Water Quality in the State Water Project, 2000 and 2001

April 2004

State of California
The Resources Agency
Department of Water Resources
Division of Operations and Maintenance
Environmental Assessment Branch

Cover photograph: Filling of the newly constructed California Aqueduct
(Location unknown)

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Acronyms and Abbreviations

af	acre-feet
Ag	silver
Al	aluminum
As	arsenic
B	boron
Ba	barium
Br	bromide
C	carbon
Ca	calcium
Cd	cadmium
cfs	cubic feet per second
Cl	chloride
CO_3	carbonate
Cr	chromium
Cu	copper
CVP	Central Valley Project
DHS	Department of Health Services
DMC	Delta-Mendota Canal
DOC	dissolved organic carbon
DWR	Department of Water Resources
EPA	Environmental Protection Agency
F	fluoride
Fe	iron
Hg	mercury
K	potassium
meq/L	milliequivalents per liter
MCL	maximum contaminant level
MFL	million fibers per liter
Mg	magnesium
Mn	manganese
MtBE	methyl *tertiary*-butyl ether
N	nitrogen
Na	sodium
NH_4	ammonia
NO_2	nitrite
NO_3	nitrate
NTU	nephelometric turbidity unit
P	phosphorus
Pb	lead
pH	negative log of the hydrogen ion activity
PO_4	phosphate
Se	selenium
SLC	San Luis Canal
SO_4	sulfate
SRI	Sacramento River Index
SWP	State Water Project
taf	thousand acre-feet
TDS	total dissolved solids
TOC	total organic carbon
TSS	total suspended solids
The Bureau	Bureau of Reclamation
μg/L	micrograms per liter
μmole/L	micromoles per liter
μS/cm	microseimens per centimeter

I. Introduction

Water quality is routinely monitored at about 30 stations throughout the State Water Project (SWP). Water quality samples are collected by staff of the five field divisions in the Division of Operations and Maintenance and sent to Bryte Laboratory for analysis. SWP stations include those located in the Feather River watershed, North Bay Aqueduct, South Bay Aqueduct, and the California Aqueduct with its four terminus lakes in Southern California (Figure 1-1). Samples are collected on the third Wednesday of each month at the regular stations. Analyses include minerals, metals, metalloids, nutrients, organic chemicals, and disinfection by-product precursors. Further, around 15 automated water quality stations continuously monitor parameters such as salinity and turbidity on a real-time basis. Station descriptions and water quality constituents analyzed are detailed in Appendix A.

Monitoring in the SWP is done on a routine basis to identify trends and assess water quality conditions with respect to long-term trends, operations, hydrology, seasons, emergencies, water treatment issues, and drinking water standards. Primary and secondary Maximum Contaminant Levels (MCLs) apply to drinking water and were compared to SWP data to provide a relative indication of raw water quality. MCLs are presented in Appendix B. Water quality trend assessment focused on salinity, bromide, and organic carbon.

Water quality in the California and South Bay Aqueducts was good during 2000 due, in part, to above normal water year conditions in the Sacramento and San Joaquin Valleys. Drier conditions in 2001 resulted in less favorable water quality with respect to mineralogy. North Bay Aqueduct exports exhibited the usual impairments during winter as a result of organic carbon and turbidity increases. Water quality in the Feather River watershed was excellent, as usual, with low to non-detectable levels of minerals and minor elements.

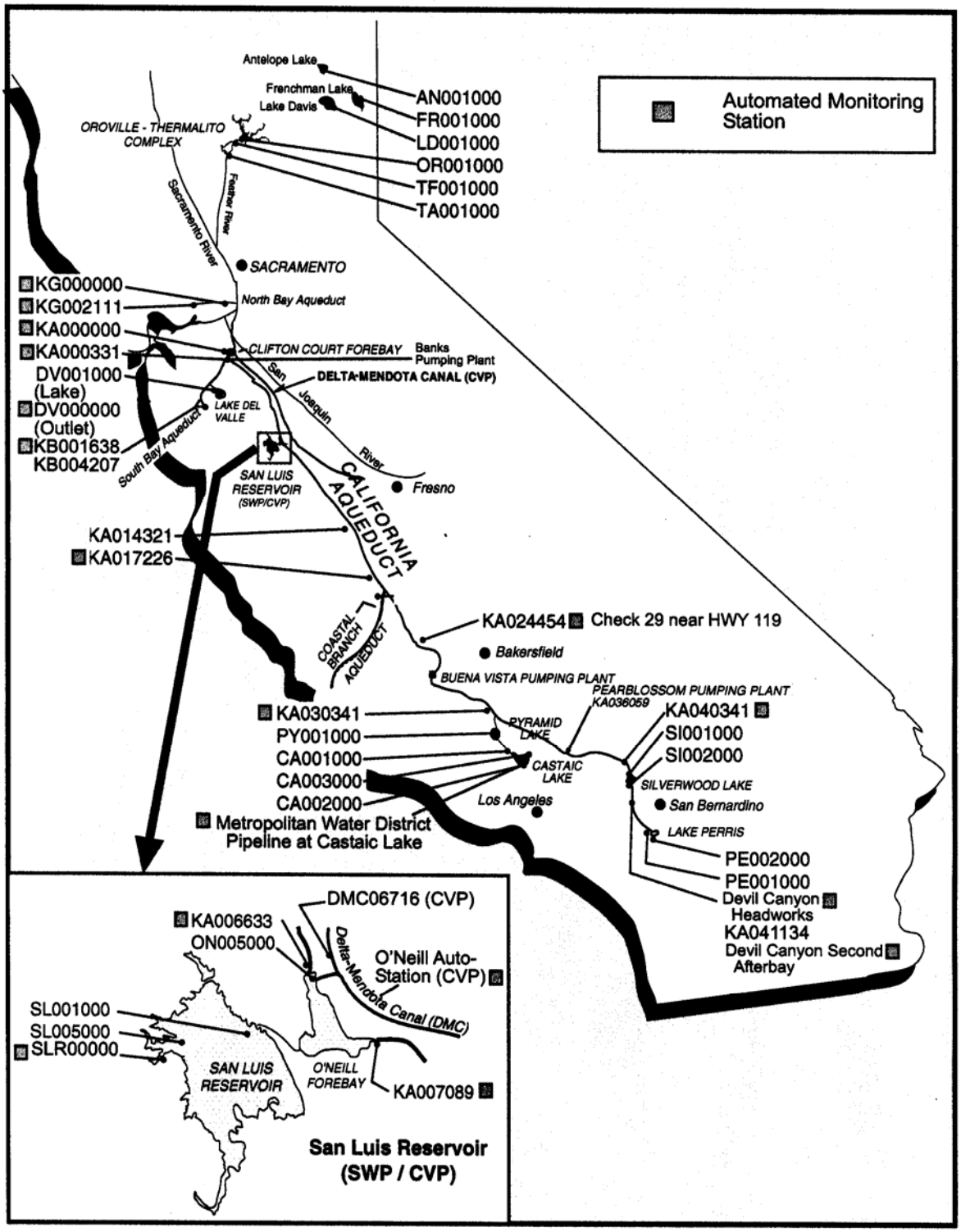

Figure 1-1. Water quality monitoring stations in the State Water Project

II. California Aqueduct

Major minerals and conventional parameters in the California Aqueduct during 2000 and 2001 are summarized in Table 2-1. MCLs for salinity, sulfate, chloride, and nitrate in treated drinking water were not exceeded.

Salinity at most stations in the Aqueduct was generally highest in the fall months of 2000 and the winter, summer, and fall months of 2001 (Figure 2-1). Higher salinity near the end of both years usually coincided with an increase in chloride relative to sulfate (Figure 2-2). This is an indication of seawater intrusion from the San Francisco Bay that was supported with further geochemical and hydrological analysis at Banks Pumping Plant (see Special Studies).

Conductivity at Banks Pumping Plant averaged 371 μS/cm in 2000 and 515 μS/cm in 2001, a 39 percent increase between years. The dissimilarity in conductivity between years in State exports reflects the different water year classifications for 2000, an above normal water year, and 2001, a dry water year. Water year classifications for the Sacramento and San Joaquin River Valleys are based on formulas that incorporate, into numerical indices, unimpaired runoff from the river basins and the preceding year's index. The water year index denotes water supply availability in the Central Valley from rainfall runoff, snowmelt, and reservoir carryover storage (DWR 2004a). It is used to determine how much water will be approved for delivery to SWP water contractors. Most of the water requested by SWP contractors (Table A water) in 2000 was approved for delivery while less than half was approved in 2001 – 90 and 39 percent, respectively.

Annual average conductivity at Banks Pumping Plant for 2000 was in the 45th percentile of historic averages at this station (1970-02). The 2001 annual average was in the 80th percentile. As discussed above, annual salinity trends largely reflect water supply availability in the Central Valley described by the water year index. Water year indices for the Sacramento and San Joaquin rivers and annual average conductivity at Banks Pumping Plant are inversely correlated with an exponential r-squared value of 0.86 (DWR 2004b).

Disinfection by-product precursors are summarized in Table 2-2. Organic carbon concentrations at most Aqueduct stations were generally highest during winter and lowest during summer/fall (Figure 2-3). Dissolved organic carbon at Banks Pumping Plant averaged 3.54 mg/L in 2000 and 3.59 mg/L in 2001, a 1.4 percent increase between years. Unlike conductivity, DOC at Banks Pumping Plant is not well correlated with water year indices (Figure 2-4).

One factor that may contribute to this lack of correlation is rainfall runoff exhibiting a first flush effect. Certain water quality constituents in rainfall runoff are relatively highest at the beginning of both a rainfall event and a rainy season (CVRWQCB 1988 and 1987). An analogous trend was observed with Sacramento River flow and organic carbon during 2000. Figure 2-5 shows organic carbon peaked during the first and second flow increase of the rainy season, and subsequently declined through the remainder of the season despite similarly high flow. High flow later in the rainy season did not equate with elevated organic carbon concentrations observed during earlier hydrograph peaks. Winter organic

carbon levels were high or low depending on whether the measurements were made nearer to the start or end of the high flow season. Seasonally elevated organic carbon in the Sacramento River appeared to be largely controlled by flow increases at the beginning of the rainy season. In terms of a first flush effect, less organic carbon was available to be flushed into the Sacramento River later in the rainy season.

Seasonal bromide trends in the California Aqueduct were similar to those of salinity. Bromide was generally highest at most stations during fall 2000 and winter, summer, and fall 2001 (Figure 2-3). Peak levels were detected during periods when seawater intrusion was evident (see Special Studies).

Bromide at Banks Pumping Plant averaged 0.153 mg/L in 2000 and 0.263 mg/L in 2001, a 72 percent increase between years. Like conductivity, annual average bromide in State exports and water year indices for the Sacramento and San Joaquin Rivers are inversely correlated with an exponential r-squared value of 0.9 (Figure 2-6).

Groundwater turn-ins to the California Aqueduct between March and December 2001 usually coincided with decreases in organic carbon downstream of Check 21 (see Special Studies). There was no consistent change in Aqueduct bromide as a result of turn-ins.

Minor elements and nutrients in the California Aqueduct during 2000 and 2001 are summarized in Tables 2-3 and 2-4. Existing MCLs for these parameters in treated drinking water were not exceeded. Arsenic and nitrate increased downstream of Check 21 during certain months in 2001 when groundwater turn-ins were active (see Special Studies).

Table 2-1. Summary of major minerals and conventional parameters in the California Aqueduct, 2000 and 2001

Station Name	Station Number	Major Minerals	Units	Median	Low	High	Sample Size	Conventional Parameters	Units	Median	Low	High	Sample Size
Banks PP	KA000331	Alkalinity	mg/L as CaCO3	72	47	86	23	Conductivity	micro S/cm	446	236	715	23
O'Neill Forebay Outlet	KA007089			75	50	91	24			489	285	732	24
Check 21	KA017226			76	54	89	29			475	293	664	29
Check 29	KA024454			77	55	91	26			484	307	693	26
Check 41	KA030341			75	56	93	29			480	312	693	29
Devil Canyon Headworks	KA041134			77	60	86	24			487	325	624	24
Banks PP	KA000331	Calcium	mg/L	18	13	24	23	Hardness	mg/L as CaCO3	96	64	127	23
O'Neill Forebay Outlet	KA007089			20	14	27	24			100	68	139	24
Check 21	KA017226			20	15	29	29			102	70	138	29
Check 29	KA024454			21	14	28	26			103	70	128	27
Check 41	KA030341			21	16	29	29			99	81	128	29
Devil Canyon Headworks	KA041134			20	15	27	24			102	79	130	24
Banks PP	KA000331	Chloride	mg/L	53	25	147	23	pH	pH units	7.5	7.2	8.0	14
O'Neill Forebay Outlet	KA007089			64	29	138	23			7.8	7.4	8.1	16
Check 21	KA017226			71	33	133	29			7.7	7.4	8.2	14
Check 29	KA024454			71	34	127	26			7.8	7.5	8.2	11
Check 41	KA030341			71	34	134	29			7.8	7.4	8.3	14
Devil Canyon Headworks	KA041134			73	40	120	24			7.8	7.3	8.3	11
Banks PP	KA000331	Magnesium	mg/L	12	7	17	23	TDS	mg/L	246	130	387	21
O'Neill Forebay Outlet	KA007089			13	8	18	24			269	162	405	24
Check 21	KA017226			13	8	16	29			265	166	378	28
Check 29	KA024454			12	9	17	26			263	164	374	25
Check 41	KA030341			12	8	17	29			262	167	378	27
Devil Canyon Headworks	KA041134			12	9	17	24			263	172	336	22
Banks PP	KA000331	Nitrate	mg/L as N03	2.5	0.4	5.3	23	TSS	mg/L	8	<1	32	21
O'Neill Forebay Outlet	KA007089			3.1	0.7	5.7	24			8	2	24	24
Check 21	KA017226			2.7	0.9	6	29			12	<1	22	22
Check 29	KA024454			3.1	0.2	6.6	27			13	4	26	26
Check 41	KA030341			3.1	<0.1	7.1	29			16	<1	23	23
Devil Canyon Headworks	KA041134			2.6	1.0	5.2	24			2	<1	8	8
Banks PP	KA000331	Sodium	mg/L	43	22	85	23	Turbidity	NTU	10	5	32	21
O'Neill Forebay Outlet	KA007089			50	27	87	24			7.5	3	24	24
Check 21	KA017226			53	27	78	29			10	1	40	28
Check 29	KA024454			53	30	82	26			9	3	20	26
Check 41	KA030341			53	29	82	29			13	3	21	27
Devil Canyon Headworks	KA041134			54	31	75	24			2.6	1	6	23
Banks PP	KA000331	Sulfate	mg/L	32	14	56	23	VSS	mg/L	2	<1	4	23
O'Neill Forebay Outlet	KA007089			38	19	65	24			2	<1	6	24
Check 21	KA017226			39	21	60	29			NA			
Check 29	KA024454			41	20	64	26			2	<1	5	27
Check 41	KA030341			41	22	59	29			2	<1	5	24
Devil Canyon Headworks	KA041134			40	22	57	24			NA			

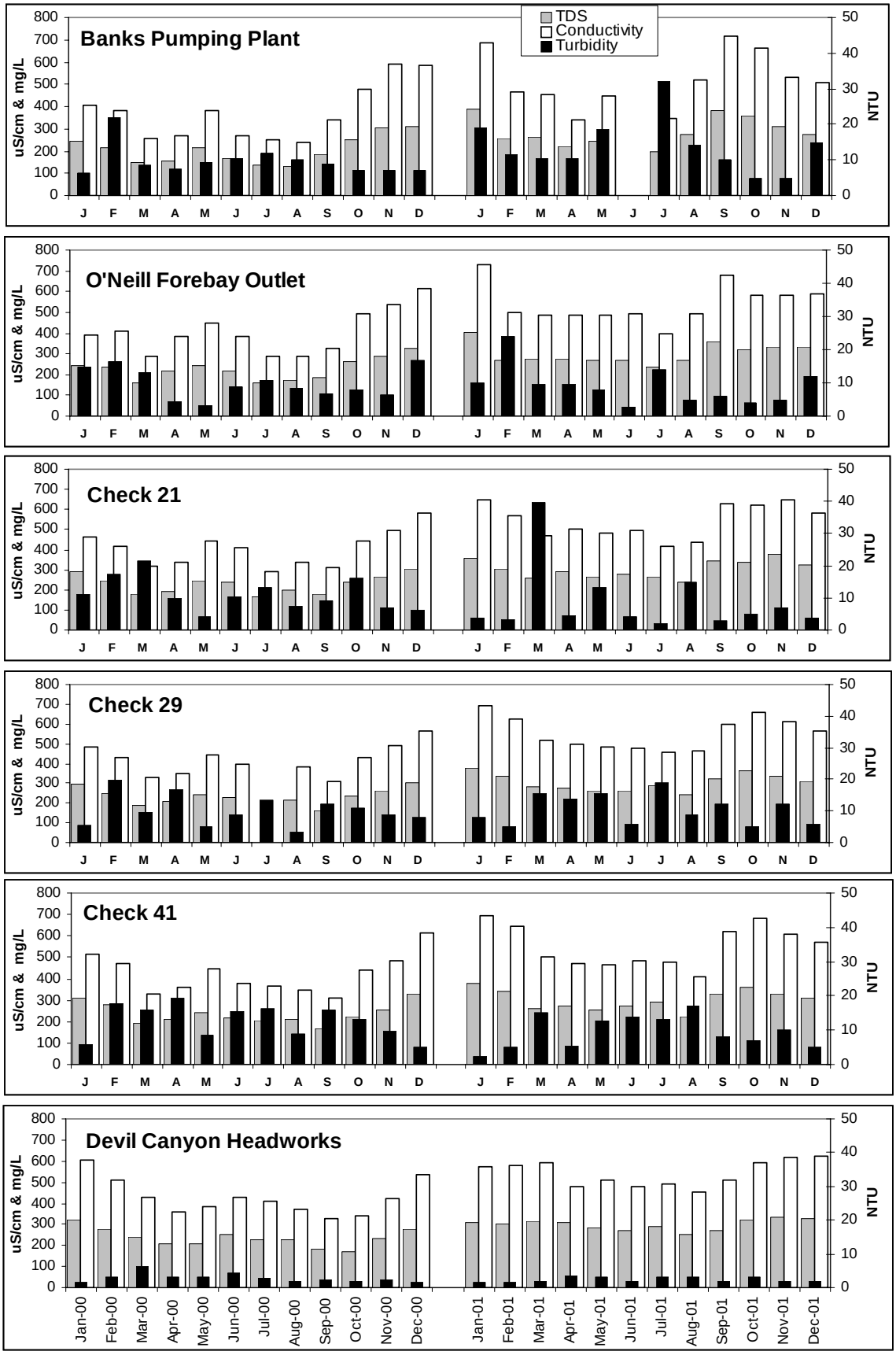

Figure 2-1. Monthly salinity and turbidity in the California Aqueduct

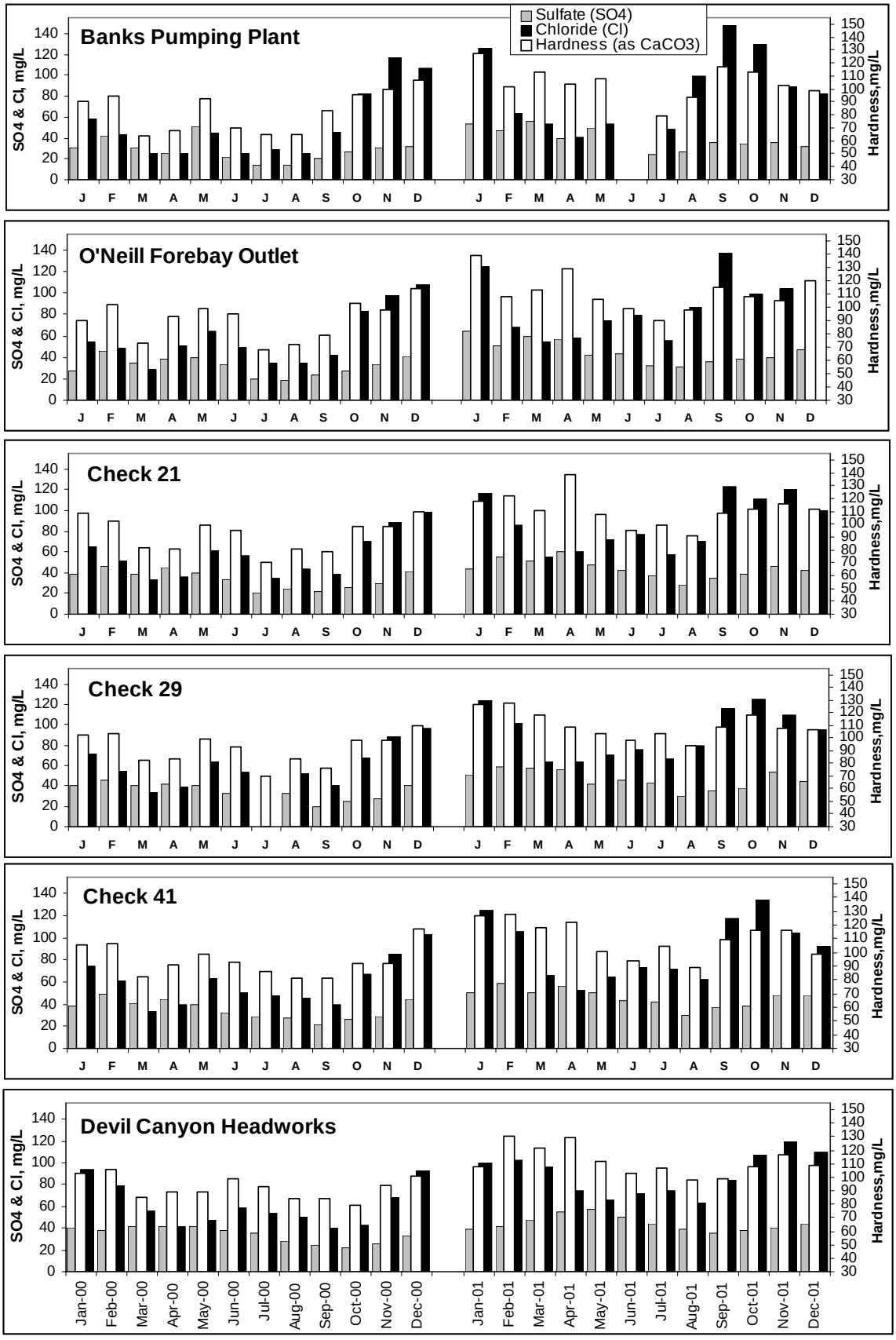

Figure 2-2. Monthly sulfate, chloride, and hardness in the California Aqueduct

Table 2-2. Summary of disinfection by-product precursors in the California Aqueduct, 2000 and 2001 (DWR and MWDSC)

Station Name	Station Number		Units	Median	Low	High	Sample Size
Banks PP	KA000331	Bromide	mg/L	0.16	0.06	0.49	41
O'Neill Forebay Inlet	KA006633			0.18	0.07	0.48	40
O'Neill Forebay Outlet	KA007089			0.22	0.07	0.47	64
Check 21	KA017226			0.19	0.07	0.41	28
Check 29	KA024454			0.21	0.07	0.41	26
Check 41	KA030341			0.21	0.07	0.42	71
Check 66	KA040341			0.21	0.09	0.45	45
Devil Canyon Headworks	KA041134			0.21	0.10	0.40	70
Banks PP	KA000331	DOC	mg/L as C	3.90	2.30	6.20	38
O'Neill Forebay Inlet	KA006633			2.90	2.21	6.70	5
O'Neill Forebay Outlet	KA007089			3.30	2.30	6.20	42
Check 21	KA017226			2.80	2.40	5.40	23
Check 29	KA024454			2.80	2.10	4.70	23
Check 41	KA030341			2.60	2.00	5.10	31
Check 66	KA040341			NA			
Devil Canyon Headworks	KA041134			3.10	2.30	5.30	34
Banks PP	KA000331	TOC	mg/L as C	4.00	2.20	6.40	47
O'Neill Forebay Inlet	KA006633			3.10	2.33	6.31	40
O'Neill Forebay Outlet	KA007089			3.30	2.40	6.40	81
Check 21	KA017226			2.90	2.40	6.80	20
Check 29	KA024454			2.70	2.20	4.60	21
Check 41	KA030341			3.20	2.00	5.40	64
Check 66	KA040341			3.40	2.60	7.12	46
Devil Canyon Headworks	KA041134			3.30	2.40	5.32	70
Banks PP	KA000331	UV 254	Absorbance/cm	0.120	0.073	0.256	38
O'Neill Forebay Inlet	KA006633			0.089	0.066	0.191	34
O'Neill Forebay Outlet	KA007089			0.096	0.069	0.249	60
Check 21	KA017226			NA			
Check 29	KA024454			NA			
Check 41	KA030341			0.080	0.052	0.193	38
Check 66	KA040341			0.079	0.054	0.132	42
Devil Canyon Headworks	KA041134			0.082	0.065	0.158	29

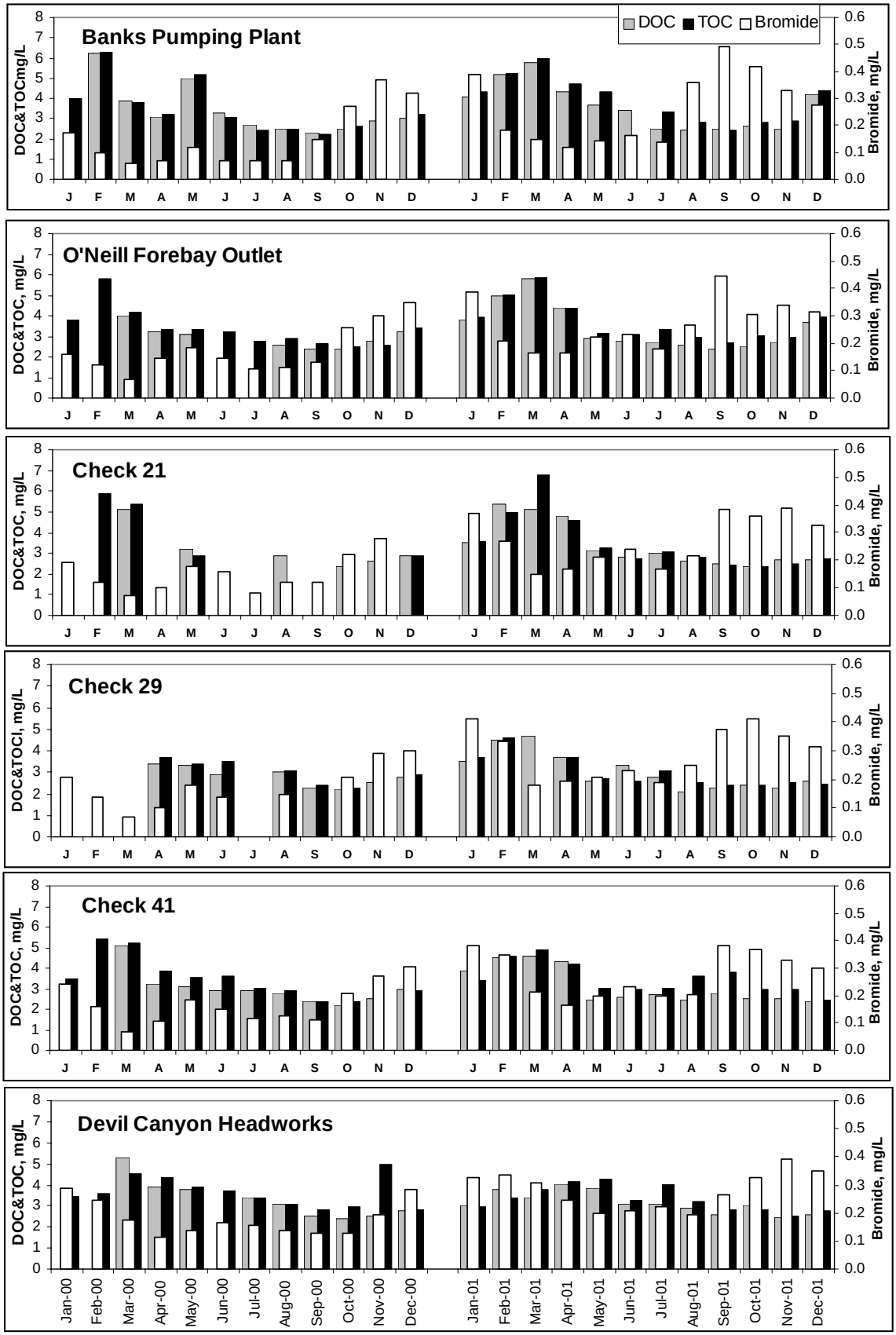

Figure 2-3. Monthly dissolved and total organic carbon (DOC and TOC) and bromide in the California Aqueduct (DWR and MWDSC)

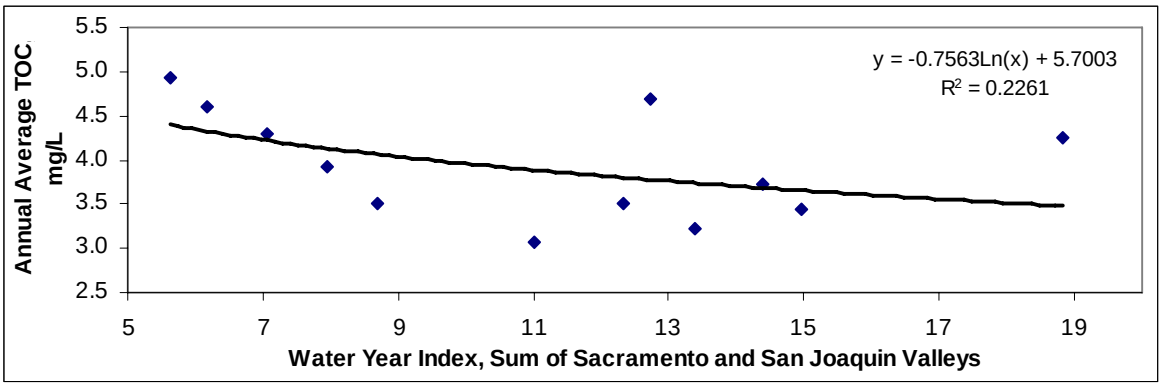

Figure 2-4. Relationship between water year indices and annual average total organic carbon at Banks Pumping Plant

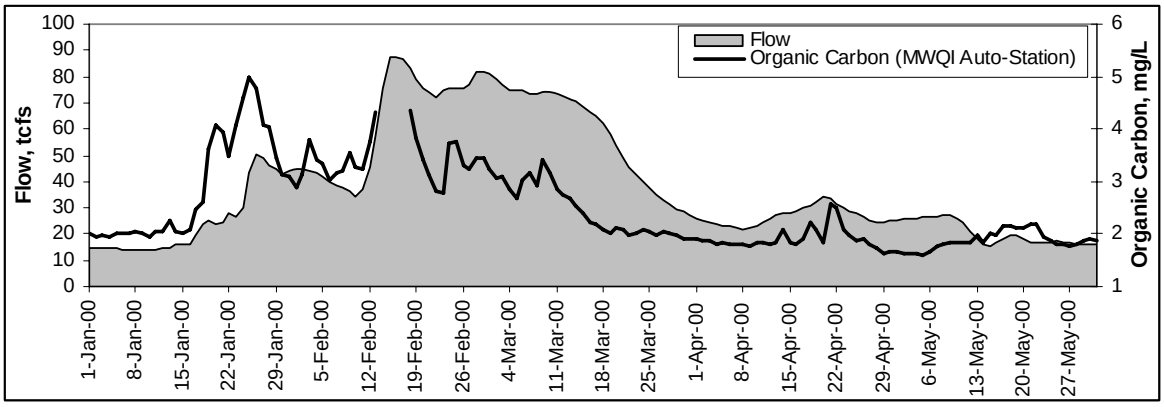

Figure 2-5. Daily organic carbon (from MWQI database) and flow in the Sacramento River near Hood

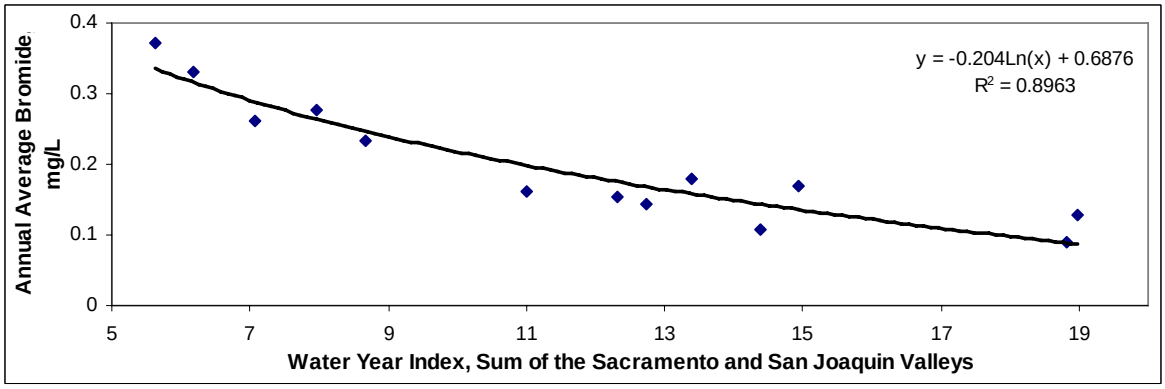

Figure 2-6. Relationship between water year indices and annual average bromide at Banks Pumping Plant

Table 2-3. Summary of minor elements in the California Aqueduct, 2000 and 2001 (mg/L)

Station Name	Station Number	Minor Element	Median	Low	High	Sample Size	Minor Element	Median	Low	High	Sample Size	Minor Element	Median	Low	High	Sample Size
Banks PP	KA000331	Aluminum	<0.01	<0.01	0.04	23	Chromium +3	0.005	<0.001	0.008	23	Mercury		<0.0002	<0.0002	23
O'Neill Forebay Outlet	KA007089		0.012	<0.01	0.10	23		0.004	<0.001	0.011	24			<0.0002	<0.0002	22
Check 21	KA017226		0.017	<0.01	0.11	24		0.004	<0.001	0.008	29			<0.0002	<0.0002	23
Check 29	KA024454		<0.01	<0.01	0.01	26		0.004	<0.001	0.007	26			<0.0002	<0.0002	27
Check 41	KA030341		<0.01	<0.01	0.03	29		0.005	<0.001	0.007	29			<0.0002	<0.0002	29
Devil Canyon Headworks	KA041134		<0.01	<0.01	<0.01	24		0.005	<0.001	0.007	24			<0.0002	<0.0002	23
Banks PP	KA000331	Antimony		<0.005	<0.005	23	Chromium +6		<0.001	<0.001	9	Nickel	0.001	<0.001	0.002	23
O'Neill Forebay Outlet	KA007089			<0.005	<0.005	23			<0.001	<0.001	11		0.001	0.001	0.004	24
Check 21	KA017226			<0.005	<0.005	24			<0.001	<0.001	11		0.001	0.001	0.002	27
Check 29	KA024454			<0.005	<0.005	26		<0.001	<0.001	0.001	11		0.001	<0.001	0.002	26
Check 41	KA030341			<0.005	<0.005	11			<0.001	<0.001	1		0.001	<0.001	0.003	21
Devil Canyon Headworks	KA041134			<0.005	<0.005	9		NA					0.001	0.001	0.002	24
Banks PP	KA000331	Arsenic	0.002	0.001	0.003	23	Copper	0.002	0.001	0.004	23	Selenium	0.001	<0.001	0.002	23
O'Neill Forebay Outlet	KA007089		0.002	0.001	0.003	24		0.003	0.001	0.004	24		0.001	<0.001	0.001	5
Check 21	KA017226		0.002	0.002	0.003	29		0.002	0.001	0.005	29		0.001	<0.001	0.001	5
Check 29	KA024454		0.002	0.001	0.004	26		0.002	0.001	0.004	26		0.001	<0.001	0.003	26
Check 41	KA030341		0.002	0.002	0.004	29		0.002	0.001	0.004	29		0.001	<0.001	0.001	6
Devil Canyon Headworks	KA041134		0.002	<0.001	0.004	24		0.003	0.001	0.013	24		0.001	<0.001	0.001	7
Banks PP	KA000331	Barium		<0.05	<0.05	23	Fluoride	<0.1	<0.1	0.3	23	Silver		<0.001	<0.001	23
O'Neill Forebay Outlet	KA007089			<0.05	<0.05	23		<0.1	<0.1	0.1	24			<0.001	<0.001	23
Check 21	KA017226			<0.05	<0.05	24		<0.1	<0.1	0.3	29			<0.001	<0.001	24
Check 29	KA024454			<0.05	<0.05	26		<0.1	<0.1	0.1	28			<0.001	<0.001	26
Check 41	KA030341			<0.05	<0.05	29		<0.1	<0.1	0.1	29			<0.001	<0.001	29
Devil Canyon Headworks	KA041134			<0.05	<0.05	24		<0.1	<0.1	0.1	24			<0.001	<0.001	24
Banks PP	KA000331	Beryllium		<0.001	<0.001	23	Iron	0.015	<0.005	0.066	23	Thallium	NA			
O'Neill Forebay Outlet	KA007089			<0.001	<0.001	24		0.030	<0.005	0.124	24			<0.001	<0.001	1
Check 21	KA017226			<0.001	<0.001	27		0.034	<0.005	0.087	29			<0.001	<0.001	3
Check 29	KA024454			<0.001	<0.001	26		<0.005	<0.005	0.043	26		NA			
Check 41	KA030341			<0.001	<0.001	26		<0.005	<0.005	0.033	29		NA			
Devil Canyon Headworks	KA041134			<0.001	<0.001	24		<0.005	<0.005	0.024	24		NA			
Banks PP	KA000331	Boron	0.1	<0.1	0.22	23	Lead		<0.001	<0.001	23	Zinc		<0.005	<0.005	23
O'Neill Forebay Outlet	KA007089		0.18	0.1	0.2	24			<0.001	<0.001	24		<0.005	<0.005	0.01	24
Check 21	KA017226		0.2	0.1	0.3	29			<0.001	<0.001	29			<0.005	<0.005	29
Check 29	KA024454		0.2	0.1	0.2	26			<0.001	<0.001	26			<0.005	<0.005	26
Check 41	KA030341		0.2	0.1	0.2	29			<0.001	<0.001	29		0.005	<0.005	0.033	29
Devil Canyon Headworks	KA041134		0.2	0.1	0.2	24			<0.001	<0.001	24		<0.005	<0.005	0.008	24
Banks PP	KA000331	Cadmium		<0.001	<0.001	23	Manganese	0.012	<0.005	0.028	23					
O'Neill Forebay Outlet	KA007089			<0.001	<0.001	23		0.009	<0.005	0.018	24					
Check 21	KA017226			<0.001	<0.001	24		<0.005	<0.005	0.016	29					
Check 29	KA024454			<0.001	<0.001	26		<0.005	<0.005	<0.005	26					
Check 41	KA030341			<0.001	<0.001	29		<0.005	<0.005	0.008	29					
Devil Canyon Headworks	KA041134			<0.001	<0.001	24		<0.005	<0.005	0.815	24					

Table 2-4. Summary of nutrients in the California Aqueduct, 2000 and 2001

Station Name	Station Number	Parameter	Units	Median	Low	High	Sample Size
Banks PP	KA000331	Ammonia	mg/L as N	0.06	0.02	0.15	23
Check 21	KA017226			0.02	<0.01	0.05	21
Check 41	KA030341			0.01	<0.02	0.06	24
Devil Canyon Headworks	KA041134			0.03	<0.03	0.06	24
Banks PP	KA000331	Nitrite+Nitrate	mg/L as N	0.6	0.13	1.2	23
Check 21	KA017226			0.62	0.21	1.37	21
Check 41	KA030341			0.75	0.04	1.6	24
Devil Canyon Headworks	KA041134			0.6	0.21	1.2	24
Banks PP	KA000331	Ortho-Phosphate	mg/L as P	0.07	0.05	0.15	23
Check 21	KA017226			0.07	0.04	0.09	21
Check 41	KA030341			0.07	0.03	0.12	24
Devil Canyon Headworks	KA041134			0.07	0.03	0.15	24
Banks PP	KA000331	Total Kjeldahl Nitrogen	mg/L as N	0.5	0.3	0.8	23
Check 21	KA017226			0.4	0.3	1.2	21
Check 41	KA030341			0.4	0.2	0.8	24
Devil Canyon Headworks	KA041134			0.4	0.2	0.7	24
Banks PP	KA000331	Total Phosphorus	mg/L	0.10	0.07	0.16	23
Check 21	KA017226			0.11	0.07	0.2	21
Check 41	KA030341			0.10	0.07	0.18	24
Devil Canyon Headworks	KA041134			0.08	0.04	0.13	24

III. Joint-Use Facilities

Part of the Joint-Use Facilities, San Luis Reservoir is the major off-stream storage unit of the SWP and The Bureau's Central Valley Project (CVP). It supplies water to both SWP and CVP service areas. Water is pumped into San Luis Reservoir from O'Neill Forebay usually during winter, early spring, and fall. Water in O'Neill Forebay originates from the Sacramento-San Joaquin Delta via the California Aqueduct or the CVP Delta-Mendota Canal (DMC) at O'Neill Pumping-Generating Plant. During late spring and summer when downstream water demand is greater than direct Delta diversions, water is released from San Luis Reservoir via Gianelli Pumping-Generating Plant into O'Neill Forebay for conveyance down the California Aqueduct or DMC.

Major minerals, conventional parameters, and disinfection by-product precursors in San Luis Reservoir during 2000 and 2001 are summarized in Tables 3-1 and 3-2. MCLs for salinity, sulfate, chloride, and nitrate in treated drinking water were not exceeded.

Filling of San Luis Reservoir between fall 2000 and winter 2001 coincided with an increase in reservoir conductivity. Conductivity went from 419 μS/cm in September 2000 to over 500 μS/cm in February and March 2001 (Figure 3-1). Inflow to O'Neill Forebay during that period originated from Banks Pumping Plant and, to a lesser extent, the DMC (Figure 3-2). Conductivity at Banks Pumping Plant was elevated during fall 2000 and winter 2001 generally due to seawater intrusion and high conductivity in the San Joaquin River (see Special Studies). This period of elevated conductivity in exports coincided with reservoir filling and a subsequent increase in San Luis Reservoir conductivity. Over the same 5-month period, bromide in San Luis Reservoir went from 0.19 to 0.24 mg/L due to similar circumstances. The following year, a smaller rise in conductivity was observed in San Luis Reservoir between September and December (2001), also related to reservoir filling during a period when salinity in exports had risen due, in part, to seawater intrusion.

Total organic carbon in San Luis Reservoir generally declined from late summer to fall 2000, coincident with reservoir filling with water from Banks Pumping Plant and, to a lesser extent, the DMC (Figures 3-1 and 3-2). Organic carbon at Banks Pumping Plant during this period was seasonally low. Total organic carbon in the reservoir then increased by almost 1 mg/L between January and March 2001 when reservoir filling continued with water from Banks Pumping Plant and, to a lesser extent, the DMC that exhibited seasonally elevated organic carbon levels.

Minor elements and nutrients in San Luis Reservoir during 2000 and 2001 are summarized in Tables 3-3 and 3-4. MCLs for these parameters in treated drinking water were not exceeded.

Major minerals, conventional parameters, disinfection by-product precursors, and minor elements in the CVP DMC near O'Neill Pumping-Generating Plant during 2000 and 2001 are summarized in Tables 3-1 to 3-3. The Secondary MCL of 500 mg/L for TDS in drinking water was exceeded in the February 2000 sample (501 mg/L), although chloride and sulfate remained below the 250 mg/L secondary MCL for these minerals (Figure 3-3).

A low chloride/sulfate ratio of 0.9 in that sample indicates that the high TDS was not related to seawater intrusion. The elevated TDS likely reflects influence from the San Joaquin River which exhibited levels ranging between 530 and 642 mg/L during the first half of February 2000 (calculated from conductivity). Water from the San Joaquin River can flow directly to the DMC export site at Tracy Pumping Plant via south Old River and Grant Line Canal.

Higher levels of chloride relative to sulfate during the last few months of both 2000 and 2001 are an indication that exports down the DMC were affected by seawater intrusion from the San Francisco Bay (Figure 3-3). Evidence of seawater intrusion was also observed at Banks Pumping Plant during the same months (see Special Studies). Organic carbon trends were somewhat similar to those at Banks Pumping Plant during the 2-year period with the highest levels detected during winter of both years.

Although there were similarities in water quality between the DMC and Banks Pumping Plant, grab samples from the DMC may not be entirely representative of daily trends. The composition of water sent down the DMC can often change hourly due to the effects of tide (DWR 2004b). DMC composition can oscillate between that of the San Joaquin River, cross-Delta flow, or a mixture of both on an hourly basis. If this is occurring when water quality in the San Joaquin River and cross-Delta flow is different, parameters such as conductivity and organic carbon in water moving down the DMC will change hourly. This does not occur in the California Aqueduct because of operations at Clifton Court Forebay.

Water quality at O'Neill Forebay Outlet exhibited influence from San Luis Reservoir releases. Conductivity was from 63 to 117 μS/cm higher at the forebay outlet than at Banks Pumping Plant during April-June 2000, coinciding with increased releases from San Luis Reservoir (Figures 3-2 and 3-4). Conductivity in the reservoir was between 400 and 500 μS/cm during that period, while at Banks Pumping Plant, conductivity ranged from 270 to 384 μS/cm. Bromide was also higher at O'Neill Forebay Outlet than at Banks Pumping Plant during April-June 2000 (Figure 3-4).

A similar event was observed during May-June 2001 when most of the water entering O'Neill Forebay was from San Luis Reservoir. However, pumping at Banks Pumping Plant during those months was reduced or suspended, so water quality there did not represent actual conditions in the south Delta near the time of sampling (see Special Studies). Therefore, concentration differences observed between O'Neill Forebay Outlet and Banks Pumping Plant during May-June 2001 was not a totally accurate depiction of water quality between reservoir releases and Delta exports.

Trends regarding organic carbon downstream of reservoir releases were less definable due to limited data, reduced Delta exports, and an unexplained spike in DOC at Banks Pumping Plant in May 2000.

Assessment of DMC inflow on water quality at O'Neill Forebay Outlet was hampered by several factors:

1. DMC inflow to O'Neill Forebay was often less than that from the California Aqueduct or San Luis Reservoir. Any effect of the DMC on water quality at O'Neill Forebay Outlet may be overshadowed by these greater inflows.

2. Based on grab samples, monthly water quality trends in the DMC near O'Neill Pumping-Generating Plant were sometimes similar to those at Banks Pumping Plant. Separating their individual influence on water quality at the forebay outlet would not be probable with the existing data.

3. During months when water quality at Banks Pumping Plant and the DMC were dissimilar – conductivity was 390 μS/cm at Banks Pumping Plant in the February 2000 sample while in the DMC, conductivity was more than twofold (862 μS/cm) – other factors could complicate analysis. Water quality in the DMC can vary hourly due to side channel inflow and influences in the south Delta such as tide. Consequently, the effects of DMC inflow on water quality in O'Neill Forebay would also be variable.

Table 3-1. Summary of major minerals and conventional parameters in the CVP Delta-Mendota Canal and San Luis Reservior, 2000 and 2001

Station Name	Station Number	Major Minerals	Units	Median	Low	High	Sample Size	Conventional Parameters	Units	Median	Low	High	Sample Size
CVP Delta Mendota Canal	DMC06716	Alkalinity	mg/L as CaCO3	74	46	112	24	Conductivity	micro S/cm	470	247	862	23
San Luis Reservoir	SLR00000			76	73	84	19			497	419	580	19
CVP Delta Mendota Canal	DMC06716	Calcium	mg/L	19	14	39	24	Hardness	mg/L as CaCO3	100	60	184	24
San Luis Reservoir	SLR00000			20	18	21	20			103	94	113	20
CVP Delta Mendota Canal	DMC06716	Chloride	mg/L	58	23	144	25	pH	pH units	7.6	7.4	8.1	10
San Luis Reservoir	SLR00000			77	60	96	20			7.7	7.2	8.0	8
CVP Delta Mendota Canal	DMC06716	Magnesium	mg/L	13	6	21	24	TDS	mg/L	250	137	501	24
San Luis Reservoir	SLR00000			13	12	15	20			272	242	320	19
CVP Delta Mendota Canal	DMC06716	Nitrate	mg/L as N03	3.3	1.1	9.8	23	TSS	mg/L	16	4	47	6
San Luis Reservoir	SLR00000			2.6	0.8	3.8	19			7.5	<1	15	2
CVP Delta Mendota Canal	DMC06716	Sodium	mg/L	50	22	102	24	Turbidity	NTU	16	5.8	29.3	24
San Luis Reservoir	SLR00000			55	48	64	20			1.4	<1	35	16
CVP Delta Mendota Canal	DMC06716	Sulfate	mg/L	33	22	125	24	VSS	mg/L	3.5	<1	5	6
San Luis Reservoir	SLR00000			40	32	44	20			2.5			1

Table 3-2. Summary of disinfection by-product precursors in the CVP Delta Mendota Canal and San Luis Reservoir, 2000 and 2001 (DWR and MWDSC)

Station Name	Station Number	Parameter	Units	Median	Low	High	Sample Size
CVP Delta Mendota Canal	DMC06716	Bromide	mg/L	0.18	<0.05	0.47	25
San Luis Reservoir, Pacheco Pumping Plant	SLR00000			0.20	0.18	0.27	11
San Luis Reservoir, Trashracks	SLR01000			0.23	0.12	0.46	35
CVP Delta Mendota Canal	DMC06716	DOC	mg/L as C	2.9	2.3	5.8	20
San Luis Reservoir	SLR00000			2.9	2.7	5.9	4
San Luis Reservoir, Trashracks	SLR01000			3.0			1
CVP Delta Mendota Canal	DMC06716	TOC	mg/L as C	3.5	2.6	5.9	19
San Luis Reservoir	SLR00000			2.9	2.9	6.9	4
San Luis Reservoir, Trashracks	SLR01000			3.3	2.6	6.1	36
CVP Delta Mendota Canal	DMC06716	UVA	Absorbance/cm	NA			
San Luis Reservoir	SLR00000			NA			
San Luis Reservoir, Trashracks	SLR01000			0.088	0.066	0.190	35

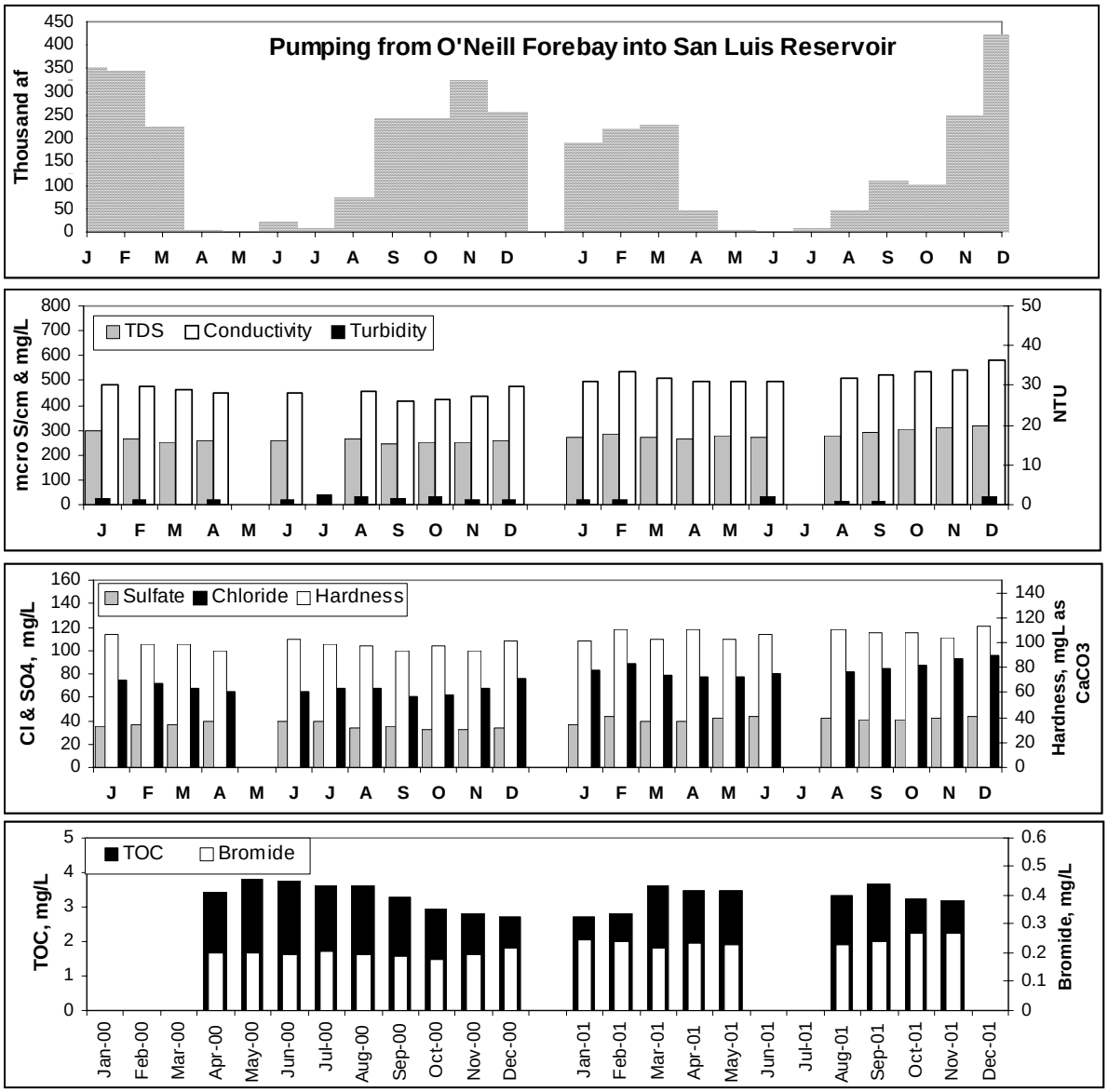

Figure 3-1. Monthly pumping (combined SWP and CVP) and water quality in San Luis Reservoir. Water quality stations included SLR00000 and SL001000 (TOC and bromide)

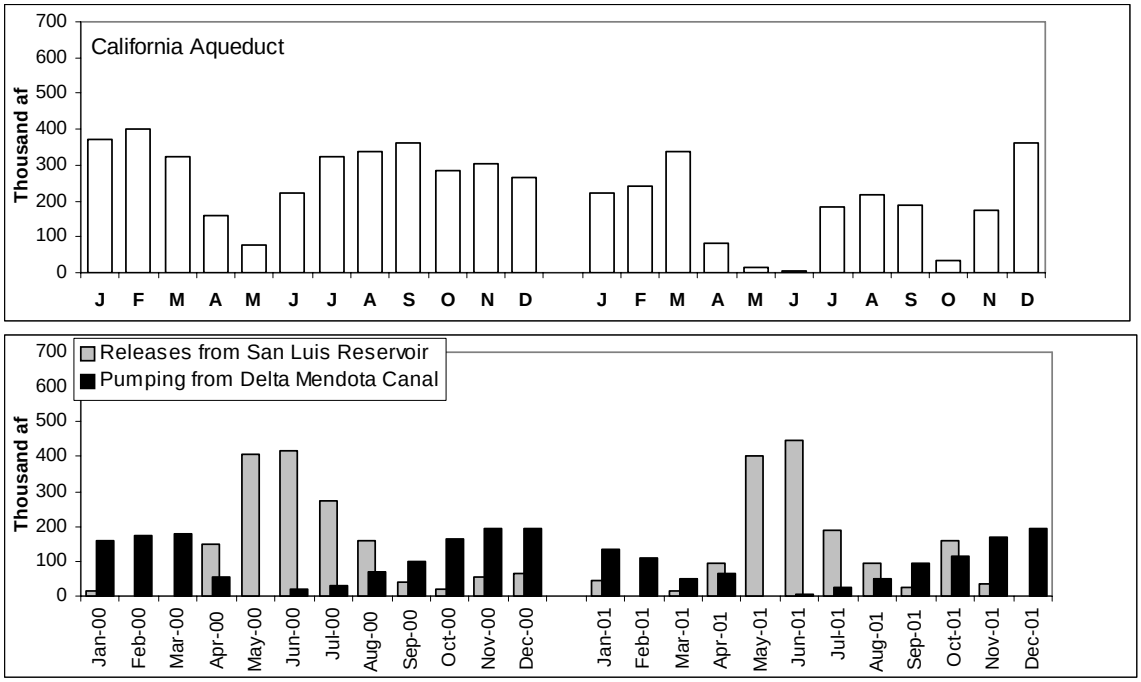

Figure 3-2. Monthly inflow to O'Neill Forebay

Table 3-3. Summary of minor elements in the CVP Delta-Mendota Canal near O'Neill Forebay Pumping-Generating Plant and the San Luis Reservoir, 2000 and 2001 (mg/L)

Station Name	Station Number	Minor Element	Median	Low	High	Sample Size	Minor Element	Median	Low	High	Sample Size	Minor Element	Median	Low	High	Sample Size
CVP Delta Mendota Canal	DMC06716	Aluminum	0.18	<0.01	0.064	24	Chromium +3	0.004	<0.001	0.009	24	Mercury		<0.0002	<0.0002	23
San Luis Reservoir	SLR00000			<0.01	<0.01	20		0.005	<0.001	0.007	19			<0.0002	<0.0002	18
CVP Delta Mendota Canal	DMC06716	Antimony		<0.005	<0.005	12	Chromium +6		<0.001		1	Nickel	0.001	0.001	0.002	24
San Luis Reservoir	SLR00000			<0.005	<0.005	19			<0.001		1			<0.001	0.002	19
CVP Delta Mendota Canal	DMC06716	Arsenic	0.002	0.002	0.003	24	Copper	0.002	0.002	0.005	24	Selenium	<0.001	<0.001	0.003	5
San Luis Reservoir	SLR00000		0.002	0.002	0.003	19		0.004	0.003	0.014	19		<0.001	<0.001	0.001	2
CVP Delta Mendota Canal	DMC06716	Barium	<0.05	<0.05	0.053	24	Fluoride	<0.1	<0.1	0.1	23	Silver		<0.001	<0.001	24
San Luis Reservoir	SLR00000		<0.05	<0.05	<0.05	19		<0.1	<0.1	0.3	19			<0.001	<0.001	19
CVP Delta Mendota Canal	DMC06716	Beryllium		<0.001	<0.001	24	Iron	0.029	<0.005	0.117	24	Thallium		<0.001	<0.001	4
San Luis Reservoir	SLR00000			<0.001	<0.001	19		<0.005	<0.005	0.020	19		NA			
CVP Delta Mendota Canal	DMC06716	Boron	0.122	0.1	0.6	24	Lead		<0.001	<0.001	24	Zinc		<0.005	<0.005	24
San Luis Reservoir	SLR00000		0.2	0.1	0.2	20			<0.001	<0.001	19			<0.005	<0.005	19
CVP Delta Mendota Canal	DMC06716	Cadmium		<0.001	<0.001	24	Manganese	<0.01	<0.01	0.02	23					
San Luis Reservoir	SLR00000			<0.001	<0.001	19		<0.01	<0.01	0.03	19					

Table 3-4. Summary of nutrients in San Luis Reservoir, 2000 and 2001

Station Name	Station Number	Minor Element	Units	Median	Low	High	Sample Size
San Luis Reservoir	SLR00000	Ammonia	mg/L as N	0.01	<0.01	0.07	20
		Nitrate + Nitrite	mg/L as N	0.56	0.28	0.88	20
		Ortho-Phosphate	mg/L as P	0.08	0.04	0.09	20
		Total Kjeldahl Nitrogen	mg/L as N	0.4	0.2	0.6	20
		Total Phosphorus	mg/L	0.09	0.06	0.38	20

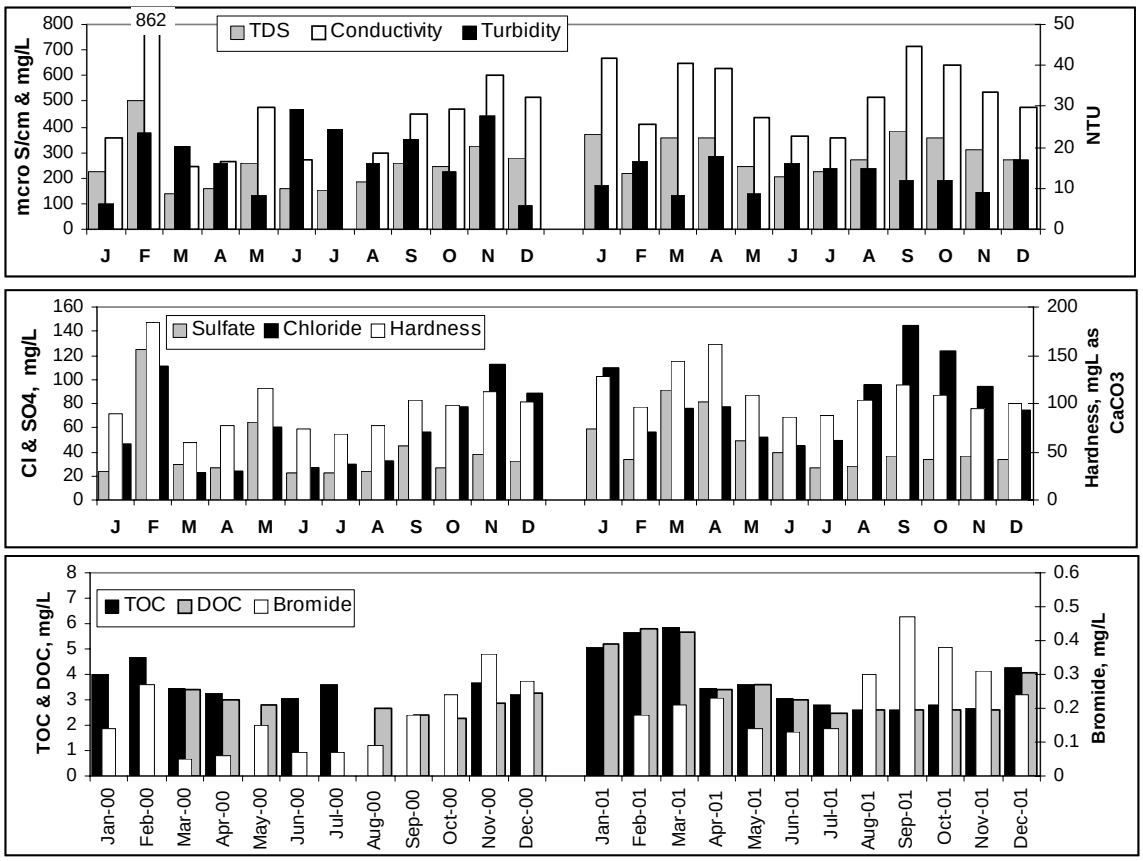

Figure 3-3. Monthly water quality in the CVP Delta-aMendota Canal near O'Neill Pumping-Generating Plant

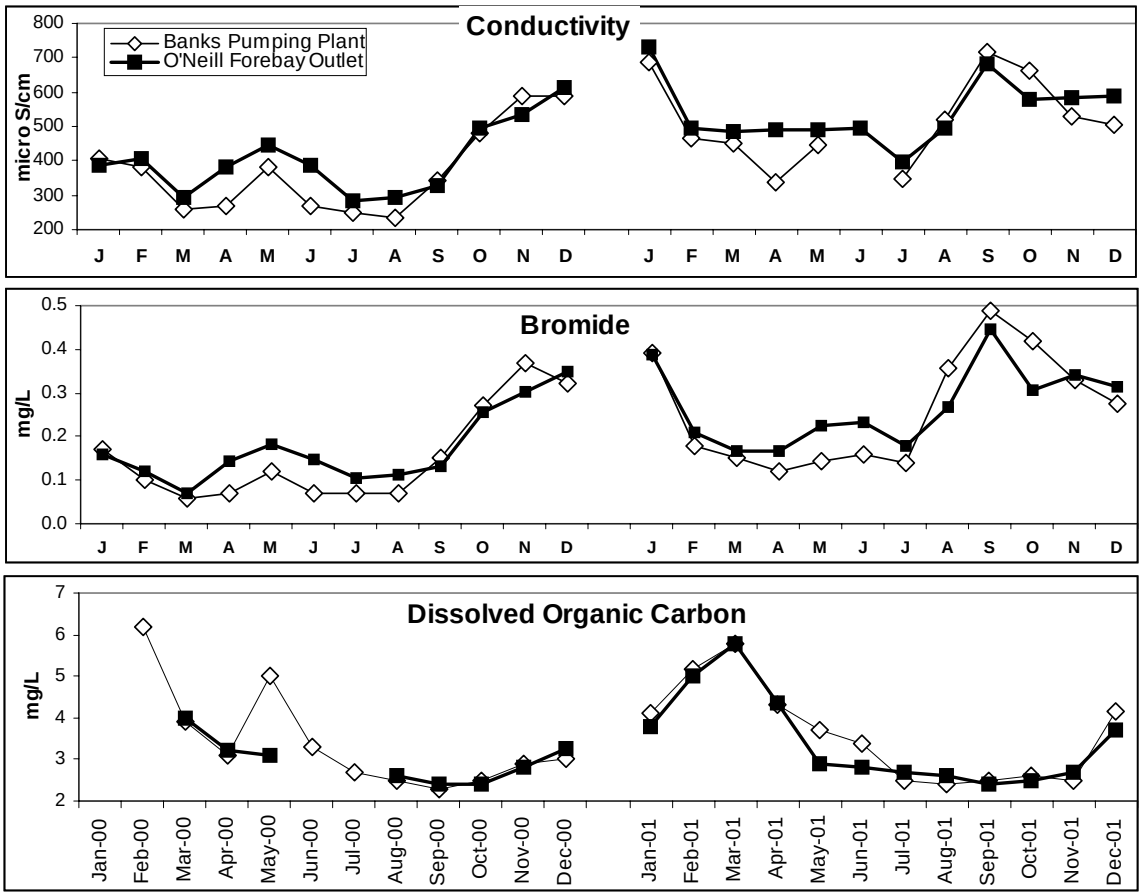

Figure 3-4. Water quality differences between Banks Pumping Plant and O'Neill Forebay Outlet

IV. State Water Project Lakes in Southern California

Major minerals, conventional parameters, and disinfection by-product precursors in Southern California SWP lakes during 2000 and 2001 are summarized in Tables 4-1 and 4-2. MCLs for salinity, sulfate, chloride, and nitrate in treated drinking water were not exceeded.

Salinity was most variable in Silverwood Lake and least variable in Lake Perris (Figure 4-1). Chloride in Pyramid and Silverwood Lakes was generally highest in the first and last quarters of both years (Figure 4-2). Somewhat similar trends were observed in the California Aqueduct due, in part, to seawater intrusion in the Sacramento-San Joaquin Delta. Along with inflow from the Aqueduct, water quality in Pyramid and Silverwood Lakes can be influenced by local runoff from the surrounding watersheds (DWR 1999). Pyramid Lake also receives pump-back inflow from Elderberry Forebay for power generation.

Disinfection by-product precursors in SWP Southern California lakes are summarized in Table 4-2. Median bromide in all lakes was around 0.2 mg/L with a maximum of 0.38 mg/L in Silverwood Lake. Organic carbon levels in Castaic Lake gradually increased and decreased between the spring and fall months of both 2000 and 2001 (Figure 4-3). TOC spiked above 6 mg/L in the February 2001 samples from Castaic Lake and Lake Perris, although there was no corresponding spike in DOC.

Minor elements and nutrients in SWP Southern California lakes during 2000 and 2001 are summarized in Tables 4-3 and 4-4. Existing MCLs for these parameters in treated drinking water were not exceeded.

Project and local inflows to Pyramid Lake are shown in Figure 4-4. Local inflow during 2000 and 2001 was highest in March 2001, accounting for 58 percent of the combined monthly inflow from the California Aqueduct and local inflow. Overall, local inflow to Pyramid Lake accounted for 2.3 percent of the total during 2000 and 8.6 percent during 2001. Local inflow to Castaic Lake, Elderberry Forebay, and Silverwood Lake was highest in February and March of both 2000 and 2001 (Figures 4-5 and 4-6).

Table 4-1. Summary of major minerals and conventional parameters in SWP lakes in Southern California, 2000 and 2001

Station Name	Station Number	Major Minerals	Units	Median	Low	High	Sample Size	Conventional Parameters	Units	Median	Low	High	Sample Size
Pyramid Lake	PY001000	Alkalinity	mg/L as CaCO3	79	71	93	8	Conductivity	micro S/cm	482	386	584	8
Castaic Lake	CA002000			86	71	97	8			495	436	547	8
Silverwood Lake	SI002000			77	72	86	8			467	369	615	8
Lake Perris	PE002000			100	94	106	8			545	514	578	8
Pyramid Lake	PY001000	Calcium	mg/L	23	18	27	8	Hardness	mg/L as CaCO3	110	90	119	8
Castaic Lake	CA002000			26	22	31	8			121	104	135	8
Silverwood Lake	SI002000			20	18	25	8			100	86	114	8
Lake Perris	PE002000			25	25	26	8			121	116	127	8
Pyramid Lake	PY001000	Chloride	mg/L	63	47	99	8	pH	pH units	8.7	8.0	9.2	4
Castaic Lake	CA002000			62	50	78	8			8.3	8.0	9.2	5
Silverwood Lake	SI002000			64	48	114	10			7.9	7.7	8.0	4
Lake Perris	PE002000			77	70	84	8			8.3	7.7	8.8	4
Pyramid Lake	PY001000	Magnesium	mg/L	12	11	15	8	TDS	mg/L	266	215	314	8
Castaic Lake	CA002000			13	12	15	8			281	239	304	8
Silverwood Lake	SI002000			12	10	15	8			264	196	330	8
Lake Perris	PE002000			14	13	15	8			287	278	314	8
Pyramid Lake	PY001000	Nitrate	mg/L as N03	2	0.2	3.2	8	Turbidity	NTU	2.5	<1.0	5.6	8
Castaic Lake	CA002000			1.4	<0.1	2.1	8			<1.0	<1.0	3.4	8
Silverwood Lake	SI002000			2	0.9	4	8			2.4	1.5	4.0	9
Lake Perris	PE002000			<0.1	<0.1	0.2	8			<1.0	<1.0	2.0	8
Pyramid Lake	PY001000	Sodium	mg/L	51	39	65	8						
Castaic Lake	CA002000			47	42	55	8						
Silverwood Lake	SI002000			50	38	70	8						
Lake Perris	PE002000			59	53	64	8						
Pyramid Lake	PY001000	Sulfate	mg/L	46	31	62	8						
Castaic Lake	CA002000			58	46	73	8						
Silverwood Lake	SI002000			38	26	58	10						
Lake Perris	PE002000			48	44	51	8						

Table 4-2. Summary of bromide, dissolved and total organic carbon (DOC and TOC), and UVA 254 in SWP Southern California Lakes, 2000 and 2001 (DWR and MWDSC)

Station Name	Station Number	Analyte	Units	Median	Low	High	Sample Size
Pyramid Lake	PY001000	Bromide	mg/L	0.2	0.10	0.32	20
Castaic Lake	CA002000			0.20	0.13	0.26	54
Silverwood Lake	SI002000			0.21	0.11	0.38	55
Lake Perris	PE002000			0.23	0.14	0.30	68
Pyramid Lake	PY001000	DOC	mg/L as C	NA			
Castaic Lake	CA002000			2.8	2.3	3.8	20
Silverwood Lake	SI002000			NA			
Lake Perris	PE002000			3.8	3.2	4.1	22
Pyramid Lake	PY001000	TOC	mg/L as C	NA			
Castaic Lake	CA002000			3.4	2.3	6.2	54
Silverwood Lake	SI002000			3.2	2.5	5.0	41
Lake Perris	PE002000			4.0	1.9	7.9	70
Pyramid Lake	PY001000	UVA	Absorbance/cm	NA			
Castaic Lake	CA002000			0.070	0.050	0.085	34
Silverwood Lake	SI002000			0.082	0.057	0.135	37
Lake Perris	PE002000			0.220	0.140	0.300	46

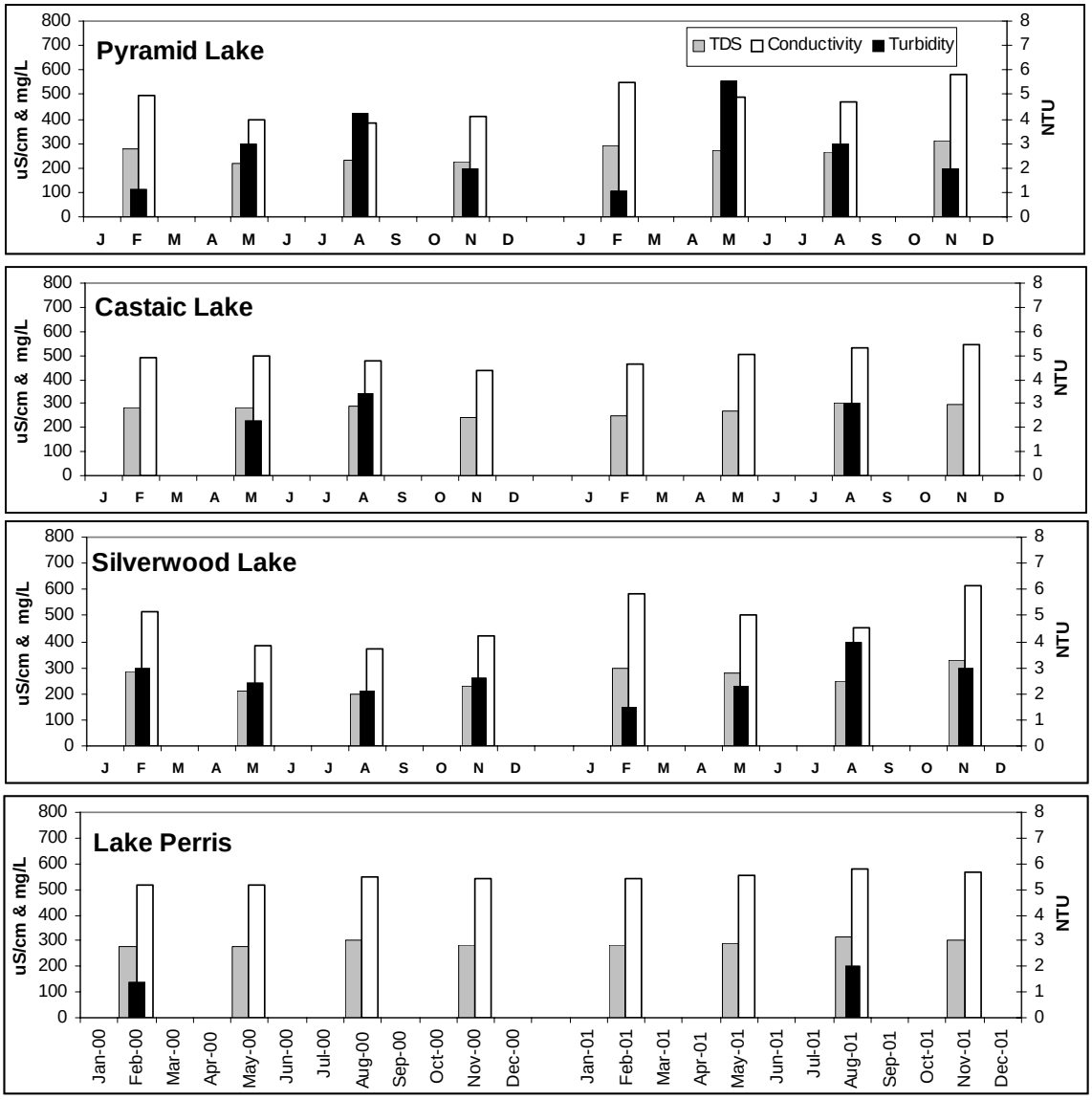

Figure 4-1. Quarterly salinity and turbidity in SWP Southern California Lakes. Samples with turbidity below the reporting limit (<1 NTU) were excluded from the graphs

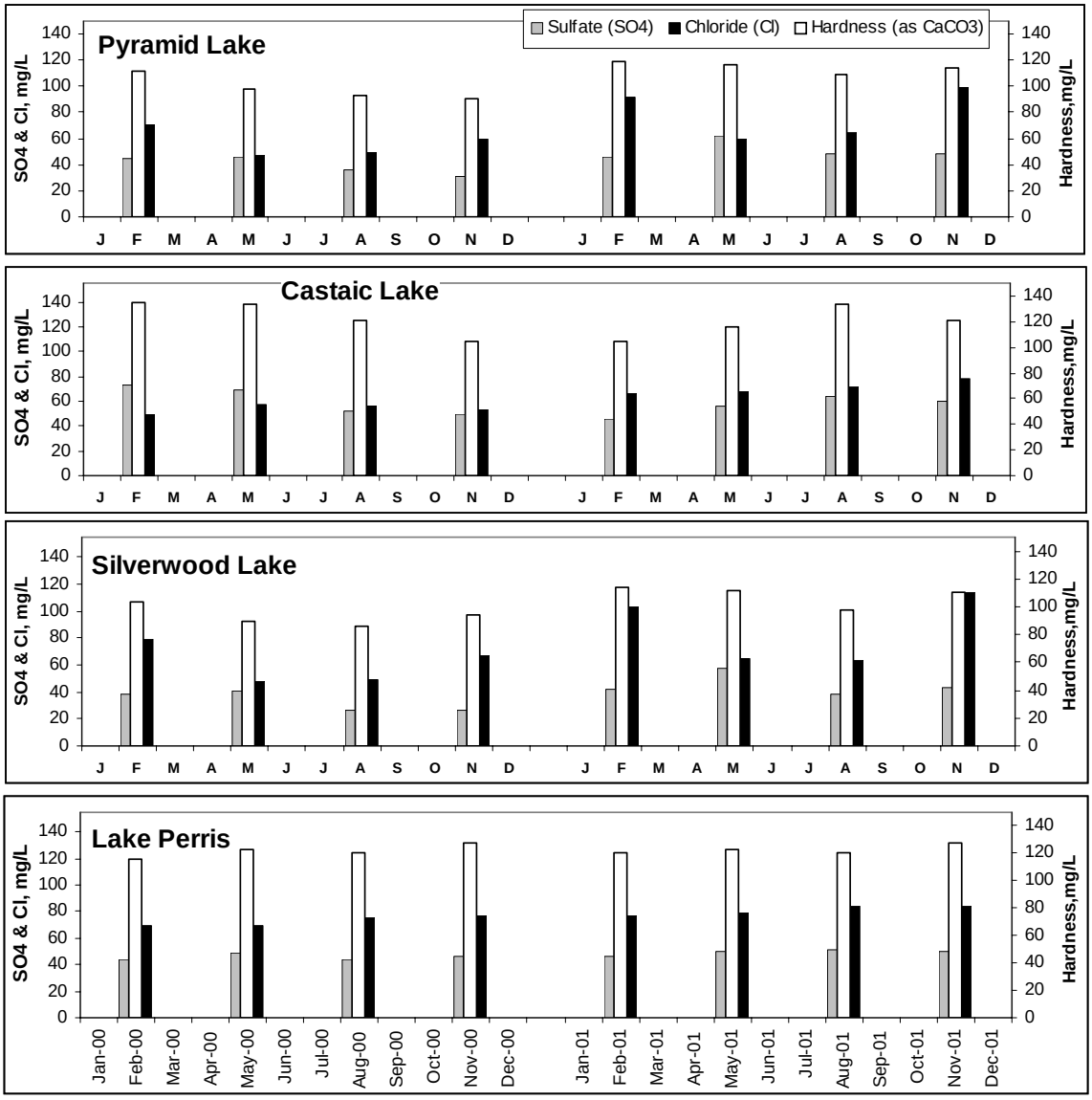

Figure 4-2. Quarterly sulfate, chloride, and hardness in SWP Southern California Lakes

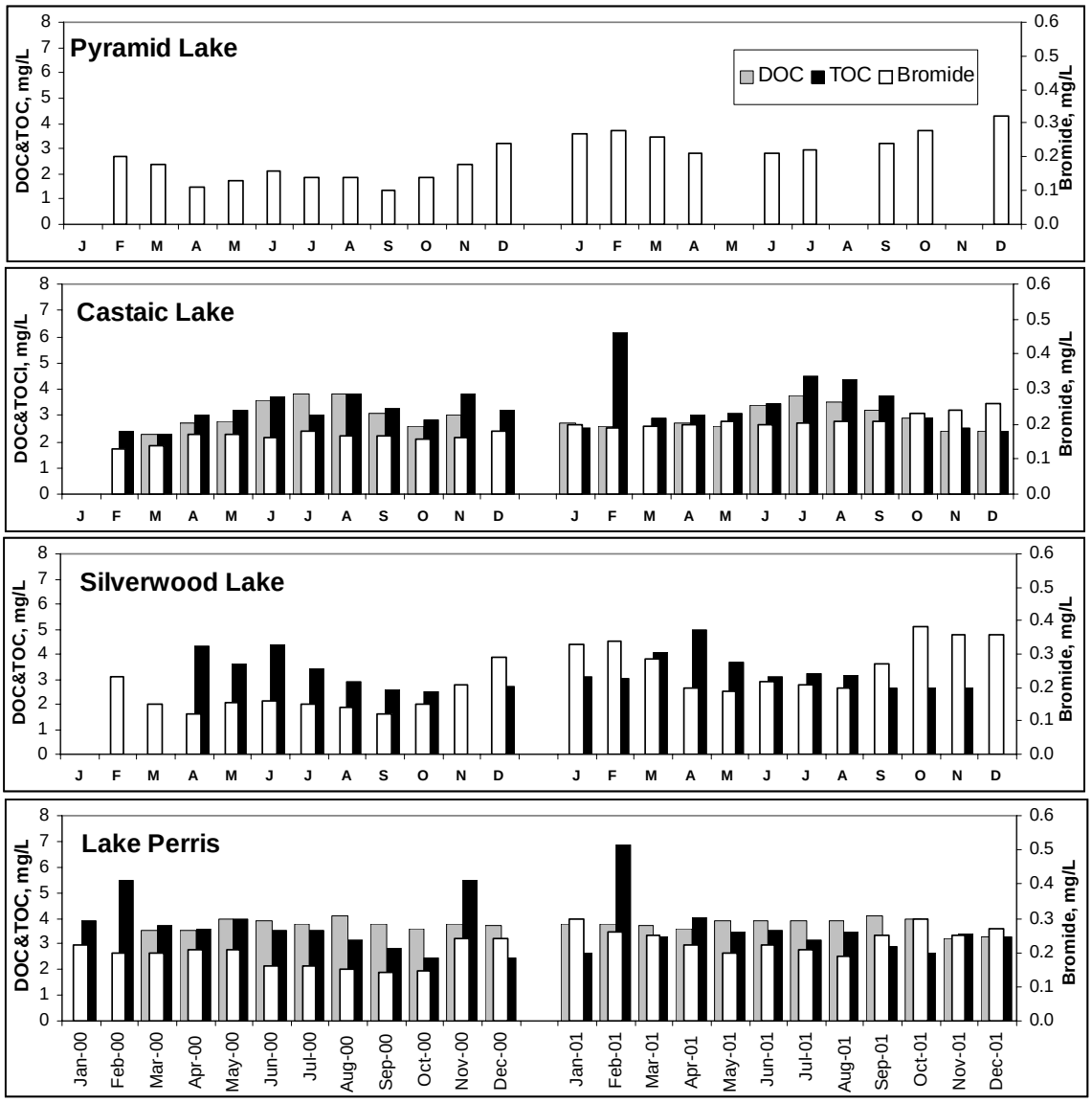

Figure 4-3. Monthly bromide and dissolved and total organic carbon (DOC and TOC), in SWP Southern California lakes (DWR and MWDSC)

Table 4-3. Summary of minor elements in SWP Southern California lakes, 2000 and 2001 (mg/L)

Station Name	Station Number	Minor Element	Median	Low	High	Sample Size	Minor Element	Median	Low	High	Sample Size	Minor Element	Median	Low	High	Sample Size
Pyramid Lake	PY001000	Aluminum		<0.01	<0.01	8	Chromium +3	0.002	<0.001	0.007	8	Mercury		<0.0002	<0.0002	8
Castaic Lake	CA002000			<0.01	<0.01	8		0.005	<0.001	0.008	8			<0.0002	<0.0002	8
Silverwood Lake	SI002000			<0.01	<0.01	8		0.003	<0.001	0.008	8			<0.0002	<0.0002	7
Lake Perris	PE002000			<0.01	<0.01	8		0.002	<0.001	0.009	8			<0.0002	<0.0002	8
Pyramid Lake	PY001000	Antimony		<0.005	<0.005	4	Chromium +6	NA				Nickel	0.001	0.001	0.002	8
Castaic Lake	CA002000			<0.005	<0.005	4		NA					0.001	0.001	0.002	8
Silverwood Lake	SI002000			<0.005	<0.005	4		NA					0.001	0.001	0.002	8
Lake Perris	PE002000			<0.005	<0.005	3		NA						0.001	0.001	8
Pyramid Lake	PY001000	Arsenic	0.002	0.002	0.003	8	Copper	0.002	0.002	0.003	8	Selenium	0.001	<0.001	0.001	3
Castaic Lake	CA002000			0.002	0.002	8		0.004	0.003	0.045	9			0.001	0.001	3
Silverwood Lake	SI002000		0.002	0.002	0.004	8		0.003	0.002	0.004	8		<0.001	<0.001	0.001	3
Lake Perris	PE002000			0.002	0.002	8		0.006	0.003	0.026	8		0.001	<0.001	0.001	3
Pyramid Lake	PY001000	Barium		<0.05	<0.05	8	Fluoride		0.1	0.1	7	Silver		<0.001	<0.001	8
Castaic Lake	CA002000			<0.05	<0.05	8		0.2	0.1	0.2	7			<0.001	<0.001	8
Silverwood Lake	SI002000			<0.05	<0.05	8		<0.1	<0.1	0.1	7			<0.001	<0.001	8
Lake Perris	PE002000		0.053	<0.05	0.057	8			0.1	0.1	7			<0.001	<0.001	8
Pyramid Lake	PY001000	Beryllium		<0.001	<0.001	8	Iron		<0.005	<0.005	8	Zinc	<0.005	<0.005	0.01	8
Castaic Lake	CA002000			<0.001	<0.001	8			<0.005	<0.005	8		<0.005	<0.005	0.011	8
Silverwood Lake	SI002000			<0.001	<0.001	8		<0.005	<0.005	0.006	8			<0.005	<0.005	6
Lake Perris	PE002000			<0.001	<0.001	8		<0.005	<0.005	0.007	8		<0.005	<0.005	0.005	8
Pyramid Lake	PY001000	Boron	0.20	0.19	0.20	8	Lead		<0.001	<0.001	8					
Castaic Lake	CA002000		0.20	0.20	0.30	8			<0.001	<0.001	8					
Silverwood Lake	SI002000		0.20	0.10	0.20	8			<0.001	<0.001	8					
Lake Perris	PE002000			0.20	0.20	8			<0.001	<0.001	8					
Pyramid Lake	PY001000	Cadmium		<0.001	<0.001	8	Manganese		<0.005	<0.005	8					
Castaic Lake	CA002000			<0.001	<0.001	8			<0.005	<0.005	8					
Silverwood Lake	SI002000			<0.001	<0.001	8		<0.005	<0.005	0.009	8					
Lake Perris	PE002000			<0.001	<0.001	8		<0.005	<0.005	0.008	8					

Table 4-4. Summary of nutrients in SWP Southern California lakes, 2000 and 2001

Station Name	Station Number	Nutrient	Units	Median	Low	High	Sample Size
Pyramid Lake	PY001000	Ammonia	mg/L as N	<0.01	<0.01	0.07	24
Castaic Lake	CA002000			<0.01	<0.01	0.06	23
Silverwood Lake	SI002000			0.03	<0.01	0.06	24
Lake Perris	PE002000			0.01	<0.01	0.03	24
Pyramid Lake	PY001000	Nitrate + Nitrite	mg/L as N	0.53	<0.01	0.73	24
Castaic Lake	CA002000			0.30	<0.01	0.50	24
Silverwood Lake	SI002000			0.58	<0.01	0.92	24
Lake Perris	PE002000			<0.01	<0.01	2.30	24
Pyramid Lake	PY001000	Ortho-phosphate	mg/L as P	0.05	<0.01	0.10	24
Castaic Lake	CA002000			0.02	<0.01	0.06	24
Silverwood Lake	SI002000			0.06	0.02	0.09	24
Lake Perris	PE002000			<0.01	<0.01	0.09	24
Pyramid Lake	PY001000	Total Kjeldahl Nitrogen	mg/L as N	0.5	0.2	1.8	24
Castaic Lake	CA002000			0.4	0.2	0.6	23
Silverwood Lake	SI002000			0.4	0.2	1.9	24
Lake Perris	PE002000			0.5	0.3	0.8	24
Pyramid Lake	PY001000	Total Phosphorus	mg/L	0.07	0.03	0.17	24
Castaic Lake	CA002000			0.04	0.01	0.08	24
Silverwood Lake	SI002000			0.08	0.04	0.42	24
Lake Perris	PE002000			0.02	<0.01	0.05	24

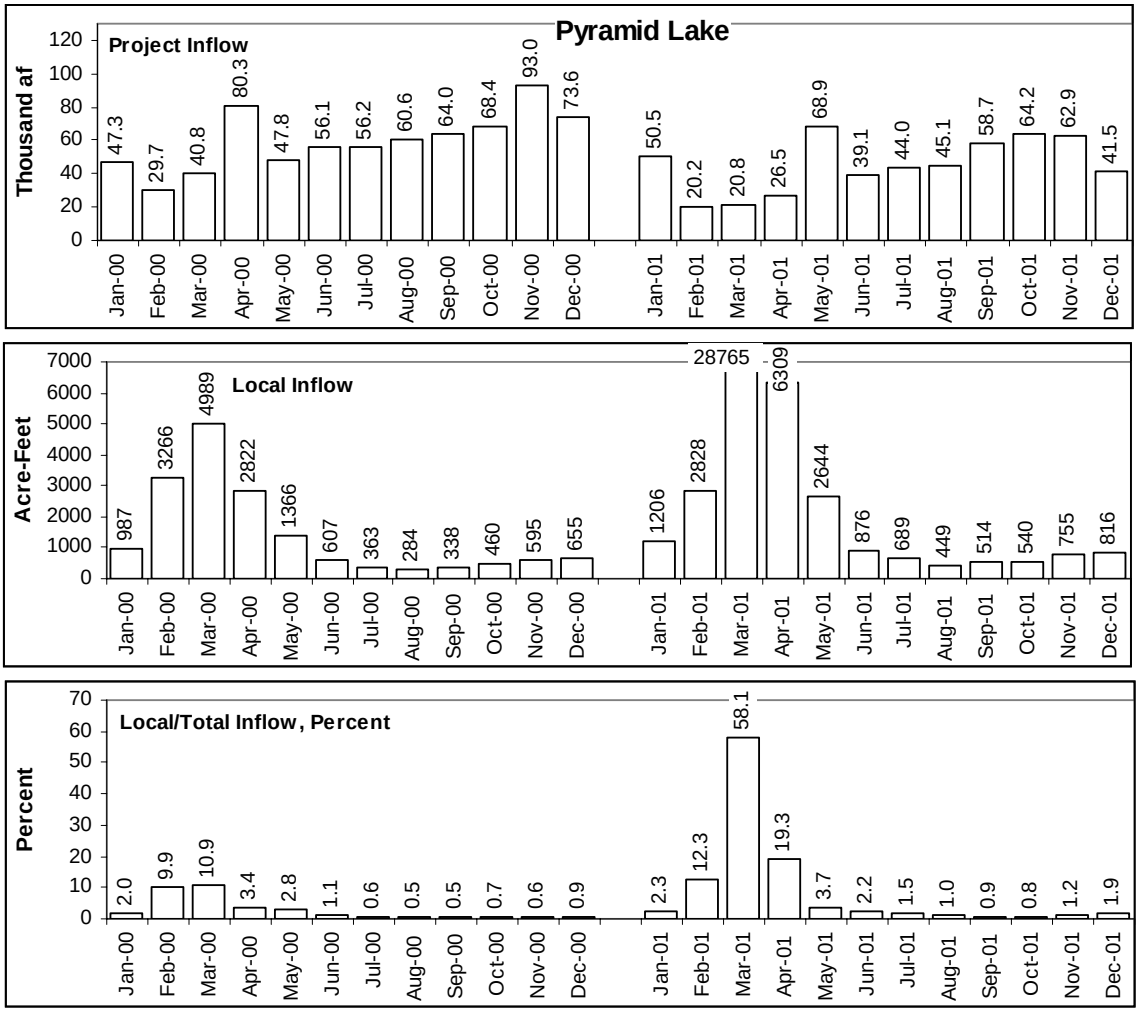

Figure 4-4. Project and local inflows to Pyramid Lake

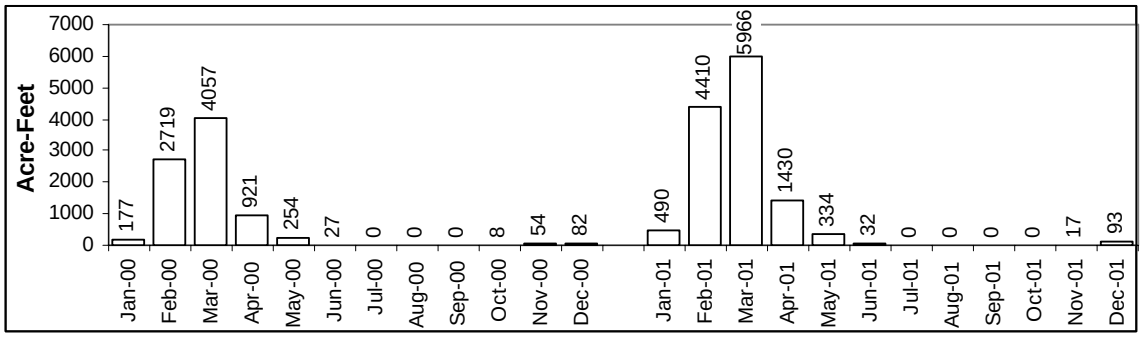

Figure 4-5. Local inflow to Castaic Lake and Elderberry Forebay

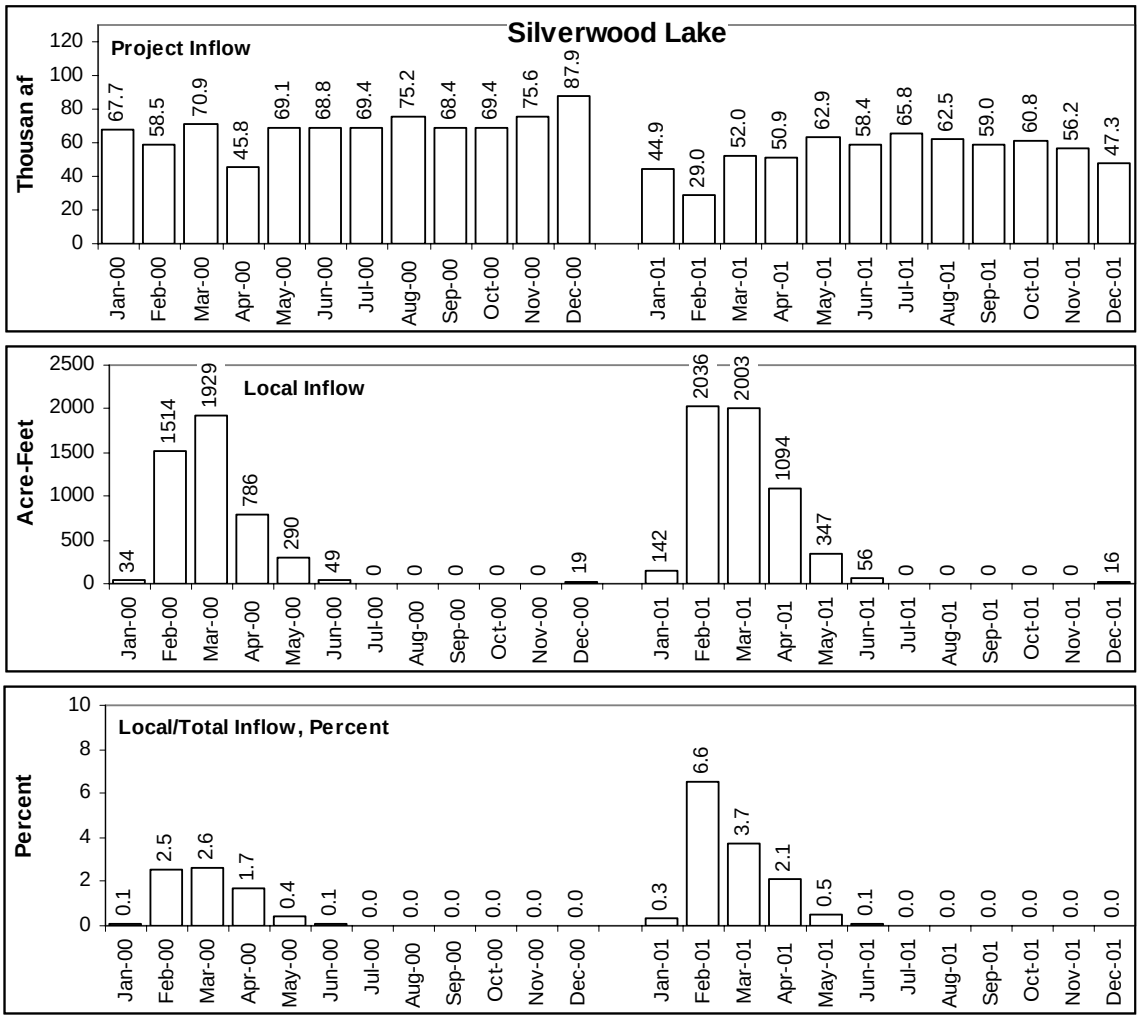

Figure 4-6. Project and local inflows to Silverwood Lake

V. South Bay Aqueduct

Major minerals, conventional parameters, disinfection by-product precursors, minor elements, and nutrients in the South Bay Aqueduct during 2000 and 2001 are summarized in Tables 5-1 to 5-4. MCLs for salinity, chloride, sulfate, minor elements, and nitrate in treated drinking water were not exceeded.

Salinity, chloride, sulfate, and bromide levels at Del Valle Check 7 were similar to those observed at Banks Pumping Plant during 2000 and 2001 (Figure 5-1). Monthly mineral concentrations between Del Valle Check 7 and Banks Pumping Plant are well correlated with r-squared values ranging from 0.96 to 0.99 (DWR 2000). Salinity generally increased towards the end of each year due, in large part, to seawater intrusion in the south Sacramento-San Joaquin Delta (see Special Studies).

Monthly organic carbon trends at Del Valle Check 7 were also similar to those at Banks Pumping Plant with the exception of May 2000 and possibly other months, although data was limited (Figure 5-1). Dissolved and total organic carbon concentrations were around 3.5 mg/L at Del Valle Check 7 in the May 2000 sample, while at Banks Pumping Plant levels were near 5 mg/L.

Local inflow to Lake Del Valle totaled 22.6 taf in 2000 and 13.5 taf in 2001. The inflow amounted to 17 and 12 percent, respectively, of the annual volumes pumped at South Bay Pumping Plant. Local inflow to the Lake Del Valle during the 2-yerar period was highest in February 2000 (Figure 5-2). Releases from Lake Del Valle to the South Bay Aqueduct were generally highest in fall 2000 and June 2001 and composed a maximum 80 percent of the monthly South Bay Aqueduct flow in December 2001 when very little water was pumped at South Bay Pumping Plant (Figure 5-2). Water quality in major releases from Lake Del Valle during 2000 and 2001 is shown in Figure 5-3.

A special water quality study was conducted in Lake Del Valle during 2000 and 2001. The full suite of water quality constituents listed in Title 22 of the California Code of Regulations was analyzed in quarterly samples collected between November 2000 and August 2001. The goal was to provide South Bay Aqueduct contractors with DHS compliance data and assess the relative quality of the lake as a source for drinking water.

None of the over 200 water quality constituents measured during the study exceeded either the primary or secondary MCLs for treated drinking water (the full report is presented in Appendix C). The study concluded that the lake is an excellent source of drinking water.

Table 5-1. Summary of major minerals and conventional parameters in the South Bay Aqueduct, 2000 and 2001

Station Name	Station Number	Major Minerals	Units	Median	Low	High	Sample Size	Conventional Parameters	Units	Median	Low	High	Sample Size
Del Valle Check 7	KB001638	Alkalinity	mg/L as CaCO3	71	50	111	21	Conductivity	micro S/cm	435	239	722	21
Lake Del Valle	DV001000			140	127	148	4			443	431	461	4
Del Valle Outlet	DV000000			146	131	158	9			406	387	453	9
Santa Clara Terminal Tank	KB004207			96	62	150	13			432	254	510	13
Del Valle Check 7	KB001638	Calcium	mg/L	17	13	26	21	Hardness	mg/L as CaCO3	96	65	132	21
Lake Del Valle	DV001000			31	27	38	4			160	142	187	4
Del Valle Outlet	DV000000			33	29	34	9			165	147	177	9
Santa Clara Terminal Tank	KB004207			25	14	34	12			120	67	176	13
Del Valle Check 7	KB001638	Chloride	mg/L	48	24	149	21	pH	pH units	7.5	7.2	8.1	9
Lake Del Valle	DV001000			30	27	36	4				8.4	8.8	2
Del Valle Outlet	DV000000			16	15	33	9			7.8	7.8	8.1	5
Santa Clara Terminal Tank	KB004207			37	16	97	12			7.4	7.3	7.8	7
Del Valle Check 7	KB001638	Magnesium	mg/L	13	7	17	21	TDS	mg/L	238	123	398	21
Lake Del Valle	DV001000			20	18	23	4			250	248	258	4
Del Valle Outlet	DV000000			20	19	23	9			235	210	260	9
Santa Clara Terminal Tank	KB004207			16	8	22	12			245	133	277	13
Del Valle Check 7	KB001638	Nitrate	mg/L as N03	2.1	0.3	5.6	21	TSS	mg/L	8	2.7	63	21
Lake Del Valle	DV001000			0.5	<0.1	0.8	4			1.3	0.5	3	4
Del Valle Outlet	DV000000			0.4	0.1	1.3	9			2	<1	5	9
Santa Clara Terminal Tank	KB004207			1.3	0.2	4.4	12			6.5	5	10	4
Del Valle Check 7	KB001638	Sodium	mg/L	38	22	86	21	Turbidity	NTU	8.0	3.8	42	21
Lake Del Valle	DV001000			29	28	31	4			3.0	1.8	4.5	4
Del Valle Outlet	DV000000			21	18	30	9			1.9	1.0	11	9
Santa Clara Terminal Tank	KB004207			33	18	59	12			7.9	3.0	21	13
Del Valle Check 7	KB001638	Sulfate	mg/L	32	14	59	21	VSS	mg/L	2	<1	11.5	21
Lake Del Valle	DV001000			44	42	46	4			0.5	<1	1.5	4
Del Valle Outlet	DV000000			41	38	49	9			<1	<1	2	9
Santa Clara Terminal Tank	KB004207			41	16	51	12			2	1	2	4

Table 5-2. Summary of disinfection by-product precursors in the South Bay Aqueduct, 2000 and 2001

Station Name	Station Number	Parameter	Units	Median	Low	High	Sample Size
Del Valle Check 7	KB001638	Bromide	mg/L	0.15	0.05	0.48	21
Lake Del Valle	DV001000			0.09	0.07	0.095	4
Del Valle Outlet	DV000000			0.04	0.02	0.12	10
Del Valle Check 7	KB001638	DOC	mg/L as C	3.1	2.4	5.7	20
Lake Del Valle	DV001000			4.1	4.05	4.3	4
Del Valle Outlet	DV000000				3.4	4.5	2
Del Valle Check 7	KB001638	TOC	mg/L as C	3.6	2.4	5.9	18
Lake Del Valle	DV001000			4.1	4.1	4.5	4
Del Valle Outlet	DV000000				3.5	4.7	2

Table 5-3. Summary of minor elements in the South Bay Aqueduct, 2000 and 2001 (mg/L)

Station Number	Minor Element	Median	Low	High	Sample Size	Minor Element	Median	Low	High	Sample Size	Minor Element	Median	Low	High	Sample Size
KB001638	Aluminum	<0.01	<0.01	0.017	21	Chromium +3	0.005	<0.001	0.007	21	Mercury		<0.0002	<0.0002	21
DV001000			<0.01	<0.01	4		0.01	<0.001	0.0105	4			<0.0002	<0.0002	4
DV000000		<0.01	<0.01	<0.01	9		0.012	0.006	0.018	9			<0.0002	<0.0002	9
KB004207		<0.01	<0.01	<0.01	12		0.008	<0.001	0.012	12			<0.0002	<0.0002	13
KB001638	Antimony		<0.005	<0.005	21	Chromium +6		<0.0002		1	Nickel		<0.001	0.002	21
DV001000			<0.005	<0.005	4			<0.0002	<0.0002	3		0.001	0.001	0.002	4
DV000000			<0.005	<0.005	9		NA					0.001	0.001	0.002	9
KB004207			<0.005	<0.005	12		NA					0.001	0.001	0.002	12
KB001638	Arsenic	0.002	0.001	0.003	21	Copper	0.002	0.002	0.026	21	Selenium	<0.001	<0.001	0.002	21
DV001000		0.002	0.002	0.003	4		0.003	0.001	0.004	4			<0.001	<0.001	4
DV000000		0.002	0.002	0.003	9		0.003	0.002	0.004	9			<0.001	<0.001	9
KB004207		0.002	0.002	0.003	12		0.004	0.002	0.099	12		<0.001	<0.001	0.001	12
KB001638	Barium	<0.05	<0.05	0.042	21	Fluoride	<0.1	<0.1	0.1	20	Silver		<0.001	<0.001	21
DV001000		0.063	0.056	0.064	4			0.1	0.1	4			<0.001	<0.001	4
DV000000		0.067	0.064	0.078	9			0.1	0.1	8			<0.001	<0.001	9
KB004207		<0.05	<0.05	0.075	12		<0.1	<0.1	0.1	12			<0.001	<0.001	12
KB001638	Beryllium		<0.001	<0.001	21	Iron	0.007	<0.005	0.030	21	Zinc	<0.005	<0.005	0.027	21
DV001000			<0.001	<0.001	4			<0.005	<0.005	4			<0.005	<0.005	4
DV000000			<0.001	<0.001	9			<0.005	<0.005	9		0.039	0.021	0.092	9
KB004207			<0.001	<0.001	12		<0.005	<0.005	0.023	12		0.007	<0.005	0.014	12
KB001638	Boron	0.1	<0.1	0.3	21	Lead		<0.001	<0.001	21					
DV001000		0.2	0.15	0.2	4			<0.001	<0.001	4					
DV000000		0.2	0.1	0.2	9			<0.001	<0.001	9					
KB004207		0.2	<0.1	0.2	12			<0.001	<0.001	12					
KB001638	Cadmium		<0.001	<0.001	21	Manganese	<0.005	<0.01	0.088	21					
DV001000			<0.001	<0.001	4		NA								
DV000000			<0.001	<0.001	9			<0.01	<0.01	9					
KB004207			<0.001	<0.001	12		0.01	<0.01	0.008	12					

Table 5-4. Summary of nutrients in the South Bay Aqueduct, 2000 and 2001

Station Name	Station Number	Parameter	Units	Median	Low	High	Sample Size
Check 7	KB001638	Ammonia	mg/L as N	0.02	<0.01	0.15	21
Lake Del Valle	DV001000			<0.01	<0.01	0.08	17
Del Valle Outlet	DV000000			<0.01	<0.01	0.03	9
Check 7	KB001638	Nitrate + Nitrite	mg/L as N	0.52	0.14	1.3	21
Lake Del Valle	DV001000			<0.01	<0.01	0.27	18
Del Valle Outlet	DV000000			0.15	0.03	0.895	9
Check 7	KB001638	Ortho-Phosphate	mg/L as P	0.07	0.0167	0.1	21
Lake Del Valle	DV001000			NA			
Del Valle Outlet	DV000000			<0.01	<0.01	0.02	9
Check 7	KB001638	Total Kjeldahl Nitrogen	mg/L as N	0.5	0.4	1.6	21
Lake Del Valle	DV001000			0.4	0.3	0.9	18
Del Valle Outlet	DV000000			0.3	0.3	0.7	9
Check 7	KB001638	Total Phosphorus	mg/L	0.11	0.0433	0.3	21
Lake Del Valle	DV001000			0.2	<0.01	0.36	18
Del Valle Outlet	DV000000			0.01	<0.01	0.03	9

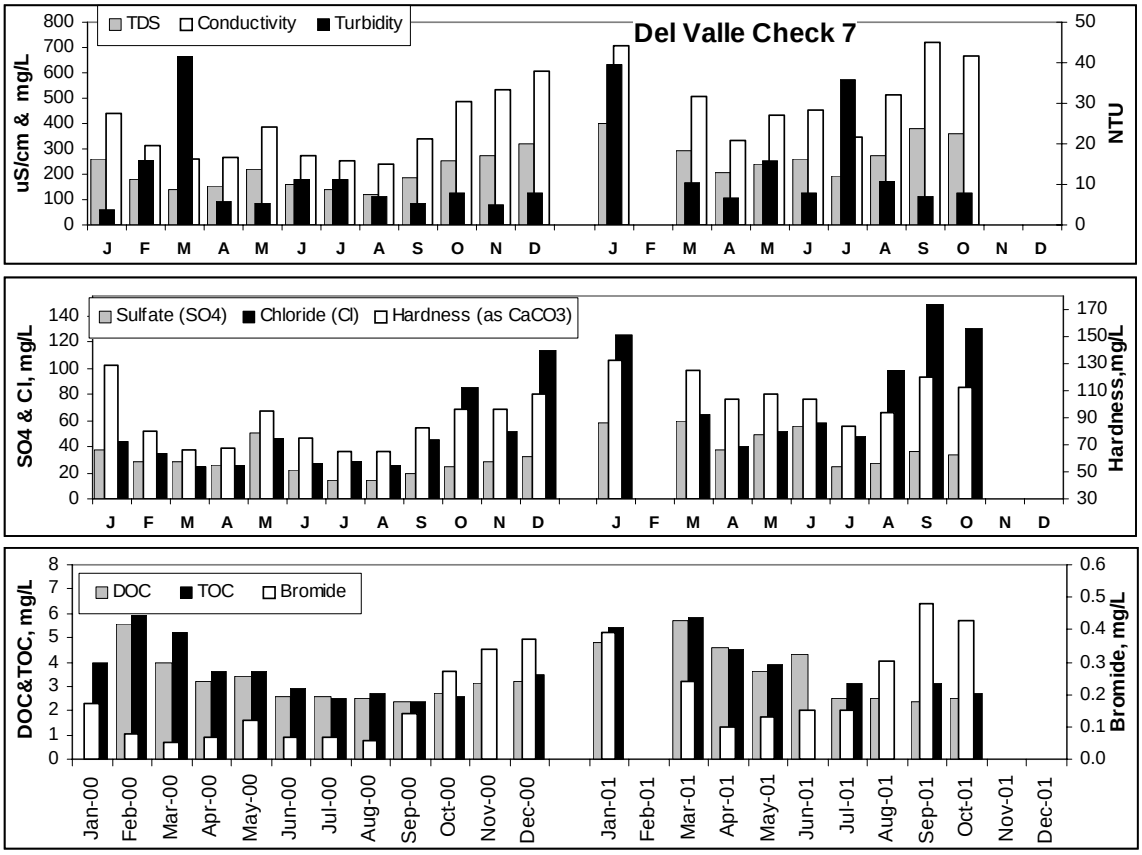

Figure 5-1. Monthly water quality in the South Bay Aqueduct at Del Valle Check 7

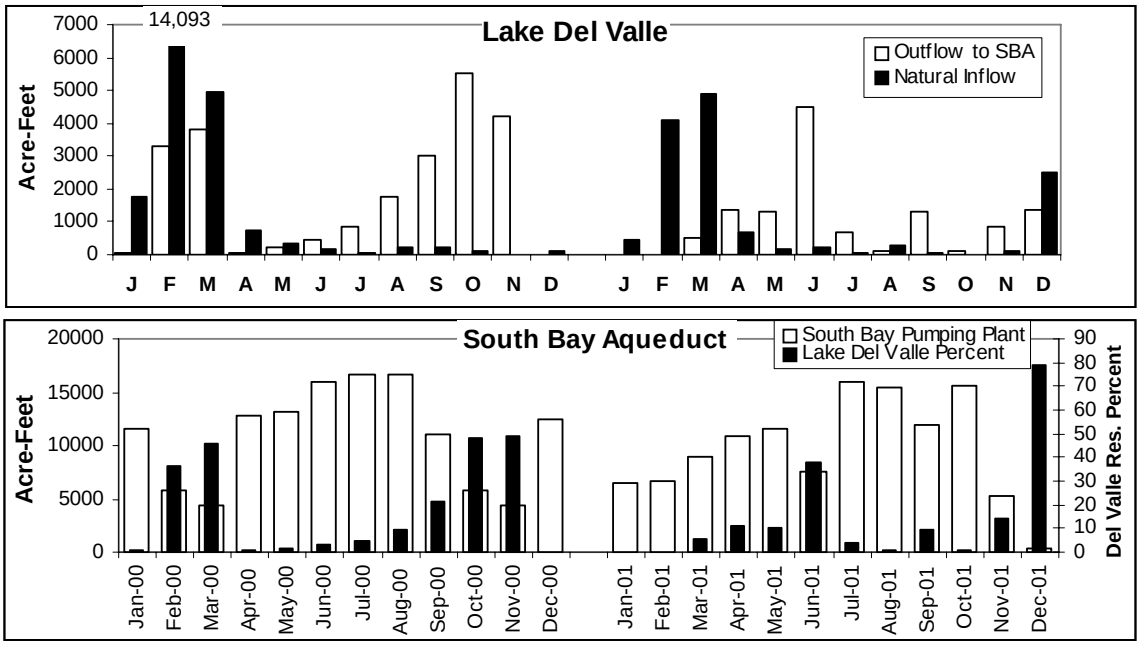

Figure 5-2. Local inflow to Lake Del Valle, outflow from Lake Del Valle to the South Bay Aqueduct, and the percent volume of Lake Del Valle releases compared to the total (South Bay Aqueduct Pumping + Lake Del Valle releases)

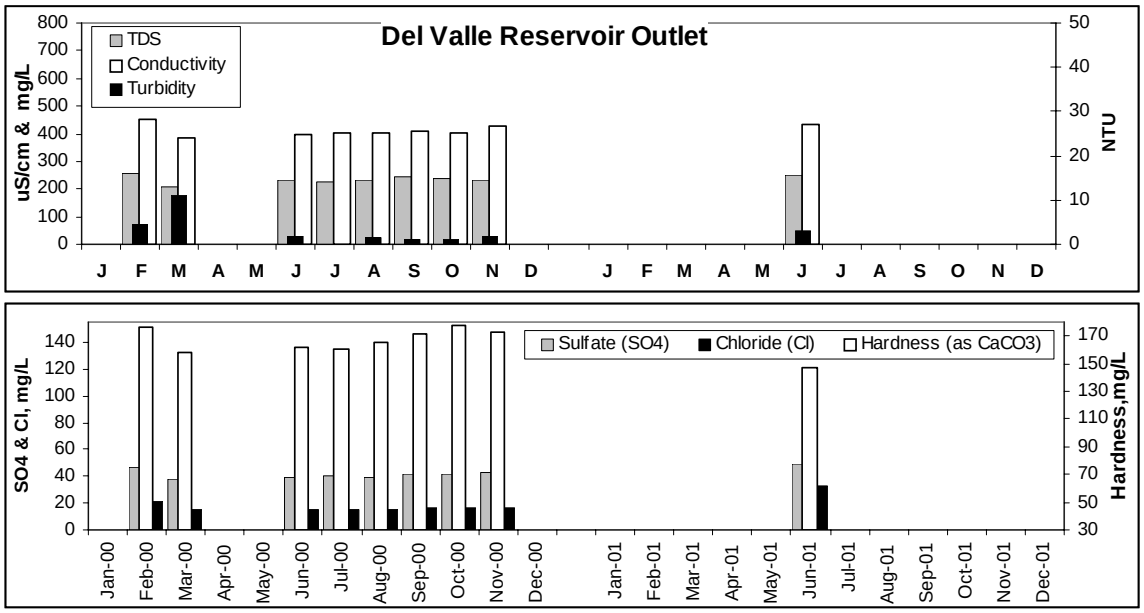

Figure 5-3. Monthly water quality in major releases from Del Valle Reservoir to the South Bay Aqueduct

VI. North Bay Aqueduct

Water quality in the North Bay Aqueduct at Barker Slough Pumping Plant is summarized in Table 6-1. MCLs for salinity, chloride, sulfate, nitrate, minor elements, and nutrients in treated drinking water were not exceeded. Monthly average turbidity was seasonally highest during both winter and summer (Figure 6-1). Major minerals increased through the spring months. Monthly average organic carbon was highest in March of both 2000 and 2001.

During 2000, TOC at Barker Slough Pumping Plant was above the wet season average (December-April) of 9 mg/L for 4 consecutive months during January through April. The following year, TOC exceeded the wet season average during 2 months (February and March 2001). Annual average TOC for both years was around 6 mg/L, roughly midway in the range of annual averages at Barker Slough Pumping Plant over the last 13 years (range = 4.5 to 9.5 mg/L).

Table 6-1. Summary of water quality in the North Bay Aqueduct at Barker Slough Pumping Plant, 2000 and 2001

Parameter	Units	Median	Low	High	Sample Size	Parameter	Units	Median	Low	High	Sample Size
Major Minerals						**Minor Elements (Con't)**					
Alkalinity	mg/L as CaCO3	91	40	145	24	Barium	mg/L	<0.05	<0.05	0.062	24
Calcium	mg/L	15	6	25	24	Beryllium	mg/L		<0.001	<0.001	24
Chloride	mg/L	18	4	90	24	Boron	mg/L	0.12	<0.1	0.3	24
Magnesium	mg/L	12	4	22	24	Cadmium	mg/L		<0.001	<0.001	24
Nitrate	mg/L as N03	1.2	<0.1	2.0	24	Chromium +3	mg/L	0.007	<0.001	0.015	24
Sodium	mg/L	22	9	67	24	Chromium +6	mg/L		<0.0002	<0.0002	8
Sulfate	mg/L	21	4	54	24	Copper	mg/L	0.003	0.002	0.005	24
Conventional Parameters						Fluoride	mg/L	0.1	<0.1	0.2	23
Conductivity	micro S/cm	268	104	573	24	Iron	mg/L	0.0025	<0.005	0.127	24
Hardness	mg/L as CaCO3	89	31	151	24	Lead	mg/L		<0.001	<0.001	24
pH	pH units	7.5	7.4	8.0	11	Manganese	mg/L	0.01	<0.01	0.128	24
TDS	mg/L	162	68	296	24	Mercury	mg/L		<0.0002	<0.0002	24
TSS	mg/L	34	7	64	23	Nickel	mg/L	0.002	0.001	0.005	24
Turbidity	NTU	36.4	6.8	148	50	Selenium	mg/L	<0.001	<0.001	0.001	24
VSS	mg/L	4	1	9	23	Silver	mg/L		<0.001	<0.001	24
Disinfection By-Product Precursors						Zinc	mg/L		<0.005	<0.005	24
Bromide	mgL	0.04	<0.01	0.27	24						
DOC	mg/L as C	3.6	2.4	14.3	41	**Nutrients**					
TOC	mg/L as C	5	2.4	17.9	45	Ammonia	mg/L as N	0.02	0.02	0.06	23
UVA 254	Absorbance/cm	0.1	0.066	1.032	39	Nitrate + Nitrite	mg/L as N	0.3	0.03	0.5	23
Minor Elements						Ortho-Phosphate	mg/L as P	0.08	0.06	0.12	23
Aluminum	mg/L	<0.01	<0.01	0.044	24	Total Kjeldahl Nitrogen	mg/L as N	0.6	0.2	1.1	23
Antimony	mg/L		<0.005	<0.005	24	Total Phosphorus	mg/L	0.17	0.05	0.28	23
Arsenic	mg/L	0.003	0.001	0.005	24						

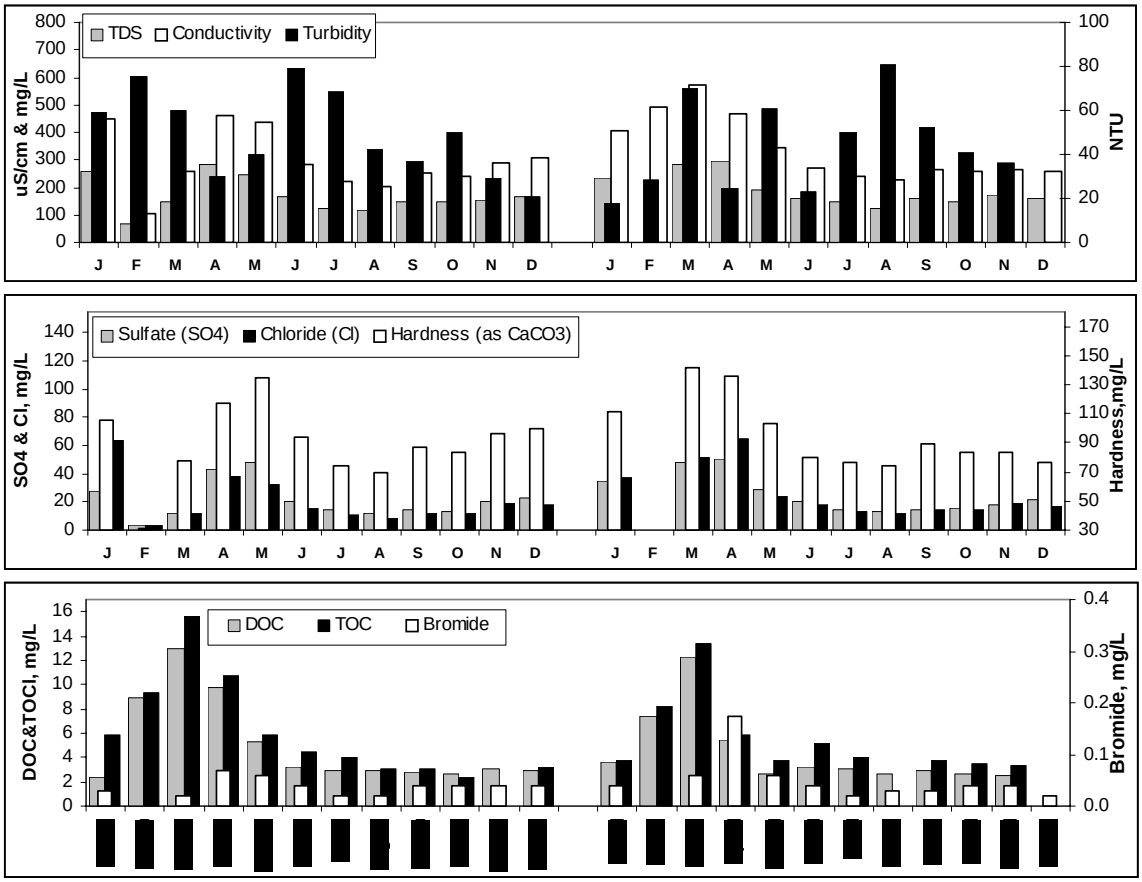

Figure 6-1. Monthly average water quality in the North Bay Aqueduct at Barker Slough Pumping Plant

VII. State Water Project Stations in the Feather River Watershed

Water quality at SWP stations in the Feather River watershed during 2000 and 2001 is summarized in Tables 7-1 to 7-4. Water quality at all stations was characteristically excellent with low to less-than detectable levels of minerals, minor elements, nutrients, and precursors of disinfection by-products. MCLs for salinity, chloride, sulfate, nitrate, minor elements, and nutrients in treated drinking water were not exceeded.

A special study was conducted to measure MtBE (methyl *tertiary*-butyl ether) in Lake Oroville after major summer holidays when levels were expected to be highest (DWR 2002a). MtBE in samples collected just below the surface ranged as high as 6.9 mg/L, above the secondary MCL of 5 mg/L. MtBE was not detected above the reporting limit of <1 mg/L in all samples collected below the thermoline.

Table 7-1. Summary of major minerals and conventional parameters at SWP stations in the Feather River watershed, 2000 and 2001

Station Name	Station Number	Major Minerals	Units	Median	Low	High	Sample Size	Conventional Parameters	Units	Median	Low	High	Sample Size
Antelope Lake	AN001000	Alkalinity	mg/L as CaCO3		38	44	2	Conductivity	micro S/cm		37	88	2
Lake Davis	LD001000				44	49	2				81	95	2
Thermalito Forebay	TF001000			42	36	52	6			90	75	106	6
Thermalito Afterbay	TA001000			40	36	50	22			87	76	103	22
Lake Oroville	OR001000			47	41	50	4			97	92	110	4
Antelope Lake	AN001000	Calcium	mg/L		8	8	2	Hardness	mg/L as CaCO3		28	32	2
Lake Davis	LD001000				9	9	2				35	37	2
Thermalito Forebay	TF001000			8	8	10	6			38	32	45	6
Thermalito Afterbay	TA001000			8	7	10	22			36	30	45	22
Lake Oroville	OR001000			10	8	10	3			39	34	45	3
Antelope Lake	AN001000	Chloride	mg/L	<1			1	pH	pH units	7.1			1
Lake Davis	LD001000				<1	<1	2			7.1			1
Thermalito Forebay	TF001000			1	<1	1	5				6.8	7.2	2
Thermalito Afterbay	TA001000			1	<1	1	22			6.9	6.7	7.8	10
Lake Oroville	OR001000			1	<1	1	4			7.0	6.8	7.3	3
Antelope Lake	AN001000	Magnesium	mg/L		2	3	2	TDS	mg/L		51	63	2
Lake Davis	LD001000				3	4	2				58	66	2
Thermalito Forebay	TF001000			4	3	5	6			59	46	88	6
Thermalito Afterbay	TA001000			4	3	5	22			57	48	82	22
Lake Oroville	OR001000			4	4	5	4			63	56	70	4
Antelope Lake	AN001000	Nitrate	mg/L as N03		<0.1	<0.1	2	TSS	mg/L	NA			
Lake Davis	LD001000				<0.1	<0.1	2			NA			
Thermalito Forebay	TF001000			0.1	<0.1	0.2	6			<1	<1	2	6
Thermalito Afterbay	TA001000				<0.1	<0.1	22			4	1	8	28
Lake Oroville	OR001000			<0.1	<0.1	0.1	4			NA			
Antelope Lake	AN001000	Sodium	mg/L		4.0	5.0	2	Turbidity	NTU	NA			
Lake Davis	LD001000				4.5	4.7	2			NA			
Thermalito Forebay	TF001000			4.0	3.0	4.4	6			1	<1	3	6
Thermalito Afterbay	TA001000			4.0	3.0	4.4	22			3	1	10	22
Lake Oroville	OR001000			4.0	3.0	4.6	4			2	<1	5	4
Antelope Lake	AN001000	Sulfate	mg/L		<1	<1	2	VSS	mg/L	NA			
Lake Davis	LD001000				<1	0.3	2			NA			
Thermalito Forebay	TF001000				<1	<1	4				<1	<1	6
Thermalito Afterbay	TA001000			2.0	<1	2.0	22			<1	<1	2	7
Lake Oroville	OR001000				2.0	2.0	4			NA			

Table 7-2. Summary of disinfection by-product precursors at SWP stations in the Feather River watershed, 2000 and 2001

Station Name	Station Number	Parameter	Units	Median	Low	High	Sample Size
Antelope Lake	AN001000	Bromide	mg/L	<0.01			1
Lake Davis	LD001000				<0.01	<0.01	2
Thermalito Forebay	TF001000				<0.01	<0.01	4
Thermalito Afterbay	TA001000				<0.01	<0.01	14
Lake Oroville	OR001000				<0.01	<0.01	4
Antelope Lake	AN001000	TOC	mg/L as C	NA			
Lake Davis	LD001000			NA			
Thermalito Forebay	TF001000			NA			
Thermalito Afterbay	TA001000			NA			
Lake Oroville	OR001000			1.75	1.1	1.8	4

Table 7-3. Summary of minor elements at SWP stations in the Feather River watershed, 2000 and 2001 (mg/L)

Station Name	Station Number	Minor Element	Median	Low	High	Sample Size	Minor Element	Median	Low	High	Sample Size	Minor Element	Median	Low	High	Sample Size
Antelope Lake	AN001000	Aluminum	<0.01			1	Chromium +3		<0.001	0.002	2	Mercury	<0.0002			1
Lake Davis	LD001000		<0.01			1			<0.001	0.002	2		<0.0002			1
Thermalito Forebay	TF001000			<0.01	<0.01	5		<0.001	<0.001	0.002	6			<0.0002	<0.0002	4
Thermalito Afterbay	TA001000		<0.01	<0.01	0.013	18		<0.001	<0.001	0.003	22			<0.0002	<0.0002	16
Lake Oroville	OR001000			<0.01	<0.01	4		0.002	<0.001	0.003	4			<0.0002	<0.0002	4
Antelope Lake	AN001000	Antimony		<0.005	<0.005	2	Chromium +6	NA				Nickel		<0.001	<0.001	2
Lake Davis	LD001000			<0.005	<0.005	2		NA						<0.001	<0.001	2
Thermalito Forebay	TF001000			<0.005	<0.005	2		NA						<0.001	0.001	2
Thermalito Afterbay	TA001000			<0.005	<0.005	12			<0.001	<0.001	8		<0.001	<0.001	0.001	13
Lake Oroville	OR001000			<0.005	<0.005	4			<0.001	<0.001	9			<0.001	<0.001	8
Antelope Lake	AN001000	Arsenic		<0.001	<0.001	2	Copper		<0.001	0.001	2	Selenium		<0.001	<0.001	2
Lake Davis	LD001000			<0.001	<0.001	2			<0.001	0.001	2			<0.001	<0.001	2
Thermalito Forebay	TF001000		<0.001	<0.001	0.001	5			<0.001	<0.001	6			<0.001	<0.001	3
Thermalito Afterbay	TA001000			<0.001	<0.001	21		<0.001	<0.001	0.002	22			<0.001	<0.001	8
Lake Oroville	OR001000			<0.001	<0.001	4		0.001	0.001	0.007	4			<0.001	<0.001	4
Antelope Lake	AN001000	Barium	<0.05			1	Fluoride		<0.1	<0.1	2	Silver	<0.001			1
Lake Davis	LD001000		<0.05			1			<0.1	<0.1	2		<0.001			1
Thermalito Forebay	TF001000			<0.05	<0.05	5			<0.1	<0.1	5			<0.001	<0.001	6
Thermalito Afterbay	TA001000			<0.05	<0.05	18			<0.1	<0.1	22			<0.001	<0.001	18
Lake Oroville	OR001000			<0.05	<0.05	4			<0.1	<0.1	4			<0.001	<0.001	4
Antelope Lake	AN001000	Beryllium		<0.001	<0.001	2	Iron		0.049	0.053	2	Zinc		<0.005	<0.005	2
Lake Davis	LD001000			<0.001	<0.001	2		0.025	0.009	0.061	9			<0.005	<0.005	2
Thermalito Forebay	TF001000			<0.001	<0.001	2		<0.005	<0.005	0.006	6			<0.005	<0.005	6
Thermalito Afterbay	TA001000			<0.001	<0.001	13		<0.005	<0.005	0.012	22		<0.005	<0.005	0.006	22
Lake Oroville	OR001000			<0.001	<0.001	4			<0.005	<0.005	4		0.009	<0.005	0.014	4
Antelope Lake	AN001000	Boron		<0.1	<0.1	2	Lead		<0.001	<0.001	2					
Lake Davis	LD001000			<0.1	<0.1	2			<0.001	<0.001	2					
Thermalito Forebay	TF001000			<0.1	<0.1	5		<0.001	<0.001	<0.001	6					
Thermalito Afterbay	TA001000			<0.1	<0.1	22		<0.001	<0.001	<0.001	22					
Lake Oroville	OR001000			<0.1	<0.1	4		<0.001	<0.001	0.009*	4					
Antelope Lake	AN001000	Cadmium	<0.001			1	Manganese		<0.005	<0.005	2					
Lake Davis	LD001000		<0.001			1		0.016	0.003	0.087	9					
Thermalito Forebay	TF001000			<0.001	<0.001	6			<0.005	<0.005	6					
Thermalito Afterbay	TA001000			<0.001	<0.001	18			<0.005	<0.005	22					
Lake Oroville	OR001000			<0.001	<0.001	4		<0.005	<0.005	0.003	4					

* Sample contamination suspected.

Figure 7-4. Summary of nutrients at SWP stations in the Feather River watershed, 2000 and 2001

Station Name	Station Number	Parameter	Units	Median	Low	High	Sample Size
Antelope Lake	AN001000	Ammonia	mg/L as N		0.02	0.02	2
Lake Davis	LD001000				0.007	0.007	2
Thermalito Afterbay	TA001000			<0.01	<0.01	0.02	22
Lake Oroville	OR001000			<0.01	<0.01	0.01	19
Antelope Lake	AN001000	Nitrite+Nitrate	mg/L as N		<0.01	<0.01	2
Lake Davis	LD001000				<0.01	<0.01	2
Thermalito Afterbay	TA001000			<0.01	<0.01	0.03	21
Lake Oroville	OR001000			<0.01	<0.01	0.02	19
Antelope Lake	AN001000	Ortho-Phosphate	mg/L as P	<0.01			1
Lake Davis	LD001000			<0.01			1
Thermalito Afterbay	TA001000				<0.01	<0.01	22
Lake Oroville	OR001000				<0.01	<0.01	19
Antelope Lake	AN001000	Total Kjeldahl Nitrogen	mg/L as N		0.30	0.40	2
Lake Davis	LD001000				0.37	0.43	2
Thermalito Afterbay	TA001000			0.2	<0.1	0.60	22
Lake Oroville	OR001000			0.2	<0.1	0.50	19
Antelope Lake	AN001000	Total Phosphorus	mg/L		<0.01	<0.01	2
Lake Davis	LD001000				<0.01	<0.01	2
Thermalito Afterbay	TA001000			<0.01	<0.01	0.03	21
Lake Oroville	OR001000			<0.01	<0.01	0.005	19

VIII. Organic Chemicals

Samples for organic chemicals are collected throughout the SWP in March, June, and September. Chemical method scans include carbamate pesticides, chlorinated organic pesticides, chlorinated phenoxy herbicides, sulfur pesticides, glyphosate, phosphorus/nitrogen pesticides, and purgeable organics. Specific chemicals analyzed within each method scan are listed in Appendix A, Table A-3.

The chemical scans performed and the compounds detected in the SWP during 2000 and 2001 are shown in Table 8-1. Diazinon, diuron, and simazine were detected in most samples collected in March 2001 from the California Aqueduct, the North Bay Aqueduct, and the CVP Delta-Mendota Canal. Diazinon is an insecticide while diuron and simazine are herbicides. The data indicate that all three compounds were present in waters from both the north and south Sacramento-San Joaquin Delta. The MCL of 0.004 mg/L for simazine in drinking water was not exceeded in any of the samples. MCLs for the other two pesticides do not exist. Tetrachloroethene, toluene, carbaryl, and trifluralin were each detected once or twice during the 2-year period. Toluene was below the MCL of 0.15 mg/L and tetrachloroethene (also termed tetrachloroethylene) was below the MCL of 0.005 mg/L. No MCLs exist for the other compounds.

Methyl *tertiary*-butyl ether (MtBE) was detected more than once at Devil Canyon Headworks, CVP DMC, and Lake Del Valle (Table 8-1). MtBE at all stations ranged from 0.5 to 7.1 μg/L, below the Primary MCL of 13 μg/L for MtBE in drinking water.

The secondary MCL of 5 μg/L for MtBE in drinking water was exceeded in the June and September 2001 samples from Devil Canyon Headworks (7.1 and 5.1 μg/L, respectively). Secondary MCLs address taste, odor, or appearance characteristics of treated drinking water. MtBE was also detected above the secondary MCL in Lake Oroville (see SWP Stations in the Feather River Watershed).

Table 8-1. Organic chemicals in the State Water Project, 2000 and 2001 (X=scans were performed)

Station	Year	Sample Dates	Carbamate Pesticides	Chlorinated Organic Pesticides	Chlorinated Phenoxy Acid Herbicides	DWR Sulfur Pesticides	Glyphosate	Phosphorus / Nitrogen Pesticides	Volatile Organics (Purgeable Organics)	Methyl Tert-butyl Ether (MtBE)	Compounds Detected (concentration)
Banks Pumping Plant	2000	15-Mar	X	X	X	X	X	X	X	X	Simazine (0.04 ug/L)
		21-Jun	X	X	X	X	X	X	X	X	Toluene (1 ug/L)
		20-Sep							X	X	MtBE (1.6 ug/L)
	2001	21-Mar	X	X	X	X	X	X	X	X	Diazinon (0.01 ug/L), Diuron (0.69 ug/L), Simazine (0.12 ug/L)
		19-Sep	X	X	X	X	X	X	X	X	Toluene (0.73 ug/L)
O'Neill Forebay Outlet	2000	15-Mar	X	X	X	X	X	X	X	X	Simazine (0.05 ug/L)
		21-Jun	X	X	X	X	X	X	X	X	
		20-Sep	X	X	X	X	X	X	X	X	
	2001	20-Mar	X	X	X	X	X	X	X	X	Diazinon (0.01 ug/L), Diuron (0.48ug/L), Simazine (0.14 ug/L)
		20-Jun	X	X	X	X	X	X	X	X	
		19-Sep	X	X	X	X	X	X	X	X	
Check 21	2000	14-Mar	X	X	X	X	X	X	X	X	Simazine (0.09 ug/L)
		20-Jun	X	X	X	X	X	X	X	X	
		20-Sep	X	X	X	X	X	X	X	X	
	2001	20-Mar	X	X	X	X	X	X	X	X	Diazinon (0.01 ug/L), Diuron (0.6 ug/L), Simazine (0.08 ug/L)
		19-Jun	X	X	X	X	X	X	X	X	
		18-Sep	X	X	X	X	X	X	X	X	
Check 29	2000	14-Mar	X	X	X	X	X	X	X	X	Diruon (0.73 ug/L), Simazine (0.05 ug/L), Carbaryl (3.5 ug/L)
		20-Jun	X	X	X	X	X	X	X	X	
		19-Sep	X	X	X	X	X	X	X	X	
	2001	20-Mar	X	X	X	X	X	X	X	X	Diazinon (0.03 ug/L), Diuron (0.94 ug/L), Trifluralin (0.08 ug/L)
		17-Sep	X	X	X	X	X	X	X	X	
Check 41	2000	15-Mar	X	X	X	X	X	X	X	X	Diuron (0.39 ug/L), Simazine (0.1 ug/L)
		21-Jun	X	X	X	X	X	X	X	X	
		20-Sep	X	X	X	X	X	X	X	X	
	2001	21-Mar	X	X	X	X	X	X	X	X	Diazinon (0.01 ug/L), Diuron (0.73 ug/L), Simazine (0.05 ug/L)
		20-Jun	X	X	X	X	X	X	X	X	
		19-Sep	X	X	X	X	X	X	X	X	
Devil Canyon Headworks	2001	20-Jun	X	X	X	X	X	X	X	X	MtBE (7.1 ug/L)
		19-Sep	X	X	X	X	X	X	X	X	MtBE (5.1 ug/L)
DMC06716	2000	15-Mar	X	X	X	X	X	X	X	X	Simazine (0.02 ug/L)
		21-Jun	X	X	X	X	X	X	X	X	MtBE (1.3 ug/L)
		20-Sep	X	X	X	X	X	X	X	X	MtBE (1.1 ug/L)
	2001	20-Mar	X	X	X	X	X	X	X	X	Diazinon (0.01 ug/L), Diuron (0.69 ug/L), Simazine (0.09 ug/L)
		20-Jun	X	X	X	X	X	X	X	X	MtBE (2.2 ug/L)
		19-Sep	X	X	X	X	X	X	X	X	MtBE (1.2 ug/L)
Lake Del Valle	2000	18-Dec	X		X		X		X	X	MtBE (0.52-1.6 ug/L)
	2001	20-Feb	X	X	X	X	X	X	X	X	MtBE (0.6-1.7 ug/L)
		14-May	X	X	X	X	X	X	X	X	
		13-Aug	X	X	X	X	X	X	X	X	
Barker Slough Pumping Plant	2000	15-Mar	X	X	X	X	X	X	X	X	Tetrachloroethene (1.98 ug/L), Simazine (0.04 ug/L)
		21-Jun	X	X	X	X	X	X	X	X	Toluene (2.4 ug/L)
	2001	21-Mar	X	X	X	X	X	X	X	X	Diazinon (0.01 ug/L), Diuron (0.28 ug/L), Simazine (0.02 ug/L)
		20-Jun	X	X	X	X	X	X	X	X	
		19-Sep	X	X	X	X	X	X	X	X	Toluene (1.1 ug/L)

IX. Special Studies

Water Composition at Banks Pumping Plant

Water quality at Banks Pumping Plant was assessed to determine trends in export composition with respect to major sources of salt. Three of the larger sources of salt in exports from the south Sacramento-San Joaquin Delta are the Sacramento and San Joaquin Rivers and seawater intrusion from the San Francisco Bay (DWR 2004b). Each source can exhibit a distinct geochemistry identified through mineral analysis. Geochemical differences as well as Project operations and Delta hydrology were used to define the relative influence of each on salt levels at Banks Pumping Plant.

Seawater Intrusion

Conductivity and bromide were often highest at Banks Pumping Plant during late summer and fall of both 2000 and 2001, coinciding with some of the highest levels of chloride relative to sulfate (Figures 9-1A and B). The chloride/sulfate ratio was used as an indicator of seawater intrusion from the San Francisco Bay. This ratio is 7 in seawater, while in the San Joaquin and Sacramento Rivers; it is usually between 0.5 and 1.5. Figure 9-1B shows this range as the 99 percent confidence interval of chloride to sulfate in the San Joaquin River. A chloride/sulfate ratio higher than around 1.5 infers at least some seawater intrusion from San Francisco Bay or influence from waters with seawater-like characteristics (e.g., certain Delta island drainage).

The geochemical evidence of seawater intrusion during 2000 and 2001 was supported with Delta hydrology and operations data. Figure 9-1C shows the ratio of total Delta freshwater inflow to total exports from the south Delta (State and federal). Some of the lowest inflow/export ratios coincided with the highest chloride/sulfate ratios. Conversely, some of the highest inflow/export ratios were observed during February-May of both years when the chloride/sulfate ratio at Banks Pumping Plant was below 1.5. When freshwater inflow to the Delta was low relative to south Delta exports, water at Banks Pumping Plant exhibited influence from seawater intrusion.

The inverse correlation between these two ratios (change in chloride/sulfate with inflow/export) was exponential with a modest r-squared value of 0.71. Other factors such as pumping curtailments, Clifton Court Forebay operations, and south Delta temporary barrier placement may affect this correlation. The chloride/sulfate ratios were usually derived from one monthly sample while the inflow/export ratios were monthly averages. Because inflow and export conditions can change within a period of a month, one water quality sample is not expected to represent Delta conditions for the entire month.

The occurrence of seawater intrusion was also supported with QWEST values. QWEST is an estimate of San Joaquin River flow at Jersey Point in the west Delta. Negative values indicate that water is moving into the Delta, possibly along with commingled seawater. Negative monthly QWEST values usually coincided with elevated chloride/sulfate ratios (Figure 9-1D); supporting the contention that Delta seawater intrusion occurred and affected water quality at Banks Pumping Plant.

Based on this, at least some seawater intrusion was observed in more than half of the samples collected monthly at Banks Pumping Plant during 2000 and 2001. The chloride/sulfate ratio exceeded 1.5 in 14 of 23 samples collected during this period.

Major Sources of Salt

Major sources of salt in samples from Banks Pumping Plant were quantified with ternary diagrams. Anionic data from Banks Pumping Plant, seawater, and the Sacramento and San Joaquin Rivers were plotted in ternary diagrams. Data from the freshwater stations came from samples collected during the same month (not necessarily the same day). River data was obtained from the web sites of USGS and the Central Valley Regional Water Quality Control Board. Anion concentrations in seawater were from Hem 1985. This method of analysis did not account for other sources of salt (e.g., in-Delta agricultural drainage).

Sacramento River: The chloride/sulfate ratio at Banks Pumping Plant in August 2000 was just outside of the upper 99 percent confidence interval for this ratio in the San Joaquin River, inferring a slight degree of seawater intrusion (Figure 9-1B).

The anionic mineralogy of the August 2000 sample from Banks Pumping Plant is represented in a ternary diagram as an open square with a round icon in it (Figure 9-2). The round icon represents a calculated mixture of the two river sources for that month along with seawater. Anion concentrations for all three sources were adjusted to place the round icon in the center of the open square, representing the anionic content at Banks Pumping Plant. The calculated mixture was estimated to be volumetrically composed of 0.07 percent seawater, 10.2 percent San Joaquin River water, and the rest from the Sacramento River (Figure 9-2). In this mixture, the Sacramento River was the largest volumetric component of the August 2000 sample (89.7 percent), followed by the San Joaquin River and seawater. These percentages are considered maximums since this method does not account for other sources such as Delta island drainage and east-side tributaries.

Volumetric composition (volume or L) is distinguished from gravimetric composition (weight or mg) which is an actual measure of salt. A curvilinear relationship exits between these two values in dilutions of Sacramento River water with that from the San Joaquin River and seawater (Figure 9-3). Because of the large salinity differential between these waters, the two percentages can be disparate. For instance, in the 20 percent dilution (volumetric) of the San Joaquin River with the Sacramento River, the San Joaquin River contributed 61 percent of the gravimetric salt content. The San Joaquin River contributed a majority of the salt while composing only a fifth of the volume.

A breakdown of the gravimetric salt content in the August 2000 sample from Banks Pumping Plant is shown in Table 9.1. Although seawater made up an estimated 0.07 percent of the volumetric composition, it contributed 13.7 percent of the gravimetric salt content in the sample. The gravimetric contribution from the San Joaquin and Sacramento rivers was estimated at 24.9 and 61.3 percent, respectively.

To test the accuracy of the preceding analysis, volumetric percentages were used to estimate conductivity at Banks Pumping Plant in the August 2000 sample. Conductivity

measurements from the Sacramento and San Joaquin Rivers that month were multiplied by the volumetric percentages derived from the ternary diagram analysis (Table 9-1). A conductivity of 50,000 μS/cm was used for seawater (from Hem 1985). From this, the estimated conductivity at Banks Pumping Plant in the August 2000 sample was 259 μS/cm. The actual conductivity in that sample was 236 μS/cm (Table 9-1). Results from the ternary diagram analysis produced an estimated conductivity that was 9.7 percent higher than the actual measurement at Banks Pumping Plant (shown as +9.7 in Table 9-1).

Several factors can affect this technique of estimating composition and conductivity at Banks Pumping Plant. One potentially significant one is mixing in the central Delta. The south Delta temporary barriers were in place on both Grant Line Canal and south Old River when the August 2000 sample was collected at Banks Pumping Plant (Figure 9-4A). When these barriers are in place, water from the San Joaquin River is restricted from directly approaching the Clifton Court Forebay intake gates via south Old River and Grant Line Canal (DWR 2004b). The San Joaquin River can still influence State exports by flowing into the central Delta before moving south to Banks Pumping Plant via West Canal.

As San Joaquin River flow slows down in the central Delta, it mixes with other inputs such as Delta island drainage and river inflows. This mixture then becomes a component of cross-Delta flow approaching the export sites from the north via West Canal. Therefore, one sample from the San Joaquin River, upstream of the Delta, may not be representative of the water quality in this river as it makes its way through the Delta. Estimating composition at Banks Pumping Plant using the above method is not expected to be strongly accurate when certain south Delta barriers are in place.

Seawater: One of the highest chloride/sulfate ratios at Banks Pumping Plant was measured in November 2000 (Figure 9-1B). Water at Banks Pumping Plant that month exhibited greater influence from seawater than the August 2000 sample (Figure 9-5). Using a ternary diagram, the volumetric percentage of seawater in the November 2000 sample was estimated to be 0.555 percent, with the Sacramento and San Joaquin rivers making up 85.8 and 13.6 percent, respectively (Table 9-1). A similar composition was exhibited in the September 2001 sample when monthly conductivity and bromide at Banks Pumping Plant reached their highest levels during the 2-year period.

Although the Sacramento River made up a majority of the volumetric composition in the November 2000 sample from Banks Pumping Plant, seawater contributed a majority of the gravimetric salt content. Seawater contributed an estimated 55 percent of the salt content, followed by the Sacramento and San Joaquin Rivers with 27.5 and 17.5 percent, respectively (the similarity between the volumetric and gravimetric percentages of seawater was coincidental). The estimated conductivity from this analysis was 504 μS/cm, 14.6 percent lower than the actual measurement of 590 μS/cm at Banks Pumping Plant (Table 9-1). The South Delta barriers on Grant Line Canal and south Old River were in place when the November 2000 sample was collected and, as previously discussed, may be a cause of increased error for this type of analysis.

San Joaquin River: The second highest conductivity during the 2-year period was measured in January 2001 (Figure 9-1A). However, the chloride/sulfate ratio in that sample

was lower than other months with elevated salinity. This infers another major source of salt along with seawater.

Analysis with a ternary diagram shows the January 2001 sample from Banks Pumping Plant was more influenced by the San Joaquin River than the previous samples (Figure 9-6). The estimated volumetric composition at Banks Pumping Plant was 58.9 percent Sacramento River water, 40.6 percent San Joaquin River water, and 0.49 percent seawater (Table 9-1). The Sacramento River was estimated to compose the largest volumetric portion of the sample (58.9 percent) but not the largest gravimetric amount. The San Joaquin River contributed 47 percent of the gravimetric salt content followed by seawater and the Sacramento River with 35.8 and 17.1 percent, respectively. In this sample, the San Joaquin River was estimated to be the largest source of salt followed by seawater.

The volumetric percentages for the January 2001 sample produced an estimated conductivity of 689 μS/cm. The actual conductivity at Banks Pumping Plant that month was 685 μS/cm; a 0.6 percent difference (Table 9-1). None of the south Delta barriers (in Figure 9-4A) were in place during January 2001, allowing the San Joaquin River to flow directly to the export sites via south Old River and Grant Line Canal. In this example, the San Joaquin River sample verifies that river's influence at Banks Pumping Plant (see earlier discussion) and greater accuracy was achieved in estimating conductivity at Banks Pumping Plant using ternary diagram analysis.

High Flow in the San Joaquin River

Another event that had a major influence on composition at Banks Pumping Plant was high flow in the San Joaquin River. When flow in that river exceeds about 7,400 cfs, much of the water at the Clifton Court Forebay gates is from the San Joaquin River flowing directly to the export site via south Old River and Grant Line Canal (DWR 2004b). Flow in the San Joaquin River exceeded 7,400 cfs in February-March 2000 (Figure 9-4B). During that period, salinity trends at Banks Pumping Plant mimicked those of the San Joaquin River.

On February 16, 2000, flow in the San Joaquin River exceeded 7,400 cfs (Figure 9-7A). Several days later, conductivity in the San Joaquin River, at Banks Pumping Plant, and at the Clifton Court Forebay gates converged (Figure 9-7B). Conductivity at all three stations was nearly identical for a period of more than 40 consecutive days and ranged between 200 and 400 μS/cm. Pumping at Banks Pumping Plant during this period was relatively high, yielding a residence time in Clifton Court Forebay of 3 days or less (Figures 9-8A and B). As a result of the relatively brief residence time, water quality conditions at the Clifton Court Forebay gates were quickly conveyed to Banks Pumping Plant.

About 5 days after flow in the San Joaquin River dropped below 7,400 cfs, conductivity in that river increased relative to levels at the Clifton Court Forebay gates and Banks Pumping Plant, indicating more influence from cross-Delta flow with lower salinity at the export sites (Figure 9-7B). From this analysis, exports at Banks Pumping Plant were largely composed of water from the San Joaquin River during mid-February through March 2000.

Effects of Reduced Pumping at Banks Pumping Plant

During periods of reduced pumping at Banks Pumping Plant, water quality there can exhibit the characteristics of a mixture of water admitted to Clifton Court Forebay over a period of weeks instead of days (DWR 2004b). Lower pumping rates result in longer residence times through Clifton Court Forebay. Small volumes of water admitted to the forebay on a daily basis mix with water already present from earlier admissions. As a result, water quality at Banks Pumping Plant can represent a composite of south Delta water over a period of time that is dependent on pumping rate. Water quality changes in the south Delta during periods of reduced pumping will not be immediately reflected at Banks Pumping Plant. Further, quickly changing water quality conditions in the south Delta will be moderated at Banks Pumping Plant to the extent that pumping is reduced.

Exports were limited in May of both years due, in part, to restrictions in the Vernalis Adaptive Management Plan (VAMP), increasing residence time through Clifton Court Forebay (Figure 9-8B). Samples collected at Banks Pumping Plant during those 2 months probably reflect a running composite of water quality conditions in the south Delta over a period of a week or more. The same reasoning applies to much of October 2001, when exports at Banks Pumping Plant were reduced to maintain the Contra Costa Canal chloride standard.

In early June 2001, exports at Banks Pumping Plant were halted or severely curtailed for the rest of the month due to a leak in the California Aqueduct at Milepost 4.2 (Figure 9-8A). Water quality at Banks Pumping Plant during the later part of the month largely represents conditions in the south Delta when water was admitted to Clifton Court Forebay during the first few days of the month.

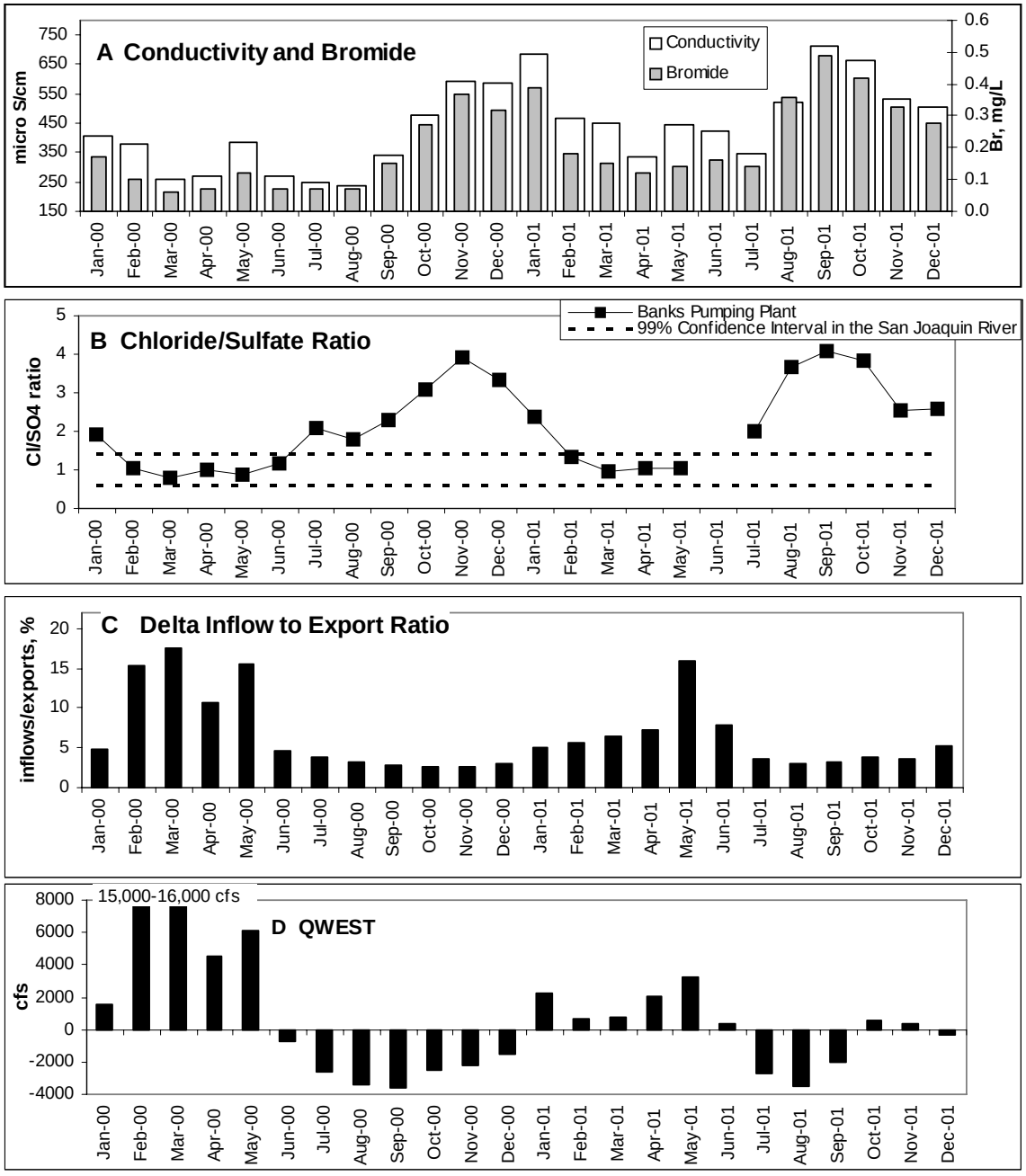

Figure 9-1. Monthly conductivity and bromide at Banks Pumping Plant (A), chloride/sulfate ratios at Banks Pumping Plant and in the San Joaquin River (B), Delta inflow to export ratio (C), and QWEST (D)

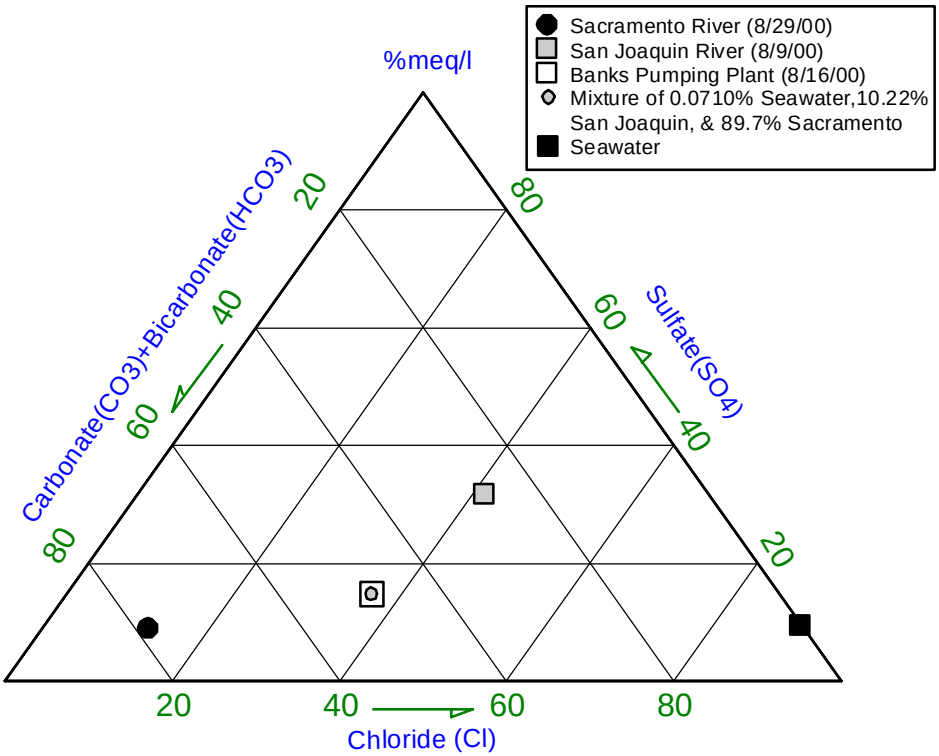

Figure 9-2. Ternary diagram of anions in the Sacramento and San Joaquin Rivers and seawater. Also shown is a mixture calculated from these sources to match the anionic content in the 8/16/00 sample from Banks Pumping Plant (Explanation of a ternary diagram is presented in Appendix D)

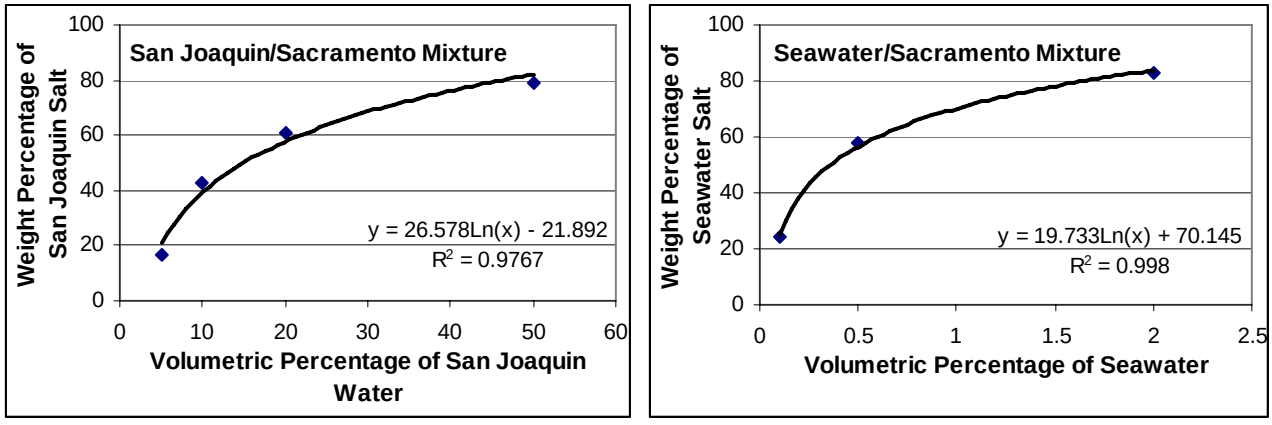

Figure 9-3. The relationship between volumetric and gravimetric composition. Several dilutions were made with waters from the Sacramento and San Joaquin Rivers and from the Sacramento River and seawater. The resulting dilutions show a curvilinear relationship between volumetric (percent by volume) and gravimetric (percent by weight of salt) percentages.

Table 9-1. Estimates of composition and conductivity in three different samples from Banks Pumping Plant

		Conductivity	% Contribution		Conductivity at Banks Pumping Plant		
Month-Year	Source Water	micro S/cm	Volumetric	Gravimetric	Estimated	Measured	% Difference
August-00	Seawater	50000	0.071	13.7	36		
	San Joaquin River	632	10.2	24.9	65		
	Sacramento River	177	89.7	61.3	159		
			100	100	259	236	+9.7
November-00	Seawater	50000	0.555	55.1	278		
	San Joaquin River	643	13.6	17.4	88		
	Sacramento River	161.5	85.8	27.5	139		
			100	100	504	590	-14.6
January-01	Seawater	50000	0.494	35.8	247		
	San Joaquin River	799	40.6	47.1	325		
	Sacramento River	200	58.9	17.1	118		
			100	100	689	685	+0.6

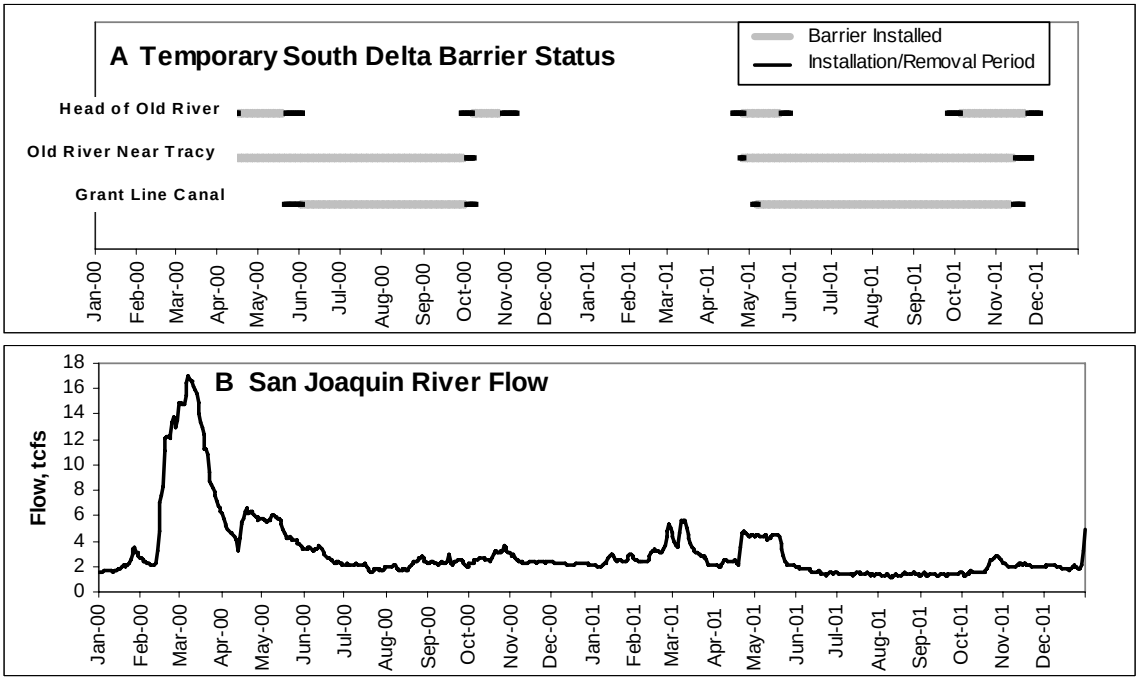

Figure 9-4. Status of certain south Delta Temporary Barriers (A) and San Joaquin River flow (B)

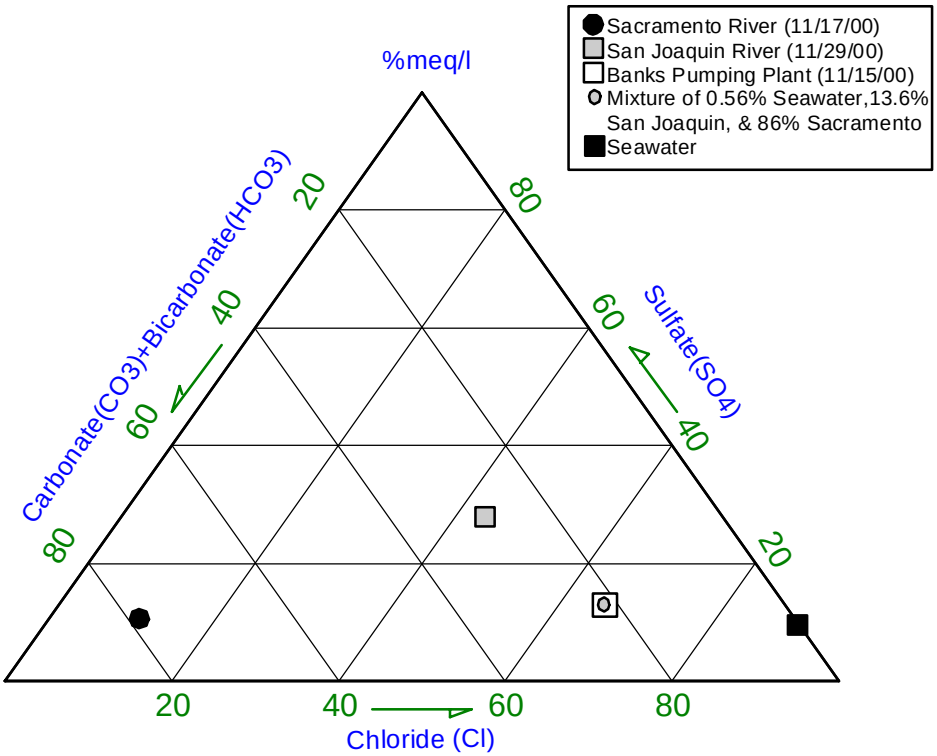

Figure 9-5. Ternary diagram of anions in the Sacramento and San Joaquin Rivers during November 2000 and seawater. Also shown is a mixture calculated from these sources to match the anionic content in the 11/15/00 sample from Banks Pumping Plant.

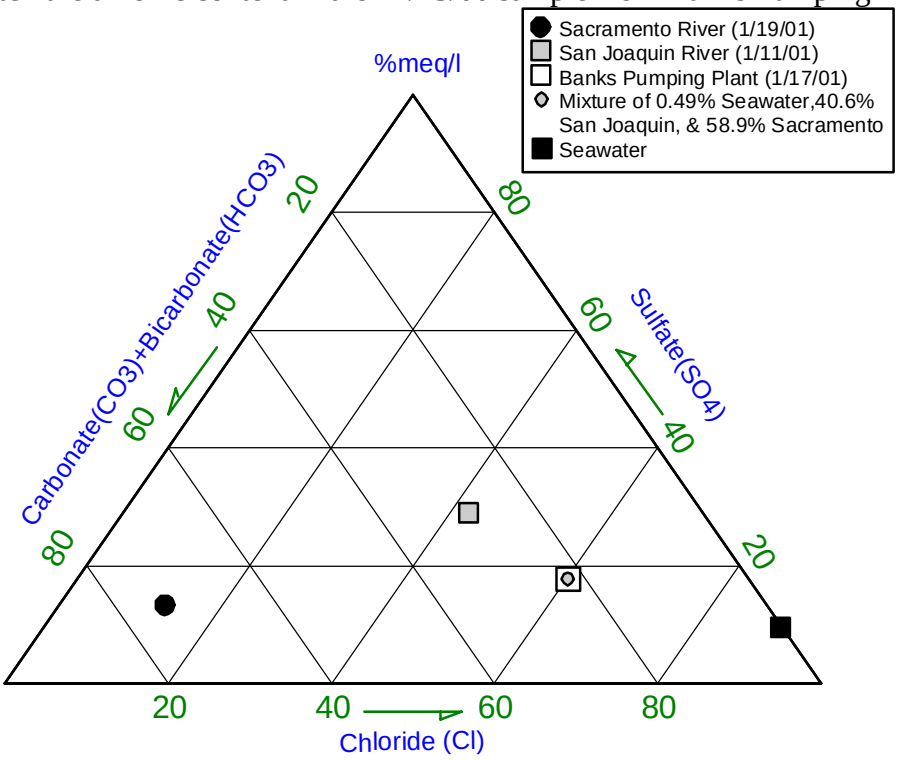

Figure 9.6. Ternary diagram of anions in the Sacramento and San Joaquin Rivers during January 2001 and seawater. Also shown is a mixture calculated from these sources to match the anionic content in the 1/17/01 sample from Banks Pumping Plant.

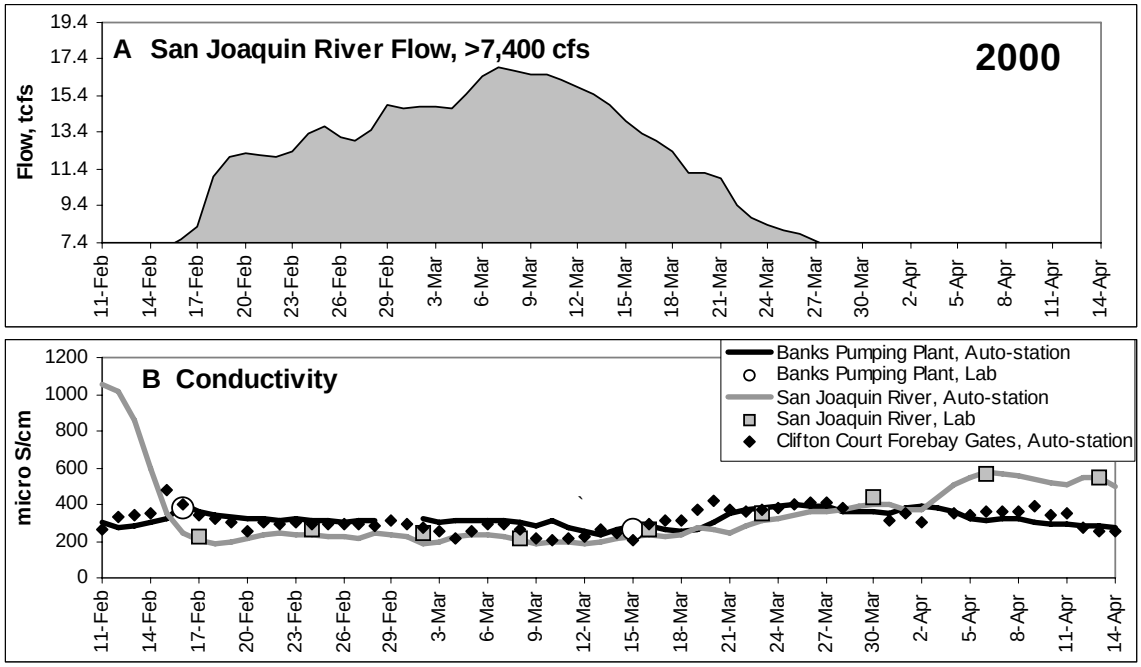

Figure 9-7. San Joaquin River flow (A) and conductivity at Banks Pumping Plant, as well as several other locations (B), during February to April, 2000

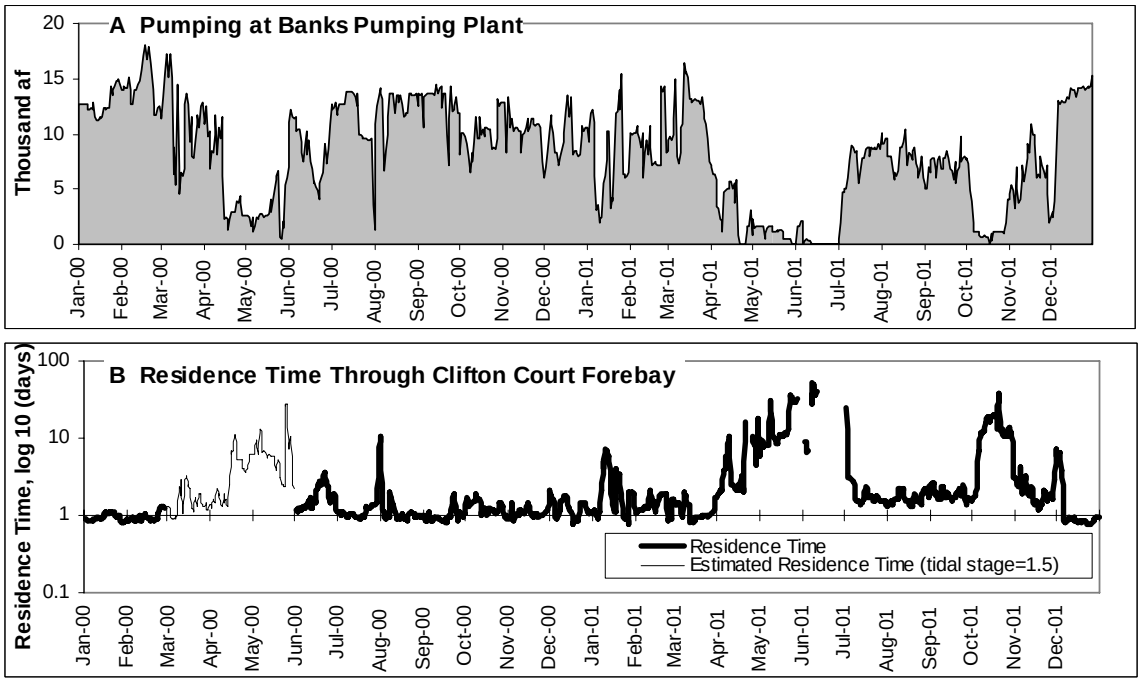

Figure 9-8. Pumping at Banks Pumping Plant and residence time through Clifton Court Forebay. Residence time was estimated for March through May 2000 with a fixed tidal stage of 1.5 feet. During that period, data was not available, possibly due to higher flow in the San Joaquin River. The residence times for March-May 2000, are likely underestimates because gage height can increase during periods of high flow in the San Joaquin River.

Loading Trends in the California Aqueduct

Loads were calculated for salt, bromide, and dissolved organic carbon at various locations throughout the California Aqueduct to assess sources, sinks, and seasonal trends. Calculations were made with water quality data from monthly grab samples and total monthly export or flow volumes.

Banks Pumping Plant

Monthly export water volumes at Banks Pumping Plant were fairly evenly distributed during 2000 except for 2 months. Excluding April and May, monthly export volumes ranged from 7 to 11 percent of the total for the year (Figure 9-9).

During 2000, 37 percent of the total salt load was pumped within a 3-month period from October through December (Figure 9-9). This compares with 25 percent of the total export water volume during the same 3 months. The bromide loading percentage was even higher – 51 percent – meaning half of the year's bromide load at Banks Pumping Plant occurred during a 3-month period (October-December 2000). The elevated salt and bromide loading during this period was due to sustained pumping during a period of influence from seawater intrusion.

During 2001, salt and bromide loads were high during a variety of months due, in part, to different pumping trends. Monthly exports were heavily reduced during April-June and October (2001): The salt and bromide loads were spread throughout most other months.

Dissolved organic carbon loading at Banks Pumping Plant was greatest during the winter months. From 42 to 50 percent of the annual DOC load at Banks Pumping Plant occurred during January-March of both years (Figure 9-9). This compares with 31 to 37 percent of the total export water volume for the same 3-month periods. Sustained or increased monthly exports coincided with seasonally elevated organic carbon levels that resulted in substantial DOC loading during winter of both 2000 and 2001.

Although more water was exported in 2000 than 2001, bromide loading was disproportionately higher in 2001. Sixty-two percent of the water volume exported at Banks Pumping Plant during the 2-year period occurred in 2000 versus 38 percent in 2001 (Figure 9-10). More water was exported in 2000 but the annual bromide load between years was roughly equal – 48 percent in 2000 and 52 percent in 2001 (Figure 9-10. The higher average bromide concentration for 2001 (72 percent increase from 2000) resulted in a disproportionately higher bromide load that year relative to export volumes.

Annual DOC loading between 2000 and 2001 at Banks Pumping Plant was similar to the water volume exported due, to a certain extent, to the similarity in annual DOC averages between years.

Check 21

The same analysis for Check 21 showed a different seasonal pattern. Monthly volumes were more evenly distributed between months at Check 21 than exports at Banks Pumping

Plant, especially in 2001 (Figure 9-11). Further, monthly volumes were consistently highest during the summer months and often lowest during winter and fall. Because of these factors, monthly loading percentages for salt and bromide were more evenly distributed throughout each year, despite concentration trends that were similar to those at Banks Pumping Plant (Figure 9-11). The same trend was observed for DOC during 2001: Data was less available for 2000.

Evenly distributed loads at Check 21 contrast with those at Banks Pumping Plant that were usually highest during fall and winter. Monthly loads at Check 21 were not as strongly influenced by seasonal concentration increases. Water volumes were highest during the summer when conductivity, bromide, and DOC levels were near their seasonal lows. As a result, the high loads observed at Banks Pumping Plant during certain fall and winter periods were more evenly distributed throughout the year at Check 21. For instance, DOC loading during January-March 2001 accounted for 28 percent of the annual load at Check 21 and 50 percent at Banks Pumping Plant.

San Luis Reservoir

The difference in monthly loading trends between Banks Pumping Plant and Check 21 reveals the seasonal redirection of water quality constituents into, and out of, the California Aqueduct. A portion of the high bromide load observed at Banks Pumping Plant during late summer and fall of both years was directed out of the Aqueduct and into San Luis Reservoir when reservoir filling was usually greater than reservoir releases (see Joint-Use Facilities). After filling, the bromide load in San Luis Reservoir was then released to the Aqueduct during April through July of both 2000 and 2001 when reservoir releases were greater than reservoir filling. These releases contained higher levels of bromide than exports at Banks Pumping Plant, resulting in higher levels at O'Neill Forebay Outlet during those months. A certain amount of the load (bromide, salt, etc.) in San Luis Reservoir is removed by CVP contractors at Pacheco Pumping Plant.

Filling of San Luis Reservoir was also increased from January through March of both years, coinciding with seasonally elevated DOC loading at Banks Pumping Plant. A portion of those DOC loads were directed out of the Aqueduct and into the reservoir. Releases from San Luis Reservoir during May 2000 and May-June 2001 coincided with lower, not higher, organic carbon concentrations at O'Neill Forebay Outlet compared to Banks Pumping Plant. The lower DOC at O'Neill Forebay Outlet contrasts with bromide which was higher there than at Banks Pumping Plant during releases. Several factors affected this outcome: limited available data, reduced or suspended exports, greater filling of San Luis Reservoir in fall when DOC concentrations were seasonally low, and a spike in DOC at Banks Pumping Plant in May 2000.

San Luis Canal

Water can also be directed out of the Aqueduct for use by CVP contractors. Around 190 turnout locations exist throughout the San Luis Canal, a 101 mile stretch of the California Aqueduct between O'Neill Forebay Outlet and Check 21. Along with water, these diversions remove a portion of the salt, bromide, and organic carbon load from the Aqueduct.

Figure 9-12 shows monthly water volume past O'Neill Forebay Outlet (Dos Amigos Pumping Plant) and Check 21. The greatest difference in volume between sites was from May through August of both years. Monthly volume at Check 21 was as much as 49 percent lower than at O'Neill Forebay Outlet during those months.

Loads leaving the San Luis Canal at Check 21 were usually less than those entering at O'Neill Forebay Outlet. Loading differences are shown in Figure 9-12 as the percent decline in load between stations each month. During 2000, the greatest decline in salt and bromide loading occurred during April through July when loads at Check 21 were 30 to 49 percent lower than at O'Neill Forebay Outlet (Figure 9-12). An incomplete DOC dataset for 2000 precluded the same analysis. During 2001, loading decline percentages for salt, bromide, and DOC were highest during several different months from January through August. However, because of the similar concentrations, the greatest load declines (actual, not percent) during 2001 would generally be expected during months when the water volume decline between O'Neill Forebay Outlet and Check 21 was greatest – May through August.

Over the 2-year period, the volume of water conveyed past Check 21 was about 30 percent less than at O'Neill Forebay Outlet. Loads for salt and bromide were also about 30 percent lower at Check 21 for the same 2-year period. This infers that 30 percent of the salt and bromide load sent down the San Luis Canal was diverted out of the Aqueduct. The amount of water removed from the San Luis Canal essentially represented the load removal of these parameters over the 2-year period. Because salt and bromide concentrations were similar between sites, the largest factor controlling load declines was the volume of water diverted out of the San Luis Canal.

For DOC, the loading decline between O'Neill Forebay and Check 21 during 2001 was 36 percent. This compares with a decline in water volume between stations of 35 percent. Similar to salt and bromide, the largest factor controlling load declines for DOC was the volume of water diverted out of the San Luis Canal. The volume of water removed from the San Luis Canal approximates the load removal of DOC. This relationship can likely be extended to most other water quality parameters. The exceptions are purgeable organics that could appreciably volatilize during the 101-mile journey between stations.

Factors that could affect this 1-to-1 relationship between volume and load removal from the San Luis Canal are groundwater turn-ins and floodwater inflows. Neither of these inflows occurred during 2000 or 2001. Floodwater inflows are saline, muddy, discharges that originate as rainfall runoff from the Coastal Range (DWR 1995). Groundwater turn-ins in the past have resulted in increased salinity and arsenic at Check 21 (DWR 1994) and have not been allowed in recent years.

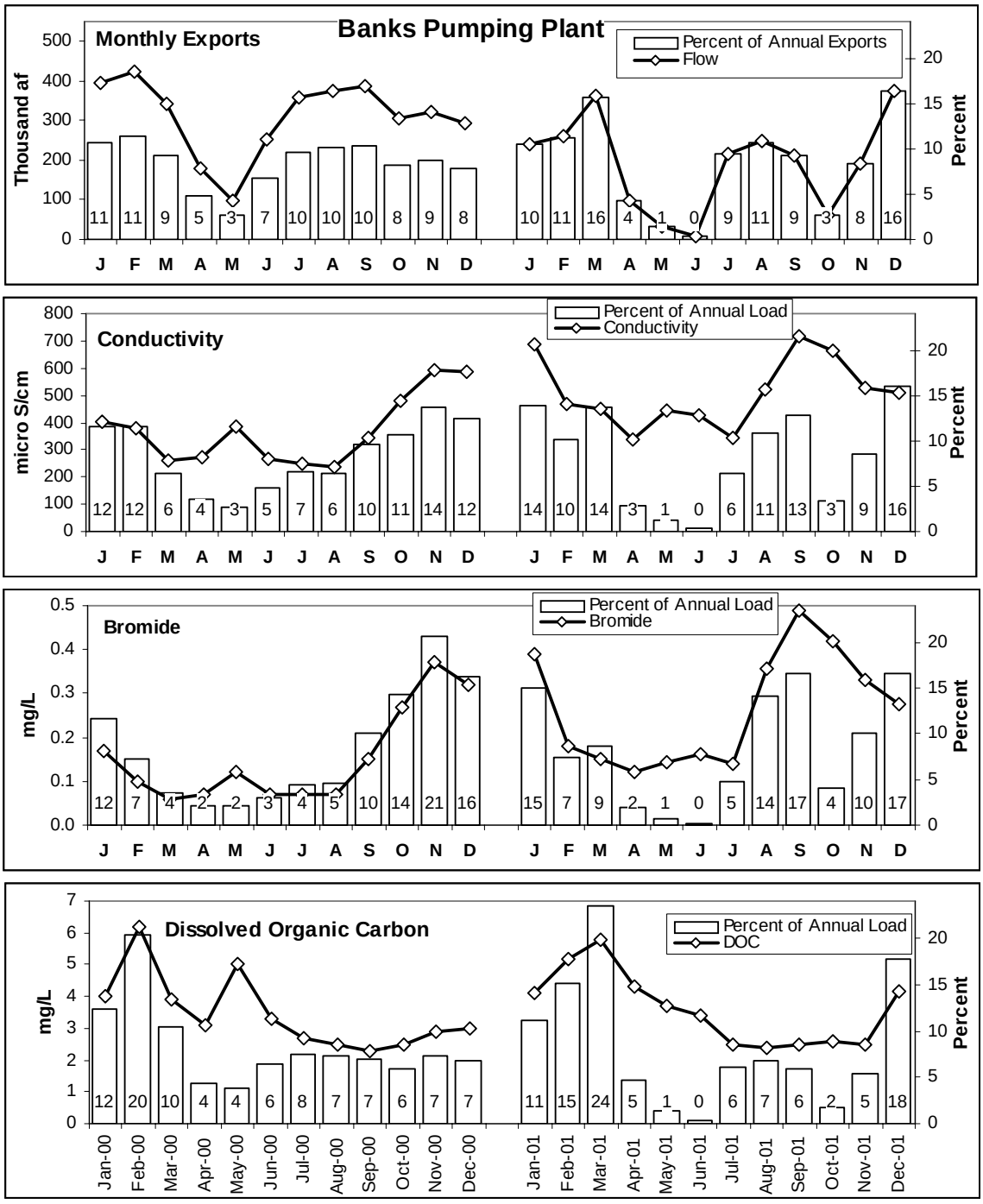

Figure 9-9. Monthly exports, conductivity, bromide, and dissolved organic carbon at Banks Pumping Plant along with percent of the total annual load

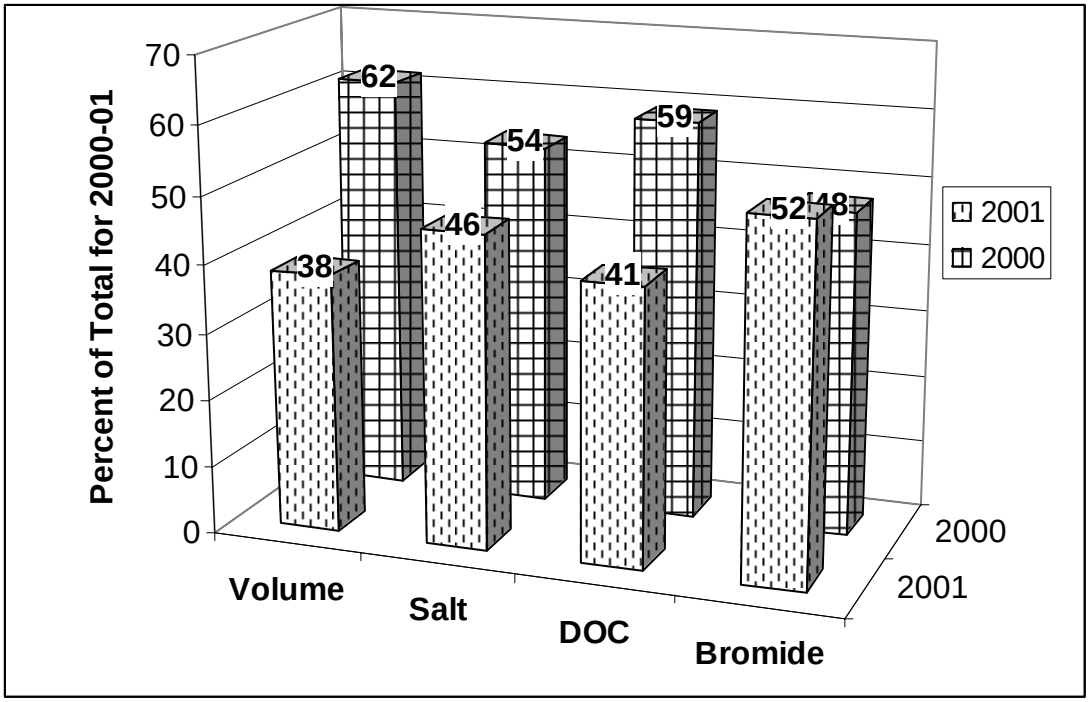

Figure 9-10. Annual percent of total volume and load at Banks Pumping Plant for 2000-01

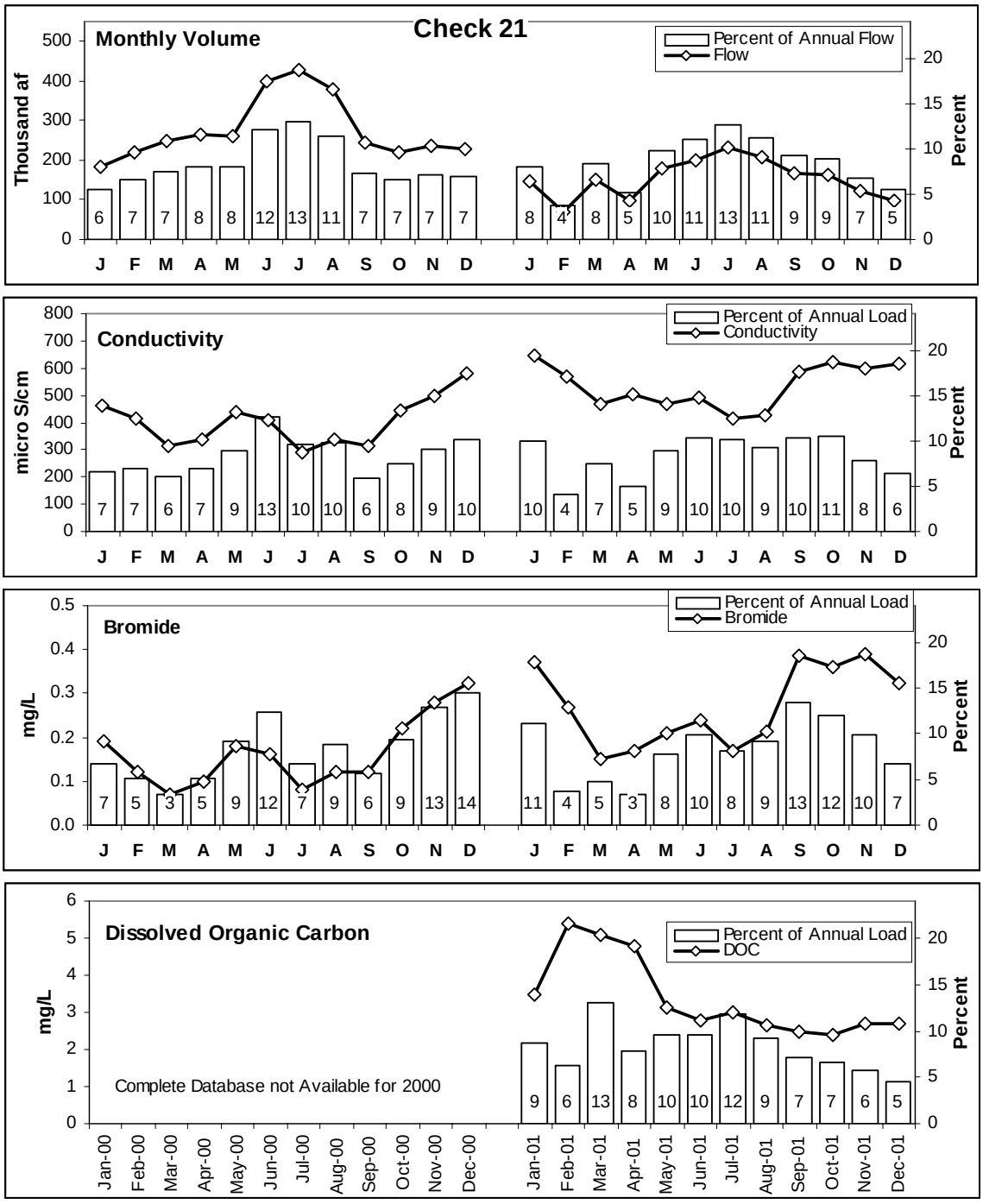

Figure 9-11. Monthly volume, conductivity, bromide, and dissolved organic carbon at Check 21 along with percent of the total annual load

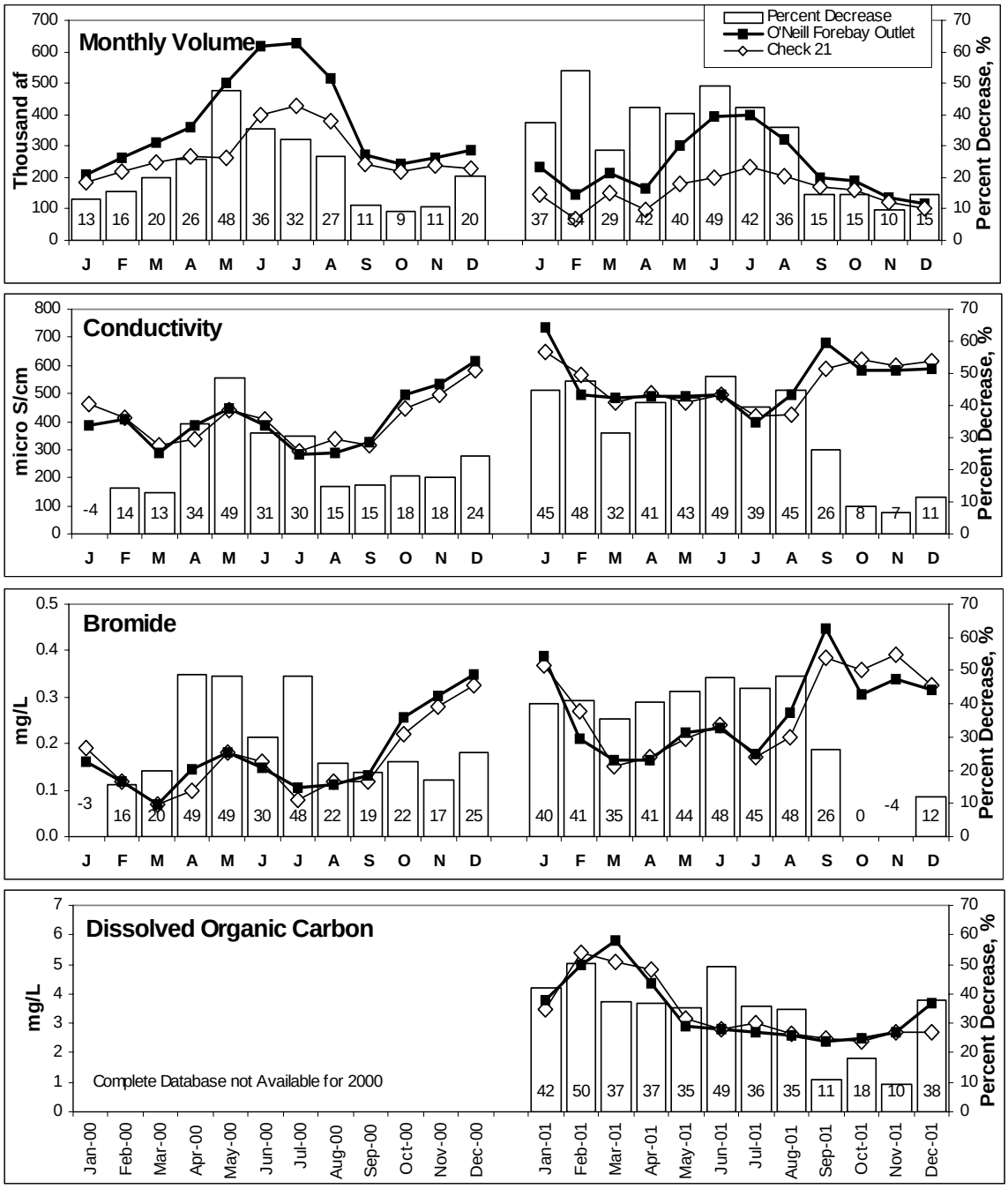

Figure 9-12. Monthly volume, conductivity, bromide, and dissolved organic carbon levels at O'Neill Forebay Outlet and Check 21. Also shown is the percent decrease in monthly volume and load between stations

Summary Analysis of Groundwater Turn-ins to the California Aqueduct

A complete analysis is reported in DWR 2002b.

Approximately 158,000 acre-feet of non-Project groundwater was conveyed into the California Aqueduct between March and December 2001.Over 99 percent of the total volume came from the Kern County Water Agency (Kern Water Bank Authority and Semitropic Water Storage District) (Table 9-2). Water quality in the Aqueduct was monitored upstream and downstream of the turn-ins at checks 21 and 29, respectively.

Turn-ins usually coincided with monthly decreases of organic carbon in the Aqueduct (Figure 9-13). Conversely, turn-ins also coincided with increases in Aqueduct nitrate and sulfate, although levels remained 4 to 41 times below the applicable drinking water MCLs. Monthly changes in Aqueduct arsenic during the turn-in season were equally divided between no change and increases: levels remained 12.5 to 25 times below the drinking water MCL in all samples. Hexavalent chromium (chromium VI) was undetectable in all but one sample from Check 29 (0.001 mg/L). Monthly changes in bromide in the Aqueduct during the turn-in season were equally divided between decreases and no change/increases.

Table 9-2. Monthly turn-in and California Aqueduct volumes (af) and turn-in percentages

Month	Check 21	SWSD	KWBA	BVAL	Check 29	% of Aqueduct Flow a/	WRMWSD	Check 41	% of Aqueduct Flow b/	AVEKWA	Total Pump-in
March	151,673		6,363	168	88,061	7.4		79,541			6,531
April	96,029	1,273	22,953		91,715	26	16	83,772			24,242
May	179,800	184	26,972		159,413	17	189	141,622	0.13		27,345
June	201,042	1,629	23,956		137,242	19	125	110,059	0.11	62	25,772
July	231,094		21,232		147,537	14	153	122,730	0.12	66	21,451
August	208,526		20,827		139,048	15	90	121,116	0.07	24	20,941
September	168,083		6,639		138,887	4.8	65	128,021	0.05		6,704
October	161,853		1,471		138,276	1.1		132,801			1,471
November	123,447	14,364			126,178	11		126,339			14,364
December	99,717	7,455	1,815		93,059	10		92,651			9,270
Total	1,621,264	24,905	132,228	168	1,259,416		638	1,138,652		152	158,091
% of Total Pump-in		15.8	83.6	0.11			0.40			0.10	

a/ The product of 100 and the upstream pump-ins/Check 29 flow ratio.
b/ The product of 100 and the WRMWSD/Check 41 flow ratio.

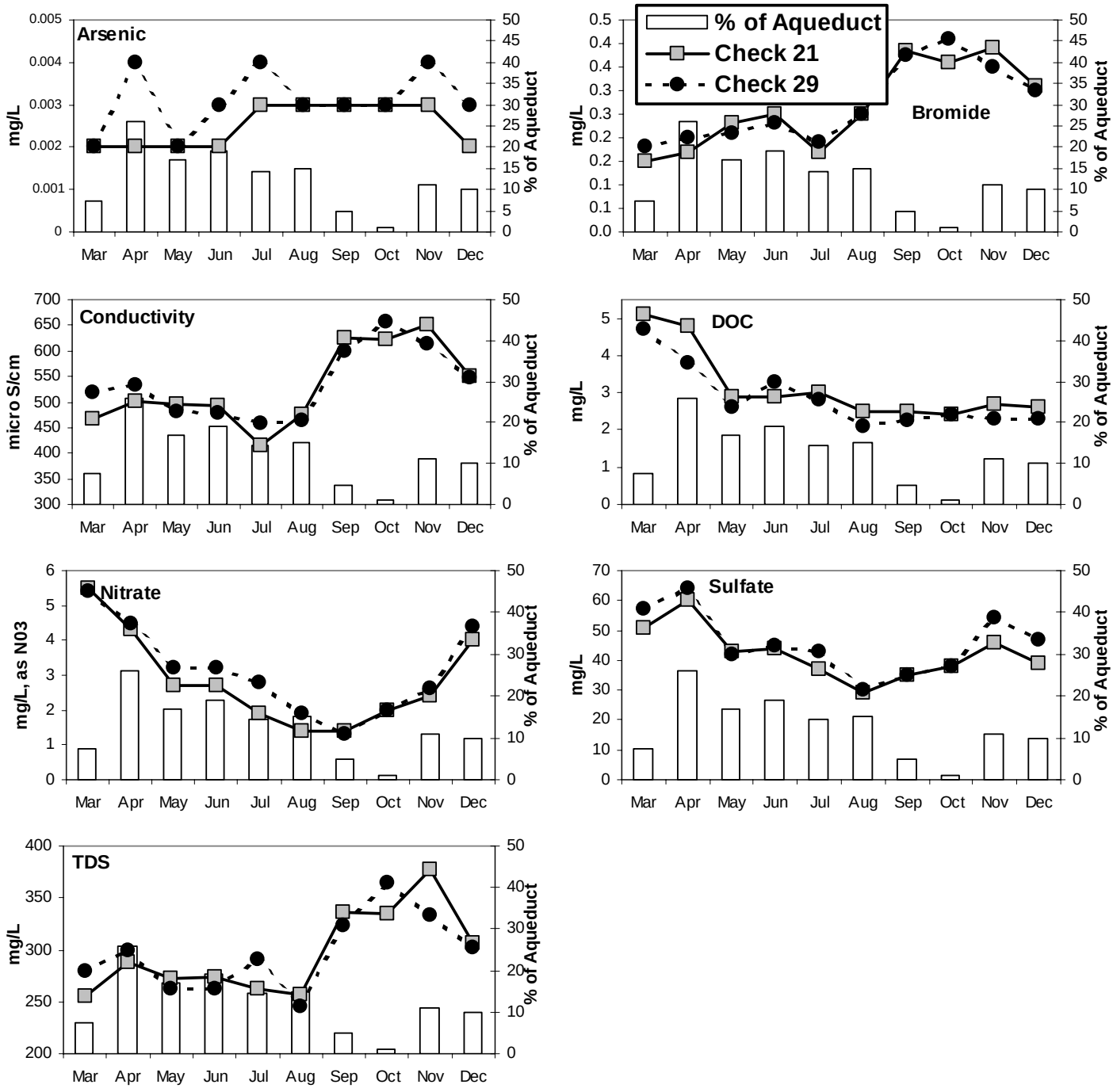

Figure 9-13. Constituents-of-concern in the California Aqueduct at checks 21 and 29 along with turn-in percent of Aqueduct volume

X. Conclusions

Water quality in the State Water Project during 2000 and 2001 was assessed to identify trends and compare with drinking water standards. Primary and secondary Maximum Contaminant Levels apply to drinking water and were compared to SWP data to provide a relative indication of raw water quality.

Primary and secondary MCLs for salinity, chloride, sulfate, minor elements, and nutrients were not exceeded in any of the samples collected throughout the SWP. The secondary MCL of 5 μg/L for MtBE (methyl *tert*-butyl ether) in drinking water was exceeded in two samples from Devil Canyon Headworks in June and September 2001 (5.1 and 7.1 μg/L, respectively). It was also detected just above the secondary MCL in two samples from Lake Oroville. Secondary MCLs address taste, odor, or appearance characteristics of treated drinking water.

Trend assessment focused on salinity, bromide, and organic carbon in the California Aqueduct.

Water Composition at Banks Pumping Plant

- Conductivity and bromide were highest at Banks Pumping Plant during summer/fall of both 2000 and 2001 largely due to seawater intrusion from the San Francisco Bay. At least some seawater intrusion was evident in more than half of the months during the 2-year period. Annual average conductivity at Banks Pumping Plant was 39 percent higher in 2001, a dry water year, than in 2000, an above normal water year. The increase in annual average bromide between years was 72 percent. Both parameters are inversely correlated with water year indices for the Sacramento and San Joaquin Valleys.
- Using ternary diagrams, seawater contributed an estimated 55 percent of the salt content in the November 2000 sample from Banks Pumping Plant followed by the Sacramento and San Joaquin Rivers with 27.5 and 17.5 percent, respectively. These estimates are considered maximums since this method does not account for other sources of salt such as Delta island drainage. An equally high contribution from seawater was evident in the September 2001 sample.
- Using the same analysis, the San Joaquin River was estimated to contribute 46 percent of the salt content in the January 2001 sample from Banks Pumping Plant followed by seawater (36.5 percent) and the Sacramento River (17.4 percent).
- Exports at Banks Pumping Plant were composed largely of water from the San Joaquin River for approximately 40 consecutive days during February-March 2000 due to high flow in that river.
- Dissolved organic carbon (DOC) at Banks Pumping Plant peaked at 6.2 mg/L in February 2000 and at 5.8 mg/L in March 2001. Annual average DOC was essentially the same between years despite the difference in water year classification.

Loading Trends in the California Aqueduct

Loads for salt, bromide, and DOC were calculated at Banks Pumping Plant, O'Neill Forebay Outlet, and Check 21 to assess sources, sinks, and seasonal trends.

- During 2000, 37 to 51 percent of the salt and bromide load at Banks Pumping Plant occurred during October-December due to increased seawater intrusion and sustained pumping. DOC loading at Banks Pumping Plant was greatest during winter of both years due to sustained or increased pumping and seasonally elevated DOC concentrations.
- Check 21 loads were not as strongly influenced by seasonal concentration increases as those at Banks Pumping Plant. Flow at Check 21 was usually highest during the late spring/summer months of both 2000 and 2001 when conductivity, bromide, and DOC were near seasonal lows.
- The difference in monthly loading trends between Banks Pumping Plant and Check 21 reveals the seasonal redirection of water into, and out of, the California Aqueduct. The elevated bromide and DOC loading at Banks Pumping Plant during fall/winter were banked in San Luis Reservoir when reservoir filling was usually greater than reservoir releases. These loads were then released to the Aqueduct during May-June of both years when reservoir releases were greater than reservoir filling.
- Salt, bromide, and DOC loads at Check 21 were 30 to 36 percent less than those at O'Neill Forebay Outlet. This reflects the removal of water (with the accompanying loads) out of the Aqueduct by CVP contractors with turnouts on the San Luis Canal. Load reductions in the San Luis Canal were roughly equal to the volume of water taken, and this was seasonally greatest during the late spring/summer months.

Groundwater Turn-ins to the California Aqueduct

Approximately 158,000 acre-feet of nonProject groundwater, largely from Kern Water Bank Authority and Semitropic Water Storage District, was conveyed into the California Aqueduct between March and December 2001. Water quality in the Aqueduct was monitored upstream and downstream of the turn-ins. While some constituents-of-concern in the Aqueduct were sometimes increased by the turn-ins (arsenic, nitrate, and sulfate), organic carbon was often lowered. The net result over the year was that the turn-ins had little effect on water quality in the SWP. In no case did changes in Aqueduct levels approach drinking water standards.

References

APHA (American Public Health Association). 1995. Standard Methods for the Examination of Water and Wastewater, 18th Edition. American Public Health Association, Washington, D.C.

CVRWQCB (Central Valley Regional Water Quality Control Board). 1987. Urban Runoff Discharges from Sacramento, California. 1984-85. Report Number 87-1SPSS. Sacramento, California. June.

----. 1988. Annual Loading of Seven Trace Metals from a Sacramento (CA) Storm Drain. Internal Memo from Barry Montoya, Environmental Specialist, to Jerry Bruns, Chief, Standards, Policies, and Special Studies Section. Sacramento, California.

DWR (Department of Water Resources). 2004a. Management of the California State Water Project-Appendix E. 2000 Water Operations in the Sacramento-San Joaquin Delta. Bulletin 132-01. January.

----. 2004b. Factors Affecting the Composition and Salinity of Exports from the South Sacramento-San Joaquin Delta. Memorandum report from Barry Montoya, Staff Environmental Scientist, to Dan Peterson, Environmental Program Manager. Division of Operations and Maintenance, Environmental Assessment Branch. Sacramento, California. February.

----. 2002a. Results of MTBE Sampling in Lake Oroville. Memo from Larry Joyce, Senior Environmental Specialist, Water Quality Section, Division of Operations and Maintenance, to Ed Craddack, County of Butte. Sacramento, California. November 14.

----. 2002b. Quality of Non-Project Groundwater Pump-ins to the California Aqueduct and effect on State Water Project Water Quality, 2001. Division of Operations and Maintenance, Environmental Assessment Branch. Sacramento, California. November.

----. 2000. Water Quality Assessment of the State Water Project, 1998-99. DWR, Division of Operations and Maintenance, Environmental Assessment Branch. Sacramento, California. July.

----. 1999. Water Quality Assessment of the State Water Project, 1996-1997. DWR, Division of Operations and Maintenance, Environmental Assessment Branch. Sacramento, California. September.

----. 1995. Water Quality Assessment of Floodwater Inflows to the San Luis Canal, California Aqueduct. DWR, Division of Operations and Maintenance, Environmental Assessment Branch. Sacramento, California. March.

----. 1994. Analysis of Water Quality Impacts from Ground Water Pump-in on the State Water Project, 1990-1992. Division of Operations and Maintenance, Environmental Assessment Branch. Sacramento, California. February.

Hem, J. D. 1985. Study and Interpretation of the Chemical Characteristics of Natural Water. Third Edition. U.S. Geological Survey Water-Supply Paper 2254.

U. S. Environmental Protection Agency. 1983. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020. Rev. March.

U. S. Geological Survey. 1985. Methods for Detection and Determination of Inorganic Substances in Water and Fluvial Sediments. Techniques of Water Resources Investigations of USGS, Book 5.

Appendix A
Methods

Monitoring Stations

Water quality samples are routinely collected at around 30 stations throughout the State Water Project (Table A-1, Figure A-1, and Plates 1 to 5). Samples are collected on, or around, the third Wednesday of each month. Automated water quality monitoring stations measure conventional parameters such as conductivity, temperature, or turbidity on a continuous basis at 15 locations throughout the Project (Figure A-1, and Plates 1 to 5).

Water Collection

Water quality sampling, preservation, and transportation protocols were followed as per EPA 1983, USGS 1985, and *Standard Methods for the Examination of Water and Wastewater* (APHA et al. 1995). Monitoring protocol for the Project is documented in O&M's *Water Quality Field Manual for the State Water Project*, DWR, Environmental Assessment Branch, January 1998. The specifics are briefly described here.

Water samples are collected from just below the surface at all stations. The collection device is either an acrylic Van Dorn Beta sampler with polypropylene stoppers, hand-dipped bottle, stainless steel bucket for organics, or plastic bucket for metals. At sites with automated stations, samples are collected directly from the circulation system. Water is drained from a spigot for 2 to 3 minutes before the sample bottle is filled. The circulation piping is PVC and the submerged pump forces around 3 to 5 GPM through the system. Automated stations on the California Aqueduct usually draw water from a depth of about 3 meters.

Precautions are taken to eliminate sample contamination in the field. These include use of a "clean" sampling box for storage and transport of items used in the filtration process. Clean items include unused filter cartridges, unused sample bottles, filter tubing, and unused baggies. Containers used include coolers with hinged tops or polyethylene security containers with flip lids.

Sample filtration is usually performed in the field using a peristaltic pump. A segment of Masterflex platinum-cured polypropylene tubing is connected to a Gelman 0.45 micron filter capsule. One capsule is used for all filtered samples at a station, including the filtered field blanks. Filtration of samples is conducted on a clean surface. A clean piece of plastic wrapping is spread out on the sampling bench prior to sampling. Items set on this surface include sample bottles, filter tubing, preservatives, and unused filter cartridges. At automated station sampling sites, water is filtered directly from the circulation system.

Field blanks for dissolved metals are filtered with a peristaltic pump before the environmental samples are processed. Unfiltered field blanks are processed at the same location that the environmental samples are processed. A travel blank is included when

purgeable organic samples are collected. Once the samples are collected and filtered, they are immediately placed in a cooler with ice and transported to the lab within 24 hours.

Laboratory Methods

Water quality samples are transported to the Bryte Chemical Laboratory within 24 to 48 hours of collection. Analytical work was performed by Bryte Laboratory using the analytical methods shown in Tables A-2 and A-3. As required for environmental laboratory accreditation in California, Bryte Laboratory filed a Quality Assurance Plan with the California Department of Health Services. The plan covers items required by EPA, such as organization and responsibility, laboratory sample procedures and identification, analytical methods, internal quality control, and corrective action. Internal quality control checks include duplicates, spikes, check standards, reference standards, and control charts.

Table A-1. Water quality monitoring schedule

Waterbody or Facility	Station Name or Description	Station I.D.	Sampling Frequency 1/				Organics							
			Project Standard 2/	Nutrients	Bromide	Iron and Manganese	Chlorinated Organics	Organo-Phosphorus Pesticides	Herbicides	Carbamates	Purgeable Organics	Tot. & Dis. Organic Carbon	UV 254	Automated Monitoring Station
California Aqueduct	Clifton Court Forebay	KA000000	M		M							M		X
	Banks Pumping Plant	KA000331	M	M	M		T	T	T	T	T	M	M	X
	O'Neill Forebay Outlet	KA007089	M		M		T	T	T	T	T	M	M	X
	Check 21	KA017226	M	M	M		T	T	T	T	T	M		X
	Check 29	KA024454	M		M		T	T	T	T	T	M		X
	Check 41	KA030341	M	M	M		T	T	T	T	T	M	M	X
	Check 66	KA040341	Q											X
	Devil Canyon Headworks	KA041134	M	M	M		T	T	T	T	T	M		X
Joint Use Facilities and the DMC	San Luis Res., Trashracks	SL001000												
	San Luis Res., Tunnel Island	SL005000												
	San Luis Res., Pacheco PP	SLR00000	M	M	M							M		X
	CVP Delta Mendota Canal	DMC06716	M		M		T	T	T	T	T	M		
SWP Lakes in Southern California	Pyramid Lake	PY001000	Q	M	Q									
		PY002000												
		PY003000												
	Castaic Lake	CA001000												
		CA002000	Q	M	Q							Q		X
		CA003000												
	Silverwood Lake	SI001000												
		SI002000	Q	M	Q							Q		
	Lake Perris	PE001000												
		PE002000	Q	M	Q							Q		
		PE003000												X
South Bay Aqueduct	Del Valle Check 7	KB001638	M	M	M							M		X
	Del Valle Reservoir	DV001000		M										
	Del Valle Res. Outlet	DV000000	M1	M1	M1							M1		
	Santa Clara Terminal Tank	KB004207												X
North Bay Aqueduct	Barker Sl. Pumping Plant	KG000000	M	M	M		T	T	T	T	T	M4	M4	X
	Cordelia Forebay	KG002111	Q											
Feather River Watershed	Antelope Lake	AN001000	A	A		M3								
	Frenchman Lake	FR001000	A	A										
	Lake Davis	LD001000	A	A		M2								
	Lake Oroville	OR001000		M										
	Thermalito Forebay	TF001000	Q											
	Thermalito Afterbay	TA001000	M	M	Q									

1/ Sampling Frequency : A=Annual Q=Quarterly Q1=Feb, May, Aug-Dec M=Monthly M1=Monthly When Flowing
M2=Apr-Nov M3=May-Sep M4=Weekly in Winter else Monthly, T=Mar, Jun, Sep,

2/ Project Standard: Arsenic, Chromium, Copper, Iron, Lead, Manganese, Selenium, Zinc, Calcium, Magnesium, Sodium, Alkalinity, Sulfate, Chloride, Fluoride, Boron, Nitrate, Dissolved Solids, Turbidity, and Conductivity Barium, Berillium, Cadmium, Aluminum, Mercury, Nickel, and Silver.

Figure A-1. Water Quality Monitoring Stations in the State Water Project

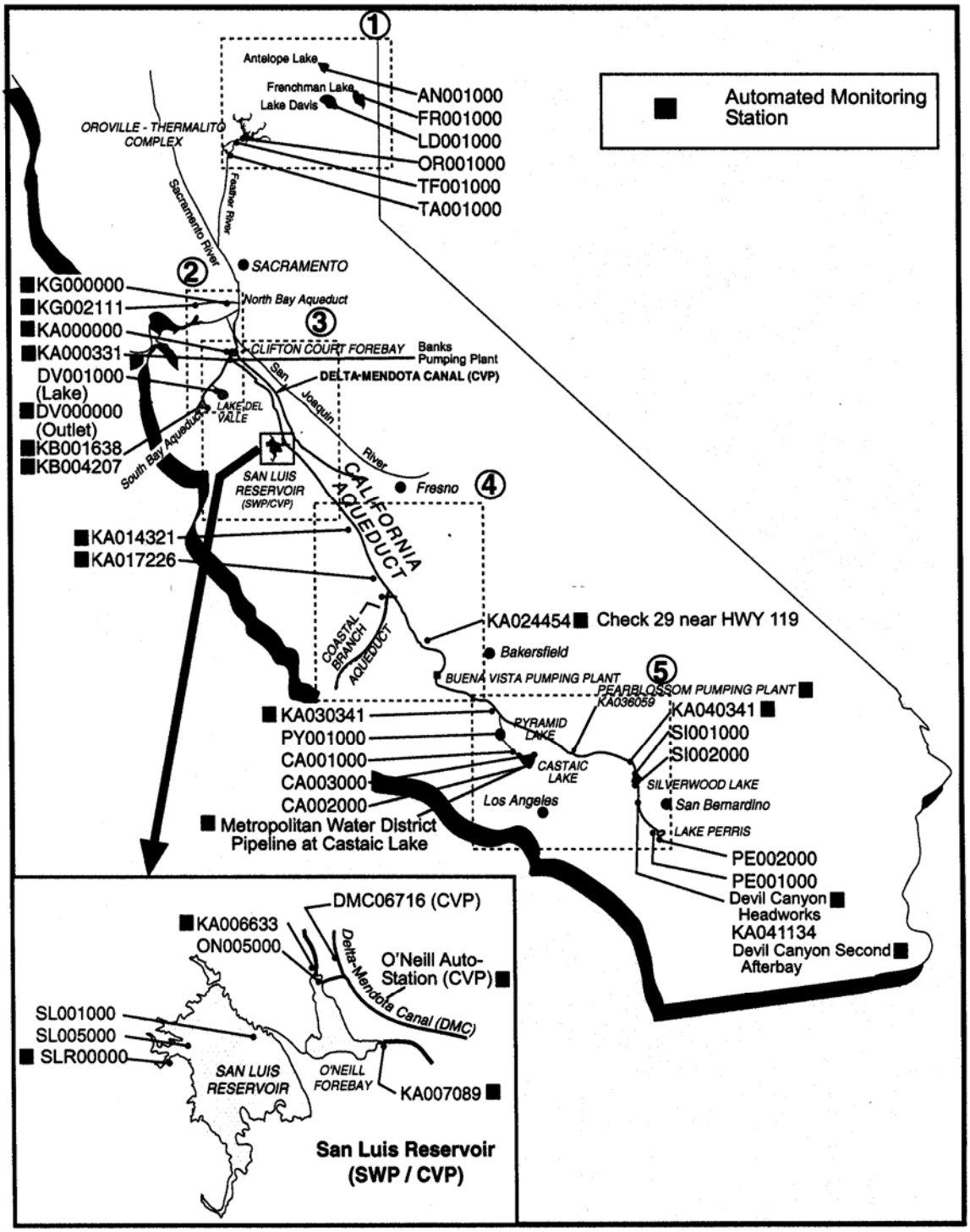

Plate 1

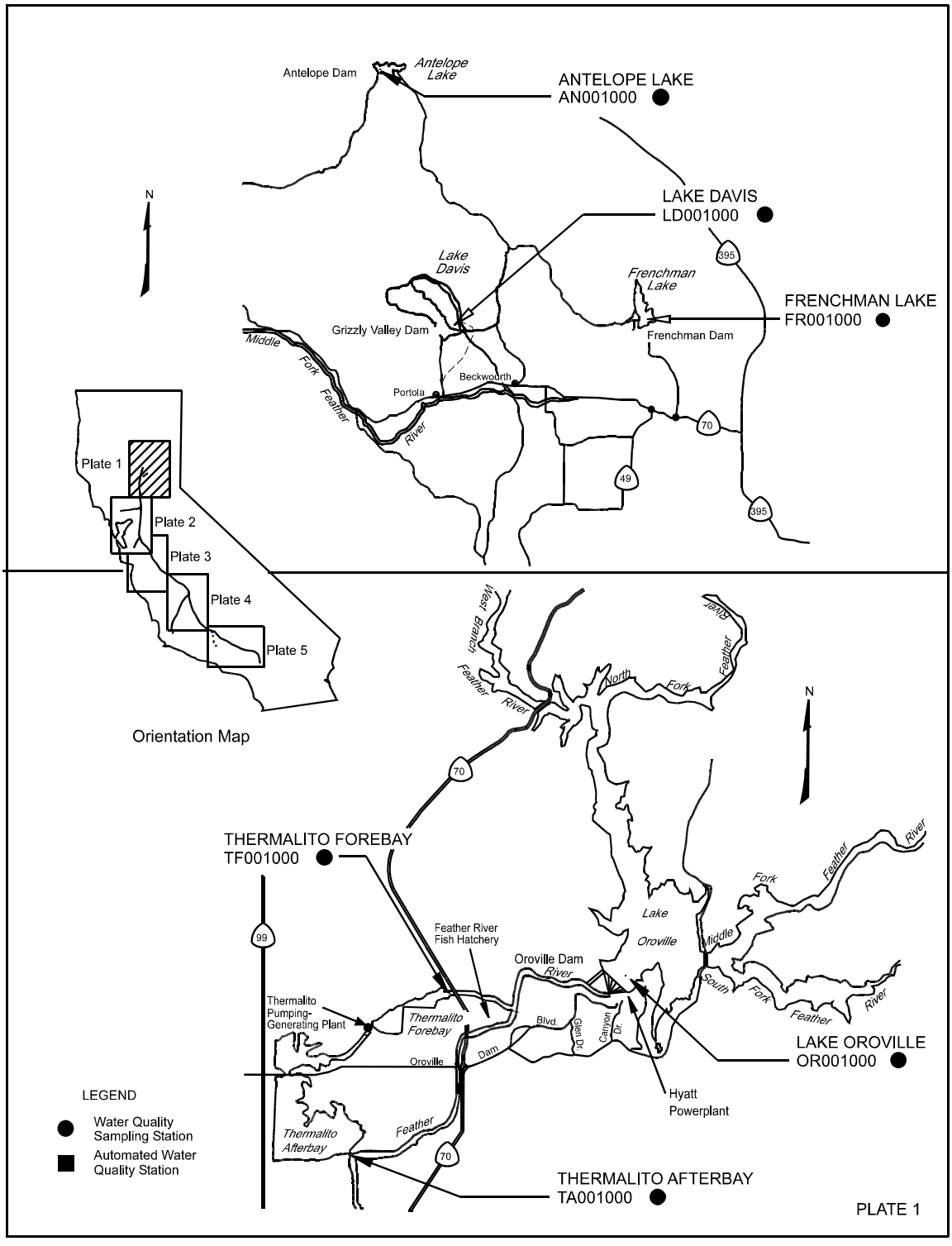
Antelope Dam
Antelope Lake
ANTELOPE LAKE
AN001000
LAKE DAVIS
LD001000
Lake Davis
Frenchman Lake
FRENCHMAN LAKE
FR001000
Grizzly Valley Dam
Frenchman Dam
Middle Fork Feather River
Beckwourth
Portola
395
70
49
N
Plate 1
Plate 2
Plate 3
Plate 4
Plate 5
Orientation Map
West Branch Feather River
North Fork Feather River
THERMALITO FOREBAY
TF001000
99
Feather River Fish Hatchery
Oroville Dam
Thermalito Pumping-Generating Plant
Thermalito Forebay
Blvd.
Glen Dr.
Canyon Dr.
Oroville
Dam
Lake Oroville
Middle Fork Feather River
South Fork Feather River
LAKE OROVILLE
OR001000
Hyatt Powerplant
Thermalito Afterbay
THERMALITO AFTERBAY
TA001000
LEGEND
Water Quality Sampling Station
Automated Water Quality Station
PLATE 1

Plate 2

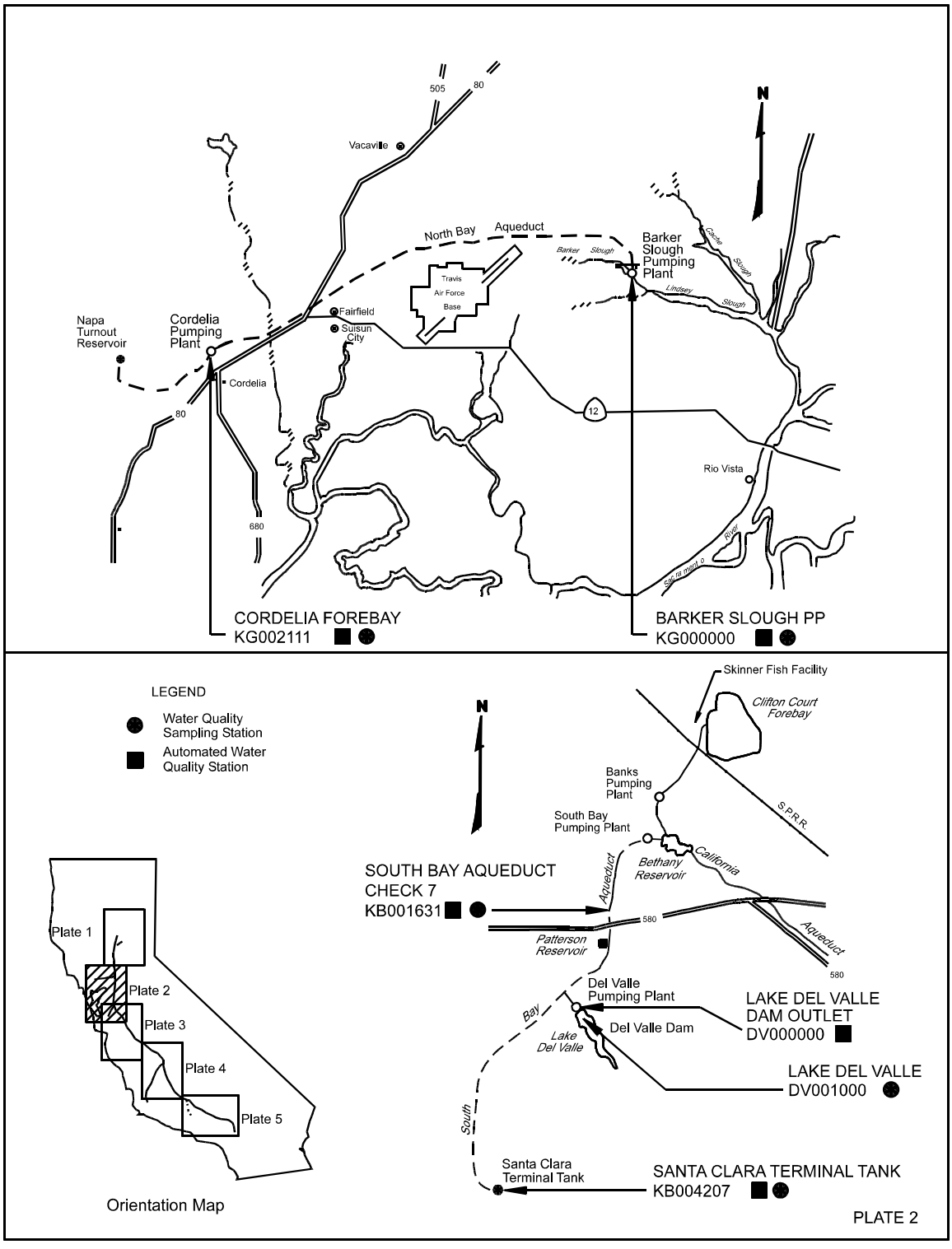
505
80
Vacaville
North Bay Aqueduct
Barker Slough Pumping Plant
Travis Air Force Base
Fairfield
Suisun City
Napa Turnout Reservoir
Cordelia Pumping Plant
Cordelia
80
680
12
Rio Vista
Barker Slough
Cache Slough
Lindsey Slough
Sacramento River
N
CORDELIA FOREBAY
KG002111
BARKER SLOUGH PP
KG000000
LEGEND
Water Quality Sampling Station
Automated Water Quality Station
Plate 1
Plate 2
Plate 3
Plate 4
Plate 5
Orientation Map
Skinner Fish Facility
Clifton Court Forebay
Banks Pumping Plant
South Bay Pumping Plant
S.P.R.R.
California Aqueduct
Bethany Reservoir
SOUTH BAY AQUEDUCT
CHECK 7
KB001631
580
Patterson Reservoir
Del Valle Pumping Plant
Del Valle Dam
LAKE DEL VALLE
DAM OUTLET
DV000000
Lake Del Valle
LAKE DEL VALLE
DV001000
South Bay
Santa Clara Terminal Tank
SANTA CLARA TERMINAL TANK
KB004207
PLATE 2

Plate 3

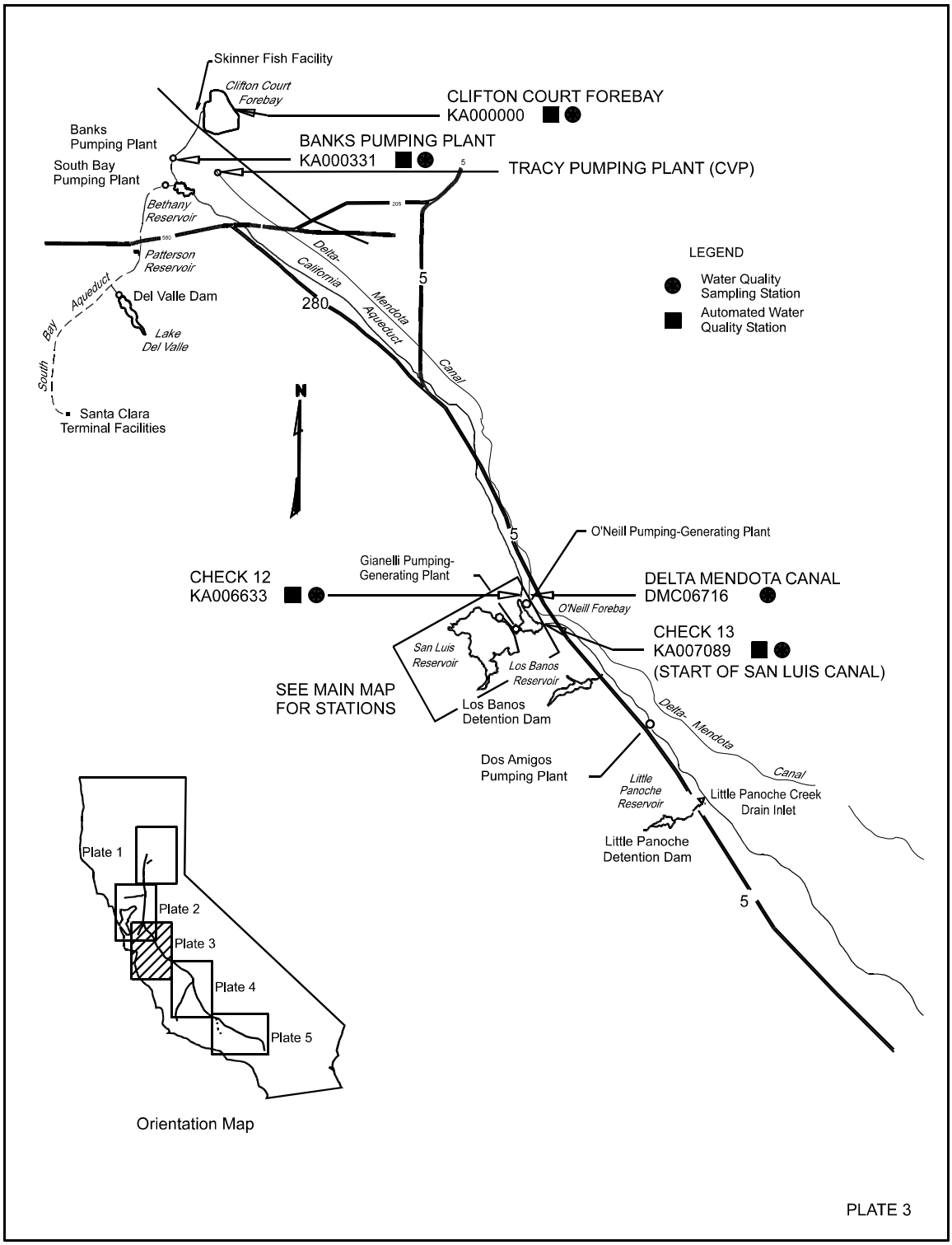
Skinner Fish Facility
Clifton Court Forebay
CLIFTON COURT FOREBAY
KA000000
Banks Pumping Plant
BANKS PUMPING PLANT
KA000331
South Bay Pumping Plant
TRACY PUMPING PLANT (CVP)
Bethany Reservoir
Patterson Reservoir
Delta-California Mendota Aqueduct Canal
Del Valle Dam
Lake Del Valle
South Bay Aqueduct
Santa Clara Terminal Facilities
LEGEND
Water Quality Sampling Station
Automated Water Quality Station
N
O'Neill Pumping-Generating Plant
Gianelli Pumping-Generating Plant
CHECK 12
KA006633
DELTA MENDOTA CANAL
DMC06716
O'Neill Forebay
CHECK 13
KA007089
(START OF SAN LUIS CANAL)
San Luis Reservoir
Los Banos Reservoir
SEE MAIN MAP FOR STATIONS
Los Banos Detention Dam
Delta-Mendota Canal
Dos Amigos Pumping Plant
Little Panoche Reservoir
Little Panoche Creek Drain Inlet
Little Panoche Detention Dam
Plate 1
Plate 2
Plate 3
Plate 4
Plate 5
Orientation Map
PLATE 3

Plate 4

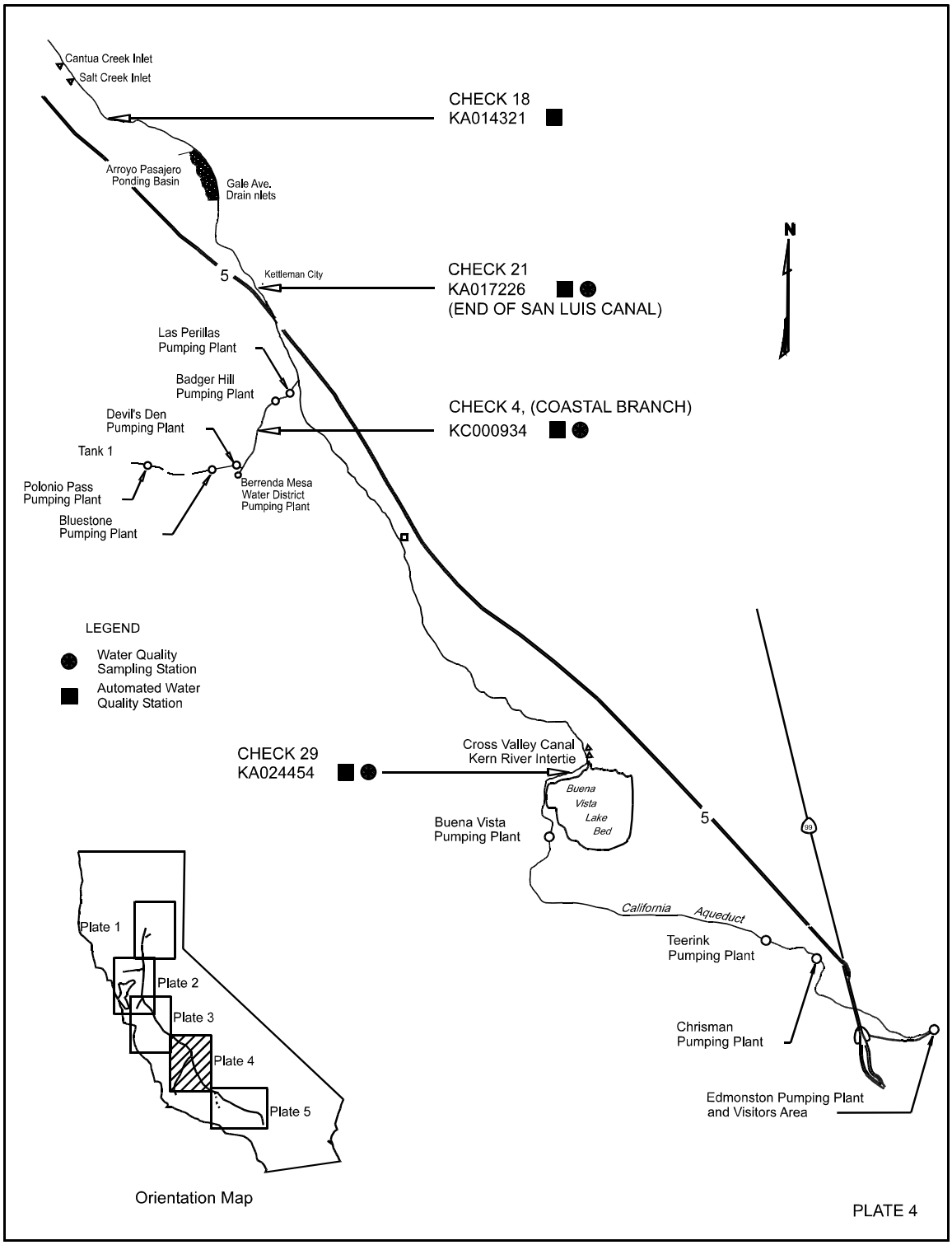
Cantua Creek Inlet
Salt Creek Inlet
CHECK 18
KA014321
Arroyo Pasajero
Ponding Basin
Gale Ave.
Drain nlets
N
5
Kettleman City
CHECK 21
KA017226
(END OF SAN LUIS CANAL)
Las Perillas
Pumping Plant
Badger Hill
Pumping Plant
Devil's Den
Pumping Plant
CHECK 4, (COASTAL BRANCH)
KC000934
Tank 1
Polonio Pass
Pumping Plant
Berrenda Mesa
Water District
Pumping Plant
Bluestone
Pumping Plant
LEGEND
Water Quality
Sampling Station
Automated Water
Quality Station
CHECK 29
KA024454
Cross Valley Canal
Kern River Intertie
Buena
Vista
Lake
Bed
Buena Vista
Pumping Plant
5
99
California
Aqueduct
Teerink
Pumping Plant
Chrisman
Pumping Plant
Edmonston Pumping Plant
and Visitors Area
Plate 1
Plate 2
Plate 3
Plate 4
Plate 5
Orientation Map
PLATE 4

Plate 5

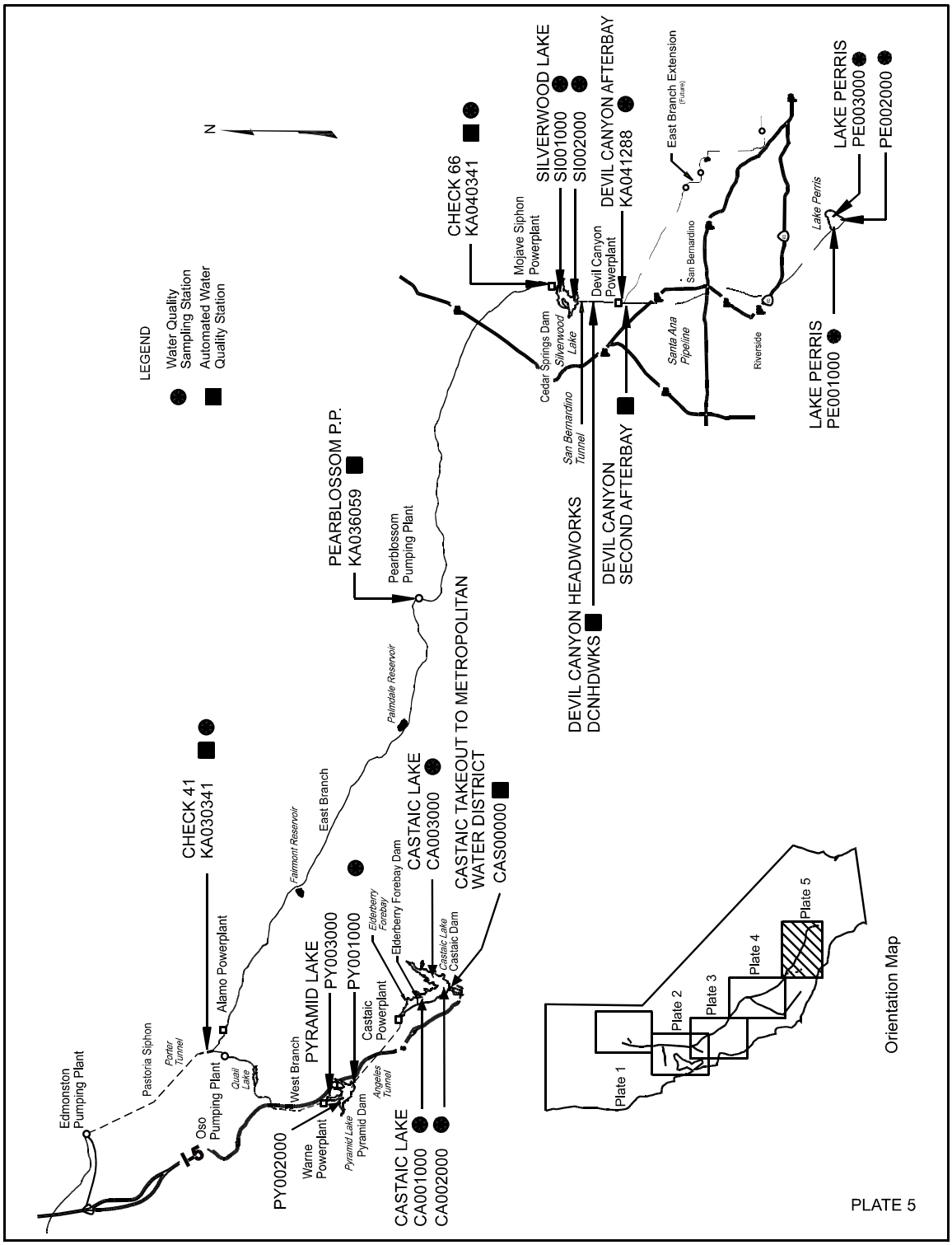
LEGEND
Water Quality Sampling Station
Automated Water Quality Station
N
CHECK 41
KA030341
CHECK 66
KA040341
PEARBLOSSOM P.P.
KA036059
Pearblossom Pumping Plant
CASTAIC TAKEOUT TO METROPOLITAN WATER DISTRICT
CAS00000
CASTAIC LAKE
CA003000
CASTAIC LAKE
CA001000
CA002000
PY002000
PYRAMID LAKE
PY003000
PY001000
SILVERWOOD LAKE
SI001000
SI002000
DEVIL CANYON AFTERBAY
KA041288
DEVIL CANYON HEADWORKS
DCNHDWKS
DEVIL CANYON SECOND AFTERBAY
LAKE PERRIS
PE001000
LAKE PERRIS
PE003000
PE002000
Edmonston Pumping Plant
Pastoria Siphon
Porter Tunnel
Oso Pumping Plant
Quail Lake
Alamo Powerplant
West Branch
East Branch
Fairmont Reservoir
Palmdale Reservoir
Warne Powerplant
Pyramid Lake
Pyramid Dam
Angeles Tunnel
Castaic Powerplant
Elderberry Forebay
Elderberry Forebay Dam
Castaic Lake
Castaic Dam
Mojave Siphon Powerplant
Cedar Springs Dam
Silverwood Lake
San Bernardino Tunnel
Devil Canyon Powerplant
Santa Ana Pipeline
East Branch Extension (Future)
San Bernardino
Riverside
Lake Perris
Orientation Map
Plate 1
Plate 2
Plate 3
Plate 4
Plate 5
I-5
PLATE 5

Table A-2. Analytical methods for non-organic chemical parameters

Analyte	Method Title	Reporting Limit	Units	MethodName
Alkalinity	Alkalinity	1	mg/L as CaCO3	Std Method 2320 B
Conductance (EC)	Electrical Conductivity (EC)	1	µS/cm	Std Method 2510-B
Dissolved Aluminum	ICP/MS Trace Elements (Dissolved)	0.01	mg/L	EPA 200.8 (D)
Dissolved Ammonia	Ammonia, Nitrogen (Dissolved)	0.01	mg/L as N	EPA 350.1
Dissolved Antimony	ICP/MS Trace Elements (Dissolved)	0.005	mg/L	EPA 200.8 (D)
Dissolved Arsenic	ICP/MS Trace Elements (Dissolved)	0.001	mg/L	EPA 200.8 (D)
Dissolved Barium	ICP/MS Trace Elements (Dissolved)	0.050	mg/L	EPA 200.8 (D)
Dissolved Beryllium	ICP/MS Trace Elements (Dissolved)	0.001	mg/L	EPA 200.8 (D)
Dissolved Boron	ICP Metals and Trace Elements (Dissolved)	0.100	mg/L	EPA 200.7 (D)
Dissolved Bromide	Inorganic Anions 28d hold	0.01	mg/L	EPA 300.0 28d Hold
Dissolved Cadmium	ICP/MS Trace Elements (Dissolved)	0.001	mg/L	EPA 200.8 (D)
Dissolved Calcium	ICP Metals and Trace Elements (Dissolved)	1	mg/L	EPA 200.7 (D)
Dissolved Chloride	Inorganic Anions 28d hold	1	mg/L	EPA 300.0 28d Hold
Dissolved Chromium	ICP/MS Trace Elements (Dissolved)	0.001	mg/L	EPA 200.8 (D)
Dissolved Chromium, hexavalent (Cr6+)	Chromium, Hexavalent by Ion Chromatography	0.001	mg/L	EPA 218.6
Dissolved Copper	ICP/MS Trace Elements (Dissolved)	0.001	mg/L	EPA 200.8 (D)
Dissolved Fluoride	Inorganic Anions 28d hold	0.1	mg/L	EPA 300.0 28d Hold
Dissolved Iron	ICP/MS Trace Elements (Dissolved)	0.005	mg/L	EPA 200.8 (D)
Dissolved Lead	ICP/MS Trace Elements (Dissolved)	0.001	mg/L	EPA 200.8 (D)
Dissolved Magnesium	ICP Metals and Trace Elements (Dissolved)	1	mg/L	EPA 200.7 (D)
Dissolved Manganese	ICP/MS Trace Elements (Dissolved)	0.005	mg/L	EPA 200.8 (D)
Dissolved Mercury	Mercury by EPA Method 200.8 (Dissovled)	0.0002	mg/L	EPA 200.8 (Hg Dissolved)
Dissolved Nickel	ICP/MS Trace Elements (Dissolved)	0.001	mg/L	EPA 200.8 (D)
Dissolved Nitrate	Nitrate, Ortho Phosphate 48hr Hold	0.1	mg/L	EPA 300.0 48 hr (N03, OP)
Dissolved Nitrite + Nitrate	Nitrite, Nitrate (DWR Modified) (Dissolved)	0.01	mg/L as N	Std Method 4500-NO3-F Modified
Dissolved Organic Carbon	Organic Carbon (Dissolved) by Wet Oxidation	0.1	mg/L as C	EPA 415.1 (D) Ox
Dissolved Ortho-phosphate	Ortho-phosphate (Dissolved)	0.01	mg/L as P	Std Method 4500-P, F
Dissolved Selenium	ICP/MS Trace Elements (Dissolved)	0.001	mg/L	EPA 200.8 (D)
Dissolved Silver	ICP/MS Trace Elements (Dissolved)	0.001	mg/L	EPA 200.8 (D)
Dissolved Sodium	ICP Metals and Trace Elements (Dissolved)	1	mg/L	EPA 200.7 (D)
Dissolved Sulfate	Inorganic Anions 28d hold	1	mg/L	EPA 300.0 28d Hold
Dissolved Zinc	ICP/MS Trace Elements (Dissolved)	0.005	mg/L	EPA 200.8 (D)
Hardness	Hardness By Calculation	1	mg/L as CaCO3	Std Method 2340 B
Total Dissolved Solids	Total Dissolved Solids (TDS)	1	mg/L	Std Method 2540-C
Total Kjeldahl Nitrogen	Kjeldahl Nitrogen	0.1	mg/L as N	EPA 351.2
Total Organic Carbon	Organic Carbon (Total) by Combustion	0.5	mg/L as C	EPA 415.1 (T) Cmbst
Total Organic Carbon	Organic Carbon (Total) by Wet Oxidation	0.1	mg/L as C	EPA 415.1 (T) Ox
Total Phosphorus	Phosphorus (Total)	0.01	mg/L	EPA 365.4
Total Suspended Solids	Total Suspended Solids	1	mg/L	EPA 160.2
Turbidity	Turbidity	1	N.T.U.	EPA 180.1
UV Absorbance @254nm	UVA	0.001	absorbance/cm	Std Method 5910B
Volatile Suspended Solids	Volatile Suspended Solids	1	mg/L	EPA 160.4

Table A-3. Analytical methods for organic chemicals

Method Title	Analyte	Reporting Limit	Units	Method Name
Carbamate Pesticides	3-Hydroxycarbofuran	2	µg/L	EPA 531.1
	Aldicarb	2	µg/L	EPA 531.1
	Aldicarb sulfone	2	µg/L	EPA 531.1
	Aldicarb sulfoxide	2	µg/L	EPA 531.1
	Carbaryl	2	µg/L	EPA 531.1
	Carbofuran	2	µg/L	EPA 531.1
	Formetanate hydrochloride	100	µg/L	EPA 531.1
	Methiocarb	4	µg/L	EPA 531.1
	Methomyl	2	µg/L	EPA 531.1
	Oxamyl	2	µg/L	EPA 531.1
Chlorinated Organic Pesticides	Alachlor	0.05	µg/L	EPA 608
	Aldrin	0.01	µg/L	EPA 608
	Atrazine	0.02	µg/L	EPA 608
	BHC-alpha	0.01	µg/L	EPA 608
	BHC-beta	0.01	µg/L	EPA 608
	BHC-delta	0.01	µg/L	EPA 608
	BHC-gamma (Lindane)	0.01	µg/L	EPA 608
	Captan	0.02	µg/L	EPA 608
	Chlordane	0.05	µg/L	EPA 608
	Chlorothalonil	0.01	µg/L	EPA 608
	Chlorpropham	0.02	µg/L	EPA 608
	Chlorpyrifos	0.01	µg/L	EPA 608
	Cyanazine	0.3	µg/L	EPA 608
	Dacthal (DCPA)	0.01	µg/L	EPA 608
	Dichloran	0.01	µg/L	EPA 608
	Dicofol	0.05	µg/L	EPA 608
	Dieldrin	0.01	µg/L	EPA 608
	Diuron	0.25	µg/L	EPA 608
	Endosulfan sulfate	0.02	µg/L	EPA 608
	Endosulfan-I	0.01	µg/L	EPA 608
	Endosulfan-II	0.01	µg/L	EPA 608
	Endrin	0.01	µg/L	EPA 608
	Endrin aldehyde	0.01	µg/L	EPA 608
	Heptachlor	0.01	µg/L	EPA 608
	Heptachlor epoxide	0.01	µg/L	EPA 608
	Methoxychlor	0.05	µg/L	EPA 608
	Metolachlor	0.2	µg/L	EPA 608
	Oxyfluorfen	0.2	µg/L	EPA 608
	p,p'-DDD	0.01	µg/L	EPA 608
	p,p'-DDE	0.01	µg/L	EPA 608
	p,p'-DDT	0.05	µg/L	EPA 608
	PCB-1016	0.1	µg/L	EPA 608
	PCB-1221	0.1	µg/L	EPA 608
	PCB-1232	0.1	µg/L	EPA 608
	PCB-1242	0.1	µg/L	EPA 608
	PCB-1248	0.1	µg/L	EPA 608
	PCB-1254	0.1	µg/L	EPA 608
	PCB-1260	0.1	µg/L	EPA 608
	Pentachloronitrobenzene (PCNB)	0.01	µg/L	EPA 608
	Simazine	0.02	µg/L	EPA 608
	Thiobencarb	0.02	µg/L	EPA 608
	Toxaphene	0.4	µg/L	EPA 608
Chlorinated Phenoxy Acid Herbicides	2,4,5-T	0.1	µg/L	EPA 615
	2,4,5-TP (Silvex)	0.1	µg/L	EPA 615
	2,4-D	0.1	µg/L	EPA 615
	2,4-DB	0.1	µg/L	EPA 615
	Dacthal (DCPA)	0.1	µg/L	EPA 615
	Dicamba	0.1	µg/L	EPA 615
	Dichlorprop	0.1	µg/L	EPA 615
	Dinoseb (DNPB)	0.1	µg/L	EPA 615
	MCPA	0.1	µg/L	EPA 615
	MCPP	0.1	µg/L	EPA 615
	Pentachlorophenol (PCP)	0.1	µg/L	EPA 615
	Picloram	0.1	µg/L	EPA 615
	Triclopyr	0.1	µg/L	EPA 615
DWR Sulfur Pesticides	Propargite	1	µg/L	DWR Sulfur Pesticides
Glyphosate	Aminomethylphosphonic Acid (AMPA)	100	µg/L	EPA 547
Glyphosate	Glyphosate	100	µg/L	EPA 547
Phosphorus / Nitrogen Pesticides	Azinphos methyl (Guthion)	0.05	µg/L	EPA 614
	Benfluralin	0.01	µg/L	EPA 614
	Bromacil	1	µg/L	EPA 614
	Carbophenothion (Trithion)	0.02	µg/L	EPA 614
	Chlorpyrifos	0.01	µg/L	EPA 614
	Cyanazine	0.3	µg/L	EPA 614
	Demeton (Demeton O + Demeton S)	0.02	µg/L	EPA 614
	Diazinon	0.01	µg/L	EPA 614
	Dimethoate	0.01	µg/L	EPA 614
	Disulfoton	0.01	µg/L	EPA 614
	Ethion	0.01	µg/L	EPA 614
	Malathion	0.01	µg/L	EPA 614
	Methidathion	0.02	µg/L	EPA 614
	Mevinphos	0.01	µg/L	EPA 614
	Naled	0.02	µg/L	EPA 614
	Napropamide	5	µg/L	EPA 614
	Norflurazon	5	µg/L	EPA 614
	Parathion (Ethyl)	0.01	µg/L	EPA 614
	Parathion, Methyl	0.01	µg/L	EPA 614
	Pendimethalin	5	µg/L	EPA 614
	Phorate	0.01	µg/L	EPA 614
	Phosalone	0.02	µg/L	EPA 614
	Phosmet	0.02	µg/L	EPA 614

Table A-3. Analytical methods for organic chemicals (Con't)

Method Title	Analyte	Reporting Limit	Units	Method Name
	Profenofos	0.01	µg/L	EPA 614
	Prometryn	0.05	µg/L	EPA 614
	Propetamphos	0.1	µg/L	EPA 614
	s,s,s-Tributyl Phosphorotrithioate (DEF)	0.01	µg/L	EPA 614
	Trifluralin	0.01	µg/L	EPA 614
Volatile Organics in Water (Purgeable Organics)	1,1,1,2-Tetrachloroethane	0.5	µg/L	EPA 502.2
	1,1,1-Trichloroethane	0.5	µg/L	EPA 502.2
	1,1,2,2-Tetrachloroethane	0.5	µg/L	EPA 502.2
	1,1,2-Trichloroethane	0.5	µg/L	EPA 502.2
	1,1-Dichloroethane	0.5	µg/L	EPA 502.2
	1,1-Dichloroethene	0.5	µg/L	EPA 502.2
	1,1-Dichloropropene	0.5	µg/L	EPA 502.2
	1,2,3-Trichlorobenzene	0.5	µg/L	EPA 502.2
	1,2,3-Trichloropropane	0.5	µg/L	EPA 502.2
	1,2,4-Trichlorobenzene	0.5	µg/L	EPA 502.2
	1,2,4-Trimethylbenzene	0.5	µg/L	EPA 502.2
	1,2-Dibromo-3-chloropropane (DBCP)	0.5	µg/L	EPA 502.2
	1,2-Dibromoethane	0.5	µg/L	EPA 502.2
	1,2-Dichlorobenzene	0.5	µg/L	EPA 502.2
	1,2-Dichloroethane	0.5	µg/L	EPA 502.2
	1,2-Dichloropropane	0.5	µg/L	EPA 502.2
	1,3,5-Trimethylbenzene	0.5	µg/L	EPA 502.2
	1,3-Dichlorobenzene	0.5	µg/L	EPA 502.2
	1,3-Dichloropropane	0.5	µg/L	EPA 502.2
	1,4-Dichlorobenzene	0.5	µg/L	EPA 502.2
	2,2-Dichloropropane	0.5	µg/L	EPA 502.2
	2-Chlorotoluene	0.5	µg/L	EPA 502.2
	4-Chlorotoluene	0.5	µg/L	EPA 502.2
	4-Isopropyltoluene	0.5	µg/L	EPA 502.2
	Benzene	0.5	µg/L	EPA 502.2
	Bromobenzene	0.5	µg/L	EPA 502.2
	Bromochloromethane	0.5	µg/L	EPA 502.2
	Bromodichloromethane	0.5	µg/L	EPA 502.2
	Bromoform	0.5	µg/L	EPA 502.2
	Bromomethane	0.5	µg/L	EPA 502.2
	Carbon tetrachloride	0.5	µg/L	EPA 502.2
	Chlorobenzene	0.5	µg/L	EPA 502.2
	Chloroethane	0.5	µg/L	EPA 502.2
	Chloroform	0.5	µg/L	EPA 502.2
	Chloromethane	0.5	µg/L	EPA 502.2
	cis-1,2-Dichloroethene	0.5	µg/L	EPA 502.2
	cis-1,3-Dichloropropene	0.5	µg/L	EPA 502.2
	Dibromochloromethane	0.5	µg/L	EPA 502.2
	Dibromomethane	0.5	µg/L	EPA 502.2
	Dichlorodifluoromethane	0.5	µg/L	EPA 502.2
	Ethyl benzene	0.5	µg/L	EPA 502.2
	Hexachlorobutadiene	0.5	µg/L	EPA 502.2
	Isopropylbenzene	0.5	µg/L	EPA 502.2
	m + p Xylene	0.5	µg/L	EPA 502.2
	Methyl tert-butyl ether (MTBE)	1	µg/L	EPA 502.2
	Methylene chloride	0.5	µg/L	EPA 502.2
	Naphthalene	0.5	µg/L	EPA 502.2
	n-Butylbenzene	0.5	µg/L	EPA 502.2
	n-Propylbenzene	0.5	µg/L	EPA 502.2
	o-Xylene	0.5	µg/L	EPA 502.2
	sec-Butylbenzene	0.5	µg/L	EPA 502.2
	Styrene	0.5	µg/L	EPA 502.2
	tert-Butylbenzene	0.5	µg/L	EPA 502.2
	Tetrachloroethene	0.5	µg/L	EPA 502.2
	Toluene	0.5	µg/L	EPA 502.2
	trans-1,2-Dichloroethene	0.5	µg/L	EPA 502.2
	trans-1,3-Dichloropropene	0.5	µg/L	EPA 502.2
	Trichloroethene	0.5	µg/L	EPA 502.2
	Trichlorofluoromethane	0.5	µg/L	EPA 502.2
	Vinyl chloride	0.5	µg/L	EPA 502.2

Appendix B
Maximum Contaminant Levels and Article 19 Objectives

Table B-1. Inorganic Parameters

						Article 19 Objectives	
		Primary	Secondary MCLs			Monthly	10 year
Parameter	Units	MCL	Recommended	Upper	Short Term	Average	Average
Asbestos	MFL a/	7					
Conductivity (Specific Conductance)	μS/cm		900	1600	2200		
Chloride	mg/L		250	500	600	110	55
Nitrate as NO3	mg/L	45					
Nitrate + Nitrite sum as N	mg/L	10					
Nitrite as N	mg/L	0.4					
Sodium	% b/					50	40
Sulfate	mg/L		250	500	600		
Total Dissolved Solids	mg/L		500	1000	1500	440	220
Total Hardness as CaCO3	mg/L					180	110

a/ Million Fibers per Liter: MCL for fibers exceeding 10 um in length.
b/ Percentage of cationic composition

Table B-2. Minor Elements

	mg/L		
	Article 19 Objectives	Primary	Secondary
Minor Element	Maximum	MCL	MCL
Aluminum		1	0.2
Antimony		0.006	
Arsenic	0.05	0.05	
Barium		1	
Beryllium		0.004	
Boron	0.6 b/		
Cadmium		0.005	
Chromium		0.05	
Hexavalent Chromium	0.05		
Copper	3.0		1.0
Cyanide		0.15	
Fluoride	1.5	2	
Iron			0.3
Iron+Manganese	0.3		
Lead	0.1		
Manganese			0.05
Mercury		0.002	
Nickel		0.1	
Selenium	0.05	0.05	
Silver			0.1
Thallium		0.002	
Zinc	15		5.0

Table B-3. Organic Chemicals

Volatile Organic Chemicals (VOCs)	MCL mg/L	Non-Volatile Synthetic Organic Chemicals	MCL mg/L
Benzene	0.001	Alachlor	0.002
Carbon Tetrachloride	0.0005	Atrazine	0.001
1,2-Dichlorobenzene	0.6	Bentazon	0.018
1,4-Dichlorobenzene	0.005	Benzo(a)pyrene	0.0002
1,1 -Dichloroethane	0.005	Carbofuran	0.018
1,2-Dichloroethane	0.0005	Chlordane	0.0001
1,1 -Dichloroethylene	0.006	2,4-D	0.07
cis- 1,2-Dichloroethylene	0.006	Dalapon	0.2
trans- 1,2-Dichloroethylene	0.01	Dacthal (DBCP)	0.0002
Dichloromethane	0.005	Di(2-ethylhexyl)adipate	0.4
1,2-Dichloropropane	0.005	Di(2-ethylhexyl)phthalate	0.004
1,3-Dichloropropene	0.0005	Dinoseb	0.007
Ethylbenzene	0.3	Diquat	0.02
Methyl tertiary-butyl ether (MtBE) c/	0.013	Endothall	0.1
Monochlorobenzene	0.07	Endrin	0.002
Styrene	0.1	Ethylene Dibromide (EDP)	0.00005
1,1,2,2-Tetrachloroethane	0.001	Glyphosate	0.7
Tetrachloroethylene	0.005	Heptachlor	0.00001
Toluene	0.15	Heptachlor Epoxide	0.00001
1,2,4-Trichlorobenzene	0.005	Hexachlorobenzene	0.001
1,1,1 -Trichloroethane	0.2	Hexachlorocyclopentadiene	0.05
1,1,2-Trichloroethane	0.005	Lindane	0.0002
Trichloroethylene	0.005	Methoxychlor	0.03
Trichlorofluoromethane	0.15	Molinate	0.02
1,1,2-Trichloro- 1,2,2-Trifluoroethane	1.2	Oxamyl	0.05
Vinyl Chloride	0.0005	Pentachlorophenol	0.001
Xylenes	1.750 a/	Picloram	0.5
		Polychlorinated Biphenyls	0.0005
		simazine	0.004
		Thiobencarb b/	0.07
		Toxaphene	0.003
		2,3,7,8-TCDD (Dioxin)	3 x 10-8
		2,4,5-TP (Silvex)	0.05

a/ MCL is for either a single isomer or the sum of the isomers.

b/ Secondary MCL=0.001 mg/L mg/L

Appendix C

April 16, 2002

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Title 22 Water Quality Monitoring of Lake Del Valle

Introduction

In order to comply with Chapter 15, the California Domestic Water Quality and Monitoring regulations, in Title 22 of the California Code of Regulations, State Water Contractors receiving South Bay Aqueduct water requested the Department of Water Resources (DWR) to conduct a water quality sampling program for Lake Del Valle. Lake Del Valle is a water supply storage reservoir off the South Bay Aqueduct. DWR collected samples for metals, minerals, nutrients, organic chemicals, radionuclides, organic matter, and physical parameters.

This report is a compilation and assessment of the Title 22 water quality monitoring data from Lake Del Valle. Monitoring began in November 2000 and continued each quarter completing one year of monitoring on August 2001. Samples were collected at the Lake's outlet (Station No. DV001000) at two sampling depths of 0.5 and 4 meters to give a representation of the constituents' concentrations at the point of release to the South Bay Aqueduct for delivery to water treatment facilities. The objectives of this study were to identify concentrations of various water quality constituents, and to assess the relative quality of Lake Del Valle as a source water by comparing concentration data to State Drinking Water Standards as regulated by the CA Department of Health Services (CDHS).

Description of Study Area

Lake Del Valle is located in Arroyo Del Valle, 11 miles south of the City of Livermore. Figure 1 provides a general location map of Lake Del Valle. The Lake was created to provide recreation, fish and wildlife enhancement, flood control for Alameda Creek, and regulatory storage for a portion of the water delivered through the South Bay Aqueduct. The 235-foot high Del Valle Dam impounds a reservoir with a total gross capacity of 77,100 acre-feet. With a surface area of 1,060 acres and a shoreline of 16-miles, the Lake provides numerous recreational opportunities. Operated by the East Bay Regional Park District, Lake Del Valle's 5,200 acre recreation area offers swimming, boating, fishing, biking, hiking, windsurfing, and camping. Swimming is permitted only at two designated beach

locations, personal watercrafts are not allowed, and the maximum boat speed limit is 10 miles per hour.

Lake Del Valle and its watershed lie in mostly undeveloped land. Major land uses include cattle grazing throughout the watershed and recreation on and around Lake Del Valle. Although Lake Del Valle has little development in its watershed, there are several potential sources of contamination to its water. Potential sources of contamination include body contact recreation and boating, cattle grazing and livestock production, waste treatment facilities, and agricultural crop production. The "2001 California State Water Project Watershed Sanitary Survey" has an in-depth description of all these potential contaminating sources.

Water supply releases from Lake Del Valle usually begin in September to provide capacity for flood control. The reservoir is refilled by June but this pattern may change as demand increases. During the wet season, natural watershed inflows exceeding downstream water rights may be impounded. Additional water is pumped from the South Bay Aqueduct into the Lake to maintain the reservoir at 40,000 acre-feet during the summer. Water can be released to supply State Water Project contractor needs on the South Bay Aqueduct, to meet stream flow requirements in Arroyo Valle, or to recharge groundwater in Livermore Valley.

During the water quality monitoring, water supply inflows into Lake Del Valle were divided into State Water Project water via the South Bay Aqueduct and natural inflows from Arroyo Valle Creek. Over the 4 quarters of monitoring, SWP inflows ranged from 22.8 to 94 percent of the total inflows and Arroyo Valle Creek inflows ranged from 6 to 77.2 percent.

Methods

Sampling was conducted at Lake Del Valle Dam (Station No. DV001000) from November 2000 to August 2001. Surface and depth samples of 0.5 and 4 meters, respectively, were sampled to give a representation of the constituents' concentrations of the water that would be delivered for domestic water treatment.

In order to obtain samples from the field that are the best representation of water quality conditions at Lake Del Valle, Delta Field Division staff took all the proper field quality assurance to prevent and minimize changes that could affect the concentration of constituents being analyzed. Samples were collected using a Van Dorn sampler rinsed with laboratory prepared distilled water before each sample. Samples requiring filtration were filtered in the field after collection with a 0.45-micron Gelman capsule filter. Samples were then transported in an ice chest at 4 ºC to DWR's Bryte Chemical Laboratory in West Sacramento River, CA within 24 hours of collection. Radiological samples were shipped overnight to FGL Environmental Laboratory in Santa Paula, CA.

Delta Field Division staff filtered many of the inorganic chemical samples to stay in accordance to Title 22 monitoring requirements. According to CDHS' engineers concerning Title 22 water quality monitoring, only dissolved metal analysis is used for raw water samples and total analysis for treated effluent samples. Title 22 requirements state that inorganic chemical monitoring is to be conducted within the distribution system. Since this was a raw water examination, DWR used a dissolved metal analysis, which is indicative of a treated effluent sample.

To ensure there was not any contamination coming from field equipment, Field Blanks were collected at each quarterly sample run. These samples are used to determine if any steps during the sample collection, processing, or transportation altered the concentration of the sample water.

All organic and inorganic chemical analyses were performed using EPA approved methods. Bryte Chemical Laboratory is certified to perform chemical analysis by DHS' Environmental Laboratory Accreditation Program. In addition, quality assurance in the laboratory followed all standard procedures for the various EPA chemical methods including laboratory control samples to evaluate and document data quality.

Results

This section is a tabulated summary of the analytical results from monitoring conducted at Lake Del Valle from November 2000 to August 2001. Each of the tables indicate the constituent analyzed, the range (from minimum to maximum concentration) over the two depths sampled, and an overall yearly average.

Metals

Of the 16 metals sampled, only barium, total chromium, copper, and nickel were found in concentrations greater than their respective detection limits. Table 1 summarizes all metals analyzed over the 4 quarters of sampling. All detected metals were considerably lower than their respective maximum contaminant levels (MCL).

Delta Field Division staff filtered all metals in the field to give a representative concentration of the metal after treatment operations. According to Department of Health Services' staff, only dissolved metal analysis is used for raw water samples and total metal analysis for treated effluent samples for the purposes of Title 22 water quality monitoring.

As of March 2001, DWR's Bryte Chemical Laboratory tightened its reporting limits for total and hexavalent chromium from 0.005 to 0.001 mg/L and 0.001 to 0.0002 mg/L, respectively. With the lowered detection limit for hexavalent chromium, there was not a positive detection in any sample analyzed.

Minerals

All minerals and other inorganic constituents analyzed in this study are summarized in Table 2. Of all the minerals and other various inorganic constituents sampled only two had a primary MCL: arsenic and nitrate. Arsenic had a concentration range of 0.002 to 0.003 mg/L, which was well below its MCL. Nitrate had a concentration range of < 0.1 to 0.8 mg/L with a yearly average of 0.5 mg/L. All other minerals analyzed were considered to be within normal surface water parameters. A few constituents had secondary MCLs, such as chloride and sulfate, but were well below these standards.

Nutrients

All nutrients sampled are summarized in Table 3. The nutrients detected were within the acceptable levels found in natural water bodies. Out of the five

nutrients monitored, only Nitrate+Nitrite had a primary MCL. The yearly average of Nitrate+Nitrite of 0.09 mg/L was well below its MCL.

Organic Matter and Physical Parameters

Table 4 summarizes the organic matter and physical parameters analyzed in this study. Over the depths sampled in the quarterly monitoring total organic carbon (TOC) ranged from 4.1 to 6.4 mg/L, with the higher concentrations occurring during the rainy part of the year. In addition, the dissolved organic carbon (DOC) had concentrations ranging from 4.0 to 4.3 mg/L. Most typical natural water bodies have organic concentrations, without anthropogenic influences, less than 5 mg/L. However, the Sacramento River/San Joaquin River Delta water as measured at Banks Pumping Plant can range from 2.9 to 8.0 mg/L and higher during large runoff events.

With the current Stage 1 Disinfectants and Disinfection Byproducts Rule, treatment facilities along the South Bay Aqueduct will be required to remove a specified percentage of TOC. This TOC percent removal will be based on the source water's alkalinity, as TOC removal is generally more difficult in higher alkalinity waters. With Lake Del Valle having an alkalinity range of 126 to 148 mg/L as $CaCO_3$ and TOC of 4.1 to 6.4 mg/L, during this year of monitoring, there could be a required TOC reduction of 25 percent depending on time of year and actual levels measured at the treatment facilities.

Physical parameters such as turbidity and total suspended solids were very low throughout the sampling year. Turbidity ranged from 1.6 to 5.0 NTUs.

Organic Chemicals

As required in the Title 22 regulations, samples were collected for both volatile and synthetic organic chemicals. Volatile organic chemicals were not present in the lake at detectable levels with the exception of MTBE and toluene. In addition, the synthetic organic chemicals were also not detected in the lake at reportable levels. Table 5 summarizes the organic chemicals that had any positive detection levels. Appendix A provides the complete list of organic chemicals analyzed in this study as well as presenting all raw water quality data.

MTBE had a concentration range of < 1.0 to 1.7 μg/L and a yearly average of 1.0 μg/L. On the other hand, toluene had a concentration range of < 0.5 to 1.1 μg/L and a yearly average of < 0.5 μg/L. MTBE is a chemical oxygenate that is added to fuel to reduce air pollution and toluene is used in the manufacture of gasoline. Although MTBE and toluene have had positive detections, their concentrations are well below their respective MCLs. The MTBE and toluene concentrations are likely contributed by two-stroke gasoline engines discharging a fuel/oil mixture. DWR's report, "Assessment of MTBE in State Water Project Reservoirs" has well documented the occurrence of MTBE and recreational boat use. During this assessment in 1997, MTBE at Station No. DV001000 was detected in 92 percent of the samples collected and concentrations ranged from < 1.0 to 4.8 μg/L with an average concentration of 2.5 μg/L. Compared to the MTBE data of this report, there was a 64 percent decline in concentration.

With the strong relationship between MTBE concentrations and recreational boat use, East Bay Regional Park District has replaced the fuel for the marina boat fleet and the park's gasoline supplies with MTBE free fuels. DWR Water Quality

staff believe the use of MTBE free gasoline in the rental boat fleet has significantly reduced concentrations in the Lake since the rental fleet contributes to about 30-50% of the boat use.

Radionuclides

The radiological constituents analyzed are presented in Table 6. The natural radioactive parameters sampled included total radium-226 and uranium. Both constituents had very low concentrations. The man-made radioactive parameters sampled included gross beta particle activity, tritium, and strontium-90. These constituents were all well below their respective MCLs. In addition, to meet the future Radon Rule, radon-222 was sampled. Radon is a naturally occurring radioactive gas formed from the decay of uranium-238, most often associated with groundwater. The proposed Radon MCL is 300 pCi/L and the yearly average for Lake Del Valle was determined to be 1.78 pCi/L.

Bacteriological Constituents

Besides sample collection for organic and inorganic chemicals, this sampling program also included coliform bacteria and *E. coli*. All bacteriological analysis was performed using the multiple-tube fermentation technique (SM18; 9221 B&E Modified Mug). Table 7 summarizes these results. Lake Del Valle concentrations for total and fecal coliform ranged from < 2 to 110 MPN/100 mL and < 2 to 24 MPN/100 mL, respectively. For a raw water source, these concentrations are very low. According to DHS guidance manuals as the level of total coliform contamination increases the mandatory log removal and inactivation for Giardia cysts and viruses increases. If the monthly total coliform average stays below a 1,000 MPN/100 mL threshold than the treatment facility will only have treatment requirements of 3 and 4-log removals of Giardia cysts and viruses, respectively.

Table 1. Metals analyzed from Lake Del Valle at 0.5 and 4 meter sampling depths.

Metals (mg/L)	Range at 0.5 m Depth (min to max)		Range at 4 m Depth (min to max)		Yearly Average
Dissolved Aluminum	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Dissolved Antimony	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Dissolved Barium	0.06	0.06	0.06	0.06	0.06
Dissolved Beryllium	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Dissolved Cadmium	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Dissolved Chromium, total*	0.004	0.01	< 0.005	0.01	0.007
Dissolved Chromium, hexavalent**	< 0.0002	< 0.001	< 0.0002	< 0.0002	< 0.0002
Dissolved Copper	0.001	0.004	0.001	0.004	0.003
Dissolved Iron	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Dissolved Lead	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Dissolved Manganese	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Dissolved Mercury	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Dissolved Nickel	0.001	0.002	0.001	0.002	0.001
Dissolved Selenium	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Dissolved Silver	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Dissolved Zinc	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005

Notes:
* - DWR's Bryte Lab has changed the detection limit from < 0.005 to < 0.001 mg/L
** - DWR's Bryte Lab has changed the detection limit from < 0.001 to < 0.0002 mg/L

Table 2. Minerals from Lake Del Valle at 0.5 and 4 meter sampling depths.

Minerals (mg/L unless otherwise noted)	Range at 0.5 m Depth (min to max)		Range at 4 m Depth (min to max)		Yearly Average
Conductance, EC (μS/cm)	431	461	432	460	444
Dissolved Arsenic	0.002	0.003	0.002	0.003	0.002
Dissolved Boron	0.2	0.2	0.1	0.2	0.2
Dissolved Bromide	0.06	0.1	0.08	0.09	0.08
Dissolved Calcium	27	38	27	37	32
Dissolved Chloride	27	36	27	36	31
Dissolved Fluoride	0.1	0.1	0.1	0.1	0.1
Dissolved Magnesium	18	23	17	22	20
Dissolved Nitrate	< 0.1	0.8	< 0.1	0.8	0.5
Dissolved Sodium	28	31	27	31	30
Dissolved Sulfate	42	46	42	46	44
Hardness (mg/L as $CaCO_3$)	142	190	140	183	162
Total Alkalinity (mg/L as $CaCO_3$)	126	148	127	148	139
Total Dissolved Solids	249	258	244	258	251

Table 3. Nutrients analyzed from Lake Del Valle at sample depths of 0.5 and 4 meters.

Nutrients (mg/L unless otherwise noted)	Range at 0.5 m Depth (min to max)		Range at 4 m Depth (min to max)		Yearly Average
Dissolved Ammonia (as N)	< 0.01	0.04	< 0.01	0.04	0.01
Dissolved Nitrite + Nitrate (as N)	< 0.01	0.2	< 0.01	0.2	0.09
Ortho-phosphate (as P)	< 0.01	0.01	< 0.01	< 0.01	< 0.01
Total Kjeldahl Nitrogen (as N)	0.3	0.9	0.4	0.6	0.5
Total Phosphorus	< 0.01	0.4	0.02	0.1	0.05

Table 4. Organic matter and physical parameters analyzed from Lake Del Valle.

Other Constituents	Range at 0.5 m Depth (min to max)		Range at 4 m Depth (min to max)		Yearly Average
Dissolved Organic Carbon (mg/L as C)	4.0	4.3	4.0	4.3	4.1
Total Organic Carbon (mg/L as C)	4.1	5.8	4.2	6.4	4.9
pH (pH units)	8.1	8.8	8.1	8.8	8.4
Temperature, Water (Field) (°C)	9.1	22.7	9.1	22.5	15.4
Total Suspended Solids (mg/L)	< 1	3	< 1	3	2
Turbidity (NTU)	1.6	4.0	1.9	5.0	3.1
Volatile Suspended Solids (mg/L)	< 1	2	< 1	2	< 1

Table 5. Organic chemicals with positive detections analyzed from Lake Del Valle.

Organic Chemicals (µg/L)	Range at 0.5 m Depth (min to max)		Range at 4 m Depth (min to max)		Yearly Average
MTBE	< 1.0	1.4	< 1.0	1.7	1.0
Toluene	< 0.5	1.1	< 0.5	< 0.5	< 0.5

Table 6. Radiological constituents analyzed from Lake Del Valle.

Radionuclides (pCi/L)	Range at 0.5 m Depth (min to max)		Range at 4 m Depth (min to max)		Yearly Average
Gross Beta Particle Activity	ND	3.28	2.70	5.67	2.77
Radon-222	ND	4.31	ND	2.34	1.78
Total Radium-226	ND	0.3	ND	0.4	0.1
Total Strontium-90	ND	0.45	ND	0.49	0.15
Total Tritium	ND	248	ND	260	107
Uranium	ND	2.83	ND	2.34	0.89

Notes:
ND = Not Detected at/or above method detection limit.

Table 7. Bacteriological parameters analyzed from Lake Del Valle.

Coliform Bacteria (MPN/100 mL)	Range at 0.5 m Depth (min to max)	Range at 4 m Depth (min to max)	Yearly Average
Total Coliform	< 2 50	< 2 110	19
Fecal Coliform	< 2 8	< 2 24	4
E. coli	< 2 8	< 2 24	4

Conclusions

With over 200 constituents sampled, there were no raw water violations of primary or secondary MCLs. Volatile and synthetic organic chemicals were all below their detection levels except for MTBE and toluene. Although these chemicals were detected above their detection levels, they were considerably below their MCLs. These two constituents are well known to be contamination from watercraft. Authorities representing recreation on Lake Del Valle have taken measures to reduce contamination.

In addition, many of the inorganic chemicals, such as the various metals and minerals, had positive detections but were considered to be within normal parameters for a surface water body. Radionuclides were also sampled per Title 22 requirements but also were well below their MCLs.

Based upon the water quality monitoring conducted in the past year and all historical records, Lake Del Valle can be classified as an excellent source of water for domestic water supply. It is of consistent quality and can be easily treated to produce clean water that meets and exceeds all applicable standards. In addition, it is generally of better quality than Delta water.

References

California Department of Health Services. 1991. *Surface Water Treatment Staff Guidance Manual*. Office of Drinking Water, Department of Health Services. Sacramento River, CA. May 15.

California Department of Water Resources. 1997. *Water Quality Assessment of the State Water Project, 1994-1995*. Division of Operations and Maintenance, Water Quality Section, Sacramento River, CA. June.

_____ 1998. *Water Quality Field Manual for the State Water Project*. Division of Operations and Maintenance, Water Quality Section, Sacramento River, CA. January.

_____ 1999. *Assessment of MTBE in State Water Project Reservoirs*. Division of Operations and Maintenance, Water Quality Section, Sacramento River, CA. April.

_____. 2001. *California State Water Project Watershed Sanitary Survey Update Report 2001*. Division of Planning and Local Assistance, Municipal Water Quality Investigations Program, Sacramento River, CA. December.

Appendix D
Explanation of a ternary diagram

Table D-1 shows the anionic mineralogy of samples collected around the Delta in November 2000. The table also shows the mineralogy of seawater.

The anions plotted in a ternary diagram show different water types (Figure D-1). The Sacramento River is bicarbonate-dominant because bicarbonate makes up more than 50 percent of the anions. Seawater is chloride-dominant while the San Joaquin River exhibits an anionic content that is not dominated by any one anion. In the San Joaquin River sample, chloride made up 44 percent of the total anionic content followed by sulfate and bicarbonate with 28 percent.

Table D-1. Anionic mineralogy at several sites around the Delta in November 2000 along with seawater (meq/L=milliequivalents per liter)

	Banks Pumping Plant			San Joaquin River			Sacramento River			Seawater		
Anion	mg/L	meq/L	% of Total	mg/L	meq/L	% of Total	mg/L	meq/L	% of Total	mg/L	meq/L	% of Total
Chloride	117	3.3	66	87	2.45	44	5.4	0.15	11	19000	536	90
Bicarbonate	66	1.08	22	96	1.57	28	64	1.05	78	142	2.3	0.4
Sulfate	30	0.62	12	76	1.58	28	6.9	0.14	10	2700	56	9

Figure D-1. Ternary diagram with anionic data from Table D-1