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THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

MUNICIPAL WATER QUALITY INVESTIGATIONS PROGRAM

ANNUAL REPORT

1997-1998

OCTOBER 2000

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Chapter 1

Introduction

Table of Contents

Figures

Contents (continued)

Tables

MWQI MISSION STATEMENT:

"To determine and evaluate the sources of contaminants that affect the drinking water quality of the Sacramento and San Joaquin Delta."

The 1997-1998 Municipal Water Quality Investigations Annual Report was written to provide two types of information. The chapters on water quality monitoring, the Spiked Matrix Recovery Study, the Coordinated Pathogen Monitoring Program, and the Barker Slough Watershed Study present data and interpretation from monitoring and research. The other chapters provide a summary and status of MWQI program studies that are in progress or are scheduled. This report was written two years after the period of record. The status of the projects discussed in this report reflects time ending in July 1998. Despite the dated status reports, this report provides newly released information about Delta monitoring data and results from the Coordinated Pathogen Monitoring Program and Spiked Matrix Recovery Study.

The work in this report was conducted by the California Department of Water Resources Municipal Water Quality Investigations Program. The MWQI Program has been in existence since the early 1980s when it was determined that urban and agricultural land uses within the Delta and watersheds of major tributaries contributed disinfection byproduct precursors. The Program has since expanded to address all drinking water parameters of concern within the source waters of the Delta and the State Water Project.

This program is funded through a contract with the Urban State Water Contractors outside of the standard contract that DWR has with the State Water Contractors. Elements of the MWQI work plan are developed under direction and review of a committee of the Urban State Water Contractors and representatives from the California Department of Health Services, DWR Operations and Maintenance Water Quality Branch, United States Environmental Protection Agency, California Urban Water Agencies, and the California Water Resources Control Board.

Contra Costa Water District also participates through an agreement with DWR. Even though CCWD pumps water directly from the Delta and does not have any water delivered through the State Water Project, the MWQI Program provides important information about the water quality in the Delta that affects CCWD's source water.

A second working committee, the Sanitary Survey Action Committee, oversees the completion of the State Water Project Sanitary Survey Update every five years.

The pathogen studies and the Barker Slough Monitoring Study were developed based on recommendations from the SSAC and action items from the 1996 SWP Sanitary Survey.

MWQI resources include:

- ✓ Five full-time scientists as project leaders
- ✓ A field crew of three with two mobile labs
- ✓ DWR's Bryte Chemical Laboratory (ELAP-certified)
- ✓ DWR's Quality Assurance and Quality Control Unit
- ✓ Marvin Jung and Associates on contract
- ✓ An outside laboratory contract for soil and pathogen analysis

The annual budget for the MWQI Program is $1.8 million. Approximately two-thirds of the budget is allocated for personnel costs while the remaining third is used for operational and analytical expenses.

This report reflects a period of change for the MWQI Program. Until 1996 most of the work done by the program was completed in response to the drinking water utilities' concerns over the contaminants in the source water of the Delta. The studies focused on existing problem definition and possible solutions. With the Bay-Delta Accord and expansion of the CALFED process, the MWQI Program expanded its scope of study to address potential changes in land use, water storage, and conveyance. The concern that extensive wetland restoration may discharge large quantities of reactive organic carbon in the source water has led to MWQI studies such as the SMARTS study and the Decker Island Tidal Wetlands Restoration Project. As the CALFED process continues, the MWQI Program will continue to address potential impacts to drinking water by those who receive their drinking water from the Sacramento-San Joaquin Delta.

Richard S. Breuer, Chief
Municipal Water Quality Investigations

Chapter 2

MWQI Monitoring Data

Purpose: The MWQI Program has monitored the water quality of major channels and agricultural drains in the Sacramento-San Joaquin Delta for many drinking water parameters since 1983. During the months covered in this report, from January 1997 through June 30, 1998, 15 stations were monitored (see Figure 2-1). These stations were selected because they represent the major intakes and diversions of the Delta and are representative of the Delta's major regions. With three exceptions, all samples collected were monthly grab samples. Weekly grab samples were collected at the San Joaquin River at Vernalis, the Sacramento River at Greene's Landing, and at Hood. Table 2-1 lists sample stations and the parameters analyzed.

Background: This report marks the replacement of the Greene's Landing sampling site with the Hood sampling site. Greene's Landing is important for several reasons. First, a database, pre-dating MWQI sampling, exists at this spot. Secondly, Greene's Landing is a few miles downstream of major urban inputs. Problems with deteriorating safety and access necessitated the replacement of the Greene's Landing site. The replacement site, Hood, is approximately 2 miles upstream of Greene's Landing with no major inputs between the two sites. To determine if waters collected at Hood were representative of waters collected at Greene's Landing, samples were collected weekly at both sites from August 1997 through May 1998. Both sites were analyzed for the constituents listed in Table 2-1. For all parameters, there was no significant difference in water quality between the two sites ($p < 0.05$). Samples were collected only from Hood beginning June 10, 1998.

Findings: Monitoring data was examined two ways: First, as a function of time, and secondly as a function of source water (channel sites versus agricultural drain sites). Although a number of parameters were monitored, only the analytes of greatest interest to drinking water quality were presented graphically. In the analyses sections of this report, non-detects are reported as "0" value.

Analyte concentrations were analyzed at four sites: Sacramento/West Sacramento Intake, Greene's Landing/Hood, Banks Pumping Plant, and the San Joaquin River at Vernalis. Two of the sites were chosen to examine Sacramento River water quality before and after major urban inputs: Sacramento/West Sacramento Intake and Greene's Landing/Hood, respectively. Samples collected at Vernalis represent San Joaquin River water quality before inflow into the Delta. Samples collected at the Banks Pumping Plant indicate the water quality pumped into the State Water Project. For graphing purposes, data from samples collected at Greene's Landing and at Hood were treated as the same sampling site.

Trends as a function of source water were examined for nine major channels and three agricultural drains. These are presented as box and whiskers plots. When applicable, stations were examined for trends in organic carbon, electrical conductivity, turbidity, total dissolved solids, and bromide.

Hydrology

The reporting period covers the last nine months of water year 1997 and the first nine months of water year 1998. The unimpaired Sacramento Valley River runoff was 25.69 and 31.41 million acre-feet for water years 1997 and 1998, respectively. Based on the calculated Sacramento Valley Water Year Type Index, both years were classified as wet year types. Water year 1998 was the third wettest water year on record since 1906.

Sacramento, San Joaquin and Delta outflow from January 1997 to the beginning of April 1998 are shown in Figures 2-2 and 2-3. Pumping plant output for the State Water Project, the Central Valley Project and the ratio between exports and imports are also shown. The remainder of the reporting year is shown in Figure 2-4. Between January 1, 1997, and September 30, 1997, average Delta inflows were approximately 59,890 cubic feet per second. Average outflows were approximately 51,472 cfs with the largest outflow (584,500 cfs) occurring on January 3, 1998 because of increased precipitation and high reservoir flood control releases. During this period, average inflows to the Delta were approximately 4.88 maf from the San Joaquin River, and 9.17 maf from the Yolo Bypass. Between October 1, 1997, and June 30, 1998, average Delta inflows were approximately 77,616 cfs. Average outflows during this period were approximately 72,460 cfs with the largest outflow (329,203 cfs) occurring on February 8, 1998. During this period, total flow volumes into the Delta were approximately 24.27 maf from the Sacramento River, 6.98 maf from the San Joaquin River, and 8.89 maf from the Yolo Bypass. Acre-feet were calculated by multiplying daily cfs by 1.98 and the number of days in the period of interest.

Average export rates for the SWP between January 1, 1997, and September 30, 1997, were approximately 2,881 cfs. During this same period, average export rates for the CVP were 3,247 cfs. Between October 1, 1997, and June 30, 1998, average export rates for the SWP and the CVP were 2,526 and 3,133 cfs, respectively.

Monitoring Results

Bromide

Figure 2-5 shows the concentration of bromide over time for Sacramento/West Sacramento Intake, Greene's Landing/Hood, Banks, and Vernalis. Laboratory detection limits for bromide are 0.01 mg/L. Any value below the detection limit was reported as 0 mg/L. With the exception of one sample collected in December 1997 at Greene's Landing/Hood, bromide levels at Sacramento/West Sacramento Intake and Greene's Landing/Hood showed little change regardless of the season. Concentrations at both sites never went above 0.1 mg/L. Average values were lower than either southern Delta site by approximately a factor of 10 (see Table 2-2).

Bromide concentrations at Banks and Vernalis displayed more fluctuation over time with levels as high as 0.49 mg/L. Bromide levels appeared to increase in the winter months from November through January. Increases in bromide at Banks and Vernalis are based on a complex interaction between tidal influence at the pumping plant, volume discharged by the Sacramento River and Delta islands, agricultural discharge into the San Joaquin, the release schedule at the reservoirs, and flushing of accumulated salts from rainfall events. Overall, the primary source of bromide in Delta waters is a result of seawater intrusion. Seawater intrusion would not be expected to be a source of bromide at the Sacramento/West Sacramento Intake and Greene's Landing/Hood sampling sites.

Total Dissolved Solids

Patterns between TDS and bromide should be similar. TDS would be expected to be lower at the northern Delta stations and higher at the southern Delta stations. Monthly sampling verified this pattern (see Figure 2-6). With the exception of one sample collected in September at Greene's Landing/Hood, all samples collected at Sacramento/West Sacramento Intake and Greene's Landing /Hood ranged between 50-130 mg/L, see Table 2-2. In contrast, TDS values at Banks and Vernalis generally had higher TDS levels and fluctuated over time. Like bromide, TDS at the Banks pumps and at Vernalis show a complex interaction between hydrology and agricultural inputs. During dry years, the return of San Joaquin River water to the Central Valley via the Delta-Mendota Canal has been observed in studies of movement of selenium and mineral salts in the South Delta. Over time, this phenomenon can concentrate salts above basin background levels.

Total and Dissolved Organic Carbon

Beginning in this reporting period, TOC was analyzed at selected stations. Samples collected at Banks for DOC were discontinued after July 1, 1997. DOC has been collected by MWQI at a number of sites. However, samples were also collected by DWR Operations and Maintenance staff at some of the same sites and for the same parameters. To avoid duplication of effort, it was agreed that MWQI would discontinue sampling at Banks Pumping Plant for DOC and TOC. O&M would continue to sample for TOC (currently O&M does not sample for DOC). During this reporting period, TOC was also sampled at selected stations. DOC and TOC are shown in Figures 2-7 and 2-8.

The lowest concentration of DOC was observed at the Greene's Landing/Hood sampling site. The highest was observed in the San Joaquin River at Vernalis. At the Greene's Landing/Hood and the Banks pumping station, approximately 90 percent of the TOC consisted of dissolved carbon. On average, TOC and DOC levels were always less than 4 mg/L, however, DOC values as high as 7 mg/L were recorded in the late winter at Vernalis.

Methyl Tertiary-Butyl Ether

In January 1999, California adopted a secondary maximum contaminant level of 5 µg/L of MTBE based on taste and odor concerns. As of March 1999, the California Department of Health Services established an action level for MTBE of 13 µg/L. This requires a water supplier to notify customers of the presence of the compound if this value is exceeded. It is expected that in 1999 13 µg/L will be adopted as the primary maximum concentration level. The secondary maximum contaminant level is 5 µg/L (22 CCR 64449). This level is not for human health protection, but is based on taste and odor parameters. MTBE will be phased out as a gasoline additive by 2002.

Monthly sampling results for MTBE are shown in Figure 2-9. Throughout the reporting period, MTBE levels never exceeded 5 µg/L. Laboratory detection limits were 1µg/L. Any value below the detection limit was reported as 0 µg/L.

At the Sacramento/West Sacramento Intake sampling site, MTBE levels fell from 2.8 µg/L in April 1997 to below detection the following month. In the summer months, when recreational boating increased, MTBE was detected from July through September 1997. In October, MTBE levels again fell below the detection limit. MTBE was not detected at this site for the rest of the reporting period. With the exception of June and August, MTBE was detected from April through November 1997 at the Greene's Landing/Hood sample site. At the Banks Pumping Plant, MTBE was detected in September 1997. Sampling by MWQI ended July 2, 1997, just before the Fourth of July weekend. At Vernalis, MTBE was detected only in December and April. In both cases, MTBE levels fell below detection limits in the following month.

To assess the impacts of recreational watercraft on MTBE levels, samples were collected at selected sites before and after summer holidays. Based on inputs from DWR's Division of Planning and Local Assistance, sites were chosen based on potential impacts from recreational watercraft. Sites were confined to the South Delta at Station 9 (Byron), Contra Costa Pumping Plant No. 1 and the Delta-Mendota Canal. Sampling results for samples collected on Memorial Day, Fourth of July and Labor Day weekends are shown in Table 2-3. With one exception, MTBE levels increased after a holiday weekend, and in one case, levels were detected at the Delta-Mendota Canal at levels slightly above the secondary contaminant level. Although post-holiday MTBE levels at Station 9 were slightly lower than levels detected before the holiday weekend, studies have indicated that MTBE is highly volatile and has a very short half-life. Volatilization half-lives of MTBE from streams and rivers have been estimated to be approximately 3.5 to 9.5 hours, respectively. Monthly grab samples collected at Sacramento/West Sacramento Intake, Greene's Landing/Hood and Vernalis indicate that MTBE levels could fall below detection limits. Lower MTBE concentrations at Station 9 could have occurred from rapid volatilization before sampling, or as an artifact of the grab sample collection process.

Box and Whiskers Plots

Box and whisker plots were used to examine bromide, DOC/TOC, electrical conductivity, TDS, and turbidity occurring at channel and drain stations. Channel stations were defined as major sources of drinking water. Channel stations examined in this report were American River at the Fairbairn Sacramento Water Treatment Plant, Banks Pumping Plant, Barker Slough Pumping Plant, the Delta-Mendota Canal, Greene's Landing/Hood, Mallard Island, Sacramento River at the West Sacramento Intake, the San Joaquin River at Highway 4, and the San Joaquin River at Vernalis. Drain stations included Bacon Island Drain No.1, Natomas East Main Drain, and Twitchell Island Drain No.1. These stations are drains for agricultural and urban sources. Concentrations below the detection limit are reported as "0." Outliers were defined as 1.5 (quartile spread) beyond the 25^{th} and 75^{th} quartiles. An extreme outlier was defined as 3 (quartile spread) beyond these two quartiles.

Bromide

With the exception of Mallard Island, bromide levels were similar between the channels (see Figure 2-10). In many cases bromide values were below the detection limit of 0.01 mg/L. Median bromide levels at Mallard Island were higher than all other channel stations. Variability was also greater than at any of the other stations. Bromide levels at Mallard Island are strongly influenced by tidal and riverine forces. Since a large proportion of the bromide may be due to seawater influences, higher bromide levels would be expected at Mallard Island.

Bromide was detected at all three drainage stations. Of the three sites, Twitchell Island had the highest variability and median values (see Figure 2-16).

Dissolved Organic Carbon

With the exception of the Barker Slough Pumping Plant, all channel DOC median values were less than 4 mg/L (see Figure 2-11). At the American and Sacramento Rivers' sites, DOC values were even lower, with median DOC values falling below 2 mg/L at the American River at the Fairbairn Treatment Plant, Greene's Landing/Hood and the Sacramento/West Sacramento Intake. Relative to the Sacramento stations, DOC levels were higher in the southern Delta. DOC levels at the Barker Slough Pumping Plant were near 6 mg/L and in some cases, increased to more than 14 mg/L. The *1996 SWP Sanitary Survey* found that Barker Slough had more water quality problems than any other system in the SWP. Results of an ongoing study of the slough are in this report's *Chapter 6, North Bay Aqueduct Watershed Study.*

In general, median DOC levels in the drain stations were higher than in the channels (see Figure 2-17). Higher levels may reflect the contributions of Delta peat soils to the drainage systems.

Electrical Conductivity

With the exception of Mallard Island, electrical conductivity in the channels ranged between 42 and 800 microsiemens (see Figure 2-12). The lowest values occurred at the Sacramento River sampling sites, while the highest values occurred at samples collected from Banks Pumping Plant and the San Joaquin River. Mallard Island, where water quality is the most strongly influenced by seawater, had the highest median electrical conductivity values.

Electrical conductivity was not measured at Bacon Island. Values measured at Natomas East Main Drain and the Twitchell Island sampling sites were similar to those observed at the San Joaquin, the Delta-Mendota Canal and Banks sampling sites (see Figure 2-18).

Total Dissolved Solids

TDS for channel stations are shown in Figure 2-13. The secondary maximum concentration level for drinking water is 500 mg/L. With the exception of Mallard Island, which is heavily influenced by seawater, median channel station TDS levels were below the secondary maximum concentration level.

TDS were measured at the Natomas East Main Drain and Twitchell Island. Measured TDS levels at the Twitchell Island sampling point were higher than at the Natomas East Main Drain. The channel stations median values fell below the 500 mg/L secondary MCL (see Figure 2-19).

Total Organic Carbon

TOC was collected at the Barker Slough Pumping Plant, Greene's Landing/Hood, the Delta-Mendota Canal and the Banks Pumping Plant (see Figure 2-14). In all cases, median TOC levels were only slightly higher than DOC values, suggesting that most of the organic carbon was in the dissolved state. The variability in TOC and DOC at the Barker Slough Pumping Plant was relatively high, therefore, the assumption that most of the organic carbon at Barker Slough was in the dissolved state may not be accurate. TOC was not analyzed at the drain stations.

Turbidity

The channel stations had the highest levels of turbidity and the greatest number of outliers, see Figure 2-15. On at least one occasion, turbidity at the Barker Slough Pumping Plant was more than 200 NTUs, however median values at this site were closer to 40 NTUs. Median values at all other channel sites were below 40 NTUs.

Of the three drains profiled, only the Natomas East Main Drain was evaluated for turbidity and the median turbidity was below 40 NTUs (see Figure 2-20).

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Figure 2-1.
Municipal Water Quality Investigations
Delta Sampling Locations
1997 - 1998

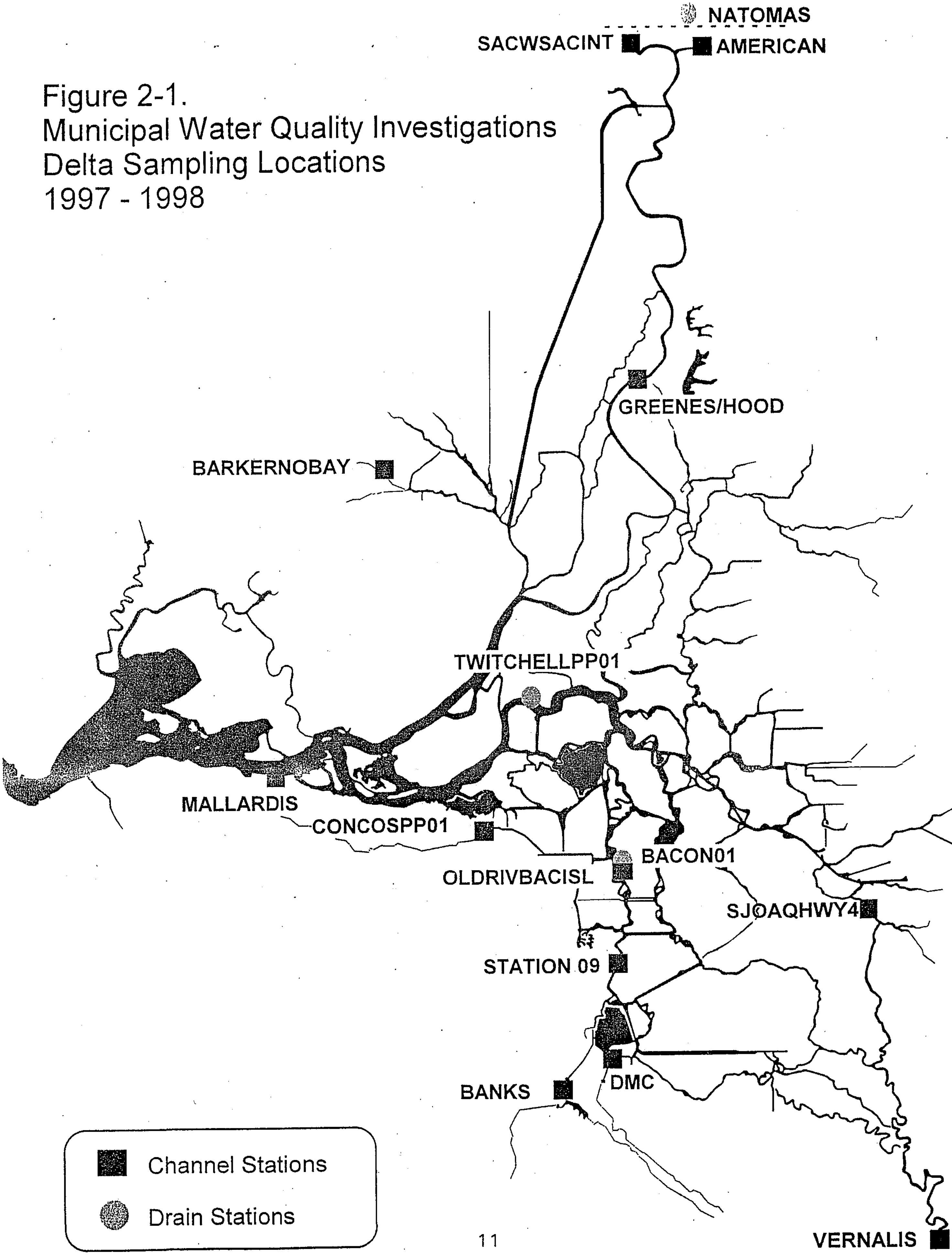


Table 2-1. Monthly Delta Monitoring (Grab Samples)

Sampling Run	Station Name (Station Number)	Station Description	Analyses
North Delta Day One	**GREENES/HOOD**[1] (B9D82071327/ B9D82211312)	Sacramento River at Greenes Landing / Sacramento River at Hood	Minerals, Turbidity, DOC, TOC, UVA, Bromide, MTBE, Color, Fecal Coliform, As, Cu, Se, Al, Fe, Mn
	AMERICAN (A0714010)	American River at Water Treatment Plant Intake	Minerals, Turbidity, DOC, UVA, Bromide, MTBE, Fecal Coliform
	SACWSACINT (A02104.51)	Sacramento River at West Sacramento Intake	Minerals, Turbidity, DOC, TOC, UVA, Bromide, MTBE, Color, Fecal Coliform, As, Cu, Se
	NATOMAS (A0V83671280)	Natomas Main Drain at ElCamino	Minerals, Turbidity, DOC, TOC, UVA, Bromide, MTBE, Fecal Coliform, As, Cu, Fe, Al, Mn,
North Delta Day Two	**MALLARDIS** (E0B80261551)	Sacramento River at Mallard Island	Minerals, Turbidity, DOC, UVA, Bromide, MTBE, Color, Fecal Coliform, As, Cu, Se
	BARKERNOBAY[2] (B9D81661478/ KG000000)	Barker Slough at North Bay Pumping Plant / North Bay Aqueduct at Barker Slough Pumping Plant	Minerals, Turbidity, DOC, TOC, UVA, Bromide, MTBE, Color, Fecal Coliform, Al, Sb, As, Ba, Be, Cd, Cr, Cu, Fe, Mn, Hg, Ni, Se, Tl, Zn
	CONCOSPP1 (B9591000)	Contra Costa Pumping Plant Number 1	Minerals, Turbidity, DOC, UVA, Bromide, MTBE, Color, Fecal Coliform, Sb, As, Ba, Be, Cd, Cr, Cu, Mn, Hg, Ni, Se, Tl, Zn
	TWITCHELLPP01 (B9V80661391)	Ag. Drain on Twitchell Island Pumping Plant Number 1	Minerals, Turbidity, DOC, UVA, Bromide, MTBE, Al, Fe, Mn
	VERNALIS[1] (B0702000)	San Joaquin River at Vernalis	Minerals, Turbidity, DOC, UVA, Bromide, MTBE, Color, Fecal Coliform, As, Cu, Se
South Delta	**STATION09** (B9D75351342)	Old River Near Byron	Minerals, Turbidity, DOC, TOC, UVA, Bromide, MTBE, Color, Fecal Coliform, Sb, As, Ba, Be, Cd, Cr, Cu, Mn, Hg, Ni, Se, Tl, Zn
	BACON01 (B9V75881342)	Ag. Drain on Bacon Island Pumping Plant Number 1	Minerals, Turbidity, DOC, TOC, UVA, Bromide, MTBE
	OLDRIVBACISL (B9D75811344)	Old River at Bacon Island	Minerals, Turbidity, DOC, TOC, UVA, Bromide, MTBE, Color, Fecal Coliform
	DMC[3] (B9C74901336/ DMC06716)	Delta Mendota Canal At Lindeman Road / Delta Mendota Canal Upstream McCabe Road	Minerals, Turbidity, DOC, TOC, UVA, Bromide, MTBE, Color, Fecal Coliform, Al, Sb, As, Ba, Be, Cd, Cr, Cu, Fe, Mn, Hg, Ni, Se, Tl, Zn
	BANKS[4] (KA000331)	Harvey O. Banks Pumping Plant	Minerals, Turbidity, DOC, TOC, UVA, Bromide, MTBE, Color, Fecal Coliform, Al, Sb, As, Ba, Be, Cd, Cr, Cu, Fe, Mn, Hg, Ni, Se, Tl, Zn
	SJOAQHWY4 (B9D75571196)	San Joaquin River at Highway 4	Minerals, Turbidity, DOC, UVA, Bromide, MTBE

[1] Samples collected on a monthly and weekly basis.
[2] MWQI program ceased monitoring this station 6/2/97, Operations and Maintenance monitors this station continuously.
[3] MWQI program ceased monitoring this station 9/2/97, Operations and Maintenance monitors this station continuously.
[4] MWQI program ceased monitoring this station 7/2/97, Operations and Maintenance monitors this station continuously.

Table 2-2. Average Concentration for bromide, TDS, total and dissolved organic carbon, and MTBE between 1/1/97 and 6/30/98. Values are the mean ± std. error. Ranges are shown in parentheses

Parameter	SACWSACINT	Greene's/Hood	Banks	Vernalis
Bromide (mg/L)	**0.007 ± 0.002** (<0.01 - 0.02)	**0.02 ± 0.002** (<0.01 - 0.09)	**0.15 ± 0.02** (0.05 - 0.44)	**0.16 ± 0.02** (0.03 - 0.49)
TDS (mg/L)	**88 ± 4.26** (56 - 127)	**98 ± 5.97** (50 - 374)	**210 ± 15.73** (106 - 338)	**268 ± 23.3** (83 - 578)
Dissolved Organic Carbon (mg/L)	**2.56 ± 0. 87** (1.3 - 16.3)	**2.07 ± 0.08** (1.31 - 5.01)	**3.52 ± 0.33** (2.7 - 4.9)	**3.66 ± 0.17** (2.31 - 7.22)
Total Organic Carbon (mg/L)	not sampled	**2.36 ± 0.12** (<0.1 - 4.18)	**3.79 ± 0.20** (2.7 - 4.9)	not sampled
MTBE (μg/L)	**2.03 ± 0.34** (<1.0 - 2.8)	**2.62 ± 0.71** (<1.0 - 3.0)	**0.5 ± 0** (<1.0 - 0.5)	**2.60 ± 0.2** (<1.0 - 2.8)

Table 2-3. Methyl tert-butyl ether (MTBE) Concentrations in µg/L During Heavy Boating Seasons.

	Memorial Day		Fourth of July		Labor Day	
Station	Pre (5/23/97)	Post (5/27/97)	Pre (7/1/97, 7/2/97)	Post (7/7/97, 7/9/97)	Pre (8/28/97)	Post (9/2/97, 9/3/97)
CONCOSPP01	3.3	3.3	<1	5.6	<1	1.9
STATION09	3.9	3.3	1.7	4.2	<1	2.7
DMC	2.4	4.2	1.6	5.6	<1	4.6

NS[1]: Sample not collected.

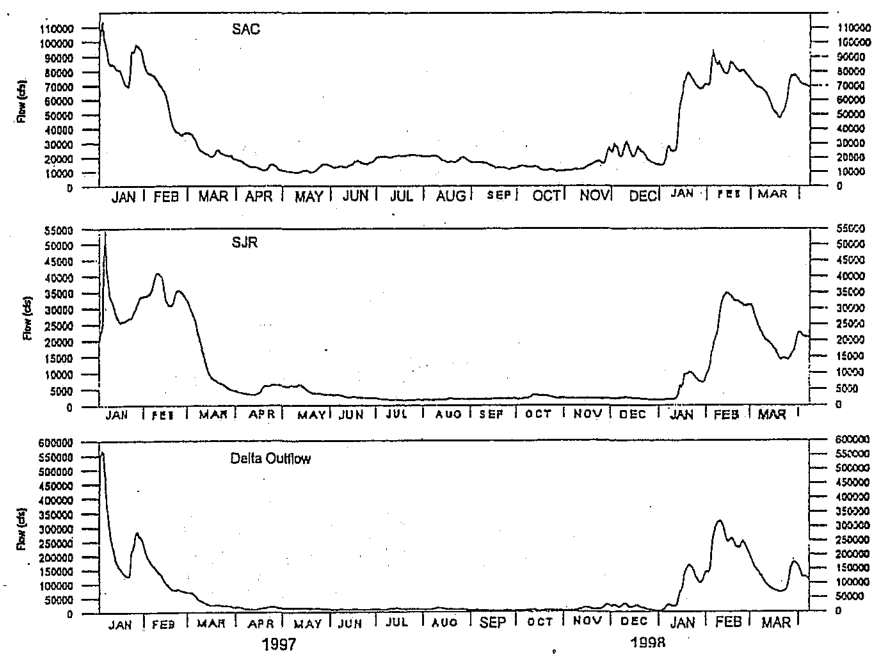


Figure 2-2. Sacramento and San Joaquin Rivers and Delta Outflow for January 1, 1997 through April 7, 1998

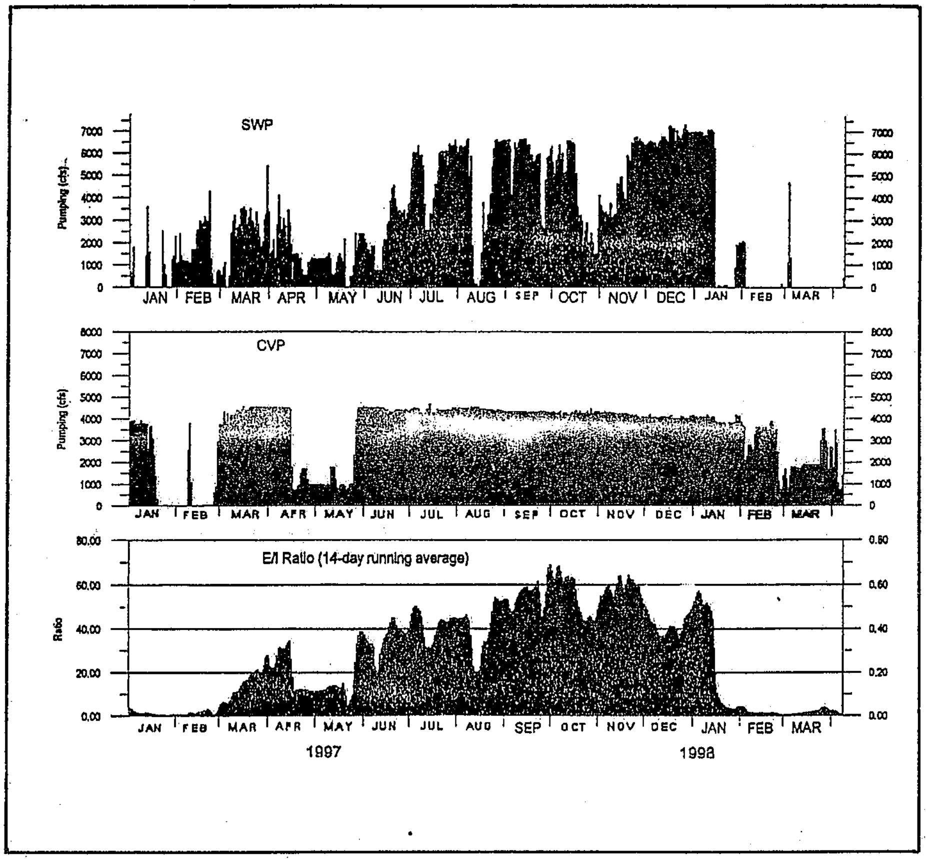


Figure 2-3. SWP, and CVP and 14-Day E/I Ratio for January 1, 1997 through April 7, 1998

Figure 2-4. Delta Inflow, Outflow, and Pumping April – June 1998

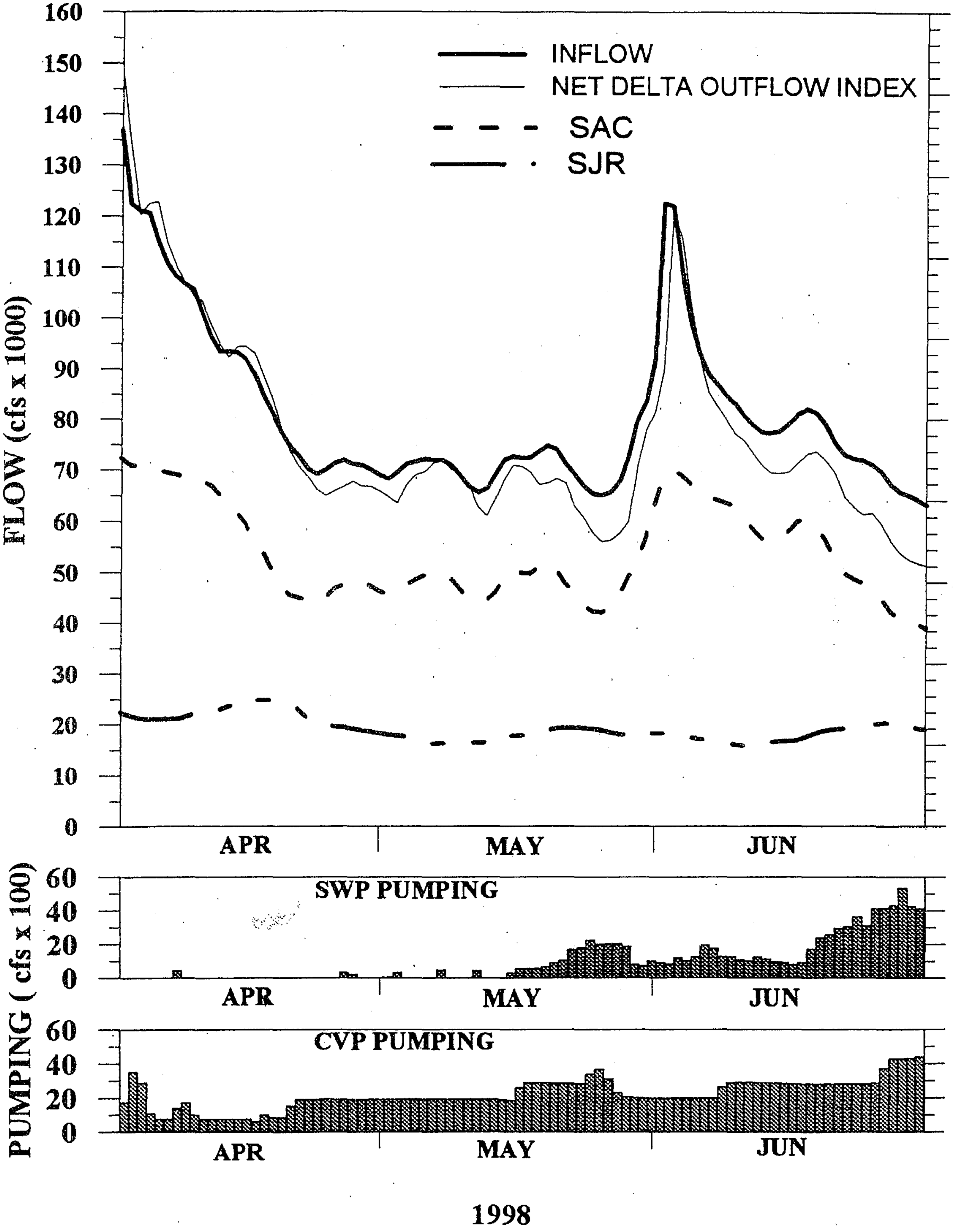
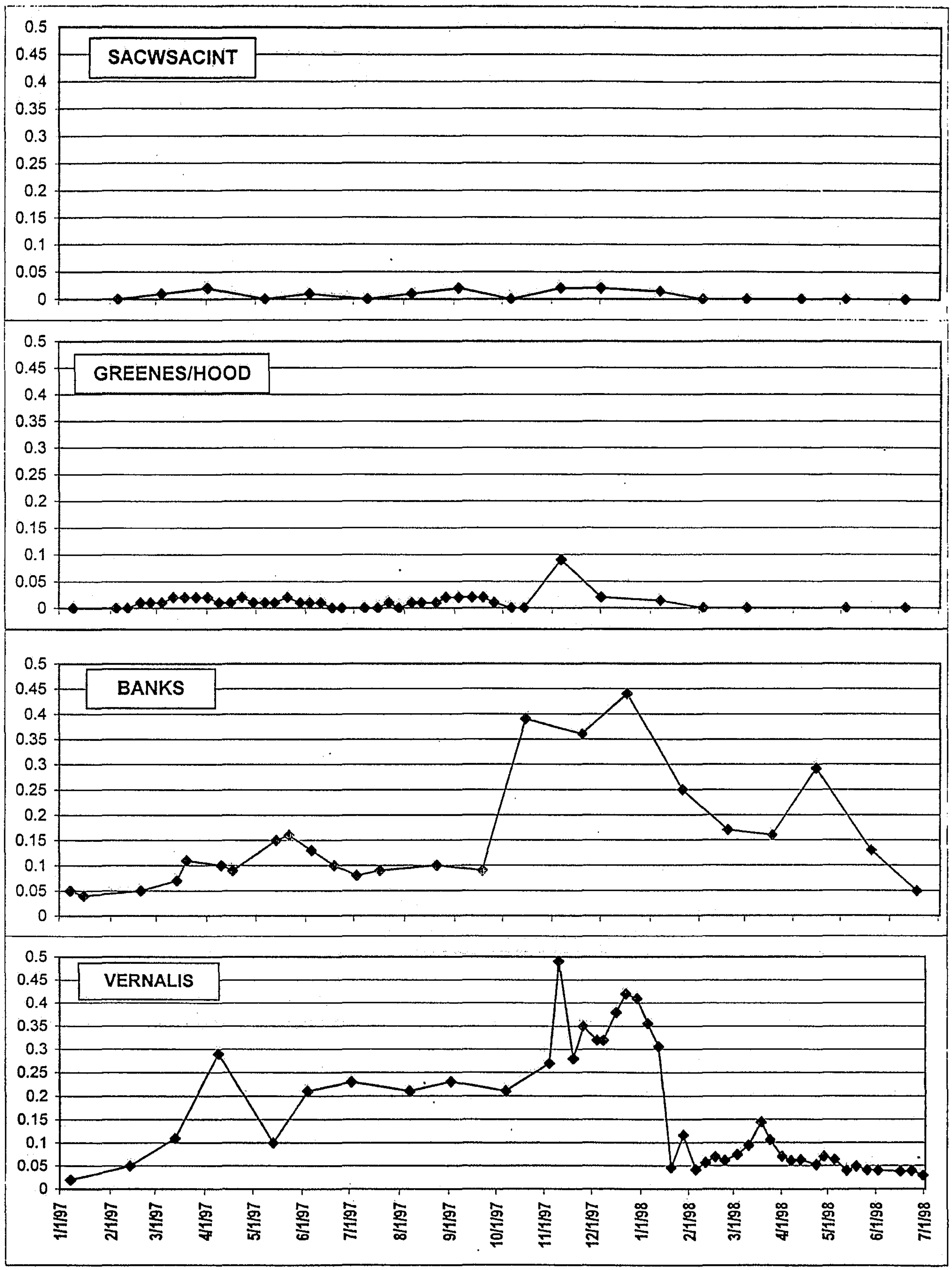


Figure 2-5. Bromide Concentrations Versus Time (mg/L)



Zero values are reported less than the detection limit of 0.01 mg/L.

Figure 2-6. Total Dissolved Solids Concentrations Versus Time (mg/L)

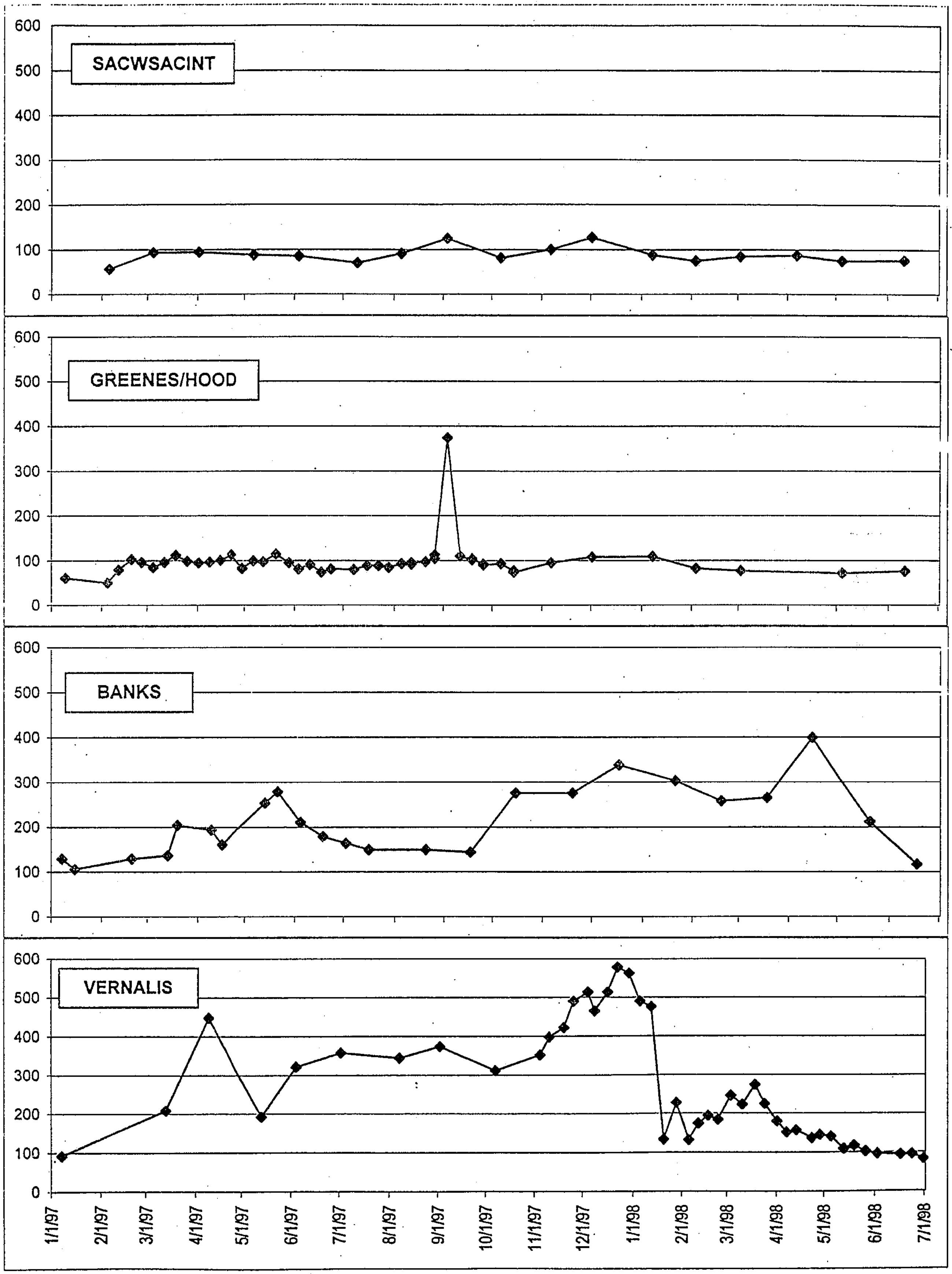


Figure 2-7. Total Organic Carbon Concentrations Versus Time (mg/L as C)

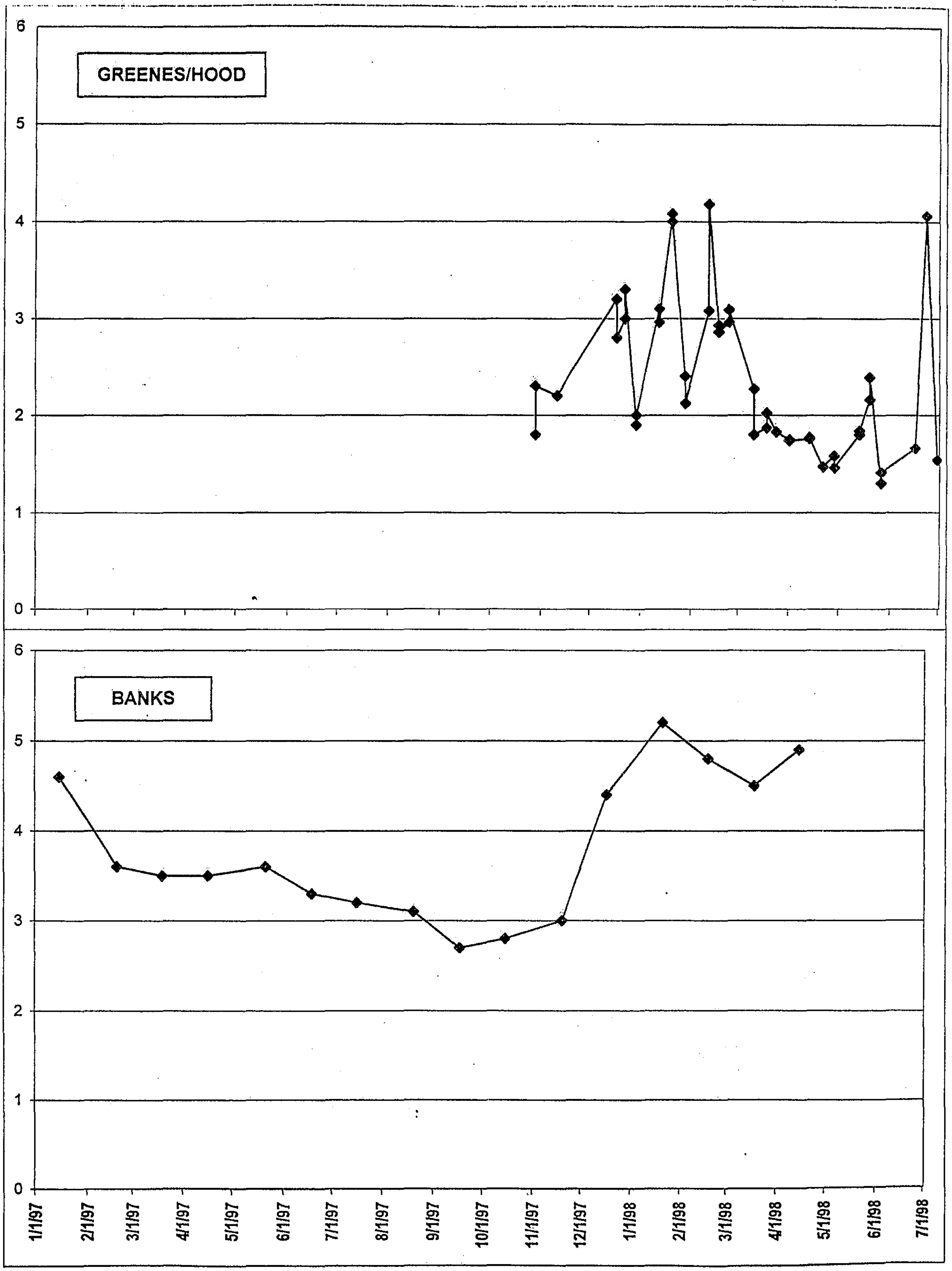


Figure 2-8. Dissolved Organic Carbon Concentrations Versus Time (mg/L as C)

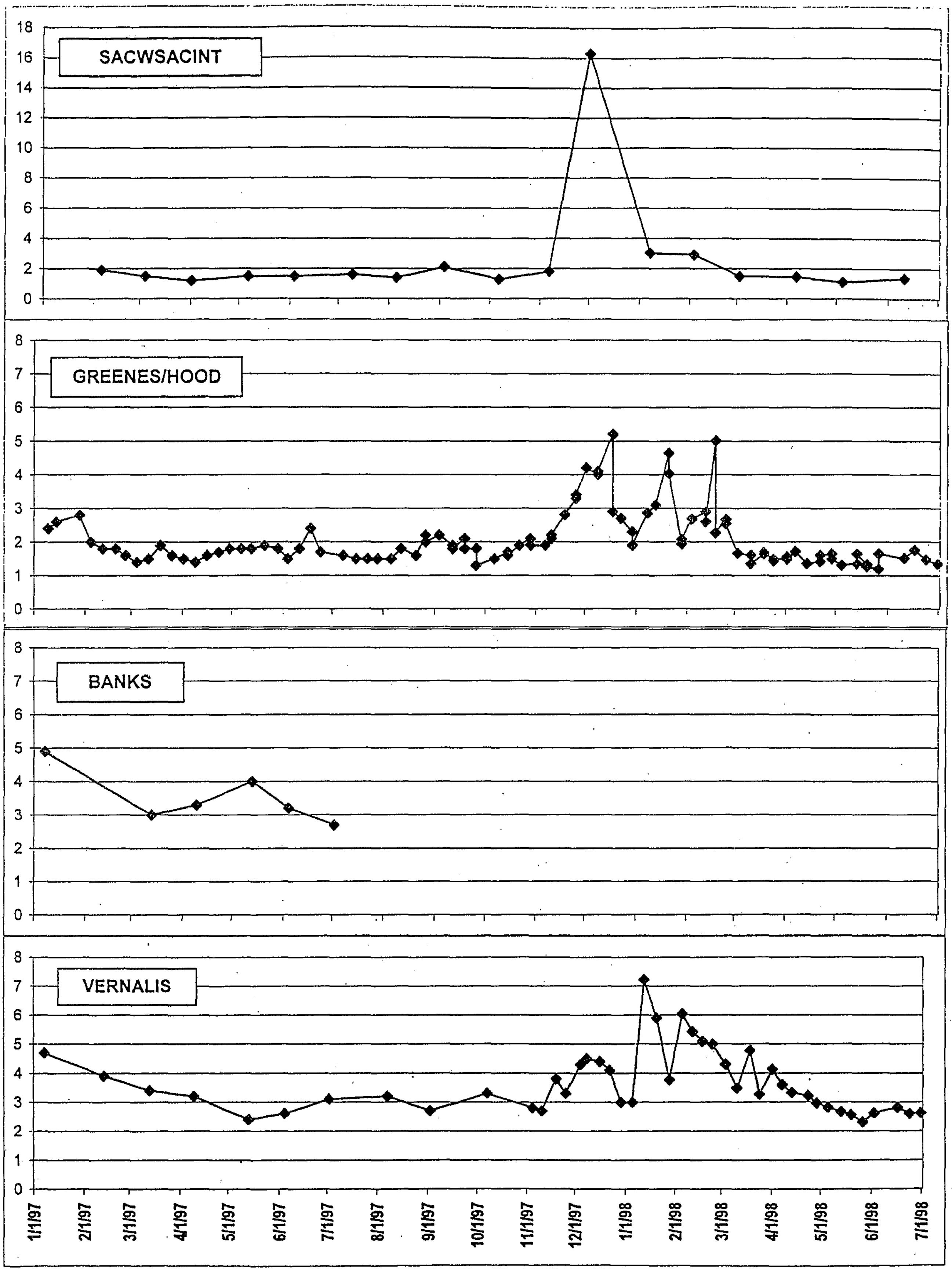
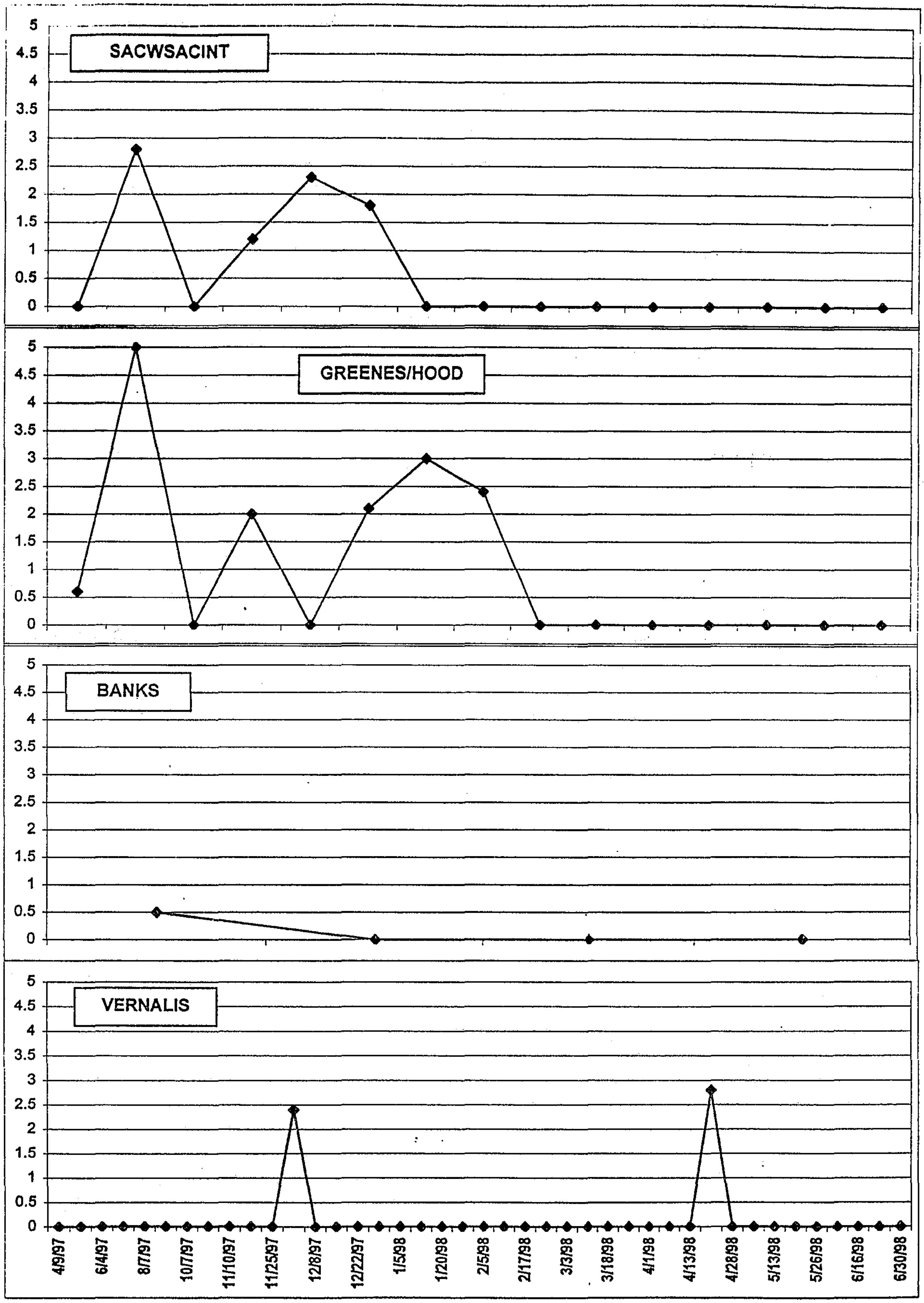


Figure 2-9. Methyl tert-butyl ether (MTBE) Concentrations Versus Time (µg/L)



Zero values are reported less than the detection limit of 1 µg/L.

Figure 2-10. Bromide at Channel Stations (mg/L)

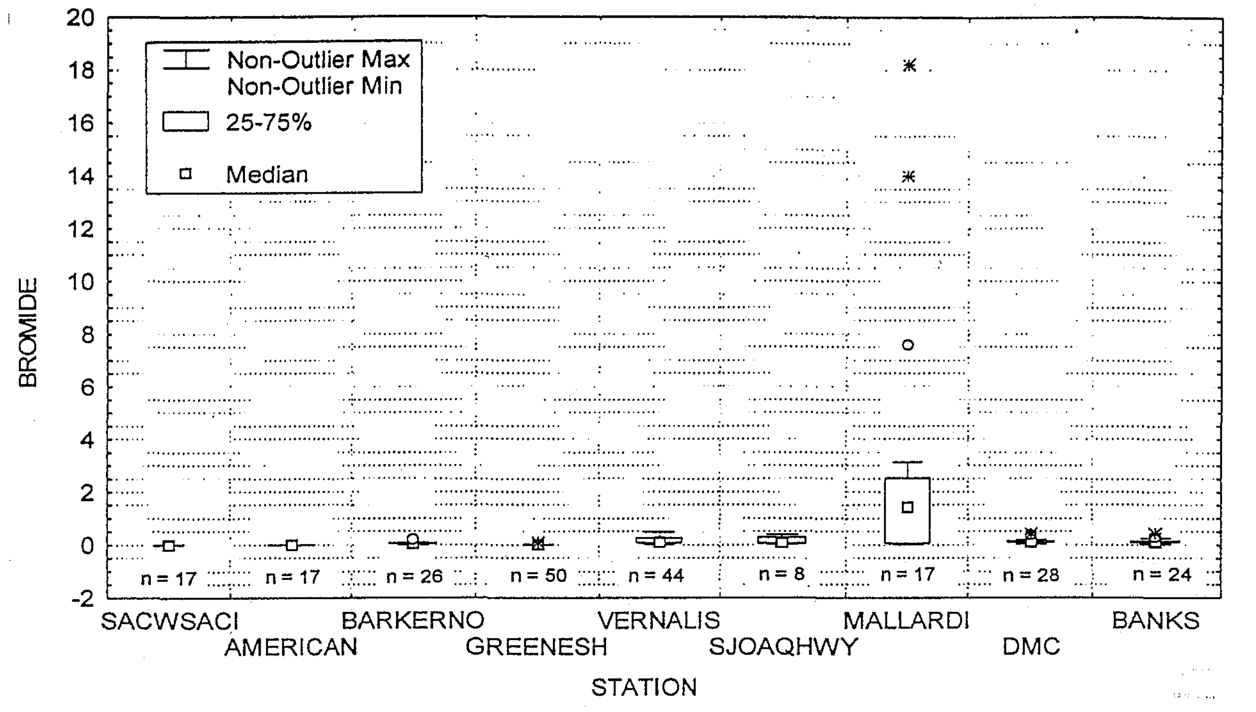
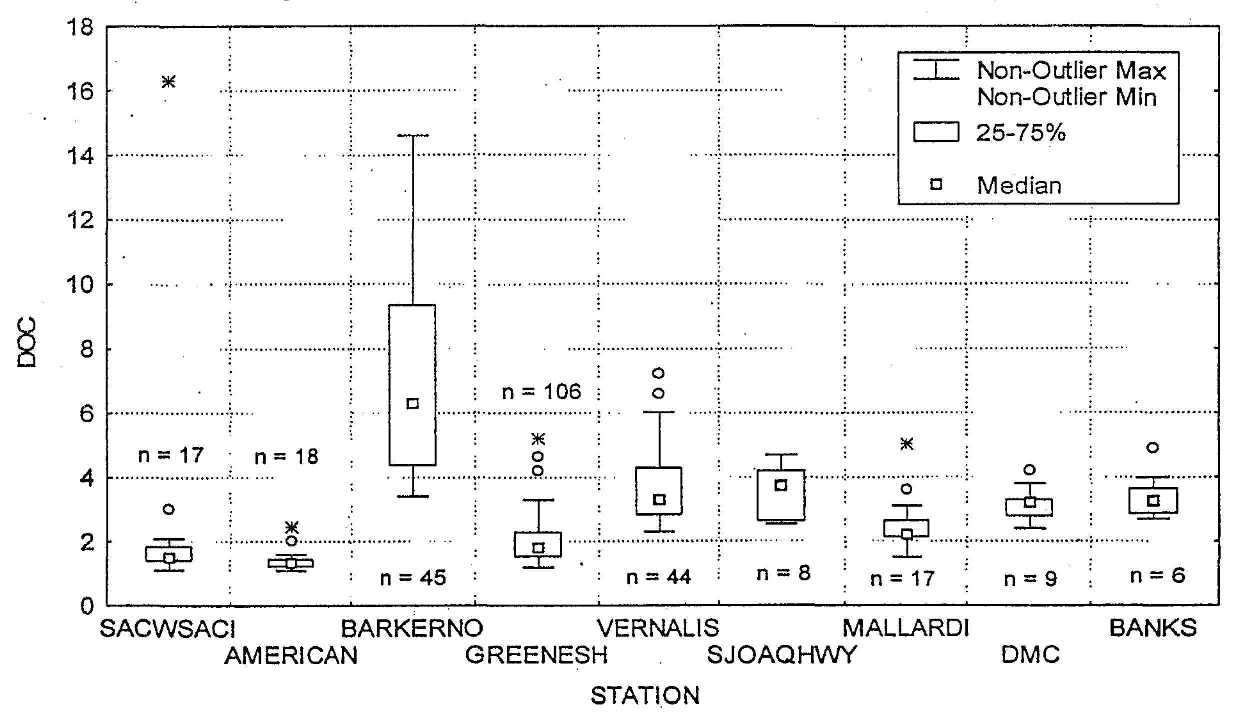
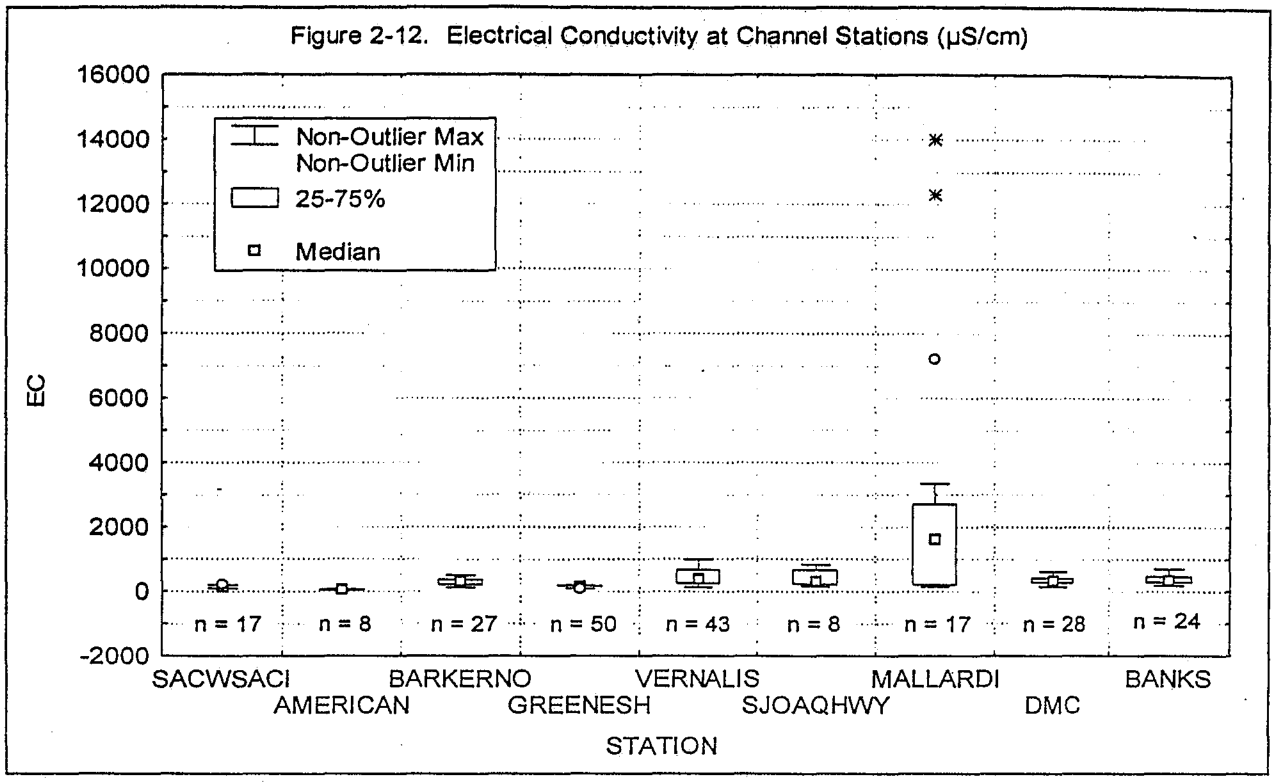
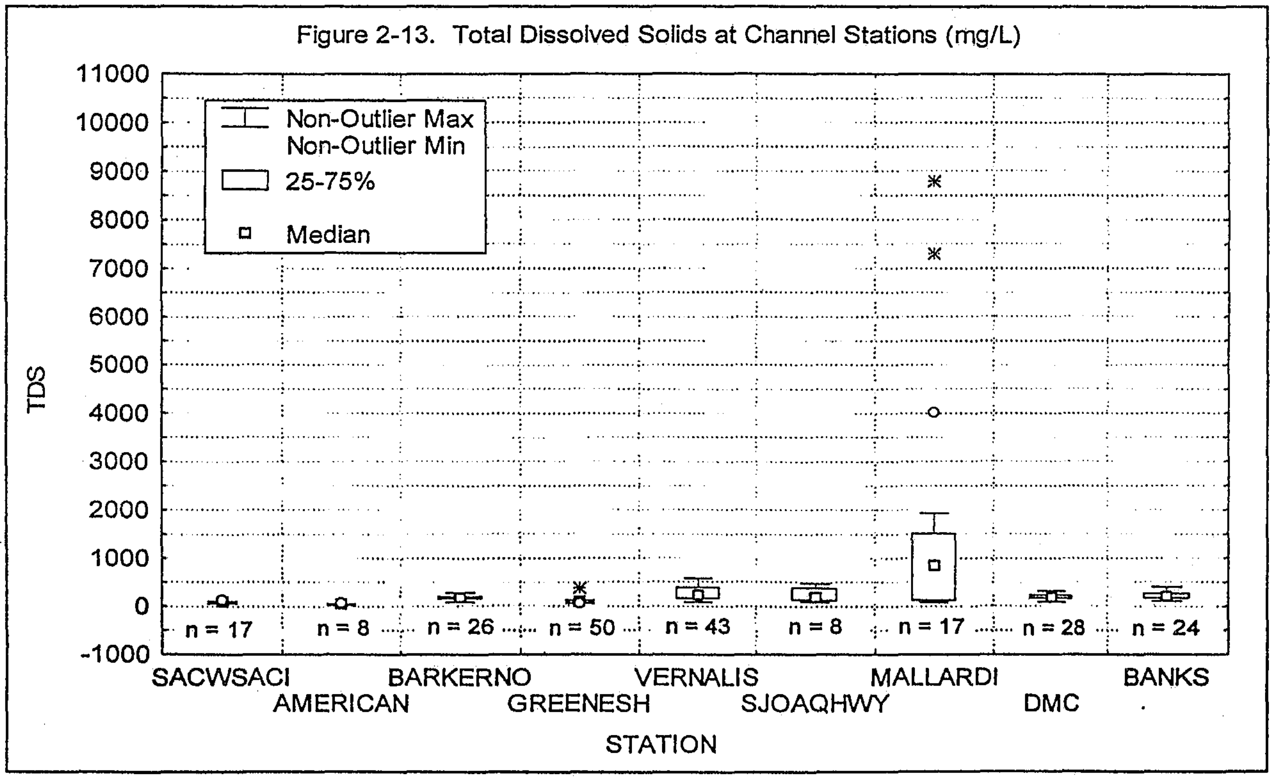


Figure 2-11. Dissolved Organic Carbon at Channel Stations (mg/L)



o = outlier
* = extreme outlier





o = outlier
* = extreme outlier

Figure 2-14. TOC at Channel Stations (mg/L)

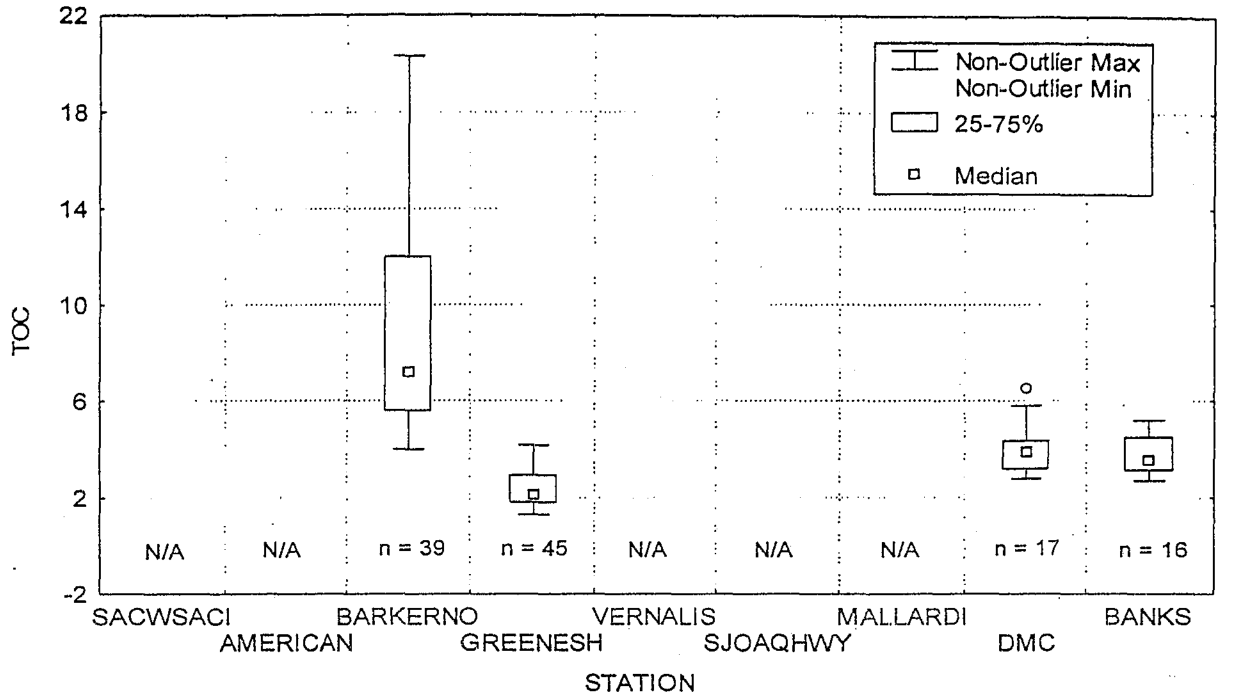
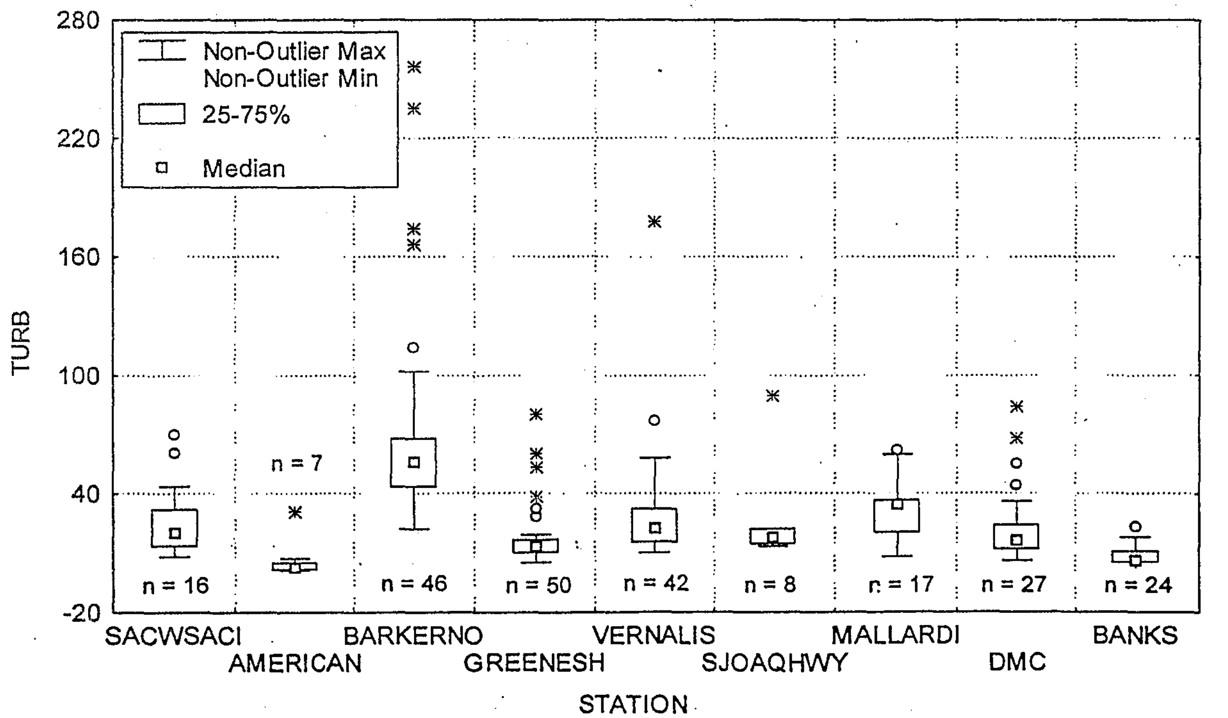


Figure 2-15. Turbidity at Channel Stations (NTU)



o = outlier

* = extreme outlier

Figure 2-16. Bromide at Drain Stations (mg/L)

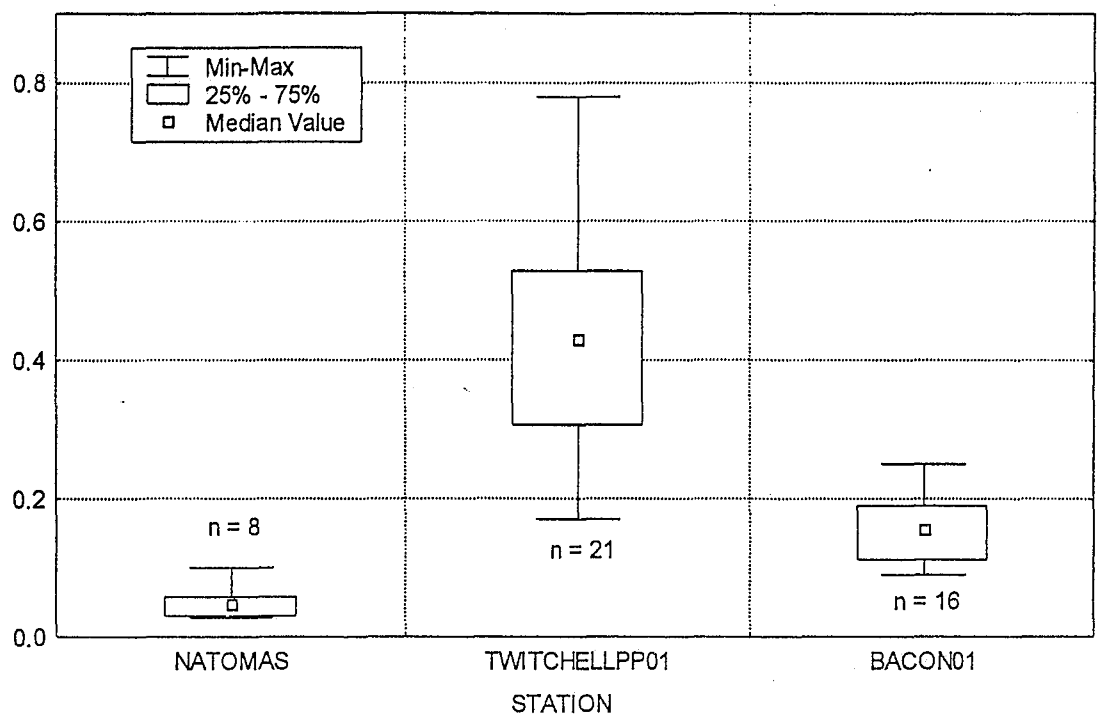
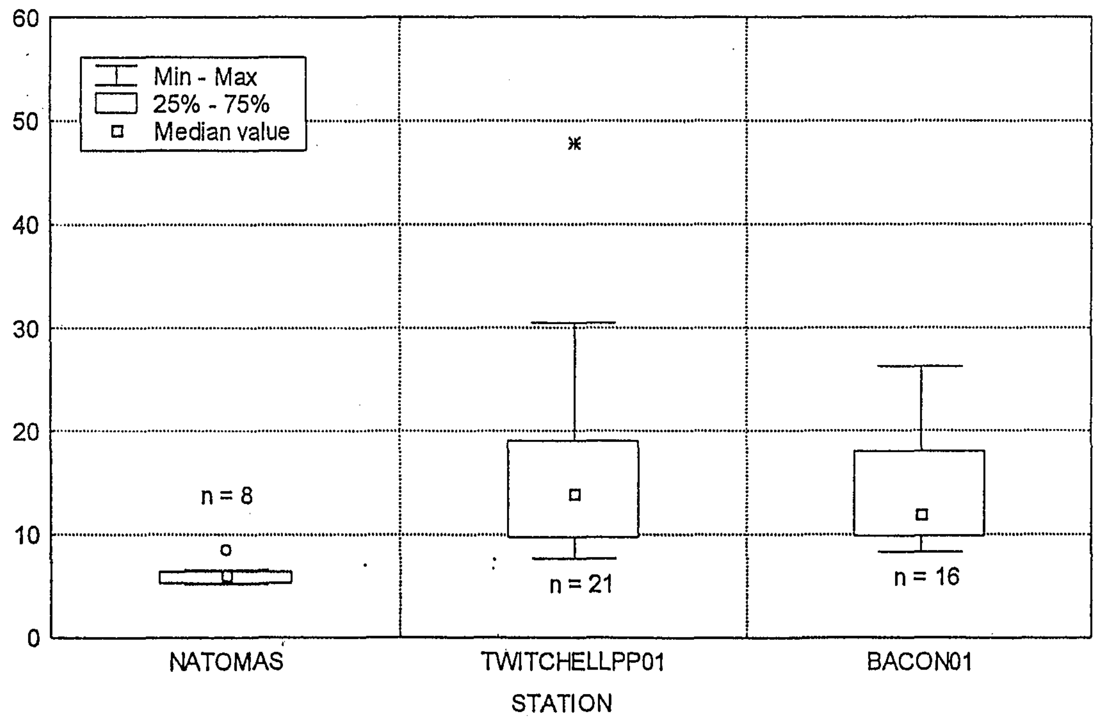


Figure 2-17. Dissolved Organic Carbon at Drain Stations (mg/L)



o = outlier
* = extreme outlier

Figure 2-18. Electrical Conductivity at Drain Stations (µS/cm)

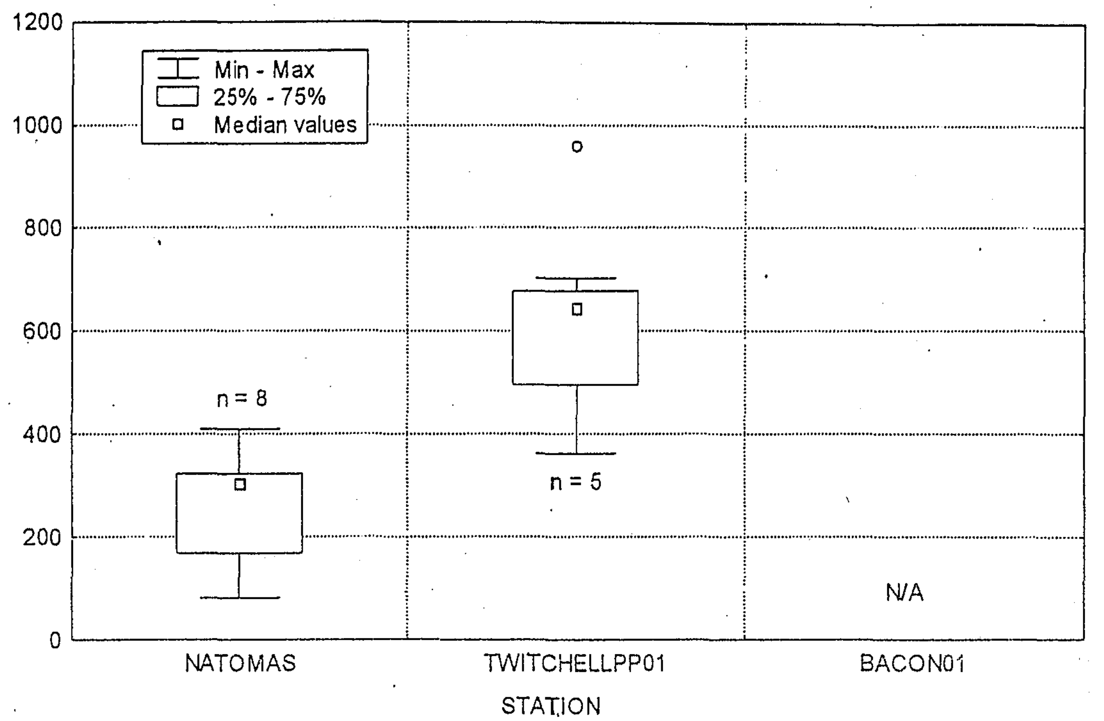
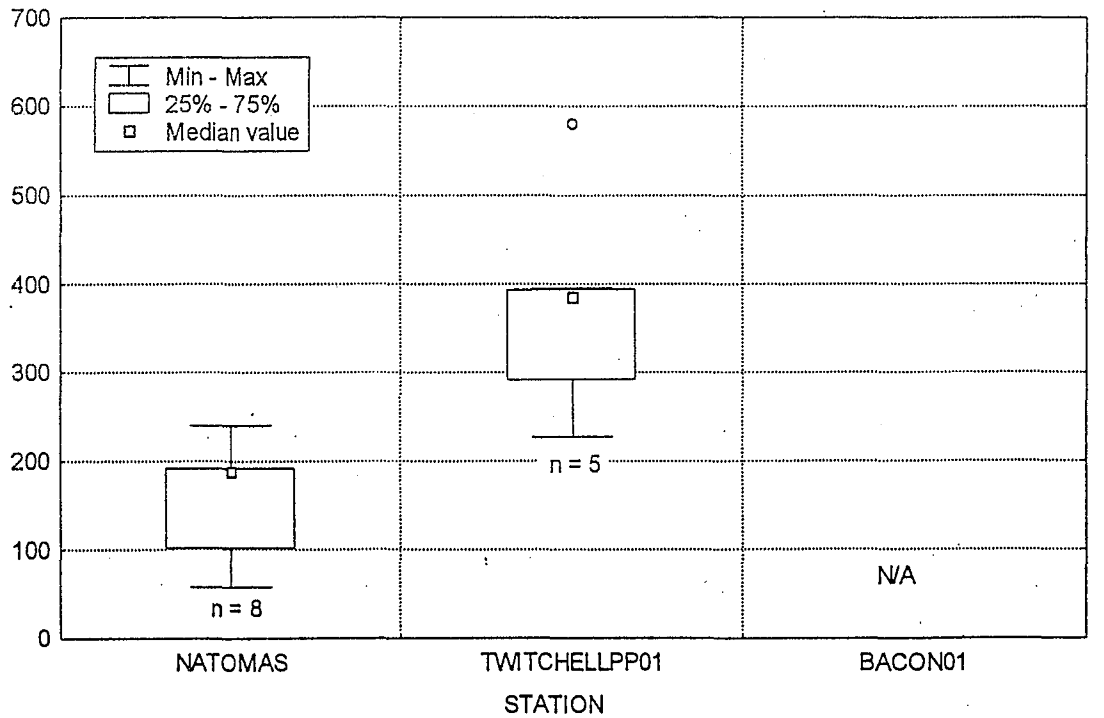
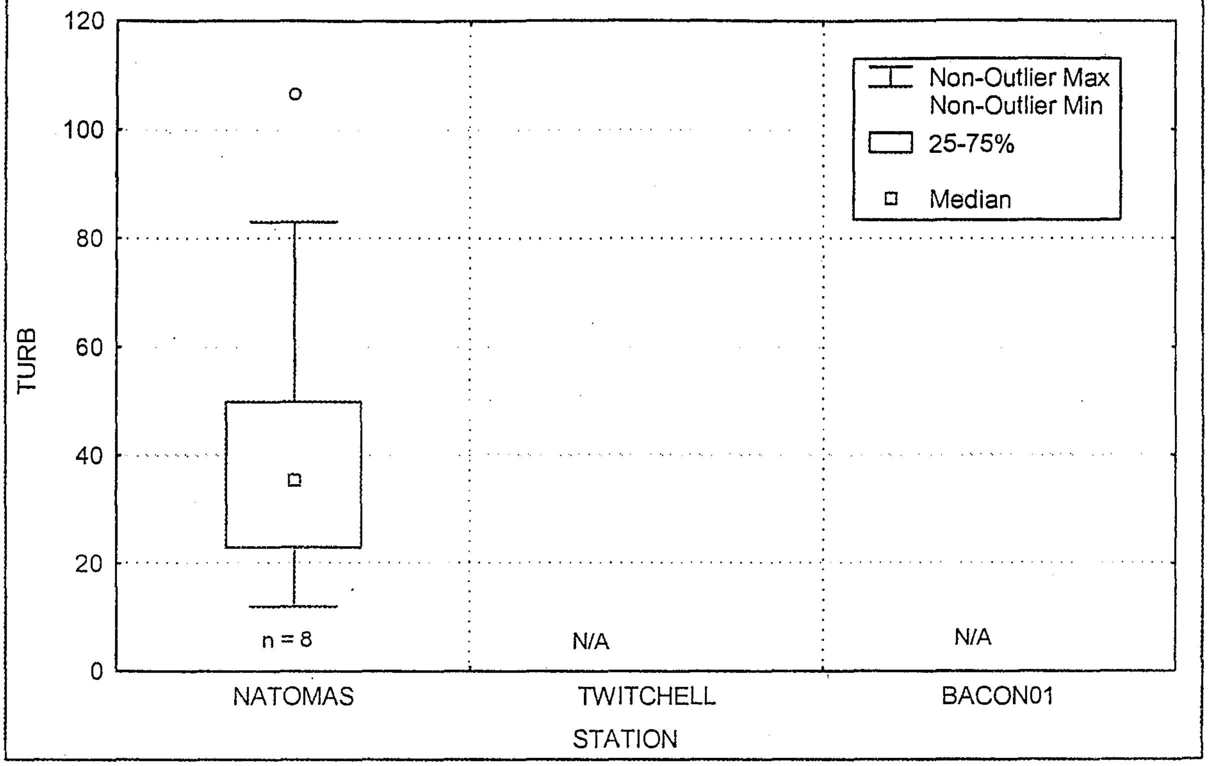


Figure 2-19. Total Dissolved Solids at Drain Stations (mg/L)



o = outlier
* = extreme outlier

Figure 2-20. Turbidity at Drain Stations (NTU)



o = outlier
* = extreme outlier

Chapter 3

Data Quality Review

Purpose: To review MWQI quality control data from January 1997 to December 1998. The review involved comparing data from field and laboratory quality control analytical results against acceptable control limits. Data that fell outside these control limits were flagged.

Background: Some of the 1997 quality control data were in paper format and the quality review was conducted manually. The rest of the data were in electronic format and the data quality review used the DWR Field and Laboratory Information Management System database to flag analyses that were out of control.

The available quality control data indicated that overall the 1997-98 MWQI data were of acceptable quality. A few analyses were outside the control limits, but they were not considered to have significant effect on the data quality. The results of the data quality review are presented in this chapter.

Findings:

Field Duplicates

Field duplicates are replicate samples taken at predetermined stations to evaluate analytical precision. At DWR, it is recommended that at least one duplicate sample be collected per field run. The results of field duplicate analyses are evaluated by calculating relative percent differences and comparing these RPDs with acceptable limits. Approximately 5,200 field duplicate analyses were performed and only 64 (about 1 percent) exceeded the acceptable RPD limits, (see Table 3-2). Thus, the MWQI analytical results were of acceptable precision for this reporting period.

Field Blanks

Field blanks are purified water samples taken to the field and filtered or left unfiltered. Filtered blanks help check for contamination from field sample processing procedures. Unfiltered blanks check for contamination from containers and preservatives. Of the 538 field blanks analyzed during the study period, 18 blanks (3.3 percent) were contaminated (see Table 3-3).

Most of the contaminated blanks were ammonia, a difficult analyte to prevent cross-contamination since it is so prevalent in cleaning products. The contaminations were in low-range concentrations and MWQI field procedures were considered to have acceptable quality controls.

Internal Quality Controls

Internal quality controls are procedures used in the laboratory to ensure that analytical methods are in control. For the internal quality control analyses performed (see Table 3-4). The results indicated that the analyses performed by Bryte Chemical Laboratory were acceptable for accuracy and precision. Check standards monitor the analytical method during the analysis. One check standard is analyzed for every 10 samples.

If the check standard is out of control, the analysis is stopped until the problem is fixed. Of the 1,416 check standards analyzed, none were out of control. Surrogates are compounds similar in analytical behavior to organic compounds of interest. A known amount of surrogate is added to samples, standards and blanks. Surrogate recoveries monitor the analytical performance of the method. All the recoveries were within the control limits.

Sample Holding Times

Holding time is the time during which a sample can be stored after collection and preservation without significantly affecting the accuracy of the analysis. During the 1997-1998 period covered in this report, approximately 6,500 environmental analyses were conducted. Only 17 analyses (approximately 0.3 percent) exceeded the holding time as shown in Table 3-1. These exceedances were not considered significant.

Method Blanks

The purpose of method blanks is to detect and quantify contamination introduced through sample preparation or analysis procedure (some "background noise" is allowed). Out of approximately 3,021 method blanks analyzed, only 33 were contaminated (see Table 3-5). This was about 1 percent of the total, which indicates that laboratory sample contamination was not a problem.

Laboratory Control Samples

Laboratory control samples recoveries are used to assess the accuracy of the analytical method especially when matrix interferences occur in the analyses of the environmental samples. A known concentration of analyte of interest is spiked into a clean medium and analyzed. The results are compared to the laboratory's control limits.

In this study period, 2,992 laboratory control samples analyses were performed (see Table 3-4). Only 16, or approximately 0.5 percent, exceeded the control limits (see Table 3-6). The laboratory analyses were acceptable.

Matrix Spike Recoveries

Matrix spike recoveries indicate the accuracy of recovering a known concentration of substance in the matrix. The results of a matrix spike indicate the accuracy of recovery given the interference peculiarto a given matrix. The percent recovery must fall within acceptable limits.

Approximately 2,221 matrix spike analyses were performed. Of those, 74 analyses or about 3 percent exceeded the control limits (see Table 3-6). This was not considered significant.

Table 3-1: 1997-1998 Holding Time Exceedances

Analyte	Collection Date	Run Name	Sample Number	Holding Time	Limit
Alkalinity	11/25/97	Vern in the Hood	CB1197A1393	21 days	14 days
Alkalinity	12/29/97	Vern in the Hood	CB1297A1545	15 days	14 days
Ammonia, Nitrogen (Dissolved)	11/4/97	South Delta Day 1	CA1197A1516	29 days	28 days
Ammonia, Nitrogen (Dissolved)	11/4/97	South Delta Day 1	CA1197A1514	29 days	28 days
Ammonia, Nitrogen (Dissolved)	11/4/97	South Delta Day 1	CA1197A1512	29 days	28 days
Ammonia, Nitrogen (Dissolved)	11/4/97	South Delta Day 1	CA1197A1511	29 days	28 days
Ammonia, Nitrogen (Dissolved)	11/4/97	South Delta Day 1	CA1197A1515	29 days	28 days
Ammonia, Nitrogen (Dissolved)	11/4/97	South Delta Day 1	CA1197A1517	29 days	28 days
Ammonia, Nitrogen (Dissolved)	11/4/97	South Delta Day 1	CA1197A1518	29 days	28 days
Color	2/13/97	South Delta Day 2	C970082	120 hours	48 hours
Color	2/13/97	South Delta Day 2	C970083	120 hours	48 hours
DWR THMFP Reactivity Test	12/4/97	South Delta Day 1	CA1297A1652	110 days	90 days
Ortho-phosphate (Dissolved)	1/20/98	Vern in the Hood	CB0198A0061	172 hours	48 hours
Ortho-phosphate (Dissolved)	1/20/98	Vern in the Hood	CB0198A0062	172 hours	48 hours
Phosphorus and Nitrogen pesticides	2/13/97	South Delta Day 2	C970084	35 days	7 days
Total Dissolved Solids	12/29/97	Vern in the Hood	CB1297A1545	14 days	7 days

Table 3-2: Field Dupe RPD Exceedances

Analyte	Station Name	Collection Date	Sample	Sample Dupe	RPD	RPD Limit
Bromide	AMERICAN	04/01/97	C0497A0218	C0497A0214	33%	20
Bromide	GREENES	07/09/97	C0797A0601	C0797A0559	39%	20
Bromide	SJOAQHWY4	11/04/97	CA1197A1515	CA1197A1511	35%	20
Bromide	VERNALIS	06/02/98	CB0698A0906	CB0698A0902	30%	20
Bromide	SACRAMENTO R A HOOD	06/10/98	CB0698A0894	CB0698A0893	32%	20
Bromochloroacetic Acid	TWITCHELLPP01	03/03/98	CA0398A0051	CA0398A0050	40%	30
Bromochloroacetic Acid	BACON01	04/06/98	CB0498A0368	CB0498A0364	39%	30
Bromochloroacetic Acid	TWITCHELLPP01	05/05/98	CB0598A0758	CB0598A0757	33%	30
Bromodichloromethane	TWITCHELLPP01	02/06/97	C0297A0042	C0297A0041	41%	30
Bromodichloromethane	GREENES	07/09/97	C0797A0601	C0797A0559	36%	30
Bromodichloromethane	JERSEYPP01	09/02/97	C0997A0735	C0997A0731	32%	30
Bromodichloromethane	TWITCHELLPP01	03/03/98	CA0398A0051	CA0398A0050	33%	30
Bromoform	CONCOSPP1	10/07/97	C1097A0890	C1097A0887	33%	30
Bromoform	TWITCHELLPP01	11/12/97	C1197A1068	C1197A1066	41%	30
Bromoform	TWITCHELLPP01	03/03/98	CA0398A0051	CA0398A0050	30%	30
Chloride	GREENES	07/09/97	C0797A0601	C0797A0559	38%	20
Chloride	SACRAMENTO R A HOOD	06/10/98	CB0698A0894	CB0698A0893	42%	20
Chloroform	JERSEYPP01	09/02/97	C0997A0735	C0997A0731	31%	30
Chloroform	TWITCHELLPP01	11/12/97	C1197A1068	C1197A1066	34%	30
Chloroform	TWITCHELLPP01	03/03/98	CA0398A0051	CA0398A0050	40%	30
Color	JERSEYPP01	09/02/97	C0997A0735	C0997A0731	39%	30?
Conductance (EC)	SACRAMENTO R A HOOD	06/10/98	CB0698A0894	CB0698A0893	22%	15
Dibromoacetic Acid	TWITCHELLPP01	11/12/97	C1197A1070	C1197A1068	35%	30
Dibromoacetic Acid	TWITCHELLPP01	05/05/98	CB0598A0758	CB0598A0757	33%	30
Dibromoacetic Acid	STATION09	08/04/98	CB0898A2659	CB0898A2658	30%	30
Dibromochloromethane	JERSEYPP01	09/02/97	C0997A0735	C0997A0731	30%	30
Dibromochloromethane	CONCOSPP1	10/07/97	C1097A0890	C1097A0887	44%	30
Dibromochloromethane	TWITCHELLPP01	11/12/97	C1197A1068	C1197A1066	33%	30
Dibromochloromethane	TWITCHELLPP01	03/03/98	CA0398A0051	CA0398A0050	30%	30
Dichloroacetic Acid	TWITCHELLPP01	11/12/97	C1197A1068	C1197A1066	35%	30
Dichloroacetic Acid	TWITCHELLPP01	03/03/98	CA0398A0051	CA0398A0050	35%	30
Dichloroacetic Acid	TWITCHELLPP01	05/05/98	CB0598A0758	CB0598A0757	34%	30
Dissolved Ammonia	CONCOSPP1	11/05/97	CB1197A1371	CB1197A1368	39%	20
Dissolved Boron	STATION09	03/05/97	C0397A0140	C0397A0139	49%	25
Dissolved Boron	GREENES	10/06/97	CA1097A1277	CA1097A1274	45%	25
Dissolved Nitrate	SJRMOSSDALE	01/07/97	C0197A2451	C0197A2450	41%	20
Dissolved Nitrate	GREENES	07/09/97	C0797A0601	C0797A0559	29%	20
Dissolved Nitrate	SACRAMENTO R A HOOD	06/10/98	CB0698A0894	CB0698A0893	48%	20
Dissolved Nitrite + Nitrate	TWITCHELLPP01	11/12/97	C1197A1068	C1197A1066	46%	20
Dissolved Potassium	SACRAMENTO R A HOOD	06/10/98	CB0698A0894	CB0698A0893	35%	25
Hardness	SACRAMENTO R A HOOD	11/03/98	CB1198A3841	CB1198A3840	48%	15
Methyl tert-butyl ether	MIDDLER	06/03/97	C0697A0442	C0697A0440	23%	20
Methyl tert-butyl ether	VERNALIS	04/23/98	CB0498A0483	CB0498A0480	24%	20
Monobromoacetic Acid	TWITCHELLPP01	10/01/97	C1097A0405	C1097A0390	33%	30
Monobromoacetic Acid	TWITCHELLPP01	11/12/97	C1197A1068	C1197A1066	33%	30
Monobromoacetic Acid	TWITCHELLPP01	05/05/98	CB0598A0758	CB0598A0757	33%	30
Monobromoacetic Acid	TWITCHELLPP01	11/12/97	C1197A1068	C1197A1066	33%	30
Monobromoacetic Acid	TWITCHELLPP01	05/05/98	CB0598A0758	CB0598A0757	33%	30
Nitrate	SJOAQHWY4	11/04/97	CA1197A1515	CA1197A1511	50%	20
Total Alkalinity	TWITCHELLPP01	11/12/97	C1197A1068	C1197A1066	27%	15
Total Alkalinity	OLDRivPPCCWD	06/01/98	CB0698A0922	CB0698A0923	48%	15
Total Dissolved Solids	TWITCHELLPP01	11/12/97	C1197A1068	C1197A1066	22%	15
Total Dissolved Solids	VERNALIS	11/17/98	CB1198A3874	CB1198A3873	50%	15
Total Dissolved Solids	SACRAMENTO R A HOOD	11/23/98	CB1198A3890	CB1198A3888	49%	15
Trichloroacetic Acid	BANKS	04/09/97	C0497A0249	C0497A0245	14%	30
Trichloroacetic Acid	TWITCHELLPP01	11/12/97	C1197A1068	C1197A1066	34%	30
Trichloroacetic Acid	TWITCHELLPP01	03/03/98	CA0398A0051	CA0398A0050	38%	30
Trichloroacetic Acid	TWITCHELLPP01	05/05/98	CB0598A0758	CB0598A0757	34%	30
Turbidity	GREENES	02/25/97	C0297A0105	C0297A0103	49%	15
UV Absorbance @254nm	OLDRIVBACISL	06/23/97	C0697A0521	C0697A0519	14%	10
UV Absorbance @254nm	GREENES	07/09/97	C0797A0601	C0797A0559	15%	10
UV Absorbance @254nm	TWITCHELLPP01	08/19/97	C0897A0631	C0897A0629	28%	10
UV Absorbance @254nm	SACRAMENTO R A HOOD	06/10/98	CB0698A0894	CB0698A0893	26%	10

Table 3-3: Field Blank Exceedances

Analyte	Sample Description	Date	Run Name	Sample Number	Result	Limit	Units
Dissolved Ammonia	UNFILT NUTRIENT BLK	2/3/98	North Delta Day 1	CA0298A1772	0.05	0.01	mg/L as N
Dissolved Ammonia	FILT.NUTRIENT BLK	2/5/98	North Delta Day 2	CA0298A1806	0.04	0.01	mg/L as N
Dissolved Ammonia	UNFILT NUTRIENT BLK	3/2/98	North Delta Day 1	CA0398A0037	0.02	0.01	mg/L as N
Dissolved Ammonia	UNFILT NUTRIENT BLK	3/18/98	Vern in the Hood	CA0398A0071	0.02	0.01	mg/L as N
Dissolved Ammonia	FILT.NUTRIENT BLK	11/4/97	South Delta Day 1	CA1197A1518	0.16	0.01	mg/L as N
Dissolved Ammonia	UNFILT NUTRIENT BLK	4/7/98	North Delta Day 2	CB0498A0396	0.03	0.01	mg/L as N
Dissolved Ammonia	FILT.NUTRIENT BLK	4/23/98	Vern in the Hood	CB0498A0485	0.06	0.01	mg/L as N
Dissolved Ammonia	FILT.NUTRIENT BLK	5/4/98	South Delta Day 1	CB0598A0756	0.04	0.01	mg/L as N
Dissolved Ammonia	FILT.NUTRIENT BLK	6/1/98	South Delta Day 1	CB0698A0928	0.03	0.01	mg/L as N
Dissolved Ammonia	UNFILT NUTRIENT BLK	7/8/98	North Delta Day 2	CB0798A2039	0.02	0.01	mg/L as N
Dissolved Ammonia	UNFILT NUTRIENT BLK	8/11/98	Vern/Hood Run	CB0898A2552	0.02	0.01	mg/L as N
Dissolved Ammonia	UNFILT NUTRIENT BLK	8/25/98	Vern/Hood Run	CB0898A2566	0.03	0.01	mg/L as N
Dissolved Ammonia	FILT.NUTRIENT BLK	11/6/97	North Delta Day 1	CB1197A1366	0.02	0.01	mg/L as N
Dissolved Ammonia	UNFILT NUTRIENT BLK	12/1/97	North Delta Day 1	CB1297A1502	0.02	0.01	mg/L as N
Dissolved Copper	UNFILT NUTRIENT BLK	3/24/98	Vern in the Hood	CA0398A0081	0.002	0.001	mg/L
Dissolved Copper	FILT.NUTRIENT BLK	3/24/98	Vern in the Hood	CA0398A0082	0.005	0.001	mg/L
Dissolved Copper	Filtered Blank-Metal	4/6/98	North Delta Day 1	CB0498A0345	0.002	0.001	mg/L
Dissolved Copper	FILTERED BLANK-METAL	4/7/98	North Delta Day 2	CB0498A0399	0.003	0.001	mg/L

Table 3-4: 1997-98 Internal QC Summary

Analyte	Method Name	Method Blank	Check Standard	RPD: Check Standard	LCS Recovery	RPD: LCS	Matrix Spike Recovery	RPD Matrix Spike	Surrogate Recovery
1,1,1,2-Tetrachloroethane	EPA 502.2	20					32		146
1,1,1-Trichloroethane	EPA 502.2	20					32		146
1,1,2,2-Tetrachloroethane	EPA 502.2	20					32		146
1,1,2-Trichloroethane	EPA 502.2	20					32		146
1,1-Dichloroethane	EPA 502.2	20					32		146
1,1-Dichloroethene	EPA 502.2	20					60	14	142
1,1-Dichloropropene	EPA 502.2	20					32		146
1,2,3-Trichlorobenzene	EPA 502.2	20					32		146
1,2,3-Trichloropropane	EPA 502.2	20					32		142
1,2,4-Trichlorobenzene	EPA 502.2	20					32		142
1,2,4-Trimethylbenzene	EPA 502.2	20					32		146
1,2-Dibromo-3-chloropropane	EPA 502.2	20					32		146
1,2-Dibromoethane	EPA 502.2	20					32		146
1,2-Dichlorobenzene	EPA 502.2	20					40	6	146
1,2-Dichloroethane	EPA 502.2	20					32		146
1,2-Dichloropropane	EPA 502.2	20					32		146
1,3,5-Trimethylbenzene	EPA 502.2	20					32		146
1,3-Dichlorobenzene	EPA 502.2	20					40	6	146
1,3-Dichloropropane	EPA 502.2	20					32		146
1,4-Dichlorobenzene	EPA 502.2	20					40	6	146
1-Chloro-2-Fluorobenzene	EPA 502.2	35							
2,2-Dichloropropane	EPA 502.2	20					32		146
2,3-Dibromoproprionic Acid	DWR HAAFP (Reactivity)				14		14		55
2-Bromo-1-chloropropane	DWR THMFP (Buffered)	18	6		64		24	12	164
2-Bromo-1-chloropropane	DWR THMFP (Reactivity)	38	9				18	8	130
2-Chlorotoluene	EPA 502.2	20					32		146
4-Chlorotoluene	EPA 502.2	20					32		146
4-Isopropyltoluene	EPA 502.2	20					32		146
Alkalinity	Std Method 2320 B	38	108	49	100	65	181	107	
Aluminum	EPA 200.8 (D)	15	12	6	87	66	104	81	
Ammonia	EPA 350.1	50			76	58	68	53	
Arsenic	EPA 200.8 (D)	26	12	6	90	73	110	88	
Arsenic	EPA 206.3 (D)	1			38	37	4	2	
Barium	EPA 200.8 (D)	7	8	4	14	7	64	52	
Benzene	EPA 502.2	20					68	20	146
Boron	EPA 200.7 (D)	88	108	34	139	90	112	112	
Bromide	EPA 300.0	121	44		171	126	244	139	
Bromobenzene	EPA 502.2	20					32		146
Bromochloroacetic Acid (BCAA)	DWR HAAFP (Reactivity)	7			14	7	90	7	509
Bromochloromethane	EPA 502.2	20					32		146
Bromodichloromethane	DWR THMFP (Buffered)	30	12		64	64	154	66	544
Bromodichloromethane	DWR THMFP (Reactivity)	47	9				96	9	548
Bromodichloromethane	EPA 502.2	20					32		140
Bromoform	DWR THMFP (Buffered)	30	12		64	64	154	66	541
Bromoform	DWR THMFP (Reactivity)	47	9				96	9	551
Bromoform	EPA 502.2	20					32		144
Bromomethane	EPA 502.2	20					32		146
Cadmium	EPA 200.8 (D)	7	8	4	70	7	68	65	
Calcium	EPA 200.7 (D)	77	112	34	119	78	118	118	
Carbon tetrachloride	EPA 502.2	20					32		146
Chloride	EPA 325.2	97	46		147	100	368	133	
Chlorobenzene	EPA 502.2	20					68	20	146
Chloroethane	EPA 502.2	20					32		146
Chloroform	DWR THMFP (Buffered)	30	12		64	64	154	66	544
Chloroform	DWR THMFP (Reactivity)	47	9				96	9	548
Chloroform	EPA 502.2	20					32		140
Chloromethane	EPA 502.2	20					32		146
Chromium	EPA 200.8 (D)	10	8	4	20	66	30	69	
Conductance (EC)	Std Method 2510-B	32	88	44			43	42	
Copper	EPA 200.8 (D)	16	14	7	32	77	105	27	
Dibromoacetic Acid (DBAA)	DWR HAAFP (Reactivity)	7			14	7	90	7	509

Analyte	Method Name	Method Blank	Check Standard	RPD: Check Standard	LCS Recovery	RPD: LCS	Matrix Spike Recovery	RPD Matrix Spike	Surrogate Recovery
Dibromochloromethane	DWR THMFP (Buffered)	30	12		64	64	154	66	541
Dibromochloromethane	DWR THMFP (Reactivity)	47	9				96	9	548
Dibromochloromethane	EPA 502.2	20					32		146
Dibromomethane	EPA 502.2	20					32		146
Dichloroacetic Acid (DCAA)	DWR HAAFP (Reactivity)	7			14	7	90	7	509
Dichlorodifluoromethane	EPA 502.2	20					32		146
Dissolved Alkalinity	Std Method 2320 B						8		
Dissolved Aluminum	EPA 200.8 (D)						64		
Dissolved Ammonia	EPA 350.1						72		
Dissolved Arsenic	EPA 200.8 (D)						74		
Dissolved Beryllium	EPA 200.8 (D)						4		
Dissolved Boron	EPA 200.7 (D)						152		
Dissolved Cadmium	EPA 200.8 (D)						4		
Dissolved Calcium	EPA 200.7 (D)						152		
Dissolved Chromium	EPA 200.8 (D)						4		
Dissolved Copper	EPA 200.8 (D)						74		
Dissolved Iron	EPA 200.8 (D)						64		
Dissolved Lead	EPA 200.8 (D)						4		
Dissolved Magnesium	EPA 200.7 (D)	20					152		
Dissolved Manganese	EPA 200.8 (D)						64		
Dissolved Nickel	EPA 200.8 (D)						4		
Dissolved Nitrate	EPA 300.0						16		
Dissolved Nitrate	Std Method 4500-						104		
Dissolved Nitrite + Nitrate	Std Method 4500-						2		
Dissolved Organic Carbon	EPA 415.1 (D)	3			3	3	3		
Dissolved Potassium	EPA 200.7 (D)						150		
Dissolved Selenium	EPA 270.3 (D)						59		
Dissolved Silver	EPA 200.8 (D)						4		
Dissolved Sodium	EPA 200.7 (D)						156		
Dissolved Solids	Std Method 2540-C								
Dissolved Sulfate	EPA 375.2						142		
Dissolved Thallium	EPA 200.8 (D)						4		
Dissolved Zinc	EPA 200.8 (D)						4		
Ethyl benzene	EPA 502.2	20					40	6	146
Fluorobenzene	EPA 502.2	2					78		445
Hexachlorobutadiene	EPA 502.2	20					32		146
Iron	EPA 200.8 (D)	15	12	6	110	91	140	113	
Isopropylbenzene	EPA 502.2	20					32		146
Lead	EPA 200.8 (D)	10	8	4	58	47	69	54	
Magnesium	EPA 200.7 (D)	57	112	34	119	78	162	101	
Manganese	EPA 200.8 (D)	15	12	6	108	94	142	113	
Methyl tert-butyl ether (MTBE)	EPA 502.2	39					154	41	554
Methylene chloride	EPA 502.2	20					32		146
Monobromoacetic Acid (MBAA)	DWR HAAFP (Reactivity)	7			14	7	90	7	509
Monochloroacetic Acid (MCAA)	DWR HAAFP (Reactivity)	7			14	7	90	7	505
Naphthalene	EPA 502.2	20					32		146
Nitrate	EPA 300.0	28	8		99	93	106	92	
Nitrate	Std Method 4500-	73	33		66	33	70	76	
Nitrite + Nitrate	Std Method 4500-	1					2	1	
Organic Carbon	EPA 415.1 (D)	47	105	49	100	44			
Organic Carbon	EPA 415.1 (T)	39	78	38	78	39			
Ortho-phosphate	Std Method 4500-P, F	1			2	1	28		
Potassium	EPA 200.7 (D)	77	113	34	119	79	145	48	
Selenium	EPA 200.8 (D)	1			53	52	64	3	
Selenium	EPA 270.3 (D)	16			20	10	40	20	
Silica (SiO2)	EPA 200.7 (D)	8	16	5	12	6	12	6	
Silver	EPA 200.8 (D)	15	8	4	33	26	43	31	
Sodium	EPA 200.7 (D)	77	108	34	119	78	162	101	
Solids	Std Method 2540-C	42	84	42	39				
Styrene	EPA 502.2	20					32		146
Sulfate	EPA 375.2	94	44		86	97	127	140	
Tetrachloroethene	EPA 502.2	20					40	6	146
Toluene	EPA 502.2	20					68	20	146

Analyte	Method Name	Method Blank	Check Standard	RPD: Check Standard	LCS Recovery	RPD: LCS	Matrix Spike Recovery	RPD Matrix Spike	Surrogate Recovery
Total Alkalinity	Std Method 2320 B						136		
Total Dissolved Solids	Std Method 2540-C	33				39	40	41	
Total Organic Carbon	EPA 415.1 (T)					67			
Total Selenium	EPA 270.3 (D)						4		
Trichloroacetic Acid (TCAA)	DWR HAAFP (Reactivity)	7			14	7	90	7	509
Trichloroethene	EPA 502.2	20					68	20	146
Trichlorofluoromethane	EPA 502.2	20					32		146
Turbidity	EPA 180.1	45			90	45			
UV Absorbance @254nm	Std Method 5910B	41			82	41			
Vinyl chloride	EPA 502.2	20					32		146
Zinc	EPA 200.8 (D)	10	8	4	75	10	30	15	
cis-1,2-Dichloroethene	EPA 502.2	20					32		146
cis-1,3-Dichloropropene	EPA 502.2	20					32		146
m + p Xylene	EPA 502.2	14							
m-Xylene	EPA 502.2	6					32		146
n-Butylbenzene	EPA 502.2	20					32		146
n-Propylbenzene	EPA 502.2	20					32		146
o-Xylene	EPA 502.2	20					32		146
p-Xylene	EPA 502.2	6					32		146
pH	Std Method 5910B								
sec-Butylbenzene	EPA 502.2	20					32		146
tert-Butylbenzene	EPA 502.2	20					32		146
trans-1,2-Dichloroethene	EPA 502.2	20					32		146
trans-1,3-Dichloropropene	EPA 502.2	20					32		146
Total		**3,021**	**1,416**	**452**	**2,992**	**2221**	**8,641**	**2,570**	**17,497**

Table 3-5: Method Blank Exceedances

Analyte	Method	Method Blank
Chloroform	DWR THMFP (Buffered)	12
Chloroform	DWR THMFP (Reactivity)	9
Fluorobenzene	EPA 502.2	2
Organic Carbon	EPA 415.1 (D)	5
Organic Carbon	EPA 415.1 (T)	5

Table 3-6: Laboratory Control Samples and Matrix Spike Recoveries

Analyte	Method Name	LCS Recovery	Matrix Spike
Alkalinity	Std Method 2320 B		11
Aluminum	EPA 200.9	3	3
Ammonia	EPA 350.1		7
Antimony	EPA 200.8	1	2
Arsenic	EPA 200.8		1
Barium	EPA 200.8		2
BCAA	DWR HAAFP (reactivity)		1
Beryllium	EPA 200.8	1	
Bromoform	DWR THMFP (Buffered)		2
Bromoform	DWR THMFP (Reactivity)		5
Chloride	EPA 325.2		2
DCAA	DWR HAAFP (reactivity)		1
Dibromochloromethane	DWR THMFP (Reactivity)		1
Dissolved orthophosphate	Std methods 4500-P, F		1
Iron	EPA 200.8	2	5
Lead	EPA 200.8	2	
Magnesium	EPA 200.8		3
Nitrite	Std methods 1500-NO_2		1
Potassium	EPA 200.7 (D)	5	1
Selenium	EPA 270.3 (D)		2
Silica (SiO2)	EPA 200.7 (D)		3
Silver	EPA 200.8 (D)		4
Sodium	EPA 200.7		1
Strontium	EPA 200.8		2
Sulfate	EPA 375.2	1	6
Total Kjedahl Nitrogen	EPA 375.2		1
Trichloroacetic Acid (TCAA)	DWR HAAFP (Reactivity)		6
Zinc	EPA 200.8	1	
Total		**16**	**74**

Chapter

4

Spiked Matrix Recovery Study

Purpose: To determine the performance of the EPA's Information Collection Rule Protozoan Method in the ambient waters sampled, and to determine if the method's performance was consistent throughout the Project area.

Background: The Project area covered a distance of approximately 600 miles from the most northern sampling site at Alamar on the Sacramento River to Lake Perris, the terminal reservoir on the eastern branch of the California Aqueduct.

The Coordinated Pathogen Monitoring Program was intended to link and augment the pathogen monitoring programs of the Metropolitan Water District of Southern California, the Department of Water Resources, Operations & Maintenance, and the Division of Planning and Local Assistance Municipal Water Quality Investigations Program, and the EPA's Information Collection Rule monitoring study. The EPA's Information Collection Rule methods for *Giardia/Cryptosporidium* were used for this study. Determining the accuracy of this methodology was important to compare results by utilities using State Water Project water and was a requirement to participate in the ICR study using this protozoan method. Changes in the physical and chemical nature of the water may occur as the water travels this distance. This includes passage through the open channel California Aqueduct and several SWP reservoirs, tunnels, pipes, pumps, and electric power-generating turbines. In addition, water from the reservoirs' watersheds is added to Aqueduct water. By conducting the split matrix spike recovery study using matrix water from the Project area, any gross changes in the performance of the method in the water matrix may be detected.

Methods: The Project area was sampled at five points along the SWP system and its source waters. In order to sample a range of turbidities and water matrices, matrix water was collected from the American River (a component of the Sacramento River flow), which has relatively low turbidity. The turbidities at the other four sampling locations were generally higher than that of the American River and represented the range of turbidity and matrix variability encountered throughout the project area during any time interval.

The field protocol used to conduct the study incorporates the following elements:

1. Matrix water of sufficient volume for two ICR protozoan samples (200+ liters) was collected in a polyethylene container, spiked with a certified number of *Giardia* cysts and *Cryptosporidium* oocysts, and kept well mixed using mechanical and manual mixing devices during filtering.

2. Spike concentrations were 3,656 *Giardia* cysts and 4,480 *Cryptosporidium* oocysts in 200+ liters of matrix water. The formalin inactivated spike cysts and oocysts were obtained from ERA Labs in premeasured amounts.

3. Matrix water was maintained at <22°C to avoid spontaneous lysing of the oocysts, which occurs at approximately 30°C.

4. Two split samples were filtered according to ICR specifications by drawing a single stream of spiked and well mixed matrix water from the sampling container in through a single intake opening, which was then split and sent to two identically configured ICR filter assemblies arranged in parallel.

5. The sampling equipment was thoroughly cleaned using the field cleaning procedures in the EPA ICR manual prior to performing the next matrix spike split. An additional detergent wash was added to the ICR procedure before the bleach rinse of the equipment as specified in the ICR manual.

6. Blank split samples were collected using deionized water with the equipment used for the split samples to determine if spike cysts or oocysts were carried over from one split spiked sample set to another.

7. A standard filtered ICR protozoan sample was taken at the time of collection of the matrix water in order to determine the background concentrations of *Giardia* and *Cryptosporidium* in the matrix water.

As shown in Table 4-1, the recovery of spiked cysts and oocysts was much less than the minimum recovery expected by the EPA for the ICR Study. The range of recoveries for the *Giardia* splits was <10 -158 cysts/100 liters, with an average recovery for all split samples of 46.3 cysts/100 liters (2.53 percent). In one instance cysts were detected in the background sample with no cysts detected in one of the spiked samples. The background levels for the matrix water are included for reference, as is the standard deviation in parentheses in Table 4-2.

The recovery results for the *Cryptosporidium* splits are also shown in Table 4-1, and were much less than the EPA expected minimum recovery for the ICR Study. The range of recoveries for the *Cryptosporidium* splits was <4.5 - 24 oocysts/ 100 L, with an average recovery for all split samples of 7.75 oocysts/ 100 L (0.35 percent); 5 of 10 spiked samples had no oocysts detected. The background levels for the matrix water are included for reference in Table 4-2, as is the standard deviation in parentheses.

Table 4-1 Coordinated Pathogen Monitoring Program Split Matrix Spike Results	*GIARDIA* Recovery 1,828 cysts/spike		*Cryptosporidium* Recovery 2,240 oocysts/spike		TURBIDITY
Matrix Water Source	cysts/100 L	% recovered	oocysts/100 L	% recovered	NTU
American River @ Fairbarn					2.6
Split Sample 1	5.0	0.27	<5	0	
Split Sample 2	6.7	0.37	<6.7	0	
Background	<6.7		<6.7		
San Joaquin River @ Vernalis					21.5
Split Sample 1	<10	0	<10	0	
Split Sample 2	33.7	1.84	<11.1	0	
Background	10		<10		
Banks at Bethany Reservoir					8.6
Split Sample 1	36	1.96	24	1.07	
Split Sample 2	45.5	2.50	22.6	1.01	
Background	<4.5		<4.5		
Devil Canyon					4.8
Split Sample 1	16.7	0.91	<8.3	0	
Split Sample 2	104.2	5.7	8.3	0.37	
Background	<6.3		<6.3		
California Aqueduct at Check 29					10.8
Split Sample 1	158	8.66	8.3	0.37	
Split Sample 2	57.1	3.12	14.3	0.64	
Background	<8.4		<8.4		
All Samples Average Recovery (SD_{n-1})[1]	46.3 (50)	2.53 (2.74)	7.75 (9.59)	0.35 (0.43)	
Positive Samples Only Average Recovery (SD_{n-1})[1]	51.5 (50.2)	2.81 (2.75)	15.5 (7.55)	0.69 (0.34)	

1 Standard Deviation with n-1 degrees of freedom

Equipment Blanks

Equipment blanks were conducted using 80 liters of distilled water, sending 40 liters to each filter apparatus. The equipment blanks were performed with the parallel sampling devices and all other equipment used to conduct the split matrix spike procedure. These blanks were run after three split matrix spike samples were filtered and before the final two split matrix spike samples were filtered. The results for both splits were non-detect (see Table 4-2) and indicate that no detectable spiked cysts or oocysts were carried over from one split matrix spike sample to another.

Table 4-2
Coordinated Pathogen Monitoring Program Split Matrix Spike Equipment Blank Results

Sample Type	*GIARDIA*	*Cryptosporidium*	TURBIDITY
	cysts/100L	oocysts/100L	NTU
Equipment Blank			<1
Sample 1	<2.7	<2.7	
Sample 2	<2.7	<2.7	

These results demonstrate that method performance is generally consistent with all water matrices obtained from the Coordinated Pathogen Monitoring Program sites. The low recoveries for both protozoa, the large standard deviations, with the 50 percent non-detects for *Cryptosporidium* in spiked samples are indicative of the performance concerns related to the use of this method and of the difficulties in interpreting the results obtained.

A detection limit goal of 10 cysts or oocysts per 100 L was specified and achieved for all but one of the 10 split matrix spike samples and achieved or approached for most samples throughout the Coordinated Pathogen Monitoring Program Study. A detection limit of 10 cysts or less does not necessarily indicate that any cysts were actually detected in the spiked matrix. Any value where the "< " sign is present, indicates the detection limit was calculated without the presence of any cysts. When no cysts are present, the detection limit is based on a calculation using only various water quality parameters of the sample.

Running additional slides did not affect the ability of the ICR method to detect either the approximately 1,100 *Cryptosporidium* oocysts or 900 *Giardia* cysts spiked per sample (100 liters). Analyzing more of the sample by interpreting additional slides (five-slide maximum) to achieve a lower detection limit should increase the chance of detecting the protozoa if they are present.

The calculated detection limit did not appear to indicate the actual performance of the method when recovery was low.

In the absence of other information in the waters analyzed, the results obtained in this split spiked matrix study should be considered as an estimate of its performance when interpreting the overall results of the Coordinated Pathogen Monitoring Program Study. It should be noted that the analyzing laboratory for all Coordinated Pathogen Monitoring Program samples had achieved and maintained EPA ICR approval to participate in and analyze samples for the ICR Study through analysis of ICR supplied monthly performance evaluation samples. As with any other ICR protozoan approved laboratory, at this time, the results provided by this laboratory have been accepted for the purposes of the ICR Study.

Direct Filter Spike Study

In January 1996, the MWQI staff conducted a performance evaluation study using two laboratories and two protozoan methods. BioVir and MWDSC Laboratories used the August 1995 version of the EPA ICR method, and only BioVir used a flow cytometry method. The cysts and oocysts were spiked directly onto the yarn wound filter, and matrix waters of three turbidities were added to the container with the filter and submitted to the analyzing laboratories, with the results shown in Table 4-3. The wastewater matrix was obtained from a wastewater treatment plant and was included in this study to estimate the methods performance with water matrices of this type. Effluents from wastewater treatment plants are a source of protozoa.

By spiking the filters with the cysts and oocysts, any loss due to the spike passing through the filter was eliminated. As with the ICR Study, a detection limit was not specified. The spike cysts and oocysts were provided by Clancy Environmental Consultants (St. Albans, Vermont).

With the exception of the BioVir results for *Giardia,* which had good recoveries for the ICR Protozoan Method, other recoveries were similar to those seen in the split spiked matrix recovery study discussed previously, with only a small fraction of the spiked cysts and oocysts recovered. Recoveries for *Cryptosporidium* were consistently less than those for *Giardia*, with one sample having no spiked oocysts detected.

Table 4-3
Direct Filter Spike Study[1]

GIARDIA	Cysts Seeded 2928 ± 447					
Matrix	MWD (8/95 Information Collection Rule)		BioVir (8/95 Information Collection Rule)		BioVir (Flow Cytometry)	
NTU	cysts/100L	%	cysts/100L	%	cysts/100L	%
60	350	11.9	1,266.7	43.3	233.3	7.97
10	232	7.92	1,220	41.7	110	3.76
Wastewater	90.4	3.09	1,733.3	59.2	166.7	5.69
CRYPTO	Oocysts Seeded 5532 ± 880					
Matrix	MWD (8/95 Information Collection Rule)		BioVir (8/95 Information Collection Rule)		BioVir (Flow Cytometry)	
NTU	oocysts/100L	%	oocysts/100L	%	oocysts/100L	%
60	440	7.97	33.3	0.60	166.67	3.01
10	200	3.6	<10	0	120	2.12
Wastewater	142.5	2.58	50	0.90	116.7	2.1

1 Municipal Water Quality Investigations Program, Annual Report, Water Year 1995. August 1996. Department of Water Resources, Division of Local Assistance.

References

EPA 1996c, 1996d, 1997; Butler and Mayfield 1996; LeChevallier and Norton 1995; Jakubowski and others 1995.

Chapter 5

Coordinated Pathogen Monitoring Program

Purpose: To address the potential threat to human health by microbial contaminants, including *Giardia lamblia* and *Cryptosporidium parvum* in State Water Project waters. This project was designed to augment data that was collected by the microbiological monitoring required by the EPA's Information Collection Rule, which also included *Giardia* and *Cryptosporidium*. The Sanitary Survey Action Committee provided Coordinated Pathogen Monitoring Program review. Metropolitan Water District of Southern California provided a workshop for all agencies participating in the study to ensure sampling consistency, with technical support as needed throughout the study.

Background: The *California State Water Project Sanitary Survey Update Report 1996* recommended that the microbiological safety of SWP source waters be comprehensively evaluated, and monitoring be coordinated with municipal SWP contractors to make data collected by the contracting agencies comparable to data collected from within the SWP system and its source waters by the Coordinated Pathogen Monitoring Program.
The project design incorporated monthly samples and storm event samples. Sampling was conducted over 18 months in two phases. After the first 12 months of sampling, the number of sampling stations was reduced. Sampling for the last six months of the study concentrated on locations having the greatest detection frequency, which included the more northern SWP stations, the Sacramento River, the San Joaquin River, and Delta sampling locations. Flood event sampling was added to the storm event monitoring as a result of the January 1997 floods. DWR's Division of Planning and Local Assistance conducted sampling at source water locations; DWR's O&M sampled at locations within the SWP; and MWDSC sampled at Castaic and Silverwood Lakes. Kern County Water Agency assisted with sampling at the Check 29 sampling location.

Monitoring Locations

Monthly samples were collected at locations listed in Table 5-1. Event sampling was conducted at the sites listed in Table 5-2. MWDSC conducted monthly sampling at Castaic and Silverwood Lakes from the intakes for the Jensen and Mills Water Treatment Plants, respectively, and at Devil Canyon. The source water for these plants at the time of sampling consisted of 100 percent SWP water.

Table 5-1. Monthly Monitoring Sites

Sampling Site	Sampled by:
Sacramento River at Bryte Bend, at the marina (Alamar)	DPLA
Sacramento River above Sacramento Regional Wastewater Treatment Plant and below confluence with American River at the Miller Park dock (Miller)	DPLA
Sacramento River below Sacramento Regional Wastewater Treatment Plant at Greene's Landing	DPLA
San Joaquin River at Vernalis at the Airport Road bridge	DPLA
San Joaquin River[1] at Holt Road	DPLA
Banks Pumping Plant[2] at Bethany Reservoir	O&M
Delta-Mendota Canal at McCabe Road	O&M
Arroyo Valle Creek Inflow to Lake Del Valle (when flowing, approximately 5 months/year), at the creek mouth	O&M
California Aqueduct at Check 29	KCWA/O&M
Pyramid Lake at the tower in Elderberry Forebay, release from Elderberry Forebay to Castaic	O&M
Castaic Lake influent to Jensen Water Treatment Plant	MWDSC
Silverwood Lake, influent at Mills Water Treatment Plant or Devil Canyon	MWDSC
Lake Perris at the outlet tower	O&M
Barker Slough Pumping Plant, North Bay Aqueduct Intake	O&M

[1] Samples are taken downstream of the Stockton Publicly Owned Treatment Works outfall at or shortly after the midpoint of an ebb tide at the sampling site to ensure flow toward the Delta.

[2] Sample collected at the inlet to Bethany Reservoir just downstream from Banks Pumping Plant.

Table 5-2 Event-Based Monitoring Sites

Sampling Site	Sampled by:
Sacramento River at Bryte Bend, at the marina	DPLA
Sacramento River above Sacramento Regional Wastewater Treatment Plant and below confluence with American River, at Miller Park dock	DPLA
San Joaquin River at Vernalis, at the Airport Road bridge	DPLA
Banks Pumping Plant at Bethany Reservoir	O&M
Clifton Court at the West Canal intake near radial gates	O&M
Delta-Mendota Canal at McCabe Road	O&M
Arroyo Valle Creek Inflow to Lake Del Valle, near the creek mouth	O&M
California Aqueduct, Check 29 [1]	KCWA/O&M
Pyramid Lake at the Piru Creek gauging station	O&M
Castaic Lake at Elderberry Forebay [2]	O&M
Silverwood Lake [3]	O&M
Barker Slough Pumping Plant	O&M
Mokelumne River at New Hope [4]	O&M
Shag Slough at Liberty Island Bridge [4]	DPLA
Kern River Intertie just prior to confluence with the California Aqueduct [4]	O&M
California Aqueduct at MI 241.02 just upstream of the Kern River Intertie [4]	O&M

[1] Inflow to the San Luis Reach of the California Aqueduct from Cantua and Salt Creeks may be used as a storm event-monitoring trigger for this site.

[2] a. Fish Creek and Castaic Creek confluence at the lowest debris basin above Elderberry Forebay
b. Fish Creek - if no water in debris basin
c. Castaic Creek
d. Elizabeth arm of lake at the gauging station

[3] a. Miller Canyon gauging station
b. Cleghorn drainage
c. Sawpit

[4] Flood event related sites.

Findings: The results of the 248 samples collected and analyzed for these sampling programs are included in this discussion. The highly variable and poor recovery of both protozoa make it impossible to compare actual numbers between locations (see *Chapter 4 Spiked Matrix Recovery Study*). All results are combined to represent ranges and summary statistics for the entire study. Percent positives for monthly and event sampling are presented for each site for both protozoans. Because of the poor recovery, non-detects within the specific site results should be weighed very carefully. In reality, large numbers of cysts or oocysts may have been present during sampling.

Analytical Methods

The EPA's ICR methods for *Giardia* and *Cryptosporidium* were used for this study. All *Giardia* and *Cryptosporidium* results discussed are based on total immunofluorescence antibody counts. The total immunofluorescence antibody count is the sum of the empty, amorphous structure, and internal structure counts which results from analysis of the protozoan sample using the ICR method. The total count includes structures which are known to be nonviable and is intended to account for all structures which could be classified as cysts and oocysts according to the ICR method protocol and represents a conservative use of the data.

The EPA ICR protozoan method has several performance characteristics, which should be considered when interpreting results. It is widely recognized as being tedious and difficult to run, with poor recovery, precision and accuracy; characteristics that were evident in this study. The method is not intended to determine either the viability or infectivity of cysts or oocysts.

Summary: The summary results for *Giardia* and *Cryptosporidium* are shown in Table 5-3, with results from the LeChevallier and Norton (1995) and MWDSC (1993) studies. All *Giardia* and *Cryptosporidium* results in this report are reported as total immunofluorescence antibody counts, which represents a conservative use of the data.

Table 5-3 *Giardia* and *Cryptosporidium* Summary Statistics for Phase I (Total IFA count)

Study		*Giardia* (Cysts/100L)			*Cryptosporidium* (Oocysts/100L)			
		Number Positive	Range	Geo. Mean	Number Positive	Range	Geo. Mean	N
CPMP Monthly	Phase I[a]	22% (35 of 158)	2.4 - 92.3	16.6	4% (6 of 158)	9.0 - 26.7	18.0	158
	Phase II[b]	30% (11 of 37)	2.5 - 62.8	15.6	3% (1 of 37)	13.3	N/A	37
	Combined	24% (46 of 195)	2.4 - 92.3	16.4	4% (7 of 195)	9.0 - 26.7	17.2	195
CPMP Program Event	Phase I	33% (9 of 27)	10.05 - 129.8	58.9	30% (8 of 27)	4.4 - 200	35.0	27
	Phase II	35% (9 of 26)	10 - 140	28.5	19% (5 of 26)	10 - 50	22.6	26
	Combined	34% (18 of 53)	10 - 140	40.9	24% (13 of 53)	4.4 - 200	29.6	53
CPMP Combined	Phase I	24% (44 of 185)	2.4 - 129.8	21.5	8% (14 of 185)	4.4 - 200	26.3	185
	Phase II	32% (20 of 63)	2.5 - 140	20.4	10% (6 of 63)	10 - 50	20.7	63
	Combined	26% (64 of 248)	2.4 - 140	21.2	8% (20 of 248)	4.4 - 200	24.5	248
MWDSC 1993		12% (6 of 48)	6 - 82	20	35% (17 of 48)	5 - 132	32	48
L & N 1995 (method differences)		54% (187 of 347)	2 - 4,380	200	60% (209 of 347)	6.6 - 6,510	240	347

A Phase I: October 1996 through October 1997

B Phase II: November 1997 through April 1998

The previous studies referenced in Table 5-3 used an earlier version or versions of an immunofluorescence antibody method similar to the EPA ICR IFA method used for the Coordinated Pathogen Monitoring Program and the ICR studies.

The LeChevallier and Norton (1995) study reflects the results of 347 surface water samples collected between 1988 and 1993 from 72 water treatment plants in 15 states and two Canadian provinces. Most samples were obtained from water treatment plants in the eastern United States and Canada, although some were from the western United States. The average sample size for this study was 499 liters, with a range of 86.6 to 3,394 liters; this average is significantly larger than the 100 liters specified by the ICR IFA method used for the Coordinated Pathogen Monitoring Program Study. A larger filtered sample volume generally produces greater analytical sensitivity with this method, and therefore it is likely that recoveries for this study were higher than the Coordinated Pathogen Monitoring Program.

One cannot compare the results of the LeChevallier and Norton study to the Coordinated Pathogen Monitoring Program results because of this difference in methodology and recovery. Based on the filtering challenges encountered using the ICR methodology on SWP source waters, attempting to process the 500 liters as in the LeChevallier and Norton study would be difficult or impossible. The reporting of the LeChevallier and Norton results is for informational purposes only.

The 1993 MWDSC study was conducted in 1992-1993 and used an IFA method similar to the EPA ICR method. Sampling locations included three sites in the Sacramento-San Joaquin Delta, Greene's Landing, Banks Pumping Plant, Delta-Mendota Canal, and one site at Check 29 in the California Aqueduct. All four of these sites were included in the Coordinated Pathogen Monitoring Program Study. While a detection limit was not specified, the detection limits for this study ranged from <2 to <126 cysts or oocysts/100L.

Because of method performance, very few conclusions can be accurately drawn from the Coordinated Pathogen Monitoring Program summary statistics. They do show that the percent of positive *Giardia* and *Cryptosporidium* samples for the Coordinated Pathogen Monitoring Program event samples were higher than that of the monthly samples.

Figure 5-1 Giardia Percent Positive - Monthly Samples

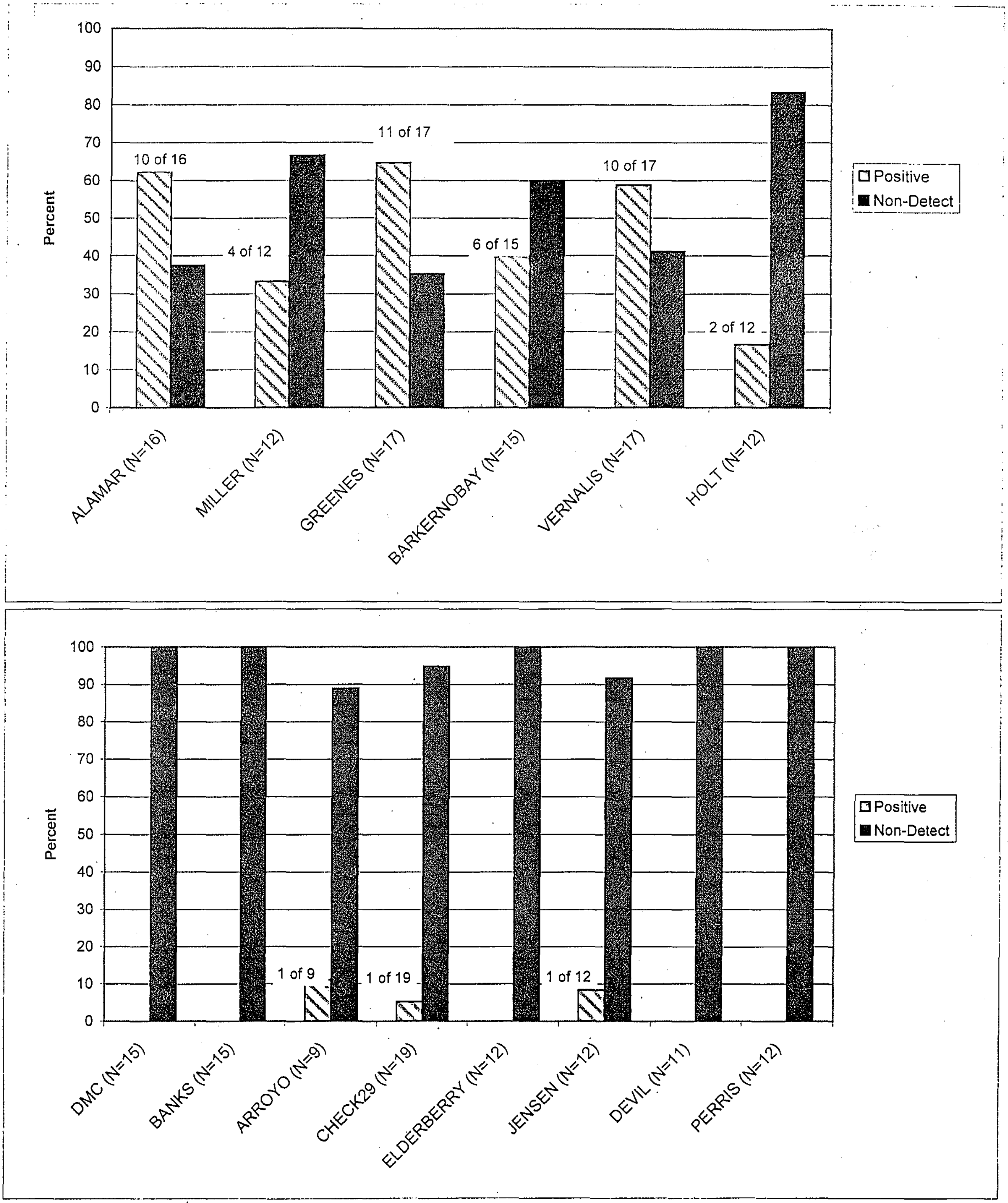
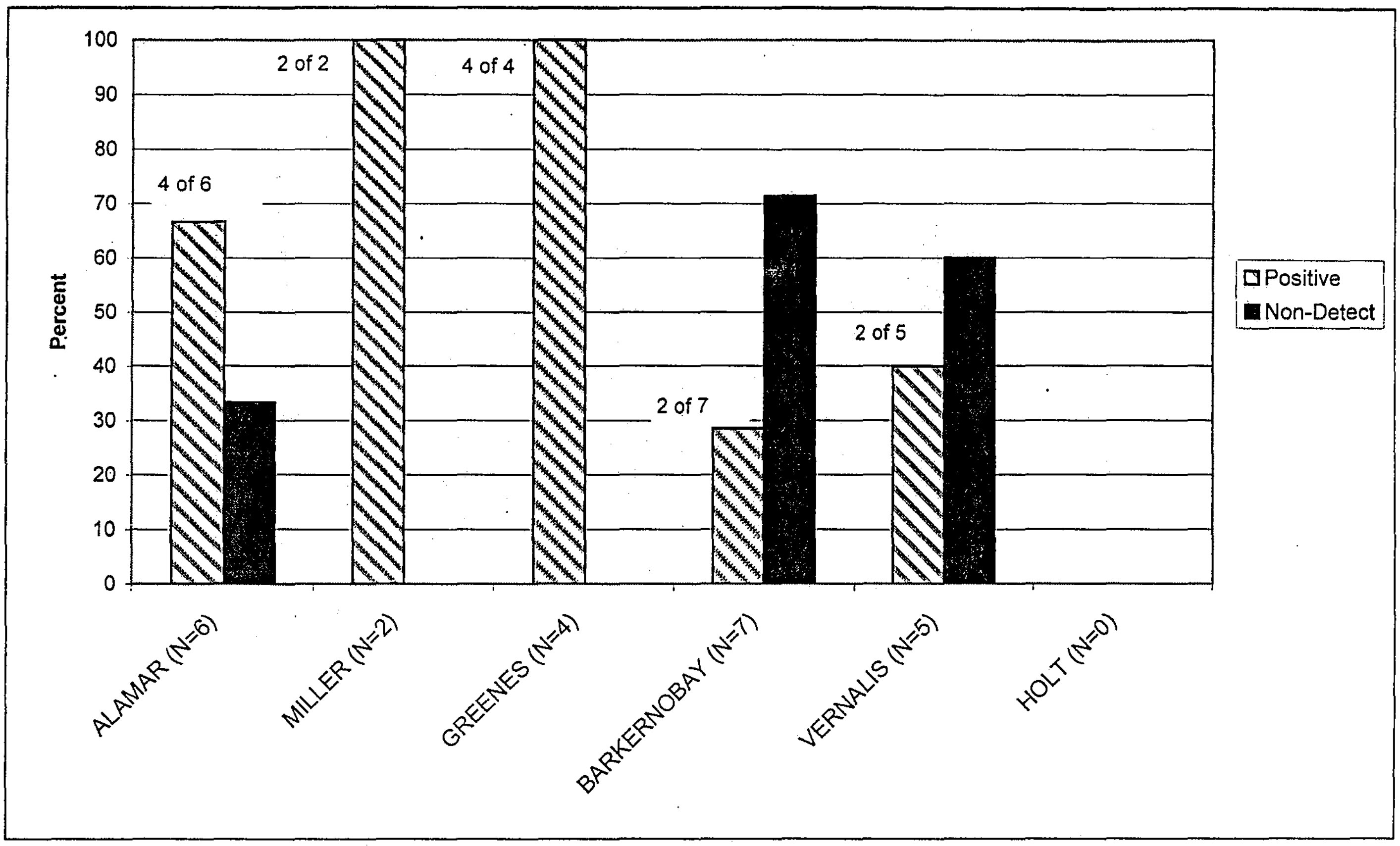


Figure 5-2. Giardia Percent Positive - Event Samples



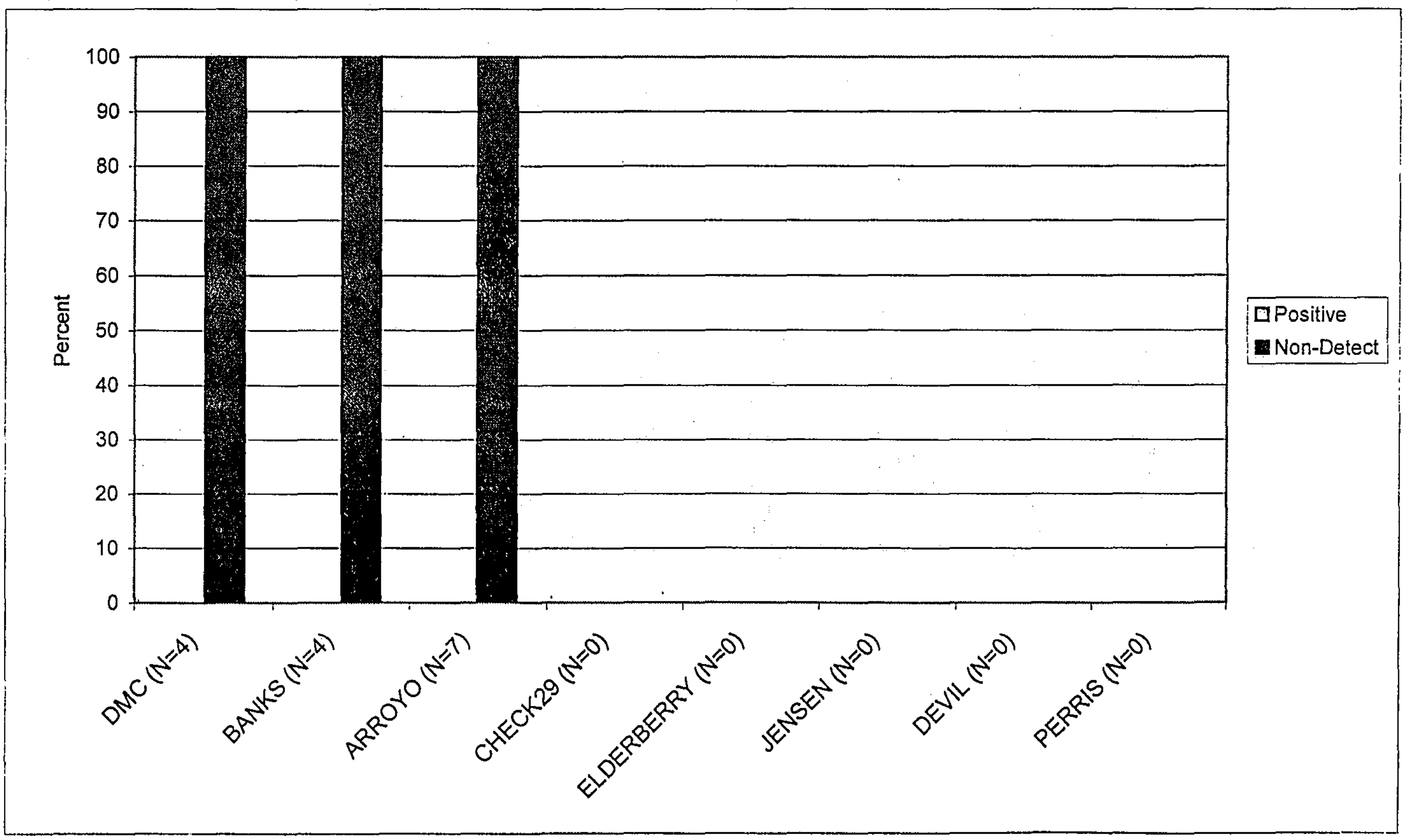
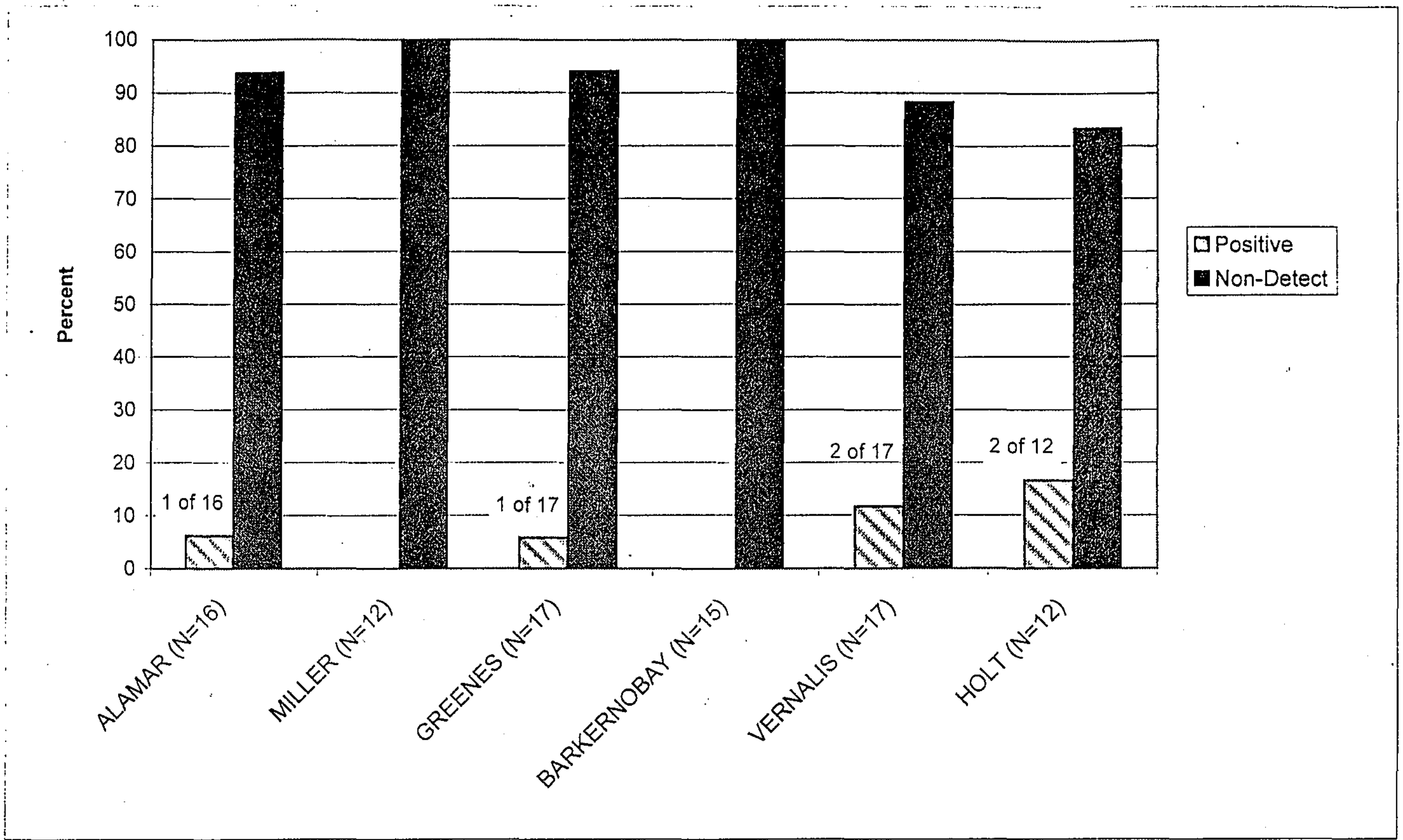


Figure 5-3. Cryptosporidium Percent Positive - Monthly Samples



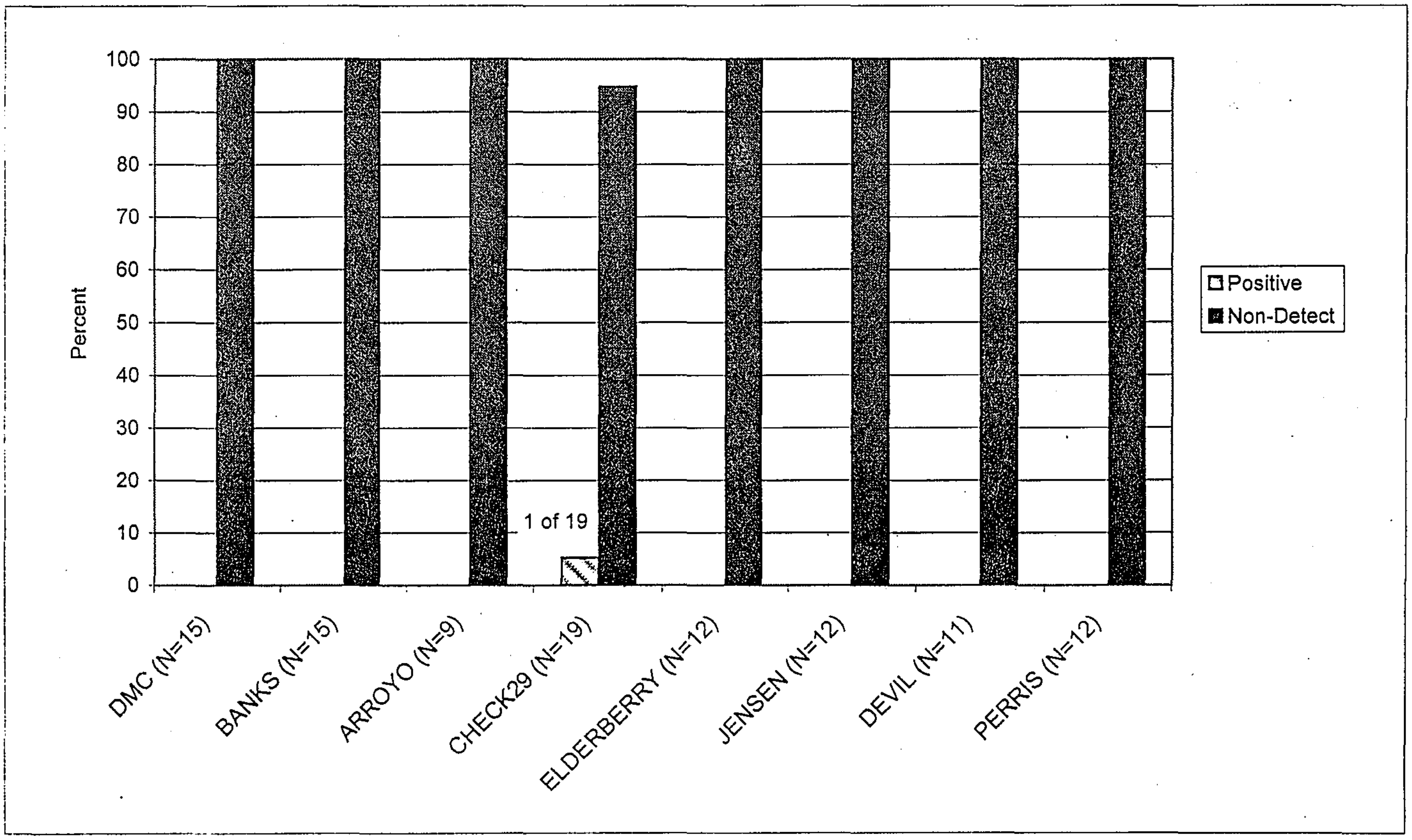
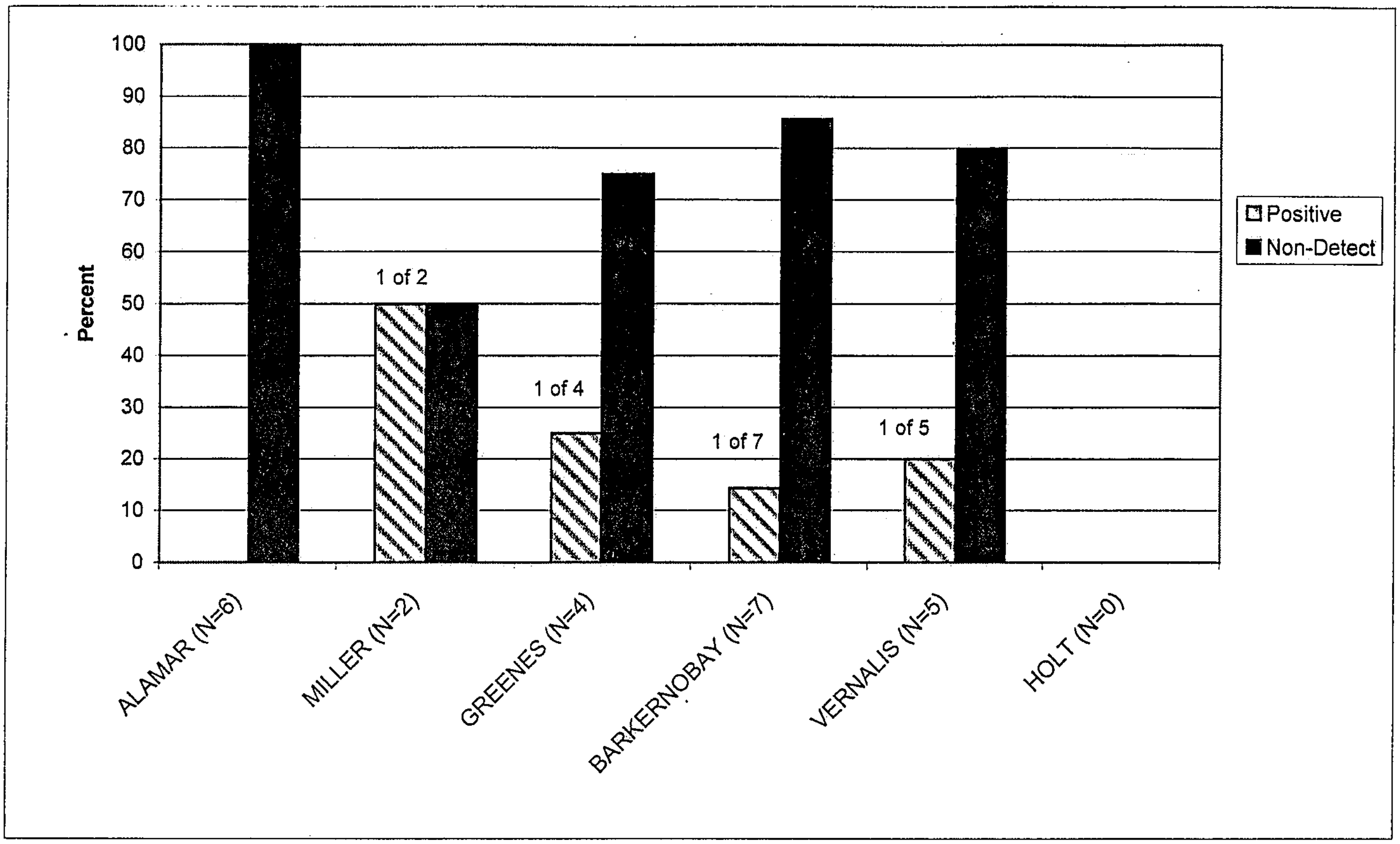
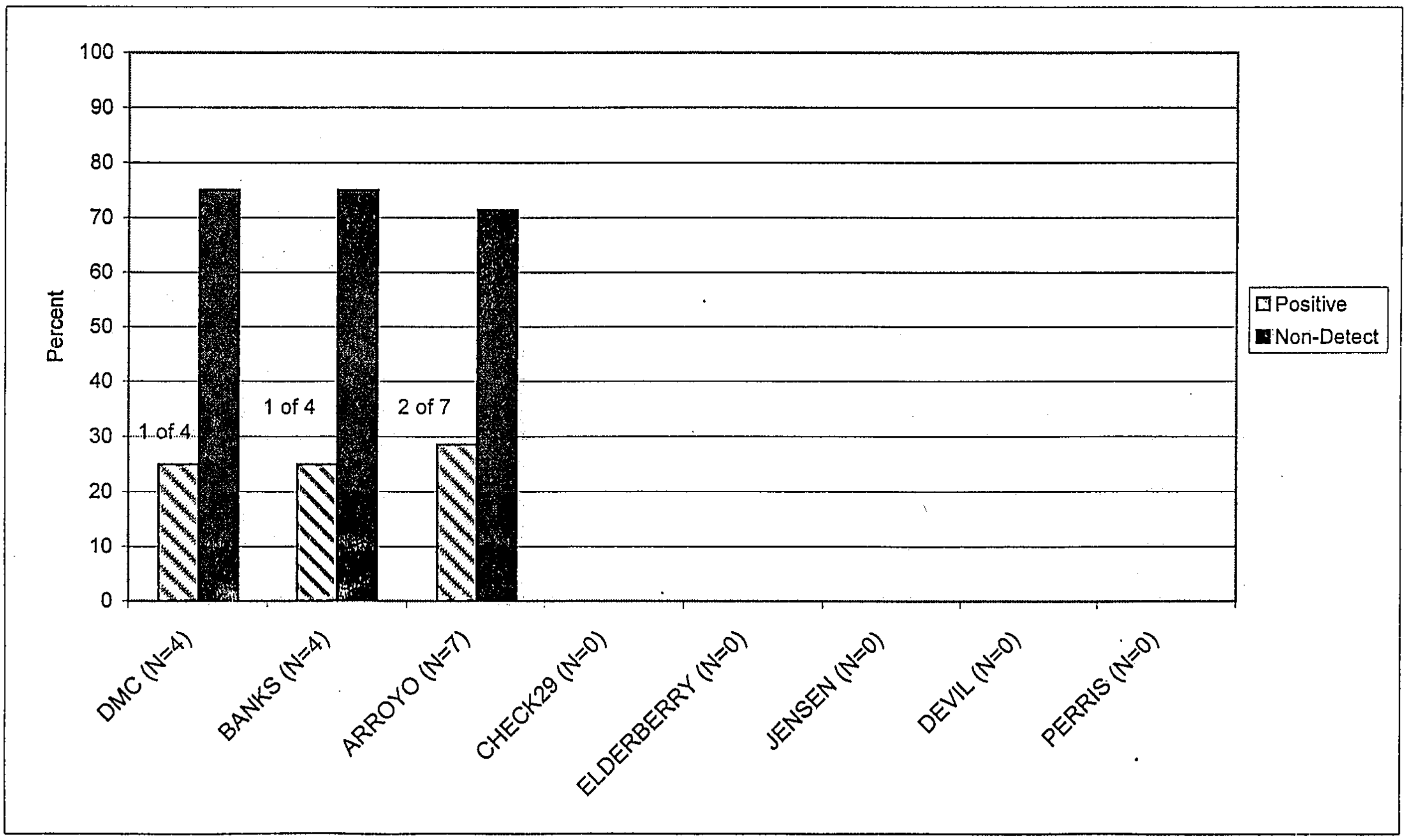


Figure 5-4. Cryptosporidium Percent Positive - Event Samples





Giardia Monthly Sampling Results

The highest detection frequencies for *Giardia* for stations with either monthly or monthly and event samples were found in the Sacramento and San Joaquin Rivers, which are the source waters of the SWP (see Figure 5-1).

For the monthly sampling, beginning at Alamar (63 percent), the most northern Sacramento River site, the detection frequency decreased at Miller Park site (33 percent). This is downstream of the confluence of the Sacramento and American Rivers, and downstream of one of the City of Sacramento's relatively minor wastewater/storm water discharge. The frequency again increased at the Sacramento River at Greene's Landing site (65 percent), which is approximately 10 miles downstream of the Sacramento Regional Wastewater Treatment Plant's 160 mgd and West Sacramento's approximately 5.4 mgd wastewater discharge. But the variability and inconsistency of this method prevents drawing conclusions about the increased numbers at Greene's Landing and its location downstream of the treatment plants. Greene's Landing had the highest *Giardia* detection frequency of any sampling location in the Coordinated Pathogen Monitoring Program Study.

Giardia detection frequency at the San Joaquin River site at Vernalis (59 percent), which is upstream of the City of Stockton's major wastewater discharge was much higher than the frequency at the San Joaquin River Holt site (17 percent), which is downstream of the City of Stockton's wastewater discharge. Though at the Holt site, San Joaquin River water becomes blended with Delta water. *Giardia* detection frequency at the North Bay Aqueduct intake located at the Barker Slough Pumping Plant (40 percent positive) was less than that seen at the Sacramento River sites or the Vernalis site on the San Joaquin River, but higher than the levels seen within other sites within the SWP.
The majority of results from samples collected from sampling locations either in the California Aqueduct or in the SWP reservoirs were non-detects.

The Banks Pumping Plant site represents water that has entered the SWP at the intake point in Clifton Court, and the Clifton site (at the radial gates in Clifton Court) represents storm water flows into Clifton Court. Neither *Giardia* nor *Cryptosporidium* was detected at Banks Pumping Plant, and only one of four event water samples from the Clifton site was positive for *Cryptosporidium*.

Giardia detection was more frequent in the river source waters of the SWP compared with the sampling locations within the SWP system itself, including the reservoirs. The majority of results from samples collected from sampling locations either in the California Aqueduct or in the SWP reservoirs were below the detection limit. Once again, poor and variable recovery from this method precludes any definitive statement of total numbers of protozoa at any of the sites.

Giardia Event Sampling Results

Event sampling for *Giardia and Cryptosporidium* was not conducted at all the sites within the SWP that were sampled for the monthly monitoring (see Figure 5-2). Detection frequencies for Delta sites ranged from 29 to 100 percent, with all six event samples at Miller and Greene's Landing showing positive detection for *Giardia*. Twenty-nine percent (2 of 7) of the samples at the Barker Slough Pumping Plant were positive for *Giardia* for event sampling. The Delta-Mendota Canal and Banks sites showed no detections for the eight samples taken at these locations. The Arroyo Valle Creek site had no detections for event sampling.

Cryptosporidium Monthly Sampling Results

Cryptosporidium detection frequencies were relatively low compared with those of *Giardia* (see Figure 5-3). The spiked matrix study showed that the ICR method percent recovery of *Cryptosporidium* was less than that for *Giardia* for the study matrix. The highest detection frequency in the Coordinated Pathogen Monitoring Program Study for stations with monthly samples (17 percent) was at the Holt Road sampling site on the San Joaquin River.

While *Cryptosporidium* was detected at the Sacramento River at Alamar and Greene's Landing sites and the San Joaquin River at Vernalis and Holt sites, the Barker Slough and Banks Pumping Plant sampling locations had zero detections for monthly sampling. Detection frequencies within the remainder of the SWP system were zero, except for one detection at Check 29.

Cryptosporidium Event Sampling Results

Figure 5-4 shows the detection frequency for event sampling for *Cryptosporidium*. Except for Alamar, *Cryptosporidium* was detected at all event sites at least once, but at a frequency lower than for *Giardia* but higher than *Cryptosporidium* monthly sampling. The Sacramento and San Joaquin Rivers' sites showed one detection per site for all event sampling, as did the Delta-Mendota Canal, Banks, and Barker Slough sites. Arroyo Valle Creek showed two detections for seven sampling events.

Conclusions

Analytical

- ✓ The average recoveries of *Giardia* and *Cryptosporidium* from split spiked matrix samples was 2.53 percent and 0.35 percent, respectively. The EPA ICR protozoan method demonstrated poor recovery, accuracy, and precision in the Coordinated Pathogen Monitoring Program study, which has been observed in other studies. The detection frequency and concentrations of both protozoa are likely higher than the analytical results indicate.

- ✓ Because of the low recovery of *Giardia* and *Cryptosporidium*, the detection limit calculated for an ICR protozoan analytical result does not reflect the actual detection limit, which is much higher (greater number of cysts or oocysts present before detection).

Results

- ✓ The range, geometric mean, and percent positive samples of the Coordinated Pathogen Monitoring Program event samples are higher compared with the monthly samples.

- ✓ *Giardia* and *Cryptosporidium* detection frequencies were highest in the Sacramento and San Joaquin Rivers and in the Delta compared with the SWP aqueduct and reservoirs. This difference does not appear to be related to any change in the performance of the EPA ICR protozoan method caused by possible physical or chemical changes in the water as it moves from the source through the SWP system, a distance of nearly 600 miles.

- ✓ *Cryptosporidium* was detected less frequently compared to *Giardia* in the Coordinated Pathogen Monitoring Program study. While *Giardia* may actually be present more often and at higher concentrations than *Cryptosporidium*, the recovery of *Cryptosporidium* by the analytical method was less than *Giardia* in this study, a finding that has been observed in other studies using similar analytical methodology.

- ✓ An improved analytical method is needed for analysis of *Giardia* and *Cryptosporidium* in raw and finished waters. The current ICR Protozoan Method exhibited poor recovery, accuracy, and precision for both protozoans in this and other studies. The method is inadequate based on the high cost and effort required to obtain results, along with the resulting performance-related qualitative and quantitative limitations placed on the interpretation and use of the data experienced in this study.

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Chapter 6

North Bay Aqueduct Watershed Study

Purpose: To assess the source of water quality problems for the North Bay Aqueduct and develop solutions.

Background: *The California State Water Project Sanitary Survey Update 1998* concluded that the North Bay Aqueduct had more water quality problems than any other part of the State Water Project. The North Bay Aqueduct is a 27-mile underground pipeline constructed as part of the State Water Project to provide water to municipal and industrial customers in Solano and Napa Counties. The Barker Slough Pumping Plant, located upstream of the confluence of Barker and Lindsey Sloughs, provides water for the North Bay Aqueduct (see Figure 6-1).

Municipal Water Quality Investigations staff began studies in 1996 to understand the contributions of different surface waters to the pumping plant's water quality. Water quality investigations were divided into two phases. The first phase was designed to quantify the severity of potential water quality problems. Results from the first phase of the study were documented in the MWQI's report, *The North Bay Aqueduct Barker Slough Watershed Water Quality Phase I Report, July 1998.* Phase I investigations determined that there were seasonal and spatial components associated with the pumping plant's water quality. Seasonally, the most severe problems occurred during the winter rainy season. Spatially, water quality in the winter was influenced by waters upstream of the plant and not the slough connecting the plant to the Sacramento River. This annual report summarizes the results of the second phase of North Bay Aqueduct investigations from September 1997 to March 1998.

Initially, Phase II sampling was designed to investigate specific pollutants and identify mitigation measures based on the results of the first phase. Phase II's focus was changed to evaluate the inputs to the pumping plant from the upper watershed during the winter rainy season. Samples were collected downstream at Calhoun Cut and Lindsey Slough, and upstream at Noonan Drain at Hay Road, Barker Slough at Dally Road, and Barker Slough at Cook Lane (see Figure 6-1). Samples were analyzed for a number of constituents including organic carbon and turbidity. Objectives of the second phase included the following:

- Examine the upper watershed's contribution to water quality at the pumping plant
- Focus sampling during the wet season by collecting samples during or within 24 hours after a storm with >1" of rain
- Collect hydrological data to determine carbon loading, where and when possible

Status: All Phase II sampling was collected between September 1997 and March 1998. The Solano County Water Agency has applied to the State Water Resources Control Board for 305 (j) grant funds to work with local landowners to implement trial Best Management Practices. Preliminary analysis of Phase II results has been completed.

Findings: Depending on the site, six to seven sampling events occurred between September 1997 and March 1998. Baseline samples were collected from September to November 1997. Four sampling events between December 1997 and February 1998 met the criteria of >1" of rainfall during or within 24 hours of sampling. One sampling event occurred within 48 hours of 1" of rainfall. Two of the samples were collected after rainfall less than 1". These samples and the sample collected 48 hours after a rainfall event were not included in wet weather analysis. Because of flooding, samples were not collected from Dally road during two of the four rainfall sampling events. Although a number of parameters were analyzed, results are presented only for organic carbon and turbidity. These parameters represent two of the main constituents of concern to water treatment facilities.

In all cases, all parameters increased over baseline values when rainfall was >1" (see Table 6-1). In the case of Hay Road, average turbidity during the wet period increased by an order of magnitude over baseline conditions. In general, average TOC and DOC concentrations doubled between baseline and wet conditions. Increases in turbidity, TOC, and DOC during the winter rainfall season reflected the same patterns observed in the first phase of the study. Statistically, TOC at all sites were greater than Lindsey ($p<0.05$). However, turbidity results were mixed. Turbidity at the Cook and Hay Roads sites were significantly higher than Lindsey Slough or Calhoun Cut. There were no significant differences in turbidity at any of the other sites. These mixed results are probably due to the large amount of variability in turbidity measurements. Dally Road was not included in any statistical analyses because only two sites were sampled during the reporting period.

During rainfall events, there was no apparent improvement in water quality upstream of the pumping plant. Average turbidities were highest at Hay Road, the site farthest from the pumping plant. Similarly, average TOC and DOC levels did not decrease upstream of the plant. However, regardless of season, turbidities, TOC and DOC at Lindsey Slough were consistently lower than any other site sampled. This was not the case for Calhoun Cut, the second downstream site. Although turbidity concentrations were half those of the next lowest site (Barker Slough Pumping Plant), average TOC and DOC values appeared comparable to upstream sites.

Flow measurements were collected when stream and weather conditions permitted. Mass loading calculations for TOC are shown in Table 6-2. Hydrology at Cook Road was measured the most frequently. On December 17, 1997, when flow rates and rainfall were low, carbon loading at Cook Road was only 546 lbs/day, despite high carbon levels.

When all three parameters were high, carbon loading at Cook Road increased more than 7,100 percent to 39,534 lbs/day.

Table 6-1 Average concentrations of Turbidity, TOC and DOC by site and rainfall (ranges given in parentheses)

Sample Site	Turbidity (NTUs)		TOC (mg/L)		DOC (mg/L)	
	baseline	wet	baseline	wet	baseline	wet
Calhoun Cut	46 (37-54)	80 ± 17 (43-112)	6.3 (6.2-6.3)	16 ± 4.4 (11.3-20.7)	4.8 (4.4-5.2)	12.8 (10.3-15.9)
Lindsey Slough	33 (31-35)	76 ± 59 (38-162)	3.0 (2.7-3.2)	5.4 ± .55 (3.8-6.2)	2.2 (2-2.3)	4.8 (4-5.5)
Barker Sl Pumping Plant	47 (44-51)	198 ± 84 (102-256)	6.1 (5.5-7)	16.8 ± 1.9 (13.7-20.3)	4.8 (3.4-6)	9.5*
Cook Road	112 (95-128)	361 ± 74 (304-469)	9.4 (8.8-10)	17.3 ± 1.5 (13.9-20.5)	6.2 (6-6.4)	11.4 (9.9-12.8)
Dally Road	60 (50-70)	265 ± 17 (93-436)	8.8 (4.8-12.8)	18.5 ± 17 (17-20)	7.7 (4-11.4)	13.8 (12.5-15)
Hay Road	33 (18-47)	437 ± 270 (35-608)	9.4 (3.7-15.1)	14.1 ± 1.4 (10.8-17.4)	9.1 (3.4-14.8)	9.7 (6.1-16.1)

* Only one sample analyzed

Table 6-2 Total Organic Carbon Loading in lbs/day for Barker Slough Watershed

Date	24 hr. rainfall (inches)	Sample Site	cfs	TOC (mg/L)	Mass Loading (lbs/day)
12/17/97	0.03	Hay Road	0.26	10.9	15.24
12/17/97	0.03	Dally Road	1.03	11.2	62.07
12/17/97	0.03	Cook Road	5.26	19.3	546.23
12/17/97	0.03	Barker Sl Pumping Plant	29	11.9	1,856.86
1/12/98	0.9	Cook Road	294	19.1	30,214.47
2/2/98	2.32	Cook Road	471	15.6	39,534.8

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Chapter 7

Modeling Delta Alternatives

Purpose: To assess possible options within the proposed CALFED Delta alternatives for protecting and improving the Delta's drinking water quality.

Background: The first need is to review the historical drinking water quality of the Delta to develop sets of input data for the Delta Simulations Model II and the Delta Island Consumptive Use Model. We will evaluate different scenarios of actions within the Delta including the original 12-plus proposed CALFED alternatives that might improve water quality and treatment.

The scenarios include the following actions and in combination with each other:

- ✓ Reduce agricultural drainage volume by
  - conversion to fallow land
  - conversion to flooded wetlands for soil subsidence control
- ✓ Reduce TOC concentrations in agricultural drainage by
  - treating drainwater by chemical flocculation prior to discharge
  - reducing leaching frequency
- ✓ Relocate or add intake and water storage sites
  - out-of-Delta storage
  - In-Delta storage
- ✓ Blend water
- ✓ Reduce water residence time in the Delta with
  - wider channels to increase flow
  - deep flooded islands to increase flow and provide storage
  - a separate canal

Status: Technical briefings or workshops will be made before the MWQI Advisory Group as the work proceeds to each milestone. The Advisory Group will contribute to the program by providing guidance, suggestions, and review of the tasks. A series of technical summary reports will be prepared as consultant's reports to DWR. This will enable faster distribution of information to the MWQI Advisory Group. These reports will become official DWR publications.

The following work plan describes the goals and products of modeling alternatives to improve the drinking water quality of Delta water supplies. The tasks are grouped into three topics that were common themes in the original set of proposed CALFED list of Delta alternatives.

The topics for study are:
- drainage control options
- designing wetlands and shallow water storage options
- water supply intake options

These three topics will be studied concurrently.

Status:

Task 1. Examining Drainage Control Options

Goal: Estimating Monthly DOC Loads from Delta Island Drainage

Report: Delta Island Drainage Estimates, 1954-55 vs. 1995
Completion Date: January 15, 1998

We compared the 1995 and 1996 Delta island drainage volume estimates computed by USGS for DWR in the Delta Island Water Use Study to the 1954-55 estimates in DWR Report No. 4 (1956). We compared the methodologies used, seasonal trends in estimated drainage volumes discharged, land use changes, computational assumptions, and water year hydrologies. We will determine if there are significant differences between the annual and monthly estimates for the Delta and subregions.

The next step is to confer with the Delta Modeling Group on our analysis. We may recommend a range of values to use for monthly drainage volume discharges rather than a single value such as an average. It is probable that there will be more than one set of monthly drainage volume numbers that will be recommended for use in the Delta water quality and hydrology models.

Goal: Developing Drainage Reduction Options

Report: *Candidate Regions in the Delta for Reduction of Organic Carbon Loads*
Completion Date: January 1999

We will develop a set of island drainage reduction options. Organic carbon mass loads will be computed from drainage volume estimates and DOC concentration data collected under the MWQI Program since 1982. The historical and regional distribution of DOC has been studied and reported in previous MWQI reports. Mass load estimation work will begin in February 1998. Delta areas with the highest organic carbon loads discharged into the Delta channels will be identified.

Brown and Caldwell Engineers completed a study for MWQI on the treatment of Delta island drainage in 1997. The study found that a reduction of up to 60 percent could be achieved by conventional coagulation/flocculation processes. Fallowing land could be another option. The options will be developed on the basis of proximity to water supply intakes, dominant water circulation patterns in the Delta, and size of DOC mass load from each island or subregion. A candidate list of islands or regions for organic carbon reduction will be developed.

The regional distribution of DOC in the Delta was discussed in the *MWQI Five-Year Report for January 1987 - December 1991* (DWR, 1994). Further analysis of MWQI data will be performed to develop expected monthly DOC values across the regions of the Delta. These values will be used with monthly drainage volume estimates to compute monthly mass loads of DOC discharged from the Delta islands. As with drainage volume estimates, we expect to generate more than one set of DOC concentration values to be used in the modeling work because of different water year classifications and conditions.

Goal: Model Runs of Drainage Control Options

Proposed Report: *Water Quality Benefits from Controlling Delta Island Drainage*

The Delta Modeling Group will run predictive Delta water quality models on various scenarios we define that cover the above spectrum of alternatives for the Delta. In turn, the results will be used to help us develop other alternatives. For example, modeled results might show only slight improvement in water quality by reducing organic loads from three islands. Another model run that simulates more islands under treatment or intake relocation might result in better water quality. There will be interaction between MWQI and Delta Modeling staff in refining possible alternatives.

Task 2. Designing Wetlands and Shallow Water Storage Facilities

Goal: Study of Factors Affecting Organic Carbon Availability from Flooded Environments (Wetlands and Water Storage)

Report: *A Trial Experiment On Studying Short-Term Water Quality Changes In Flood Peat Soil Environments*
Completion Date: July 1999

Initial experiments at the new SMARTS facility will be conducted to study the major factors that may affect DOC in waters overlying peat soil from wetlands creation and water storage on Delta islands. The experimental protocol will be a full or partial factorial experimental design or response surface methodology.
The information will be used to design and operate such projects with minimal impact on drinking water quality, specifically organic carbon concentrations. Iterations of the experiments are necessary, and peat soil may be substituted with other soil types to study out-of-Delta water storage options. Other follow-up experiments might examine TOC contributions from algae, decaying crop biomass, and wetland plants.

Goal: Assessing Organic Carbon Loads from Wetland and Water Storage Projects

Proposed Report: *Model Runs of Proposed Wetland and Water Storage Projects in the Delta*

Computer model runs of hypothetical wetlands and water storage facilities in the Delta (e.g., flooded islands) will be performed.

Task 3. Examining Water Supply Intake Options

Goal: Examine Water Quality at Proposed Water Supply Intakes

Proposed Report: *Existing Data Report, MWQI 1982 - 1999*
Completion Date: 2000

Channel water quality data collected since 1982 will be summarized and interpreted. The report will describe the history, mission, and milestones of the Interagency Delta Health Aspects Monitoring Program and MWQI Program. The analysis will provide input data sets for the model runs.

Data needs will be identified and further data collection needs will be recommended to the MWQI Program for monitoring.

Goal: Assess Water Supply Intake Location Options

Proposed Report: *Model Runs of Water Quality Benefits from Various Water Supply Intake Locations*

Computer model runs using historical and predicted water quality data for various potential water supply intakes in the Delta will be performed.

Task 4. Alternatives Assessment

Goal: Assess CALFED Delta Alternatives

Proposed Report: *Summary Report of CALFED Water Transfer and Storage Alternatives to Improve Drinking Water Quality in the Delta*

Additional (or as needed) SMARTS experiments, computer model runs, Delta water quality monitoring, and refinements to Delta alternative scenarios are expected to continue into the future. A final report will summarize the predicted water quality benefits from the computer model runs of the modeled Delta alternatives and combinations of scenarios.

Chapter 8

Development of Special Applied Research Technology Station (SMARTS)

Purpose: To construct a flexible multipurpose testing facility to conduct experiments on the factors that affect water quality from flooded peat soil environments such as the Delta wetlands.

Background: The Special Multipurpose Applied Research Technology Station (SMARTS) is an experimental facility of the MWQI Program under the Water Quality Assessment Branch of DWR's Division of Planning and Local Assistance. The facility will include a series of large tanks (4 810-gallon capacity and 5 1,500-gallon capacity) designed for studying a variety of water quality effects under controlled static or continuous water flow conditions. The tanks will be located adjacent to the Water Quality Assessment field trailer near the Bryte Chemical Laboratory.

Initial experiments at the station will include a study of the factors that affect dissolved organic carbon concentrations in impounded waters from proposed wetland and water storage facilities in the Delta. These factors include peat soil depth, water depth, and water residence time. This information is important for the impact assessment of CALFED alternatives and proposed Delta Wetlands Project. The length of the planned experiments is about two years. The facility is not permanent and can be disassembled after the studies are completed.

MWQI consultant, Marvin Jung, designed SMARTS. The Division of Flood Management Sacramento Maintenance Yard staff will perform construction.

Status: The bidding process for procuring the tanks and equipment began in August 1997. Foundation work for SMARTS began in November. Completion of the main structure platform was in March 1998. Full completion and operation of SMARTS and start-up of the first experiment will be July 1998. The first experiment will run for three months.

A report will be prepared for each experiment conducted at SMARTS. The results will lead to the development of the best practices to minimize organic carbon levels in waters overlying peat soils during the construction and operation of flooded peat soil environments. The data will be used to provide guidelines on the design, construction, and operation of a shallow flooded peat soil wetland.

Chapter 9

Real-time Monitoring

Purpose: To install an automated TOC analyzer at a new field facility located at Hood on the Sacramento River. The purpose of this pilot study is to determine the practicality of establishing on-site remote monitoring of real-time TOC levels using an automated TOC analyzer. When operational, this project will provide telemetered information on TOC levels in the river. The combination of concentration and flow data can be used to correlate the impact of upstream events such as storm runoff, drainage discharge, and dam releases on the TOC loading of the river. The successful operation of this project could lead to establishing similar stations at key locations throughout the Delta.

Background: The TOC analyzer is tabletop laboratory equipment designed for the analysis of finished water. Since this application is different than the standard operation of this instrument, certain issues like turbidity and suspended particulates had to be addressed. Staff used the technical assistance of the manufacturer in planning and determining the design needed for the instrument installation to assure the proper performance of the analyzer.

A conservative approach was selected to evaluate the instrument's ability to operate satisfactorily with raw surface water. It was determined that the sample water should pass through a 1 µm filter before entering the analyzer. This would reduce the possibility of particulates accumulating on the inside of the unit where they could eventually clog the flow of water through the analyzer. This required that the materials comprising the filter and filter housing did not contribute significant amounts of TOC to the sample water. Tests were conducted previously in December 1996 on different filter materials to determine the level of TOC contribution to the sample for each filter type. Two specific filter types, one made of baked glass fibers and the other of spun polypropylene, were identified as providing no significant contribution of TOC to the sample. Corresponding tests were conducted for filter housings, with one made of virgin polypropylene selected after it was found not to contribute TOC to the samples.

It has been noted that the use of a 1 µm filter will provide analytical results that do not reflect true TOC values. This is an issue that will be addressed once the instrument has been installed on site. An evaluation of comparative analyses of TOC and DOC samples analyzed by Bryte Chemical Laboratory and the TOC data produced by the instrument will be performed to determine trends and/or correlations in the data.

Findings: A water sample was collected at the site in March 1998 for particle size analysis. This analysis provided information on the range in size of suspended particles and percent of the total particles present in the sample. This analysis showed that particles >1 µm comprised approximately 80 percent of the particulates in the sample. DOC is defined as the fraction of organic carbon that passes through a 0.45 µm filter. On the average DOC is 90 percent of the TOC in the Sacramento River. These screening experiments will help determine what pre-screening can be done to prevent damage to the analyzer while allowing the passage of the majority of organic carbon. Additional samples will be collected to provide data that reflect seasonal conditions and the respective suspended particle load of the water. Tests are also planned on filters of pore sizes larger than 1 µm. When installed in the continuous in-line-sampling mode, the instrument can process one sample every 6 minutes. This continuous flow of water through the filter could result in rapid particulate loading of the filter, especially during times of high turbidity in storm events. This would require frequent filter changes to prevent the possibility of a plugged filter interrupting the water flow to the analyzer. Therefore, a timed sampling procedure was developed to minimize the need for frequent filter replacements. A system was designed and tested that incorporated a timer and solenoid valve that regulated the frequency and duration of sampling events within 24 hours. This configuration turns on the analyzer for the length of time necessary for the unit to perform the requested number of analyses then shuts down the unit and turns on again for the next sampling event. Initial bench tests of this system have provided favorable results. Further testing with this timed system will be required when the instrument is installed at the new field facility at Hood.

Status: Construction on the new monitoring facility that will house the analyzer is almost complete. Most of the remaining work is interior related. The finished facility will be climate controlled to assure constant operating temperature for the instruments. It will also be equipped with telemetry capabilities to allow remote access to the instrument data. The estimated completion date of the facility was the fall of 1998. A pilot study to start field testing the installed instrument and the corresponding water delivery components is planned for late winter 1998, or as soon as the facility is operational.

Summary: This project has made considerable progress in 1997. Most of the components needed for the installation and operation of the unit have been identified, purchased, and tested. A permanent secure facility to house the instrument is in the final stage of construction. The feasibility testing of long-term operation of the unit under field conditions is planned for next year.

Chapter 10

Decker Island Tidal Wetlands Restoration Project

Purpose: To monitor changes in water quality during the operation of the tidal wetland restoration project and to evaluate potential changes in constituents of concern associated with tidal flow and flushing. Specific monitoring would assess the production of TOC/DOC relative to adjacent channels and determine the potential for organic carbon produced from the project to form trihalomethanes following treatment for use as drinking water.

Background: CALFED identified the need for a substantial increase in tidal wetland creation and restoration in the Sacramento-San Joaquin Delta as part of its draft Ecosystem Restoration Program Plan. Accordingly, the Port of Sacramento proposed a 70-acre tidal wetland enhancement pilot project on Decker Island. The project was approved for funding under the CALFED Category III program in November 1996. The project was designed to address concerns with the proposed wetland restoration projects and Delta water quality, specifically the potential impacts of these projects on organic carbon levels in the Sacramento River. This project would provide important additional information to begin to assess potential impacts on downstream drinking water quality with respect to parameters of concern (e.g., organic carbon) as a result of the changes associated with the project. Data and information from the project would help with evaluation of tidal wetland designs that could be incorporated into CALFED's Delta alternatives. The overall goal is to study factors affecting organic carbon production from flooded environments.

The project would also:

- provide continuous monitoring of tidal flows entering the island through the created channel.
- quantify mass loading of water quality constituents of concern that are released from the project drainage during ebb tidal cycles.
- provide data to create a database from which to evaluate future tidal wetland restoration projects such as envisioned in CALFED's ERPP.

Status: The project was evaluated by the Port of Sacramento, CALFED, Department of Fish and Game, DWR, and others to determine feasibility of being continued on a larger scale and in additional geographic areas. This process is expected to take up to one year (July 1999) and is contingent on finding available funds. To date, available funding and agreements between project proponents have not been determined. Because of its inactive status, MWQI is no longer actively involved in the project.

Acronyms & Abbreviations

Acronyms and Abbreviations

af
acre-feet

Ag
silver

Al
aluminum

B
boron

BMP
Best Management Practices

Ca
calcium

CALFED's ERPP
Ecosystem Restoration Program Plan

Cd
cadmium

cfs
cubic feet per second

Cl
chloride

CO_3
carbonate

CPMP
Coordinated Pathogen Monitoring Program

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

EC
electrical conductivity

ELAP
Environmental Laboratory Accreditation Program

EPA
Environmental Protection Agency

F
fluoride

Fe
iron

Hg
mercury

ICR
Information Collection Rule

IFA
immunofluorescence antibody

K
Potassium

KCWD
Kern County Water District

L
Liters

1 μm
one micron

maf
million acre-feet

MCL
maximum concentration level

MFL
million fibers per liter

MGD
million gallons per day

mg/L
milligrams per liter

Mg
magnesium

Mn
manganese

mp
milepost

MTBE
methyl tertiary-butyl ether

MWDSC
Metropolitan Water District of Southern California

MWQI
Municipal Water Quality Investigations

n
number

N
nitrogen

Na
sodium

NH_4
ammonia

NO_2
nitrite

NO_3
nitrate

NBA
North Bay Aqueduct

NTU
nephelometric turbidity units

O&M
Operations and Maintenance (DWR)

P
phosphorus

Pb
lead

pH
negative log of the hydrogen ion activity

PO_4
phosphate

RPD
relative percent difference

Se
selenium

SLC
San Luis Canal

SMARTS
Special Multipurpose Applied Research Technology Station

SO_4
sulfate

SRI
Sacramento River Index

SWC
State Water Contractors

SSAC
Sanitary Survey Action Committee

SWP
State Water Project

TDS
total dissolved solids

THM
trihalomethane

TTHMFP
total trihalomethane formation potential

TOC
total organic carbon

TSS
total suspended solids

μg/L
micrograms per liter

μm
micrometers

μmole/L
micromoles per liter

μS/cm
microseimens per centimeter

USBR
United States Bureau of Reclamation

US EPA
United States Environmental Protection Agency

USGS
United States Geological Survey

WQT
water quality threshold

Zn
Zinc