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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

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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February 23, 2011

Ventura County Water Works-District 1
7150 Walnut Canyon Road
Post Office Box 250
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Lab ID : SP 1101704-001
Customer ID : 2-14617

Sampled On : February 16, 2011
Sampled By : Javier Ambriz
Received On : February 17, 2011
Matrix : Non Potable Water

Description : MWTP-Reclaimed Water
Project : Ventura County Water Works

General Irrigation Suitability Analysis

Test Description	Result				Graphical Results Presentation				
Cations	mg/L	Meq/L	% Meq	Lbs/AF	Good	Possible Problem	Moderate Problem	Increasing Problem	Severe Problem
Calcium	36	1.8	21	98	**				
Magnesium	13	1.1	13	35	**				
Potassium	16	0.41	5	44	**				
Sodium	119	5.2	61	320					
Anions									
Carbonate	< 10	0	0	0					
Bicarbonate	150	2.5	28	410	**				
Sulfate	96	2	23	260	**				
Chloride	146	4.1	47	400					
Nitrate	5.4	0.087	1	15					
Fluoride	0.6	0.032	0	2					
Minor Elements									
Boron	0.40			1.1					
Copper	< 0.01			0.00					
Iron	< 0.05			0.00					
Manganese	< 0.01			0.00					
Zinc	0.060			0.16					
TDS by Summation	582			1600					
Other									
pH	7.7			units					
E. C.	920			umhos/cm					
SAR	4.3								
Crop Suitability									
No Amendments	Fairly		Poor						
With Amendments	Fairly		Poor						
Amendments									
Gypsum Requirement	0.6			Tons/AF	Do not apply if Sulfuric Acid amendment is applied.				
Sulfuric Acid (98%)	8.4			oz/1000Gal	Or 20 oz/1000Gal of urea Sulfuric Acid (15/49).				
Leaching Requirement	7			%					

Good Problem Indicates physical conditions and/or phenological and amendment requirements.

Note: Color coded bar graphs have been used to provide you with 'AT-A-GLANCE' interpretations.

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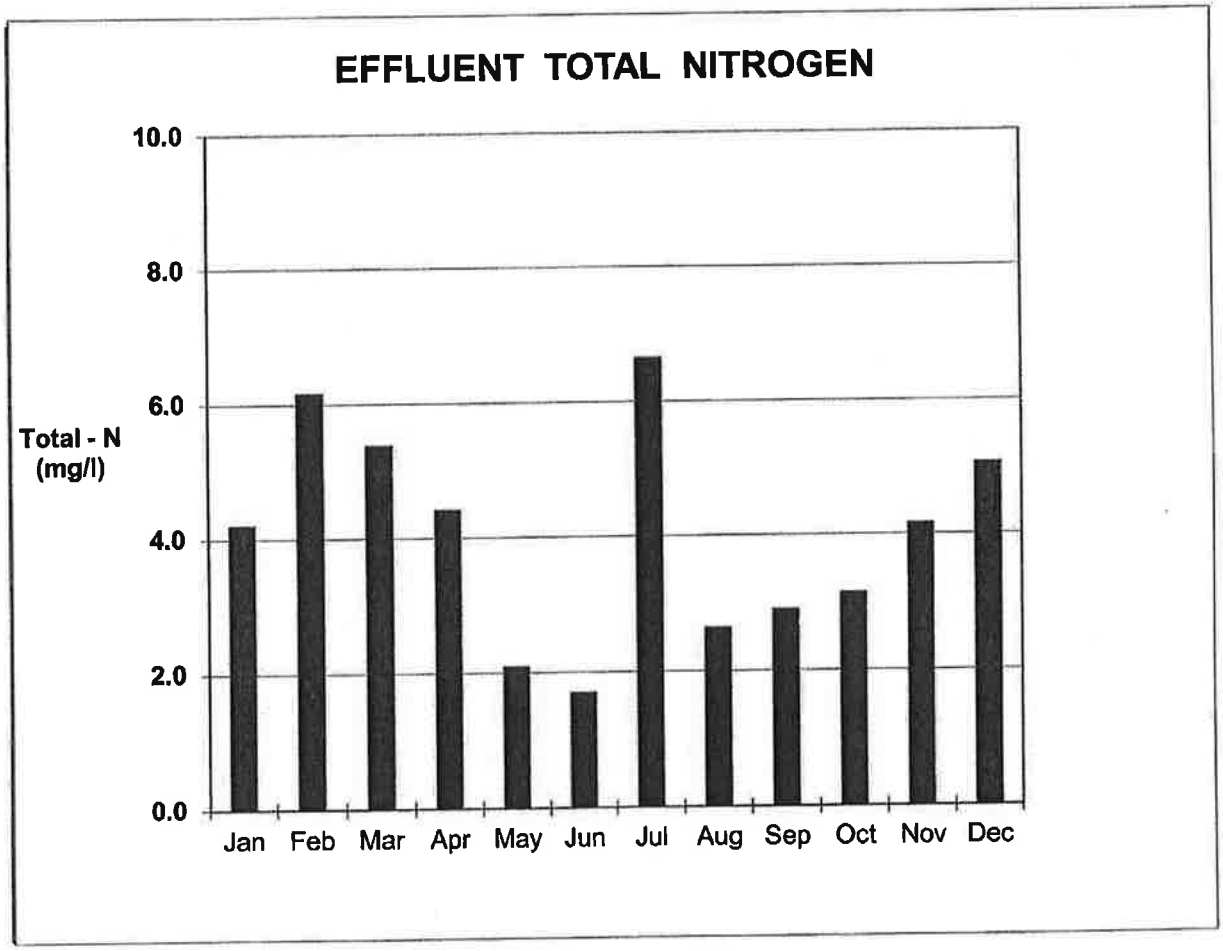
Figure XVII

MOORPARK WASTEWATER TREATMENT PLANT

2012 ANNUAL REPORT



Month	Total - N (mg/L)	Month	Total - N (mg/L)
Jan	4.21	Jul	6.67
Feb	6.17	Aug	2.64
Mar	5.39	Sep	2.91
Apr	4.43	Oct	3.15
May	2.10	Nov	4.17
Jun	1.71	Dec	5.07

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.

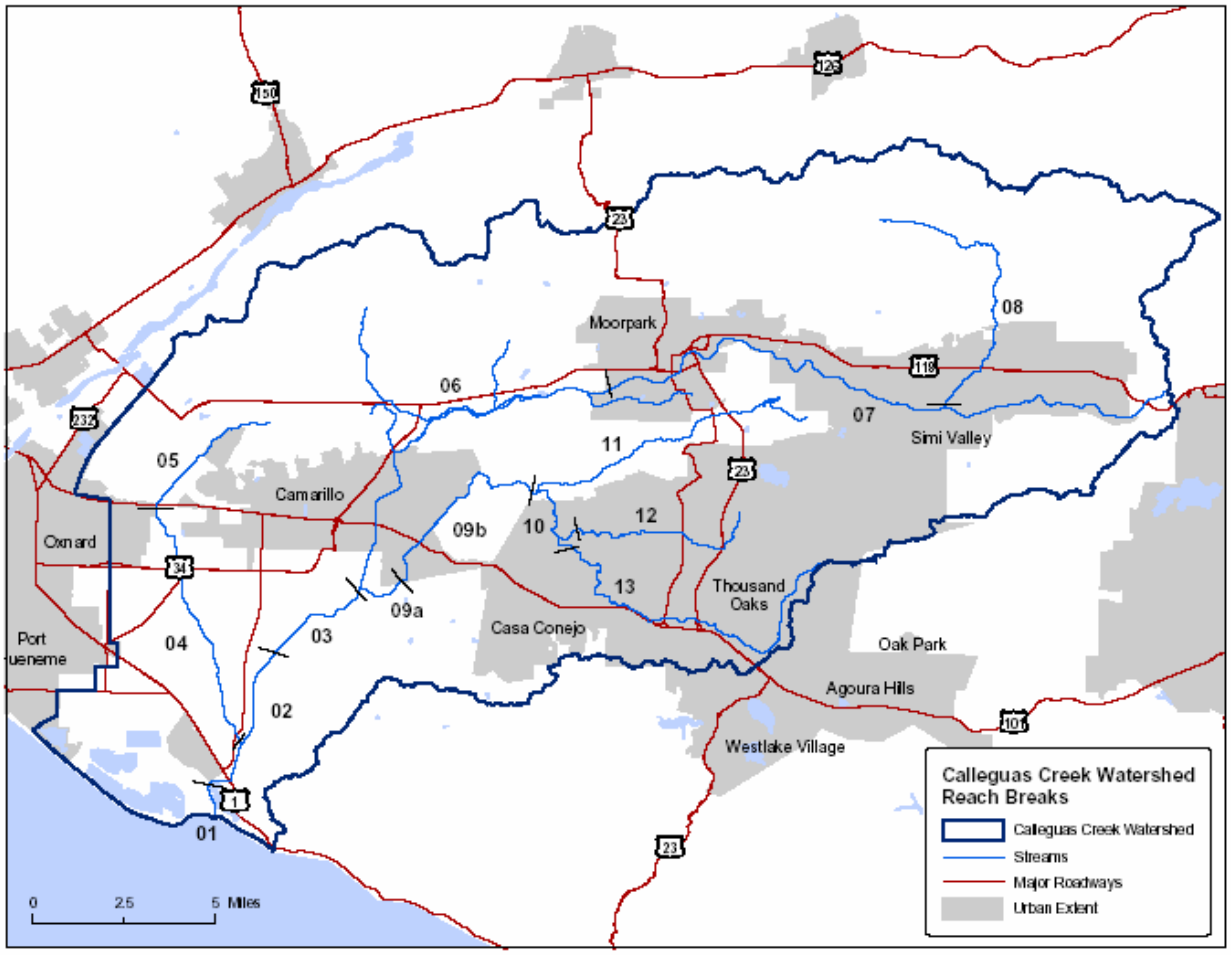

Figure 1. Calleguas Creek Watershed Reaches

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.

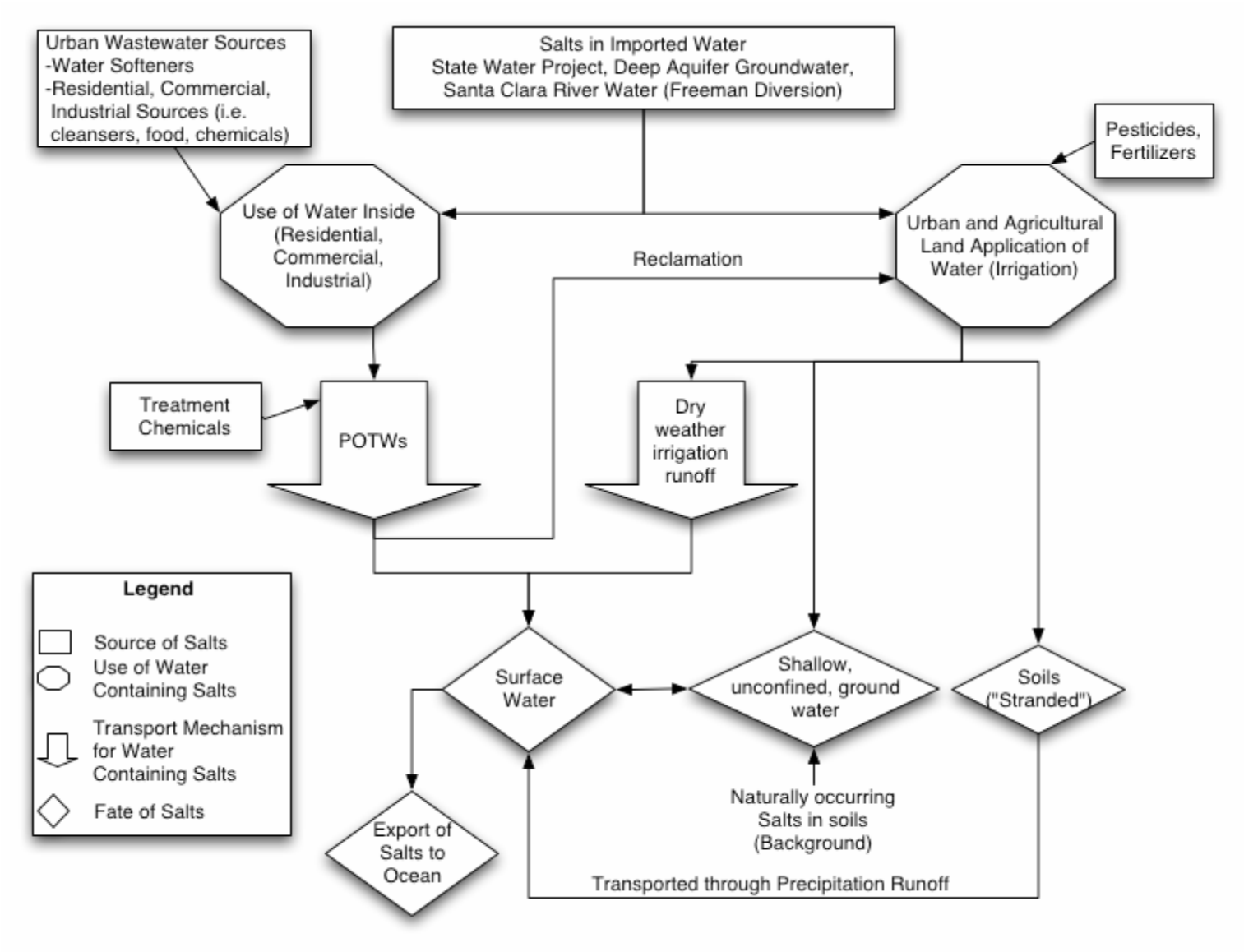

Figure 2: A Generalized Conceptual Model of salts flow for the Calleguas Creek Watershed.

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.

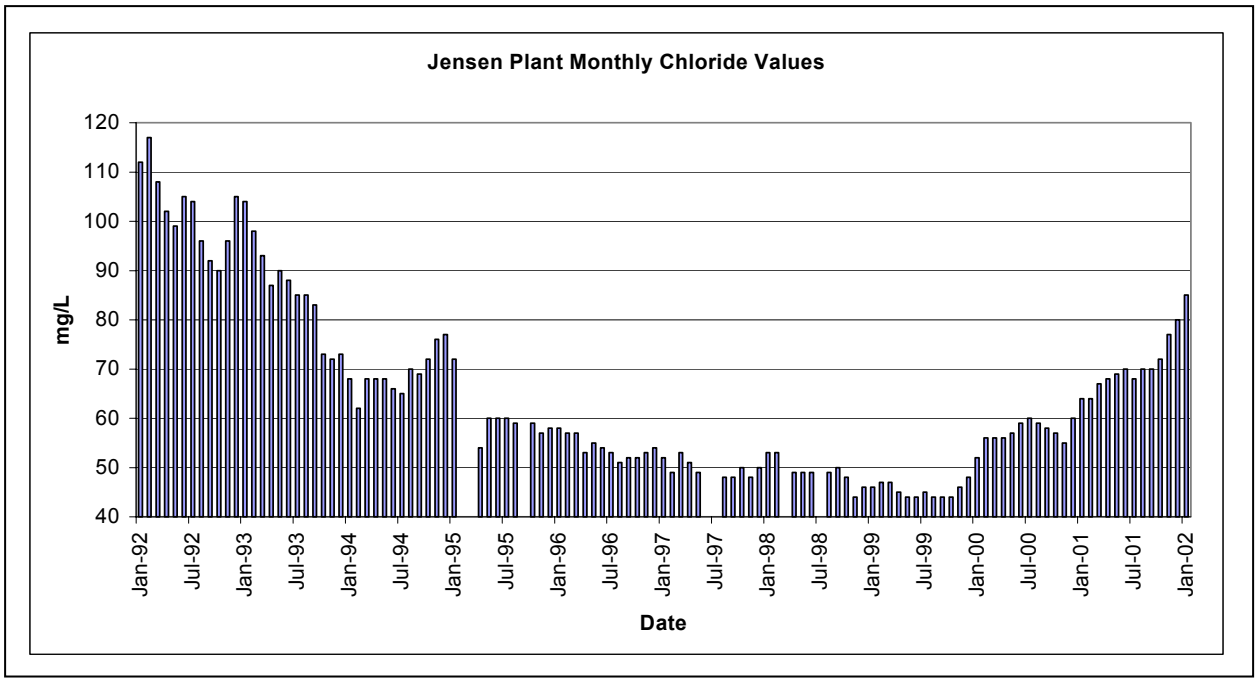

Figure 3. Imported Water Chloride History

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.

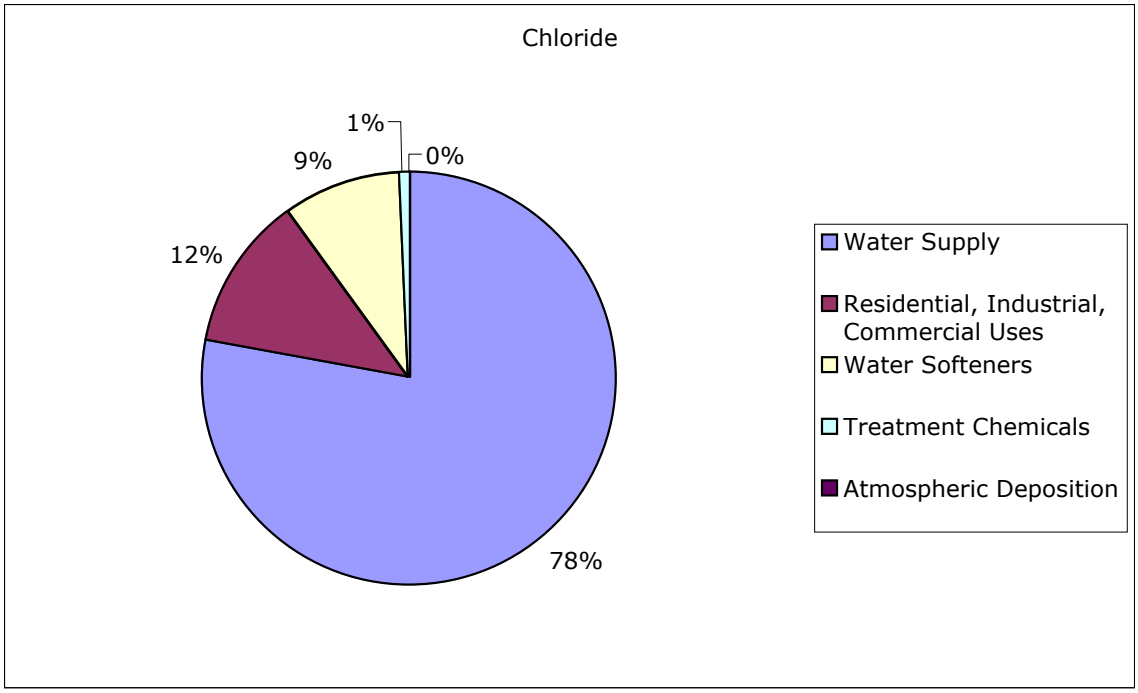

Figure 4. Sources of Total Chloride Load to Watershed of 97,000 lbs/day

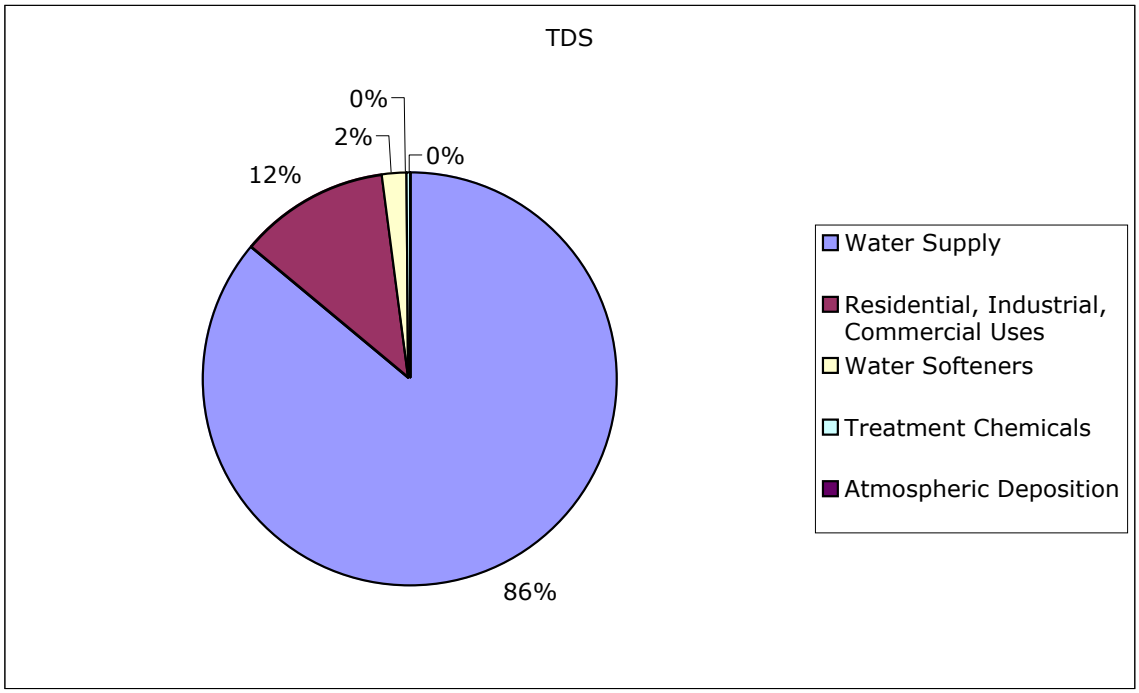

Figure 5. Sources of Total TDS Load to Watershed of 670,000 lbs/day

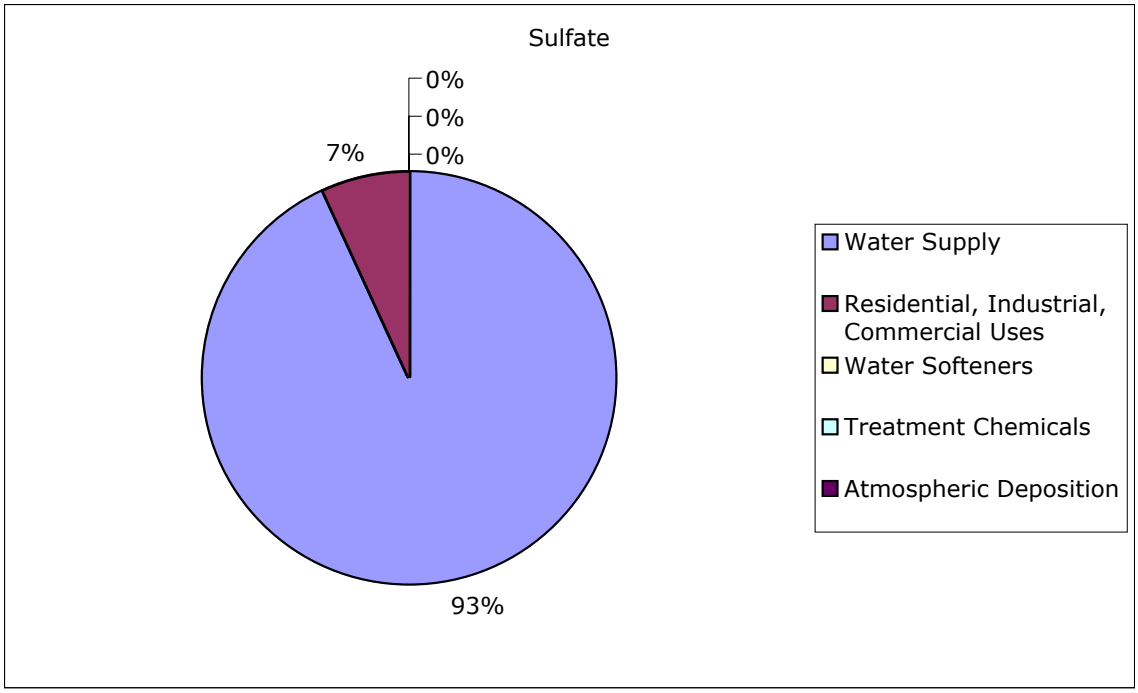

Figure 6. Sources of Total Sulfate Load to Watershed of 207,000 lbs/day

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.

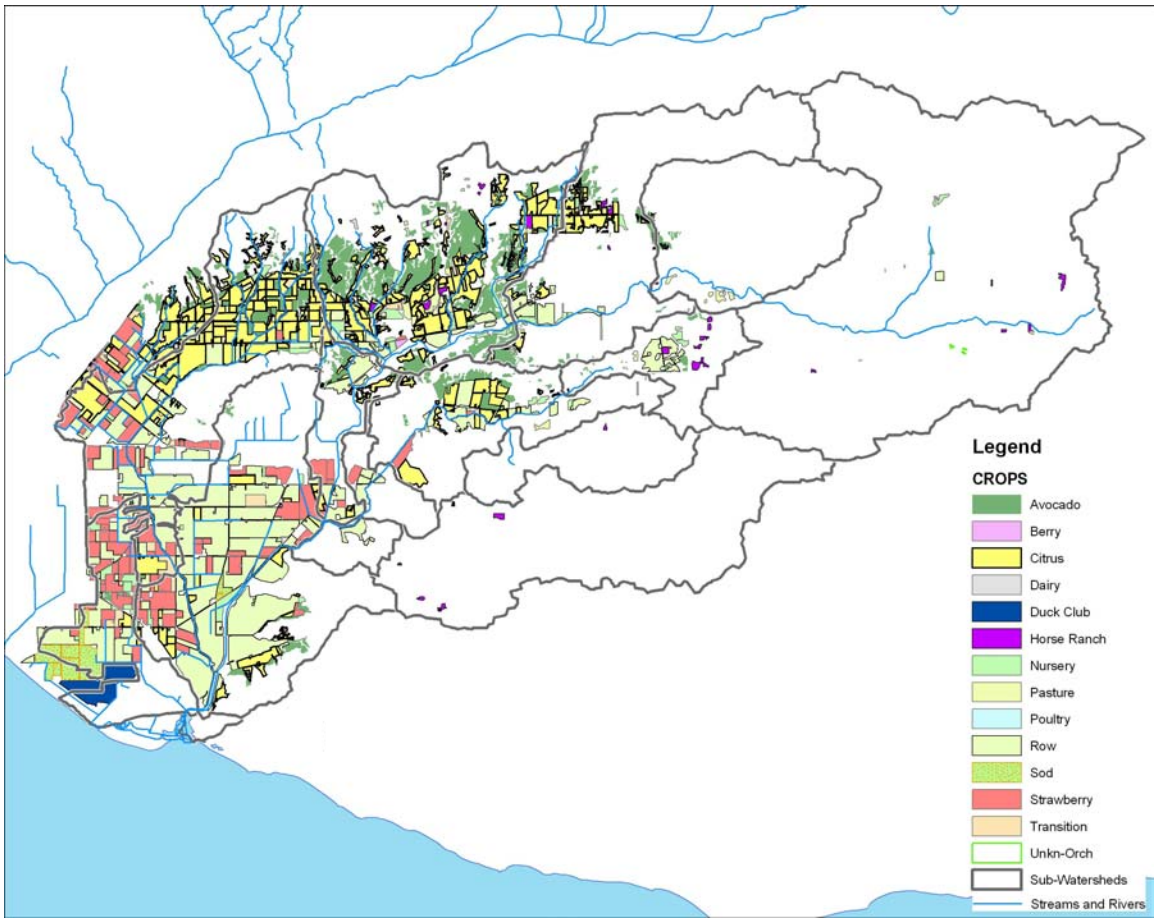

Figure 7. Crops Grown in Calleguas Creek Watershed

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.

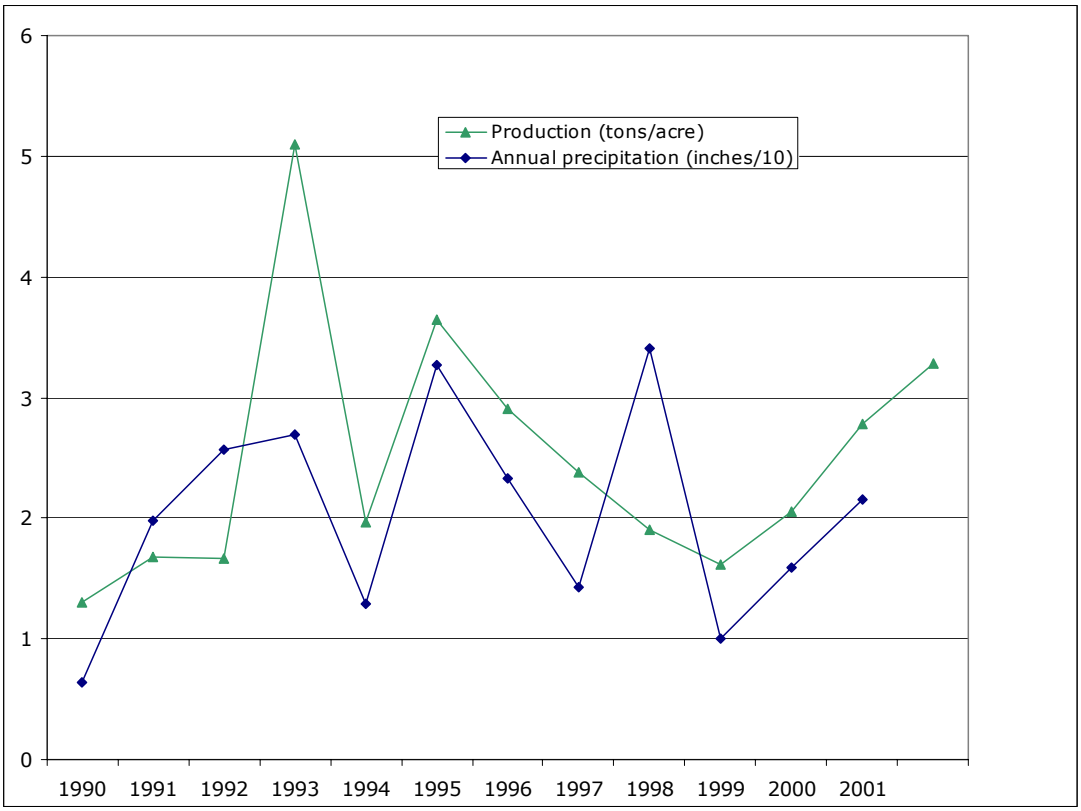

Figure 8. Ventura County Avocado Production and Annual Precipitation

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

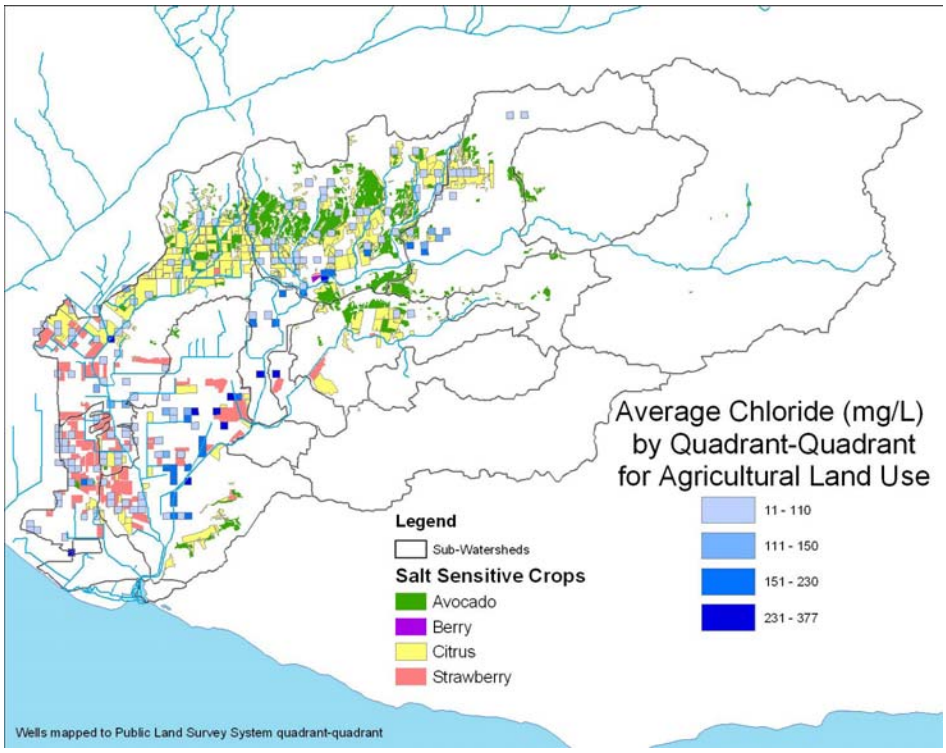

Figure 9. Average groundwater chloride levels in Calleguas Creek Watershed

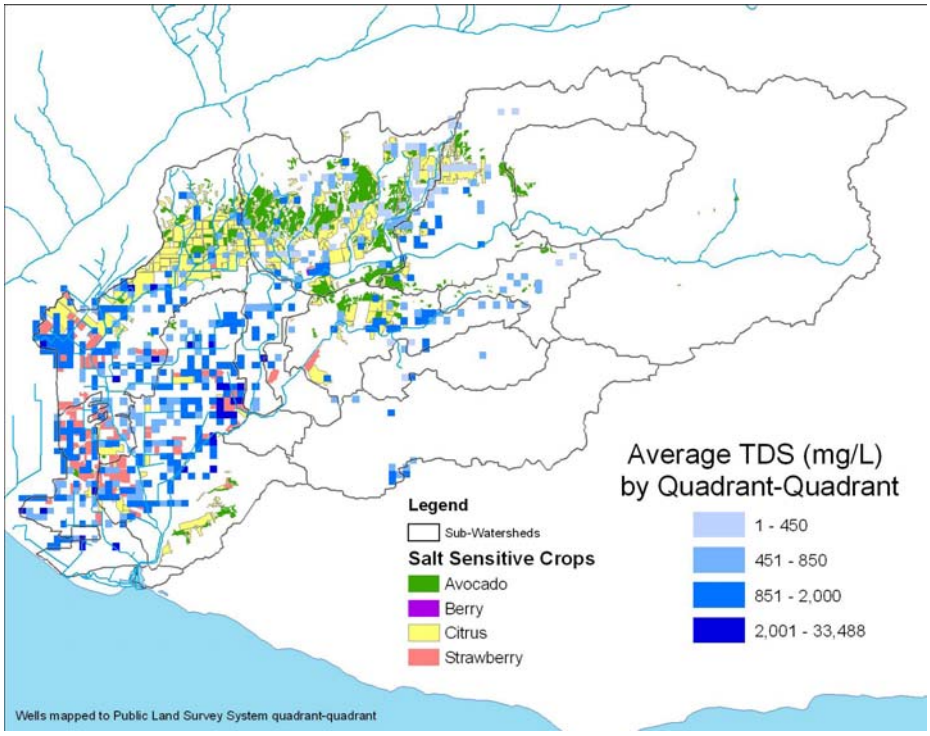

Figure 10.Average groundwater TDS levels in Calleguas Creek Watershed

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.

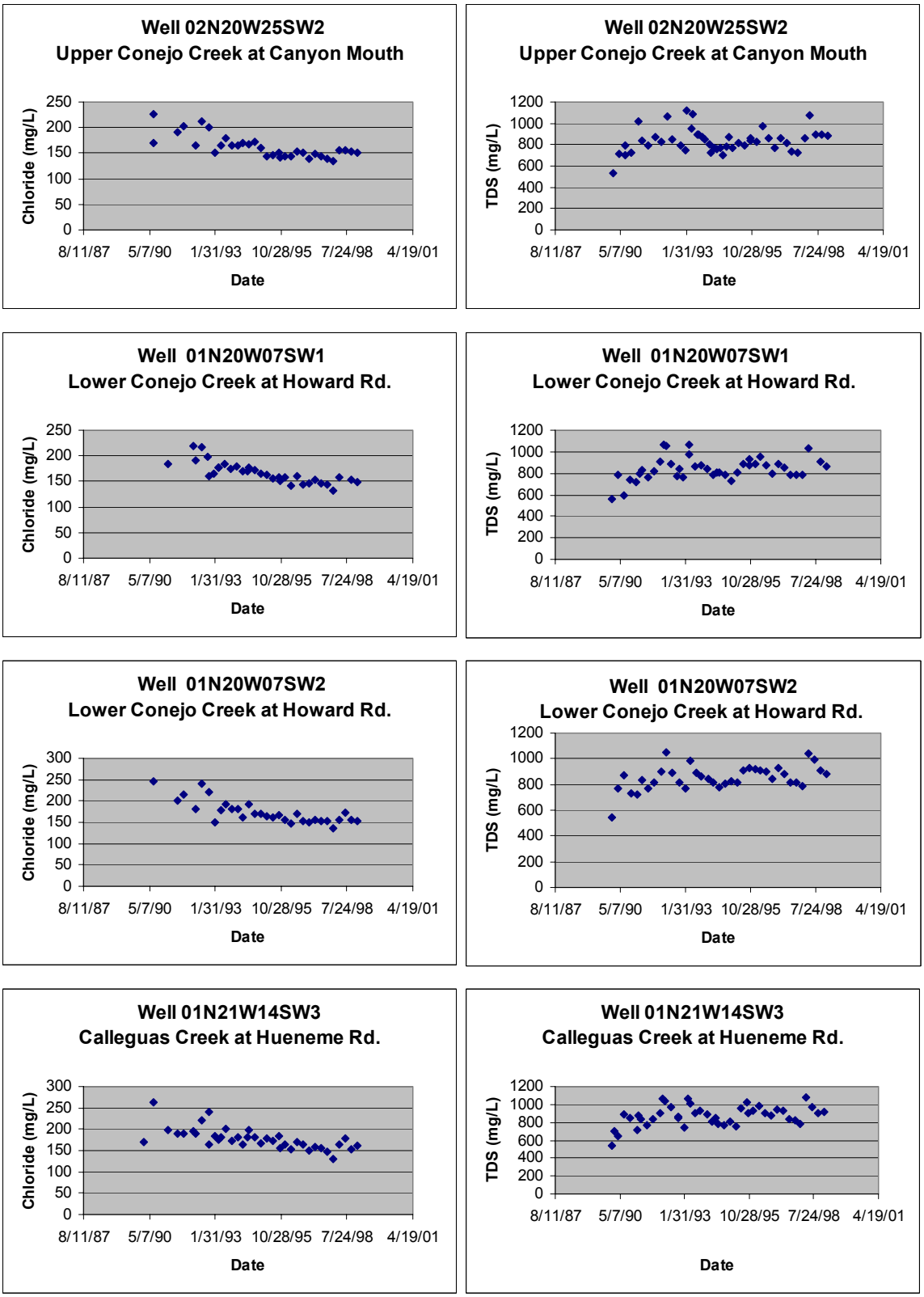

Figure 11. Groundwater quality data from wells near Conejo Creek and Lower Calleguas Creek

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.

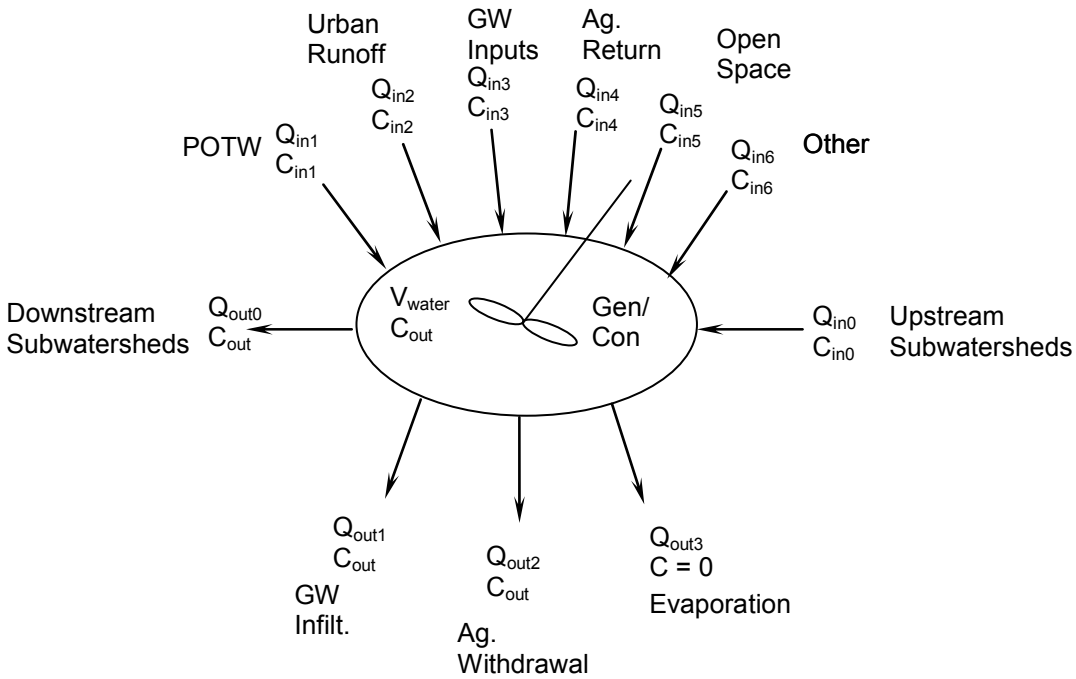

Figure 12: Schematic of Inputs and Outputs for a General Computational Element used in the CCMS Mass Balance Model to Estimate Water Flow and Quality within Surface Water Reaches.

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.

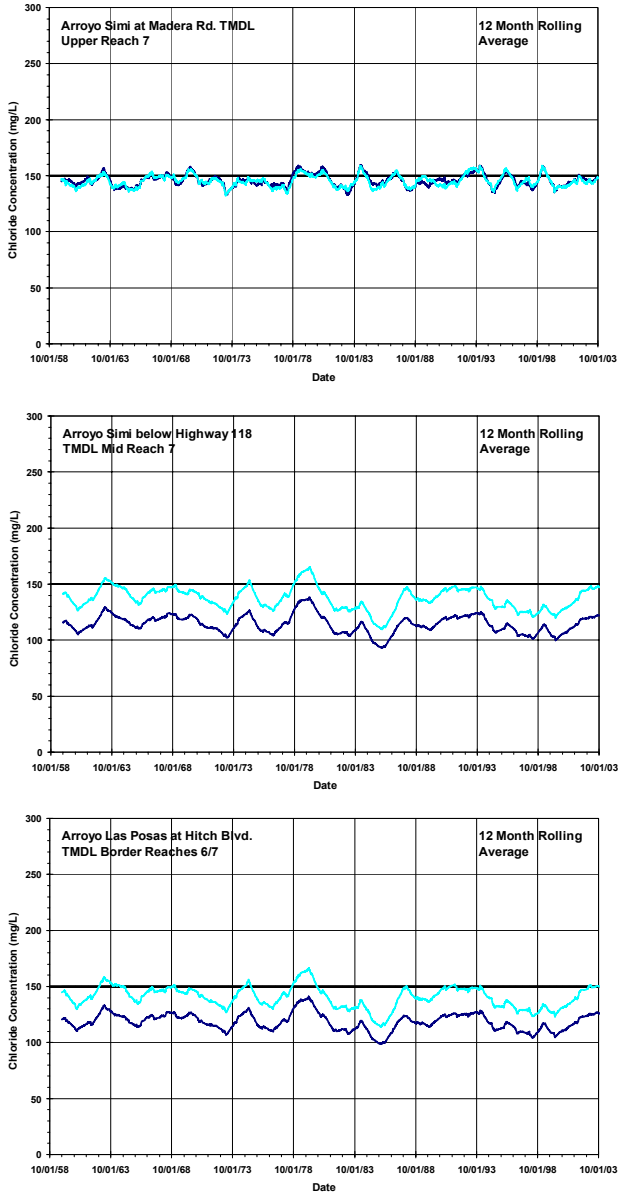

Figure 13: Current (light line) and Estimated (dark line) Chloride 12-month Rolling Average Concentrations in Arroyo Simi/Las Posas With No Future SRW and Incentives/Disincentives to Reduce SRW Use.

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.

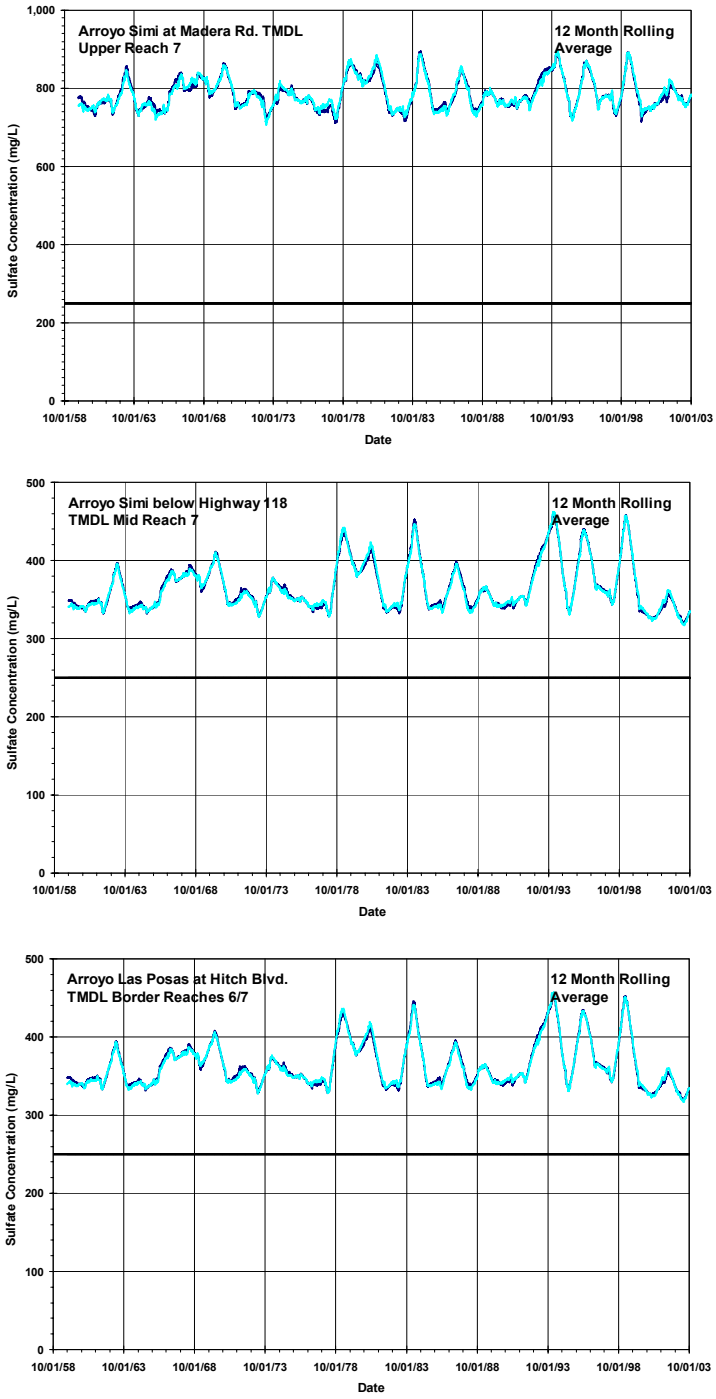

Figure 14: Current (light line) and Estimated (dark line) Sulfate 12-month Rolling Average Concentrations in Arroyo Simi/Las Posas With No Future SRW and Incentives/Disincentives to Reduce SRW Use.

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.

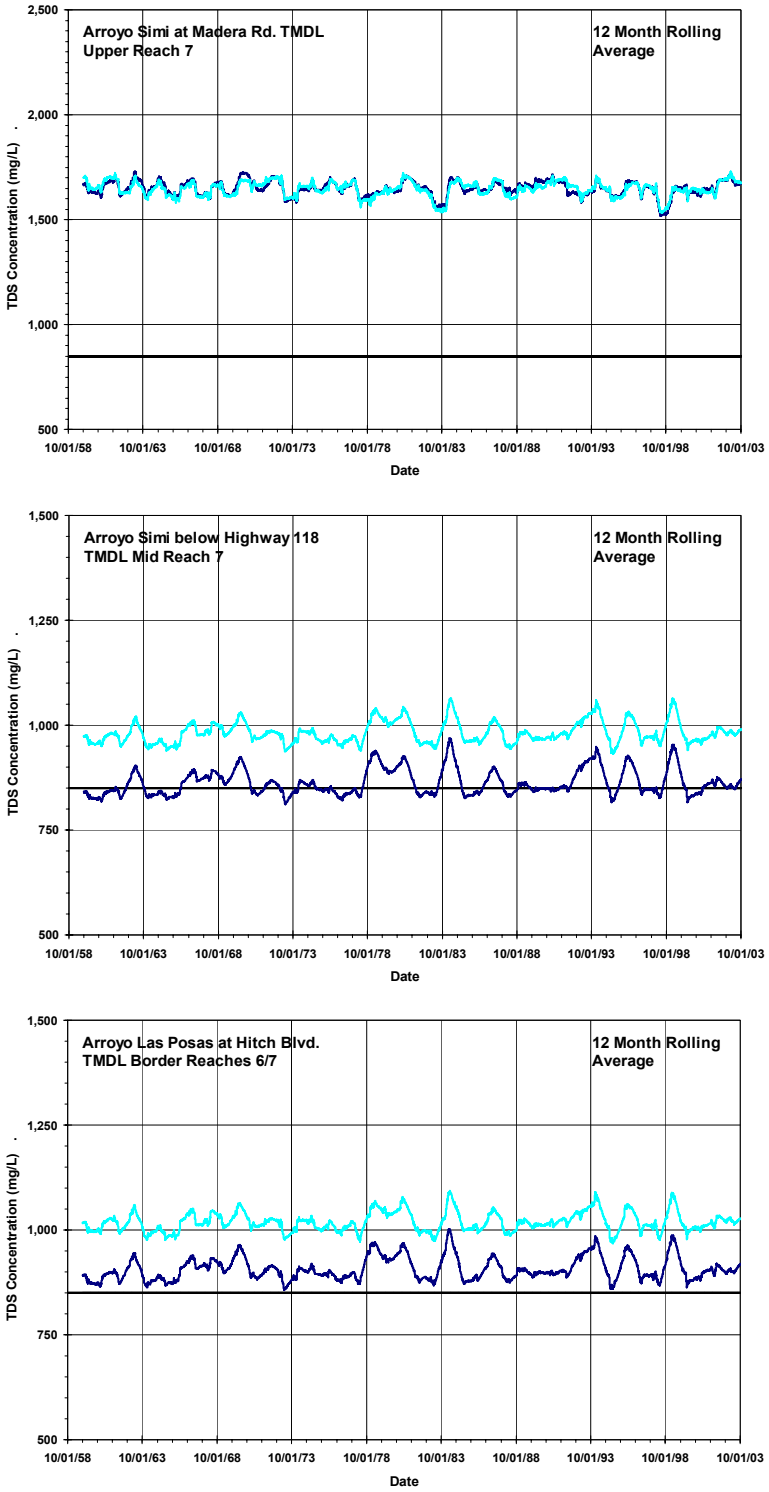

Figure 15: Current (light line) and Estimated (dark line) TDS 12-month Rolling Average Concentrations in Arroyo Simi/Las Posas With No Future SRW, and Incentives/Disincentives to Reduce SRW Use.

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.

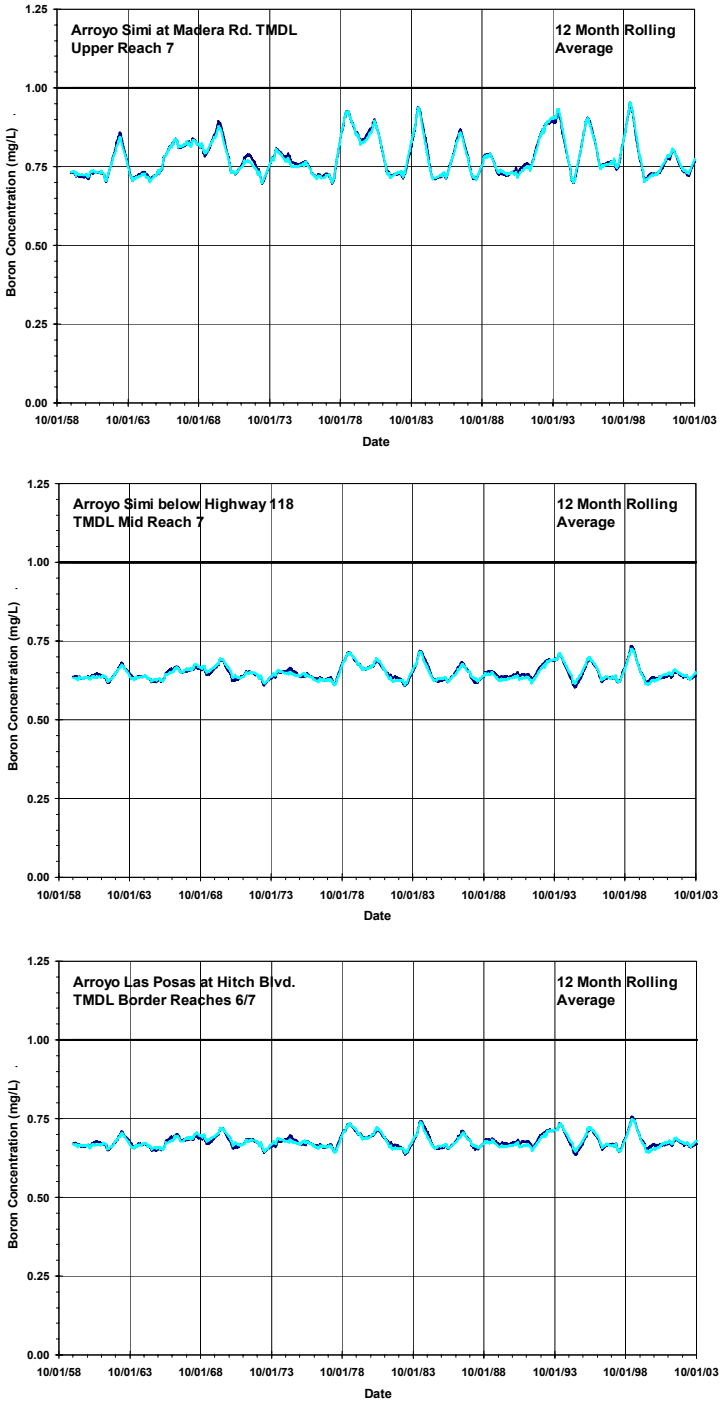

Figure 16: Current (light line) and Estimated (dark line) Boron 12-month Rolling Average Concentrations in Arroyo Simi/Las Posas With No Future SRW, and Incentives/Disincentives to Reduce SRW Use.

Boron consistently meets the 12 month rolling average objective even without implementation of the projects. The projects have no significant impact on boron concentrations.

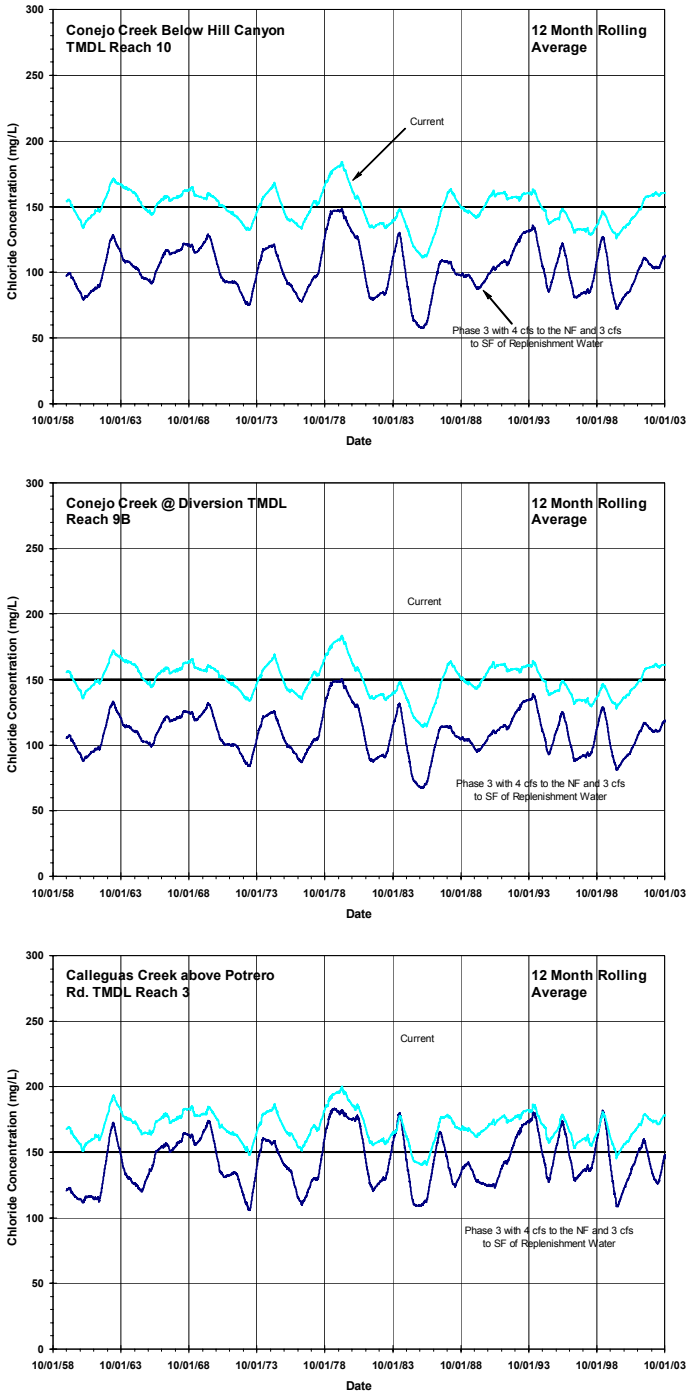

Figure 17: Current and Estimated Chloride 12-month Rolling Average Concentrations in Lower Watershed After Implementing Phase 3 of the RWRMP and supplying 4 cfs to the NF and 3 cfs to the SF Arroyo Conejo of Replenishment Water.

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.

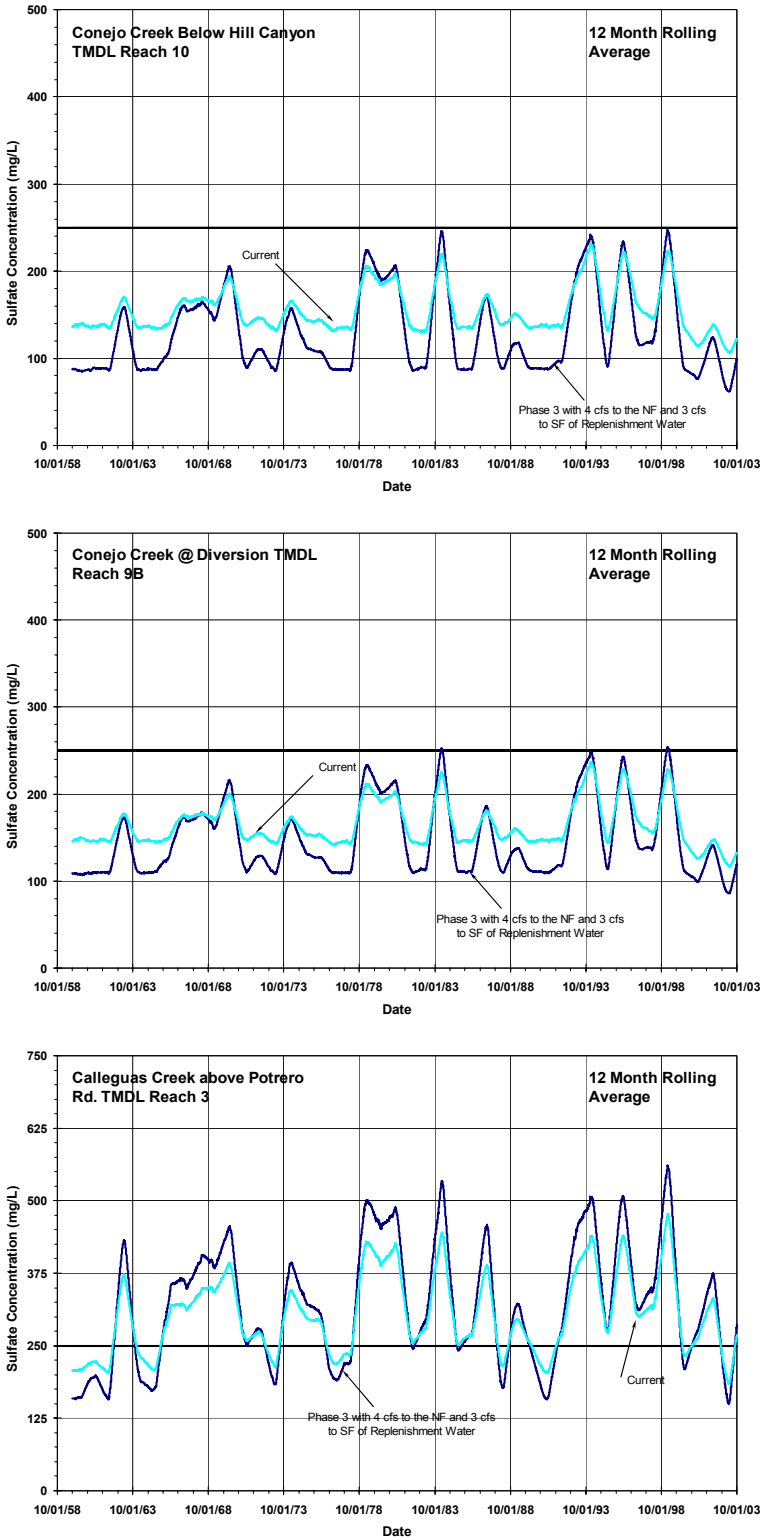

Figure 18: Current and Estimated Sulfate 12-month Rolling Average Concentrations in Lower Watershed After Implementing Phase 3 of the RWRMP and supplying 4 cfs to the NF and 3 cfs to the SF Arroyo Conejo of Replenishment Water.

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.

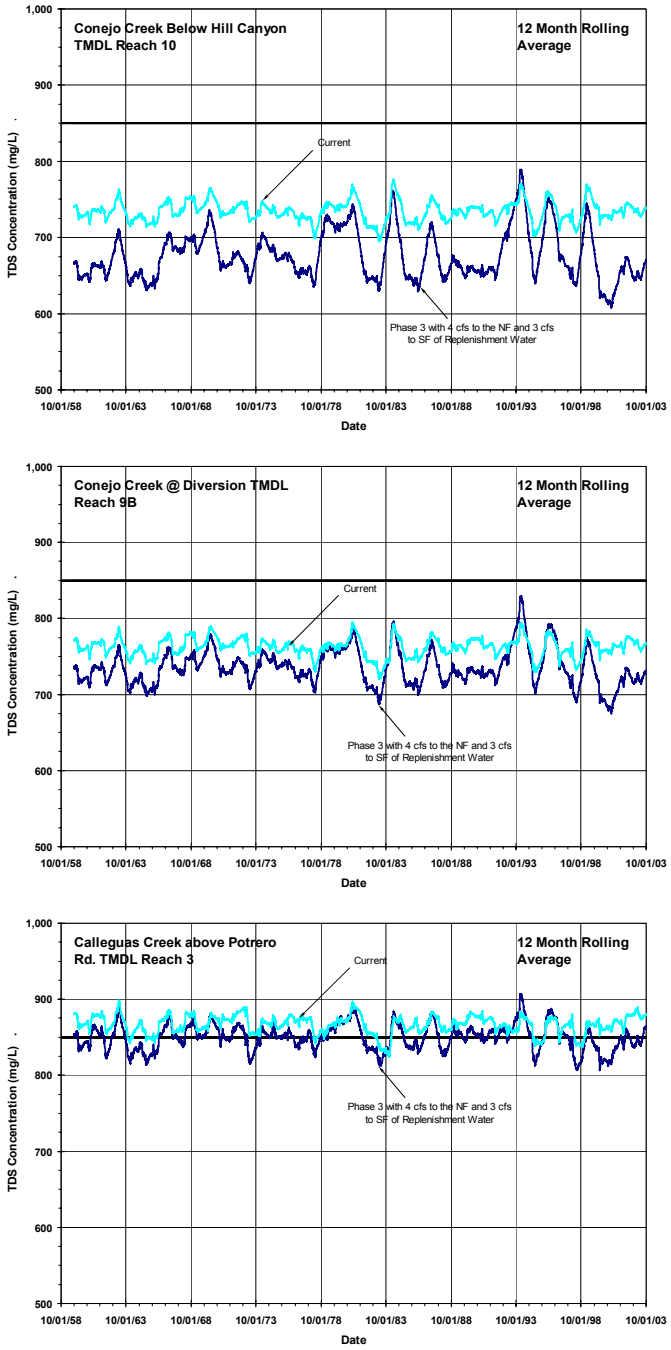

Figure 19: Current and Estimated TDS 12-month Rolling Average Concentrations in Lower Watershed After Implementing Phase 3 of the RWRMP and supplying 4 cfs to the NF and 3 cfs to the SF Arroyo Conejo of Replenishment Water.

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.

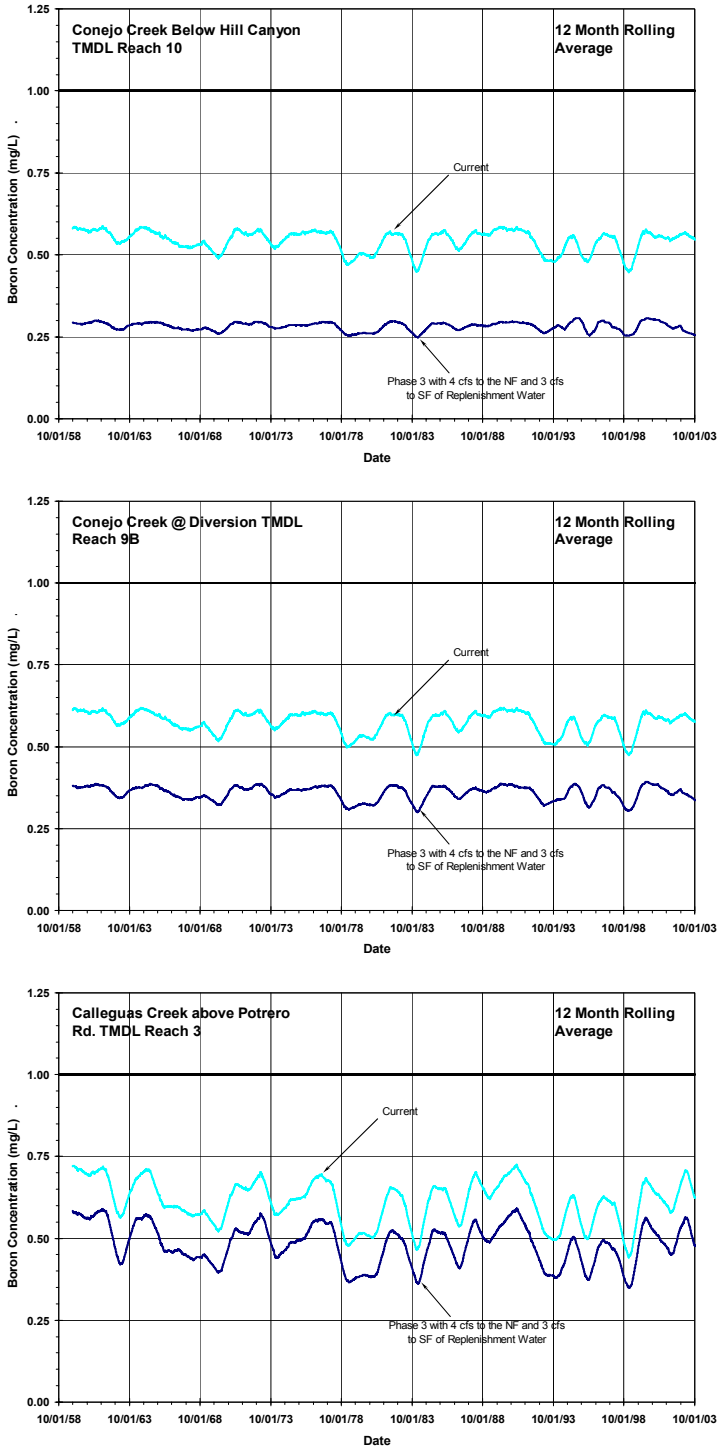

Figure 20: Current and Estimated Boron 12-month Rolling Average Concentrations in Lower Watershed After Implementing Phase 3 of the RWRMP and supplying 4 cfs to the NF and 3 cfs to the SF Arroyo Conejo of Replenishment Water.

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.

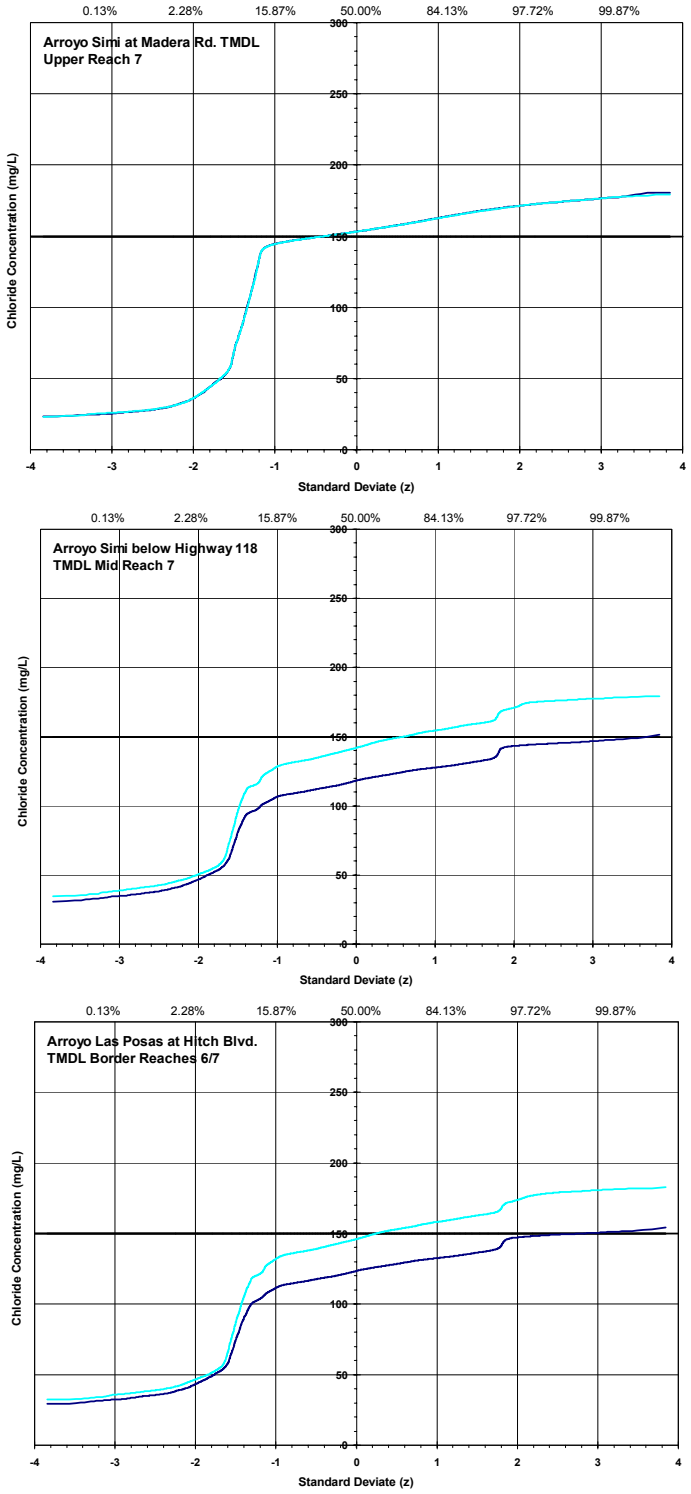

Figure 21: Current (light line) and Estimated (dark line) Probability Distributions of Daily Average Chloride Concentrations in Arroyo Simi/Las Posas with No Future SRW, and Incentives/Disincentives to Reduce SRW Use.

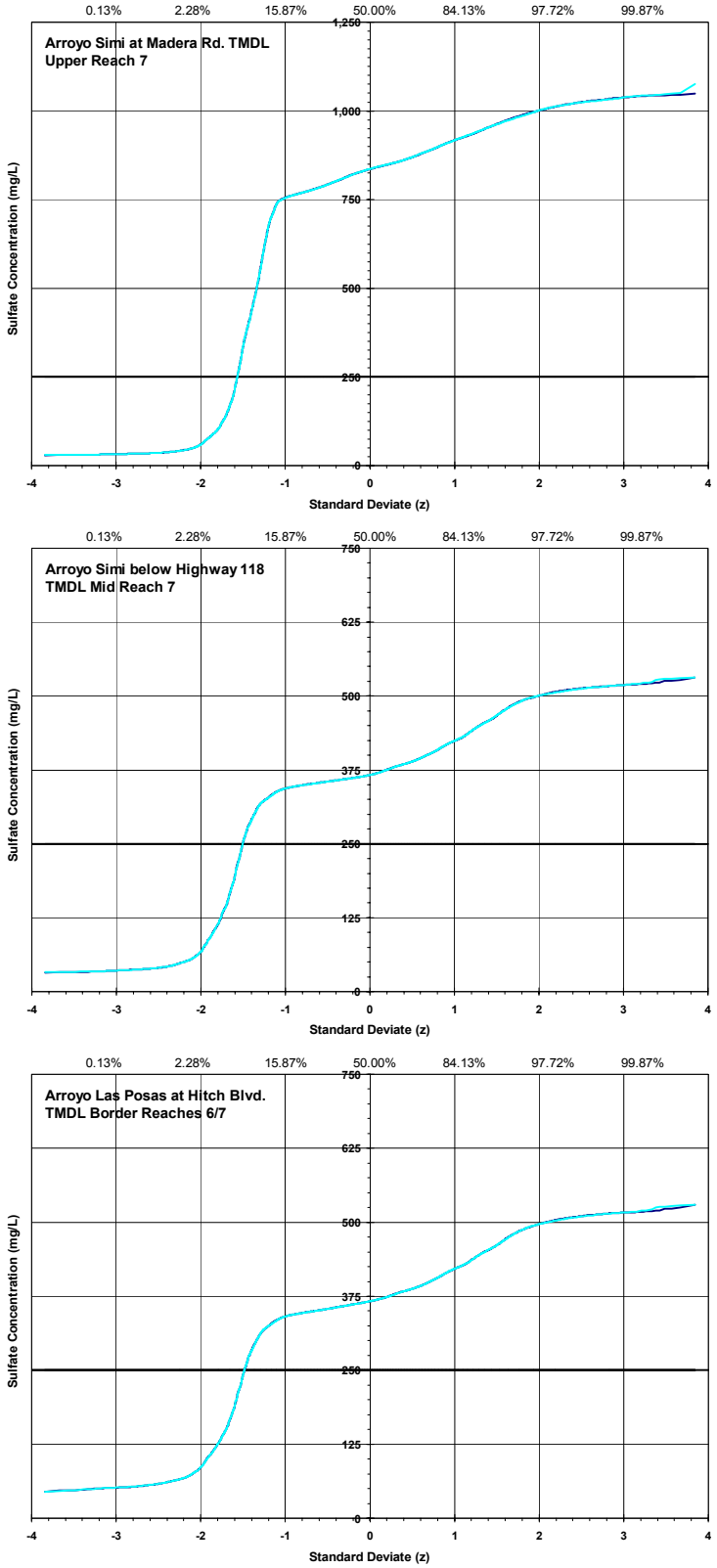

Figure 22: Current (light line) and Estimated (dark line) Probability Distributions of Daily Average Sulfate Concentrations in Arroyo Simi/Las Posas with No Future SRW and Incentives/Disincentives to Reduce SRW Use.

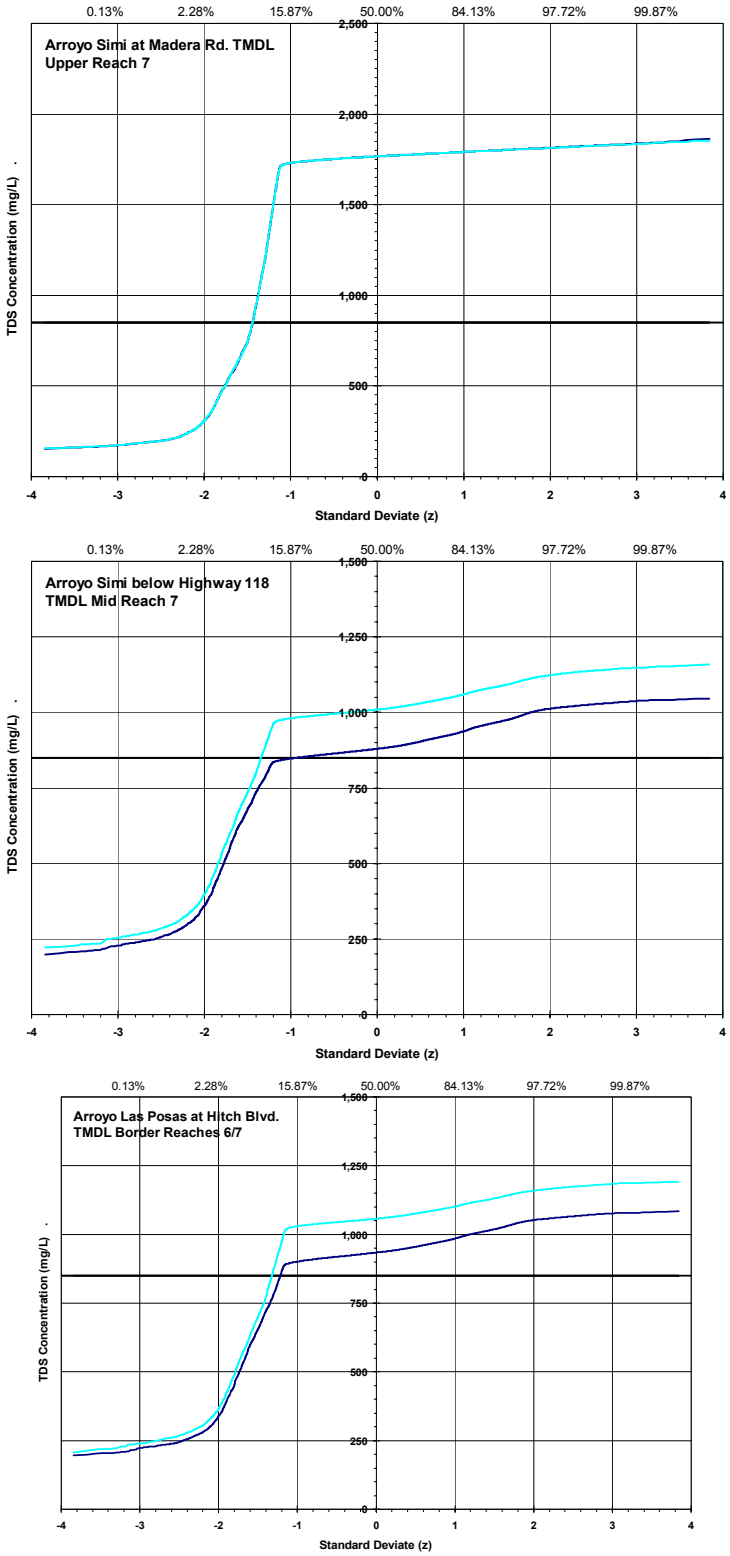

Figure 23: Current (light line) and Estimated (dark line) Probability Distributions of Daily Average TDS Concentrations in Arroyo Simi/Las Posas with No Future SRW and Incentives/Disincentives to Reduce SRW Use.

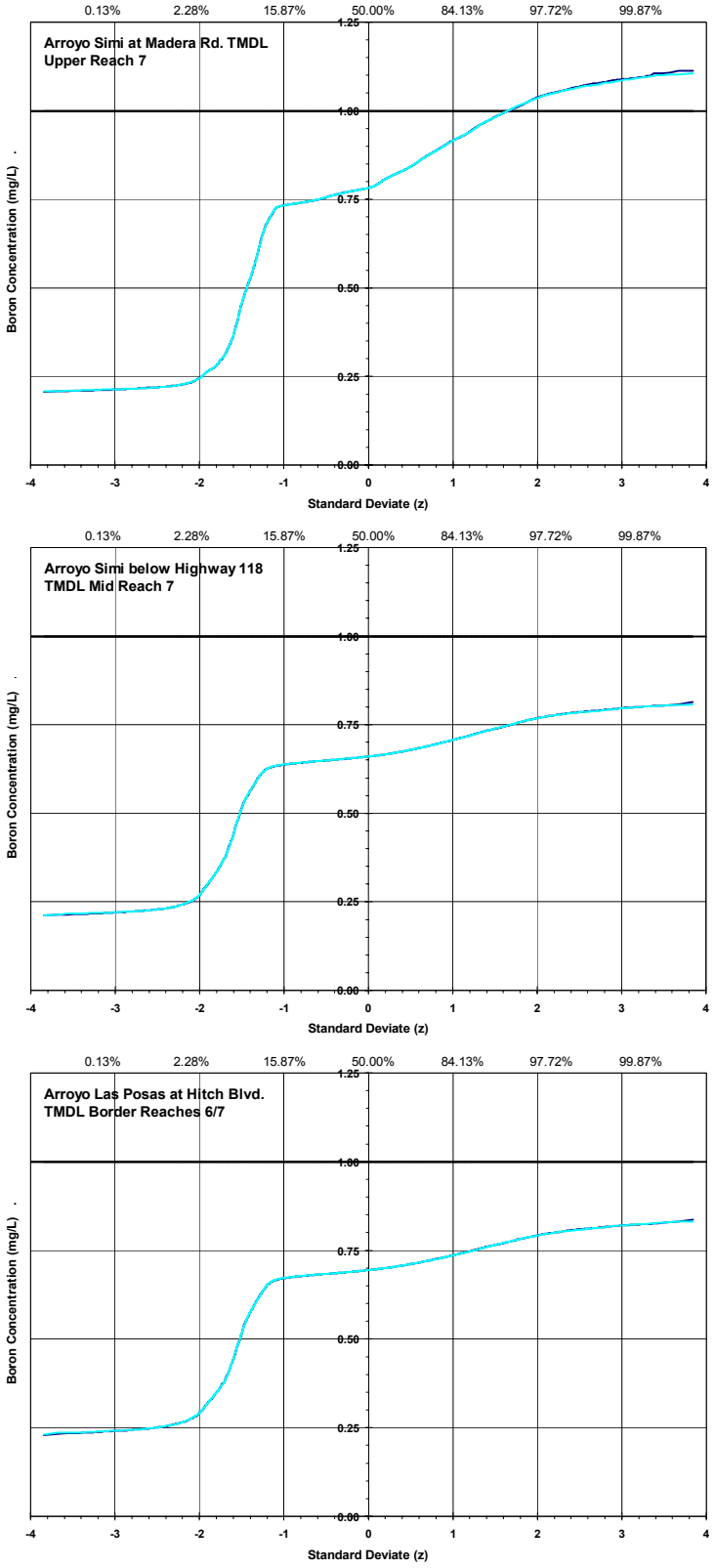

Figure 24: Current (light line) and Estimated (dark line) Probability Distributions of Daily Average Boron Concentrations in Arroyo Simi/Las Posas with No Future SRW and Incentives/Disincentives to Reduce SRW Use.

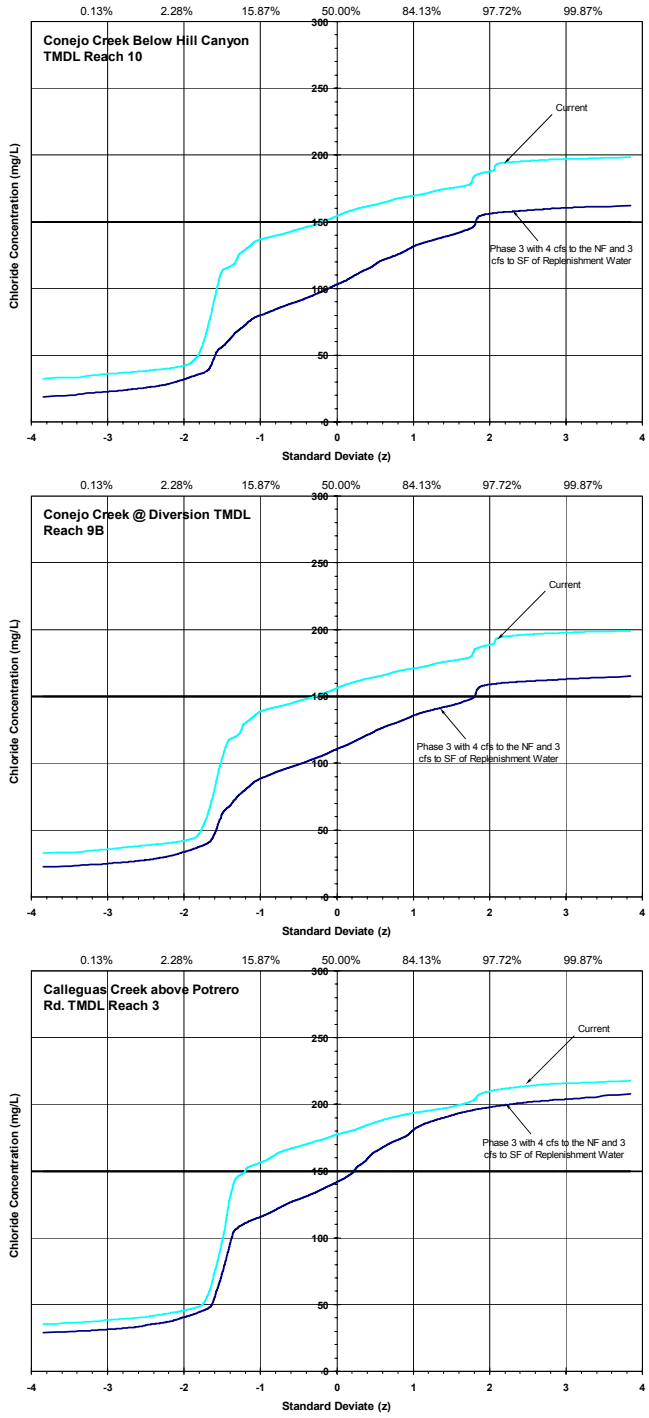

Figure 25: Current and Estimated Chloride Probability Distribution of Daily Average Concentrations in Lower Watershed After Implementing Phase 3 of the RWRMP and supplying 4 cfs to the NF and 3 cfs to the SF Arroyo Conejo of Replenishment Water.

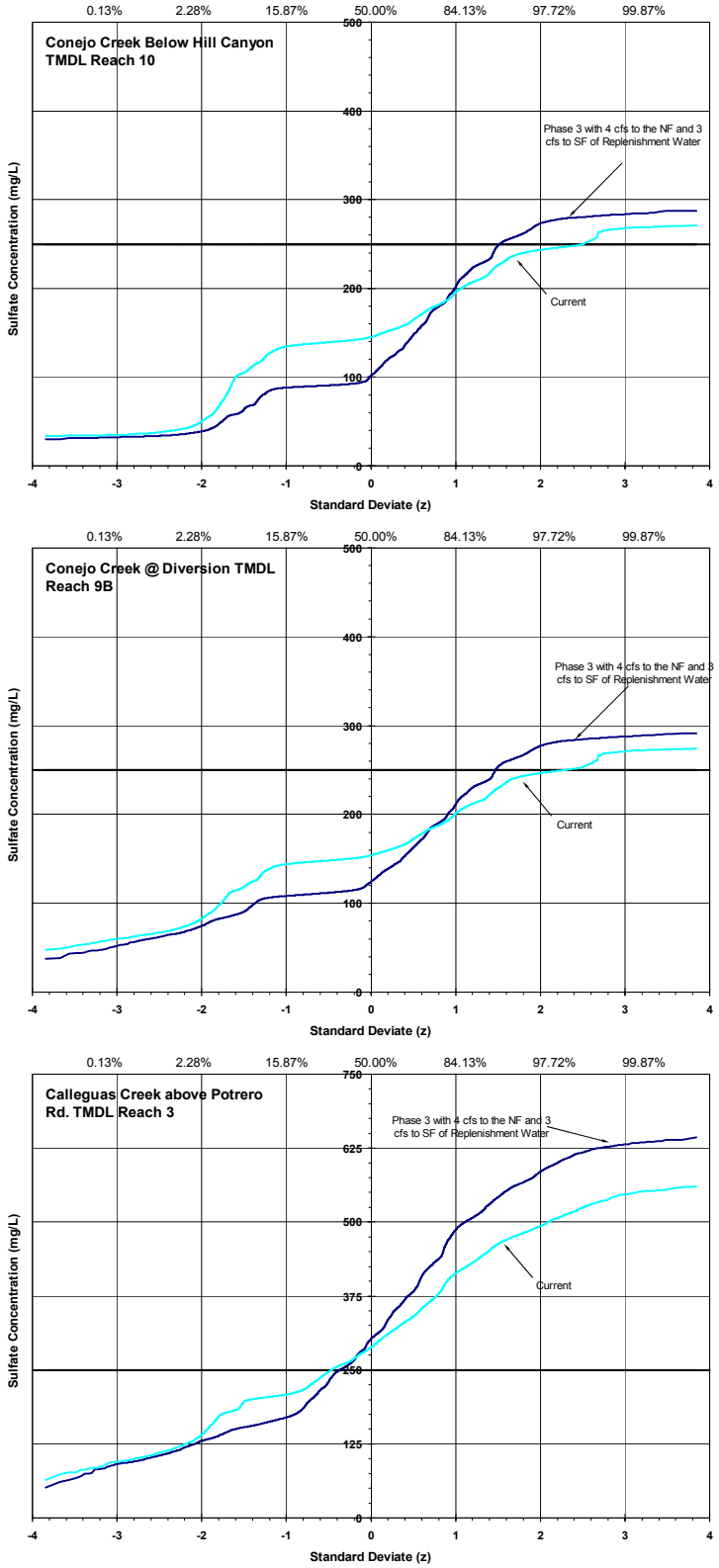

Figure 26: Current and Estimated Sulfate Probability Distribution of Daily Average Concentrations in Lower Watershed After Implementing Phase 3 of the RWRMP and supplying 4 cfs to the NF and 3 cfs to the SF Arroyo Conejo of Replenishment Water.

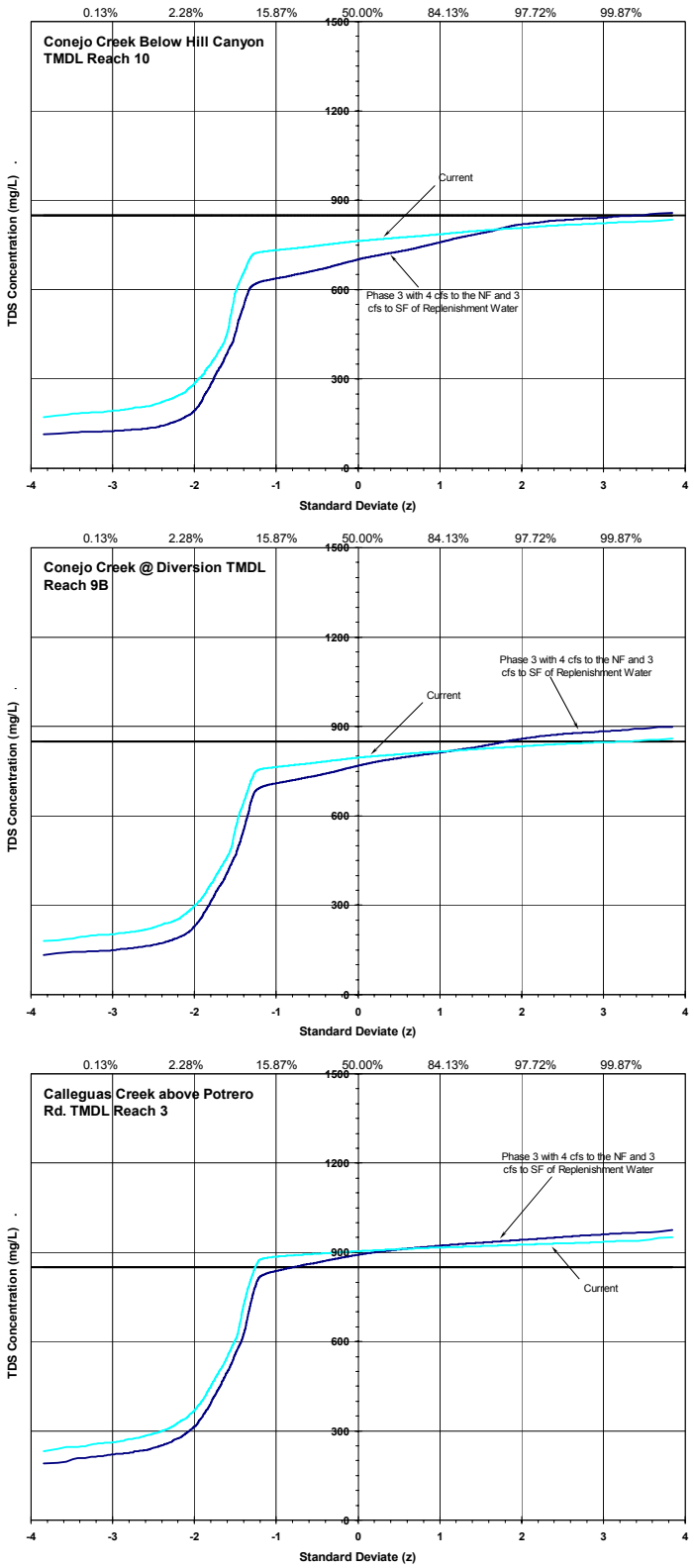

Figure 27: Current and Estimated TDS Probability Distribution of Daily Average Concentrations in Lower Watershed After Implementing Phase 3 of the RWRMP and supplying 4 cfs to the NF and 3 cfs to the SF Arroyo Conejo of Replenishment Water.

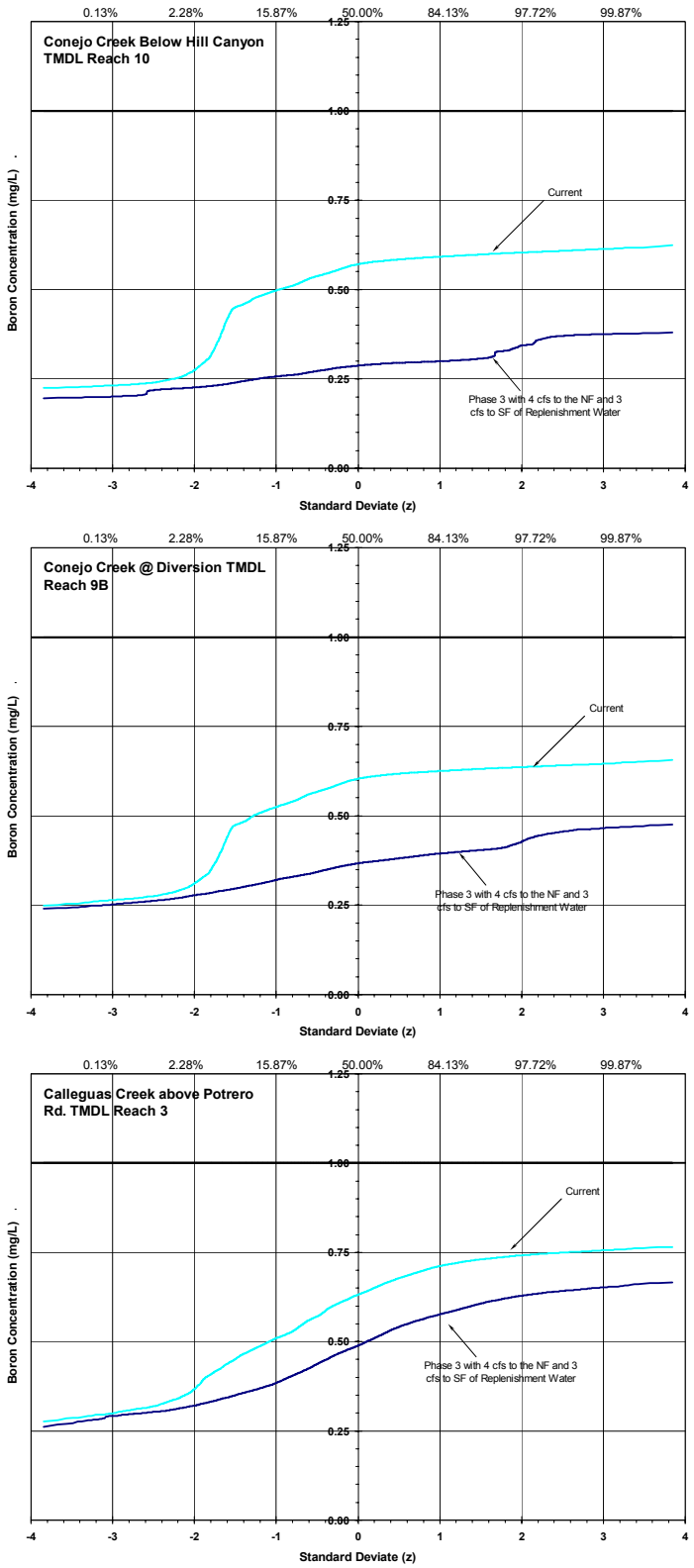

Figure 28: Current and Estimated Boron Probability Distribution of Daily Average Concentrations in Lower Watershed After Implementing Phase 3 of the RWRMP and supplying 4 cfs to the NF and 3 cfs to the SF Arroyo Conejo of Replenishment Water.

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.

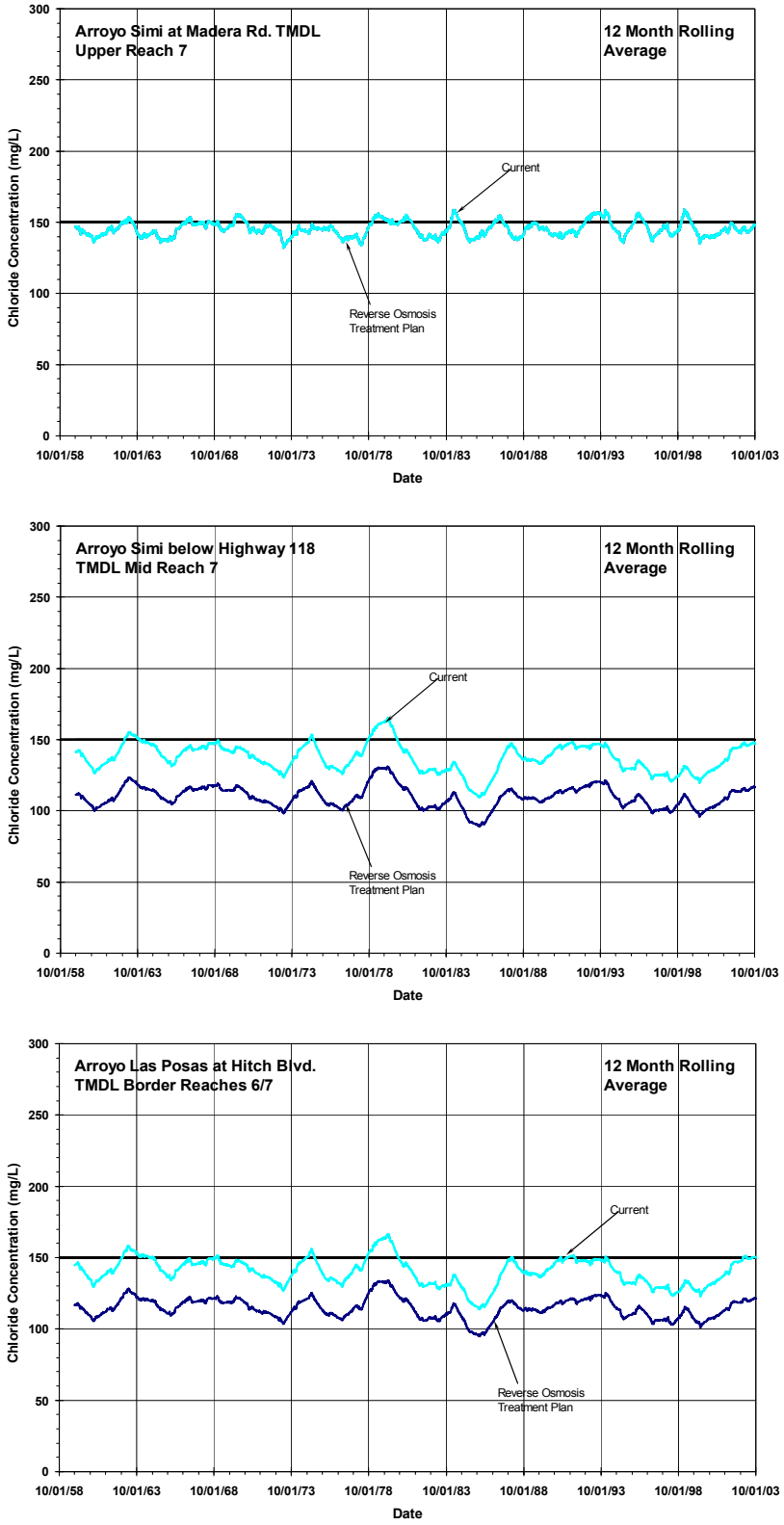

Figure 29: Current and Estimated 12-month Rolling Average Chloride Concentrations in Arroyo Simi for the Reverse Osmosis Treatment Plan.

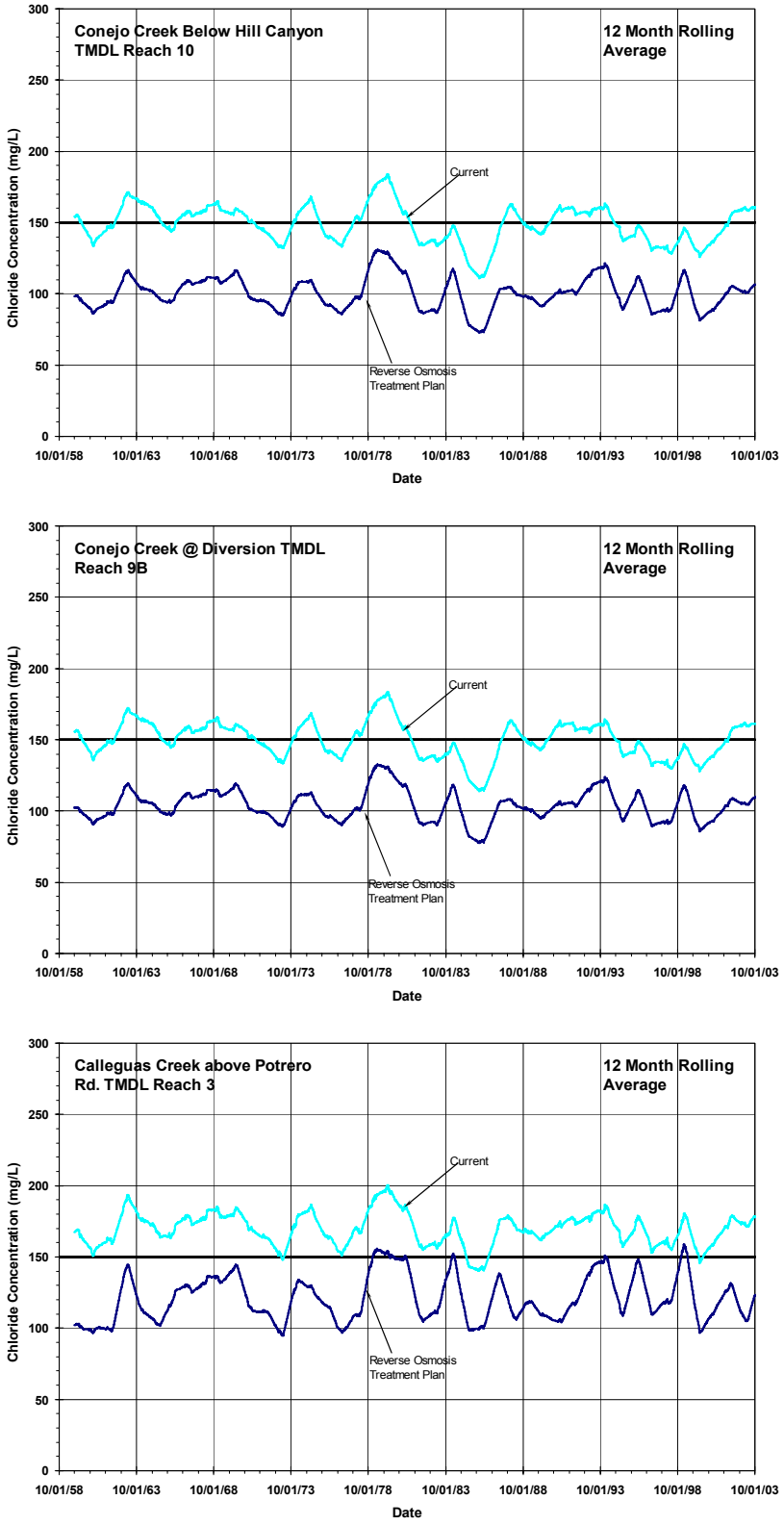

Figure 30: Current and Estimated 12-month Rolling Average Chloride Concentrations in the Lower CCW Reaches for the Reverse Osmosis Treatment Plan.

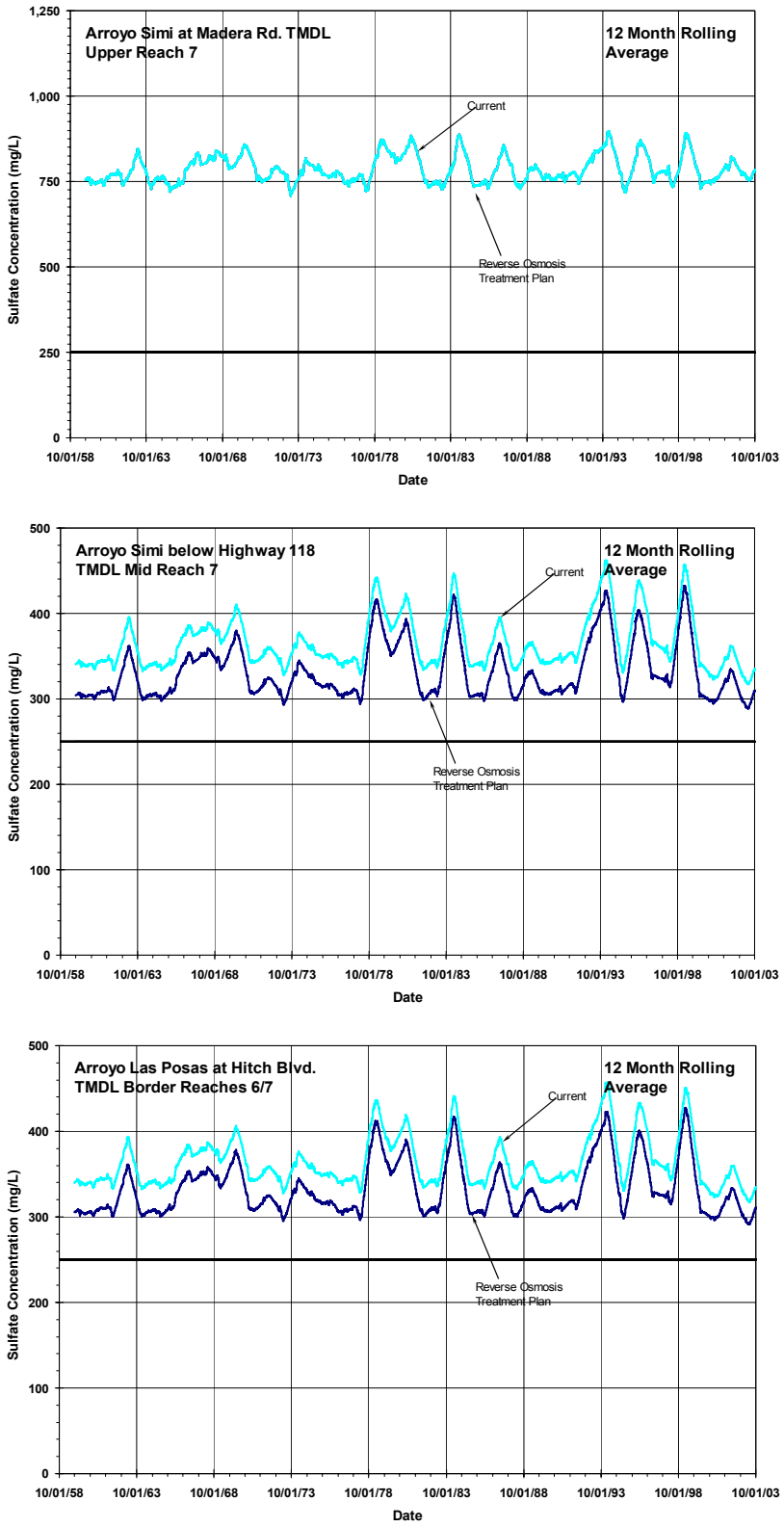

Figure 31: Current and Estimated 12-month Rolling Average Sulfate Concentrations in Arroyo Simi for the Reverse Osmosis Treatment Plan.

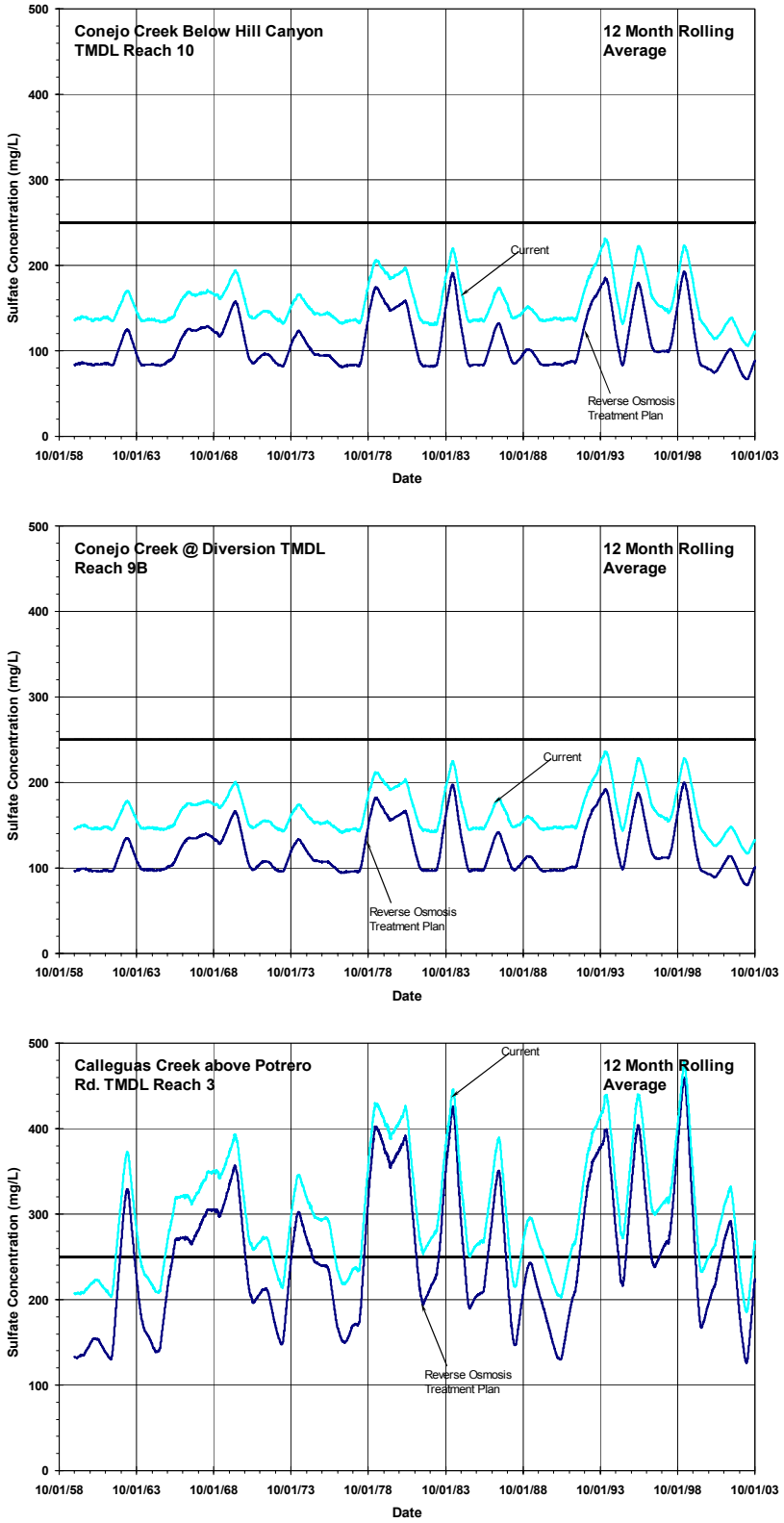

Figure 32: Current and Estimated 12-month Rolling Average Sulfate Concentrations in the Lower CCW Reaches for the Reverse Osmosis Treatment Plan.

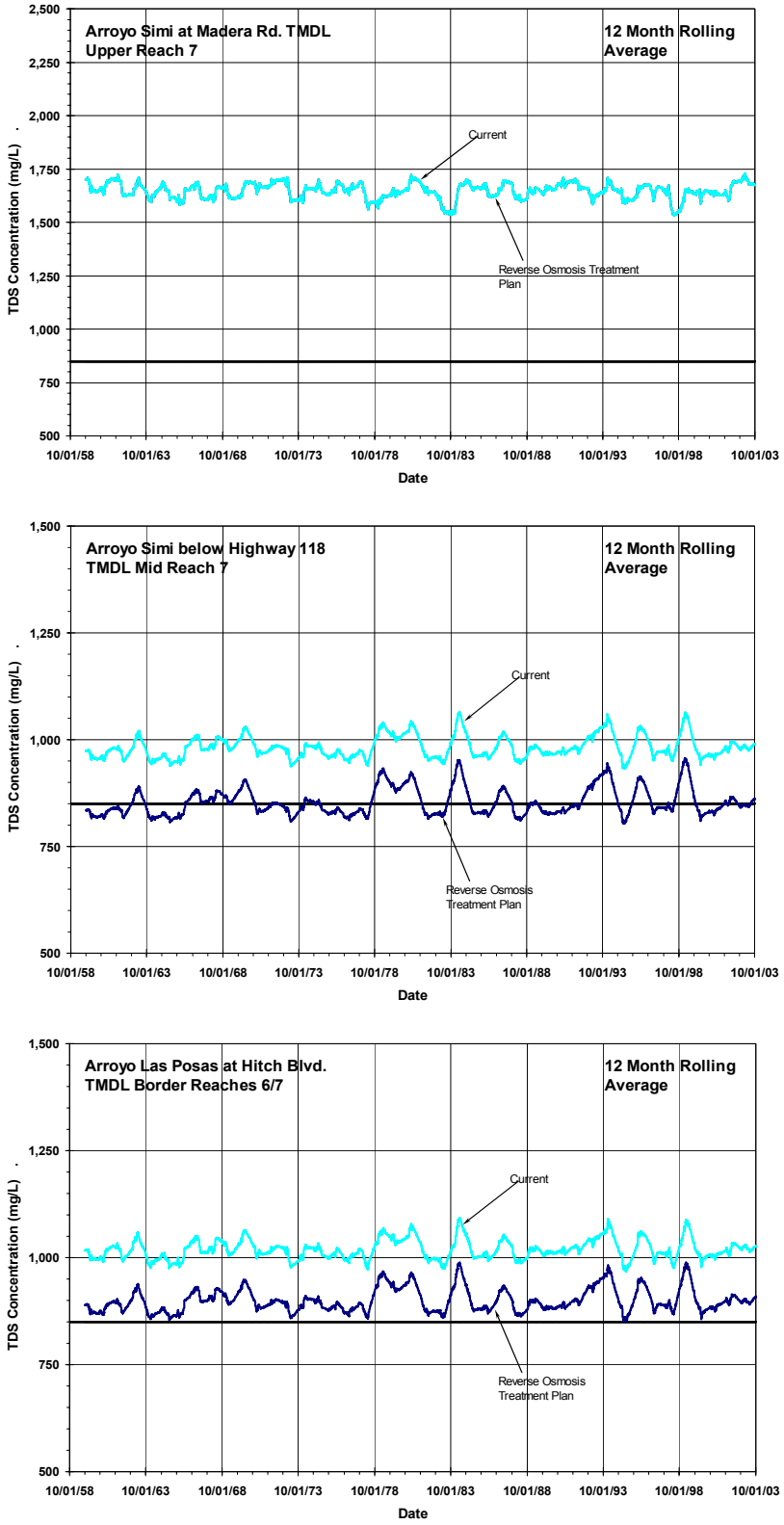

Figure 33: Current and Estimated 12-month Rolling Average TDS Concentrations in Arroyo Simi for the Reverse Osmosis Treatment Plan.

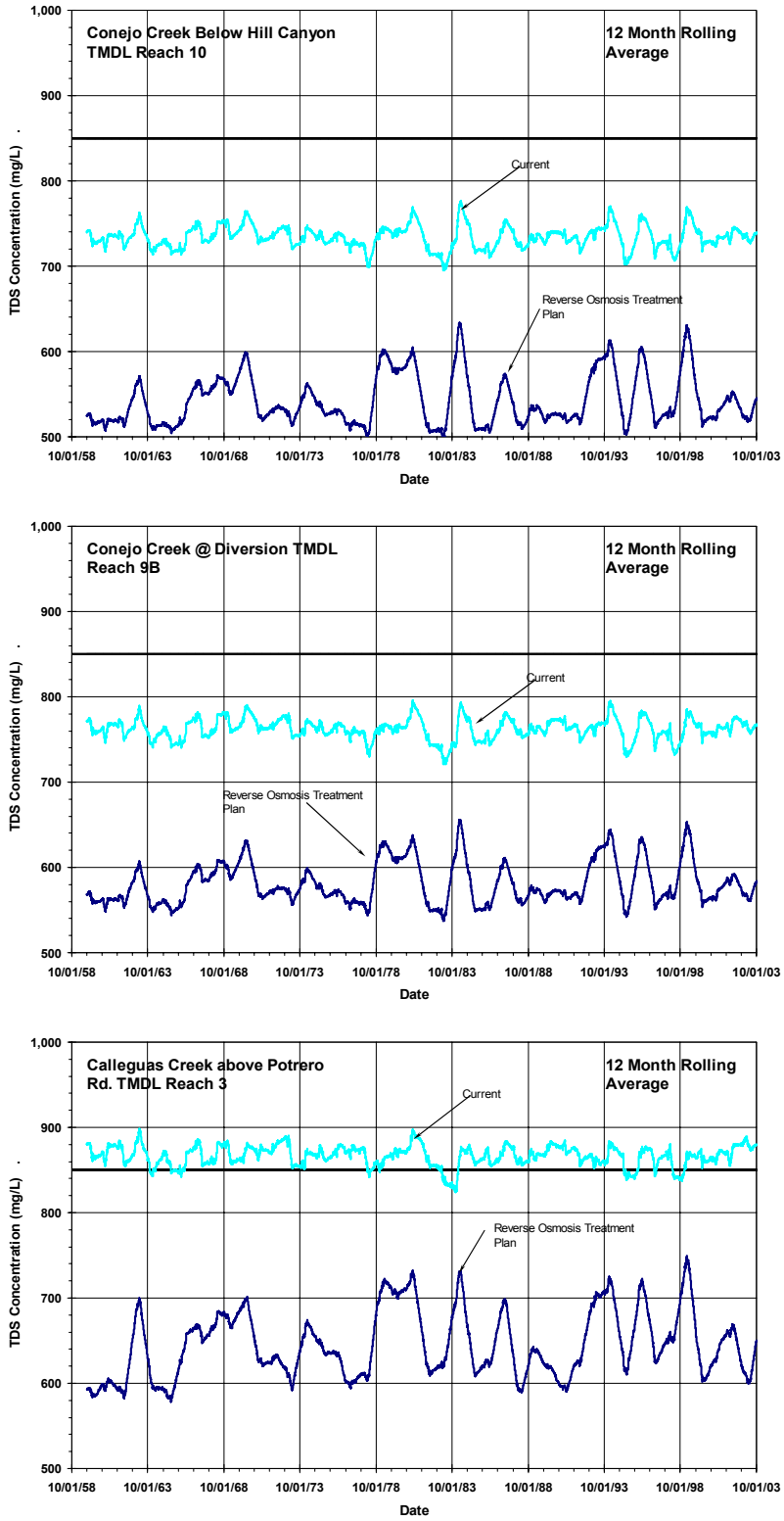

Figure 34: Current and Estimated 12-month Rolling Average TDS Concentrations in the Lower CCW Reaches for the Reverse Osmosis Treatment Plan.

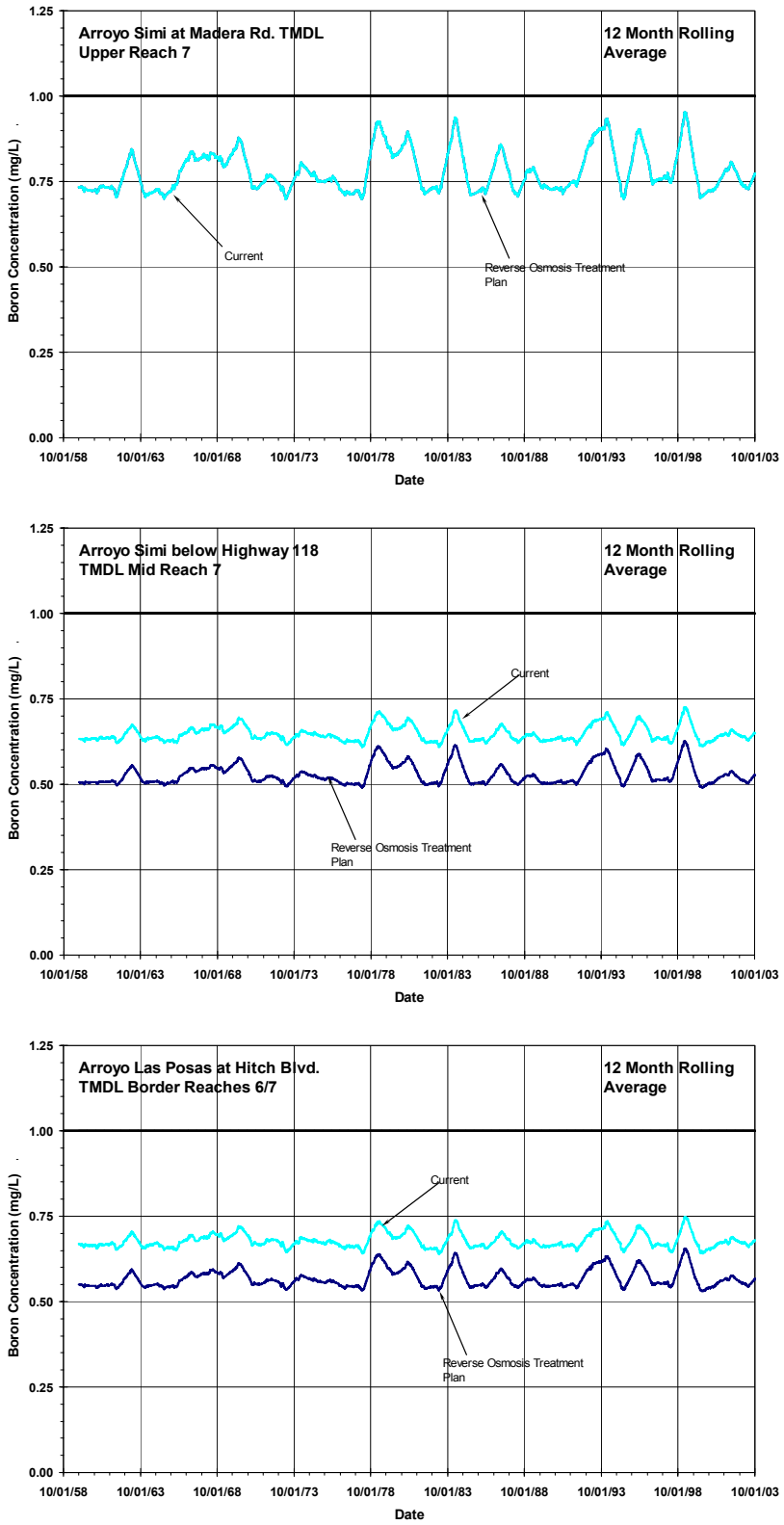

Figure 35: Current and Estimated 12-month Rolling Average Boron Concentrations in Arroyo Simi for the Reverse Osmosis Treatment Plan.

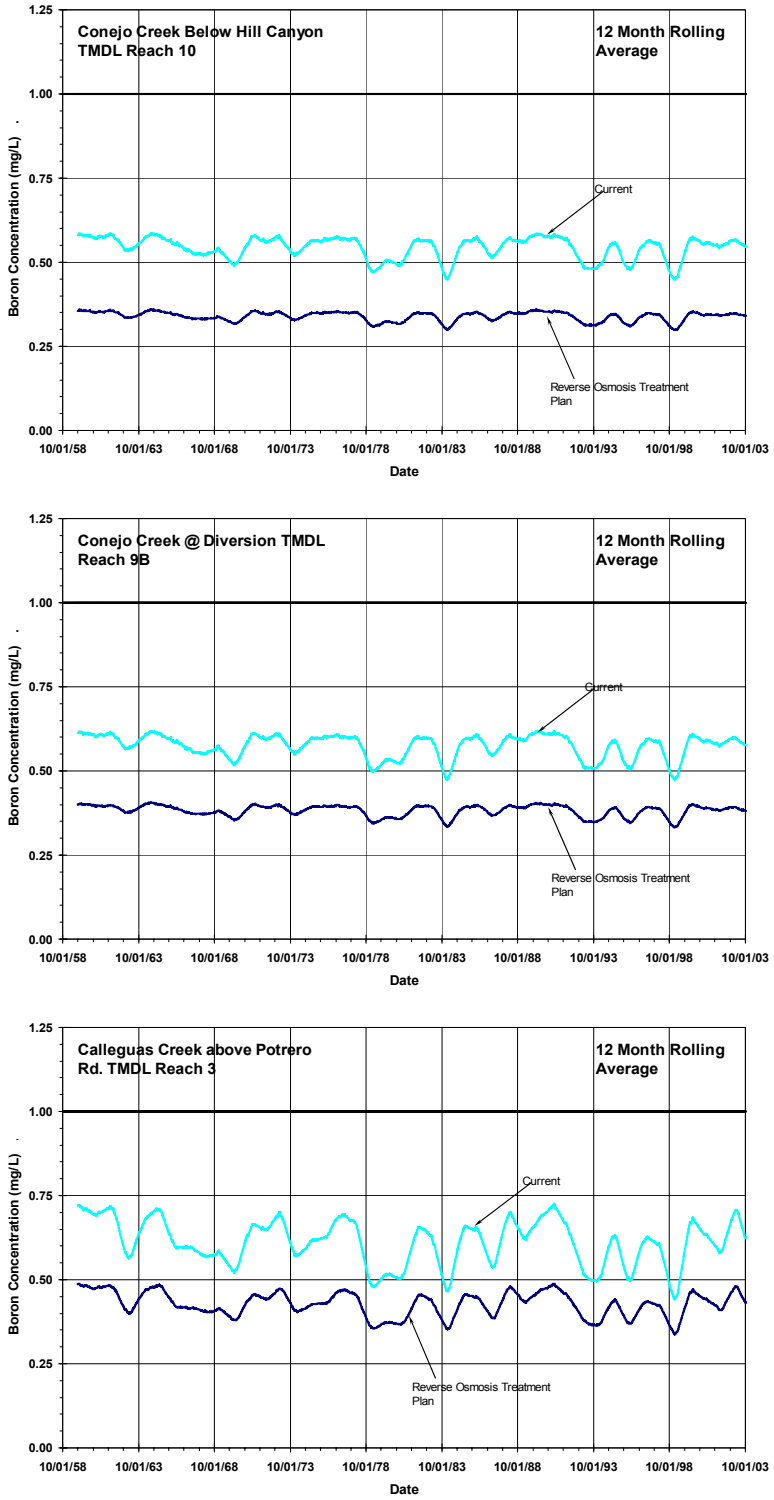

Figure 36: Current and Estimated 12-month Rolling Average Boron Concentrations in the Lower CCW Reaches for the Reverse Osmosis Treatment Plan.

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.

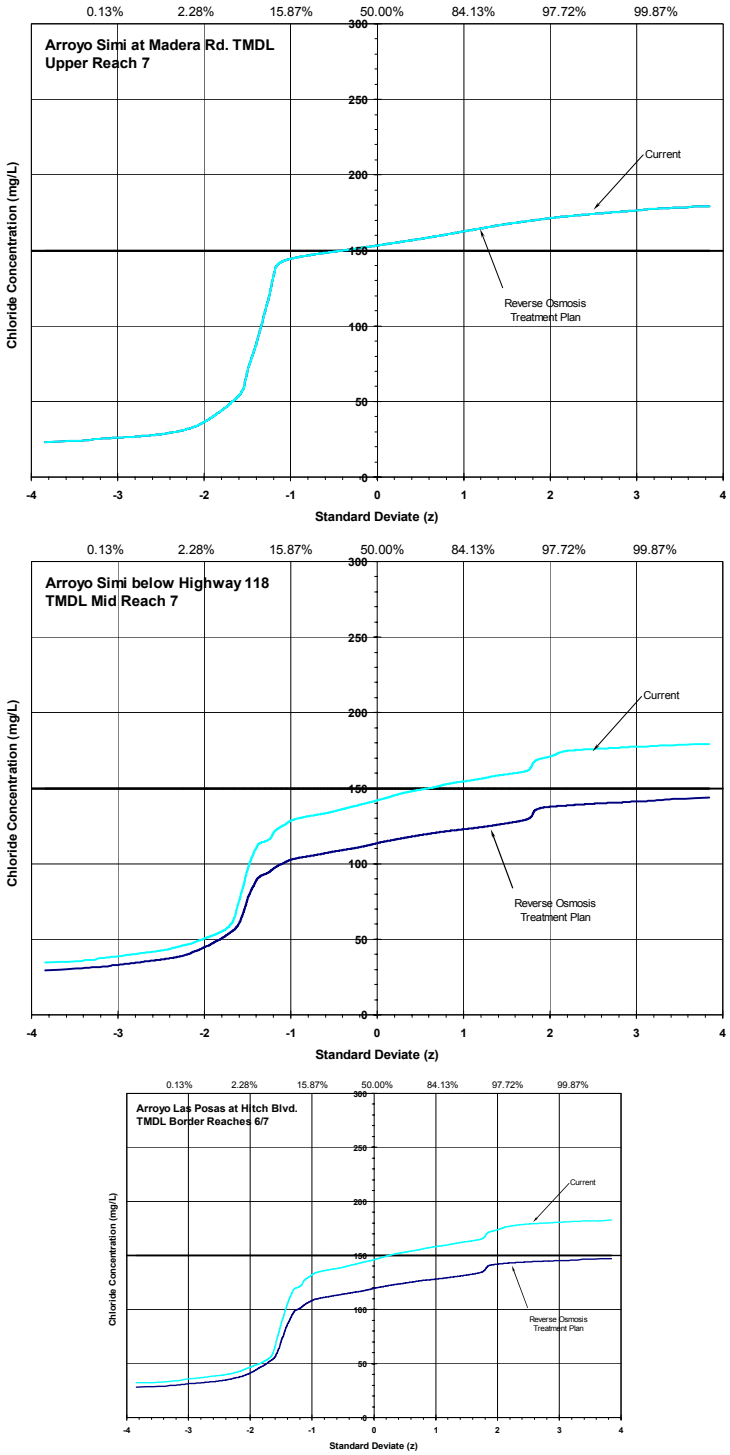

Figure 37: Current and Estimated Probability Distributions of Average Daily Chloride Concentrations in Arroyo Simi for the Reverse Osmosis Treatment Plan.

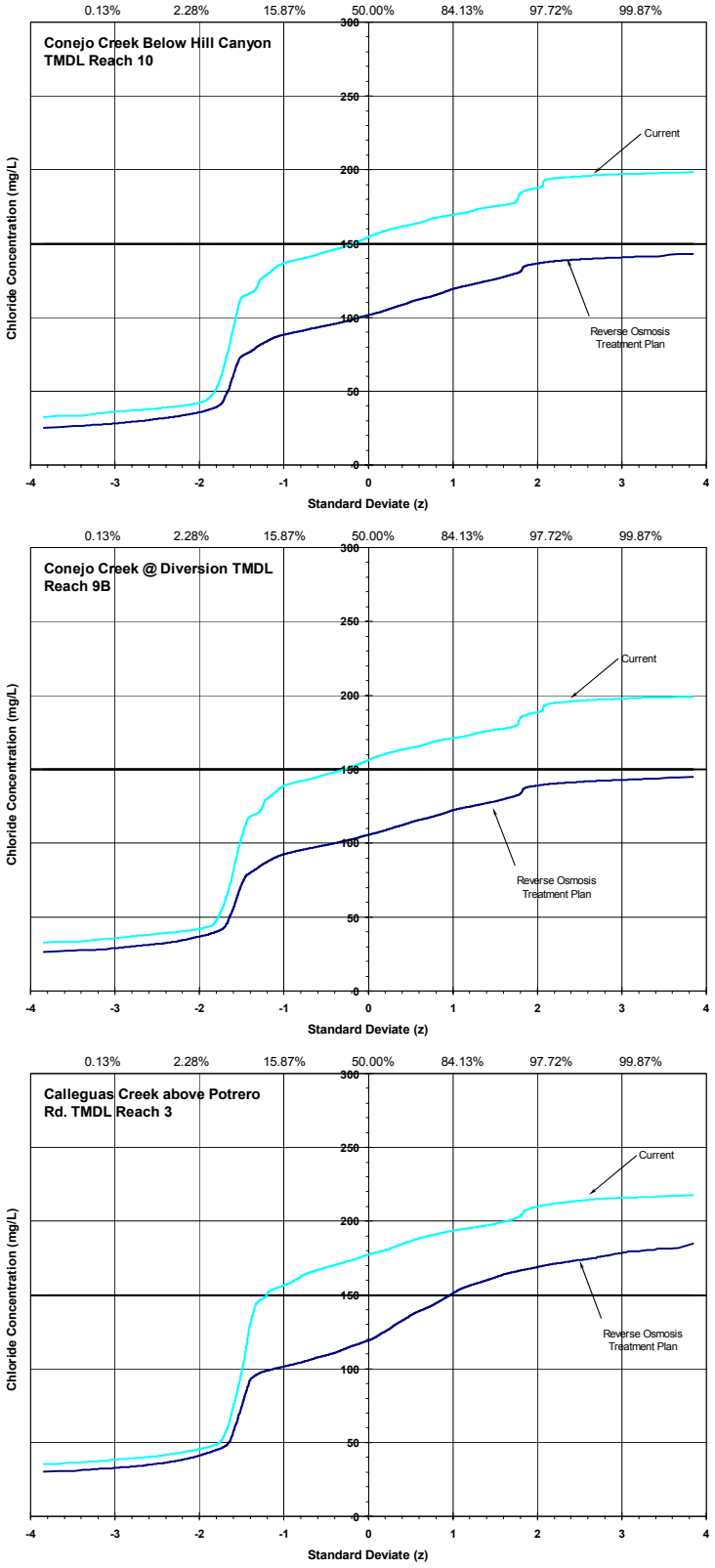

Figure 38: Current and Estimated Probability Distributions of Average Daily Chloride Concentrations in the Lower CCW Reaches for the Reverse Osmosis Treatment Plan.

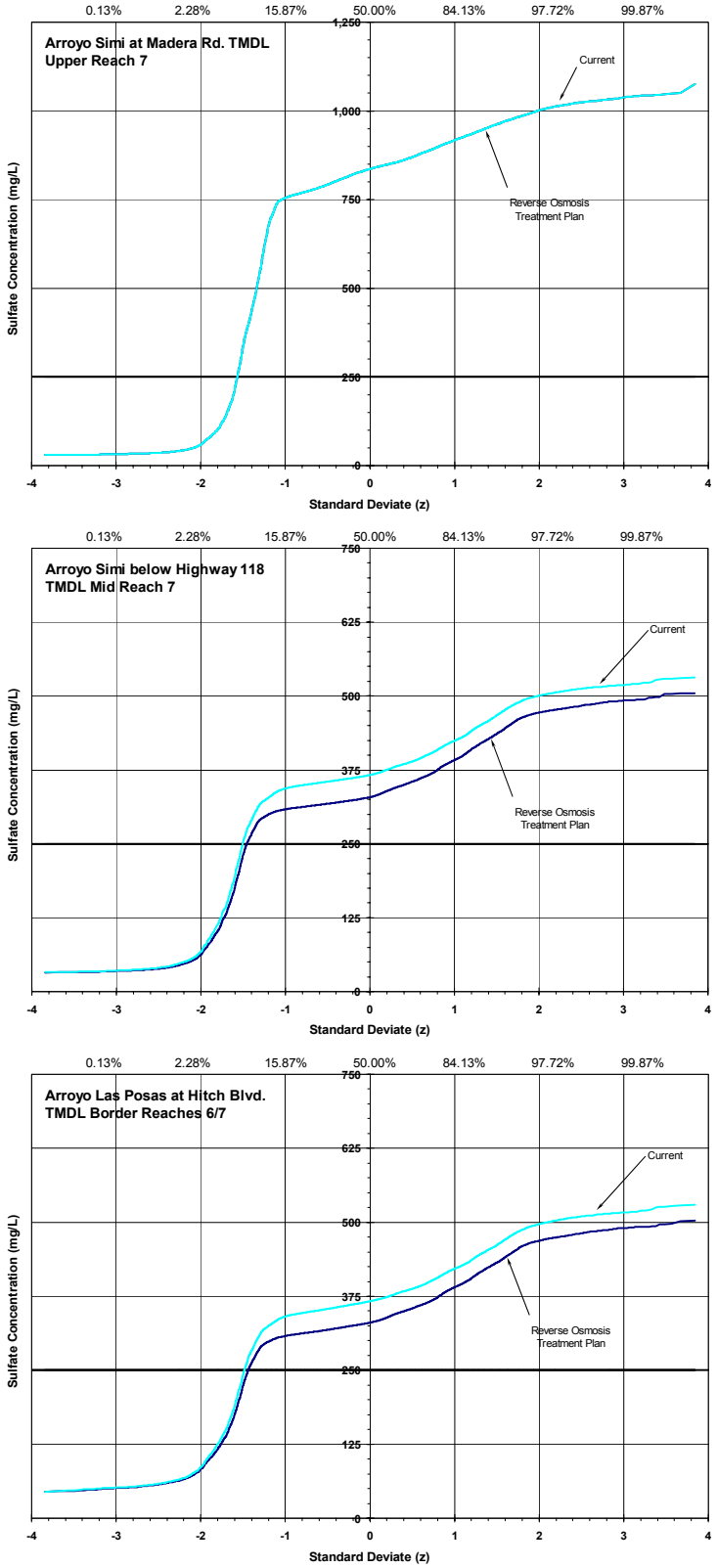

Figure 39: Current and Estimated Probability Distributions of Average Daily Sulfate Concentrations in Arroyo Simi for the Reverse Osmosis Treatment Plan.

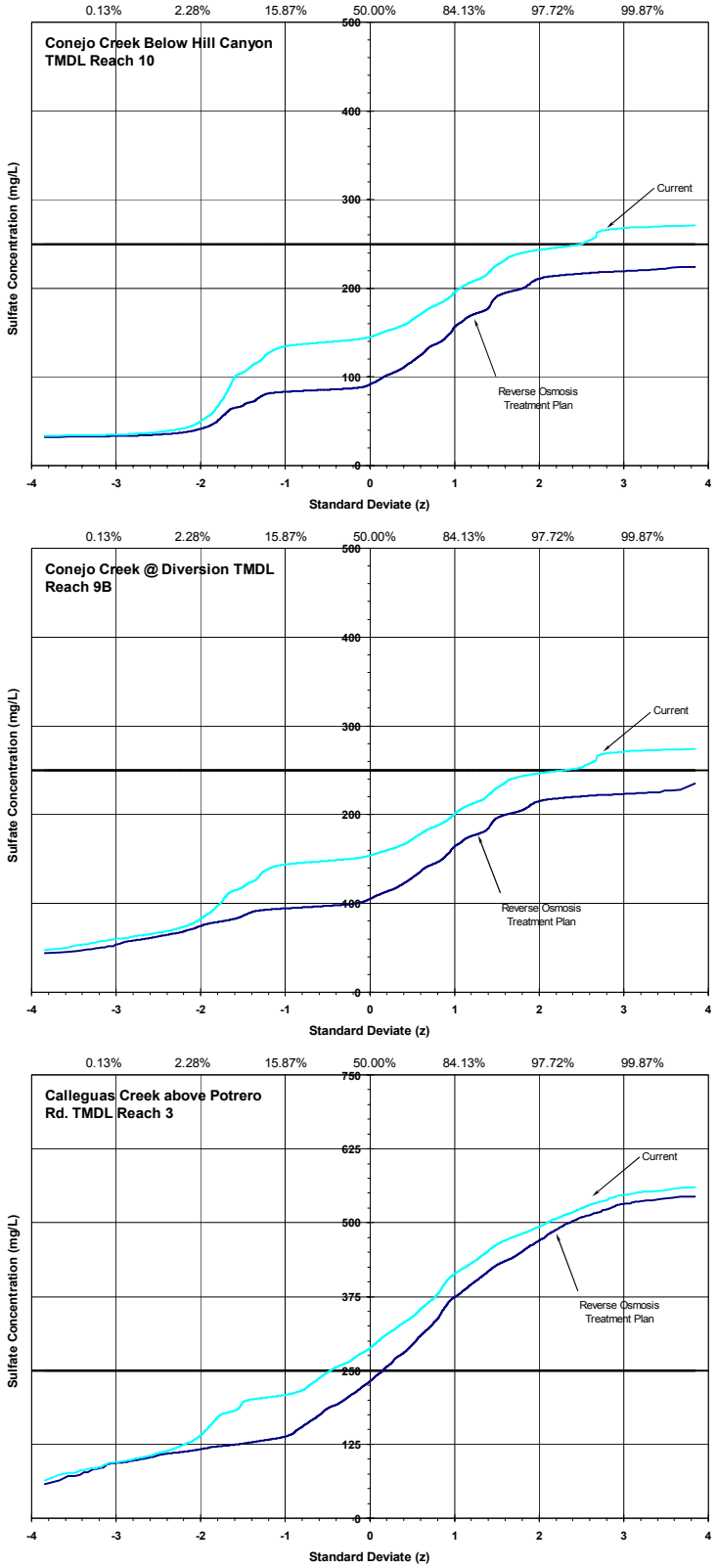

Figure 40: Current and Estimated Probability Distributions of Average Daily Sulfate Concentrations in the Lower CCW Reaches for the Reverse Osmosis Treatment Plan.

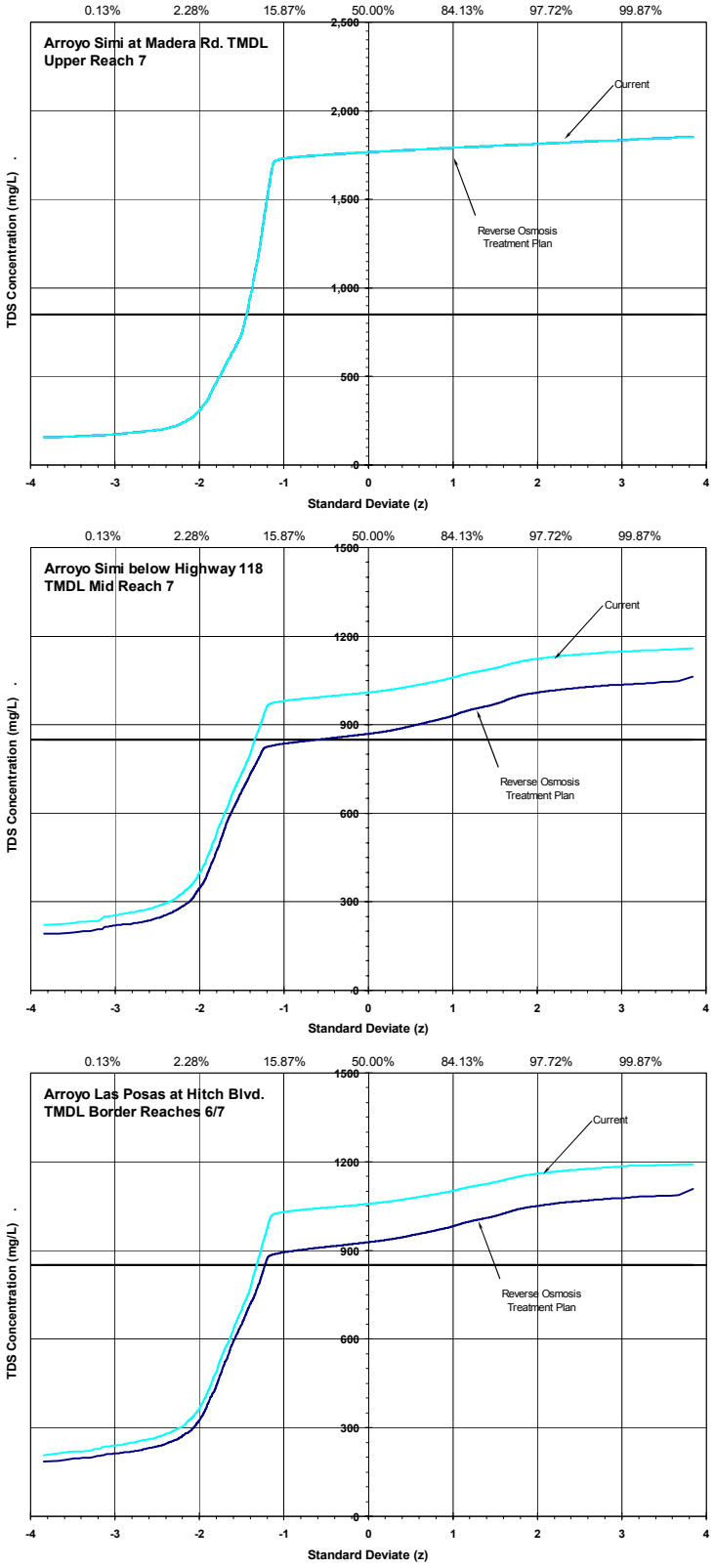

Figure 41: Current and Estimated Probability Distributions of Average Daily TDS Concentrations in Arroyo Simi for the Reverse Osmosis Treatment Plan.

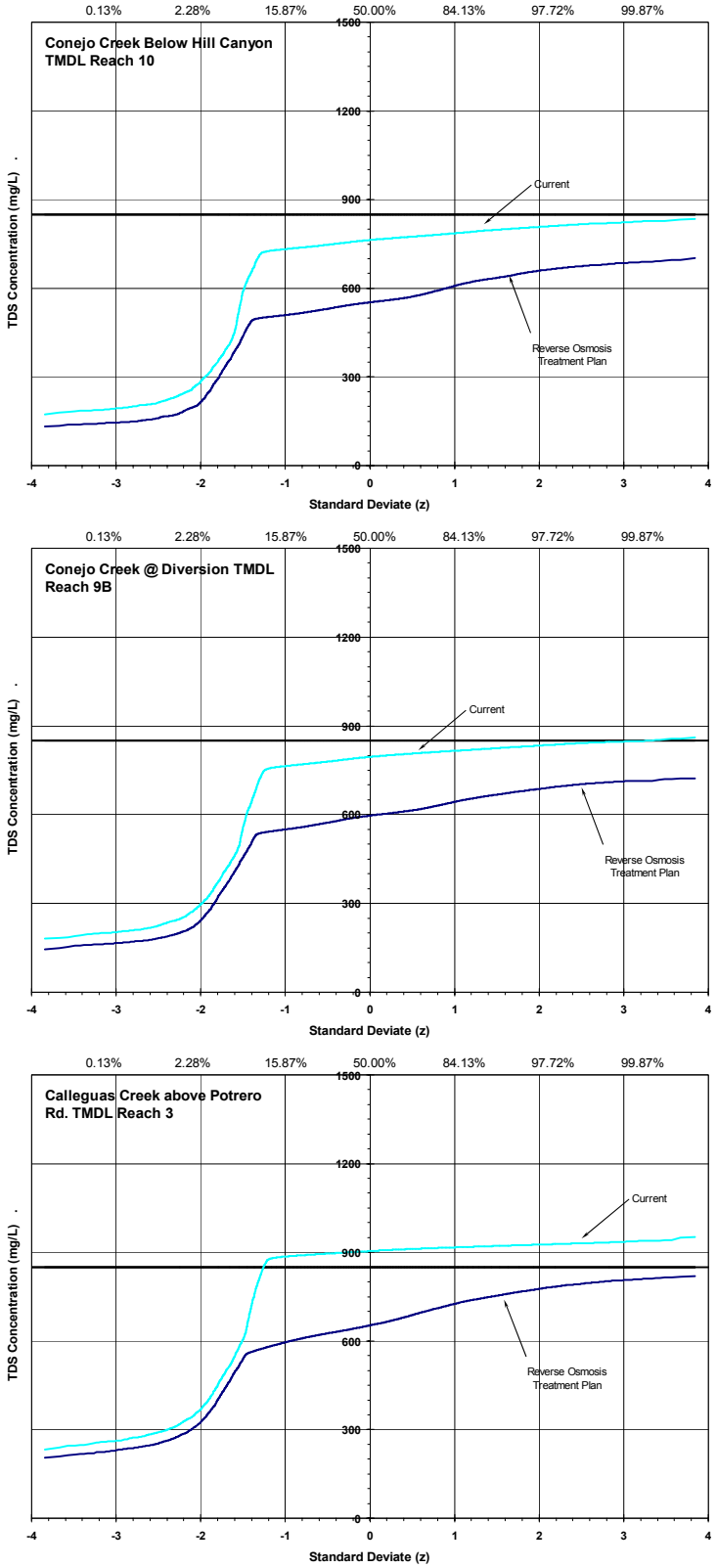

Figure 42: Current and Estimated Probability Distributions of Average Daily TDS Concentrations in the Lower CCW Reaches for the Reverse Osmosis Treatment Plan.

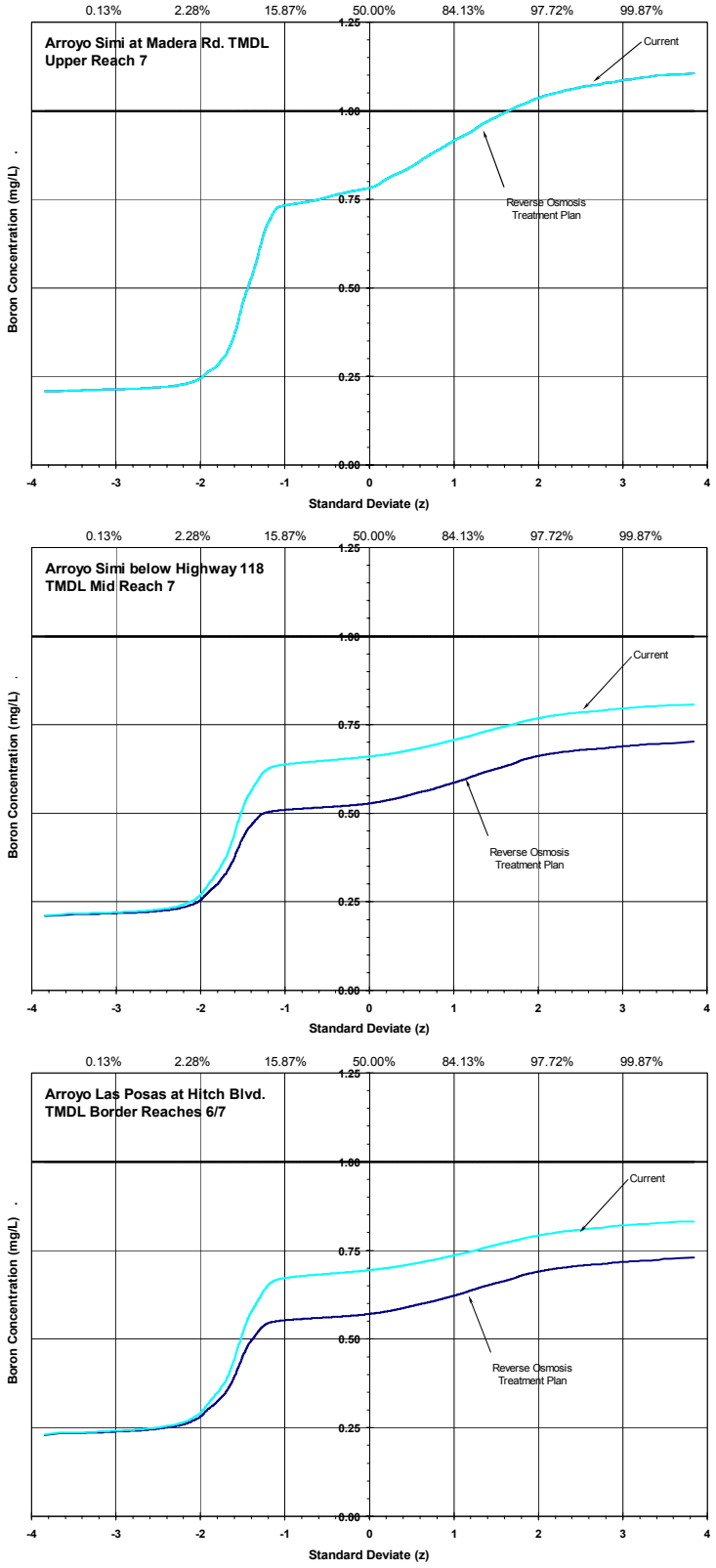

Figure 43: Current and Estimated Probability Distributions of Average Daily Boron Concentrations in Arroyo Simi for the Reverse Osmosis Treatment Plan.

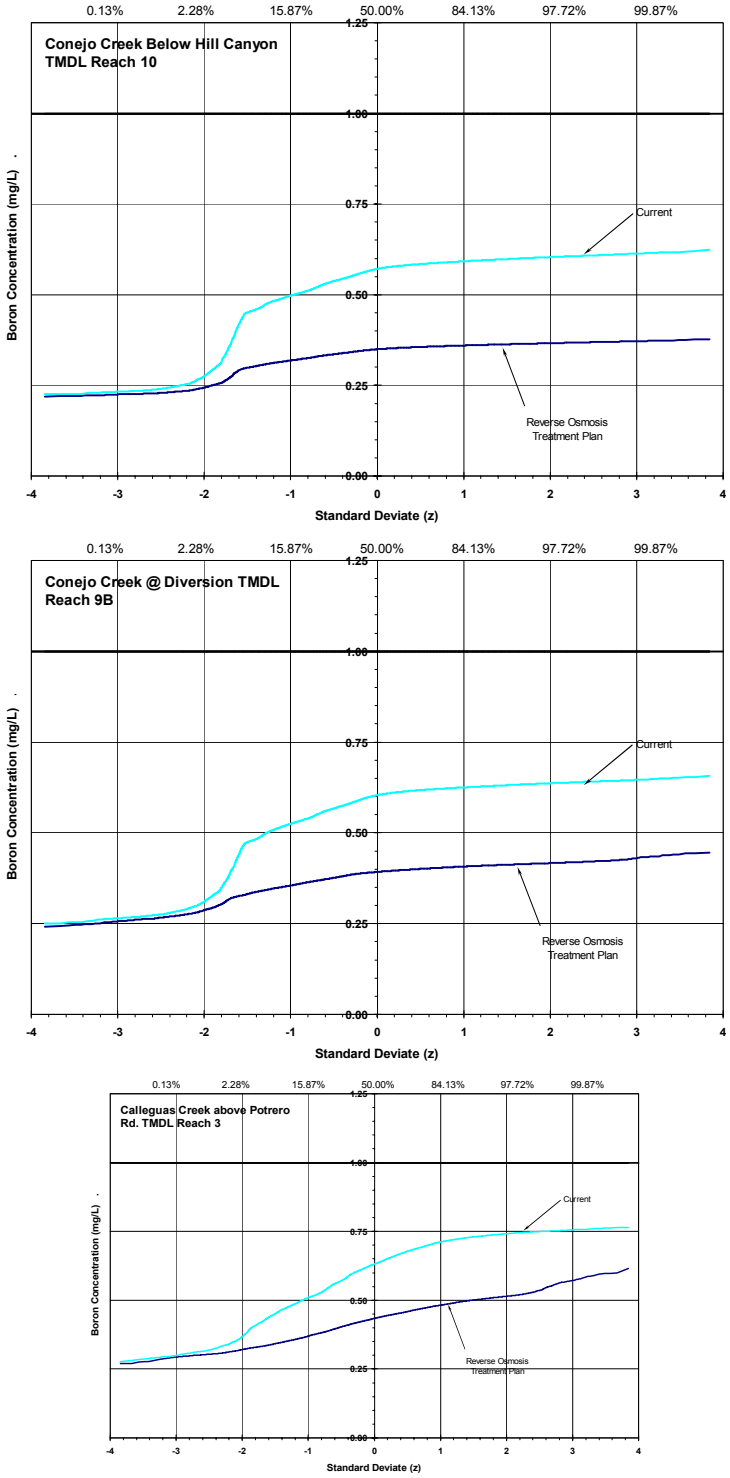

Figure 44: Current and Estimated Probability Distributions of Average Daily Boron Concentrations in the Lower CCW Reaches for the Reverse Osmosis Treatment Plan.

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.

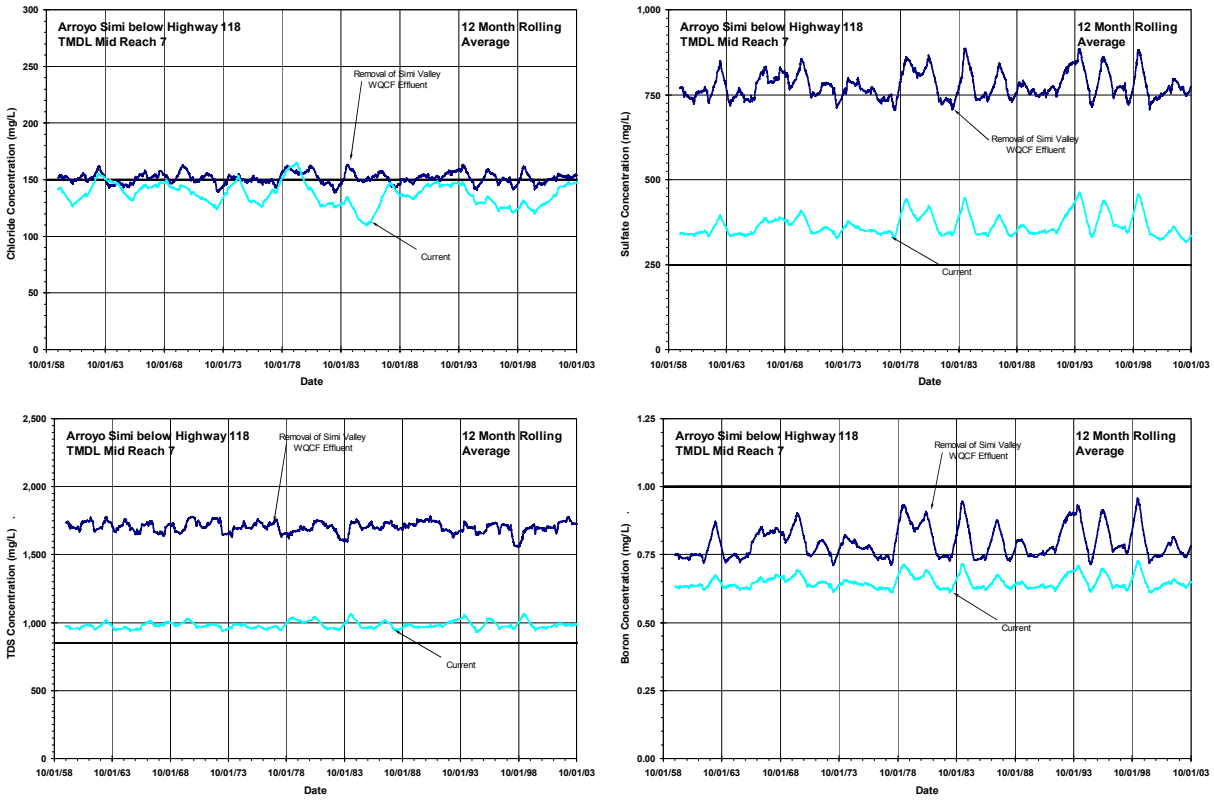

Figure 45. Salts Concentrations in Arroyo Simi at Hwy 118 after Removal of Simi Valley WQCP effluent

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

LARRY WALKER ASSOCIATES

DATE: February 25, 2004

TO: File

CC:

SUBJECT: CCMS Computational Element

DRAFT

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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.

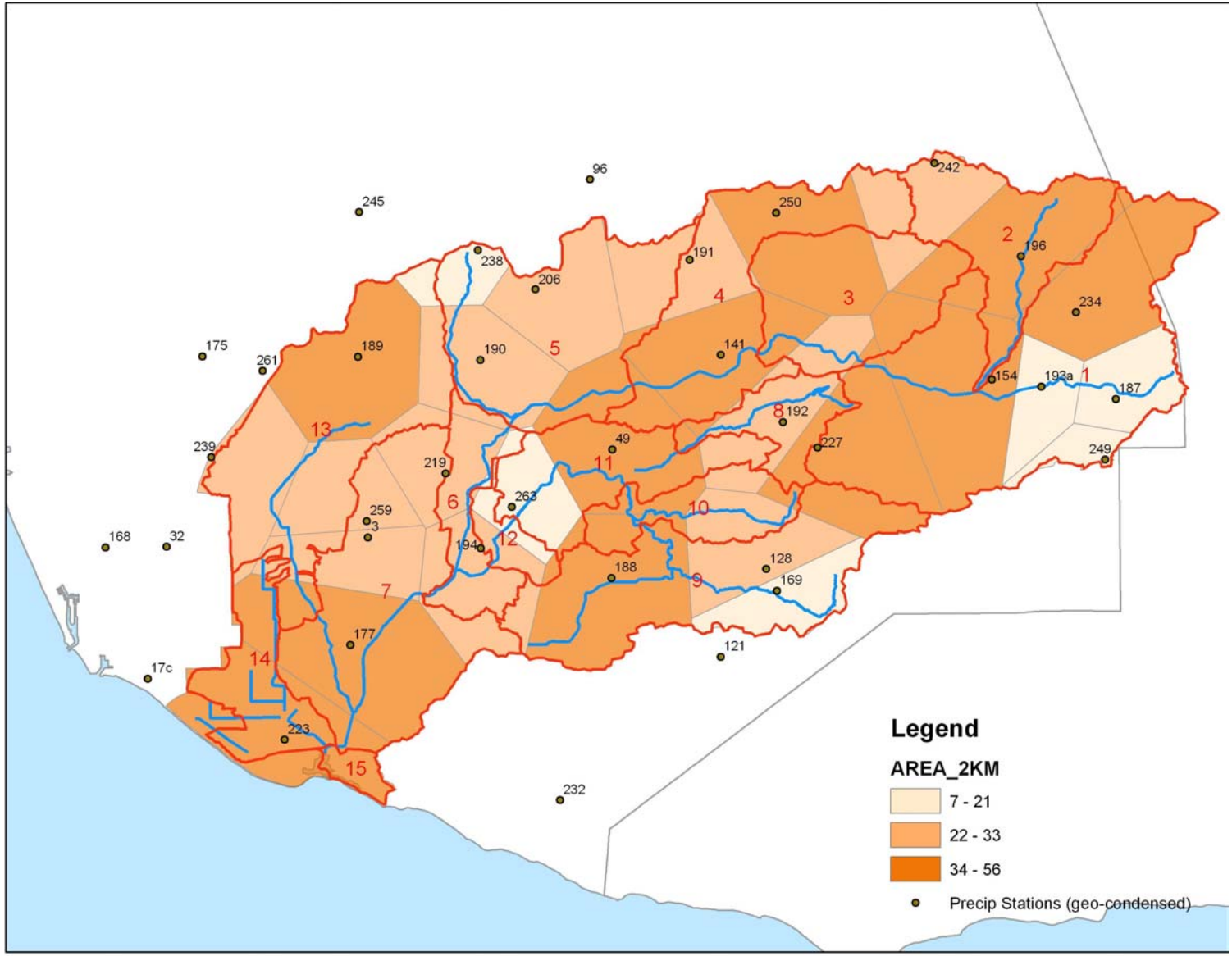

Figure 46: Precipitation Stations in the CCW with Area of Influence Superimposed on CCMS Subwatershed Boundaries.

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.

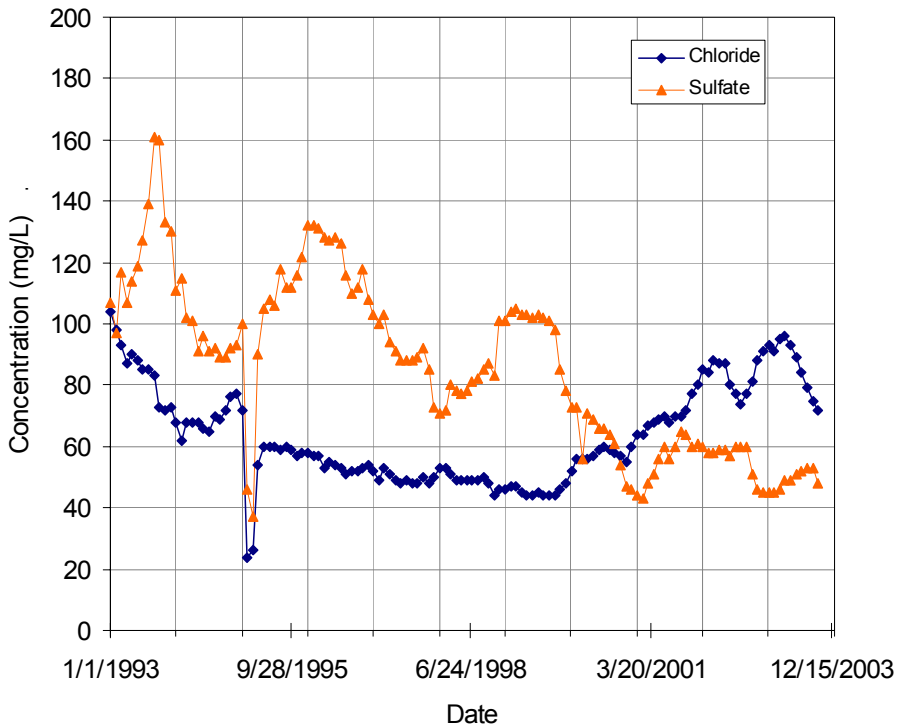

Figure 47: Chloride and Sulfate Concentrations Measured at the CMWD Jensen Plant.

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.

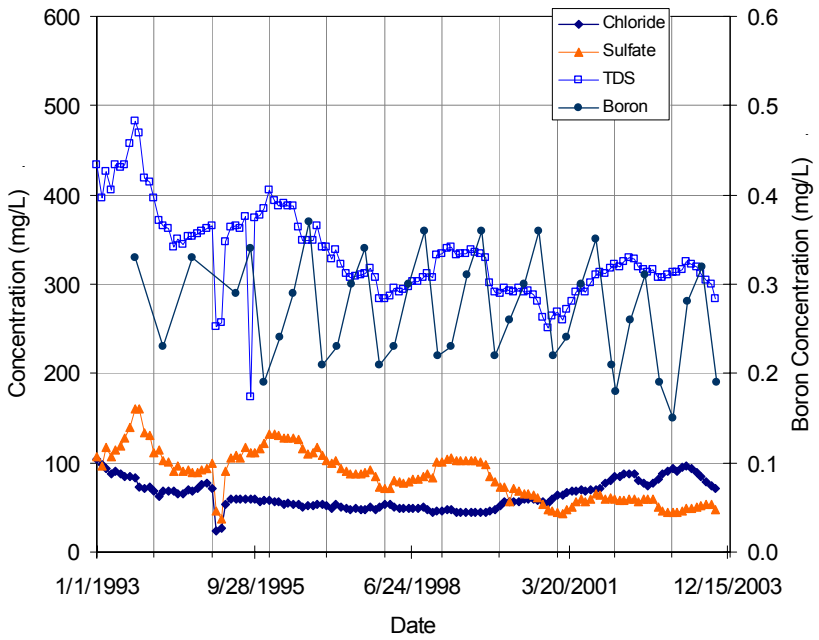

Figure 48: Concentrations of All Salts Species as Measured at the Jensen Plant.

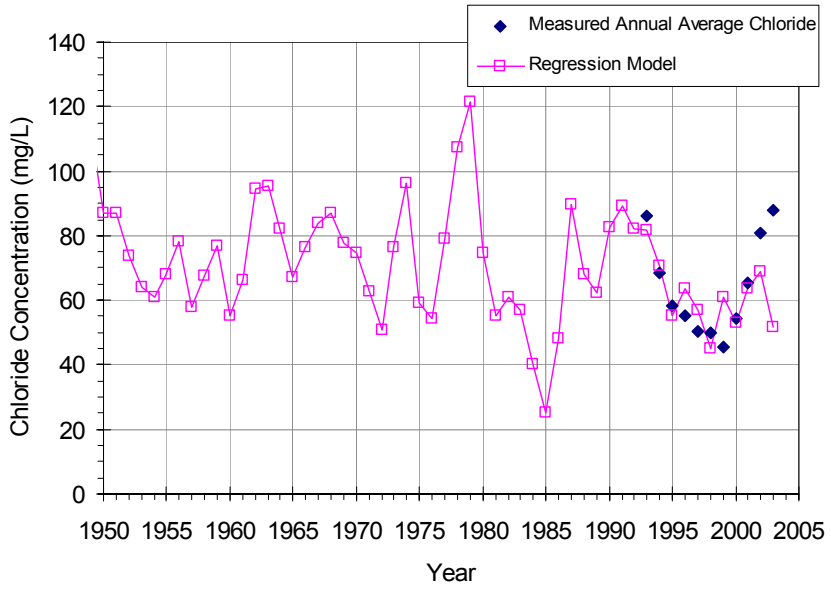

Figure 49: State Import Water Chloride Concentration Regression Based on Annual Precipitation in Sacramento, CA.

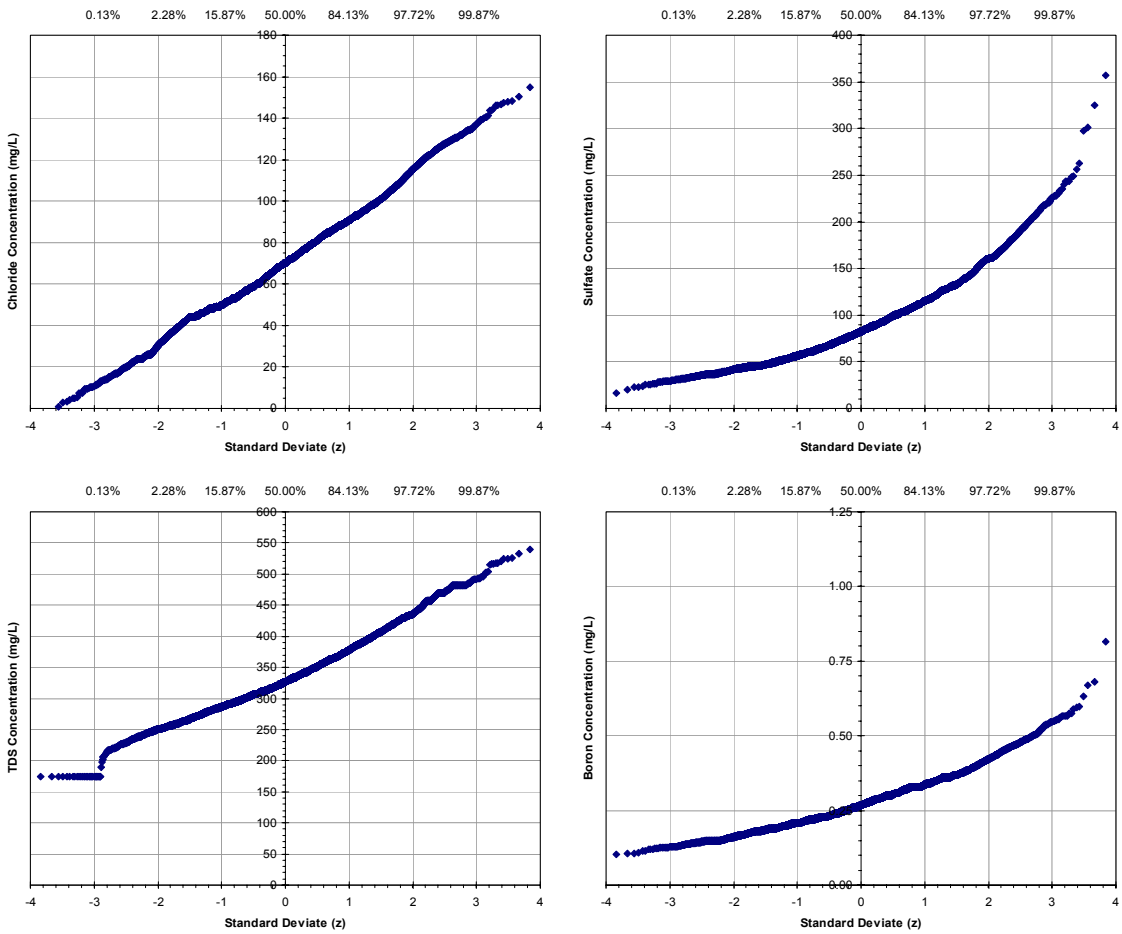

Figure 50: Probability distributions for State Import Water quality as used in the Dynamic CCMS.

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.

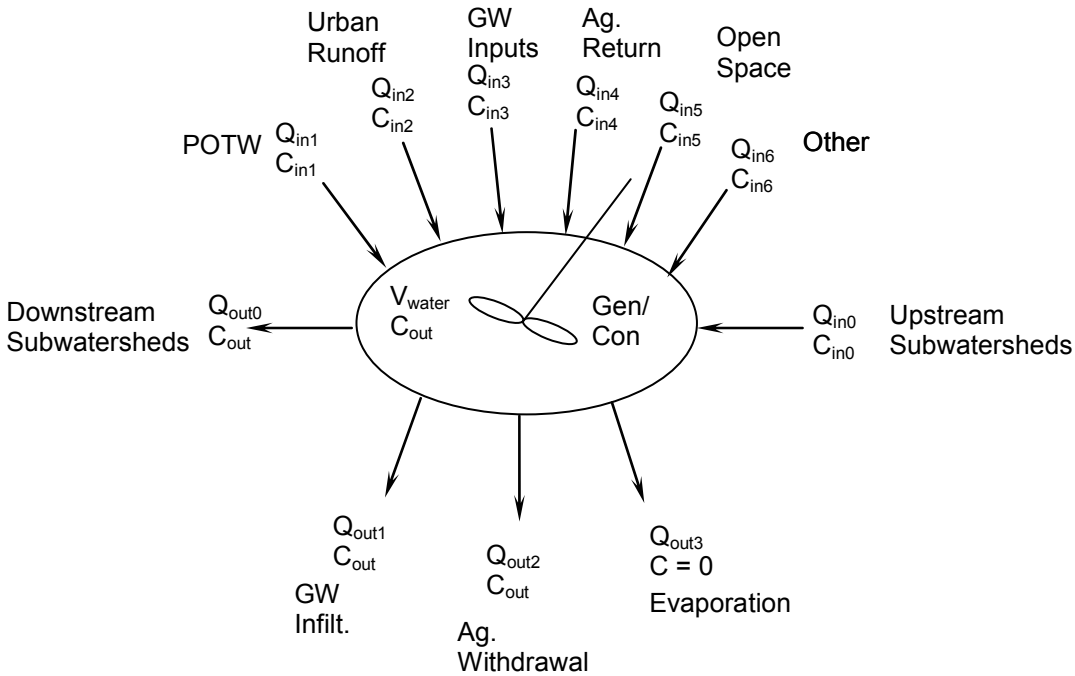

Figure 51: Schematic of Inputs and Outputs for a General Computational Element used in the CCMS Mass Balance Model to Estimate Water Flow and Quality within Surface Water Reaches.

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.

$$C_{in0}Q_{in0} = C_A Q_{out0\,A} + C_B\, Q_{out0\,B} \tag{15}$$

$$C_{in0} = \frac{C_A Q_{out0\,A} + C_B\, Q_{out0\,B}}{Q_{in0}} \tag{16}$$

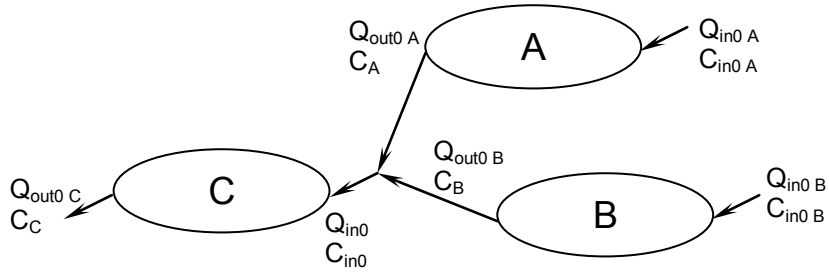

Figure 52: Schematic of Case where Two Upstream Subwatersheds, A and B, Contribute to the Inflow of a Computational Element, C.

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.

$$\begin{aligned} Q_{in2} &= \text{Total Area} \cdot \left(f_{res} \cdot runoff_{res} + f_{com} \cdot runoff_{com} + f_{ind} \cdot runoff_{ind} \right) \cdot \text{reductions}_{urban} \\ &\quad + \text{Storm runoff}_{last} \cdot exp\{-(\#\text{ antecedent dry days}) \cdot \text{lag}\} \end{aligned} \tag{18}$$

$$\begin{aligned} \text{Storm runoff}_{day} &= \text{Total Area} \cdot \left(f_{res} \cdot C + f_{com} \cdot C_{com} + f_{ind} \cdot C_{ind} \right) \\ &\quad \cdot \left(\text{precip}_{day} - \text{threshold}_{urban} \right) \cdot \text{conversion} + \text{Storm runoff}_{day-1} \cdot exp\{-\text{lag}\} \end{aligned} \tag{19}$$

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).

$$Q_{in5} = \text{Total Area} \cdot \left(f_{\text{open}} \cdot runoff_{\text{open}}\right) \cdot \text{reductions}_{\text{open}} \tag{21}$$

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.

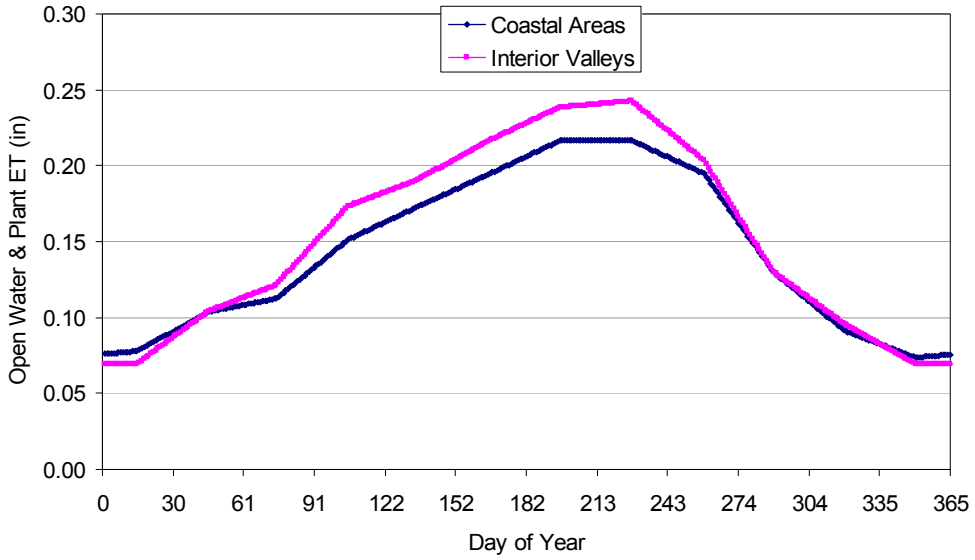

Figure 53: Base evapotranspiration from coastal and inland areas of the CCW.

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

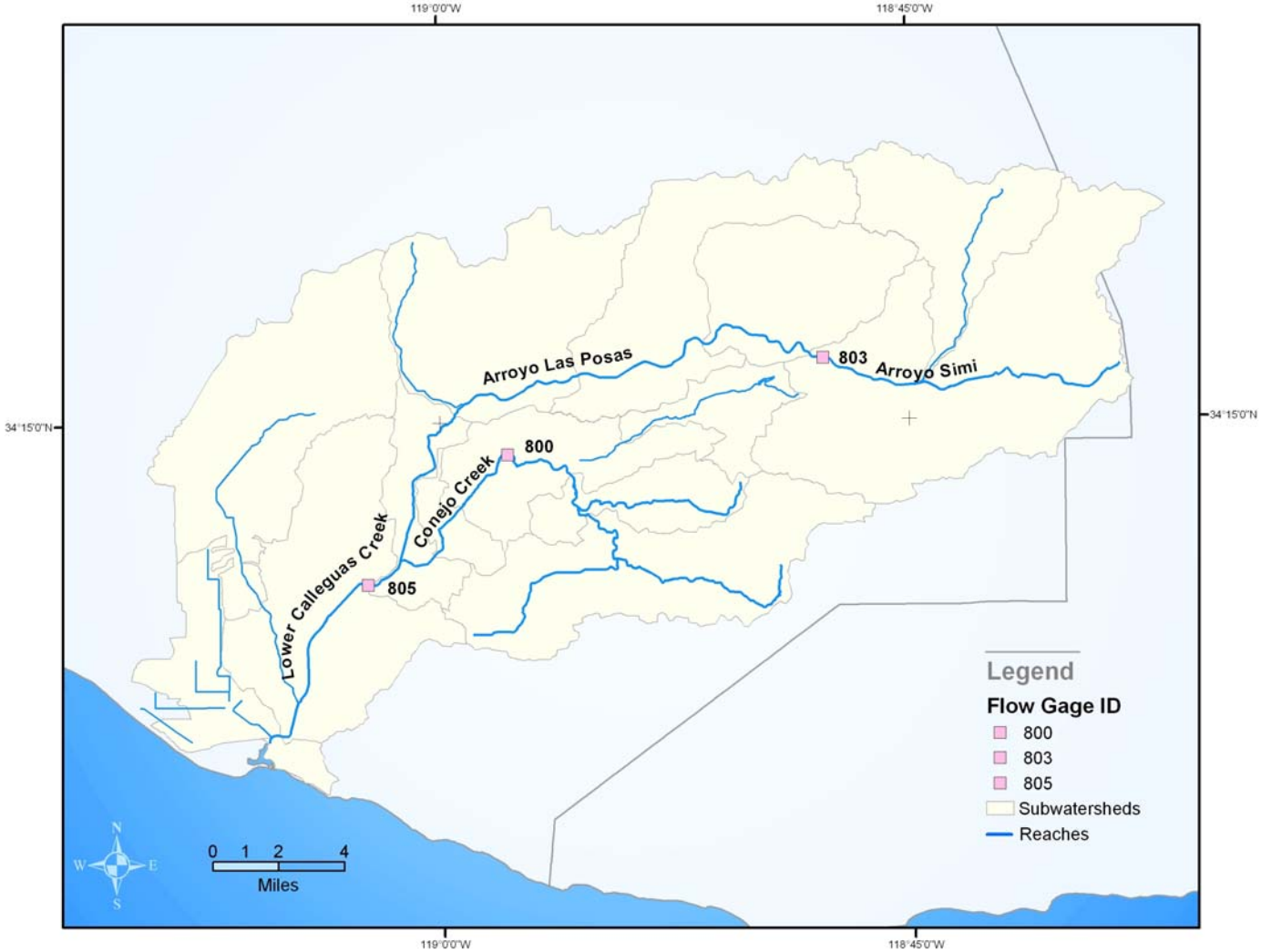


Figure 1. Calleguas Creek VCWPD Flow Gage Locations

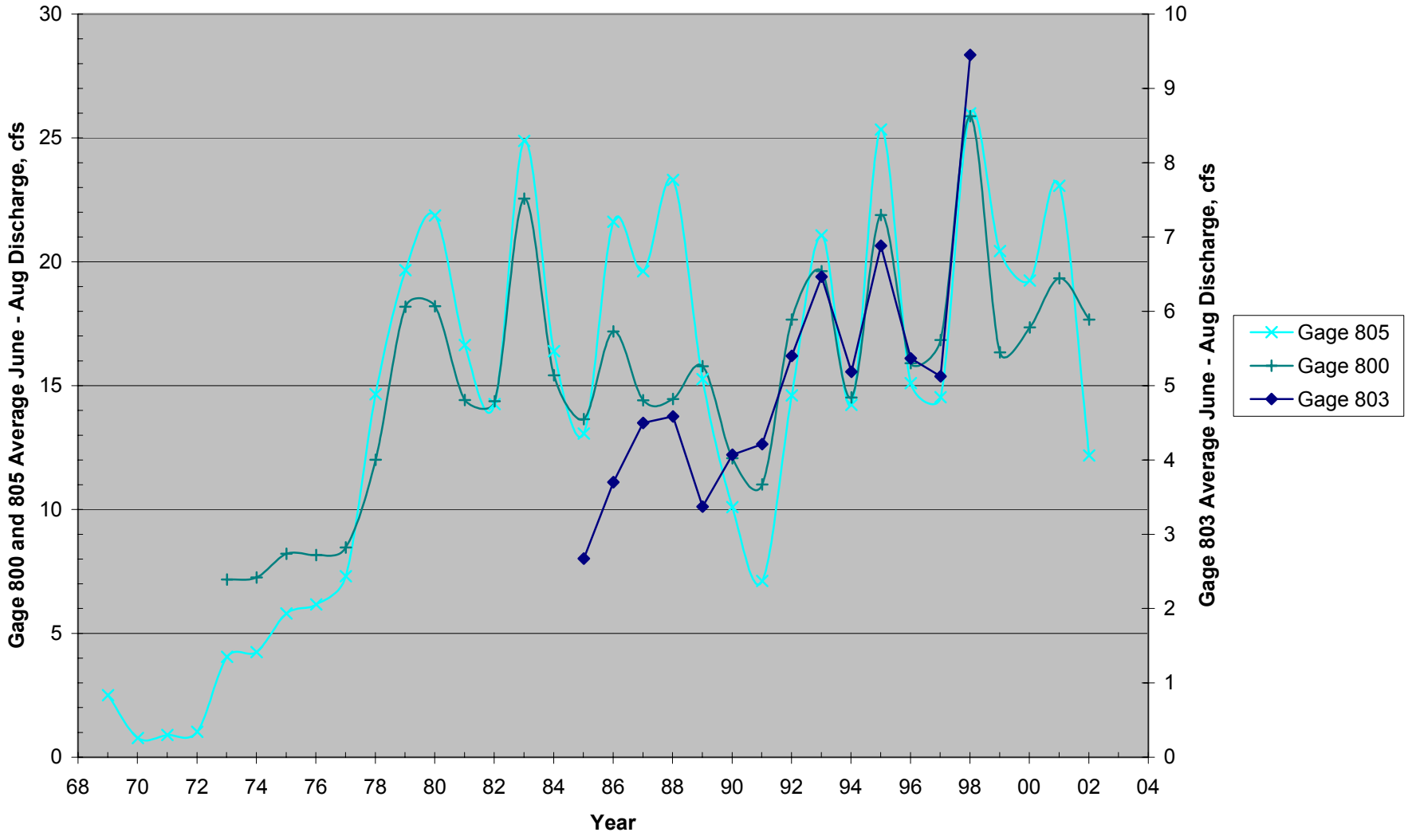


Figure 2. 1981 - 2002 Calleguas Creek Watershed Mean Summer (6/1 - 8/31) Flows

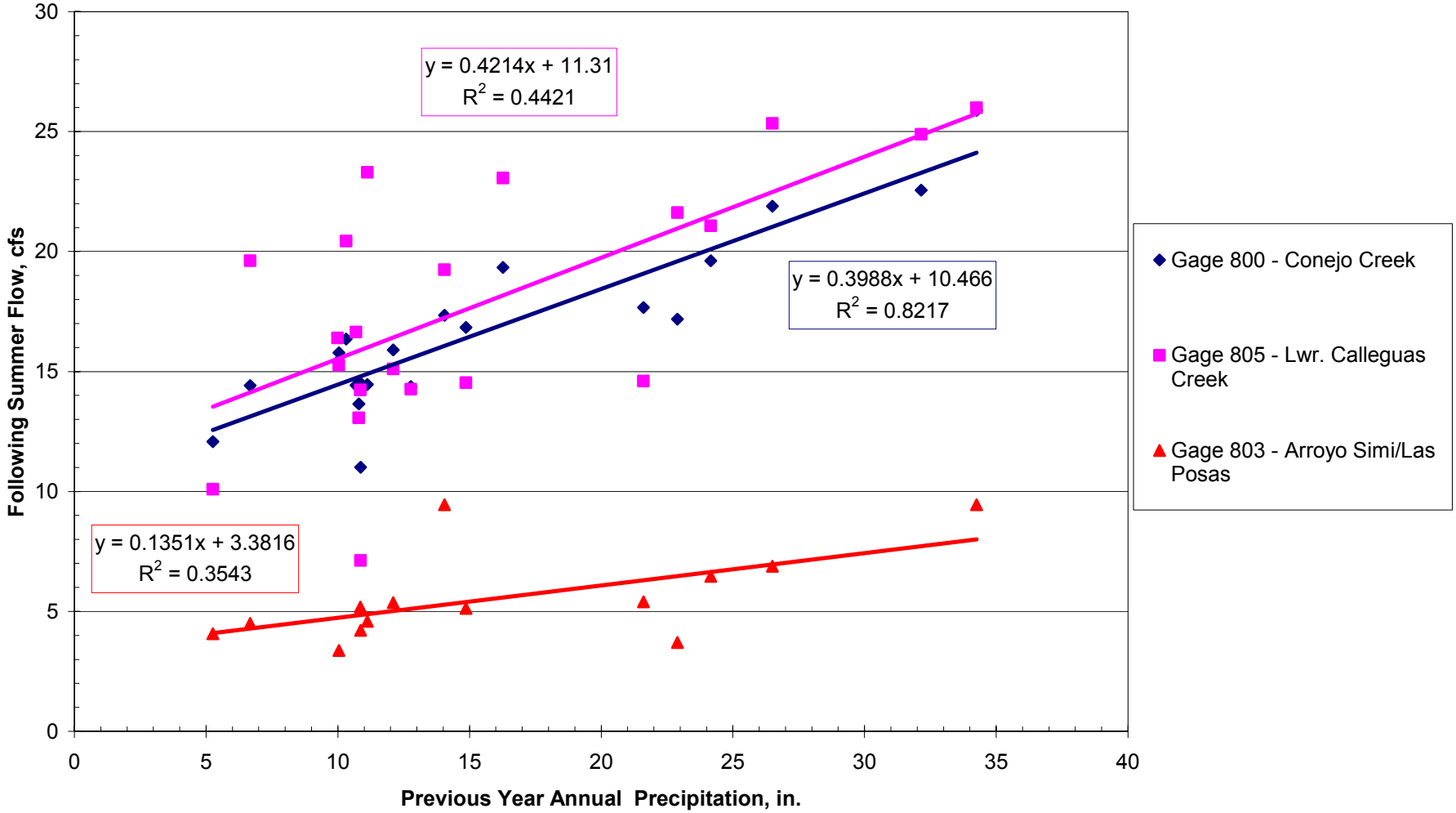


Figure 3. Calleguas Creek 1981 - 2001 Mean Summer Discharge vs. Previous-Year Annual Precipitation

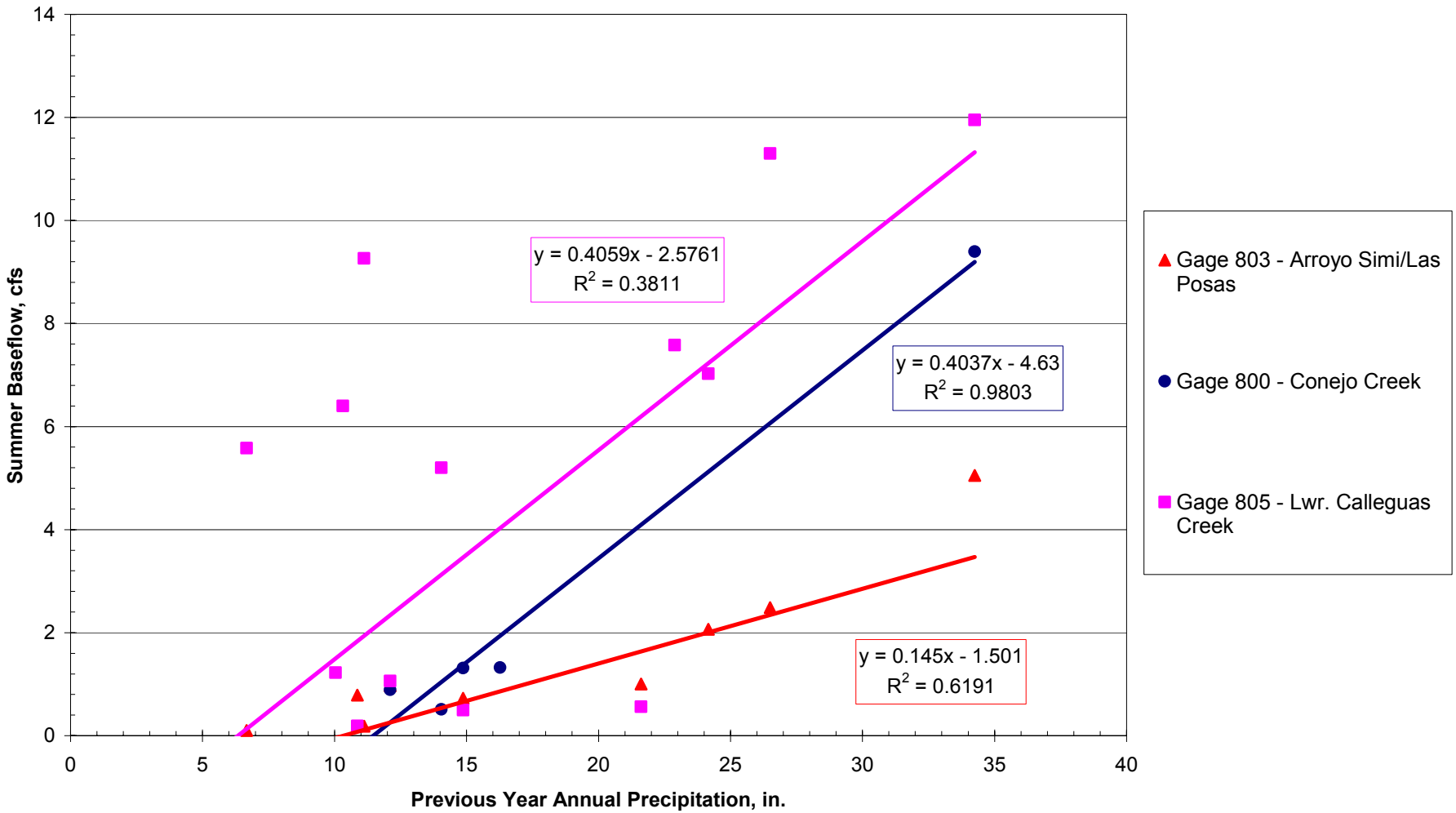


Figure 4. Calleguas Mean Summer Baseflow vs. Previous Year Annual Precipitation

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.

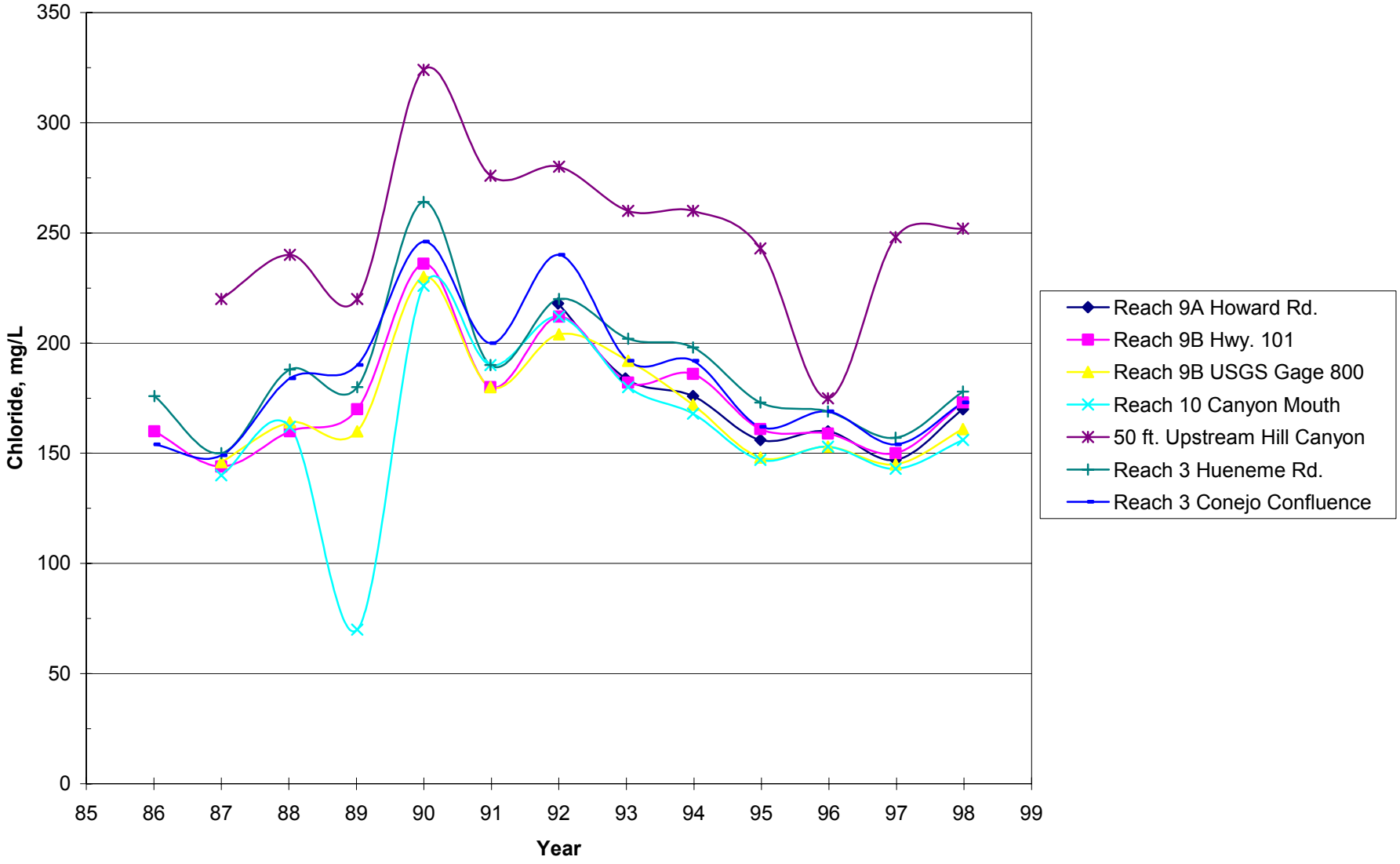


Figure 5. Calleguas and Conejo Creek Summer Recieving Water Chloride

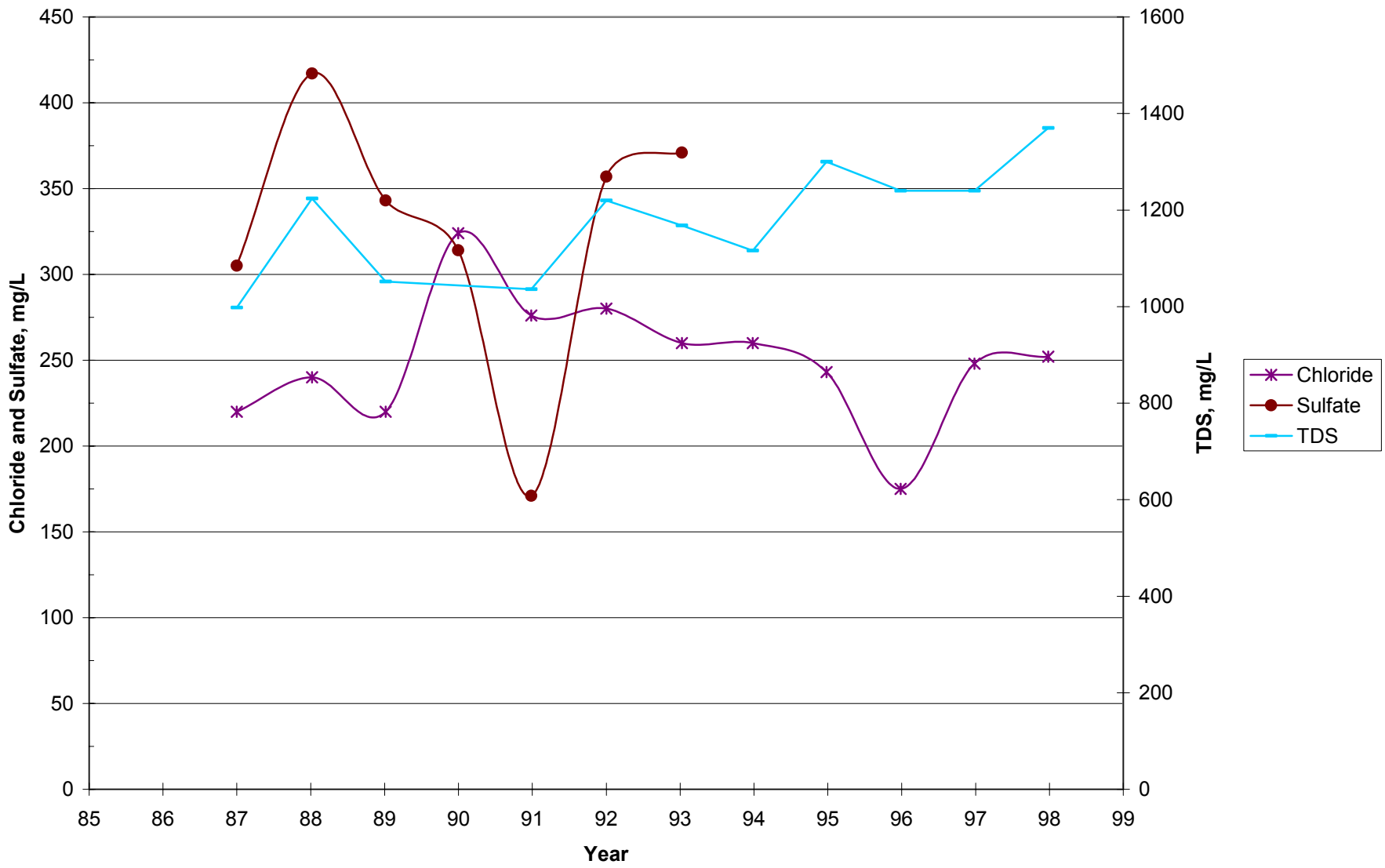


Figure 6. Conejo Creek Above Hill Canyon Summer Chloride, Sulfate, and TDS

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.

References

Durbin, T.J. Surface-Water and Groundwater Impacts of Wastewater Treatment Alternatives: Calleguas Creek Watershed, Ventura County, California. Fair Oaks, CA. 2002.

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.

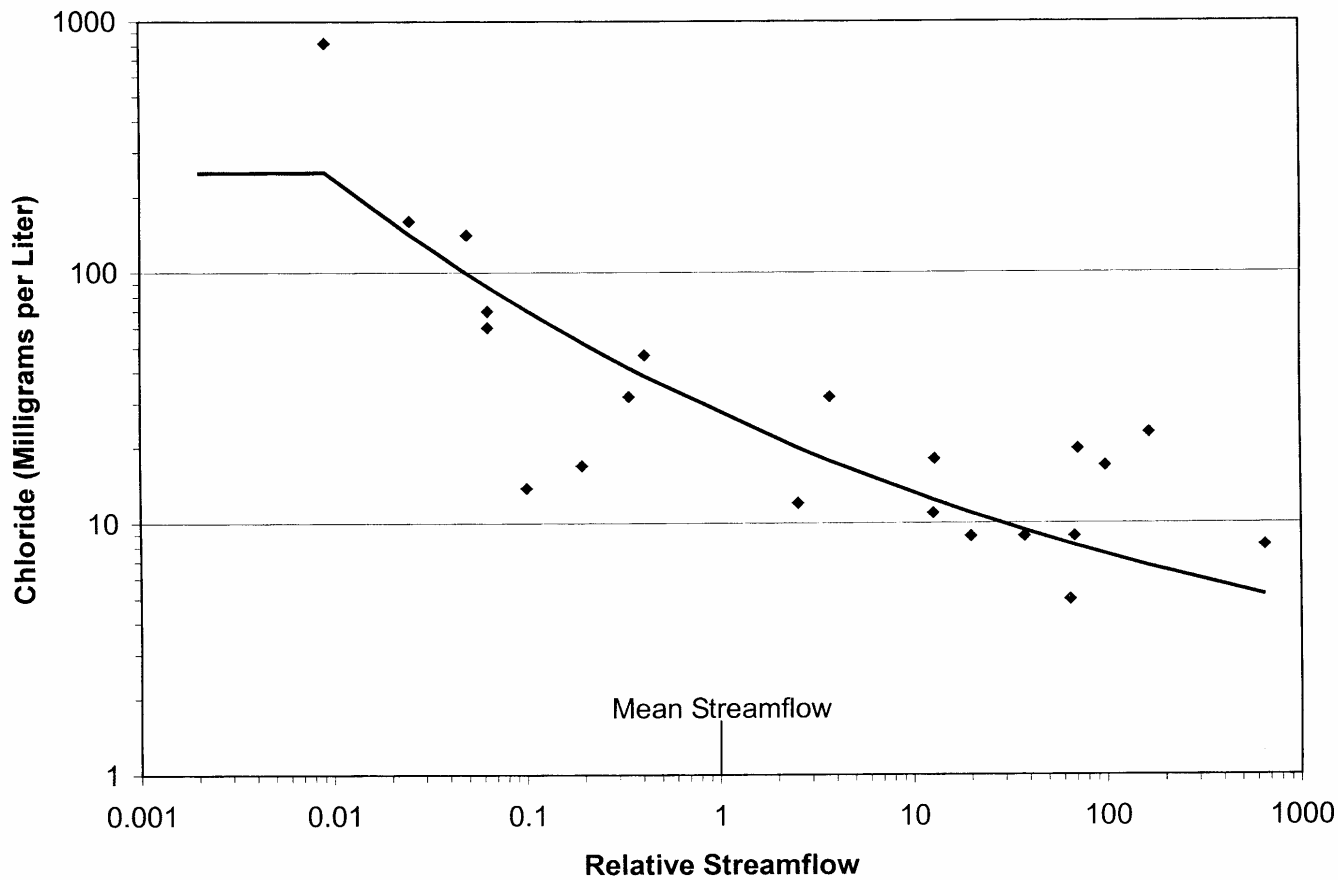


Figure 7. CC Surface Water Chloride Concentration vs. Relative Streamflow (from Durbin, 2002)

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**

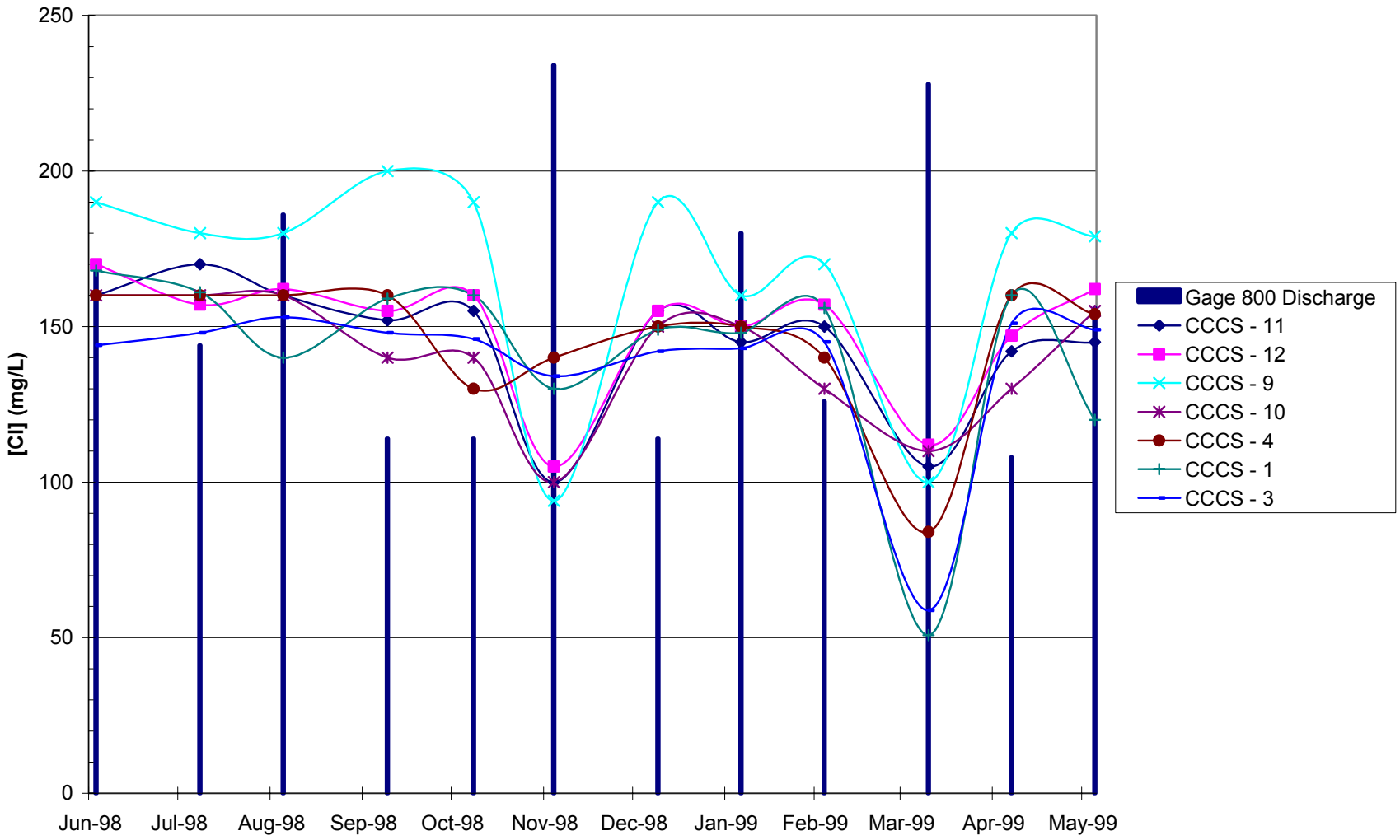


Figure 8. CCCS Receiving Water Chloride and Corresponding Gage 800 Discharge

Technical Memorandum
on
Stochastic Descriptions of Water Quality and Flows in the Calleguas Creek Watershed to Support the Calleguas Creek Dynamic Modeling System

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	

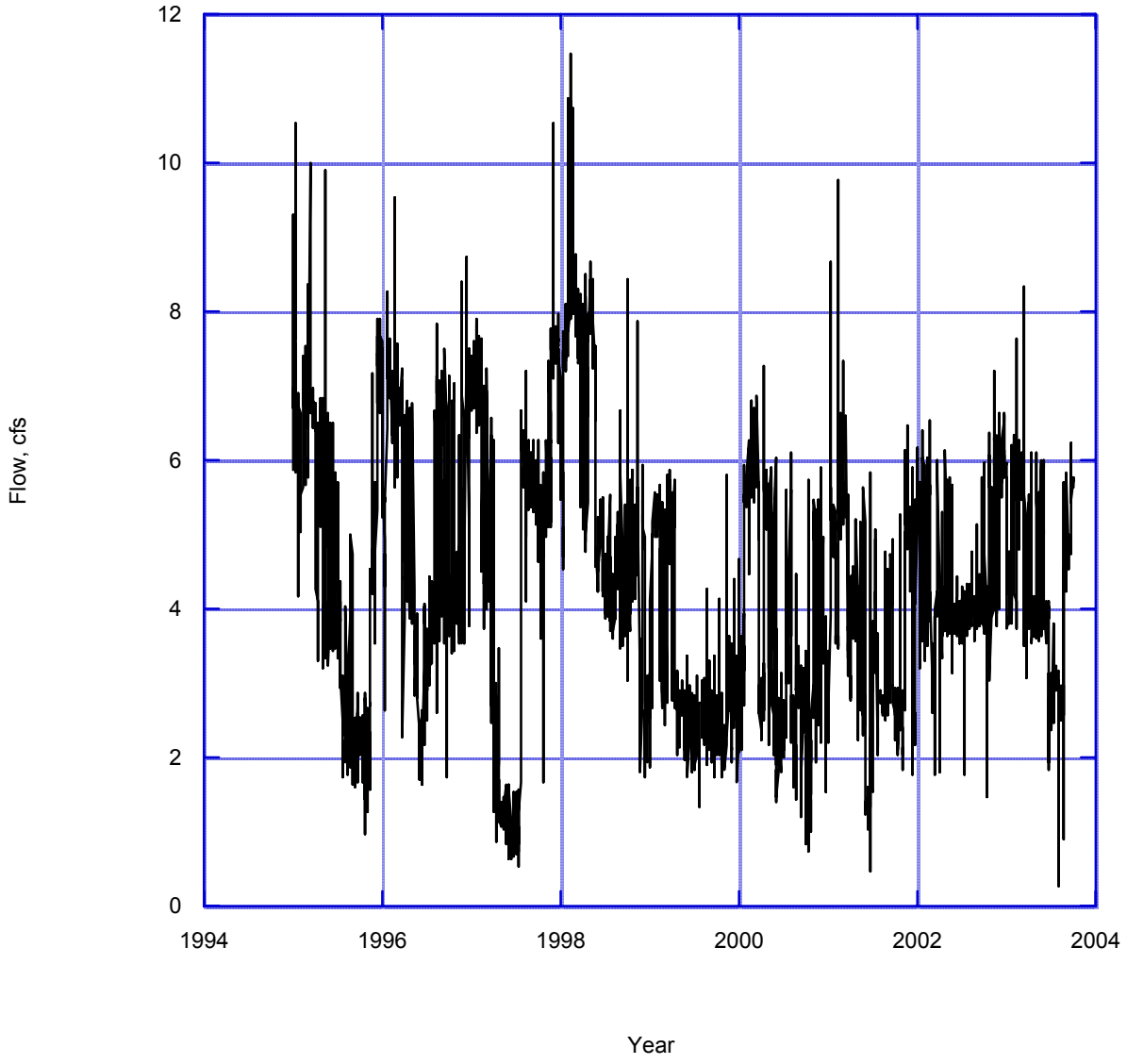


Figure 1. Camarillo Effluent Flow vs. Time

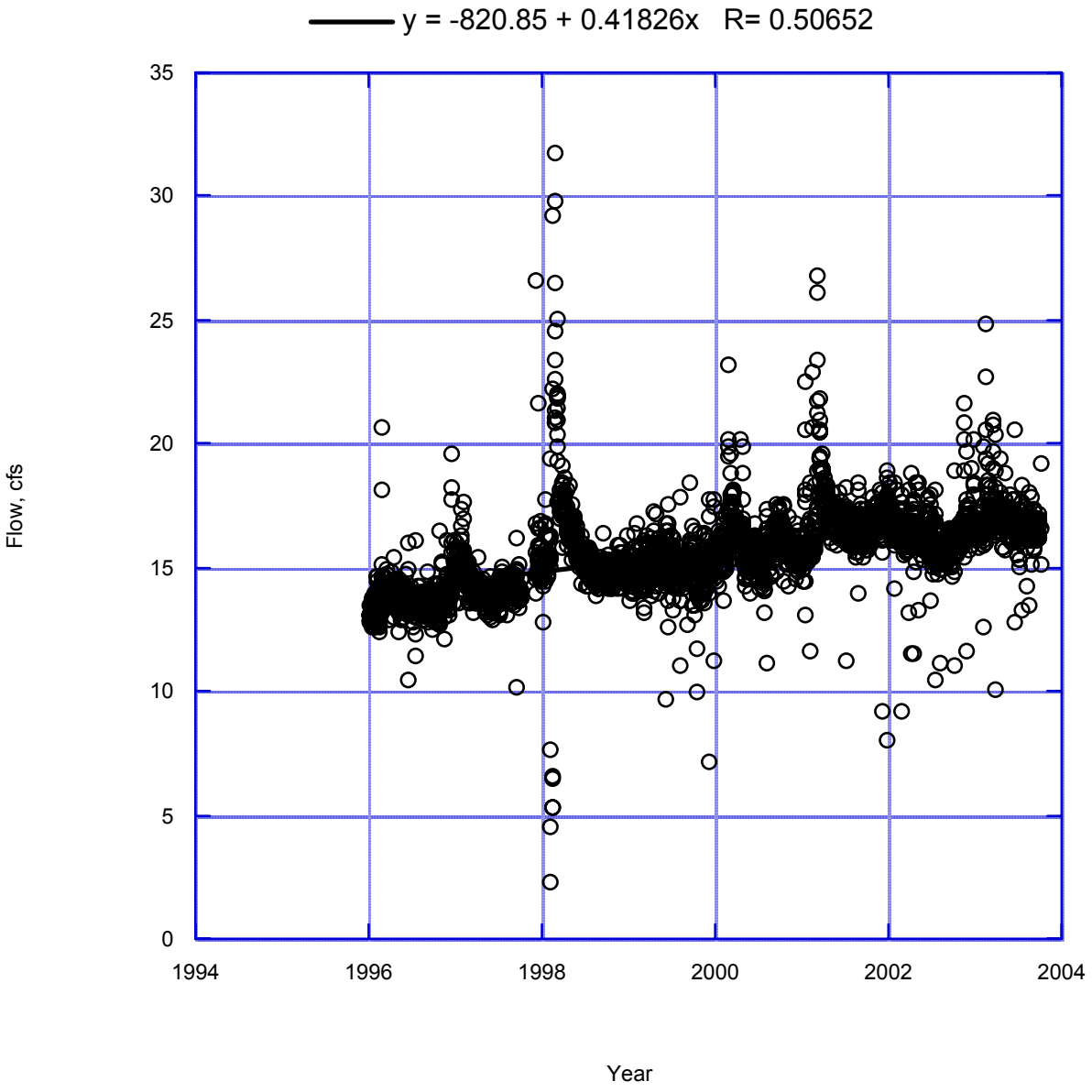


Figure 2. Hill Canyon Effluent Flow vs. Time

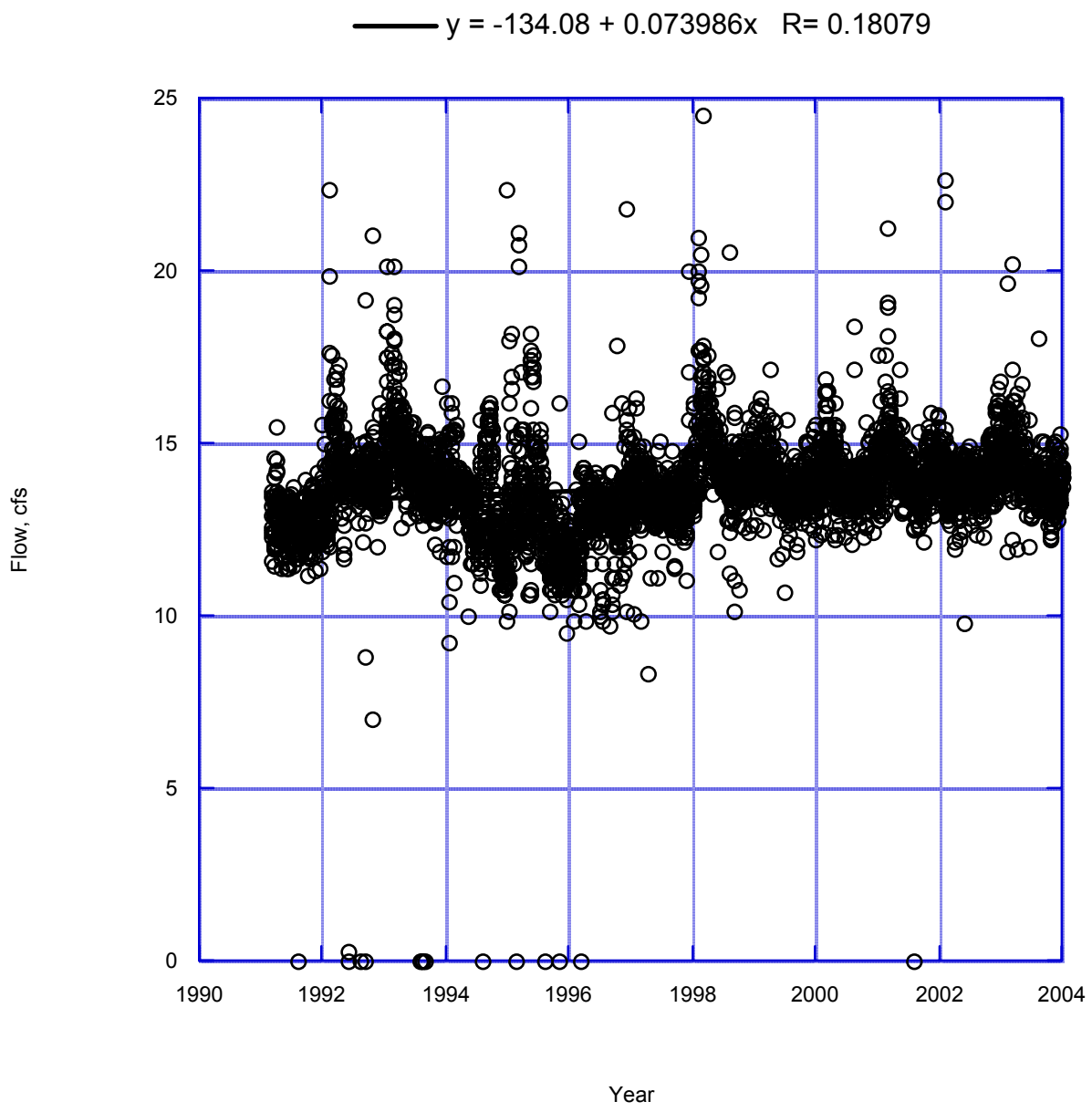


Figure 3. Simi Valley Effluent Flow vs. Time

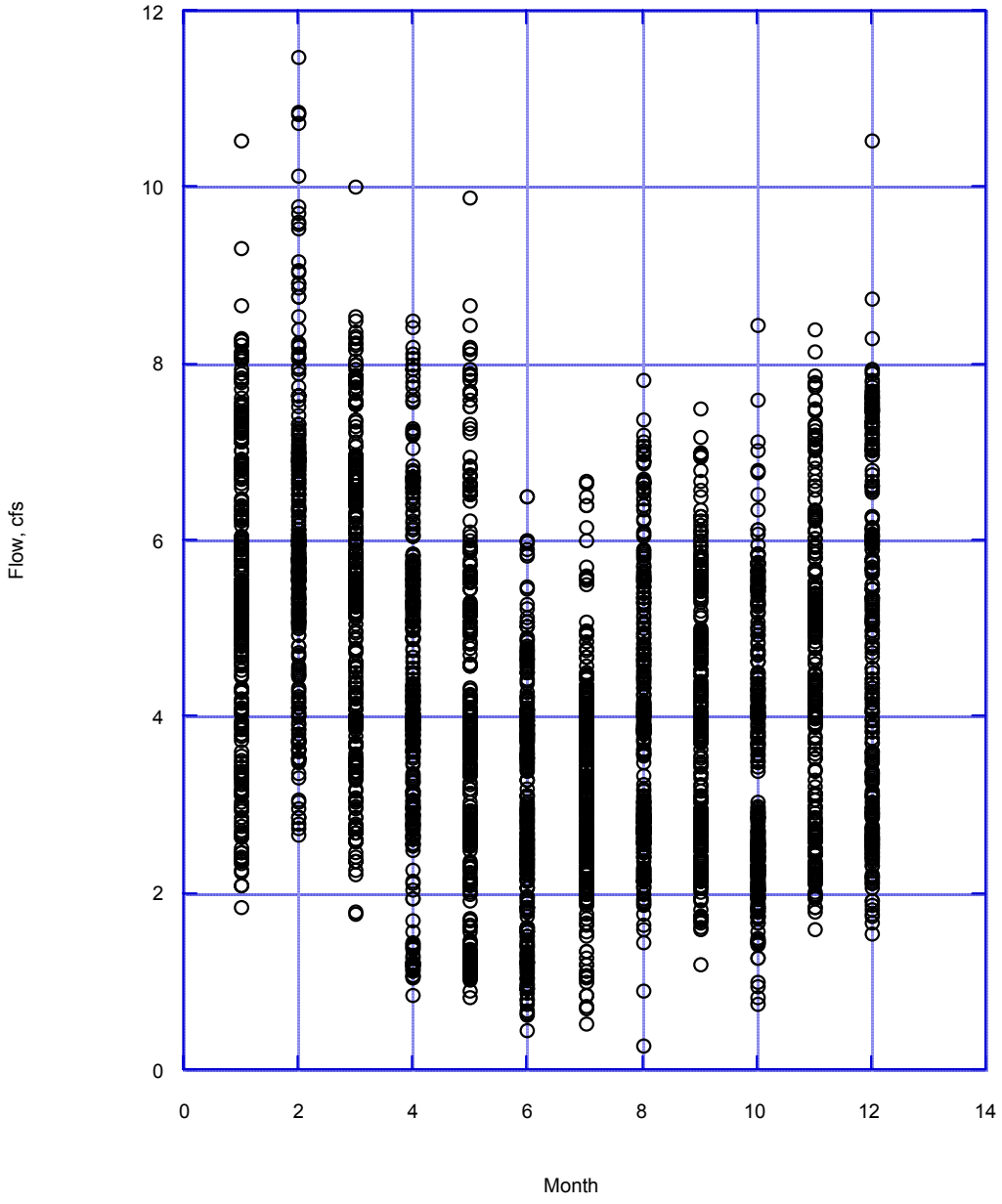


Figure 4. Camarillo Effluent Flow vs. Month

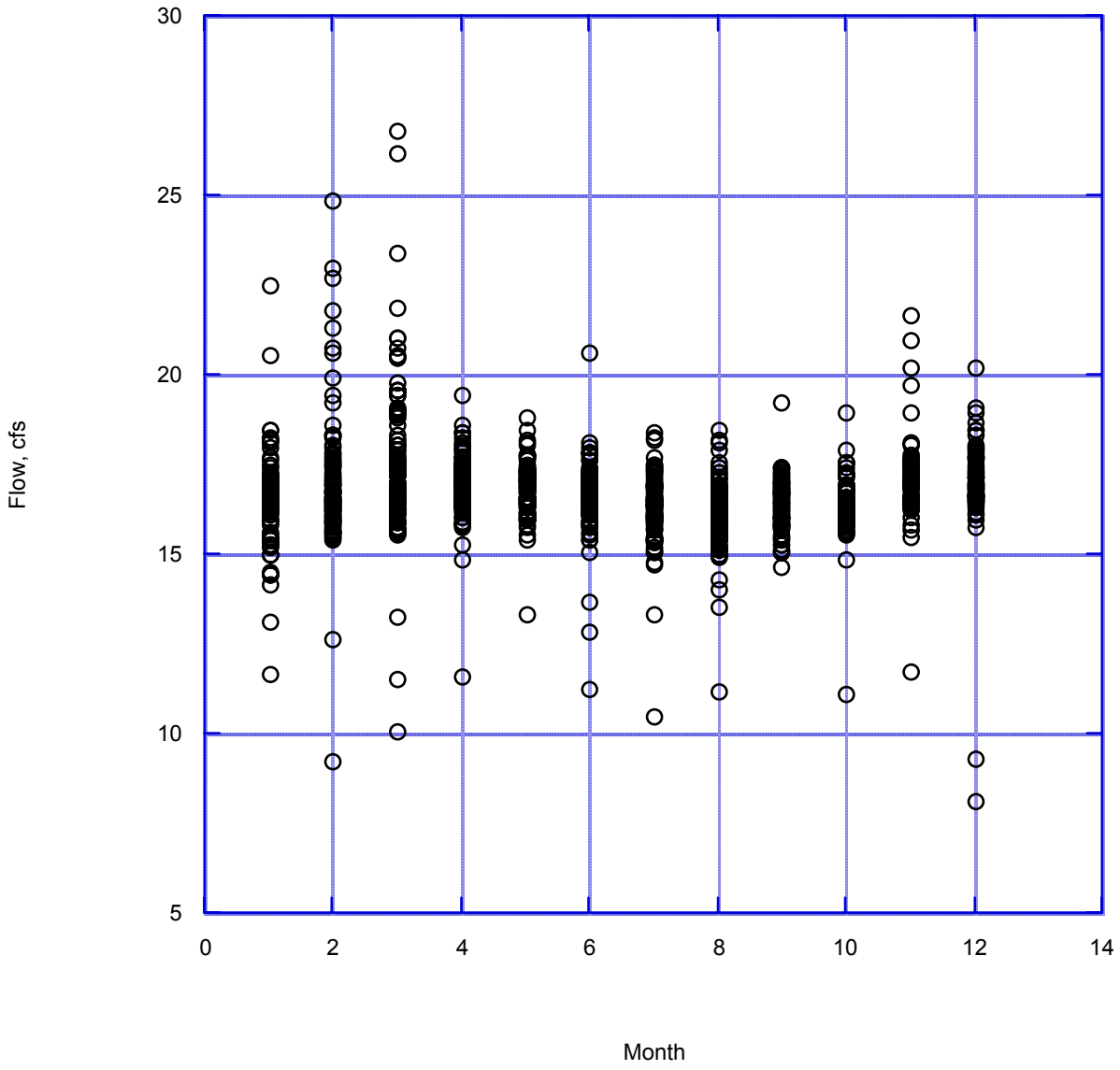


Figure 5. Hill Canyon Effluent Flow vs. Month (2001-2003)

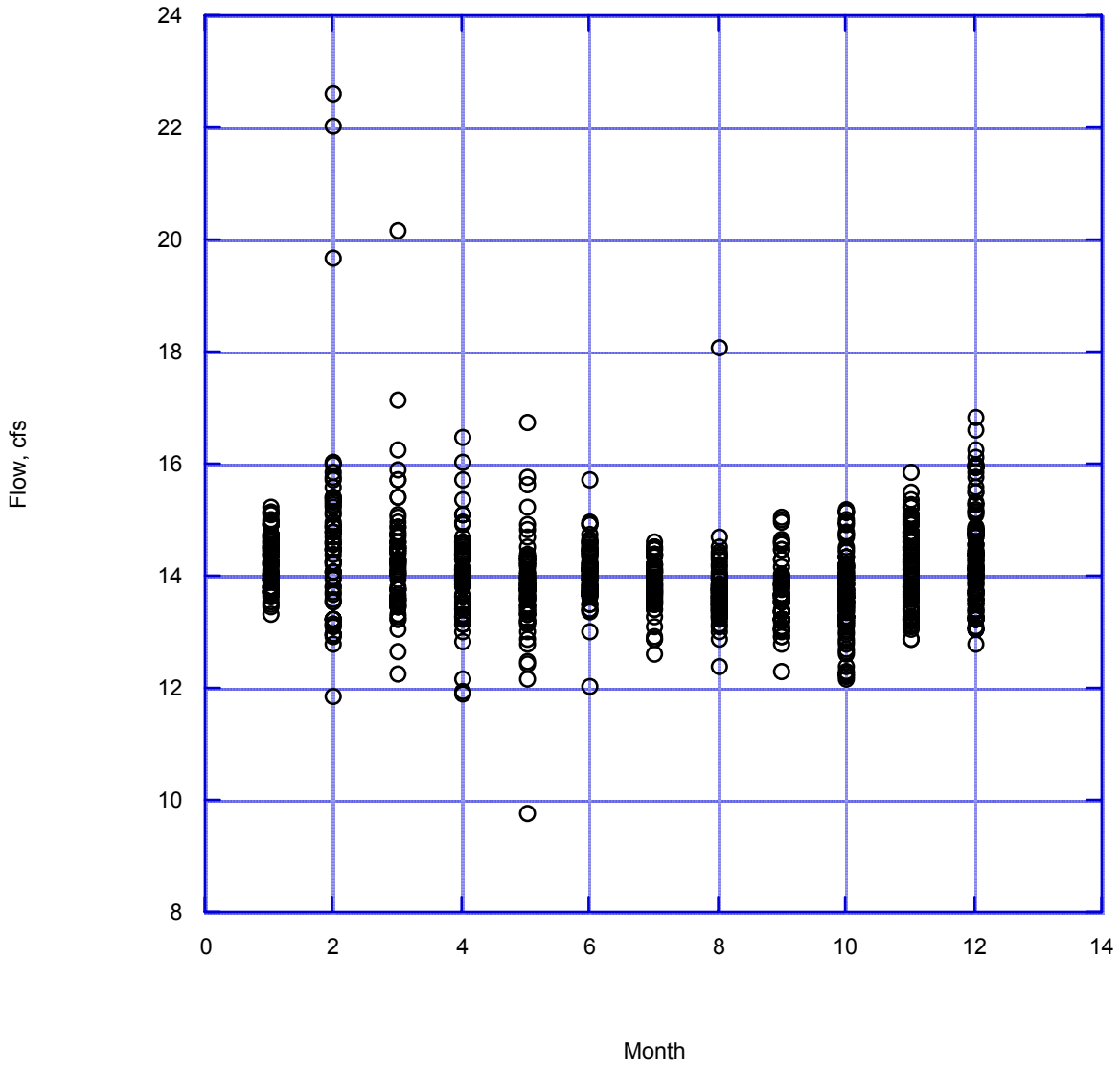


Figure 6. Simi Valley Effluent Flow vs. Month (2001-2003)

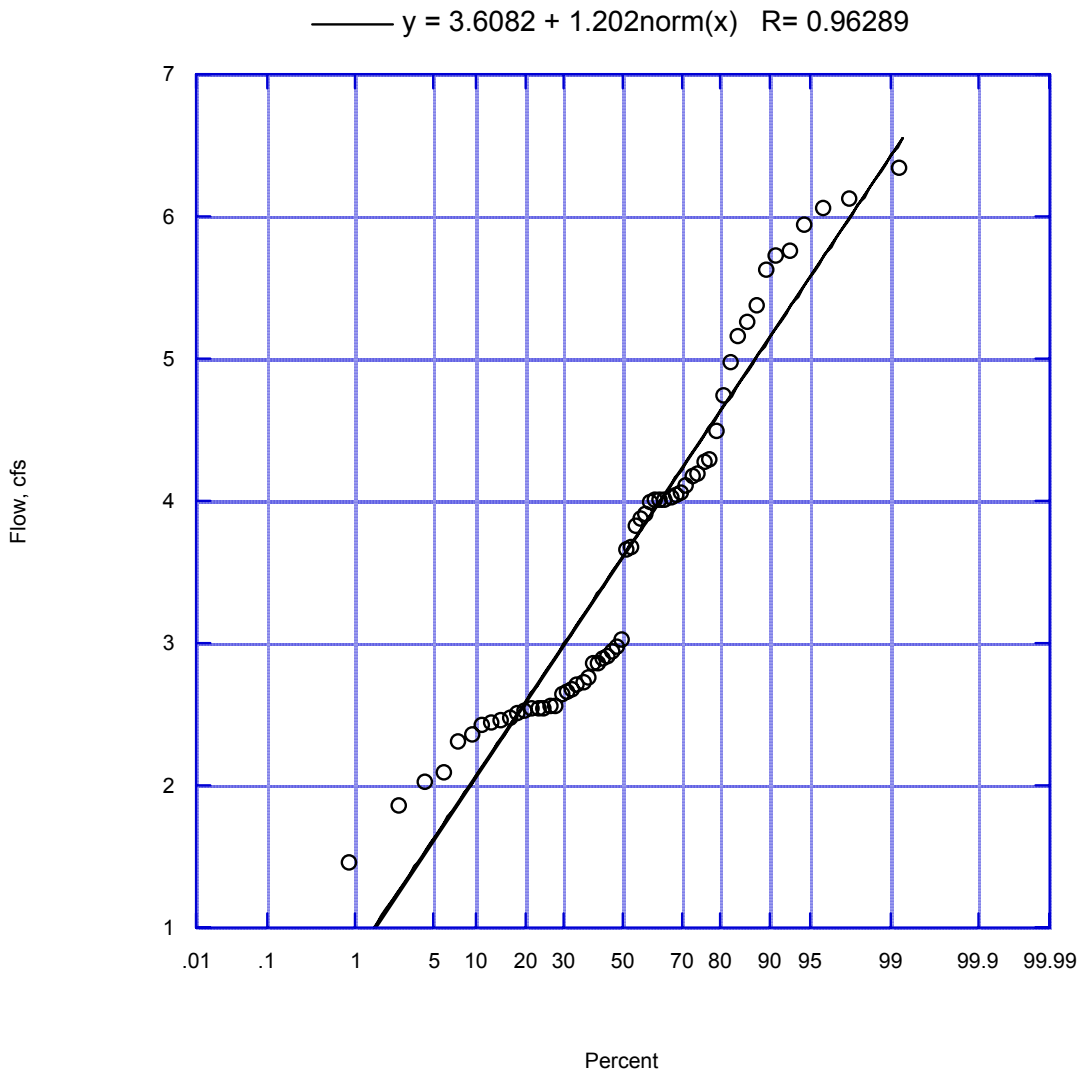


Figure 7. Camarillo Effluent Flow Frequency Distribution – Oct (01-02)

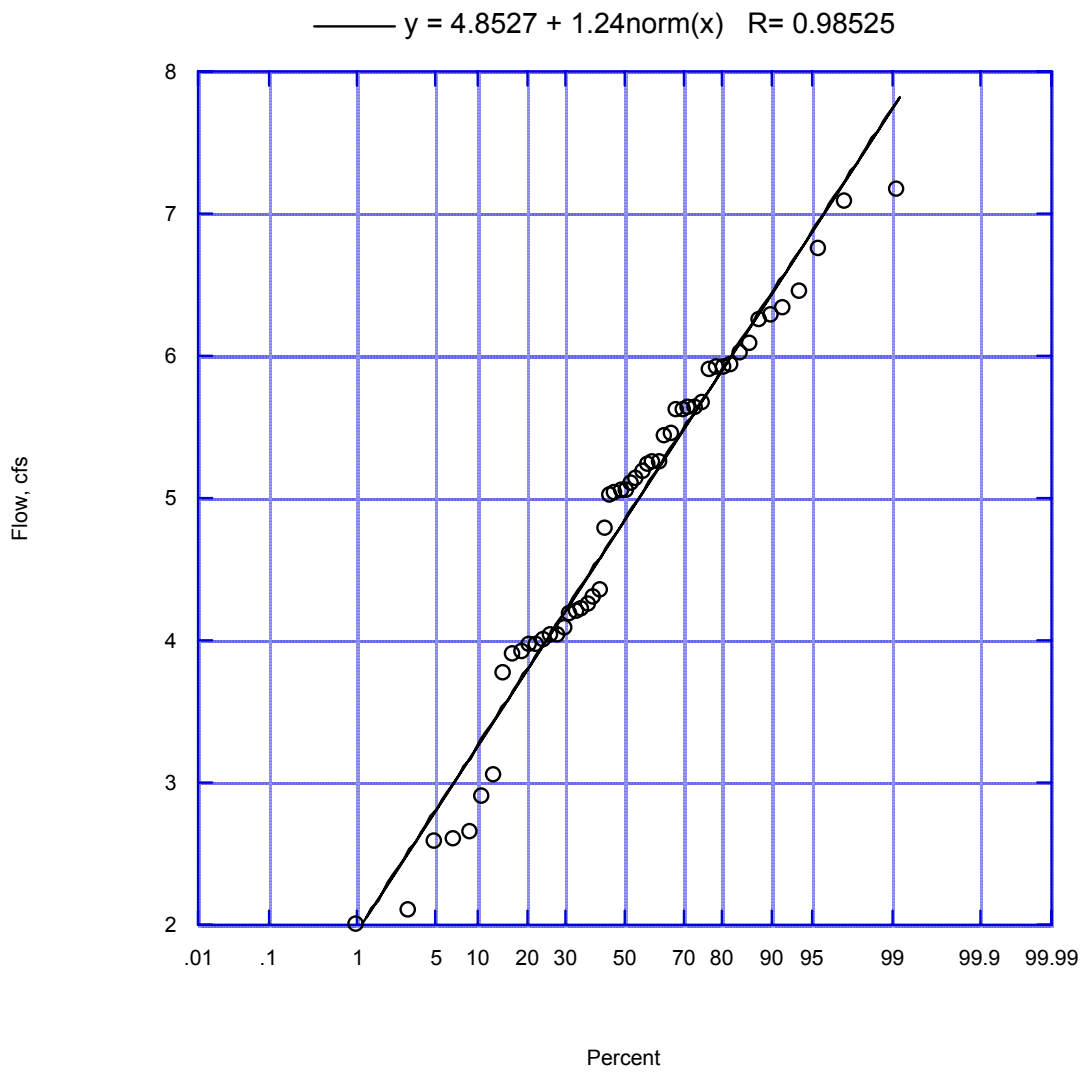


Figure 8. Camarillo Effluent Flow Frequency Distribution - Nov (01-02)

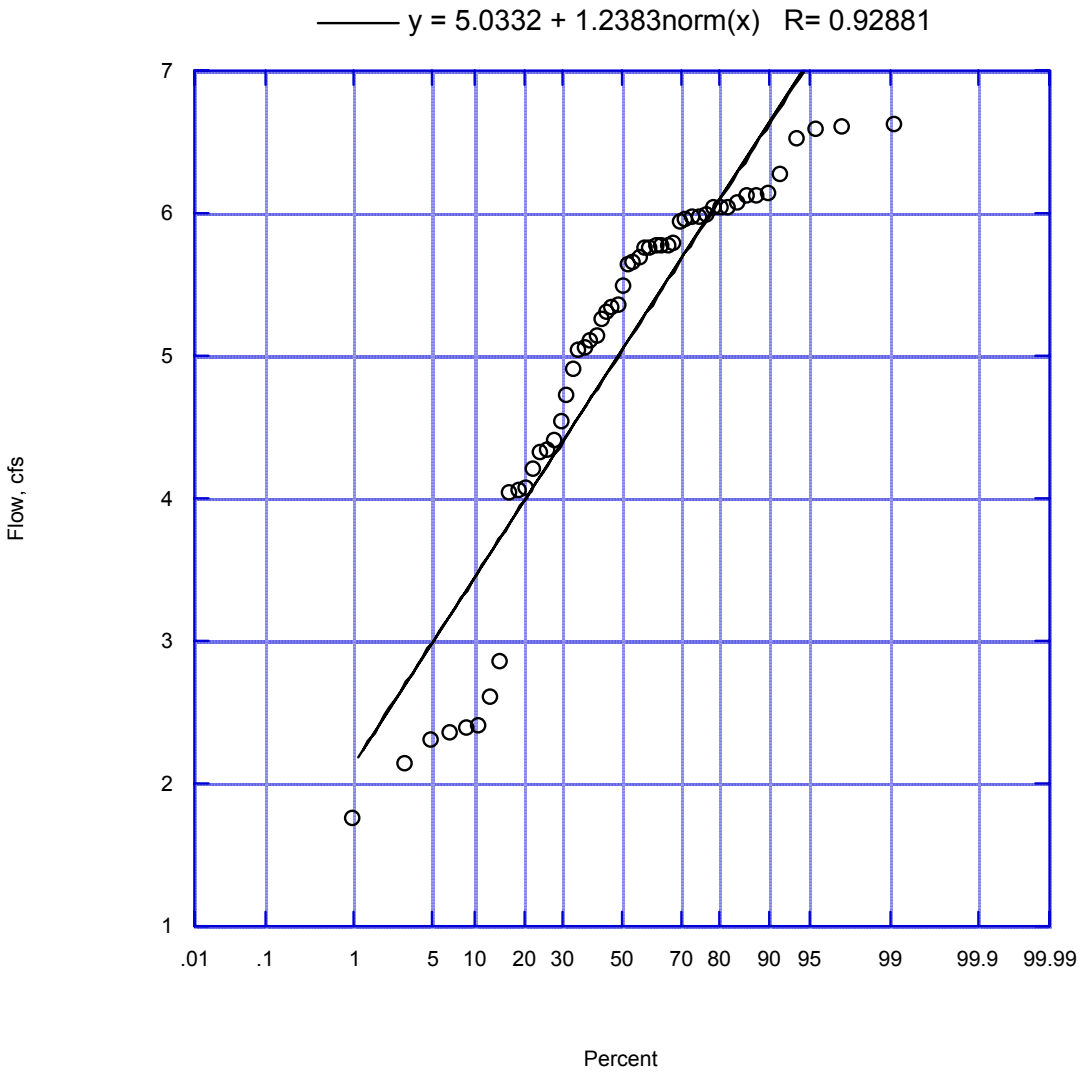


Figure 9. Camarillo Effluent Flow Frequency Distribution - Dec (01-02)

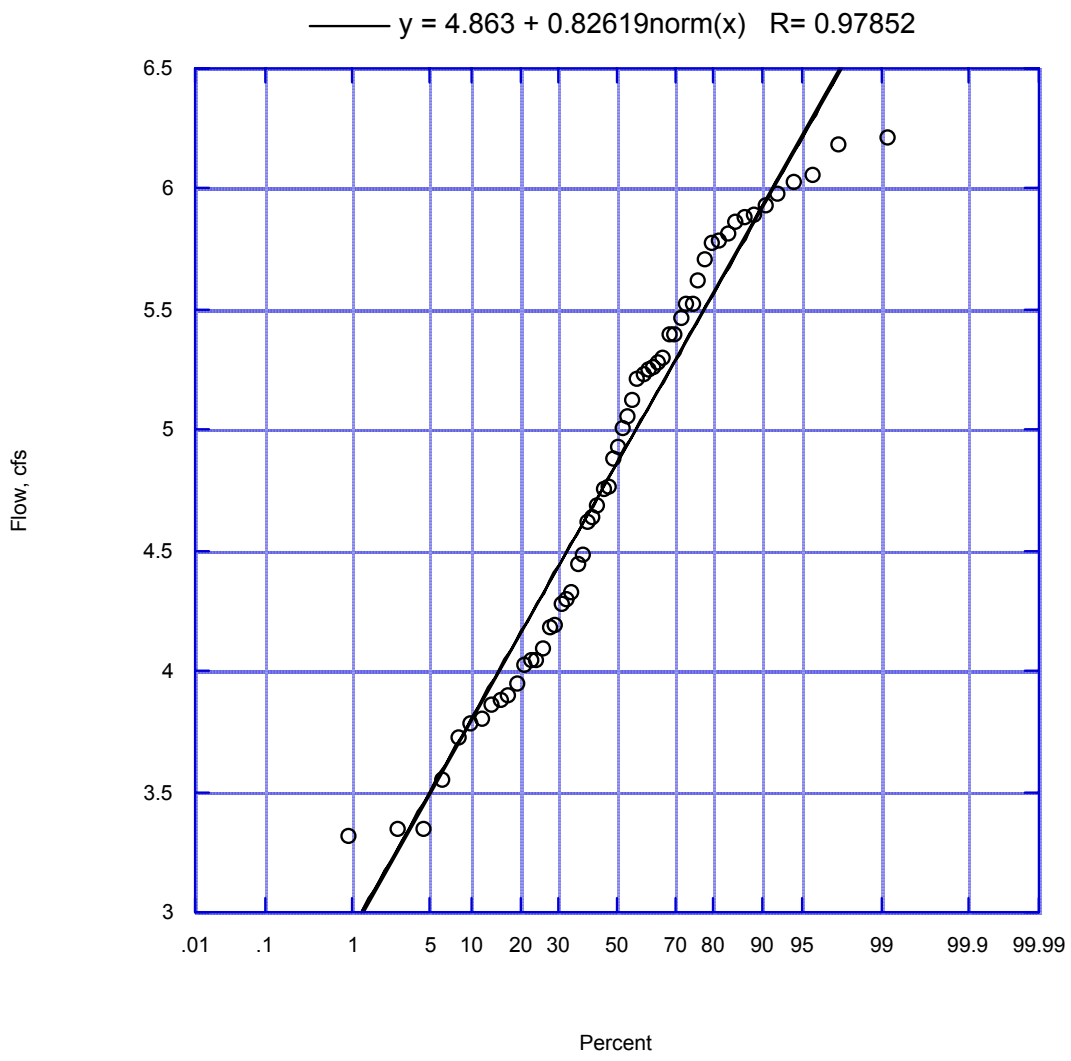


Figure 10. Camarillo Effluent Flow Frequency Distribution - Jan (02-03)

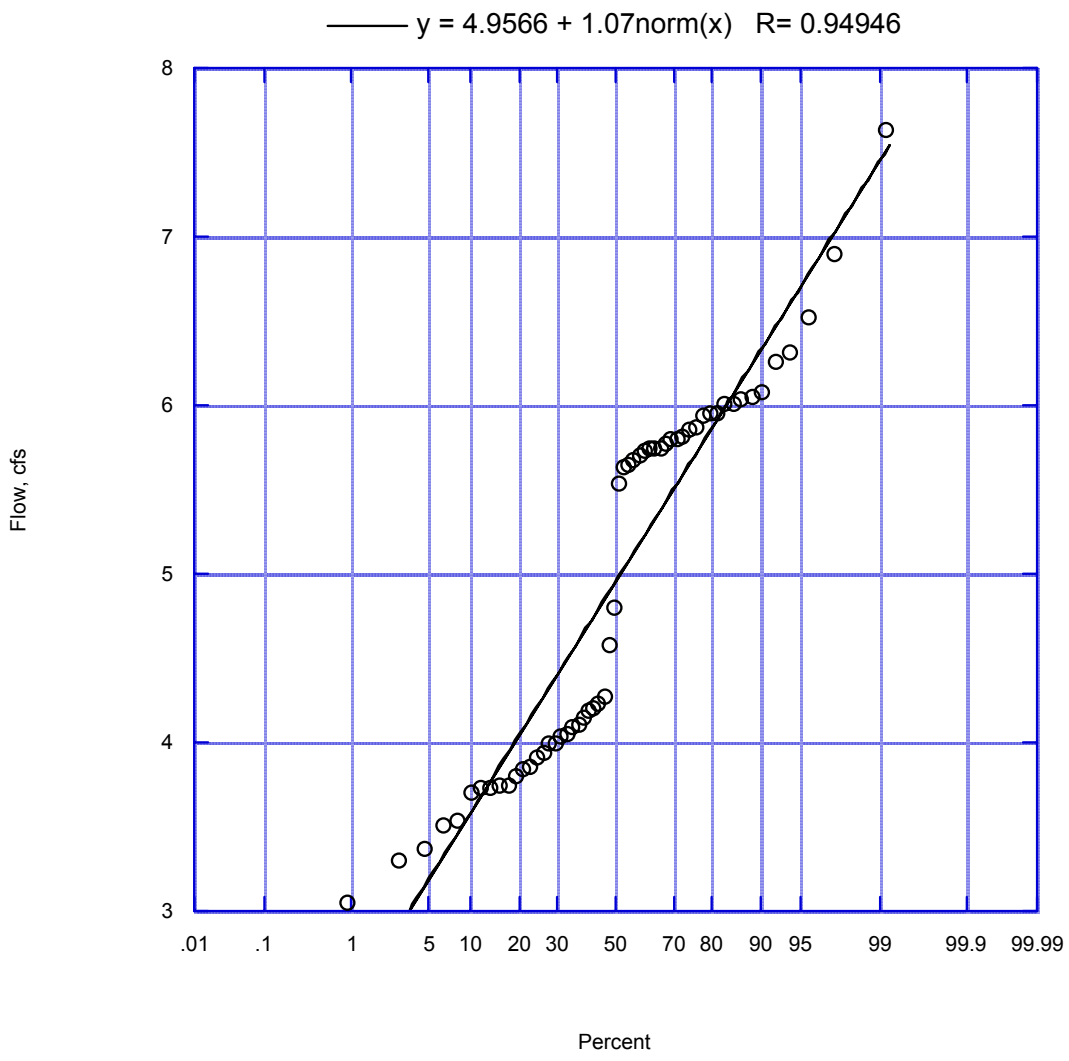


Figure 11. Camarillo Effluent Flow Frequency Distribution - Feb (02-03)

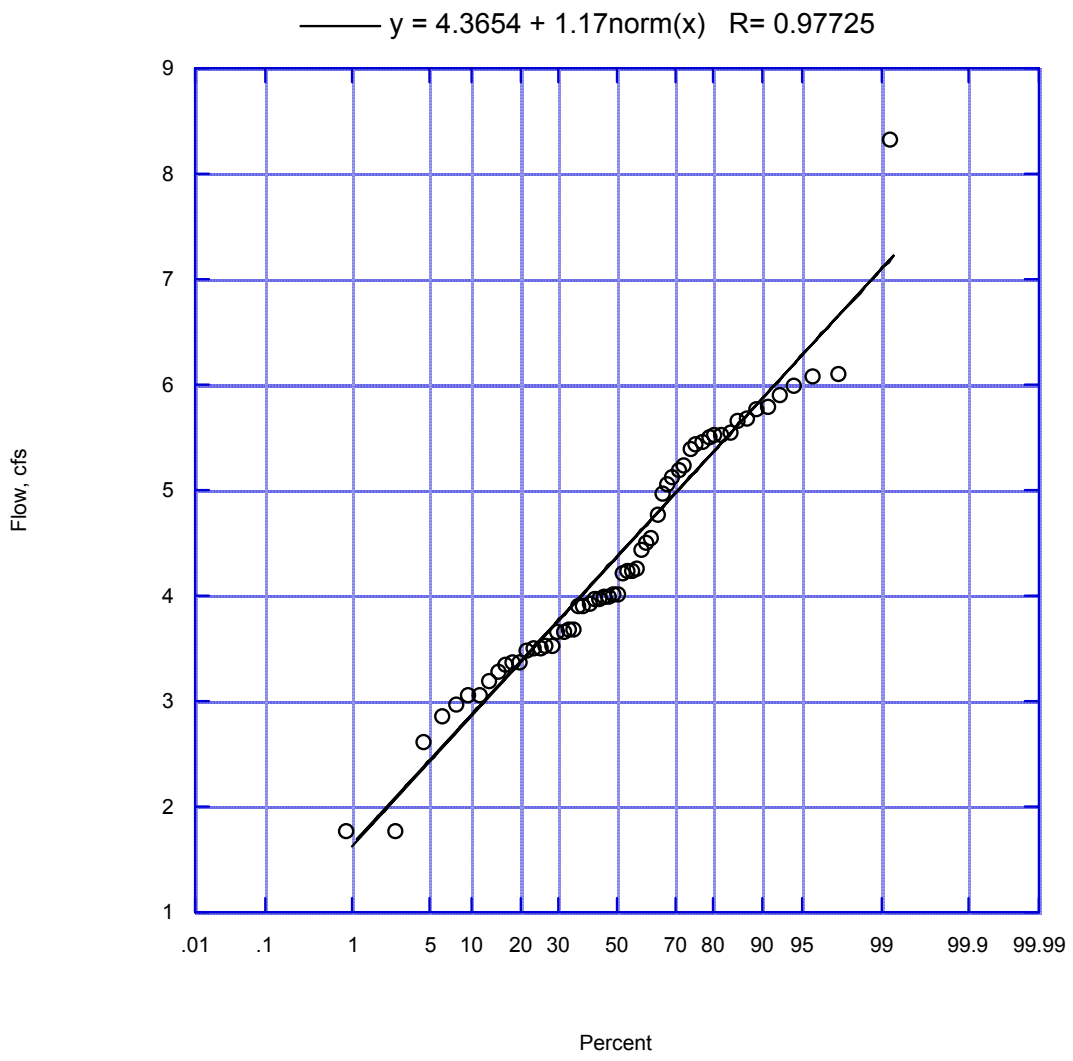


Figure 12. Camarillo Effluent Flow Frequency Distribution - Mar (02-03)

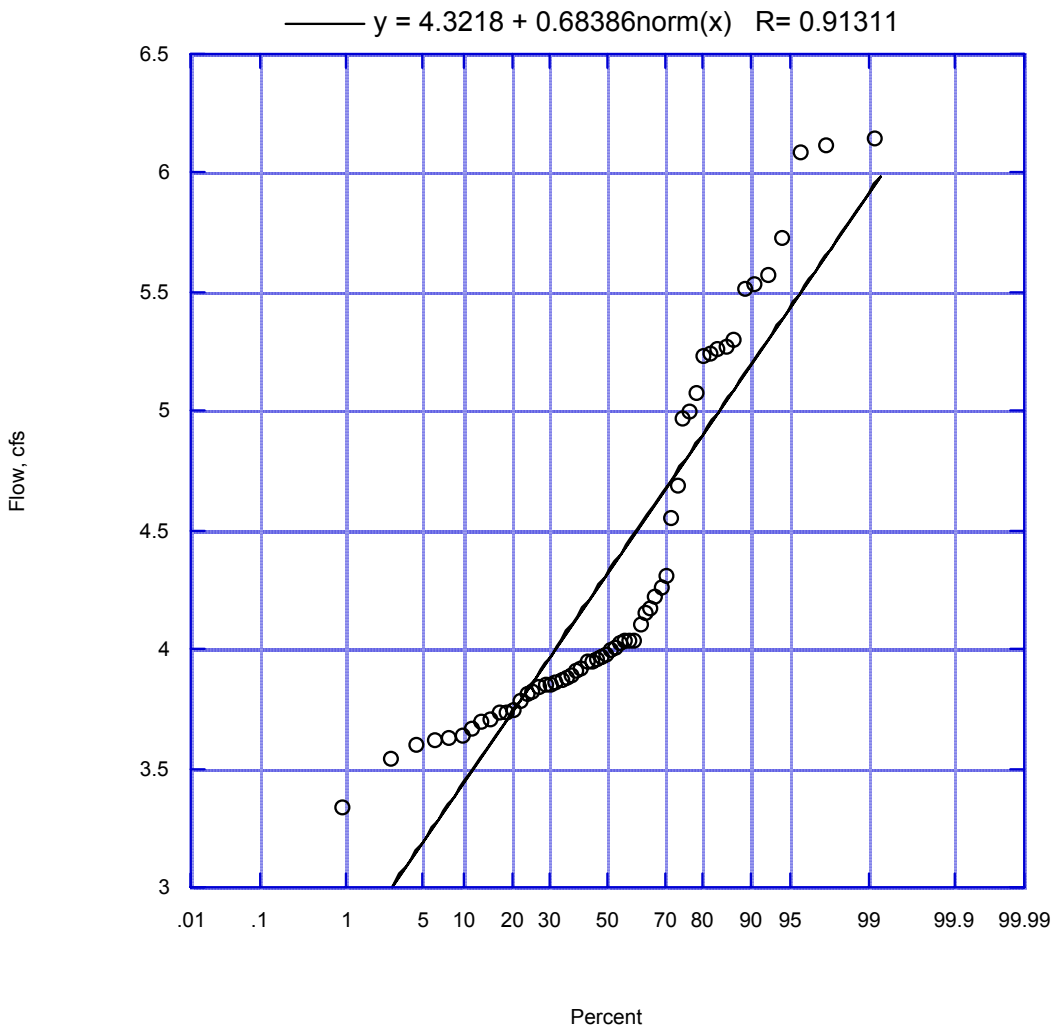


Figure 13. Camarillo Effluent Flow Frequency Distribution - April (02-03)

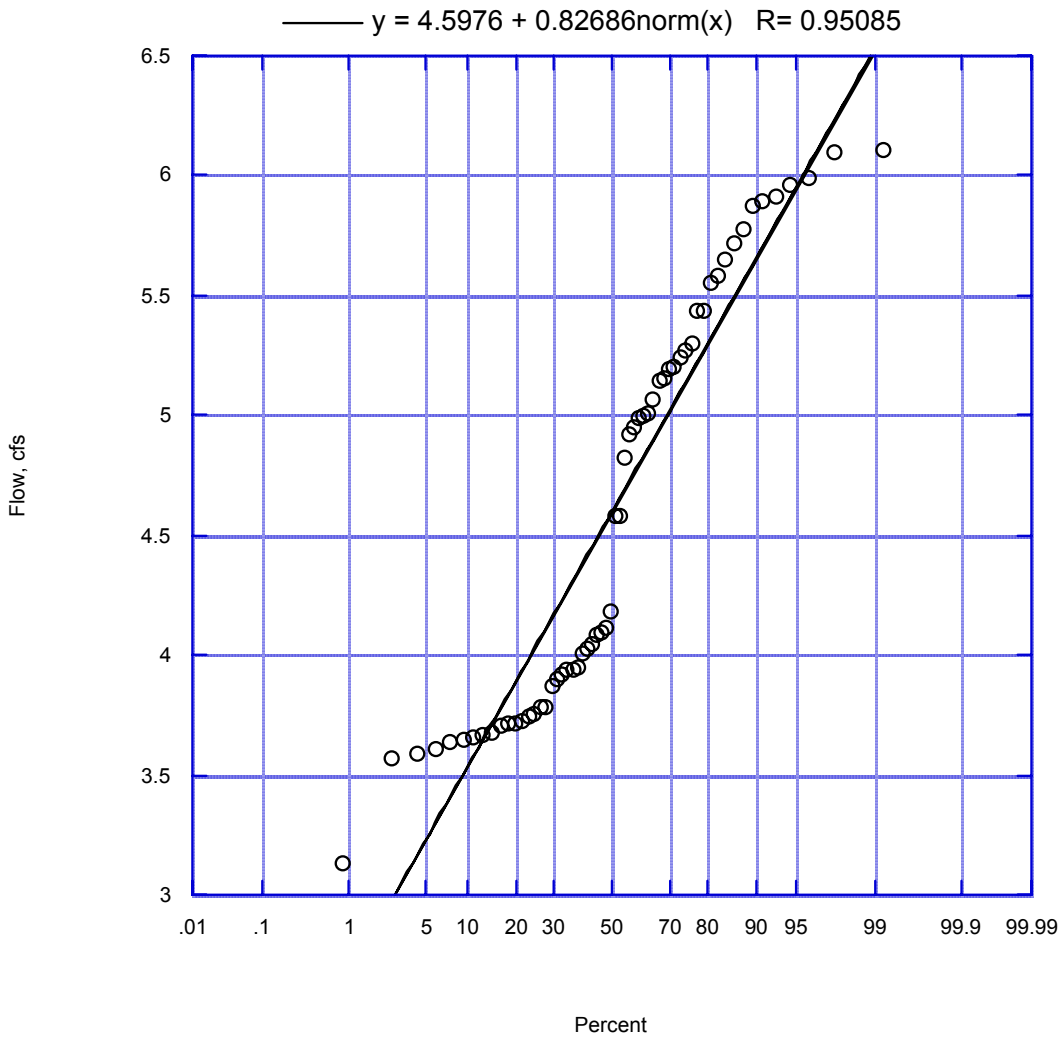


Figure 14. Camarillo Effluent Flow Frequency Distribution - May (02-03)

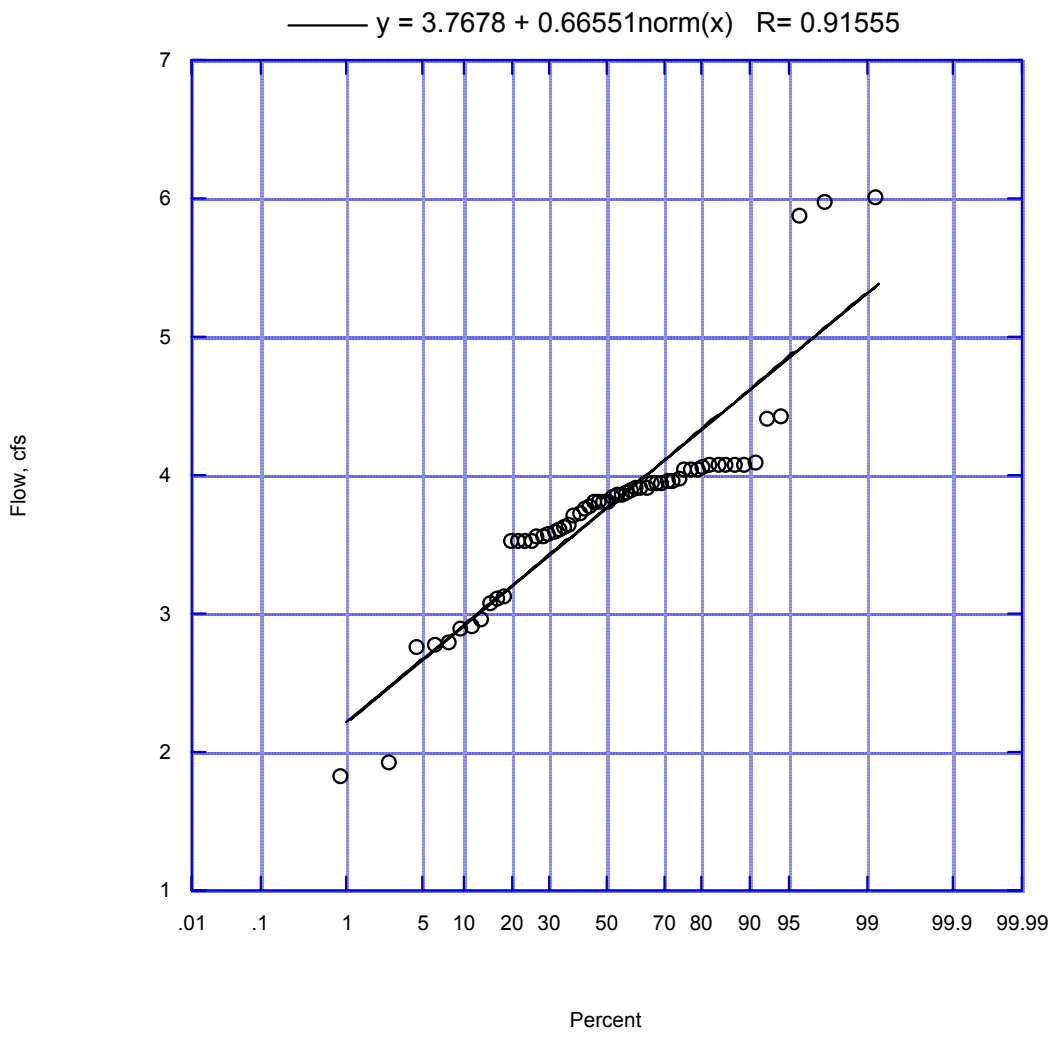


Figure 15. Camarillo Effluent Flow Frequency Distribution - June (02-03)

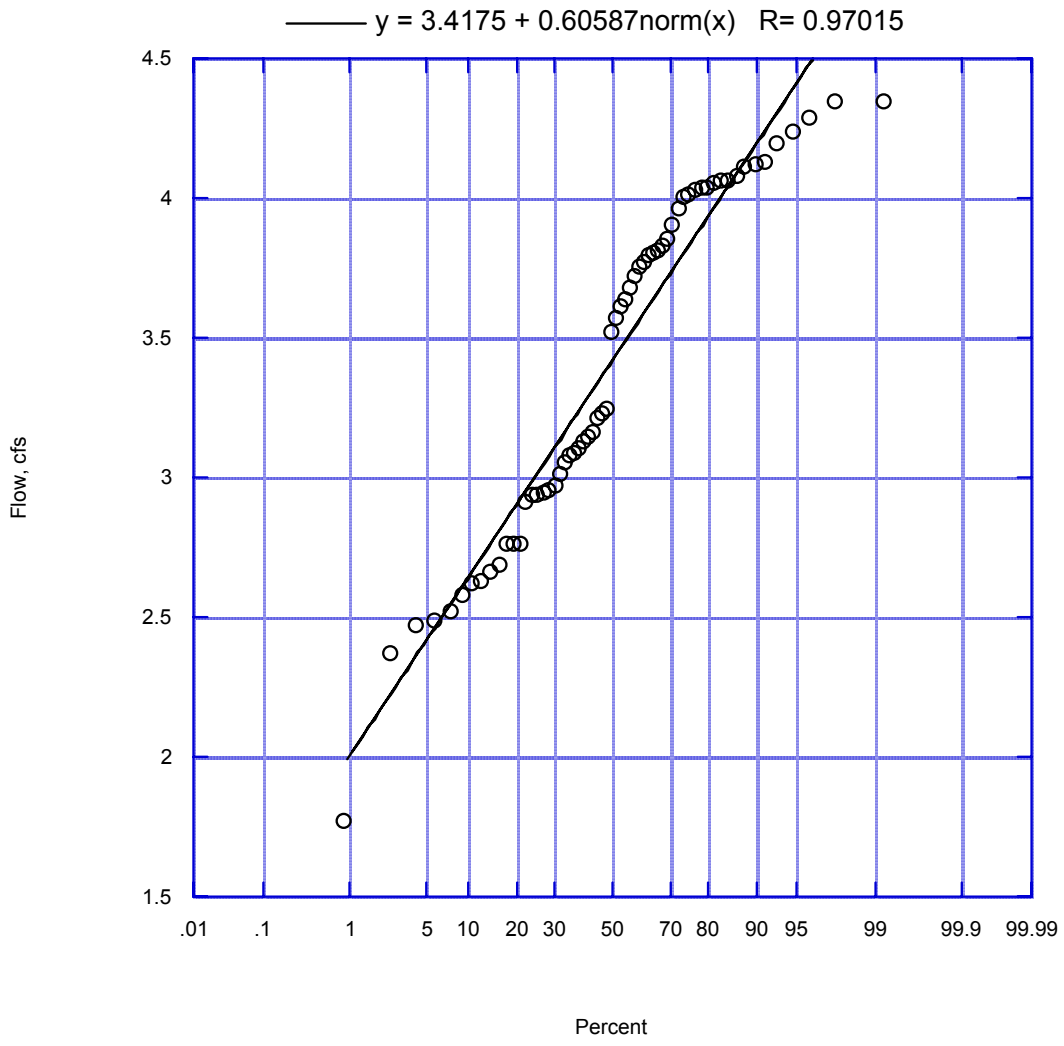


Figure 16. Camarillo Effluent Flow Frequency Distribution - July (02-03)

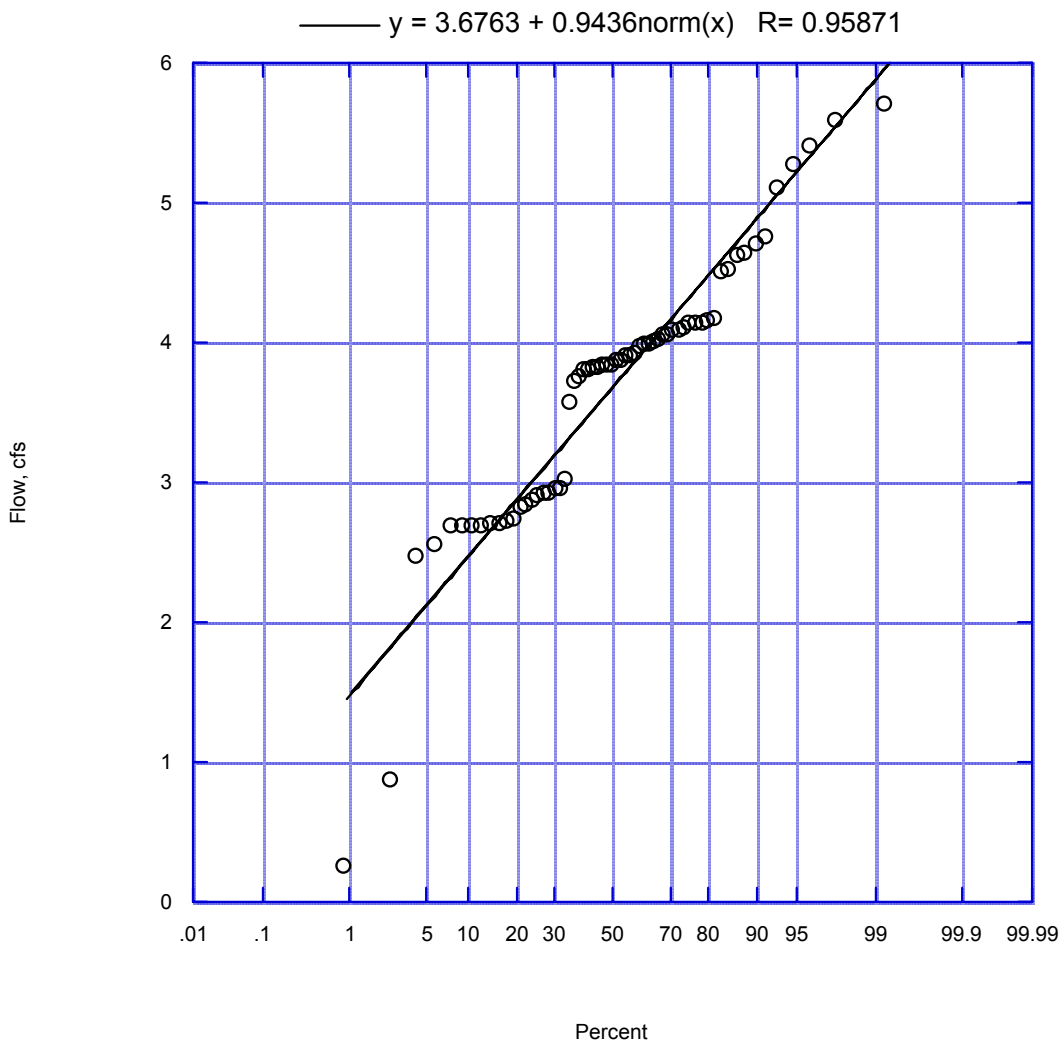


Figure 17. Camarillo Effluent Flow Frequency Distribution - Aug (02-03)

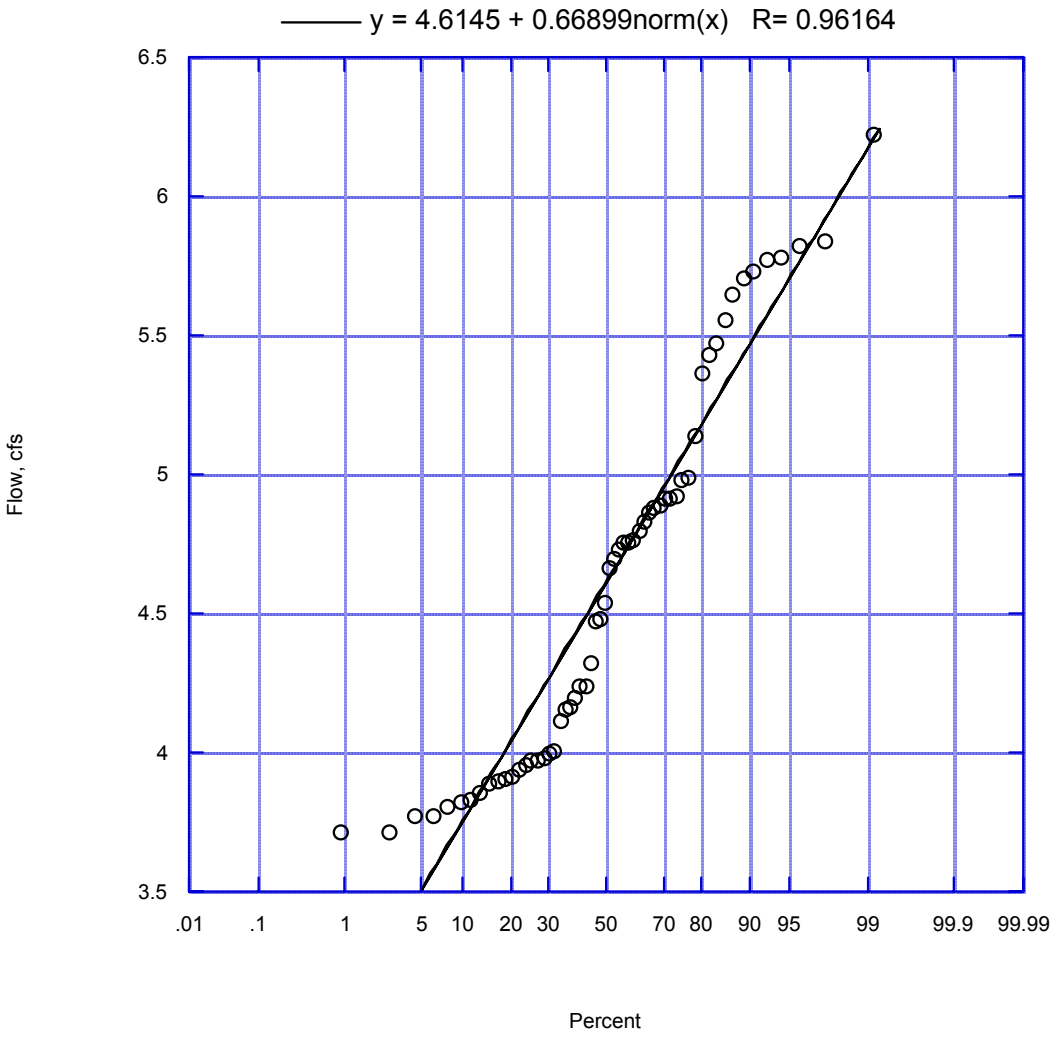


Figure 18. Camarillo Effluent Flow Frequency Distribution - Sept (02-03)

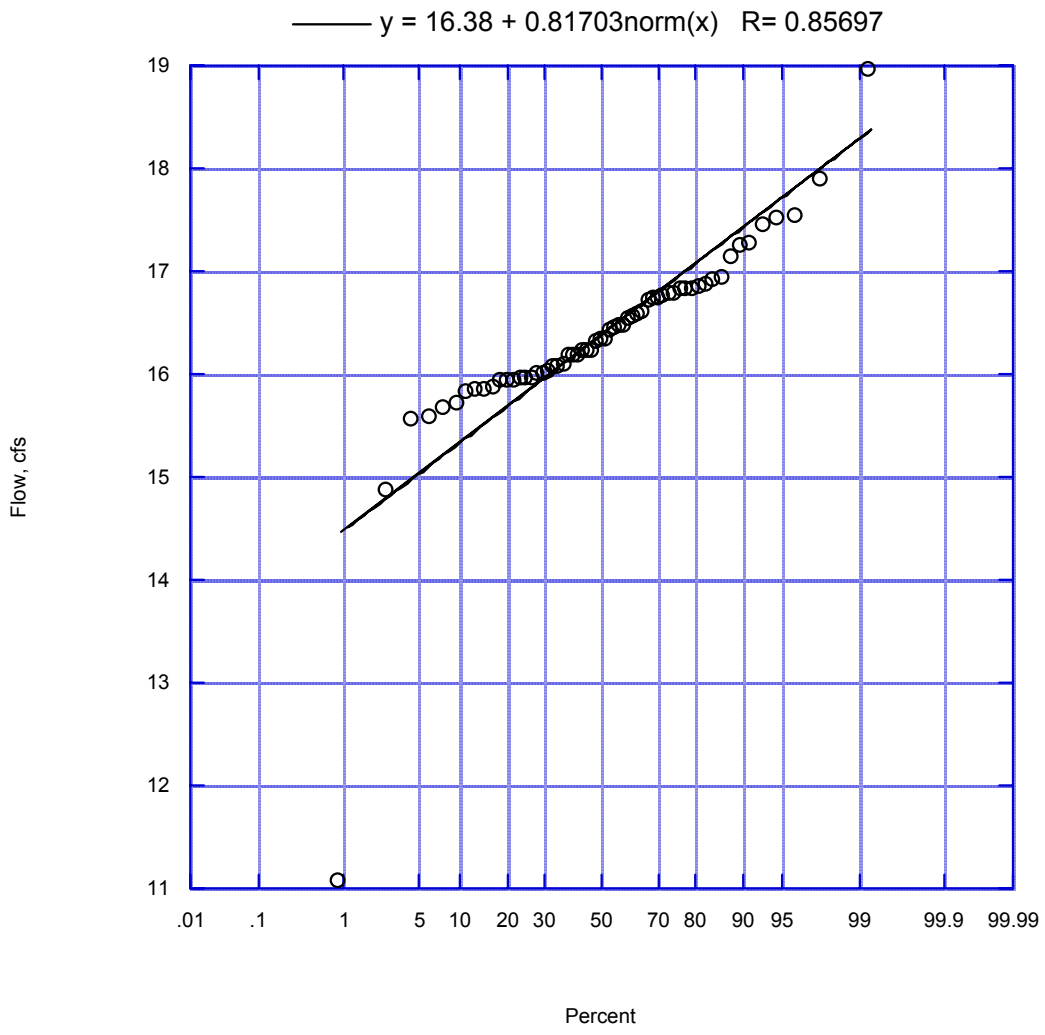


Figure 19. Hill Canyon Effluent Flow Frequency Distribution - Oct (01-02)

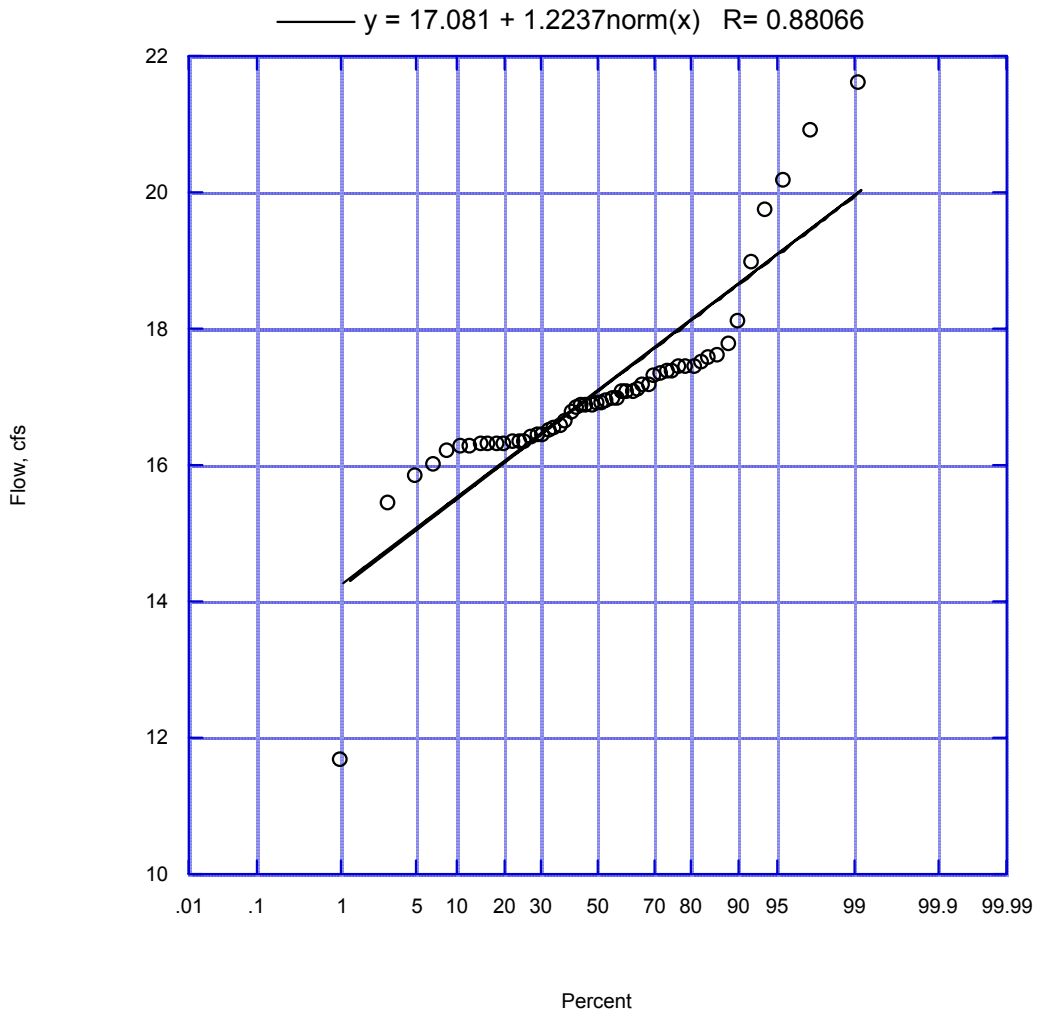


Figure 20. Hill Canyon Effluent Flow Frequency Distribution - Nov (01-02)

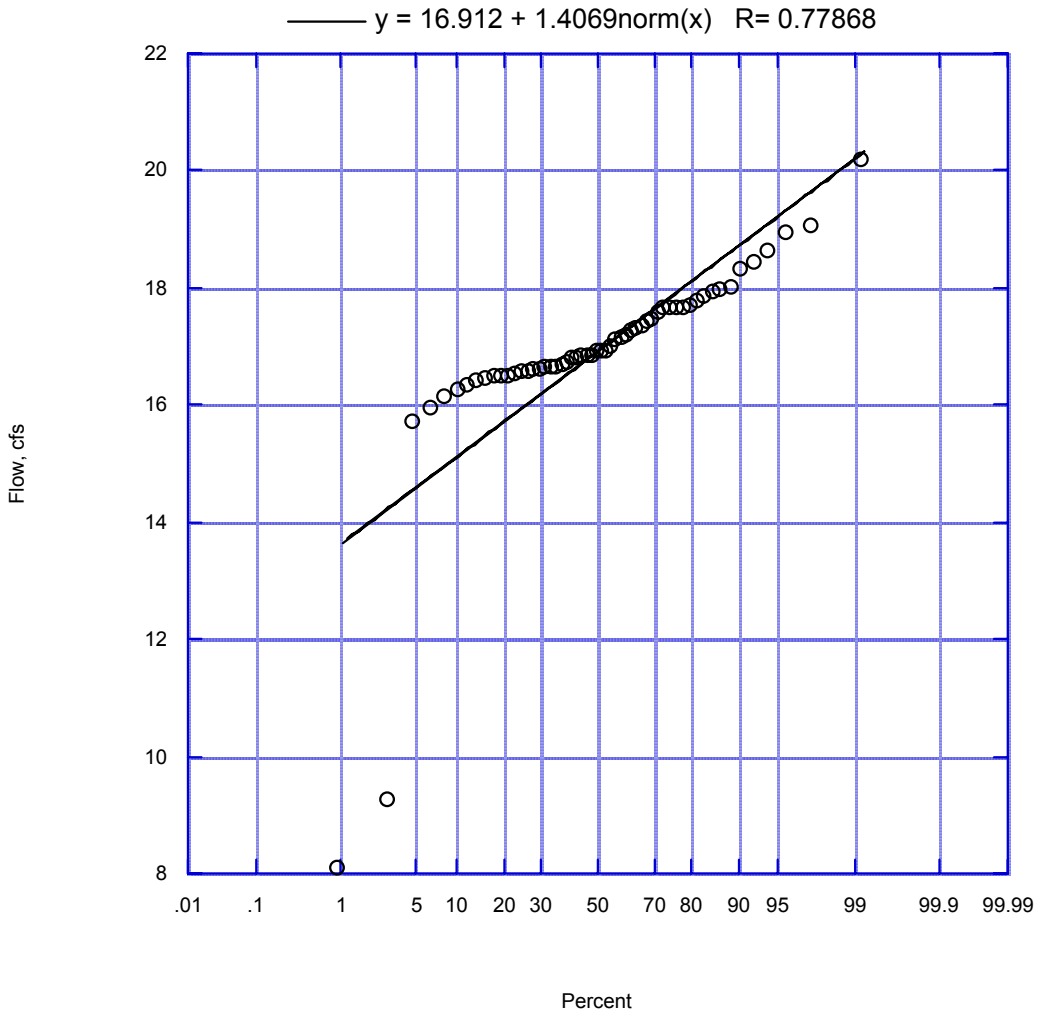


Figure 21. Hill Canyon Effluent Flow Frequency Distribution - Dec (01-02)

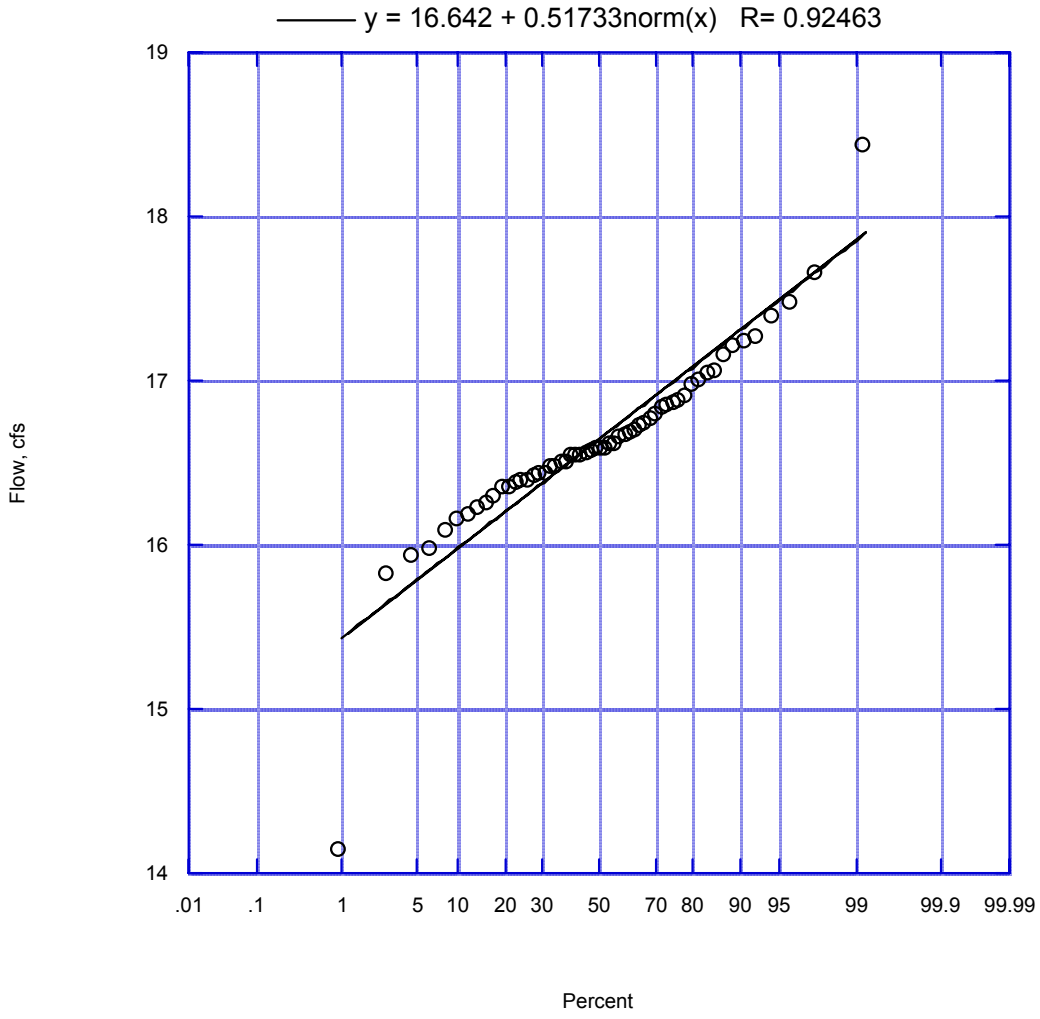


Figure 22. Hill Canyon Effluent Flow Frequency Distribution - Jan (02-03)

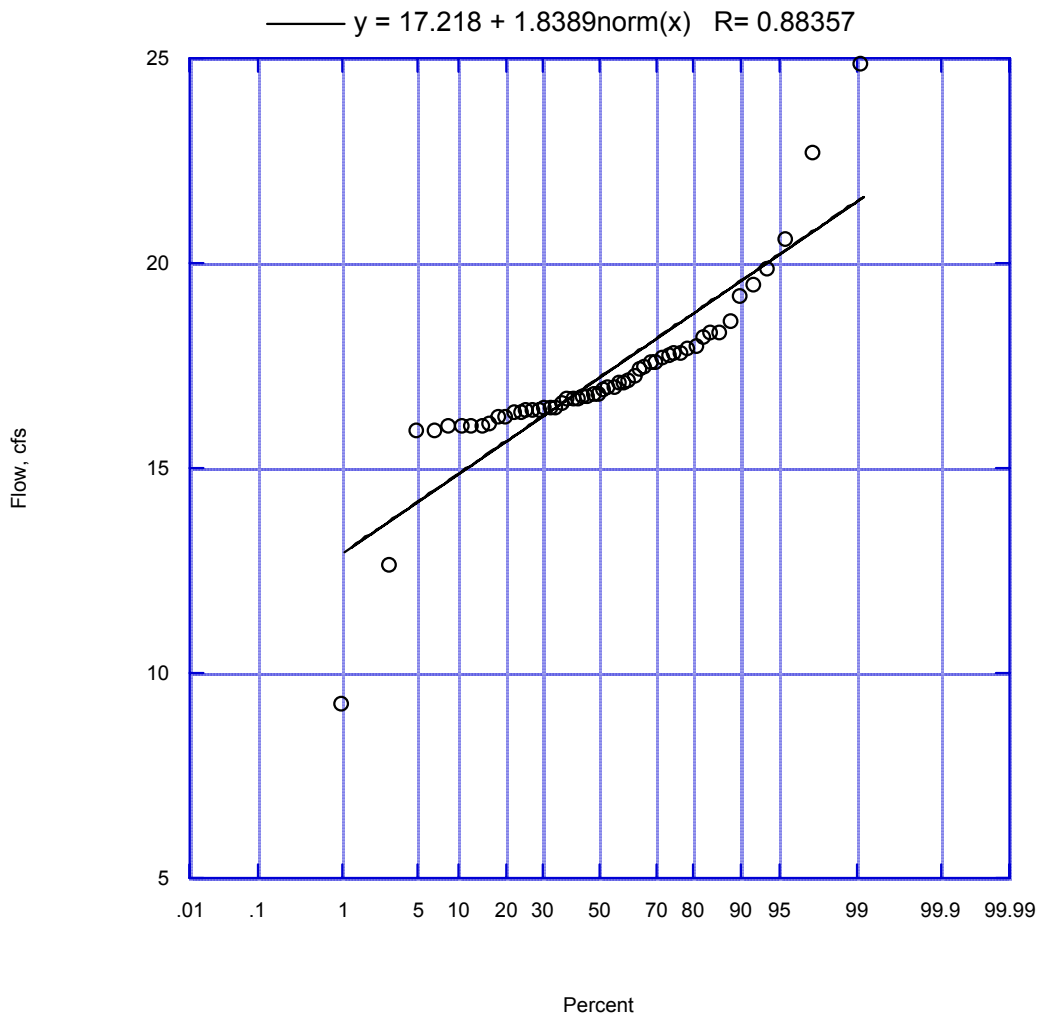


Figure 23. Hill Canyon Effluent Flow Frequency Distribution - Feb (02-03)

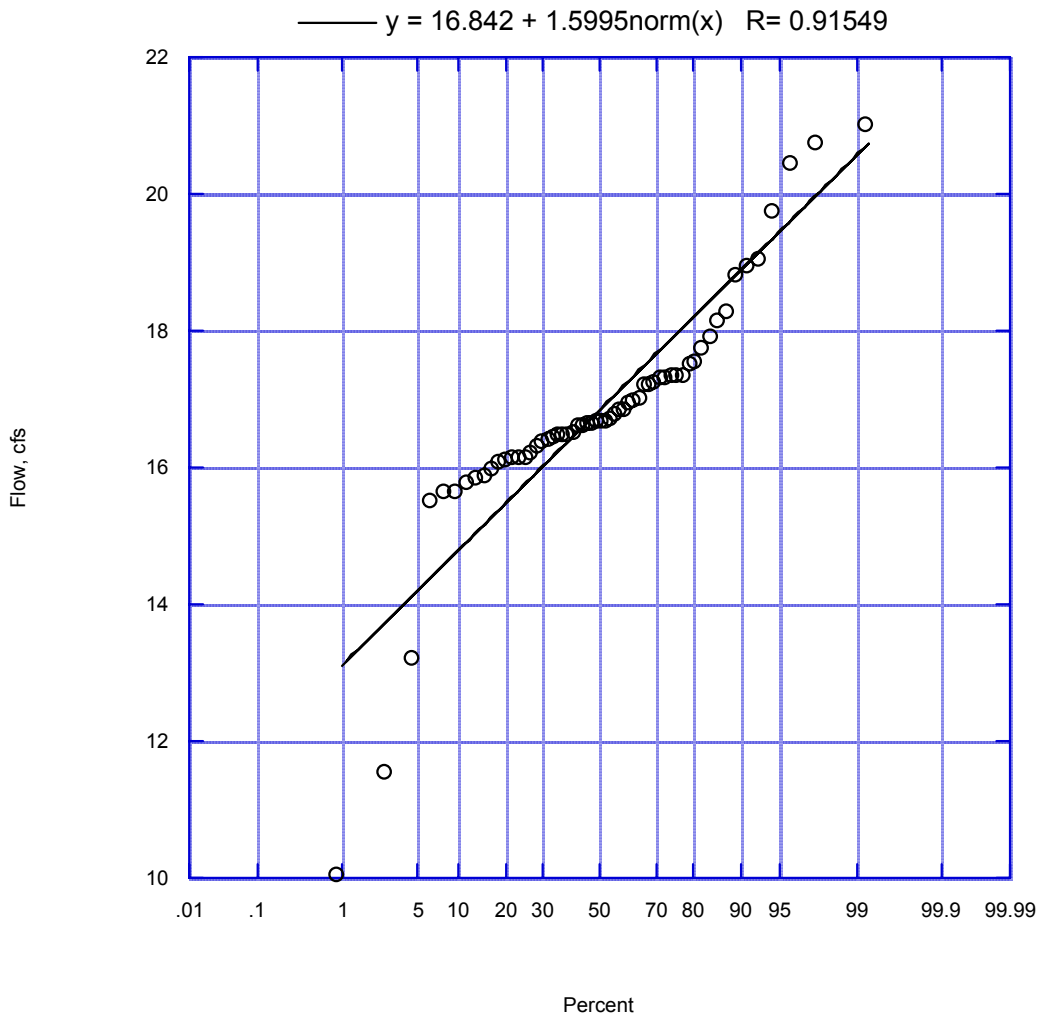


Figure 24. Hill Canyon Effluent Flow Frequency Distribution - Mar (02-03)

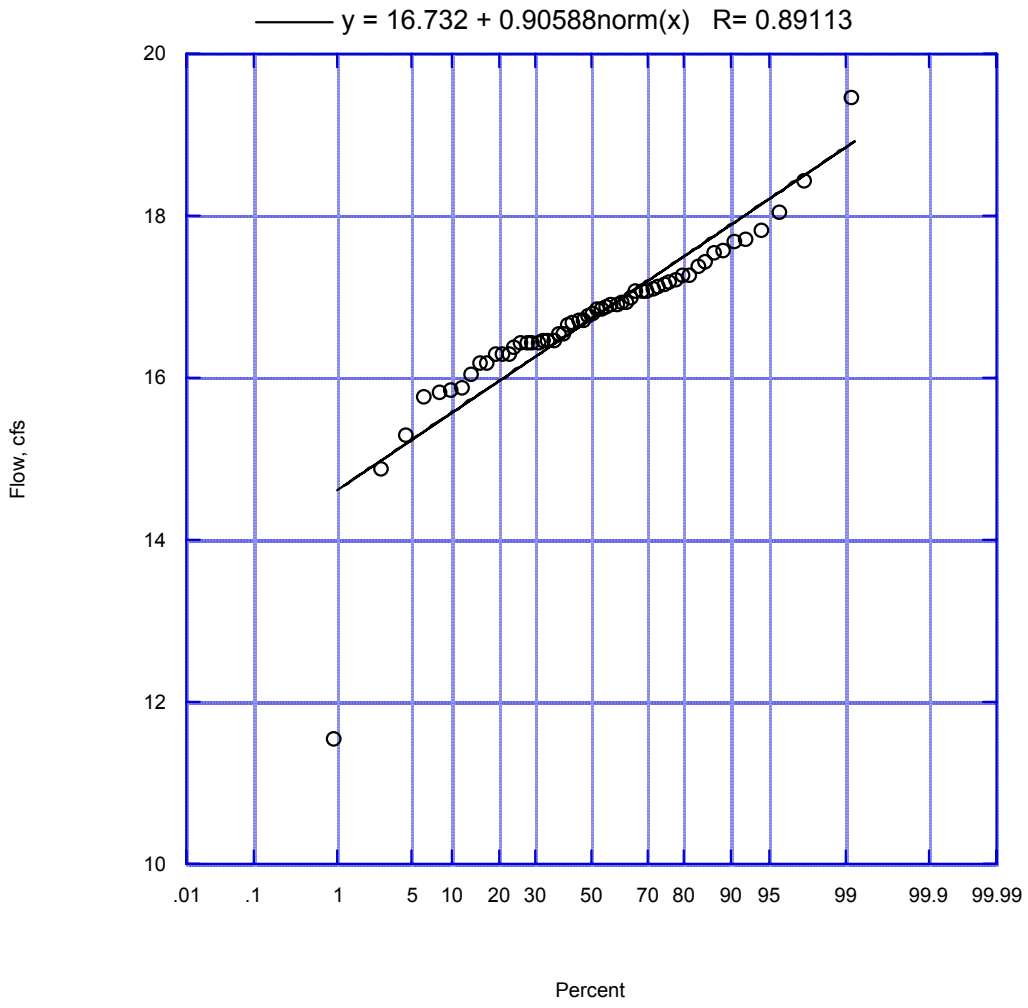


Figure 25. Hill Canyon Effluent Flow Frequency Distribution - April (02-03)

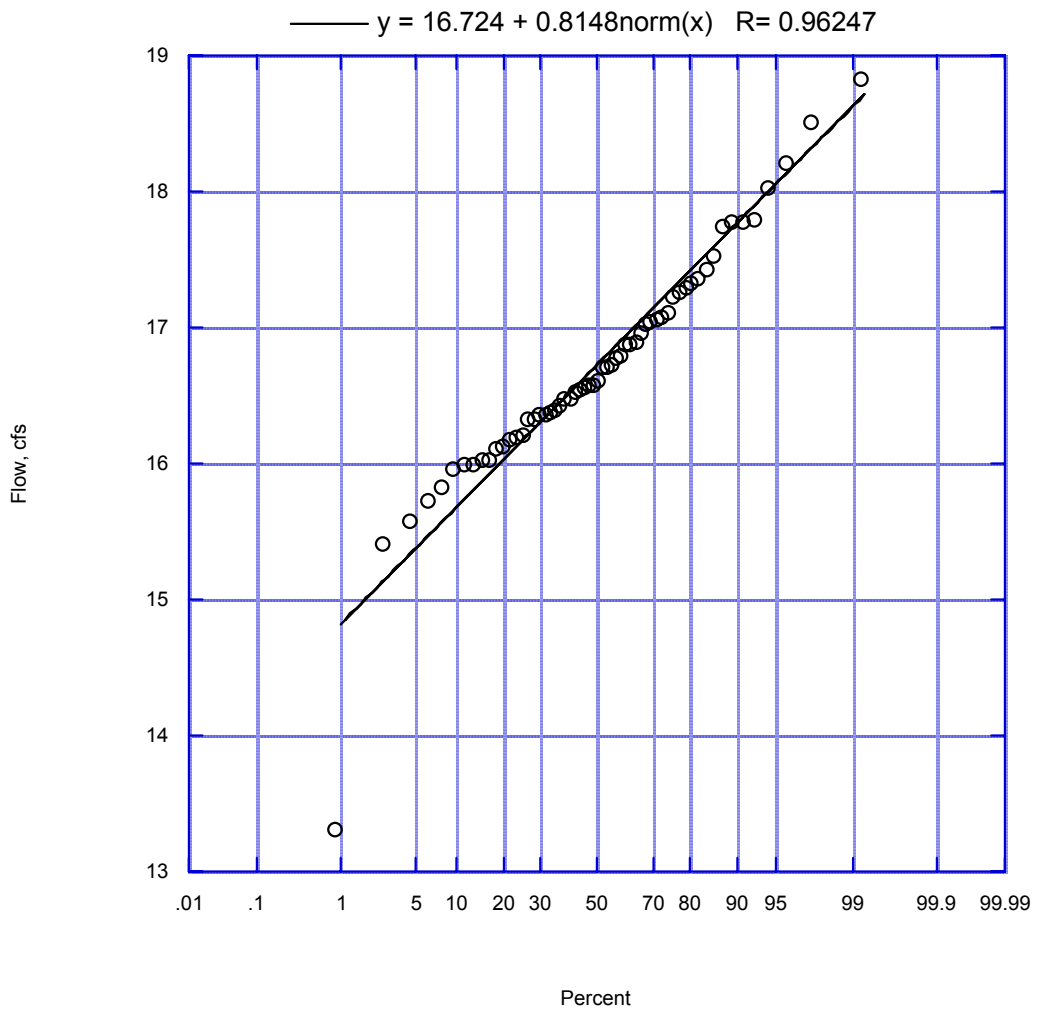


Figure 26. Hill Canyon Effluent Flow Frequency Distribution - May (02-03)

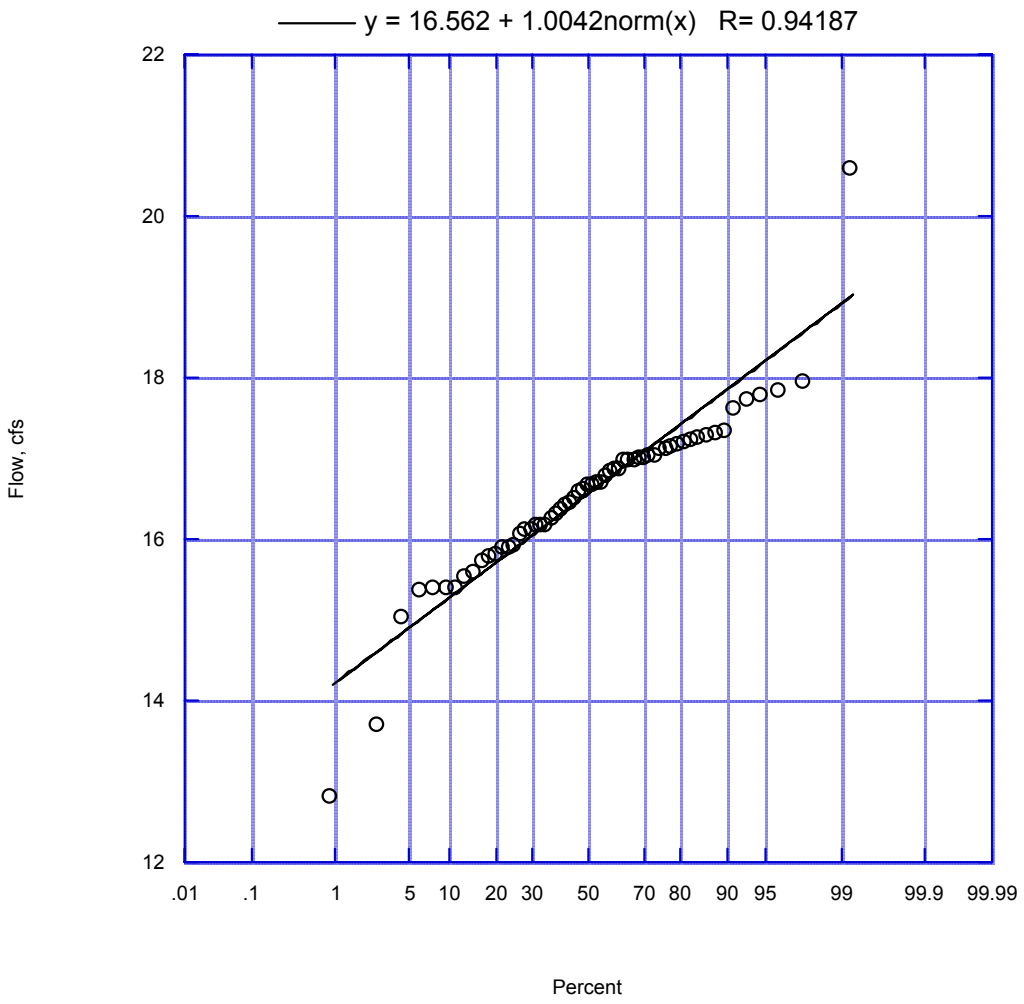


Figure 27. Hill Canyon Effluent Flow Frequency Distribution - June (02-03)

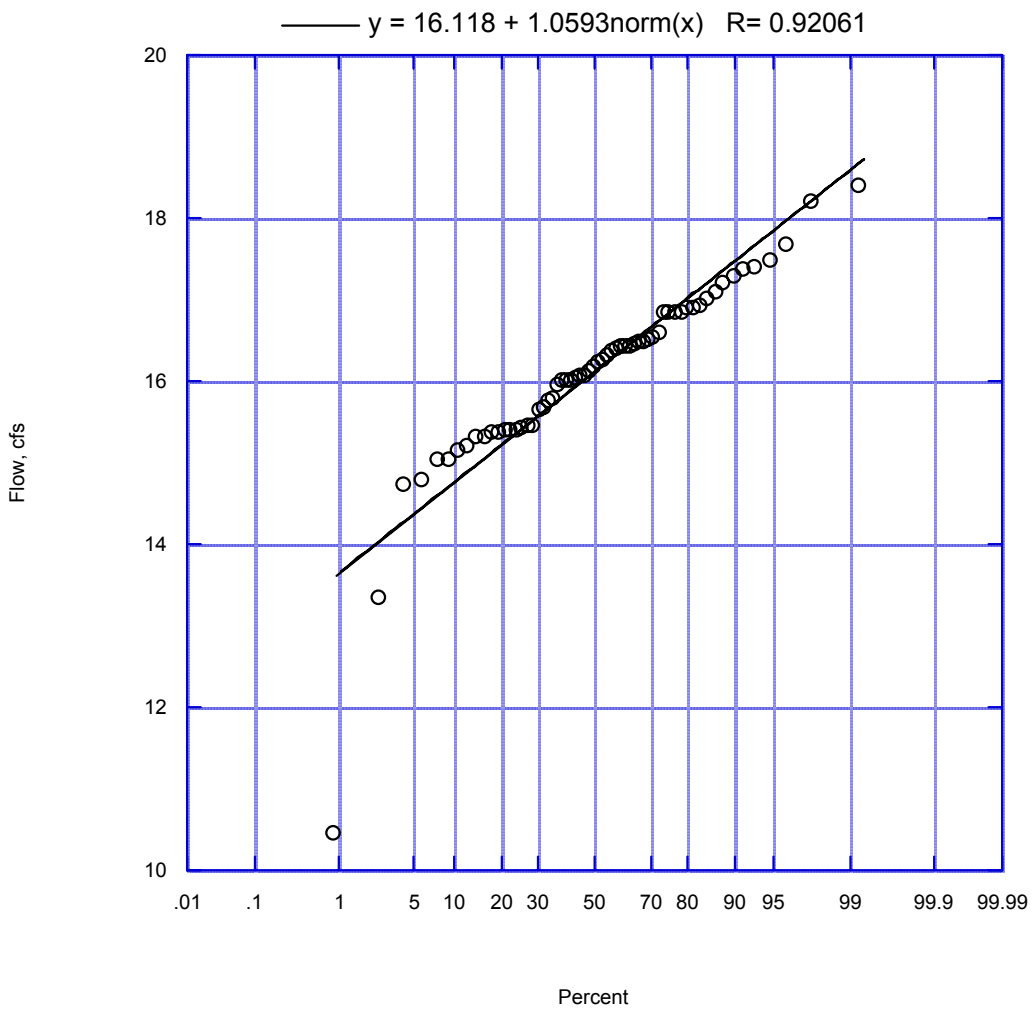


Figure 28. Hill Canyon Effluent Flow Frequency Distribution - July (02-03)

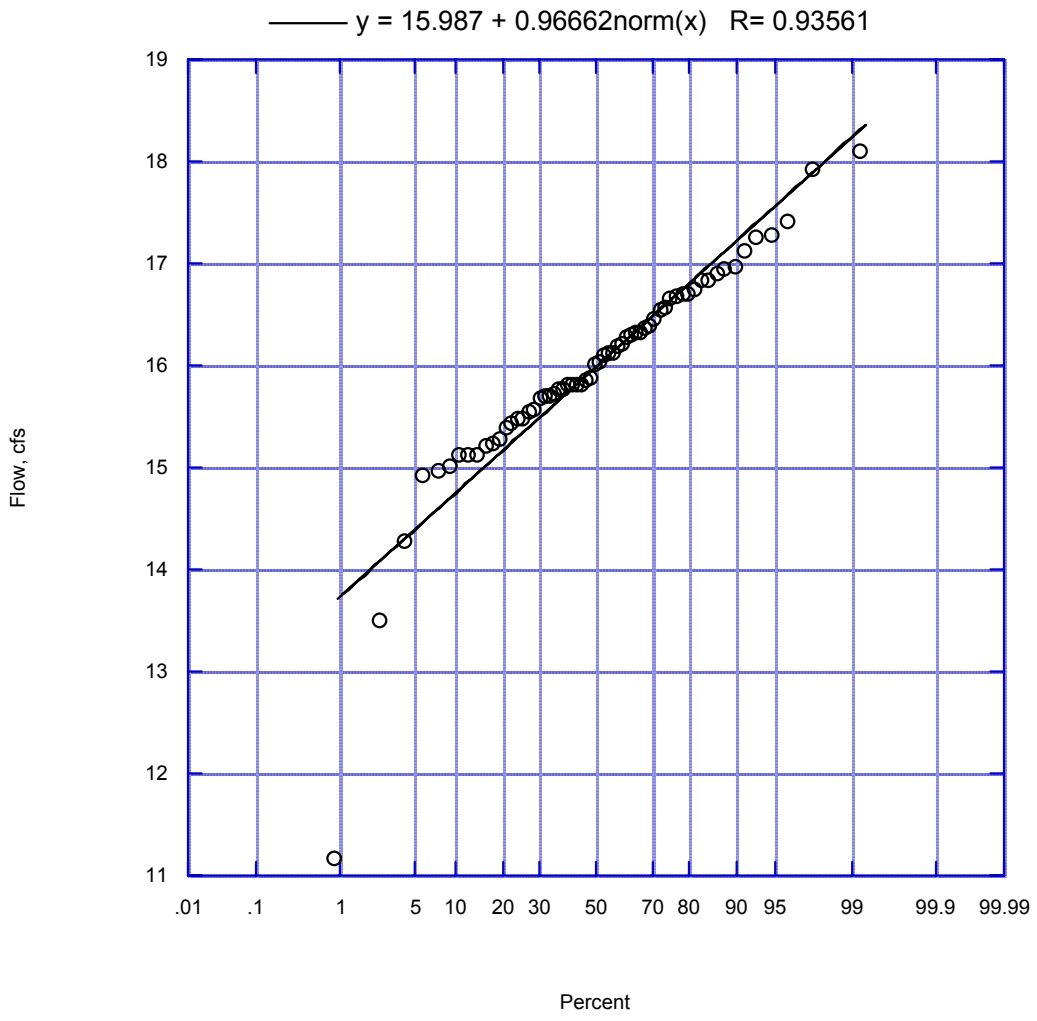


Figure 29. Hill Canyon Effluent Flow Frequency Distribution - Aug (02-03)

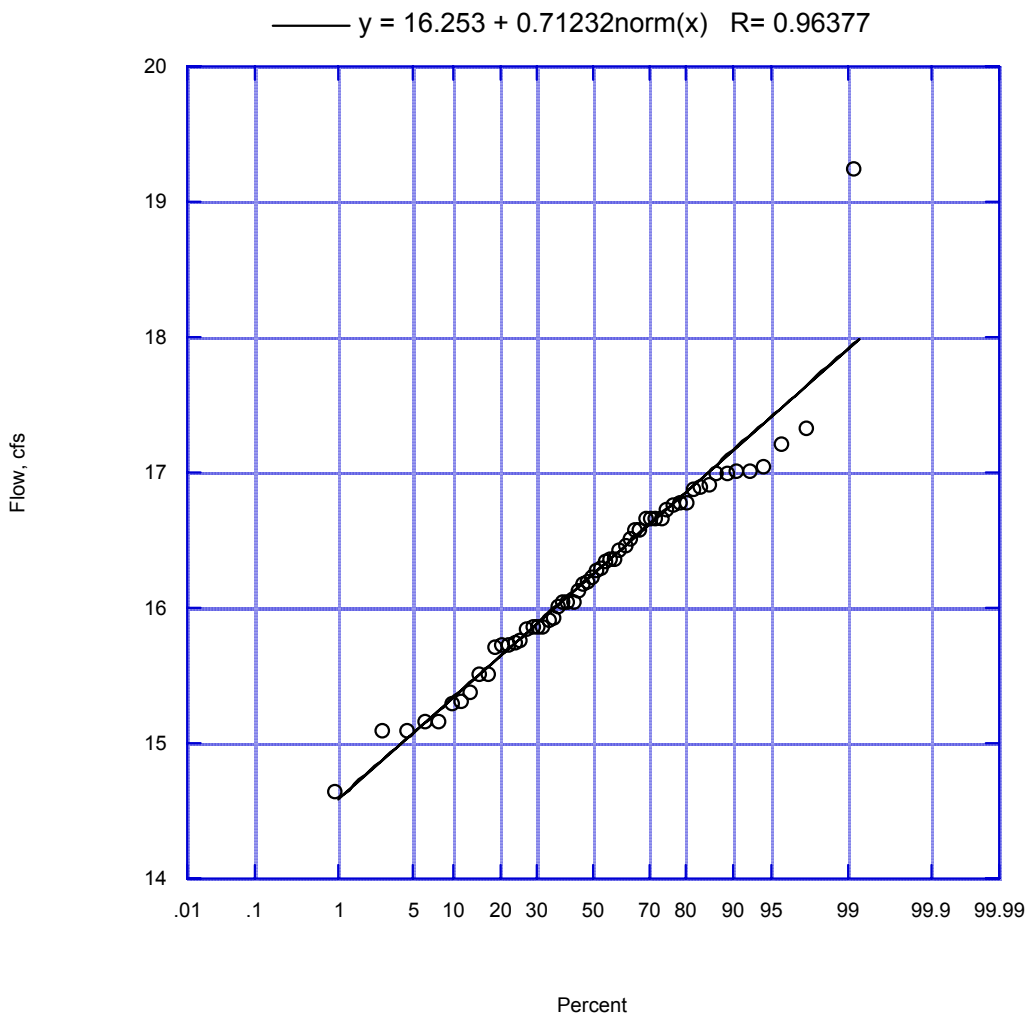


Figure 30. Hill Canyon Effluent Flow Frequency Distribution - Sept (02-03)

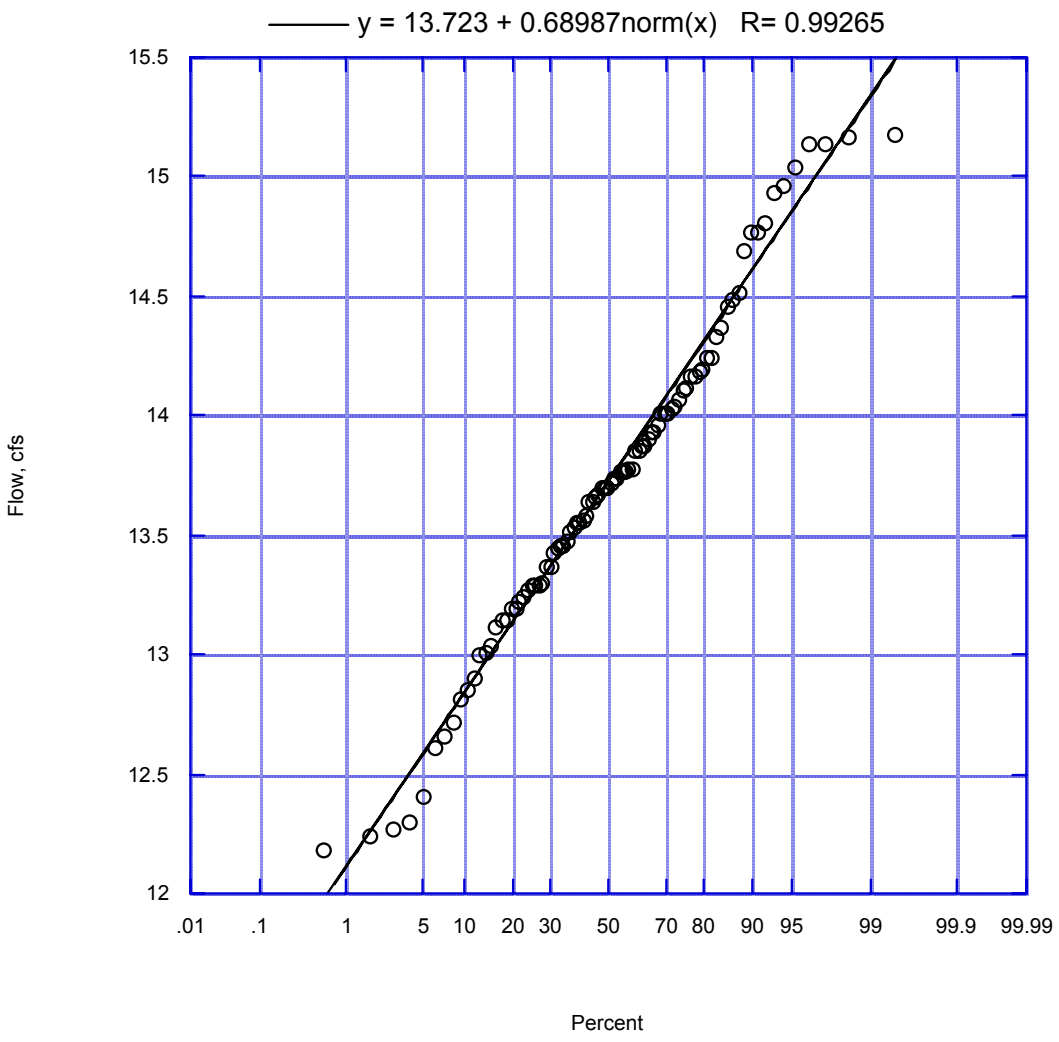


Figure 31. Simi Valley Effluent Flow Frequency Distribution - Oct (01-02)

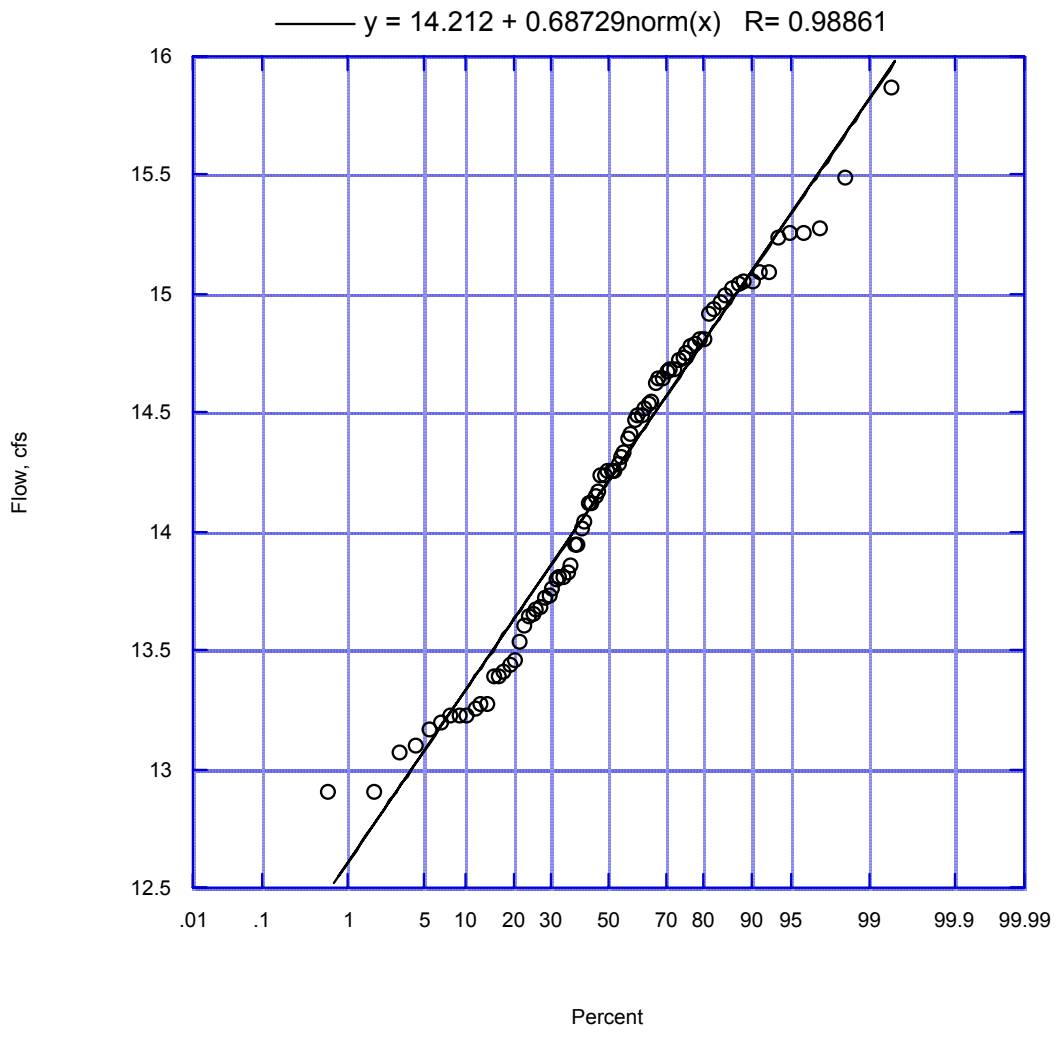


Figure 32. Simi Valley Effluent Flow Frequency Distribution - Nov (01-02)

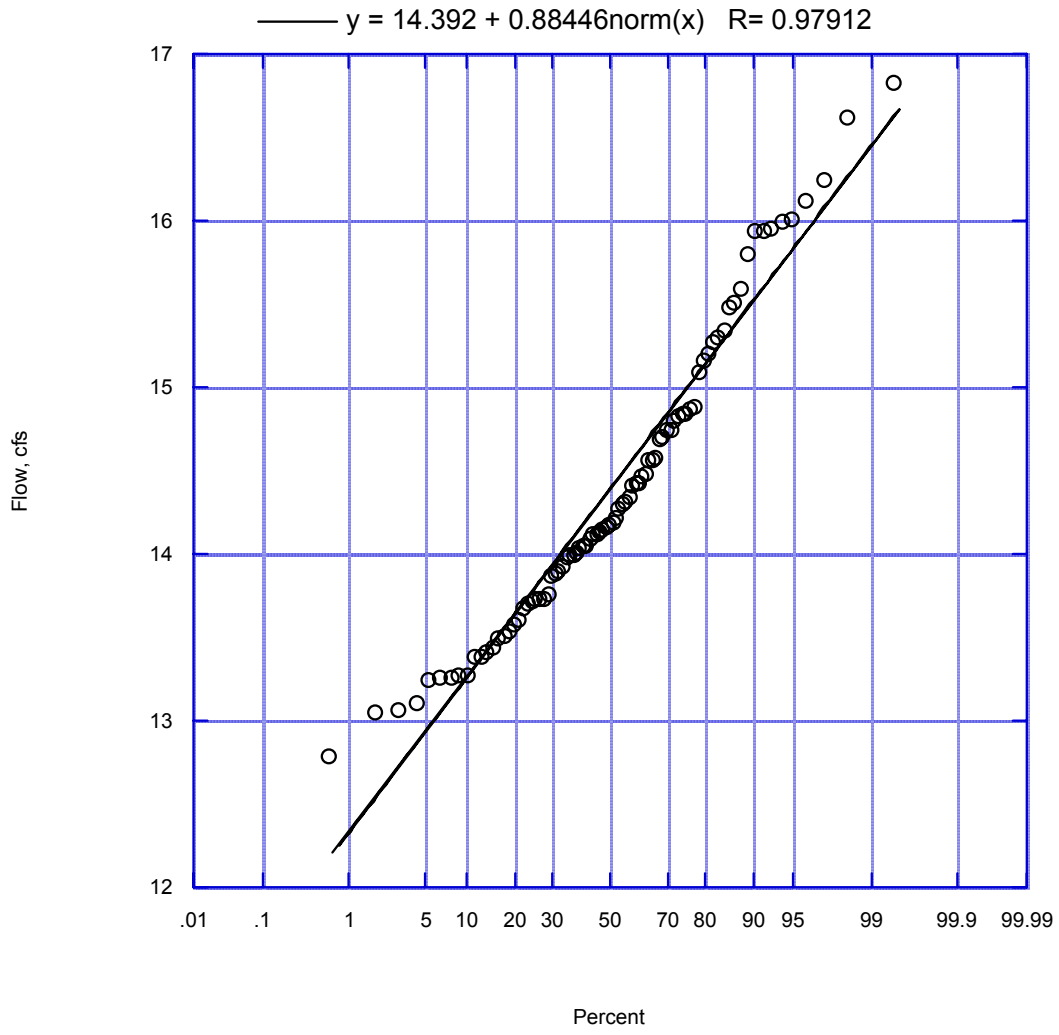


Figure 33. Simi Valley Effluent Flow Frequency Distribution - Dec (01-02)

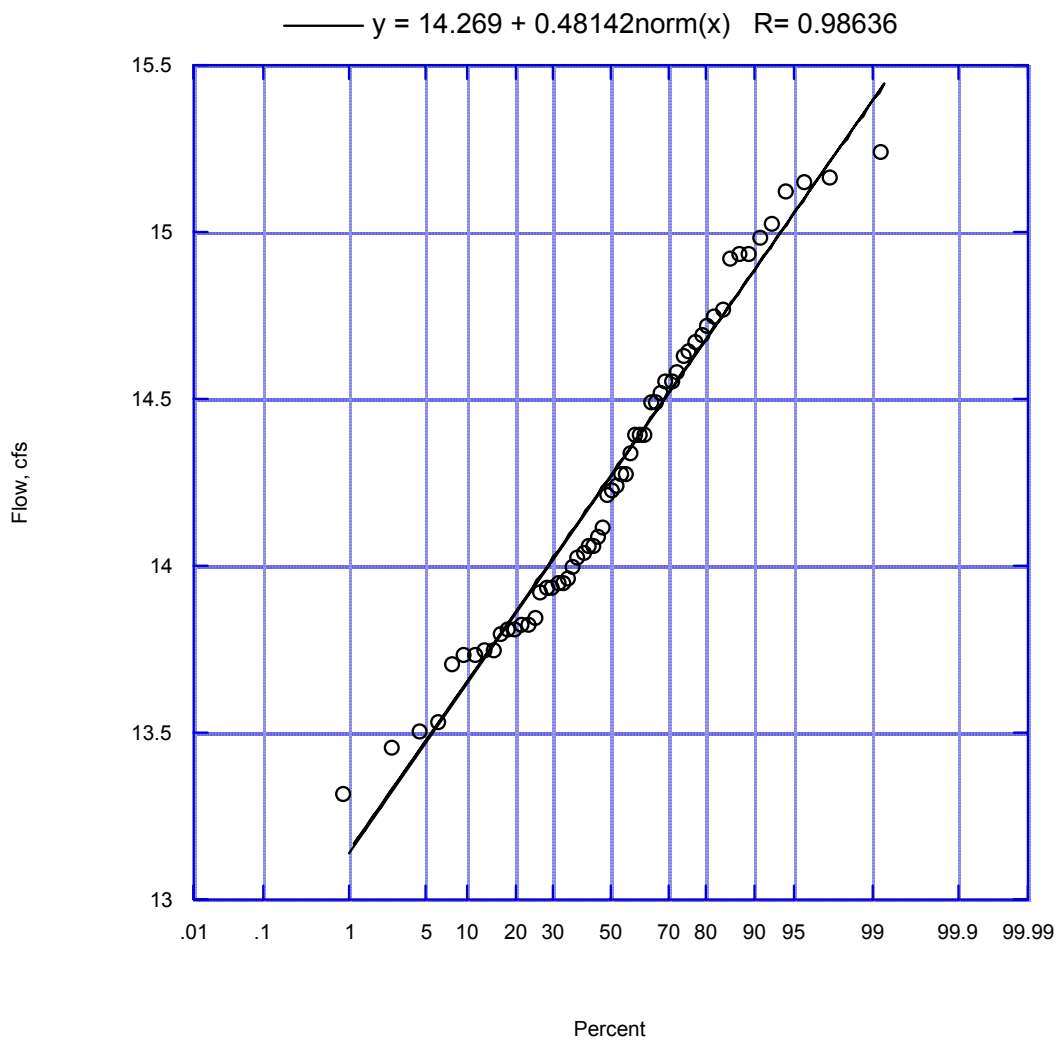


Figure 34. Simi Valley Effluent Flow Frequency Distribution - Jan (02-03)

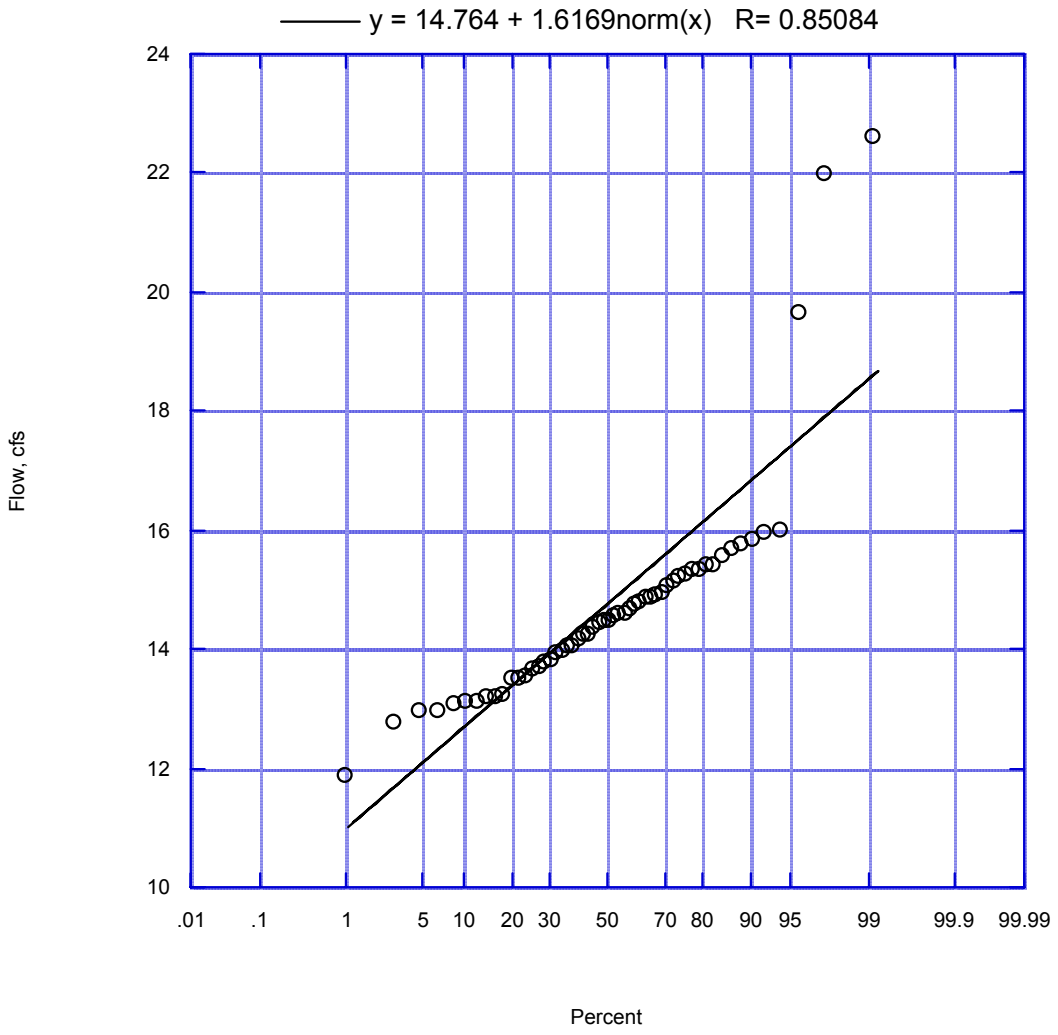


Figure 35. Simi Valley Effluent Flow Frequency Distribution - Feb (02-03)

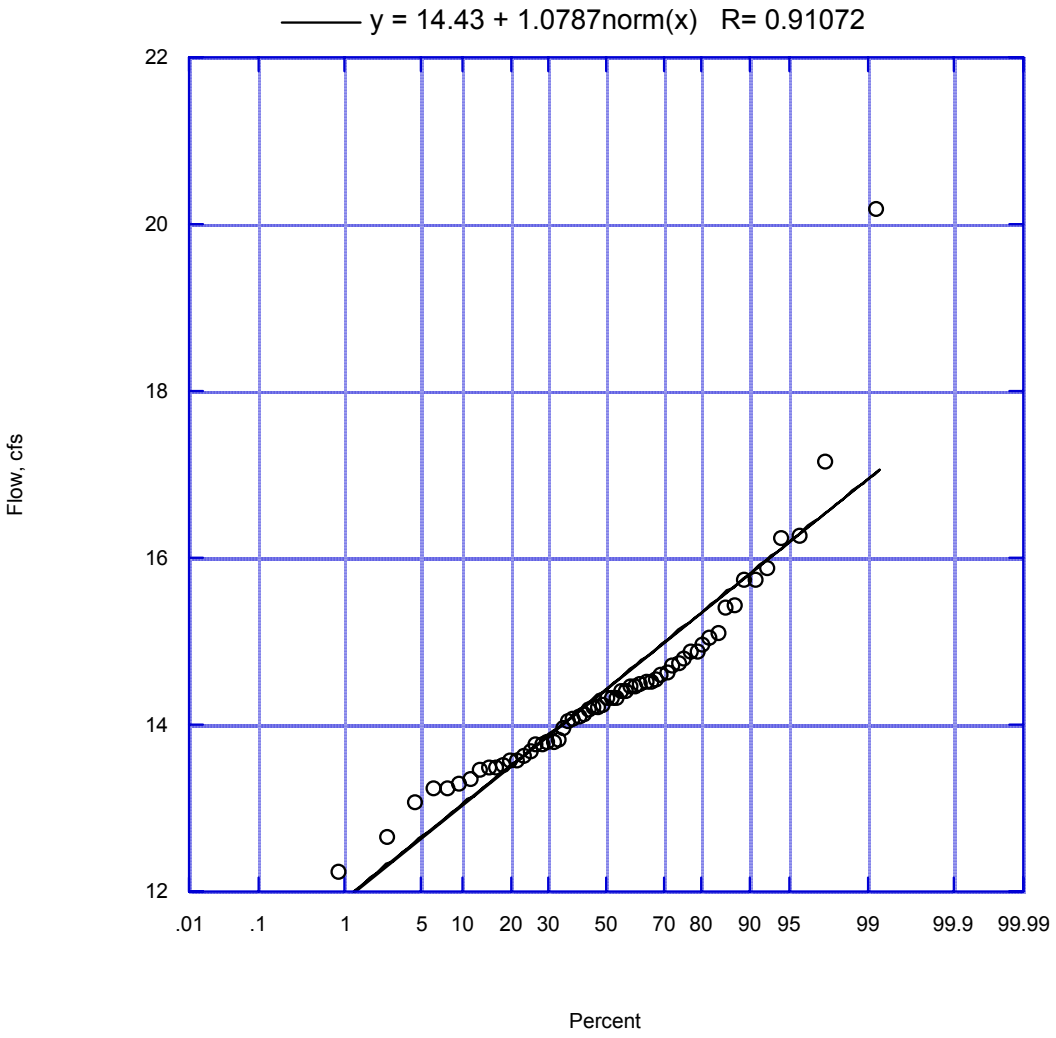


Figure 36. Simi Valley Effluent Flow Frequency Distribution - Mar (02-03)

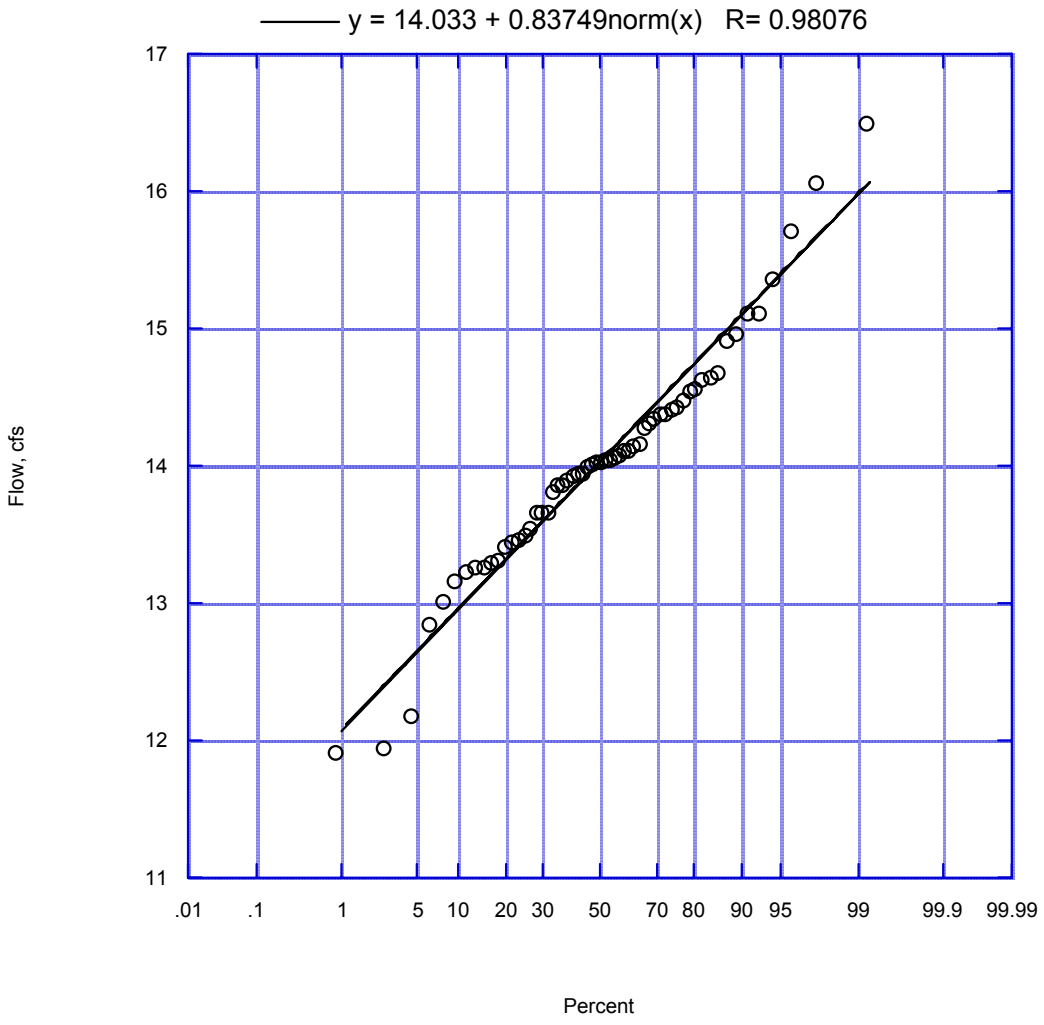


Figure 37. Simi Valley Effluent Flow Frequency Distribution - April (02-03)

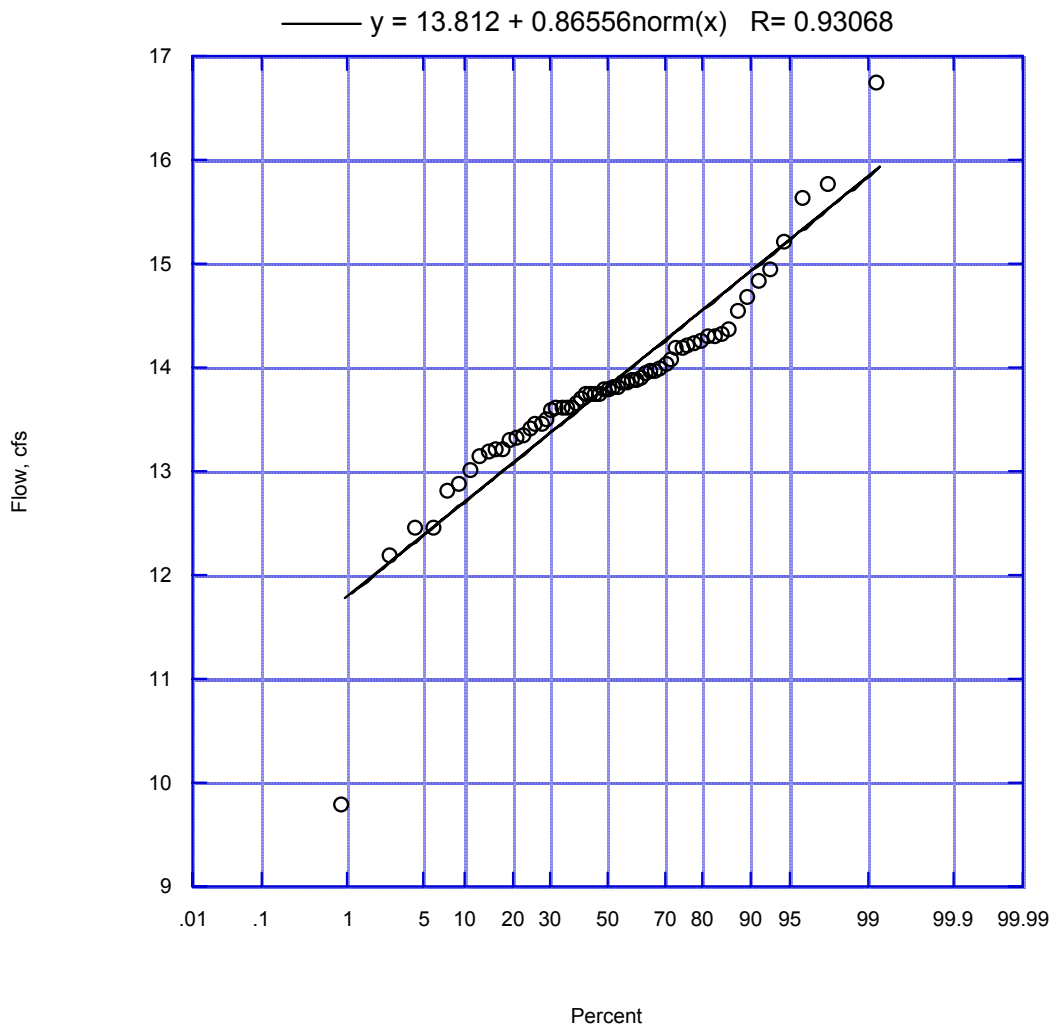


Figure 38. Simi Valley Effluent Flow Frequency Distribution - May (02-03)

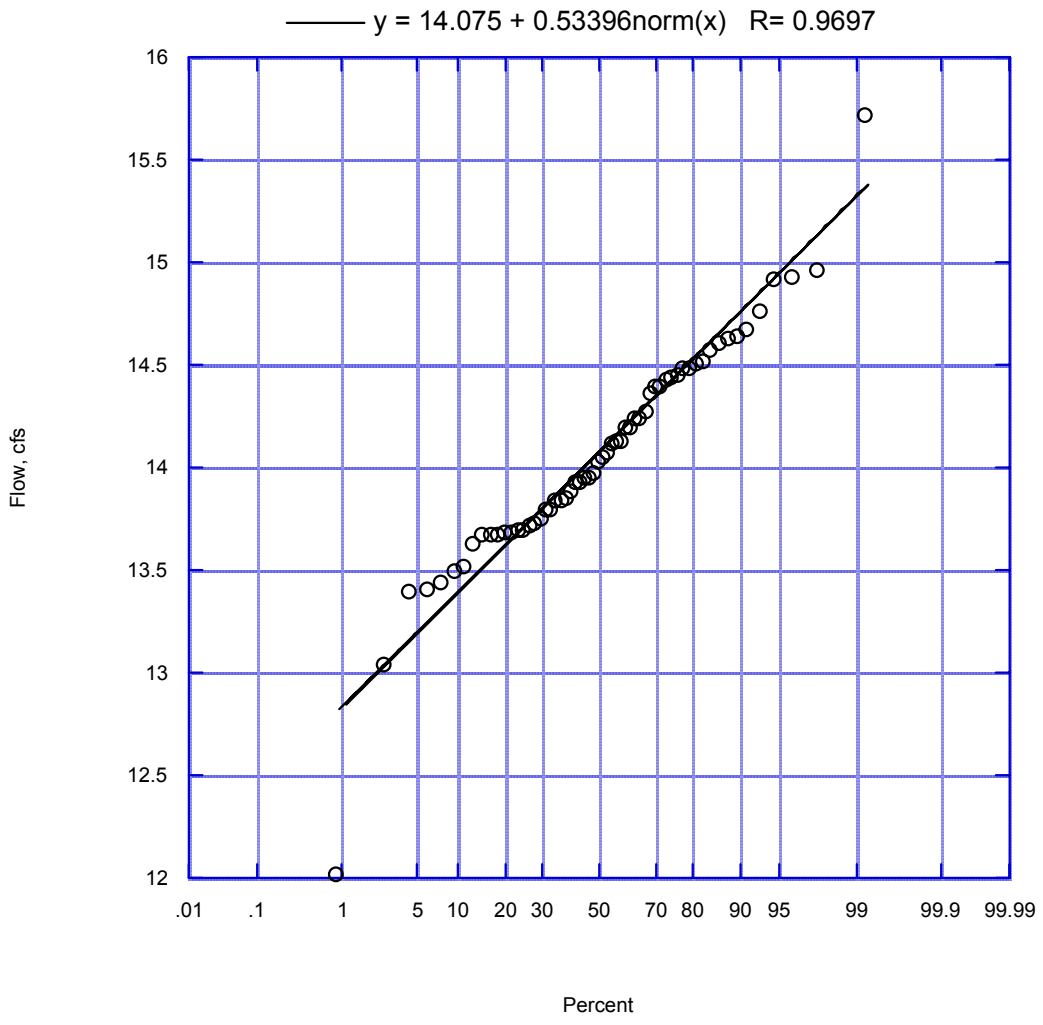


Figure 39. Simi Valley Effluent Flow Frequency Distribution - June (02-03)

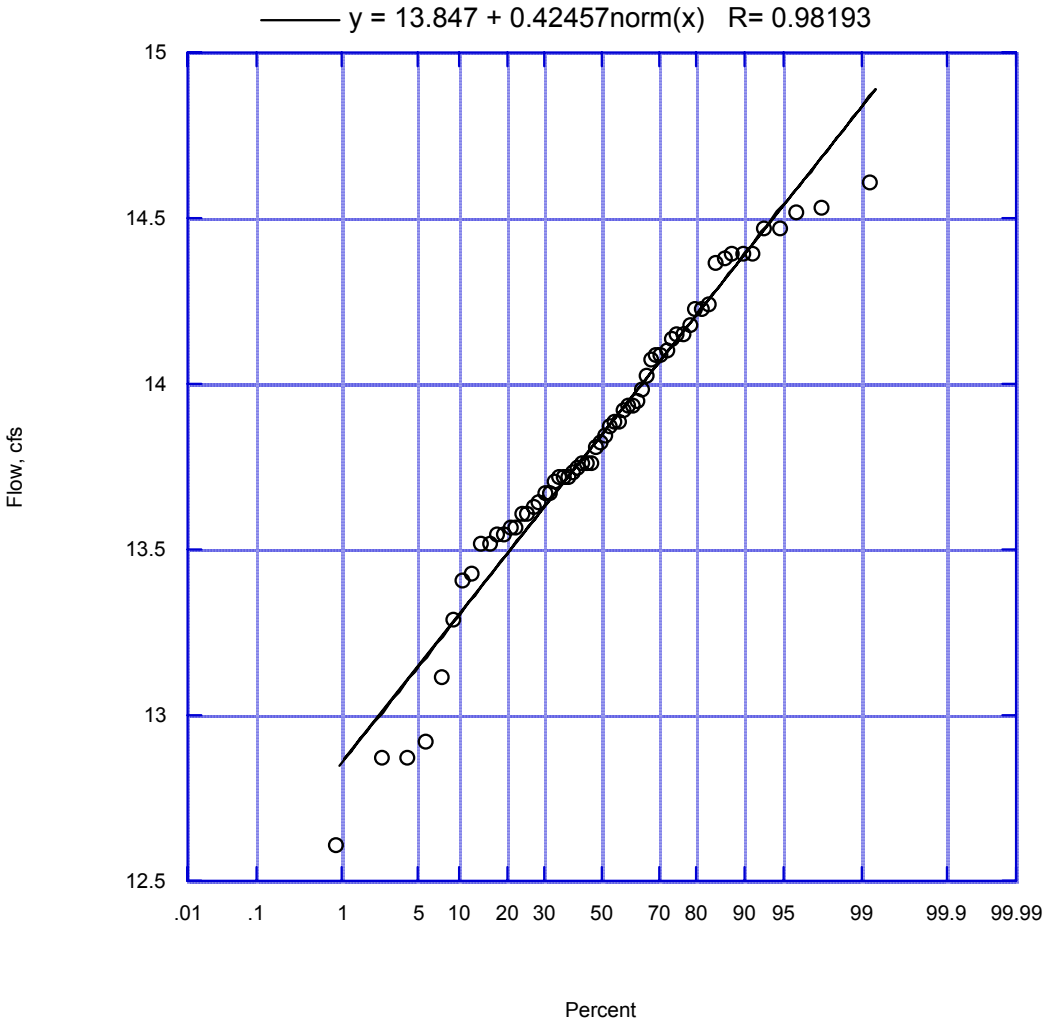


Figure 40. Simi Valley Effluent Flow Frequency Distribution - July (02-03)

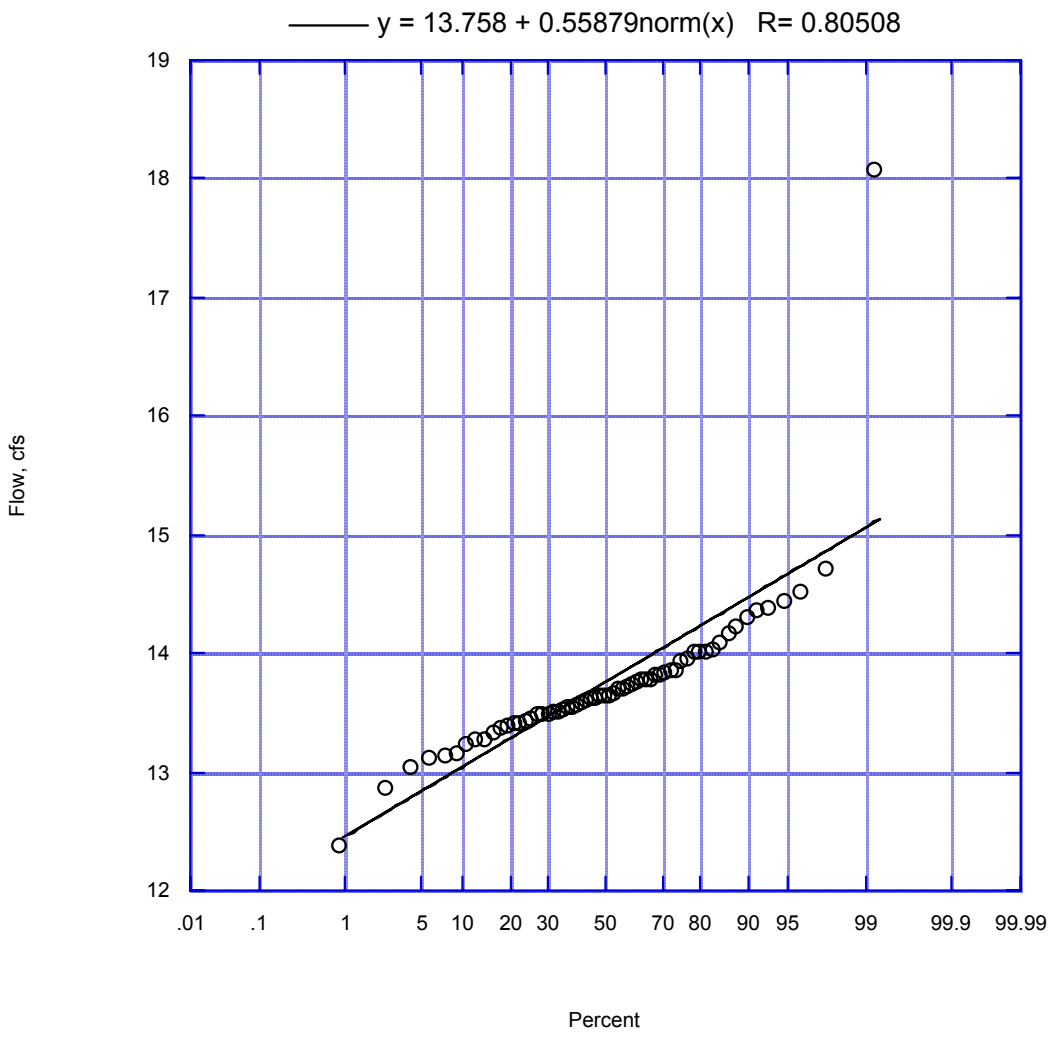


Figure 41. Simi Valley Effluent Flow Frequency Distribution - Aug (02-03)

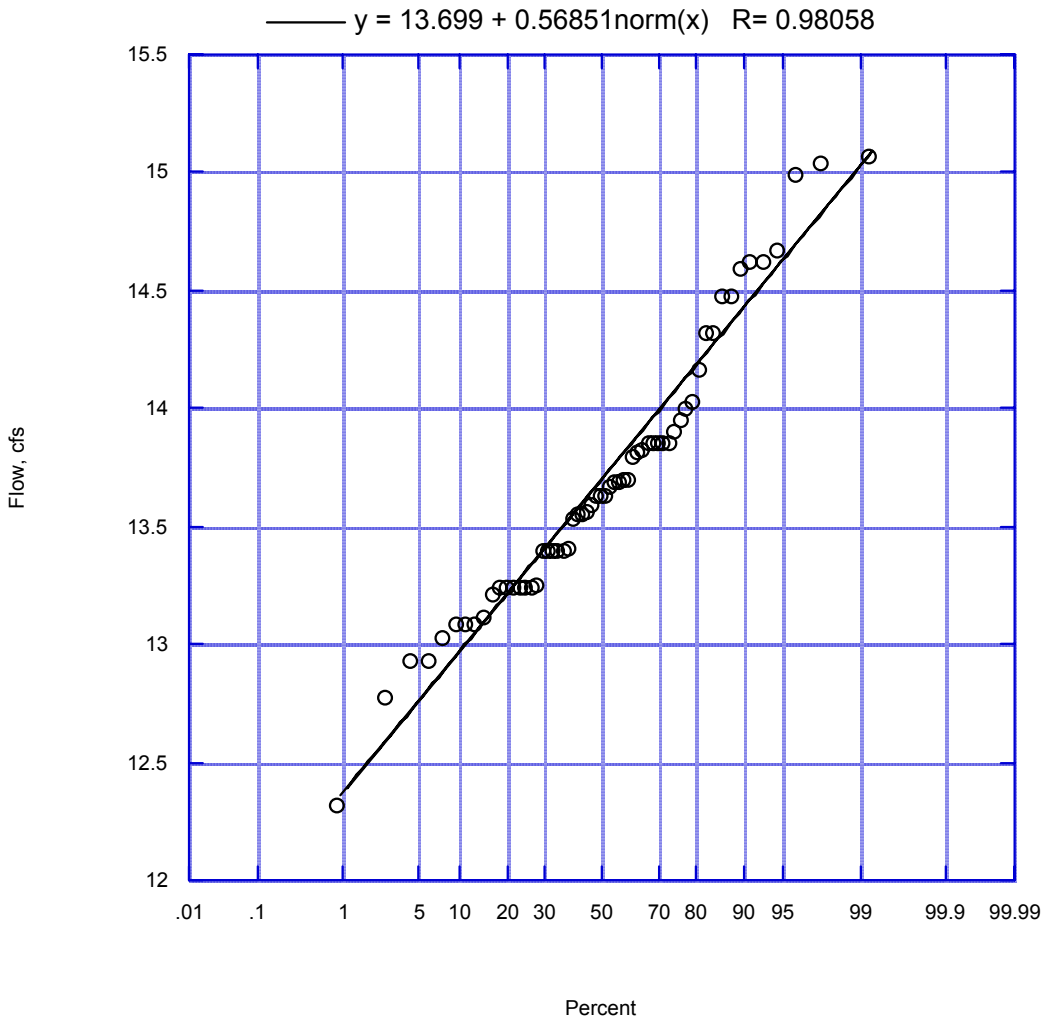


Figure 42. Simi Valley Effluent Flow Frequency Distribution - Sept (02-03)

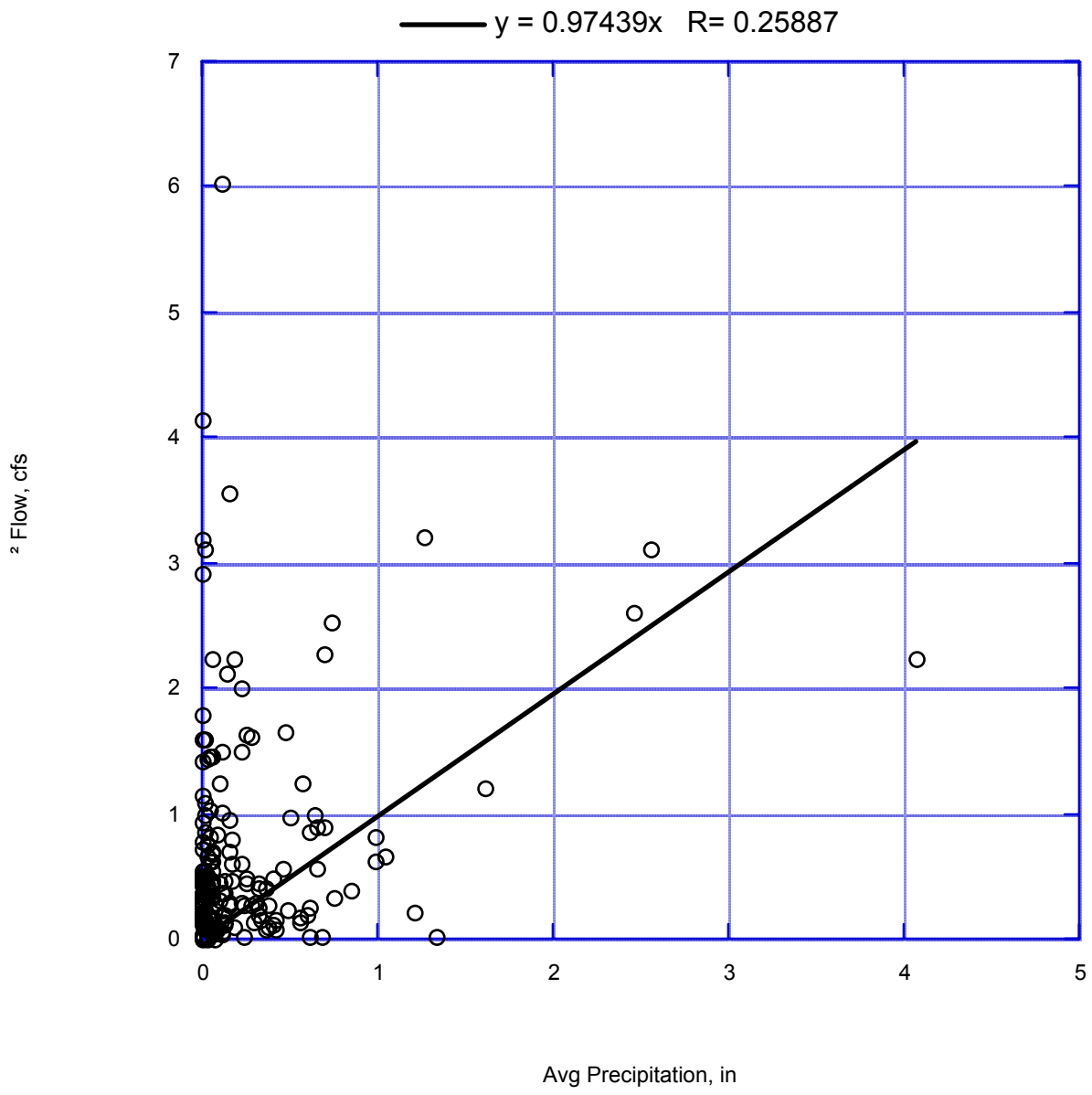


Figure 43. Camarillo ² Effluent Flow vs. Precipitation

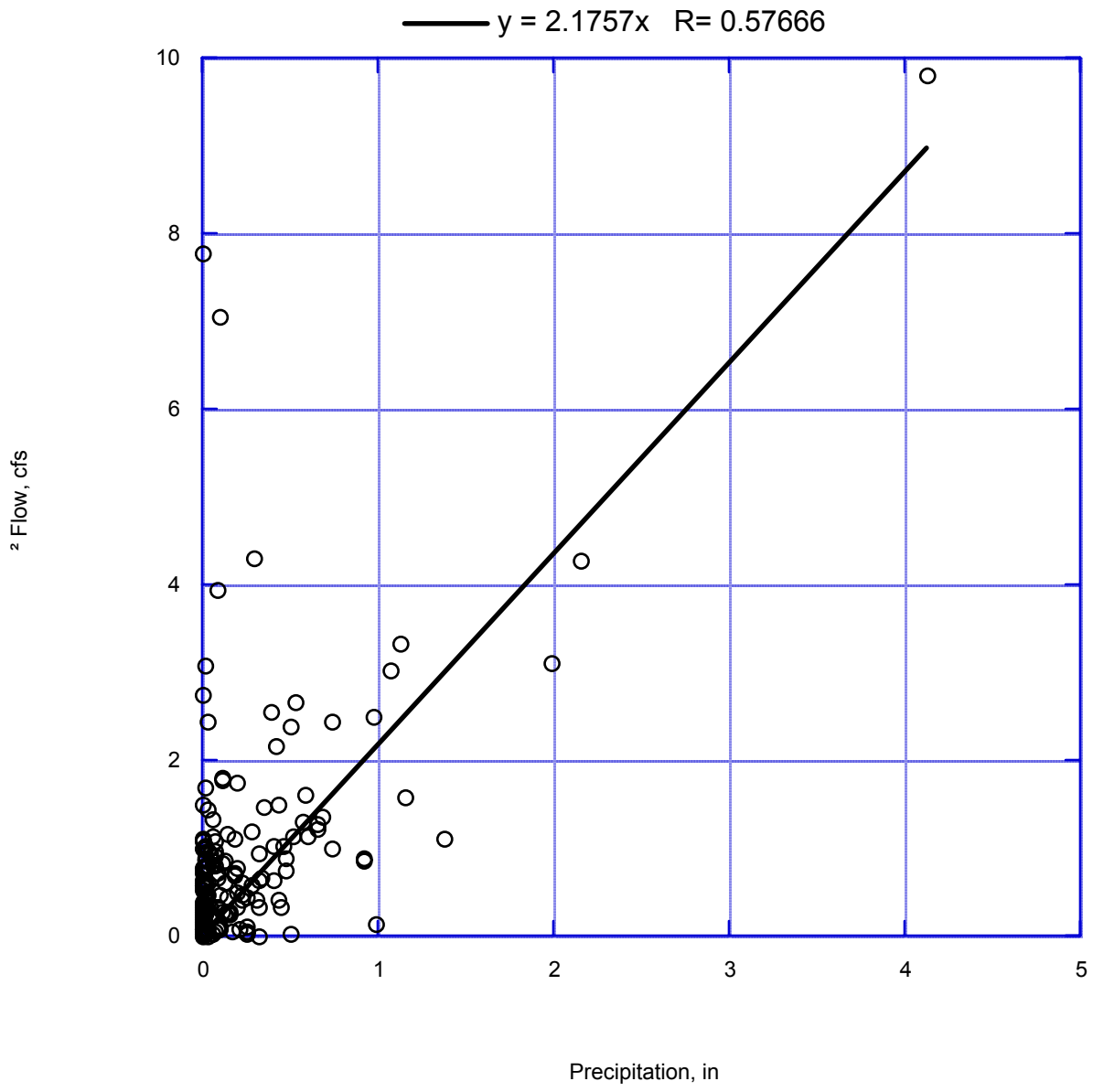


Figure 44. Hill Canyon ² Effluent Flow vs. Precipitation

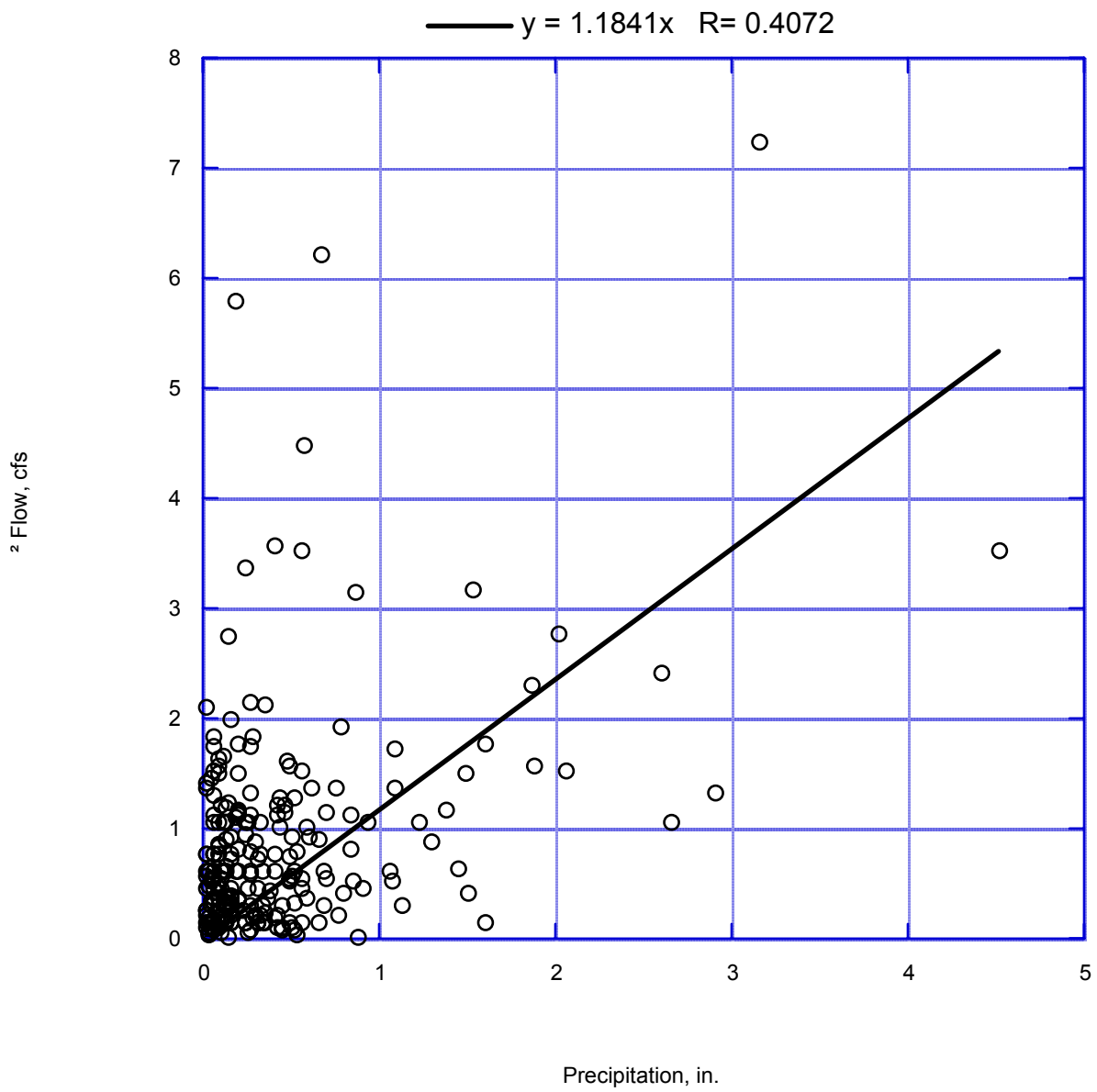


Figure 45. Simi Valley ² Effluent Flow vs. Precipitation

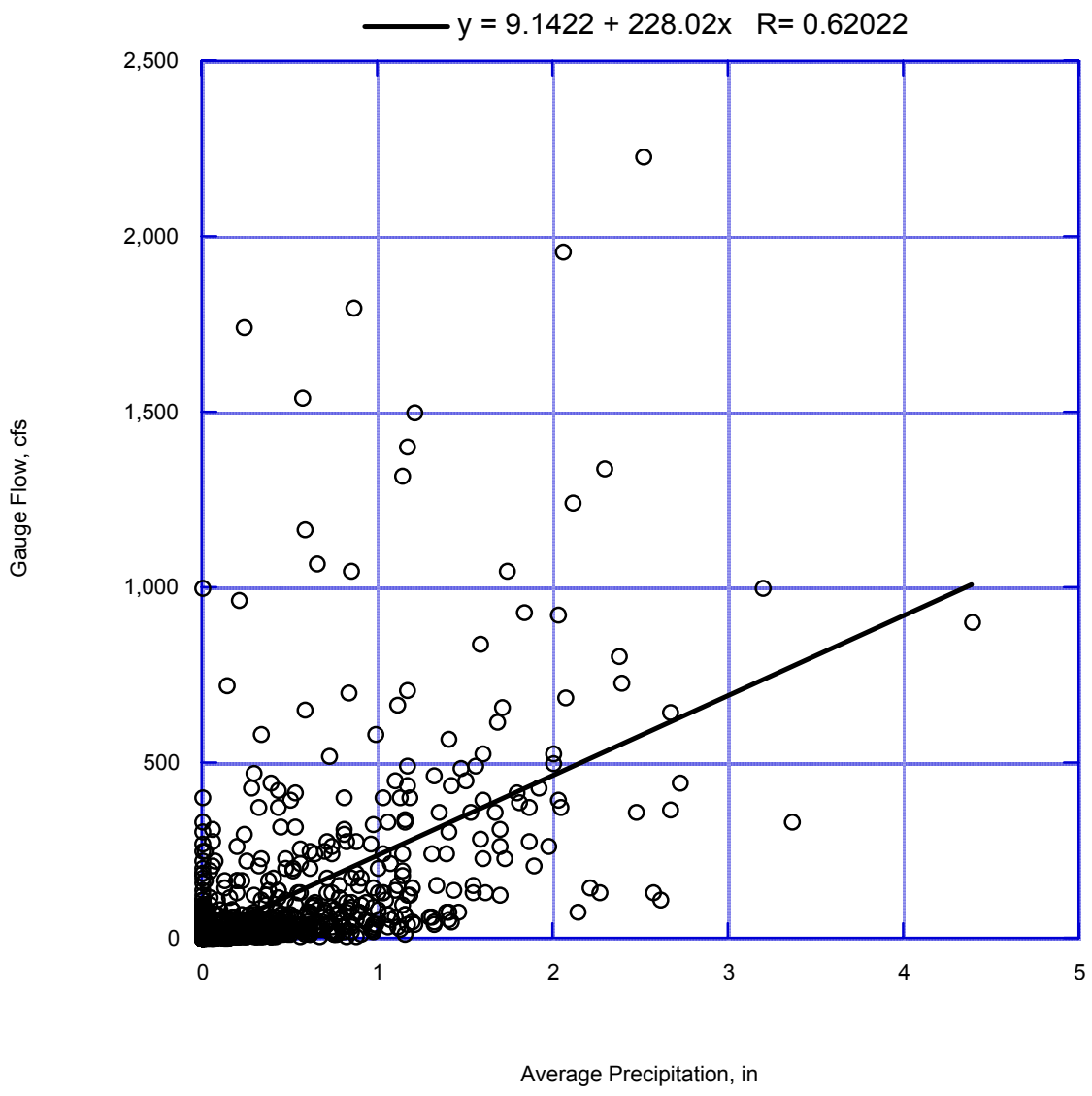


Figure 46. Gauge 776 Flow vs. Average Watershed Precipitation

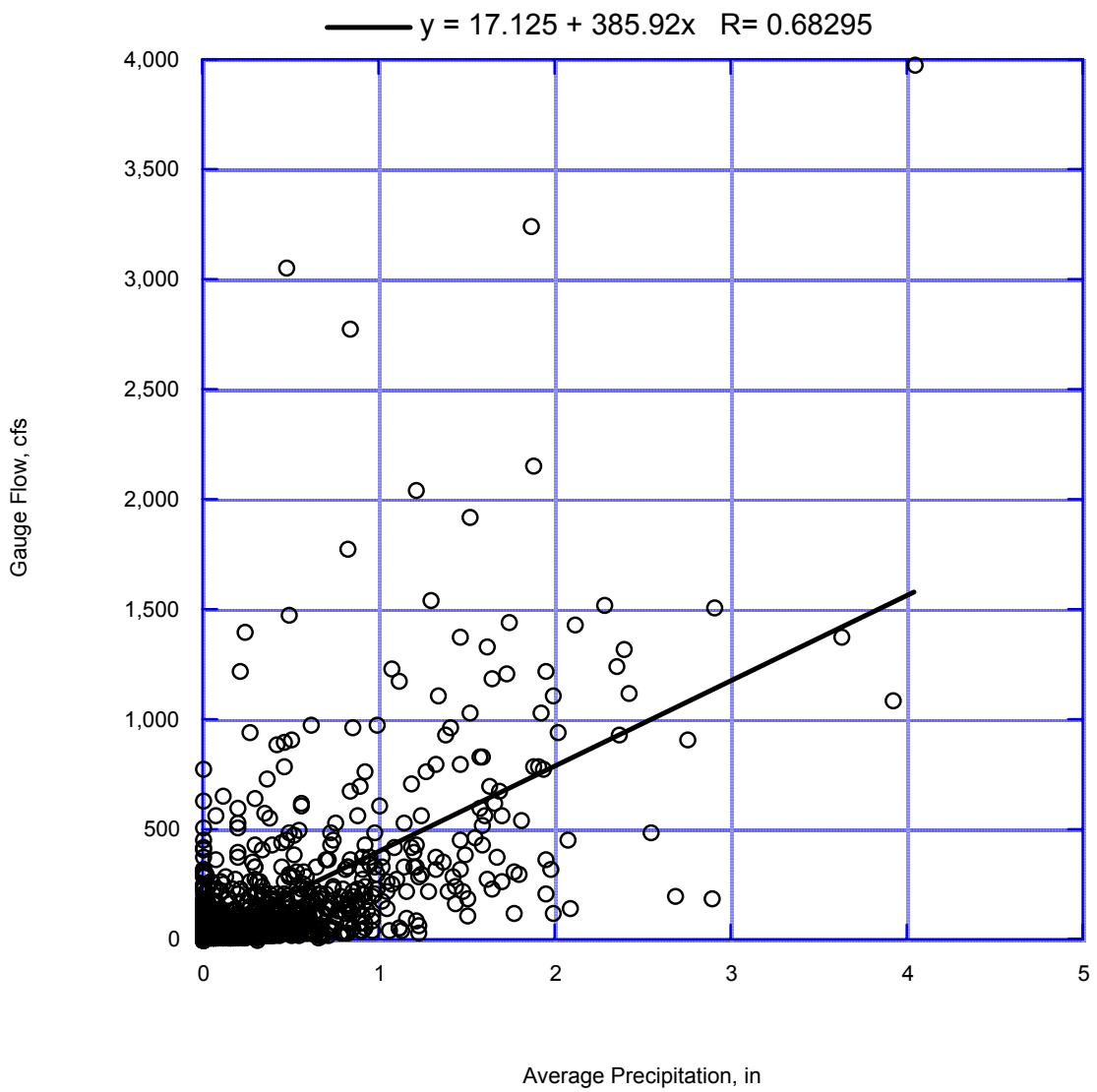


Figure 47. Gauge 800 Flow vs. Average Watershed Precipitation

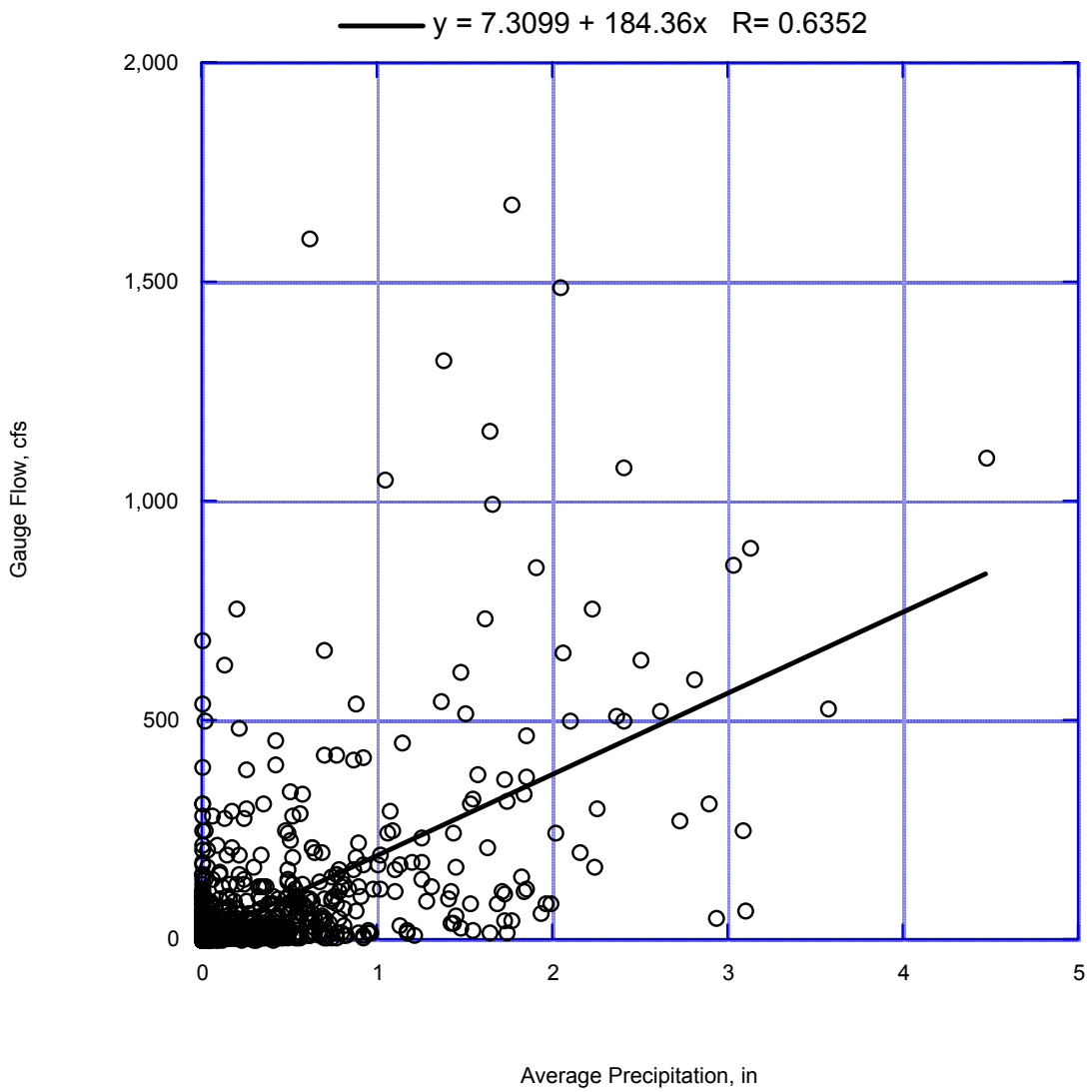


Figure 48. Gauge 803 Flow vs. Average Watershed Precipitation

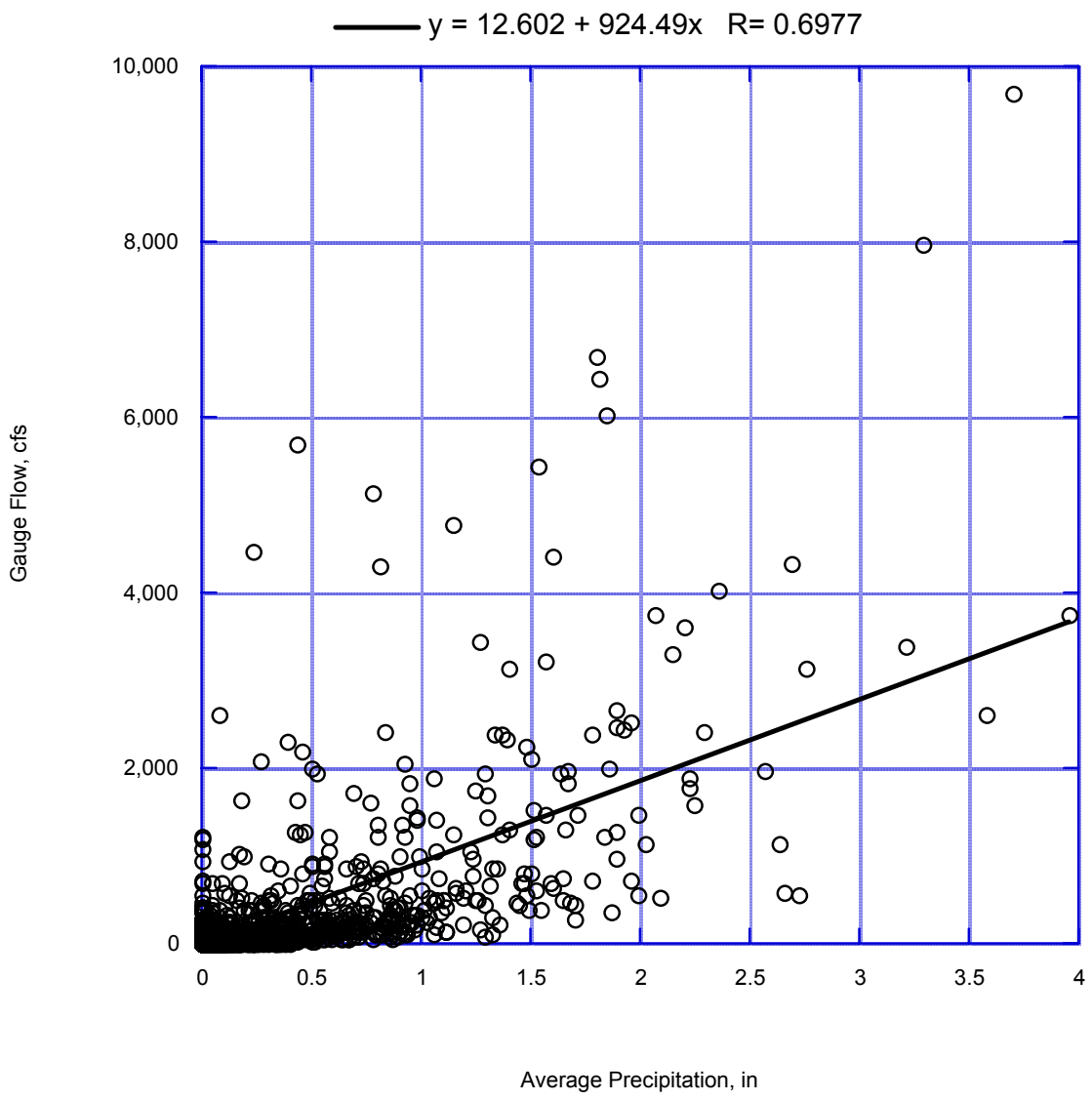


Figure 49. Gauge 805 Flow vs. Average Watershed Precipitation

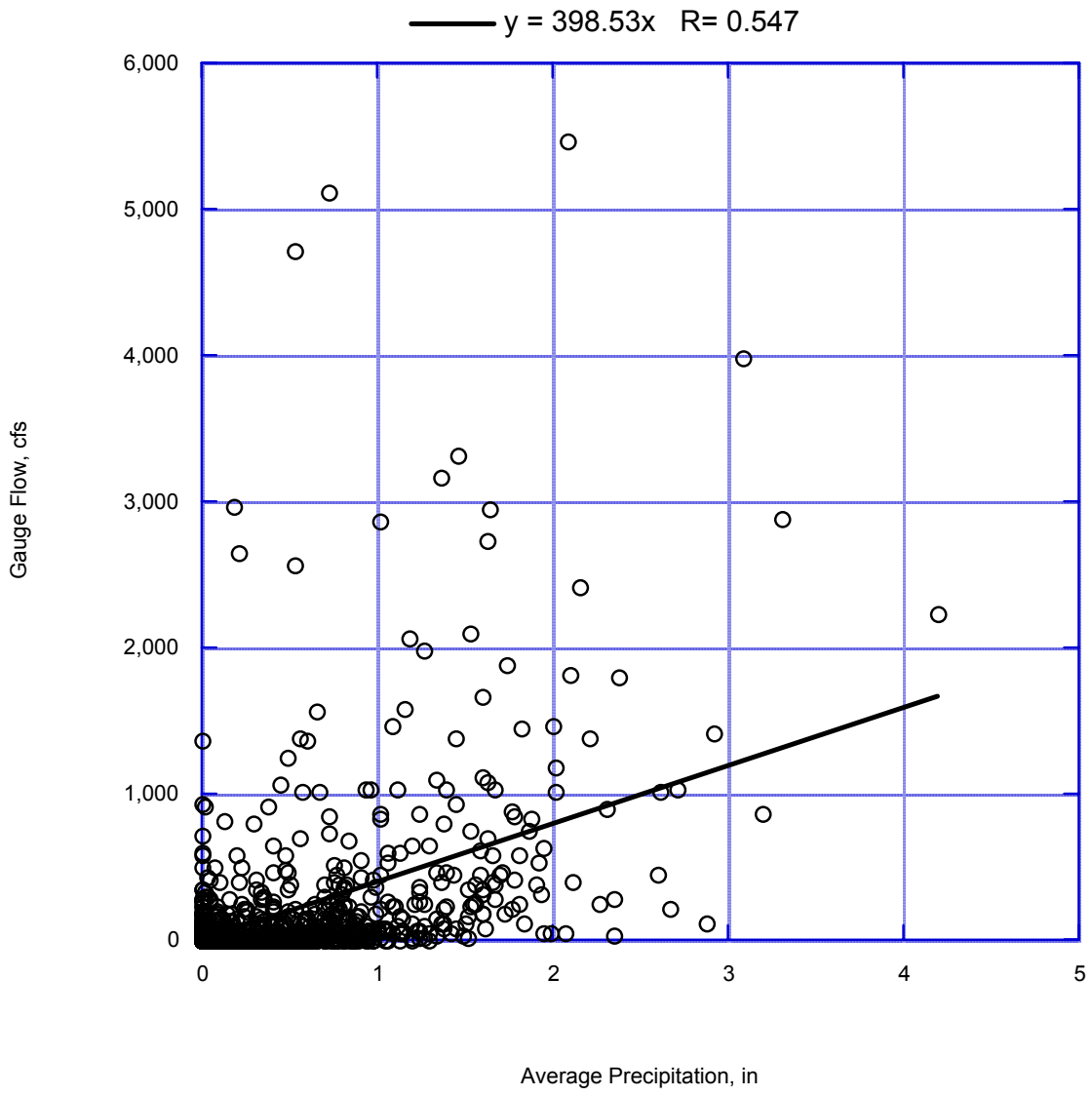


Figure 50. Gauge 806 Flow vs. Average Watershed Precipitation

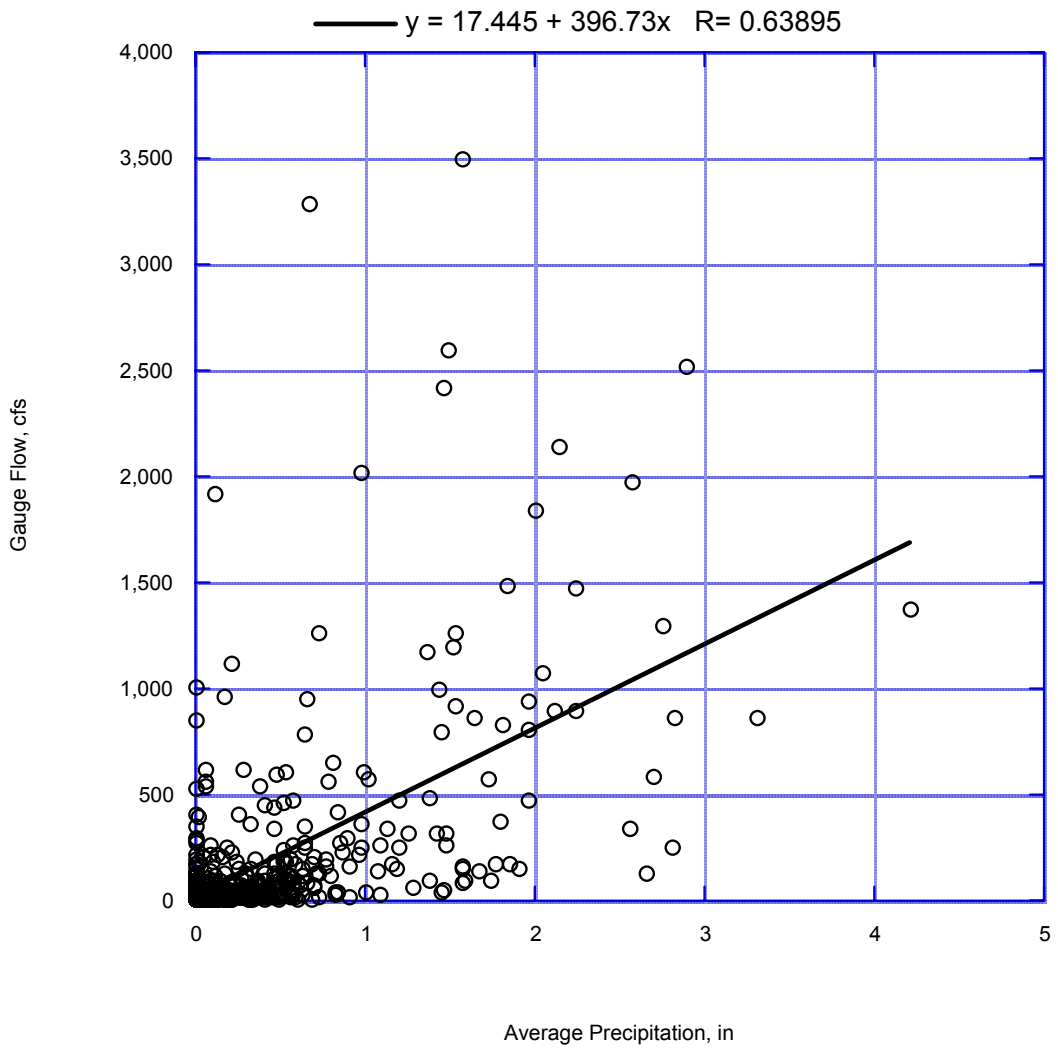


Figure 51. Gauge 841 Gauge Flow vs. Average Watershed Precipitation

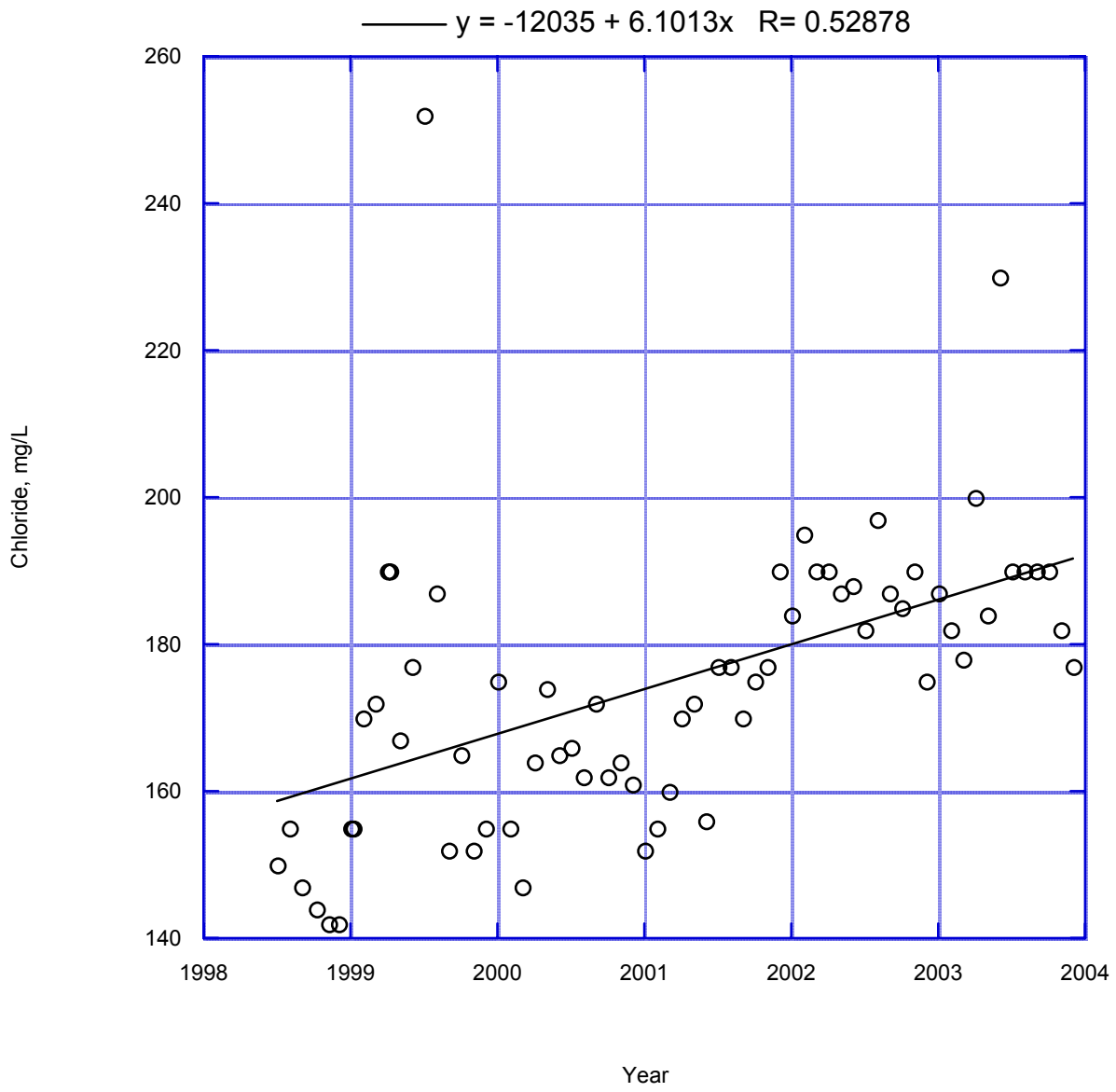


Figure 52. Camarillo Effluent Chloride vs. Time

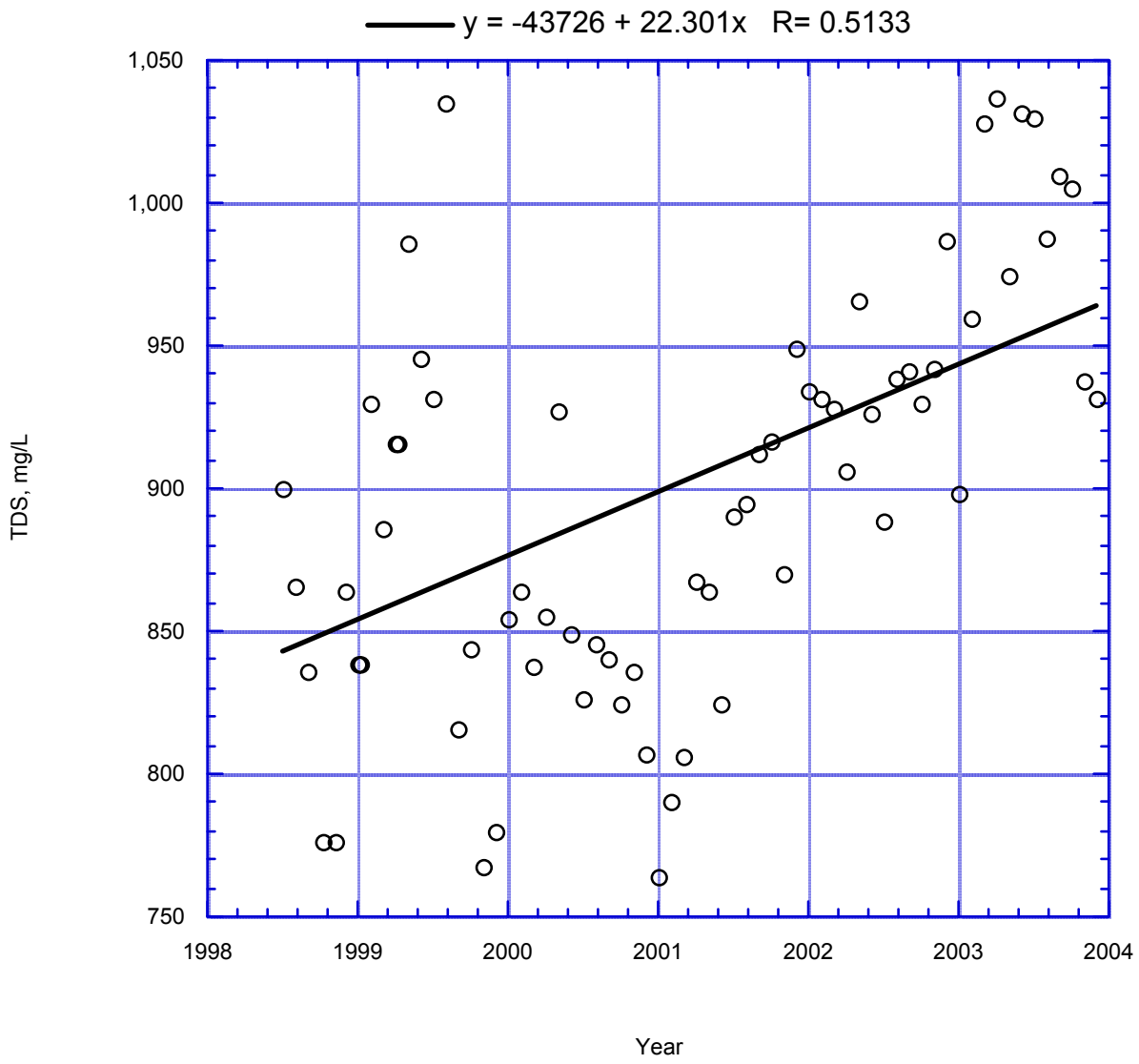


Figure 53. Camarillo Effluent TDS vs. Time

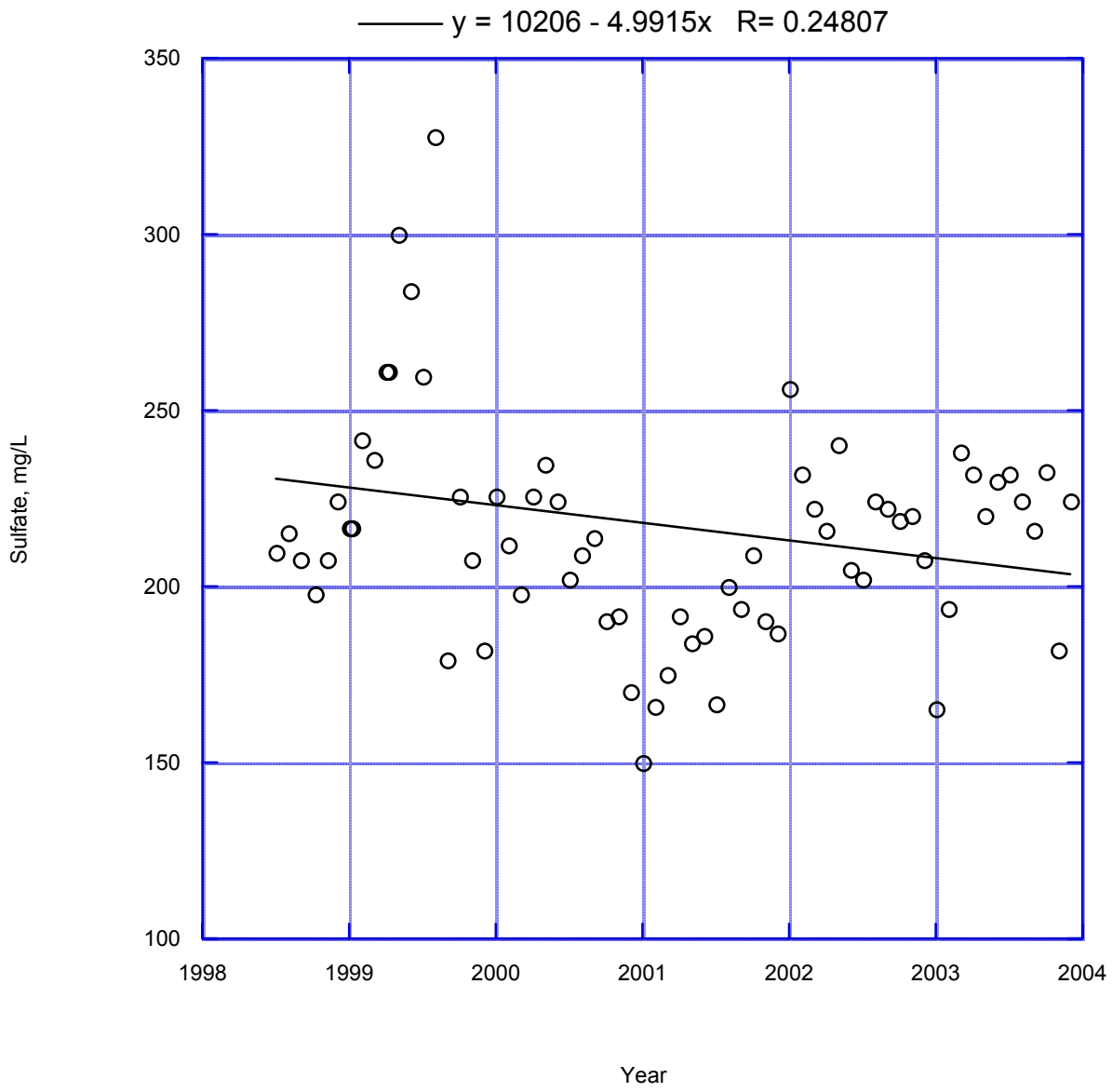


Figure 54. Camarillo Effluent Sulfate vs. Time

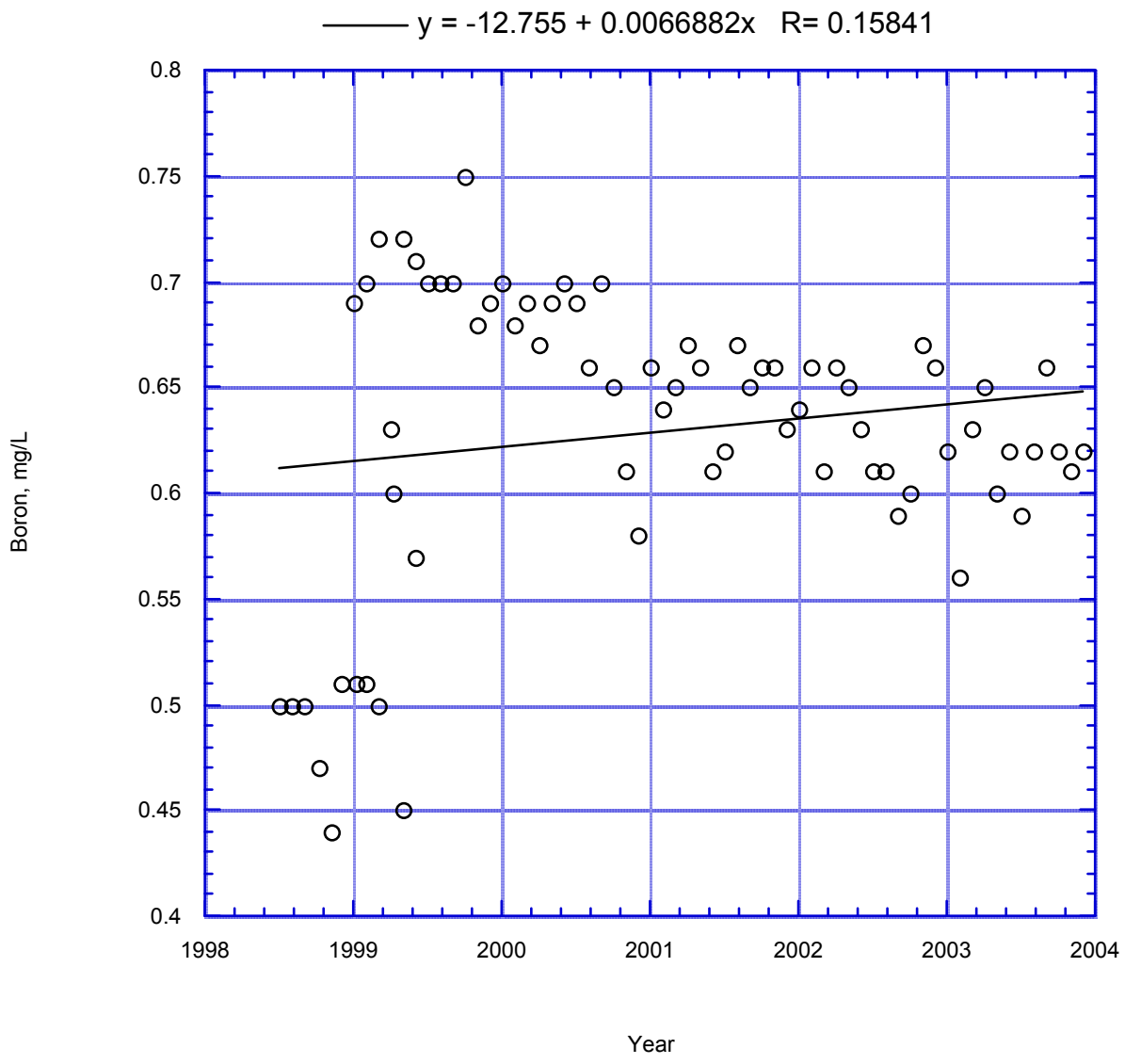


Figure 55. Camarillo Effluent Boron vs. Time

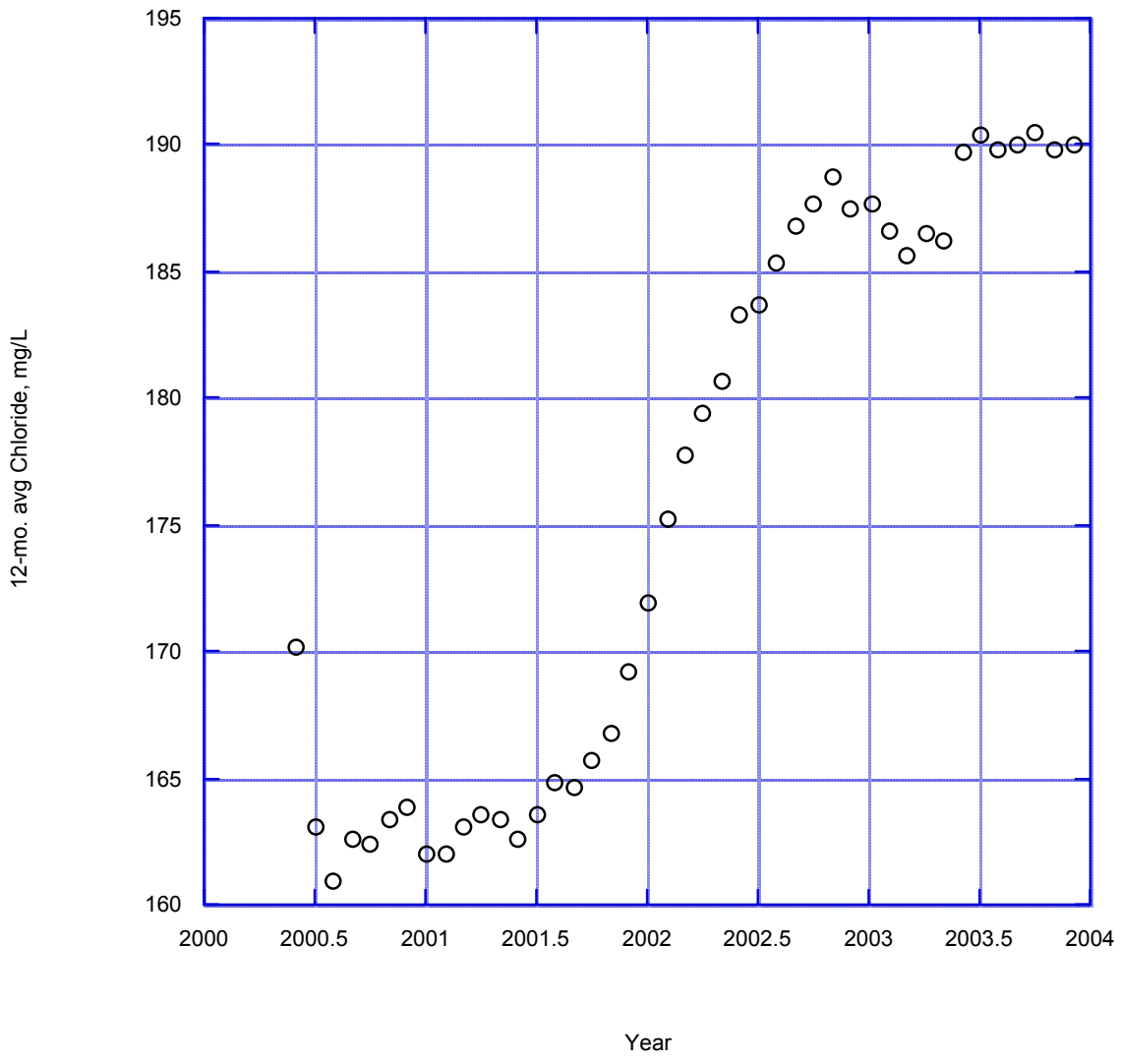


Figure 56. Camarillo Effluent 12-mo. Average Chloride vs. Time

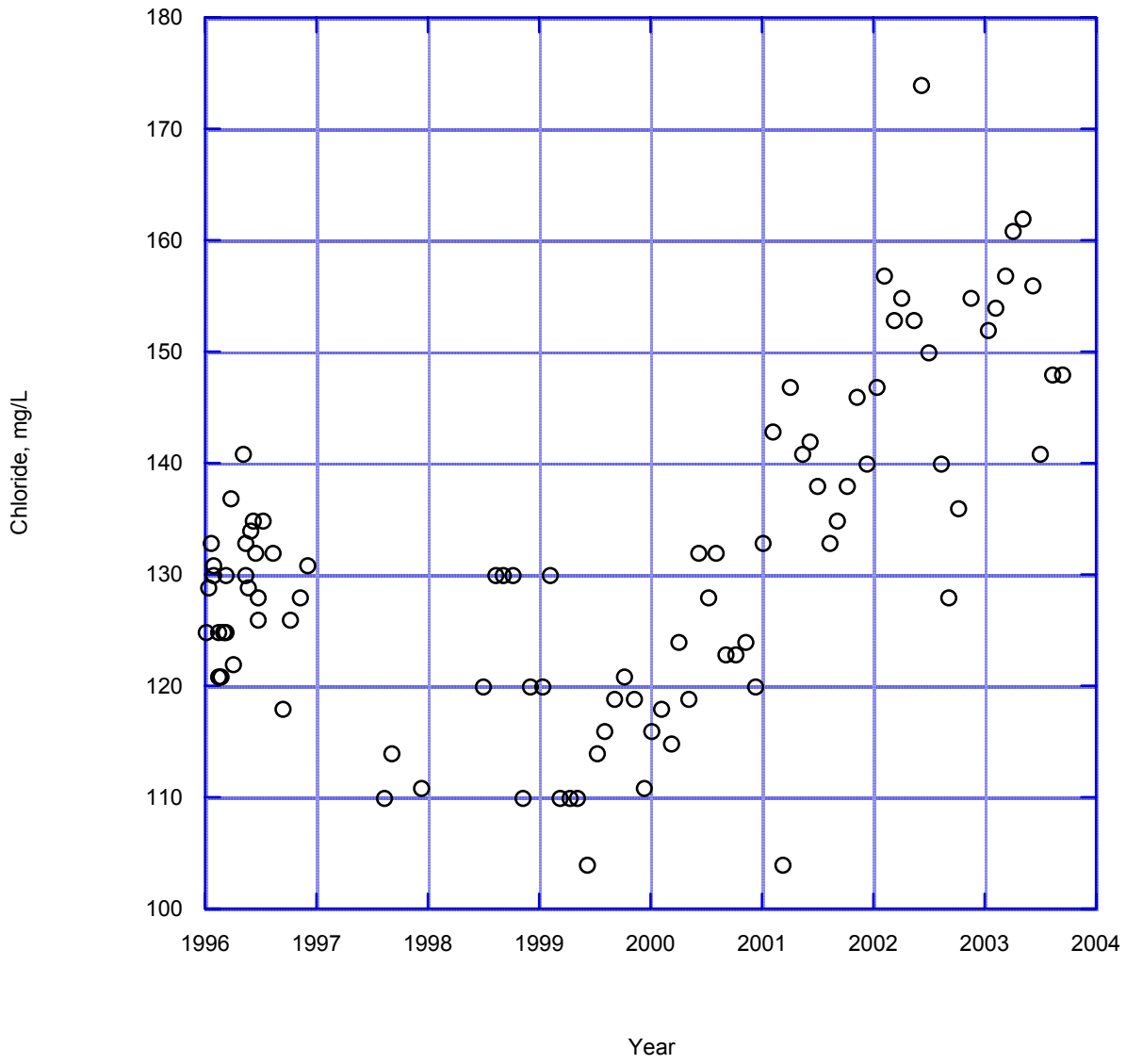


Figure 57. Hill Canyon Effluent Chloride vs. Time

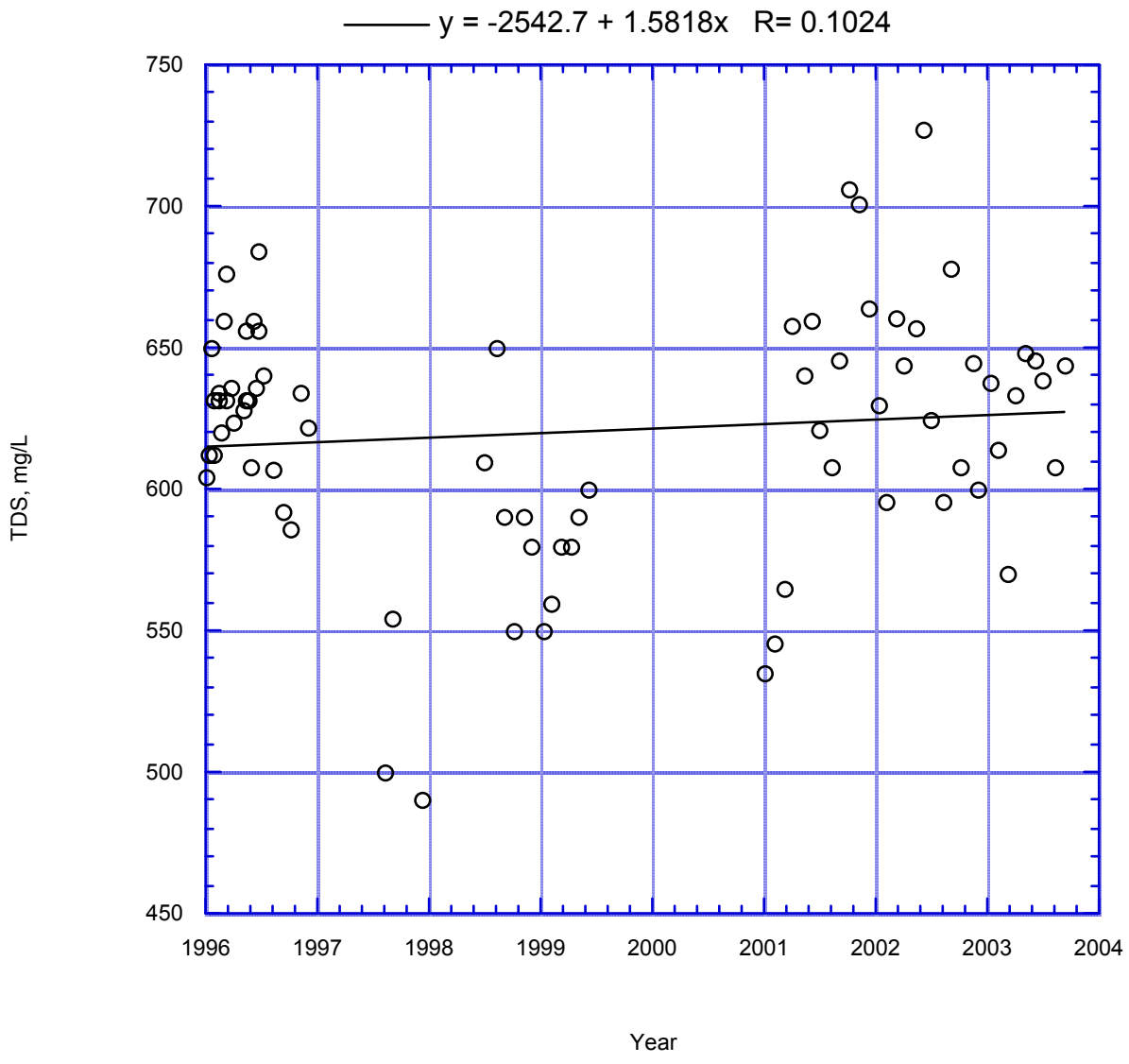


Figure 58. Hill Canyon Effluent TDS vs. Time

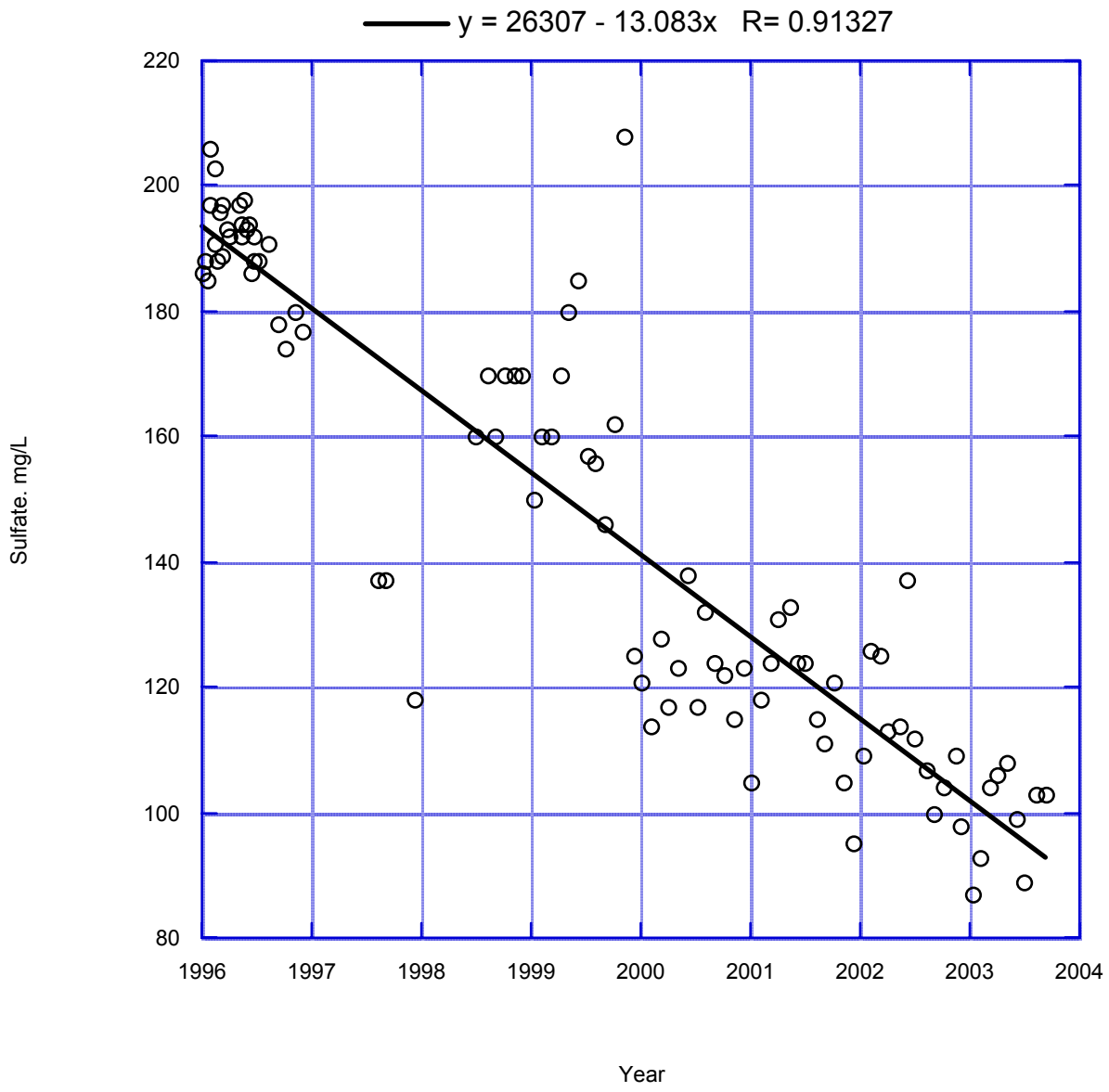


Figure 59. Hill Canyon Effluent Sulfate vs. Time

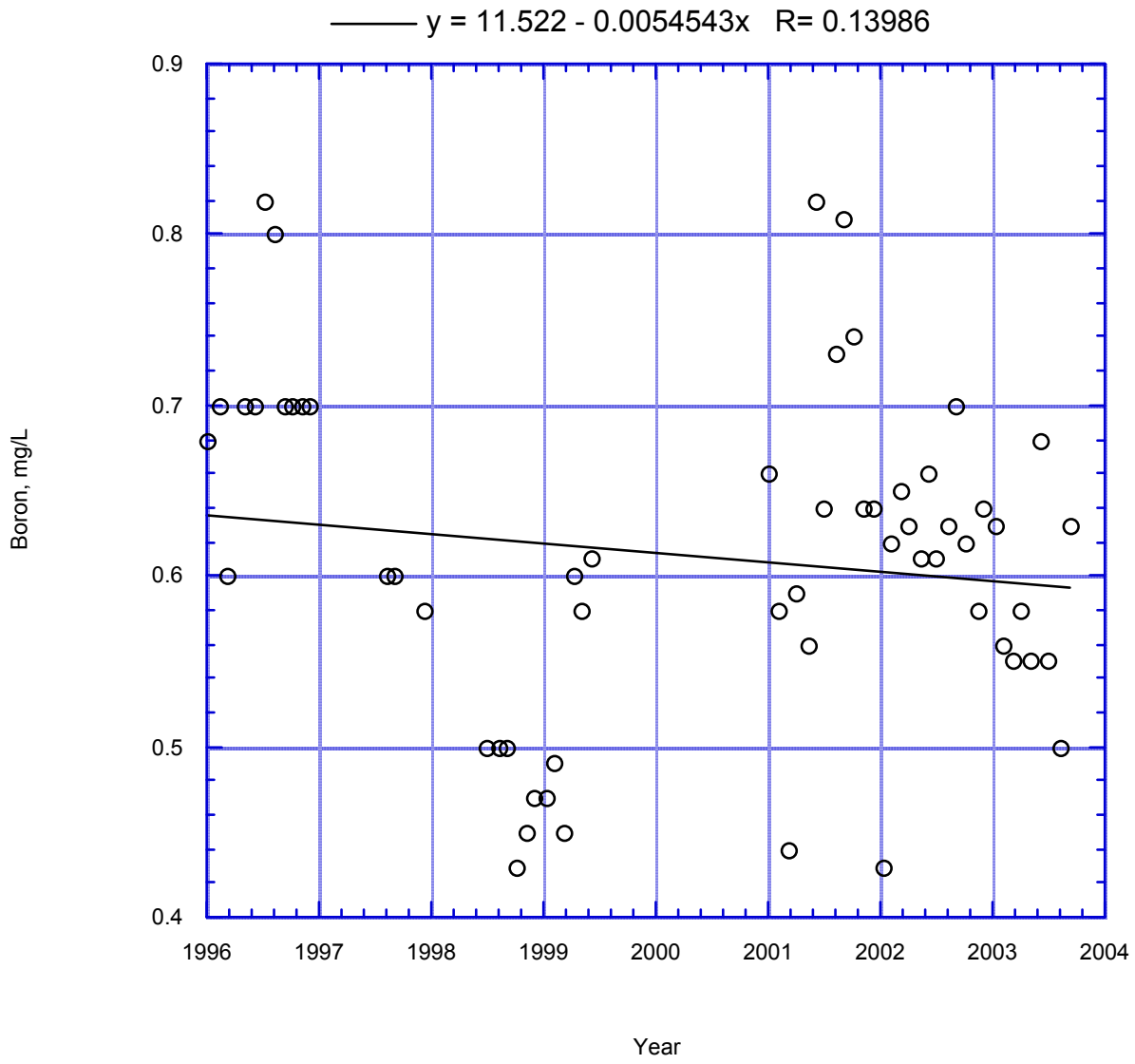


Figure 60. Hill Canyon Effluent – Boron vs. Time

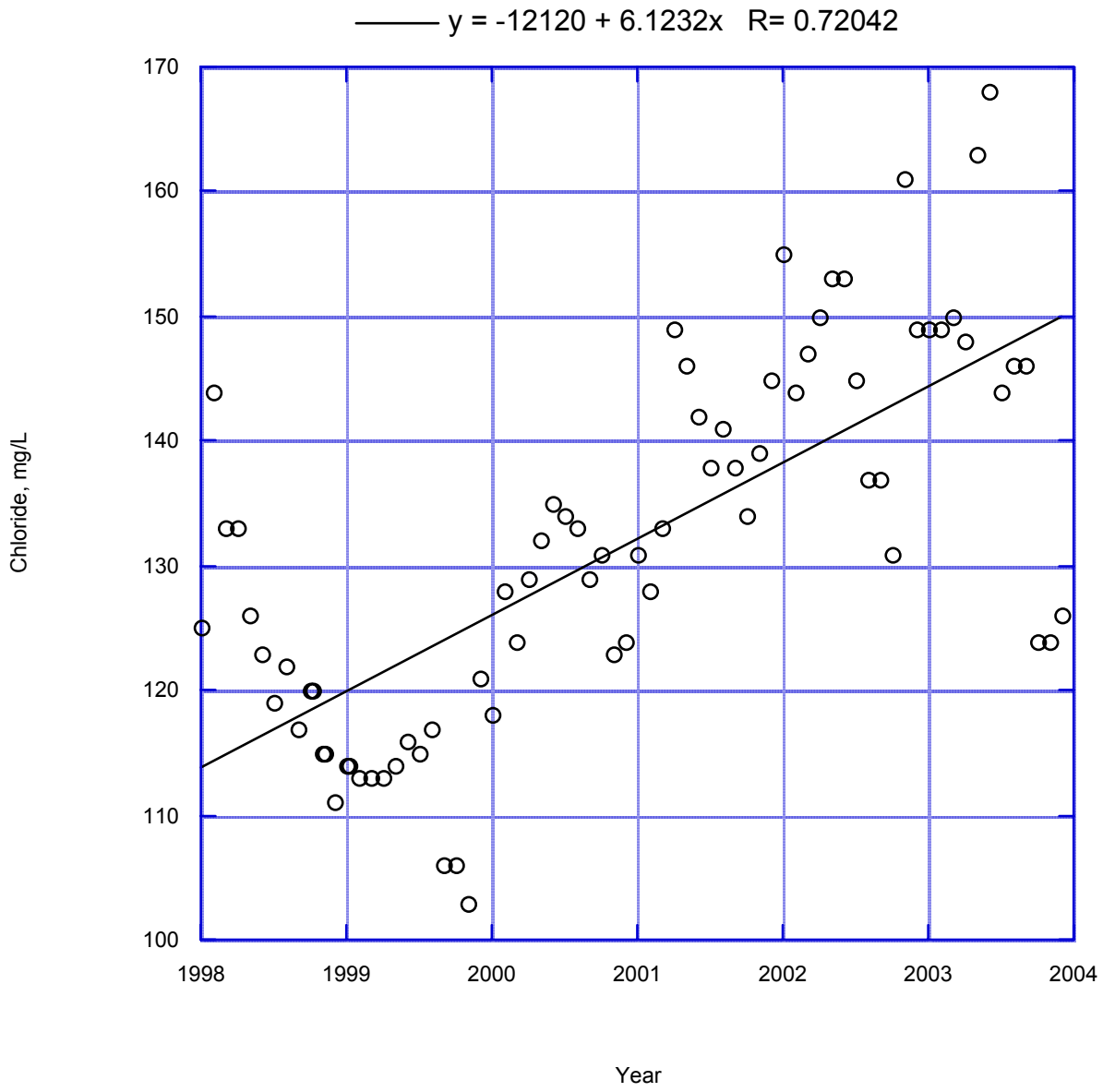


Figure 61. Simi Valley Effluent Chloride vs. Time

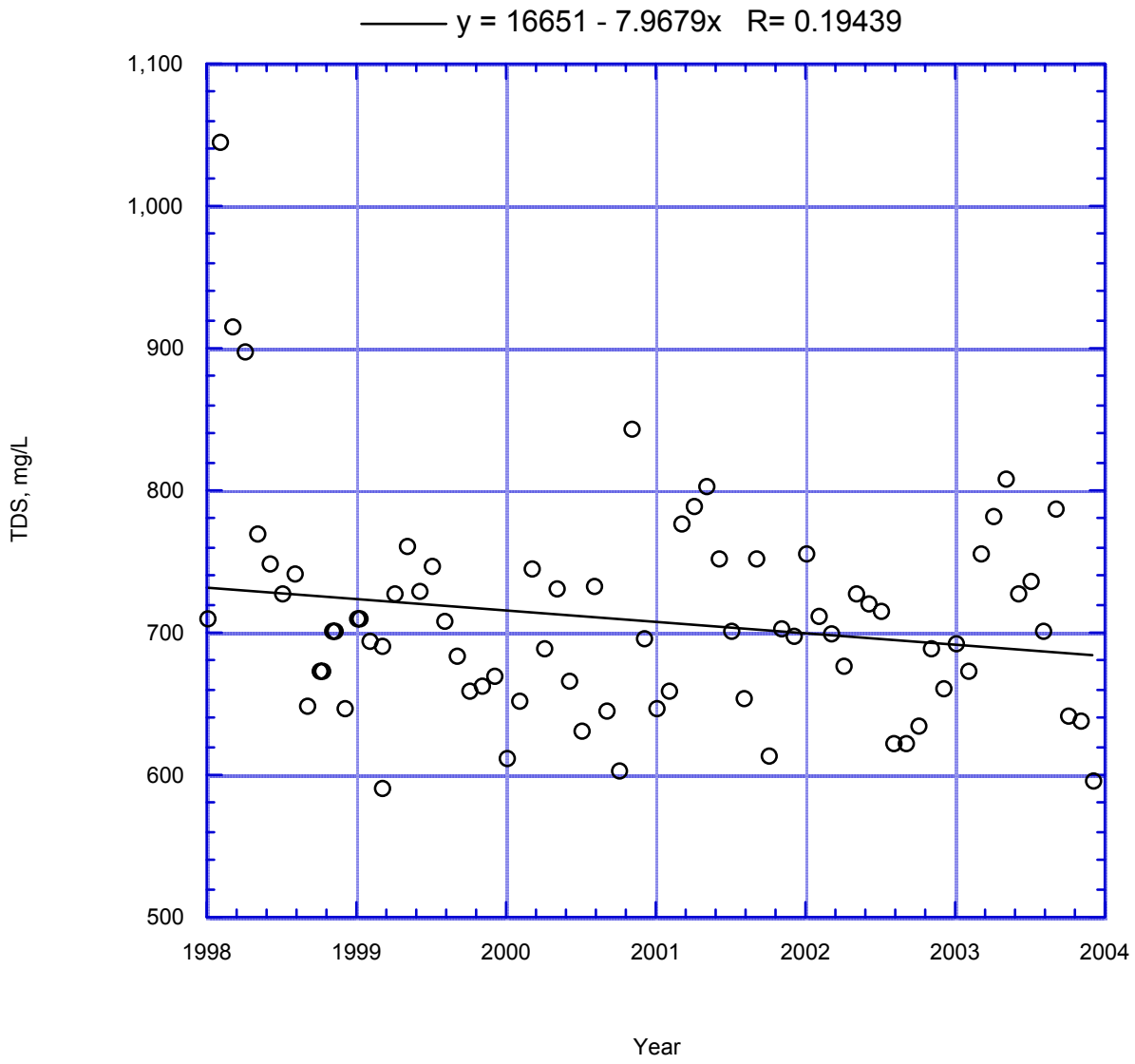


Figure 62. Simi Valley Effluent TDS vs. Time

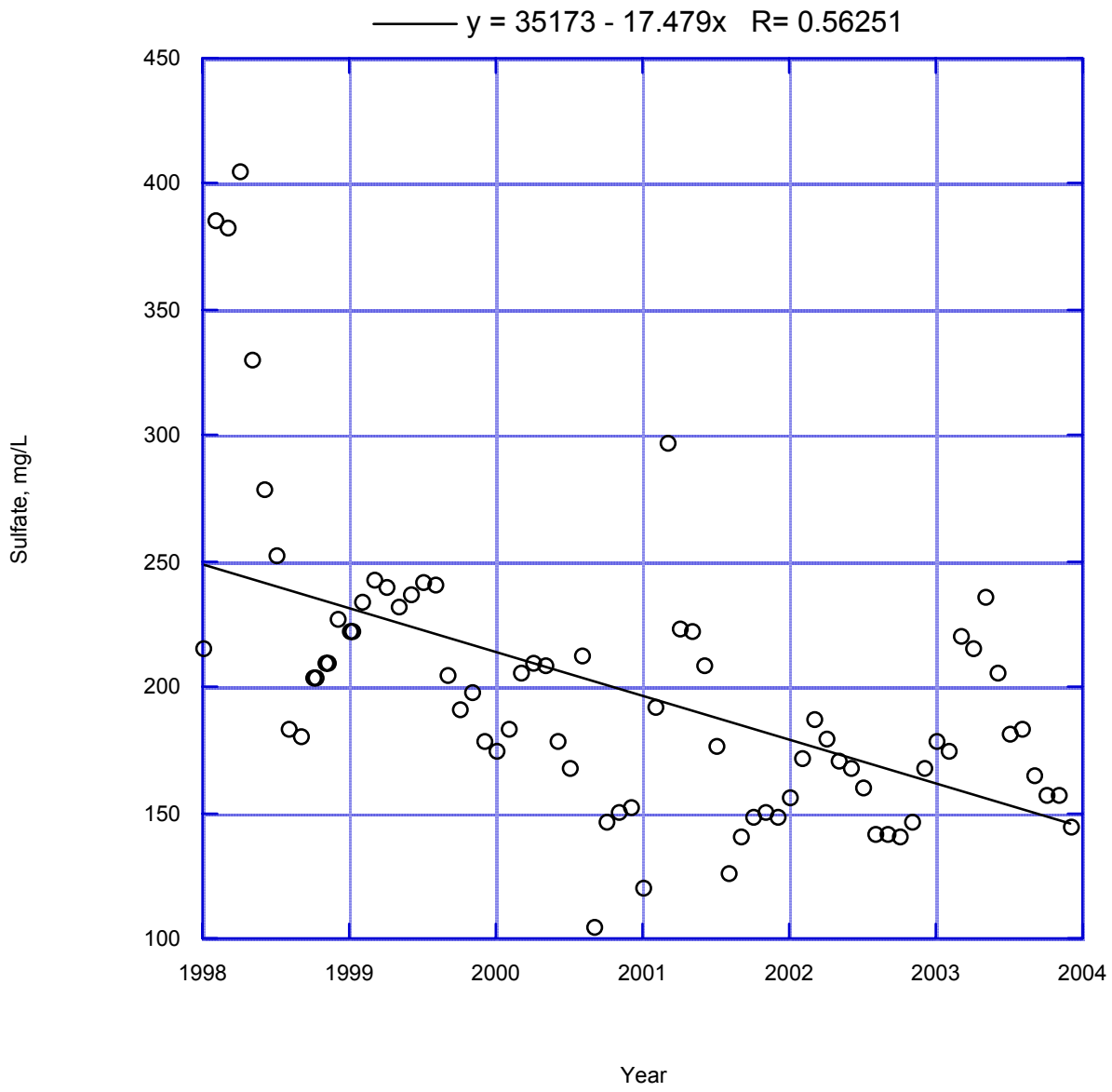


Figure 63. Simi Valley Effluent Sulfate vs. Time

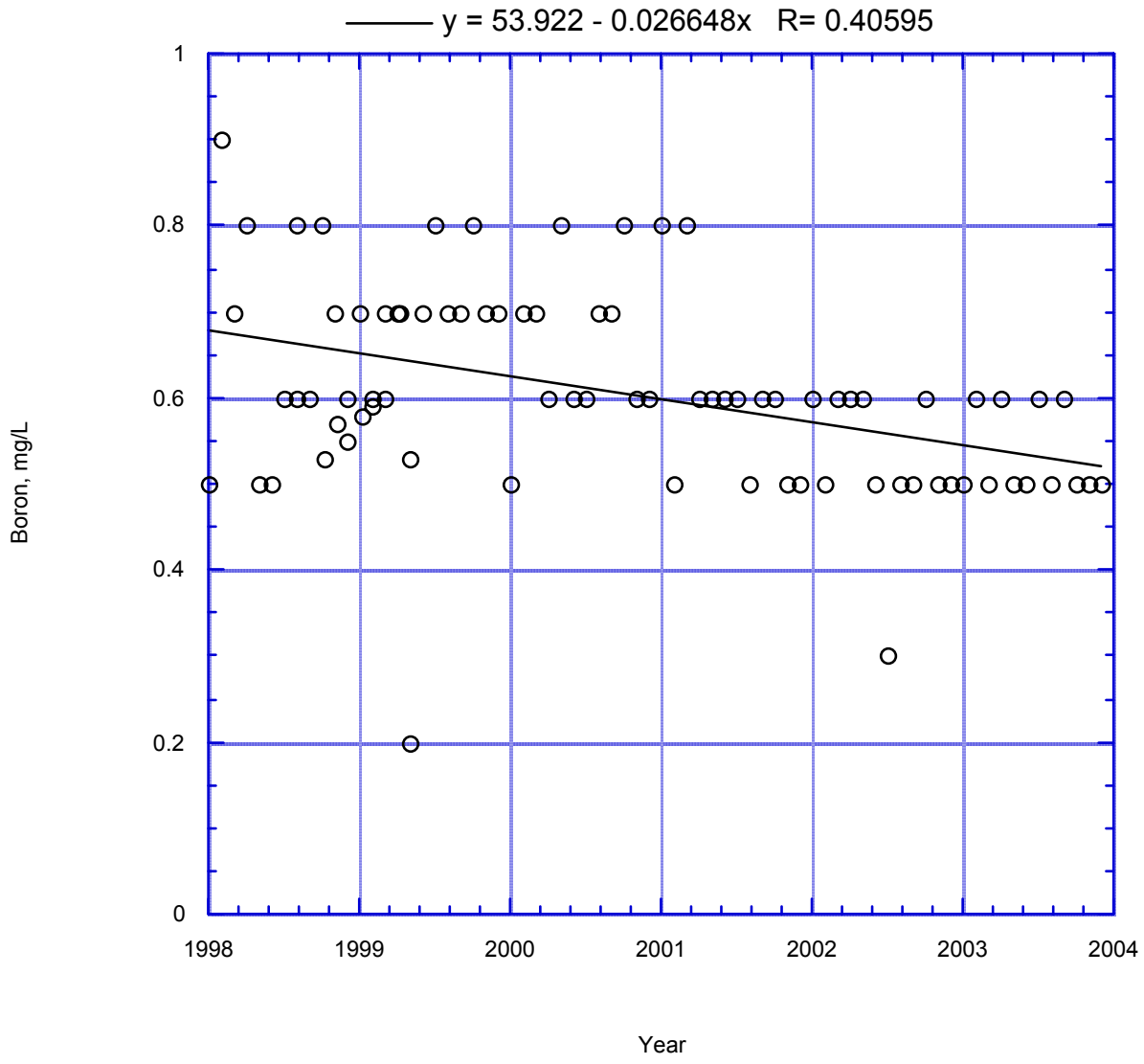


Figure 64. Simi Valley Effluent Boron vs. Time

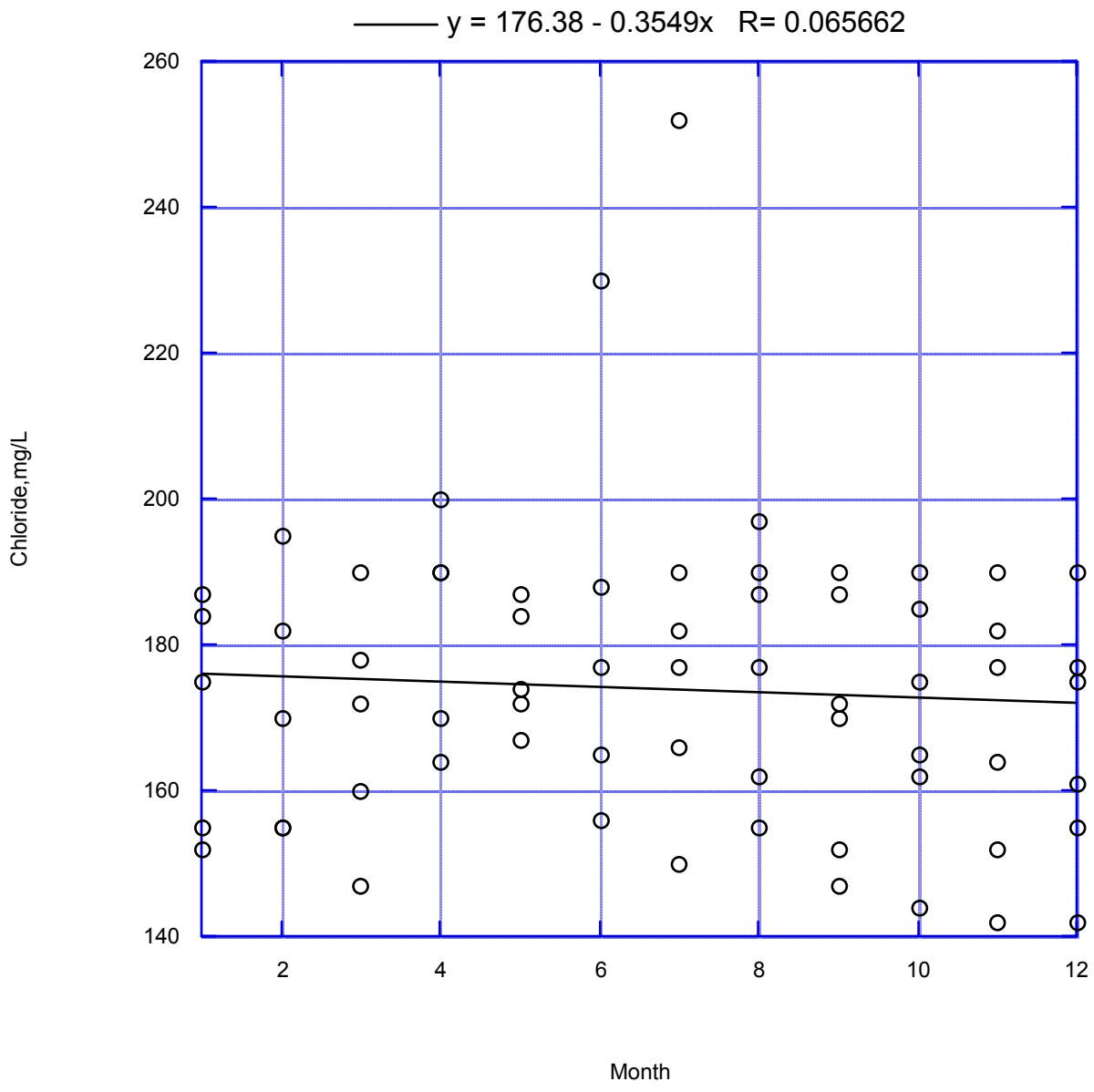


Figure 65. Camarillo Effluent Chloride v. Month

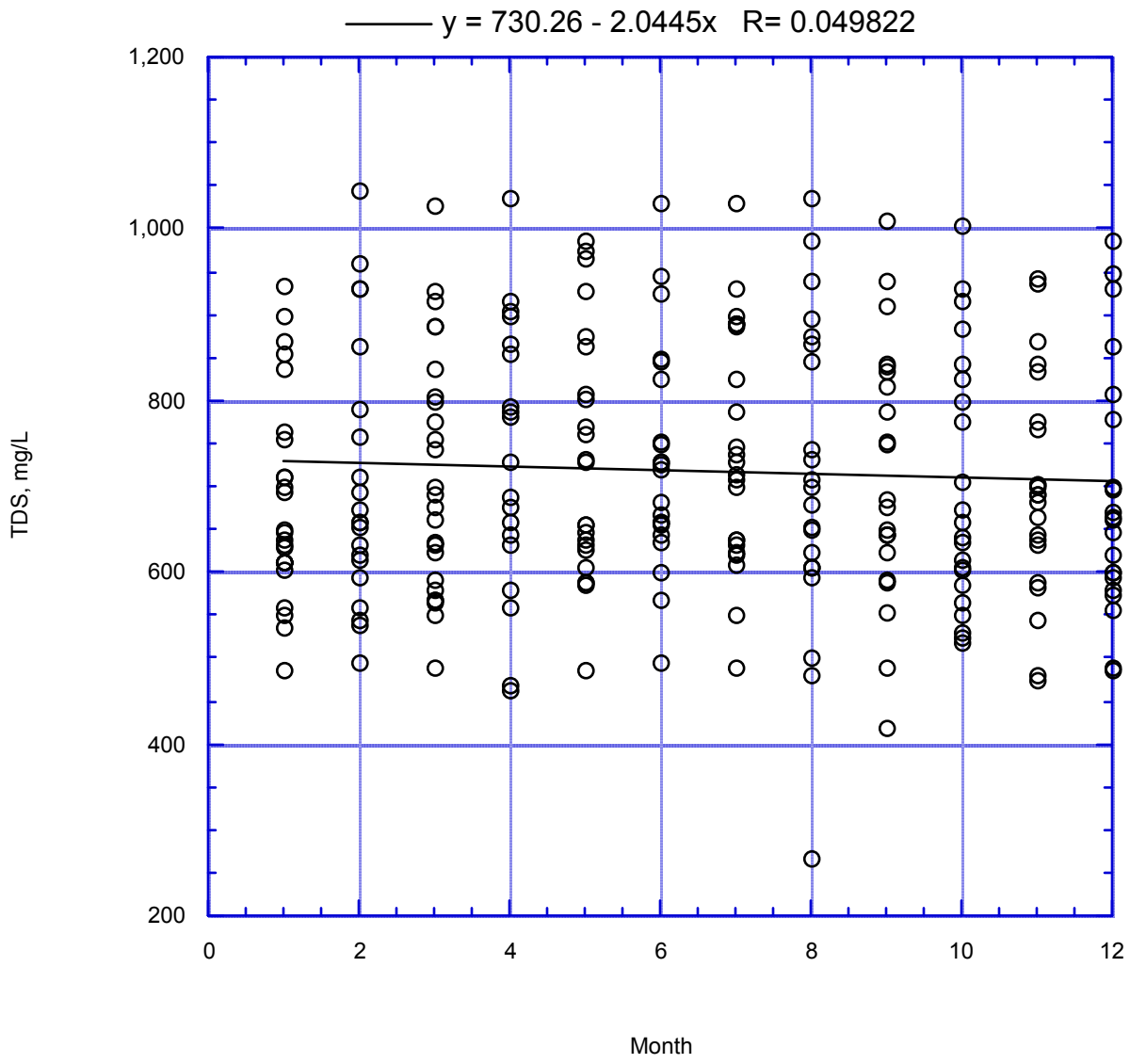


Figure 66. Camarillo Effluent TDS vs. Month

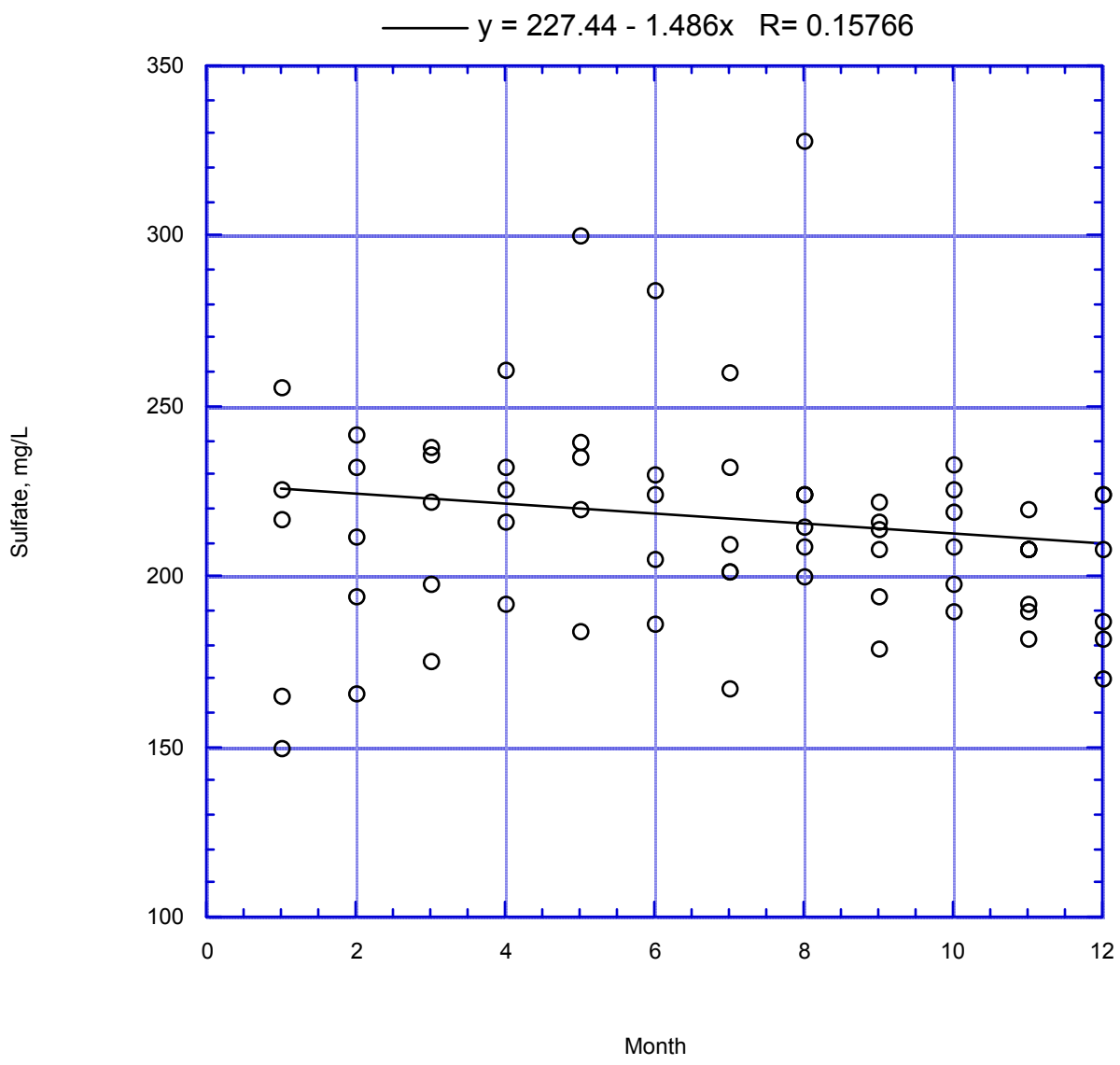


Figure 67. Camarillo Effluent Sulfate vs. Month

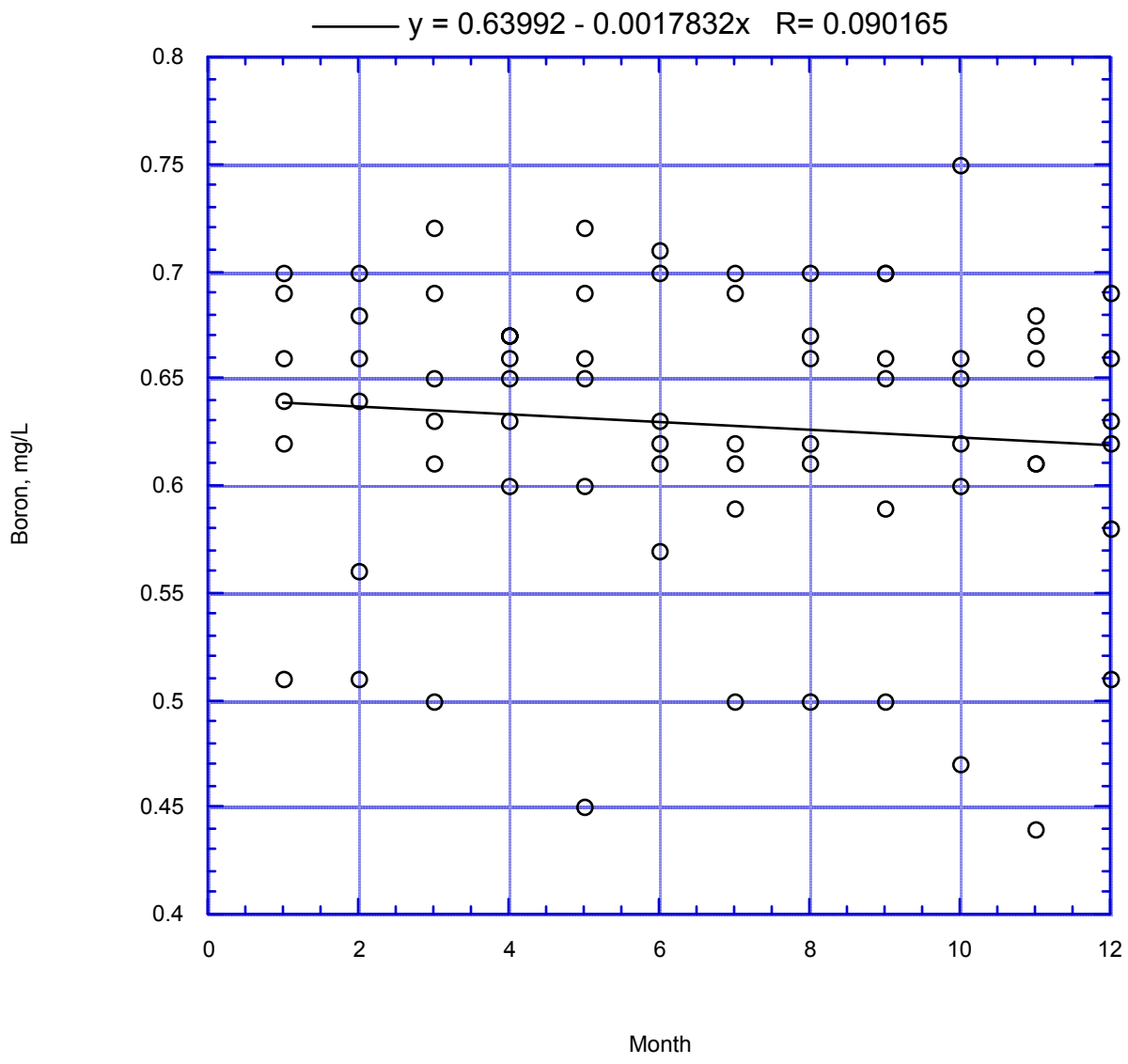


Figure 68. Camarillo Effluent Boron vs. Month

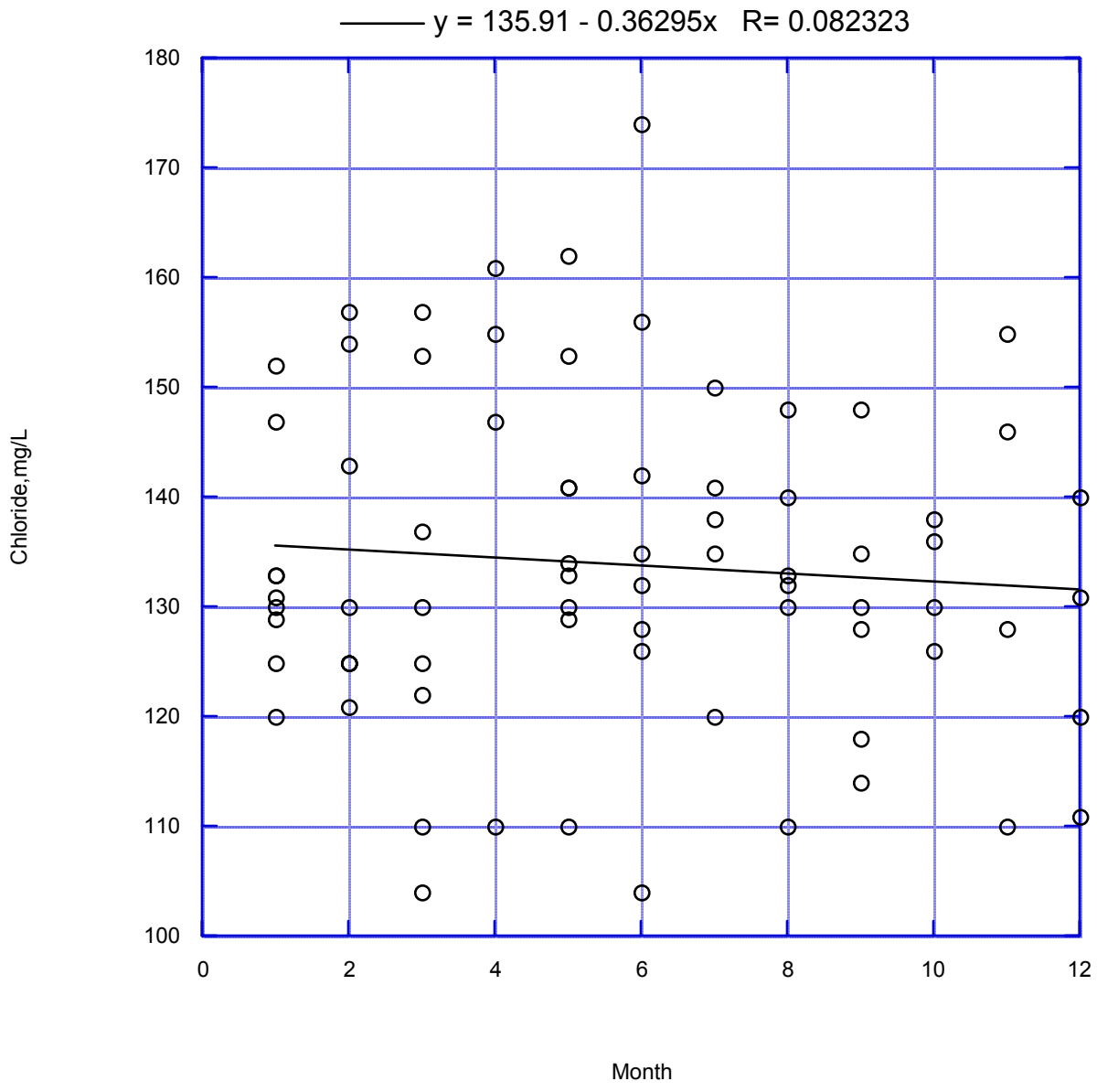


Figure 69. Hill Canyon Effluent Chloride vs. Month

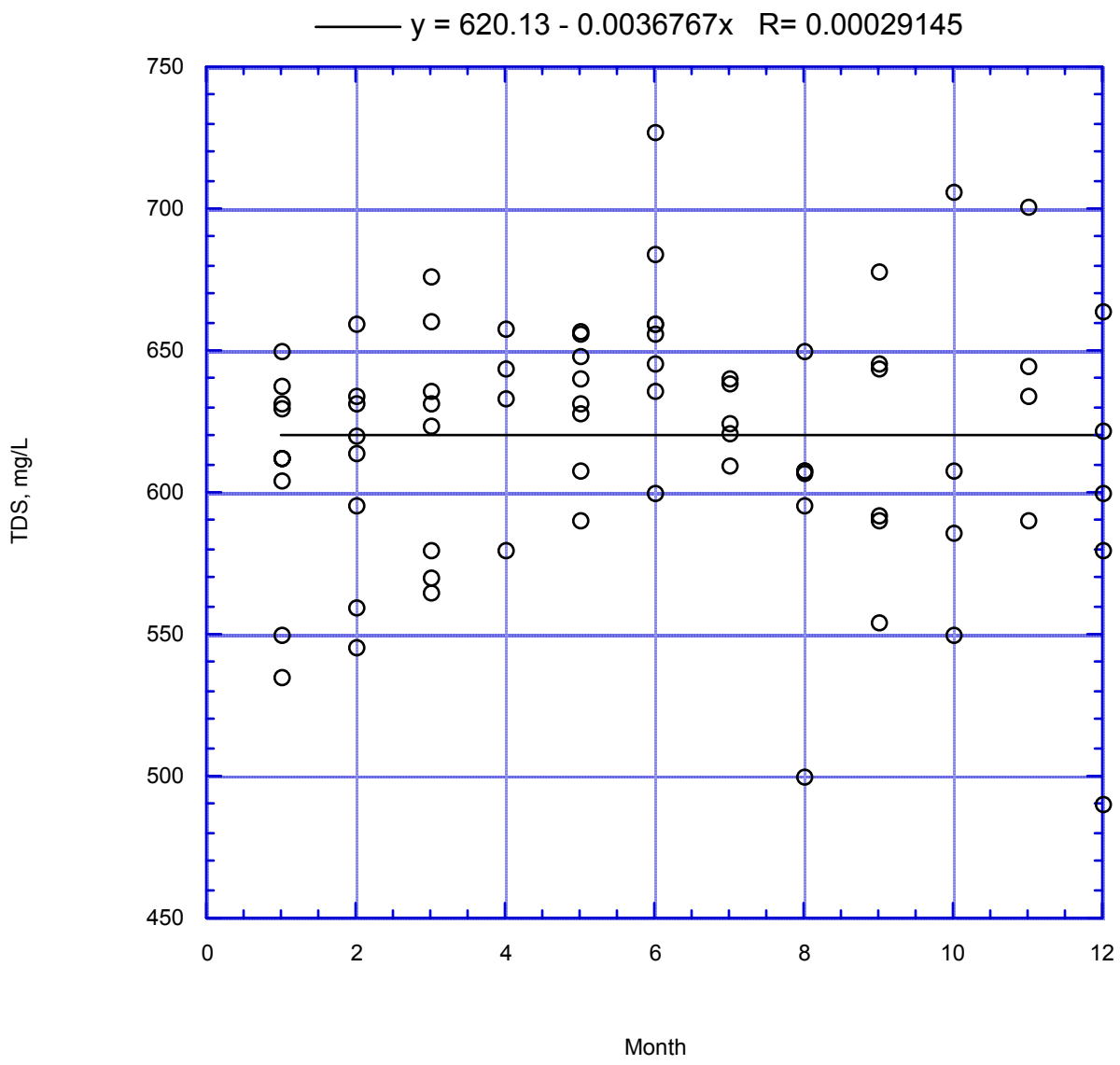


Figure 70. Hill Canyon Effluent TDS vs. Month

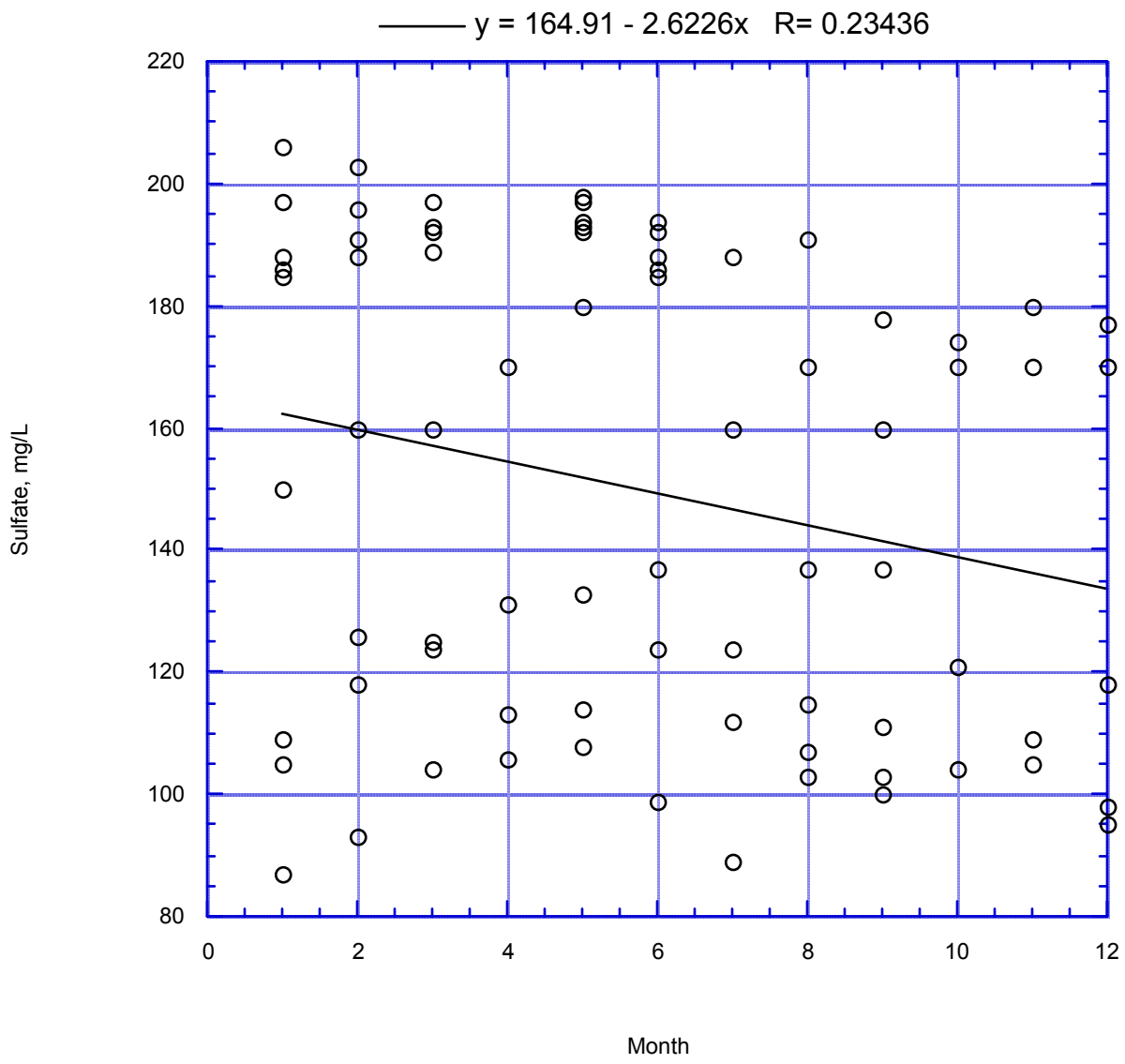


Figure 71. Hill Canyon Effluent Sulfate vs. Month

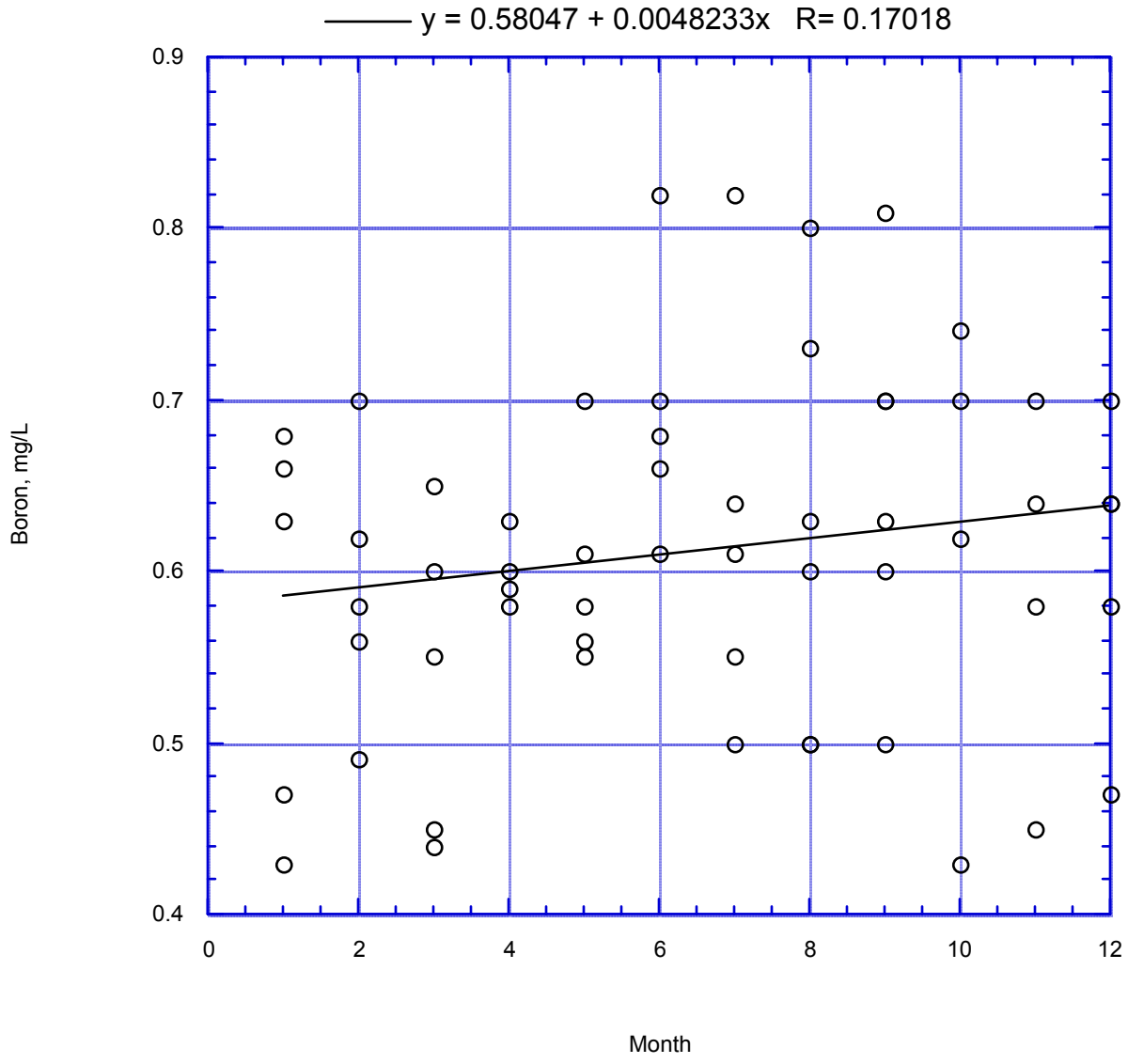


Figure 72. Hill Canyon Effluent Boron vs. Month

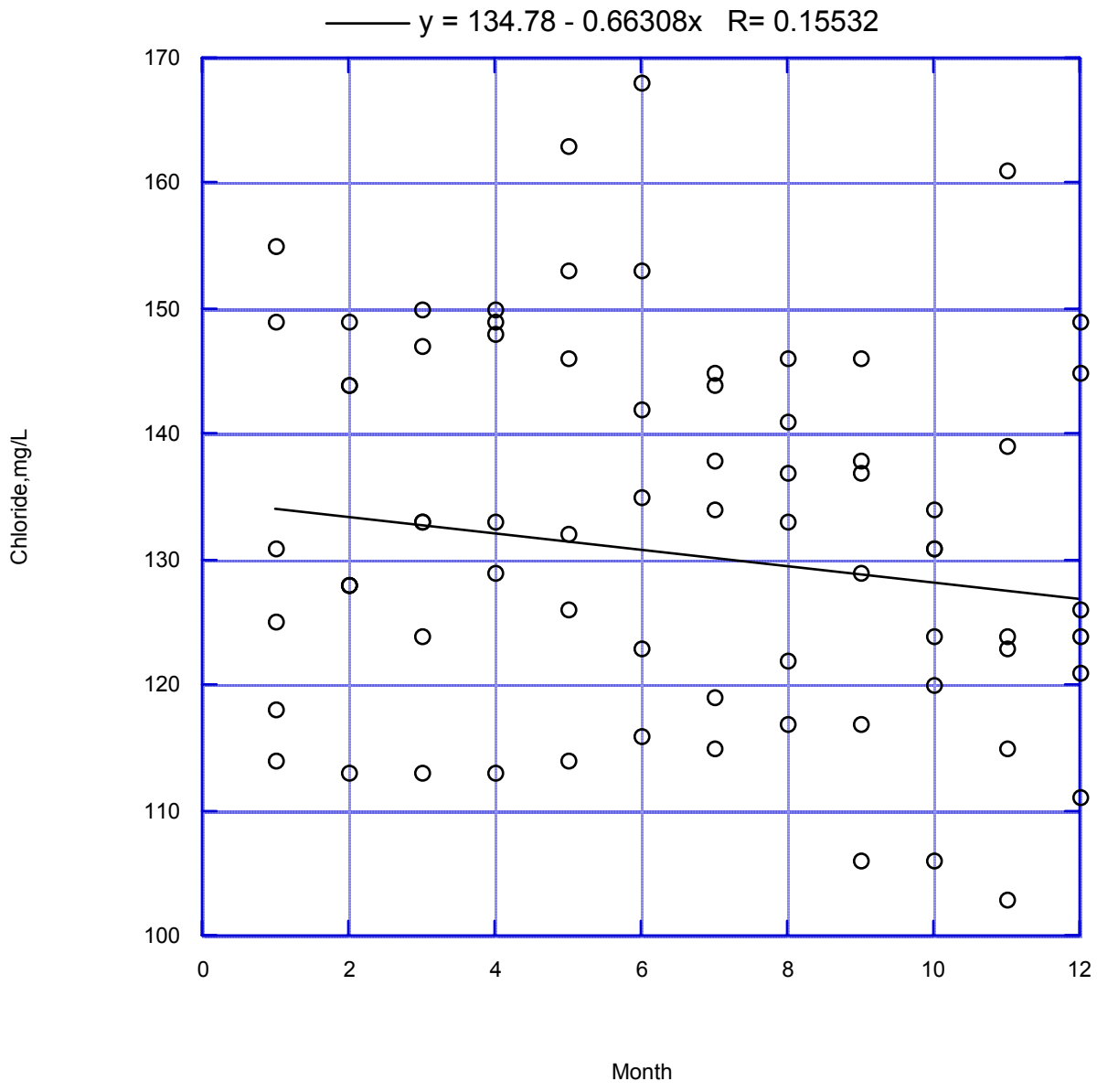


Figure 73. Simi Valley Effluent Chloride vs. Month

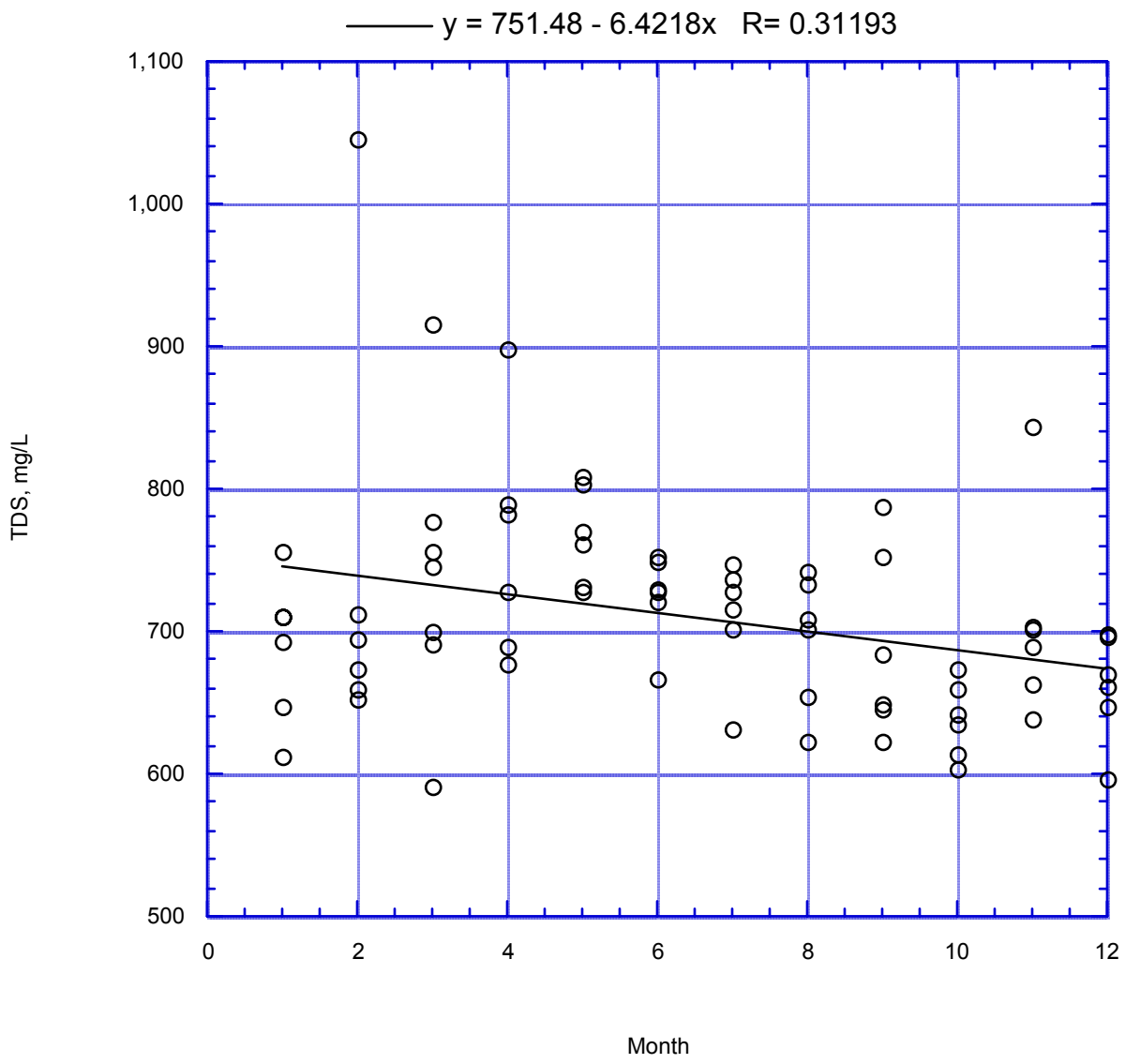


Figure 74. Simi Valley Effluent TDS vs. Month

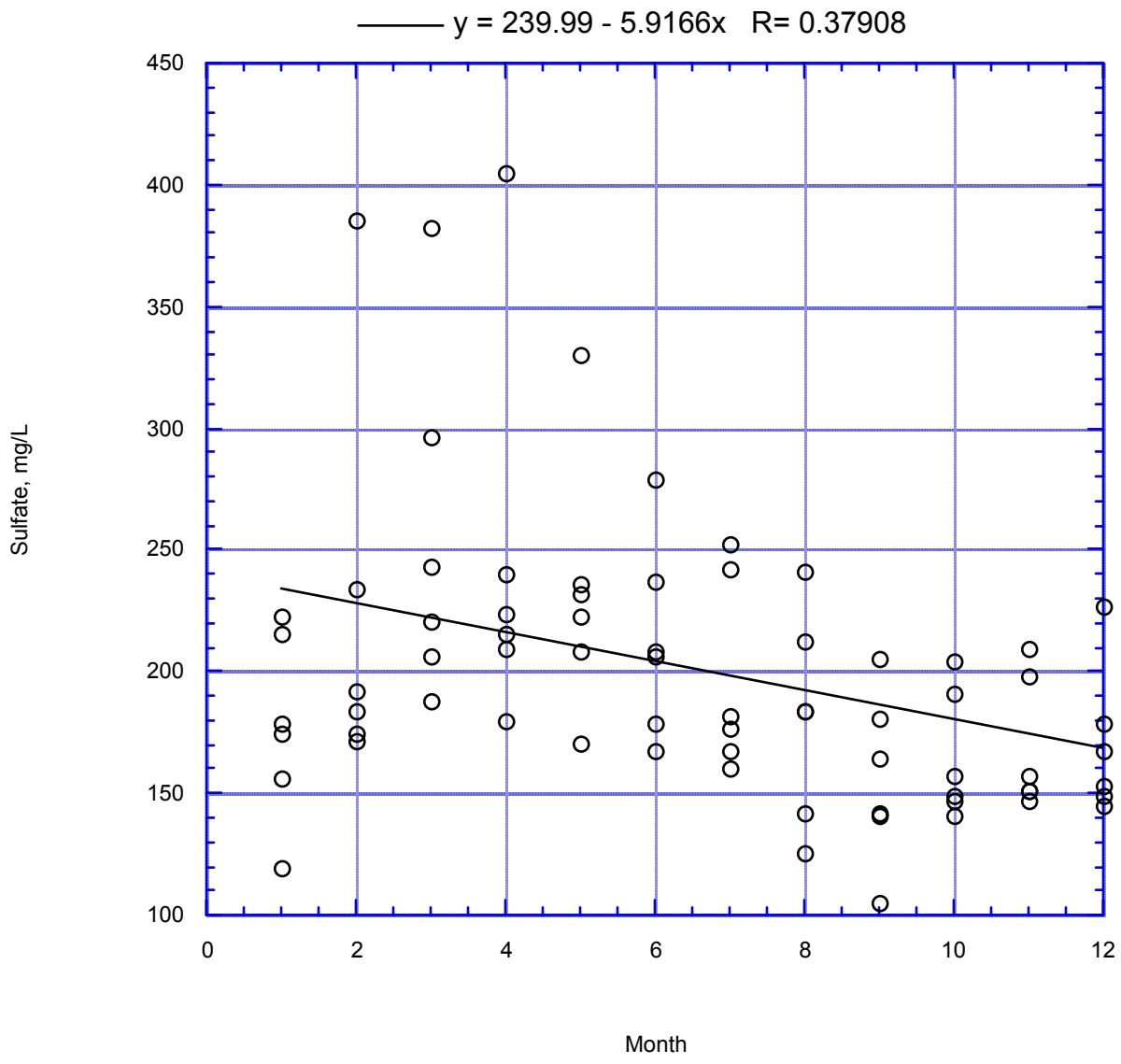


Figure 75. Simi Valley Effluent Sulfate vs. Month

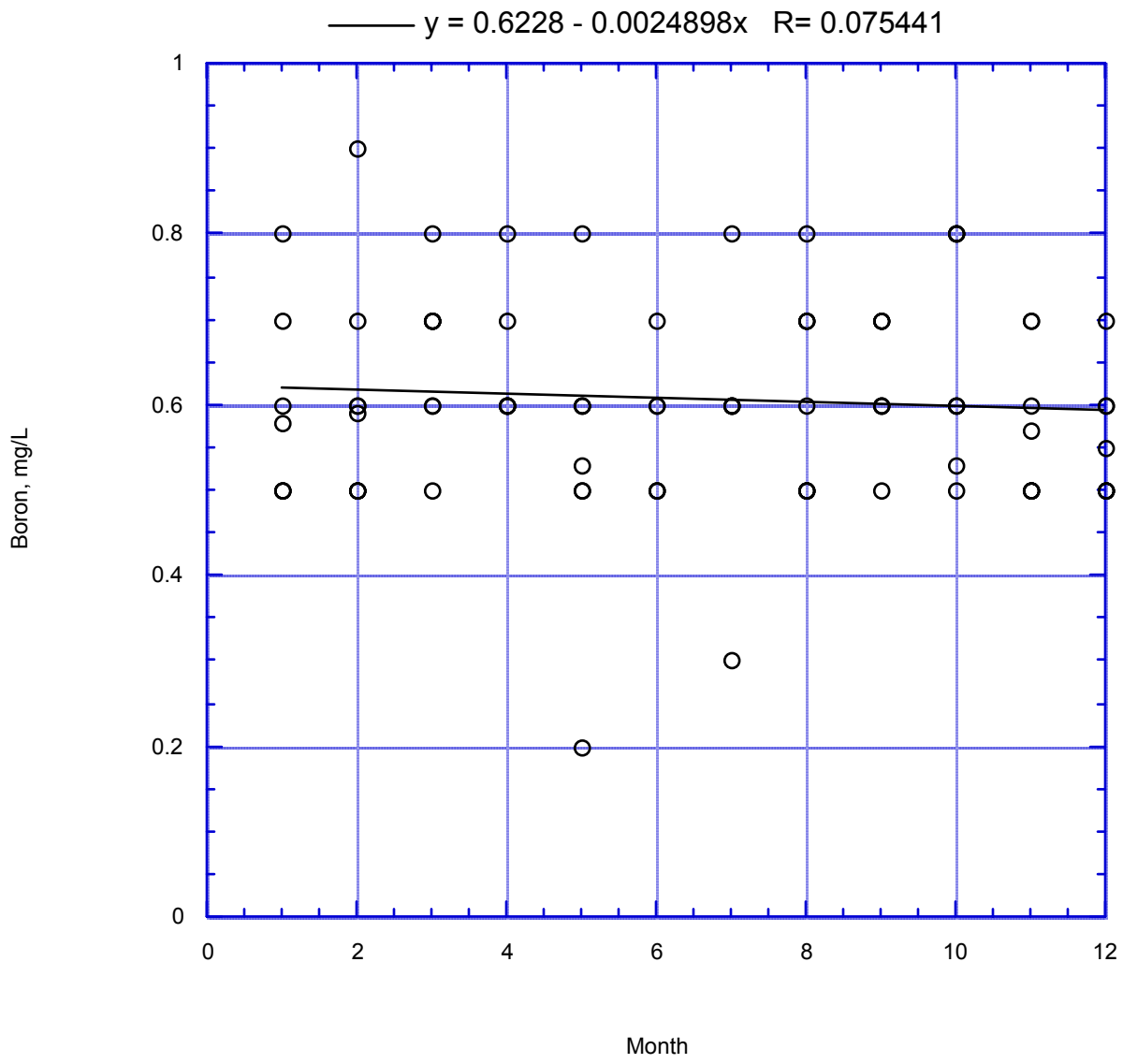


Figure 76. Simi Valley Effluent Boron vs. Month

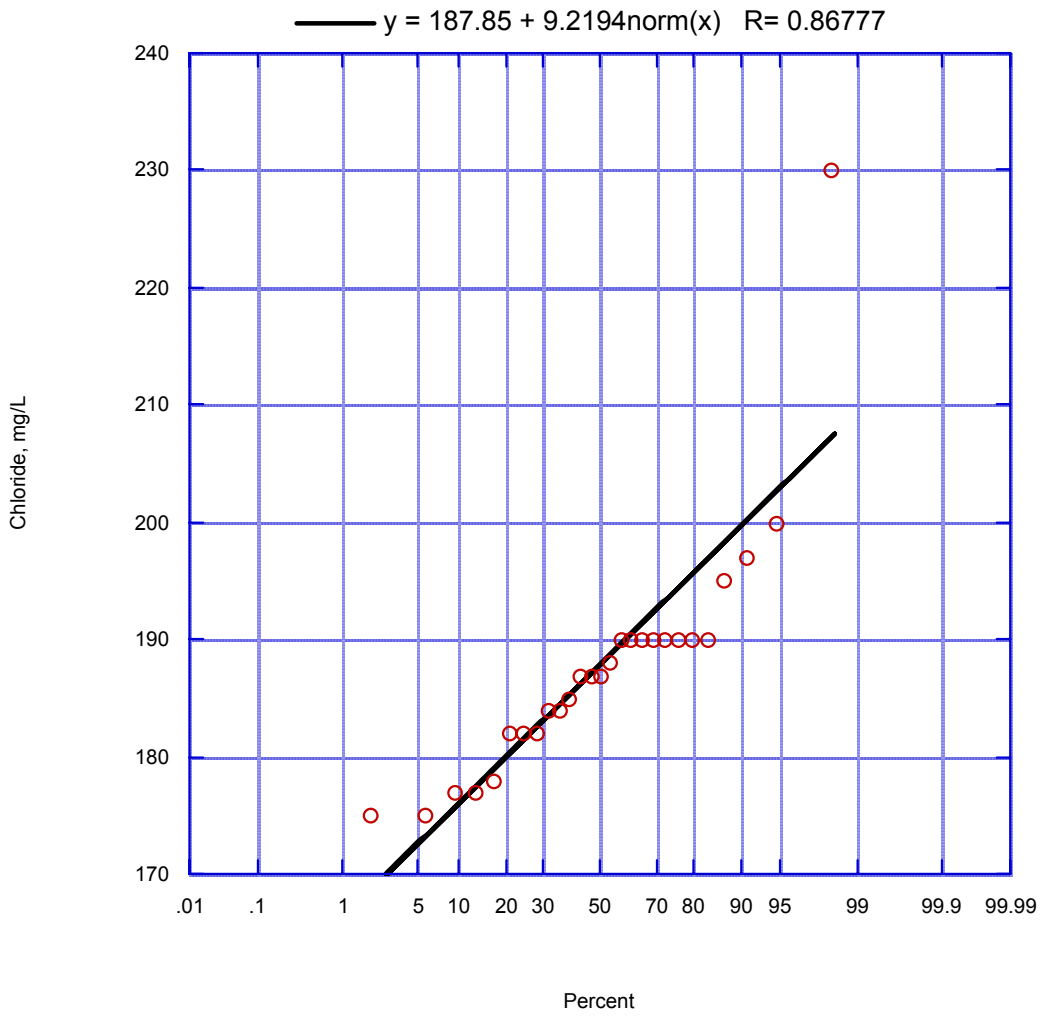


Figure 77. Camarillo Effluent Chloride Frequency Distribution (10/01-9/03)

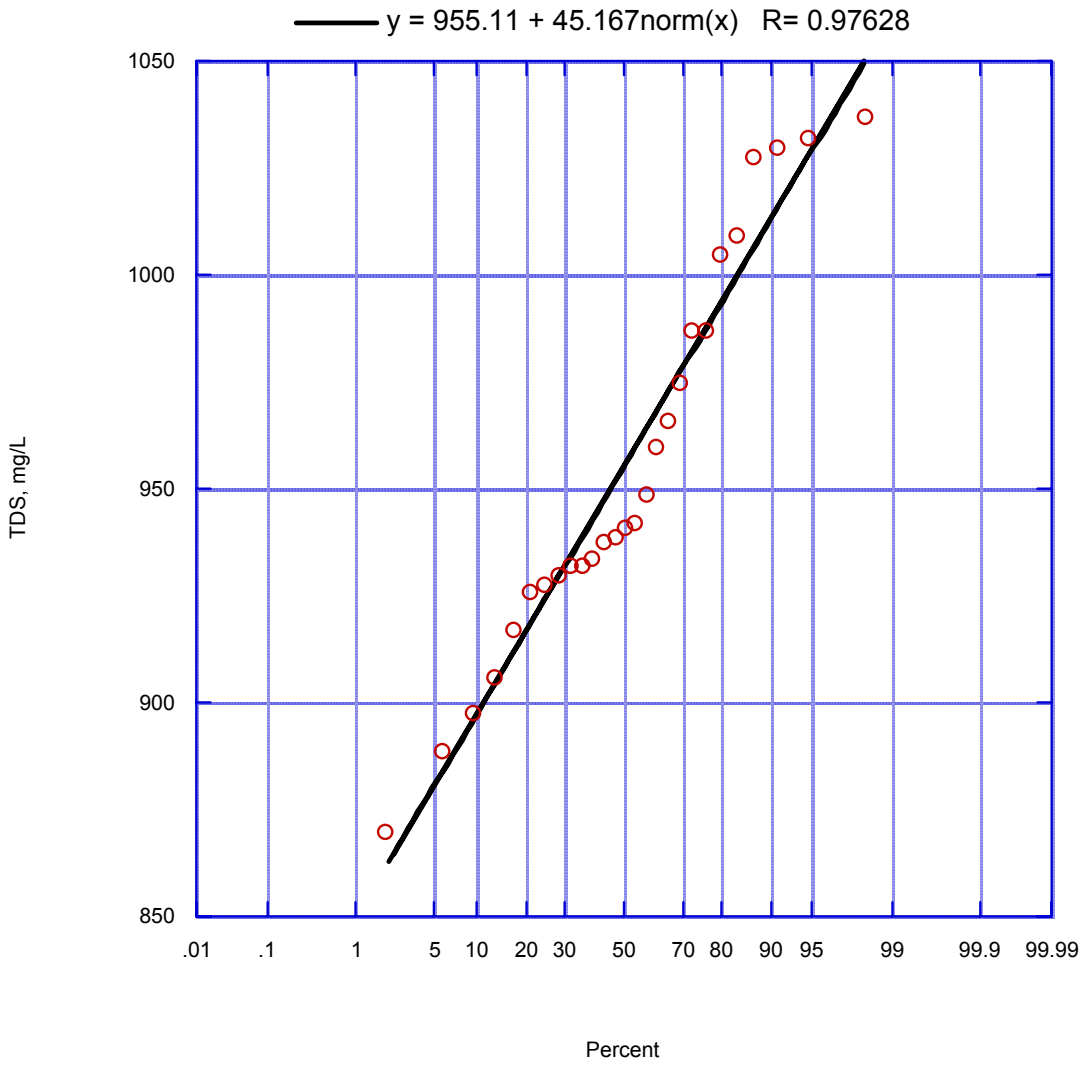


Figure 78. Camarillo Effluent TDS Frequency Distribution (10/01-12/03)

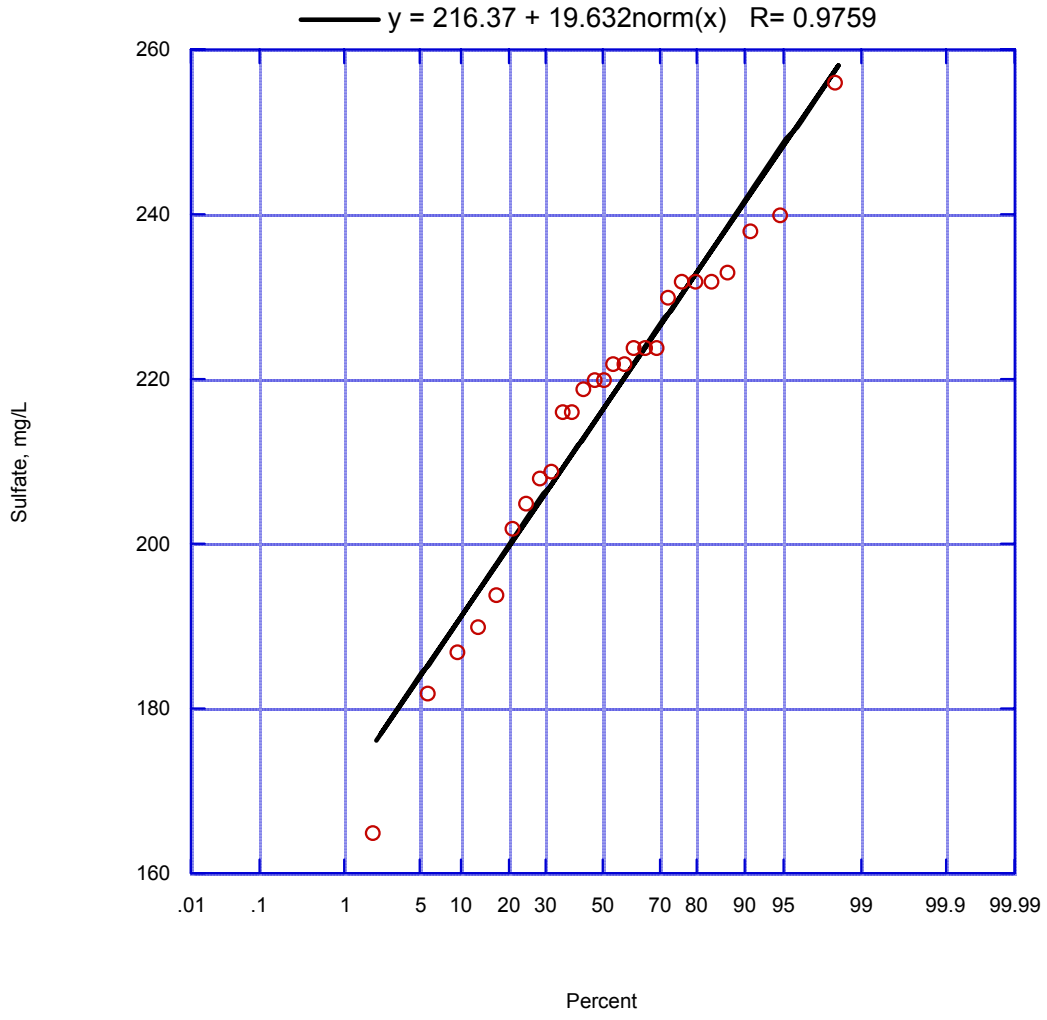


Figure 79. Camarillo Effluent Sulfate Frequency Distribution (10/01-12/03)

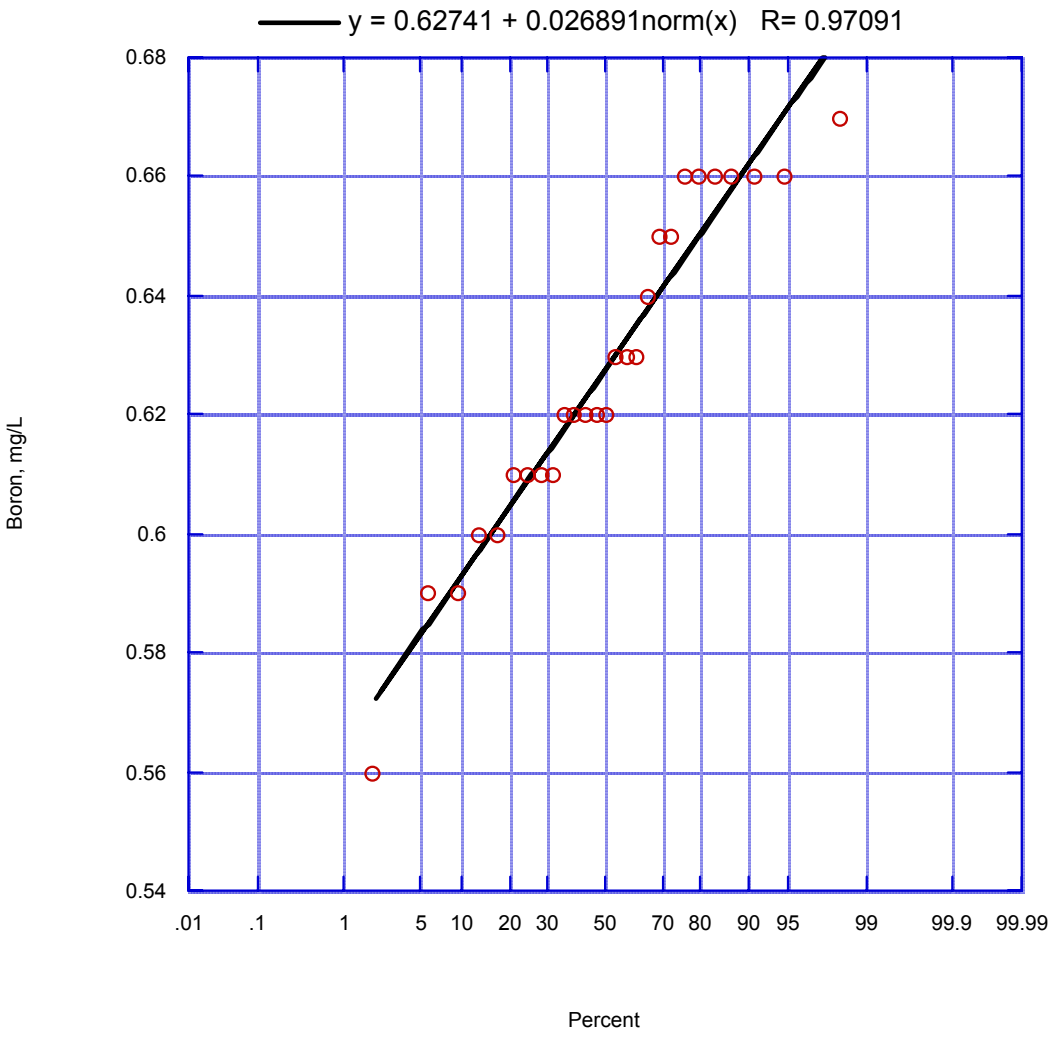


Figure 80. Camarillo Effluent Boron Frequency Distribution (10/01-12/03)

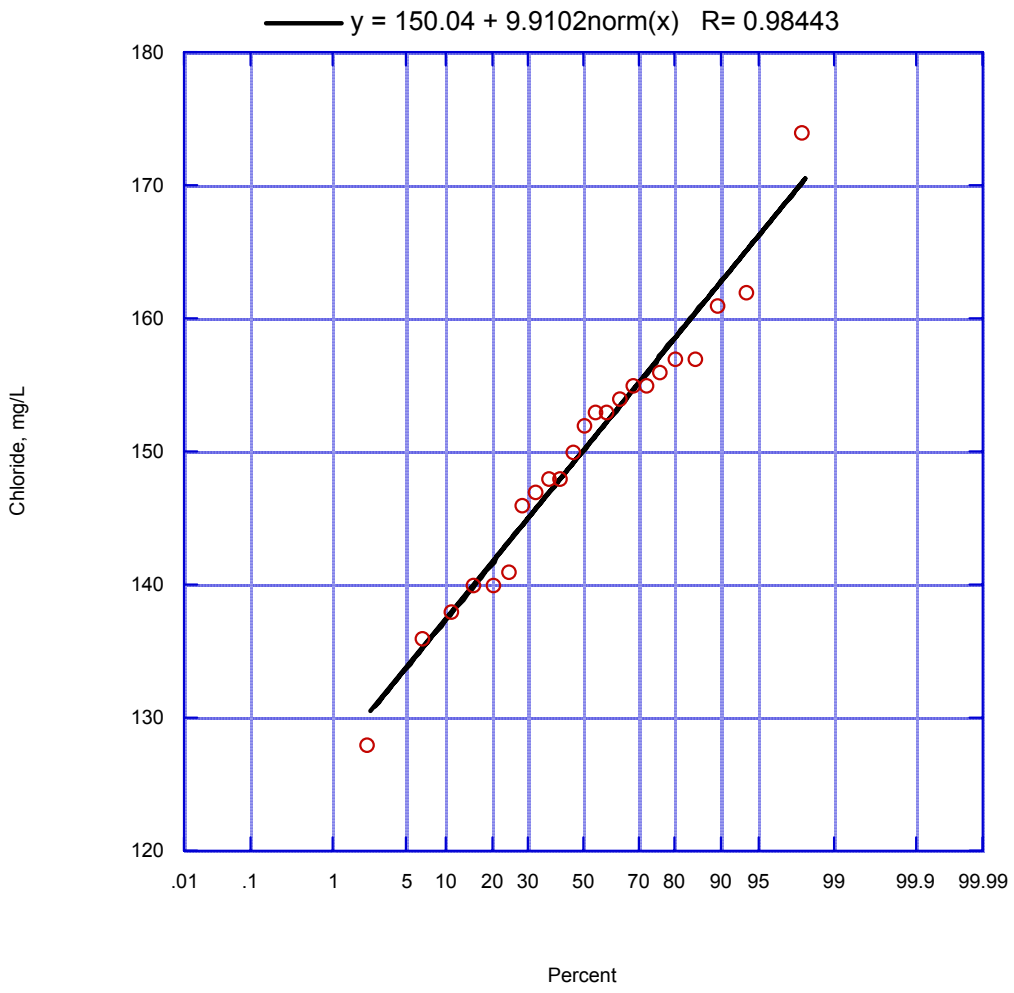


Figure 81. Hill Canyon Effluent Chloride Frequency Distribution (10/01-9/03)

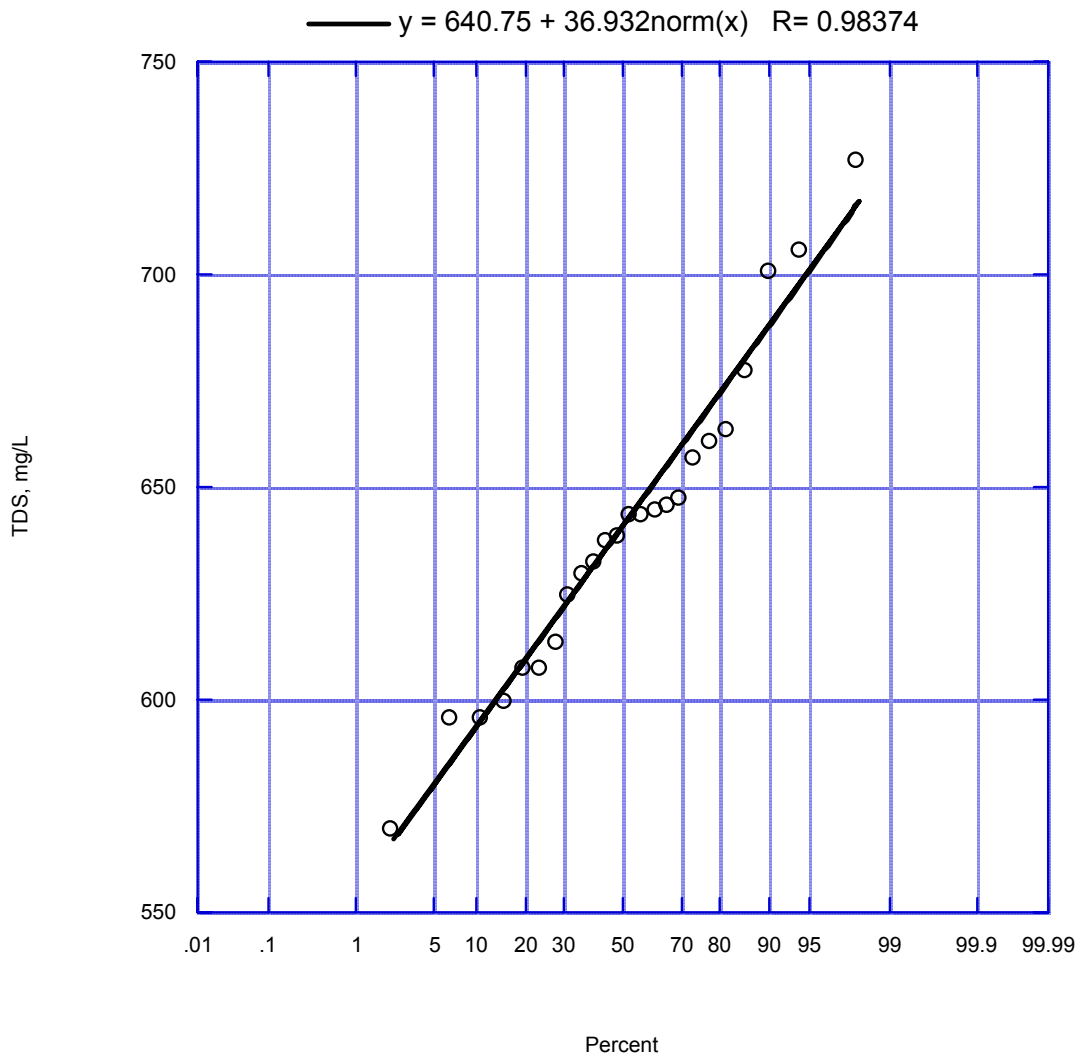


Figure 82. Hill Canyon Effluent TDS Frequency Distribution(10/01-9/03)

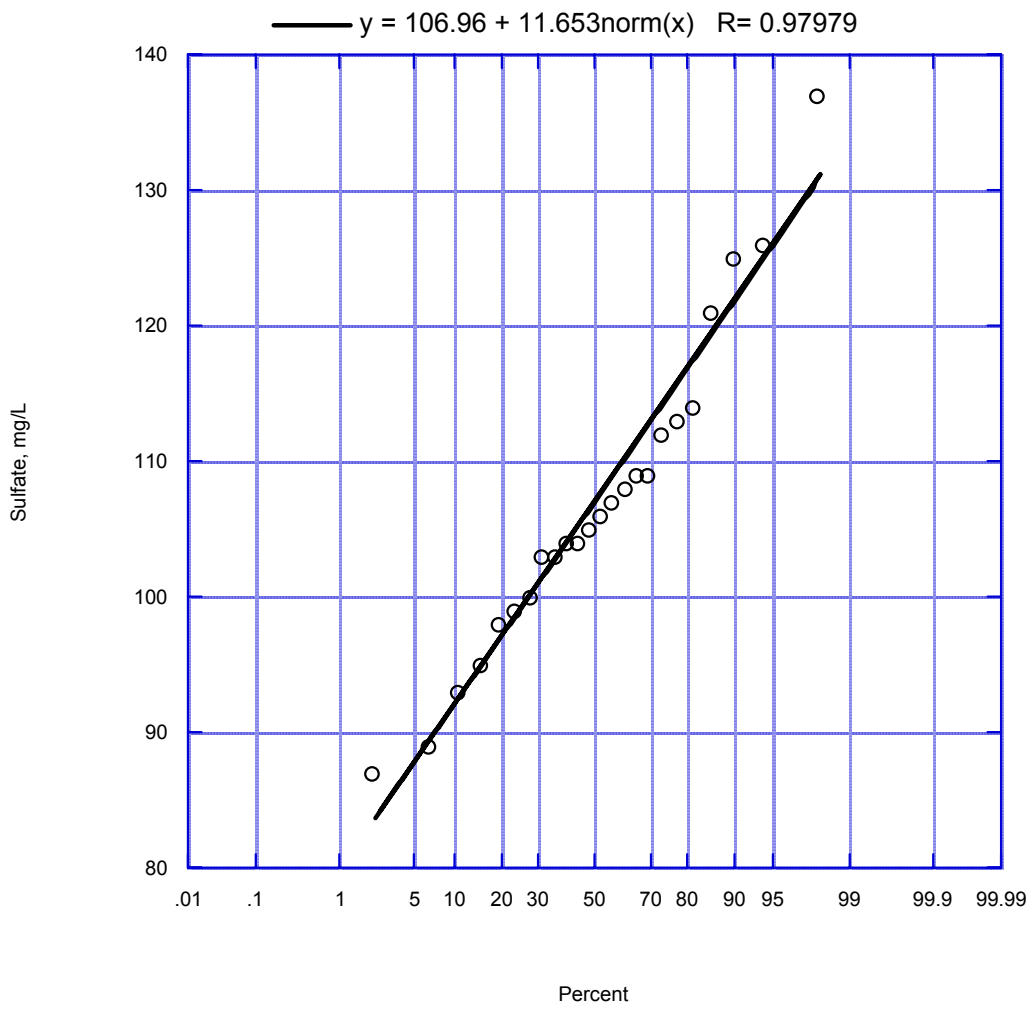


Figure 83. Hill Canyon Effluent Sulfate Frequency Distribution (10/01-9/03)

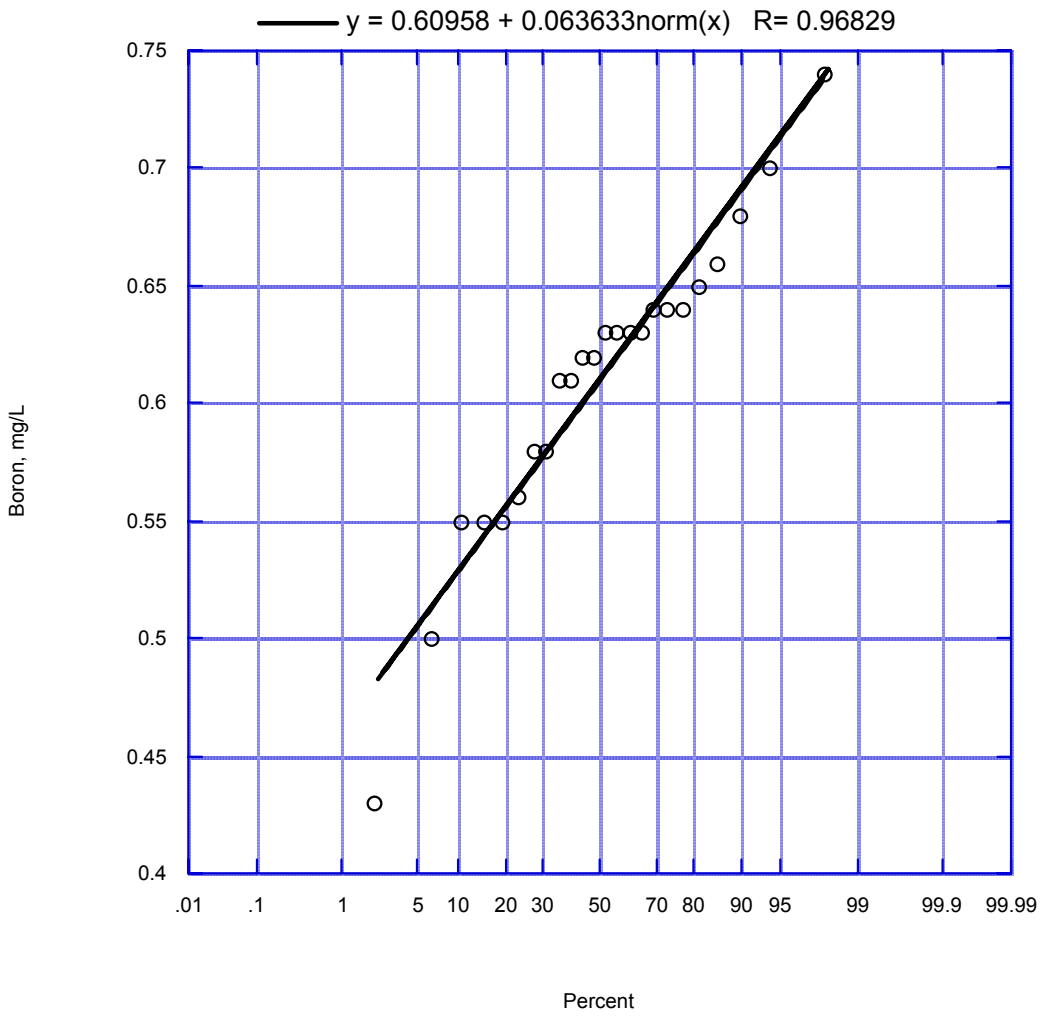


Figure 84. Hill Canyon Effluent Boron Frequency Distribution (10/01-9/03)

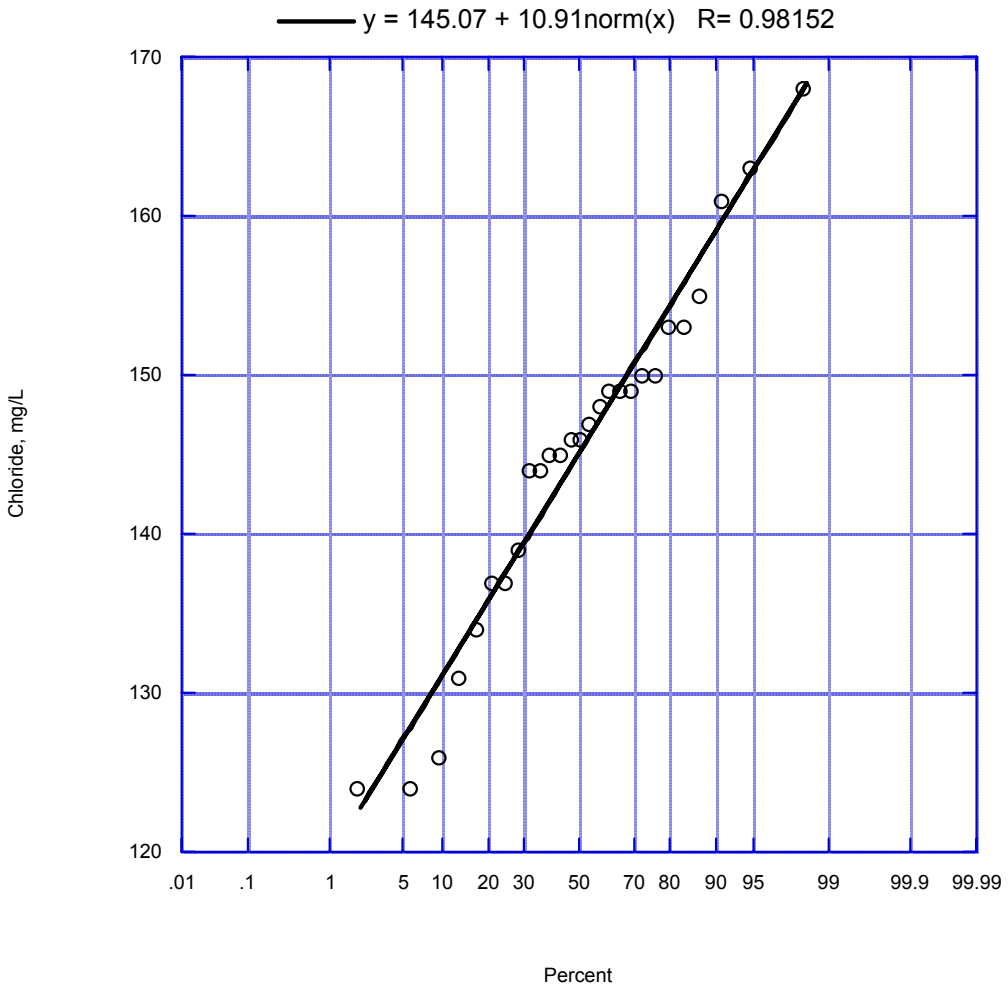


Figure 85. Simi Valley Effluent Chloride Frequency Distribution (10/01-12/03)

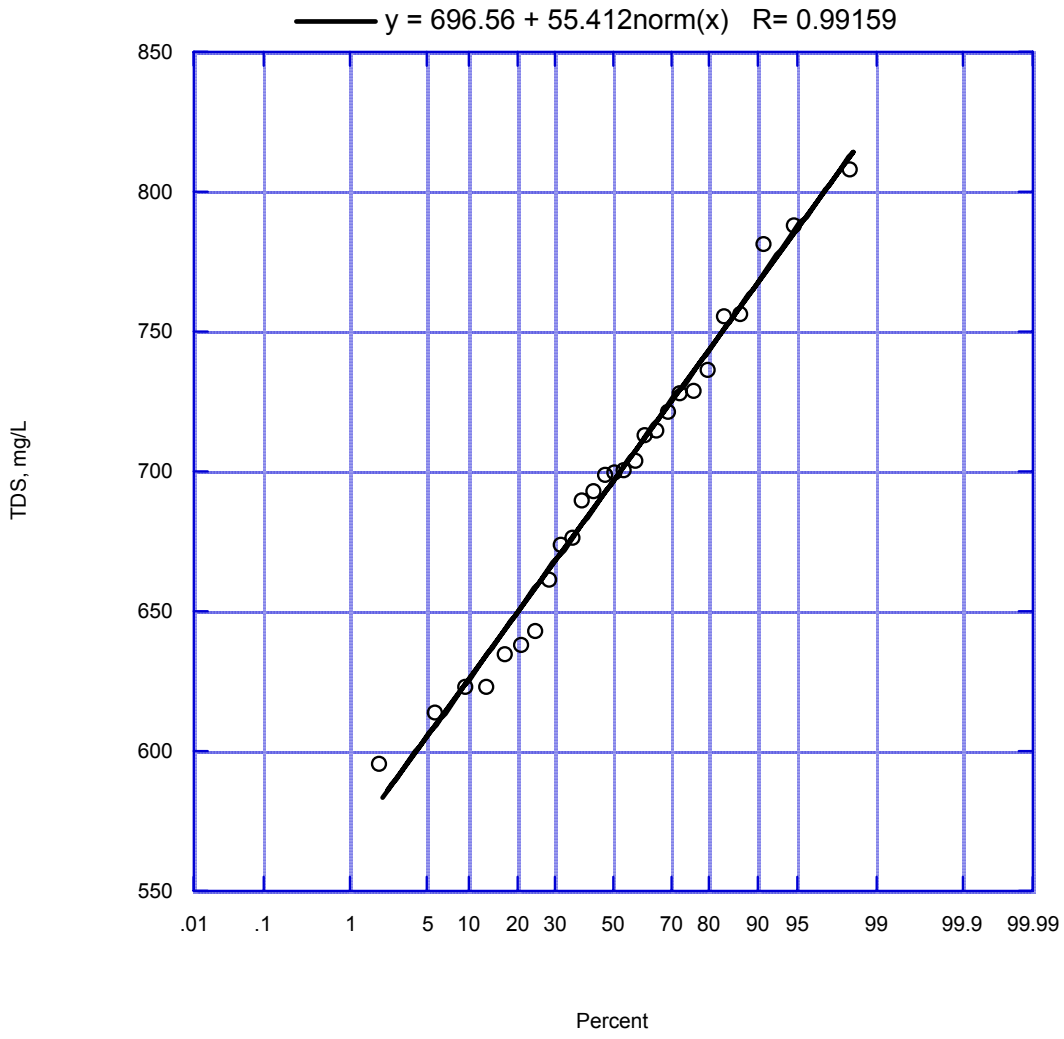


Figure 86. Simi Valley Effluent TDS Frequency Distribution (10/01-12/03)

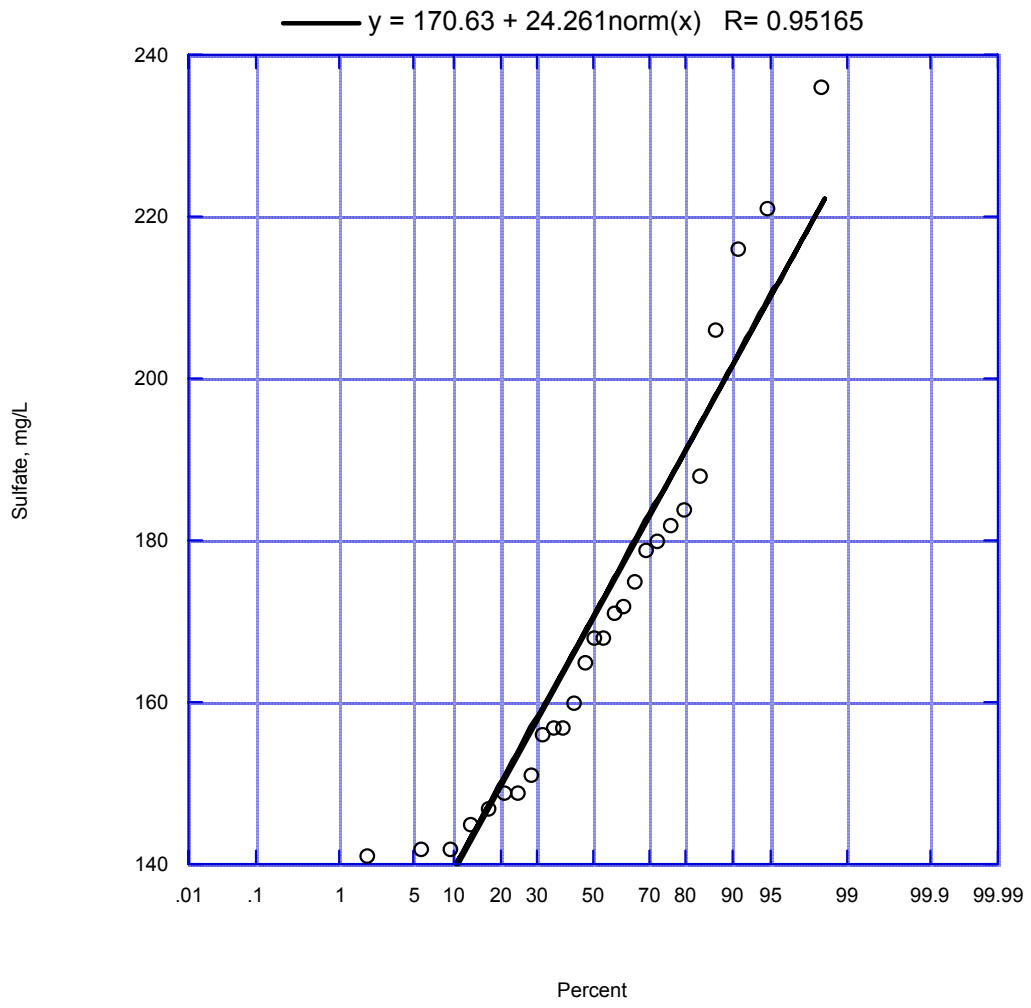


Figure 87. Simi Valley Effluent Sulfate Frequency Distribution (10/01-12/03)

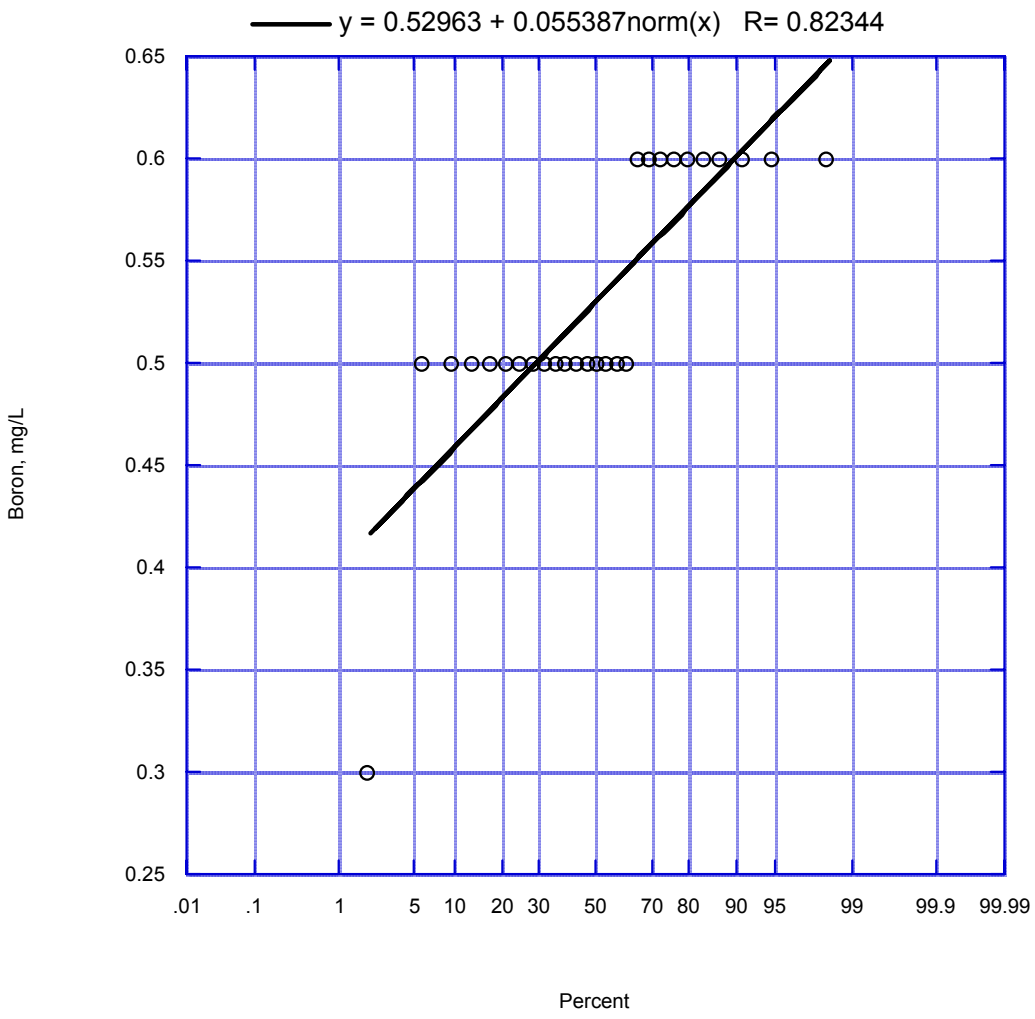


Figure 88. Simi Valley Effluent Boron Frequency Distribution (10/01-12/03)

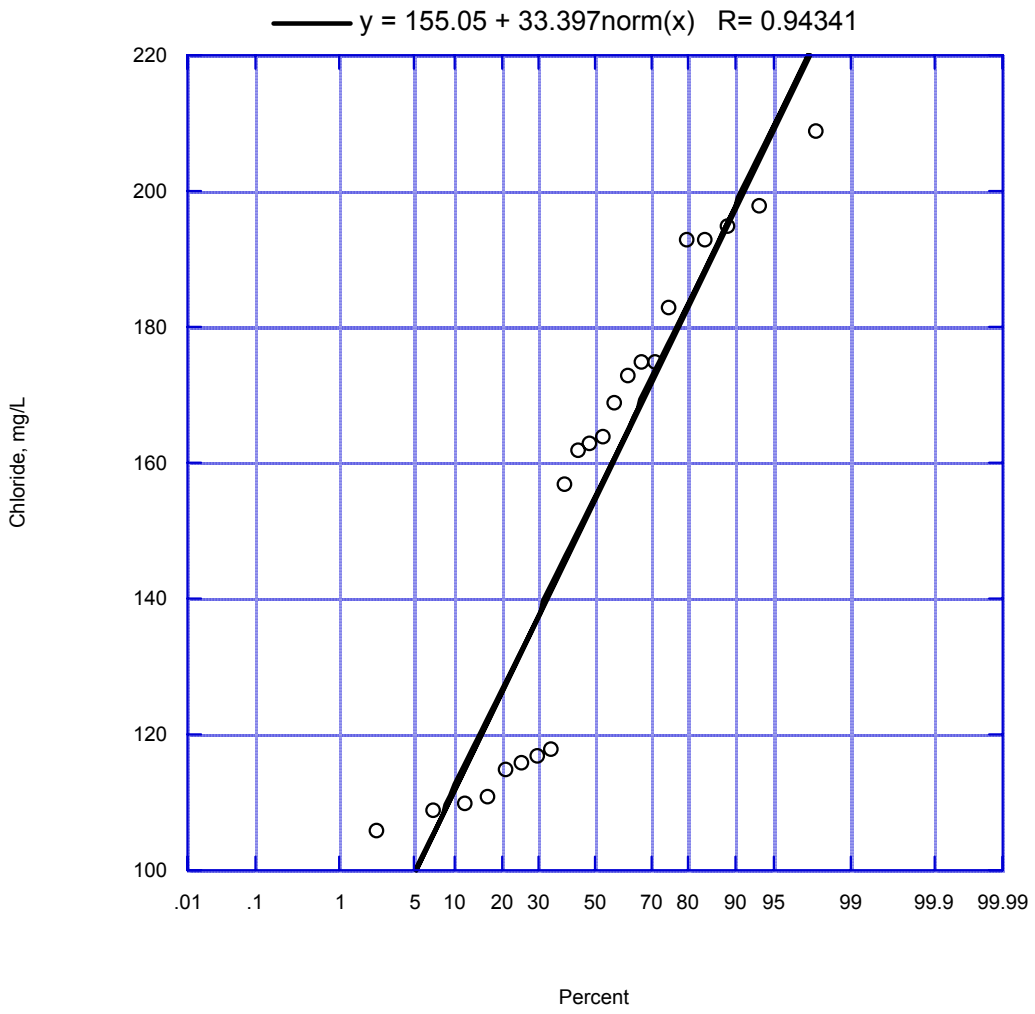


Figure 89. Camrosa Effluent Chloride Frequency Distribution (10/01-10/03)

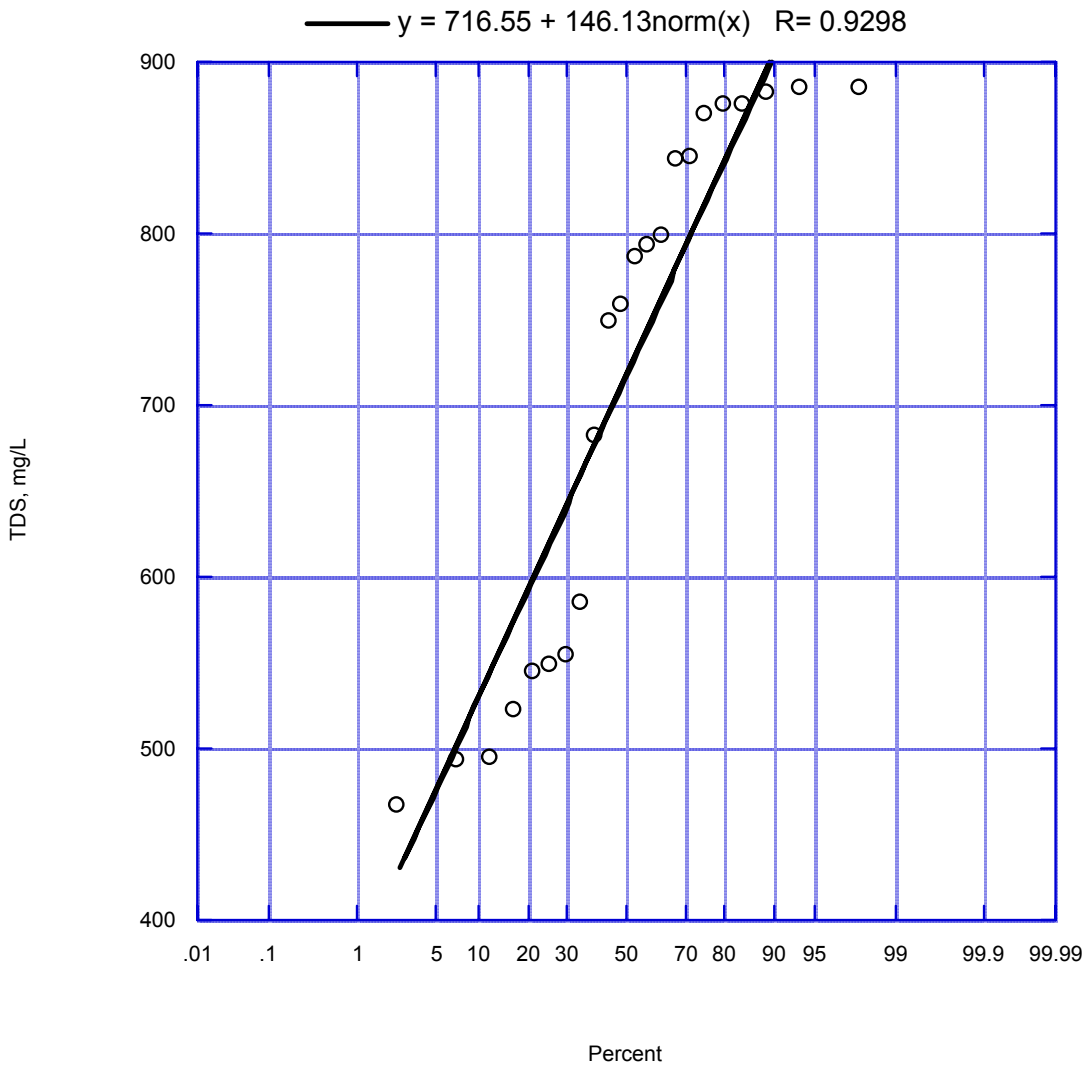


Figure 90. Camrosa Effluent TDS Frequency Distribution (10/01-10/03)

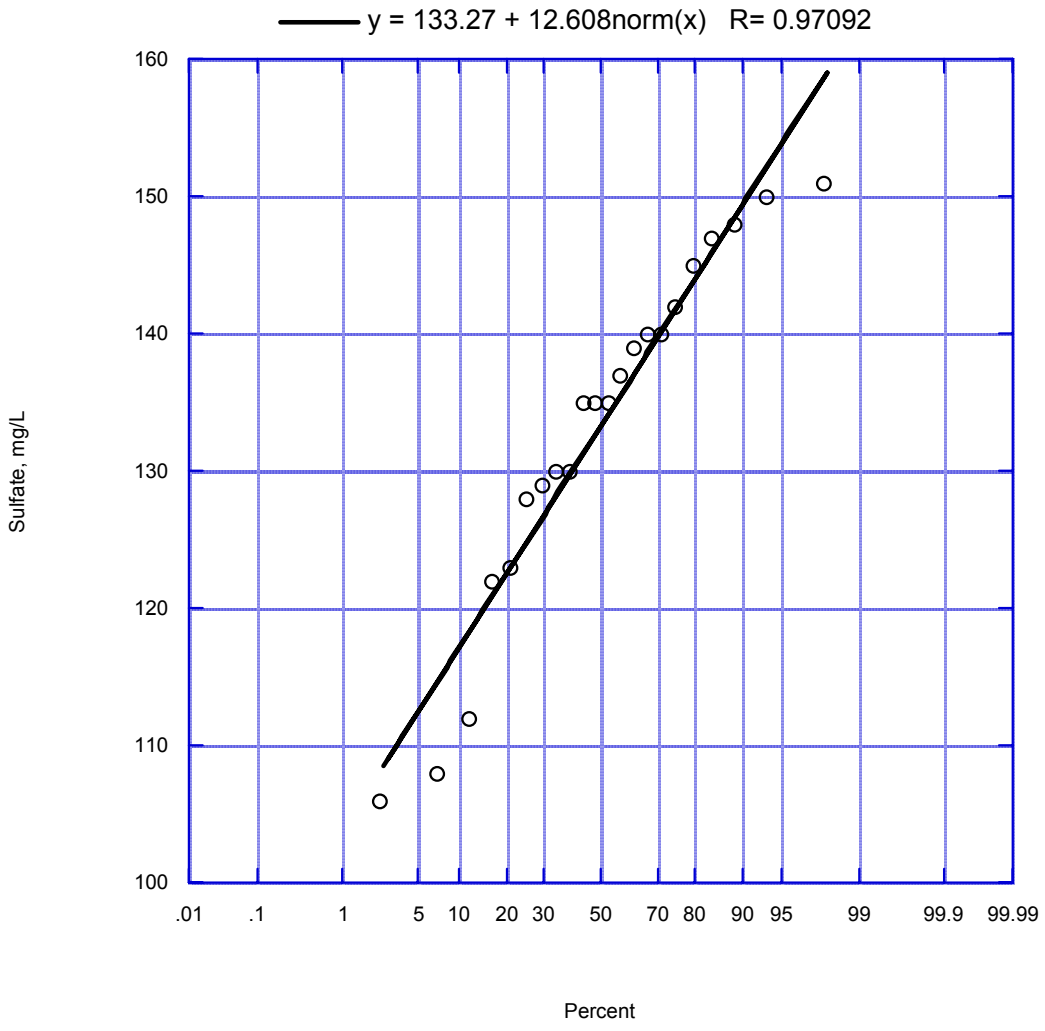


Figure 91. Camrosa Effluent Sulfate Frequency Distribution (10/01-10/03)

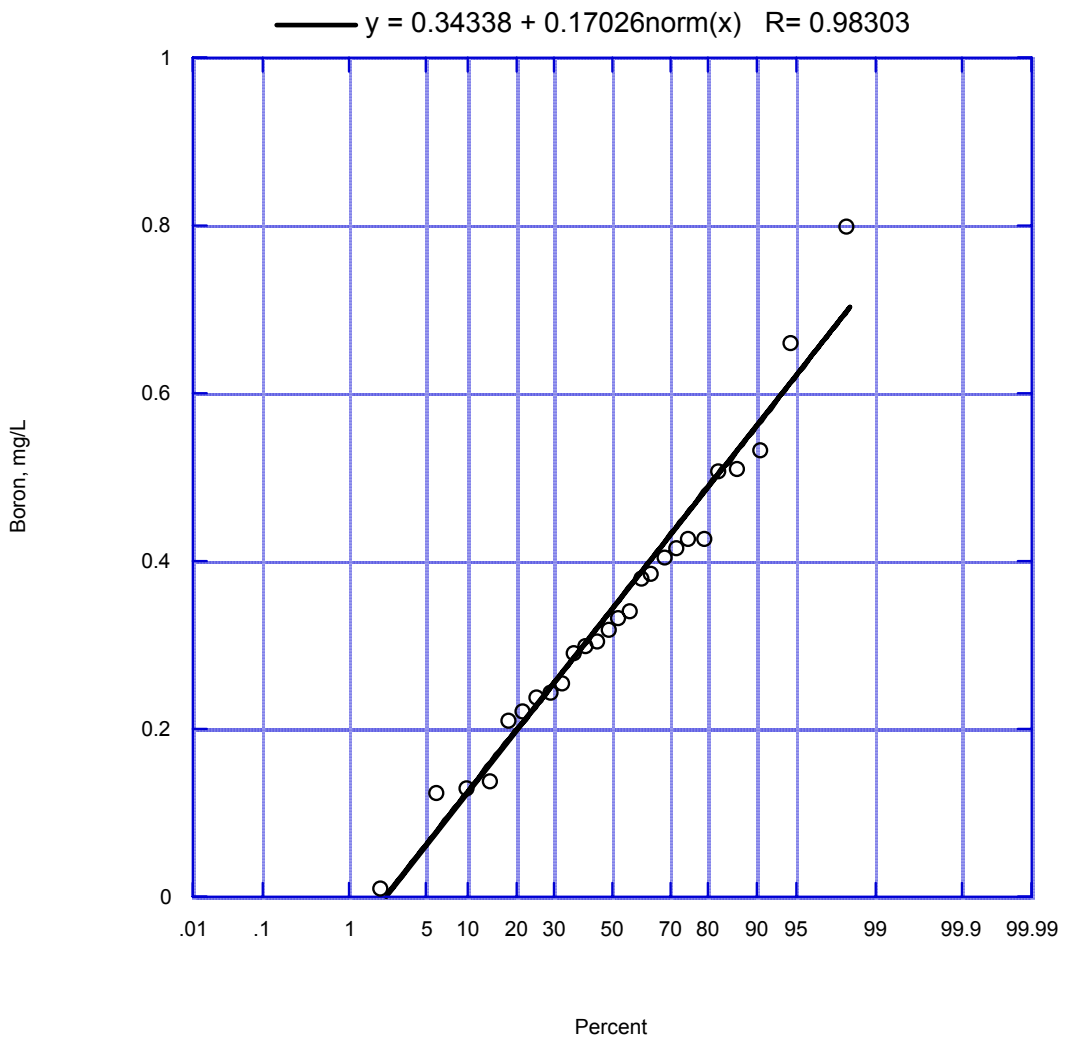


Figure 92. Camrosa Effluent Boron Frequency Distribution (10/01-11/03)

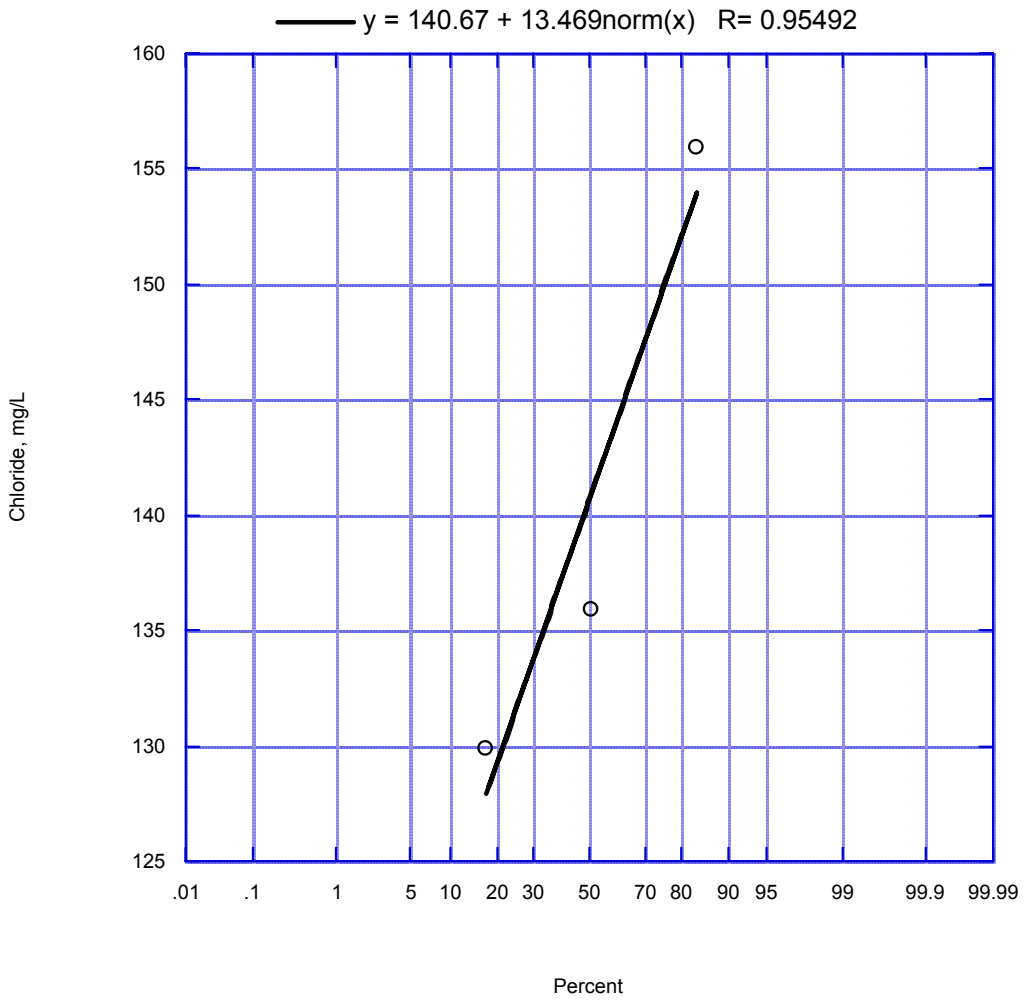


Figure 93. Moorpark Effluent Chloride Frequecny Distribution (10/01-12/01)

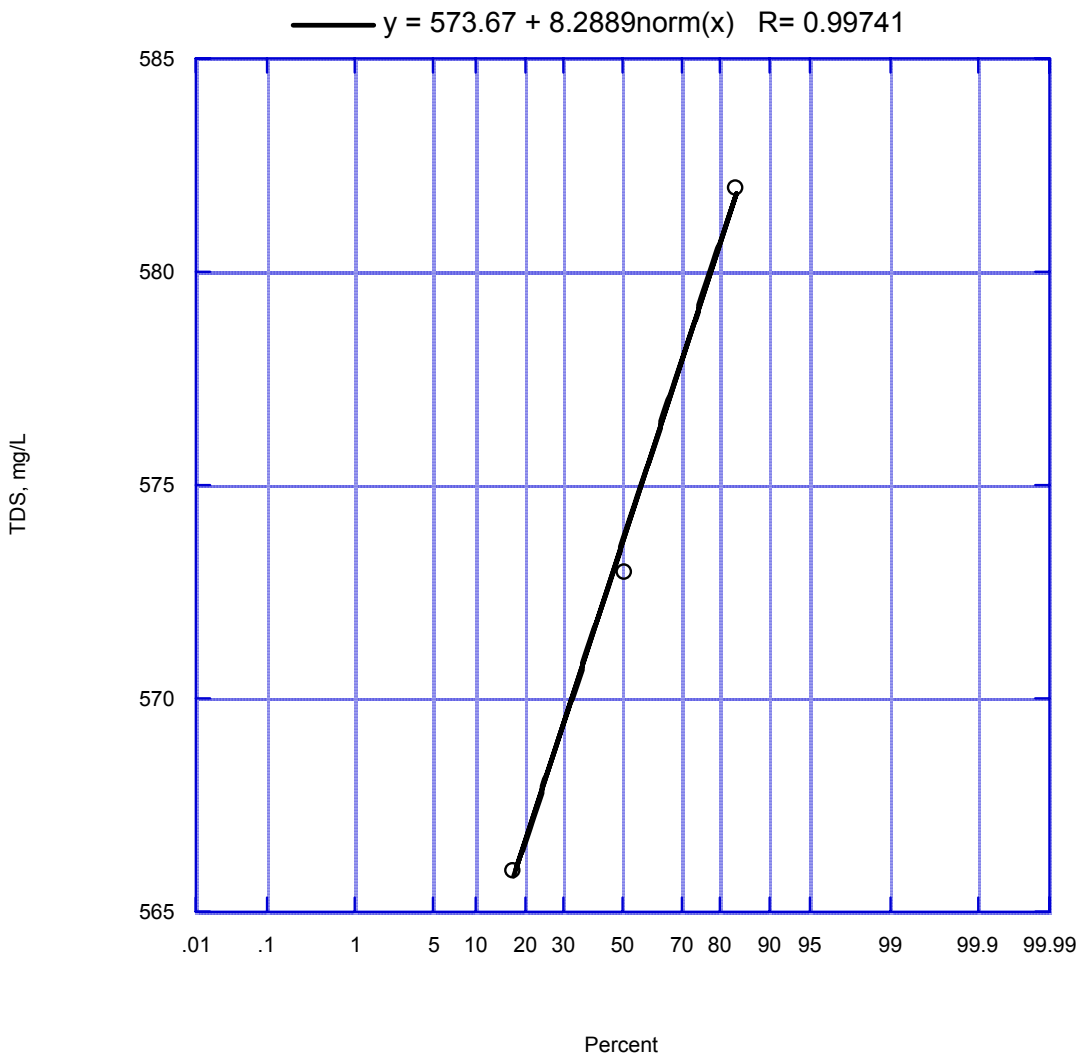


Figure 94. Moorpark Effluent TDS Frequency Distribution (10/01-12/01)

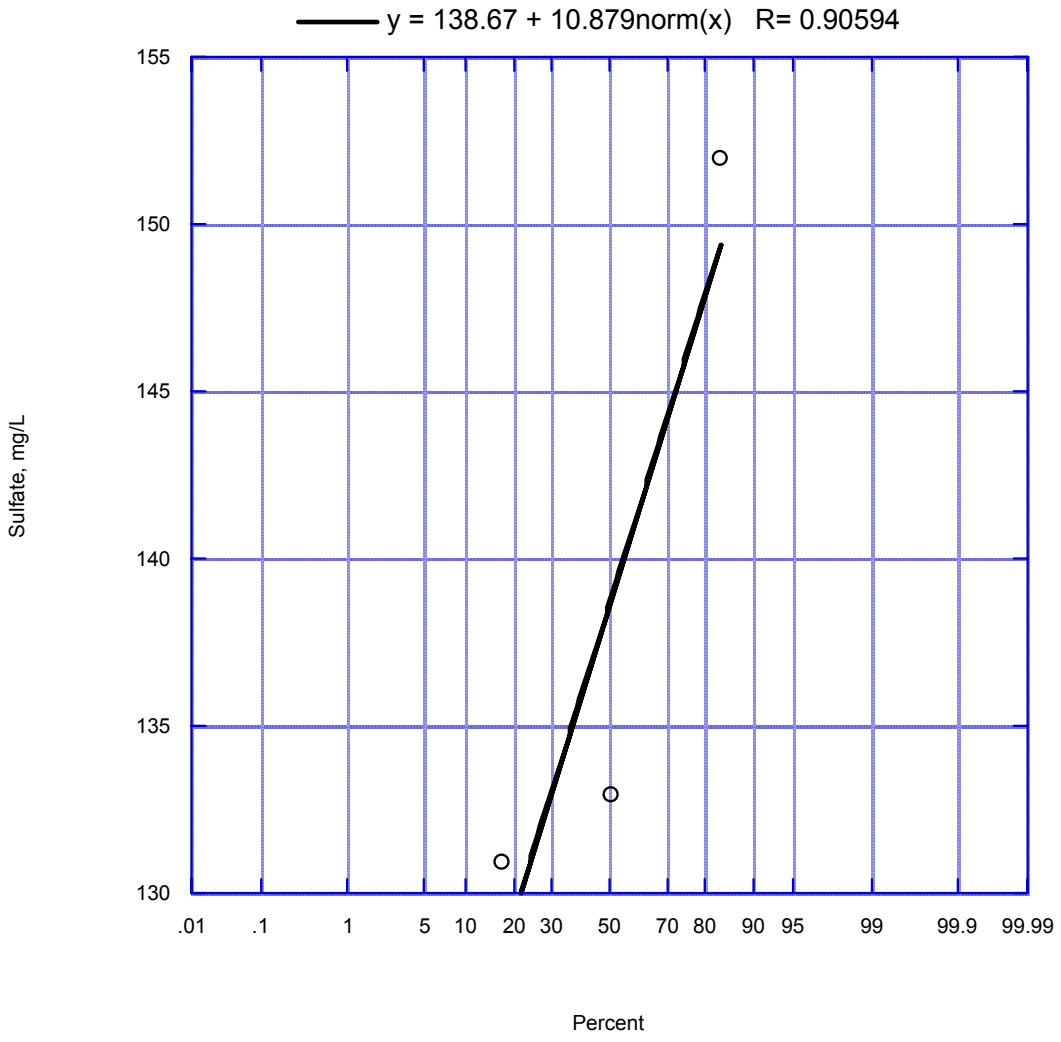


Figure 95. Moorpark Effluent Sulfate Freuency Distribution (10/01-12/01)

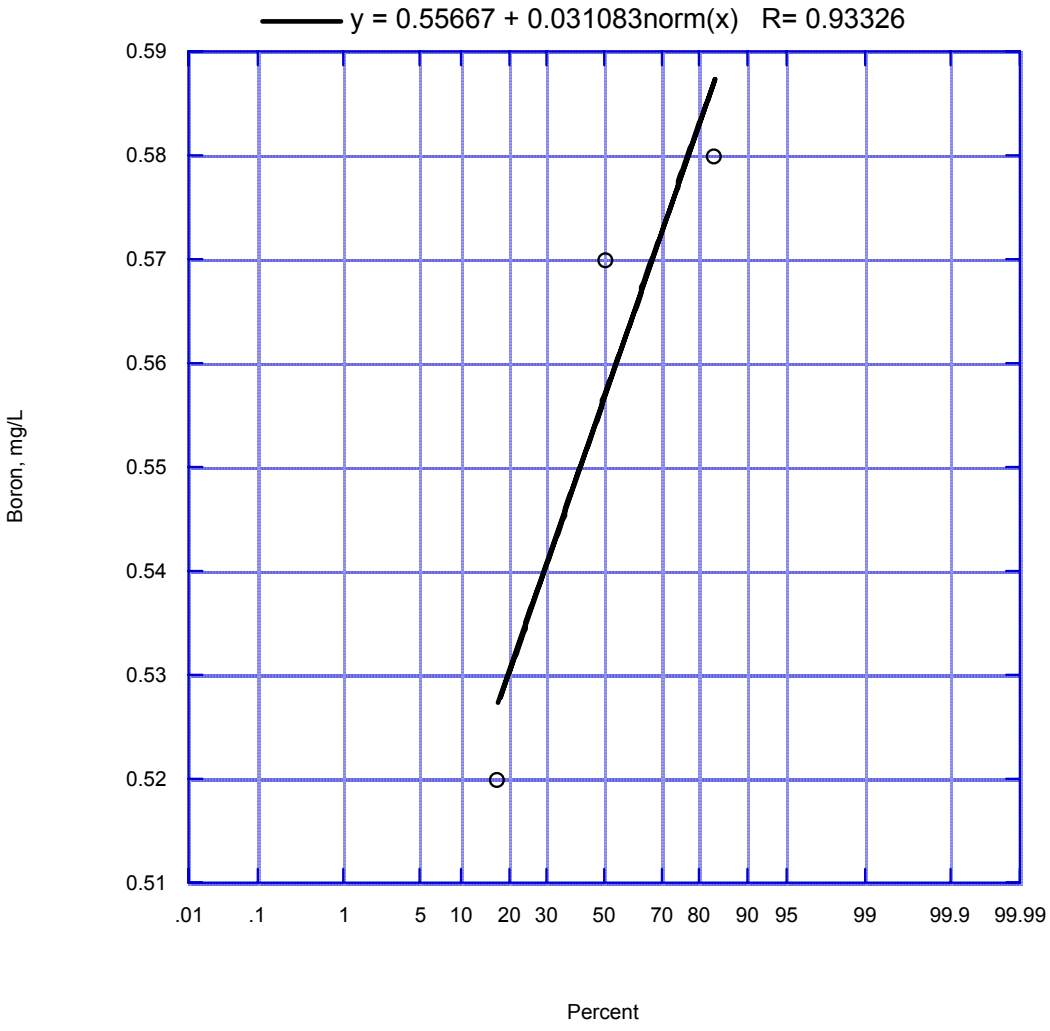


Figure 96. Moorpark Effluent Boron Frequency Distribution (10/01-12/01)

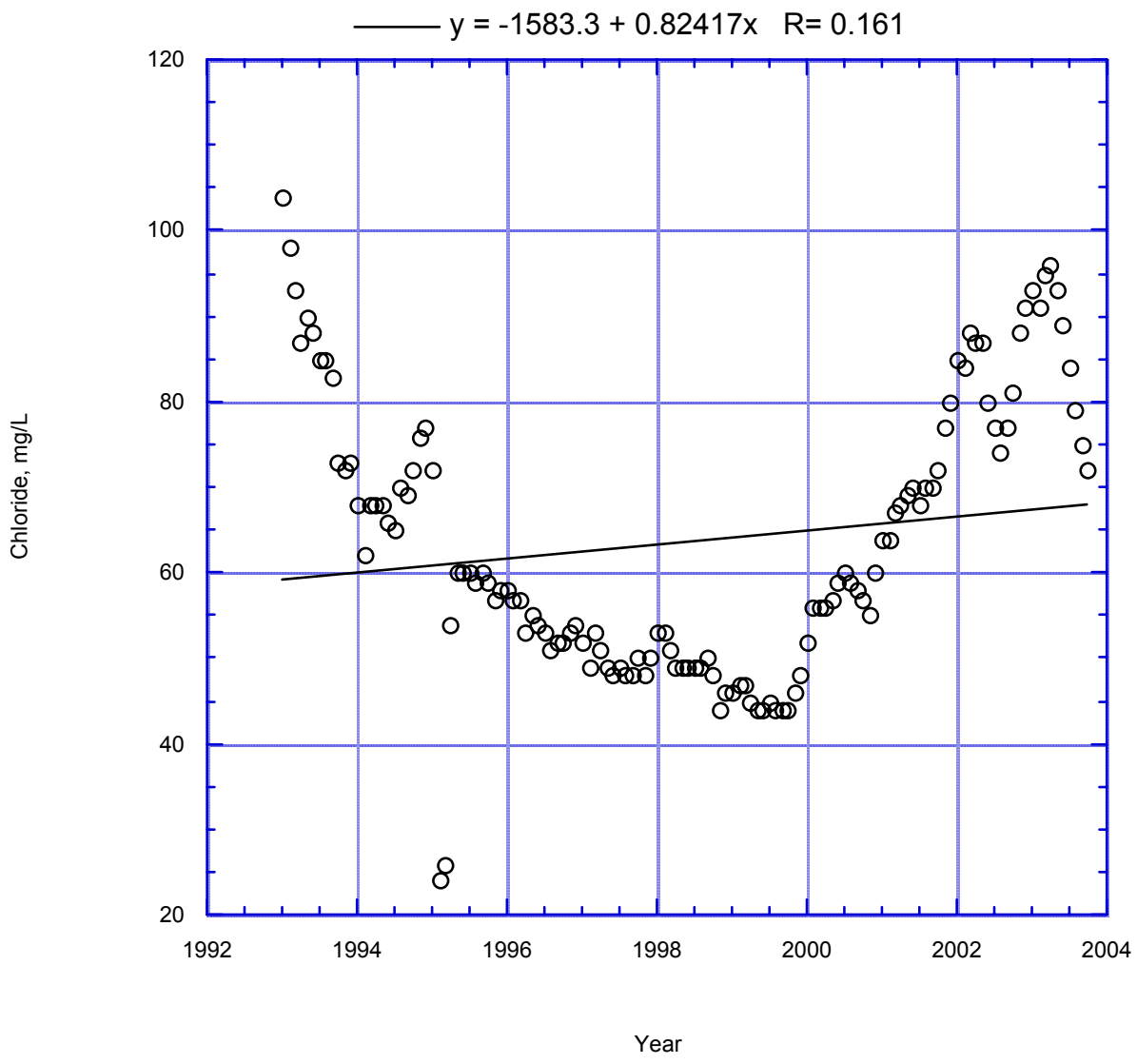


Figure 97. Jensen Plant Chloride vs. Time

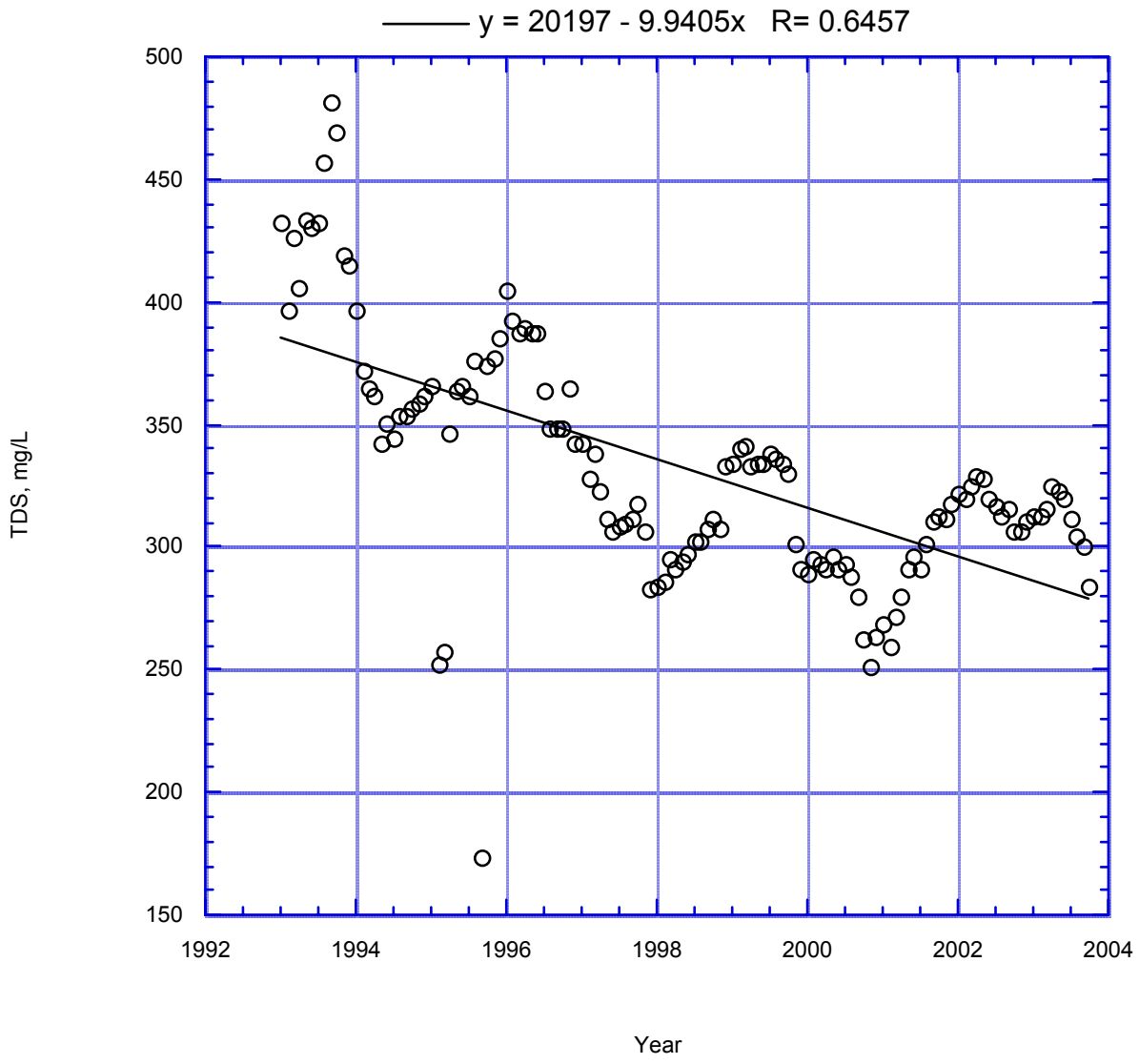


Figure 98. Jensen Plant TDS vs. Time

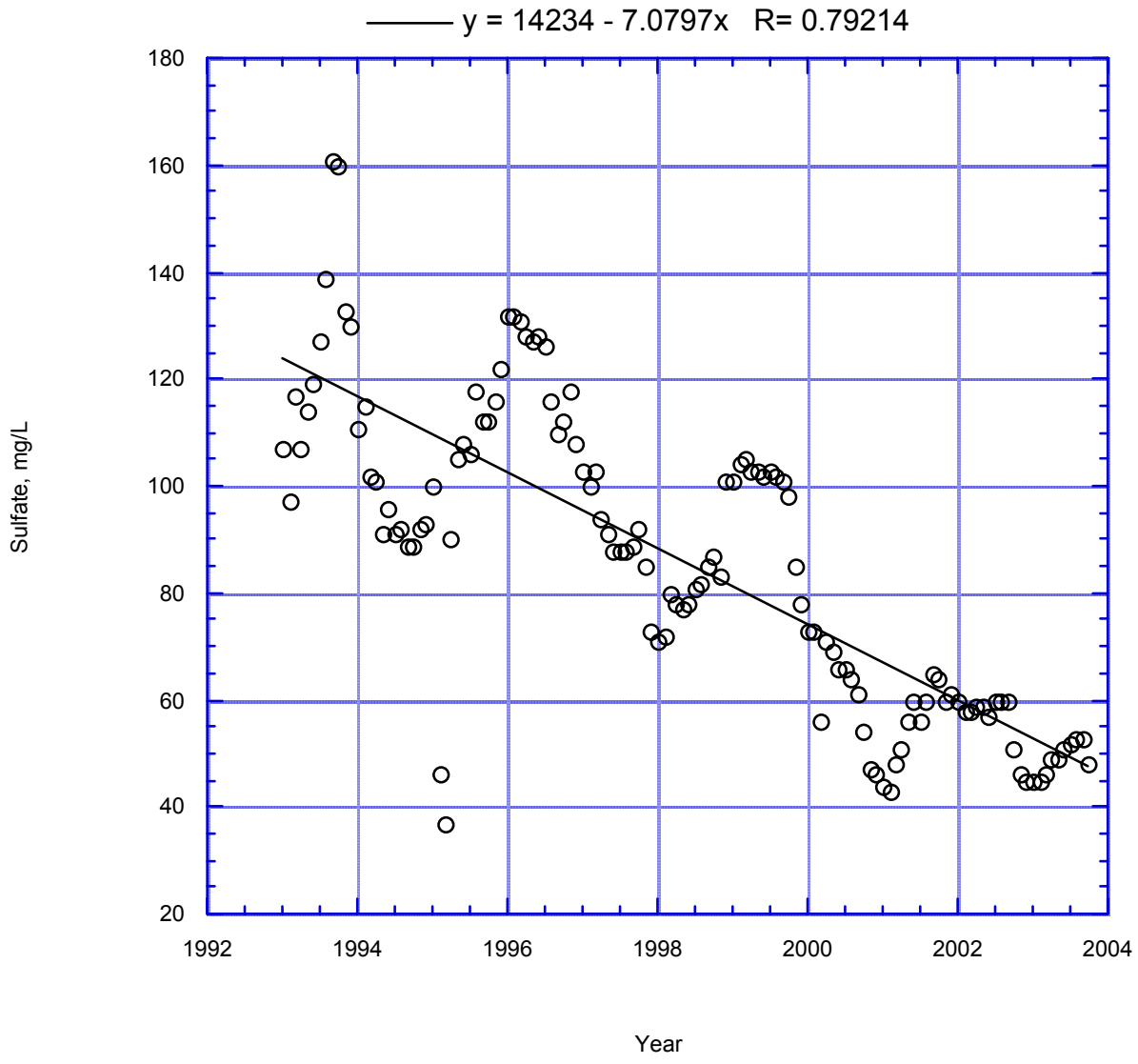


Figure 99. Jensen Plant Sulfate vs. Time

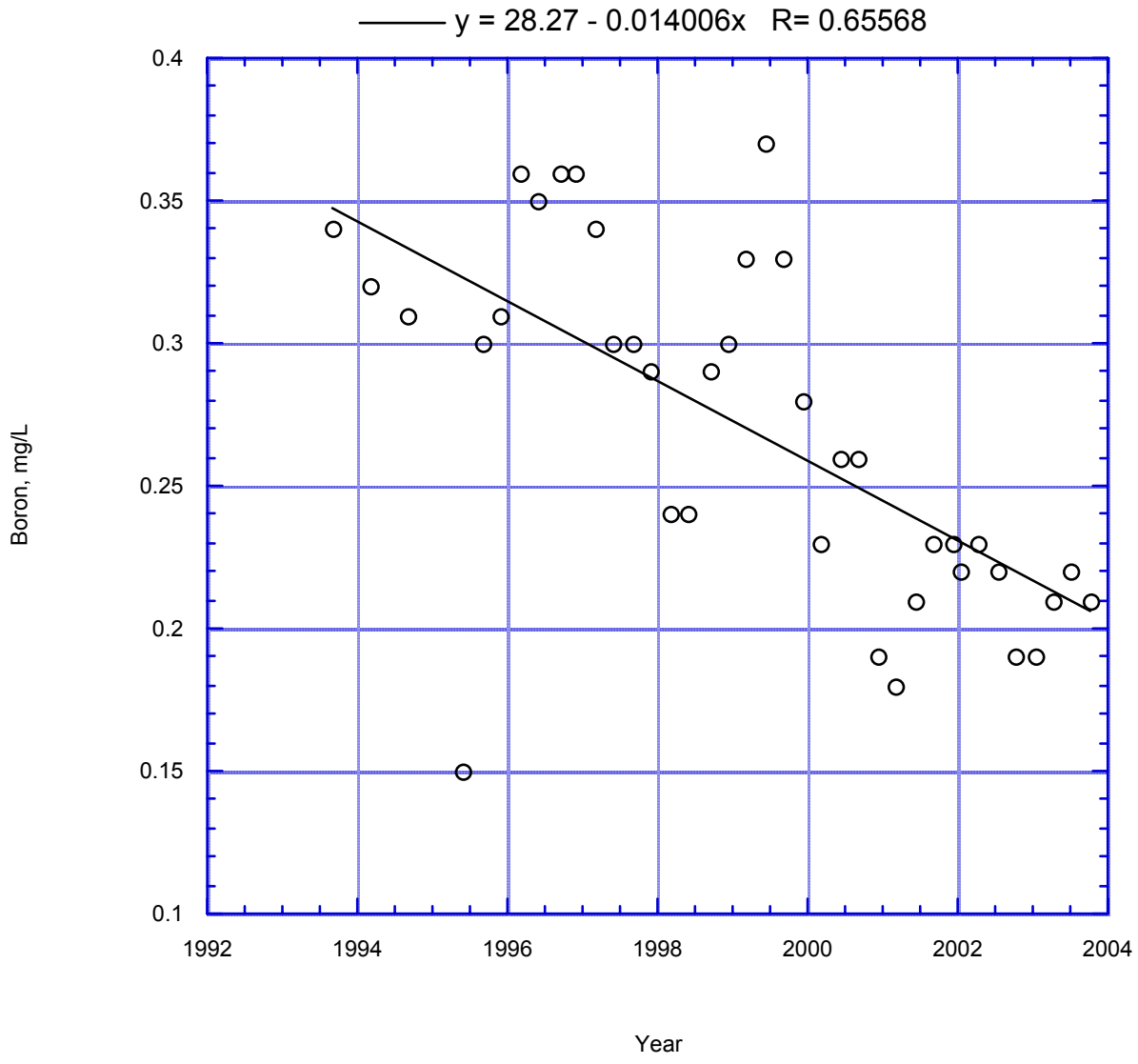


Figure 100. Jensen Plant Boron vs. Time

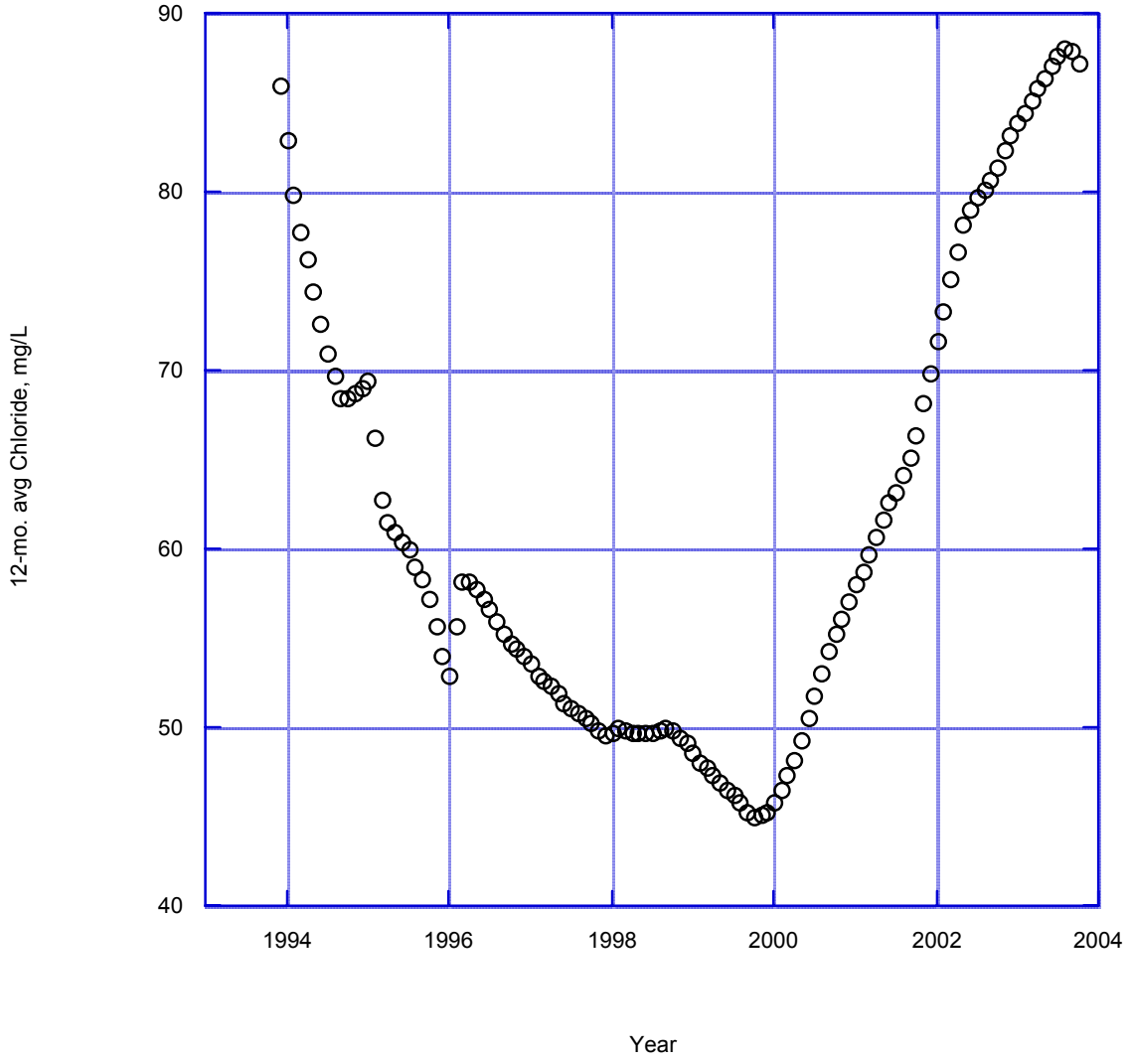


Figure 101. Jensen Plant 12-month Average Chloride vs. Time

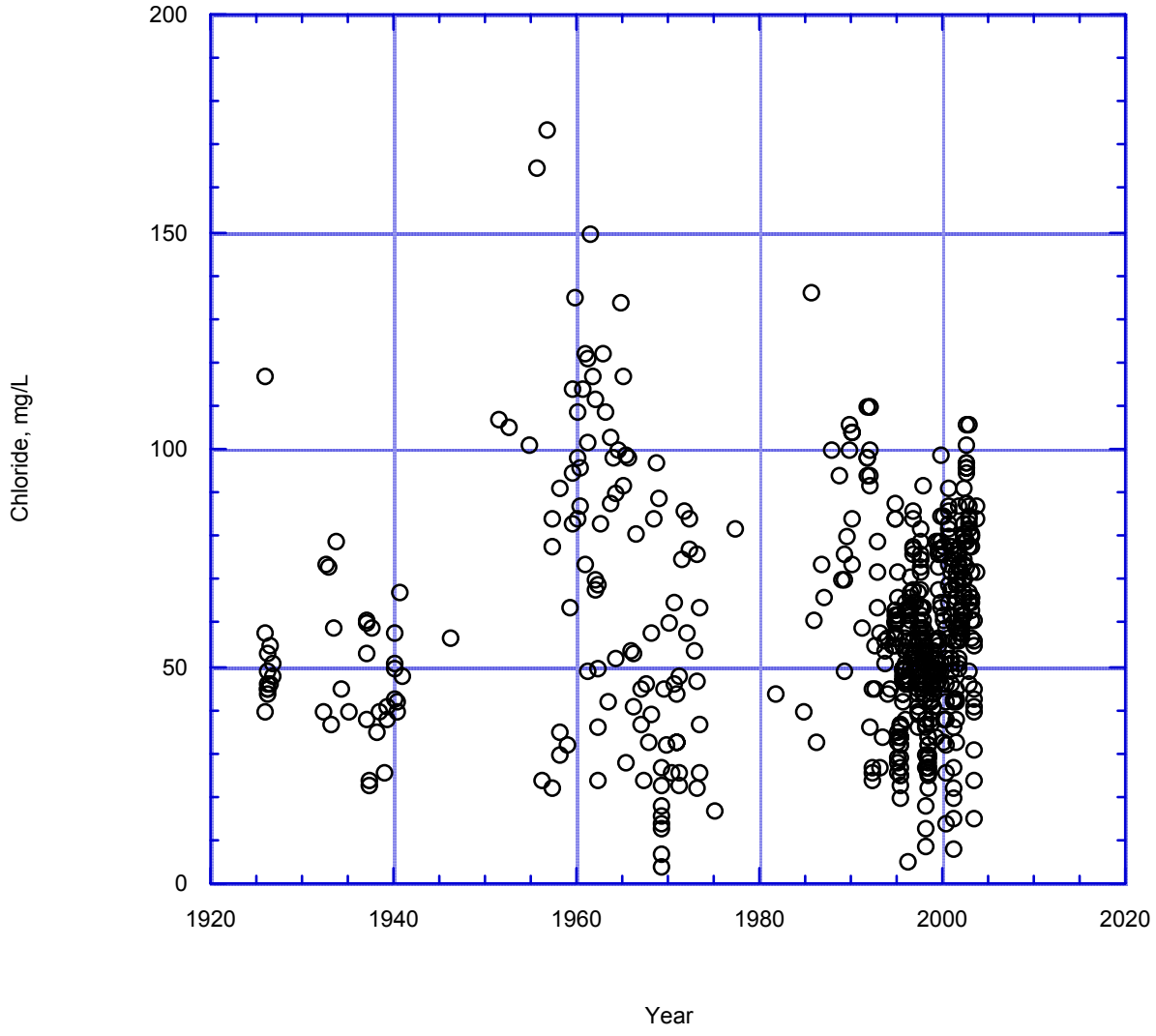


Figure 102. Freeman Diversion Chloride vs. Time

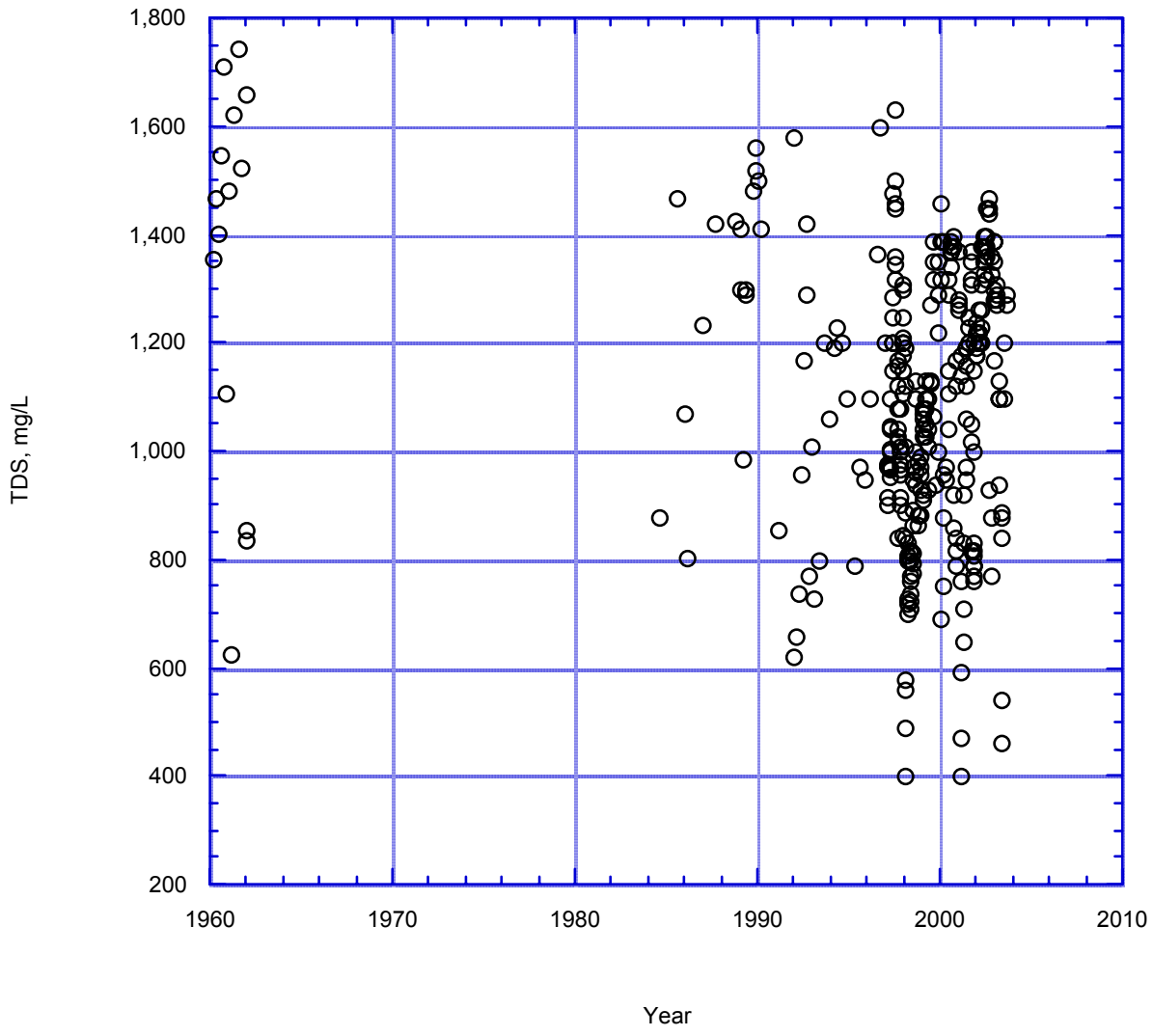


Figure 103. Freeman Diversion TDS vs. Time

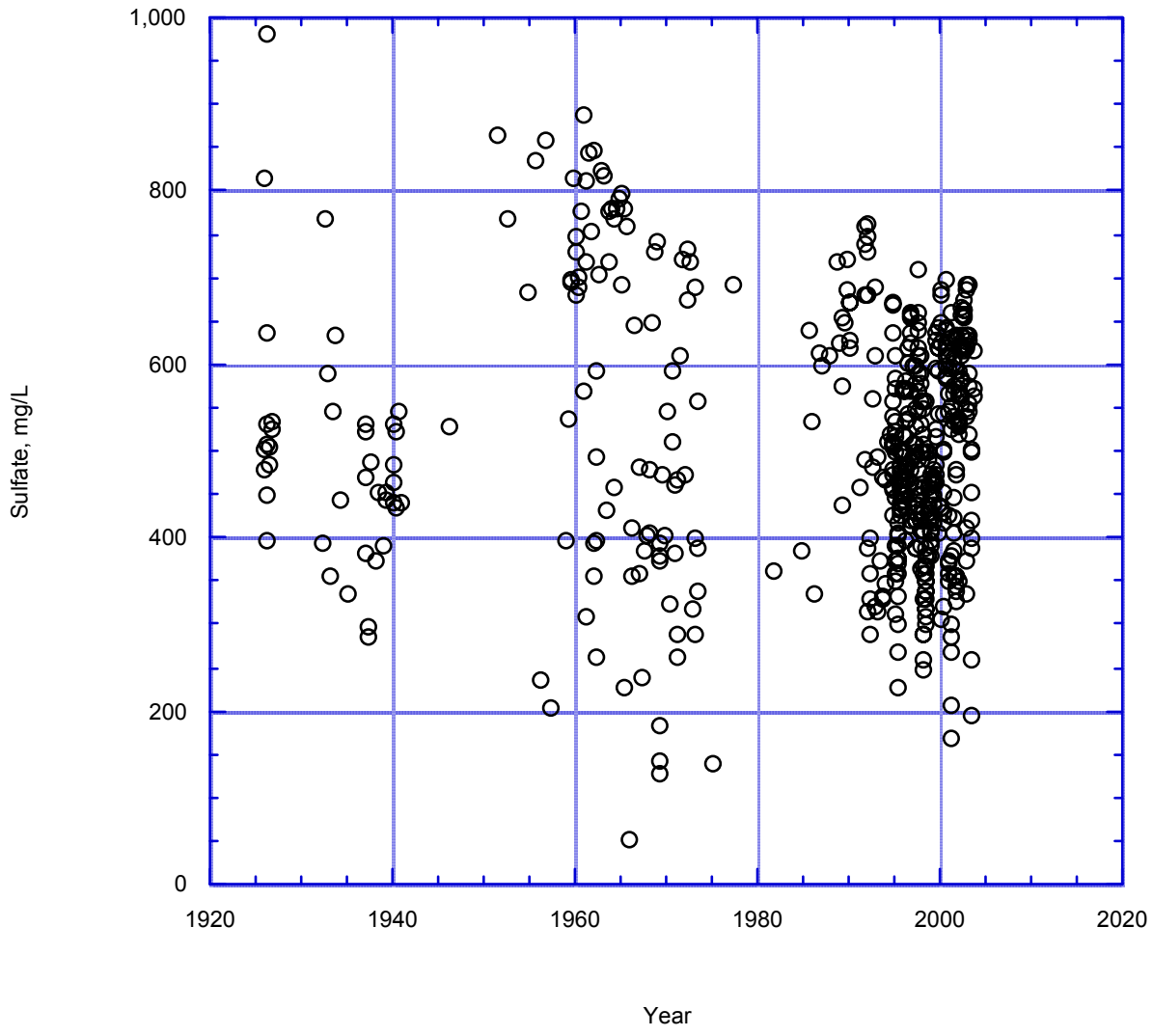


Figure 104. Freeman Diversion Sulfate vs. Time

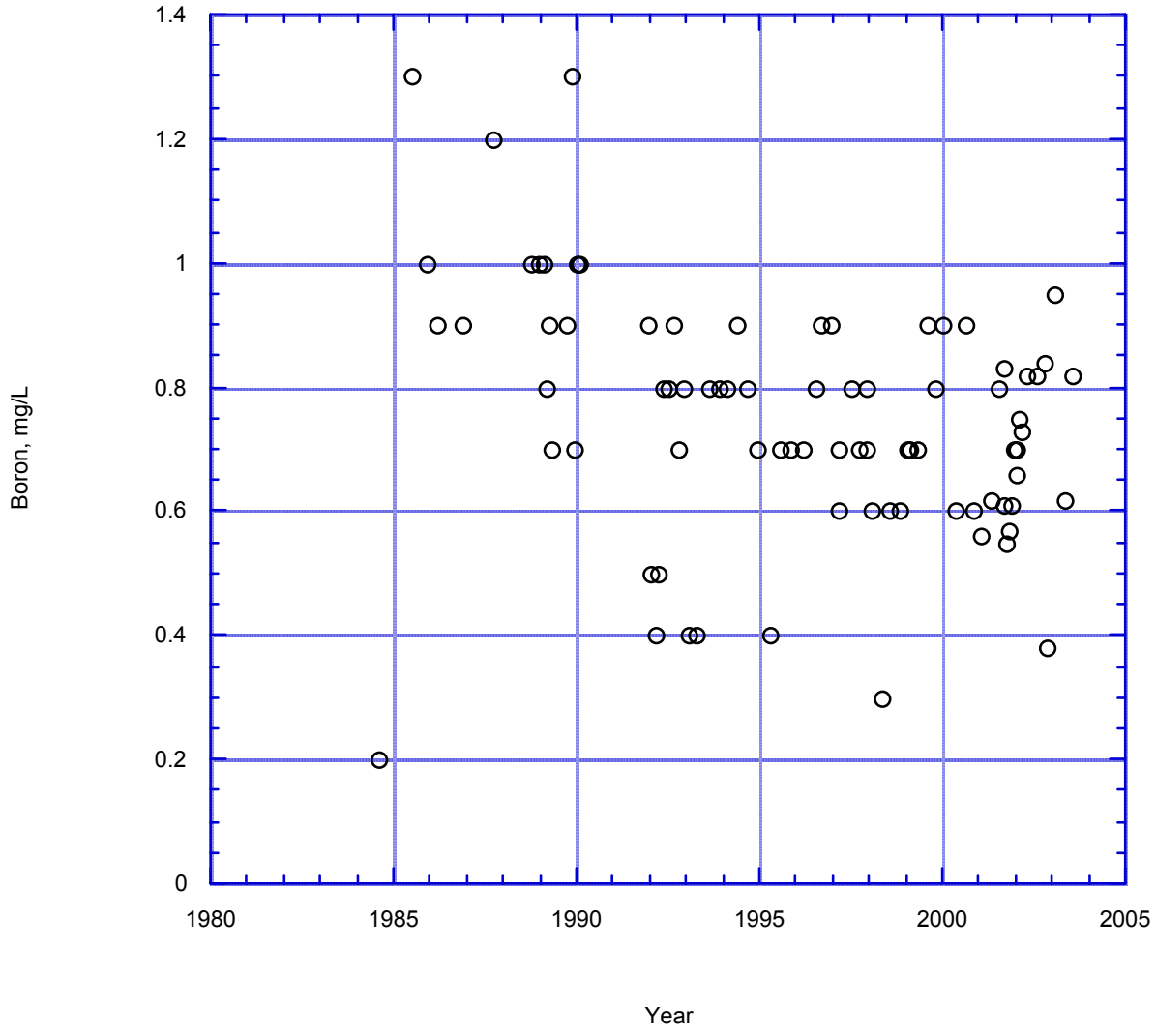


Figure 105. Freeman Diversion Boron vs. Time

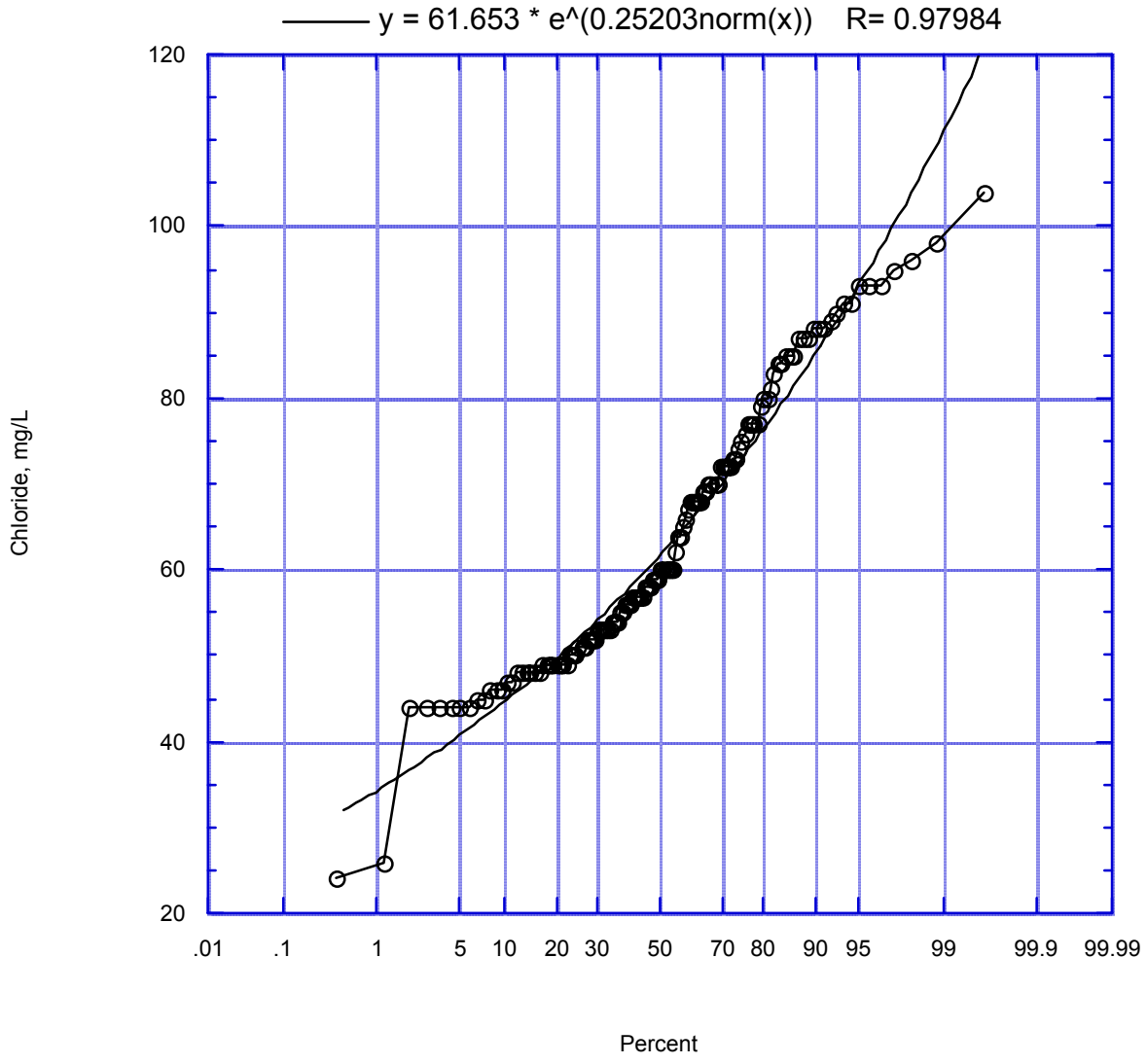


Figure 106. Jensen Plant Chloride Frequency Distribution

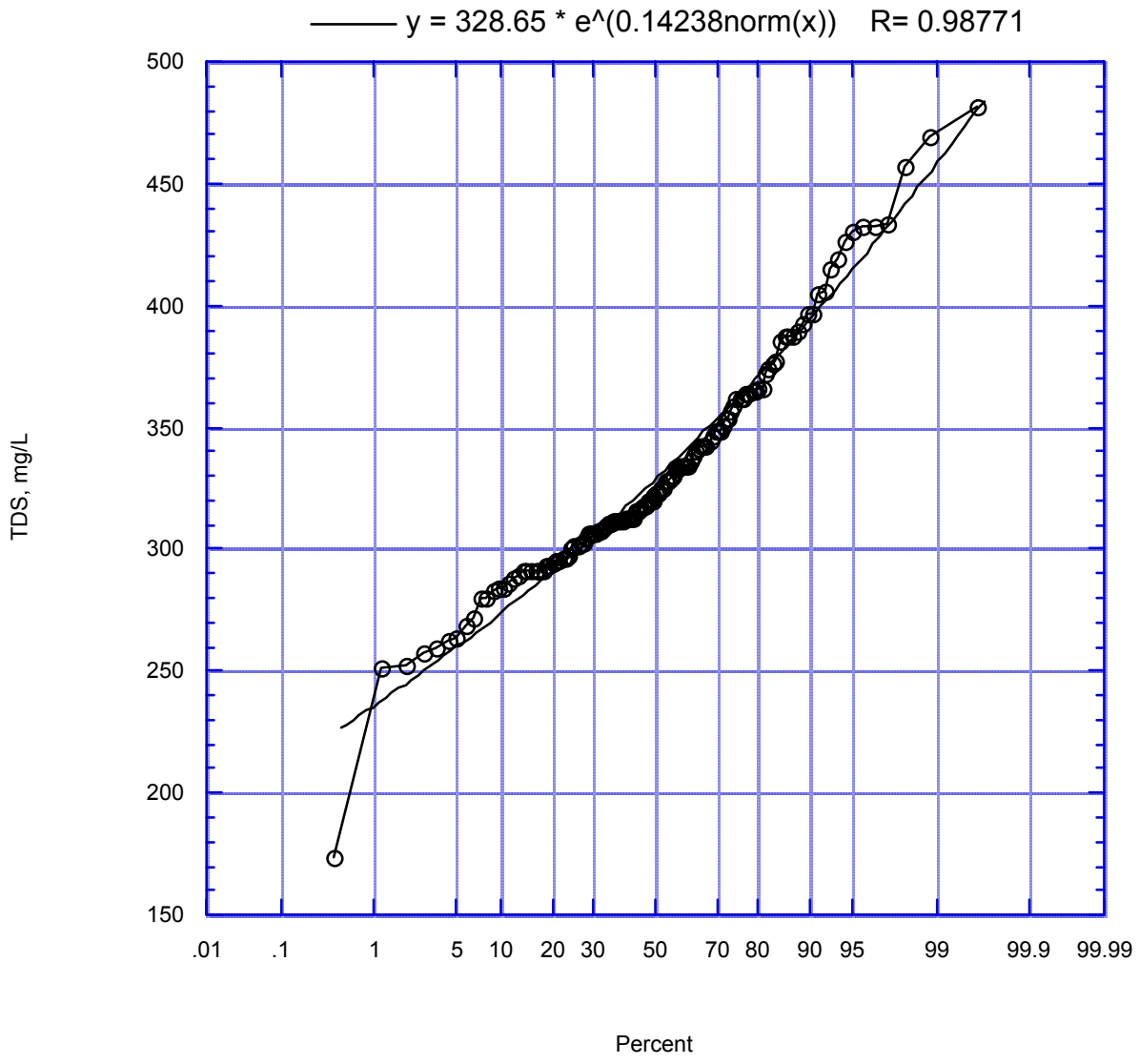


Figure 107. Jensen Plant TDS Frequency Distribution

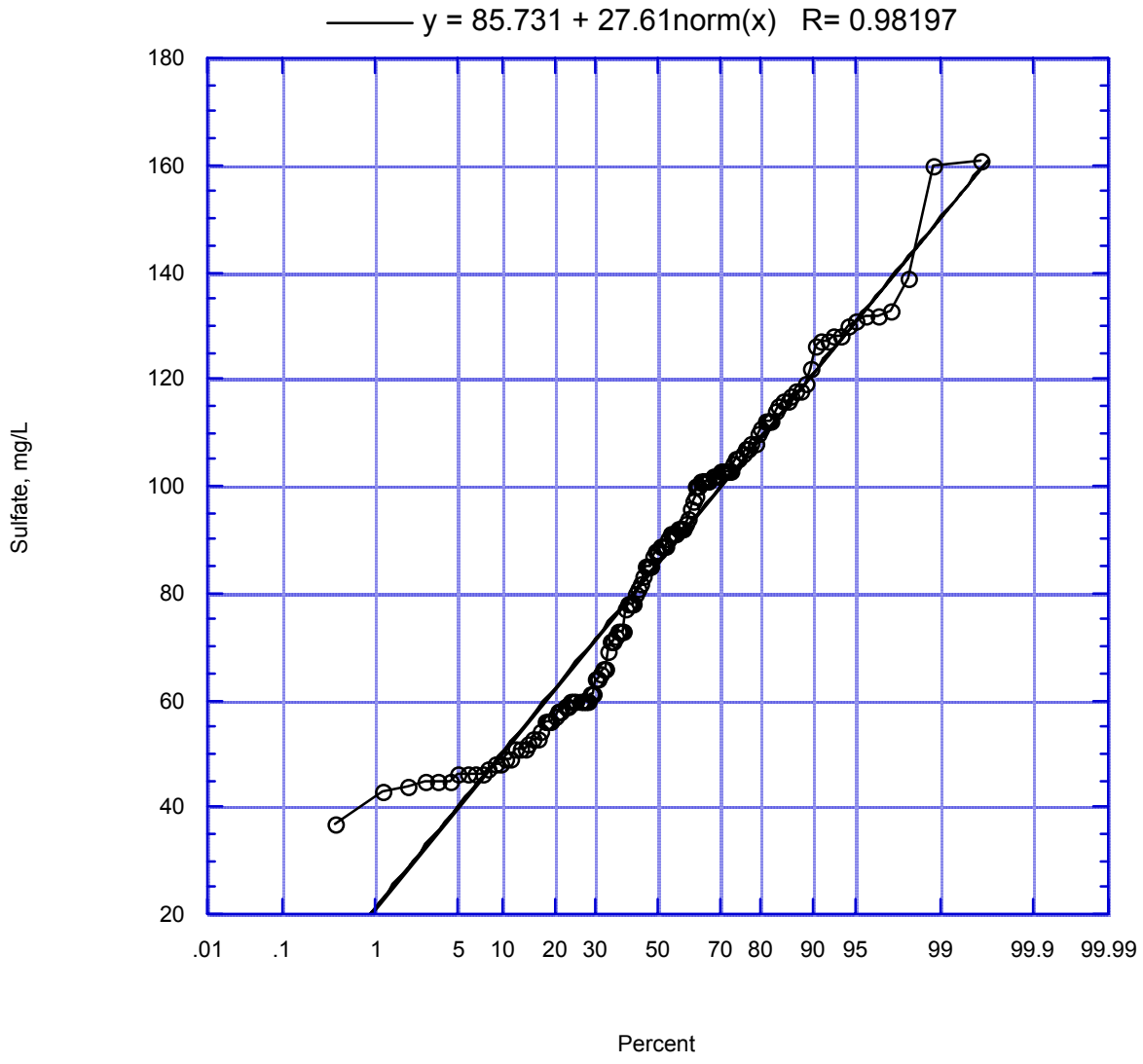


Figure 108. Jensen Plant Sulfate Frequency Distribution

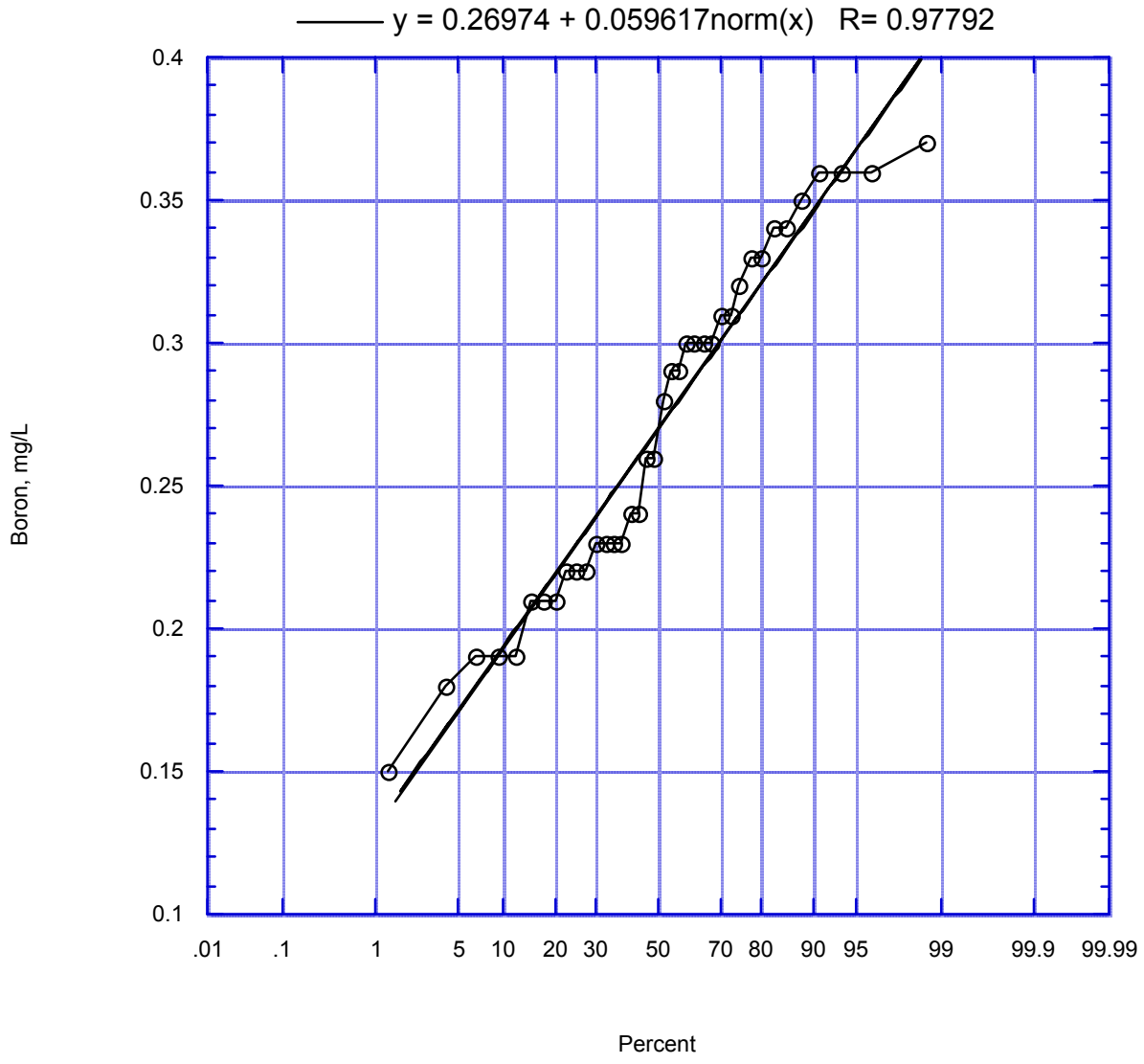


Figure 109. Jensen Plant Boron Frequency Distribution

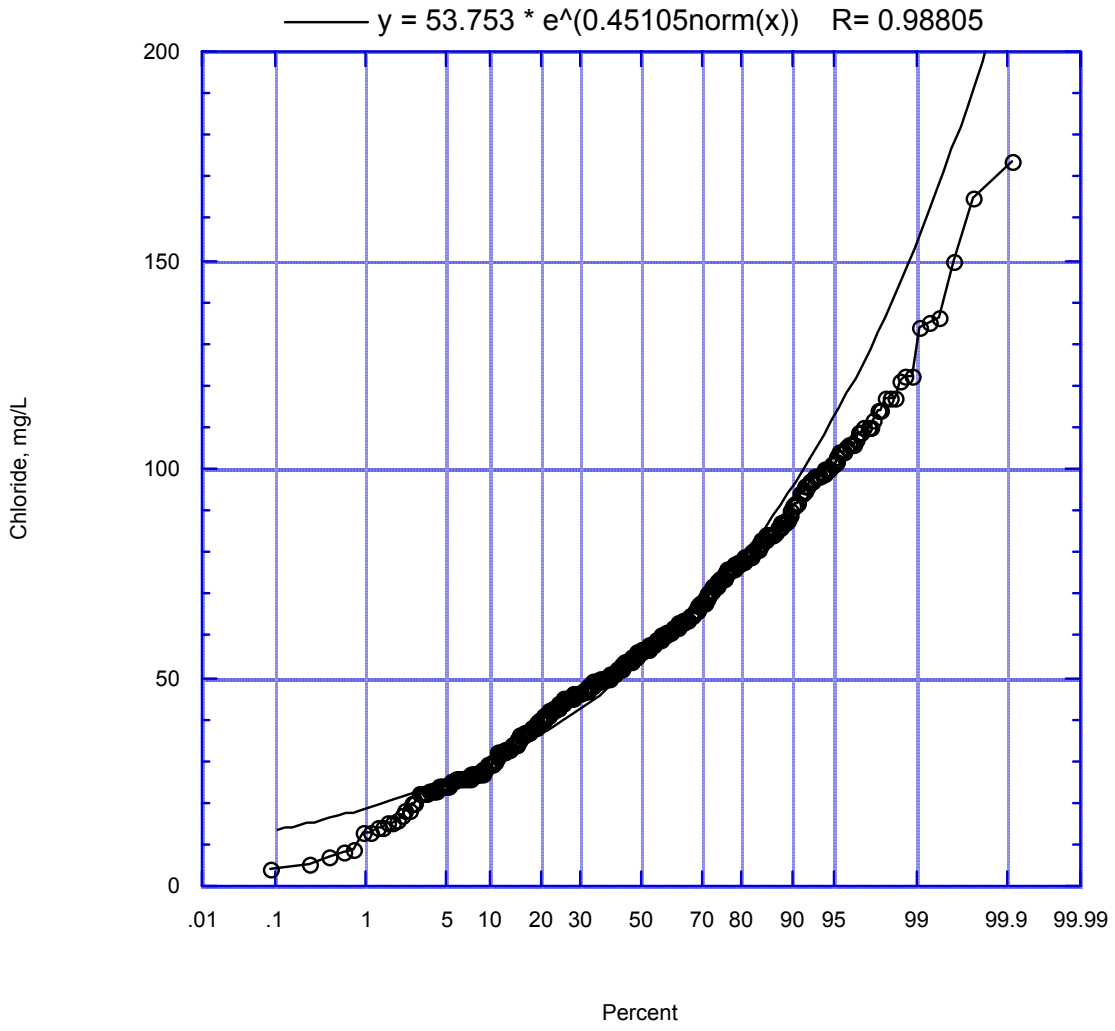


Figure 110. Freeman Diversion Chloride Frequency Distribution

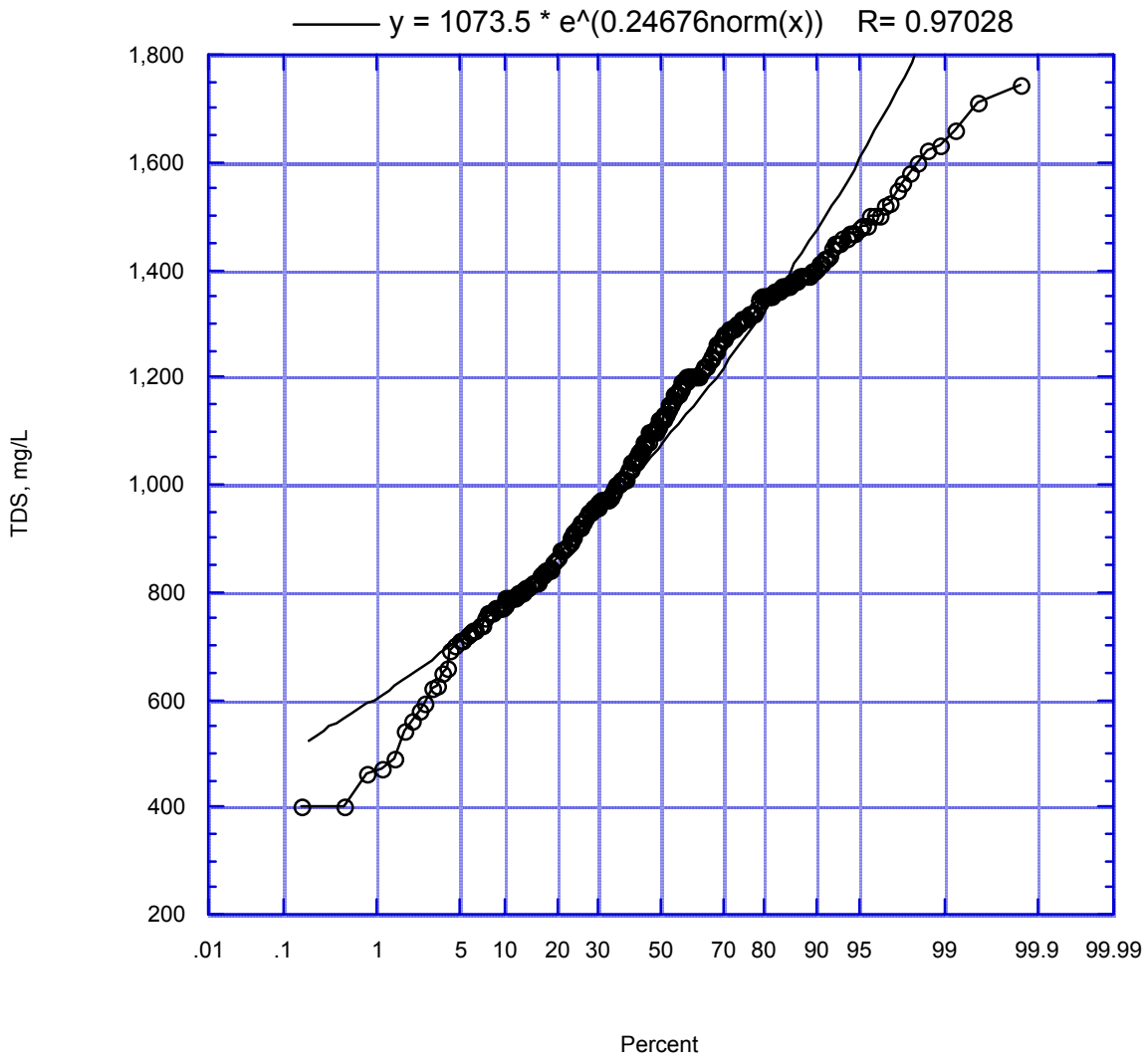


Figure 111. Freeman Diversion TDS Frequency Distribution

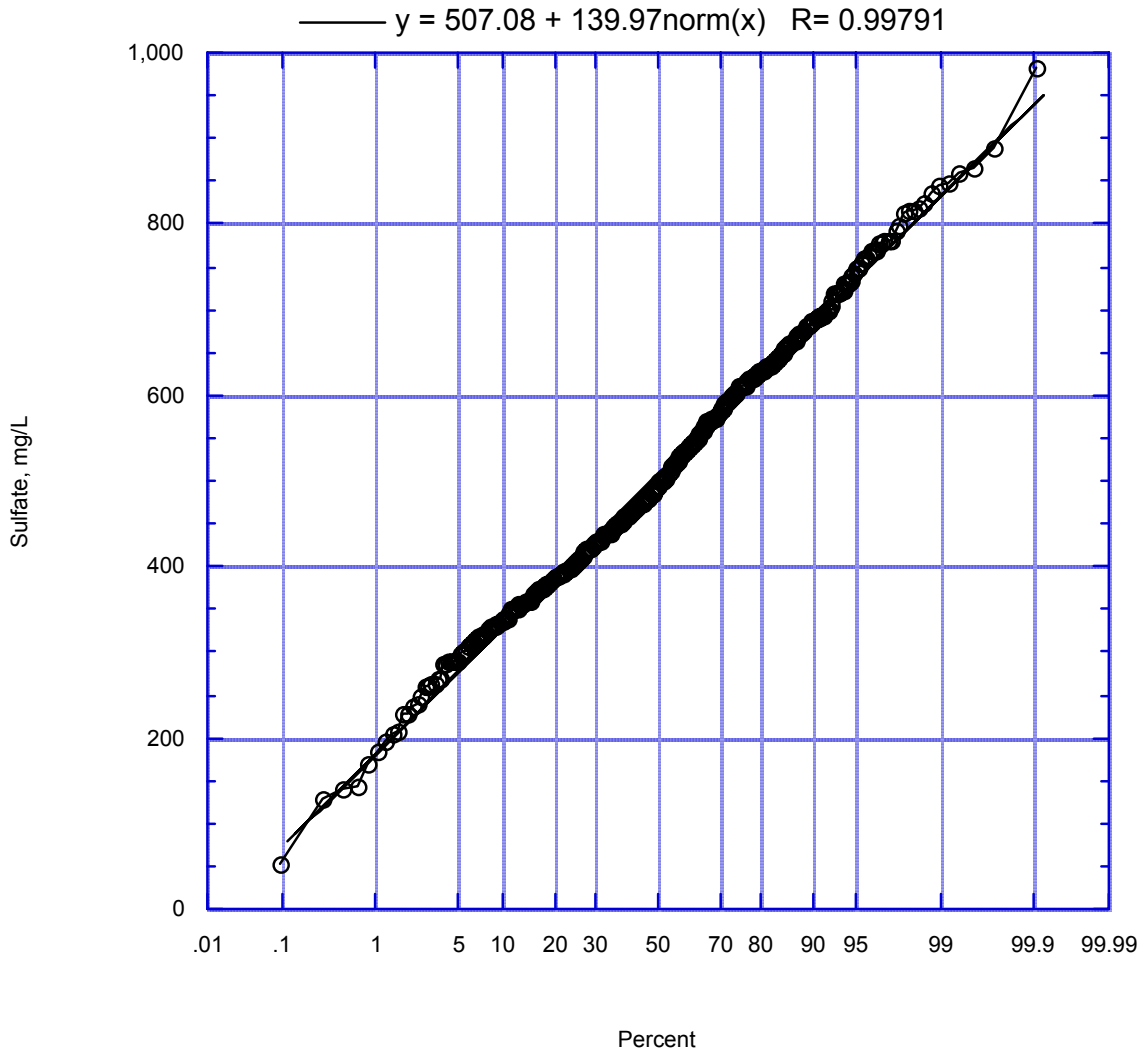


Figure 112. Freeman Diversion Sulfate Frequency Distribution

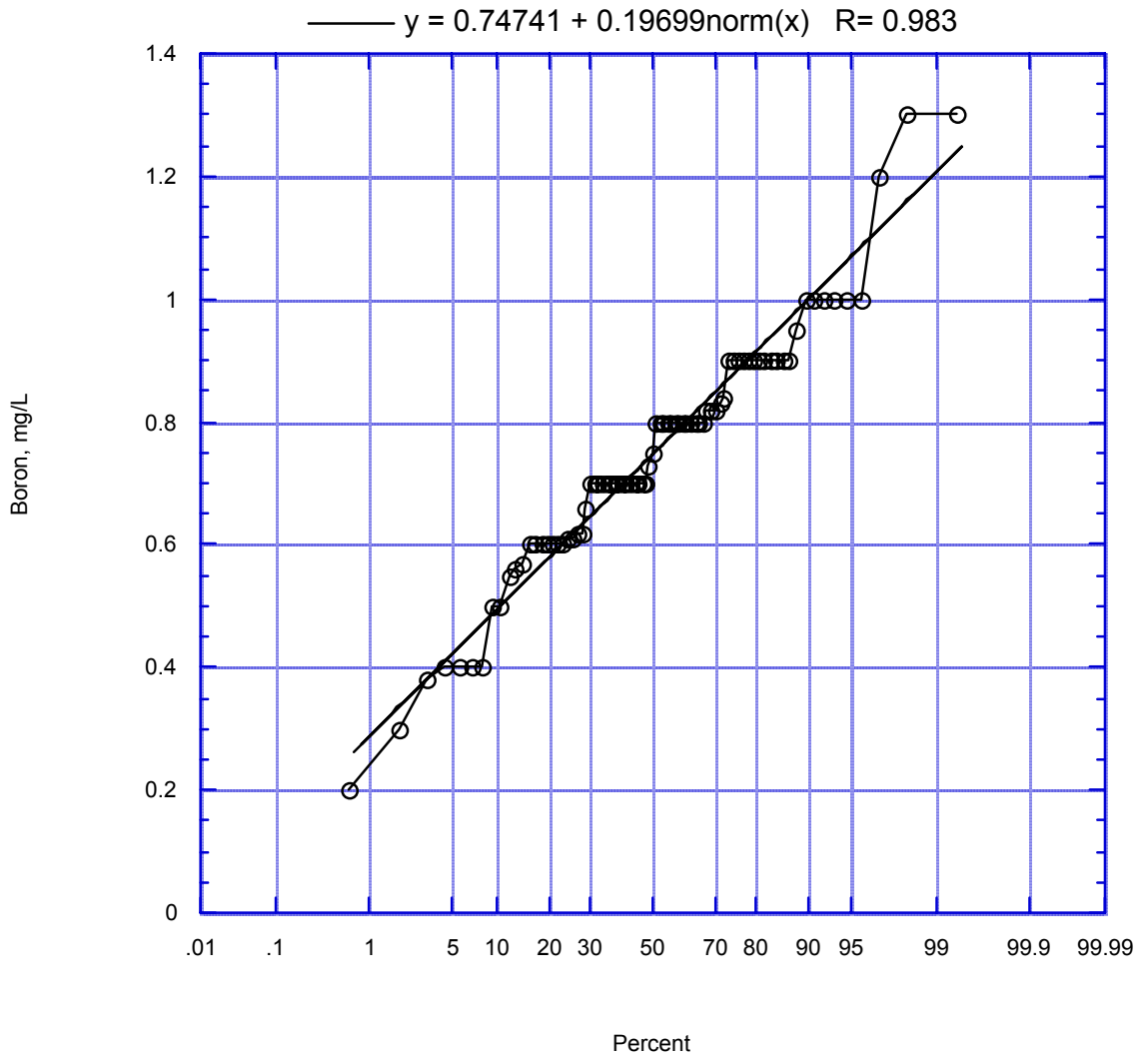


Figure 113. Freeman Diversion Boron Frequency Distribution

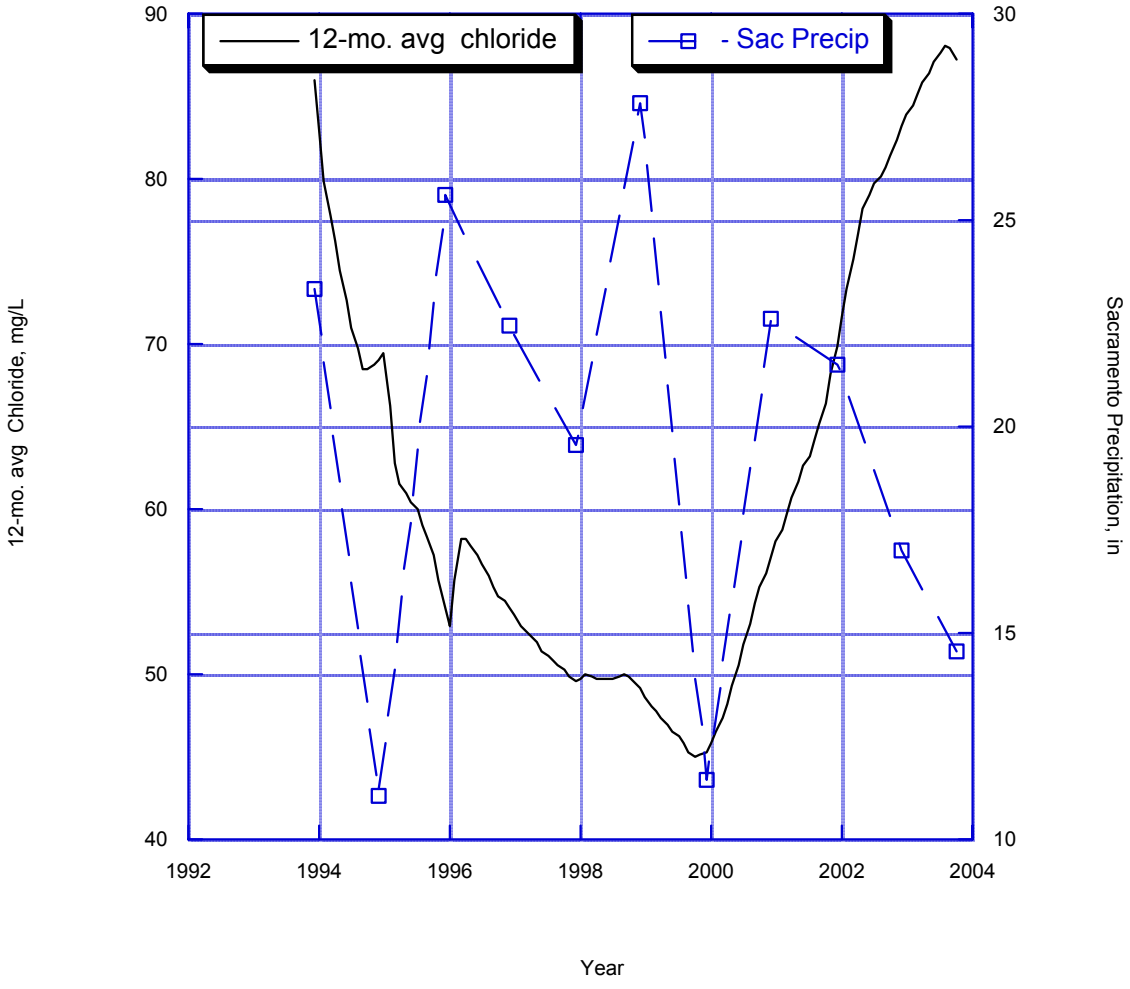


Figure 114. Jensen Plant Chloride and Sacramento Precipitation vs. Time

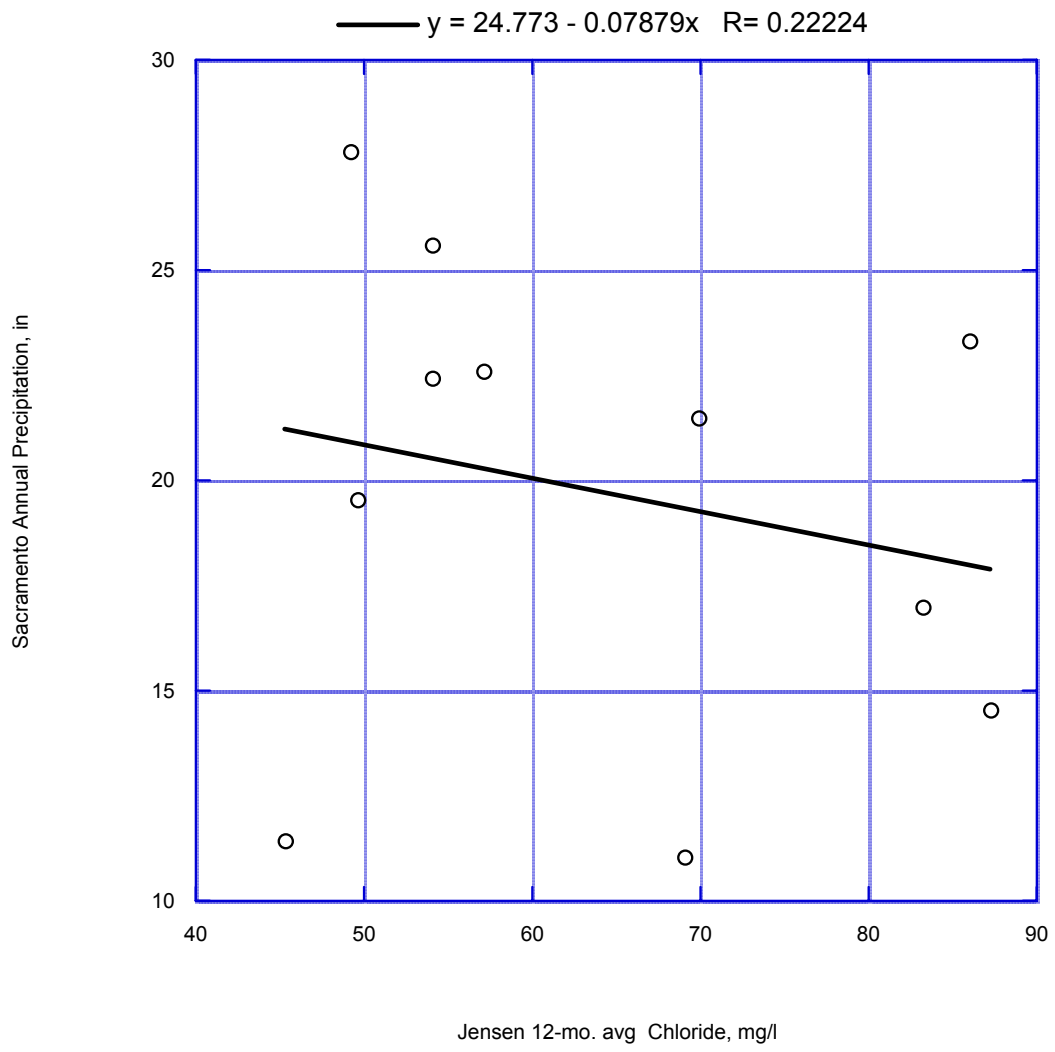


Fig 115. Jensen Plant 12-mo. avg Chloride vs. Sacramento Precipitation

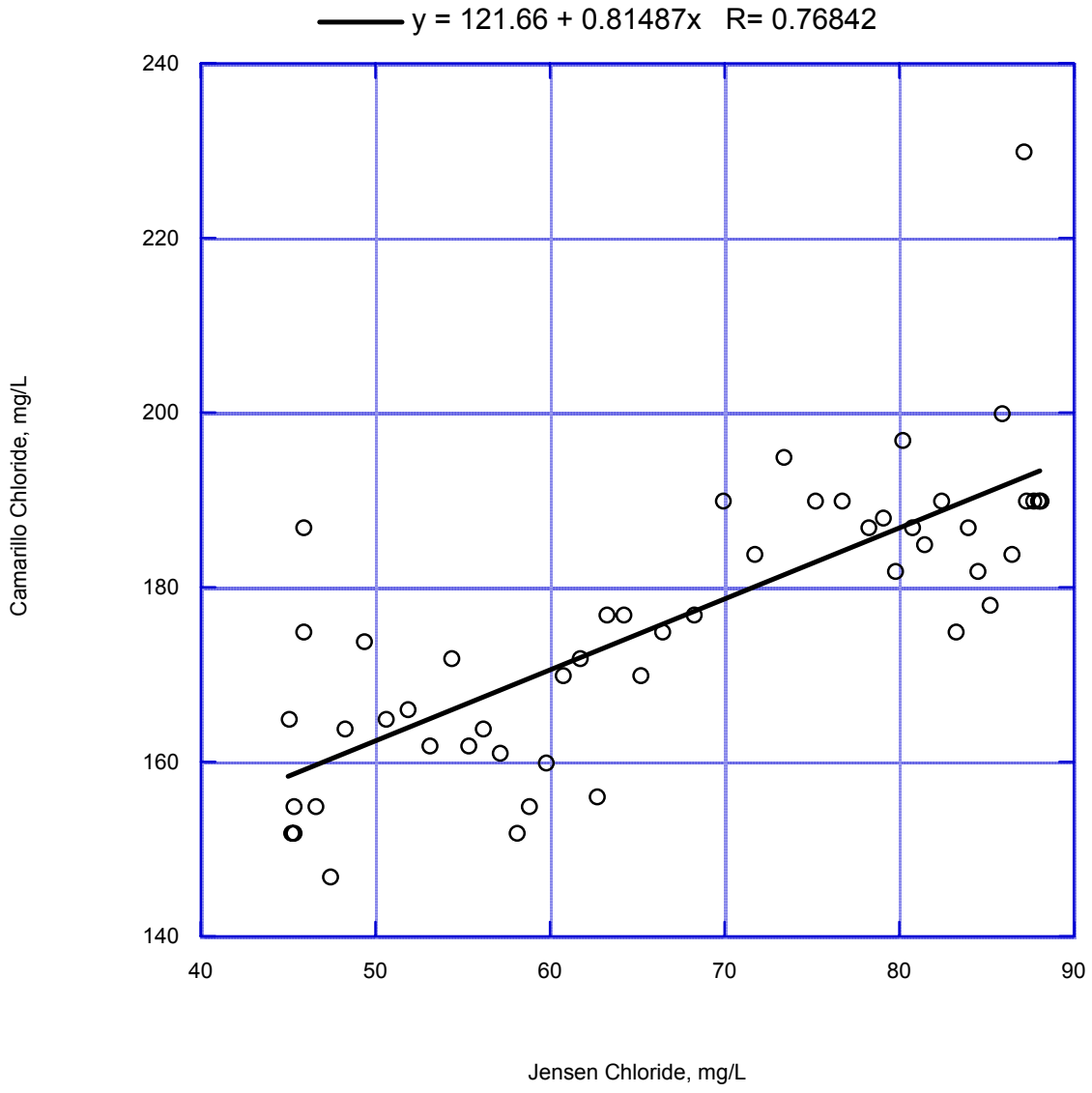


Figure 116. Camarillo Effluent Chloride vs. Jensen Plant Chloride

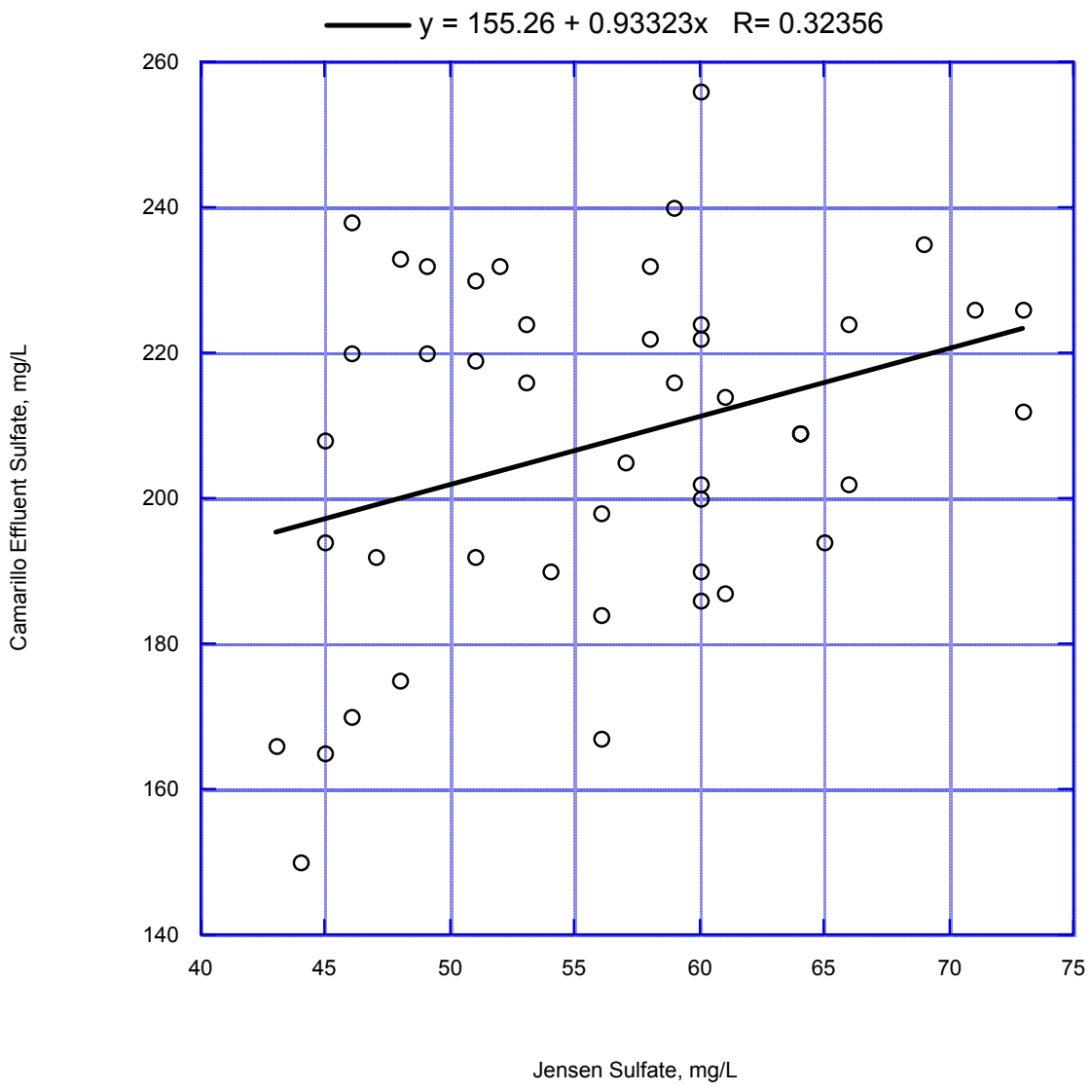


Figure 117. Camarillo Effluent Sulfate vs. Jensen Plant Sulfate

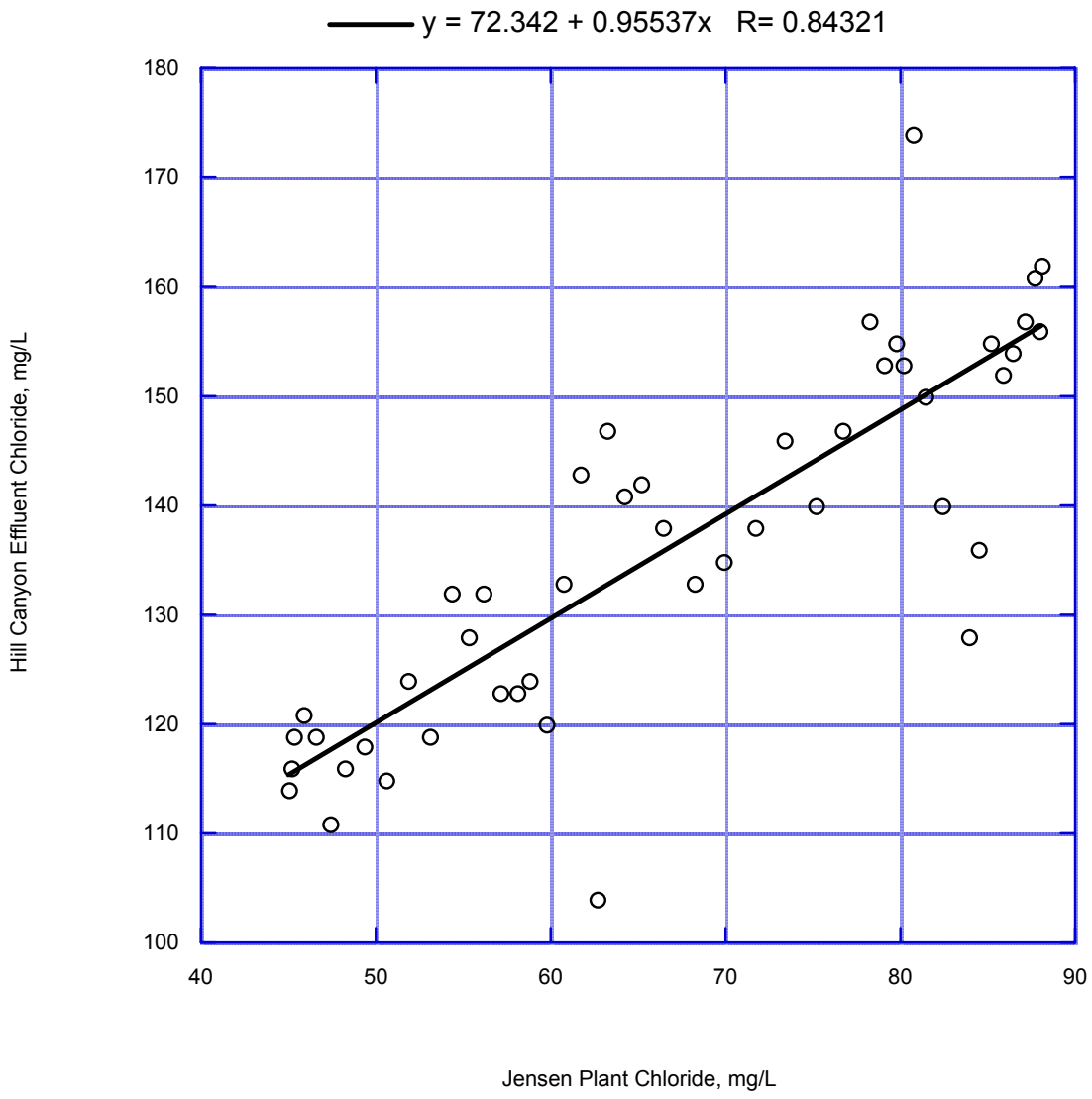


Figure 118. Hill Canyon Effluent Chloride vs. Jensen Plant Chloride

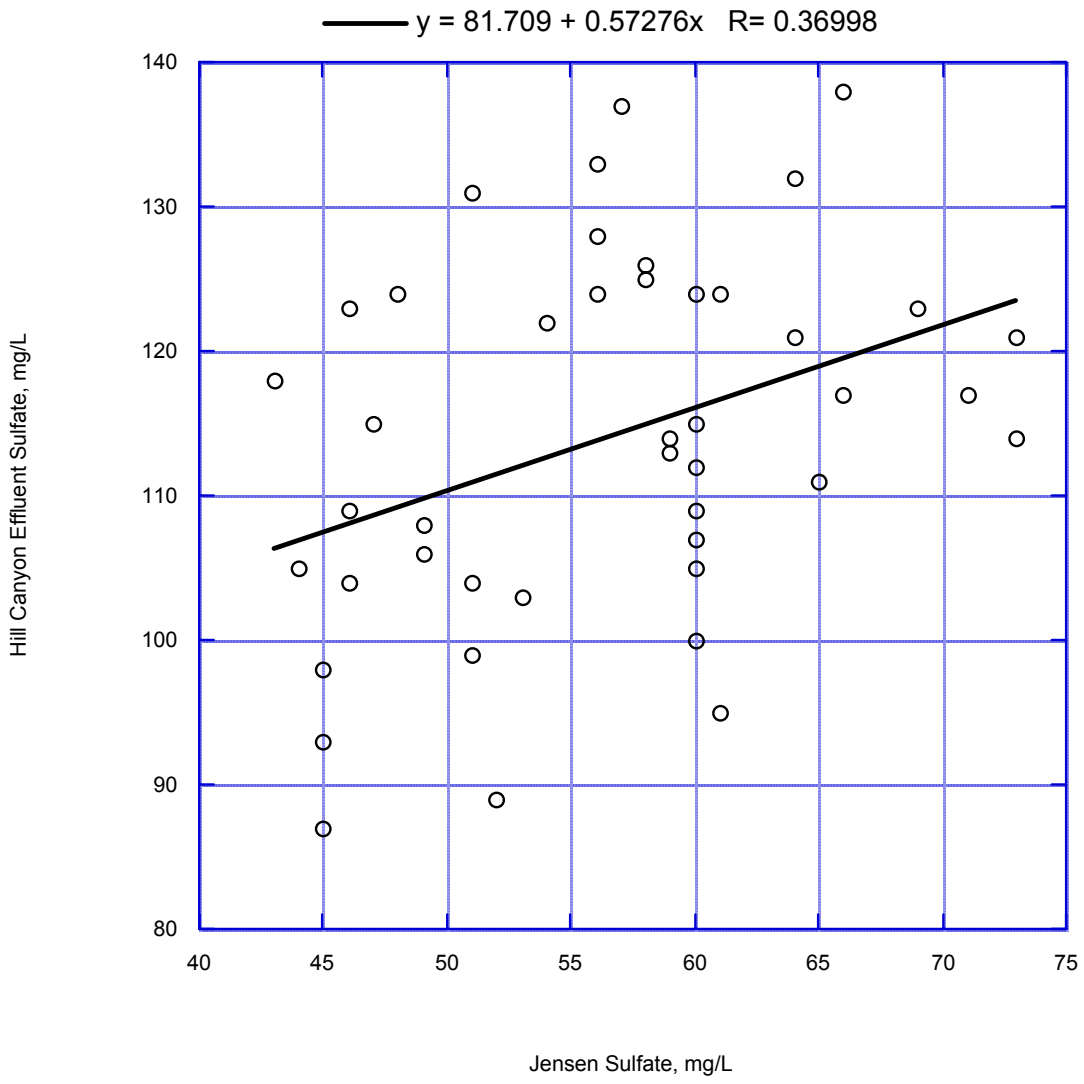


Figure 119. Hill Canyon Effluent Sulfate vs. Jensen Plant Sulfate

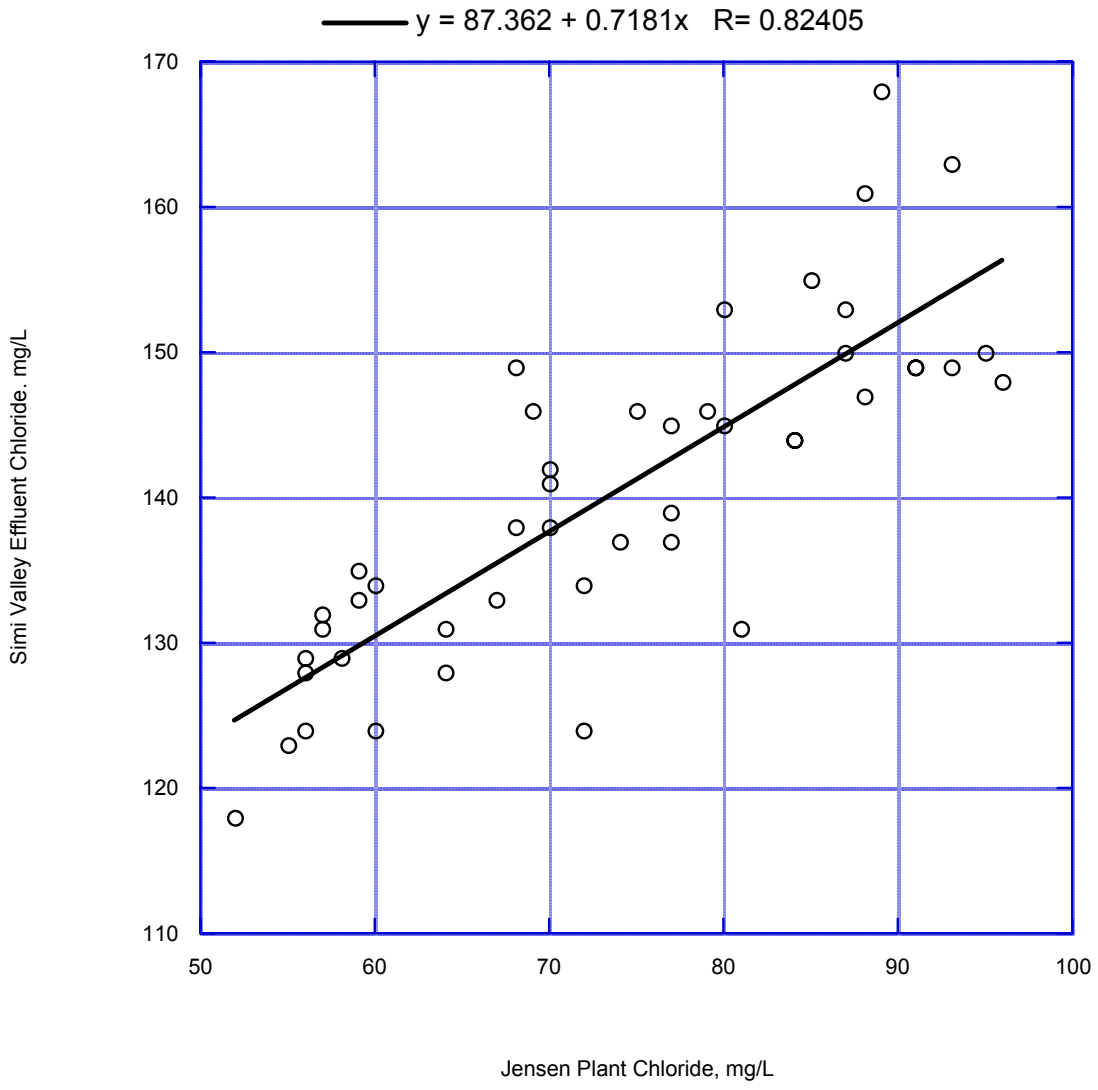


Figure 120. Simi Valley Effluent Chloride vs. Jensen Plant Chloride

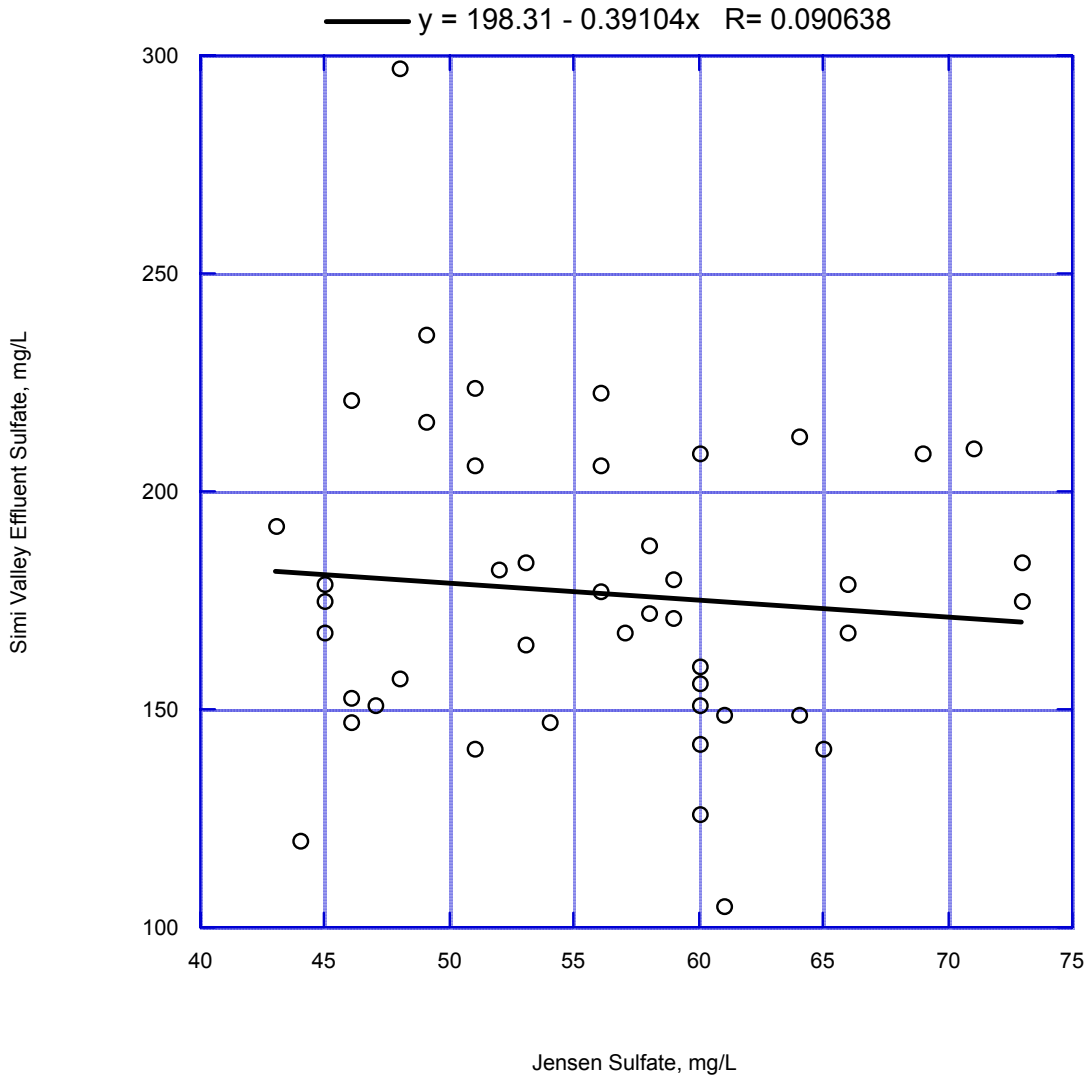


Figure 121. Simi Valley Effluent Sulfate vs. Jensen Plant Sulfate

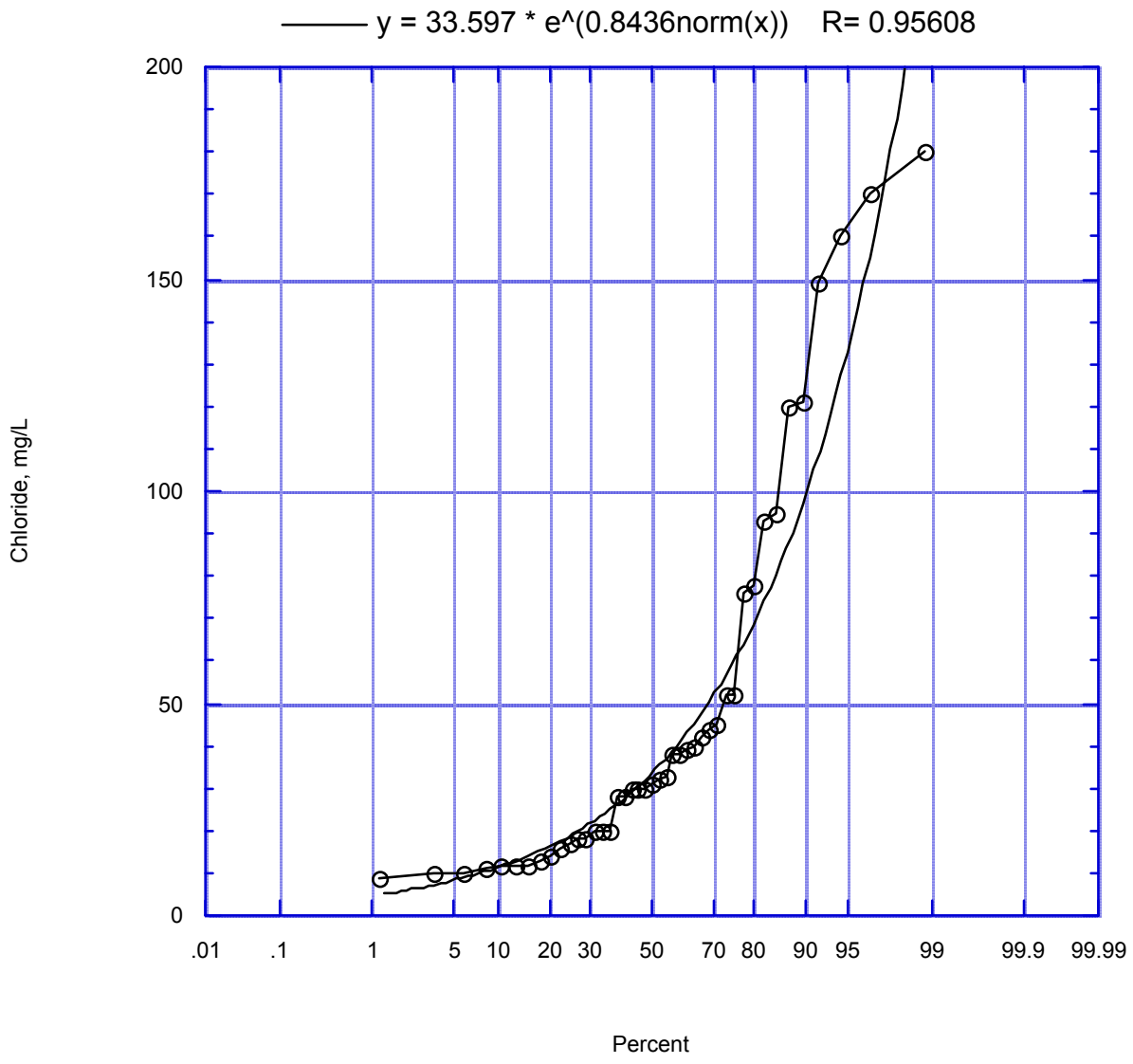


Figure 122. Frequency Distribution of Chloride in Stormwater Runoff form Agricutural Land Use

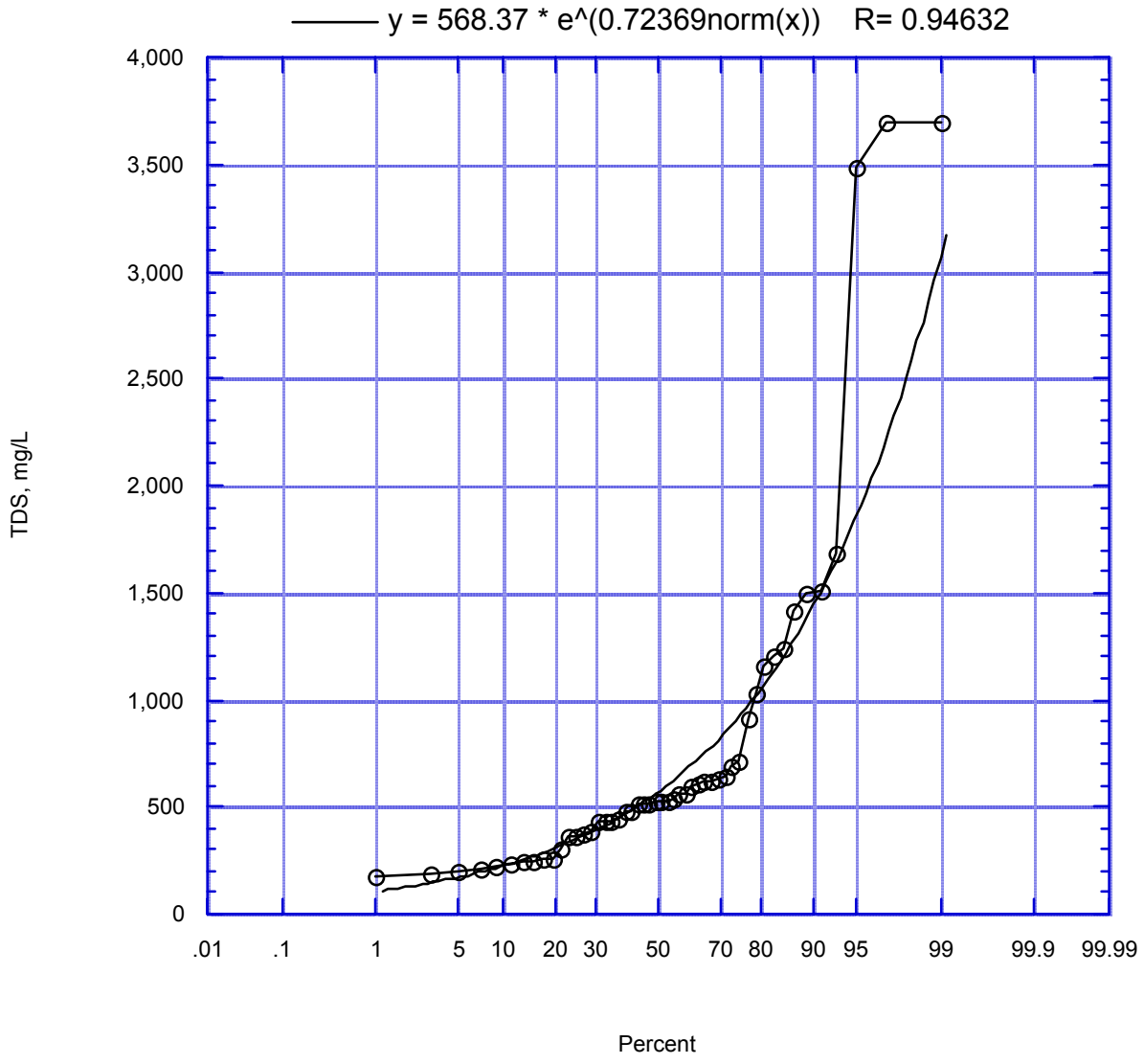


Figure 123. Frequency Distribution of TDS in Stormwater Runoff form Agricutural Land Use

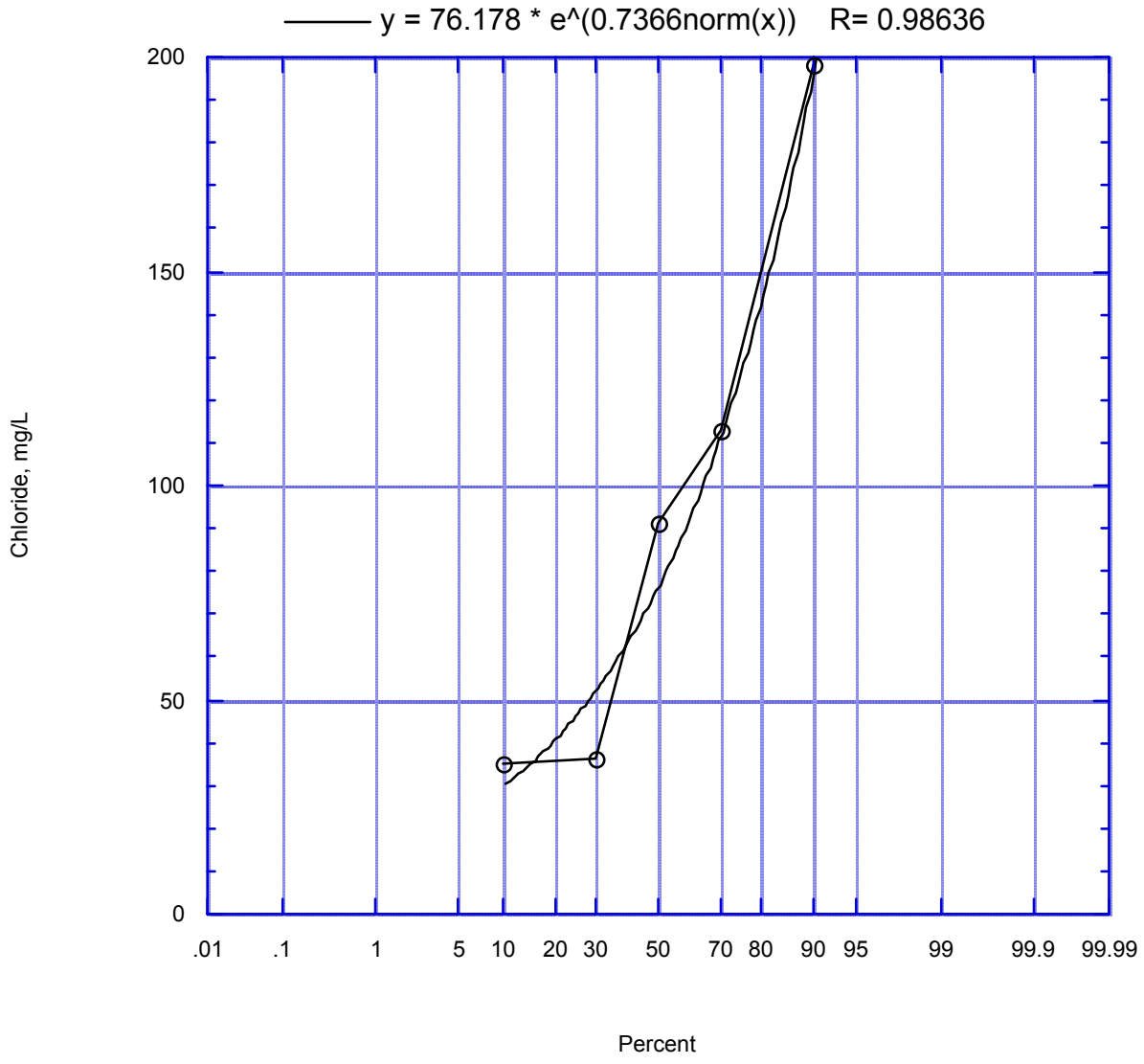


Figure 124. Frequency Distribution of Chloride in Stormwater Runoff form Open Space Land Use

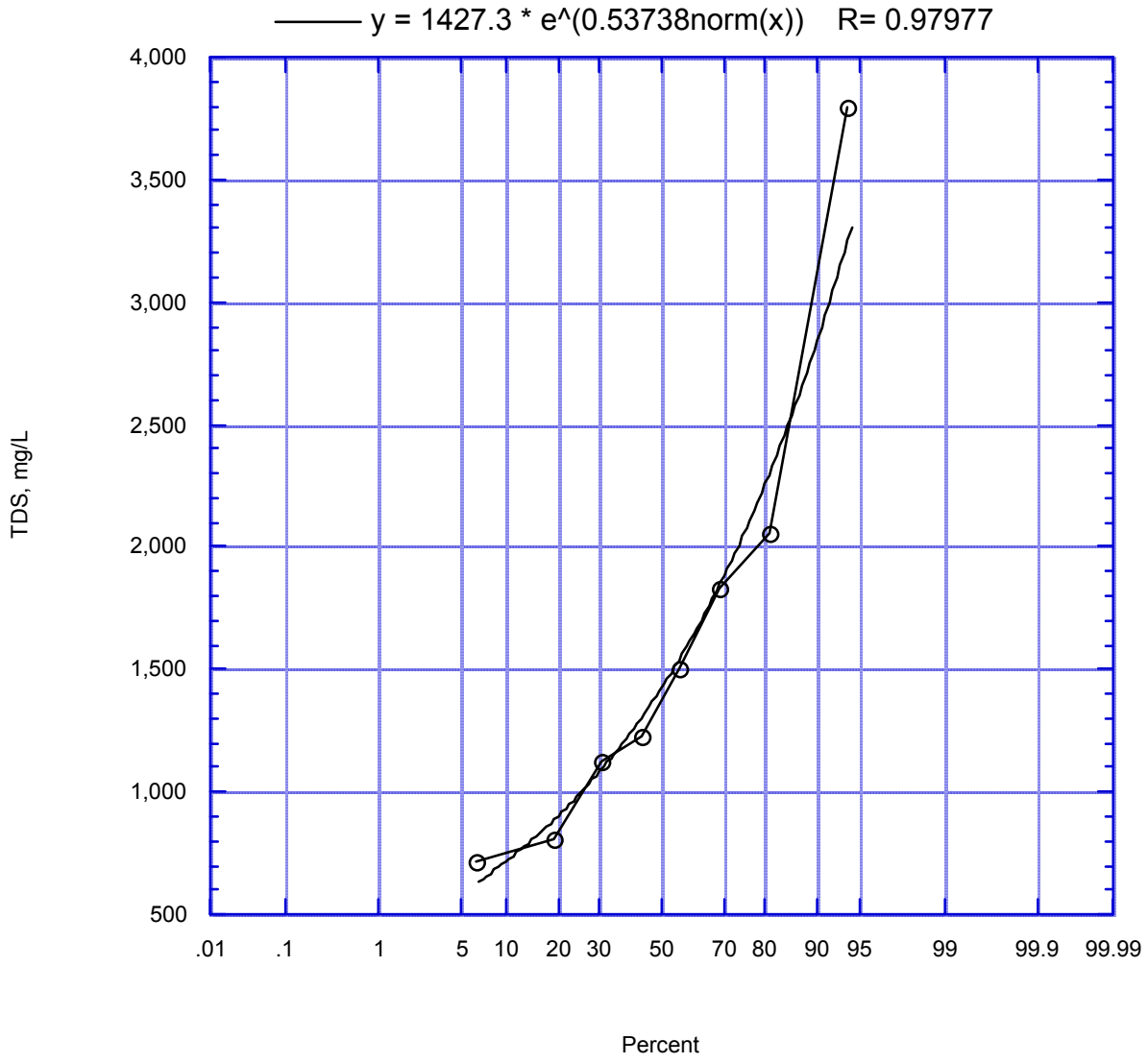


Figure 125. Frequency Distribution of TDS in Stormwater Runoff form Open Space Land Use

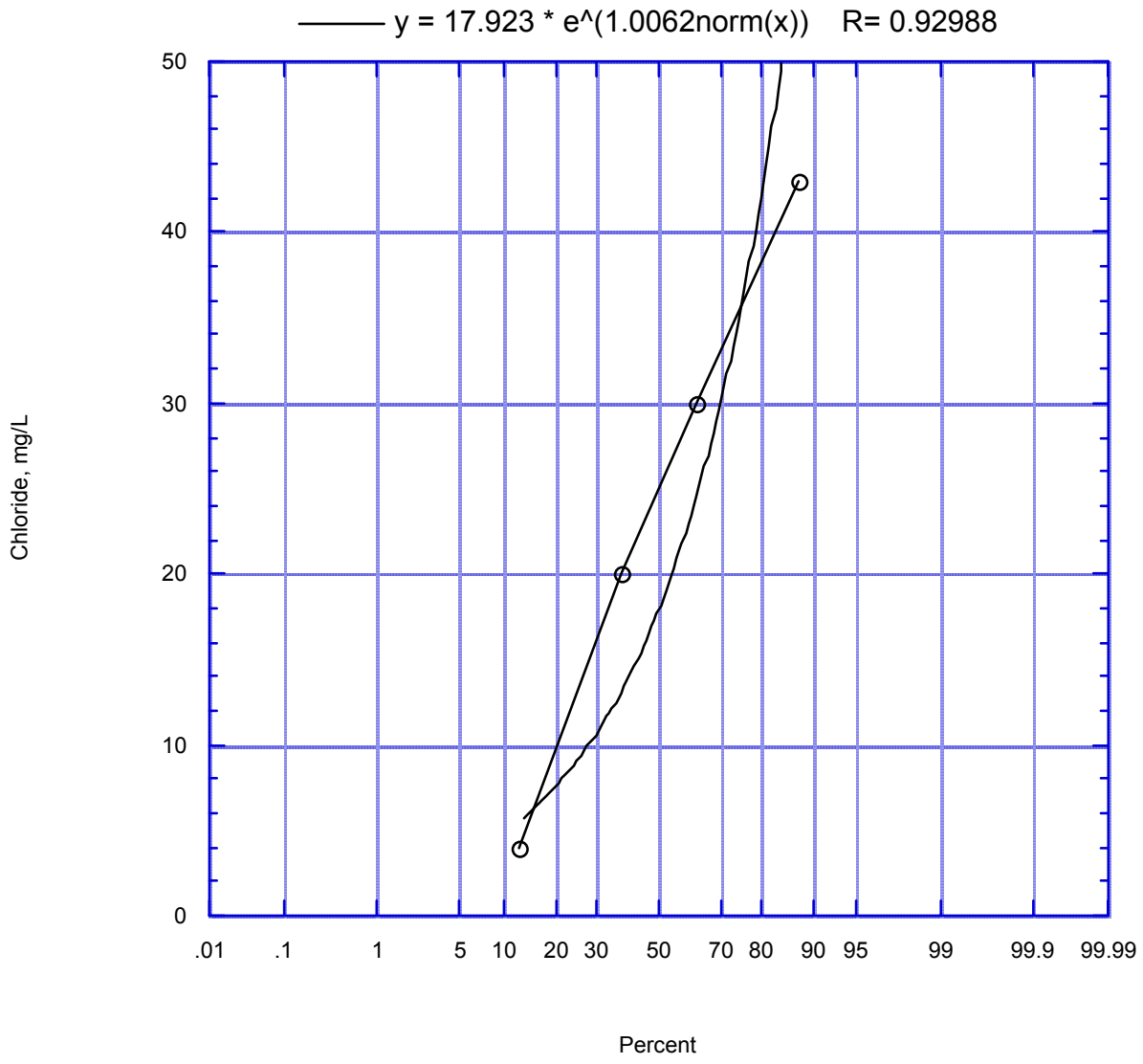


Figure 126. Frequency Distribution of Chloride in Stormwater Runoff form Industrial Land Use

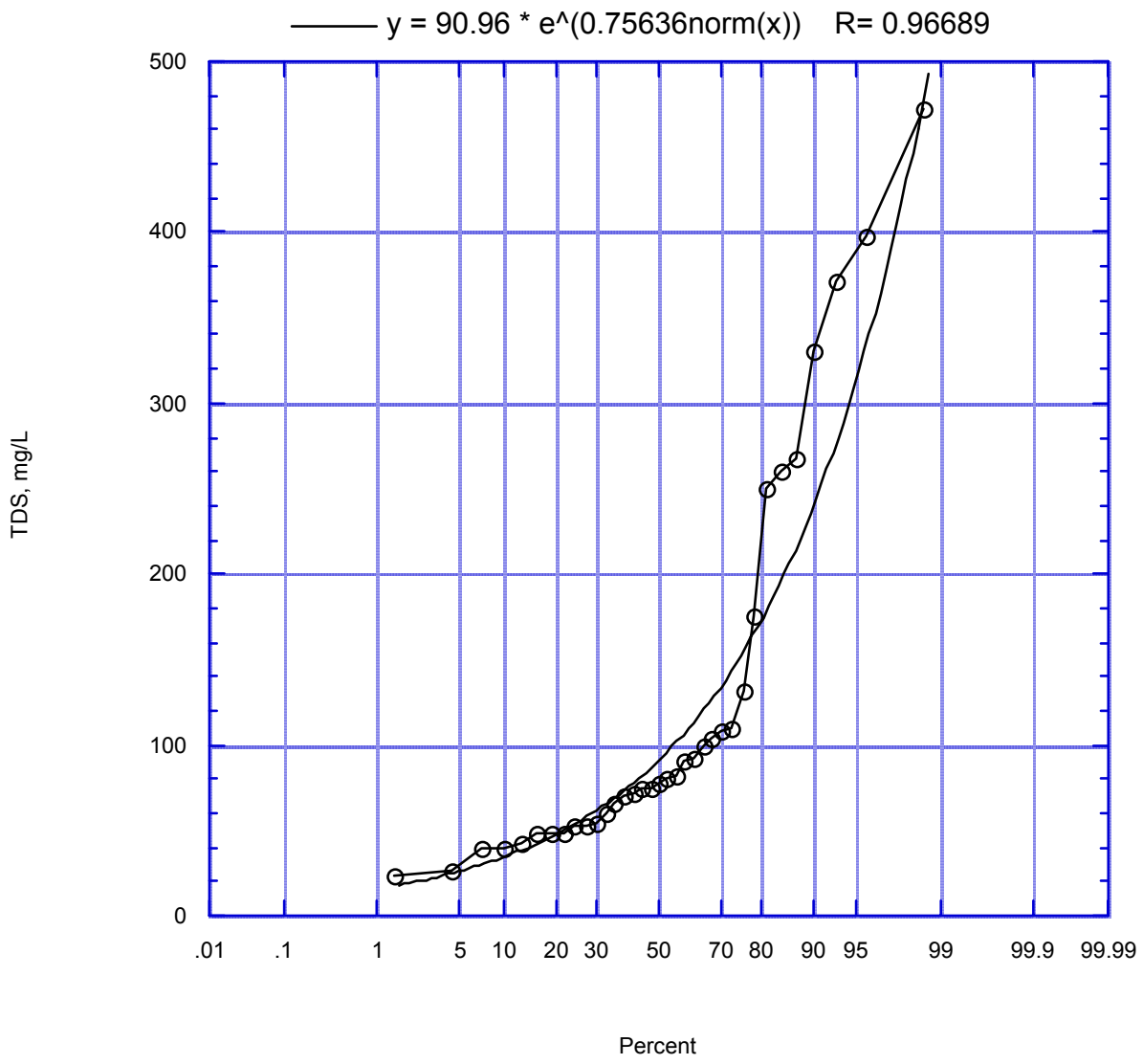


Figure 127. Frequency Distribution of TDS in Stormwater Runoff form Industrial Land Use

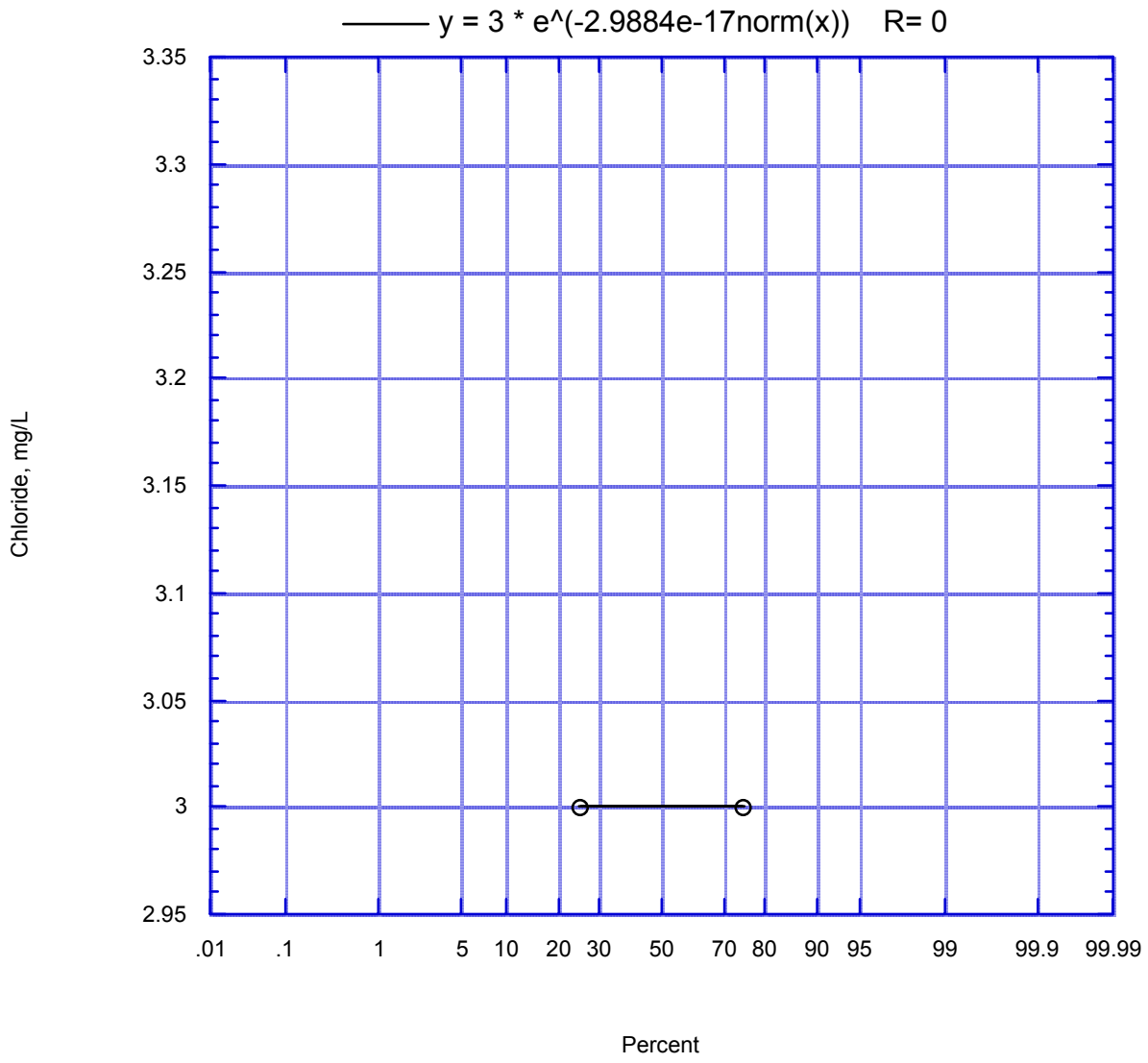


Figure 128. Frequency Distribution of Chloride in Stormwater Runoff form Commercial Land Use

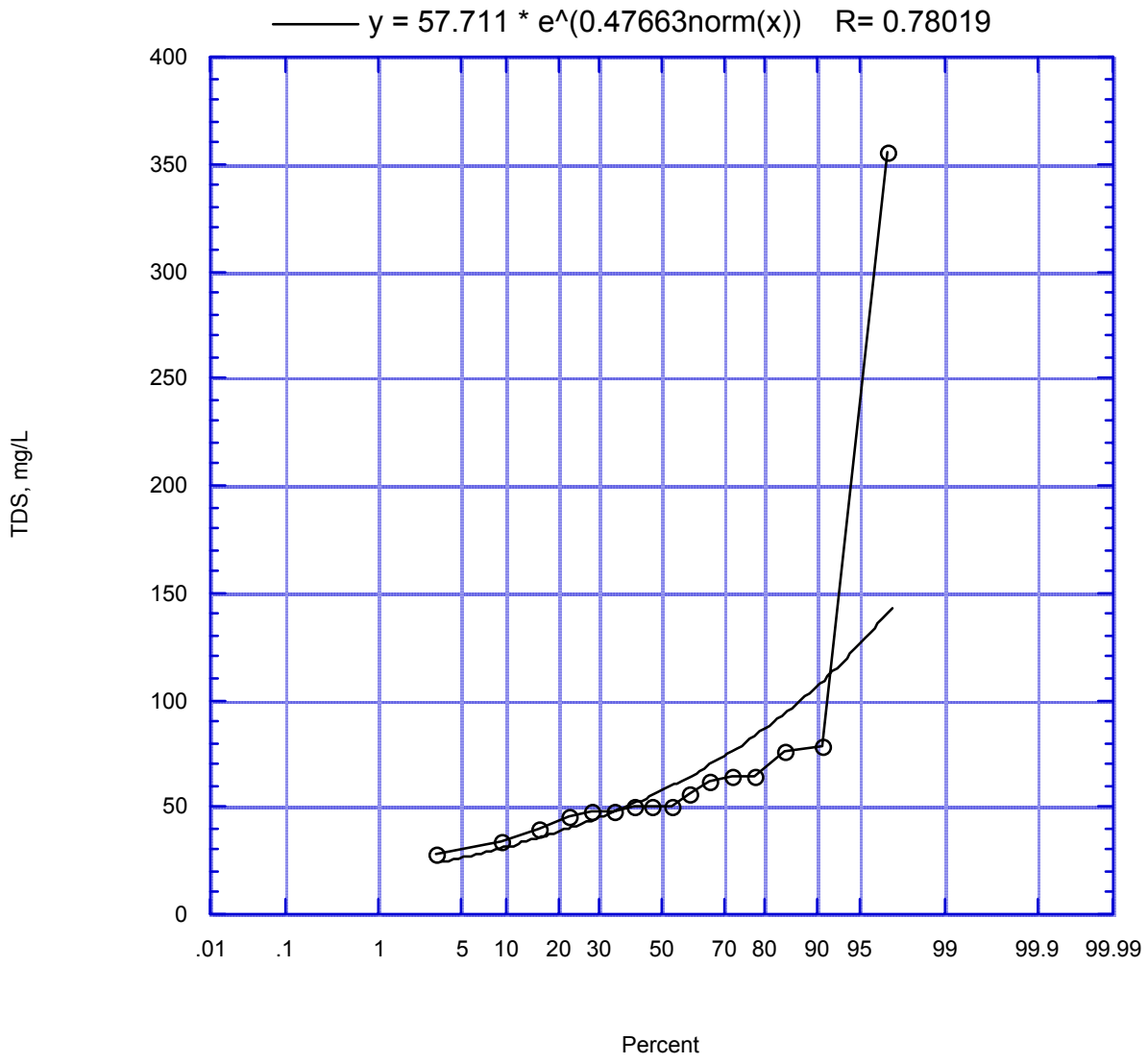


Figure 129. Frequency Distribution of TDS in Stormwater Runoff form Commercial Land Use

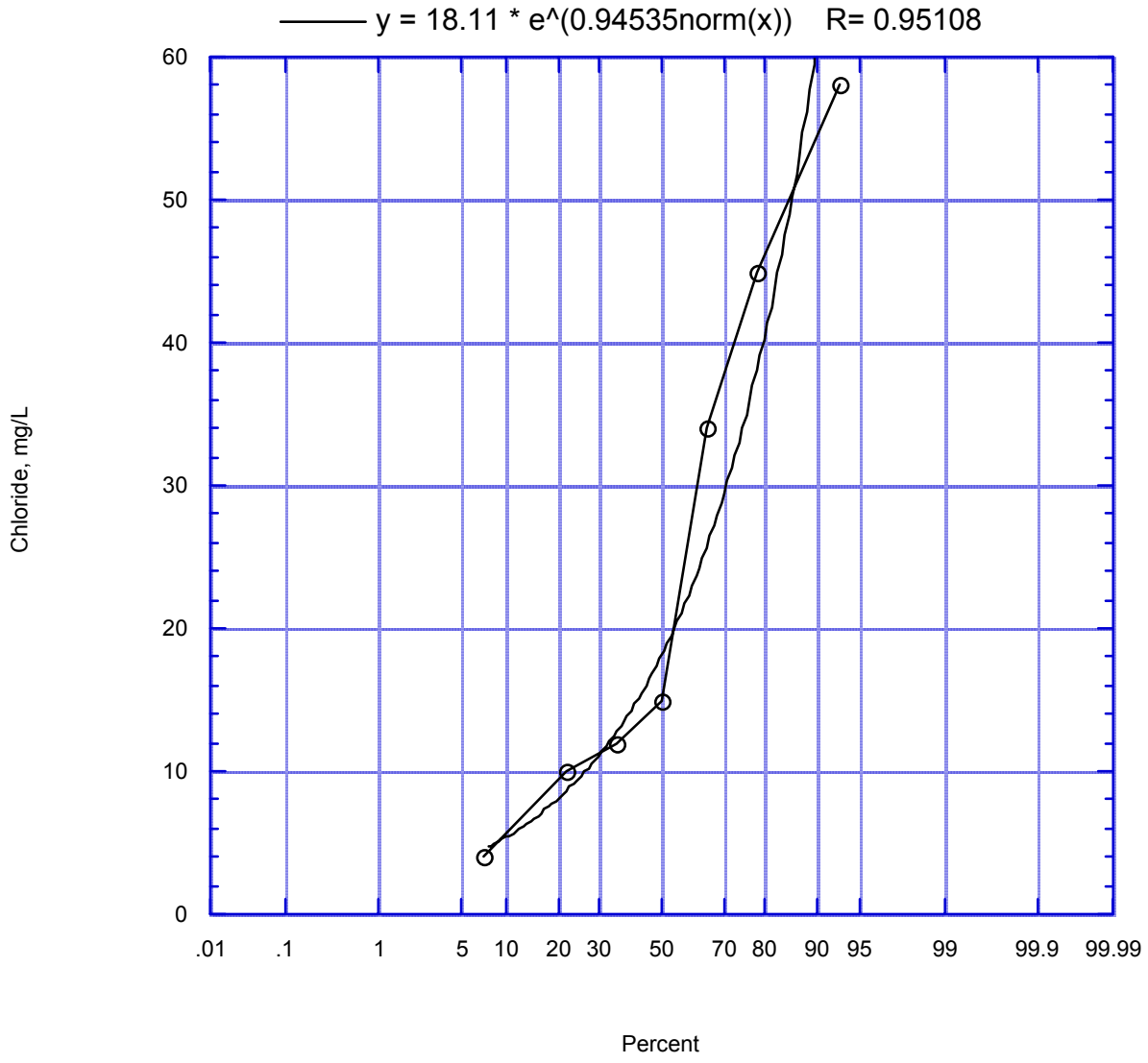


Figure 130. Frequency Distribution of Chloride in Stormwater Runoff form Residential Land Use

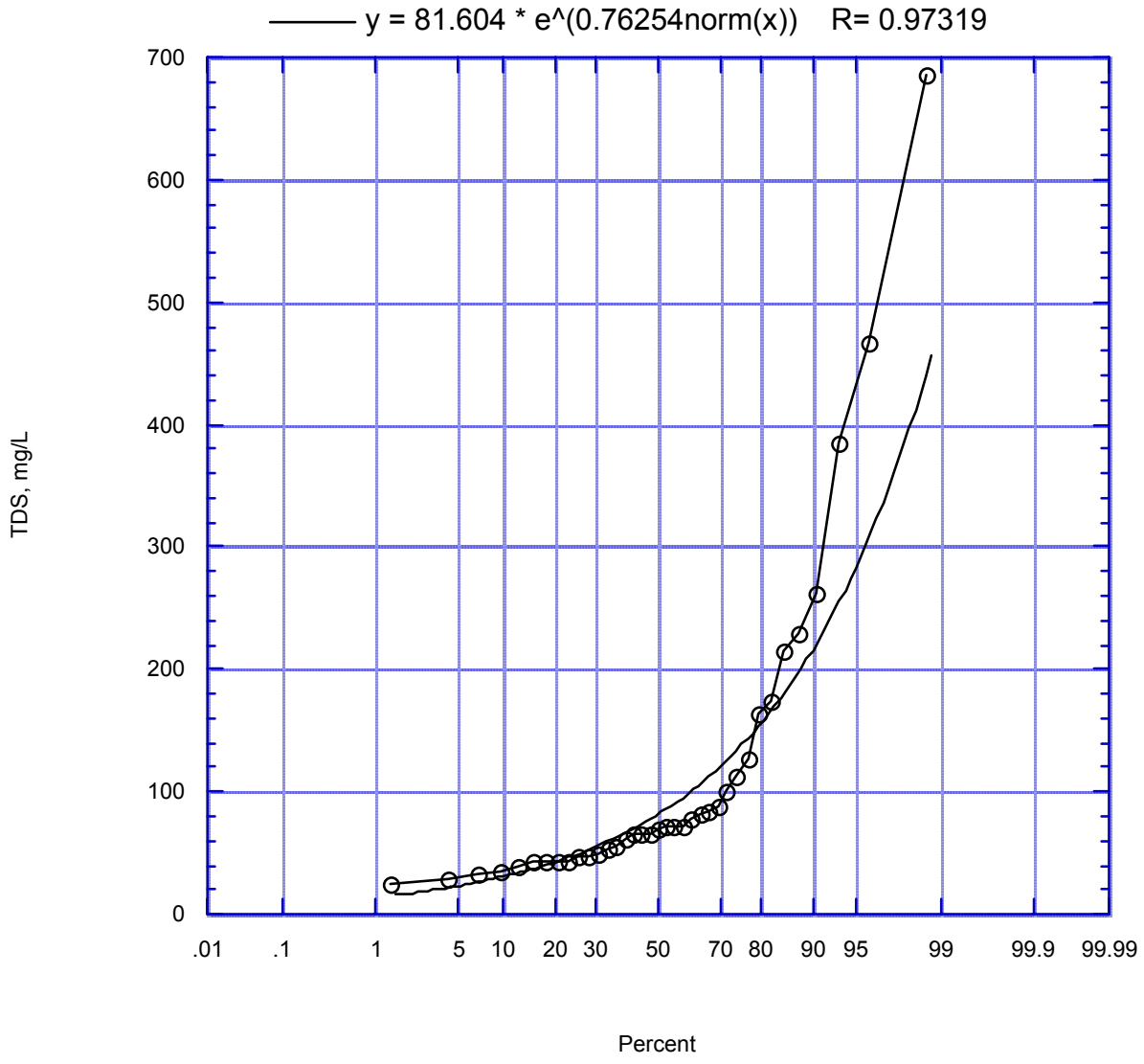


Figure 131. Frequency Distribution of TDS in Stormwater Runoff form Residential Land Use

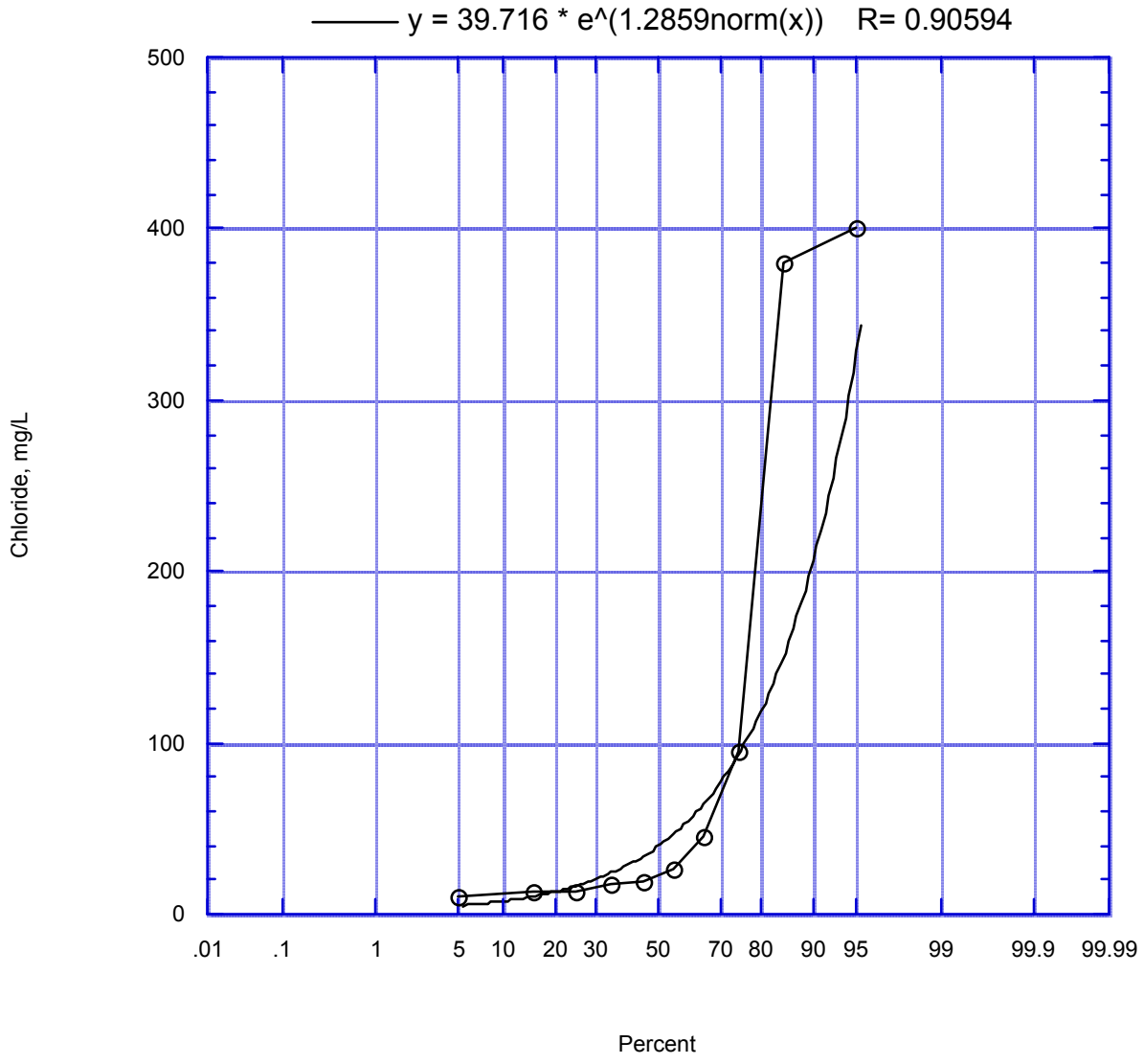


Figure 132. Frequency Distribution of Chloride in Stormwater Runoff form Mixed-use Land Use

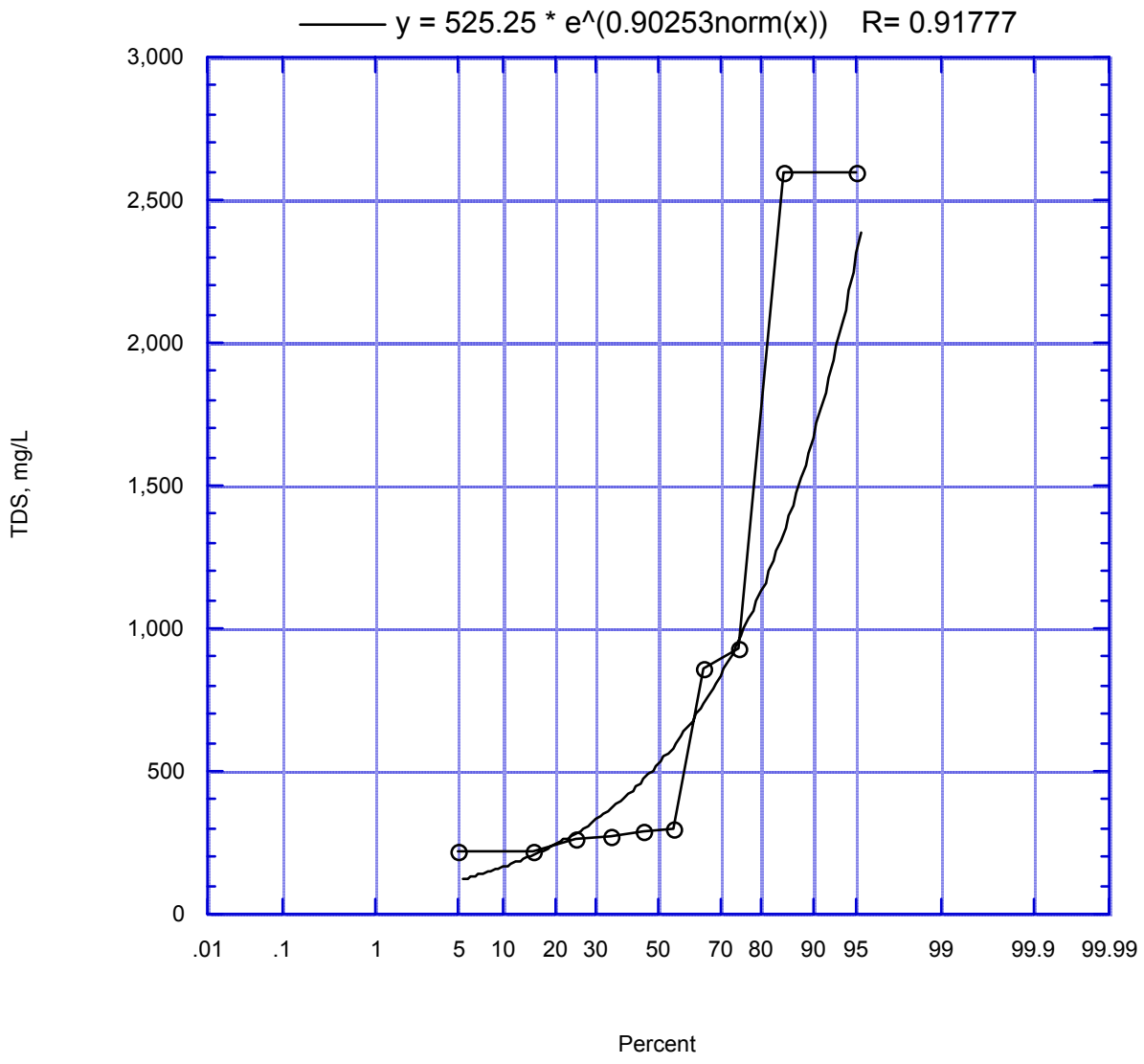


Figure 133. Frequency Distribution of TDS in Stormwater Runoff form Mixed-use Land Use

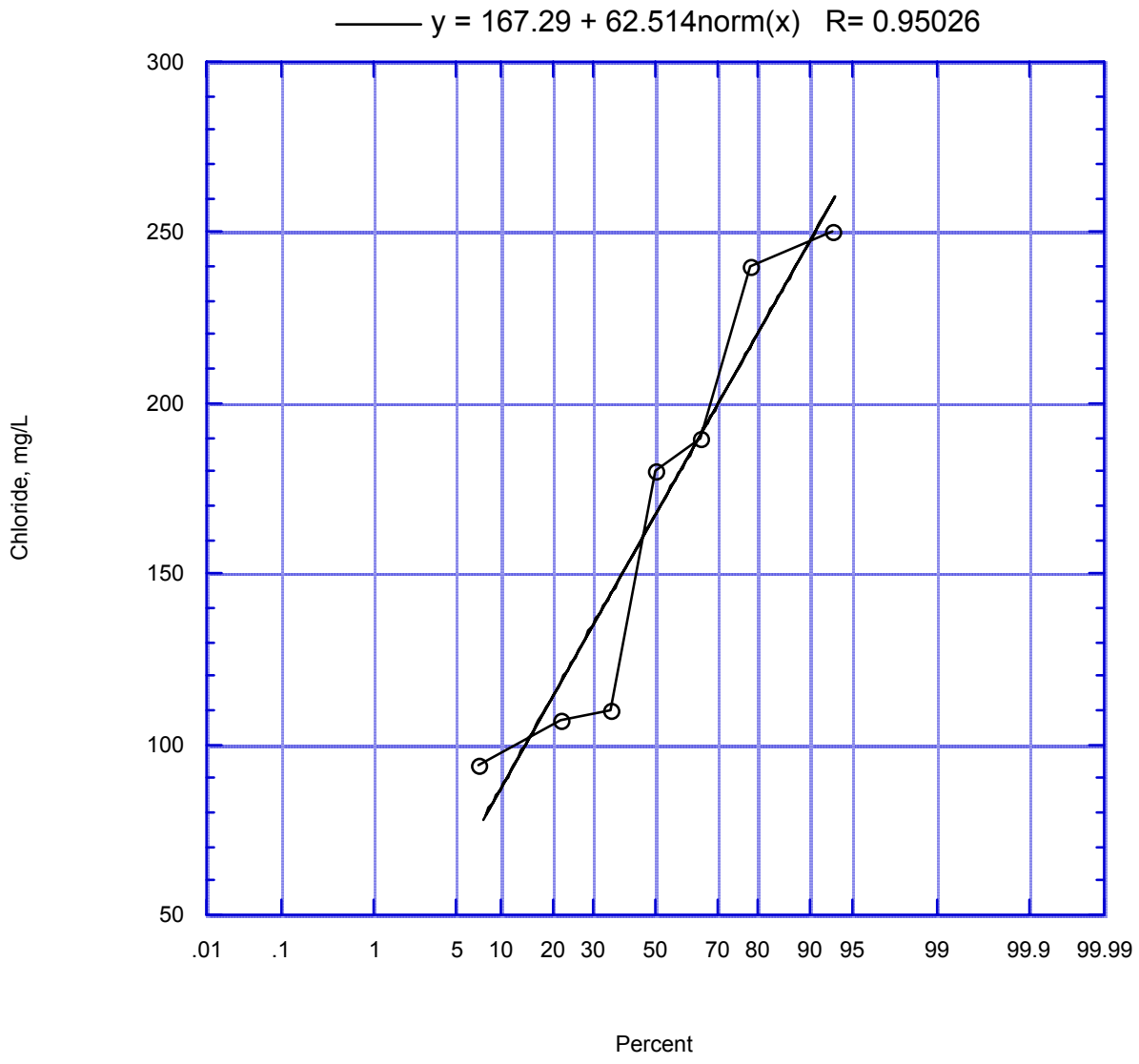


Figure 134. Frequency Distribution of Chloride in Non-stormwater Runoff form Agricutural Land Use

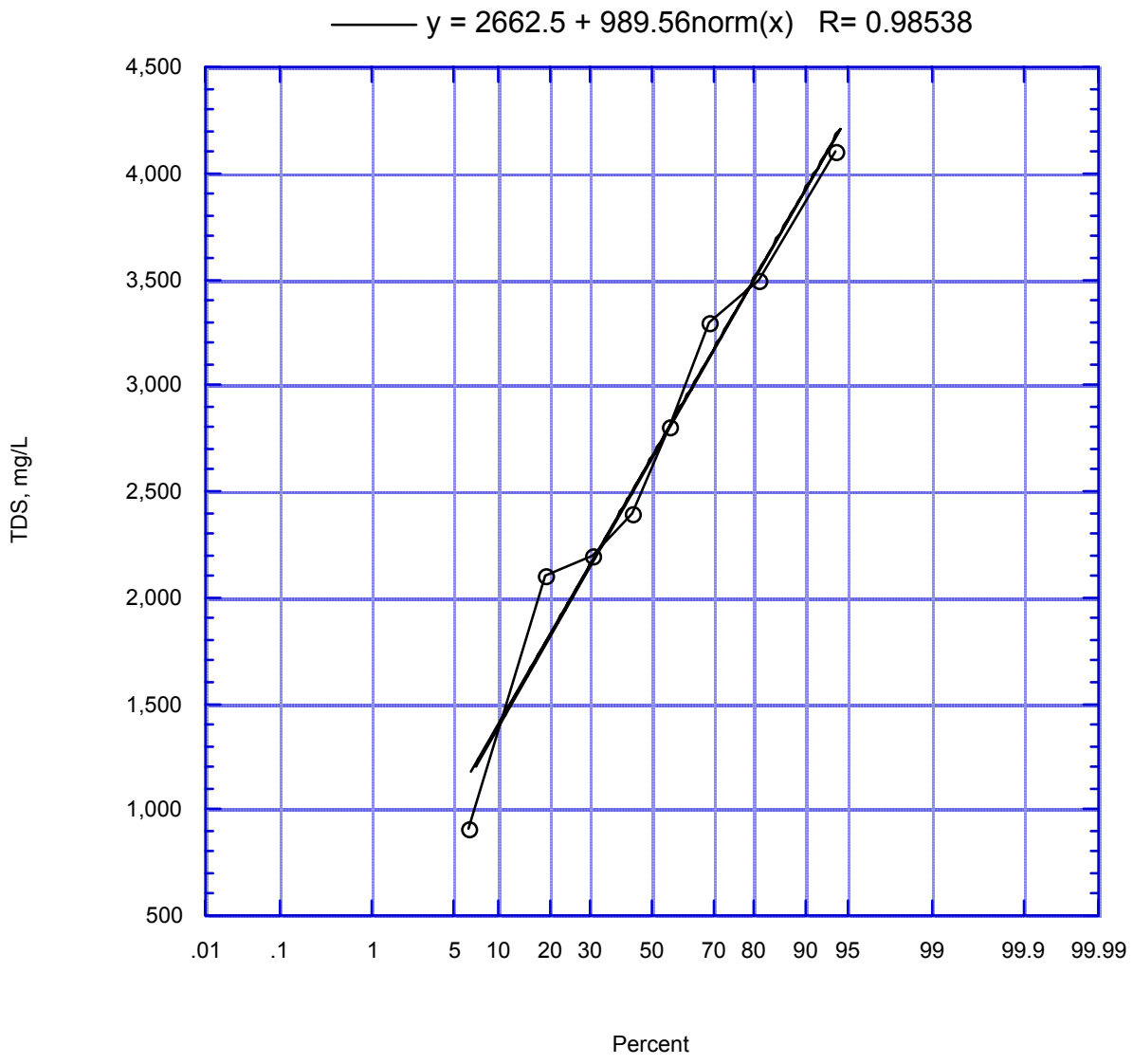


Figure 135. Frequency Distribution of TDS in Non-stormwater Runoff form Agricutural Land Use

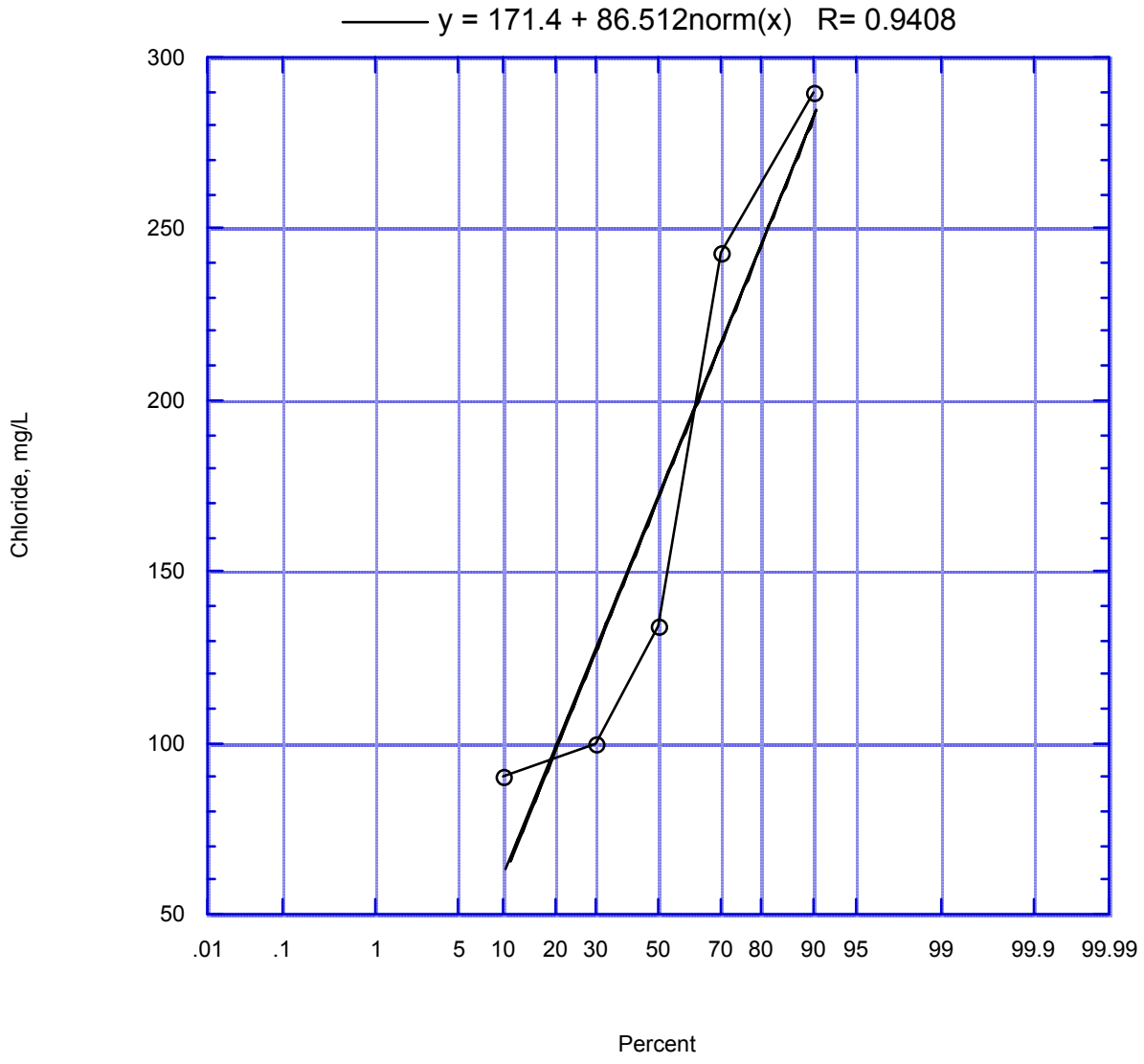


Figure 136. Frequency Distribution of Chloride in Non-stormwater Runoff form Open Space Use

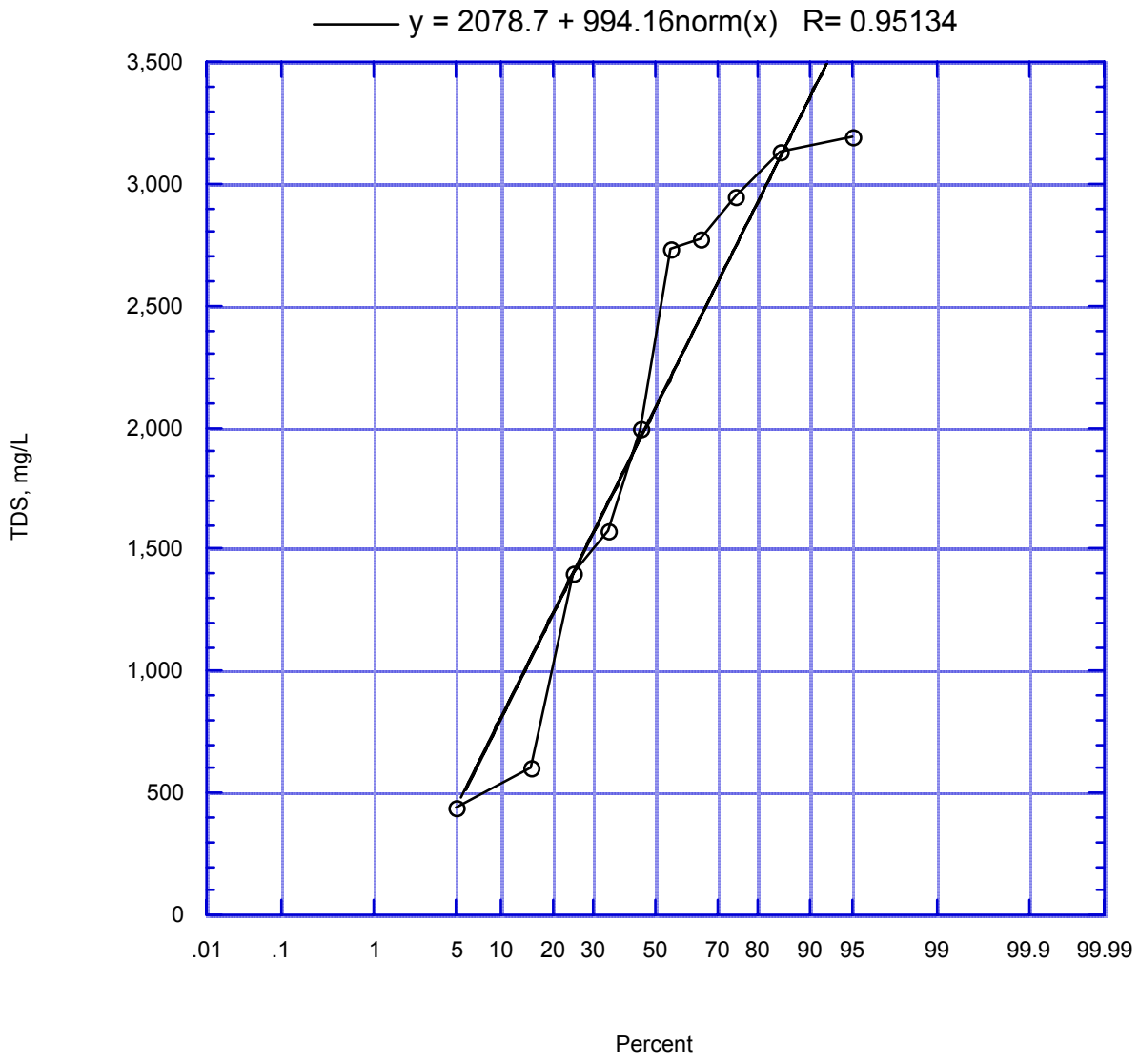


Figure 137. Frequency Distribution of TDS in Non-stormwater Runoff form Open Space Use

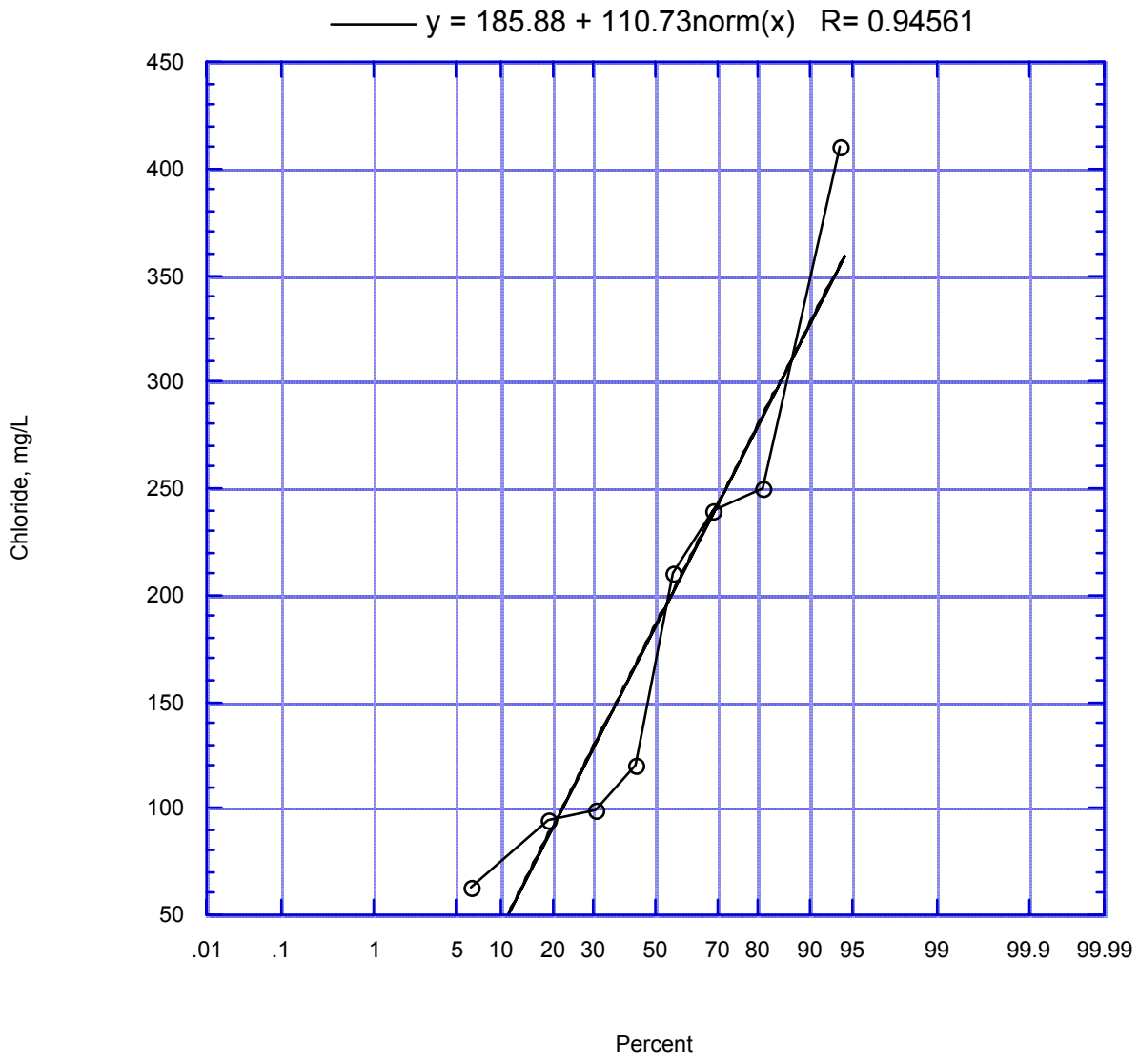


Figure 138. Frequency Distribution of Chloride in Non-stormwater Runoff form Mixed-use Use

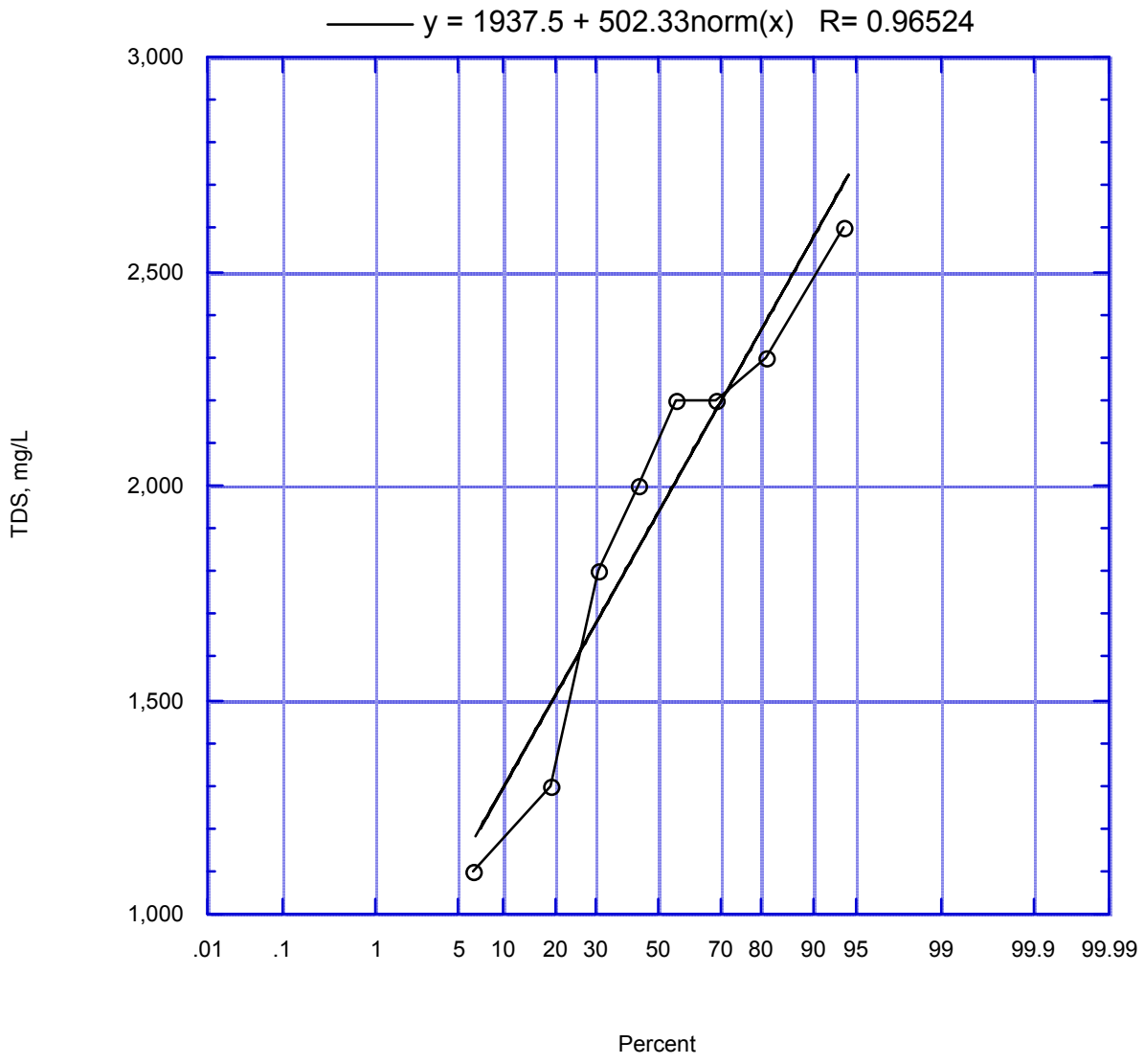


Figure 139. Frequency Distribution of TDS in Non-stormwater Runoff form Mixed-use Use

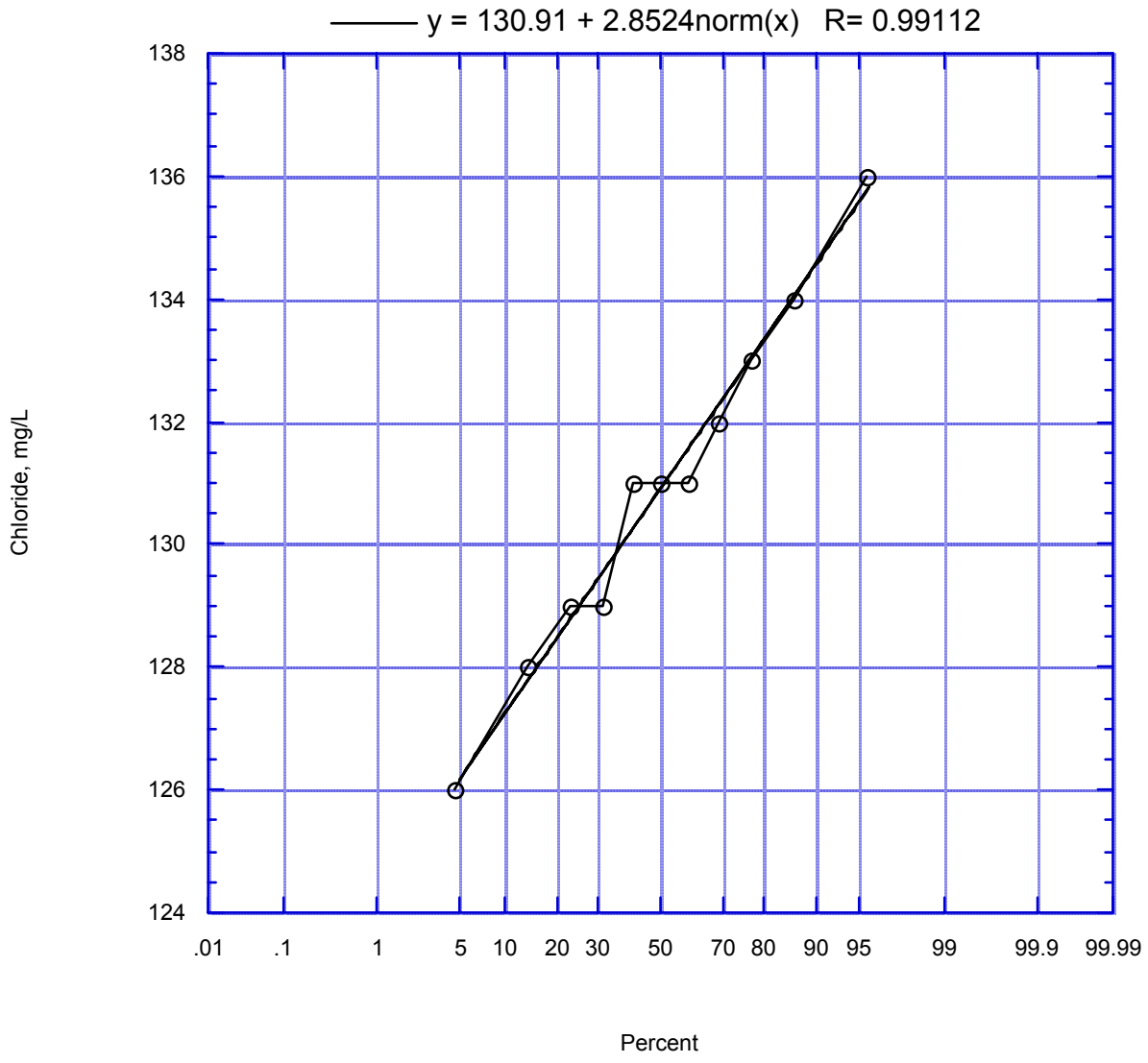


Figure 140. Frequency Distribution of Chloride in Pumped Groundwater Discharge

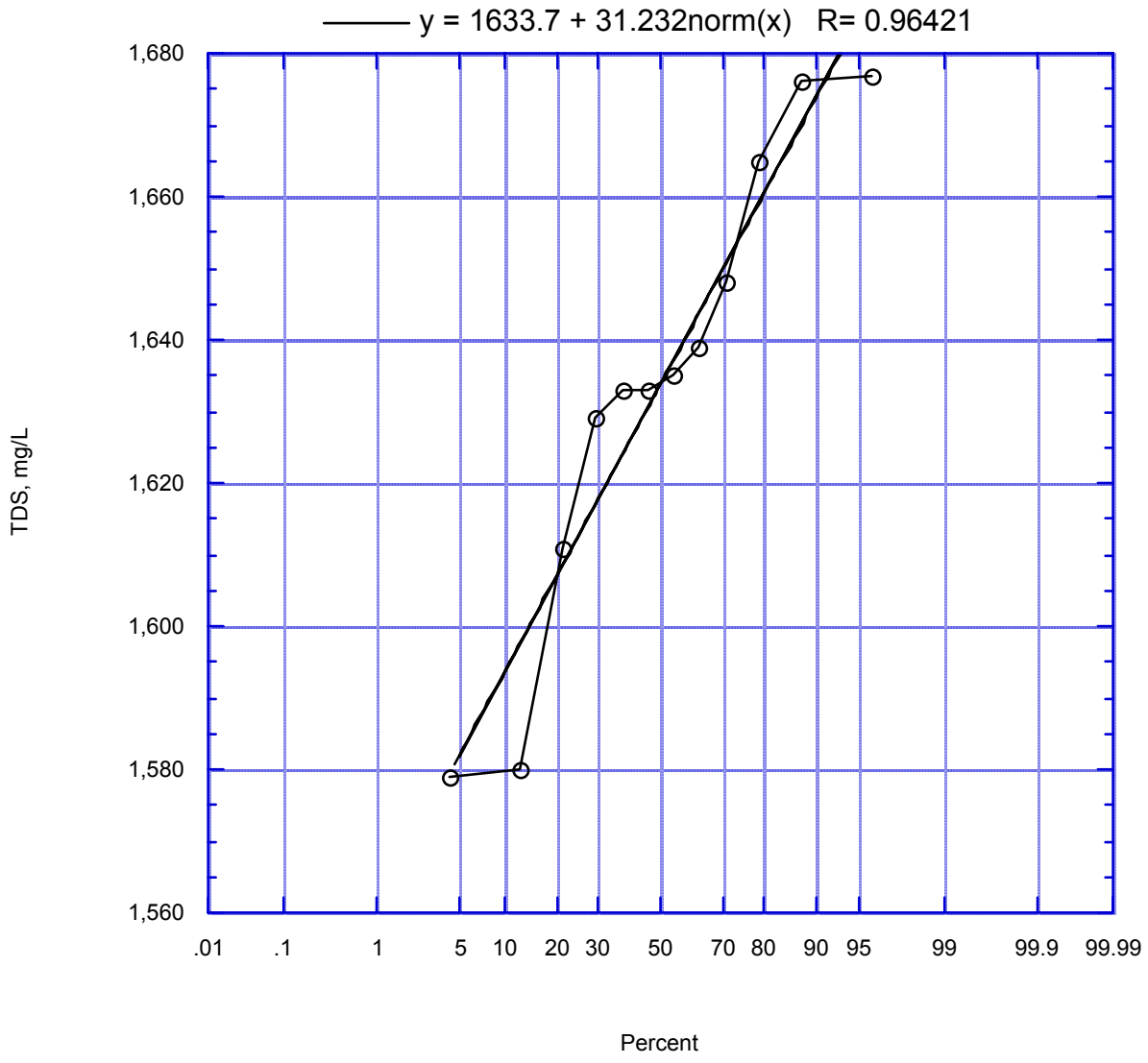


Figure 141. Frequency Distribution of TDS in Pumped Groundwater Discharge

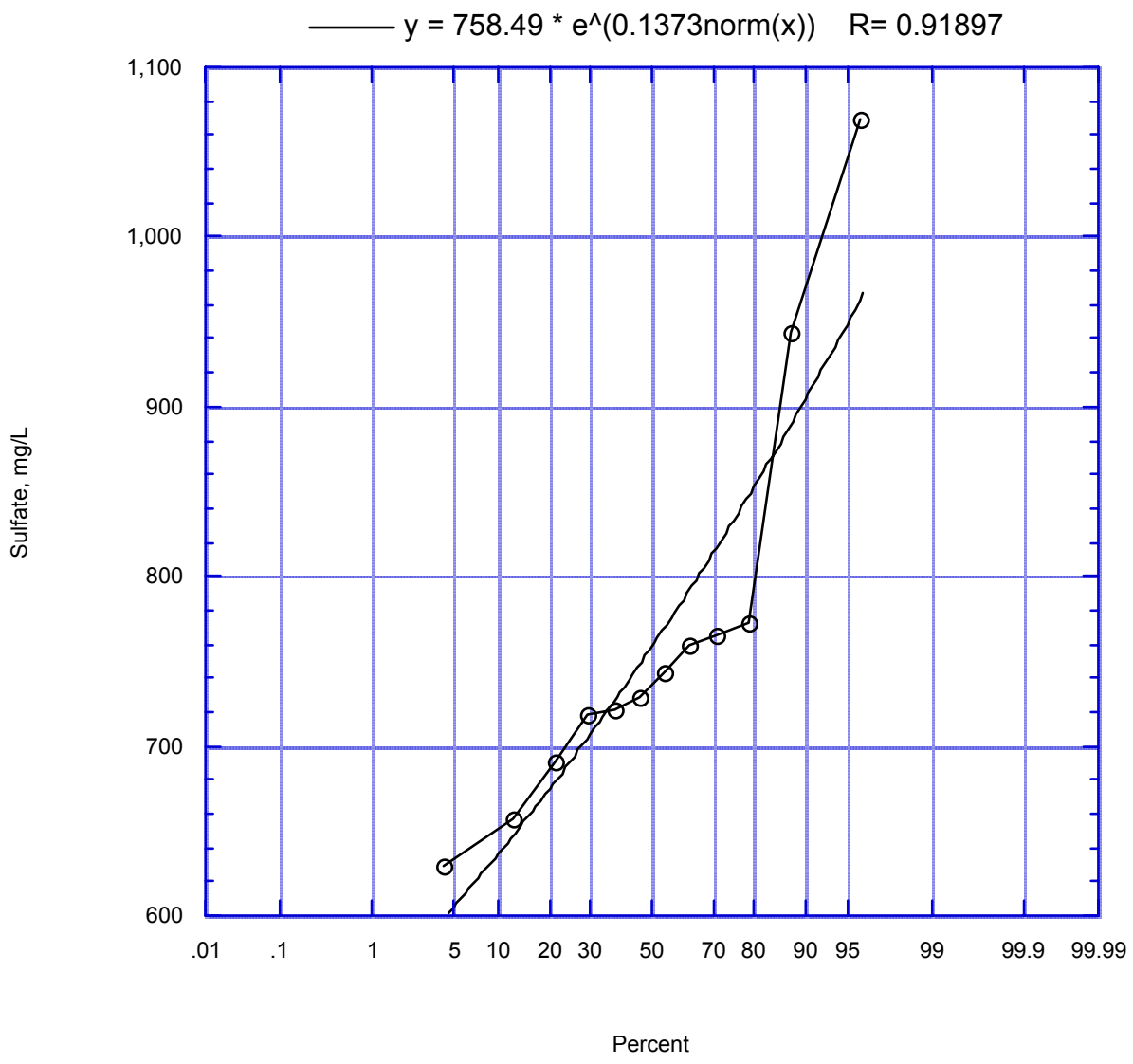


Figure 142. Frequency Distribution of Sulfate in Pumped Groundwater Discharge

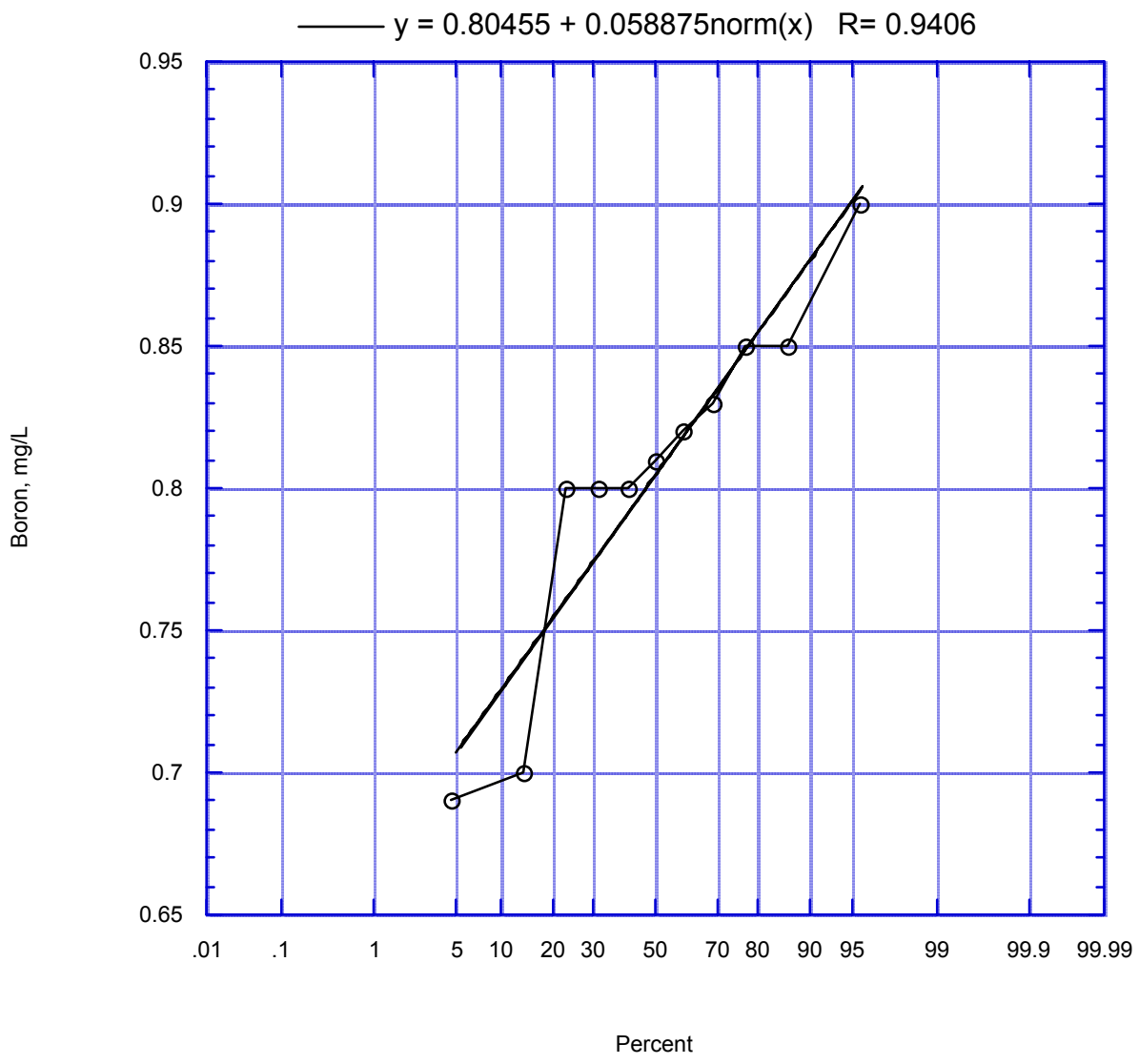


Figure 143. Frequency Distribution of Boron in Pumped Groundwater Discharge

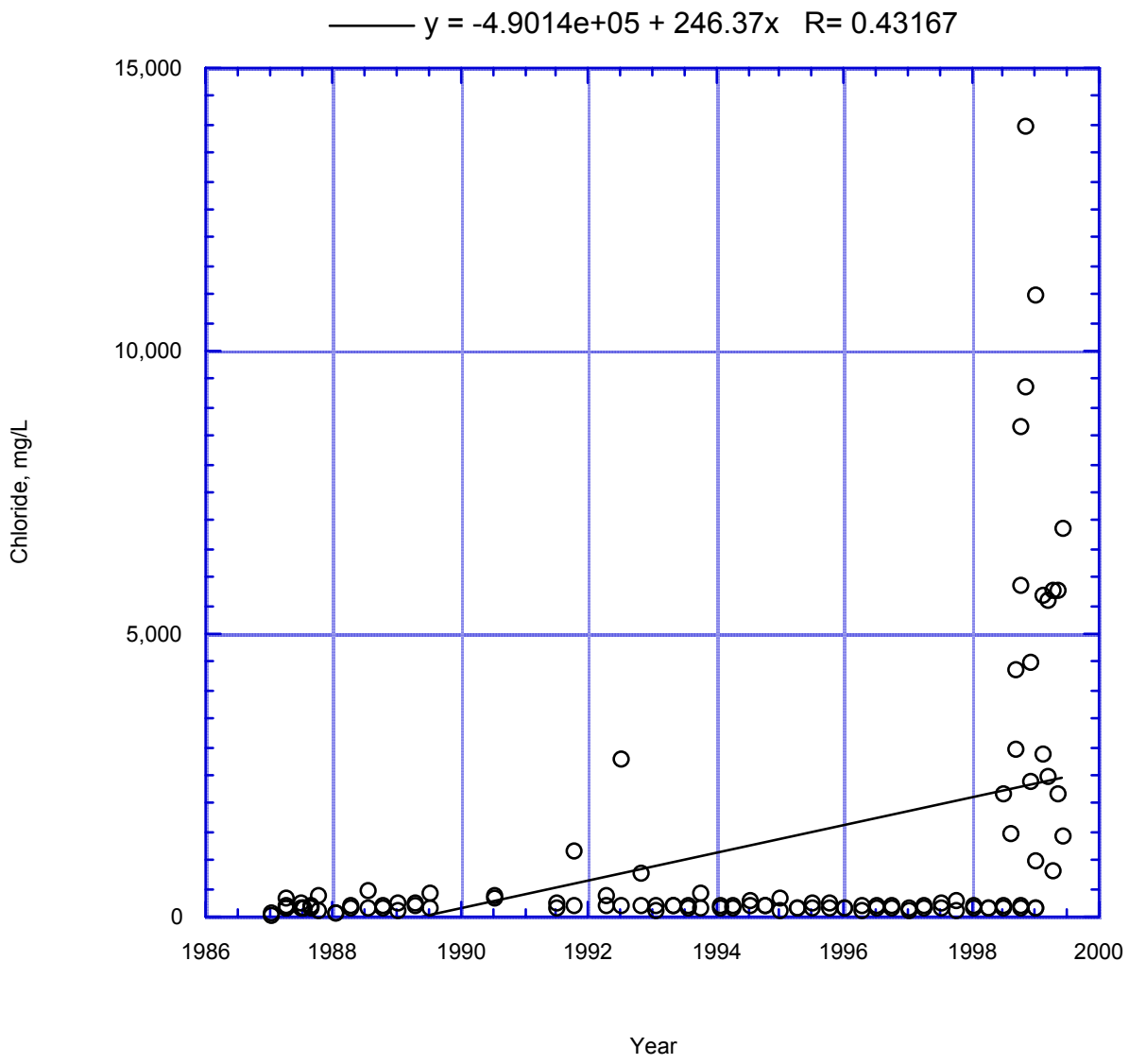


Figure 144. Reach 2 Chloride vs. Time

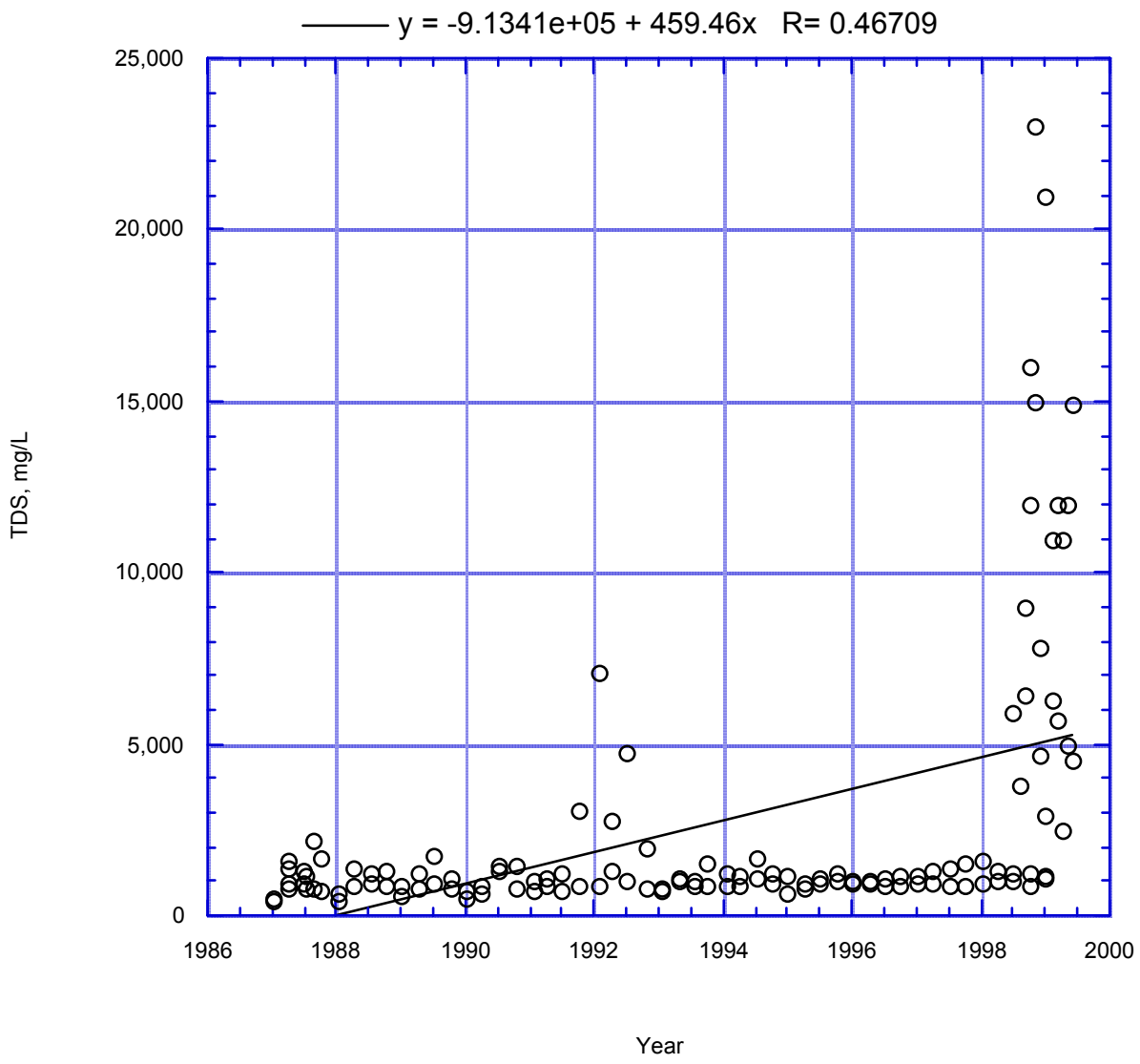


Figure 145. Reach 2 TDS vs. Time

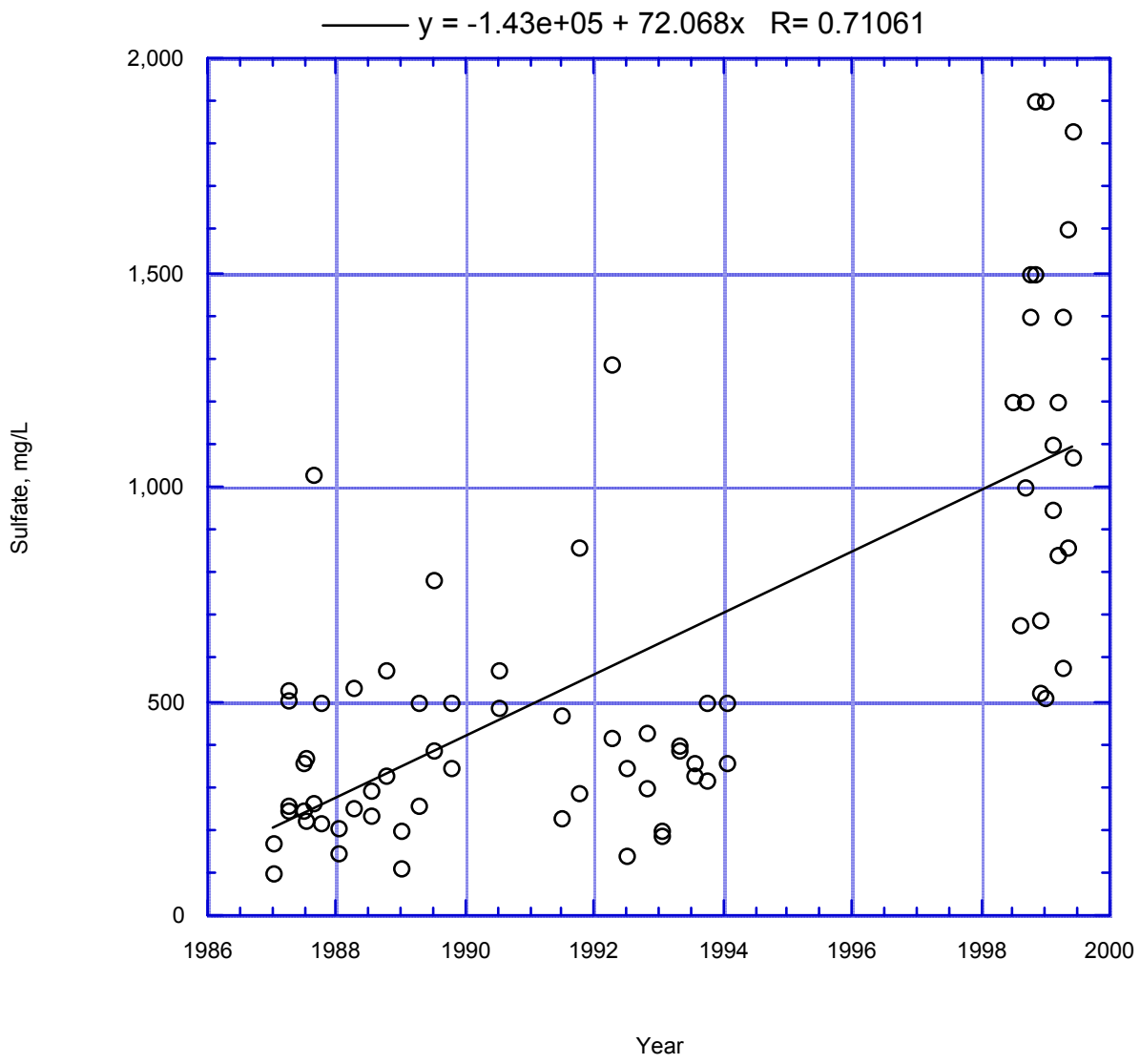


Figure 146. Reach 2 Sulfate vs. Time

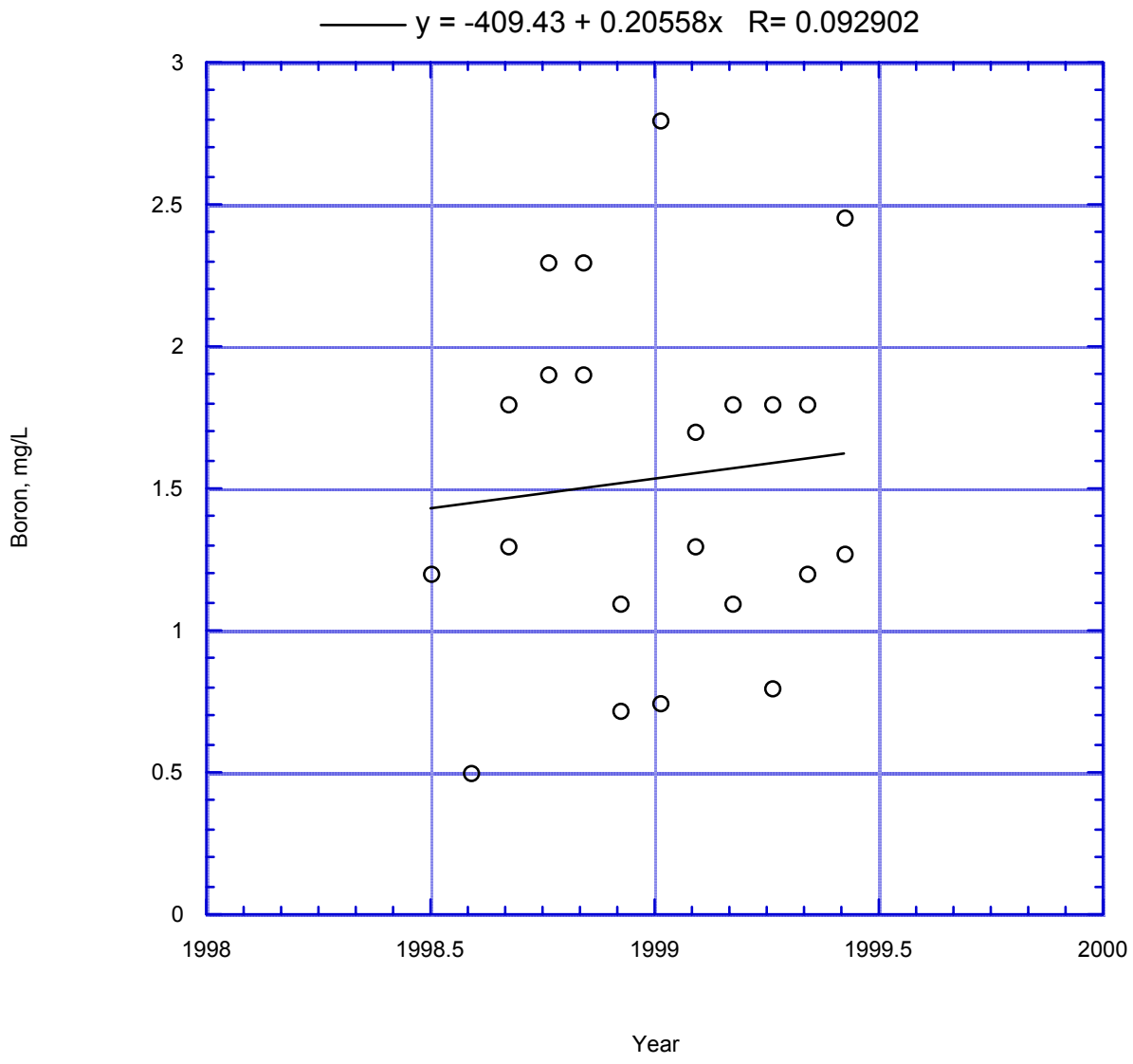


Figure 147. Reach 2 Boron vs. Time

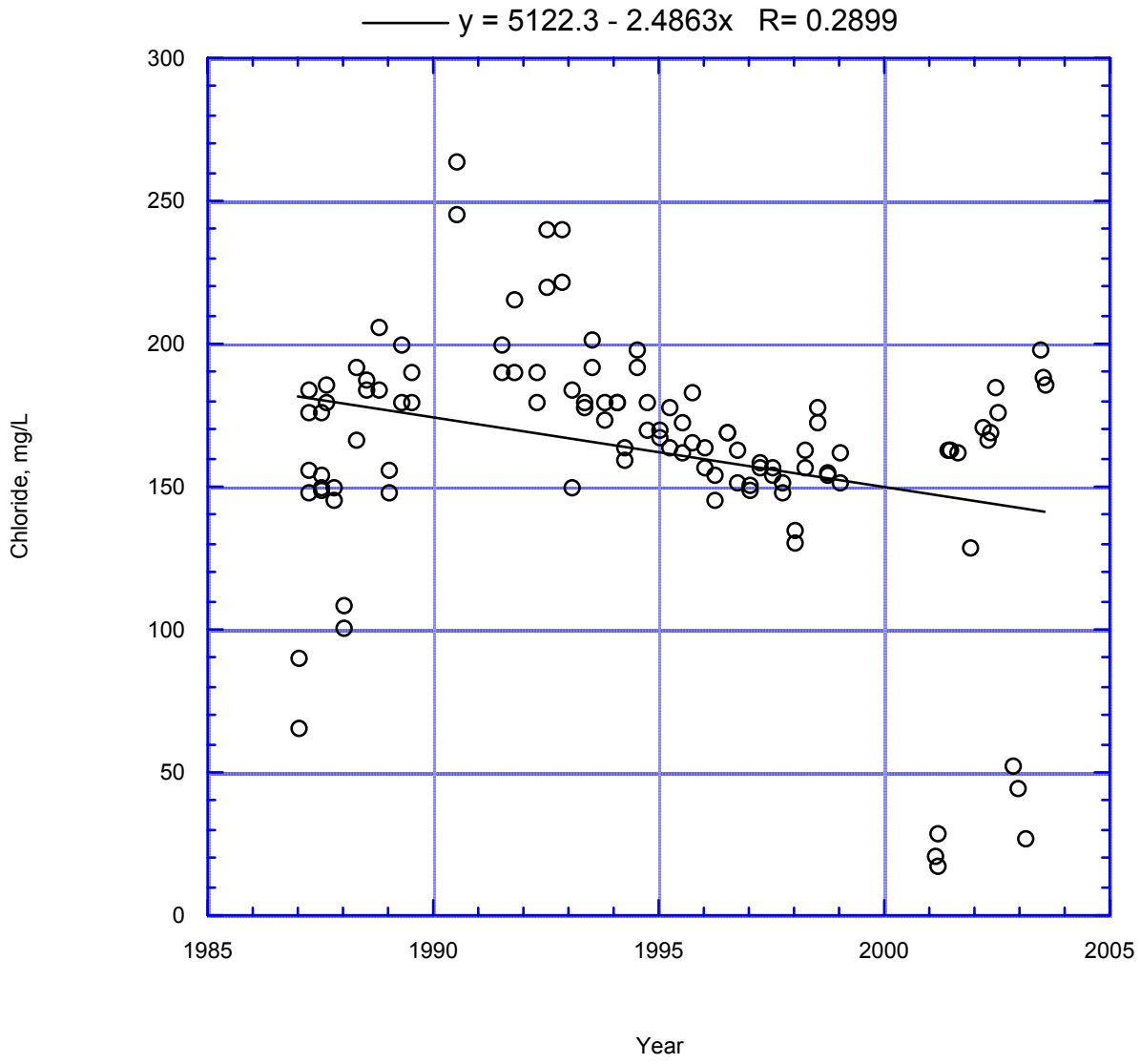


Figure 148. Reach 3 Chloride vs. Time

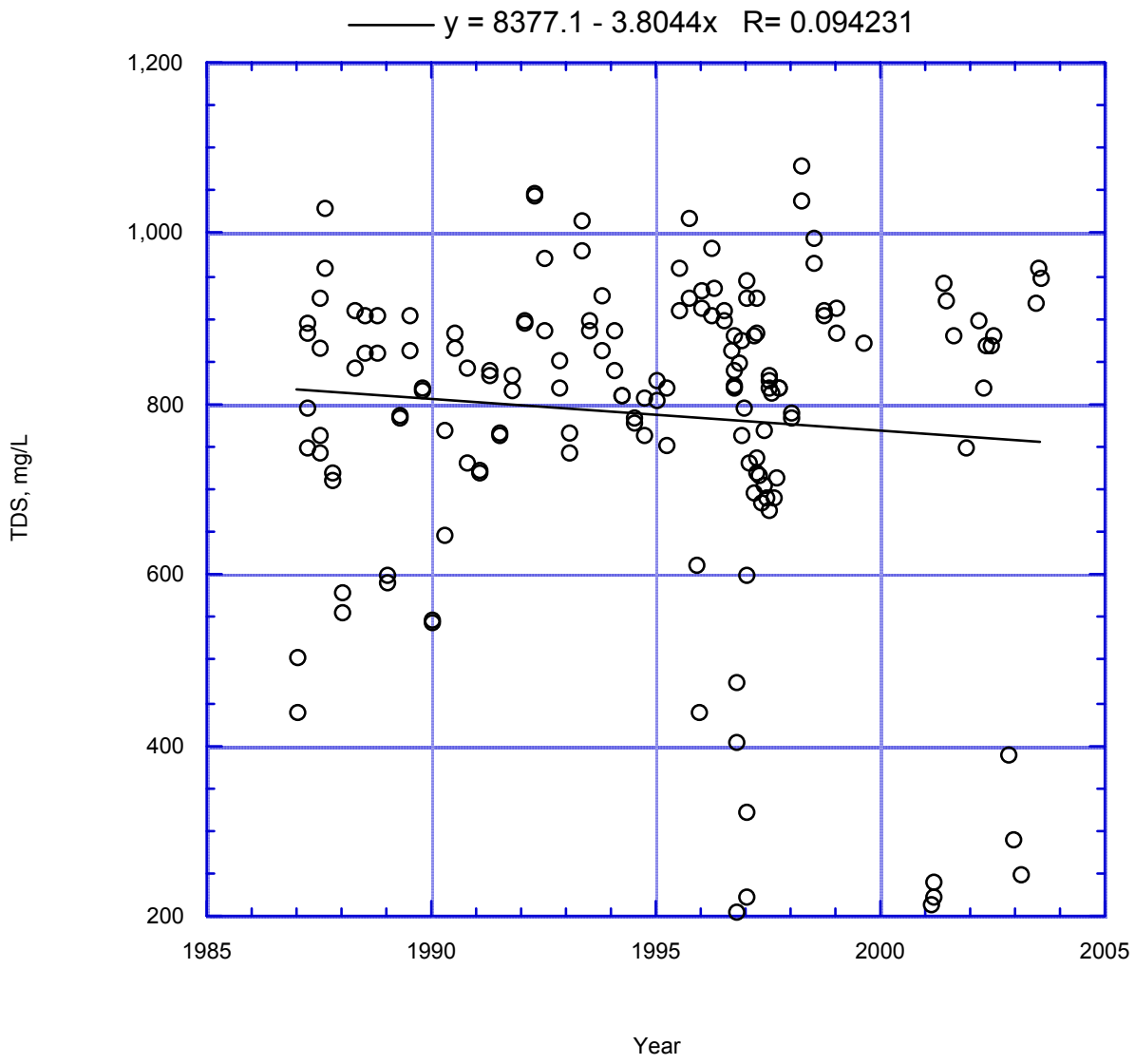


Figure 149. Reach 3 TDS vs. Time

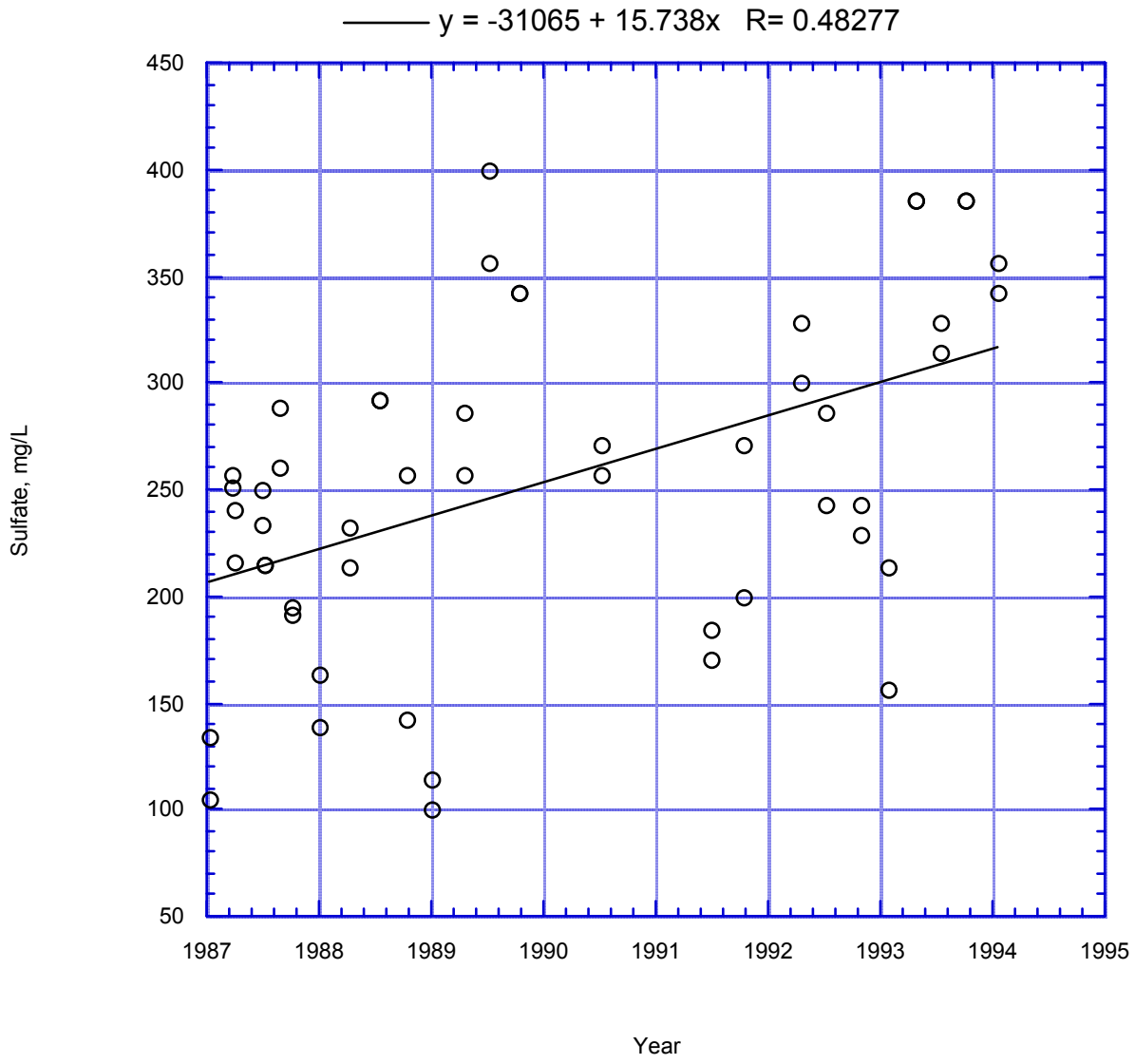


Figure 150. Reach 3 Sulfate vs. Time

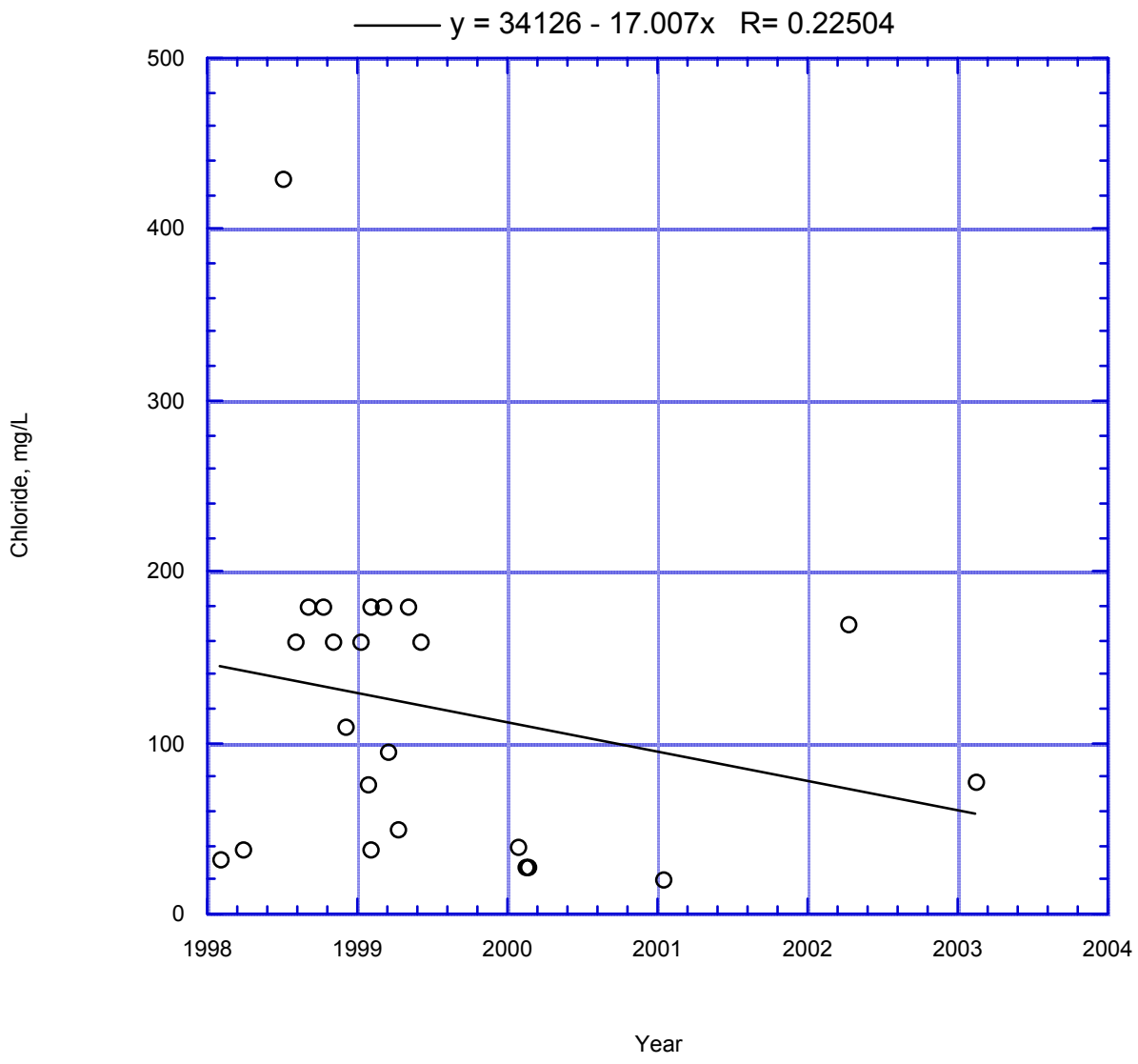


Figure 151. Reach 4 Chloride vs. Time

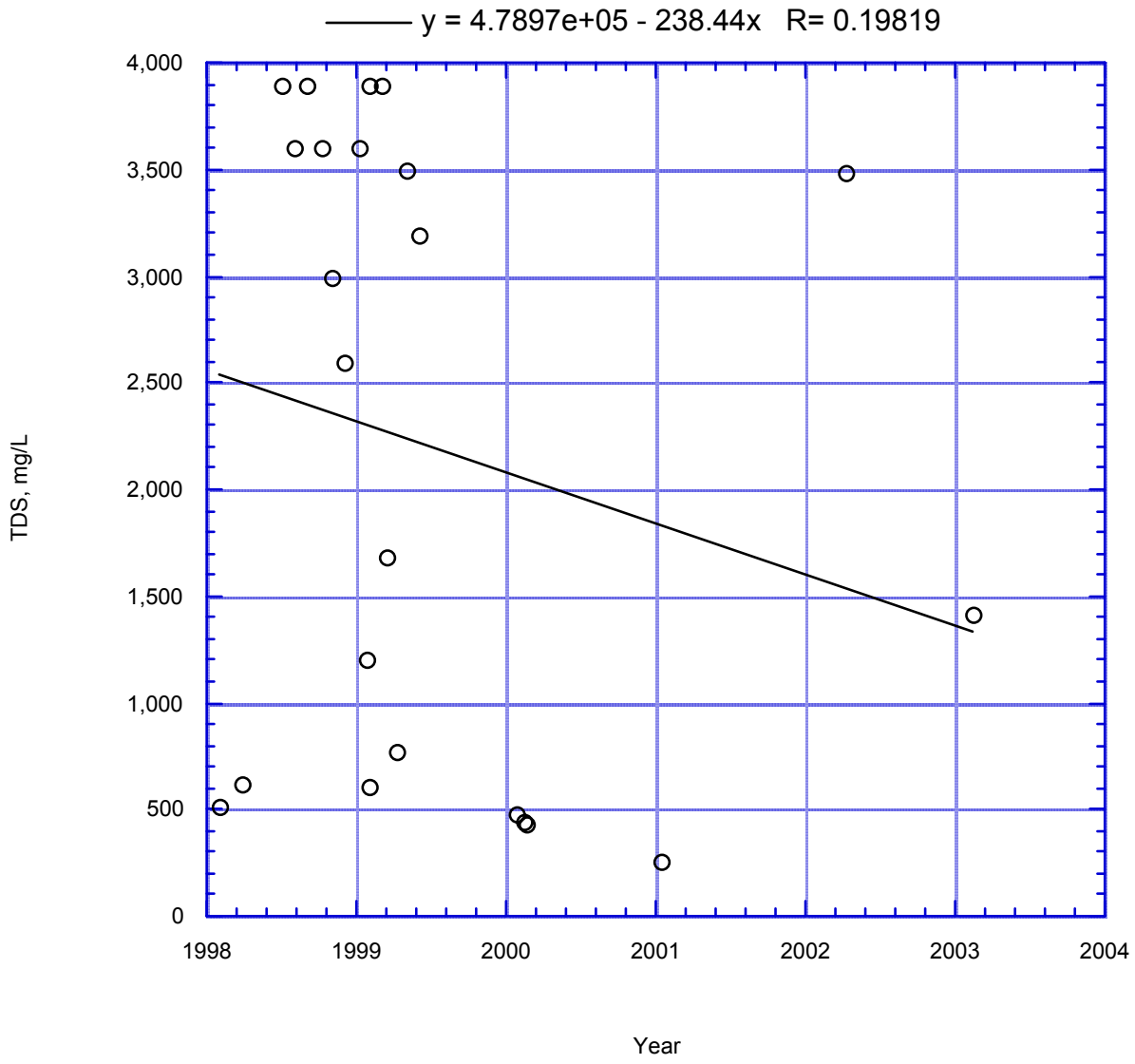


Figure 152. Reach 4 TDS vs. Time

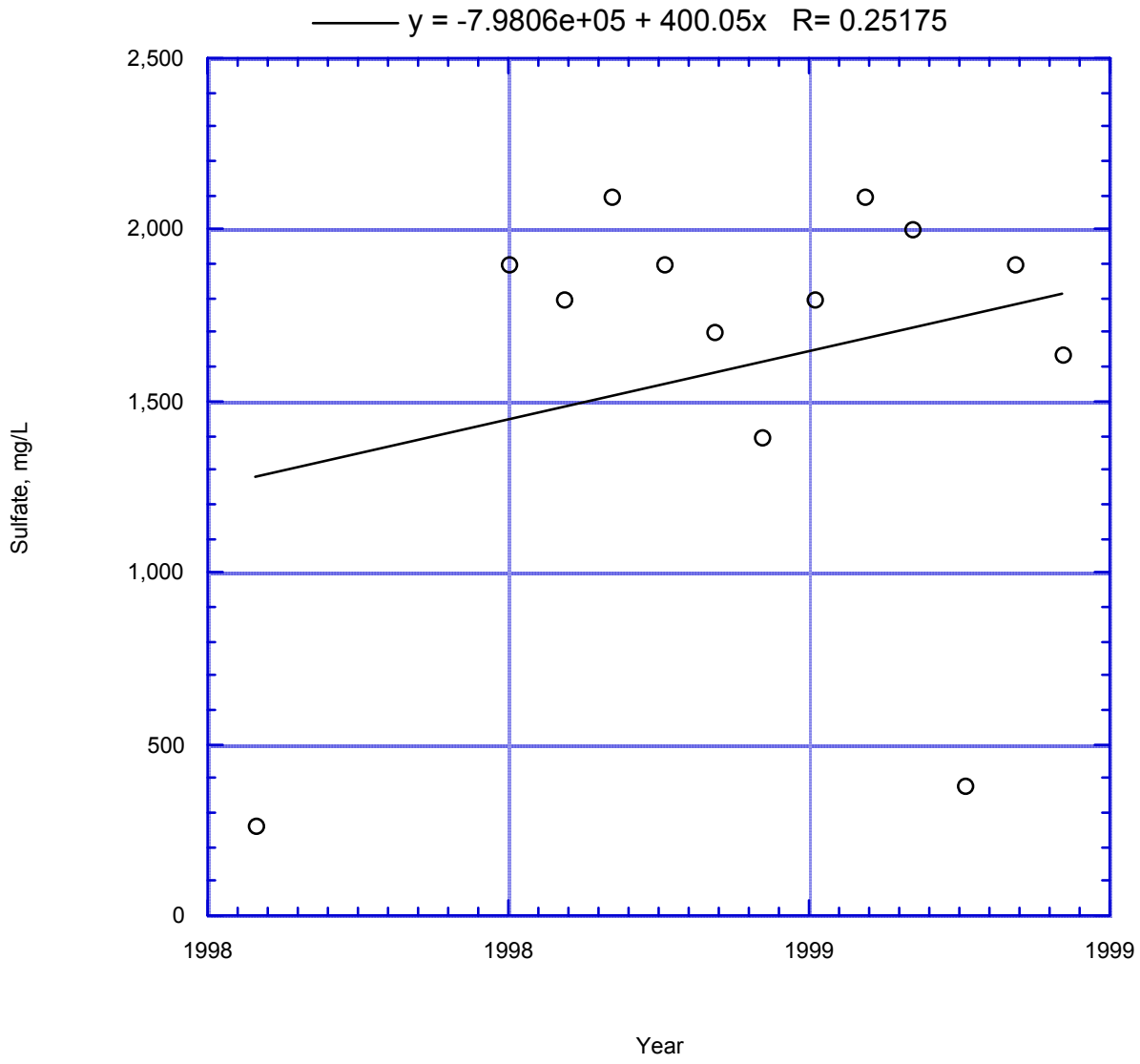


Figure 153. Reach 4 Sulfate vs. Time

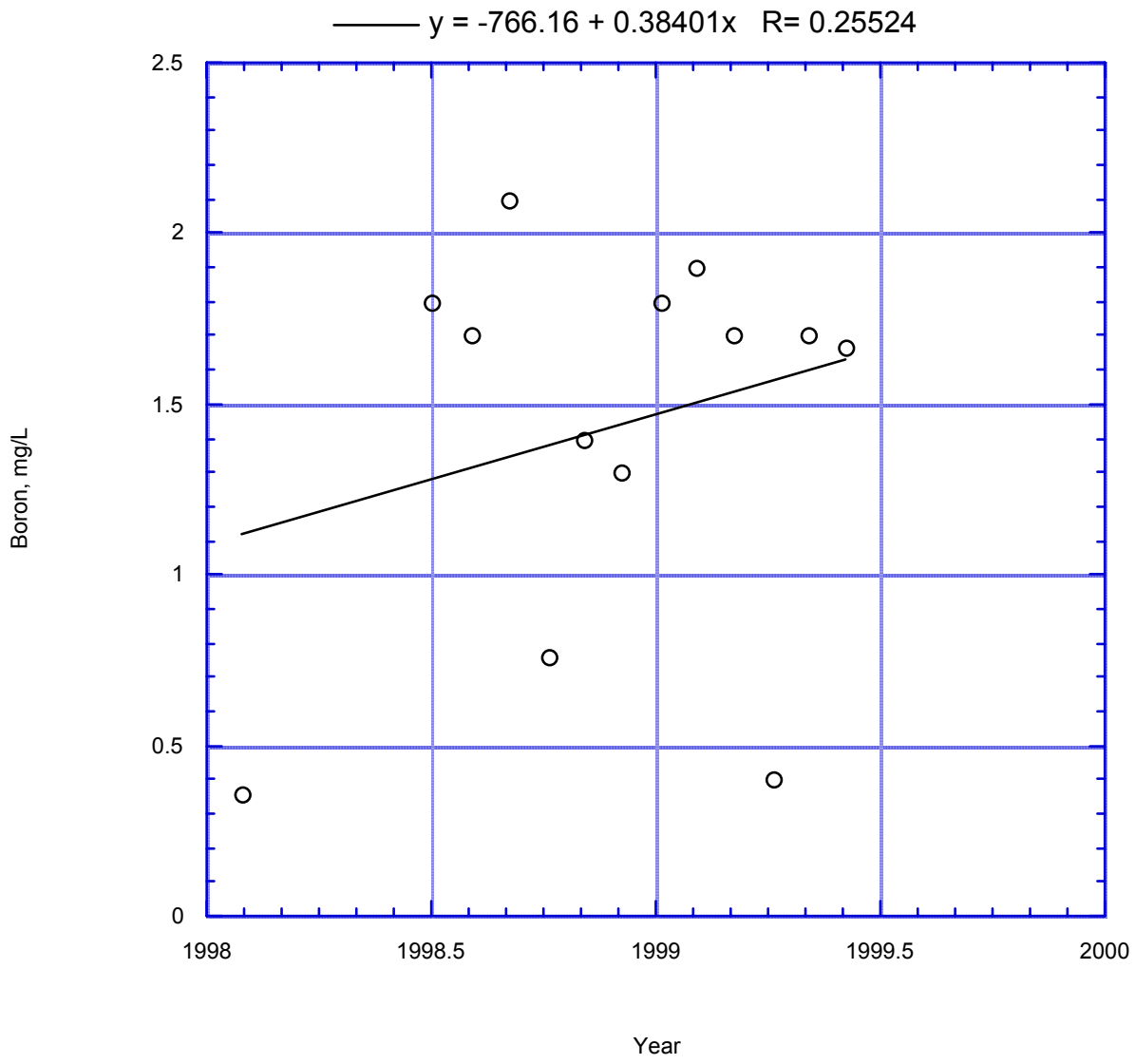


Figure 154. Reach 4 Boron vs. Time

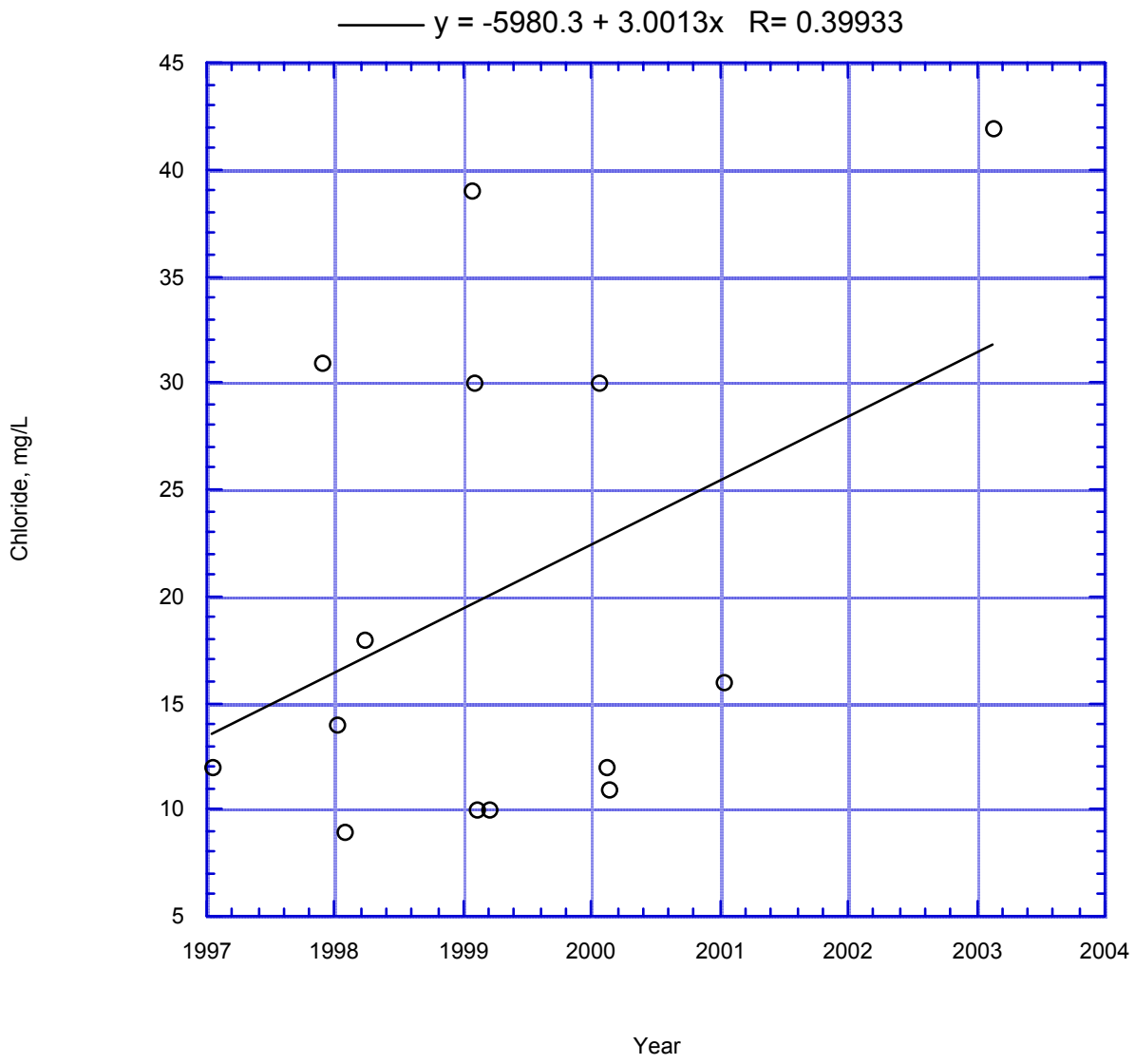


Figure 155. Reach 5 Chloride vs. Time

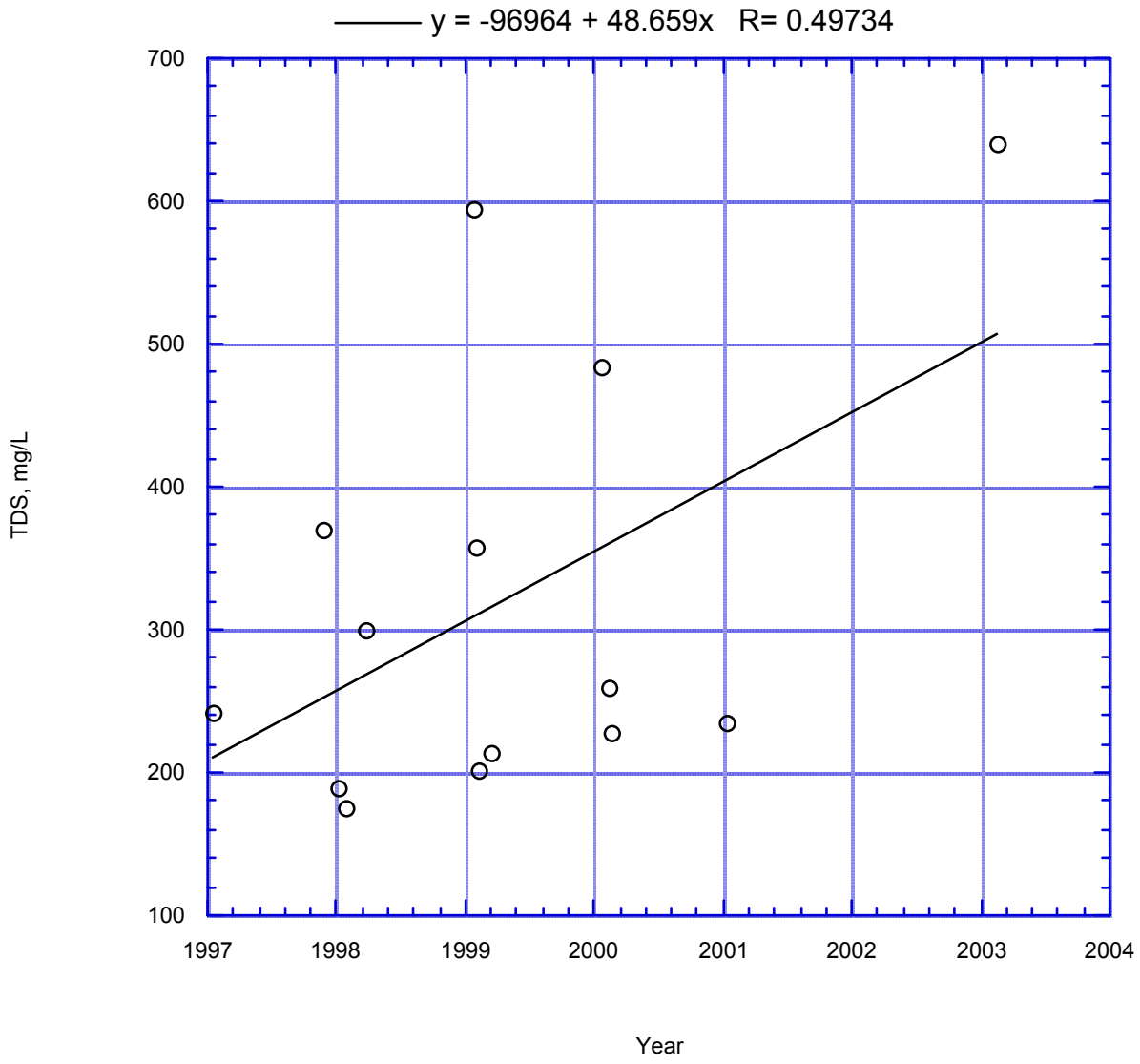


Figure 156. Reach 5 TDS vs. Time

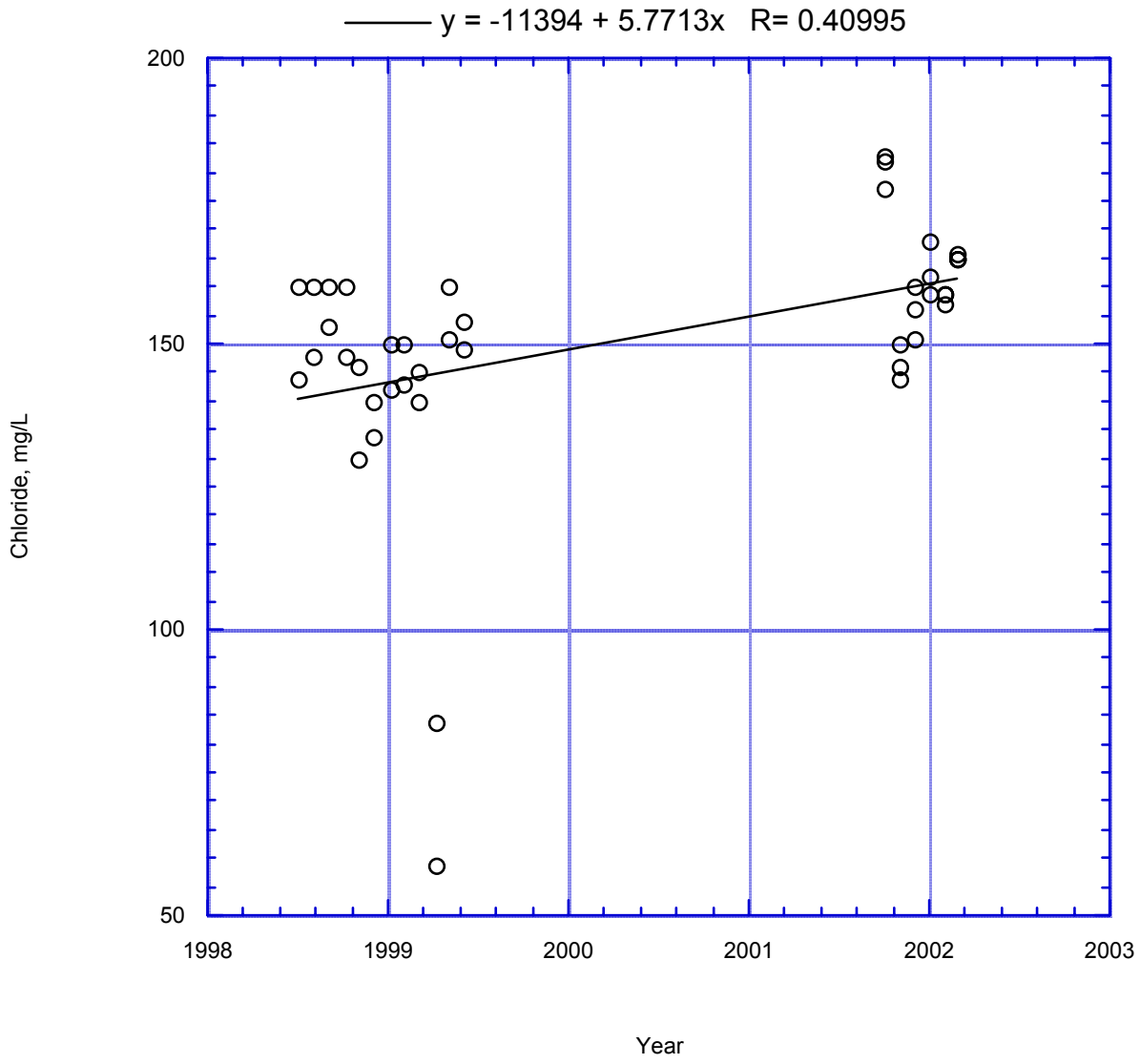


Figure 157. Reach 6 Chloride vs. Time

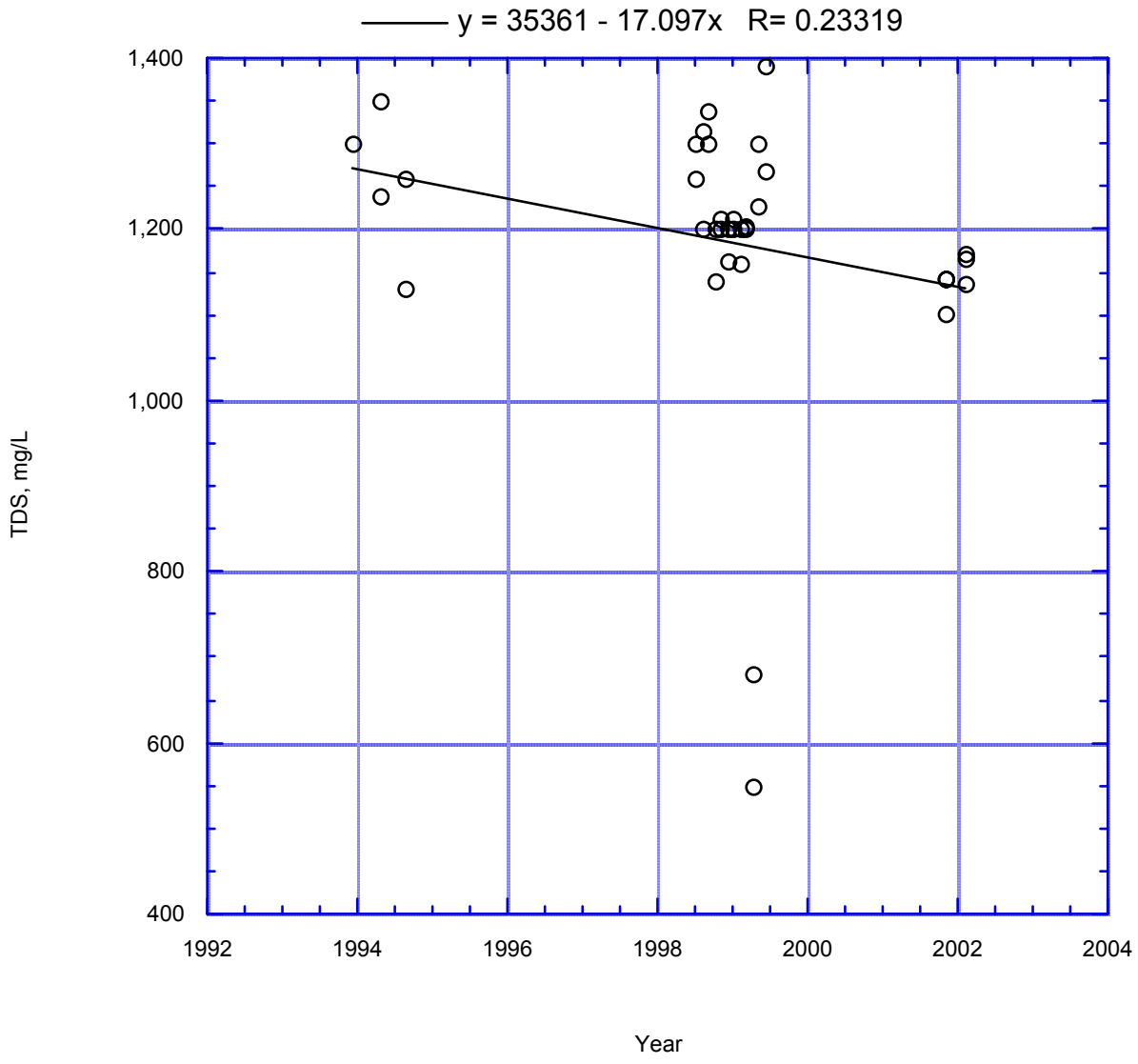


Figure 158. Reach 6 TDS vs. Time

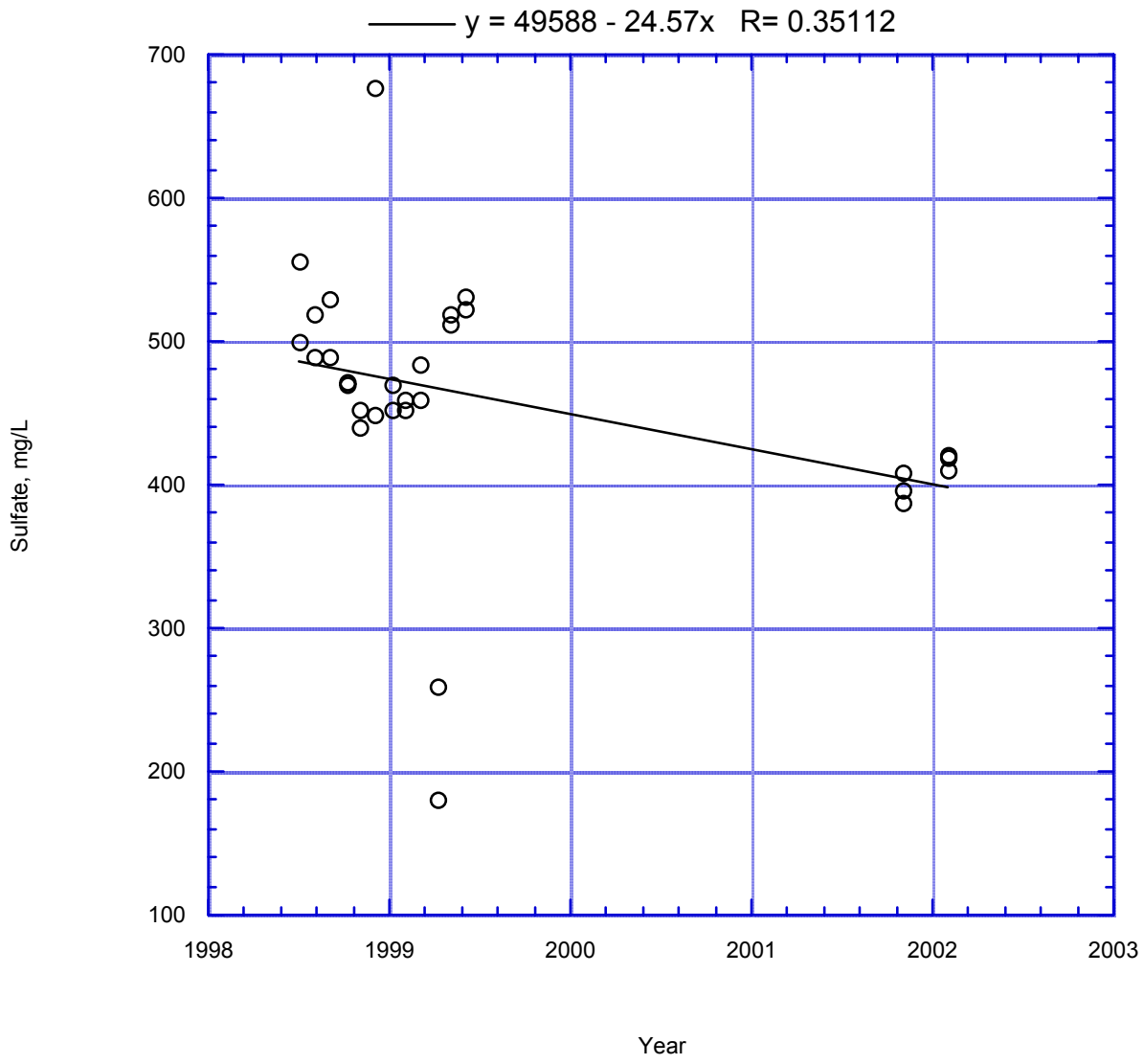


Figure 159. Reach 6 Sulfate vs. Time

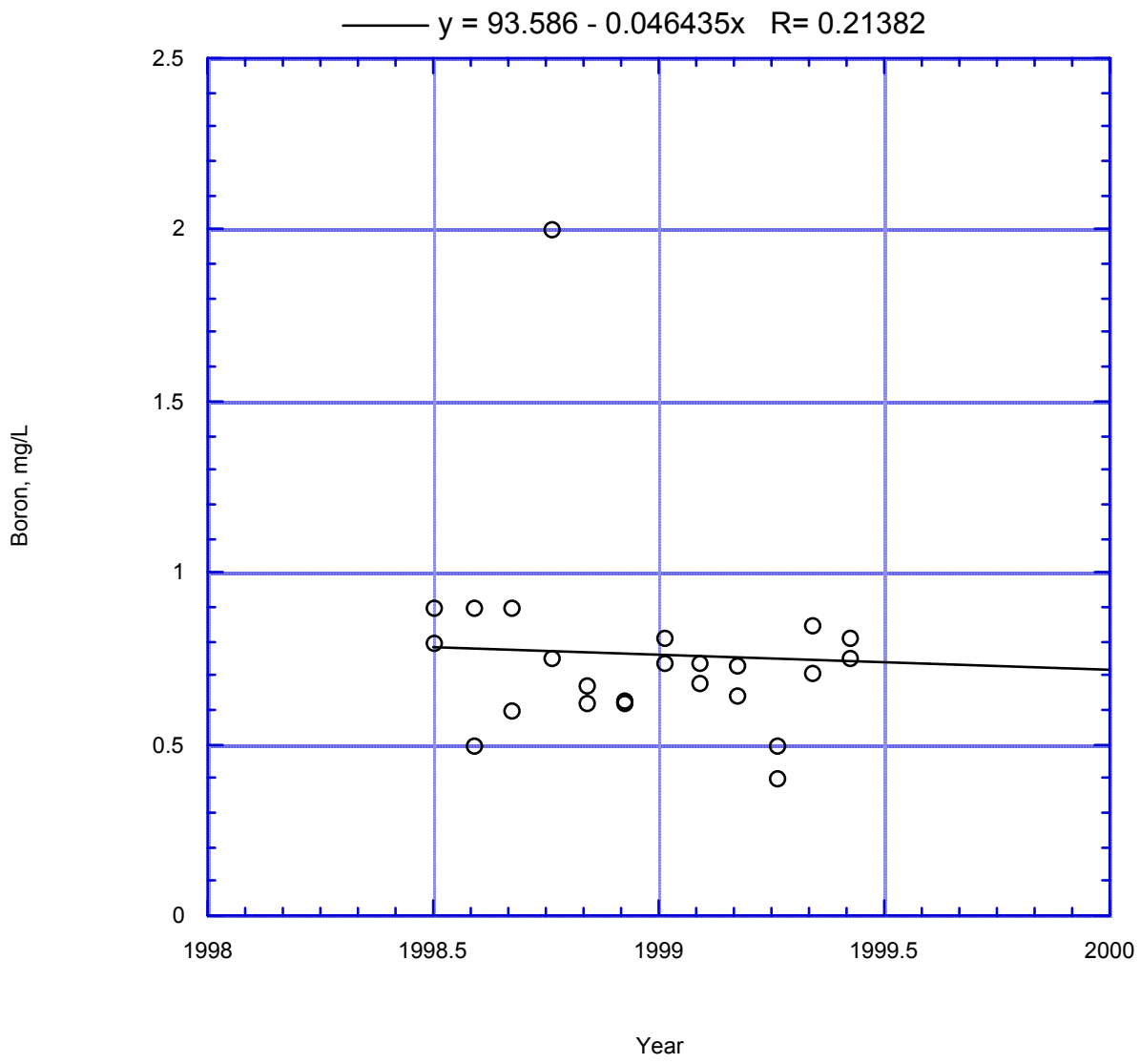


Figure 160. Reach 6 Boron vs. Time

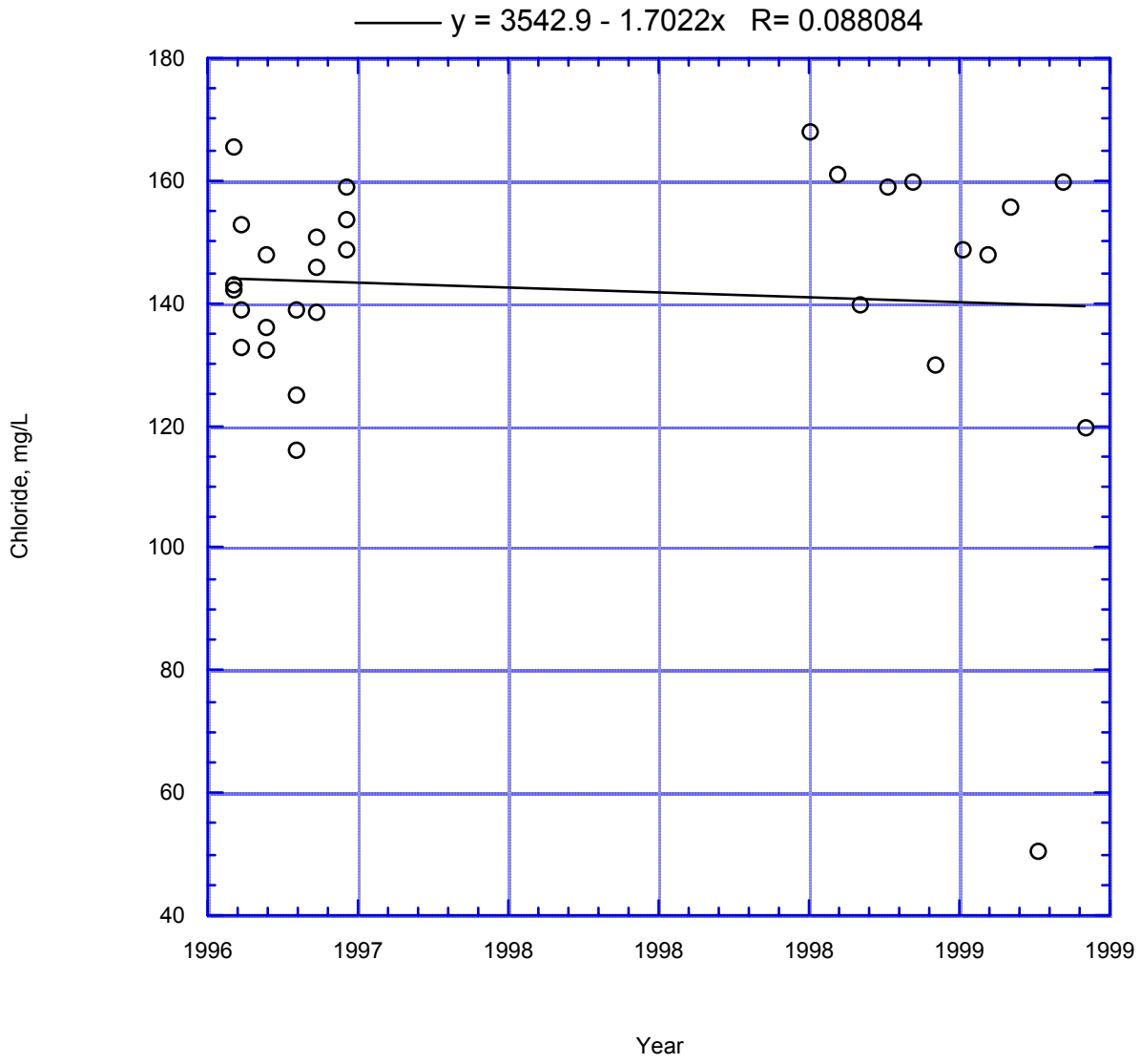


Figure 161. Reach 7 Chloride vs. Time

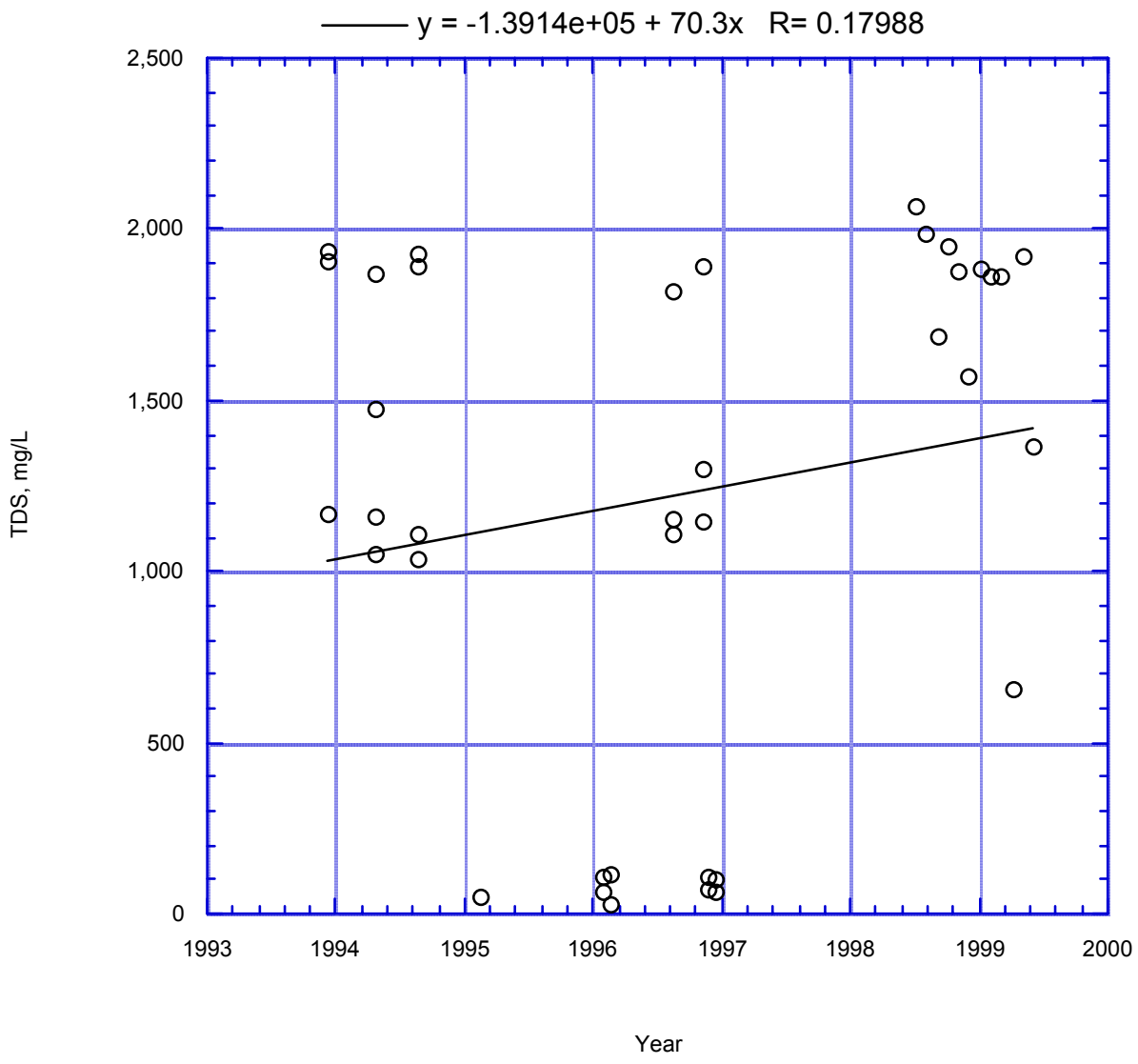


Figure 162. Reach 7 TDS vs. Time

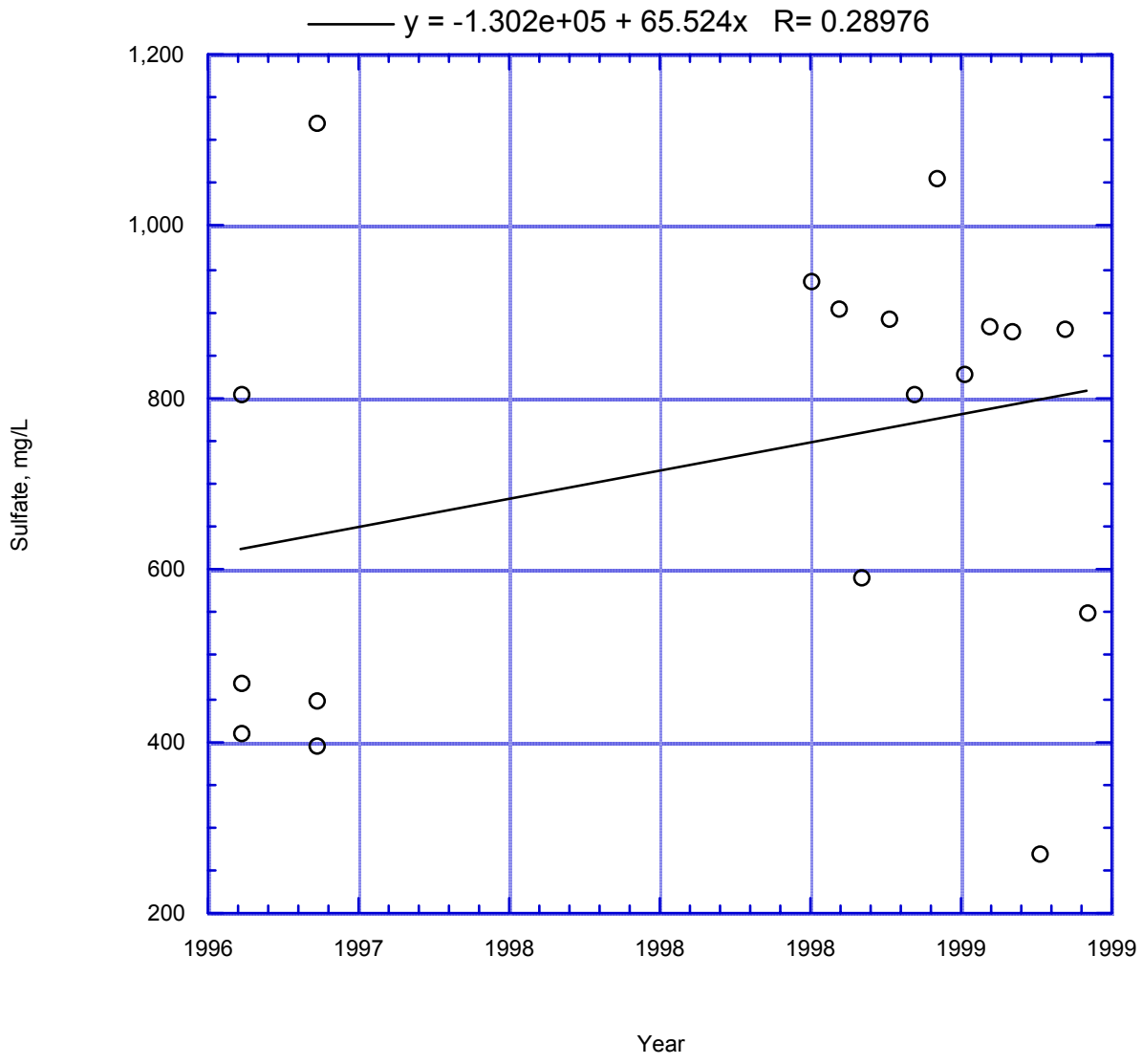


Figure 163. Reach 7 Sulfate vs. Time

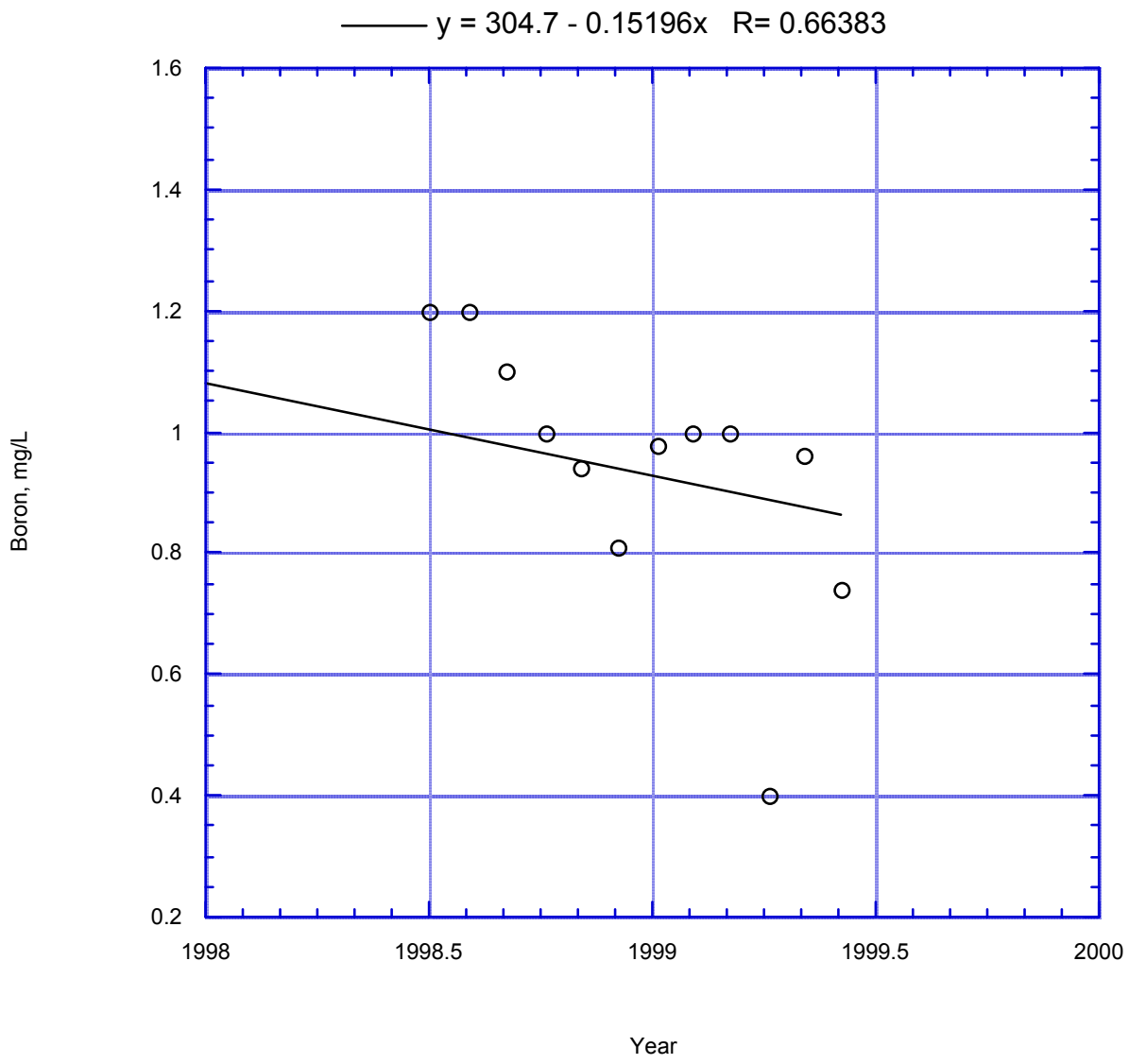


Figure 164. Reach 7 Boron vs. Time

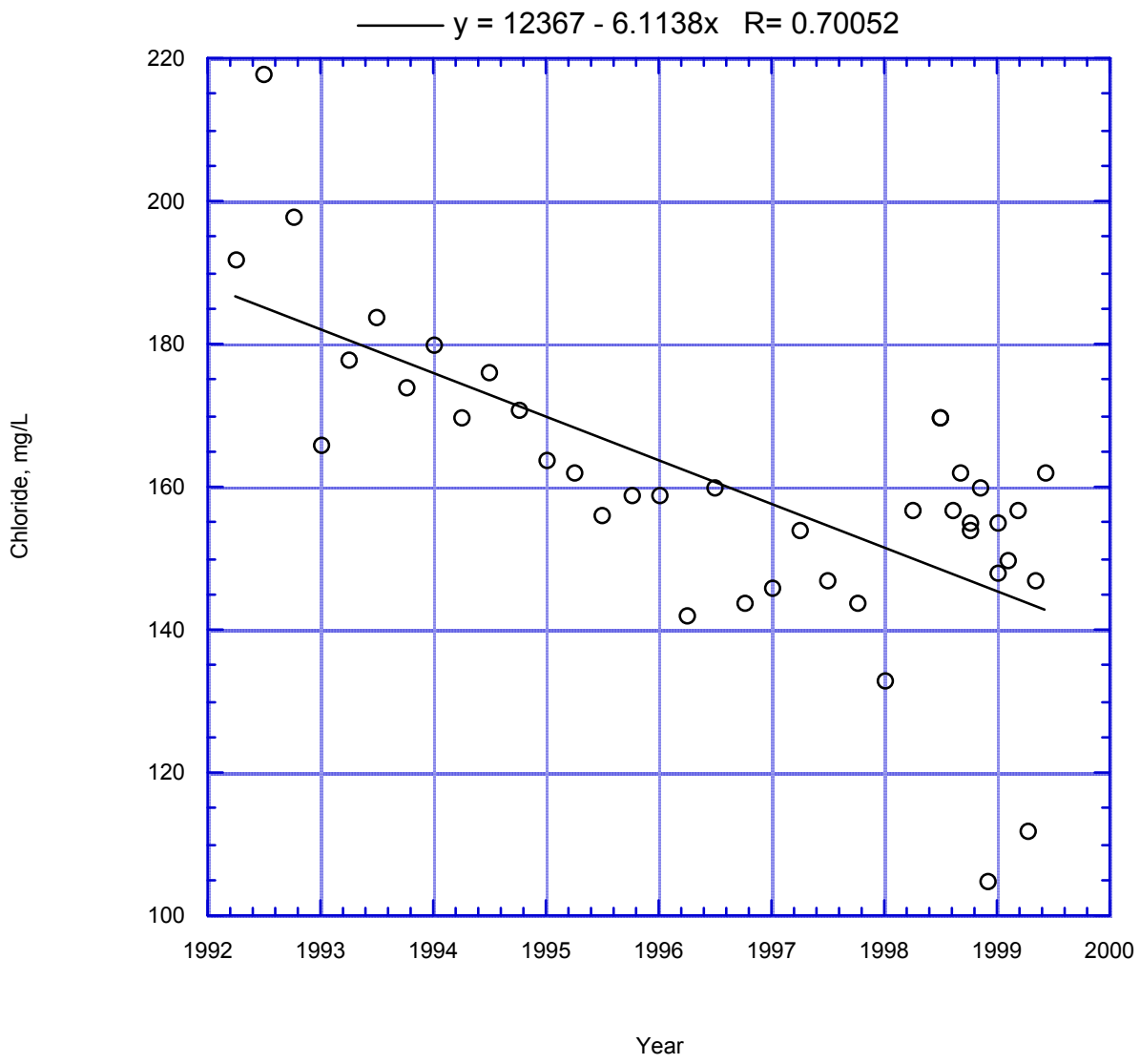


Figure 165. Reach 9A Chloride vs. Time

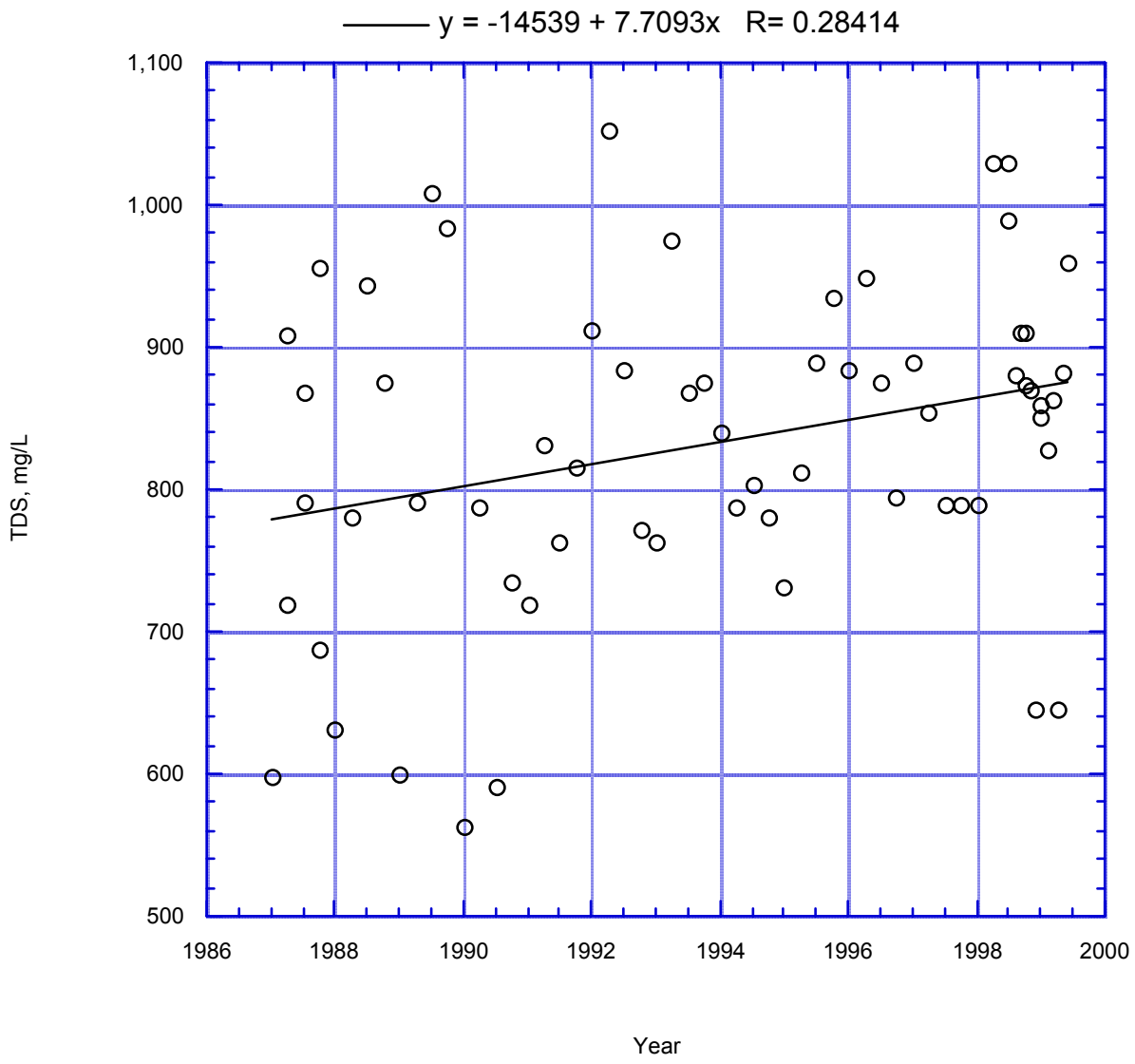


Figure 166. Reach 9A TDS vs. Time

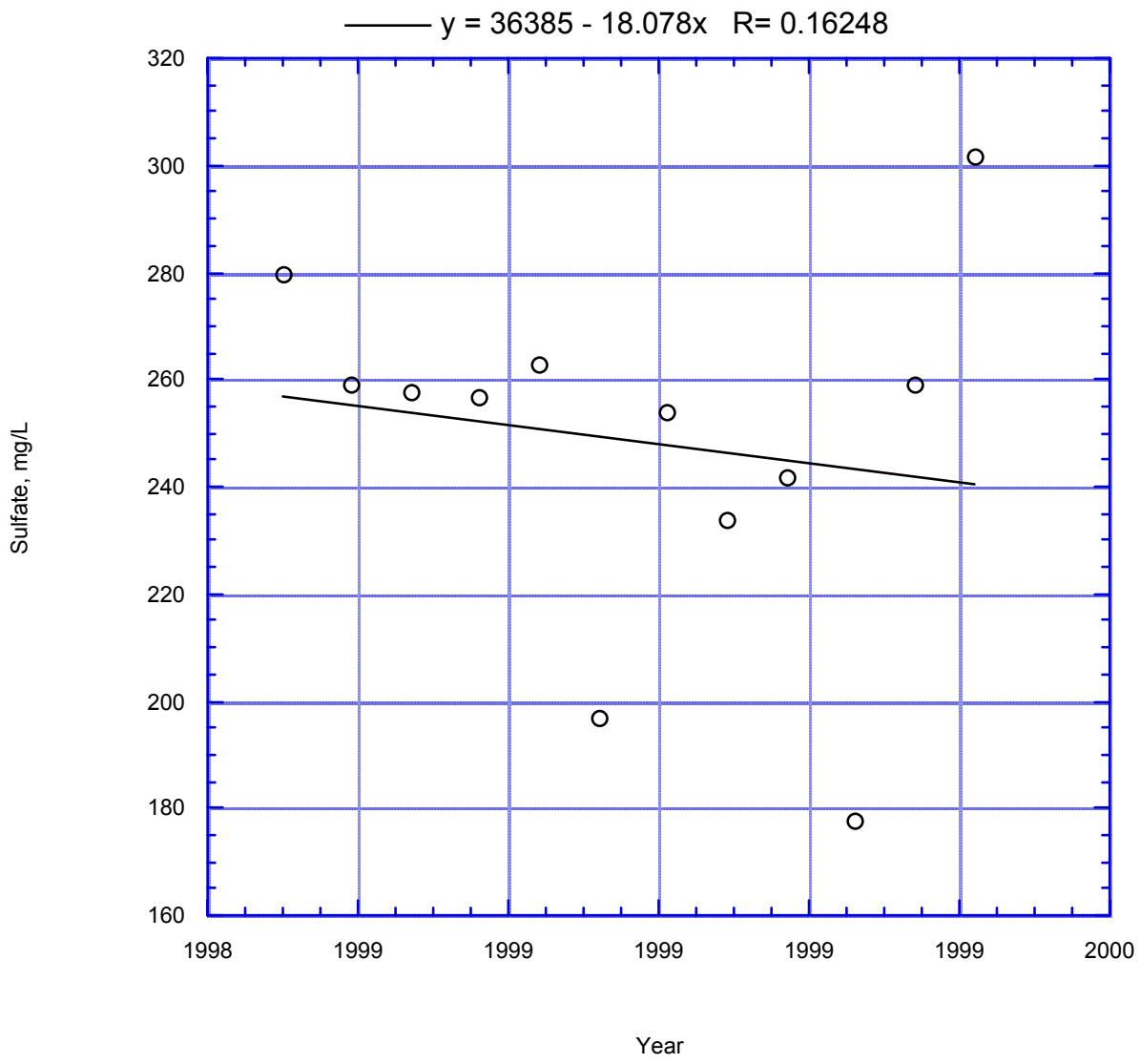


Figure 167. Reach 9A Sulfate vs. Time

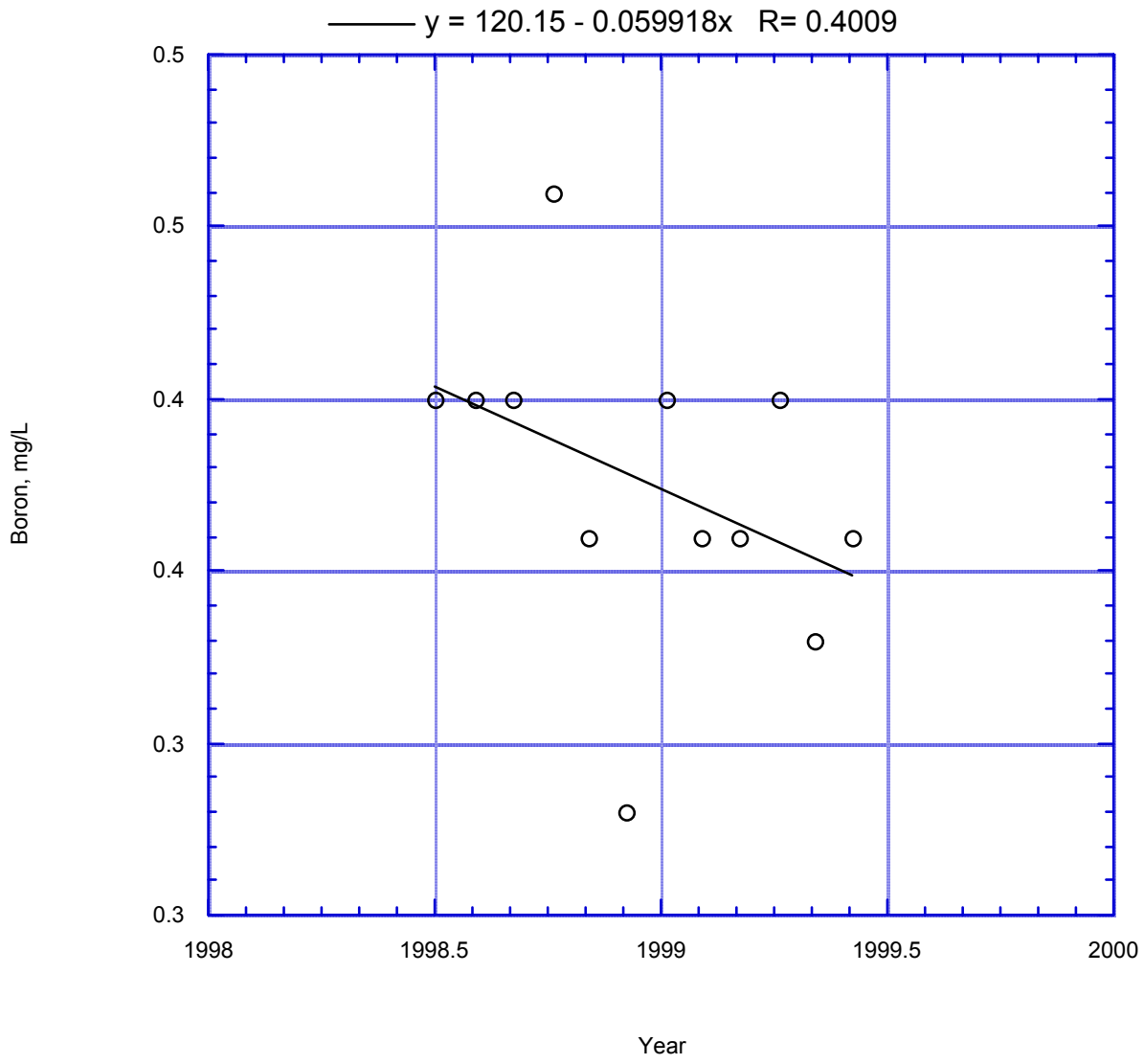


Figure 168. Reach 9A Boron vs. Time

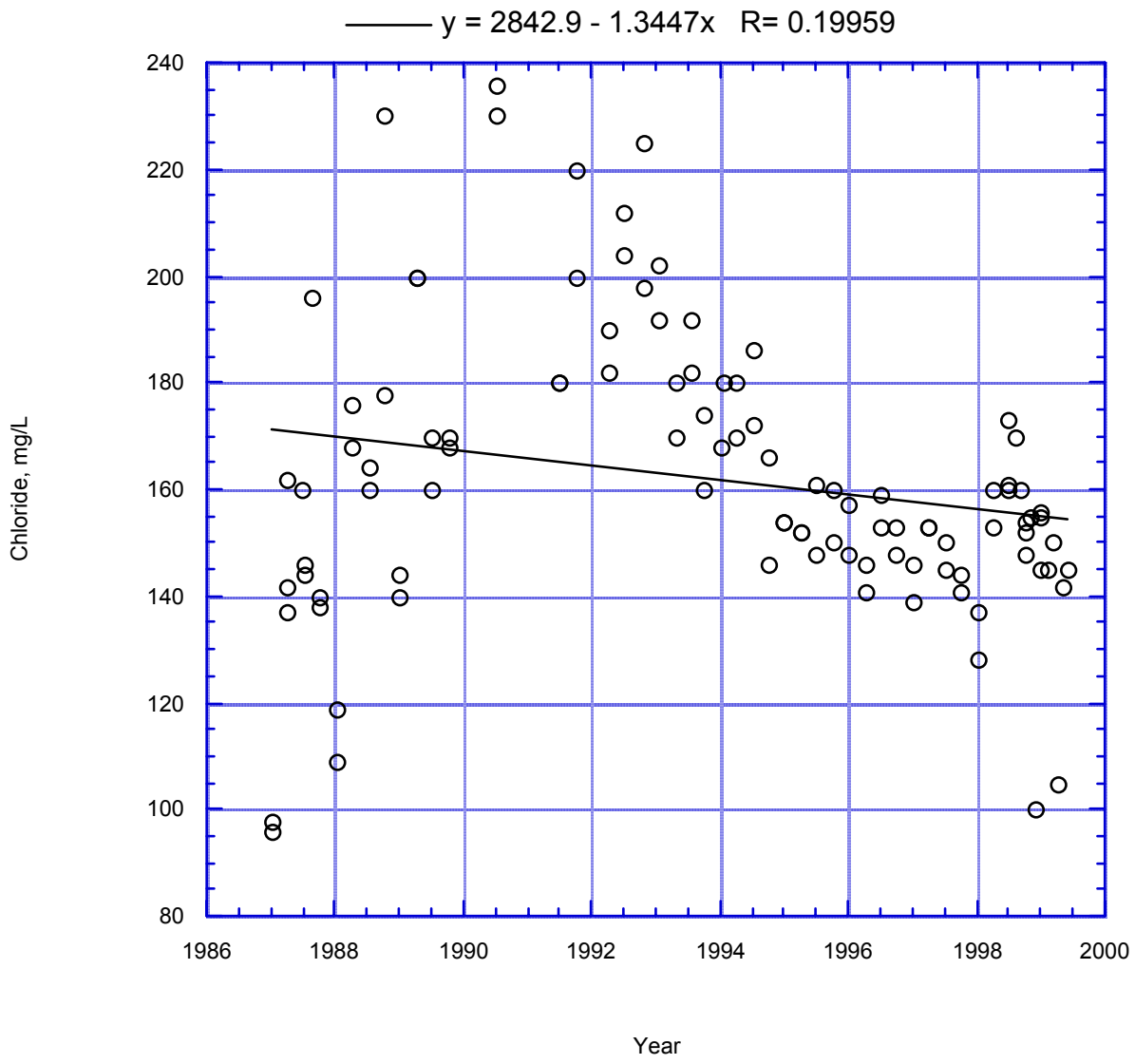


Figure 169. Reach 9B Chloride vs. Time

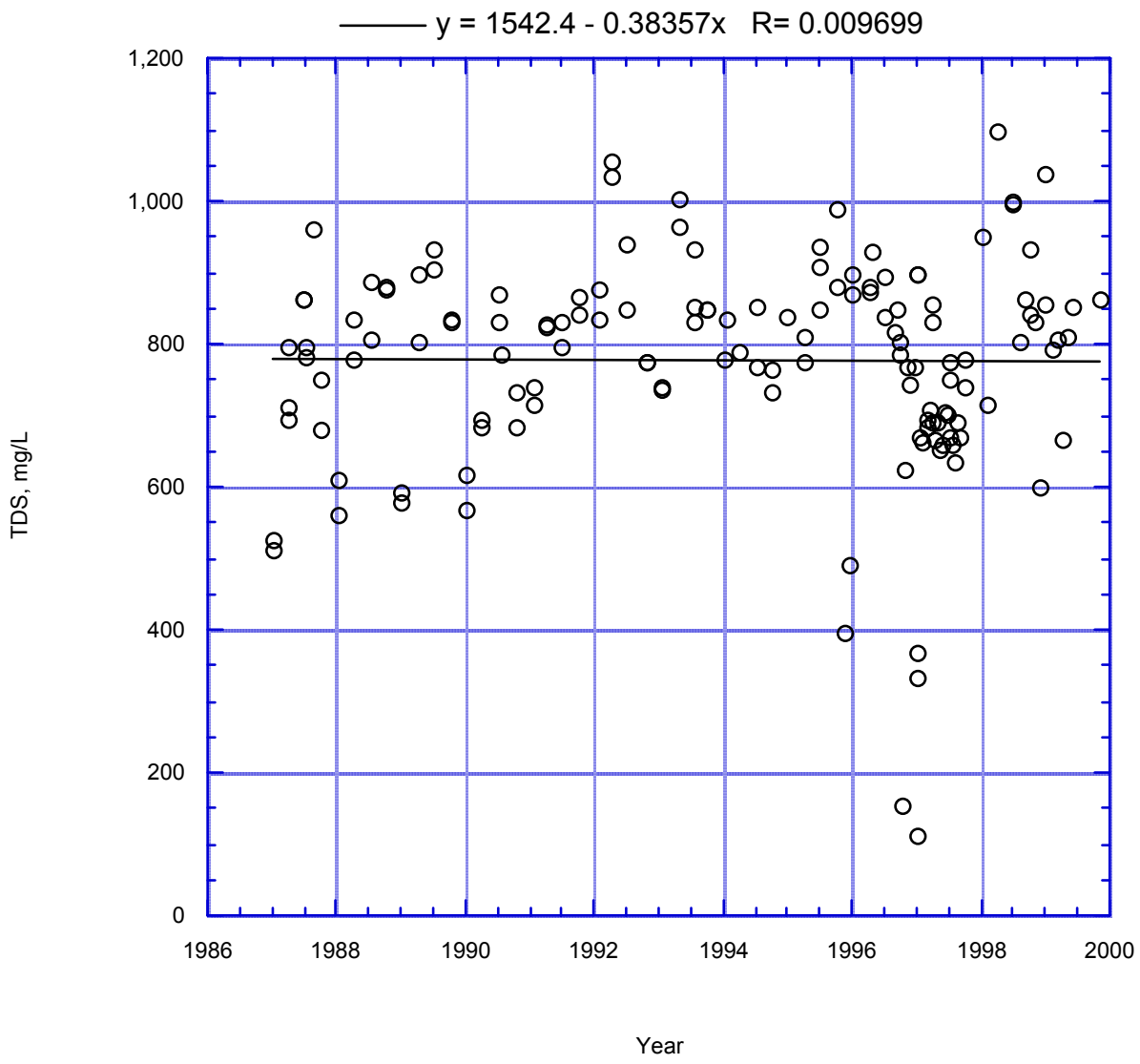


Figure 170. Reach 9B TDS vs. Time

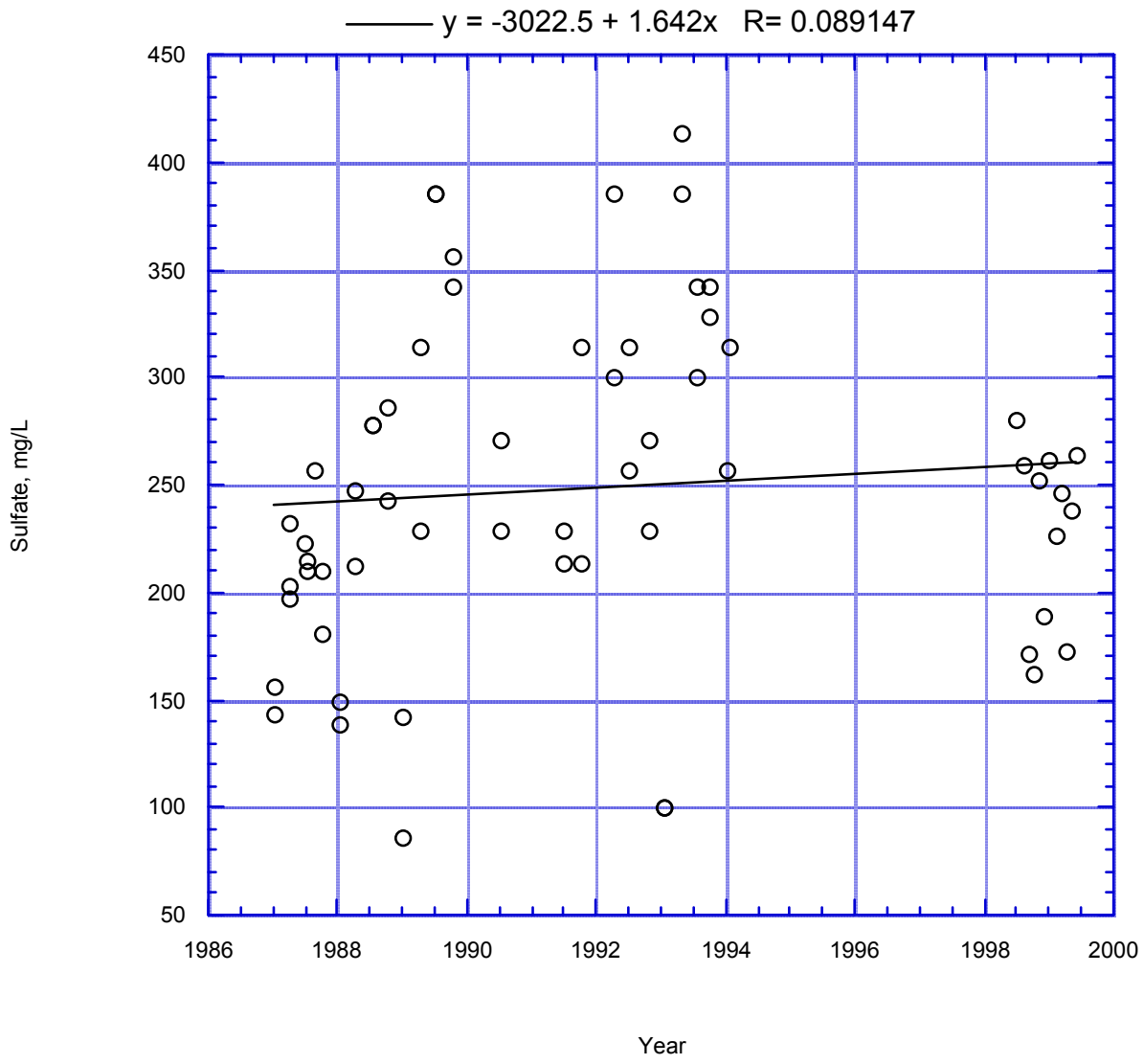


Figure 171. Reach 9B Sulfate vs. Time

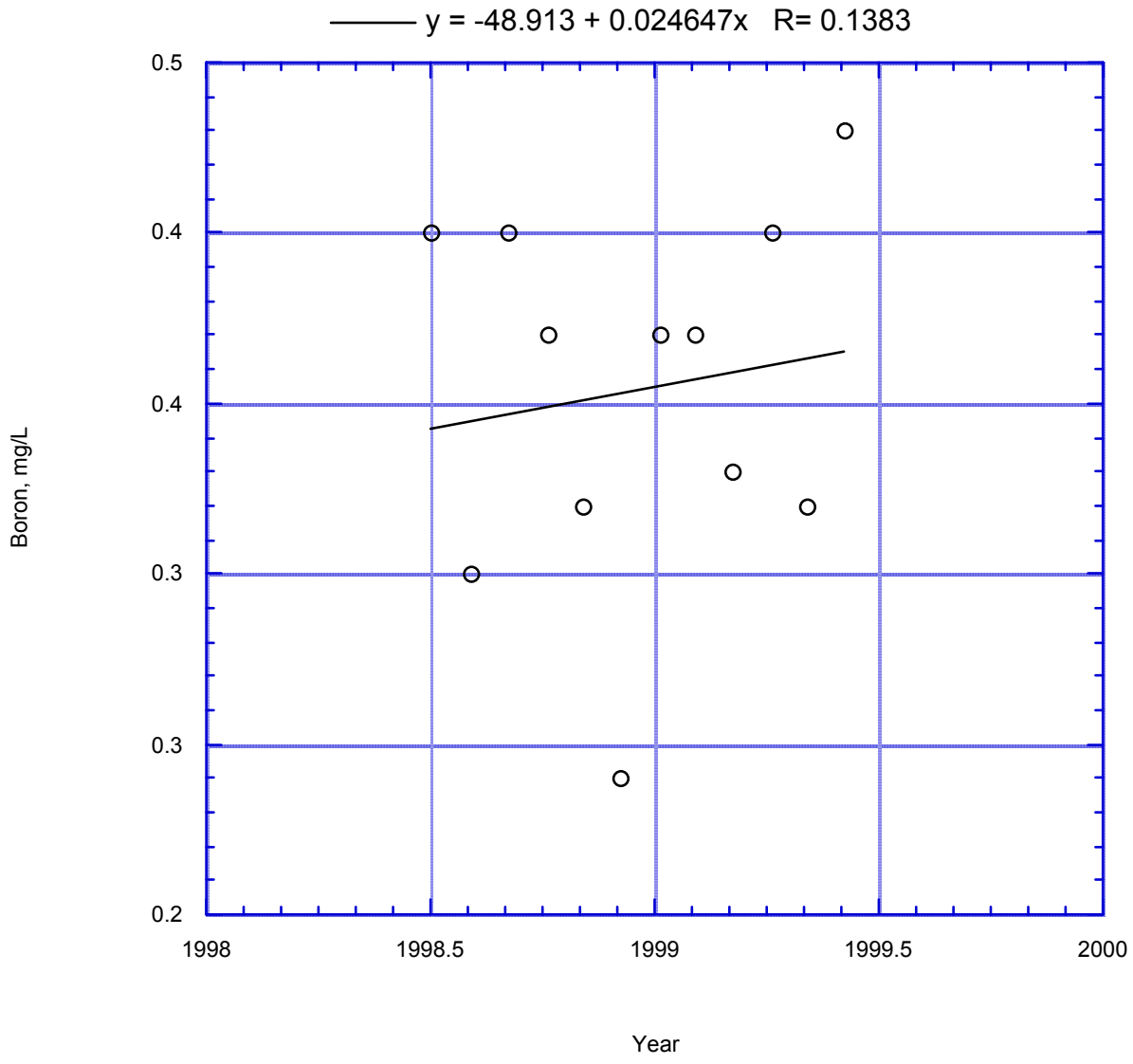


Figure 172. Reach 9B Boron vs. Time

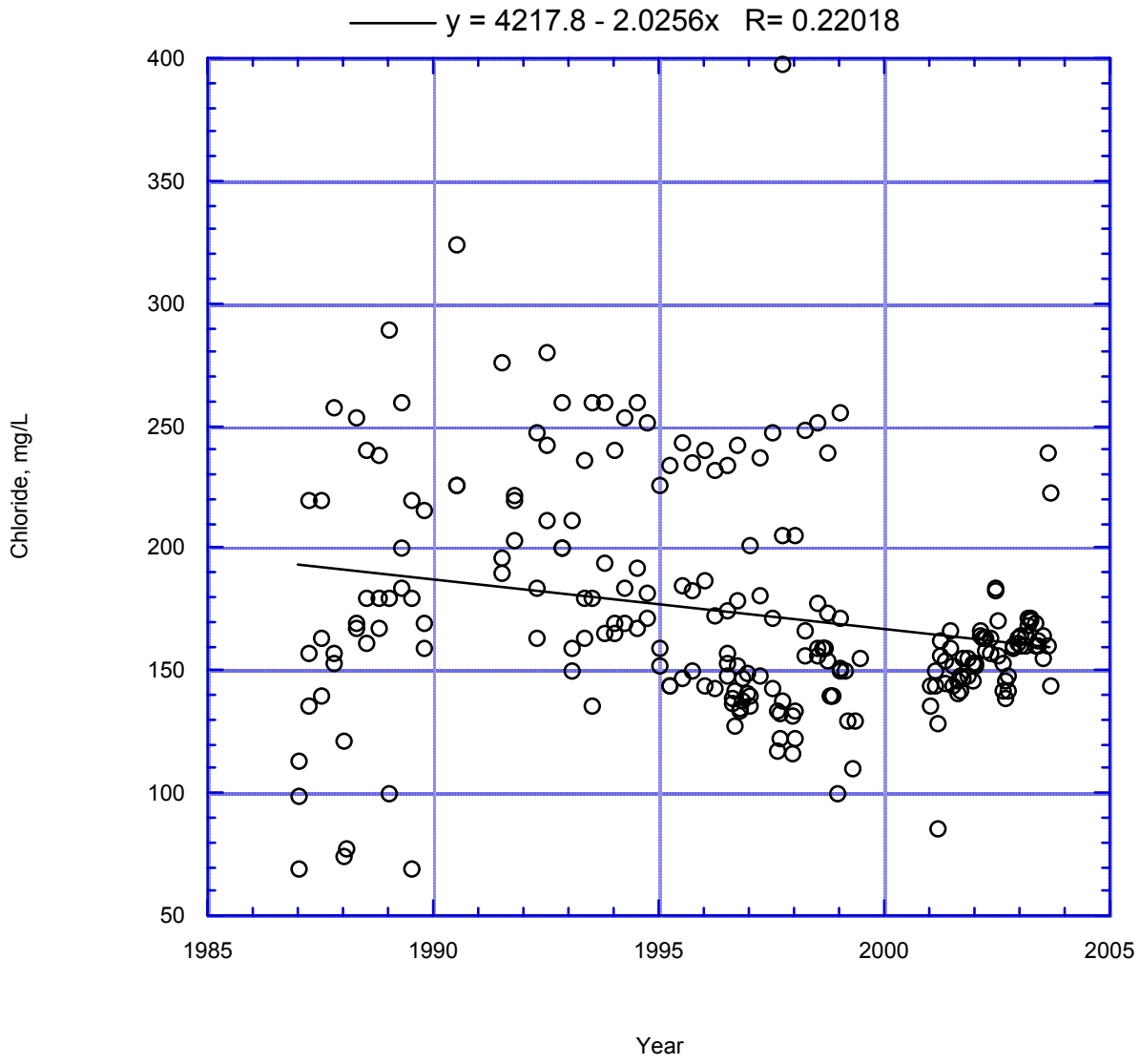


Figure 173. Reach 10 Chloride vs. Time

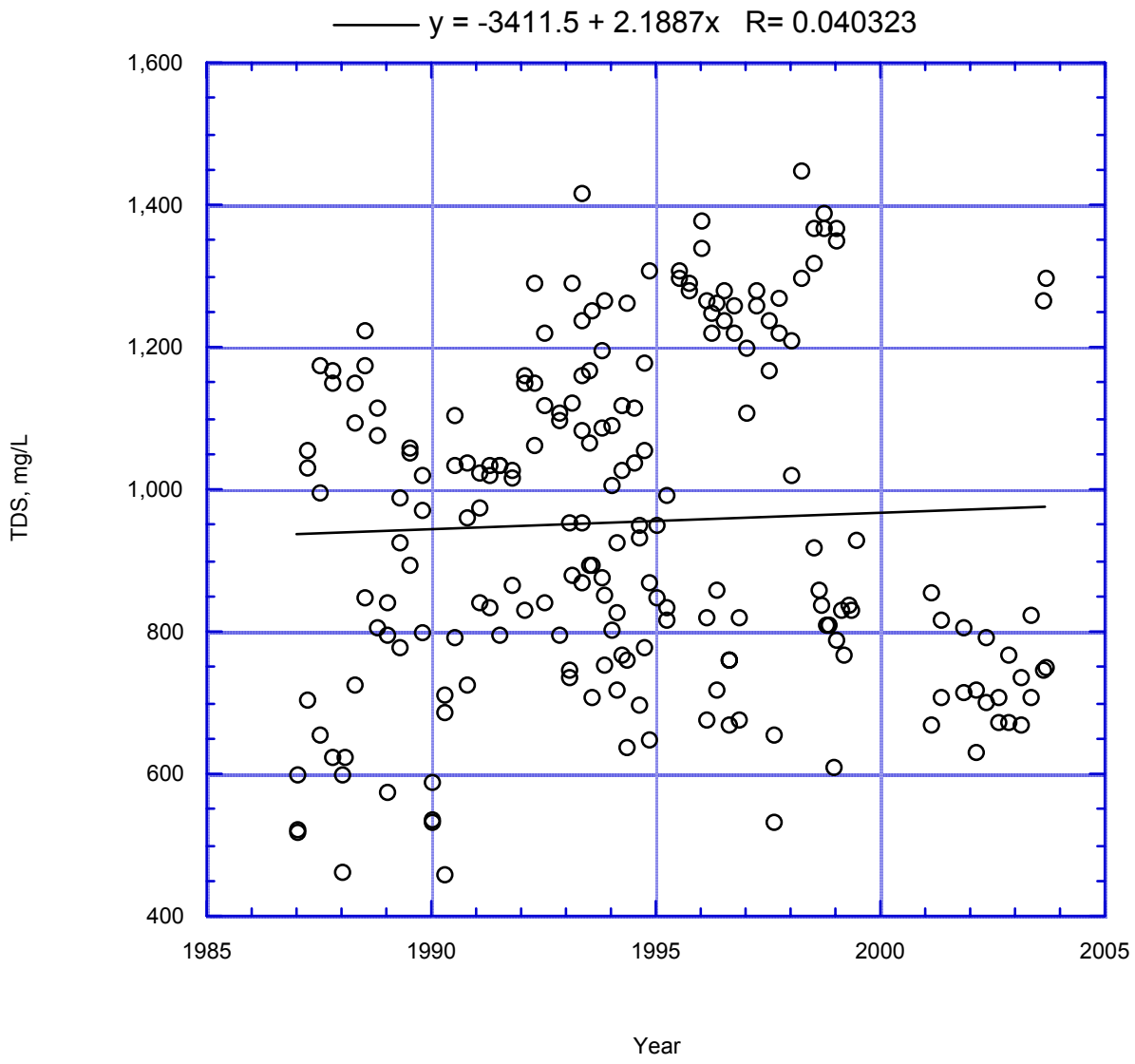


Figure 174. Reach 10 TDS vs. Time

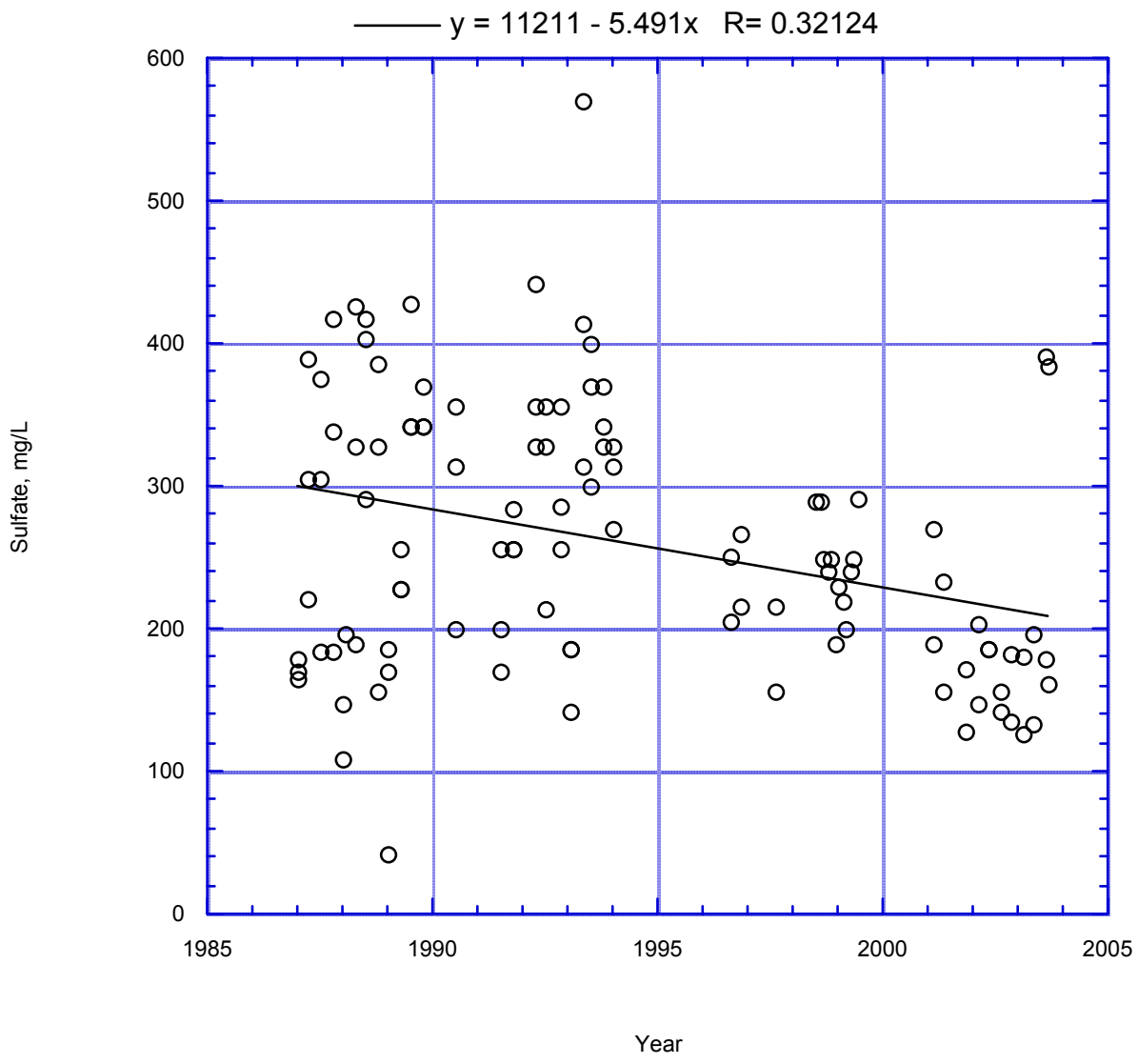


Figure 175. Reach 10 Sulfate vs. Time

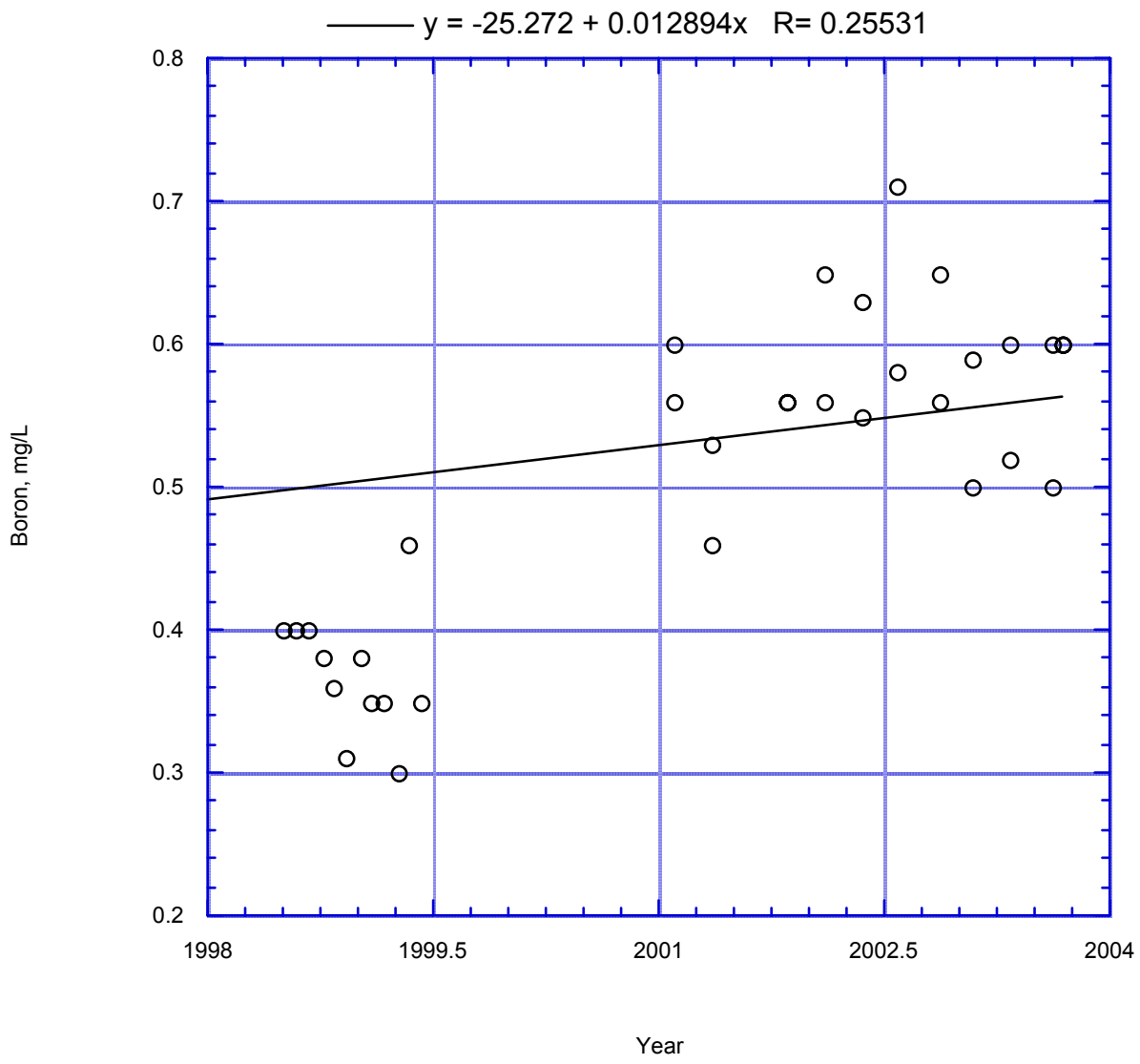


Figure 176. Reach 10 Boron vs. Time

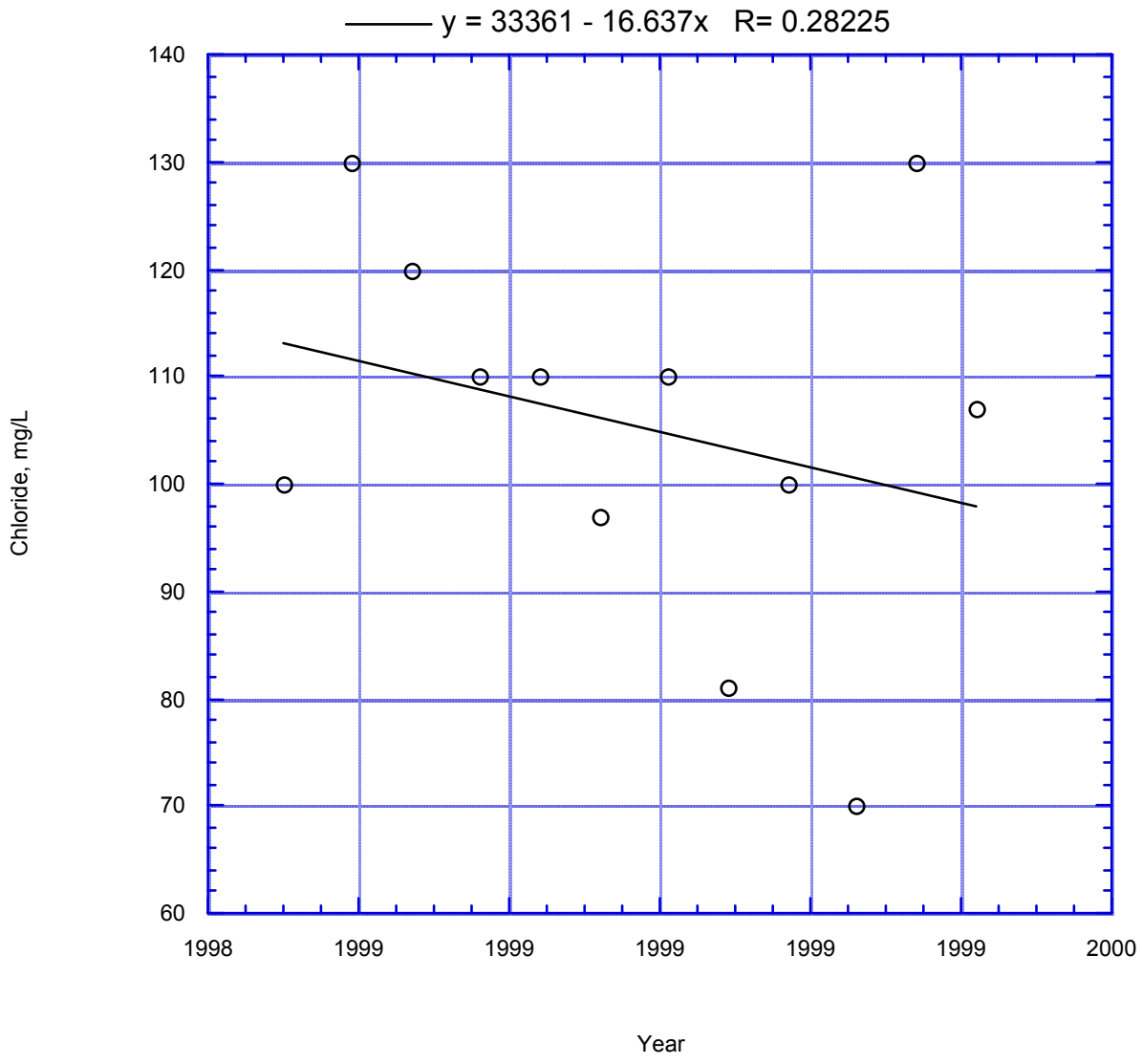


Figure 177. Reach 11 Chloride vs. Time

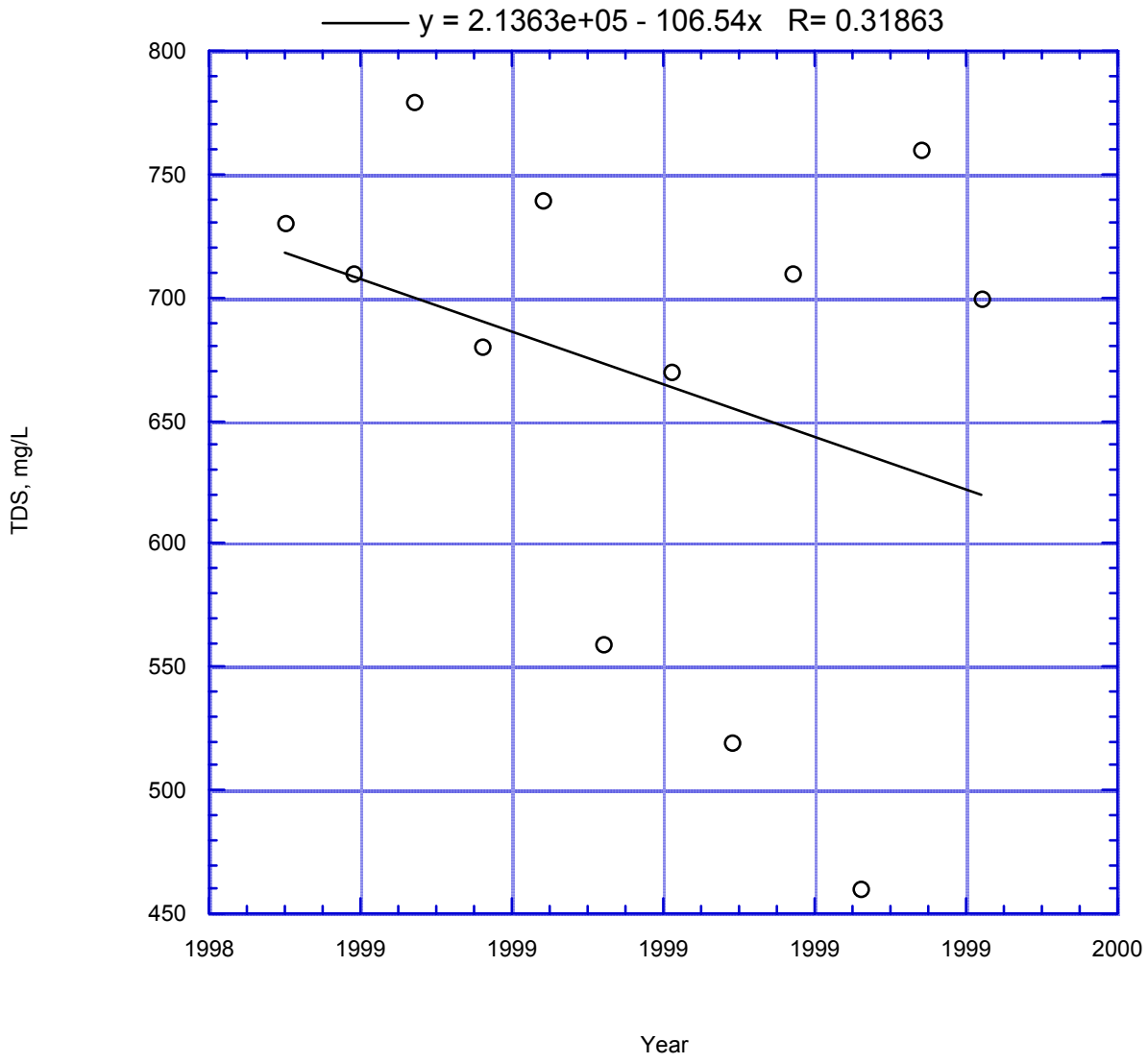


Figure 178. Reach 11 TDS vs. Time

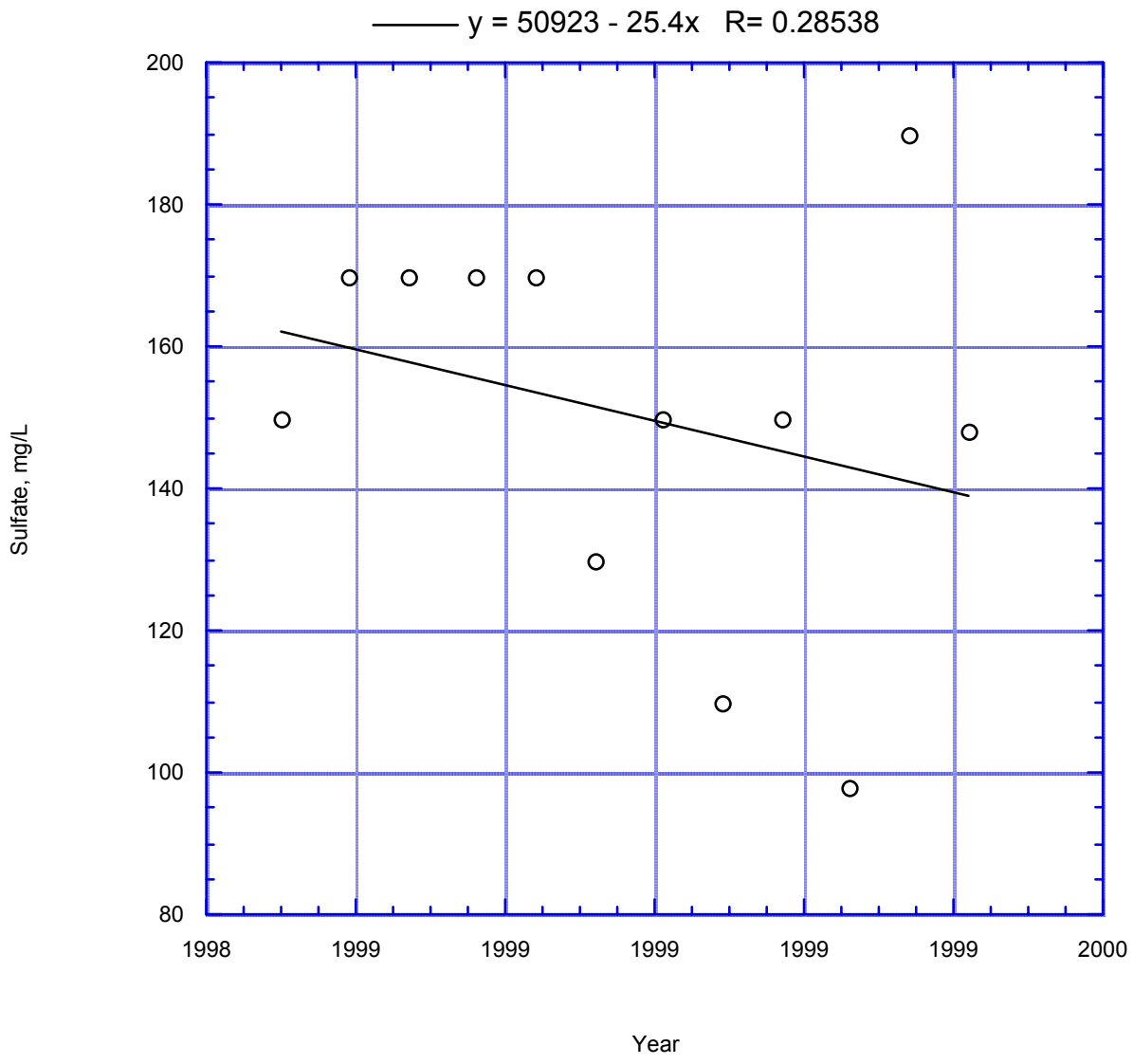


Figure 179. Reach 11 Sulfate vs. Time

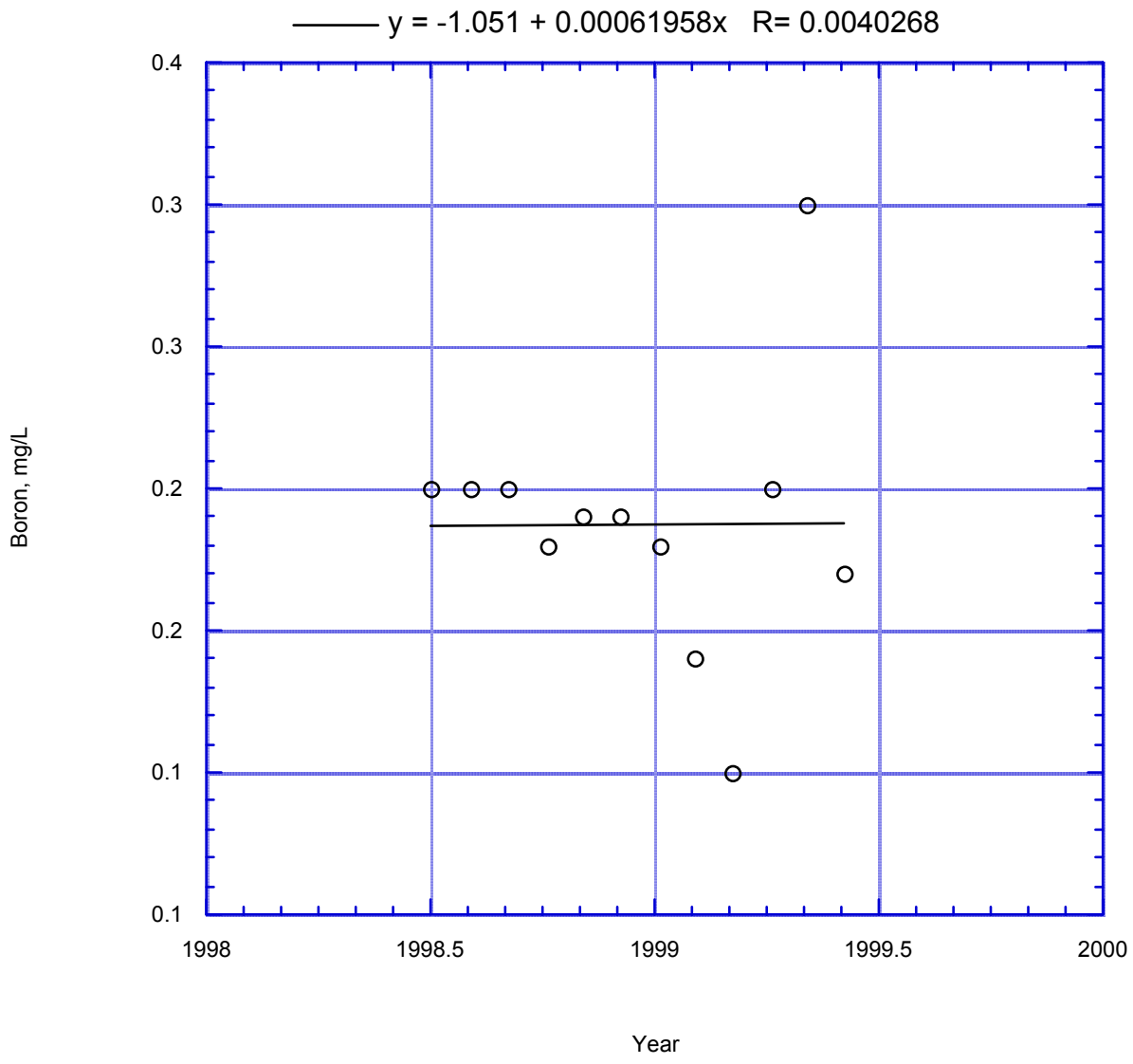


Figure 180. Reach 11 Boron vs. Time

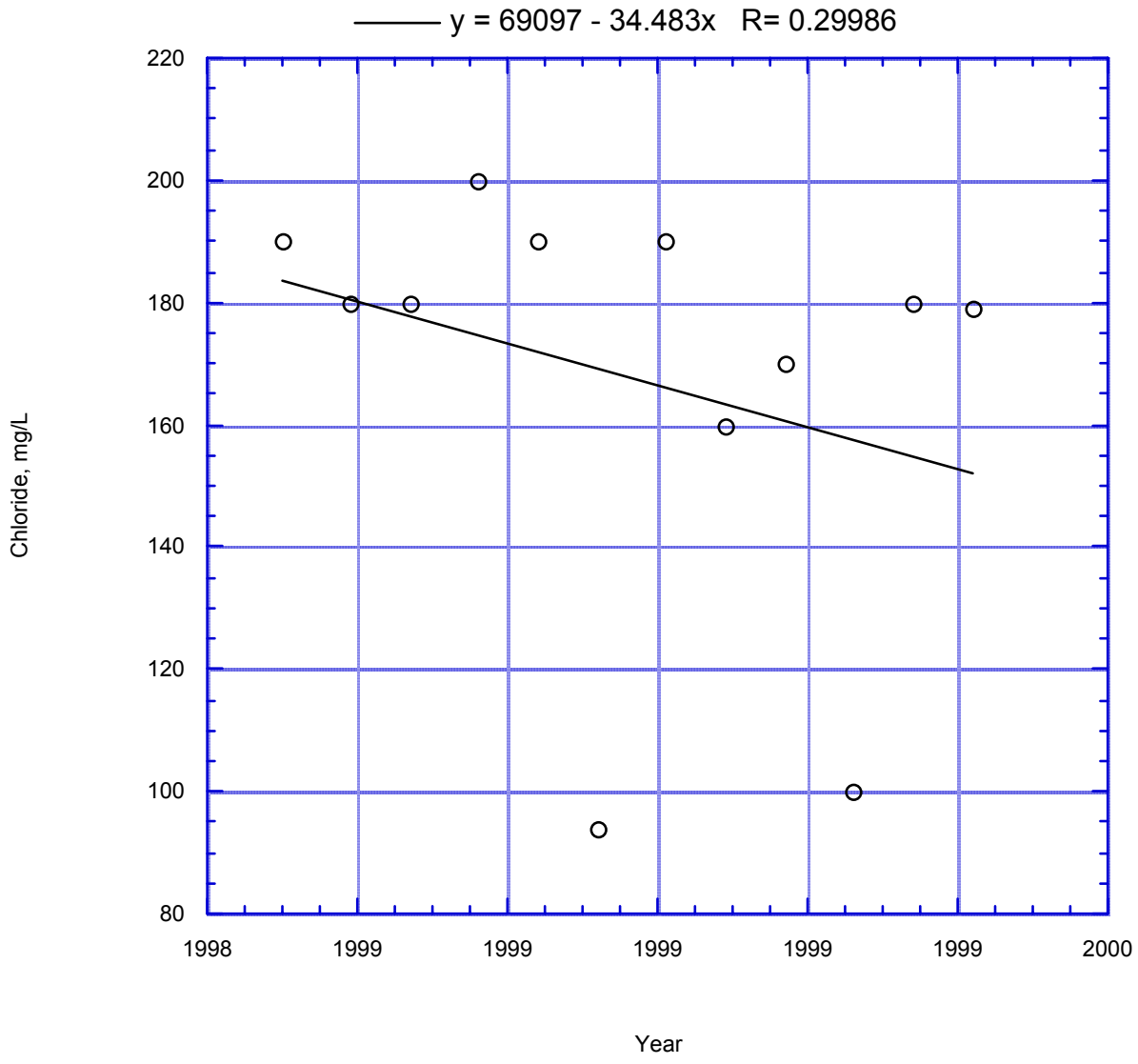


Figure 181. Reach 13 Chloride vs. Time

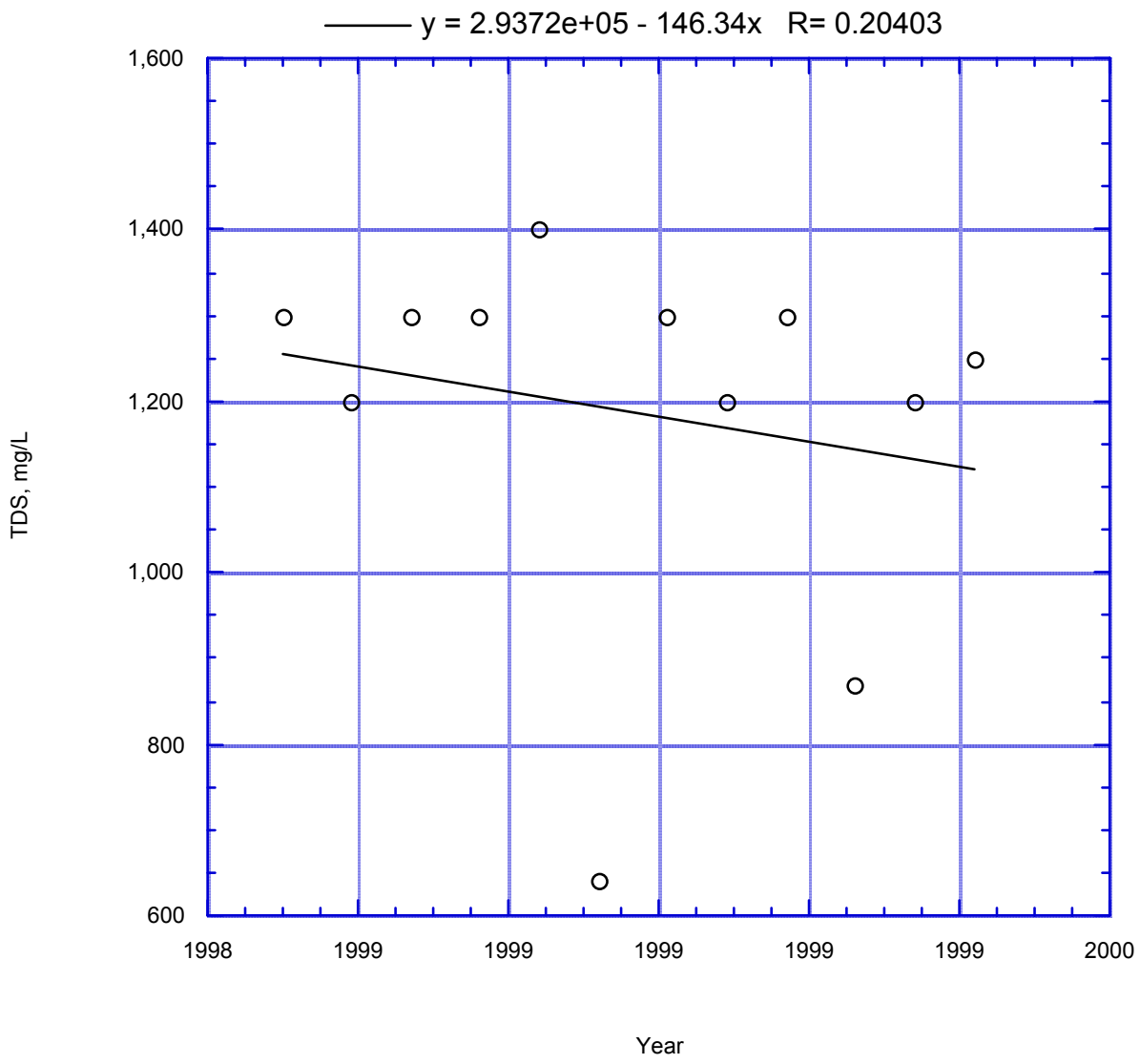


Figure 182. Reach 13 TDS vs. Time

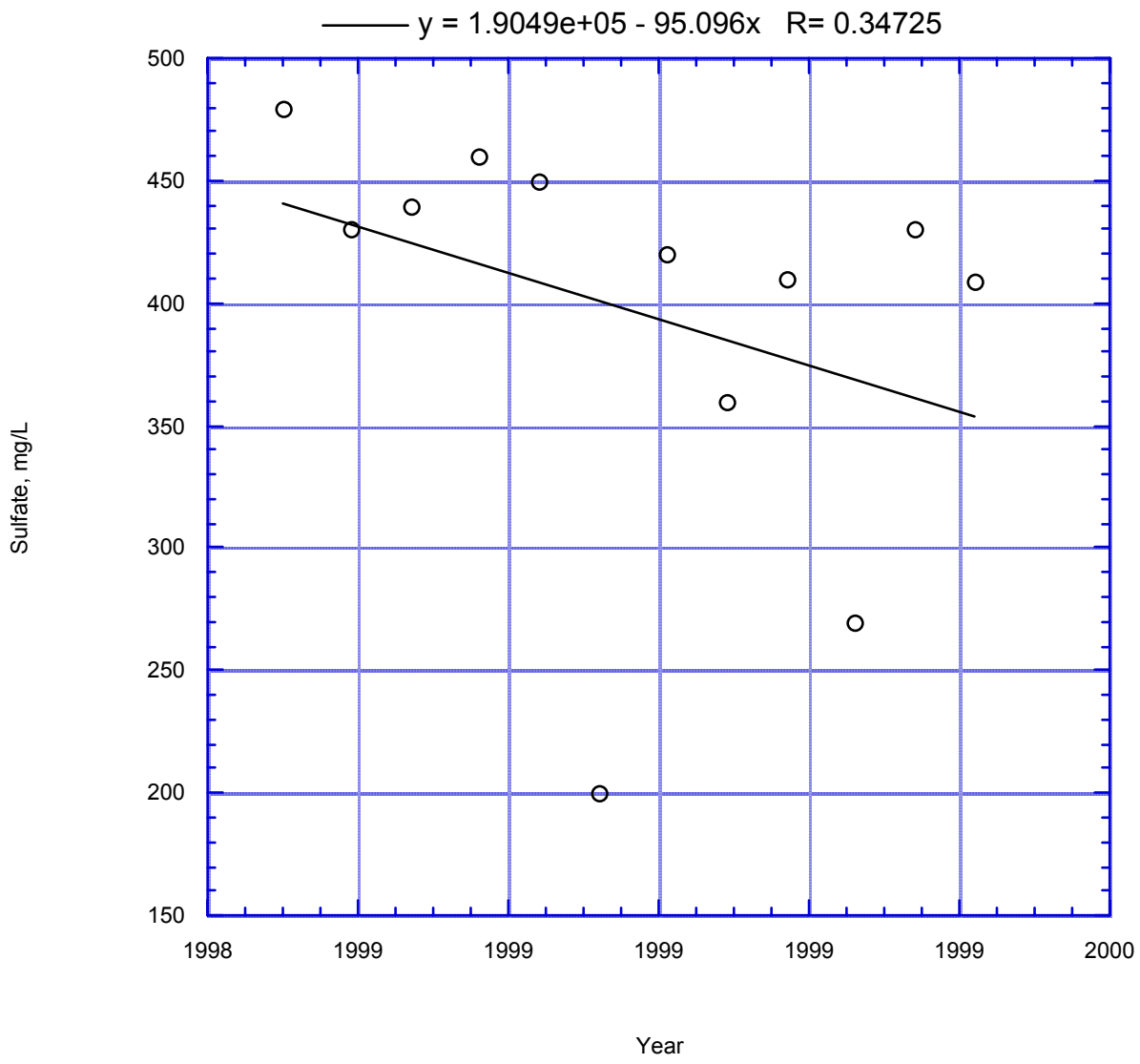


Figure 183. Reach 13 Sulfate vs. Time

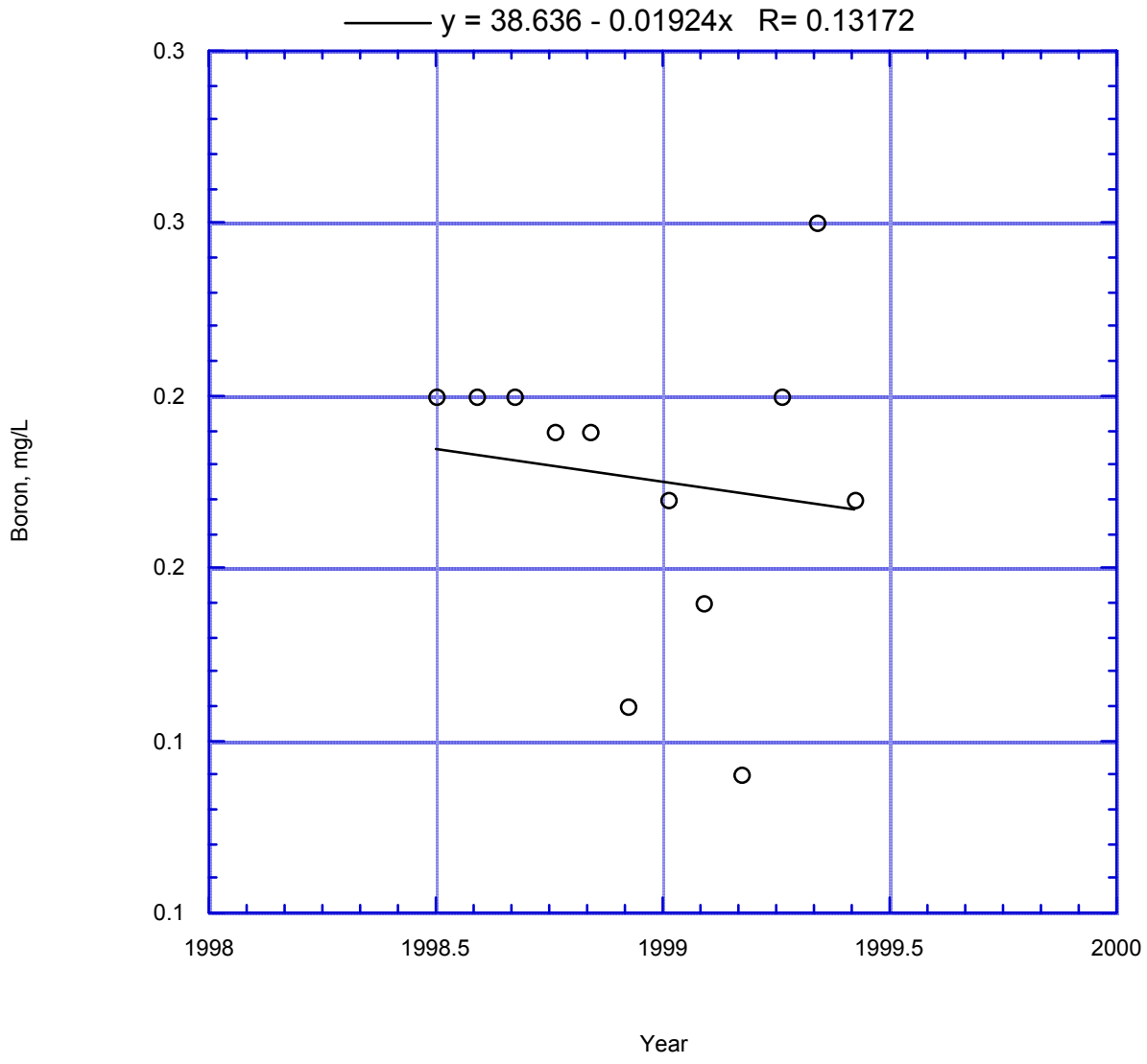


Figure 184. Reach 13 Boron vs. Time

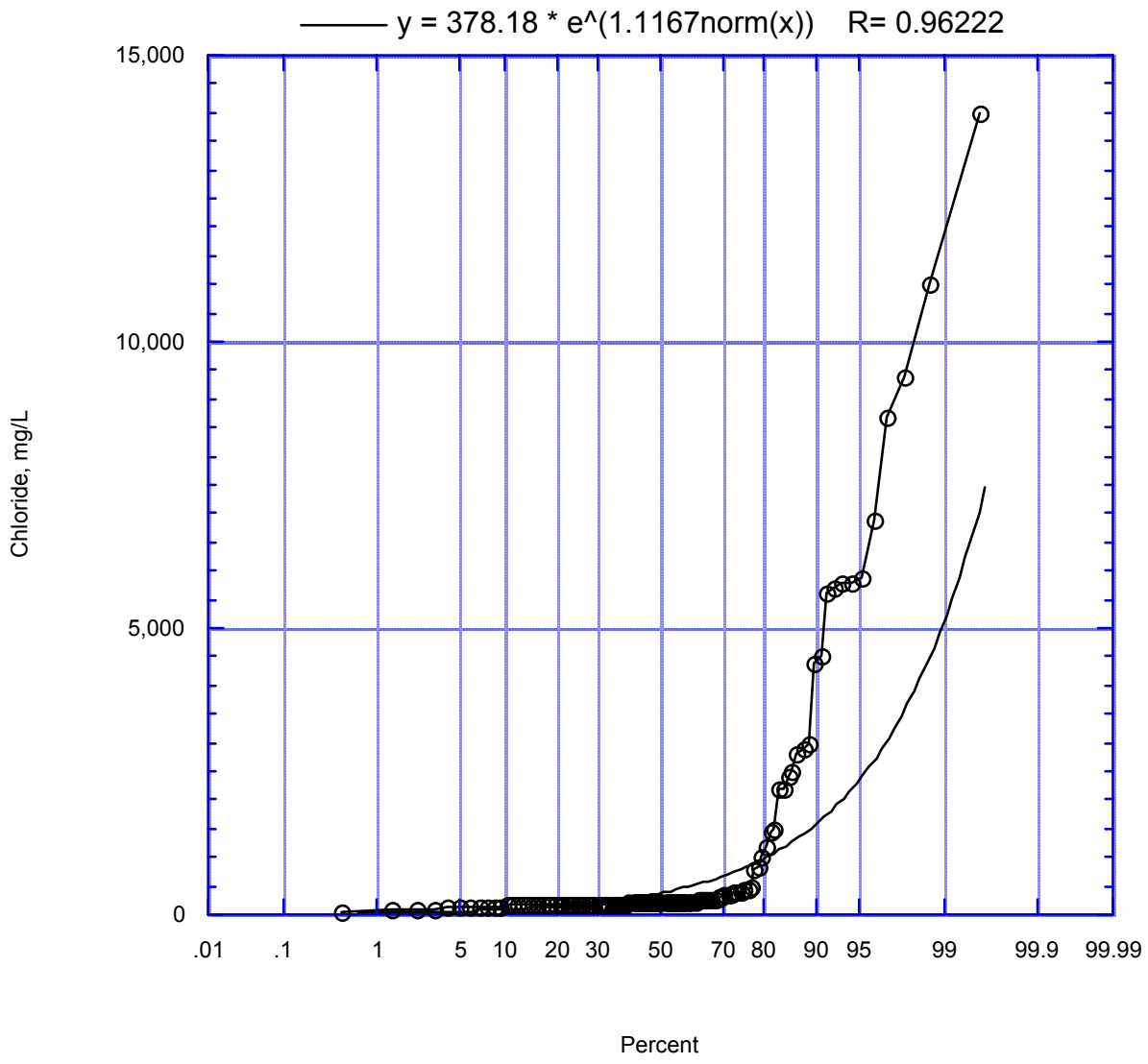


Figure 185. Reach 2 Chloride Frequency Distribution

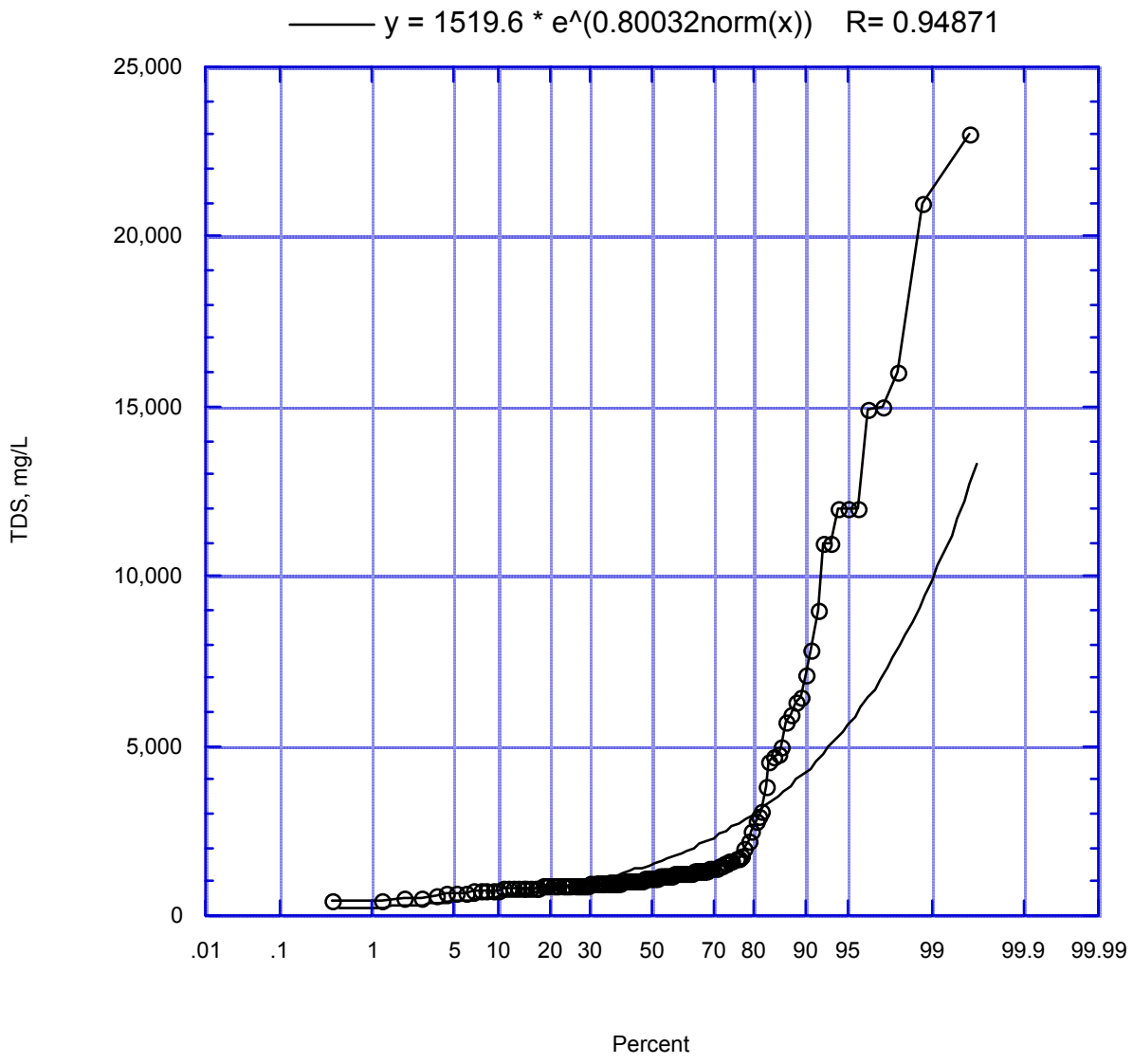


Figure 186. Reach 2 TDS Frequency Distribution

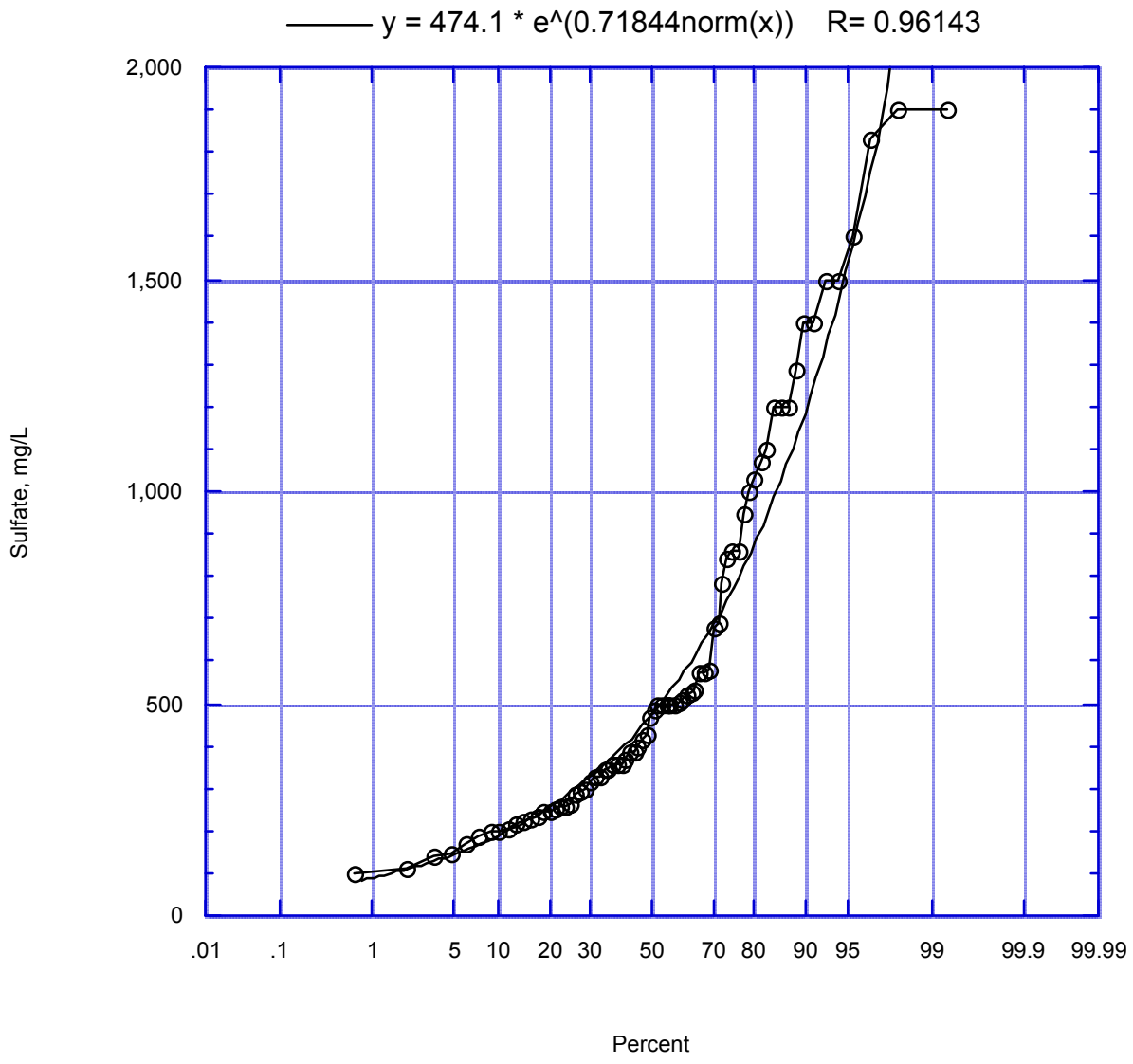


Figure 187. Reach 2 Sulfate Frequency Distribution

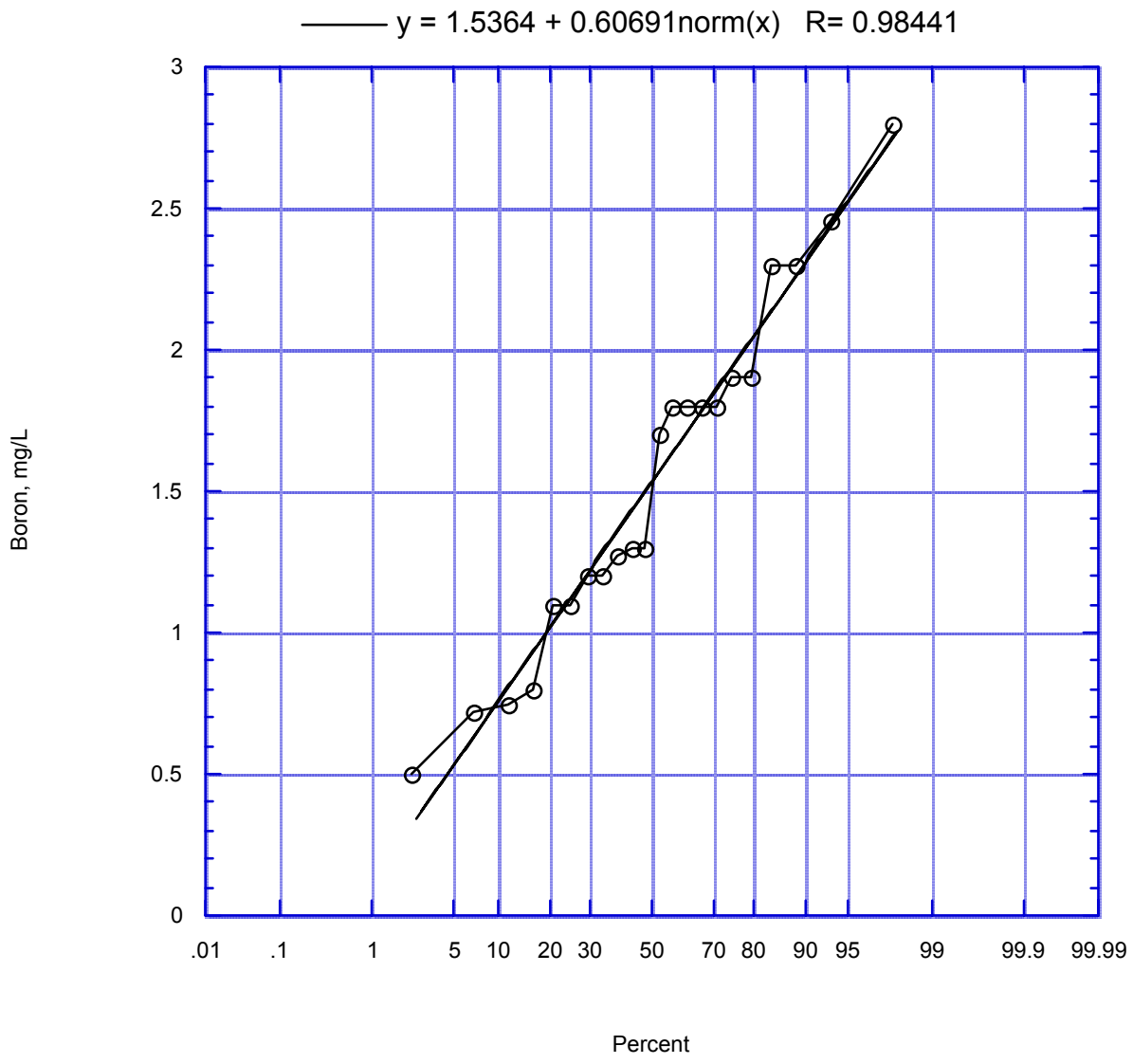


Figure 188. Reach 2 Boron Frequency Distribution

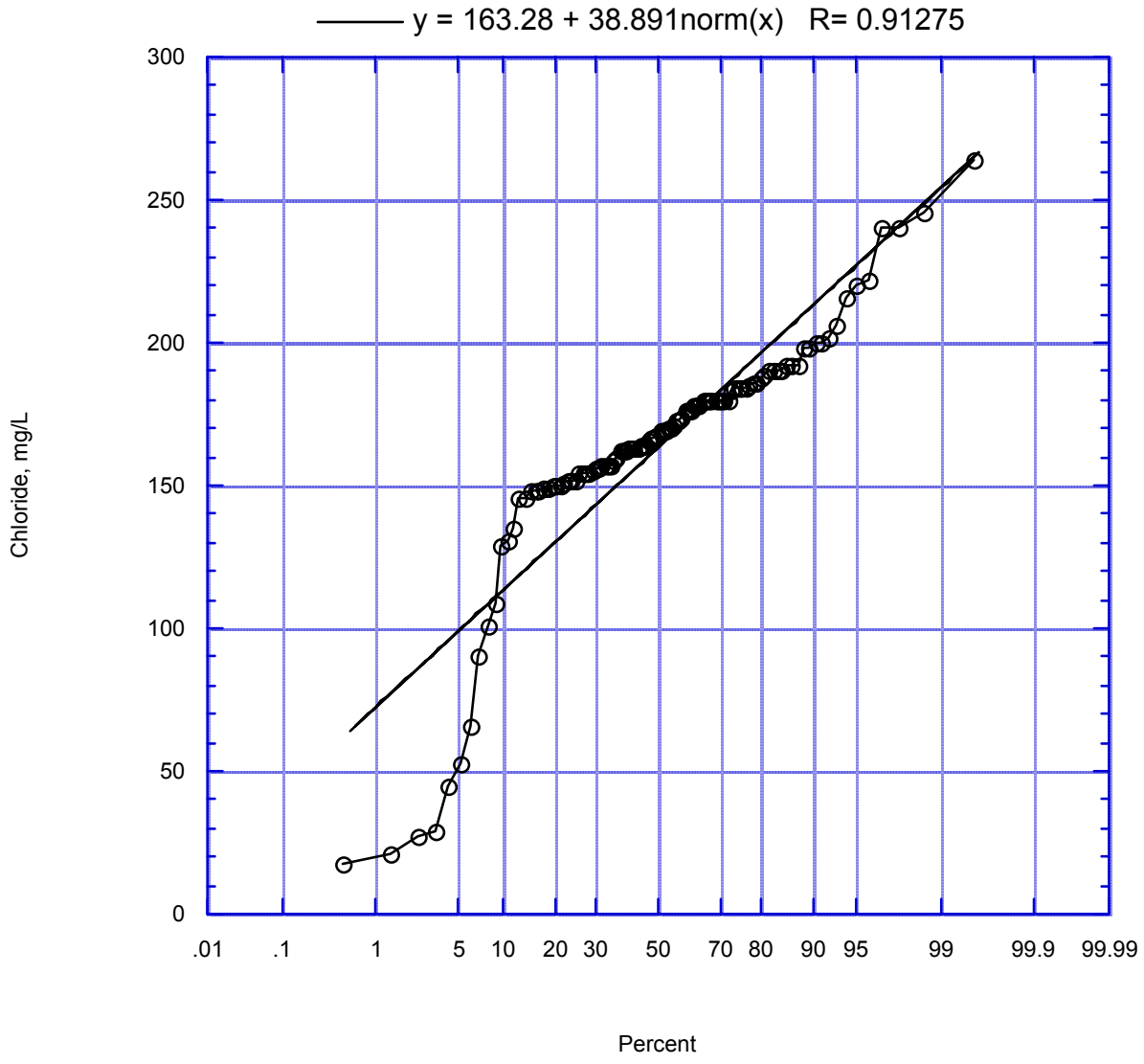


Figure 189. Reach 3 Chloride Frequency Distribution

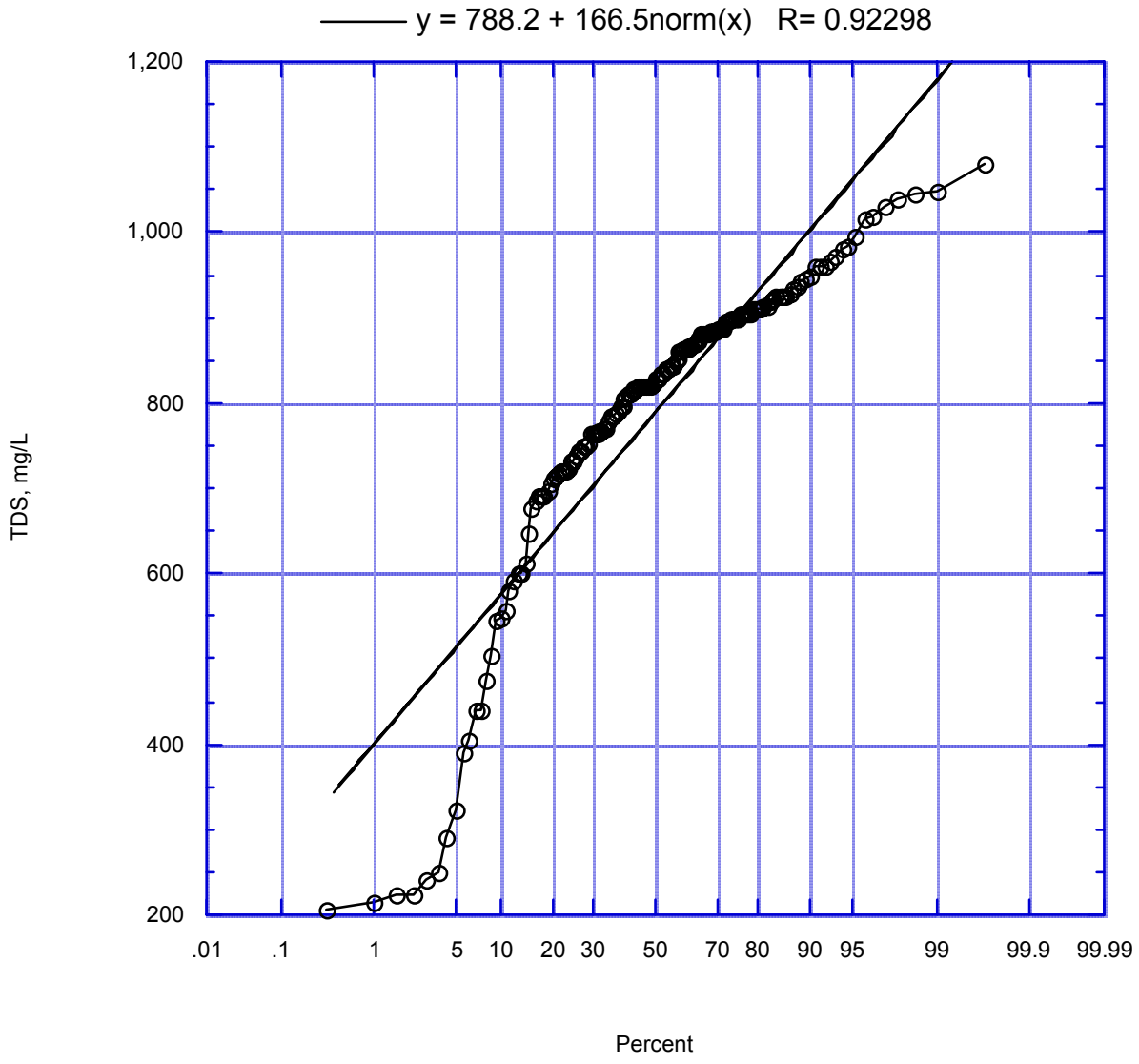


Figure 190. Reach 3 TDS Frequency Distribution

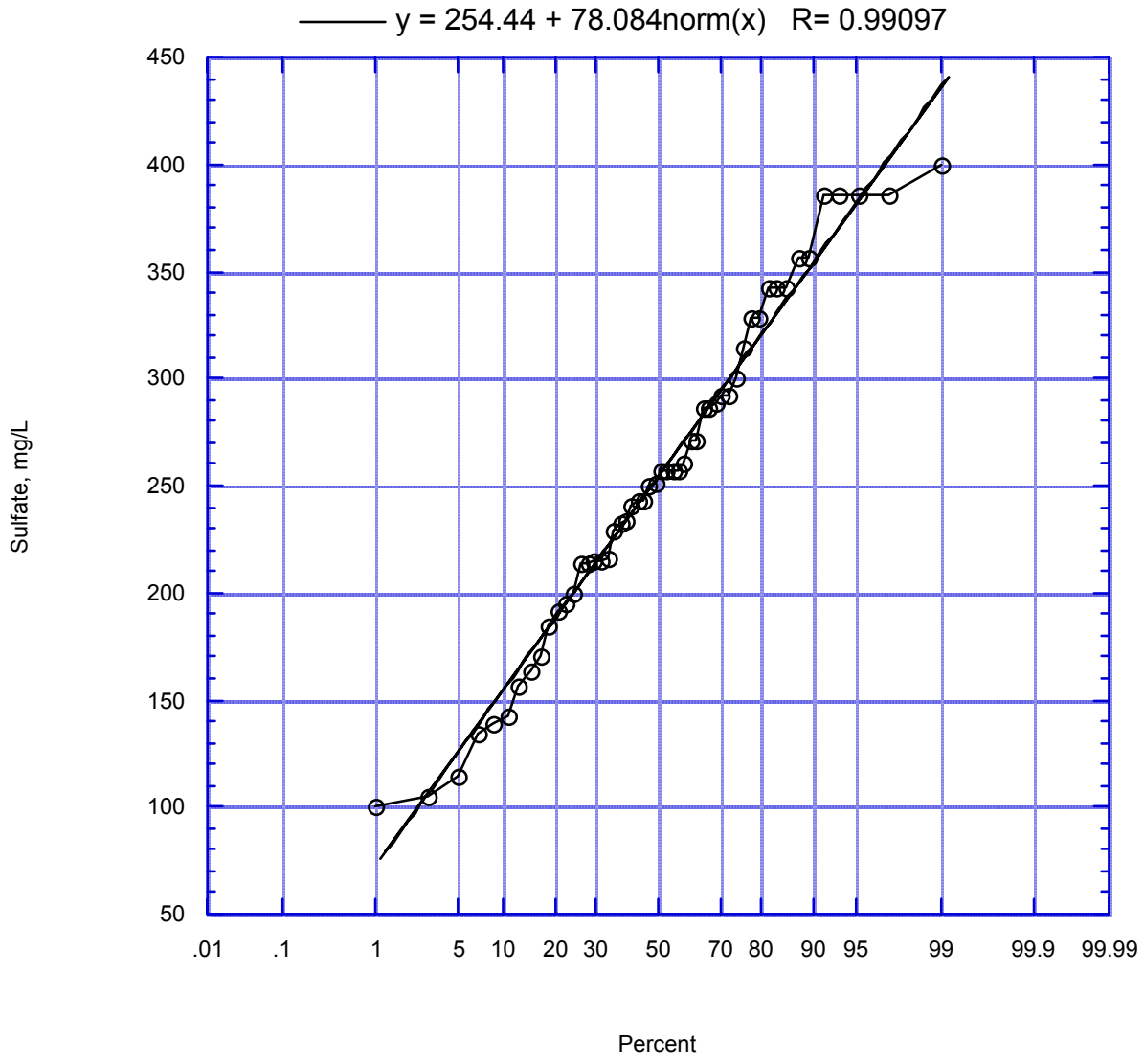


Figure 191. Reach 3 Sulfate Frequency Distribution

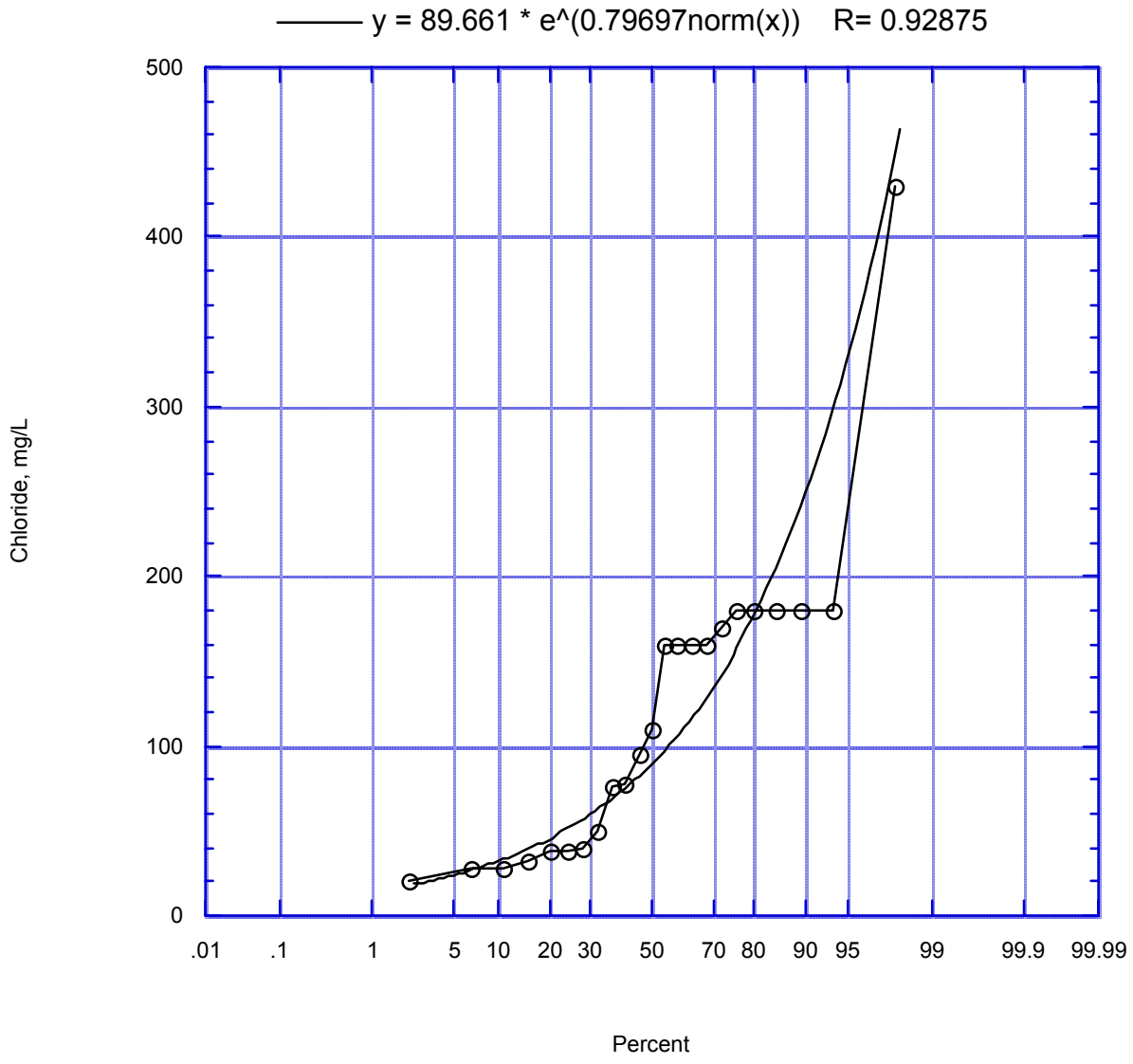


Figure 192. Reach 4 Chloride Frequency Distribution

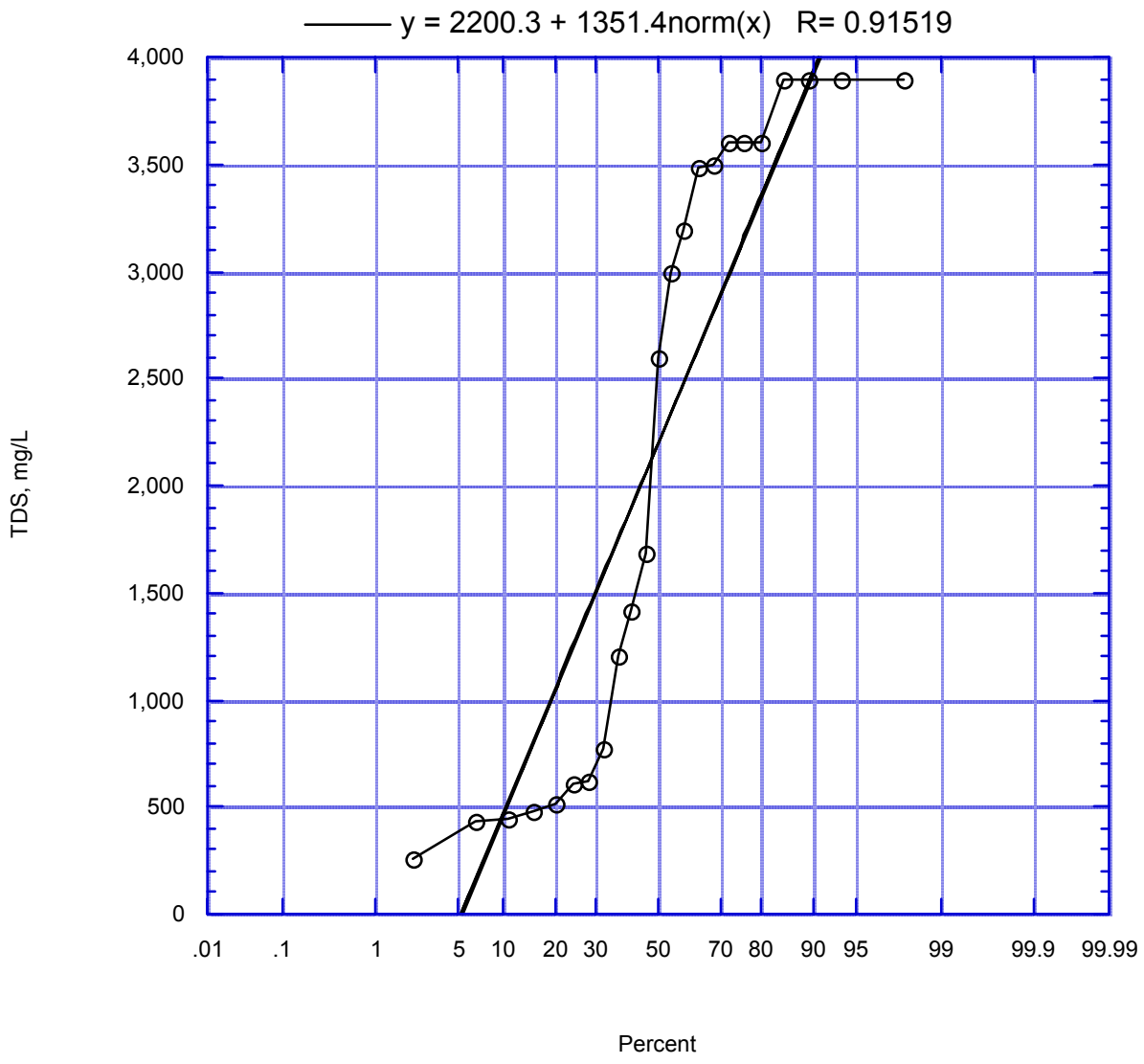


Figure 193. Reach 4 TDS Frequency Distribution

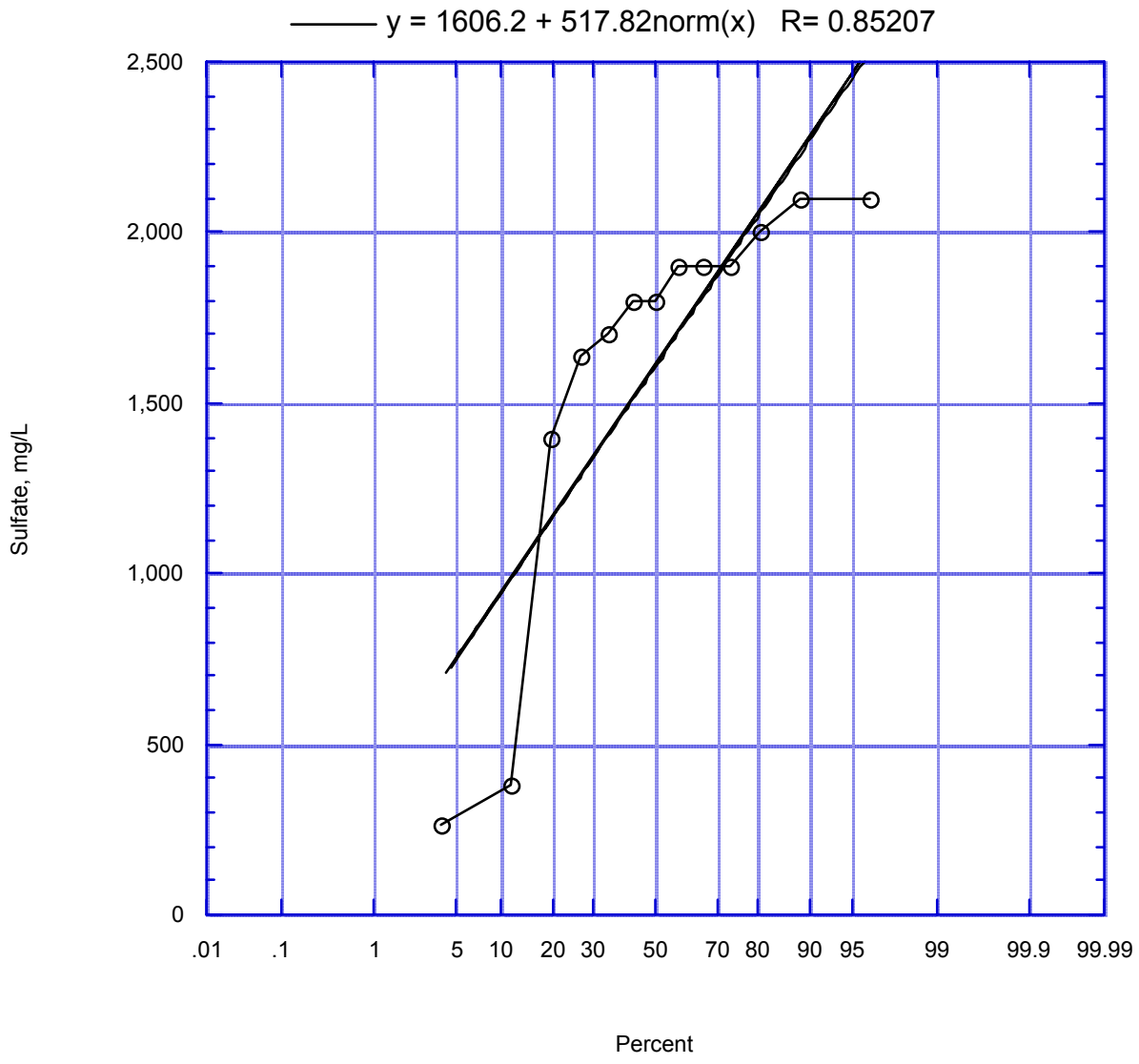


Figure 194. Reach 4 Sulfate Frequency Distribution

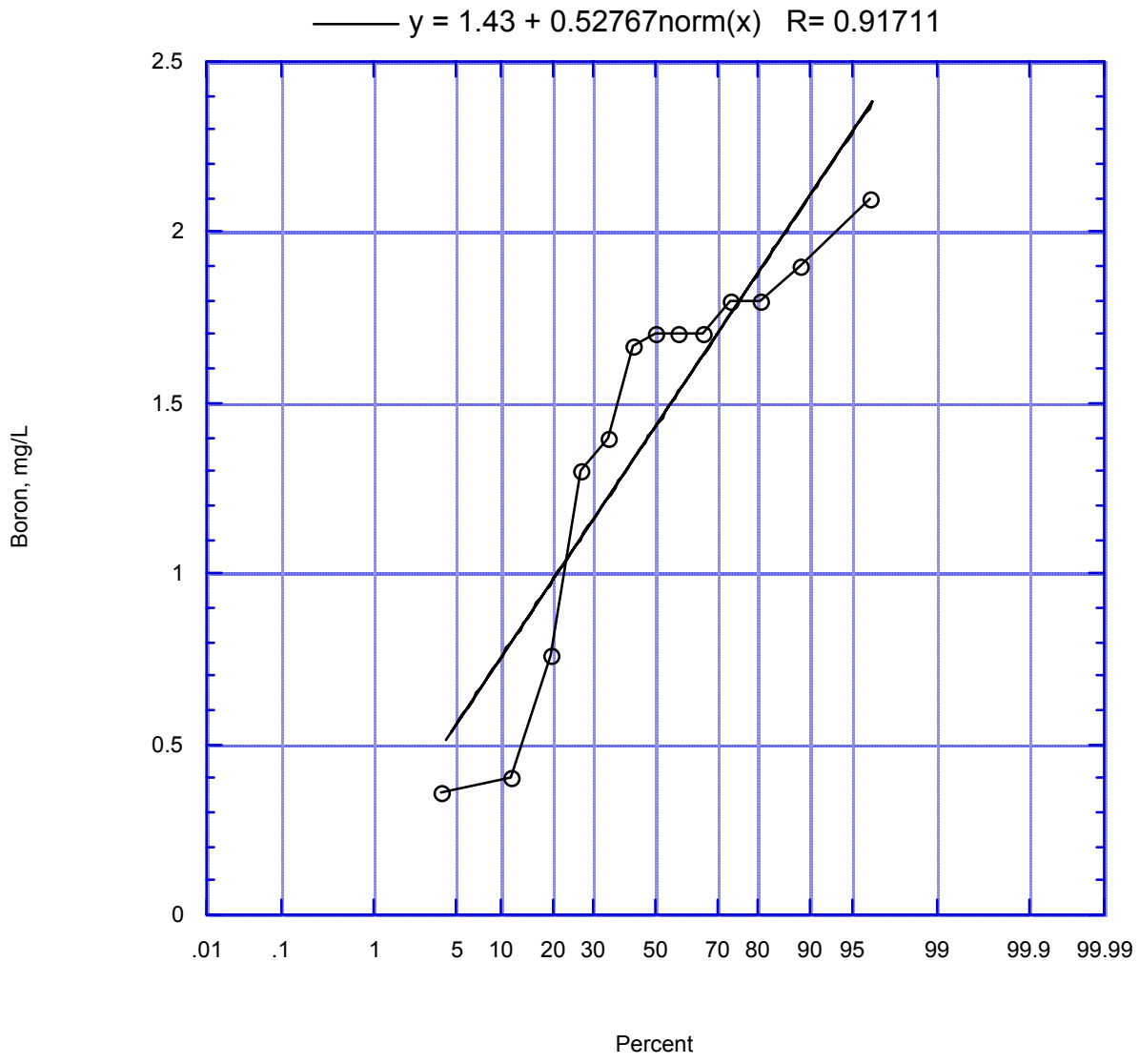


Figure 195. Reach 4 Boron Frequency Distribution

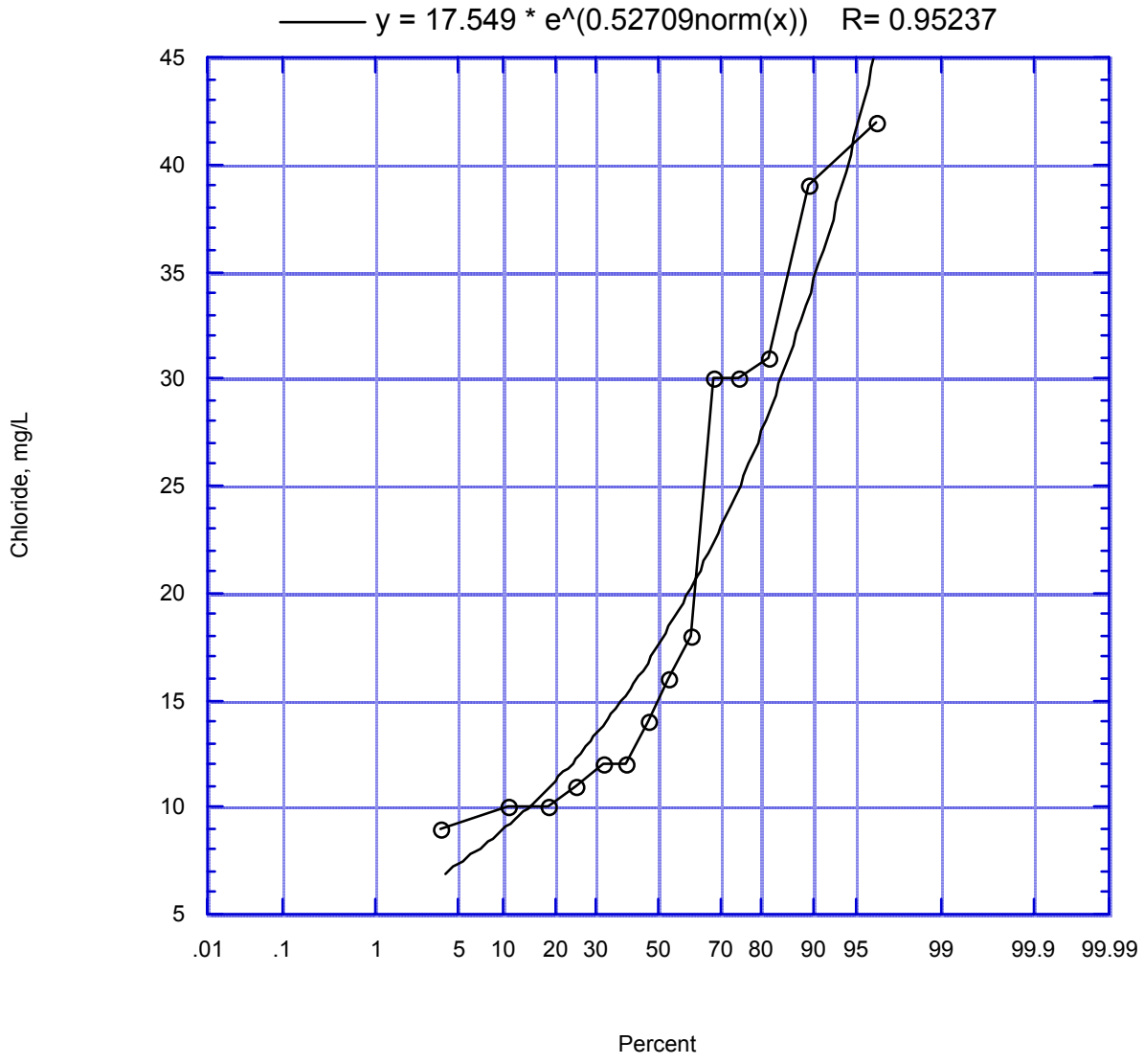


Figure 196. Reach 5 Chloride Frequency Distribution

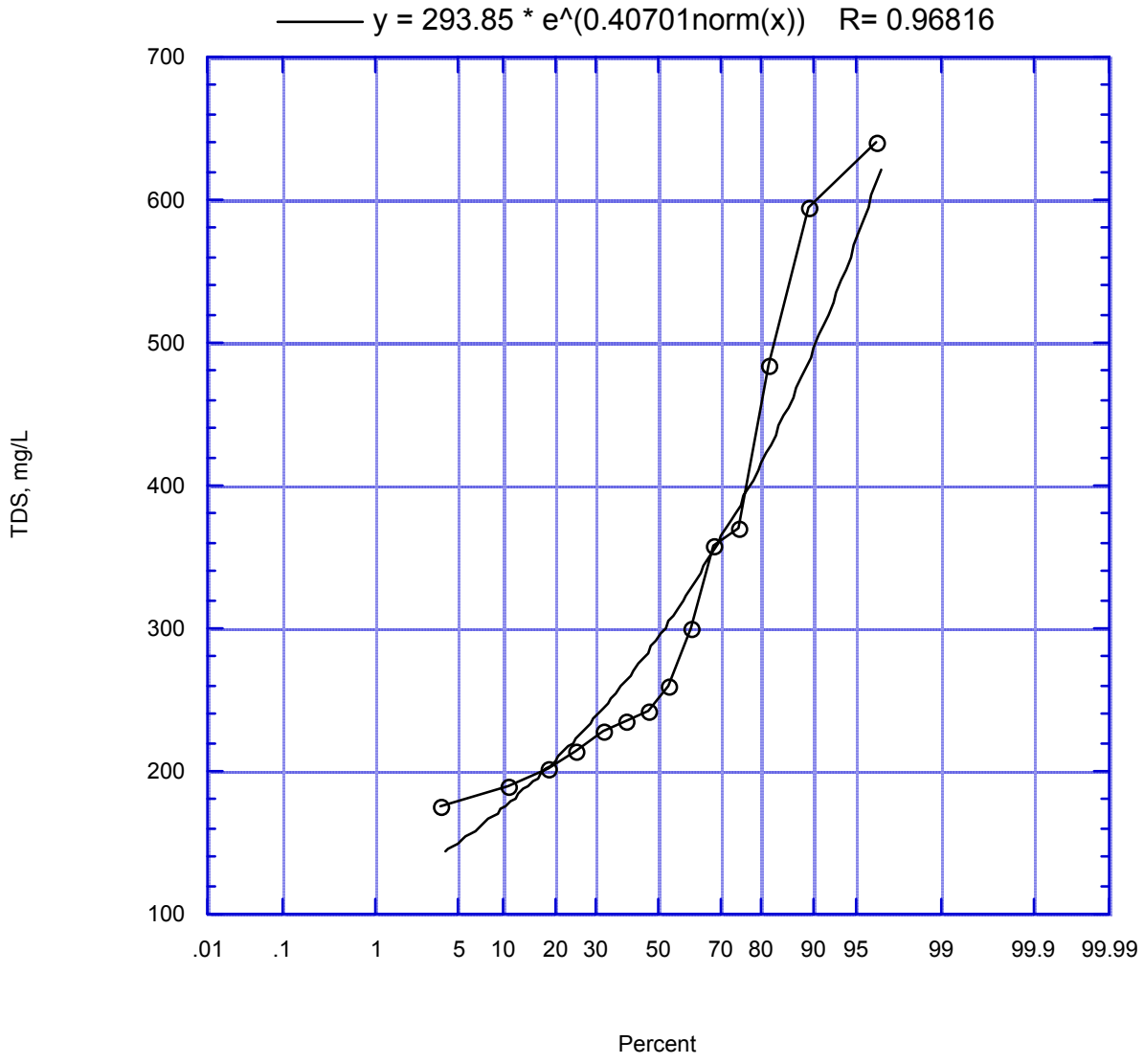


Figure 197. Reach 5 TDS Frequency Distribution

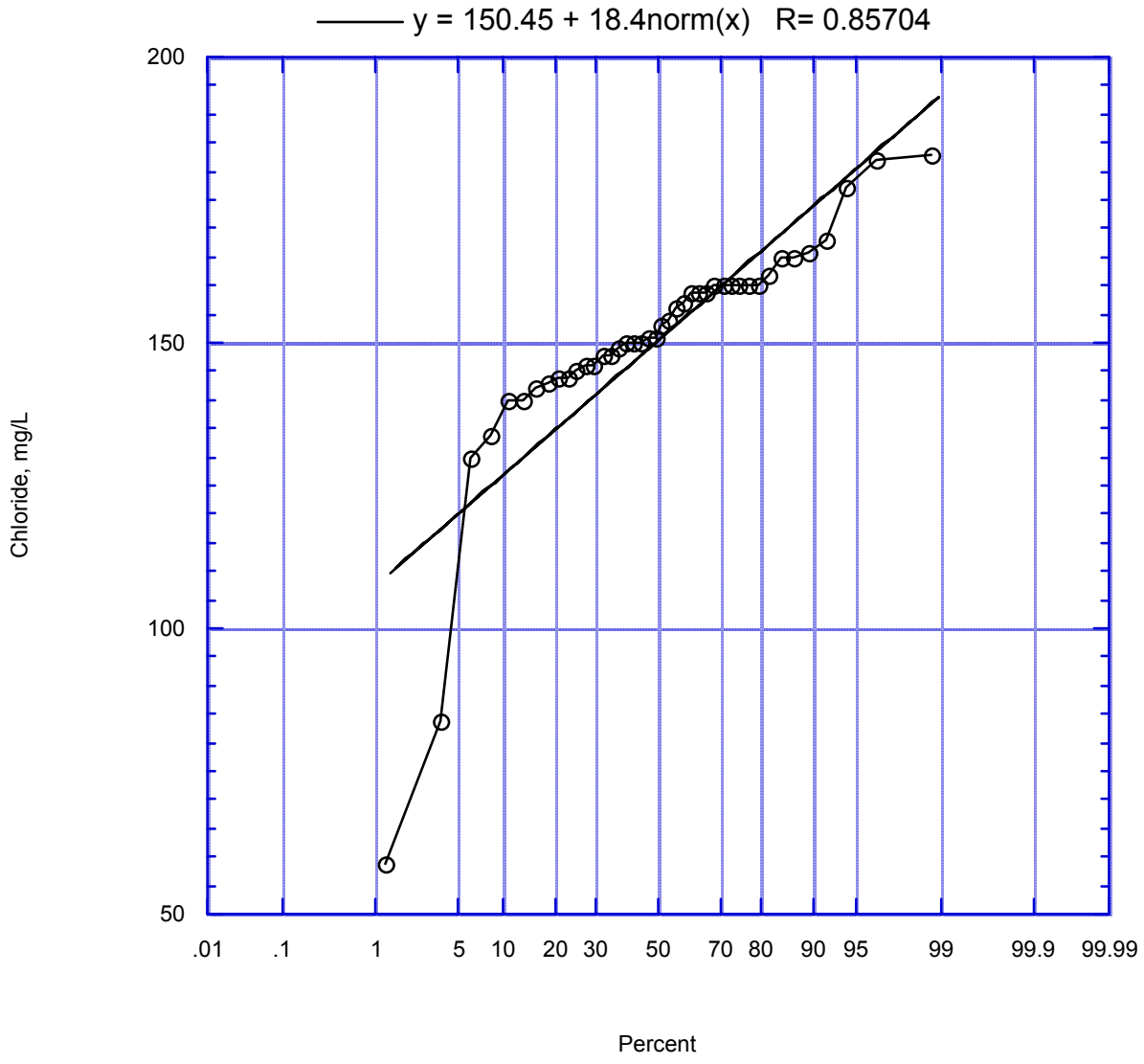


Figure 198. Reach 6 Chloride Frequency Distribution

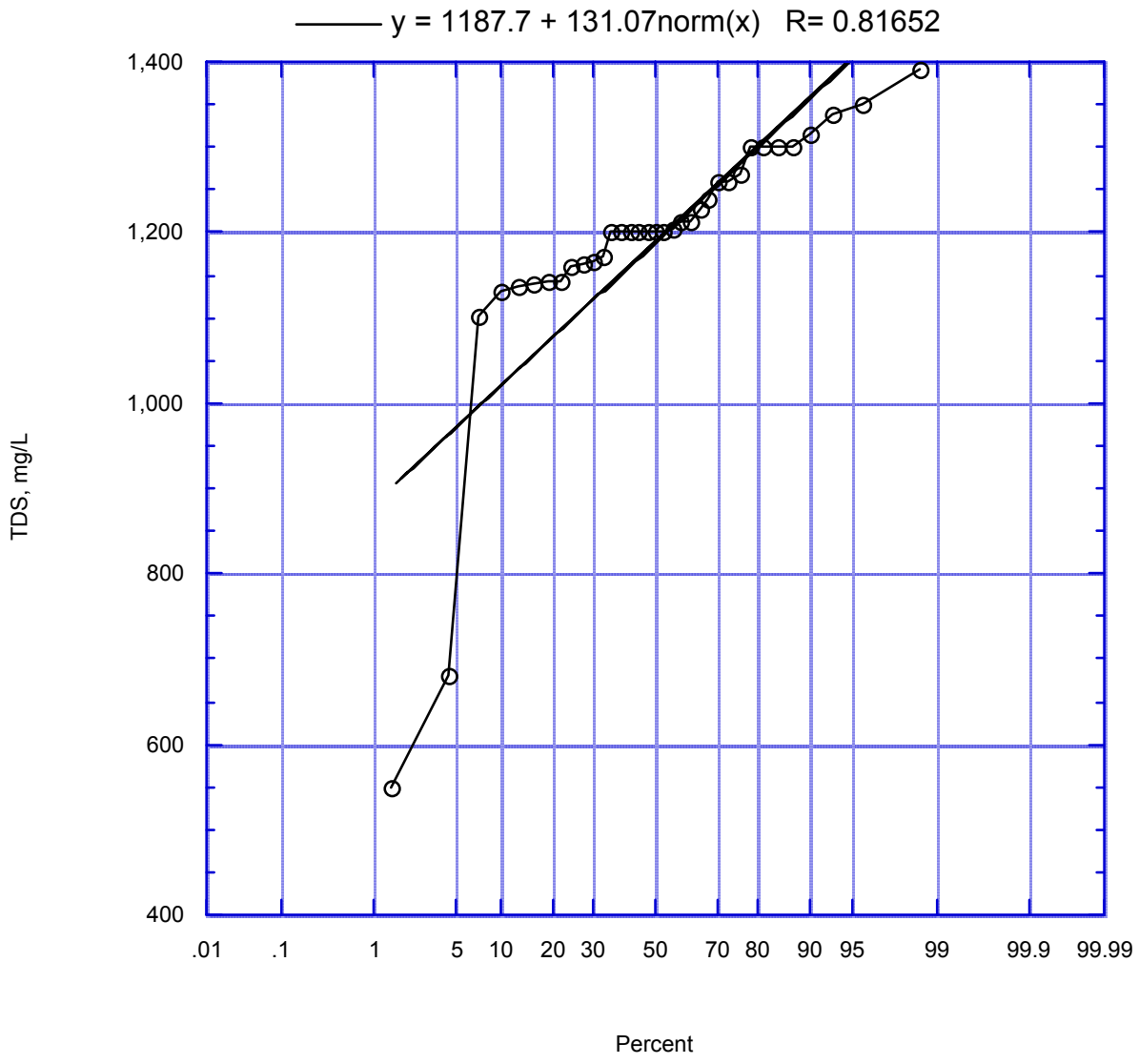


Figure 199. Reach 6 TDS Frequency Distribution

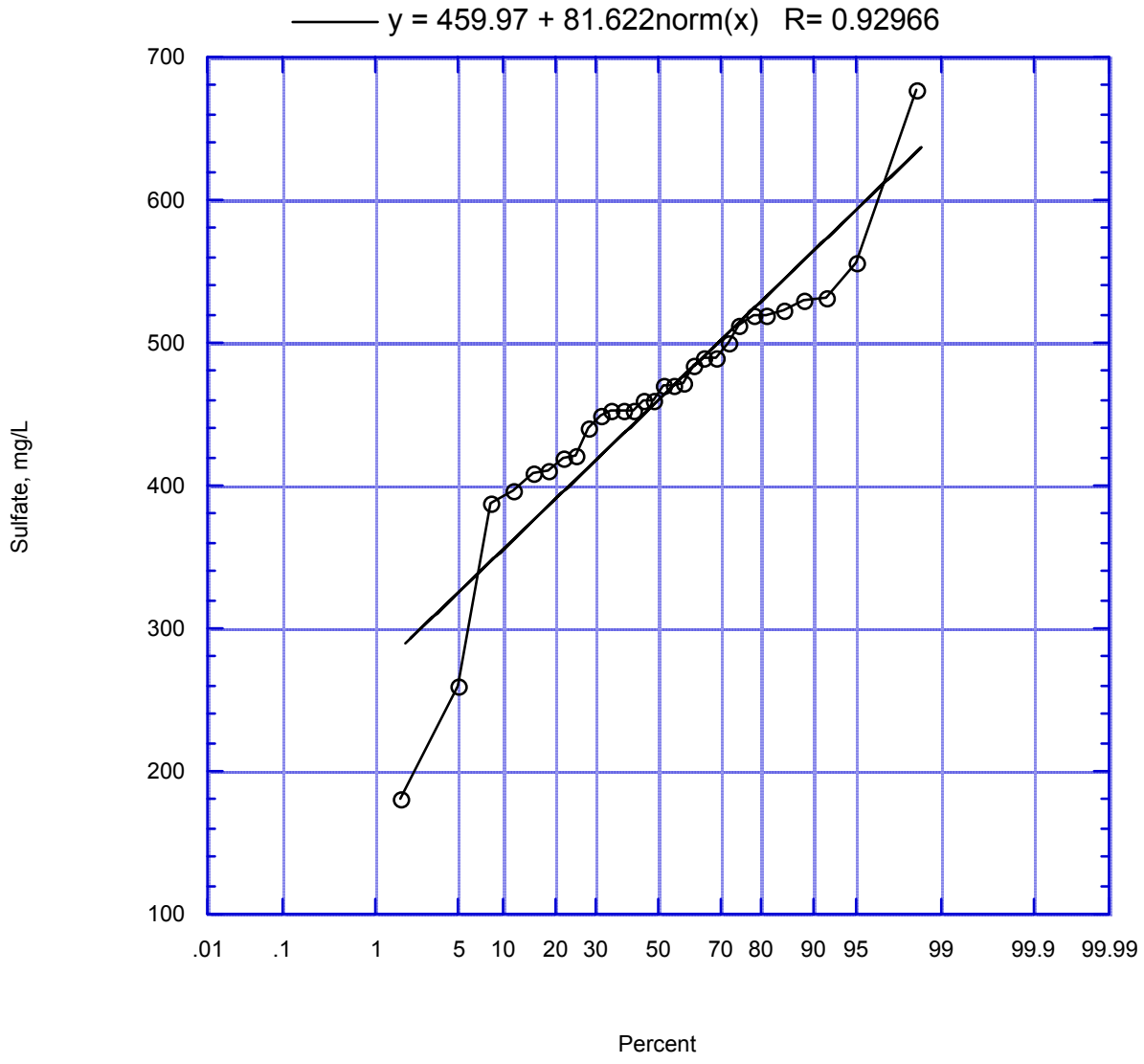


Figure 200. Reach 6 Sulfate Frequency Distribution

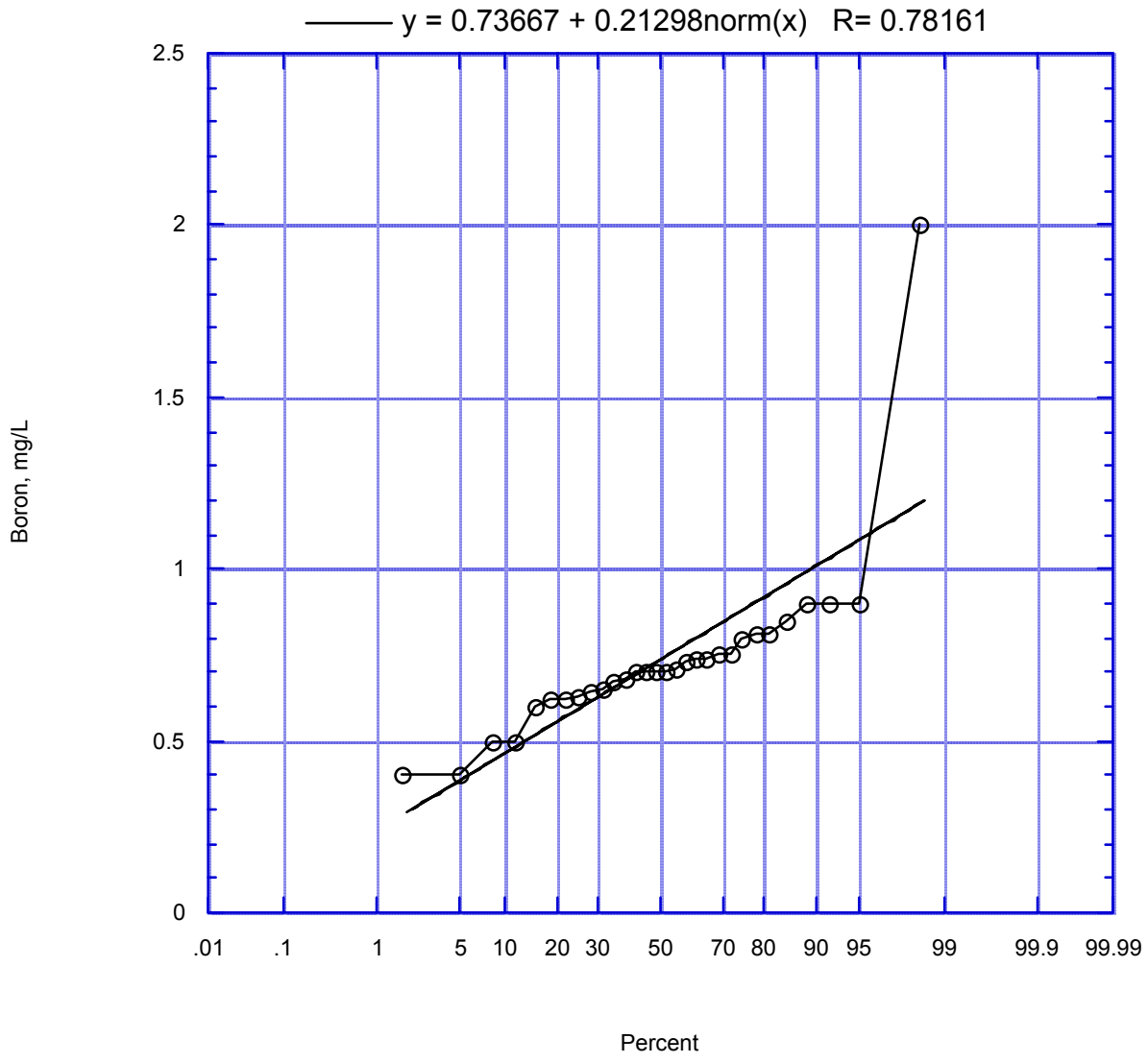


Figure 201. Reach 6 Boron Frequency Distribution

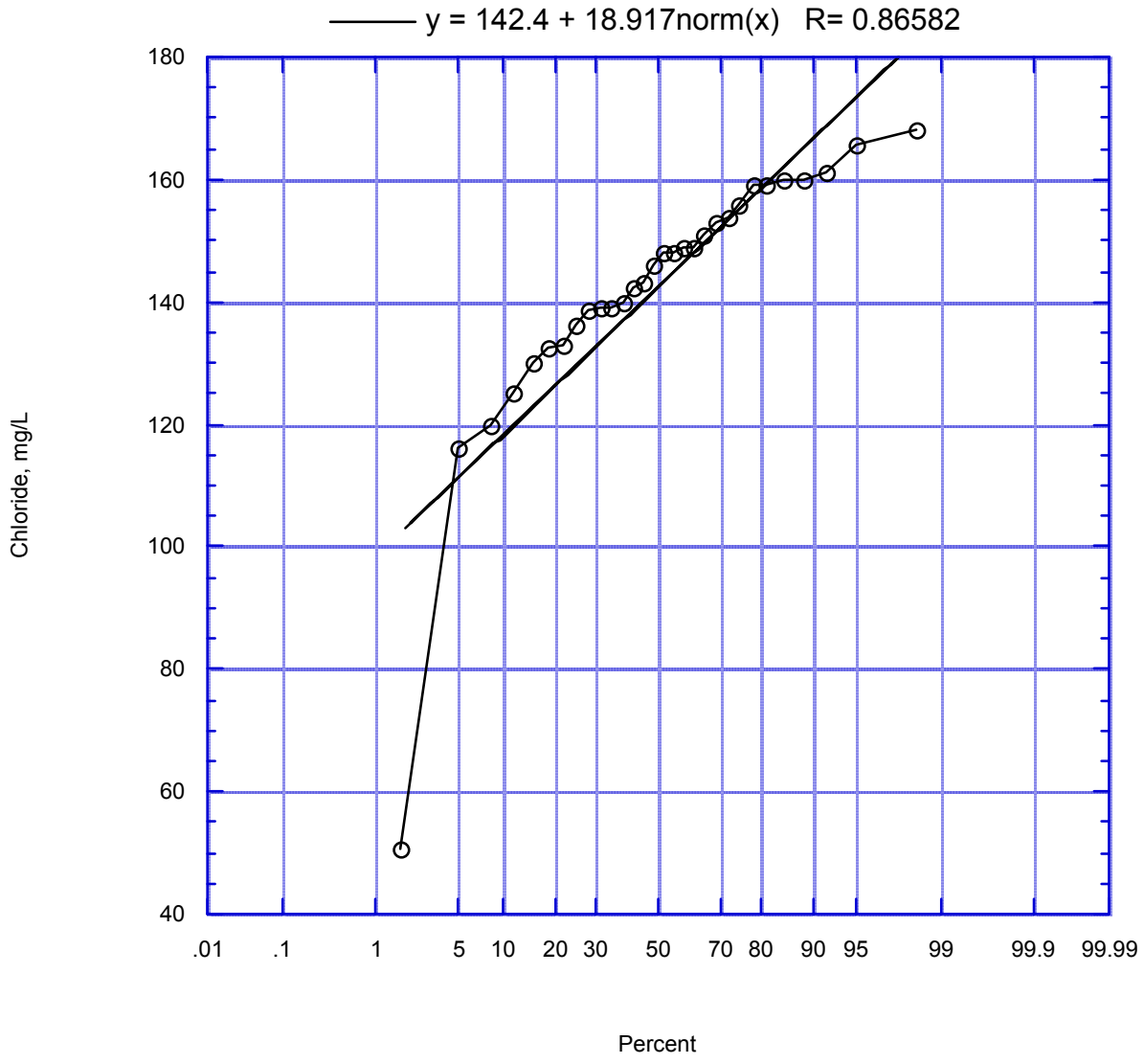


Figure 202. Reach 7 Chloride Frequency Distribution

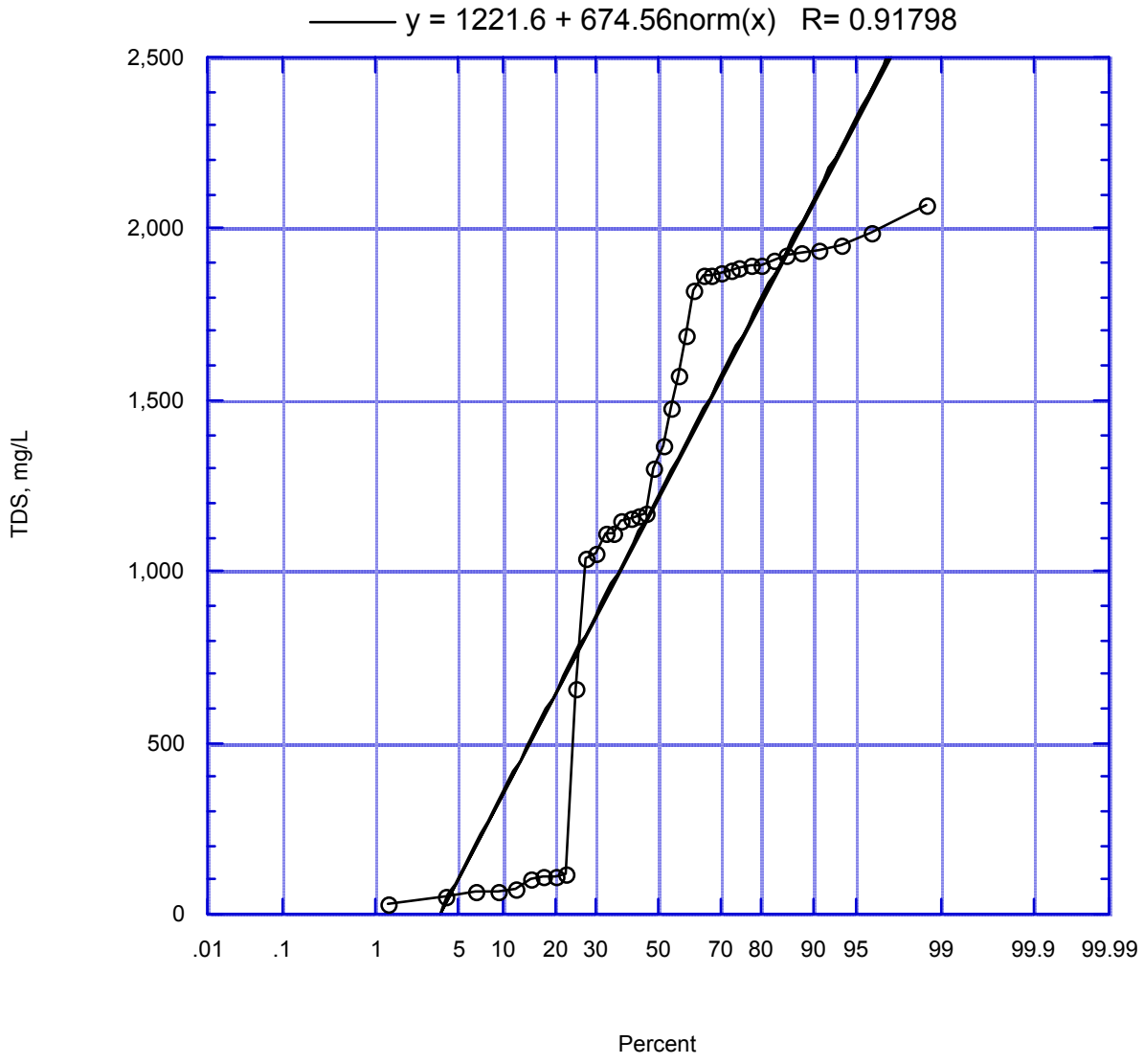


Figure 203. Reach 7 TDS Frequency Distribution

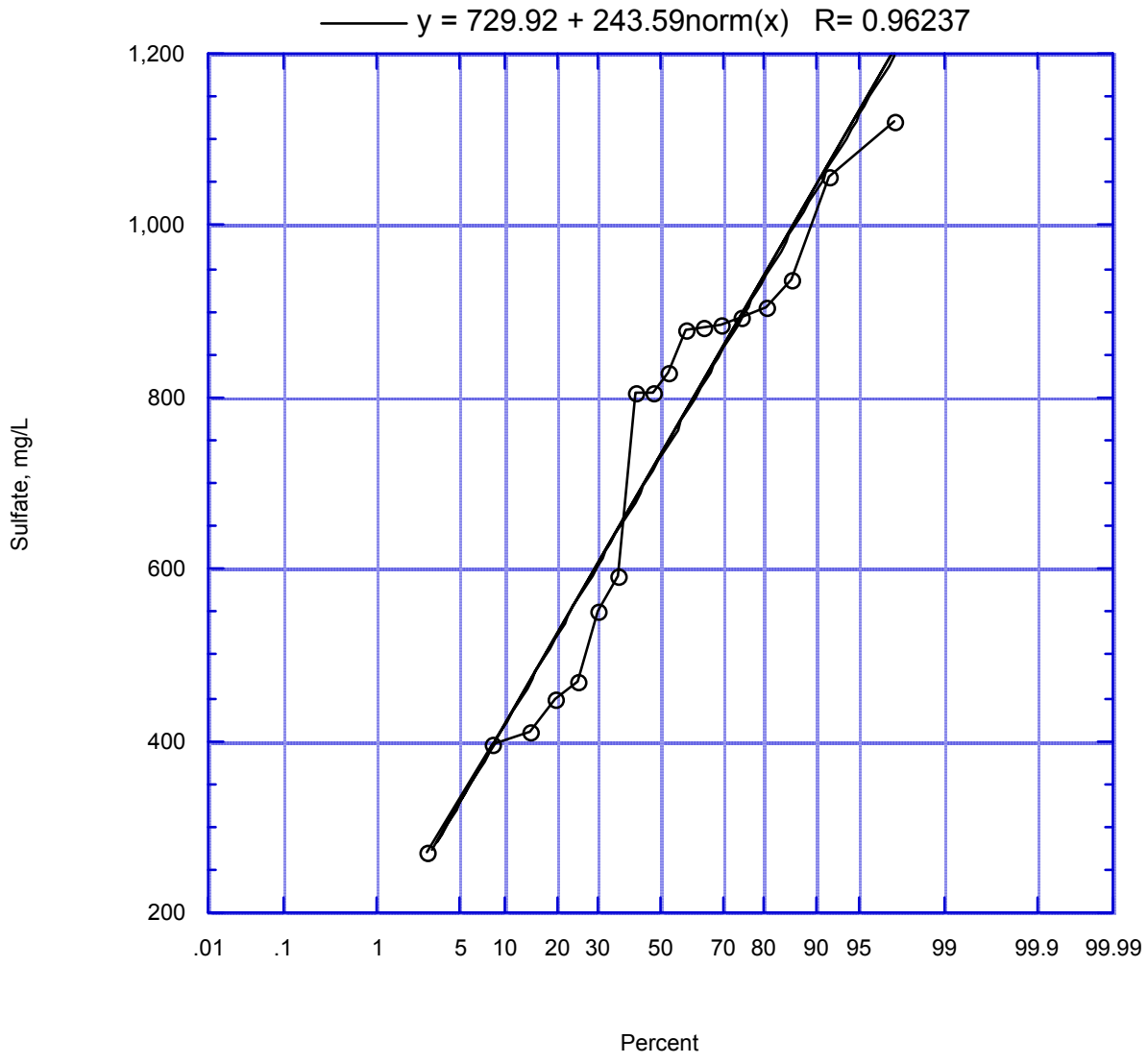


Figure 204. Reach 7 Sulfate Frequency Distribution

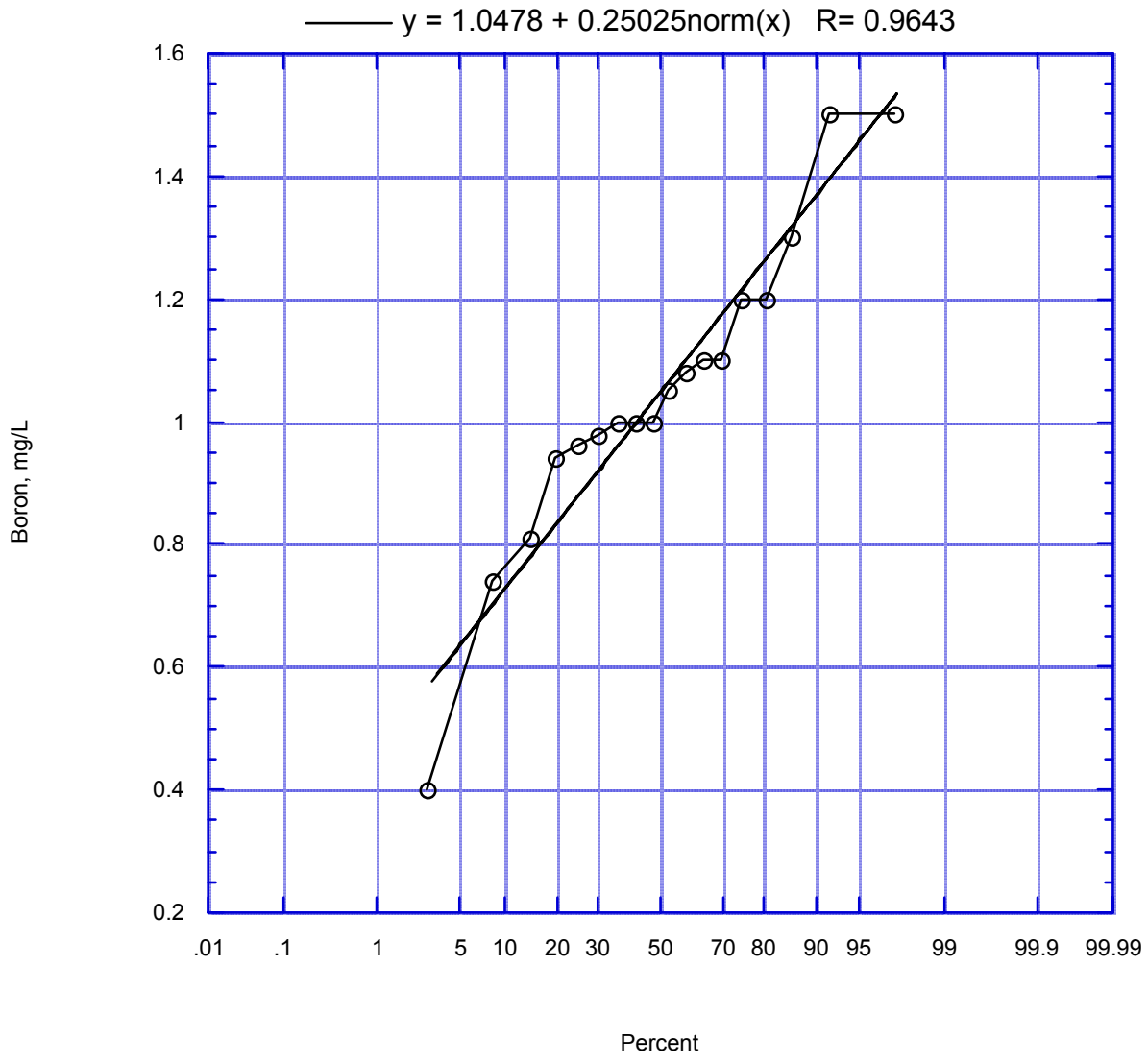


Figure 205. Reach 7 Boron Frequency Distribution

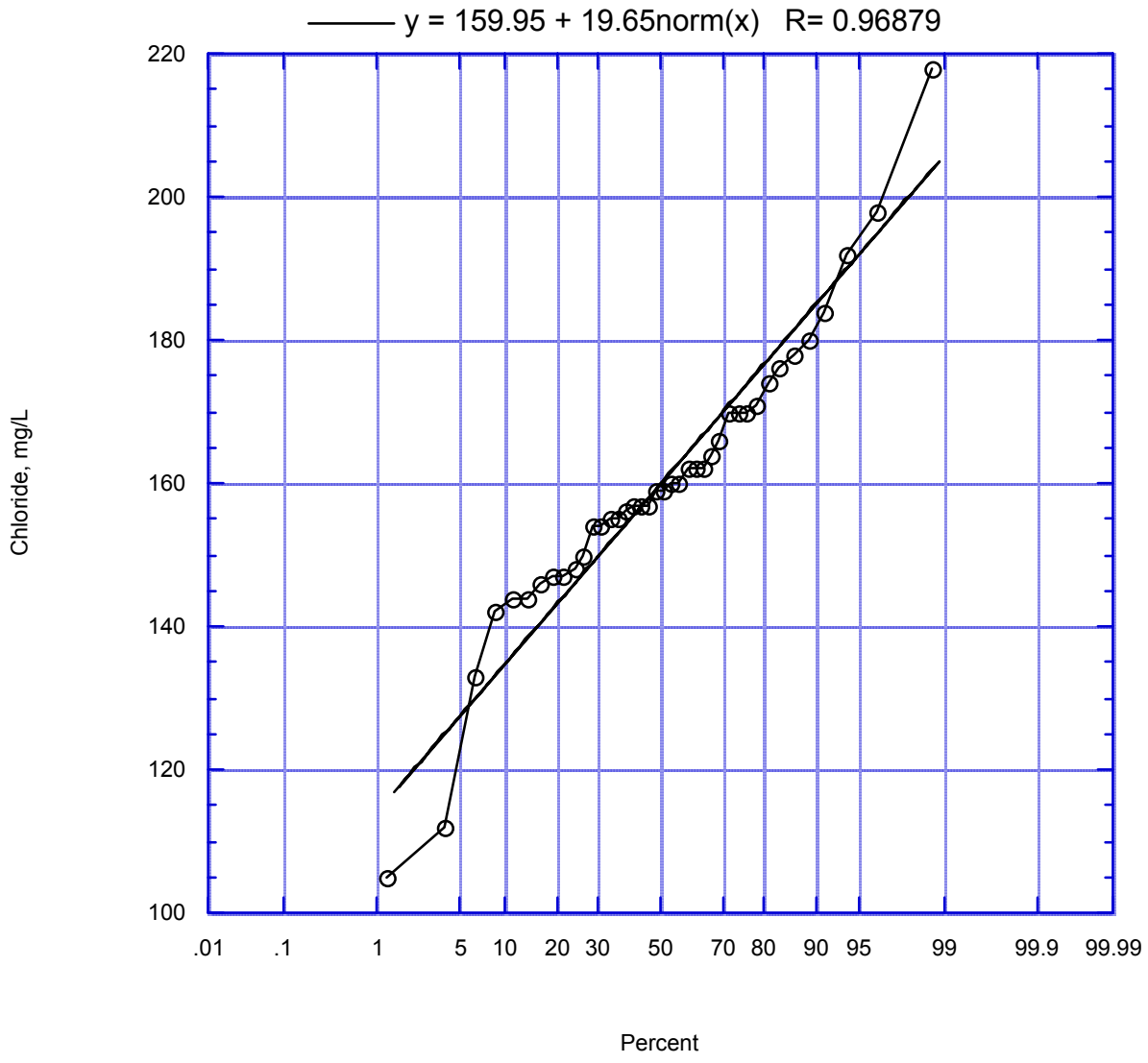


Figure 206. Reach 9A Chloride Frequency Distribution

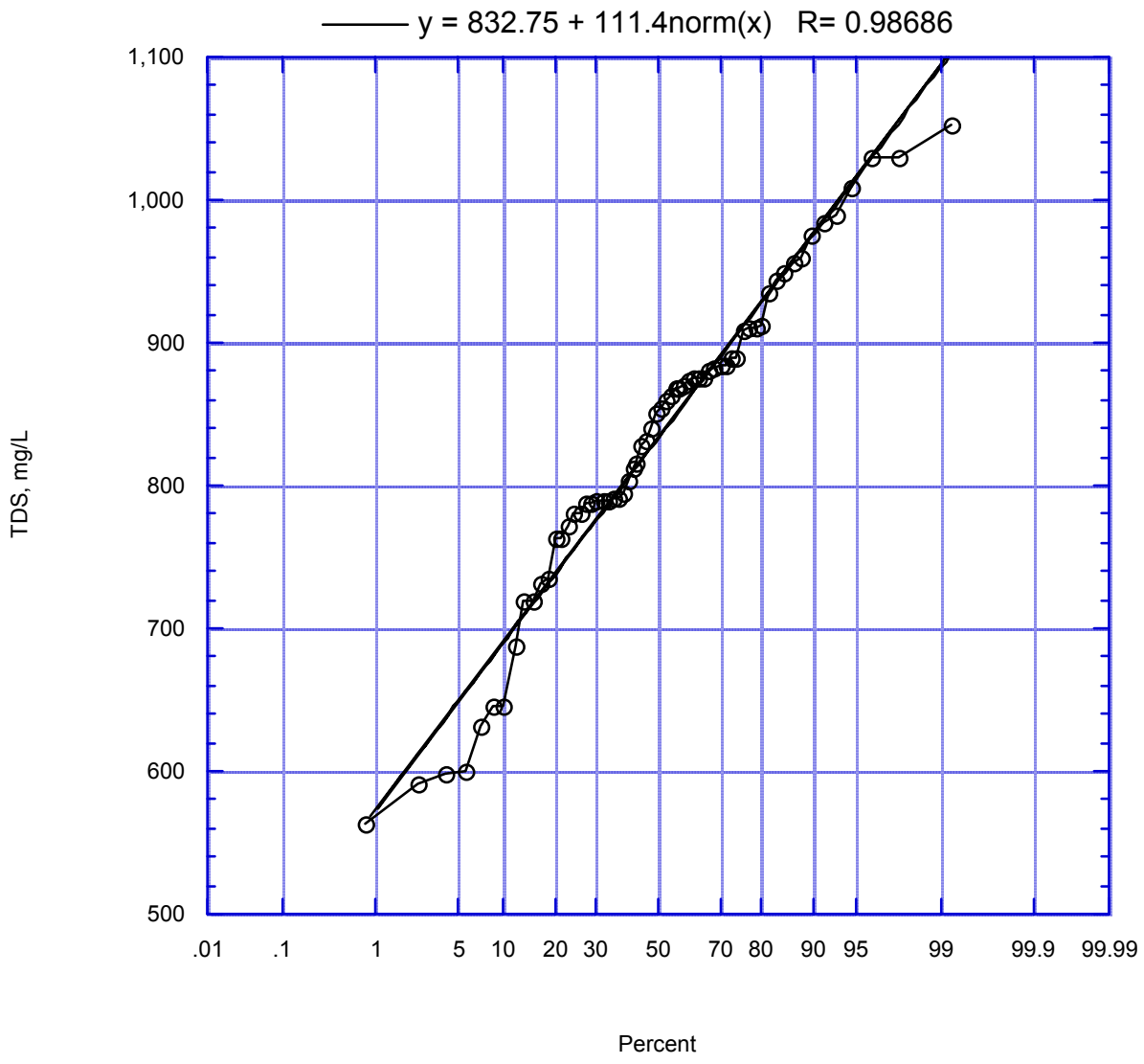


Figure 207. Reach 9A TDS Frequency Distribution

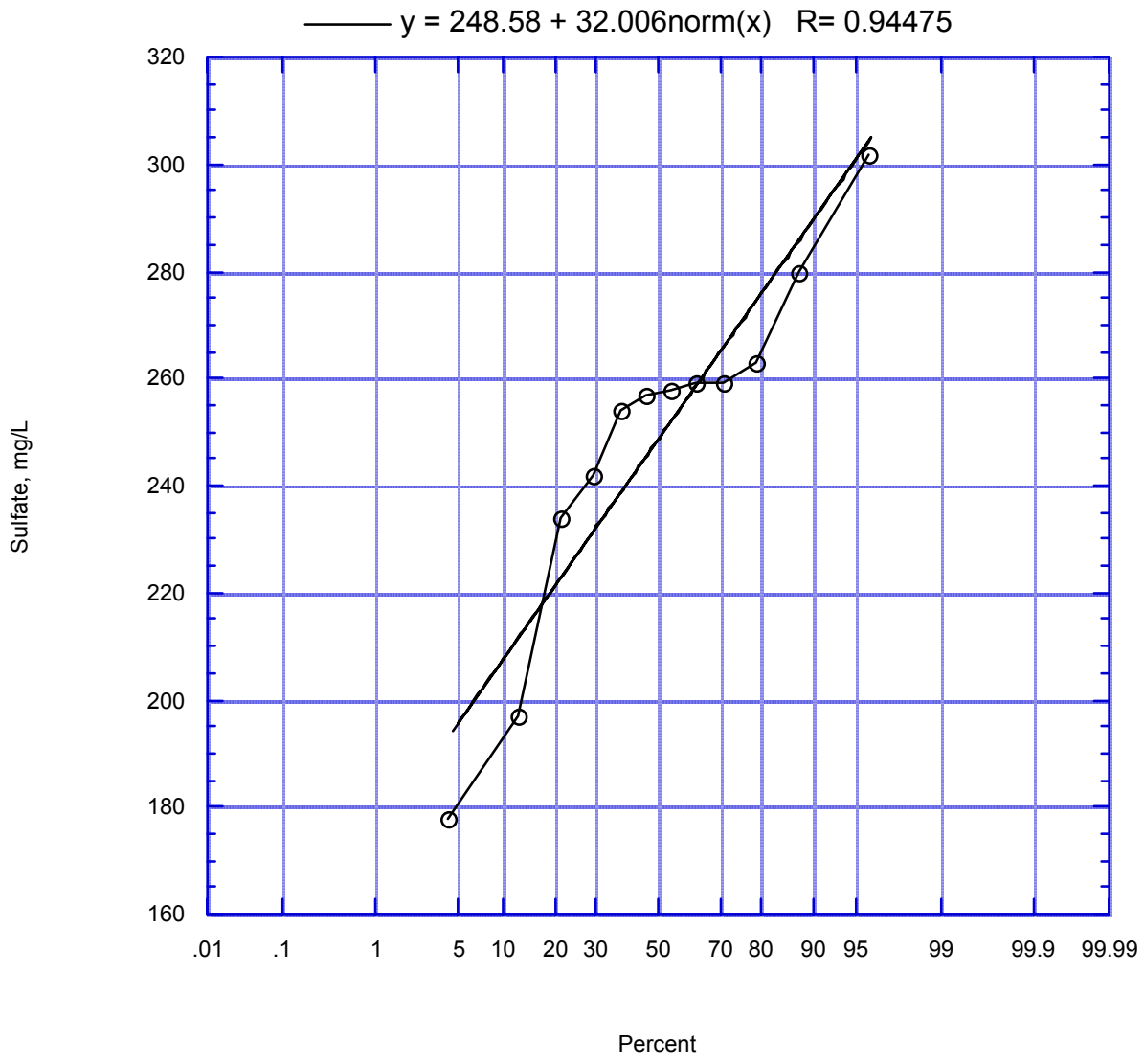


Figure 208. Reach 9A Sulfate Frequency Distribution

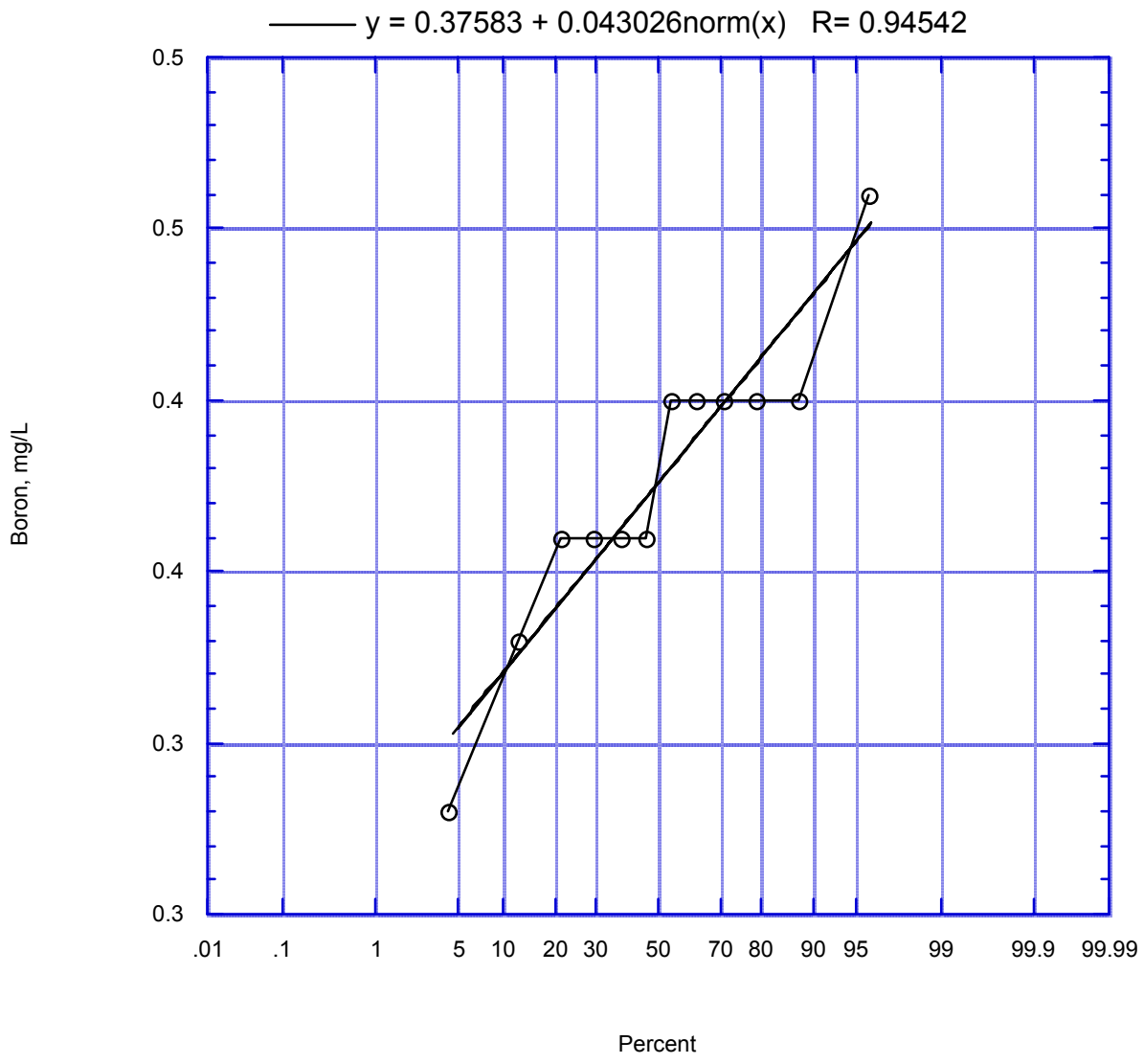


Figure 209. Reach 9A Boron Frequency Distribution

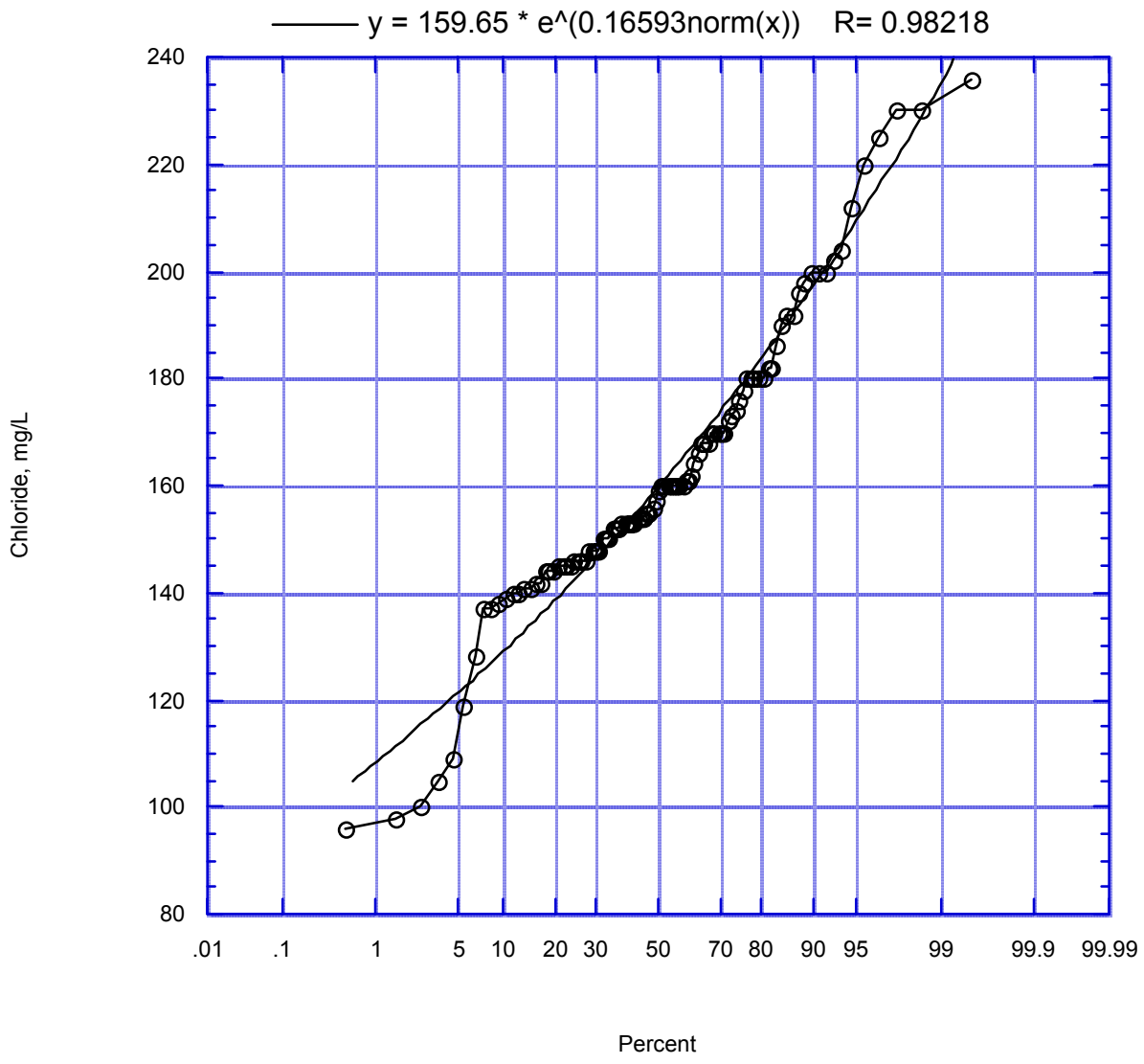


Figure 210. Reach 9B Chloride Frequency Distribution

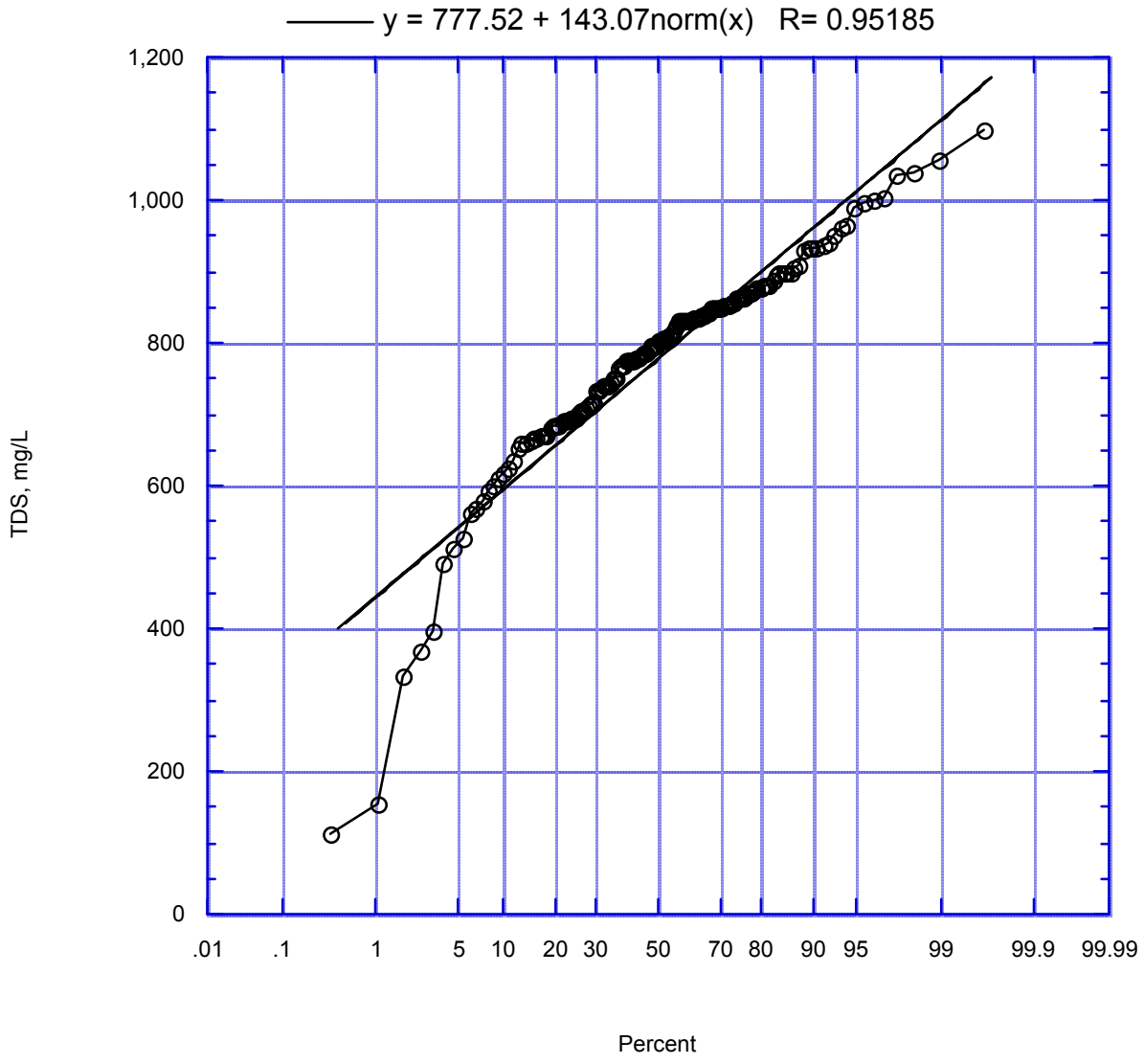


Figure 211. Reach 9B TDS Frequency Distribution

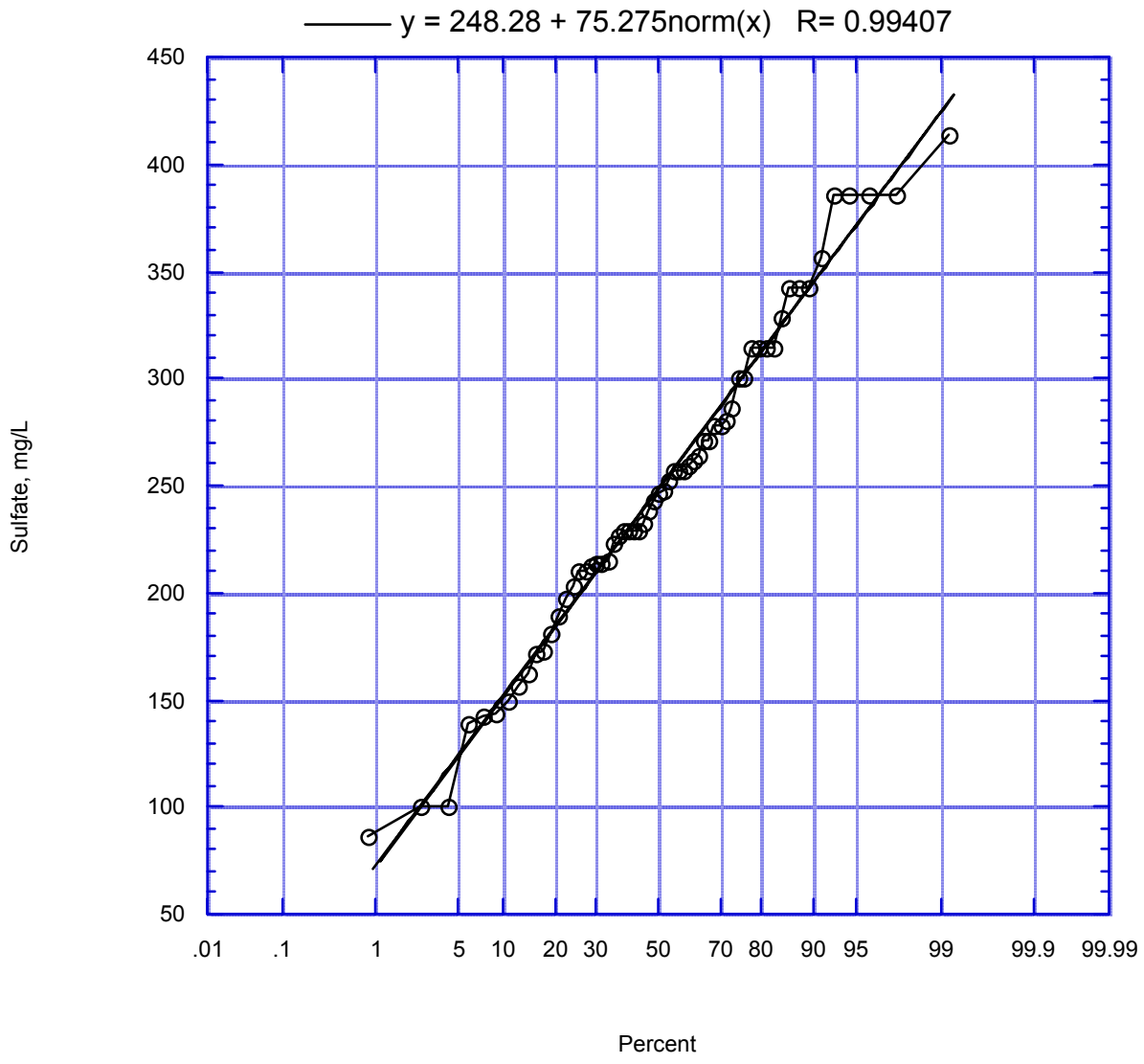


Figure 212. Reach 9B Sulfate Frequency Distribution

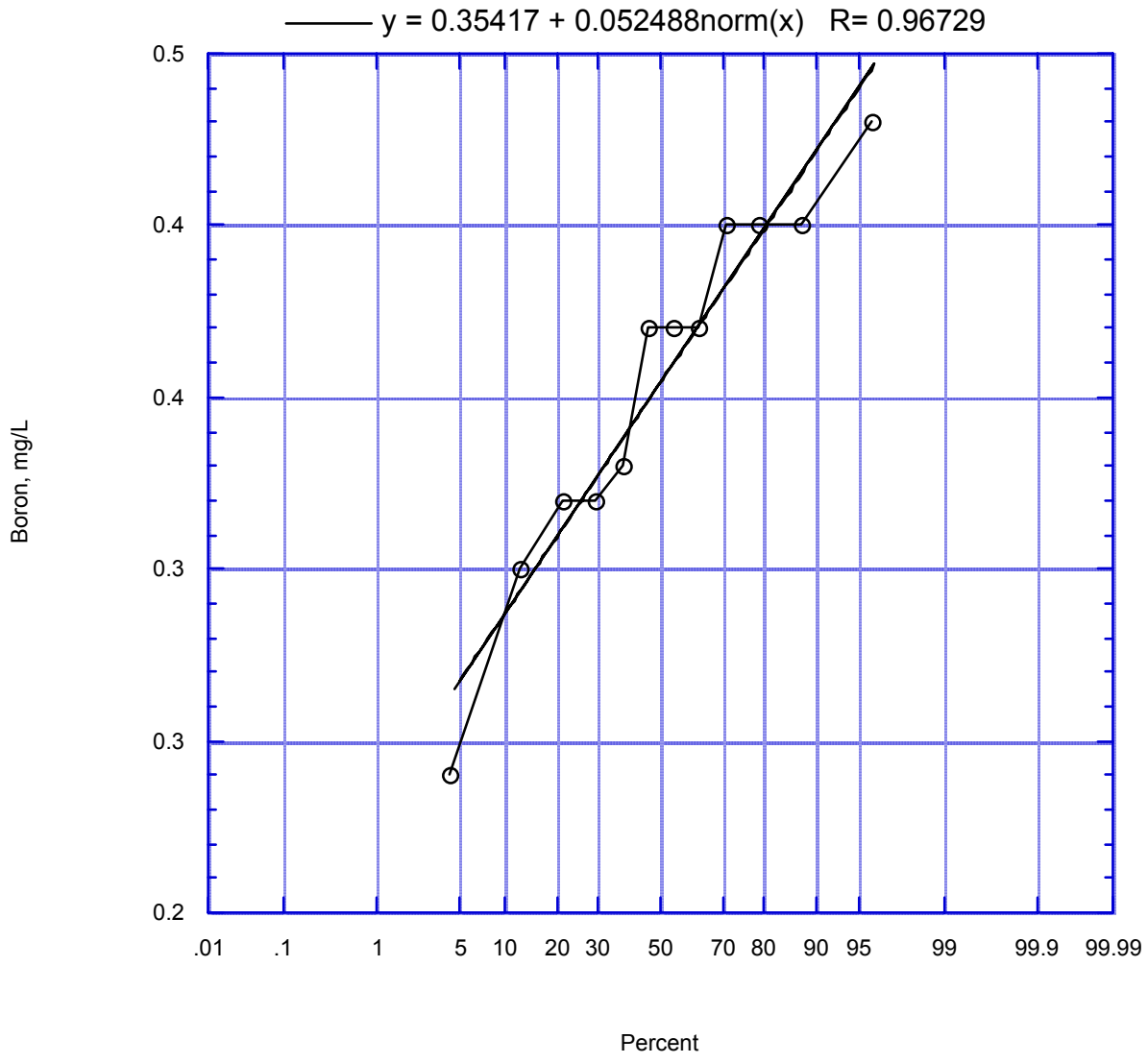


Figure 213. Reach 9B Boron Frequency Distribution

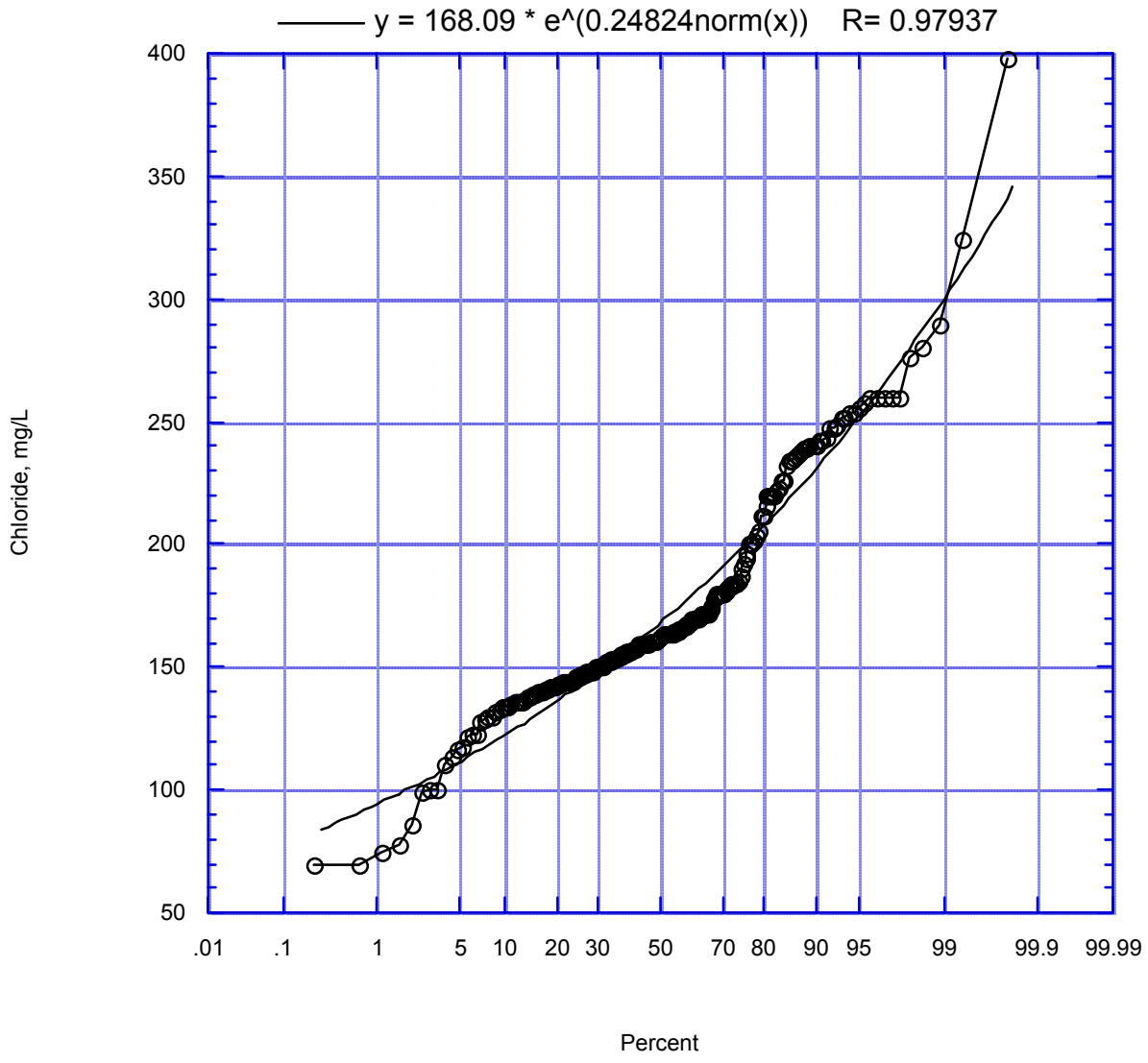
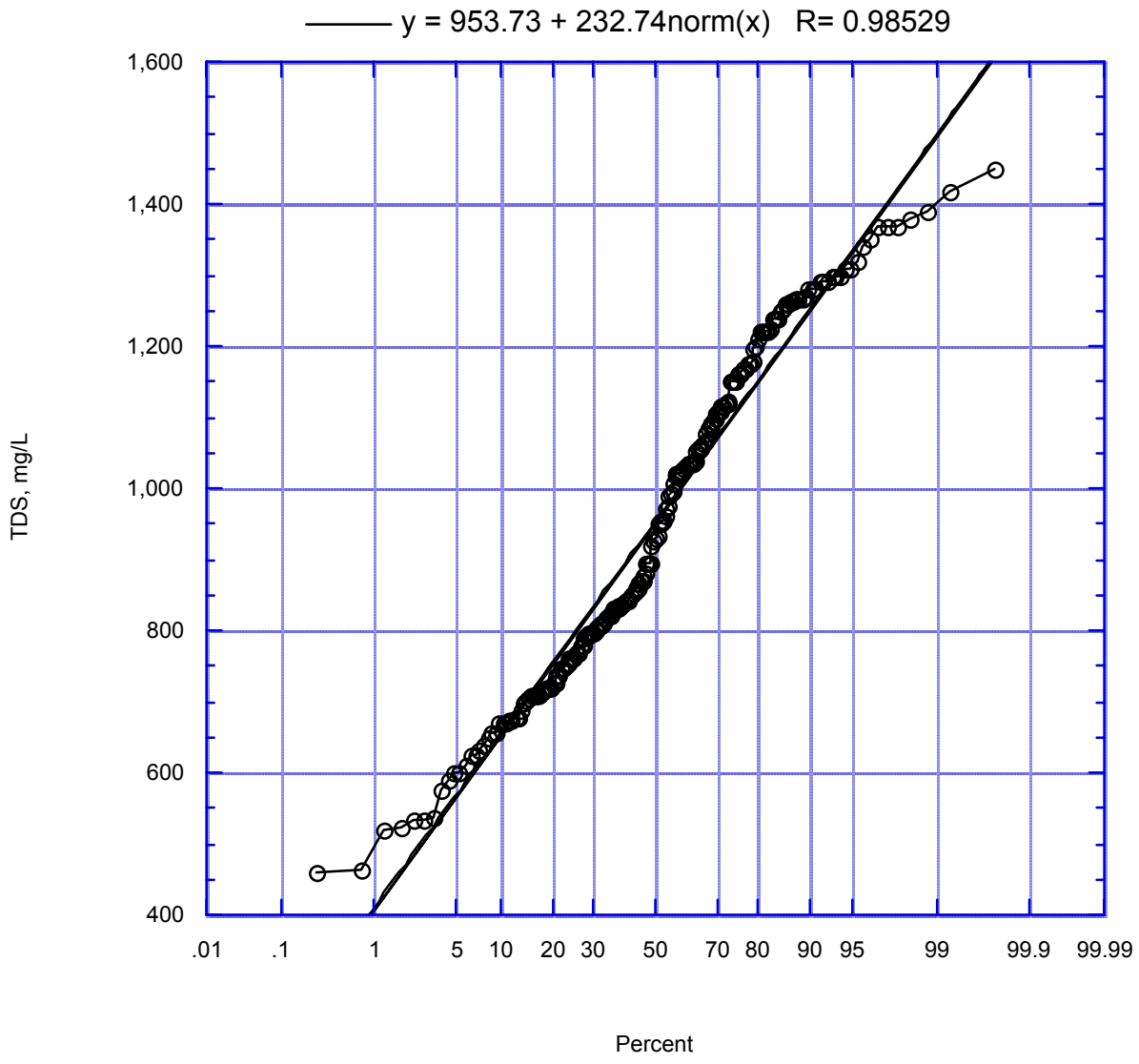
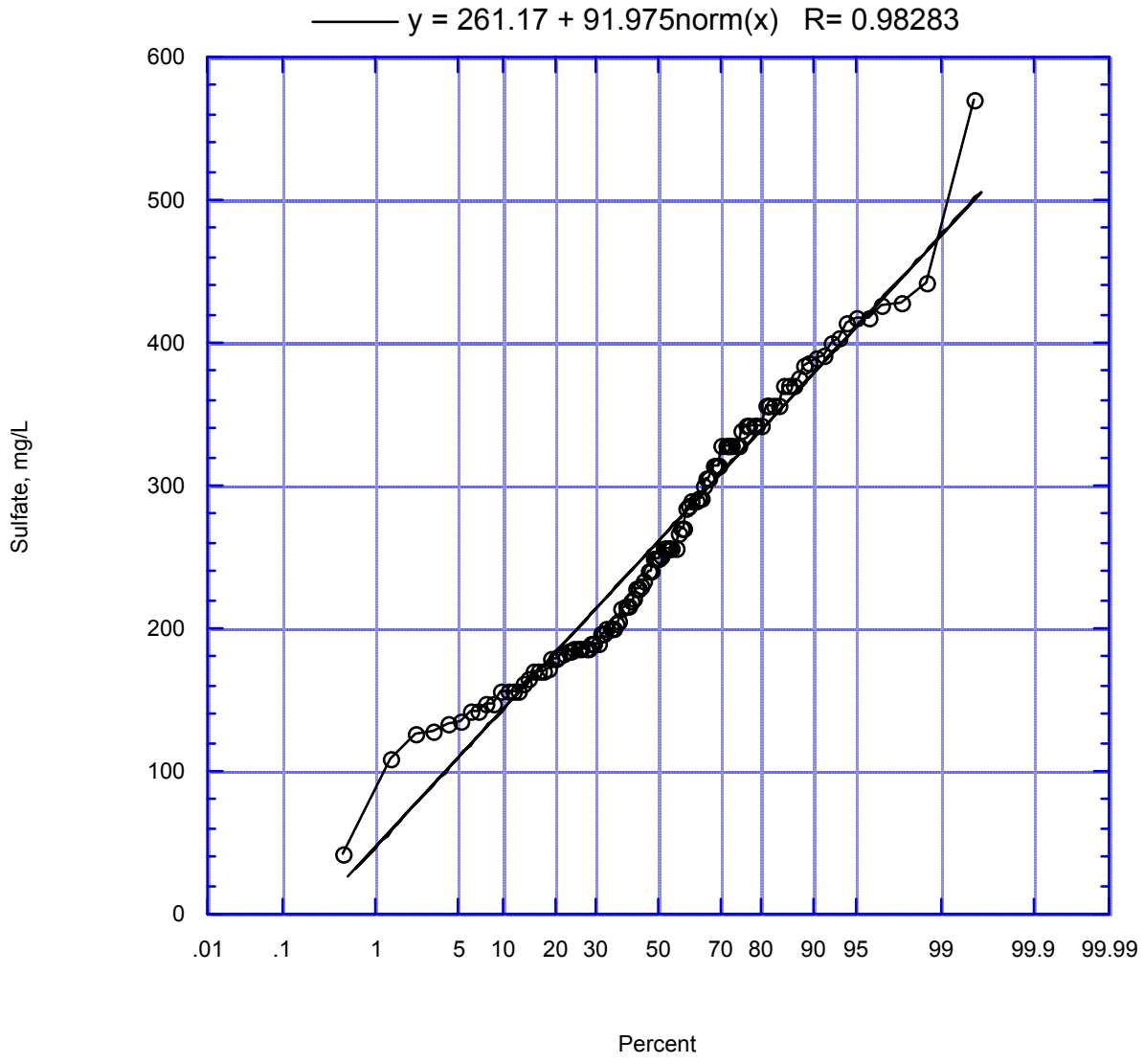


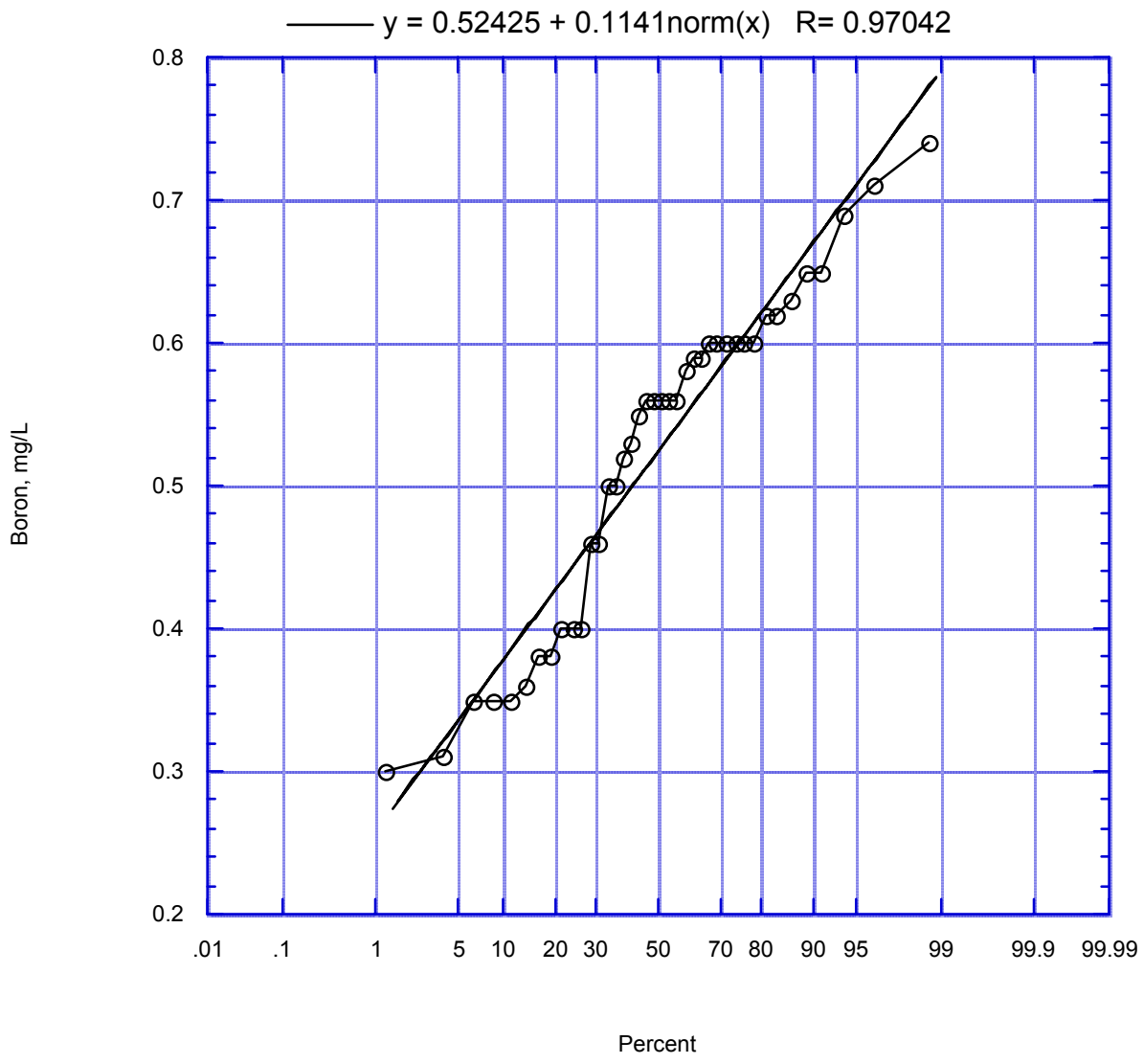
Figure 214. Reach 10 Chloride Frequency Distribution



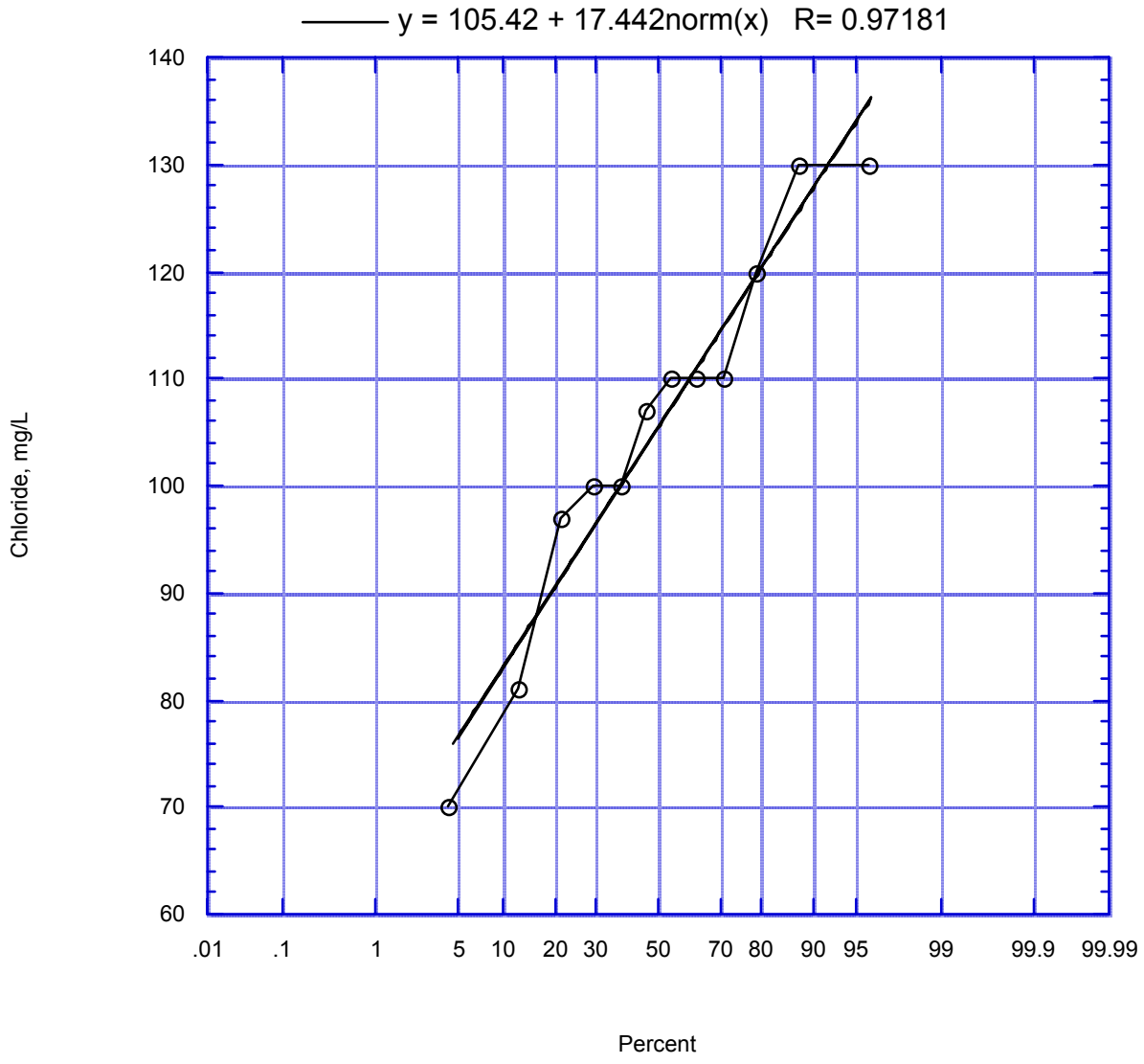
Fgure 215. Reach 10 TDS Frequency Distribution



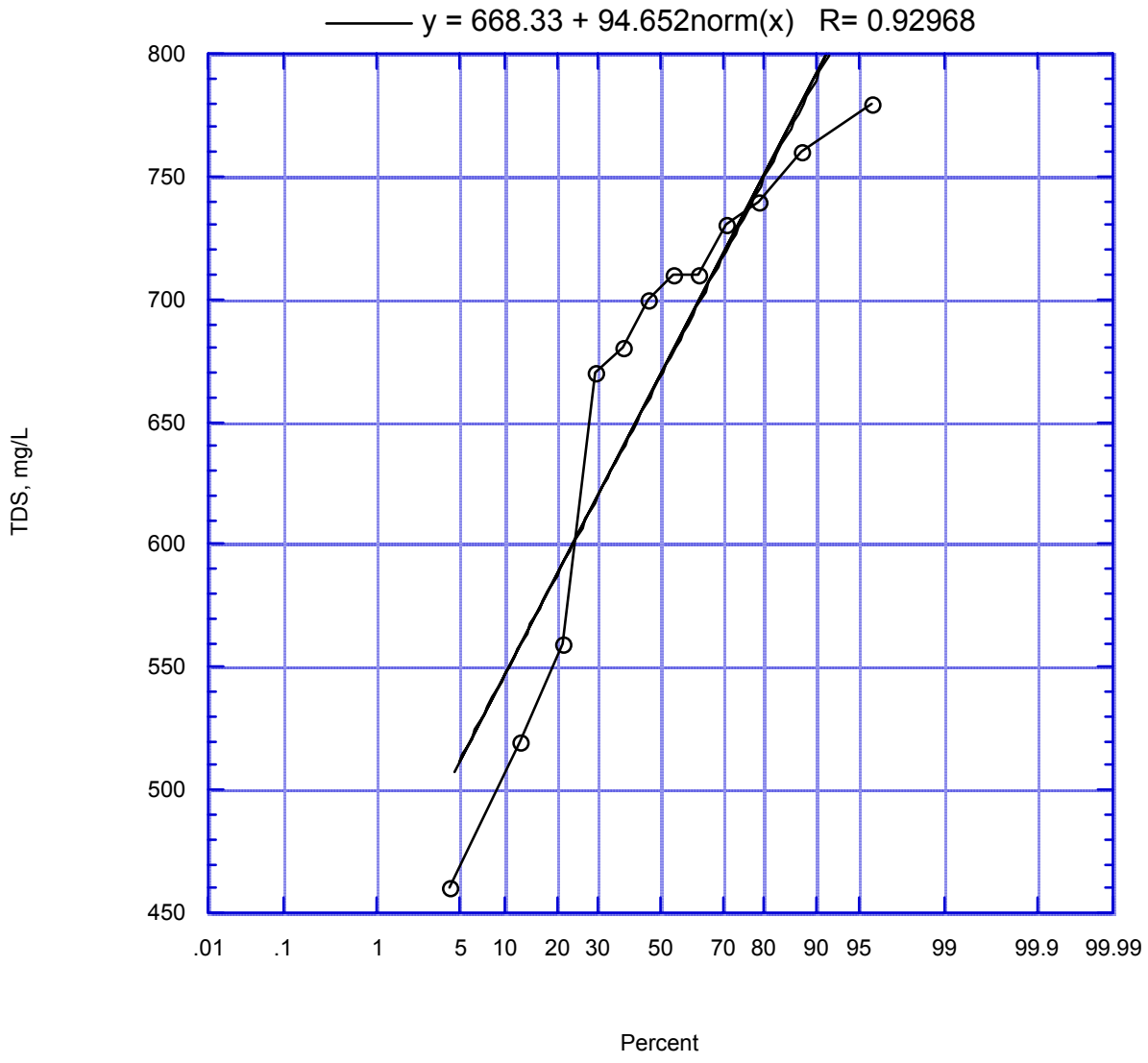
Fgure 216. Reach 10 Sulfate Frequency Distribution



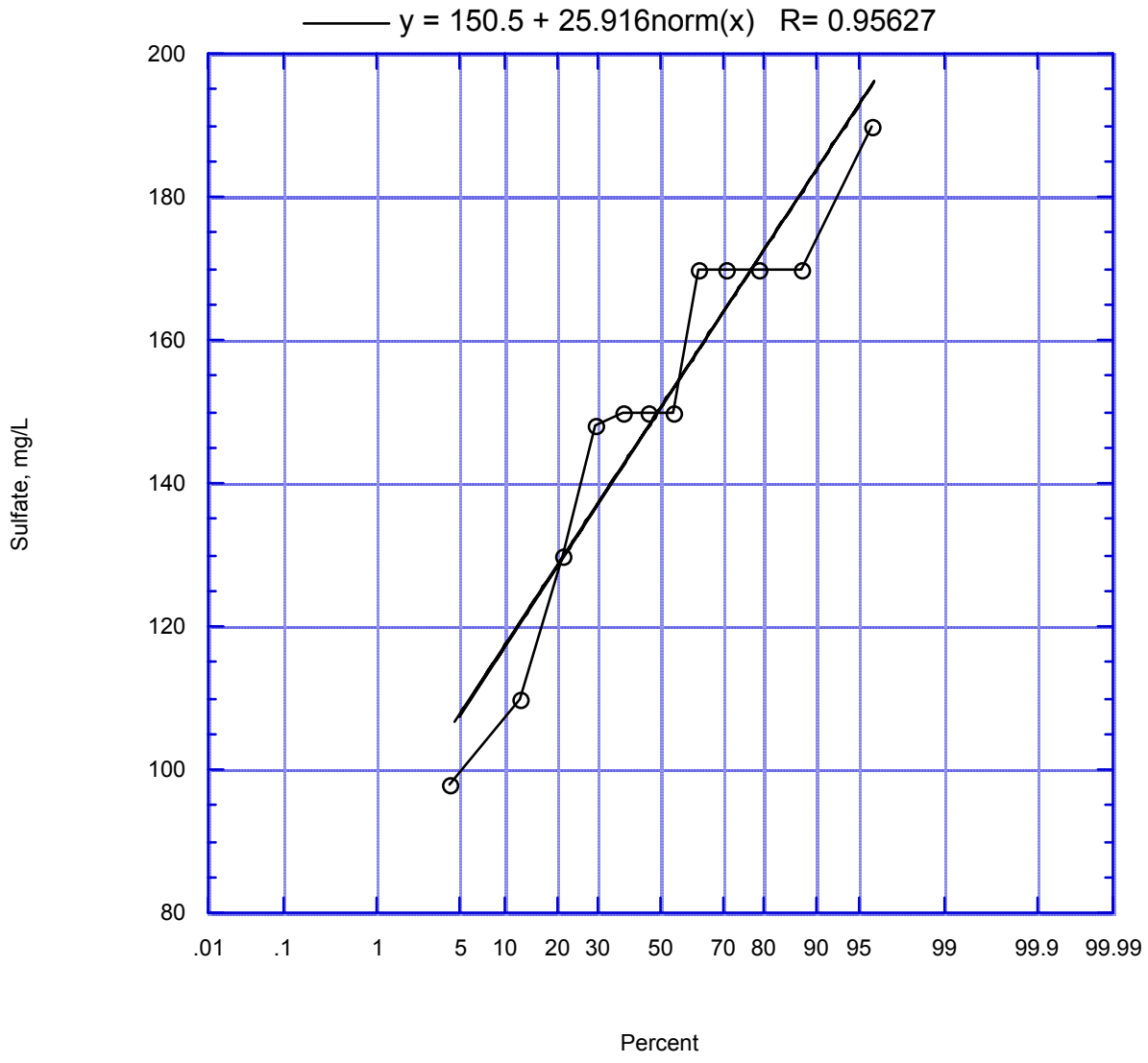
Fgure 217. Reach 10 Boron Frequency Distribution



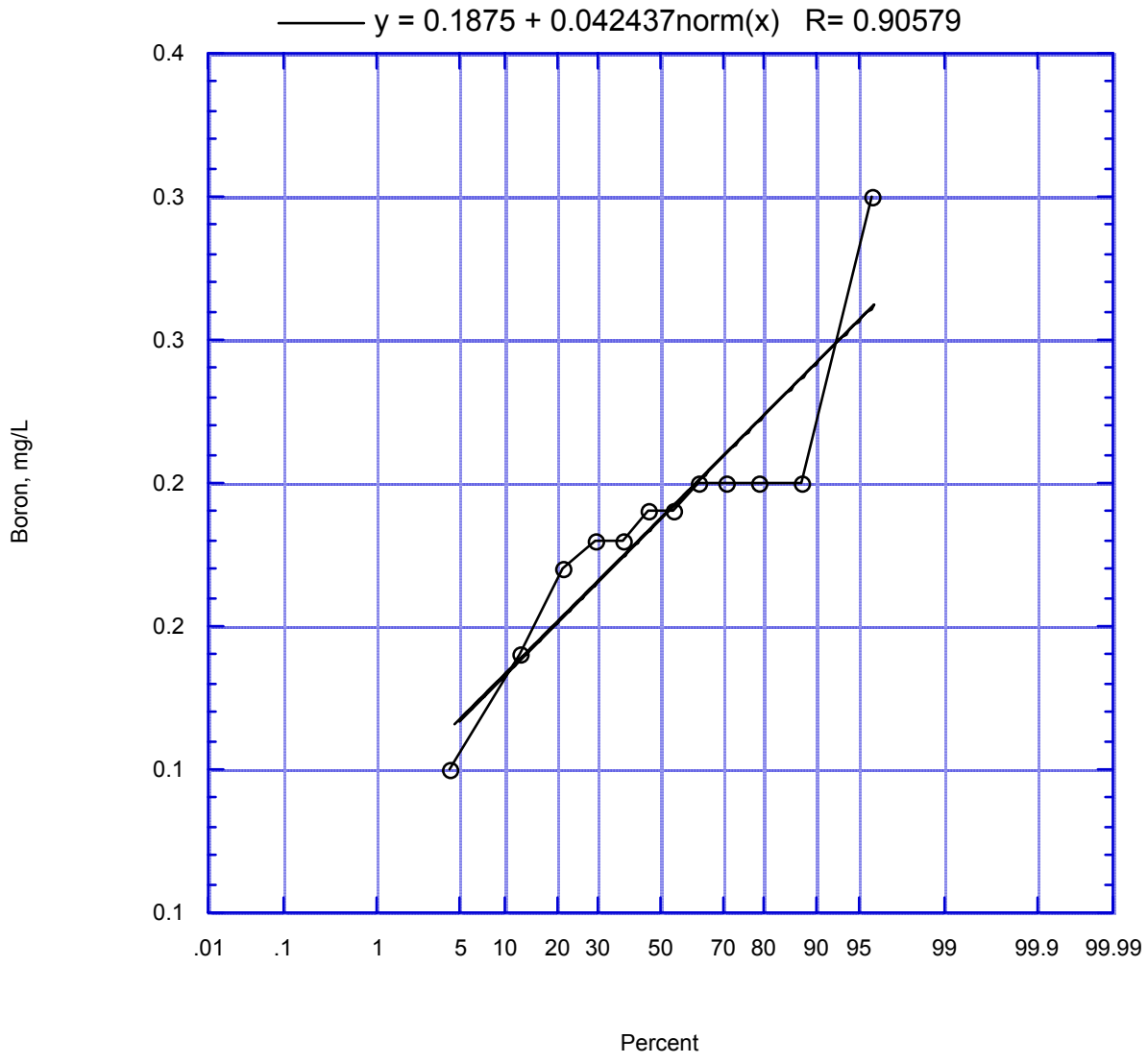
Fgure 218. Reach 11 Chloride Frequency Distribution



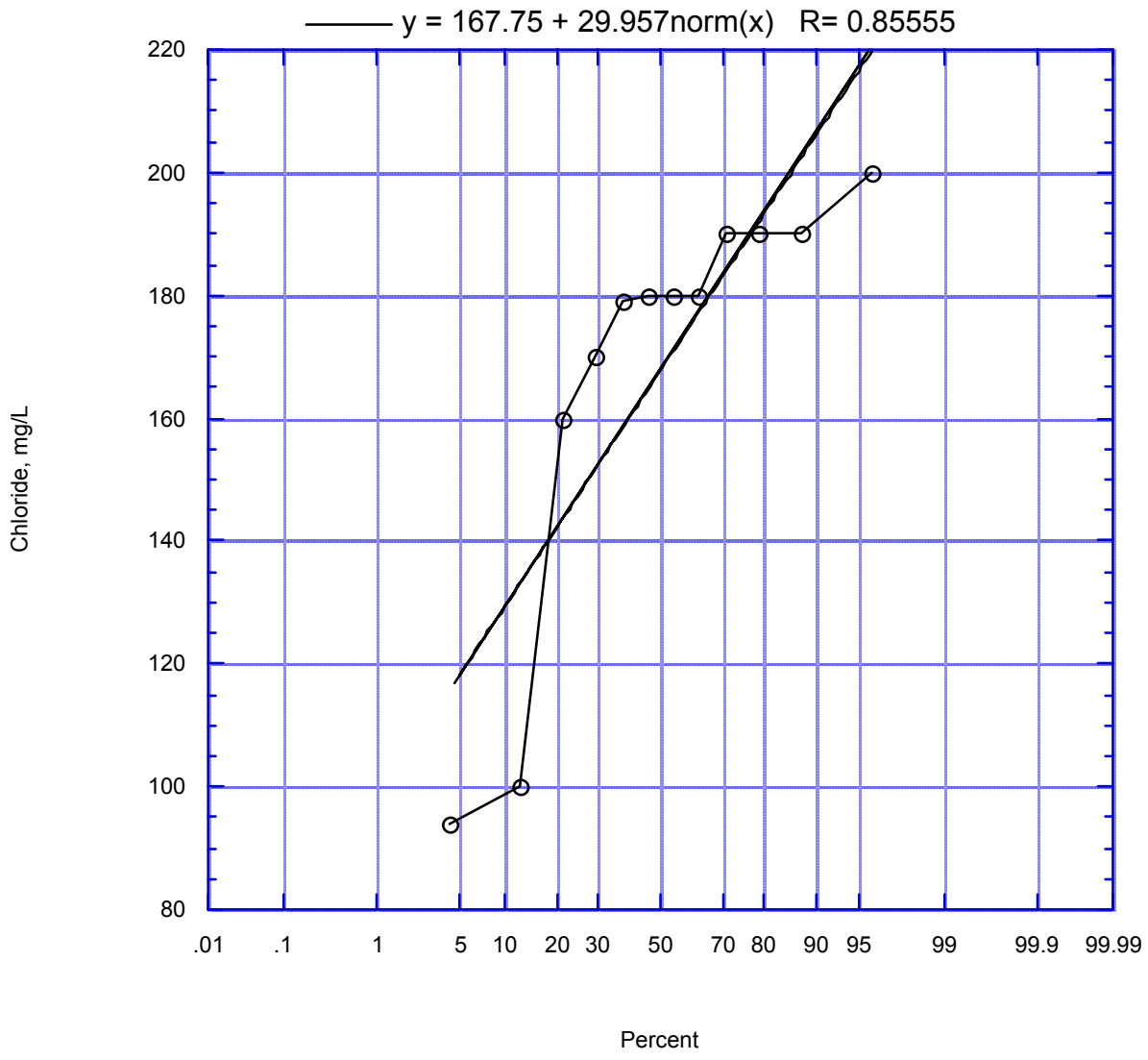
Fgure 219. Reach 11 TDS Frequency Distribution



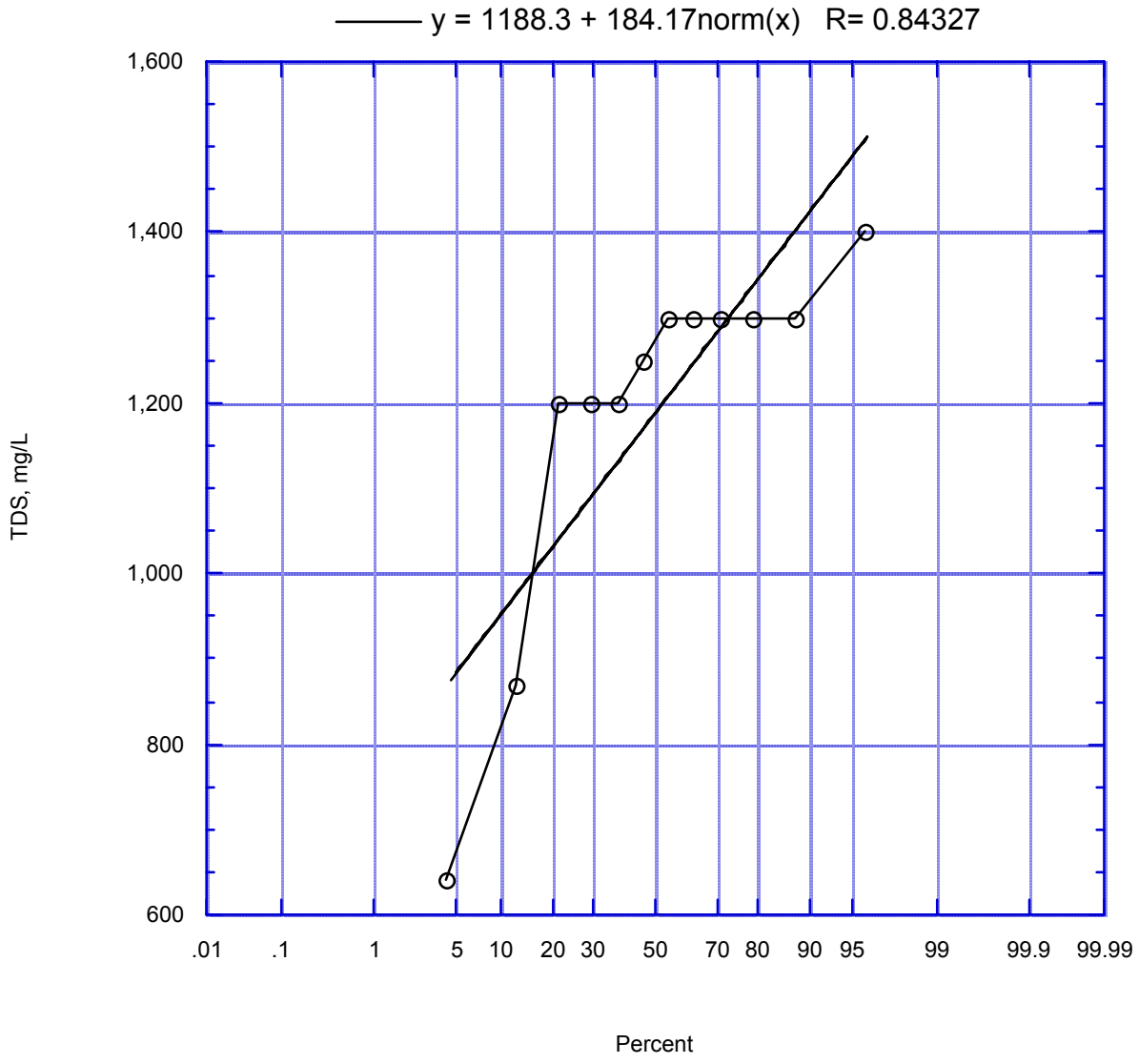
Fgure 220. Reach 11 Sulfate Frequency Distribution



Fgure 221. Reach 11 Boron Frequency Distribution



Fgure 222. Reach 13 Chloride Frequency Distribution



Fgure 223. Reach 13 TDS Frequency Distribution

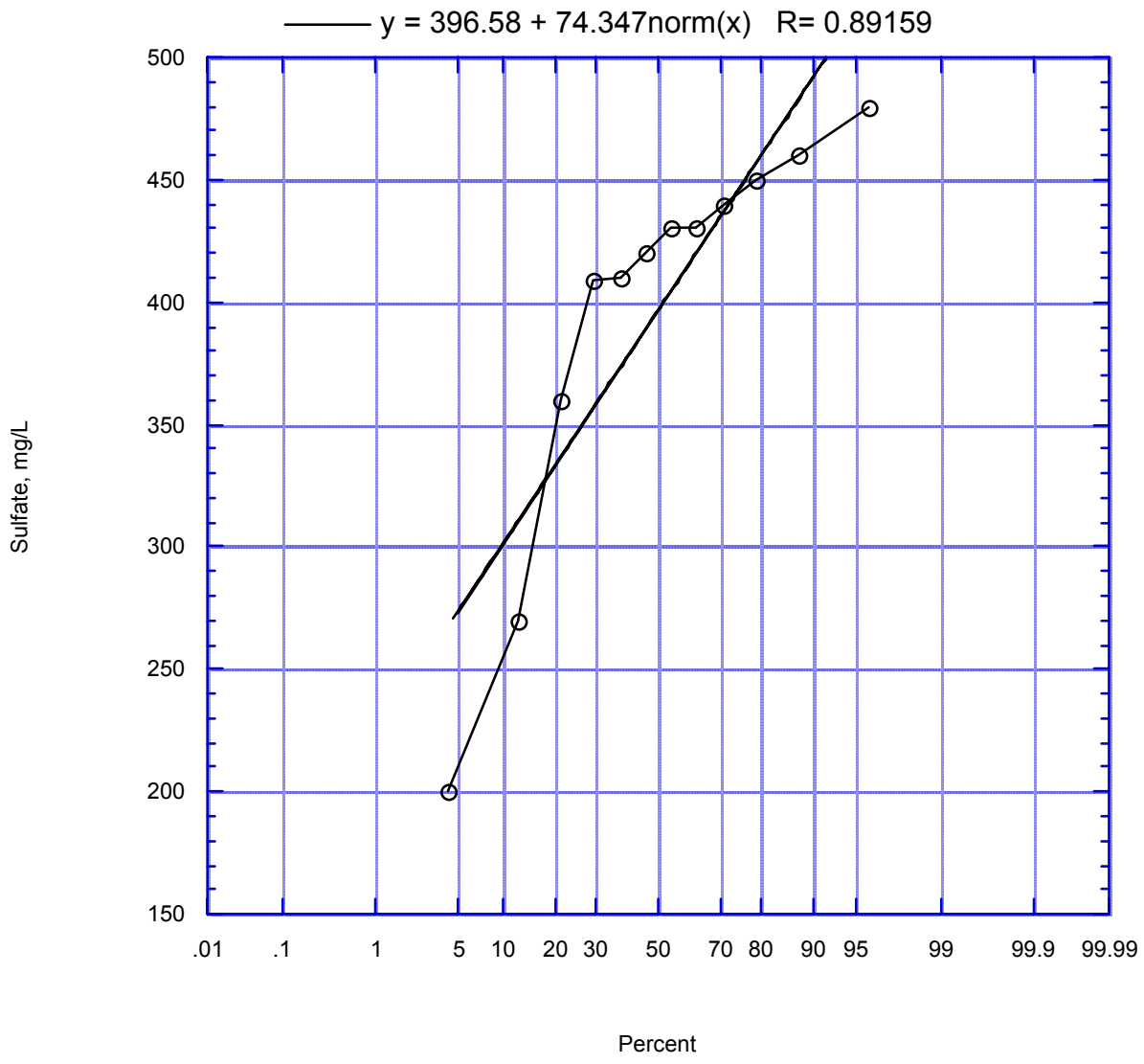


Figure 224. Reach 13 Sulfate Frequency Distribution

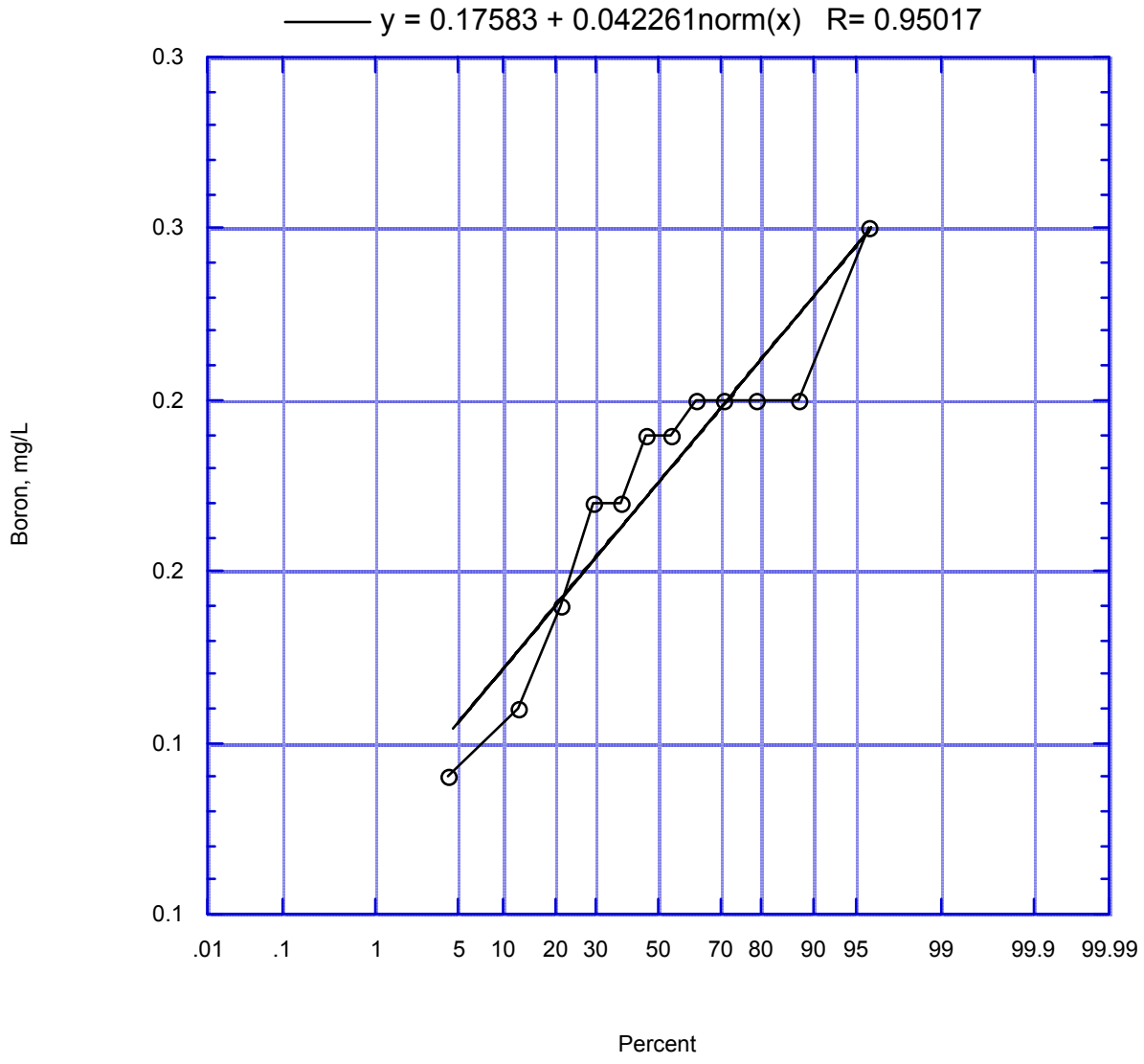


Figure 225. Reach 13 Boron Frequency Distribution

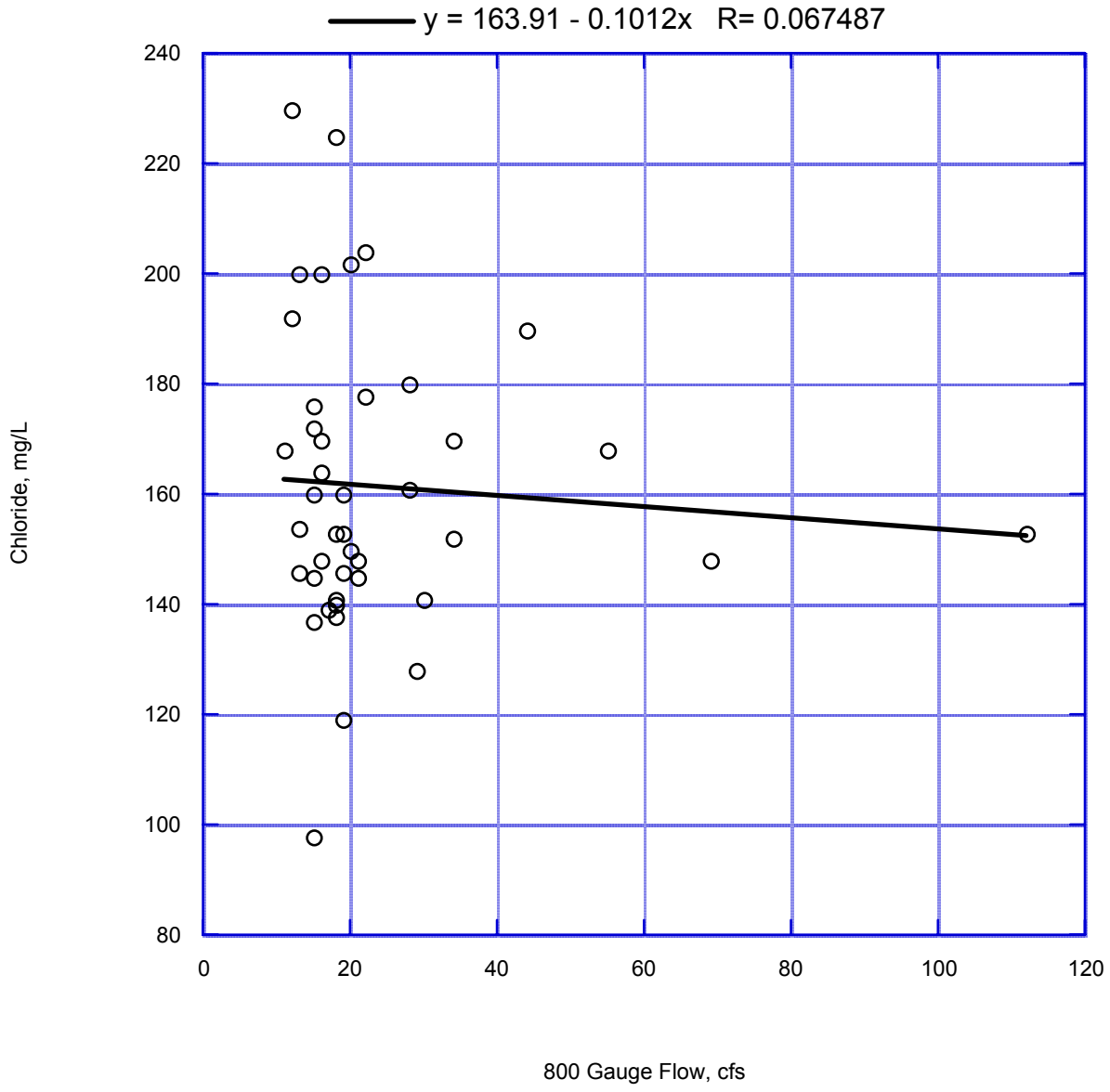


Figure 226. Chloride vs. Stream Flow at Gauge 800

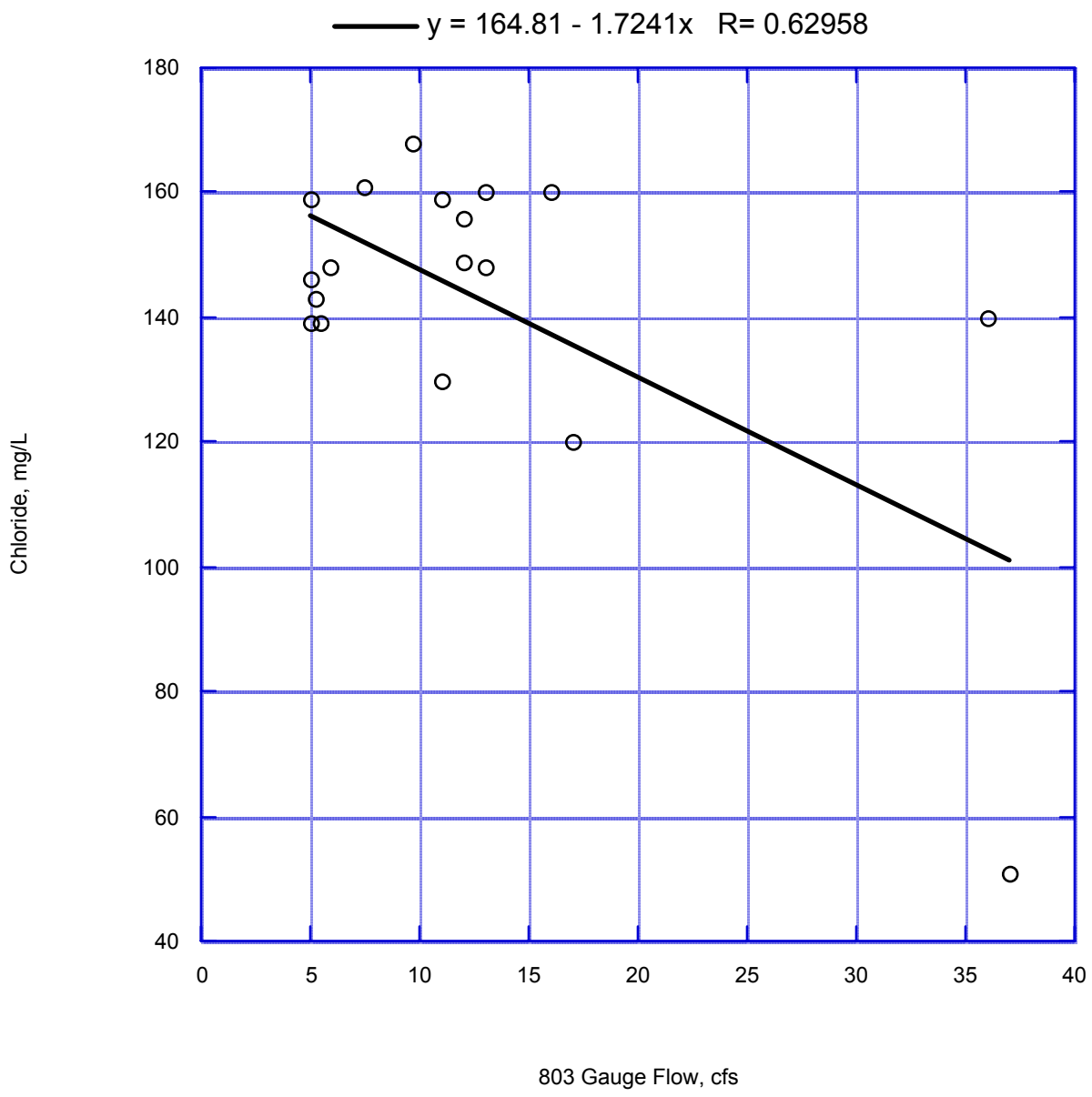


Figure 227. Chloride vs. Stream Flow at Gauge 803

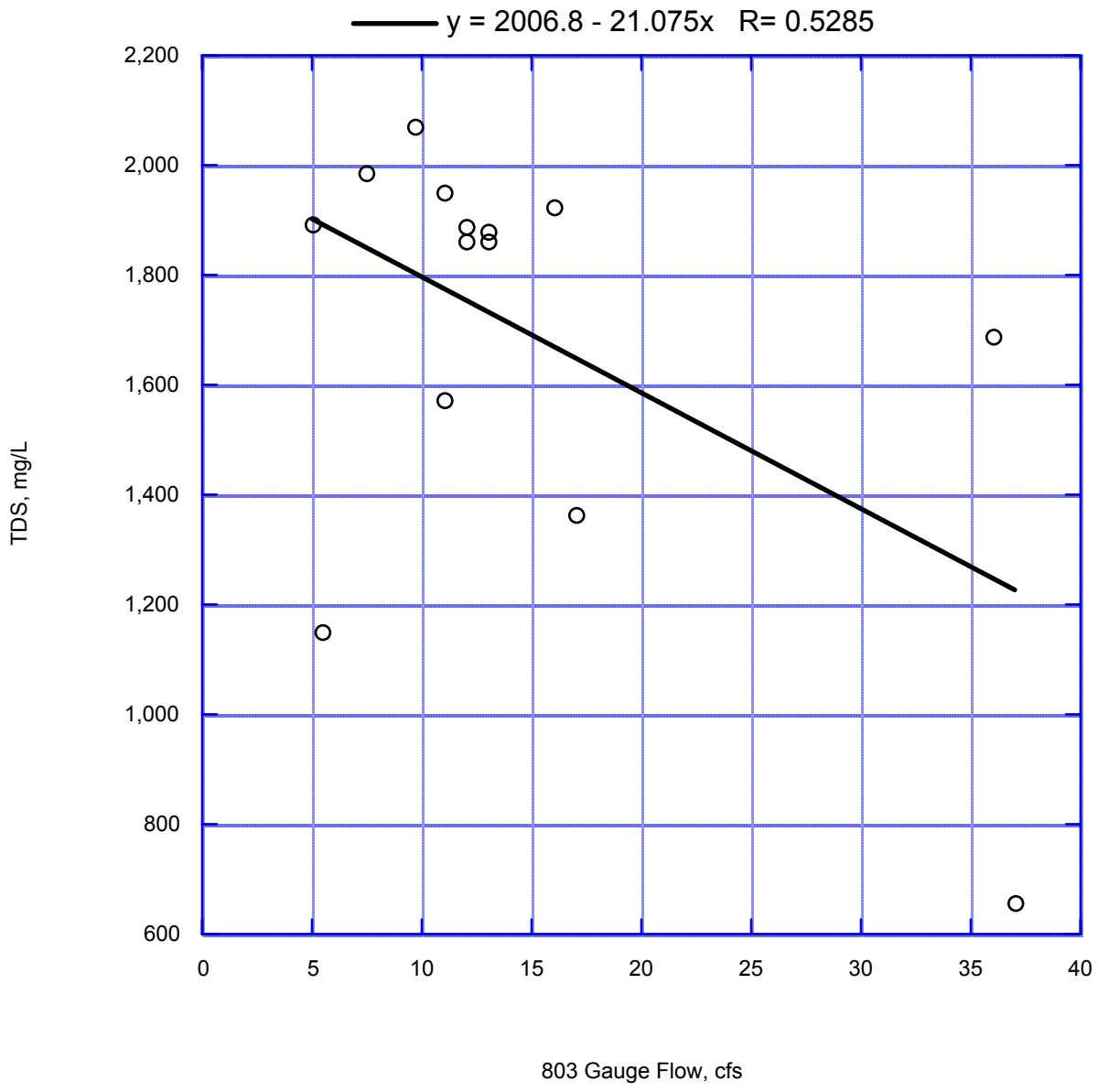


Figure 228. TDS vs. Stream Flow at Gauge 803

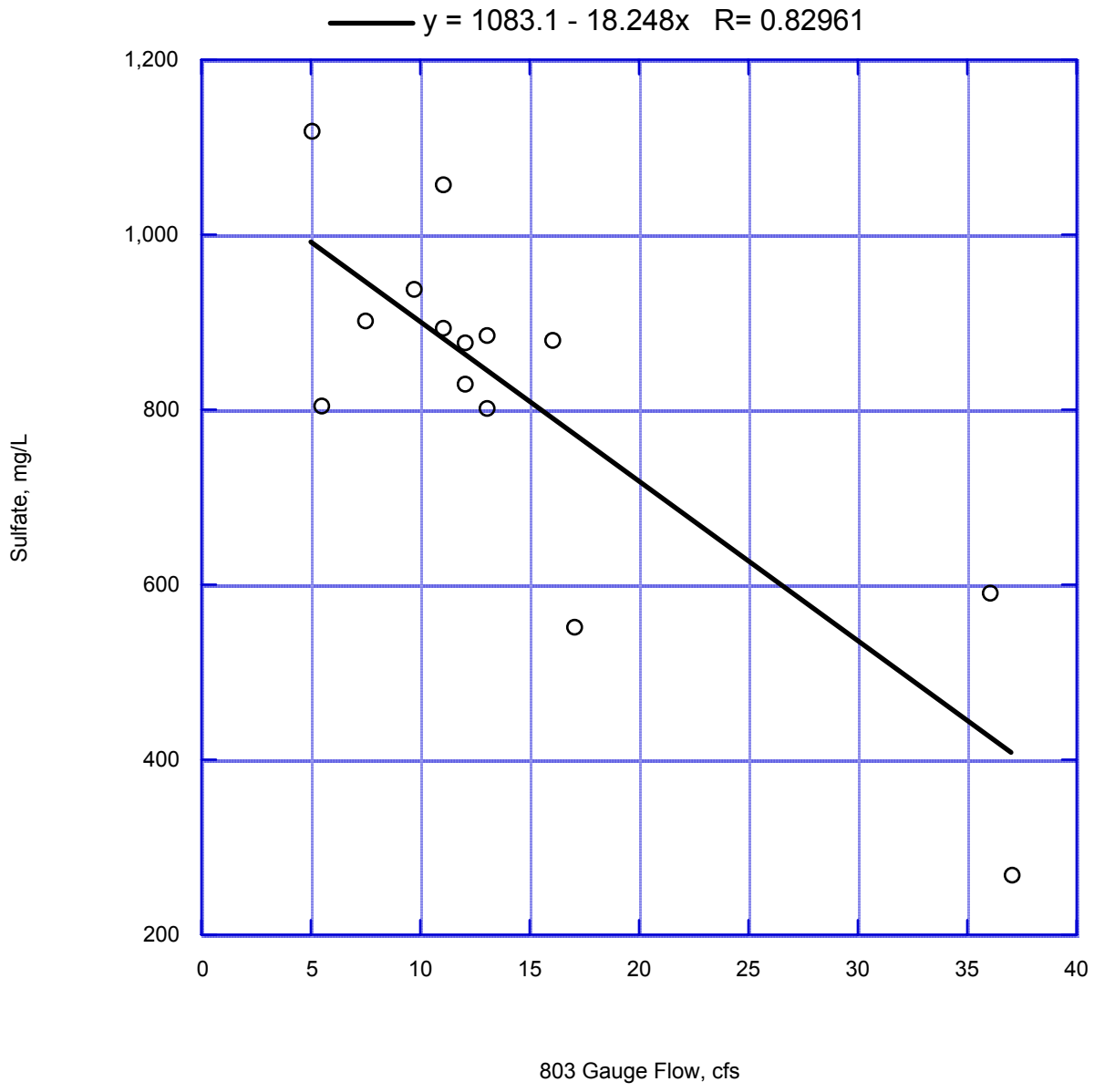


Figure 229. Sulfate vs. Stream Flow at Gauge 803

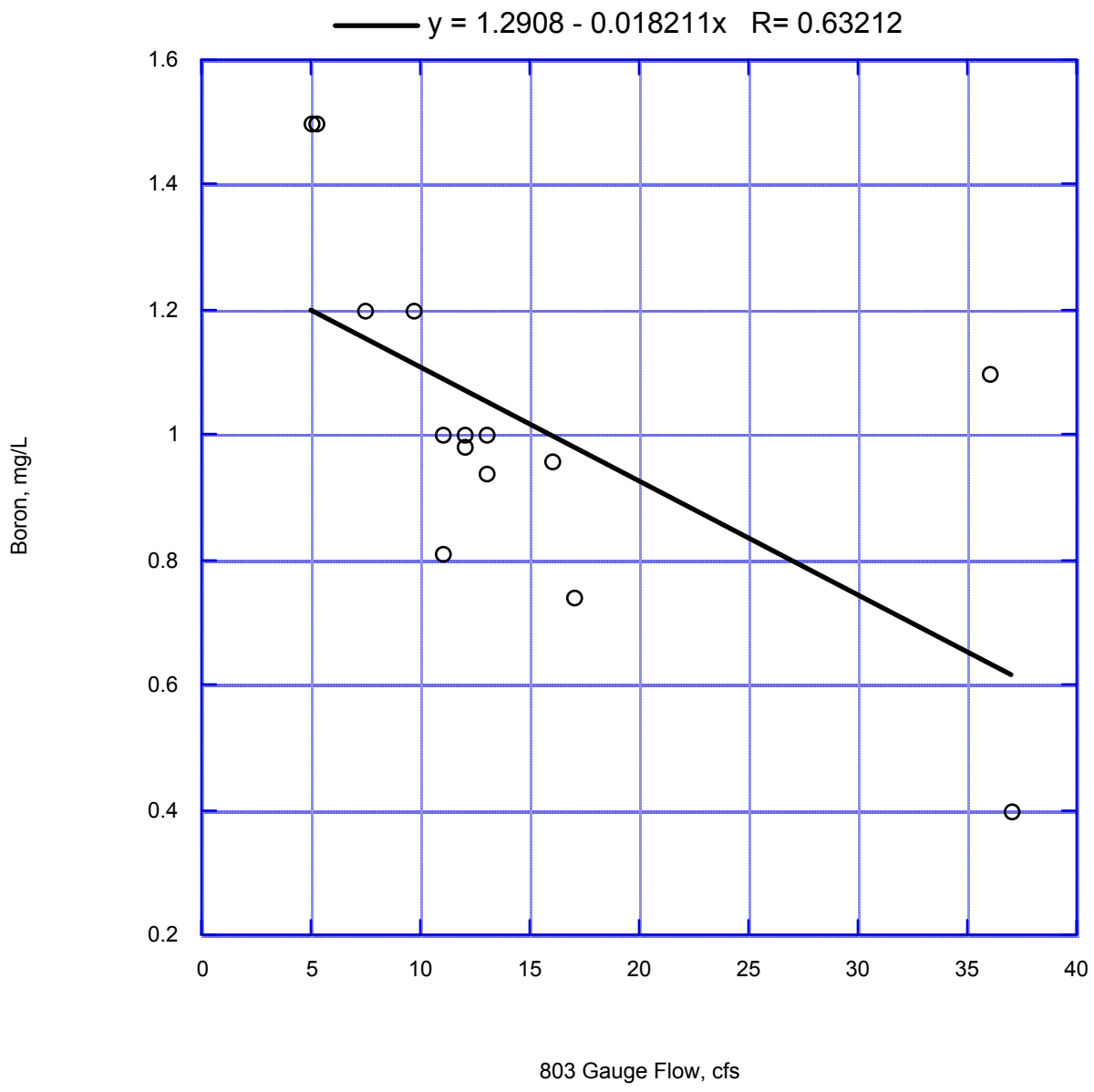


Figure 230. Boron vs. Stream Flow at Gauge 803

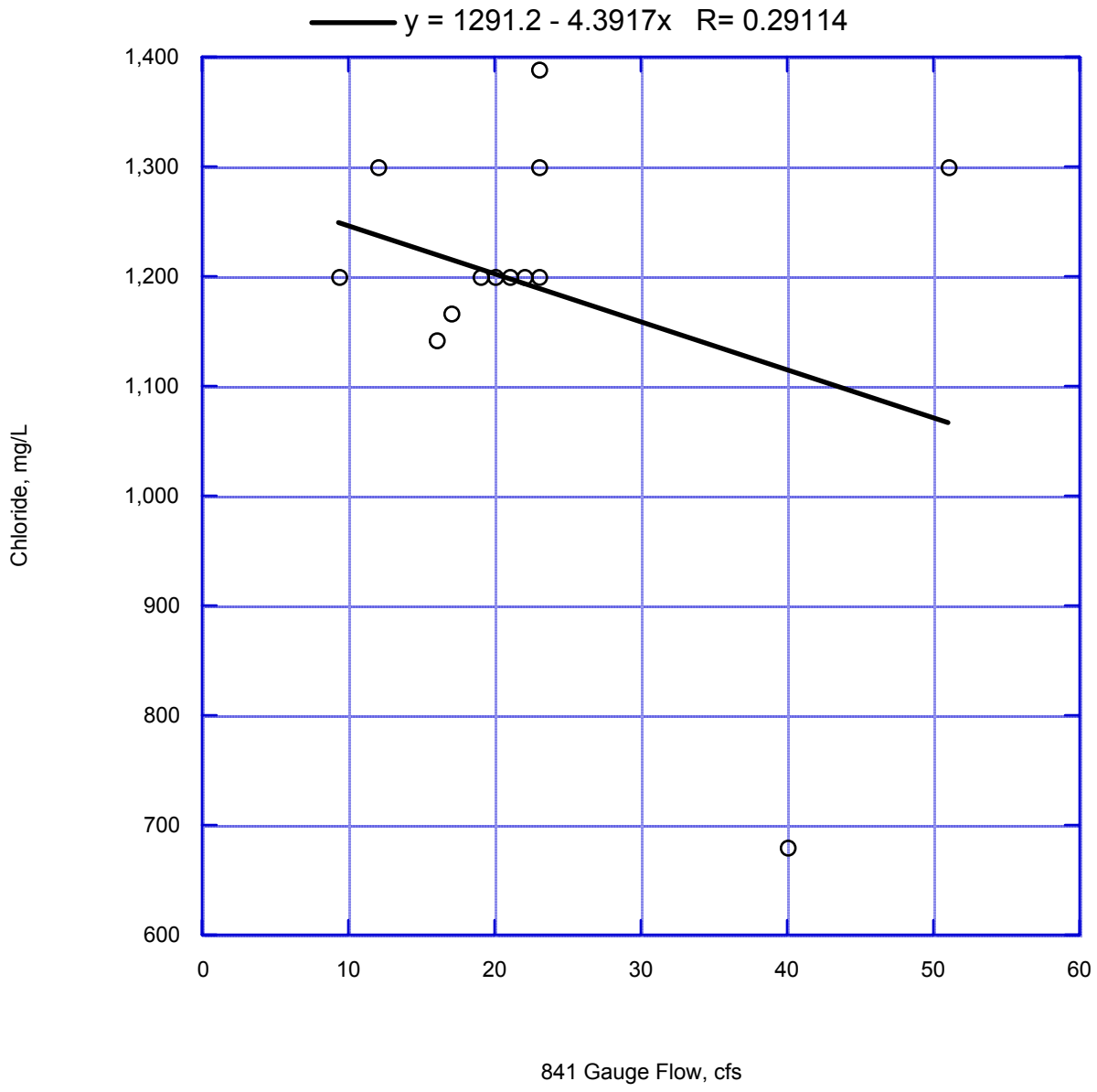


Figure 231. Chloride vs. Stream Flow at Gauge 841

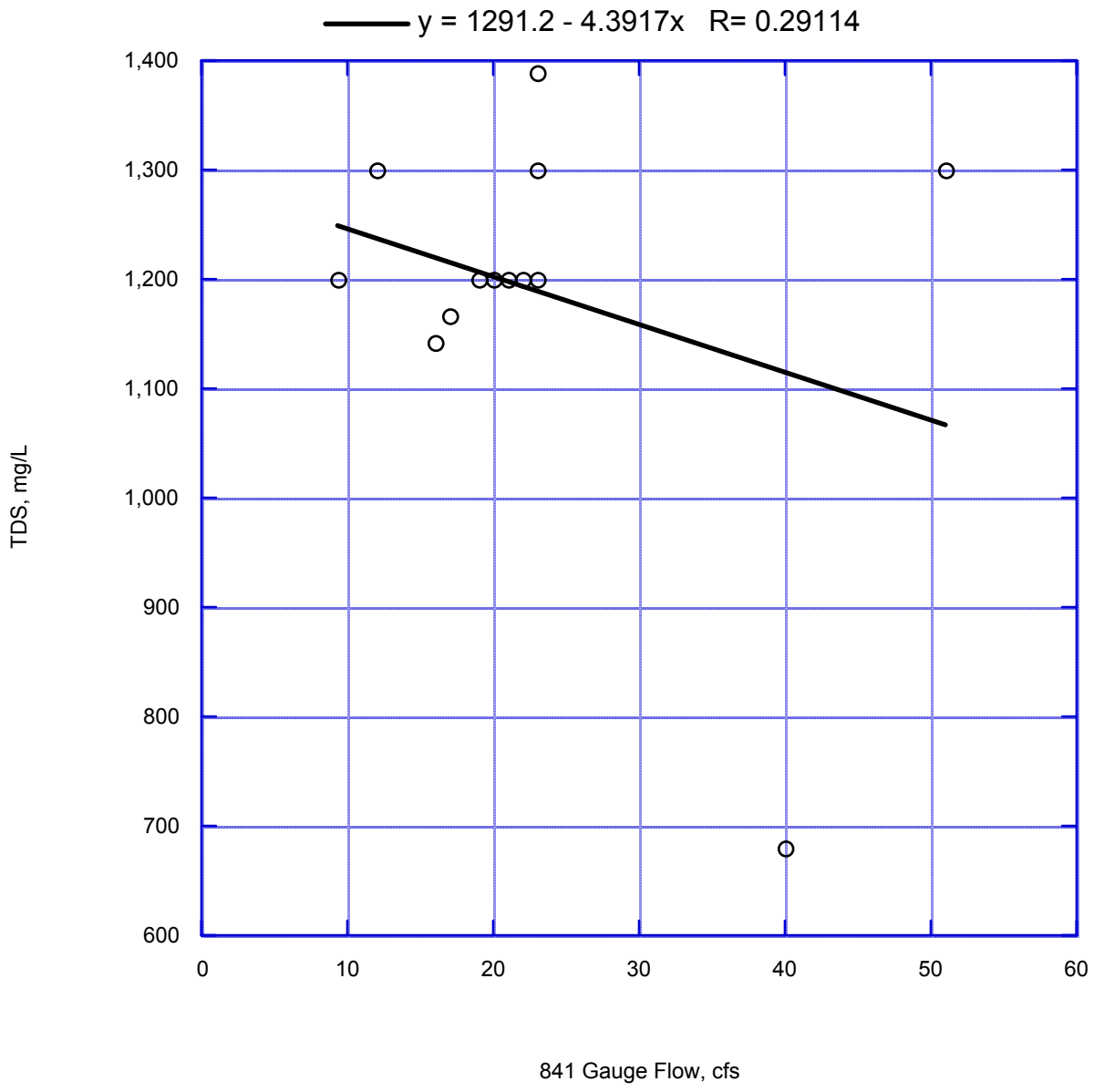


Figure 232. TDS vs. Stream Flow at Gauge 841

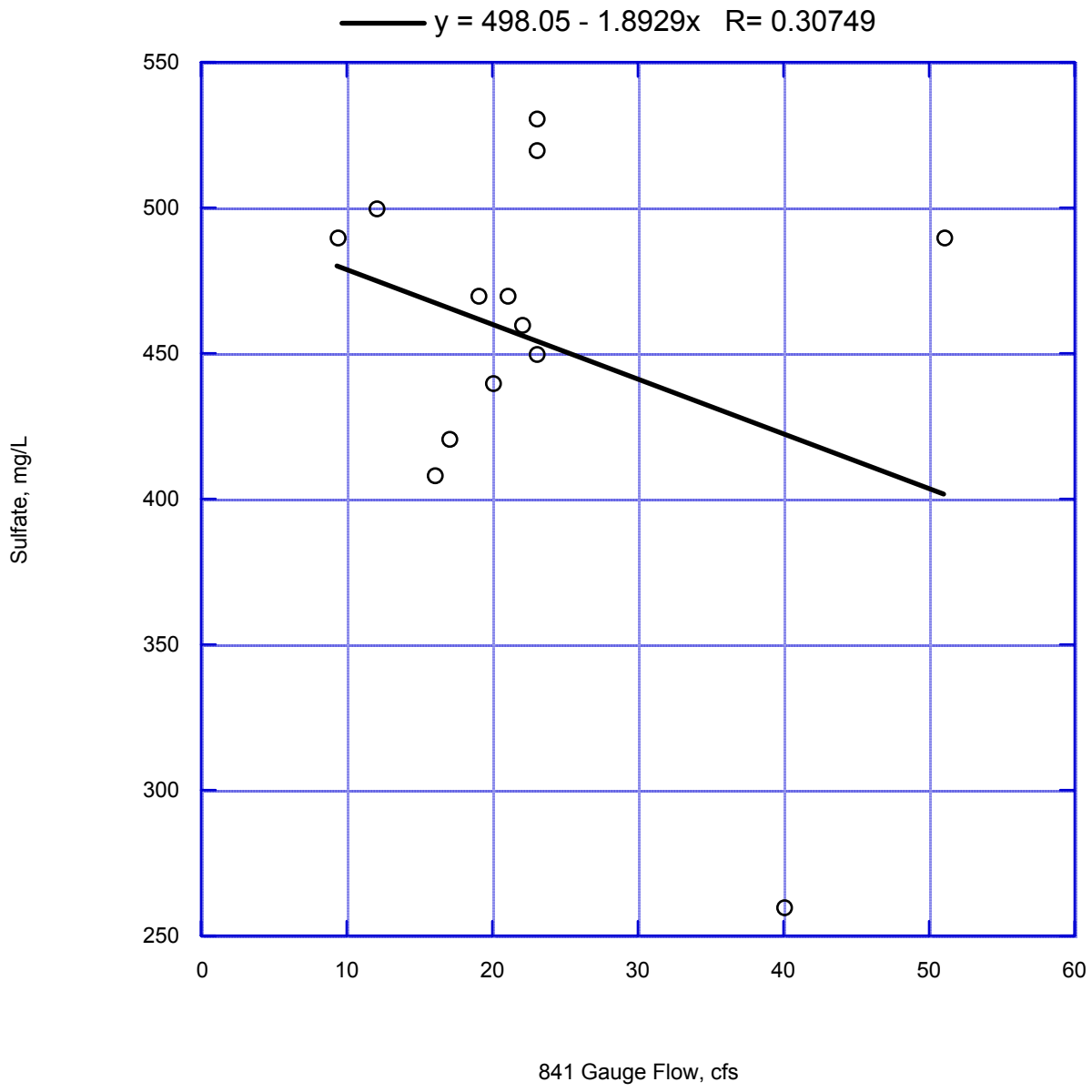


Figure 233. Sulfate vs. Stream Flow at Gauge 841

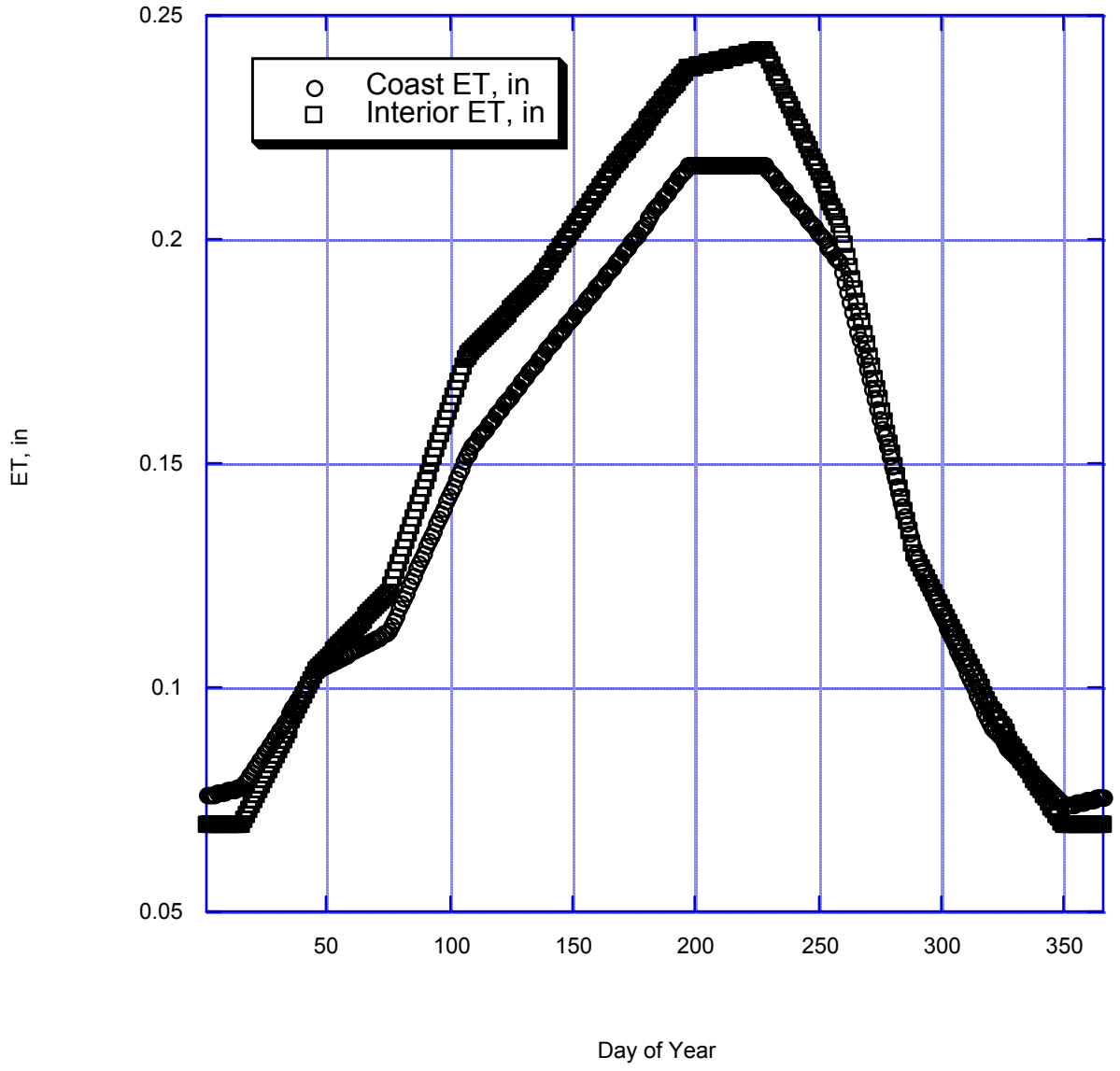


Figure 234. Water Surface and Mixed-plant ET vs. Time

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

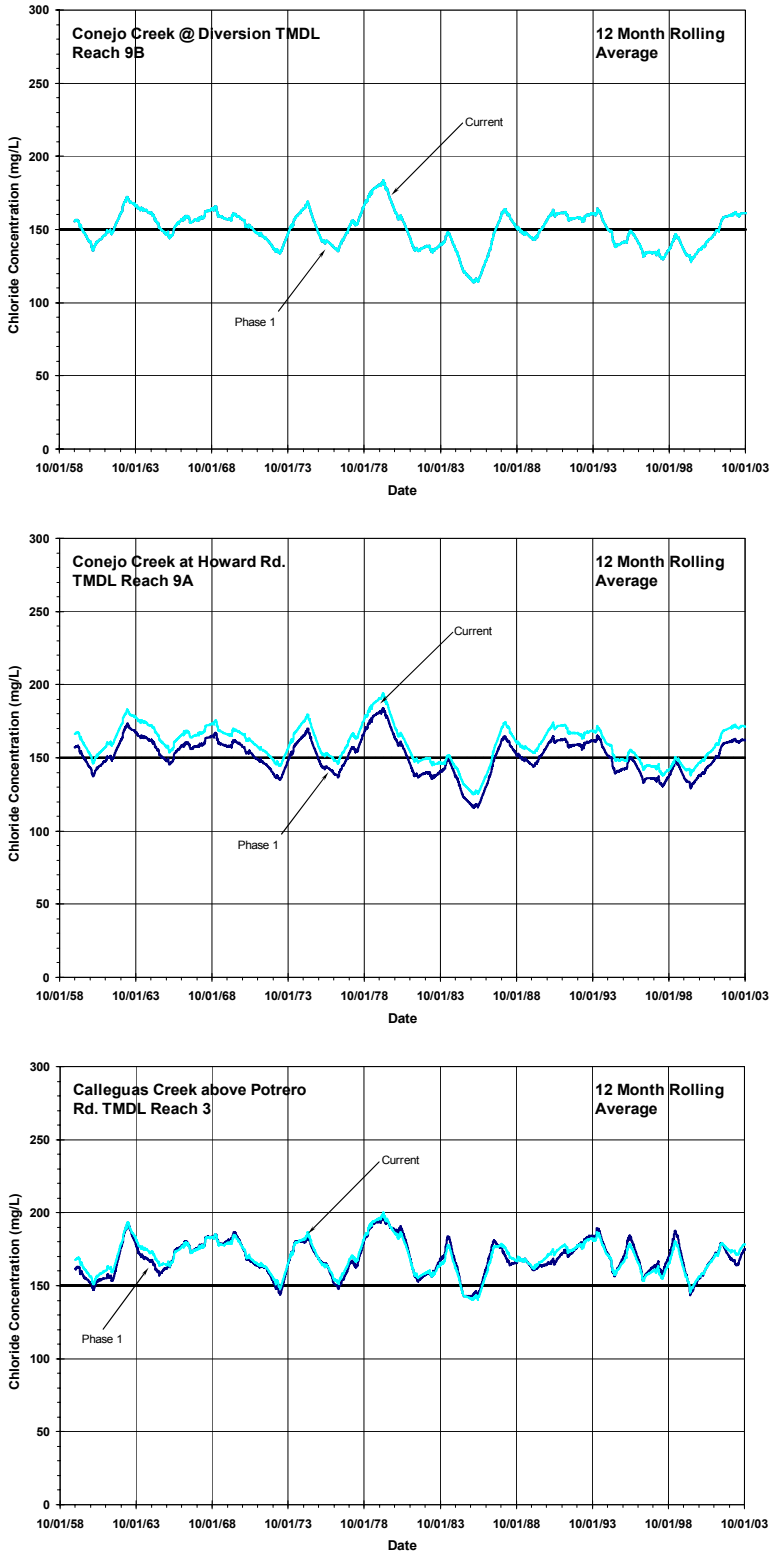


Figure 54: Current and Estimated Chloride 12-month Rolling Average Concentrations in Lower Watershed After Implementing Phase 1 of the RWRMP.

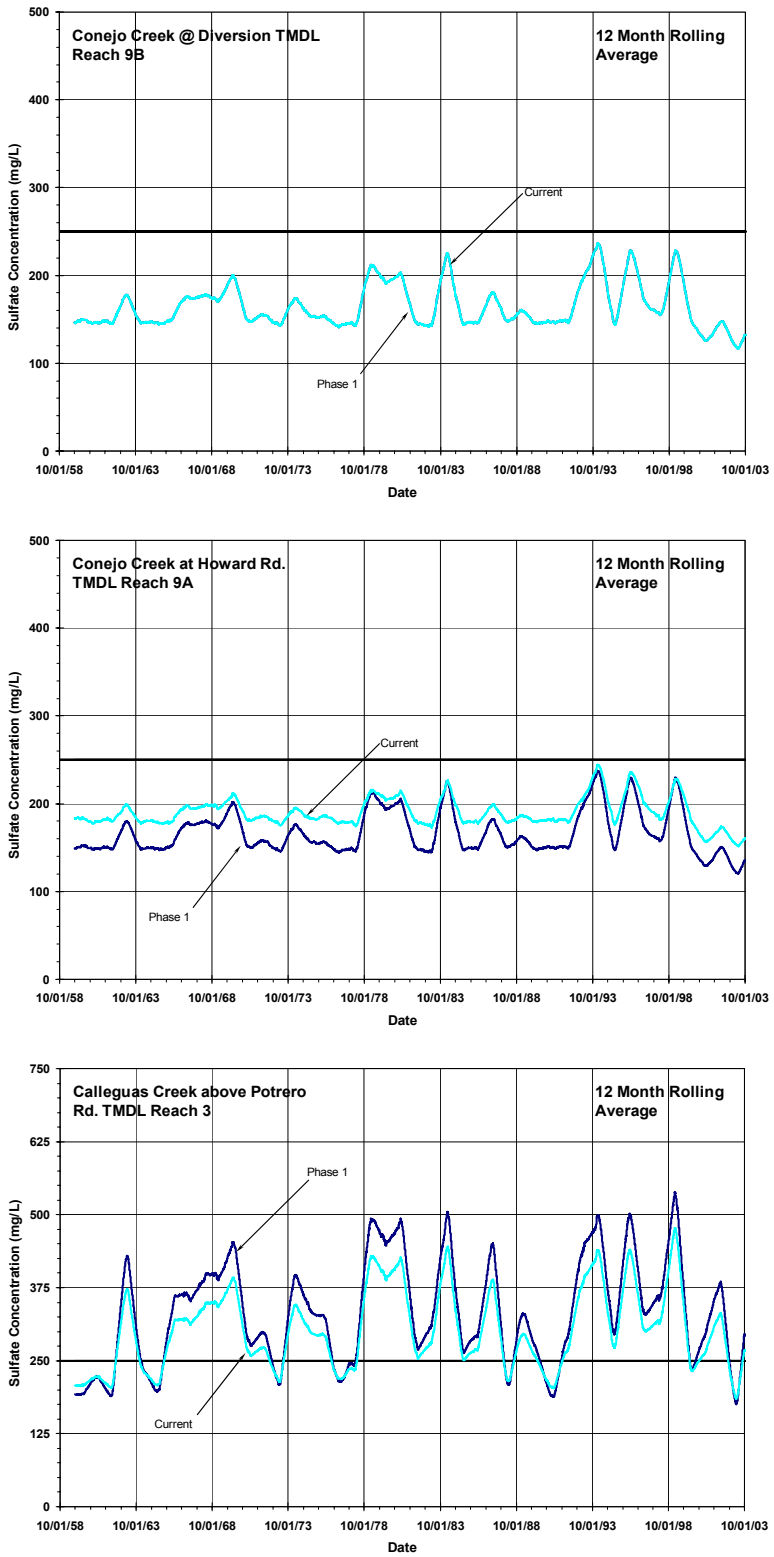


Figure 55: Current and Estimated Sulfate 12-month Rolling Average Concentrations in Lower Watershed After Implementing Phase 1 of the RWRMP.

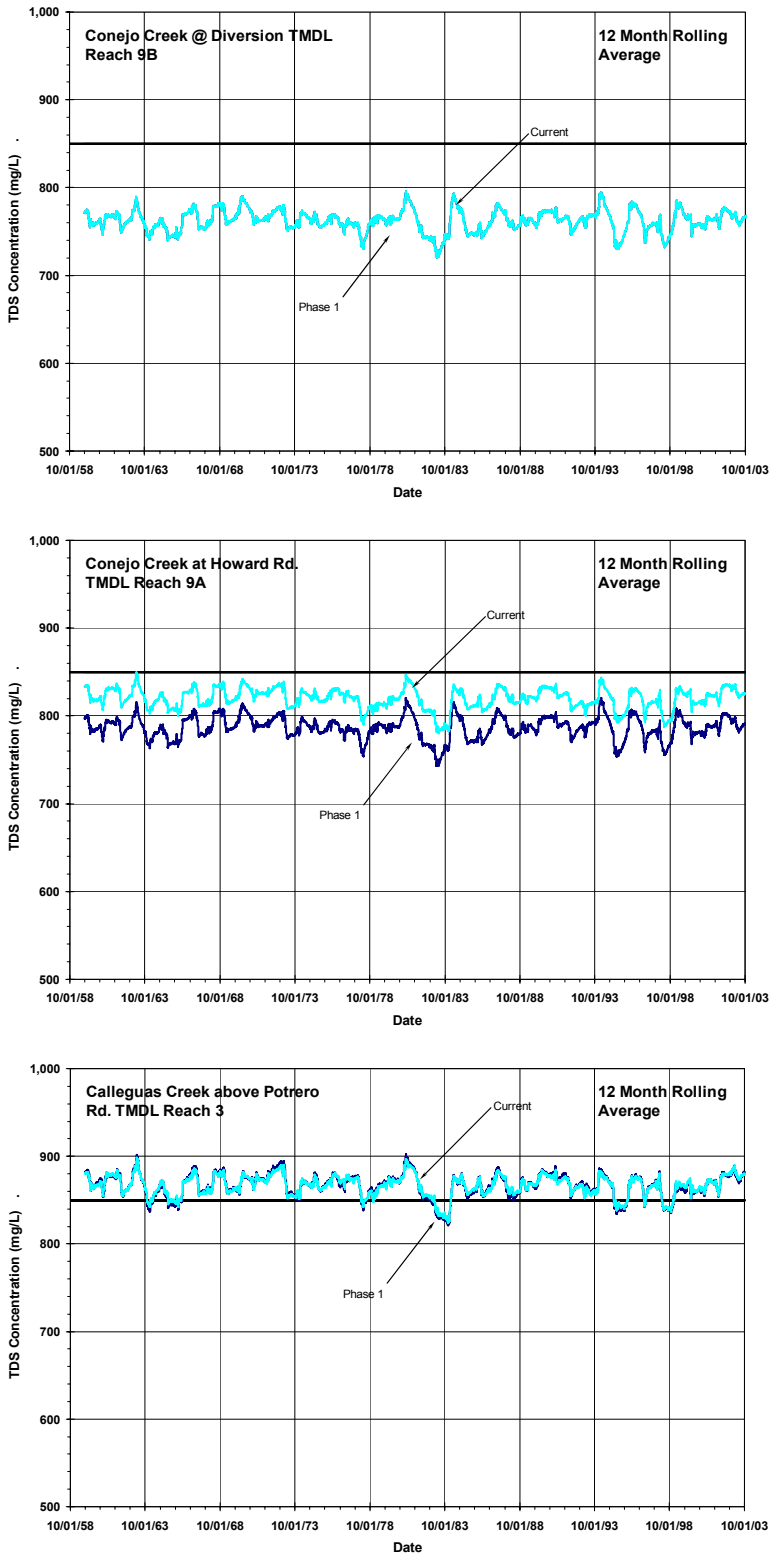


Figure 56: Current and Estimated TDS 12-month Rolling Average Concentrations in Lower Watershed After Implementing Phase 1 of the RWRMP.

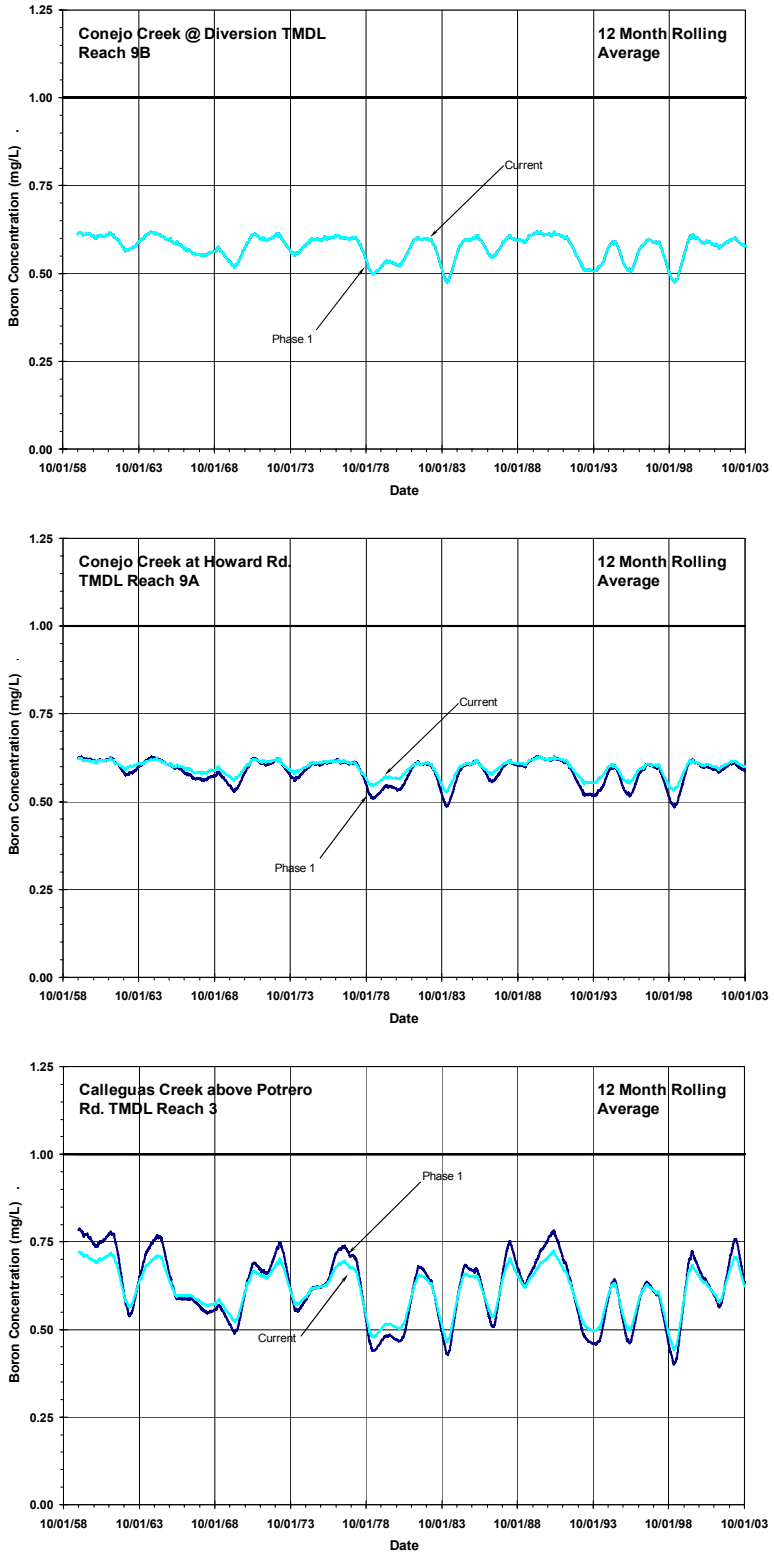


Figure 57: Current and Estimated Boron 12-month Rolling Average Concentrations in Lower Watershed After Implementing Phase 1 of the RWRMP.

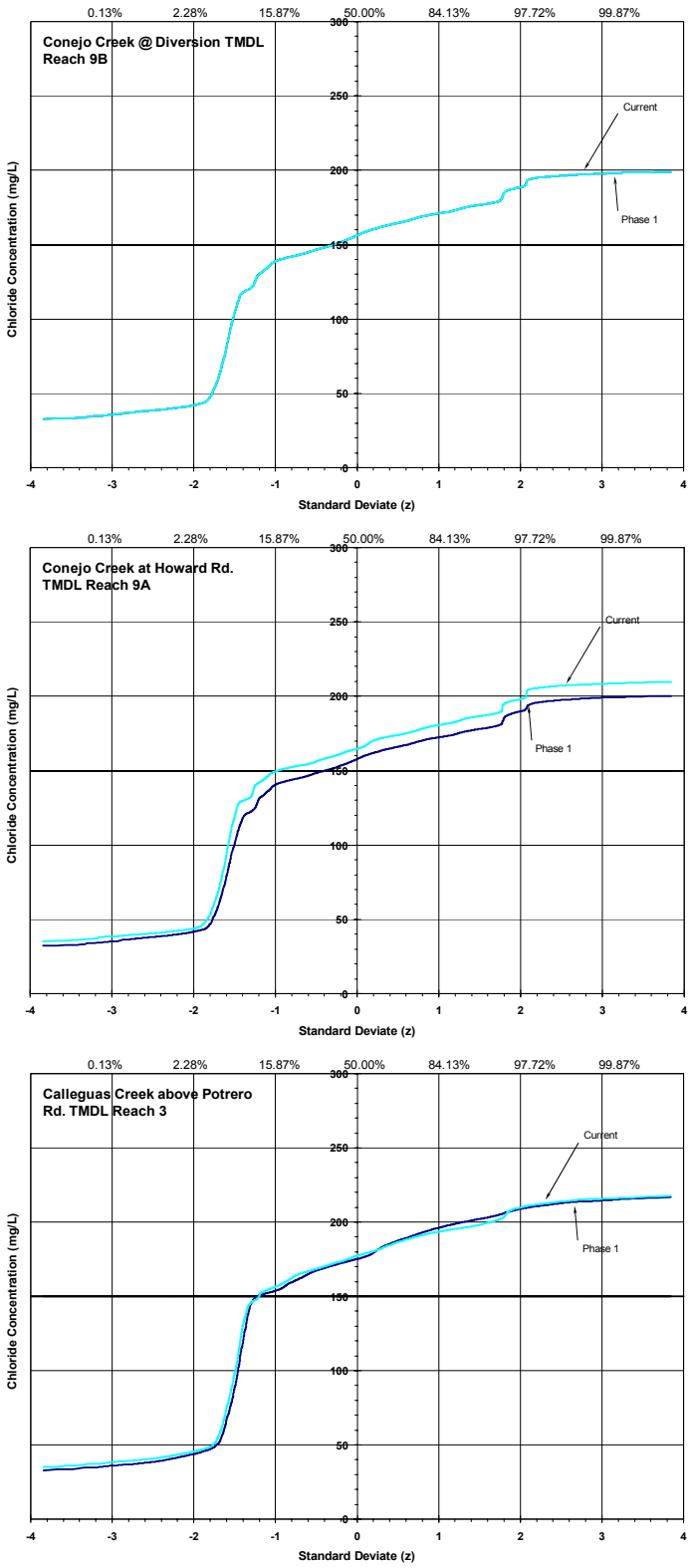


Figure 58: Current and Estimated Chloride Probability Distribution of Daily Average Concentrations in Lower Watershed After Implementing Phase 1 of the RWRMP.

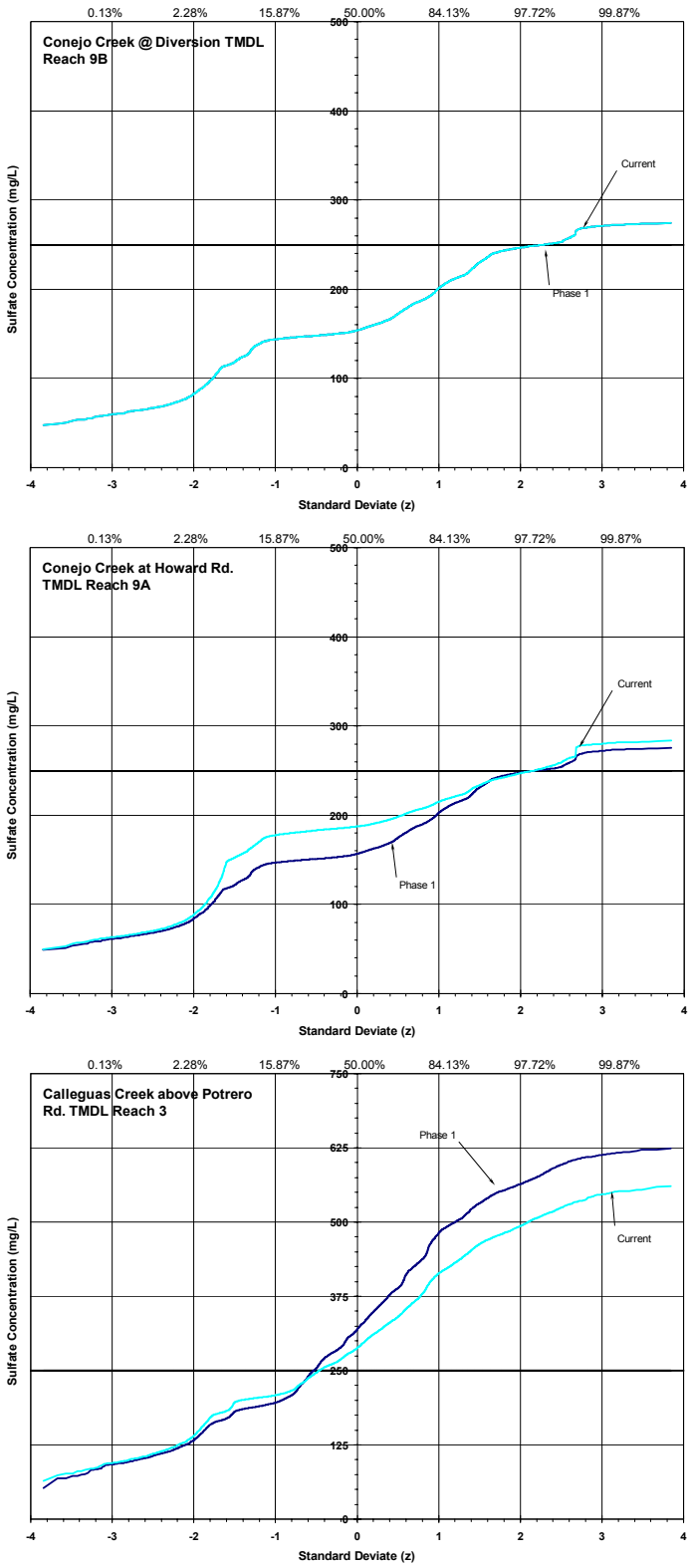


Figure 59: Current and Estimated Sulfate Probability Distribution of Daily Average Concentrations in Lower Watershed After Implementing Phase 1 of the RWRMP.

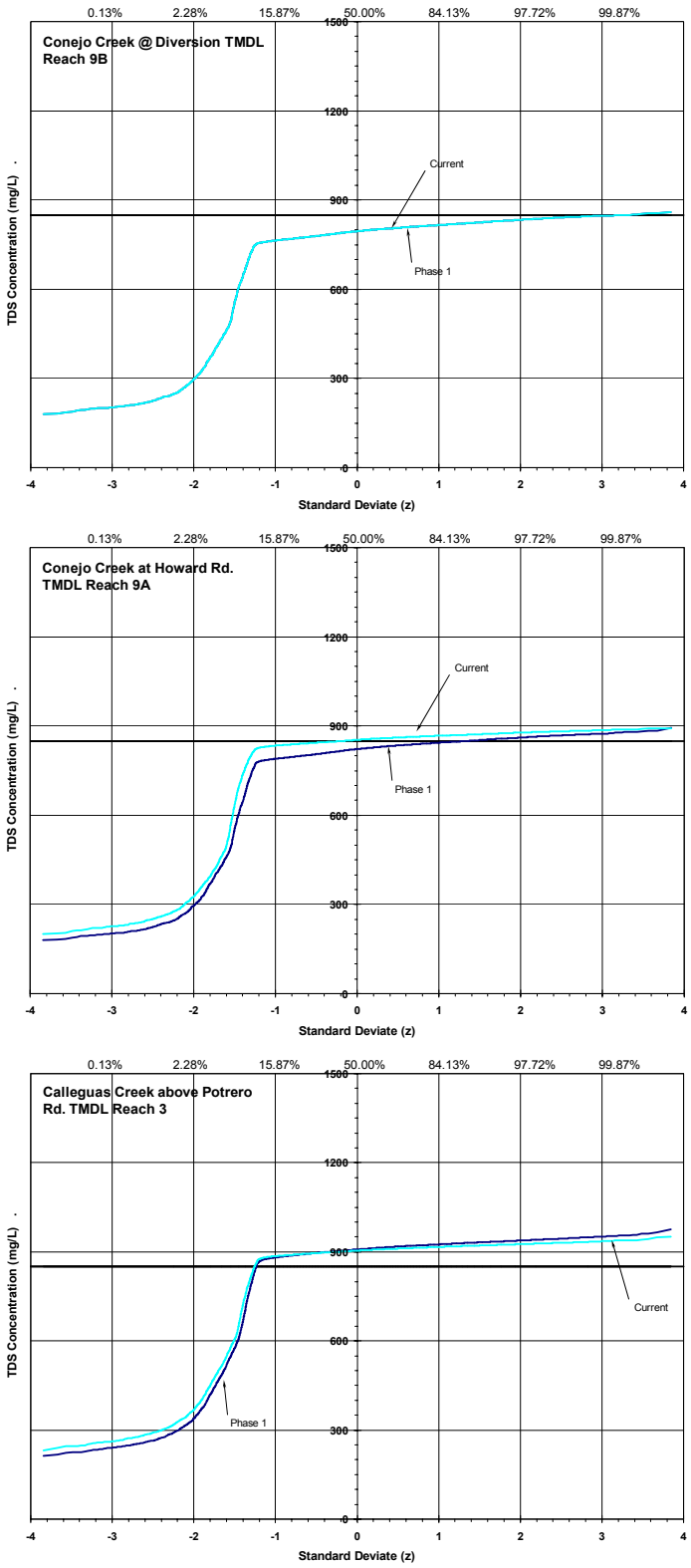


Figure 60: Current and Estimated TDS Probability Distribution of Daily Average Concentrations in Lower Watershed After Implementing Phase 1 of the RWRMP.

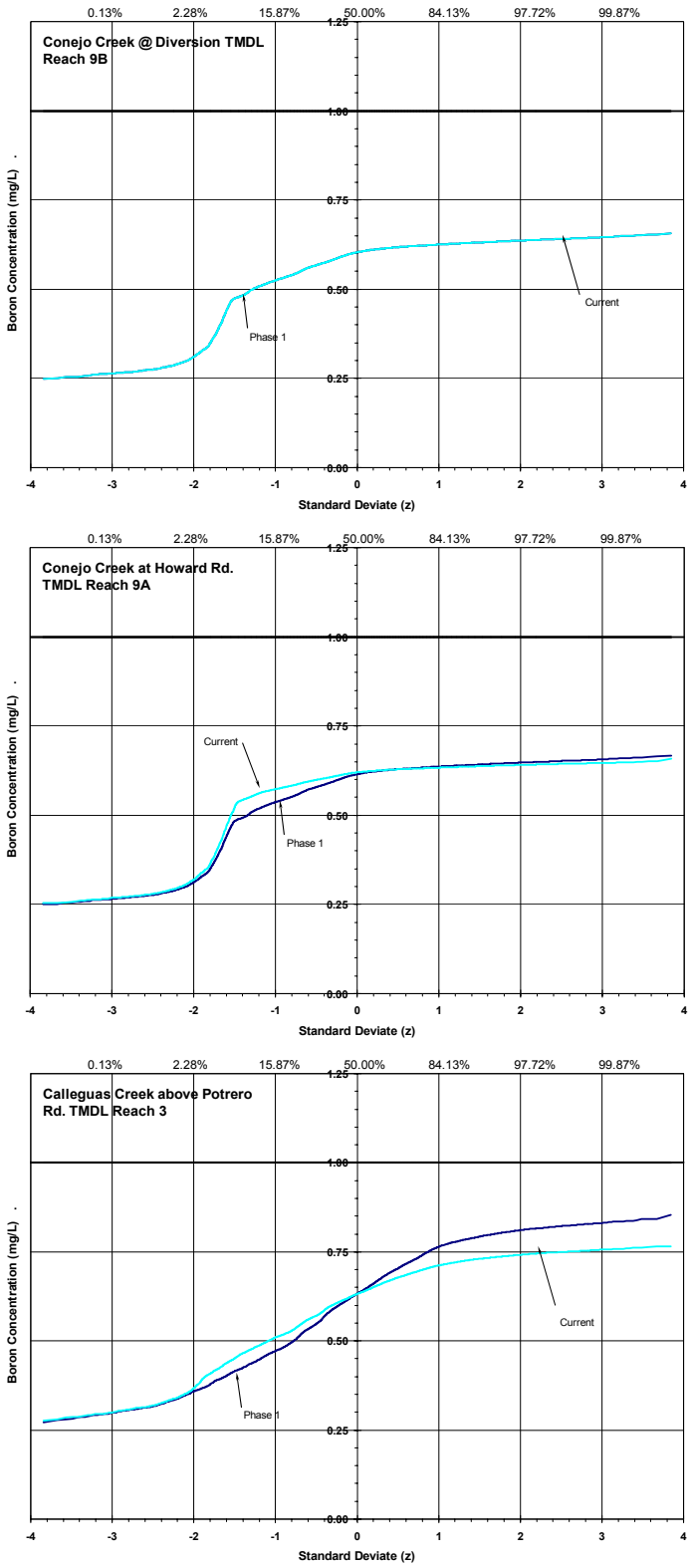


Figure 61: Current and Estimated Boron Probability Distribution of Daily Average Concentrations in Lower Watershed After Implementing Phase 1 of the RWRMP.

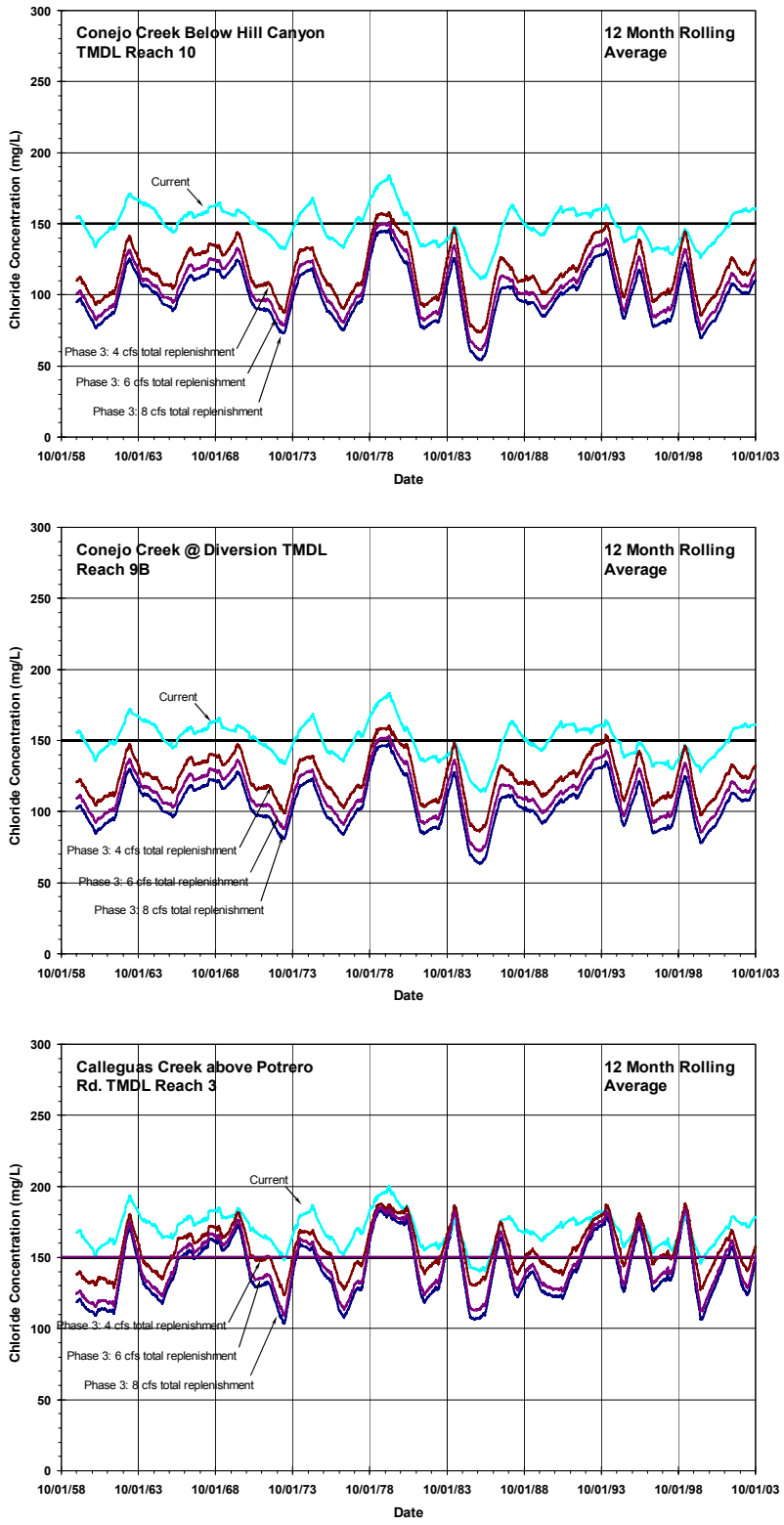


Figure 62: Current and Estimated Chloride 12-month Rolling Average Concentrations in Lower Watershed After Implementing Phase 3 of the RWRMP with Various Total Replenishment Flowrates Equally Divided between the North and South Forks of Arroyo Conejo.

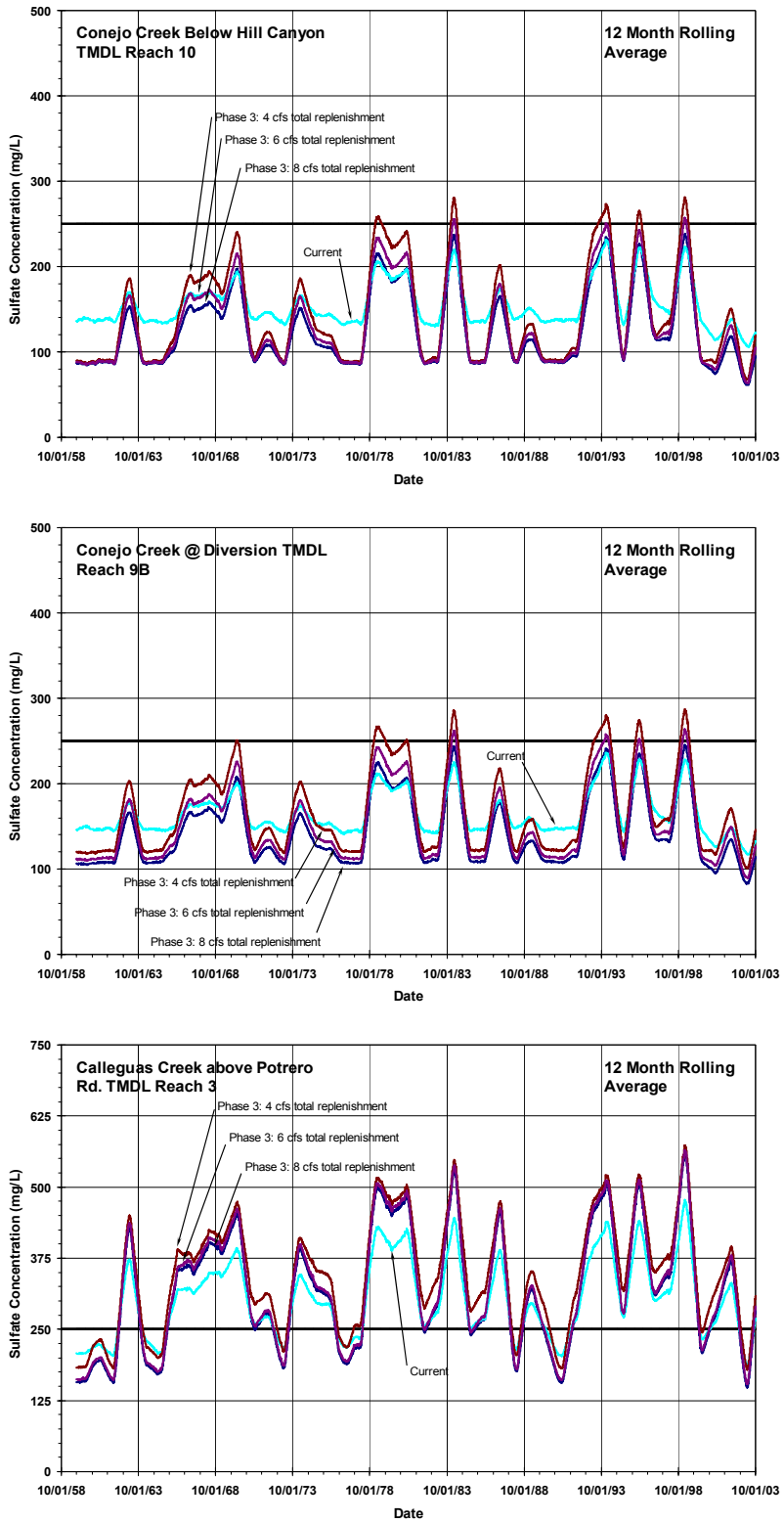


Figure 63: Current and Estimated Sulfate 12-month Rolling Average Concentrations in Lower Watershed After Implementing Phase 3 of the RWRMP with Various Total Replenishment Flowrates Equally Divided between the North and South Forks of Arroyo Conejo.

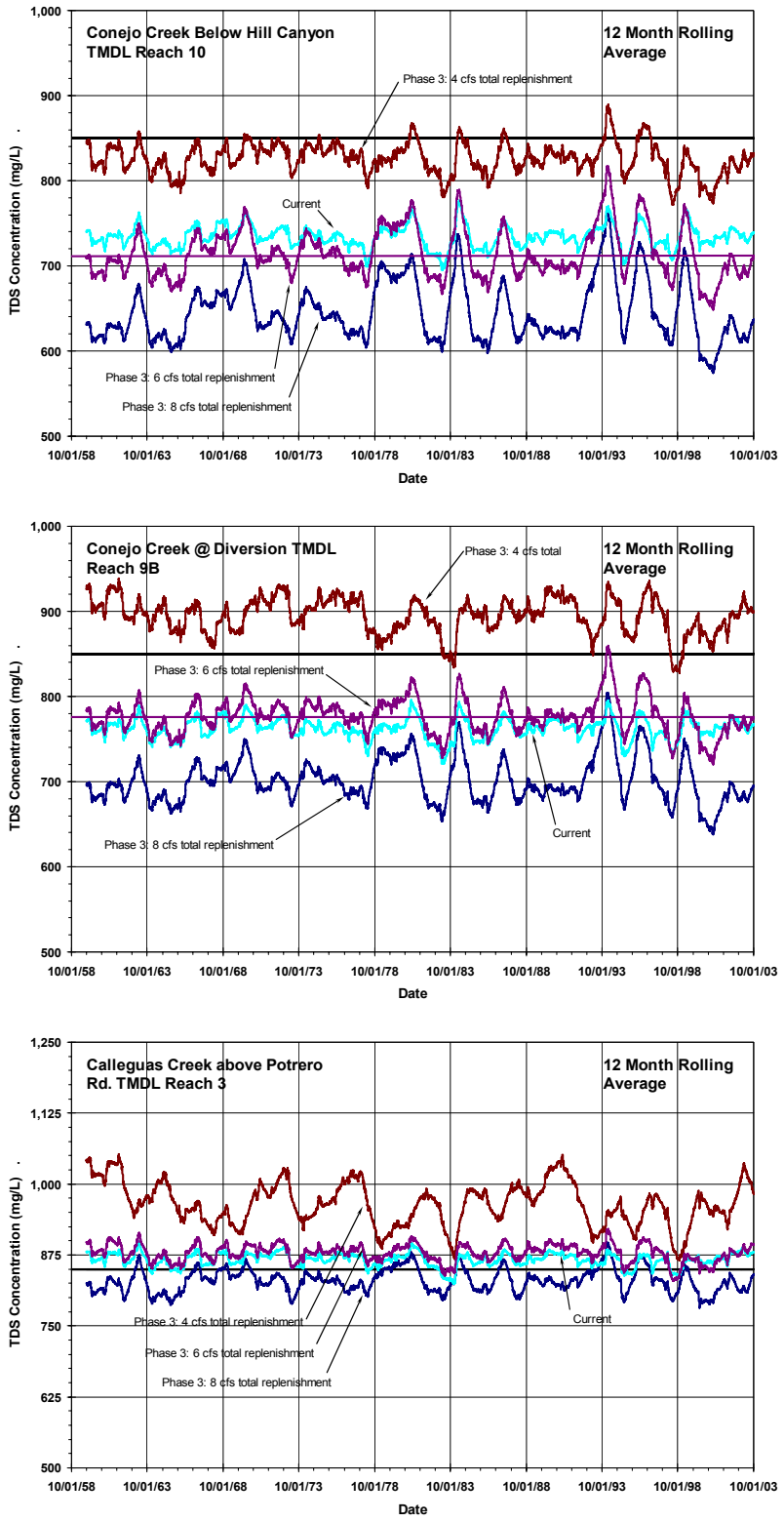


Figure 64: Current and Estimated TDS 12-month Rolling Average Concentrations in Lower Watershed After Implementing Phase 3 of the RWRMP with Various Total Replenishment Flowrates Equally Divided between the North and South Forks of Arroyo Conejo.

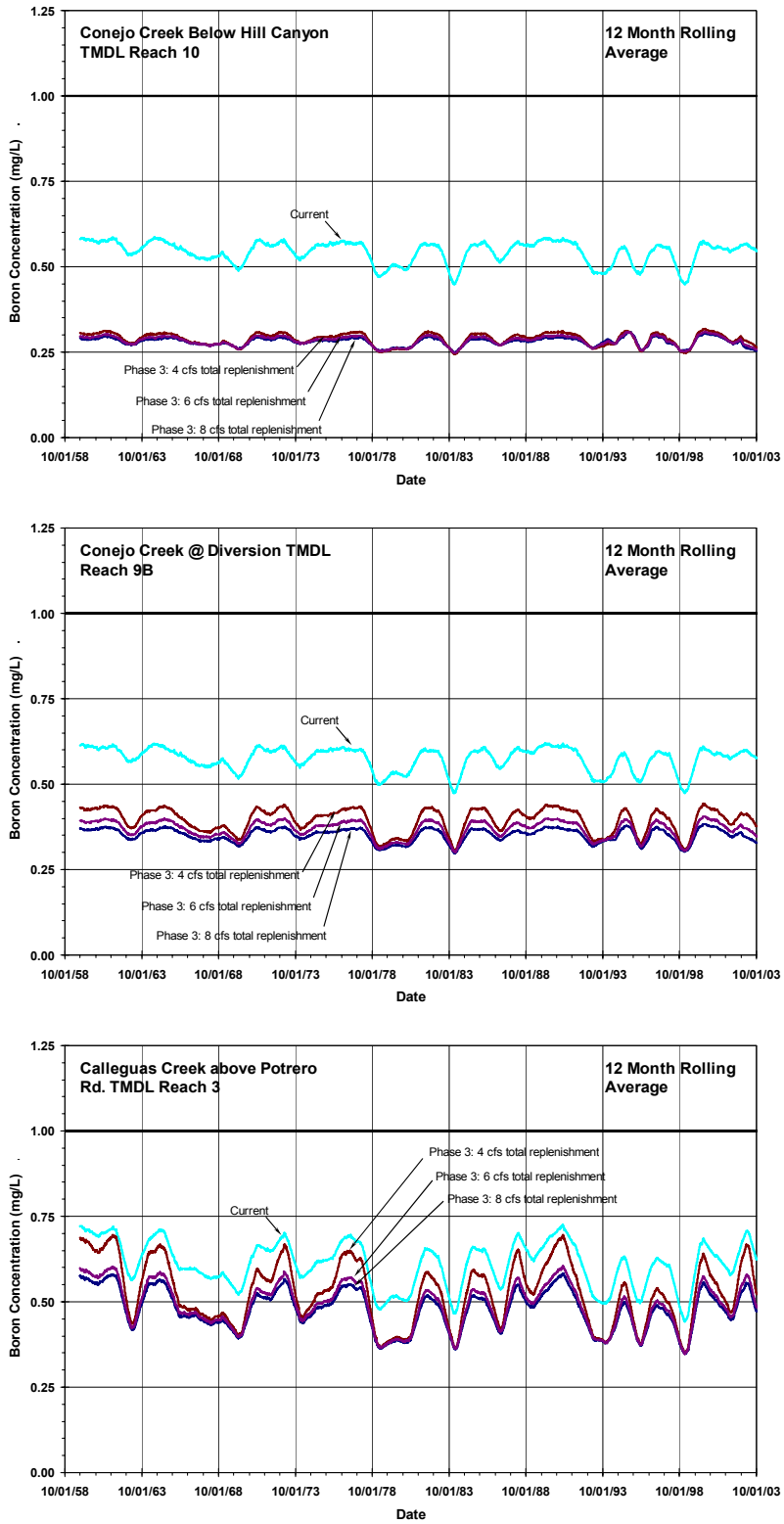


Figure 65: Current and Estimated Boron 12-month Rolling Average Concentrations in Lower Watershed After Implementing Phase 3 of the RWRMP with Various Total Replenishment Flowrates Equally Divided between the North and South Forks of Arroyo Conejo.

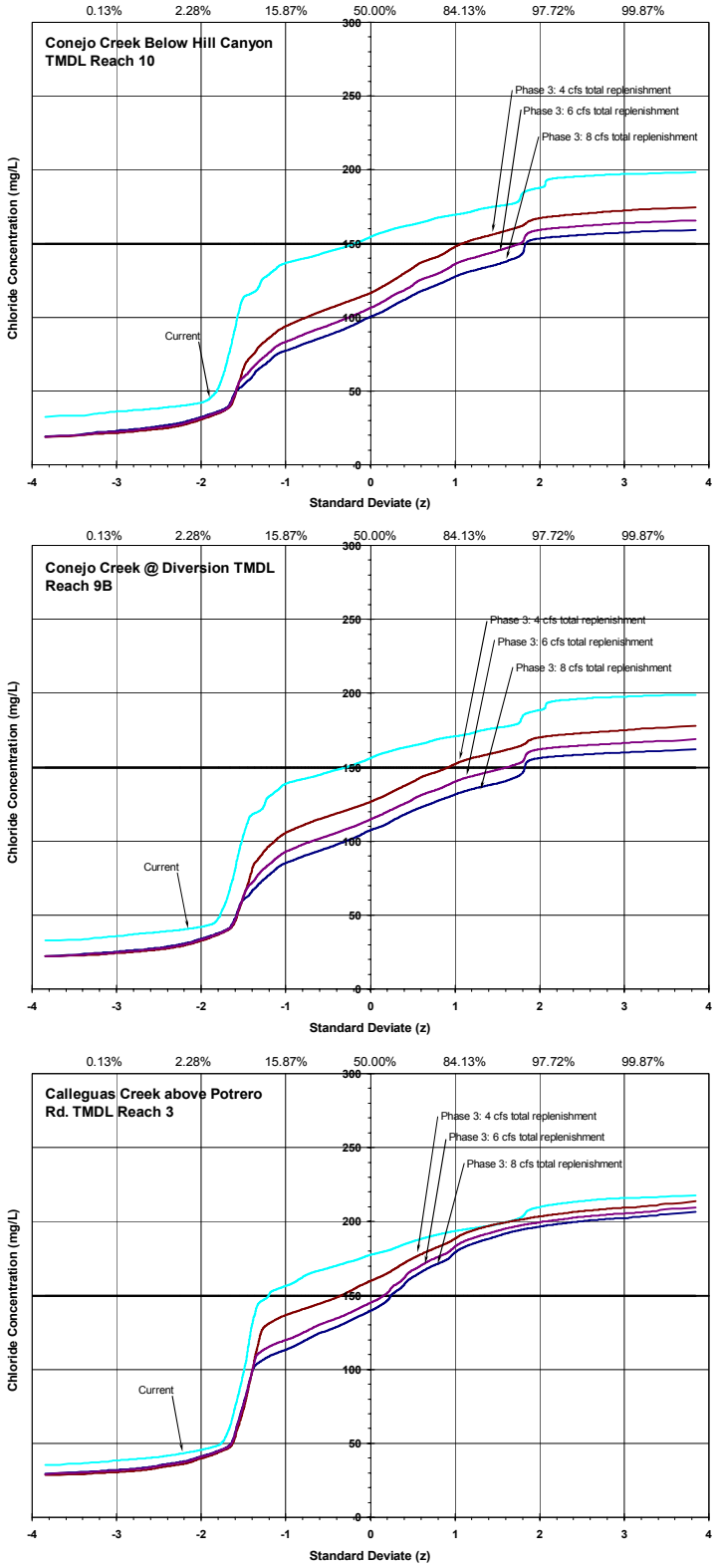


Figure 66: Current and Estimated Chloride Probability Distribution of Daily Average Concentrations in Lower Watershed After Implementing Phase 3 of the RWRMP with Various Total Replenishment Flowrates Equally Divided between the North and South Forks of Arroyo Conejo.

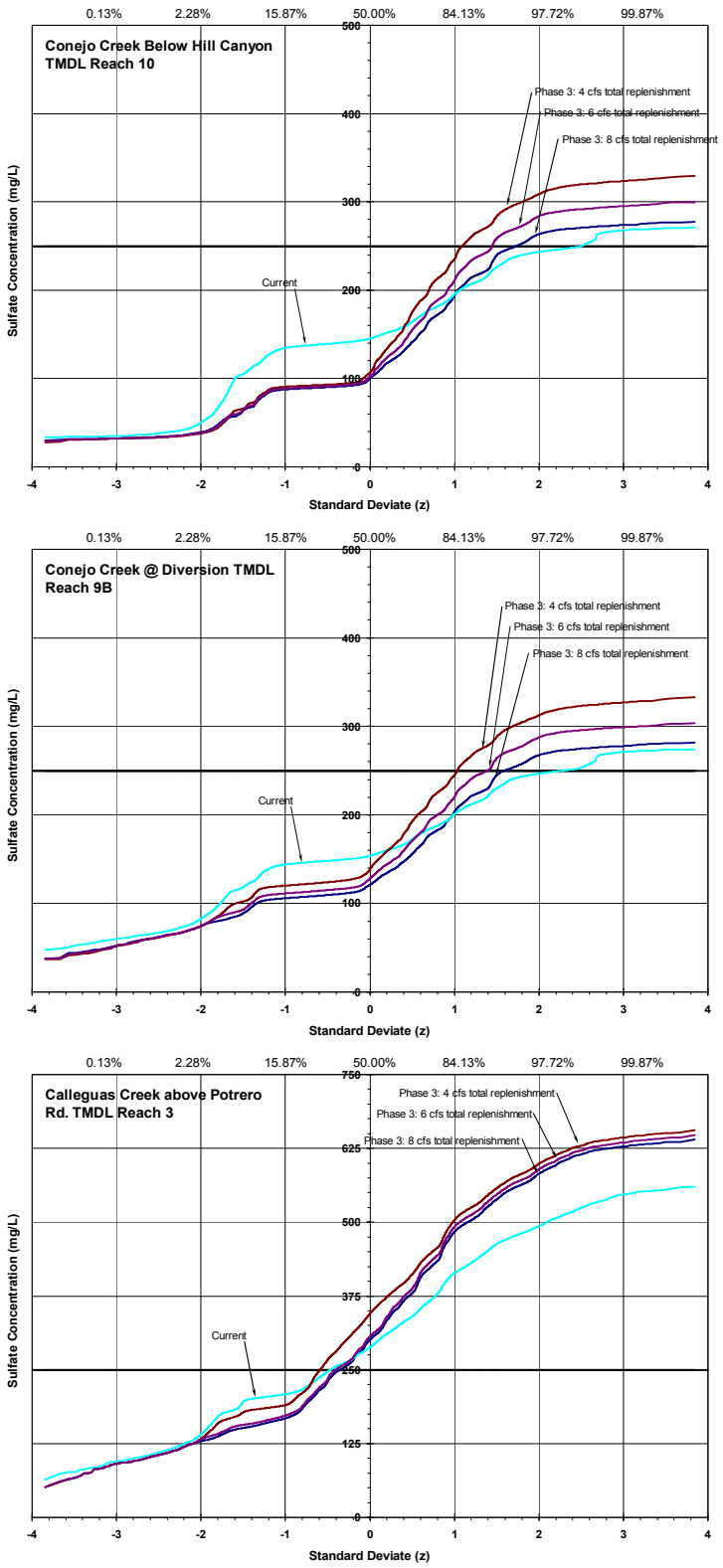


Figure 67: Current and Estimated Sulfate Probability Distribution of Daily Average Concentrations in Lower Watershed After Implementing Phase 3 of the RWRMP with Various Total Replenishment Flowrates Equally Divided between the North and South Forks of Arroyo Conejo.

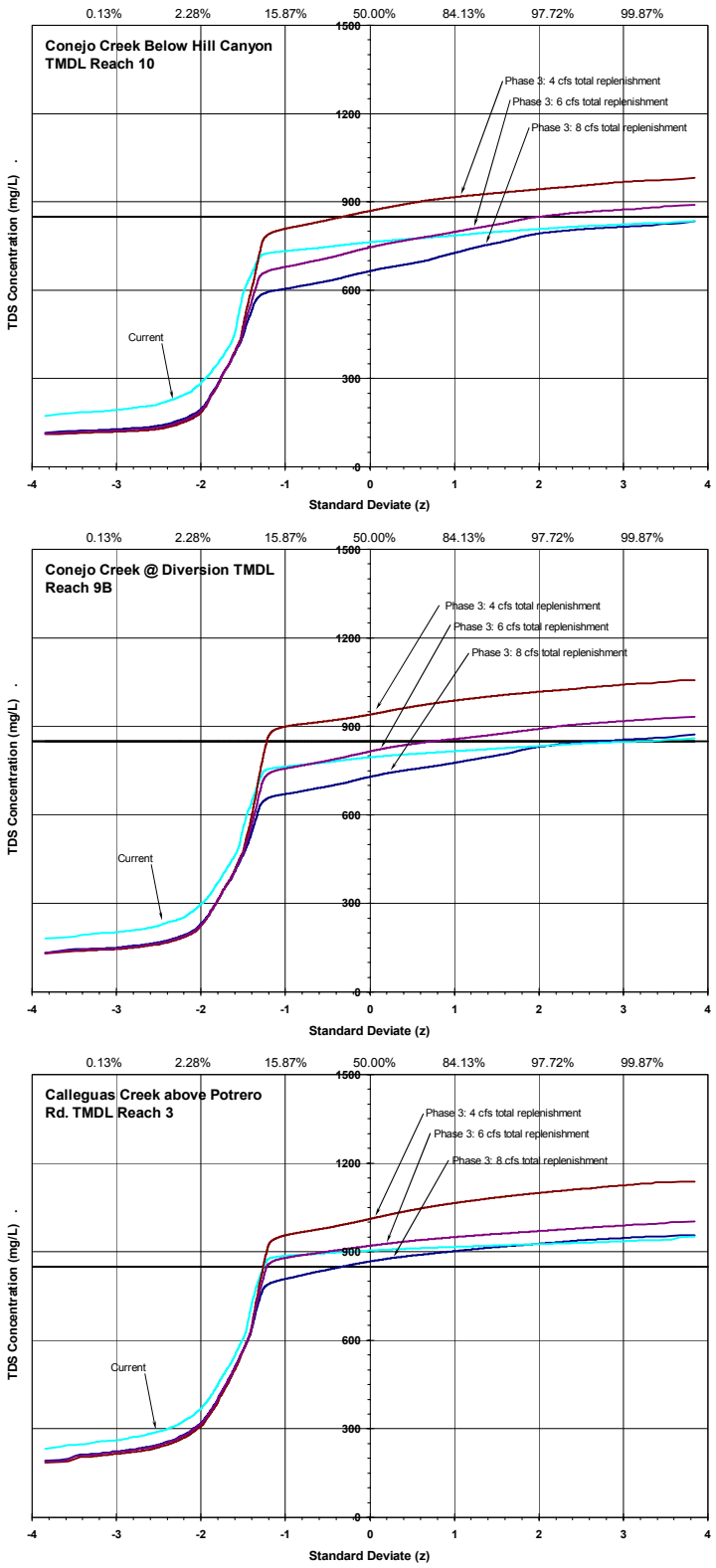


Figure 68: Current and Estimated TDS Probability Distribution of Daily Average Concentrations in Lower Watershed After Implementing Phase 3 of the RWRMP with Various Total Replenishment Flowrates Equally Divided between the North and South Forks of Arroyo Conejo.

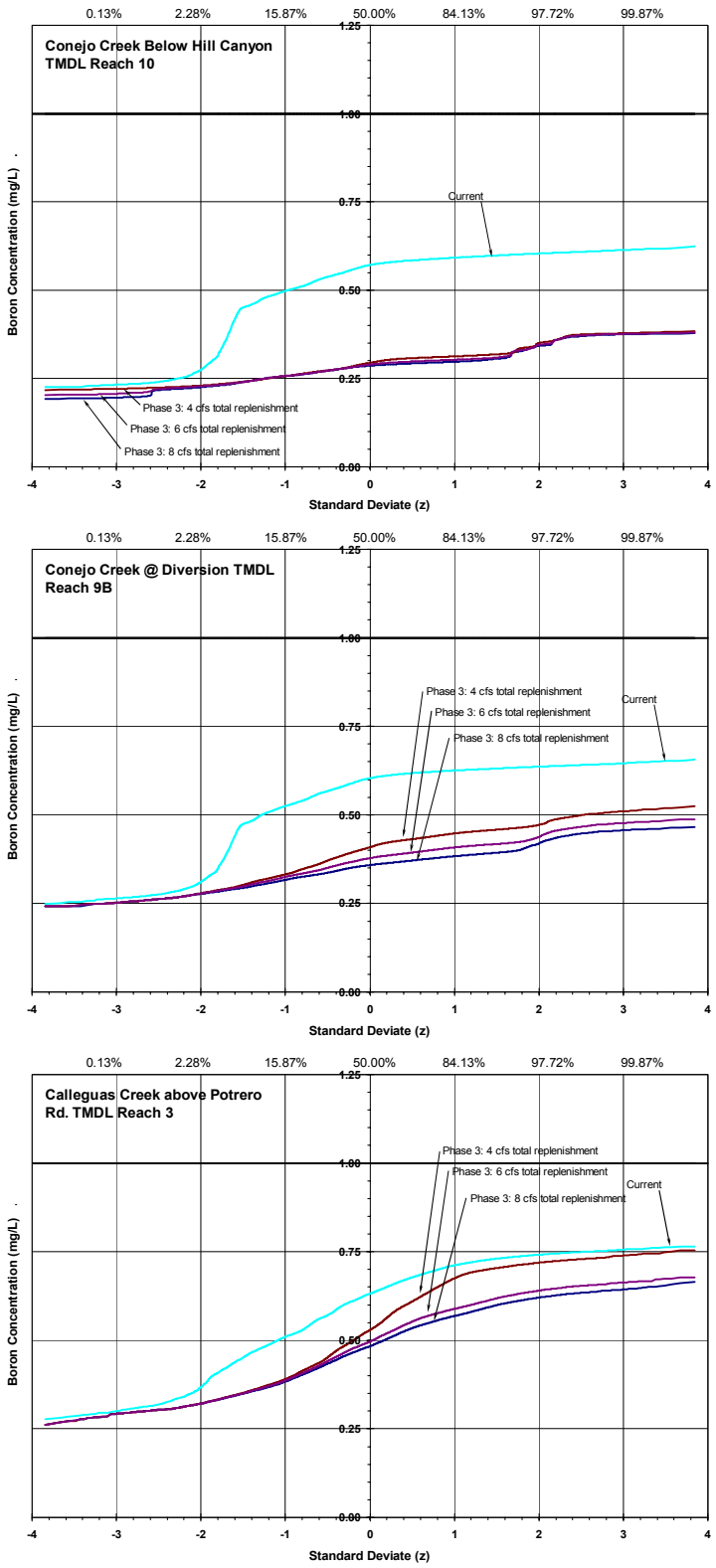


Figure 69: Current and Estimated Boron Probability Distribution of Daily Average Concentrations in Lower Watershed After Implementing Phase 3 of the RWRMP with Various Total Replenishment Flowrates Equally Divided between the North and South Forks of Arroyo Conejo.

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>
</table>

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.

TMDL Element	Key Findings and Regulatory Provisions
	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.

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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

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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>
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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.

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<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.

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</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

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	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

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	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.

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	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

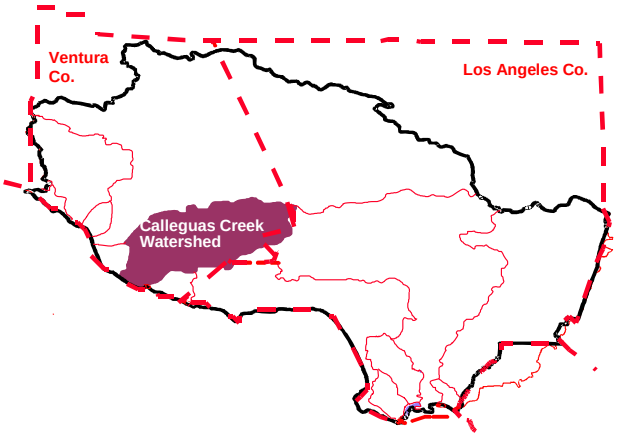
[1] Permitted stormwater dischargers that are responsible parties to this TMDL include the Municipal Stormwater Dischargers (MS4s) of the Cities of Camarillo, Moorpark, Thousand Oaks, County of Ventura, Ventura County Watershed Protection District, and general industrial and construction permittees.

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.

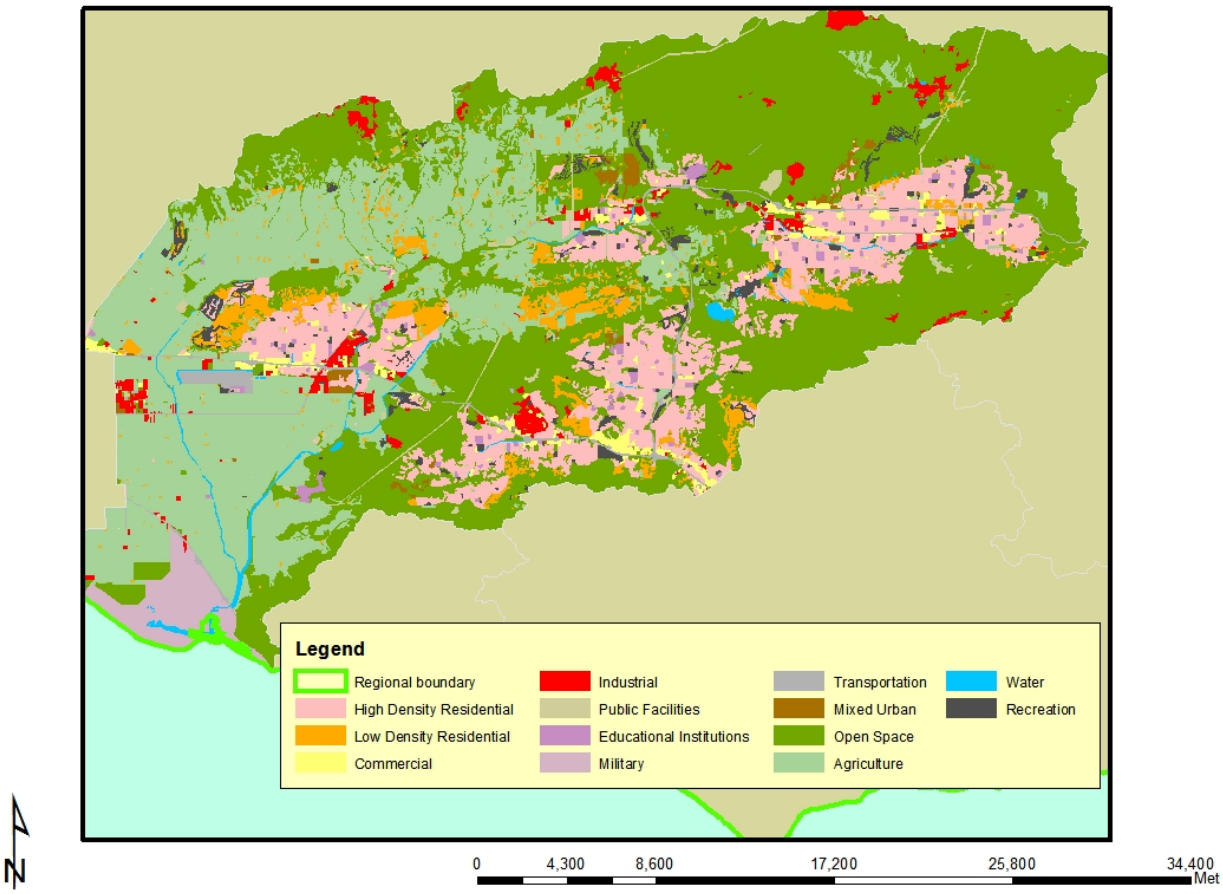
Overview of Watershed



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.

Land Use in the Calleguas Creek Watershed



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.

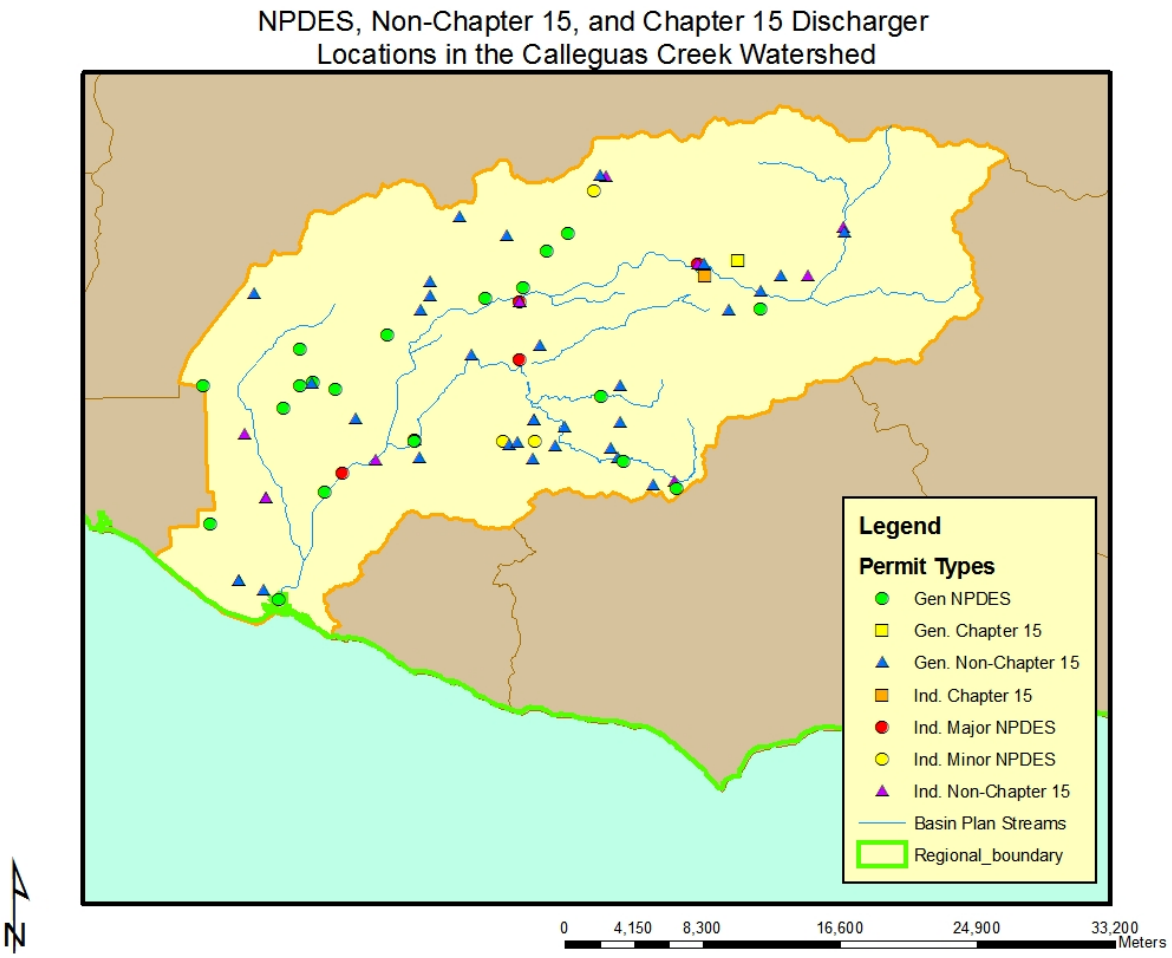
Permitted discharges:

- 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.

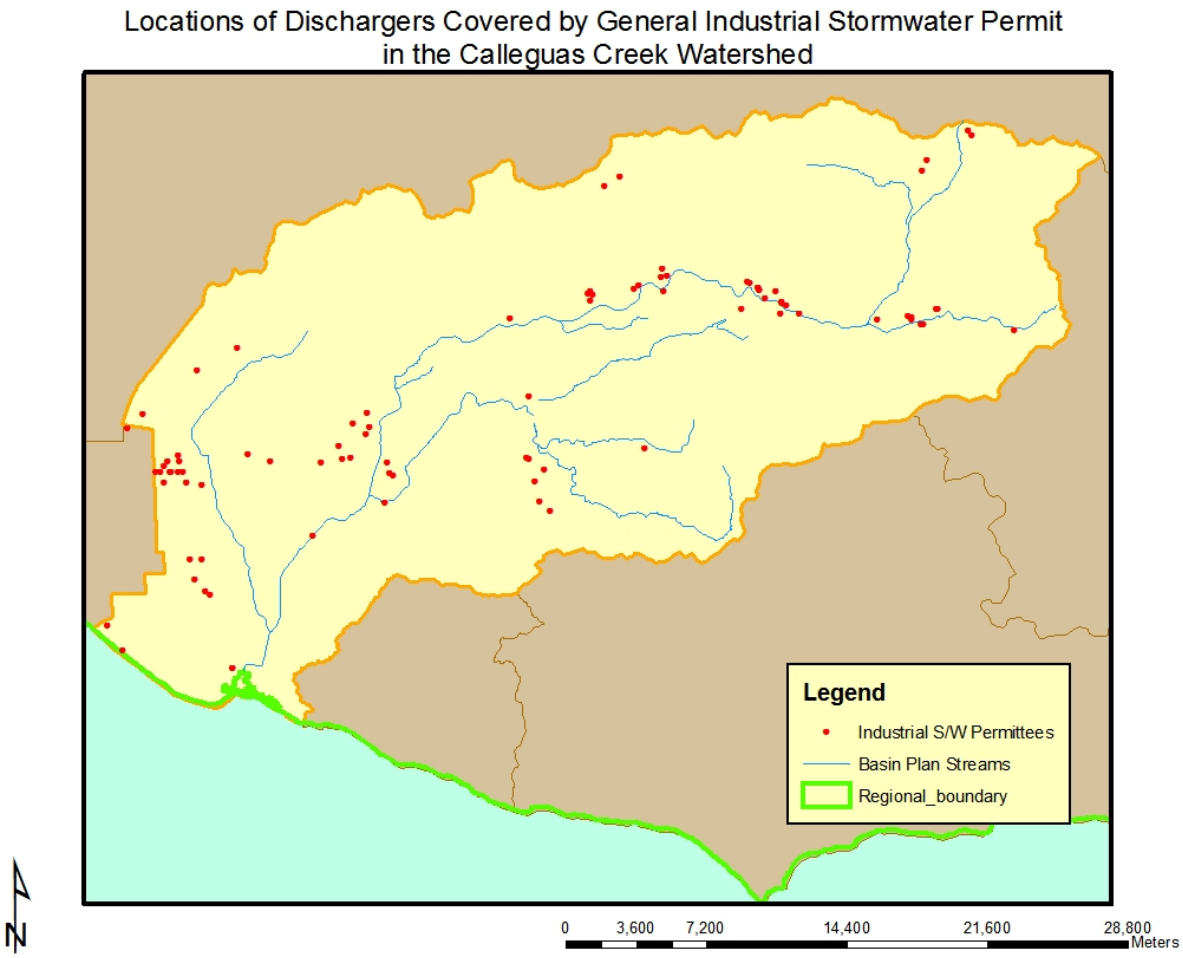
Primary issues related to POTW discharges include ammonia toxicity and high mineral content (i.e., salinity), the latter, in part, due to imported water supplies.

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.

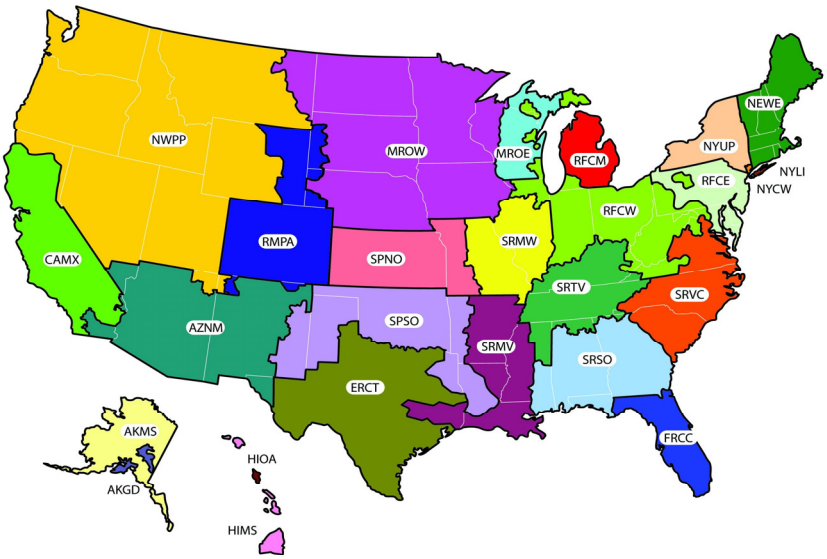
Review and comment on watershed issues in CEQA documents (for the highest priority projects) will also continue; however, this is currently an unfunded program.

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.

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

VENTURA COUNTY WATERWORKS DISTRICTS

Representing: Ventura County Waterworks Districts No. 1, 16, 17 & 19

COUNTY OF VENTURA
PUBLIC WORKS AGENCY
JEFF PRATT
Agency Director

Water & Sanitation Department
R. Reddy Pakala
Director

Anne Dana
Administration

Cliff Finley
Operations

Cefe Munoz
Engineering

January 20, 2012

Information Technology Unit
California Regional Water Quality Control Board
Los Angeles Region
320 West 4th Street, Suite 200
Los Angeles, CA 90013

Subject: Ventura County Waterworks District No. 1 (District)
Moorpark Wastewater Treatment Plant
2011 Annual WDR Summary Report
2011 Annual Groundwater Monitoring and Summary Report
File No. 64-148 CI No. 6374

Attached are the 2011 Annual WDR Summary and Annual Groundwater Summary Reports for the Ventura County Waterworks District No. 1, Moorpark Wastewater Treatment Plant. The laboratory tests were performed by the District's laboratory, Pat-Chem Laboratories, and FGL Environmental, State certified laboratories.

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

Executed on this 20th day of January 2012 in Moorpark, California.

R. R. Pakala, Director
Water and Sanitation Department

RRP:AS:ec

6767 Spring Road • P.O. Box 250 • Moorpark, California 93021-0250
(805) 378-3005 • FAX (805) 529-7542 • http://publicworks.countyofventura.org

VENTURA COUNTY WATERWORKS DISTRICT NO. 1
MOORPARK WASTEWATER TREATMENT PLANT

2011 ANNUAL REPORT

6767 Spring Road
P.O. Box 250
Moorpark, CA 93020

MOORPARK WASTEWATER TREATMENT PLANT
2011 ANNUAL REPORT

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MOORPARK WASTEWATER TREATMENT PLANT
2011 ANNUAL SUMMARY REPORT

The Ventura County Waterworks District No. 1 Moorpark Wastewater Treatment Plant has met all discharge requirements for 2011 as set forth in Order No. 00-048.

Figure I

MOORPARK WASTEWATER TREATMENT PLANT
2011 ANNUAL REPORT
DAILY INFLUENT FLOW (MGD)

DATE	JAN	FEB	MAR	APR	MAY	JUN
1	2.09	2.12	2.09	2.12	2.32	2.17
2	2.27	2.15	2.16	2.19	2.19	2.19
3	2.29	2.12	2.16	2.34	2.10	2.13
4	2.14	2.07	2.11	2.19	2.15	2.21
5	2.20	2.22	2.22	2.19	2.10	2.23
6	2.19	2.28	2.29	2.09	2.12	2.16
7	2.10	2.17	2.22	2.10	2.19	2.13
8	2.25	2.15	2.18	2.08	2.30	2.12
9	2.33	2.19	2.13	2.22	2.15	2.22
10	2.32	2.09	2.15	2.29	2.15	2.08
11	2.15	2.03	2.06	2.25	2.19	2.10
12	2.16	2.22	2.18	2.11	2.17	2.22
13	2.15	2.26	2.27	2.18	2.31	2.23
14	2.08	2.17	2.12	2.16	2.02	2.14
15	2.22	2.12	2.13	2.11	2.37	2.10
16	2.15	2.16	2.12	2.16	2.19	2.09
17	2.39	2.13	2.10	2.32	2.19	2.13
18	2.10	2.16	2.11	2.12	2.17	2.15
19	2.16	2.23	2.27	2.15	2.13	2.18
20	2.11	2.20	3.20	2.17	2.14	2.23
21	2.07	2.28	2.28	2.12	2.19	2.16
22	2.20	2.18	2.21	2.15	2.29	2.15
23	2.29	2.14	2.26	2.19	2.15	2.16
24	2.22	2.14	2.28	2.18	2.12	2.09
25	2.10	2.30	2.17	2.20	2.13	2.17
26	2.10	2.26	2.25	2.08	2.16	2.21
27	2.12	2.31	2.34	2.10	2.10	2.18
28	2.06	2.28	2.25	2.08	2.14	2.12
29	2.20		2.30	2.04	2.11	2.16
30	2.28		2.17	2.15	2.38	2.12
31	2.20		2.09		2.18	
MAX	**2.39**	**2.31**	**3.20**	**2.34**	**2.38**	**2.23**
MIN	**2.06**	**2.03**	**2.06**	**2.04**	**2.02**	**2.08**
AVG	**2.18**	**2.18**	**2.22**	**2.16**	**2.18**	**2.16**

Figure I

MOORPARK WASTEWATER TREATMENT PLANT
2011 ANNUAL REPORT
DAILY INFLUENT FLOW (MGD)

DATE	JUL	AUG	SEP	OCT	NOV	DEC
1	2.14	2.18	2.15	2.17	2.36	2.11
2	2.18	2.07	2.11	2.32	1.93	2.15
3	2.16	2.07	2.11	2.20	2.14	2.26
4	2.18	2.10	2.05	2.14	2.08	2.26
5	2.19	2.14	2.32	2.36	2.26	2.17
6	2.16	2.07	2.20	2.19	2.40	2.13
7	2.15	2.18	2.13	2.12	2.14	2.14
8	2.13	2.13	2.16	2.20	2.12	2.12
9	2.11	2.08	2.09	2.30	2.17	2.09
10	2.18	2.05	2.15	2.20	2.05	2.21
11	2.18	2.06	2.33	2.24	2.25	2.34
12	2.12	2.14	2.11	1.97	2.15	2.23
13	2.11	2.00	2.14	2.11	2,31	2.16
14	2.08	2.16	2.15	2.11	2.23	2.17
15	2.15	2.17	2.14	2.20	2.14	2.17
16	2.09	2.11	2.10	2.27	2.17	2.16
17	2.15	2.12	2.18	2.20	2.17	2.24
18	2.17	2.09	2.32	2.16	2.09	2.25
19	2.13	2.13	2.18	2.10	2.24	2.21
20	2.11	2.13	2.12	2.14	2.36	2.20
21	2.11	2.21	2.16	2.09	2.25	2.21
22	2.11	2.30	2.15	2.20	2.08	2.20
23	2.14	2.14	2.11	2.28	2.38	2.33
24	2.19	2.18	2.14	2.24	2.23	2.37
25	2.15	2.17	2.21	2.05	2.10	2.11
26	2.13	2.08	2.20	2.14	2.19	2.27
27	2.11	2.21	2.30	2.14	2.32	2.19
28	2.11	2.26	2.03	2.02	2.20	2.18
29	2.13	2.23	2.18	2.23	2.08	2.17
30	2.12	2.16	2.11	2.32	2.17	2.18
31	2.14	2.15		2.08		2.32
MAX	**2.19**	**2.30**	**2.33**	**2.36**	**2.40**	**2.24**
MIN	**2.08**	**2.00**	**2.03**	**1.97**	**1.93**	**2.38**
AVG	**2.14**	**2.14**	**2.16**	**2.18**	**2.19**	**2.20**

Figure II

MOORPARK WASTEWATER TREATMENT PLANT
2011 ANNUAL REPORT
DAILY EFFLUENT FLOW (MGD)

DATE	JAN	FEB	MAR	APR	MAY	JUN
1	2.09	2.12	2.09	2.12	2.32	0.87
2	2.27	2.05	2.16	2.19	2.19	1.54
3	2.29	1.20	2.16	2.34	2.10	2.13
4	2.14	0.77	2.11	2.19	1.50	2.21
5	1.36	1.30	2.22	2.19	0.80	2.23
6	1.27	2.28	2.29	2.09	0.82	1.40
7	1.83	2.17	2.22	2.10	1.27	1.43
8	2.25	2.15	2.18	2.08	2.30	1.20
9	2.33	1.49	0.83	2.22	2.15	1.57
10	2.32	0.79	0.85	2.29	1.66	2.08
11	2.15	1.17	1.41	2.25	0.89	2.10
12	2.16	2.22	2.18	1.30	1.41	2.22
13	2.15	2.26	2.27	1.05	1.82	1.42
14	2.08	2.17	2.12	1.62	1.88	1.38
15	2.22	1.36	2.13	1.78	2.37	1.72
16	0.85	1.24	1.47	2.16	2.19	1.55
17	1.74	2.13	0.80	2.32	2.19	2.13
18	2.10	1.65	1.38	2.12	1.41	2.15
19	1.51	2.23	2.27	2.15	1.59	2.18
20	0.87	2.20	3.20	1.25	2.14	1.47
21	1.58	2.28	2.28	1.25	2.19	1.24
22	2.20	2.18	2.21	1.61	2.29	1.55
23	2.29	1.27	2.26	2.19	2.15	1.62
24	2.22	1.44	2.28	2.18	1.63	1.60
25	2.10	2.30	2.17	2.20	1.83	2.17
26	1.23	2.26	2.25	2.08	1.04	2.21
27	0.82	2.31	2.34	1.23	1.40	2.18
28	1.36	2.28	2.25	1.16	2.14	0.82
29	2.20		2.30	1.55	2.11	1.24
30	2.28		2.17	1.60	2.38	2.12
31	2.20		2.09		1.56	
MAX	**2.33**	**2.31**	**3.20**	**2.34**	**2.38**	**2.23**
MIN	**0.82**	**0.77**	**0.80**	**1.05**	**0.80**	**0.82**
AVG	**1.89**	**1.83**	**2.03**	**1.90**	**1.80**	**1.72**

Figure II

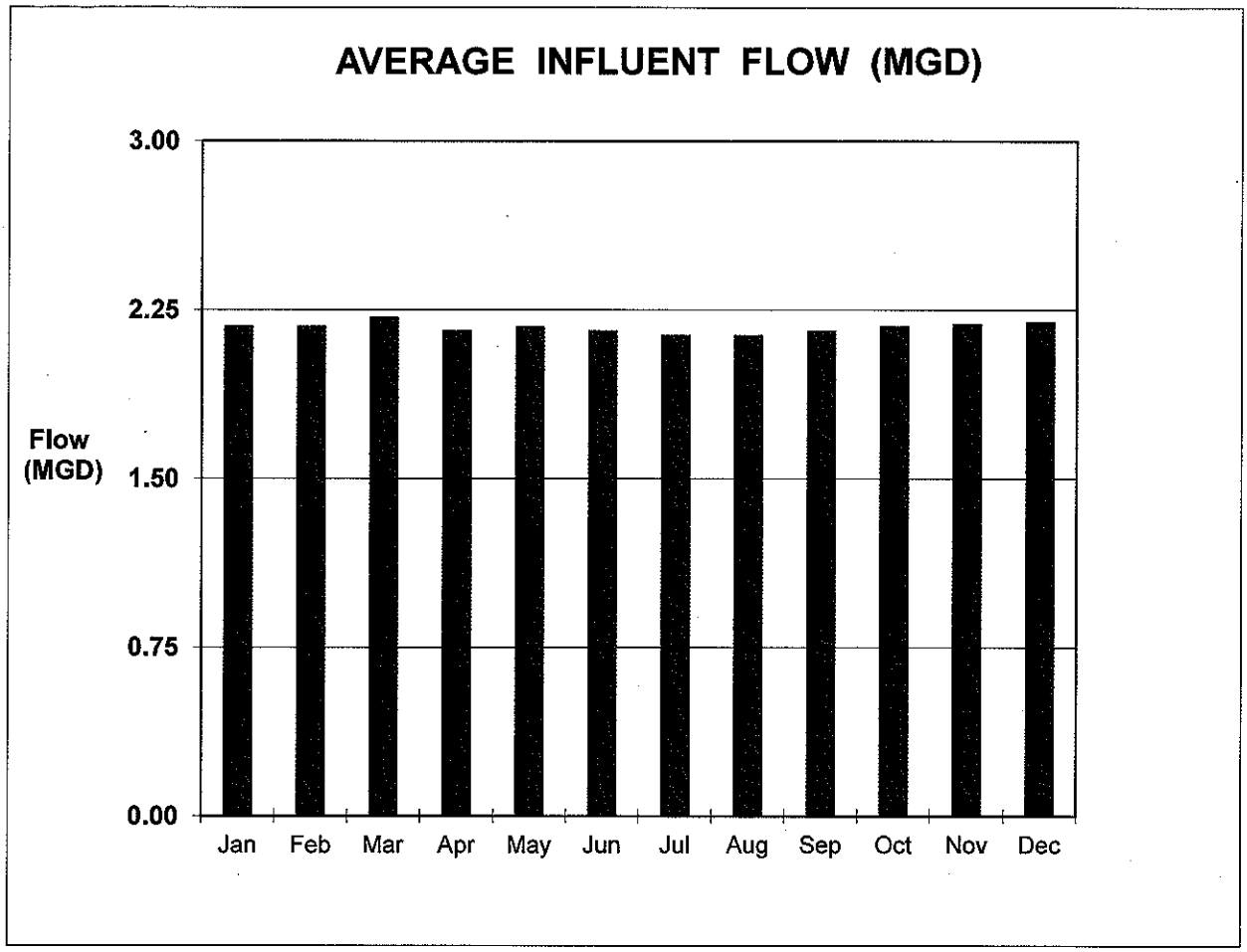
MOORPARK WASTEWATER TREATMENT PLANT
2011 ANNUAL REPORT
DAILY EFFLUENT FLOW (MGD)

DATE	JUL	AUG	SEP	OCT	NOV	DEC
1	1.22	1.48	1.23	1.37	1.48	1.56
2	1.32	0.77	1.57	2.32	1.00	1.60
3	2.16	0.77	2.11	2.20	1.82	2.26
4	2.18	1.18	2.05	1.34	1.59	2.26
5	1.54	1.60	1.62	1.76	2.26	2.17
6	0.89	2.07	0.90	2.19	2.40	1.20
7	0.86	2.18	0.83	2.12	2.14	1.21
8	1.21	1.37	1.24	2.20	2.12	2.12
9	2.11	0.78	1.60	2.30	1.68	2.09
10	2.18	1.13	1.66	2.20	1.67	2.21
11	1.37	1.52	2.33	1.69	2.25	2.34
12	0.82	1.60	1.73	1.10	2.15	2.23
13	0.81	2.00	0.84	1.66	2.31	1.23
14	1.16	2.16	0.85	1.91	2.23	1.57
15	1.61	1.41	1.38	2.20	2.14	2.17
16	2.09	0.81	2.10	2.27	1.95	2.16
17	2.15	1.20	2.18	1.65	1.62	2.24
18	1.68	1.76	2.32	0.96	1.16	2.25
19	0.83	1.70	2.18	0.90	2.24	2.21
20	0.81	2.13	1.42	1.39	2.36	2.20
21	1.19	1.56	0.96	1.59	2.25	2.21
22	1.57	1.38	1.30	2.20	1.59	1.27
23	1.76	1.22	1.68	2.28	2.38	1.40
24	2.19	1.26	2.14	2.24	2.23	2.37
25	1.50	1.79	2.21	2.05	2.05	2.11
26	0.83	1.19	2.20	2.14	2.19	2.27
27	0.81	1.45	1.65	1.69	2.32	2.19
28	1.19	2.26	1.43	2.02	1.49	1.41
29	1.59	2.23	2.18	1.78	1.42	1.29
30	2.12	1.35	1.26	2.32	1.62	2.18
31	2.14	0.85		2.08		2.32
MAX	**2.19**	**2.26**	**2.33**	**2.32**	**2.40**	**2.37**
MIN	**0.81**	**0.77**	**0.83**	**0.90**	**1.00**	**1.20**
AVG	**1.48**	**1.49**	**1.64**	**1.87**	**1.94**	**1.95**

Figure III

MOORPARK WASTEWATER TREATMENT PLANT

2011 ANNUAL REPORT

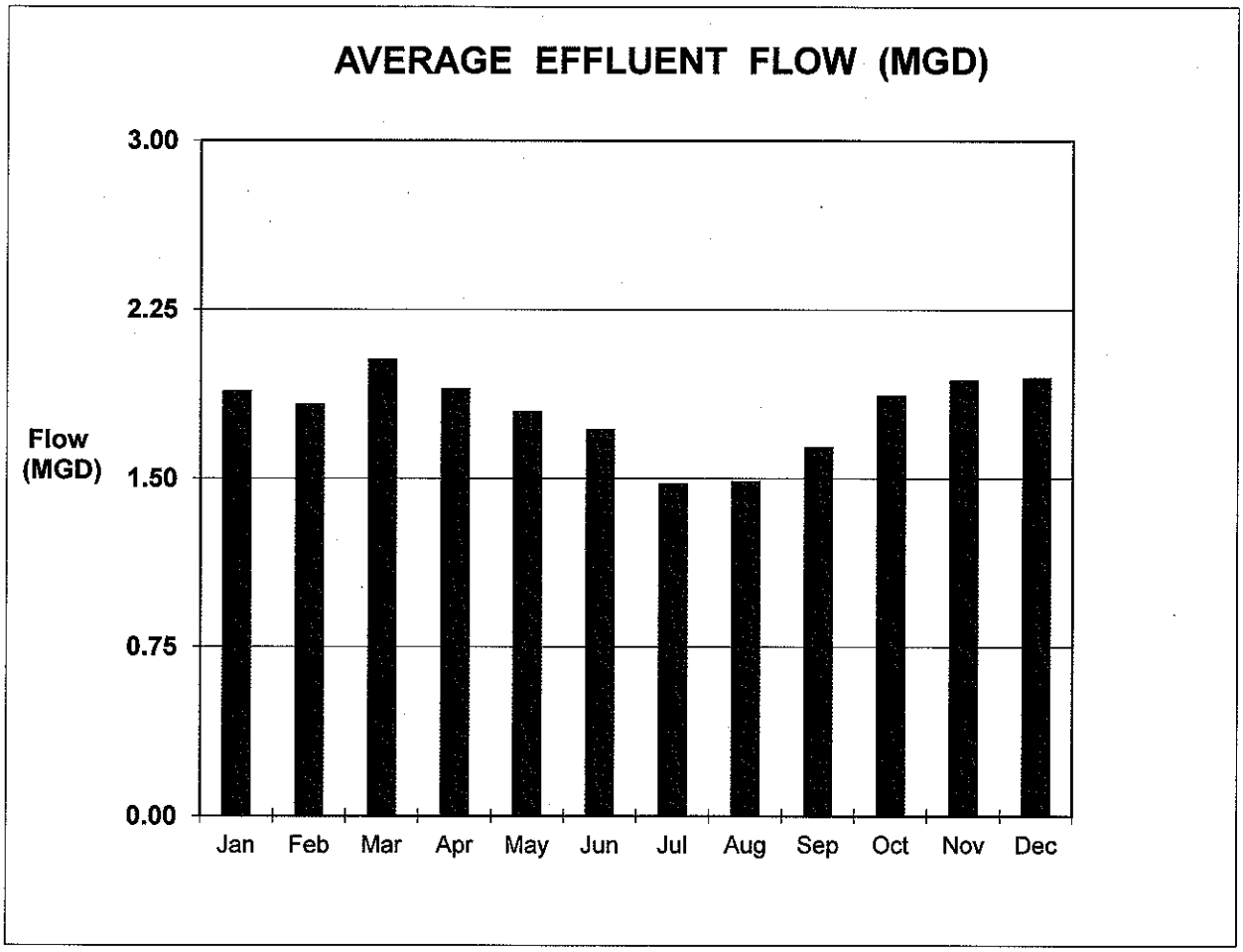


Month	Average Flow	Month	Average Flow
Jan	2.18	Jul	2.14
Feb	2.18	Aug	2.14
Mar	2.22	Sep	2.16
Apr	2.16	Oct	2.18
May	2.18	Nov	2.19
Jun	2.16	Dec	2.20

Figure IV

MOORPARK WASTEWATER TREATMENT PLANT

2011 ANNUAL REPORT

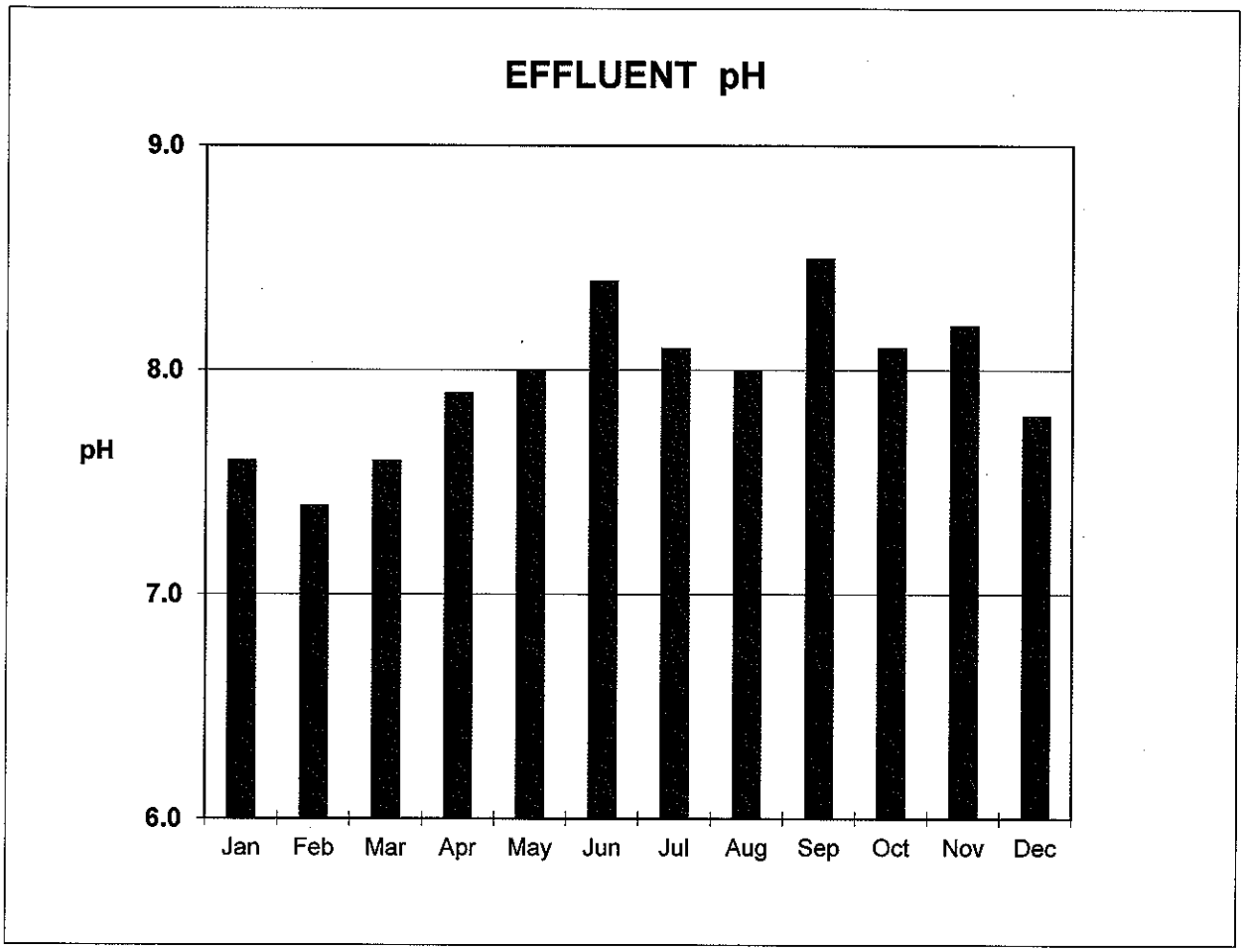


Month	Average Flow	Month	Average Flow
Jan	1.89	Jul	1.48
Feb	1.83	Aug	1.49
Mar	2.03	Sep	1.64
Apr	1.90	Oct	1.87
May	1.80	Nov	1.94
Jun	1.72	Dec	1.95

Figure V

MOORPARK WASTEWATER TREATMENT PLANT

2011 ANNUAL REPORT



Month	pH	Month	pH
Jan	7.6	Jul	8.1
Feb	7.4	Aug	8.0
Mar	7.6	Sep	8.5
Apr	7.9	Oct	8.1
May	8.0	Nov	8.2
Jun	8.4	Dec	7.8

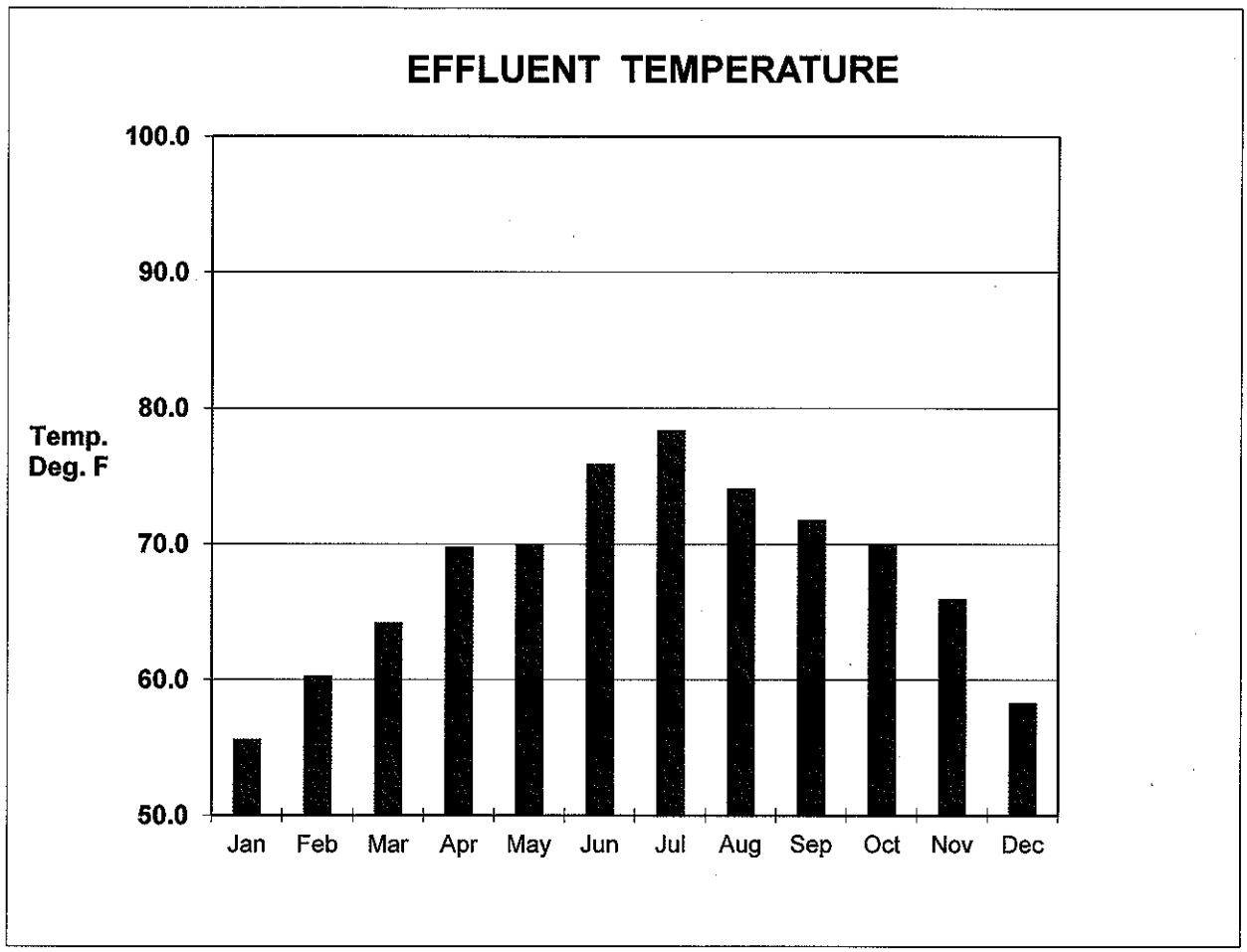
Note:

1. pH limits = 6.5 to 8.5 pH Units.

Figure VI

MOORPARK WASTEWATER TREATMENT PLANT

2011 ANNUAL REPORT

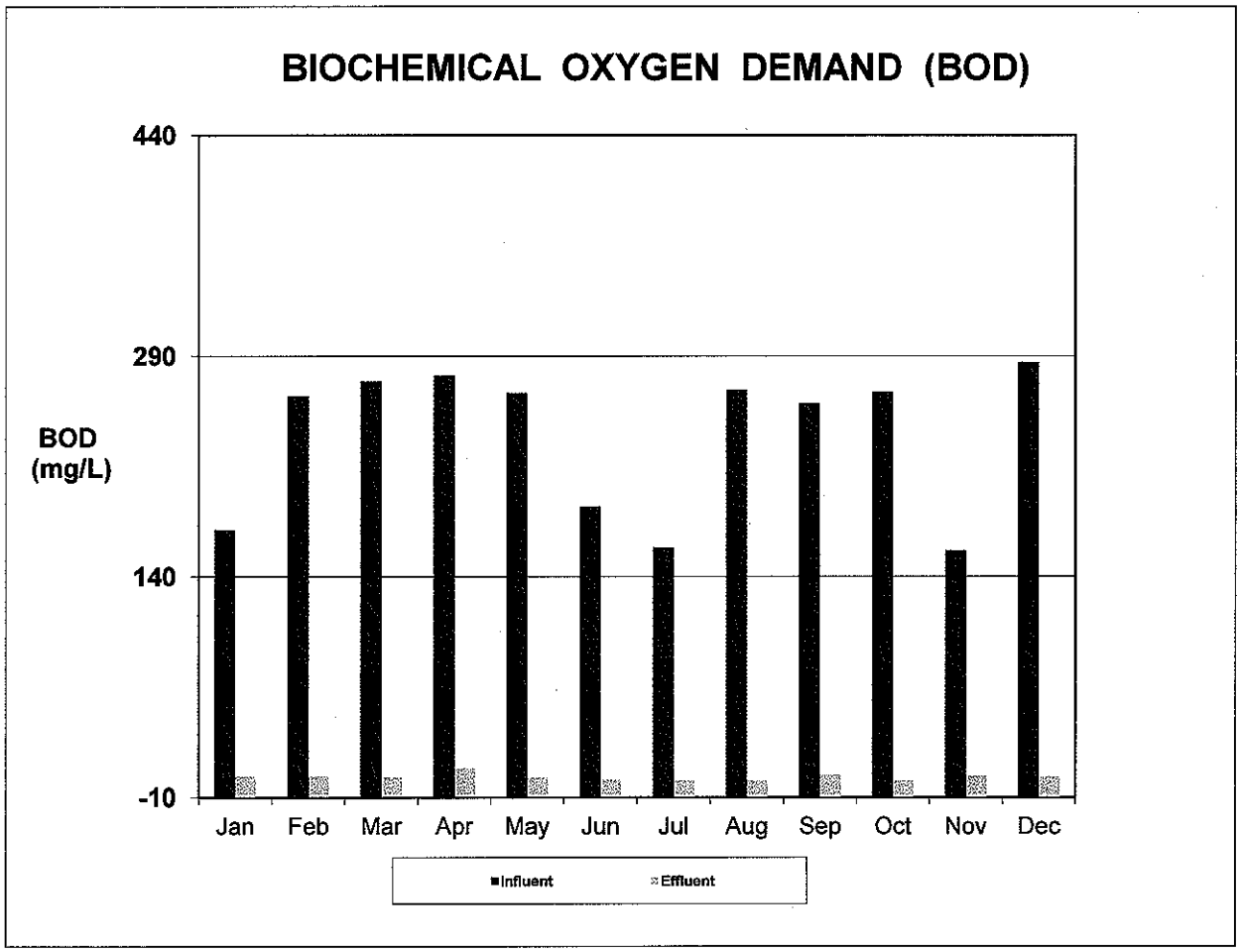


Month	Temp. Deg. F	Month	Temp. Deg. F
Jan	55.6	Jul	78.4
Feb	60.3	Aug	74.1
Mar	64.2	Sep	71.8
Apr	69.8	Oct	70.0
May	70.0	Nov	66.0
Jun	75.9	Dec	58.3

Figure VII

MOORPARK WASTEWATER TREATMENT PLANT

2011 ANNUAL REPORT



Influent		Effluent	
Month	BOD (mg/L)	Month	BOD (mg/L)
Jan	172	Jan	4.5
Feb	263	Feb	4.7
Mar	273	Mar	3.6
Apr	277	Apr	10
May	265	May	3.5
Jun	188	Jun	2.1
Jul	160	Jul	< 2.0
Aug	267	Aug	< 2.0
Sep	258	Sep	5.3
Oct	266	Oct	< 2.0
Nov	158	Nov	4.5
Dec	286	Dec	4.2

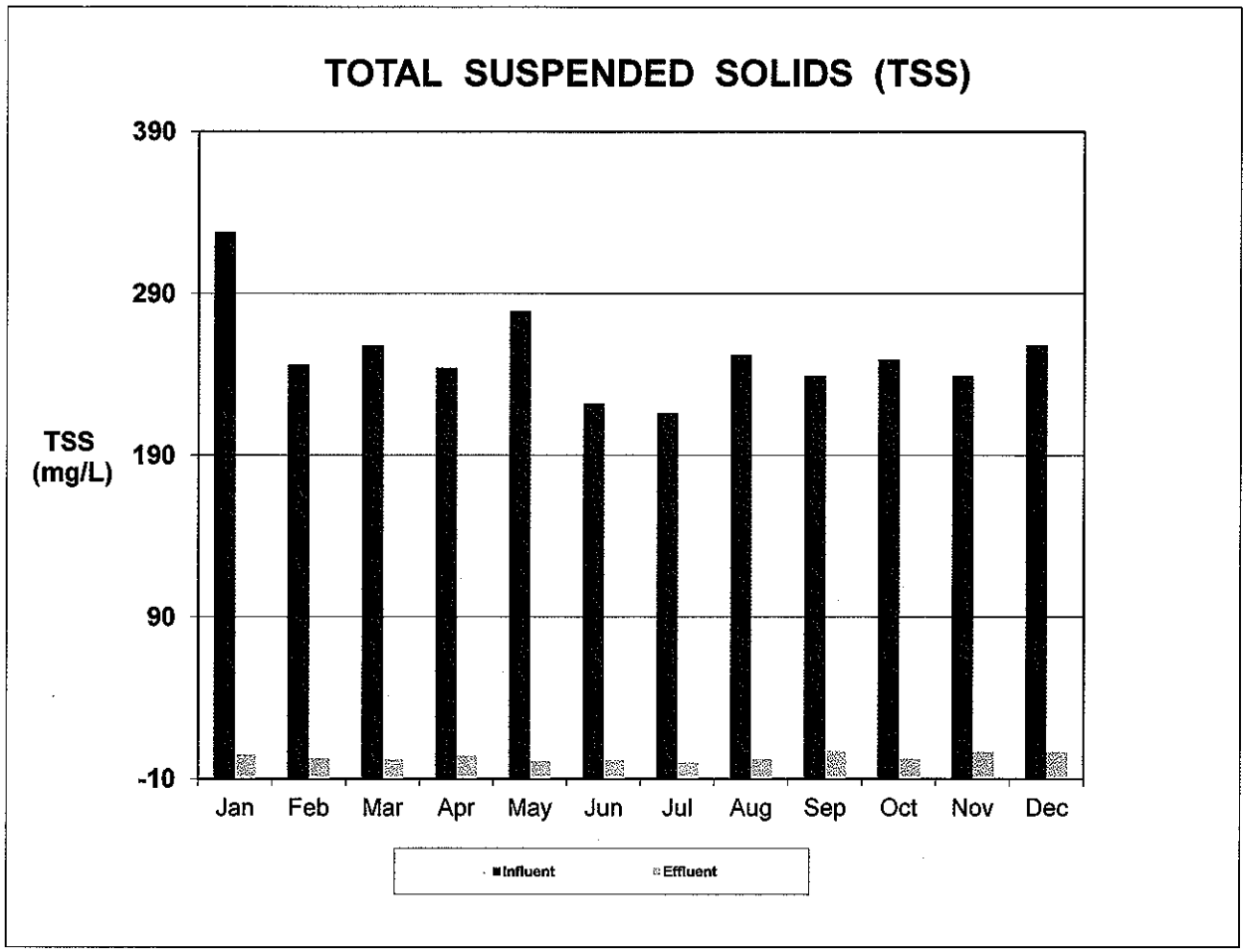
Notes:

1. Effluent BOD limit = 30 mg/l.

Figure VIII

MOORPARK WASTEWATER TREATMENT PLANT

2011 ANNUAL REPORT



Influent		Effluent	
Month	TSS (mg/L)	Month	TSS (mg/L)
Jan	328	Jan	5.0
Feb	246	Feb	2.8
Mar	258	Mar	2.1
Apr	244	Apr	4.4
May	279	May	1.1
Jun	222	Jun	1.7
Jul	216	Jul	< 1.0
Aug	252	Aug	2.2
Sep	239	Sep	7.4
Oct	249	Oct	2.6
Nov	239	Nov	6.8
Dec	258	Dec	6.8

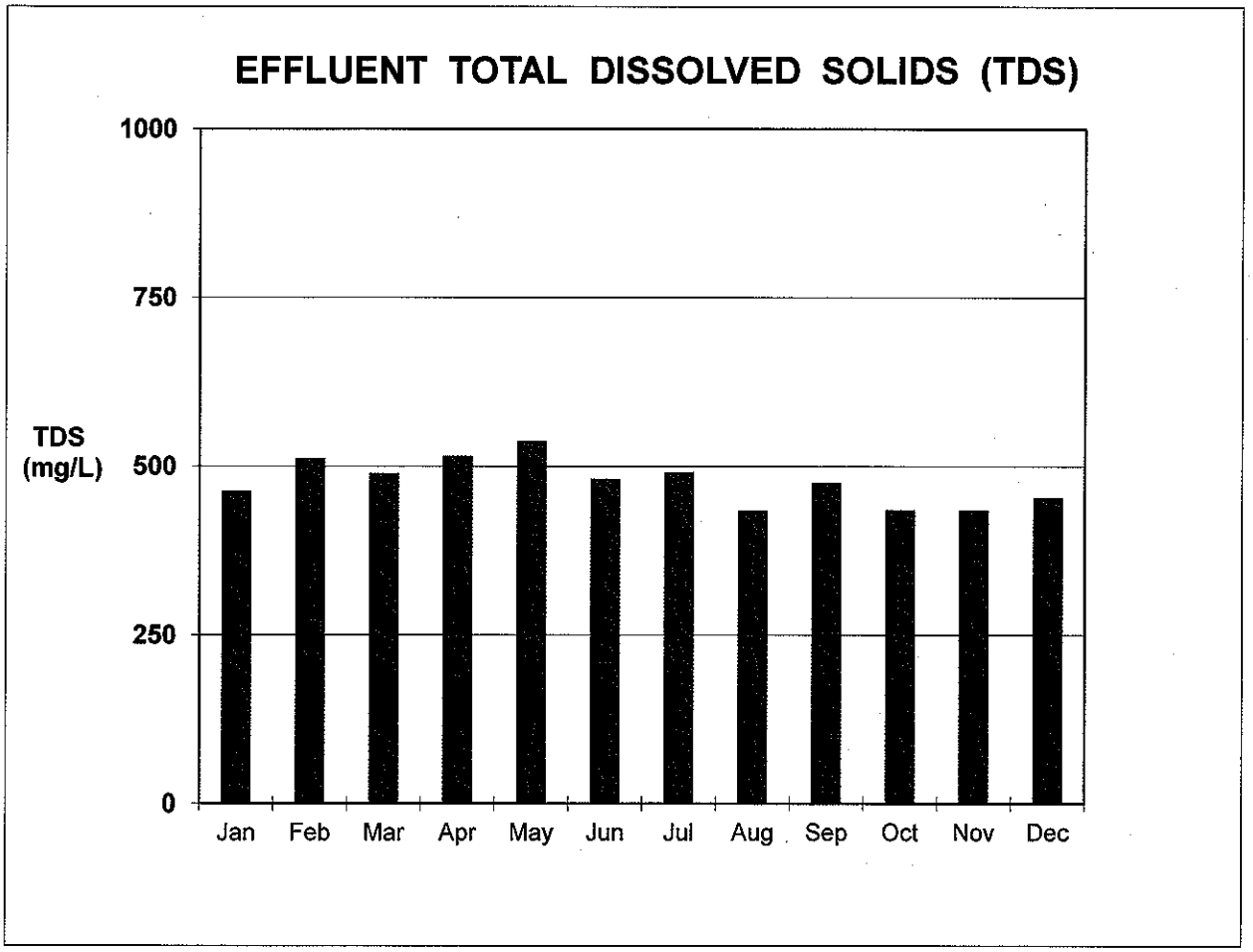
Notes:

1. Effluent TSS limit = 30 mg/l.

Figure IX

MOORPARK WASTEWATER TREATMENT PLANT

2011 ANNUAL REPORT



Month	TDS (mg/L)	Month	TDS (mg/L)
Jan	464	Jul	492
Feb	512	Aug	435
Mar	490	Sep	476
Apr	516	Oct	436
May	538	Nov	436
Jun	482	Dec	454

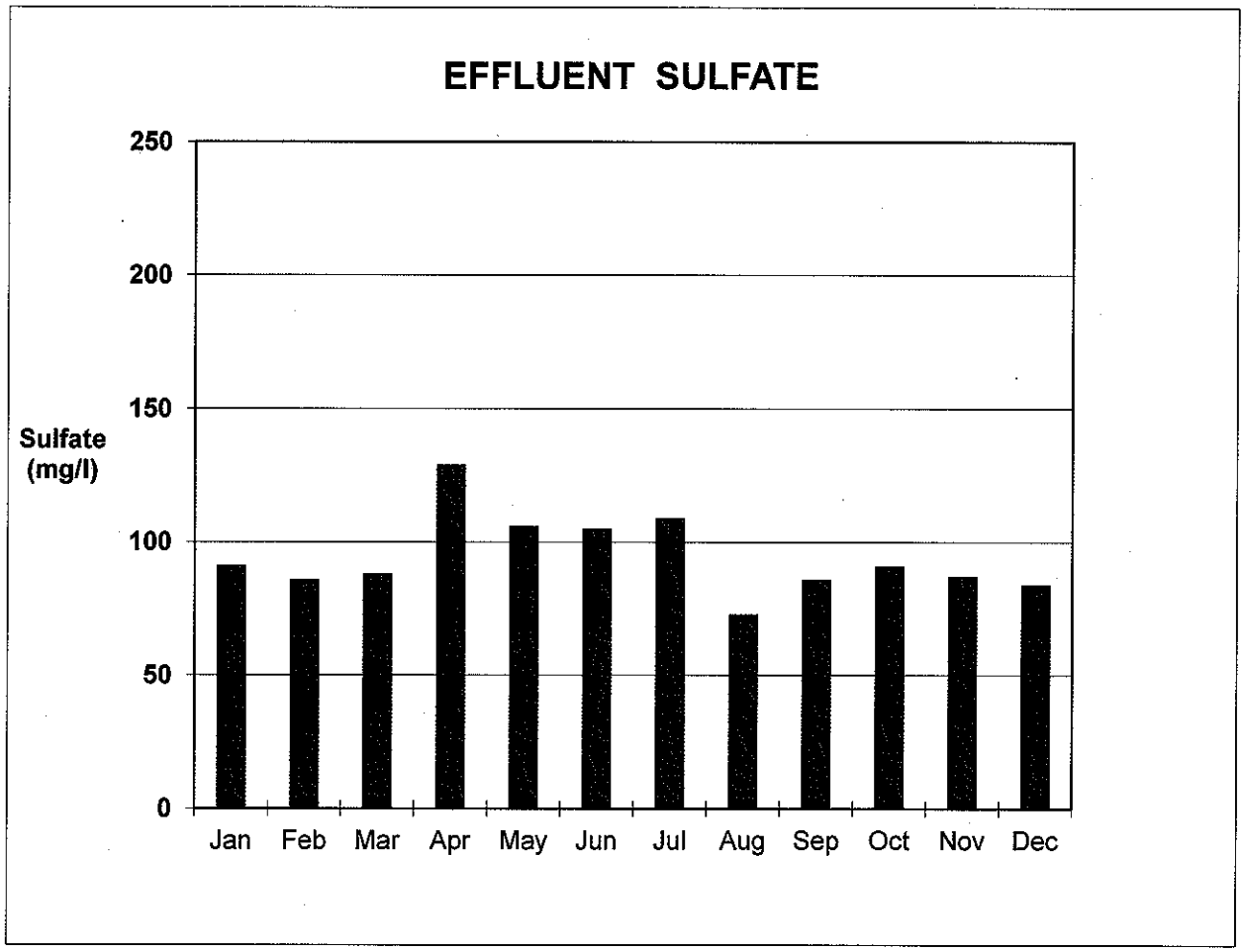
Notes:

1. TDS limit = 1500 mg/l.

Figure X

MOORPARK WASTEWATER TREATMENT PLANT

2011 ANNUAL REPORT



Month	Sulfate (mg/L)	Month	Sulfate (mg/L)
Jan	91.3	Jul	109
Feb	85.9	Aug	72.8
Mar	88.1	Sep	85.9
Apr	129	Oct	91.1
May	106	Nov	87.2
Jun	105	Dec	84.0

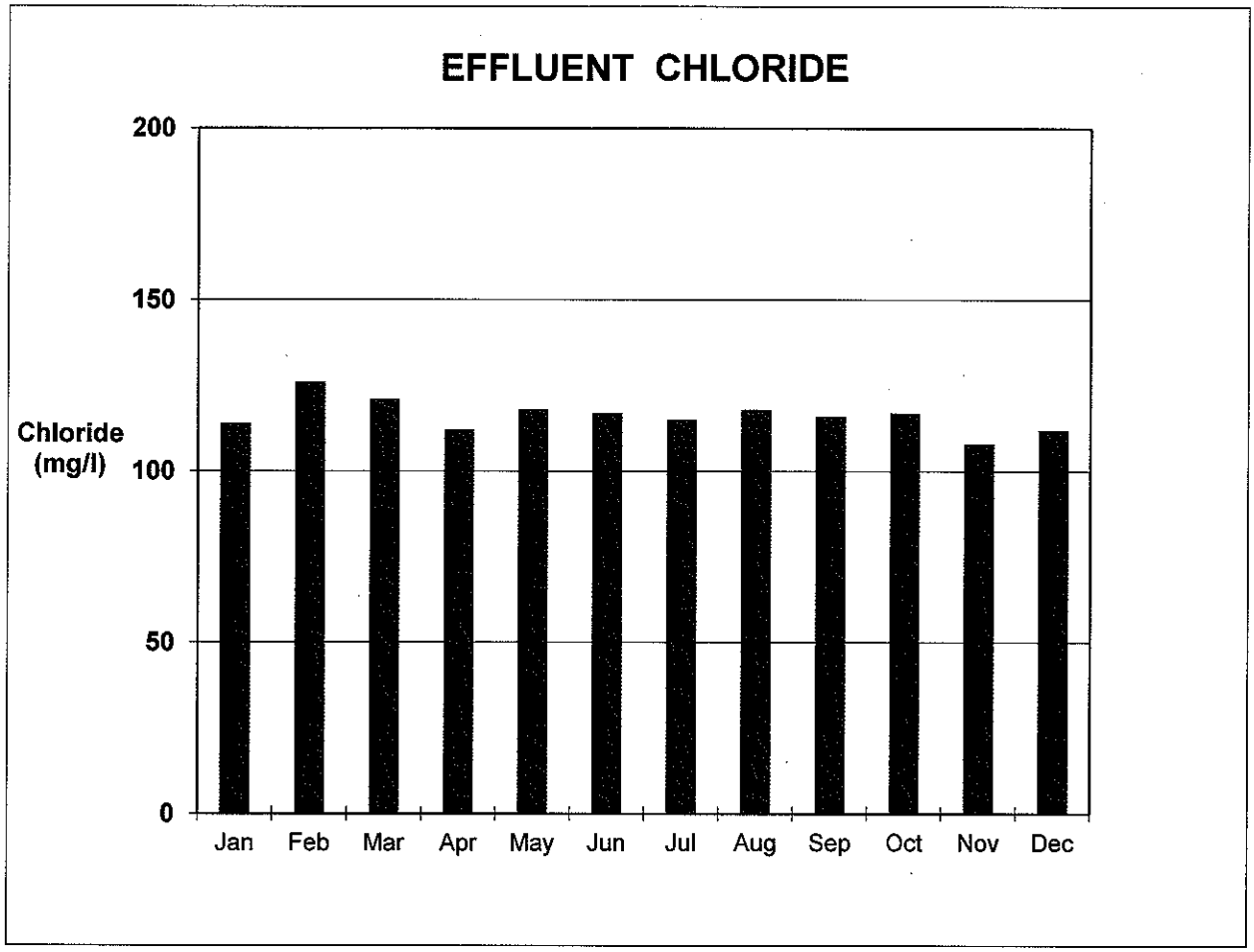
Notes:

1. Sufate limit = 700 mg/l.

Figure XI

MOORPARK WASTEWATER TREATMENT PLANT

2011 ANNUAL REPORT



Month	Chloride (mg/L)	Month	Chloride (mg/L)
Jan	114	Jul	115
Feb	126	Aug	118
Mar	121	Sep	116
Apr	112	Oct	117
May	118	Nov	108
Jun	117	Dec	112

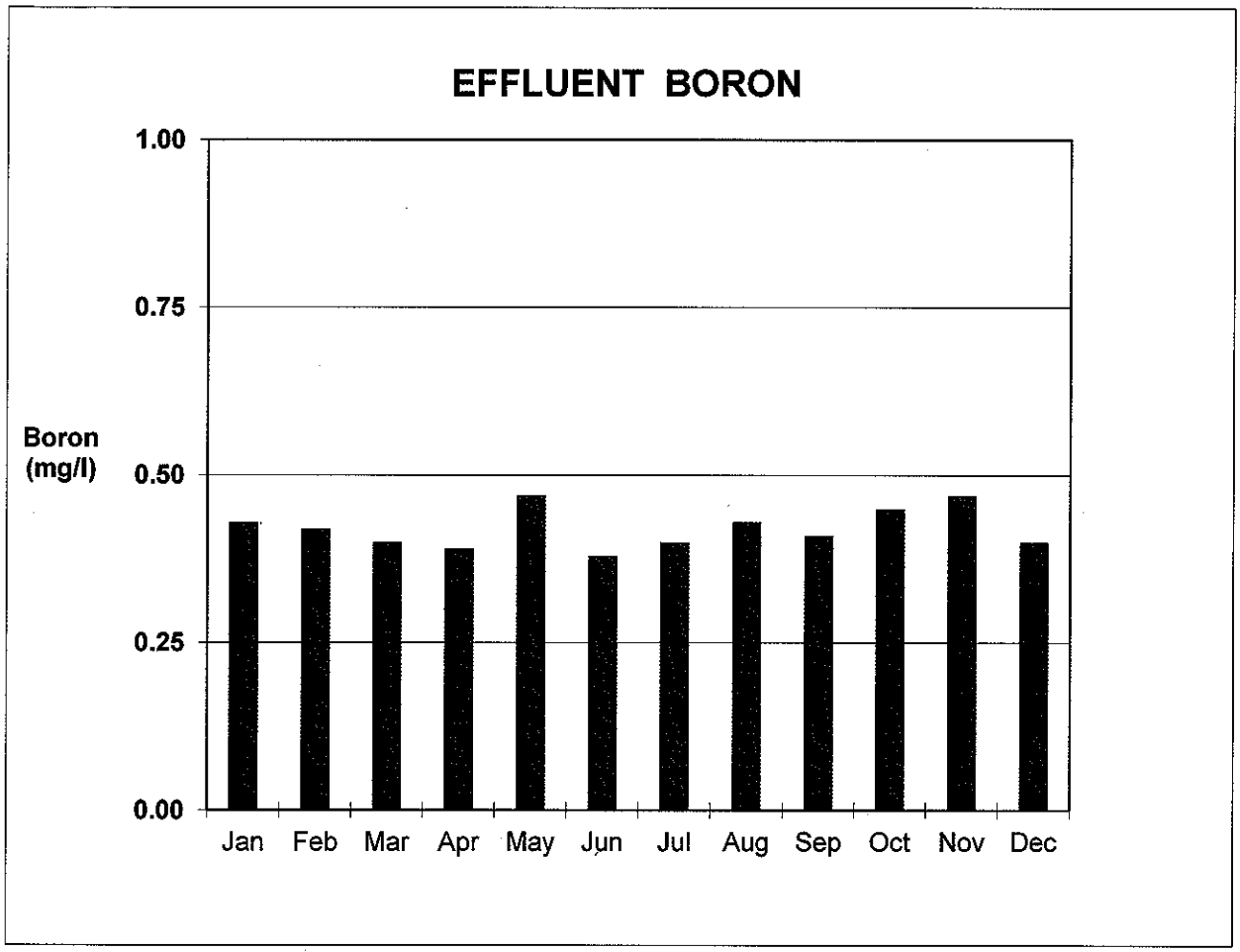
Notes:

1. Chloride limit = 250 mg/l.

Figure XII

MOORPARK WASTEWATER TREATMENT PLANT

2011 ANNUAL REPORT



Month	Boron (mg/L)	Month	Boron (mg/L)
Jan	0.43	Jul	0.40
Feb	0.42	Aug	0.43
Mar	0.40	Sep	0.41
Apr	0.39	Oct	0.45
May	0.47	Nov	0.47
Jun	0.38	Dec	0.40

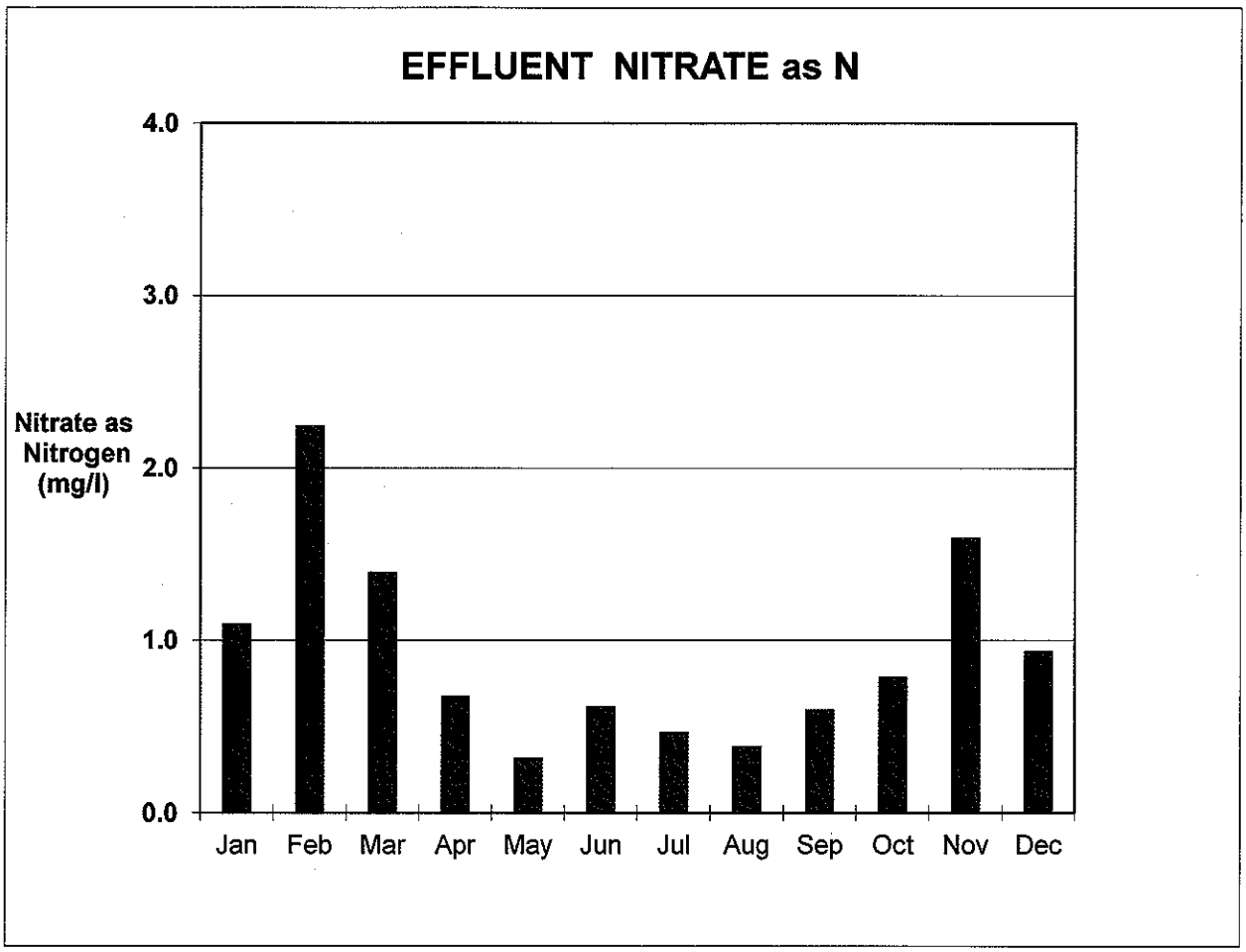
Notes:

1. Boron limit = 1.0 mg/l.

Figure XIII

MOORPARK WASTEWATER TREATMENT PLANT

2011 ANNUAL REPORT



Month	Nitrate-N (mg/l)	Month	Nitrate-N (mg/l)
Jan	1.10	Jul	0.47
Feb	2.25	Aug	0.39
Mar	1.40	Sep	0.60
Apr	0.68	Oct	0.79
May	0.32	Nov	1.60
Jun	0.62	Dec	0.94

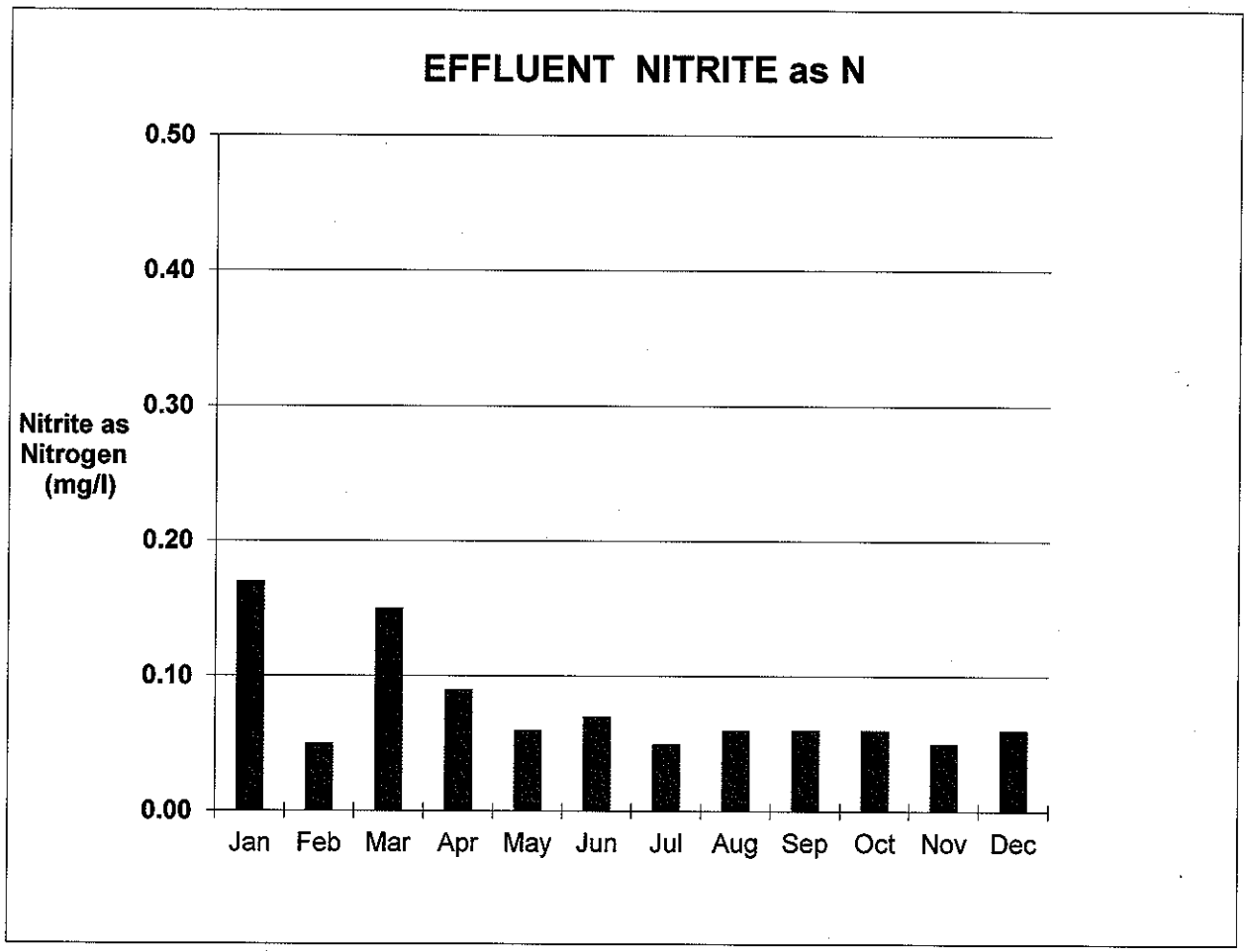
Notes:

1. Nitrate as N + Nitrite as N limit = 10 mg/l.

Figure XIV

MOORPARK WASTEWATER TREATMENT PLANT

2011 ANNUAL REPORT



Month	Nitrite-N (mg/l)	Month	Nitrite-N (mg/l)
Jan	0.17	Jul	0.05
Feb	<0.05	Aug	0.06
Mar	0.15	Sep	0.06
Apr	0.09	Oct	0.06
May	0.06	Nov	< 0.05
Jun	0.07	Dec	0.06

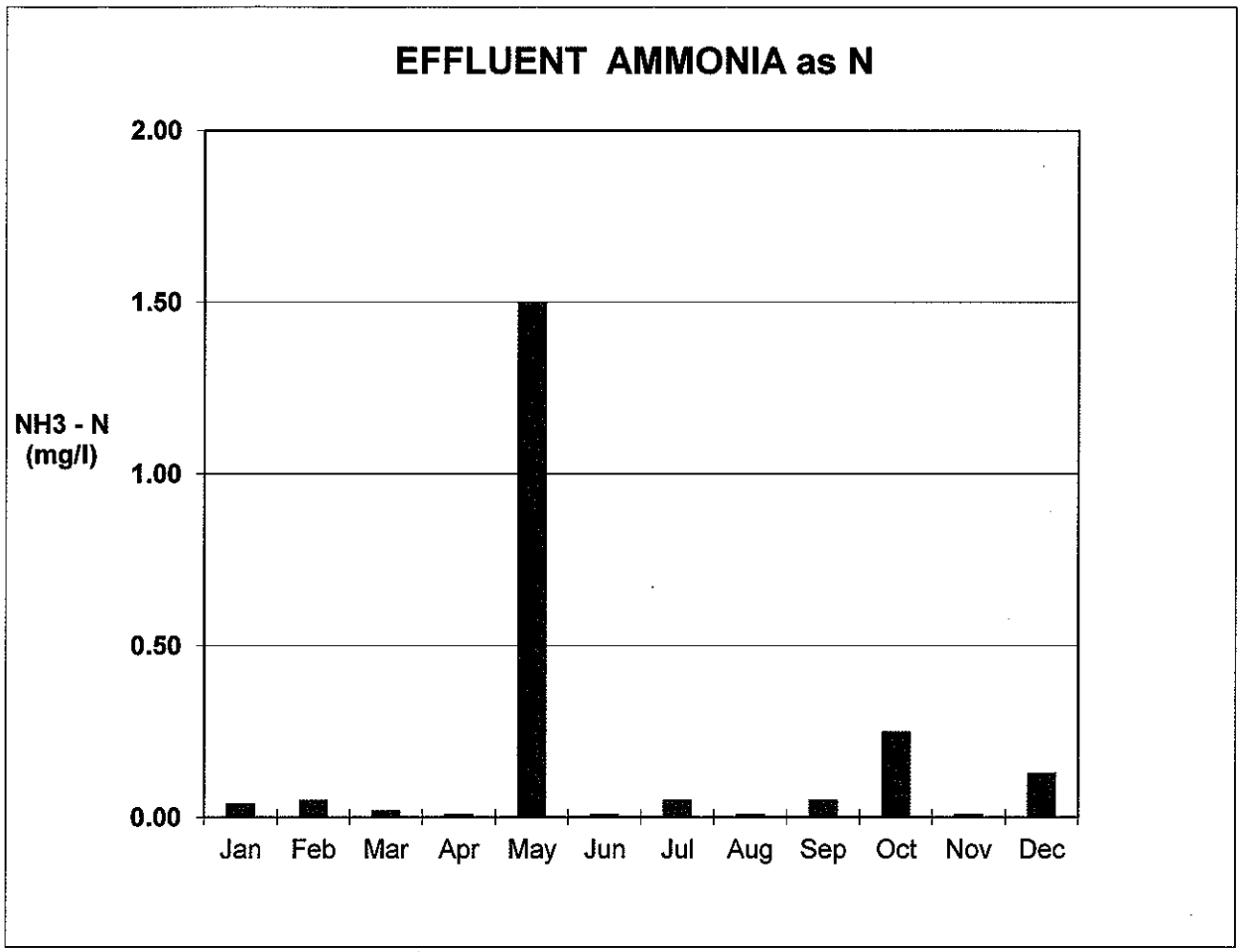
Notes:

1. Nitrate as N + Nitrite as N limit = 10 mg/l.

Figure XV

MOORPARK WASTEWATER TREATMENT PLANT

2011 ANNUAL REPORT

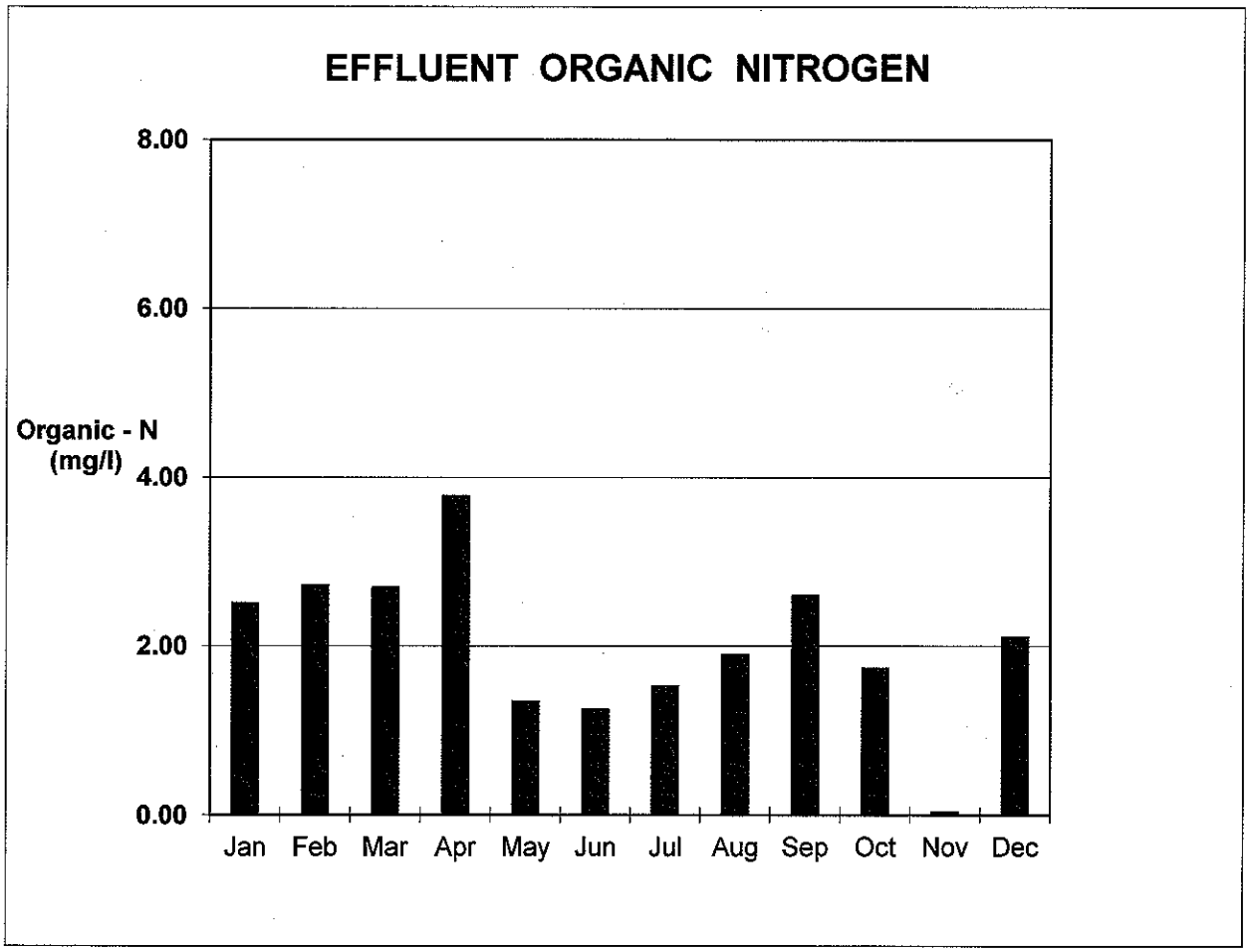


Month	NH_3 - N (mg/L)	Month	NH_3 - N (mg/L)
Jan	0.04	Jul	0.05
Feb	0.05	Aug	< 0.01
Mar	0.02	Sep	0.05
Apr	< 0.01	Oct	0.25
May	1.50	Nov	< 0.01
Jun	< 0.01	Dec	0.13

Figure XVI

MOORPARK WASTEWATER TREATMENT PLANT

2011 ANNUAL REPORT

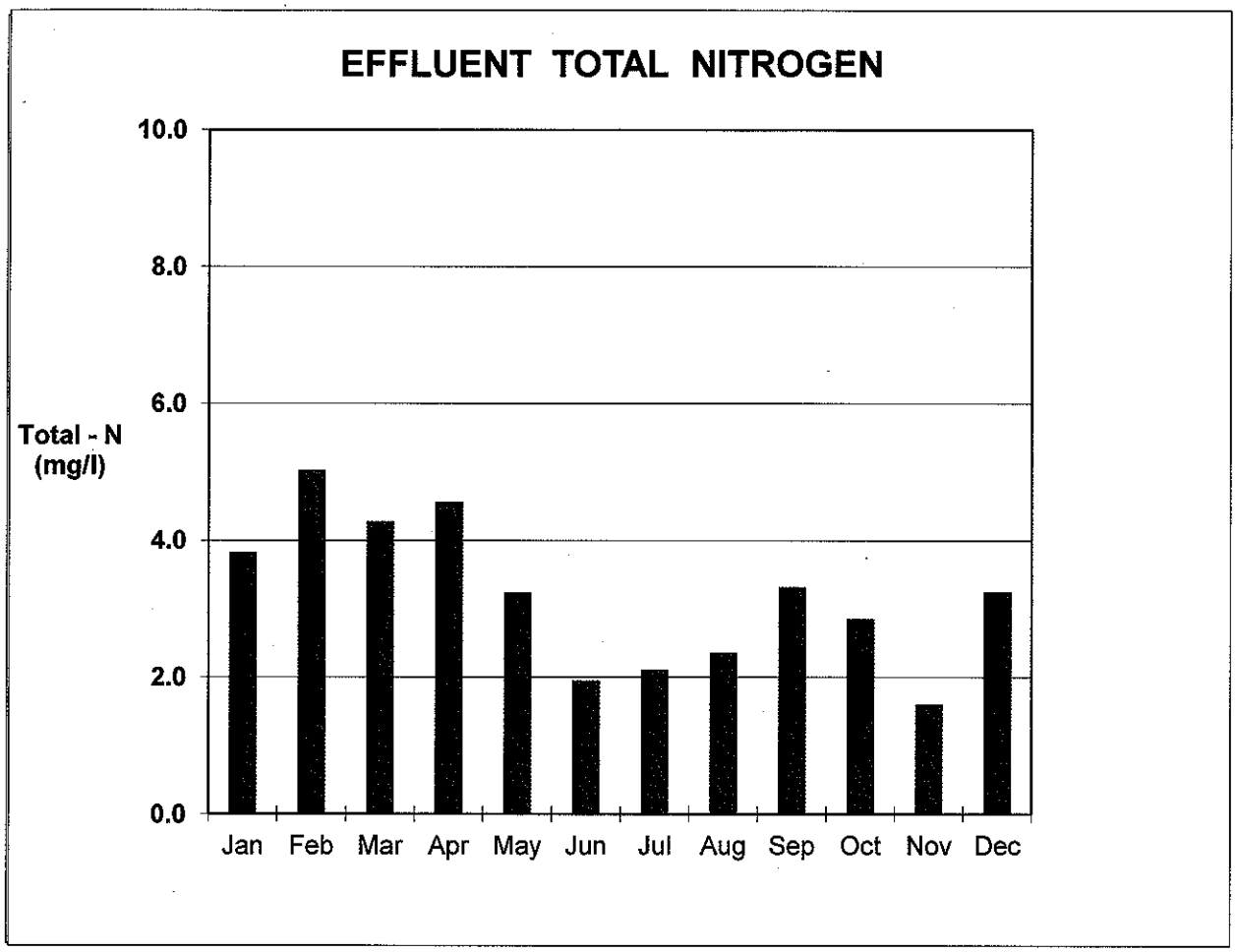


Month	Organic-N (mg/L)	Month	Organic-N (mg/L)
Jan	2.52	Jul	1.54
Feb	2.73	Aug	1.91
Mar	2.71	Sep	2.61
Apr	3.79	Oct	1.75
May	1.36	Nov	< 0.05
Jun	1.26	Dec	2.12

Figure XVII

MOORPARK WASTEWATER TREATMENT PLANT

2011 ANNUAL REPORT



Month	Total - N (mg/L)	Month	Total - N (mg/L)
Jan	3.83	Jul	2.11
Feb	5.03	Aug	2.36
Mar	4.28	Sep	3.32
Apr	4.56	Oct	2.85
May	3.24	Nov	1.60
Jun	1.95	Dec	3.25

VENTURA COUNTY WATERWORKS DISTRICT NO. 1
MOORPARK WASTEWATER TREATMENT PLANT
2011 ANNUAL MONITORING REPORT

SLUDGE HAULING

Disposal Dates	Hauler	Type	Disposal Location	Quantity (Wet Tons)
January	Western Express, Inc.	Belt Press	Rancho del Topo	428.05
February	through	"	Delano, CA	473.31
March	Tule Ranches/Magan Farms	"	"	439.06
April	Delano, CA	"	"	478.03
May	"	"	"	467.45
June	"	"	"	368.13
July	"	"	"	380.75
August	"	"	"	458.20
September	"	"	"	457.80
October	"	"	"	421.17
November	"	"	"	329.84
December	"	"	"	328.94
Total				5,030.73

ATTACHMENT A

ANNUAL LABORATORY TEST RESULTS

VENTURA COUNTY WATERWORKS DISTRICT NO. 1
MOORPARK WASTEWATER TREATMENT PLANT

2011 ANNUAL REPORT

6767 Spring Road
P.O. Box 250
Moorpark, CA 93020

Ventura County Waterworks Districts

Water and Sanitation Laboratory

Moorpark Wastewater Treatment Plant
Monitoring / Reporting Program No. 6374
WDR File No. 00-048

November 02, 2011

Annual Effluent Metals & Radioactivity Results

Analyte	Method	Units	Effluent Concentration
Antimony	200.8	ug/L	< 1.0
Arsenic	200.8	ug/L	1.3
Beryllium	200.8	ug/L	< 0.2
Cadmium	200.8	ug/L	< 0.2
Chromium	200.8	ug/L	2.2
Copper	200.8	ug/L	4.3
Lead	200.8	ug/L	0.2
Mercury	245.1	ug/L	< 0.20
Nickel	200.8	ug/L	2.5
Selenium	200.8	ug/L	< 2.0
Silver	200.8	ug/L	< 0.2
Thallium	200.8	ug/L	< 1.0
Zinc	200.8	ug/L	58
Gross Alpha	900.0	pCi/L	1.19 ± 0.956
Gross Beta	900.0	pCi/L	6.52 ± 1.20

< X denotes result below X, detection limit of reporting.

Ventura County Waterworks Districts
Water and Sanitation Laboratory

Moorpark Wastewater Treatment Plant
Monitoring / Reporting Program No. 6374
WDR File No. 00-048

November 02, 2011

Annual Effluent Miscellaneous Results

Analyte	Method	Units	Effluent Concentration
Total Cyanide	SM 4500-CN-E	mg/L	< 0.05

< X denotes result below X, detection limit of reporting.

Ventura County Waterworks Districts
Water and Sanitation Laboratory

Moorpark Wastewater Treatment Plant
Monitoring / Reporting Program No. 6374
WDR File No. 00-048

November 02, 2011

Annual Effluent 608 (Pesticides) Results

Analyte	Units	Effluent Concentration
Aldrin	ug/L	< 0.005
Chlordane	ug/L	< 0.5
Dieldrin	ug/L	< 0.01
4,4'-DDT	ug/L	< 0.01
4,4'-DDE	ug/L	< 0.01
4,4'-DDD	ug/L	< 0.01
Alpha Endosulfan	ug/L	< 0.01
Beta Endosulfan	ug/L	< 0.01
Endosulfan Sulfate	ug/L	< 0.01
Endrin	ug/L	< 0.01
Endrin Aldehyde	ug/L	< 0.01
Heptachlor	ug/L	< 0.01
Heptachlor Epoxide	ug/L	< 0.01
Alpha BHC	ug/L	< 0.01
Beta BHC	ug/L	< 0.005
Gamma BHC	ug/L	< 0.01
Delta BHC	ug/L	< 0.005
Toxaphene	ug/L	< 0.5
PCB 1016	ug/L	< 0.5
PCB 1221	ug/L	< 0.5
PCB 1232	ug/L	< 0.5
PCB 1242	ug/L	< 0.5
PCB 1248	ug/L	< 0.5
PCB 1254	ug/L	< 0.5
PCB 1260	ug/L	< 0.5

< X denotes result below X, detection limit of reporting.

Ventura County Waterworks Districts
Water and Sanitation Laboratory

Moorpark Wastewater Treatment Plant
Monitoring / Reporting Program No. 6374
WDR File No. 00-048

November 02, 2011

Annual Effluent 624 (VOA) Results

Analyte	Units	Effluent Concentration
Acrolein	ug/L	< 10.0
Acrylonitrile	ug/L	< 10.0
Benzene	ug/L	< 0.5
Carbon Tetrachloride	ug/L	< 0.5
Chlorobenzene	ug/L	< 0.5
1,2-Dichloroethane	ug/L	< 0.5
1,1,1-Trichloroethane	ug/L	< 0.5
1,1-Dichloroethane	ug/L	< 0.5
1,1,2-Trichloroethane	ug/L	< 0.5
1,1,2,2-Tetrachloroethane	ug/L	< 0.5
Chloroethane	ug/L	< 0.5
Chloroform	ug/L	< 0.5
1,1-Dichloroethylene	ug/L	< 0.5
1,2-TransDichloroethylene	ug/L	< 0.5
1,2-Dichloropropane	ug/L	< 0.5
1,2-Dichloropropylene	ug/L	< 0.5
Ethylbenzene	ug/L	< 0.5
Methylene Chloride	ug/L	< 0.5
Methyl Chloride	ug/L	< 0.5
Methyl Bromide	ug/L	< 0.5
Bromoform	ug/L	< 0.5
Dichlorobromomethane	ug/L	< 0.5
Chlorodibromomethane	ug/L	< 0.5
Tetrachloroethylene	ug/L	< 0.5
Toluene	ug/L	< 0.5
Trichloroethylene	ug/L	< 0.5
Vinyl Chloride	ug/L	< 0.5
2-Chloroethyl Vinyl Ether	ug/L	< 0.5
Xylene	ug/L	< 0.5

< X denotes result below X, detection limit of reporting.

Ventura County Waterworks Districts
Water and Sanitation Laboratory

Moorpark Wastewater Treatment Plant
Monitoring / Reporting Program No. 6374
WDR File No. 00-048

November 02, 2011

Annual Effluent 625 (Base / Neutral) Results

Analyte[1]	Units	Effluent Concentration
Acenaphthene	ug/L	< 2.0
Benzidine	ug/L	< 10.0
1,2,4-Trichlorobenzene	ug/L	< 2.0
Hexachlorobenzene	ug/L	< 2.0
Hexachloroethane	ug/L	< 2.0
Bis (2-Chloroethyl) Ether	ug/L	< 2.0
2-Chloronaphthalene	ug/L	< 2.0
1,2-Dichlorobenzene	ug/L	< 5.0
1,3-Dichlorobenzene	ug/L	< 5.0
1,4-Dichlorobenzene	ug/L	< 5.0
3,3'-Dichlorobenzidine	ug/L	< 2.0
2,4-Dinitrotoluene	ug/L	< 5.0
2,6-Dinitrotoluene	ug/L	< 5.0
1,2-Diphenylhydrazine	ug/L	< 1.0
Fluoranthene	ug/L	< 2.0
4-Chlorophenyl Phenyl Ether	ug/L	< 2.0
4-Bromophenyl Phenyl Ether	ug/L	< 2.0
Bis (2-Chloroisopropyl) Ether	ug/L	< 2.0
Bis (2-Chloroethoxy) Methane	ug/L	< 2.0
Hexachlorobutadiene	ug/L	< 2.0
Hexachlorocyclopentadiene	ug/L	< 2.0
Isophorone	ug/L	< 2.0
Naphthalene	ug/L	< 2.0
Nitrobenzene	ug/L	< 2.0
N-Nitrosodimethylamine	ug/L	< 5.0
N-Nitrosodi-N-Propylamine	ug/L	< 2.0
N-Nitrosodiphenylamine	ug/L	< 2.0

< X denotes result below X, detection limit of reporting.

Ventura County Waterworks Districts
Water and Sanitation Laboratory

Moorpark Wastewater Treatment Plant
Monitoring / Reporting Program No. 6374
WDR File No. 00-048

November 02, 2011

Annual Effluent 625 (Base / Neutral) Results

Analyte[1]	Units	Effluent Concentration
Bis (2-Ethylhexyl) Phthalate	ug/L	< 2.0
Butyl Benzyl Phthalate	ug/L	< 2.0
Di-N-Butyl Phthalate	ug/L	< 2.0
Di-N-Octyl Phthalate	ug/L	< 2.0
Diethyl Phthalate	ug/L	< 2.0
Dimethyl Phthalate	ug/L	< 2.0
Benzo (A) Anthracene	ug/L	< 2.0
Benzo (A) Pyrene	ug/L	< 2.0
Benzo (B) Fluoranthene	ug/L	< 2.0
Benzo (K) Fluoranthene	ug/L	< 2.0
Chrysene	ug/L	< 2.0
Acenaphthylene	ug/L	< 2.0
Anthracene	ug/L	< 2.0
1,12-Benzoperylene	ug/L	< 2.0
Fluorene	ug/L	< 2.0
Phenanthrene	ug/L	< 2.0
1,2,5,6-Dibenzanthracene	ug/L	< 2.0
Indeno (1,2,3-CD) Pyrene	ug/L	< 2.0
Pyrene	ug/L	< 2.0
TCDD (625 SIM)	ug/L	< 2.0

< X denotes result below X, detection limit of reporting.

Ventura County Waterworks Districts
Water and Sanitation Laboratory

Moorpark Wastewater Treatment Plant
Monitoring / Reporting Program No. 6374
WDR File No. 00-048

November 02, 2011

Annual Effluent 625 (Acid) Results

Analyte[1]	Units	Effluent Concentration
2,4,6-Trichlorophenol	ug/L	< 5.0
p-Chloro-M-Cresol	ug/L	< 5.0
2-Chlorophenol	ug/L	< 5.0
2,4-Dichlorophenol	ug/L	< 2.0
2,4-Dimethylphenol	ug/L	< 2.0
2-Nitrophenol	ug/L	< 2.0
4-Nitrophenol	ug/L	< 10.0
2,4-Dinitrophenol	ug/L	< 10.0
4,6-Dinitro-O-Cresol	ug/L	< 10.0
Pentachlorophenol	ug/L	< 10.0
Phenol	ug/L	< 5.0

< X denotes result below X, detection limit of reporting.

ATTACHMENT B

ANNUAL GROUNDWATER SUMMARY

VENTURA COUNTY WATERWORKS DISTRICT NO. 1
MOORPARK WASTEWATER TREATMENT PLANT

2011 ANNUAL REPORT

6767 Spring Road
P.O. Box 250
Moorpark, CA 93020

MOORPARK WASTEWATER TREATMENT PLANT
2011 ANNUAL REPORT

GROUNDWATER MONITORING & REPORTING PROGRAM

ATTACHMENT B
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Cumulative Water Level Data B-5

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SUMMARY

INTRODUCTION

The 2011 Annual Groundwater Monitoring Report (Report) for Moorpark Wastewater Treatment Plant (Plant) is the 14th annual report since the baseline-monitoring program was completed in May 1997.

The baseline monitoring program was developed and implemented by Fugro West, Inc. for the Ventura County Waterworks District No. 1 (District) in compliance with the monitoring requirements of the waste discharge permit issued by the California Regional Water Quality Control Board (Regional Board) (File No. 64-148, CI 6374) in Order No. 90-061.

The Regional Board issued a revised permit on April 25, 2000 (File No. 64-148, CI 6374) in Order No. 00-048.

FINDINGS

Purging and Sampling

Water samples were collected from the three existing groundwater wells on February 08, 2011, May 18, 2011, August 18, 2011, and November 15, 2011. An electric submersible pump was used for purging and sampling of the wells.

Temperature, pH, electrical conductivity and turbidity were measured and recorded at regular intervals during purging. Static water levels were measured and recorded for each well.

The following table enumerates the actual purge volumes:

DATE	MW - 1 (Gallons)	MW - 2 (Gallons)	MW - 3 (Gallons)
February 08, 2011	30+	8+	15+
May 18, 2011	30+	9+	10+
August 18, 2011	25+	3+	9+
November 15, 2011	27+	6+	10+

WATER QUALITY DATA

Groundwater samples were collected and analyzed for the constituents specified by the Regional Board. Attached laboratory data summarizes the results for the reporting periods.

Attached are the annual priority pollutant metals for the three monitoring wells.

WATER LEVEL DATA

Water level data was collected from the three monitoring wells. Water levels were taken from established reference points at each well. The elevations of these reference points were used to determine the water surface elevations. The table on page B-5 shows the water level data from February 21, 2007 to November 15, 2011.

Figure 2 on page B-4 shows the magnitude and direction of the groundwater gradient at the MWTP based on the water level data taken by the District on November 15, 2011. The water surface elevations at MW-1 and MW-2 are 371.98 and 330.86 feet (above mean sea level), respectively. The direction of the groundwater gradient is due westerly, parallel to the direction of flow in the Arroyo Las Posas. The magnitude (or slope) of the water gradient is 0.009790476 ft. per linear foot [i.e., (371.98 – 330.86) ÷ 4,200], where 4,200 ft is the distance between MW-1 and MW-2.

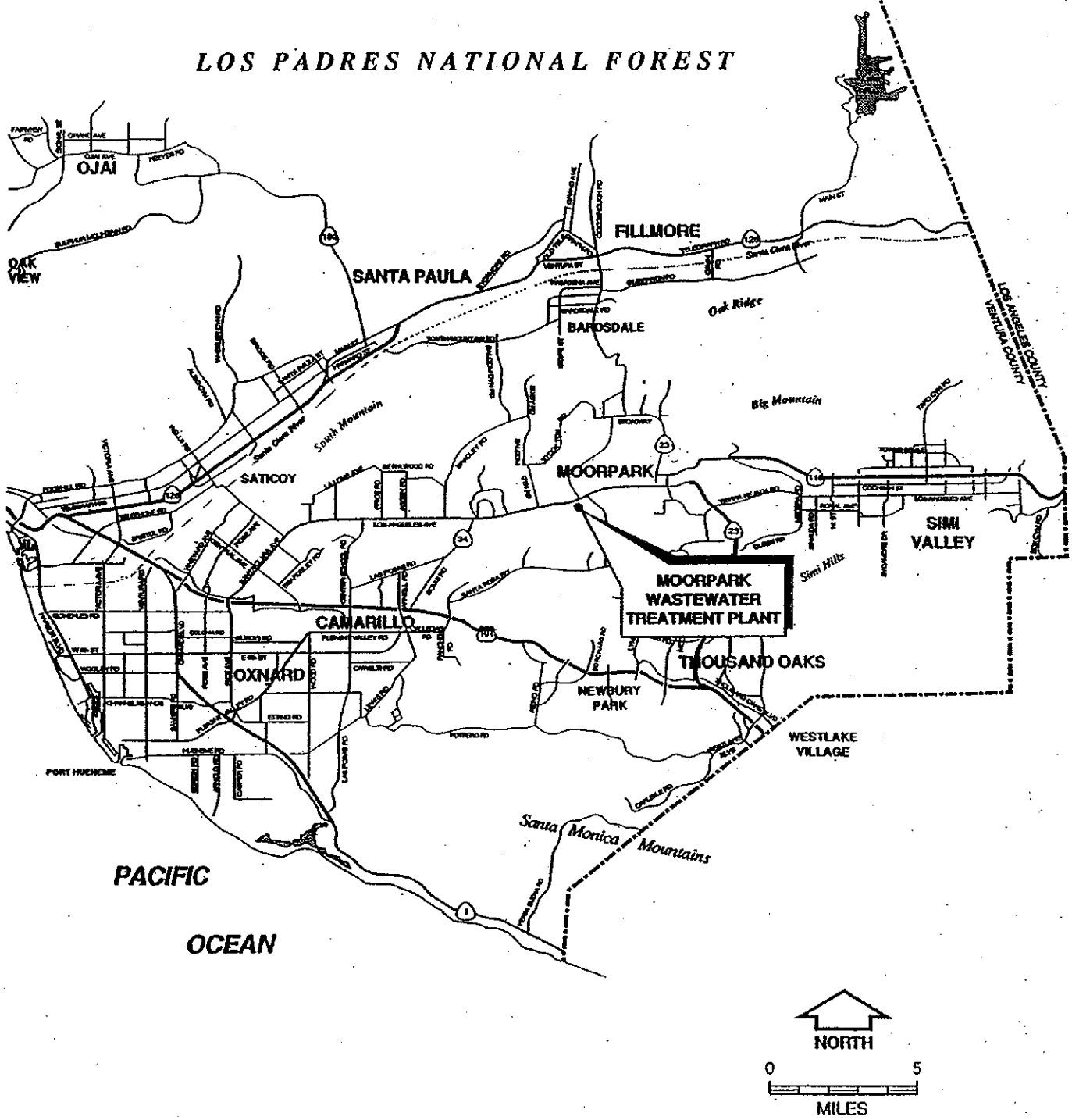
The direction and magnitude of the water gradient for this report have remained relatively consistent with the data obtained during the baseline-monitoring period.

CONCLUSION

Groundwater level and quality data obtained for this 2011 annual report are consistent with the data gathered during the baseline monitoring program and the 2010 annual report.

Collection of water level data at each well will continue to be monitored and reported to the Regional Board quarterly.

Figure 1



SITE LOCATION MAP
Moorpark Wastewater
Treatment Plant

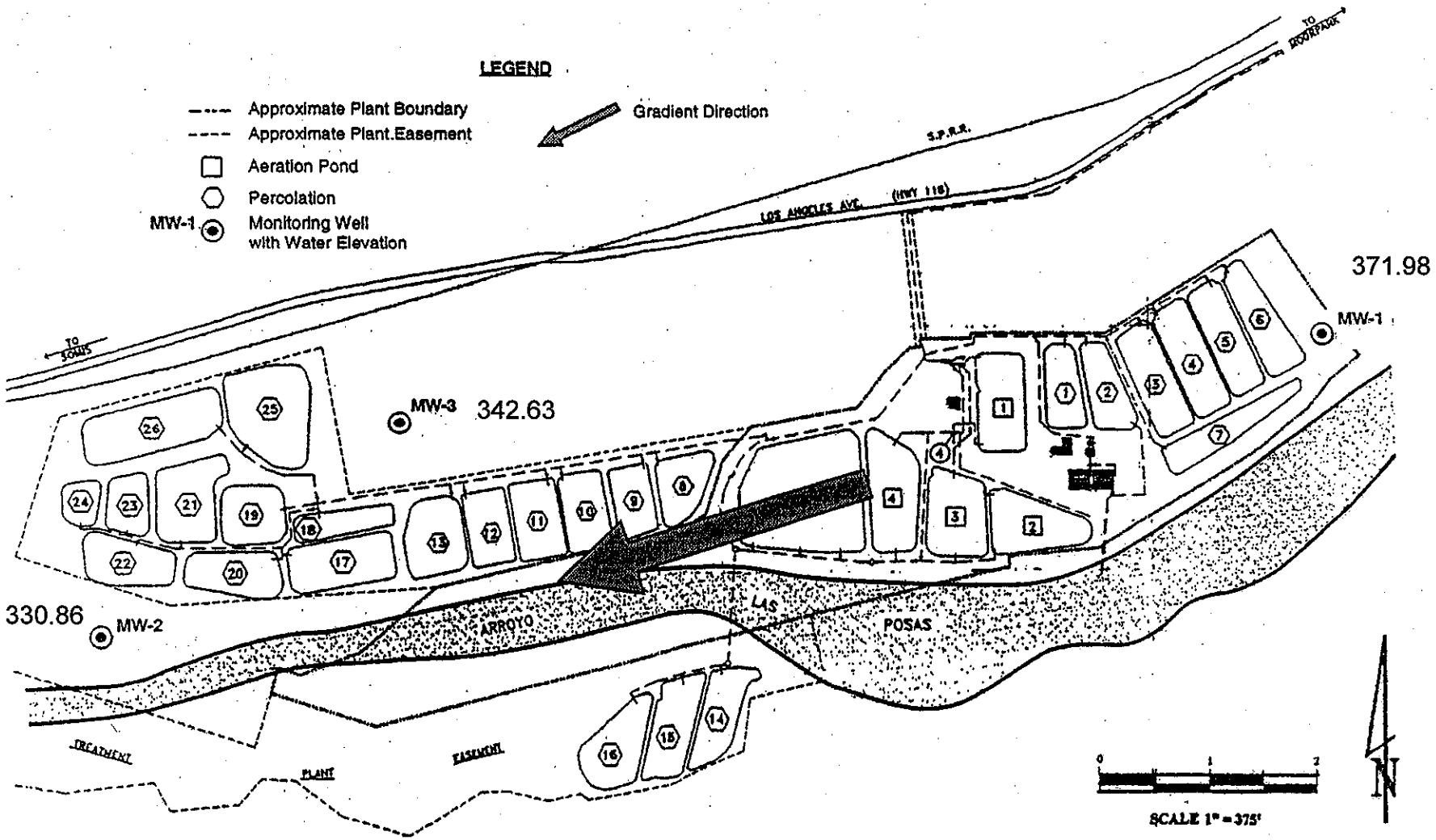


Figure 2

WATER SURFACE ELEVATION MAP

Moorpark Wastewater
Treatment Plant

MOORPARK WASTEWATER TREATMENT PLANT

Monitoring / Reporting Program No. 6374
WDR Order No. 00-048

Cumulative Water Level Data

Date	MW - 1 Ref Pt @ 391.18 ft, MSL Static Water		MW - 2 Ref Pt @ 357.66 ft, MSL Static Water		MW - 3 Ref Pt @ 386.48 ft, MSL Static Water	
	Depth	Elev. Ft.	Depth	Elev. Ft.	Depth	Elev. Ft.
02/21/07	17.95	373.23	21.53	336.13	42.20	344.28
05/07/07	19.31	371.87	22.00	335.66	41.58	344.90
08/15/07	22.90	368.28	25.87	331.79	44.21	342.27
11/27/07	17.32	373.86	26.23	331.43	45.57	340.91
02/12/08	16.67	374.51	23.78	333.88	42.40	344.08
05/13/08	18.50	372.68	24.79	332.87	41.37	345.11
08/12/08	20.51	370.67	26.82	330.84	45.12	341.36
11/18/08	19.40	371.78	25.61	332.05	37.20	349.28
02/19/09	17.85	373.33	23.85	333.81	36.20	350.28
05/18/09	19.87	371.31	24.50	333.16	38.05	348.43
08/20/09	20.15	371.03	27.10	330.56	45.37	341.11
11/17/09	19.72	371.46	27.40	330.26	44.87	341.61
02/02/10	15.47	375.71	25.31	332.35	43.93	342.55
05/11/10	17.30	373.88	24.52	333.14	43.30	343.18
08/17/10	19.42	371.76	26.96	330.70	45.67	340.81
11/15/10	21.53	369.65	26.66	331.00	34.63	351.85
02/08/11	17.67	373.51	25.62	332.04	41.22	345.26
05/18/11	17.83	373.35	25.16	332.50	34.95	351.53
08/18/11	20.19	370.99	28.40	329.26	44.40	342.08
11/15/11	19.20	371.98	26.80	330.86	43.85	342.63

Notes:
MSL = Mean Sea Level
Reference point is the top of the well casing extended above the ground.
Depth of static water is the vertical distance between the top of the well casing and water surface.
Elevation of Static Water = Reference Point Elevation - Depth of Static Water.

MOORPARK WASTEWATER TREATMENT PLANT

Groundwater Monitoring / Reporting Program No. 6374
WDR Order No. 00-048

2011 FIRST QUARTER REPORT

Quarterly Results			Sample Date: February 08, 2011
CONSTITUENTS	MW - 1 Upgradient Well	MW - 2 Downgradient Well	MW - 3 Intermediate Well
pH (pH Units)	6.9	7.5	7.3
Temperature (Deg. F)	65.5	66.0	63.4
Dissolved Oxygen	5.54	6.70	3.10
Nitrite as N	< 0.05	< 0.05	< 0.05
Total Nitrogen	137	4.29	0.75
Total Phosphate	0.09	0.23	0.26
Ammonia as N	< 0.01	0.26	0.07
Nitrate as N	137	3.58	< 0.01
Organic Nitrogen as N	< 0.05	0.45	0.68
Oil & Grease	< 5	< 5	< 5
BOD	< 5	< 5	< 5
TOC	5.27	4.73	3.08
MBAS	0.16	0.10	0.10

Note: < X denotes result below X, detection limit of reporting.
Unit of measurement in mg/l unless noted.

MOORPARK WASTEWATER TREATMENT PLANT

Groundwater Monitoring / Reporting Program No. 6374
WDR Order No. 00-048

2011 SECOND QUARTER REPORT

Quarterly & Semi-Annual Results			Sample Date: May 18, 2011
CONSTITUENTS	MW - 1 Upgradient Well	MW - 2 Downgradient Well	MW - 3 Intermediate Well
pH (pH Units)	7.2	7.5	7.7
Temperature (Deg. F)	65.3	67.3	67.1
Dissolved Oxygen	3.50	3.20	2.37
Total Coliform (MPN / 100mls)	< 1.1	< 1.1	< 1.1
Fecal Coliform (MPN / 100mls)	< 1.1	< 1.1	< 1.1
TDS	3064	872	528
Sulfate	1143	145	120
Chloride	254	122	115
Nitrite as N	< 0.05	< 0.05	< 0.05
Total Nitrogen	113	0.93	0.29
Total Phosphate	0.08	0.16	0.24
Ammonia as N	< 0.01	0.09	< 0.01
Nitrate as N	113	0.70	< 0.01
Organic Nitrogen as N	< 0.05	0.14	0.29
Oil & Grease	< 5	< 5	< 5
BOD	< 5	< 5	< 5
TOC	3.07	2.16	3.22
CTAS	< 0.10	< 0.10	< 0.10
MBAS	0.42	0.14	0.14
Boron	1.34	0.63	0.48

Note: < X denotes result below X, detection limit of reporting.

Unit of measurement in mg/l unless noted.

MOORPARK WASTEWATER TREATMENT PLANT

Groundwater Monitoring / Reporting Program No. 6374
WDR Order No. 00-048

2011 THIRD QUARTER REPORT

Quarterly Results			Sample Date: August 18, 2011
CONSTITUENTS	MW - 1 Upgradient Well	MW - 2 Downgradient Well	MW - 3 Intermediate Well
pH (pH Units)	6.9	7.2	7.2
Temperature (Deg. F)	67.1	67.1	69.8
Dissolved Oxygen	6.83	7.00	6.81
Nitrite as N	< 0.05	< 0.05	< 0.05
Total Nitrogen	138	2.26	0.63
Total Phosphate	0.06	0.26	0.35
Ammonia as N	0.04	0.03	0.03
Nitrate as N	138	1.93	< 0.01
Organic Nitrogen as N	< 0.05	0.30	0.60
Oil & Grease	< 5	< 5	< 5
BOD	< 5	< 5	< 5
TOC	3.09	1.88	3.84
MBAS	0.10	< 0.05	0.06

Note: < X denotes result below X, detection limit of reporting.
Unit of measurement in mg/l unless noted.

MOORPARK WASTEWATER TREATMENT PLANT

Groundwater Monitoring / Reporting Program No. 6374
WDR Order No. 00-048

2011 FOURTH QUARTER REPORT

Quarterly & Semi-Annual Results			Sample Date: November 15, 2011
CONSTITUENTS	MW - 1 Upgradient Well	MW - 2 Downgradient Well	MW - 3 Intermediate Well
pH (pH Units)	7.5	7.8	7.6
Temperature (Deg. F)	65.7	66.0	68.0
Dissolved Oxygen	6.05	5.61	5.99
Total Coliform (MPN / 100mls)	< 1.1	< 1.1	< 1.1
Fecal Coliform (MPN / 100mls)	< 1.1	< 1.1	< 1.1
TDS	3840	760	610
Sulfate	1470	183	123
Chloride	310	107	117
Nitrite as N	< 0.1	< 0.1	< 0.1
Total Nitrogen (Sum)	160	3.1	2.1
Total Phosphate	< 0.1	0.3	0.3
Ammonia as N	< 0.2	< 0.2	< 0.2
Nitrate as N	160	3.1	2.1
Organic Nitrogen as N	< 1	< 1	< 1
Oil & Grease	< 3	< 3	< 3
BOD	< 2	< 2	< 2
TOC	3.3	2.3	1.8
CTAS	< 0.20	< 0.20	< 0.30
MBAS	< 0.1	< 0.1	< 0.1
Boron	1.8	0.6	0.5

Note: < X denotes result below X, detection limit of reporting.
Unit of measurement in mg/l unless noted.

MOORPARK WASTEWATER TREATMENT PLANT

Groundwater Monitoring / Reporting Program No. 6374
WDR Order No. 00-048

2011 FOURTH QUARTER REPORT

Annual Priority Pollutant Metals Results		Sample Date: November 15, 2011	
CONSTITUENTS	MW - 1 Upgradient Well	MW - 2 Downgradient Well	MW - 3 Intermediate Well
Antimony	< 1.0	< 1.0	< 1.0
Arsenic	3.0	4.0	6.0
Beryllium	< 1.0	< 1.0	< 1.0
Cadmium	< 1.0	3.0	1.0
Chromium	6.0	2.0	1.0
Copper	3.0	6.0	6.0
Lead	< 0.2	< 0.2	< 0.2
Mercury	0.04	0.04	0.03
Nickel	6.0	164	13
Selenium	29	2.0	2.0
Silver	< 1.0	< 1.0	< 1.0
Thallium	< 1.0	< 1.0	< 1.0
Zinc	< 10	< 10	< 10

Note: < X denotes result below X, detection limit of reporting.
Unit of measurement in ug/l unless noted.