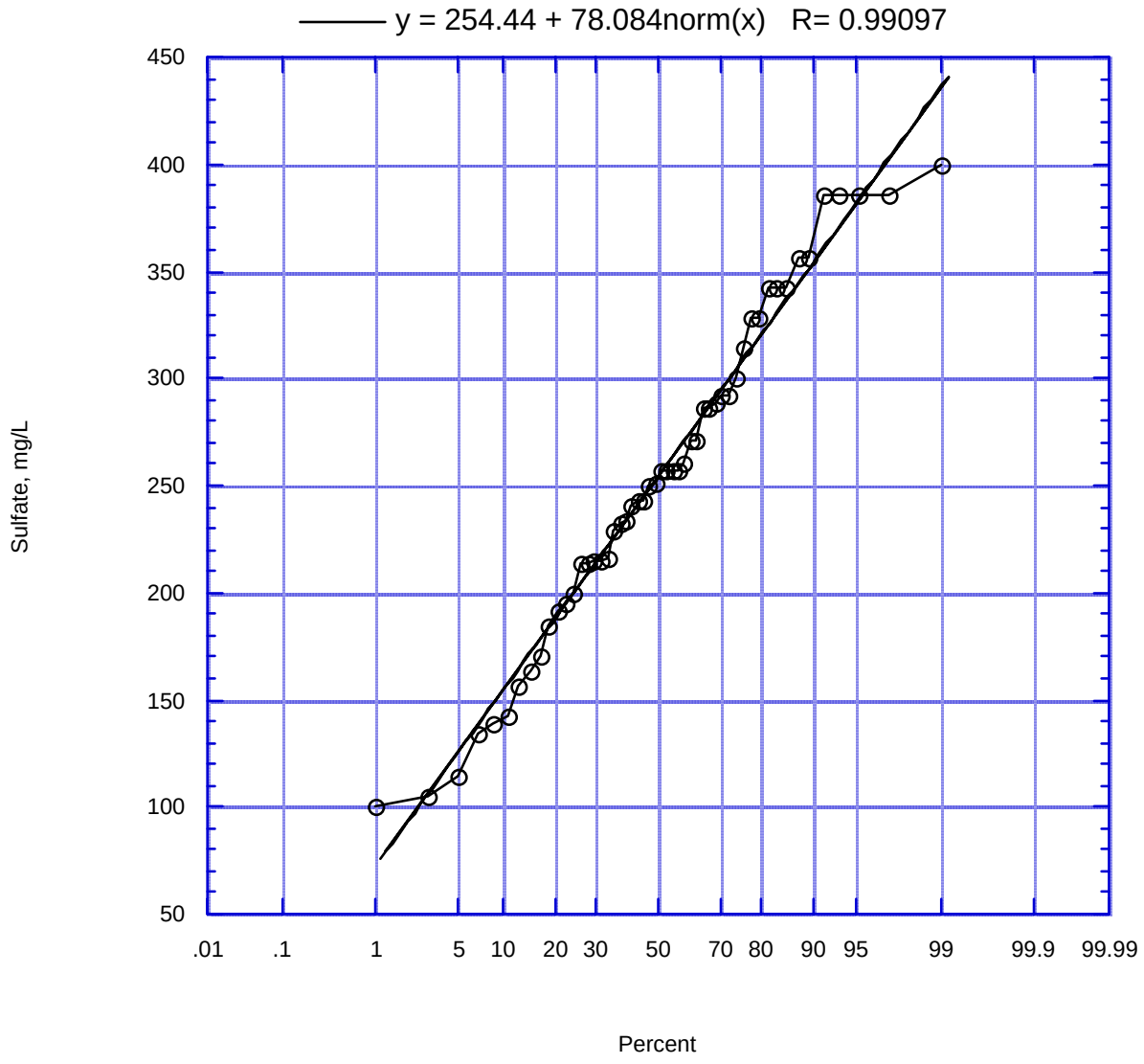


Figure 191. Reach 3 Sulfate Frequency Distribution

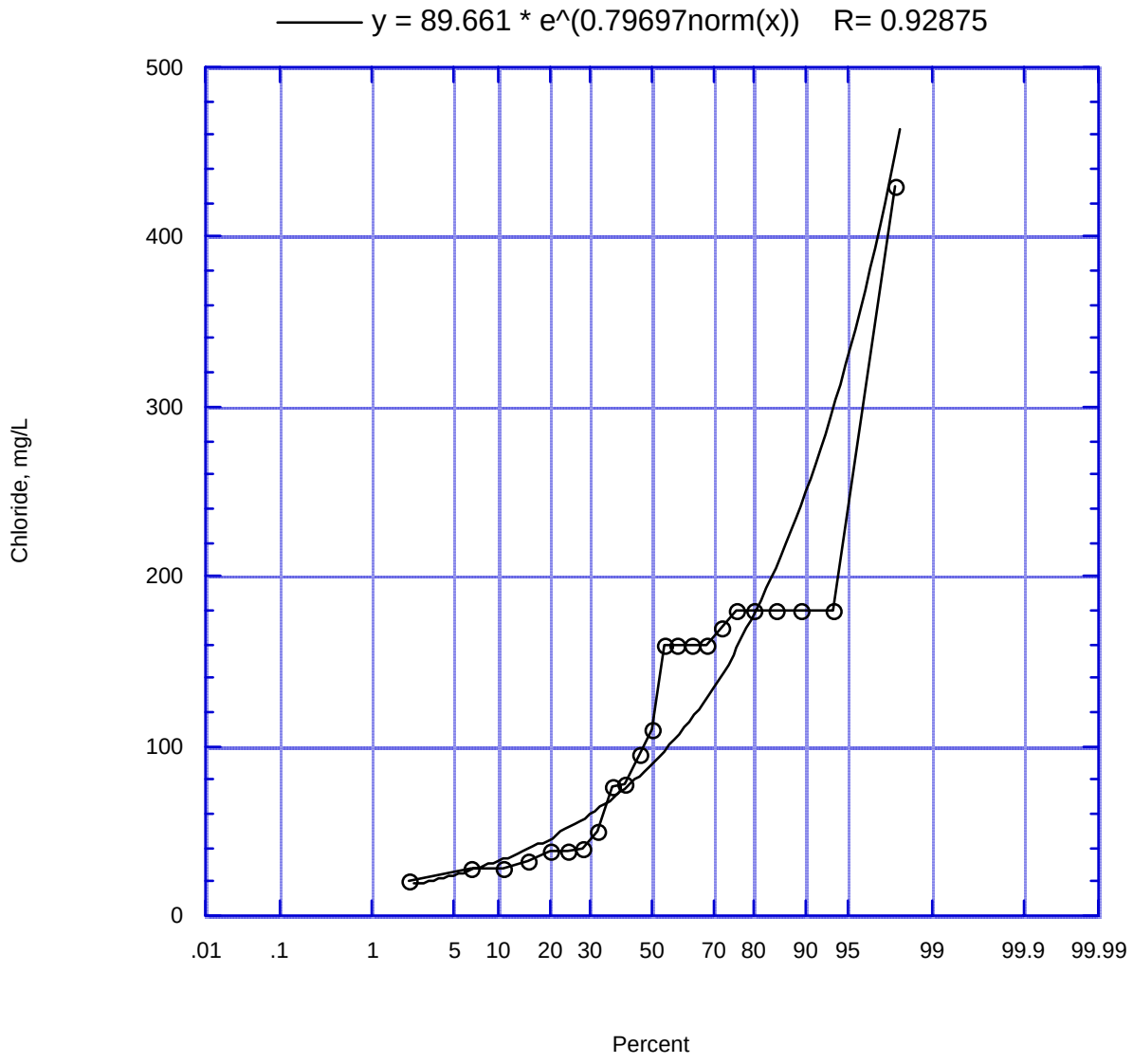


Figure 192. Reach 4 Chloride Frequency Distribution

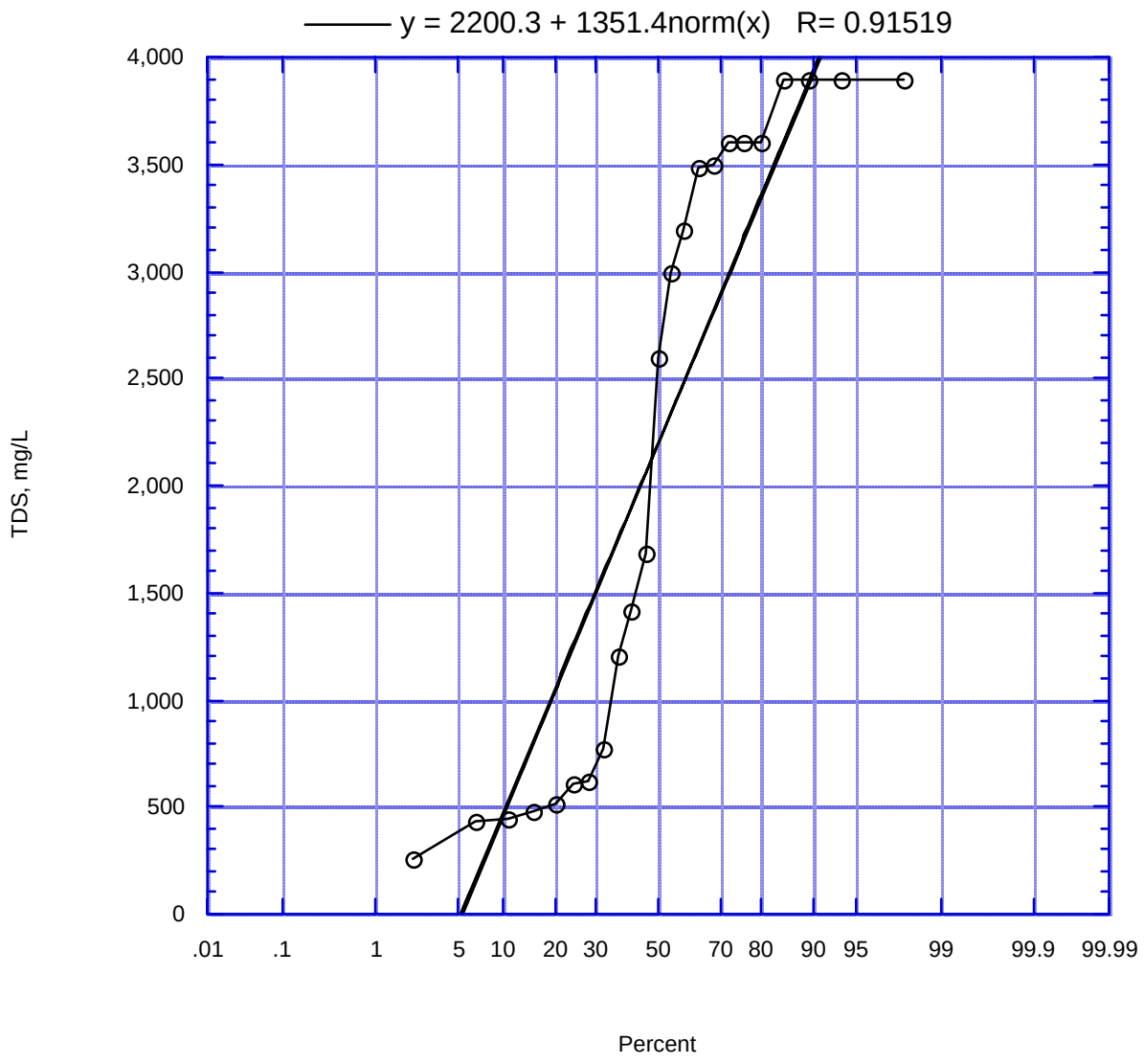


Figure 193. Reach 4 TDS Frequency Distribution

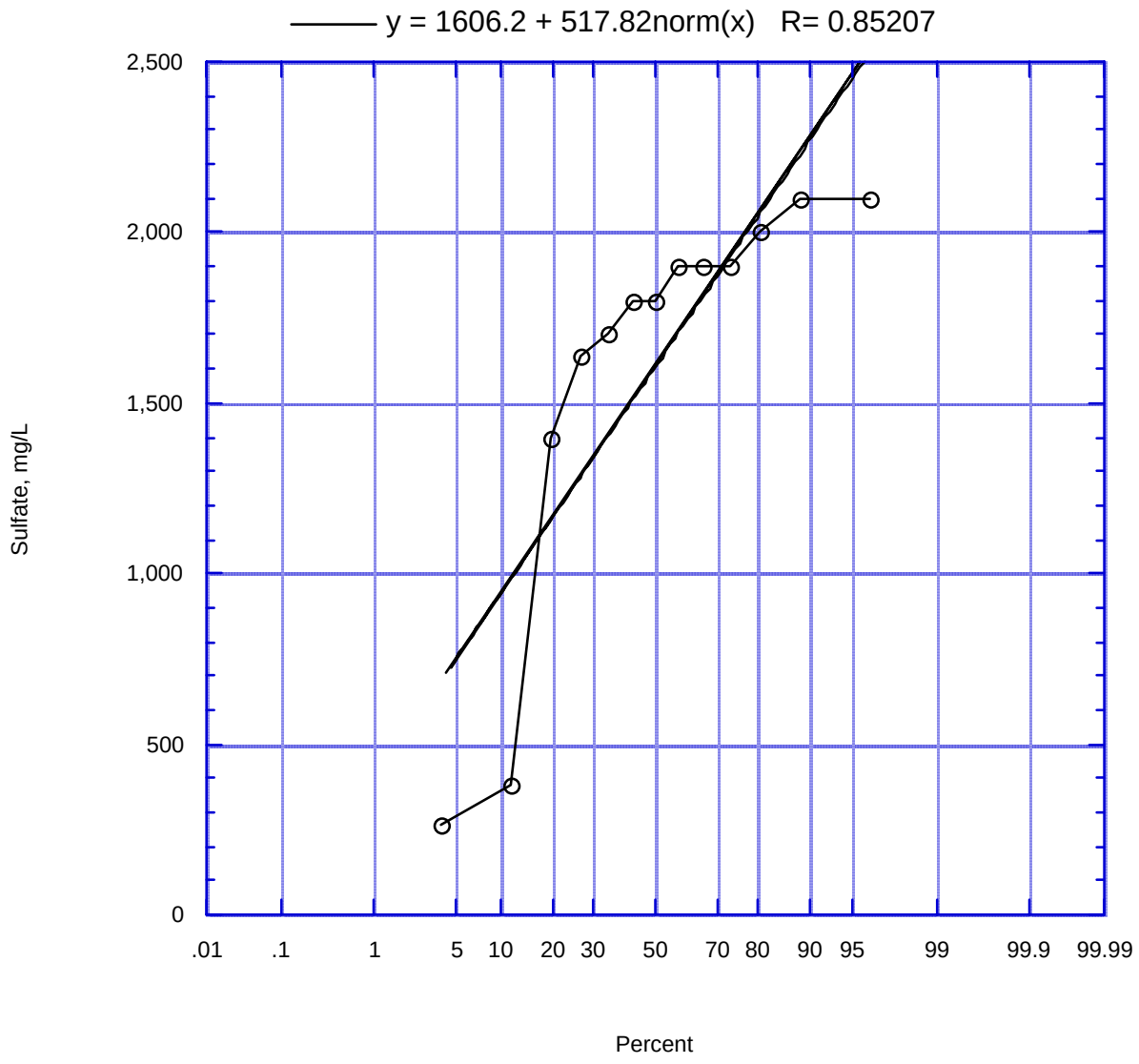


Figure 194. Reach 4 Sulfate Frequency Distribution

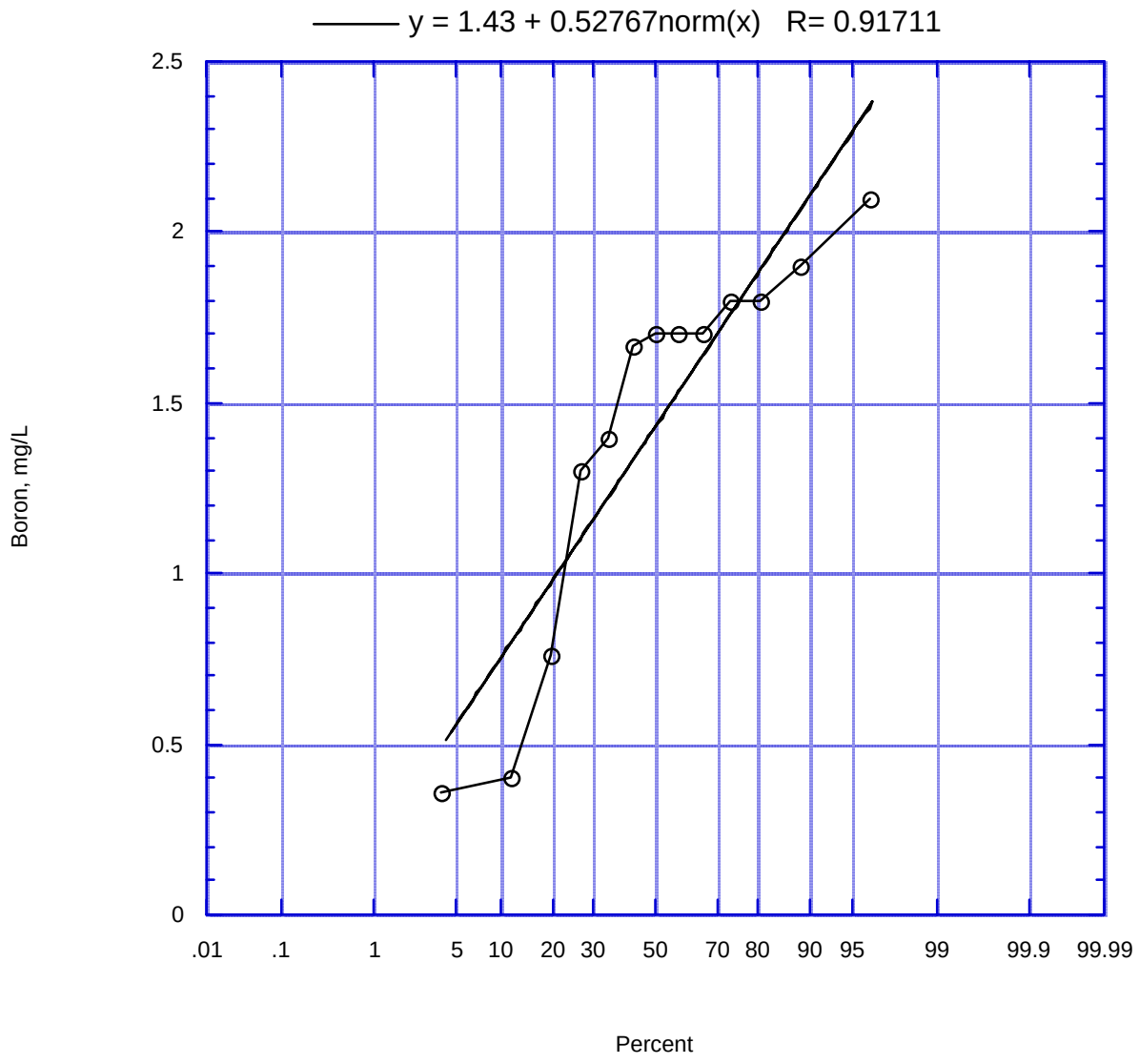


Figure 195. Reach 4 Boron Frequency Distribution

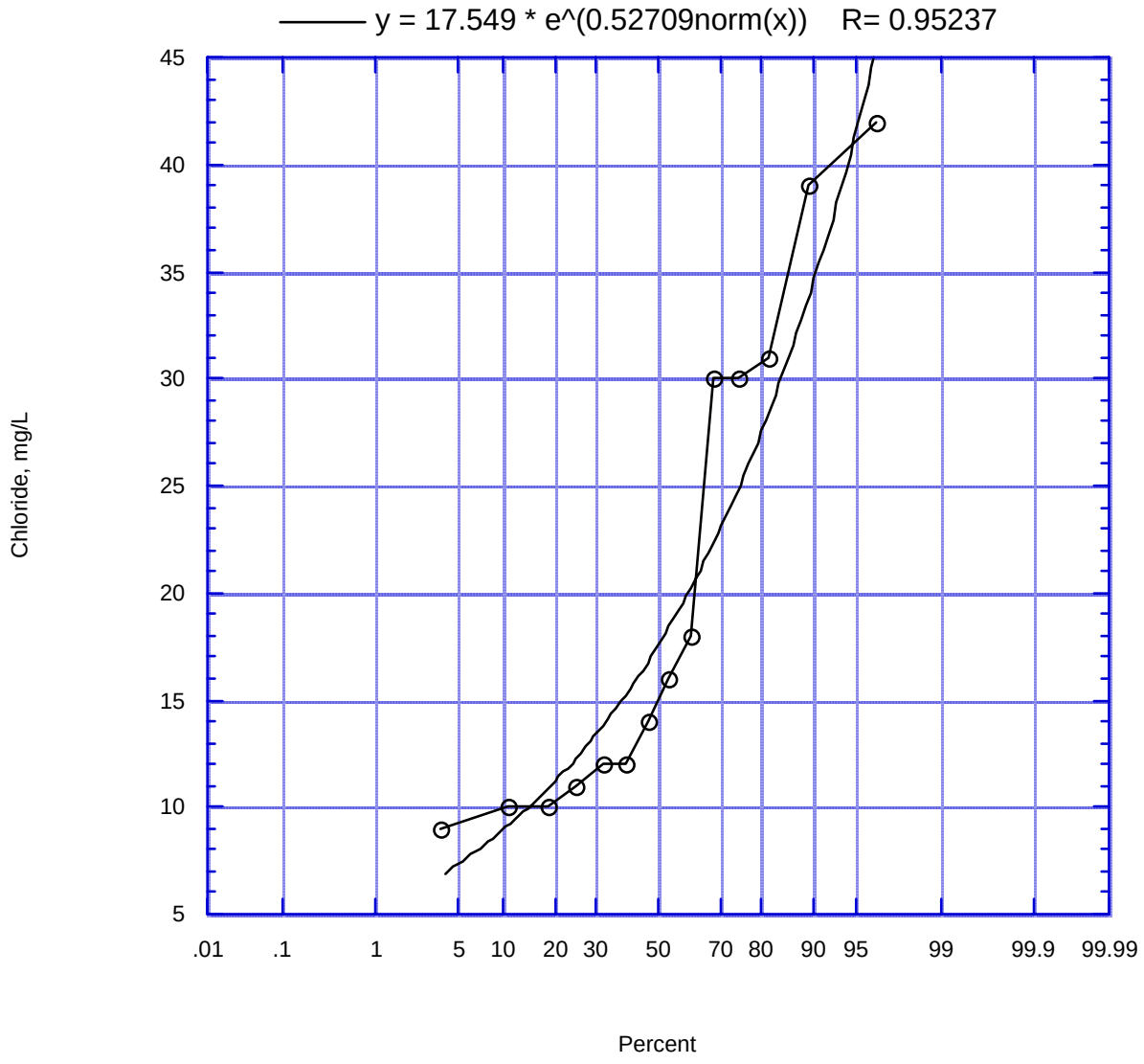


Figure 196. Reach 5 Chloride Frequency Distribution

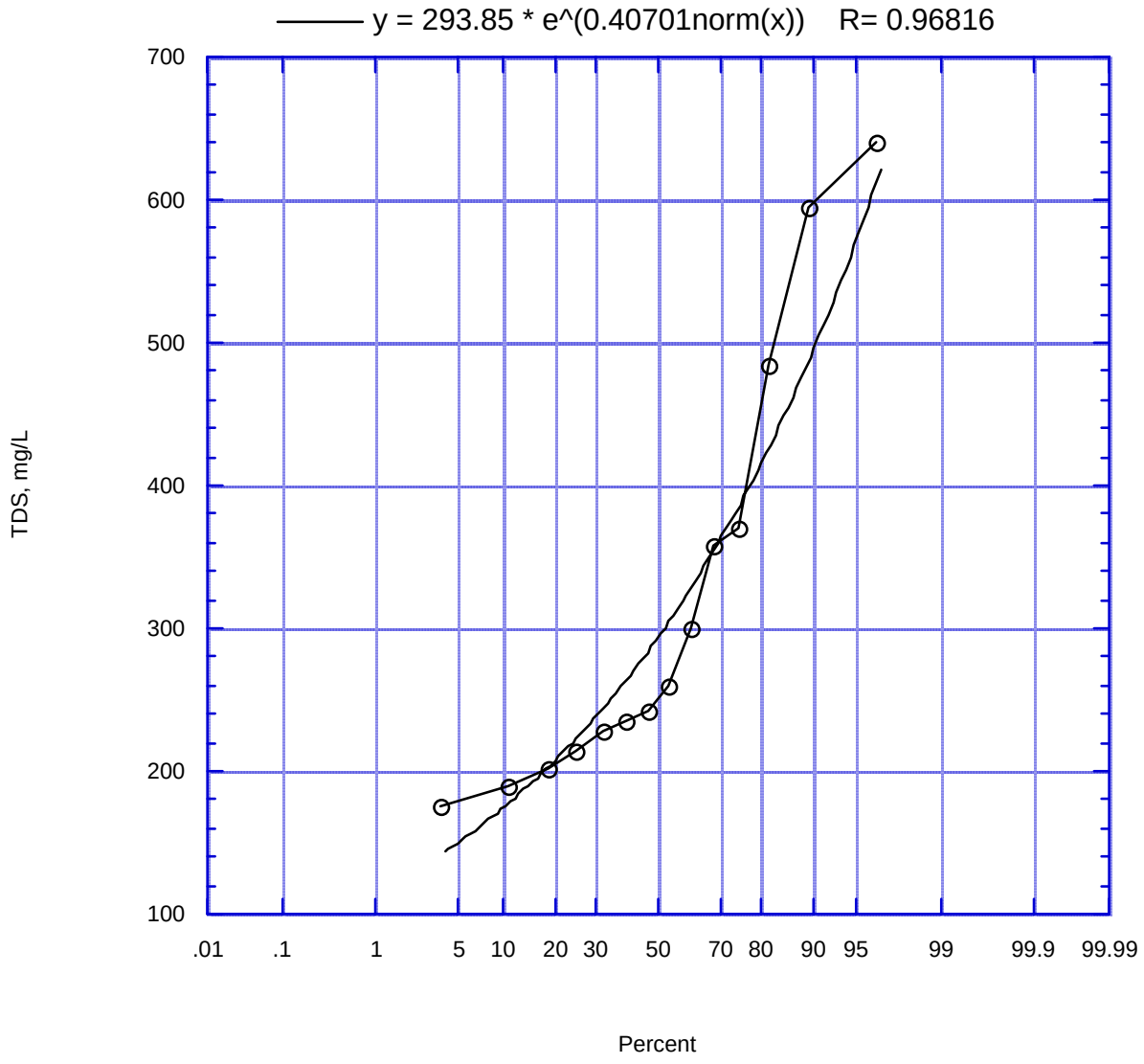


Figure 197. Reach 5 TDS Frequency Distribution

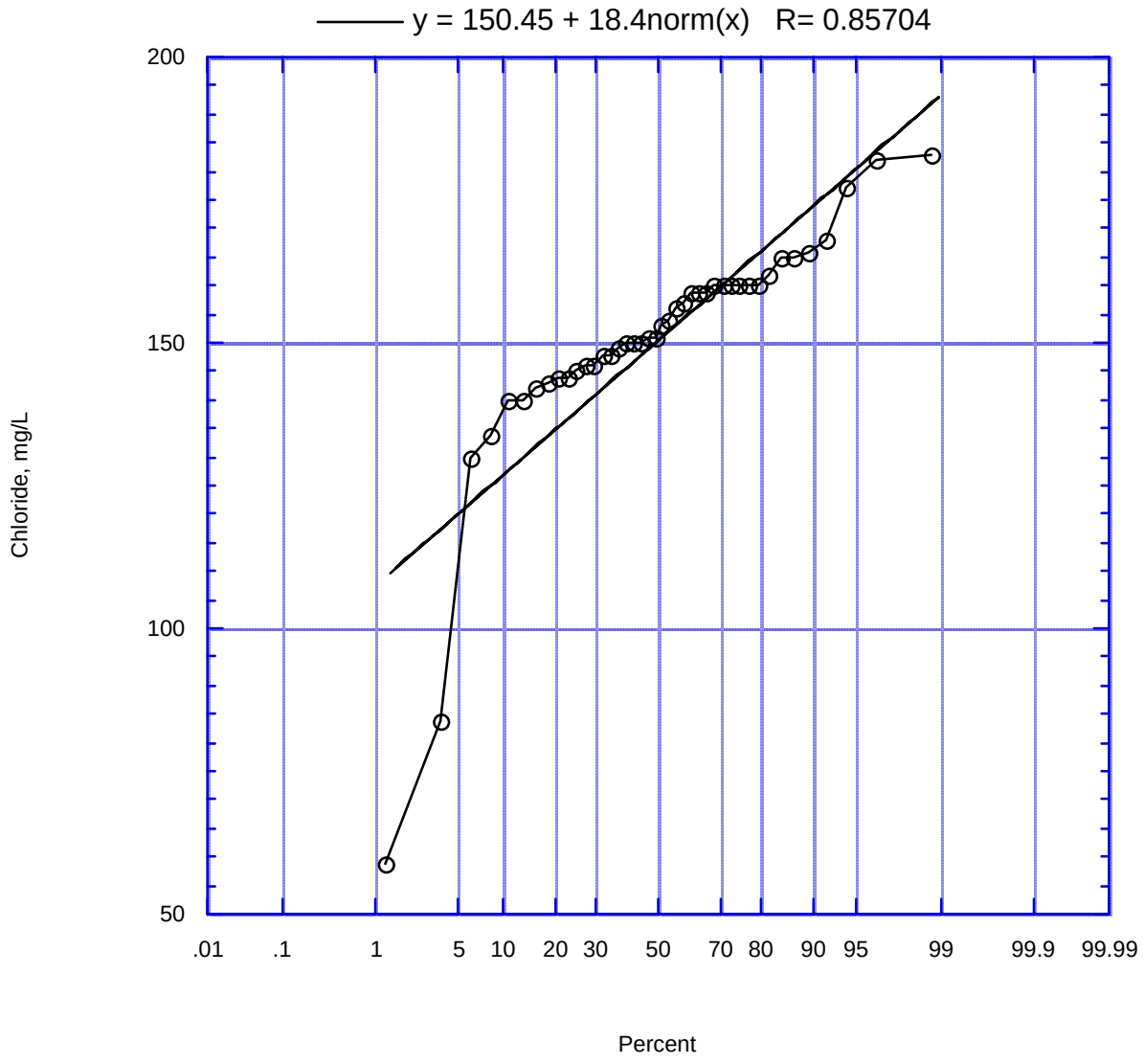


Figure 198. Reach 6 Chloride Frequency Distribution

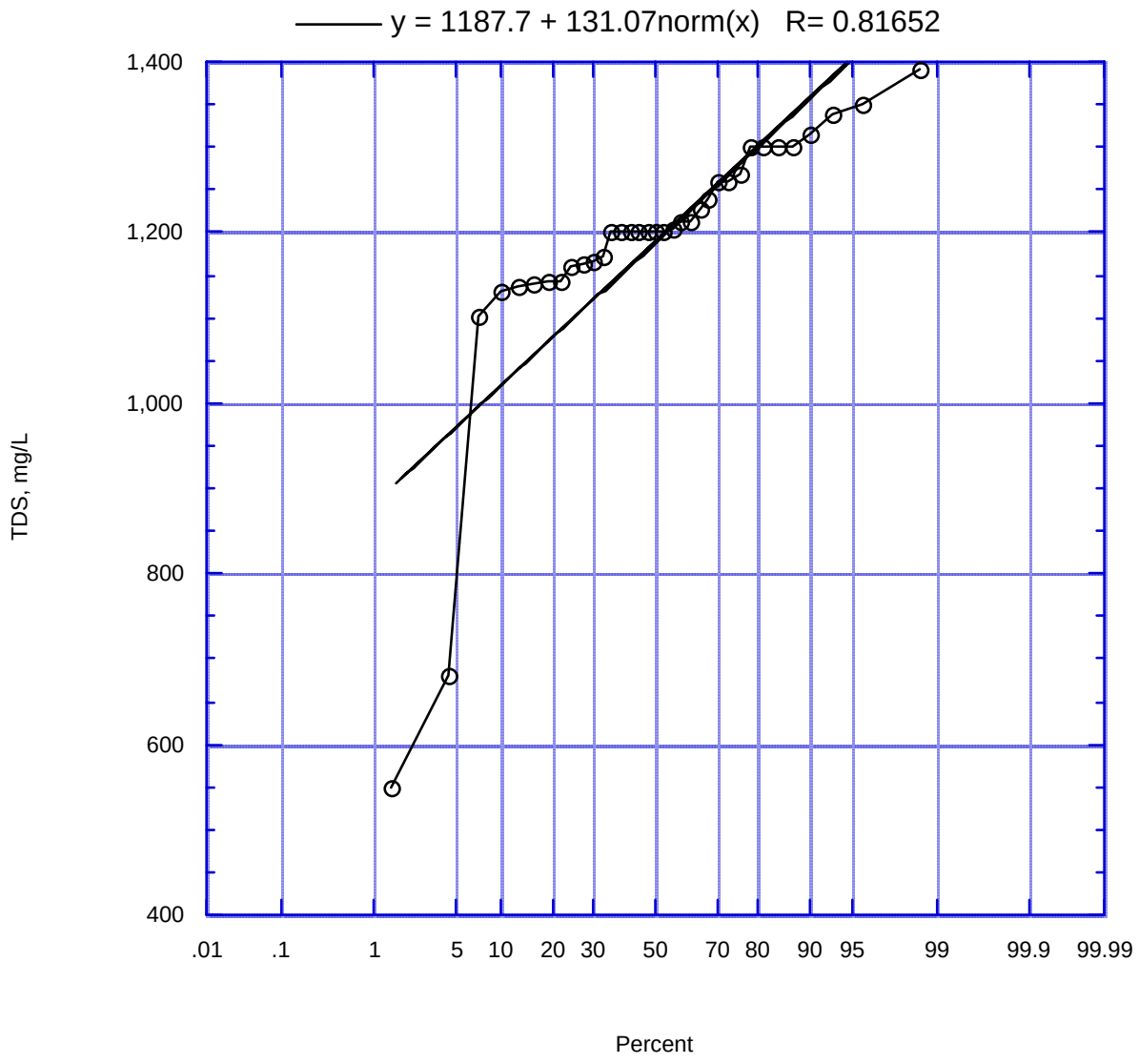


Figure 199. Reach 6 TDS Frequency Distribution

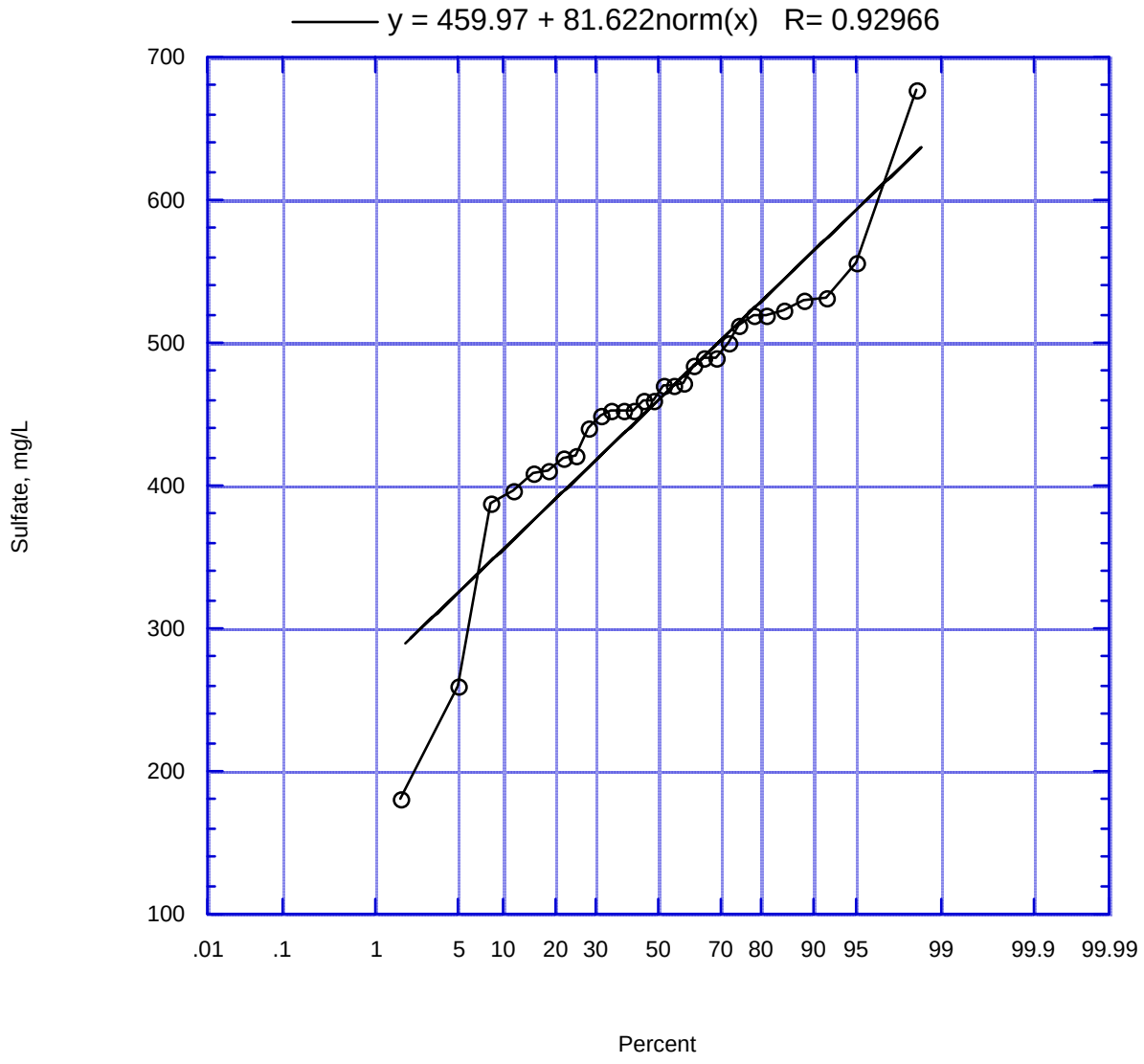


Figure 200. Reach 6 Sulfate Frequency Distribution

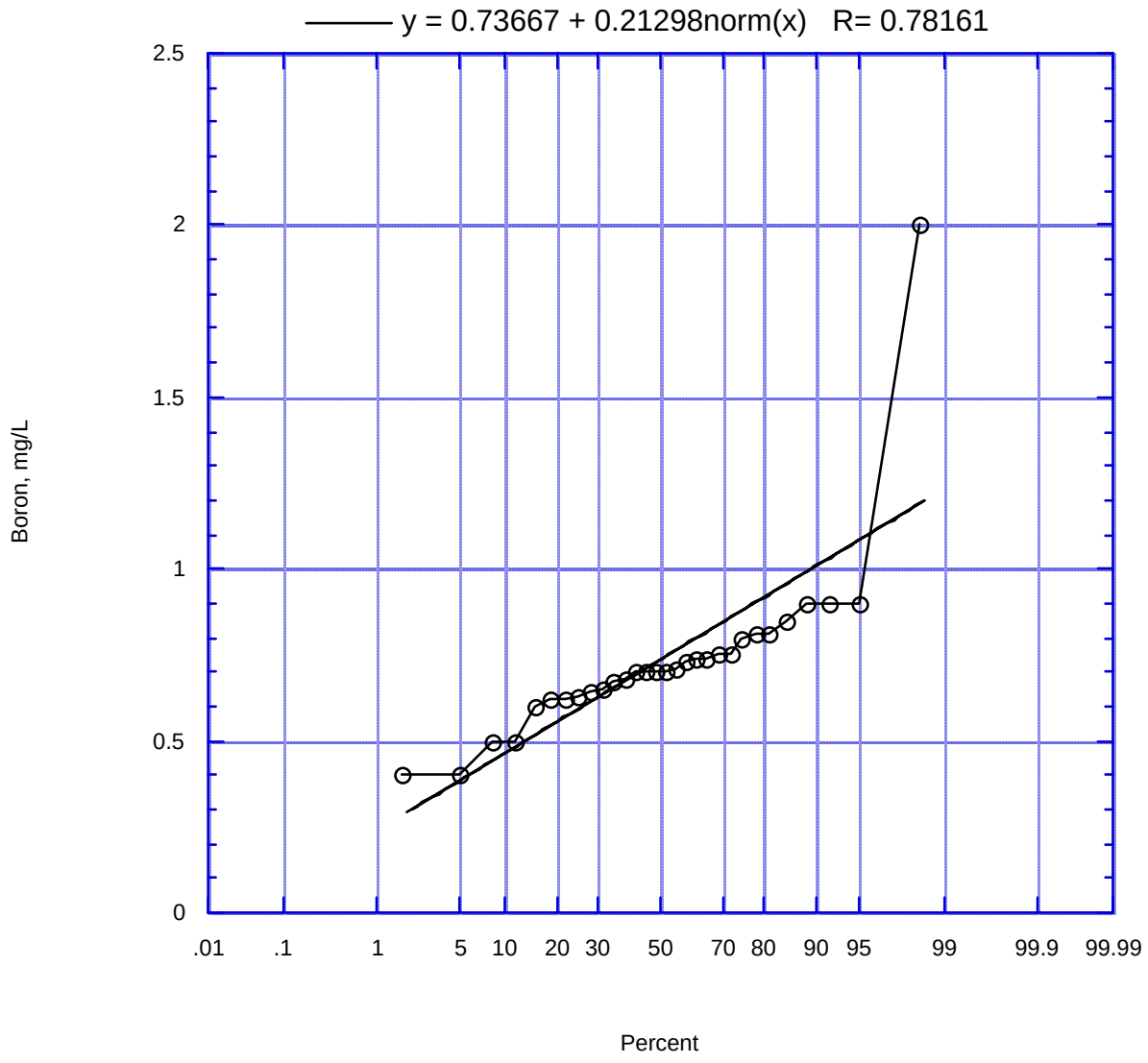


Figure 201. Reach 6 Boron Frequency Distribution

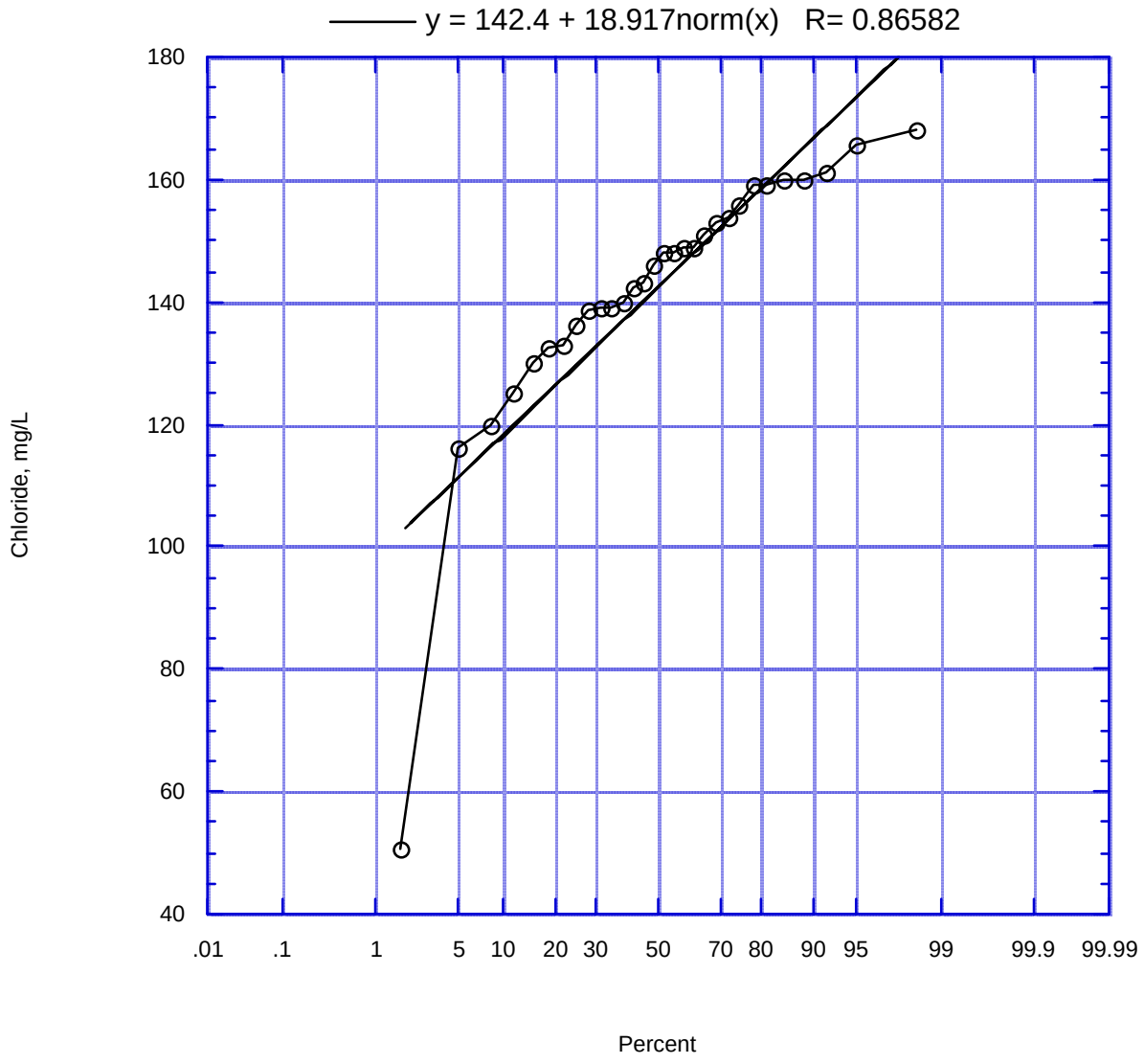


Figure 202. Reach 7 Chloride Frequency Distribution

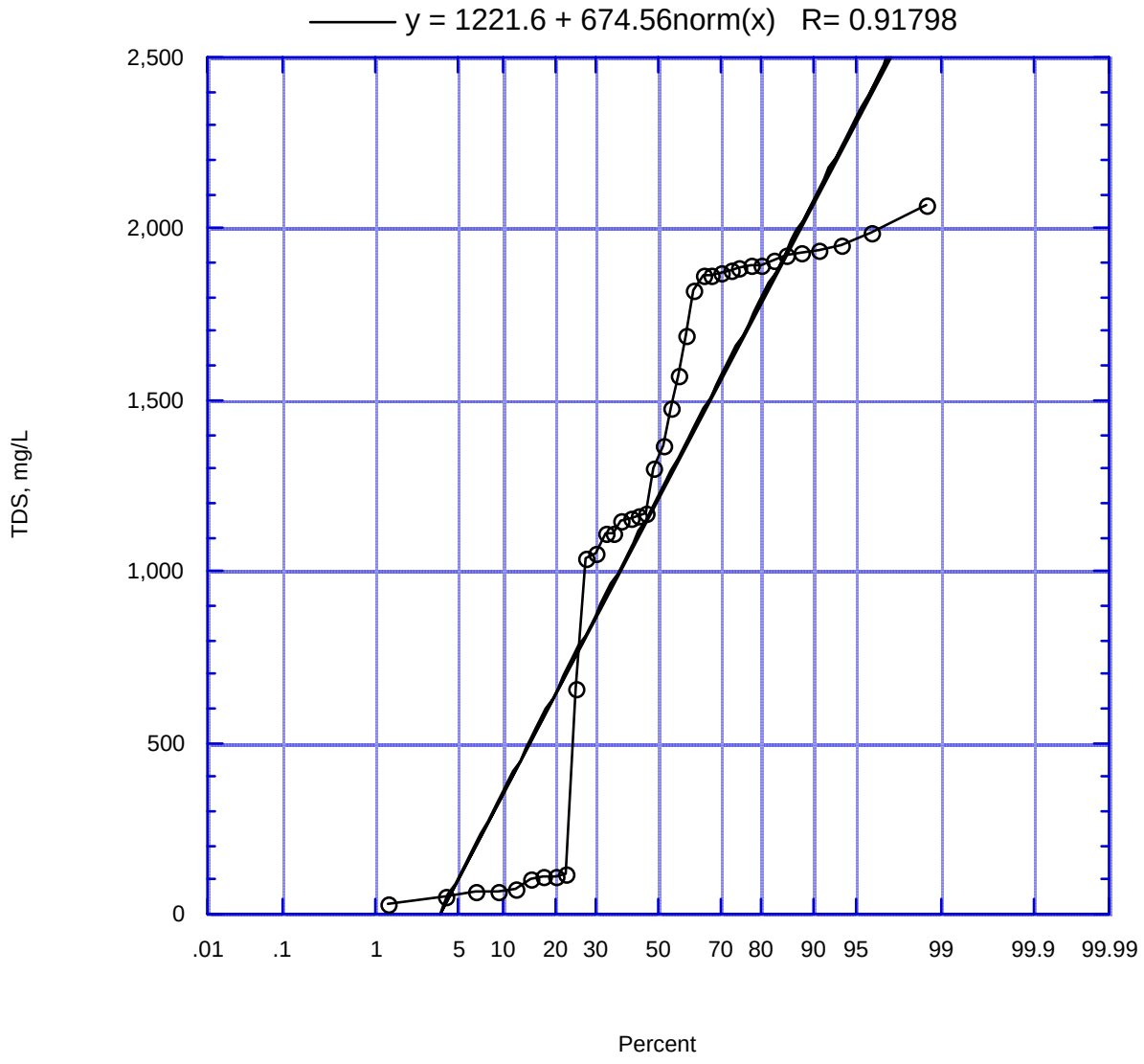


Figure 203. Reach 7 TDS Frequency Distribution

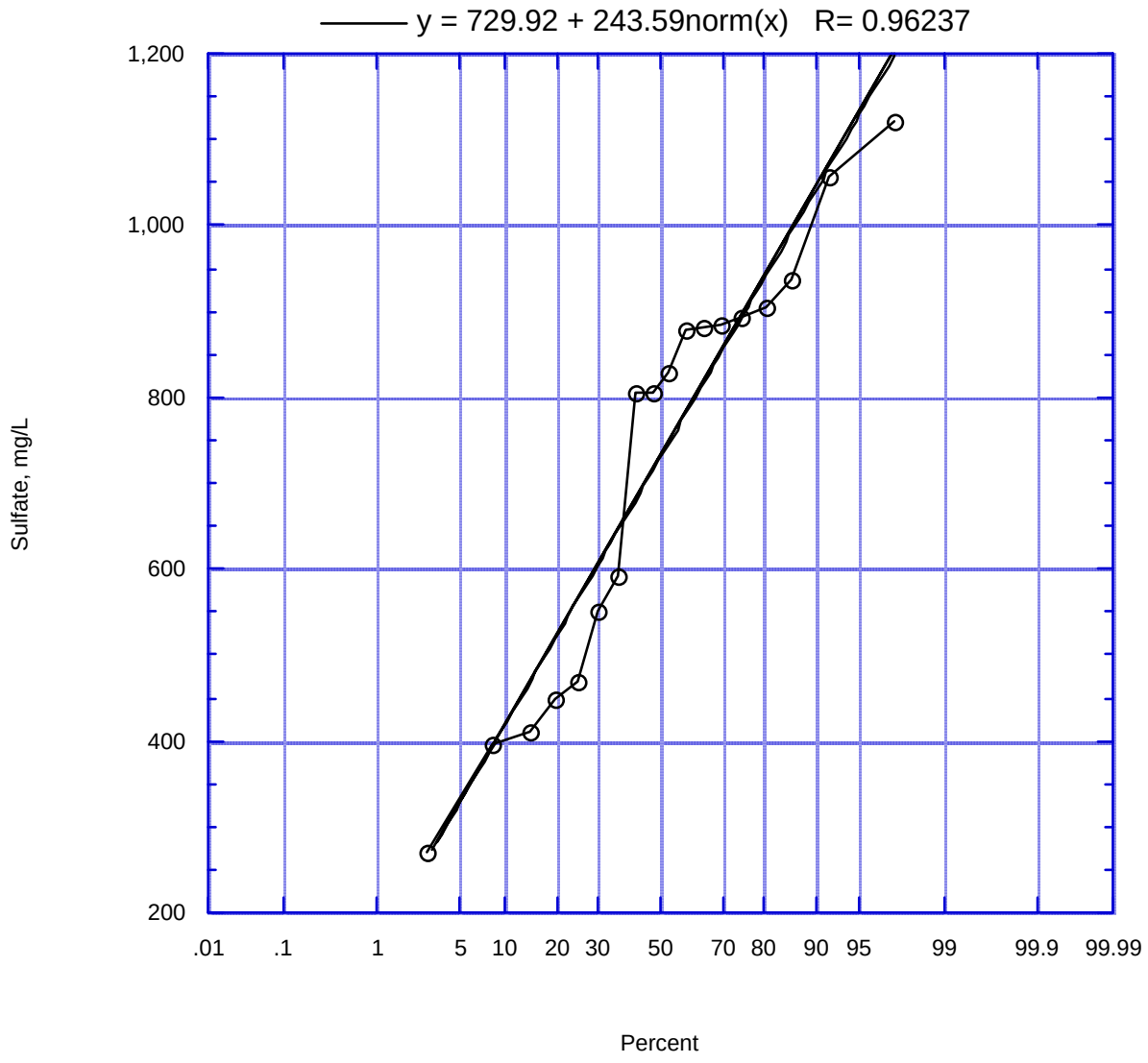


Figure 204. Reach 7 Sulfate Frequency Distribution

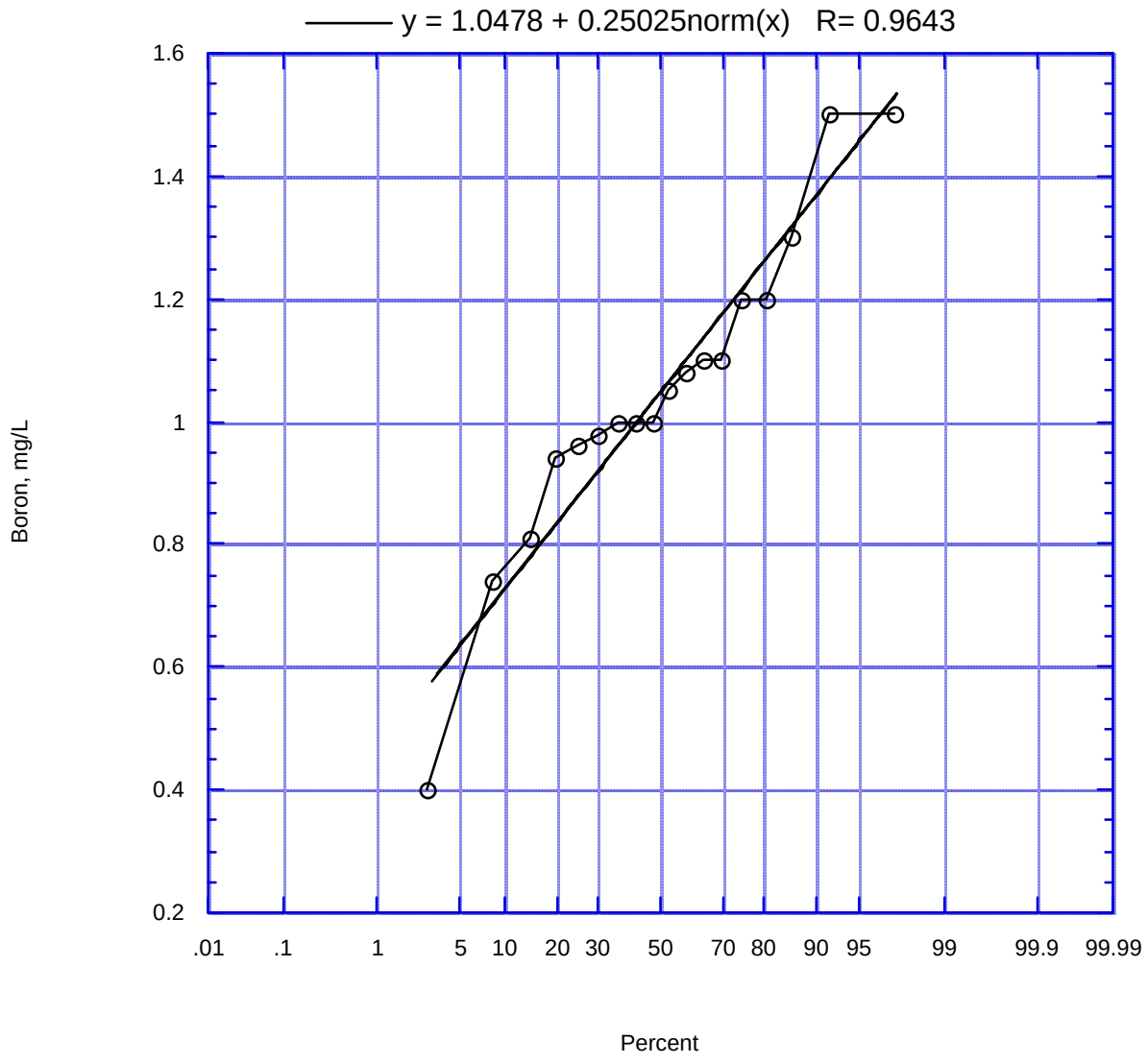


Figure 205. Reach 7 Boron Frequency Distribution

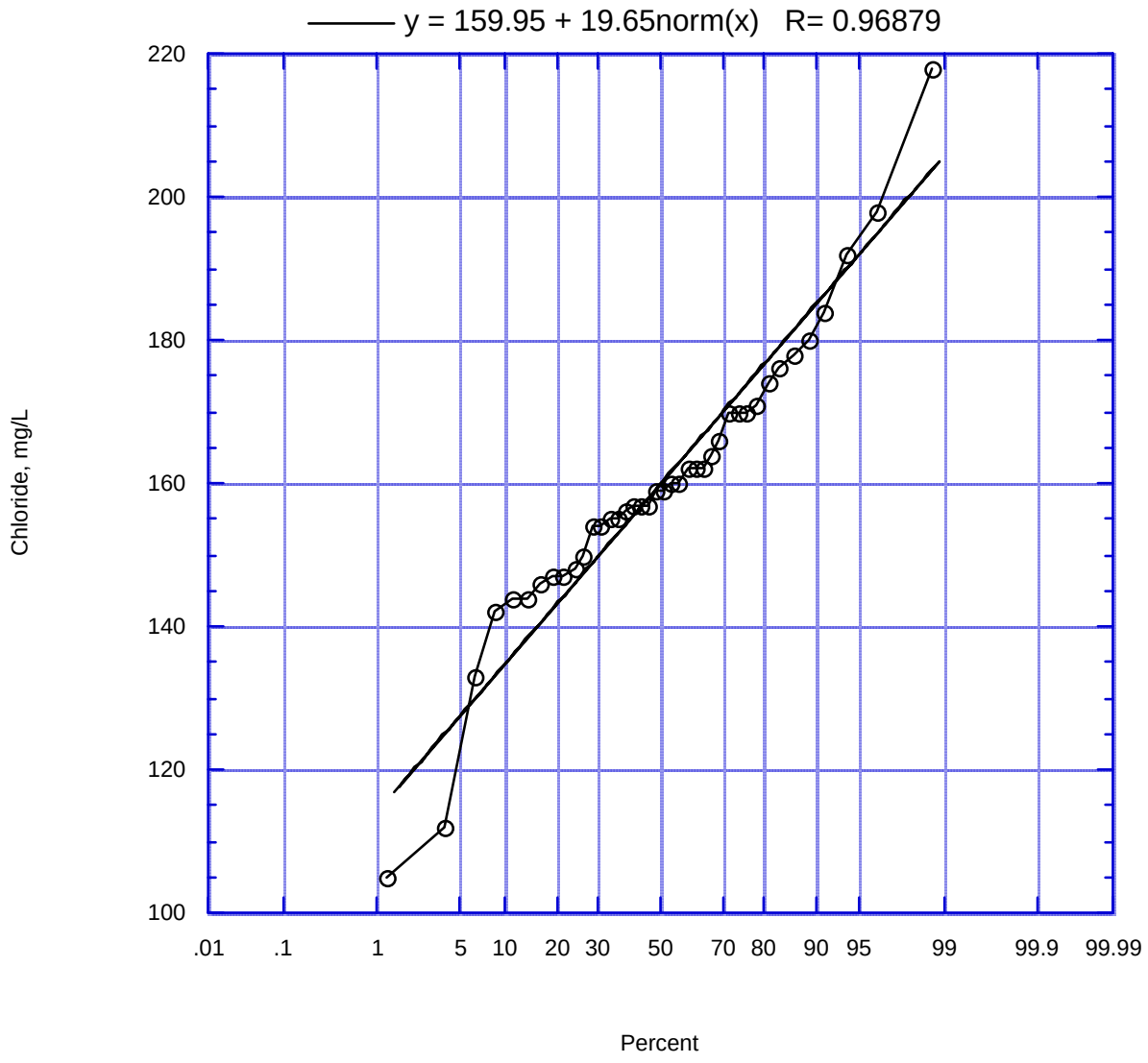


Figure 206. Reach 9A Chloride Frequency Distribution

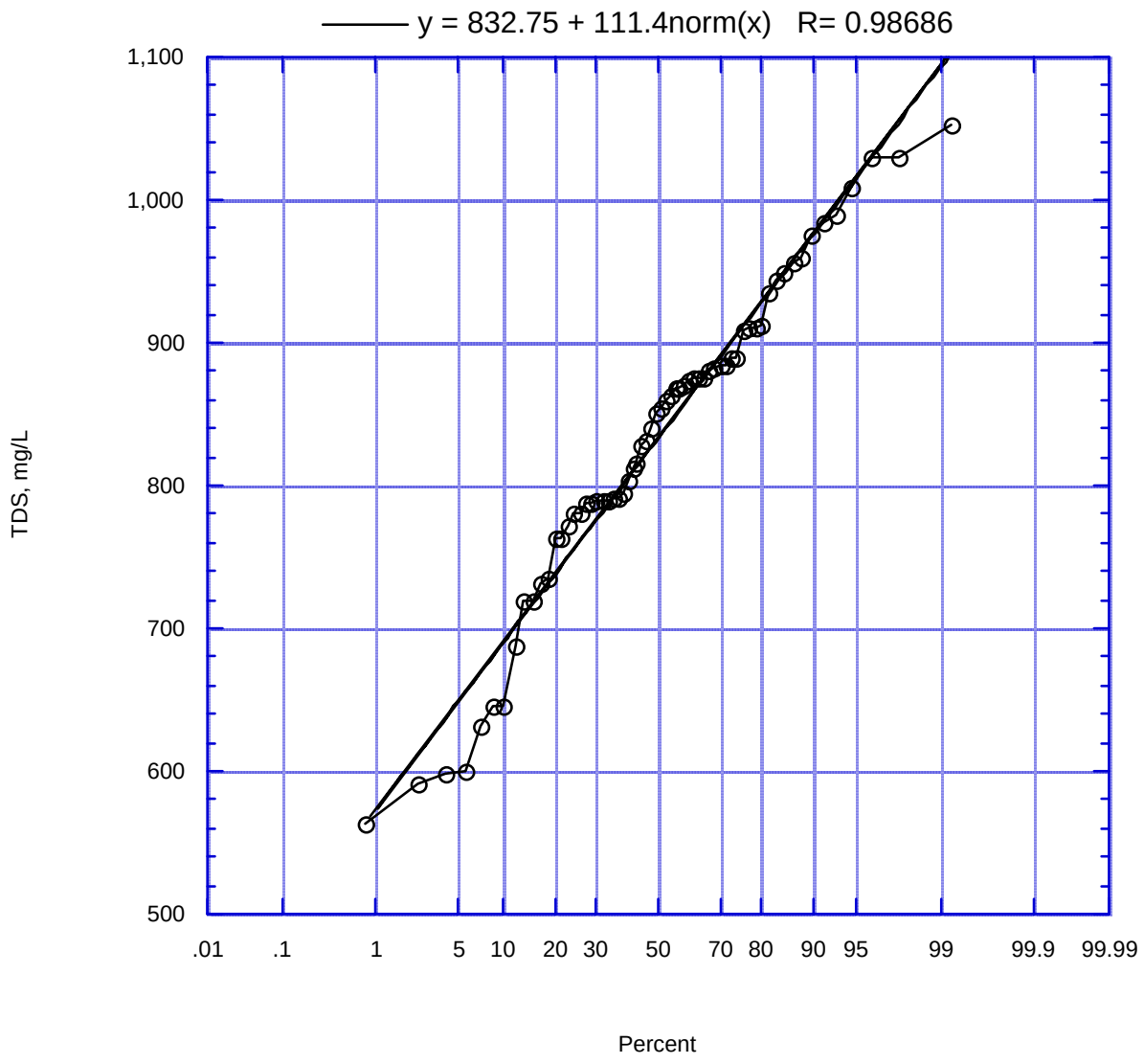


Figure 207. Reach 9A TDS Frequency Distribution

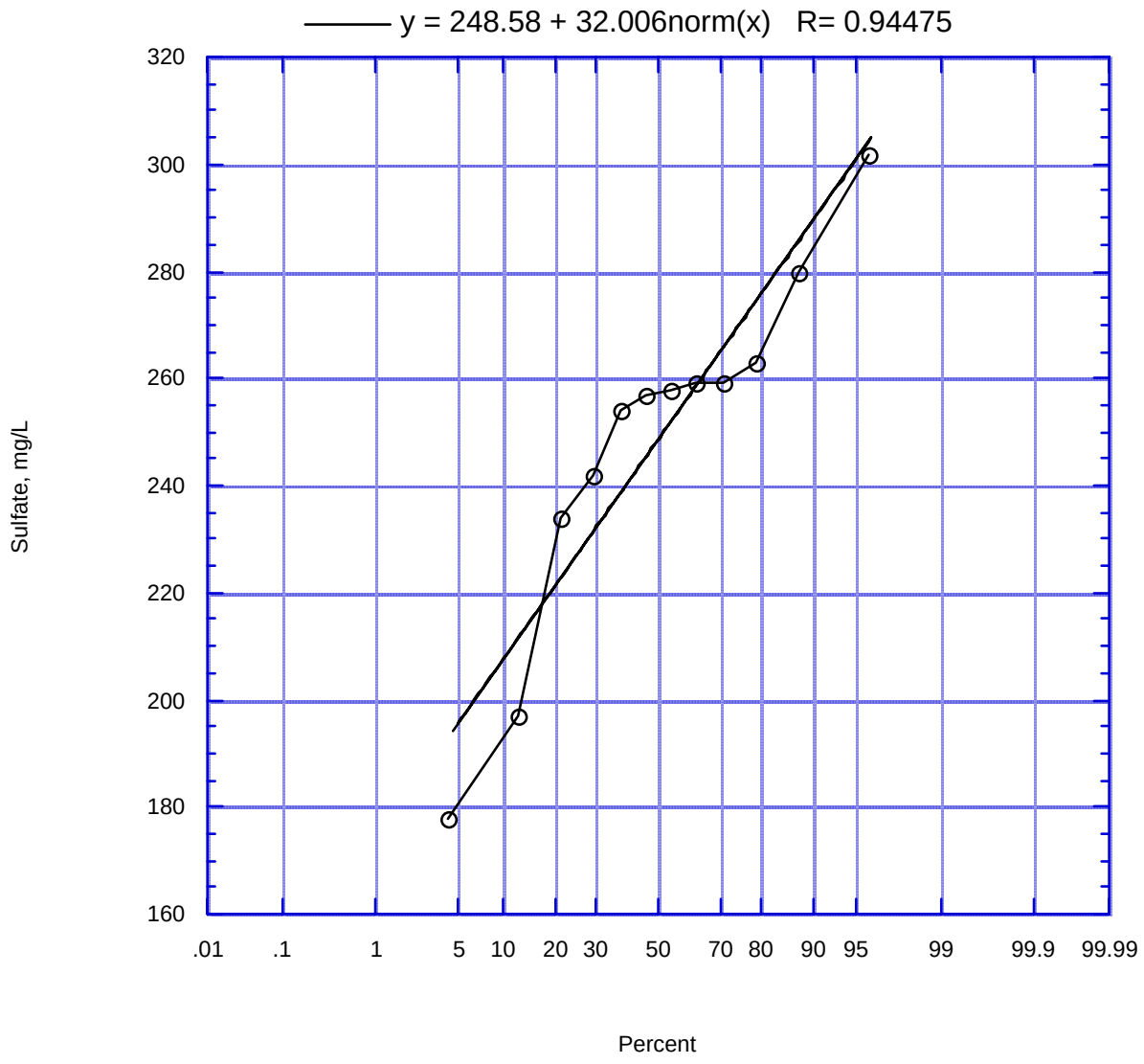


Figure 208. Reach 9A Sulfate Frequency Distribution

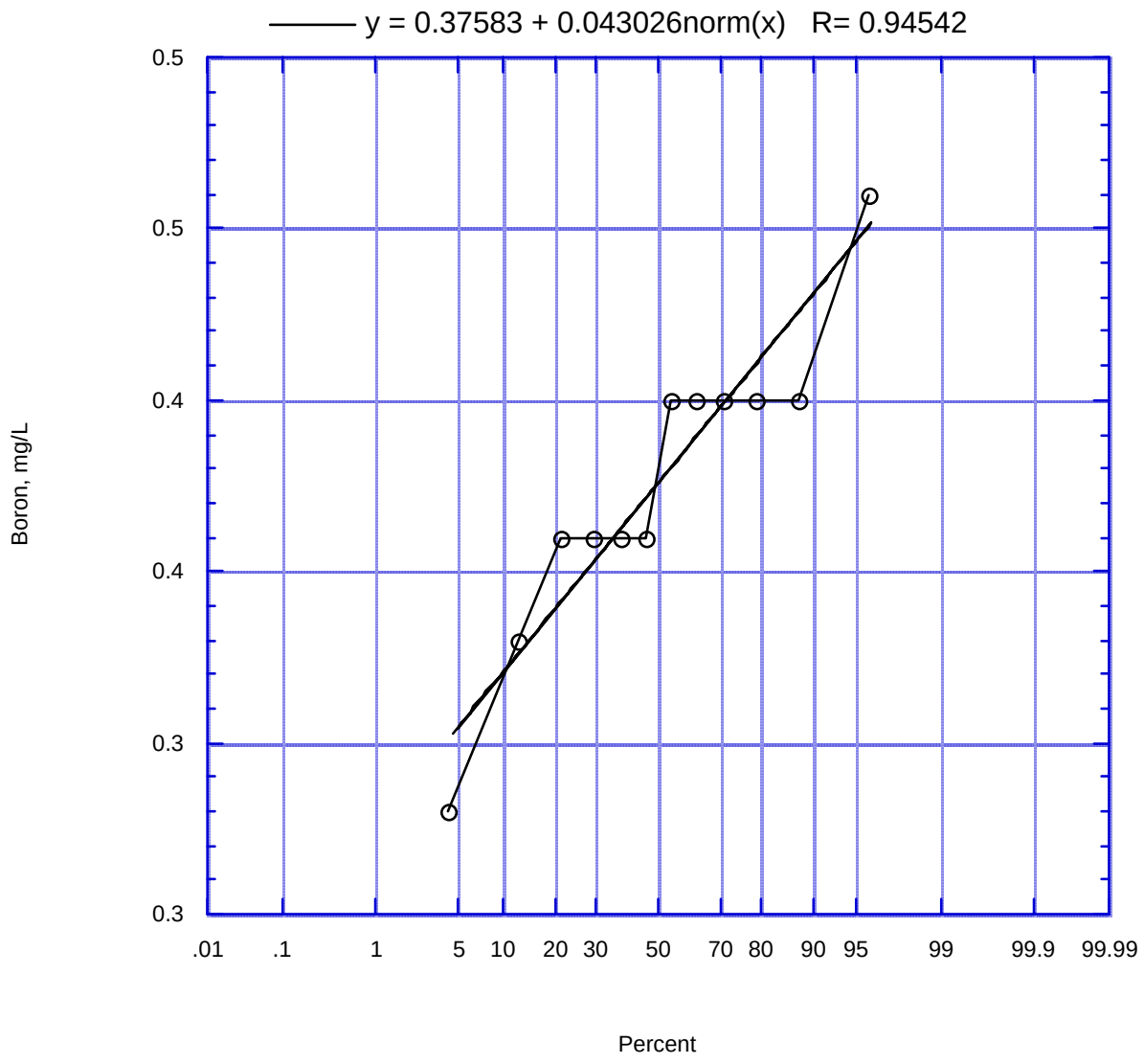


Figure 209. Reach 9A Boron Frequency Distribution

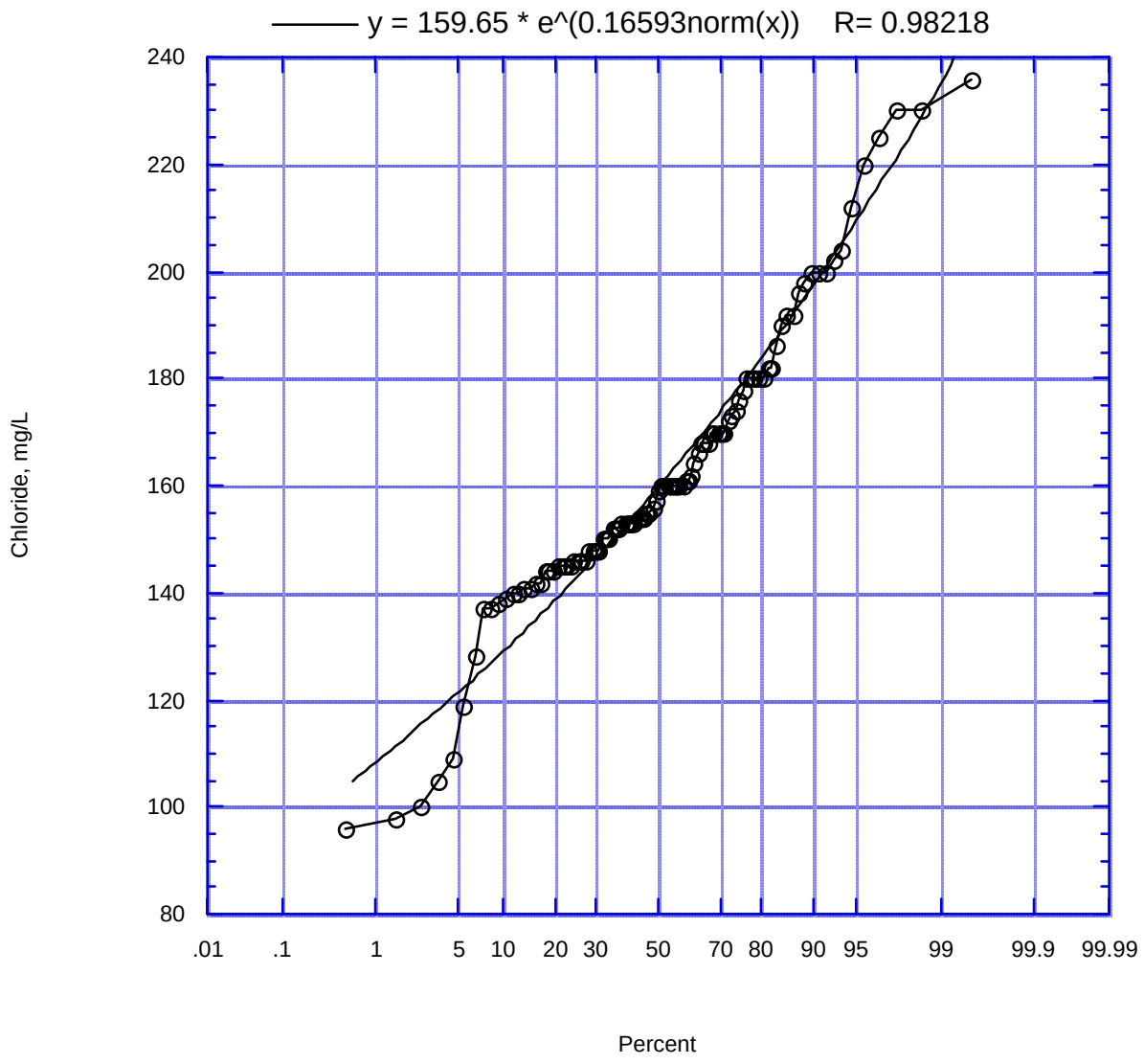


Figure 210. Reach 9B Chloride Frequency Distribution

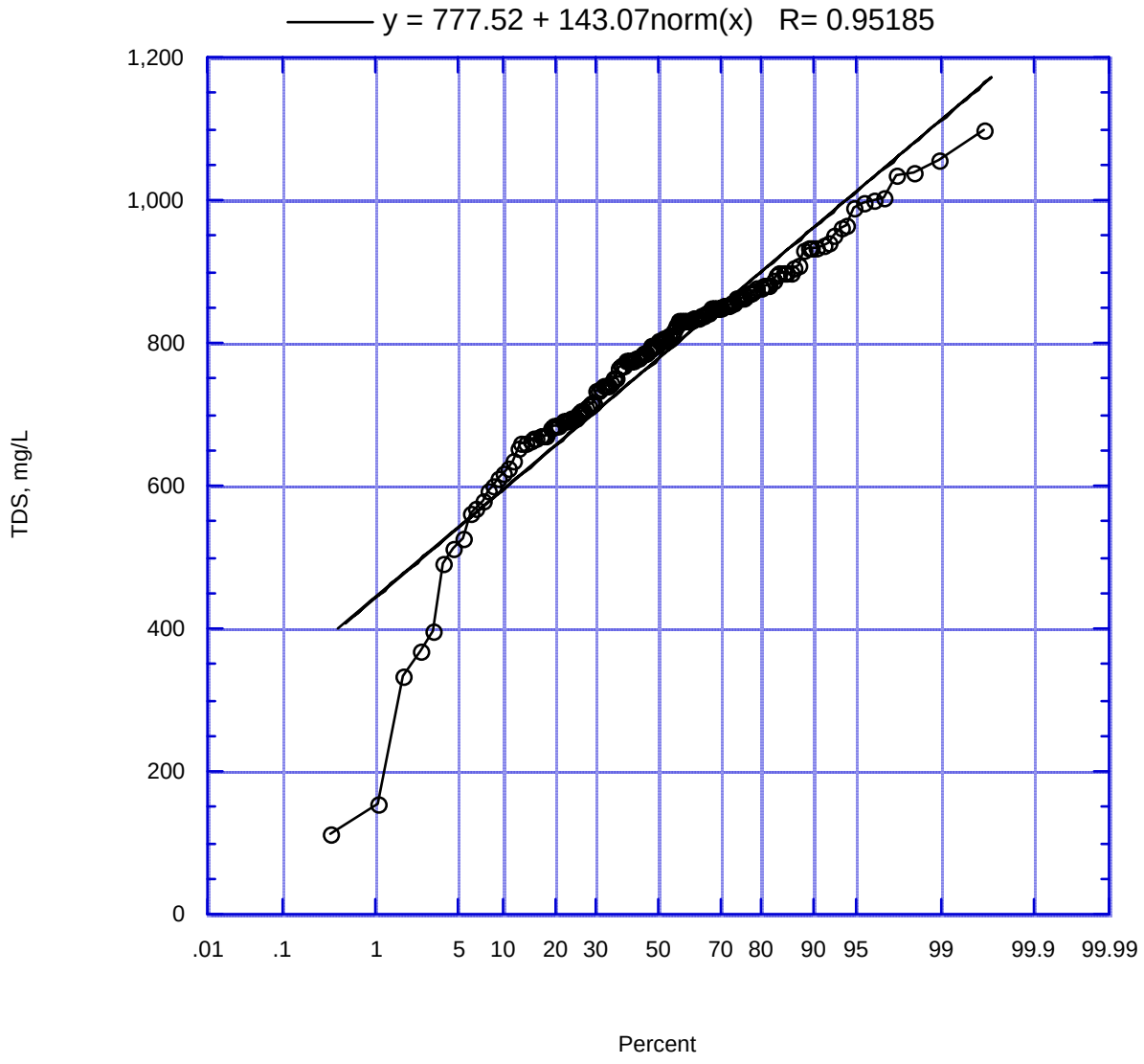


Figure 211. Reach 9B TDS Frequency Distribution

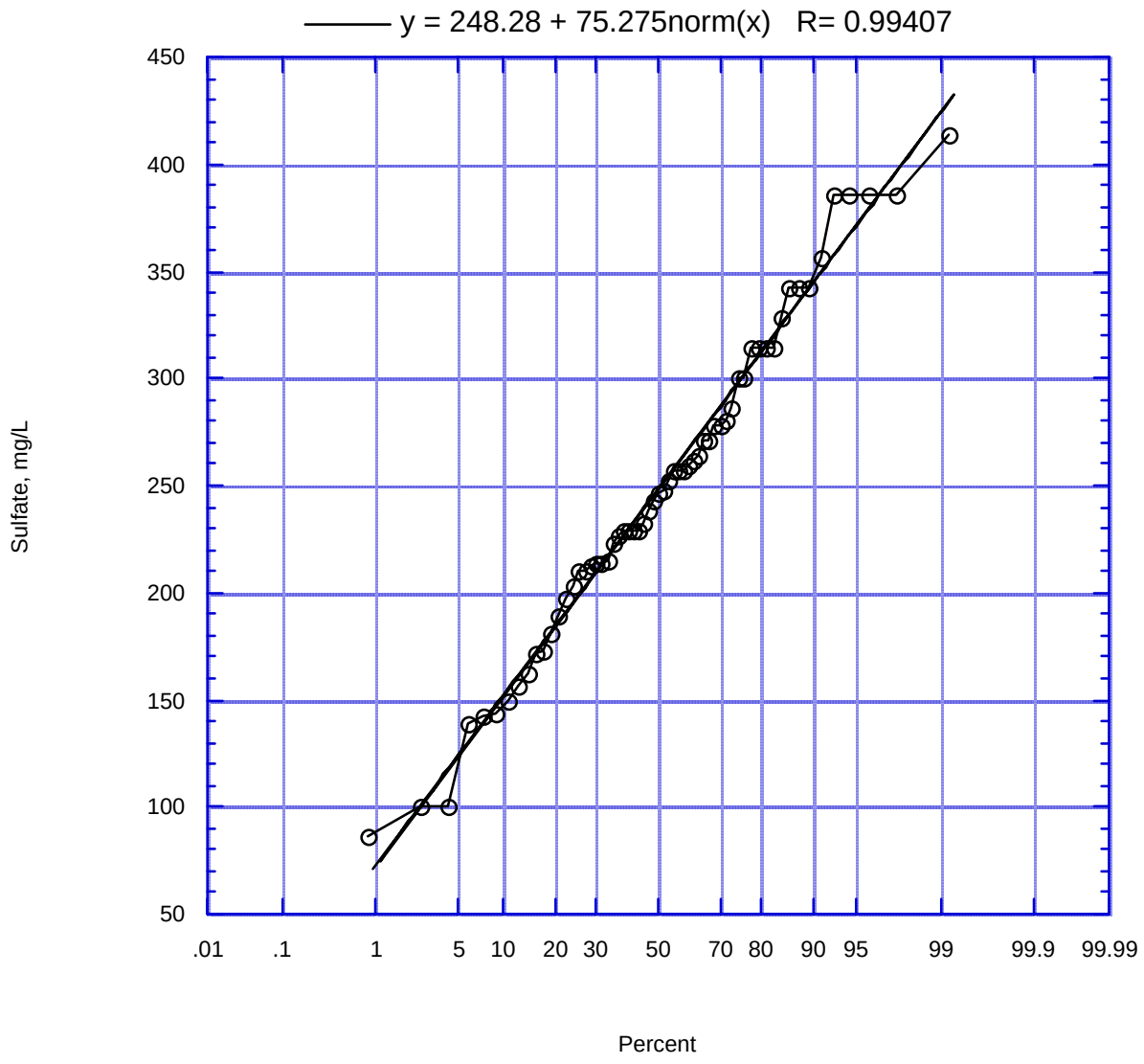


Figure 212. Reach 9B Sulfate Frequency Distribution

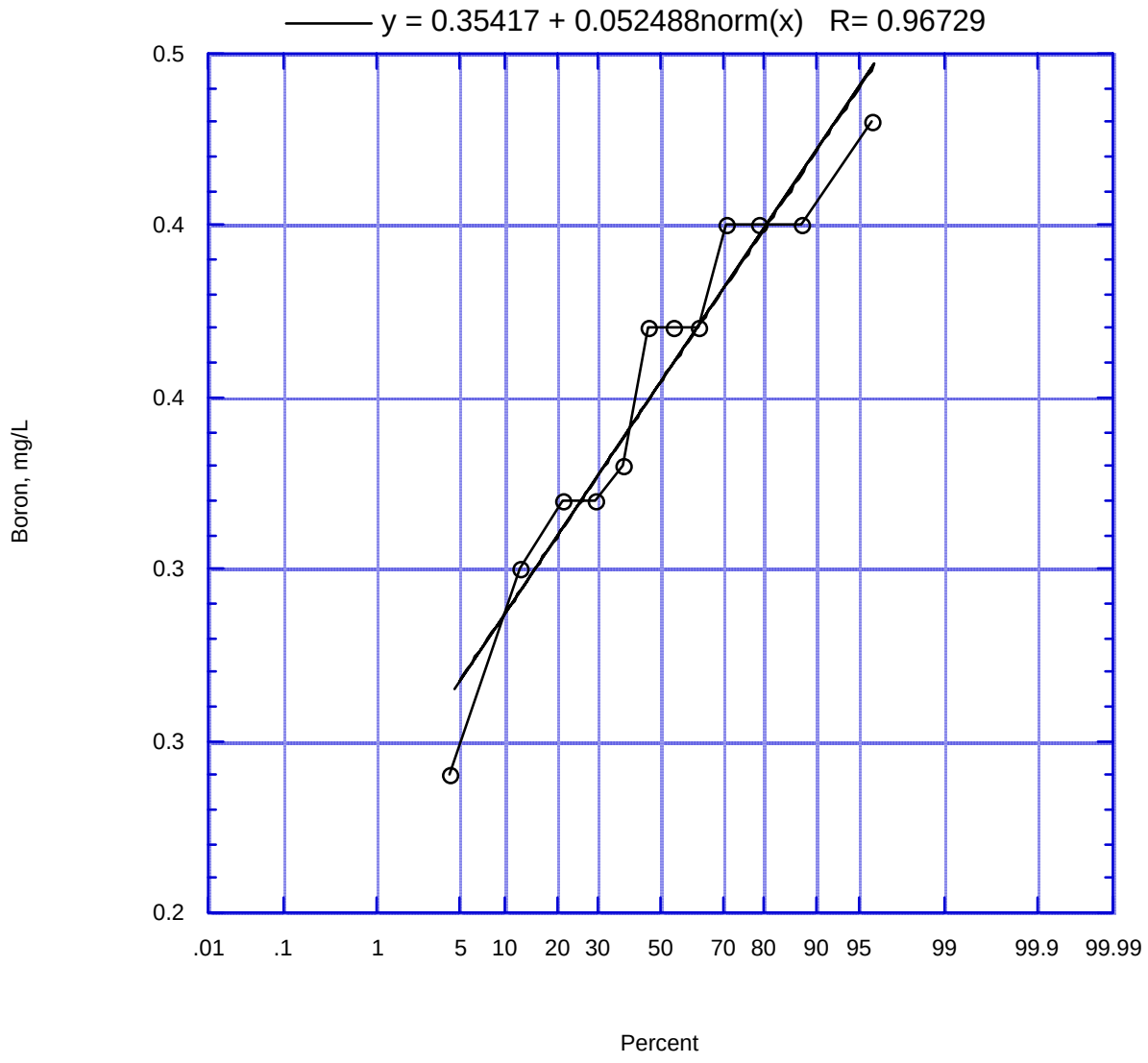


Figure 213. Reach 9B Boron Frequency Distribution

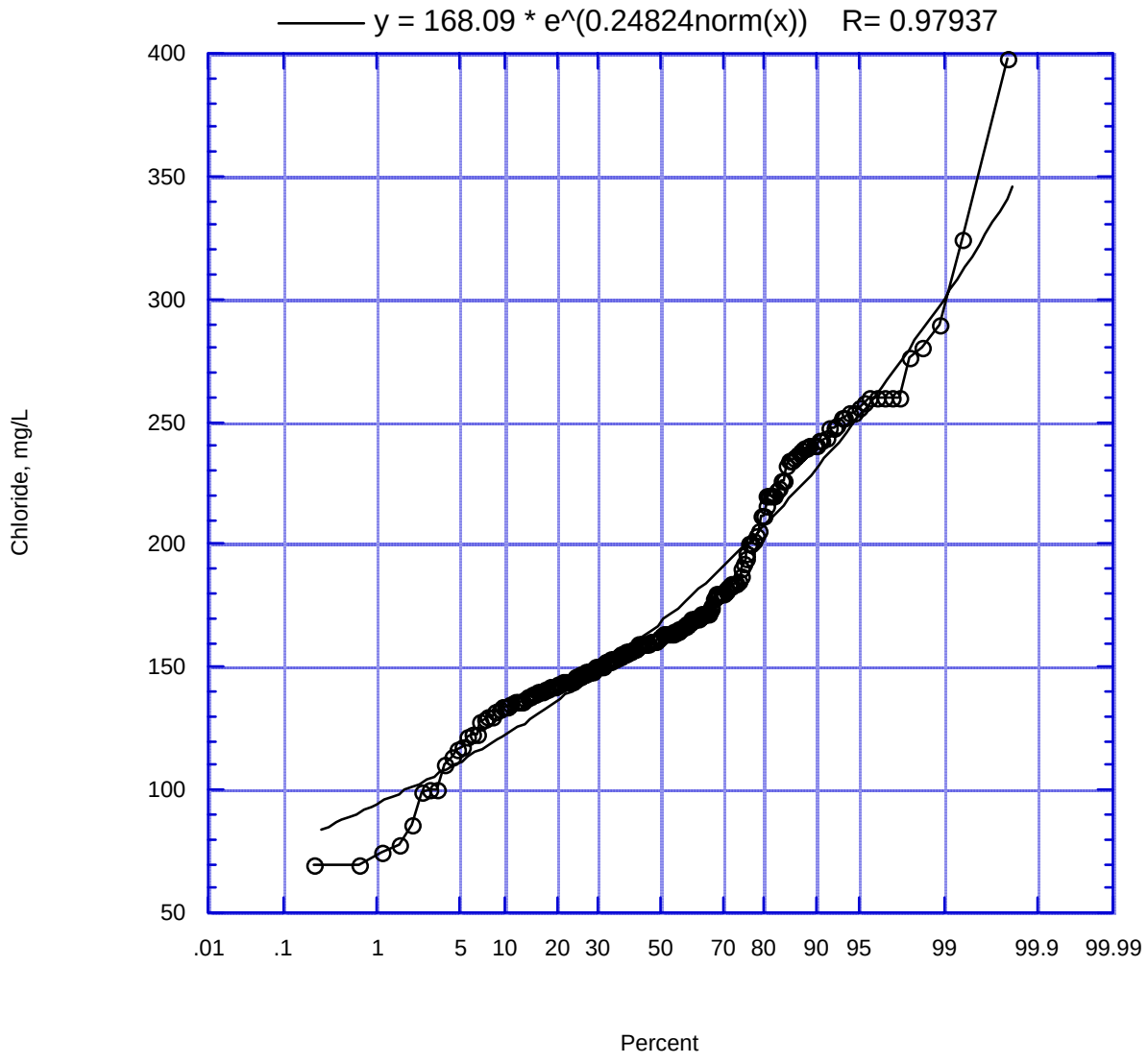
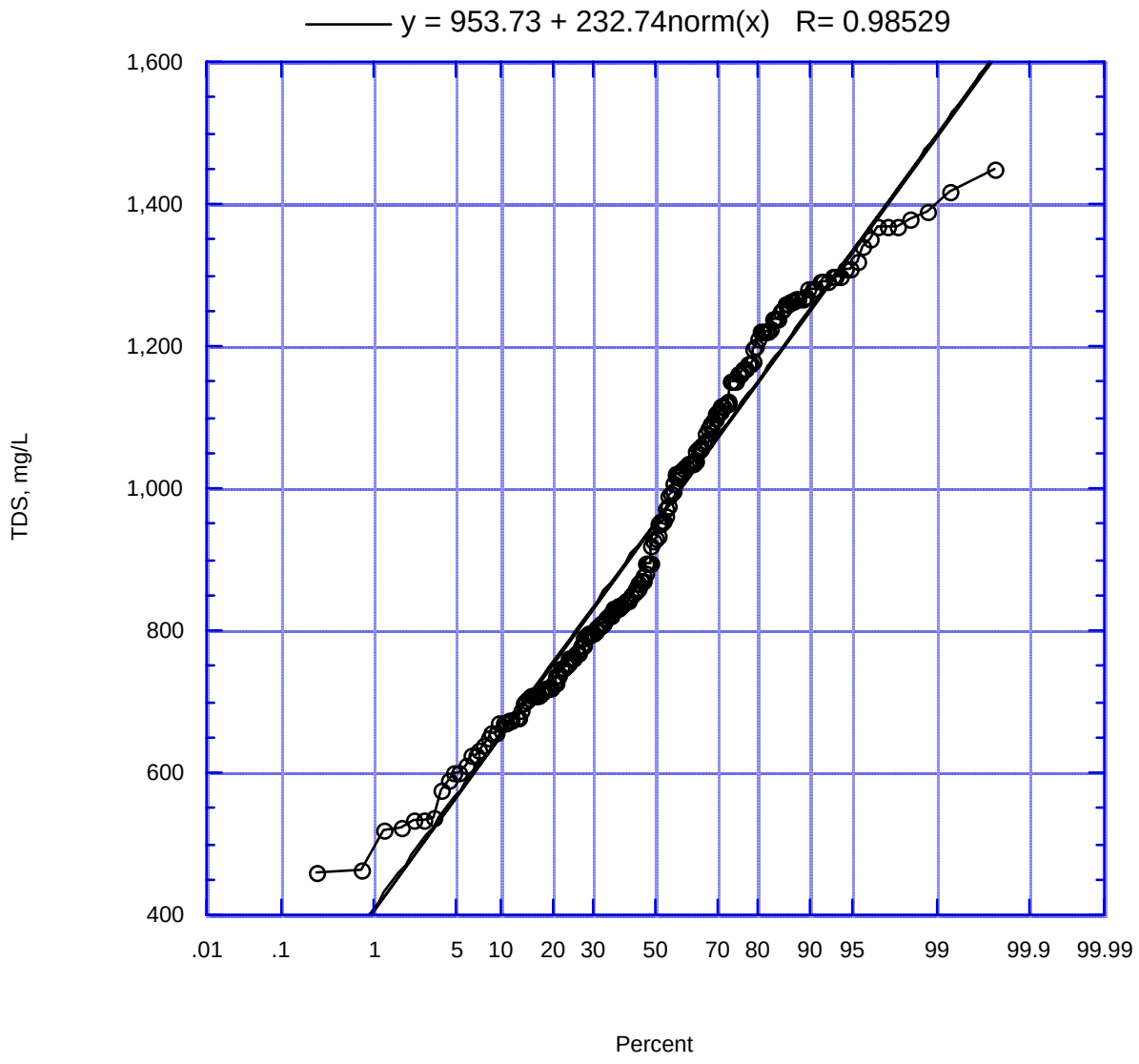
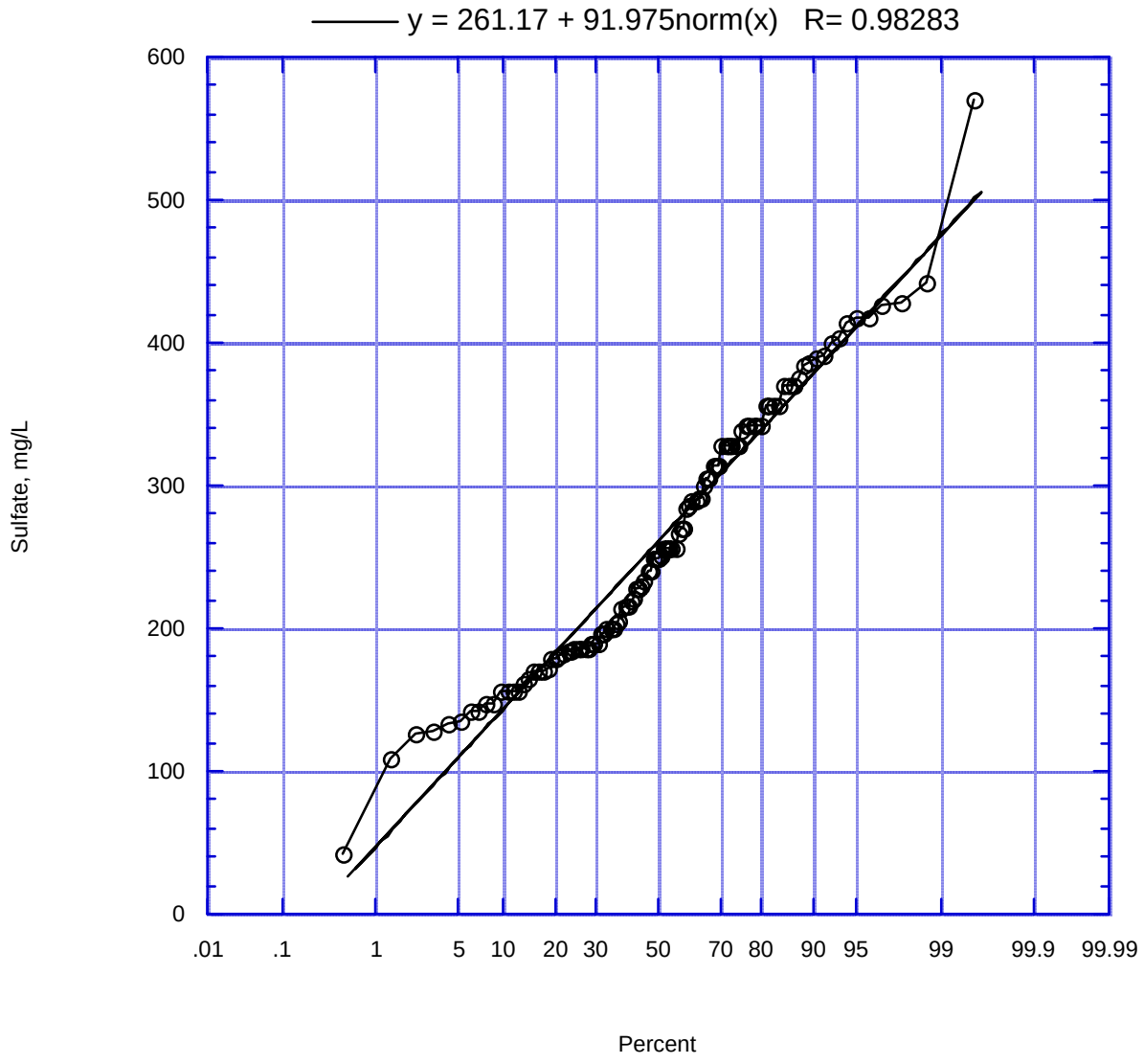


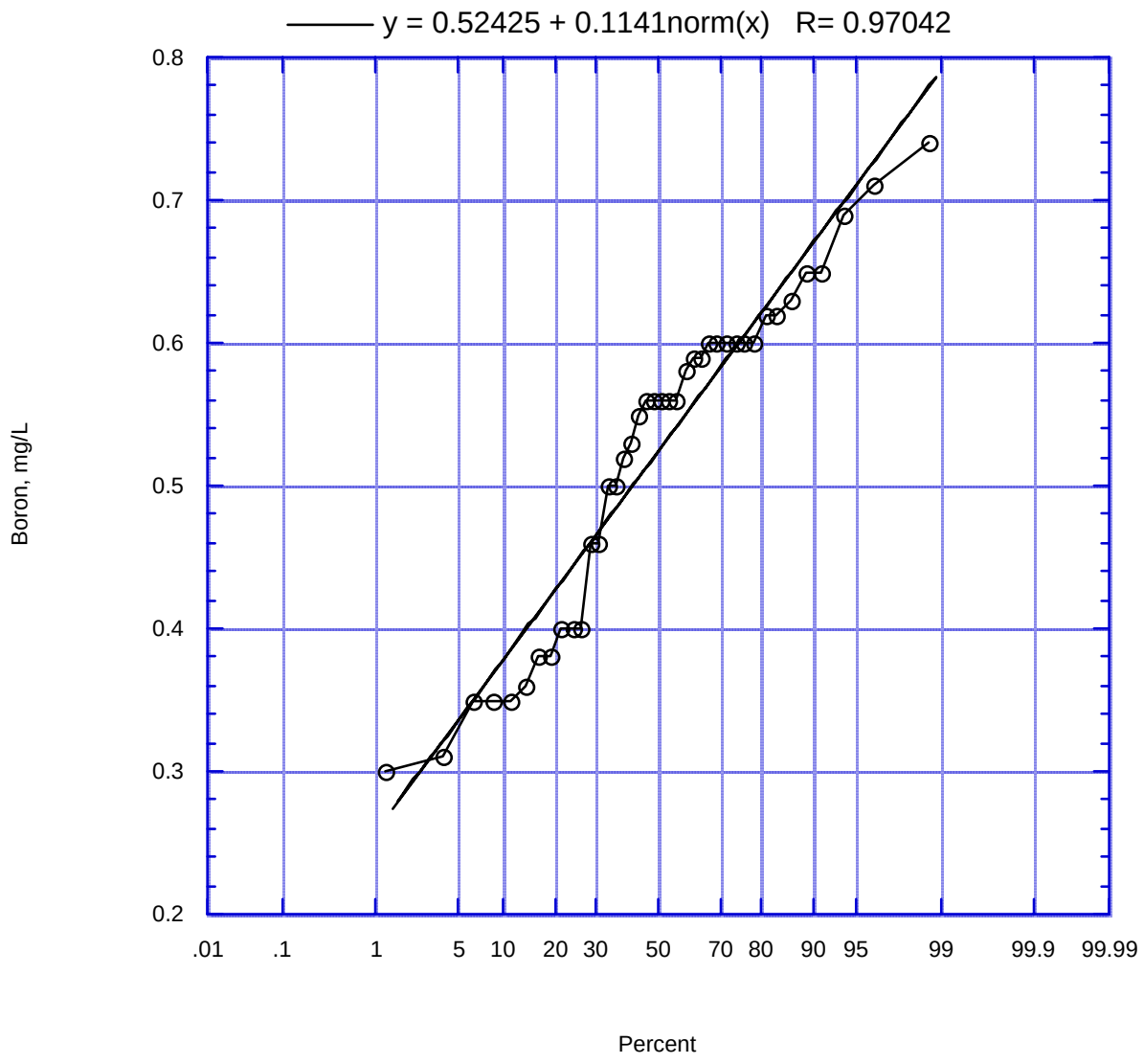
Figure 214. Reach 10 Chloride Frequency Distribution



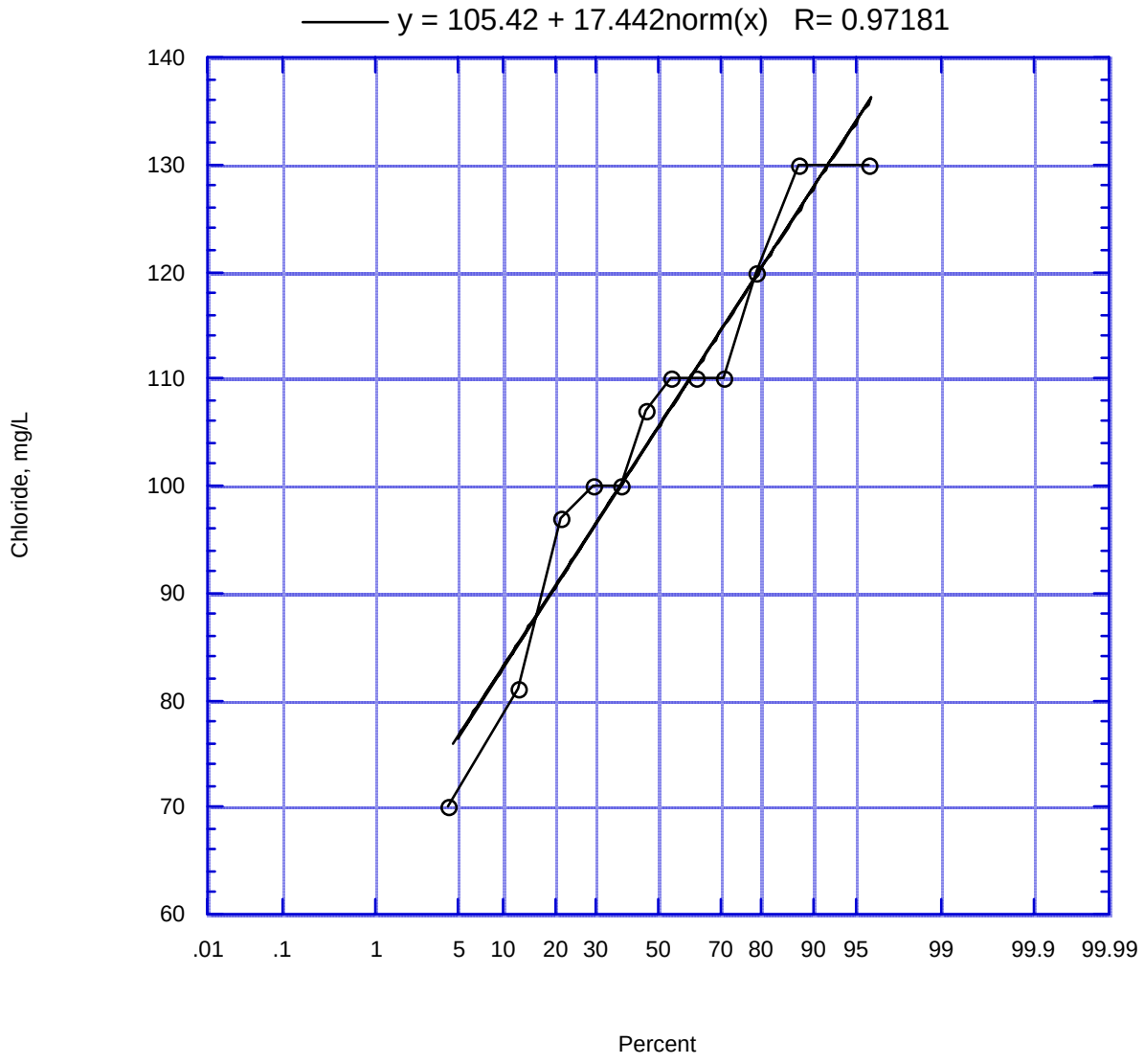
Fgure 215. Reach 10 TDS Frequency Distribution



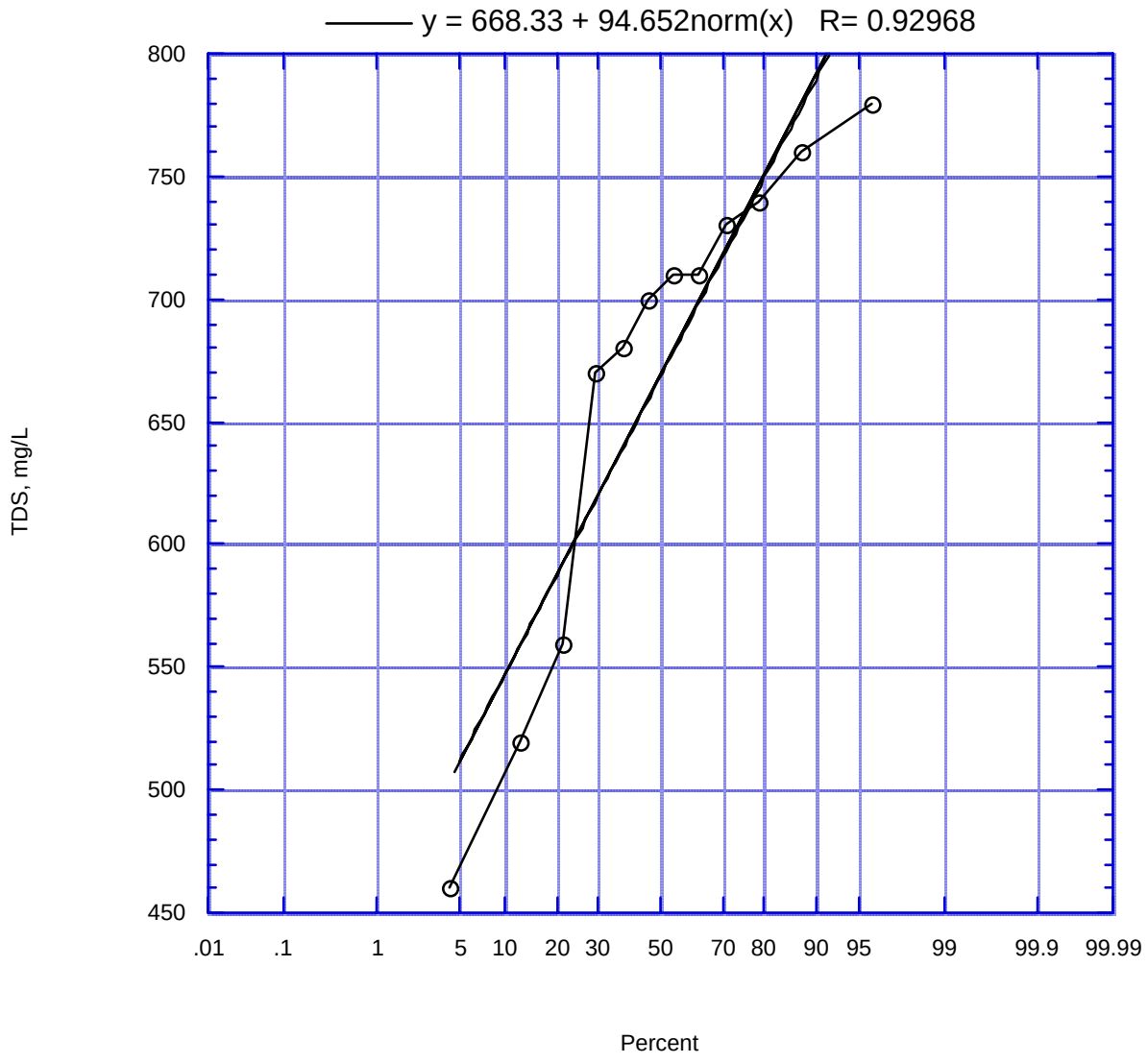
Fgure 216. Reach 10 Sulfate Frequency Distribution



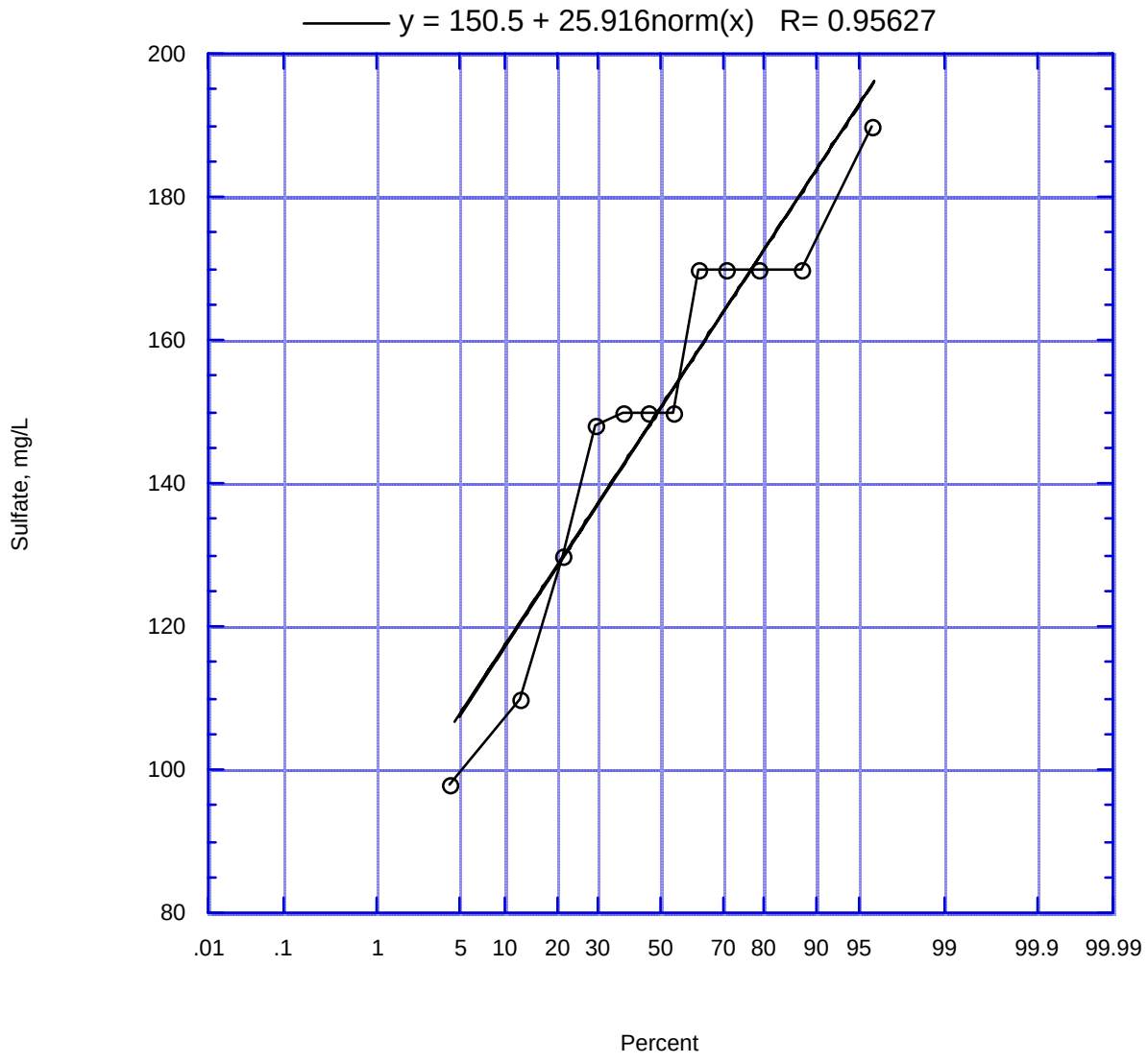
Fgure 217. Reach 10 Boron Frequency Distribution



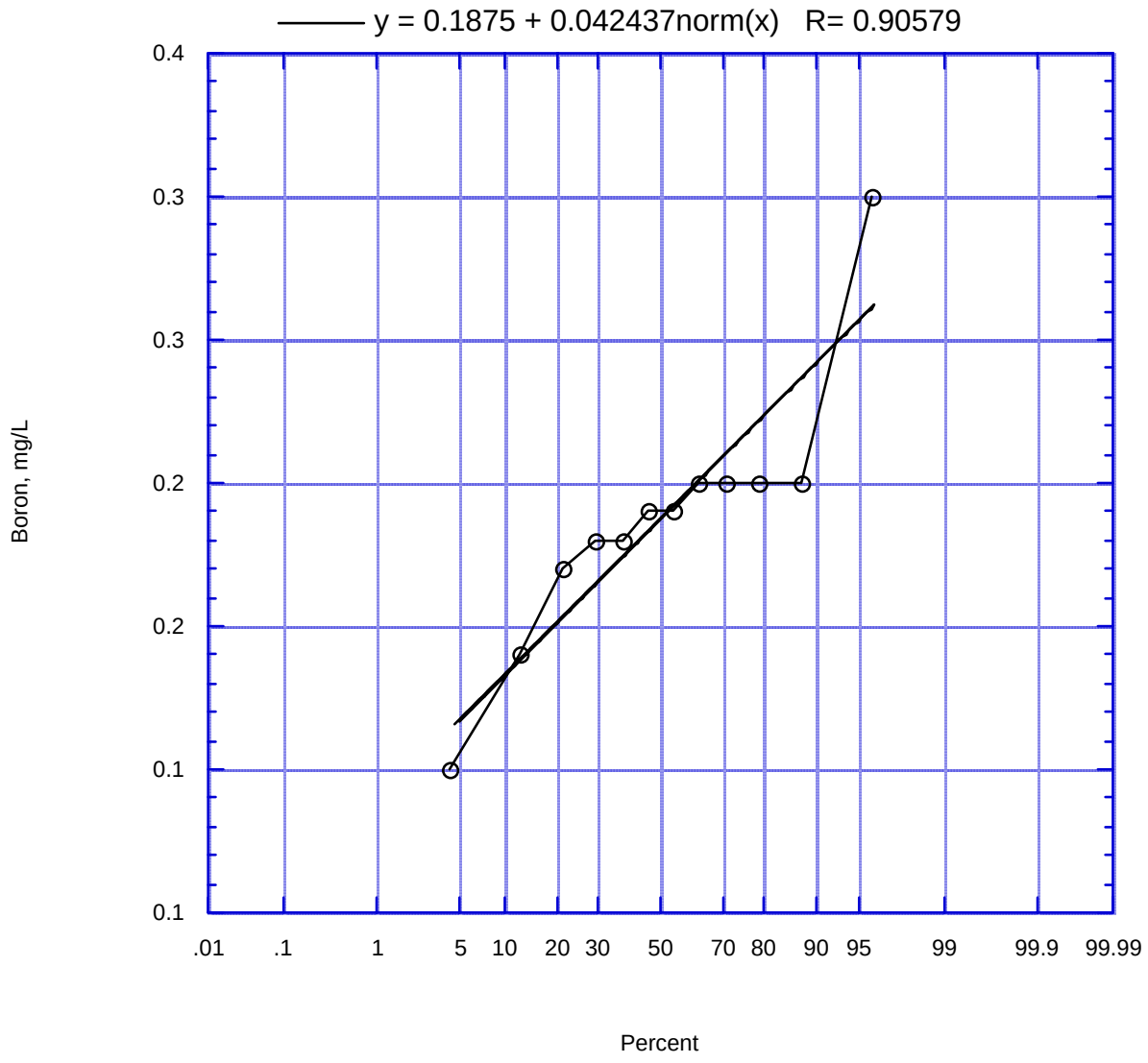
Fgure 218. Reach 11 Chloride Frequency Distribution



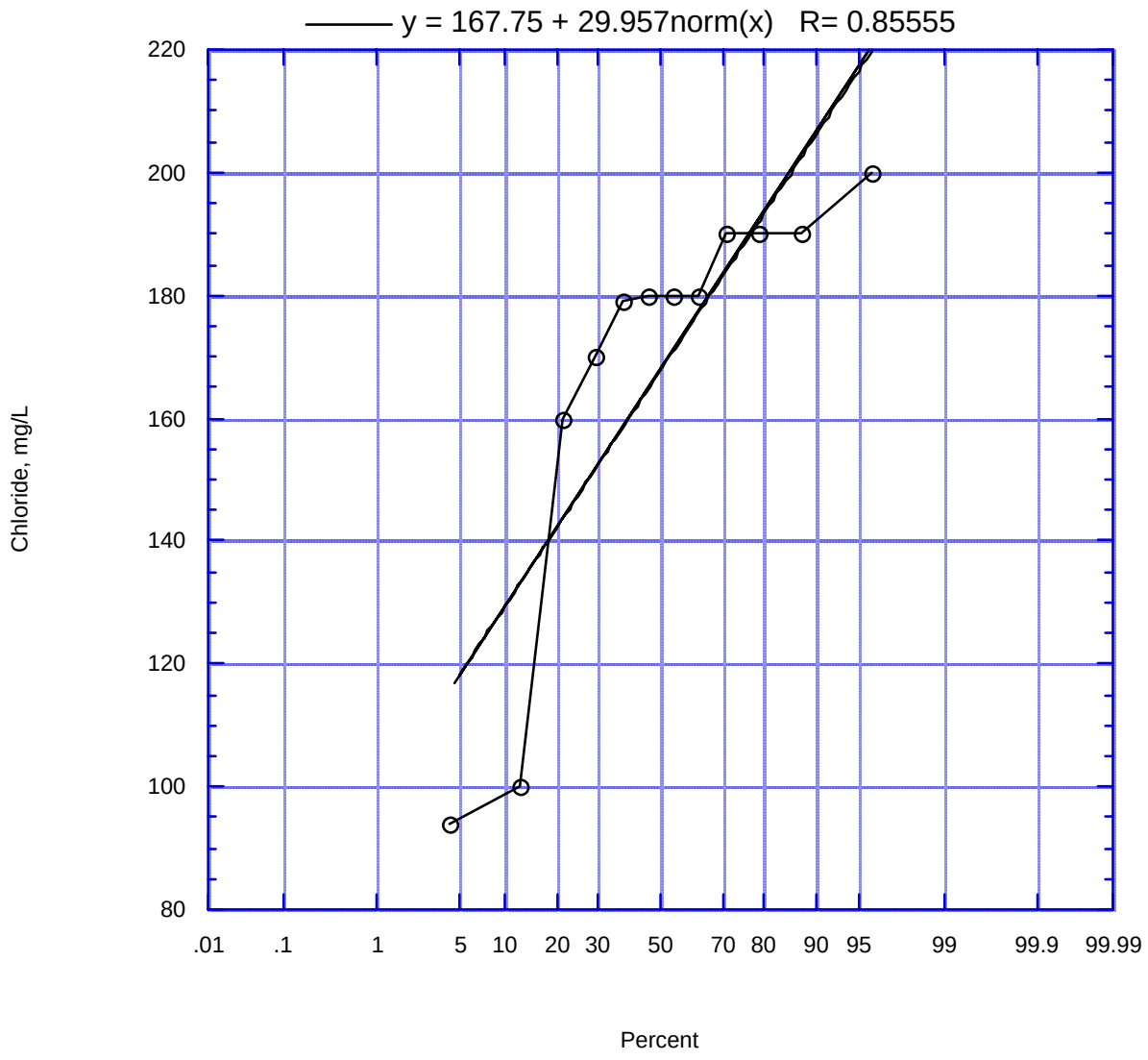
Fgure 219. Reach 11 TDS Frequency Distribution



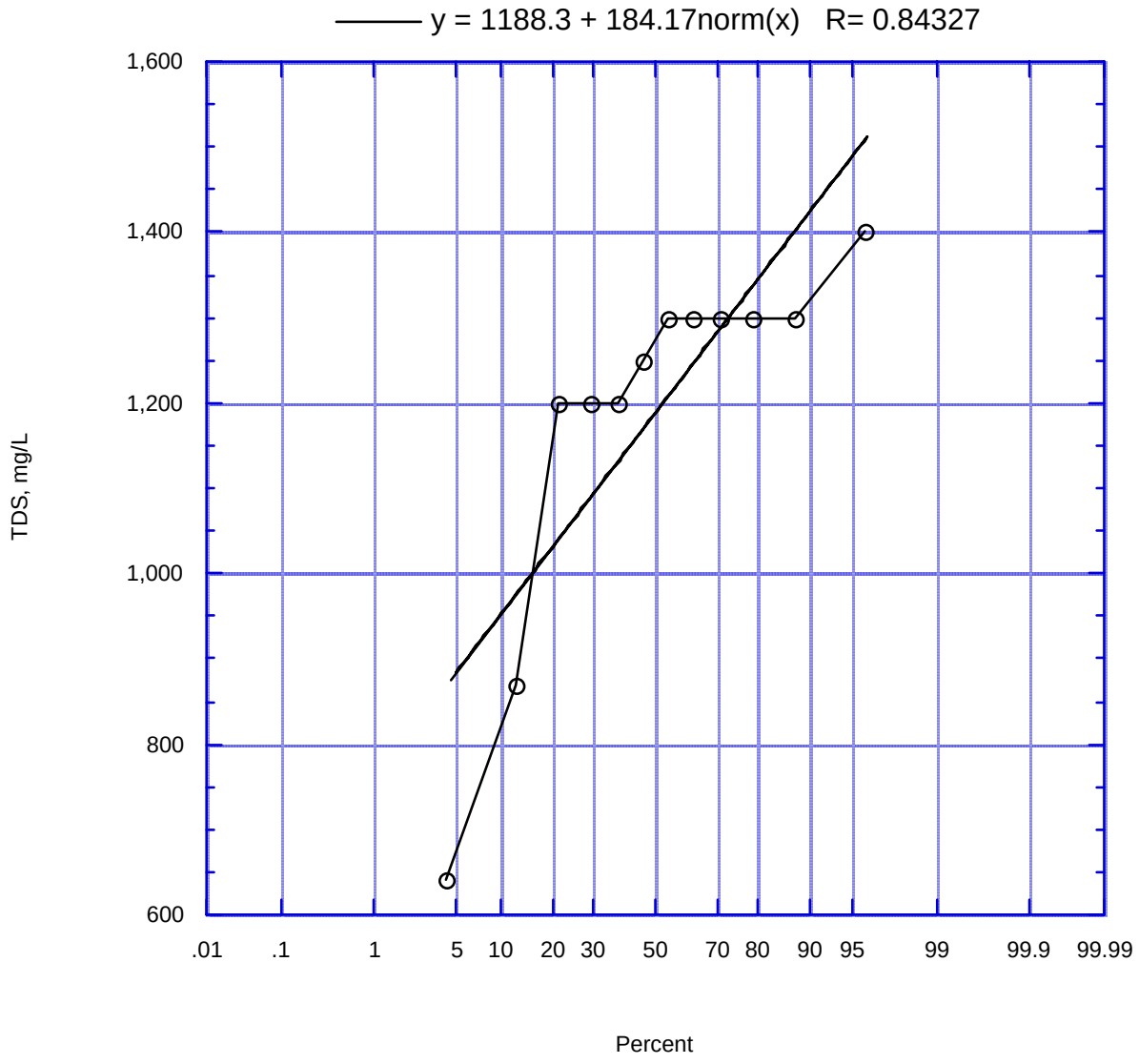
Fgure 220. Reach 11 Sulfate Frequency Distribution



Fgure 221. Reach 11 Boron Frequency Distribution



Fgure 222. Reach 13 Chloride Frequency Distribution



Fgure 223. Reach 13 TDS Frequency Distribution

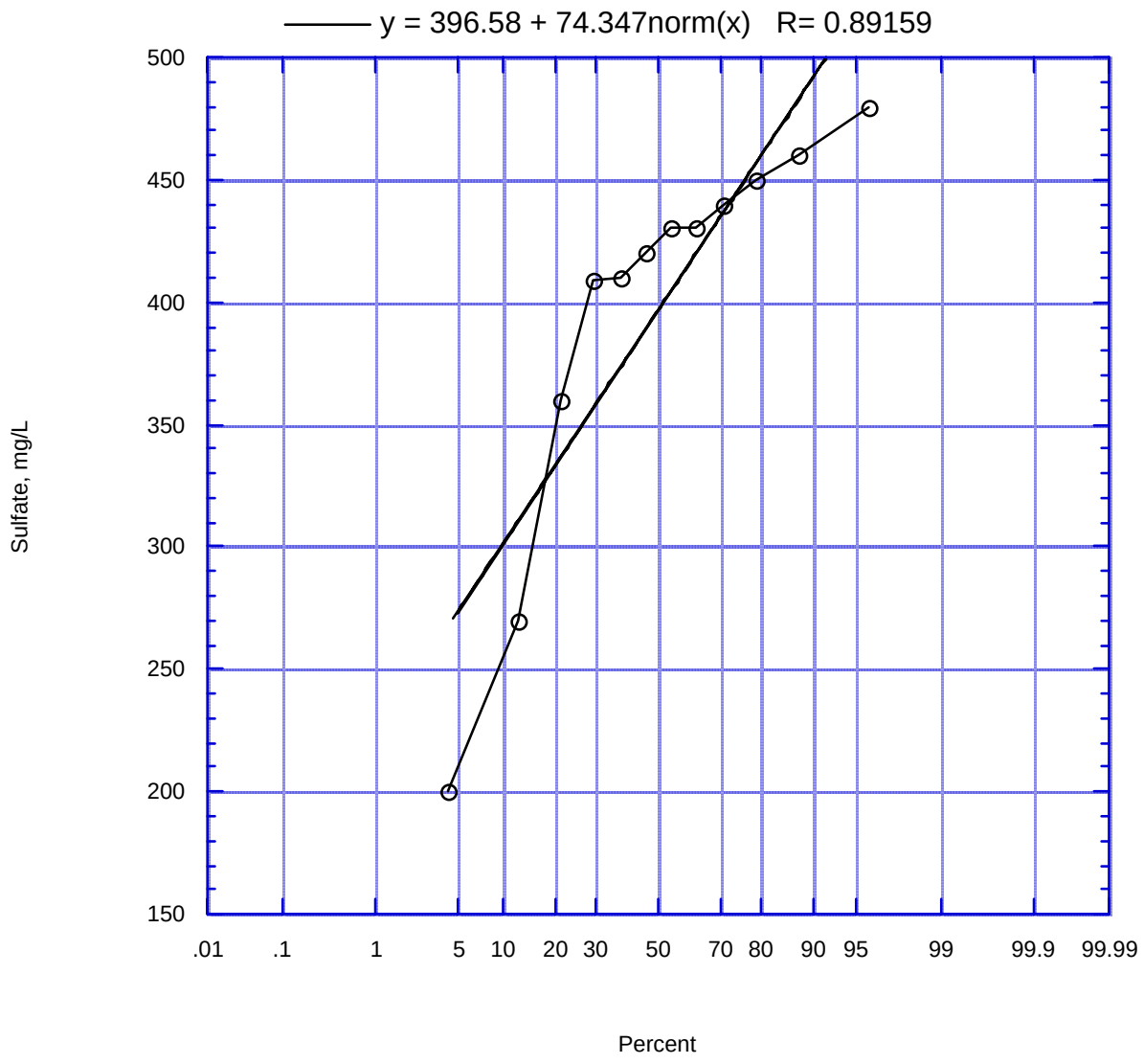


Figure 224. Reach 13 Sulfate Frequency Distribution

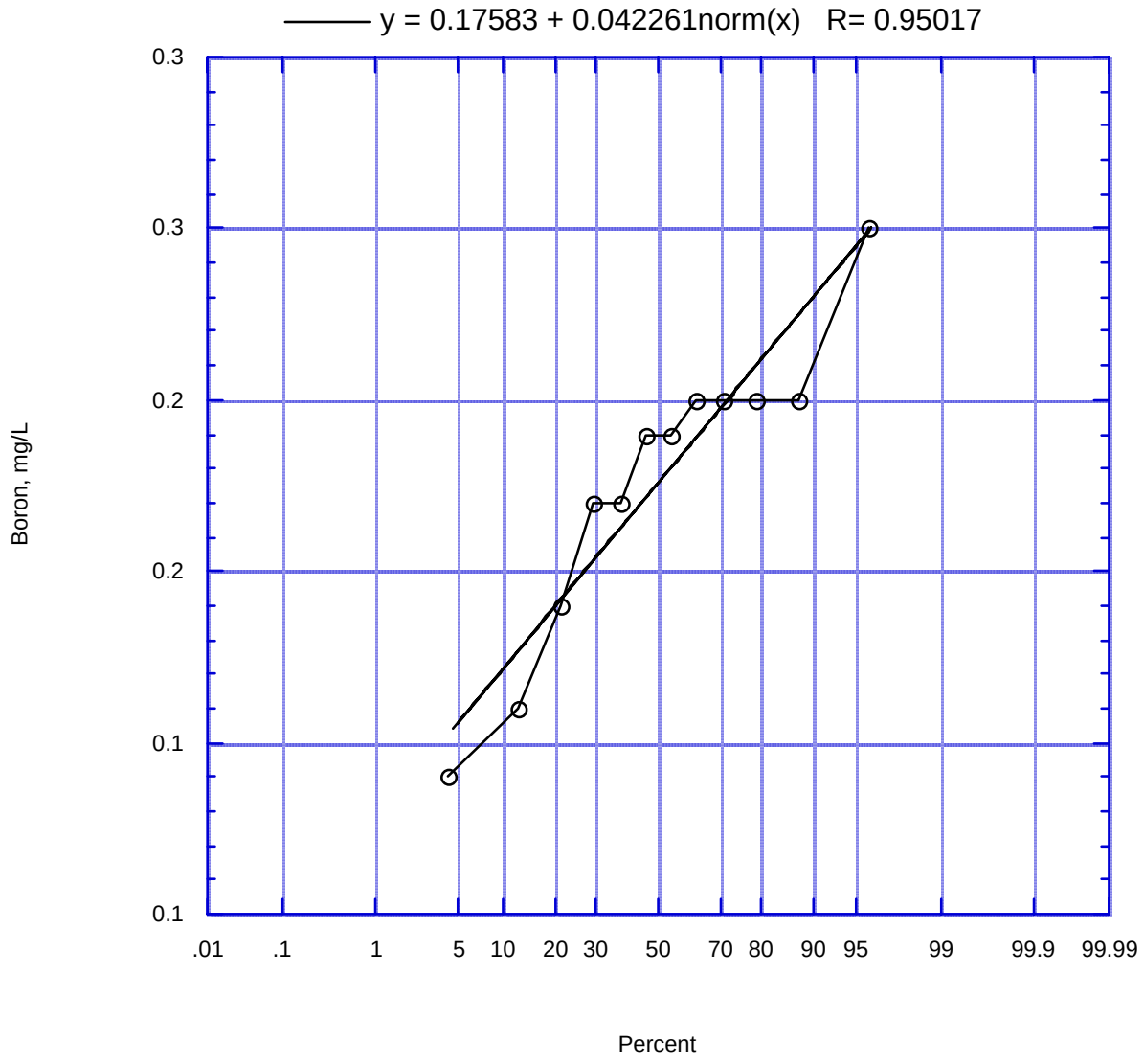


Figure 225. Reach 13 Boron Frequency Distribution

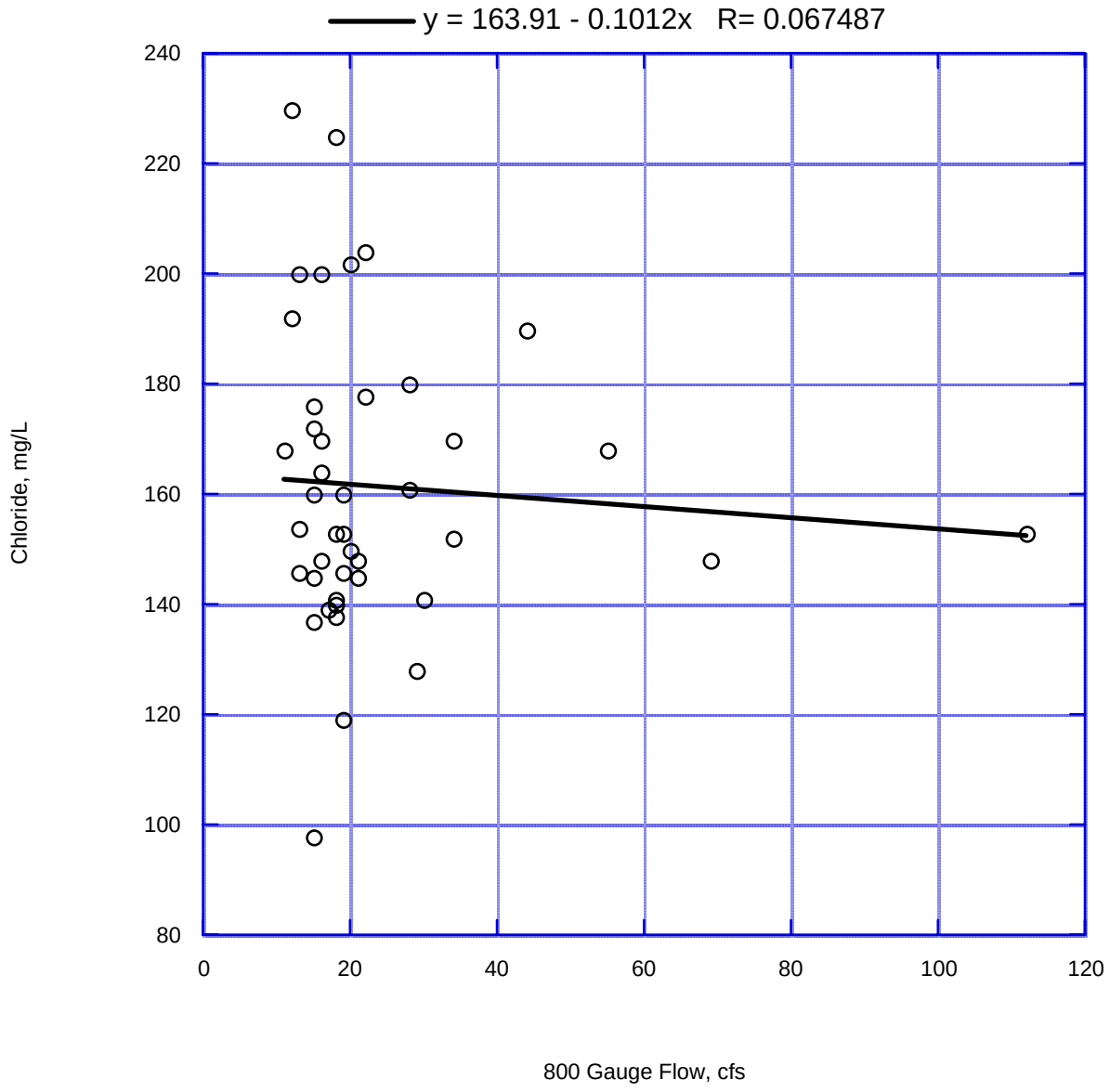


Figure 226. Chloride vs. Stream Flow at Gauge 800

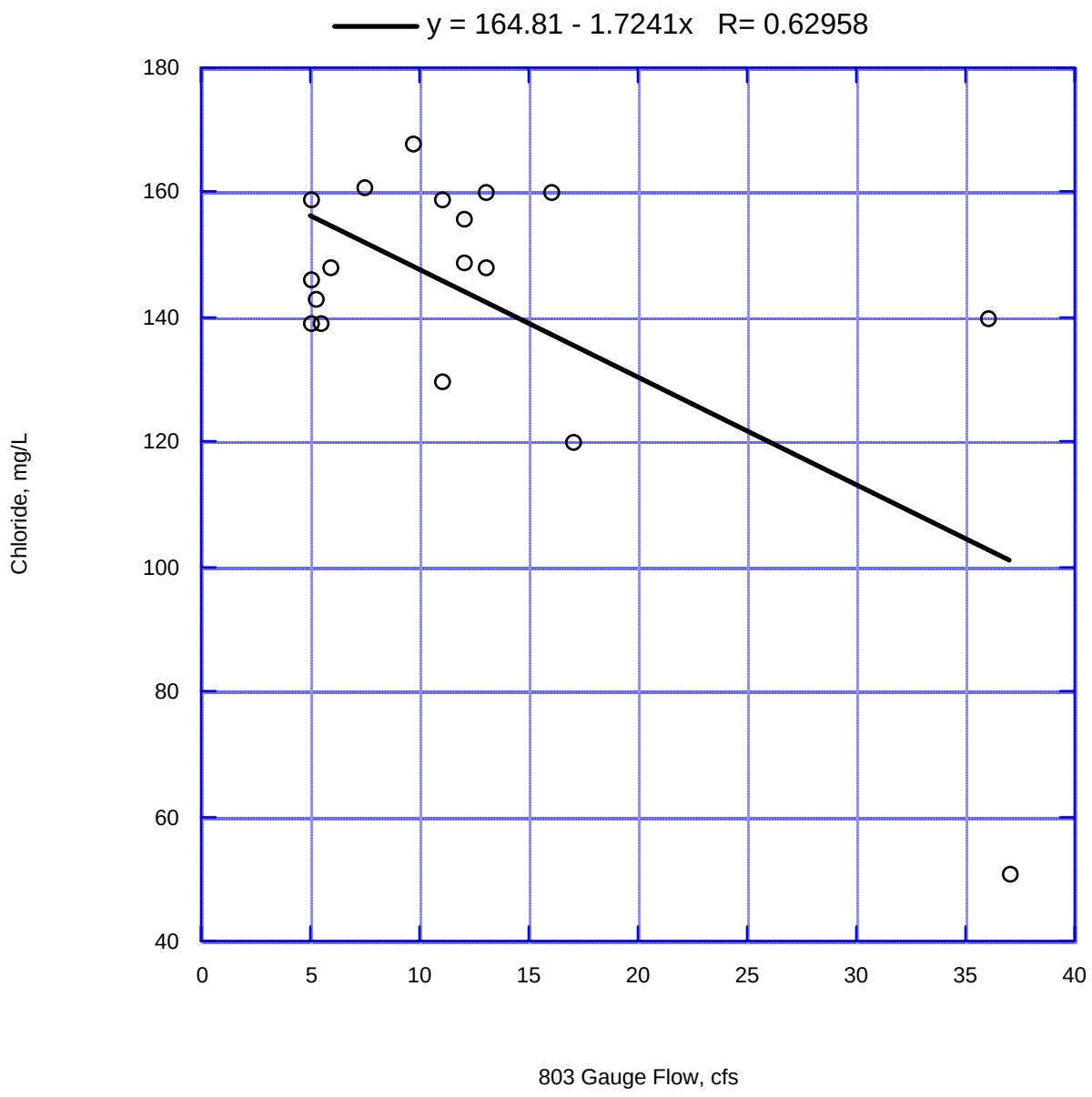


Figure 227. Chloride vs. Stream Flow at Gauge 803

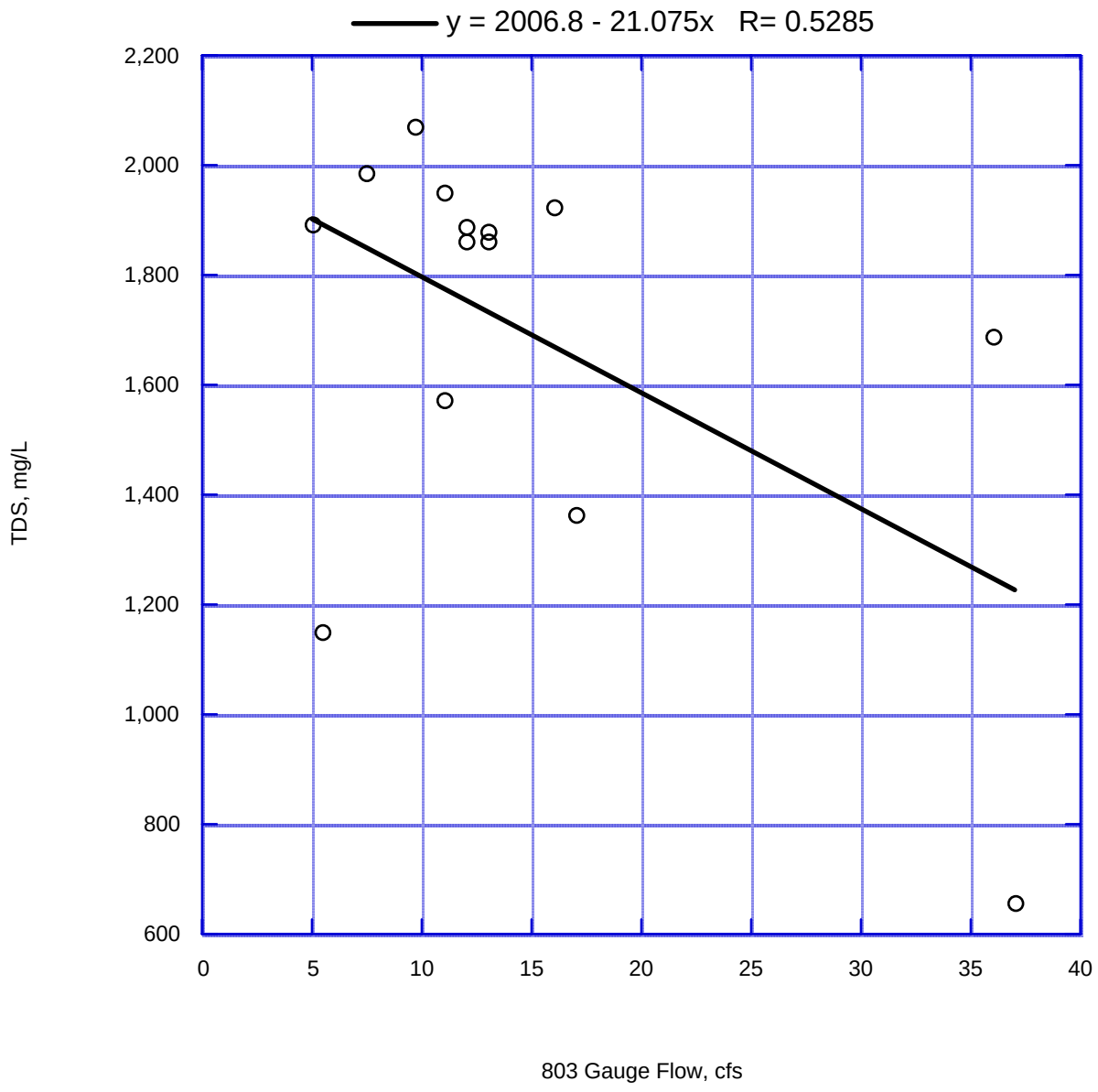


Figure 228. TDS vs. Stream Flow at Gauge 803

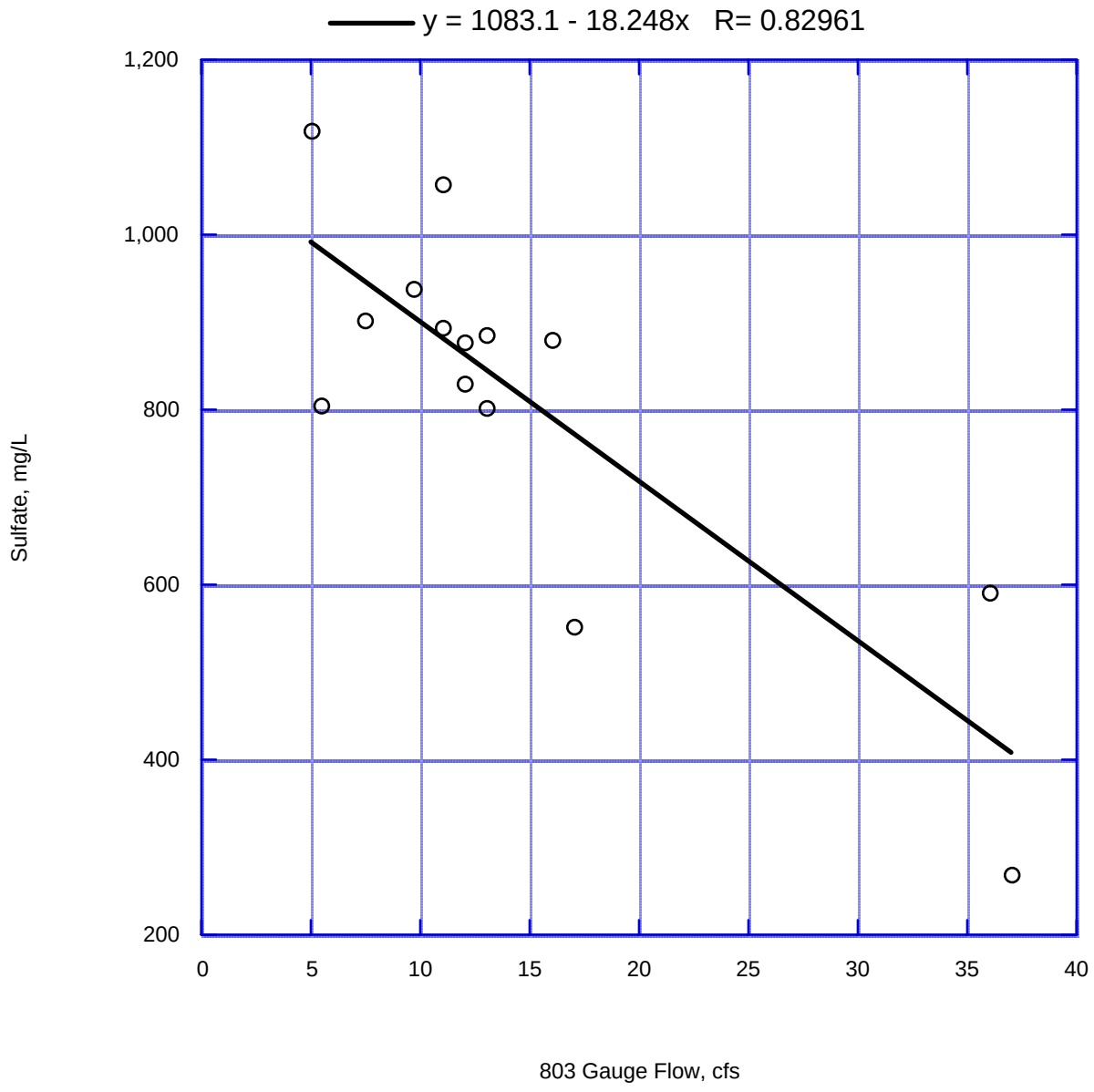


Figure 229. Sulfate vs. Stream Flow at Gauge 803

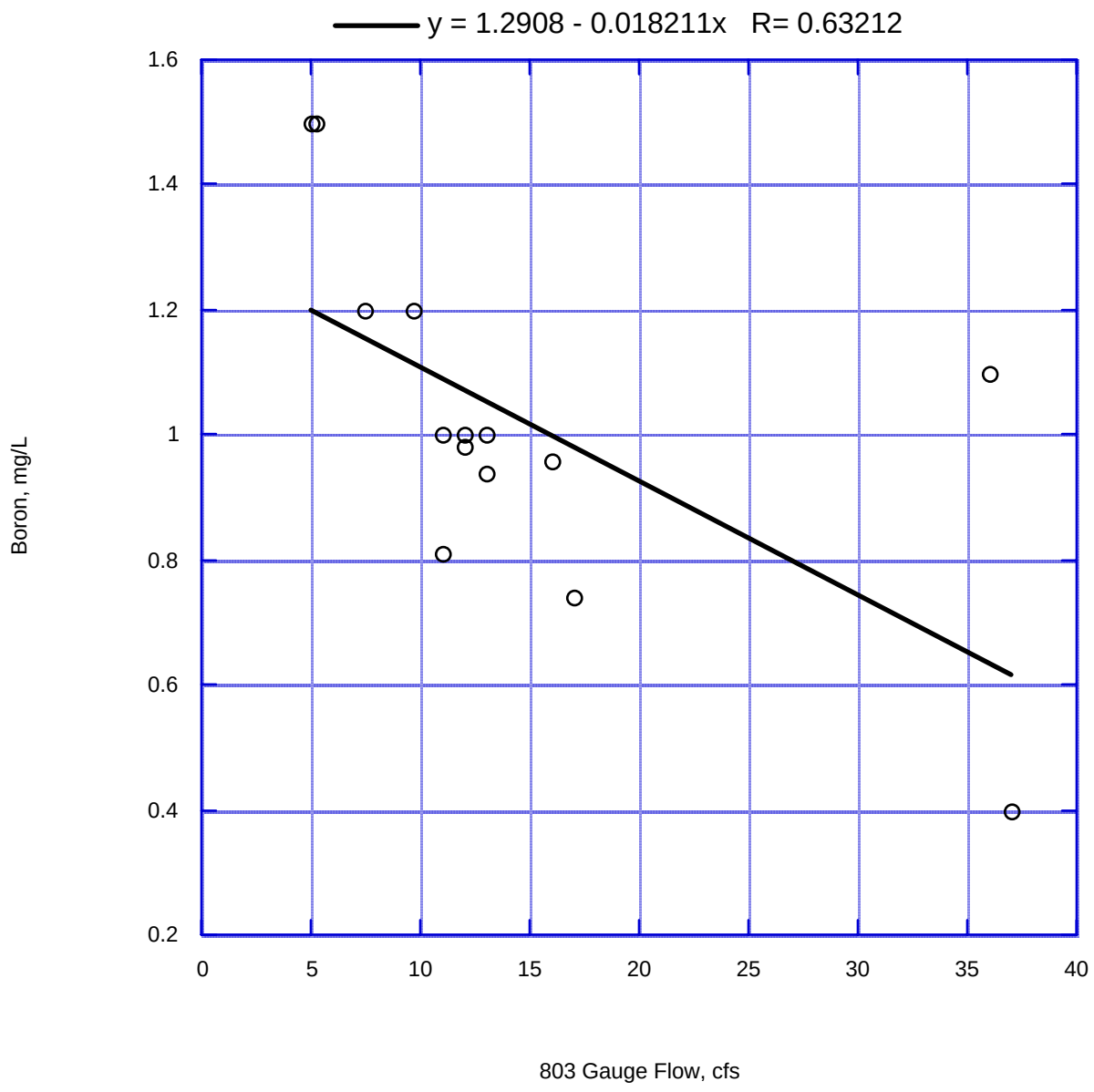


Figure 230. Boron vs. Stream Flow at Gauge 803

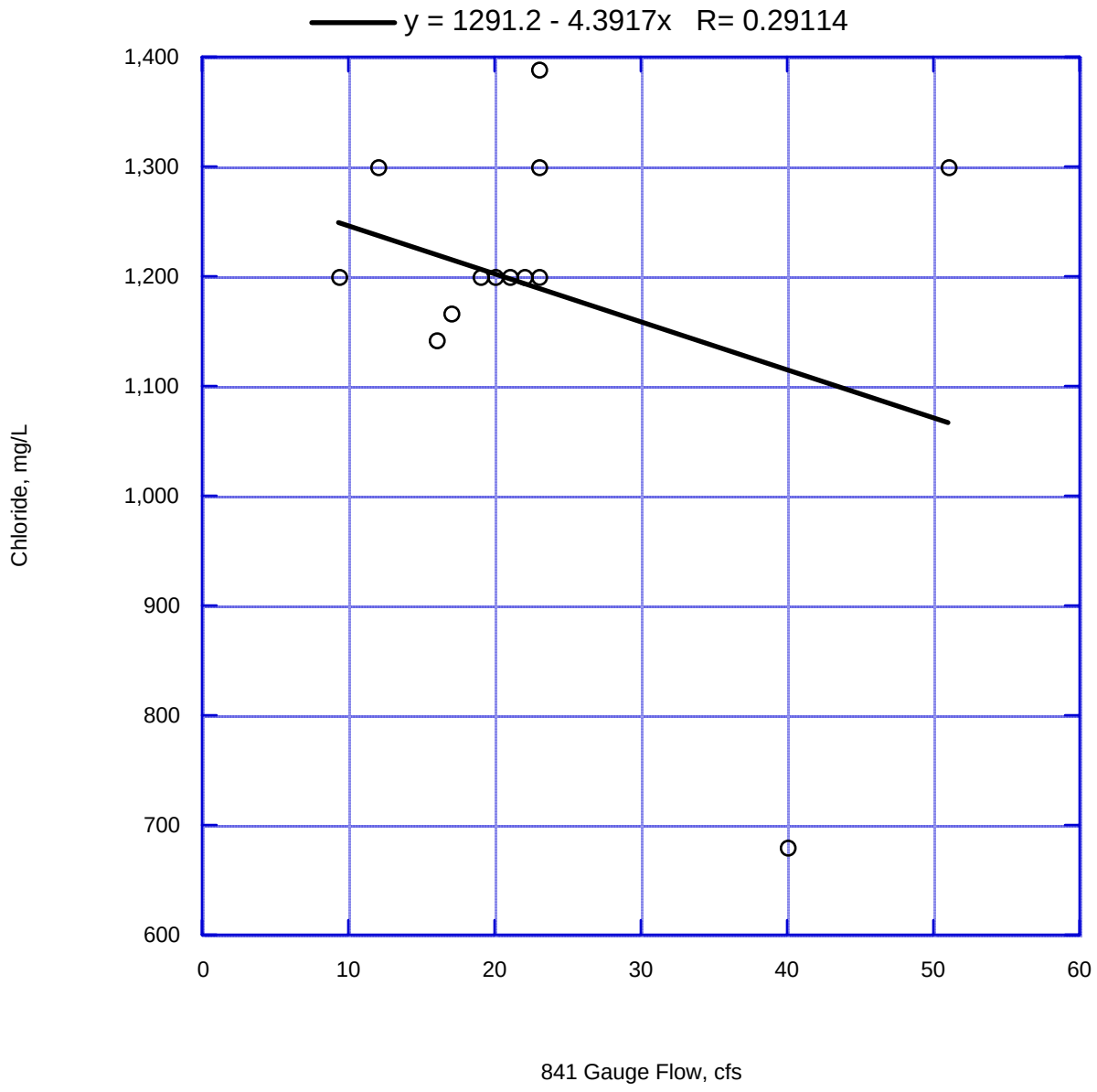


Figure 231. Chloride vs. Stream Flow at Gauge 841

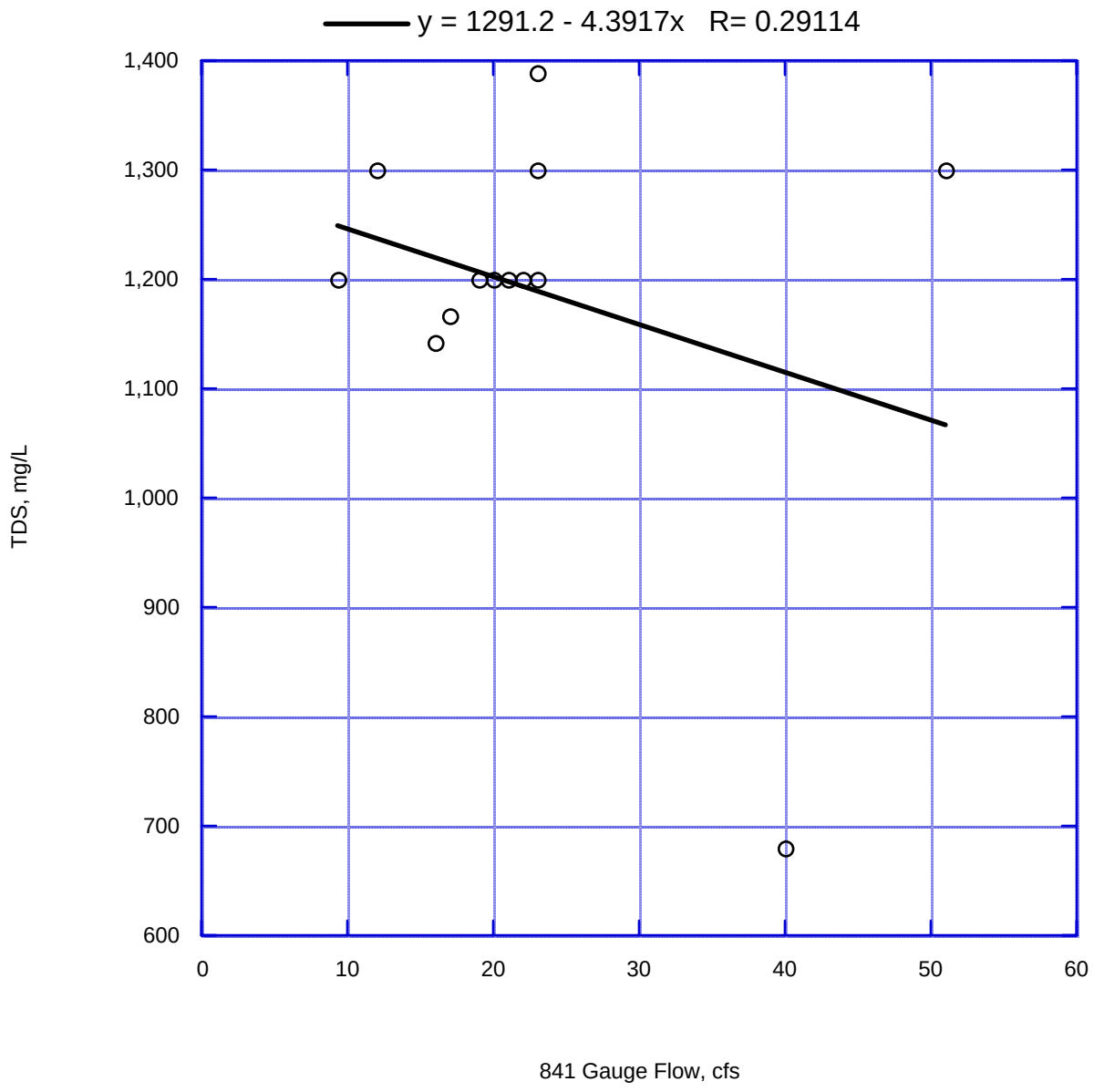


Figure 232. TDS vs. Stream Flow at Gauge 841

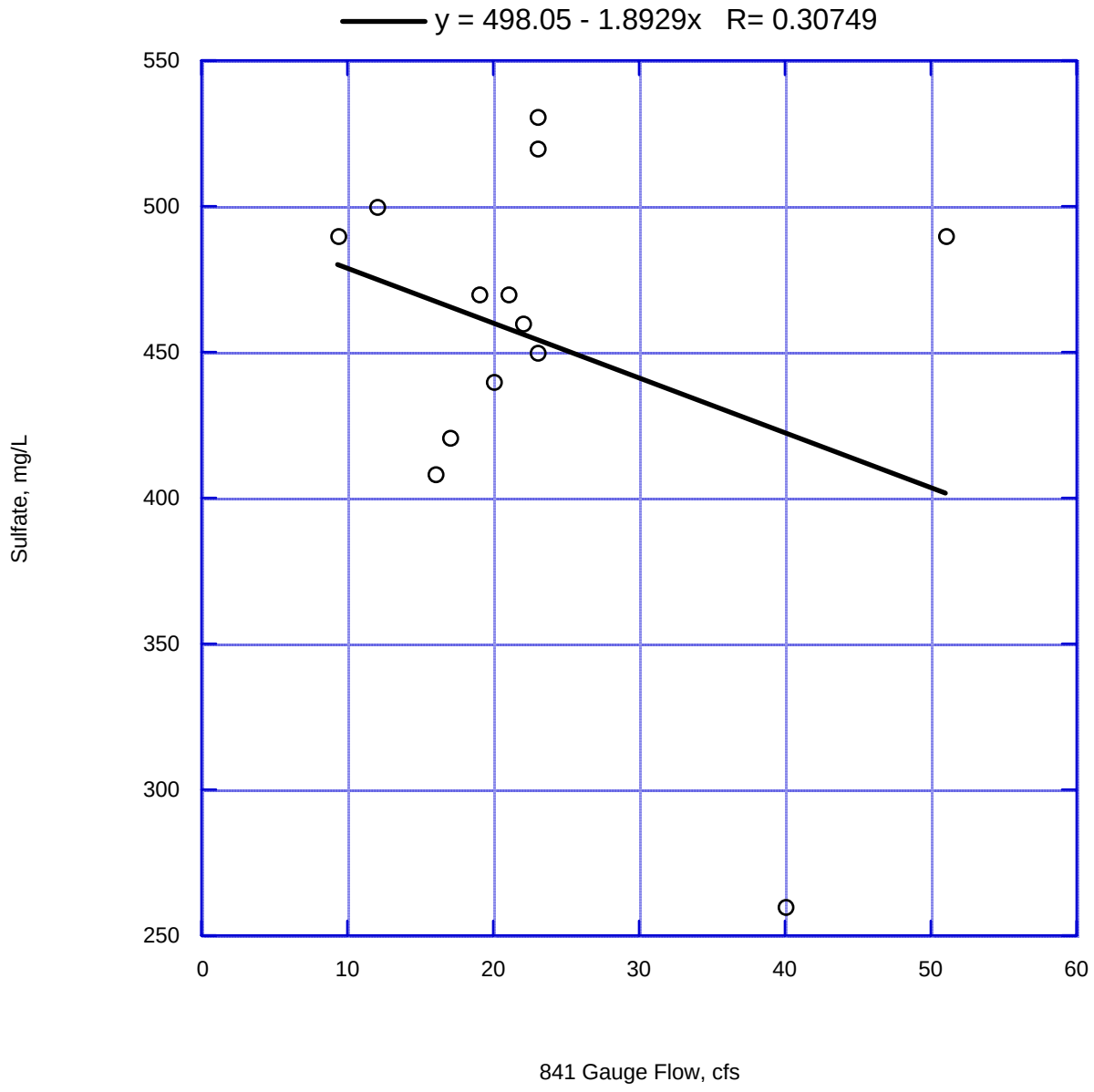


Figure 233. Sulfate vs. Stream Flow at Gauge 841

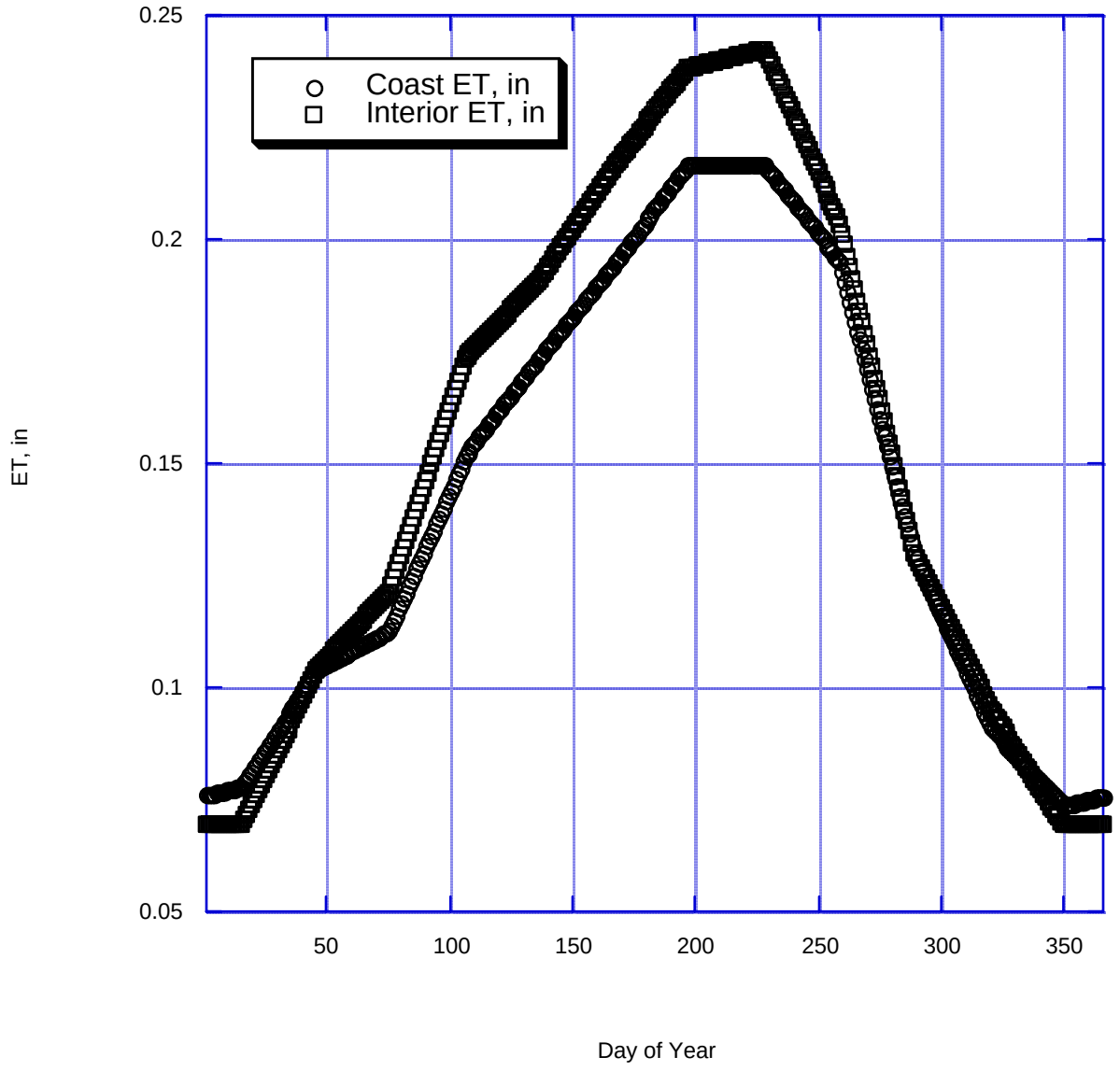


Figure 234. Water Surface and Mixed-plant ET vs. Time

Appendix B

POTW Source Analysis

Appendix B is included as an associated electronic file entitled App B-Urban Wastewater 6-30.xls.

Appendix C

EPA Chloride TMDL Model

Appendix C is included as an associated electronic file entitled Appendix C EPA Model 6-30.xls.

Appendix D

Plots of Modeled Scenarios

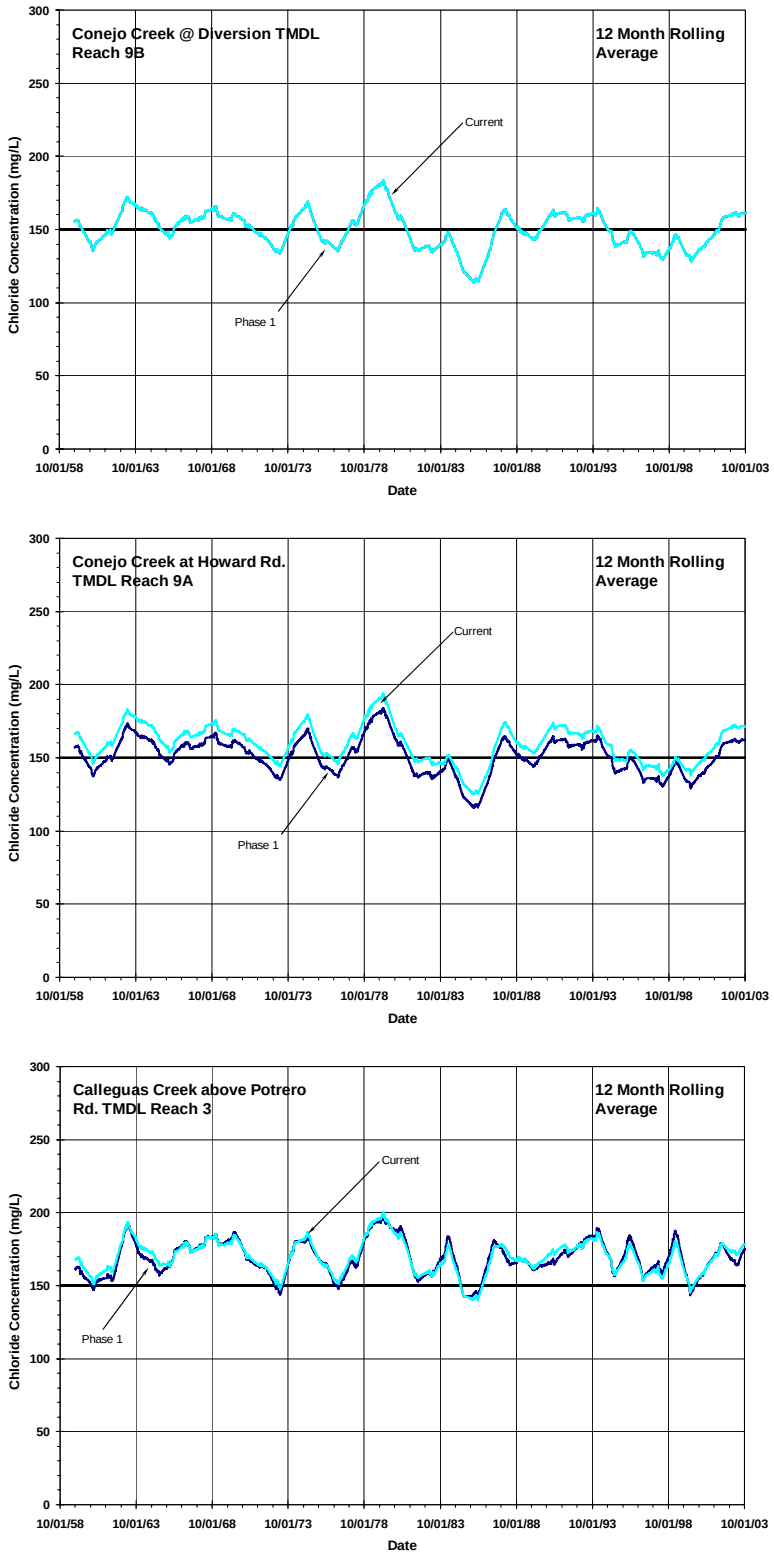


Figure 54: Current and Estimated Chloride 12-month Rolling Average Concentrations in Lower Watershed After Implementing Phase 1 of the RWRMP.

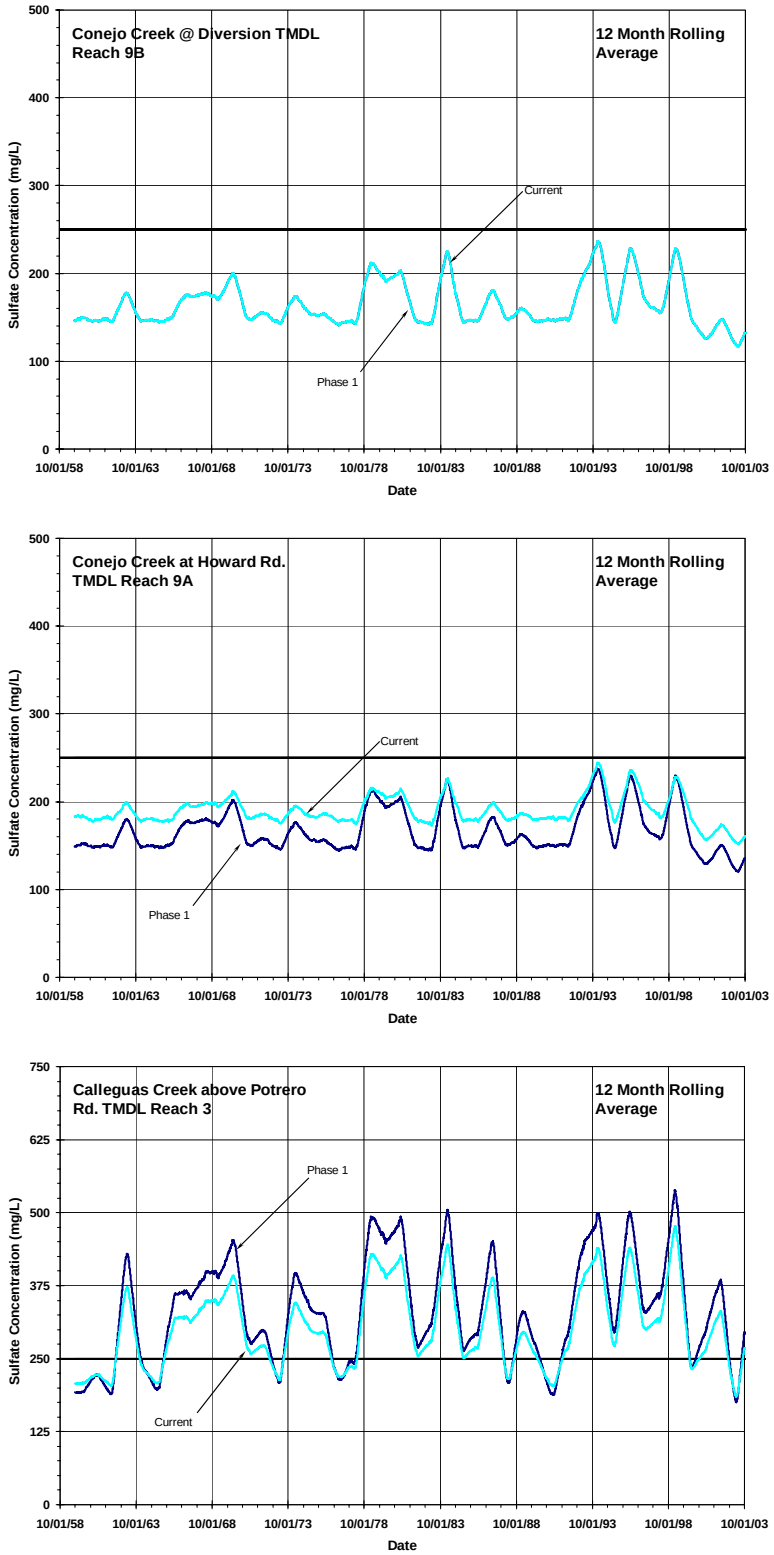


Figure 55: Current and Estimated Sulfate 12-month Rolling Average Concentrations in Lower Watershed After Implementing Phase 1 of the RWRMP.

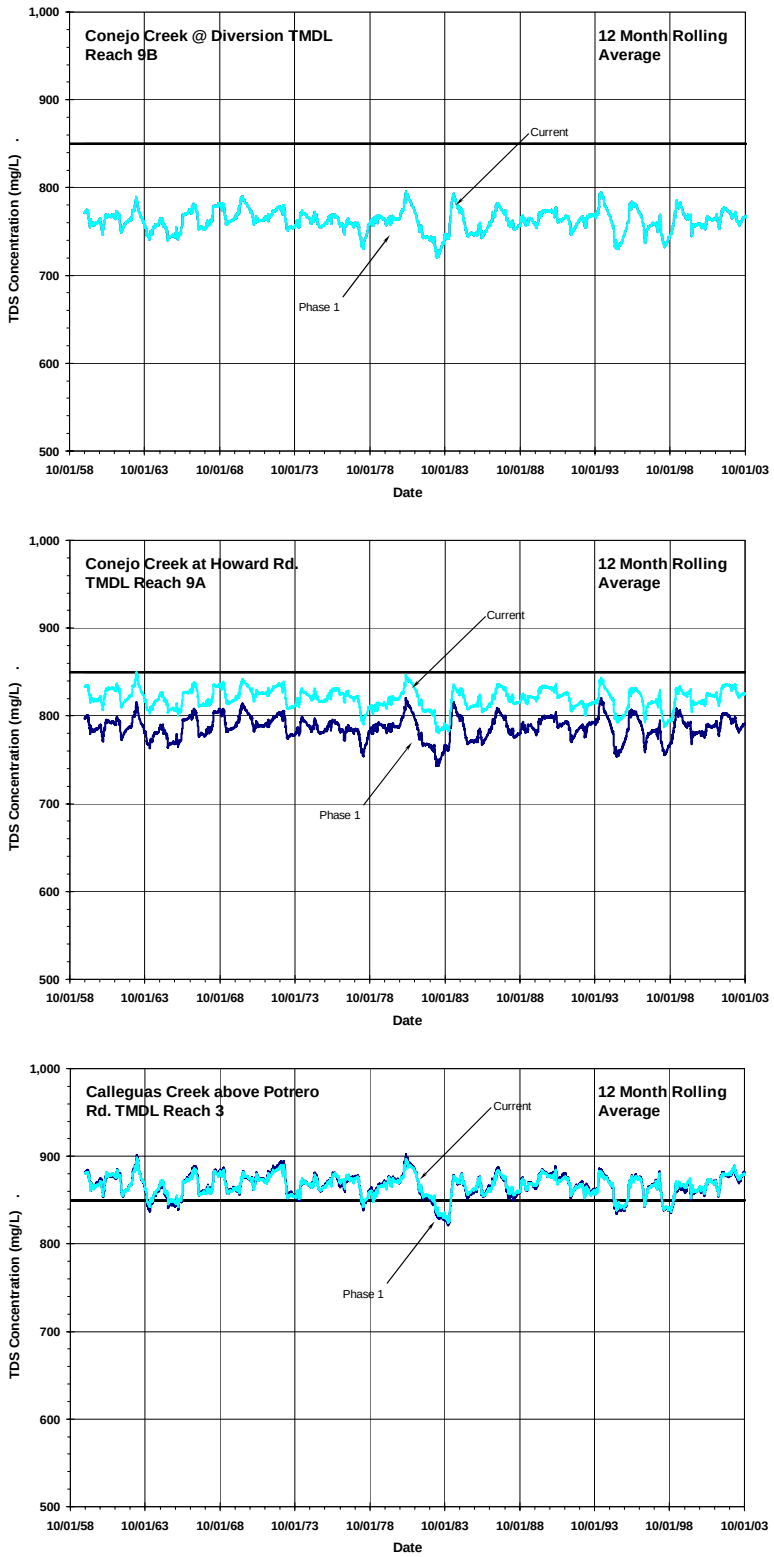


Figure 56: Current and Estimated TDS 12-month Rolling Average Concentrations in Lower Watershed After Implementing Phase 1 of the RWRMP.

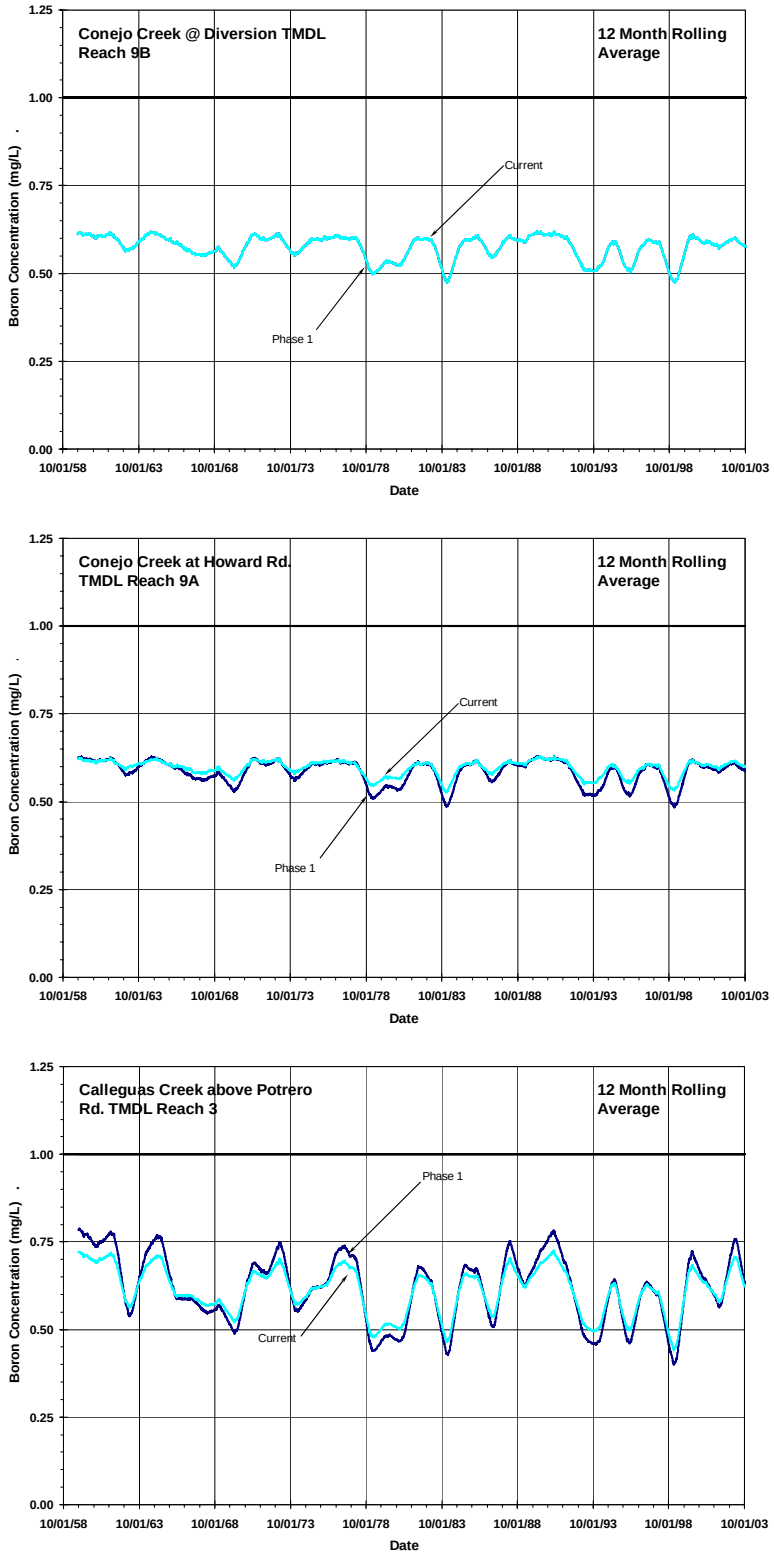


Figure 57: Current and Estimated Boron 12-month Rolling Average Concentrations in Lower Watershed After Implementing Phase 1 of the RWRMP.

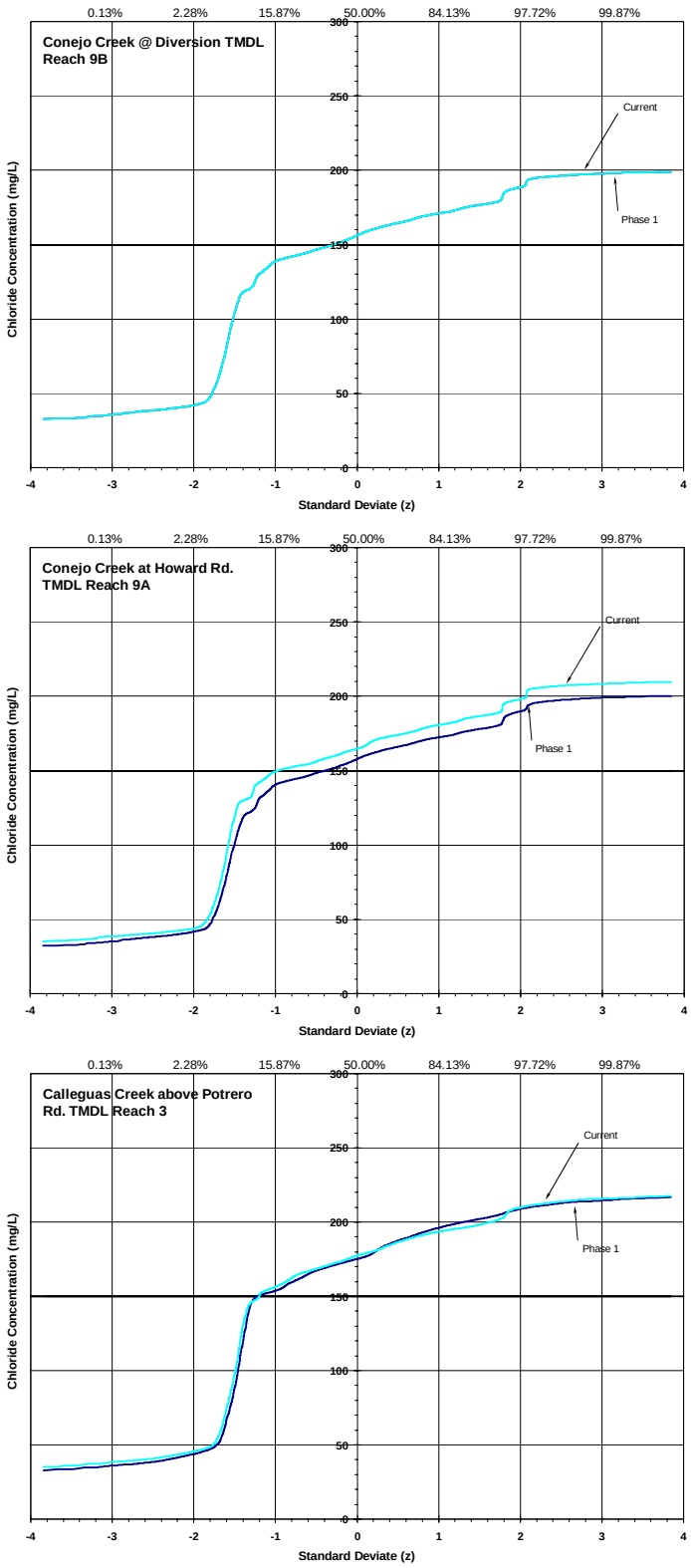


Figure 58: Current and Estimated Chloride Probability Distribution of Daily Average Concentrations in Lower Watershed After Implementing Phase 1 of the RWRMP.

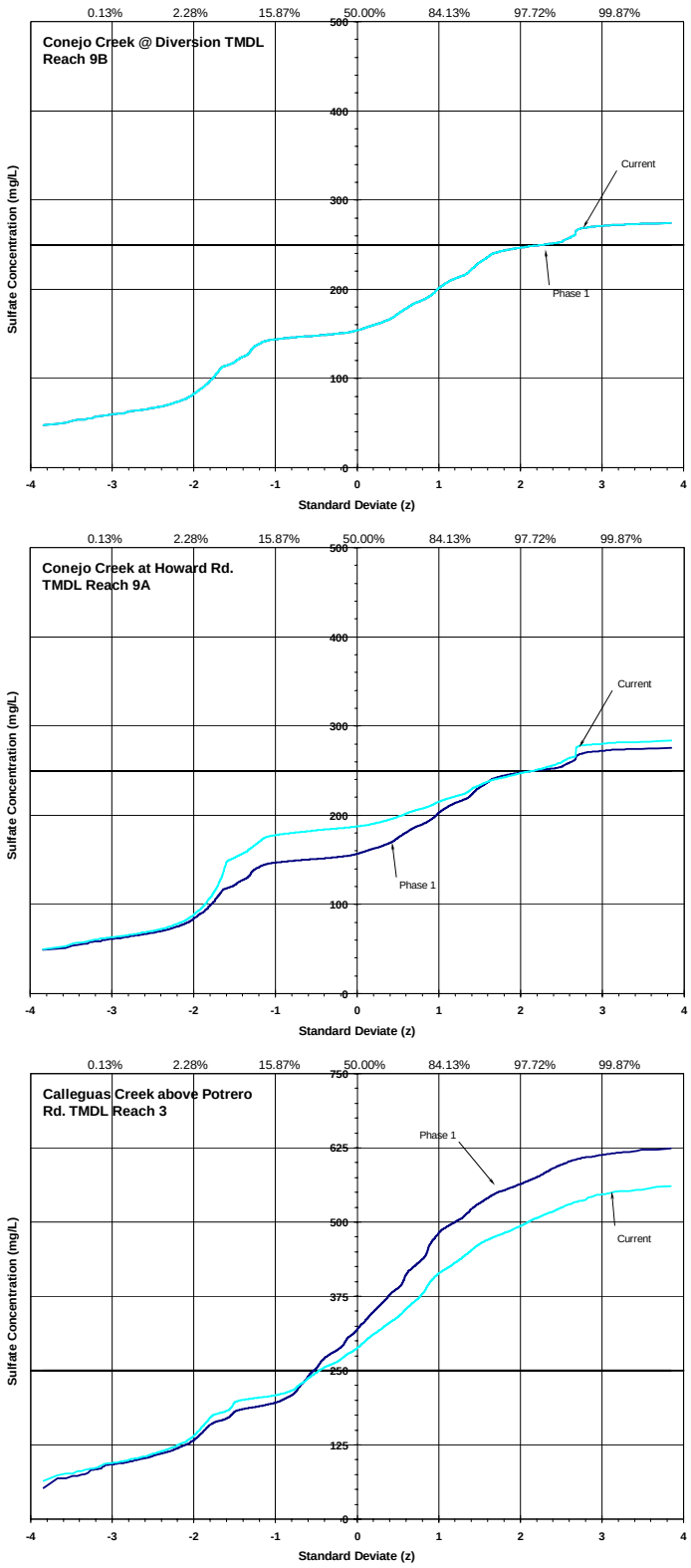


Figure 59: Current and Estimated Sulfate Probability Distribution of Daily Average Concentrations in Lower Watershed After Implementing Phase 1 of the RWRMP.

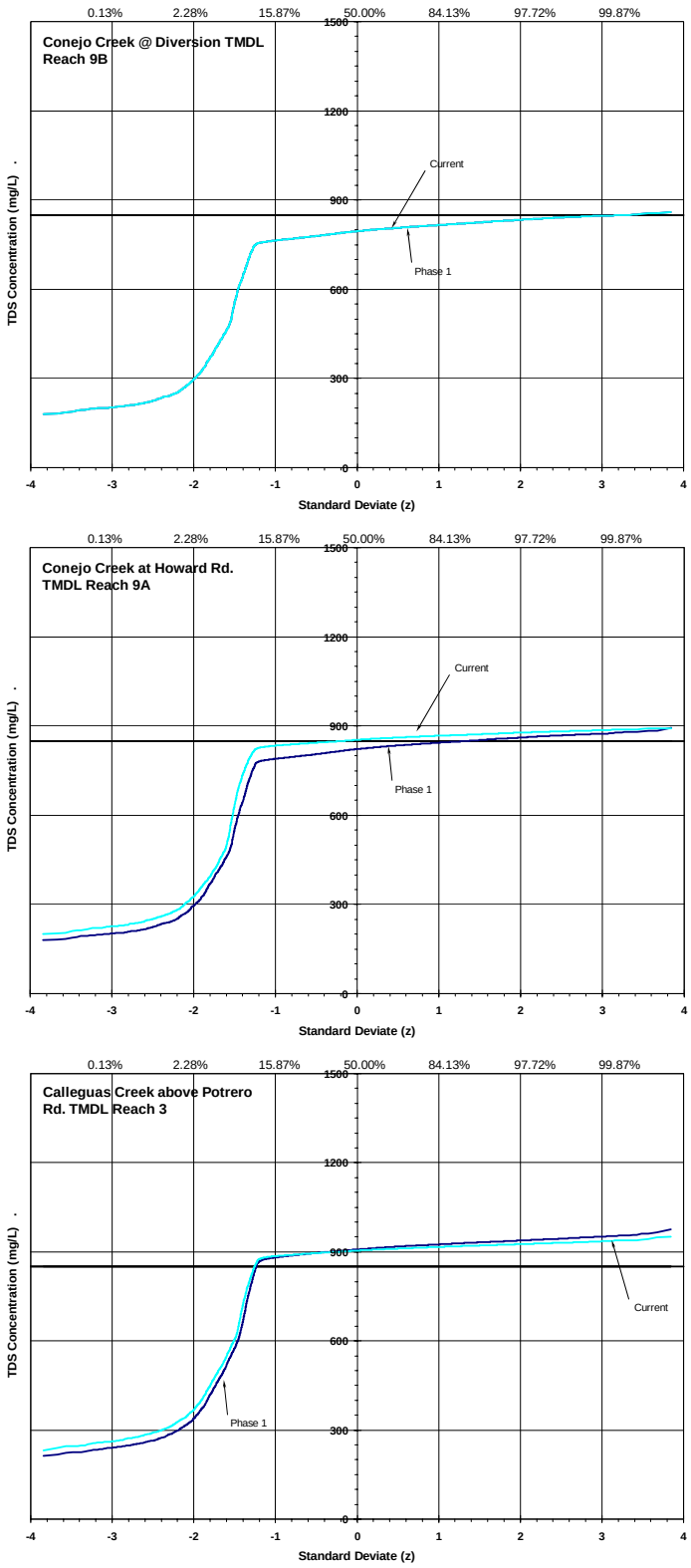


Figure 60: Current and Estimated TDS Probability Distribution of Daily Average Concentrations in Lower Watershed After Implementing Phase 1 of the RWRMP.

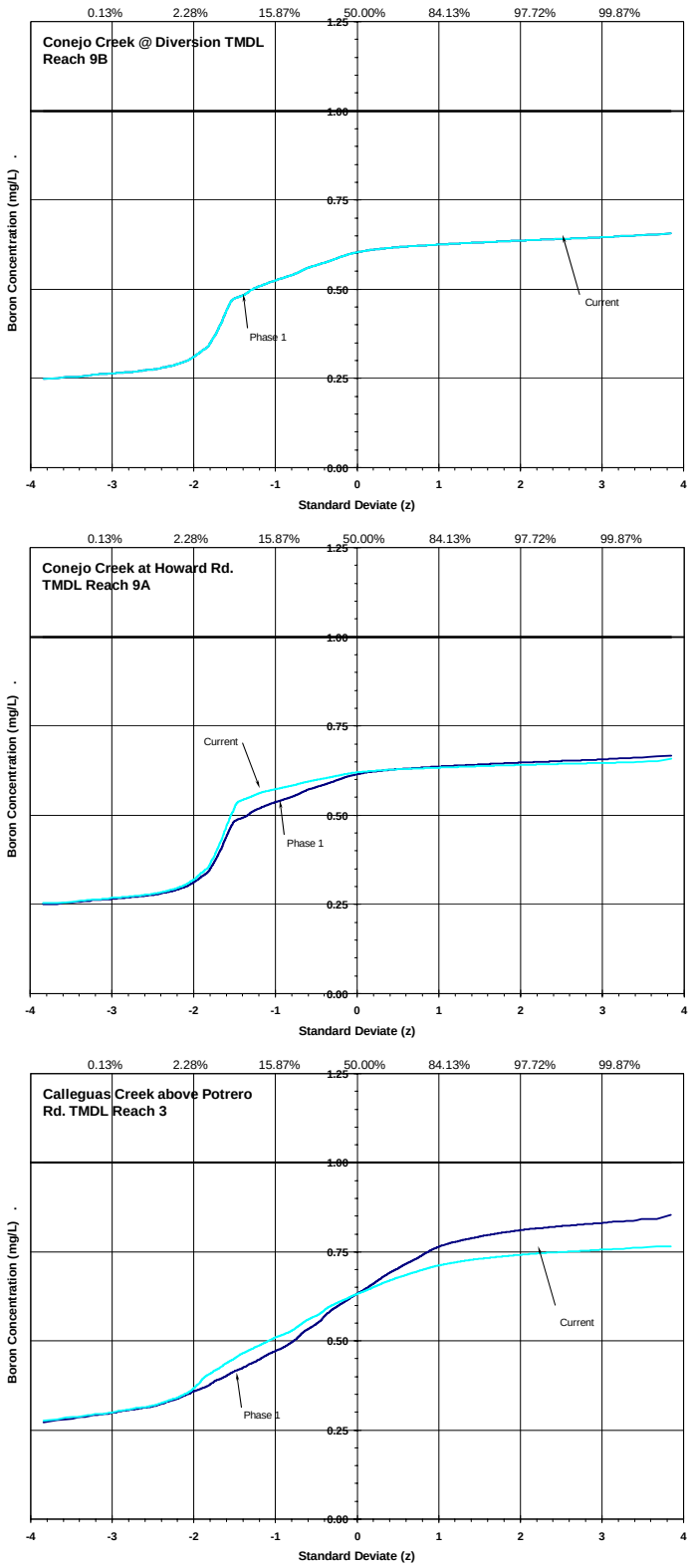


Figure 61: Current and Estimated Boron Probability Distribution of Daily Average Concentrations in Lower Watershed After Implementing Phase 1 of the RWRMP.

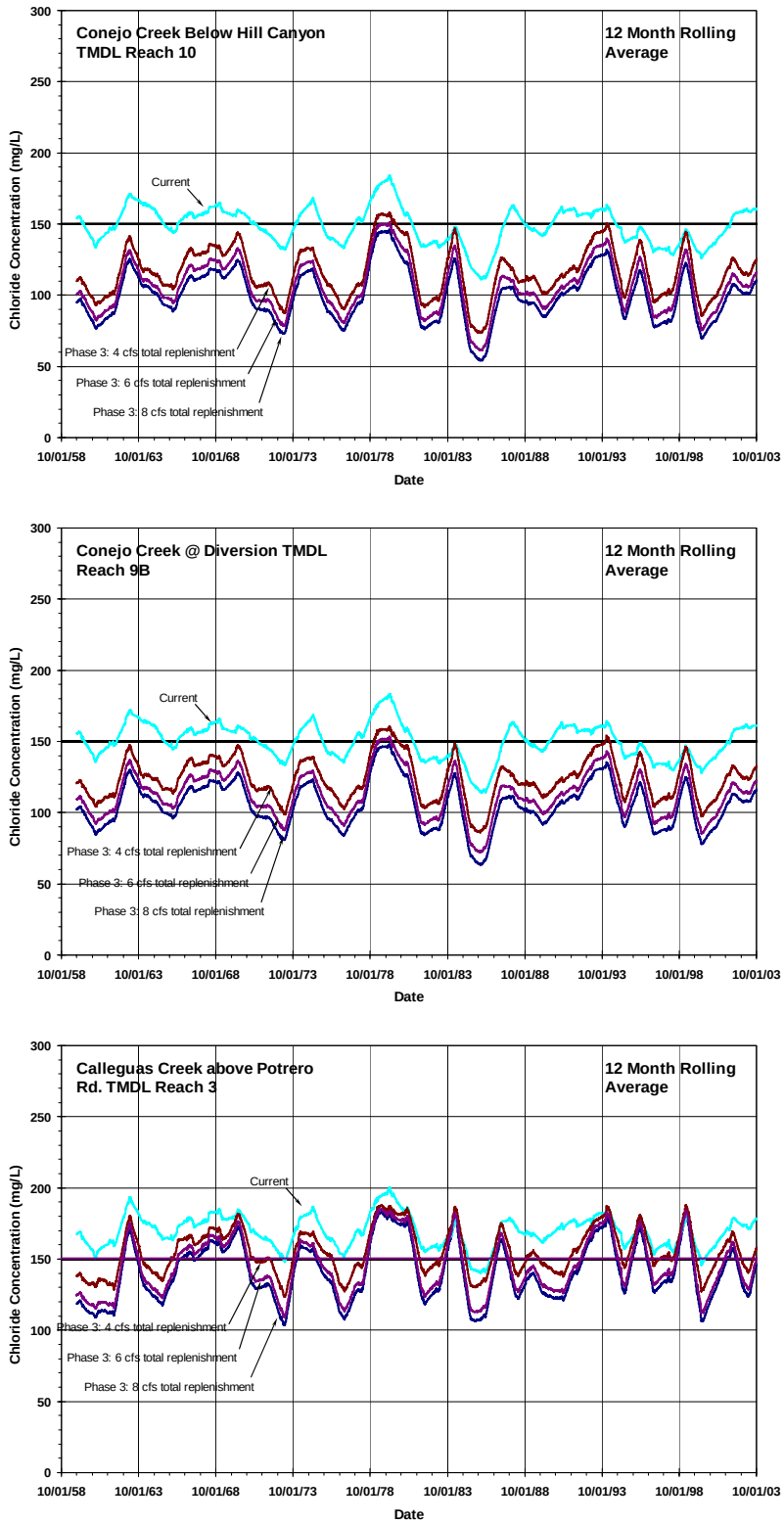


Figure 62: Current and Estimated Chloride 12-month Rolling Average Concentrations in Lower Watershed After Implementing Phase 3 of the RWRMP with Various Total Replenishment Flowrates Equally Divided between the North and South Forks of Arroyo Conejo.

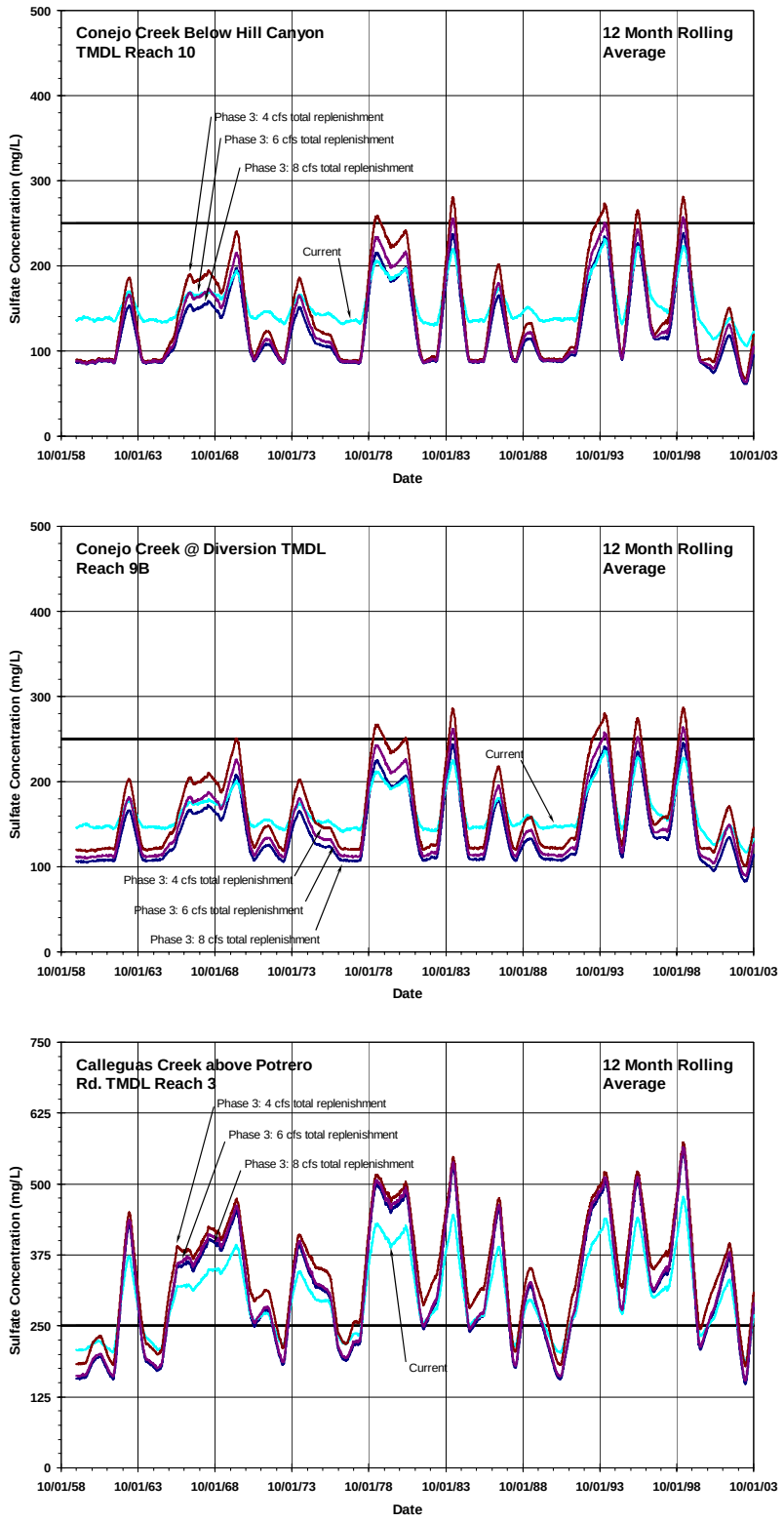


Figure 63: Current and Estimated Sulfate 12-month Rolling Average Concentrations in Lower Watershed After Implementing Phase 3 of the RWRMP with Various Total Replenishment Flowrates Equally Divided between the North and South Forks of Arroyo Conejo.

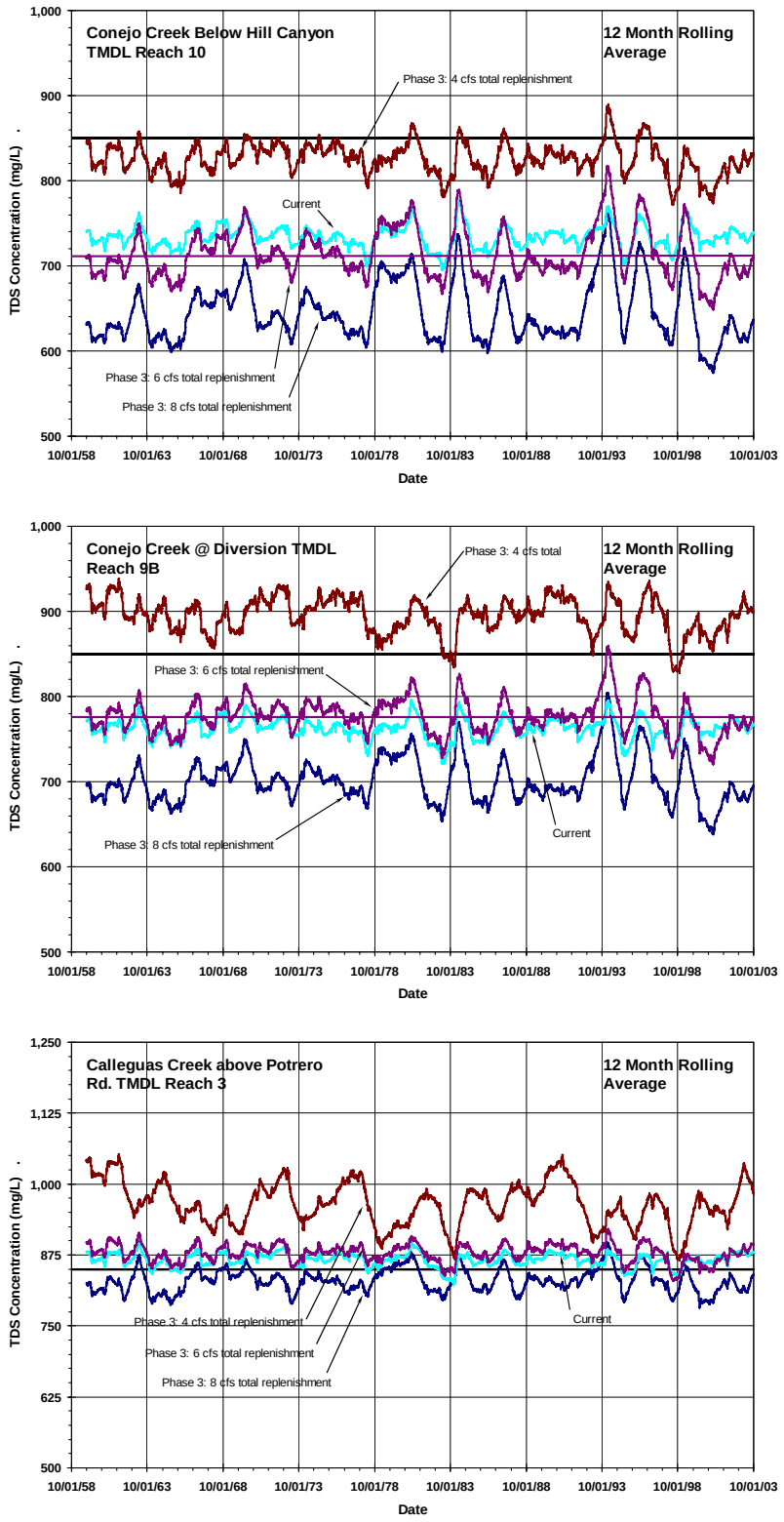


Figure 64: Current and Estimated TDS 12-month Rolling Average Concentrations in Lower Watershed After Implementing Phase 3 of the RWRMP with Various Total Replenishment Flowrates Equally Divided between the North and South Forks of Arroyo Conejo.

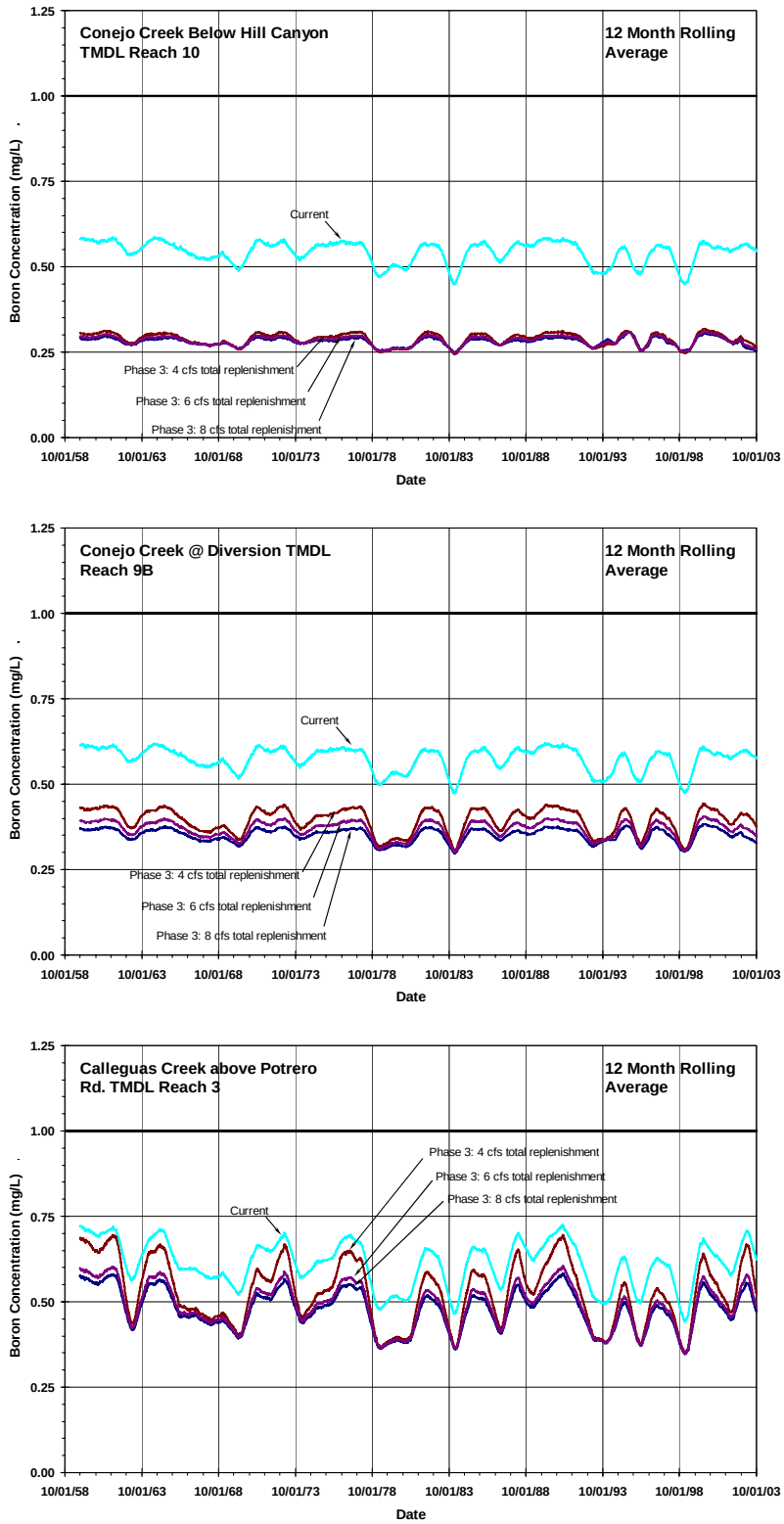


Figure 65: Current and Estimated Boron 12-month Rolling Average Concentrations in Lower Watershed After Implementing Phase 3 of the RWRMP with Various Total Replenishment Flowrates Equally Divided between the North and South Forks of Arroyo Conejo.

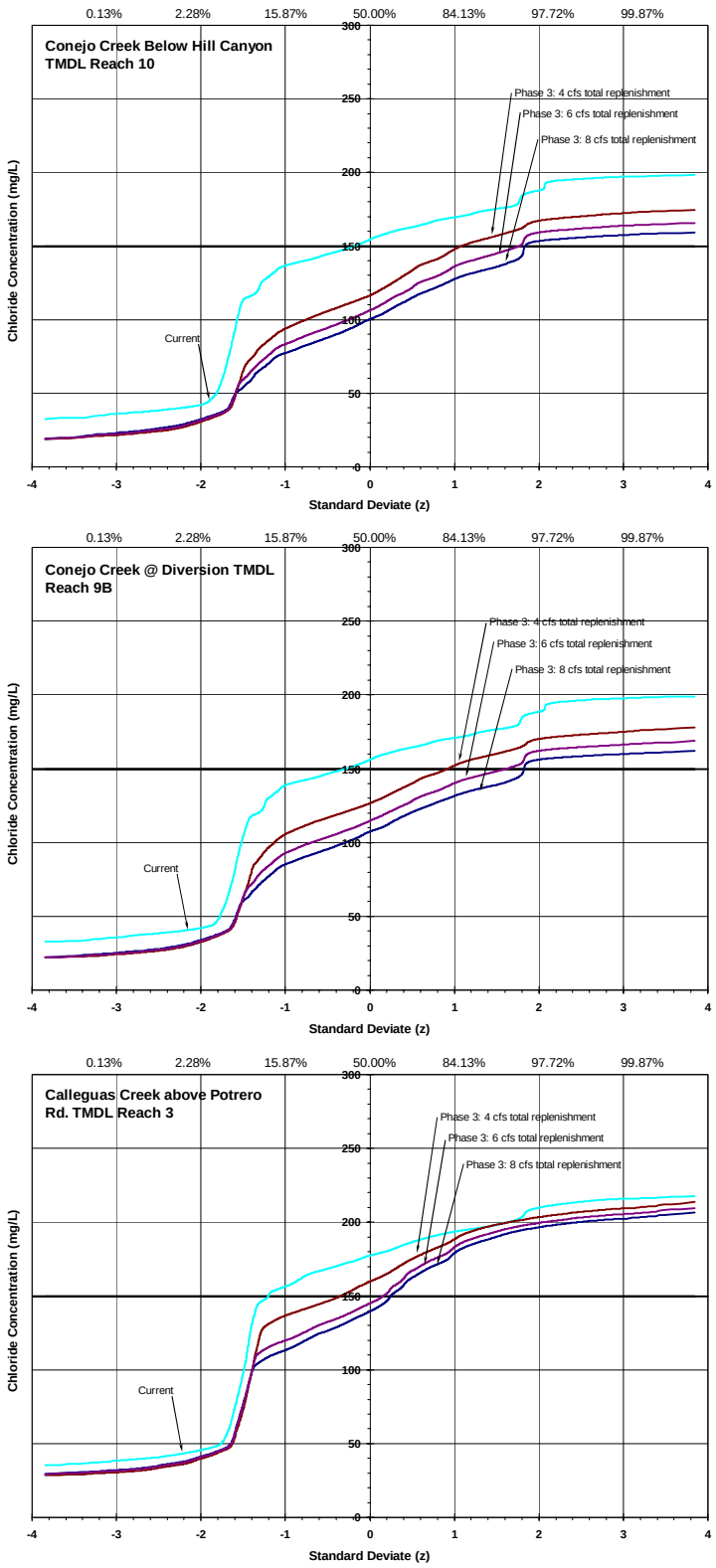


Figure 66: Current and Estimated Chloride Probability Distribution of Daily Average Concentrations in Lower Watershed After Implementing Phase 3 of the RWRMP with Various Total Replenishment Flowrates Equally Divided between the North and South Forks of Arroyo Conejo.

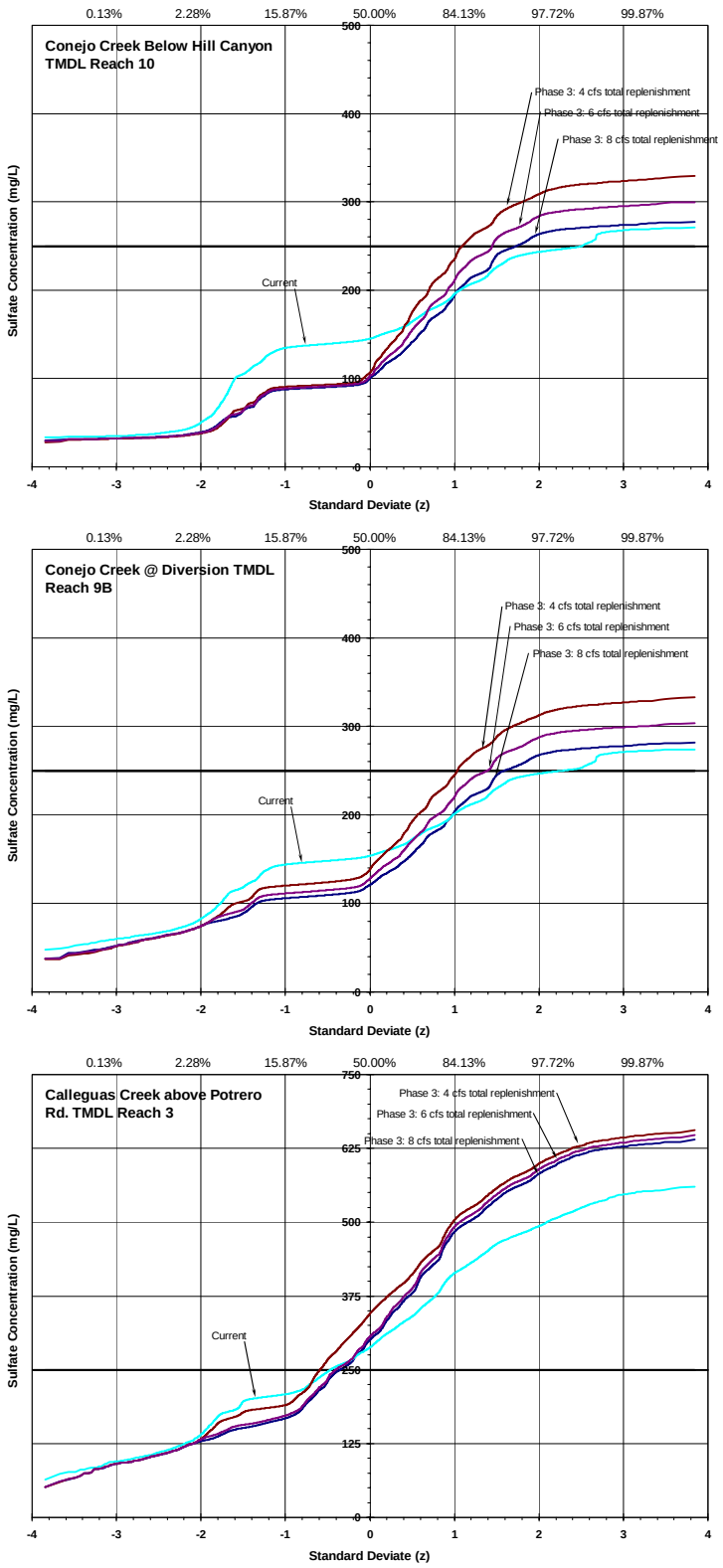


Figure 67: Current and Estimated Sulfate Probability Distribution of Daily Average Concentrations in Lower Watershed After Implementing Phase 3 of the RWRMP with Various Total Replenishment Flowrates Equally Divided between the North and South Forks of Arroyo Conejo.

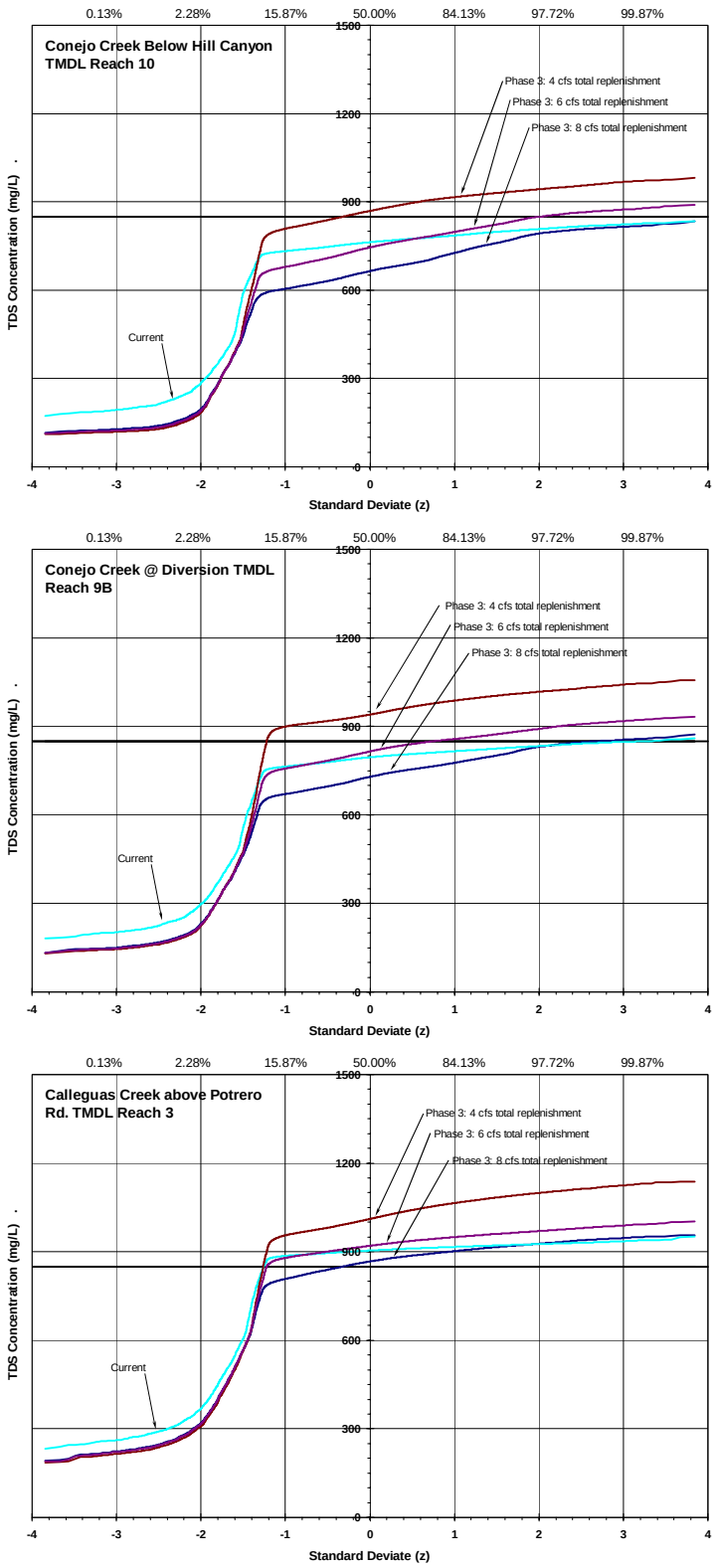


Figure 68: Current and Estimated TDS Probability Distribution of Daily Average Concentrations in Lower Watershed After Implementing Phase 3 of the RWRMP with Various Total Replenishment Flowrates Equally Divided between the North and South Forks of Arroyo Conejo.

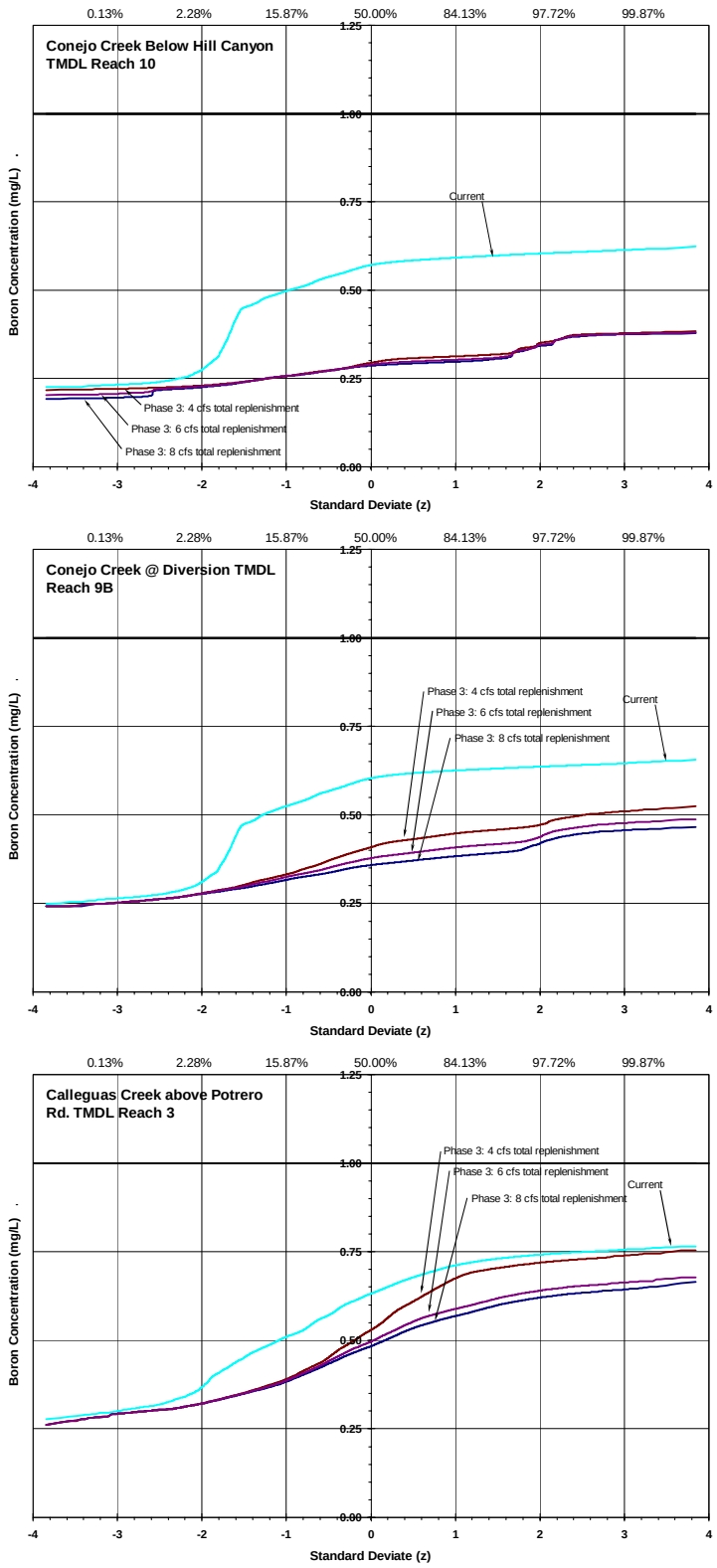
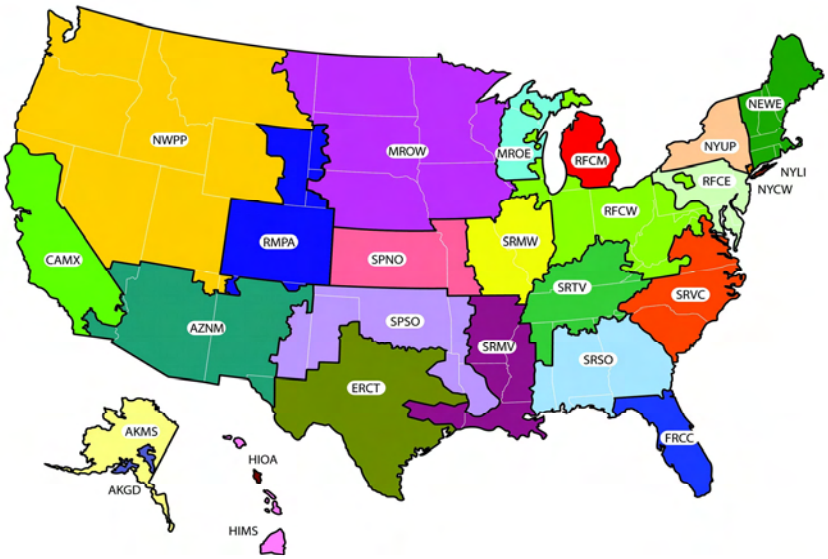


Figure 69: Current and Estimated Boron Probability Distribution of Daily Average Concentrations in Lower Watershed After Implementing Phase 3 of the RWRMP with Various Total Replenishment Flowrates Equally Divided between the North and South Forks of Arroyo Conejo.

eGRID2012 Version 1.0 Year 2009 GHG Annual Output Emission Rates

Annual total output emission rates for greenhouse gases (GHGs) can be used as default factors for estimating GHG emissions from electricity use when developing a carbon footprint or emission inventory. Annual non-baseload output emission rates should not be used for those purposes, but can be used to estimate GHG emissions reductions from reductions in electricity use.

eGRID subregion acronym	eGRID subregion name	Annual total output emission rates			Annual non-baseload output emission rates		
		Carbon dioxide (CO_2) (lb/MWh)	Methane (CH_4) (lb/GWh)	Nitrous oxide (N_2O) (lb/GWh)	Carbon dioxide (CO_2) (lb/MWh)	Methane (CH_4) (lb/GWh)	Nitrous oxide (N_2O) (lb/GWh)
AKGD	ASCC Alaska Grid	1,280.86	27.74	7.69	1,320.75	33.16	6.34
AKMS	ASCC Miscellaneous	521.26	21.78	4.28	1,469.44	61.53	12.10
AZNM	WECC Southwest	1,191.35	19.13	15.58	1,187.67	22.25	9.12
CAMX	WECC California	658.68	28.94	6.17	993.89	33.52	4.07
ERCT	ERCOT All	1,181.73	16.70	13.10	1,155.44	19.66	7.59
FRCC	FRCC All	1,176.61	39.24	13.53	1,301.40	36.04	11.91
HIMS	HICC Miscellaneous	1,351.66	72.40	13.80	1,615.98	91.06	17.19
HIOA	HICC Oahu	1,593.35	101.74	21.98	1,621.42	107.94	18.73
MROE	MRO East	1,591.65	23.98	27.04	1,868.23	29.40	30.40
MROW	MRO West	1,628.60	28.80	27.79	2,114.93	61.83	37.41
NEWE	NPCC New England	728.41	75.68	13.86	1,157.44	61.72	14.43
NWPP	WECC Northwest	819.21	15.29	12.50	1,404.55	38.56	18.79
NYCW	NPCC NYC/Westchester	610.67	23.75	2.81	1,118.06	22.47	2.31
NYLI	NPCC Long Island	1,347.99	96.86	12.37	1,336.59	30.78	3.51
NYUP	NPCC Upstate NY	497.92	15.94	6.77	1,347.12	41.08	16.87
RFCE	RFC East	947.42	26.84	14.96	1,628.97	32.94	22.46
RFCM	RFC Michigan	1,659.46	31.41	27.89	1,834.66	35.17	29.15
RFCW	RFC West	1,520.59	18.12	25.13	2,001.76	24.56	32.10
RMPA	WECC Rockies	1,824.51	22.25	27.19	1,756.62	23.54	22.51
SPNO	SPP North	1,815.76	21.01	28.89	2,147.53	26.32	31.82
SPSO	SPP South	1,599.02	23.25	21.79	1,513.73	25.22	15.11
SRMV	SERC Mississippi Valley	1,002.41	19.45	10.65	1,201.66	25.72	7.11
SRMW	SERC Midwest	1,749.75	19.57	28.98	2,192.85	25.04	35.89
SRSO	SERC South	1,325.68	22.27	20.78	1,622.00	27.22	23.50
SRTV	SERC Tennessee Valley	1,357.71	17.28	22.09	1,921.12	25.16	30.61
SRVC	SERC Virginia/Carolina	1,035.87	21.51	17.45	1,677.35	38.55	25.56
U.S.		**1,216.18**	**24.03**	**18.08**	**1,555.48**	**30.83**	**19.76**



This is a representational map; many of the boundaries shown on this map are approximate because they are based on companies, not on strictly geographical boundaries.

http://www.epa.gov/egrid