

Water Quality in the State Water Project, 2002 and 2003

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

Cover photograph: Temporary rock barrier on Old River in the south Sacramento-San Joaquin Delta near the junction with West Canal. Objectives of the South Delta Temporary Barriers program are to:

- Increase water levels, circulation patterns, and water quality in the southern Delta area for local agricultural diversions, and
- Improve operational flexibility of the State Water Project to help reduce fishery impacts and improve fishery conditions.

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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
maf	million acre-feet
Mg	magnesium
Mn	manganese
MtBE	methyl <i>tertiary</i> -butyl ether
Na	sodium
NH ₄	ammonia
NO ₂	nitrite
NO ₃	nitrate
NTU	nephelometric turbidity unit
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
SWRCB	State Water Resources Control Board
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
VSS	volatile suspended solids

I. Executive Summary

Water quality in the California State Water Project (SWP) during 2002 and 2003 was assessed in this report for trends and accordance with drinking water standards. State Water Project facilities include the Oroville complex, California Aqueduct, South Bay Aqueduct, North Bay Aqueduct, and four Southern California reservoirs. More than 30 water quality sampling stations are situated throughout the SWP. Samples are analyzed for parameters such as minerals, minor elements, organic carbon, pesticides, and nutrients. Trend analysis in this report focused on parameters-of-concern such as salinity, organic carbon, and bromide.

California Aqueduct and South Bay Aqueduct

Water is exported from the south Sacramento-San Joaquin Delta (south Delta) and conveyed down the California Aqueduct and South Bay Aqueduct. Water quality in south Delta exports was relatively good during 2002, a dry water year, and better during 2003, an above normal water year. Salinity was low to moderate with the exception of the last five months of 2002 and the last three months of 2003. Seawater intrusion became evident during those months with conductivity and bromide reaching maximums of 671 $\mu\text{S}/\text{cm}$ and 0.47 mg/L, respectively. Regardless, all analyses for major minerals, nutrients, and organic chemicals in both aqueducts were below drinking water Maximum Contaminant Levels (MCLs). The minor element manganese was above the Secondary MCL in three samples from Devil Canyon Headworks. Secondary MCLs address taste, odor, or appearance characteristics of treated drinking water.

Median conductivity during the two years was 24% to 30% higher in the California Aqueduct south of Harvey O. Banks Pumping Plant. Most salt-related parameters including bromide exhibited the same trend. Salinity in the California Aqueduct increased downstream of Banks Pumping Plant due to releases from San Luis Reservoir and inputs from the Central Valley Project's (CVP's) Delta-Mendota Canal (DMC). Water from both sources enters O'Neill Forebay before flowing down the aqueduct at milepost 70.89 (O'Neill Forebay Outlet). Conductivity in San Luis Reservoir fluctuates within a narrow range that is more often higher than at Banks. Reservoir salinity is unintentionally maintained at higher levels due, in part, to: 1) reservoir filling during fall when seawater intrusion is usually prevalent, and 2) reservoir filling with water from the DMC which exhibits a statistically greater salt content than exports at Banks (DWR 2004B). The combined influence of reservoir releases and DMC inputs increased conductivity in the California Aqueduct south of O'Neill Forebay for over half of the months in 2002 and 2003.

Dissolved organic carbon (DOC) in the California Aqueduct and South Bay Aqueduct was relatively low to moderate during most of the two-year period with medians ranging from 2.8 to 3.1 mg/L. The exception was during January 2002 when DOC at Clifton Court Forebay, Banks Pumping Plant, O'Neill Forebay Outlet, and Check 21 increased to between 5.4 and 8.5 mg/L. The elevated DOC levels that month likely originated from a first-flush event in the San Joaquin River. The first major runoff event of the season during early January 2002 sent a slug of high-DOC water into south Delta waterways leading to the export sites. The elevated-DOC water never made it into the South Bay

Aqueduct because pumping at South Bay Pumping Plant had stopped during January and February 2002. Dissolved organic carbon in all other samples collected from both aqueducts during the two years was at or below 4.8 mg/L.

Sampling frequency for the gas additive methyl *tert*-butyl ether (MtBE) in the California Aqueduct and South Bay Aqueduct (including Lake Del Valle) was increased during 2002 and 2003. Of the 78 samples collected monthly over the two years, MtBE was detected above the reporting limit in two samples from Devil Canyon Headworks (1.4 and 3 µg/L) and two samples from Lake Del Valle (1.1 and 1.2 µg/L) – all below the Secondary MCL of 5 µg/L.

Total dissolved solids (TDS) in three monthly samples from the CVP's DMC were above the Recommended Secondary MCL of 500 mg/L. The high-salinity water originated from San Joaquin River inflows to the Delta. Elevated salinity from the river was accompanied by bromide that reached a maximum 0.52 mg/L – slightly higher than the maximum 0.47 mg/L detected at Banks Pumping Plant during the two-year period. Water pumped into O'Neill Forebay from the DMC accounted for about 30% of the total from south Delta exports during 2002 and 2003.

North Bay Aqueduct

Turbidity in the North Bay Aqueduct at Barker Slough Pumping Plant was relatively high during most of 2002 and 2003. Values ranged from 4 to 88 nephelometric turbidity units (NTU) with a median of 49 NTU. Salinity, chloride, and sulfate reached seasonal maximums in March of both years but remained below their respective MCLs. Bromide in all samples was below 0.1 mg/L. Monthly DOC ranged from 2.4 to 15.6 mg/L with a median of 3.15 mg/L. Dissolved organic carbon was elevated in four monthly samples collected in 2002 (5.4 to 15.6 mg/L) and three collected in 2003 (6.3 to 12.6 mg/L). Analyses for minor elements, nutrients, and organic chemicals were below existing MCLs for these parameters in treated drinking water. All monthly analyses for MtBE during the two-year period were below the reporting limit.

Oroville Complex and Upper Feather River Reservoirs

The Oroville complex includes Lake Oroville, Thermalito Forebay, and Thermalito Afterbay. Water quality in the Oroville complex and upper Feather River reservoirs was characteristically excellent with less-than-detectable to low levels of minerals, most minor elements, and nutrients. Several samples collected near a marina in Lake Oroville contained MtBE at levels just above the Secondary MCL of 5 µg/L. Manganese in several samples from Lake Davis and Thermalito Afterbay was above the Secondary MCL of 0.05 mg/L.

Special Studies

Ultraviolet absorbance at 254 nanometers and DOC were well correlated at Banks Pumping Plant with an r^2 of 0.94. The low cost and maintenance effort associated with continuous operation of ultraviolet spectrophotometers makes them practicable instruments for tracking DOC trends at Banks.

Conductivity in south Delta exports increased due to spring-pulse flows in the San Joaquin River. Spring-pulse flows forced more water out of the Stockton Deep Water Ship Channel and into central Delta channels leading to the export sites from the north. The ship channel can function as a large repository of higher-salinity water from antecedent San Joaquin River inflows, agricultural drainage, and other saline inputs. During the spring-pulse period, a greater volume of this water is forced out of the ship channel from upstream flow increases in the San Joaquin River, becoming a larger component of cross-Delta flow than would normally commingle with lower-salinity water from the Sacramento River.

Nearly 100,000 acre-feet of Kern Fan groundwater was turned into the California Aqueduct during 2002 and 2003. Upstream-downstream organic carbon in the aqueduct decreased by as much as 2.5 mg/L with an overall load reduction of 16% during the eight months of groundwater turn-in activity.

II. Introduction

The Department of Water Resources manages various facilities to store and convey water to SWP contractors throughout California. Facilities include the Oroville complex, the California Aqueduct with its four terminus lakes in Southern California, and the North Bay and South Bay aqueducts (Figure 2-1). Most SWP water is exported from the Delta and delivered to municipal and industrial water supply contractors.

Water quality is routinely monitored at numerous stations throughout the SWP (Figure 2-1). The physical and chemical analyses are mandated in DWR's Water Supply Contracts (DWR 1965). Water quality monitoring is an important operational component of the SWP and the data generated is used to assess short- and long-term trends, impacts from emergencies like spills and pipe ruptures, influence of operations and hydrology, and the general suitability of SWP water for public consumption. The data are periodically assessed and disseminated with more exhaustive analyses performed in biennial reports.

Water quality data are also used by municipal contractors in their decision-making processes for water treatment. The data are necessary for contractors deliberating blending strategies with multiple raw water sources. Water from the Delta is routinely blended with other sources to meet drinking water goals or regulatory requirements for parameters such as salinity and trihalomethanes (SWRCB et al. 1991, Bookman-Edmonston Engineering, Inc. 1999, and DWR 2001). Drinking water must meet increasingly stringent numeric water quality criteria to protect public health.

Water quality in the SWP is kept under close watch by treatment plant operators for estimating coagulant and disinfectant dosages. Dosage adjustments are necessary on a real-time basis with fluctuating water quality conditions. Turbidity and organic carbon are consistently identified as two of the more problematic constituents for treatment plants using water from the Delta (SWRCB et al. 1991 and DWR 2001). Turbidity spikes require rapid treatment adjustments to maintain optimal removal of suspended solids. Upon disinfection, chlorine can combine with organic carbon to form unwanted compounds such as trihalomethanes. Trihalomethanes and other disinfection byproducts are considered carcinogens and tightly regulated by health agencies. Certain other parameters such as salinity, while not a major concern to human health, can pose their own set of issues for SWP contractors (Bookman-Edmonston Engineering, Inc. 1999). Salinity in drinking water, for instance, can:

1. Corrode plumbing and home appliances
2. Produce an undesirable taste
3. Limit use of recycled water for groundwater recharge or crop irrigation
4. Limit blending opportunities with other higher-salinity sources

Staff of the five field divisions in DWR's Division of Operations and Maintenance collect water samples, which they send to DWR's Bryte Laboratory for analysis. Samples are collected on the third Wednesday of each month at most aqueduct or reservoir stations. Analyses include minerals, minor elements, nutrients, organic chemicals, and disinfection byproduct precursors such as organic carbon and bromide. Station descriptions and water quality constituents analyzed are detailed in Appendix A.

Water quality data are compared to applicable State and federal drinking water MCLs. These numerical standards address the public health and aesthetic aspects of potable water. Maximum Contaminant Levels provide a benchmark with which to compare the relative quality of raw water in the SWP.

Water quality in south Delta exports to the California Aqueduct and South Bay Aqueduct was relatively good during 2002 and 2003. Salinity was low to moderate for most months of each year. Seawater intrusion – with the resulting elevation in salinity and bromide – was evident during the last five months of 2002 and the last three months of 2003. With the exception of one month, dissolved organic carbon in both aqueducts was 4.8 mg/L or less. North Bay Aqueduct exports exhibited relatively high levels of organic carbon and turbidity. Water quality in the Oroville complex and upper Feather River reservoirs was excellent, as usual, with non-detectable to low levels of minerals, nutrients, and most minor elements.

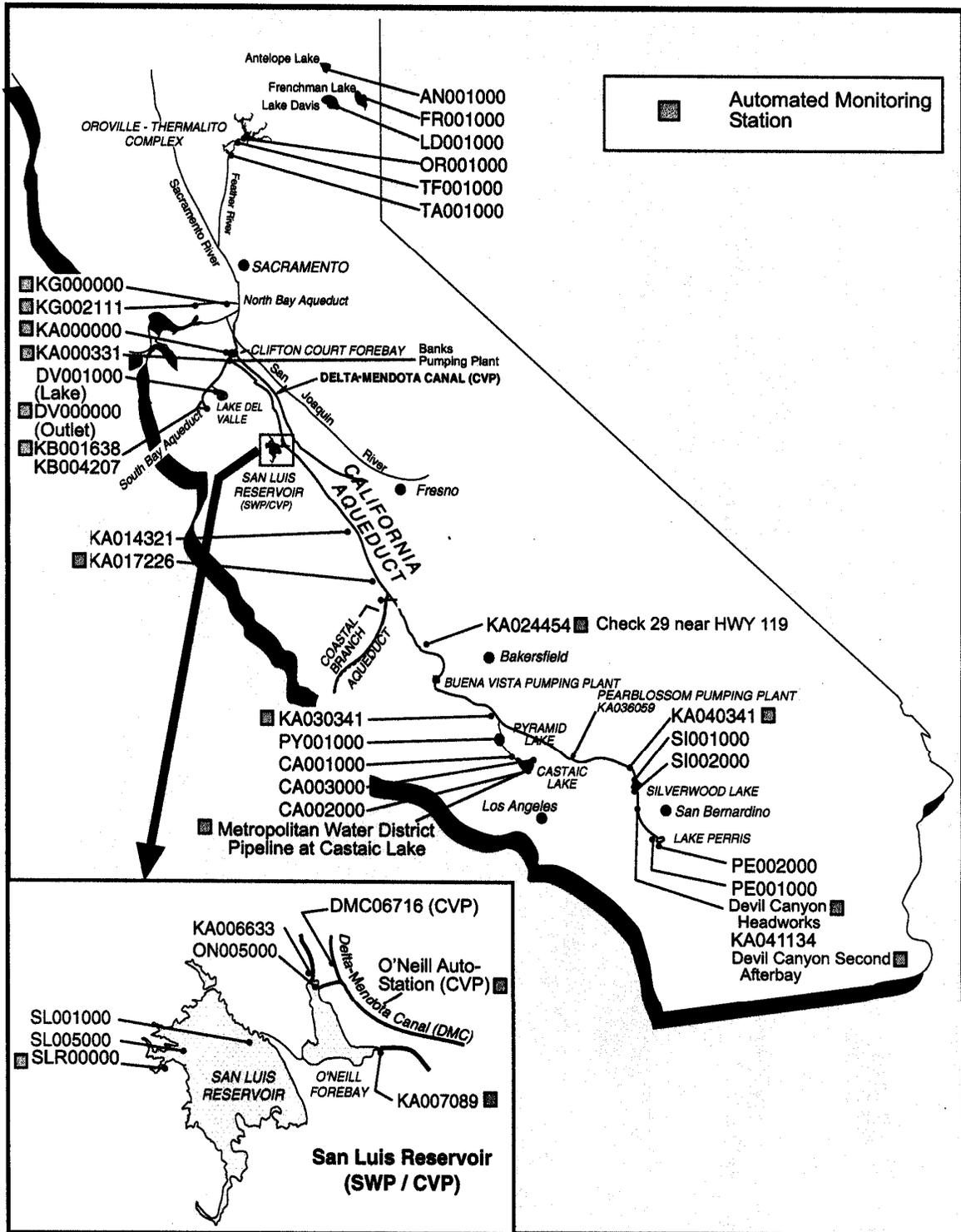


Figure 2-1. Water quality monitoring stations in the State Water Project. Station identification numbers are described in Appendix A.

III. California Aqueduct

Water from the south Delta is pumped into the California Aqueduct at Harvey O. Banks Pumping Plant. Pumpage at Banks Pumping Plant totaled 2.792 million acre-feet (maf) in 2002, a dry water year in the Sacramento Valley, and 3.548 maf in 2003, an above-normal water year. Pumping was characteristically highest during the winter and summer (Figure 3-1).

Major minerals and conventional parameters in the California Aqueduct during 2002 and 2003 are summarized in Table 3-1. Maximum Contaminant Levels for salinity, sulfate, chloride, and nitrate in treated drinking water were not exceeded (see Appendix B for MCLs).

Salinity was lower at Banks Pumping Plant compared to other stations farther south on the California Aqueduct. Median conductivity at Banks during the two years was 387 $\mu\text{S}/\text{cm}$ whereas at the downstream stations it was 24% to 30% higher ranging from 479 to 504 $\mu\text{S}/\text{cm}$ (Figure 3-2). Most salt-related parameters including bromide exhibited the same trend.

Salinity in the California Aqueduct increased downstream of Banks Pumping Plant due to releases from San Luis Reservoir and inputs from the Central Valley Project's (CVP's) Delta-Mendota Canal (DMC). Water from both sources enters O'Neill Forebay before flowing down the aqueduct at milepost 70.89 (O'Neill Forebay Outlet). Salinity in San Luis Reservoir fluctuates within a narrow range and is more often higher than at Banks. Reservoir salinity is unintentionally maintained at higher levels due, in part, to:

- Reservoir filling during fall when seawater intrusion is usually prevalent
- Reservoir filling with water from the DMC which exhibits a statistically greater salt content than exports at Banks (DWR 2004B)

The combined influence of reservoir releases and DMC inputs increased conductivity in the California Aqueduct south of O'Neill Forebay during a majority of the two-year period.

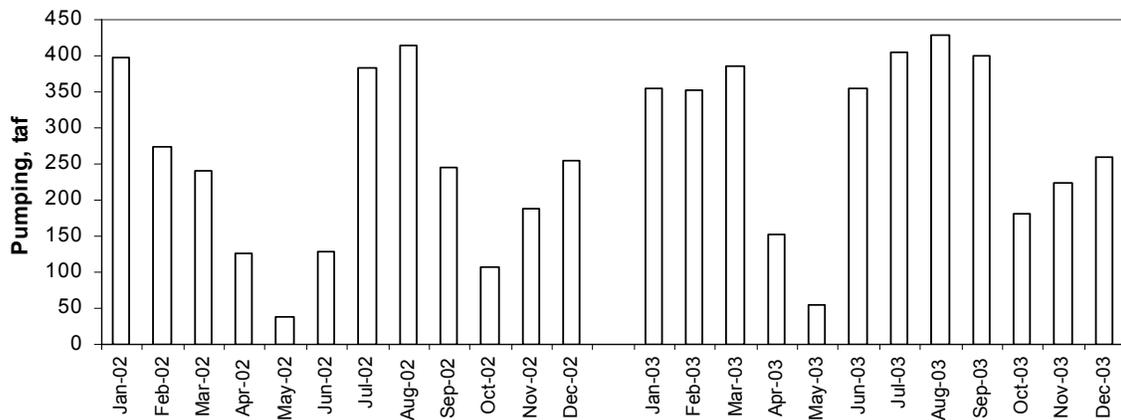


Figure 3-1. Monthly pumping at Banks Pumping Plant (thousand acre-feet)

Table 3-1. Summary of major minerals and conventional parameters in the California Aqueduct, 2002 and 2003

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 CaCO ₃	73	58	92	24	Conductivity	μS/cm	387	173	671	24
O'Neill Forebay Outlet	KA007089			81	67	92	24			486	276	661	24
Check 21	KA017226			81	65	92	27			488	317	624	27
Check 29	KA024454			82	66	97	27			504	277	675	27
Check 41	KA030341			82	65	97	25			496	280	638	25
Devil Canyon Headworks	KA041134			83	67	91	24			479	311	609	24
Banks PP	KA000331	Calcium	mg/L	18	11	23	24	Hardness	mg/L as CaCO ₃	96	52	112	24
O'Neill Forebay Outlet	KA007089			21	14	25	24			106	68	123	24
Check 21	KA017226			21	15	25	27			108	72	122	27
Check 29	KA024454			21	13	33	27			104	65	127	27
Check 41	KA030341			21	13	29	25			105	65	127	25
Devil Canyon Headworks	KA041134			22	15	25	24			105	75	118	24
Banks PP	KA000331	Chloride	mg/L	47	13	143	24	pH	pH units	6.6	5.9	7.8	24
O'Neill Forebay Outlet	KA007089			64	32	131	24			6.8	5.9	7.9	24
Check 21	KA017226			74	39	124	27			6.8	5.5	8	27
Check 29	KA024454			73	31	127	27			6.8	5.9	8.1	27
Check 41	KA030341			74	34	127	25			6.8	6.2	8.2	25
Devil Canyon Headworks	KA041134			71	40	118	24			6.9	6.1	7.9	24
Banks PP	KA000331	Magnesium	mg/L	12	6	16	24	TDS	mg/L	212	104	409	24
O'Neill Forebay Outlet	KA007089			13	9	16	24			287	167	397	25
Check 21	KA017226			13	9	16	27			288	189	388	28
Check 29	KA024454			13	6	16	27			290	167	412	27
Check 41	KA030341			13	8	17	25			277	170	384	25
Devil Canyon Headworks	KA041134			13	9	15	24			284	185	373	24
Banks PP	KA000331	Nitrate	mg/L as NO ₃	2.2	0.6	6.5	24	TSS	mg/L	8	2	44	24
O'Neill Forebay Outlet	KA007089			3.2	0.8	8.1	24			4	1	11	22
Check 21	KA017226			3.0	1.0	7.2	27			4	1	15	24
Check 29	KA024454			3.1	0.6	8.8	27			6	2	59	27
Check 41	KA030341			3.0	0.8	7.8	25			8	1	27	25
Devil Canyon Headworks	KA041134			3.0	0.9	5.3	24			2	<1	3	12
Banks PP	KA000331	Sodium	mg/L	34	14	81	24	Turbidity	NTU	11	3	39	24
O'Neill Forebay Outlet	KA007089			47	26	75	24			5	2	18	24
Check 21	KA017226			50	31	71	27			6	2	13	27
Check 29	KA024454			52	25	79	27			5	2	25	27
Check 41	KA030341			53	26	79	25			7	2	24	25
Devil Canyon Headworks	KA041134			50	30	73	24			2	<1	16	24
Banks PP	KA000331	Sulfate	mg/L	30	10	52	24	VSS	mg/L	2	<1	6	24
O'Neill Forebay Outlet	KA007089			43	18	54	24			1	<1	3	22
Check 21	KA017226			41	20	59	27			2	<1	3	24
Check 29	KA024454			40	16	55	27			2	<1	5	27
Check 41	KA030341			41	16	54	25			2	<1	5	24
Devil Canyon Headworks	KA041134			43	20	53	24			1	<1	2	8

Salinity at Banks Pumping Plant was generally highest toward the end of each year (Figure 3-3). The higher salinity was accompanied by an increase in chloride relative to sulfate (Figure 3-4) – an indication of seawater intrusion. Seawater intrusion from the Francisco Bay (or influence from waters with seawater-like characteristics) is evident when the chloride:sulfate ratio exceeds about 1.5. Pure seawater exhibits a chloride:sulfate ratio of 7 and can dramatically alter the mineralogical balance of freshwater even in very small amounts. This ratio at Banks was above 1.5 (range = 1.70 to 4.87) between July and December of both 2002 and 2003, suggesting seawater intrusion during 12 of 24 months.

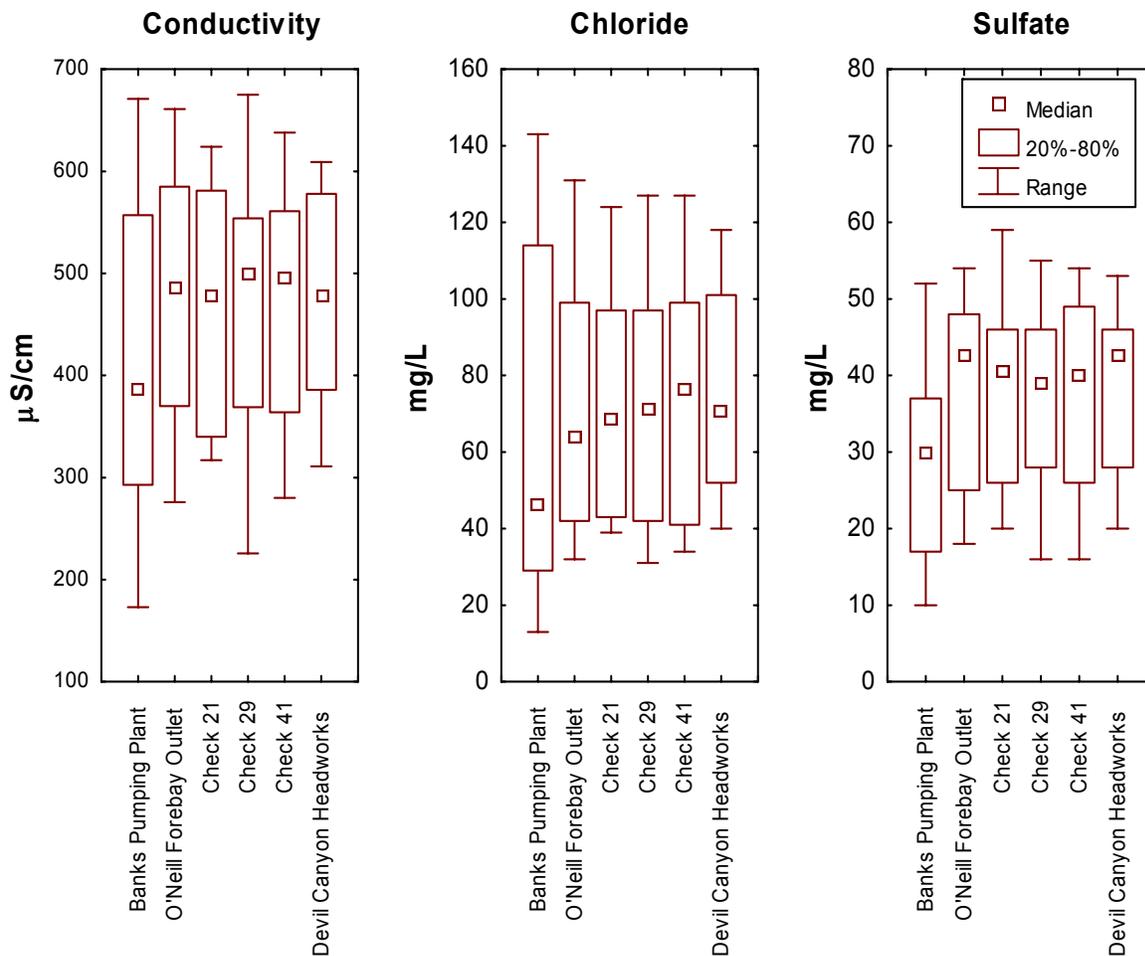


Figure 3-2. Conductivity, chloride, and sulfate in the California Aqueduct, 2002 and 2003

Seawater intrusion was less prevalent during 2002-03 than 2000-01 despite similar water supply conditions for both two-year periods. The chloride:sulfate ratio at Banks Pumping Plant exceeded 1.5 in 12 months of 2002-03 and 14 months of 2000-01 (Figure 3-5). Both two-year periods overlapped dry and above normal water years in the Sacramento Valley, yet seawater intrusion was more prevalent during 2000-01 than 2002-03. Evidence of seawater intrusion at Banks extended beyond fall and into January of both 2000 and 2001 whereas exports unaltered by seawater were apparent in January of 2002 and 2003 (Figure 3-5). While January is not considered a month when seawater intrusion is routine, specific hydrological and operational conditions can sometimes dictate the presence of intrusion indicators beyond the fall.

A rise in salinity at Banks Pumping Plant was observed during May of both 2002 and 2003 (Figures 3-3 and 3-4). The increase began a week or so following initiation of spring-pulse flows in the San Joaquin River. As a consequence of greater flow in the San Joaquin River during the spring-pulse months of April and May, more higher-salinity water in the Port of Stockton Deep Water Ship Channel was forced into the

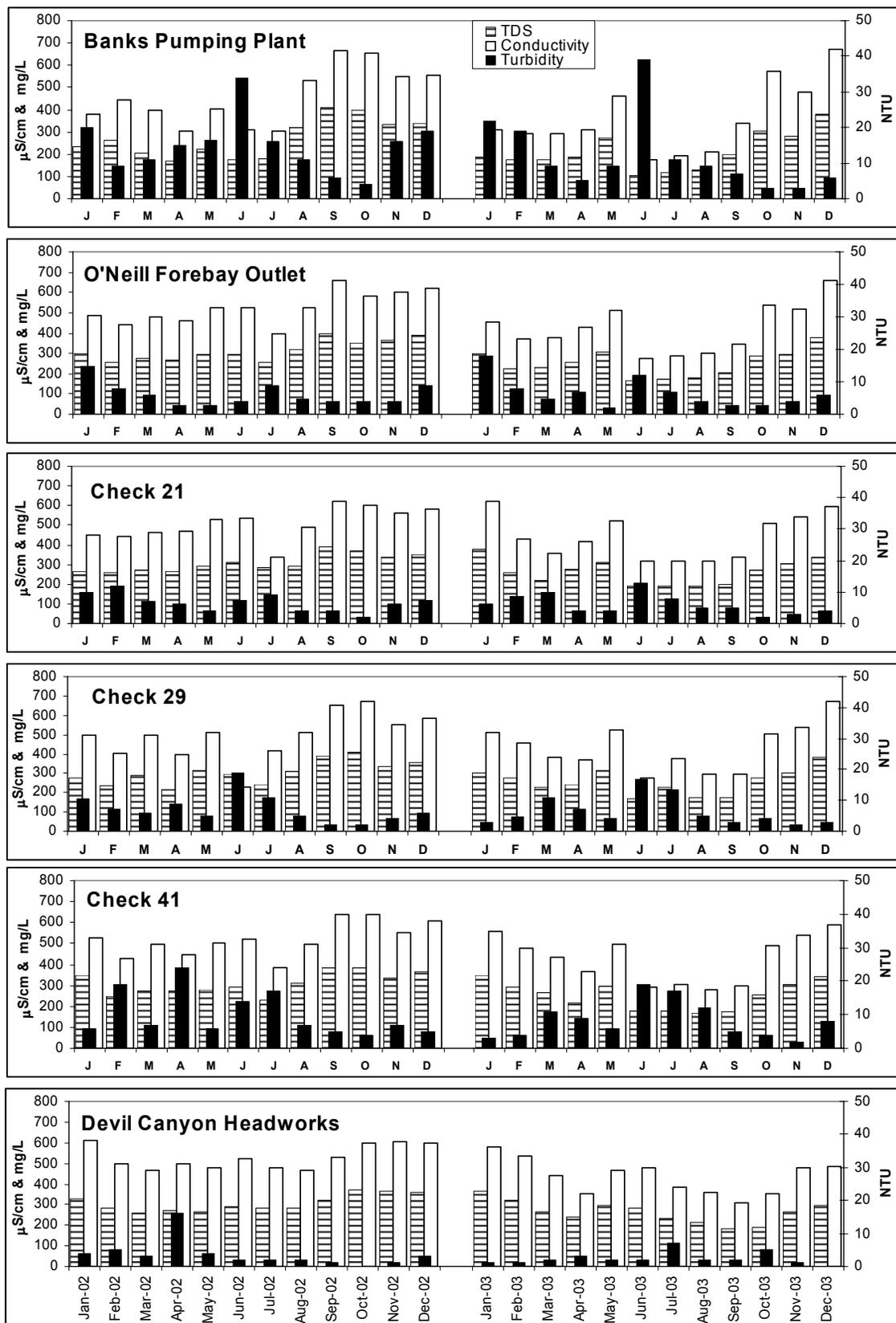


Figure 3-3. Monthly salinity and turbidity in the California Aqueduct. Turbidity values below the reporting limit (<1 NTU) were excluded from the graphs.

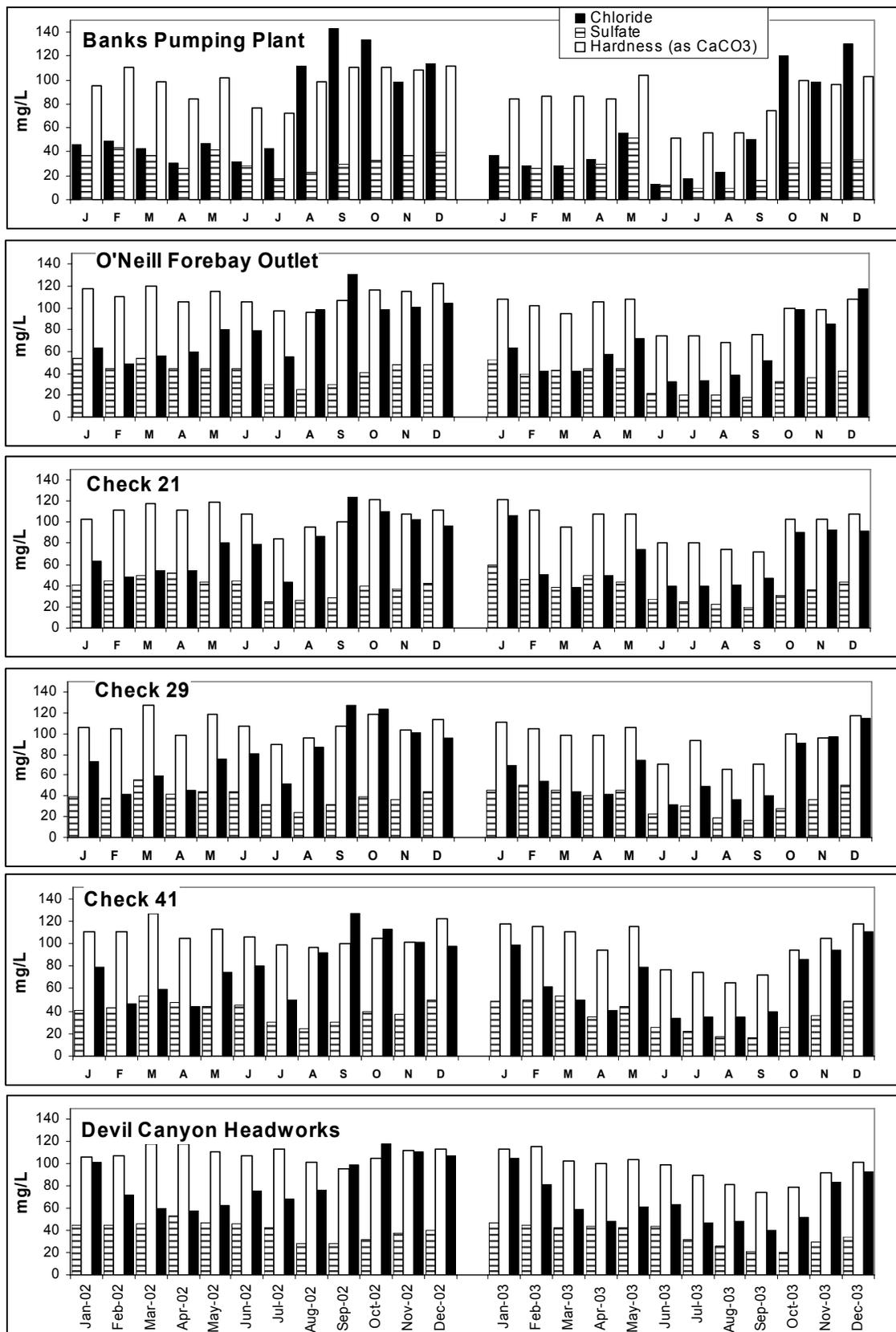


Figure 3-4. Monthly sulfate, chloride, and hardness in the California Aqueduct

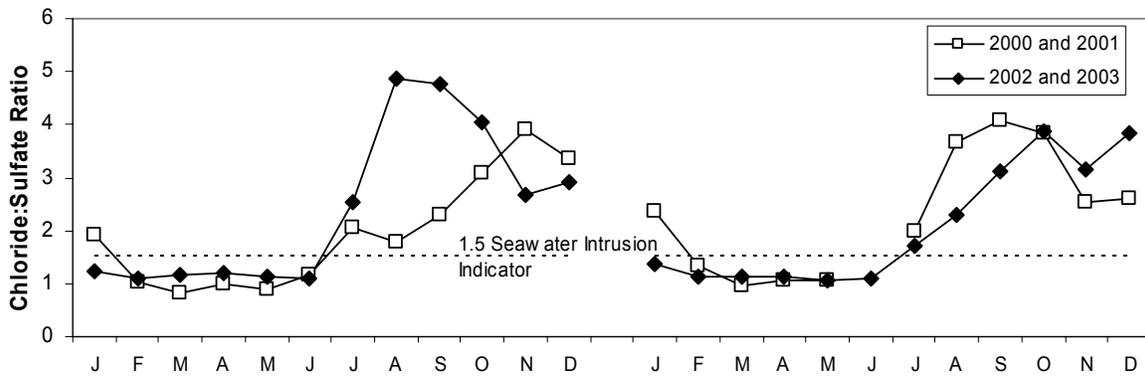


Figure 3-5. Chloride:sulfate ratios at Banks Pumping Plant. The 1.5 seawater intrusion indicator represents the upper 99% confidence interval for this ratio in the San Joaquin River, a major source of high salt in south Delta exports besides seawater intrusion.

central Delta, becoming a greater proportion of cross-Delta flow approaching the export sites from the north (see Special Studies). The significance of this aspect of the spring-pulse period was moderated by a reduction in pumping at Banks during the same period.

Annual average conductivity at Banks Pumping Plant extending back to 1968 – the first full year of California Aqueduct operation – is shown in Figure 3-6. During 2002, annual average conductivity was 458 $\mu\text{S}/\text{cm}$ and below the 75th percentile for historic conductivity at this station (Figure 3-6). The following year, annual average conductivity was below the historic median of 382 $\mu\text{S}/\text{cm}$ but above the 25th percentile of 321 $\mu\text{S}/\text{cm}$ (358 $\mu\text{S}/\text{cm}$).

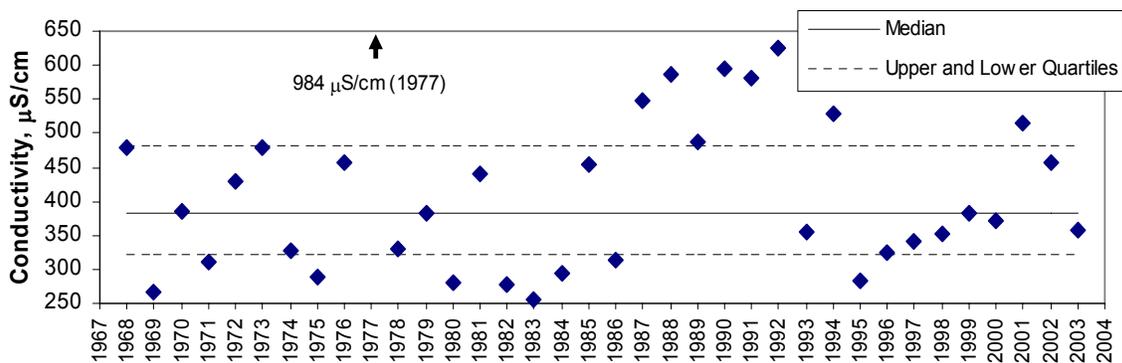


Figure 3-6. Annual average conductivity at Banks Pumping Plant, 1968 to 2003

Therefore, conductivity at Banks Pumping Plant during 2002 was higher than median historical conditions with a percentile of 0.68. As discussed, 2002 was classified as a dry water year in the Sacramento Valley. One manifestation of drier water years is higher salinity conditions in south Delta exports. Annual average conductivity at Banks is inversely correlated with Sacramento and San Joaquin valley water year hydrologic

indices (DWR 2004B). Water year 2003 was classified as above normal and salinity conditions at Banks were better-than-usual with an annual average conductivity percentile of 0.43.

Bromide, dissolved organic carbon (DOC), total organic carbon (TOC), and ultraviolet absorbance at 254 nanometers (UVA₂₅₄) in the California Aqueduct during 2002 and 2003 are summarized in Table 3-2. Bromide was most variable at Banks Pumping Plant ranging from 0.04 to 0.47 mg/L and least variable at Devil Canyon Headworks with a range of 0.12 to 0.38 mg/L (Figure 3-7). Similar to most salt-related parameters, median bromide increased with distance down the aqueduct. Bromide was generally highest towards the end of each year at most stations owing to seawater intrusion as discussed earlier (Figure 3-8).

Median DOC and TOC at all California Aqueduct stations ranged narrowly between 2.8 and 3.2 mg/L (Table 3-2 and Figure 3-7). The highest concentrations during the two-year period were detected in one sample each from Clifton Court Forebay, Banks Pumping Plant, O'Neill Forebay Outlet, and Check 21 in January 2002 (Figure 3-8). Levels of DOC and TOC in these samples ranged between 5.4 and 8.5 mg/L. Organic carbon concentrations in all other aqueduct samples during the two-year period were at or below 4.8 mg/L (DOC) or 5.2 mg/L (TOC).

The high organic carbon levels in the California Aqueduct during January 2002 can be explained by San Joaquin River hydrology and water quality. Figure 3-9 shows flow and DOC in the San Joaquin River at Vernalis from December 2001 to March 2002. Flow went from 1,800 cfs near the end of December 2001 to a maximum 6,000 cfs on January 4, 2002. The surge in flow was accompanied by an increase in DOC to 8 mg/L. This was the first major flow surge of the year in the San Joaquin Valley, constituting a first-flush event whereby residuals accumulated in the watershed from deposits during the dry season are flushed off-site in high concentrations with the season's first runoff event. The DOC loading spike would have inundated much of the south Delta with elevated-DOC water. The south Delta barriers are not installed in winter so flow from the San Joaquin River to the export sites via Old River and Grant Line Canal was unimpeded. Water from the San Joaquin River could also make it to the export sites from the north via Middle River, Victoria Canal, and West Canal. Runoff from the San Joaquin Valley has been implicated as a major source of elevated organic carbon levels in south Delta exports during winter (DWR 2005). Although flow in the San Joaquin River also spiked the following winter (2003), it peaked at 3,000 cfs with a maximum DOC of 6.6 mg/L, resulting in lower DOC loads entering the south Delta. The maximum DOC at Banks Pumping Plant that winter was 4.7 mg/L.

Nearly 100,000 af of groundwater was conveyed into the California Aqueduct during 2002 and 2003 (termed "groundwater turn-ins"). Most of the water originated from the Kern Fan aquifer program coordinated by Kern County Water Agency. Organic carbon in groundwater from the Kern Fan aquifer ranges narrowly around 1 mg/L. During the eight months of groundwater turn-in activity, organic carbon in the aqueduct downstream of

Table 3-2. Disinfection byproduct precursors and ultraviolet absorbance at 254 nanometers (UVA₂₅₄) in the California Aqueduct, 2002 and 2003

Station Name	Station Number	Units	Median	Low	High	Sample Size
Clifton Court Forebay	KA000000	Bromide mg/L	0.11	0.04	0.43	20
Banks PP	KA000331		0.15	0.04	0.47	24
O'Neill Forebay Outlet	KA007089		0.19	0.10	0.44	24
Check 21	KA017226		0.23	0.10	0.42	27
Check 29	KA024454		0.23	0.09	0.42	27
Check 41	KA030341		0.24	0.09	0.47	25
Devil Canyon Headworks	KA041134	0.22	0.12	0.38	24	
Clifton Court Forebay	KA000000	DOC mg/L as C	2.85	1.90	7.90	24
Banks PP	KA000331		2.90	1.90	8.30	24
O'Neill Forebay Outlet	KA007089		3.00	2.10	8.00	24
Check 21	KA017226		2.90	2.00	5.40	27
Check 29	KA024454		2.80	1.80	4.70	27
Check 41	KA030341		2.80	2.10	4.80	25
Devil Canyon Headworks	KA041134	3.10	2.10	4.80	24	
Clifton Court Forebay	KA000000	TOC mg/L as C	3.05	1.90	8.50	24
Banks PP	KA000331		3.15	1.90	8.40	24
O'Neill Forebay Outlet	KA007089		3.10	2.10	8.10	24
Check 21	KA017226		3.10	2.10	5.40	27
Check 29	KA024454		2.90	1.90	4.70	27
Check 41	KA030341		3.00	2.10	4.90	25
Devil Canyon Headworks	KA041134	3.20	2.10	5.20	24	
Clifton Court Forebay	KA000000	UVA ₂₅₄ Absorbance/cm	NA			
Banks PP	KA000331		0.09	0.07	0.30	23
O'Neill Forebay Outlet	KA007089		0.10	0.07	0.20	15
Check 21	KA017226		NA			
Check 29	KA024454		NA			
Check 41	KA030341		0.08	0.06	0.17	22
Devil Canyon Headworks	KA041134	0.08	0.06	0.17	17	

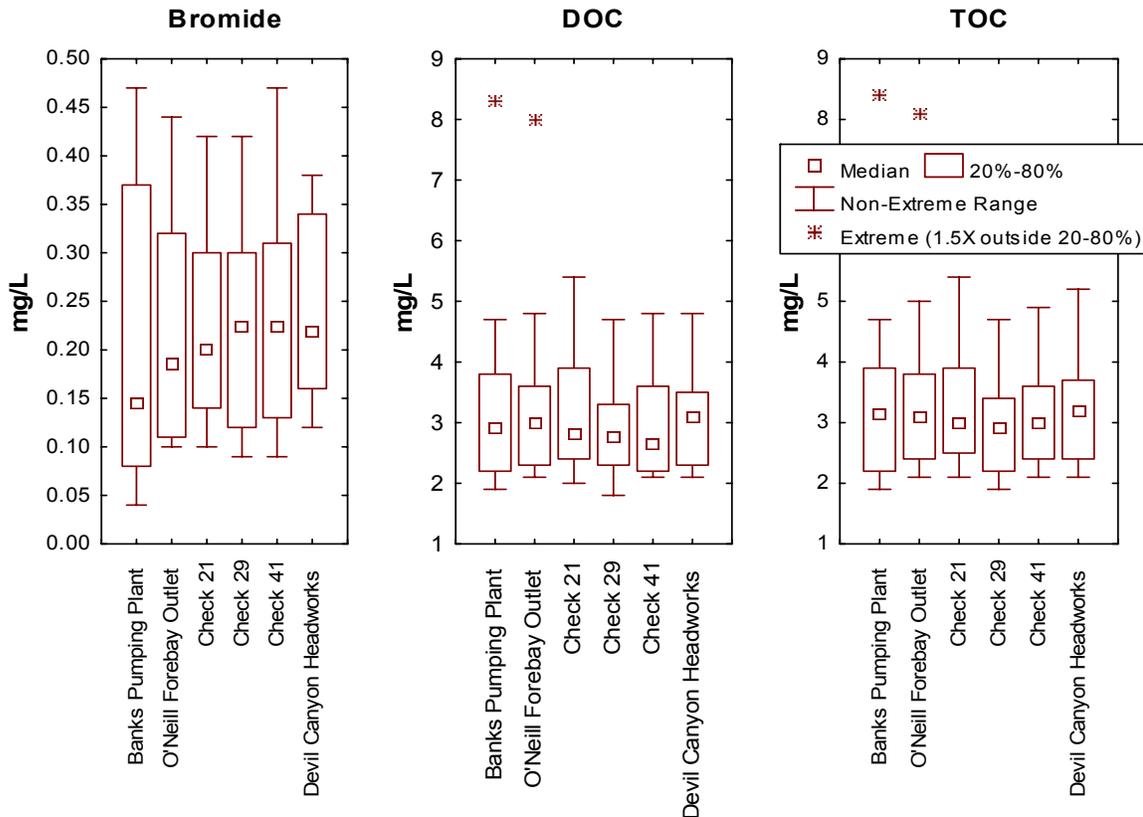


Figure 3-7. Bromide and dissolved and total organic carbon in the California Aqueduct, 2002 and 2003

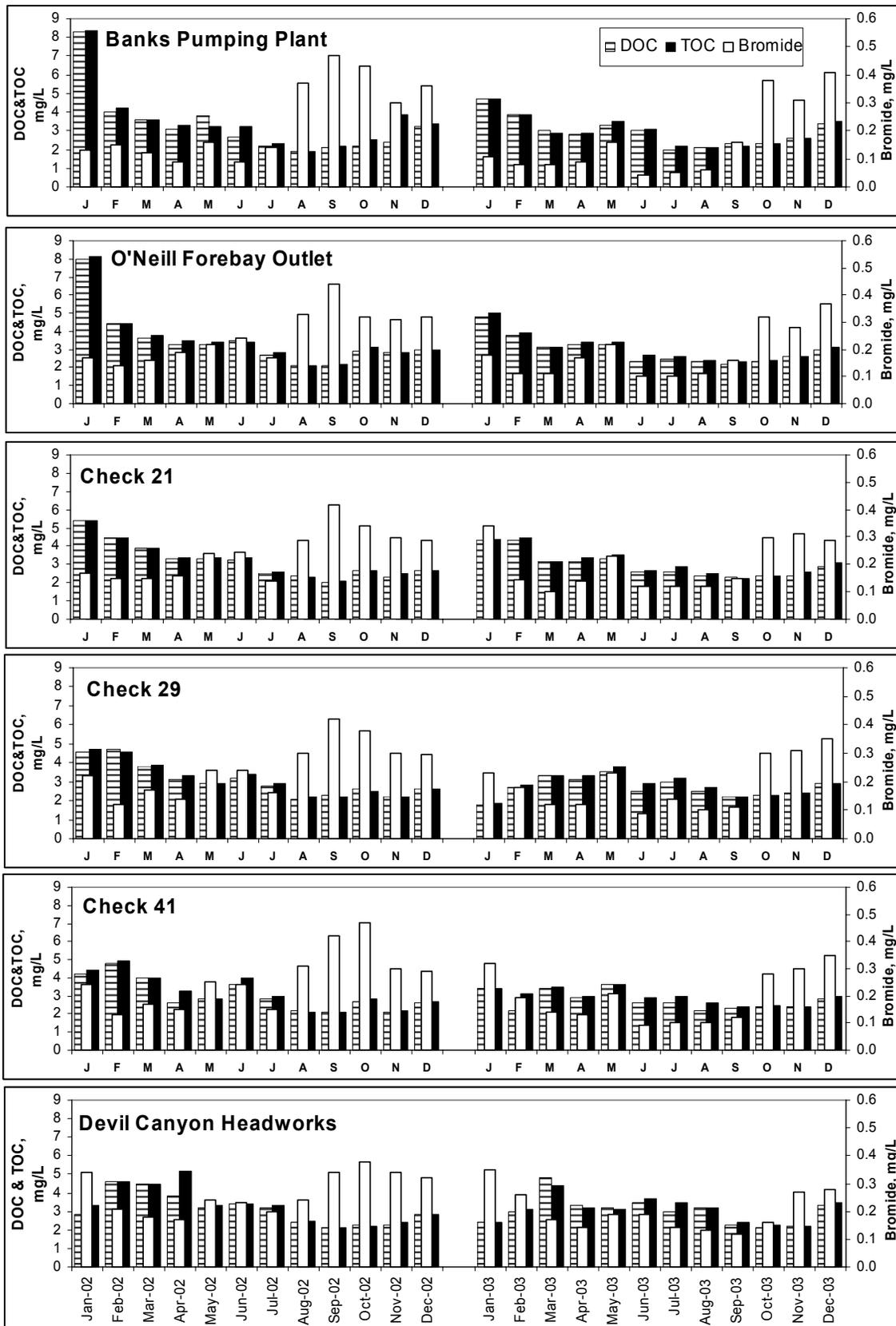


Figure 3-8. Monthly bromide and dissolved and total organic carbon in the California Aqueduct

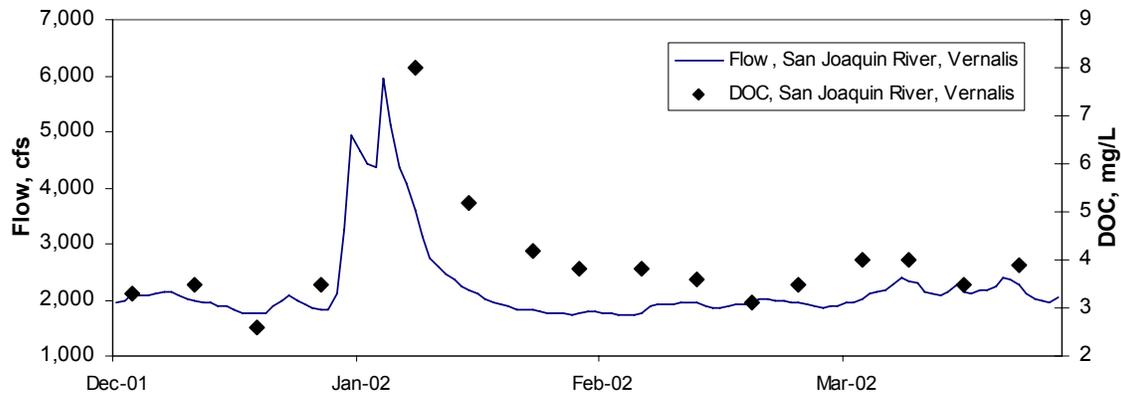


Figure 3-9. Flow and dissolved organic carbon in the San Joaquin River at Vernalis, December 2001 to March 2002 (flow data from HEC-DSS, DOC data from DWR’s MWQI Program accessed from the Water Data Library)

the turn-ins declined by as much as 2.5 mg/L depending on the relative amount of turn-in water. The declines were largest during January and February 2003 when turn-ins comprised 23% and 31% of aqueduct flow, respectively. The declines can be seen in Figure 3-8 by comparing upstream-downstream organic carbon between Checks 21 and 29 for those months. Turn-ins were responsible for a 16% reduction in organic carbon loads flowing down the aqueduct during the eight months of activity and a 39% load reduction during most of January-February 2003 when upstream organic carbon levels were highest in the California Aqueduct (see detailed analysis in Special Studies).

Minor elements and nutrients in the California Aqueduct are summarized in Tables 3-3 and 3-4. All analyses were below existing MCLs for treated drinking water with the exception of manganese. Manganese was detected above the Secondary MCL of 0.05 mg/L in three samples from Devil Canyon Headworks (0.058 to 0.078 mg/L). The MCL for manganese was established to address drinking water aesthetics, not public health protection (DHS 2005). Noticeable effects of manganese above the Secondary MCL can include dark coloration, black staining from oxides of manganese, and a bitter metallic taste (USEPA 1992).

Detection of manganese above the Secondary MCL at Devil Canyon Headworks can be explained by the source water. Water at this station is taken directly from San Bernardino Tunnel, a pipeline that conveys water from Silverwood Lake to Devil Canyon Afterbay for power generation and delivery to East Branch contractors. Water sent down the San Bernardino Tunnel can originate from the deeper portions of Silverwood Lake via multi-elevation intake louvers on San Bernardino Intake Tower. These lower elevation releases can contain higher levels of soluble manganese due to lake stratification and the subsequent drop in oxygen.

Table 3-3. Summary of minor elements in the California Aqueduct, 2002 and 2003
(mg/L)

Station Name	Station Number	Minor Element	Sample			Minor Element	Sample			Minor Element	Sample						
			Median	Low	High		Median	Low	High		Median	Low	High				
Banks PP	KA000331	Aluminum	<0.01	<0.01	20	Chromium +3	0.003	<0.001	0.007	24	Mercury	<0.0002	<0.0002	24			
O'Neill Forebay Outlet	KA007089		<0.01	<0.01	14		0.002	0.001	0.007	24		<0.0002	<0.0002	14			
Check 21	KA017226		<0.01	<0.01	14		0.003	0.001	0.007	27		<0.0002	<0.0002	27			
Check 29	KA024454		<0.01	<0.01	27		0.003	<0.001	0.007	27		<0.0002	<0.0002	27			
Check 41	KA030341	<0.01	<0.01	25	0.004	<0.001	0.007	25	<0.0002	<0.0002	25						
Devil Canyon Headworks	KA041134	<0.01	<0.01	24	0.003	0.001	0.006	24	footnote #3	<0.0002	<0.0002	24					
Banks PP	KA000331	Antimony	<0.001	<0.005	24	Chromium +6	0.0002	<0.0002	0.0007	13	Nickel	0.001	<0.001	0.002	24		
O'Neill Forebay Outlet	KA007089		footnote #1	<0.001	<0.005		22	footnote #2	<0.0002	<0.0002		0.0006	13	0.001	0.001	0.002	22
Check 21	KA017226		<0.001	<0.005	19		0.0002	<0.0002	0.0006	13		0.001	0.001	0.002	22		
Check 29	KA024454		<0.001	<0.005	27		0.0005	<0.0002	0.001	13		0.001	<0.001	0.002	27		
Check 41	KA030341	NA	NA	NA	NA	NA	NA	NA	NA	0.001	0.001	0.002	16				
Devil Canyon Headworks	KA041134	NA	NA	NA	NA	NA	NA	NA	NA	0.001	0.001	0.002	24				
Banks PP	KA000331	Arsenic	0.002	0.001	0.003	24	Copper	0.002	0.002	0.009	24	Selenium	<0.001	<0.001	0.002	24	
O'Neill Forebay Outlet	KA007089		0.002	0.001	0.003	24		0.002	0.002	0.003	24		0.001	0.001	0.002	1	
Check 21	KA017226		0.002	0.001	0.003	27		0.002	0.001	0.003	27		NA	NA	NA	NA	
Check 29	KA024454		0.002	0.002	0.003	27		0.002	0.001	0.003	27		0.001	<0.001	0.002	27	
Check 41	KA030341	0.002	0.002	0.003	25	0.002	0.002	0.003	28	NA	NA	NA	NA				
Devil Canyon Headworks	KA041134	0.002	0.002	0.003	24	0.003	0.002	0.009	24	NA	NA	NA	NA				
Banks PP	KA000331	Barium	<0.05	<0.05	20	Fluoride	<0.1	<0.1	0.1	24	Silver	<0.001	<0.001	0.002	20		
O'Neill Forebay Outlet	KA007089		<0.05	<0.05	14		<0.1	<0.1	0.1	24		<0.001	<0.001	0.002	14		
Check 21	KA017226		<0.05	<0.05	14		<0.01	<0.01	0.1	27		<0.001	<0.001	0.002	14		
Check 29	KA024454		<0.05	<0.05	27		<0.1	<0.1	0.1	27		<0.001	<0.001	0.002	27		
Check 41	KA030341	<0.05	<0.05	25	<0.1	<0.1	0.1	25	<0.001	<0.001	0.002	25					
Devil Canyon Headworks	KA041134	<0.05	<0.05	24	<0.1	<0.1	0.4	24	<0.001	<0.001	0.002	24					
Banks PP	KA000331	Beryllium	<0.001	<0.001	24	Iron	0.009	<0.005	0.085	24	Thallium	NA	NA	NA	1		
O'Neill Forebay Outlet	KA007089		<0.001	<0.001	22		<0.005	<0.005	0.058	24		<0.001	<0.001	0.002	3		
Check 21	KA017226		<0.001	<0.001	22		<0.005	<0.005	0.034	27		<0.001	<0.001	0.002	3		
Check 29	KA024454		<0.001	<0.001	27		0.005	<0.005	0.049	27		NA	NA	NA	NA		
Check 41	KA030341	<0.001	<0.001	24	<0.005	<0.005	0.047	25	NA	NA	NA	NA					
Devil Canyon Headworks	KA041134	<0.001	<0.001	24	<0.005	<0.005	0.023	24	NA	NA	NA	NA					
Banks PP	KA000331	Boron	0.1	< 0.1	0.3	24	Lead	<0.001	<0.001	0.007	24	Zinc	<0.005	<0.005	0.015	24	
O'Neill Forebay Outlet	KA007089		0.2	< 0.1	0.2	24		<0.001	<0.001	0.007	24		<0.005	<0.005	0.015	24	
Check 21	KA017226		0.2	< 0.1	0.2	27		<0.001	<0.001	0.007	27		<0.005	<0.005	0.015	27	
Check 29	KA024454		0.2	< 0.1	0.2	27		<0.001	<0.001	0.007	27		<0.005	<0.005	0.015	27	
Check 41	KA030341	0.2	< 0.1	0.2	25	<0.001	<0.001	0.007	25	<0.005	<0.005	0.015	25				
Devil Canyon Headworks	KA041134	0.2	< 0.1	0.2	24	<0.001	<0.001	0.007	24	<0.005	<0.005	0.015	24				
Banks PP	KA000331	Cadmium	<0.001	<0.001	20	Manganese	0.01	<0.005	0.028	24		<0.005	<0.005	0.015	24		
O'Neill Forebay Outlet	KA007089		<0.001	<0.001	14		0.005	<0.005	0.019	24		<0.005	<0.005	0.015	24		
Check 21	KA017226		<0.001	<0.001	14		<0.005	<0.005	0.019	24		<0.005	<0.005	0.015	24		
Check 29	KA024454		<0.001	<0.001	27		<0.005	<0.005	0.019	27		<0.005	<0.005	0.015	27		
Check 41	KA030341	<0.001	<0.001	25	<0.005	<0.005	0.019	26	<0.005	<0.005	0.015	26					
Devil Canyon Headworks	KA041134	<0.001	<0.001	24	<0.005	<0.005	0.078	24	<0.005	<0.005	0.015	24					

1 Reporting limit changed from < 0.005 to < 0.001 mg/L in July, 2002

2 Reporting limit changed from < 0.001 to < 0.0002 mg/L in February, 2002

3 A positive was reported (0.0002 mg/L) in the database for the 8/20/03 sample but the lab sheet reported <0.0002 mg/L.

Table 3-4. Summary of nutrients in the California Aqueduct, 2002 and 2003

Station Name	Station		Parameter	Units	Median	Low	High	Sample Size
	Number	Element						
Banks PP	KA000331	Ammonia	mg/L as N		0.04	< 0.01	0.14	24
Check 21	KA017226				0.02	< 0.01	0.09	22
Check 41	KA030341				0.01	< 0.01	0.02	24
Devil Canyon Headworks	KA041134				0.03	< 0.01	0.07	24
Banks PP	KA000331	Nitrite+Nitrate	mg/L as N		0.53	0.13	1.7	24
Check 21	KA017226				0.73	0.26	1.6	22
Check 41	KA030341				0.74	0.17	1.6	24
Devil Canyon Headworks	KA041134				0.74	0.21	1.3	24
Banks PP	KA000331	Ortho-Phosphate	mg/L as P		0.07	0.05	0.15	24
Check 21	KA017226				0.08	0.06	0.13	22
Check 41	KA030341				0.07	< 0.01	0.11	24
Devil Canyon Headworks	KA041134				0.08	0.05	0.71	24
Banks PP	KA000331	Total Kjeldahl Nitrogen	mg/L as N		0.30	0.2	0.5	24
Check 21	KA017226				0.30	0.2	0.6	22
Check 41	KA030341				0.35	0.2	0.6	24
Devil Canyon Headworks	KA041134				0.30	0.1	0.8	24
Banks PP	KA000331	Total Phosphorus	mg/L		0.10	0.07	0.14	24
Check 21	KA017226				0.10	0.07	0.18	22
Check 41	KA030341				0.10	< 0.1	0.13	24
Devil Canyon Headworks	KA041134				0.09	< 0.1	0.15	24

Although the solubility of certain metals is known to increase with decreasing pH, manganese solubility also increases in anoxic environments like the hypolimnia of thermally stratified lakes (Wetzel 2001 and Hem 1985). The increase in manganese solubility follows the shift to anoxia from the sediment-water interface to the hypolimnion as stratification sets up. Manganese is reduced from the oxidized state of +4 to the +2 state and released from bed sediment and insoluble colloidal/adsorbed forms in the water column. In this instance, the redox potential plays a role in the dissolution of manganese. The redox potential is a scale of the electrochemical environment to oxidize or reduce elemental substances. When an element is reduced, it gains one or more electrons from another elemental substance that had been oxidized (the electron provider). The same electrochemical principals are involved when iron is reduced from the less soluble ferric ion (Fe^{+3}) to the more soluble ferrous ion (Fe^{+2}) in an anoxic environment. However, manganese remains soluble under higher redox conditions than iron resulting in an increase in manganese solubility and not iron due to an oxygen saturation that is low enough to reduce manganese but not iron.

IV. Joint-Use Facilities

Joint-Use Facilities include O’Neill Forebay, San Luis Reservoir, and about a 100-mile stretch of the California Aqueduct from O’Neill Forebay Outlet to Check 21, called the San Luis Canal. They are operated jointly to store and deliver water to both State and federal water contractors.

San Luis Reservoir provides off-stream storage for the SWP and CVP. Water from O’Neill Forebay is pumped into San Luis Reservoir generally during fall and winter to augment supplies during the high-demand spring and summer. South Delta exports can enter O’Neill Forebay from the California Aqueduct at Check 12 or from the CVP’s Delta-Mendota Canal (DMC) at O’Neill Pumping-Generating Plant (see previous Figure 2-1).

Inflow to O’Neill Forebay from the California Aqueduct at Check 12 was 2.517 million acre-feet (maf) in 2002 and 3.166 maf in 2003. Monthly flow at Check 12 was generally highest during winter and summer of both years (Figure 4-1).

Annual pumpage from the DMC into O’Neill Forebay at O’Neill Pumping-Generating Plant was 1.192 maf in 2002 and 1.309 maf in 2003. Pumpage from the DMC amounted to about 30% of the total inflow volume to O’Neill Forebay from south Delta exports during the two-year period. Releases from San Luis Reservoir during both years were generally greatest from April to July and lowest from January to March (Figure 4-1).

Major minerals, conventional parameters, and disinfection byproduct precursors in the DMC and San Luis Reservoir during 2002 and 2003 are summarized in Tables 4-1 and 4-2. Maximum Contaminant Levels for sulfate, chloride, and nitrate in treated drinking water were not exceeded.

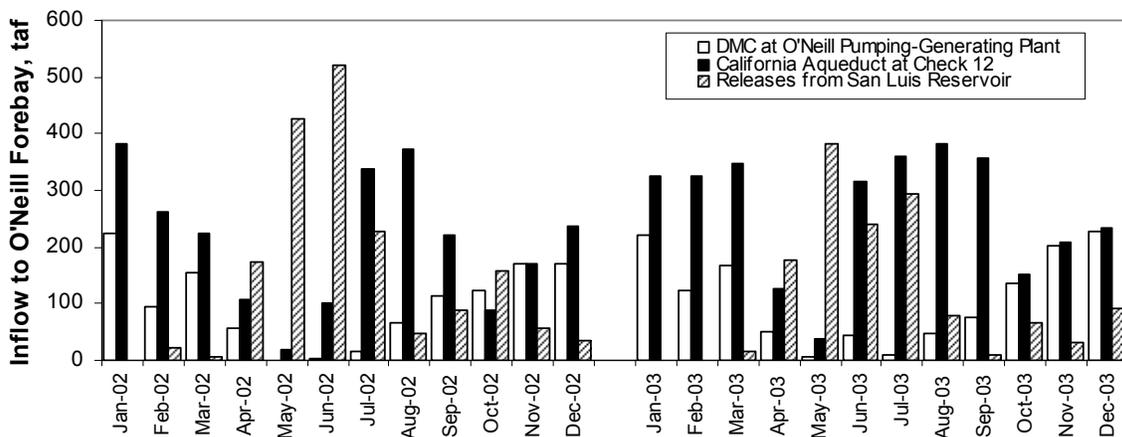


Figure 4-1. Monthly inflow to O’Neill Forebay from the California Aqueduct at Check 12 and the CVP’s Delta-Mendota Canal at O’Neill Pumping-Generating Plant (in thousand acre-feet). Also shown are releases from San Luis Reservoir at Gianelli Pumping-Generating Plant.

Table 4-1. Summary of major minerals and conventional parameters in the CVP's Delta-Mendota Canal and San Luis Reservoir at Pacheco Pumping Plant, 2002 and 2003

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 CaCO ₃	81	57	150	24	Conductivity	μS/cm	485	184	1,140	24
San Luis Reservoir	SL000000			87	77	92	24			527	475	577	24
CVP Delta-Mendota Canal	DMC06716	Calcium	mg/L	19	12	58	24	Hardness	mg/L as CaCO ₃	107	55	277	24
San Luis Reservoir	SL000000			22	19	24	24			113	98	119	24
CVP Delta-Mendota Canal	DMC06716	Chloride	mg/L	67	15	178	24	pH	pH units	6.9	5.9	7.9	24
San Luis Reservoir	SL000000			79	72	98	24			7.0	6.2	8.2	24
CVP Delta-Mendota Canal	DMC06716	Magnesium	mg/L	13	6	32	24	TDS	mg/L	290	111	686	24
San Luis Reservoir	SL000000			14	13	15	24			310	267	361	24
CVP Delta-Mendota Canal	DMC06716	Nitrate	mg/L as NO ₃	3.3	1.2	11.4	24	TSS	mg/L	12	11	14	5
San Luis Reservoir	SL000000			3.4	1.6	4.5	24			< 1	< 1	1	
CVP Delta-Mendota Canal	DMC06716	Sodium	mg/L	50	14	138	24	Turbidity	NTU	15	6	35	24
San Luis Reservoir	SL000000			56	49	63	24			3	1	6	21
CVP Delta-Mendota Canal	DMC06716	Sulfate	mg/L	36	13	167	24	VSS	mg/L	1	< 1	3	4
San Luis Reservoir	SL000000			44	39	49	24			< 1	< 1	1	

Table 4-2. Summary of bromide and total and dissolved organic carbon in the CVP's Delta-Mendota Canal and San Luis Reservoir at Pacheco Pumping Plant, 2002 and 2003

Station Name	Station Number	Parameter	Units	Median	Low	High	Sample Size
CVP Delta Mendota Canal	DMC06716	Bromide	mg/L	0.18	0.04	0.52	24
San Luis Reservoir, Pacheco Pumping Plant	SL000000			0.24	0.22	0.31	15
CVP Delta Mendota Canal	DMC06716	DOC	mg/L as C	3.2	2.1	8.3	24
San Luis Reservoir, Pacheco Pumping Plant	SL000000			3.4	2.9	3.9	7
CVP Delta Mendota Canal	DMC06716	TOC	mg/L as C	3.2	2.0	8.5	23
San Luis Reservoir, Pacheco Pumping Plant	SL000000			3.4	2.8	3.8	8

The Recommended Secondary MCL for TDS (500 mg/L) was exceeded in three samples from the DMC during November 2002 and January and December 2003 (511 to 686 mg/L) (Figure 4-2). Bromide was also relatively high in the same samples reaching a maximum 0.52 mg/L, exceeding the period maximum at Banks Pumping Plant of 0.47 mg/L. Conductivity in two of the same three samples was above the Recommended Secondary MCL (900 μS/cm) with values of 984 and 1,149 μS/cm. Noticeable effects of salinity above the secondary MCLs in drinking water can include hardness, deposits, colored water, staining, or salty taste (USEPA 1992).

Chloride:sulfate ratios in the three samples were below 1.5, indicating that seawater intrusion was not the source of the elevated salinity (Figure 4-3). One manifestation of seawater intrusion is a chloride:sulfate ratio that exceeds 1.5 – a higher ratio indicates greater intrusion. The 1.5 value is the upper 99% confidence limit for chloride:sulfate in the San Joaquin River. This river is the other major source of high salt in south Delta exports besides seawater intrusion. Further investigation confirms that water from the San Joaquin River was present in the DMC when the salinity-based MCLs were exceeded.

Figure 4-4A shows hourly conductivity in the DMC near O'Neill Forebay during the two-year period. The wide vertical spread in conductivity between the highest and lowest levels during certain times of the year portray hourly conductivity oscillations typically observed at C. W. "Bill" Jones (formerly Tracy) Pumping Plant and farther down the DMC (DWR 2004B). The oscillations reflect swings in conductivity between cross-Delta flow, the San Joaquin River, and various mixtures of the two.

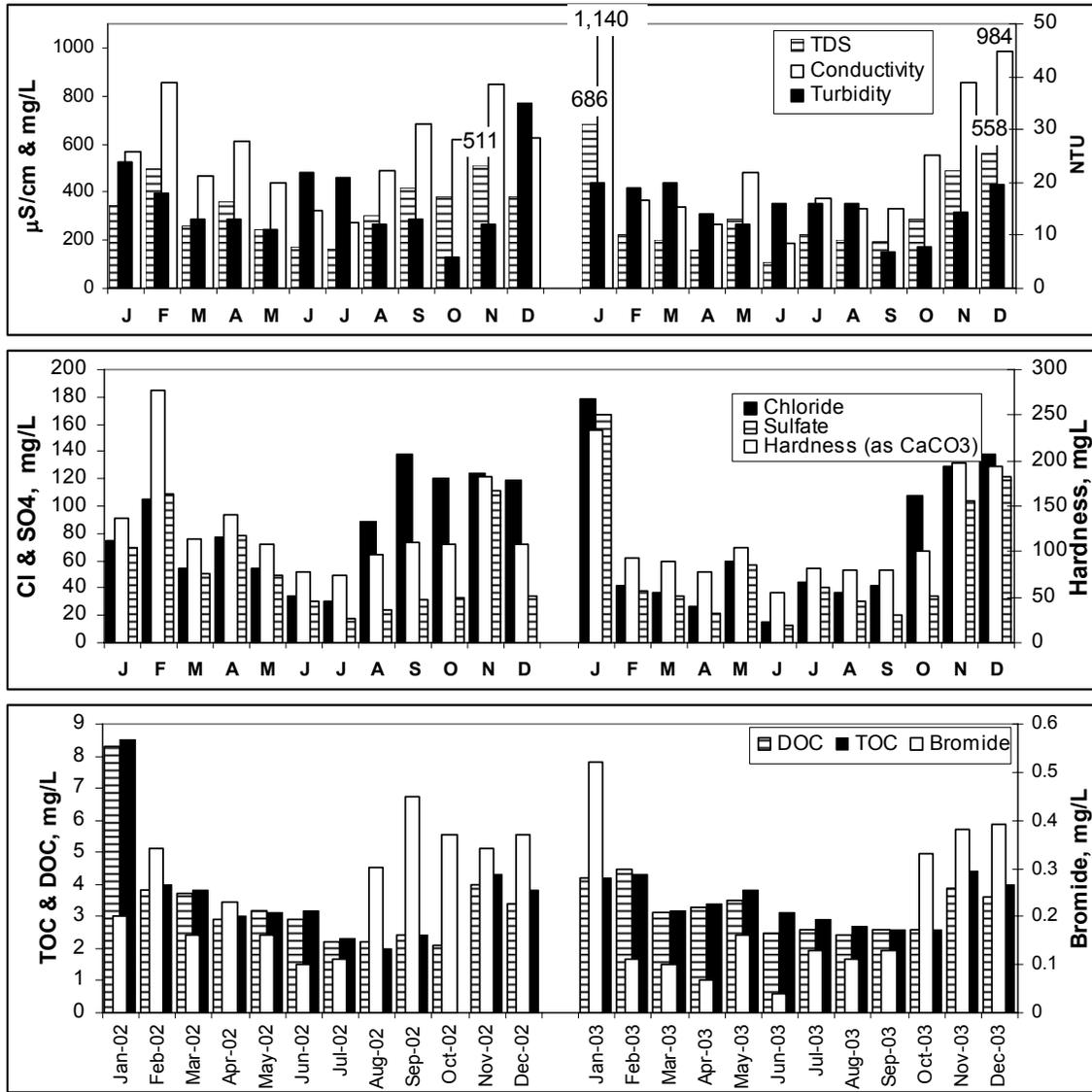


Figure 4-2. Monthly water quality in the CVP's Delta-Mendota Canal near O'Neill Forebay

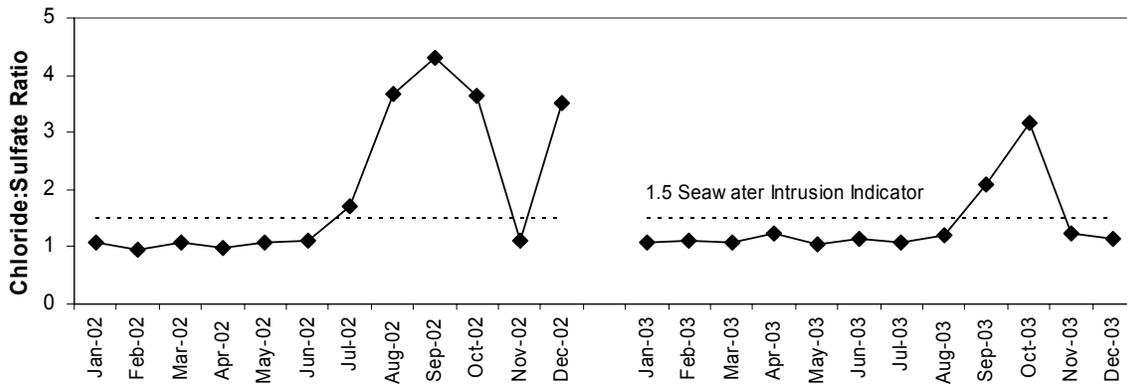


Figure 4-3. Chloride:sulfate ratios in the CVP's Delta-Mendota Canal. The 1.5 seawater intrusion indicator is the upper 99% confidence interval for this ratio in the San Joaquin River, a major source of high salt in south Delta exports besides seawater intrusion.

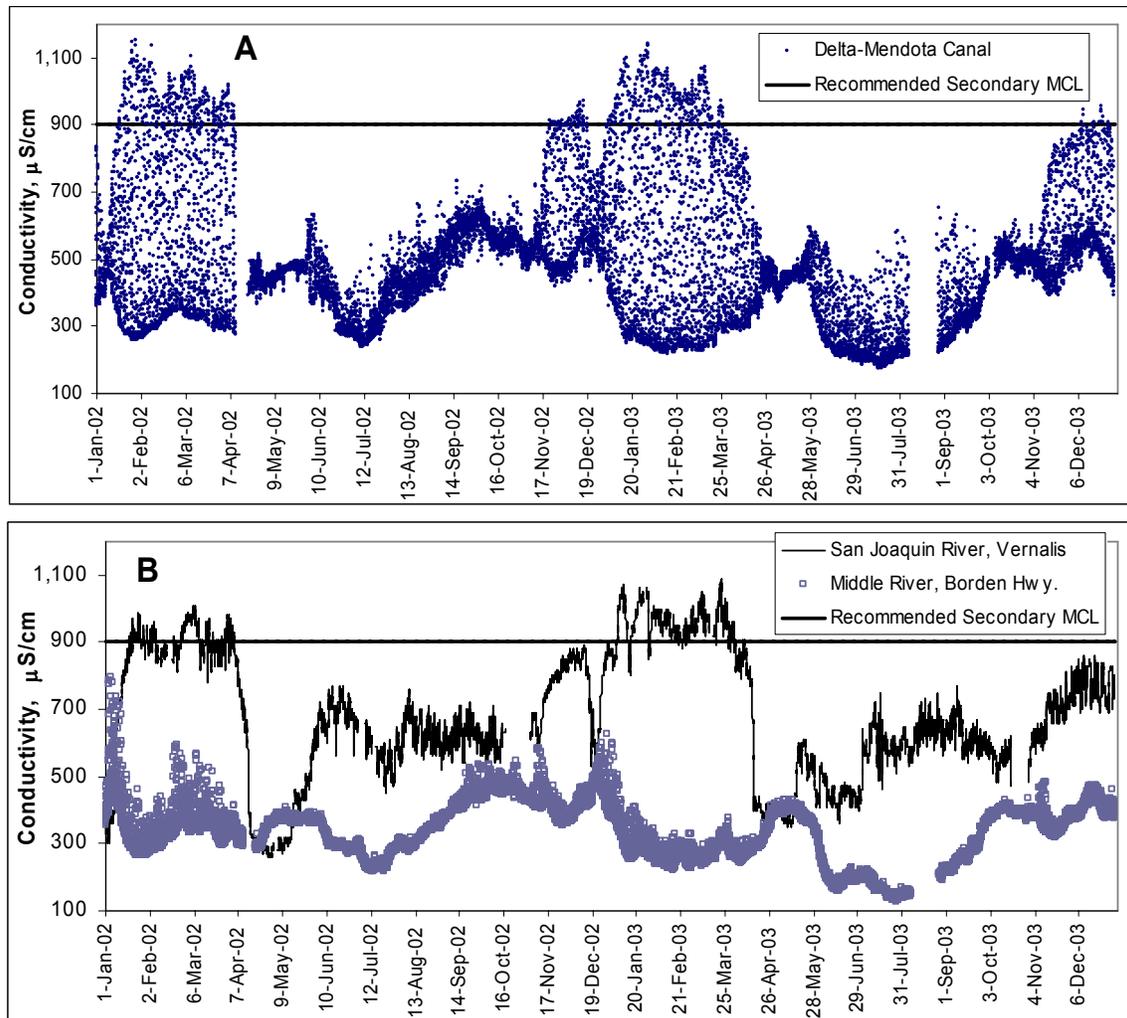


Figure 4-4. Hourly conductivity in the CVP's Delta Mendota-Canal near O'Neill Forebay (A), the San Joaquin River at Vernalis, and Middle River at Borden Highway (B) (source: HEC-DSS Time-Series database)

Conductivity oscillations in the DMC were most exaggerated between November and March of both years (Figure 4-4A). During these months, the San Joaquin River was the source of the conductivity crests in the DMC and Middle River – representing cross-Delta flow – was the source of the lower-salinity water (Figure 4-4B). The San Joaquin River is commonly the source of the higher-salinity water except during certain periods of moderately-high to high flows in the San Joaquin River or extreme seawater intrusion (DWR 2004B). During April to October, conductivity oscillations in the DMC were more subdued due to south Delta barrier installation (discussed later) (Figure 4-4A).

Conductivity oscillations in the DMC are induced by tide and become apparent when water quality in the San Joaquin River can be distinguished from that in cross-Delta flow. Cross-Delta flow is defined as water approaching the export sites from the north via Old and/or Middle rivers. Cross-Delta flow can be forced into the DMC's export zone on the incoming tide while water from the San Joaquin River can be drawn into the export zone via Grant Line Canal and south Old River on the outgoing tide. The export zone for the

DMC is the approach channel to Jones Pumping Plant at the juncture with south Old River (the export zone for the SWP's California Aqueduct is the Clifton Court Forebay gates). Water composition in the DMC's export zone can alternate from that of the San Joaquin River, cross-Delta flow, or various mixtures of the two on an hourly basis. The permutations in composition generated in the export zone remain intact down the DMC under continuous pumping conditions at Jones Pumping Plant (this is not the case for the California Aqueduct due to the compositing effect of Clifton Court Forebay).

The frequency and amplitude of conductivity oscillations at both State and federal export sites are shaped by the 25-hour tidal cycle. When conductivity is higher in the San Joaquin River than cross-Delta flow, as it usually is, conductivity oscillates upward on the outgoing tide. Effects of the low-low and high-low tides on these oscillations can manifest as two uneven conductivity crests within a tidal cycle. Increases in conductivity are greatest and most prolonged during the low-low tide. More water from the San Joaquin River is drawn into the export zone, and for a longer time, on the low-low tide, generating a higher and more extended conductivity excursion than the high-low tide.

Oscillations may also be mono-modal when water from the San Joaquin River is drawn into the export zone only on the low-low tide. Factors affecting these oscillation modes (besides tide) include the installation of south Delta barriers, pumping rates, and San Joaquin River flow.

A more detailed example of these oscillations is shown for January 2003 in Figure 4-5 when salinity in the DMC exceeded the drinking water MCLs. Along with displaying the characteristic uneven bimodal oscillation mode, Figure 4-5 also shows that the January grab sample was unintentionally collected from the DMC at the precise time that hourly conductivity had reached a peak (archived auto-station values are hourly averages and not expected to exactly match discrete measurements). Had the sample been collected five hours earlier, the monthly sample would have exhibited a conductivity of about 300 $\mu\text{S}/\text{cm}$ instead of 1,140 $\mu\text{S}/\text{cm}$. The high salinity water originated from the San Joaquin River flowing to Jones Pumping Plant via south Old River and Grant Line Canal as demonstrated with a mineralogical comparison.

The mineralogy of samples collected from the DMC and San Joaquin River at Vernalis in January 2003 is depicted in Figure 4-6. The mineral composition of both samples was nearly identical with a cationic content dominated by sodium and an anionic dominance shared by chloride, and secondarily, sulfate. The Vernalis sample was collected on January 8 while the DMC sample was collected seven days later on January 15 (sample conductivities are shown in Figure 4-5). Although the samples were collected on different dates, the DMC sample is believed to have captured roughly the same slug of water passing Vernalis seven days earlier.

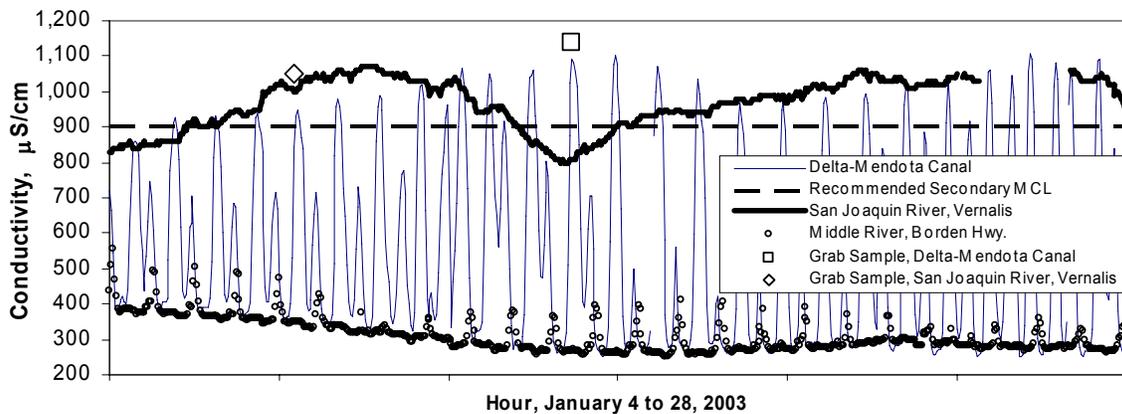


Figure 4-5. Hourly conductivity in the CVP's Delta-Mendota Canal near O'Neill Forebay, the San Joaquin River at Vernalis, and Middle River at Borden Highway (source: HEC-DSS Time-Series database). Also shown is laboratory conductivity for samples collected from the Delta-Mendota Canal on January 15, 2003, and from the San Joaquin River on the 8th.

The nearly identical mineralogy of the previous two samples collected seven days apart can be explained by travel time. The distance from Vernalis on the San Joaquin River to the DMC station near O'Neill Forebay is roughly 93 miles via Grant Line Canal and 106 miles via Old River (DWR 2007). Under the particular conditions during January 2003, this distance was traversed in seven days with an overall velocity of 0.55 to 0.63 miles per hour. The velocity will, of course, vary from fastest in the DMC and San Joaquin River to slowest in the tidally influenced waterways of Old River and Grant Line Canal.

Therefore, the slug of water flowing by Vernalis on January 8 eventually made it to the DMC station on January 15. In fact, conductivity trends at Vernalis were clearly associated with certain peak conductivity trends in the DMC. Examples of this were most apparent during January to April 2002 and November 2002 to March 2003 (see previous Figure 4-4).

The clearly related trends associated with conductivity between the Vernalis and DMC stations permitted travel time estimations. Conductivity crests and troughs at Vernalis were matched to clearly associated conductivity crests in the DMC. The number of days between the matching trends represented travel time from Vernalis on the San Joaquin River to the DMC station near O'Neill Forebay. Estimated travel times during 2002 and 2003 using this technique ranged from four to seven days with an average of 5.7 days. All estimates were made when the South Delta Temporary Barriers were not in place.

One major factor controlling conductivity oscillations at the export sites (and down the DMC) is the South Delta Temporary Barriers program. Barrier placement at the head of Old River or the combination of barriers on Grant Line Canal and Old River impedes direct flow to the export sites from the San Joaquin River. As a result of barrier

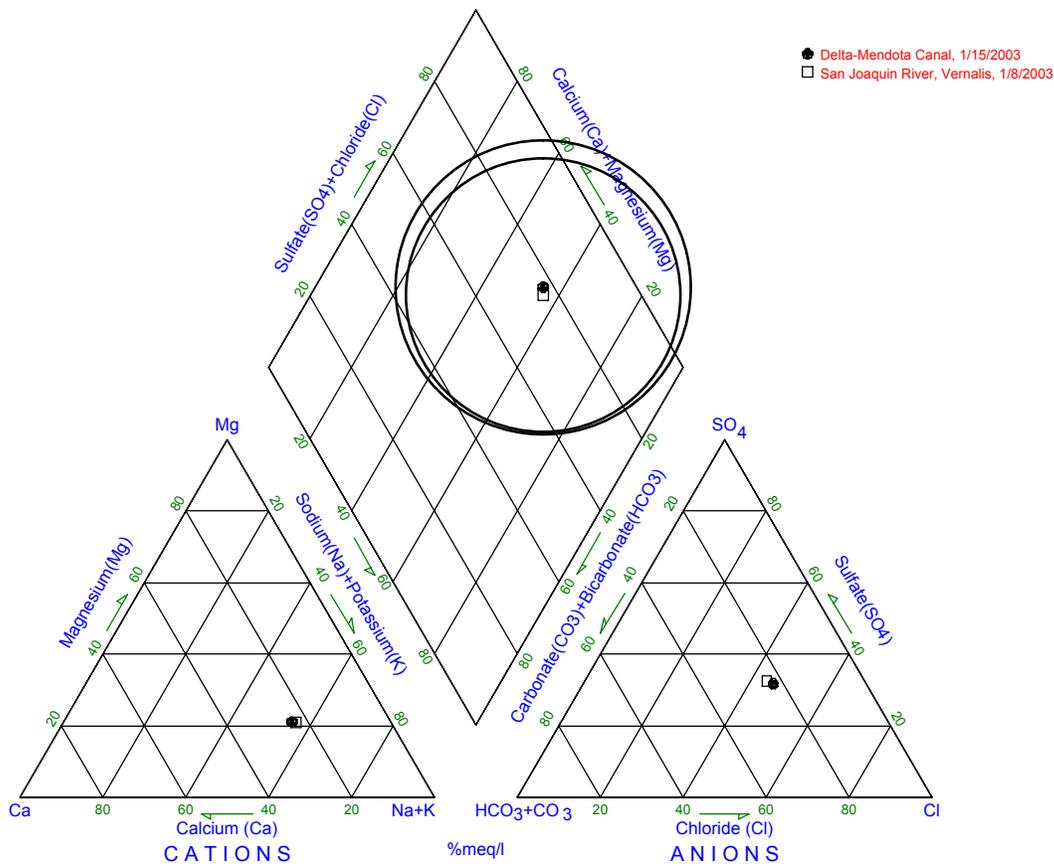


Figure 4-6. Piper graph depiction of the mineralogy of the San Joaquin River at Vernalis and the CVP's Delta-Mendota Canal near O'Neill Forebay, January 2003. The large rings represent relative calculated salinity (San Joaquin River data source: DWR's MWQI data accessed from the Water Data Library).

placement, conductivity oscillations in the DMC can stop, but more often their frequency and amplitude are just lessened by varying degrees. Oscillations at the Clifton Court Forebay gates usually cease altogether with barrier placement. More water from cross-Delta flow is exported at the expense of direct flow from the San Joaquin River when certain barriers are installed. These trends are contingent upon how much water is allowed to pass through the barriers. The barriers are installed with culverts that can be opened, closed, or operated uni-directionally depending on the intended goals.

The effects of barrier placement during 2002 and 2003 can be observed by comparing DMC conductivity in Figure 4-4A with barrier installation in Figure 4-7. Conductivity oscillations in the DMC were less exaggerated during April to October of both years corresponding with the period when two or three of the barriers had been installed. The amplitude of the conductivity oscillations was lowered or flattened during these periods, despite a differential in conductivity between the San Joaquin and Middle rivers.

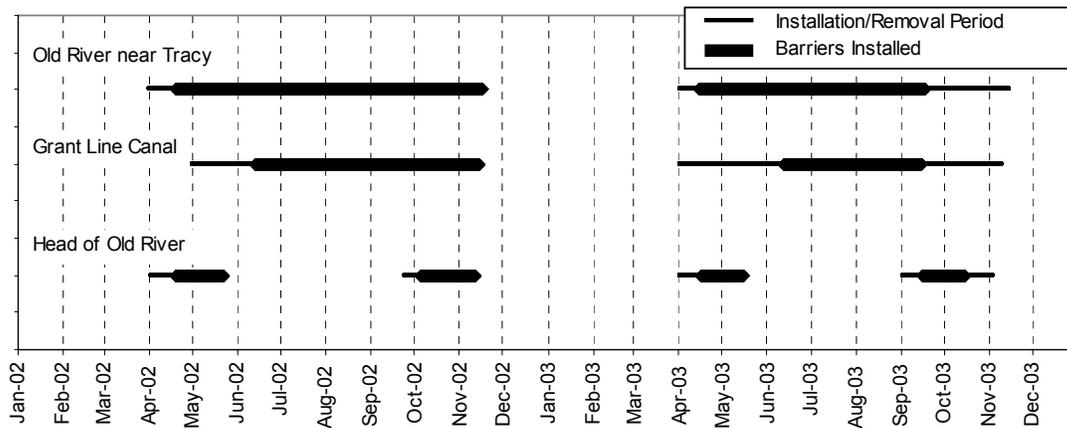


Figure 4-7. Operating schedule of the South Delta Temporary Barriers on Old River, Grant Line Canal, and the head of Old River. During 2002, the installation period shown in this graph extended from start to completion and the removal period extended from start to breached. During 2003, a new category for the installation phase was included termed “closed.”

Conductivity crests in the DMC were often higher than at Vernalis during certain times of the year. This can be seen in Figure 4-4 by comparing conductivity at both stations with the 900 $\mu\text{S}/\text{cm}$ MCL outside of the periods of barrier installation (generally November to March of both years). During January 2002, hourly conductivity in the DMC reached 1,152 $\mu\text{S}/\text{cm}$ while in the San Joaquin River it was nearly 200 $\mu\text{S}/\text{cm}$ lower at 970 $\mu\text{S}/\text{cm}$. Conductivity differentials were also apparent from November 2002 to January 2003 and November-December 2003. Conductivity crests in the DMC were 5% to 19% higher than levels in the San Joaquin River. Increases in conductivity between Vernalis on the San Joaquin River and the export sites have been generally attributable to agricultural discharges located on the waterways between both locations (DWR 1956 and 2004B). A more detailed analysis concluded that over 70 saline point-, non-point, and groundwater discharges are cumulatively raising the conductivity of channel water flowing from Vernalis to the export sites from the east (DWR 2007).

Conductivity and bromide were periodically higher in the DMC than at Banks Pumping Plant during 2002 and 2003. The largest differences were observed during January 2003 when both parameters in the DMC were higher by more than 200% (Figure 4-8). The previous discussion indicated that the January 2003 DMC sample captured water originating from the San Joaquin River when the composition of water in the DMC was oscillating hourly between low-salinity water from cross-Delta flow and high-salinity water from the San Joaquin River. Bromide in the sample represented a daily maximum due to the wide 24-hour conductivity excursions (300 to 1,140 $\mu\text{S}/\text{cm}$) occurring that day. Bromide and conductivity trend together in south Delta exports with correlation coefficients that vary in strength depending on station (unpublished O&M data). When accounting for the composition oscillations, the average bromide concentration for that

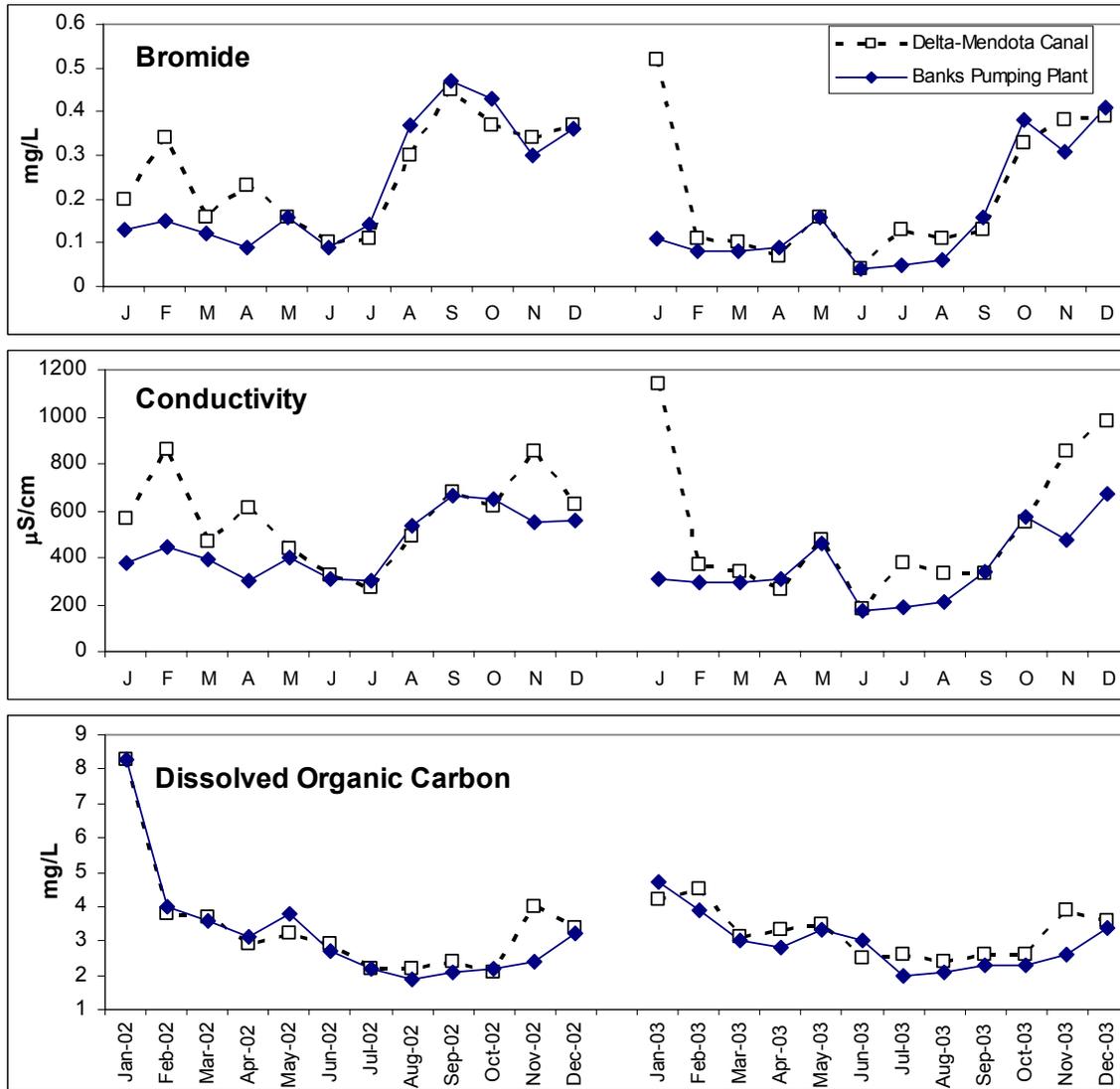


Figure 4-8. Monthly conductivity and bromide in the CVP’s Delta-Mendota Canal and the California Aqueduct at Banks Pumping Plant

day in January 2003 was approximately halfway between 0.11 and 0.52 mg/L. The higher bromide levels in the DMC are not unexpected since conductivity at Jones Pumping Plant, the start of the DMC, is statistically higher than at Banks (DWR 2004B). Another, less extreme, example of the differential in bromide and conductivity between stations was apparent during January to April 2002 (Figure 4-8).

Differences in DOC between Banks Pumping Plant and the DMC were not as great (Figure 4-8). Concentration differences were broadest in November 2002 and 2003 when DOC was 1.3 to 1.6 mg/L higher in the DMC. With the exception of these months, concentration differences between stations were relatively nominal (≤ 0.6 mg/L). A longer-term analysis determined no statistical difference in TOC between Banks and the DMC (DWR 2005). Therefore, greater influence from the San Joaquin River on DMC water quality as exhibited by higher bromide and conductivity levels compared to Banks does not usually translate into similarly elevated organic carbon concentrations.

Filling of San Luis Reservoir at William R. Gianelli Pumping-Generating Plant during 2002 and 2003 was generally highest during fall and winter (Figure 4-9). Conductivity in San Luis Reservoir at Pacheco Pumping Plant varied by about 100 $\mu\text{S}/\text{cm}$ during the two years ranging from 475 to 577 $\mu\text{S}/\text{cm}$ while turbidity ranged from <1 to 6 NTU (Figure 4-9).

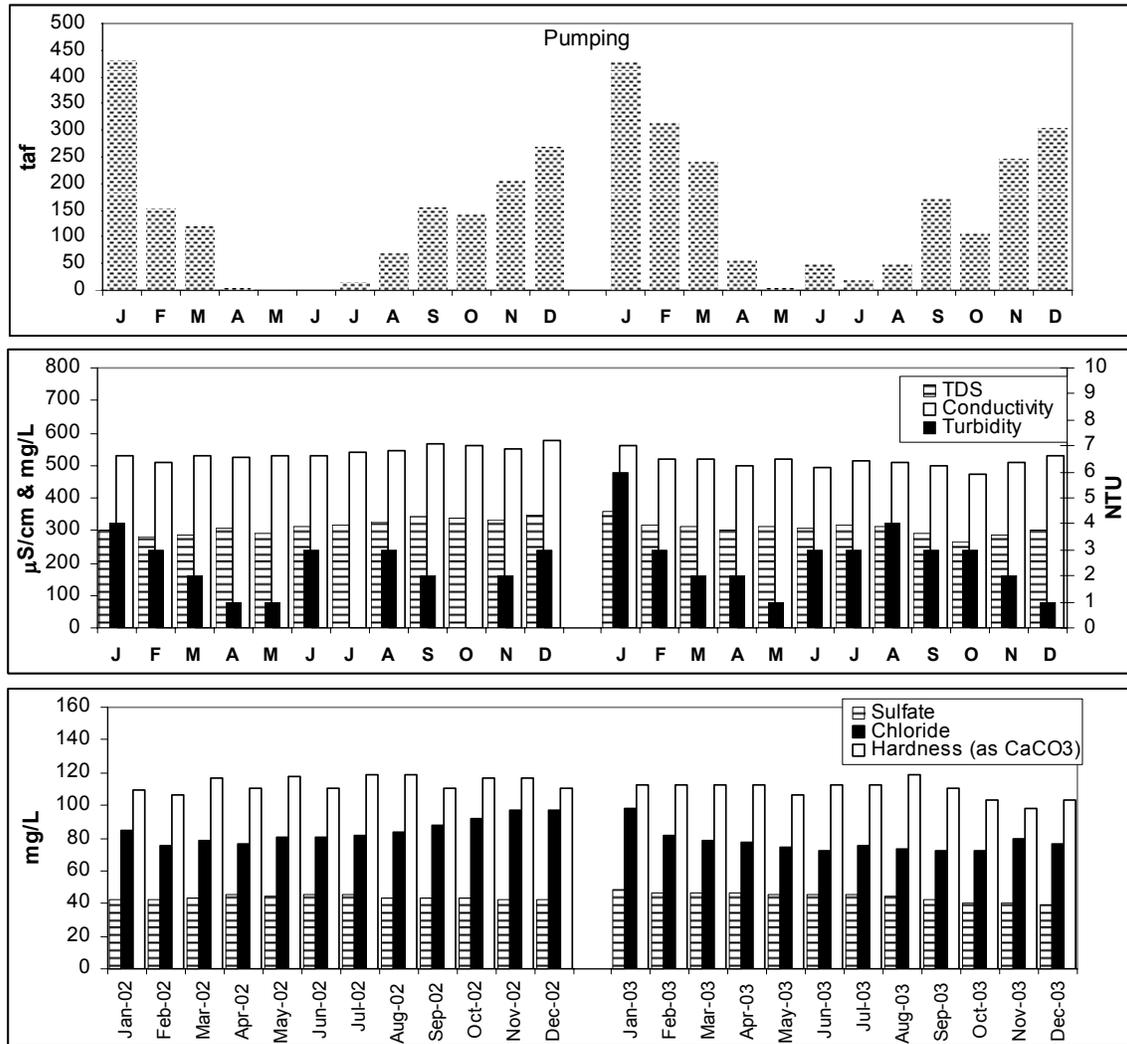


Figure 4-9. Monthly pumping into San Luis Reservoir (combined SWP and CVP) at Gianelli Pumping-Generating Plant and water quality in San Luis Reservoir at Pacheco Pumping Plant. Turbidity values below the reporting limit (<1 NTU) were excluded from the graph.

Minor elements in the DMC and San Luis Reservoir are summarized in Table 4-3 and nutrients in San Luis Reservoir are summarized in Table 4-4. Existing MCLs for these parameters in treated drinking water were not exceeded with the exception of manganese. Of the 24 samples collected from San Luis Reservoir in 2002 and 2003, manganese was above the reporting limit in six. Manganese was detected at just above the Secondary

MCL of 0.05 mg/L in one sample (0.054 mg/L). The MCL for manganese was established to address issues of drinking water aesthetics (DHS 2005). Noticeable effects of manganese in water above the Secondary MCL can include dark coloration, black staining from oxides of manganese, and a bitter metallic taste (USEPA 1992).

Water collected from San Luis Reservoir at Pacheco Pumping Plant originates from near the bottom of the reservoir, providing an explanation for the higher manganese levels at this station. The intake pipe for Pacheco Pumping Plant extends deep into San Luis Reservoir to allow for continued pumping when lake levels recede. Therefore, water at this station originates from near the bottom of the reservoir where manganese solubility can increase due to lower dissolved oxygen concentrations at depth (see detailed discussion in California Aqueduct).

Table 4-3. Summary of minor elements in the CVP's Delta-Mendota Canal and San Luis Reservoir at Pacheco Pumping Plant, 2002 and 2003 (mg/L)

Station Name	Station Number	Minor Element	Sample			Minor Element	Sample			Minor Element	Sample					
			Median	Low	High		Median	Low	High		Median	Low	High			
CVP Delta Mendota Canal	DMC06716	Aluminum	<0.01	<0.01	14	Chromium +3	0.003	<0.001	0.009	24	Mercury	<0.0002	<0.0002	14		
San Luis Reservoir	SL000000		<0.01	<0.01	15		0.0035	<0.001	0.006	24		<0.0002	<0.0002	19		
CVP Delta Mendota Canal	DMC06716	Antimony	<0.001	<0.001	19	Chromium +6	0.0002	<0.0002	0.0002	2	Nickel	0.001	0.001	0.003	22	
San Luis Reservoir	SL000000	footnote #1	<0.001	<0.005	20		NA					0.001	<0.001	0.002	20	
CVP Delta Mendota Canal	DMC06716	Arsenic	0.002	0.001	0.003	24	Copper	0.002	0.001	0.007	24	Silver	<0.001	<0.001	14	
San Luis Reservoir	SL000000		0.002	0.002	0.003	24		0.003	<0.001	0.004	24		<0.001	<0.001	21	
CVP Delta Mendota Canal	DMC06716	Barium	<0.05	<0.05	0.063	14	Fluoride	<0.1	<0.1	0.2	22	Thallium	<0.001	<0.001	<0.001	3
San Luis Reservoir	SL000000		<0.05	<0.05	0.15	15		<0.1	<0.1	0.2	24		NA			
CVP Delta Mendota Canal	DMC06716	Beryllium	<0.001	<0.001	0.003	22	Iron	<0.005	<0.005	0.06	24	Zinc	<0.005	<0.005	24	
San Luis Reservoir	SL000000		<0.001	<0.001	0.003	20		<0.005	<0.005	0.017	24		<0.005	<0.005	24	
CVP Delta Mendota Canal	DMC06716	Boron	0.2	<0.1	0.60	24	Lead	<0.001	<0.001		24					
San Luis Reservoir	SL000000		0.2	0.2	0.2	24		<0.001	<0.001		24					
CVP Delta Mendota Canal	DMC06716	Cadmium	<0.001	<0.001	0.003	14	Manganese	<0.005	<0.005	0.025	24					
San Luis Reservoir	SL000000		<0.001	<0.001	0.003	15		<0.005	<0.005	0.054	24					

1 Reporting limit changed from < 0.005 to < 0.001 in July, 2002

Table 4-4. Summary of nutrients in San Luis Reservoir at Pacheco Pumping Plant, 2002 and 2003

Station Name	Station Number	Parameter	Units	Median	Low	High	Sample
							Size
San Luis Reservoir	SL000000	Ammonia	mg/L as N	<0.01	<0.01	0.05	24
		Nitrate + Nitrite	mg/L as N	0.86	0.34	1	23
		Ortho-Phosphate	mg/L as P	0.10	0.08	0.12	24
		Total Kjeldahl Nitrogen	mg/L as N	0.35	0.2	0.7	24
		Total Phosphorus	mg/L	0.11	0.07	0.19	23

V. State Water Project Southern Reservoirs

Major minerals and conventional parameters in SWP southern reservoirs during 2002 and 2003 are summarized in Table 5-1. Maximum Contaminant Levels for salinity, sulfate, chloride, and nitrate in treated drinking water were not exceeded. Minerals were most variable in Silverwood and Pyramid lakes during both years with conductivity ranging from 351 to 587 $\mu\text{S}/\text{cm}$ and chloride ranging from 47 to 112 mg/L (Figures 5-1 and 5-2). Conductivity was consistently highest in Lake Perris ranging narrowly between 581 and 621 $\mu\text{S}/\text{cm}$.

Disinfection byproduct precursors in SWP southern reservoirs are summarized in Table 5-2. Bromide in all four reservoirs ranged between 0.12 and 0.4 mg/L . Total organic carbon in Castaic Lake reached a maximum 4.6 mg/L in August 2002 while the following year it reached a maximum 3.9 mg/L in June (Figure 5-3).

Minor elements and nutrients in SWP southern reservoirs are summarized in Tables 5-3 and 5-4. Existing MCLs for these parameters in treated drinking water were not exceeded. One sample from Lake Perris contained manganese at the Secondary MCL concentration of 0.05 mg/L .

Natural inflows to Castaic, Pyramid, and Silverwood lakes were greatest during 2003 (Figure 5-4). Natural inflows accounted for 0.031% of the total (natural + Project) to Silverwood Lake in 2002 and 0.6% in 2003. Natural inflows to Pyramid Lake accounted for 2.6% of the total (natural + generation at William E. Warne Powerplant) in 2002 and 0.9% in 2003. Natural inflows to Castaic Lake and Elderberry Forebay were greatest during February to May, 2003 (Figure 5-4).

Table 5-1. Summary of major minerals and conventional parameters in SWP southern reservoirs, 2002 and 2003

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 CaCO_3	86	74	92	8	Conductivity	$\mu\text{S}/\text{cm}$	482	359	587	8
Castaic Lake	CA002000			90	85	103	8			542	465	578	8
Silverwood Lake	SI002000			84	73	91	8			478	351	587	8
Lake Perris	PE002000			108	101	114	8			593	581	621	8
Pyramid Lake	PY001000	Calcium	mg/L	22	17	25	8	Hardness	mg/L as CaCO_3	112	84	122	8
Castaic Lake	CA002000			25	23	28	8			121	111	136	8
Silverwood Lake	SI002000			22	16	25	8			108	81	118	8
Lake Perris	PE002000			26	25	28	8			126	118	131	4
Pyramid Lake	PY001000	Chloride	mg/L	71	46	99	8	pH	pH units	7.0	6.7	7.5	8
Castaic Lake	CA002000			82	60	89	8			7.1	6.5	8.8	8
Silverwood Lake	SI002000			75	47	112	8			6.8	6	7.5	8
Lake Perris	PE002000			91	85	95	8			7.3	6.7	7.9	8
Pyramid Lake	PY001000	Magnesium	mg/L	14	10	15	8	TDS	mg/L	290	216	355	8
Castaic Lake	CA002000			14	13	16	8			315	265	334	11
Silverwood Lake	SI002000			13	10	16	8			274	210	353	8
Lake Perris	PE002000			15	14	17	8			358	311	373	9
Pyramid Lake	PY001000	Nitrate	mg/L as NO_3	2.6	1.2	3.6	8	Turbidity	NTU	2.5	<1.0	3	10
Castaic Lake	CA002000			2.1	<0.1	3.4	8			<1.0	<1.0	3	9
Silverwood Lake	SI002000			2.5	1.4	5.4	8			2	<1.0	3	10
Lake Perris	PE002000			0.2	<0.1	0.4	5			<1.0	<1.0	2	10
Pyramid Lake	PY001000	Sodium	mg/L	51	34	64	8						
Castaic Lake	CA002000			58	46	63	8						
Silverwood Lake	SI002000			51	34	72	8						
Lake Perris	PE002000			64	60	71	8						
Pyramid Lake	PY001000	Sulfate	mg/L	42	28	50	8						
Castaic Lake	CA002000			52	46	56	8						
Silverwood Lake	SI002000			40	26	48	8						
Lake Perris	PE002000			50.5	48	51	8						

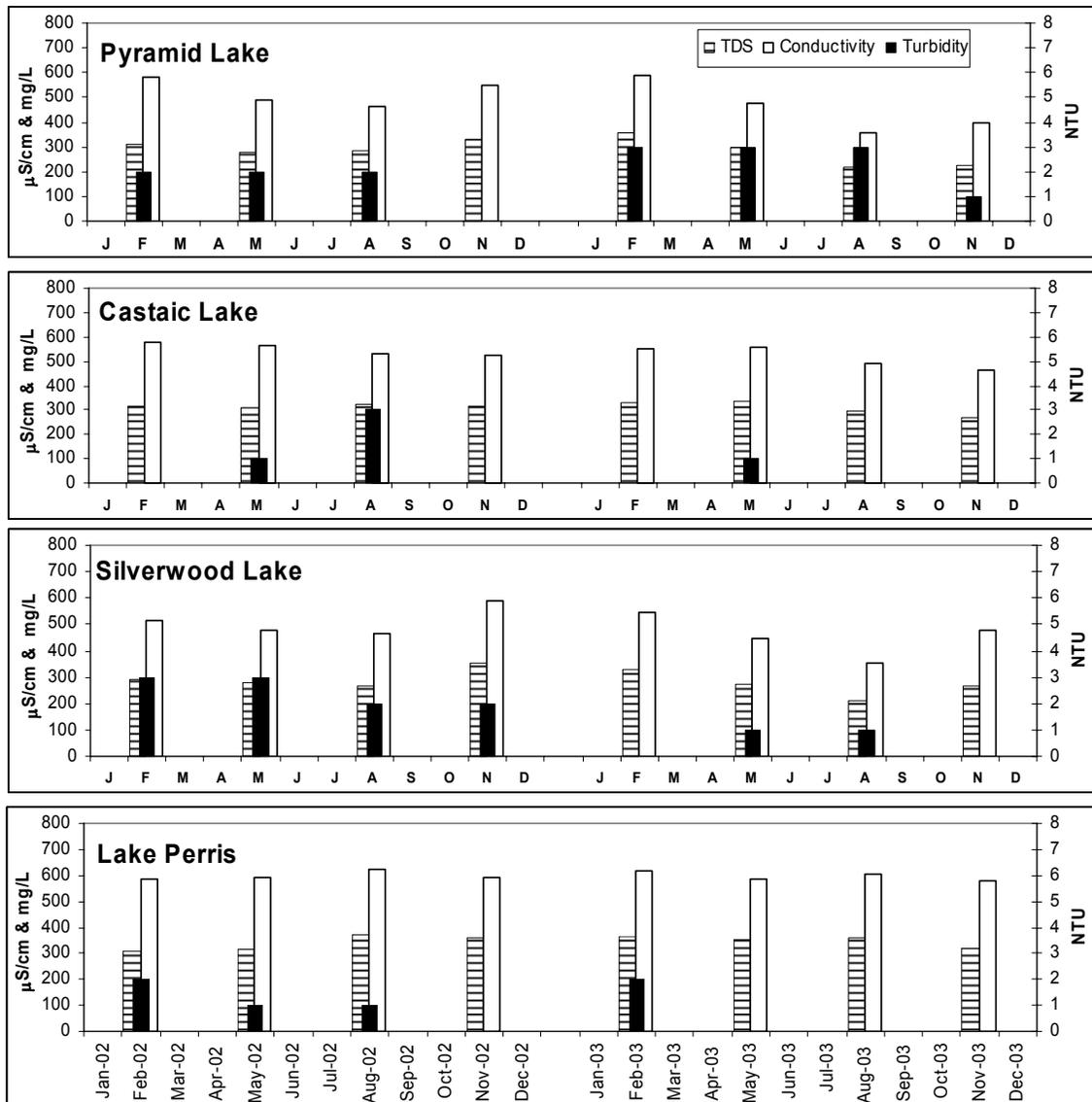


Figure 5-1. Quarterly salinity and turbidity in SWP southern reservoirs. Turbidity values below the reporting limit (<1 NTU) were excluded from the graphs.

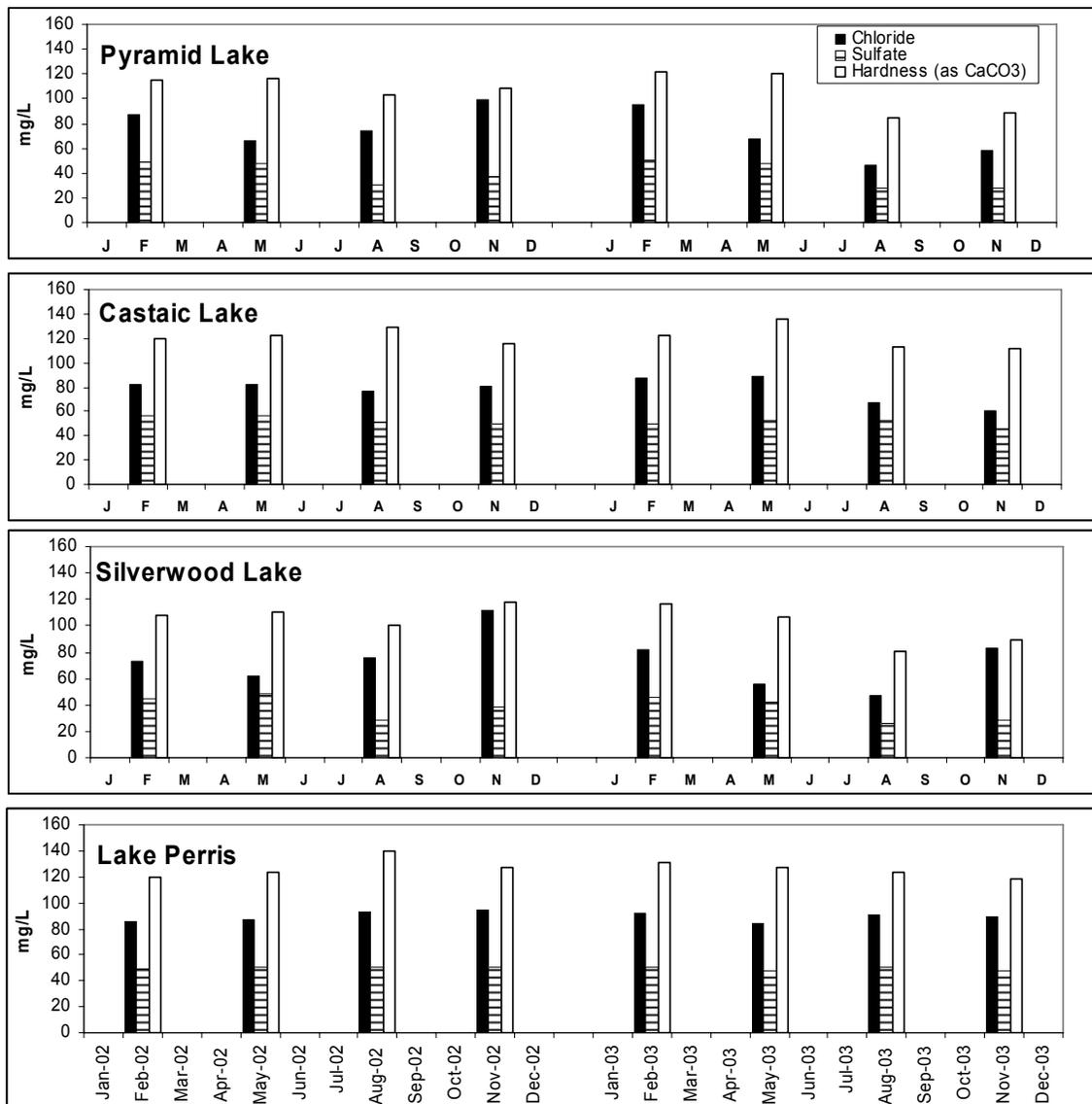


Figure 5-2. Quarterly sulfate, chloride, and hardness in SWP southern reservoirs

Table 5-2. Summary of bromide and dissolved and total organic carbon in SWP southern reservoirs, 2002 and 2003

Station Name	Station Number	Parameter	Units	Median	Low	High	Sample Size
Pyramid Lake	PY001000	Bromide	mg/L	0.21	0.13	0.40	18
Castaic Lake	CA002000			0.24	0.18	0.33	24
Silverwood Lake	SI002000			0.20	0.12	0.38	17
Lake Perris	PE002000			0.29	0.27	0.32	24
Pyramid Lake	PY001000	DOC	mg/L as C	NA			
Castaic Lake	CA002000			2.7	2.3	3.9	24
Silverwood Lake	SI002000			NA			
Lake Perris	PE002000			3.5	3.0	4.0	25
Pyramid Lake	PY001000	TOC	mg/L as C	NA			
Castaic Lake	CA002000			2.7	2.3	4.6	23
Silverwood Lake	SI002000			NA			
Lake Perris	PE002000			3.5	3.0	4.0	25

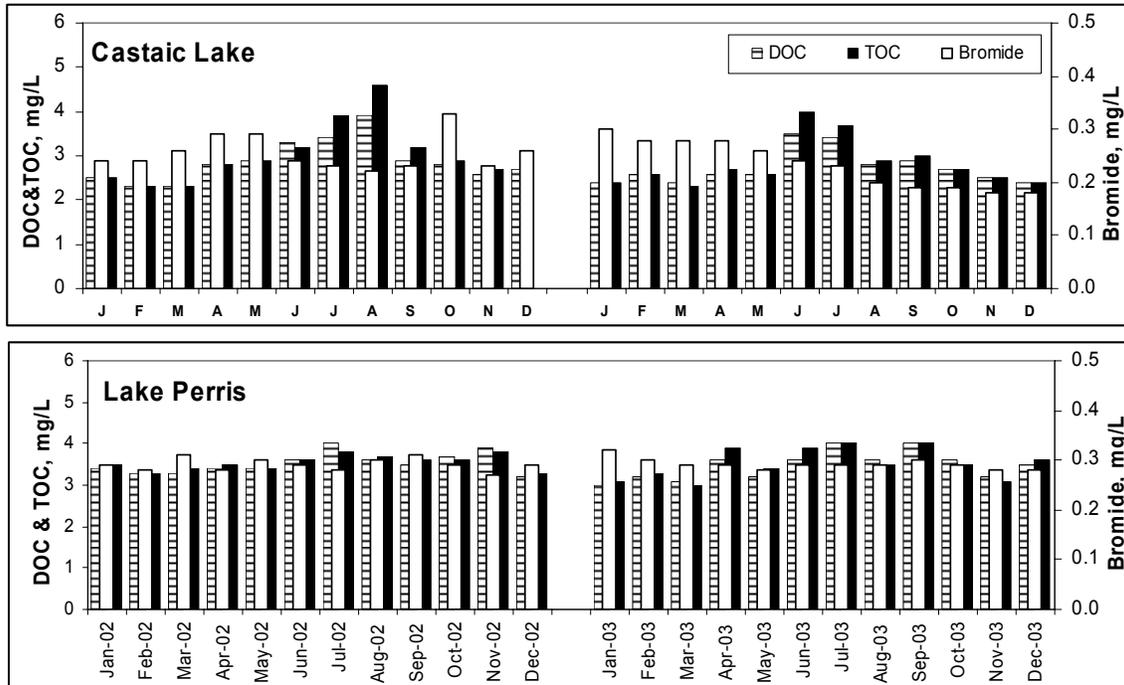


Figure 5-3. Monthly bromide and dissolved and total organic carbon in Castaic Lake and Lake Perris

Table 5-3. Summary of minor elements in SWP southern reservoirs, 2002 and 2003 (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	0.059	8	Chromium +3	0.0035	0.001	0.006	8	Mercury	<0.0002	<0.0002		8
Castaic Lake	CA002000		<0.01	<0.01		8		0.0035	0.001	0.006	8		<0.0002	<0.0002		8
Silverwood Lake	SI002000		<0.01	<0.01		8		0.0030	0.001	0.006	8		<0.0002	<0.0002		8
Lake Perris	PE002000		<0.01	<0.01		8		0.0045	0.002	0.007	8		<0.0002	<0.0002		8
Pyramid Lake	PY001000	Antimony	NA				Chromium +6	NA				Nickel	0.001	0.001	0.003	8
Castaic Lake	CA002000		NA					NA					<0.001	<0.001		8
Silverwood Lake	SI002000		NA					NA					0.001	0.001	0.002	8
Lake Perris	PE002000		NA					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	NA			
Castaic Lake	CA002000		0.002	0.002	0.003	8		0.005	0.002	0.057	13		NA			
Silverwood Lake	SI002000		0.002	0.002	0.003	8		0.004	0.002	0.005	8		NA			
Lake Perris	PE002000		<0.001	<0.001		8		0.004	0.002	0.022	27		NA			
Pyramid Lake	PY001000	Barium	<0.05	<0.05		8	Fluoride	0.1	<0.1	0.1	8	Silver	<0.001	<0.001		8
Castaic Lake	CA002000		<0.05	<0.05		8		0.1	<0.1	0.1	8		<0.001	<0.001		8
Silverwood Lake	SI002000		<0.05	<0.05		8		<0.1	<0.1	0.1	8		<0.001	<0.001		8
Lake Perris	PE002000		<0.05	<0.05	0.052	8		0.1	<0.1	0.1	8		<0.001	<0.001		8
Pyramid Lake	PY001000	Beryllium	<0.001	<0.001		8	Iron	<0.005	<0.005	0.078	8	Zinc	<0.005	<0.005		8
Castaic Lake	CA002000		<0.001	<0.001		8		<0.005	<0.005		8		<0.005	<0.005		8
Silverwood Lake	SI002000		<0.001	<0.001		8		0.005	<0.005	0.032	8		<0.005	<0.005	0.008	8
Lake Perris	PE002000		<0.001	<0.001		8		<0.005	<0.005		8		<0.005	<0.005	0.007	8
Pyramid Lake	PY001000	Boron	0.2	<0.1	0.2	8	Lead	<0.001	<0.001		8					
Castaic Lake	CA002000			0.2	0.2	8		<0.001	<0.001		8					
Silverwood Lake	SI002000		0.2	0.1	0.2	8		<0.001	<0.001		8					
Lake Perris	PE002000			0.2	0.2	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	0.007	8					
Lake Perris	PE002000		<0.001	<0.001		8		0.006	<0.005	0.05	8					

Table 5-4. Summary of nutrients in SWP southern reservoirs, 2002 and 2003

Station Name	Station Number	Parameter	Units	Median	Low	High	Sample Size
Pyramid Lake	PY001000	Ammonia	mg/L as N	<0.01	<0.01	0.04	24
Castaic Lake	CA002000			<0.01	<0.01	0.05	24
Silverwood Lake	SI002000			0.03	0.01	0.08	24
Lake Perris	PE002000			0.01	<0.01	0.1	24
Pyramid Lake	PY001000			Nitrite+Nitrate	mg/L as N	0.71	0.27
Castaic Lake	CA002000			0.49	0.02	1.01	24
Silverwood Lake	SI002000			0.76	0.2	1.6	24
Lake Perris	PE002000			0.02	<0.01	0.27	24
Pyramid Lake	PY001000	Total Kjeldahl Nitrogen	mg/L as N	0.25	0.2	0.9	24
Castaic Lake	CA002000			0.25	<0.1	0.6	24
Silverwood Lake	SI002000			0.3	0.1	0.7	24
Lake Perris	PE002000			0.4	0.2	0.9	24
Pyramid Lake	PY001000			Total Phosphorus	mg/L	0.08	<0.01
Castaic Lake	CA002000			0.05	<0.1	0.09	24
Silverwood Lake	SI002000			0.08	<0.1	0.12	24
Lake Perris	PE002000			0.02	<0.01	0.08	24

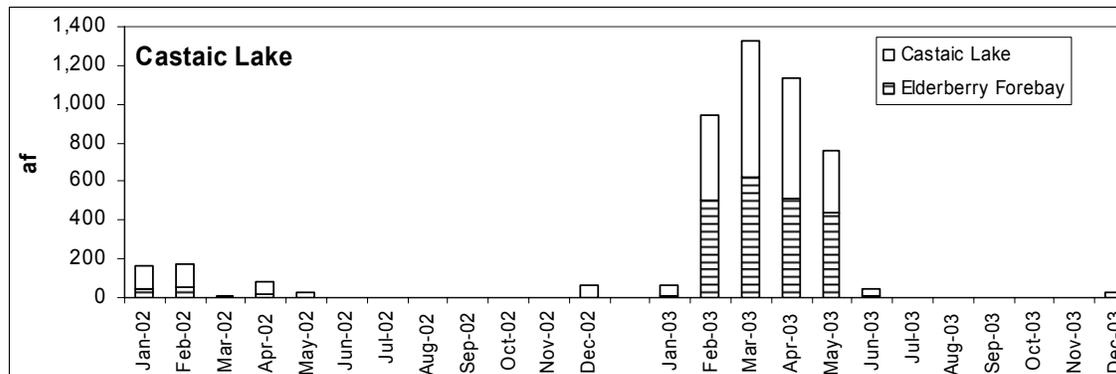
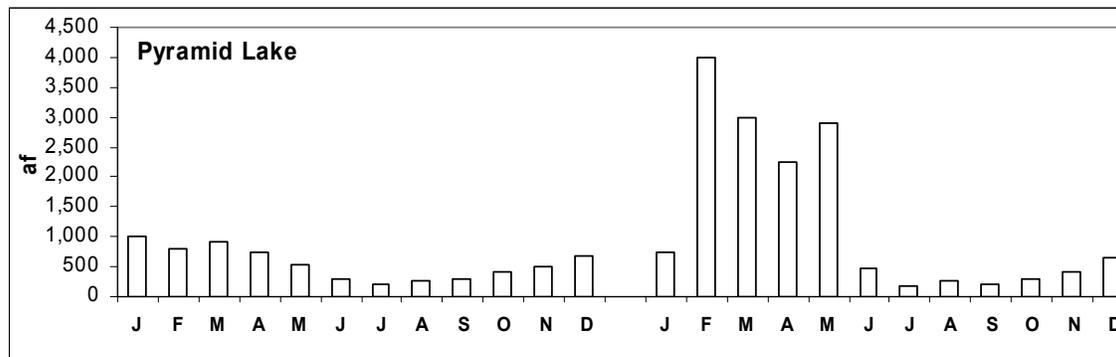
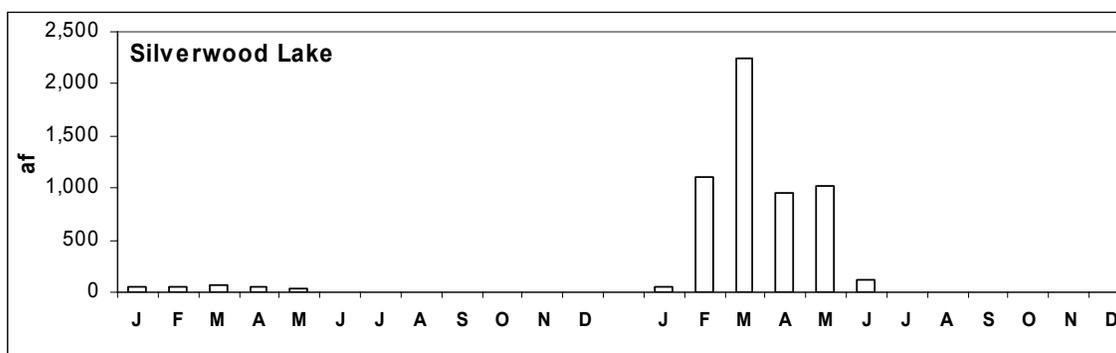


Figure 5-4. Monthly natural inflows to SWP southern reservoirs

VI. South Bay Aqueduct

Annual pumpage to the South Bay Aqueduct at South Bay Pumping Plant was 115 thousand acre-feet (taf) in 2002 and 133 taf in 2003 – about 10% of the total volume pumped at Banks Pumping Plant each year. Monthly pumping was generally lowest around the beginning and end of each year (Figure 6-1).

Natural inflows to Lake Del Valle totaled 18.7 taf in 2002 and 8 taf in 2003: The highest inflows by far occurred in December 2002 (Figure 6-1). Natural inflows accounted for 14% of the total volume conveyed into the South Bay Aqueduct system during 2002 and 5.7% during 2003 (total = natural inflows to Lake Del Valle + pumpage at South Bay Pumping Plant). Releases from Lake Del Valle comprised 100% of flow down the South Bay Aqueduct during January-February 2002 due to a complete halt in pumping at South Bay Pumping Plant (Figure 6-1).

Major minerals, conventional parameters, and disinfection byproduct precursors in the South Bay Aqueduct and Lake Del Valle outflows during 2002 and 2003 are summarized in Tables 6-1 and 6-2. Maximum Contaminant Levels for salinity, chloride, nitrate, and sulfate in treated drinking water were not exceeded.

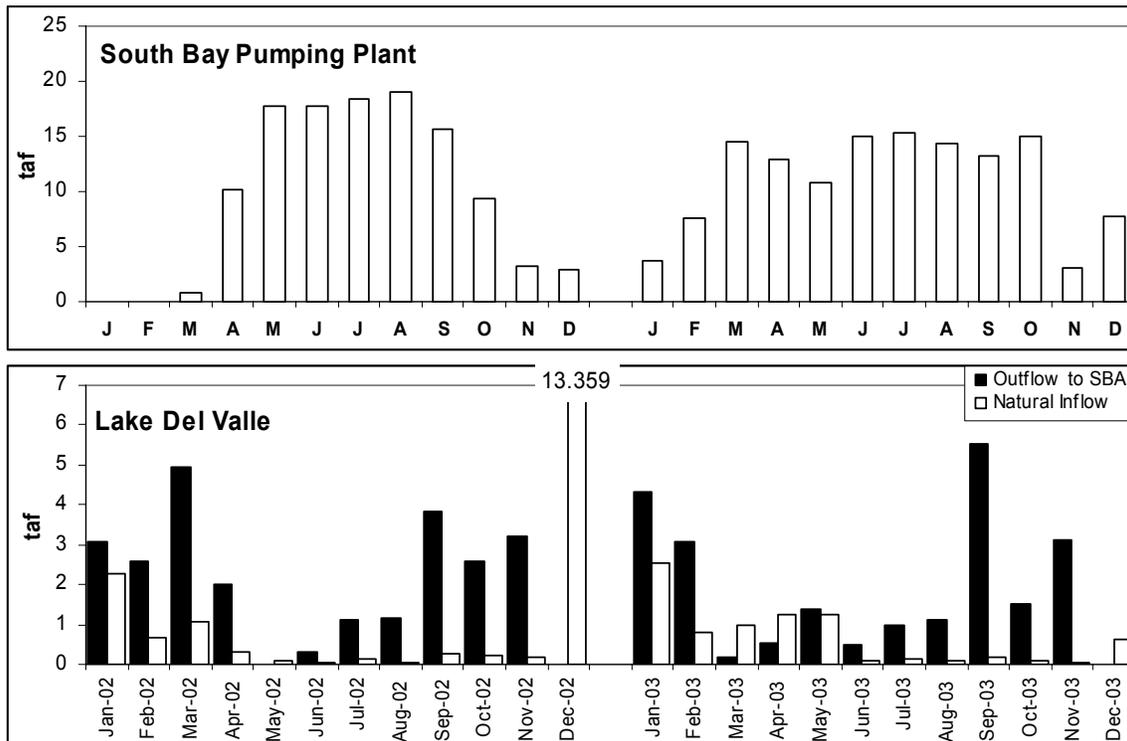


Figure 6-1. Monthly pumping at South Bay Pumping Plant, natural inflows to Lake Del Valle, and outflows from Lake Del Valle to the South Bay Aqueduct

Table 6-1. Summary of major minerals and conventional parameters in the South Bay Aqueduct and Lake Del Valle outflows, 2002 and 2003

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	76	59	85	20	Conductivity	μS/cm	330	178	699	20
Del Valle Outlet	DV000000			131	126	142	8			413	394	459	8
Santa Clara Terminal Tank	KB004207			78	64	85	8			414	201	591	8
Del Valle Check 7	KB001638	Calcium	mg/L	17	11	21	20	Hardness	mg/L as CaCO3	93.5	72	124	12
Del Valle Outlet	DV000000			28	27	30	8			144	133	153	8
Santa Clara Terminal Tank	KB004207			19	12	23	8			101	59	115	8
Del Valle Check 7	KB001638	Chloride	mg/L	42	14	144	20	pH	pH units	6.6	6.0	7.8	20
Del Valle Outlet	DV000000			27	25	38	8			6.95	6.7	8.1	8
Santa Clara Terminal Tank	KB004207			49.5	16	118	8			6.6	6.2	7.7	8
Del Valle Check 7	KB001638	Magnesium	mg/L	10	6	18	20	TDS	mg/L	194	106	416	20
Del Valle Outlet	DV000000			18	16	19	8			248	237	272	8
Santa Clara Terminal Tank	KB004207			12.5	7	14	8			273	121	355	9
Del Valle Check 7	KB001638	Nitrate	mg/L as N03	1.35	0.4	4.4	20	TSS	mg/L	8	2	67	20
Del Valle Outlet	DV000000			0.25	<0.1	0.8	8			2	<1	22	9
Santa Clara Terminal Tank	KB004207			1.9	0.5	5.1	8			8	5	17	7
Del Valle Check 7	KB001638	Sodium	mg/L	31.5	14	89	20	Turbidity	NTU	10	4	34	20
Del Valle Outlet	DV000000			25	23	32	8			3	1	15	8
Santa Clara Terminal Tank	KB004207			39.5	15	72	8			12	6	18	9
Del Valle Check 7	KB001638	Sulfate	mg/L	29.5	10	50	20	VSS	mg/L	2	1	15.5	20
Del Valle Outlet	DV000000			38	36	45	8			2	<1	6	9
Santa Clara Terminal Tank	KB004207			35	12	51	8			2.5	2	4	6

Table 6-2. Summary of disinfection byproduct precursors in the South Bay Aqueduct and Lake Del Valle outflows, 2002 and 2003

Station Name	Station Number	Parameter	Units	Median	Low	High	Sample Size
Del Valle Check 7	KB001638	Bromide	mg/L	0.13	0.04	0.47	20
Del Valle Outlet	DV000000			0.075	0.07	0.11	8
Del Valle Check 7	KB001638	DOC	mg/L as C	3.0	2.0	4.6	19
Del Valle Outlet	DV000000			3.9	3.6	4.7	5
Del Valle Check 7	KB001638	TOC	mg/L as C	3.2	2.1	5.7	18
Del Valle Outlet	DV000000			4.0	3.7	4.9	5

Monthly salinity trends in the South Bay Aqueduct at Del Valle Check 7 are shown in Figure 6-2. Mineral trends generally mimicked those at Banks Pumping Plant. Salinity, chloride, and bromide increased toward the end of both years due to seawater intrusion in the south Delta (see discussion in California Aqueduct).

Monthly TOC and DOC trends at Del Valle Check 7 (Figure 6-2) were roughly similar to those at Banks Pumping Plant with the exception of March 2002. Samples collected that month exhibited a wide disparity between TOC (5.7 mg/L) and DOC (3.7 mg/L). The concentration of both parameters at Banks that month was 3.6 mg/L. The wide differential between TOC and DOC at Del Valle Check 7 can be explained by the relatively high accompanying turbidity of 34 NTU (Figure 6-2). Concentration differences between TOC and DOC are most likely to be widest when the accompanying turbidity is greater than about 15 NTU (DWR 2005).

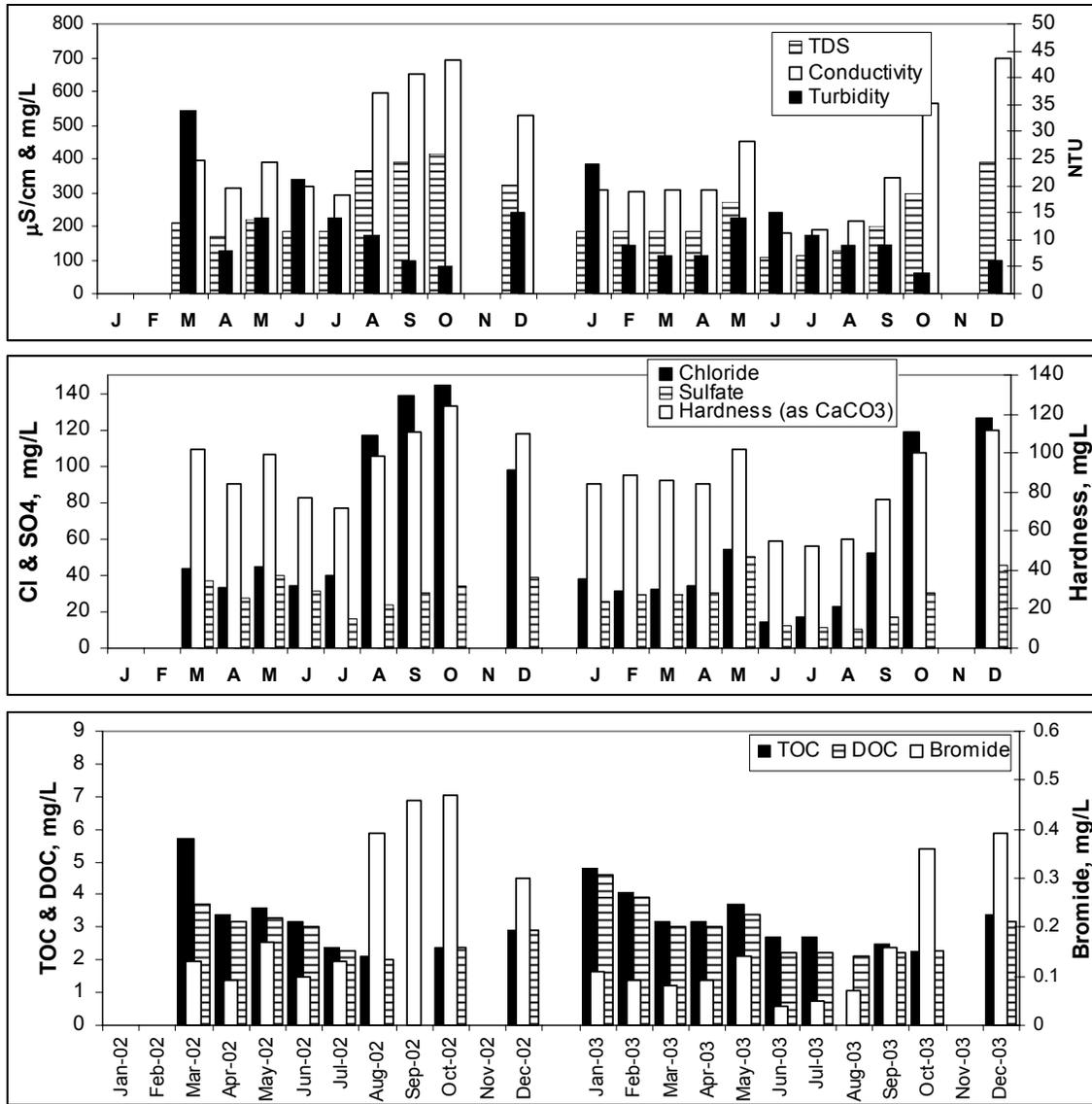


Figure 6-2. Monthly water quality in the South Bay Aqueduct at Del Valle Check 7

Minor elements and nutrients in the South Bay Aqueduct and Lake Del Valle outflows are summarized in Tables 6-3 and 6-4. Nutrients in Lake Del Valle are summarized in Table 6-4. Existing MCLs for these parameters in treated drinking water were not exceeded.

Table 6-3. Summary of minor elements in the South Bay Aqueduct and Lake Del Valle outflows, 2002 and 2003 (mg/L)

Station Name	Station Number	Minor Element	Sample			Sample Size	Minor Element	Sample			Sample Size	Minor Element	Sample			Sample Size
			Median	Low	High			Median	Low	High			Median	Low	High	
Del Valle Check 7	KB001638	Aluminum	<0.01	<0.01	<0.01	17	Chromium +3	0.003	<0.001	0.007	19	Mercury	<0.0002	<0.0002	19	
Del Valle Outlet	DV000000		<0.01	<0.01	<0.01	8		0.005	0.001	0.012	8		<0.0002	<0.0002	8	
Santa Clara Terminal Tank	KB004207		<0.01	<0.01	<0.01	7		0.003	<0.1	0.005	8		<0.0002	<0.0002	8	
Del Valle Check 7	KB001638	Antimony ¹ footnote 1	<0.001	<0.001	<0.005	19	Chromium +6	<0.0002			1	Nickel	0.001	<0.001	0.002	19
Del Valle Outlet	DV000000		<0.001	<0.001	<0.005	8		0.0005			1		0.001	0.001	0.002	8
Santa Clara Terminal Tank	KB004207		<0.001	<0.001	<0.005	8	NA					0.001	<0.001	0.002	8	
Del Valle Check 7	KB001638	Arsenic	0.002	0.001	0.003	19	Copper	0.003	0.002	0.256	27	Selenium	<0.001	<0.001	0.002	19
Del Valle Outlet	DV000000		0.002	0.002	0.003	8		0.002	0.002	0.003	8		<0.001	<0.001	0.001	8
Santa Clara Terminal Tank	KB004207		0.002	0.001	0.002	8		0.004	0.002	0.05	8		<0.001	<0.001	0.001	8
Del Valle Check 7	KB001638	Barium	<0.05	<0.05	<0.05	17	Fluoride	<0.1	<0.1	0.1	19	Silver	<0.001	<0.001	0.016	17
Del Valle Outlet	DV000000		0.057	<0.05	0.07	8		0.1	<0.1	0.2	8		<0.001	<0.001	0.063	8
Santa Clara Terminal Tank	KB004207		<0.05	<0.05	<0.05	7		<0.1	<0.1	<0.5	9		<0.001	<0.001	0.011	7
Del Valle Check 7	KB001638	Beryllium	<0.001	<0.001	<0.001	19	Iron	<0.005	<0.005	0.052	19	Zinc	<0.005	<0.005	0.016	19
Del Valle Outlet	DV000000		<0.001	<0.001	<0.001	8		<0.005	<0.005	<0.005	8		0.031	0.021	0.063	8
Santa Clara Terminal Tank	KB004207		<0.001	<0.001	<0.001	8		0.006	<0.005	0.05	8		0.005	<0.005	0.011	8
Del Valle Check 7	KB001638	Boron	0.1	<0.1	0.2	20	Lead	<0.001	<0.001	<0.001	19		<0.001	<0.001	<0.001	19
Del Valle Outlet	DV000000		0.2	0.2	0.2	8		<0.001	<0.001	<0.001	8		<0.001	<0.001	<0.001	8
Santa Clara Terminal Tank	KB004207		0.15	<0.1	0.2	8		<0.001	<0.001	<0.001	8		<0.001	<0.001	<0.001	8
Del Valle Check 7	KB001638	Cadmium	<0.001	<0.001	<0.001	17	Manganese	<0.005	<0.005	0.024	19		<0.005	<0.005	<0.005	19
Del Valle Outlet	DV000000		<0.001	<0.001	<0.001	8		<0.005	<0.005	<0.005	8		<0.005	<0.005	<0.005	8
Santa Clara Terminal Tank	KB004207		<0.001	<0.001	<0.001	7		<0.005	<0.005	0.005	8		<0.005	<0.005	<0.005	8

¹ Reporting limit changed from < 0.005 to < 0.001 in July, 2002

Table 6-4. Summary of nutrients in the South Bay Aqueduct, Lake Del Valle, and Lake Del Valle outflows, 2002 and 2003

Station Name	Station Number	Parameter	Units	Sample			Sample Size
				Median	Low	High	
Del Valle Check 7	KB001638	Ammonia	mg/L as N	<0.01	<0.01	0.05	20
Lake Del Valle	DV001000			<0.01	<0.01	0.02	18
Del Valle Outlet	DV000000			<0.01	<0.01	<0.01	9
Del Valle Check 7	KB001638	Nitrite+Nitrate	mg/L as N	0.40	<0.01	0.99	20
Lake Del Valle	DV001000			<0.01	<0.01	0.19	17
Del Valle Outlet	DV000000			0.05	<0.01	0.19	9
Del Valle Check 7	KB001638	Total Kjeldahl Nitrogen	mg/L as N	0.3	0.2	1.2	20
Lake Del Valle	DV001000			0.3	0.2	0.4	18
Del Valle Outlet	DV000000			0.3	0.2	0.5	9
Del Valle Check 7	KB001638	Total Phosphorus	mg/L	0.09	0.02	0.23	20
Lake Del Valle	DV001000			0.02	<0.01	0.08	18
Del Valle Outlet	DV000000			0.02	<0.01	0.05	9

VII. North Bay Aqueduct

Annual pumpage to the North Bay Aqueduct at Barker Slough Pumping Plant was about 46 taf in both 2002 and 2003. Monthly pumping during both years generally increased to a maximum in July then decreased through the end of the year (Figure 7-1).

Water quality at Barker Slough Pumping Plant during 2002 and 2003 is summarized in Table 7-1. Existing MCLs for salinity, chloride, sulfate, nitrate, minor elements, and nutrients in treated drinking water were not exceeded.

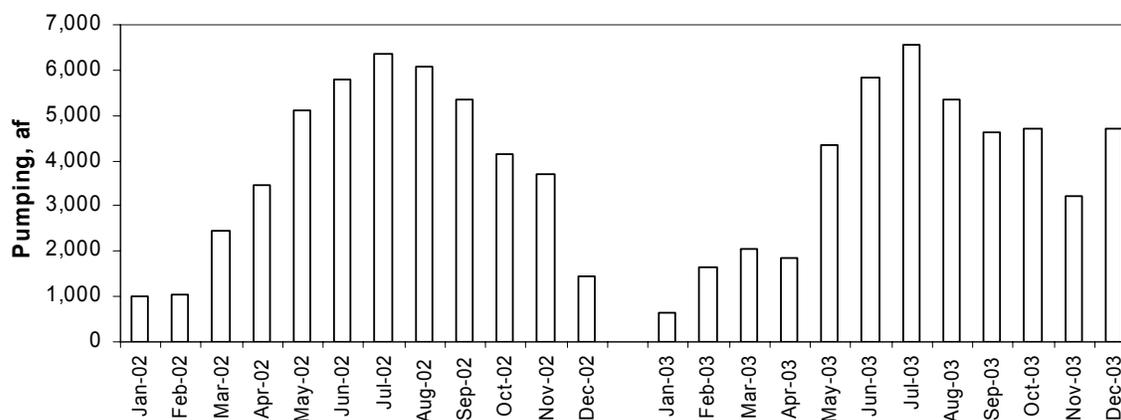


Figure 7-1. Monthly pumping to the North Bay Aqueduct at Barker Slough Pumping Plant

Table 7-1. Summary of water quality in the North Bay Aqueduct at Barker Slough Pumping Plant, 2002 and 2003

Parameter	Units	Median	Low	High	Sample Size	Parameter	Units	Median	Low	High	Sample Size
Major Minerals						Minor Elements (Cont.)					
Alkalinity	mg/L as CaCO ₃	89	42	167	24	Barium	mg/L	<0.05	<0.05	0.066	20
Calcium	mg/L	14	6	24	24	Beryllium	mg/L	<0.001	<0.001		24
Chloride	mg/L	16	9	50	24	Boron	mg/L	0.1	<0.1	0.5	24
Magnesium	mg/L	11	5	24	24	Cadmium	mg/L	<0.001	<0.001		20
Nitrate	mg/L as NO ₃	1	<0.1	3.1	24	Chromium +3	mg/L	0.002	<0.001	0.011	24
Sodium	mg/L	19	12	56	24	Chromium +6	mg/L	<0.0002	<0.0002	0.0011	12
Sulfate	mg/L	17	7	63	24	Copper	mg/L	0.002	0.001	0.008	24
Conventional Parameters						Fluoride	mg/L	0.1	<0.1	0.2	24
Conductivity	µS/cm	262	134	572	24	Iron	mg/L	0.005	<0.005	0.245	24
Hardness	mg/L as CaCO ₃	78	36	159	24	Lead	mg/L	<0.001	<0.001		24
pH	pH units	7.0	6.0	8.2	25	Manganese	mg/L	0.012	<0.005	0.046	24
TDS	mg/L	156	83	345	24	Mercury	mg/L	<0.0002	<0.0002		24
TSS	mg/L	38	12	72	24	Nickel	mg/L	0.002	0.001	0.005	24
Turbidity	NTU	49	4	88	24	Selenium	mg/L	<0.001	<0.001		24
VSS	mg/L	6	2	10	24	Silver	mg/L	<0.001	<0.001		20
Disinfection By-Product Precursors						Zinc	mg/L	<0.005	<0.005		24
Bromide	mg/L	0.03	0.01	0.09	24	Nutrients					
DOC	mg/L as C	3.15	2.4	15.6	24	Ammonia	mg/L as N	0.02	<0.01	0.06	24
TOC	mg/L as C	4.4	3	17.4	23	Nitrate + Nitrite	mg/L as N	0.23	<0.01	0.81	24
UVA 254	Absorbance/cm	0.096	0.073	0.671	25	Total Kjeldahl Nitrogen	mg/L as N	0.5	0.3	1.2	24
Minor Elements						Total Phosphorus	mg/L	0.16	0.08	0.34	24
Aluminum	mg/L	<0.01	<0.01	0.016	20						
Antimony *footnote #1	mg/L		<0.001	<0.005	24						
Arsenic	mg/L	0.002	<0.001	0.003	24						

1 Reporting limit changed from < 0.005 to < 0.001 mg/L in July 2002

Turbidity at Barker Slough Pumping Plant was relatively high during both years. Monthly turbidity ranged from 4 to 88 NTU with a median of 49 NTU (Figure 7-2). Salinity, chloride, and sulfate reached seasonal maximums in March of both years but remained below applicable MCLs (Figure 7-2). Bromide in all samples was below 0.1 mg/L.

Monthly TOC and DOC at Barker Slough Pumping Plant ranged from 2.4 to 17.4 mg/L (Figure 7-2). Both parameters were elevated during four months in 2002 (≥ 5.4 mg/L) and three months in 2003 (≥ 6.3 mg/L). Organic carbon and UVA₂₅₄ were correlated with r^2 values ranging from 0.74 to 0.80 (Figure 7-3). The correlations were nearly exact ($r^2 = 0.98-0.99$) without one obvious non-conforming data pair. The outliers can be explained if the UVA₂₅₄ sample (the same for both correlations) was submitted to the lab unfiltered. An unfiltered sample would produce a higher-than-normal UVA₂₅₄ value evident in Figure 7-3. This outlier explanation was supported with 2004-05 data that exhibited a near exact correlation between UVA₂₅₄ and both TOC and DOC (DWR in prep.).

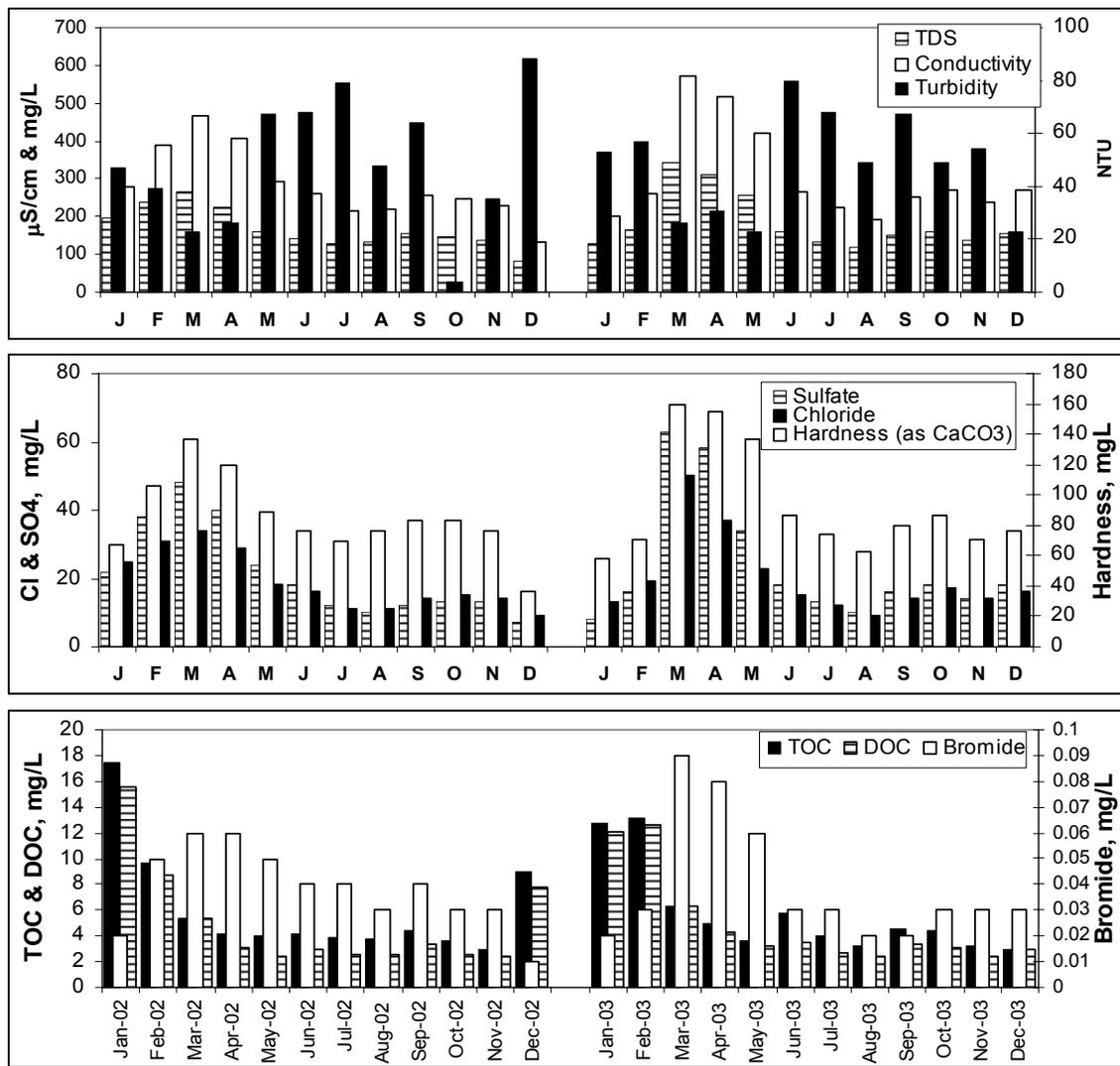


Figure 7-2. Monthly water quality in the North Bay Aqueduct at Barker Slough Pumping Plant

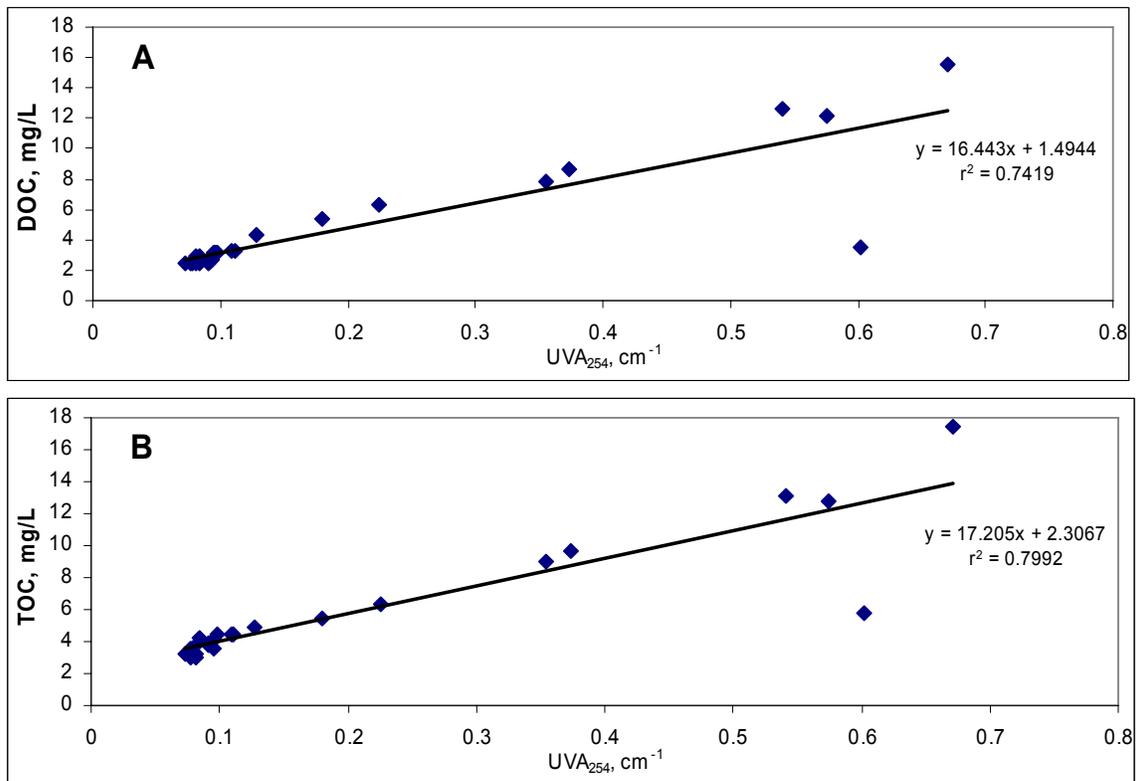


Figure 7-3. Correlation between ultraviolet absorbance at 254 nanometers and dissolved organic carbon (A) and total organic carbon (B)

VIII. Oroville Complex and Upper Feather River Reservoirs

The Oroville complex includes Lake Oroville, Thermalito Forebay, and Thermalito Afterbay. Water quality in the Oroville complex and upper Feather River reservoirs during 2002 and 2003 is summarized in Tables 8-1 to 8-3. Water quality at most stations was characteristically excellent with less-than-detectable to low levels of minerals, most minor elements, and nutrients. Existing MCLs for salinity, chloride, sulfate, nitrate, and nutrients in treated drinking water were not exceeded.

The minor element manganese was above the Secondary MCL of 0.05 mg/L in four of ten samples collected from Lake Davis during the two-year period (0.12 to 0.245 mg/L) (Table 8-2). Manganese was also above the MCL in a sample collected from Thermalito Afterbay (0.072 mg/L). The gas additive methyl *tert*-butyl ether was detected in several samples collected near Lime Saddle Marina in Lake Oroville during 2003 (see Organic Chemicals).

Table 8-1. Summary of major minerals and conventional parameters at SWP stations in the Oroville complex and upper Feather River reservoirs, 2002 and 2003

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 CaCO ₃		40	44	2	Conductivity	µS/cm		80	85	2
Lake Davis	LD001000			45.5	44	47	4			87	82	90	4
Thermalito Forebay	TF001000			42	40	44	7			86	80	102	7
Thermalito Afterbay	TA001000			42	38	52	21			89	79	103	21
Antelope Lake	AN001000	Calcium	mg/L		7	8	2	Hardness	mg/L as CaCO ₃		26	28	2
Lake Davis	LD001000			8.5	8	9	4			33.5	32	35	4
Thermalito Forebay	TF001000			8	8	9	7			36	32	39	7
Thermalito Afterbay	TA001000			8	7	10	21			36	30	41	21
Antelope Lake	AN001000	Chloride	mg/L		<1	<1	2	pH	pH units		6.1	6.8	2
Lake Davis	LD001000			<1	<1	4	6.4			6.1	6.8	4	
Thermalito Forebay	TF001000			1	<1	1	7			6.3	6.1	6.8	7
Thermalito Afterbay	TA001000			1	<1	1	21			6.4	5.5	7	21
Antelope Lake	AN001000	Magnesium	mg/L		2	2	2	TDS	mg/L		51	56	2
Lake Davis	LD001000				3	3	4			54	53	56	4
Thermalito Forebay	TF001000			4	3	4	7			53	50	63	7
Thermalito Afterbay	TA001000			4	3	4	21			56.5	48	63	22
Antelope Lake	AN001000	Nitrate	mg/L as NO ₃		<0.1	<0.1	2	TSS	mg/L		NA		
Lake Davis	LD001000				<0.1	<0.1	4			NA			
Thermalito Forebay	TF001000			0.2	0.2	0.3	7			<1	<1	8	8
Thermalito Afterbay	TA001000			<0.1	<0.1	0.4	21			6	2	8	7
Antelope Lake	AN001000	Sodium	mg/L		5	5	2	Turbidity	NTU		1	1	2
Lake Davis	LD001000				4	4	4			3.5	2	5	4
Thermalito Forebay	TF001000			3	3	4	7			<1	<1	7	8
Thermalito Afterbay	TA001000			3	3	4	21			3	1	23	23
Antelope Lake	AN001000	Sulfate	mg/L		<1	<1	2	VSS	mg/L		NA		
Lake Davis	LD001000				<1	<1	4			NA			
Thermalito Forebay	TF001000				2	2	7			<1	<1	2	8
Thermalito Afterbay	TA001000				2	2	21			2	1	3	7

Table 8-2. Summary of minor elements at SWP stations in the Oroville complex and upper Feather River reservoirs, 2002 and 2003 (mg/L)

Station Name	Station Number	Minor Element	Sample			Minor Element	Sample			Minor Element	Sample						
			Median	Low	High		Size	Median	Low		High	Size	Median	Low	High	Size	
Antelope Lake	AN001000	Aluminum	<0.01	<0.01	<0.01	2	Chromium +3	<0.001	<0.001	<0.001	2	Mercury	<0.0002	<0.0002	<0.0002	2	
Lake Davis	LD001000		<0.01	<0.01	<0.01	2	<0.001	<0.001	<0.001	2	<0.0002	<0.0002	<0.0002	2			
Thermalito Forebay	TF001000		<0.01	<0.01	<0.01	7	0.002	<0.001	0.003	7	<0.0002	<0.0002	<0.0002	7			
Thermalito Afterbay	TA001000		<0.01	<0.01	<0.01	15	0.002	<0.001	0.003	21	<0.0002	<0.0002	<0.0002	15			
Antelope Lake	AN001000	Antimony ^{footnote #1}	<0.001	<0.005	<0.001	2	Chromium +6	N A				Nickel	<0.001	<0.001	<0.001	2	
Lake Davis	LD001000		<0.001	<0.005	<0.001	2	N A				<0.001	<0.001	<0.001	2			
Thermalito Forebay	TF001000		<0.005	<0.005	<0.001	1	N A				<0.001	<0.001	<0.001	1			
Thermalito Afterbay	TA001000		<0.005	<0.005	<0.001	1	0.0003	<0.001	0.0007	13	<0.001	<0.001	<0.001	1			
Antelope Lake	AN001000	Arsenic	<0.001	<0.001	<0.001	2	Copper	<0.001	<0.001	<0.001	2	Selenium	<0.001	<0.001	<0.001	2	
Lake Davis	LD001000		<0.001	<0.001	<0.001	2	<0.001	<0.001	<0.001	2	<0.001	<0.001	<0.001	2			
Thermalito Forebay	TF001000		<0.001	<0.001	<0.001	7	<0.001	<0.001	<0.001	7	<0.001	<0.001	<0.001	1			
Thermalito Afterbay	TA001000		<0.001	<0.001	<0.001	21	<0.001	<0.001	0.001	21	<0.001	<0.001	<0.001	1			
Antelope Lake	AN001000	Barium	<0.05	<0.05	<0.05	2	Fluoride	<0.1	<0.1	<0.1	2	Silver	<0.001	<0.001	<0.001	2	
Lake Davis	LD001000		<0.05	<0.05	<0.05	2	<0.1	<0.1	<0.1	2	<0.001	<0.001	<0.001	2			
Thermalito Forebay	TF001000		<0.05	<0.05	<0.05	7	<0.1	<0.1	<0.1	7	<0.001	<0.001	<0.001	7			
Thermalito Afterbay	TA001000		<0.001	<0.001	<0.001	21	<0.1	<0.1	<0.1	21	<0.001	<0.001	<0.001	15			
Antelope Lake	AN001000	Beryllium	<0.001	<0.001	<0.001	2	Iron	<0.001	0.043	<0.001	0.043	2	Zinc	<0.005	<0.005	<0.005	2
Lake Davis	LD001000		<0.001	<0.001	<0.001	2	0.010	<0.005	0.045	10	<0.005	<0.005	<0.005	2			
Thermalito Forebay	TF001000		<0.001	<0.001	<0.001	1	0.005	<0.005	0.007	7	<0.005	<0.005	<0.005	7			
Thermalito Afterbay	TA001000		<0.001	<0.001	<0.001	1	<0.005	<0.005	0.021	21	<0.005	<0.0015	<0.005	21			
Antelope Lake	AN001000	Boron	<0.1	<0.1	<0.1	2	Lead	<0.001	<0.001	<0.001	2						
Lake Davis	LD001000		<0.1	<0.1	<0.1	2	<0.001	<0.001	<0.001	2							
Thermalito Forebay	TF001000		<0.1	<0.1	<0.1	7	<0.001	<0.001	<0.001	7							
Thermalito Afterbay	TA001000		<0.1	<0.1	<0.1	22	<0.001	<0.001	<0.001	21							
Antelope Lake	AN001000	Cadmium	<0.001	<0.001	<0.001	2	Manganese	<0.005	0.006	<0.005	0.006	2					
Lake Davis	LD001000		<0.001	<0.001	<0.001	2	0.016	<0.005	0.245	10							
Thermalito Forebay	TF001000		<0.001	<0.001	<0.001	7	<0.005	<0.005	0.03	7							
Thermalito Afterbay	TA001000		<0.001	<0.001	<0.001	15	<0.005	<0.005	0.072	21							

1 Reporting limit changed from < 0.005 to < 0.001 in July, 2002

Figure 8-3. Summary of nutrients at SWP stations in the Oroville complex and upper Feather River reservoirs, 2002 and 2003

Station Name	Station Number	Parameter	Units	Median	Low	High	Sample Size
Antelope Lake	AN001000	Ammonia	mg/L as N		<0.01	<0.01	2
Lake Davis	LD001000			<0.01	<0.01	<0.01	2
Thermalito Afterbay	TA001000			<0.01	<0.01	0.24	21
Lake Oroville	OR001000			<0.01	<0.01	0.02	13
Antelope Lake	AN001000	Nitrite +Nitrate	mg/L as N		<0.01	<0.01	2
Lake Davis	LD001000			<0.01	<0.01	<0.01	2
Thermalito Afterbay	TA001000			<0.01	<0.01	0.09	21
Lake Oroville	OR001000			<0.01	<0.01	0.01	13
Antelope Lake	AN001000	Ortho-Phosphate	mg/L as P		<0.01		1
Lake Davis	LD001000			<0.01	<0.01		1
Thermalito Afterbay	TA001000			NA			
Lake Oroville	OR001000			NA			
Antelope Lake	AN001000	Total Kjeldahl Nitrogen	mg/L as N		0.2	0.3	2
Lake Davis	LD001000				0.4	0.4	2
Thermalito Afterbay	TA001000			<0.1	<0.1	0.2	21
Lake Oroville	OR001000			<0.1	<0.1	0.2	13
Antelope Lake	AN001000	Total Phosphorus	mg/L		0.02	0.02	2
Lake Davis	LD001000				0.02	0.03	2
Thermalito Afterbay	TA001000			0.01	<0.01	0.04	21
Lake Oroville	OR001000			<0.01	<0.01	0.02	13

IX. Organic Chemicals

Organic chemicals are analyzed in samples collected throughout the SWP in March, June, and September of each year. The EPA method chemical scans include carbamate pesticides, chlorinated organic pesticides, chlorinated phenoxy herbicides, sulfur pesticides (DWR method), glyphosate, phosphorus/nitrogen pesticides, and purgeable organics. Specific chemicals analyzed in each method scan are listed in Appendix A, Table A-3. Sampling was intensified for the gas additive methyl *tert*-butyl ether (MtBE) at several stations throughout the SWP during 2002 and 2003. The chemical scans and any positive detections are listed in Table 9-1.

Sampling frequency for MtBE was increased to monthly at Banks Pumping Plant, the South Bay Aqueduct at Del Valle Check 7, and the North Bay Aqueduct at Barker Slough Pumping Plant. Besides the usual volatile organics scans that include MtBE at the routine stations, a limited number of MtBE samples were also collected from Lake Oroville. Of the 121 samples from stations around the SWP (including the CVP's DMC), MtBE was detected above the reporting limit in 13. Concentrations ranged between 0.3 to 6.9 µg/L, below the Primary MCL of 13 µg/L for MtBE in treated drinking water. Three samples from Lake Oroville near Lime Saddle Marina contained MtBE at concentrations of 5.1 to 6.9 µg/L – just above the Secondary MCL of 5 µg/L. Secondary MCLs address taste, odor, or appearance characteristics of treated drinking water.

Several herbicides were detected in and around the SWP during 2002 and 2003. Simazine was above the reporting limit throughout much of the California Aqueduct on two occasions in 2002 with concentrations ranging between 0.02 and 0.04 µg/L, well below the drinking water MCL of 4 µg/L. The herbicide 2,4-D was detected in the California Aqueduct, DMC, and North Bay Aqueduct on dates in September 2002. Concentrations ranged from 0.11 to 0.32 µg/L and were well below the MCL of 70 µg/L. Diuron was detected in the same waterways in March 2003 at concentrations ranging from 0.89 to 3.2 µg/L (no MCL exists for diuron).

The insecticide diazinon was detected in three samples from the California Aqueduct and DMC. Other compounds detected once each included styrene, dacthal (DCPA), chlorpyrifos, atrazine, and pentachlorophenol. All detections were below existing MCLs.

Table 9-1 (Con't). Organic chemical scans performed during 2002 and 2003 around the State Water Project (and the CVP's DMC) and those chemical compounds detected above the reporting limit ($\mu\text{g/L}$) (X=scans were performed)

Facility	Station	Year	Date	EPA Method # Scan 1/															
				531.1	608	615	Sulfur Pest.	547	614	502.2	502.2 (MBE)	2,4-D	Diazinon	Diuron	MIBE	Simazine	Other Compounds		
South Bay Aqueduct																			
	Del Valle Check 7	2002	20-Mar								X								
			15-May								X								
			19-Jun								X								
			17-Jul								X								
			21-Aug								X								
			16-Oct									X							
			18-Dec								X								
		2003	15-Jan								X								
			19-Feb								X								
			19-Mar								X								
			16-Apr								X								
			21-May								X								
			18-Jun								X								
			16-Jul								X								
			20-Aug								X								
			14-Oct								X								
			16-Dec								X								
	Lake Del Valle	2002	19-Feb									X							
			13-May									X					1.2		
		2003	3-Jan									X							
			17-Mar								X								
			14-Apr								X								
			16-Jul								X								
		**	15-Sep								X						1.1		
		**	14-Oct								X								
		**	17-Nov								X								
		**	15-Dec								X								
	Lake Del Valle Outlet (COW)		16-Jul								X								
North Bay Aqueduct																			
	Barker Slough Pumping Plant	2002	16-Jan								X								
			20-Feb								X								
			20-Mar	X	X	X	X	X	X	X	X								
			15-May								X								
			19-Jun								X								
			17-Jul								X								
			21-Aug								X								
			18-Sep	X	X	X	X	X	X	X	X	0.32					Styrene (0.7 $\mu\text{g/L}$)		
			20-Nov								X								
			18-Dec								X								
		2003	15-Jan								X								
			19-Feb								X								
			19-Mar	X	X	X	X	X	X	X	X			0.89					
			16-Apr								X								
			21-May								X								
			18-Jun	X	X	X	X	X	X	X	X								
			20-Aug								X								
			17-Sep	X	X	X	X	X	X	X	X								
			15-Oct								X								
			19-Nov								X								
			17-Dec								X								
Lake Oroville																			
	west bank at Dam footnote 2/	2002	8-Jul								X						3.2, 2.9		
			3-Sep								X						2.8, 2.0		
	Lime Saddle Marina		8-Jul								X						6.9, 5.9		
	footnote 2/		3-Sep								X						5.1, 4.9		

1/ 531.1: Carbamate Pesticides; 608: Chlorinated Organic Pesticides; 615: Chlorinated Phenoxy Acid Herbicides;

Sulfur Pest.: DWR Sulfur Pesticides; 547: Glyphosate; 614: Phosphorus/Nitrogen Pesticides;

502.2: Volatile Organics (Purgeable Organics).

2/ 0.2 and 6 meters depth, respectively

** 1, 4, and 8 meters depth

X. Special Studies

Ultraviolet Absorbance at 254 Nanometers and Total and Dissolved Organic Carbon in the California Aqueduct

Ultraviolet absorbance at 254 nanometers (UVA_{254}) was correlated with DOC in the California Aqueduct with r^2 values ranging from 0.81 at Check 41 to 0.95 at Banks Pumping Plant (Figure 10-1). Correlation strength between UVA_{254} and TOC was lower with r^2 values ranging from 0.73 to 0.90 (Figure 10-2).

For most of the relationships, correlation strength was somewhat overestimated by one data pair in the high organic carbon range. For instance, the r^2 for DOC at Banks Pumping Plant dropped from 0.946 to 0.873 with the exclusion of one DOC value on the far right of Figure 10-1. Although the strength of many of the correlations were similarly bolstered by one data pair in the high concentration range, an r^2 of 0.94 was obtained for UVA_{254} and DOC at Banks using all available data (2000 to 2003) (Figure 10-3). Routine sampling for UVA_{254} at the other stations began in mid-2002.

The strong correlation between these two parameters supports the application of cost-effective UVA_{254} meters for measuring real-time DOC trends. Three on-line UVA_{254} spectrophotometers (Tytronics model FP 1100) are situated along the California Aqueduct to continuously track DOC. These meters are relatively easy to maintain and do not require the somewhat costly consumable media (gas, reagents, and moving parts) necessary for certain other on-line instruments analyzing actual organic carbon concentrations (Amburgey 2004, see cost estimates in Appendix C). Further, a study of four on-line organic carbon analyzers showed that output concentrations often varied between brands and some routinely generated unexplained phantom spikes (ibid.).

Based on the preceding information and cited study, the increased maintenance effort and costs associated with recently tested on-line organic carbon analyzers would not appear to produce data that was any more accurate than what is produced from the relationship between UVA_{254} and DOC and, in many cases, the outputs were less accurate. This and the low cost and maintenance effort associated with the continuous operation of ultraviolet spectrophotometers makes these meters more practicable instruments for tracking DOC trends at Banks Pumping Plant and possibly other stations. Correlation strength at other California Aqueduct stations will be better defined as more data are accumulated.

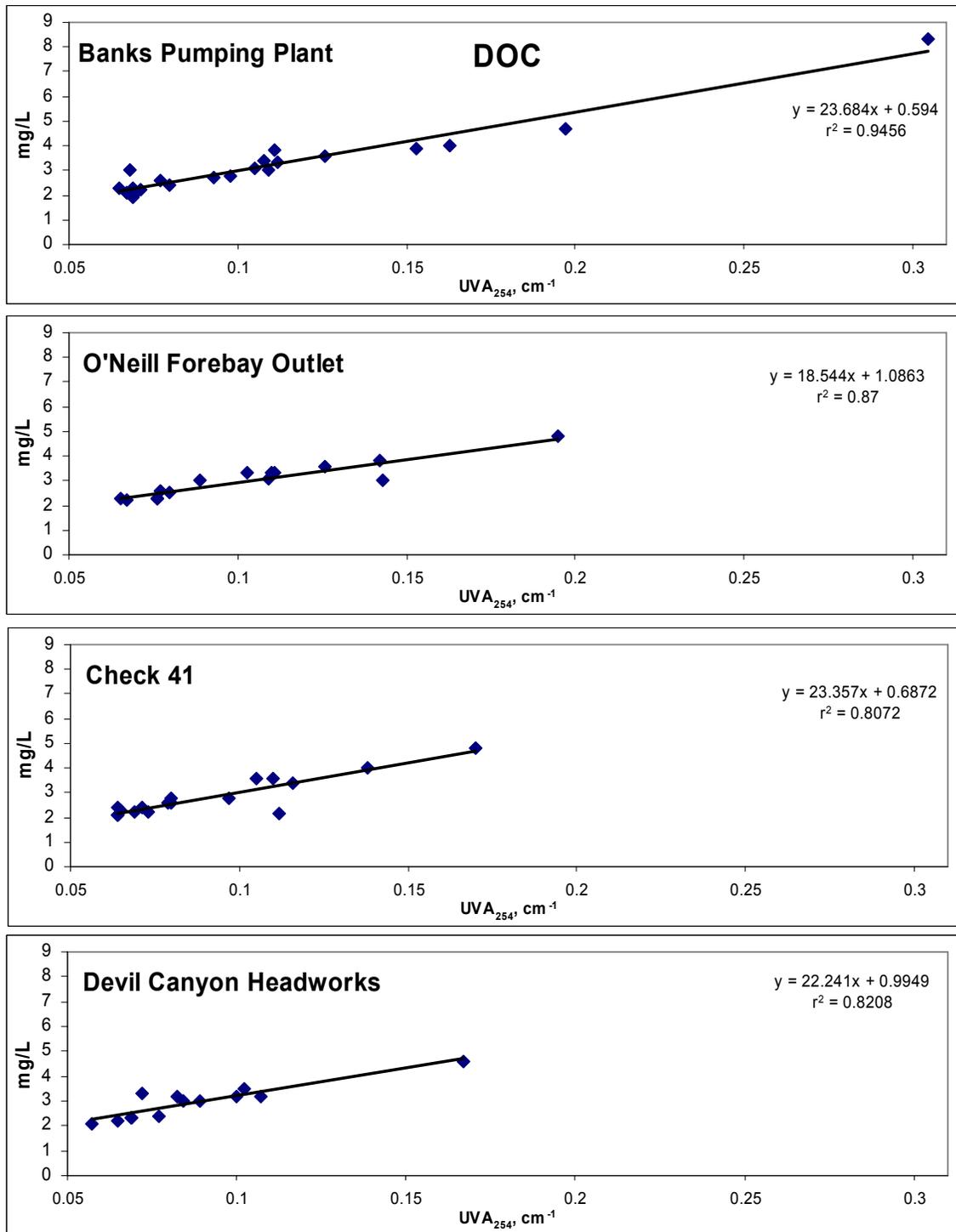


Figure 10-1. Correlation between ultraviolet absorbance at 254 nanometers and dissolved organic carbon in the California Aqueduct, 2002 and 2003

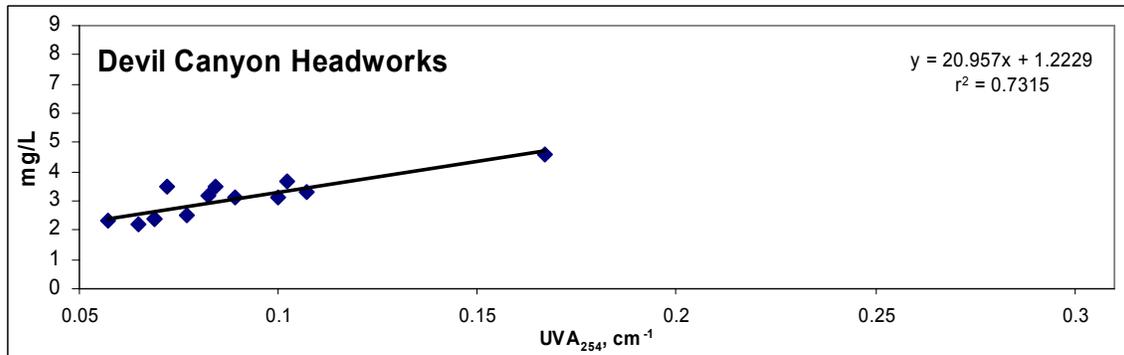
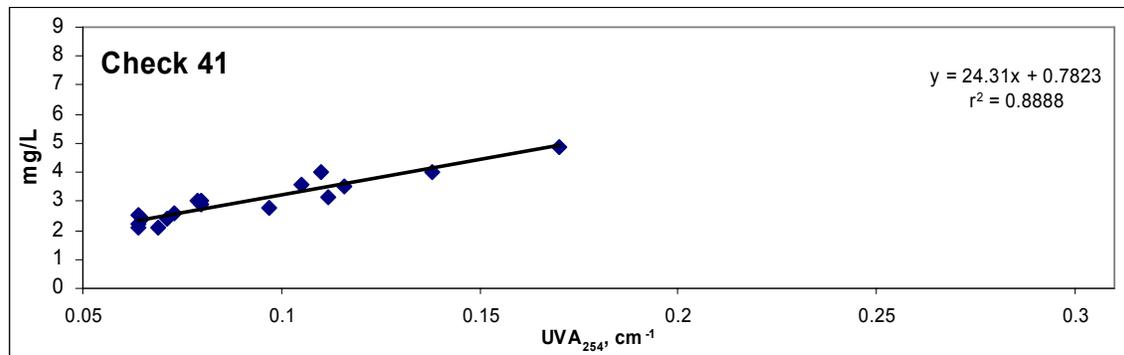
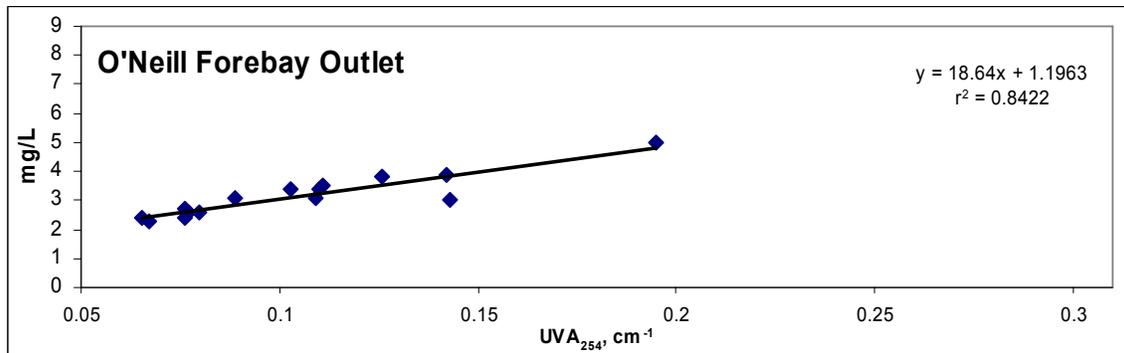
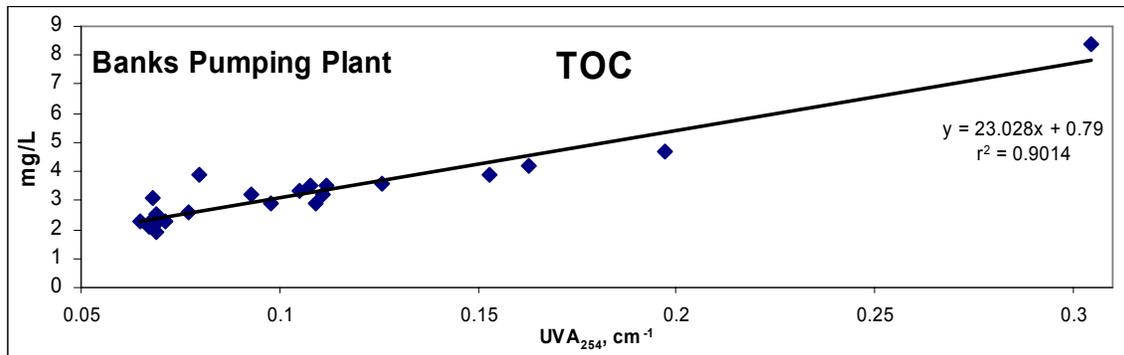


Figure 10-2. Correlation between ultraviolet absorbance at 254 nanometers and total organic carbon in the California Aqueduct, 2002 and 2003

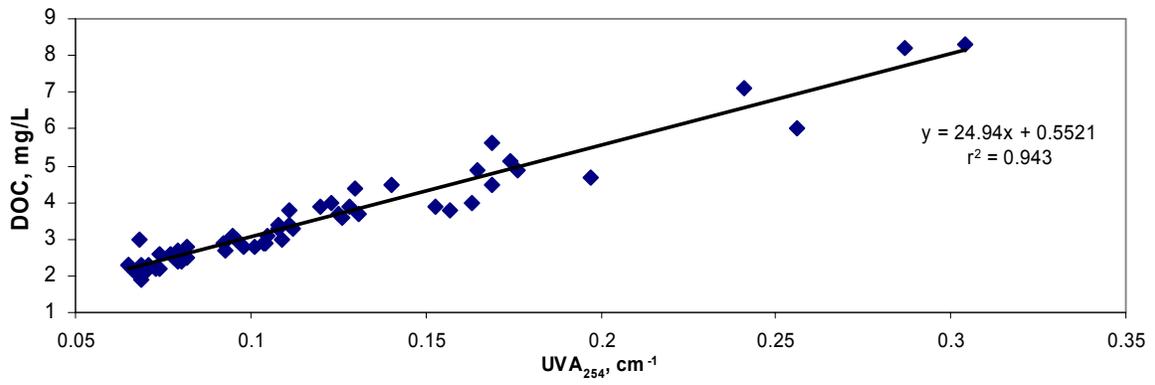


Figure 10-3. Correlation between ultraviolet absorbance at 254 nanometers and dissolved organic carbon in the California Aqueduct at Banks Pumping Plant, late 2000 to late 2005

San Joaquin River Spring-Pulse Flows and Export Salinity Spikes

This section describes salinity increases in south Delta exports due to water operations in spring when salinity would otherwise be declining. During mid-April to mid-May, flow in the lower San Joaquin River is artificially pulsed to aid out-migrating salmon. Spring-pulse flows were first codified in the 1995 Water Quality Control Plan (SWRCB 1995) followed by the Vernalis Adaptive Management Plan (VAMP) in 1999 (D-1641). Along with conditional flow targets in the San Joaquin River at Vernalis, VAMP requirements can also include restricted south Delta pumping and barrier installation at the head of Old River. Spring-pulse flows during 2002 and 2003 coincided with salinity spikes in south Delta exports lasting more than a month.

The spring-pulse hydrograph in the San Joaquin River at Vernalis appeared as a month-long increase in flow between April and May of both 2002 and 2003 (Figure 10-4A). A similar trend in conductivity was observed in Middle River just north of Banks Pumping Plant. During 2002, conductivity in Middle River began to rise on April 23, nine days after flow in the San Joaquin River began increasing on April 14, going from 300 $\mu\text{S}/\text{cm}$ to a maximum 380 $\mu\text{S}/\text{cm}$ before returning back to 300 $\mu\text{S}/\text{cm}$ after about 50 days (Figure 10-4A). A similar rise-and-fall in conductivity was observed at Banks during the same period.

The potential exists for a cause-and-effect relationship between pulse flows in the San Joaquin River and subsequent salinity spikes at Banks. When flow in the San Joaquin River increases, more water enters the eastern end of the Port of Stockton Deep Water Ship Channel (DWSC). Consequently, more water in the DWSC is hydraulically forced west and into the central Delta waterways leading to the export sites. Flows entering the DWSC from the San Joaquin River are enhanced by barrier installation at the head of Old River. Salinity in the DWSC can be maintained from antecedent San Joaquin River inflows and saline point and non-point discharges such as agricultural drainage and municipal/industrial wastewater. During the spring-pulse period, a greater volume of this water is forced west from upstream flow increases in the San Joaquin River. More higher-salinity water from the DWSC becomes a component of cross-Delta flow than would normally commingle with lower-salinity water from the Sacramento River.

Water in the DWSC can become a component of cross-Delta flow via Turner Cut, the first waterway along the DWSC from the San Joaquin River juncture leading to Middle River and eventually the south Delta export sites (Figure 10-5). From Turner Cut, water can transit Empire Cut, Middle River, Victoria Canal, and West Canal, the main approach channel to the Clifton Court Forebay gates and Jones Pumping Plant from the north (Figure 10-5). Depending on the hydrodynamics, water from the DWSC may also continue west into Old River before flowing south to the export sites. Flow into Turner Cut from the DWSC assumes net negative flow in Middle River, as was the case during the 2002 spring-pulse period.

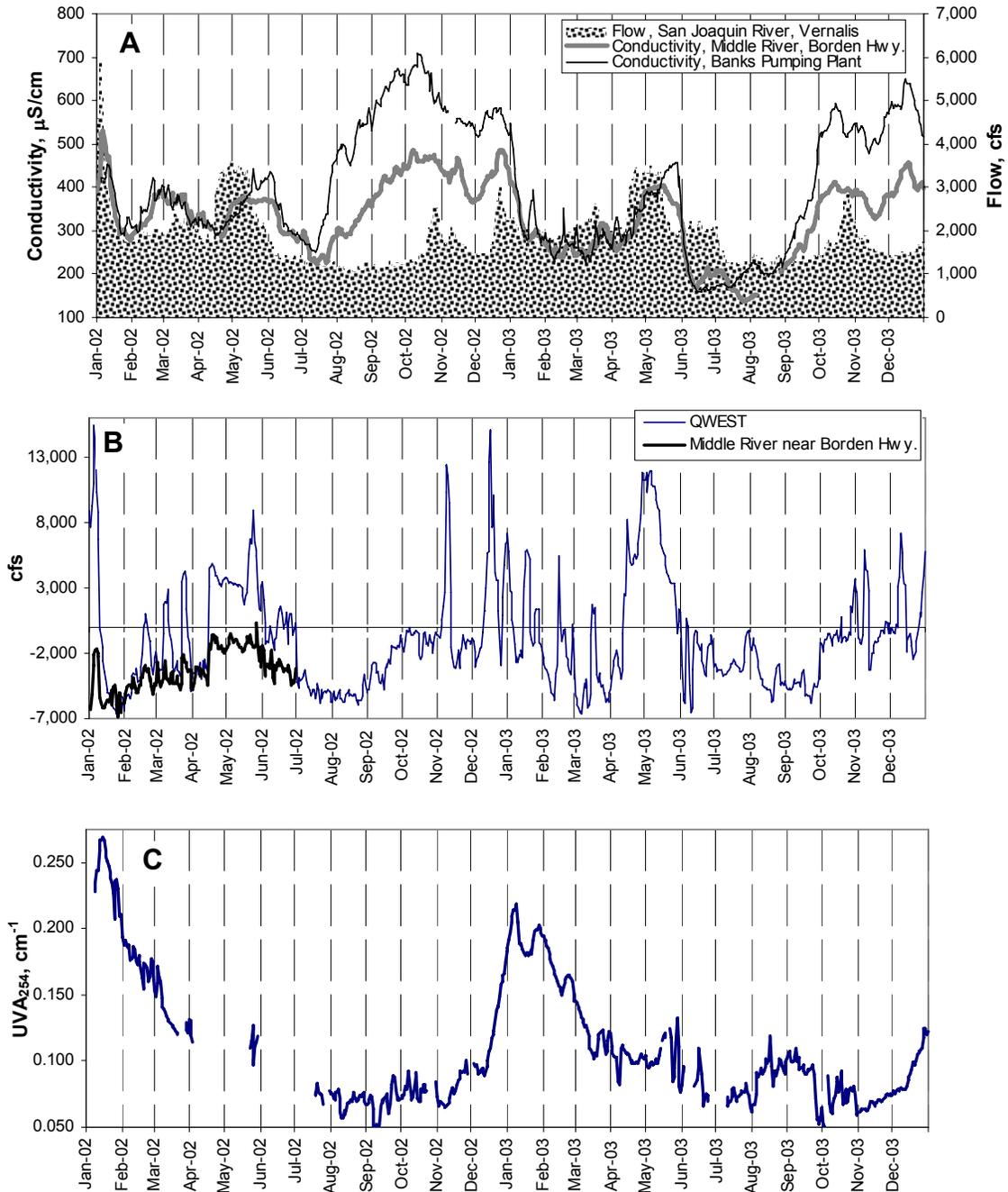


Figure 10-4. Flow in the San Joaquin River, conductivity in Middle River, conductivity at Banks Pumping Plant (A), flow in Middle River, QWEST (B), and ultraviolet absorbance at 254 nanometers (UVA_{254}) (C). QWEST is estimated flow in the San Joaquin River at Jersey Island and represents west Delta outflow (positive) or inflow (negative). Middle River flow data was not available for most of 2003 including May (flow and conductivity sources: HEC-DSS (A), HEC-DSS, and Dayflow (B) websites accessed April 2006).

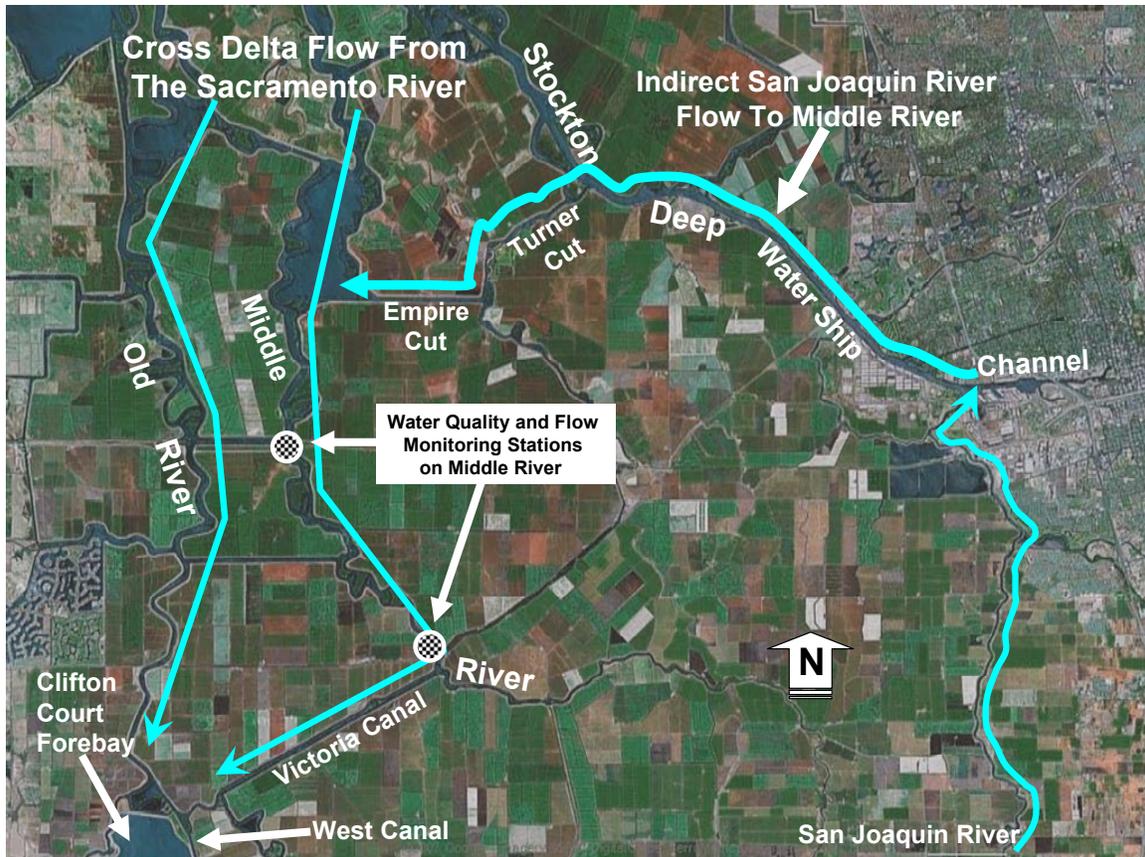


Figure 10-5. Indirect route of water flowing from the San Joaquin River to Middle River via the Stockton Deep Water Ship Channel

Figure 10-4B shows that flow out of the Delta at Jersey Island (QWEST) was positive during the 2002 spring-pulse period while flow in Middle River remained mostly negative. Therefore, water hydraulically forced out of the DWSC and into Middle River was flowing south to the export sites. The increase in Middle River conductivity during this period was subsequently reflected at Banks Pumping Plant. A similar sequence-of-events occurred during the 2003 spring-pulse period (Figure 10-4A and B) (most 2003 flow data for Middle River was not available from the cited source).

In the preceding example, the DWSC was a repository of higher-salinity water from past inputs because of its large capacity. The DWSC has the capacity to detain large volumes of water from river inflows and discharges. The channel is about 500 feet wide and dredged to an average depth of 30-35 feet (Jones & Stokes 2004). The DWSC spans about 12 miles from the San Joaquin River juncture to Turner Cut, the first channel branching off toward the export sites. Because of the DWSC's considerable length, width, and depth, it can function as a reservoir of high-salinity water that is forced into central Delta waterways due to upstream hydraulic pressure from the San Joaquin River and other inputs.

Conductivity excursions at Banks Pumping Plant during the 2002 and 2003 spring-pulse periods were higher than those in Middle River. The higher conductivity was likely associated with direct flows from the San Joaquin River via south Old River and Grant Line Canal. As San Joaquin River flow decreased at the conclusion of the 2002 spring-pulse period, salinity immediately began to rise sharply (see previous Figure 4-4B). Salinity in the San Joaquin River continued to rise as the barrier at the head of Old River was removed on May 24. Barrier removal allowed more water from the San Joaquin River to flow directly to the export sites via Old River and Grant Line Canal. This flow began to influence water quality at Banks Pumping Plant to the extent that it increased conductivity above levels in Middle River.

A week or so later in early June 2002, the San Joaquin River was again restricted from directly approaching the exports sites due to barrier installation on Old River (the Grant Line Canal barrier was already in place). As a result, conductivity at Banks Pumping Plant began to decline to levels present in Middle River about a week before barrier installation was completed on June 12, 2002 (barrier installation started on April 1). A similar series of events were evident in the DMC during the 2002 spring-pulse period except that water in the DMC was more influenced by direct flows from the San Joaquin River, resulting in a higher conductivity compared to Banks (see previous Figure 4-4). The same trends in export salinity were observed during the 2003 spring-pulse flow period.

Available data from the UVA₂₅₄ spectrophotometer at Banks Pumping Plant shows that calculated DOC increased by about 1 mg/L during the latter half of the spring-pulse period in 2003 (Figure 10-4C). Water quality during this period was shown to be affected by direct flows from the San Joaquin River. Therefore, the increase in UVA₂₅₄ near the end of the spring-pulse period at Banks was due to greater influence from direct San Joaquin River flow not cross-Delta flow.

Although this section described the effects of operations and hydrology on water quality in the south Delta, the overall impact of this specific aspect of the spring-pulse period on water quality in the California Aqueduct was minimized because the amount of water pumped at Banks Pumping Plant and O'Neill Pumping-Generating Plant was relatively low during May of both years (see previous Figures 3-1 and 4-1, respectively).

Groundwater Turn-ins to the California Aqueduct

This section describes the groundwater turn-in program during 2002 and 2003 and the program's influence on water quality in the California Aqueduct.

Introduction

Groundwater is periodically conveyed, or “turned”, into the California Aqueduct. The groundwater turn-in program facilitates the independent exchange of water between cooperating agencies. Agencies with groundwater assets can convey them into the aqueduct for credit or payment by willing participants. Groundwater is admitted to the aqueduct at bidirectional interties that serve the dual function of either accepting water into the aqueduct (turn-ins) or diverting water out of the aqueduct for delivery to water contractors (turn-outs). Turn-in sites may also simply consist of a groundwater pumping station. Groundwater turned – and/or pumped – into the aqueduct can be redirected for local redistribution, transferred to other water contractors, or exchanged with the Environmental Water Account. The wheeling of water between agencies or programs using conveyances like the California Aqueduct is encouraged by the State.

Sections 1810 through 1814 of the California Water Code (Code) require owners of conveyance facilities to conditionally make available any unused capacity for wheeling purposes. It is the policy of the State to facilitate the “sales, lease, or exchange” of water to promote efficient water uses. The wheeling of water is allowed provided the transfers do not result in a diminution of water quality or beneficial uses. The Code mandates that the commingled water be “...of substantially the same quality as the water in the facility.”

Criteria for accepting groundwater into the California Aqueduct were codified in the prevailing 2001 policy (see Appendix D). Kern County Water Agency (KCWA) was the lead proponent of the 2001 groundwater turn-in policy. Groundwater with no threat of adversely impacting water quality (based on historic conditions) was allowed provided its quality was consistent. Groundwater exceeding historic water quality conditions in the aqueduct was referred to the “facilitation group” for consideration of input on a case-by-case basis.

Much of the groundwater conveyed into the California Aqueduct during 2002 and 2003 originated from the Kern Fan groundwater bank located west of the City of Bakersfield and east of the aqueduct. The Kern Fan project is a groundwater storage and recovery system investigated by DWR in the mid-1980s (DWR 1987). The Kern River alluvial fan, located at the base of the Sierra Nevada mountain range in the southwest Tulare Basin (Figure 10-6), was identified as an ideal groundwater storage basin. The recharge, extraction, and quality characteristics of the alluvial fan were thoroughly analyzed. The porous soils of the alluvium are composed of sand and gravel interspersed with silt and clay lenses with the capacity to capture and store vast amounts of water. Further, the salt content of the alluvium was acceptably low as were other undesirable constituents such as arsenic.

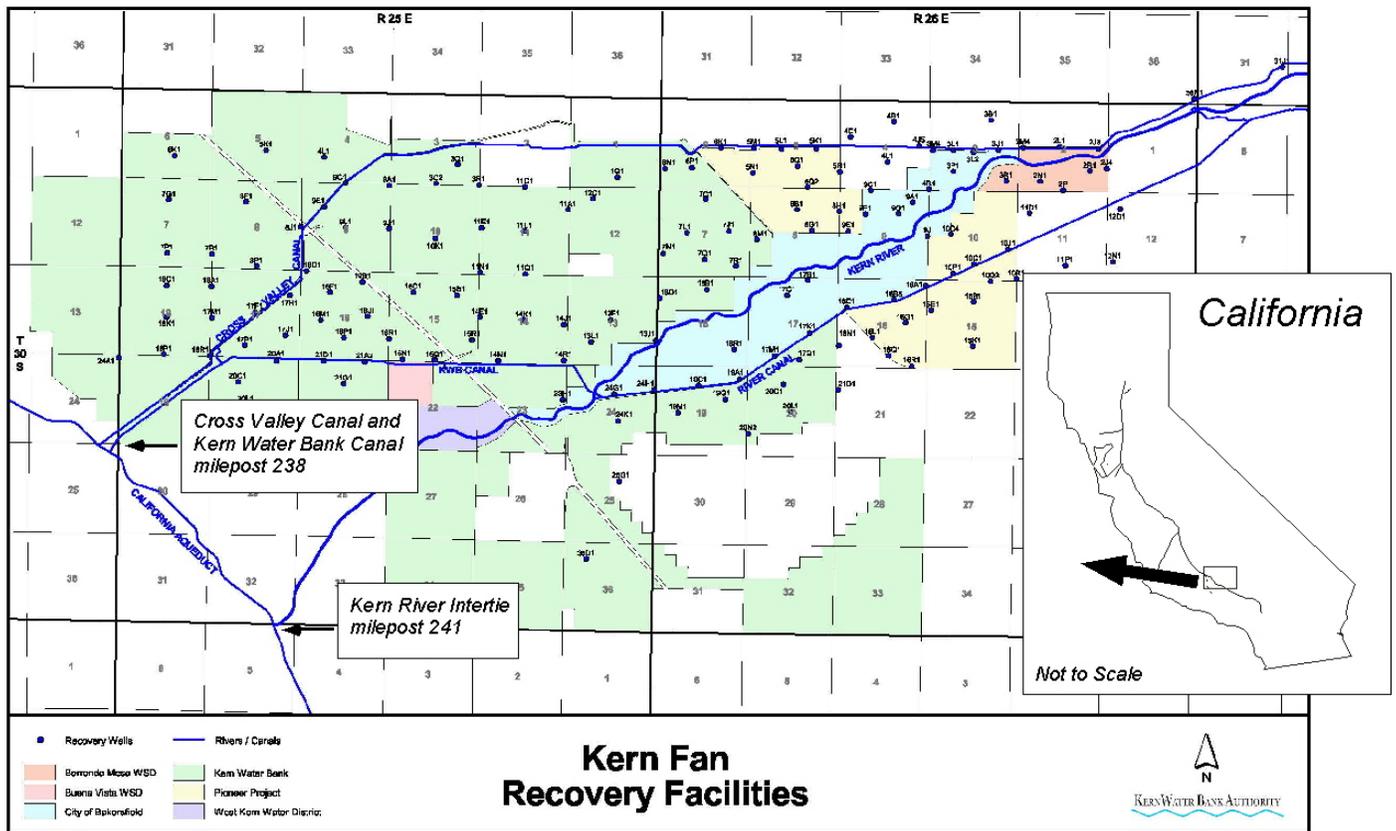


Figure 10-6. The Kern Fan groundwater storage and recovery project. The numbered dots represent one or more well heads.

The Kern Fan project incorporates several spreading basins or percolation ponds to recharge the aquifer. Surface water from the California Aqueduct can be conveyed to the basins via the Cross Valley Canal (CVC) or Kern Water Bank Canal (KWBC) (Figure 10-6). Flow is reversed in the same two canals when groundwater from the Kern Fan project is extracted and distributed to turn-in recipients along the aqueduct. The CVC and KWBC are connected to an array of well fields situated around the Kern Fan for the recovery and distribution of groundwater (Figure 10-6).

The turn-in program increases SWP water yield by utilizing groundwater banked in the Kern Fan. Yields are in the form of increased water storage and greater operational flexibility afforded by the conjunctive use of surface and groundwater supplies. Benefits to KCWA (and affiliates) include reduced overdraft, more yield and reliability, better coordination between local and SWP suppliers, and a reduction in pumping lift. Since the program began, the Kern Fan project has been used for “in lieu recharge” whereby other sources of water are used in lieu of groundwater pumping. Instead of using groundwater supplies during periods of reduced allocations, surface water is obtained from participants with the promise of repayment with Kern Fan groundwater at a later date. Under the precepts of the 2001 policy, the utility of the Kern Fan project – and the groundwater turn-in program overall – was expanded in 2002 and 2003 to specifically encompass energy cost savings and improvements to SWP drinking water quality.

Groundwater Turn-in Program, 2002 and 2003

Nearly 100,000 af of groundwater was turned into the California Aqueduct during 2002 and 2003. Turn-ins between April and June 2002 were generally a continuance of the 2001 program. The goals of the program were modified in mid-2002 to adapt to changing hydrological conditions. Water year 2002 was the second consecutive year classified as dry in the Sacramento and San Joaquin valleys. Due to reduced water supply availability that year, KCWA received approximately 65% of its SWP water allocation – a deficit that would have to be made up by increased groundwater pumping.

To avoid the high costs associated with pumping during the peak-energy demand season of summer, an accord was struck between KCWA and Metropolitan Water District of Southern California (MWDSC) to use the Kern Fan project for mutual cost savings. Instead of pumping groundwater during the summer of 2002, KCWA obtained water from MWDSC to make up the allocation deficit. Water in San Luis Reservoir, originally scheduled for delivery to MWDSC, was diverted to KCWA with the promise of in-kind payment at a later date (in lieu recharge). Replacement water for MWDSC was acquired by drawing down SWP reservoirs in Southern California. The payback to MWDSC came in the form of groundwater turn-ins to the California Aqueduct during winter 2003 and the subsequent dilution of organic carbon when levels are typically highest. Organic carbon in groundwater from the Kern Fan aquifer is consistently around 1 mg/L.

The KCWA-MWDSC accord provided mutual benefits with no impact on normal operations. Benefits to KCWA included acquisition of water to make up the 2002 allocation deficit without the high cost of groundwater pumping during summer. Benefits to MWDSC included lower organic carbon-removal costs for meeting the disinfection byproduct drinking water standards during winter when organic carbon levels were seasonally highest in the California Aqueduct.

Groundwater turn-ins initiated in April 2002 were discontinued in early June. Turn-ins from the Kern Fan aquifer resumed the following November and continued intermittently through April 2003. Groundwater from Arvin-Edison Water Storage District (AEWSD) was also accepted into the aqueduct during the first three months of 2003. The AEWSD well fields are located south-east of the Kern Fan property and the turn-in site is located at milepost 277 on the aqueduct.

Turn-in Volumes

Groundwater turn-ins to the California Aqueduct totaled 99,261 af during 2002 and 2003 (Table 10-1). Nearly 88% originated from the Cross Valley and Kern Water Bank canals (CVC+KWBC) with 86,881 af. The remainder of the turn-in volume (12,380 af) was inputted to the aqueduct by AEWSD.

Table 10-1. Monthly groundwater turn-ins volumes and flow in the California Aqueduct (af)

Year	Month	Check 21	CVC	KWBC	Sub-Total	Check 29 a/	Percent of Aqueduct Flow (%) b/	AEWSD	Total
2002	April	213,326	3,775	9,959	13,734	150,332	9.1		13,734
	May	239,035	918	11,631	12,549	186,960	6.7		12,549
	June	365,089	0	571	571	186,965	0.31		571
	July		0	0	0				0
	August		0	0	0				0
	September		0	0	0				0
	October		0	0	0				0
	November	175,959	5,645	0	5,645	157,349	3.6		5,645
	December	161,019	4,300	0	4,300	139,632	3.1		4,300
	2003	January	63,578	1,569	10,718	12,287	53,182	23	5,795
February		80,696	3,504	11,805	15,309	49,857	31	5,688	20,997
March		241,633	439	2,239	2,678	178,216	1.5	897	3,575
April		204,188	4,731	15,077	19,808	178,339	11		19,808
Total		1,744,523	24,881	62,000	86,881	1,280,832	6.8	12,380	99,261
	% of Total Turn-in		25.07	62.46				12.47	

a/ Pumping at Buena Vista Pumping Plant, 6 miles downstream from Check 29

b/ The product of 100 and the upstream turn-ins/Check 29 flow.

Monthly turn-ins from CVC+KWBC ranged between 571 and 19,808 af (Table 10-1). Arvin-Edison Water Storage District contributed from 897 to 5,795 af per month from January to March 2003. Monthly turn-ins from CVC+KWBC comprised between 0.31% and 31% of California Aqueduct flow (pumping at Buena Vista Pumping Plant just downstream from Check 29).

Turn-ins from CVC+KWBC began on April 11, 2002, fluctuated from near zero to a maximum 873 af per day before ceasing on June 12, 2002 (Figure 10-7). Turn-ins were again activated in early November and continued on an intermittent basis until the end of April 2003 (Figure 10-8). Turn-ins from AEWSD were intermittently active from January to March 2003. Monthly or bimonthly samples were collected downstream at Checks 29 and 41 (Figures 10-7 and 10-8).

Turn-In Water Quality

Table 10-2 shows constituents-of-concern in groundwater turn-ins and the California Aqueduct upstream of the turn-ins (Check 21) during 2002 and 2003. Concentrations of DOC and TOC in turn-ins were characteristically low ranging from 0.4 to 1.5 mg/L – values at Check 21 were higher ranging from 2.0 to 5.4 mg/L. Sulfate, bromide, and salinity levels in turn-ins were within the range of those at Check 21. Nitrate was usually higher in turn-ins ranging from 6.3 to 11.9 mg/L but below the Primary MCL of 45 mg/L. Hexavalent chromium (chromium VI) was also higher in turn-ins (no unique MCL exists for this species of chromium). Arsenic ranged from 0.002 to 0.006 mg/L in turn-ins and from 0.001 to 0.003 mg/L at Check 21. The MCL for arsenic in drinking water is 0.010 mg/L.

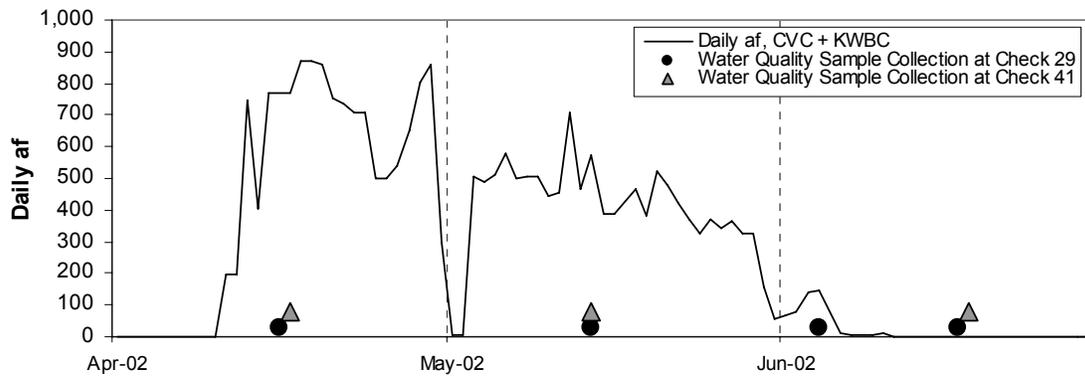


Figure 10-7. Daily groundwater turn-ins from CVC+KWBC and water quality sample collection dates in the California Aqueduct at Checks 29 and 41, April to June 2002

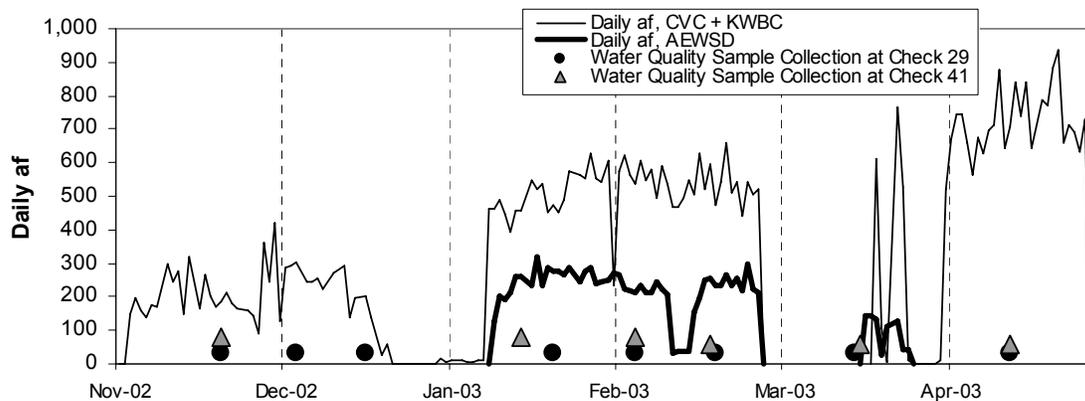


Figure 10-8. Daily groundwater turn-ins from CVC+KWBC and AEWSD, and water quality sample collection dates in the California Aqueduct at Checks 29 and 41, November 2002 to April 2003

Table 10-2. Constituents-of-concern in groundwater turn-ins and the California Aqueduct at Check 21, 2002 and 2003

Source	Date	Concentration (mg/L unless stated otherwise)								
		As	Br	Cond. ($\mu\text{S}/\text{cm}$)	Cr+6	DOC	TOC	NO3	SO4	TDS
	MCL 1/	0.010	none	900 2/	none	none	none	45	250 2/	500 2/
CVC & KWBC	Historic Average 3/	0.003	0.16	374	0.0011	1.3	NA	7.3	41	240
CVC	11/20/2002	0.003	0.17	437	0.002	0.5	0.5	9.1	54	263
	4/8/2003	0.006	0.16	367	NA	0.4	0.4	7.3	41	220
KWBC	1/3/2003	0.002	0.20	430	0.001	NA	0.6	11.9	47	280
	4/8/2003	0.005	0.21	415	NA	0.4	0.6	7.8	46	246
AEWSD	1/8/2003	0.002	0.10	389	0.002	NA	1.5	6.3	26	235
2002-03 Summary	CVC, KWBC, AEWSD									
	Median	0.003	0.17	415	0.002	0.4	0.6	7.8	46	246
	Range	0.002 to 0.006	0.1 to 0.21	367 to 437	0.001 to 0.002	0.4 to 0.5	0.4 to 1.5	6.3 to 11.9	26 to 54	220 to 263
	Check 21									
Median	0.002	0.23	488	<0.0002	2.9	3.1	3.0	40	288	
Range	0.001 to 0.003	0.1 to 0.42	317 to 624	<0.0002 to 0.0006	2.0 to 5.4	2.1 to 5.4	1.0 to 7.2	20 to 59	189 to 388	

1/ Primary Maximum Contaminant Level unless otherwise specified

2/ Recommended Secondary MCL

3/ From 2001 season (n = 1 to 5)

Upstream-Downstream Analysis

Figure 10-9 shows constituents-of-concern in the California Aqueduct upstream and downstream of the turn-ins. Check 21 is upstream of all turn-ins at milepost 172; Check 29, at milepost 244.5, is 6 to 7 miles downstream of both CVC and KWBC at milepost ~238; and Check 41, at milepost 303.4, is 26 to 27 miles downstream of the AEWSA turn-in site at milepost 277.

Intermittent turn-in activity is shown in Figure 10-9 as two horizontal arrows. Water quality data outside of the periods of turn-in activity were also shown to portray any variations in water quality between stations without any interjacent inputs. These variations in water quality are largely due to the effects of travel time under fluctuating water quality conditions and, in the case of parameters with a narrow concentration range (e.g., arsenic), possibly method precision. Effects of travel time can be seen in the July 2002 samples whereby most parameters were lower at Check 21 than Checks 29 and 41 (Figure 10-9). The lower levels at Check 21 had not yet arrived at the downstream stations when sampling occurred. These effects will also have some influence on the upstream-downstream analysis during periods of turn-in activity.

During April to early June 2002, turn-ins comprised up to 20% of the aqueduct at Check 29 with an overall average of 8% (Figure 10-10A). The only substantial upstream-downstream change in water quality between Checks 21 and 29 in April was a decrease in salinity and sulfate (Figure 10-9). The only substantial change between Checks 21 and 41 in April was a decline in DOC. During May, an approximate 0.5 mg/L decrease in upstream-downstream organic carbon was observed at both Checks 29 and 41 with little change in any other parameter with the possible exception of salinity.

Upstream-downstream conductivity decreased slightly in the May sample from Check 29 while TDS increased. Conflicts in upstream-downstream trends between these two parameters were also observed in the early June sample. The more accurate of the two is conductivity due to the higher number of potential sources of error associated with measuring TDS. Methodological and compositional sources of error in the TDS measurement include filtration, desiccation, weighing, and the presence of dissolved non-electrolytes (such as silica) and non-volatile organics in the sample. Therefore, to eliminate the potential for further discrepancies between the two measurements, conductivity will represent salinity in the upstream-downstream analysis.

Turn-ins started up again in early November 2002 and continued into December. During these two months, daily turn-in volumes from CVC+KWBC comprised less than 10% of the aqueduct at Check 29 with the exception of a few days in mid-December when pumping at Buena Vista Pumping Plant ceased altogether (Figure 10-10B). Upstream-downstream organic carbon concentrations declined slightly in the November samples while sulfate and nitrate were slightly higher at both downstream stations in December (Figure 10-9). Arsenic declined from 0.003 to 0.002 mg/L at both downstream stations in November and was 0.002 mg/L at all upstream-downstream stations in December. All other parameters remained essentially unchanged between the upstream-downstream stations during November and December 2002.

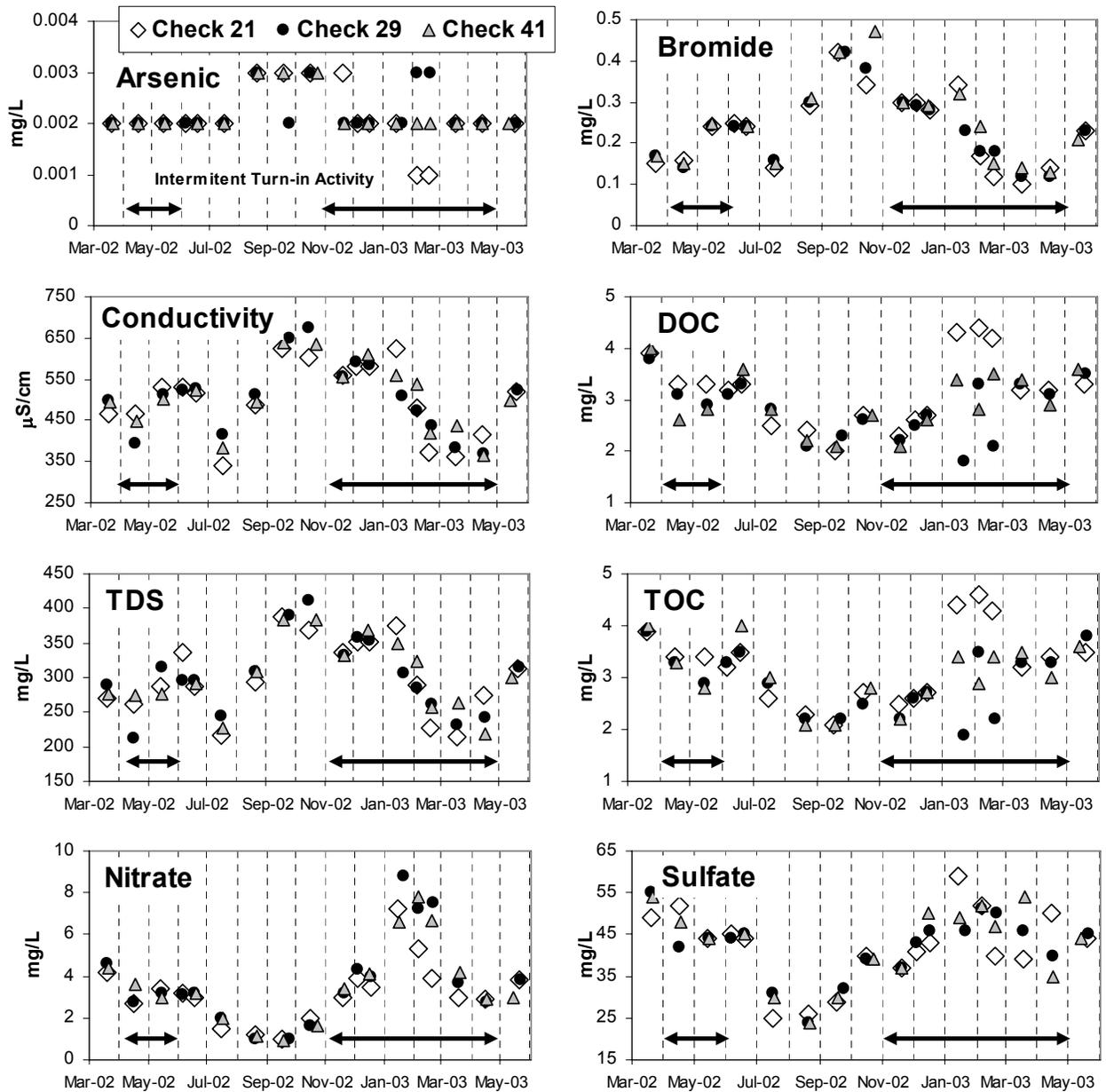


Figure 10-9. Constituents-of-concern in the California Aqueduct at Checks 21, 29, and 41. Check 21 is situated upstream of groundwater turn-ins. Check 29 is located downstream of the CVC and KWBC turn-ins and Check 41 is downstream of all turn-ins including AEWS. The horizontal arrows indicate periods when intermittent groundwater turn-ins were active.

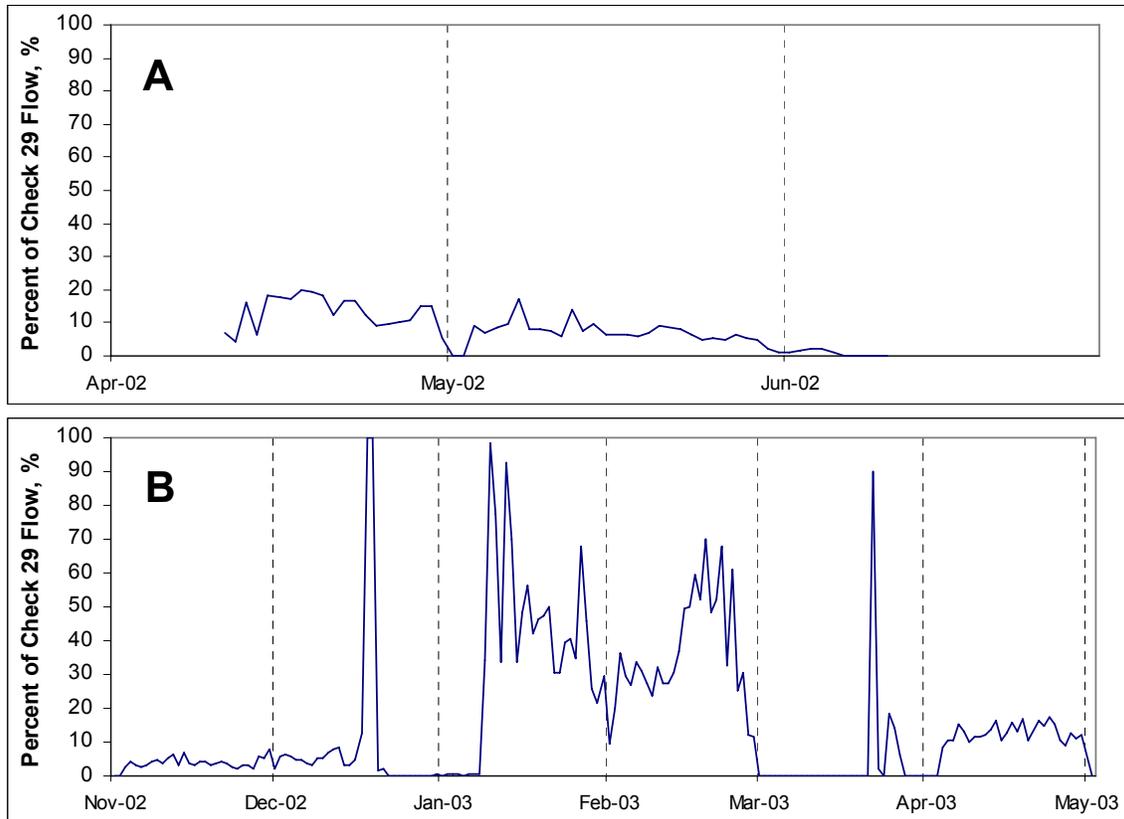


Figure 10-10. Percent of Check 29 flow comprised of groundwater turn-ins. Flow at Check 29 is from Buena Vista Pumping Plant at milepost 251.

Turn-in volumes were consistently highest relative to aqueduct flow during January and February 2003. In January, turn-ins from CVC+KWBC comprised from 0.04% to 98% of aqueduct flow at Check 29 with an overall average of 23% (Figure 10-10B). Turn-ins comprised about half of aqueduct flow when the January samples were collected and organic carbon exhibited a 56% decline between Checks 21 and 29. Organic carbon in the January samples went from 4.3-4.4 mg/L at Check 21 to 1.8-1.9 mg/L at Check 29 (Figure 10-9). The influence of turn-ins on aqueduct water quality that month was confirmed with a mineralogical analysis. Figure 10-11A shows that the anionic and cationic signature at Check 29 in January was approximately halfway between that at Check 21 and the average of all CVC and KWBC samples.

Bromide, sulfate, and salinity were lower at Check 29 than Check 21 in the January 2003 samples while nitrate was higher (Figure 10-9). Alternately, arsenic remained unchanged between Checks 21 and 29.

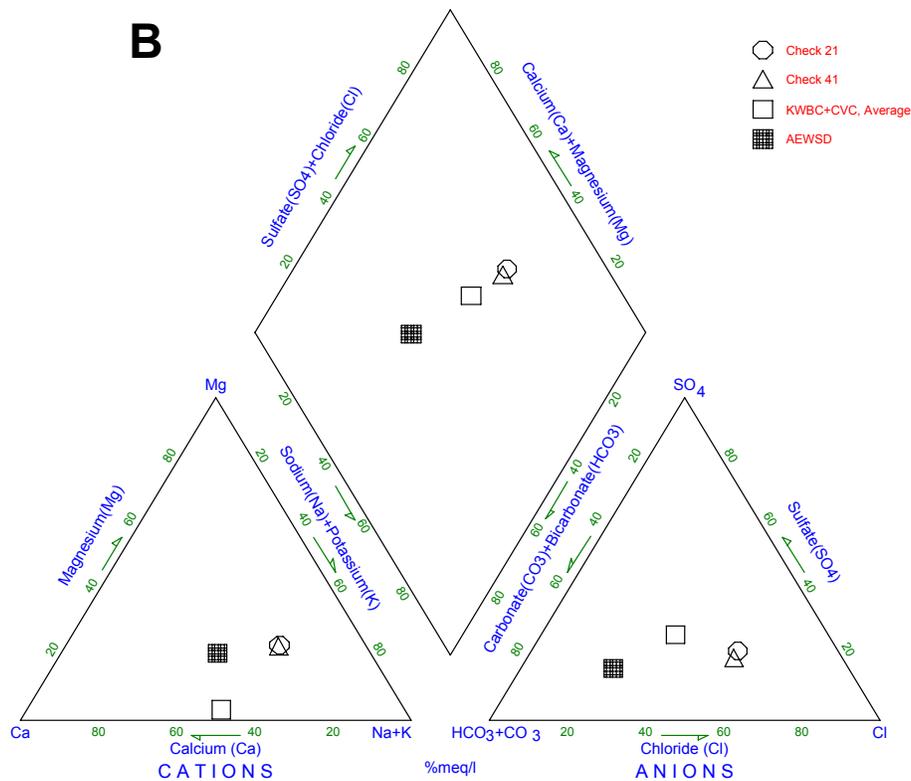
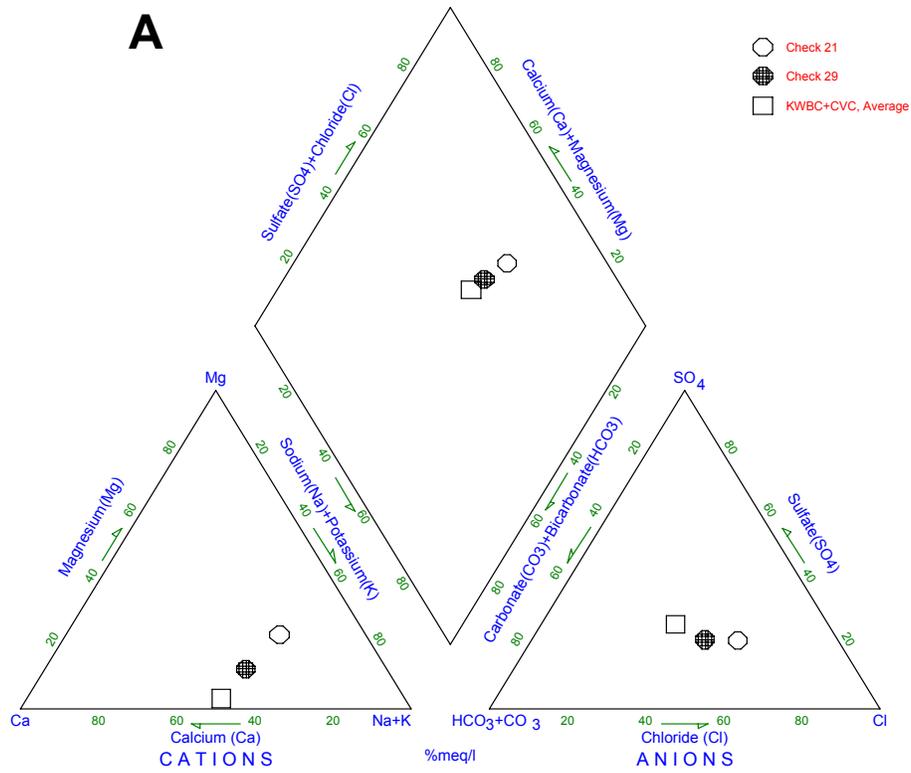


Figure 10-11. Piper graph depiction of mineralogy in the California Aqueduct (January 2003) and groundwater turn-ins

Although upstream-downstream differences in some constituents-of-concern were observed between Checks 21 and 41 during January 2003, both stations exhibited substantially similar mineralogies (Figure 10-11B). It appears that a large portion of the CVC+KWBC turn-in volume had not made it to Check 41 at the time of sampling. Inflows from CVC+KWBC increased from 9 to 464 af per day on January 9 while the Check 41 sample was collected six days later on January 15. Flow rates in the aqueduct were such that the higher turn-in volumes likely had not traversed the 65-mile distance between CVC+KWBC and Check 41 at the time of sampling.

All stations were sampled twice in February 2003. Turn-ins from CVC+KWBC comprised 27% of aqueduct flow when the first sample set was collected on February 5. The anionic composition of all upstream-downstream samples collected on that date was relatively similar to that of CVC+KWBC (Figure 10-12A). However, downstream samples from Checks 29 and 41 did show a slight cationic shift generally towards that of CVC+KWBC. The Check 29 sample collected in mid-February showed more influence from the turn-ins. On the day of sampling, turn-ins comprised 49% of aqueduct flow and the cationic content at Check 29 was in-between that of CVC+KWBC and Check 21 (Figures 10-10B and 10-12B). Conversely, the mineralogy at Check 41 in mid-February did not exhibit as much influence from the turn-ins (Figure 10-12B).

The decrease in organic carbon between Checks 21 and 29 was 1.1 mg/L in the early February samples and 2.1 mg/L in the mid-February samples (Figure 10-9). Organic carbon was lowest at Check 29 in the mid-February sample owing to a greater volume of turn-in water present in the aqueduct on the day of sampling. Organic carbon was 1.6-1.7 mg/L lower at Check 41 than Check 21 in both February samples.

Arsenic increased from 0.001 mg/L at Check 21 to 0.003 mg/L at Check 29 in both February samples but decreased to 0.002 mg/L at Check 41. Upstream-downstream nitrate was higher at Checks 29 and 41 in both February samples. Sulfate, conductivity, and bromide were higher at both downstream stations only in the mid-February samples.

Turn-ins ceased at the end of February and did not restart until after the March sampling dates. Turn-ins comprised 13% of aqueduct flow when samples were collected on April 16 and upstream-downstream organic carbon, conductivity, and bromide exhibited slight declines. A more substantial decline was observed for sulfate while nitrate and arsenic remained unchanged between upstream-downstream stations.

With the exception of organic carbon, summarizing the upstream-downstream analysis in a statement about the overall impacts of the 2002-03 groundwater turn-in program on water quality in the California Aqueduct is difficult due to several impinging factors. Effects of travel time, fluctuating water quality in the aqueduct, and fluctuating turn-in composition were three of the largest factors affecting this analysis. For instance, parameters such as bromide and conductivity sometimes increased or decreased in the

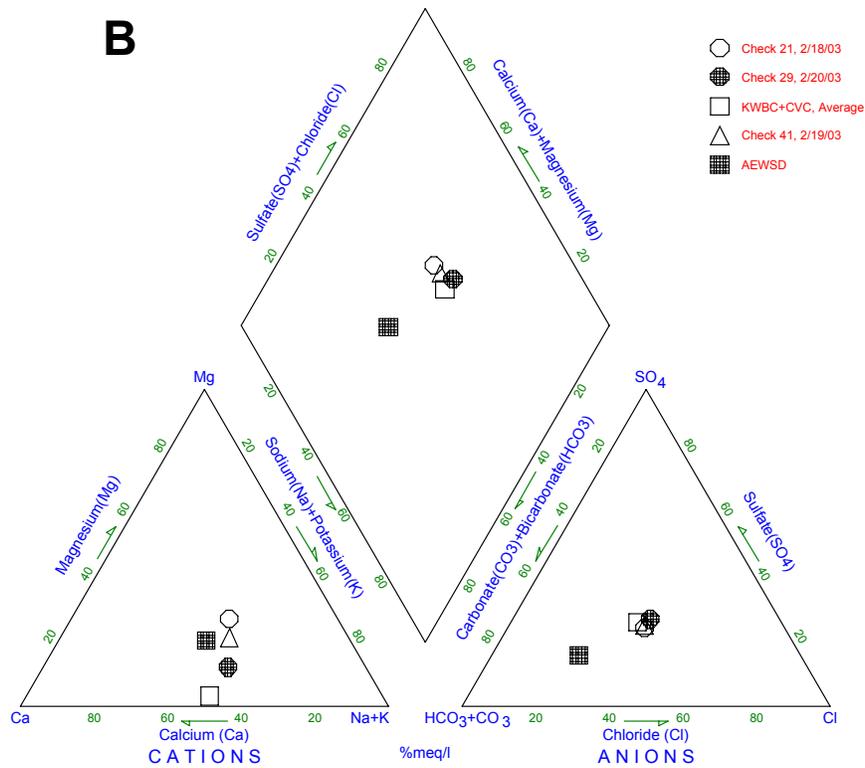
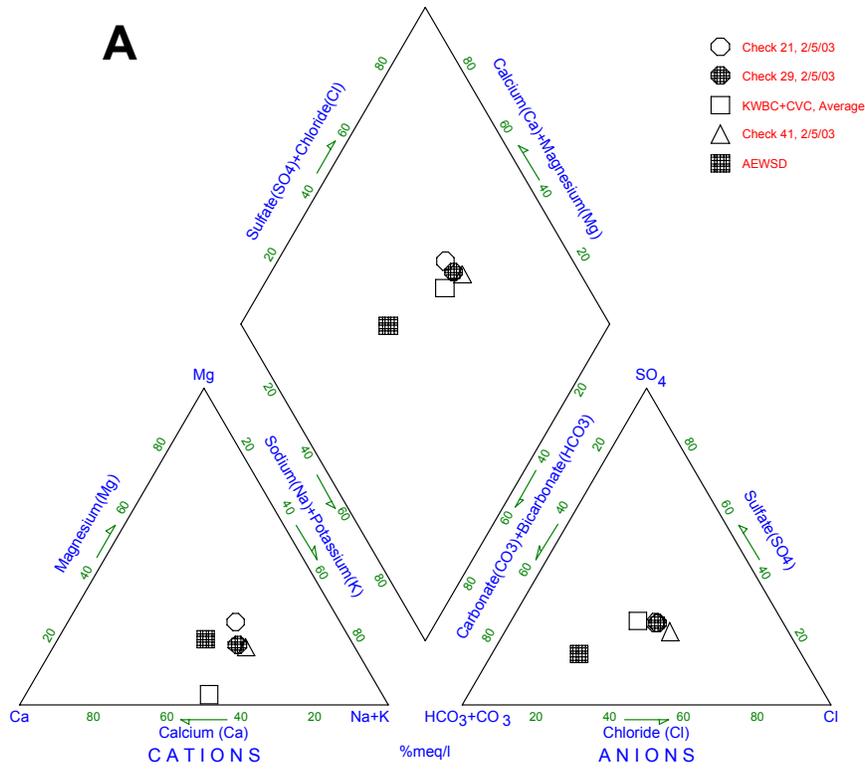


Figure 10-12. Piper graph depiction of mineralogy in the California Aqueduct (early (A) and mid- (B) February 2003) and groundwater turn-ins

aqueduct downstream of the turn-ins depending on specific conditions at the time of sampling. One might argue that there was a net benefit to aqueduct water quality (besides reduced organic carbon) due to a reduction in certain parameters when they were highest in the aqueduct. This was the case for conductivity and sulfate during January 2003 (Figure 10-9). Although the exception may be nitrate, which was higher in a majority of the downstream samples, the period maximum concentration of 8.8 mg/L detected at Check 29 was below the MCL of 45 mg/L for nitrate in treated drinking water.

With respect to organic carbon, the groundwater turn-in program overwhelmingly provided a net benefit to California Aqueduct drinking water quality in the form of reduced concentrations. The reductions were greatest during January-February 2003 when organic carbon in the aqueduct upstream of the turn-ins increased to over 4 mg/L, while at the downstream stations, organic carbon fluctuated between 1.8 and 3.5 mg/L. Organic carbon reductions in the aqueduct benefit downstream water contractors by lowering the costs of removing organic carbon to meet enforceable disinfection byproduct standards when producing drinking water.

Load reductions were estimated to quantify the mass of organic carbon eliminated from the aqueduct due to the 2002-03 turn-ins. The load reductions were based on the fact that turn-ins were a substitute for upstream deliveries, i.e., the same volume of water would have been sent south absent the turn-ins. The estimation method relied on the correlation between turn-in composition at Check 29 and the upstream-downstream decline in DOC between Checks 21 and 29. This relationship was rather strong with an r^2 of 0.88 (Figure 10-13). An exponential equation (as opposed to a linear one) was used because it eliminated negative values in the load calculations. Daily values from the equation were combined with flow at Check 29 when turn-ins were active. These loads were subtracted from equivalent ones calculated with DOC from Check 21. The resulting load reductions are considered underestimates due to a probable further decline in organic carbon in the aqueduct due to turn-ins from AEWS.

The overall DOC load reduction attributable to the CVC+KWBC turn-ins when they were active during 2002 and 2003 was estimated at 16%. Load reductions increased to 39% during most of January-February 2003 when turn-in composition was highest in the aqueduct. Turn-ins were responsible for a substantial reduction in the transmission of DOC down the aqueduct during months when upstream organic carbon levels were highest.

Benefits of the turn-in program extend beyond the periods of activity by incrementally reducing the amount of organic carbon sent south. The 2002-03 turn-in program lowered the mass of DOC flowing south to SWP southern reservoirs by approximately 340 metric tons (from the above analysis). This load reduction may not have an immediate impact on organic carbon concentrations in the larger reservoirs such as Pyramid or Castaic Lakes, but turn-in activities on a consistent basis may produce a long-term decline in organic carbon at these sites.

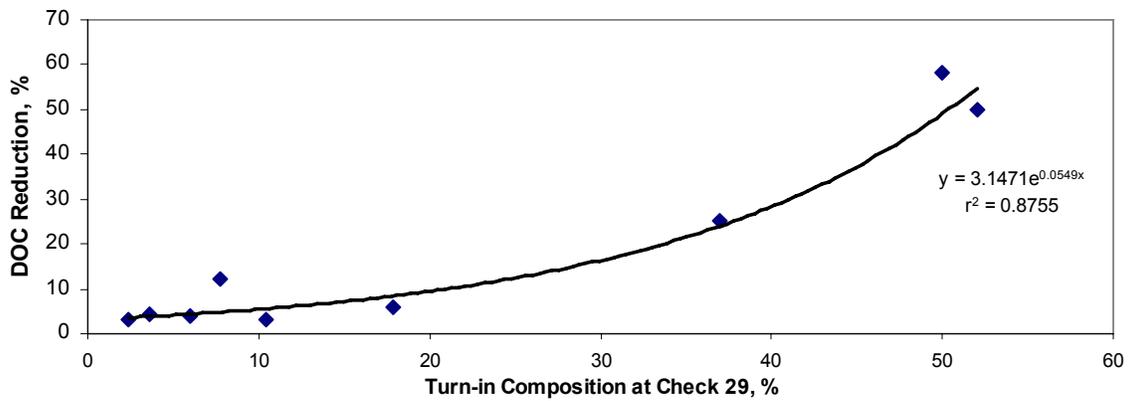


Figure 10-13. Correlation between turn-in composition at Check 29 and upstream-downstream DOC reduction between Checks 21 and 29

A small number of upstream-downstream samples were analyzed for hexavalent chromium (chromium VI). Concentrations increased between Checks 21 and 29 in four of six sample pairs collected during turn-in activity (Table 10-3). Upstream-downstream increases were greatest in April 2002 when chromium VI went from 0.0004 to 0.001 mg/L. This increase seems inordinate because turn-ins composed only 17% of the aqueduct on the day of sampling. Regardless, no specific MCL exists for chromium VI which is currently regulated under the 0.05 mg/L MCL for total chromium (mostly trivalent chromium in surface waters) (DHS 2007). Further, there has been scientific disagreement as to whether chromium VI in drinking water poses any threat to public health due to the potential for transformation in the digestive tract (ACWA 2005).

Table 10-3. Chromium VI in the California Aqueduct upstream and downstream of the turn-ins at Checks 21 and 29, respectively

Date	Chromium VI, mg/L	
	Check 21	Check 29
Apr-02	0.0004	0.001
May-02	0.0005	0.0004
Jun-02	0.0006	0.0005
Nov-02	<0.0002	0.0005
Dec-02	0.0002	0.0005
Jan-03	0.0002	0.0006

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Appendix A Methods

Monitoring Stations

Water quality samples are routinely collected at 40 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 physical parameters such as conductivity, temperature, and turbidity 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 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, 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 collected. Unfiltered field blanks are processed at the same station. A travel blank is included along with the purgeable organics vials. 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/													
			Project Standard 2/		Organics								Automated Monitoring Station			
			Nutrients	Bromide	Iron and Manganese	Chlorinated Organics	Organo-Phosphorus	Pesticides	Herbicides	Carbamates	Purgeable Organics	Tot. & Dis. Organic Carbon		UV 254		
California Aqueduct	Clifton Court Forebay	KA000000	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				
	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.

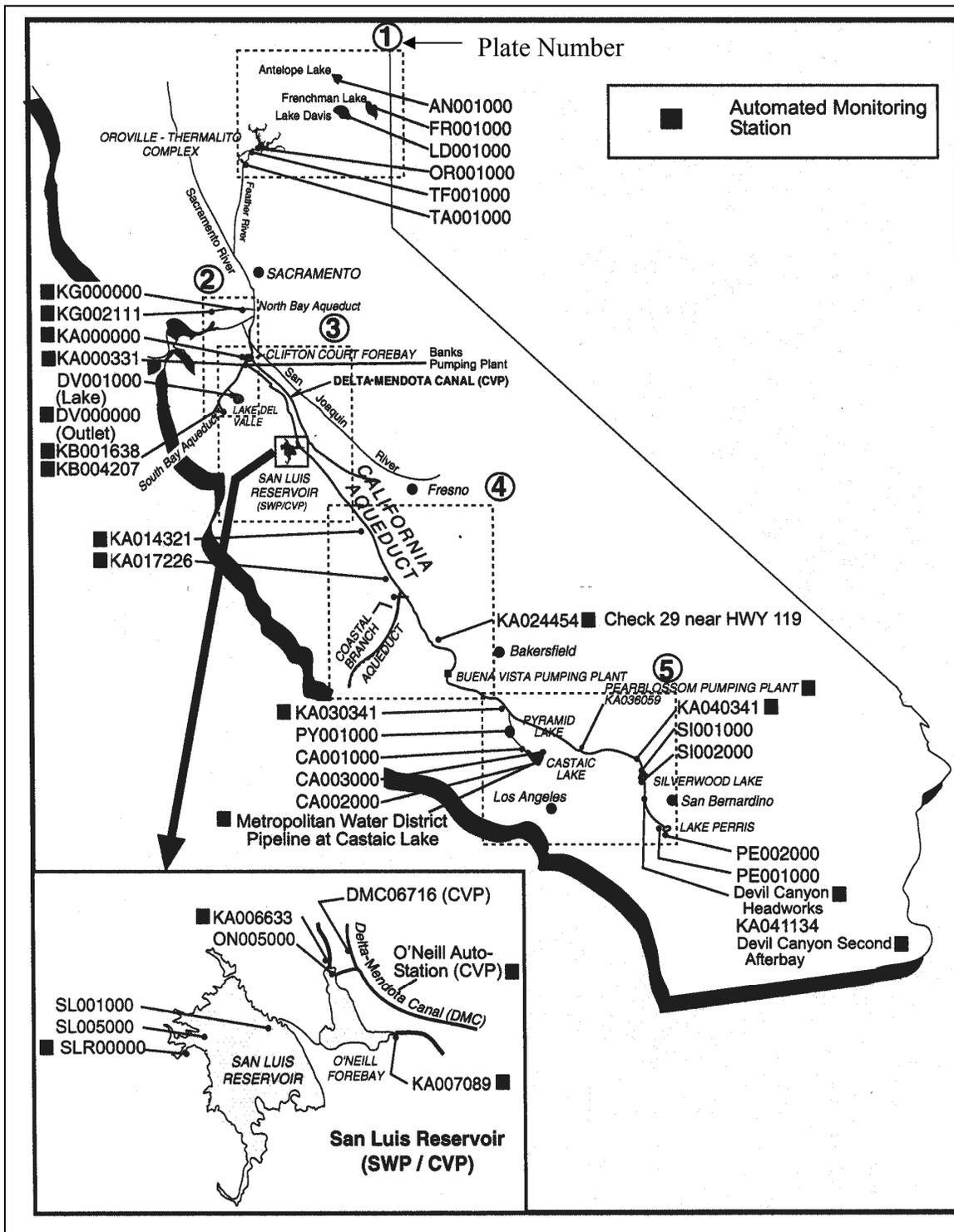


Figure A-1. Water Quality Monitoring Stations in the State Water Project. The circled numbers indicate plate numbers that detail the dotted-outlined areas.

Plate 1

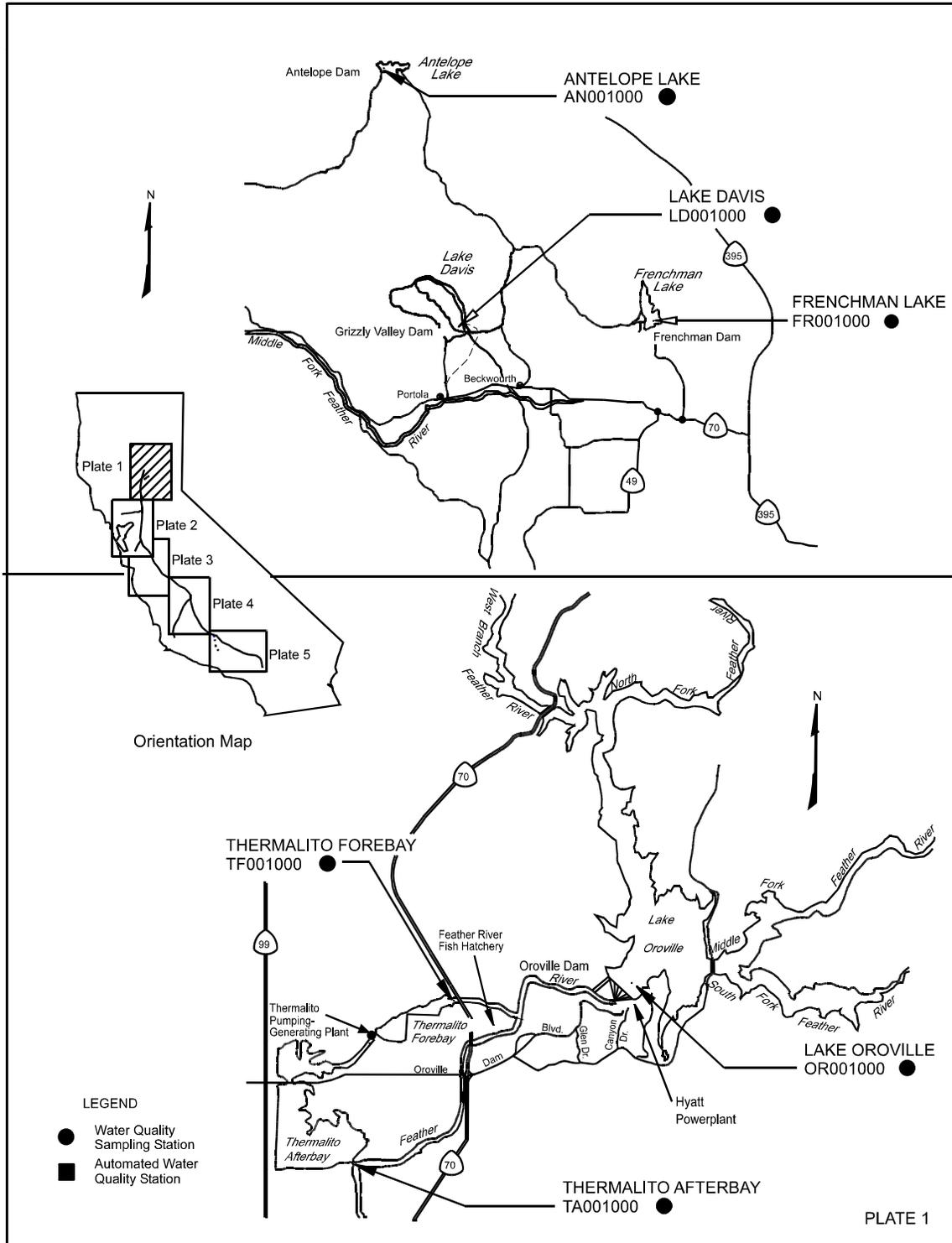


Plate 2

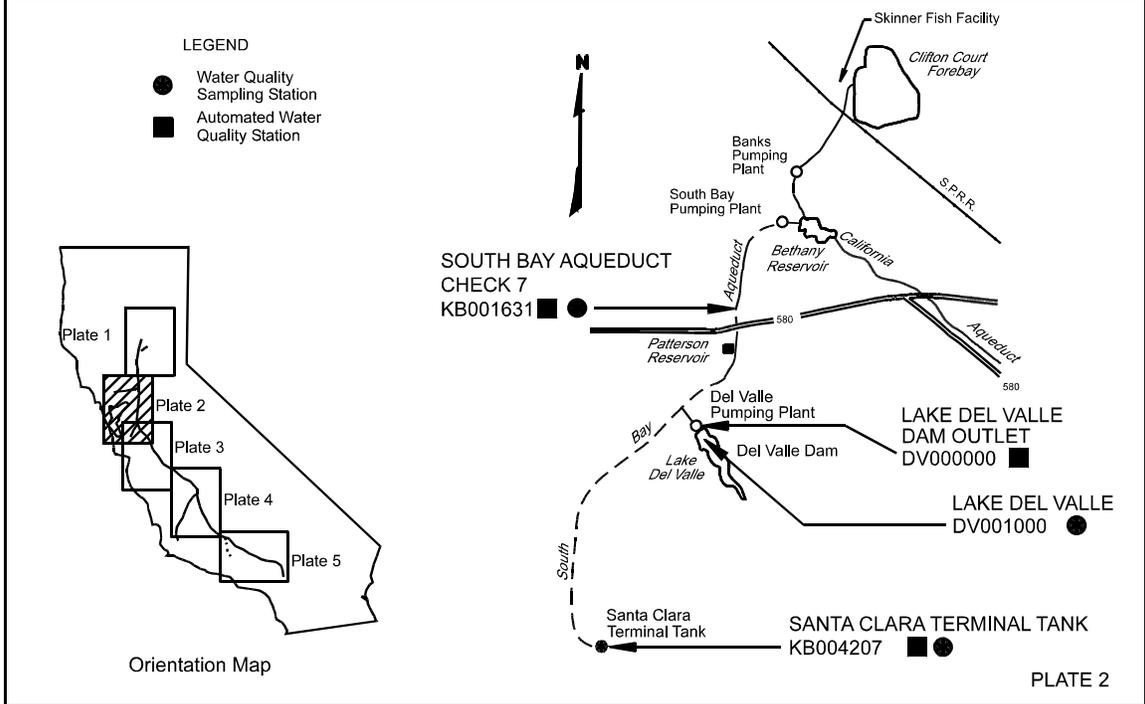
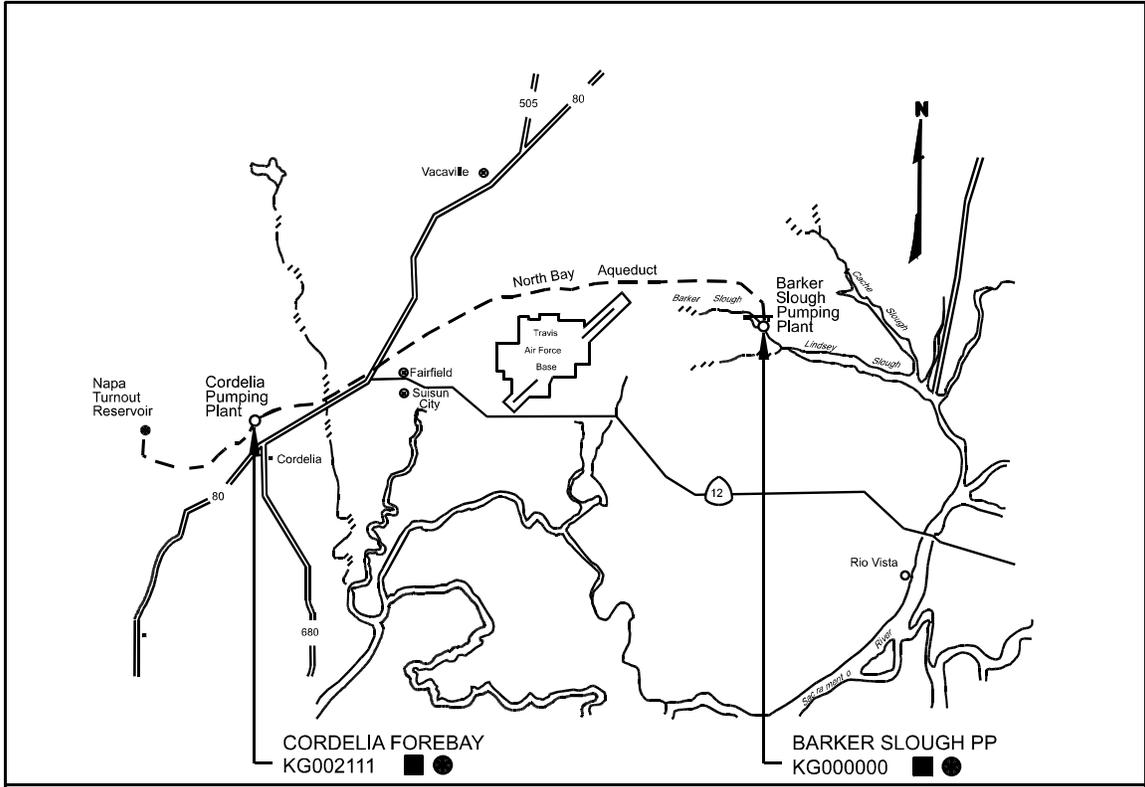


Plate 3

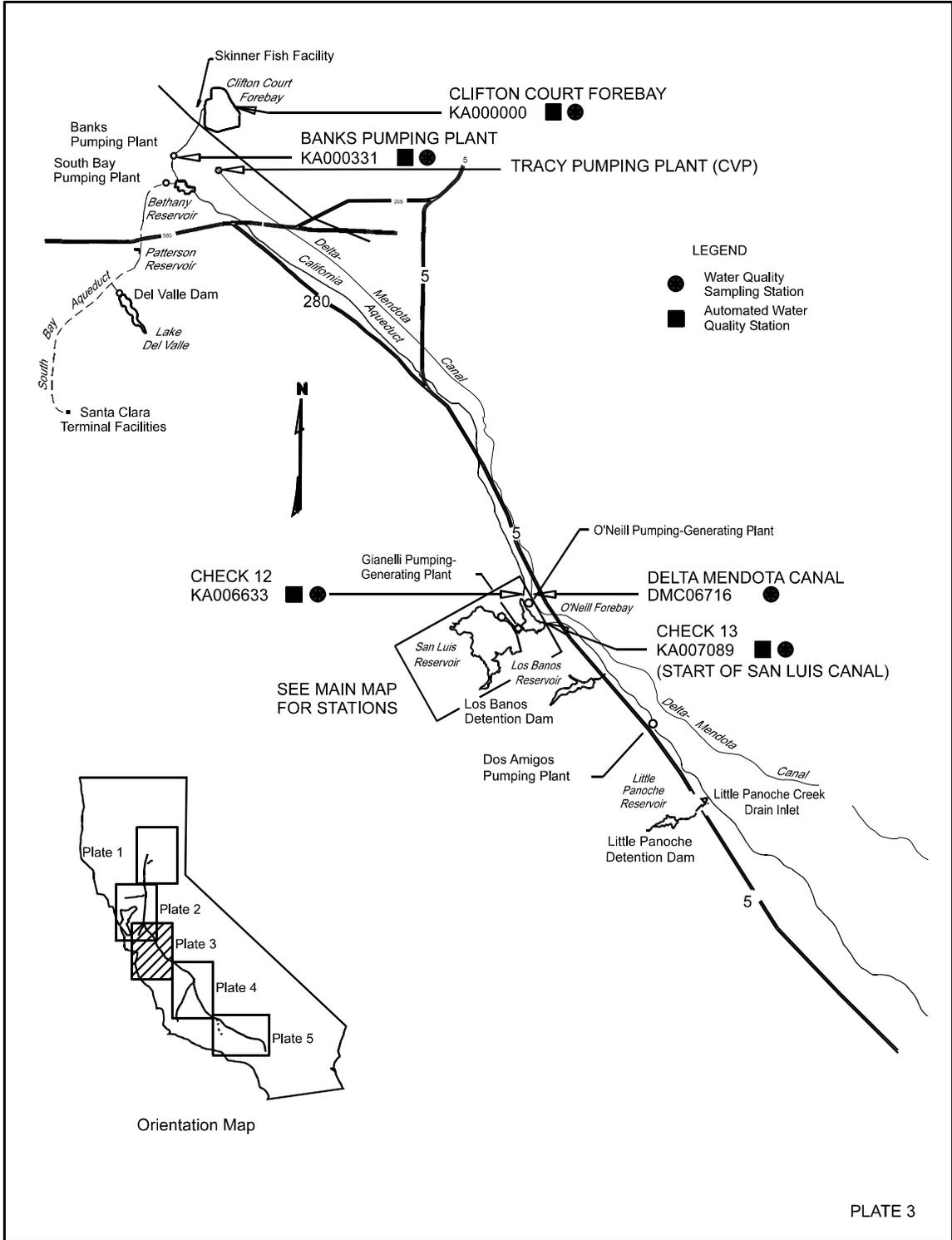


Plate 4

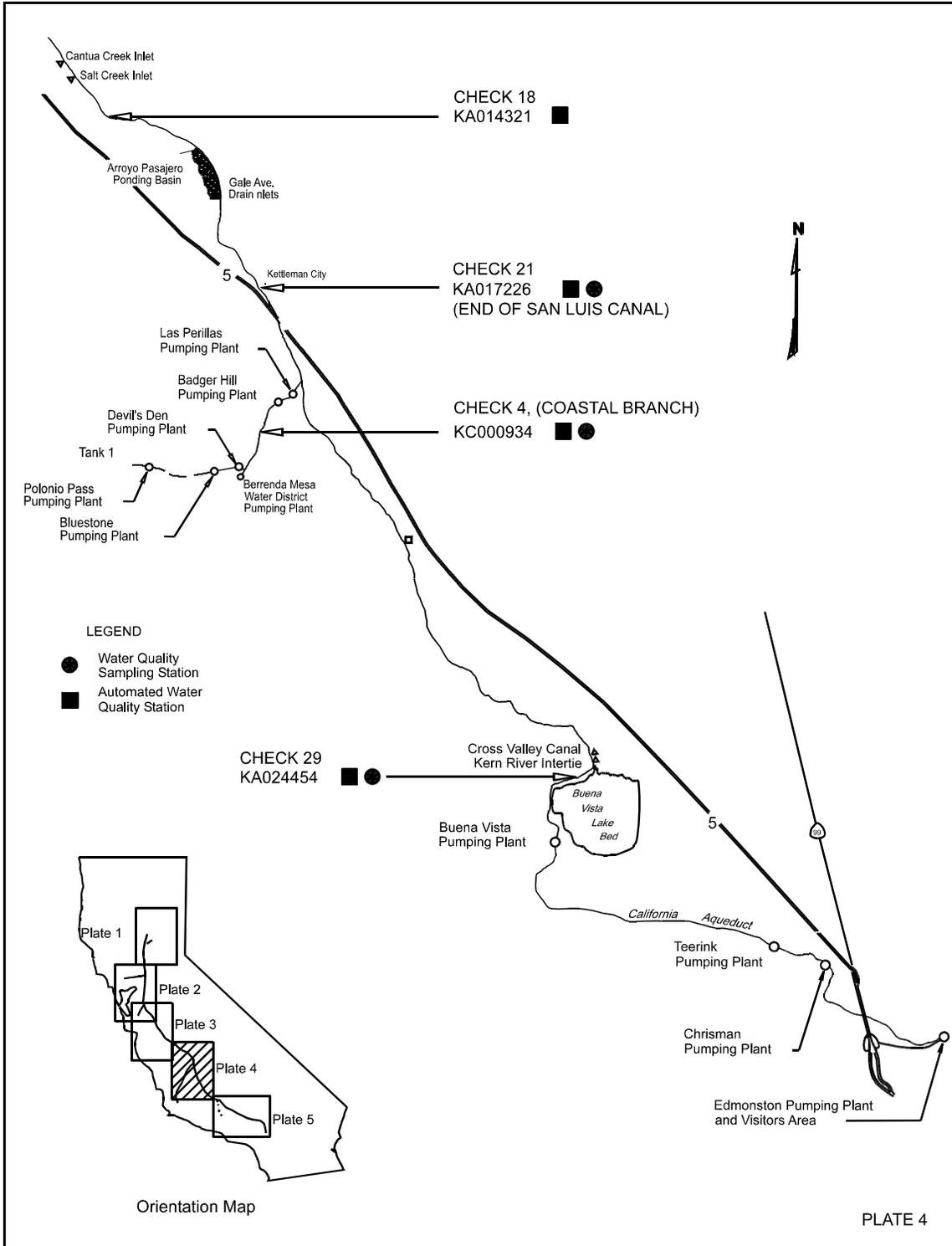


Table A-2. Analytical methods for non-organic chemical parameters

Analyte	Method Title	Reporting		
		Limit	Units	MethodName
Alkalinity	Alkalinity	1	mg/L as CaCO ₃	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 (Dissolved)	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 (NO ₃ , OP)
Dissolved Nitrite + Nitrate	Nitrite, Nitrate (DWR Modified) (Dissolved)	0.01	mg/L as N	Std Method 4500-NO ₃ -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 CaCO ₃	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		Method Name	
		Limit	Units		
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
		Aminomethylphosphonic Acid (AMPA)	100	µg/L	EPA 547
	Glyphosate	Glyphosate	100	µg/L	EPA 547
		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	
Methodathion		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		Method Name
		Limit	Units	
Volatile Organics in Water (Purgeable Organics)	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
	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-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

**Primary Maximum Contaminant Levels and their regulation dates
For drinking water contaminants
USEPA VS CDHS
(<http://www.dhs.ca.gov/ps/ddwem/chemicals/MCL/EPAandDHS.pdf>)
SEPTEMBER 2003**

Contaminant	USEPA		CDHS	
	MCL (mg/L)	Date ^a	MCL (mg/L)	Effective Date
<i>Inorganics</i>				
Aluminum	0.05 to 2 ^b	1/91	1 0.2 ^b	2/25/89 9/8/94
Antimony	0.006	7/92	0.006	9/8/94
Arsenic	0.05 0.01	eff: 6/24/77 2001	0.05	77
Asbestos	7 MFL ^c	1/91	7 MFL ^c	9/8/94
Barium	1 2	eff: 6/24/77 1/91	1	77
Beryllium	0.004	7/92	0.004	9/8/94
Cadmium	0.010 0.005	eff: 6/24/77 1/91	0.010 0.005	77 9/8/94
Chromium	0.05 0.1	eff: 6/24/77 1/91	0.05	77
Copper	1.3 ^d	6/91	1 ^b 1.3 ^d	77 12/11/95
Cyanide	0.2	7/92	0.2 0.15	9/8/94 6/12/03
Fluoride	4 2 ^b	4/86 4/86	2	4/98
Lead	0.05 ^e 0.015 ^d	eff: 6/24/77 6/91	0.05 ^e 0.015 ^d	77 12/11/95
Mercury	0.002	eff: 6/24/77	0.002	77
Nickel	Remanded		0.1	9/8/94
Nitrate	(as N) 10	eff: 6/24/77	(as N03) 45	77
Nitrite (as N)	1	1/91	1	9/8/94
Total Nitrate/Nitrite (as N)	10	1/91	10	9/8/94
Selenium	0.01 0.05	eff: 6/24/77 1/91	0.01 0.05	77 9/8/94
Thallium	0.002	7/92	0.002	9/8/94
<i>Radionuclides</i>				
Uranium	30 ug/L	12/7/00	20 pCi/L	1/1/89
Combined radium-226 & 228	5 pCi/L	eff: 6/24/77	5 pCi/L	77
Gross Alpha particle activity	15 pCi/L	eff: 6/24/77	15 pCi/L	77

Gross Beta particle activity	dose of 4 millirem/yr	eff: 6/24/77	50 pCi/L ^f	77
Strontium-90	8 pCi/L	eff: 6/24/77	8 pCi/L ^f	77
			now covered by Gross Beta	
Tritium	20,000 pCi/L	eff: 6/24/77	20,000 pCi/L ^f	77
			now covered by Gross Beta	

USEPA

CDHS

Contaminant	USEPA		CDHS	
	MCL (mg/L)	Date ^a	MCL (mg/L)	Effective Date
VOCS				
Benzene	0.005	6/87	0.001	2/25/89
Carbon Tetrachloride	0.005	6/87	0.0005	4/4/89
1,2-Dichlorobenzene	0.6	1/91	0.6	9/8/94
1,4-Dichlorobenzene	0.075	6/87	0.005	4/4/89
1,1-Dichloroethane	-	-	0.005	6/24/90
1,2-Dichloroethane	0.005	6/87	0.0005	4/4/89
1,1-Dichloroethylene	0.007	6/87	0.006	2/25/89
cis-1,2-Dichloroethylene	0.07	1/91	0.006	9/8/94
trans-1,2-Dichloroethylene	0.1	1/91	0.01	9/8/94
Dichloromethane	0.005	7/92	0.005	9/8/94
1,3-Dichloropropene	-	-	0.0005	2/25/89
1,2-Dichloropropane	0.005	1/91	0.005	6/24/90
Ethylbenzene	0.7	1/91	0.68	2/25/89
			0.7	9/8/94
			0.3	6/12/03
Methyl-tert-butyl ether (MTBE)	-	-	0.005 ^b	1/7/99
			0.013	5/17/00
Monochlorobenzene	0.1	1/91	0.03	2/25/89
			0.07	9/8/94
Styrene	0.1	1/91	0.1	9/8/94
1,1,2,2-Tetrachloroethane	-	-	0.001	2/25/89
Tetrachloroethylene	0.005	1/91	0.005	5/89
Toluene	1	1/91	0.15	9/8/94
1,2,4 Trichlorobenzene	0.07	7/92	0.07	9/8/94
			0.005	6/12/03
1,1,1-Trichloroethane	0.200	6/87	0.200	2/25/89
1,1,2-Trichloroethane	0.005	7/92	0.032	4/4/89
			0.005	9/8/94
Trichloroethylene	0.005	6/87	0.005	2/25/89
Trichlorofluoromethane	-	-	0.15	6/24/90
1,1,2-Trichloro-1,2,2-Trifluoroethane	-	-	1.2	6/24/90
Vinyl chloride	0.002	6/87	0.0005	4/4/89
Xylenes	10	1/91	1.750	2/25/89
SOCS				
Alachlor	0.002	1/91	0.002	9/8/94

Atrazine	0.003	1/91	0.003	4/5/89
			0.001	6/12/03
Bentazon	-	-	0.018	4/4/89
Benzo(a) Pyrene	0.0002	7/92	0.0002	9/8/94
Carbofuran	0.04	1/91	0.018	6/24/90
Chlordane	0.002	1/91	0.0001	6/24/90
Dalapon	0.2	7/92	0.2	9/8/94
Dibromochloropropane	0.0002	1/91	0.0001	7/26/89
			0.0002	5/3/91
Di(2-ethylhexyl)adipate	0.4	7/92	0.4	9/8/94
Di(2-ethylhexyl)phthalate	0.006	7/92	0.004	6/24/90
2,4-D	0.1	eff: 6/24/77	0.1	77
	0.07	1/91	0.07	9/8/94
Dinoseb	0.007	7/92	0.007	9/8/94
Diquat	0.02	7/92	0.02	9/8/94
Endothall	0.1	7/92	0.1	9/8/94
Endrin	0.0002	eff: 6/24/77	0.0002	77
	0.002	7/92	0.002	9/8/94
Ethylene Dibromide	0.00005	1/91	0.00002	2/25/89
			0.00005	9/8/94
Glyphosate	0.7	7/92	0.7	6/24/90
Heptachlor	0.0004	1/91	0.00001	6/24/90
Heptachlor Epoxide	0.0002	1/91	0.00001	6/24/90
Hexachlorobenzene	0.001	7/92	0.001	9/8/94
Hexachlorocyclopentadiene	0.05	7/92	0.05	9/8/94
Lindane	0.004	eff: 6/24/77	0.004	77
	0.0002	1/91	0.0002	9/8/94
Methoxychlor	0.1	eff: 6/24/77	0.1	77
	0.04	1/91	0.04	9/8/94
			0.03	6/12/03
Molinate	-	-	0.02	4/4/89
Oxamyl	0.2	7/92	0.2	9/8/94
			0.05	6/12/03
Pentachlorophenol	0.001	1/91	0.001	9/8/94
Picloram	0.5	7/92	0.5	9/8/94
Polychlorinated Biphenyls	0.0005	1/91	0.0005	9/8/94
Simazine	0.004	7/92	0.010	4/4/89
			0.004	9/8/94
Thiobencarb	-	-	0.07	4/4/89
			0.001 ^b	4/4/89
Toxaphene	0.005	eff: 6/24/77	0.005	77
	0.003	1/91	0.003	9/8/94
2,3,7,8-TCDD (Dioxin)	3×10^{-8}	7/92	3×10^{-8}	9/8/94
2,4,5-TP (Silvex)	0.01	eff: 6/24/77	0.01	77
	0.05	1/91	0.05	9/8/94
<i>Disinfection Byproducts</i>				
Total trihalomethanes	0.100	11/29/79	0.100	3/14/83
	0.080	eff: 11/29/83 ^g		
		eff: 1/1/02		

Total haloacetic acids		0.060		eff: 1/1/02 ^g
Bromate		0.010		eff: 1/1/02 ^g
Chlorite		1.0		eff: 1/1/02 ^g
<i>Treatment Technique</i>				
Acrylamide	TT ^h	1/91	TT ^h	9/8/94
Epichlorohydrin	TT ^h	1/91	TT ^h	9/8/94

- a. "eff." indicates the date the MCL took effect; any other date provided indicates when USEPA established (i.e., published) the MCL.
- b. Secondary MCL.
- c. MFL = million fibers per liter, with fiber length > 10 microns.
- d. Regulatory Action Level; if system exceeds, it must take certain actions such as additional monitoring, corrosion control studies and treatment, and for lead, a public education program; replaces MCL.
- e. The MCL for lead was rescinded with the adoption of the regulatory action level described in footnote d.
- f. MCLs are intended to ensure that exposure above 4 millirem/yr does not occur.
- g. Effective for surface water systems serving more than 10,000 people; effective for all others 1/1/04.
- h. TT = treatment technique, because an MCL is not feasible.

Secondary maximum contaminant levels
(<http://www.dhs.ca.gov/ps/ddwem/chemicals/MCL/regextract.pdf>)

Constituents	Maximum Contaminant Levels/Units
Aluminum	0.2 mg/L
Color	15 Units
Copper	1.0 mg/L
Corrosivity	Non-corrosive
Foaming Agents (MBAS)	0.5 mg/L
Iron	0.3 mg/L
Manganese	0.05 mg/L
Methyl-tert-butyl ether (MTBE)	0.005 mg/L
Odor—Threshold	3 Units
Silver	0.1 mg/L
Thiobencarb	0.001 mg/L
Turbidity	5 Units
Zinc	5.0 mg/L

Level Ranges Constituent, Units	Maximum Contaminant		
	Recommended	Upper	Short Term
Total Dissolved Solids, mg/L	500	1,000	1,500
or			
Specific Conductance, micromhos	900	1,600	2,200
Chloride, mg/L	250	500	600
Sulfate, mg/L	250	500	600

Appendix C
Comparison of Organic Carbon Analyzers (Amburgey 2004, American Works Association 2004 Water Quality Technology Conference)

Relative Comparison Matrix of Instruments Tested

Brand Name:	Hach	ISCO	Sievers/Ionics	Shimadzu
Model #:	1950 Plus	EZ TOC	800	4100
PERFORMANCE	7.5	7.0	7.8	6.8
Reliability	8	8	8	6
Accuracy	5	8	8	8
Reproducibility of readings	8	7	7	5
Drift of measurements over time	9	5	8	8
COSTS	6.0	7.0	9.0	8.0
Instrument Cost (\$)	\$23,650	\$19,995	\$21,700	\$24,799
Operating & Maintenance Cost (\$/yr)	\$3,468	\$2,696	\$2,256	\$1,698
Reagents and Standards	\$2,268	\$1,771	\$1,572	included
Spare parts kit	\$950	\$775	\$288	included
UV lamp (cost/yr based on 3 yr life)	\$250	\$150	\$396	n/a
Air purifier (\$)	\$2,800	\$2,500	\$0	\$250
Air/Air purifier elements(\$/yr)	\$843	\$450	\$0	\$750
ESTIMATED ANNUAL OPERATING COST	\$4,311	\$3,146	\$2,256	\$2,448
TOTAL EQUIPMENT COST	\$26,450	\$22,495	\$21,700	\$25,049
TOTAL COST For 10 yrs. Of Service	\$69,560	\$53,955	\$44,260	\$49,529
EASE OF USE	7.6	7.0	7.6	6.0
Ease of Calibration	9	3	7	9
User-friendly	7	9	8	3
Easy to understand software	7	9	8	5
Ease of Installation	7	5	9	4
Ease of grab sample analysis	8	9	6	9
GENERAL	6.7	6.8	8.3	8.0
Appearance	7	9	8	8
Quality workmanship	8	8	8	9
Display	5	7	8	9
Portability	3	1	9	3
Enclosure	9	7	8	9
Customer support	8	9	9	10
Physical Properties				
Dimensions: Width x Depth x Height (inches)	24x8x39	24x22x30	22x15x6	22x13x47
Overall size (cubic feet)	4.3	9.2	1.1	7.8
Weight (lbs)	120	160	30	154
Response time / Flow through time (minutes)	8	8	6	4
AVERAGE SCORE:	6.9	7.0	8.2	7.2
<i>Scale of Ratings</i>	1-2	3-5	6-8	9-10
	<i>Poor</i>	<i>Fair</i>	<i>Good</i>	<i>Excellent</i>

Appendix D
Implementation Procedures for the
Review of Water Quality from Non-Project Water
Introduced into the State Water Project
March 14, 2001

This document describes the approval and implementation procedures, as well as, responsibilities of the various parties involved in the introduction of Non-Project water into the State Water Project under the ***Department of Water Resources Water Quality Criteria for Acceptance of Non-Project Water into the State Water Project.***

This document does not in anyway affect, modify or have any bearing upon any provisions of law, contract, policy or procedure governing water resources or the State Water Project other than stated above. Non-project inflow shall not constrain the ability of DWR to operate the SWP for its intended purposes or to protect the SWP integrity during emergencies and it shall not adversely impact SWP operations, deliveries, existing contracts or any other agreements.

DWR shall consider all non-project water input proposals based upon the approved water quality ***Criteria*** and the procedures established in this document. This document describes the procedures and responsibilities of the Project Proponent, Department of Water Resources, and the Facilitation Group as described in the ***Criteria.***

Project Proponent

The proponent of a program that will introduce Non-Project water into the SWP will submit a complete detailed proposal to the Department of Water Resources for purposes of evaluating the water quality impacts. The proponent shall demonstrate that the non-project water is of consistent, predictable and reliable quality.

The Proponent is responsible for preparation of and compliance with any and all contracts, environmental documents, permits or licenses that are necessary consistent with applicable laws, regulations, agreements, procedures, or policies external to this document.

Project Description

The proponent will submit to DWR a document describing the proposed program, identifying the water source(s), planned operation, characterizing the inflow water quality and any anticipated impacts to SWP water quality and/or operations. The proposal will at a minimum include:

- Identify names, locations, addresses, and contact person(s) for all participants.

- Detailed information including maps identifying all sources of water, point of inflow to the SWP and ultimate fate of the introduced water.
- All terms and conditions of inflow, timing, rates and volumes of inflow, pumping, conveyance and storage requirements will be described.
- All construction details adjacent to SWP facilities will be described including valves, meters, pumps and piping size, location, etc.
- All potential impacts and/or benefits to downstream users will be identified
- Detailed water quality data will be provided for all sources of water and any blend of sources that will be introduced into the SWP.
- Describe anticipated water quality changes within the SWP.
- Identify other relevant environmental issues such as subsidence, ground water overdraft or, presence of endangered species.

Water Quality Monitoring

In order to demonstrate that the source(s) of water are of consistent, predictable, and acceptable quality the Proponent will monitor water quality. The proponent is responsible for all costs associated with characterizing and monitoring water quality up to and including the point of discharge into the SWP for the duration of the program. The proponent will, for the duration of the program, regularly report on operations as they affect water quality, monitoring data and water quality changes. One of three water quality monitoring schedules will be used and all information will be submitted to DWR on a regular basis (within 30 days of sampling).

Projects proponents shall select one of the testing options below and perform and provide all water quality testing described therein.

Option 1 - *Baseline tests*: Title 22 tests of record are required for all wells (sources), but a post inflow Title 22 test is allowed for any well near a similar well with a Title 22 test of record. *Periodic tests*: Constituents of Concern tests are required upon startup and quarterly for each discharge point.

Option 2 - *Baseline tests*: Constituents of Concern tests of record are required for all wells (sources) and Title 22 tests of record are required for representative wells comprising a subset of all wells. Representative wells shall be identified on a case-by-case basis to be representative of the manifold area; proximity, water levels, and agricultural water tests are significant for this purpose. The proponent shall identify representative wells subject to approval. *Start up tests in any year*: Title 22 tests are required for all discharge points upon startup. Constituents of Concern tests are required for all wells within two weeks of inflow startup. *Periodic tests*: Constituents of Concern tests are required monthly for each discharge point.

Option 3 – A project proponent may propose a monitoring schedule that is fully protective of water quality and consistent with the Criteria. The proposed monitoring schedule will be submitted to the Facilitation Group for review and approval.

Under any of the three testing option all Title 22 tests will be repeated every three years or as otherwise acceptable to the Department of Health Services to be compliant with Title 22. Sampling for pathogens (including giardia and cryptosporidium) may be required for any waters under the influence of surface water at the discretion of DWR and/or the Facilitation Group.

Flow Measurements

The proponent will provide flow measurements and analytical data for all sources and discharges into the SWP to demonstrate compliance with the *Criteria*.

- The proponent will maintain current, accurate records of production rate and volume from each source, as well as, each point of discharge into the SWP.
- Meters will be properly calibrated and maintained.
- All flow measurements will be regularly submitted to DWR.

Reconsideration

If a proponent disagrees with the DWR decision of compliance with the Non-Project inflow *criteria* or feels that there is overriding benefit of the proposal, the proponent may seek review from the Facilitation Group.

- The SWC Facilitation Group may recommend to DWR that a proposal has some overriding benefit(s) and DWR may reconsider the proposal.
- Reconsideration by DWR will be on a case-by-case basis and DWR may waive or modify the Inflow Criteria for specific proposals if conditions warrant.

DWR

DWR, in consultation with the State Water Project contractors, DHS, and other appropriate parties, will develop the ***Department of Water Resources Water Quality Criteria for Acceptance of Non-Project Water into the State Water Project and Implementation Procedures for the Review of Water Quality from Non-Project Water Introduced into the State Water Project***. The criteria and procedures will be reviewed annually and revised as needed to protect SWP water quality.

DWR will seek, as needed DHS or State Water Contractor recommendations on changes or additions to the *criteria* and *procedures* documents governing Non-Project water inflow proposals. The Facilitation Group will review proposed changes or additions prior to implementation by DWR.

DWR will have ultimate responsibility for approving the water quality of all non-project inflow, as well as, the oversight of monitoring and tracking the water quality of operating programs.

Project Proposal

Upon receipt of a proposal for Non-Project water inflow DWR will review the proposal for adequacy. DWR shall consider all non-project water inflow proposals

based upon the approved *Criteria*. If necessary, DWR will convene timely meetings with the Facilitation Group during the review of a proposal. At the minimum the review will include

- Examination of all documents and data for completeness of the submittal.
- Affected Field Divisions, the Facilitation group and all affected downstream users will be immediately notified of the submittal.
- Comments from all parties may be considered by DWR before the final decision.
- Upon completion of the review DWR will notify the proponent, and downstream users of the acceptance of the proposal, the need for modification of a proposal, or explain the reason(s) for rejecting the proposal.
- DWR may reconsider a decision on a proposal based upon a recommendation from the Facilitation Group. Reconsideration by DWR will be on a case-by-case basis and DWR may waive or modify the *Criteria* for specific proposals if conditions warrant

Annual Review

Once a program for delivery on non-Project water to the Aqueduct has been approved, an annual review of the program will occur with input from the Facilitation Group. As part of the review, program proponents will provide the following information:

- Summary of deliveries to the Aqueduct.
- Water quality monitoring results.
- Proposed changes in the program operation.

The review may result in changes in program operations, monitoring and testing required of the program proponent as a result of;

- New constituents being added to the EPA /DHS list of primary drinking water standards.
- Changes in the maximum contaminant levels for the EPA/DHS list of primary drinking water standards.
- Identification of new constituents of concern
- Changes in the water quality provided by the program.
- Changes in concentrations in the California Aqueduct.

This procedure shall recognize emerging contaminants as they are identified by the regulatory agencies and shall set appropriate standards for introduction based upon ambient levels in the California Aqueduct or State Action Levels, which ever is lower. Emerging contaminants are those that may pose significant risk to public health, but as yet do not have an MCL. Currently the Office of Environmental Health Hazard Assessment and the Department of Health Services establish Public Health Goals and Action Levels, respectively. These levels, though not regulated, do provide health-based guidance to water utilities and can require public notification if exceeded.

Water Quality Review

For operating projects DWR will track and annually report on water quality impacts to the SWP from Non-Project water inflow.

- DWR will review analyze and maintain all records of water quality testing conducted by the proponent of the well(s), source(s) and discharge(s) into the SWP.
- DWR will determine what additional water quality monitoring, if any, is necessary within the SWP to assure compliance with the Criteria. DWR will conduct all water quality monitoring within the SWP
- DWR will prepare an annual report of water quality impacts in the SWP from Non-Project water and make all water quality data available to interested parties.

On-site Surveillance

The appropriate Field Division within DWR will be responsible for review and approval of all construction activities within the SWP right-of-way. Plans showing the discharge system piping, valves, sampling point, meters and locations must be submitted and approved prior to any construction. In addition, the appropriate Field Division will be responsible for confirmation of all meter readings and water quality monitoring conducted by the proponent.

- Field division staff may visit, inspect, calibrate meters and measure flow conditions at each source or point of discharge into the SWP.
- Flow meters, sampling ports and anti-siphon valves must be conveniently located near the SWP right-of-way.
- Field division staff may collect water samples at each source or point of discharge into the SWP.
- The appropriate Field Division will conduct additional water quality monitoring within the SWP, if deemed necessary, to assure compliance with the Non-Project Inflow Criteria.

SWC Facilitation Group

Upon initial review of a Non-project water inflow proposal, DWR shall notify the State Water Contractors of its receipt, its contents, and the possible need for a Facilitation Group. The State Water Contractors may form a Facilitation Group to advise DWR on any or all proposals for introduction of Non-Project water into the SWP.

- It is the responsibility of the State Water Contractors to form and coordinate the activities of the Facilitation Group. DWR will assist in coordination of Facilitation Group activities as requested.
- The SWC Facilitation Group can consist of State Water Contractors, DWR, the project proponent, other state or federal agencies, private consultants or other interested parties as needed to fully evaluate a Non-project Inflow Proposal.

The Facilitation Group is an advisory body that will review the *criteria* and *Procedures* for approval of water quality for Non-project inflow. The Facilitation Group will review and recommend action on Proposals that could degrade SWP water quality. Also, if a proponent proposes a monitoring Schedule under Option 3, above, the Facilitation Group will review the proposal and make appropriate monitoring recommendations.

Recommendations of the Facilitation Group

The Facilitation Group will consider the merits, impacts, mitigation, cost/benefits or other issues, in addition water quality, in an effort to develop a consensus recommendation for action on Non- Project Inflow Proposals.

- State Water Contractors will make all decisions on the direction and actions of Facilitation Group activities or development of a recommendation on any proposal.
- The facilitation group may provide comment or recommendations to DWR at any time, on any aspect, of any proposal. The facilitation group can also provide comment or recommendations to DWR on the *Criteria* or *Procedures* at any time.
- The Facilitation Group will provide DWR recommendations for formal approval, disapproval or modification of each individual Non-Project Inflow Project submitted for consideration. The recommendation shall include an explanation the reasons for the recommendation.
- If consensus among State Water Contractors is not possible the Facilitation Group may submit both majority and minority opinions and recommendations.