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SACRAMENTO RIVER WATERSHED PROGRAM

Annual Monitoring Report: 1999–2000

Prepared for the

Sacramento River Watershed Program

By

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Report Review Process

The review process and schedule for the 1999-2000 Annual Monitoring Report of the Sacramento River Watershed Program (SRWP) is outlined in the table below. This process includes internal reviews by the SRWP Monitoring, Toxics, and Public Outreach and Education Sub-Committees, and review by the all SRWP stakeholders and other interested public. The Public Draft report and the Final report are available from the SRWP website,

http://www.sacriver.org.

Comments received for the Administrative Draft and Public Draft Annual Monitoring Report were compiled, responded to, and included in the Final version.

SRWP Annual Monitoring Report (AMR) Review and Submittal Schedule

	Date	Review Milestones
✔	1/8/2001	AMR Administrative Draft to Monitoring Sub-Committee for internal review
✔	1/24/2001	Discuss initial comments on Administrative Draft at Monitoring Sub-Committee Meeting
✔	2/21/2001	Comments due on Administrative Draft from Monitoring Sub-Committee
✔	2/28/2001	Review proposed responses to Monitoring Sub-Committee comments on Administrative Draft at Monitoring Sub-Committee Meeting
✔	5/31/2001	Public Draft submitted to Monitoring and other Sub-Committees and Peer Reviewers. Other SRWP stakeholders notified of Public Draft AMR availability for review.
✔	6/15/2001	Written comments on Public Draft due from all reviewers and stakeholders.
✔	6/27/2001	Review and approve responses to major Public Draft comments at June Monitoring Sub-Committee meeting (6/27/2001, tentative meeting date)
✔	6/30/2001	Submit Final AMR approved by Monitoring Sub-Committee to SRCSD and EPA

Acknowledgements

The Sacramento River Watershed Program Monitoring Program and the Annual Monitoring Report are products of the efforts of many people. A great deal of effort has been expended in field, laboratory, and office work to collect and analyze samples, to manage, summarize data, and to interpret the results of the Sacramento River Watershed Program monitoring effort.

While the names of all of the individuals involved in the SRWP monitoring program are too numerous to list here, we would like to gratefully acknowledge the assistance of all of the participating members of the Monitoring Sub-Committee, the Toxics Sub-Committee, the Biological and Habitat Sub-Committee, and the Public Outreach and Education Sub-Committee. The members of these committees have provided invaluable assistance and advice in developing the monitoring program and in preparing and reviewing this document.

In additional to the participating SRWP committee members, the following agencies and contractors have been instrumental in implementing the SRWP monitoring program.

U. S. Environmental Protection Agency

Sacramento Regional County Sanitation District

Central Valley Regional Water Quality Control Board

San Francisco Estuary Institute

California Department of Water Resources

U. S. Geological Survey

California Department of Fish and Game

University of California Aquatic Toxicology Laboratory

Moss Landing Marine Lab

Sierra Environmental Services

Sequoia Analytical Laboratories

BioVir Laboratories

Acronyms and abbreviations Used in this Document

BMIs	Benthic Macroinvertebrates
CDFG	California Department of Fish and Game
CSBP	California Stream Bioassessment Procedure
CTR	California Toxics Rule
D/DB-P	Disinfection/Disinfection By-Product Rule
DDTs	Dichlorodiphenylethane compounds
DHS	California Department of Health Services
DOC	Dissolved Organic Carbon
DWR	California Department of Water Resources
EPT Index	Ephemera/Plecoptera/Tricoptera Index
FFGs	Functional Feeding Groups
FPOM	Fine Particulate Organic Matter
IBI	Index of Biotic Integrity
ICR	Information Collection Rule
MCLs	Maximum Contaminant Levels
µg/L	micrograms per liter
mg/L	milligrams per liter
MPN/100 mL	Most Probable Number of Bacteria per 100 mL
MWQI	Municipal Water Quality Investigations Program
NAWQA	National Water Quality Assessment Program
ng/L	nanograms per liter
NPDES	National Pollutant Discharge Elimination System
NTR	National Toxics Rule

NTU	Nephelometric Turbidity units
PCBs	Polychlorinated Biphenyls
RWQCB	Regional Water Quality Control Board
SRCSD	Sacramento Regional County Sanitation District
TIE	Toxicity Identification Evaluation
TDS	Total Dissolved Solids
TMDL	Total Maximum Daily Load
TOC	Total Organic Carbon

Executive Summary

This is the second Annual Monitoring Report for Sacramento River Watershed Program (SRWP). This document provides a review of the Sacramento River Watershed Program (SRWP) monitoring effort and the data generated by the SRWP and other collaborating water quality monitoring programs (USGS NAWQA, Sacramento River Coordinated Monitoring Program, City of Redding NPDES Monitoring, Department of Water Resources intensive tributary monitoring program). This report describes data collected from 1998–2000 by the SRWP and from varying periods for programs coordinating with the SRWP. These data are used to assess spatial and temporal distributions of a variety of important water quality characteristics, to evaluate the attainment of beneficial uses and potential impairment in the Sacramento River watershed, and to compare the relative contributions of different inputs to the Sacramento-San Joaquin Delta.

The categories of water quality data considered in this review are mercury (in water and fish tissue), trace metals in water, drinking water parameters of concern, aquatic toxicity, sediment toxicity, organochlorine compounds and PCBs in fish tissue, and bioassessment parameters (based on physical habitat, benthic macroinvertebrate, and attached benthic algae community data). The preliminary conclusions of this review of SRWP and other monitoring data are summarized below.

Mercury

- Mercury concentrations in fish tissue collected in 1997,1998, and 1999 from the mainstem Sacramento River below Shasta Reservoir and major tributaries to this section of the river were higher than several of the human health-based and wildlife-based advisory and screening values. Frequent exceedances of the tissue-based water quality criterion for mercury recently developed by the EPA (0.3 mg/kg) and adopted by the California Office of Health Hazard Assessment (OEHHA), and less frequent exceedance of the previous EPA screening value of 0.6 mg/kg, indicate that there are human health concerns associated with consumption of some fish species from the lower Sacramento River watershed. The current water quality EPA criterion of 0.3 mg/kg is based on a fish consumption rate of 17.5 g/day (equivalent to 4 quarter-pound servings per month). There is some disagreement whether the available data are adequate to warrant issuing fish consumption advisories, and OEHHA has not issued advisories for these waters. Although there also continues to be substantial scientific disagreement about the actual level of risk posed by these concentrations of mercury in fish, there is agreement that the risks are greatest for small children and pregnant women, and that the risks increase with greater consumption of fish. General consumption guidelines are provided by OEHHA on their web page (http://www.oehha.org), in addition to consumption advisories for specific waterbodies. Concerns over mercury in fish from the lower Sacramento River watershed are being addressed with more focused monitoring being performed for 2000-2002 (Years 3 and 4). This shift in focus is in large part a result of coordination and consultation with OEHHA, which has been an active participant in the SRWP, and has provided the SRWP with guidance regarding data needs and study design for evaluation of human health risks related to fish consumption.

- Total water column mercury concentrations in the Sacramento River from Keswick to River Mile 44 rarely exceeded the CTR total mercury criterion of 50 ng/L (USEPA 2000). Total mercury concentrations exceeded the 50 ng/L limit in 22% of Cache Creek samples and 32% of samples from the upper Mill Creek watershed. The Feather and Yuba rivers are significant sources of mercury loads, but concentrations are not elevated compared to the Sacramento River mainstem. However, high concentrations of mercury in fish from the lower Feather River suggest that it may be a significantly elevated source of bioavailable methylmercury, and indicate the need for more fish tissue and water column monitoring in this part of the watershed. Spring Creek in the upper Sacramento River watershed, Deer Creek, Big Chico Creek, and the American River do not appear to be major sources of total mercury—concentrations are low compared to the Sacramento River and were never observed to exceed the 50 ng/L CTR criterion at these sites. With the exceptions of Mill Creek and Cache Creek, total mercury concentrations rarely exceeded the 50 ng/L CTR criterion at any site.
- Methylmercury concentrations in water column samples exceeded the Great Lakes human health-based criterion of 0.24 ng/L in less than 25% of samples from Sacramento River and Cache Creek, and in slightly more than 25% of samples from two ag drain sites. Methyl mercury concentrations exceeded the Great Lakes wildlife-based criterion of 0.05 ng/L in nearly every sample collected from every site.
- The Sacramento River watershed drainage is a major source of mercury to the Delta. This watershed contributes approximately 90% of the total mercury loads to the Delta. Within the Sacramento River watershed, the Cache Creek drainage is the single largest source of total mercury.

Other Trace Metals

- The beneficial use most likely to be impacted by (i.e. most sensitive to) elevated trace metal concentrations is aquatic life. In comparisons to CTR water quality criteria and Basin Plan water quality objectives designed to protect aquatic life, trace metal concentrations in the Sacramento River watershed are generally much lower than these values. A notable exception is that dissolved copper concentrations in individual samples continue to exceed hardness-adjusted CTR chronic criteria for copper approximately 9% of the time in the Sacramento River below Keswick Reservoir. This results indicates a potential impact on sensitive aquatic life species in this reach of the Sacramento River. Additionally, dissolved copper concentrations exceeded hardness-adjusted CTR chronic criteria for copper approximately 20% of the time in Arcade Creek, and 7% of the time in Colusa Basin Drain. To the degree that these locations are representative of urban runoff and waters dominated by agricultural drainage, these results indicate a potential for adverse impacts from elevated copper concentrations on sensitive aquatic life species in these types of waterbodies.
- There is a significant potential that elevated arsenic concentrations in Mill Creek may limit the use of this water as a drinking water source.

Aquatic Toxicity

- Recent water column toxicity test results for some of the smaller, upper watershed creeks (Clear Creek, Mill Creek, and Deer Creeks) indicate more frequent toxicity to test organisms (the water flea, *Ceriodaphnia dubia*, and fathead minnows, *Pimephales promelas*) than samples collected in lower tributaries such as the Feather and American rivers. Research is being performed by the Regional Water Quality Control Board to determine the cause of such results in the fathead minnow tests. Samples collected from Arcade Creek (an urban creek in the Sacramento area) continue to exhibit a relatively high frequency of toxicity to *Ceriodaphnia* as compared to other lower watershed tributaries.
- The results of the 1999-2000 monitoring and of previous aquatic toxicity monitoring efforts (cited in main text) have documented that significant toxicity to test organisms occurs throughout the watershed. *Ceriodaphnia dubia* toxicity attributable to organophosphate pesticides in agricultural runoff and urban runoff has been definitively shown by SRWP monitoring and other studies.
- The strategy of regularly scheduled monitoring conducted in 1998-1999 and 1999-2000 has been valuable in evaluating the overall frequency and distribution of observed water column toxicity, and for identifying or confirming the causes of some of the observed toxicity. Significant questions remain regarding the sources, severity, persistence, and ecological significance of periodic toxicity in the Sacramento River watershed. To address these questions, the SRWP aquatic toxicity monitoring effort in 2000-2001 will focus primarily on monitoring specific episodic events (e.g. agricultural dormant spray season, runoff events, high flow events).

Organophosphate, Carbamate, and Triazine Pesticides

- The results of SRWP and other monitoring programs strongly support the focus of the SRWP and of both state and federal regulatory agencies on the management of organophosphate pesticides in surface waters. Diazinon and chlorpyrifos appear to have the greatest potential for impacts on aquatic life uses, with other monitored pesticides appearing to have relatively low to minimal risk of impacts.
- Because no data were available for the many minor tributaries to the Sacramento River watershed, no evaluation of the incidence and distribution of pesticides in these watersheds can be made in this report. For smaller tributary watersheds with a substantial proportion of agricultural land use, there is a significant potential for pesticide concentrations to occasionally reach concentrations of concern. This lack of data should be considered a significant information gap. Pesticide monitoring data should be evaluated for these watersheds as soon as they become available.
- The shift from use of organophosphate and carbamate pesticides indicates the need to increase monitoring for other relatively new pesticides, such as pyrethroids and pyrethrins.

Drinking Water Parameters of Concern

The Sacramento River and major tributaries provide water supplies for municipal, industrial and agricultural use in the Sacramento River Basin. In addition, the Sacramento River is the primary source of flow to the Sacramento-San Joaquin Delta, the source of drinking water for an additional 20 million people in the Bay Area, Central Coast, and Southern California. The Sacramento River and its major tributaries are generally considered high quality drinking water sources, and although the quality of the Sacramento River is changed as it moves downstream and into the Delta, data collected to date indicate that drinking water beneficial uses are substantially realized in the Sacramento River watershed. Water supply agencies treating Sacramento River and Delta water are currently able to meet drinking water standards and provide safe drinking water to millions of consumers throughout California. However, anticipated future drinking water regulations may require agencies treating Delta water to implement additional treatment. Drinking water parameters of potential concern included in the SRWP monitoring program include organic carbon, total dissolved solids, pathogens, and turbidity. Organic carbon is of concern primarily due to its role in the creation of carcinogenic trihalomethanes (THMs) and other disinfection by-products during disinfection of source water. Total dissolved solids (TDS) can have an important effect on the taste and palatability of drinking-water. At very high levels, total dissolved solids may cause health problems in sensitive individuals. The presence of high levels of TDS may also be objectionable to consumers owing to excessive scaling in water pipes, heaters, boilers, and household appliances. Pathogens such as *Cryprosporidium* and *Giardia* are of concern due to their potential to cause adverse human health effects. The primary concern associated with turbidity is its effect on disinfection, because high levels have been shown to protect microorganisms from the action of disinfectants and to increase the chlorine and oxygen demand.

The mainstem Sacramento River, and major tributaries (the Yuba, Feather, and American rivers) consistently meet drinking water quality goals and objectives, suggesting achievement of the designated beneficial uses as sources of municipal and agricultural supply water. However, there were occasional exceedances of some goals and objectives:

- Primary MCLs for nitrate and nitrite, and secondary MCLs for TDS were not exceeded at any site. Dissolved concentrations of iron and manganese occasionally exceeded secondary MCLs in Arcade Creek (an urban creek in the Sacramento area), and in two agricultural drains (Sacramento Slough and Colusa Basin Drain). No exceedances of Secondary Drinking Water MCLs for chloride (250 mg/L) or sulfate (500 mg/L) were observed for any site.
- The Basin Plan limit for median fecal coliform numbers (200 MPN/100mL) was not exceeded at any site, and the maximum limit for single samples (400 MPN/100 mL) was exceeded only infrequently in the Sacramento River (8 of 157 samples), the American River (2 of 41 samples), and Cache Slough (1 of 6 samples).
- TOC concentrations measured in the Sacramento River at Colusa, Verona, and Freeport often exceed the Stage 1 D/DBP Rule treatment threshold of 2.0 mg/l. The 2.0 mg/L threshold is significant because exceedance of this threshold may require

utilities to remove up to 35% percent of TOC in their source water. It is not clear that the observed levels of organic carbon will result in a requirement for municipal drinking water suppliers to remove *additional* TOC in source water. The Stage 1 D/DBP Rule does not require such treatment if certain treatment technology requirements used, or if other water quality requirements are met in influent or treated water. Additionally, treatment technologies currently in use by many utilities are already able to remove ≥35% of source water TOC from Sacramento River water. Even if additional TOC removal is necessary, this requirement would not limit the water supply use.

- *Giardia* cysts were detected in 42% to 82% of samples collected from the mainstem Sacramento River and major tributaries, and in one of six Cache Slough samples. *Cryptosporidium* oocysts were detected in 6 of 51 samples from the mainstem Sacramento River. Although the analytical method used to monitor *Giardia* and *Cryptosporidium* in 1999-2000 is much improved (compared to the ICR method used previously), there remains a high degree of uncertainty associated with data for these pathogens. Due to the uncertainties associated with the analytical method and interpretation of the results, monitoring of these pathogens has been temporarily suspended by the SRWP.

The primary parameters of concern for drinking water quality (TOC, TDS, and pathogens) are largely unregulated by the Regional Water Quality Control Board (RWQCB) and the Water Quality Control Plan (Basin Plan). The combination of existing and future land use changes, and the resulting increases in point source and nonpoint source discharges in the Sacramento River watershed, has the potential to increase loadings of these largely unregulated parameters of concern. The RWQCB is currently implementing a work plan for the development of an effective drinking water policy. This policy is expected to address these parameters and establish water quality objectives for eventual inclusion in the Basin Plan.

PCBs and Organochlorine Pesticides in Fish Tissue

- Data collected by the SRWP indicates the need for continued monitoring to assess the potential for human health risks related to consumption of fish, particularly in the lower Sacramento River watershed. Concentrations of PCBs, DDTs, and dieldrin exceeded screening values in fish collected from eight locations, primarily in the lower watershed, indicating some potential human health risks to consumers of fish caught in this region.
- Monitoring of organochlorine compounds in fish tissue has been continued for 2000-2001 monitoring.

Sediment Toxicity

- No sediment toxicity was observed in any samples from the mainstem Sacramento River sites. Only one sample (collected at the Feather River at Nicolaus site in September 1998) was found to be toxic to *Hyallela* in bulk sediment tests (1998-2000 data). Although not conclusive, these results provide no evidence that suggests potential impairment of beneficial uses in the Sacramento River watershed.

- No spatial or temporal patterns of sediment toxicity were identified in the SRWP sediment toxicity data.
- This monitoring element was undertaken as a pilot project designed to evaluate the value of sediment toxicity testing in identifying potential sources of toxic pollutants, and to assess the occurrence and distribution of sediment toxicity. Based on the results of the 1998–2000 monitoring efforts, it was concluded by the Monitoring Sub-committee that data from this type of monitoring was difficult to interpret on a local or regional scale. Therefore, sediment toxicity testing was not ranked as a high priority tool for assessing the attainment of beneficial uses in the watershed. This pilot program was not continued in 2000-2001.

Bioassessment

- Available data indicate that the beneficial uses evaluated by bioassessment monitoring (i.e. aquatic life uses and habitat) are achieved to a fairly high degree in the Sacramento River mainstem, major tributaries, and in all of the smaller tributaries assessed to date (Deer Creek, Big Chico Creek, Mill Creek, Butte Creek). However, because appropriate sampling techniques and reference conditions are in the process of being developed for assessing biological communities in non-wadable river systems, these results should not be considered conclusive (particularly for the mainstem Sacramento River).
- There was a strong correlation between elevation and physical habitat and aquatic life metrics. Although the mainstream sites were in relatively good condition, there was a strong decrease in quality as we went downstream. Lower elevation sites were more impacted by sedimentation and had much lower diversity and less complex community structure. This finding contrasts with the results of toxicity testing, which did not identify a strong spatial pattern within tributary watersheds.
- The majority of sites evaluated had similar physical habitat characteristics and were considered to be in good to excellent condition. However, it is important to note that there is no physical habitat data for the non-wadable sites to compare and that these appear to be the most physically impacted sites.
- Macroinvertebrate communities at most sites were described as complex with a wide range of taxa represented. Macroinvertebrate communities were dominated by sensitive taxa at almost all sites. Because reference conditions and biocriteria have not been developed for the Sacramento River watershed, it is not clear how the sampled stream and river reaches compare to other systems and ecoregions. The dataset for the complete 1997-1999 sampling effort will contain three years of data from DFG, USGS and DWR. Together, these data are expected provide a baseline of biological information that will contribute to developing an Index of Biotic Integrity (IBI) for the Sacramento River watershed.
- Bioassessment monitoring has been continued in 2000-2001, with a shift to several new tributary watersheds. The Biological and Habitat Assessement Sub-Committee has recommended that SRWP bioassessment monitoring efforts in 2001 and 2002 should be focused toward developing reference conditions and baseline information in Sierra foothill ecoregion.

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I. Program Overview

Organization and Funding

The Sacramento River Watershed Program (SRWP) is an association of stakeholders in the Sacramento River watershed. These stakeholders include representatives of local municipalities and districts, state and federal agencies, agriculture, industry, landowners, environmental organizations, universities, technical consultants, and watershed conservancies. The SRWP was formed in 1996 and has functioned through a series of stakeholder meetings.

Formation of the SRWP was facilitated by the Sacramento River Toxic Pollutant Control Program (SRTPCP), a locally initiated effort led by Sacramento County and the Sacramento Regional County Sanitation District (SRCSD). The SRTPCP is a watershed-based approach to the management of toxic pollutants in surface waters of the Sacramento River watershed.

Funding for the SRTPCP is provided primarily by the federal government and is administered by USEPA Region IX. Local matching funds are provided by the Sacramento Regional County Sanitation District, and in-kind services are provided by several participating stakeholders. Additionally, significant public and private support of the program is being provided through the active participation of numerous representatives on the SRWP sub-committees. A portion of the SRTPCP funding was specifically designated to assist in the formation of the broader watershed program.

Program Goals and Objectives

The goal statement developed by the participating stakeholders for the SRWP in 1996 is as follows:

> ***SRWP Goal Statement***
> *To ensure that current and potential uses of the watershed's resources are sustained, restored and, where possible, enhanced while promoting the long-term social and economic vitality of the region.*

One of the primary tasks of the SRTPCP and the SRWP is the design and implementation of a water quality monitoring program for the watershed. In early stakeholder meetings, a Monitoring Sub-committee was formed to lead the development of the water quality monitoring program.

Monitoring Program Goals

The Monitoring Sub-committee established the following long-term goal for the SRWP water quality monitoring program:

SRWP Monitoring Program Goal
In coordination with other sub-committees and the larger stakeholder group, develop a cost-efficient and well-coordinated long term monitoring program within the watershed to identify the causes, effects and extent of constituents of concern that affect the beneficial uses of water and to measure progress as control strategies are implemented.

The SRWP water quality monitoring program is envisioned by the sub-committee to be a long-term (e.g. 20 year) effort that provides information to promote the understanding of conditions in the watershed and to assess the health of the watershed. The monitoring program is a dynamic activity that changes as information is accumulated and new information needs are identified. It is projected that the water quality program will be integrated with other resource monitoring activities, including biological communities, habitat, land use, etc. More in depth descriptions of the monitoring program are provided in the Phase 1 Monitoring Plan (LWA 1998a), and the Quality Assurance Project Plans for monitoring conducted from 1998 through 2001 (LWA1998b, 1999, and 2000).

The Monitoring Sub-committee established the following goal for the first year of the monitoring program, and retained this goal for the second year of monitoring:

SRWP Monitoring Program—Initial Goal
To assess conditions in the main stem of the Sacramento River through the collection of baseline information, with an emphasis on examining the degree to which beneficial uses are attained or potentially impaired.

The SRWP has made substantial progress towards meeting both the long-term and short-term goals for the monitoring program. The monitoring program developed by the SRWP through the stakeholder process is currently coordinating with a number of ongoing monitoring programs managed by federal, state, and regional public agencies. The collection and evaluation of baseline information for water quality parameters of interest to the SRWP is being accomplished directly through SRWP monitoring, and through cooperative data sharing with other monitoring programs conducted by the Department of Water Resources, the Central Valley Regional Water Quality Control Board, the U.S Geological Survey, the Sacramento River Coordinated Monitoring Program, and the City of Redding. Additionally, the program also compiles and reports water quality data generated prior to the initiation of SRWP monitoring in 1998. Evaluating the available information and identifying gaps in the data needed to assess the degree to which beneficial uses are achieved or potentially impaired in the watershed was (and continues to be) an integral part of the development of the monitoring program. The evaluation of water quality monitoring information documented herein is an extension of this ongoing process.

Objectives

The Monitoring Sub-committee also adopted long-term and short-term objectives. The long-term objectives include:

- Identification of available monitoring program elements which will provide information which we need to know to understand the condition of the watershed (i.e. to inventory the characteristics of the watershed).
- Identification of an approach for determining the relative health of the watershed (i.e. a means to assess and evaluate the meaning of the above information).

The short-term objectives developed by the sub-committee include:

- Identification of the monitoring goals and future uses for the data being collected, including:
    - Water quality characterization
    - Biological assessment
    - Long-term trend analysis
    - Compliance with applicable water quality regulations
- Identification of data needs and data quality objectives (i.e. to ensure that data collected will be useful, understandable, accessible, manageable, and scientifically valid).
- Coordination with other sub-committees of the SRWP (e.g. Toxics, Biological and Habitat, Education and Outreach).
- Coordination with the *Pilot Study to Integrate Ambient and Compliance Monitoring Programs in the Sacramento River Basin*.

Assessment of Beneficial Uses and Compliance with Water Quality Objectives

As stated above, the initial goal for the SWRP monitoring effort includes examining the degree to which beneficial uses are attained or potentially impaired. The existing and potential beneficial uses for the Sacramento River watershed are outlined in the water quality control plan (Basin Plan) for the Central Valley Region. The following are existing beneficial uses in the Sacramento River watershed, as defined in the Central Valley Region Basin Plan (CVRWQCB 1995):

- municipal and domestic water supply
- agriculture (irrigation and stock watering)
- industry (process, service supply, power)
- contact recreation
- non-contact recreation
- freshwater habitat
- migration

- spawning
- wildlife habitat
- navigation

Beneficial uses designated by the Central Valley Basin Plan (CVRWQCB 1994) for specific reaches within the Sacramento River basin are presented in Appendix A.

Another purpose of the SRWP monitoring program is the comparison of observed ambient concentrations with adopted water quality objectives and criteria. Numeric and narrative objectives have been adopted in the Basin Plan for the Sacramento River watershed and in the National Toxics Rule (NTR)(for selected toxic pollutants in California). Numeric water quality objectives that have been adopted to date in the Basin Plan for the Sacramento River watershed are summarized in Appendix B. Water quality criteria for toxic pollutants for the watershed are included in the California Toxics Rule (CTR)(USEPA 2000). The adopted NTR objectives and CTR criteria are summarized in Appendix C. The CTR criteria are largely the same as the current USEPA recommended national ambient water quality criteria.

The Regional Water Quality Control Boards for the Central Valley and San Francisco Bay have developed lists of impaired waters which will not meet water quality objectives after implementation of technology-based controls for point sources and best management practices for nonpoint sources. These lists are required under Section 303(d) of the Clean Water Act. The portions of the lists that address the Sacramento River and its tributaries and the Sacramento-San Joaquin Delta are provided in individual data review sections. Management plans that establish Total Maximum Daily Loads (TMDLs) for listed pollutants must be prepared for all waters contained on the 303(d) lists. TMDLs must lead to compliance with adopted water quality objectives.

Monitoring Program Description

The 1999-2000 SRWP monitoring program includes chemical, physical, biological and toxicological monitoring elements. The proposed program augments and coordinates with a number of other monitoring efforts that are ongoing in the watershed, including the USGS National Water Quality Assessment Program (NAWQA), the Sacramento Coordinated Water Quality Monitoring Program (CMP), and monitoring efforts by the Department of Water Resources (DWR), Department of Pesticide Regulation (DPR), City of Sacramento, and City of Redding.

The SRWP Monitoring Program was developed through an interest-based, coordinated approach. Managers of major water quality monitoring activities in the watershed were identified and invited to participate on the Monitoring Sub-committee. Numerous Sub-committee meetings were held to discuss and evaluate considerations in the development of the first year SRWP monitoring program. Existing monitoring programs were described and opportunities for coordination and integration were identified. Parameters of interest, candidate monitoring locations, monitoring frequency, sample collection methods, appropriate analytical methods, quality assurance/quality control, and program costs were evaluated by the Sub-committee.

Several possible monitoring approaches were discussed and evaluated during development of the proposed program design, including:

1. Mainstem river emphasis, with most parameters monitored.
2. More stations sampled with limited set of parameters monitored, with emphasis on parameters that are currently monitored by existing major programs.
3. More parameters monitored at fewer sites, with emphasis on existing major program sites.
4. Selected stations, parameters, and analytical methods chosen to facilitate an initial evaluation of beneficial use attainment in the watershed, with main stem and major tributary emphasis.

Ultimately, the fourth approach was selected by the Monitoring Sub-committee as the starting point for the SWRP monitoring program. The emphasis on the main stem Sacramento River was favored to provide a foundation to which other programs and future additions to the SRWP Monitoring Program could be connected. This approach was chosen to provide best achievable information using conventional monitoring tools that would be most immediately useful in evaluating beneficial use attainment and potential impairment, and in the identification of management issues. Monitoring parameters and methods were selected which best addressed these issues. Sites were chosen to match with ongoing monitoring, to provide information at the mouths of major tributaries, and to coincide with flow monitoring stations.

The sites and parameters selected, monitoring frequency, sample collection and analytical methods, quality assurance/quality control, data management, and costs for the first year monitoring program are discussed below.

Sampling Sites

Site selection criteria were developed by the Monitoring Sub-committee to determine the monitoring locations for the SWRP monitoring program. Criteria for initial selection of sites included the following:

- existing sampling station
- flow gauging station
- land use (i.e. major drainage type (agriculture, municipal, industrial, mining, etc.)
- streamflow
- critical habitat area
- site access constraints
- sampling access constraints
- potential water quality impairment
- previous water quality data
- in existing watershed program

After an initial screening using the criteria listed above, the selection was narrowed to include sites along the main stem of the Sacramento River and at the mouths of major tributaries. Major tributaries were identified using existing streamflow data. Main stem sites were selected to facilitate coordination with existing programs and to provide information below major reservoirs. Major tributaries were selected based on the magnitude of flow into the main stem. The three major tributaries into Lake Shasta were included to capture these inputs and large tributary areas.

In addition to the main stem work, three smaller Sierra Nevada tributaries (Mill Creek, Big Chico Creek, and Deer Creek) were selected for special studies for Year 1 monitoring (1998-1999). These same tributaries were monitored again in 1999-2000. The Sub-committee included these tributaries on a demonstration basis to encourage monitoring in these areas and to coordinate with the monitoring activities of the Department of Water Resources, Northern District.

The SRWP monitoring performed in 1999-2000 was largely a continuation of the program implemented in June, 1998. The primary changes to the program were the addition of several new sites monitored for water chemistry parameters and fish tissue, and a few new parameters were monitored. Monitoring for several parameters was initiated at two new sites: Sacramento River near Hamilton City, and at Putah Creek. The Hamilton City site was added to better characterize the long stretch of the mainstem Sacramento River between Red Bluff and Colusa. Fish tissue monitoring was added at one new site (Putah Creek) to better characterize the human health risks from relatively high concentrations of mercury and organochlorine pesticides reported at this site. Additionally, fish tissue monitoring was discontinued at three upper watershed sites (the Pit River above Shasta, the McCloud river above Shasta, and the Sacramento River above Shasta). Fish tissue monitoring at these locations was discontinued because concentrations of pollutants in trout caught from these sites did not appear to warrant continued monitoring for potential human health risks, and because the program shifted focus to largemouth bass and white catfish, which tend to accumulate higher concentrations of pollutants than trout, and are typically caught only in the lower watershed. Monitoring for three pesticides classes in water was also initiated for the 1999-2000 monitoring year. Organophosphate pesticides, carbamate pesticides, and triazine pesticides were monitored at a total of 6 sites with evidence of (or significant potential for) water quality degradation due to these parameters.

The 1999-2000 SRWP monitoring program included sample collection at a total of 81 locations in the Sacramento River watershed. Eight of these sites are located on the main stem of the Sacramento River, ranging from the Sacramento River below Keswick Reservoir (the location farthest upstream) to the Sacramento River at River mile 44 (the location farthest downstream). The remaining 73 sites in the 1999-2000 monitoring program are located on tributaries to the Sacramento River, with 48 sites located on 3 tributaries selected for more intensive monitoring under the special tributary monitoring program. The SRWP monitoring sites cover over 300 miles of the Sacramento River system and represent a drainage area of over 23,000 square miles. Table 1 lists each of the sampling sites selected for the SWRP Year 2 monitoring program, including a description of the location, and the agency or agencies responsible for monitoring at the site. The site locations are illustrated in Figure 1.

Monthly or semi-monthly monitoring was conducted at 24 of the sites, including 8 of the main stem sites and 17 of the tributary sites. Monitoring at the other sites consisted of either (a) one-time biological monitoring events (at 42 sites), or (b) two sediment toxicity events (at 10 sites). Sampling was also coordinated with additional monitoring by DWR at the 36 sites in the three special tributary watersheds. Aquatic toxicity monitoring performed as part of the special tributary monitoring element is performed in accordance with the procedures described herein and in the project Quality Assurance Project Plan (LWA 1999)

Table 1. SRWP 1999-2000 Monitoring Sites

Site Description	Site Type	Agencies Performing Supplemental Ongoing Monitoring[1]
Pit River above Lake Shasta	tributary	DWR
McCloud River above Lake Shasta (3 sites)	tributary	DWR
Sacramento River above Lake Shasta	tributary	DWR
Spring Creek Powerplant discharge to Keswick Reservoir	tributary	
Sacramento River below Keswick Reservoir	mainstem	City of Redding
Sacramento River at Bend Bridge near Red Bluff	mainstem	NAWQA, DWR
Mill Creek (9 sites)	special tributary	DWR
Deer Creek (12 sites)	special tributary	DWR
Big Chico Creek (27 sites)	special tributary	DWR
Sacramento River at Hamilton City	mainstem	DWR
Sacramento River at Colusa	mainstem	DWR
Butte Creek (9 sites)	tributary	DWR
Sacramento Slough	tributary	NAWQA, DWR
Colusa Basin Drain	tributary	DWR
Yuba River at Marysville	tributary	DWR
Feather River near Nicolaus	tributary	DWR
Sacramento River at Verona	mainstem	DWR
Sacramento River at Veterans Bridge	mainstem	CMP
Arcade Creek	tributary	City of Sacramento
American River at J Street	tributary	
American River at Discovery Park	tributary	CMP
Sacramento River at Freeport	mainstem	NAWQA, CMP
Sacramento River at River Mile 44	mainstem	CMP
Cache Creek at Rumsey	tributary	USGS
Putah Creek	tributary	
Cache Slough near Ryers Island Ferry	tributary	

(1) USGS = U.S. Geological Survey
NAWQA = USGS National Ambient Water Quality Assessment Program
DWR = Department of Water Resources
CMP = Sacramento Coordinated Monitoring Program

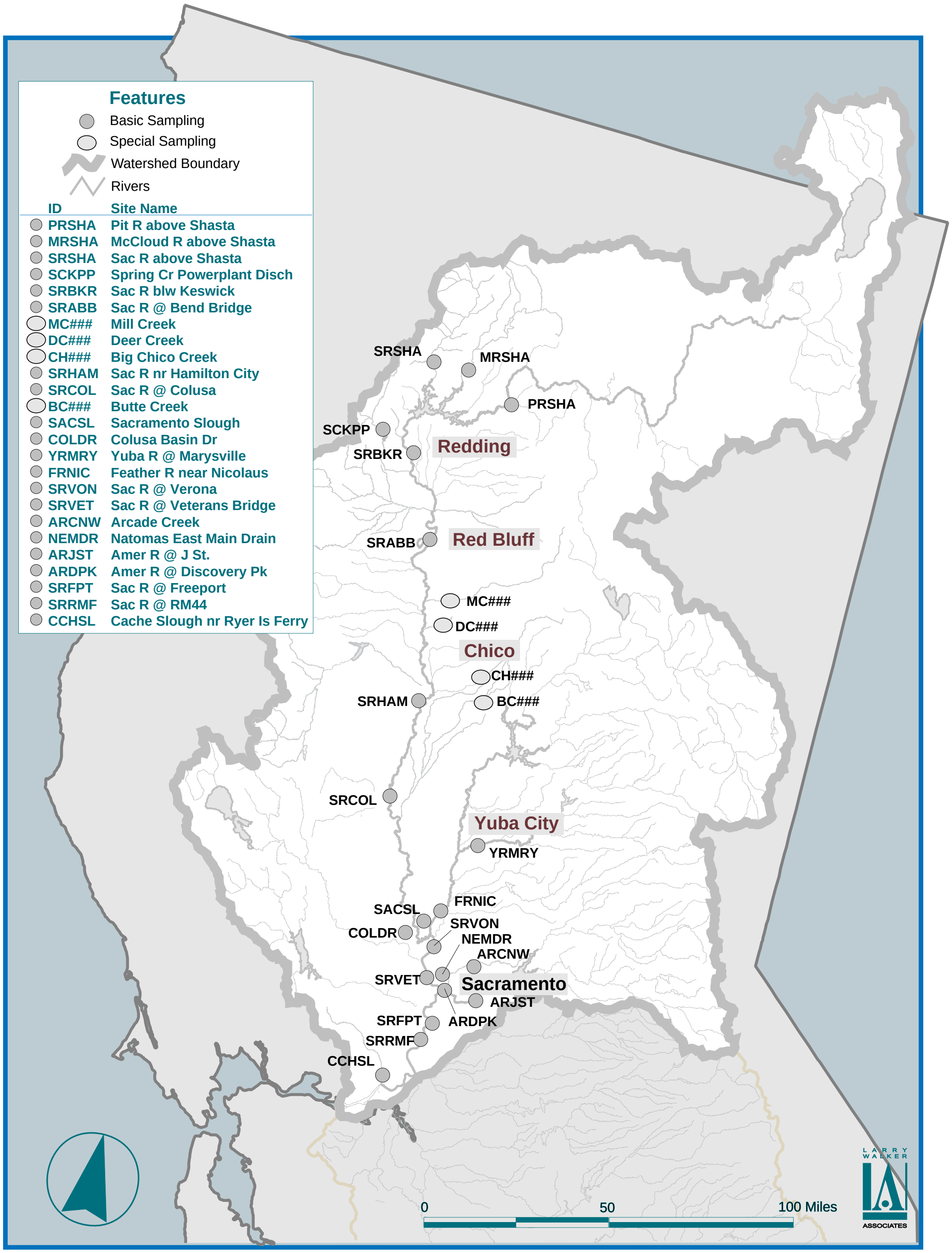

Figure 1. SRWP Monitoring Program Sampling Sites

Monitoring Parameters

The following environmental monitoring elements are included in the SRWP monitoring program:

- Mercury, PCBs, and chlorinated pesticides in fish tissue
- Trace metals in water
- Pesticides in water
- Toxicity in water and sediment
- Pathogens in water
- Organic carbon in water
- General constituents (minerals, nutrients, solids, turbidity, hardness) in water
- Benthic invertebrates and habitat characterization
- Benthic algae (periphyton)

Specific individual parameters measured by the SRWP monitoring effort are listed in Table 2. The rationale for monitoring these parameters is discussed below.

Fish Tissue Monitoring. Mercury and certain organic contaminants (including DDT and PCBs) readily accumulate in the food web, resulting in concentrations in fish tissue which may be of concern to humans and wildlife. Monitoring levels of these pollutants in fish provides an effective way to assess the degree of contamination of the Sacramento River system. Because fish accumulate contaminants throughout their life span and their habitat, measurements of contaminant concentrations in fish tissue provide an indication of average conditions over space and time. Fish tissue data can be useful in the determination of long term levels and trends of bioaccumulative contaminants (such as mercury, DDT and PCBs) in the watershed. This long-term data set can be used to measure the effectiveness of activities to control these pollutants.

Trace metals in water. Low levels of trace metals in water can affect the growth, reproduction and/or survival of sensitive aquatic species. Trace metals of potential concern to aquatic life in the Sacramento River system include copper, cadmium, zinc, lead, chromium (VI), selenium, silver, nickel, and arsenic. Mercury and arsenic are metals that have been found to be present in the Sacramento River and tributaries at levels of potential concern to human health. Several programs are currently under way in the Sacramento River watershed to monitor trace metals levels at various locations, including the Sacramento Coordinated Water Quality Program, the USGS National Water Quality Assessment for the Sacramento River, DWR’s tributary monitoring and Off-site Storage Investigation programs, and seasonal monitoring by the US Bureau of Reclamation and the US Environmental Protection Agency near Keswick. The SRWP trace metal monitoring supplements the existing data with information for three additional locations. Data obtained will be used to quantify ambient levels of metals in the Sacramento River watershed and to assess whether these levels are adversely affecting uses.

Pesticides in water. Low levels of pesticides in water can affect the growth, reproduction and/or survival of sensitive aquatic species. Pesticides of potential concern to aquatic life in the Sacramento River system include organophosphate (OP), carbamate, and triazine pesticides. These classes of pesticides are responsible for the presence of several Sacramento River watershed waterbodies on the 303(d) list of impaired waterbodies. Several programs are currently under way in the Sacramento River watershed to monitor pesticides at various locations in the Sacramento River watershed, including programs administered by the California Department of Pesticide Regulation (DPR), the California Regional Water Quality Control Board, and the USGS National Water Quality Assessment for the Sacramento River. SRWP pesticide monitoring will supplement the existing data with information for 10 additional locations. Locations for pesticide monitoring were selected on the basis of documented use of these pesticides upstream from the locations monitored, on pesticide-caused toxicity detected at these streams/rivers, and on inclusion for pesticides on the 303(d) list of impaired water bodies. Data obtained will be used to quantify ambient levels of pesticides in the Sacramento River watershed and to assess whether these levels are adversely affecting uses.

Toxicity in water and sediment. Ambient samples of water and sediment can be tested in the laboratory for toxicity to provide an indication of the conditions that exist in the natural environment. Standard test species and test procedures are used to provide reliable and comparable results. Toxicity is deemed to occur when test species are significantly affected by exposure to ambient water or sediment as compared to laboratory controls. Toxic effects may include reduced growth or reproduction, and increased mortality of test species. Effects may occur rapidly over a period of hours to four days (acute toxicity) or may occur over a longer period (chronic toxicity). For the SRWP monitoring program, the results of toxicity testing are used primarily to trigger further investigations to determine the cause of observed toxicity. These toxicity identification investigations include the consideration of a number of factors, including contributing watershed characteristics, chemical characteristics of the water, biology, and additional toxicity testing wherein classes of toxicants are selectively removed or rendered non-toxic. Results from these weight-of-evidence investigations are useful in identifying potential water quality problems in the watershed. Toxicity testing in water is conducted at 27 locations throughout the watershed. Sediment toxicity testing is conducted at nine locations under the SRWP. Sites for aquatic and sediment toxicity monitoring were selected to provide an overall survey of the distribution of toxicity in the watershed, and to coordinate with existing monitoring programs.

Pathogens in water. Pathogens are disease-producing organisms (protozoa, bacteria, and viruses) which adversely affect the quality of drinking water and/or may pose human health risks for water contact recreation. Two pathogens of particular concern are *Giardia lamblia* and *Cryptosporidium parvum.* Water treatment agencies are currently required to remove or inactivate at least three logs of *Giardia* (99.9%) and effective December 20091, will be required to remove two logs of *Cryptosporidium* (99%) (Interim Enhanced Surface Water Treatment Rule, USEPA 1998). Although most facilities utilizing conventional or direct filtration remove at least 2 logs of *Cryptosporidium* (*ibid.*), this organism is resistant to disinfection with chlorine, and high levels of *Cryptosporidium* in source waters may require water supply agencies to switch to ozone or other disinfectants. Although data sets exist for the Sacramento River near Redding and in the Sacramento River below Sacramento, data on the levels of these pathogens are otherwise lacking for most of the Sacramento River system. Monitoring efforts by the Department of Water Resources, and the Metropolitan Water District in the lower end of the watershed near Sacramento to assess levels of *Cryptosporidium*, *Giardia*, and coliform organisms (indicators of fecal contamination) were completed in April, 1998, but no final report is expected to be released. The results of a second DWR study conducted in 2000 may be released in summer or fall of 2001. The SRWP pathogen monitoring effort extends monitoring for these specific parameters to several additional upstream locations in the Sacramento River watershed. Coliform bacteria are monitored primarily as indicators of other pathogenic organisms, and are monitored at the same locations as *Cryptosporidium* and *Giardia*. It was anticipated that SRWP data would be used to determine the magnitude and extent of levels of these pathogens in the main stem of the river below major dams.

Organic carbon in water. The organic content of water (measured as total and dissolved organic carbon) is a parameter important to drinking water suppliers. High levels of organic compounds in source waters contributes to the production of disinfection by-products (trihalomethanes and halo-acetic acids) as a result of conventional water treatment. Some of these by-products are carcinogenic and pose human health problems at relatively low concentrations. Additionally, the Stage 1 Disinfectants and Disinfection By-Product Rule (effective December 2001) requires drinking water systems to meet specified total organic carbon (TOC) removals dependant on source water TOC concentrations. For these reasons, baseline data on typical organic carbon levels and seasonal variability of those levels in the Sacramento River system are important to the assessment of drinking water uses. SRWP monitoring for organic carbon augments fairly extensive monitoring already being performed by the USGS NAWQA program, the City of Sacramento and the Department of Water Resources.

General constituents (suspended and dissolved solids, hardness, turbidity, minerals, and nutrients) in water. These conventional water quality characteristics are important to the evaluation of the attainment of a variety of uses, including drinking water supply, recreation, aesthetics, aquatic habitat, and agricultural supply. Data on these parameters is available from a number of programs, including USGS NAWQA, the Sacramento Coordinating Monitoring Program and the Department of Water Resources. SRWP monitoring augments the ongoing data collection efforts for some of these constituents. SRWP monitoring for minerals and nutrients was conducted at only one site for each of these categories.

Benthic invertebrates. Benthic invertebrates are the aquatic insects and other organisms that live along the bottom of water bodies. Procedures have been developed and recently refined to standardize the assessment of biological habitat and benthic communities for use as a monitoring tool (Plafkin et al. 1989, CDFG 1996, DWR 1997). Information on invertebrate diversity, abundance, species richness, and other community metrics collected at specific sites is compared against expected conditions (or reference stream conditions) to evaluate the relative health of the biological community at that location. This information is used in combination with chemical concentration and toxicity data to assess ecosystem conditions at various locations. Different procedures are used depending on the characteristics of the stream (i.e. wadable versus non-wadable). This monitoring tool can be effectively used by citizen monitoring groups in smaller tributary watersheds. The Department of Water Resources and Department of Fish and Game are working actively with a number of tributary watershed groups to provide education and training regarding the assessment methods. Data from the SRWP monitoring program is intended to supplement and integrate results from projected tributary efforts.

Algae. Levels of algae in surface waters may be used to assist in the evaluation of the health of an ecosystem. Community analysis of algal species can be used in a fashion similar to benthic invertebrate data. Species diversity, number of species, presence of sensitive species and other measures are used in the evaluation. Elevated algal levels indicate a biologically productive, organically enriched aquatic environment. Detrimental effects of elevated algal levels may include poor water clarity, aesthetic impairment, reduced dissolved oxygen levels and degraded drinking water quality. Data on community parameters and algal biomass will be used to assess these beneficial use issues and to establish a baseline for future trend monitoring.

Table 2. Parameters Measured for the SRWP 1999-2000 Monitoring Program

Chemical, and Physical Water Quality Characteristics	
Trace Metals	*General Constituents*
Arsenic, total and dissolved	Alkalinity
Cadmium, total and dissolved	Chloride
Chromium, total	Iron
Copper, total and dissolved	Manganese
Lead, total and dissolved	Calcium
Mercury, total	Magnesium
Nickel, total and dissolved	Silica
Selenium, total	Sodium
Silver, total	Sulfate
Zinc, total and dissolved	Potassium
	Total Suspended Solids
Field Parameters	Hardness
Temperature	Turbidity
pH	Total Dissolved Solids
Dissolved Oxygen	Dissolved Organic Carbon
Conductivity	Total Organic Carbon
Nutrients	*Pesticides*
Total Ammonia	Organophosphate Pesticides
Nitrate & Nitrite	Carbamate Pesticides
Total Kjeldahl Nitrogen	Triazine Pesticides
Ortho-Phosphate	
Total Phosphorus	
Microbiological Water Quality Characteristics	
Cryptosporidium parvans	Total coliform bacteria
Giardia lamblia	Fecal coliform bacteria
Aquatic Toxicity	
Ceriodaphnia reproduction	*Ceriodaphnia* mortality
Sediment Toxicity	
Hyalella mortality	*Ceriodaphnia* reproduction
	Ceriodaphnia mortality
Biota	
Fish Tissue	*Benthic Invertebrates*
Mercury	Community abundance and diversity metrics
Chlorinated pesticides	
PCBs	*Algae*
	Community abundance and diversity metrics

Sampling Frequency and Schedule

The sample collection frequency varies by location and the parameter to be tested, as summarized below:

- *Basic water quality monitoring*—frequency of sampling was generally monthly for main stem sites, and monthly or semi-monthly for selected tributary sites.
- *Pathogens*—frequency of sampling was monthly at 6 main stem/large tributary sites, and semi-monthly at one main stem site (Sacramento River at Freeport) and one tributary site (Cache Slough).
- *Chronic water column toxicity*—sampling was generally conducted monthly for main stem sites, and monthly or semi-monthly for tributary sites.
- *Sediment toxicity*—sampling was conducted twice annually at all sites monitored.
- *Fish tissue*—sampling was conducted once annually for all sites monitored.
- *Bioassessment*—biota sampling and physical habitat assessment was conducted once annually for all sites monitored.

A breakdown of sampling sites, sampling frequency, and parameters to be analyzed are provided in Table 3.

Table 3. Summary of Sampling Sites, Sampling Frequency, and Parameters.

1999-2000 SRTPCP MONITORING
Sacramento River Watershed Program

Sampling Station	Water Chemistry																								Path-ogens		Aquatic Toxicity		Sediment		Fish Tissue		Bioassessment (e)				
	Hg (total)	MeHg (total)	As (total & dissolved)	Cd (total & dissolved)	Cr (total)	Cu (total & dissolved)	Pb (total & dissolved)	Ni (total)	Se (total)	Ag (total)	Zn (total & dissolved)	TSS	Hardness	Turbidity	Alkalinity	TOC	DOC	TDS	DO,T,pH, EC	Nutrients (a)	General Minerals (b)	OP pesticides	carbamate pesticides	triazines	Giardia/Crypto	Total and Fecal Coliforms	Ceriodaphnia	WC Tox Followup (c)	Toxicity (Cerio and Hyallela)	Sediment Toxicity Followup (d)	Mercury	PCBs & chlor. pest.	Benthic Inverts, wadable	Benthic Inverts, nonwadable	Algae	Sampling and Physical Habitat	Special Tributary Monitoring
Pit R. above Shasta												6		6		6	6	6	6								6										
McCloud R. above Shasta												6		6		6	6	6	6								6						1 (g)			1 (g)	
Sac. R. above Shasta												6		6		6	6	6	6								6										
Spring Ck. PP Discharge	6											6		6		6	6	6	6								6										
Sac. R. below Keswick	8		8	8	8	8	8	8	8	8	8	8		12		12	12	12	12							12	12				1	1					
Sac. R. at Bend Br	12			12		12					12	12		12		12	12	12	12						12	12	12		2	2	1	1					
Mill Creek																																	6 (h)			6 (h)	12 (f)
Deer Creek																																	10 (i)			10 (i)	12 (f)
Big Chico Creek																																	12 (j)			12 (j)	12 (f)
Sac. R. near Hamilton City	12			12		12					12	12		12		12	12		12			12			12	12	12		2	2	2	2		1	1	1	
Sac. R. @ Colusa														12				12				12			12	12	12		2	2	2	2		1	1	1	
Butte Creek																											6						6 (k)			6 (k)	
Sac. Slough	12					12						12	3		3	12	12		12	12	12	12	12				9		2	2	2	2					
Colusa Basin Dr	12					12						12	3		3	12	12		12	12	12	12	12				9		2	2	1	1					
Yuba R. at Marysville	12											12				12	12		12										2	2				1	1	1	
Feather R. near Nicolaus	12											12		12		12	12	12	12						12	12	12		2	2	2	2		1	1	1	
Sac. R. at Veterans Br.														12				12			12	12			12		12		2	2	2	2					
Arcade Creek	12					12						12				12	12		12	12	12	12	12	12			12							1	1	1	
Natomas East Main Drain																															2	2					
American R. at J St.																													2	2	2	2		1	1	1	
American R. at Discovery Pk																											12				2	2					
Sac. R. at Freeport														12				12							6		12		2	2							
Sac. R. at RM44														12	12	12	12	12		12											6	6					
Putah Creek																															1	1					
Cache Creek at Rumsey																																					
Cache Sl. near Ryers Ferry	6		6	6	6	6	6	6	6	6	6	6		6		6	6	6	6		6				6	6	6				2	2					

Table Notes: Numeric entries indicate number of samples per year at each location, unless noted otherwise.
(a) Nutrients include nitrogen compounds (nitrite, nitrate, ammonia, TKN) and phosphorus compounds (orthophosphate, total).
(b) General minerals include alkalinity, chloride, iron, manganese, calcium, magnesium, silica, sodium, sulfate and potassium
(c) Toxicity follow-up consists of chemistry and TIE testing that has no fixed frequency.
(d) Sediment Toxicity Followup consists of TIEs and/or chemical analyses of selected samples for metals and organic compounds.
(e) Bioassessment monitoring includes both physical habitat and biological assessments
(f) Special Tributary Sampling
(g) Bioassessment monitoring performed at 1 reach (one event) on McCloud River.
(h) Bioassessment monitoring performed at 6 reaches (one event each) on Mill Creek
(i) Bioassessment monitoring performed at 10 reaches (one event each) on Deer Creek
(j) Bioassessment monitoring performed at 12 reaches (one event each) on Big Chico Creek
(k) Bioassessment monitoring performed at 6 reaches (one event each) on Butte Creek

II. Data Review

The purpose of this data review is to present the results of monitoring performed by the SRWP and coordinating programs, and to present the critical results of evaluation of these data. This review is based on data compiled for the period 1994 through 2000. The primary data considered and presented for this review were generated by the following programs:

- The Sacramento River Watershed Program (SRWP) (http://www.sacriver.org)
- The Sacramento River Coordinated Monitoring Program (CMP) (LWA 2001),
- The City of Redding NPDES monitoring program,
- USGS National Assessment of Water Quality (NAWQA) for the Sacramento River (http://water.wr.usgs.gov/sac_nawqa/index.html),
- Department of Water Resources (Northern District) Intensive Tributary Monitoring Program (http://wwwdpla.water.ca.gov/nd/index.html),

Data from these programs were pooled for subsequent evaluations, presentation of summary data (e.g. summary statistics), and plots of data, unless stated otherwise. Additionally, selected results were also considered and evaluated from a number of other monitoring studies[1], including:

- Several Regional Board studies on mercury, trace metals, OP pesticides, and toxicity
- The San Francisco Estuary Regional Monitoring Program for Trace Substances (http://www.sfei.org),
- Department of Water Resources Municipal Water Quality Investigations (MWQI) monitoring program (http://wwwdpla.water.ca.gov/supply/sampling/mwq/main.htm),
- Department of Pesticide Regulation Surface Water Data Base (http://www.cdpr.ca.gov/docs/surfwatr/surfdata.htm)
- USGS National Water Quality Assessment (NAWQA) for the San Joaquin River (http://water.wr.usgs.gov/sanj_nawqa/),
- USGS Trace Metals and Mercury Transport Studies (Alpers *et al*. 1999 and 2000, Domagalski 1998),
- The State Water Resources Control Board's Toxic Substances Monitoring Program (TSMP) (http://www.swrcb.ca.gov/programs/smw/).

The review of data from the 1999–2000 SRWP monitoring effort is organized into the following general categories:

- Mercury in water and fish tissue
- Aquatic toxicity

[1] Specific studies and reports are referenced in following data review sections.

- ♦ Drinking water parameters of concern (organic carbon, minerals, dissolved solids, nutrients, pathogens)
- ♦ Trace metals
- ♦ Organochlorine pesticides and PCBs in fish tissue
- ♦ Sediment toxicity
- ♦ Bioassessment

The evaluations presented within each data review category are designed specifically to address the goals of the SRWP monitoring program. For each data review category, an overview of relevant monitoring programs and evaluations of spatial and temporal trends were performed to support the SRWP goal of collecting and evaluating water quality data for the purpose of characterizing baseline conditions in the watershed. Due to the limitations of the currently available data (e.g. only a few years data for most parameters, different monitoring periods for different programs, high percentages of data below detection, very few data for same sites and parameters), formal statistical analysis of the spatial and temporal trends would be difficult and very resource-intensive, and would provide little additional useful information for the SRWP. The discussions of general trends are therefore qualitative and descriptive and are not characterized as statistically significant. Summary statistics and time series plots of chemical physical, and microbiological water quality characteristics were also prepared and are provided in Appendix E and Appendix G, respectively. If appropriate for the specific data category, a semi-quantitative assessment was performed of the relative importance of the loads of selected pollutants to the Delta.

Evaluation of Attainment and Potential Impairment of Beneficial Uses

Comparisons with applicable water quality criteria, objectives, and other advisory criteria were performed as a preliminary evaluation of the degree to which beneficial uses of the Sacramento River watershed are attained or potentially impaired. Concentrations in water are compared to California Toxics Rule (CTR) criteria, EPA Maximum Contaminant Levels (MCLs) for drinking water, and Central Valley Basin Plan objectives. Concentrations of mercury and organic compounds in fish tissue were compared to various screening values developed by several different state and federal regulatory agencies. As a rule, these regulatory criteria and other limits define what are believed to be “safe levels”, rather than thresholds of adverse effects. Because these limits are conservative by design, individual exceedances are not necessarily predictive of actual impairments of beneficial uses. For the purpose of these evaluations, concentrations that exceed these regulatory limits in water or tissue are considered indicators of *potential* impairment of beneficial uses. Cases where concentrations clearly do not exceed regulatory limits indicate that beneficial uses are not being impaired by a specific constituent, but do not provide unequivocal evidence that a specific beneficial use is being fully attained. The results of these comparisons to regulatory criteria and other limits were also evaluated for consistency with the State Water Resources Control Board’s 303(d) list of waterbodies which the State considers to be impaired and not attaining beneficial uses.

Statement of Data Quality

Data presented in this report have been reviewed and validated as required by the Quality Assurance Project Plan for the SRWP. In general, data collected by the SRWP and cooperating programs are adequate for the purposes intended and the evaluations presented in this review. A detailed review of data quality is presented in Appendix D of this report.

A. Mercury Data Summary

Monitoring results for the Sacramento River Watershed Program (SRWP) for the period June 1998 through May 2000 and for primary coordinating programs (USGS NAWQA, Sacramento River Coordinated Monitoring Program, City of Redding NPDES monitoring, and Department of Water Resources) are presented and summarized in this section. Data are evaluated for spatial and temporal trends, and summary statistics are also provided in Appendix E. Data are also compared to adopted water quality objectives and to advisory criteria to evaluate predicted attainment of beneficial uses and potential impairment of these uses in the watershed. Qualitative comparisons of mass loads from the Sacramento River watershed and other major Delta inputs are used to evaluate the relative contributions of mercury to the San Francisco Bay – Sacramento/San Joaquin Delta system.

i. Background and Available Data Overview

The sources of data utilized for this report are summarized in Table 4. The monitoring locations for the primary data considered for this report (USGS NAWQA, Sacramento River Coordinated Monitoring Program, City of Redding NPDES monitoring, the California Department of Water Resources, and the Sacramento River Watershed Program) are illustrated in Figure 2.

Table 4. Mercury monitoring programs (water column and fish tissue) in the Sacramento River Watershed

Program	Monitoring Period(s)	Parameters	# of locations & geographic reference
SRWP	6/98–5/00	▪ Total Hg in water ▪ Total Hg in fish tissue	3 water column sites: 2 upper watershed, and 1 in lower watershed; 13 fish tissue sites on Sacramento River and major tributaries
SRWP Special Study (USGS)	1/19/00, 2/20/00	▪ TSS, total Hg, and methylmercury in water	Sac. R. at bend Bridge and Woodson Bridge, Antelope Creek, Elder Creek, and Mill Creek
Sacramento River Mercury Control Planning Project (LWA 1997)	3/95–2/96	▪ Total and filtered Hg and MeHg, and TSS in water ▪ Hg and MeHg in benthic invertebrates and fish	7 water column sites on Sacramento River, Feather River, and Yuba River. MeHg at selected sites. 55 benthic invertebrate and 25 fish sites on Sierra tributaries to the Sacramento River.
Sacramento River CMP (SRCSD)	12/92–6/00	▪ Total and dissolved Hg in water	5 sites on Sacramento and American rivers in Sacramento metropolitan area
USGS Mercury Transport Study (Roth et al. 1998)	6/96–5/97	▪ Total, dissolved, and colloidal Hg in water	6 sites on Sacramento River and 7 sites on selected tributaries.
Sacramento River Basin NAWQA (USGS)	2/96–4/98	▪ Total Hg and MeHg in water ▪ Total Hg in sediments	12 Hg sites (5 MeHg sites), distributed throughout watershed
USGS (Domagalski 1998)	2/96–2/97	▪ Total Hg and MeHg in water ▪ Total Hg in sediments	11 water column and 17 sediment sites on the Sacramento River and major tributaries.
CVRWQCB (Slotton et al. 1997)	Spring, 1996	▪ Hg in benthic invertebrates.	38 sites in the Cache Creek watershed
CVRWQCB (Foe and Croyle 1998)	10/93–4/95, 1996-1998	▪ Total and dissolved Hg, and TSS in water	22 sites in major Delta tributaries, and 10 additional sites in Cache Ck watershed
City of Redding	1/98–5/00	▪ Total Hg in water	1 site at Sacramento River below Keswick Dam
SF Estuary Regional Monitoring Program	1989–1997	▪ Total and dissolved Hg in water ▪ Total Hg in fish tissue	18 Bay-Delta sites, including Sacramento River and San Joaquin River at the Delta terminus
Special Tributary Program (DWR)	6/98–5/99	▪ Total Hg in water ▪ Total Hg in fish tissue	13 water column sites and 8 fish tissue sites on Mill Creek, Big Chico Creek, and Deer Creek

ii. Spatial Distributions & Patterns

Note: this evaluation compares summary data for monitoring periods that vary for individual sites, e.g. one location may have data for 1996 through 2000, while another location may have data only for 1998-2000. The specific monitoring periods for each location are documented in Appendix E (Summary Statistics). Fish tissue data reviewed in this section are also presented in Appendix E.

Water Column

Total water column mercury concentrations in the mainstem Sacramento River generally increase with distance downstream from the Keswick Reservoir discharge (Figure 3). A significant proportion of the increase appears to occur between Bend Bridge and Colusa, with an approximately two fold increase in median concentrations (from 2.0 ng/L to 4.6 ng/L). Concentrations of mercury in Mill Creek, a tributary that enters the Sacramento River between Bend Bridge and Colusa, are significantly higher than those in the mainstem Sacramento River, and may contribute significantly to the observed increase in mainstem mercury. The first year of mercury results for Sacramento River at Hamilton City (between Bend Bridge and Colusa, and below Mill Creek) appears to confirm this conclusion: for the 1999-2000 monitoring year the median mercury concentration at the Hamilton City site was 1.8 ng/L vs. 1.4 ng/L at Bend Bridge. Median concentrations from 7.4 ng/L to 42.3 ng/L were measured at different Mill Creek sites in 1998-99 monitoring by DWR, with maximum concentrations as high as 222 ng/L at one location. Mercury concentrations in Deer Creek and Big Chico Creek were substantially lower (medians between 0.3 ng/L and 1.1 ng/L) than in the mainstem Sacramento River or Mill Creek. An SRWP special study conducted in 2000 by USGS (Domagalski 2000) to identify potential sources of the observed increase in mercury between Red Bluff and Colusa confirmed that Mill Creek was a significant source of mercury during some storm events. This same study concluded that there were also other significant sources of mercury in this stretch of the river. It was determined that Elder Creek (on the West side of the valley) and Antelope Creek (on the East side of the valley) were probably not significant sources. Thomes Creek was not monitored by this study, but was identified as a potentially significant source of mercury that should be included in future source identification monitoring efforts.

Increases in total mercury concentrations in the Sacramento River below Colusa are less dramatic, with median concentrations of 6.4 ng/L observed for the Sacramento River at Verona, and 7.2 ng/L and 7.6 ng/L at Freeport and River Mile 44, respectively. Median total mercury concentrations in the Yuba River and American River are lower than in the Sacramento River mainstem. Total mercury concentrations in the Feather River are similar to concentrations in the Sacramento River at Verona, immediately downstream from the confluence of the Feather and Sacramento rivers. Median concentrations of total mercury measured by USGS in Cache Creek (15 ng/L) and the Yolo Bypass (31 ng/L) are highest, substantially higher than in the Sacramento River mainstem. The Cache

Creek drainage has been identified as the major source of episodic mercury loads to the Sacramento-San Joaquin Delta (see section on mass loadings).

Total methylmercury concentrations (measured by USGS at six locations) exhibit a somewhat different spatial distribution pattern (see Figure 4). The range of methylmercury concentrations in the mainstem Sacramento River (median concentrations range from 0.10 ng/l at Colusa to 0.12 ng/l at Freeport) exhibits little net change from the Sacramento River at Colusa to the Sacramento River at Freeport. Higher methylmercury concentrations have been measured in Sacramento Slough and Colusa Basin Drain (concentrations approximately twice those measured in the mainstem), with lower methylmercury concentrations measured in the Feather River and American River drainages.

Summary statistics for water column data are presented in Appendix E.

Fish Tissue

Fish tissue samples (typically consisting of composites of five fish each) were collected from 16 locations ranging from the three tributaries above Lake Shasta, to Cache Slough (near Rio Vista) in the Delta (Figure 5) during the months of September and October from 1997 to 1999. Six fish species were sampled (depending on species present at different sites), including rainbow trout, largemouth bass, Sacramento pikeminnow, Sacramento sucker, carp, and white catfish. There was a generally increasing upstream-to-downstream trend in both the number of fish species captured and in mercury concentrations in tissue. Rainbow trout (a cold water, primarily insect-eating species) were only captured upstream from Bend Bridge and were found to have low levels of mercury (relative to other species and locations), with a mean concentration of 0.04 mg/kg (wet weight) for all sites. The average mercury concentration in Sacramento pikeminnow collected from six locations (from the Sacramento River above Bend Bridge to the American River at Discovery Park) was 0.45 mg/kg, with the highest concentration (1.2 mg/kg) observed at the Feather River location. White catfish collected downstream from Colusa exhibited average mercury concentrations (0.46 mg/kg) similar to those for pikeminnow. Average mercury concentrations reported for largemouth bass (a warm water, fish-eating predator) were substantially higher (0.89 mg/kg). The results for the three striped bass caught (all from Feather River near Nicolaus) were quite variable and ranged from 0.32 to 3.5 mg/kg, with an average concentration of 1.7 mg/kg. Carp, Sacramento suckers, and bluegill were each captured at only a few locations and all had relatively low average mercury concentrations (carp—0.13 mg/kg; Sacramento sucker—0.13 mg/kg; bluegill—0.11 mg/kg).

It should be noted that mercury concentrations in fish tissue are dependent not only on water column concentrations of bioavailable mercury, but also on trophic level and feeding patterns. For this reason, mercury concentrations in rainbow trout, which was the predominant species caught in the upper watershed and a mid-trophic level species, should not be directly compared with concentrations in largemouth bass (a high trophic level species typically caught lower in the watershed) as a means of inferring spatial differences in levels of bioavailable mercury.

iii. Temporal Distribution & Patterns

Unfiltered total mercury and methylmercury concentrations in the water column in the mainstem Sacramento River exhibit a strong seasonal pattern. Concentrations of total mercury typically peak following precipitation and with increased river flows of the early wet season, and then decrease steadily through the remainder of the wet season. In general, this pattern is consistent with the seasonal mobilization of fine-grained particulates in river sediments and runoff deposited during the dry season and during lower stream flows. Mercury tends to adsorb to fine grained sediments, leading to the close correlation between sediment transport and mercury transport phenomena. This pattern appears to be consistent at all the mainstem Sacramento River sites monitored between Redding and River Mile 44, and in the major tributaries in the lower watershed (the Feather River, Yuba River, and American River). This pattern is less distinct for total mercury concentrations in the agricultural drainage-dominated Colusa Basin Drain and Sacramento Slough.

Methylmercury concentrations exhibit a similar seasonal pattern. At the five locations monitored for the Sacramento River basin NAWQA program for this parameter, water column concentrations of methylmercury exhibited a rapid increase during the early wet season, with a more gradual decline through the dry season. This pattern was fairly consistent for mainstem Sacramento River sites (at Colusa, Verona, and Freeport) and in the two agricultural drain sites (Sacramento Slough and Colusa Basin Drain). The sources of the methylmercury and the cause(s) of the observed periodicity in concentrations in the Sacramento River is not yet known. Probable causes may include seasonal mobilization of total mercury, increased methylation due to seasonal water temperature changes, or increased inflows of methylmercury from tributaries. Ongoing methylmercury monitoring by the SRWP monitoring program (begun in July 2000) and continued methyl mercury monitoring by the DWR special tributary program is expected to provide valuable information to address this question.

Seasonal variations in total mercury and methylmercury concentrations are illustrated for the Sacramento River at Freeport in Figure 6. Time series plots of water column mercury concentrations are also presented in Appendix G of this report.

iv. Attainment of Beneficial Uses and Potential Impairment

One of the SRWP monitoring program's initial goals is to assess the degree to which beneficial uses are attained or potentially impaired in the watershed. For the purpose of these evaluations, mercury concentrations in water and fish tissue were compared to various regulatory criteria and screening or advisory thresholds. Concentrations that exceed these regulatory limits in water or tissue are considered indicators of *potential* impairment of beneficial uses. Cases where concentrations clearly do not exceed regulatory limits indicate that beneficial uses are not being impaired by a specific constituent, but do not provide unequivocal evidence that a specific beneficial use is being fully attained. The results of these comparisons to regulatory criteria and other limits were also evaluated for consistency with the State Water Resources Control

Board's 303(d) list of waterbodies which the State considers to be impaired and not attaining beneficial uses.

Water Column

Human Health Thresholds

Total mercury concentrations in water were compared with a variety of regulatory, screening, and advisory thresholds (Table 5). Adopted total mercury water quality objectives for the Sacramento River watershed include a human health-based water quality objective for drinking water of 2000 ng/L (the drinking water Maximum Contaminant Level or MCL) adopted in the Central Valley Basin Plan, and a human-health-based federal water quality criterion of 50 ng/L (30-day average) adopted in the May 2000 California Toxics Rule (CTR). The CTR criterion reflects the latest USEPA national water quality criterion for total mercury for protection of human health, which has superceded the 1985 USEPA national criterion value of 12 ng/L. The CTR criterion does not reflect the approach used in the Great Lakes Initiative, where an objective of 3.1 ng/L was adopted based on use of field derived bioaccumulation factors (BAFs). The fish consumption-based human health criteria for mercury are aimed at the protection of sensitive individuals (pregnant women, unborn children, infants) and are based on different assumptions regarding fish consumption rates and bioaccumulation rates.

It should be noted that USEPA has stated that it intends to re-evaluate and revise its 304(a) national criteria guidance for mercury criteria by the year 2002, and that new human health criteria could be proposed for California within a year of USEPA's 304(a) revisions. USEPA Region IX (which has jurisdiction in the Sacramento River watershed) is advising that future human health criteria for total mercury, based on information in the Mercury Report to Congress, could range from 2–5 ng/L (Phil Woods, USEPA Region IX, personal communication, 1999).

Wildlife Thresholds

No wildlife-based water quality objectives have been adopted for mercury in California. Similarly, USEPA has not issued national wildlife-based advisory criteria for mercury in water. A wildlife-protective standard of 1.3 ng/L total mercury has been adopted for the Great Lakes area, based on criteria developed by USEPA. USEPA revised these Great Lakes values for protection of wildlife species in its Mercury Report to Congress (USEPA 1997), an advisory document. Total mercury values presented in the Mercury Report to Congress ranged from 0.6 ng/L to 1.8 ng/L, with an average of 0.9 ng/L for the species considered. The Mercury Report to Congress also identified a methylmercury criterion of 0. 05 ng/L in water for protection of wildlife.

Comparison with Water Column Threshold Values

Because the mercury objective for protection of human health for drinking water exposure is so much higher than the fish consumption-based concentrations, the remaining discussion will focus only on the fish consumption-based values. The percentage of data meeting specific regulatory or advisory thresholds are presented in Table 6.

Total mercury concentrations in the Sacramento River (from Keswick to River Mile 44) and in the major tributaries were rarely observed to exceed the CTR criterion for mercury (0.4%, or 2 of 503 total samples in the Sacramento River, and in no samples from the American, Feather, and Yuba rivers). Mercury concentrations in Cache Creek exceeded the 50 ng/L limit in 22% of samples, based on data collected by USGS from 1996 through 1999. Based on data collected by DWR in 1998-2000, mercury concentrations in the Mill Creek exceeded the 50 ng/L limit in 13% of samples collected from the mouth of the creek. Higher concentrations and percent exceedances (32%) were observed in the upper Mill Creek watershed, where the influence from geothermal activity (hot springs) is greatest. DWR data for Deer Creek and Big Chico Creek for this same period from indicate that the CTR criterion was met in every sample collected in the Deer Creek watershed, and in all but one sample (of 86) collected in the Big Chico Creek watershed.

In comparison with total mercury advisory criteria in the range from 2–5 ng/L (as indicated by staff of USEPA Region IX) for human health protection, or at 1.3 ng/L levels (as has been adopted in the Great Lakes for wildlife protection), ambient water column concentrations of total mercury frequently exceed these values at all sites tested throughout the Sacramento River watershed. In comparison with the 3.1 ng/L Great Lakes criterion for the protection of human health, the Sacramento River above Hamilton City exceeded this criterion in 35% of samples, while the 3.1 ng/L limit was exceeded in 94% of samples collected from the Sacramento River from Colusa to River Mile 44. The 3.1 ng/L limit was exceeded in fewer than 12% of samples from the Deer Creek watershed, in 17% of samples from the Big Chico Creek watershed, and in nearly every sample (91%) from Mill Creek.

The Great Lakes Initiative adopted a human health-based methylmercury criterion of 0.24 ng/L. Methylmercury concentrations measured by USGS at three mainstem Sacramento River sites (1996–98 for the Verona and Colusa locations, and 1996–2000 at Freeport) exceeded 0.24 ng/L in 21% of samples, and methylmercury concentrations in the two agricultural drain sites (Colusa Drain and Sacramento Slough,1996-1998) exceeded 0.24 ng/L in 30% and 36% of samples. Methylmercury concentrations in Cache Creek (1999 data) exceeded 0.24 ng/L in 9% of samples. In comparison with the wildlife-based methylmercury advisory criterion of 0.05 ng/l identified in the Mercury Report to Congress by USEPA, USGS concentrations exceeded 0.24 ng/L in more than 81% of samples collected at each site collected (see Figure 6b).

Table 5. Regulatory Standards and Other Threshold Values for Mercury in Water.

Basis for Limit	Concentration in water, ng/L	Form of Hg	Reference
Human Health	2000	Total	Maximum Contaminant Level (MCL) in drinking water (USEPA, 1996)
Human Health	50[2]	Total	Federal water quality criterion per California Toxics Rule (May 2000), Recommended National Water Quality Criteria (USEPA 1999)
Human Health	0.24 3.1	Methyl Total	Specific to Great Lakes, federal water quality criterion for Great Lakes (USEPA 1995)
Wildlife[1]	0.05 0.641 0.91	Methyl Dissolved Total	Mercury Report to Congress, Vol. VI (USEPA 1997)
Wildlife	1.3	Total	Specific to Great Lakes, federal water quality criterion for Great Lakes (USEPA 1995)

(1) Lowest average criterion, based on the average for all mammalian wildlife species studied in Mercury Report to Congress.
(2) This value represents a 30-day average not to be exceeded more than once in three years.

Table 6. Comparisons With USEPA Total Mercury Water Quality Criteria for Human Health: Percent of Data (1996-2000) Below Criteria

Location	Years monitored	% of data meeting USEPA criteria for protection of human health: 1997 USEPA 3.1 ng/L Great Lakes std	1985 USEPA 12 ng/L criterion	1999 USEPA 50 ng/L criterion	Total number of samples
Spring Creek PP Discharge to Keswick Res.	1998-2000	100%	100%	100%	11
Sacramento River below Keswick	1998-2000	95%	100%	100%	39
Sacramento River above Bend Bridge	1996-2000	59%	97%	100%	39
Mill Creek at Mouth	1998-2000	11%	53%	84%	19
Mill Creek at Black Rock	1998-2000	17%	39%	83%	18
Mill Creek at Highway 36	1998-2000	0%	16%	68%	19
Sacramento River near Hamilton City	1999-2000	64%	82%	100%	11
Deer Creek at Mouth	1998-2000	93%	100%	100%	14
Deer Creek at Upper Diversion Dam	1998-2000	75%	100%	100%	20
Deer Creek at Ponderosa Way	1998-1999	92%	100%	100%	12
Deer Creek below Childs Meadows	1998-2000	95%	100%	100%	19
Big Chico Creek above Mud Creek	1998-2000	76%	100%	100%	21
Mud Creek above Big Chico Creek	1998-2000	64%	91%	91%	11
Big Chico Creek at Chico (Rose Ave.)	1998-2000	89%	100%	100%	19
Big Chico Creek above Salmon Hole	1998-2000	81%	100%	100%	16
Big Chico Creek at Hwy 32	1998-2000	95%	100%	100%	19
Sacramento River at Colusa(1)	1996-2000	18%	82%	98%	45
Sacramento Slough(1)	1996-2000	0%	79%	100%	34
Colusa Basin Drain	1996-2000	3%	84%	100%	37
Yuba River at Marysville	1996-2000	54%	84%	100%	37
Feather River near Nicolaus(1)	1996-2000	8%	87%	100%	38
Sacramento River at Verona(1)	1996-1998	7%	86%	100%	28
Sacramento River at Veterans Bridge(1)	1994-2000	0%	74%	100%	99
Arcade Creek at Norwood Ave.	1996-2000	5%	76%	97%	37
American River at Discovery Park(1)	1994-2000	53%	98%	100%	96
Sacramento River at Freeport(1)	1994-2000	7%	79%	100%	148
Sacramento River at River Mile 44(1)	1994-2000	5%	71%	99%	94
Cache Creek at Rumsey(1)	1996-1999	4%	49%	79%	47
Cache Slough near Ryers Ferry(1)	1998-2000	9%	82%	100%	11
Yolo Bypass near Woodland	1997-1998	0%	0%	90%	10

(1) Included on California 1998 303(d) list of impaired waterbodies

Fish Tissue

Threshold Values

Mercury concentrations in composite and individual fish tissue samples were compared with several different advisory thresholds and criteria for mercury in fish tissue (all expressed as wet weight) (Table 6). Human health-based limits range from 1.0 mg/kg (the Food and Drug Administration (FDA) Action Level applicable to commercially-caught fish), to 0.30 mg/kg (national ambient water quality criterion for protection of human health; USEPA 2001), to 0.14 mg/kg (California Department of Fish and Game screening value used in San Francisco Bay; SFRWQCB 1995). USEPA fish tissue advisory criteria for protection of wildlife in the Great Lakes, as revised in the 1997 Mercury Report to Congress, range from 0.68 mg/kg to 0.028 mg/kg. These criteria and screening values are risk-based advisory values against which tissue concentrations can be compared to determine whether more intensive monitoring, evaluation, or risk management (e.g. consumption advisories) is warranted. Note that these risk-based values are based on assumed fish consumption rates for humans (6.5 g/day to 30 g/day) or wildlife species. For individuals or populations consuming more or less fish than assumed for a specific limit or screening value, the risk of adverse health effects is correspondingly increased or decreased. Additionally, each criterion or screening value is calculated from a reference dose (RfD) based on a daily intake level estimated not to cause adverse effects, and a safety factor to account for uncertainties in the reference dose. The current USEPA human health-based reference dose incorporates a safety factor of 10, and reference doses for birds and mammalian wildlife range from 2 to 10. The consumption rate and reference dose associated with each limit are specified in Table 7.

Comparison with Fish Tissue Threshold Values

Fish tissue data from the SRWP monitoring effort at various locations were compared with fish tissue advisory values. The levels of mercury accumulated in fish are known to be species specific, with predatory, upper trophic level fish having higher mercury levels. Additionally, levels of mercury are size- and age-dependent within a given species, with older, larger fish typically having higher mercury levels. (The process which produces these observed conditions is termed “biomagnification”.) To control for these species-, age, and size-dependent effects, SRWP fish tissue monitoring focused on mercury concentrations in individual fish and composite samples comprised of fish of similar legal catchable size. Where there were sufficient numbers of a particular species (largemouth bass and white catfish), tissue concentrations were plotted against length to illustrate this relationship.

- Tissue concentrations of mercury exceeded the lowest human health-based screening values (0.14 mg/kg and 0.23 mg/kg) in most samples of largemouth bass and white catfish (Figures 5a and 5b). These two species were typically collected from the lower Sacramento River and in tributaries from Colusa to Cache Slough.
- Most white catfish collected exceeded USEPA’s human health-based criterion (0.3 mg/kg) at every location where they were collected. A few individuals from several

locations exceeded EPA’s 1996 Screening Value (0.6 mg/kg), and one individual white catfish from also exceeded the 1.0 mg/kg FDA Action Level (Figure 5a).

- Fish tissue mercury concentrations were greater than the 0.3 mg/kg criterion in individual and composite largemouth bass samples collected from most locations in the lower watershed (below the confluence with the Feather River). Most largemouth bass collected also exceeded the USEPA 1996 Screening Value (0.6 mg/kg), and a number of individual largemouth bass collected from the Feather River, the Sacramento River at River Mile 44, and from Cache Slough exceeded the FDA Action Level of 1.0 mg/kg (Figure 5b).
- In addition to largemouth bass and white catfish, eight other fish species are represented in the data set (Figure 5c). With the exceptions noted below, most of these fish were below EPA’s 0.3 mg/kg criterion. None of the four species collected in the Sacramento River above the confluence with the Feather River (rainbow trout, pikeminnow, carp, and Sacramento sucker) contained concentrations greater than 0.3 mg/kg. All rainbow trout from the Sacramento River at Red Bluff and Keswick, tributaries above Lake Shasta, Deer Creek, and Big Chico Creek were lower than EPA’s 0.3 mg/kg criterion, and most were below the lowest screening value. One riffle sculpin composite sample from upper Mill Creek had tissue concentrations greater than the 0.3 mg/kg criterion. One white catfish composite from Sacramento Slough exceeded the USEPA 1996 0.6 mg/kg Screening Value.
- Rainbow trout, bluegill, carp, smallmouth bass, and Sacramento sucker had tissue concentrations below EPA’s 0.3 mg/kg criterion at all locations where they were collected. All three pikeminnow collected from the American River and the Feather River exceeded the 0.3 mg/kg criterion, and all three striped bass from the Feather River exceeded the 0.3 mg/kg criterion. Two striped bass, and one Sacramento pikeminnow from the Feather River also exceeded the 1.0 mg/kg FDA Action Level (Figure 5c).

Table 7. Criteria and Screening Values for Mercury in Fish Tissue

Basis for limit	Criterion or Screening Value[1], mg/kg	RfD (µg/kg/day)	Body Weight (kg)	Consumption Rate (kg/day)	Reference
Human Health	1.0	0.11	60	0.0065	FDA Action Level[3] (vm.cfsan.fda.gov/~dms/)
	1.0	0.3	60	0.018	ATSDR 1999 (www.atsdr.cdc/gov/press/ma990419.html)
	0.6	0.06	60	0.065	USEPA Screening Value (USEPA 1995)
	0.33	0.1	60	0.018	Mercury Report to Congress, Vol. VI (USEPA 1997)
	0.14	0.06	70	0.030	SFRWQCB Screening Value (SFRWQCB 1995)
	0.23	0.1	70	0.030	OEHHA and SFEI Screening Value (OEHHA 1999, SFEI 1999)
	0.3	0.1	70	0.0175	Ambient Water Quality Criterion for Human Health (USEPA 2001)
Wildlife[2]	0.08 0.34	Hg criterion in trophic level 3 fish Hg criterion in trophic level 4 fish (See USEPA 1997 for calculations)			Mercury Report to Congress, Vol. VI (USEPA 1997)

(1) Expressed as mg/kg wet weight Values are calculated as (RfD x Body Weight) ÷ Consumption Rate.
(2) Lowest average criterion, based on the average for all mammalian wildlife species studied in Mercury Report to Congress.
(3) The FDA Action Level is intended to apply only to commercially caught fish, and not to locally-caught or sport fish.

What do the data say about attainment of beneficial uses and potential impairment, and how does this compare with any relevant 303(d) listings for parameter and sites?

The beneficial uses at greatest potential risk from elevated mercury concentrations are wildlife protection and human health protection related to the consumption of fish. An interim sport fish consumption advisory is currently in effect for the San Francisco Bay and Delta Region for elevated levels of mercury and other chemicals. Sport fish consumption advisories are also in effect for elevated mercury levels in fish in Clear Lake and Lake Berryessa, and more fish consumption advisories have been issued at the County Health Department level for foothill reservoirs on both sides of the watershed. The California Office of Environmental Health and Hazard Assessment (OEHHA) has also issued an interim advisory and consumption guidance for Black Butte Reservoir, in the Stony Creek Watershed. Based on these advisories (which recommend limiting consumption of specific sizes and species of fish), the local sportfishing beneficial use has been described by the Regional Board and SWRCB as impaired in the Bay, in the Delta, and in Clear Lake and Lake Berryessa.

A number of both mainstem and tributary reaches in the Sacramento River watershed are included for mercury on the California 1998 303(d) list (Table 8). All of the listings for mercury are based on elevated concentrations of mercury in fish tissue, and the 1998

303(d) list cites mining activity (resource extraction) as the major source of mercury. Water column data from the SRWP and other monitoring programs are not necessarily consistent with the 303(d) listings. With the exception of Cache Creek, the waterbodies included on the 303(d) list had a fairly high frequency of compliance with the CTR criterion of 50 ng/L (97-100%) and the EPA 1985 criterion of 12 ng/L (70-98%). Conversely, with the exceptions of the Sacramento River at Hamilton City and the American River at Discovery Park, 303(d)-listed waterbodies had very low rates of compliance (less than 25%) with the Great Lakes 3.1 ng/L human health objective. Fish tissue data indicate that levels of mercury in certain species (particularly largemouth bass and white catfish) are at levels of potential concern for a number of locations in the lower watershed. Comparisons of data for largemouth bass and white catfish to the recently-adopted 0.3 mg/kg EPA criterion generally support the need for fish consumption advisories where they are already in effect. Based on guidance from OEHHA, the available fish tissue data from the SRWP are not sufficient to support additional consumption advice in the Sacramento River watershed. However, the fish tissue data clearly indicate a need to further evaluate potential human health and wildlife concerns in the lower Sacramento River watershed. The SRWP is continuing to investigate these concerns with fish tissue monitoring in the fall of 2000 and 2001.

Table 8. Waterbodies Listed For Mercury On the California 1998 303(d) List.

Waterbody	Listed Source of Mercury	Area Affected		Fish Advisory
Delta Waterways	Resource Extraction	480000	Acres	Yes
Berryessa Lake	Resource Extraction	20700	Acres	Yes
Clear Lake	Resource Extraction	43000	Acres	Yes
Davis Creek Reservoir	Resource Extraction	290	Acres	No
Marsh Creek Reservoir	Resource Extraction	375	Acres	No
American River, Lower	Resource Extraction	23	Miles	No
Cache Creek	Resource Extraction	35	Miles	No
Feather River, Lower	Resource Extraction	60	Miles	No
Harley Gulch	Resource Extraction	8	Miles	No
Humbug Creek	Resource Extraction	9	Miles	No
James Creek	Resource Extraction	6	Miles	No
Sacramento River (Red Bluff To Delta)	Resource Extraction	30	Miles	No
Sacramento Slough	Source Unknown	1	Miles	No
Sulfur Creek	Resource Extraction	7	Miles	No

v. Mass Load Comparisons

Comparisons of mass load contributions from major Delta tributaries have been evaluated based on annual average mercury concentrations and streamflows. These evaluations were performed to provide some perspective on the relative importance of mercury loads from the Sacramento in the Delta and San Francisco Bay. The information is also relevant to development of pollutant management strategies and Total Maximum Daily

Loads (TMDLs). It should be noted that mass loads are not direct indicators of water quality or predictors of instantaneous concentrations of mercury in the Delta or beyond.

For annual average estimates, average annual loads from the Sacramento River at River Mile 44, the Yolo Bypass, the San Joaquin River, and the Mokelumne River were calculated as the long-term annual average flow (USGS Water Resources Data, 1996) multiplied by the average concentration value for the available data for each major input. The resulting estimates are intended only to provide a semi-quantitative comparison of the relative magnitude of the major Delta inputs, and are not intended to be definitive estimates of actual loads. Because these estimates are based on limited data and long-term average flows (which do not consider massive spikes in mass loadings during peak streamflow events), they undercount total mercury loads to the Delta. It should also be noted that estimates of mass loads of *total* mercury provide little direct information regarding causes of excessive mercury bioaccumulation in the Delta, primarily because total mercury concentrations are not closely related to concentrations of bioavailable mercury.

The results of this annual average mass loading comparison (Table 9) illustrate the dominance of the Sacramento River watershed with respect to total riverine flows and mercury inputs to the Delta (approximately 90% of estimated total average loads for the Sacramento River and Yolo Bypass). The estimated mercury loads for the Yolo Bypass (which includes Cache Creek flows) don't fully convey the variability and importance of this mercury source. In years with relatively high annual flows, such as 1998, loads from the Yolo Bypass and the Cache Creek watershed are estimated to exceed the loads from the rest of the Sacramento River watershed. Although the available data for the San Joaquin River and the Mokelumne River are very limited, the low annual flows (in comparison to the Sacramento River flows) and moderate mercury concentrations in these rivers suggest that these inputs are responsible for only a relatively low percentage of total mercury inputs to the Delta (less than 10% for the San Joaquin River and Mokelumne River, combined).

Table 9. Estimated Mercury Loads From Major Delta Inflows: A Preliminary Qualitative Comparison.

Location or Source (period of water quality data)	Monitoring Program	Annual average flow to Delta, cfs (period of record)	Average Total Mercury Concentration (ng/L)	Estimated average annual load (kg)	Estimated percent of total load to Delta (for an average water year)
Sacramento River, at Mile 44 (1994-2000)	Sac. River CMP (SRCSD 2000)	23410 (1949-1995)	10.5	220	48%
Yolo Bypass and Cache Ck (1996-1998)	Sac. R. NAWQA (USGS 1999)	3758[a] (1946-1995)	61	204	44%
San Joaquin River (10/93-4/94)	CVRWQCB (Foe and Croyle 1998)	4500 (1951-1995)	7	28	6%
Mokelumne River (10/93-5/94)	CVRWQCB (Foe and Croyle 1998)	766 (1965-1994)	5.5	3.8	1%

a. Estimated as Cache Creek at Yolo flows + Yolo Bypass at Woodland flows (USGS 1996)

vi. Conclusions and Recommendations

Conclusions of this review of mercury monitoring data can be summarized as follows:

- Total water column mercury concentrations in the Sacramento River from Keswick to River Mile 44 rarely exceeded the CTR mercury criterion of 50 ng/L(USEPA 2000). Total mercury concentrations exceeded the 50 ng/L limit in 22% of Cache Creek samples and 32% of samples from the upper Mill Creek watershed. The Feather and Yuba rivers are significant sources of mercury loads, but concentrations are not elevated compared to the Sacramento River mainstem. However, high concentrations of mercury in fish from the lower Feather River suggest that it may be a significantly elevated source of bioavailable methylmercury, and indicate the need for more fish tissue and water column monitoring in this part of the watershed. Spring Creek in the upper Sacramento River watershed, Deer Creek, Big Chico Creek, and the American River do not appear to be major sources of total mercury—concentrations are low compared to the Sacramento River and were never observed to exceed the 50 ng/L CTR criterion at these sites. With the exceptions of Mill Creek and Cache Creek, total mercury concentrations rarely exceeded the 50 ng/L CTR criterion at any site.
- Methylmercury concentrations in water column samples exceeded the Great Lakes human health-based criterion of 0.24 ng/L in less than 25% of samples from Sacramento River and Cache Creek, and in slightly more than 25% of samples from two ag drain sites. Methyl mercury concentrations exceeded the Great Lakes wildlife-based criterion of 0.05 ng/L in nearly every sample collected from every site.
- Mercury in tissues of fish collected from tributaries above Shasta Reservoir were lower than human health-based and wildlife-based advisory/screening values. Based on these results, and on recommendations from OEHHA, the focus of fish tissue

monitoring has been shifted to sites in the lower watershed with tissue mercury levels of greater concern.

- Mercury concentrations in fish tissue collected in 1997,1998, and 1999 from the mainstem Sacramento River below Shasta Reservoir and major tributaries to this section of the river were higher than several of the human health-based and wildlife-based advisory/screening values. Exceedance of the screening values indicate that more data are needed to evaluate potential human health concerns associated with consumption of fish in the lower Sacramento River watershed. This concern is being addressed with more focused monitoring of mercury in fish from the lower Sacramento River watershed planned for 2000-2001 (Year 3). This shift in focus is in large part a result of coordination and consultation with the California Office of Environmental Health and Hazard Assessment (OEHHA). OEHHA has been an active participant in the SRWP, and has provided the SRWP with guidance regarding data needs and study design for evaluation of human health risks related to fish consumption.
- The Sacramento River watershed drainage is a major source of mercury to the Delta. This watershed contributes approximately 90% of the total mercury loads to the Delta. Within the Sacramento River watershed, the Cache Creek drainage is the single largest source area for total mercury.

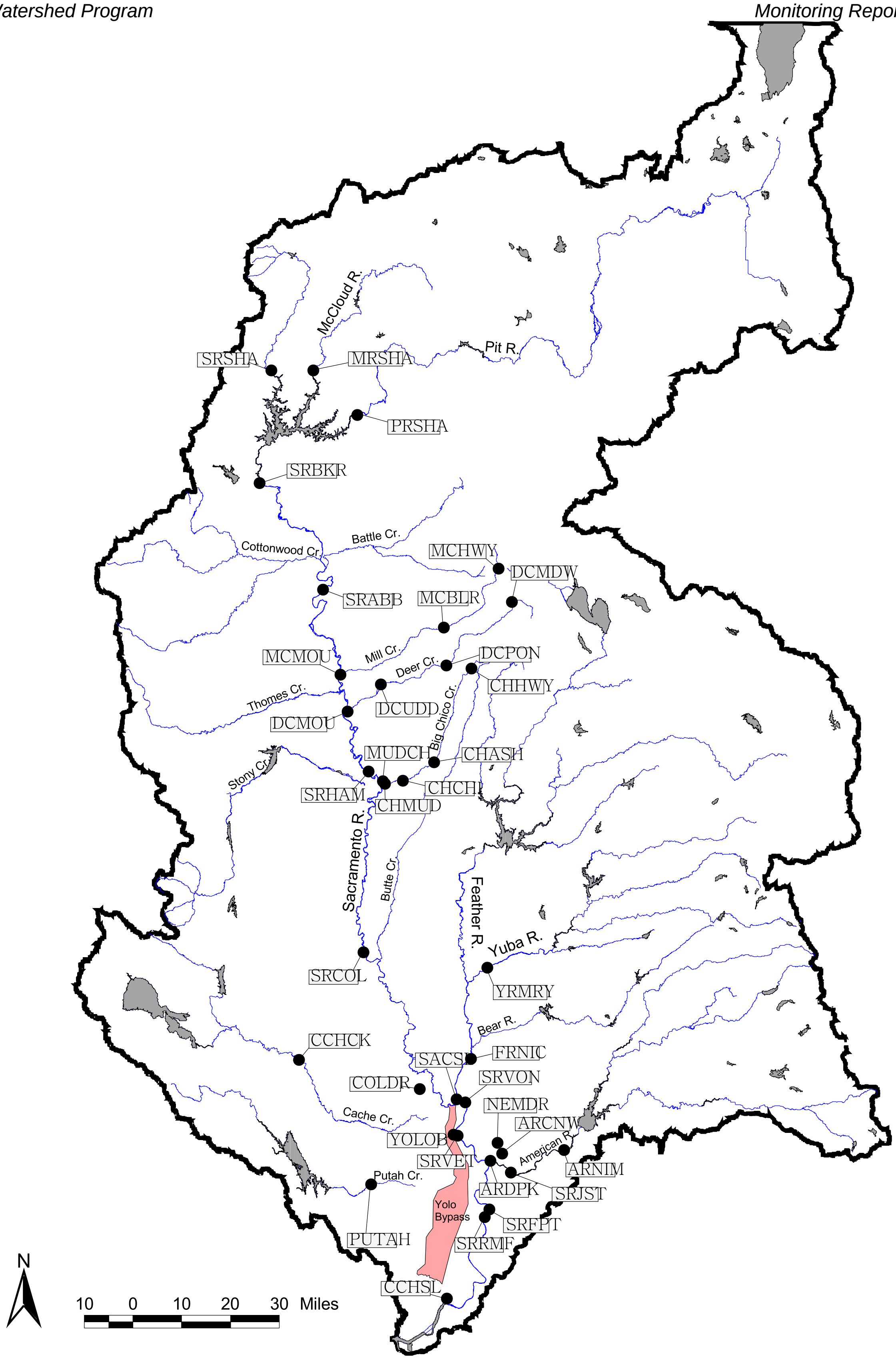

Figure 2. Mercury Monitoring Sites for the Sacramento River Watershed Program: USGS NAWQA, City of Redding, Sacramento River CMP, and SRWP

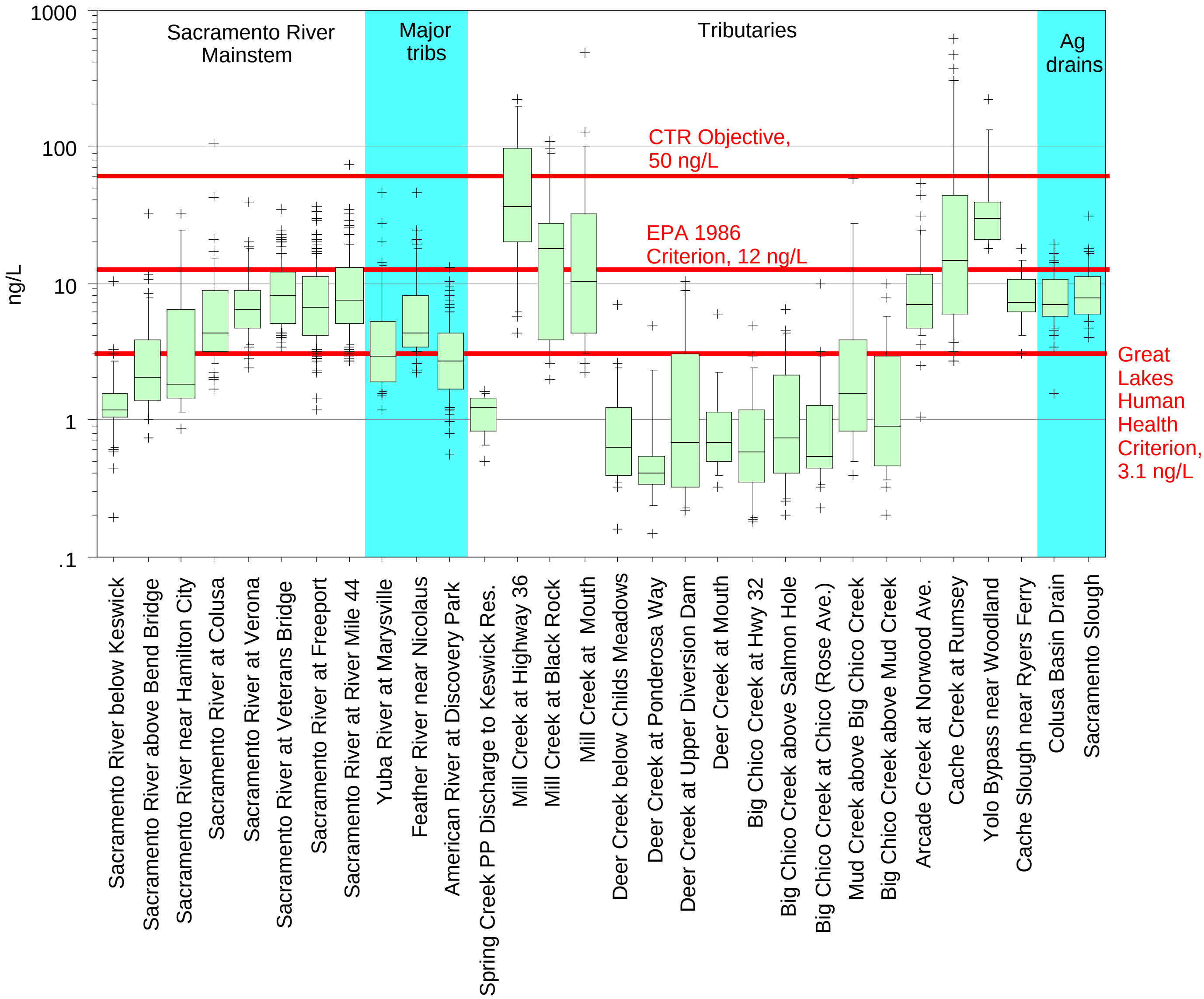

Figure 3. Mercury in the Sacramento River Watershed, Unfiltered Total Mercury Concentrations in Water, 1996–2000 data

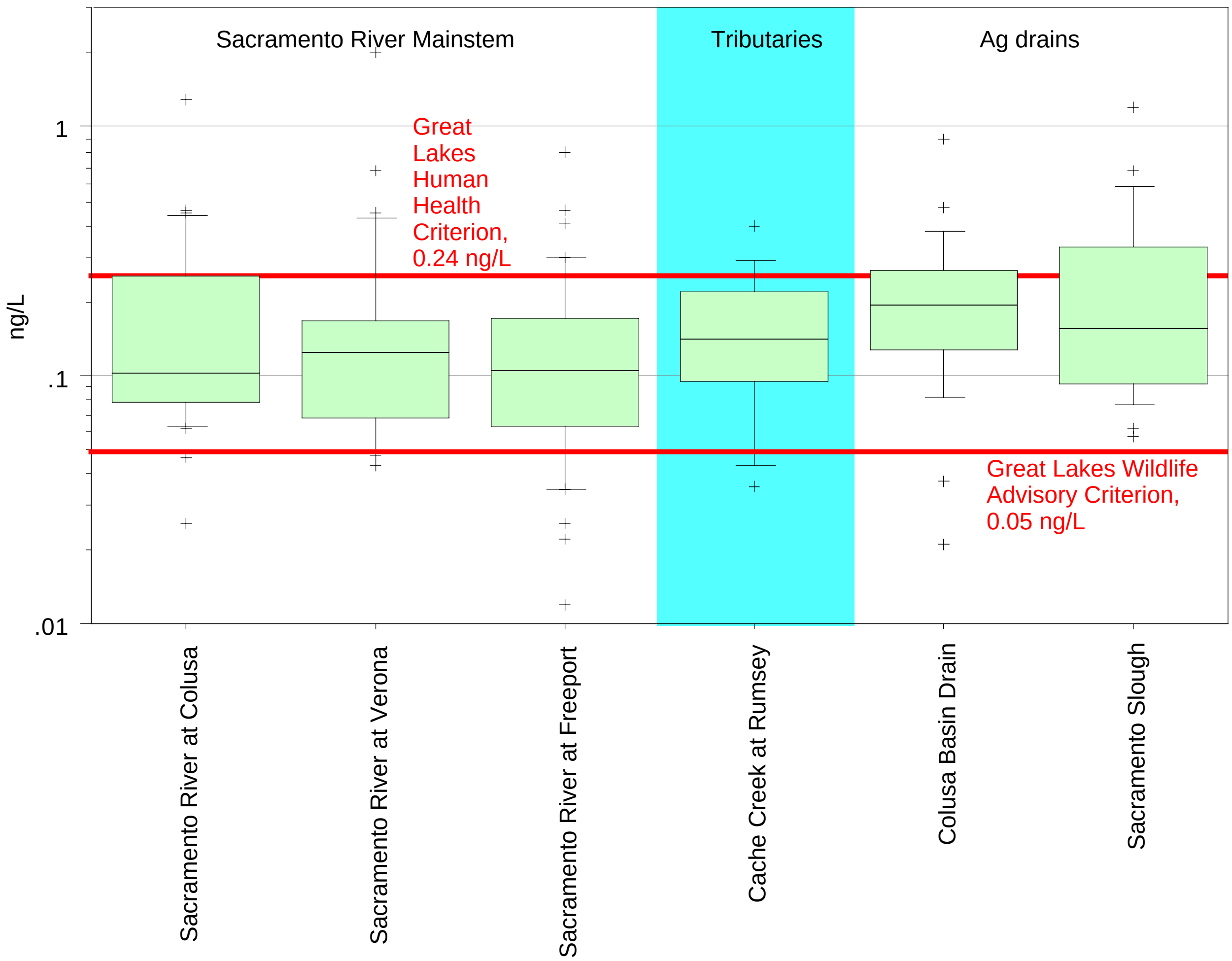

Figure 4. Methylmercury in the Sacramento River Watershed, Unfiltered Mercury Concentrations in Water (USGS data, 1996-2000)

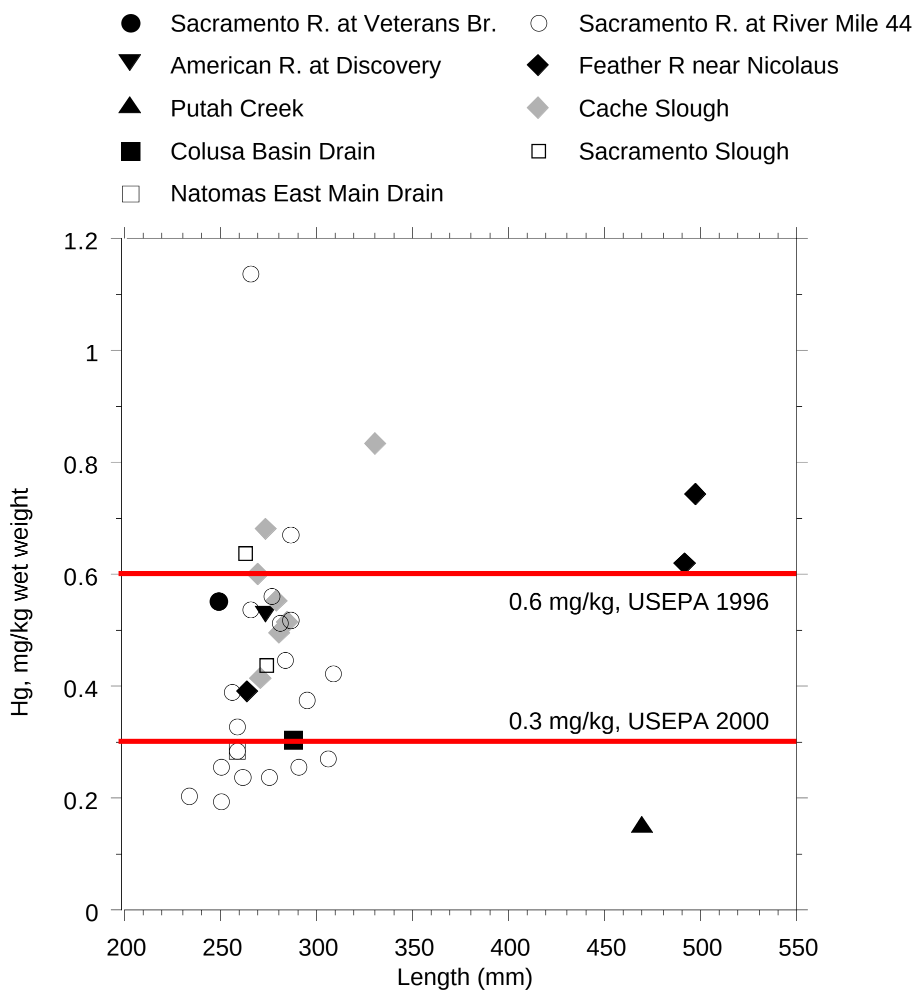

Figure 5a. Mercury in White Catfish in the Sacramento River Watershed: SRWP Data, 1997-1999

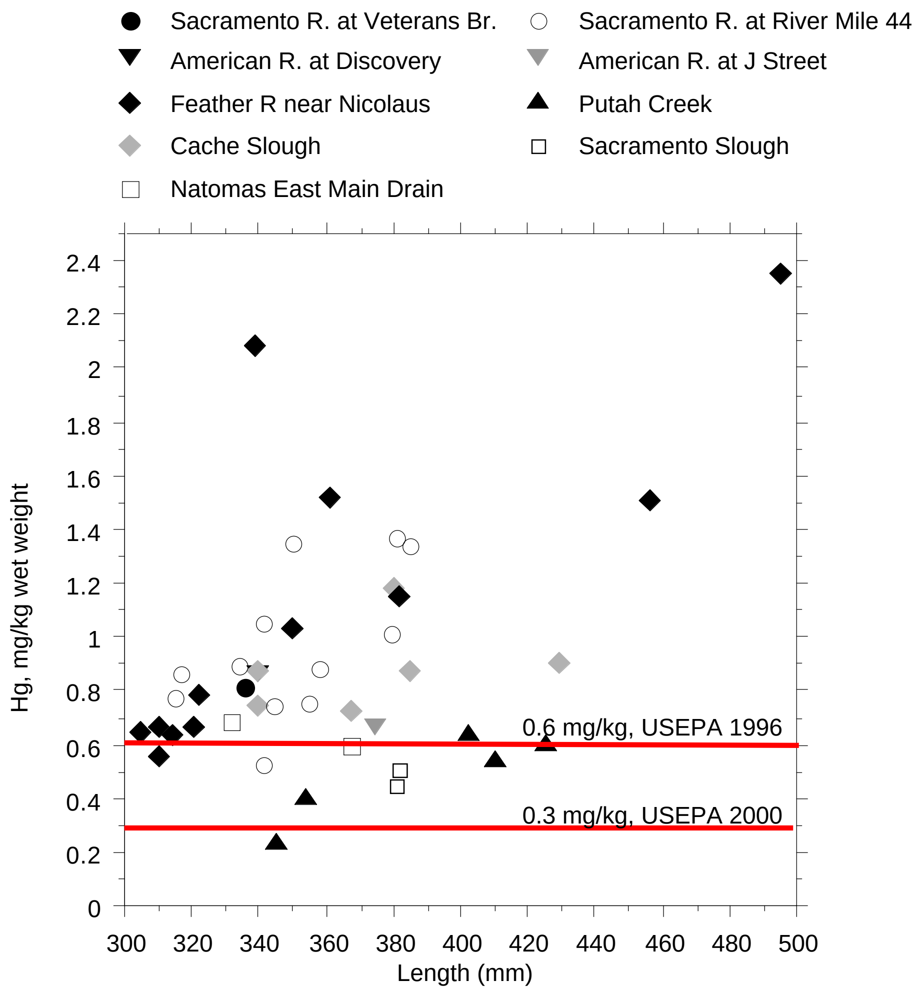

Figure 5b. Mercury in Largemouth Bass in the Sacramento River Watershed: SRWP Data, 1997-1999

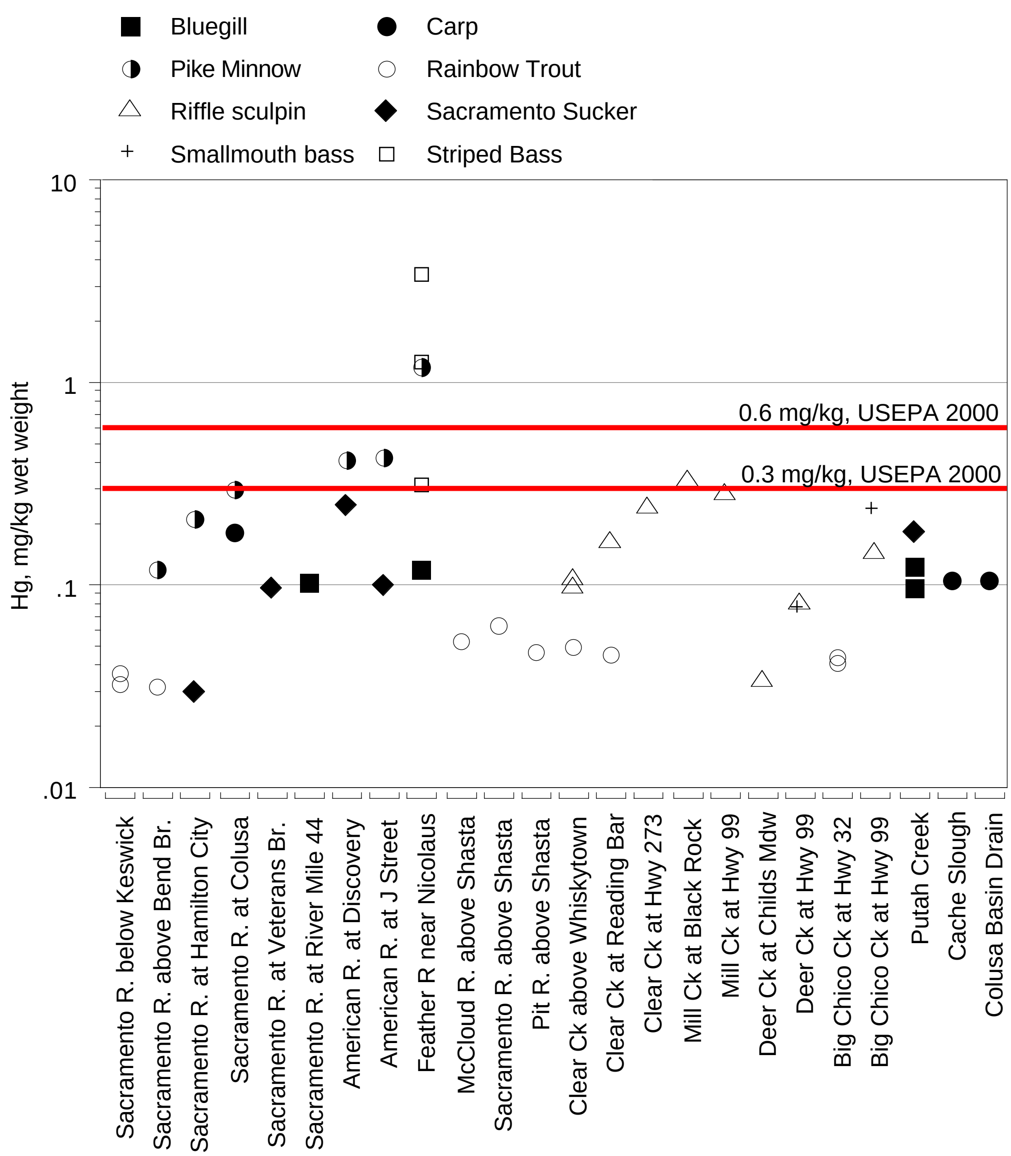

Figure 5c. Mercury in Other Fish Species in the Sacramento River Watershed: SRWP Data, 1997–1999, and DWR Data, 1999

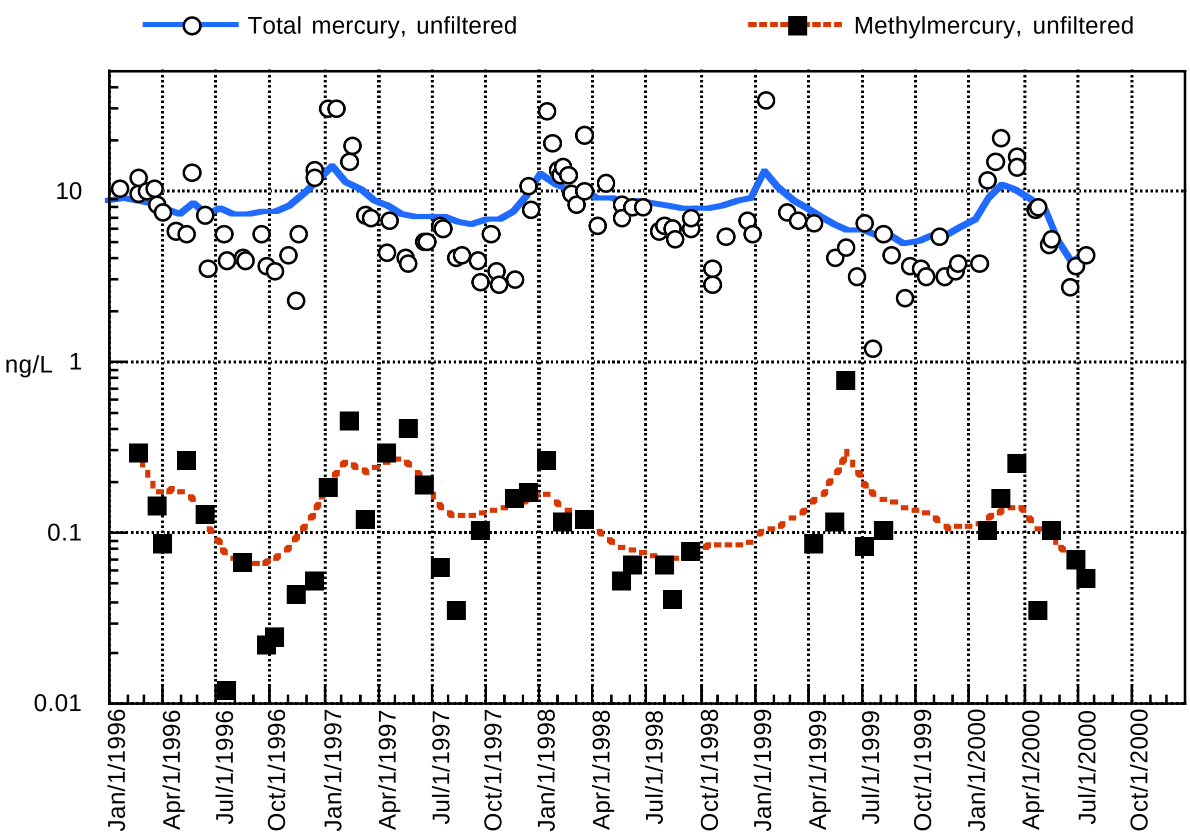

Figure 6. Unfiltered Total Mercury and Methyl Mercury in Water: Sacramento River at Freeport (USGS NAWQA data, 1996-2000, and Sacramento River CMP data, 1994-2000)

B. Other Trace Metals

Monitoring results for the Sacramento River Watershed Program (SRWP) and for primary coordinating programs (USGS NAWQA, Sacramento River Coordinated Monitoring Program, City of Redding NPDES monitoring, and Department of Water Resources) are presented and summarized in this section. Data are evaluated for spatial and temporal trends, and summary statistics are also provided in Appendix E. Data are also compared to relevant water quality objectives and to advisory criteria to evaluate attainment and potential impairment of beneficial uses in the watershed. Qualitative comparisons of mass loads from major Delta inputs are used to evaluate the relative importance of Sacramento River watershed trace metals sources to the Delta.

i. Background and Available Data Overview

The sources of data utilized for this report are summarized in Table 10. The monitoring locations for the primary data considered for this report (USGS NAWQA, Sacramento River Coordinated Monitoring Program, City of Redding NPDES monitoring, the California Department of Water Resources, and the Sacramento River Watershed Program) are illustrated in Figure 7. As stated in the beginning of this Data Review, data from these primary coordinating programs are pooled for the analyses and evaluations presented herein, unless otherwise noted.

Table 10. Trace Metals Monitoring Programs In The Sacramento River Watershed

Program	Monitoring Period	Parameters	# of monitoring locations & geographic reference
SRWP	6/98 – 5/00	▪ Total and dissolved As, Cd, Cu, Pb, Zn ▪ Total Cr, Se, Ni, Ag	2 sites: 1 in upper watershed, and 1 in lower watershed
Sacramento River Basin NAWQA (USGS)	2/96 – 4/98	▪ Dissolved As, Cd, Cr, Cu, Pb, Ni, Se, Ag, Zn (and other metals)	12 sites, distributed throughout watershed
Sacramento River Basin NAWQA, low intensity phase (USGS)	5/98 – 8/00	▪ Dissolved As, Cd, Cr, Cu, Pb, Ni, Se, Ag, Zn (and other metals)	Sacramento River at Freeport
Sacramento River CMP (SRCSD)	12/92 – 6/00	▪ Total and dissolved As, Cd, Cr, Cu, Pb, Ni, Se, Ag, Zn	5 sites, on Sacramento and American rivers in Sacramento metropolitan area
City of Redding	1/98–5/00	▪ Total and dissolved As, Cd, Cr, Cu, Pb, Ni, Zn ▪ Total Se, Ag	1 site at Sacramento River below Keswick Dam
SFBay Regional Monitoring Program	1987– 1998	▪ Total and dissolved As, Cd, Cr, Cu, Pb, Ni, Se, Ag, and Zn in water	18 Bay-Delta sites, including Sacramento River and San Joaquin River at the Delta terminus
Intensive Tributary Monitoring (DWR)	6/98–5/99	▪ Total As, Cd, Cr, Cu, Pb, Ni, Se, Ag, and Zn in water	Numerous locations in Deer Ck, Mill Ck, Big Chico Ck

ii. Spatial Distribution & Patterns

Data were evaluated for spatial trends in concentration data in the Sacramento River mainstem, and for differences between major and minor tributaries and the Sacramento River mainstem. The primary reason for spatial evaluation of concentrations is to help in the detection of sources with higher pollutant concentrations. Typical spatial distributions are described using median concentrations of trace metals. Median data are used for spatial analysis because the median is a representative and relatively stable statistic that represents “typical” concentrations for a water body. (Note that median data are generally not used for evaluation of attainment or potential impairment of beneficial uses in this report, because these evaluations require consideration of the full range of data.) Variability of the data was evaluated by comparing the interquartile range-to-median ratios for each parameter and site (this is a non-parametric equivalent of the coefficient of variation value). Results for the range of data are presented in Figures 8–12 and are discussed below. Summary statistics for trace metals data are presented in Appendix E.

Spatial Distribution of Arsenic.—Typical total arsenic concentrations in the Sacramento River mainstem range from a median of 1.1 µg/L below the Keswick Reservoir discharge to a median of 1.7 µg/L for the Sacramento River at Veterans Bridge. The median total concentration in the American River (0.48 µg/L) is less than one half the median concentration for the Sacramento River at Veterans Bridge, and is responsible for a slight decrease in the concentrations observed for the Sacramento River at Freeport and River Mile 44, where the median concentration is 1.5 µg/L. The median total concentration at Cache Slough near Ryers Ferry (1.6 µg/L) is similar to that in the Sacramento mainstem. Total arsenic concentrations were much higher in the Mill Creek watershed, with medians of 16 µg/L and 51 µg/L in the lower and upper watershed, respectively. Concentrations in the lower Deer Creek watershed were also higher than the mainstem, with medians near 2 µg/L. Arsenic concentrations in the Big Chico Creek watershed were substantially lower than in the mainstem, with medians ranging from 0.06 – 0.27 µg/L. The variability of total arsenic concentrations was similar at Sacramento River at Veterans Bridge, Freeport, and River Mile 44, with slightly lower variability for the American River and somewhat more variability in the three smaller tributaries (Mill, Deer, and Big Chico creeks). The highest total arsenic concentrations observed were in the upper Mill Creek watershed at Highway 36 (109 µg/L).

Evaluation of spatial trends in dissolved arsenic are somewhat hampered because the majority of the available data (from the USGS NAWQA program) are below detection at a reporting limit of 1 µg/L. Median concentrations in the Sacramento River mainstem remained relatively consistent between 1 and 1.1 µg/L, with no apparent downstream trend (although it should be noted that these median dissolved data are influenced by the reporting limits for USGS data). It is apparent that dissolved arsenic concentrations in the major tributaries (the Feather, Yuba, and American rivers) are lower than in the Sacramento River mainstem since dissolved arsenic concentrations were not observed to exceed 1 µg/L in any of these tributaries. Median dissolved concentrations in Colusa Basin Drain (2.4 µg/L), Sacramento Slough (4.0 µg/L), and Arcade Creek (2.0 µg/L) were considerably higher than in the mainstem, while median concentrations for Cache

Creek and Yolo Bypass were both similar to the mainstem at about the 1 µg/L reporting level. Variability in dissolved arsenic concentrations was difficult to evaluate due to the high percentage of data below reporting limits, but the highest dissolved concentrations observed were at Sacramento Slough, Colusa Basin Drain, and Arcade Creek (6 µg/L at all three sites). Total and dissolved arsenic data are presented in Figure 8.

Spatial Distribution of Cadmium—Median total cadmium concentrations in the Sacramento River mainstem range from a minimum of 0.02 µg/L below the Keswick Reservoir discharge to a maximum of 0.04 µg/L for the Sacramento River at Veterans Bridge. The estimated median total concentration in the American River (below the reporting limit of 0.02 µg/L) is much lower the median concentration for the Sacramento River at Veterans Bridge (0.04 µg/L), and results in a significant decrease in the median concentrations observed for the Sacramento River at Freeport and River Mile 44 (0.03 µg/L at both sites). The median total concentration at Cache Slough near Ryers Ferry (0.02 µg/L) is substantially lower than observed in the Sacramento River mainstem. Total cadmium concentrations were also lower in the Mill Creek, Deer Creek, and Big Chico Creek watersheds, with medians less than 0.01 µg/L. Variability of total cadmium concentrations appears similar at most mainstem and major tributary sites, with somewhat greater variability at Sacramento River below Keswick Reservoir. Variability in the smaller tributary watersheds (Mill, Deer, and Big Chico creeks) could not be assessed due to the proportion of data below reporting limits. The highest single sample total cadmium concentration observed was reported for Mud Creek above Big Chico Creek (5.4 µg/L).

Evaluation of spatial trends in dissolved cadmium are difficult because most available data are below detection at reporting limits between 1 µg/L and 0.005 µg/L. Median concentrations in the Sacramento River mainstem ranged from a maximum of 0.019 µg/L for the Sacramento River below Keswick to an estimated minimum of less than 0.01 µg/L at Veterans Bridge, Freeport, and River Mile 44 (CMP data, 1994-2000). It is apparent that concentrations in the American River are typically somewhat lower than in the Sacramento River mainstem, but there were insufficient detected data to estimate medians for any of the tributaries (USGS NAWQA data, 1996-98; CMP data, 1994-2000). Median dissolved cadmium in Sacramento Slough and Colusa Basin Drain were below the NAWQA detection limit of 1 µg/L. The highest dissolved cadmium concentrations observed were at Sacramento River below Keswick Reservoir (0.019 µg/L).

Total and dissolved cadmium data are also presented in Figure 9.

Spatial Distribution of Copper—Median total copper concentrations in the Sacramento River mainstem range from a minimum of 2.1 µg/L below the Keswick Reservoir discharge to 3.7 µg/L for the Sacramento River at Veterans Bridge. The median total concentration in the American River (0.8 µg/L) is approximately one quarter the median concentrations for the Sacramento River at Veterans Bridge (3.7 µg/L). The median total concentration at Cache Slough near Ryers Ferry (4.5 µg/L) is higher than observed in the Sacramento mainstem. Total copper concentrations were lower in the Mill Creek, Deer Creek, and Big Chico Creek watersheds, with medians ranging from 0.15–1.7 µg/L.

Median total copper concentrations in the two agricultural drainage-dominated locations, Sacramento Slough and Colusa Basin Drain (5.1 and 7.4 µg/L, respectively), were high compared to the Sacramento River. Variability of total copper concentrations was higher at Sacramento River below Keswick (due primarily to lower minimum concentrations), but the highest single sample total copper concentrations observed were at Colusa Basin Drain and Arcade Creek (21.5 and 21.1 µg/L, respectively). Variability in the smaller tributary watersheds (Mill, Deer, and Big Chico creeks) was not markedly different than in the Sacramento River mainstem. Note that the high concentrations observed in Arcade Creek (an urban creek) and Colusa Basin Drain (an agricultural drain) are indicative of influence from two potentially significant copper sources: urban runoff and agricultural use of copper-based pesticides. The influence of mine drainage (another potentially significant source of copper) on spatial trends in copper distribution is not readily apparent from these data.

Median dissolved copper concentrations for the available data for the Sacramento River mainstem are very consistent and range between 1.2 µg/L and 1.7 µg/L from the Sacramento River below Keswick to River Mile 44. The median dissolved concentration in the American River at Discovery Park (0.5 µg/L) is less than half the median concentration for the Sacramento River near Hamilton City (1.2 µg/L). Median dissolved concentrations in the other major tributaries (the Feather River and Yuba River) were 1.0 and <1.0 µg/L, respectively. Median dissolved concentrations were clearly higher in the two agricultural drains (Colusa Basin Drain—2.4 µg/L; Sacramento Slough—2.0 µg/L), an urban creek (Arcade Creek, 4.0 µg/L), and the Yolo Bypass (1.4 µg/L). Median dissolved concentrations were lower in Cache Creek (<1 µg/L) than in the mainstem Sacramento River. Variability in dissolved copper concentration data was similar for all sites. The highest individual dissolved copper concentrations observed were at Colusa Basin Drain (8.0 µg/L) and in Arcade Creek (9.0 µg/L).

Total and dissolved copper data are also presented in Figure 10.

Spatial Distribution of Lead—Median total lead concentrations in the Sacramento River mainstem range from a low of 0.05 µg/L below the Keswick Reservoir discharge, to a high of 0.53 µg/L for the Sacramento River at River Mile 44 (CMP data, 1994-2000). There is a substantial increase in total lead concentrations in the Sacramento River between Keswick Reservoir and Veterans Bridge, but median concentrations change little in the lower reach from Veterans Bridge to River Mile 44. The median total concentration in the American River (0.2 µg/L) is less than one half the median concentration for the Sacramento River at Veterans Bridge (0.52 µg/L). The median total concentration at Cache Slough near Ryers Ferry (0.68 µg/L, SRWP data 1998-2000) is slightly higher than observed in the Sacramento mainstem. Total lead concentrations in the Mill Creek, Deer Creek, and Big Chico Creek watersheds were generally lower than in the mainstem, with medians ranging from less than 0.01 to 0.05 µg/L, but maximum concentrations in Mill Creek (1.3–2.6 µg/L) were higher than observed in the mainstem between Keswick and Colusa. Variability of total lead data is not notably different among sites, but the maximum single sample concentrations observed were at Veterans Bridge (7.2 µg/L) and River Mile 44 (3.4 µg/L).

Evaluation of spatial trends in dissolved lead are difficult because a preponderance of available data (primarily from USGS NAWQA and the Sacramento CMP) are below detection at a reporting limit of 1 µg/L. The median dissolved lead concentrations in the Sacramento River below Keswick and near Hamilton City were 0.02 µg/L (SRWP and City of Redding data, 1998-2000), and the median dissolved lead concentration at Cache Slough was 0.07 µg/L (SRWP data, 1998-2000). There were insufficient detected data to calculate medians for other Sacramento River or tributary locations. Variability of dissolved lead data could not be adequately assessed, but the highest single sample dissolved lead concentration observed was at Arcade Creek (1.32 µg/L).

Total and dissolved lead data are also presented in Figure 11.

Spatial Distribution of Nickel—Median total nickel concentrations in the mainstem Sacramento River increase by more than a factor of three between Keswick (1.5 µg/L) and the Veterans Bridge (4.6 µg/L). The median total nickel concentration in the American River (0.9 µg/L) is less than one fourth the median concentration for the Sacramento River at Veterans Bridge and results in decreases in the median concentrations observed for the Sacramento River at Freeport and River Mile 44 (3.2 µg/L and 3.6 µg/L, respectively). The median total concentrations for Cache Creek at Rumsey and Cache Slough near Ryers Ferry (6.5 and 7.5 µg/L) are approximately twice the median concentration in the Sacramento mainstem. Total nickel concentrations in the Mill Creek, Deer Creek, and Big Chico Creek watersheds were generally lower than in the mainstem, with medians less than 1.0 µg/L, with the exception of the upper Mill Creek watershed, where the median was 2.3 µg/L and the maximum (7.5 µg/L) was higher than observed in the mainstem between Keswick and Colusa. Variability of total nickel concentrations is not notably different among sites. The maximum observed total nickel concentrations were reported for Cache Creek (180 µg/L) and in the mainstem Sacramento River at Veterans Bridge, Freeport and, River Mile 44 (22.5 µg/L, 18 µg/L, and 17 µg/L, respectively).

Median dissolved nickel concentrations in the mainstem Sacramento River decrease from Keswick (1.2 µg/L) to Freeport (<1µg/L). In the major tributaries, most dissolved nickel data were below the USGS reporting limit (1 µg/L), and it is clear that dissolved nickel concentrations are lower than in the mainstem. Median dissolved nickel concentrations in the major agricultural drains (Colusa Basin Drain and Sacramento Slough), Arcade Creek, Cache Creek, and the Yolo Bypass are approximately 2 to 3 times higher than observed in the Sacramento River mainstem. Variability of dissolved nickel data could not be adequately evaluated for all sites. However, based on the narrow range of median and maximum values, variability within and among sites was relatively low compared to other parameters. The highest single sample dissolved nickel concentrations observed were reported at Cache Slough (5.4 µg/L), Colusa Basin Drain (5.0 µg/L), and Arcade Creek (4.4 µg/L).

Spatial Distribution of Zinc.—Median total zinc concentrations in the Sacramento River mainstem range from a low of 3.8 µg/L below the Keswick Reservoir discharge to a high of 5.9 µg/L for the Sacramento River at River Mile 44. The median total concentration in the American River (2.8 µg/L) is less than the median concentration for the Sacramento

River at Veterans Bridge (5.8 µg/L) and produces a decrease in the median concentrations observed for the Sacramento River at Freeport (4.8 µg/L). The median total concentration for Cache Slough near Ryers Ferry (6.7 µg/L) is higher than the median concentration in the Sacramento mainstem. Total zinc concentrations in the Mill Creek, Deer Creek, and Big Chico Creek watersheds were generally lower than in the mainstem, with medians at most locations less than 1.0 µg/L, with the exception of the upper Mill Creek watershed, where the median of 2.7 µg/L was higher than in the mainstem between Keswick and Colusa. Variability of total zinc concentrations was generally similar among sites, with the exception of the Sacramento River at Keswick which was notably more variable than other mainstem sites. The highest total zinc concentrations observed were reported for the American River at Discovery Park (230 µg/L) and the Sacramento River below Keswick (143 µg/L).

In general, median dissolved zinc concentrations exhibit a decreasing trend with distance downstream from Keswick Dam. Median dissolved zinc concentrations for the available data for the Sacramento River mainstem range from a high of 2.8 µg/L for the Sacramento River below Keswick, to approximately 1.0 µg/L and 1.2 µg/L for Freeport and River Mile 44, respectively. In the major tributaries to the mainstem, most dissolved zinc data were below the USGS reporting limit (1 µg/L). Median dissolved zinc concentrations in the major agricultural drains (Colusa Basin Drain and Sacramento Slough), and Cache Creek are also below detection at a reporting limit of 1 µg/L. Arcade Creek stands out with a substantially higher median dissolved zinc concentration of 7.7 µg/L (USGS data, 1996-99). Variability of dissolved zinc data was not notably different among locations, with the exceptions of Cache Slough and the Sacramento River near Hamilton, which were relatively high compared to the other locations. The highest single sample dissolved zinc concentrations observed were reported for the Sacramento River at Veterans Bridge (23 µg/L) and Freeport (27 µg/L).

Total and dissolved zinc data are also presented in Figure 12.

iii. Temporal Distribution & Patterns

Total trace metals concentrations in the mainstem Sacramento River generally exhibit a strong seasonal pattern (Figure 13). Concentrations typically peak after the early precipitation events and increased river flows of the early wet season, and then decrease steadily through the next wet season. In general, this pattern is consistent with the adsorption of metals to fine-grained particles and the seasonal wash-off, resuspension and transport of these particulates deposited during the dry season. This pattern appears to be consistent for total concentrations of all trace metals at all the mainstem Sacramento River sites monitored between Redding and River Mile 44, and in the major tributaries in the lower watershed (the Feather River, Yuba River, and American River). This pattern in the data is somewhat less distinct for dissolved metals concentrations in the mainstem Sacramento River and the American River. There are insufficient data to assess temporal patterns in dissolved trace metals in other major tributaries because the majority of NAWQA dissolved trace metals concentrations are below detection.

Time series plots of water column trace metal concentrations are also presented in Appendix G of this report.

iv. Attainment of Beneficial Uses and Potential Impairment

Comparisons with water quality criteria: All total and dissolved trace metals concentration data from the SRWP and primary coordinating programs (1994-2000) were compared to CTR water quality criteria and Central Valley Region Basin Plan objectives (Table 11). Metals with hardness-dependent criteria (cadmium, chromium, copper, lead, nickel, and zinc) were first screened using criteria based on the lowest reported hardness (i.e. the most stringent criterion) for each specific monitoring location. If the maximum reported metal concentration for a site exceeded the "worst-case" criterion, individual metal concentrations for that site were compared to criteria calculated using the matching hardness data for each value. All comparisons to CTR criteria are to the more stringent "chronic" criterion intended to apply to 4-day average concentrations, with the exception of silver, for which there is no adopted chronic criterion. It should be noted that because all samples are effectively instantaneous grabs, actual 4-day average concentrations may not have exceeded CTR chronic criteria. Objectives in the Central Valley Basin Plan are expressed as maximum concentrations, not to be exceeded.

Trace metals concentrations in the Sacramento River mainstem and in the American River were rarely observed to exceed CTR criteria or other water quality objectives for trace metals. Dissolved concentrations of copper for the American River at J Street exceeded the hardness-adjusted chronic copper criterion in 8% of samples analyzed (2 of 26), in 20% of samples analyzed for Arcade Creek (8 of 40 samples), and in 8% (3 of 40) samples from Colusa Basin Drain. Dissolved copper concentrations exceeded the CTR chronic criterion in approximately 9% of the samples (4 of 43) from Sacramento River below Keswick, and exceeded the Basin Plan objective in 7% (3 of 43) of the samples from this site. Dissolved copper concentrations were not observed to exceed CTR criterion values or other applicable water quality objectives in the Sacramento River mainstem from Red Bluff to Freeport. Dissolved copper exceeded the CTR criterion in only one sample (of 94 total samples) below Freeport (collected in November 1994 from River Mile 44).

Dissolved concentrations of other trace metals were not observed to exceed CTR criteria or Basin Plan objectives at any location. In the Mill Creek watershed, total concentrations of copper, lead, silver and zinc exceeded the lowest hardness-adjusted criteria for dissolved metals at several locations. Total concentrations of cadmium exceeded the lowest dissolved chronic criterion at one location in the Deer Creek watershed and total copper concentrations exceeded the lowest dissolved chronic criterion at one location in the Big Chico Creek watershed. Because dissolved concentrations of metals were not measured in Mill Creek, Deer Creek, and Big Chico Creek, it was not possible to determine whether exceedances of the dissolved metals criteria actually occurred.

EPA is in the process of reassessing scientific and cost issues associated with the fianl arsenic rule published on January 22, 2001 which establishes a new Maximum Contaminant Level (MCL) of 10 μg/L as total arsenic (revised from 50 μg/L) to protect consumers against the effects of long-term, chronic exposure to arsenic in drinking water (66 FR 6976 / January 22, 2001). EPA has extended the effective date for the arsenic rule to February 22, 2002, to allow time to conduct additional studies. If the 10 µg/L limit is not revised as a result of these studies, it would automatically be incorporated by reference as a Basin Plan objective. It appears that waters of the mainstem Sacramento River and major tributaries would consistently meet an MCL of 10 µg/L for total arsenic. However, concentrations of total arsenic in Mill Creek consistently exceed this limit. Although the current Basin Plan objective for dissolved arsenic (10 µg/L) does not specifically apply in Mill Creek, it should be noted that total arsenic concentrations exceeded this objective in more than 90% of the samples analyzed from this watershed. The high arsenic concentrations in this small and relatively undeveloped watershed appear to be derived from natural sources, primarily from hot springs near the Mill Creek headwaters near Lassen.

Longer-term data sets (e.g. Sacramento CMP data, 1992-2000) indicate that total and dissolved trace metals concentrations in the lower Sacramento River (below the confluence with the Feather River) and the American River nearly always meet the CTR criteria and Basin Plan objectives (greater than 99.9% of the time). In summary, trace metal concentrations in the mainstem Sacramento River and major tributaries have been observed to comply with applicable regulatory limits a high percentage of the time, with the exceptions of dissolved copper concentrations in the Sacramento River below Keswick Reservoir, in Arcade Creek, and in Colusa Basin Drain. These exceedences of regulatory limits for copper at these locations are consistent with the influences of mine drainage on the Sacramento River below Keswick, of urban runoff in Arcade Creek, and of the agricultural use of copper-based pesticides in the area drained by Colusa Basin Drain. Compliance statistics with CTR criteria and Basin Plan objectives are summarized in Table 12.

What do the data say about attainment of beneficial uses and potential impairment, and how does this compare with any relevant 303(d) listings for parameter and sites?
The current CTR water quality criteria for the trace metals of interest are based on the protection of aquatic life. The CTR criteria define what USEPA believes to be "safe levels", rather than toxicity threshold levels. Because these criteria are conservative by design (to protect all waters in the United states) and are not reflective of site-specific conditions, exceedances of the criteria are not necessarily predictive of actual impairments of beneficial uses. For the purpose of these evaluations, ambient concentrations that exceed criteria or objectives are considered indicators of potential impairment of beneficial uses.

A number of tributary reaches and one mainstem reach in the Sacramento River watershed are included for trace metals on the California 1998 303(d) list (Table 13). Most of these listings are for elevated cadmium, copper, lead, and zinc in water and sediment. There is one listing for arsenic (Kanaka Creek) and one listing for nickel (James Creek). All of the listings are attributed to the effects of mining (resource extraction and mine tailings). There are also listings for copper, nickel, and selenium for the San Francisco Bay estuary and the Sacramento-San Joaquin Delta, attributed to a variety of sources. The listings for copper and nickel in the Bay and Delta cite elevated concentrations in water, sediment, and tissue as reasons for the listings. Observed exceedances of CTR criteria and Basin Plan objectives for dissolved copper in the Sacramento River immediately below Keswick Reservoir appear to be consistent with the 303(d) listing for this reach of the Sacramento River. Although this stretch of the Sacramento River is also listed for cadmium and zinc, dissolved concentrations in the Sacramento River below Keswick Reservoir were not observed to exceed or approach CTR hardness-adjusted criteria or Basin Plan objectives for these metals.

Based on monitoring results from the SRWP (1998-2000), NAWQA (1996-98), the Sacramento CMP (1992-2000), and the City of Redding (1998-2000), it appears that aquatic life beneficial uses are not being adversely impacted by trace metals in the mainstem Sacramento River below Red Bluff, in the major tributaries (Feather River, Yuba River, and American River), and in Sacramento Slough (which is dominated by agricultural drainage). However, in the Sacramento River between Shasta Dam and Red Bluff, in Colusa Basin Drain, and in Arcade Creek, dissolved copper concentrations may exceed levels potentially harmful to sensitive aquatic species. It should be noted that these evaluations of the potential for impairment of aquatic life uses are performed on a constituent-by-constituent basis, and do not consider the potential for additive, synergistic, or antagonistic effects on toxicity from some metals and other constituents. Likewise, factors likely to moderate or reduce the toxic effects or bioavailability of metals (e.g. organic carbon and colloidal complexes) are not incorporated into these evaluations. However, given that the criteria and objectives used for comparisons to water quality data are designed to be protective of aquatic life with some margin of safety, it seems reasonable to conclude that these evaluations are more likely to err on the side of protection.

In the Mill Creek watershed, total arsenic concentrations consistently exceed the 10 µg/L arsenic drinking water MCL. If the 10 µg/L arsenic MCL is retained, the use of Mill Creek water as a drinking water source could be limited or prohibited. This watershed is not currently included on California’s 303(d) list of impaired waterbodies. It appears that the 10 µg/L total arsenic MCL would not limit the use of the Sacramento River and major tributaries as drinking water sources.

Table 11. California Toxics Rule Water Quality Criteria and Central Valley Region Basin Plan Objectives for Trace Metals.

	Arsenic, dissolved, µg/L		Cadmium, dissolved, µg/L		Chromium, dissolved, µg/L	Copper, dissolved, µg/L		Lead, dissolved, µg/L	Nickel, dissolved, µg/L	Selenium, total, µg/L	Silver, dissolved, µg/L		Zinc, dissolved, µg/L	
Location	CTR	BP	CTR	BP	CTR	CTR	BP	CTR	CTR	CTR	CTR	BP	CTR	BP
Sacramento River below Keswick	150	10	1.1	0.20	77	3.7	5.1	1.1	22	5	0.60	10	50	15
Sacramento River above Bend Bridge	150	10	0.92	0.16	66	3.2	4.3	1.2	19	5	0.43	10	43	13
Mill Ck at Mouth	150	NA	0.78	0.12	55	2.6	3.5	1.1	16	5	0.30	10	35	10
Mill Ck at USGS gage	150	NA	1.1	0.20	77	3.7	5.1	1.2	22	5	0.60	10	50	15
Mill Ck at Black Rock	150	NA	0.87	0.15	63	3.0	4.1	0.91	18	5	0.39	10	40	12
Deer Ck at Highway 99	150	NA	0.87	0.15	63	3.0	4.1	0.91	18	5	0.39	10	40	12
Deer Ck at Upper Diversion Dam	150	NA	0.85	0.14	61	2.9	3.9	0.79	17	5	0.36	10	39	12
Deer Ck at Ponderosa Way	150	NA	1.3	0.28	98	4.8	6.6	1.2	28	5	0.98	10	63	19
Deer Ck at A Line Road	150	NA	0.68	0.10	48	2.3	3.0	0.65	13	5	0.22	10	30	9.0
Deer Ck below Childs Meadows	150	NA	0.46	0.055	31	1.5	1.9	0.39	9	5	0.09	10	20	5.9
Big Chico Ck above Mud Ck	150	NA	0.78	0.12	55	2.6	3.5	1.8	16	5	0.30	10	35	10
Mud Ck above Big Chico Ck	150	NA	0.96	0.17	70	3.4	4.6	1.0	20	5	0.49	10	45	13
Big Chico Ck at Chico (Rose Ave.)	150	NA	0.68	0.10	48	2.3	3.0	2.1	13	5	0.22	10	30	9.0
Big Chico Ck above Salmon Hole	150	NA	1.7	0.41	130	6.4	9.1	1.8	38	5	1.8	10	85	25
Sacramento River near Hamilton City	150	10	1.2	0.25	91	4.4	6.1	1.3	26	5	0.84	10	59	17
Sacramento River at Colusa	150	10	0.96	0.17	70	3.4	5	1.0	20	5	0.49	10	45	13
Sacramento Slough	NA	NA	1.4	NA	104	5.1	NA	3.9	30	5	1.1	NA	68	NA
Colusa Basin Drain	NA	NA	1.3	NA	98	4.8	NA	6.0	28	5	0.98	NA	63	NA
Yuba River at Marysville	NA	NA	0.63	NA	44	2.1	NA	0.72	12	5	0.18	NA	28	NA
Feather River near Nicolaus	NA	NA	0.73	NA	52	2.5	NA	0.88	14	5	0.26	NA	33	NA
Sacramento River at Verona	NA	10	0.78	NA	55	2.6	10	1.4	16	5	0.30	10	35	100
Sacramento River at Veterans Bridge	NA	10	0.87	NA	63	3.0	10	1.6	18	5	0.39	10	40	100
Arcade Ck at Norwood Ave.	NA	NA	0.75	NA	53	2.6	NA	2.6	15	5	0.28	NA	34	NA
American River at J Street	NA	10	0.58	NA	40	1.9	10	0.43	11	5	0.15	10	25	100
American River at Discovery Park	NA	10	0.52	NA	36	1.7	10	0.56	10	5	0.12	10	22	100
Sacramento River at Freeport	NA	10	0.65	NA	46	2.2	10	1.4	13	5	0.20	10	29	100
Sacramento River at River Mile 44	NA	10	0.78	NA	55	2.6	10	1.4	16	5	0.30	10	35	100
Cache Slough near Ryers Ferry	NA	NA	1.5	NA	115	5.7	NA	1.8	33	5	1.4	NA	75	NA

CTR criteria are California Toxic Rule (USEPA 2000) chronic criteria for protection of aquatic life. All CTR criteria are expressed as 4-day averages, except for silver, which is expressed as an instantaneous maximum concentration.
CTR criteria presented for cadmium, chromium, copper, lead, nickel, silver and zinc are adjusted for ***minimum*** reported hardnes
Basin Plan values are Central Valley Region Basin Plan water quality objectives for the protection of aquatic life, and are expressed as maximum values not to be exceeded.
Basin Plan objectives for cadmium, copper, and zinc are hardness-adjusted for selected locations.
"NA" indicates that there is no applicable criterion.

Table 12. Percent compliance with CTR criteria and Basin Plan objectives.

Location	Arsenic, dissolved CTR	Arsenic, dissolved BP	Cadmium, dissolved CTR	Cadmium, dissolved BP	Chromium, dissolved CTR	Copper, dissolved CTR	Copper, dissolved BP	Lead, dissolved CTR	Nickel, dissolved CTR	Selenium, total CTR	Silver, dissolved CTR	Silver, dissolved BP	Zinc, dissolved CTR	Zinc, dissolved BP
Sacramento River below Keswick	100	100	100	100	100	91	93	100	100	100	100	100	100	100
Sacramento River above Bend Bridge	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Mill Ck at Mouth	100	—	100	100	100	100	T>C	T>C	100	100	T>C	T>C	100	T>C
Mill Ck at Black Rock	100	—	100	100	100	100	T>C	T>C	100	100	T>C	T>C	100	100
Mill Ck at Highway 36	100	—	100	100	100	100	T>C	T>C	100	100	T>C	T>C	100	T>C
Deer Creek at Mouth	100	—	100	100	100	100	100	100	100	100	100	100	100	100
Deer Creek at Upper Diversion Dam	100	—	100	100	100	100	100	100	100	100	100	100	100	100
Deer Creek at Ponderosa Way	100	—	100	100	100	100	100	T>C	100	100	100	100	100	100
Deer Creek below Childs Meadows	100	—	100	100	100	100	100	100	100	100	100	100	100	100
Big Chico Ck above Mud Ck	100	—	100	100	100	100	100	100	100	100	100	100	100	100
Mud Ck above Big Chico Ck	100	—	100	T>C	100	100	100	100	100	100	100	100	100	100
Big Chico Ck at Chico (Rose Ave.)	100	—	100	100	100	100	100	100	100	100	100	100	100	100
Big Chico Ck below Five-Mile Rec.	100	—	100	100	100	100	100	100	100	100	100	100	100	100
Big Chico Ck at Golf Course	100	—	100	100	100	100	100	100	100	100	100	100	100	100
Big Chico Ck above Salmon Hole	100	—	100	100	100	100	100	100	100	100	100	100	100	100
Sacramento River near Hamilton City	—	—	100	100	—	100	100	—	—	—	—	—	100	100
Sacramento River at Colusa	100	100	100	NA	100	100	NA	100	100	—	100	NA	100	NA
Sacramento Slough	—	—	—	NA	—	100	NA	100	100	—	100	NA	100	NA
Colusa Basin Drain	100	—	100	NA	100	93	NA	100	100	—	100	NA	100	NA
Yuba River at Marysville	100	—	100	NA	100	100	NA	100	100	—	100	NA	100	NA
Feather River near Nicolaus	100	—	100	NA	100	100	NA	100	100	—	100	NA	100	NA
Sacramento River at Verona	100	100	100	NA	100	100	100	100	100	—	100	100	100	100
Sacramento River at Veterans Bridge	100	100	100	NA	100	100	100	100	100	100	—	—	100	100
Arcade Ck at Norwood Ave.	100	—	100	NA	100	80	NA	100	100	—	100	NA	100	NA
American River at J Street	100	100	100	NA	100	92	100	100	100	—	100	100	100	100
American River at Discovery Park	100	100	100	NA	100	100	100	100	100	100	—	—	100	100
Sacramento River at Freeport	100	100	100	NA	100	100	100	100	100	100	100	100	100	100
Sacramento River at River Mile 44	100	100	100	NA	100	99	100	100	100	100	—	—	100	100
Cache Slough near Ryers Ferry	100	—	100	NA	100	100	—	100	100	100	100	NA	100	NA

Values indicate percent of samples that meet applicable water quality criteria or objective.
"NA" indicates that there is no applicable criterion.
"—" indicates that parameter was not monitored at location.
"T>C" total concentration exceeded criterion, but dissolved fraction was not reported
Bold outlined values indicate observed exceedance of water quality criterion.

Table 13. Waterbodies Listed For Trace Metals On California's 1998 303(D) List.

Waterbody	Pollutant	Source	Area affected	Units
Keswick Reservoir	Cadmium, Copper, Zinc	Resource Extraction	200	Acres
Shasta Lake	Cadmium, Copper, Zinc	Resource Extraction	20	Acres
Dolly Creek	Copper, Zinc	Resource Extraction	1	Miles
Horse Creek	Cadmium, Copper, Lead, Zinc	Resource Extraction	2	Miles
Humbug Creek	Copper, Zinc	Resource Extraction	9	Miles
James Creek	Nickel	Resource Extraction	6	Miles
Kanaka Creek	Arsenic	Resource Extraction	1	Miles
Little Backbone Creek	Cadmium, Copper, Zinc	Resource Extraction	1	Miles
Little Cow Creek	Cadmium, Copper, Zinc	Resource Extraction	1	Miles
Little Grizzly Creek	Copper, Zinc	Mine Tailings	10	Miles
Sacramento River (Shasta Dam To Red Bluff)	Cadmium, Copper, Zinc	Resource Extraction	40	Miles
Spring Creek	Cadmium, Copper, Zinc	Resource Extraction	5	Miles
Town Creek	Cadmium, Copper, Lead, Zinc	Resource Extraction	1	Miles
West Squaw Creek	Cadmium, Copper, Lead, Zinc	Resource Extraction	2	Miles
Willow Creek (Whiskeytown Reservoir)	Copper, Zinc	Resource Extraction	3	Miles
Sacramento-San Joaquin Delta	Selenium	Industrial point sources, agriculture, natural sources,	15,000	Acres
Sacramento-San Joaquin Delta and San Francisco Bay Estuary	Copper, Nickel	Municipal point sources, urban runoff, atmospheric deposition	290,000	Acres
Sacramento-San Joaquin Delta and San Francisco Bay Estuary	Selenium.	Agriculture, ground water, industrial point sources, natural sources,	210,000	Acres

v. Mass Load Comparisons

Because elevated concentrations of copper and nickel in sediments and tissues are cited as reasons for the listing of San Francisco Bay and Delta waterways as impaired waterbodies on the 303(d) list, there is a need to evaluate contributions of the mass loads of these metals to the Delta. However, comparisons of mass load contributions from major Delta inputs could not be adequately performed, due to a general lack of appropriate trace metals data. Nearly all of the trace metals data from the USGS NAWQA program are for dissolved trace metals, which are not appropriate for estimation of total mass loads. Total metals concentration data from the Sacramento Coordinated Monitoring Program are adequate for estimating mass loads for some constituents in the Sacramento River near Sacramento, but there are insufficient total metals data for other potentially significant trace metal sources to the Delta, including Cache Creek, Yolo Bypass, the San Joaquin River, the Cosumnes River, and the Mokelumne River. To the degree that this information may be needed to evaluate or manage mass loads of copper and nickel (or other metals), this lack of appropriate data for estimating mass loads can be considered a significant data gap for trace metals of interest in the Delta and San Francisco Bay.

vi. Conclusions and Recommendations

- The beneficial use most likely to be impacted by (i.e. most sensitive to) elevated trace metal concentrations is aquatic life. In comparisons to CTR water quality criteria and Basin Plan water quality objectives designed to protect aquatic life, trace metal concentrations in the Sacramento River watershed are generally much lower than these values. A notable exception is that dissolved copper concentrations in individual samples continue to exceed hardness-adjusted CTR chronic criteria for copper approximately 9% of the time in the Sacramento River below Keswick Reservoir. This results indicates a potential impact on sensitive aquatic life species in this reach of the Sacramento River. Additionally, dissolved copper concentrations exceeded hardness-adjusted CTR chronic criteria for copper approximately 20% of the time in Arcade Creek, and 7% of the time in Colusa Basin Drain. To the degree that these locations are representative of urban runoff and waters dominated by agricultural drainage, these results indicate a potential for adverse impacts from elevated copper concentrations on sensitive aquatic life species in these types of waterbodies.
- There is a significant potential that elevated arsenic concentrations in Mill Creek may limit the use of this water as a drinking water source.

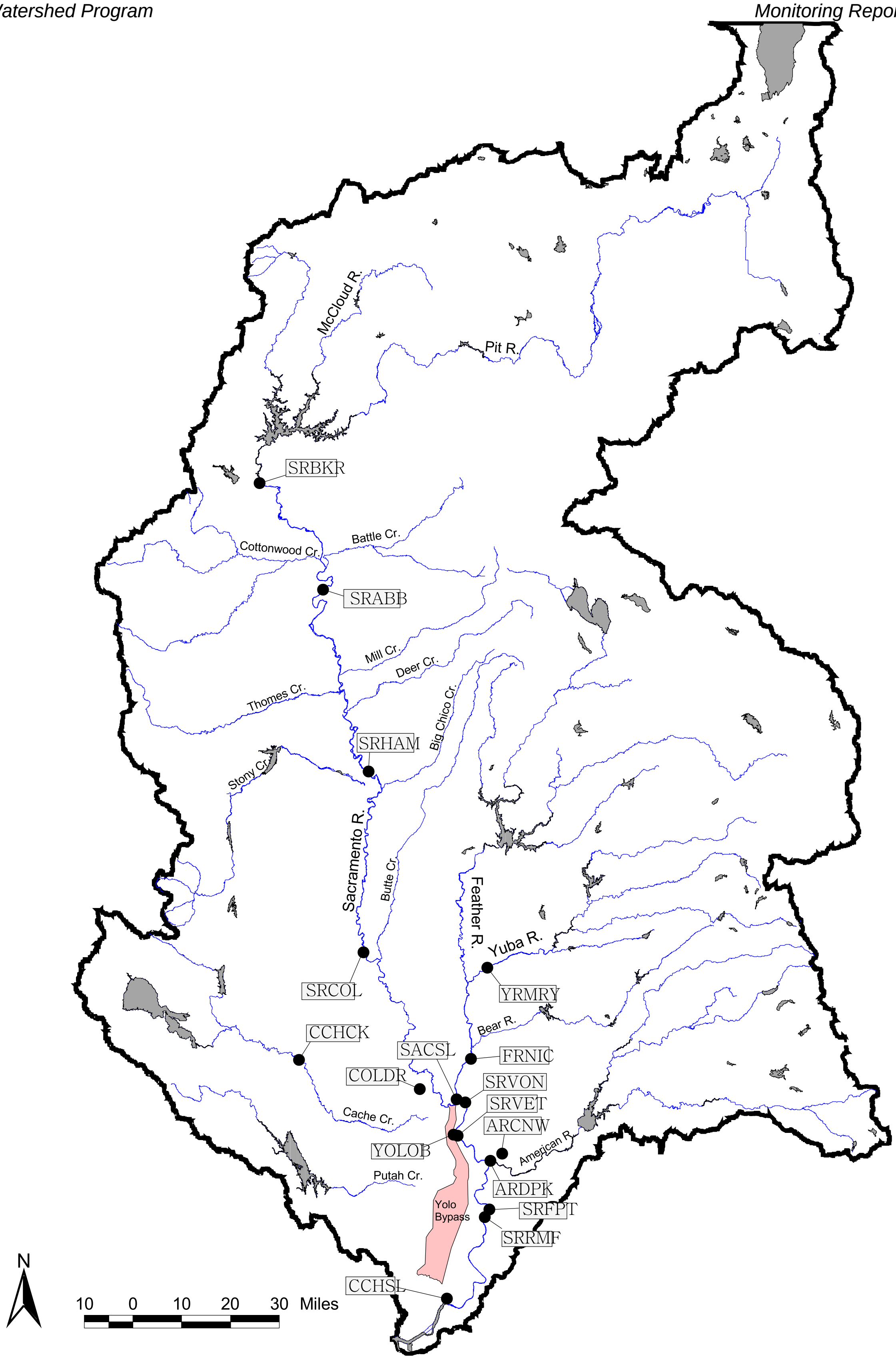

Figure 7. **Trace Metals Monitoring Sites for the Sacramento River Watershed Program, USGS NAWQA, City of Redding, Sacramento River CMP, and SRWP.**

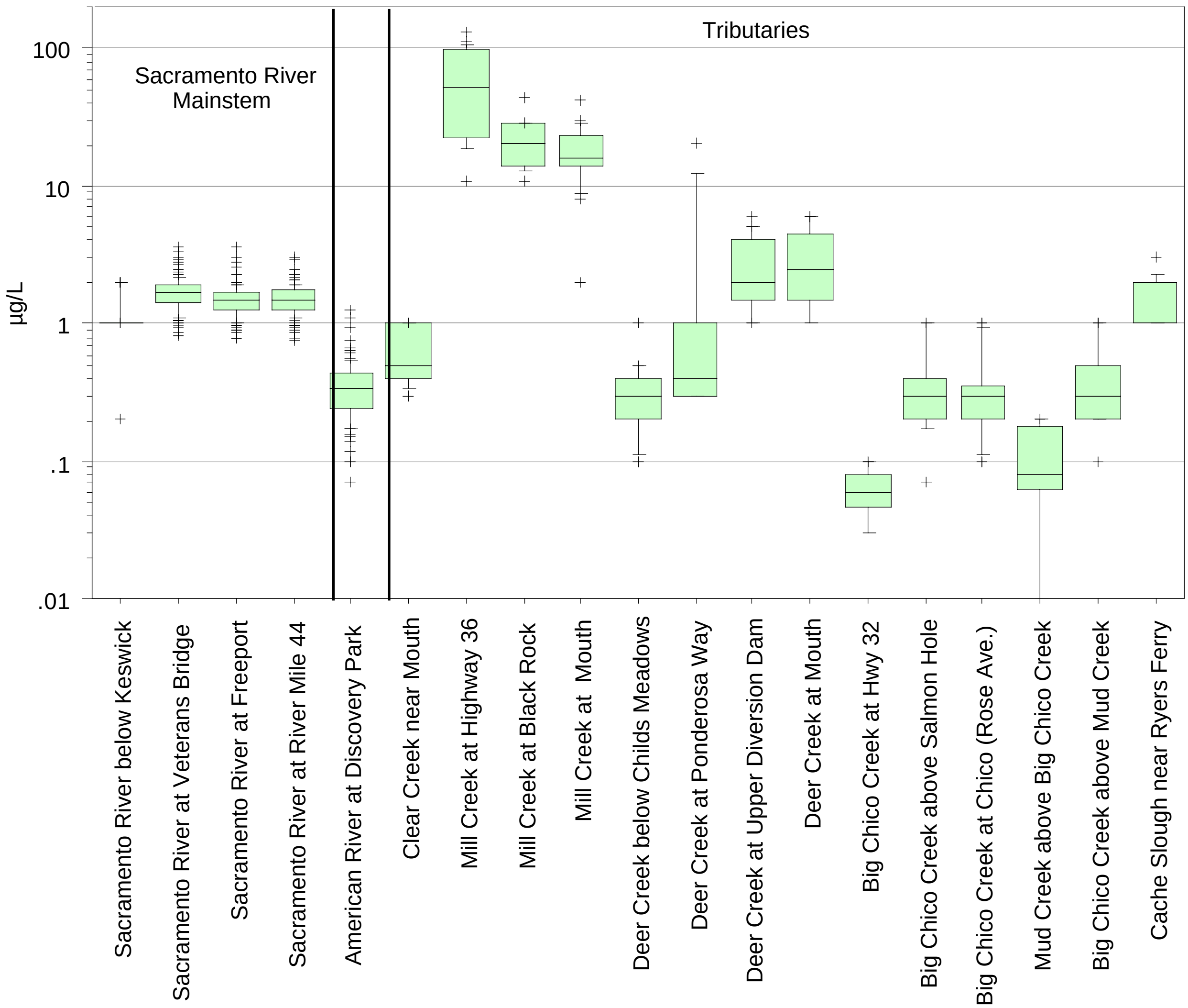

Figure 8a. Total Arsenic in the Sacramento River Watershed, 1994-2000

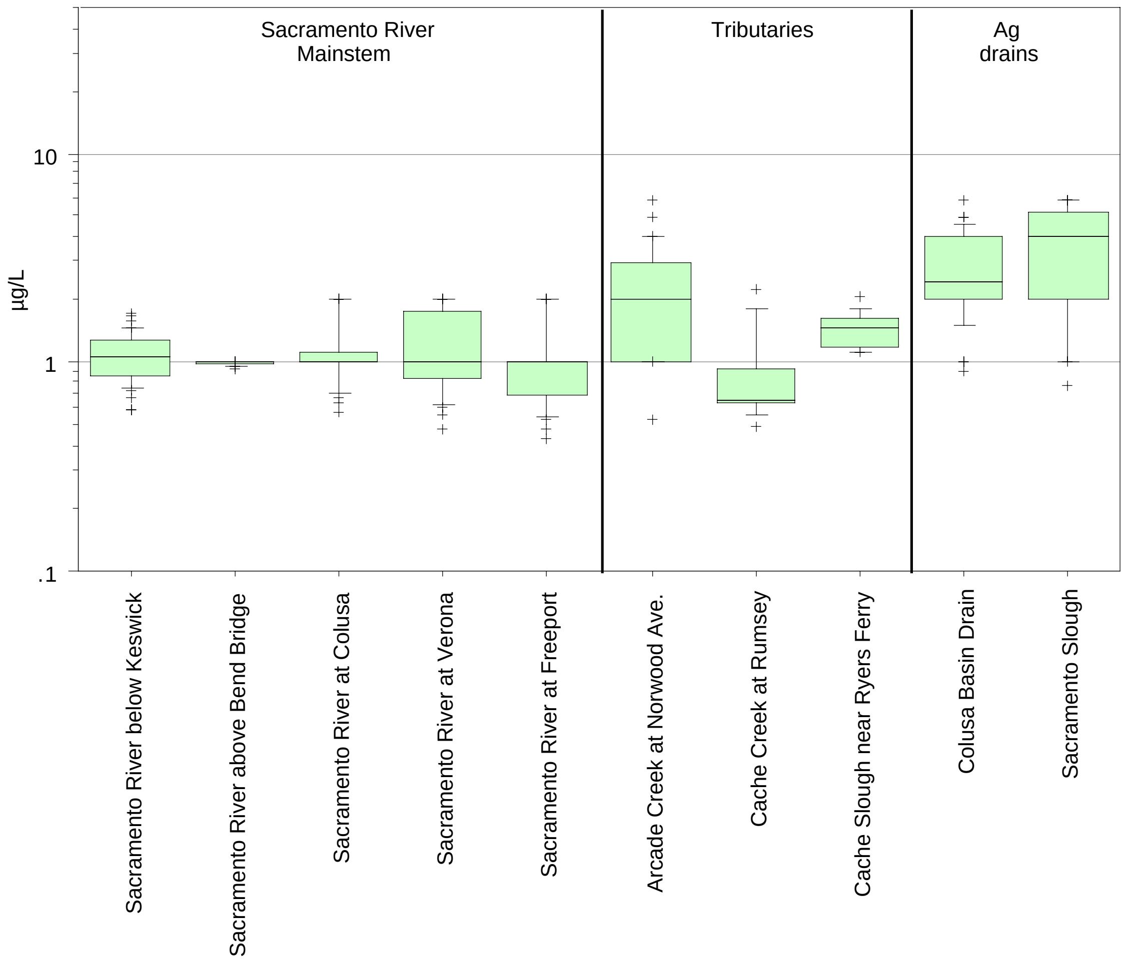

Figure 8b. Dissolved Arsenic in the Sacramento River Watershed, 1994-2000

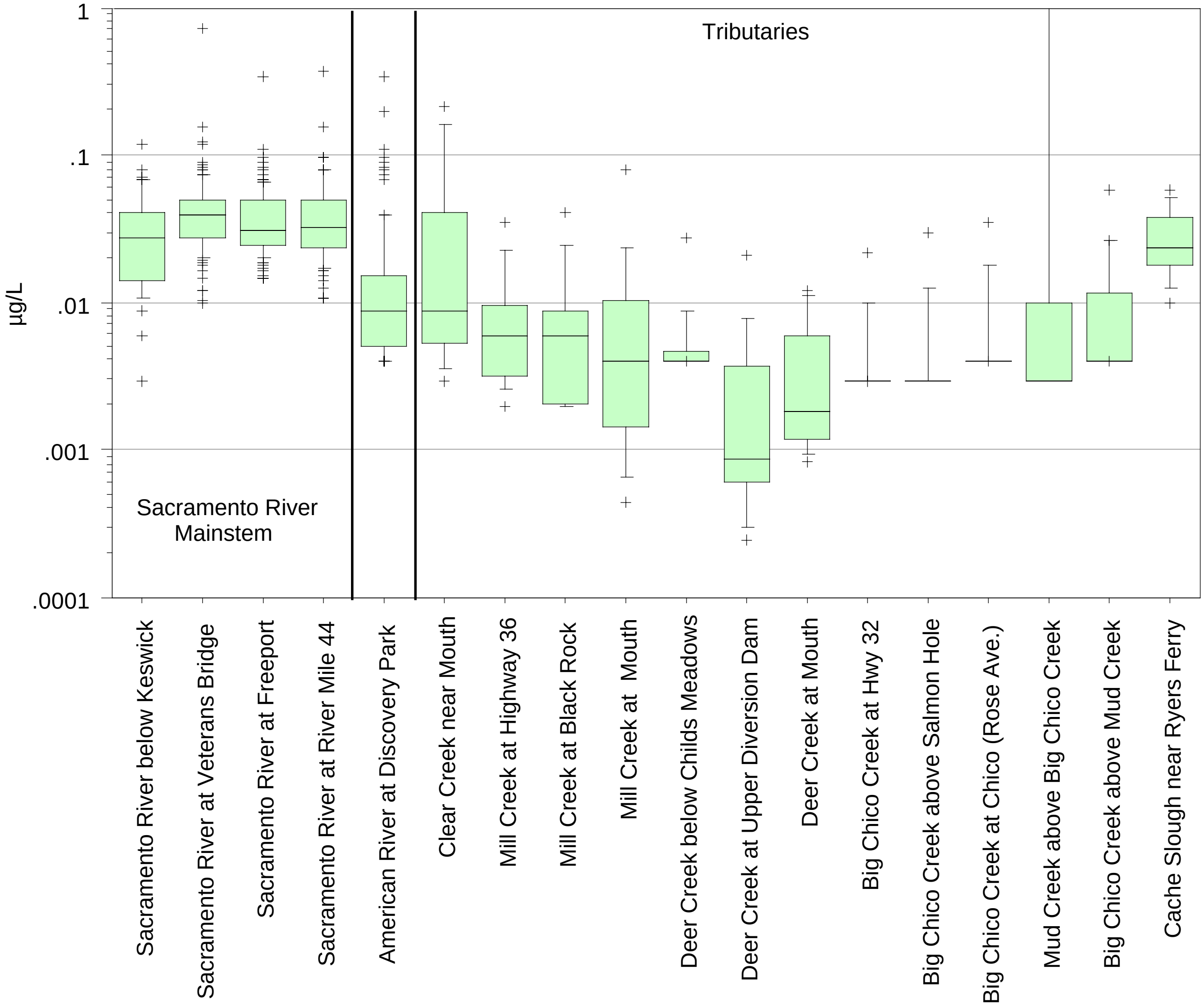

Figure 9a. Total Recoverable Cadmium in the Sacramento River Watershed., 1994-2000

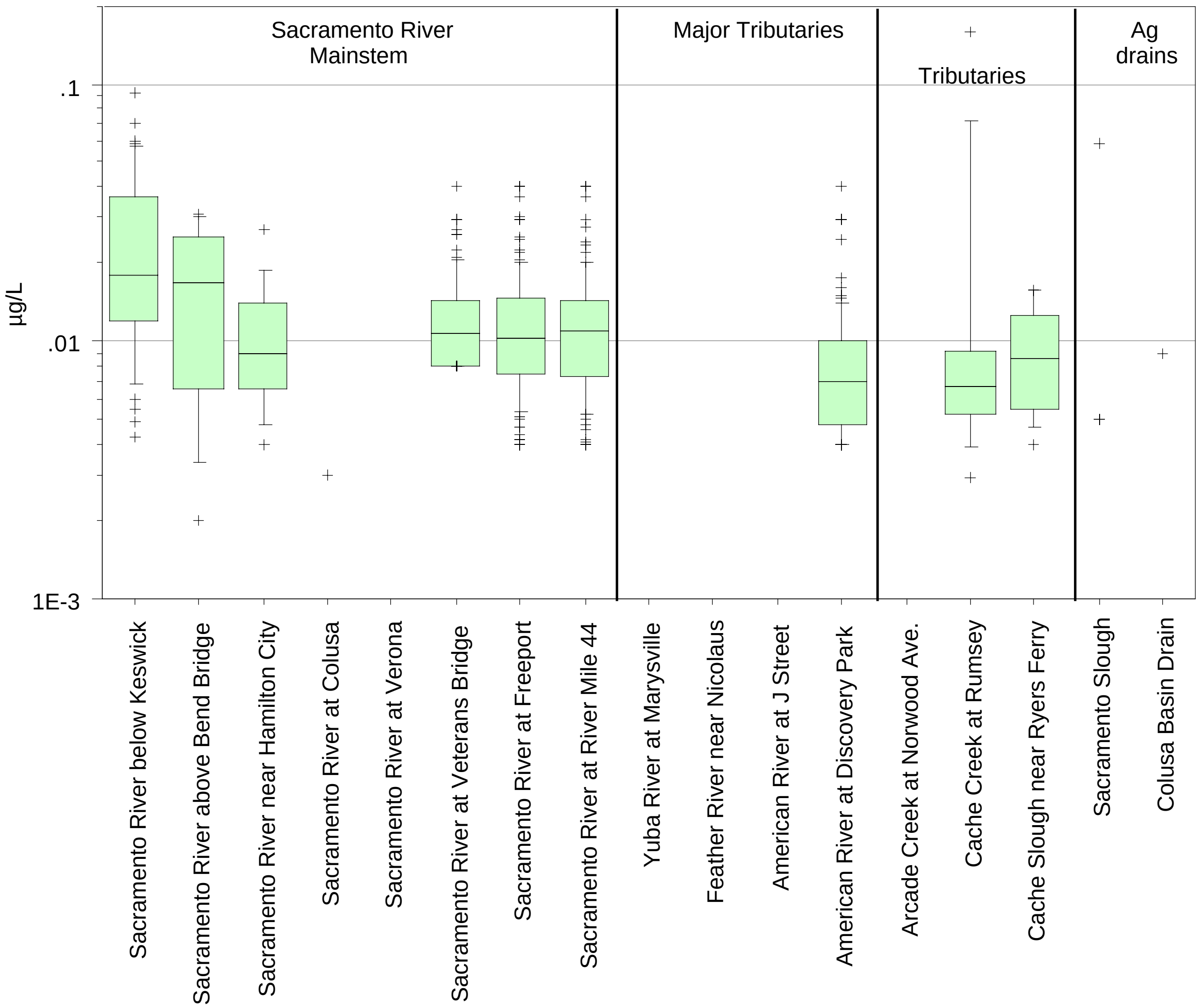

Figure 9b. Dissolved Cadmium in the Sacramento River Watershed., 1994-2000

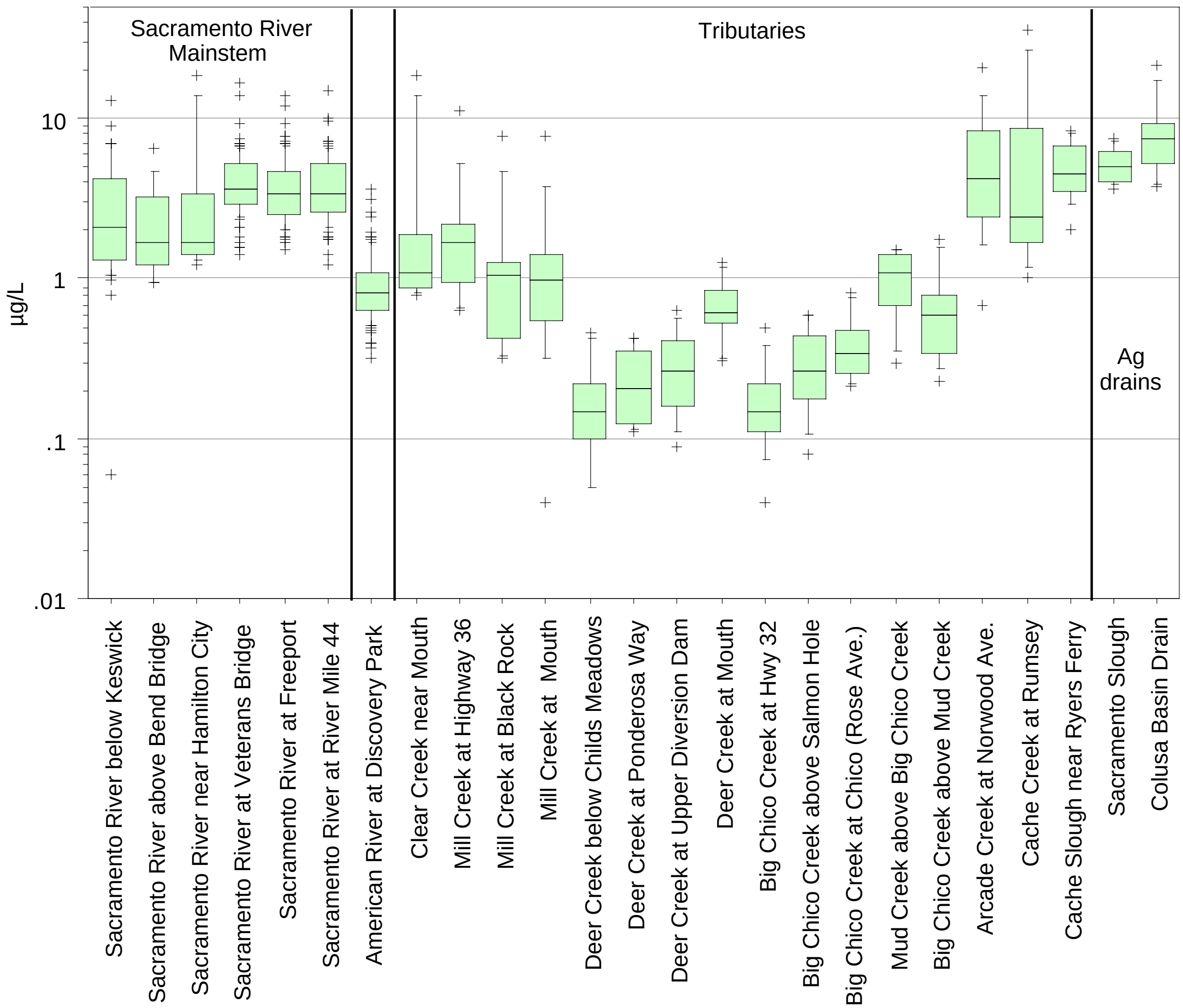

Figure 10a. Total Recoverable Copper in the Sacramento River Watershed.

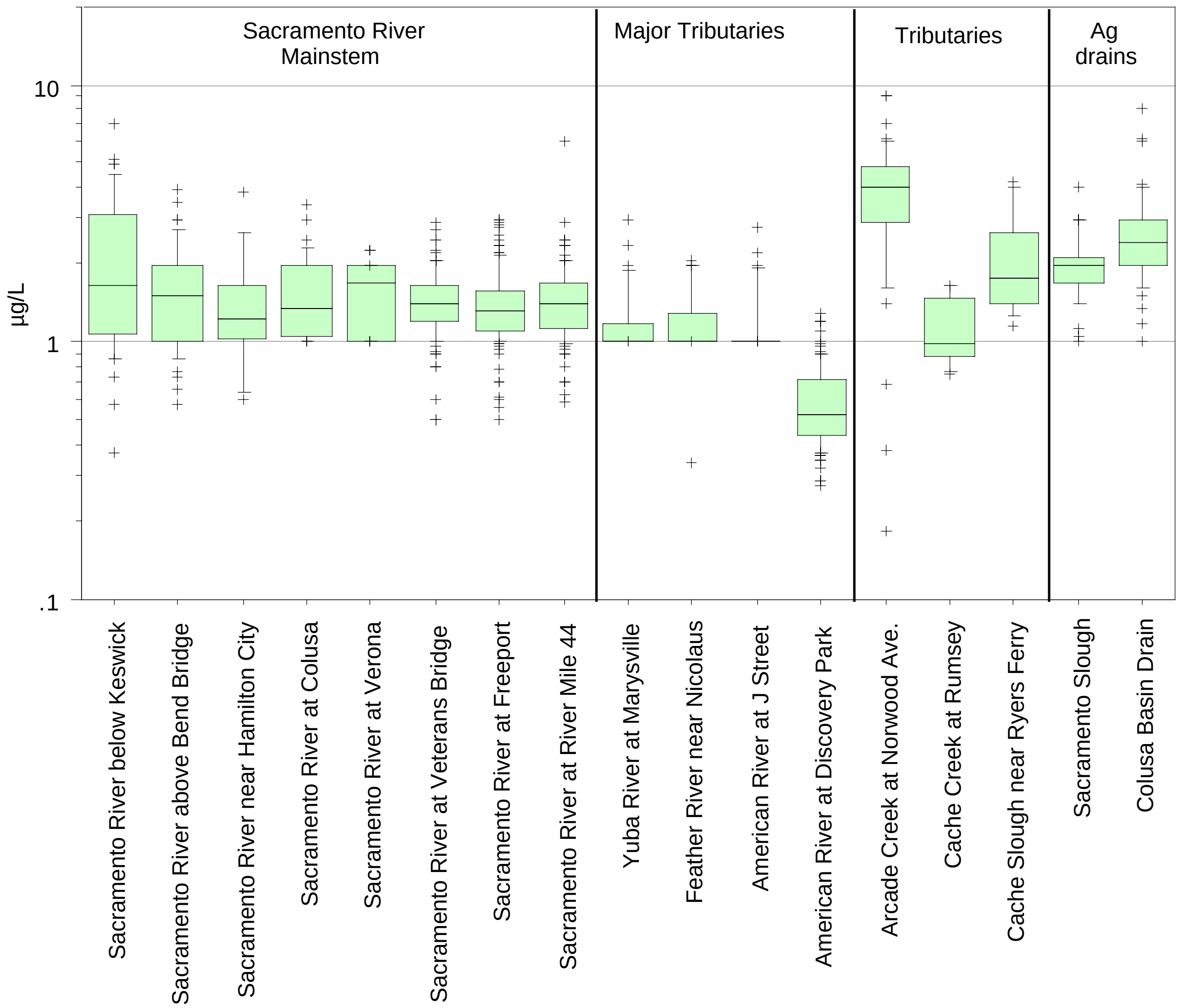

Figure 10b. Dissolved Copper in the Sacramento River Watershed., 1994-2000

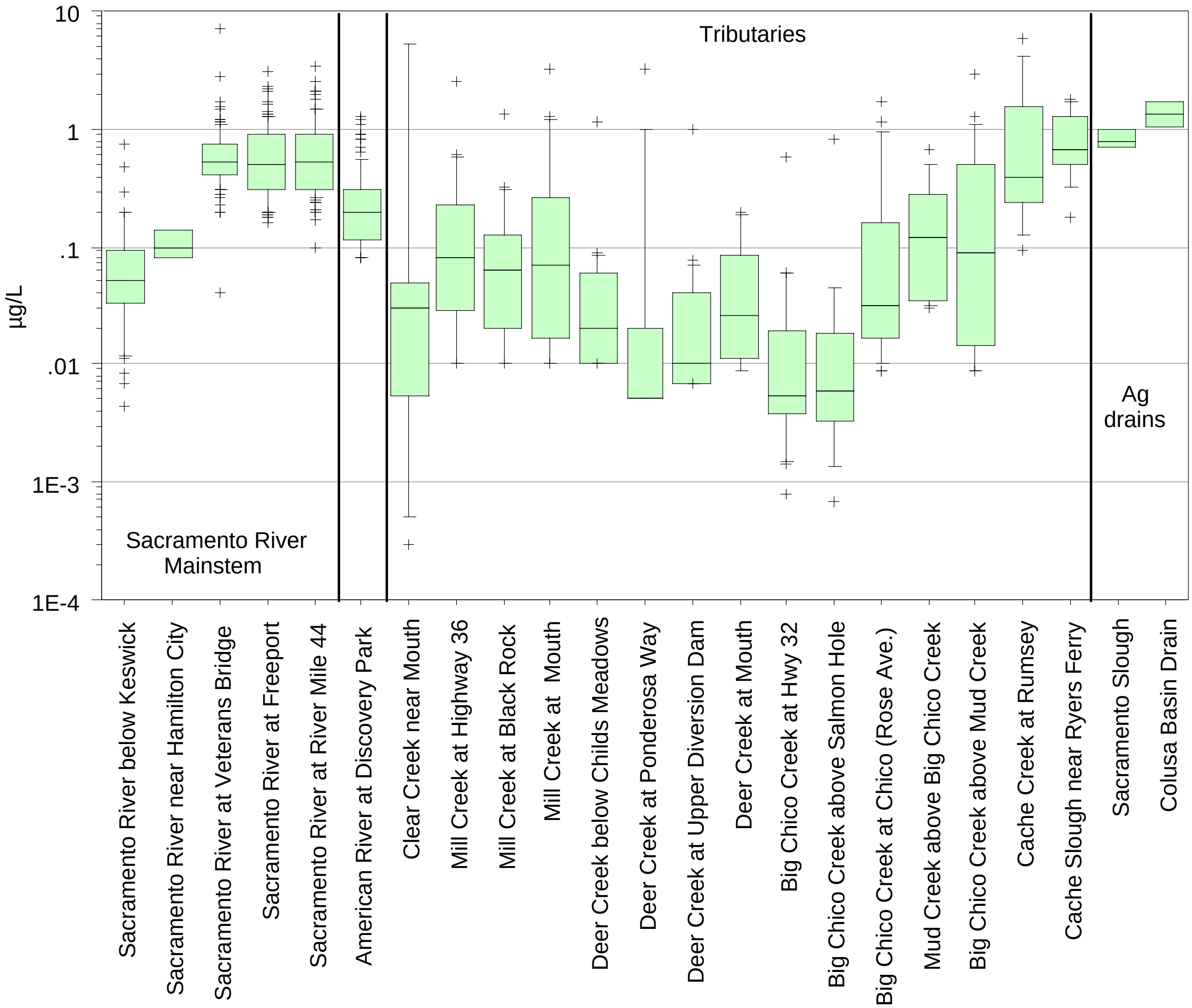

Figure 11a. Total Recoverable Lead in the Sacramento River Watershed., 1994-2000

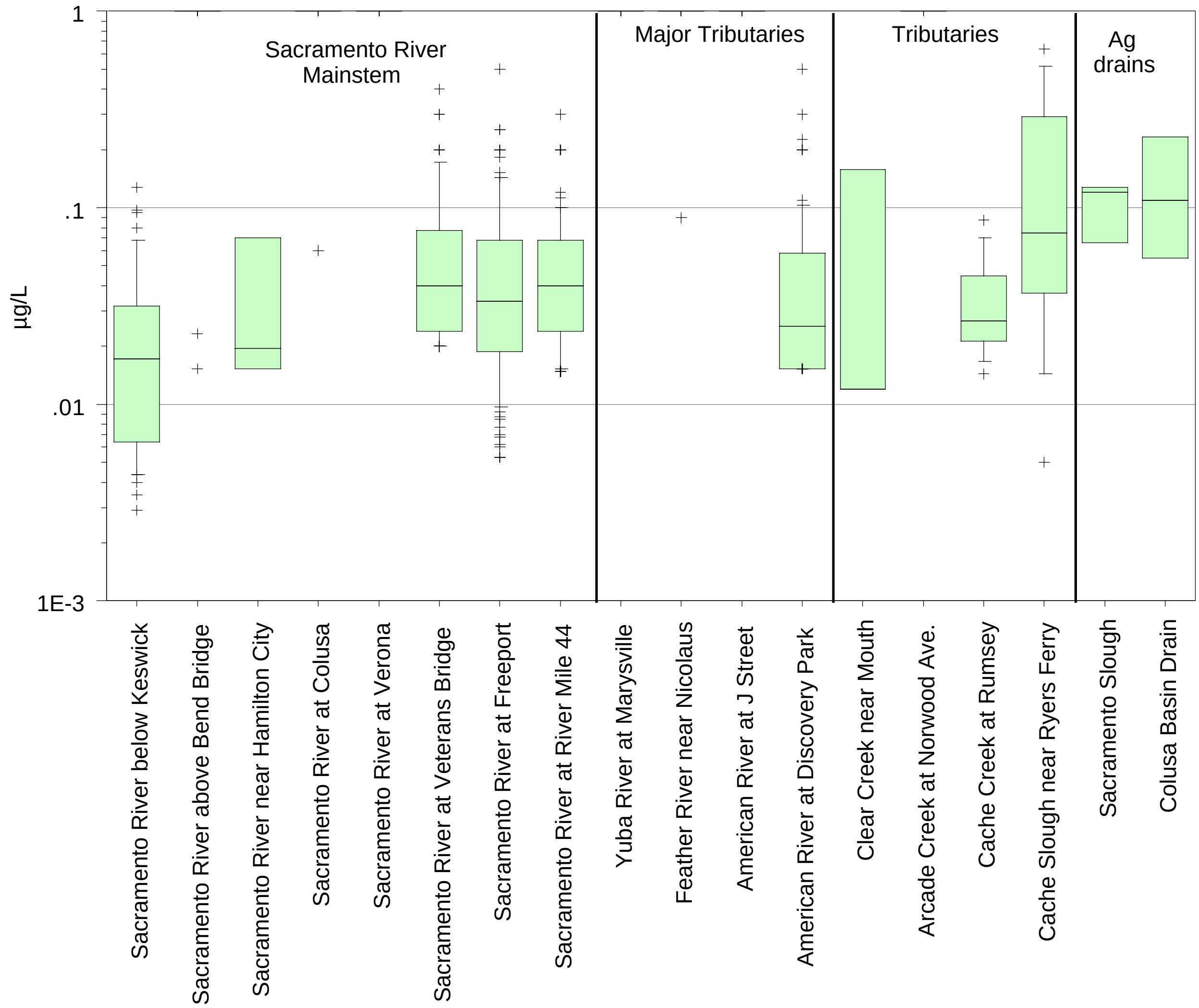

Figure 11b. Dissolved Lead in the Sacramento River Watershed, 1994-2000

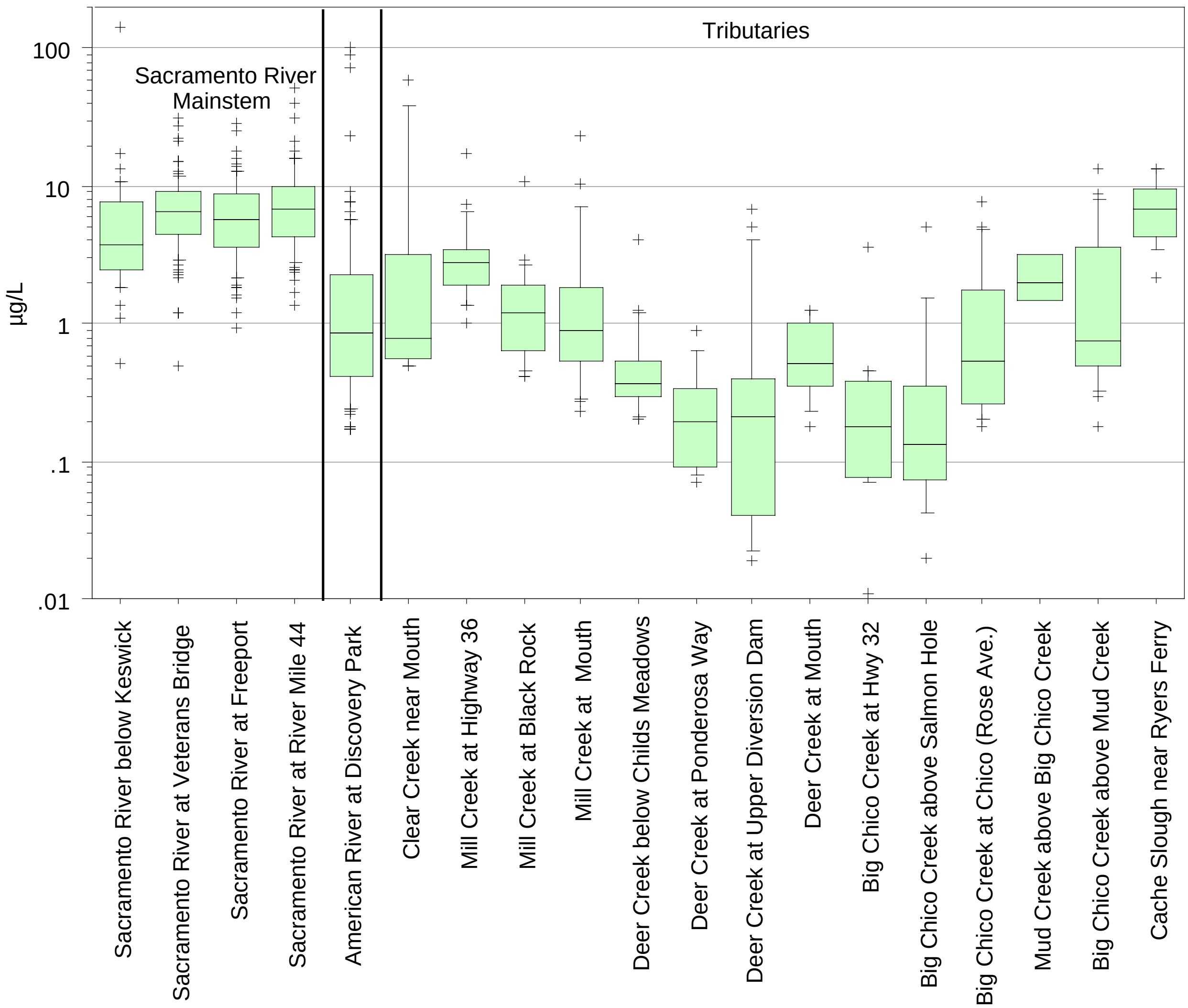

Figure 12a. Total Recoverable Zinc in the Sacramento River Watershed, 1994-2000.

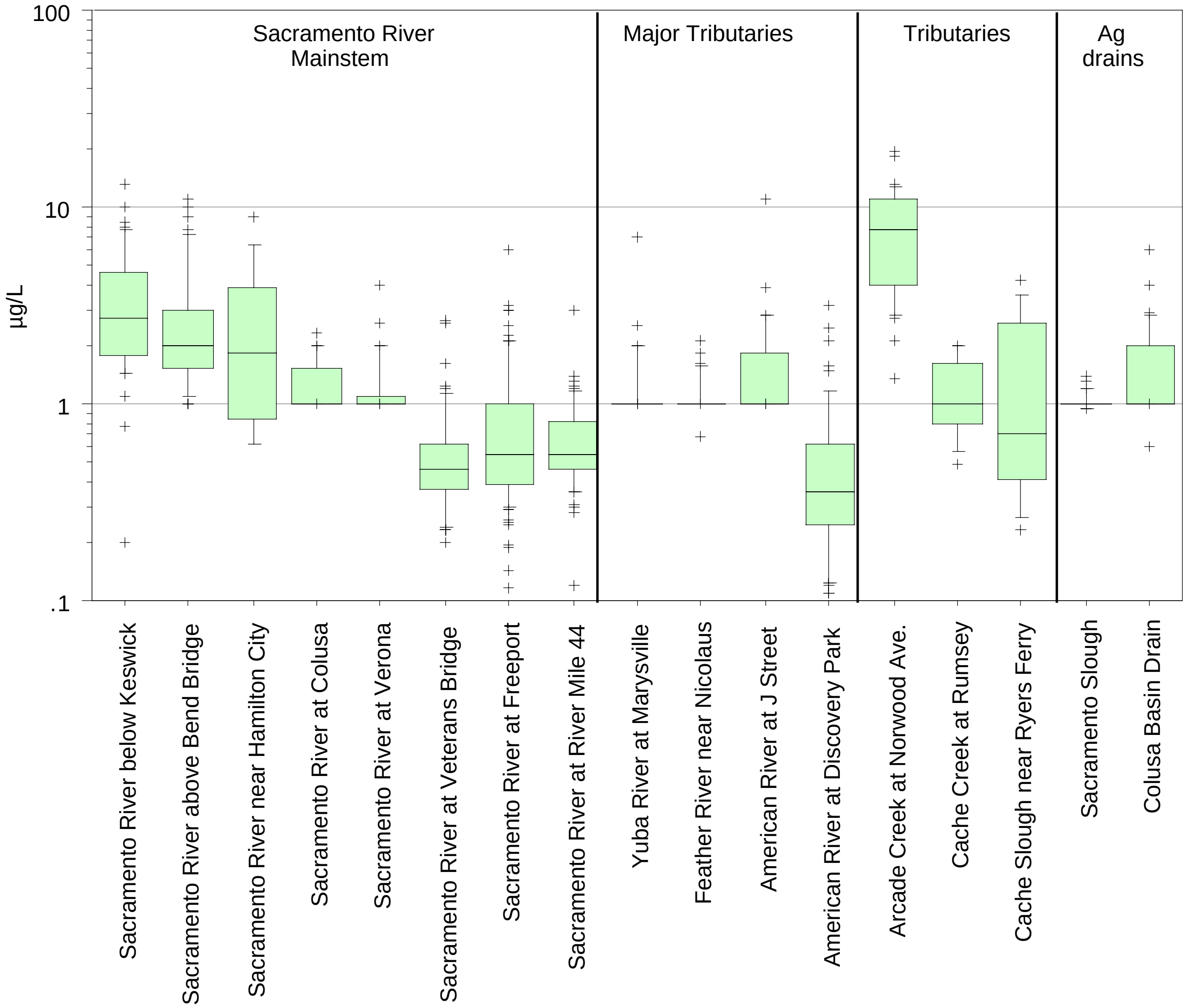

Figure 12b. Dissolved Zinc in the Sacramento River Watershed, 1994-2000.

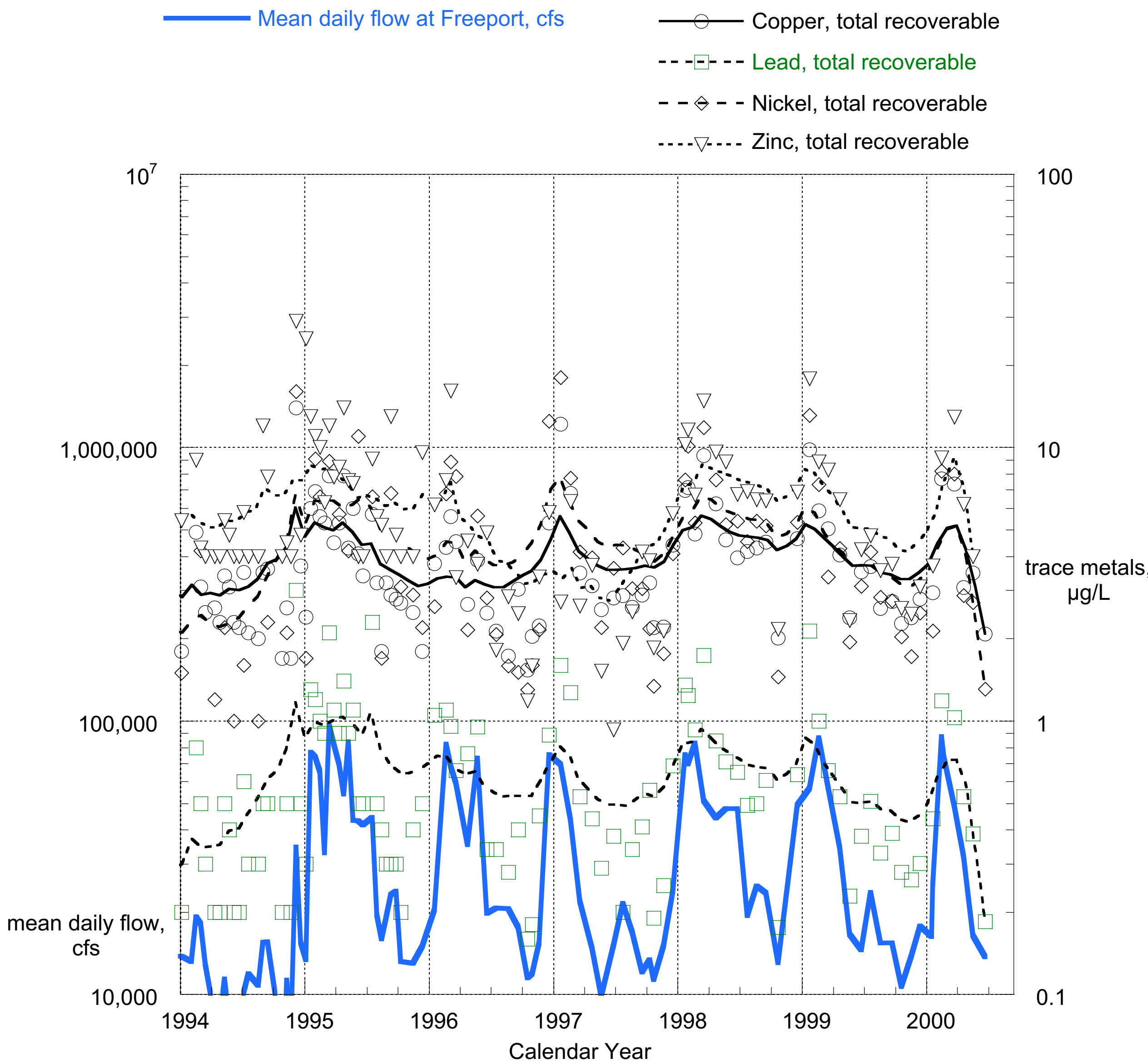

Figure 13. River Flows and Total Recoverable Trace Metals Concentrations: Sacramento River at Freeport, Sacramento River CMP Data, 1994-2000

C. Pesticide Data Summary

Monitoring results for the Sacramento River Watershed Program (SRWP) and for primary coordinating programs (USGS NAWQA, Sacramento River Coordinated Monitoring Program, City of Redding NPDES monitoring, and Department of Water Resources) are presented and summarized in this section. Data are evaluated for spatial and temporal trends, and summary statistics are also provided in Appendix E. Data are also compared to relevant water quality objectives and toxicity thresholds to evaluate predicted attainment of beneficial uses and potential impairment of these uses in the watershed.

i. Background and Available Data Overview

The sources of data utilized for this report are summarized in Table 15. The majority of non-SRWP data discussed in this report was obtained from the Department of Pesticide Regulation Surface Water Database (June 15, 2000). The monitoring locations for the primary data considered for this report (USGS NAWQA, California, the Sacramento River Coordinated Monitoring Program, California Department of Pesticide Regulation, and the Sacramento River Watershed Program) are illustrated in Figure 14.

The majority of the pesticide monitoring performed in the Sacramento River watershed has been focused on rice pesticides, pesticides used in orchard dormant spray applications, and pesticides commonly found in urban runoff. Of these, the SRWP monitoring program has focused primarily on organophosphate and carbamate pesticides, with triazine pesticides also monitored at one urban runoff-affected location (Arcade Creek in the Sacramento metropolitan area).

Table 14. Pesticides most frequently monitored in the Sacramento River Watershed (DPR Surface Water Database, June 2000), and their major uses.

Pesticide	Use category	Top uses (lbs applied in x 1,000) [1]	Total use reported for Sacramento River watershed[4] in 1999, lbs x 1000	Number of monitoring results in DPR SW DB
Diazinon	Insecticide	Pest control[2] (346), Almonds (124), lettuce (115), walnuts (146), stonefruit[2] (110)	99	849
Carbofuran	Insecticide	Alfalfa (64), rice (29), grapes (18)	33	768
Malathion	Insecticide	Alfalfa (246), oranges (71), strawberries (76), pest control[3] (58), lettuce (46),	47	613
Methyl parathion	Insecticide	Walnut (60), stonefruit[2] (45), pears (23), apples (13)	39	584
Molinate	Herbicide	Rice (913)	851	530
Simazine	Herbicide	Oranges (214), grapes (166), almonds (56), walnuts (37)	29	481
Thiobencarb	Herbicide	Rice (734)	703	443
Atrazine	Herbicide	Forest trees (28), corn (16), sudan grass (15)	18	373
Chlorpyrifos	Insecticide	Pest control[3] (526), Almonds (203), cotton (275), landscape maintenance (158), walnuts (146), alfalfa (188), broccoli (76), stonefruit (71)	155	370
Carbaryl	Insecticide	Citrus crops (60), nut crops (56), stonefruit[2] (51) , apples (31), tomatoes (31), landscape maintenance (9)	37	364
Fonofos	Insecticide	Broccoli (6), beans (5), tomatoes (5)	0.68	349

(1) Total lbs used in California in 1999 (DPR 2000). The DPR Pesticide Use database available for this report was characterized as “preliminary” by the Department of Pesticide Regulation.
(2) Apricot, nectarines, peaches, plums, prunes
(3) Public health and structural pest control
(4) Total pounds of active ingredient applications reported for major agricultural counties in Sacramento River watershed (Butte, Sutter, Colusa, Yolo, Yuba, Glenn, Sacramento, and Tehama)

Table 15. Pesticide monitoring programs in the Sacramento River Watershed

Program	Monitoring Period(s)	Parameters	# of locations & geographic reference
SRWP	6/99–5/00	▪ Organophosphate, carbamate, and triazine pesticides in water	6 sites: 3 Sac. River sites (OPs), 2 Ag. Drain sites (OPs, carbamates), and 1 urban runoff-dominated site (all parameters)
Sacramento River CMP (SRCSD)	12/92–12/98	▪ Diazinon and chlorpyrifos in water	5 sites on Sacramento and American rivers in Sacramento metropolitan area
Sacramento River Basin NAWQA (USGS)	2/96–4/98	▪ Wide range of pesticides, including OPs, carbamates,	5 sites: 1 Sac. River site, 2 Ag. Drainage dominated sites, 1 urban runoff-dominated site, and Yolo Bypass
USGS (Domagalski 1998)	5/98–9/00	▪ Wide range of pesticides, including OPs, carbamates,	Continuation of NAQWA monitoring at Sac. River at Freeport
Department of Pesticide Regulation	1996–2000 (wet season episodic sampling)	▪ Organophosphate, carbamate, and triazine pesticides in water	2 sites: Sacramento River at Veterans Bridge (Alamar) and Sutter Bypass near Karnak
Department of Pesticide Regulation	1995–1997	▪ Rice Pesticides	3 sites: Sacramento River at Village Marina, Butte Slough, and Colusa Basin Drain
CVRWQCB	1/94–3/94	▪ Organophosphate, carbamate, and triazine pesticides in water	21 sites: Sacramento River, Feather River, Yuba River, and multiple ag. drainage-affected sites
Sacramento Area Stormwater NPDES Monitoring Program	1990–1999	▪ Organophosphate and carbamate pesticides in water	13 Sacramento area urban runoff and river sites
SF Estuary Regional Monitoring Program	1989–1997	▪ Pesticides in water	18 Bay-Delta sites, including Sacramento River and San Joaquin River at the Delta terminus
Special Tributary Program (DWR)	6/98–5/99	▪ Pesticides in water	13 water column sites on Mill Creek, Big Chico Creek, and Deer Creek *Data not available for draft report*
Offstream Storage Study (DWR)	1999 to present	▪ Pesticides in water	42 sites: 7 Sac. River sites and 32 tributary sites between Keswick and Colusa, and 3 reservoir sites. *Data not available for draft report*

ii. Spatial Distributions & Patterns

As with other pollutants, the ability to evaluate spatial distribution patterns is highly dependent on the sites selected for monitoring. SRWP monitoring was performed at only a few sites selected to complement monitoring performed by USGS NAWQA and the Department of Pesticide Regulation. The majority of data available is from monitoring performed in water bodies dominated by agricultural drainage or urban runoff, and for the mainstem Sacramento River. There are relatively few data available for the major tributaries to the Sacramento River (Feather River, Yuba River, and American River), and no data currently available for the greater number of minor tributaries to the Sacramento River. Within these limitations, there are still a number of general patterns discernible in the available data.

General patterns

(a) As expected, the frequency of detection and maximum concentrations detected are generally highest in waterbodies dominated by agricultural drainage or urban runoff, and lowest in the main stem Sacramento River and major tributaries.

(b) In the Sacramento River, the frequency of detection and maximum values are generally lower above (upstream of) the major agricultural production areas in the watershed. As an example, in SRWP monitoring, no organophosphate pesticides were detected in any samples collected from the Sacramento River near Hamilton City and Colusa sites, which are above the region of the most intensive agricultural use of organophosphate pesticides for dormant spray applications.

(c) In SRWP monitoring, the greatest number of different pesticides (7 of 10 pesticides detected) and the most frequent detections were observed at Arcade Creek. Although only organophosphate pesticides were monitored by the SRWP in the Sacramento River mainstem, this pattern is consistent with results of USGS NAWQA monitoring.

Organophosphate pesticides

Organophosphate pesticides were monitored at six locations by the SRWP. Of the pesticides analyzed in the organophosphate pesticide scan (EPA Method 8141), five were detected in SRWP monitoring conducted in 1999-2000. These were chlorpyrifos, diazinon, malathion, prometon, and prowl.

(d) Diazinon is a widely used organophosphate insecticide. Its pattern of detection reflects its use in a variety of agricultural and urban/residential settings. In SRWP monitoring, it was the most frequently detected organophosphate pesticide, detected 3 of 6 sites monitored (Colusa Basin Drain, Sacramento River at Veteran Bridge, and Arcade Creek). At these SRWP sites, diazinon was detected most frequently at Arcade Creek (10 of 12 samples), an urban creek affected by both urban runoff and aerial deposition from nearby agricultural areas. In studies contained in the DPR

Surface Water database, diazinon was frequently detected (and concentrations were highest) in both urban runoff and waterways dominated by agricultural runoff. Diazinon was less frequently detected in the Sacramento River mainstem and major tributaries monitored. Reporting limits for most of the data ranged from 0.002 µg/L for the USGS NAWQA program, to 0.01-0.05 µg/L for most of the other studies in the DPR Surface Water database.

(e) In the 10 studies contained in the DPR Surface Water database, chlorpyrifos was most frequently detected in urban runoff. It was never detected in the Sacramento River mainstem and was rarely detected in other water bodies. Chlorpyrifos was detected in only one SRWP sample (from Arcade Creek). Reporting limits for most of the data ranged from 0.004 µg/L for the USGS NAWQA program, to 0.03-0.05 µg/L for most of the other studies in the DPR Surface Water database.

(f) Malathion was detected in only one SRWP sample, from Sacramento Slough. In studies contained in the DPR Surface Water database, malathion was most frequently detected in waterways dominated by agricultural drainage, and it has been less frequently detected in urban runoff and urban creeks. Malathion was not reported at detectable levels for any of the hundreds of results reported for the Sacramento River in the DPR Surface Water database. Reporting limits for most of the data ranged from 0.005 µg/L for the USGS NAWQA program, to 0.03-0.1 µg/L for most of the other studies in the DPR Surface Water database.

(g) Prometon is used most commonly for landscape maintenance and rarely in production agriculture. The pattern of detection of this herbicide is consistent with its primary use in urban settings. Prometon was detected in three SRWP samples from Arcade Creek, and was detected in 29 of 30 USGS NAWQA samples collected at the same location. Prometon was not reported at detectable levels for any results reported for the Sacramento River in the DPR Surface Water database. Reporting limits for these data ranged from 0.018 µg/L for the USGS NAWQA program, to 0.1 µg/L for the SRWP, and from 0.008–0.1 µg/L for most of the other studies in the DPR Surface Water database. Prometon rarely detected at concentrations greater than 0.008 µg/L in waterways dominated by agricultural drainage.

(h) Prowl (pendimethalin) was detected in only two SRWP samples, both from Arcade Creek. Studies in the DPR Surface Water database reported detection of prowl only in urban runoff and in Arcade Creek, and was not detected in any Sacramento River samples or waterways dominated by agricultural drainage. Reporting limits for these data ranged from 0.004 µg/L for the USGS NAWQA program, to 0.1 µg/L for the SRWP, and from 0.018–0.1 µg/L for other studies in the DPR Surface Water database. The pattern of detection is consistent with the primary uses of the herbicide prowl. The most common agricultural use for this herbicide in California is for cotton, a crop with very limited (but increasing) planted acres in the Sacramento valley. The second most common use for prowl is for weed control (for landscape maintenance and rights of way), and this use is likely the primary source of prowl in urban runoff and creeks.

Carbamate pesticides

Carbamate pesticides were monitored at three locations by the SRWP (one urban creek and two agricultural drainage dominated waterways). Pesticides analyzed in the carbamate pesticide scan (EPA Method 8321) includes both herbicides and insecticides, six of which were detected in SRWP monitoring conducted in 1999-2000. These were aldicarb, bromacil, carbaryl, carbofuran, diuron, and tebuthiuron.

- Aldicarb is a carbamate insecticide used primarily on cotton. In was detected in only one SRWP sample from Colusa Basin Drain, and was not reported as detected by any study in DPR's Surface Water database. Reporting limits for these data were 0.016 µg/L for the USGS NAWQA program, 0.1 µg/L for the SRWP, and ranged from 0.05–0.4 µg/L for other studies in the DPR Surface Water database.
- Bromacil is an herbicide used most frequently for weed control in citrus orchards and public rights of way, and for general landscape maintenance. It was detected in both agricultural drainage (Colusa Basin Drain) and in urban runoff (Arcade Creek) in SRWP monitoring. In DPR's Surface Water database, it was reported as infrequently detected in waterways dominated by agricultural drainage, and there were no reported detections of bromacil in urban runoff, urban creeks, or in the Sacramento River mainstem. Reporting limits for these data ranged from 0.035–0.4 µg/L.
- Carbaryl is an insecticide commonly used on a variety of orchard and other crops. It is less frequently used for landscape maintenance (2.3% of total lbs used in California in1999). In SRWP monitoring, it was detected only in Arcade Creek. In DPR's Surface Water database, it was most frequently detected in Arcade Creek and in urban runoff, and was only infrequently detected in waterways dominated by agricultural drainage. It was detected in few samples (3 of 27) in the Feather River, and was never detected in the Sacramento River mainstem. Reporting limits for these data ranged from 0.003–0.07 µg/L.
- Carbofuran is an insecticide used primarily on alfalfa, with some use for rice, grapes, and cotton. In SRWP monitoring, carbofuran was detected in Sacramento Slough and Colusa Basin Drain. In DPR's Surface Water database, carbofuran was frequently detected in waterways dominated by agricultural drainage (including Colusa Basin Drain). It was detected in only one urban runoff sample and was not detected in Arcade Creek (in 29 samples). It was detected in only 6 of 869 samples collected from the Sacramento River. Reporting limits for most of these studies ranged from 0.003–0.07 µg/L.
- Diuron is an herbicide commonly used for weed control on public rights of way and for landscape maintenance, with significant amounts also used for alfalfa and citrus crops. In SRWP monitoring, diuron was detected in Arcade Creek and Colusa Basin Drain. In DPR's Surface Water database, diuron was commonly detected at nearly every location monitored, including the Sacramento River mainstem, urban creeks, urban runoff, and in many waterways dominated by agricultural drainage. The highest concentrations were reported in smaller agricultural drains. Reporting limits for most of these studies ranged from 0.003–0.07 µg/L.

- Tebuthiuron is an herbicide used almost exclusively for weed control on public rights of way and for landscape maintenance. In SRWP monitoring, tebuthiuron was detected only in Arcade Creek. In DPR's Surface Water database, it was reported in Arcade Creek and in some waterways dominated by agricultural drainage. It was not reported to be detected in the Sacramento River mainstem. Reporting limits for these studies ranged from 0.01–0.4 µg/L.

Triazine pesticides

Triazine pesticides were monitored only at Arcade Creek by the SRWP. Of the pesticides analyzed in the triazine pesticide scan (EPA Method 619), only propazine was detected (in 3 of 12 samples) in SRWP monitoring conducted in 1999-2000. Propazine is an herbicide used primarily for weed control on public rights of way. No results were reported for propazine in DPR's Surface Water database.

Summary statistics for pesticides detected in SRWP monitoring are presented in Appendix E.

Table 16. Pesticides detected in Sacramento River Watershed: Major uses and number of results in DPR's Surface Water Database (June 2000)

Pesticide	Use category	Top uses (lbs applied x 1,000)[1]	Total use reported for Sacramento River watershed[4] in 1999, lbs x 1000	Number of results in DPR SW DB
Aldicarb	Insecticide	Cotton (267), sugarbeets (5), greenhouse and container grown plants (4)	8	751
Bromacil	Herbicide	Citrus crops (53), rights of way (16), landscape maintenance (3)	4.6	303
Carbaryl	Insecticide	Citrus crops (60), nut crops (56), stonefruit[2] (51) , apples (31), tomatoes (31), landscape maintenance (9)	37	364
Carbofuran	Insecticide	Alfalfa (64), rice (29), grapes (18), cotton (13)	33	768
Chlorpyrifos	Insecticide	Pest control[2] (526), Almonds (203), cotton (275), landscape maintenance (158), walnuts (146), alfalfa (188), broccoli (76), stonefruit[2] (71)	156	370
Diazinon	Insecticide	Pest control[2] (346), Almonds (124), lettuce (115), walnuts (146), stonefruit[2] (110)	99	849
Diuron	Herbicide	Rights of way (497), citrus crops (233), alfalfa (216), landscape maintenance (39),	96	307
Malathion	Insecticide	Alfalfa (246), oranges (71), strawberries (76), pest control[3] (58), lettuce (46),	47	613
Prometon	Herbicide	landscape maintenance (0.0021), indoor and greenhouse-grown plants (0.0017)	0	317
Propazine	Herbicide	Rights of way (0.020), greenhouse-grown flowers (0.005)	0	0
Prowl (pendimethalin)	Herbicide	Cotton (188), landscape maintenance and rights of way (60), nut crops (40)	21	98
Tebuthiuron	Herbicide	Rights of way (4.9), landscape maintenance (0.6)	0.8	134

(1) Total lbs used in California in 1999 (DPR 2000). The DPR Pesticide Use database available for this report was characterized as "preliminary" by the Department of Pesticide Regulation.
(2) apricot, nectarines, peaches, plums, prunes
(3) public health and structural pest control
(4) Total pounds of active ingredient applications reported for major agricultural counties in Sacramento River watershed (Butte, Sutter, Colusa, Yolo, Yuba, Glenn, Sacramento, and Tehama)

iii. Temporal Distribution & Patterns

Most of the available monitoring data are focused on the periods of greatest use of particular pesticides or categories of pesticides (e.g. rice pesticide monitoring in late spring and organophosphate pesticide monitoring during the dormant spray application season). Although this focused approach to monitoring provides relatively little information about other periods or seasons, the available data tend to confirm that the pattern of detections and greatest concentrations of pesticides generally reflects their patterns of use. Specific examples include:

- The highest concentrations of diazinon were detected in the months of January and February throughout the watershed. This period coincides with the dormant spray application season.
- The highest concentrations of carbofuran, malathion, and molinate have been observed in May and June, coincident with the release of water from rice fields.
- The percent detections reported for carbofuran in DPR's Surface Water Database decreased from approximately 85% in 1994, to 0% in 2000. A similar pattern was observed for malathion. These decreases corresponds to changes made by the rice farming industry to pesticide application practices and in holding times for irrigation water after pesticide application. Granular formulations of carbofuran were also banned in 1994 to protect wildlife.

Overall use of cholinesterase-inhibiting organophosphate and carbamate insecticides has declined over the last several years (DPR 2000). In contrast, over the same period, the total number of acres planted in fruit and vegetable crops and the total pounds of pesticides applied has increased in California (*ibid.*). This suggests that there may be a general shift from organophosphate and carbamate insecticides to other categories of pesticides, such as pyrethroid insectides. The Department of Pesticide Regulation documented an increase in the number of pyrethroid applications from 1991 to 1996, and a corresponding decrease in the number of organophosphate pesticide applications (DPR 1999). However, for the five pyrethroids that accounted for 93% of the total pyrethroid use in California (bifenthrin, cyfluthrin, cypermethrin, esfenvalerate, and permethrin), reported applications appear to have stabilized in counties in the Sacramento River watershed, with no substantial increases from 1995 to 1999 (based on published pesticide use reports from DPR). Other means of pest control, including biopesticides (e.g. bacteria, naturally-occurring compounds, and pheromones), reduced-risk pesticides, and non-chemical pest management practices have also increased dramatically since 1995 (*ibid*.). Given the extremely low toxicity thresholds of some of these relatively new pesticides (e.g. pyrethrins and pyrethroids, Table 18), the lack of monitoring data is a significant information gap that should be addressed in future monitoring efforts.

There were generally insufficient detected pesticide data to generate meaningful time series plots for Appendix G.

iv. Attainment of Beneficial Uses and Potential Impairment

Pesticide concentrations in water were compared with a variety of regulatory and toxicity thresholds and (Table 17). The regulatory thresholds considered included EPA aquatic life criteria, EPA's Maximum Contaminant Levels (MCL) for drinking water, reference doses for drinking water from EPA's IRIS database, and minimum toxic thresholds from EPA's Office of Pesticide Programs (OPP) Ecotoxicity database. Also considered were recommended aquatic life criteria developed by the California Department of Fish and Game for diazinon and chlorpyrifos (CDFG 2000). There are no criteria in the adopted California Toxics Rule for any of the pesticides detected in SRWP monitoring. Of the pesticides detected in SRWP monitoring, only chlorpyrifos, diazinon, and malathion have aquatic life criteria based on EPA methodology. Carbofuran is the only detected pesticide with an adopted Drinking Water MCL. No relevant regulatory limits are available for other detected pesticides (aldicarb, bromacil, carbaryl, diuron, prometon, propazine, prowl, and tebuthiuron). The results of these comparisons provide some perspective regarding potential impacts on beneficial uses. However, these results do not provide definitive or conclusive information regarding such impacts.

Comparisons with water quality criteria and toxicity thresholds

- *Chlorpyrifos* was detected at greater than DFG's recommended Continuous Concentration Criterion (CCC) of 0.014 µg/L in only one SRWP sample (at Arcade Creek). Toxicity thresholds for crustacean species (which includes *Ceriodaphnia dubia*) are as low as 0.01–0.035 µg/L. In other studies, chlorpyrifos has been documented at much higher concentrations than these thresholds in urban creeks and urban runoff, and has been shown to contribute to significant mortality in tests with *Ceriodaphnia dubia* (LWA 1999, Katznelson and Mumley 1997, Bailey et al. in press). Data in DPR's Surface Water Database indicate that these levels have been occasionally exceeded in agricultural drainage-affected waterways, urban runoff, and urban creeks, and sometimes by more than an order of magnitude. Based on SRWP and USGS NAWQA monitoring and data reported by other studies in DPR's Surface Water Database, concentrations have not been observed to exceed these thresholds in the Sacramento River and major tributaries.
- *Diazinon* was detected at greater than DFG's recommended Continuous Concentration Criterion (CCC) of 0.051 µg/L in nearly all of the samples collected from Arcade Creek. Aquatic toxicity testing at this site indicates that metabolically activated toxicants are often the cause of significant mortality and/or reproductive toxicity frequently observed at this site—a pattern that is consistent with diazinon toxicity. Although, diazinon was not detected at greater than the recommended CCC at any other SRWP-monitored site, data in the DPR Surface Water database indicate that diazinon concentrations have commonly exceeded this value at nearly every location monitored, including the Sacramento River mainstem, and major and minor tributaries. The greatest magnitude and most frequent exceedances of the recommended CCC have been observed in the numerous waterways most directly affected by agricultural drainage or urban runoff. Based on the data in the DPR Surface Water database, diazinon concentrations in agricultural drainage-dominated

waterways commonly exceed 0.2 µg/L, the lowest LC_{50} (for crustacea) recorded in the EPA's OPP Ecotoxicity database. Although it appears that this level is not frequently exceeded in the Sacramento River or major tributaries, others have documented cases of significant reproductive effects and mortality to *Ceriodaphnia dubia* due to diazinon, or have observed diazinon concentrations high enough to cause toxicity (Foe and Sheipline 1993, Larsen *et al*. 1998a and b, Holmes *et al*. 1998). Concentrations many times higher than DFG's recommended CCC and other toxicity thresholds have been documented in urban creeks and agricultural drains by numerous researchers and monitoring programs (Ogle and Cooke 2000).

- *Malathion* was detected at EPA's Instantaneous Maximum concentration criterion (USEPA 1986) of 0.1 µg/L in one sample from Sacramento Slough. This criterion is equal to the lowest toxicity threshold (LOEC, crustacean species) in EPA's OPP Ecotoxicity database (USEPA 2000, July 2000 version). Data in DPR's Surface Water Database indicate that these levels have been infrequently exceeded in agricultural drainage-affected waterways and urban runoff, although sometimes by as much as an order of magnitude. Based on SRWP and USGS NAWQA monitoring and data reported by other studies in DPR's Surface Water Database, concentrations have not been observed to exceed these thresholds in the Sacramento River and major tributaries.
- *Carbofuran* was not observed to exceed the Drinking Water MCL of 40 µg/L in any SRWP sample, or in any data reported in DPR's Surface Water Database (including USGS NAWQA results). A few samples collected from Colusa Basin Drain and Butte Slough and reported in DPR's Surface Water Database have exceeded the lowest LOEC (0.98 µg/L, crustacea) reported in the EPA's OPP Ecotoxicity database, but no reported cases exceed the lowest LC_{50} (4.6 µg/L, crustacean species).
- *Aldicarb* was not detected at concentrations exceeding or approaching the lowest toxic threshold reported in EPA's OPP Ecotoxicity Database (12 µg/L, crustacean species), either in SRWP monitoring or data reported in DPR's Surface Water Database.
- *Bromacil* was not detected at concentrations exceeding or approaching the lowest toxic threshold reported in EPA's OPP Ecotoxicity Database (6.8 µg/L, aquatic plant species EC_{50}), either in SRWP monitoring or data reported in DPR's Surface Water Database.
- *Carbaryl* was not detected at concentrations exceeding the lowest toxic threshold reported in EPA's OPP Ecotoxicity Database (1.5 µg/L, crustacean species), either in SRWP monitoring or data reported in DPR's Surface Water Database.
- *Diuron* was detected in Arcade Creek at greater than the minimum toxicity threshold in EPA's OPP Ecotoxicity Database (2.4 µg/L, aquatic plant species EC_{50}). Data reported in DPR's Surface Water Database indicate that this threshold was exceeded occasionally in agricultural drainage, urban runoff, and urban creeks, sometimes by more than an order of magnitude. It was not exceeded in any samples reported for the Sacramento River.
- *Prometon* was not detected at concentrations exceeding or approaching the lowest toxic threshold reported in EPA's OPP Ecotoxicity Database (98 µg/L, aquatic plant

species EC_{50}), either in SRWP monitoring or data reported in DPR's Surface Water Database.

- *Propazine* was not detected at concentrations exceeding or approaching the lowest toxic thresholds reported in EPA's OPP Ecotoxicity Database (25 µg/L, aquatic plant species EC_{50}; 91 µg/L, crustacean species LOEC). No propazine data were reported in DPR's Surface Water Database.
- *Prowl (Pendimthalin)* was not detected at concentrations exceeding or approaching the lowest toxic thresholds reported in EPA's OPP Ecotoxicity Database (5.2 µg/L, aquatic plant species EC_{50}; 9.8 µg/L, crustacean species LOEC), either in SRWP monitoring or data reported in DPR's Surface Water Database.
- *Tebuthiuron* was not detected at concentrations exceeding or approaching the lowest toxic thresholds reported in EPA's OPP Ecotoxicity Database (15.4 µg/L, aquatic plant species EC_{50}), either in SRWP monitoring or data reported in DPR's Surface Water Database.

No pesticides were detected at levels exceeding or approaching drinking water reference doses (RfD) reported in the EPA's IRIS data base.

Table 17. Advisory Criteria and Other Threshold Values for Pesticides Detected in SRWP Monitoring (1999–2000).

Pesticide	Aquatic Life Criterion (Units = µg/L)	MCL (Units = µg/L)	IRIS RFd (Units = µg/L)	Minimum Toxicity Thresholds [3] (threshold type, taxonomic class)
Aldicarb	— [4]	—	7	12 (minimum LC_{50}, crustacea)
Bromacil	—	—	—	6.8 (minimum EC_{50}, aquatic plants)
Carbaryl	—	—	700	1.5 (minimum LC_{50}, crustacea)
Carbofuran	—	40	35	4.6 (minimum LC_{50}, crustacea) 0.98 (LOEC, crustacea)
Chlorpyrifos	0.014 [1] 0.041 [2]	—	21	0.035 (minimum LC_{50}, crustacea) 0.01 (LOEC, crustacea)
Diazinon	0.051 [1]	—	—	0.2 (minimum LC_{50}, crustacea)
Diuron	—	—	14	2.4 (minimum EC_{50}, aquatic plants)
Malathion	0.1	—	140	0.1 (LOEC, crustacea) 0.5 (minimum LC_{50}, crustacea)
Prometon	—	—	100	98 (minimum EC_{50}, aquatic plants)
Propazine	—	—	14	25 (minimum EC_{50}, aquatic plants) 91 (LOEC, crustacea)
Prowl (Pendimethalin)	—	—	280	5.2 (minimum EC_{50}, aquatic plants) 9.8 (LOEC, crustacea)
Tebuthiuron	—	—	490	15.4 (minimum EC_{50}, aquatic plants)

Table 18. Total Pounds Applied (1995 and 1999) and Toxicity Threshold Values for the Five Pyrethroid Pesticides Most-Used in the Sacramento River Watershed

Pesticide	Total use reported for Sacramento River watershed[5], lbs x 1000: 1995	1999	IRIS RFd	Minimum Toxicity Thresholds [3] (threshold type, taxonomic class)
Bifenthrin	2.2	2.0	—	0.004 (EC_{50}, crustacea)
Cyfluthrin	0.6	1.1	180	250,000 (LC_{50}, aves)
Cypermethrin	3.6	14.1	70	0.0047 (LC_{50}, crustacea) 0.0006 (LOEC, crustacea)
Esfenvalerate	9.3	6.8	—	0.15 (EC_{50}, crustacea) 0.07 (LC_{50}, fishes)
Permethrin	30.7	25.2	350	0.018 (minimum EC_{50}, crustacea)

(1) Recommended Continuous Criterion Concentration (CCC), (CDFG 2000)
(2) U.S. EPA CCC, (USEPA 1986)
(3) From U.S. EPA's Environmental Fate and Effects Division of the Office of Pesticide Programs Pesticide Ecotoxicity Database, (USEPA 2000).
(4) "—" indicates no relevant criterion or threshold available.
(5) Total pounds of active ingredient applications reported for major agricultural counties in Sacramento River watershed (Butte, Sutter, Colusa, Yolo, Yuba, Glenn, Sacramento, and Tehama)

What do the data say about attainment of beneficial uses and potential impairment, and how does this compare with any relevant 303(d) listings for parameter and sites?

Waterbodies in the Sacramento River watershed included on the California 1998 303(d) list as a result of concern for pesticide levels are presented in Table 19.

As stated above, it should be noted that comparisons with advisory criteria and toxicity thresholds do not provide conclusive evidence of attainment or impairment of beneficial uses. However, for the purpose of these evaluations, repeated significant exceedances of these values are considered as an indication of potential impairment of beneficial uses. In general, regulatory agency advisory criteria (e.g. EPA aquatic life criteria or drinking water MCLs) are given the most weight in these evaluations. However, because most of the pesticides detected do not have any adopted regulatory limits, detected concentrations were compared to available toxicity threshold data as a coarse screen for potential impairment of beneficial uses.

The beneficial uses at greatest potential risk from elevated pesticide concentrations in surface water are “Cold Freshwater and Estuarine Habitat” and “Commercial and Sport Fishing” (as defined in the Central Valley Region Basin Plan, CVRWQCB 1998). The most direct effects are likely to be on aquatic plants and crustacea, taxonomic groups which include the species most sensitive to the most widely used insecticides and herbicides. Based on data from the SRWP and other monitoring efforts, there may be significant potential for localized impacts on these beneficial uses due to elevated concentrations of some pesticides in some surface waters of the Sacramento River watershed. Based on findings of elevated concentrations and documented toxicity in surface waters ranging from small urban creeks and agricultural drains to the Sacramento River mainstem and Delta waterways, diazinon appears to pose the greatest and most extensive risks. The Central Valley Regional Board has concluded that beneficial uses are impaired by diazinon, and has cited diazinon as the primary reason for including numerous waterbodies on the 303(d) list of impaired waterbodies (Table 19). Direct effects of elevated diazinon concentrations are likely to be limited primarily to sensitive zooplankton species. These invertebrate species are also important food sources for higher organisms in the ecosystem, and reduction of this resource during critical periods could impact populations of these higher organisms (e.g. fish) (Ogle and Cooke 2000).

Although less frequently detected at toxic levels in the mainstem Sacramento River, elevated chlorpyrifos concentrations appears to pose similar risks. Because of its toxic mode of action is the same as diazinon, chlorpyrifos may also contribute significantly to organophosphate toxicity even at concentrations below its single-chemical toxicity threshold. The available pesticide concentration data agree well with the California 303(d) List of impaired waterbodies. Chlorpyrifos and diazinon are responsible for the greatest number of the individual listings on the California 303(d) List of impaired waterbodies, with diazinon alone responsible for the listing of 300 Sacramento River miles, 60 Feather River miles, 480,000 acres in the Delta, 265,000 acres in the San Francisco Bay Estuary. Diazinon is also responsible for numerous listings in urban creeks in the Sacramento metropolitan area, as well as in other urban area in California. Based on a weight of evidence approach, it appears clear that these two organophosphate pesticides have a high potential for impairment of aquatic life and related beneficial uses in the Sacramento River watershed.

There appears to be some potential for localized impacts on aquatic life in specific waters in the watershed due to occasionally elevated concentrations of malathion and carbofuran, primarily in waterways dominated by agricultural drainage. As with diazinon and chlorpyrifos, direct toxic effects of these insecticides are likely to be limited to sensitive aquatic invertebrate species. There appears to be little risk of beneficial use impairment in the Sacramento River and larger tributaries from these pesticides. The available data appear to support the single 303(d) listing for malathion in the Sacramento River watershed (Colusa Basin Drain), although detections and potential impacts of both carbofuran and malathion have been substantially reduced in recent years by changes in rice farming practices. There are no 303(d) listings due specifically to carbofuran.

There appears to be some potential for localized impacts on aquatic life due to occasionally elevated concentrations of diuron, primarily in urban creeks and waterways dominated by agricultural drainage. There appears to be little risk of beneficial use impairment in the Sacramento River and larger tributaries from this herbicide. Direct toxic effects of this pesticide are probably limited to sensitive aquatic plant species. There are no 303(d) listings due specifically to diuron.

There appears to be little to no significant potential for impairment of aquatic life uses due to elevated concentrations of other pesticides monitored by the SRWP. Beneficial uses related to human health concerns (e.g. drinking water supply, and contact and non-contact recreational uses) do not appear to be at risk from any of the pesticides monitored by the SRWP.

Table 19. Waterbodies in the Sacramento River Watershed Listed For Pesticides On the California 1998 303(d) List.

Pesticide	Waterbody	Area Affected	Listed Source of Pesticides
Chlorpyrifos	Delta Waterways	480000 Acres	Agriculture; Urban Runoff
	Arcade Creek	10 Miles	Urban Runoff
	Elder Creek	10 Miles	Urban Runoff
	Chicken Ranch Slough	5 Miles	Urban Runoff
	Strong Ranch Slough	5 Miles	Urban Runoff
Diazinon	Delta Waterways	480000 Acres	Agriculture; Urban Runoff
	Sacramento River (Red Bluff To Delta)	300 Miles	Agriculture
	Feather River, Lower	60 Miles	Agriculture; Urban Runoff
	Morrison Creek	20 Miles	Agriculture; Urban Runoff
	Arcade Creek	10 Miles	Agriculture; Urban Runoff
	Elder Creek	10 Miles	Agriculture; Urban Runoff
	Chicken Ranch Slough	5 Miles	Agriculture; Urban Runoff
	Strong Ranch Slough	5 Miles	Agriculture; Urban Runoff
	Natomas East Main Drain	5 Miles	Agriculture; Urban Runoff
	Elk Grove Creek	5 Miles	Agriculture
	Sacramento Slough	1 Miles	Agriculture; Urban Runoff
	San Francisco Bay/Delta Estuary	265460 Acres	Nonpoint Source
Group A Pesticides	Delta Waterways	480000 Acres	Agriculture
	Colusa Drain	70 Miles	Agriculture
	Feather River, Lower	60 Miles	Agriculture
	American River, Lower	23 Miles	Urban Runoff
Malathion & Methyl Parathion	Colusa Drain	70 Miles	Agriculture
DDT	Delta Waterways	480000 Acres	Agriculture
Dieldrin	San Francisco Bay/Delta Estuary	292520 Acres	Nonpoint Source
Chlordane	San Francisco Bay/Delta Estuary	292520 Acres	Nonpoint Source

v. Mass Load Comparisons

Mass load contributions from major Delta inflows can not be adequately estimated, due primarily to the infrequent detection of pesticides in the these inflows.

vi. Conclusions and Recommendations

Conclusions of this review of pesticide monitoring data can be summarized as follows:

- The results of SRWP and other monitoring programs strongly support the focus of the SRWP and of both state and federal regulatory agencies on the management of organophosphate pesticides in surface waters. Diazinon and chlorpyrifos appear to have the greatest potential for impacts on aquatic life uses, with other monitored pesticides appearing to have relatively low to minimal risk of impacts.
- Because no data were available for the many minor tributaries to the Sacramento River watershed, no evaluation of the incidence and distribution of pesticides in these watersheds can be made in this report. For smaller tributary watersheds with a substantial proportion of agricultural land use, there is a significant potential for pesticide concentrations to occasionally reach concentrations of concern. This lack of data should be considered a significant information gap. Pesticide monitoring data should be evaluated for these watersheds as soon as they become available.
- The shift from use of organophosphate and carbamate pesticides to other relatively new pesticides, such as pyrethroids and pyrethrins, indicates the need to increase monitoring for these pesticides. For pyrethroid pesticides, this will require development of new sampling and analytical techniques to adequately identify and measure toxic concentrations of these pesticides in water, sediment, and tissue.

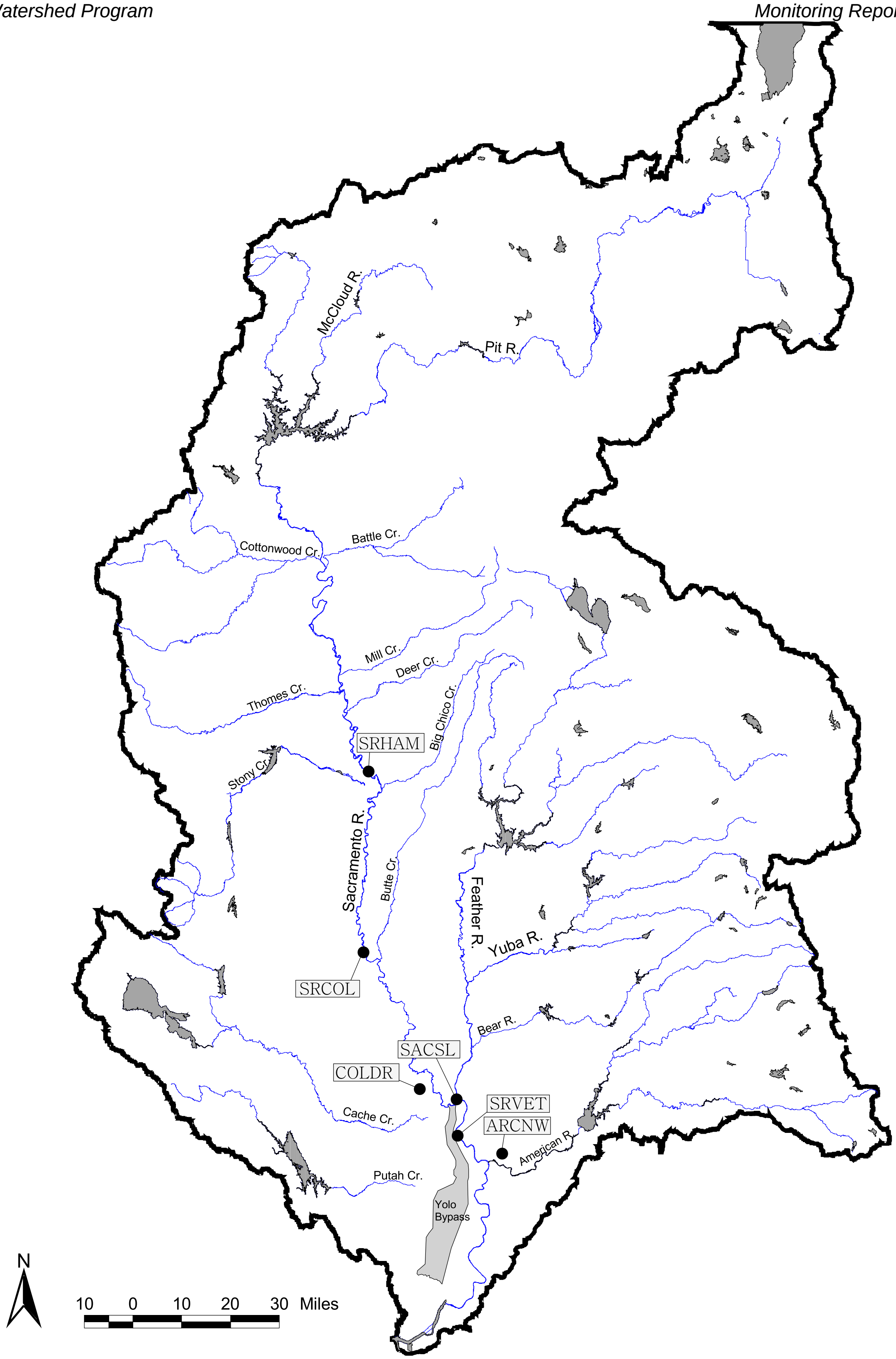

Figure 14. Pesticide Monitoring for the Sacramento River Watershed Program, 1999-2000 Monitoring Locations

D. Aquatic toxicity

i. Background and Overview of Available Data

Toxicity monitoring in the mainstem Sacramento River and its tributaries was undertaken to characterize the spatial and temporal distribution of toxicity in the watershed, and to identify potential sources and causes of toxicity. Laboratory toxicity tests were performed using USEPA procedures and standard freshwater test organisms, *Ceriodaphnia* (water flea) 7-day reproduction and survival test, and *Selenastrum* (algae) 4-day cell growth test to assess water quality and toxicity. Determination of significant toxicity for each test endpoint was accomplished using hypothesis testing statistical procedures as specified in the method documents for the specific tests. Toxicity Identification Evaluations (TIEs) (USEPA 1991, 1992, 1993) were performed on selected samples to attempt to identify the toxicants responsible for repeated adverse effects in toxicity tests. The toxicity monitoring program (implemented in 1996 and continuing to present) was designed to assess the success of implemented pollution control programs (e.g. for rice pesticides), as well as to identify toxicity concerns in the study area.

Toxicity monitoring conducted in 1999-2000 (SRWP Year 2) was performed at 47 locations throughout the watershed. Sampling sites were located on the Sacramento mainstem, 3 major tributaries, two agricultural drainage-dominated sites, and one urban runoff-dominated site. Monitoring also was performed on 5 smaller tributaries—more intensive monitoring on Mill Creek, Deer Creek, and Big Chico Creek, and on a more limited number of locations on Clear Creek, and Butte Creek. The locations of these monitoring sites are illustrated in Figure 15.

A summary of a number of other relevant studies of toxicity in the Sacramento River watershed is provided in Table 20. The critical results of these studies can be briefly summarized as follows:

Foe 1998—This study identified diazinon as the responsible toxicant in each of 10 samples (out of 33) exhibiting toxicity from Orestimba Creek, San Joaquin River at Vernalis, and Sacramento Slough. Samples from the Sacramento River at Greene's Landing were not toxic to *Ceriodaphnia* (3 samples, Jan 97). Samples were collected following precipitation events of 0.5 inches or more.

Nordmark et al. 1998-2000—This five-year study is focused on the occurrence of toxicity attributable to detections of dormant-spray pesticides in a small agricultural drainage (Wadsworth Canal), the Sutter Bypass, and in the Sacramento River. Preliminary results reported from this ongoing study indicate that significant chronic toxicity was rarely observed in samples from the Sacramento River (one sample in 1998-99 monitoring, and one sample in 1999-00 monitoring). At the Sutter Bypass location, only acute toxicity to *Ceriodaphnia* was monitored, and no significant toxicity was observed (1996-1998). Acute toxicity monitoring was changed to the Wadsworth Canal location for 1998-99 monitoring, and multiple occurrences of acute toxicity to Ceriodaphnia were observed in 1998-99 and 1999-00 monitoring. The authors state that occurrences of acute toxicity generally corresponded with diazinon concentrations of approximately 0.2 µg/L. Diazinon and methidathion were the most commonly detected pesticides, with occasional detections of carbaryl, diuron, simazine, bromacil, and hexazinone also reported. The highest concentrations and most frequent detections were reported for Wadsworth Canal.

SFEI 1998—The Regional Monitoring Program for Trace Substances aquatic toxicity results for the Sacramento River: 1 of 2 samples caused significant toxicity to *Mysidopsis bahia*, 0 of 2 samples caused significant toxicity to *Mytilus edulis* larvae.

DPR 1998—Studies performed by the Department of Pesticide Regulation have concluded that aquatic toxicity attributed to pesticides in rice field drainage has been greatly reduced, due to changes in farming practices and extended holding times for applied pesticides.

CVRWQCB 2000—Sacramento River Watershed Program aquatic toxicity data discussed in this document have also been compiled and reported in a separate report prepared by the Central Valley Regional Water Quality Control Board. The report was not available in time for review and inclusion in this document.

Table 20. Selected Aquatic Toxicity Monitoring Programs in the Sacramento River Watershed

Program	Monitoring Period and (frequency)	Parameters	# of sampling locations & geographic reference
SRWP	8/96–5/00 (monthly)	▪ 7-day *Ceriodaphnia* toxicity tests ▪ 4-day *Selenastrum* toxicity tests ▪ 7-day *Pimephales* toxicity tests ▪ Toxicity Identification Evaluations	21 sampling sites throughout the Sacramento River watershed (*Selenastrum* testing limited to 3 sites after 5/98; *Pimephales* testing discontinued after 5/99)
Regional Board/CalFed	6/99–5/00 (monthly)	▪ 7-day *Pimephales* toxicity tests	24 sampling sites throughout the Sacramento River watershed
CUWA	2/98–3/99 (monthly)	▪ *Pimephales* toxicity tests with SRWP samples split with UCD Aquatic Toxicology Lab	6 SRWP sites: 5 mainstem Sacramento River sites and one Feather River site
DWR Special Tributary Monitoring	6/98–5/00 (monthly)	▪ 7-day *Ceriodaphnia* and 10-day*Pimephales* toxicity tests ▪ Toxicity Identification Evaluations	27 (*Cerio.*) sampling sites in Sac River tributaries (Clear Ck, Mill Ck, Deer Ck, Big Chico Ck)
SF Bay Regional Monitoring Program (SFEI 1997)	1994–1997 (episodic storm events)	▪ 48-hour *Mytilus* and *Crassostrea* toxicity tests, and 7-day *Mysidopsis* bahia toxicity tests ▪ Dissolved and particulate diazinon and chlorpyrifos in water	10-13 Bay-Delta sampling sites, including the Sacramento River and San Joaquin River at the Delta terminus
CVRWQCB (Foe *et al*. 1998)	1996 and 1997 wet seasons	▪ 7-day *Ceriodaphnia* toxicity tests ▪ Toxicity Identification Evaluations ▪ Dormant-spray pesticides in water	4 sampling sites: Sac Slough and Sac River at Greene's Landing; Orestimba Ck, and San Joaquin River at Vernalis
DPR (Nordmark *et al*. 1998-00)	1996–00, weekly during dormant spray season	▪ 96-hour and 7-day *Ceriodaphnia* toxicity tests ▪ Dormant-spray pesticides, herbicides in water	2 Sutter Bypass sampling sites, Wadsworth Canal, 1 sampling site at Sacramento River at Bryte *or* Alamar
Rice Pesticide Monitoring (DPR 1998)	5/95–7/95 (episodic discharge events)	▪ 96-hour *Ceriodaphnia* toxicity tests ▪ Rice pesticides in water	4 sampling sites: Colusa Basin Drain, Butte Slough, and Sacramento River at Village Marina and near Bryte

ii. Spatial Distribution & Patterns

Toxicity results from the 1999–2000 monitoring survey are summarized in Table 21 and Tables 23-25. Results from the 1999–2000 survey confirm general spatial patterns of toxicity observed in the 1996–99 monitoring surveys. The results of 1999-2000 aquatic toxicity monitoring can be summarized as follows:

Ceriodaphnia

♦ Thirteen of 289 samples (4.5%) caused significant mortality. Five of these thirteen samples were collected from Arcade Creek (an urban runoff-dominated site). The toxicity in each these samples was determined through TIE procedures to be caused by two metabolically-activated organophosphate pesticides. This is consistent with the patterns of organophosphate pesticide-caused toxicity observed in previous years and attributed to diazinon and chlorpyrifos. One of 12 samples collected from the Feather River and 1 of 31 samples collected from Big Chico Creek also caused significant mortality. The remaining samples causing significant mortality were collected from Lindo Drain (3 of 4 samples) and Chico Drain (3 of 4 samples), which are urban sites in the Big Chico Creek watershed. No significant mortality was observed in any of the 63 samples collected from the Sacramento River mainstem.

- One of 6 samples collected in the Sacramento River above Lake Shasta exhibited significant toxicity (decreased reproduction) to *Ceriodaphnia.* TIEs performed during the first and second years of the monitoring program indicated nickel as the cause of the significant toxicity observed during that period. Patterns of toxicity for other tributaries above Lake Shasta included 2 of 6 samples collected at Pit River and 2 of 10 samples collected at McCloud River.
- Few significant mortality or adverse reproductive effects were observed in the two agricultural drainage-dominated sites. At Colusa Basin Drain, 3 of 11 samples caused significant adverse reproductive effects. At Sacramento Slough, 1 of 12 samples caused significant adverse reproductive effects. Monitoring performed prior to 1996 reported 100% *Ceriodaphnia* mortality in samples collected from these sites during the spring when rice field runoff was present in the watershed (Connor *et al.* 1993). No significant mortality was observed at either of these sites for monitoring performed in 1999-2000. The decrease in toxicity at these locations is attributed largely to the effectiveness of changes in pesticide application practices and longer holding times implemented by the rice farming industry for rice flood water to allow for degradation of pesticides.
- Significant adverse reproductive effects have been observed at various locations in the Sacramento River watershed during the past three years. In 1999-2000 monitoring, 5 of 24 samples collected from the Sacramento River from Redding to Bend Bridge caused significant decreases in reproduction. In the Sacramento River mainstem from Hamilton City to Freeport, 3 of 47 samples caused significant adverse reproductive effects, with no significant toxicity observed for the Sacramento River at Colusa and Veterans Bridge. Some significant decreases in reproduction were observed in samples collected from a number of smaller tributaries (3 of 20 samples from Mill Creek, 1 of 14 samples from Deer Creek, 2 of 30 samples from Big Chico Creek, and 0 of 8 from Little Chico Creek), and major tributaries (4 of 24 samples collected from the Feather and American rivers). No decrease in reproduction was observed in samples collected from Cache Slough. In nearly all cases, the specific causes of observed toxicity have not been determined.

Pimephales

Between June 1999 and May 2000, the Central Valley Regional Water Quality Control Board conducted a toxicity study with fathead minnows. The monitoring was conducted at the same sampling locations as ongoing SRWP toxicity monitoring with *Ceriodaphnia*. The study was performed to supplement toxicity monitoring by the SRWP, and as follow-up for significant toxicity observed in previous toxicity monitoring. The results of previous toxicity testing surveys with Pimephales suggested that the observed toxicity may have been attributable to the presence of pathogens. Symptoms of the pathogen-related toxicity included an atypical dose response, high variability among replicates, and late onset of mortality. The focus of the Regional Board study was to confirm and evaluate the role of pathogens in fathead minnow toxicity.

To evaluate the role of pathogens in the observed toxicity, the Regional Board study (conducted with the UC Davis Aquatic Toxicity Lab) performed toxicity tests in Teflon™ beakers, and implemented intensive cleaning procedures (developed by AQUA *Science*) to minimize the potential for pathogen-related effects. Samples were also tested with and without antibiotic treatment. The intensive cleaning procedures and Teflon™ containers eliminated most of the observed toxicity, and treatment with antibiotics further reduced any remaining toxic effects. These results confirmed the role of pathogens in most of the toxicity observed in fathead minnow toxicity surveys. Future studies by the Regional Board intend to focus on the potential ecological relevance of pathogen-related fathead minnow toxicity.

Results of the Regional Board study (Larsen 2001) and previous surveys of fathead toxicity by the SRWP have indicated no apparent spatial trends in toxicity.

Selenastrum

Limited *Selenastrum* testing was performed in 1999-2000. Most of the samples (31 of 40) were collected from the Sacramento River at Keswick and at Freeport, and from Arcade Creek in the Sacramento metropolitan area. Of the samples tested, 2 of 40 samples (one each from the Sacramento River below Keswick Dam and at Freeport) caused significant decreases in algal growth. (No significant toxicity was observed for samples collected in 1998–1999.) Previous toxicity surveys (Connor *et al.* 1995) attributed significant algal growth impairment in samples from the Sacramento River below Keswick Reservoir and Lake Shasta to elevated concentrations of metals. Because the algal test is a sensitive indicator of metals toxicity, these observations appear to support the finding that various pollution control programs (most significantly, the Iron Mountain Mine control program) aimed at reducing the levels of acid mine drainage (and associated trace metals) entering the watershed have been effective. Significant decreases in algal cell growth (compared to laboratory controls) observed at Arcade Creek in 1996-97 and 1997-98 were attributed to diuron and possibly to glyphosate. No toxicity was observed in the 12 samples collected from Arcade Creek in 1999-2000.

Table 21. Summary of 1999-2000 Toxicity Monitoring Survey Results: Percent of Samples Exhibiting Significant Toxicity

	% of samples exhibiting significant toxicity[a]		
Location	*Pimephales* [b]	*Ceriodaphnia*	*Selenastrum*
Pit River above Shasta	0 of 1	2 of 6	0 of 1
McCloud River Above Shasta	4 of 10	2 of 10	0 of 2
Sacramento River above Shasta	1 of 1	1 of 6	n/t
Spring Creek Power Plant Dischg to Keswick	1 of 2	3 of 6	n/t
Sacramento River below Keswick Dam	2 of 12	3 of 12	1 of 10
Clear Creek above Whiskeytown	1 of 3	1 of 3	n/t
Clear Creek near Mouth	1 of 3	0 of 3	n/t
Sacramento River at Bend Bridge	2 of 12	2 of 12	0 of 1
Mill Creek (5 sites)	0 of 6	3 of 20	n/t
Deer Creek (4 sites)	0 of 5	0 of 14	n/t
Sacramento River at Hamilton City Hwy 32	1 of 5	1 of 11	n/t
Mud Creek above Big Chico Creek	n/t	0 of 3	n/t
Big Chico Creek (8 sites)	0 of 9	3 of 31	n/t
Chico Drain (2 sites)	n/t	4 of 4	n/t
Little Chico Creek (3 sites)	n/t	0 of 8	n/t
Lindo Drain (2 sites)	n/t	4 of 4	n/t
Sacramento River at Colusa	2 of 12	0 of 12	n/t
Butte Creek (4 sites)	0 of 4	3 of 19	n/t
Sacramento Slough	1 of 12	1 of 12	0 of 1
Colusa Basin Drain	3 of 12	3 of 12	0 of 1
Feather River near Nicolaus	2 of 12	4 of 12	0 of 1
Sacramento River at Veterans Bridge	0 of 12	0 of 12	n/t
Arcade Creek at Norwood Avenue	2 of 12	5 of 12	0 of 12
American River at Discovery Park	4 of 12	1 of 12	0 of 1
Sacramento River at Freeport	2 of 12	2 of 12	1 of 9
Cache Slough near Ryer Island	0 of 2	0 of 6	n/t

n/t—Not Tested;

(a) Significant toxicity is defined as increased mortality and/or decreased growth (Pimephales), increased mortality and/or decreased reproduction (Ceriodaphnia), or decreased cell growth (Selenastrum) that is significantly different from controls at a 95% statistical confidence level.

(b) Regional Board CalFed study data

iii. Temporal Distribution and Patterns

The watershed-wide pattern of reproductive toxicity to *Ceriodaphnia* observed in January and February of 1997, 1998, and 1999 was repeated in February of 2000, and 27% of all significant reproductive toxicity observed in 1999-2000 SRWP monitoring occurred during this month, which coincides with seasonal high flows and application of dormant-spray pesticide application. Most of the remaining significant *Ceriodaphnia* reproductive toxicity (69%) observed during the 1999-2000 monitoring effort occurred July through November of 1999 (Figure 17a-c).

In general, there was no other strong seasonal pattern observed in the incidence of significant toxicity to *Ceriodaphnia* (Figures 18a-c). The results of this and other monitoring programs support the conclusion that significant adverse effects on test organisms (at most locations) tend to be associated with episodic events. The episodic events most commonly associated with observed toxicity are the application and subsequent runoff of dormant-spray pesticides from agricultural areas, and seasonal hydrologic events such as first-flush storms in areas affected by urban runoff.

There were no temporal patterns apparent in *Pimephales* or *Selenastrum* toxicity.

iv. Attainment of Beneficial Uses and Potential Impairment

Comparisons with water quality criteria and 303(d) listings: What do the data say about attainment of beneficial uses and potential impairment? Toxicity to aquatic organisms in surface waters outside designated mixing zones[2] is prohibited by Basin Plan narrative water quality criteria:

> *"All waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life. This objective applies regardless of whether the toxicity is caused by a single substance or the interactive effect of multiple substances. Compliance with this objective will be determined by analyses of indicator organisms, species diversity, population density, growth anomalies, and biotoxicity tests of appropriate duration or other methods as specified by the Regional Water Board."*

The results of SRWP monitoring and other studies have documented that water collected from different streams and rivers throughout the watershed caused episodic toxicity to test organisms. The magnitude of the observed effects on test organisms ranged from small decreases in growth or reproduction to 100% mortality of the test organisms. Whether such observed toxicity to test organisms indicates non-attainment of specific designated beneficial uses is open to interpretation. Observed toxicity to *Ceriodaphnia* or *Pimephales* or *Selenastrum* may be of ecological significance, e.g. if it translates to significant decreases in instream populations. Although the link between significant effects in laboratory toxicity tests and ecosystem impairment has not been clearly established, studies indicate there are correlations between laboratory results and ecosystem effects (de Vlaming *et al.* 2000).

A number of sites have been included on California's 1998 303(d) list of impaired waterbodies for unknown toxicity and for organophosphate pesticides (Table 22), which have been identified as causes of observed toxicity in the watershed. The observed toxicity attributed to diazinon and chlorpyrifos in Arcade Creek samples is consistent with the 303(d) listings of this and several other waterbodies for toxicity due to these pesticides. The Sacramento River mainstem from Shasta to the Delta, the lower Feather River, and the American River are all listed for unknown toxicity, and some samples

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[2] The Central Valley Basin Plan states that mixing zones *may* be allowed and that objectives *may* not apply within designated mixing zones, but will apply at the edge of designated mixing zones (CVRWQCB 1995). If granted, mixing zones are generally designated in NPDES permits for specific point source discharges. None of the locations monitored by the SRWP are within designated mixing zones.

from each of these reaches were toxic to test organisms in 1998-99 monitoring. The causes of observed toxicity at these locations has not yet been determined. The Toxicity focus group of the SRWP has begun work on developing a strategy to address toxicity of unknown causes through funding from CALFED.

v. Conclusions and Recommendations

Monitoring performed in 1998–99 indicated more frequent toxicity to test organisms for some of the smaller tributary creeks (Clear Creek, Mill Creek, Deer Creek, Big and Little Chico creeks, and Butte Creek) than samples collected in lower tributaries such as the Feather and American rivers. This pattern was not evident in the 1999–2000 results, and the incidence of toxicity in these smaller tributary watershed was similar to that observed in the Sacramento River mainstem and major tributaries. Arcade Creek samples continue to exhibit a high frequency of toxicity as compared to other lower watershed tributaries and mainstem Sacramento River sites.

The results of the 1999-2000 monitoring and of previous aquatic toxicity monitoring efforts have confirmed that significant toxicity to test organisms occurs throughout the watershed. *Ceriodaphnia dubia* toxicity attributable to organophosphate pesticides in agricultural runoff and urban runoff has been definitively shown by SRWP monitoring and other studies.

The strategy of regularly scheduled monitoring conducted in 1998–2000 has been valuable in evaluating the overall frequency and distribution of observed water column toxicity, and for identifying or confirming the causes of some of the observed toxicity. However, significant questions remain regarding the sources, severity, persistence, and ecological significance of periodic toxicity in the Sacramento River watershed. To address these questions, the SRWP aquatic toxicity monitoring effort in 2000-2001 will focus primarily on monitoring specific episodic events (e.g. agricultural dormant spray season, runoff events, high flow events).

Table 22. Waterbodies cited on California 1998 303(d) list for unknown toxicity and organophosphate pesticides .

Waterbody	Cause for Listing	Source	Area Affected	Units
Delta Waterways	Unknown Toxicity	Source Unknown	480000	Acres
Delta Waterways	Chlorpyrifos	Agriculture, Urban Runoff	480000	Acres
Delta Waterways	Diazinon	Agriculture, Urban Runoff	480000	Acres
American River, Lower	Unknown Toxicity	Source Unknown	23	Miles
Arcade Creek	Chlorpyrifos	Urban Runoff	10	Miles
Arcade Creek	Diazinon	Agriculture, Urban Runoff	10	Miles
Cache Creek	Unknown Toxicity	Source Unknown	35	Miles
Chicken Ranch Slough	Chlorpyrifos	Urban Runoff	5	Miles
Chicken Ranch Slough	Diazinon	Agriculture, Urban Runoff	5	Miles
Colusa Basin Drain	Unknown Toxicity	Agriculture	70	Miles
Elder Creek	Chlorpyrifos	Urban Runoff	10	Miles
Elder Creek	Diazinon	Agriculture, Urban Runoff	10	Miles
Elk Grove Creek	Diazinon	Agriculture, Urban Runoff	5	Miles
Feather River, Lower	Unknown Toxicity	Source Unknown	60	Miles
Feather River, Lower	Diazinon	Agriculture, Urban Runoff	60	Miles
Morrison Creek	Diazinon	Agriculture, Urban Runoff	20	Miles
Natomas East Main Drain	Diazinon	Agriculture, Urban Runoff	5	Miles
Sacramento River (Red Bluff To Delta)	Unknown Toxicity	Source Unknown	185	Miles
Sacramento River (Red Bluff To Delta)	Diazinon	Agriculture	30	Miles
Sacramento River (Shasta Dam To Red Bluff)	Unknown Toxicity	Source Unknown	50	Miles
Sacramento Slough	Diazinon	Agriculture, Urban Runoff	1	Miles
Strong Ranch Slough	Diazinon	Agriculture, Urban Runoff	5	Miles

Table 23. Summary of SRWP 1999-2000 *Ceriodaphnia* Toxicity test Results

Site	Toxicity testing endpoint: Reproduction (average neonates/adult) *% Mortality (days to 100% mortality)*											
	Sample Dates:											
	22-23 Jun 99	20-21 Jul 99	17-18 Aug 99	21-22 Sep 99	19-20 Oct 99	15-16 Nov 99	13-14 Dec 99	18-19 Jan 00	15-16 Feb 00	21-22 Mar 00	20-21 Apr 00	18-19 May 00 [1]
Laboratory Control	24.8 *15*	23.6 *0*	27.1 *0*	30.7 *0*	27.7 *0, 5*	23.8 *5*	28.9 *0*	24.0 *5*	22.6 *0*	20.2 *15*	26.3 *0*	25.4a, 23.3b *0 a,b*
Pit River above Shasta		12.8 *20*		24.2 *0*		20.7 *10*		28.2 *0*		17.0 *10*		25.9a *0*
McCloud River Above Shasta		19.8 *10*		25.0 *0*	30.3 *0*	23.7 *0*	27.8 *10*	19.1 *10*	21.4 *0*	18.4 *0*	22.8 *0*	29b *0*
Sacramento River above Shasta		17.8 *0*		28.4 *0*		19.2 *0*		16.2 *0*		23.5 *20*		24.3a *0*
Spring Creek PP Discharge to Keswick Reservoir	25.5 *10*		19.0 *0*		22.8 *0*		29.7 *0*		17.9 *10*		22.7 *0*	
Sacramento River below Keswick Dam	31.1 *11*	19.4 *10*	20.5 *10*	21.7 *10*	25.7 *0*	12.9 *0*	27.5 *0*	21.6 *0*	18.9 *20*	18.2 *0*	24.1 *0*	27b *0*
Sacramento River at Bend Bridge	40.8 *0*	24.2 *0*	24.7 *0*	32.4 *0*	26.9 *10*	16.2 *10*	32.4 *0*	39.7 *10*	16.9 *0*	22.5 *0*	29.3 *0*	26.6b *0*
Sacramento River near Hamilton City		28.0 *0*	27.1 *0*	33.2 *0*	32.2 *0*	27.7 *0*	30.0 *0*	43.1 *0*	18.1 *0*	19.1 *0*	28.0 *0*	29.6a *0*
Sacramento River at Colusa	46.5 *0*	24.8 *0*	32.5 *0*	28.6 *0*	38.6 *0*	29.4 *0*	31.1 *0*	48.9 *10*	21.7 *0*	17.3 *0*	25.8 *0*	31.9b *0*
Butte Creek at Colusa Hwy.	40.6 *0*		25.3 *0*				37.5 *0*		17.9 *0*		31.4 *0*	
Butte Creek at Honey Run Gauge	30.9 *10*		18.8 *0*		10.5 *0*		27.4 *0*		19.9 *10*		26.7 *0*	
Butte Creek above Okie Dam				20.1 *10*	33.6 *0*	10.9 *10*		30.2 *0*				
Butte Creek below Pool Four				23.5 *0*	25.9 *10*	18.5 *10*		22.3 *0*				
Sacramento Slough	30.3 *0*	25.0 *0*	19.3 *0*	24.6 *0*	24.4 *0*	30.5 *0*	30.5 *10*	43.4 *10*	22.3 *0*	29.2 *0*	29.2 *0*	21.4a *0*
Colusa Basin Drain	40.3 *11*	25.9 *0*	21.9 *0*	28.1 *0*	42.1 *0*	31.1 *0*	31.1 *0*	22.5 *0*	16.6 *0*	29.5 *10*	29.9 *0*	20.5a *0*
Feather River near Nicolaus	31.2 *10*	25.2 *0*	21.2 *0*	24.1 *10*	20.5 *10*	NC *50*	29.2 *0*	47.9 *0*	21.7 *0*	17.2 *0*	27.8 *10*	27.2b *0*
Sacramento River at Veterans Bridge	35.1 *0*	16.1 *20*	29.1 *0*	27.7 *0*	23.7 *10*	25.1 *10*	28.4 *0*	52.7 *0*	17 *0*	25.7 *0*	24.5 *0*	26.9a *0*
American River at Discovery Park	32.4 *0*	22.2 *10*	27.9 *0*	28.0 *0*	30.8 *0*	29.9 *0*	17.0 *0*	50.2 *10*	16.9 *11*	21.3 *10*	28.4 *0*	21.7a *10*
Sacramento River at Freeport	38.5 *0*	27.0 *0*	21.1 *11*	34.0 *0*	27.4 *0*	21.6 *0*	31.8 *0*	53.4 *0*	16.0 *0*	13.9 *20*	32.3 *0*	28.9b *0*
Cache Slough near Ryer Island	31.6 *10*		25.5 *0*		29.3 *0*		25.3 *10*		22.6 *0*		21.8 *0*	
Arcade Creek at Norwood Avenue	46.0 *0*	28.4 *0*	29.5 *0*	29.7 *0*	40.2 *10*	NC *90*	30.2 *0*	NC *100 (4)*	NC *100 (4)*	31.6 *0*	NC *100 (2)*	NCa *100 (3)*

Table Notes:

The laboratory controls met all EPA criteria for test acceptabili

Outlined cells indicate a significant reduction in reproduction or increase in mortality compared to the laboratory control.

The reproduction endpoint was analyzed with Dunnett's test (p<.05) and the mortality endpoint was analyzed with Fisher's exact test.

NC indicates reproductive result could not be calculated due to significant mortality.

Footnotes:

1. Ceriodaphnia tests were set up on separate days with separate controls.

Endpoints labelled "a" or "b" were compared to the first and second endpoint listed, respectively.

Table 24. Summary of DWR 1999-2000 Ceriodaphnia Toxicity test Results

Toxicity testing endpoint: Reproduction (average neonates/adult)
% Mortality (days to 100% mortality)

Site	Sample Dates: 22-23 Jun 99	20-21 Jul 99	17-18 Aug 99	21-22 Sep 99	19-20 Oct 99	15-16 Nov 99	13-14 Dec 99	18-19 Jan 00 [1]	15-16 Feb 00	21-22 Mar 00	20-21 Apr 00	18-19 May 00
Laboratory Control	24.8 *15*	23.6 *0*	27.1 *0*	27.6 *0*	28.5 *5*	18.3 *16*		27.7a, 23.9b *5*	23.4 *0*		25.7 *0*	
Clear Creek near Mouth	39.4 *0*	22.5 *0*	28.9 *0*									
Clear Creek above Whiskeytown	38.9 *0*	28.8 *0*	19.4 *0*									
Mill Creek at Black Rock	40.4 *0*	17.8 *0*	22.1 *0*			25.7 *0*		18.9a *10*			26.1 *10*	
Mill Creek at USGS Gauge					31.8 *0*	21.2 *0*		27.7a *0*				
Mill Creek at Hole in the Ground					29.3 *0*							
Mill Creek at Highway 36						10.6 *0*		40.3a *0*				
Mill Creek at Mouth	40.8 *0*	25 *0*	27.1 *11*		32.3 *0*	19.2 *0*		24.8a *0*	24.7 *0*		30.8 *0*	
Chico Drain at Bidwell Ave					NC *100*			NCa *100*				
Chico Drain below Warner Street					NC *100*			8.5a *20*				
Big Chico Creek above Campbell				19.3 *20*								
Big Chico Creek above Golf Course				18.4 *10*	34.9 *0*	18.9 *10*		28.1a, 19.2b *10a, 0b*	23.8 *0*		25.6 *0*	
Big Chico Creek above Salmon Hole	33.5 *10*	23.6 *0*	12.8 *0*									
Big Chico Creek at Chico (Rose Ave)	43.4 *0*	23.8 *0*	13.4 *30*			27.6 *0*		30.1a *0*	26.8 *0*		24.3 *0*	
Big Chico Creek below Five-Mile Rec.					33.6 *0*							
Big Chico at Golf Course above Five-Mile					34.4 *0*			32.1a *0*				
Big Chico Creek at Highway 32					32.5 *0*	24.5 *0*		20.9a *10*				
Big Chico Creek above Mud Creek	46.9 *0*	25.2 *0*	27.9 *0*		NC *90*	25.1 *0*		32.4a, 45.8b *0 a,b*	26.3 *0*		37 *0*	
Mud Creek above Big Chico Creek								50a *0*	25.2 *10*		24.9 *0*	
Little Chico Creek at Crown Point				17.9 *0*								
Little Chico Creekat Stilson Canyon				21.2 *0*	30.1 *0*	21.7 *20*		35.8a *0*				
Little Chico Creek at Ten Mile					29.9 *0*	28.7 *0*		14.9a *0*				
Lindo Drain near East Ave Railroad					NC *100*			NCa *100*				
Lindo Drain near Mission Ranch					14.1 *20*			NCa *100*				
Deer Creek at A Line Road								25.7a *0*	23.8 *10*		24 *0*	
Deer Creek at Highway 99	40.7 *0*	28.3 *0*						21.8a *10*	25.1 *0*		25.3 *0*	
Deer Creek at Ponderosa Way	39.4 *0*	23.2 *0*	15.9 *0*			17.4 *10*						
Deer Creek at Mouth			28.2 *0*			20.7 *0*						

The laboratory control met all EPA criteria for test acceptability.

Outlined cells indicate a significant reduction in reproduction or increase in mortality compared to the laboratory control.
The reproduction endpoint was analyzed with Dunnett's test (p<.05) and the mortality endpoint was analyzed with Fisher's exact test

"NC" indicates reproductive result could not be calculated due to significant mortality.

Footnotes:1. Ceriodaphnia tests were set up on separate days with separate controls. Endpoints labelled "a" or "b" were compared to the first and second endpoint listed, respectively.

Table 25. Summary of SRWP 1998-99 Selenastrum Toxicity test Results

Endpoint: Number of cells (x 10,000)

Site	**Sample Dates:**											
	22-23 Jun 99	20-21 Jul 99[1]	17-18 Aug 99	21-22 Sep 99[1]	19-20 Oct 99[1]	15-16 Nov 99	13-14 Dec 99	18-19 Jan 00	15-16 Feb 00	21-22 Mar 00	20-21 Apr 00	18-19 May 00
Lab Control	126	91 a 89 b	73	87 a 100 b	176 a 188 b	153	145	180	158	100	80	80
Pit River above Shasta								295				
McCloud River Above Shasta							330			319		
Sacramento River below Keswick Dam	266	185 b	180	192 a	242 b	229	258	331	105			216
Sacramento River at Bend Bridge								376				
Sacramento River at Veterans Bridge				210 b								
Sacramento Slough				187 b								
Colusa Basin Drain				198 b								
Feather River near Nicolaus				220 b								
American River at Discovery Park				283 b								
Sacramento River at Freeport	267	127 a	135	76 a	129 a	249	356	405			166	
Arcade Creek at Norwood Avenue	262	169 a	272	157 a	247 a	214	296	165	227	351	193	226

Table Notes:

Outlined cells indicate significant decreases in cell numbers

Footnotes:

1. Tests were set up on separate days with separate controls. Endpoints labelled "a" or "b" were compared to the first and second endpoint listed, respectively.

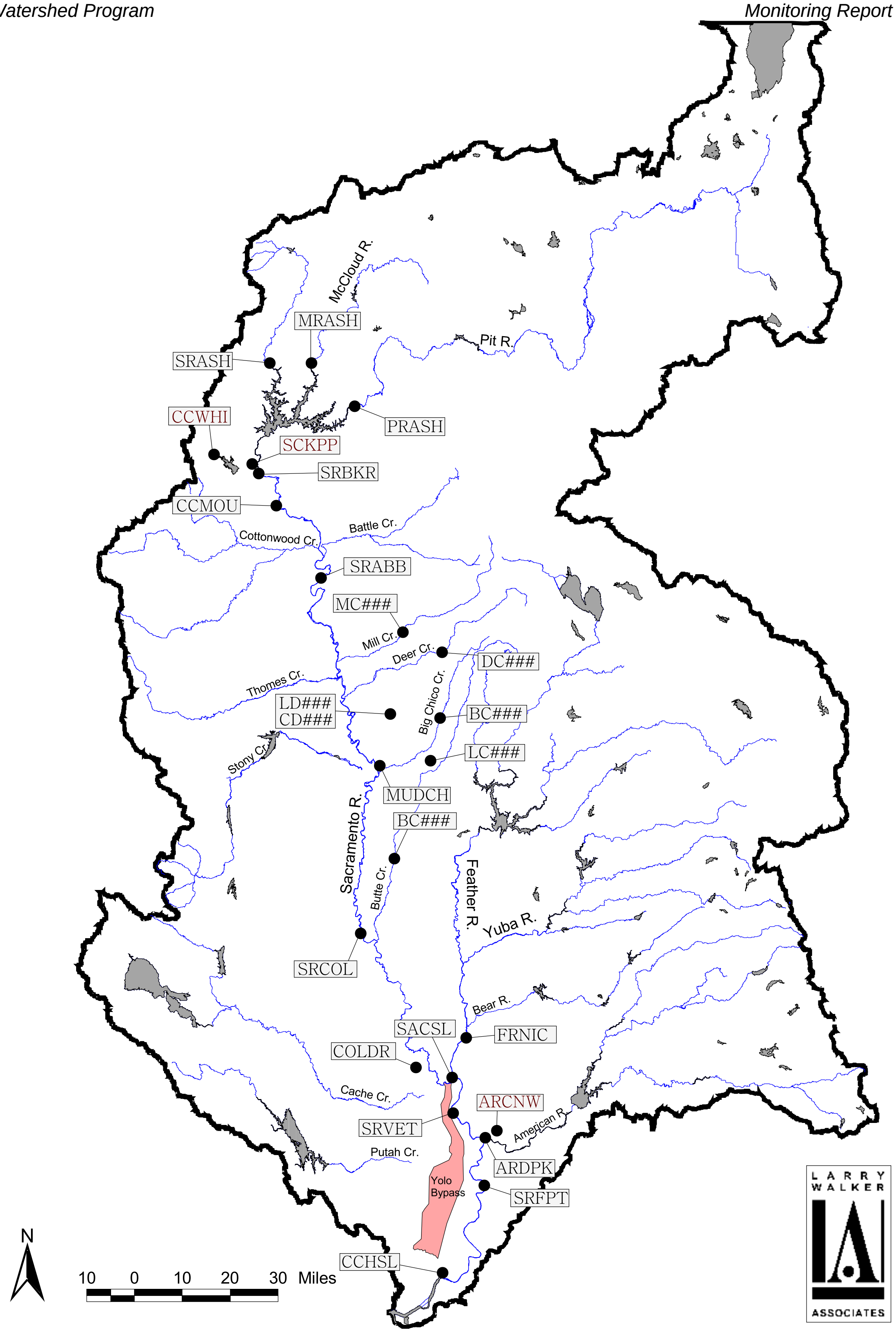
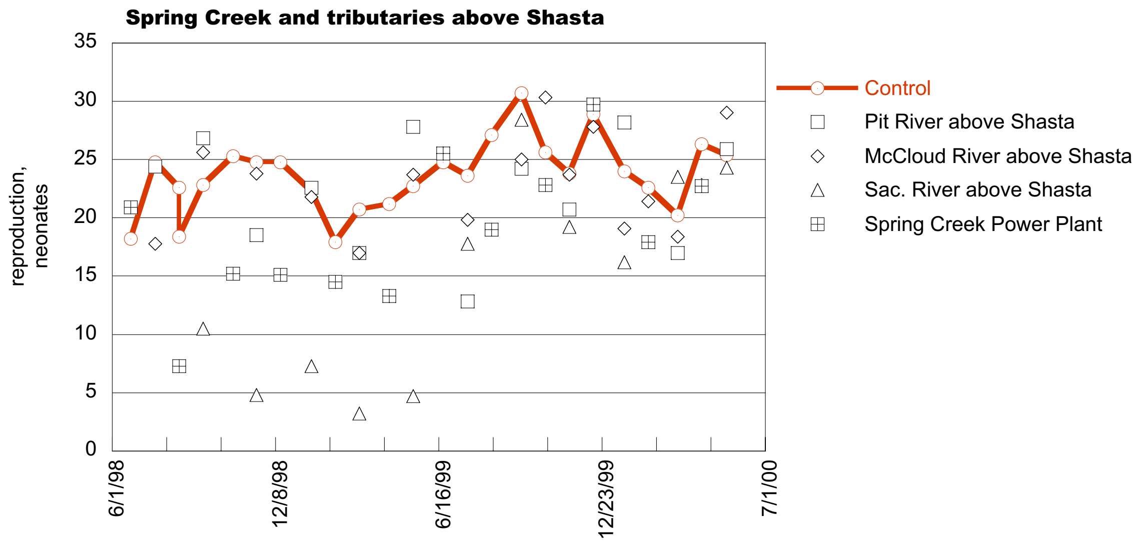


Figure 15. Aquatic Toxicity Monitoring for the Sacramento River Watershed Program, 1999-2000 Monitoring Locations



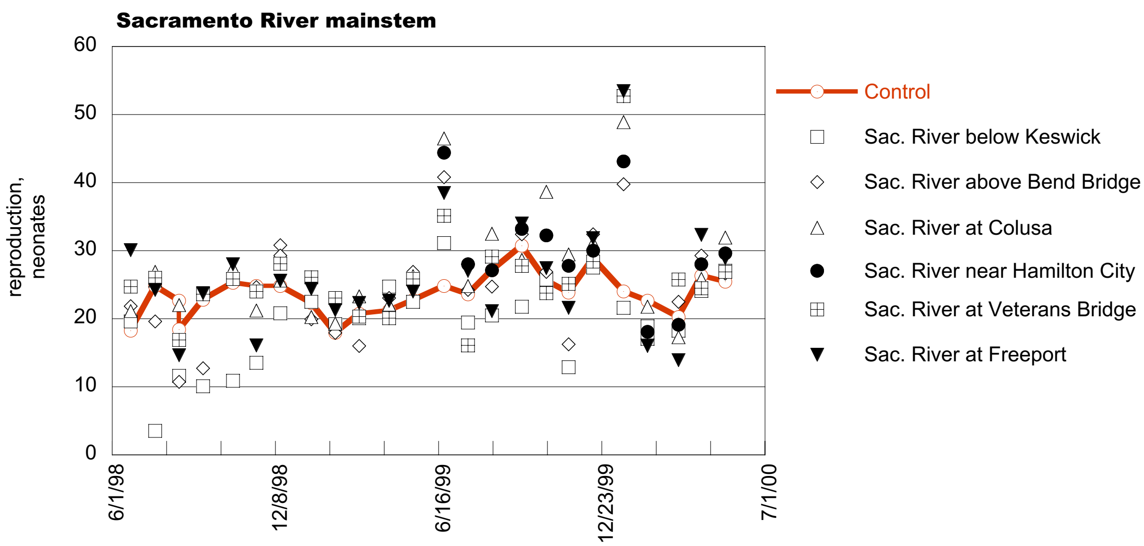
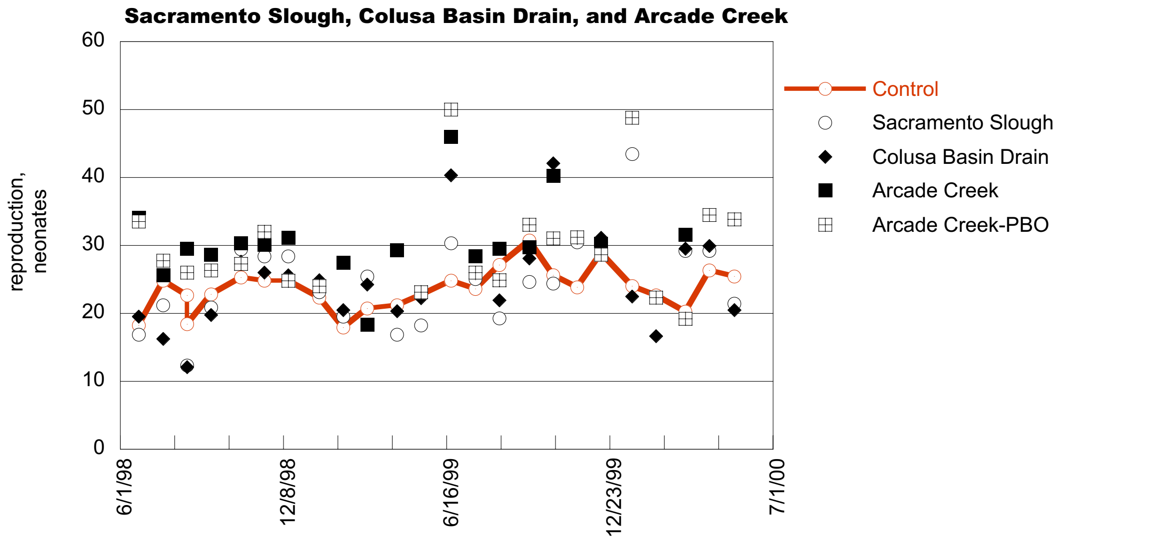


Figure 17a. Ceriodaphnia Reproduction in Toxicity Tests of Samples Collected in the Sacramento River Watershed



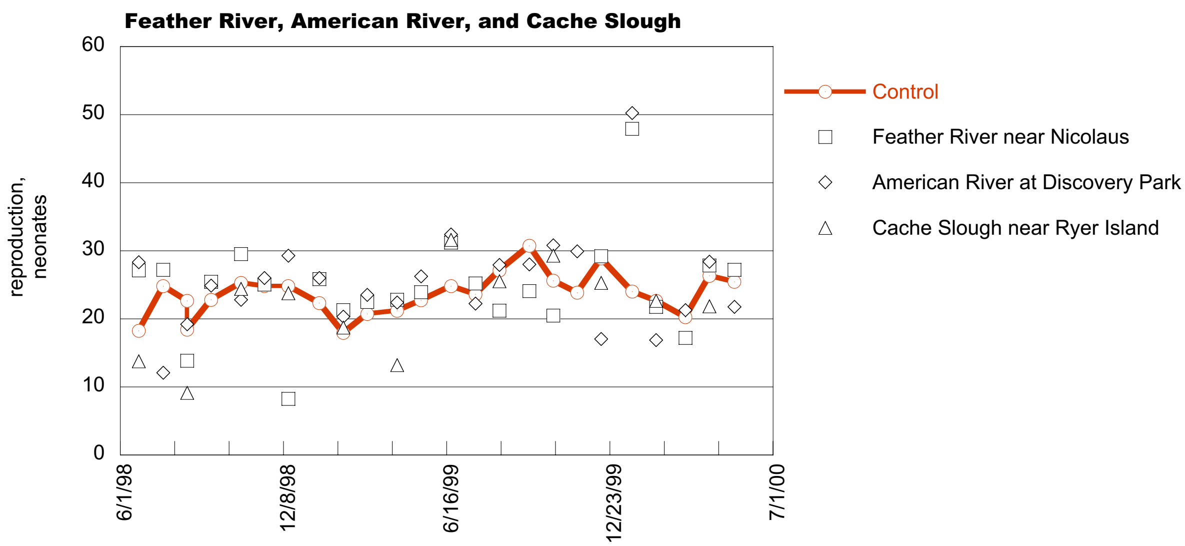
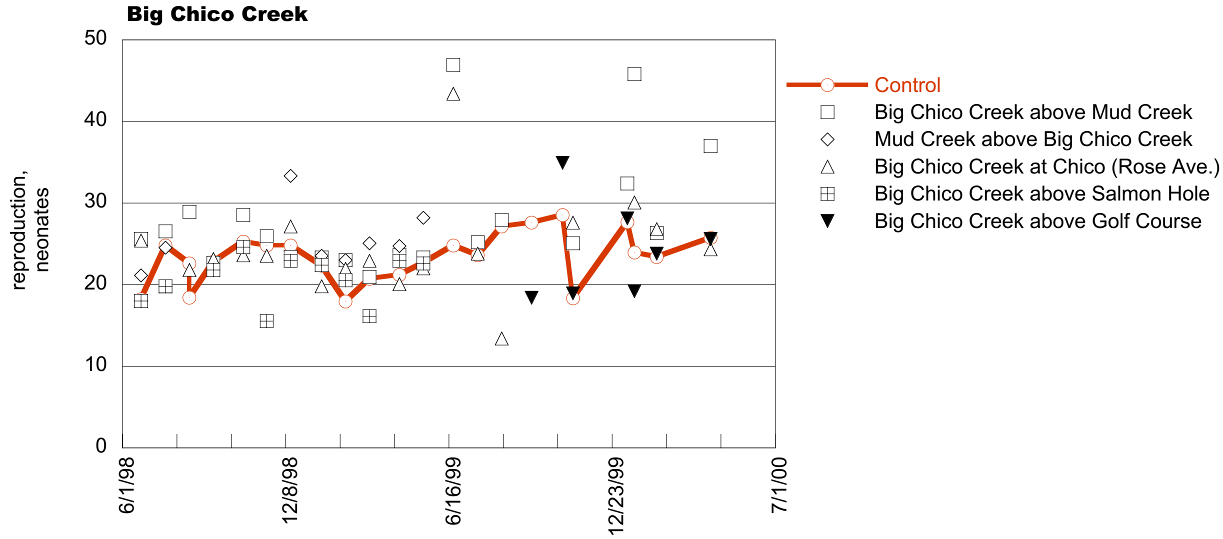
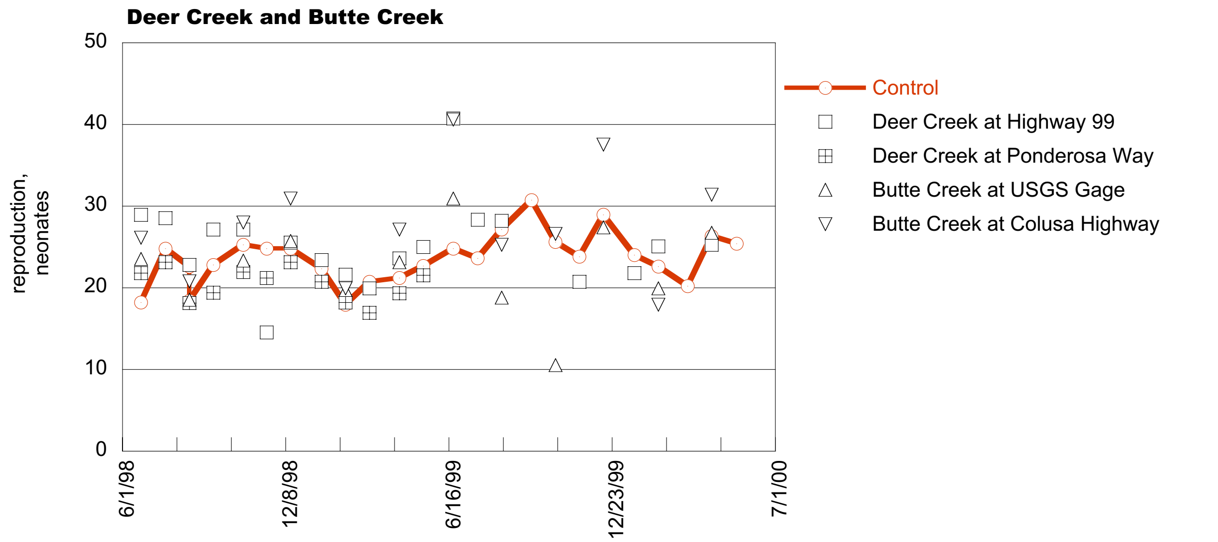


Figure 17b. Ceriodaphnia Reproduction in Toxicity Tests of Samples Collected in the Sacramento River Watershed





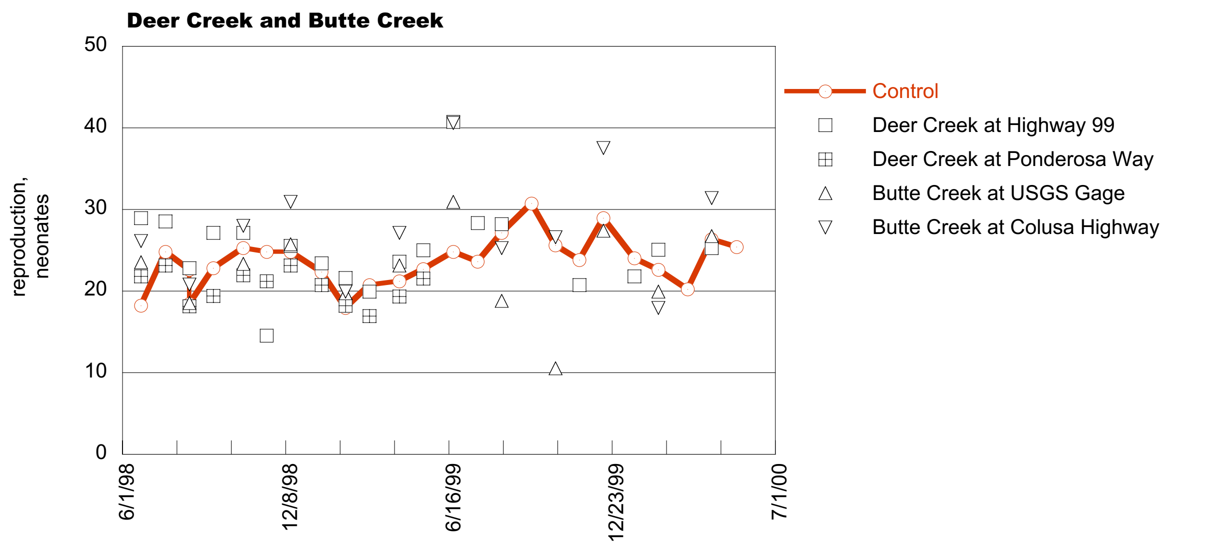


Figure 17c. **Ceriodaphnia Reproduction in Toxicity Tests of Samples Collected in the Sacramento River Watershed**

E. Drinking Water Parameters of Concern

i. Background and Available Data Overview

For the purposes of this analysis, drinking water parameters are grouped into five separate categories: total dissolved solids, total and dissolved organic carbon, pathogens, nutrients, and general minerals. Each category and the parameters included within them are discussed below in terms of their spatial and temporal distributions, and attainment of beneficial uses. For selected parameters, relative contribution to mass loads within the Sacramento-San Joaquin Delta are also discussed. When considering spatial distribution patterns, parameter concentrations at one site are evaluated against concentrations at other sites by comparing median concentrations. Summary statistics for all parameters discussed are also provided in Appendix E.

The sources of data utilized for this report are summarized in Table 26. The monitoring locations for the primary data considered for this report (USGS NAWQA, Sacramento River Coordinated Monitoring Program, City of Redding NPDES monitoring, the California Department of Water Resources, and the Sacramento River Watershed Program) are illustrated in Figure 18.

Table 26. Selected Drinking Water Monitoring Programs in the Sacramento River Watershed

Program	Monitoring Period(s)	Parameters	# of sampling locations & geographic reference
NAWQA (USGS)	2/96–4/98	▪ Total Dissolved Solids in water ▪ Total and Dissolved Organic Carbon in water ▪ Nutrients in water: nitrite as N; nitrate as N; ammonia as N organic nitrogen as N; dissolved orthophosphate as P; total phosphorus as P ▪ General Minerals in water: total alkalinity; sodium; chloride; sulfate; calcium; dissolved magnesium, manganese, potassium, iron, silica as SiO_2	12 sampling sites distributed throughout the Sacramento River watershed
SRWP	6/98–5/00	▪ Total Dissolved Solids in water ▪ Nutrients in water: nitrite as N nitrate as N; ammonia as N dissolved orthophosphate as P total phosphorus as P ▪ General Minerals in water: Total Alkalinity; Sodium; Chloride; Sulfate; Calcium; Total Magnesium, Manganese, Potassium, Iron Total and Fecal Coliform in water ▪ *Giardia* and *Cryptosporidium* in water	12 sampling sites on Sacramento River and major tributaries
MWQIP (DWR)	3/86–3/98 (1/96–3/98 considered for present analysis)	▪ Total Dissolved Solids in water ▪ Dissolved Organic Carbon in water ▪ Nutrients in water: Nitrate as N; Ammonia as N ▪ General Minerals in water: Total Alkalinity; Sodium; Chloride; Sulfate; Calcium; Dissolved Magnesium, Potassium ▪ Fecal Coliform in water	19 sampling sites distributed throughout the Sacramento-San Joaquin Delta (5 sites considered for present analysis)
CMP (SRCSD)	12/92–6/00 (10/96–6/00 considered for present analysis)	▪ Total and Fecal Coliform in water	5 sites on Sacramento and American rivers in Sacramento metropolitan area
City of Redding	1/98–5/00	▪ Total Dissolved Solids in water	1 site at Sacramento River below Keswick Dam

ii. Spatial Distribution & Patterns

Results from SRWP monitoring conducted 1998-2000, and from other major monitoring efforts covering various monitoring periods are used to evaluate general patterns in spatial distributions.

a. Total Dissolved Solids (TDS)

Total dissolved solids concentrations in the mainstem Sacramento River, in tributaries above Shasta, and in major Sierra tributaries are considered relatively low (compard to Basin Plan objectives and TDS concentrations in the Delta), with median concentrations ranging from 62-101 mg/L in the mainstem, and from 40–62 mg/L in major tributaries (Figure 19). TDS concentrations in the Sacramento River below Shasta and above the Feather River confluence gradually increase, due to agricultural inflows and Coast Range and Cascade Range tributary streams that have relatively high TDS. Below the Feather River confluence, the effects of these TDS sources are moderated by dilution provided by the low-TDS Sierra tributaries (the Yuba, Feather, and American rivers). Median TDS concentrations in the two major agricultural drains monitored (Sacramento Slough and Colusa Basin Drain) were 2- to 4-fold greater than those measured in the Sacramento River mainstem (191 mg/L and 352 mg/L, respectively). Median TDS concentrations are also much higher in tributaries draining the Coast Range (Cache Slough, 136 mg/L) and the lower west side of the valley (Barker Slough in the North Delta, 191 mg/L). Data compiled for the Sacramento-San Joaquin Delta (Woodard 2000) indicate that TDS concentrations are considerably higher in the Delta than in the lower Sacramento River. The mean TDS concentration reported for the State Water Project Harvey Banks Pumping Plant was 254 mg/L, compared to 99 mg/L reported for the Sacramento River at Greene's Landing. The mean TDS concentration reported for internal Delta island agricultural drainage was 624 mg/L.

b. Total and Dissolved Organic Carbon

Total and dissolved organic carbon concentrations have similar spatial distributions in the mainstem Sacramento River and its tributaries. Median organic carbon concentrations in the mainstem increase slightly in the downstream direction from Bend Bridge to Freeport, with median TOC concentrations ranging from 1.6–2.2 mg/L. Median TOC for the Sacramento River at River Mile 44 was markedly higher (2.7) than at Freeport, but was based on only nine samples collected throughout 1999-2000. The primary sources of organic carbon in the mainstem are considered to be agricultural inflows and a variety of natural sources in the watershed. Urban runoff and treated wastewater discharges also contain relatively high levels of organic carbon, but are not considered major sources of organic carbon loads. TOC and DOC concentrations are substantially higher in Sacramento Slough and the Colusa Basin Drain. Median TOC concentrations in these two major agricultural drains are 2.5- to 3.5-fold higher than in the mainstem Sacramento River. The highest organic carbon concentrations were observed at Arcade Creek, with a median TOC concentration of 7.8 mg/L and a median DOC concentration of 7.0 mg/L.

The increases in organic carbon in the mainstem are somewhat moderated by the lower organic carbon concentrations in the major Sierra tributaries, with median TOC concentrations of 1.3 mg/L in the Yuba River; 1.9 mg/L in the Feather River, and 1.8 mg/L in the American River. Median DOC concentrations in the Yuba, Feather, and American rivers demonstrate a similar pattern.

Data compiled for the Sacramento-San Joaquin Delta (Woodard 2000) indicate that organic carbon concentrations are typically much higher in the Delta than in the Sacramento River mainstem. Summary data provided in this report are provided as means and monthly means. The mean DOC concentrations in Barker Slough (at the North Bay Aqueduct Pumping Plant) and the State Water Project Harvey Banks Pumping Plant are considerably elevated (5.2 mg/L and 3.9 mg/L, respectively) relative to mean concentrations reported for the lower mainstem Sacramento River at Greene's Landing (2.5 mg/L). Barker Slough is located in the northwestern Delta and receives drainage from the lower western part of the Sacramento Valley and Coast Range. The mean DOC concentration reported for internal Delta island agricultural drainage was 17 mg/L. Available TOC data compiled in the Woodard report are from a much smaller data set than the DOC data, and for most locations the reported mean TOC is slightly lower than the mean DOC. However, Woodard states that TOC concentrations are approximately 93% dissolved organic carbon (on average), so that any conclusions about spatial distributions based on DOC will also be reasonably accurate for spatial distributions of TOC. The distribution of organic carbon concentrations (as DOC) in the Sacramento River watershed are illustrated in Figures 20a and 20b.

c. Pathogens

For this analysis, the pathogens group is considered to be comprised of the following organisms: *Giardia* and *Cryptosporidium*, and total and fecal coliform bacteria, which are considered indicators for these and other pathogenic organisms. Total and fecal coliform bacteria show similar general spatial distribution patterns within the Sacramento River watershed (fecal coliform data are presented in Figure 21). Median total coliform concentrations increase steadily from the Sacramento River below Keswick to Veterans Bridge (from 10 MPN/100 mL to 500 MPN/100 mL), while median fecal coliform values range from <2 MPN/100 mL at Keswick to 30 MPN/100 mL at Veterans Bridge. The highest median fecal coliform value in the mainstem was for Hamilton City (80 MPN/100 mL). By comparison, Barker Slough in the North Delta exhibited a greater median fecal coliform number (123 MPN/100 mL) than for any site monitored in the Sacramento River watershed. Median total coliform concentrations are somewhat lower in the mainstem Sacramento River at Freeport than at the Veterans Bridge site (300 MPN/100 mL and 500 MPN/100 mL, respectively) upstream from the confluence with the American River, but median fecal coliform numbers were similar (28 MPN/100 mL and 30 MPN/100 mL, respectively). (Note:The Sacramento River Coordinated Monitoring Program began monitoring total and fecal coliform, and *Cryptosporidium* and *Giardia* at River Mile 44 (below the Sacramento Regional Wastewater Treatment Plant discharge) in 2000, but there were too few data available yet to make meaningful comparisons to other locations in this report. Total coliform data for the Sacramento-San Joaquin Delta were not available for analysis.

Giardia and *Cryptosporidium* concentrations are evaluated using only data from sites monitored by the Sacramento River Watershed Program (SRWP data 1999-2000). Median numbers of cysts detected in the mainstem Sacramento River ranged from <0.1—0.4 cysts/L, with no apparent spatial trend. Percent detection of *Giardia* in the mainstem Sacramento River ranged from 45% (Sacramento River at Veterans Bridge) to 82% (Sacramento River above Bend Bridge), again with no apparent trend. The median *Giardia* numbers in samples from the Feather River near Nicolaus and from Cache Slough near Ryer Island Ferry was <0.1 cysts/L, with percent detections of 42% and 20%, respectively. The maximum number of *Giardia* cysts detected in any sample was 0.6 cysts/L (6 cysts in a 10 liter sample) from the Sacramento River at Hamilton City. Nearly all samples evaluated for *Cryptosporidium* were below detection, and again, there was no discernible trend. The maximum number of *Cryptosporidium* oöcysts detected in any sample was 0.8 cysts/L (8 cysts in a 10 liter sample) from the Sacramento River at Colusa. Although the method (EPA 1623) used for analysis of Giardia and Cryptosporidium in 1999-2000 monitoring is significantly improved compared to the ICR method used previously, there are still significant concerns regarding the recoveries and reliability of the method (particularly in turbid samples). There remains a high degree of uncertainty associated with data for these pathogens, due to the lack of meaningful thresholds or guidelines for comparison, the lack of information about infectivity, and the probable under-reporting of true pathogen numbers by current analytical methods.

d. Nutrients

For this discussion, the nutrients group is considered to be comprised of the following constituents: nitrite, nitrate, ammonia, organic nitrogen, dissolved orthophosphate, and total phosphorus.

Median nitrite (as N) concentrations in the Sacramento River mainstem are less than the 0.01 mg/L NAWQA reporting limit from Bend Bridge to Freeport. Median nitrite concentrations are also less than 0.01 mg/L in the Yuba, Feather, and American rivers. Median nitrite concentrations were higher in Colusa Basin Drain (0.03 mg/L and Arcade Creek (0.04 mg/L). Nitrite data for the Sacramento-San Joaquin Delta were not available for analysis. The maximum nitrite concentration observed in SRWP and NAWQA monitoring was 0.19 mg/L in the Yuba River.

Nitrate (as N) concentrations in the mainstem Sacramento River exhibit no clear trend with distance downstream from Bend Bridge. Median nitrate concentrations are relatively constant from Sacramento River above Bend Bridge (0.10 mg/L) to River Mile 44 (0.13 mg/L). Median nitrate concentrations in the Yuba, Feather, and American rivers are lower than those observed in the mainstem Sacramento River. In contrast, median nitrate concentrations in the agricultural drains (Colusa Basin Drain, 0.38 mg/L, and Sacramento Slough, 0.16 mg/L) and Arcade Creek (0.51 mg/L) were higher than observed in the Sacramento mainstem and the major tributaries. The maximum nitrate concentration observed in SRWP and NAWQA monitoring was 2.3 mg/L in Arcade Creek. Data compiled for the Sacramento-San Joaquin Delta (Woodard 2000) indicate that nitrate concentrations are typically much higher in the Delta than in the Sacramento River mainstem. The mean nitrate concentration reported for Barker Slough (at the North Bay Aqueduct Pumping Plant) and the State Water Project Harvey Banks Pumping Plant are considerably elevated (0.45 mg/L and 0.66 mg/L as N, respectively) relative to mean concentrations reported for the lower mainstem Sacramento River at Greene's Landing (.32 mg/L as N). The mean nitrate concentration reported for internal Delta island agricultural drainage was very high compared to other locations (2.15 mg/L as N). Nitrate data for the Sacramento River watershed are presented as representative of the nutrient category in Figure 22.

Median concentrations of ammonia nitrogen in the mainstem are generally less than 0.02 mg/L from Bend Bridge to Freeport. Ammonia nitrogen concentrations increase appreciably in the lower mainstem Sacramento River at River Mile 44 (0.11 mg/L) and Greene's Landing (0.26 mg/L). The Yuba, Feather, and American rivers also exhibited median ammonia nitrogen concentrations of less than 0.02 mg/L. Other Sacramento River tributaries exhibit median ammonia nitrogen concentrations ranging from 0.04 mg/L (Sacramento Slough) to 0.07 mg/L (Arcade Creek at Norwood Avenue).

Median organic nitrogen concentrations (NAWQA data) in the mainstem are less than 0.20 mg/L from Bend Bridge to River Mile 44. The Yuba, Feather, and American rivers show similar median organic nitrogen levels. The two agricultural drains and Arcade Creek exhibit substantially elevated organic nitrogen concentrations (compared to the mainstem), with median values ranging from 2.5-fold (Sacramento Slough) to 4.4- fold (Arcade Creek at Norwood Avenue) greater than in the mainstem Sacramento River.

Median dissolved orthophosphate concentrations (as P) are relatively constant in the mainstem Sacramento River at 0.02 mg/L from Bend Bridge to Freeport. Similar to other nutrients considered above, median dissolved orthophosphate concentrations in the Yuba, Feather, and American rivers (0.01 mg/L or less) are lower than those observed in the mainstem Sacramento River. In contrast, Sacramento Slough, the Colusa Basin Drain, and Arcade Creek show elevated dissolved orthophosphate—median concentrations in these three tributaries range from 0.06 mg/L (Sacramento Slough) to 0.12 mg/L (Arcade Creek at Norwood Avenue). The maximum dissolved orthophosphate concentration observed in SRWP and NAWQA monitoring was 0.28 mg/L in Arcade Creek.

Total phosphorus concentrations (as P) in the mainstem Sacramento River exhibit no clear trend with distance downstream from Bend Bridge. Median phosphorus concentrations are relatively constant from Sacramento River above Bend Bridge (0.04 mg/L) to Freeport (0.05 mg/L), but appear to increase substantially in the lower mainstem Sacramento River, as evidenced by relatively elevated median concentrations at River Mile 44 (0.08 mg/L). As above, median total phosphorus concentrations in the Yuba, Feather, and American rivers are less than those observed in the mainstem Sacramento River. Likewise, total phosphorus concentrations are noticeably elevated in the two agricultural drains and Arcade Creek, with median concentrations ranging from 0.15 mg/L (Sacramento Slough) to 0.23 mg/L (Arcade Creek). Dissolved orthophosphate and total phosphorus data were not available for the Sacramento-San Joaquin Delta.

e. General Minerals

For the following discussion, the general minerals group is considered to be comprised of total alkalinity, hardness, sodium, chloride, calcium, magnesium, sulfate, potassium, manganese, iron, and silica. Total alkalinity concentrations in the mainstem Sacramento River and its tributaries above Keswick Reservoir are generally similar to mainstem sites below the dam. The Spring Creek Power plant discharge into Keswick Reservoir is an exception, with a median total alkalinity of 40 mg/L, as compared to a mainstem range of approximately 50 mg/L below Keswick to 65 mg/L (Sacramento River at Veterans Bridge). Alkalinity decreases in the mainstem Sacramento River below Veterans Bridge exhibits due to the diluting influence of the American River. The Yuba, Feather, and American rivers all exhibit median total alkalinity concentrations substantially lower than those found in the mainstem Sacramento River. As is the case with the nutrients discussed above, both Sacramento Slough and the Colusa Basin Drain have noticeably elevated (3–4 fold) median total alkalinity concentrations as compared to mainstem sites. Median alkalinity for the lower Sacramento River watershed (70 mg/L – Cache Slough near Ryers Island Ferry) is considerably lower than that measured in the North Delta (91 mg/L – Barker Slough; MWQI data 1996-98).

Sodium, chloride, and calcium have similar spatial distribution patterns. All three constituents increase in a downstream direction within the mainstem Sacramento River from Bend Bridge to Verona. The three constituents also exhibit a decrease in their concentrations at Freeport, due to the diluting influence of the American River. Median concentrations of sodium, chloride, and calcium in the Yuba, Feather, and American rivers were all lower than the concentrations of these same constituents measured in the mainstem Sacramento River. Median concentrations of all three constituents are substantially higher in the two agricultural drains and Arcade Creek than in the mainstem Sacramento River. Sodium and chloride concentrations at Barker Slough in the North Delta (MWQI data 1996-98) are only slightly higher than levels detected in the lower Sacramento River mainstem.

Magnesium, sulfate, and potassium show similar general spatial distribution patterns in the Sacramento River watershed. Magnesium and sulfate increase slightly in a downstream direction in the mainstem Sacramento River from Bend Bridge to Verona, and exhibit a small decrease in median concentrations at Freeport, due to the diluting influence of the American River. Median potassium concentrations remain relatively constant in mainstem. Median concentrations of these three constituents are lower in the Yuba and Feather rivers than in the mainstem Sacramento River. In the American River, median concentrations of sulfate are lower, magnesium is similar, and potassium is higher than in the mainstem. Median levels of all three constituents are slightly to substantially higher in the two agricultural drains and Arcade Creek than in the mainstem Sacramento River. Median concentrations of all three constituents in the Sacramento River at Greene's Landing are slightly higher than at Freeport, while concentrations at Barker Slough in the North Delta are approximately 2- to 5-fold higher than in the mainstem Sacramento River (MWQI data 1996-98).

Manganese, iron, and silica (as SiO_2) all exhibit unique spatial distribution patterns within the Sacramento River watershed. Dissolved manganese increases slightly in a downstream direction within the mainstem Sacramento River from Bend Bridge to Verona, followed by a decrease in concentration at Freeport, due to the diluting influence of the American River. The median dissolved manganese concentration in the Feather River is similar to the mainstem Sacramento River, while the median dissolved manganese concentration in the Yuba River at Marysville is slightly higher than levels observed in the mainstem. The median dissolved manganese concentration in the American River at J Street is similar to concentrations observed in the mainstem Sacramento River. In accord with other constituents analyzed above, dissolved manganese concentrations in the two agricultural drains and Arcade Creek are substantially higher than levels measured in the mainstem Sacramento River. The median total manganese concentration at Cache Slough is lower than in the mainstem Sacramento River at Veterans Bridge.

Dissolved iron increases slightly in a downstream direction in the mainstem Sacramento River from Bend Bridge to Verona, followed by a decrease in concentration at Freeport, due to the diluting influence of the American River. Similar to manganese, dissolved iron concentrations in both the Yuba and Feather rivers are higher than those measured in the mainstem Sacramento River. The median dissolved iron concentration in the American River at J Street is lower than concentrations detected in the mainstem. In contrast with most constituents evaluated above, median dissolved iron concentrations in Sacramento Slough and the Colusa Basin Drain are similar to concentrations in the mainstem. The median dissolved iron concentration in Arcade Creek at Norwood Avenue is about 6 times greater than in the Sacramento River mainstem. The median total iron concentration at Cache Slough is over 50% greater than total iron in the mainstem Sacramento River at Veterans Bridge. Iron data for the Sacramento-San Joaquin Delta were not available for analysis.

Dissolved silica (as SiO_2) decreases slightly in a downstream direction within the mainstem Sacramento River from Bend Bridge to Freeport, with a slightly elevated median at Veterans Bridge. Dissolved silica concentrations in the Yuba, Feather, and American rivers are appreciably lower than those measured in the mainstem Sacramento River. Median dissolved silica concentrations in both Sacramento Slough and Arcade Creek are greater than those detected in the mainstem, while the Colusa Basin Drain exhibits a median dissolved silica level similar to those found in the mainstem Sacramento River.

f. Turbidity

The spatial distribution of turbidity levels is similar to that described for total dissolved solids concentrations in the Sacramento River watershed. Turbidity levels in the mainstem and its tributaries above Keswick Reservoir are generally lower than at mainstem sites below the dam. Median turbidity values in the mainstem change little from below Keswick Reservoir (3.4 NTU) to Hamilton City (4.0 NTU), and increase substantially at Colusa (17.5 NTU). Turbidity remains elevated downstream in the mainstem Sacramento River to River Mile 44 (19.0 NTU), and is similar at Greene's

Landing (18.1 NTU; MWQI data). Elevated turbidity levels are also observed at Cache Slough near Ryer Island (29.0 NTU). As exhibited by other parameters discussed above, turbidity levels for the Feather River are appreciably lower than those measured in the lower mainstem Sacramento River. Turbidity in the Feather River (5.3 NTU) is similar to that observed in the Sacramento River upstream of Colusa. Turbidity was not monitored by the Sacramento River Watershed Program in either of the two agricultural drains or Arcade Creek. Average turbidity data reported for the Delta by Woodard (2000) include a mean turbidity of 37 NTU at Barker Slough (1988-1999) and 11 NTU at the State Water Project Harvey Banks Pumping Plant (1982-1999), compared to a mean turbidity of 14 NTU at Greene's Landing (1983-1998). Turbidity data are presented in Figure 23.

iii. Temporal Distribution & Patterns

a. Total Dissolved Solids

Total dissolved solids concentrations in the mainstem Sacramento River exhibit a general seasonal pattern. Concentrations of TDS typically exhibit two seasonal peaks, one in the late winter or early spring, and one in the late summer or early fall before the beginning of the wet season (Figure 24 and 25).

b. Total and Dissolved Organic Carbon

Total and dissolved organic carbon concentrations in the mainstem Sacramento River typically peak in the late fall or early winter at the beginning of the wet season, and then tend to decrease until late summer or early fall (Figure 26a). The Yuba, Feather, and American rivers show seasonal concentration patterns similar to those found in the mainstem Sacramento River (not illustrated). Organic carbon concentrations in agricultural drains (Colusa Drain and Sacramento Slough) and urban runoff did not exhibit any consistent seasonal patterns (Figure 26b).

c. Pathogens

Total and fecal coliform concentrations in the mainstem Sacramento River demonstrate seasonal patterns similar to those observed for TDS, TOC, and DOC. Limited available data suggest that total and fecal coliform concentrations peak in the late fall or early winter at the beginning of the wet season, and then decrease in a steady or punctuated manner until late summer or early fall, prior to the start of the following wet season. While the causes are unknown, fecal coliform concentrations detected in the Sacramento River at Freeport show much greater seasonal variability than those measured at other sites along the mainstem. Coliform concentrations in the Feather River show a similar seasonal pattern to those observed in the mainstem Sacramento River. Analysis of coliform data by the city of Sacramento indicate that coliform numbers in the American River are typically highest during storm events (E. Archibald, pers. comm.). *Giardia* data collected within the Sacramento River watershed are insufficient to determine seasonal distribution patterns of this pathogen. Similarly, "non-detect" *Cryptosporidium* data does not allow for analysis of temporal distribution patterns for this pathogen.

d. Nutrients

The six parameters comprising the nutrients group generally demonstrate seasonal distribution patterns similar to those observed for TDS, TOC, and DOC. However, nitrite, ammonia nitrogen, and organic nitrogen concentrations measured throughout the Sacramento River watershed all exhibit a high degree of within-season variability. Nitrite, ammonia nitrogen, and organic nitrogen concentrations in the mainstem Sacramento River typically peak in the late fall or early winter at the beginning of the wet season, and then decrease in a steady or punctuated manner until late summer or early fall, prior to the start of the following wet season. This same pattern is observed for the three constituents in all waterbodies tributary to the Sacramento River.

Nitrate demonstrates a seasonal distribution pattern within the mainstem Sacramento River that possesses a typical late fall – early winter peak. However, its concentrations within all the tributaries under study tend to vary enough so as not to allow simple temporal classifications. Nitrate concentrations in the Yuba and Feather rivers vary little over the course of a single season. In contrast, nitrate levels in Arcade Creek at Norwood Avenue and the American River at J Street exhibit high degrees of within season variability.

Dissolved orthophosphate and total phosphorus concentrations also demonstrate temporal patterns with peaks in the late fall or early winter. These peaks are followed by steady or punctuated decreases in concentrations until late summer or early fall, prior to the start of the following wet season.

e. General Minerals

The parameters comprising the general minerals group generally demonstrate seasonal distribution patterns similar to those observed for TDS, TOC, and DOC. In general, all of the general minerals constituents exhibit similar temporal distributions in the mainstem Sacramento River. Concentrations typically peak in the late fall or early winter at the beginning of the wet season, and then decrease in a steady or punctuated manner until late summer or early fall, prior to the start of the following wet season.

f. Turbidity

The available 1998-2000 data suggest that turbidity in the mainstem Sacramento River below Keswick Reservoir exhibits two peaks: one in the fall and one in the early winter. Comparisons of hydrographs and turbidity plots for various sites reveal that turbidity peaks in early winter occur during periods of increased discharge within the mainstem. In contrast, the fall turbidity peaks observed in the mainstem from Colusa to River Mile 44 (SRWP data 1998-99) are not well correlated with discharge measurements at these sites. Increases in turbidity levels in the Feather River are closely associated with increases in the river’s discharge that occur during the wet season. Cache Slough near Ryer Island Ferry also exhibits increases in turbidity that appear to track closely with seasonal flow increases through the slough.

Table 27. Median Concentrations of Selected Drinking Water Parameters

Location	TDS, mg/L	TOC, mg/L	DOC, mg/L	Nitrate (N) mg/L	Total Coliform MPN/ 100mL	Fecal Coliform MPN/ 100 mL	*Giardia*[a], oocysts/L	*Crypto-sporidium*[a], oöcysts/L
Pit R. above Shasta	90	1.4	1.3	—[(d)]	—	—	—	—
McCloud R. above Shasta	58	0.8	0.7	—	—	—	—	—
Sac. R. above Shasta	62	1.5	1.4	—	—	—	—	—
Spring Ck Power Plant	53	1.3	1.2	—	—	—	—	—
Sac R. below Keswick	77	1.2	1.0	—	10	<2	—	—
Sac R. above Bend Br.	85	1.6	1.4	0.10	130	23	0.2	<0.1
Mill Creek at Mouth	98	1.2	—	—	—	3	—	—
Deer Creek at Mouth	100	1.1	—	—	—	5	—	—
Big Chico Ck in Chico	122	1.2	—	—	—	40	—	—
Sac R. at Hamilton City	—	1.7	1.4		150	80	0.15	<0.1
Sac R. at Colusa	94	1.9	1.4	0.13	185	23	0.4	<0.1
Sacramento Slough	191	4.4	3.5	0.16	—	—	—	—
Colusa Basin Drain	352	6.9	5.2	0.38	—	—	—	—
Yuba R. at Marysville	52	1.3	1.0	0.06	—	—	—	—
Feather R. nr Nicolaus	62	1.9	1.5	0.08	130	13	<0.1	<0.1
Sac R. at Verona	90	2.2	1.6	0.12	—	—	—	—
Sac R. at Veterans Br.	101	—	—	—	500	30	<0.1	<0.1
Arcade Ck at Norwood	178	7.8	7.0	0.51	—	—	—	—
American R. at J St	40	1.8	1.5	0.05	—	—	—	—
American R. at Discovery Pk	—	—	—	—	240	30	—	—
Sac. R. at Freeport	87	2.0	1.6	0.11	300	28	0.1	<0.1
Sac. R. at Mile 44	92	2.7	2.3	0.13	—	—	—	—
Cache Creek	173	3.6	3.0	0.10	—	—	—	—
Cache Slough	136	2.2	2.0	—	125	12	<0.1	<0.1
Greene's Landing[c]	99[c]	2.4[c]	2.5[c]	0.32[c]	—	10	—	—
Barker Slough[c]	176[c]	6.3[c]	5.2[c]	0.45[c]	—	123[e]	—	—
Banks Pumping Plant[c]	254[c]	3.6[c]	3.9[c]	0.66[c]	—	—	—	—
San Joaquin R. at Vernalis[c]	361[c]	3.2[c]	3.3[c]	6.1[c]	—	—	—	—

Note: Table lists median values for available data from 1994-2000, except for mean data from Woodard (2000) which are generally based on longer periods of record.

(a) *Giarda* cysts per liter and *Cryptosporidium* öocysts per liter
(b) TOC and DOC data from the SRWP were not evaluated due to analytical problems.
(c) Mean data reported from Woodard (2000).
(d) "—" indicates parameter not evaluated at this location.
(e) Median data from MWQI data base (DWR 1999)

iv. Attainment of Beneficial Uses and Potential Impairment

a. Comparisons with Relevant Water Quality Objectives

The Central Valley Basin Plan has adopted by reference California Title 22 of the California Code of Regulations Maximum Contaminant Levels (MCLs) for drinking water, as Basin Plan objectives. Specifically, the Basin Plan states:

> *"At a minimum, water designated for use as domestic or municipal supply (MUN) shall not contain concentrations of chemical constituents in excess of the maximum contaminant levels (MCLs) specified in the following provisions of Title 22 of the California Code of Regulations, which are incorporated by reference into this plan: Tables 64431-A (Inorganic Chemicals) and 64431-B. "*

Note that these drinking water MCLs are originally intended to apply to finished tap water, rather than to untreated sources of drinking water. For this reason, comparisons of surface water characteristics with MCL can provide a clear indication that the beneficial use (e.g. municipal water supply) is being achieved, but does not provide direct evidence that the use is impaired or potentially impaired. Although it is clear that waters that comply with MCLs are achieving the designated use as sources of drinking water, it is not the case that waters that exceed specific MCLs are not achieving this use.

Existing applicable water quality objectives and goals for the various parameters included within the five drinking water categories (TDS, TOC and DOC, pathogens, nutrients, and general minerals) are listed in Table 28. The results of comparisons with these numeric thresholds can be summarized as follows:

- Total dissolved solids concentrations in the Sacramento River watershed were not observed to exceed DHS and USEPA's Secondary Drinking Water Standard Maximum Contaminant Level (MCL) of 500 mg/L.
- Total organic carbon concentrations were compared to the 2.0 mg/L TOC treatment threshold included in the Stage 1 Disinfectants/Disinfection By-products (D/DBP) Rule. This regulation is designed to limit precursors to disinfection byproducts such as trihalomethanes, which are human carcinogens. In cases where the running annual average TOC in source water (measured at water treatment plant intakes) is 2.0–4.0 mg/L, water utilities may be required to remove up to 35% of the TOC (depending on source water alkalinity) unless they meet other specific quality or treatment technology requirements[3]. If the running average source water TOC is greater than

[3] Utilities would not have to meet these removal requirements if they meet one of several possible conditions, including: (1) average TOC in their treated water less than 2.0 mg/L; (2) average levels of haloacetic acids and trihalomethanes below 30 µg/L and 40 µg/L, respectively, or a clear commitment to implement treatment to meet these levels by June 2005; or (3) average Specific UV Absorbance (SUVA) less than 2.0 L/mg-m in source water or treated water.

4.0 mg/L, water utilities may be required to remove up to 45% of the TOC in their influent. Total organic carbon concentrations occasionally exceeded the D/DBP goal at all sites evaluated (Table 29). TOC levels measured in Sacramento Slough and the Colusa Basin Drain exceeded the 2 mg/L D/DBP treatment threshold in almost every sample analyzed, and exceeded the 4.0 mg/L threshold in more than 50% of samples collected. The percentage of TOC concentrations in the mainstem Sacramento River exceeding the D/DBP threshold value increased in a downstream direction from Keswick to Verona, followed by a small decrease in percent exceedance at Freeport, likely due to the diluting influence of the American River. The Yuba, Feather, and American rivers also occasionally have TOC concentrations above the relevant drinking water quality threshold value, with percent exceedances ranging from 10% (in the Yuba River at Marysville) to 40% (in the Feather River near Nicolaus). With the exception of the Yuba River, the Sacramento River above Bend Bridge, and tributaries above Shasta, long-term average TOC concentrations were greater than 2.0 mg/L at all locations monitored.

- Limits for total coliform, *Giardia*, and *Cryptosporidium* in surface waters have not yet been adopted by regulatory agencies. Fecal coliform levels were evaluated in comparison to the Basin Plan water quality objective of 200 Most Probable Number (MPN) per 100 milliliters (ml) as a median value and a maximum value of 400 MPN/100 ml. Median fecal coliform numbers were not observed to exceed the 200 MPN/100 ml objective at any site. Maximum fecal coliform numbers were observed to exceed the 400 MPN/100 ml objective infrequently in the Sacramento River (in 8 of 157 total samples from the mainstem) and in the American River (in 2 of 41 samples), and in Cache Slough (in 1 of 6 samples). Other pathogen numbers in the Sacramento River watershed are not directly comparable with drinking water quality objectives.

Total and fecal coliform data are also relevant to another important beneficial use, contact recreation. Although EPA has identified as a priority the transition to using *E. coli* and *Enterococcus* bacteria (instead of total and fecal coliform bacteria) as indicators of microbial contamination (Action Plan for Beaches and Recreational Waters; EPA/600/R-98/079, March 1999), in this same document, EPA reaffirmed commitment to the limits established in the 1986 criteria document (*Ambient Water Criteria for Bacteria—1986*), which include specific limits for total and fecal coliform bacteria. The 1986 criteria document is also referenced in EPA's *National Recommended Water Quality Criteria* (USEPA 1999). The California Department of Health Services (DHS) *Guidance for Freshwater Beaches* (Draft, February 11, 2000) recommends limits and testing for total and fecal coliform bacteria, as well as *E. coli* or Enterococcus. The non-regulatory DHS *Guidance* also cites the numbers of bacteria at which closing and posting beaches is recommended. These recommended limits are the same limits cited by EPA in the 1986 criteria document (*Ambient Water Criteria for Bacteria—1986*).

For the purpose of evaluating achievement and potential impairment of contact recreational uses, total and fecal coliform data were compared to the limits recommended by USEPA and DHS. The recommended limits for total coliform are 1,000 MPN/100 mL as a geometric mean and 10,000 MPN/100 mL as a single sample maximum. The limits for fecal coliform bacteria are essentially the same values adopted in the Central Valley Basin Plan (200 MPN/100 mL as a geometric mean and 400 MPN/100 mL as a single sample maximum). These limits for total coliform bacteria were exceeded in two samples collected from the American River at Discovery Park, and not at any other site evaluated by the SRWP. Comparisons to fecal coliform limits are provided in the previous paragraph.

- Of the six constituents comprising the nutrients group under consideration by the SRWP, only nitrite and nitrate currently have relevant water quality objectives. Neither of these parameters were observed at concentrations approaching relevant water quality objectives for any sites monitored. Median concentrations of both constituents were well below their DHS and USEPA maximum contaminant levels (Table 28). Although excessive nutrient concentrations in source waters can be a factor in increased algal growth (and consequently taste and odor problems and increased treatment costs for domestic water suppliers), the effect of nutrient concentrations is generally not easily separated from the effects of storage and transport (e.g. increased temperature and sunlight exposure), and no specific limits for nutrients have been developed to address these problems. Although there are currently no relevant objectives for ammonia, organic nitrogen, dissolved orthophosphate, or total phosphorus, U.S. EPA is in the process of developing Ecoregional nutrient criteria. As part of this process, EPA will attempt to establish critical nutrient levels based on conditions in minimally impacted waterbodies ("reference" conditions), or on empirical data for waterbodies in each ecoregion, if no appropriate reference conditions can be identified. The current generic guidelines provided in EPA guidance are 0.01 mg/L total phosphorus and 0.15 mg/L total nitrogen, but EPA expects that these values will be refined to be specific for each ecoregion or sub-ecoregion.. Recommended criteria for the Central Valley sub-ecoregion have not yet been published, but recommended criteria based on data for the ecoregion which contains the Central Valley (Ecoregion III, "the Xeric West") have been released (USEPA 2000). These recommended criteria (0.022 mg/L total phosphorus, and 0.377 mg/L total nitrogen) are not based on reference conditions, but instead are empirically derived as the lower 25th percentile concentrations for data available for th ecoregion.
- Mineral concentrations in water are subject to several drinking water quality standards adopted by the Central Valley Basin Plan (Table 28). Dissolved iron and manganese concentrations exceeded DHS and USEPA Secondary Drinking Water Standards in the two agricultural drains (Colusa Basin Drain and Sacramento Slough), and the urban runoff-dominated site (Arcade Creek) (Table 30). Dissolved iron concentrations in Arcade Creek exceeded the 300 µg/L limit in 1 of 38 samples. No exceedances of the iron MCL were observed for the mainstem Sacramento River or major tributaries. Dissolved manganese concentrations exceeded the Secondary MCL of 50 µg/L in both of the agricultural drains (in 6% and 7% of samples from Colusa Drain and Sacramento Slough, respectively), and in 17% of samples from Arcade Creek (Table 30). Dissolved manganese concentrations did not exceed the Secondary MCL in the mainstem Sacramento River or any major tributaries. No exceedances of Secondary Drinking Water Standards for chloride (250 mg/L) or sulfate (250 mg/L) were observed for any site.

- The Central Valley Basin Plan specifies that except during periods of storm runoff, turbidity shall not exceed 50 Nephelometric Turbidity Units (NTU) in the waters of the central Delta, or 150 NTU in other waters of the Delta. For waters not specifically named in the Basin Plan, the objectives for turbidity are expressed as a maximum allowable increase above natural turbidity levels attributable to controllable water quality factors (e.g. a maximum of 20% for waters naturally between 5 and 50 NTU. Comparing data for the Sacramento River watershed to the 50 NTU limit suggests that beneficial uses protected by this objective are generally achieved throughout the watershed. Median turbidity levels were well below 50 NTU at all sites evaluated by the SRWP, including all mainstem Sacramento River sites (from Shasta to River Mile 44), Cache Slough, Colusa Basin Drain, and Sacramento Slough. Turbidity exceeded 50 NTU in several samples collected from mainstem Sacramento River sites, but these exceedances occurred during wet weather-affected periods in January and February 2000. One of 6 samples collected in Cache Slough was observed to exceed the 50 NTU benchmark. Major and minor tributaries to the Sacramento River typically exhibit much lower turbidity than observed in the mainstem. In contrast, turbidity levels in Barker Slough in the North Delta occasionally exceed the applicable 150 NTU objective, with a median turbidity level of 47.2 NTU (MWQI data, 1996-98) and a mean of 37 NTU (1988-1999) reported by Woodard (2000). Turbidity was observed to exceed the150 NTU turbidity limit in only one sample collected from Sacramento River at Colusa on February 15, 2000. It was not possible to determine whether turbidity levels exceeded the maximum 20% above “natural” turbidity allowed by the Basin Plan.

Table 28. Water Quality Objectives Relevant to Drinking Water Parameters[a]

Parameter	Units	Threshold Value	Basis
TDS	mg/L	500	DHS and USEPA Secondary Drinking Water Standard MCL
TOC	mg/L	2	Disinfectants/Disinfection By-products Rule Treatment Threshold
Nitrite (as N)	mg/L	1	DHS and USEPA Primary Drinking Water Standard MCL
Nitrate (as N)	mg/L	10	DHS and USEPA Primary Drinking Water Standard MCL
Iron	µg/L	300	DHS and USEPA Secondary Drinking Water Standard MCL
Manganese	µg/L	50	DHS and USEPA Secondary Drinking Water Standard MCL
Chloride	mg/L	250	DHS and USEPA Secondary Drinking Water Standard MCL
Sulfate	mg/L	250	DHS and USEPA Secondary Drinking Water Standard MCL
Fecal coliforms	MPN/100 mL	200 (median) 400 (maximum)	CVRWQCB Basin Plan Objective, DHS Recommended Limits (CDHS 2000), and USEPA Recommended Criteria (USEPA 1999)
Total coliforms	MPN/100 mL	1,000 (median) 10,000 (maximum)	DHS Recommended Limits for freshwater beaches (CDHS 2000), and USEPA Recommended Criteria (USEPA 1999)
Turbidity[b]	NTU	50 (central Delta) 150 (other Delta waters) 20% increase for waters naturally between 5 and 50 NTU	CVRWQCB Basin Plan Objective
Arsenic[c]	µg/L	10	DHS and USEPA Primary Drinking Water Standard MCL

(a) Primary and Secondary Drinking Water Standard MCLs have been adopted by reference in the Central Valley Basin Plan.
(b) Turbidity objectives apply only during non-storm affected periods.
(c) Arsenic is discussed in the trace metals section of this report.

Table 29. Comparisons with Total Organic Carbon Water Quality Goals

Location	% of Data Meeting Water Quality Goal[(a)]
Sacramento River below Keswick	100
Sacramento River above Bend Bridge	72
Sacramento River at Hamilton City	61
Sacramento River at Colusa	72
Sacramento Slough	4
Colusa Basin Drain	0
Yuba River at Marysville	89
Feather River near Nicolaus	61
Sacramento River at Verona	43
American River at J Street	72
Sacramento River at Freeport	50
Sacramento River at Mile 44	11[(b)]

(a) Disinfectants/Disinfection Byproduct Rule treatment threshold for DBP precursor removal. If average source water TOC is >2 mg/L and ≤4 mg/L, water utilities may be required to remove up to 35% of the TOC in their influent. If average source water TOC is >4 mg/L and ≤8 mg/L, water utilities may be required to remove up to 45% of the TOC in their influent. TOC removal depends on influent alkalinity and treatment technologies used, and is not required when the running annual average TOC in source water or treated water is less than 2.0 mg/L, or if other specific D/DBP conditions are met.
(b) Based on only 9 results for River Mile 44 in 1999-2000.

Table 30. Comparisons with Iron and Manganese Secondary MCLs

Location	% of Data Meeting MCL[(a)] for Fe	% of Data Meeting MCL[(b)] for Mn
Sacramento River at Bend Bridge	100	100
Mill Creek[(d)]	40	92
Deer Creek[(d)]	91	100
Big Chico Creek[(d)]	94	100
Sacramento River at Colusa	100	100
Sacramento Slough	100	93
Colusa Basin Drain	100	93
Yuba River at Marysville	100	100
Feather River at Nicolaus	100	100
Arcade Creek at Norwood Avenue	98	82
American River at J St	100	100
Sacramento River at Freeport	100	100
Cache Creek	100	100
Yolo Bypass[(c)]	100	100
Cache Slough near Ryers Island Ferry[(d)]	0	66

(a) DHS and USEPA 2° Drinking Water Standard Maximum Contaminant Level: Fe < 300 µg/L.
(b) DHS and USEPA 2° Drinking Water Standard Maximum Contaminant Level: Mn < 50 µg/L.
(c) Only six sample events were monitored at this location.
(d) Measured only as total Mn

Although water from the Sacramento River from Hood and upstream is considered to be of high quality for drinking water supply, the quality of water in the Central and Southern Sacramento-San Joaquin Delta is often marginal for drinking water supply and compliance with increasingly stringent drinking water objectives is becoming more difficult. The Sacramento River alone provides up to 75% of the water entering the Delta, including a large portion of seasonal organic carbon and TDS mass loads. Although the Sacramento River therefore has a substantial effect on Delta drinking water supply quality, there are also significant internal sources of TOC and TDS within the Delta. As stated previously, the parameters of primary concern for drinking water quality—TOC, TDS, and pathogens—are currently largely unregulated by the RWQCB and the Water Quality Control Plan (Basin Plan). Expected changes in Sacramento River watershed land uses (e.g. increased urbanization and development) have the potential to increase regulated point source discharges and (relatively) unregulated non-point source discharges, and therefore to increase loads of TOC, TDS, and pathogens to the Delta. In order to address these and other drinking water concerns, the RWQCB is implementing a work plan for the development of an effective drinking water policy. This policy is expected to address these parameters and to establish water quality objectives for eventual inclusion in the Basin Plan.

b. Beneficial Use Attainment and Comparison with 303(d) Designated Waterbodies

The California 1998 303(d) list does not consider all of the contaminants of concern to drinking water supply, and few waterbodies tributary to the Sacramento River are cited on the 303(d) list for pollutants relevant to drinking water concerns. The Pit River above Shasta is listed for nutrients and other organic enrichments at levels that may cause impairment of beneficial uses. Delta waterways and Clear Lake are listed for excessive levels of electrical conductivity. It is clear however, that in general, the Sacramento River and major tributaries provide water that is of very high quality for municipal and agricultural supply. The above comparisons of drinking water parameters with relevant water quality goals and objectives for the Sacramento River watershed show that the mainstem Sacramento River, and major tributaries (the Yuba, Feather, and American rivers) consistently meet water quality goals and objectives, suggesting achievement of the designated beneficial uses of sources of municipal and agricultural supply water, and of the designated contact recreation beneficial use (as per the Central Valley Region Basin Plan – CVRWQCB 1995). Although the TOC concentrations measured in the Sacramento River at Verona and Freeport often exceed the 2.0 mg/l goal, it is not clear that these levels of organic carbon will result in a requirement for additional treatment for municipal drinking water suppliers to remove additional TOC in source water. The Stage 1 D/DBP Rule does not require such treatment if certain treatment technology requirements used, or if other water quality requirements are met (e.g. for specific ultraviolet absorbance in source or treated water, TOC <2.0 mg/L in treated water, or trihalomethanes and haloacetic acids less than specified levels in treated water). Additionally, treatment technologies currently in use by many utilities are already able to remove ≥35% of TOC from Sacramento River water. Even if additional TOC removal is necessary, this requirement would not limit the water supply use. Additionally, comparisons of coliform bacteria data to limits recommended by USEPA and California Department of Health Services indicate that these limits are infrequently exceeded and suggest that recreational uses protected by these limits are generally well-supported in the mainstem Sacramento River and its major tributaries.

iv. Mass Loads Comparisons

Comparisons of mass load contributions from major Delta inputs could not be adequately evaluated, due to a lack of appropriate concentration data for parameters of greatest concern with regard to mass loads of pollutants (TDS and organic carbon). Estimation of mass loads requires both concentration and flow data. Although data from some programs are adequate for estimating mass loads for some constituents (e.g. NAWQA data for selected Sacramento River basin locations, and Sacramento CMP data for the Sacramento River near Sacramento), there are insufficient synoptic flow and concentration data for other potentially significant TDS and TOC sources to the Delta, including Cache Creek, Yolo Bypass, the San Joaquin River, the Cosumnes River, the Mokelumne River. In addition, there are significant internal sources of organic carbon and TDS loads within the Delta that make comparative evaluations among sources difficult. This lack of appropriate data for estimating mass loads may be considered a significant data gap for drinking water parameters of concern in the Delta.

v. Conclusions and Recommendations

The mainstem Sacramento River, and major tributaries (the Yuba, Feather, and American rivers) consistently meet water quality goals and objectives, suggesting achievement of the designated beneficial uses as sources of municipal and agricultural supply water:

- There was a general trend for concentrations of several parameters (TDS, organic carbon, nutrients) to increase in the mainstem Sacramento River from the upper watershed to the lower watershed. This trend can generally be attributed to a combination of natural and anthropogenic sources, and is moderated by high quality Sierra tributary inflows.
- Primary MCLs for nitrate and nitrite, and secondary MCLs for TDS were not exceeded at any site. Dissolved concentrations iron and manganese occasionally exceeded secondary MCLs in Arcade Creek, and the two agricultural drains (Sacramento Slough and Colusa Basin Drain). No exceedances of Secondary Drinking Water MCLs for chloride (250 mg/L) or sulfate (500 mg/L) were observed for any site.
- The Basin Plan limit for median fecal coliform numbers (200 MPN/100mL) was not exceeded at any site, and the maximum limit for single samples (400 MPN/100 mL) was exceeded only infrequently in the Sacramento River (8 of 157 samples), the American River (2 of 41 samples), and Cache Slough (1 of 6 samples).
- TOC concentrations measured in the Sacramento River at Colusa, Verona, and Freeport often exceed the Stage 1 Disinfectant/Disinfection By-Product (D/DBP) Rule treatment threshold of 2.0 mg/l. The 2.0 mg/L threshold is significant because exceedance of this threshold may require utilities to remove up to 35% percent of

TOC in their source water. It is not clear that the observed levels of organic carbon will result in a requirement for municipal drinking water suppliers to remove *additional* TOC in source water. The Stage 1 D/DBP Rule does not require such treatment if certain treatment technology requirements used, or if other water quality requirements are met in influent or treated water. Additionally, treatment technologies currently in use by many utilities are already able to remove ≥35% of source water TOC from Sacramento River water. Even if additional TOC removal is necessary, this requirement would not limit the water supply use.

- *Giardia* cysts were detected in 42% to 82% of samples collected from the mainstem Sacramento River and major tributaries, and in one of six Cache Slough samples. *Cryptosporidium* öocysts were detected in 6 of 51 samples from the mainstem Sacramento River. Although the analytical method used for *Giardia* and *Cryptosporidium* is much improved (compared to the ICR method used previously), there remains a high degree of uncertainty associated with data for these pathogens. This monitoring has been suspended by the SRWP Monitoring Sub-committee until these analytical issues are resolved.

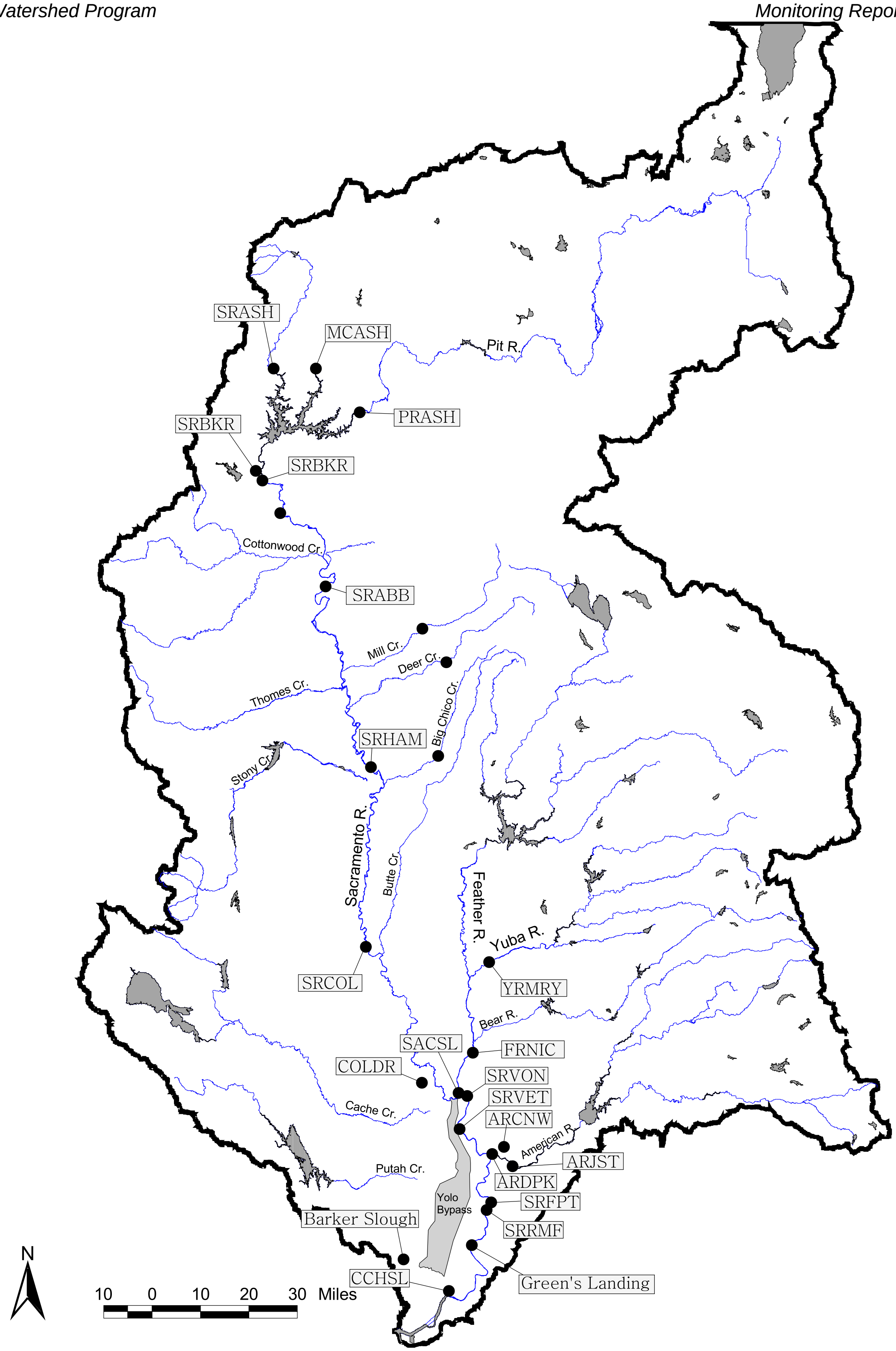


Figure 18. Drinking Water Constituent Monitoring in the Sacramento River Watershed, USGS NAWQA, Sacramento River CMP, City of Redding, DWR MWQI, and SRWP

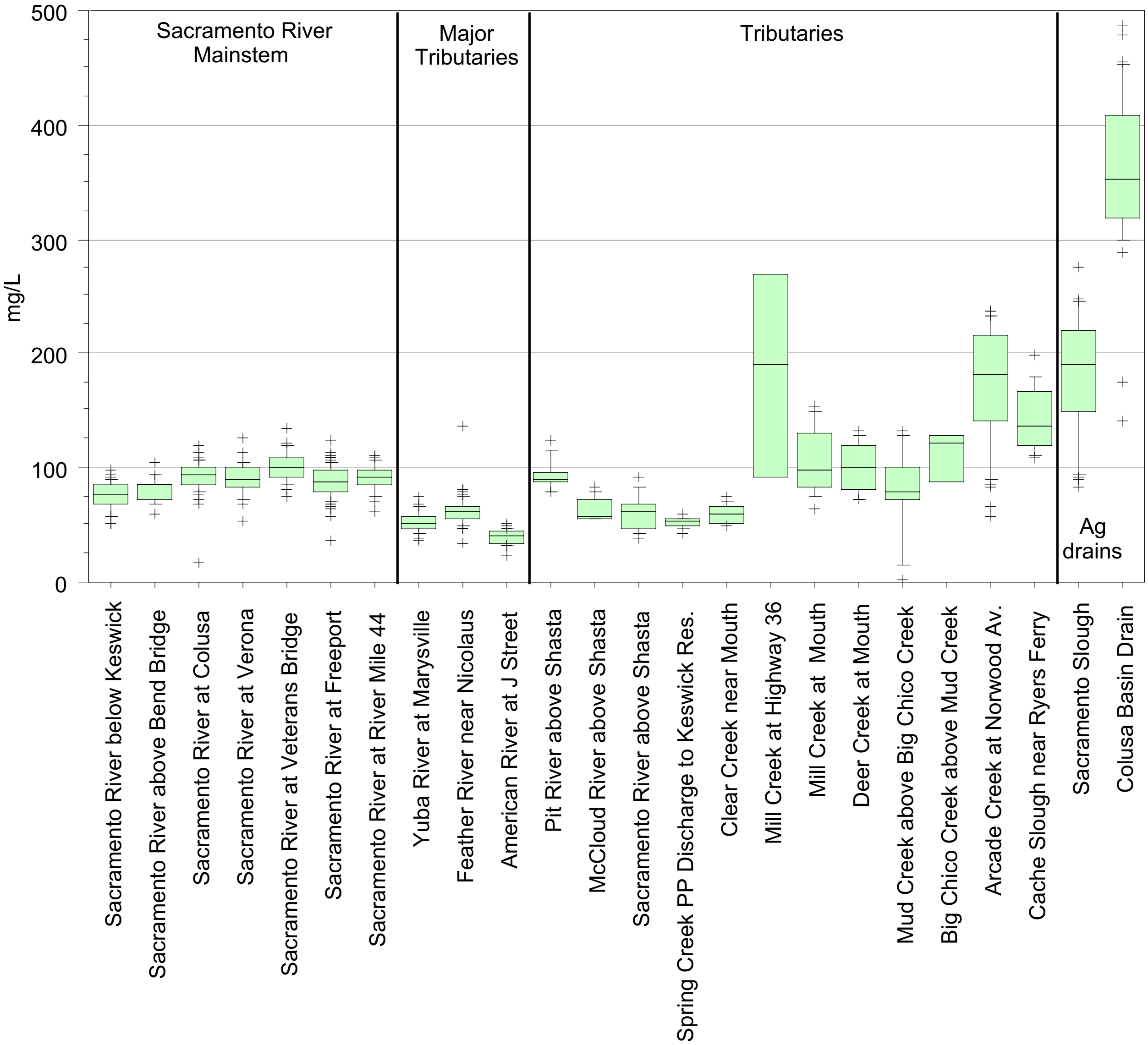


Figure 19. Total Dissolved Solids in the Sacramento River Watershed, 1996-2000

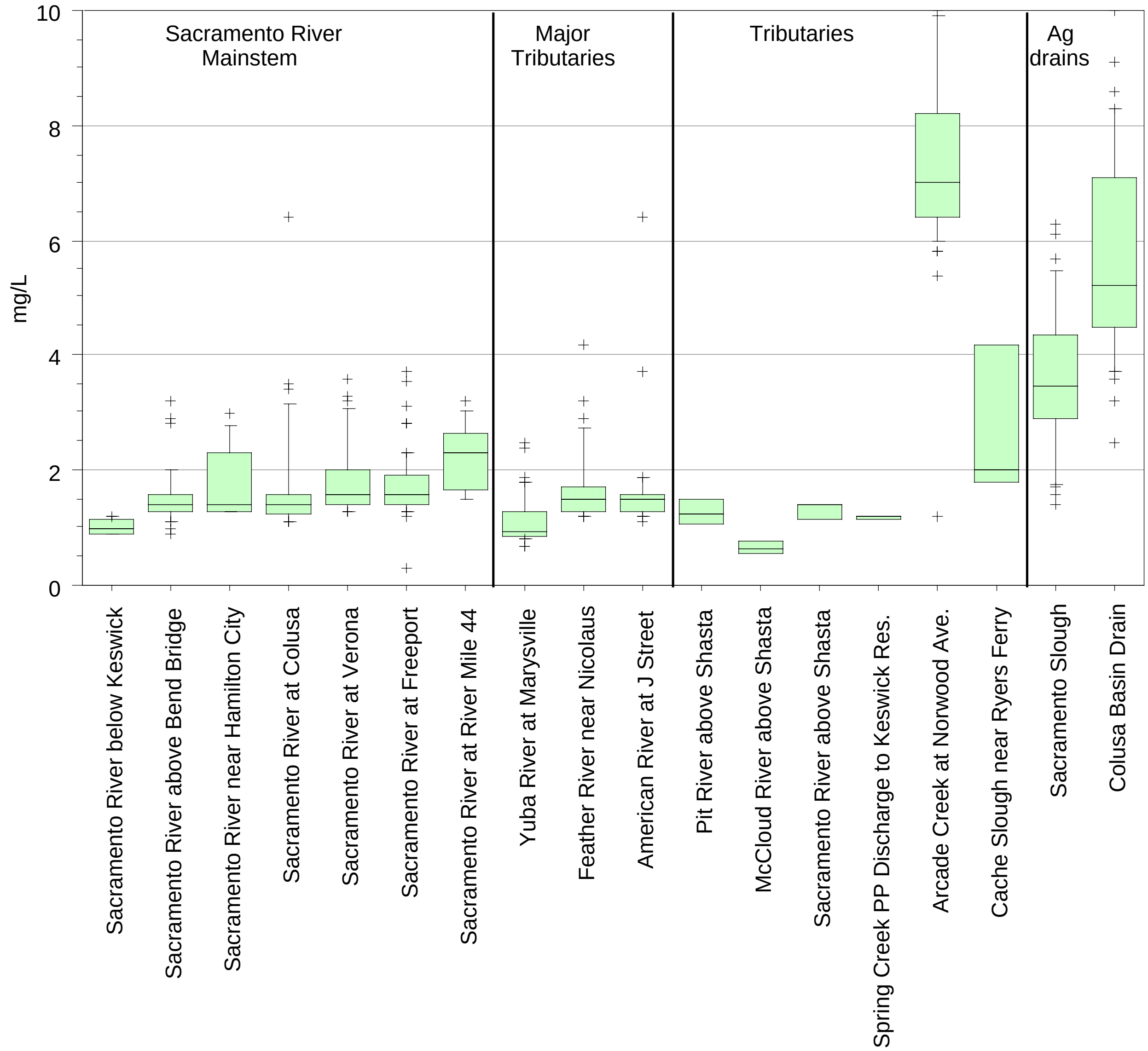


Figure 20a. Dissolved Organic Carbon in the Sacramento River Watershed, 1996-2000

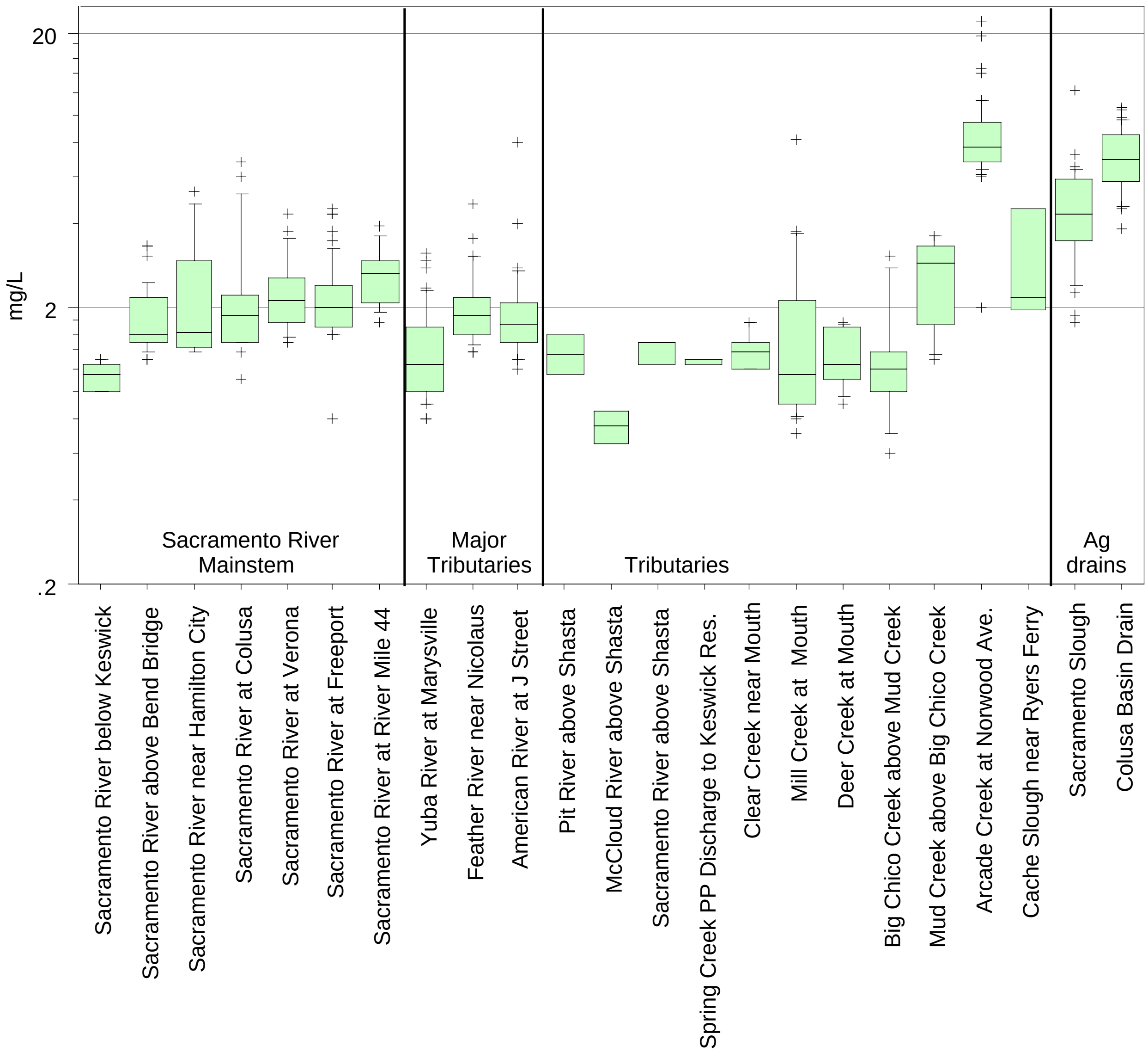


Figure 20b. Total Organic Carbon in the Sacramento River Watershed, 1996-2000

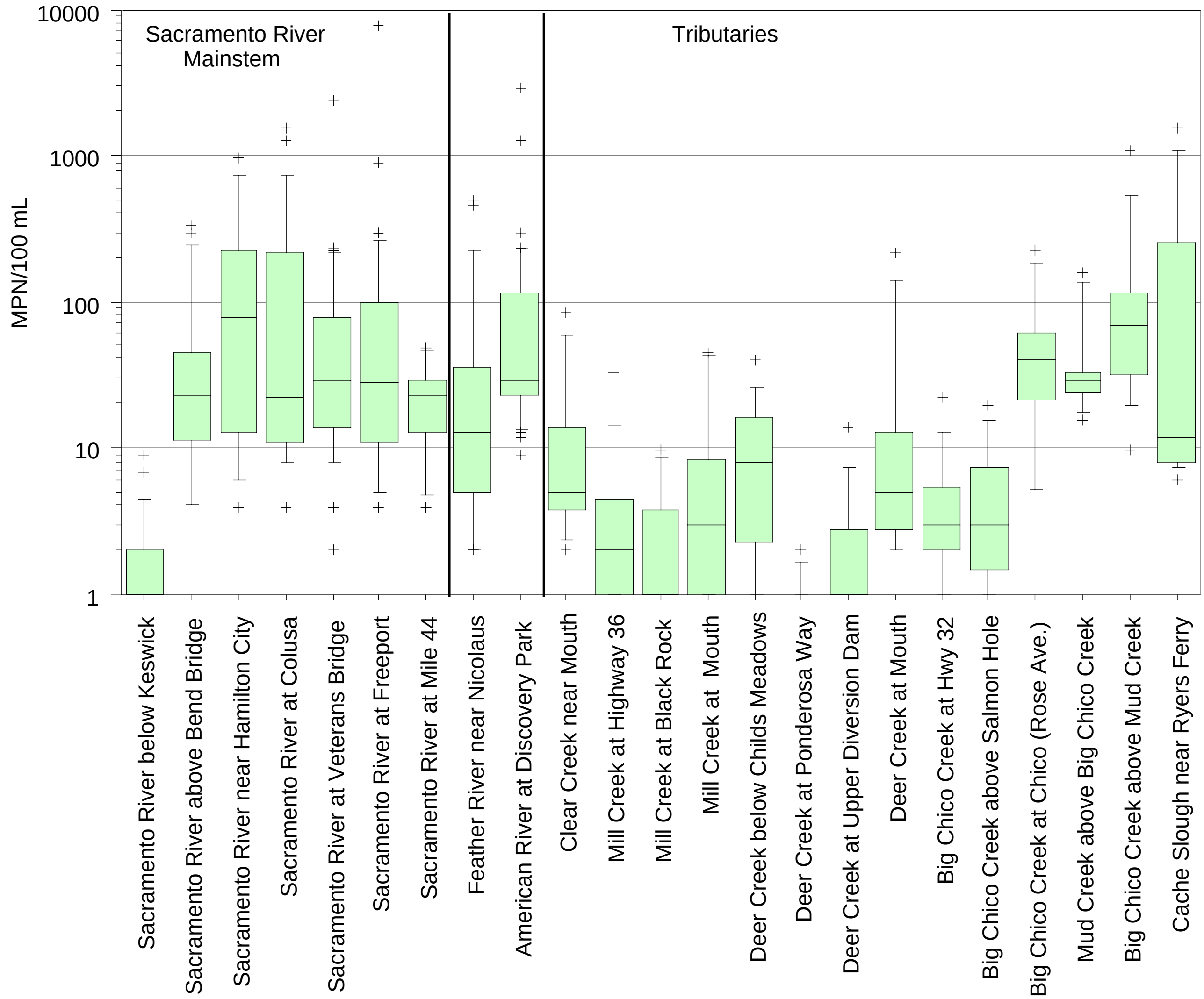


Figure 21. Fecal Coliform Bacteria in the Sacramento River Watershed, 1996-2000

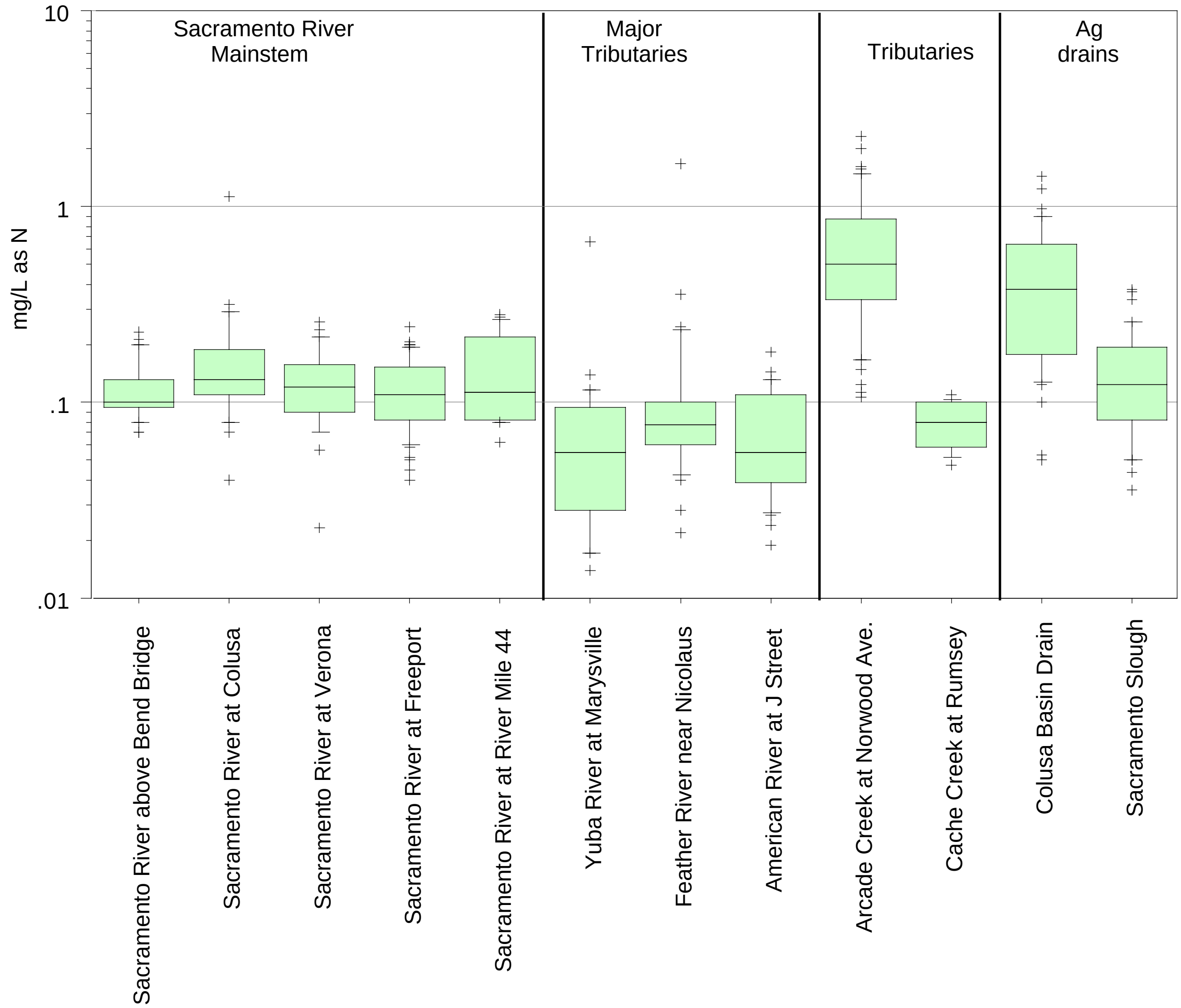


Figure 22. Nitrate in the Sacramento River Watershed, 1996-2000

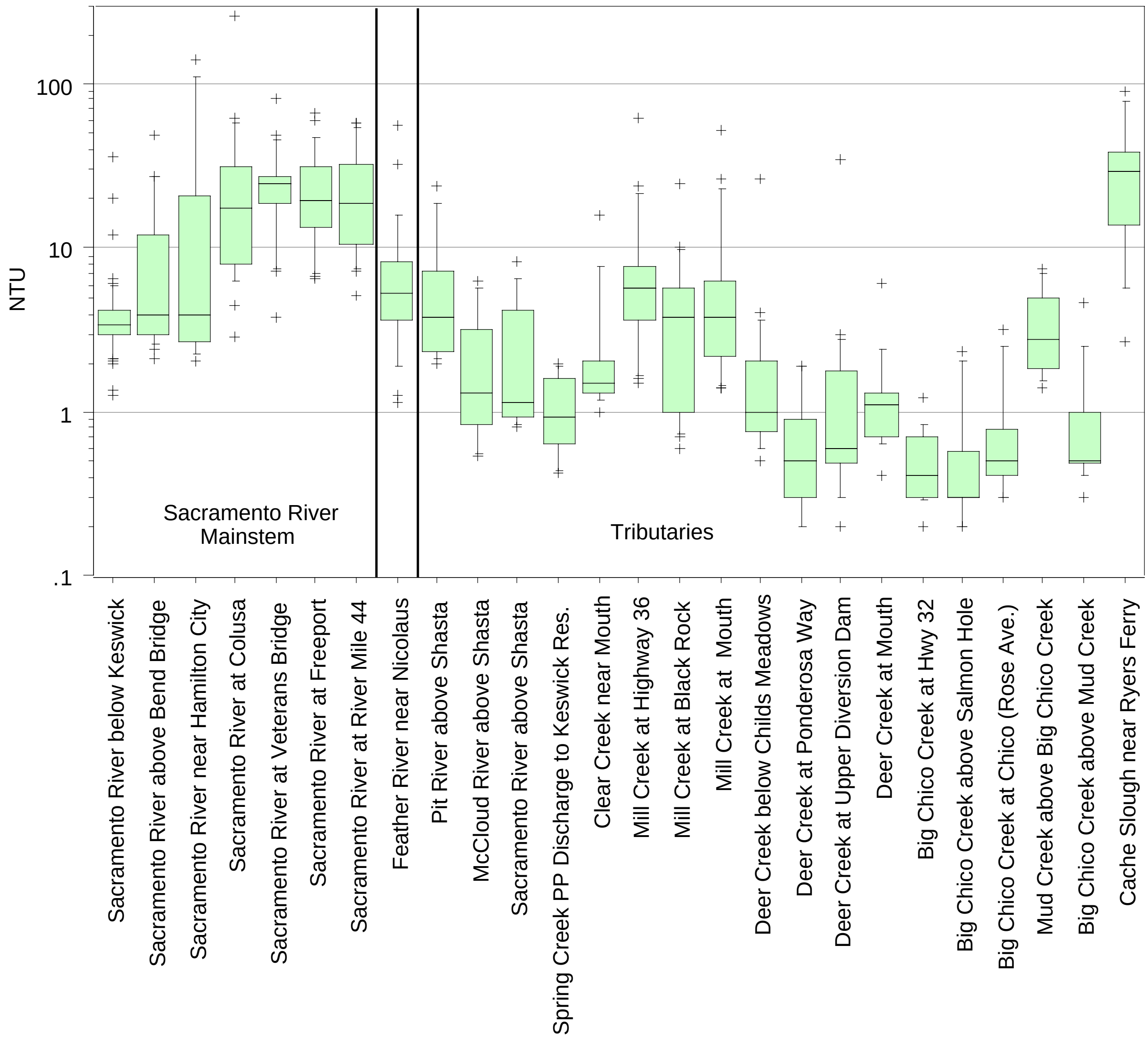


Figure 23. Turbidity in the Sacramento River Watershed: Turbidity Values (NTU) in Water, 1998-2000

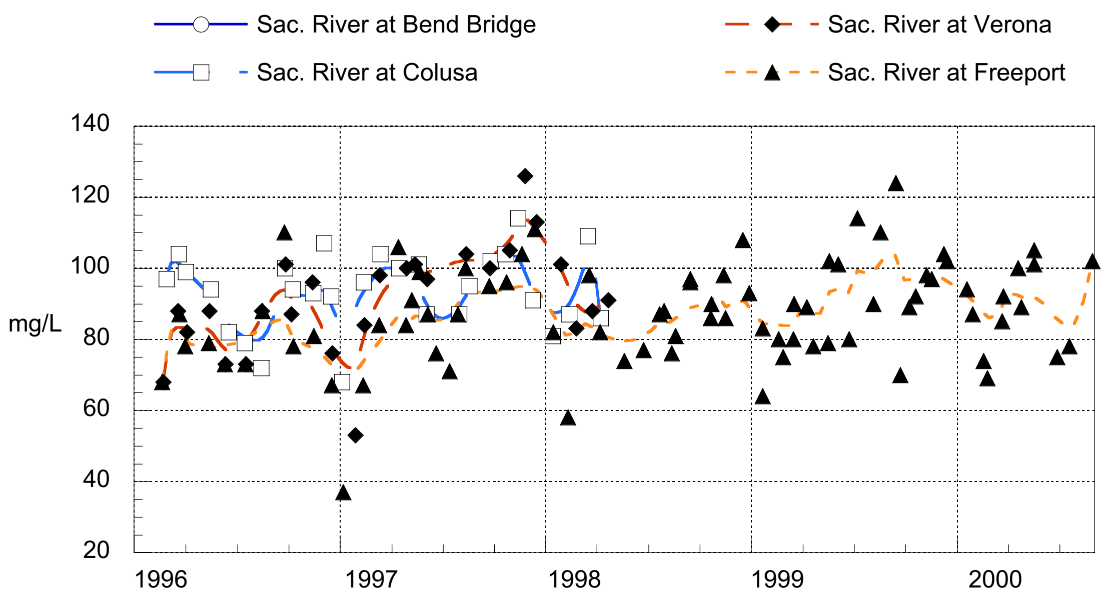


Figure 24a. **Total Dissolved Solids in the Sacramento River, USGS NAWQA Data, 1996-2000**

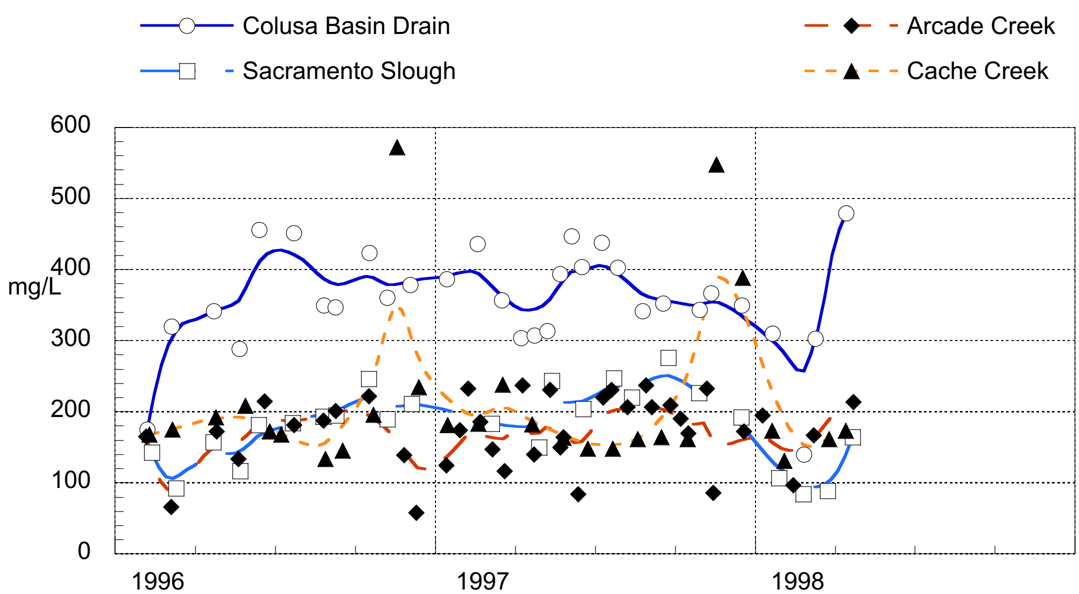


Figure 24b. **Total Dissolved Solids in Agricultural Drains and Urban Runoff, USGS NAWQA Data, 1996-1998**

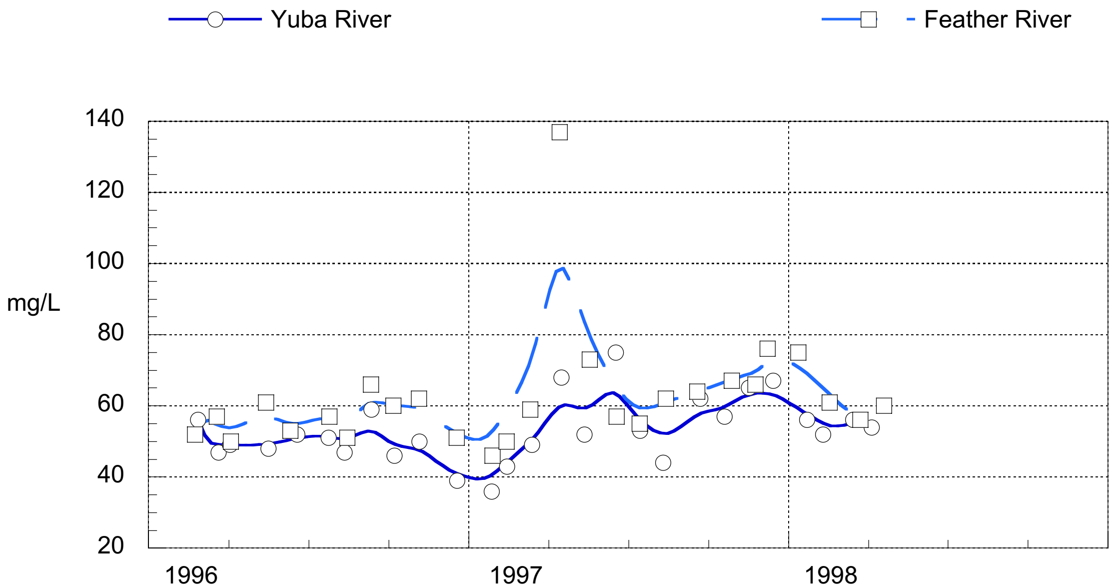


Figure 25a. Total Dissolved Solids in the Yuba and Feather rivers, USGS NAWQA Data, 1996-1998

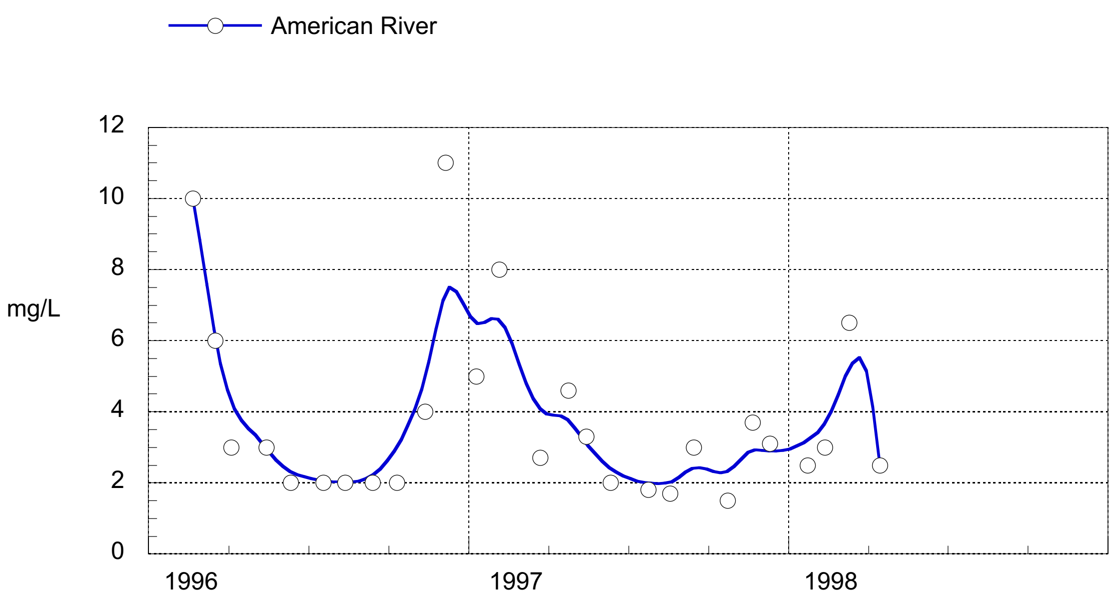


Figure 25b. Total Dissolved Solids in the American River, USGS NAWQA Data, 1996-1998

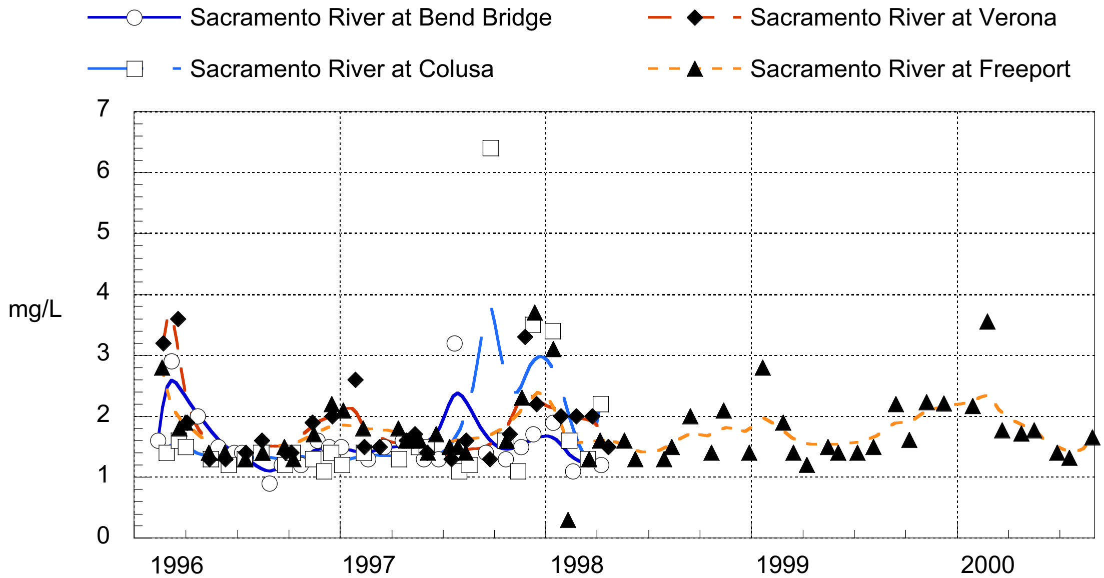


Figure 26a. **Dissolved Organic Carbon in the Sacramento River, USGS NAWQA Data, 1996-2000**

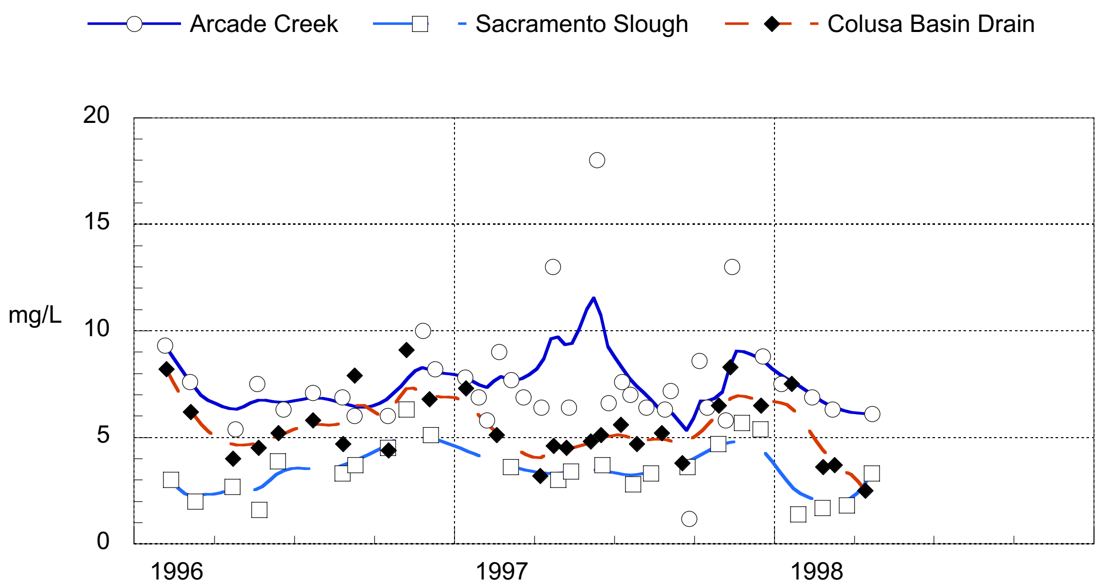


Figure 26b. **Dissolved Organic Carbon in Agricultural Drains and Urban Runoff, USGS NAWQA Data, 1996-1998**

F. Organochlorine Pesticides and PCBs in Fish Tissue

i. Background and Available Data Overview

In September and October of 1997-1999, the SRWP monitoring program collected fish from 14 locations and analyzed tissue for concentrations of organochlorine pesticides (DDTs, chlordanes, aldrin, dieldrin, endrin, hexachlorocyclohexanes, hexachlorobenzene, endosulfans, methoxychlor, mirex, and oxadiazinon) and PCB compounds. Monitoring in the Sacramento River watershed for these compounds in fish tissue has been performed previously by the Toxic Substances Monitoring Program (administered by the State Water Resources Control Board) between 1977 and 1996. Studies of these pollutants in fish tissue were also performed in San Francisco Bay in 1994 and 1997 (Table 31).

The locations of sites monitored in 1997–1999 by the SRWP are illustrated in Figure 27.

Table 31. Fish Contamination Monitoring programs in the Sacramento River Watershed

Program	Monitoring Period	Parameters	# of locations & geographic reference
SRWP	Sep-Oct '97, Sep-Oct '98, Sep-Oct '99	▪ Organochlorine pesticides and PCBs in edible fish tissue	14 fish tissue sites, distributed throughout the watershed
TSMP (SWRCB)	1977–1996	▪ metals, organics, and pesticides in fish	Many sites distributed throughout the watershed
SFBRWQCB	1994	▪ mercury and organochlorines in fish	San Francisco Bay
SF Estuary RMP (SFEI)	1997	▪ mercury and organochlorines in fish	San Francisco Bay

ii. Spatial Distribution & Patterns

The concentrations of organochlorines accumulated in fish tissue are dependent on a number of factors in addition to exposure to these compounds, including species and trophic level, age, size, and tissue lipid concentrations. The species and size of fish analyzed for this study varied by location, and it is difficult to describe purely spatial variation independent of these factors. The results of SRWP 1997 monitoring for organochlorines in fish tissue are summarized in Table 32 and Figures 30a and 30b, and are discussed below.

PCBs: PCBs were detected in 56% of all samples analyzed, and were most frequently detected in samples from the Sacramento River at River Mile 44 and from the American

River at Discovery Park. Aroclor concentrations tended to be lower in fish from upper watershed sites, and were not detected in samples from the Sacramento River above Bend Bridge and Colusa, and Sacramento Slough. Aroclor concentrations tended to be highest in white catfish, lowest in the two carp samples, and similar in the other four species captured (rainbow trout, largemouth bass, Sacramento pikeminnow, and Sacramento sucker). The highest single tissue concentration of PCBs reported was in a white catfish sample from the American River at Discovery Park.

Chlordanes: Chlordanes were detected in 50% of all samples analyzed, and were most frequently detected in samples from the lower Sacramento River (Veterans Bridge and River Mile 44). Concentrations tended to be lower in fish from upper watershed sites, and were not detected in samples from the Sacramento River at Colusa and above Bend Bridge, or from Colusa Basin Drain. The highest chlordane concentrations were reported in white catfish and Sacramento pikeminnow. Chlordane concentrations were lower and similar in the other four species. The highest single concentration reported was in a Sacramento pikeminnow sample from the American River at Discovery Park.

DDTs: DDTs were detected in all samples analyzed. The highest DDT concentrations were reported in common carp and white catfish. The highest tissue concentration reported was in a single carp sample collected from the Colusa Basin Drain. Concentrations tended to be lower in fish from upper watershed sites. The next highest single concentration was in a white catfish sample from the Sacramento River at Mile 44. The lowest mean concentrations were observed in the Sacramento River at Bend Bridge and Hamilton City, and in the American river at J Street..

Dieldrin: Dieldrin were detected in only 27% of samples analyzed. It was not detected in samples from Natomas East Main Drain, Putah Creek, or the American River at J Street, and was detected in only one of nine samples from the Sacramento River from Keswick to Colusa. The highest dieldrin concentration was reported in a single carp sample from Colusa Basin Drain. Concentrations were much lower and in the other five species, and were lowest in trout and Sacramento sucker.

iii. Temporal Distribution & Patterns

There are currently insufficient data available to assess seasonal or long-term temporal trends in the concentrations of organic chemicals in fish tissue.

iv. Attainment of Beneficial Uses and Potential Impairment

Concentrations of organochlorine compounds in fish tissue were compared primarily to USEPA national screening values (SFRWQCB *et al*. 1995, USEPA 1995, USEPA 1998) adjusted for a fish consumption rate of 30 g/day and an updated PCB cancer slope factor (SFEI 1999), and to California Office of Environmental Health Hazard Assessment screening values (OEHHA 1999; SFEI 1998). Concentrations were also compared to FDA Action Levels, which apply to commercially-caught and distributed fish, and are not intended to locally-caught and consumed sport fish. Exceedance of screening values is considered an indication that more intensive site-specific monitoring or evaluation of human health risks should be conducted (SFEI 1998, 1999). Note that these risk-based human health limits are based on assumptions of specific fish consumption rates that are typically averages for the general population. For individuals or populations (e.g. sport fisherman or some ethnic populations) consuming more fish than assumed for a specific limit or screening value, the risk of adverse health effects is increased.

Concentrations of PCBs exceeded the SFRWQCB screening value (23 ng/g wet weight) in 15% of all samples, including samples from four of the fourteen sites, and in three of the six species analyzed. The screening value for chlordanes (18 ng/g wet weight) was not exceeded in any sample. The screening value for DDTs (69 ng/g wet weight) was exceeded in 10% of all samples, including samples from three of fourteen sites, and in three of the six species analyzed. Dieldrin exceeded the screening value (1.5 ng/g) in 16% of all samples, including samples collected from five of fourteen sites and in four of the six species analyzed. Samples collected from the Sacramento River from Keswick to Colusa exceeded screening values in only one sample (PCBs in one Rainbow trout sample from the Sacramento River below Keswick). In general, exceedances of screening values were more frequent in the lower watershed. Concentrations of all organochlorines in SRWP-collected fish were well below FDA Action Levels for these compounds (Table 32).

There are several waterbodies included on the 1998 California 303(d) list for organochlorine compounds (Table 33). Levels of organochlorines in SRWP samples from the Feather River and American River suggest levels of these chemicals may not be sufficiently high in fish tissue to warrant 303(d) listing at these sites, but additional data are required to fully evaluate potential human health risks. Results from the monitoring conducted in 2000 and planned for 2001 will provide additional data. This monitoring has been designed in concert with OEHHA to provide the more complete data needed to evaluate attainment of beneficial uses and the need for fish consumption advisories in the lower Sacramento River watershed.

vi. Conclusions and Recommendations

- Data collected by the SRWP indicates the need for continued monitoring to assess the potential for human health risks related to consumption of fish, particularly in the lower Sacramento River watershed. Concentrations of PCBs, DDTs, and dieldrin exceeded screening values in fish collected from eight locations, primarily in the lower watershed, indicating some potential human health risks to consumers of fish caught in this region.
- Monitoring of organochlorine compounds in fish tissue has been continued for 2000-2001 monitoring.

Table 32. Organochlorines in Fish Tissue: Regulatory Limits, Screening Values, and Summary of SRWP Data (1997-1999)

	PCBs (as Aroclors)	Sum of Chlordanes	Sum Of DDTs	Dieldrin
Updated USEPA Screening Values[a] (SFRWQCB *et al.* 1995)	23 ng/g	18 ng/g	69 ng/g	1.5 ng/g
OEHHA Screening Values[b] (OEHHA 1999, SFEI 1998)	20 ng/g	30 ng/g	100 ng/g	2 ng/g
FDA Action Levels[c]	2000 ng/g	300 ng/g	5000 ng/g	300 ng/g
Total number of samples analyzed (1997 – 1999)	48	48	48	48
Number of samples exceeding EPA screening value	7	0	5	8
Percent of samples exceeding EPA screening value	15%	0%	10%	16%
Species exceeding screening values	Carp, trout, white catfish	None	carp, largemouth bass, Sacramento sucker, white catfish	carp, largemouth bass, pikeminnow, white catfish
Sites[(d)] exceeding screening values	SRBKR NEMDR ARDPK SRRMF	None	COLDR PUTAH SRRMF	COLDR SACSL ARDPK SRRMF CCHSL
Sites exceeding no screening values	SRABB, SRHAM, SRCOL, SRVET, FRNIC, ARJST			

(a) Screening value is based on a consumption rate of 30 g/day.
(b) Screening value is based on a consumption rate of 21 g/day.
(c) FDA Action Level is based on a consumption rate of 6.5 g/day.
(d) Sites in downstream order: SRBKR–Sac. River below Keswick; SRABB–Sac. River at Bend Bridge; SRHAM–Sac. River at Hamilton City; SRCOL–Sac. River at Colusa; SRVET–Sac. River at Vets Bridge; COLDR–Colusa Basin Drain; SACSL–Sacramento Slough; Feather River near Nicolaus; ARJST–Amercian River at J Street; NEMDR–Natomas East Main Drain; ARDPK–American River at Discovery Park; PUTAH–Putah Creek; SRRMF–Sac. River at Mile 44; CCHSL–Cache Slough near Ryers Ferry.

Table 33. Waterbodies Cited On California's 1998 303(D) List For PCBs And Organochlorine Pesticides.

Water Body	Cause for 303(d) Listing	Source of Pollution	Size Affected	Unit
Delta Waterways	DDT	Agriculture	480000	Acres
Delta Waterways	Group A Pesticides[(a)]	Agriculture	480000	Acres
American River, Lower	Group A Pesticides	Urban Runoff	23	Miles
Colusa Basin Drain	Group A Pesticides	Agriculture	70	Miles
Feather River, Lower	Group A Pesticides	Agriculture	60	Miles
Natomas East Main Drain	PCBs	Industrial Point Source	12	Miles
Natomas East Main Drain	PCBs	Urban Runoff	12	Miles

(a) Group A pesticides: aldrin, dieldrin, chlordane, endrin, heptachlor, heptachlor epoxide, hexachlorocyclohexanes (including lindane), endosulfan, and toxaphene

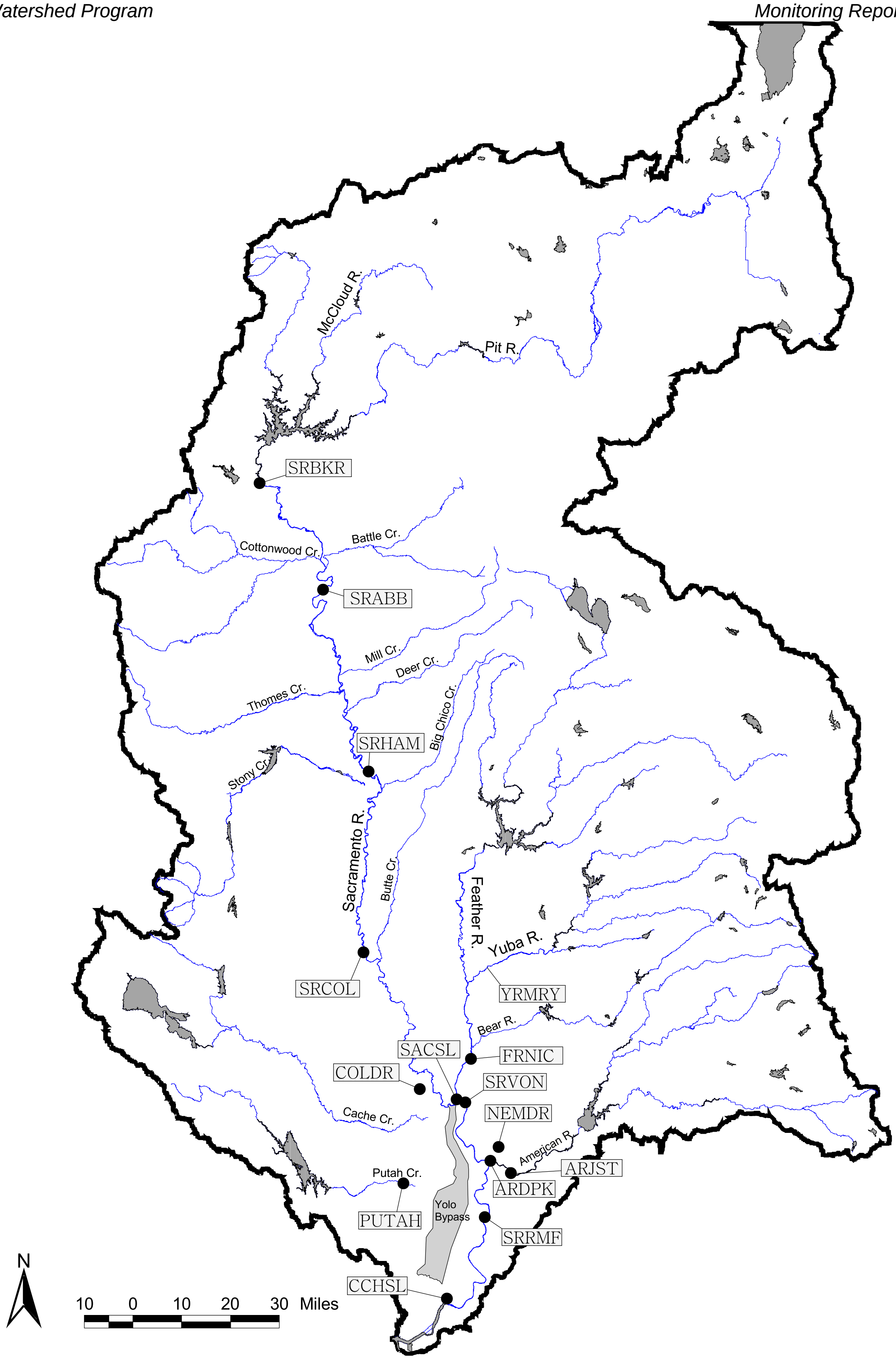


Figure 27. SRWP Monitoring for Organochlorines in Fish Tissue: 1997 - 1999 Monitoring Locations

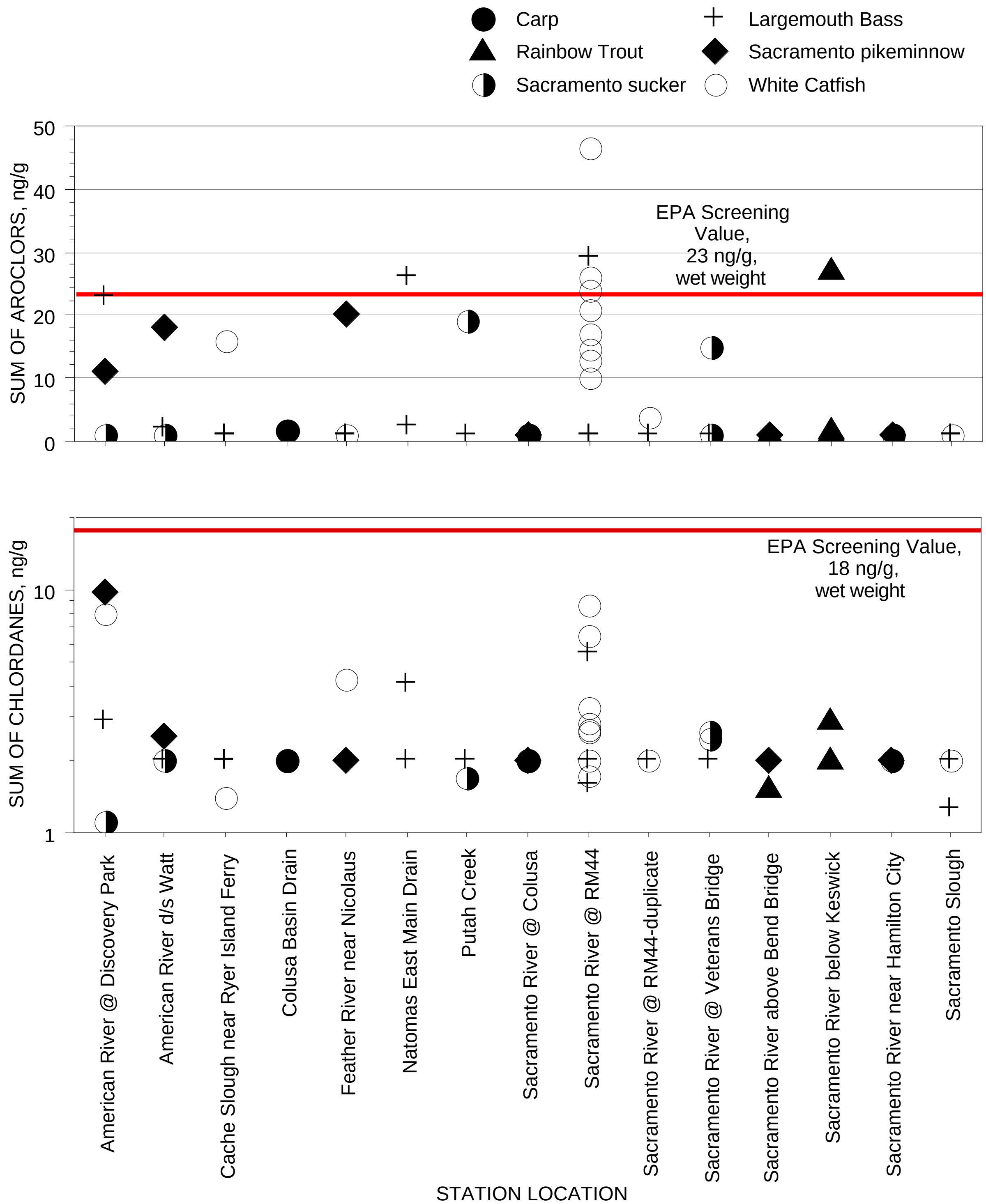


Figure 28a. PCBs and Chlordanes in Fish Tissue: SRWP 1997 - 1999 Data

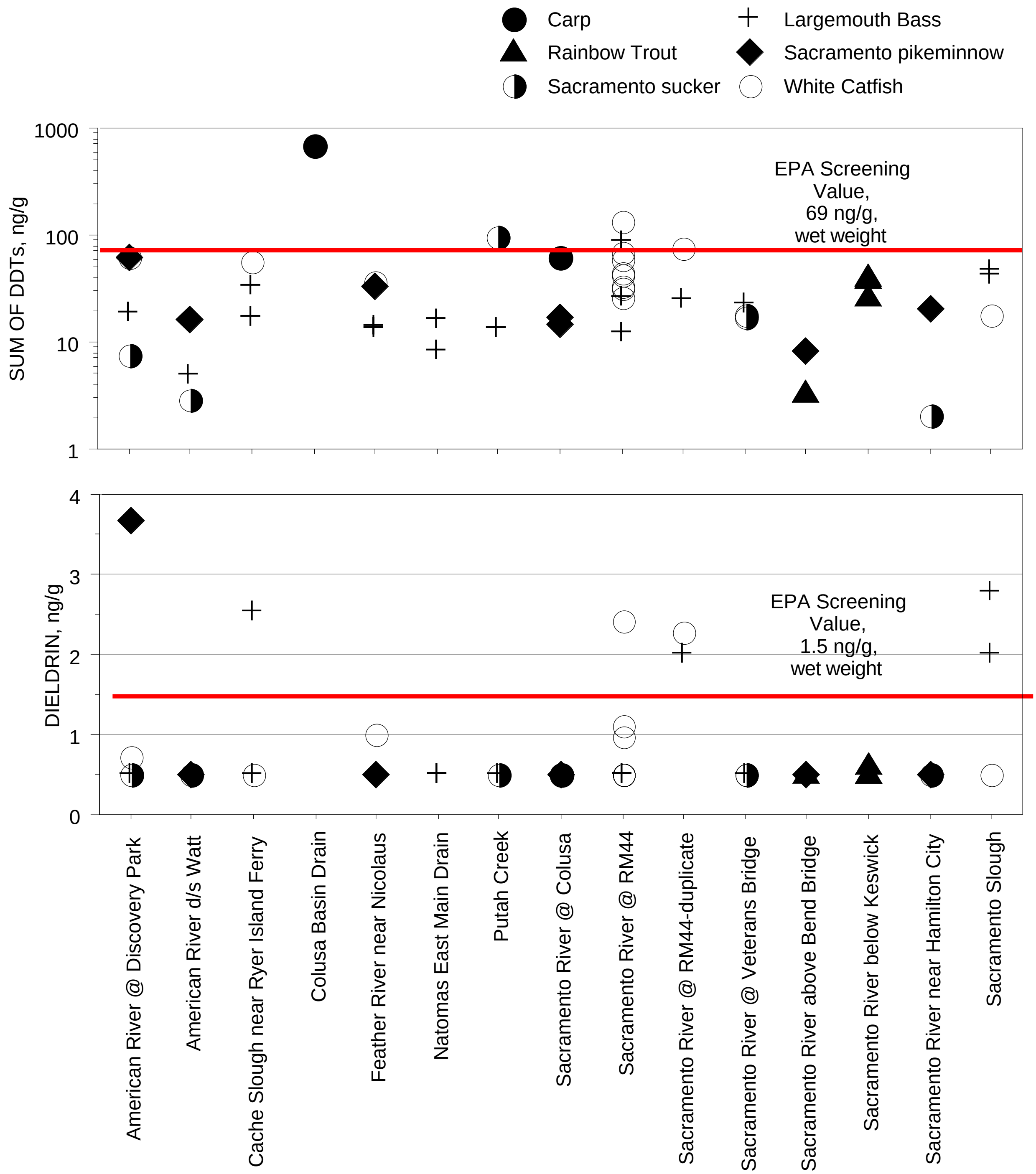


Figure 28b. DDTs and Dieldrin in Fish Tissue: SRWP 1997 - 1999 Data

G. Sediment Toxicity

i. Background and Available Data Overview

Sediment toxicity monitoring was implemented by the SRWP as a pilot project to evaluate sediment toxicity testing as a monitoring tool. This monitoring was performed in September of 1998, April and November of 1999, and May of 2000, at 9 SRWP sites selected to match USGS NAWQA sediment monitoring sites in the Sacramento River watershed (Figure 29). Sediment toxicity monitoring was also performed at an additional 10 sites as part of DWR's intensive tributary monitoring program. Toxicity testing was performed in elutriates[4] of sediment samples with *Ceriodaphnia* (daphnid or water flea) and in bulk sediment samples with *Hyalella* (an amphipod). Sediment collection methods were consistent with USGS methods for collecting surface sediment samples from depositional areas.

There were no other sediment toxicity monitoring efforts in the Sacramento River watershed.

ii. Spatial Distribution

No significant mortality to *Hyallela* or *Ceriodaphnia*, or reduction in *Ceriodaphnia* reproduction was observed for any of the sediment elutriate toxicity tests conducted in 1999-2000. The only pattern identifiable in the available data is a general lack of detectable significant sediment toxicity using these methods.

iii. Temporal Distribution

There are insufficient monitoring data to evaluate seasonal or long-term temporal trends in sediment toxicity.

iv. Attainment of Beneficial Uses and Potential Impairment

No Sacramento River watershed waterbodies are listed on the California 1998 303(d) list of impaired waterbodies for sediment toxicity. Because SRWP sediment toxicity monitoring data cover only a limited time period and spatial scope, they do not provide conclusive information about whether beneficial uses are affected by sediment toxicity. However, within the limitations of this monitoring effort, the preliminary results indicate that sediments collected from depositional zones from the Sacramento River mainstem and major tributaries generally did not cause toxicity to test organisms. While this result can not be considered conclusive and can not be readily extrapolated to all of the

[4] Elutriate water samples are produced by vigorously shaking one part sediment with four parts water. The elutriate is isolated by allowing the sediment-water mixture to settle, and centrifuging and filtering the liquid phase.

watershed, this result is generally consistent with the protection of related beneficial uses, and does not indicate widespread impairment of beneficial uses.

V. Conclusions, Recommendations

- No sediment toxicity was observed in any samples from mainstem Sacramento River sites. Only one sample (collected at the Feather River at Nicolaus site in September 1998) was found to be toxic to *Hyallela* in bulk sediment tests. Although not conclusive, SRWP sediment toxicity data provide no evidence that suggests potential impairment of beneficial uses in the Sacramento River watershed.
- No spatial or temporal patterns of sediment toxicity were identified in the SRWP sediment toxicity data.
- This monitoring element was undertaken as a pilot project designed to evaluate the value of sediment toxicity testing in identifying potential sources of toxic pollutants, and to assess the occurrence and distribution of sediment toxicity. The Monitoring Sub-committee concluded that data from this type of monitoring was difficult to interpret on a local or regional scale, based on the results of the 1998–2000 monitoring efforts. Therefore, sediment toxicity testing was not ranked as a high priority tool for assessing the attainment or protection of beneficial uses in the watershed. This pilot program was not continued in 2000-2001.

Table 34. Summary of 1999–2000 Sediment Toxicity Monitoring Results

Ceriodaphnia toxicity tests	November 1999 Reproduction (neonates/adult)	November 1999 Test significance[(a)]	May 2000 Reproduction (neonates/adult)	May 2000 Test significance[(a)]
laboratory control	18.5	—	25.8	—
Sacramento River at Bend Bridge	21.1	No	40.6	No
Sacramento River at Colusa	25.5	No	29.8	No
Colusa Basin Drain	28.0	No	37.9	No
Sacramento Slough	23.6	No	19.1	No
Yuba River at Marysville	25.1	No	29.1	No
Feather R. near Nicolaus	20.0	No	29.3	No
Sacramento River at Verona	36.3	No	36.7	No
American River at J St	27.0	No	33.6	No
Sacramento River at Freeport	27.0	No	37.8	No

Hyalella toxicity tests	November 1999 Survival (%)	November 1999 Test significance[(b)]	May 2000 Survival (%)	May 2000 Test significance[(b)]
laboratory control	80	—	95	—
Sacramento River at Bend Bridge	90	No	90	No
Sacramento River at Colusa	88	No	93	No
Colusa Basin Drain	85	No	80	No
Sacramento Slough	85	No	90	No
Yuba River at Marysville	73	No	78	No
Feather R. near Nicolaus	100	No	90	No
Sacramento River at Verona	78	No	100	No
American River at J St	85	No	95	No
Sacramento River at Freeport	85	No	90	No

(a) Reproduction significantly less than control at a 95% confidence level.
(b) Survival significantly less than control at a 95% confidence level.

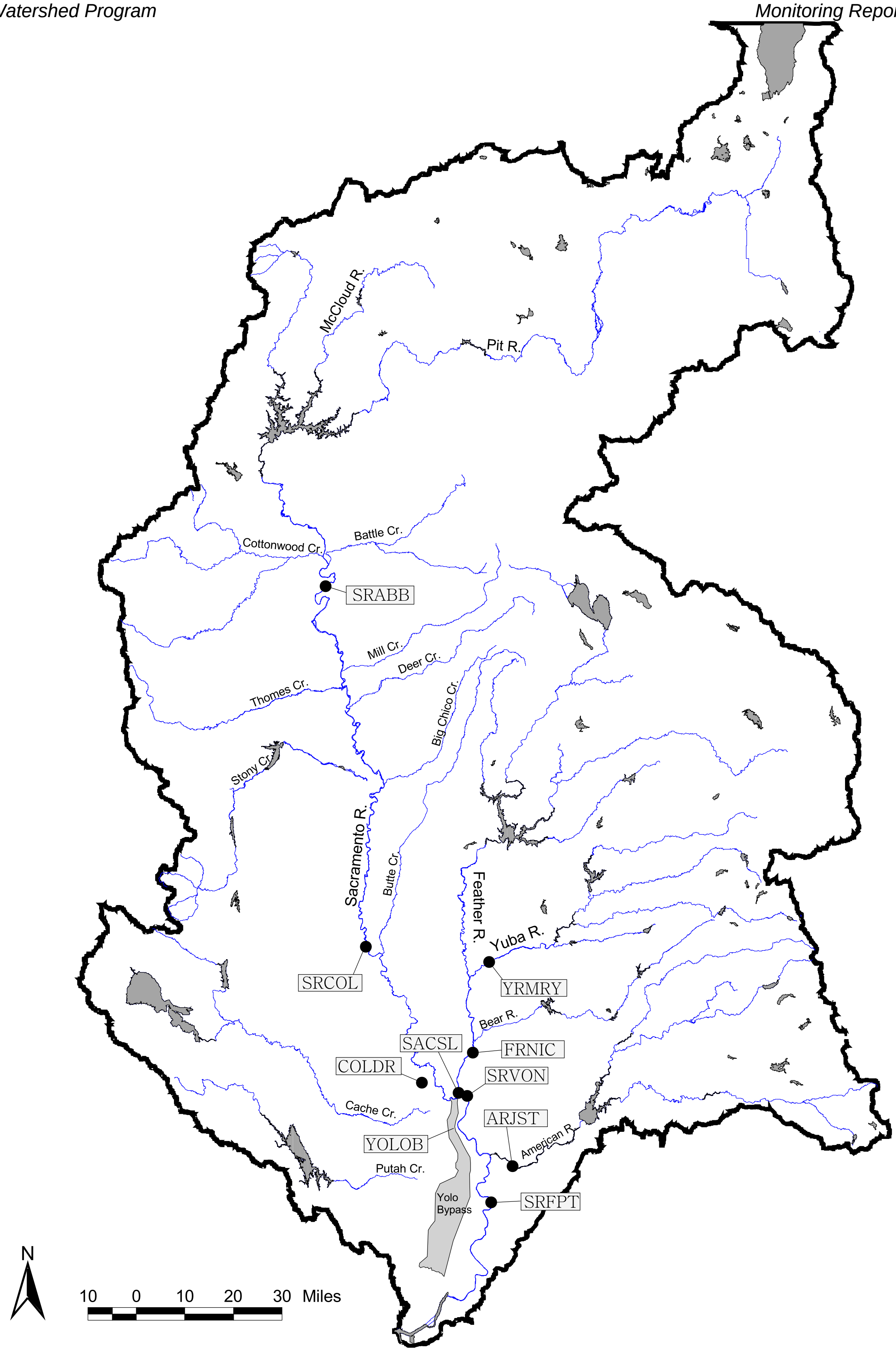


Figure 29. SRWP Sediment Toxicity Monitoring in the Sacramento River Watershed: 1999-2000 Monitoring Locations

H. Bioassessment

i. Background

The overall objectives of the bioassessment monitoring effort were to provide data useful in evaluating relative health of biological communities in the watershed, and to supplement and integrate with monitoring efforts being performed in tributary watersheds. The information generated will provide data needed to develop biocriteria for the Sacramento River watershed, which will eventually allow more direct evaluations of the degree to which specific beneficial uses are achieved or impaired (e.g. the warm and cold freshwater beneficial uses designated in the Central Valley Basin Plan).

As part of a multi-agency program to evaluate water quality in the Sacramento River watershed, macroinvertebrate samples were collected from 13 wadable and five non-wadable sites to assess their biological condition. The California Stream Bioassessment Procedure (CSBP), developed by the California Department of Fish and Game (DFG), was used to evaluate the benthic macroinvertebrate communities at each site (Harrington 1996). The CSBP is a regional adaptation of the U.S. Environmental Protection Agency (USEPA) Rapid Bioassessment Protocols (Barbour *et al*. 1997) and is recognized by the USEPA as California's standardized bioassessment procedure (Davis *et al*. 1996). Additional samples were collected by the United States Geological Survey (USGS) at five non-wadable sites using their National Water Quality Assessment (NAWQA) procedures. Data collected at non-wadable sites were used to evaluate methodologies for sampling in deepwater sites.

Bioassessment is a general term that may include assessment of fish, amphibian, algal or other communities, or single indicator species. The CSBP utilizes measures of the stream's benthic macroinvertebrate (BMI) community and its physical/ habitat structure to assess the biotic health of a site. BMIs can have a diverse community structure, with individual species residing within the stream for a period of months to several years. They are also sensitive, in varying degrees, to temperature, dissolved oxygen, sedimentation, scouring, nutrient enrichment and chemical and organic pollution (Resh and Jackson 1993). Together, biological and physical assessments integrate the effects of water quality over time, are sensitive to multiple aspects of water and habitat quality, and provide the public with more familiar expressions of ecological health (Gibson 1996).

Macroinvertebrate samples were collected during three fall sampling periods between 1997 and 1999 by DFG, USGS and the California Department of Water Resources (DWR). This report presents results from samples collected by DFG and USGS in Fall 1999. Results of DWR's sampling events are reported in a separate document.

ii. Materials and Methods

Site Selection and Reach Designation

Monitoring reach descriptions are summarized in Table 35 and a map of sampling locations is shown in Figure 30. Within the selected tributary watershed, sampling sites were selected using the procedures outlined for non-point source sampling in the CSBP (Harrington 1996), and considering the sites being monitored by other programs (e.g. the DWR tributary monitoring program). Sites were designated as wadable or non-wadable, depending on whether reaches could be sampled by wading and using standard riffle sampling methodology. Non-wadable sites were sampled using USGS NAWQA methods developed for deep water (i.e. non-wadable) streams and rivers.

Benthic Macroinvertebrate Sampling

Benthic Macro Invertebrates (BMIs) were sampled between September and October 1999 using Department of Fish and Game (DFG) and USGS NAWQA sampling methods.

Sampling Wadable Sites

DFG Riffle Methodology—Riffle length was determined for each riffle and a random number table was used to establish a point randomly along the upstream third of the riffle from which a transect was established perpendicular to the stream flow. Starting with the transect at the lowermost riffle, the benthos within a 2 ft^2 area was disturbed upstream of a 1 ft wide, 0.5 mm mesh D-frame kick-net. Sampling of the benthos was performed manually by rubbing cobble and boulder substrates in front of the net followed by "kicking" the upper layers of substrate to dislodge any invertebrates remaining in the substrates. The duration of sampling ranged from 60-120 seconds, depending on the amount of boulder and cobble-sized substrates that required rubbing by hand; more and larger substrates required more time to process. Three locations representing the habitats along the transect were sampled and combined into a composite sample (representing a six ft^2 area). This composite sample was transferred into a 500 ml wide-mouth jar containing approximately 200 ml of 95% ethanol. This technique was repeated for each of three riffles in each reach.

USGS Riffle Methodology—The NAWQA sampling method is similar to that of the CSBP with the following exceptions:

- A 0.5 m wide USGS "slack" net with 425 µ mesh was used to collect macroinvertebrate samples instead of a 1 ft wide D-net with 500 µm mesh.
- Five sampling areas of ~4 ft^2 each were composited into one sample representing ~20 ft^2 of riffle habitat as opposed to three 6 ft^2 composites (total area = 18 ft^2) collected in the CSBP protocol.

Sampling Non-Wadable Sites

USGS Snag Sampling Methodology— The USGS has developed its snag sampling methodology to accommodate collection of biological information from non-wadable sites where riffles are either difficult to sample or non-existent. In this methodology, conditioned woody debris (snags) was sampled at five locations within the sampling reach.

When possible, well-conditioned snags were selected, but the condition of each snag was not assessed. A slack net was held downstream from the snag to capture any organisms dislodged during manipulation of the snag. When feasible, snags were sampled in situ by brushing organisms into the net; otherwise, the snag was carefully removed using a pruning saw or pruning shears, and the organisms were brushed into a bucket. Loose bark was removed and concealed organisms were brushed into the net or bucket. Snags were then carefully examined for boring or clinging organisms. The length and diameter of the sampled area were measured with a ruler to provide a rough calculation of surface area. Depending on the size of the snags available, one or more snags were sampled at each of the five locations within the reach. Organisms from all five locations were composited into a single sample.

Composited samples were sieved through a 425-µm mesh screen. If the volume of the remaining sample was 750 mL or less, the entire sample was preserved in 10-percent formalin. If the volume of the remaining sample was greater than 750 mL, the sample was split into equal-sized components prior to adding the preservative. Large or rare taxa that might be missed in a random split were picked out from the sample by hand and included with the subsample to ensure that all taxa present at a site were collected (*see Cuffney et al., 1993a and 1993b, for additional details*).

DFG Snag Sampling Methodology— DFG collected two additional samples at each of the non-wadable sites that USGS sampled. When USGS collected riffle samples, DFG followed the CSBP protocol; when USGS collected snag samples, DFG followed the USGS snag-sampling methodology, with the exception that samples were preserved in 95% EtOH instead of formalin.

Physical Habitat Quality Assessment and Ambient Water Characteristics

Physical habitat quality was assessed for the monitoring reaches using U.S. Environmental Protection Agency (USEPA) Rapid Bioassessment Protocols (RBPs) (Plafkin *et al.* 1989). Habitat quality assessments were recorded for each monitoring reach during each sampling event. Photographs were taken within each of the monitoring reaches to document overall riffle condition at the time of sampling. At a minimum, photographs were taken upstream and downstream through each riffle sampled. Ambient water quality characteristics were also recorded at each site using a YSI 3800 water quality meter. Recorded measurements included water temperature, dissolved oxygen concentration, specific conductance, alkalinity and pH.

Table 35. Benthic Macroinvertebrate Sampling Location Information For Reaches Sampled Within The Sacramento River Watershed.

Watershed Name	Location Description	Site ID	Latitude/ Longitude
Butte Creek	Reach consisted of 5 riffles downstream of Honey Run Covered Bridge	BC-HR	N34˚43' 19.4", W121˚ 42' 39.9"
Butte Creek	Reach consisted of 5 riffles upstream of Doe Mill Road	BC-DMR	N39˚47' 00", W121˚ 36' 12"
Butte Creek	Reach consisted of 5 riffles upstream of Cherry Hill Campground	BC-CHC	N40˚06' 1.9", W121˚ 29' 47.6"
Big Chico Creek	Reach consisted of 5 riffles within Upper Bidwell Park	BCC-BP	N34˚46' 20.2", W121˚ 46' 27.5"
Big Chico Creek	Reach consisted of 5 riffles in the vicinity of Forest Ranch	BCC-FR	N39˚53' 15.4", W121˚ 41' 46.6"
Big Chico Creek	Reach consisted of 5 riffles upstream of Highway 32 crossing	BCC-H32	N40˚03' 49.5", W121˚ 36' 13.3"
Deer Creek	Reach consisted of 5 riffles downstream of railroad crossing at the Clairveaux Monastery	DC-M	N39˚56' 26.8", W121˚ 03' 33.2"
Deer Creek	Reach consisted of 5 riffles upstream and downstream of the Deer Creek Fish Screen	DC-FS	N40˚00' 41.2", W121˚ 57' 14.4"
Deer Creek	Reach consisted of 5 riffles in the Ishii Wilderness downstream of Ponderosa Way	DC-P	N40˚04' 10.6", W121˚ 42' 31.9"
Deer Creek	Reach consisted of 5 riffles upstream of Potato Patch Campground	DC-PPC	N40˚10' 22.6", W121˚ 33' 14.0"
Upper Sacramento River	Reach consisted of 5 riffles downstream of the Lamoine exit off Interstate-5	SR-L	N40˚58' 33.5", W122˚ 25' 49.6"
McCloud River	Reach consisted of 5 riffles downstream of Ladybug Creek at	MR-TNC	N41˚05' 39", W122˚ 06' 56"
	The Nature Conservancy Property		
McCloud River	Reach consisted of 5 riffles upstream of Stout's Road Bridge	MR-SR	N41˚15' 22.4", W121˚ 52' 54.1"
	DEEP WATER SITES		
American River	Three supplemental riffle samples were collected from in the vicinity of Harrington Bar	AR-HB	N38˚34' 05", W121˚ 25' 20"
Sacramento River at Colusa	Two supplemental snag samples were collected upstream of Sacramento State Park	CR-SSP	N38˚48' 45", W121˚ 46' 23"
Yuba River	Two supplemental riffle samples were collected upstream of Marysville	YR-M	N39˚10' 33", W121˚ 31' 26"
Arcade Creek	Three supplemental riffle samples were collected within the boundaries of Del Paso Park	AC	N38˚38' 31", W121˚ 22' 54"
Feather River	Two supplemental snag samples were collected upstream of East Nicolaus	FR	N38˚54' 01", W121˚ 35' 00"

BMI Sample Processing and Data Analysis

At the laboratory, each sample was rinsed through a No. 35 standard testing sieve (0.5 mm brass mesh) and transferred into a tray marked with twenty, 25 cm^2 grids. All detritus was removed from one randomly selected grid at a time and placed in a petri dish for inspection under a stereomicroscope. All invertebrates from the grid were separated from the surrounding detritus and transferred to vials containing 70% ethanol and 5% glycerol. This process was continued until 300 organisms were removed from each sample. The material left from the processed grids was transferred into a jar with 70% ethanol and labeled as “remnant” material. Any remaining unprocessed sample from the tray was transferred back to the original sample container with 70% ethanol and archived. Macroinvertebrates were then identified to a standard taxonomic level, typically genus level for insects and order or class for non-insects using standard taxonomic keys.

Data Analysis—A taxonomic list of benthic macroinvertebrates identified from the samples was entered into a Microsoft Excel® spreadsheet program. Excel® was used to calculate and summarize macroinvertebrate community based metric values. A description of the metric values used to describe the community is provided in Table 36.

Each of the monitoring reaches was given a relative BMI Ranking Score based on 6 of the BMI metric values (Table 36; metrics 1,2,4,6,8 and 9). The scores were computed as follows:

$$Score = \sum \left(\frac{x_i - \bar{x}}{sem_i} \right)$$

where: x_i = site value for the *i*-th metric;
$\bar{x}$ = overall mean for the *i*-th metric;
sem_i = standard error of the mean for the *i*-th metric.
Note: An overall score of “0" is the average relative score.

iii. Results

A complete list of macroinvertebrates identified from the samples is presented in Appendix H.

Dominant BMI Taxa and General Taxonomic Notes

The five most abundant taxa observed in each of the monitoring reaches are presented in Table 37.

The macroionvertebrate communities were very similar to those found in 1998. We noted the same overall trend of decreased diversity at lower sites and an increase in tolerant taxa at lower sites. There were 153 taxa found in the 18 sites we sampled (20 more than in 1998). The macroinvertebrate communities at most sites were fairly complex, with a wide range of taxa represented. This was especially true of sites at the uppermost elevations. The BMI communities at almost all sites were dominated by relatively sensitive insect taxa; 72 of the taxa present at all sites were sensitive Ephemeroptera, Plecoptera or Trichoptera. Riffle beetles (Coleoptera: Elmidae) were common at most sites and elmid diversity was very high overall (12 genera). Although there were 24 dipteran taxa present, two families (Simuliidae and Chironomidae) were responsible for the vast majority of the individuals. True bugs (Hemiptera) were very rare; the genus *Ambrysus* (Hemiptera: Naucoridae) was present at only one site. Lepidoptera, Megaloptera and Odonata were also rare, with only a few individuals present in the lower elevation sites.

Mayflies (Ephemeroptera, especially families Heptageniidae and Baetidae), stoneflies (Plecoptera, especially family Perlodidae) and caddisflies (Trichoptera, especially families Hydroptilidae and Glossosomatidae) were well represented in this dataset. Although the genus *Baetis* was common in upstream sites, it rarely reached the levels of dominance common in lower elevation sites. Although there were 26 non-insect taxa found in all sites (the same as in 1998), nearly all of the non-insect abundance was accounted for by mites and a few worms (Oligochaeta) and flatworms (Planariidae); the remaining non-insect taxa were rare.

The distribution of non-insect taxa across sites was much more even in the non-wadable sites. Non-wadable sites were much less species rich than the wadable sites (61 taxa vs. 153 taxa) and had a disproportionate number of non-insect taxa (24 of the 26 taxa found at all sites). These sites were dominated by chironomid midges (Diptera: Chironomidae), segmented worms (Oligochaeta), a few baetid mayflies (Ephemeroptera: Baetidae) and hydropsychid caddisflies (Trichoptera: Hydropsychidae). Beetles (Coleoptera), stoneflies (Plecoptera) and most other insect groups were rare in comparison to the wadable sites.

Table 36. Bioassessment Metrics Used To Describe Characteristics Of The Benthic Macroinvertebrate (BMI) Community At Sampling Reaches Within The Sacramento River Watershed

BMI Metric	Description	Response to Impairment[a]
	Richness Measures	
1. Taxa Richness	Total number of individual taxa	decrease
2. EPT Taxa	Number of taxa in the Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly) insect orders	decrease
	Composition Measures	
3. EPT Index	Percent composition of mayfly, stonefly and caddisfly larvae	decrease
4. Sensitive EPT Index	Percent composition of mayfly, stonefly and caddisfly larvae with tolerance values between 0 and 3	decrease
5. Shannon Diversity Index	General measure of sample diversity that incorporates richness and evenness (Shannon and Weaver 1963)	decrease
	Tolerance/Intolerance Measures	
6. Tolerance Value	Value between 0 and 10 weighted for abundance of individuals designated as pollution tolerant (higher values) or intolerant (lower values)	increase
7. Percent Intolerant Organisms	Percent of organisms in sample that are highly intolerant to impairment as indicated by a tolerance value of 0, 1 or 2	decrease
8. Percent Tolerant Organisms	Percent of organisms in sample that are highly tolerant to impairment as indicated by a tolerance value of 8, 9 or 10	increase
9. Percent Dominant Taxa	Percent composition of the single most abundant taxon	increase
	Functional Feeding Groups (FFG)	
10. Percent Collectors	Percent of macrobenthos that collect or gather fine particulate matter	increase
11. Percent Filterers	Percent of macrobenthos that filter fine particulate matter	increase
12. Percent Grazers	Percent of macrobenthos that graze upon periphyton	variable
13. Percent Predators	Percent of macrobenthos that feed on other organisms	variable
14. Percent Shredders	Percent of macrobenthos that shreds coarse particulate matter	decrease
	Abundance Measures	
15. Estimated Abundance	Estimated number of macroinvertebrates in sample calculated by extrapolating from the proportion of organisms counted in the subsample	variable

a. Metrics that increase in response to impairment are assigned a negative value.

Benthic Macroinvertebrate Community Metrics

Macroinvertebrate community metrics were analyzed in two different ways:

(i) Results of all DFG samples were analyzed as one group which included both wadable and non-wadable sites. BMI metric values from this analysis are presented by transect and summarized by reach mean and coefficient of variation in Appendix H.

(j) The USGS data from the non-wadable sites were added to DFG data from these sites. The two data sets were adjusted to make the taxonomic resolution comparable. For example, when one data set had more precise levels of taxonomic resolution, its resolution was reduced to match the least precise level. The taxonomic list of non-wadable sites in Appendix H reflects that of the adjusted data set. Since the USGS data represented total counts of the samples as opposed to the subsamples used in the DFG data, summary statistics for the non-wadable sites refer only to the DFG data. However, the metrics calculated from the two data sets and are roughly comparable and are also presented in Appendix H.

Table 37. Dominant Macroinvertebrate Taxa (And Their Percent Contribution) By Reach From Samples Collected From Sites Within The Sacramento River Watershed.

Location	**Dominant Taxon (% contribution)**				
BUTTE CREEK BC-HR	*Serratella* (31)	Oligochaeta (9)	Orthocladiinae (7)	*Baetis* (7)	Chironomini (6)
BUTTE CREEK BC -DMR	*Baetis* (16)	*Epeorus* (16)	*Micrasema* (11)	Orthocladiinae (9)	*Serratella* (7)
BUTTE CREEK BC -CHC	*Rhithrogena* (15)	*Cinygmula* (8)	*Goerita* (7)	*Epeorus* (5)	*Serratella* (5)
BIG CHICO CREEK BCC -BP	*Lymnaeidae* (36)	Orthocladiinae (10)	*Hydropsyche* (10)	*Fossaria* (7)	*Prostoma* (4)
BIG CHICO CREEK BCC -FR	Orthocladiinae (22)	*Baetis* (14)	*Epeorus* (9)	*Serratella* (5)	Simuliidae/ Sperchontidae (4/4)
BIG CHICO CREEK BCC -H32	Epeorus (15)	Micrasema (12)	*Ironodes* (8)	*Baetis* (7)	Orthocladiinae (6)
DEER CREEK DC-M	Orthocladiinae (25)	Hydropsyche (14)	*Baetis* (14)	Tanytarsini (7)	Planariidae (5)
DEER CREEK DC -FS	Orthocladiinae (15)	*Cheumatopsyche* (12)	*Baetis* (11)	*Serratella* (11)	*Hydropsyche* (9)
DEER CREEK DC -PW	Orthocladiinae (16)	Simuliidae (10)	*Serratella* (10)	Oligochaeta (9)	*Hydropsyche/* *Optioservus* (6/6)
DEER CREEK DC -PPC	*Serratella* (20)	*Baetis* (11)	*Epeorus* (11)	Orthocladiinae (9)	*Hydropsyche* (9)
SAC. RIVER SR-L	*Hydropsyche* (24)	*Baetis* (16)	*Maruina* (15)	*Orthocladiinae* (9)	*Serratella/* *Epeorus* (6/6)
MC CLOUD RIVER MR-TNC	Orthocladiinae (21)	*Serratella* (17)	Rhithrogena (17)	Tanytarsini (9)	Oligochaeta (9)
MC CLOUD RIVER MR-SR	*Anagapetus* (19)	Glossosoma (12)	*Rhithrogena* (11)	Orthocladiinae (8)	Glossosomatidae (7)
			NON-WADABLE SITES		
American River AR-HB	Oligochaeta (37)	*Hydropsyche* (16)	*Acentrella* (10)	Orthocladiinae (10)	Hydroptila (4)
Sac. River, Colusa SR-SSP	Oligochaeta (20)	Orthocladiinae (19)	*Hydropsyche* (17)	Tanytarsini (15)	*Acentrella* (10)
Yuba River YR-M	*Hydropsyche* (22)	*Acentrella* (21)	Orthocladiinae (14)	*Rhithrogena* (13)	Baetis (7)
Arcade Creek AC-DPP	Chironomini (63)	Oligochaeta (16)	Tanytarsini (8)	Cyclopidae (5)	Orthocladiinae (2)
Feather River FR-EN	Tanytarsin (30)	*Hydropsyche* (16)	*Acentrella* (11)	Chironomini (7)	Orthocladiinae (6)

Biological Data — Wadable and Non-wadable Sites

Richness

Average Taxonomic Richness values were fairly high, ranging from a low of 25 taxa to a high of 42 taxa in the wadable sites and between 13 and 23 in the non-wadable sites (Table 35). Site taxa totals were as high as 66 taxa and 31 taxa in the non-wadable sites. The relatively sensitive EPT taxa were very abundant with averages of 9 to 27 taxa in the wadable sites and 4 to 14 taxa in the non-wadable sites. Total EPT taxa at each site was 21-22 at the upper sites in Deer Creek and Butte Creek and Big Chico Creek.

Composition Measures

Shannon Diversity values were moderately high at all sites, ranging from 2.2 to 2.9 in the wadable sites and 1.2 to 2.2 in the non-wadable sites. EPT Index scores were high at most sites, comprising at least 40 percent and as much as 81 percent of the total abundance, except at the Bidwell Park site and Arcade Creek, where EPT taxa were much less common. Sensitive EPT taxa were also very abundant and often made up a considerable portion of the EPT abundance. Sensitive EPT taxa were especially rare at the lower elevation tributary sites (e.g. Bidwell Park, Monastery) and all the non-wadable sites except the Yuba River site. Extreme dominance of a community by one or a few taxa was rare in this dataset with percent dominance ranging between 18 and 49 percent; only the Arcade Creek site was characterized by dominance of one taxon (63 percent Chironomini).

Tolerance Measures

Average tolerance value appears to be a good metric for discrimination between sites in this dataset. All tolerance measures indicated that most of the communities in this dataset were intolerant to disturbance, wit the exceptions of the lowest elevation site on Big Chico Creek and Deer Creek, and all the non-wadable sites except for the Yuba River site. The level of community tolerance was much higher in the lower elevation sites, both within a watershed and at the individual non-wadable sites. Average tolerance values ranged between 1.7 and 5.2 in the wadable sites and 3.6 and 6.4 in the non-wadable sites. Intolerant taxa were abundant at the higher elevation tributary sites (72 percent intolerant organisms at the upper McCloud River site at Stout's Road Bridge) and much less common at the lower elevation sites.

There were very few tolerant taxa overall. Of the non-wadable sites, only the Yuba River and American River sites had tolerance measures comparable to the upstream sites. Overall, the Butte Creek sites had less tolerant communities than did any of the Deer Creek or Big Chico Creek sites.

Functional Feeding Groups

All of the FFGs were present within the entire project, but shredders were encountered only rarely and at only a few sites. Grazing taxa were fairly common in this dataset, a reflection of the high abundance of sensitive mayfly and caddisfly taxa, which are often algae-scraping organisms. Although there were many predator taxa, these also represented a small proportion of the community. Most of the remaining organisms in this watershed were either collector-gatherers or filtering collectors, both of which feed on fine particulate organic matter (FPOM). The relative proportion of collector-gatherers to filterers varied considerably in wadable sites while collector gatherers were dominant in the non-wadable sites.

Abundance

Abundance of organisms was variable, ranging from a low value of 600 organisms per sample to 4200 organisms per sample in the wadable sites. Abundance was less variable in the non-wadable sites, ranging between 2200 and 4800 organisms in the non-wadable sites. Note that because of differences in sampling method, abundance is not directly comparable for wadable and non-wadable sites.

Physical Habitat Quality Assessment

The majority of sites in this study had similar physical habitat characteristics and were in very good condition. All sites scored in the low end of the “excellent” category or in the high end of the “good” category. The only major physical habitat problem noted for these sites was sedimentation. Some sites had fairly good riparian protection and bank vegetation, but had moderate amounts of sediment deposition and low substrate diversity. The downstream tributary sites tended to have poorer sedimentation scores.

Physical habitat quality scores are summarized in Table 38. Description of the specific habitat parameters are in the method documents. Photographs of sites are archived at DFG's Aquatic Bioassessment Lab. Physical habitat quality data was not recorded for non-wadable sites.

BMI Ranking Score

The BMI ranking scores are presented in Figures 33 and 34.

Most of the wadable sites clustered closely together. In general, the tributary streams (Butte Creek, Big Chico Creek and Deer Creek) ranked higher than the larger river sites, except at the most downstream sites on these tributary streams (BC-HR, BCC-BP and DC-M). The non-wadable sites from which riffle samples were collected (Feather River near Nicolaus, American River at Harrington Bar, Yuba River at Marysville) ranked close to the other large river sites sites (Sacramento River at Lamoine, McCloud River at the Nature Conservancy), while the sites sampled with snag sampling scored lower than all other sites. It should be noted that the difference in sampling methodology for the snag samples precludes a strict comparison between these sites and the riffle samples.

As observed in 1998, there was a strong relationship between elevation and overall ranking score in some sites (Deer Creek, Big Chico Creek, Sacramento River)as higher elevation sites tended to have the highest ranks. This relationship is summarized for all three years of data in Figure 32a. This is especially evident in the Deer Creek sites; the Potato Patch Campground site on Deer Creek (DC-PPC) scored particularly high for most metrics and these values decreased with decreasing elevation downstream on Deer Creek. The McCloud River site at Stout's Bridge Road scored much higher than reported for 1998, when it was surprisingly low for an upper watershed site.

There was a poor relationship between physical/ habitat scores and overall site rankings based on the bioassessment metrics (summarized for all three years in Figure 32b). The habitat score range of 129 to 176 provided very little range to enable discrimination of habitat quality.

There was also a strong correspondence between the 1998 ranking scores and the 1999 ranking scores. The ranks of only two sites were notably different in the two years (American River at Harrington Bar and McCloud River at Stout’s Bridge). The American River site ranked somewhat lower in the 1999 samples and the McCloud River site ranked somewhat higher in the 1999 samples.

Table 38. Physical Habitat Quality Scores For Sampling Reaches In Eight Drainages In The Sacramento River Watershed, 1999(1).

	Butte Creek			Big Chico Creek			Deer Creek				Sac River	McCloud River	
Habitat Parameter	HR	DMR	CHC	BP	FR	H32	M	FS	PW	PPC	L	TNC	SR
1. Instream Cover	15	12	15	15	15	17	15	15	17	16	14	17	18
2. Embedded-ness	15	14	12	14	15	13	14	14	11	12	11	11	12
3. Velocity/ Depth Regimes	15	18	12	10	10	16	12	16	17	15	18	16	12
4. Sediment Deposition	15	14	14	13	14	12	14	14	11	15	10	10	12
5. Channel Flow	11	11	16	14	18	11	12	10	15	16	13	18	17
6. Channel Alteration	18	17	18	17	19	18	12	18	19	19	12	20	17
7. Riffle Frequency	5	15	15	13	17	12	14	13	17	15	15	18	14
8. Bank Vegetation	14	12	12	15	19	17	12	12	15	16	3	18	15
9. Bank Stability	11	18	14	14	19	18	10	12	16	16	18	18	17
10. Riparian Zone	18	17	18	18	19	19	17	19	19	19	15	19	16
TOTAL	137	148	146	143	165	153	132	143	157	159	129	165	150
Physical Condition(2)	G	G	G	G	E	E	G	G	E	E	G	E	E

(1) Scores for each habitat parameter range from 0 (poor) to 20 (excellent).
(2) Physical Condition Abbreviations: P = Poor; G = Good; E = Excellent;

iv. Conclusions and Recommendations

Summary of 1999 Data

This report describes one year (1999) of biological data from macroinvertebrate samples collected by the DFG. When completed, the final biological dataset for the initial three-year sampling plan will contain three years of data from DFG, USGS and DWR. Together, these data will provide a baseline of biological information that could be used to develop an Index of Biotic Integrity (IBI) for the Sacramento River watershed.

At this point, we are not able to make statements about the absolute rankings of these sites or their degree of impairment in the absence of reference condition information. Identification of reference sites and reference conditions within the Sacramento River watershed will be critical to assessing the biological integrity of these monitoring sites.

Most of the upper tributary sites covered in this report were in good to excellent biological condition. The tributary sites farthest downstream had consistently lower biological metric scores than upstream sites. The differences among the upper watershed sites were minimal. The larger river sites typically had lower scores than the upper sites and had lower diversity levels typical of more impacted streams. As is typical within high-gradient watersheds, there was a strong elevational gradient in biological quality for the tributary streams Deer Creek, Butte Creek and Big Chico Creek. Deer Creek in particular had a strong elevational component to the biological ranking. Sites similar to those in Deer Creek are likely to be good reference sites to be used in the development of an IBI. An IBI is essentially a formalized version of the ranking scores used in this study. An IBI is a sum of scores calculated from a set of bioassessment metrics. Metrics are selected for use based on objective criteria, and metric values are assigned a score based on the range of values observed for the metric (e.g. 10-15 taxa = a taxa score of 3; > 15 taxa = taxa score of 5). Reference sites and a range of sampling sites are used to establish the range of natural variability for each metric. The resulting IBI may become part of biocriteria established as benchmarks for biological and physical habitat integrity.

Most of the tributary sites were also in good to excellent physical condition, but physical condition was not evaluated for the non-wadable sites. The poor relationship between habitat score and biological ranking score is a reflection of the prevalence of good to excellent habitat scores in the tributary sites, and should not be taken as an indication of an overall lack of correspondence between these factors.

The non-wadable sites had much lower diversity than the tributary sites, but at this point, there is not enough information about the range of natural variation in these types of sites to define their biological condition.

Summary of 1997-1999 Data

Prior bioassessment reports for the SRWP were presented as yearly summaries of baseline data collected from sites in the Sacramento River watershed. In these reports, it was cautioned that was not enough information about the range of natural variability to enable us to define the biological condition of each site relative to the attainment or potential impairment of beneficial uses. However, we can make some statements about the relative complexity of communities at each site.

Figure 31 below summarizes the ranking scores of all sites across all years. Note that sites from each stream are listed in order from downstream to upstream. There was a strong correlation within sampling locations across the three years. Although in some cases there are fairly large changes (e.g. MR-SB, BC-HR) in different years, the strong elevational component we noted before is very apparent (Figure 32a), with higher sites having higher rank scores. The annual variation seen here can be interpreted in several ways, but it is likely that in most cases it reflects the natural range of variation in communities as measured by the bioassessment technique.

In contrast to the results obtained from toxicity testing, there was a strong correlation between elevation and physical habitat and aquatic life metrics. Most of the upper tributary sites covered in this report were in good to excellent biological condition. The tributary sites farther downstream had consistently lower biological metric scores. Deer Creek in particular had a strong elevational component to the biological ranking.

The elevational component observed is typical of studies of ecosystem health. However, there are several potential sources of this pattern. Downstream sites integrate impacts from a larger area, but downstream sites also tend to be in different ecoregions than upstream sites, making it difficult to distinguish water quality effects from ecosystem effects. This is the main reason it is critical to put resources into identifying the range of natural variation within ecoregions.

There was only a weak relationship between physical habitat scores in tributary stream and the biological ranking scores for these sites. This resulted from the relatively low variation in the habitat scores at these sites. Lower elevation tributary sites were more impacted by sedimentation and had much lower diversity and less complex community structure. It is important to note that we have no physical habitat data for the non-wadable sites but that these are probably the most physically impacted sites. The poor relationship between habitat score and biological ranking score is most likely a reflection of the prevalence of good to excellent habitat scores in the tributary sites. Physical habitat quality is only one of the variables that affect biological condition and most of the biological variation was not explained by variation in physical habitat conditions at sites of higher physical quality.

The non-wadable (deep water) sites had much lower diversity than the tributary sites, but at this point, there is not enough information about the range of natural variation in these types of sites to define their biological condition.

Recommendations for future monitoring

At this point in the SRWP monitoring effort, it is not feasible to make reliable statements about the degree of attainment or potential impairment of beneficial uses in the absence of reference condition information for the Sacraemento River watershed. Identification of reference sites and reference conditions within the Sacramento River watershed would be the best means to assess the biological integrity of the watershed. The SRWP Biological and Physical Habitat Assessment Sub-Committee has recommended that future SRWP bioassessment efforts be directed to improving the ability to detect and monitor changes to the biological communities in the Sierra foothills ecoregion. This area will be experiencing dramatic growth in the next 10 to 20 years, which is likely to increasingly influence the water quality and biological integrity of the Sacramento River watershed. Macroinvertebrate bioassessment can play an important role in assessing and monitoring water quality in this region and the watershed in general. The work done to date has provided a strong set of baseline information on aquatic invertebrate communities in the Sacramento River watershed as a whole, but there is a need for more sites within the Sierra Nevada Foothills ecoregion to infer the range of natural variation in aquatic macroinvertebrate communities.

The SRWP Biological and Physical Habitat Assessment Sub-Committee has strongly recommended that the SRWP focus its upcoming bioassessment efforts on identifying reference conditions in this Sierra foothills ecoregion. This foundation could be developed fairly quickly and would be invaluable to future bioassessment work in the region. The process used to develop reference conditions in the Sierra foothills ecoregion would be applicable to other ecoregions in the watershed (and throughout the state) with relatively little modification.

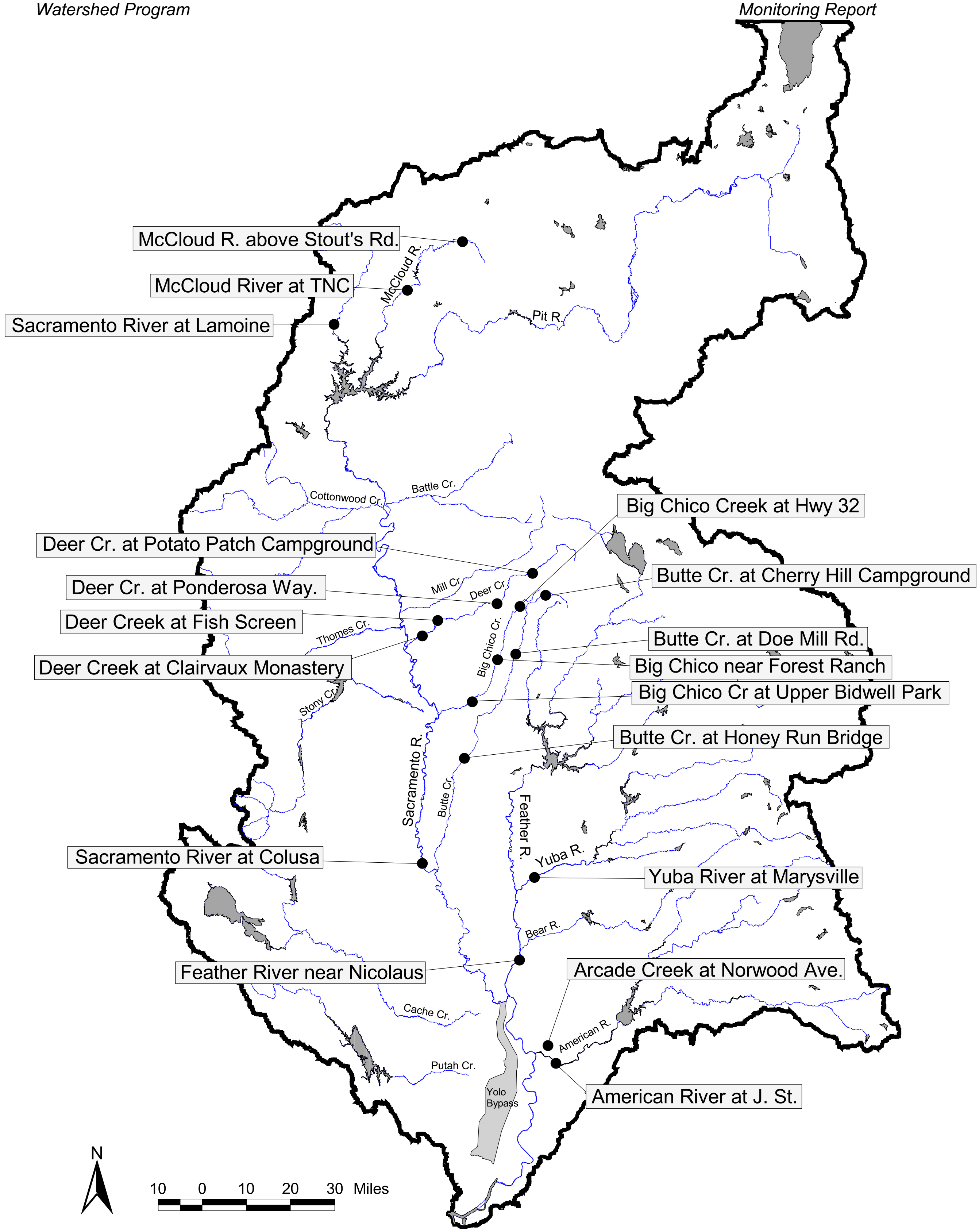


Figure 30. **SRWP Bioassessment Monitoring in the Sacramento River Watershed: 1999 Monitoring Locations**

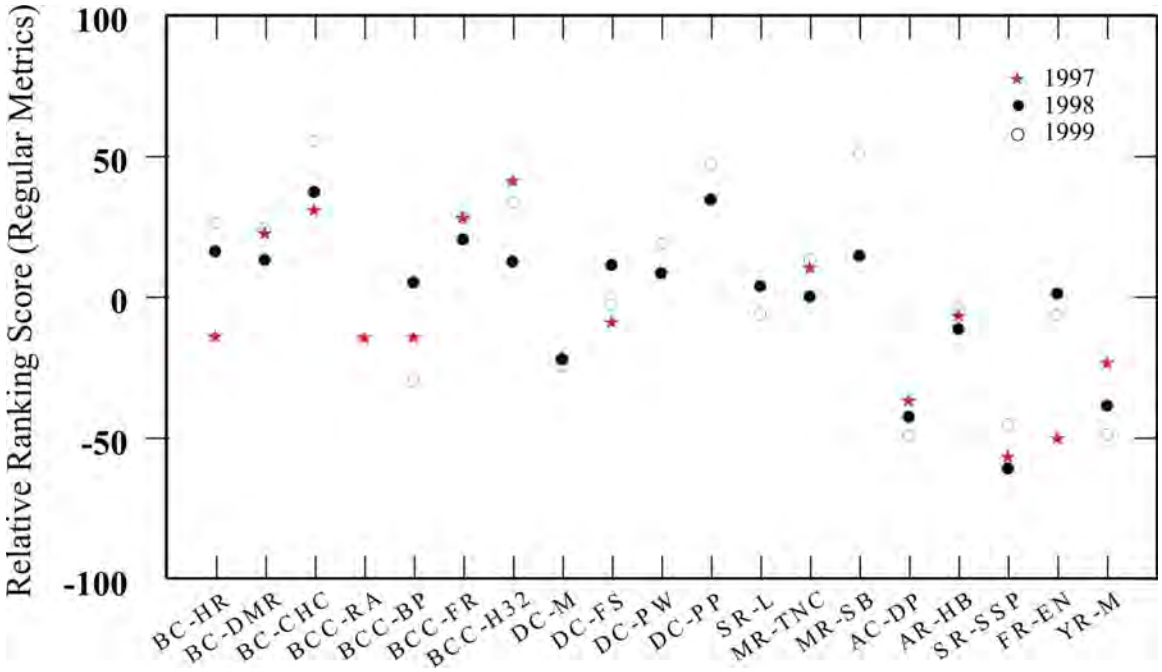


Figure 31. Relative ranking scores for all sites sampled in years 1997 through 1999

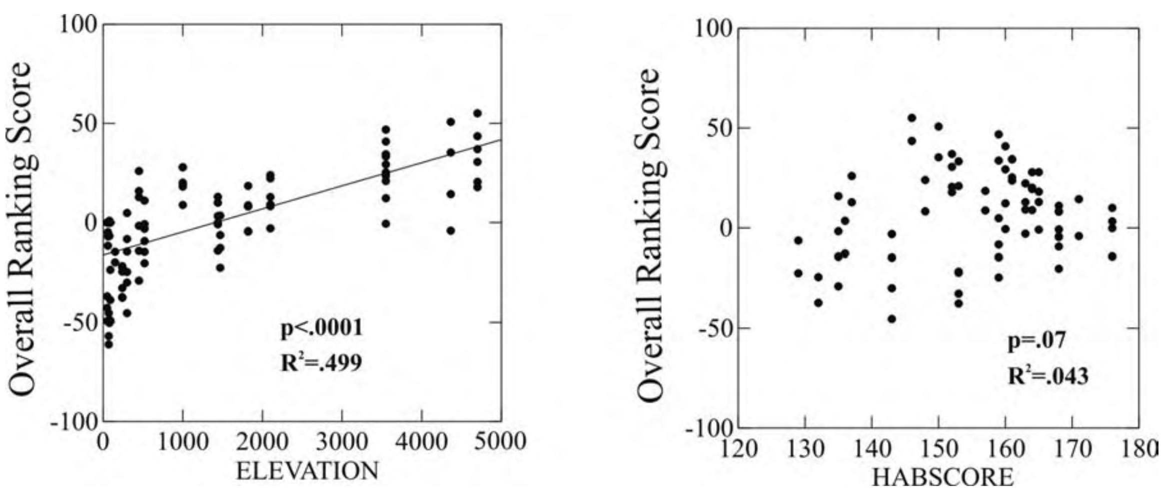


Figure 32. Relationships Between Biological Ranking Score and (a) Physical Habitat Score, and (b) Elevation, 1997-1999.

III. Year 3 and Year 4 Monitoring Plans

Year 3 Monitoring (2000-2001)

The proposed monitoring program for the 2000-2001 (Year 3) is summarized in Table 39. The third full year of monitoring for the Sacramento River Watershed Program was initiated in June of 2000.

A number of significant changes were implemented by the Monitoring Sub-Committee for the Year 3 monitoring effort. These changes were implemented to meet the following objectives:

- To provide more focus on the water quality issues of greatest concern (mercury and organophosphate pesticides);
- To provide additional support for development of Water Quality Management Strategies for these pollutants;
- To shift more funding to special studies designed to follow-up on identified water quality problems or to fill identified data gaps;
- To provide more funding to tributary watershed groups for monitoring and other projects.

In order to meet these monitoring and funding objectives for Year 3, the Monitoring Sub-Committee conducted a thorough evaluation and reprioritization of monitoring needs for Year 3, based on criteria designed to support the objectives outlined above. The following is a summary of the resulting changes implemented by the Monitoring Sub-Committee for Year 3 monitoring:

- Monitoring for pesticides and for aquatic toxicity to *Ceriodaphnia* will be performed primarily on an episodic basis to allow better identification of sources of pesticides and causes of toxicity.
- Analysis of metals (other than mercury) in water will be limited to follow-up analyses for aquatic toxicity monitoring. This change was implemented based on available data (from the SRWP and other monitoring programs) indicating that trace metals are (generally) pollutants of lesser concern than mercury, OP pesticides, and unidentified causes of toxicity.
- The number of regularly scheduled annual monitoring events was reduced from a maximum of 12 monthly events to a maximum of 9 events annually for most parameters.
- Sediment toxicity monitoring was discontinued. On the basis of available data for this pilot program, it was concluded by the Monitoring Sub-committee that data from this type of monitoring was difficult to interpret on a local or regional scale, and was not an effective tool for evaluating beneficial use attainment or potential impairment.
- The budget for fish tissue monitoring was increased to allow better evaluation of potential human health risks in the lower Sacramento River watershed.

- Some of the bioassessment monitoring effort was shifted to 3 new tributaries (Stony Creek, Battle Creek, and Cow Creek).
- Approximately $100,000 from the monitoring budget was committed by the Monitoring Sub-Committee for special studies. Three studies are intended to address critical data gaps and to provide support for development of Water Quality Management Strategies for mercury. Special study funds were also approved to support investigation of nickel toxicity in the upper Sacramento River, and to analyze benthic macroinvertebrate samples collected prior to the initiation of the monitoring program.

Year 4 Monitoring (2001-2002)

The SRWP is currently in the process of finalizing the scope of the Year 4 monitoring program planned to be implemented starting in June 2001. The Year 4 monitoring effort will is planned to be largely a continuation of the monitoring performed in Year 3, with a primary focus on supporting development of the management strategies for mercury and organophosphate pesticides. Monitoring will be conducted primarily on an event-based schedule, and will include elements in the following categories:

- Mercury and methylmercury in water;
- Organophosphate, carbamate, and triazine pesticides in water;
- Parameters related to drinking water uses and issues, including nitrogen and phosphorous compounds, coliform bacteria, organic carbon, and selected "conventional" parameters in water;
- Causes and sources of aquatic toxicity (*Ceriodaphnia* toxicity testing and TIEs)
- Mercury and organochlorine compounds in fish tissue;
- Bioassessment (benthic macroinvertebrate and habitat assessment);
- Continued funding of current "Special Tributary Monitoring" projects;
- Selected special studies for mercury.

The frequency of monitoring and final selection of sites to be monitored will depend to some degree on the level of cooperative funding for elements of the program from other sources. The Year 4 monitoring plan approved by the SRWP Monitoring Sub-Committee is summarized in Table 40.

Table 39. SRWP Monitoring for 2000-2001: Locations, Analytes, and Numbers of Annual Sample Events

Location	Water Chemistry											Path-ogens		Aquatic Toxicity		Fish Tissue		Bioassess-ment (b)	
	Hg (filtered and unfiltered)	MeHg (filtered and unfiltered)	TSS	Hardness	Alkalinity	TOC	DOC	TDS	OP pesticides	carbamate pesticides	triazines	Giardia/Crypto	Total, Fecal Coliforms	Ceriodaphnia	WC Tox Followup (a)	Mercury	PCBs & chlor. pest.	Benthic Invertebrates	Habitat Assessment
Sac. R. above Shasta															E				
Sac. R. below Keswick	5	5												9 E	E	2	2		
Cow Creek																		5	5
Battle Creek																		5	5
Sac. R. at Bend Br	9	9	9			9	9	9				9	9	9 E	E	2	2		
Mill Creek at Mouth	9	9	9						3 E							4	4		
Deer Creek									3 E									4	4
Stony Creek																4	4	7	7
Big Chico Creek									3 E									4	4
Sac. R. near Hamilton City	9	9	9	9		9	9	9	9 E							2	2	1	1
Sac. R. @ Colusa	9	9	9			9	9	9	9 E			9	9	9 E	E	2	2	1	1
Butte Creek																		6	6
Sac. Slough	9	9	9			9	9	9	9 E	9 E				9 E	E	2	2		
Colusa Basin Dr	9	9	9			9	9	9	9 E	9 E				9 E	E	2	2		
Yuba R. at Marysville	9	9	9			9	9	9										1	1
Feather R. near Nicolaus	9	9	9			9	9	9	9 E		4 E			9 E	E	2	2	1	1
Sac. R. at Veterans Br.	AMP		AMP	AMP		AMP	AMP	9	9 E		4 E	9	AMP			2	2		
Arcade Creek	9	9							9 E	9 E	9 E			9 E	E			1	1
Natomas East Main Drain						DWR	DWR	DWR								2	2		
American R. at J St.																2	2	1	1
American R. at Discovery Pk	AMP		AMP	AMP									AMP	9 E	E	2	2		
Sac. R. at Freeport	NAQ AMP	NAQ	NAQ	AMP	NAQ	NAQ AMP	NAQ AMP	9	NAQ	NAQ	NAQ	6	AMP	9 E	E				
Sac. R. at RM44	AMP		AMP	AMP	9	9	9	9				6	AMP			4	4		
Sac. R. at Greene's Lndg (c)	21 E	21 E	21 E																
Yolo Bypass	GS	GS	GS	GS		GS	GS	GS	GS	GS	GS								
Cache Creek at Rumsey			GS	GS		GS	GS	GS											
Cache Sl. near Ryers Ferry																2	2		

Table Notes: Numerical values indicate number of environmental samples collected annually. Additional samples may be collected for Quality Assurance. Values appended with "E" indicate that some or all of the monitoring will be "event-based" or episodic in nature.
Text entries indicate data or samples collected by primary coordinating programs: AMP = Sacramento River Ambient Program; NAQ = USGS NAWQA; CF = CALFED; GS = USGS
Funding for special tributary monitoring is set at 15% of a projected $500,000 monitoring budget.
(a) A fixed budget of $60,000 is allocated for Toxicity follow-up consisting of chemistry, TIE testing, and episodic monitoring that has no fixed frequency.
(b) Bioassessment monitoring includes both physical habitat and biological assessments. Sites are monitored once peryear, and values indicate number of sites in watershed.
(c) Includes 9 scheduled events, plus two episodic events consising of 6 samples each.

Table 40. SRWP Monitoring for 2001-2002: Locations, Analytes, and Numbers of Annual Sample Events

Monitoring Locations	Chemical Characteristics																		Aquatic Toxicity		Fish Tissue			Bioassess-ment[(b)]	
	Hg (unfiltered)	Hg (filtered)	MeHg (unfiltered)	MeHg (filtered)	TSS	Hardness	Alkalinity	TOC	DOC	UVA 254	TDS	Nitrogen and Phosphorus compounds	OP pesticides	carbamate pesticides	triazines	E. coli	Enterococcus	Total, Fecal Coliforms	Ceriodaphnia	WC Tox Followup (a)	Mercury	PCBs & chlor. pest.	Sampling	Benthic Invertebrates	Habitat Assessment
Pit R. above Shasta																			6 E	E				RB	RB
Sac. R. above Shasta																				E				(c)	
Sac. R. below Keswick	5 E	5 E	5 E	5 E	5 E	RED					RED		DWR	DWR					6 E	E	(c)	(c)	(c)	(c)	
Clear Creek	DWR		DWR		DWR	DWR							DWR	DWR										(c)	
Cow Creek at Mouth	DWR		DWR		DWR	DWR							DWR	DWR										(c)	
Cow Creek (multiple sites)																								(c)	
Cottonwood Ck at mouth	DWR		DWR		DWR	DWR							DWR	DWR					6 E	E				(c)	
Cottonwood Creek (multiple sites)	12 E	12 E	12 E	12 E	12 E																			(c)	
Battle Creek at mouth	DWR		DWR		DWR	DWR							DWR	DWR										(c)	
Battle Creek (multiple sites)	12 E	12 E	12 E	12 E	12 E																			(c)	
Sac. R. at Bend Br	5 E	5 E	5 E	5 E	5 E	6 E	6 E	6 E	6 E	6 E	6 E	6 E	DWR	DWR		6 E	6 E	6 E	6 E	E	(c)	(c)	(c)	(c)	
Paynes Ck	DWR		DWR		DWR	DWR							DWR	DWR										(c)	
Reeds Ck	DWR		DWR		DWR	DWR							DWR	DWR										TEH	TEH
Red Bank Ck	DWR		DWR		DWR	DWR							DWR	DWR										TEH	TEH
Elder Ck	DWR		DWR		DWR	DWR							DWR	DWR										(c)	
Antelope Ck	DWR		DWR		DWR	DWR							DWR	DWR										(c)	
Mill Creek @ Los Molinos	DWR		DWR		DWR	DWR							3 E								(c)	(c)	(c)	(c)	
Mill Creek (multiple sites)																								(c)	
Deer Creek	DWR		DWR		DWR	DWR							3 E											(c)	
Thomes Ck	DWR		DWR		DWR	DWR							DWR	DWR										(c)	
Thomes Creek (multiple sites)	12 E	12 E	12 E	12 E	12 E																			(c)	
Coast Range reservoirs (3)	DWR		DWR		DWR	DWR							DWR	DWR										(c)	
Stony Creek	DWR		DWR		DWR	DWR							DWR	DWR							(c)	(c)	(c)	(c)	
Stony Creek (multiple sites)																								(c)	
Dry Creek (trib to Little Chico Ck)	4 E	4 E	4 E	4 E	4 E																			(c)	
Little Chico Creek	4 E	4 E	4 E	4 E	4 E																			(c)	
Big Chico Creek	DWR		DWR		DWR	DWR							3 E											(c)	
Sac. R. near Hamilton City	5 E	5 E	5 E	5 E	5 E	6 E	6 E	6 E	6 E	6 E	6 E	6 E	6 E			6 E	6 E	6 E	6 E	E	(c)	(c)	(c)	(c)	
Sac. R. @ Colusa	5 E	5 E	5 E	5 E	5 E	6 E	6 E	6 E	6 E	6 E	6 E	6 E	6 E			6 E	6 E	6 E	6 E	E	(c)	(c)	(c)	(c)	
Butte Creek													DPR						DWR					(c)	
Sutter Bypass													DPR	DPR	DPR				DPR					(c)	
Ag Drains (Sutter, Colusa, Tehama Co.)																			6 E					RB	RB
Sac. Slough	4 E	4 E	4 E	4 E	4 E	6 E	6 E	6 E	6 E	6 E	6 E	6 E	6 E	6 E		6 E	6 E	6 E	6 E	E	(c)	(c)	(c)	(c)	
Colusa Basin Dr	4 E	4 E	4 E	4 E	4 E	6 E	6 E	6 E	6 E	6 E	6 E	6 E	6 E	6 E		6 E	6 E	6 E	6 E	E	(c)	(c)	(c)	(c)	
Bear River	GS		GS										DPR						DPR					(c)	
Bear River reservoirs																					GS			(c)	
Other Yuba River sites													DPR	DPR										(c)	
Yuba R. at Marysville	5 E	5 E	5 E	5 E	5 E	6 E	6 E	6 E	6 E	6 E	6 E	6 E	6 E	6 E		6 E	6 E	6 E	6 E	E				(c)	
South Yuba River sites	GS		GS																		GS			(c)	
Feather R. (multiple reference sites)																								RB	RB
Feather R. near Nicolaus	5 E	5 E	5 E	5 E	5 E	6 E	6 E	6 E	6 E	6 E	6 E	6 E	6 E		4 E	6 E	6 E	6 E	6 E	E	(c)	(c)	(c)	(c)	
Sac. R. at Veterans Br.	CMP	CMP	CMP		CMP	CMP	6	CMP	CMP	6	6	6	6 E		4 E	CMP	6	CMP			(c)	(c)	(c)	(c)	
Coon Ck/Auburn Ravine																								RB	RB
Arcade Creek	4 E	4 E	4 E	4 E	4 E								6 E	6 E	6 E				6 E	E				(c)	
Natomas East Main Drain						DWR	DWR	DWR	DWR	DWR	DWR	6				6 E	6 E	DWR			(c)	(c)	(c)	(c)	
American R. at J St.																					(c)	(c)	(c)	(c)	
American R. at Discovery Pk	CMP	CMP	CMP		CMP	CMP	atox	CMP	CMP	6	CMP	6	CMP			CMP	6	CMP	6 E	E	(c)	(c)	(c)	(c)	
Sac. R. at Freeport		CMP, GS			CMP	CMP	NAQ	CMP	CMP	6	CMP	6	NAQ	NAQ	NAQ	CMP	6	CMP	6 E	E				(c)	
Sac. R. at RM44	CMP	CMP	CMP		CMP	CMP	6	CMP	CMP	6	CMP	6	CMP			CMP	6	CMP			(c)	(c)	(c)	(c)	
Sac. R. at Greene's Landing																								(c)	
Yolo Bypass	GS		GS		GS	GS		GS	GS	GS	GS		GS	GS	GS									(c)	
Cache Creek at Rumsey					CF	CF		CF	CF	CF	CF								6 E	E				(c)	
Cache Sl. near Ryers Ferry																					(c)	(c)	(c)	(c)	

Table Notes: Values indicate number of environmental samples collected annually. Additional samples are collected for Quality Assurance. Values appended with "E" indicate that monitoring will be "event-based". Text entries indicate data or samples collected by primary coordinating programs: CMP = Sacramento River Coordinated Monitoring Program; NAQ = USGS NAWQA; CF = CALFED; GS = USGS; RB =Central Valley Regional Board
(a) A fixed budget of $60,000 is allocated for Toxicity follow-up consisting of chemistry, TIE testing, and additional sampling that has no fixed frequency.
(b) Bioassessment monitoring includes both physical habitat and biological assessments. Sites are monitored once peryear, and values indicate number of sites in watershed.
(c) Specifics To Be Determined

IV. Database and Data Access

Larry Walker Associates (LWA) is responsible for both data management and database development for the Sacramento River Watershed Program. All data collected by the SRWP is stored in a normalized, relational database (Microsoft Access 97) specifically designed by LWA and the Department of Water Resources (Interagency Ecological Program) to house water chemistry, toxicity test, and bioassessment data. Various sampling crews and laboratories contracted to collect and analyze the Program's monitoring data provide the data manager (LWA) with electronic and hard copy data that are then imported into the SRWP Database. Once monitoring data is entered into the database, and qualified if necessary, it is ready to be exported to the Interagency Ecological Program's (IEP) Bay-Delta Tributary Database (BDTDB). The IEP Database Management System (http://www.iep.ca.gov/dbms/) allows stakeholders and other interested parties to access SRWP monitoring data through the use of its Database Interaction Map (DBIMap) web interface for the Bay-Delta Tributary Database. This web interface is a data viewing and retrieval tool with the ability to query data both spatially and by selected search criteria. Queries by selected criteria allow specific values to be searched in the database. Spatial queries allow selected areas on a map to be used to search data in the database. Selected search criteria and spatial queries can be used independently or in combination. Data users can download SRWP data from the Bay-Delta Tributary Database in HTML, Excel, and Text File formats for further inspection. Note that the IEP Bay-Delta Tributary Database interface is still undergoing revision at this time, and that accessibility of SRWP data will continue to improve as the IEP database improves.

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APPENDIX A

Beneficial Uses in the Sacramento River Basin (CVRWQCB 1994)

The Central Valley Region Basin Plan is available at:

http://www.swrcb.ca.gov/~rwqcb5/bsnplnab.pdf

APPENDIX B

Basin Plan Numeric Water Quality Objectives (CVRWQCB 1994)

The Central Valley Region Basin Plan is available at:

http://www.swrcb.ca.gov/~rwqcb5/bsnplnab.pdf

APPENDIX C

National Toxics Rule and California Toxics Rule Water Quality Criteria

The National Toxics Rule is available at:

http://www.epa.gov/fedrgstr/EPA-WATER/1995/May/Day-04/pr-107DIR/fulltext.html

The California Toxics Rule is available at:

http://www.epa.gov/OST/standards/ctrindex.html

APPENDIX D

Review of Quality Assurance Data

Review of Quality Assurance Data

The Quality Assurance procedures for the 1999-2000 SRWP monitoring program are documented in the Quality Assurance Project Plan (QAPP) (LWA 1999). This appendix documents the types of quality control assessments used in the SRWP monitoring program (described below and summarized in Tables 1 through 6), and presents the results of those evaluation.. Detailed procedures for preparation and analysis of quality control samples are provided in the analytical method documents referenced in the QAPP.

Quality Assurance Procedures and Objectives

Qualitative Objectives

Comparability— Comparability of the data can be defined as the similarity of data generated by different monitoring programs. For the purpose of the SRWP Monitoring Program, this objective is addressed primarily by using standard sampling and analytical procedures where possible. Additionally, comparability of analytical data is addressed by analysis of standard reference materials (discussed subsequently in this document).

Representativeness—Representativeness can be defined as the degree to which the environmental data generated by the monitoring program accurately and precisely represent actual environmental conditions. For the SRWP, this objective is addressed by the overall design of the monitoring program. Specifically, assuring the representativeness of the data is addressed primarily by selecting appropriate locations, methods, times, and frequencies of sampling for each environmental parameter, and by maintaining the integrity of the sample after collection. Each of these elements of the quality assurance program are addressed elsewhere in this document.

Completeness

Data completeness is a measure of the amount of successfully collected and validated data relative to the amount of data planned to be collected for the project. Completeness is usually expressed as a percentage value. A project objective for percent completeness is typically based on the percentage of the data needed for the program or study to reach valid conclusions. Because the SRWP is intended to be a long term monitoring program, data that are not successfully collected for a specific sample event or site can typically be recollected at a later sampling event. For this reason, most of the data planned for collection can not be considered absolutely critical, and it is difficult to set an meaningful objective for data completeness. However, some reasonable objectives for data are desirable, if only to measure the effectiveness of the Monitoring Program. The following program goals for data completeness are based on the planned sampling frequency and a subjective determination of the relative importance of the monitoring element within the Monitoring Program:

Table 1. SRWP goals for data completeness.

Monitoring Element	Completeness Objective
Trace Metals	90%
Pesticides	90%
General Water Quality Constituents	90%
Pathogens	90%
Aquatic Toxicity	90%
Sediment Toxicity	100%
Benthic Invertebrates	100%
Algae	100%
Fish Tissue	85%

Field Procedures

For basic water quality analyses, quality control samples to be prepared in the field consisted of field blanks and field duplicates.

Field Blanks

The purpose of analyzing field blanks is to demonstrate that sampling procedures and equipment do not result in contamination of the environmental samples. Field blanks were generally prepared and analyzed for all analytes of interest at the rate of one per sample event, along with the associated environmental samples. Field blanks consisted of laboratory-prepared blank water processed through the sampling equipment using the same procedures used for environmental samples. If the concentration in the associated environmental samples was less than five times the value detected in the field blank, the results for the environmental samples may be affected by contamination and were qualified as *below detection* at the reported value.

Field Duplicates

The purpose of analyzing field duplicates is to demonstrate the precision of sampling and analytical processes. Field duplicates were prepared and analyzed at a rate of 1 per event for most analytes. Field duplicates consisted of two aliquots from the same composite sample, or of two grab samples collected in rapid succession. If the relative Percent Difference (RPD) of field duplicate results was greater than 25% and the absolute difference is greater than the RL, environmental results were qualified as *estimated*.

Laboratory Analyses

For basic water quality analyses, quality control samples prepared in the contract laboratory(s) will typically consist of equipment blanks, method blanks, standard reference materials, laboratory duplicates, matrix spikes, and matrix spike duplicates. Laboratory analyses for *Giardia* and *Cryptosporidium*, and coliform bacteria will include negative and positive quality control samples, as specified in the method documents.

Equipment Blanks

The purpose of analyzing equipment blanks is to demonstrate that sampling equipment is free from contamination. Prior to using sampling equipment for the collection of environmental samples, the laboratory responsible for cleaning and preparation of the equipment will prepare bottle blanks and sampler blanks. These were prepared and analyzed at the rate of one each per batch of bottles or sampling equipment. The blanks were analyzed using the same analytical methods specified for environmental samples.

Method Blanks

The purpose of analyzing method blanks is to demonstrate that the analytical procedures do not result in sample contamination. Method blanks were prepared and analyzed by the contract laboratory at a rate of at least one for each analytical batch. Method blanks consisted of laboratory-prepared blank water processed along with the batch of environmental samples. If the result for a single method blank was greater than the MDL, the source(s) of contamination should be corrected, and the associated samples should be reanalyzed. If reanalysis was not possible, the associated sample results were qualified as *below detection* at the reported value.

Laboratory Control Samples

The purpose of analyzing laboratory control samples is to demonstrate the accuracy of the analytical method. Laboratory control samples were analyzed at the rate of one per sample batch for most analytes. Laboratory control samples consisted of laboratory fortified method blanks. If recovery of any analyte is outside the acceptable range for accuracy, the analytical process is not being performed adequately for that analyte. In this case, the sample batch should be prepared again, and the laboratory control sample should be reanalyzed. If reanalysis was not possible, the associated sample results were qualified as *low or high biased*.

Laboratory Duplicates

The purpose of analyzing laboratory duplicates is to demonstrate the precision of the analytical method. Laboratory duplicates were analyzed at the rate of one pair per sample batch. Laboratory duplicates will consist of duplicate laboratory fortified method blanks. If the Relative Percent Difference (RPD) for any analyte is greater than the precision criterion *and* the absolute difference between duplicates is greater than the RL, the analytical process is not being performed adequately for that analyte. In this case, the sample batch should be prepared again, and laboratory duplicates should be reanalyzed. If reanalysis was not possible, the associated sample results were qualified as *not reproducible* due to analytical variability.

Matrix Spikes and Matrix Spike Duplicates

The purpose of analyzing matrix spikes and matrix spike duplicates is to demonstrate the performance of the analytical method in a particular sample matrix. Matrix spikes and matrix spike duplicates were typically analyzed at the rate of one pair per sample batch for most analytes. Each matrix spike and matrix spike duplicate consisted of an aliquot of laboratory-fortified environmental sample.

If matrix spike recovery of any analyte is outside the acceptable range, the results for that analyte have failed the acceptance criteria for that specific matrix. If recovery of laboratory control samples is acceptable, the analytical process is being performed adequately for that analyte, and the problem is attributable to the sample matrix. If the matrix problem can't be corrected, the results for that analyte were qualified as appropriate (*low or high biased*) due to matrix interference.

If matrix spike duplicate RPD for any analyte is greater than the precision criterion, the results for that analyte have failed the acceptance criteria for that specific matrix. If the RPD for laboratory duplicates is acceptable, the analytical process is being performed adequately for that analyte, and the problem is attributable to the sample matrix. If the matrix problem can't be corrected, the results for that analyte were qualified as *not reproducible*, due to matrix interference.

Aquatic and Sediment Toxicity Quality Control

For aquatic and sediment toxicity tests, the acceptability of test results was determined primarily by performance-based criteria for test organisms, culture and test conditions, and the results of control bioassays. Control bioassays included testing with reference toxicants, reference sediments, and negative and solvent controls. Test acceptability requirements are documented in the method documents for each bioassay method and in the QAPP.

In addition to the QA requirements for the toxicity testing methods, a total of twenty percent of the samples collected for aquatic toxicity testing were reserved for other QC analyses. Ten percent of aquatic toxicity samples were split and tested at the California Department of Fish and Game Laboratory at Elk Grove. An additional ten percent of analyses consisted of laboratory splits, spikes, and blanks. The results of duplicate and interlaboratory split analyses are considered acceptable if the results are not significantly different at the 95% confidence level *or* the RPD for the results is less than 30%. Acceptable results for tests with blanks are no significant toxicity. Although the laboratory has no formal limit of acceptability for analysis of spiked samples, the pattern and progress of toxic responses are evaluated subjectively for consistency with expected responses for the level of the spiked compound.

Benthic Invertebrates Processing and Analysis

Accuracy of identifications and precision of enumeration of benthic invertebrate collections was assessed by re-analysis of samples at the rate of one for every ten samples analyzed. This consisted of complete re-examination of the organisms in the archived original sample, including remnants from the sorting process. If any additional organisms are identified in the "remnant" fraction of the archived sample, the numbers of taxa and organisms was recorded. The total number of organisms and enumeration of individual taxa for the re-examined sample should be within 5% of the original total. Discrepancies in taxonomic identification or enumeration were resolved by consultation between taxonomic analysts.

Fish Tissue

Quality control requirements and assessment procedures for analysis of contaminants in fish tissue were generally similar to those for water quality samples (documented above). However, for analysis of PCBs and chlorinated pesticides, surrogate compounds (internal standards) were added to each sample to assess analytical accuracy of classes of similar compounds. The acceptable range for recovery of surrogate compounds was set by the analyzing laboratory. If surrogate recoveries were outside the defined range, the sample batch was prepared again and reanalyzed. If reanalysis was not possible, the associated environmental data for all analytes by the specific method was qualified as low or high biased, consistent with the surrogate recovery bias. If surrogate recovery bias is inconsistent for different surrogate compounds, the associated environmental data was qualified as biased due to indeterminate surrogate recovery bias.

Table 2a. Project Quality Control Requirements for Analysis of Water Quality Samples for Trace Metals, Organic Carbon, and General Water Quality Constituents.

QA Procedure	QA Parameter	Frequency	Criterion	Corrective Action
Equipment Blanks: • bottle blanks • sampler blanks	Contamination	1 per bottle or reagent batch.	< MDL	Identify contamination source. Reclean equipment. Reanalyze blank(s).
Field Blanks	Contamination	1 per event (trace metals and TOC)	< RL *or* < sample ÷ 5	Examine field log. Identify contamination source. Qualify data as needed.
Field Duplicate	Precision	1 per event	RPD ≤ 25% if |Difference| ≥ RL	Reanalyze both samples. Identify variability source. Qualify data as needed.
Method Blank	Contamination	≥1 per batch (trace metals and TOC)	< MDL *or*, if n≥3, avg ± 2 s.d. < RL	Identify contamination source. Reanalyze method blank and all samples in batch.
LCS or SRM	Accuracy	1 per batch	80-120% REC	Recalibrate and reanalyze LCS or SRM and samples
Lab Duplicate	Precision	1 per batch	RPD ≤ 20% if |Difference| ≥ RL	Recalibrate and reanalyze.
Matrix Spike	Accuracy	1 per batch	80-120% REC	Check SRM recovery. Attempt to correct matrix problem and reanalyze sample. Qualify data as needed.
Matrix Spike Duplicate	Precision	1 per batch	RPD ≤ 20%	Check lab dup RPD. Attempt to correct matrix problem and reanalyze samples. Qualify data as needed.
Assess percent of data successfully collected	Data Completeness	1 per planned sample event	90%	Reschedule sample events as necessary or appropriate.

MDL = Method Detection Limit; RL = Reporting Limit; RPD = Relative Percent Difference; RSD = Relative Standard Deviation; REC = Recovery; LCS = Laboratory Control Sample; SRM = Standard Reference Material (=Certified Reference Material)

Table 2b. Project Quality Control Requirements for Analysis of Water Quality Samples: Requirements for Triazine Pesticide Analyses by EPA Method 619.

QA Procedure	QA Parameter	Frequency[1]	Criterion	Corrective Action
Equipment Blanks: • bottle blanks • sampler blanks	Contamination	1 per bottle or reagent lot	< MDL	Identify contamination source. Reclean equipment. Reanalyze blank(s).
Field Blanks	Contamination	1 per 3 events	< RL *or* < sample ÷ 5	Examine field log. Identify contamination source. Qualify data as needed.
Field Duplicate	Precision	1 per 6 events	RPD ≤ 25% if |Difference| ≥ RL	Reanalyze both samples. Identify variability source. Qualify data as needed.
Matrix Spike & LCS Atrazine Terbutryn Tributylphosphate Triphenlyphosphate	Accuracy	1 per batch	 28-163% REC 60-117% REC 60-150% REC 76-140% REC	Check SRM recovery. Attempt to correct matrix problem and reanalyze sample. Qualify data as needed.
Matrix Spike & LCS Duplicates: Atrazine Terbutryn	Precision	1 per batch	 31% RPD 25% RPD	Check lab dup RPD. Attempt to correct matrix problem and reanalyze samples. Qualify data as needed.
Assess percent of data successfully collected	Data Completeness	1 per event	90%	Reschedule sample events as necessary or appropriate.

Notes: MDL = Method Detection Limit; RL = Reporting Limit; RPD = Relative Percent Difference; RSD = Relative Standard Deviation; REC = Recovery; LCS = Laboratory Control Sample; SRM = Standard Reference Material (=Certified Reference Material)

(1) The term “lot” refers to a set of bottles or reagents identifiable by a common production lot number, or to sampling equipment subjected to the same cleaning procedures as a set.
The term “batch”, as used in this document, refers to an uninterrupted series of analyses.

Table 2c. Project Quality Control Requirements for Analysis of Water Quality Samples: Requirements for Organophosphorus Pesticide Analyses by EPA Method 8141A.

QA Procedure	QA Parameter	Frequency[1]	Criterion	Corrective Action
Equipment Blanks: • bottle blanks • sampler blanks	Contamination	1 per bottle or reagent lot	< MDL	Identify contamination source. Reclean equipment. Reanalyze blank(s).
Field Blanks	Contamination	1 per event	< RL *or* < sample ÷ 5	Examine field log. Identify contamination source. Qualify data as needed.
Field Duplicate	Precision	1 per 2 events	RPD ≤ 25% if |Difference| ≥ RL	Reanalyze both samples. Identify variability source. Qualify data as needed.
Matrix Spike & LCS Phorate Diazinon Disulfoton Methyl Parathion Stirophos Ethion Tributylphosphate Triphenlyphosphate	Accuracy	1 per batch	 22-96% REC 57-130% REC 47-117% REC 55-164% REC 68-128% REC 65-134% REC 60-150% REC 76-140% REC	Check SRM recovery. Attempt to correct matrix problem and reanalyze sample. Qualify data as needed.
Matrix Spike & LCS Duplicates: Phorate Diazinon Disulfoton Methyl Parathion Stirophos Ethion	Precision	1 per batch	 24% RPD 21% RPD 22% RPD 24% RPD 25% RPD 20% RPD	Check lab dup RPD. Attempt to correct matrix problem and reanalyze samples. Qualify data as needed.
Assess percent of data successfully collected	Data Completeness	1 per event	90%	Reschedule sample events as necessary or appropriate.

Notes: MDL = Method Detection Limit; RL = Reporting Limit; RPD = Relative Percent Difference; RSD = Relative Standard Deviation; REC = Recovery; LCS = Laboratory Control Sample; SRM = Standard Reference Material (=Certified Reference Material)

(1) The term “lot” refers to a set of bottles or reagents identifiable by a common production lot number, or to sampling equipment subjected to the same cleaning procedures as a set.
The term “batch”, as used in this document, refers to an uninterrupted series of analyses.

Table 2d. Project Quality Control Requirements for Analysis of Water Quality Samples: Requirements for Carbamate Pesticide Analyses by EPA Method 8321.

QA Procedure	QA Parameter	Frequency[1]	Criterion	Corrective Action
Equipment Blanks: • bottle blanks • sampler blanks	Contamination	1 per bottle or reagent lot	< MDL	Identify contamination source. Reclean equipment. Reanalyze blank(s).
Field Blanks	Contamination	1 per 3 events	< RL *or* < sample ÷ 5	Examine field log. Identify contamination source. Qualify data as needed.
Field Duplicate	Precision	1 per 6 events	RPD ≤ 25% if |Difference| ≥ RL	Reanalyze both samples. Identify variability source. Qualify data as needed.
Matrix Spike & LCS Methomyl Bromacil Neburon Oryzalin	Accuracy	1 per batch	 37-113% REC 58-111% REC 55-132% REC 40-140% REC	Check SRM recovery. Attempt to correct matrix problem and reanalyze sample. Qualify data as needed.
Matrix Spike & LCS Duplicates: Methomyl Bromacil Neburon	Precision	1 per batch	 25% RPD 25% RPD 25% RPD	Check lab dup RPD. Attempt to correct matrix problem and reanalyze samples. Qualify data as needed.
Assess percent of data successfully collected	Data Completeness	1 per event	90%	Reschedule sample events as necessary or appropriate.

Notes: MDL = Method Detection Limit; RL = Reporting Limit; RPD = Relative Percent Difference; RSD = Relative Standard Deviation; REC = Recovery; LCS = Laboratory Control Sample; SRM = Standard Reference Material (=Certified Reference Material)

(1) The term "lot" refers to a set of bottles or reagents identifiable by a common production lot number, or to sampling equipment subjected to the same cleaning procedures as a set.
The term "batch", as used in this document, refers to an uninterrupted series of analyses.

Table 3. Project Quality Control Requirements for Analysis of Water Quality Samples for Pathogens.

QA Procedure	Parameter	Frequency[1]	Criterion	Corrective Action
Coliform Bacteria Analyses				
Field Blanks	Contamination	1 per event	< RL *or* < sample ÷ 5	Examine field log. Identify contamination source. Qualify data as needed.
Method Blanks (Sterility Checks)	Contamination	1 per batch	< RL	Identify contamination source. Clean equipment and slides. Check reagents. Re-analyze blank.
Lab Duplicate	Precision[2]	1 per 10 samples, & at least 1 per batch	$R_{log} \leq 3.27 \bullet$mean R_{Log}	Recalibrate and reanalyze.
Cryptosporidium and Giardia Analyses				
Method Blanks	Contamination	1 per 20 samples	<1 cyst	Identify contamination source. Clean equipment and slides. Check reagents. Re-analyze blank.
Ongoing Precision and Recovery Samples	Precision	1 per 20 samples	56% RPD	Identify and correct problem. Re-examine OPR sample.
Ongoing Precision and Recovery Samples	Accuracy	1 per 20 samples	10-100% REC	Identify and correct problem. Re-examine OPR sample.
Matrix Spike	Accuracy	1 per 20 samples	11-100% REC	Attempt to correct matrix problem and reanalyze sample. Qualify data as needed.
All Pathogen Analyses				
Negative Control Samples	Contamination	1 per culture medium or reagent lot	< RL	Identify source. Clean equipment and prepare new media. Re-examine negative control
Negative Control Samples	Assay function	1 per culture medium or reagent lot	≥ RL	Identify and correct problem. Re-examine positive control.
Assess percent of data successfully collected	Data Completeness	1 per planned sample event	90%	Reschedule sample events as necessary or appropriate.

Notes: MDL = Method Detection Limit; RL = Reporting Limit; RPD = Relative Percent Difference; RSD = Relative Standard Deviation; REC = Recovery; LCS = Laboratory Control Sample; SRM = Standard Reference Material (=Certified Reference Material)

(1) The method documentation defines an analytical batch as an “uninterrupted series of analyses”.

(2) R_{log} is the absolute difference between logarithms of coliform counts for duplicate analyses. The mean R_{log} is determined by performing duplicate analyses on the first 15 positive sample analyzed for each matrix type.

Table 4. Project Quality Control Requirements for Analysis of Benthic Invertebrates and Algae.

QA Procedure	Parameter	Frequency	Criterion	Corrective Action
Split Samples	Accuracy Precision	1 per 10 algal samples	*See USGS 1997* *See USGS 1997*	Resolve differences in identification and enumeration.
Re-examination of sample	Accuracy Precision	1 per 10 benthic invertebrate samples	≤5% difference ≤5% difference	Resolve differences in identification and enumeration.
Assess percent of data successfully collected	Data Completeness	1 per planned sample event	100%	Reschedule sample events as necessary or appropriate.

Table 5. Project Quality Control Requirements for Analysis of Fish Tissue for Mercury.

QA Procedure	Parameter	Frequency	Criterion	Corrective Action
Method Blank (a.k.a. analytical blank or lab reagent blank)	Contamination	1 per batch	< MDL *or* < 10% of lowest sample	Identify contamination source. Reanalyze method blank and all samples in batch.
SRM (a.k.a. certified reference material)	Accuracy	1 per batch of 20 or fewer samples	Within 20% of the certified 95% confidence interval, *or* within 20% of the certified mean	Review raw data quantitation reports Check instrument response using calibration standard Recalibrate and reanalyze SRM and samples Repeat analysis until control limits are met
SRM (a.k.a. certified reference material)	Precision	1 per batch of 20 or fewer samples	RPD ≤ 35%, *or* RSD ≤ 30%	Recalibrate and reanalyze. If problem persists eliminate source of imprecision and reanalyze.
Field Duplicate (two aliquots from same composite sample: RMP calls this a lab duplicate)	Precision	1 per batch	RPD ≤ 35%	Recalibrate and reanalyze. If problem persists eliminate source of imprecision and reanalyze.
Matrix Spike	Accuracy	1 per batch	> 50% REC	Check SRM or LCS recovery. Review raw data quantitation reports Check instrument response using calibration standard Attempt to correct matrix problem and reanalyze sample. Qualify data as needed.
Matrix Spike Duplicate	Precision	1 per batch	RPD ≤ 35%	Check lab duplicate RPD. Review raw data quantitation reports Check instrument response using calibration standard Attempt to correct matrix problem and reanalyze samples. Qualify data as needed.
Assess percent of data successfully collected	Data Completeness	1 per planned sampling event	85%	Reschedule sampling as necessary or appropriate.

MDL = Method Detection Limit; RL = Reporting Limit; RPD = Relative Percent Difference; RSD = Relative Standard Deviation; REC = Recovery; LCS = Laboratory Control Sample; SRM = Standard Reference Material (=Certified Reference Material)

Table 6. Project Quality Control Requirements for Analysis of Fish Tissue for Organochlorine Pesticides and PCBs.

QA Procedure	Parameter	Frequency	Criterion	Corrective Action
Method Blank (a.k.a. analytical blank or lab reagent blank)	Contamination	1 per batch	< MDL *or* < 10% of lowest sample	Identify contamination source. Reanalyze method blank and all samples in batch.
SRM (a.k.a. certified reference material)	Accuracy	1 per batch of 20 or fewer samples	As a group: 70% of the analytes within 35% of the 95% confidence interval Individually: No analyte >30% of 95% confidence interval for 2 consecutive analyses	Review chromatograms and raw data quantitation reports Check instrument response using calibration standard Recalibrate and reanalyze SRM and samples Repeat analysis until control limits are met
SRM (a.k.a. certified reference material)	Precision	1 per batch of 20 or fewer samples	RPD ≤ 35%, *or* RSD ≤ 30%	Recalibrate and reanalyze. If problem persists eliminate source of imprecision and reanalyze.
Field Duplicate (two aliquots from same composite sample: RMP calls this a lab duplicate)	Precision	1 per batch	RPD ≤ 35%	Recalibrate and reanalyze. If problem persists eliminate source of imprecision and reanalyze.
Matrix Spike	Accuracy	1 per batch	> 50% REC	Check SRM or LCS recovery. Review chromatograms and raw data quantitation reports Check instrument response using calibration standard Attempt to correct matrix problem and reanalyze sample. Qualify data as needed.
Matrix Spike Duplicate	Precision	1 per batch	RPD ≤ 35%	Check lab duplicate RPD. Review raw data quantitation reports Check instrument response using calibration standard Attempt to correct matrix problem and reanalyze samples. Qualify data as needed.
Surrogate Spike	Accuracy	1 per batch	set by analyzing laboratory	Check SRM or LCS recovery. Attempt to correct matrix problem and reanalyze sample. Qualify data as needed.
Assess percent of data successfully collected	Data Completeness	1 per planned sampling event	85%	Reschedule sampling as necessary or appropriate.

MDL = Method Detection Limit; RL = Reporting Limit; RPD = Relative Percent Difference; RSD = Relative Standard Deviation; REC = Recovery; LCS = Laboratory Control Sample; SRM = Standard Reference Material (=Certified Reference Material)

Summary of Quality Control Data

Aquatic Toxicity

For SRWP samples collected and analyzed in 1999-2000, aquatic toxicity tests met all performance criteria and all reported data were unqualified. The results for quality assurance analyses for aquatic toxicity testing are presented in quarterly monitoring data summaries produced by the University of California Davis Aquatic Toxicology Laboratory.

The overall completion rate was greater than the 90% objective for the program, and this monitoring element provided data that were adequate for the purposes of the SRWP.

Sediment Toxicity

For SRWP samples collected in 1999 and 2000, sediment toxicity tests with *Ceriodaphnia* and *Hyalella* met all performance criteria for these analyses. The overall completion rate was 100% and this monitoring element provided data that were adequate for the purposes of the SRWP.

Fish Tissue Monitoring

The results of Quality Assurance analyses performed for 1999 fish tissue monitoring are reported in "Quality Assurance/Quality Control Document for the Sacramento River Toxic Pollutant Control Program" prepared by the California Department of Fish and Game.

A problem with low recoveries for mercury analyses was discovered during analysis of the 1999 fish tissue samples. The problem was corrected and because the low recoveries may have affected the previous year's data, all 1999 and 1998 fish tissue samples were reanalyzed. All of the reanalyzed results met data quality objectives, and replaced all of the previous results. The overall completion rate was greater than the 85% objective for the program, and this monitoring element provided data that were adequate for the purposes of the SRWP.

Bioassessment

Quality assurance analyses for 1998-99 benthic macroinvertebrate analyses performed by DWR are reported in "Sacramento River Watershed Program: QC Analysis of DWR 1998 Taxonomic Data: prepared by the California Department of Fish and Game (CDFG). The results of this report are as follows:

- Some of the planned QA assessments could not be completed properly because the DWR laboratory analyzed complete samples instead of a 300-count sub-sample. This prevented evaluation of enumeration discrepancies and comparison of calculated metrics. This variance from the QAPP also prevents combining DWR's 1998 results directly with the CDFG's results as originally intended by the SRWP monitoring plan. Comparable results and comparison of calculated metrics can still be performed with the 1998 data but would require complex statistical reanalysis of DWR's results.

- The most common identification discrepancies fell into two categories: failure to distinguish between multiple taxa in single vials, and disputed identifications of a few difficult taxa. Note that disputed taxonomic identifications may be due to errors by either laboratory, and are usually resolved by repeated consultation between laboratories.

The overall completion rate for bioassessment is approximately 50%, due to variances from SRWP analytical protocols by DWR's laboratory in analyzing the 1998 data, and delays in reporting the 1999 data. Data produced by the Department of Fish and Game Aquatic Biology Lab resulted from procedures consistent with the SRWP QAPP, and are adequate for the purposes of this program. Samples collected by DWR in 1999 were analyzed using SRWP QAPP procedures and should provide results that are directly comparable to those provided by the CDFG Aquatic Biology Lab. However, because the Quality Assurance analyses have not been completed and fully reported, it is not yet known whether data produced by the DWR analytical laboratory are adequate for the purposes of the SRWP.

Water Column Chemistry and Microbiology Monitoring

Quality control data for SRWP monitoring data collected from June 1999 through May 2000 are summarized below. Quality control data were evaluated using methods documented in the Quality Assurance Project Plan (QAPP) for the SRWP (LWA 1998). Sample results were reviewed for conformance with recommended allowable holding times for specific analyses and for compliance with SRWP Monitoring Program data quality objectives for laboratory and external QC results. Internal laboratory QC data reviewed include results for method blanks, laboratory control samples (standard reference materials), laboratory duplicates, matrix spikes, and matrix spike duplicates. Field and external laboratory QC data reviewed include results for field blanks and field duplicates. Program specifications for data quality are summarized in Tables 1-6 .

Holding Times

Data quality objectives for holding times generally conformed to EPA recommendations specified for the analytical methods used for individual parameters. Allowable holding times for the project ranged from 24 hours for microbiological analyses to 6 months for metals and hardness (after preservation). 96% of the total analyses were performed within acceptable holding times. Analyses performed outside of acceptable limits resulted in qualification of 370 analytical results (for orthophosphate, TDS, TSS, turbidity, coliform bacteria, and organophosphate pesticides). Most of the qualified data (192 of 370) were for individual OP pesticide analytes from only two samples analyzed just past the 40-day holding time. Coliform bacteria analyses were the most problematic, due to the short holding time and the logistics of getting samples to the lab from distant sampling locations. A summary of allowable holding times and compliance for individual analytes is presented in Table 7.

Laboratory Method and Filter Blanks

Laboratory method blanks and filter blanks were analyzed to evaluate the potential for contamination attributable to analytical reagents and sample processing. The project data quality objective for laboratory method and filter blanks was defined as below the project reporting limit. If detectable levels of an analyte were determined to be present in method or filter blanks, sample results were accepted without qualification if the associated environmental sample results were greater than five times the concentration detected in the blank. If detectable levels of an analyte were determined to be present in method or filter blanks and associated environmental sample results were less than five (5) times the concentration detected in the blank, the reported analytical results were qualified as an upper limit of the actual sample result.

For SRWP 1999-2000 monitoring results, chromium, copper, lead, mercury, zinc, TDS, TDS, alkalinity, iron, and silica were detected at greater than program reporting limits in laboratory method blanks in 21 of 1647 analyses. The overall success rates for analyses of laboratory method and filter blanks was 99%. Analytes detected in method blanks did not result in qualification of any analytical results. These results indicate that laboratory contamination of water quality samples is not a significant problem. Results for laboratory method blanks are summarized in Table 8.

Laboratory Control Sample Recoveries

Laboratory control samples were analyzed to evaluate analytical accuracy. If recoveries were outside the acceptable range for the analysis, associated samples results were qualified as “low- or high-biased” as indicated by the control sample recovery.

For SRWP 1999-2000 monitoring results, 49 of 1,158 laboratory control sample recoveries were outside project specifications, including 41 pesticide analyses. A total of 12 analytical results were qualified on the basis of lab control sample recoveries, with no pesticide results requiring qualification. The overall success rate for analysis of laboratory control samples was 993% for organophosphate pesticide analyses, 100% for carbamate pesticide analyses, 92% for triazine pesticide analyses, and 99% for all other analyses. These results indicate that analytical accuracy was adequate for analysis of water quality samples for the project. Results for laboratory control sample recoveries are summarized in Tables 9a–9d.

Laboratory Duplicates

Analyses of duplicate samples were conducted to evaluate analytical precision. If laboratory duplicate results were outside the project data quality objective, associated samples results were qualified as “estimated” (not reproducible) due to analytical variability. An RPD greater than the project data quality objective was not considered cause for qualification of analytical results if measured differences between replicates were less than the reporting limit, or if matrix spike duplicate results were acceptable.

For SRWP 1999-2000 monitoring results, 8 of 130 laboratory duplicate results were outside program specification. The overall success rate for analyses of laboratory control sample duplicate RPDs was 94%. No environmental data were qualified on the basis of laboratory duplicate analyses. These results indicate that analytical precision was adequate to produce reliable data for the SRWP. Results for laboratory duplicate analyses are summarized in Table 10.

Matrix Spike Recoveries

Analyses of matrix spike samples (spiked environmental samples) were performed to evaluate the effect of water quality sample matrix on analytical accuracy. When a matrix spike recovery does not meet the project data quality objective, associated sample results are considered "low- or high-biased" due to matrix interference, as indicated by the recovery.

For SRWP 1999-2000 monitoring results, reported matrix spike recoveries exceeded program specifications for analyses of TDS, total Kjeldahl nitrogen, total phosphorus, calcium, iron, magnesium, and manganese for a total of 19 of 324 pesticide analyses, and 19 of 208 other analyses. A total of 17 analytical results were qualified on the basis of matrix spike recoveries outside the range of the project data quality objectives. The overall success rates for analyses of matrix spike recoveries were 94% and 91%, for pesticide and other analyses, respectively. In combination with the results for laboratory control samples, these results indicate that matrix interference did not represent a significant problem and that analytical accuracy was adequate to produce reliable data for water quality samples for the SRWP. Results for matrix spike recoveries are summarized in Tables 11a and 11b.

Matrix Spike Duplicates

Analyses of matrix spike duplicate samples were performed to evaluate the effect of water quality sample matrix on analytical precision. If matrix spike duplicate results were outside this range, associated samples results were qualified as "estimated" (not reproducible) due to matrix variability.

For SRWP 1999-2000 monitoring results, nearly all matrix spike duplicate RPDs reported were within program specifications for all analytes. Matrix spike duplicate RPDs exceeded project objectives in a total of 4 of 204 analyses. A total of 4 environmental data were qualified on the basis of these results. The overall success rate for analyses of matrix spike duplicates was 98%. In combination the results for laboratory duplicates, these results indicate that matrix interference did not represent a significant problem and that analytical precision was adequate to produce reliable data for water quality samples for the SRWP. Results for matrix spike duplicate RPDs are summarized in Table 12.

Field Blanks

Field blanks were submitted and analyzed to evaluate the potential for sampling equipment and procedures to contaminate water quality samples. The project data quality objective for field and equipment blanks was defined as below the program reporting limit. If detectable levels of an analyte were determined to be present in field blanks, sample results were accepted without qualification if the environmental results were greater than five (5) times the concentrations detected in the blank. If detectable levels of an analyte were determined to be present in field or equipment blanks and sample results were less than five (5) times the concentrations detected in the blank, the reported results were qualified as an upper limit of the true sample concentration.

For SRWP 1999-2000 monitoring results, SRWP analytes were detected above reporting limits in 6 of 316 field blank analyses: 4 dissolved organic carbon analyses and 2 total organic carbon analyses. Field blank analyses resulted in the qualification of 33 environmental organic carbon data. The problem with the organic carbon analyses was determined to be due to a change in the formulation of filters used in sample collection and was corrected early in the monitoring season. The overall success rate for analysis of field blanks was 98%. Results of analyses of field blanks indicate that sampling procedures and equipment were generally adequate to prevent detectable or significant levels of contamination of samples collected for the SRWP. Results for field blank analyses are summarized in Table 13.

Field Duplicates

The purpose of analyzing duplicate field samples is to measure the reproducibility (i.e. precision) of analyte concentrations in field samples from replicate composite or grab samples. The results provide a measure of the variability attributable to sampling and sample handling procedures after sample collection. The project data quality objective for duplicates field samples was defined as a relative percent difference (RPD) of less than or equal to 25%. Duplicate RPDs outside this range resulted in the qualification of sample result data as “estimated” (not reproducible) due to sample variability. An RPD greater than 25% was not considered cause for qualification of data if measured differences between replicates were less than the reporting limit.

For SRWP 1998-99 monitoring results, field duplicate RPDs exceeded program specifications for 11 of 718 pairs of analyses. Analysis of field duplicates resulted in qualification of 11 environmental data. The overall success rate for analysis of field duplicates was 98%. These results indicate that sampling and sample handling-generated variability was not excessive, and that sampling procedures were performed in a manner to provide adequate data for the SRWP. Results for field duplicates are summarized in Table 14.

Summary

From June 1999 through May 2000, the SRWP monitoring program successfully completed 7,286 of 8,563 planned water chemistry analyses for an completion rate of

85%. Most of the uncompleted analyses were due to several uncontrollable factors, including contracting delays for sampling, prevention of sample collection due to high flows, and samples lost in shipping. The primary controllable cause of uncompleted analyses was sample containers broken in shipping or in the laboratory. Additionally, 46 of 59 total phosphorus results (78%) were excluded during the validation process as unusable because the results were incorrectly calculated and could not be corrected by the laboratory. Of the of 7,286 completed analyses, data qualifications were required for 402 analytical results, leaving 6,884 unqualified results for an overall analytical success rate of 80% for water chemistry and microbiology monitoring in Year 2. These results are summarized in Table 15.

The quality control results for 1999-2000 indicate that sampling and analytical methods for water chemistry and microbiology were generally adequate to produce reliable data for the SRWP.

Table 7. Summary of Compliance with Holding Times for SRWP Analyses, 1999-2000 Monitoring

Parameters	DQO (1)	Number tested (2)	Number outside DQO (3)	% success (4)
trace metals				
arsenic - dissolved	6 months	34	0	100
arsenic - total	6 months	36	0	100
cadmium - dissolved	6 months	57	0	100
cadmium - total	6 months	56	0	100
chromium - total	6 months	36	0	100
copper - dissolved	6 months	90	0	100
copper - total	6 months	88	0	100
lead - dissolved	6 months	35	0	100
lead - total	6 months	36	0	100
mercury - total	6 months	111	0	100
nickel - dissolved	6 months	35	0	100
nickel - total	6 months	36	0	100
selenium - total	6 months	14	0	100
silver - total	6 months	36	0	100
zinc - dissolved	6 months	57	0	100
zinc – total	6 months	55	0	100
Conventional parameters				
total dissolved solids	7 days	124	36	71
total suspended solids	7 days	116	13	89
Turbidity	48 hours	119	33	72
hardness (atox)	6 months	352	0	100
hardness (wc)	6 months	8	0	100
organic carbon - dissolved	48 hours	117	0	100
organic carbon - suspended	48 hours	111	0	100
nutrients				
nitrate	28 days	64	0	100
nitrite	28 days	64	0	100
ammonia	28 days	64	0	100
nitrogen - total Kjeldahl	28 days	62	0	100
orthophosphate - dissolved	48 hours	62	8	87
phosphorus - total	28 days	19	0	100

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Table 7. ...continued from previous page.

Parameter	DQO (1)	Number tested (2)	Number outside DQO (3)	% success (4)
minerals				
alkalinity - total (atox)	14 days	352	0	100
alkalinity - total	14 days	105	0	100
calcium - total	6 months	68	0	100
chloride	28 days	69	0	100
iron - total	6 months	66	0	100
magnesium - total	6 months	68	0	100
manganese - total	6 months	67	0	100
potassium - total	6 months	68	0	100
silica - dissolved as SiO_2	6 months	61	0	100
sodium - total	6 months	68	0	100
sulfate	28 days	67	0	100
pathogens				
coliform - fecal	24 hours	75	44	41
coliform - total	24 hours	75	44	41
cryptosporidium	96 hours	68	0	100
giardia	96 hours	68	0	100
pesticides				
pesticides - EPA 619	40 days	363	0	100
pesticides - EPA 8141A	40 days	3275	192	94
pesticides - EPA 8321A	40 days	1392	0	100
	total for all parameters	8469	370	96%

(1) Data quality objectives (DQO) are as specified in the Quality Assurance Project Plan (LWA 2000)
(2) Total number of results for parameter
(3) Number of results not achieving DQO
(4) Success rate, i.e. percent of results achieving DQO

Table 8. Summary of Compliance with Laboratory Method Blank Results for SRWP Analyses, 1999-2000 Monitoring

Parameters	DQO (1)	Number tested (2)	Number outside DQO (3)	% success (4)
trace metals				
arsenic - total	<RL	10	0	100
cadmium - total	<RL	11	0	100
chromium - total	<RL	10	2	80
copper - total	<RL	11	0	100
lead - total	<RL	9	1	89
mercury - total	<RL	12	6	50
nickel - total	<RL	9	0	100
selenium - total	<RL	6	0	100
silver - total	<RL	9	0	100
zinc - total	<RL	12	1	92
conventionals				
total dissolved solids	<RL	28	1	96
total suspended solids	<RL	24	0	100
turbidity	<RL	26	0	100
nutrients				
nitrate as NO3	<RL	31	0	100
nitrite as NO2	<RL	31	0	100
ammonia as NH3	<RL	19	0	100
nitrogen - total Kjeldahl	<RL	19	0	100
orthophosphate - dissolved	<RL	31	0	100
phosphorus - total	<RL	12	0	100
minerals				
alkalinity - total	<RL	20	0	100
calcium - total	<RL	22	0	100
chloride	<RL	32	0	100
iron - total	<RL	23	0	100
magnesium - total	<RL	22	0	100
manganese - total	<RL	22	0	100
potassium - total	<RL	23	0	100
silica - dissolved as SiO2	<RL	12	0	100
sodium - total	<RL	24	0	100
sulfate	<RL	33	0	100
pesticides				
triazine pesticides (EPA 619)	<RL	143	0	100
OP pesticides (EPA 8141A)	<RL	615	0	100
carbamate pesticides (EPA 8321A)	<RL	336	0	100
	total for all analyses	1647	11	99%

(1) Data quality objectives (DQO) f are as specified in the Quality Assurance Project Plan (LWA 2000)
(2) Total number of results for parameter
(3) Number of results not achieving DQO
(4) Success rate, i.e. percent of results achieving DQO

Table 9a. Summary of Laboratory Control Sample and SRM Recoveries for SRWP Analyses, 1999-2000 Monitoring

Parameters	DQO (1)	Number tested (2)	Number outside DQO (3)	% success (4)
trace metals				
arsenic - total	80% - 120%	10	0	100
cadmium - total	80% - 120%	12	2	83
chromium - total	80% - 120%	10	1	90
copper - total	80% - 120%	12	0	100
lead - total	80% - 120%	10	0	100
mercury - total	80% - 120%	13	0	100
nickel - total	80% - 120%	10	1	90
selenium - total	80% - 120%	6	0	100
silver - total	80% - 120%	10	1	90
zinc - total	80% - 120%	12	1	92
conventionals				
total dissolved solids	80% - 120%	29	0	100
turbidity	80% - 120%	26	0	100
nutrients				
nitrate	80% - 120%	31	0	100
nitrite	80% - 120%	31	0	100
ammonia	80% - 120%	19	0	100
nitrogen - total Kjeldahl	80% - 120%	19	0	100
orthophosphate - dissolved	80% - 120%	31	0	100
phosphorus - total	80% - 120%	12	0	100
minerals				
alkalinity - total	80% - 120%	20	0	100
calcium - total	80% - 120%	21	0	100
chloride	80% - 120%	34	0	100
iron - total	80% - 120%	24	2	92
magnesium - total	80% - 120%	21	0	100
manganese - total	80% - 120%	23	0	100
potassium - total	80% - 120%	22	0	100
silica - dissolved as SiO2	80% - 120%	13	0	100
sodium - total	80% - 120%	22	0	100
sulfate	80% - 120%	33	0	100
	total for all analyses	536	8	99%

(1) Data quality objectives (DQO) are as specified in the Quality Assurance Project Plan (LWA 2000)
(2) Total number of results for parameter
(3) Number of results not achieving DQO
(4) Success rate, i.e. percent of results achieving DQO

Table 9b. Summary of Laboratory Control Sample Surrogate Recoveries for SRWP Organophosphate Pesticide Analyses, 1999-2000 Monitoring

Parameters	DQO (1)	Number tested (2)	Number outside DQO (3)	% success (4)
Azinphosmethyl	10% - 165%	15	4	73
Bolstar	39% - 117%	15	3	80
Chlorpyrifos	44% - 113%	15	2	87
Coumaphos	22% - 165%	14	0	100
Def	58% - 165%	15	0	100
Demeton-s	7% - 71%	14	2	86
Diazinon	57% - 130%	15	1	93
Dichlorvos	20% - 141%	14	0	100
Dimethoate	27% - 157%	15	2	87
Disulfoton	24% - 135%*	16	1	94
EPN	37% - 144%	9	0	100
Ethion	37% - 131%*	16	0	100
Ethoprop	49% - 107%	15	3	80
Ethyl parathion	34% - 139%	14	1	93
Fensulfothion	29% - 140%	14	1	93
Fenthion	31% - 139%	14	0	100
Malathion	37% - 134%	14	0	100
Merphos	33% - 133%	14	3	79
Methyl parathion	45% - 113%*	17	0	100
Mevinphos	40% - 138%	15	2	87
Naled	37% - 254%	15	0	100
Phorate	40% - 100%*	17	0	100
Prowl	11% - 110%	15	1	93
Ronnel	37% - 127%	14	0	100
Stirophos	34% - 149%*	11	1	91
Sulfotepp	34% - 131%	8	0	100
Tokuthion	49% - 108%	9	2	78
Tributylphosphate (surrogate)	46% - 131%*	17	0	100
Trichloronate	25% - 134%	14	0	100
Trifluralin	33% - 111%	15	0	100
Triphenylphosphate (surrogate)	50% - 135%*	17	2	88
total for EPA method 8141A		442	31	93%

(1) Data quality objectives (DQO) are as specified in the Quality Assurance Project Plan (LWA 2000)
(2) Total number of results for parameter
(3) Number of results not achieving DQO
(4) Success rate, i.e. percent of results achieving DQO

Table 9c. Summary of Laboratory Control Sample Surrogate Recoveries for SRWP Carbamate Pesticide Analyses, 1999-2000 Monitoring

Parameters	DQO (1)	Number tested (2)	Number outside DQO (3)	% success (4)
Aldicarb	22% - 146%	2	0	100
Bromacil	58% - 111%*	7	0	100
Carbaryl	40% - 131%	6	0	100
Carbofuran	44% - 128%	4	0	100
Diuron	57% - 133%*	11	0	100
Linuron	53% - 135%	1	0	100
Methiocarb	42% - 129%	1	0	100
Methomyl	37% - 113%	3	0	100
Monuron	55% - 134%	5	0	100
Neburon	55% - 132%	2	0	100
oryzalin (surrogate)	40% - 140%	14	0	100
total for EPA method 8321A		56	0	100%

(1) Data quality objectives (DQO) are as specified in the Quality Assurance Project Plan (LWA 2000)
(2) Total number of results for parameter
(3) Number of results not achieving DQO
(4) Success rate, i.e. percent of results achieving DQO

Table 9d. Summary of Laboratory Control Sample Recoveries for SRWP Triazine Pesticide Analyses, 1999-2000 Monitoring

Parameters	DQO (1)	Number tested (2)	Number outside DQO (3)	% success (4)
Ametryn	60% - 135%	8	1	87.5
Atraton	60% - 147%	8	1	87.5
Atrazine	68% - 139%*	13	0	100
Cyanazine	67% - 175%	8	2	75
Prometon	63% - 133%	8	2	75
Prometryn	65% - 133%	8	0	100
Propazine	65% - 137%	8	0	100
Simazine	18% - 92%	8	1	87.5
Simetryn	61% - 156%	8	0	100
Terbuthylazine	68% - 140%	8	0	100
Terbutryn	60% - 117%	13	2	85
Tributylphosphate (surrogate)	46% - 131%*	13	0	100
Triphenylphosphate (surrogate)	50% - 135%*	13	1	92
totals for EPA method 619		124	10	92%

(1) Data quality objectives (DQO) are as specified in the Quality Assurance Project Plan (LWA 2000)
(2) Total number of results for parameter
(3) Number of results not achieving DQO
(4) Success rate, i.e. percent of results achieving DQO

Table 10. Summary of Laboratory Duplicate Results for SRWP Analyses, 1999-2000 Monitoring

Parameters	DQO (1)	Number tested (2)	Number outside DQO (3)	% success (4)
arsenic - dissolved	≤20% RPD	2	0	100
arsenic - total	≤20% RPD	8	0	100
Cadmium - dissolved	≤20% RPD	3	1	67
Cadmium - total	≤20% RPD	9	3	67
Chromium - total	≤20% RPD	9	0	100
copper - dissolved	≤20% RPD	2	0	100
copper – total	≤20% RPD	10	0	100
lead – dissolved	≤20% RPD	2	0	100
lead – total	≤20% RPD	8	0	100
mercury - total	≤20% RPD	12	0	100
nickel – dissolved	≤20% RPD	2	0	100
nickel – total	≤20% RPD	8	0	100
Selenium - total	≤20% RPD	6	0	100
silver – total	≤20% RPD	9	2	78
zinc – dissolved	≤20% RPD	2	0	100
zinc – total	≤20% RPD	10	0	100
total suspended solids	≤20% RPD	28	2	93
	total for all analyses	130	8	94%

(1) Data quality objectives (DQO) are as specified in the Quality Assurance Project Plan (LWA 2000)
(2) Total number of results for parameter
(3) Number of results not achieving DQO
(4) Success rate, i.e. percent of results achieving DQO

Table 11a. Summary of Matrix Spike Recoveries for SRWP Analyses, 1999-2000 Monitoring

Parameters	DQO (1)	Number tested (2)	Number outside DQO (3)	% success (4)
trace metals				
arsenic - dissolved	80% - 120%	2	0	100
arsenic - total	80% - 120%	5	0	100
cadmium - dissolved	80% - 120%	4	0	100
cadmium - total	80% - 120%	8	0	100
chromium - total	80% - 120%	9	0	100
copper - dissolved	80% - 120%	4	1	75
copper - total	80% - 120%	8	1	88
lead - dissolved	80% - 120%	3	0	100
lead - total	80% - 120%	7	0	100
mercury - total	80% - 120%	9	1	89
nickel - dissolved	80% - 120%	3	0	100
nickel - total	80% - 120%	7	0	100
selenium - total	80% - 120%	2	0	100
silver - total	80% - 120%	9	0	100
zinc - dissolved	80% - 120%	3	2	33
zinc - total	80% - 120%	9	1	89
conventionals				
total dissolved solids	80% - 120%	7	0	100
turbidity	80% - 120%	15	2	87
nutrients				
nitrate as NO3	80% - 120%	7	0	100
nitrite as NO2	80% - 120%	8	0	100
ammonia as NH3	80% - 120%	3	0	100
nitrogen - total Kjeldahl	80% - 120%	2	0	100
orthophosphate - dissolved	80% - 120%	7	0	100
phosphorus - total	80% - 120%	4	3	25
minerals				
alkalinity - total	80% - 120%	11	0	100
calcium - total	80% - 120%	5	1	80
chloride	80% - 120%	8	0	100
iron - total	80% - 120%	5	4	20
potassium - total	80% - 120%	5	0	100
magnesium - total	80% - 120%	5	1	80
manganese - total	80% - 120%	5	0	100
silica - dissolved as SiO2	80% - 120%	6	2	67
sodium - total	80% - 120%	5	0	100
sulfate	80% - 120%	8	0	100
	total for all analyses	208	19	91%

(1) Data quality objectives (DQO) are as specified in the Quality Assurance Project Plan (LWA 2000)
(2) Total number of results for parameter
(3) Number of results not achieving DQO
(4) Success rate, i.e. percent of results achieving DQO

Table 11b. Summary of Matrix Spike Surrogate Recoveries for SRWP Pesticide Analyses, 1999-2000 Monitoring

Parameters	Method	DQO (1)	Number tested (2)	Number outside DQO (3)	% success (4)
oryzalin (surrogate)	EPA 8321A	40% - 140%	58	0	100
tributylphosphate (surrogate)	EPA 619	46% - 131%	33	0	100
tributylphosphate (surrogate)	EPA 8141A	46% - 131%	100	0	100
triphenylphosphate (surrogate)	EPA 619	50% - 135%	33	4	88
triphenylphosphate (surrogate)	EPA 8141A	50% - 135%	100	15	85
		total for all analyses	324	19	94%

(1) Data quality objectives (DQO) are as specified in the Quality Assurance Project Plan (LWA 2000)
(2) Total number of results for parameter
(3) Number of results not achieving DQO
(4) Success rate, i.e. percent of results achieving DQO

Table 12. Summary of Matrix Spike Duplicate Results for SRWP Analyses, 1999-2000 Monitoring

Parameters	DQO (1)	Number tested (2)	Number outside DQO (3)	% success (4)
trace metals				
arsenic - dissolved	≤20% RPD	2	0	100
arsenic - total	≤20% RPD	5	0	100
cadmium - dissolved	≤20% RPD	4	0	100
cadmium - total	≤20% RPD	8	0	100
chromium - total	≤20% RPD	9	0	100
copper - dissolved	≤20% RPD	4	0	100
copper - total	≤20% RPD	8	0	100
lead - dissolved	≤20% RPD	3	0	100
lead - total	≤20% RPD	7	0	100
mercury - total	≤20% RPD	9	0	100
nickel - dissolved	≤20% RPD	3	0	100
nickel - total	≤20% RPD	7	0	100
selenium - total	≤20% RPD	2	0	100
silver - total	≤20% RPD	9	0	100
zinc - dissolved	≤20% RPD	3	0	100
zinc - total	≤20% RPD	9	0	100
conventionals				
total dissolved solids	≤20% RPD	7	0	100
turbidity	≤20% RPD	14	0	100
Nutrients				
nitrate as NO3	≤20% RPD	7	0	100
nitrite as NO2	≤20% RPD	8	0	100
ammonia as NH3	≤20% RPD	3	0	100
nitrogen - total Kjeldahl	≤20% RPD	2	0	100
orthophosphate – dissolved	≤20% RPD	7	0	100
phosphorus – total	≤20% RPD	2	1	50
minerals				
alkalinity - total	≤20% RPD	11	0	100
calcium - total	≤20% RPD	4	1	75
chloride	≤20% RPD	8	0	100
iron - total	≤20% RPD	5	1	80
magnesium - total	≤20% RPD	5	1	80
manganese - total	≤20% RPD	5	0	100
potassium - total	≤20% RPD	5	0	100
silica - dissolved as SiO2	≤20% RPD	6	0	100
sodium - total	≤20% RPD	5	0	100
sulfate	≤20% RPD	8	0	100
	total for all analyses	204	4	98%

(1) Data quality objectives (DQO) are as specified in the Quality Assurance Project Plan (LWA 2000)
(2) Total number of results for parameter
(3) Number of results not achieving DQO
(4) Success rate, i.e. percent of results achieving DQO

Table 13. Summary of Field Blank Results for SRWP Analyses, 1999-2000 Monitoring

Parameters	DQO (1)	Number tested (2)	Number outside DQO (3)	% success (4)
arsenic - dissolved	<RL or <S/5	2	0	100
arsenic - total	<RL or <S/5	1	0	100
cadmium - dissolved	<RL or <S/5	2	0	100
cadmium - total	<RL or <S/5	1	0	100
chromium - total	<RL or <S/5	1	0	100
copper - dissolved	<RL or <S/5	3	0	100
copper - total	<RL or <S/5	3	0	100
lead - dissolved	<RL or <S/5	2	0	100
lead - total	<RL or <S/5	1	0	100
mercury - total	<RL or <S/5	10	0	100
nickel - dissolved	<RL or <S/5	2	0	100
nickel - total	<RL or <S/5	1	0	100
silver - total	<RL or <S/5	1	0	100
zinc - dissolved	<RL or <S/5	2	0	100
zinc - total	<RL or <S/5	1	0	100
organic carbon - dissolved	<RL or <S/5	10	4	60
organic carbon - suspended	<RL or <S/5	5	2	60
coliform - fecal	<RL or <S/5	15	0	100
coliform - total	<RL or <S/5	15	0	100
Triazine pesticides - EPA 619	<RL or <S/5	33	0	100
OP pesticides - EPA 8141A	<RL or <S/5	133	0	100
Carbamate pesticides - EPA 8321A	<RL or <S/5	72	0	100
	total for all analyses	316	6	98%

(1) Data quality objectives (DQO) are as specified in the Quality Assurance Project Plan (LWA 2000)
(2) Total number of results for parameter
(3) Number of results not achieving DQO
(4) Success rate, i.e. percent of results achieving DQO

Table 14. Summary of Field Duplicate Results for SRWP Analyses, 1999-2000 Monitoring

Parameters	DQO (1)	Number tested (2)	Number outside DQO (3)	% success (4)
trace metals				
arsenic - dissolved	≤25% RPD	1	0	100
arsenic - total	≤25% RPD	3	0	100
cadmium - dissolved	≤25% RPD	3	1	67
cadmium - total	≤25% RPD	3	1	67
chromium - total	≤25% RPD	3	0	100
copper - dissolved	≤25% RPD	6	0	100
copper - total	≤25% RPD	4	0	100
lead - dissolved	≤25% RPD	1	0	100
lead - total	≤25% RPD	3	1	67
mercury - total	≤25% RPD	10	0	100
nickel - dissolved	≤25% RPD	1	0	100
nickel - total	≤25% RPD	3	0	100
selenium - total	≤25% RPD	4	0	100
silver - total	≤25% RPD	3	0	100
zinc - dissolved	≤25% RPD	3	0	100
zinc - total	≤25% RPD	3	0	100
conventionals				
total dissolved solids	≤25% RPD	10	1	90
total suspended solids	≤25% RPD	9	0	100
turbidity	≤25% RPD	9	1	89
hardness	≤25% RPD	1	0	100
organic carbon - dissolved	≤25% RPD	11	1	91
organic carbon - suspended	≤25% RPD	10	0	100
nutrients				
nitrate as NO3	≤25% RPD	10	0	100
nitrite as NO2	≤25% RPD	10	0	100
ammonia as NH3	≤25% RPD	10	2	80
nitrogen - total Kjeldahl	≤25% RPD	10	0	100
orthophosphate - dissolved	≤25% RPD	10	0	100
phosphorus - total	≤25% RPD	3	0	100

Table continues on following page…

Table 14. ...continued from previous page.

Parameters	DQO (1)	Number tested (2)	Number outside DQO (3)	% success (4)
minerals				
alkalinity - total	≤25% RPD	21	0	100
calcium - total	≤25% RPD	9	0	100
chloride	≤25% RPD	10	0	100
iron - total	≤25% RPD	9	2	78
magnesium - total	≤25% RPD	9	0	100
manganese - total	≤25% RPD	9	1	89
potassium - total	≤25% RPD	9	0	100
silica - dissolved as SiO2	≤25% RPD	8	0	100
sodium - total	≤25% RPD	9	0	100
sulfate	≤25% RPD	10	0	100
pathogens				
coliform - fecal	≤25% RPD	2	0	100
coliform - total	≤25% RPD	2	0	100
pesticides				
pesticides - EPA 619	≤25% RPD	33	0	100
pesticides - EPA 8141A	≤25% RPD	325	0	100
pesticides - EPA 8321A	≤25% RPD	96	0	100
	totals for all analyses	718	11	98%

(1) Data quality objectives (DQO) are as specified in the Quality Assurance Project Plan (LWA 2000)
(2) Total number of results for parameter
(3) Number of results not achieving DQO
(4) Success rate, i.e. percent of results achieving DQO

Table 15. Summary of Planned and Completed Environmental Analyses for SRWP Monitoring, 1999-2000 Monitoring

parameter	total environmental analyses planned	total environmental analyses completed	percent completeness
trace metals			
arsenic - dissolved	28	31	100
arsenic - total	28	32	100
cadmium - dissolved	52	52	100
cadmium - total	52	52	100
chromium - total	28	32	100
copper - dissolved	85	81	95
copper - total	83	81	98
lead - dissolved	25	32	100
lead - total	23	32	100
mercury - total	102	91	89
nickel - dissolved	22	32	100
nickel - total	31	32	100
selenium - total	12	10	83
silver - total	29	32	100
zinc - dissolved	52	52	100
zinc - total	52	51	98
conventionals			
total dissolved solids	114	114	100
total suspended solids	120	107	89
turbidity	126	110	87
hardness	6	7	100
hardness (aquatic toxicity)	178	178	100
organic carbon			
organic carbon - dissolved	138	96	70
organic carbon - suspended	138	96	70
nutrients			
nitrate	59	54	92
nitrite	59	54	92
ammonia	59	54	92
nitrogen - total kjeldahl	59	52	88
orthophophate - dissolved	59	52	88
phosphorus - total	59	16	27

Table continues on following page…

Table 15. ...continued from previous page.

parameter	total environmental analyses planned	total environmental analyses completed	percent completeness
general minerals			
alkalinity - total	89	91	100
alkalinity - total (aquatic toxicity)	178	178	100
calcium	65	59	91
chloride	65	59	91
iron -total	65	57	88
magnesium - total	65	59	91
manganese - total	65	58	89
potassium	65	59	91
silica - dissolved as Si02	65	53	82
sodium	65	59	91
sulfate	65	57	88
pathogens			
Giardia	72	68	94
Cryptosporidium	72	68	94
total coliform	66	58	88
fecal coliform	66	58	88
pesticides			
EPA Method 619	308	297	96
EPA Method 8141A	2904	2817	97
EPA Method 8321A	1248	1224	98
field analyses			
temperature	126	192	100
temperature (aquatic toxicity)	174	178	100
dissolved oxygen	126	173	100
pH	126	192	100
pH (aquatic toxicity)	174	171	98
specific conductance	197	191	97
specific conductance (aquatic tox.)	174	178	100
total for all analyses	8563	7286	85%
minus total qualified data		402	
total unqualified data		6884	80%
		% success averaged by parameter	92%

APPENDIX E

Summary Statistics for Monitoring Data: SRWP, USGS NAWQA, Sacramento River CMP, and City of Redding

Mercury, total, unfiltered

Units = ng/L

		monitoring period							percentile statistics					
Site ID	Site Description	start	end	n	n det	% det	min det	max det	10th	25th	median (50th)	75th	90th	min RL
SCKPP	Spring Creek PP Discharge to Keswick Res.	6/24/98	4/18/00	11	11	100%	0.5	1.7	0.8	0.8	1.2	1.4	1.6	—
SRBKR	Sacramento River below Keswick	1/20/98	4/18/00	39	39	100%	0.2	10.4	0.7	1.1	1.2	1.6	2.5	—
SRABB	Sacramento River above Bend Bridge	2/13/96	5/17/00	39	39	100%	0.8	32.6	1.0	1.4	2.0	3.9	7.3	—
MCMOU	Mill Creek at Mouth	6/23/98	4/17/00	19	19	100%	2.3	485	3.4	4.4	10.6	31.9	70.0	—
MCBLR	Mill Creek at Black Rock	6/23/98	4/17/00	18	18	100%	2.0	110	2.7	4.6	18.2	27.2	81.1	—
MCHWY	Mill Creek at Highway 36	6/23/98	4/17/00	19	19	100%	4.4	1910	6.5	21.5	36.9	87.8	184	—
SRHAM	Sacramento River near Hamilton City	6/23/99	5/16/00	11	11	100%	0.9	32.4	1.3	1.5	1.8	5.5	19.0	—
DCMOU	Deer Creek at Mouth	6/24/98	4/17/00	14	14	100%	0.3	6.0	0.4	0.5	0.7	1.1	1.8	—
DCUDD	Deer Creek at Upper Diversion Dam	6/24/98	4/17/00	20	20	100%	0.2	10.3	0.2	0.3	0.7	2.6	8.9	—
DCPON	Deer Creek at Ponderosa Way	6/24/98	11/8/99	12	12	100%	0.2	5.0	0.3	0.4	0.4	0.5	1.1	—
DCMDW	Deer Creek below Childs Meadows	6/24/98	4/17/00	19	19	100%	0.2	7.0	0.4	0.4	0.6	1.1	2.2	—
CHMUD	Big Chico Creek above Mud Creek	6/23/98	4/17/00	21	20	95%	0.3	10.1	0.4	0.5	0.9	2.7	4.3	0.2
MUDCH	Mud Creek above Big Chico Creek	6/23/98	4/17/00	11	11	100%	0.4	57.7	0.6	0.9	1.6	3.7	7.7	—
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/23/98	4/17/00	19	19	100%	0.2	10.0	0.4	0.5	0.5	1.3	2.6	—
CHASH	Big Chico Creek above Salmon Hole	6/23/98	2/14/00	16	15	94%	0.2	6.4	0.3	0.4	0.8	1.7	4.2	3
CHHWY	Big Chico Creek at Hwy 32	6/23/98	4/17/00	19	18	95%	0.2	4.9	0.2	0.4	0.6	1.2	1.9	3
SRCOL	Sacramento River at Colusa	2/28/96	7/19/00	45	45	100%	1.7	105.2	2.6	3.2	4.4	8.9	14.6	—
SACSL	Sacramento Slough	2/12/96	4/18/00	34	34	100%	4.1	30.8	5.5	6.0	8.0	11.3	15.9	—
COLDR	Colusa Basin Drain	3/6/96	5/16/00	37	37	100%	1.6	19.3	4.7	5.8	7.1	10.8	14.0	—
YRMRY	Yuba River at Marysville	2/27/96	5/16/00	37	37	100%	1.2	46.7	1.7	1.9	3.0	5.3	13.7	—
FRNIC	Feather River near Nicolaus	2/23/96	5/16/00	38	38	100%	2.3	46.2	3.2	3.5	4.4	7.9	16.1	—
SRVON	Sacramento River at Verona	2/22/96	5/20/98	28	28	100%	2.5	39.8	3.7	4.8	6.4	8.8	17.0	—
SRVET	Sacramento River at Veterans Bridge	1/18/94	6/20/00	99	99	100%	3.4	34.9	4.5	5.2	8.3	12.3	16.4	—
ARCNW	Arcade Creek at Norwood Ave.	3/5/96	5/17/00	37	37	100%	1.1	54.3	4.2	4.7	7.0	11.0	23.2	—
ARDPK	American River at Discovery Park	1/18/94	6/20/00	96	96	100%	0.6	13.3	1.3	1.7	2.7	4.4	6.2	—
SRFPT	Sacramento River at Freeport	2/15/94	7/18/00	148	148	100%	1.2	36.2	3.4	4.2	6.8	11.2	16.4	—
SRRMF	Sacramento River at River Mile 44	1/18/94	6/21/00	94	94	100%	2.7	73.4	3.6	5.1	7.6	13.4	19.5	—
CCHCK	Cache Creek at Rumsey	2/9/96	8/18/99	47	47	100%	2.7	2248	3.9	6.0	14.9	42.5	306.2	—
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	11	11	100%	3.1	18	4.9	6.4	7.3	10.5	12.8	—
YOLOB	Yolo Bypass near Woodland	1/31/97	4/30/98	10	10	100%	17.9	223.7	18.2	21.3	30.6	37.2	64.9	—

Methylmercury, unfiltered

Units = ng/L

		monitoring period							percentile statistics					
Site ID	Site Description	start	end	n	n det	% det	min det	max det	10th	25th	median (50th)	75th	90th	min RL
SRCOL	Sacramento River at Colusa	2/28/96	6/10/98	29	28	97%	0.05	1.27	0.06	0.08	0.10	0.25	0.42	0.025
SACSL	Sacramento Slough	2/12/96	4/22/98	23	23	100%	0.06	1.18	0.08	0.09	0.15	0.31	0.54	—
COLDR	Colusa Basin Drain	3/6/96	4/15/98	25	25	100%	0.02	0.89	0.09	0.13	0.19	0.26	0.36	—
SRVON	Sacramento River at Verona	2/22/96	4/22/98	27	27	100%	0.01	1.98	0.05	0.07	0.12	0.16	0.37	—
SRFPT	Sacramento River at Freeport	2/20/96	7/18/00	42	41	98%	0.01	0.78	0.04	0.06	0.10	0.17	0.29	0.025
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	11	11	100%	0.04	0.39	0.05	0.10	0.14	0.21	0.22	—

Summary Statistics Table Notes:
monitoring period start and end — Dates of first and last reported data.
n — Total number of data reported.
n det — Total number of data above reporting limits.
% det — Percent of data above reporting limits.
min det — Minimum value for data detected above reporting limits.
max det — Maximum value of data detected above reporting limits.
percentiles — Percentile data are provided for data above reporting limits. "<RL" indicates insufficient data to calculate statistic.
min RL — Lowest reporting limit for data below detection. min RL only reported where percent detection (% det) < 100%.

Summary Statistics: Trace Metals Data

Arsenic, dissolved

Units = µg/L

Site ID	Site Description	monitoring period start	monitoring period end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
SRBKR	Sacramento River below Keswick	1/20/98	4/18/00	39	39	100%	0.59	1.71	0.8	0.9	1.1	1.3	1.5	—
SRABB	Sacramento River above Bend Bridge	2/13/96	7/21/99	29	17	59%	0.94	1	<RL	<RL	1.0	1.0	1.0	1
SRCOL	Sacramento River at Colusa	2/28/96	11/16/99	33	28	85%	1	2	<RL	1.0	1.0	1.0	2.0	1
SACSL	Sacramento Slough	2/12/96	11/16/99	28	27	96%	1	6	1.0	2.0	4.0	5.2	6.0	1
COLDR	Colusa Basin Drain	2/7/96	8/18/99	30	29	97%	1	6	1.9	2.0	2.4	4.0	4.2	1
YRMRY	Yuba River at Marysville	2/27/96	4/6/98	27	1	4%	1	1	<RL	<RL	<RL	<RL	<RL	1
FRNIC	Feather River near Nicolaus	2/23/96	1/18/00	28	2	7%	0.52	1	<RL	<RL	<RL	<RL	<RL	1
SRVON	Sacramento River at Verona	2/22/96	4/22/98	27	20	74%	1	2	<RL	<RL	1.0	1.5	2.0	1
ARCNW	Arcade Creek at Norwood Ave.	2/6/96	7/20/99	30	29	97%	1	6	1.0	1.0	2.0	3.0	4.0	1
ARJST	American River at J Street	3/18/96	4/16/98	26	0	0%	0	0	<RL	<RL	<RL	<RL	<RL	1
SRFPT	Sacramento River at Freeport	2/20/96	6/21/00	33	20	61%	0.012	2	<RL	<RL	1.0	1.0	1.8	1
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	11	11	100%	0.489	2.2	0.6	0.6	0.7	0.9	1.6	—
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	12	12	100%	1.1	2.1	1.1	1.2	1.5	1.6	1.7	—

Arsenic, total

Units = µg/L

Site ID	Site Description	monitoring period start	monitoring period end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
SRBKR	Sacramento River below Keswick	1/20/98	4/18/00	39	39	100%	0.22	2.04	0.68	0.89	1.09	1.41	1.60	—
CCMOU	Clear Creek near Mouth	9/15/98	7/20/99	9	9	100%	0.3	0.9	0.4	0.4	0.5	0.6	0.6	—
MCMOU	Mill Creek at Mouth	6/23/98	4/17/00	18	18	100%	2.0	41.0	10.1	13.9	15.6	22.4	27.9	—
MCBLR	Mill Creek at Black Rock	6/23/98	4/17/00	17	17	100%	11.3	44.5	13.1	14.3	19.6	27.8	28.7	—
MCHWY	Mill Creek at Highway 36	6/23/98	4/17/00	19	19	100%	10.8	129.0	18.8	23.9	50.9	95.9	103.4	—
DCMOU	Deer Creek at Mouth	6/24/98	4/17/00	12	12	100%	0.58	5.94	1.28	1.56	2.05	3.80	5.34	—
DCUDD	Deer Creek at Upper Diversion Dam	6/24/98	4/17/00	16	16	100%	0.68	6.33	1.06	1.50	1.74	3.60	5.21	—
DCPON	Deer Creek at Ponderosa Way	6/24/98	11/8/99	9	9	100%	0.27	19.80	0.30	0.32	0.42	0.71	4.55	—
DCMDW	Deer Creek below Childs Meadows	6/24/98	4/17/00	16	16	100%	0.13	0.65	0.16	0.22	0.26	0.36	0.44	—
CHMUD	Big Chico Creek above Mud Creek	6/23/98	4/17/00	17	17	100%	0.15	0.62	0.18	0.24	0.27	0.45	0.56	—
MUDCH	Mud Creek above Big Chico Creek	6/23/98	4/17/00	11	10	91%	0.03	0.22	0.05	0.06	0.08	0.16	0.21	0.05
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/23/98	4/17/00	16	16	100%	0.11	0.61	0.15	0.20	0.26	0.34	0.50	—
CHASH	Big Chico Creek above Salmon Hole	6/23/98	2/14/00	13	13	100%	0.07	0.65	0.16	0.18	0.27	0.38	0.56	—
CHHWY	Big Chico Creek at Hwy 32	6/23/98	4/17/00	16	16	100%	0.002	0.15	0.03	0.05	0.06	0.08	0.11	—
SRVET	Sacramento River at Veterans Bridge	1/4/94	6/20/00	101	96	95%	0.83	3.63	1.10	1.41	1.70	1.89	2.19	1
ARDPK	American River at Discovery Park	1/4/94	6/20/00	83	48	58%	0.07	1.23	<RL	<RL	0.48	1.00	1.00	0.05
SRFPT	Sacramento River at Freeport	1/4/94	6/21/00	99	92	93%	0.78	3.60	1.00	1.27	1.48	1.70	1.90	1
SRRMF	Sacramento River at River Mile 44	1/1/04	6/21/00	92	86	93%	0.76	3.07	1.10	1.26	1.45	1.76	1.93	1
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	11	1	9%	11.5	11.5	<RL	<RL	<RL	<RL	<RL	10
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	12	12	100%	1.2	2.6	1.29	1.35	1.62	1.84	1.99	—

Cadmium, dissolved

Units = µg/L

Site ID	Site Description	monitoring period start	monitoring period end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
SRBKR	Sacramento River below Keswick	1/20/98	4/18/00	39	35	90%	0.006	0.092	<RL	0.01	0.02	0.04	0.06	0.005
SRABB	Sacramento River above Bend Bridge	2/13/96	5/17/00	39	12	31%	0.002	0.031	<RL	<RL	<RL	1.0	1.0	1
SRHAM	Sacramento River near Hamilton City	6/23/99	5/16/00	13	12	92%	0.004	0.027	0.01	0.01	0.01	0.01	0.02	0.005
SRCOL	Sacramento River at Colusa	2/28/96	11/16/99	33	1	3%	0.003	0.003	<RL	<RL	<RL	<RL	<RL	1
SACSL	Sacramento Slough	2/12/96	11/16/99	28	2	7%	0.005	0.059	<RL	<RL	<RL	<RL	<RL	0.005
COLDR	Colusa Basin Drain	2/7/96	8/18/99	30	3	10%	0.004	0.011	<RL	<RL	<RL	<RL	1.00	1
YRMRY	Yuba River at Marysville	2/27/96	4/6/98	27	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	1
FRNIC	Feather River near Nicolaus	2/23/96	1/18/00	28	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.005
SRVON	Sacramento River at Verona	2/22/96	4/22/98	27	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	1
SRVET	Sacramento River at Veterans Bridge	1/4/94	6/20/00	90	35	39%	0.008	0.04	<RL	<RL	<RL	0.03	0.03	0.01
ARCNW	Arcade Creek at Norwood Ave.	2/6/96	7/20/99	30	2	7%	0.002	0.006	<RL	<RL	<RL	<RL	<RL	1
ARJST	American River at J Street	3/18/96	4/16/98	26	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	1
ARDPK	American River at Discovery Park	1/4/94	6/20/00	89	22	25%	0.004	0.04	<RL	<RL	<RL	<RL	0.03	0.01
SRFPT	Sacramento River at Freeport	1/4/94	6/21/00	122	40	33%	0.004	0.04	<RL	<RL	<RL	1.00	1.00	0.01
SRRMF	Sacramento River at River Mile 44	1/18/94	6/21/00	86	34	40%	0.004	0.04	<RL	<RL	<RL	0.03	0.03	0.01
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	11	11	100%	0.003	0.16	0.00	0.01	0.01	0.01	0.01	—
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	12	11	92%	0.004	0.016	0.005	0.006	0.009	0.012	0.016	0.005

Summary Statistics: Trace Metals Data

Cadmium, total

Units = µg/L

		monitoring period							percentile statistics					
Site ID	Site Description	start	end	n	n det	% det	min det	max det	10th	25th	median (50th)	75th	90th	min RL
SRBKR	Sacramento River below Keswick	1/20/98	4/18/00	39	36	92%	0.003	0.12	0.008	0.014	0.021	0.041	0.067	0.005
CCMOU	Clear Creek near Mouth	9/15/98	7/20/99	11	10	91%	0.004	0.21	0.004	0.006	0.009	0.032	0.127	0.003
SRABB	Sacramento River above Bend Bridge	6/23/99	5/17/00	12	12	100%	0.004	0.059	0.009	0.017	0.026	0.038	0.044	—
MCMOU	Mill Creek at Mouth	6/23/98	4/17/00	15	9	60%	0.003	0.082	<RL	<RL	0.005	0.010	0.021	0.003
MCBLR	Mill Creek at Black Rock	6/23/98	4/17/00	13	9	69%	0.002	0.042	<RL	<RL	0.007	0.008	0.019	0.003
MCHWY	Mill Creek at Highway 36	6/23/98	4/17/00	15	9	60%	0.006	0.035	<RL	<RL	0.008	0.010	0.019	0.002
SRHAM	Sacramento River near Hamilton City	6/23/99	5/16/00	13	13	100%	0.008	0.12	0.012	0.017	0.021	0.026	0.096	—
DCMOU	Deer Creek at Mouth	6/24/98	4/17/00	12	5	42%	0.003	0.012	<RL	<RL	<RL	0.006	0.011	0.001
DCUDD	Deer Creek at Upper Diversion Dam	6/24/98	4/17/00	15	6	40%	0.001	0.021	<RL	<RL	<RL	0.006	0.008	0.001
DCPON	Deer Creek at Ponderosa Way	6/24/98	11/8/99	9	1	11%	0.007	0.007	<RL	<RL	<RL	<RL	0.005	0.001
DCMDW	Deer Creek below Childs Meadows	6/24/98	4/17/00	15	5	33%	0.004	0.028	<RL	<RL	<RL	0.006	0.009	0.001
CHMUD	Big Chico Creek above Mud Creek	6/23/98	4/17/00	16	7	44%	0.004	0.058	<RL	<RL	<RL	0.010	0.025	0.001
MUDCH	Mud Creek above Big Chico Creek	6/23/98	4/17/00	10	5	50%	0.003	5.4	<RL	<RL	0.005	0.009	0.561	0.002
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/23/98	4/17/00	15	4	27%	0.004	0.035	<RL	<RL	<RL	0.008	0.018	0.001
CHASH	Big Chico Creek above Salmon Hole	6/23/98	2/14/00	12	3	25%	0.003	0.03	<RL	<RL	<RL	0.005	0.007	0.001
CHHWY	Big Chico Creek at Hwy 32	6/23/98	4/17/00	15	7	47%	0.003	0.022	<RL	<RL	<RL	0.005	0.009	0.001
SRVET	Sacramento River at Veterans Bridge	1/4/94	6/20/00	98	83	85%	0.01	0.74	<RL	0.030	0.040	0.050	0.077	0.01
ARDPK	American River at Discovery Park	1/4/94	6/20/00	90	31	34%	0.004	0.2	<RL	<RL	<RL	0.030	0.030	0.005
SRFPT	Sacramento River at Freeport	1/4/94	6/21/00	97	83	86%	0.015	0.35	<RL	0.030	0.031	0.050	0.065	0.01
SRRMF	Sacramento River at River Mile 44	1/18/94	6/21/00	90	72	80%	0.011	0.37	<RL	0.030	0.033	0.050	0.080	0.01
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	11	8	73%	0.011	0.15	<RL	<RL	0.030	0.035	0.057	0.005
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	12	12	100%	0.01	0.058	0.014	0.019	0.024	0.038	0.050	—

Chromium, dissolved

Units = µg/L

		monitoring period							percentile statistics					
Site ID	Site Description	start	end	n	n det	% det	min det	max det	10th	25th	median (50th)	75th	90th	min RL
SRABB	Sacramento River above Bend Bridge	2/13/96	4/9/98	27	10	37%	1	1.5	<RL	<RL	<RL	1.0	1.1	1
SRCOL	Sacramento River at Colusa	2/28/96	9/16/98	32	15	47%	1	2	<RL	<RL	<RL	1.1	1.4	1
SACSL	Sacramento Slough	2/12/96	4/22/98	25	22	88%	1	3.2	<RL	1.0	1.9	2.0	2.5	1
COLDR	Colusa Basin Drain	2/7/96	4/15/98	27	25	93%	1	6.3	1.1	2.0	2.0	3.4	4.0	1
YRMRY	Yuba River at Marysville	2/27/96	4/6/98	27	3	11%	1	1	<RL	<RL	<RL	<RL	1.0	1
FRNIC	Feather River near Nicolaus	2/23/96	4/20/98	27	4	15%	1	1.1	<RL	<RL	<RL	<RL	1.0	1
SRVON	Sacramento River at Verona	2/22/96	4/22/98	27	15	56%	1	1.6	<RL	<RL	1.0	1.3	1.5	1
ARCNW	Arcade Creek at Norwood Ave.	2/6/96	4/23/98	28	24	86%	1	2.9	<RL	1.0	1.1	1.7	2.0	1
ARJST	American River at J Street	3/18/96	4/16/98	26	1	4%	1.4	1.4	<RL	<RL	<RL	<RL	<RL	1
SRFPT	Sacramento River at Freeport	2/20/96	9/15/98	32	9	28%	1	2	<RL	<RL	<RL	1.0	1.4	1
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	11	9	82%	0.21	0.94	<RL	0.3	0.7	0.7	0.8	0.3

Chromium, total

Units = µg/L

		monitoring period							percentile statistics					
Site ID	Site Description	start	end	n	n det	% det	min det	max det	10th	25th	median (50th)	75th	90th	min RL
SRBKR	Sacramento River below Keswick	1/20/98	4/18/00	39	39	100%	0.38	3.65	0.60	0.66	0.80	1.14	1.61	—
CCMOU	Clear Creek near Mouth	9/15/98	7/20/99	10	9	90%	0.22	2.15	0.20	0.28	0.40	0.72	1.02	0.05
MCMOU	Mill Creek at Mouth	6/23/98	4/17/00	19	18	95%	0.07	10.4	0.10	0.29	0.49	0.67	2.20	0.05
MCBLR	Mill Creek at Black Rock	6/23/98	4/17/00	17	17	100%	0.12	7.7	0.19	0.23	0.42	0.56	0.81	—
MCHWY	Mill Creek at Highway 36	6/23/98	4/17/00	19	17	89%	0.19	12.8	<RL	0.24	0.35	0.75	1.68	0.05
DCMOU	Deer Creek at Mouth	6/24/98	4/17/00	14	13	93%	0.07	1.3	0.09	0.20	0.38	0.86	1.16	0.05
DCUDD	Deer Creek at Upper Diversion Dam	6/24/98	4/17/00	20	19	95%	0.08	4.5	0.10	0.17	0.28	0.41	1.09	0.04
DCPON	Deer Creek at Ponderosa Way	6/24/98	11/8/99	12	11	92%	0.07	0.66	0.07	0.15	0.26	0.38	0.43	0.06
DCMDW	Deer Creek below Childs Meadows	6/24/98	4/17/00	19	15	79%	0.09	3.4	<RL	0.11	0.22	0.37	0.51	0.04
CHMUD	Big Chico Creek above Mud Creek	6/23/98	4/17/00	21	21	100%	0.07	5.1	0.10	0.32	0.57	1.36	1.81	—
MUDCH	Mud Creek above Big Chico Creek	6/23/98	4/17/00	11	10	91%	0.14	2.9	0.14	0.32	0.76	0.95	1.61	0.04
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/23/98	4/17/00	19	18	95%	0.029	7.0	0.08	0.21	0.49	0.67	0.99	0.06
CHASH	Big Chico Creek above Salmon Hole	6/23/98	2/14/00	16	15	94%	0.1	53	0.12	0.26	0.38	0.61	2.93	0.05
CHHWY	Big Chico Creek at Hwy 32	6/23/98	4/17/00	19	19	100%	0.14	4.5	0.22	0.32	0.48	0.64	0.86	—
SRVET	Sacramento River at Veterans Bridge	1/4/94	6/20/00	101	92	91%	0.03	14.3	1.00	1.40	2.30	3.76	5.01	1
ARDPK	American River at Discovery Park	1/4/94	6/20/00	100	62	62%	0.03	2.3	<RL	<RL	0.76	1.00	1.11	0.05
SRFPT	Sacramento River at Freeport	1/4/94	6/21/00	98	86	88%	0.21	9.7	<RL	1.10	1.95	3.27	4.56	1
SRRMF	Sacramento River at River Mile 44	1/18/94	6/21/00	92	83	90%	0.8	10	1.00	1.23	1.89	3.22	4.69	1
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	11	8	73%	3.2	75.9	<RL	<RL	5.24	24.69	48.34	2
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	12	12	100%	1.4	10.8	2.87	4.06	5.46	7.54	9.70	—

Summary Statistics: Trace Metals Data

Copper, dissolved

Units = µg/L

Site ID	Site Description	monitoring period start	monitoring period end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
SRBKR	Sacramento River below Keswick	1/20/98	4/18/00	43	42	98%	0.57	7.0	0.9	1.1	1.7	3.0	4.4	0.04
SRABB	Sacramento River above Bend Bridge	2/13/96	5/17/00	39	37	95%	0.57	3.9	1.0	1.0	1.5	2.0	2.4	1
SRHAM	Sacramento River near Hamilton City	6/23/99	5/16/00	13	13	100%	0.60	3.8	0.7	1.0	1.2	1.6	2.3	—
SRCOL	Sacramento River at Colusa	2/28/96	11/16/99	33	31	94%	1	3.4	1.0	1.1	1.4	2.0	2.2	1
SACSL	Sacramento Slough	2/12/96	5/16/00	37	37	100%	1	4	1.4	1.7	2.0	2.1	3.0	—
COLDR	Colusa Basin Drain	2/7/96	5/16/00	40	40	100%	1	8.0	1.7	2.0	2.4	3.0	4.0	—
YRMRY	Yuba River at Marysville	2/27/96	4/6/98	27	12	44%	1	3	<RL	<RL	<RL	1.2	1.6	1
FRNIC	Feather River near Nicolaus	2/23/96	1/18/00	28	20	71%	0.34	2.1	<RL	<RL	1.0	1.3	2.0	1
SRVON	Sacramento River at Verona	2/22/96	4/22/98	27	25	93%	1	2.3	1.0	1.0	1.7	2.0	2.0	1
SRVET	Sacramento River at Veterans Bridge	1/4/94	6/20/00	101	100	99%	0.5	3.0	1.0	1.2	1.4	1.7	2.1	0.5
ARCNW	Arcade Creek at Norwood Ave.	2/6/96	5/17/00	40	40	100%	0.19	9	1.8	3.0	4.0	4.8	6.0	—
ARJST	American River at J Street	3/18/96	4/16/98	26	6	23%	1.00	2.8	<RL	<RL	<RL	<RL	1.7	1
ARDPK	American River at Discovery Park	1/4/94	6/20/00	96	83	86%	0.28	1.3	<RL	0.5	0.5	0.7	0.9	0.5
SRFPT	Sacramento River at Freeport	1/4/94	6/21/00	133	131	98%	0.50	3	1.0	1.1	1.3	1.6	2.1	0.5
SRRMF	Sacramento River at River Mile 44	1/18/94	6/21/00	94	93	99%	0.63	6	1.0	1.1	1.4	1.7	2.1	0.5
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	11	11	100%	0.75	1.7	0.8	0.9	1.0	1.5	1.6	—
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	12	12	100%	1.16	4.2	1.3	1.5	1.8	2.4	3.9	—

Copper, total

Units = µg/L

Site ID	Site Description	monitoring period start	monitoring period end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
SRBKR	Sacramento River below Keswick	1/20/98	4/18/00	39	39	100%	0.06	13.0	1.06	1.32	2.13	4.18	6.94	—
CCMOU	Clear Creek near Mouth	9/15/98	7/20/99	11	11	100%	0.79	18.8	0.82	0.89	1.08	1.71	10.60	—
SRABB	Sacramento River above Bend Bridge	6/23/99	5/17/00	12	12	100%	0.93	6.5	0.99	1.27	1.70	3.10	3.82	—
MCMOU	Mill Creek at Mouth	6/23/98	4/17/00	19	18	95%	0.43	18.9	0.47	0.60	1.18	1.51	3.23	0.04
MCBLR	Mill Creek at Black Rock	6/23/98	4/17/00	17	17	100%	0.32	7.9	0.35	0.43	1.04	1.27	2.16	—
MCHWY	Mill Creek at Highway 36	6/23/98	4/17/00	19	19	100%	0.58	11.2	0.67	0.87	1.65	2.19	3.88	—
SRHAM	Sacramento River near Hamilton City	6/23/99	5/16/00	13	13	100%	1.21	18.9	1.31	1.46	1.72	3.32	11.09	—
DCMOU	Deer Creek at Mouth	6/24/98	4/17/00	14	14	100%	0.31	1.3	0.38	0.55	0.65	0.84	1.18	—
DCUDD	Deer Creek at Upper Diversion Dam	6/24/98	4/17/00	19	19	100%	0.09	5.9	0.14	0.21	0.29	0.52	0.66	—
DCPON	Deer Creek at Ponderosa Way	6/24/98	11/8/99	12	12	100%	0.11	0.43	0.12	0.13	0.19	0.32	0.42	—
DCMDW	Deer Creek below Childs Meadows	6/24/98	4/17/00	19	17	89%	0.06	2.2	<RL	0.11	0.17	0.39	0.48	0.04
CHMUD	Big Chico Creek above Mud Creek	6/23/98	4/17/00	20	20	100%	0.23	4.3	0.34	0.47	0.64	1.51	3.36	—
MUDCH	Mud Creek above Big Chico Creek	6/23/98	4/17/00	11	11	100%	0.30	3.0	0.50	0.99	1.29	1.56	1.69	—
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/23/98	4/17/00	19	19	100%	0.21	5.2	0.24	0.31	0.37	0.68	1.01	—
CHASH	Big Chico Creek above Salmon Hole	6/23/98	2/14/00	16	16	100%	0.08	3.8	0.14	0.19	0.27	0.38	0.60	—
CHHWY	Big Chico Creek at Hwy 32	6/23/98	4/17/00	19	18	95%	0.09	2.6	0.10	0.13	0.19	0.36	0.52	0.04
SACSL	Sacramento Slough	6/22/99	5/16/00	12	12	100%	3.6	7.4	4.06	4.11	5.11	6.19	6.98	—
COLDR	Colusa Basin Drain	6/23/99	5/16/00	13	13	100%	3.8	21.5	4.16	5.27	7.48	8.87	15.42	—
SRVET	Sacramento River at Veterans Bridge	1/4/94	6/20/00	101	101	100%	1.4	16.9	2.60	3.07	3.69	5.16	6.54	—
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	5/17/00	12	12	100%	0.69	21.1	2.05	2.49	4.29	7.86	10.76	—
ARDPK	American River at Discovery Park	1/4/94	6/20/00	99	96	97%	0.40	3.6	0.52	0.60	0.80	1.10	1.71	0.5
SRFPT	Sacramento River at Freeport	1/4/94	6/21/00	99	99	100%	1.5	14.0	2.08	2.50	3.40	4.74	6.92	—
SRRMF	Sacramento River at River Mile 44	1/18/94	6/21/00	91	91	100%	1.2	15.0	2.21	2.56	3.38	5.19	6.80	—
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	11	11	100%	1.0	36.0	1.25	1.75	2.42	8.58	20.21	—
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	13	13	100%	2.0	8.3	3.21	3.49	4.47	6.56	8.01	—

Lead, dissolved

Units = µg/L

Site ID	Site Description	monitoring period start	monitoring period end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
SRBKR	Sacramento River below Keswick	1/20/98	4/18/00	39	30	77%	0.004	0.13	<RL	0.01	0.02	0.04	0.08	0.005
CCMOU	Clear Creek near Mouth	12/14/98	2/16/99	3	3	100%	0.012	0.20	0.01	0.01	0.01	0.11	0.16	—
SRHAM	Sacramento River near Hamilton City	6/23/99	8/18/99	3	3	100%	0.014	0.09	0.02	0.02	0.02	0.05	0.07	—
SRCOL	Sacramento River at Colusa	2/28/96	11/16/99	33	1	3%	0.060	0.06	<RL	<RL	<RL	<RL	<RL	1
SACSL	Sacramento Slough	2/12/96	11/16/99	28	3	11%	0.049	0.13	<RL	<RL	<RL	<RL	1.00	1
COLDR	Colusa Basin Drain	2/7/96	8/18/99	30	3	10%	0.038	0.26	<RL	<RL	<RL	<RL	1.00	1
YRMRY	Yuba River at Marysville	2/27/96	4/6/98	27	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	1
FRNIC	Feather River near Nicolaus	2/23/96	1/18/00	28	1	4%	0.088	0.09	<RL	<RL	<RL	<RL	<RL	1
SRVON	Sacramento River at Verona	2/22/96	4/22/98	27	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	1
SRVET	Sacramento River at Veterans Bridge	1/4/94	6/20/00	93	30	32%	0.020	0.40	<RL	<RL	<RL	0.10	0.15	0.1
ARCNW	Arcade Creek at Norwood Ave.	2/6/96	7/20/99	30	3	10%	1.040	1.32	<RL	<RL	<RL	<RL	1.00	1
ARJST	American River at J Street	3/18/96	4/16/98	26	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	1
ARDPK	American River at Discovery Park	1/4/94	9/21/99	81	17	21%	0.016	0.50	<RL	<RL	<RL	<RL	0.10	0.1
SRFPT	Sacramento River at Freeport	1/4/94	6/21/00	123	28	23%	0.006	0.50	<RL	<RL	<RL	<RL	1.00	0.1
SRRMF	Sacramento River at River Mile 44	1/18/94	6/21/00	86	26	30%	0.015	0.30	<RL	<RL	<RL	0.10	0.10	0.1
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	11	11	100%	0.014	0.09	0.02	0.02	0.03	0.04	0.06	—
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	12	11	92%	0.018	0.64	0.02	0.04	0.07	0.21	0.48	0.005

Summary Statistics: Trace Metals Data

Lead, total

Units = µg/L

		monitoring period							percentile statistics					
Site ID	Site Description	start	end	n	n det	% det	min det	max det	10th	25th	median (50th)	75th	90th	min RL
SRBKR	Sacramento River below Keswick	1/20/98	4/18/00	39	36	92%	0.005	0.75	0.02	0.03	0.05	0.09	0.19	0.005
CCMOU	Clear Creek near Mouth	9/15/98	7/20/99	10	8	80%	0.018	12.1	<RL	0.02	0.03	0.05	1.76	0.01
MCMOU	Mill Creek at Mouth	6/23/98	4/17/00	18	14	78%	0.017	3.3	<RL	0.03	0.07	0.23	1.09	0.009
MCBLR	Mill Creek at Black Rock	6/23/98	4/17/00	16	12	75%	0.024	1.3	<RL	0.03	0.06	0.12	0.28	0.01
MCHWY	Mill Creek at Highway 36	6/23/98	4/17/00	18	14	78%	0.029	2.6	<RL	0.04	0.08	0.21	0.55	0.009
SRHAM	Sacramento River near Hamilton City	6/23/99	8/18/99	3	3	100%	0.074	0.16	0.08	0.09	0.10	0.13	0.14	—
DCMOU	Deer Creek at Mouth	6/24/98	4/17/00	13	10	77%	0.012	0.20	<RL	0.02	0.03	0.07	0.17	0.009
DCUDD	Deer Creek at Upper Diversion Dam	6/24/98	4/17/00	18	9	50%	0.007	1.0	<RL	<RL	0.02	0.04	0.06	0.009
DCPON	Deer Creek at Ponderosa Way	6/24/98	11/8/99	12	5	42%	0.005	3.3	<RL	<RL	<RL	0.02	0.04	0.009
DCMDW	Deer Creek below Childs Meadows	6/24/98	4/17/00	18	12	67%	0.013	1.2	<RL	<RL	0.02	0.06	0.08	0.009
CHMUD	Big Chico Creek above Mud Creek	6/23/98	4/17/00	19	15	79%	0.013	2.9	<RL	0.02	0.09	0.41	0.91	0.009
MUDCH	Mud Creek above Big Chico Creek	6/23/98	4/17/00	11	10	91%	0.030	0.68	0.03	0.04	0.12	0.26	0.38	0.048
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/23/98	4/17/00	18	14	78%	0.013	1.7	<RL	0.02	0.03	0.14	0.69	0.009
CHASH	Big Chico Creek above Salmon Hole	6/23/98	2/14/00	15	6	40%	0.006	0.81	<RL	<RL	<RL	0.02	0.05	0.009
CHHWY	Big Chico Creek at Hwy 32	6/23/98	4/17/00	18	9	50%	0.005	0.57	<RL	<RL	0.01	0.03	0.06	0.009
SRVET	Sacramento River at Veterans Bridge	1/4/94	6/20/00	101	101	100%	0.04	7.2	0.30	0.40	0.51	0.73	1.10	—
ARDPK	American River at Discovery Park	1/4/94	6/20/00	95	85	89%	0.057	1.3	<RL	0.11	0.20	0.30	0.54	0.1
SRFPT	Sacramento River at Freeport	1/4/94	6/21/00	99	99	100%	0.16	3.0	0.20	0.30	0.50	0.90	1.25	—
SRRMF	Sacramento River at River Mile 44	1/18/94	6/21/00	92	92	100%	0.10	3.4	0.26	0.30	0.53	0.91	1.45	—
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	11	11	100%	0.093	5.7	0.14	0.25	0.38	1.41	3.05	—
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	12	12	100%	0.18	1.8	0.39	0.52	0.68	1.24	1.60	—

Nickel, dissolved

Units = µg/L

		monitoring period							percentile statistics					
Site ID	Site Description	start	end	n	n det	% det	min det	max det	10th	25th	median (50th)	75th	90th	min RL
SRBKR	Sacramento River below Keswick	5/20/99	4/18/00	15	15	100%	0.34	1.9	0.7	0.9	1.2	1.3	1.3	—
SRABB	Sacramento River above Bend Bridge	2/13/96	7/21/99	29	20	69%	1	2	<RL	<RL	1.0	1.4	2.0	1
SRCOL	Sacramento River at Colusa	2/28/96	11/16/99	33	22	67%	0.77	2	<RL	<RL	1.0	1.2	1.9	1
SACSL	Sacramento Slough	2/12/96	11/16/99	28	27	96%	1	3	1.3	1.5	2.0	2.4	3.0	1
COLDR	Colusa Basin Drain	2/7/96	8/18/99	30	30	100%	1.7	5	2.0	2.4	3.0	3.0	3.6	—
YRMRY	Yuba River at Marysville	2/27/96	4/6/98	27	7	26%	1	2.1	<RL	<RL	<RL	1.0	1.0	1
FRNIC	Feather River near Nicolaus	2/23/96	1/18/00	28	6	21%	0.56	1	<RL	<RL	<RL	<RL	1.0	1
SRVON	Sacramento River at Verona	2/22/96	4/22/98	27	16	59%	1	2	<RL	<RL	1.0	1.1	1.4	1
ARCNW	Arcade Creek at Norwood Ave.	2/6/96	7/20/99	30	30	100%	1.8	4.4	2.0	2.0	2.8	3.0	3.7	—
ARJST	American River at J Street	3/18/96	4/16/98	26	4	15%	1	1.3	<RL	<RL	<RL	<RL	1.0	1
SRFPT	Sacramento River at Freeport	1/4/94	6/21/00	109	71	65%	0.26	3	<RL	<RL	1.0	1.0	1.3	0.15
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	11	11	100%	1.6	3.9	1.7	1.8	2.6	3.2	3.4	—
CCHSL	Cache Slough near Ryers Ferry	6/22/99	2/16/00	6	6	100%	0.65	5.4	0.8	1.0	1.4	3.6	4.8	—

Nickel, total

Units = µg/L

		monitoring period							percentile statistics					
Site ID	Site Description	start	end	n	n det	% det	min det	max det	10th	25th	median (50th)	75th	90th	min RL
SRBKR	Sacramento River below Keswick	1/20/98	4/18/00	39	39	100%	0.51	4.7	1.03	1.25	1.53	2.54	3.07	—
CCMOU	Clear Creek near Mouth	9/15/98	7/20/99	9	8	89%	1.12	3.8	<RL	1.24	1.61	2.10	2.51	0.01
MCMOU	Mill Creek at Mouth	6/23/98	4/17/00	19	18	95%	0.05	16.6	0.19	0.33	0.82	1.00	2.34	0.05
MCBLR	Mill Creek at Black Rock	6/23/98	4/17/00	17	17	100%	0.05	5.2	0.28	0.43	0.74	0.98	1.71	—
MCHWY	Mill Creek at Highway 36	6/23/98	4/17/00	19	19	100%	0.52	7.5	1.26	1.60	2.32	2.72	3.41	—
SRHAM	Sacramento River near Hamilton City	6/23/99	8/18/99	3	3	100%	1.25	1.8	1.30	1.38	1.51	1.65	1.73	—
DCMOU	Deer Creek at Mouth	6/24/98	4/17/00	13	12	92%	0.01	1.4	0.05	0.24	0.54	0.82	1.05	0.01
DCUDD	Deer Creek at Upper Diversion Dam	6/24/98	4/17/00	16	9	56%	0.03	7.0	<RL	<RL	0.06	0.25	0.39	0.01
DCPON	Deer Creek at Ponderosa Way	6/24/98	11/8/99	9	3	33%	0.11	0.35	<RL	<RL	<RL	0.11	0.35	0.005
DCMDW	Deer Creek below Childs Meadows	6/24/98	4/17/00	16	9	56%	0.03	1.4	<RL	<RL	0.05	0.12	0.15	0.005
CHMUD	Big Chico Creek above Mud Creek	6/23/98	4/17/00	17	12	71%	0.23	6.0	<RL	<RL	0.50	1.58	3.19	0.005
MUDCH	Mud Creek above Big Chico Creek	6/23/98	4/17/00	11	11	100%	0.18	2.3	0.20	0.61	0.72	1.09	1.19	—
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/23/98	4/17/00	16	12	75%	0.027	8.7	<RL	0.04	0.13	0.59	3.06	0.005
CHASH	Big Chico Creek above Salmon Hole	6/23/98	2/14/00	13	8	62%	0.02	6.6	<RL	<RL	0.06	0.18	0.36	0.005
CHHWY	Big Chico Creek at Hwy 32	6/23/98	4/17/00	15	4	27%	0.03	2.1	<RL	<RL	<RL	0.05	0.07	0.005
SACSL	Sacramento Slough	6/22/99	11/16/99	3	3	100%	5.9	7.2	5.93	5.99	6.08	6.66	7.00	—
COLDR	Colusa Basin Drain	6/23/99	8/18/99	3	3	100%	10.1	16.9	10.78	11.80	13.50	15.20	16.22	—
SRVET	Sacramento River at Veterans Bridge	1/4/94	6/20/00	83	81	98%	1.1	22.5	2.00	2.50	4.60	6.25	9.51	1
ARDPK	American River at Discovery Park	1/4/94	6/20/00	80	67	84%	0.18	8.0	<RL	0.56	0.90	1.16	1.86	1
SRFPT	Sacramento River at Freeport	1/4/94	6/21/00	80	78	98%	1.2	18.0	1.51	2.12	3.24	6.60	8.92	1
SRRMF	Sacramento River at River Mile 44	2/1/94	6/21/00	72	71	99%	1.1	17.0	1.55	1.98	3.59	6.38	9.21	1
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	11	11	100%	3.1	180.0	3.25	4.53	6.45	35.98	70.87	—
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	12	12	100%	1.8	13.9	3.96	5.10	7.52	11.13	13.09	—

Summary Statistics: Trace Metals Data

Selenium, total

Units = µg/L

Site ID	Site Description	monitoring period start	monitoring period end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
SRBKR	Sacramento River below Keswick	6/24/98	4/18/00	13	13	100%	0.05	0.13	0.05	0.07	0.09	0.11	0.12	—
MCMOU	Mill Creek at Mouth	6/23/98	5/19/99	12	4	33%	0.09	0.23	<RL	<RL	<RL	0.24	0.50	0.1
MCBLR	Mill Creek at Black Rock	6/23/98	5/19/99	10	5	50%	0.11	0.28	<RL	<RL	0.23	0.28	0.55	0.15
MCHWY	Mill Creek at Highway 36	6/23/98	5/19/99	12	7	58%	0.15	0.45	<RL	<RL	0.25	0.41	0.52	0.1
DCMOU	Deer Creek at Mouth	6/24/98	5/18/99	10	1	10%	0.34	0.34	<RL	<RL	<RL	<RL	0.55	0.1
DCUDD	Deer Creek at Upper Diversion Dam	6/24/98	5/18/99	11	3	27%	0.26	0.28	<RL	<RL	<RL	0.28	0.53	0.1
DCPON	Deer Creek at Ponderosa Way	6/24/98	5/18/99	8	2	25%	0.31	0.33	<RL	<RL	<RL	0.32	0.44	0.1
DCMDW	Deer Creek below Childs Meadows	6/24/98	5/18/99	11	1	9%	0.29	0.29	<RL	<RL	<RL	<RL	<RL	0.1
CHMUD	Big Chico Creek above Mud Creek	6/23/98	5/20/99	11	3	27%	0.12	0.27	<RL	<RL	<RL	0.26	0.53	0.1
MUDCH	Mud Creek above Big Chico Creek	6/23/98	5/20/99	7	1	14%	0.25	0.25	<RL	<RL	<RL	<RL	0.36	0.1
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/23/98	5/20/99	11	2	18%	0.33	0.39	<RL	<RL	<RL	<RL	0.53	0.1
CHASH	Big Chico Creek above Salmon Hole	6/23/98	5/20/99	11	3	27%	0.26	0.29	<RL	<RL	<RL	0.28	0.53	0.1
CHHWY	Big Chico Creek at Hwy 32	6/23/98	5/20/99	11	3	27%	0.30	0.65	<RL	<RL	<RL	0.42	0.65	0.1
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	11	11	100%	0.05	0.24	0.08	0.08	0.09	0.19	0.23	—

1000

Silver, total

Units = µg/L

Site ID	Site Description	monitoring period start	monitoring period end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
SRBKR	Sacramento River below Keswick	1/20/98	4/18/00	39	26	67%	—	0.039	<RL	<RL	0.015	0.020	0.022	0.02
CCMOU	Clear Creek near Mouth	9/15/98	7/20/99	8	4	50%	0.006	0.019	<RL	<RL	0.01	0.01	0.01	0.001
MCMOU	Mill Creek at Mouth	6/23/98	4/17/00	16	15	94%	0.003	13.7	0.01	0.02	0.18	0.43	0.98	0.008
MCBLR	Mill Creek at Black Rock	6/23/98	4/17/00	14	12	86%	0.002	15.1	<RL	0.08	0.23	0.56	1.29	0.002
MCHWY	Mill Creek at Highway 36	6/23/98	4/17/00	16	13	81%	0.004	24.9	<RL	0.15	0.35	0.63	1.25	0.002
SRHAM	Sacramento River near Hamilton City	6/23/99	8/18/99	3	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.02
DCMOU	Deer Creek at Mouth	6/24/98	4/17/00	12	3	25%	0.008	0.07	<RL	<RL	<RL	0.008	0.009	0.001
DCUDD	Deer Creek at Upper Diversion Dam	6/24/98	4/17/00	15	7	47%	0.002	0.025	<RL	<RL	<RL	0.008	0.009	0.001
DCPON	Deer Creek at Ponderosa Way	6/24/98	11/8/99	9	4	44%	0.001	0.058	<RL	<RL	<RL	0.008	0.041	0.002
DCMDW	Deer Creek below Childs Meadows	6/24/98	4/17/00	15	8	53%	0.002	0.023	<RL	<RL	0.005	0.008	0.012	0.001
CHMUD	Big Chico Creek above Mud Creek	6/23/98	4/17/00	16	8	50%	0.003	0.013	<RL	<RL	0.006	0.008	0.011	0.001
MUDCH	Mud Creek above Big Chico Creek	6/23/98	4/17/00	10	5	50%	0.001	0.037	<RL	<RL	0.006	0.010	0.018	0.003
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/23/98	4/17/00	15	6	40%	0.003	0.012	<RL	<RL	<RL	0.008	0.010	0.001
CHASH	Big Chico Creek above Salmon Hole	6/23/98	2/14/00	12	4	33%	0.007	0.008	<RL	<RL	<RL	0.007	0.007	0.001
CHHWY	Big Chico Creek at Hwy 32	6/23/98	4/17/00	15	6	40%	0.002	0.017	<RL	<RL	<RL	0.007	0.009	0.001
SACSL	Sacramento Slough	6/22/99	11/16/99	3	2	67%	0.011	0.016	<RL	<RL	0.016	0.018	0.019	0.02
COLDR	Colusa Basin Drain	6/23/99	8/18/99	3	2	67%	0.021	0.045	<RL	<RL	0.021	0.033	0.040	0.02
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	11	11	100%	0.032	0.089	0.032	0.033	0.042	0.058	0.076	—
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	12	10	83%	0.01	0.032	<RL	0.014	0.017	0.022	0.029	0.02

Summary Statistics: Trace Metals Data

Zinc, dissolved

Units = µg/L

Site ID	Site Description	monitoring period start	monitoring period end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
SRBKR	Sacramento River below Keswick	1/20/98	4/18/00	39	39	100%	0.2	12.9	1.5	1.9	2.8	4.6	7.2	—
SRABB	Sacramento River above Bend Bridge	2/13/96	5/17/00	39	38	97%	1.0	11.0	1.2	1.5	2.0	3.0	6.7	1
SRHAM	Sacramento River near Hamilton City	6/23/99	5/16/00	13	12	92%	0.8	8.9	0.8	0.8	1.8	3.7	5.5	0.05
SRCOL	Sacramento River at Colusa	2/28/96	11/16/99	33	18	55%	1.0	2.3	<RL	<RL	1.0	1.5	1.9	0.05
SACSL	Sacramento Slough	2/12/96	11/16/99	27	8	30%	0.9	1.4	<RL	<RL	<RL	1.0	1.1	0.05
COLDR	Colusa Basin Drain	2/7/96	8/18/99	29	13	45%	0.6	6.1	<RL	<RL	<RL	2.0	2.7	1
YRMRY	Yuba River at Marysville	2/27/96	4/6/98	27	8	30%	1.0	7.0	<RL	<RL	<RL	1.0	1.9	1
FRNIC	Feather River near Nicolaus	2/23/96	1/18/00	27	7	26%	0.7	2.1	<RL	<RL	<RL	1.0	1.5	1
SRVON	Sacramento River at Verona	2/22/96	4/22/98	26	8	31%	1.0	4.0	<RL	<RL	<RL	1.1	1.9	1
SRVET	Sacramento River at Veterans Bridge	1/4/94	6/20/00	100	54	54%	0.2	23.0	<RL	<RL	1.0	4.0	4.0	0.01
ARCNW	Arcade Creek at Norwood Ave.	2/6/96	7/20/99	30	30	100%	1.4	19.0	3.0	4.1	7.7	10.8	12.1	—
ARJST	American River at J Street	3/18/96	4/16/98	26	13	50%	1.0	11.0	<RL	<RL	1.0	1.7	2.7	1
ARDPK	American River at Discovery Park	1/4/94	6/20/00	96	47	49%	0.1	7.4	<RL	<RL	<RL	4.0	4.0	0.1
SRFPT	Sacramento River at Freeport	1/4/94	6/21/00	129	76	59%	0.3	27.0	<RL	<RL	1.0	4.0	4.0	0.1
SRRMF	Sacramento River at River Mile 44	1/18/94	6/21/00	93	54	58%	0.1	18.0	<RL	<RL	1.2	4.0	4.0	0.5
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	11	11	100%	0.5	2.0	0.6	0.8	1.0	1.6	1.9	—
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	12	12	100%	0.2	4.3	0.3	0.5	0.7	2.3	3.3	—

Zinc, total

Units = µg/L

Site ID	Site Description	monitoring period start	monitoring period end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
SRBKR	Sacramento River below Keswick	1/20/98	4/18/00	39	39	100%	0.5	143	1.8	2.5	3.8	7.5	10.3	—
CCMOU	Clear Creek near Mouth	9/15/98	7/20/99	11	11	100%	0.5	58.7	0.5	0.6	0.8	2.4	25.1	—
SRABB	Sacramento River above Bend Bridge	6/23/99	5/17/00	12	12	100%	0.1	9.5	2.1	2.5	3.0	5.1	6.9	—
MCMOU	Mill Creek at Mouth	6/23/98	4/17/00	19	19	100%	0.2	22.9	0.3	0.5	0.9	1.8	4.0	—
MCBLR	Mill Creek at Black Rock	6/23/98	4/17/00	17	17	100%	0.4	10.8	0.5	0.6	1.1	1.7	2.4	—
MCHWY	Mill Creek at Highway 36	6/23/98	4/17/00	19	19	100%	1.0	17.3	1.4	1.9	2.7	3.3	5.4	—
SRHAM	Sacramento River near Hamilton City	6/23/99	5/16/00	13	13	100%	0.6	34.7	1.9	2.4	3.4	4.6	20.8	—
DCMOU	Deer Creek at Mouth	6/24/98	4/17/00	13	12	92%	0.2	1.3	0.3	0.4	0.5	1.0	1.2	0.18
DCUDD	Deer Creek at Upper Diversion Dam	6/24/98	4/17/00	17	11	65%	0.1	6.8	<RL	<RL	0.2	0.3	2.4	0.004
DCPON	Deer Creek at Ponderosa Way	6/24/98	11/8/99	10	6	60%	0.1	0.9	<RL	<RL	0.2	0.3	0.4	0.14
DCMDW	Deer Creek below Childs Meadows	6/24/98	4/17/00	17	16	94%	0.2	4.1	0.2	0.3	0.4	0.5	1.0	0.22
CHMUD	Big Chico Creek above Mud Creek	6/23/98	4/17/00	17	16	94%	0.3	13.6	0.4	0.5	0.8	3.1	7.0	0.18
MUDCH	Mud Creek above Big Chico Creek	6/23/98	4/17/00	3	3	100%	1.3	3.6	1.4	1.6	2.0	2.8	3.3	—
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/23/98	4/17/00	16	15	94%	0.2	7.8	0.2	0.3	0.5	1.3	3.8	0.18
CHASH	Big Chico Creek above Salmon Hole	6/23/98	2/14/00	13	8	62%	0.1	5.1	<RL	<RL	0.2	0.3	0.6	0.07
CHHWY	Big Chico Creek at Hwy 32	6/23/98	4/17/00	16	12	75%	0.1	3.5	<RL	0.2	0.2	0.4	0.4	0.14
SACSL	Sacramento Slough	6/22/99	11/16/99	3	3	100%	3.1	8.5	3.8	4.7	6.3	7.4	8.0	—
COLDR	Colusa Basin Drain	6/23/99	8/18/99	3	3	100%	8.1	17	8.9	10.1	12.2	14.6	16.0	—
SRVET	Sacramento River at Veterans Bridge	1/4/94	6/20/00	100	93	93%	0.5	31	3.1	4.0	5.7	8.5	11.3	4
ARDPK	American River at Discovery Park	1/4/94	6/20/00	97	64	66%	0.2	230	<RL	<RL	2.8	4.0	5.6	0.5
SRFPT	Sacramento River at Freeport	1/4/94	6/21/00	98	85	87%	0.9	29	<RL	3.8	4.8	7.8	12.0	4
SRRMF	Sacramento River at River Mile 44	1/18/94	6/21/00	91	81	89%	1.4	52	<RL	4.0	5.9	9.8	15.7	4
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	11	11	100%	2.0	69	2.1	4.1	6.2	17.1	35.3	—
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	12	12	100%	2.1	13	3.9	4.3	6.7	9.4	12.8	—

Summary Statistics Table Notes:
monitoring period start and end — Dates of first and last reported data.
n — Total number of data reported.
n det — Total number of data above reporting limits.
% det — Percent of data above reporting limits.
min det — Minimum value for data detected above reporting limits.
max det — Maximum value of data detected above reporting limits.
percentiles — Percentile data are provided for data above reporting limits. "<RL" indicates insufficient data to calculate statistic.
min RL — Lowest reporting limit for data below detection. min RL only reported where percent detection (% det) < 100%.

Summary Statistics: Data for Pesticides Detected in SRWP Monitoring

Aldicarb

Units = µg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	10th	25th	median (50th)	75th	90th	min RL
SACSL	Sacramento Slough	6/22/99	5/16/00	12	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.4
COLDR	Colusa Basin Drain	6/23/99	5/16/00	12	1	8%	0.7	0.7	<RL	<RL	<RL	<RL	<RL	0.4
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	5/16/00	12	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.4

Bromacil

Units = µg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	10th	25th	median (50th)	75th	90th	min RL
SACSL	Sacramento Slough	6/22/99	5/16/00	12	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.4
COLDR	Colusa Basin Drain	6/23/99	5/16/00	12	3	25%	0.4	0.4	<RL	<RL	<RL	0.4	0.4	0.4
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	5/16/00	12	2	17%	0.4	0.8	<RL	<RL	<RL	<RL	0.44	0.4

Carbaryl

Units = µg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	10th	25th	median (50th)	75th	90th	min RL
SACSL	Sacramento Slough	6/22/99	5/16/00	12	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.07
COLDR	Colusa Basin Drain	6/23/99	5/16/00	12	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.07
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	5/16/00	12	3	25%	0.1	0.25	<RL	<RL	<RL	0.09	0.13	0.07

Carbofuran

Units = µg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	10th	25th	median (50th)	75th	90th	min RL
SACSL	Sacramento Slough	6/22/99	5/16/00	11	1	9%	0.11	0.11	<RL	<RL	<RL	<RL	0.08	0.07
COLDR	Colusa Basin Drain	6/23/99	5/16/00	12	2	17%	0.07	0.41	<RL	<RL	<RL	<RL	0.10	0.07
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	5/16/00	12	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.07

Chlorpyrifos

Units = µg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	10th	25th	median (50th)	75th	90th	min RL
SRHAM	Sacramento River near Hamilton City	6/23/99	5/16/00	12	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.05
SRCOL	Sacramento River at Colusa	6/24/99	5/16/00	12	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.05
SACSL	Sacramento Slough	6/22/99	5/16/00	11	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.05
COLDR	Colusa Basin Drain	6/23/99	5/16/00	12	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.05
SRVET	Sacramento River at Veterans Bridge	7/20/99	5/16/00	11	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.05
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	5/16/00	12	1	8%	0.05	0.05	<RL	<RL	<RL	<RL	<RL	0.05

Diazinon

Units = µg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	10th	25th	median (50th)	75th	90th	min RL
SRHAM	Sacramento River near Hamilton City	6/23/99	5/16/00	12	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.05
SRCOL	Sacramento River at Colusa	6/24/99	5/16/00	12	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.05
SACSL	Sacramento Slough	6/22/99	5/16/00	12	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.05
COLDR	Colusa Basin Drain	6/23/99	5/16/00	12	1	8%	0.1	0.1	<RL	<RL	<RL	<RL	<RL	0.05
SRVET	Sacramento River at Veterans Bridge	7/20/99	5/16/00	12	1	8%	0.05	0.05	<RL	<RL	<RL	<RL	<RL	0.05
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	5/16/00	12	10	83%	0.11	0.83	<RL	0.12	0.17	0.31	0.42	0.05

Diuron

Units =

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	10th	25th	median (50th)	75th	90th	min RL
SACSL	Sacramento Slough	6/22/99	5/16/00	11	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.4
COLDR	Colusa Basin Drain	6/23/99	5/16/00	12	3	25%	0.4	0.7	<RL	<RL	<RL	0.4	0.43	0.4
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	5/16/00	12	4	33%	0.7	6.3	<RL	<RL	<RL	0.78	1.62	0.4

Malathion

Units =

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	10th	25th	median (50th)	75th	90th	min RL
SRHAM	Sacramento River near Hamilton City	6/23/99	5/16/00	12	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.1
SRCOL	Sacramento River at Colusa	6/24/99	5/16/00	12	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.1
SACSL	Sacramento Slough	6/22/99	5/16/00	11	1	9%	0.1	0.1	<RL	<RL	<RL	<RL	<RL	0.1
COLDR	Colusa Basin Drain	6/23/99	5/16/00	12	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.1
SRVET	Sacramento River at Veterans Bridge	7/20/99	5/16/00	11	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.1
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	5/16/00	12	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.1

Prometon

Units =

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	10th	25th	median (50th)	75th	90th	min RL
SRHAM	Sacramento River near Hamilton City	6/23/99	5/16/00	12	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.1
SRCOL	Sacramento River at Colusa	6/24/99	5/16/00	12	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.1
SACSL	Sacramento Slough	6/22/99	5/16/00	12	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.1
COLDR	Colusa Basin Drain	6/23/99	5/16/00	12	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.1
SRVET	Sacramento River at Veterans Bridge	7/20/99	5/16/00	11	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.1
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	5/16/00	12	3	25%	0.1	0.21	<RL	<RL	<RL	0.1	0.145	0.1

Summary Statistics: Data for Pesticides Detected in SRWP Monitoring

Propazine

Units =

Site ID	Site Description	monitoring period start	monitoring period end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	4/19/00	11	2	18%	1.1	2	<RL	<RL	<RL	<RL	1.1	0.5

Prowl

Units =

Site ID	Site Description	monitoring period start	monitoring period end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
SRHAM	Sacramento River near Hamilton City	6/23/99	5/16/00	13	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.1
SRCOL	Sacramento River at Colusa	6/24/99	5/16/00	13	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.1
SACSL	Sacramento Slough	6/22/99	5/16/00	11	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.1
COLDR	Colusa Basin Drain	6/23/99	5/16/00	12	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.1
SRVET	Sacramento River at Veterans Bridge	7/20/99	5/16/00	12	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.1
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	5/16/00	12	2	17%	0.1	0.47	<RL	<RL	<RL	<RL	0.1	0.1

Tebuthiuron

Units =

Site ID	Site Description	monitoring period start	monitoring period end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
SACSL	Sacramento Slough	6/22/99	5/16/00	12	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.4
COLDR	Colusa Basin Drain	6/23/99	5/16/00	12	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.4
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	5/16/00	12	3	25%	0.4	3	<RL	<RL	<RL	0.55	1.27	0.4

Table Notes:
"Monitoring Period Start and End" — Dates of first and last reported data.
"n" — Total number of data reported.
"n det" — Total number of data above reporting limits.
"% det" — Percent of data above reporting limits.
"min det" — Minimum value for data detected above reporting limits.
"max det" — Maximum value of data detected above reporting limits.
"percentiles" — Percentile data are provided for data above reporting limits. "<RL" indicates insufficient data to calculate statistic.
"min RL" — Lowest reporting limit for data below detection. "—" indicates there were no data below reporting limits.

Summary Statistics: Drinking Water Parameters

Organic Carbon, dissolved

Units = mg/L

Site ID	Site Description	monitoring period start	monitoring period end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
PRSHA	Pit River above Shasta	11/15/99	5/16/00	4	4	100%	0.9	1.7	1.0	1.1	1.3	1.4	1.6	—
MRSHA	McCloud River above Shasta	11/15/99	5/16/00	4	4	100%	0.5	0.8	0.5	0.6	0.7	0.7	0.8	—
SRSHA	Sacramento River above Shasta	11/15/99	5/16/00	4	4	100%	0.9	1.4	1.1	1.3	1.4	1.4	1.4	—
SCKPP	Spring Creek PP Discharge to Keswick Res.	10/20/99	4/18/00	4	4	100%	1.1	1.2	1.1	1.2	1.2	1.2	1.2	—
SRBKR	Sacramento River below Keswick	10/20/99	5/16/00	8	8	100%	0.9	1.2	0.9	0.9	1.0	1.1	1.2	—
SRABB	Sacramento River above Bend Bridge	2/13/96	5/17/00	35	35	100%	0.9	3.2	1.1	1.3	1.4	1.6	2.0	—
SRHAM	Sacramento River near Hamilton City	9/22/99	5/16/00	8	8	100%	1.3	3	1.3	1.3	1.4	2.3	2.5	—
SRCOL	Sacramento River at Colusa	2/28/96	4/8/98	27	27	100%	1.1	6.4	1.2	1.3	1.4	1.6	2.7	—
SACSL	Sacramento Slough	2/12/96	5/16/00	32	32	100%	1.4	6.3	1.8	3.0	3.5	4.3	5.4	—
COLDR	Colusa Basin Drain	2/7/96	5/16/00	38	38	100%	2.5	10	3.8	4.5	5.2	7.0	8.2	—
YRMRY	Yuba River at Marysville	2/27/96	5/16/00	36	36	100%	0.7	2.5	0.8	0.9	1.0	1.3	1.8	—
FRNIC	Feather River near Nicolaus	2/23/96	5/16/00	33	33	100%	1.2	4.2	1.2	1.3	1.5	1.7	2.7	—
SRVON	Sacramento River at Verona	2/22/96	4/22/98	27	27	100%	1.3	3.6	1.3	1.4	1.6	2.0	2.8	—
ARCNW	Arcade Creek at Norwood Ave.	2/6/96	5/17/00	46	46	100%	1.2	18	6.0	6.4	7.0	8.1	9.7	—
ARJST	American River at J Street	2/21/96	4/16/98	27	27	100%	1.1	6.4	1.2	1.3	1.5	1.6	1.9	—
SRFPT	Sacramento River at Freeport	2/20/96	8/29/00	57	57	100%	0.3	3.7	1.3	1.4	1.6	1.9	2.3	—
SRRMF	Sacramento River at River Mile 44	9/22/99	5/17/00	9	9	100%	1.5	3.2	1.5	1.7	2.3	2.6	2.9	—
CCHSL	Cache Slough near Ryers Ferry	10/20/99	2/16/00	3	3	100%	1.7	4.9	1.8	1.9	2.0	3.5	4.3	—

Organic Carbon, total

Units = mg/L

Site ID	Site Description	monitoring period start	monitoring period end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
PRSHA	Pit River above Shasta	11/15/99	5/16/00	4	4	100%	1.0	1.8	1.1	1.2	1.4	1.5	1.7	—
MRSHA	McCloud River above Shasta	11/15/99	5/16/00	4	4	100%	0.6	0.9	0.6	0.7	0.8	0.8	0.9	—
SRSHA	Sacramento River above Shasta	11/15/99	5/16/00	4	4	100%	1.0	1.5	1.2	1.4	1.5	1.5	1.5	—
SCKPP	Spring Creek PP Discharge to Keswick Res.	10/20/99	4/18/00	4	4	100%	1.2	1.3	1.2	1.3	1.3	1.3	1.3	—
SRBKR	Sacramento River below Keswick	10/20/99	5/16/00	8	8	100%	1.0	1.3	1.0	1.0	1.2	1.2	1.3	—
CCMOU	Clear Creek near Mouth	9/15/98	8/17/99	6	6	100%	1.2	1.8	1.2	1.3	1.4	1.5	1.7	—
SRABB	Sacramento River above Bend Bridge	2/13/96	5/17/00	35	35	100%	1.3	3.4	1.4	1.5	1.6	2.2	2.4	—
MCMOU	Mill Creek at Mouth	6/23/98	4/17/00	16	16	100%	0.7	8.2	0.9	0.9	1.2	2.1	3.4	—
SRHAM	Sacramento River near Hamilton City	9/22/99	5/16/00	8	8	100%	1.4	5.3	1.4	1.5	1.7	2.8	4.0	—
DCMOU	Deer Creek at Mouth	6/24/98	4/17/00	9	9	100%	0.9	1.8	1.0	1.1	1.1	1.5	1.7	—
CHMUD	Big Chico Creek above Mud Creek	6/23/98	4/17/00	15	15	100%	0.6	3.1	0.7	1.0	1.2	1.4	2.5	—
MUDCH	Mud Creek above Big Chico Creek	6/23/98	4/17/00	8	8	100%	1.3	3.7	1.4	1.9	2.9	3.3	3.6	—
SRCOL	Sacramento River at Colusa	2/28/96	4/8/98	25	25	100%	1.1	6.8	1.5	1.5	1.9	2.2	4.2	—
SACSL	Sacramento Slough	2/12/96	5/16/00	31	31	100%	1.8	12.4	2.5	3.6	4.4	5.8	6.3	—
COLDR	Colusa Basin Drain	2/7/96	5/16/00	37	37	100%	3.9	10.8	4.8	5.8	6.9	8.5	9.6	—
YRMRY	Yuba River at Marysville	2/27/96	5/16/00	36	36	100%	0.8	3.2	1.0	1.0	1.3	1.7	2.2	—
FRNIC	Feather River near Nicolaus	2/23/96	5/16/00	32	32	100%	1.4	4.8	1.5	1.6	1.9	2.2	3.0	—
SRVON	Sacramento River at Verona	2/22/96	4/22/98	24	24	100%	1.5	4.4	1.6	1.8	2.2	2.6	3.3	—
ARCNW	Arcade Creek at Norwood Ave.	2/6/96	5/17/00	46	46	100%	2.0	22.2	6.4	6.9	7.8	9.3	11.1	—
ARJST	American River at J Street	2/21/96	4/16/98	26	26	100%	1.2	8.1	1.4	1.5	1.8	2.1	2.5	—
SRFPT	Sacramento River at Freeport	2/20/96	8/29/00	55	55	100%	0.8	4.7	1.6	1.8	2.0	2.4	3.1	—
SRRMF	Sacramento River at River Mile 44	9/22/99	5/17/00	9	9	100%	1.8	4.0	2.0	2.1	2.7	2.9	3.4	—
CCHSL	Cache Slough near Ryers Ferry	10/20/99	2/16/00	3	3	100%	1.9	5.4	2.0	2.1	2.2	3.8	4.8	—

Total Dissolved Solids

Units = mg/L

Site ID	Site Description	monitoring period start	monitoring period end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
PRSHA	Pit River above Shasta	7/22/98	5/16/00	11	11	100%	78	125	79	89	90	95	110	—
MRSHA	McCloud River above Shasta	7/22/98	5/16/00	10	10	100%	55	83	55	56	58	70	76	—
SRSHA	Sacramento River above Shasta	7/22/98	5/16/00	10	10	100%	39	91	44	50	62	69	78	—
SCKPP	Spring Creek PP Discharge to Keswick Res.	6/24/98	4/18/00	13	13	100%	43	59	48	49	53	55	56	—
SRBKR	Sacramento River below Keswick	1/20/98	5/16/00	47	47	100%	52	98	58	70	77	85	89	—
CCMOU	Clear Creek near Mouth	9/15/98	8/17/99	10	10	100%	50	74	51	53	59	66	69	—
SRABB	Sacramento River above Bend Bridge	7/22/98	5/17/00	22	22	100%	60	104	69	72	85	86	94	—
MCMOU	Mill Creek at Mouth	6/23/98	6/8/00	14	14	100%	64	154	77	85	98	128	145	—
MCHWY	Mill Creek at Highway 36	6/23/98	6/7/00	3	3	100%	60	294	86	126	191	243	273	—
DCMOU	Deer Creek at Mouth	6/24/98	4/17/00	9	9	100%	73	132	74	84	100	117	126	—
CHMUD	Big Chico Creek above Mud Creek	6/23/98	4/17/00	4	4	100%	58	134	76	104	122	127	131	—
MUDCH	Mud Creek above Big Chico Creek	6/23/98	4/17/00	7	7	100%	2	133	44	74	80	93	117	—
SRCOL	Sacramento River at Colusa	2/28/96	5/16/00	51	51	100%	17	120	78	85	94	101	107	—
SACSL	Sacramento Slough	2/12/96	11/16/99	26	26	100%	84	276	100	152	191	218	245	—
COLDR	Colusa Basin Drain	2/7/96	8/18/99	33	33	100%	140	487	303	320	352	404	450	—
YRMRY	Yuba River at Marysville	2/27/96	4/6/98	27	27	100%	36	75	44	48	52	57	66	—
FRNIC	Feather River near Nicolaus	2/23/96	5/16/00	50	50	100%	34	137	50	55	62	67	75	—
SRVON	Sacramento River at Verona	2/22/96	4/22/98	26	26	100%	53	126	73	83	90	101	105	—
SRVET	Sacramento River at Veterans Bridge	6/24/98	5/16/00	23	23	100%	75	135	87	92	101	109	117	—
ARJST	American River at J Street	2/21/96	4/16/98	27	27	100%	24	52	33	35	40	45	48	—
SRFPT	Sacramento River at Freeport	2/20/96	5/17/00	54	54	100%	37	111	70	78	87	97	105	—
SRRMF	Sacramento River at River Mile 44	6/23/98	5/17/00	23	23	100%	63	111	76	85	92	99	106	—
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	13	13	100%	108	198	111	122	136	164	174	—

Summary Statistics: Drinking Water Parameters

Turbidity

Units = NTU

		monitoring period							percentile statistics					
Site ID	Site Description	start	end	n	n det	% det	min det	max det	10th	25th	median (50th)	75th	90th	min RL
PRSHA	Pit River above Shasta	7/22/98	5/16/00	10	10	100%	2.0	24	2.3	2.5	3.8	7.0	15	—
MRSHA	McCloud River above Shasta	7/22/98	5/16/00	10	10	100%	0.5	6	0.5	0.8	1.3	3.1	5	—
SRSHA	Sacramento River above Shasta	7/22/98	5/16/00	10	10	100%	0.8	8	0.9	0.9	1.1	3.5	5	—
SCKPP	Spring Creek PP Discharge to Keswick Res.	6/24/98	4/18/00	12	12	100%	0.4	2	0.5	0.6	0.9	1.6	2	—
SRBKR	Sacramento River below Keswick	1/20/98	5/16/00	47	47	100%	1.3	36	2.1	3.0	3.4	4.1	6	—
CCMOU	Clear Creek near Mouth	8/5/98	8/17/99	13	13	100%	1.0	16	1.2	1.3	1.5	2.0	5	—
SRABB	Sacramento River above Bend Bridge	6/24/98	5/17/00	23	23	100%	2.1	48	2.6	3.0	3.9	10.9	27	—
MCMOU	Mill Creek at Mouth	6/23/98	6/8/00	17	17	100%	1.4	53	1.5	2.4	3.7	5.5	18	—
MCBLR	Mill Creek at Black Rock	6/23/98	6/7/00	17	17	100%	0.6	25	0.8	1.0	3.8	5.6	9	—
MCHWY	Mill Creek at Highway 36	6/23/98	6/7/00	22	22	100%	1.5	62	1.7	3.8	5.8	7.6	19	—
SRHAM	Sacramento River near Hamilton City	6/23/99	5/16/00	11	11	100%	2.0	140	2.4	2.8	4.0	17.0	89	—
DCMOU	Deer Creek at Mouth	6/24/98	4/17/00	13	13	100%	0.4	6	0.7	0.7	1.1	1.3	2	—
DCUDD	Deer Creek at Upper Diversion Dam	6/24/98	6/6/00	21	21	100%	0.2	35	0.3	0.5	0.6	1.6	3	—
DCPON	Deer Creek at Ponderosa Way	6/24/98	6/6/00	12	12	100%	0.2	2	0.2	0.3	0.5	0.8	2	—
DCMDW	Deer Creek below Childs Meadows	6/24/98	5/8/00	21	20	95%	0.6	26	0.6	0.8	1.0	2.0	3	0.5
CHMUD	Big Chico Creek above Mud Creek	6/23/98	4/17/00	15	15	100%	0.3	5	0.4	0.5	0.5	1.0	2.1	—
MUDCH	Mud Creek above Big Chico Creek	6/23/98	4/17/00	8	8	100%	1.4	7	1.7	1.9	2.8	4.5	6.2	—
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/23/98	4/17/00	15	15	100%	0.3	3	0.3	0.4	0.5	0.8	1.9	—
CHASH	Big Chico Creek above Salmon Hole	6/23/98	2/14/00	15	15	100%	0.2	2	0.2	0.3	0.3	0.6	1.4	—
CHHWY	Big Chico Creek at Hwy 32	6/23/98	4/17/00	14	14	100%	0.2	1	0.3	0.3	0.4	1	1	—
SRCOL	Sacramento River at Colusa	6/24/98	5/16/00	23	23	100%	2.9	261	6.8	8.4	17.5	31	55	—
FRNIC	Feather River near Nicolaus	6/23/98	5/16/00	23	23	100%	1.1	57	2.2	3.7	5	8	12	—
SRVET	Sacramento River at Veterans Bridge	6/24/98	5/16/00	23	23	100%	3.8	81	8.3	19.0	24.5	27.4	44	—
SRFPT	Sacramento River at Freeport	6/23/98	5/17/00	23	23	100%	6.4	66	7.3	14	19	29	45	—
SRRMF	Sacramento River at River Mile 44	6/23/98	5/17/00	23	23	100%	5.1	58	7.8	12	19	31	51	—
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	11	11	100%	2.7	89	7.6	17	29	37	73	—

Summary Statistics Table Notes:
monitoring period start and end — Dates of first and last reported data.
n — Total number of data reported.
n det — Total number of data above reporting limits.
% det — Percent of data above reporting limits.
min det — Minimum value for data detected above reporting limits.
max det — Maximum value of data detected above reporting limits.
percentiles — Percentile data are provided for data above reporting limits. "<RL" indicates insufficient data to calculate statistic.
min RL — Lowest reporting limit for data below detection. min RL only reported where percent detection (% det) < 100%.

Summary Statistics: Nutrients Data

Nitrate as N

Units = mg/L

Site ID	Site Description	monitoring period start	monitoring period end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
SRABB	Sacramento River above Bend Bridge	2/13/96	4/9/98	26	26	100%	0.07	0.23	0.08	0.09	0.10	0.13	0.19	—
SRCOL	Sacramento River at Colusa	2/28/96	11/16/99	34	34	100%	0.04	1.12	0.08	0.11	0.13	0.18	0.29	—
SACSL	Sacramento Slough	2/12/96	5/16/00	36	28	78%	0.05	0.37	<RL	0.11	0.16	0.22	0.26	0.05
COLDR	Colusa Basin Drain	2/7/96	5/16/00	41	38	93%	0.05	1.44	0.14	0.21	0.38	0.63	0.89	0.22
YRMRY	Yuba River at Marysville	2/27/96	4/6/98	26	17	65%	0.05	0.67	<RL	<RL	0.06	0.09	0.11	0.05
FRNIC	Feather River near Nicolaus	2/23/96	4/20/98	27	25	93%	0.04	1.63	0.05	0.06	0.08	0.10	0.22	0.05
SRVON	Sacramento River at Verona	2/22/96	4/22/98	27	27	100%	0.02	0.26	0.07	0.09	0.12	0.15	0.21	—
ARCNW	Arcade Creek at Norwood Ave.	2/6/96	5/17/00	47	40	85%	0.12	2.27	<RL	0.34	0.51	0.84	1.42	0.022
ARJST	American River at J Street	2/21/96	4/16/98	27	14	52%	0.05	0.18	<RL	<RL	0.05	0.11	0.13	0.05
SRFPT	Sacramento River at Freeport	2/20/96	9/22/00	59	57	97%	0.05	0.25	0.06	0.08	0.11	0.15	0.19	0.05
SRRMF	Sacramento River at River Mile 44	6/23/98	5/17/00	22	14	64%	0.08	0.28	<RL	<RL	0.13	0.18	0.25	0.22

Nitrite as N

Units = mg/L

Site ID	Site Description	monitoring period start	monitoring period end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
SRABB	Sacramento River above Bend Bridge	2/13/96	4/9/98	26	5	19%	0.01	0.02	<RL	<RL	<RL	<RL	0.02	0.01
SRCOL	Sacramento River at Colusa	2/28/96	11/16/99	34	7	21%	0.01	0.03	<RL	<RL	<RL	<RL	0.02	0.01
SACSL	Sacramento Slough	2/12/96	5/16/00	36	13	36%	0.01	0.02	<RL	<RL	<RL	0.30	0.30	0.01
COLDR	Colusa Basin Drain	2/7/96	5/16/00	41	27	66%	0.01	0.06	<RL	<RL	0.03	0.06	0.30	0.01
YRMRY	Yuba River at Marysville	2/27/96	4/6/98	27	8	30%	0.01	0.19	<RL	<RL	<RL	0.01	0.02	0.01
FRNIC	Feather River near Nicolaus	2/23/96	4/20/98	27	9	33%	0.01	0.03	<RL	<RL	<RL	0.01	0.02	0.01
SRVON	Sacramento River at Verona	2/22/96	4/22/98	27	10	37%	0.01	0.04	<RL	<RL	<RL	0.01	0.02	0.01
ARCNW	Arcade Creek at Norwood Ave.	2/6/96	5/17/00	47	34	72%	0.01	0.09	<RL	<RL	0.04	0.08	0.30	0.01
ARJST	American River at J Street	2/21/96	4/16/98	27	8	30%	0.01	0.02	<RL	<RL	<RL	0.01	0.01	0.01
SRFPT	Sacramento River at Freeport	2/20/96	9/22/00	59	14	24%	0.01	0.03	<RL	<RL	<RL	<RL	0.01	0.01
SRRMF	Sacramento River at River Mile 44	6/23/98	5/17/00	22	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.03
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	11	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.01

Ammonia as N

Units = mg/L

Site ID	Site Description	monitoring period start	monitoring period end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
SRABB	Sacramento River above Bend Bridge	2/13/96	4/9/98	26	4	15%	0.02	0.09	<RL	<RL	<RL	<RL	0.02	0.015
MCMOU	Mill Creek at Mouth	6/23/98	4/17/00	19	3	16%	0.01	0.01	<RL	<RL	<RL	<RL	0.01	0.01
MCBLR	Mill Creek at Black Rock	6/23/98	4/17/00	14	2	14%	0.01	0.01	<RL	<RL	<RL	<RL	0.01	0.01
MCHWY	Mill Creek at Highway 36	6/23/98	4/17/00	19	14	74%	0.01	0.08	<RL	<RL	0.02	0.04	0.05	0.01
DCMOU	Deer Creek at Mouth	6/24/98	4/17/00	13	1	8%	0.01	0.01	<RL	<RL	<RL	<RL	<RL	0.01
DCUDD	Deer Creek at Upper Diversion Dam	6/24/98	4/17/00	18	3	17%	0.01	0.01	<RL	<RL	<RL	<RL	0.01	0.01
DCPON	Deer Creek at Ponderosa Way	6/24/98	11/8/99	12	2	17%	0.01	0.01	<RL	<RL	<RL	<RL	0.01	0.01
DCMDW	Deer Creek below Childs Meadows	6/24/98	4/17/00	18	2	11%	0.01	0.02	<RL	<RL	<RL	<RL	0.01	0.01
CHMUD	Big Chico Creek above Mud Creek	6/23/98	4/17/00	17	8	47%	0.01	0.05	<RL	<RL	<RL	0.01	0.02	0.01
MUDCH	Mud Creek above Big Chico Creek	6/23/98	4/17/00	10	7	70%	0.01	0.03	<RL	<RL	0.01	0.02	0.02	0.01
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/23/98	4/17/00	17	4	24%	0.01	0.02	<RL	<RL	<RL	<RL	0.01	0.01
CHASH	Big Chico Creek above Salmon Hole	6/23/98	4/17/00	17	5	29%	0.01	0.02	<RL	<RL	<RL	0.01	0.01	0.01
CHHWY	Big Chico Creek at Hwy 32	6/23/98	4/17/00	17	6	35%	0.01	0.05	<RL	<RL	<RL	0.01	0.02	0.01
SRCOL	Sacramento River at Colusa	2/28/96	11/16/99	33	12	36%	0.02	0.078	<RL	<RL	<RL	0.02	0.03	0.015
SACSL	Sacramento Slough	2/12/96	5/16/00	36	18	50%	0.02	1.19	<RL	<RL	0.04	0.10	0.15	0.015
COLDR	Colusa Basin Drain	2/7/96	5/16/00	41	29	71%	0.02	0.64	<RL	<RL	0.06	0.10	0.16	0.015
YRMRY	Yuba River at Marysville	2/27/96	4/6/98	27	9	33%	0.015	0.068	<RL	<RL	<RL	0.02	0.02	0.015
FRNIC	Feather River near Nicolaus	2/23/96	1/19/00	28	12	43%	0.018	0.058	<RL	<RL	<RL	0.03	0.04	0.015
SRVON	Sacramento River at Verona	2/22/96	4/22/98	27	9	33%	0.015	0.05	<RL	<RL	<RL	0.02	0.04	0.015
ARCNW	Arcade Creek at Norwood Ave.	2/6/96	5/17/00	47	38	81%	0.02	0.84	<RL	0.05	0.07	0.14	0.37	0.015
ARJST	American River at J Street	2/21/96	4/16/98	27	8	30%	0.017	0.07	<RL	<RL	<RL	0.02	0.03	0.015
SRFPT	Sacramento River at Freeport	2/20/96	9/22/00	59	21	36%	0.02	0.082	<RL	<RL	<RL	0.02	0.03	0.015
SRRMF	Sacramento River at River Mile 44	6/23/98	5/17/00	33	19	58%	0.099	0.96	<RL	<RL	0.11	0.15	0.20	0.1
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	11	1	9%	0.021	0.021	<RL	<RL	<RL	<RL	<RL	0.02

Nitrogen, total Kjeldahl

Units = mg/L

Site ID	Site Description	monitoring period start	monitoring period end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
SACSL	Sacramento Slough	6/22/99	5/16/00	11	2	18%	0.20	0.66	<RL	<RL	<RL	<RL	0.50	0.5
COLDR	Colusa Basin Drain	6/23/99	5/16/00	12	6	50%	0.26	1.29	<RL	<RL	0.50	0.70	0.83	0.5
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	5/17/00	11	9	82%	0.52	1.59	<RL	0.60	0.76	1.34	1.38	0.5
SRRMF	Sacramento River at River Mile 44	6/23/98	5/17/00	18	4	22%	0.21	0.85	<RL	<RL	<RL	<RL	0.50	0.2

Summary Statistics: Nutrients Data

Orthosphosphate as P, dissolved

Units = mg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	10th	25th	median (50th)	75th	90th	min RL
SRABB	Sacramento River above Bend Bridge	2/13/96	4/9/98	26	22	85%	0.014	0.031	<RL	0.020	0.020	0.021	0.028	0.01
MCMOU	Mill Creek at Mouth	6/23/98	4/17/00	19	5	26%	0.01	0.03	<RL	<RL	<RL	0.010	0.012	0.01
MCBLR	Mill Creek at Black Rock	6/23/98	4/17/00	14	2	14%	0.01	0.02	<RL	<RL	<RL	<RL	0.010	0.01
MCHWY	Mill Creek at Highway 36	6/23/98	4/17/00	19	12	63%	0.01	0.03	<RL	<RL	0.010	0.020	0.030	0.01
DCMOU	Deer Creek at Mouth	6/24/98	4/17/00	13	0	0%	0.01	0.01	<RL	<RL	<RL	<RL	<RL	0.01
DCUDD	Deer Creek at Upper Diversion Dam	6/24/98	4/17/00	18	4	22%	0.01	0.01	<RL	<RL	<RL	<RL	0.010	0.01
DCPON	Deer Creek at Ponderosa Way	6/24/98	11/8/99	12	1	8%	0.01	0.01	<RL	<RL	<RL	<RL	<RL	0.01
DCMDW	Deer Creek below Childs Meadows	6/24/98	4/17/00	18	3	17%	0.01	0.01	<RL	<RL	<RL	<RL	0.010	0.01
CHMUD	Big Chico Creek above Mud Creek	6/23/98	4/17/00	17	5	29%	0.01	0.03	<RL	<RL	<RL	0.010	0.014	0.01
MUDCH	Mud Creek above Big Chico Creek	6/23/98	4/17/00	10	1	10%	0.02	0.02	<RL	<RL	<RL	<RL	0.011	0.01
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/23/98	4/17/00	17	3	18%	0.01	0.02	<RL	<RL	<RL	<RL	0.010	0.01
CHASH	Big Chico Creek above Salmon Hole	6/23/98	4/17/00	17	2	12%	0.01	0.01	<RL	<RL	<RL	<RL	0.010	0.01
CHHWY	Big Chico Creek at Hwy 32	6/23/98	4/17/00	17	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.01
SRCOL	Sacramento River at Colusa	2/28/96	9/16/98	33	31	94%	0.01	0.04	0.011	0.019	0.020	0.028	0.031	0.01
SACSL	Sacramento Slough	2/12/96	5/16/00	35	24	69%	0.026	0.13	0.031	0.044	0.063	0.091	0.13	0.01
COLDR	Colusa Basin Drain	2/7/96	5/16/00	41	29	71%	0.017	0.193	0.049	0.065	0.090	0.123	0.16	0.1632
YRMRY	Yuba River at Marysville	2/27/96	4/6/98	27	5	19%	0.01	0.02	<RL	<RL	<RL	<RL	0.013	0.01
FRNIC	Feather River near Nicolaus	2/23/96	4/20/98	27	16	59%	0.01	0.029	<RL	<RL	0.010	0.013	0.018	0.01
SRVON	Sacramento River at Verona	2/22/96	4/22/98	27	25	93%	0.017	0.042	0.017	0.020	0.020	0.028	0.032	0.01
ARCNW	Arcade Creek at Norwood Ave.	2/6/96	5/17/00	47	35	74%	0.05	0.278	0.063	0.087	0.123	0.175	0.240	0.01
ARJST	American River at J Street	2/21/96	4/16/98	27	6	22%	0.01	0.02	<RL	<RL	<RL	<RL	0.015	0.01
SRFPT	Sacramento River at Freeport	2/20/96	9/22/00	59	55	93%	0.01	0.038	0.010	0.015	0.021	0.027	0.031	0.01
SRRMF	Sacramento River at River Mile 44	6/23/98	5/17/00	23	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.1632
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	11	5	45%	0.011	0.023	<RL	<RL	<RL	0.012	0.017	0.01

Phosphorus, total

Units = mg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	10th	25th	median (50th)	75th	90th	min RL
CCMOU	Clear Creek near Mouth	9/15/98	8/17/99	12	10	83%	0.01	0.03	<RL	0.01	0.02	0.02	0.03	0.01
SRABB	Sacramento River above Bend Bridge	2/13/96	4/9/98	26	25	96%	0.01	0.23	0.01	0.02	0.04	0.05	0.10	0.01
MCMOU	Mill Creek at Mouth	6/23/98	4/17/00	19	19	100%	0.02	0.63	0.03	0.03	0.04	0.08	0.26	—
MCBLR	Mill Creek at Black Rock	6/23/98	4/17/00	14	14	100%	0.01	0.15	0.02	0.02	0.03	0.04	0.08	—
MCHWY	Mill Creek at Highway 36	6/23/98	4/17/00	7	7	100%	0.02	0.23	0.04	0.05	0.05	0.17	0.22	—
DCMOU	Deer Creek at Mouth	6/24/98	4/17/00	13	13	100%	0.01	1.00	0.02	0.02	0.03	0.04	0.04	—
DCUDD	Deer Creek at Upper Diversion Dam	6/24/98	4/17/00	18	16	89%	0.01	0.14	<RL	0.01	0.02	0.02	0.04	0.01
DCPON	Deer Creek at Ponderosa Way	6/24/98	11/8/99	12	10	83%	0.01	0.04	<RL	0.01	0.02	0.03	0.03	0.01
DCMDW	Deer Creek below Childs Meadows	6/24/98	4/17/00	18	16	89%	0.01	0.11	<RL	0.01	0.02	0.03	0.04	0.01
CHMUD	Big Chico Creek above Mud Creek	6/23/98	4/17/00	17	16	94%	0.01	0.15	0.01	0.01	0.02	0.03	0.07	0.01
MUDCH	Mud Creek above Big Chico Creek	6/23/98	4/17/00	10	9	90%	0.01	0.06	0.01	0.01	0.02	0.03	0.04	0.01
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/23/98	4/17/00	17	14	82%	0.01	0.14	<RL	0.01	0.02	0.02	0.03	0.01
CHASH	Big Chico Creek above Salmon Hole	6/23/98	4/17/00	17	15	88%	0.01	0.14	<RL	0.01	0.02	0.02	0.02	0.01
CHHWY	Big Chico Creek at Hwy 32	6/23/98	4/17/00	17	14	82%	0.01	0.07	<RL	0.01	0.02	0.02	0.03	0.01
SRCOL	Sacramento River at Colusa	2/28/96	11/16/99	33	33	100%	0.01	0.29	0.02	0.03	0.04	0.08	0.15	—
SACSL	Sacramento Slough	2/12/96	5/16/00	28	28	100%	0.03	0.27	0.09	0.12	0.15	0.18	0.20	—
COLDR	Colusa Basin Drain	2/7/96	5/16/00	33	33	100%	0.11	0.36	0.13	0.19	0.24	0.27	0.30	—
YRMRY	Yuba River at Marysville	2/27/96	4/6/98	27	14	52%	0.01	0.11	<RL	<RL	0.02	0.02	0.03	0.01
FRNIC	Feather River near Nicolaus	2/23/96	1/19/00	27	23	85%	0.01	0.07	<RL	0.02	0.02	0.03	0.05	0.01
SRVON	Sacramento River at Verona	2/22/96	4/22/98	27	27	100%	0.01	0.17	0.03	0.04	0.05	0.08	0.09	—
ARCNW	Arcade Creek at Norwood Ave.	2/6/96	5/17/00	40	40	100%	0.11	1.16	0.14	0.17	0.24	0.29	0.41	—
ARJST	American River at J Street	2/21/96	4/16/98	27	14	52%	0.01	0.09	<RL	<RL	0.01	0.02	0.04	0.01
SRFPT	Sacramento River at Freeport	2/20/96	9/22/00	59	58	98%	0.02	0.21	0.02	0.04	0.05	0.06	0.10	0.05
SRRMF	Sacramento River at River Mile 44	6/23/98	5/17/00	16	14	88%	0.04	1.09	<RL	0.04	0.07	0.10	0.16	0.02
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	11	10	91%	0.01	0.53	0.01	0.04	0.09	0.17	0.26	0.004

Summary Statistics Table Notes:
monitoring period start and end — Dates of first and last reported data.
n — Total number of data reported.
n det — Total number of data above reporting limits.
% det — Percent of data above reporting limits.
min det — Minimum value for data detected above reporting limits.
max det — Maximum value of data detected above reporting limits.
percentiles — Percentile data are provided for data above reporting limits. "<RL" indicates insufficient data to calculate statistic.
min RL — Lowest reporting limit for data below detection. min RL only reported where percent detection (% det) < 100%.

Summary Statistics: Minerals Data

Calcium, dissolved

Units = mg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
CCMOU	Clear Creek near Mouth	9/15/98	8/17/99	12	12	100%	5	8	6.0	6.0	6.0	7.3	8.0	—
SRABB	Sacramento River above Bend Bridge	2/13/96	4/9/98	27	27	100%	8.9	12	9.0	9.4	11.0	11.0	11.0	—
MCMOU	Mill Creek at Mouth	6/23/98	4/17/00	17	17	100%	6	16	6.6	7.0	9.0	12.0	13.0	—
MCBLR	Mill Creek at Black Rock	6/23/98	4/17/00	14	14	100%	6	13	6.2	7.0	8.0	11.0	11.0	—
MCHWY	Mill Creek at Highway 36	6/23/98	4/17/00	17	17	100%	4	21	6.6	8.1	13.6	15.0	18.8	—
DCMOU	Deer Creek at Mouth	6/24/98	4/17/00	11	11	100%	6	14	7.0	7.5	8.0	12.0	12.0	—
DCUDD	Deer Creek at Upper Diversion Dam	6/24/98	4/17/00	16	16	100%	5	11	6.0	7.0	7.0	10.0	11.0	—
DCPON	Deer Creek at Ponderosa Way	6/24/98	11/8/99	11	11	100%	6	10	6.8	8.0	9.0	10.0	10.0	—
DCMDW	Deer Creek below Childs Meadows	6/24/98	4/17/00	16	16	100%	2	5	3.5	4.0	4.2	5.0	5.0	—
CHMUD	Big Chico Creek above Mud Creek	6/23/98	4/17/00	15	15	100%	5	16	7.4	8.5	11.9	15.2	16.0	—
MUDCH	Mud Creek above Big Chico Creek	6/23/98	4/17/00	9	9	100%	6	17.5	6.8	7.0	10.0	11.0	13.1	—
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/23/98	4/17/00	15	15	100%	5	16	8.0	9.0	11.0	15.2	16.0	—
CHASH	Big Chico Creek above Salmon Hole	6/23/98	2/14/00	14	14	100%	4.7	16	8.0	9.0	11.7	15.4	16.0	—
CHHWY	Big Chico Creek at Hwy 32	6/23/98	4/17/00	15	15	100%	5.5	16	9.0	9.5	11.5	14.4	15.0	—
SRCOL	Sacramento River at Colusa	2/28/96	9/16/98	31	31	100%	9.1	15	9.9	10.2	11.0	12.6	14.0	—
SACSL	Sacramento Slough	2/12/96	4/22/98	24	24	100%	12	33	12.3	19.3	24.0	26.0	26.0	—
COLDR	Colusa Basin Drain	2/7/96	4/15/98	31	31	100%	17	47	26.0	31.0	34.0	35.0	37.0	—
YRMRY	Yuba River at Marysville	2/27/96	4/6/98	27	27	100%	4.3	11	6.2	7.1	7.8	9.0	9.7	—
FRNIC	Feather River near Nicolaus	2/23/96	4/20/98	27	27	100%	5	11	7.2	7.7	8.1	8.7	9.2	—
SRVON	Sacramento River at Verona	2/22/96	4/22/98	26	26	100%	5.4	15	9.4	10.0	12.0	12.0	13.5	—
ARCNW	Arcade Creek at Norwood Ave.	2/6/96	4/23/98	38	38	100%	6.4	34	11.8	18.0	22.0	23.8	26.6	—
ARJST	American River at J Street	2/21/96	4/16/98	27	27	100%	7	7.8	7.2	7.4	7.5	7.7	7.7	—
SRFPT	Sacramento River at Freeport	2/20/96	9/22/00	59	59	100%	4.8	14.7	8.7	9.3	10.1	11.3	12.4	—
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	11	11	100%	17.6	22.9	18.0	19.4	20.0	20.6	21.4	—

Calcium, total

Units = mg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
SACSL	Sacramento Slough	6/22/99	5/16/00	11	11	100%	22	27.7	24.0	24.4	25.8	26.6	27.0	—
COLDR	Colusa Basin Drain	6/23/99	5/16/00	12	12	100%	24	50.1	25.0	29.3	31.3	36.9	47.0	—
SRVET	Sacramento River at Veterans Bridge	6/22/99	5/16/00	11	11	100%	10.6	15.3	11.9	12.0	12.6	13.2	13.7	—
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	5/17/00	11	11	100%	7.2	33.7	8.8	12.7	13.6	24.2	25.0	—
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	11	11	100%	18.5	24.0	18.9	20.0	20.8	22.1	22.9	—
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	12	12	100%	10.8	19.3	11.4	11.7	12.5	14.5	15.3	—

Chloride

Units = mg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
SRABB	Sacramento River above Bend Bridge	2/13/96	4/9/98	27	27	100%	1.7	4.8	1.7	1.8	2.1	2.6	3.9	—
MCMOU	Mill Creek at Mouth	6/23/98	4/17/00	12	12	100%	3.0	18.0	3.1	4.8	6.5	13.3	14.9	—
MCBLR	Mill Creek at Black Rock	6/23/98	4/17/00	9	9	100%	3.0	34.0	3.8	5.0	6.0	12.0	17.2	—
MCHWY	Mill Creek at Highway 36	6/23/98	4/17/00	12	12	100%	4.0	86.0	5.0	5.8	17.0	35.3	41.4	—
DCMOU	Deer Creek at Mouth	6/24/98	4/17/00	9	8	89%	2.0	4.0	<RL	2.0	2.0	3.0	3.2	1
DCUDD	Deer Creek at Upper Diversion Dam	6/24/98	4/17/00	11	11	100%	1.0	6.0	1.0	2.0	2.0	3.0	4.0	—
DCPON	Deer Creek at Ponderosa Way	6/24/98	11/8/99	8	5	63%	1.0	1.0	<RL	<RL	1.0	1.0	1.0	1
DCMDW	Deer Creek below Childs Meadows	6/24/98	4/17/00	7	1	14%	1.0	1.0	<RL	<RL	<RL	<RL	1.0	1
CHMUD	Big Chico Creek above Mud Creek	6/23/98	4/17/00	10	10	100%	1.0	8.0	1.9	3.0	3.5	7.0	8.0	—
MUDCH	Mud Creek above Big Chico Creek	6/23/98	4/17/00	6	6	100%	1.0	14.0	3.0	5.5	7.5	12.5	14.0	—
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/23/98	4/17/00	10	10	100%	1.0	8.0	1.9	3.0	4.0	7.0	8.0	—
CHASH	Big Chico Creek above Salmon Hole	6/23/98	2/14/00	9	9	100%	1.0	8.0	1.8	2.0	3.0	7.0	8.0	—
CHHWY	Big Chico Creek at Hwy 32	6/23/98	4/17/00	7	2	29%	1.0	1.0	<RL	<RL	<RL	1.0	1.0	1
SRCOL	Sacramento River at Colusa	2/28/96	11/16/99	33	33	100%	1.9	5.3	2.0	2.3	3.0	4.0	4.4	—
SACSL	Sacramento Slough	2/12/96	5/16/00	35	34	97%	2.1	38.1	3.6	8.2	10.0	20.5	28.4	2
COLDR	Colusa Basin Drain	2/7/96	5/16/00	43	43	100%	6.5	49.8	18.7	22.8	27.0	33.5	39.8	—
YRMRY	Yuba River at Marysville	2/27/96	4/6/98	27	27	100%	0.7	1.8	0.8	0.9	1.0	1.3	1.6	—
FRNIC	Feather River near Nicolaus	2/23/96	1/19/00	28	28	100%	1.0	4.8	1.2	1.4	1.7	2.3	3.5	—
SRVON	Sacramento River at Verona	2/22/96	4/22/98	26	26	100%	1.4	19.0	2.5	3.2	4.2	5.1	6.4	—
SRVET	Sacramento River at Veterans Bridge	6/22/99	5/16/00	11	11	100%	4.8	8.8	4.8	4.9	6.3	6.9	7.9	—
ARCNW	Arcade Creek at Norwood Ave.	2/6/96	5/17/00	49	49	100%	3.6	44.0	5.7	14.0	24.0	29.0	37.0	—
ARJST	American River at J Street	2/21/96	4/16/98	27	27	100%	0.5	1.0	0.6	0.6	0.7	0.7	0.8	—
SRFPT	Sacramento River at Freeport	2/20/96	9/22/00	59	59	100%	1.1	9.1	2.4	3.1	3.9	5.4	6.4	—
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	10	10	100%	8.2	19.4	9.1	11.8	13.9	16.9	18.6	—
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	12	12	100%	7.3	15.6	7.5	7.7	8.6	13.0	13.6	—

Summary Statistics: Minerals Data

Iron, dissolved

Units = µg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	10th	25th	median (50th)	75th	90th	min RL
SRABB	Sacramento River above Bend Bridge	2/13/96	4/9/98	27	24	89%	3	65	<RL	9	11	14	24	10
SRCOL	Sacramento River at Colusa	2/28/96	9/16/98	31	27	87%	3.6	46	<RL	10	10	14	20	10
SACSL	Sacramento Slough	2/12/96	4/22/98	24	18	75%	3.9	49	<RL	7	12	23	31	3
COLDR	Colusa Basin Drain	2/7/96	4/15/98	31	26	84%	3	74	<RL	4	11	20	35	3
YRMRY	Yuba River at Marysville	2/27/96	4/6/98	27	25	93%	4.3	86	7	9	13	19	28	10
FRNIC	Feather River near Nicolaus	2/23/96	4/20/98	27	27	100%	6.6	84	10	13	17	32	42	—
SRVON	Sacramento River at Verona	2/22/96	4/22/98	26	25	96%	4.7	110	7	10	13	18	39	10
ARCNW	Arcade Creek at Norwood Ave.	2/6/96	4/23/98	38	38	100%	27	360	54	70	81	110	159	—
ARJST	American River at J Street	2/21/96	4/16/98	27	27	100%	3	48	5	7	8	13	25	—
SRFPT	Sacramento River at Freeport	2/20/96	9/15/98	35	33	94%	3.5	37	8	10	12	16	23	10
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	11	11	100%	4.0	16.4	4	4	5	9	11	—

Iron, total

Units = µg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	10th	25th	median (50th)	75th	90th	min RL
MCMOU	Mill Creek at Mouth	6/23/98	5/19/99	12	12	100%	23	5973	72	99	280	414	1033	—
MCBLR	Mill Creek at Black Rock	6/23/98	5/19/99	11	11	100%	79	6523	105	115	179	589	1320	—
MCHWY	Mill Creek at Highway 36	6/23/98	5/19/99	12	12	100%	220	10834	246	358	593	1037	1521	—
DCMOU	Deer Creek at Mouth	6/24/98	5/18/99	11	11	100%	24	449	27	85	161	397	434	—
DCUDD	Deer Creek at Upper Diversion Dam	6/24/98	5/18/99	12	11	92%	2	154	8	24	34	96	109	27
DCPON	Deer Creek at Ponderosa Way	6/24/98	5/18/99	8	7	88%	16.1	144	<RL	35	38	54	111	27
DCMDW	Deer Creek below Childs Meadows	6/24/98	5/18/99	12	12	100%	20	141	37	43	84	115	123	—
CHMUD	Big Chico Creek above Mud Creek	6/23/98	5/20/99	12	11	92%	3	832	14	26	142	294	583	27
MUDCH	Mud Creek above Big Chico Creek	6/23/98	5/20/99	8	8	100%	58.0	451	75	106	141	328	381	—
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/23/98	5/20/99	12	11	92%	1	254	15	31	52	76	190	27
CHASH	Big Chico Creek above Salmon Hole	6/23/98	5/20/99	12	11	92%	1.3	156	7	22	37	66	111	27
CHHWY	Big Chico Creek at Hwy 32	6/23/98	5/20/99	12	12	100%	5.7	140	12	24	39	53	96	—
SACSL	Sacramento Slough	6/22/99	5/16/00	11	11	100%	600	3070	693	795	1190	1670	1960	—
COLDR	Colusa Basin Drain	6/23/99	5/16/00	11	11	100%	377	4280	915	1054	1200	2330	3840	—
SRVET	Sacramento River at Veterans Bridge	6/22/99	5/16/00	11	11	100%	356	2000	407	420	614	1175	1370	—
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	5/17/00	11	11	100%	651	10100	824	878	956	1565	3410	—
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	11	11	100%	410	29000	480	715	1300	5850	13000	—
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	12	12	100%	360	3920	441	680	852	1423	2468	—

Magnesium, dissolved

Units = mg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	10th	25th	median (50th)	75th	90th	min RL
SRABB	Sacramento River above Bend Bridge	2/13/96	4/9/98	27	27	100%	3.9	6.0	4.7	4.8	5.0	5.3	5.4	—
MCMOU	Mill Creek at Mouth	6/23/98	4/17/00	17	17	100%	2.0	16.0	3.2	5.0	7.0	8.0	12.4	—
MCBLR	Mill Creek at Black Rock	6/23/98	4/17/00	14	14	100%	2.0	11.0	3.3	4.3	6.3	7.8	10.1	—
MCHWY	Mill Creek at Highway 36	6/23/98	4/17/00	17	17	100%	2.0	20.0	2.0	4.0	8.0	13.6	15.6	—
DCMOU	Deer Creek at Mouth	6/24/98	4/17/00	11	11	100%	4.0	10.0	4.0	4.0	5.0	7.0	7.0	—
DCUDD	Deer Creek at Upper Diversion Dam	6/24/98	4/17/00	16	16	100%	3.0	6.0	3.0	4.0	4.0	6.0	6.0	—
DCPON	Deer Creek at Ponderosa Way	6/24/98	11/8/99	11	11	100%	3.0	6.0	3.0	4.2	5.0	5.0	6.0	—
DCMDW	Deer Creek below Childs Meadows	6/24/98	4/17/00	16	16	100%	1.0	3.0	1.3	2.0	2.0	2.0	2.2	—
CHMUD	Big Chico Creek above Mud Creek	6/23/98	4/17/00	15	15	100%	3.0	9.0	4.0	4.0	6.3	8.0	9.0	—
MUDCH	Mud Creek above Big Chico Creek	6/23/98	4/17/00	9	9	100%	4.0	12.4	4.0	4.0	6.0	7.0	9.7	—
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/23/98	4/17/00	15	15	100%	2.0	9.0	4.0	4.5	6.1	8.1	9.0	—
CHASH	Big Chico Creek above Salmon Hole	6/23/98	2/14/00	14	14	100%	2.4	9.0	4.0	4.3	6.0	8.1	9.0	—
CHHWY	Big Chico Creek at Hwy 32	6/23/98	4/17/00	15	15	100%	2.9	9.0	5.0	5.5	6.5	8.1	8.7	—
SRCOL	Sacramento River at Colusa	2/28/96	9/16/98	31	31	100%	3.9	7.1	5.0	5.2	5.5	6.4	6.9	—
SACSL	Sacramento Slough	2/12/96	4/22/98	24	24	100%	5.4	22.0	6.2	12.3	16.0	18.0	19.0	—
COLDR	Colusa Basin Drain	2/7/96	4/15/98	31	31	100%	9.1	31.0	18.0	20.5	24.0	25.5	27.0	—
YRMRY	Yuba River at Marysville	2/27/96	4/6/98	27	27	100%	1.6	4.5	2.2	2.5	2.6	3.2	3.7	—
FRNIC	Feather River near Nicolaus	2/23/96	4/20/98	27	27	100%	2.3	5.5	3.0	3.2	3.3	3.8	4.1	—
SRVON	Sacramento River at Verona	2/22/96	4/22/98	26	26	100%	2.5	8.0	4.5	5.0	5.9	6.5	6.9	—
ARCNW	Arcade Creek at Norwood Ave.	2/6/96	4/23/98	38	38	100%	1.7	10.0	3.0	5.0	6.7	8.8	9.2	—
ARJST	American River at J Street	2/21/96	4/16/98	27	27	100%	4.0	6.4	4.5	4.9	5.1	5.5	6.0	—
SRFPT	Sacramento River at Freeport	2/20/96	9/22/00	59	59	100%	1.7	8.9	4.2	4.7	5.3	6.0	6.6	—
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	11	11	100%	14.7	23.9	16.4	17.4	19.2	20.0	21.9	—

Magnesium, total

Units = mg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	10th	25th	median (50th)	75th	90th	min RL
SACSL	Sacramento Slough	6/22/99	5/16/00	11	11	100%	15.6	20.4	16.1	17.2	18.5	19.2	19.8	—
COLDR	Colusa Basin Drain	6/23/99	5/16/00	12	12	100%	15.6	41.3	17.4	20.8	23.4	29.0	36.9	—
SRVET	Sacramento River at Veterans Bridge	6/22/99	5/16/00	11	11	100%	5.8	9.1	6.3	6.5	6.8	7.6	7.8	—
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	5/17/00	11	11	100%	2.5	11.9	3.3	3.7	4.5	10.4	11.3	—
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	11	11	100%	15.2	32.6	15.9	16.8	20.7	23.2	27.2	—
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	12	12	100%	6.3	16.5	6.8	7.3	8.1	10.4	11.4	—

Summary Statistics: Minerals Data

Manganese, dissolved

Units = µg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
CCMOU	Clear Creek near Mouth	9/15/98	8/17/99	12	12	100%	4	6	4.0	4.0	5.0	5.0	5.9	—
SRABB	Sacramento River above Bend Bridge	2/13/96	4/9/98	27	27	100%	2	6.4	2.0	2.1	3.0	4.0	5.6	—
SRCOL	Sacramento River at Colusa	2/28/96	9/16/98	32	32	100%	1.8	18	3.0	3.5	5.0	7.7	11.0	—
SACSL	Sacramento Slough	2/12/96	4/22/98	25	25	100%	3.7	72	5.5	9.4	18.0	28.0	33.6	—
COLDR	Colusa Basin Drain	2/7/96	4/15/98	27	27	100%	1.2	71	2.0	4.5	15.0	29.0	44.6	—
YRMRY	Yuba River at Marysville	2/27/96	4/6/98	27	27	100%	1.5	48	3.0	4.4	6.6	15.0	27.2	—
FRNIC	Feather River near Nicolaus	2/23/96	4/20/98	27	26	96%	1.0	14	1.2	2.0	4.0	6.4	10.4	1
SRVON	Sacramento River at Verona	2/22/96	4/22/98	27	27	100%	1.0	24	1.8	3.1	5.0	7.1	10.4	—
ARCNW	Arcade Creek at Norwood Ave.	2/6/96	4/23/98	28	28	100%	7	106	10.5	14.0	25.5	43.0	65.9	—
ARJST	American River at J Street	3/18/96	4/16/98	26	26	100%	1.5	11	1.9	2.0	3.0	3.9	6.3	—
SRFPT	Sacramento River at Freeport	2/20/96	9/22/00	56	49	88%	1.0	10	<RL	1.7	2.4	3.1	4.0	1
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	11	11	100%	1.1	2.2	1.4	1.7	1.8	1.9	2.0	—

Manganese, total

Units = µg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
CCMOU	Clear Creek near Mouth	9/15/98	7/20/99	9	9	100%	7.5	26.3	8.3	9.1	9.9	15.1	17.4	—
MCMOU	Mill Creek at Mouth	6/23/98	5/19/99	12	12	100%	1.4	67.4	3.6	7.9	9.2	11.3	18.0	—
MCBLR	Mill Creek at Black Rock	6/23/98	5/19/99	11	11	100%	3.2	72.5	4.8	5.1	9.5	16.5	23.3	—
MCHWY	Mill Creek at Highway 36	6/23/98	5/19/99	12	12	100%	26.4	100.6	27.7	31.4	34.9	38.4	66.6	—
DCMOU	Deer Creek at Mouth	6/24/98	5/18/99	11	11	100%	6.2	29.7	13.8	14.6	17.1	19.6	28.5	—
DCUDD	Deer Creek at Upper Diversion Dam	6/24/98	5/18/99	12	12	100%	1.3	4.3	1.4	1.6	2.6	3.0	4.1	—
DCPON	Deer Creek at Ponderosa Way	6/24/98	5/18/99	8	8	100%	0.0	8.0	0.8	1.3	1.8	3.1	4.8	—
DCMDW	Deer Creek below Childs Meadows	6/24/98	5/18/99	12	12	100%	3.3	10.6	3.6	4.1	6.0	8.0	10.2	—
CHMUD	Big Chico Creek above Mud Creek	6/23/98	5/20/99	12	12	100%	2.1	23.3	2.4	2.7	6.8	11.5	18.8	—
MUDCH	Mud Creek above Big Chico Creek	6/23/98	5/20/99	8	8	100%	2.4	122.0	6.2	8.3	20.6	44.3	72.3	—
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/23/98	5/20/99	12	12	100%	0.8	6.9	1.2	1.7	2.8	4.5	6.4	—
CHASH	Big Chico Creek above Salmon Hole	6/23/98	5/20/99	12	12	100%	1.4	4.6	1.7	2.1	2.7	3.3	4.0	—
CHHWY	Big Chico Creek at Hwy 32	6/23/98	5/20/99	12	12	100%	1.8	4.5	1.8	1.9	2.2	2.6	3.9	—
SACSL	Sacramento Slough	6/22/99	5/16/00	11	11	100%	99	279	127	130	149	184	269	—
COLDR	Colusa Basin Drain	6/23/99	5/16/00	12	12	100%	118	843	124	132	183	324	473	—
SRVET	Sacramento River at Veterans Bridge	6/22/99	5/16/00	11	11	100%	28	107	35	37	47	72	91	—
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	5/17/00	11	11	100%	35	262	46	74	97	147	162	—
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	11	11	100%	11	590	19	26	53	125	260	—
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	12	12	100%	13	65	20	24	32	57	64	—

Potassium, dissolved

Units = mg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
SRABB	Sacramento River above Bend Bridge	2/13/96	4/9/98	27	27	100%	0.8	1.4	0.9	1.0	1.1	1.2	1.3	—
MCMOU	Mill Creek at Mouth	6/23/98	4/17/00	12	12	100%	0.8	3.1	1.3	1.4	1.9	2.4	2.7	—
MCBLR	Mill Creek at Black Rock	6/23/98	4/17/00	9	9	100%	1.2	3.1	1.4	1.6	1.8	2.4	2.7	—
MCHWY	Mill Creek at Highway 36	6/23/98	4/17/00	12	12	100%	1.2	7.3	1.5	1.6	3.0	4.4	5.1	—
DCMOU	Deer Creek at Mouth	6/24/98	4/17/00	9	9	100%	1.1	2.4	1.1	1.3	1.5	1.7	1.9	—
DCUDD	Deer Creek at Upper Diversion Dam	6/24/98	4/17/00	11	11	100%	1.1	2.6	1.1	1.2	1.6	1.9	2.1	—
DCPON	Deer Creek at Ponderosa Way	6/24/98	11/8/99	8	8	100%	1.0	2.7	1.1	1.6	2.0	2.3	2.7	—
DCMDW	Deer Creek below Childs Meadows	6/24/98	4/17/00	11	11	100%	0.7	3.0	1.1	1.2	1.9	2.4	2.6	—
CHMUD	Big Chico Creek above Mud Creek	6/23/98	4/17/00	10	9	90%	0.5	1.3	0.5	0.8	1.0	1.1	1.2	0.5
MUDCH	Mud Creek above Big Chico Creek	6/23/98	4/17/00	6	6	100%	0.6	1.5	0.7	0.8	0.9	1.3	1.5	—
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/23/98	4/17/00	10	10	100%	0.5	1.7	0.6	0.9	1.3	1.4	1.7	—
CHASH	Big Chico Creek above Salmon Hole	6/23/98	2/14/00	9	8	89%	0.5	1.5	<RL	0.6	0.9	1.1	1.4	0.5
CHHWY	Big Chico Creek at Hwy 32	6/23/98	4/17/00	9	8	89%	0.6	1.4	<RL	0.6	0.9	1.1	1.4	0.5
SRCOL	Sacramento River at Colusa	2/28/96	9/16/98	31	31	100%	0.8	1.5	1.0	1.1	1.1	1.2	1.4	—
SACSL	Sacramento Slough	2/12/96	4/22/98	24	24	100%	1.0	4.2	1.1	1.3	1.5	2.2	3.2	—
COLDR	Colusa Basin Drain	2/7/96	4/15/98	31	31	100%	1.2	5.8	1.8	2.1	2.4	3.2	4.3	—
YRMRY	Yuba River at Marysville	2/27/96	4/6/98	27	27	100%	0.4	0.8	0.4	0.5	0.5	0.6	0.6	—
FRNIC	Feather River near Nicolaus	2/23/96	4/20/98	27	27	100%	0.6	1.6	0.7	0.8	0.9	1.0	1.2	—
SRVON	Sacramento River at Verona	2/22/96	4/22/98	26	26	100%	0.8	2.0	0.9	1.0	1.1	1.3	1.5	—
ARCNW	Arcade Creek at Norwood Ave.	2/6/96	4/23/98	38	38	100%	2.0	5.5	2.7	3.2	4.1	4.4	5.0	—
ARJST	American River at J Street	2/21/96	4/16/98	27	27	100%	1.4	2.6	1.8	1.9	2.0	2.2	2.3	—
SRFPT	Sacramento River at Freeport	2/20/96	9/22/00	59	59	100%	0.8	1.9	0.8	0.9	1.0	1.1	1.3	—
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	11	11	100%	1.3	2.0	1.4	1.5	1.6	1.7	1.8	—

Summary Statistics: Minerals Data

Potassium, total

Units = mg/L

Site ID	Site Description	monitoring period start	monitoring period end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
SACSL	Sacramento Slough	6/22/99	5/16/00	11	11	100%	1.1	3.7	1.1	1.2	1.9	2.5	3.7	—
COLDR	Colusa Basin Drain	6/23/99	5/16/00	12	12	100%	1.1	5.8	1.2	1.7	2.2	3.6	3.8	—
SRVET	Sacramento River at Veterans Bridge	6/22/99	5/16/00	11	11	100%	0.7	1.5	0.8	1.1	1.2	1.3	1.4	—
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	5/17/00	11	11	100%	1.6	6.0	2.3	2.9	3.6	4.1	5.3	—
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	11	11	100%	1.4	2.9	1.5	1.6	1.7	2.0	2.1	—
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	12	12	100%	1.0	2.0	1.1	1.1	1.2	1.7	2.0	—

Silica as SiO_2, dissolved

Units = mg/L

Site ID	Site Description	monitoring period start	monitoring period end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
SRABB	Sacramento River above Bend Bridge	2/13/96	4/9/98	27	27	100%	18	24	19	20	20	21	23	—
SRCOL	Sacramento River at Colusa	2/28/96	11/16/99	32	32	100%	15	25	19	19	20	21	21	—
SACSL	Sacramento Slough	2/12/96	5/16/00	34	34	100%	18	34	21	22	26	28	30	—
COLDR	Colusa Basin Drain	2/7/96	5/16/00	41	41	100%	10	41	14	16	19	24	30	—
YRMRY	Yuba River at Marysville	2/27/96	4/6/98	27	27	100%	10	14	11	12	12	13	13	—
FRNIC	Feather River near Nicolaus	2/23/96	1/19/00	28	28	100%	11	15	12	13	13	13	14	—
SRVON	Sacramento River at Verona	2/22/96	4/22/98	26	26	100%	11	22	16	16	18	18	20	—
SRVET	Sacramento River at Veterans Bridge	6/22/99	5/16/00	9	8	89%	18	30	<RL	19	21	21	24	21
ARCNW	Arcade Creek at Norwood Ave.	2/6/96	5/17/00	48	48	100%	7	45	12	17	24	38	41	—
ARJST	American River at J Street	2/21/96	4/16/98	27	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.1
SRFPT	Sacramento River at Freeport	2/20/96	9/22/00	59	59	100%	9	20	15	16	16	17	18	—
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	11	11	100%	3	11	5	7	8	9	10	—
CCHSL	Cache Slough near Ryers Ferry	8/17/99	2/16/00	5	5	100%	17	28	18	18	20	28	28	—

Sodium, total

Units = mg/L

Site ID	Site Description	monitoring period start	monitoring period end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
SACSL	Sacramento Slough	6/22/99	5/16/00	11	11	100%	16	32	18	20	23	25	28	—
COLDR	Colusa Basin Drain	6/23/99	5/16/00	12	12	100%	44	121	45	47	49	77	107	—
SRVET	Sacramento River at Veterans Bridge	6/22/99	5/16/00	11	11	100%	5	13	7	8	9	11	11	—
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	5/17/00	11	11	100%	3	26	5	7	8	24	26	—
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	11	11	100%	11	22	11	14	16	17	20	—
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	12	12	100%	9	21	10	10	11	18	20	—

Sulfate

Units = mg/L

Site ID	Site Description	monitoring period start	monitoring period end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
SRABB	Sacramento River above Bend Bridge	2/13/96	4/9/98	27	27	100%	2.8	7.4	3.1	3.2	4.0	5.4	6.7	—
MCMOU	Mill Creek at Mouth	6/23/98	4/17/00	12	12	100%	4.0	17.0	5.0	5.8	10.5	13.0	16.0	—
MCBLR	Mill Creek at Black Rock	6/23/98	4/17/00	9	9	100%	5.0	15.0	5.8	8.0	11.0	12.0	14.2	—
MCHWY	Mill Creek at Highway 36	6/23/98	4/17/00	12	12	100%	5.0	51.0	6.2	14.0	29.0	38.0	45.5	—
DCMOU	Deer Creek at Mouth	6/24/98	4/17/00	9	8	89%	1.0	4.0	<RL	1.0	2.0	2.0	3.2	1
DCUDD	Deer Creek at Upper Diversion Dam	6/24/98	4/17/00	11	9	82%	1.0	2.0	<RL	1.0	2.0	2.0	2.0	1
DCPON	Deer Creek at Ponderosa Way	6/24/98	11/8/99	8	5	63%	1.0	1.0	<RL	<RL	1.0	1.0	1.0	1
DCMDW	Deer Creek below Childs Meadows	6/24/98	4/17/00	11	7	64%	1.0	2.0	<RL	<RL	1.0	1.0	2.0	1
CHMUD	Big Chico Creek above Mud Creek	6/23/98	4/17/00	10	9	90%	2.0	4.0	1.9	2.0	2.5	3.0	4.0	1
MUDCH	Mud Creek above Big Chico Creek	6/23/98	4/17/00	6	6	100%	3.0	14.0	3.0	3.3	5.0	6.0	10.0	—
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/23/98	4/17/00	10	10	100%	1.0	4.0	1.9	2.0	3.0	3.0	4.0	—
CHASH	Big Chico Creek above Salmon Hole	6/23/98	2/14/00	9	9	100%	2.0	4.0	2.0	2.0	3.0	3.0	4.0	—
CHHWY	Big Chico Creek at Hwy 32	6/23/98	4/17/00	10	3	30%	2.0	2.0	<RL	<RL	<RL	1.8	2.0	1
SRCOL	Sacramento River at Colusa	2/28/96	11/16/99	33	33	100%	3.3	8.4	3.7	4.1	4.8	6.1	7.0	—
SACSL	Sacramento Slough	2/12/96	5/16/00	35	34	97%	5.3	15.0	6.0	6.9	8.7	10.0	11.6	2
COLDR	Colusa Basin Drain	2/7/96	5/16/00	43	43	100%	19.0	141.0	39.6	52.5	65.4	85.5	100.0	—
YRMRY	Yuba River at Marysville	2/27/96	4/6/98	27	27	100%	1.5	10.0	2.5	3.0	3.4	4.8	6.8	—
FRNIC	Feather River near Nicolaus	2/23/96	1/19/00	28	28	100%	1.9	6.4	2.2	2.4	2.8	3.6	5.2	—
SRVON	Sacramento River at Verona	2/22/96	4/22/98	26	26	100%	2.4	11.0	3.6	4.2	5.3	6.3	8.4	—
SRVET	Sacramento River at Veterans Bridge	6/22/99	5/16/00	11	11	100%	5.4	13.2	5.6	6.3	7.8	8.6	10.0	—
ARCNW	Arcade Creek at Norwood Ave.	2/6/96	5/17/00	49	49	100%	3.6	24.0	5.8	8.1	9.7	12.0	16.0	—
ARJST	American River at J Street	2/21/96	4/16/98	27	27	100%	0.9	2.3	1.3	1.3	1.4	1.7	1.9	—
SRFPT	Sacramento River at Freeport	2/20/96	9/22/00	59	59	100%	1.7	20.9	3.6	4.3	5.4	6.2	7.7	—
CCHCK	Cache Creek at Rumsey	2/21/99	8/18/99	10	10	100%	7.8	24.6	9.1	14.4	19.7	21.8	23.3	—
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	12	12	100%	7.7	23.3	7.8	9.2	11.1	19.5	22.6	—

Summary Statistics Table Notes:

monitoring period start and end — Dates of first and last reported data.

n — Total number of data reported.

n det — Total number of data above reporting limits.

% det — Percent of data above reporting limits.

min det — Minimum value for data detected above reporting limits.

max det — Maximum value of data detected above reporting limits.

percentiles — Percentile data are provided for data above reporting limits. "<RL" indicates insufficient data to calculate statistic.

min RL — Lowest reporting limit for data below detection. min RL only reported where percent detection (% det) < 100%.

Summary Statistics: Pathogens Data

Cryptosporidium

Units = öocysts/L

Site ID	Site Description	monitoring period start	monitoring period end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
SRABB	Sacramento River above Bend Bridge	7/21/99	5/17/00	11	2	18%	0.1	0.1	<RL	<RL	<RL	<RL	0.1	0.1
SRHAM	Sacramento River near Hamilton City	6/24/99	5/17/00	12	2	17%	0.3	0.5	<RL	<RL	<RL	<RL	0.39	0.1
SRCOL	Sacramento River at Colusa	7/21/99	5/16/00	11	1	9%	0.8	0.8	<RL	<RL	<RL	<RL	<RL	0.1
FRNIC	Feather River near Nicolaus	6/22/99	5/16/00	12	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.1
SRVET	Sacramento River at Veterans Bridge	7/20/99	5/16/00	11	1	9%	0.3	0.3	<RL	<RL	<RL	<RL	<RL	0.1
SRFPT	Sacramento River at Freeport	6/23/99	1/9/01	30	1	3%	—	—	<RL	<RL	<RL	<RL	<RL	0.1
SRRMF	Sacramento River at River Mile 44	7/19/00	12/20/00	4	1	25%	0.3	0.3	<RL	<RL	<RL	0.15	0.24	0.1
CCHSL	Cache Slough near Ryers Ferry	6/22/99	2/16/00	5	1	20%	0.2	0.2	<RL	<RL	<RL	<RL	0.2	0.1

Giardia

Units = cysts/L

Site ID	Site Description	monitoring period start	monitoring period end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
SRABB	Sacramento River above Bend Bridge	7/21/99	5/17/00	11	9	82%	0.1	0.5	<RL	0.1	0.2	0.25	0.3	0.1
SRHAM	Sacramento River near Hamilton City	6/24/99	5/17/00	12	8	67%	0.1	0.6	<RL	<RL	0.15	0.325	0.49	0.1
SRCOL	Sacramento River at Colusa	7/21/99	5/16/00	11	7	64%	0.1	0.5	<RL	<RL	0.4	0.45	0.5	0.1
FRNIC	Feather River near Nicolaus	6/22/99	5/16/00	12	5	42%	0.08	0.2	<RL	<RL	<RL	0.2	0.2	0.1
SRVET	Sacramento River at Veterans Bridge	7/20/99	8/15/00	13	5	38%	0.1	0.3	<RL	<RL	<RL	0.1	0.3	0.1
SRFPT	Sacramento River at Freeport	6/23/99	1/9/01	30	20	67%	0.1	0.8	<RL	<RL	0.15	0.3	0.6	0.1
SRRMF	Sacramento River at River Mile 44	7/19/00	12/20/00	4	1	25%	0.5	0.5	<RL	<RL	<RL	0.2	0.38	0.1
CCHSL	Cache Slough near Ryers Ferry	6/22/99	2/16/00	5	1	20%	0.3	0.3	<RL	<RL	<RL	<RL	0.22	0.1

Coliform, total

Units = MPN/100 mL

Site ID	Site Description	monitoring period start	monitoring period end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
SRBKR	Sacramento River below Keswick	7/22/98	5/16/00	20	19	95%	1	62	1	3.75	10	22	29	1
SRABB	Sacramento River above Bend Bridge	6/24/98	5/17/00	23	23	100%	1	1600	17.6	40	130	300	468	—
SRHAM	Sacramento River near Hamilton City	6/24/99	5/17/00	10	10	100%	17	2400	28.7	50	150	810	1230	—
SRCOL	Sacramento River at Colusa	6/24/98	5/16/00	22	22	100%	21	2200	30	35	185	450	1250	—
FRNIC	Feather River near Nicolaus	6/23/98	5/16/00	23	23	100%	3	1600	15.2	30	130	500	1060	—
SRVET	Sacramento River at Veterans Bridge	10/29/96	6/20/00	42	42	100%	17	5000	80	185	500	900	1600	—
ARDPK	American River at Discovery Park	10/29/96	6/20/00	41	41	100%	17	50000	70	110	240	800	1600	—
SRFPT	Sacramento River at Freeport	10/29/96	5/16/00	41	41	100%	13	8000	80	170	300	800	1600	—
SRRMF	Sacramento River at River Mile 44	5/20/99	6/20/00	6	6	100%	130	900	150	185	265	450	700	—
CCHSL	Cache Slough near Ryers Ferry	6/23/98	2/16/00	12	12	100%	30	1600	32	50	125	500	770	—

Coliform, fecal

Units = MPN/100 mL

Site ID	Site Description	monitoring period start	monitoring period end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
SRBKR	Sacramento River below Keswick	7/22/98	5/16/00	20	8	40%	1	9	<RL	<RL	<RL	2	3	1
SRABB	Sacramento River above Bend Bridge	6/24/98	5/17/00	23	19	83%	5	340	<RL	15	23	40	218	2
MCMOU	Mill Creek at Mouth	6/23/98	5/19/99	12	12	100%	1	46	1	1	3	7	40	—
MCBLR	Mill Creek at Black Rock	6/23/98	5/19/99	11	11	100%	—	10	<RL	<RL	1	4	8	—
MCHWY	Mill Creek at Highway 36	6/23/98	5/19/99	12	12	100%	—	33	<RL	1	2	4	7	—
DCMOU	Deer Creek at Mouth	6/24/98	5/17/99	9	9	100%	2	224	2	3	5	10	62	—
DCUDD	Deer Creek at Upper Diversion Dam	6/24/98	5/17/99	11	11	100%	—	14	<RL	<RL	1	3	3	—
DCPON	Deer Creek at Ponderosa Way	6/24/98	5/18/99	8	8	100%	—	2	<RL	<RL	<RL	<RL	1	—
DCMDW	Deer Creek below Childs Meadows	6/24/98	5/17/99	11	11	100%	—	41	1	3	8	16	17	—
CHMUD	Big Chico Creek above Mud Creek	6/23/98	5/20/99	12	12	100%	10	1119	24	35	71	110	288	—
MUDCH	Mud Creek above Big Chico Creek	6/23/98	5/20/99	8	8	100%	—	162	11	22	28	33	72	—
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/23/98	5/20/99	11	11	100%	—	233	8	23	40	59	156	—
CHASH	Big Chico Creek above Salmon Hole	6/23/98	5/20/99	12	12	100%	—	20	1	2	3	6	14	—
CHHWY	Big Chico Creek at Hwy 32	6/23/98	5/20/99	11	11	100%	—	22	<RL	2	3	5	7	—
SRHAM	Sacramento River near Hamilton City	6/24/99	5/17/00	10	10	100%	4	1000	8	14	80	215	550	—
SRCOL	Sacramento River at Colusa	6/24/98	5/16/00	22	22	100%	4	1600	8	11	23	198	480	—
FRNIC	Feather River near Nicolaus	6/23/98	5/16/00	23	22	96%	2	500	2	6	13	32	162	2
SRVET	Sacramento River at Veterans Bridge	10/29/96	6/20/00	42	42	100%	2	2400	9	14	30	80	215	—
ARDPK	American River at Discovery Park	10/29/96	6/20/00	41	41	100%	9	3000	14	23	30	110	240	—
SRFPT	Sacramento River at Freeport	10/29/96	6/21/00	40	40	100%	4	8000	6	12	28	95	237	—
CCHSL	Cache Slough near Ryers Ferry	6/23/98	2/16/00	12	12	100%	6	1600	8	8	12	142	860	—

Summary Statistics Table Notes:
monitoring period start and end — Dates of first and last reported data.
n — Total number of data reported.
n det — Total number of data above reporting limits.
% det — Percent of data above reporting limits.
min det — Minimum value for data detected above reporting limits.
max det — Maximum value of data detected above reporting limits.
percentiles — Percentile data are provided for data above reporting limits. "<RL" indicates insufficient data to calculate statistic.
min RL — Lowest reporting limit for data below detection. min RL only reported where percent detection (% det) < 100%.

Summary Statistics: Other Conventional Water Chemistry Parameters

Alkalinity, total

Units = mg/L

Site ID	Site Description	monitoring period start	monitoring period end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
PRSHA	Pit River above Shasta	7/22/98	5/16/00	13	13	100%	60	220	60	64	66	70	106	—
MRSHA	McCloud River above Shasta	7/22/98	5/16/00	17	17	100%	36	130	39	46	54	58	67	—
SRSHA	Sacramento River above Shasta	7/22/98	5/16/00	12	12	100%	39	64	42	44	52	61	64	—
SCKPP	Spring Creek PP Discharge to Keswick Res.	6/24/98	4/18/00	13	13	100%	24	78	35	38	40	42	52	—
SRBKR	Sacramento River below Keswick	6/24/98	5/16/00	23	23	100%	30	62	44	47	52	56	58	—
SRABB	Sacramento River above Bend Bridge	2/13/96	5/16/00	51	51	100%	30	62	45	47	51	55	56	—
MCMOU	Mill Creek at Mouth	6/22/99	4/17/00	8	8	100%	24	51	28	34	37	44	51	—
MCBLR	Mill Creek at Black Rock	6/22/99	4/17/00	6	6	100%	24	46	27	32	36	38	42	—
SRHAM	Sacramento River near Hamilton City	6/23/99	5/17/00	13	13	100%	31	66	51	56	58	60	62	—
DCHWY	Deer Creek at Highway 99	6/23/99	4/17/00	5	5	100%	32	84	37	44	45	74	80	—
DCPON	Deer Creek at Ponderosa Way	6/23/99	11/8/99	4	4	100%	35	60	42	52	58	59	59	—
CHMUD	Big Chico Creek above Mud Creek	6/22/99	4/17/00	9	9	100%	28	89	41	47	84	88	88	—
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/22/99	4/17/00	7	7	100%	30	90	30	39	56	86	88	—
CHAGC	Big Chico Creek above Golf Course	9/14/99	4/17/00	7	7	100%	29	90	40	56	84	88	89	—
LCSTL	Little Chico Creek at Stilson Cyn	9/14/99	1/19/00	4	4	100%	57	92	67	82	90	91	91	—
SRCOL	Sacramento River at Colusa	2/28/96	9/14/00	80	80	100%	37	72	47	50	56	62	64	—
BCGGE	Butte Creek at USGS gage	6/23/99	4/19/00	6	6	100%	34	64	35	38	50	58	61	—
BCHWY	Butte Creek at Colusa Highway	6/23/99	4/19/00	8	8	100%	43	110	52	64	100	109	109	—
BCPLF	Butte Creek below Pool Four	9/14/99	1/19/00	4	4	100%	36	55	37	38	43	50	53	—
BCOKD	Butte Creek above Okie Dam	9/14/99	1/19/00	4	4	100%	43	59	46	51	55	57	58	—
SACSL	Sacramento Slough	2/12/96	5/17/00	64	64	100%	50	206	68	116	140	160	178	—
COLDR	Colusa Basin Drain	2/7/96	5/17/00	73	73	100%	60	480	130	157	200	230	269	—
YRMRY	Yuba River at Marysville	2/27/96	4/6/98	27	27	100%	16	36	23	27	30	32	33	—
FRNIC	Feather River near Nicolaus	2/23/96	5/17/00	52	52	100%	22	48	32	34	36	42	44	—
SRVON	Sacramento River at Verona	3/19/96	4/22/98	26	26	100%	24	73	45	50	55	58	63	—
SRVET	Sacramento River at Veterans Bridge	6/24/98	5/17/00	34	34	100%	34	84	51	59	64	73	77	—
ARCNW	Arcade Creek at Norwood Ave.	2/6/96	5/17/00	80	80	100%	19	130	31	49	66	94	114	—
ARJST	American River at J Street	2/21/96	4/16/98	27	27	100%	16	27	17	18	20	22	22	—
ARDPK	American River at Discovery Park	6/23/98	5/17/00	25	25	100%	18	74	19	22	24	28	30	—
SRFPT	Sacramento River at Freeport	2/20/96	10/24/00	82	82	100%	21	82	42	47	53	58	64	—
SRRMF	Sacramento River at River Mile 44	6/23/98	5/17/00	29	29	100%	36	67	40	52	55	63	65	—
CCHSL	Cache Slough near Ryers Ferry	6/23/98	4/18/00	25	25	100%	40	128	60	62	70	77	81	—

Total Suspended Solids

Units = mg/L

Site ID	Site Description	monitoring period start	monitoring period end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
SRBKR	Sacramento River below Keswick	4/21/98	5/16/00	43	22	51%	—	13	<RL	<RL	5	5	5	5
SRABB	Sacramento River above Bend Bridge	3/8/96	5/17/00	37	29	78%	3	355	<RL	5	14	33	52	5
SRHAM	Sacramento River near Hamilton City	6/23/99	5/16/00	11	5	45%	6	218	<RL	<RL	<RL	12	132	5
SRCOL	Sacramento River at Colusa	2/28/96	4/8/98	28	28	100%	23	579	29	35	47	145	185	—
SACSL	Sacramento Slough	2/12/96	5/16/00	33	33	100%	30	182	37	44	61	77	110	—
COLDR	Colusa Basin Drain	2/7/96	5/16/00	41	41	100%	21	373	60	75	119	154	202	—
YRMRY	Yuba River at Marysville	2/27/96	5/16/00	38	27	71%	1	153	<RL	<RL	5	20	63	5
FRNIC	Feather River near Nicolaus	2/23/96	5/16/00	38	34	89%	5	123	<RL	9	17	43	74	5
SRVON	Sacramento River at Verona	2/22/96	3/25/98	25	25	100%	24	117	28	38	49	77	107	—
SRVET	Sacramento River at Veterans Bridge	1/4/94	12/16/98	82	82	100%	4	200	15	21	33	49	66	—
ARCNW	Arcade Creek at Norwood Ave.	2/6/96	5/17/00	48	48	100%	5	656	13	20	28	67	158	—
ARJST	American River at J Street	2/21/96	4/16/98	26	26	100%	2	116	3	3	5	11	33	—
ARDPK	American River at Discovery Park	1/4/94	12/16/98	80	53	66%	1	41	<RL	<RL	3	6	14	1
SRFPT	Sacramento River at Freeport	1/4/94	12/17/98	113	112	99%	2	368	11	15	26	46	80	1
SRRMF	Sacramento River at River Mile 44	1/18/94	12/17/98	75	74	99%	2	230	7	14	26	47	73	1
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	8	8	100%	8	43	9	11	18	34	41	—

Hardness

Units = mg/L

Site ID	Site Description	monitoring period start	monitoring period end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
PRSHA	Pit River above Shasta	7/22/98	5/16/00	13	13	100%	14	68	44	44	48	52	56	—
MRSHA	McCloud River above Shasta	7/22/98	5/16/00	16	16	100%	32	94	36	44	48	50	60	—
SRSHA	Sacramento River above Shasta	7/22/98	5/16/00	12	12	100%	32	76	36	40	44	49	52	—
SCKPP	Spring Ck PP Discharge to Keswick Res.	6/24/98	4/18/00	12	12	100%	28	64	32	36	37	40	44	—
SRBKR	Sacramento River below Keswick	2/18/98	5/16/00	47	47	100%	36	82	40	40	44	48	50	—
CCWHI	Clear Ck above Whiskeytown	6/22/99	8/17/99	3	3	100%	16	52	21	28	40	46	50	—
CCMOU	Clear Ck near Mouth	6/22/99	8/17/99	3	3	100%	40	44	41	42	44	44	44	—
SRABB	Sacramento River above Bend Bridge	2/13/96	5/16/00	51	51	100%	30	128	42	44	48	50	54	—
MCMOU	Mill Ck at Mouth	6/22/99	4/17/00	8	8	100%	24	72	30	35	42	51	64	—
MCGGE	Mill Ck at USGS gage	10/28/99	1/19/00	3	3	100%	36	52	38	42	48	50	51	—
MCBLR	Mill Ck at Black Rock	6/22/99	4/17/00	6	6	100%	28	48	32	36	38	40	44	—
DCHWY	Deer Ck at Highway 99	6/23/99	4/17/00	5	5	100%	28	72	30	32	38	60	67	—
DCUDD	Deer Ck at Upper Diversion Dam	6/24/98	5/18/99	10	10	100%	27	52	27	34	34	43	50	—
DCPON	Deer Ck at Ponderosa Way	6/23/99	11/8/99	4	4	100%	48	56	49	51	52	53	55	—
DCALN	Deer Ck at A Line Road	1/20/00	4/17/00	3	3	100%	20	30	22	24	28	29	30	—
DCMDW	Deer Ck below Childs Meadows	6/24/98	5/18/99	10	10	100%	12	25	17	18	18	21	21	—
CHMUD	Big Chico Ck above Mud Ck	6/22/99	4/17/00	9	9	100%	24	78	37	40	64	68	75	—
MUDCH	Mud Ck above Big Chico Ck	1/19/00	4/17/00	3	3	100%	32	58	34	37	42	50	55	—
CHCHI	Big Chico Ck at Chico (Rose Ave.)	6/22/99	4/17/00	7	7	100%	20	88	33	47	72	76	81	—
CHASH	Big Chico Ck above Salmon Hole	6/22/99	8/17/99	3	3	100%	68	76	69	70	72	74	75	—
SRHAM	Sacramento River near Hamilton City	6/23/99	5/17/00	12	12	100%	44	68	48	51	54	56	60	—
SRCOL	Sacramento River at Colusa	2/28/96	5/17/00	51	51	100%	36	104	45	48	52	60	65	—
BCGGE	Butte Ck at USGS gage	6/23/99	4/19/00	6	6	100%	28	84	32	36	44	64	76	—
BCHWY	Butte Ck at Colusa Highway	6/23/99	4/19/00	6	6	100%	44	132	47	57	84	101	118	—
BCOKD	Butte Ck above Okie Dam	9/14/99	1/19/00	4	4	100%	40	60	41	43	48	54	58	—
SACSL	Sacramento Slough	2/12/96	5/17/00	51	51	100%	52	232	60	102	130	140	150	—
COLDR	Colusa Basin Drain	2/7/96	5/17/00	57	57	100%	48	372	131	164	180	200	227	—
YRMRY	Yuba River at Marysville	2/27/96	4/6/98	27	27	100%	18	45	24	28	30	36	40	—
FRNIC	Feather River near Nicolaus	2/23/96	5/17/00	51	51	100%	22	84	31	33	36	40	56	—
SRVON	Sacramento River at Verona	2/22/96	4/22/98	26	26	100%	24	69	43	45	54	58	61	—
SRVET	Sacramento River at Veterans Bridge	1/4/94	5/17/00	88	88	100%	28	96	46	50	60	68	76	—
ARCNW	Arcade Ck at Norwood Ave.	2/6/96	5/17/00	63	63	100%	23	132	36	63	84	97	110	—
ARJST	American River at J Street	2/21/96	4/16/98	27	27	100%	16	28	17	18	20	22	24	—
ARDPK	American River at Discovery Park	1/18/94	5/17/00	86	86	100%	14	56	16	20	24	30	36	—
SRFPT	Sacramento River at Freeport	1/4/94	5/17/00	118	118	100%	19	94	39	44	50	60	72	—
SRRMF	Sacramento River at River Mile 44	2/1/94	6/21/00	73	73	100%	24	94	41	46	53	68	78	—
CCHSL	Cache Slough near Ryers Ferry	6/23/98	4/18/00	18	18	100%	59	116	60	61	70	83	93	—

Summary Statistics Table Notes:

monitoring period start and end — Dates of first and last reported data.

n — Total number of data reported.

n det — Total number of data above reporting limits.

% det — Percent of data above reporting limits.

min det — Minimum value for data detected above reporting limits.

max det — Maximum value of data detected above reporting limits.

percentiles — Percentile data are provided for data above reporting limits. "<RL" indicates insufficient data to calculate statistic.

min RL — Lowest reporting limit for data below detection. min RL only reported where percent detection (% det) < 100%.

Summary Statistics: Field Data

Dissolved Oxygen

Units = mg/L

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
PRSHA	Pit River above Shasta	7/22/98	5/16/00	9	9	100%	9.9	13.0	10.4	11.0	11.5	11.6	12.3	—
MRSHA	McCloud River above Shasta	7/22/98	5/16/00	9	9	100%	8.3	11.7	8.5	10.1	11.3	11.4	11.5	—
SRSHA	Sacramento River above Shasta	7/22/98	5/16/00	9	9	100%	9.8	12.8	9.9	10.5	11.2	11.5	11.8	—
SCKPP	Spring Creek PP Discharge to Keswick Res.	6/24/98	4/18/00	12	12	100%	8.8	11.7	9.2	9.9	10.5	10.6	11.0	—
SRBKR	Sacramento River below Keswick	6/24/98	5/16/00	21	21	100%	9.4	12.9	9.7	10.1	10.6	11.1	11.4	—
SRABB	Sacramento River above Bend Bridge	2/13/96	5/17/00	50	50	100%	7.9	12.2	9.5	10.2	10.7	11.1	11.5	—
SRHAM	Sacramento River near Hamilton City	6/23/99	5/17/00	20	20	100%	8.0	13.9	8.2	9.0	9.9	10.0	10.9	—
SRCOL	Sacramento River at Colusa	2/28/96	9/14/00	72	72	100%	7.7	16.1	9.0	9.5	10.1	10.9	11.3	—
SACSL	Sacramento Slough	2/12/96	5/16/00	35	35	100%	5.1	11.2	6.1	6.8	7.6	9.0	9.9	—
COLDR	Colusa Basin Drain	2/7/96	5/16/00	38	38	100%	5.0	12.6	5.7	6.1	7.9	9.2	10.0	—
YRMRY	Yuba River at Marysville	2/27/96	5/16/00	36	36	100%	6.5	15.9	9.6	10.2	11.1	12.0	12.3	—
FRNIC	Feather River near Nicolaus	2/23/96	5/16/00	50	50	100%	7.5	15.7	8.7	9.2	10.2	10.8	11.7	—
SRVON	Sacramento River at Verona	2/22/96	4/22/98	27	27	100%	7.3	12.8	8.5	9.0	9.6	10.6	10.9	—
SRVET	Sacramento River at Veterans Bridge	1/18/94	5/16/00	95	95	100%	6.6	12.4	8.3	8.9	9.7	10.5	11.4	—
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	5/17/00	11	11	100%	1.8	8.8	2.2	2.5	4.6	7.1	8.5	—
ARJST	American River at J Street	2/21/96	4/16/98	26	26	100%	8.2	12.8	8.8	9.2	10.6	11.2	12.1	—
ARDPK	American River at Discovery Park	1/4/94	12/16/98	76	76	100%	6.2	15.2	8.3	9.0	10.1	11.2	12.0	—
SRFPT	Sacramento River at Freeport	2/20/96	10/24/00	79	79	100%	6.1	14.2	8.1	8.7	9.4	10.5	11.0	—
SRRMF	Sacramento River at River Mile 44	1/18/94	5/17/00	92	92	100%	6.7	12.2	8.0	8.4	9.2	10.5	11.1	—
CCHSL	Cache Slough near Ryers Ferry	6/23/98	2/16/00	15	15	100%	7.0	11.0	7.5	8.2	9.2	10.1	10.9	—

Temperature

Units = °C

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
PRSHA	Pit River above Shasta	7/22/98	5/16/00	16	16	100%	7.0	20.1	7.3	9.4	12.0	16.7	18.0	—
MRSHA	McCloud River above Shasta	7/22/98	5/16/00	20	20	100%	5.3	27.1	7.7	8.4	9.3	12.9	16.5	—
SRSHA	Sacramento River above Shasta	7/22/98	5/16/00	15	15	100%	7.3	19.7	7.5	7.7	9.0	13.4	17.2	—
SCKPP	Spring Creek PP Discharge to Keswick Res.	6/24/98	4/18/00	19	19	100%	7.6	13.5	9.0	10.1	10.9	12.5	13.3	—
SRBKR	Sacramento River below Keswick	1/20/98	5/16/00	59	59	100%	8.2	14.5	9.5	10.3	10.9	12.3	13.2	—
CCWHI	Clear Creek above Whiskeytown	6/22/99	8/17/99	3	3	100%	17.7	19.6	17.8	18.0	18.2	18.9	19.3	—
CCMOU	Clear Creek near Mouth	6/22/99	8/17/99	3	3	100%	18.2	20.6	18.4	18.7	19.1	19.9	20.3	—
SRABB	Sacramento River above Bend Bridge	2/13/96	5/17/00	66	66	100%	8.6	13.9	9.5	10.7	12.1	12.6	13.2	—
MCMOU	Mill Creek at Mouth	6/22/99	4/17/00	8	8	100%	8.7	29.4	10.0	10.8	12.5	24.3	28.5	—
MCGGE	Mill Creek at USGS gage	10/28/99	1/19/00	3	3	100%	10.7	13.0	10.9	11.2	11.6	12.3	12.7	—
MCBLR	Mill Creek at Black Rock	6/22/99	4/17/00	6	6	100%	7.2	16.2	7.7	8.3	11.5	14.4	15.4	—
DCHWY	Deer Creek at Highway 99	6/23/99	4/17/00	5	5	100%	10.0	28.4	10.2	10.4	11.4	27.7	28.1	—
DCPON	Deer Creek at Ponderosa Way	6/23/99	11/8/99	4	4	100%	9.5	18.8	11.2	13.8	16.0	17.3	18.2	—
DCALN	Deer Creek at A Line Road	1/20/00	4/17/00	3	3	100%	4.1	6.6	4.4	4.8	5.4	6.0	6.4	—
CHMUD	Big Chico Creek above Mud Creek	10/28/99	1/19/00	3	3	100%	6.4	8.9	6.6	7.0	7.6	8.3	8.6	—
MUDCH	Mud Creek above Big Chico Creek	1/19/00	4/17/00	3	3	100%	11.1	13.2	11.3	11.6	12.0	12.6	13.0	—
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/22/99	4/17/00	7	7	100%	9.9	23.5	10.3	11.5	13.0	22.9	23.4	—
CHAGC	Big Chico Creek above Golf Course	9/14/99	4/17/00	7	7	100%	8.6	20.8	9.3	9.9	11.1	13.2	16.7	—
CHASH	Big Chico Creek above Salmon Hole	6/22/99	8/17/99	3	3	100%	19.1	20.1	19.2	19.3	19.5	19.8	20.0	—
CHHWY	Big Chico Creek at Hwy 32	10/28/99	1/19/00	3	3	100%	6.4	8.9	6.6	7.0	7.6	8.3	8.6	—
LCSTL	Little Chico Creek at Stilson Cyn	9/14/99	1/19/00	4	4	100%	10.6	22.0	11.7	13.5	15.0	17.2	20.1	—
LCTEN	Little Chico Creek at Ten Mile	10/28/99	1/19/00	3	3	100%	10.2	13.2	10.5	11.1	11.9	12.6	12.9	—
SRHAM	Sacramento River near Hamilton City	6/23/99	5/17/00	36	36	100%	9.1	17.4	9.6	10.4	12.9	15.5	15.9	—
SRCOL	Sacramento River at Colusa	2/28/96	9/14/00	94	94	100%	8.6	24.0	9.7	11.2	15.2	18.2	19.2	—
BCGGE	Butte Creek at USGS gage	6/23/99	4/19/00	6	6	100%	7.3	19.4	8.3	9.9	13.1	17.0	18.7	—
BCHWY	Butte Creek at Colusa Highway	6/23/99	4/19/00	7	7	100%	9.8	27.4	9.8	10.5	14.3	18.9	24.2	—
BCPLF	Butte Creek below Pool Four	9/14/99	1/19/00	4	4	100%	8.4	18.1	8.8	9.5	10.5	12.9	16.0	—
BCOKD	Butte Creek above Okie Dam	9/14/99	1/19/00	4	4	100%	9.5	18.1	10.3	11.5	12.4	13.9	16.4	—
SACSL	Sacramento Slough	2/12/96	5/17/00	49	49	100%	7.7	27.8	10.5	12.8	16.3	23.0	25.5	—
COLDR	Colusa Basin Drain	2/7/96	5/17/00	56	56	100%	3.7	30.9	9.8	13.0	15.9	22.5	25.6	—
YRMRY	Yuba River at Marysville	2/27/96	5/16/00	38	38	100%	8.1	21.4	8.8	9.6	11.7	14.4	15.6	—
FRNIC	Feather River near Nicolaus	2/23/96	5/17/00	65	65	100%	8.3	25.8	9.9	10.7	14.7	19.4	20.9	—
SRVON	Sacramento River at Verona	2/22/96	4/22/98	27	27	100%	8.7	22.5	9.5	11.6	14.3	19.6	20.4	—
SRVET	Sacramento River at Veterans Bridge	1/18/94	5/17/00	113	113	100%	7.6	24.1	9.7	11.1	14.6	19.2	21.0	—
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	5/17/00	25	25	100%	6.1	28.0	10.4	12.8	16.5	20.7	22.3	—
ARJST	American River at J Street	2/21/96	4/16/98	27	27	100%	8.4	19.7	9.2	10.3	14.4	17.0	18.9	—
ARDPK	American River at Discovery Park	1/4/94	5/17/00	93	93	100%	7.6	24.4	9.1	10.4	14.3	17.1	20.2	—
SRFPT	Sacramento River at Freeport	2/20/96	10/24/00	105	105	100%	7.1	22.4	9.9	11.7	15.5	20.2	21.1	—
SRRMF	Sacramento River at River Mile 44	1/18/94	5/17/00	98	98	100%	7.9	22.9	9.6	11.1	15.3	19.4	21.3	—
CCHSL	Cache Slough near Ryers Ferry	6/23/98	4/18/00	23	23	100%	8.4	22.6	8.9	10.9	15.7	19.8	21.5	—

Summary Statistics: Field Data

pH

Units = standard units

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	10th	25th	median (50th)	75th	90th	min RL
PRSHA	Pit River above Shasta	7/22/98	5/16/00	15	15	100%	7.3	8.5	7.5	7.9	8.0	8.3	8.4	—
MRSHA	McCloud River above Shasta	7/22/98	5/16/00	18	18	100%	7.1	8.5	7.5	7.7	8.0	8.1	8.2	—
SRSHA	Sacramento River above Shasta	7/22/98	5/16/00	14	14	100%	7.4	8.9	7.5	7.7	8.0	8.1	8.5	—
SCKPP	Spring Creek PP Discharge to Keswick Res.	6/24/98	4/18/00	18	18	100%	6.8	8.3	7.3	7.3	7.3	7.9	8.2	—
SRBKR	Sacramento River below Keswick	1/20/98	5/16/00	57	57	100%	6.7	8.6	7.3	7.3	7.8	8.0	8.2	—
CCWHI	Clear Creek above Whiskeytown	6/22/99	8/17/99	3	3	100%	8.1	8.6	8.1	8.1	8.1	8.4	8.5	—
CCMOU	Clear Creek near Mouth	6/22/99	8/17/99	3	3	100%	7.5	8.1	7.6	7.8	8.0	8.1	8.1	—
SRABB	Sacramento River above Bend Bridge	2/13/96	5/17/00	63	63	100%	7.0	8.4	7.4	7.6	7.7	7.9	8.0	—
MCMOU	Mill Creek at Mouth	6/22/99	4/17/00	8	8	100%	7.4	8.9	7.5	7.5	7.5	7.9	8.3	—
MCGGE	Mill Creek at USGS gage	10/28/99	1/19/00	3	3	100%	7.3	7.6	7.3	7.4	7.4	7.5	7.6	—
MCBLR	Mill Creek at Black Rock	6/22/99	4/17/00	6	6	100%	7.3	7.6	7.4	7.4	7.4	7.5	7.6	—
DCHWY	Deer Creek at Highway 99	6/23/99	4/17/00	5	5	100%	7.6	8.4	7.6	7.7	7.8	7.8	8.2	—
DCPON	Deer Creek at Ponderosa Way	6/23/99	11/8/99	4	4	100%	7.5	8.0	7.6	7.7	7.9	8.0	8.0	—
DCALN	Deer Creek at A Line Road	1/20/00	4/17/00	3	3	100%	7.3	7.8	7.4	7.5	7.7	7.8	7.8	—
CHMUD	Big Chico Creek above Mud Creek	6/22/99	4/17/00	8	8	100%	7.4	8.4	7.4	7.5	7.9	8.3	8.4	—
MUDCH	Mud Creek above Big Chico Creek	1/19/00	4/17/00	3	3	100%	7.2	7.4	7.2	7.3	7.3	7.4	7.4	—
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/22/99	4/17/00	7	7	100%	7.3	8.3	7.5	7.8	8.0	8.2	8.2	—
CHAGC	Big Chico Creek above Golf Course	9/14/99	4/17/00	6	6	100%	7.5	8.2	7.5	7.6	8.0	8.1	8.2	—
CHASH	Big Chico Creek above Salmon Hole	6/22/99	8/17/99	3	3	100%	8.0	8.1	8.0	8.1	8.1	8.1	8.1	—
CHHWY	Big Chico Creek at Hwy 32	10/28/99	1/19/00	3	3	100%	7.5	7.9	7.5	7.5	7.5	7.7	7.8	—
LCSTL	Little Chico Creek at Stilson Cyn	9/14/99	1/19/00	4	4	100%	7.3	8.3	7.4	7.5	7.8	8.2	8.2	—
LCTEN	Little Chico Creek at Ten Mile	10/28/99	1/19/00	3	3	100%	7.2	8.0	7.2	7.3	7.4	7.7	7.9	—
SRHAM	Sacramento River near Hamilton City	6/23/99	5/17/00	36	36	100%	6.0	8.3	6.8	6.9	7.4	8.1	8.3	—
SRCOL	Sacramento River at Colusa	2/28/96	9/14/00	93	93	100%	6.9	8.5	7.5	7.7	7.9	8.0	8.1	—
BCGGE	Butte Creek at USGS gage	6/23/99	4/19/00	6	6	100%	6.5	8.7	7.0	7.8	8.5	8.6	8.7	—
BCHWY	Butte Creek at Colusa Highway	6/23/99	4/19/00	7	7	100%	6.6	8.5	6.8	7.5	8.1	8.5	8.5	—
BCPLF	Butte Creek below Pool Four	9/14/99	1/19/00	4	4	100%	7.3	7.9	7.3	7.4	7.7	7.9	7.9	—
BCOKD	Butte Creek above Okie Dam	9/14/99	1/19/00	4	4	100%	7.3	8.2	7.3	7.4	7.7	8.0	8.1	—
SACSL	Sacramento Slough	2/12/96	5/17/00	49	49	100%	6.7	8.7	7.2	7.6	7.8	7.9	8.0	—
COLDR	Colusa Basin Drain	2/7/96	5/17/00	56	56	100%	6.7	8.6	7.3	7.7	7.9	8.1	8.3	—
YRMRY	Yuba River at Marysville	2/27/96	5/16/00	38	38	100%	6.4	7.8	7.0	7.3	7.5	7.6	7.7	—
FRNIC	Feather River near Nicolaus	2/23/96	5/17/00	65	65	100%	6.6	8.7	7.3	7.5	7.6	7.8	7.9	—
SRVON	Sacramento River at Verona	2/22/96	4/22/98	27	27	100%	7.5	8.1	7.6	7.8	7.8	7.9	8.0	—
SRVET	Sacramento River at Veterans Bridge	1/4/94	5/17/00	112	112	100%	6.8	8.9	7.1	7.4	7.6	7.9	8.2	—
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	5/17/00	25	25	100%	5.9	8.6	6.1	6.3	7.0	7.5	7.9	—
ARJST	American River at J Street	2/21/96	4/16/98	27	27	100%	7.0	7.7	7.3	7.4	7.5	7.5	7.6	—
ARDPK	American River at Discovery Park	1/4/94	5/17/00	90	90	100%	6.4	8.6	6.9	7.0	7.2	7.6	8.0	—
SRFPT	Sacramento River at Freeport	2/20/96	10/24/00	95	95	100%	6.9	8.8	7.4	7.6	7.8	7.9	8.1	—
SRRMF	Sacramento River at River Mile 44	1/18/94	5/17/00	96	96	100%	6.1	8.8	7.0	7.2	7.4	7.6	8.0	—
CCHSL	Cache Slough near Ryers Ferry	6/23/98	4/18/00	23	23	100%	6.9	8.5	6.9	7.0	7.5	7.7	7.9	—

Summary Statistics: Field Data

Specific Conductance

Units = µmhos/cm at 25˚C

Site ID	Site Description	monitoring period start	end	n	n det	% det	min det	max det	percentile statistics 10th	25th	median (50th)	75th	90th	min RL
PRSHA	Pit River above Shasta	7/22/98	5/16/00	16	16	100%	121	194	125	126	131	136	164	—
MRSHA	McCloud River above Shasta	7/22/98	5/16/00	18	18	100%	77	184	94	104	112	115	143	—
SRSHA	Sacramento River above Shasta	7/22/98	5/16/00	15	15	100%	76	146	83	86	99	137	143	—
SCKPP	Spring Creek PP Discharge to Keswick Res.	6/24/98	4/18/00	19	19	100%	69	85	72	73	76	79	82	—
SRBKR	Sacramento River below Keswick	1/20/98	5/16/00	58	58	100%	74	162	95	99	110	122	137	—
CCWHI	Clear Creek above Whiskeytown	6/22/99	8/17/99	3	3	100%	109	169	115	125	140	155	163	—
CCMOU	Clear Creek near Mouth	6/22/99	8/17/99	3	3	100%	89	91	89	89	89	90	91	—
SRABB	Sacramento River above Bend Bridge	2/13/96	5/17/00	65	65	100%	85	185	102	109	118	132	160	—
MCMOU	Mill Creek at Mouth	6/22/99	4/17/00	8	8	100%	65	196	97	113	134	169	186	—
MCGGE	Mill Creek at USGS gage	10/28/99	1/19/00	3	3	100%	111	194	122	138	165	180	188	—
MCBLR	Mill Creek at Black Rock	6/22/99	4/17/00	6	6	100%	95	234	98	106	132	141	188	—
DCHWY	Deer Creek at Highway 99	6/23/99	4/17/00	5	5	100%	58	168	66	79	92	146	159	—
DCPON	Deer Creek at Ponderosa Way	6/23/99	11/8/99	4	4	100%	102	117	105	110	114	116	117	—
DCALN	Deer Creek at A Line Road	1/20/00	4/17/00	3	3	100%	43	70	46	51	58	64	68	—
CHMUD	Big Chico Creek above Mud Creek	7/20/99	4/17/00	7	7	100%	59	200	81	99	179	195	199	—
MUDCH	Mud Creek above Big Chico Creek	1/19/00	4/17/00	3	3	100%	79	176	88	102	124	150	166	—
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/22/99	4/17/00	7	7	100%	61	202	91	116	185	191	197	—
CHAGC	Big Chico Creek above Golf Course	9/14/99	4/17/00	7	7	100%	60	209	86	118	139	191	201	—
CHASH	Big Chico Creek above Salmon Hole	6/22/99	8/17/99	3	3	100%	180	196	182	185	190	193	195	—
CHHWY	Big Chico Creek at Hwy 32	10/28/99	1/19/00	3	3	100%	77	140	85	96	115	128	135	—
LCSTL	Little Chico Creek at Stilson Cyn	9/14/99	1/19/00	4	4	100%	121	190	137	162	176	180	186	—
LCTEN	Little Chico Creek at Ten Mile	10/28/99	1/19/00	3	3	100%	104	152	112	123	142	147	150	—
SRHAM	Sacramento River near Hamilton City	6/23/99	5/17/00	36	36	100%	84	222	110	128	154	177	198	—
SRCOL	Sacramento River at Colusa	2/28/96	9/14/00	91	91	100%	95	252	117	124	136	153	165	—
BCGGE	Butte Creek at USGS gage	6/23/99	4/19/00	6	6	100%	89	132	90	92	103	118	127	—
BCHWY	Butte Creek at Colusa Highway	6/23/99	4/19/00	7	7	100%	128	227	135	144	207	216	220	—
BCPLF	Butte Creek below Pool Four	9/14/99	1/19/00	4	4	100%	81	111	85	92	102	109	110	—
BCOKD	Butte Creek above Okie Dam	9/14/99	1/19/00	4	4	100%	72	111	77	84	99	110	110	—
SACSL	Sacramento Slough	2/12/96	5/17/00	48	48	100%	124	739	222	300	342	391	463	—
COLDR	Colusa Basin Drain	2/7/96	5/17/00	56	56	100%	237	1283	488	544	598	712	833	—
YRMRY	Yuba River at Marysville	2/27/96	5/16/00	38	38	100%	22	105	53	63	68	76	92	—
FRNIC	Feather River near Nicolaus	2/23/96	5/17/00	65	65	100%	52	136	72	79	85	94	105	—
SRVON	Sacramento River at Verona	2/22/96	4/22/98	27	27	100%	62	186	101	118	135	148	157	—
SRVET	Sacramento River at Veterans Bridge	1/4/94	5/17/00	113	113	100%	62	235	107	122	140	164	189	—
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	5/17/00	25	25	100%	92	477	131	155	267	378	414	—
ARJST	American River at J Street	2/21/96	4/16/98	27	27	100%	40	68	45	47	50	57	58	—
ARDPK	American River at Discovery Park	1/4/94	5/17/00	90	90	100%	28	80	39	44	51	61	67	—
SRFPT	Sacramento River at Freeport	2/20/96	10/24/00	94	94	100%	51	205	100	117	129	146	167	—
SRRMF	Sacramento River at River Mile 44	1/18/94	5/17/00	98	98	100%	62	234	90	108	130	156	191	—
CCHSL	Cache Slough near Ryers Ferry	6/23/98	4/18/00	18	18	100%	106	313	140	174	193	240	278	—

Summary Statistics Table Notes:

monitoring period start and end — Dates of first and last reported data.

n — Total number of data reported.

n det — Total number of data above reporting limits.

% det — Percent of data above reporting limits.

min det — Minimum value for data detected above reporting limits.

max det — Maximum value of data detected above reporting limits.

percentiles — Percentile data are provided for data above reporting limits. "<RL" indicates insufficient data to calculate statistic.

min RL — Lowest reporting limit for data below detection. min RL only reported where percent detection (% det) < 100%.

Fish Tissue Data:
SRWP and DWR, 1997 - 1999

YEAR	STATION LOCATION	Species	Tissue	Sample Type	Number of fish	Length (mm)	% Moisture	% Lipid	Mercury, mg/kg	Sum of PCB Congeners, µg/kg	Sum of Aroclors, µg/kg	Sum of Chlordanes, µg/kg	Sum of DDTs, µg/kg	Dieldrin, µg/kg
1997	American R. at Discovery Park	White Catfish	fillet	Composite	4	274	80.4	0.49	0.524	58.8	80.6	8.0	62.0	0.72
1997	Cache Slough	White Catfish	fillet	Composite	5	271	79.1		0.415					
1997	Cache Slough	White Catfish	fillet	Composite	5	279	78.7		0.552					
1997	Colusa Basin Drain	White Catfish	fillet	Composite	5	288	78.8		0.304					
1997	Feather R. near Nicolaus	White Catfish	fillet	Composite	5	264	81.1	0.49	0.391	10.5	ND	4.3	36.4	1.01
1997	McCloud R. above Shasta	Rainbow Trout	fillet	Composite	5	274	76.9		0.053					
1997	Pit R. above Shasta	Rainbow Trout	fillet	Individual	1	332	86.0		0.047					
1997	Sacramento Slough	White Catfish	fillet	Composite	5	274	77.6		0.438					
1997	Sacramento R. above Bend Bridge	Rainbow Trout	fillet	Composite	5	313	75.3	2.54	0.032	7.3	ND	1.5	3.3	ND
1997	Sacramento R. above Shasta	Rainbow Trout	fillet	Composite	5	321	78.8		0.064					
1997	Sacramento R. below Keswick	Rainbow Trout	fillet	Composite	5	366	72.4	3.99	0.032	23.8	27.0	2.9	26.4	0.62
1997	Sacramento R. at R. Mile 44	White Catfish	fillet	Composite	5	256	80.3	1.55	0.390	33.4	46.7	8.8	67.8	2.43
1997	Sacramento R. at R. Mile 44	White Catfish	fillet	Composite	5	258	79.9	0.92	0.285	9.4	12.9	2.8	32.7	0.96
1997	Sacramento R. at Veterans Br	White Catfish	fillet	Composite	5	249	79	0.84	0.553	10.7	14.7	3.3	42.9	1.11
1998	American R. at Discovery Park	Pike Minnow	fillet	Composite	5	283	75.00	4.02	0.418	35.7	11.0	21.8	58.2	3.67
1998	American R. at J Street	Largemouth Bass	fillet	Composite	4	375	78.48	0.67	0.659	5.3	2.0	2.0	4.8	<2
1998	Cache Slough	Largemouth Bass	fillet	Composite	5	367	80.46	0.50	0.723	5.0	0.0	ND	32.7	2.53
1998	Colusa Basin Drain	Carp	fillet	Composite	5	386	76.82	1.78	0.106	6.6	1.9	1.9	684.0	20.07
1998	Feather R. near Nicolaus	Largemouth Bass	fillet	Composite	5	382	79.13	0.72	1.154	8.2	0.0	ND	14.1	<2
1998	Natomas East Main Drain	Largemouth Bass	fillet	Composite	5	367	79.13	0.51	0.599	15.3	2.6	2.6	8.1	UJ
1998	Sacramento Slough	Largemouth Bass	fillet	Composite	5	381	78.12	1.23	0.506	5.5	0.0	ND	41.3	2.79
1998	Sacramento R. above Bend Bridge	Pike Minnow	fillet	Composite	5	254	79.80	1.06	0.119	8.7	0.0	ND	8.4	<2
1998	Sacramento R. below Keswick	Rainbow Trout	fillet	Composite	5	399	74.01	4.40	0.036	26.1	1.6	1.5	36.5	<2
1998	Sacramento R. at Colusa	Carp	fillet	Composite	5	398	80.26	1.00	0.186	5.6	0.0	ND	62.7	<2
1998	Sacramento R. at Colusa	Pike Minnow	fillet	Composite	5	278	80.60	0.76	0.301	7.0	0.0	ND	17.3	<2
1998	Sac R. at Hamilton City	Pike Minnow	fillet	Composite	5	286	79.05	1.30	0.216	10.0	0.0	1.1	20.9	<2
1998	Sac R. at Hamilton City	Sacramento Sucker	fillet	Composite	5	322	79.14	1.24	0.030	1.4	1.1	ND	2.1	<2
1998	Sacramento R. at R. Mile 44	Largemouth Bass	fillet	Composite	5	345	76.97	0.86	0.748	6.2	0.0	ND	12.4	<2
1998	Sacramento R. at R. Mile 44	Largemouth Bass	fillet	Composite	5	334	76.57	0.90	0.895	116.9	1.0	1.0	25.0	2.01
1998	Sacramento R. at R. Mile 44	White Catfish	fillet	Composite	5	250	80.00	1.94	0.258	57.1	10.0	16.4	129.5	<2
1998	Sacramento R. at R. Mile 44	White Catfish	fillet	Composite	5	286	80.47	1.67	0.518	46.5	3.8	3.8	75.9	2.28 J
1998	Sacramento R. at Veterans Br	Largemouth Bass	fillet	Composite	5	335	78.81	0.74	0.818	7.3	0.0	ND	22.5	<2
1999	American R. at Discovery Park	Largemouth Bass	fillet	Composite	5	340	78.5	0.7	0.850	22.7	23.0	2.9	18.3	<2
1999	American R. at Discovery Park	Sacramento Sucker	fillet	Composite	5	314	79.6	1.0	0.247	9.7	ND	1.1	7.6	<2
1999	American R. at J Street	Pike Minnow	fillet	Composite	5	248	78.4	1.0	0.426	16.2	18.0	2.5	16.3	<2
1999	American R. at J Street	Sacramento Sucker	fillet	Composite	5	266	77.5	1.1	0.099	2.5	ND	ND	2.9	<2
1999	Cache Slough	Carp	fillet	Composite	5	352	78.9		0.107					
1999	Cache Slough	Largemouth Bass	fillet	Composite	5		79.6	0.4		6.5	ND	ND	17.0	<2
1999	Cache Slough	Largemouth Bass	fillet	Individual	1	380	79.2		1.180					
1999	Cache Slough	Largemouth Bass	fillet	Individual	1	385	76.6		0.877					
1999	Cache Slough	Largemouth Bass	fillet	Individual	1	429	79.0		0.898					
1999	Cache Slough	Largemouth Bass	fillet	Individual	1	340	78.6		0.872					
1999	Cache Slough	Largemouth Bass	fillet	Individual	1	340	78.3		0.747					
1999	Cache Slough	White Catfish	fillet	Composite	5		81.8	0.6		15.5	16.0	1.4	56.4	<2
1999	Cache Slough	White Catfish	fillet	Individual	1	285	79.7		0.513					
1999	Cache Slough	White Catfish	fillet	Individual	1	270	79.3		0.602					
1999	Cache Slough	White Catfish	fillet	Individual	1	274	83.3		0.680					

YEAR	STATION LOCATION	Species	Tissue	Sample Type	Number of fish	Length (mm)	% Moisture	% Lipid	Mercury, mg/kg	Sum of PCB Congeners, µg/kg	Sum of Aroclors, µg/kg	Sum of Chlordanes, µg/kg	Sum of DDTs, µg/kg	Dieldrin, µg/kg
1999	Cache Slough	White Catfish	fillet	Individual	1	330	82.0		0.833					
1999	Cache Slough	White Catfish	fillet	Individual	1	280	81.2		0.497					
1999	Feather R. near Nicolaus	Bluegill	fillet	Composite	5	184	79.7		0.121					
1999	Feather R. near Nicolaus	Largemouth Bass	fillet	Composite	5		76.7	0.9		7.4	ND	ND	13.3	<2
1999	Feather R. near Nicolaus	Largemouth Bass	fillet	Individual	1	322	78.1		0.787					
1999	Feather R. near Nicolaus	Largemouth Bass	fillet	Individual	1	310	78.0		0.667					
1999	Feather R. near Nicolaus	Largemouth Bass	fillet	Individual	1	314	77.9		0.633					
1999	Feather R. near Nicolaus	Largemouth Bass	fillet	Individual	1	310	78.0		0.555					
1999	Feather R. near Nicolaus	Largemouth Bass	fillet	Individual	1	350	78.9		1.030					
1999	Feather R. near Nicolaus	Largemouth Bass	fillet	Individual	1	495	77.8		2.350					
1999	Feather R. near Nicolaus	Largemouth Bass	fillet	Individual	1	456	78.1		1.510					
1999	Feather R. near Nicolaus	Largemouth Bass	fillet	Individual	1	339	76.7		2.080					
1999	Feather R. near Nicolaus	Largemouth Bass	fillet	Individual	1	305	77.9		0.649					
1999	Feather R. near Nicolaus	Largemouth Bass	fillet	Individual	1	361	77.7		1.520					
1999	Feather R. near Nicolaus	Largemouth Bass	fillet	Individual	1	321	77.8		0.667					
1999	Feather R. near Nicolaus	Pike Minnow	fillet	Composite	5	287	80.5	0.7	1.200	19.0	20.0	ND	33.3	<2
1999	Feather R. near Nicolaus	Striped Bass	fillet	Individual	1	645	76.5		0.320					
1999	Feather R. near Nicolaus	Striped Bass	fillet	Individual	1	817	78.5		3.500					
1999	Feather R. near Nicolaus	Striped Bass	fillet	Individual	1	626	76.3		1.280					
1999	Feather R. near Nicolaus	White Catfish	fillet	Individual	1	497	77.9		0.745					
1999	Feather R. near Nicolaus	White Catfish	fillet	Individual	1	491	79.8		0.620					
1999	Natomas East Main Drain	Largemouth Bass	fillet	Composite	5	332	79.2	0.7	0.680	35.1	26.0	4.1	16.1	<2
1999	Natomas East Main Drain	White Catfish	fillet	Composite	5	258	80.7		0.286					
1999	Putah Creek	Bluegill	fillet	Composite	5	135	79.5		0.123					
1999	Putah Creek	Bluegill	fillet	Composite	5	112	78.9		0.097					
1999	Putah Creek	Largemouth Bass	fillet	Composite	5		77.9	0.6		3.9	ND	ND	13.2	<2
1999	Putah Creek	Largemouth Bass	fillet	Individual	1	402	78.6		0.630					
1999	Putah Creek	Largemouth Bass	fillet	Individual	1	425	76.0		0.592					
1999	Putah Creek	Largemouth Bass	fillet	Individual	1	345	77.1		0.231					
1999	Putah Creek	Largemouth Bass	fillet	Individual	1	354	76.7		0.396					
1999	Putah Creek	Largemouth Bass	fillet	Individual	1	410	77.0		0.540					
1999	Putah Creek	Sacramento Sucker	fillet	Composite	4	383	76.3	3.3	0.185	20.7	19.0	1.7	95.7	<2
1999	Putah Creek	White Catfish	fillet	Individual	1	470	73.3		0.146					
1999	Sacramento Slough	Largemouth Bass	fillet	Composite	5	381	80.6	1.0	0.442	11.0	ND	1.3	45.9	2.00
1999	Sacramento Slough	White Catfish	fillet	Composite	5	263	79.1	0.4	0.639	1.2	ND	ND	17.9	<2
1999	Sacramento R. at Mile 44	Bluegill	fillet	Composite	5	185	76.9		0.103					
1999	Sacramento R. at Mile 44	Largemouth Bass	fillet	Composite	5		72.2	3.9		36.6	29.0	5.5	88.6	<2
1999	Sacramento R. at Mile 44	Largemouth Bass	fillet	Composite	5		77.7	1.1		11.0	ND	1.6	26.4	<2
1999	Sacramento R. at Mile 44	Largemouth Bass	fillet	Individual	1	355	77.1		0.750					
1999	Sacramento R. at Mile 44	Largemouth Bass	fillet	Individual	1	350	78.4		1.350					
1999	Sacramento R. at Mile 44	Largemouth Bass	fillet	Individual	1	385	76.7		1.340					
1999	Sacramento R. at Mile 44	Largemouth Bass	fillet	Individual	1	341	77.2		0.524					
1999	Sacramento R. at Mile 44	Largemouth Bass	fillet	Individual	1	317	77.6		0.867					
1999	Sacramento R. at Mile 44	Largemouth Bass	fillet	Individual	1	381	82.8		1.370					
1999	Sacramento R. at Mile 44	Largemouth Bass	fillet	Individual	1	358	78.1		0.883					
1999	Sacramento R. at Mile 44	Largemouth Bass	fillet	Individual	1	315	77.2		0.775					
1999	Sacramento R. at Mile 44	Largemouth Bass	fillet	Individual	1	341	76.9		1.050					
1999	Sacramento R. at Mile 44	Largemouth Bass	fillet	Individual	1	379	76.7		1.010					

Fish Tissue Data:
SRWP and DWR, 1997 - 1999

YEAR	STATION LOCATION	Species	Tissue	Sample Type	Number of fish	Length (mm)	% Moisture	% Lipid	Mercury, mg/kg	Sum of PCB Congeners, µg/kg	Sum of Aroclors, µg/kg	Sum of Chlordanes, µg/kg	Sum of DDTs, µg/kg	Dieldrin, µg/kg
1999	Sacramento R. at Mile 44	White Catfish	fillet	Composite	5		79.8	1.0		26.0	26.0	2.6	44.3	<2
1999	Sacramento R. at Mile 44	White Catfish	fillet	Composite	5		80.4	1.2		18.1	21.0	2.0	31.5	<2
1999	Sacramento R. at Mile 44	White Catfish	fillet	Composite	5		79.8	2.0		24.8	24.0	2.7	58.8	<2
1999	Sacramento R. at Mile 44	White Catfish	fillet	Individual	1	265	81.1		1.140					
1999	Sacramento R. at Mile 44	White Catfish	fillet	Individual	1	283	69.3		0.448					
1999	Sacramento R. at Mile 44	White Catfish	fillet	Individual	1	250	58.9		0.197					
1999	Sacramento R. at Mile 44	White Catfish	fillet	Individual	1	305	80.4		0.271					
1999	Sacramento R. at Mile 44	White Catfish	fillet	Individual	1	233	82.6		0.204					
1999	Sacramento R. at Mile 44	White Catfish	fillet	Individual	1	290	80.5		0.256					
1999	Sacramento R. at Mile 44	White Catfish	fillet	Individual	1	275	81.3		0.237					
1999	Sacramento R. at Mile 44	White Catfish	fillet	Individual	1	261	80.3		0.238					
1999	Sacramento R. at Mile 44	White Catfish	fillet	Individual	1	259	78.5		0.327					
1999	Sacramento R. at Mile 44	White Catfish	fillet	Individual	1	281	82.3		0.515					
1999	Sacramento R. at Mile 44	White Catfish	fillet	Individual	1	265	78.9		0.536					
1999	Sacramento R. at Mile 44	White Catfish	fillet	Individual	1	277	78.9		0.563					
1999	Sacramento R. at Mile 44	White Catfish	fillet	Individual	1	309	78.9		0.426					
1999	Sacramento R. at Mile 44	White Catfish	fillet	Individual	1	286	78.9		0.673					
1999	Sacramento R. at Mile 44	White Catfish	fillet	Individual	1	295	78.9		0.375					
1999	Sacramento R. at Veterans Br	Sacramento Sucker	fillet	Composite	5	318	79.6	1.37	0.098	19.0	15.0	2.4	18.2	<2
1999	Mill Ck at Hwy 99	Riffle sculpin	fillet	Composite			79.7	1.01	0.279	0.2	ND	ND	<RL	<2
1999	Mill Ck at Hwy 99	Riffle sculpin	liver	Composite			79.7	1.01	0.288					
1999	Mill Ck at Black Rock	Riffle sculpin	fillet	Composite			79.1	0.73	0.327	<RL	ND	ND	<RL	<2
1999	Mill Ck at Black Rock	Riffle sculpin	liver	Composite			79.1	0.73	0.353					
1999	Big Chico Ck @ Hwy 32	Rainbow Trout	fillet	Composite			76.8	3.17	**0.041**	0.8	ND	ND	2.5	<2
1999	Big Chico Ck @ Hwy 32	Rainbow Trout	fillet	Composite			76.8	3.17	**0.044**		ND	ND	<RL	<2
1999	Big Chico Ck @ Hwy 32	Rainbow Trout	liver	Composite			76.8	3.17	0.037					
1999	Big Chico Ck @ Hwy 99	Riffle sculpin	fillet	Composite			79.6	0.61	0.146	<RL	ND	<RL	<RL	<2
1999	Big Chico Ck @ Hwy 99	Riffle sculpin	liver	Composite			79.6	0.61	0.182					
1999	Big Chico Ck @ Hwy 99	Smallmouth bass	fillet	Composite			77.8	0.99	0.231	<RL	ND	<RL	<RL	<2
1999	Big Chico Ck @ Hwy 99	Smallmouth bass	fillet	Composite			77.8	0.98		0.4	ND	ND	<RL	<2
1999	Big Chico Ck @ Hwy 99	Smallmouth bass	liver	Composite			77.8	0.99	0.124					
1999	Deer Ck below Childs Meadow	Riffle sculpin	fillet	Composite			77.9	2.11	0.034	0.2	ND	ND	<RL	<2
1999	Deer Ck below Childs Meadow	Riffle sculpin	liver	Composite			77.9	2.11	<.020					
1999	Deer Ck below Childs Meadow	Rainbow Trout	fillet	Composite			76.8	3.28	<.020	8.8	ND	<RL	4.9	<2
1999	Deer Ck below Childs Meadow	Rainbow Trout	fillet	Composite			76.9	2.42		7.2	ND	<RL	4.0	<2
1999	Deer Ck below Childs Meadow	Rainbow Trout	liver	Composite			76.8	3.28	<.020					
1999	Deer Ck @ Hwy 99	Riffle sculpin	fillet	Composite			77.2	2.84	0.082	0.4	ND	<RL	<RL	<2
1999	Deer Ck @ Hwy 99	Riffle sculpin	liver	Composite			77.2	2.84	0.043					
1999	Deer Ck @ Hwy 99	Smallmouth bass	fillet	Composite			79.2	0.93	0.075	<RL	ND	ND	<RL	<2
1999	Deer Ck @ Hwy 99	Smallmouth bass	liver	Composite			79.2	0.93	0.044					
1999	Clear Ck above Whiskeytown	Riffle sculpin	fillet	Composite			79.1	1.12	**0.107**	<RL	ND	ND	<RL	<2
1999	Clear Ck above Whiskeytown	Riffle sculpin	fillet	Composite			79.1	1.12	**0.096**					
1999	Clear Ck above Whiskeytown	Riffle sculpin	liver	Composite			79.1	1.12	0.213					
1999	Clear Ck above Whiskeytown	Rainbow Trout	fillet	Composite			78.1	1.96	0.050	0.9	ND	ND	<RL	<2
1999	Clear Ck above Whiskeytown	Rainbow Trout	liver	Composite			78.1	1.96	0.050					
1999	Clear Ck @ Reading Bar	Riffle sculpin	fillet	Composite			80	0.83	0.160	<RL	ND	ND	<RL	<2
1999	Clear Ck @ Reading Bar	Riffle sculpin	liver	Composite			80	0.83	0.088					
1999	Clear Ck @ Reading Bar	Rainbow Trout	fillet	Composite			80.5	1.13	0.046	<RL	ND	ND	<RL	<2

Fish Tissue Data:
SRWP and DWR, 1997 - 1999

YEAR	STATION LOCATION	Species	Tissue	Sample Type	Number of fish	Length (mm)	% Moisture	% Lipid	Mercury, mg/kg	Sum of PCB Congeners, µg/kg	Sum of Aroclors, µg/kg	Sum of Chlordanes, µg/kg	Sum of DDTs, µg/kg	Dieldrin, µg/kg
1999	Clear Ck @ Reading Bar	Rainbow Trout	liver	Composite			80.5	1.13	<.020					
1999	Clear Ck @ Hwy 273	Riffle sculpin	fillet	Composite			79.3	1.13	0.241	2.7	ND	<RL	2.2	<2

Table Notes
All tissue concentration data are provided on a "Wet Weight" basis
"ND" indicates "Not Detected"
"<" indicates concentration not detected above specific reporting limit (for mercury and dieldrin)
<RL indicates not detected above reporting limits for individual compounds or congeners (for PCBs, aroclors, chlordanes, DDTs)
"J" indicates the analyte was positively identified and the associated value is an estimated concentration
"UJ" indicates that the analyte was not detected above the reported quantitation limit
Blanks indicate data not reported or analyzed

APPENDIX F

Response to Comments

RESPONSE TO COMMENTS

Responses to selected comments are presented below. Numbers preceding each response are the comment number corresponding to the attached comments. Comments without specific documented responses were addressed as recommended by the reviewer. Editorial comments and requests for clarification were generally addressed as recommended, unless stated otherwise. Copies of comment letters are attached in the order presented in the responses section.

Administrative Draft Comments

Comments provided on the Administrative Draft SRWP AMR were received from the following agencies and individuals:

- Regional Water Quality Control Board (2/21/2001)
- Mitch Maidrand, Sacramento Regional County Sanitation District (1/25/2001)
- G. Fred Lee, G. Fred Lee Associates (2/16/2001)
- Elaine Archibald, California Urban Water Agencies (2/27/2001)
- Bill Crooks, Consultant to City of Sacramento (2/20/2001)

From Regional Water Quality Control Board (Comments 1-103)

4. The similarity in format, content, and tone of this year's report to the previous year's final report is intentional. That version of the report went through an extensive review process and was as close as possible to a "consensus" report for the monitoring program. The confusion resulting from a number of editorial oversights and omissions will be corrected for the public draft.

7. SRWP data is being made available through the DWR IEP Delta Tributaries database. Raw data reported in the AMR also includes data from a number of other agencies and programs (USGS, DWR, Sacramento CMP, City of Redding) that provide their data independently. References to these reports were added to the text.

17. Clarification of the rationale for suspending pathogen monitoring was added to the text. The recommendation of the monitoring Sub-Committee was retained.

21. The monitoring committee has not developed a specific second year monitoring goal and retained the original short-term goal.

23. The references to "proposed CTR" in the Administrative Draft were corrected. May 2000 CTR criteria were used for comparison to monitoring data throughout the report.

24. Changes to the SRWP monitoring program are documented in detail in the QAPP for the program and are not reproduced in detail in this report.

29. References to reports or websites for the other monitoring programs were provided.

32. For the purpose of this report, there is no need to perform statistically rigorous seasonal comparisons between sites for mercury (or other parameters).

33. All fish tissue data has been reanalyzed due to QA problems with recoveries that were significantly different from year to monitoring year. All of the fish tissue mercury data and associated text were updated for the public and final drafts.

47. The reference to "mixed results" was clarified. Comparison of annual variations in results would not be meaningful at this stage of the monitoring program and were not added to the analysis.

52. Discussion of wet weather mercury loads was modified to reflect the very preliminary status of this evaluation.

53. Fish tissue monitoring was performed at American River at J Street in 1999-2000.

56. Comment noted. Note that Figure 3 presents information for multiple monitoring years and varying periods and that the text specifies that the Sacramento River at Hamilton City site data only covers 1999-2000 monitoring. No statistical significance of the spatial comparisons is claimed or inferred, and text was added to clarify that these evaluations are qualitative in nature.

59. These figures were modified as requested. The fish tissue data was added to Appendix E (Summary Statistics).

62. The zinc criteria were incorrectly calculated in the Administrative Draft. For the subsequent and final drafts, trace metals concentrations were "screened" by comparing to the lowest hardness-adjusted criteria, and concentrations were compared to individual event-specific hardness-adjusted criteria if any of concentrations exceeded the "worst case" or lowest hardness-adjusted criterion.

63. Comment noted. The reviewers monitoring recommendation was provided to the Monitoring Sub-Committee.

66. Noted. The appropriate text was revised.

70. Fathead toxicity data from the RWQCB/CALFED study were not provided to LWA or the SRWP prior to completion of the Administrative Draft. This information was included in the public and final drafts of this report.

71. *RE: removal of toxicant with filtration in follow-up toxicity testing*: The provided data provided do not indicate any significant reduction of toxicity by filtration in follow-up testing conducted in the Winter of 1999. In fact, *Ceriodaphnia* mortality and reproduction values are nearly identical in filtered and unfiltered follow-up tests.

78. Comment noted.

79. *RE: Use of the DWR MWQIP data*. Selected sites are used in comparing Delta water quality to Sacramento river watershed water quality. It has not been an objective of the SRWP to compile and report all available data for the Delta.

82. *RE: lack of monitoring results below the Sacramento Regional Wastewater Treatment Plant (SRWTP) discharge*: Pathogens (*Giardia*, *Cryptosporidium*, and coliform bacteria) are being monitored at River Mile 44 this monitoring year (2000-2001), and will continue to be monitored by the SRWTP in the future.

RE: DWR's Coordinated Pathogen Monitoring Program data. These data have not been released by DWR.

85. Comment noted. Although the Basin Plan has adopted all MCLs as objectives, these MCLs were *originally* developed to apply to finished drinking water at the tap, and not to raw source water.

92. Temporary suspension of monitoring for *Giardia* and *Cryptosporidium* has been discussed by the Monitoring Committee. Rationales for suspending this monitoring include budgetary limitations <u>and</u> concerns over the value and interpretation of the monitoring data.

93. No change was made to Figures 26a-b. The graphs are adequate to illustrate the seasonal patterns as intended.

97. Yes, one replicate was collected from each of three riffles or reach. This was specified in subsequent versions of the report.

99. An Index of Biotic Integrity (IBI) is essentially a formalized version of the ranking scores that were used in this study. An IBI is a sum of scores calculated from a set of bioassessment metrics. A range of sampling and reference sites are used to establish the range of natural variability for each metric, and to establish acceptable limits for each metric. The acceptable ranges of the metrics and the IBI ultimately will make up the regulatory limits defined as "biocriteria".

103. The results of the samples split with CDFG have not been provided. It is expected that they will be included in the Regional Board's final report of 1999-2000 Toxicity monitoring results.

From Mitch Maidrand, for Sacramento Regional County Sanitation District (Comments 104-113)

104. Most of the methylmercury data available for this report were USGS NAWQA data. There were insufficient methylmercury and total mercury data at the same sites to evaluate methylation potentials.

109. *RE: Reporting MeHg data for 2000-2001.* We can coordinate to provide this data to the DTMC as preliminary data for evaluation, and to support planning of future monitoring and management strategies.

110. *RE: QA issues with fish tissue mercury data.* All of the fish tissue collected to date has been reanalyzed for mercury by the DFG Moss Landing Marine Lab to resolve some problems with analytical recoveries that varied from year to monitoring year. The final reanalyzed data was included in subsequent drafts.

113. The discussion was revised to clarify the significance of elevated mercury in Feather River fish tissue.

From G. Fred Lee (Comments 114-176)

114, 118, 133, 143, 144, 167. As was explained last year, median data are used as an appropriate tool to describe spatial distributions and trends of monitored constituents, and are not used (or inferred to be equivalent to) to assess water quality or the attainment or protection of beneficial uses. All available data reported (including maximum detected values) were used in comparisons to applicable water quality criteria and other limits relevant to water quality. These comments and this approach were discussed last year and the consensus of the Monitoring Sub-Committee remains that the approach was valid.

115, 139, 140, 168. Mass loads are not cited as (nor inferred to be) direct indicators of water quality or predictors of instantaneous Delta concentrations anywhere in the report. Mass loads are evaluated as information relevant to management of pollutants and to development of TMDLs.

116-117,119-120. Comments noted and provided to the Monitoring Sub-Committee.

121. *RE: There are adequate data to evaluate human health concerns.* Although the reviewer feels there are adequate data for the SRWP to unilaterally evaluate potential human health concerns in at least some areas of the watershed, it is the opinion of OEHHA/DHS and at least some other members of the SRWP fish tissue focus group that this is not the case. The text was modified to read as follows:

Exceedances of screening value for mercury in fish tissue (0.3 mg/kg) developed by the EPA and adopted by the California Office of Health Hazard Assessment (OEHHA) indicate that there are potential human health concerns associated with consumption of fish from the lower Sacramento River watershed. There is some disagreement whether the available data are adequate to warrant issuing fish consumption advisories, and OEHHA has not issued advisories for these waters. Although there also continues to be substantial scientific disagreement about the actual level of risk posed by these concentrations of mercury in fish, there is agreement that the risks are greatest for small children and pregnant women, and that the risks increase with greater consumption of fish.

123. Comparisons were made to the USEPA screening values.

128. Noted. These monitoring recommendations were provided to the Monitoring Sub-Committee.

129. The CTR did not establish a bioaccumulation-based arsenic criterion.

130. Total chromium was measured. Chromium VI has not been determined to be a constituent of concern in surface waters of the Sacramento River watershed.

137. The text was modified to clarify that risk increases with increased fish consumption.

147, 151. For the subsequent and final drafts, trace metals concentrations were "screened" by comparing to the lowest ("worst-case") hardness-adjusted criteria, and concentrations were compared to individual event-specific hardness-adjusted criteria if any of concentrations exceeded the “worst case” or lowest hardness-adjusted criterion.

154, 164. *RE: graphs and data to be updated for Public Draft*: As was the case last year, important coordinating data were not provided until after the first draft was completed. These results were updated and provided in subsequent drafts.

173. These data were not made available in time to consider for this report.

From Elaine Archibald (Comments 177-203)

178. The Monitoring Committee’s rationales for temporarily suspending *Cryptosporidium* and *Giardia* monitoring include budgetary limitations <u>and</u> concerns over the value and interpretation of the monitoring data.

180. Storm events were neither targeted or avoided, i.e. the sampling was unbiased.

182. QUESTION: Is the DWR/MWD study the same as “DWR’s Coordinated Pathogen Monitoring Program”? If so, why hasn’t the data been made available?

184. Cadmium was not monitored or considered a constituent of concern in the major agricultural drains by the SRWP.

186. The method of regular scheduled monitoring does not skew the data. Rather, it provides a *less* biased picture of instream conditions than would monitoring that targets storm events (for instance). Monitoring that focuses on presumed worst-case conditions will provide a biased worst-case picture.

188. All available data from the SRWP and the primary coordinating programs were used in comparisons to water quality objectives.

189-191. Comments noted. Additional MWQI data were not obtainable from the Bay-Delta Tributaries database. Historical MWQI data compiled Woodard 2000 were considered in subsequent versions of the report.

192. *RE: correspondence of the maximum Giardia and fecal coliform concentrations*. This would not be a meaningful comparison.

193. Comment noted. The discussions are adequate.

194. Barker Slough data are only discussed as representative of the Northern Delta for comparison to SRWP results for the Sacramento River. SRWP does not monitor this location.

195. The text is based on data from 1998-2000 SRWP monitoring and various coordinating programs. The descriptions of temporal distributions and patterns are accurate.

200. *RE: Turbidity at Barker Slough*. The 50 NTU limit doesn’t apply to Barker Slough. According to data compiled in *Sources and Magnitudes of Water Quality Constituents of Concern in Drinking Water Supplies Taken from the Sacramento-San Joaquin Delta* (Woodard 2000) turbidity levels only infrequently exceed the 150 NTU limit and most of these exceedances occurred during exempted storm-affected periods.

From Bill Crooks (Comments 204-207)

207. The analyzing laboratories are listed in the Acknowledgements section. Additional information is included in the QAPP for the SRWP.

Public Draft Comments

Comments provided on the Public Draft SRWP AMR were received from the following agencies and individuals:

- Kelly Moran, TDC Environmental (6/5/2001)
- Janice Cooke, Central Valley Regional Water Quality Control Board (6/15/2001)
- Jay Davis, San Francisco Estuary Institute (6/24/2001)
- Lynda Smith, Metropolitan Water District of Southern California (6/27/2001)

From Kelly Moran, TDC (Comments 208-209)

208. Thank you for the information.

209. *RE: Pattern of toxicity at urban locations*. Because only one urban location was monitored (Arcade Creek), it is not possible to conclude a pattern of toxicity at toxicity at urban location. Discussion of copper criteria exceedances at Arcade Creek and Colusa Basin Drain were added to the summary and the Executive Summary.

From Janice Cooke, Regional Board (Comments 210)

210. *RE: the use of uncertainty factors in calculating fish tissue screening values.* The original text was correct (e.g. …safety factors *up to* 10), but was revised to clarify..

From Jay Davis, SFEI (Comments 2111-225)

211. The screening values were added to Table 32. The conclusions relevant to these comparisons did not change with consideration of the OEHHA values.

212. The focus of the comparisons is on the screening values and the text specifies that exceedances of these screening values indicates potential impairment. The text does not state or imply that values below FDA limits are proof that fish tissue is safe to eat. However, the text was revised to further de-emphasize the relevance of the FDA Action Levels.

213. I agree that the IEP Bay Delta Tributaries database is difficult to use at this time, but DWR is working on improvements that should make it much more practical to use. The more people that use and comment on the database, the more likely DWR will be to implement these changes quickly.

From Lynda Smith, MWD (Comments 226-241)

226. *RE: Conclusion of attainment of drinking water beneficial uses in the Sacramento River watershed and Delta*. Reference to the Delta was deleted as recommended.

    RE: Recommended reference to requirement for costly additional drinking water treatment. This characterization is subjective. The original text was retained.

234. *RE: Recommended inclusion of urban runoff and treated wastewater as primary sources of organic carbon*. Although urban runoff and treated wastewater do contain higher concentrations of organic carbon than the Sacramento River, they contribute a relatively small proportion of the total river loads of organic carbon, and are not considered “primary sources”.

241. The median reported in the summary statistics was incorrectly calculated (biased by data below elevated detection limits). This was corrected for the final report.

Comments Submitted By Reviewers Of The January 2001 Administrative Draft And The March 2001 Public Draft Annual Monitoring Report

Note: Copies of original comments submitted by reviewers are available on request.

California Regional Water Quality Control Board

Central Valley Region

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21 February 2001

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COMMENTS ON THE SACRAMENTO RIVER WATERSHED PROGRAM ANNUAL MONITORING REPORT: 1999-2000 FROM REGIONAL BOARD STAFF

Enclosed are comments from staff at the Central Valley Regional Water Quality Control Board on the Sacramento River Watershed Program **Annual Monitoring Report 1999-2000** prepared by Larry Walker Associates. Thank you for the opportunity to comment on this document. If you have any questions please contact me at 916-255-3111 or contact Ms. Lori Webber at 916-255-3105.

VAL CONNOR
Environmental Specialist

Enclosure

cc: Jerry Bruns, w/enclosure
Dennis Heiman, w/enclosure
Patrick Morris, w/enclosure
Rik Rasmussen, w/enclosure
Karen Larsen, w/enclosure
Michelle Wood, w/enclosure
Lori Webber, w/enclosure

COMMENTS ON THE SRWP ANNUAL MONITORING REPORT: 1999-2000

GENERAL COMMENTS

C.1 All the headers have the date 1990-2000.

C.2 Under many of pollutant discussions, there is a sentence that reads something like the following: "the criteria was exceeded in 13 to 25% of the samples." It is not obvious what this means. Does this mean that in a given water body there were several sampling sites and the % spread reflects the differences between sites? This needs to be clearer.

C.3 Under many pollutant discussions, it is not obvious whether statements about the data include the entire data set evaluated or some subset (i.e., just the 1999-2000 data). This makes reading the document very confusing. For example, in the executive summary in the discussion of mercury, the first bullet talks about three years of data, but it is unclear in the second bullet what data set is being considered.

C.4 This report is mostly a replicate of the previous year's report with some number changes to reflect the new data. The additions to the program overview section to include information about year two monitoring have made this section confusing and not very informative. For example, year one monitoring goals are described but there is no similar section describing goals for year two monitoring. There are numerous places in the report where there are references to the 1998-99 program that have not been edited to include 1999-2000. For example, on page 11 and 12 there is a list and map of 1998-99 monitoring sites. Why is there no map of the year 2 monitoring sites? Again, on page 18 there is a table on 1998-99 parameters measured. What about 1999-2000?

C.5 On page 21, there is a discussion of the sources of information used in this review. Under the specific pollutant discussions, it is often not clear which data is being discussed. This is especially disturbing, when statistics are used to describe the data. In the data discussion sections, there must be a clear description about what data is included in the statistics.

C.6 Under the individual pollutant sections there are discussions of evaluation criteria. Many times the criteria are discussed without reference to the duration associated with the criteria (i.e., instantaneous maximum, 1 hour, 4 day). The values are not very useful without the duration information.

C.7 It would be helpful if all the raw data were presented in an appendix, rather than just the statistics.

C.8 Throughout the document the word "bioassay" should be replaced with "toxicity test".

C.9 The authors have assembled an impressive amount of data that has the potential to be very useful to SRWP stakeholders. However, a comparison of this report to last year's report indicates that the authors used last year's text as a template and simply updated the numbers cited in the text and tables with minimal updating of text or figures. Although this is an efficient strategy for updating a review document, the authors must make certain that (1) every number is indeed updated, and (2) text used last year "makes sense" when data for another year are added. The authors should clearly identify where "new data" is included (e.g., collected during the 1999-2000 period or retrieved from newly-acquired studies that contain data for previous periods) and note whether the addition of new data results in changes to spatial and temporal distributions and patterns observed last year. In addition, the authors should note differences between data collection for Year 1 and Year 2 of the program and add analyses that are now possible with the addition of more data. The authors should also "clean up" text that was unclearly written last year. In particular, the authors should address the mixed use of active and passive voices and past, present, and future tenses, and the confusion between Year 1 data and Year 2 data.

SPECIFIC COMMENTS

Page 1. Executive Summary

C.10 Change the pagination to "i, ii, iii, iv" format and include the Executive Summary text before the Table of Contents to help the reader differentiate between the Executive Summary and the main text.
The header should state 1999-2000, not 1990-2000.
State in the first paragraph which program year this report describes, e.g., "second year (1999-2000)."

Page 2
Aquatic Toxicity

C.11 Paragraph 2, sentence 2: The phrase "strongly suggested" is vague and implies uncertainty. It could be replaced with "definitively shown". In addition, the sentence refers to "other studies". What other studies? These should be cited.
Paragraph 3, sentence 1: Replace the word "regular" with "regularly".
Paragraph 3, sentence 2: The word "episodic" in this sentence implies targeted monitoring during storm events. "Periodic" would be more accurate.
Paragraph 3, sentence 3: What episodic events are going to be monitored (i.e., the dormant spray season)?

Page 3 Executive Summary – Drinking Water Parameters of Concern

C.12 Over all there is no discussion as to "why" the constituents are "of concern" . For example the problems with elevated organic carbon include the creation of trihalomethanes (THMs), known carcinogens, during disinfection. The reasons for choosing the parameters that are measured should be discussed briefly in the executive summary.

Page 3 second paragraph under *Drinking Water Parameters of Concern:*

C.13 The last sentence should be revised to read "However, there were occasional (frequency?) exceedances of some goals and **objectives."** If the sentence truly means water quality standards then by definition the water is not meeting its beneficial uses. U.S. EPA defines a Water Quality Standard as the waters designated beneficial use plus the water quality criteria (objective in California).

C.14 **Page 3 First "Bullet" Second Sentence** should read "Dissolved concentrations ***of*** iron**…"**

Page 4

C.15 **First "Bullet"** states that the fecal coliform number was exceeded only "infrequently". This is very vague. Please state how often the objective was exceeded.

C.16 **Second "Bullet".** The "**Stage 1 D/DBP"** needs to be spelled out. Additionally, the reason for concern is primarily with the production of trihalomethanes which are known carcinogens. The drinking water purveyors are very concerned about what new treatment technologies will be required as the limits on THMs are lowered. The last sentence should be removed.

C.17 **Third "Bullet"** The blanket statement that there is a high degree of uncertainty in the *Giardia* testing is overly vague. Without more information there should not be a recommendation to suspend pathogen sampling. Instead if there are specific problems associated with the method these should be simply stated and no recommendation for future monitoring should be made in the executive summary.

Page 5

Sediment Toxicity

C.18 Paragraph 1, sentence 1: This sentence indicates sediment toxicity detected in September 1998, however, this document covers monitoring data collected between June 1999 and May 2000. The reason for including 1998 monitoring data needs to be explained (was the sediment toxicity data not summarized in the first annual report?).
Paragraph 1, general comment: The sediment toxicity should be related to available water column data (i.e., aquatic toxicity data) that was collected during the same time period.
Paragraph 2, sentence 1: The phrase "available data" implies that some of the data collected is not available for this report. This needs to be clarified.

Page 6. Program Overview.

C.19 The Program Overview is a verbatim copy of last year's text. The authors edited only the years (i.e., the authors sporadically changed "1998-1999" to "1999-2000" throughout the text).

C.20 **Page 7.** Note the previous publications in which the monitoring program itself (not the data collected by the program) is described. Clearly note that the monitoring program compiles data published prior to Year 1 as well as data generated by other programs during Year 1 and Year 2.

Note which agency/consultant(s) generates "new" data specifically for the SRWP monitoring program.

C.21 **Page 7.** Provide the "Second Year Goal" and clearly note the months/years included in Year 2. Update the last paragraph to reflect recent efforts.

C.22 **Page 8.** Update the Assessment of Beneficial Uses section with the relevant elements of the Second Year Goal.

C.23 **Page 9 First Paragraph** "…proposed CTR criteria……" The CTR is no longer proposed. The EPA promulgated water quality criteria for priority toxic pollutants for California in May 2000.

C.24 **Pages 10-20.** The Second Year Monitoring Program Description section is a verbatim copy of last year's text. A new section should be created that describes the Year 1 Monitoring Program (the current text could be kept). The Second Year section should describe changes made to the monitoring program during Year 2 (e.g., new sampling locations, changes made to sampling frequency, new parameters, and locations and parameters that were not analyzed during Year 2). Update Tables 1, 2, and 3 and Figure 1 with additional sampling sites and parameters; be certain to note the locations and parameters for which no data were generated during 1999-2000.

Page 12

C.25 Table 1: The title should read "1999-2000".

Page 15

Toxicity in water and sediment.

C.26 Paragraph 1, sentence 4: This sentence lists "increased abnormalities" as a toxic effect that can be measured during toxicity testing. Was this an endpoint for any of the toxicity testing conducted for the program? If not, it should not be listed here.
Paragraph 1, sentence 5: Acute toxicity is defined as toxicity occurring in 4 days or less (not just hours) and chronic toxicity is defined as toxicity occurring in more than 4 days. In addition, none of the endpoints measured during the toxicity monitoring portion of this program were measured in periods of weeks.
Paragraph 1, sentence 7: The phrase "or rendered non-toxic" should be added to the end of this sentence.

Page 18

C.27 Table 2: The title should read "1999-2000".

C.28 **Page 20, Table 3.** What do "NAQ" and "AMP" mean?

C.29 **Page 21.** Further information on the coordinating programs is needed. If data or reports are available from these programs it would be helpful to note that here, or reference at the end of the document. For example, the SFEI's RMP program has a website at: www.sfei.org/rmp.

C.30 **Page 21.** The Data Review introduction should be updated (e.g., note whether there were any new agency/program involvements since last year and whether or not this review includes additional monitoring studies). If the USGS Trace Metals and Mercury Transport Studies data "were not made available for this review," why is the study listed? (Note: last year's text had the same note.) Make certain all "1998-99" text is changed to "1999-2000."

C.31 **Page 22-24.** On page 22, the Mercury Data Summary section states "monitoring results for the SRWP for the period June 1999 through May 2000 and for the primary coordinating programs (USGS NAWQA . . .) are presented and summarized in this section." However, the Spatial Distribution section on page 24 cites the summary statistics listed in Appendix F, which were collected for ranges of years that vary from one sampling site to another. For example, paragraph 1 on page 24 cites a median water column mercury concentration of 2.0 ng/L for Sacramento River at Bend Bridge and of 4.6 ng/L for Sacramento River at Colusa; Appendix F indicates that the Bend Bridge value represents data for the period 2/1996 to 5/2000 while the Colusa value represents data for the period 2/1996 to 6/1998. The authors must clearly state that the Spatial Distribution section compares summary statistics for varying periods, not values for 1999-2000.

C.32 **Pg. 24**. The seasonal variation in total mercury concentrations at most Sacramento River sites exceeds the variation in median concentrations compared between sites. Mercury concentrations are correlated with seasonal flow (as you point out on Pg. 25). Give this association, we recommend comparisons between sites be done on a seasonal basis.

C.33 **Page 25-26.** The Fish Tissue section has an italicized "note" that states that preliminary 1999 mercury data was used. However, the following text is a verbatim copy of last year's text; the authors did not update the text and numbers cited to reflect the preliminary 1999 data. In addition, the Temporal Distribution section does not include new data. It refers to Figure 6a, but that figure contains data that describe the period 1996-1998. In addition, the text refers to time series plots presented in Appendix H; however, because the plots were not included in this draft, it is not possible to verify the authors' observations.

C.34 **Page 26.** Water quality criteria values and total water column mercury concentrations listed in the Human Health Thresholds section are cited as μg/L, although all values previously discussed in the Spatial Distribution Temporal Distributions sections and in Table 5 are cited as ng/L. In last year's text, this section cites values as ng/L. All values should be cited as ng/L. (Why was the conversion made just for this section?)

C.35 **Page 27.** Sentence 2 of paragraph 2 of the Comparison with Water Column Threshold Values section: how many is "a few"? Throughout this section, precise numbers should be used rather than incorporating the phrases "a few," "less than" and "more than." Sentence 4: A range ("10-33%") is provided rather than a single value; these numbers appear to correlate to the numbers listed on Table 7 for the three sampling locations on Mill Creek. This sentence, and later sentences that provide ranges of values, should be rewritten to make it cleared that there are multiple sampling locations.

C.36 **Page 26-32.** The Attainment of Beneficial Uses section should have an introduction that (1) re-states the monitoring program goals for the examination of beneficial use attainment, and (2) clearly explains how the comparison of sampling results to adopted water quality objectives and criteria helps to determine whether beneficial uses have been impaired. The first 1.5 paragraphs and Table 8 on page 32 should be included in such an introduction.

C.37 **Page 26-27** In the text use consistent units for mercury, i.e., use ng/l for all mercury concentrations.

C.38 **Page 27.** The first paragraph on page 27 states that total mercury values presented in the Mercury Report to Congress ranged from 0.0006 µg/L to 0.0018 µg/L. However, last year's text indicated a range of 2.9 ng/L to 0.6 g/L. Why the change in values if the same reference was used? (Note: all other text in the paragraph remains the same.

C.39 **Page 27.** The last sentence of paragraph 2 of the Comparison with Water Column Threshold Values section states "A once-in-three-year exceedance frequency …" This sentence is a relic from the last year's text; last year's text had sentences preceding that sentence that explained the calculation. This sentence should be deleted.

C.40 **Page 27, last paragraph**. There is a statement about the Great Lakes criteria being exceeded in less than 25% of samples. This seems to imply that this is not much of a concern. We recommend that this sentence and others like it in the text be rewritten to say that the criteria was exceeded in more than 20% of the samples. This more accurately reflects the concern, especially in cases where the criteria are short term averages.

C.41 **Page 29.** The introductory paragraph of the Fish Tissue section notes that levels of mercury in fish are species specific and size- and age-dependent, and describes biomagnification. However, the introduction does not describe how this information was incorporated into the following analyses.

C.42 **Page 30.** Why was the text for the third bullet at the top of the page modified from last year's text when the Fish Tissue text on page 25 was not updated? (The text for the first two bullets was identical to last year's text.)

C.43 **Pg. 30.** Please include in Table 6 the new USEPA methylmercury ambient water quality criterion for the protection for human health. This criterion is 0.3 ppm wet weight of mercury in fish tissue (with the assumption that all mercury is methylmercury). The criterion is based on the USEPA reference dose, body weight of 70 kg and consumption rate of 17.5 g/day. The report can be obtained at: www.epa.gov./waterscience/criteria/methylmercury.

The text on pg. 30 could be changed as well. The new USEPA methylmercury criterion replaces the 1995 USEPA screening value of 0.6 ppm. It is appropriate to compare observed fish tissue concentrations with the new criterion, rather than the 0.6 ppm. OEHHA is currently using a screening value of 0.3 ppm, as well.

C.44 Please add a footnote to Table 6 to indicate that the FDA Action Level is not meant to be applied to locally-caught or sport fish. OEHHA has made this point very clearly in that agency's review of fish consumption studies (Gassel et al., 1998. Chemicals in Fish Report No. 1. Consumption of Fish and Shellfish in California and the United States. Pesticide and Environmental Toxicology Section, Office of Environmental Health Hazard Assessment. Available at: http://www.oehha.org/fish/pdf/fishrpt.pdf). The FDA Action Level is meant to be applied to fish purchased on the commercial market. It is based on an assumption that people eat a variety of commercial fish.

C.45 **Page 31. Table 7.** Note (a) at the bottom of the table should be deleted because no explanation is included in the text. However, the note raises the following question: the table title states "comparison with USEPA . . . criteria . . ." – what is the comparison? The column titles and main text (which cites the numbers from Table 7 and, on page 28, states that the table summarizes the percentage of data meeting specific regulatory thresholds) imply that the numbers reflect the actual percentage of total water column mercury concentration values that exceed the USEPA criteria. However, Note (a) implies that the numbers are probability calculations. If these numbers are indeed probability calculations, calculation method needs to be clearly explained in the text, as does the rationale for including the table; what exactly do these calculations tell us that a review of the data itself does not? Regardless, do the percentages listed in the table represent data for 1999-2000 or for all years available? Add a column describing the different periods if the data represent for different periods for each sampling site.

C.46 **Pg. 32**. OEHHA has also issued consumption guidance for Black Butte Reservoir and Lake Pillsbury.

C.47 **Page 32.** The final 3 sentences of paragraph 2 attempt to answer the question listed at the top of the page, "What do the data say . . ." However, given that Table 8 already indicates that certain water bodies are considered impaired based on elevated concentrations of mercury in fish tissue, this section should provide more details. What exactly are the "mixed results"? How do the results summarized on Table 7 relate to the water bodies listed on Table 8? How do the results change from one year to the next and relate to wet season flows?

C.48 **Page 32, second paragraph**. The paragraph concludes that mercury concentrations in fish indicate a potential concern and that more monitoring is warranted. This is too weak. There are consumer advisories and the Regional Board has determined that water bodies <u>are</u> impaired because of mercury levels in fish. I suggest leaving off the last three sentences of this paragraph.

C.49 **Page 33**. Include text to address the following questions: Why was a comparison of mass load contributions conducted? How does this exercise help achieve the monitoring program's goals and objectives? Was the wet season mass balance for mercury developed by the authors for the Delta Tributary Mercury Council published elsewhere? Which years do the wet season mass balance encompass? A table for the wet season mass balance values, similar to Table 9, would be useful.

C.50 **Page 33 and Table 9.** Note that the "Average Total Mercury Concentration" and "Estimated Average Annual Load" values were updated for the Sacramento River and Yolo Bypass, but the corresponding values for the San Joaquin and Mokelumne Rivers not updated; none of the "Annual Average Flow to Delta" values were updated. Clearly note the periods for which data were available for each waterbody.

C.51 **Page 34-35.** Update the conclusions and recommendations to reflect the addition of new data.

C.52 **Page 33, last paragraph.** There is a discussion of wet weather mercury loads. No data is presented to support the discussion.

C.53 **Page 36.** Update Figure 2 to reflect the additions of the Mill Creek, Sacramento River at Hamilton, Deer Creek, Big Chico, and Mud Creek mercury monitoring sites. Note that no data was collected for the American River at J Street location during this monitoring period.

C.54 **Page 37-36.** Note which years Figures 3 and 4 describe – 1999-2000 or all available data?

C.55 **Page 37.** Figure 3's title (and other applicable figures) should include the periods for the data being reported (e.g., all data or exclusively 1999-2000 data?)

C.56 **Page 37.** Figure 3 data indicate the mercury median at SRHAM (Hamilton City) is less the median at SRABB (Bend Bridge) while the text on page 24 indicates otherwise; the mercury median at the Hamilton City station is 1.8 ng/l and 1.4 ng/l at the Bend Bridge station. While Mill Creek and Deer Creek contribute to overall mercury loading, the median mercury concentration in the Sacramento River is not significantly different between Bend Bridge and Hamilton City.

C.57 **Page 38 and 39.** Are the mercury data presented in Figures 4 and 5 only from 1999-2000. Same comment about most of the figures.

C.58 **Pg. 38-40** Figures 4, 5, and 6 do not correspond to the List of Figures on pg. *vi.*

C.59 **Pg. 40** Figures such as the "Mercury in Fish Tissue in the Sacramento River Watershed" are so busy that they are difficult to read. It would be helpful if there were additional tables showing the fish tissue numbers. There were no fish tissue data in Appendix F.

C.60 **Page 41** - The report cites 6 independent sources metal data. In analysis and presentation of the data (i.e. medians, max. conc., variabililty, etc), where there were more than one data source for a particular location, were all data pooled for the analyis?

C.61 **Page 48** - Regarding the reference to "various listings for copper, nickel ...", I'm unclear if the concern here is concentration of dissolved metals in the water column (toxicity) or is the problem related to bioaccumulation of metals through the food chain. This has important implications for whether or not we should be at all concerned about sources of high total metal loading from upstream. Should clarify why Bay/Delta listings for certain metals. Many of the upstream tribs show high total metals concentration and load during high sediment concentration runoff events. Not sure if this has a link to the percieved metals problem in the Bay/Delta.

C.62 **Page 49** - Table 11 cites Basin Plan objectives for Cu, Zn and Cd as being 6.1, 31, and 0.25 at Sac. River Below Keswick. However, the actual Basin Plan objectives are 5.6 Cu, 16 Zn, and 0.22 Cd for this reach of the River (adjusted to 40 mg/l hardness). I'm not sure why the discrepancy, especially for Zn.

C.63 **Page 56** - Fig. 10 seems to indicate that there were no samples taken for total and dissolved Copper above Keswick (as there were for other metals). Given that we state a concern about the 10% of the dissolved Cu samples exceeding the CTR (4.4 ug/l) at Sac. R. Keswick, it would be important to know what the upstream sources to Shasta Lake show (and also at Shasta Dam which is above Keswick and above inputs from Spring Cr.). We are not convinced that 4.4 ug/l is a concern, but if the Report says it is, we should be looking at upstream sample sites.

C.64 **Page 56.** Change units on Figure 10 from ng/l to µg/l for copper.

C.65 **Page 72, third paragraph.** The discussion on diazinon is not adequate. The report needs to clearly state that the Regional Board has determined that beneficial uses are impaired, rather than only saying diazinon poses a risk.

C.66 **Page 79, last paragraph.** There is a statement that decreases in reproduction were infrequent. This term is subjective. In one of the cases it is 4/24. If you compare this exceedance rate with EPA criteria recommendations of not more than one exceedance in three years, then it is significant.

C.67 **Page 77**

Background and Overview of Available Data

Paragraph 1, sentence 2: There is an extra parenthesis in this sentence.
Paragraph 4, sentence 2: This sentence should read “Samples from **the** Sacramento **River** at Greene’s Landing…” Also, the word *“Ceriodaphnia”* should be italicized.
Paragraph 5, sentence 2: This sentence should read, “… samples from **the** Sutter Bypass…”
General Comment: The reports listed below should be added to the list of relevant studies of toxicity in the Sacramento River watershed.

Connor, V., C. Foe, and L. Deanovic. 1993. Sacramento River Basin Biotoxicity Survey Results: 1988-1990. Staff Report to the Central Valley Regional Water Quality Control Board, Sacramento, CA.

Connor, V., L. Deanovic, and E. Reyes. 1995. Central Valley Regional Water Quality Control Board Basin Plan Metal Implementation Plan Development Project Bioassay Results: 1991-1992 Final Report. Staff Report to the Central Valley Regional Water Quality Control Board, Sacramento, CA.

C.68 Page 78

Table 14

Row 1, cell 2: Toxicity monitoring began in August 1996.
Row 1, cell 3: *Selenastrum* toxicity testing only was conducted on the full suite of samples from August 1996 to May 1998. After that only Arcade Creek and the Sacramento River downstream of Keswick Reservoir and at Freeport were tested with the algae. In addition, this cell should indicate that 7-day *Pimephales* toxicity tests were conducted during the SRWP monitoring program from August 1996 through May 1999.
Rows 2 and 4, cell 3: These cells should read "7-day *Pimephales* toxicity tests".

C.69 Page 79

Spatial Distribution and Patterns: Ceriodaphnia

Paragraph 1, sentence 3: At the end of this sentence add in parentheses "two metabolically activated OP pesticides".
Paragraph 1, sentence 5: Indicate that Lindo Drain and Chico Drain are urban sites.
Paragraph 2, sentence 1: The sample collected from the Sacramento River upstream of Lake Shasta collected in July 1999 exhibited *Ceriodaphnia* reproductive impairment (this was a mistake in the tables sent to LWA from the Regional Board).
Paragraph 3, sentence 4: Connor *et al*. (1993) should be cited here.
Paragraph 3, sentence 6: This sentence refers to changes in holding times implemented by the rice industry. Clarify that holding times of rice field flood waters were increased to allow for degradation of pesticides.

C.70 Page 80

Pimephales

General Comment: The *Pimephales* toxicity testing data collected between June 1999 and May 2000 by the UCD ATL and the Regional Board is available. This data can be obtained directly from the UCD ATL.

Selenastrum

Paragraph 1, sentence 4: It is unclear what evidence supports the finding that acid mine drainage remediation efforts have been effective. Historical perspective can be found in Connor *et al*. (1995), which reported significant algal growth impairment attributed to the presence of metals in samples collected from the Sacramento River downstream of Keswick Reservoir and Lake Shasta.
Paragraph 1, sentence 5: Add "compared to the laboratory control" after the word "growth".

C.71 Page 81
Temporal Distribution and Patterns

Paragraph 1, sentence 1: This sentence implies that OP pesticides are the cause of the *Ceriodaphnia* reproductive impairment, however, follow-up testing conducted during winter 1999 indicated that the toxicant could be removed with filtration. The *Ceriodaphnia* reproductive impairment was more likely associated with high winter flows (as it occurred prior to dormant sprays in many cases) rather than dormant spray applications.

C.72 Page 82
Attainment of Beneficial Uses and Potential Impairment

Paragraph 1, sentence 2: The Basin Plan narrative objective does not state anything regarding mixing zones. Either delete the information about mixing zones or define what they are and where designated mixing zones are located in the Sacramento River watershed.
Paragraph 3, sentence 2: Delete "relatively small" and "measures" from this sentence.
Paragraph 3, sentence 4: The example in this sentence implies that only "prey species" are important to protect. Add the word "instream between "in" and "populations" and delete "of prey species".
Paragraph 3, sentence 5: Replace "have suggested" with "indicate and delete "probable".
Paragraph 4, general comment: Add at the end of this paragraph the following sentence – "The Toxicity Focus Group has begun work on developing a strategy to address unknown toxicity through funding from CALFED."

C.73 Page 83
Paragraph 2, sentence 2: See the first comment under "Page 2" above.
Paragraph 3: See the second, third, and fourth comment under "Page 2" above.

C.74 Page 85
Table 17

The reproductive endpoint for the sample collected from the Sacramento River above Shasta in July 1999 should be outlined as significant (mistake in tables sent to LWA from Regional Board).
The data for the sample collected from Colusa Basin Drain in January 2000 is missing (mistake in tables sent to LWA from the Regional Board). The reproductive endpoint should be 22.5 and the mortality endpoint should be 0.

C.75 Page 86
Table 19: The sample dates at the top of the table are unreadable.

C.76 Page 128
Background and Available Data Overview

Paragraph 1, sentence 4: "Elutriate" should be defined.

Paragraph 2, sentence 1: Add “the” before “Sacramento River”.
Spatial Distribution

Paragraph 1: This paragraph needs to indicate that the data is summarized in Table 28.
Attainment of Beneficial Uses and Potential Impairment

Paragraph 1, sentence 1: Replace “due to concerns regarding” with “for”.
Paragraph 1, sentence 2: See the third comment under “Page 5” above regarding the wording “available data”. Also, replace “regarding the attainment of” with “about whether” and add “are” between “uses” and “affected”.
Paragraph 1, sentence 4: Replace “attainment” with “protection” and delete the word “clearly”.

C.77 **Page 80, last paragraph**. There is reference to 31 of 40 samples and 2 of 43 samples. Either 43 or 41 must be wrong.

C.78 **Page 94, Summary paragraph for Drinking Water**
The first sentence is not factual. The Regional Water Board does regulate many of the parameters of concern in permits that are issued. The problem, that has been identified, is that the largest contribution of these parameters may be associated with non-point source discharges. Non-Point Source contributions have, historically, been difficult to identify and thus, difficult to regulate through traditional permits.

C.79 **Page 95, Table 20**
Why are only five sites used out of the 19 sites monitored by DWR in the MWQIP data set? Additionally, DWR Operations and Maintenance Data is also available and should be used in the analyses.

C.80 **Page 96 second paragraph first sentence.**
This sentence is unclear. What have similar spatial distributions? The Sacramento and its tributaries or the total and dissolved organic carbon concentrations. If the later revise the sentence to read “Total and dissolved organic carbon concentrations have similar spatial distributions….”

C.81 **Page 96 second paragraph third Sentence** is missing part of the sample site name. Should read “River Mile *44”*

C.82 **Page 97 c. Pathogens – General Comments**
The section on pathogens and the lack of data analyzed is a major flaw. What is particularly disturbing is the lack of data reported below the Freeport sampling site. It is suspect that there is no monitoring data below a major discharger that could be a potential source for pathogens. This lack of monitoring south (downstream) of SCRSD’s discharge gives the impression that the monitoring plan is biased and leads to a lack of credibility for the pathogen monitoring. Why was the data collected by DWR’s Coordinated Pathogen Monitoring Program not included in the analysis? The monitoring program should at least monitor for pathogens (at least coliform) at River Mile 44.

C.83 Given the poor recoveries of pathogens from turbid water using the current techniques any detection of pathogens will, most likely, be an under reporting of the true pathogen loads. While I agree that there are concerns with the current method's performance in turbid waters it is still important to monitor for pathogens as part of the monitoring for the SRWP monitoring.

C.84 **Page 99 second paragraph last sentence** states the "Comparable dissolved orthophosphate and total phosphate data was not available for the Sacramento-San Joaquin Delta." Does this indicate that there is no data available or just that the data that is available is not comparable to the data that is discussed?

C.85 **Page 105 iv. Attainment of Beneficial Use and Potential Impairment**
The quotation from the Central Valley Basin Plan should be stated in its totality. It is misleading to leave off the beginning of the objective "*At a minimum…*" The second paragraph discussion the relationship of MCLs and impairment of beneficial uses is wrong. The water quality objectives, as adopted in the Basin Plan, including the MCLs apply to raw water and not treated water. The objectives in the basin plan always apply to raw water and not to water after treatment. If you have to treat the water to meet the objectives then the water is out of compliance with the Basin Plan. If the water is not meeting the objectives, as adopted in the Basin Plan, then by definition it is potentially impaired.

C.86 **Page 107 Last Bullet.**
It is misleading to state that numeric criteria have not been adopted in surface waters for the Sacramento river upstream from the Sacramento-San Joaquin Delta. The statement should be changed to read that the adopted objectives for waters not specifically named in the turbidity objectives are expressed as numerical limits of increasing turbidity over natural background. The second to last sentence under this bullet states "..turbidity levels in Barker Slough in the North Delta come close to exceeding the **suggested** 50 NTU limit…"[emphasis added] The 50 NTU limit is not a suggestion. It is a duly adopted numeric objective which reads "…shall not exceed…"

C.87 **Page 108 Table 22**
The majority of the water quality monitoring stations are outside of the Delta. Therefore, the turbidity objective listed in the table should either list the full turbidity objective of, minimally, a foot note should be added explaining that outside the delta the objectives are expressed as "not to exceed limits" over background.

C.88 Page 109 Table 24
The title should be changed to "Comparisons with Iron and Manganese Secondary MCLs. There is no such thing as a secondary water quality objective.

C.89 Page 110 Second Paragraph "b. Benficial Use Attainments and comparison of 303(d) Designated Waterbodies.
The discussion of the D/DBP rule should state that the reason for the rule is to limit the precursors to disinfection byproducts such as trihalomethanes, which are human carcinogens. The last sentence on the page which starts "In either case, safeguards will be…" should be removed. It is overly vague.

C.90 Page 111 Third Bullet.
The statement that the maximum limit for single samples…was exceeded only **infrequently**…" is ambiguous. Please restate with the number of exceedences. These could be expressed as a percentage of times the samples exceeded the objective.

C.91 Page 112 First Paragraph last sentence.
Remove the last sentence about safeguards. It is vague and not supported.

C.92 Page 112 Last Paragraph
The recommendation to suspend the *Giardia* monitoring is inappropriate in the monitoring report. Any recommendation to change the monitoring parameters should be discussed in the appropriate committees.

C.93 Pages 119 through 121 (Figures 26a –b)
Please change the resolutions (scale) on these temporal graphs. It is important to be able to compare the concentrations to the month in which the measurement was made.

C.94 Page 128 & 129
Conclusions, Recommendations

Paragraph 1, sentence 1: See first comment under "Page 5" above.
Paragraph 1, sentence 2: See the third comment under "Page 5" above regarding the wording "available data".
Paragraph 2, sentence 1: See the third comment under "Page 5" above regarding the wording "available data".
Paragraph 3, sentence 2: This sentence would be clearer if worded as follows – "…the Monitoring Subcommittee concluded that data…"
Paragraph 3, sentence 3: Replace "attainment" with "protection".

C.95 Page 132. *Bioassessment.* When will the final revisions be done? Will they be included in the final monitoring report?

C.96 **Page 132**, second paragraph states that the bioassessment data will be useful for the development of biocriteria for the Sacramento River watershed. Page 145, second paragraphs discusses the lack of reference sites. How will biocriteria be developed without data from reference sites?

C.97 **Page 133.** Was the non-point source sampling design used?

C.98 **Page 145.** The first paragraph states that the samples were collected in 1999. This statement contradicts earlier statements on page 132.

C.99 **Page 145.** The first paragraph also states that the data will contribute to the development of an Index of Biological Integrity (IBI) for the Sacramento River watershed. The term "IBI" needs to be defined. How does an "IBI" compare to "biocriteria" (mentioned on pg. 132, second paragraph)?

C.100 **Page 145.** The last paragraph is confusing and should be re-written. The two sentences appear to contradict each other. According to previous text, non-wadable sites were sampled using the snag method and wadable sites were sampled using the riffle method. It was also stated that these two methods produced different results at the same site. The first sentence of this paragraph appears to compare the two methods, and the second sentence states that they are difficult to compare.

Page 150

C.101 Table 33: The constituents at the top of the table are unreadable.

Appendix E, Page 4

Aquatic and Sediment Toxicity Quality Control

C.102 Paragraph 2, sentence 4: What are intra-laboratory splits? Are they duplicates?

Appendix E, Page 14

Summary of Quality Control Data; Aquatic Toxicity

C.103 General Comment: A summary of the results of the splits with DFG should be included here. Is the data summarized in this report?

SACRAMENTO REGIONAL WASTEWATER TREATMENT PLANT

COUNTY OF SACRAMENTO - PUBLIC WORKS AGENCY

WATER QUALITY DIVISION **Mail Code: 99-003**

8521 Laguna Station Road Phone: (916) 875-9000

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MEMORANDUM

TO: Claus Suverkropp **DATE**: January 25, 2001

FROM: Mitch Maidrand

COPIES: Andrew Frankel, Tom Grovhoug

SUBJECT: Review Comments on 1999-2000 Annual Monitoring Report, Sacramento River Watershed Program

I have reviewed the report referenced above, dated January 7, 2001 prepared by Larry Walker Associates. My comments are focused on the mercury section and are provided below. The report was well prepared. If you have questions or comments please contact me at (916) 875-9083.

General -

C.104 1. Evaluating the ratio or % of MeHg to total Hg can be a useful tool to evaluate the methylation potential of the water body. I recommend that this parameter be evaluated on at least a portion of the data. I would also recommend a discussion of TSS as it relates to mercury transport and concentration in the water column.

C.105 2. Page 1. Identify the acronym (SRWP) for the Sacramento River Watershed Program the first time referenced.

C.106 3. Page 1, 2nd bullet. Text indicates that the Feather River does not appear to be a major source of mercury. Fish tissue concentrations in the Feather River have been found at concentrations greater than 1 ppm. If the Feather River is not a source, these high tissue concentrations need to be explained. I suggest that you rephrase the paragraph to indicate that there are high mercury fish tissue concentrations.

C.107 4. Page 23, Table 4. This table lists one USGS mercury transport study from 1996-1997 but that data is not yet available. After 3 1/2 years it seems data should be available. Please check on data availability.

C.108 5. Page 23, Table 4. This table does not appear to include a USGS study completed on mill creek and potentially other CALFED studies. Please insure this table is complete as possible.

C.109 6. Page 24, 2nd to last paragraph. Is it possible to include MeHg data collected this year? Only limited MeHg data has been collected prior to this monitoring year so it is critical that this data become available as soon as possible. This data is critical to assess the fate and transport of mercury in the system and to guide future monitoring efforts. Please include a discussion of this data if possible.

C.110 7. Page 25. I understand that there were some QA problems with the fish tissue data so that some or all the samples are being reanalyzed. As this data is critical to the program is there some estimate when it might become available?

C.111 8. Page 29. The recently published EPA MeHg fish tissue criteria of .3 ppm should be discussed in this section and added to Table 5.

C.112 9. Page 30. Fish tissue concentrations in the Feather River at Nicolaus are some of the highest found within the watershed with concentrations in multiple species and samples above 1 ppm. This is significant and should be discussed in detail. It also appears that more intensive monitoring for both fish tissue and water column to further characterize the nature of these elevated concentrations is warranted.

C.113 10. Page 34. Again here in the conclusions high mercury fish tissue concentrations in the Feather are not discussed or addressed. I would recommend discussing this and deleting the discussion that describes the Feather as a non significant mercury source.

Comments on the
Sacramento River Watershed Program
Annual Monitoring Report: 1999-2000
Dated January 7, 2001
Prepared by Larry Walker Associates

Comments Submitted by
G. Fred Lee, PhD, DEE
G. Fred Lee & Associates, El Macero, California
February 16, 2001

Overall Comments

C.114 There are several aspects of this "Administrative Draft" report of the Sacramento River Watershed Program monitoring for 1999-2000 which should be discussed by the Monitoring Subcommittee. The most important issue is that this report continues many of the same technically invalid approaches that I pointed out a year ago, associated with my comments on the previous year's monitoring report. Larry Walker Associates (LWA) persists with presenting data using median concentrations in order to compare one location to the next, or various times at a particular location, while inferring that the median concentration magnitude and trends have some implications for water quality. This is obviously not true. The median concentration of a potential pollutant at a time, or over time or distance, does not provide reliable information on water quality issues. While LWA inserted one sentence to this effect that is buried in the middle of the report, a section up front in bold capital letters should be included to discuss the fundamental problems with how the data are being presented with respect to assessing the water quality characteristics at selected locations in the Sacramento River Watershed.

C.115 Another fundamental problem with the approach followed in presenting this data/information is the attempt to use load of constituent data to imply something about water quality. Constituent load data as used in this report does not provide reliable information on any aspect of water quality. Load data are only reliable if the loads are of toxic available forms. There are little or no data of this type in the 1999-2000 monitoring program/report. Load data are only meaningful if they are translated into a receiving water concentration for the load. For example, discussions about total heavy metal loads to the Delta have no meaning with respect to water quality implications within the Delta. Constituents do not impact water quality/beneficial uses based on loads. The impact is related to concentrations of toxic available forms-duration of exposure relationships. Since the Sacramento River water does not mix throughout the Delta, it is not possible to assess potential impacts to aquatic life-related beneficial uses from the load information provided in the draft report. Again, in order to avoid misuse of the information presented in this report, at the beginning of the report a one-page all-caps, bold discussion should be inserted to inform the reader of this problem.

C.116 This report raises a fundamental issue that I have raised several times in the past regarding the nature of the monitoring program that is being conducted in the Sacramento River Watershed Program. At one of the early meetings in the development of this Program, I suggested that an Evaluation Monitoring approach should be used as the basic approach for developing the monitoring program. This was accepted by the Monitoring Subcommittee. The first year's program focused, in accord with Evaluation Monitoring principals, on beginning to define real, significant water quality problems within selected locations in the Sacramento River Watershed. The mercury and chlorinated hydrocarbon pesticide and PCB excessive bioaccumulation problem evolved from this approach. Further, additional information was obtained on the orchard dormant spray pesticide toxicity problem.

C.117 My concern is that we continue to generate chemical constituent concentration data, implying that this is in some way related to the median concentration of potential pollutants at particular times and locations within the Sacramento River Watershed. This next year's monitoring program is largely more of the same kind of constituent monitoring without developing the information needed to be able to translate the constituent monitoring data to water quality. There is an immediate need to shift away from mechanical constituent monitoring of the type that is being done to water quality-oriented studies. For constituents where there is a potential for adverse impacts, there is need to determine whether the constituents of concern are in toxic available forms and whether organisms or other beneficial uses exposed to these constituents are adversely impacted by them. This approach is a proper implementation of the Evaluation Monitoring approach.

C.118 At this time, we have defined a real, significant water quality problem in the Sacramento River Watershed – namely, excessive bioaccumulation of mercury in edible fish tissue above US EPA guidelines. We have made little or no progress in defining whether the aquatic life toxicity found impairs the beneficial uses of the waters which are found to be toxic. By impairment of uses, I mean an alteration in the numbers, types and characteristics of desirable forms of aquatic life that are of concern to the public. This is where we should be focusing our financial resources for further monitoring. Rather than allowing a contractor to continue to report median data as an assessment of water quality, the Sacramento River Watershed Program should require that a discussion of the fact that the extreme values that may have occurred at only one time and one location during the year may have done significant harm to the beneficial uses of the River through being toxic to particularly important life stages of desirable fish or fish food. Just because the median is less than the US EPA CTR criteria does not mean that the extreme values for that particular time and location are not adverse to the beneficial uses of the waterbody.

C.119 Again this year, I recommend that the Sacramento River Watershed Program Monitoring Subcommittee address these issues and adopt a more technically valid approach for reporting on the past year's data and for developing monitoring programs for future years.

Specific Comments

C.120 On page i, the bottom of the page sets forth a schedule for review, which begins with an Administrative Draft, which eventually leads to a Public Draft at the end of March. Repeatedly, in reviewing this so-called "Administrative Draft," there are major information gaps which prevent a proper review from being conducted. This is the same problem that I experienced a year ago when I tried to review the first Larry Walker Associates Sacramento River Watershed Program monitoring report. I –

and, I am sure, many others – do not have time to review reports several times, especially when the second and subsequent reviews relate to the fact that the information needed to properly review the report is not available at the time that the report is first made available for review – i.e., at the so-called "Administrative Draft" level. The Sacramento River Watershed Program needs to change the approach that is being used with respect to trying to get reviewers for its documents, or it is going to lose a number of credible reviewers simply because of the lack of proper organization of the Program. From my point of view, I will not again review preliminary drafts of items. Larry Walker Associates needs to provide me with a complete final draft that is ready to go to the printers except for final review. I will then take time to review it.

Comments on the Executive Summary

C.121 On page 1, under "Mercury," first bulleted item, fourth line, a reference is needed as to whose screening values are being used. The statement is made, beginning in the fourth line, that, "*Exceedance of the screening values indicate that more data are needed to evaluate potential human health concerns associated with consumption of fish in the lower Sacramento River watershed.*" That statement is not true. There are adequate data to evaluate human health concerns. The issue is not adequate data, but rather the approach that is used by DHS/OEHHA in evaluating these data.

C.122 Page 1, second bulleted item, second line, it needs to be specified that it is "total recoverable mercury" that is set at 12 ng/L.

C.123 Page 1, second bulleted item, last line, I would put a reference to the US EPA (2000) CTR criteria to let people know that these are recently adopted criteria.

C.124 Page 4, under "PCBs and Organochlorine Pesticides in Fish Tissue," second bulleted item, I do not understand why a comparison is made to the FDA Action Levels for the organochlorines found in edible fish tissue. Those are not the levels that should be used for comparison purposes. The comparison should be made to US EPA guideline values, which are based on risk-based approaches, rather than economic and other factors that have nothing to do with protection of health.

C.125 Page 5, third bulleted item under "Sediment Toxicity," the discussions still do not describe the situation where the approach used for assessing sediment toxicity was done incorrectly. This was pointed out before it was done. The studies were conducted even though recommended not to be done, and they produced the kind of results that would be expected.

Report Text

C.126 Page 9, the first full paragraph makes reference to the "proposed California Toxics Rule." It appears that Larry Walker Associates copied out a section of some old report without thinking about the fact that the CTR criteria were officially adopted by the US EPA last year.

C.127 Page 11, under the second bulleted item, "gaging," as related to stream gaging, is typically spelled "gaging."

C.128 Page 14 lists the monitoring parameters. While not a criticism of this report, based on the fact that nutrient criteria are going to be developed by the CVRWQCB within a couple of years, it is important to expand the monitoring program to include chlorophyll, pheophytin and Secchi depth. These are parameters for which there will be need for information as part of managing nutrients within the Sacramento River watershed. Another monitoring parameter that should be added to the list is dioxin in fish near urban areas.

C.129 Page 14, last paragraph, fourth line, with respect to arsenic, as a result of my work in Orange County, I have become aware that the CTR criteria include a value for arsenic that relates the concentrations in water to bioaccumulation to excessive levels in fish tissue. There are virtually no waters anywhere that do not have arsenic concentrations above the CTR criterion to prevent bioaccumulation. This issue should be included in the review of the arsenic data that have been collected on the Sacramento River Watershed Program, which would include measuring arsenic concentrations in edible fish tissue.

C.130 Table 2 on page 18 lists a number of parameters. With respect to chromium, it is listed as "Chromium (III), total." Does this mean that total chromium III was measured, or chromium III and total chromium? Why chromium III as opposed to chromium VI? Chromium VI is the constituent of concern.

In future, methylmercury should be monitored. I believe it is being done as part of the mercury studies, but it should be a standard parameter.

Selenium should be monitored for total and dissolved.

In the field parameters, Secchi depth should be included as a parameter.

Under "Nutrients," soluble orthophosphate and total phosphorus should be monitored.

C.131 Under "General Constituents," chlorophyll and pheophyton should be monitored.

Under "Pesticides," pyrethroid pesticides should be monitored.

Both *E. coli* and Fecal streptococci should be added to the "Microbiological Water Quality Characteristics."

Aquatic Toxicity should include fish and algae.

Under "Biota," arsenic concentrations in fish tissue should be monitored.

C.132 Page 21, in the third from bottom bullet, it should read "Organochlorine pesticides and PCBs in fish tissue."

C.133 Beginning on page 24 and continuing for a number of pages is a discussion of the data, where Larry Walker Associates has persisted with presenting data in terms of median values. As I discussed a year ago (and I thought there was agreement), median values are not an appropriate basis for examining data of this type. All of this discussion on median values can be in significant error with respect to detecting trends that mean anything with respect to water quality.

C.134 At the bottom of page 26 and the top of page 27, the mercury concentrations are reported in μg/L. In other places they are reported in ng/L. Consistent units for each type of parameter should be used throughout the report. For example, always report mercury in ng/L.

C.135 The space covering most of page 28 should be filled in with text (Table 5 could be moved up).

C.136 In the discussion on page 29 on mercury, there is need to mention the consumption rates used. Also, in the values for critical concentrations, mention should be made of wet weight.

C.137 At the end of the paragraph on page 29 on "Threshold Values," I would add a table from the US EPA (1998) guidance showing how the critical concentration of a fish tissue residue changes as a function of consumption rate.

C.138 Page 32, Table 8 should mention Putah Creek in this group. There are adequate data to demonstrate that Putah Creek has a severe mercury problem as well.

C.139 On page 33 and elsewhere there are discussions about mass loads of constituents. Discussing mass loads of constituents in situations where there is less than essentially complete mixing in the receiving waters of the load can be highly misleading. Potential pollutants do not affect water quality based on mass loads. They affect water quality based on concentrations of toxic available forms. Mass load only has meaning if the loading is to a waterbody where there is essentially complete mixing, resulting in a concentration relative to a critical concentration. In the case of the Delta, there is very poor mixing of Sacramento River water through the complete Delta; therefore, the concentrations that are found in the Delta can be much higher than anything predicted based on mass loads. These issues need to be discussed in a report of this type so that everybody understands that mass loading, *per se*, is not a very meaningful approach to assessing water quality.

C.140 Page 41, the first paragraph under "Other Trace Metals" has the same problem on mass loads. Mass loads to the Delta of heavy metals is not an issue. What needs to be discussed is the resultant concentrations relative to critical concentrations in the Delta.

C.141 Table 10 on page 41 is a hodgepodge of presenting information. It should be consistent. For example, the "SF Bay Regional Monitoring Program" should list the constituents. They are listed above – why not here? The same way for DWR.

C.142 Page 42, in the first paragraph, first line, the word "concentration" should be inserted between "spatial" and "trends," in order to distinguish it from water quality trends.

C.143 I feel mean and standard deviation is a much better parameter for displaying data of these types than the median and range that are used. The justification provided in the first paragraph on page 42 is not adequate to continue to use the median. Median is not a reliable parameter. The least that should be done is to compare, for a number of parameters, the mean and standard deviation to the median and the range, so that these two approaches for presenting data could be examined by the reviewers. These issues should be more adequately discussed in this report than is being done now.

C.144 Page 43, under "Spatial Distribution of Cadmium," the next to last line discusses the highest single value. Somewhere in this report, there needs to be a discussion about how this highest single value could represent severe degradation of water quality. A high concentration of a toxic available form for a sufficient duration to exceed the critical exposure conditions for aquatic life could be severely detrimental to fish populations through direct toxicity to fish or to fish food, which in turn affects larval fish. These issues should be discussed up front, so that others can understand the deficiencies in the approach that is used in representing the data herein, with respect to representing true water quality issues within the report.

C.145 Page 44 discusses copper. There is need to mention that elevated copper concentrations are potentially derived from three sources: mine drainage, vehicular traffic street runoff and pesticide use.

C.146 Under lead, the discussion focuses on total lead and not dissolved lead. Dissolved lead is the issue, not total.

C.147 Page 47, first paragraph, on the third and fourth line uses "median hardness." Median hardness has no meaning. The least that should be done is to use a worst-case hardness – i.e., the lowest hardness, which leads to the highest toxicity. If nothing else, show the statistical range of the hardness and discuss this issue.

C.148 Page 47, last line of the first paragraph, the word "standard" is inappropriate. There are no CTR standards. There are CTR criteria and objectives.

C.149 Page 47, third paragraph needs to mention the arsenic bioaccumulation issue in addition to the drinking water issue.

C.150 Page 48 needs to mention the potential for certain heavy metals and other constituents to be additive and synergistic with respect to impacts on toxicity.

C.151 Page 49, the table needs to discuss worst-case hardness issues, as opposed to median.

C.152 Page 50 shows that some of the DWR studies did not include measuring dissolved metals. If the DWR studies are being incorporated into this Sacramento River Watershed monitoring program, we need to be certain that they measure the forms of the constituents that are potentially significant with respect to assessing water quality impacts.

C.153 Page 52 states, under "Conclusions and Recommendations," "*Aquatic life uses are typically the most sensitive to trace metal concentrations.*" That statement is not true. Pesticides can have a "more sensitive" impact on aquatic life than heavy metals.

C.154 Beginning on page 54 and at a number of other locations is the statement "TO BE UPDATED FOR PUBLIC DRAFT." Why is it not updated now, so that it is available for review at the time it is first reviewed? I (and, I believe, many others) do not have time to review things two and three times because the information is not properly presented the first time.

C.155 Another issue that needs to be addressed in discussing the dissolved metals is that the particulate metals may lead to sediment accumulation and adverse impacts. While we have no information on this, this is an issue that needs to be understood – that, when we are focusing on dissolved metals, this is a water column effect, and ignores sediment issues.

C.156 Page 56 has the wrong units for copper. It is not ng/L, but µg/L.

C.157 Page 61 presents information on the total pounds of certain pesticides used in California, according to the 1999 DPR database. Total pounds used in California has no relevance to issues of concern to the Sacramento River Watershed. It is readily possible to extract total pounds used in the Sacramento River Watershed. This is what should be reported instead of California use. The same problem occurs on page 67 for Table C3. Note that the DPR database for 1999 pesticide use is provisional and should say so, unless DPR has recently removed the provisional listing.

C.158 Page 69, second bulleted item, "Diazinon," needs to mention the additivity of the chlorpyrifos plus diazinon toxicity.

C.159 Page 69, under "Malathion," refers to the EPA's OPP Ecotoxicity database, but no year is given as to which version of the database was examined. I have recently obtained the latest version. This contains information that is not in the earlier versions. A proper reference needs to be cited, and if the latest version was not examined, then it should be.

C.160 On page 71, Table C4 should be expanded to include the major pyrethroid pesticides used in the Sacramento River watershed. Again these data are available from the DPR database. There is need to show how the use of pyrethroids as reported by DPR has changed over the years. Again, DPR has databases for 1995 through 1999 which should be examined, and the most commonly used pyrethroid should be listed with the lbs (ai) applied within the Sacramento River watershed, or maybe by county and total for the watershed would be a more meaningful way to present these data than is being done now.

C.161 On page 75, I would mention the pyrethroid pesticide issue.

C.162 On page 78, in the first line, why is this report discussing 1998 DPR data and not the more recent data? I understand that the more recent data are available. They should be discussed.

C.163 On page 79, under "*Ceriodaphnia*," why include the word "only"? That is a comparative that has no place in this type of discussion.

C.164 On page 80, why are the fathead minnow larvae data not available? I believe the data are available. They should be reported and discussed.

C.165 Page 81 should indicate the number of samples that were tested for each of the species tested.

C.166 On page 82, at the end of the second-to-last paragraph before "Conclusions and Recommendations," there is an editorial problem with the phrase "*et al.*" It should always have a period after "*al.*"

C.167 Page 94, the first paragraph indicates that the spatial distribution pattern for parameter concentrations are evaluated against concentrations at other sites, comparing median concentrations. Again, median concentrations are not reliable indications of drinking water quality.

C.168 Page 94, under "Drinking Water Parameters of Concern," an expanded discussion should be made of the mass load issue relative to drinking water to indicate that it is the concentration that is present in domestic water supplies that is crucial, not the mass load to the Delta.

C.169 Page 95, in Table 20 (and elsewhere), there is reference to "orthophosphate," without distinguishing whether that is total orthophosphate or soluble orthophosphate. It is soluble orthophosphate that is the parameter that is a nutrient. There are appreciable concentrations of orthophosphate which are not available to support algal growth. If the sample were filtered then it needs to indicate that it is dissolved or soluble orthophosphate at this location and throughout all of this report and all reports. This is a common error that is made by those not familiar with algal nutrient issues that needs to be corrected.

C.170 In Table 20, nitrate, under the MWQIP, is presented differently than in the above column. It should be "NO_3^-" as is done above.

C.171 Page 96, first paragraph under "TDS," the statement is made in the second line that the concentrations of TDS are considered relatively low. Low compared to what? When a comparison is made, there has to be a reference point given to help the reader understand why the statement is made as it is.

C.172 Page 96, under "Total and Dissolved Organic Carbon," the second line states, "*...tributaries have similar spatial distributions.*" Similar to what? Each other?

C.173 Page 96, about halfway through the "Total and Dissolved Organic Carbon" paragraph, the statement is made that, *"TOC data for the Sacramento-San Joaquin Delta were not available for analysis."* That is not true. In August (2000), Rick Woodard, on behalf of the CALFED Drinking Water Constituents Workgroup, has compiled the Delta available data on TOC/DOC, TDS, nutrients, etc. A comparison between the Sacramento River data and his compilation of data, which includes consideration of the information on the characteristics of the Sacramento River, etc., should be made.

C.174 Page 98 presents a discussion of the nitrogen species concentrations. Rather than presenting the concentrations of nitrite as NO_2 and nitrate as NO_3, all concentrations of nitrogen species should be presented as N. This way, the numbers are comparable.

C.175 Page 107, second bulleted item should mention that the US EPA, as part of developing nutrient criteria, will be establishing critical nutrient levels in waterbodies. The guideline values at this time are 0.01 mg/L total P and 0.15 mg/L nitrate, nitrite and ammonia.

C.176 Beginning on page 153 is the reference list. There are a number of holes in the references that should have been eliminated before providing it for review. There are also problems in how some of the references are listed, such as including the year of publication twice within the reference.

**COMMENTS ON THE SACRAMENTO RIVER WATERSHED PROGRAM
ANNUAL MONITORING REPORT: 1999-2000
(January 7, 2001 Administrative Draft)**

**Prepared by Elaine Archibald on behalf of
California Urban Water Agencies**

I reviewed the administrative draft Annual Monitoring Report: 1999-2000 on behalf of the California Urban Water Agencies (CUWA). My comments on this draft are limited to the Executive Summary, Program Overview, Other Trace Metals, and Drinking Water sections of the report. I was not able to conduct a complete review of this report because many of the graphs in this report have not been updated to include the 1999-2000 data and the data were not included in the appendix. I also did not request comments from CUWA member agency staff because this draft was not complete. I expect that CUWA will submit more detailed comments on the next draft of the report. I recommend that in the future the Monitoring Subcommittee be given a complete draft that contains updated graphs and a complete set of data to review. I would much prefer to conduct a single review of a complete draft report rather than multiple reviews.

Executive Summary

C.177 **Page 3, Drinking Water Parameters of Concern section, 1st and 2nd paragraphs** – The statement that the "drinking water beneficial uses are substantially realized in the Sacramento River watershed and beyond" needs to be clarified. What does substantially realized mean? What does "and beyond" mean?

C.178 **Page 4, 3rd bullet** – The report states that "monitoring should be suspended until these analytical issues are resolved" with respect to pathogen monitoring. The Monitoring Subcommittee agreed to suspend monitoring based on budgetary constraints, not based on the methodology. The Drinking Water Focus group recommended monitoring with Method 1623 when we developed the idealized matrix for Year 4.

C.179 **Page 4, last paragraph under Drinking Water Parameters of Concern** – The statement that "The RWQCB is currently evaluating a work plan for the development of an effective drinking water policy" is outdated. The Regional Board is currently implementing the work plan. Significant progress has been made on entering the discharger data into the Bay Delta Tributaries Database and a work plan for discharger monitoring is currently under development.

Program Overview

C.180 **Page 12, 1st paragraph** – Monthly or semi-monthly sampling should not be characterized as "semi-intensive monitoring." This level of monitoring provides very little information on the temporal variability of water quality constituents. As I recall, this year of monitoring was based on a regular monthly schedule rather than targeting storm events. If this is correct, it should be pointed out in the description of the monitoring program that storm events were not targeted. This likely results in lower concentrations of most constituents than if storm event samples had been collected.

C.181 **Page 14, Trace metals in water** – Mercury and arsenic are not the only metals that are of concern to human health. There are maximum contaminant levels for a number of metals. The statement needs to be clarified as follows, "Mercury and arsenic are the only metals of potential concern to human health at the levels found in the Sacramento River and its tributaries."

C.182 **Page 16, 1st paragraph –** This paragraph needs to be corrected and updated**.** The City of Sacramento was not involved in the DWR/MWD pathogen monitoring study. The City does conduct pathogen monitoring but not jointly with DWR and MWD. DWR has decided not to release the results of the 1998 study but will be releasing results from a study conducted in 2000 during the summer or fall of 2001.

Data Review – Other Trace Metals

C.183 **Page 42, Spatial Distribution of Arsenic** – It is unclear how Mill Creek can have median arsenic concentrations between 15 ug/L and 69 ug/L. Are these medians for different years or different locations within Mill Creek?

C.184 **Page 43, Spatial Distribution of Cadmium** – The cadmium concentrations in the major agricultural drains should be included in the discussion.

C.185 **Page 43-44, Spatial Distribution of Copper** – The maximum total copper concentrations in Colusa Basin Drain and Arcade Creek are presented but the median values are not discussed.

C.186 **Page 46-47, Attainment of Beneficial Uses and Potential Impairment** – As discussed previously, the fact that samples were not collected during storm events skews the data. It should be pointed out in the discussion that these data were collected for the most part under dry weather conditions. The arsenic data need to be compared to the drinking water MCL of 10 ug/L.

C.187 **Page 49, Table 11** – Need to specify the units, ug/L, and the hardness values that were used to determine the CTR objectives at each site.

C.188 **Page 50, Table 12** – What data are used to determine compliance with objectives? Is this determination made based on the SRWP 1999-2000 data or are other data included?

Drinking Water Parameters of Concern

C.189 **Page 95, Table 20** – The MWQI Program is an on-going monitoring program; it did not end in 3/98 as shown in the table. Data are available in the Bay-Delta Tributaries Database. Other monitoring programs that should be included in the table are the DWR O&M monitoring and the City of Sacramento's drinking water monitoring program on the American and Sacramento rivers. The City of West Sacramento also collects samples at Bryte Bend for drinking water constituents.

C.190 **Page 96, Spatial Distribution & Patterns** – it is unclear if the discussion of the data is on the 1999-2000 data or the two years of data collected as part of the SRWP. The Barker Slough data should be updated to include data collected during the last two years.

C.191 **Page 96, Total and Dissolved Organic Carbon** – Need to insert "44" after River Mile in the fifth line. Urban storm drainage and treated wastewater are also sources of organic carbon in the watershed. There is a statement that "TOC data for the Sacramento-San Joaquin Delta were not available for analysis." These data can be obtained from the Bay-Delta Tributary Database or by contacting Rich Breuer at the MWQI Program. The TOC data need to be presented on a graph in this section. There is much more variability in TOC concentrations in the lower Sacramento River than in DOC concentrations due to the heavy particulate load.

C.192 **Page 97, Pathogens** – Did the maximum *Giardia* cyst concentration at Hamilton City correspond to the maximum fecal coliform concentration at this location?

C.193 **Page 99, General Minerals** – There is no presentation of data or references to graphs of the data on any of the minerals. Only relative differences are discussed in the text.

C.194 **Page 101, Turbidity** – Barker Slough has the highest turbidity and the greatest variability in turbidity but it is not discussed in this section.

C.195 **Page 101, Temporal Distribution & Patterns** – The text on these pages is taken from the 1998-1999 report. Will it be updated in the next draft?

C.196 **Page 102, Pathogens** – The report states that, "data from the American River are insufficient to evaluate temporal distribution patterns." The City of Sacramento has conducted an extensive analysis of coliform data and determined that the highest concentrations are found during storm events.

C.197 **Page 104, Table 21-** It is unclear which data are presented in this table. Does it include the 1998-1999 data or just the 1999-2000 data? There are data for many of these constituents at Barker Slough, Banks Pumping Plant, and the San Joaquin River at Vernalis.

C.198 **Page 106, 1st paragraph** – The report states that the Feather River infrequently exceeds the TOC threshold and then goes on to say that the Feather River exceeds the threshold 40% of the time. I do not believe that an exceedence of 40% should be considered infrequent, particularly since samples were not collected during storm events when there would be a greater likelihood of exceeding the 2 mg/L threshold. There is no mention in this report of the fact that the median concentrations of TOC in Sacramento Slough and Colusa Basin Drain exceed both the 2 mg/L and the 4 mg/L thresholds. The percent exceedence of both of these thresholds should be discussed.

C.199 **Page 106, last paragraph** – I have expressed concern in Monitoring Subcommittee meetings on several occasions about the coliform data that are being collected as part of this program. I believe that the levels that are being reported are much lower than the actual levels. This report found that fecal coliforms rarely exceeded 400 MPN/100 mL and that only two samples exceeded the total coliform limit of 1,000 MPN/100 mL. The data collected by the cities of Sacramento and West Sacramento that were analyzed as part of the update to the Sacramento

River Watershed Sanitary Survey show that fecal coliforms occasionally exceed 400 MPN/100 mL, total coliforms are occasionally greater than 10,000 MPN/100 mL, and total coliforms are frquently greater than 1,000 MPN/100 mL in the Sacramento River.

C.200 **Page 107, last sentence of last paragraph** – The turbidity of Barker Slough very frequently exceeds the Basin Plan objectives of 50 NTU and 150 NTU.

C.201 **Page 108, Table 22** – Add arsenic with an MCL of 10 ug/L to the table.

C.202 **Page 110, 1st paragraph** – As stated previously, the Regional Board is implementing the work plan for development of a drinking water policy. The report states they are "evaluating" the work plan.

C.203 **Page 111, 1st paragraph** – I don't support drawing conclusions that recreational uses are well-supported based on the coliform data presented in this report.

From: Bill Crooks
Sent: Tuesday, February 20, 2001 12:22 PM
To: Claus Suverkropp
Subject: 99-00 Monitoring Report

Thought you did a very good job. I have just a few comments:

C.204 p.17 Shouldn't the word "Benthic" be removed?

C.205 p.32 It says advisories have been issued for foothill reservoirs on each side of the watershed. Then it says,"...these two Coast Range reservoirs." I think both are on Coast Range.

C.206 p.96 Under T & DOC. River Mile 44.

C.207 I tried to find (speed reading) which labs did the work. I could not find them. Think we should list them. (Maybe they are there.)

From: Kelly D. Moran
Reply To: kmoran@tdcenvironmental.com
Sent: Tuesday, June 5, 2001 3:28 PM
To: clauss@lwadavis.com
Subject: SRWP Annual Monitoring Report

Claus-

C.208 I just took at look at your very nice report on water quality monitoring in the Sacramento River watershed. I'm particularly interested in the pesticides work (good for you for noting the need to monitor pesticides that will phase in as diazinon and chlorpyrifos phase out!) and copper. For copper, my interest relates to urban runoff, where vehicle brake pads are likely a major source. I've been working for the last few years on a partnership with vehicle brake manufacturers to explore the environmental importance of copper use in brakes (it is a *lot* of copper; you can get more information on that from Betsy Elzufon or Heather Kirschmann).

C.209 I am writing because I am curious why the report summary notes the elevated copper levels near Redding, but omits discussion of the elevated copper levels in Arcade Creek and the agricultural drains. Are the elevated copper levels at these other sites somehow different or less meaningful environmentally? I'd like to understand this, as it will help out my work with the brake manufacturers. Also, the presentation in Table 12, which shows "regulatory problems" with copper at a number of locations (but no certainty of such "problems" for any other metals) looks very interesting--and somewhat important, as presented. I find the correlation between ruban locations and exceedances of CTR levels to be particularly interesting in that table. If these results are environmentally meaningful, it would be helpful to note them in the report summary.

Thank you for your assistance,

Kelly Moran
TDC Environmental

Comments, SRWP Annual Monitoring Report: 1999-2000.   Public Draft

Thank your for your careful attention to our previous comments regarding the mercury section of the Administrative Draft report. We have one additional comment on new text.

C.210 **Page 45 Paragraph 1**. The last sentence of the first paragraph states that all criteria and screening values are based on reference doses with 10-fold uncertainty factors. This statement is true for some but not all reference doses. The reference doses for birds and mammalian wildlife incorporate uncertainty factors ranging from 2 to 10, depending upon whether the reference dose was derived for the Mercury Study Report to Congress or the Great Lakes Water Quality Initiative. The SRWP Candidate Targets Report for Mercury contains a good explanation of derivation of wildlife criteria. The revised USEPA reference dose of 0.1 micrograms mercury/kg bwt-day does include a 10-fold uncertainty factor. The San Francisco Bay screening value is based upon an older USEPA reference dose (0.3 micrograms/kg bwt-day) and an additional uncertainty factor to account for effects on children of five (effective reference dose of 0.06 micrograms/kg bwt-day).

From: Jay Davis
Sent: Sunday, June 24, 2001 11:45 AM
To: clauss@lwadavis.com
Cc: gfredlee@aol.com; rbrodber@oehha.ca.gov
Subject: SRWP Annual Report Comments

Hi Claus;

I know the deadline has passed, but I have some comments that can help clean up the Annual Report. I apologize for not getting to this sooner, but I have been swamped. If you can't incorporate them this year, at least they will be on the record for next year.

Overall, you have done a very nice job of pulling everything together. One thing I think you the Program should consider is developing a more concise, readable annual synthesis like we are doing in the RMP. "The Pulse" has been well received.

The more substantive criticisms are:

C.211 1) You should use screening values that were published by OEHHA in their Lakes Study (http://www.oehha.org/fish/nor_cal/CX825.html). I used these in the Delta Fish report (http://www.sfei.org/deltafish/dfc.pdf). They are:

PCBs (as Aroclors)	20 ppb
sum of DDTs	100 ppb
sum of chlordanes	30 ppb
dieldrin	2 ppb

The value for mercury is 0.3 ppm, which is what you already used.

C.212 2) Using the FDA action levels for comparison of the organochlorine data is inappropriate, meaningless, and irresponsible. USEPA and OEHHA, the agencies that regulate water quality and sport fish contamination, tell us that concentrations above screening values are a potential human health concern. The FDA action levels are 100(!) times higher. Are you suggesting that eating fish with concentrations at the FDA values is OK? These comparisons to FDA action levels should be removed from the report. I don't think the SRWP can defend including them in the report.

C.213 3) The database is not ready for public consumption. Including the link to it looks good on paper, but will only create frustration for anybody who actually tries to use it.

OK, I'll settle down now. The rest of the comments are minor edits.

C.211 p ii include SFEI in list of contractors

C.212 p ix and throughout the report Use "PCBs" instead of "Aroclors". The term PCBs is in common usage and much more recognizable. If you must use "Aroclors", it should be capitalized.

C.213 p 10 "This long term data can be used..." should be "These long term data can be used..."

C.214 Throughout The name "Sacramento squawfish" is not PC and no longer used. Just use Sacramento pikeminnow (pikeminnow is one word).

C.215 p 22 Fish Tissue Section

C.216 state sampling date in first paragraph

C.217 p 23 A sentence begins with "concentrations" not capitalized.

C.218 p 28 SFRWQCB 1996 should be 1995

C.219 p 29 text says white catfish figure is 5b, it is really 5a

C.220 p 29 bullet on other species has white catfish sentence at end

C.221 Table 7 cite OEHHA Lakes study

C.222 p 31 Sentence beginning "Comparisons of data for largemouth..." is missing something

C.223 p 31 suggest change to "data from the SRWP are not sufficient to support additional consumption advice in the Sacramento River watershed."

C.224 p 83 suggest change to "other monitored pesticides appearing to have relatively low to minimal risk of impacts."

C.225 p 131 in San Francisco Bay in 1994 and 1997

I hope you find these comments helpful.

To: Claus Suverkropp
Larry Walker Associates

From: Lynda Smith
Metropolitan Water District of Southern California

Date: June 27, 2001

Subject: Comments on the May 31, 2001, Public Draft of the Sacramento River Watershed Program 1999-2000 Annual Monitoring Report

Following are my comments on the May 31, 2001, Public Draft of the Sacramento River Watershed Program 1999-2000 Annual Monitoring Report. Most of the comments are indicated with strikeout/underline revisions to sections of the report text. I have focused my comments on technical corrections to the portions of the report discussing the monitoring data for drinking water quality parameters. Thank you for your consideration of these late comments on the draft report.

Executive summary

C.226 Page viii, first paragraph:

"…. to date indicate that drinking water beneficial uses are substantially realized in the Sacramento River watershed ~~and Delta~~. ***[Since the focus of the SRWP monitoring program is the Sac. River watershed, it is not appropriate to include statements regarding the attainment or nonattainment of beneficial uses in the Delta.]*** Water supply agencies treating Sacramento River and Delta water are currently able to meet drinking water standards and provide safe drinking water to millions of consumers throughout California. However, anticipated future drinking water regulations may require agencies treating Delta water to implement ~~additional~~ costly advanced drinking water treatment technologies. Drinking water parameters of potential concern included in the SRWP monitoring program include organic carbon, total dissolved solids, pathogens, and turbidity. Organic carbon is of concern primarily due to its role in the creation of carcinogenic trihalomethanes (THMs) and other disinfection by-products during disinfection of source water. Total dissolved solids (TDS) can have an important effect on the taste and palatability of drinking-water. At very high levels, total dissolved solids may cause health problems in sensitive individuals. The presence of high levels of TDS may also be objectionable to consumers owing to excessive scaling in water pipes, heaters, boilers, and household appliances. Pathogens such as *Cryptosporidium* and *Giardia* are of concern due to their ~~potential to cause~~ direct adverse impacts on human health ~~effects~~. The primary concern associated with turbidity is its effect on disinfection, because high levels have been shown to protect microorganisms from the action of disinfectants and to increase the chlorine and oxygen demand."

C.227 Page ix, first bullet paragraph:

- "*Giardia* cysts were detected in 42% to 82% of samples collected from the mainstem Sacramento River and major tributaries, and in one of six Cache Slough samples. *Cryptosporidium* oocysts were detected in 6 of 51 samples from the mainstem

Sacramento River. Although the analytical method used for *Giardia* and *Cryptosporidium* monitoring for Year 2 (1999-2000) is much improved (compared to the ICR method used previously), there remains a high degree of uncertainty associated with data for these pathogens. ~~SRWP monitoring for these pathogens should be suspended until these analytical issues are resolved.~~ Due to the uncertainty in the analytical method, careful consideration should be given to future plans for pathogen monitoring."

Monitoring Program Description

C.228 Page 7, second paragraph: Double check the numbers in this paragraph; I could not make sense of the numbers in this paragraph regarding sample collection locations.

C.229 Page 11, last paragraph:
"*Pathogens in wate*r. Pathogens are disease-producing organisms (protozoa, bacteria, and viruses) which adversely affect the quality of drinking water and/or may pose human health risks for water contact recreation. Two pathogens of particular concern are *Giardia lamblia* and *Cryptosporidium parvum*. Water treatment agencies are currently required to ~~remove and inactivate~~ remove/inactivate ***[use a slash here to indicate that the three-log treatment requirement can be achieved through a combination of removal and inactivation]*** at least 3 logs of *Giardia* (99.9%), and effective December 2001, will be required to remove 2 logs of *Cryptosporidium* (99%) (Interim Enhanced Surface Water Treatment Rule, USEPA 1998). Although most facilities utilizing conventional or direct filtration remove at least 2 logs of……"

C.230 Page 12, second paragraph:
"*Organic carbon in wate*r. The organic content of water (measured as total and dissolved organic carbon) is a parameter important to drinking water suppliers. High levels of organic compounds in source waters contributes to the production of disinfection by-products (trihalomethanes and halo-acetic acids) as a result of conventional water treatment. Some of these by-products are carcinogenic and pose human health problems at relatively low concentrations. In addition, the Stage 1 Disinfectants and Disinfection By-Products Rule, which will be effective in December 2001, requires drinking water systems to meet specified TOC removal requirements depending on source water TOC concentrations. For these reasons, baseline data on typical organic carbon levels and seasonal variability of those levels in the Sacramento River system are important to the assessment of drinking water uses. SRWP monitoring for organic carbon augments fairly extensive monitoring already being performed by the USGS NAWQA program, the City of Sacramento and the Department of Water Resources."

Data Review

C.231 Page 17: Correct the name of the USGS program to "National Water Quality Assessment Program" (NAWQA).

B. Other Trace Metals

C.232 Page 48, last paragraph:
"EPA is in the process of reassessing the scientific and cost issues associated with the final arsenic rule published on January 22, 2001, which sets ~~finalizing regulations to set~~ a new Maximum Contaminant Level (MCL) of 10 µg/L as total arsenic (revised from 50 µg/L) to

protect consumers against the effects of long-term, chronic exposure to arsenic in drinking water (66 FR 6976 / January 22, 2001). EPA has extended the effective date for the arsenic rule to February 22, 2002, to allow time to conduct scientific and cost of compliance reviews. ~~and is required to issue a final rule by June 22, 2001.~~ If the ~~proposed~~ 10 µg/L arsenic MCL is not revised as a result of the scientific review ~~limit is adopted~~, it would automatically be incorporated by reference as a Basin Plan objective. ……"

C.233 Page 50, third paragraph:
"In the Mill Creek watershed, total arsenic concentrations consistently exceed the new 10 µg/L ~~proposed~~ arsenic drinking water MCL that will be effective February 22, 2002. If the 10 µg/L arsenic MCL is retained ~~approved and adopted~~, the use of Mill Creek water as a drinking water source could be limited or prohibited. This watershed is not currently included on California's 303(d) list of impaired waterbodies. It appears that the ~~proposed~~ 10 µg/L total arsenic MCL would not limit the use of the Sacramento River and major tributaries as drinking water sources."

E. Drinking Water Parameters of Concern

C.234 Page 103, last paragraph: The discussion in this paragraph should indicate that urban runoff and treated wastewater are also sources of TOC in the watershed.

"Total and dissolved organic carbon concentrations have similar spatial distributions in the mainstem Sacramento River and its tributaries. Median organic carbon concentrations in the mainstem increase slightly in the downstream direction from Bend Bridge to Freeport, with median TOC concentrations ranging from 1.6–2.2 mg/L. Median TOC for the Sacramento River at River Mile 44 was markedly higher (2.7) than at Freeport, but was based on only nine samples collected in 1999-2000 ***[What time of year were the River Mile 44 samples collected?]***. The primary sources of organic carbon in the mainstem are considered to be agricultural inflows, urban runoff, treated wastewater discharges and a variety of natural sources in the watershed. TOC and DOC concentrations are substantially higher in Sacramento Slough and the Colusa Basin Drain. Median TOC concentrations in these two major agricultural drains are 2.5- to 3.5-fold higher than in the mainstem Sacramento. The highest organic carbon concentrations were observed at Arcade Creek, with a median TOC concentration of 7.8 mg/L and a median DOC concentration of 7.0 mg/L. The increases in organic carbon in the mainstem are somewhat moderated by the lower organic carbon concentrations in the major Sierra tributaries, with median TOC ….."

C.235 Page 113, first paragraph: The reference to Table 23 should be changed to Table 29.

C.236 Page 114, last paragraph: The reference to Table 22 should be changed to Table 28, and the reference to Table 24 should be changed to Table 30.

C.237 Page 116, Table 28: The footnote "(b)" should be removed from TOC.

C.238 Page 117, Table 29: This table should include information for Sacramento River at River Mile 44, since the data for River Mile 44 are discussed in the text of the report and included in Figure 20b.

C.239 Page 118, first paragraph, last sentence: The following revision is recommended to make this section consistent with the Executive Summary.

"In order to address these and other drinking water concerns, the RWQCB is currently implementing ~~evaluating~~ a work plan for the development of an effective drinking water policy.

This policy is expected to address these parameters and ~~to~~ establish water quality objectives for eventual inclusion in the Basin Plan."

C.240 Page 122, Figure 19: Include Arcade Creek data in this figure.

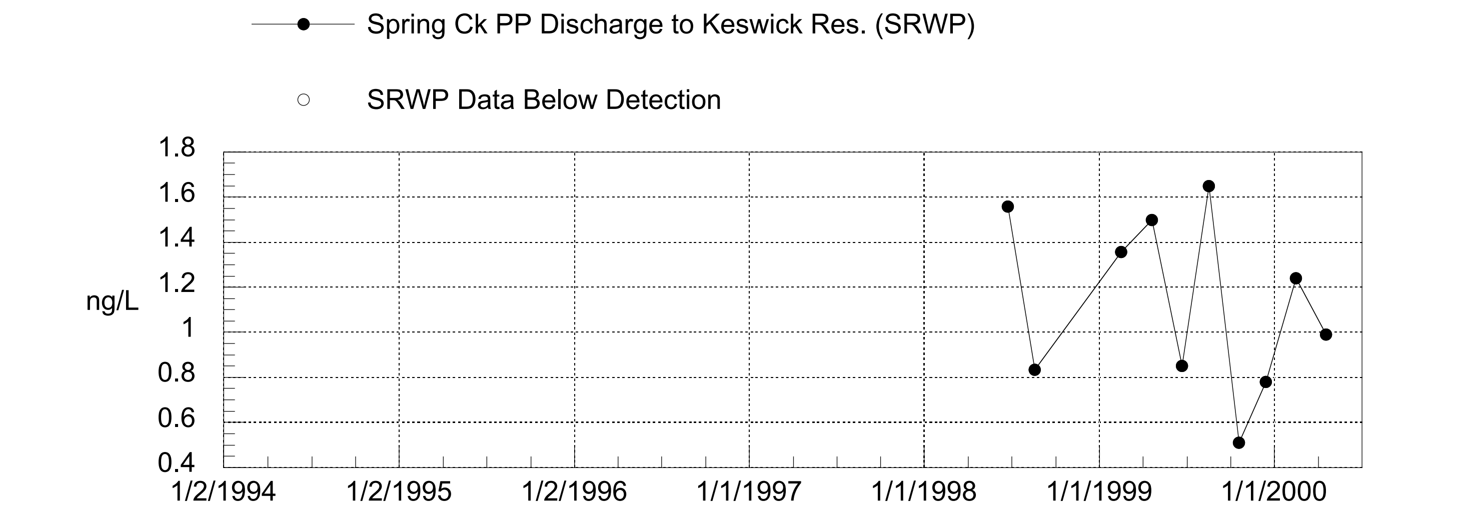
C.241 Page 126, Figure 22: The plotted nitrate data for Sacramento River at River Mile 44 appears to be incorrect when compared to median concentrations in Table 27 (i.e., median value of 0.22 mg/L). Also, the thick vertical line separating Sacramento River mainstem and major tributaries should be moved to the right.

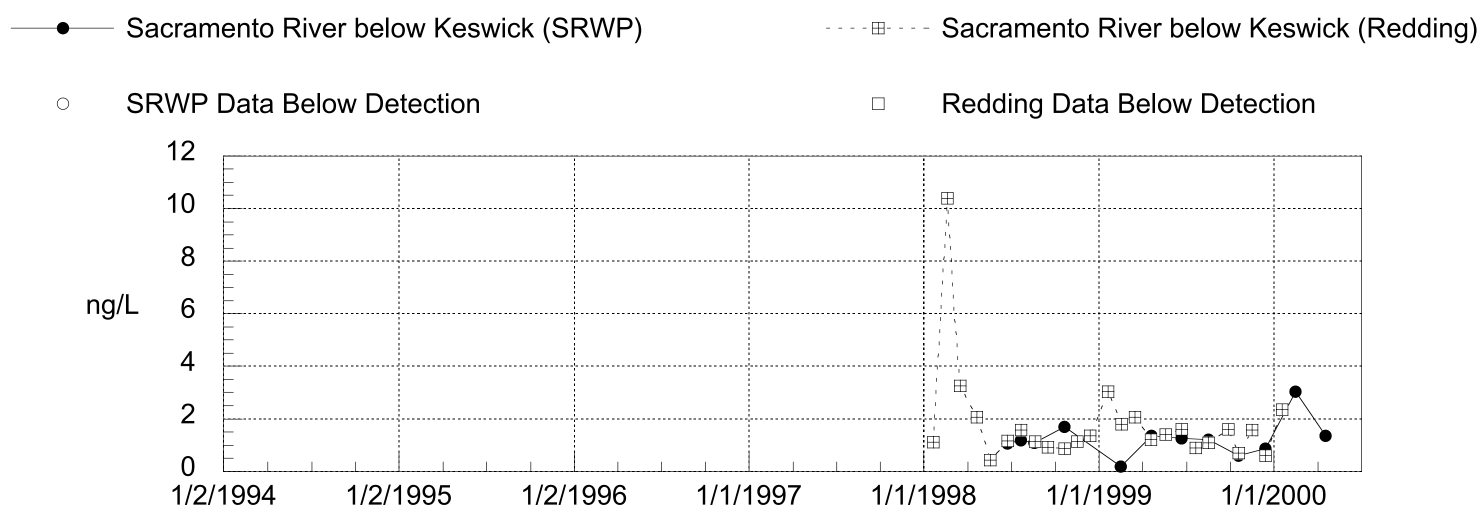
APPENDIX G

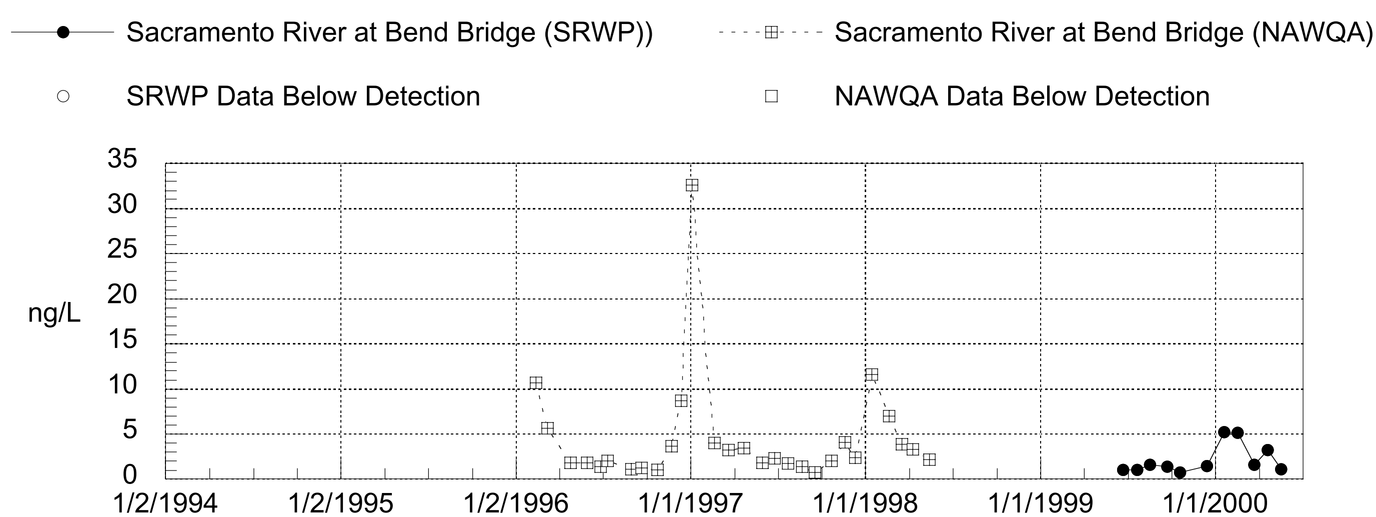
Time Series Plots of Monitoring Data: SRWP, USGS NAWQA, Sacramento River CMP, and City of Redding

Time Series Plots of Monitoring Data: Mercury Data

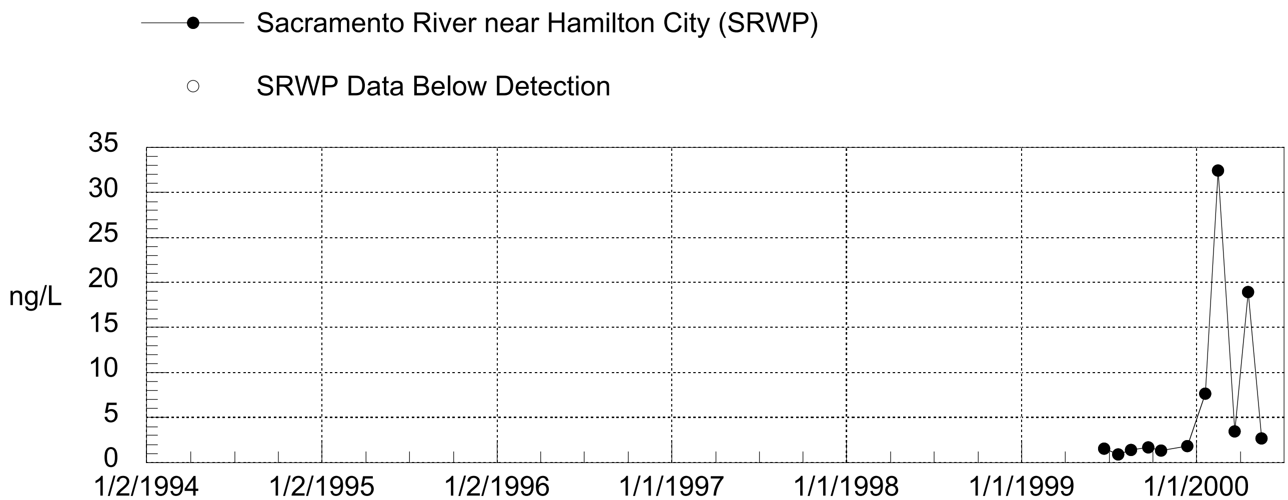
TOTAL MERCURY IN WATER

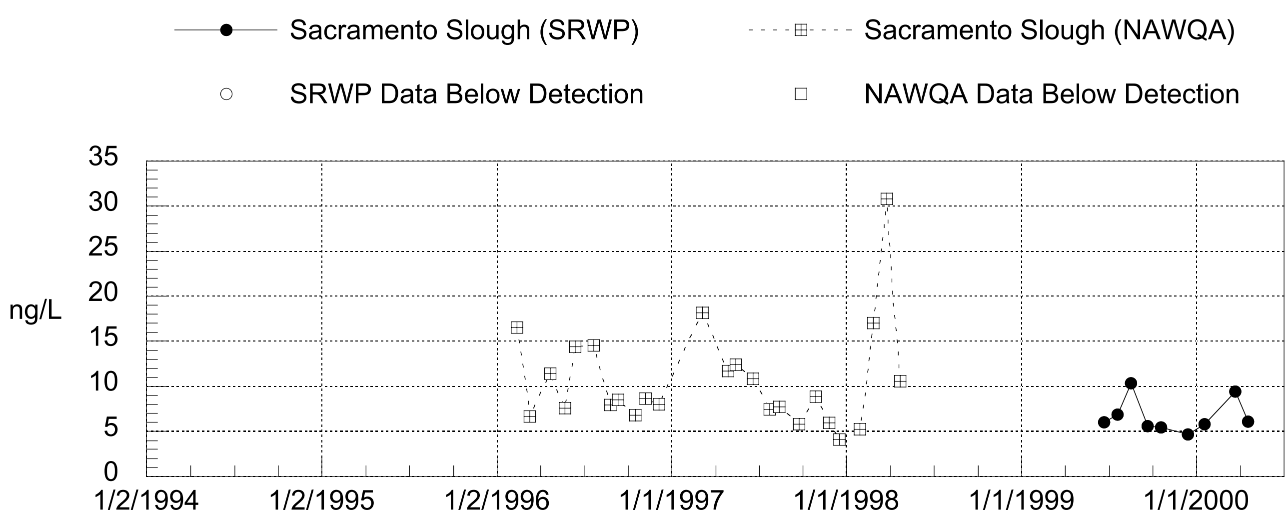


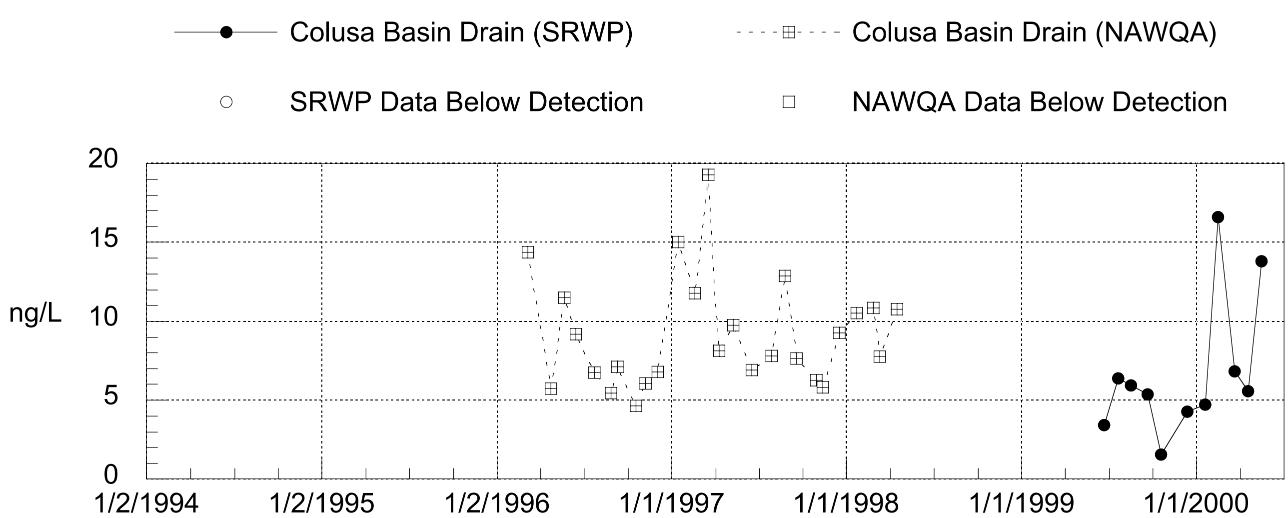




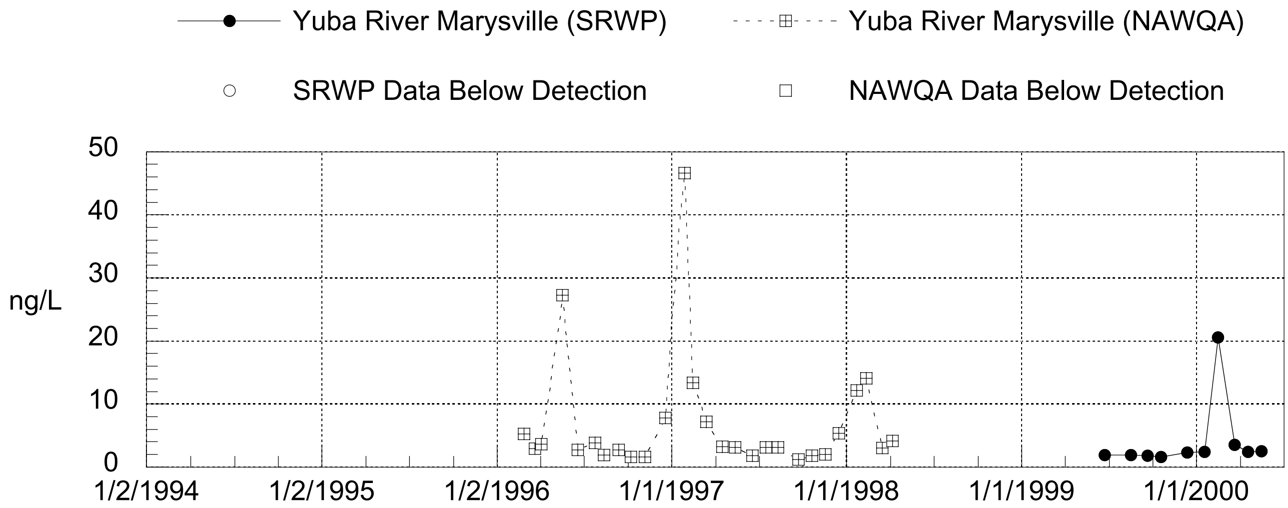
TOTAL MERCURY IN WATER

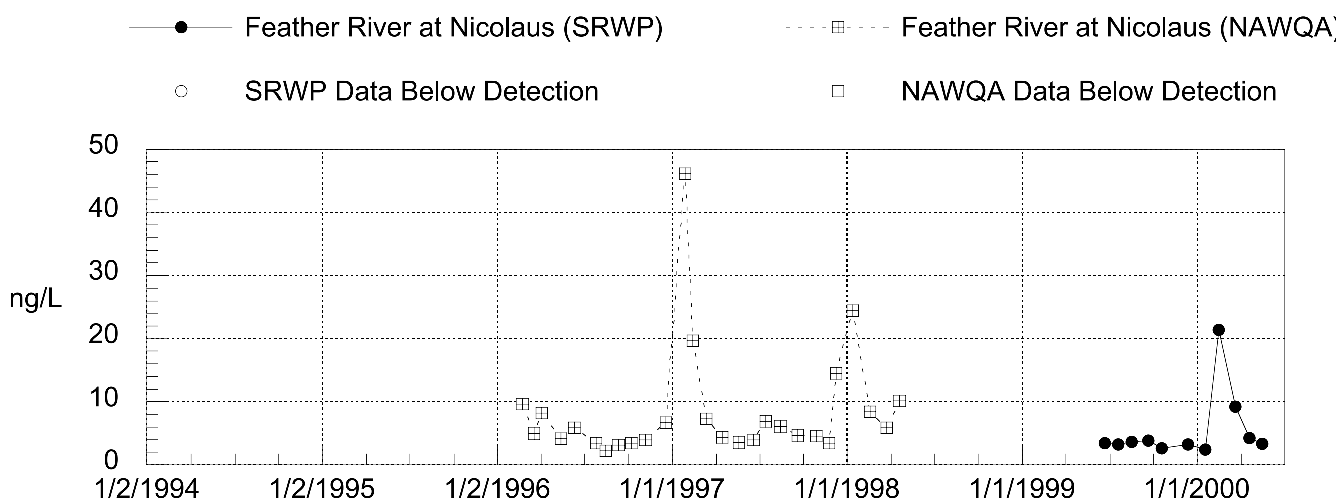


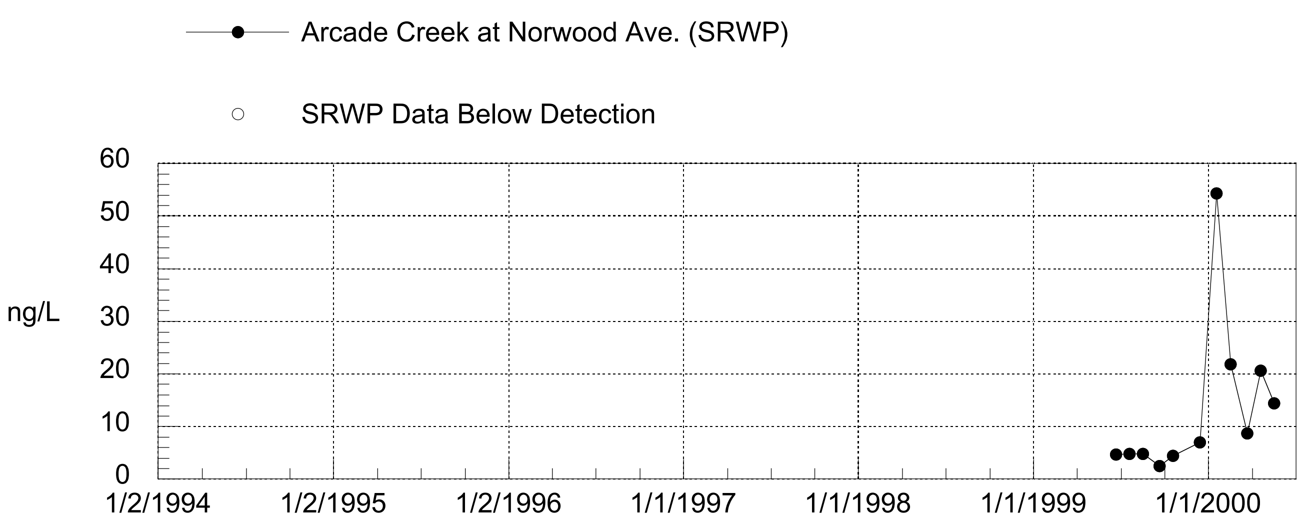




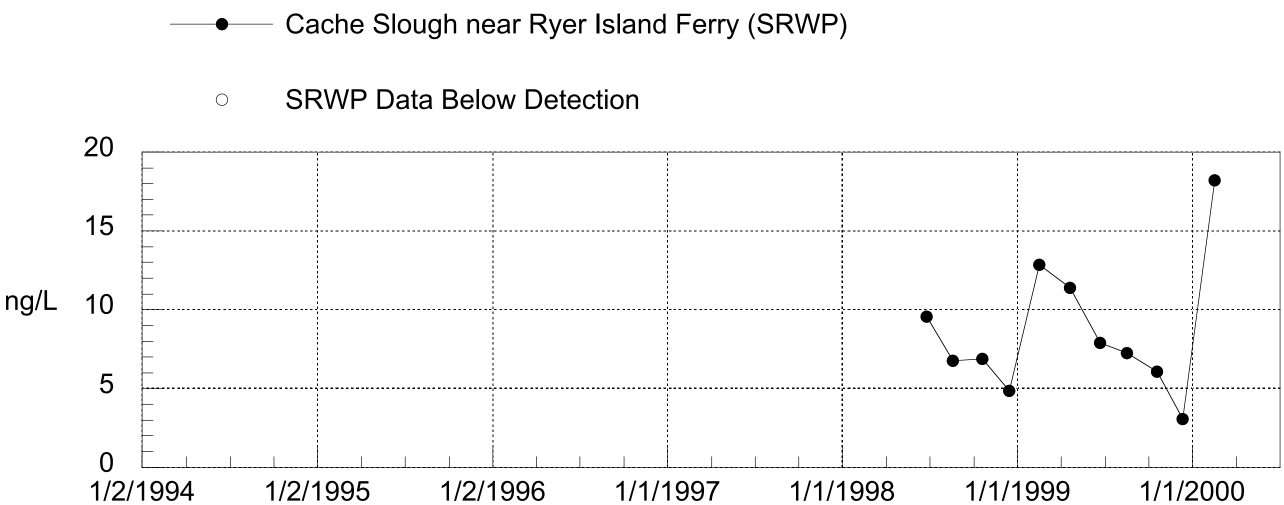
TOTAL MERCURY IN WATER







TOTAL MERCURY IN WATER



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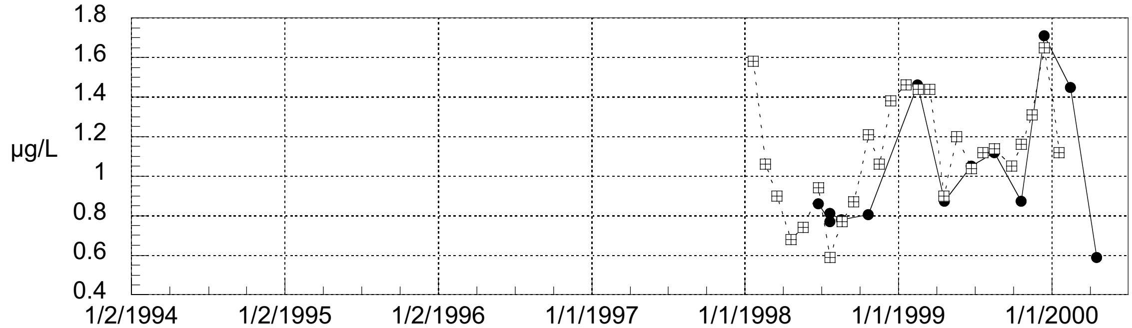
Time Series Plots of Monitoring Data: Trace Metals

Sacramento River below Keswick (SRWP)

Sacramento River below Keswick (Redding)

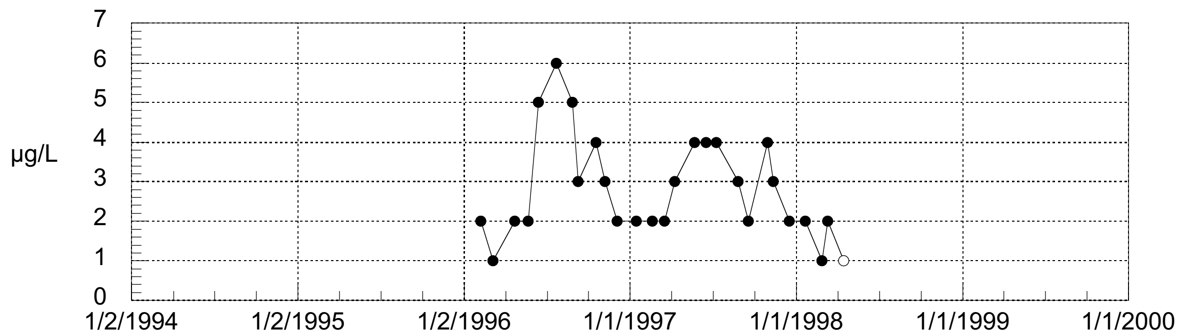
SRWP Data Below Detection

Redding Data Below Detection



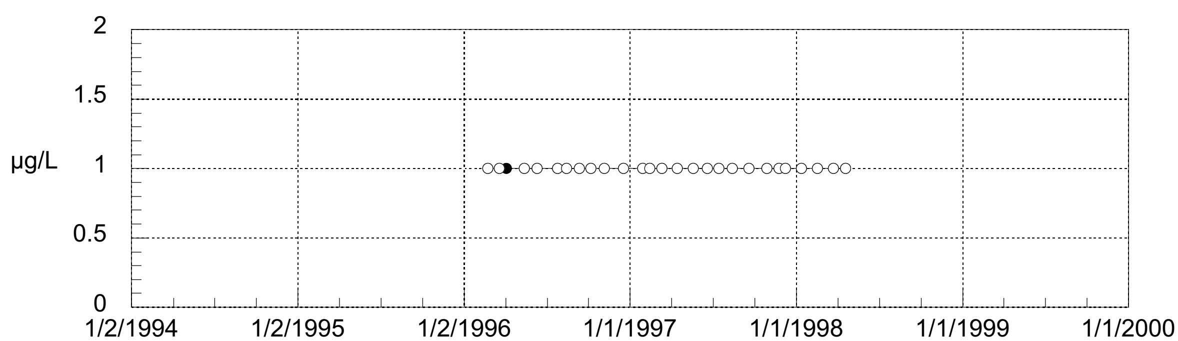
Colusa Basin Drain (NAWQA)

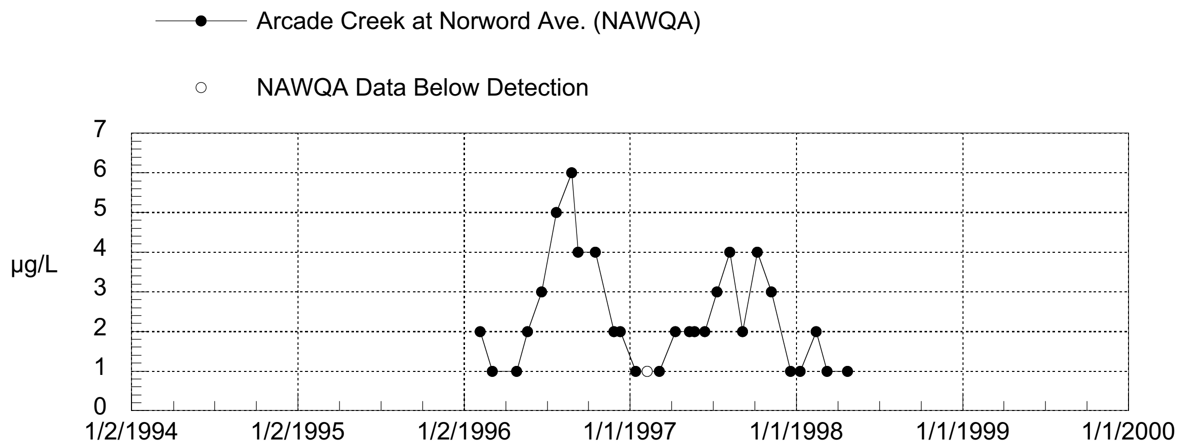
NAWQA Data Below Detection

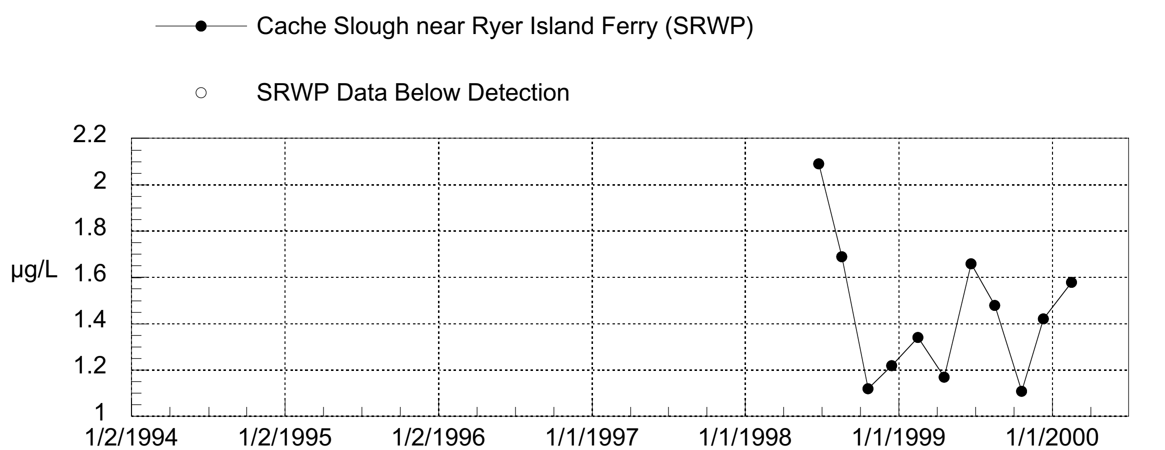


Feather River near Nicolaus (NAWQA)

NAWQA Data Below Detection







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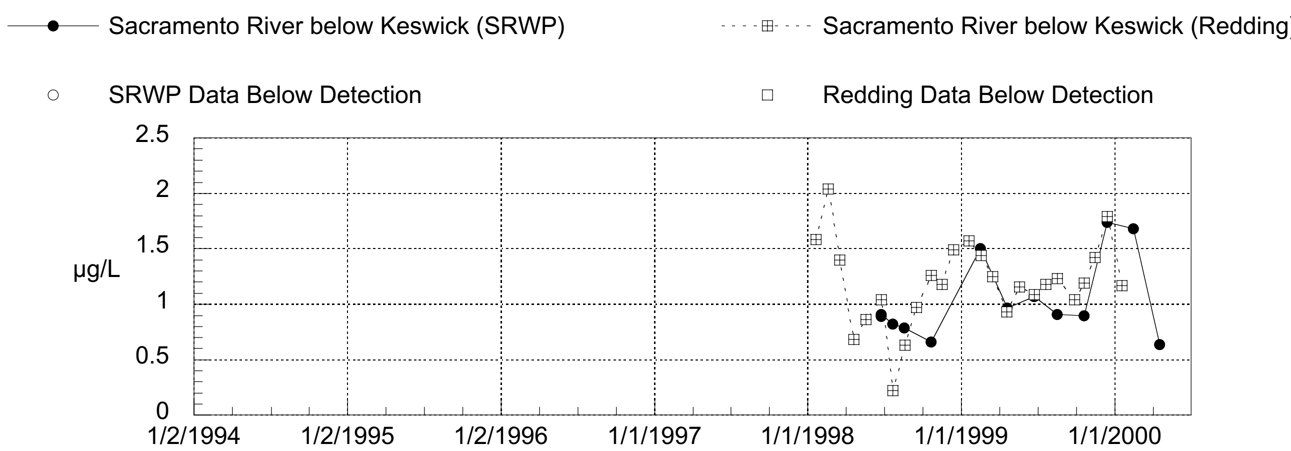

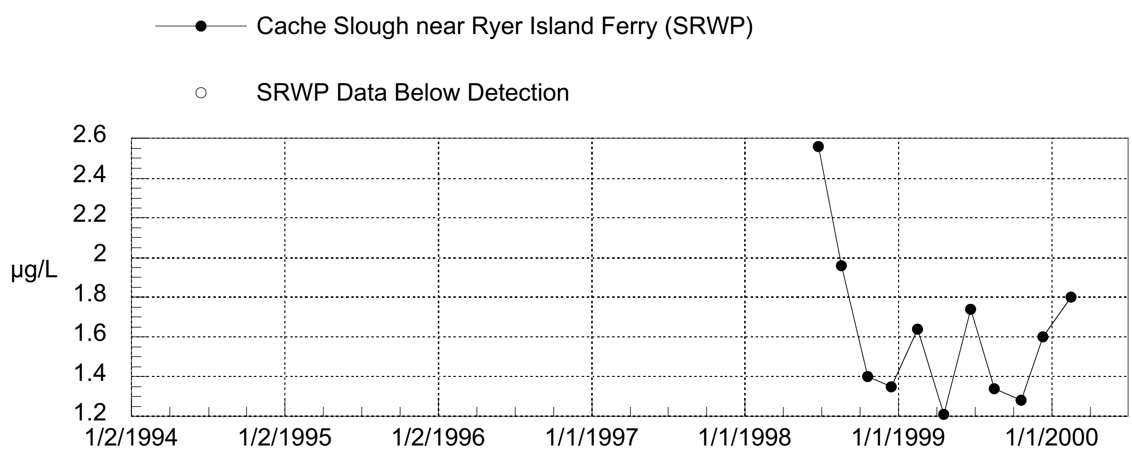

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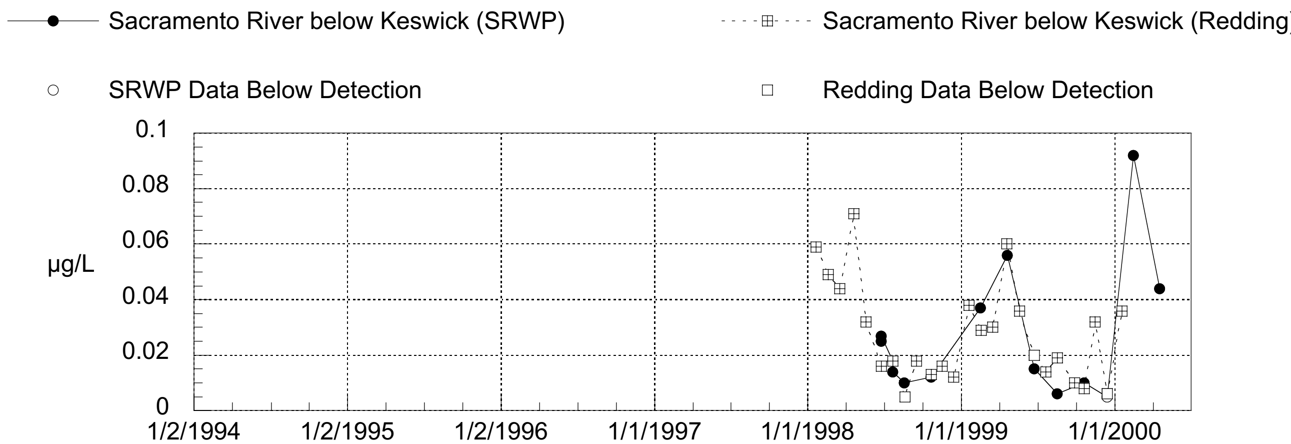
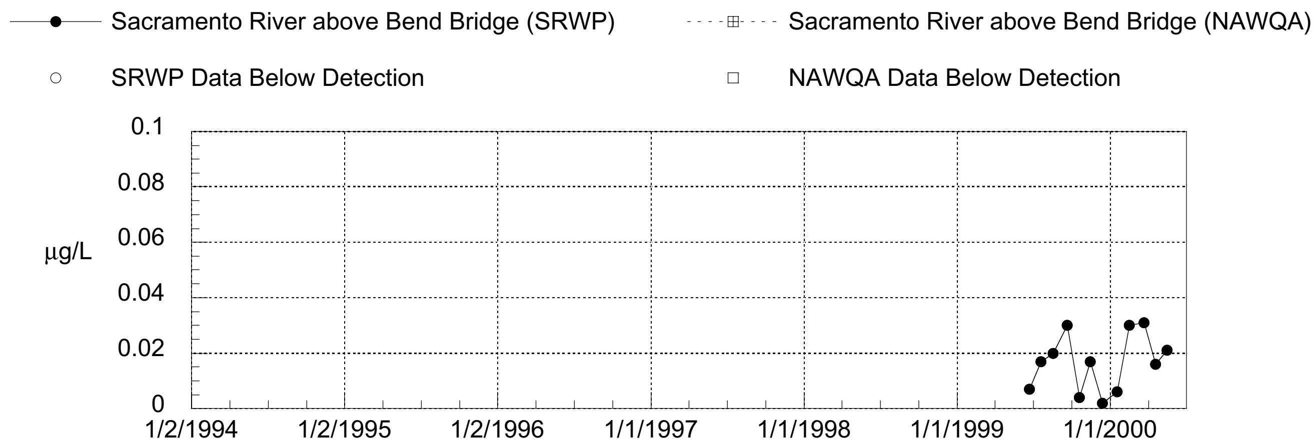
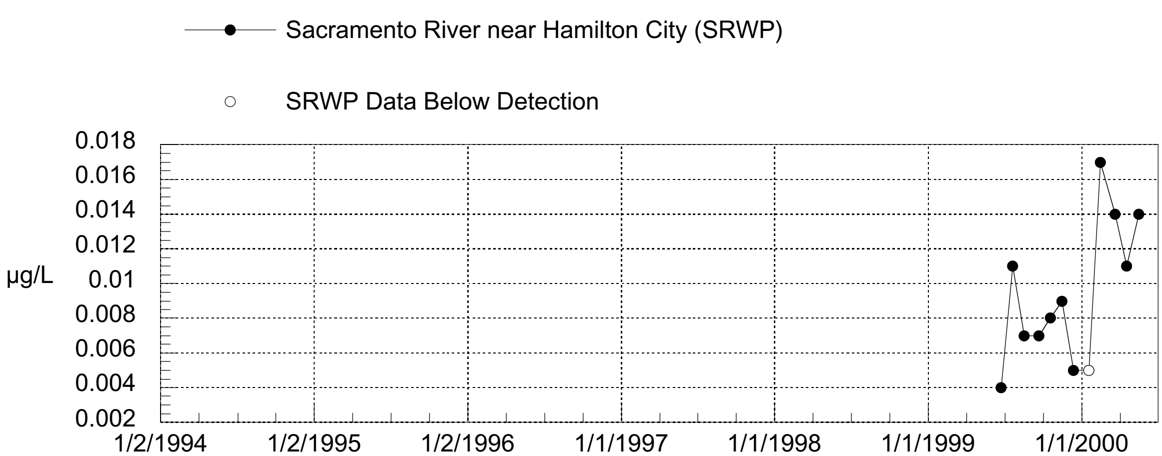
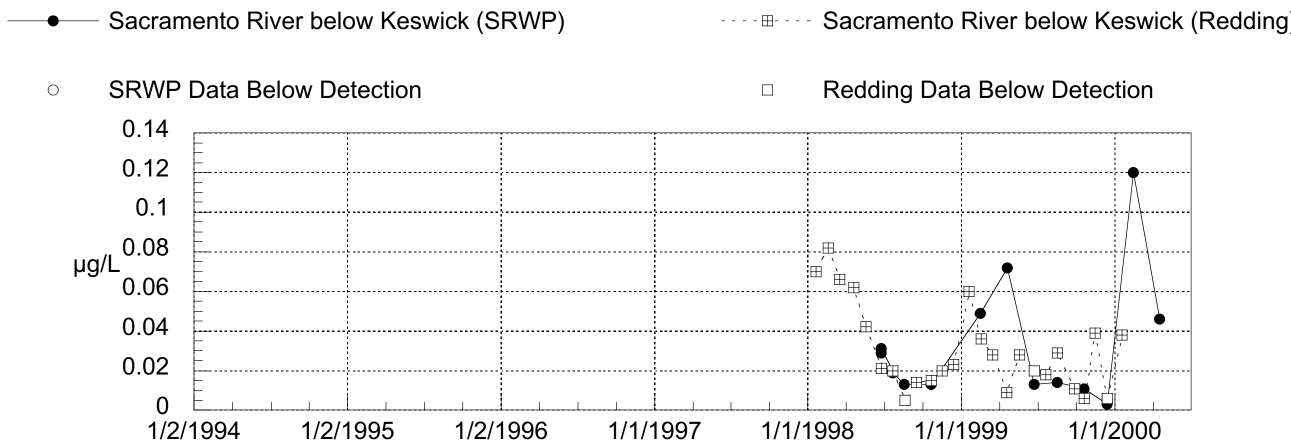
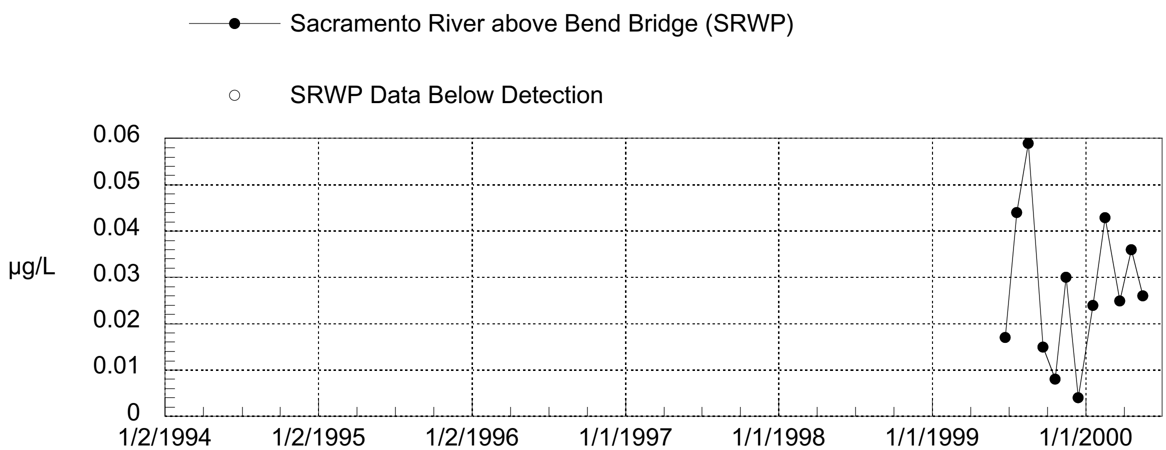
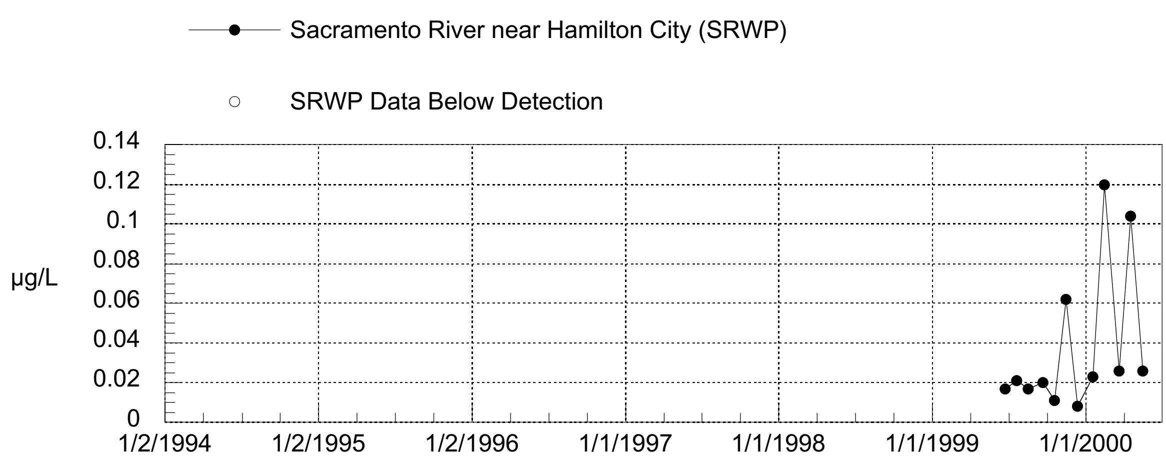

Sacramento River below Keswick (SRWP)
Sacramento River below Keswick (Redding)
SRWP Data Below Detection
Redding Data Below Detection
µg/L
0.1
0.08
0.06
0.04
0.02
0
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000

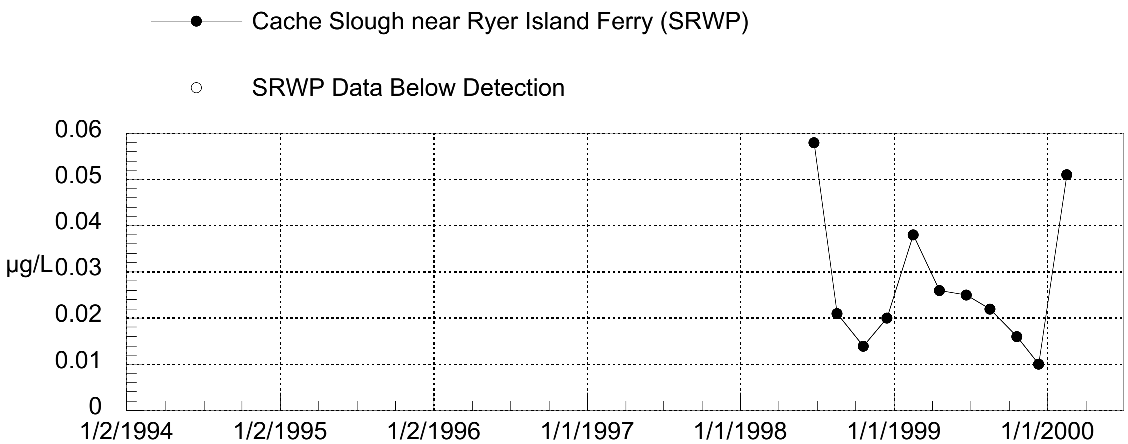

Sacramento River above Bend Bridge (SRWP)
Sacramento River above Bend Bridge (NAWQA)
SRWP Data Below Detection
NAWQA Data Below Detection
µg/L
0.1
0.08
0.06
0.04
0.02
0
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000


Sacramento River near Hamilton City (SRWP)
SRWP Data Below Detection
µg/L
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000


Sacramento River below Keswick (SRWP)
Sacramento River below Keswick (Redding)
SRWP Data Below Detection
Redding Data Below Detection
µg/L
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000


Sacramento River above Bend Bridge (SRWP)
SRWP Data Below Detection
µg/L
0.06
0.05
0.04
0.03
0.02
0.01
0
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000


Sacramento River near Hamilton City (SRWP)
SRWP Data Below Detection
µg/L
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000



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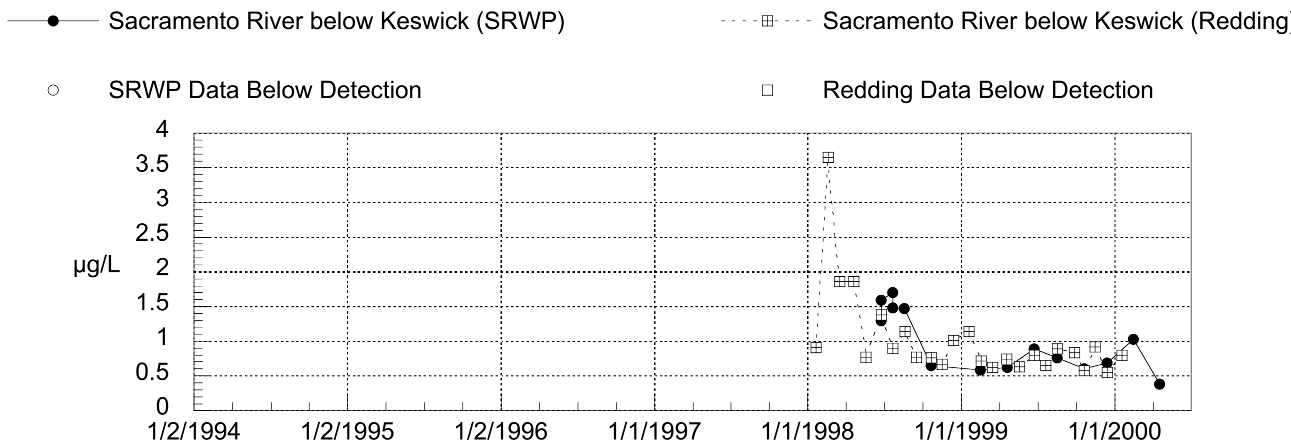

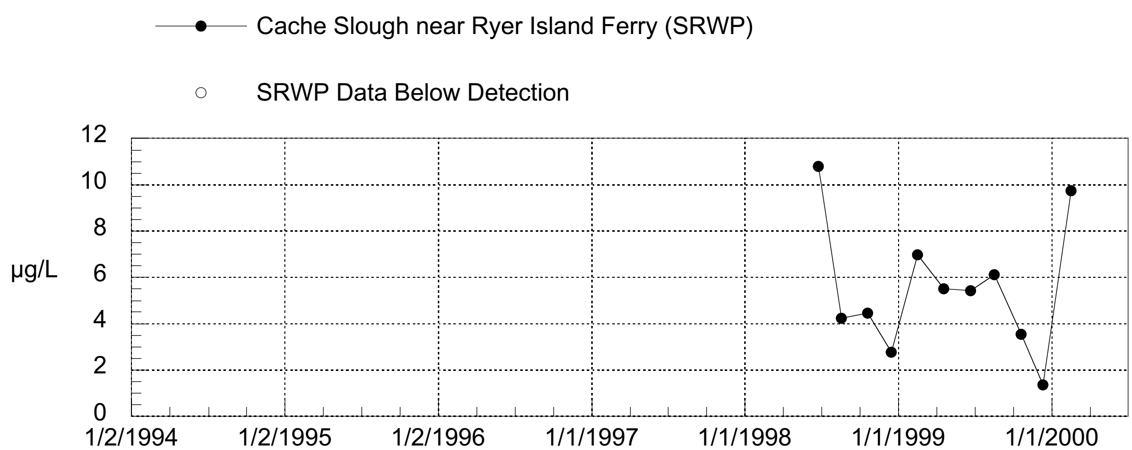

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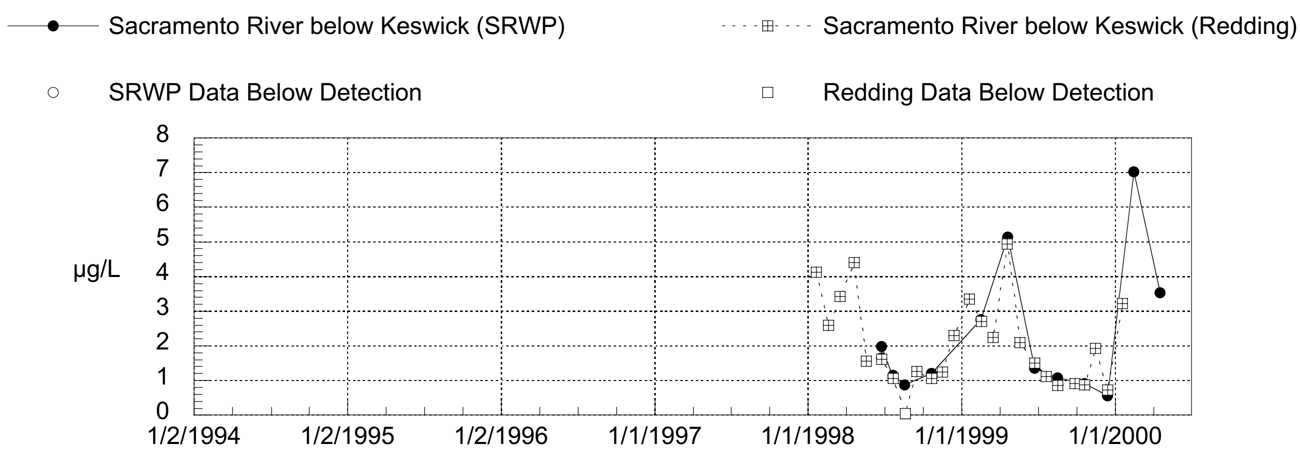
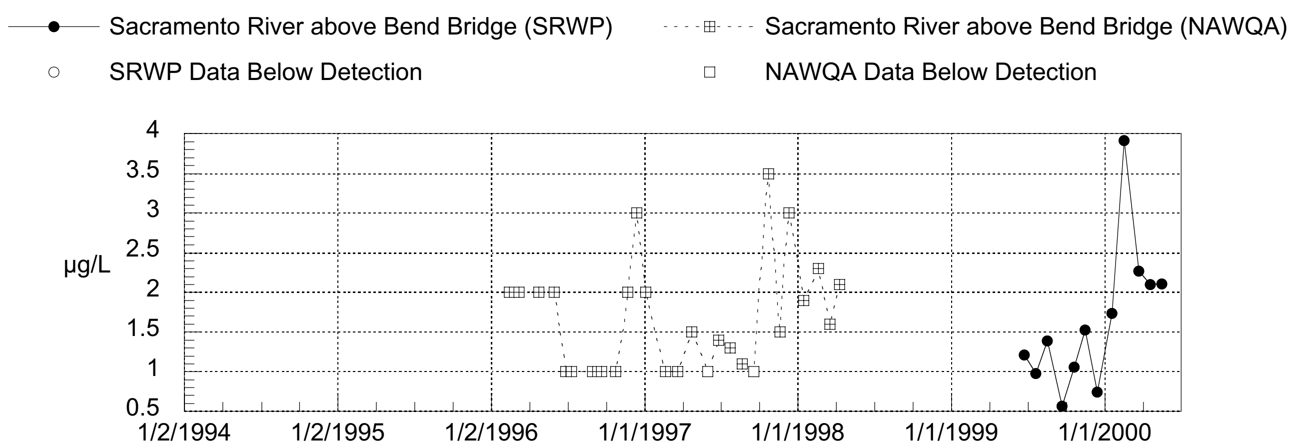
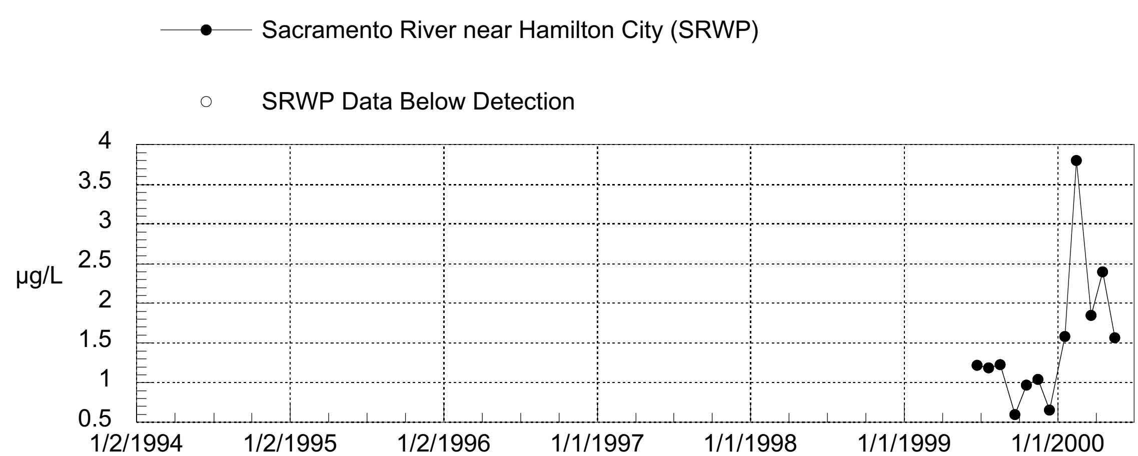
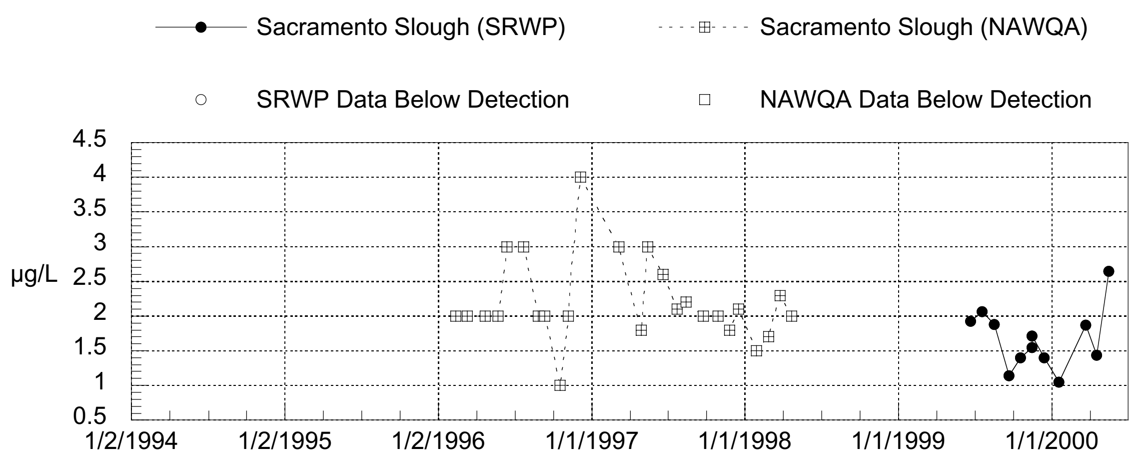
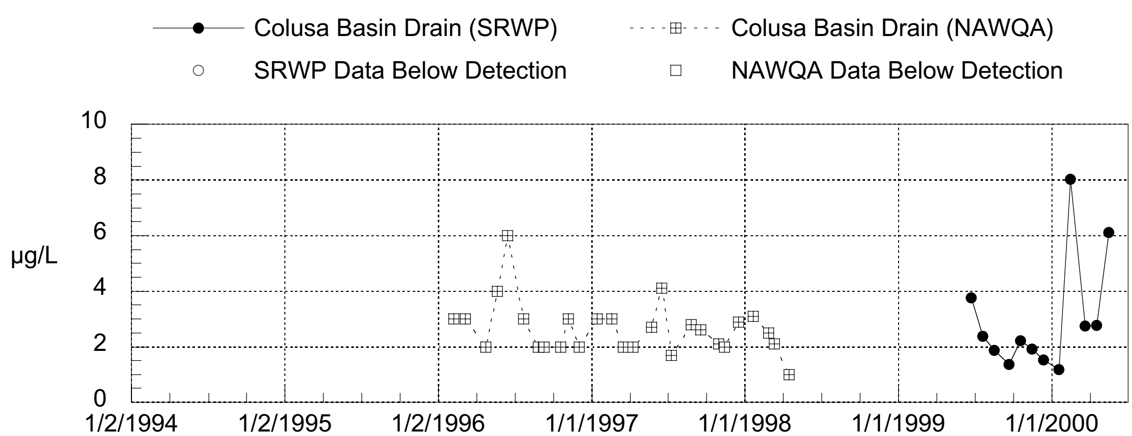
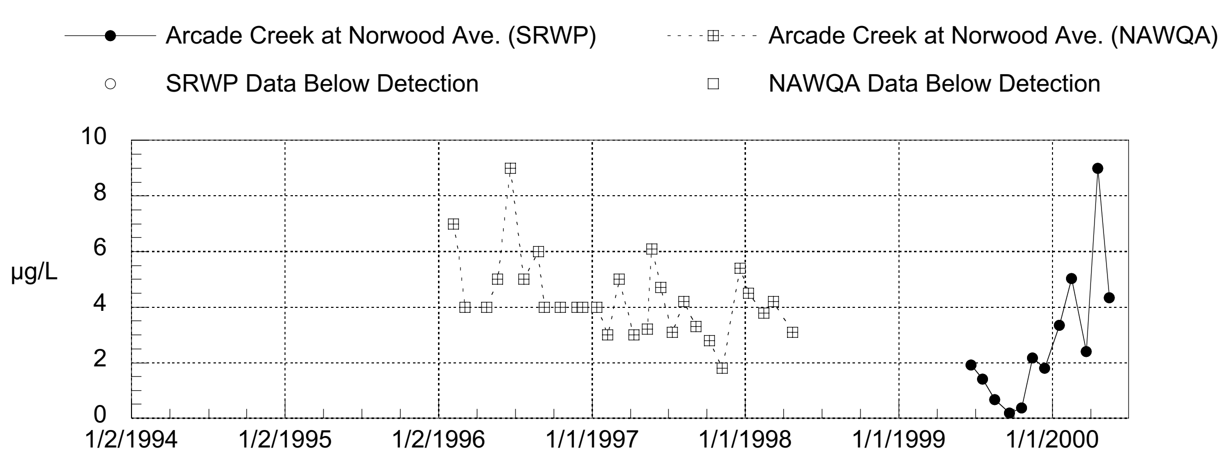

Sacramento River below Keswick (SRWP)
Sacramento River below Keswick (Redding)
SRWP Data Below Detection
Redding Data Below Detection
µg/L
8
7
6
5
4
3
2
1
0
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000

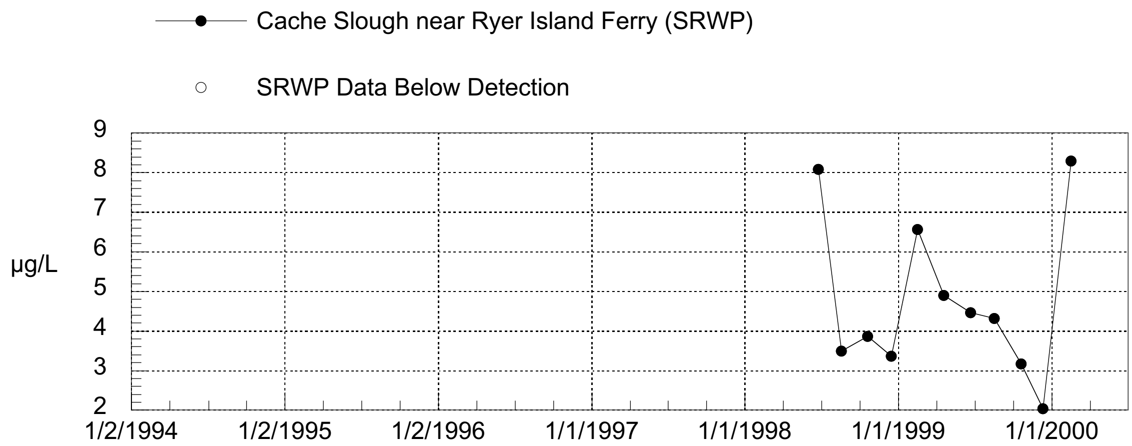

Sacramento River above Bend Bridge (SRWP)
Sacramento River above Bend Bridge (NAWQA)
SRWP Data Below Detection
NAWQA Data Below Detection
µg/L
4
3.5
3
2.5
2
1.5
1
0.5
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000


Sacramento River near Hamilton City (SRWP)
SRWP Data Below Detection
µg/L
4
3.5
3
2.5
2
1.5
1
0.5
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000


Sacramento Slough (SRWP)
Sacramento Slough (NAWQA)
SRWP Data Below Detection
NAWQA Data Below Detection
µg/L
4.5
4
3.5
3
2.5
2
1.5
1
0.5
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000


Colusa Basin Drain (SRWP)
Colusa Basin Drain (NAWQA)
SRWP Data Below Detection
NAWQA Data Below Detection
µg/L
10
8
6
4
2
0
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000


Arcade Creek at Norwood Ave. (SRWP)
Arcade Creek at Norwood Ave. (NAWQA)
SRWP Data Below Detection
NAWQA Data Below Detection
µg/L
10
8
6
4
2
0
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000



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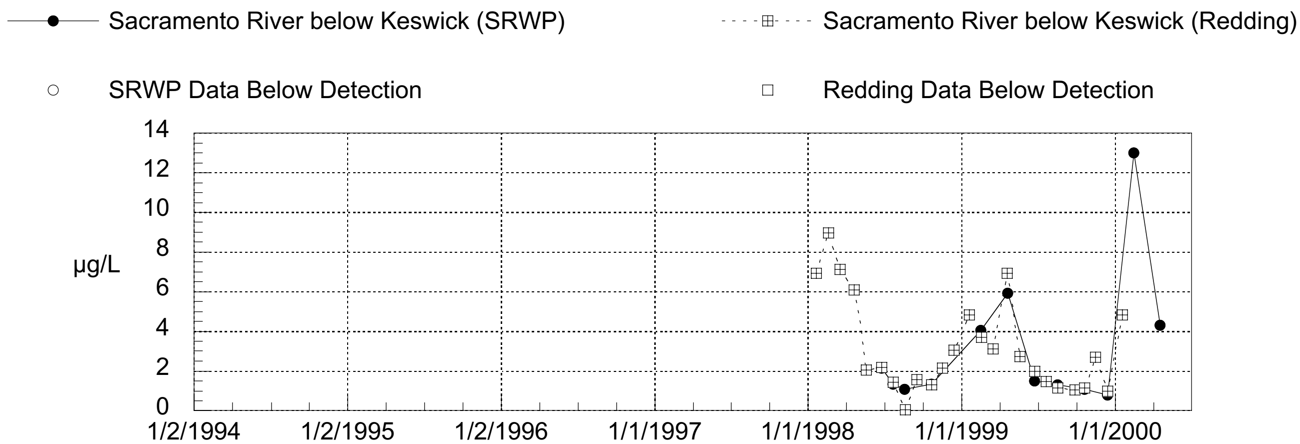
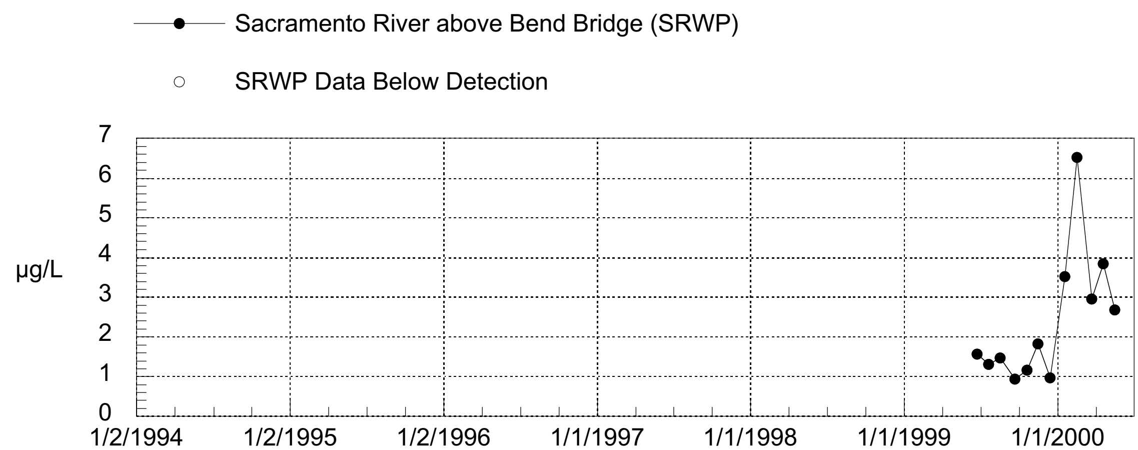
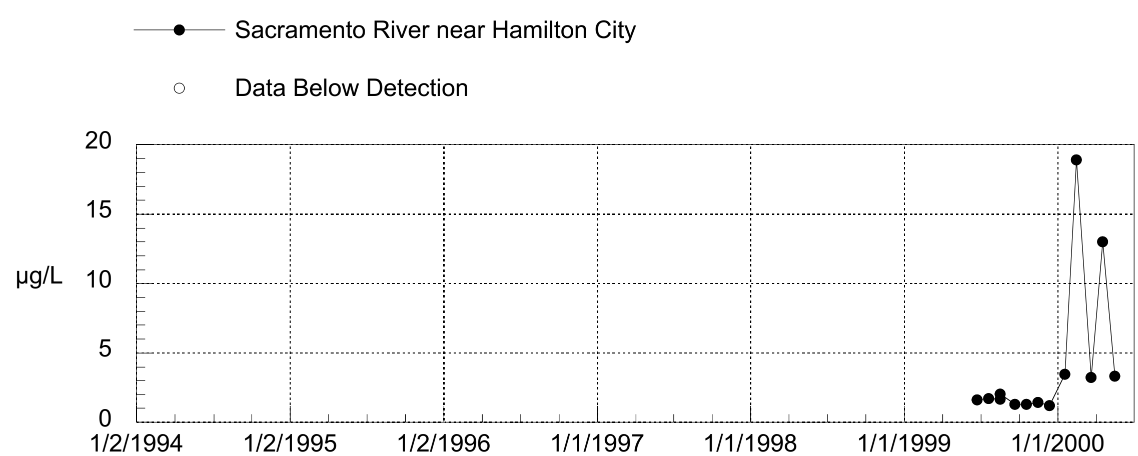
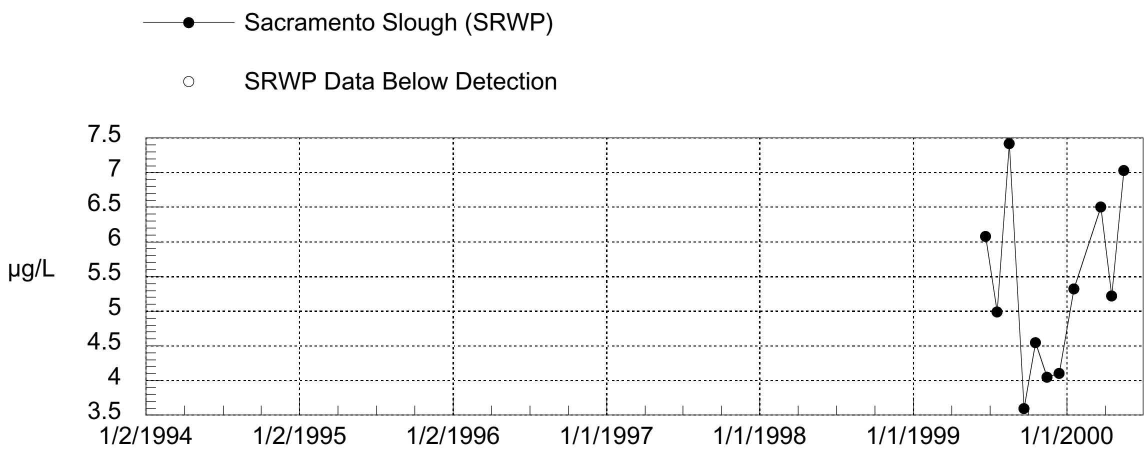

Sacramento River below Keswick (SRWP)
Sacramento River below Keswick (Redding)
SRWP Data Below Detection
Redding Data Below Detection
µg/L
0
2
4
6
8
10
12
14
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000


Sacramento River above Bend Bridge (SRWP)
SRWP Data Below Detection
µg/L
0
1
2
3
4
5
6
7
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000


Sacramento River near Hamilton City
Data Below Detection
µg/L
0
5
10
15
20
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000


Sacramento Slough (SRWP)
SRWP Data Below Detection
µg/L
7.5
7
6.5
6
5.5
5
4.5
4
3.5
1/2/1994
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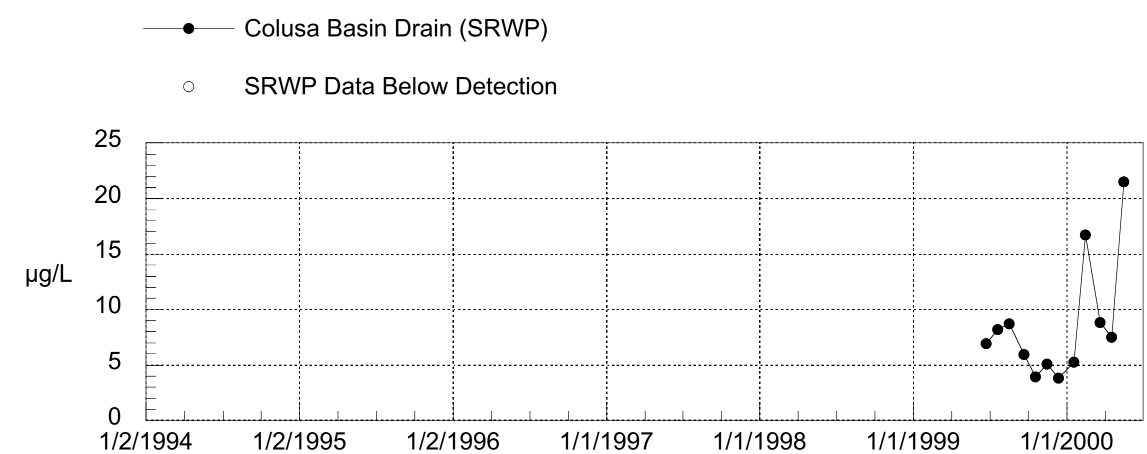
1/1/1999
1/1/2000


Colusa Basin Drain (SRWP)
SRWP Data Below Detection
µg/L
25
20
15
10
5
0
1/2/1994
1/2/1995
1/2/1996
1/1/1997
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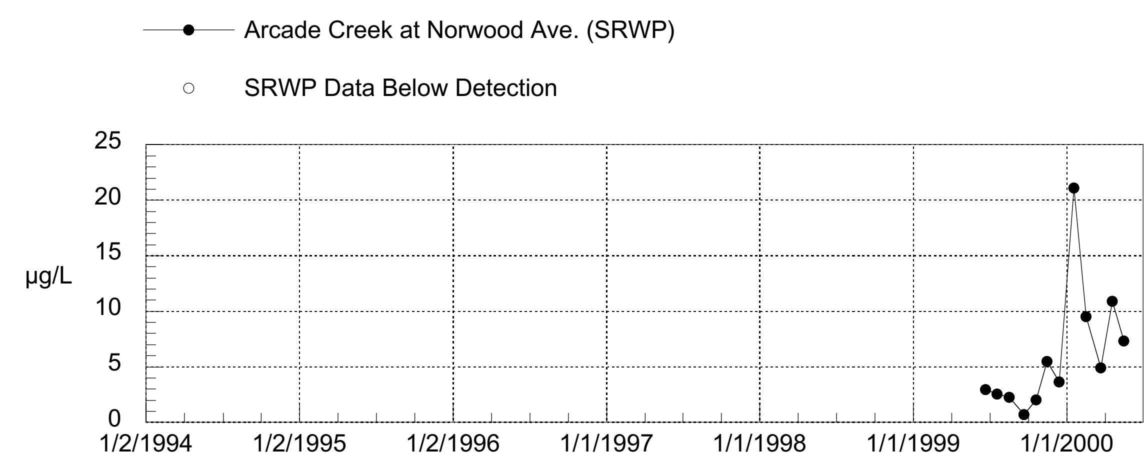
1/1/1999
1/1/2000


Arcade Creek at Norwood Ave. (SRWP)
SRWP Data Below Detection
µg/L
25
20
15
10
5
0
1/2/1994
1/2/1995
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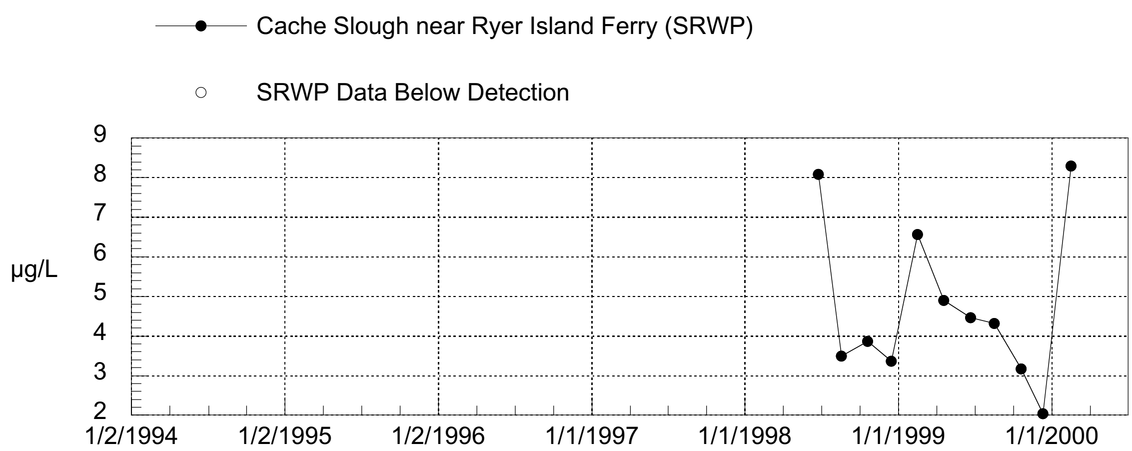
1/1/1999
1/1/2000



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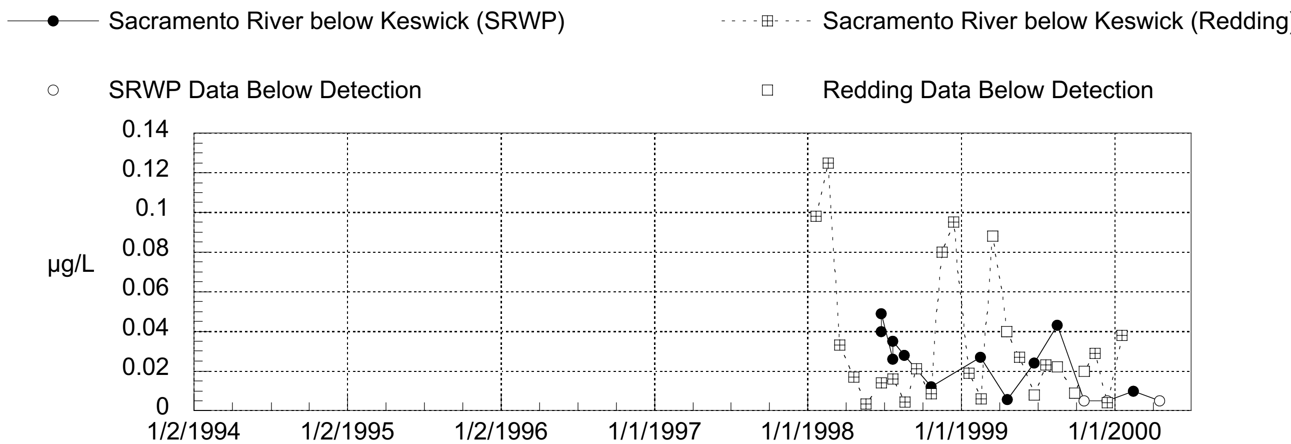

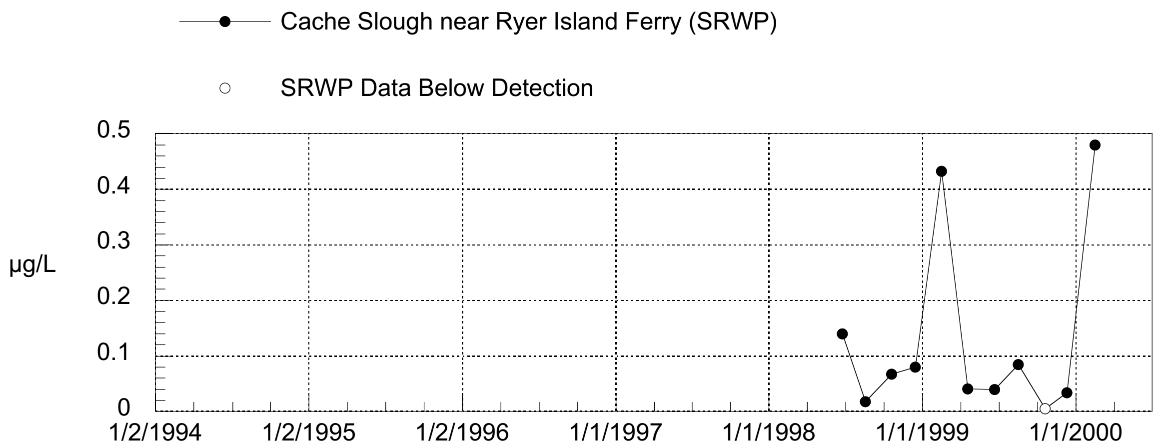

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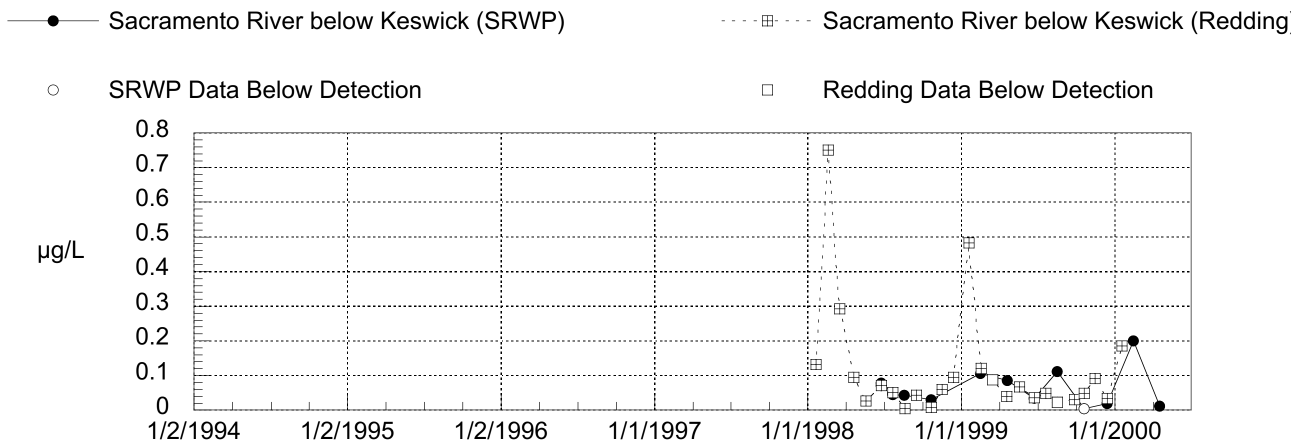

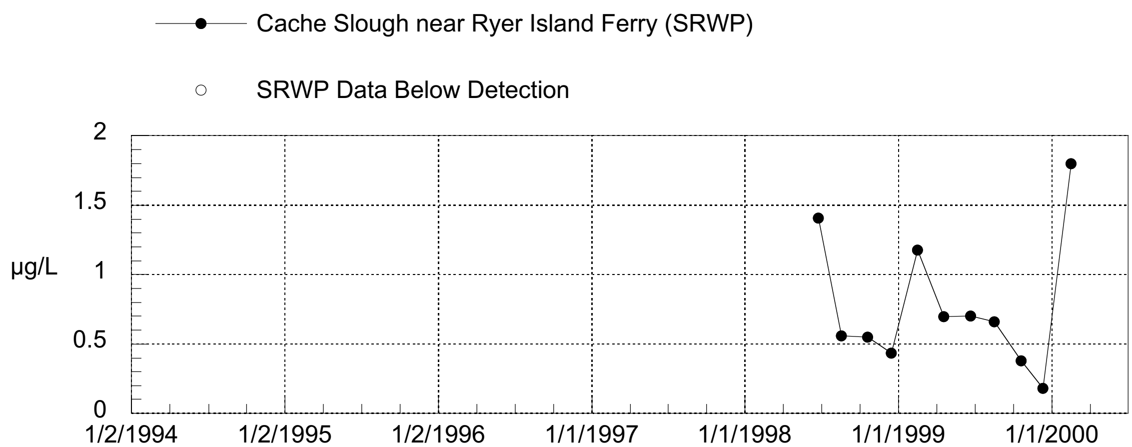

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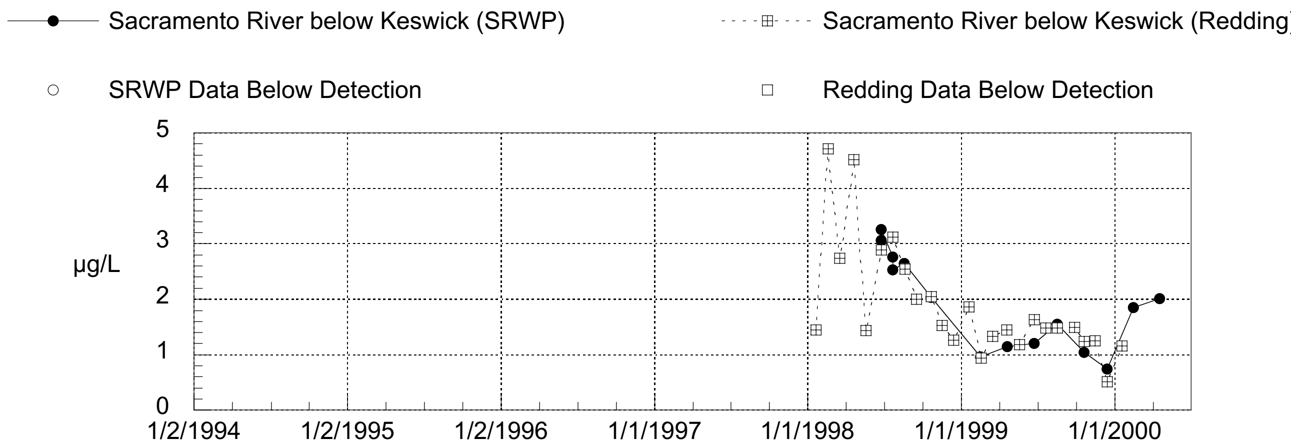

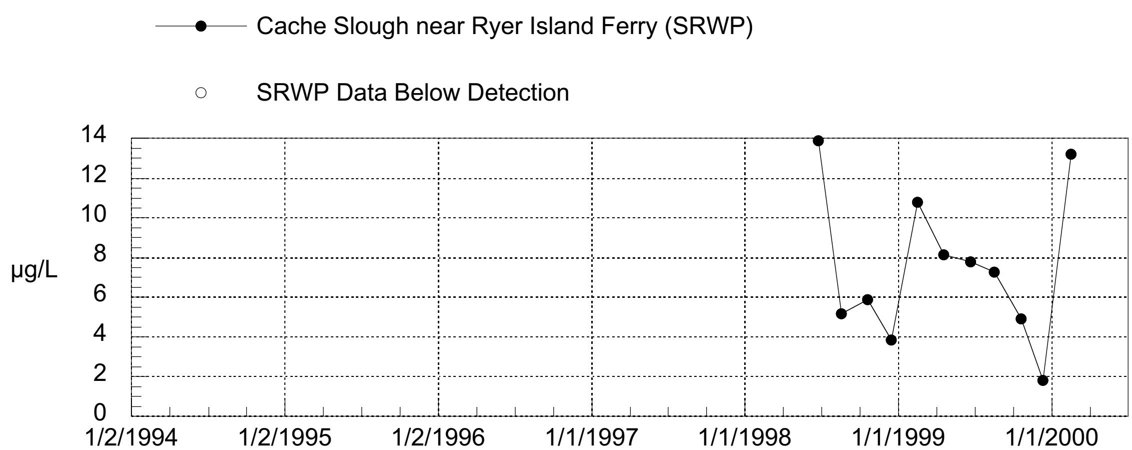

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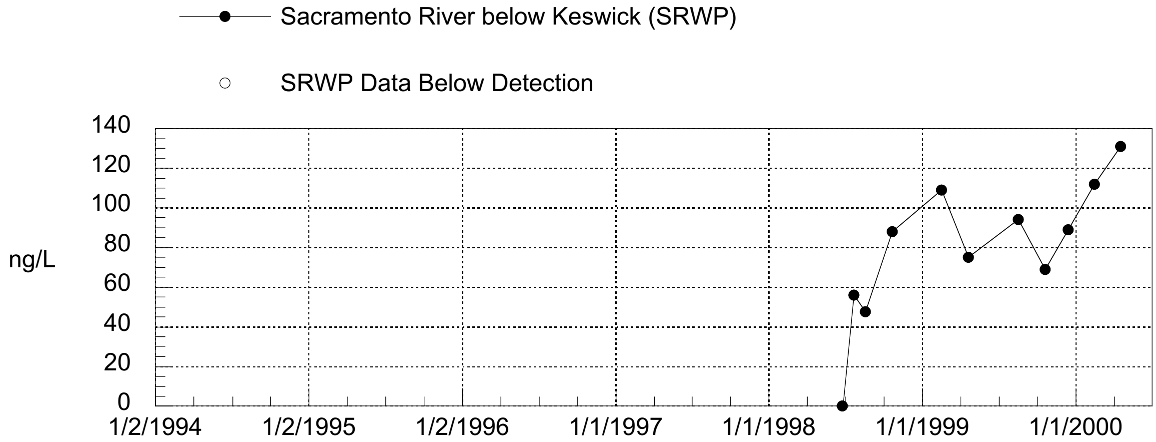

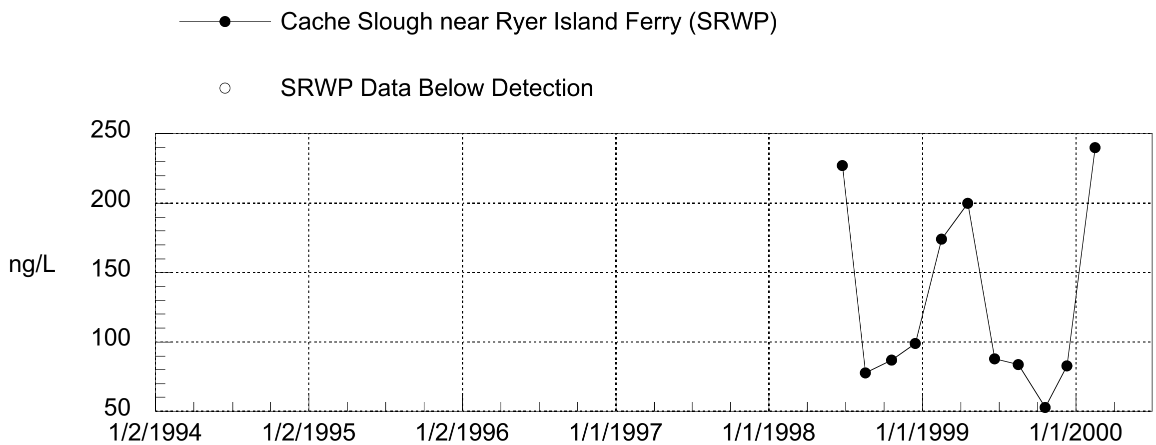

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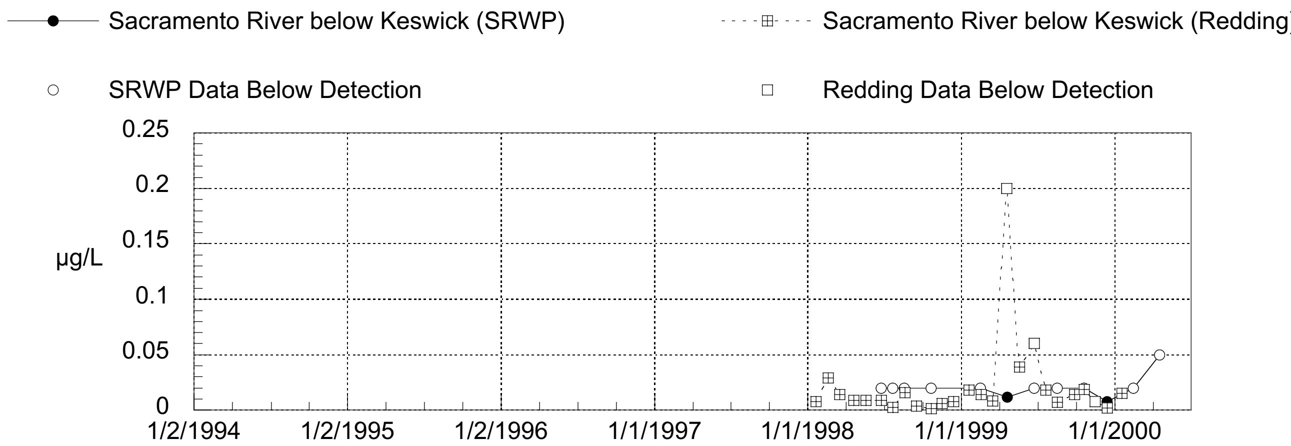

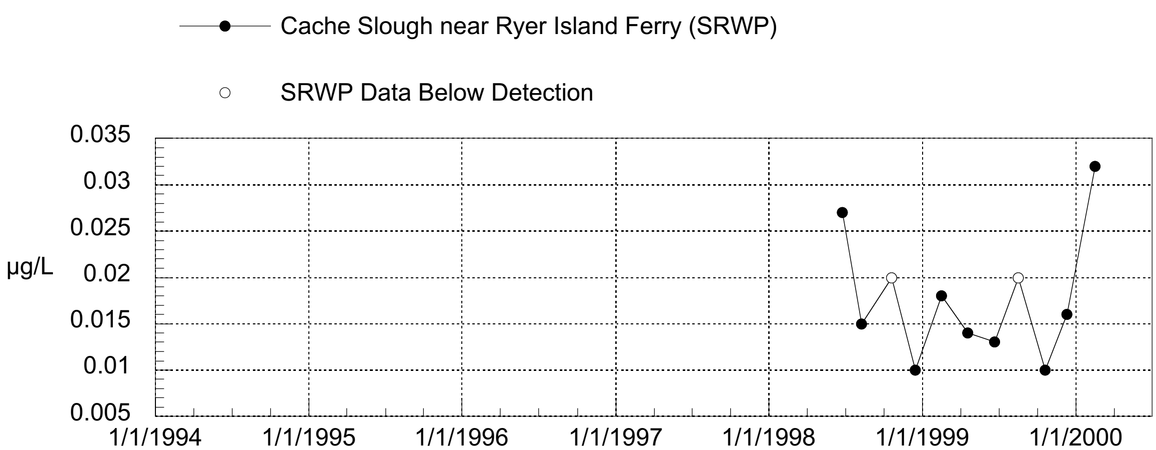

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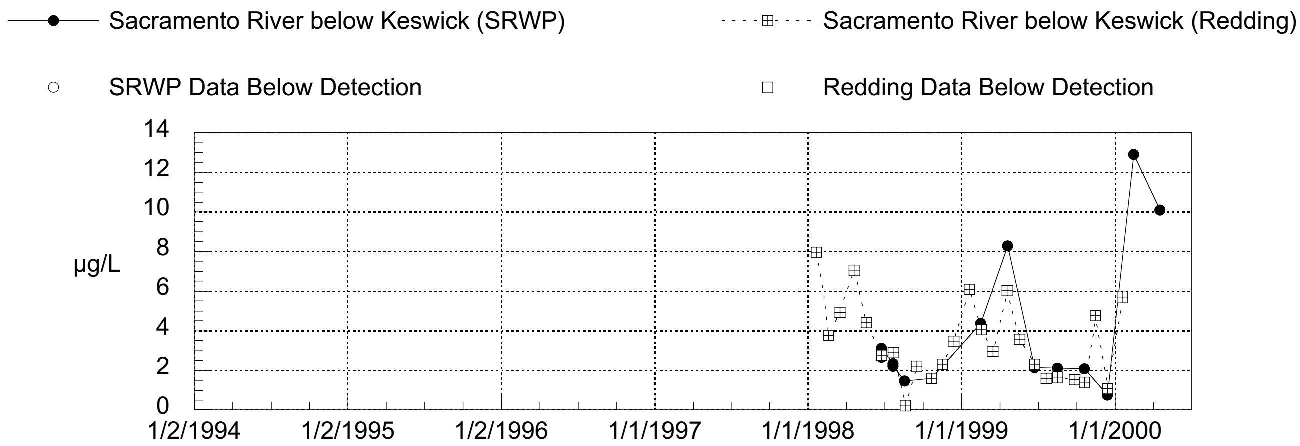
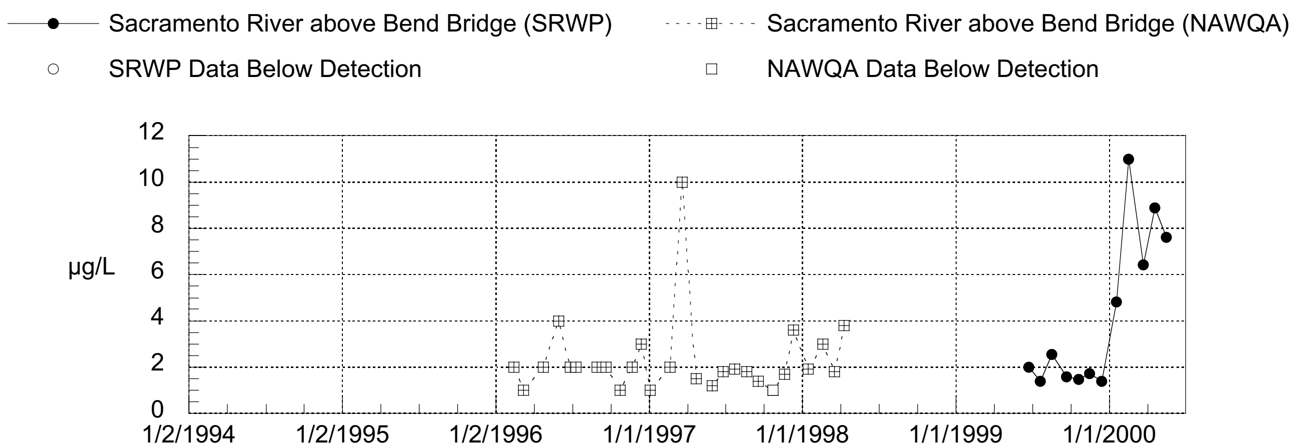
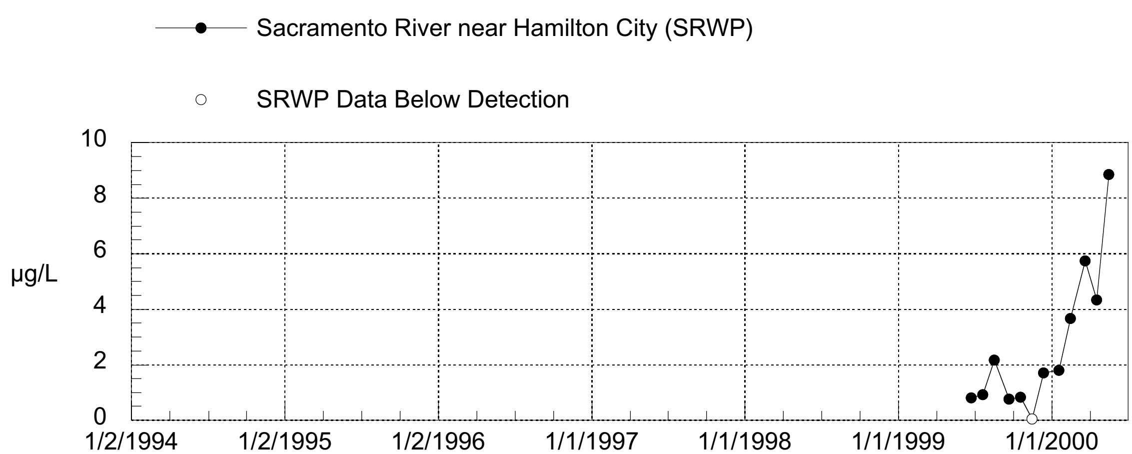
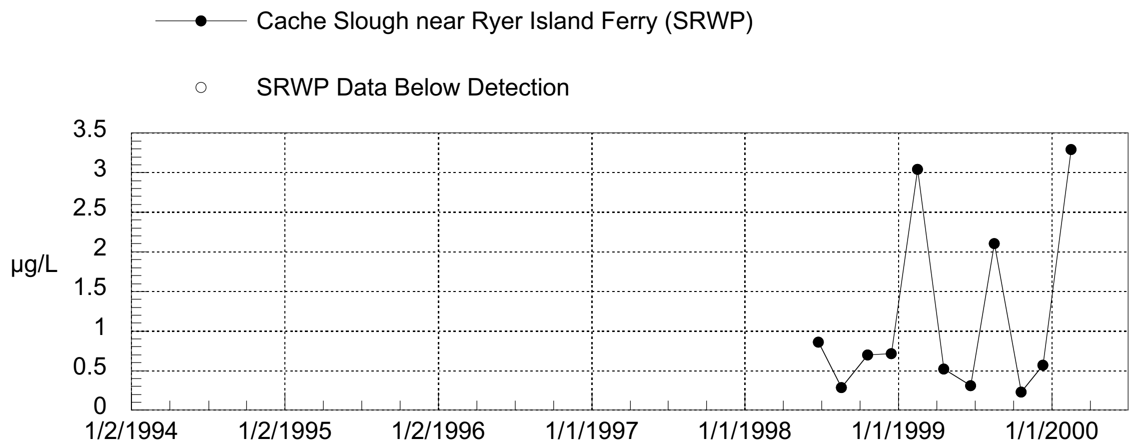

Sacramento River below Keswick (SRWP)
Sacramento River below Keswick (Redding)
SRWP Data Below Detection
Redding Data Below Detection
µg/L
14
12
10
8
6
4
2
0
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000


Sacramento River above Bend Bridge (SRWP)
Sacramento River above Bend Bridge (NAWQA)
SRWP Data Below Detection
NAWQA Data Below Detection
µg/L
12
10
8
6
4
2
0
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000


Sacramento River near Hamilton City (SRWP)
SRWP Data Below Detection
µg/L
10
8
6
4
2
0
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000



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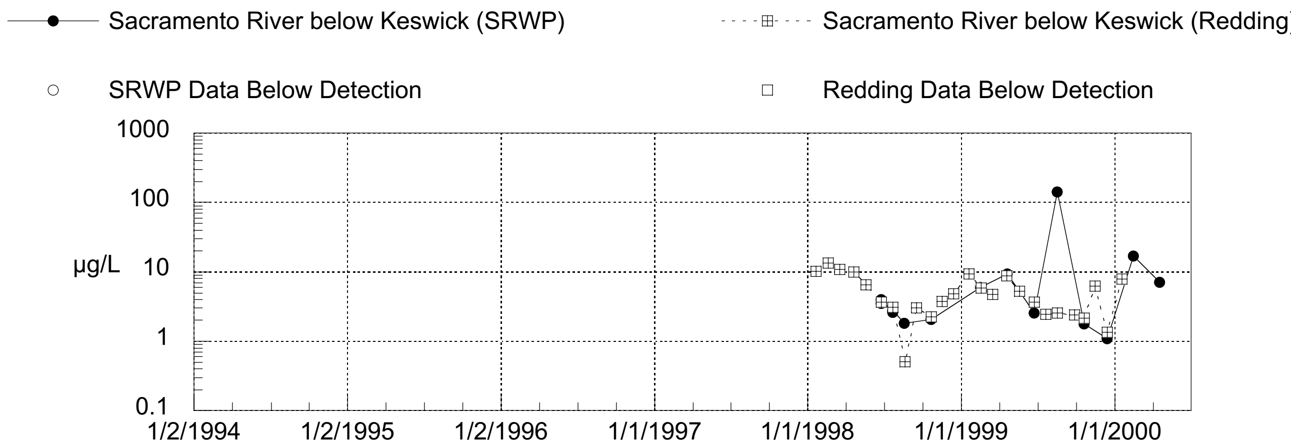
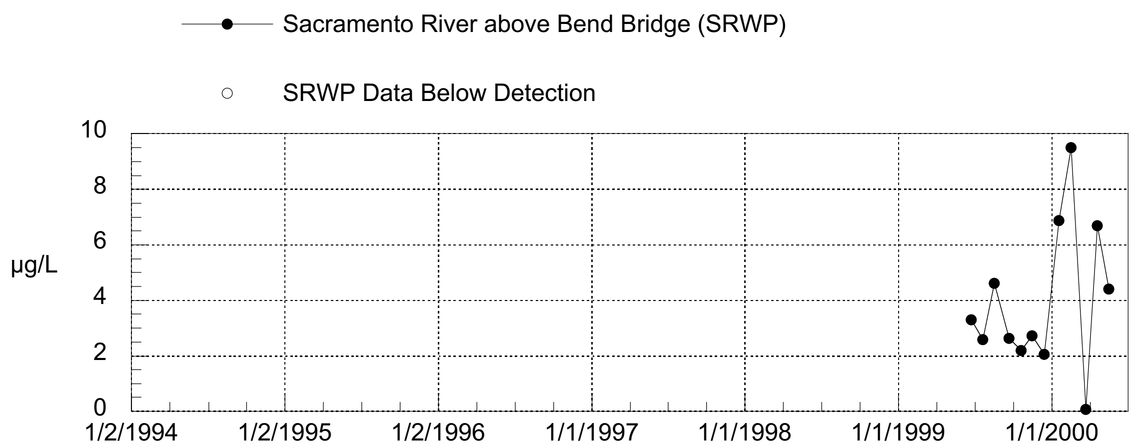
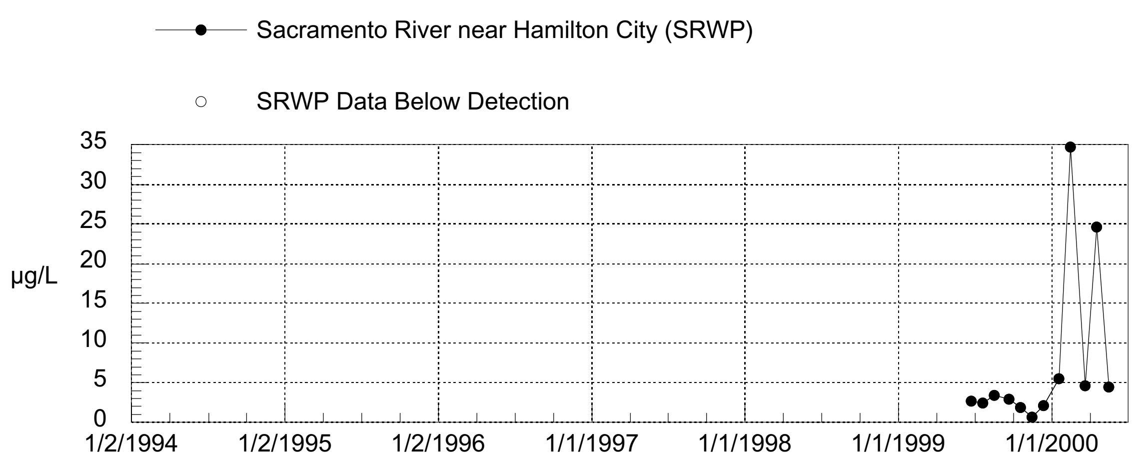
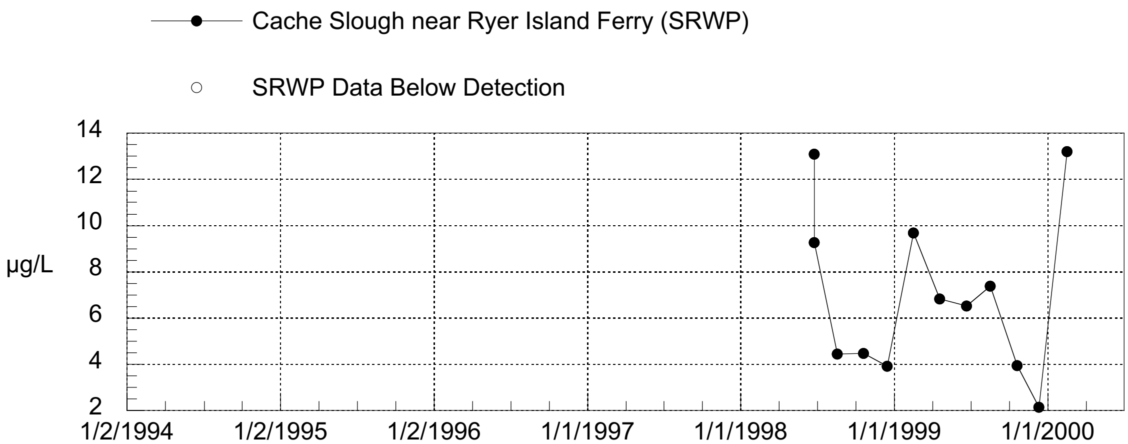
Space Intentionally Blank


Sacramento River below Keswick (SRWP)
Sacramento River below Keswick (Redding)
SRWP Data Below Detection
Redding Data Below Detection
1000
100
10
1
0.1
µg/L
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000


Sacramento River above Bend Bridge (SRWP)
SRWP Data Below Detection
10
8
6
4
2
0
µg/L
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000


Sacramento River near Hamilton City (SRWP)
SRWP Data Below Detection
35
30
25
20
15
10
5
0
µg/L
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000



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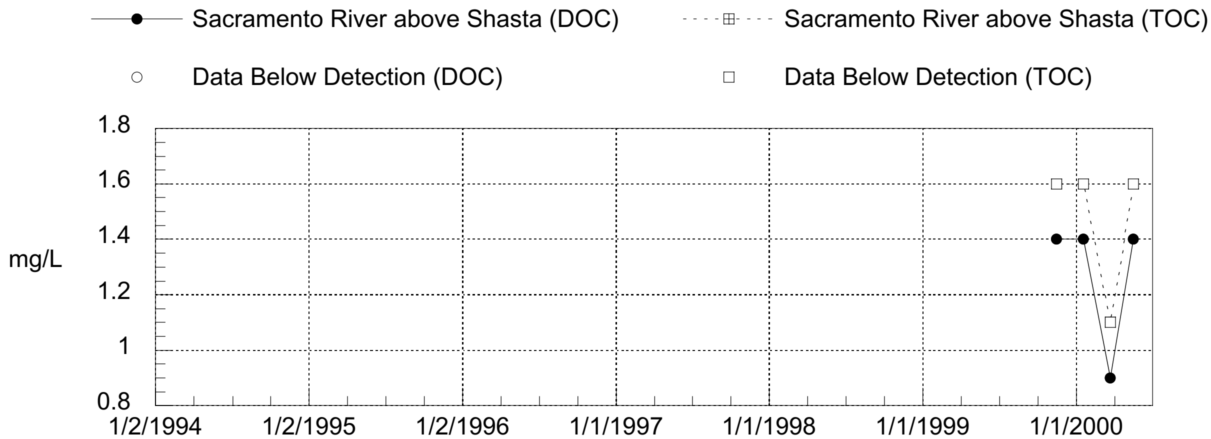
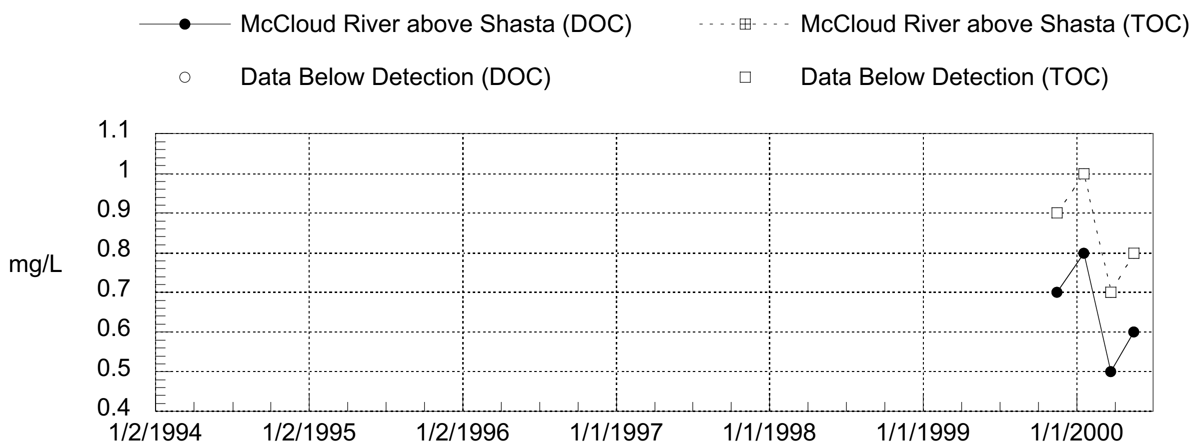
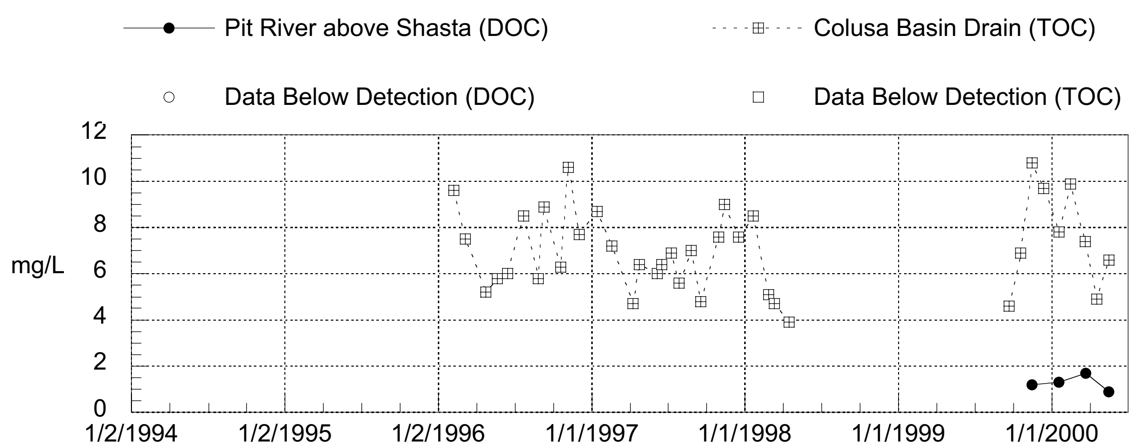
Time Series Plots of Monitoring Data: Drinking Water Parameters

ORGANIC CARBON CONCENTRATIONS IN WATER



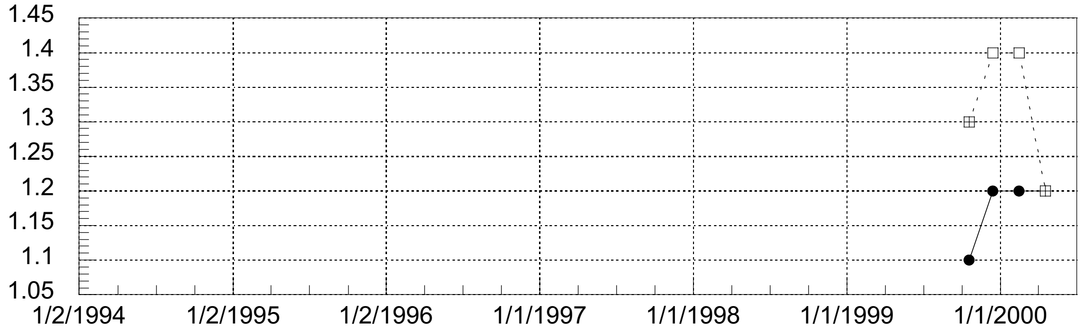




ORGANIC CARBON CONCENTRATIONS IN WATER

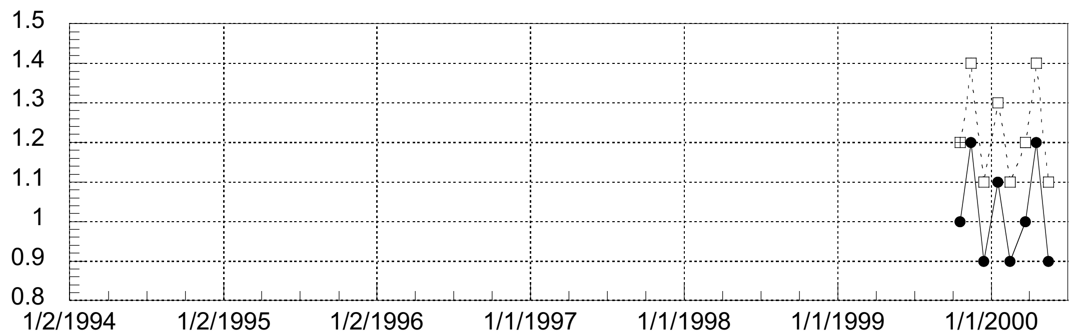
Spring Ck PP Discharge to Keswick Res. (DOC)   Spring Ck PP Discharge to Keswick Res. (TOC)

Data Below Detection (DOC)   Data Below Detection (TOC)



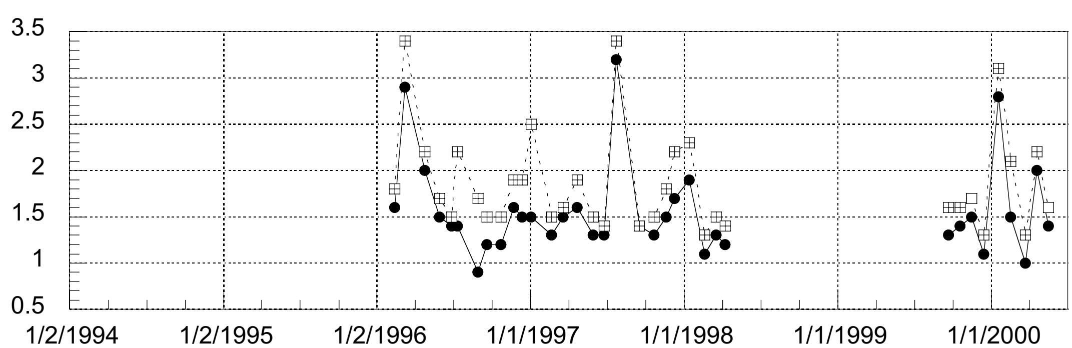
Sacramento River below Keswick Res. (DOC)   Sacramento River below Keswick Res. (TOC)

Data Below Detection (DOC)   Data Below Detection (TOC)

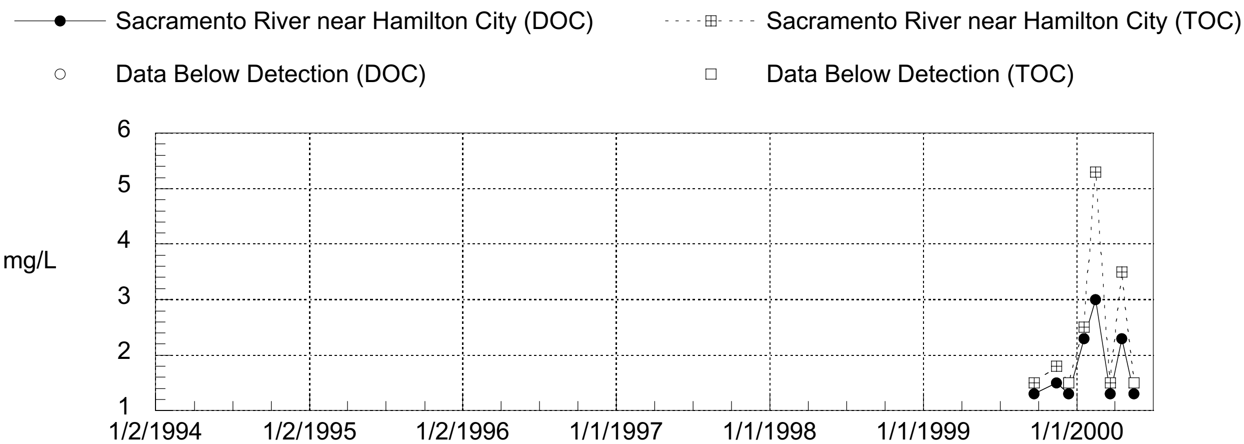


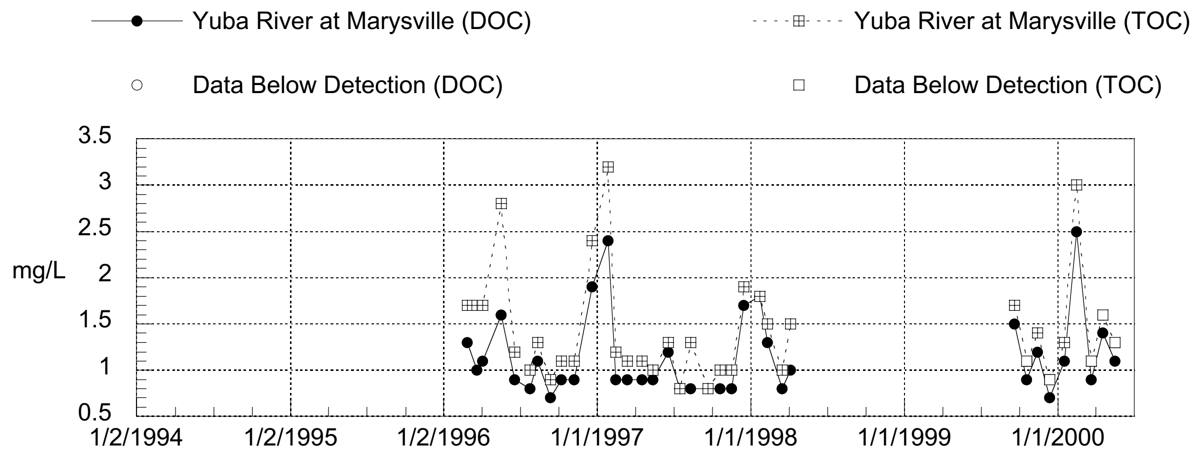
Sacramento River above Bend Br. (DOC)   Sacramento River above Bend Bridge (TOC)

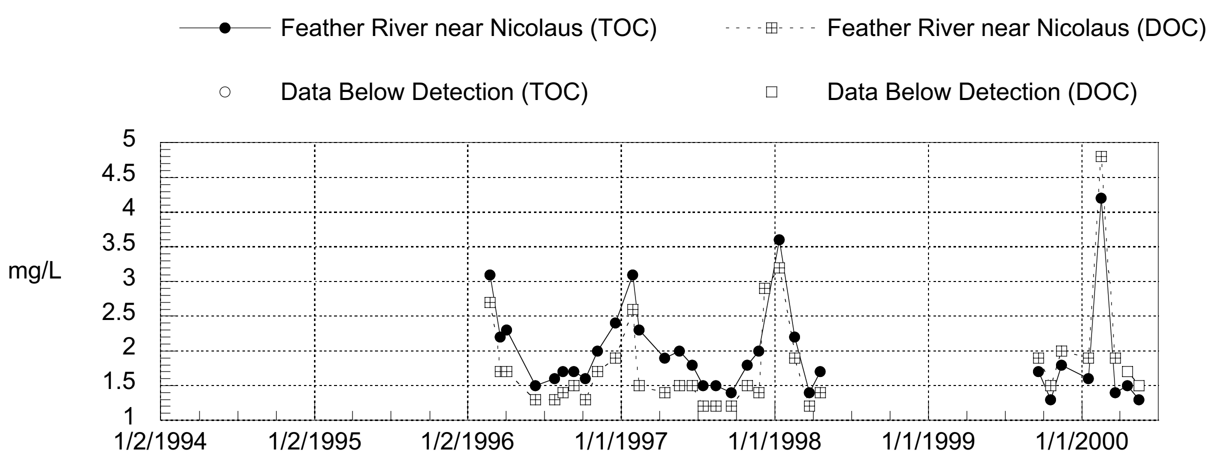
Data Below Detection (DOC)   Data Below Detection (TOC)



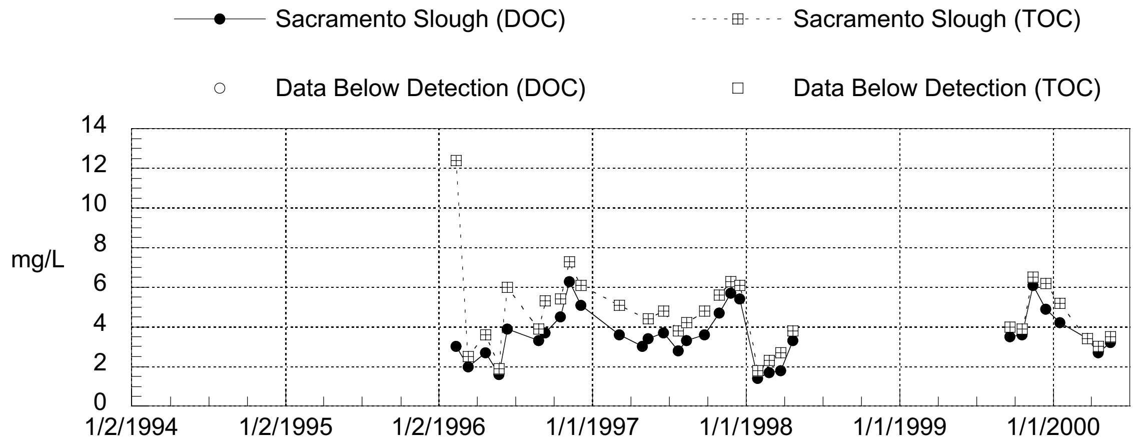
ORGANIC CARBON CONCENTRATIONS IN WATER

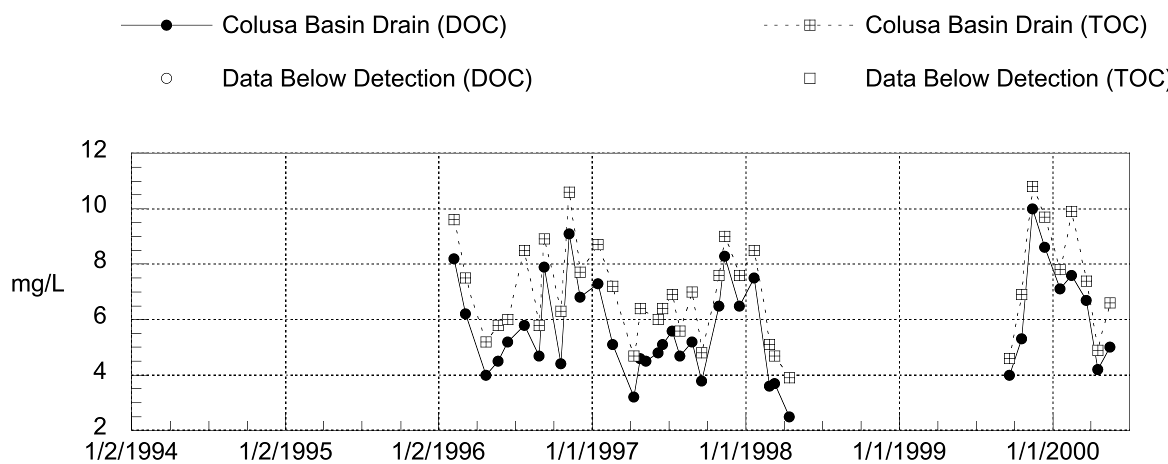


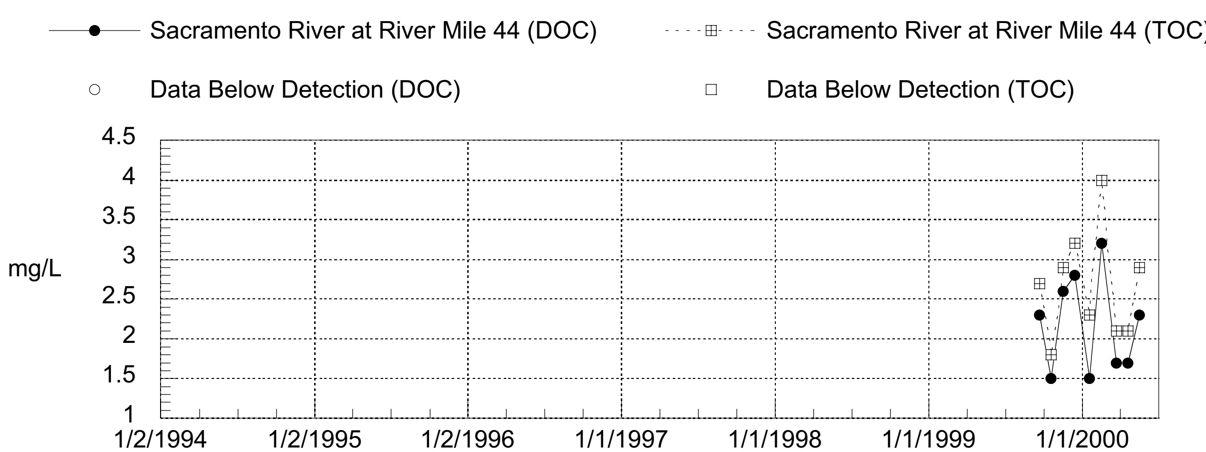




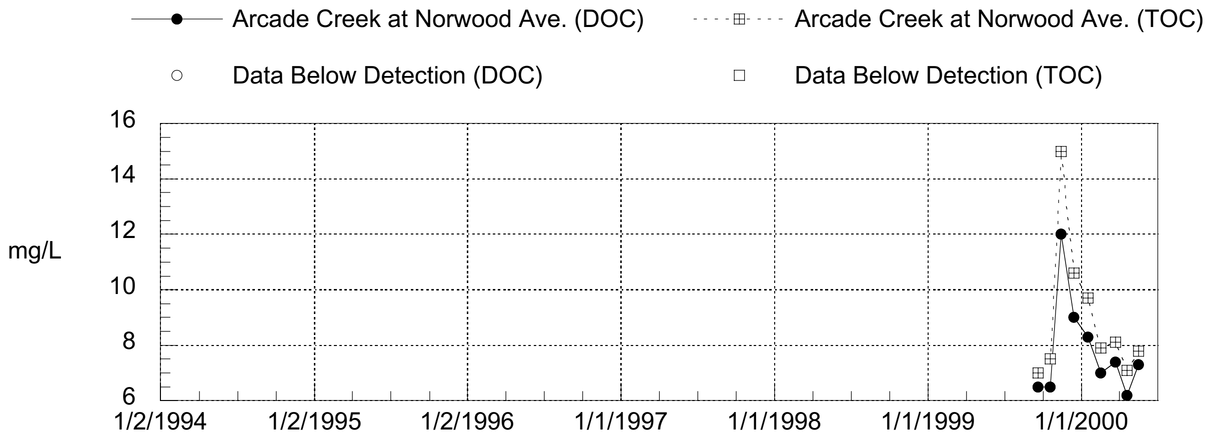
ORGANIC CARBON CONCENTRATIONS IN WATER

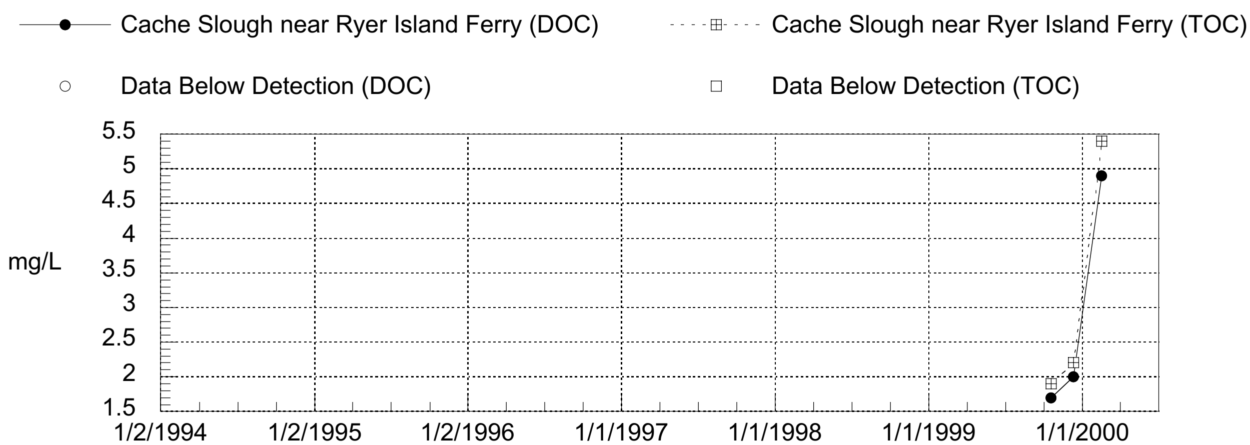






ORGANIC CARBON CONCENTRATIONS IN WATER





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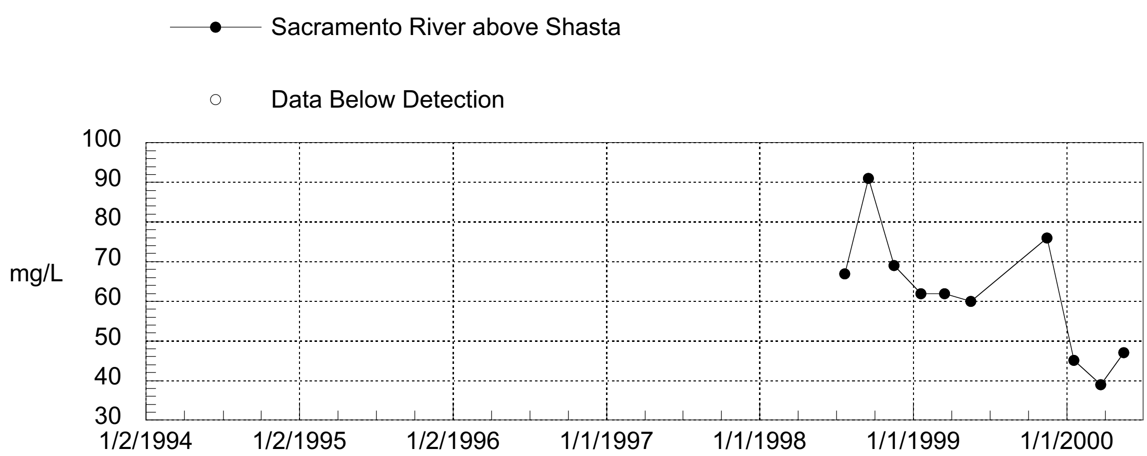
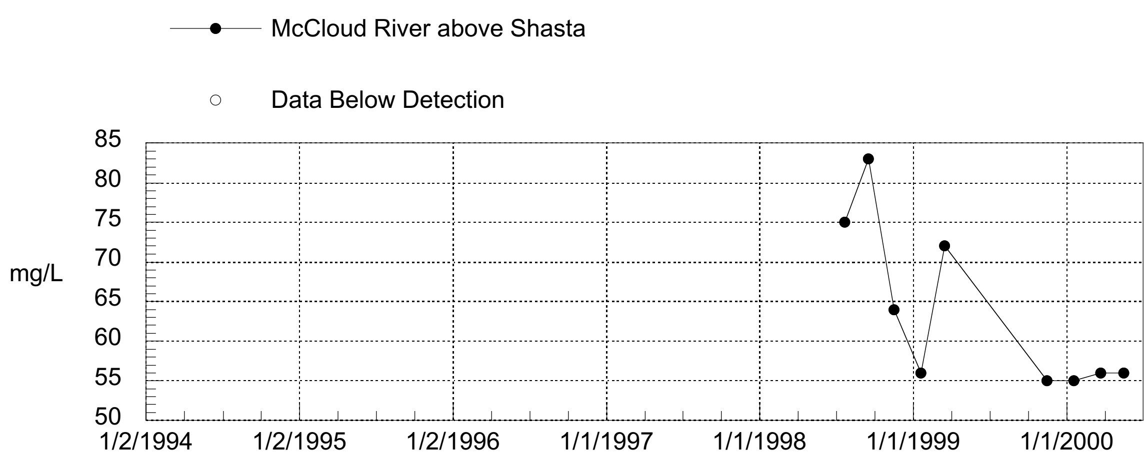
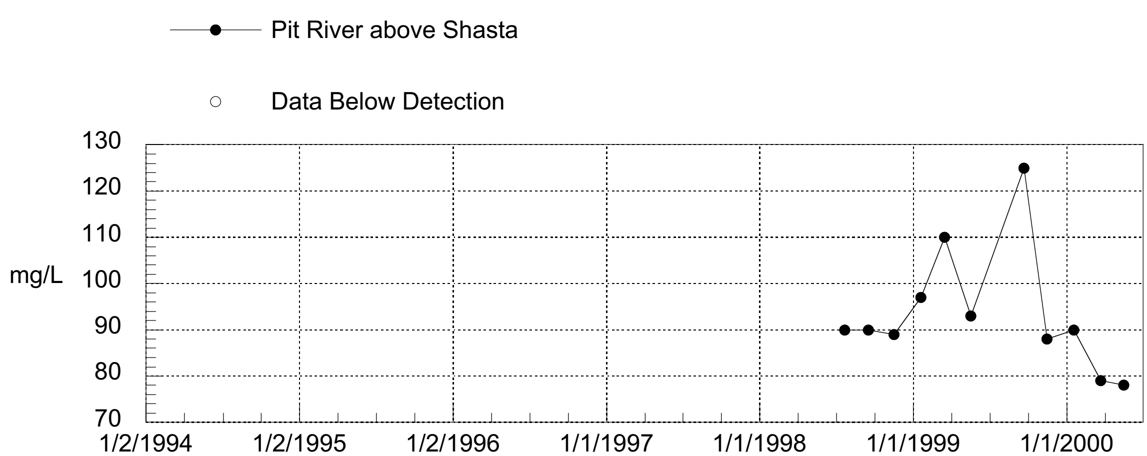
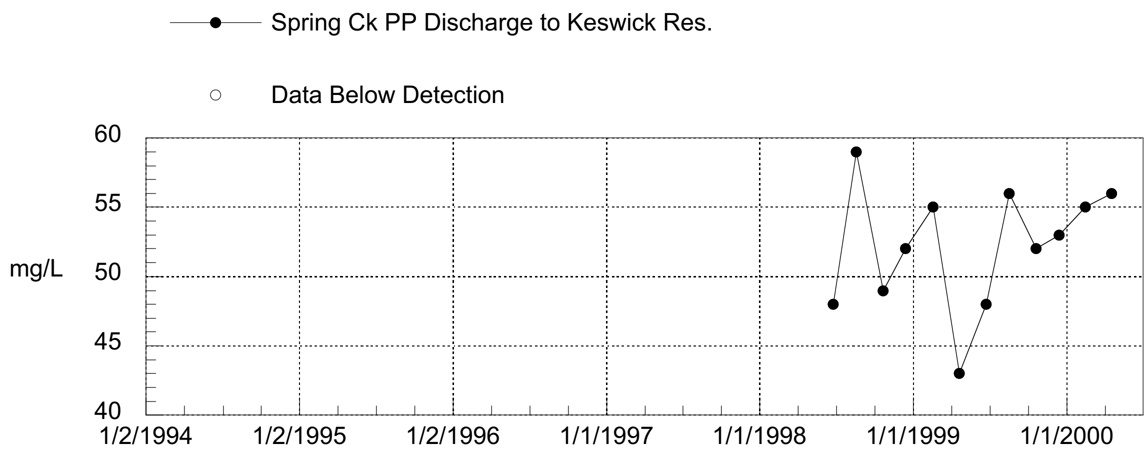
TOTAL DISSOLVED SOLIDS CONCENTRATIONS IN WATER

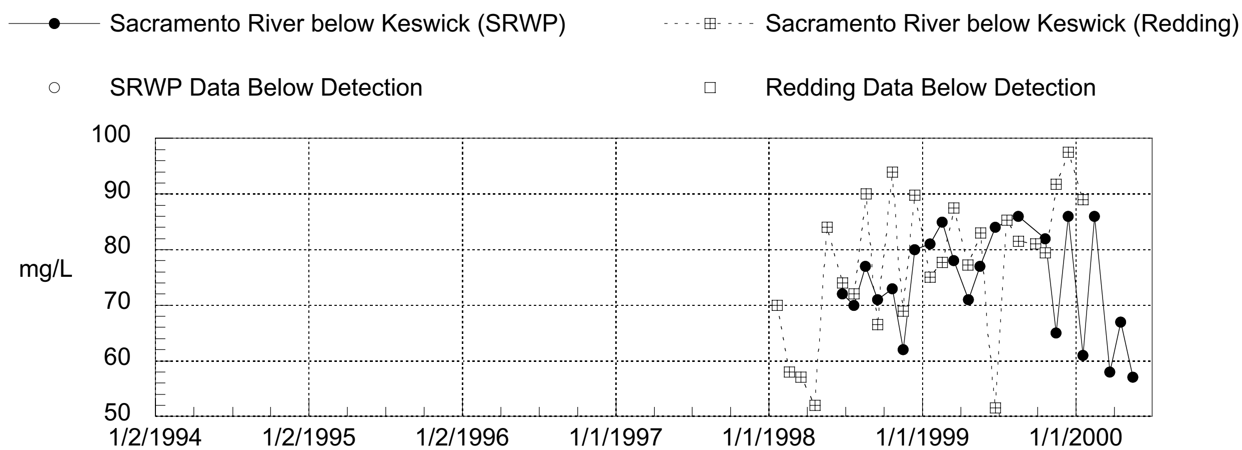


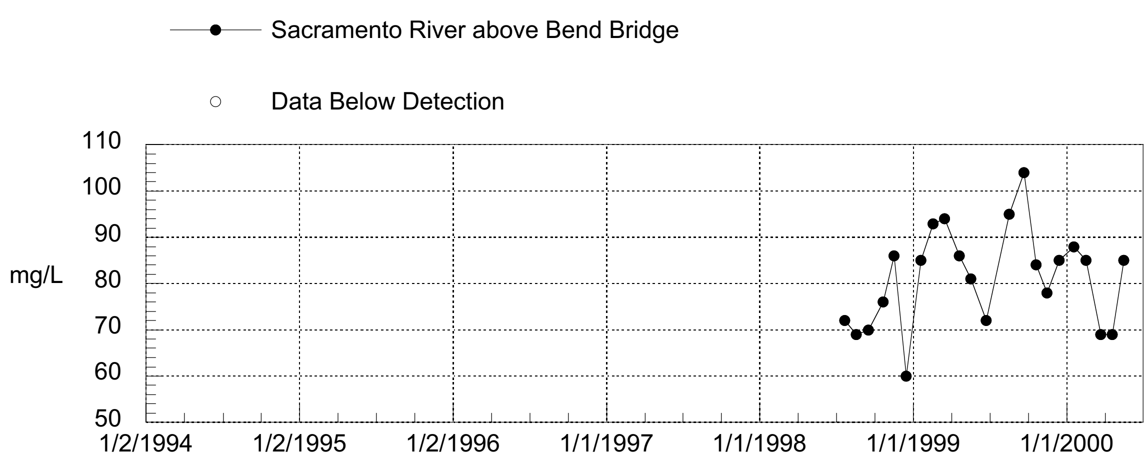




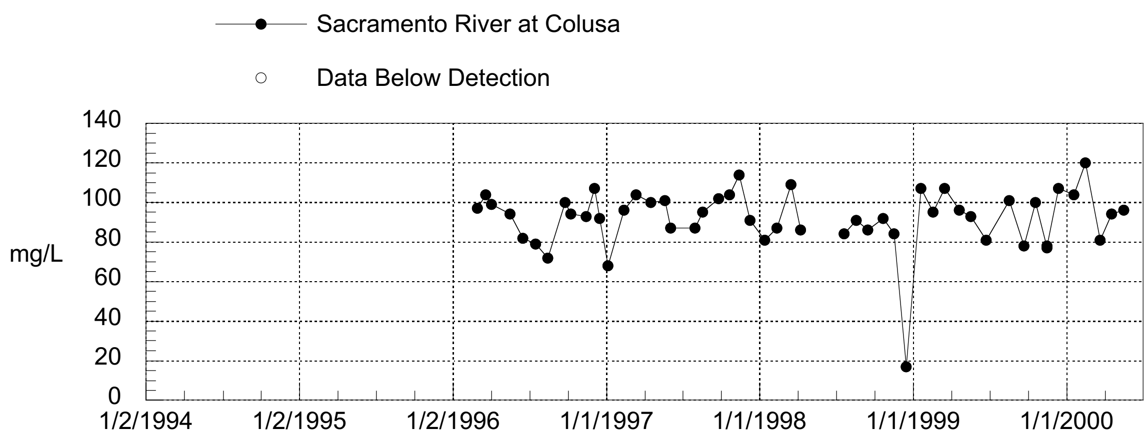
TOTAL DISSOLVED SOLIDS CONCENTRATIONS IN WATER

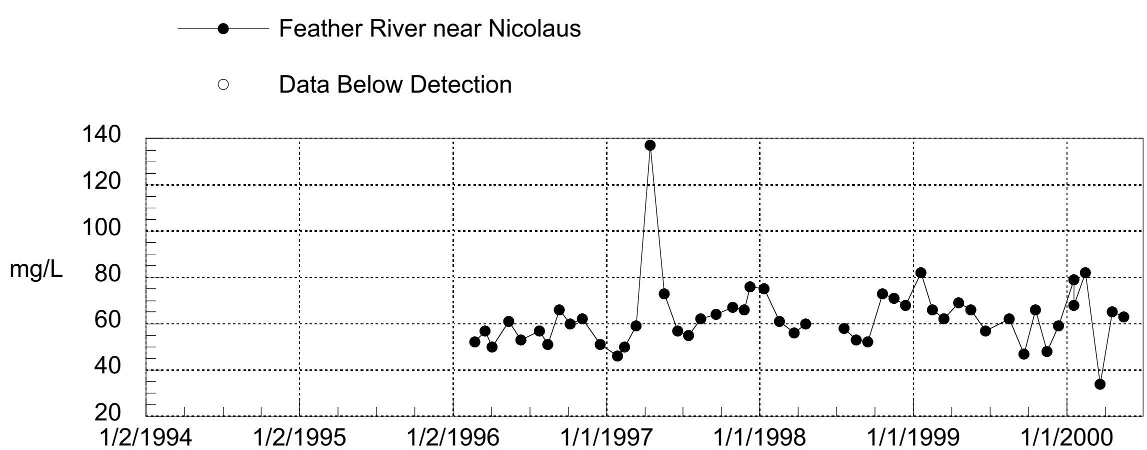


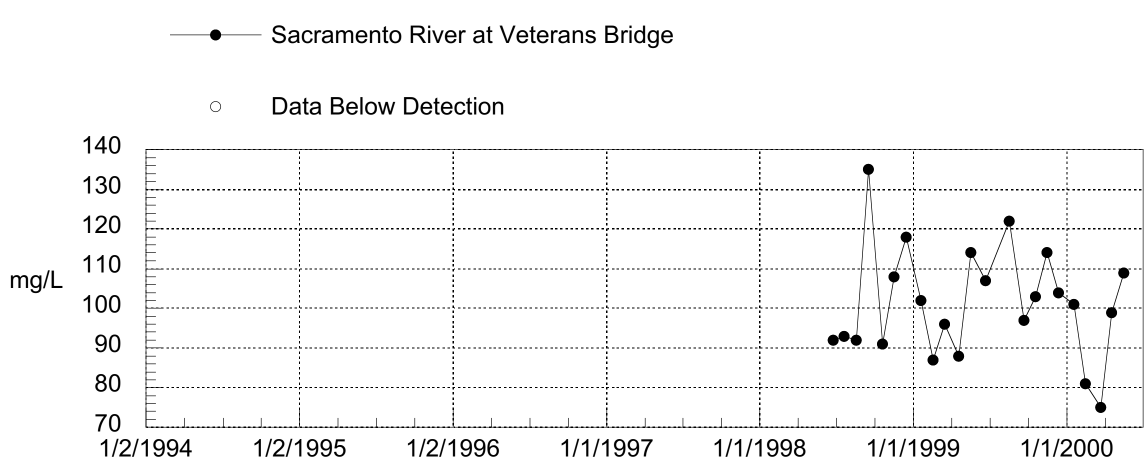




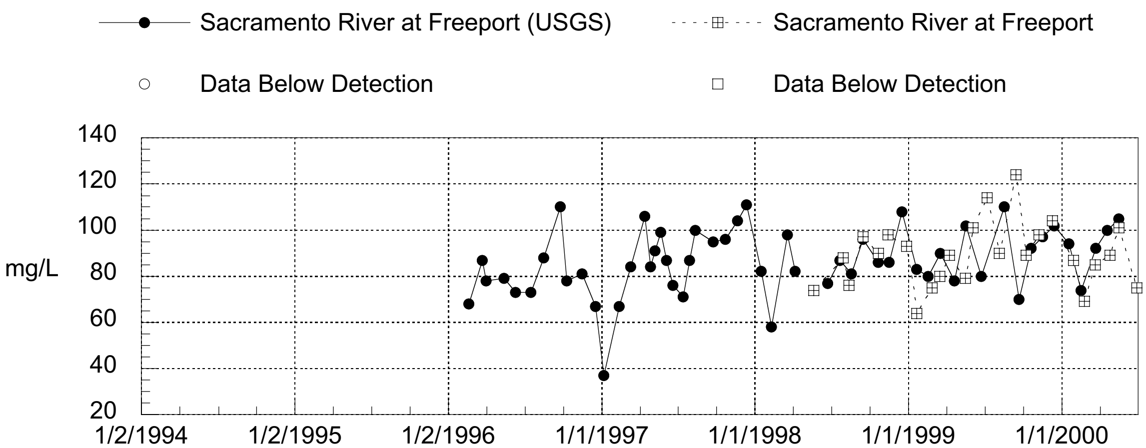
TOTAL DISSOLVED SOLIDS CONCENTRATIONS IN WATER

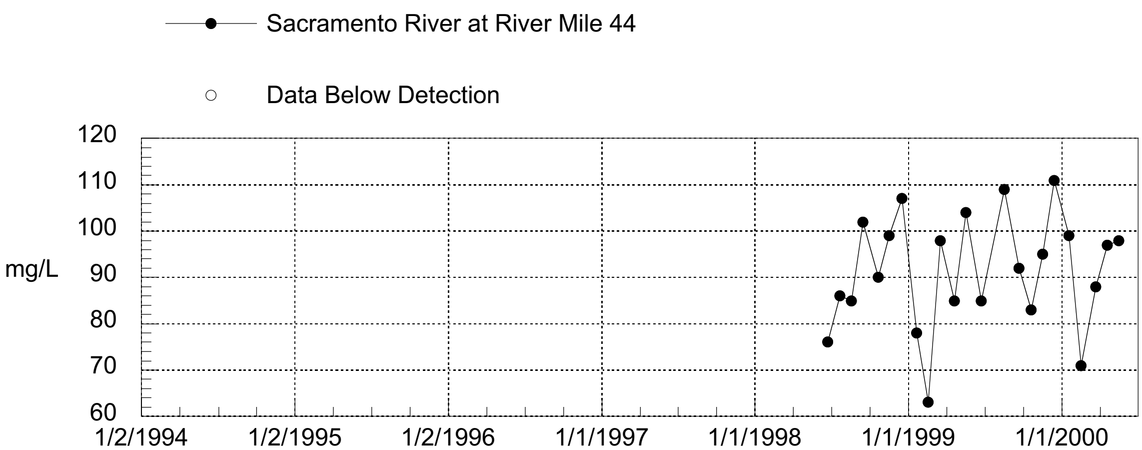


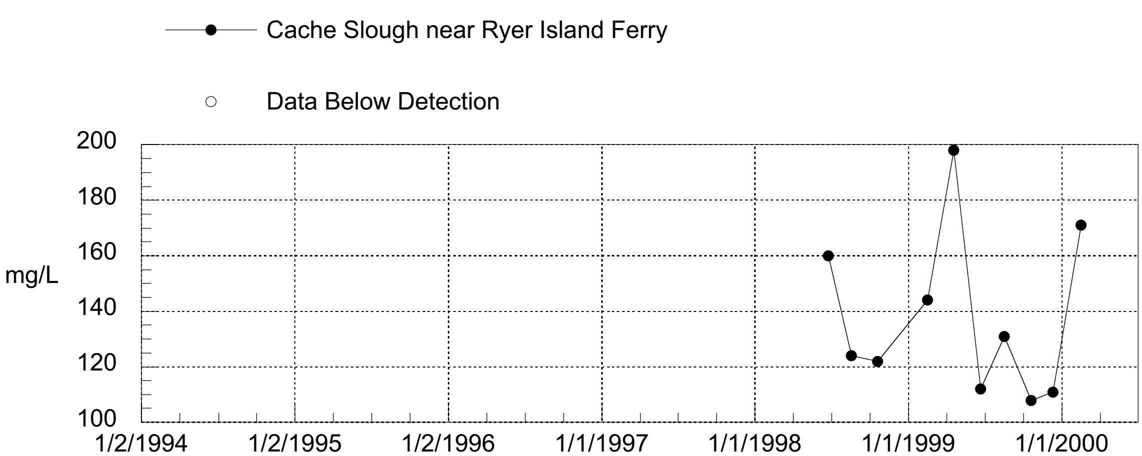


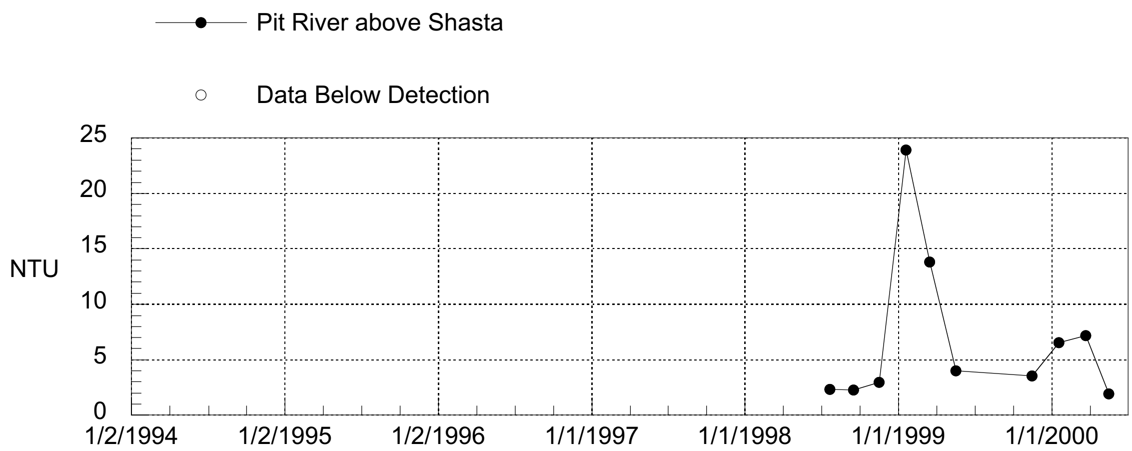


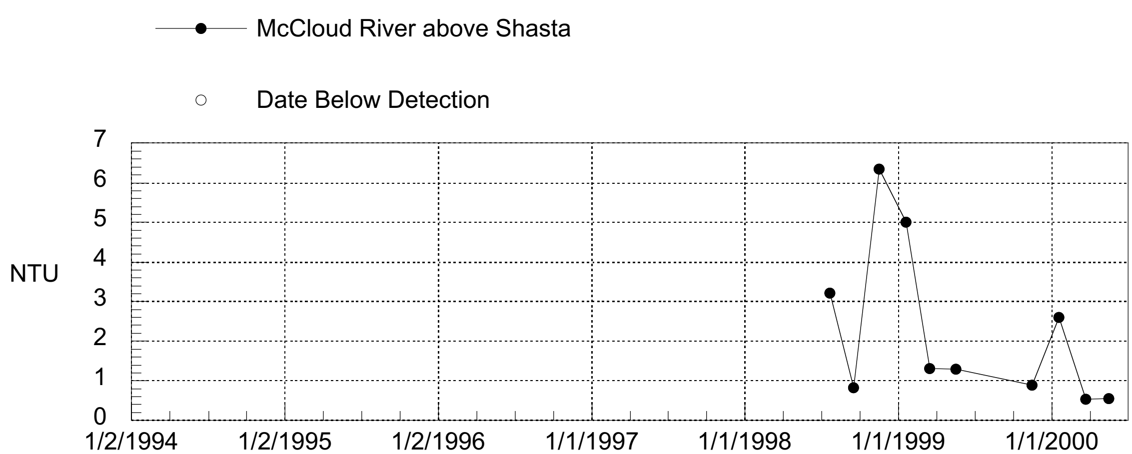
TOTAL DISSOLVED SOLIDS CONCENTRATIONS IN WATER

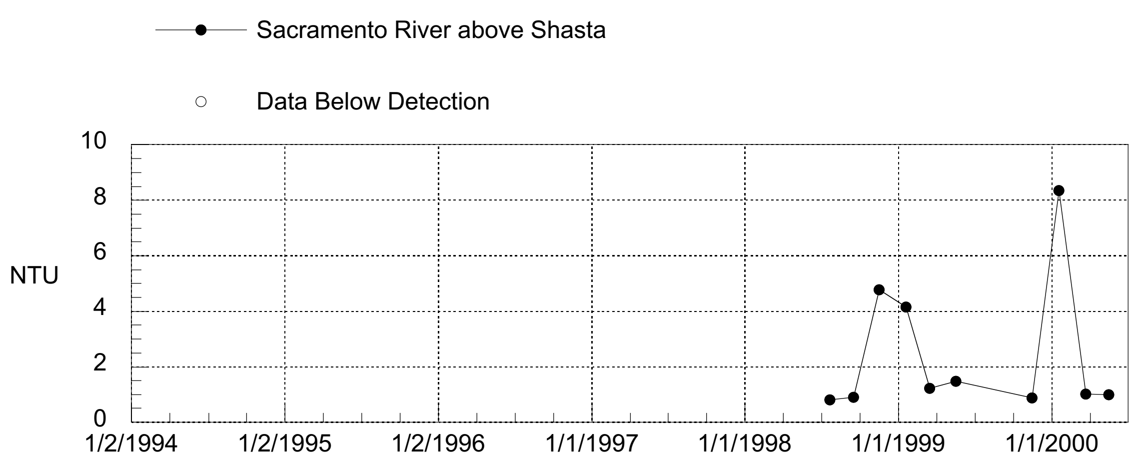


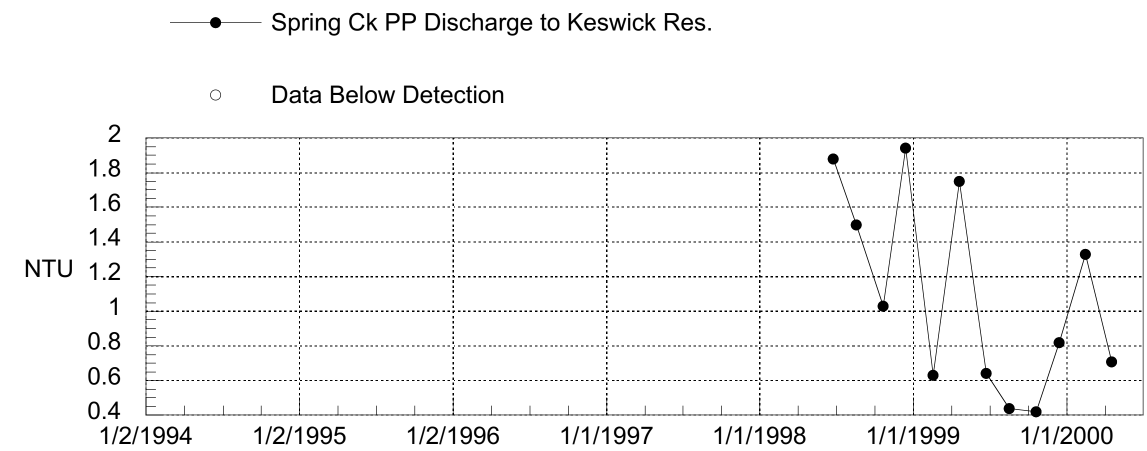


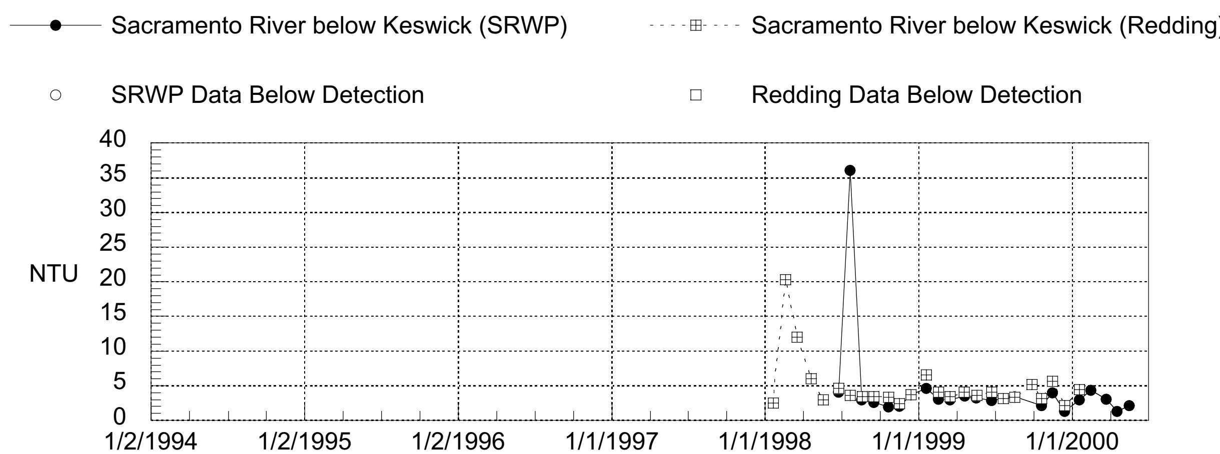


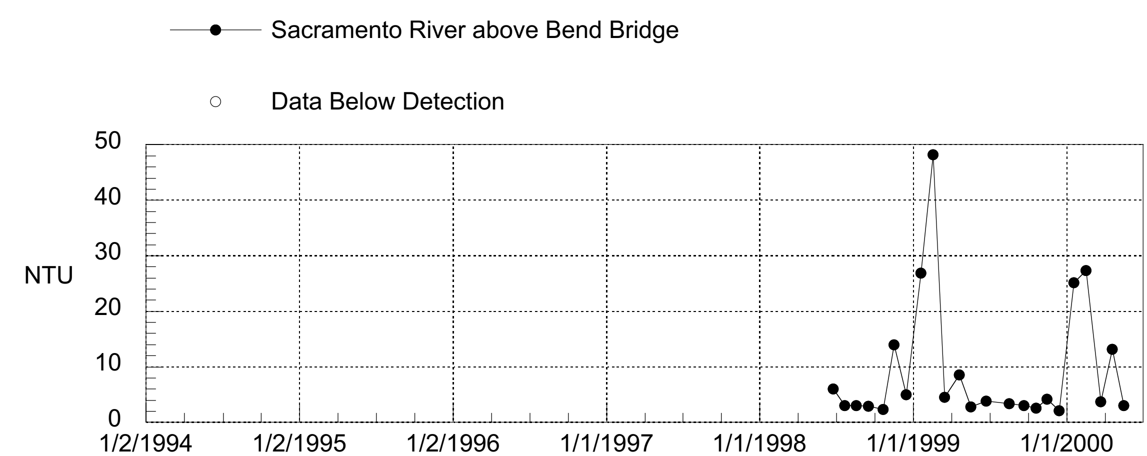

Pit River above Shasta
Data Below Detection
NTU
25
20
15
10
5
0
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000

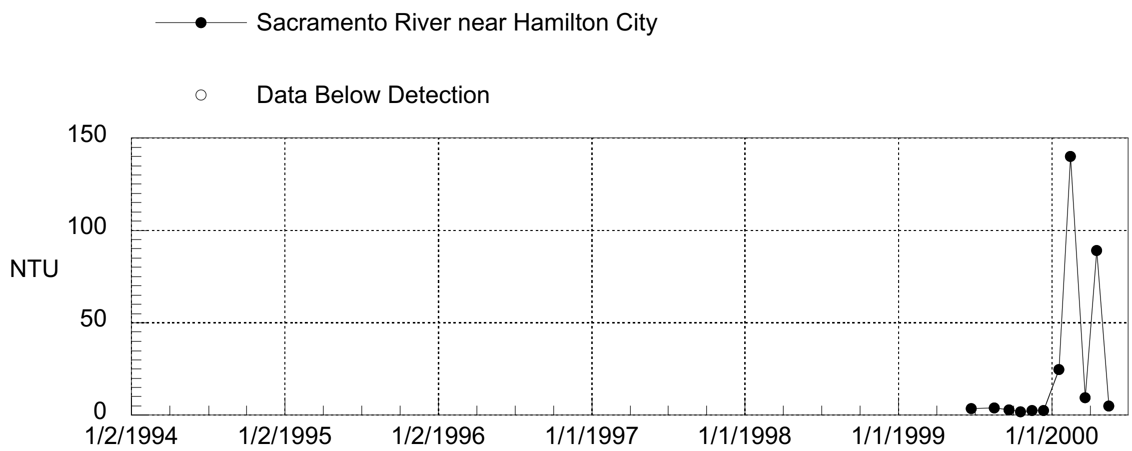

McCloud River above Shasta
Date Below Detection
NTU
7
6
5
4
3
2
1
0
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000

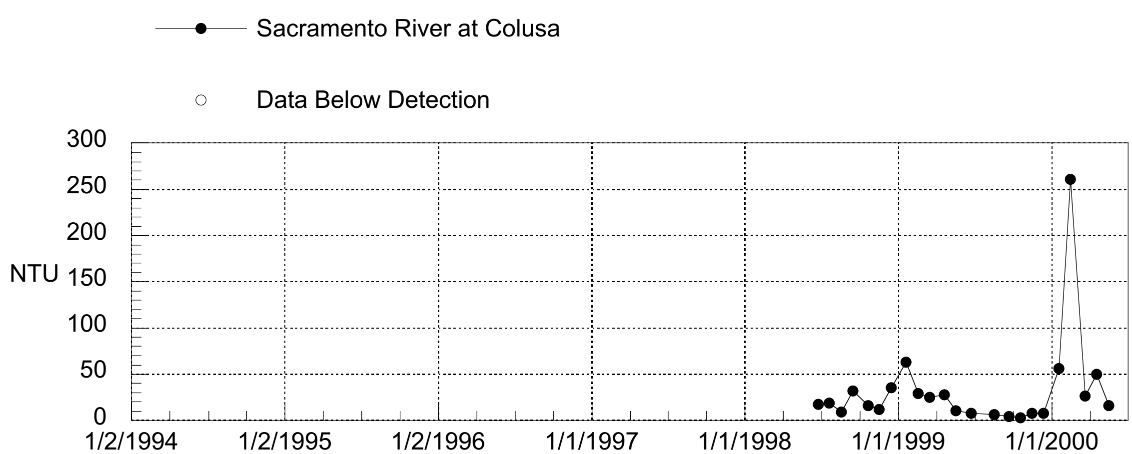

Sacramento River above Shasta
Data Below Detection
NTU
10
8
6
4
2
0
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000

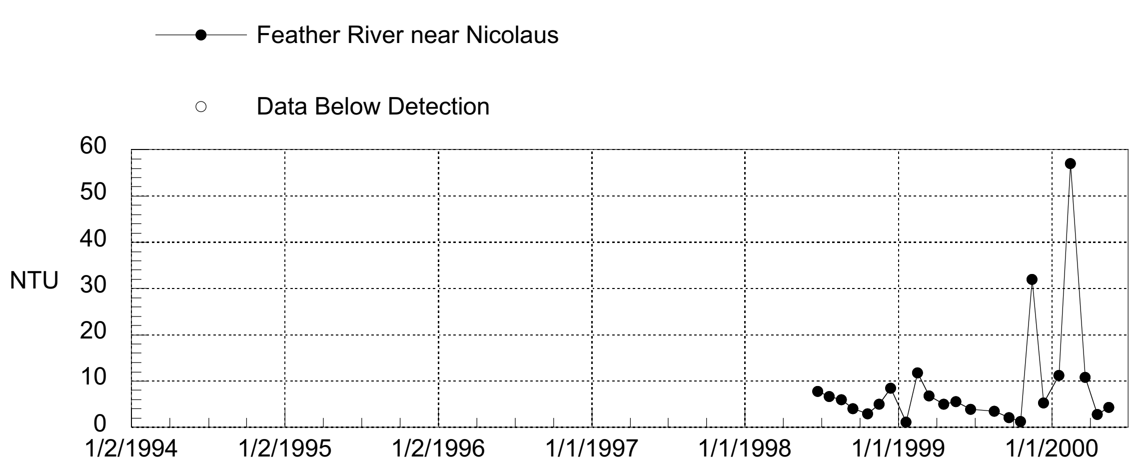

Spring Ck PP Discharge to Keswick Res.
Data Below Detection
NTU
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000

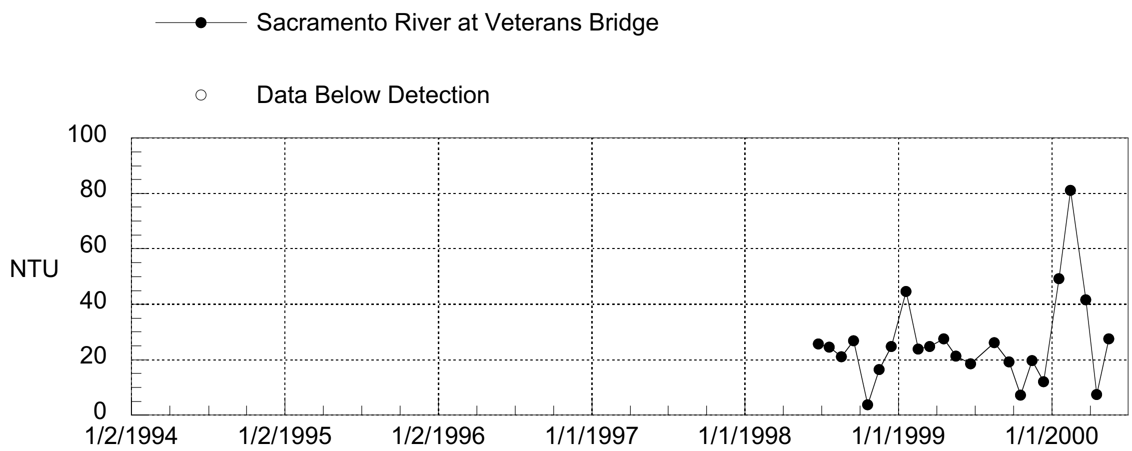

Sacramento River below Keswick (SRWP)
Sacramento River below Keswick (Redding)
SRWP Data Below Detection
Redding Data Below Detection
NTU
40
35
30
25
20
15
10
5
0
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000

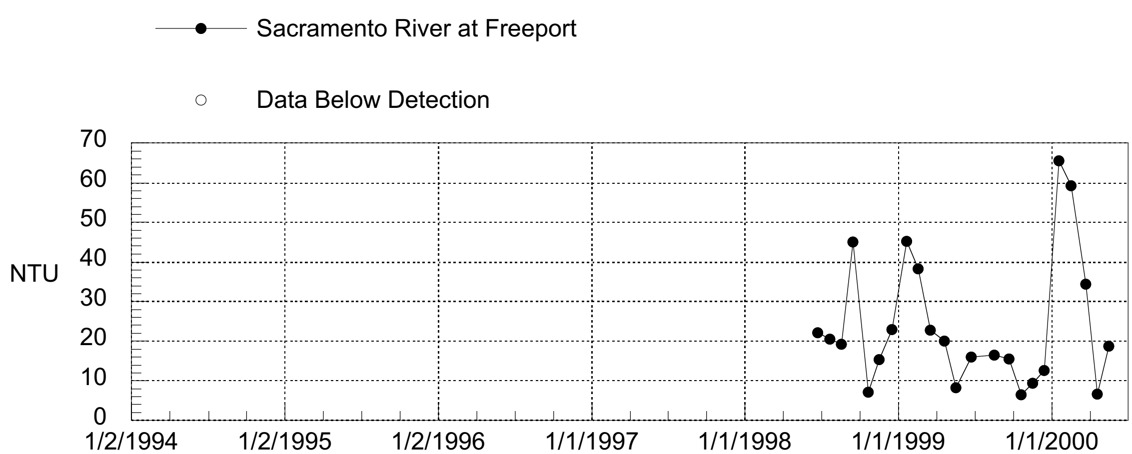

Sacramento River above Bend Bridge
Data Below Detection
NTU
50
40
30
20
10
0
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000

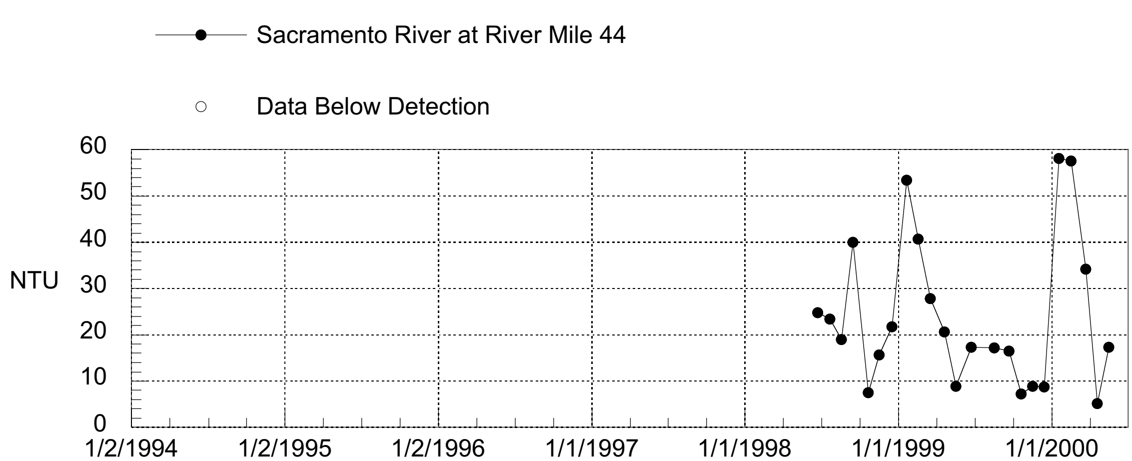

Sacramento River near Hamilton City
Data Below Detection
150
100
NTU
50
0
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000

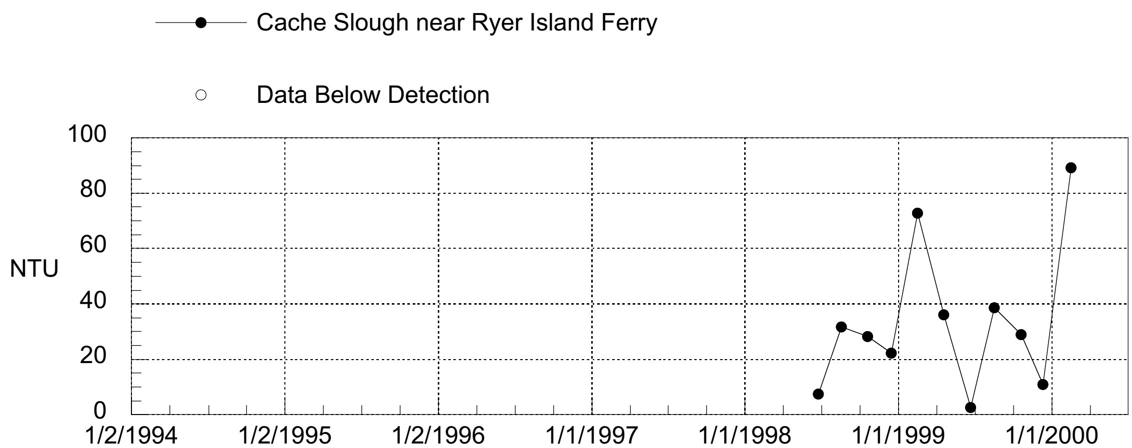

Sacramento River at Colusa
Data Below Detection
300
250
200
NTU
150
100
50
0
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000


Feather River near Nicolaus
Data Below Detection
60
50
40
NTU
30
20
10
0
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000


Sacramento River at Veterans Bridge
Data Below Detection
NTU
100
80
60
40
20
0
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000


Sacramento River at Freeport
Data Below Detection
NTU
70
60
50
40
30
20
10
0
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000


Sacramento River at River Mile 44
Data Below Detection
NTU
60
50
40
30
20
10
0
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000



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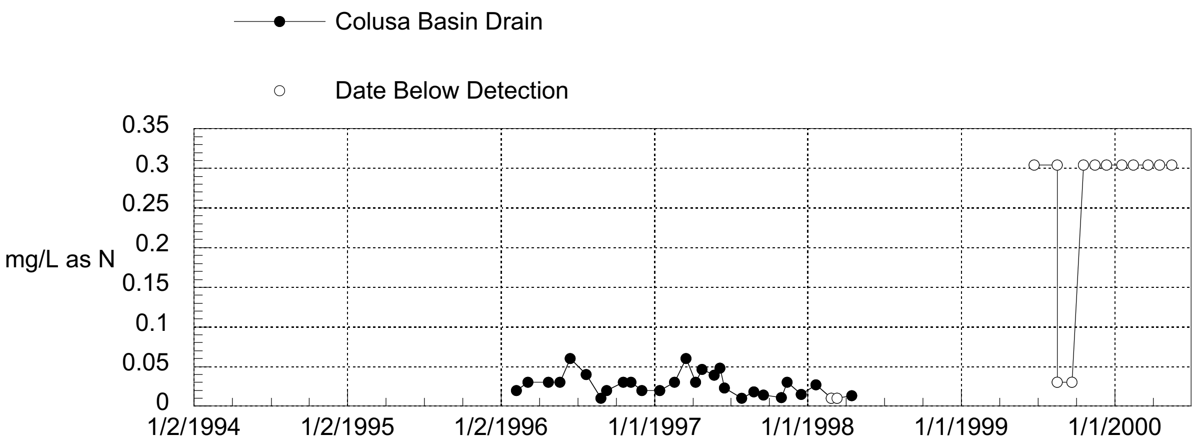
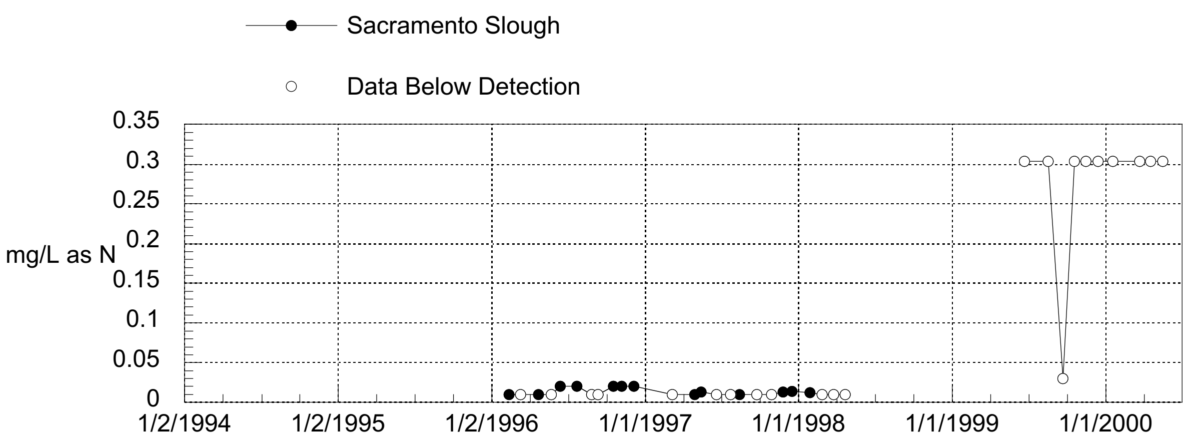
Time Series Plots of Monitoring Data: Nutrients

NITRITE CONCENTRATIONS IN WATER





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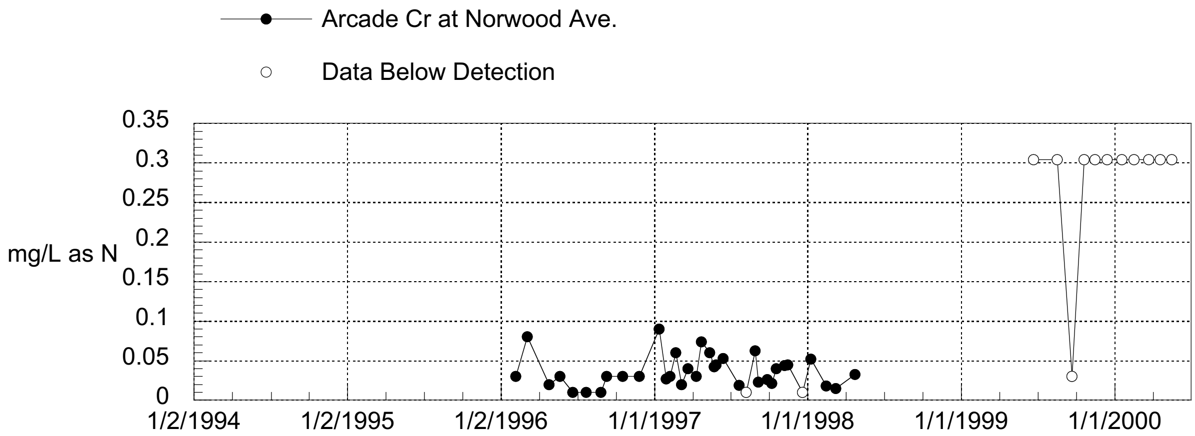

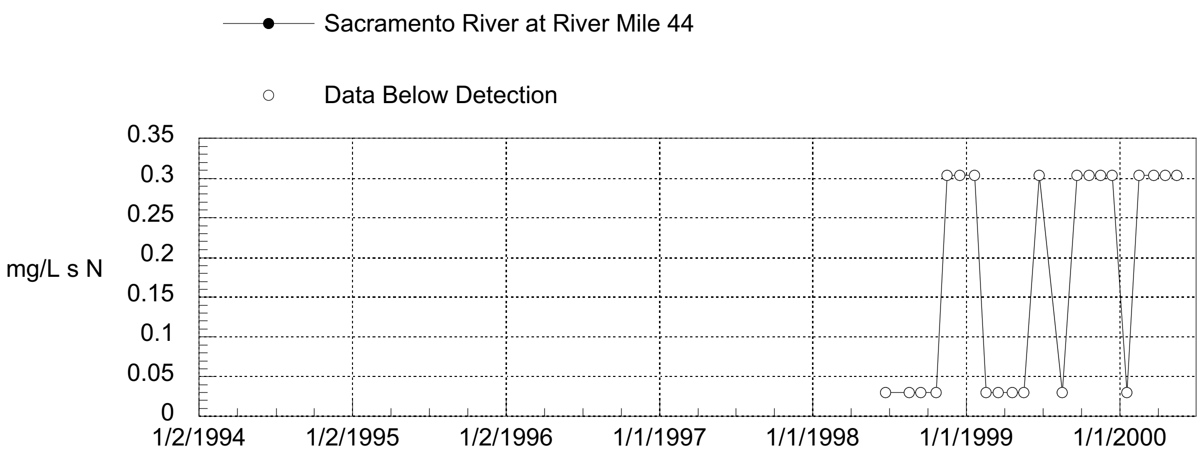

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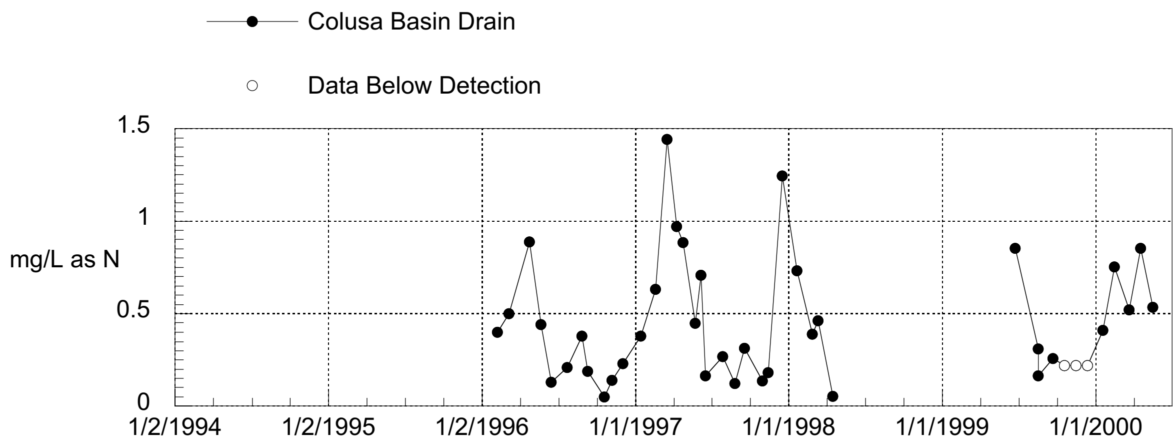

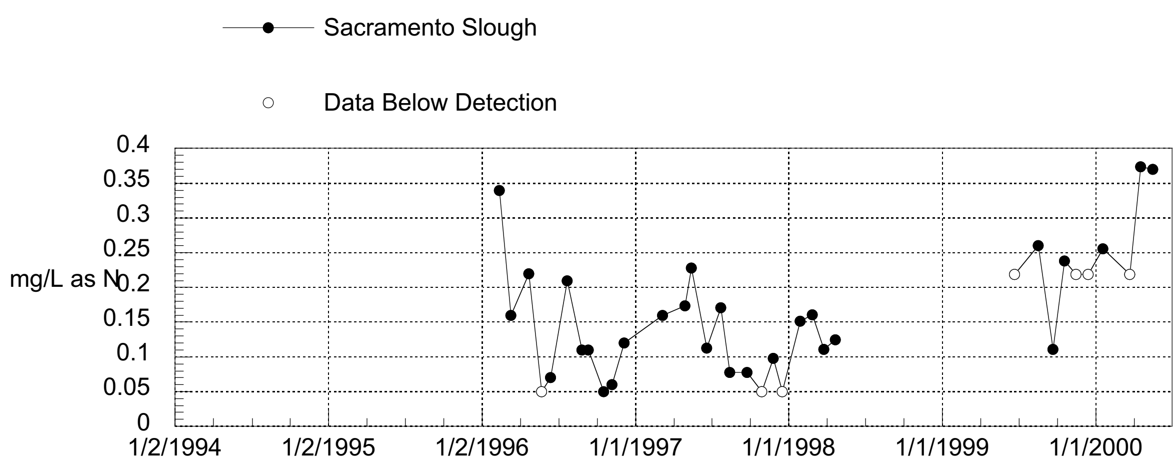

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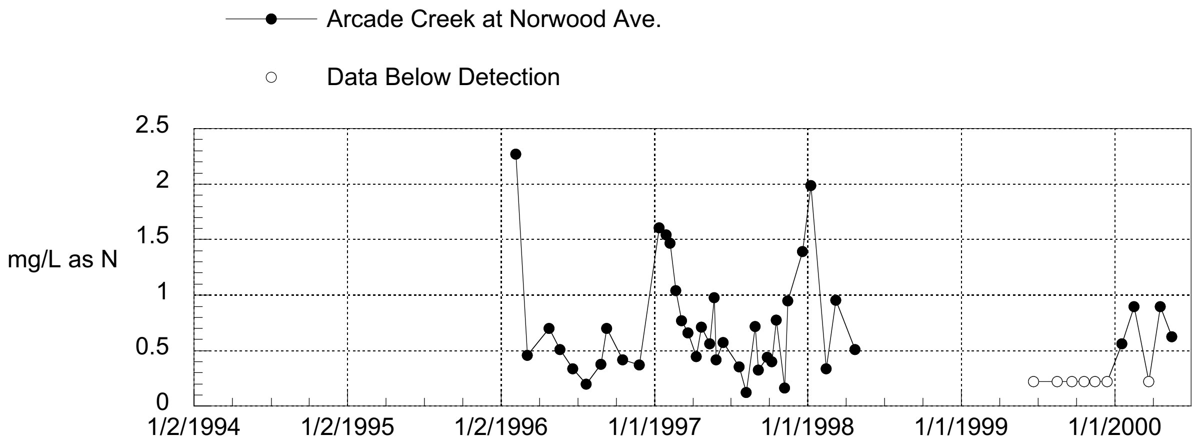

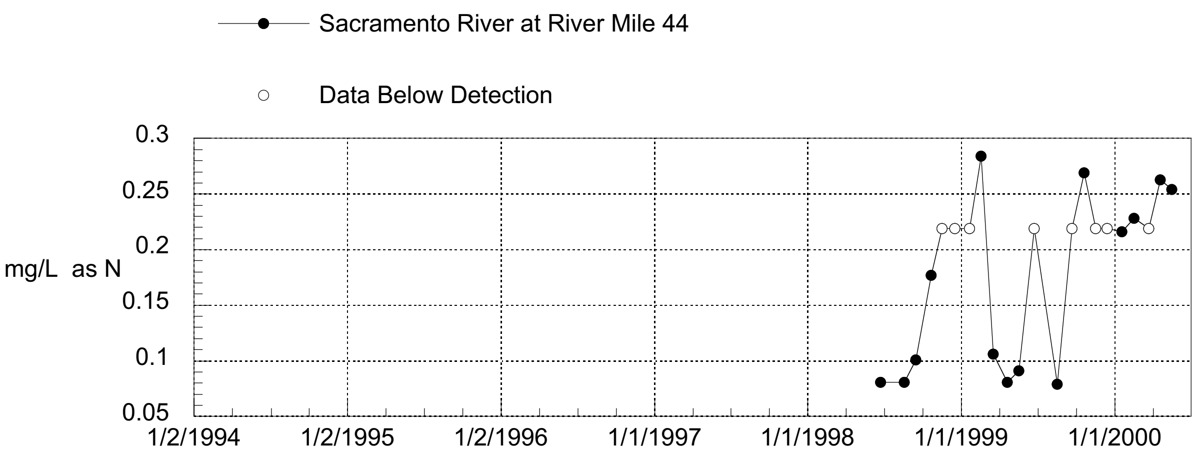

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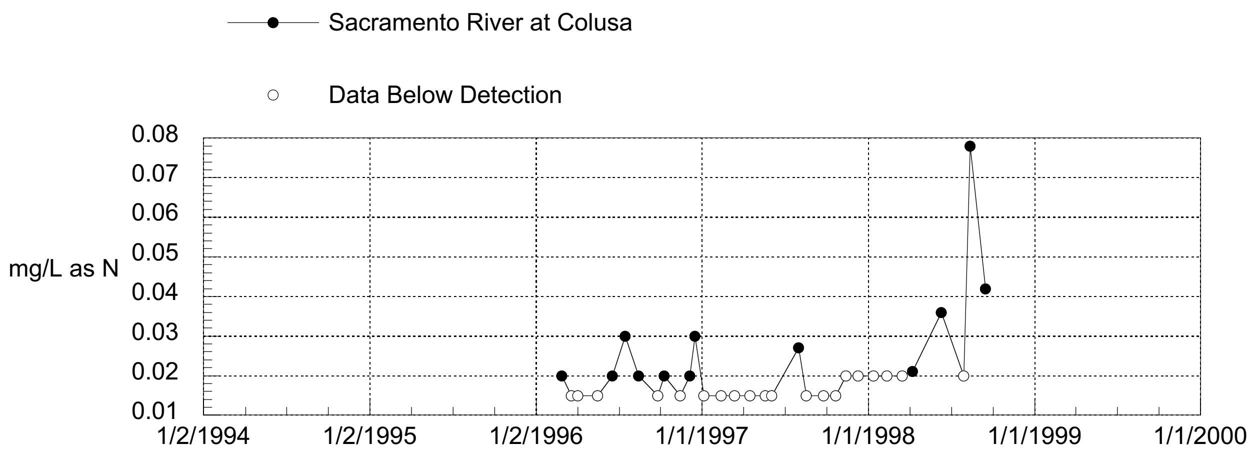
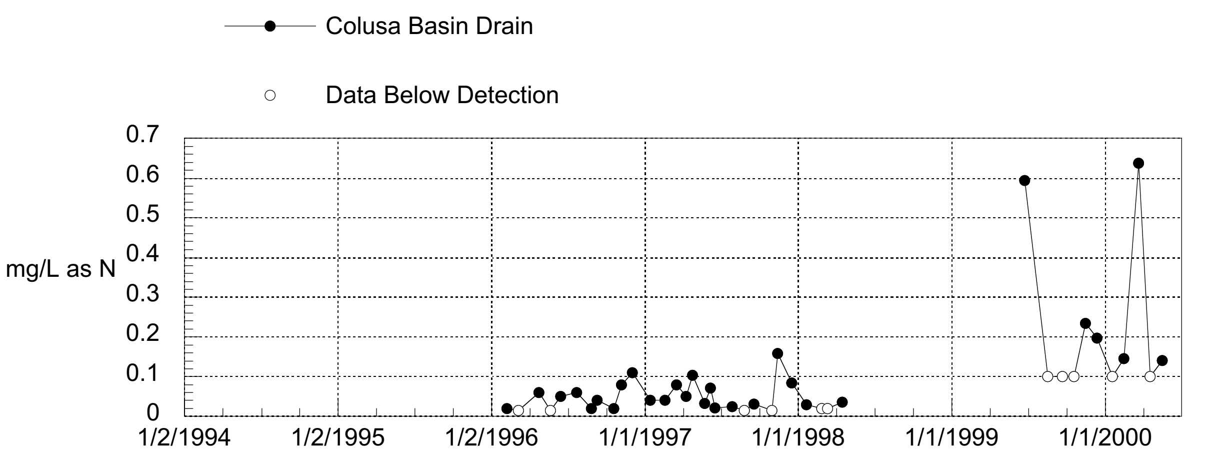
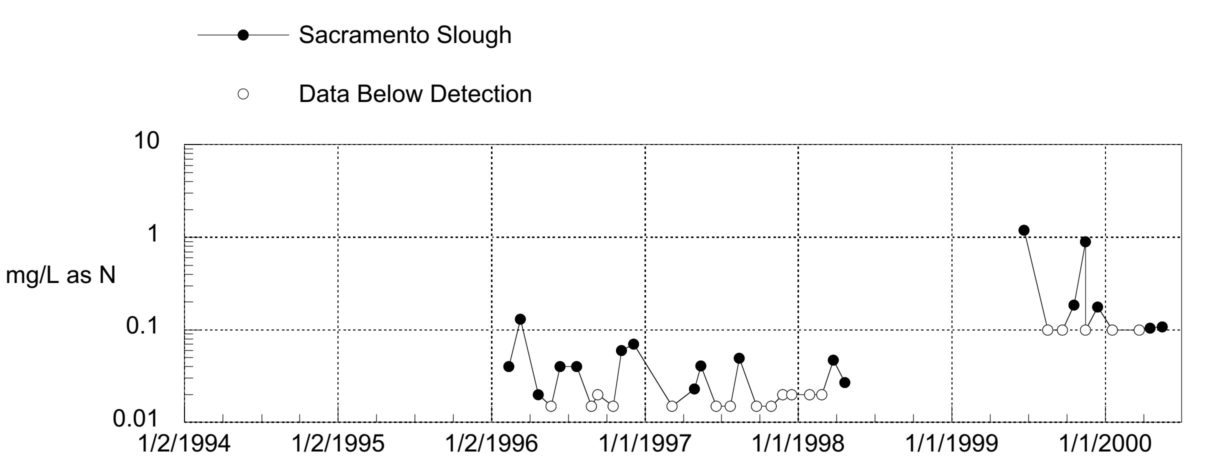
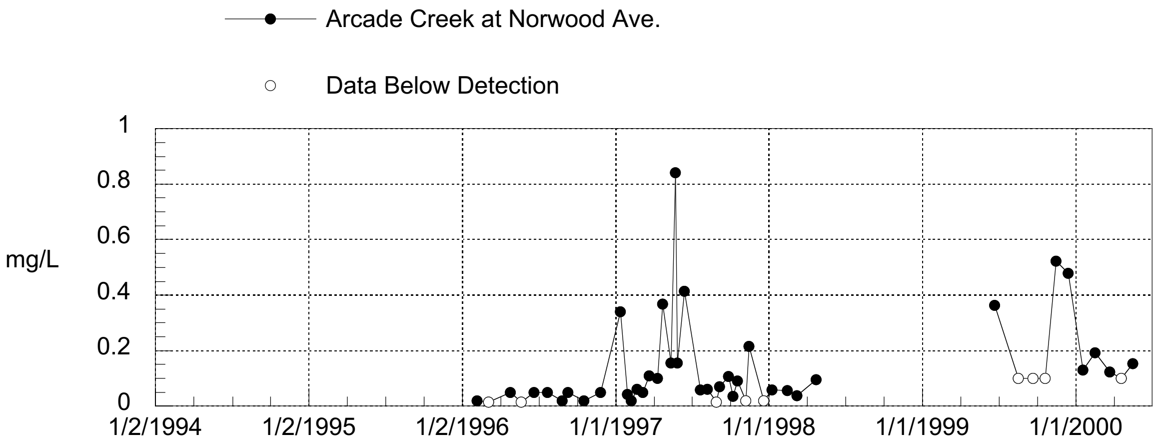
AMMONIA CONCENTRATIONS IN WATER

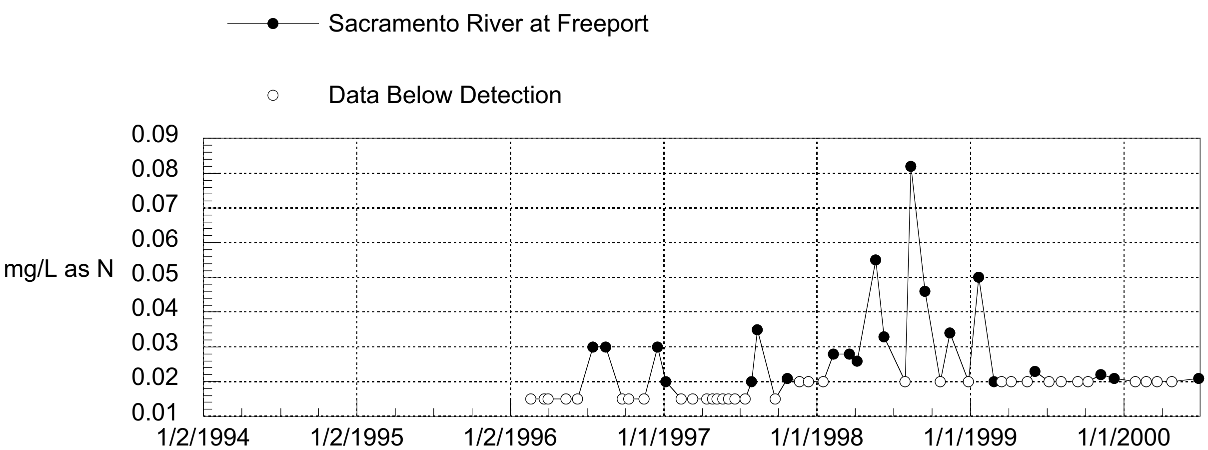


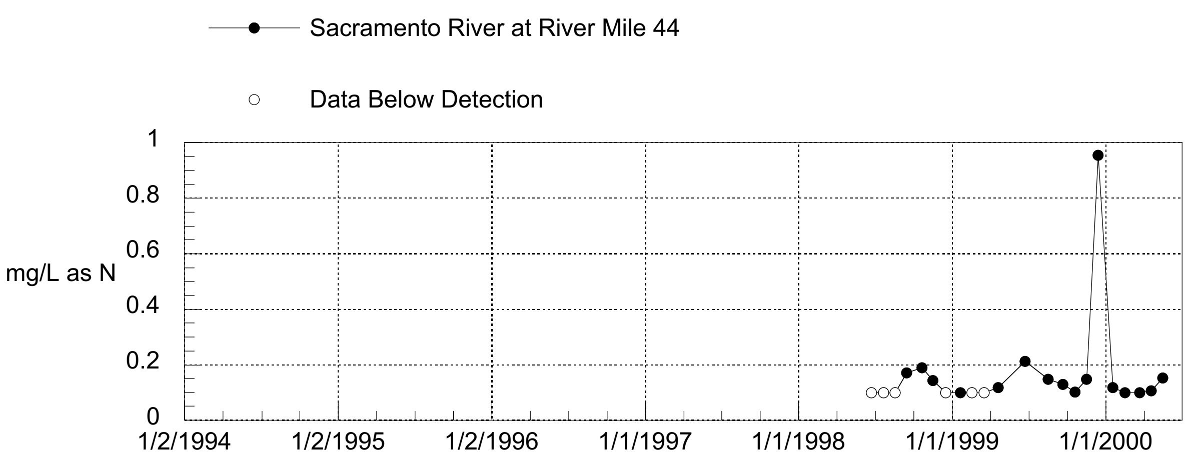




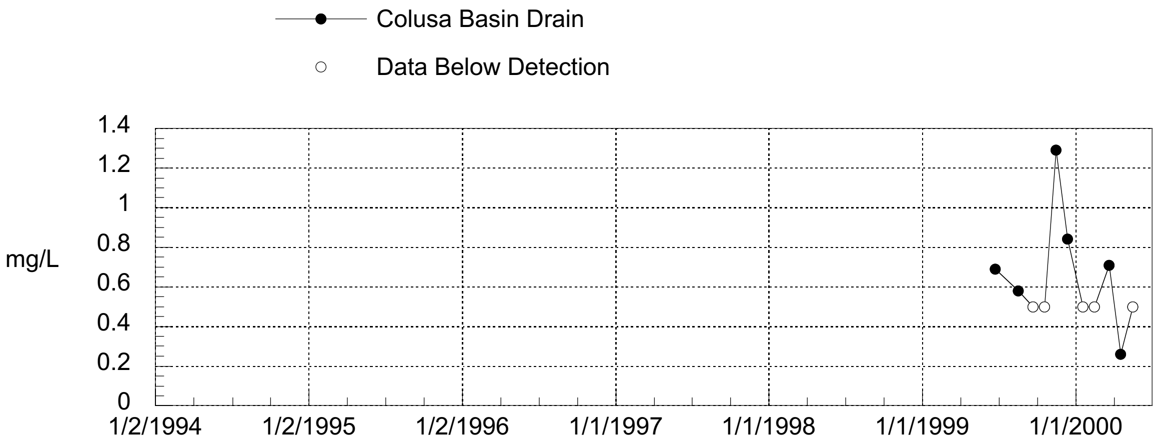
AMMONIA CONCENTRATIONS IN WATER

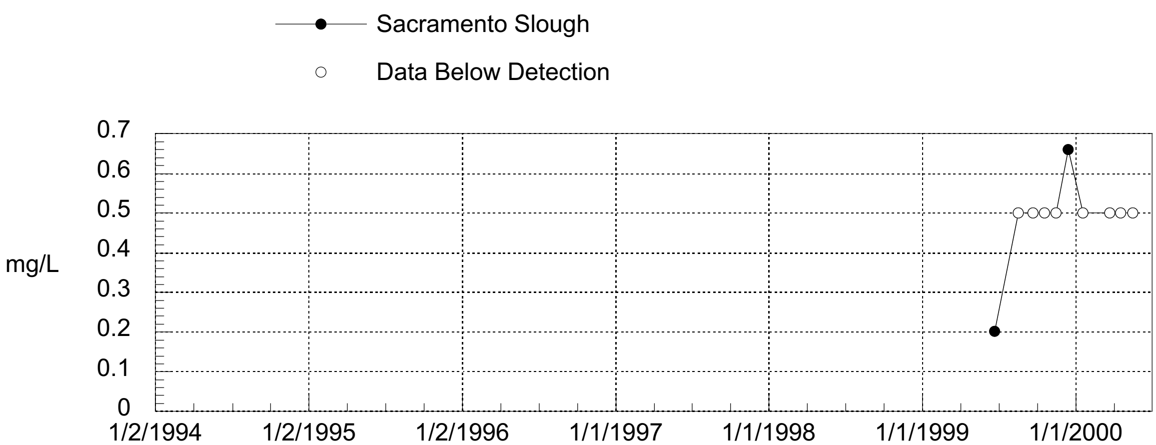






TOTAL KJELDAHL NITROGEN CONCENTRATIONS IN WATER





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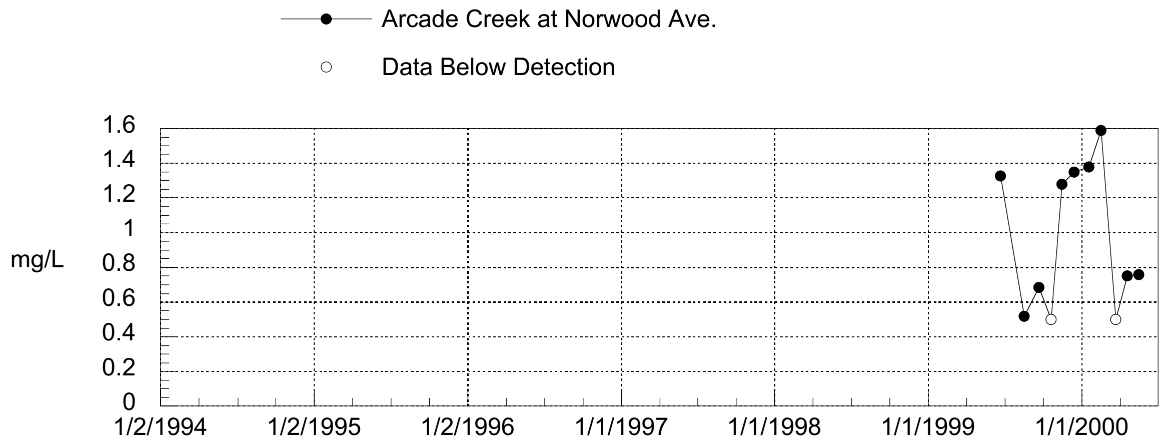
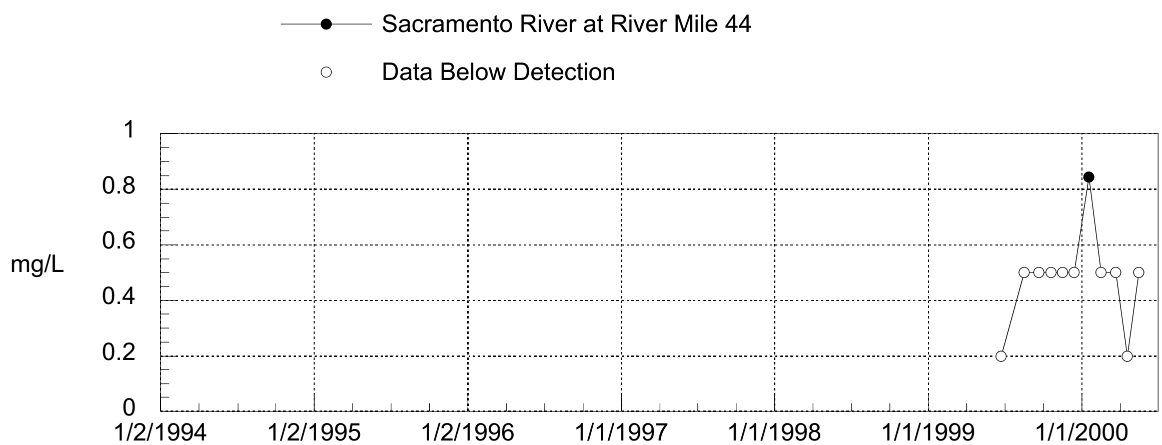
TOTAL KJELDAHL NITROGEN CONCENTRATIONS IN WATER





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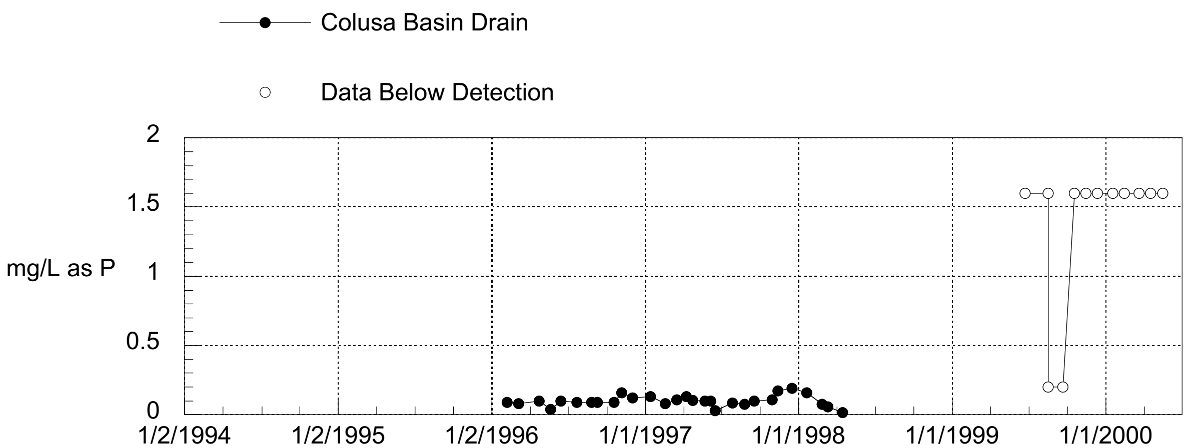
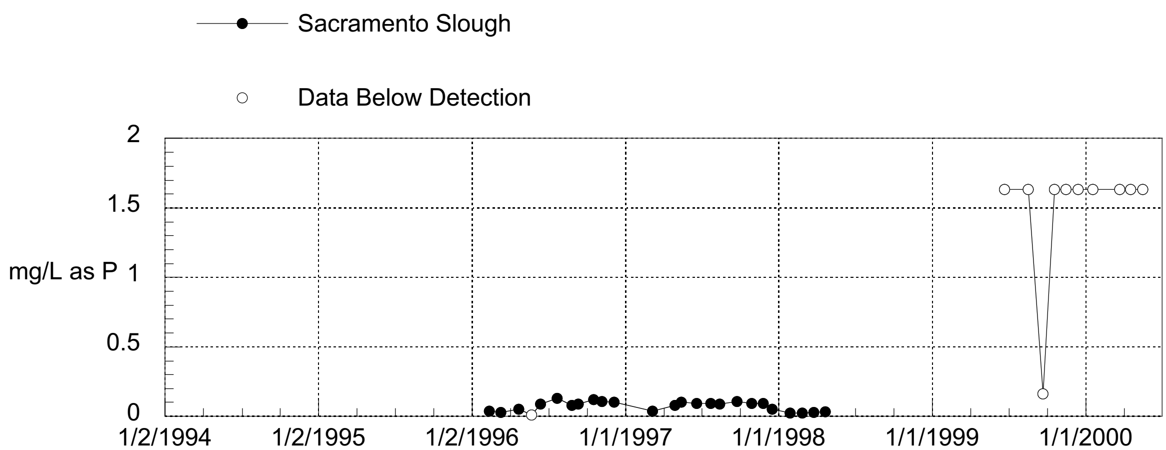
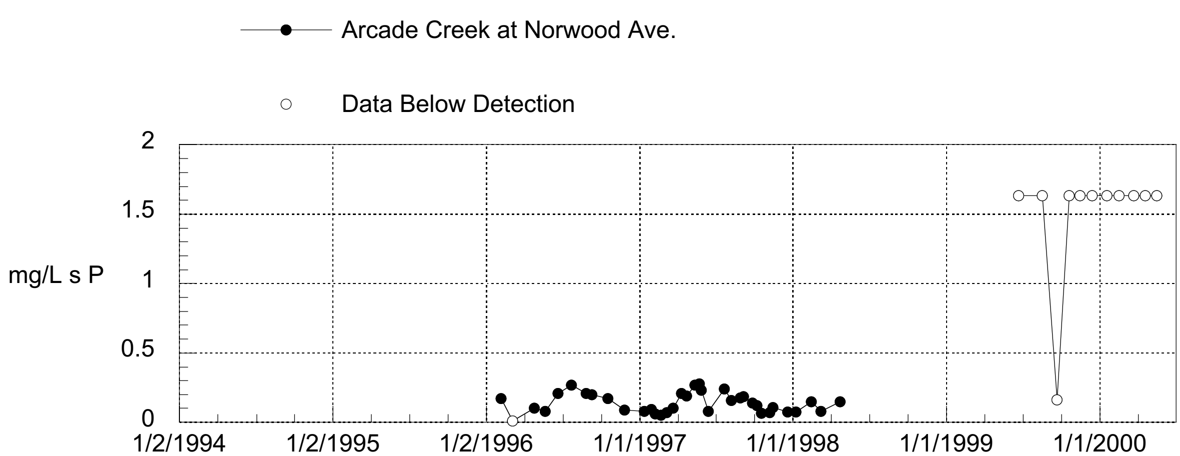
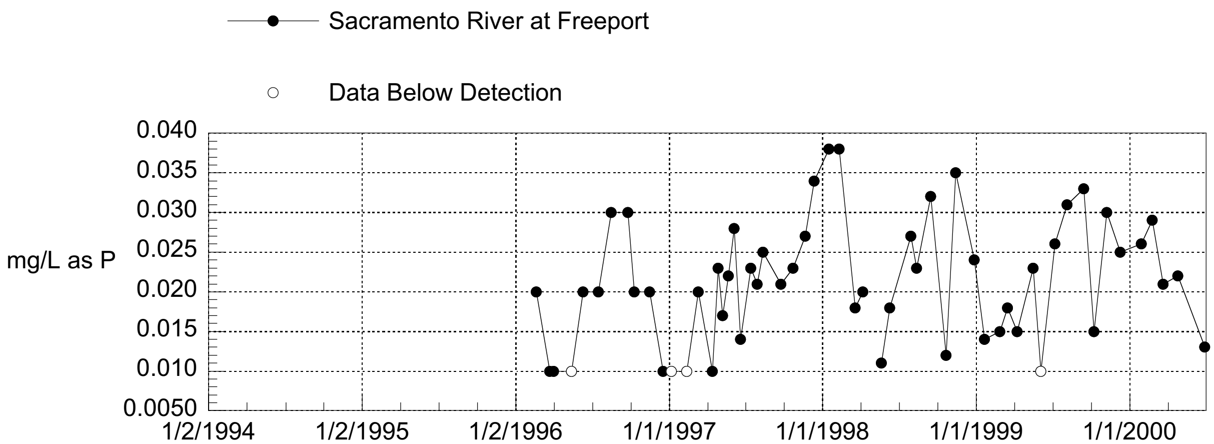
DISSOLVED ORTHOPHOSPHATE CONCENTRATIONS IN WATER

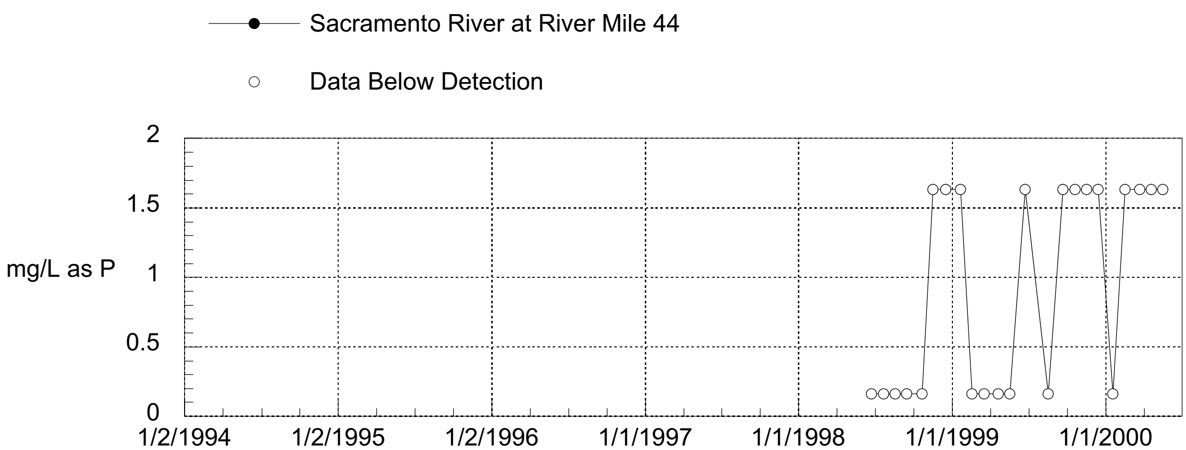






DISSOLVED ORTHOPHOSPHATE CONCENTRATIONS IN WATER





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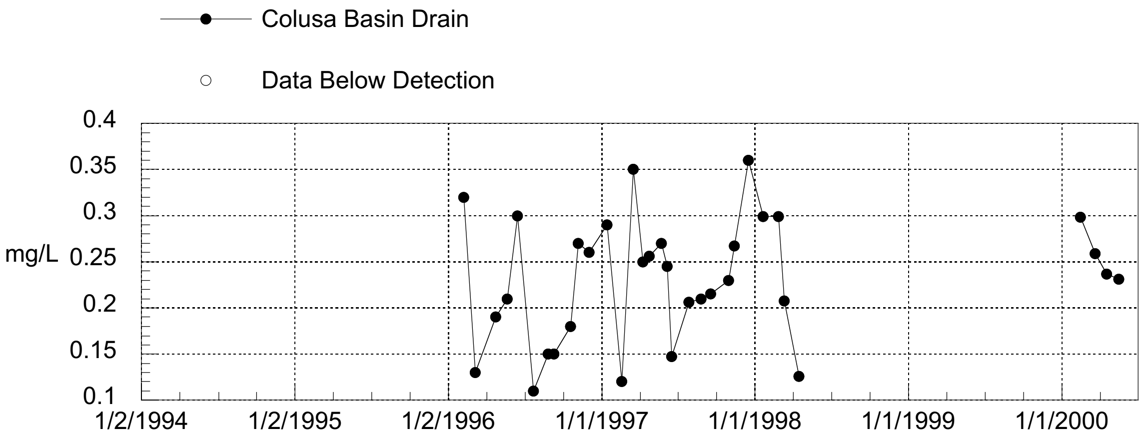
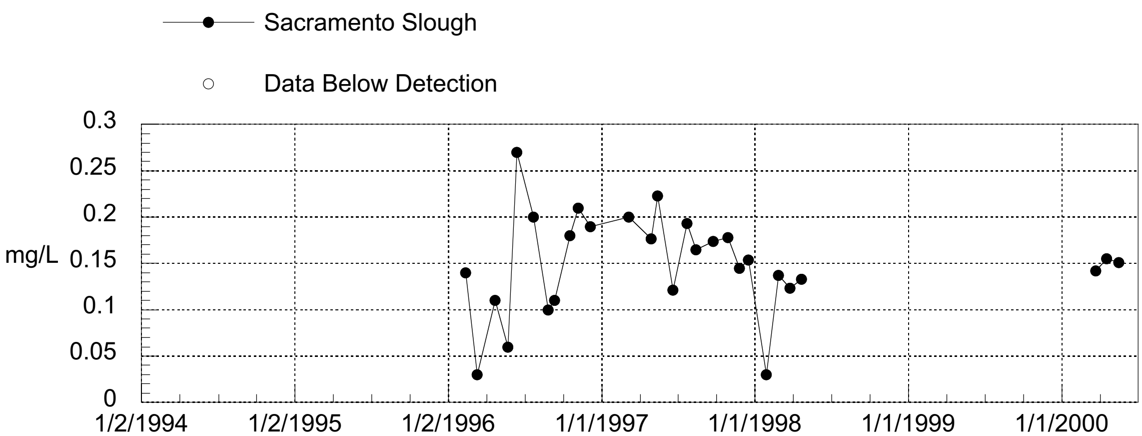
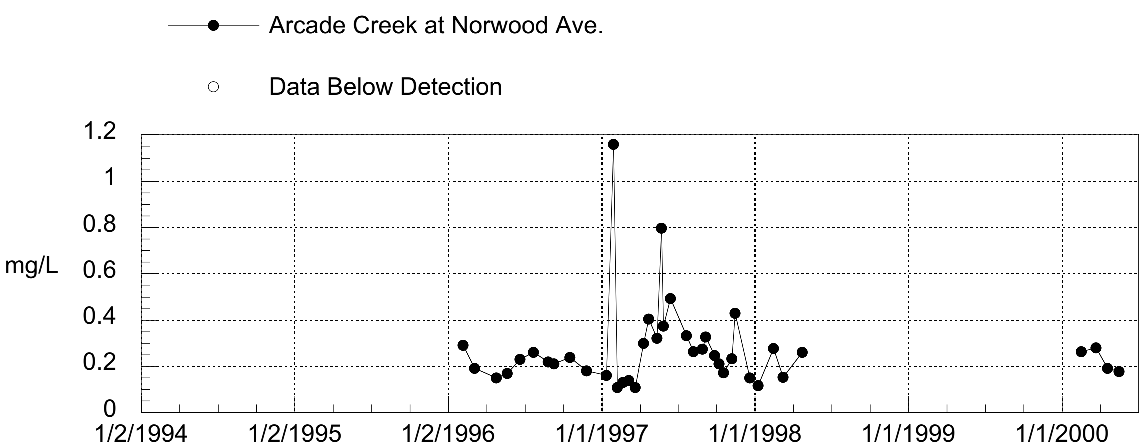
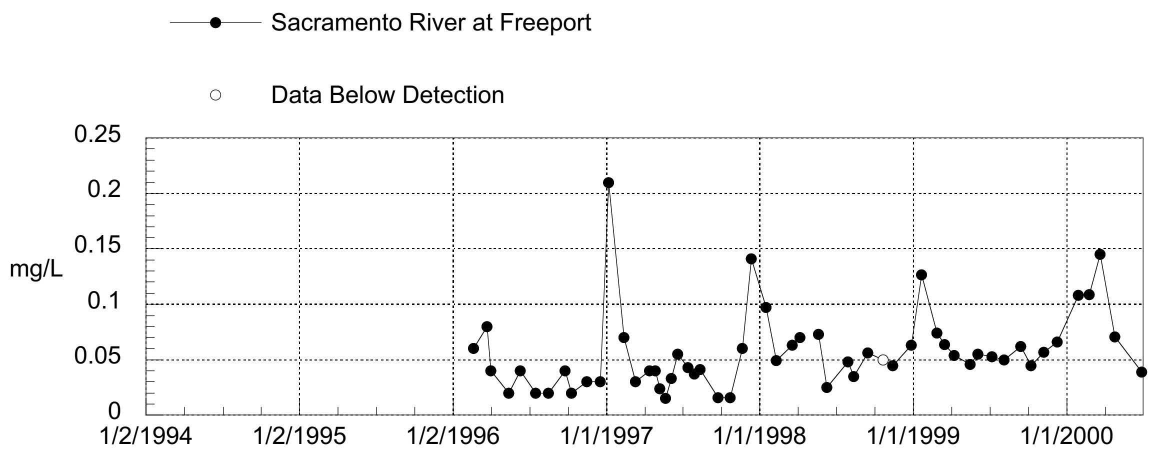
TOTAL PHOSPHOROUS CONCENTRATIONS IN WATER

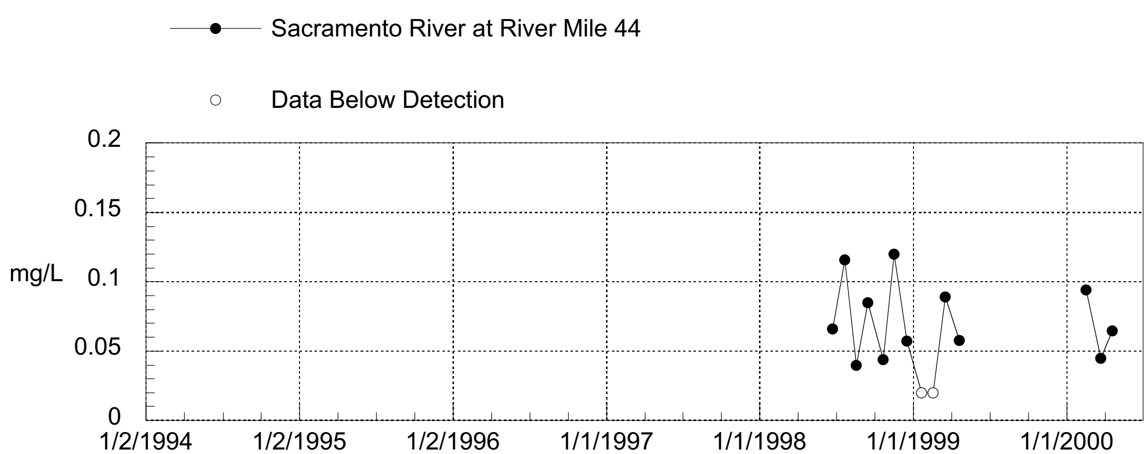






TOTAL PHOSPHOROUS CONCENTRATIONS IN WATER





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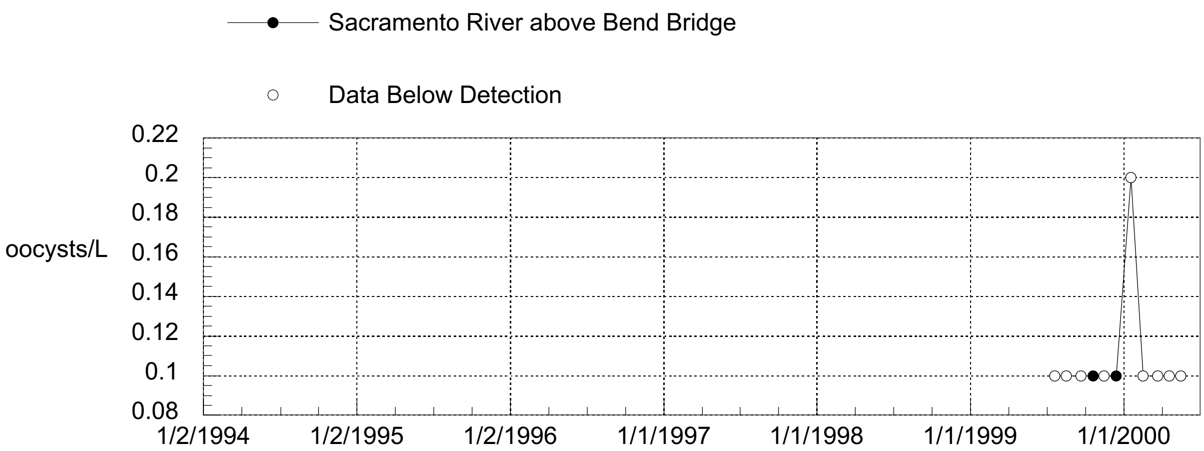
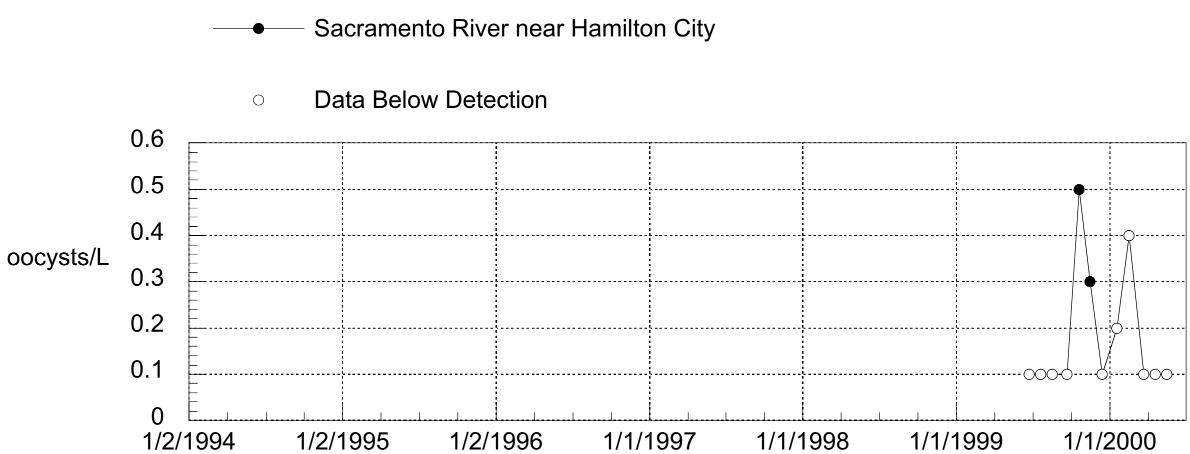
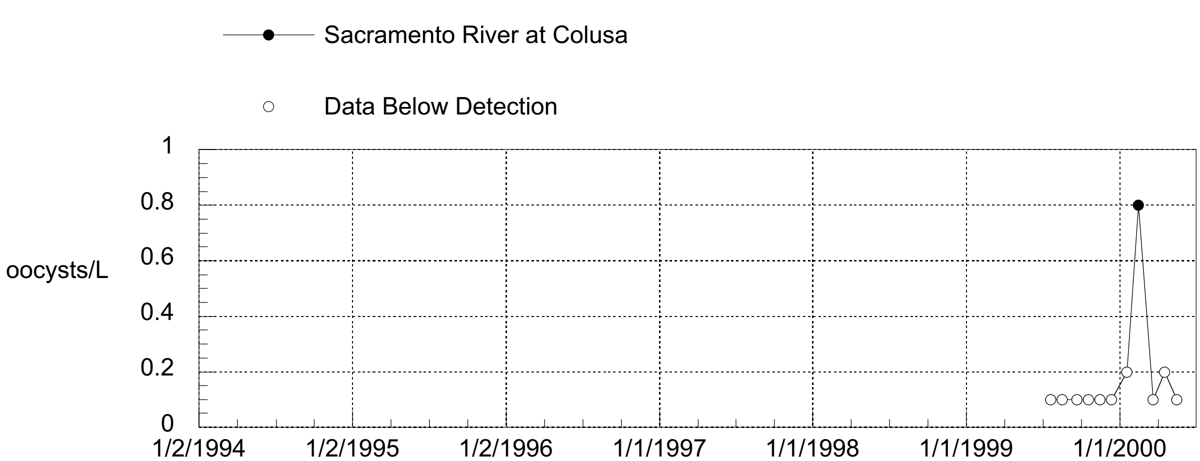
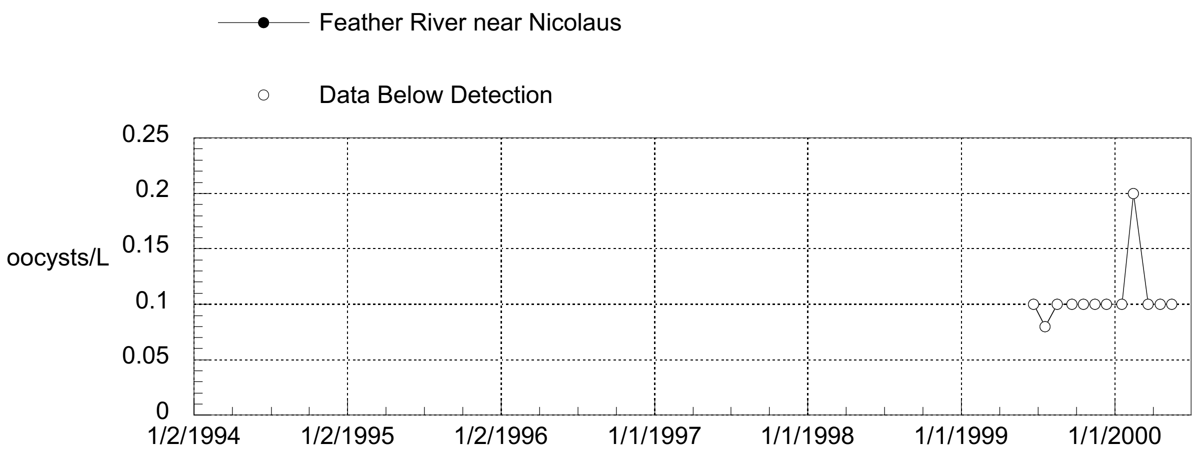
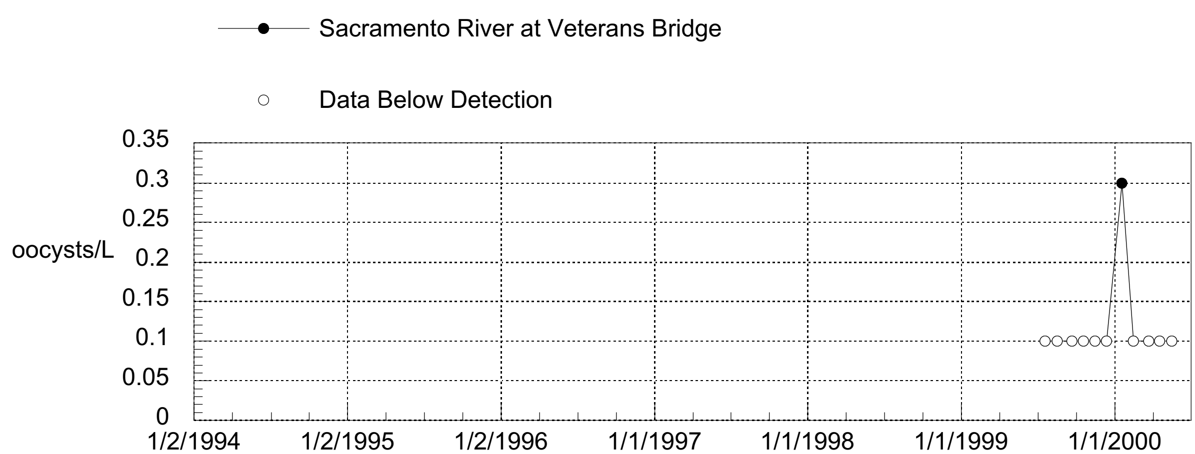
Time Series Plots of Monitoring Data: Pathogens

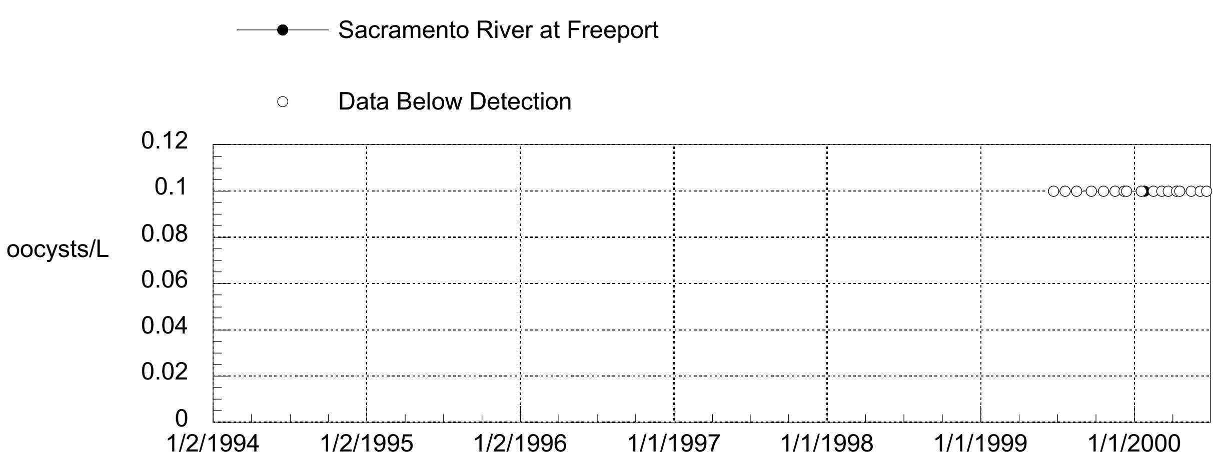

Sacramento River above Bend Bridge
Data Below Detection
oocysts/L
0.22
0.2
0.18
0.16
0.14
0.12
0.1
0.08
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000

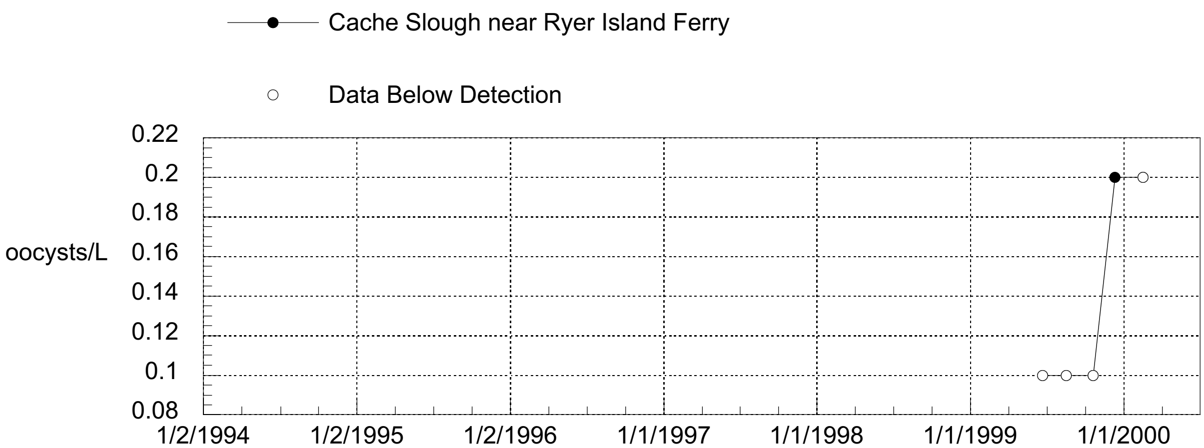

Sacramento River near Hamilton City
Data Below Detection
oocysts/L
0.6
0.5
0.4
0.3
0.2
0.1
0
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000


Sacramento River at Colusa
Data Below Detection
oocysts/L
1
0.8
0.6
0.4
0.2
0
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000


Feather River near Nicolaus
Data Below Detection
oocysts/L
0.25
0.2
0.15
0.1
0.05
0
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000


Sacramento River at Veterans Bridge
Data Below Detection
oocysts/L
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000


Sacramento River at Freeport
Data Below Detection
oocysts/L
0.12
0.1
0.08
0.06
0.04
0.02
0
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000



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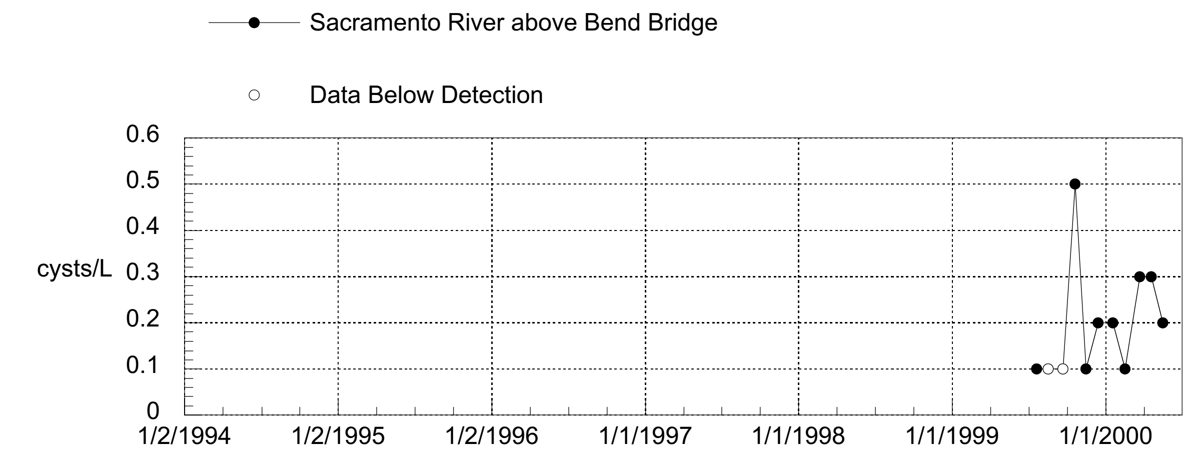
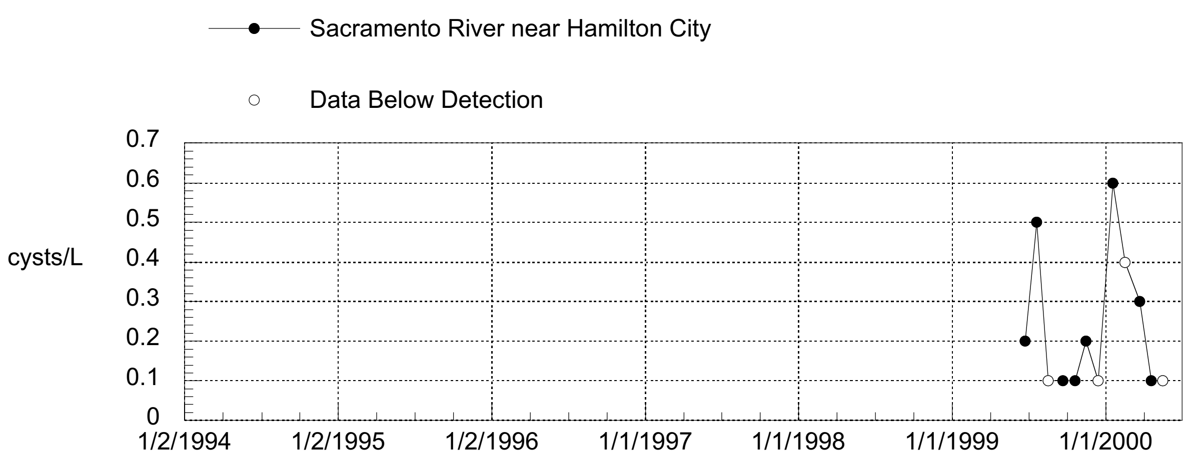
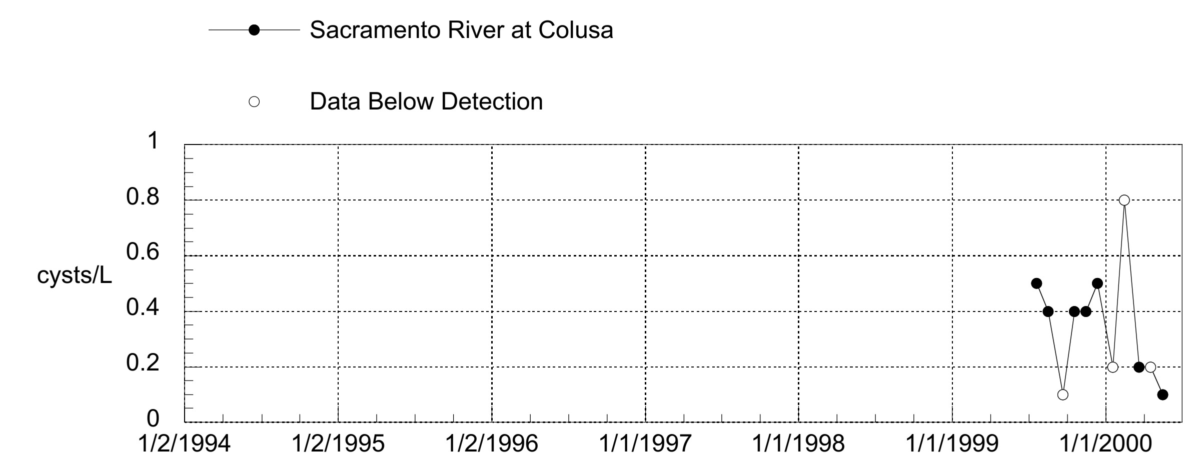


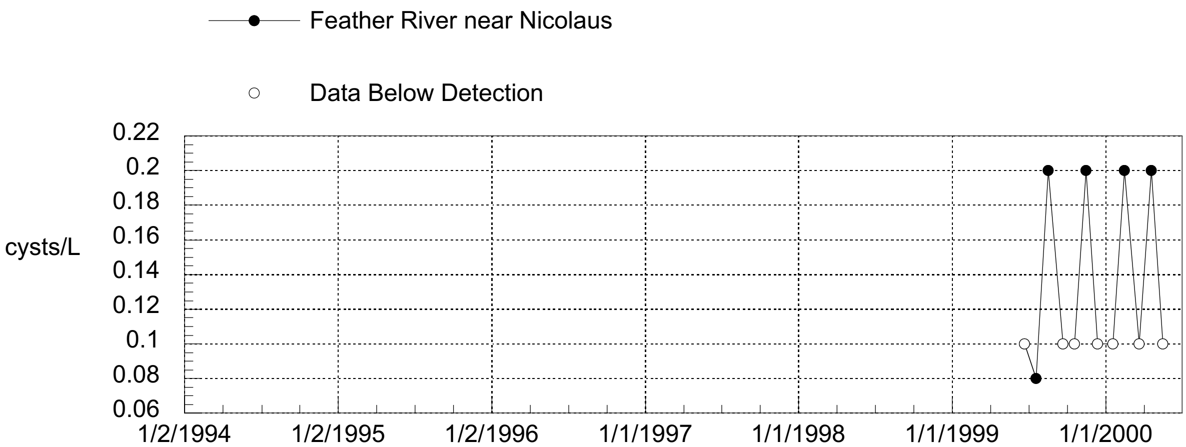
Sacramento River above Bend Bridge
Data Below Detection
cysts/L
0
0.1
0.2
0.3
0.4
0.5
0.6
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000

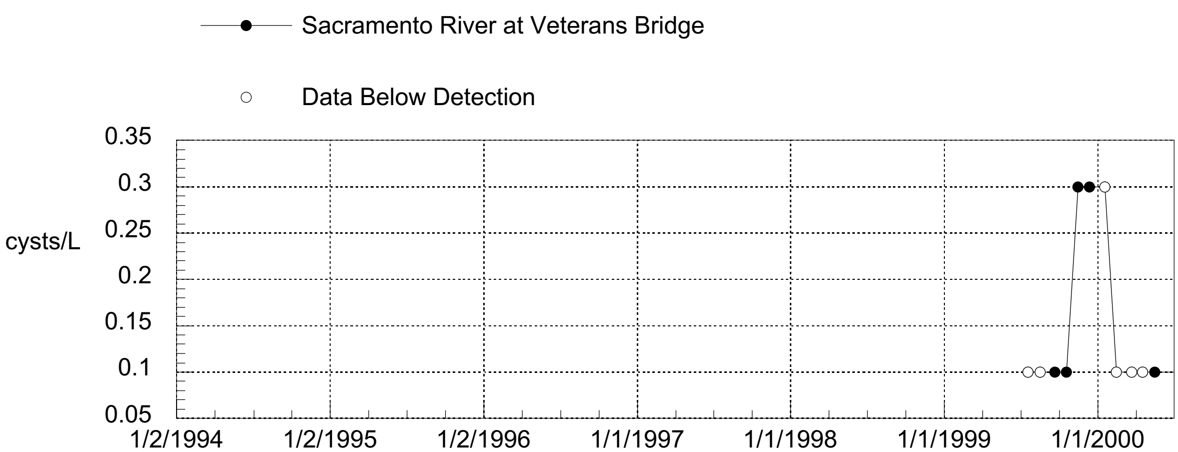


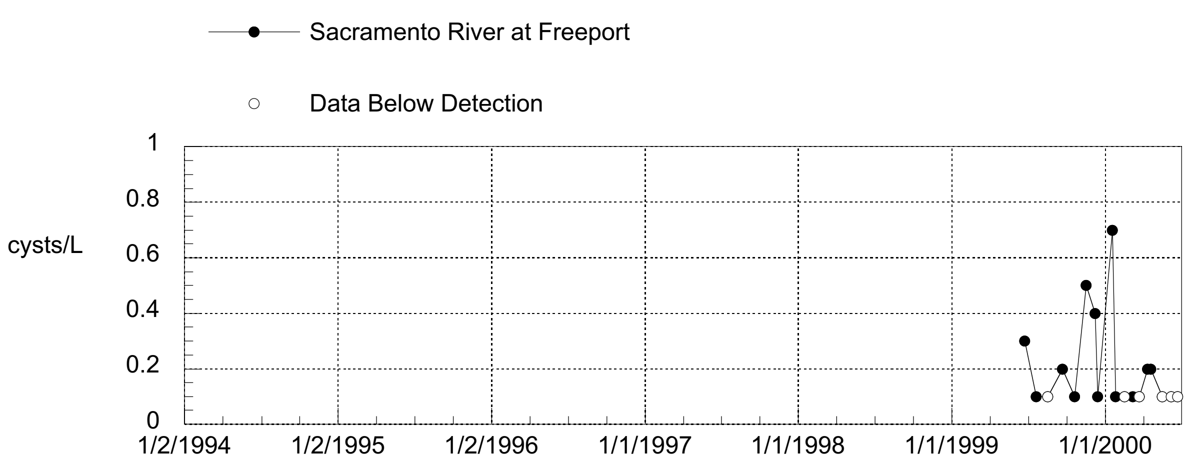
Sacramento River near Hamilton City
Data Below Detection
cysts/L
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000

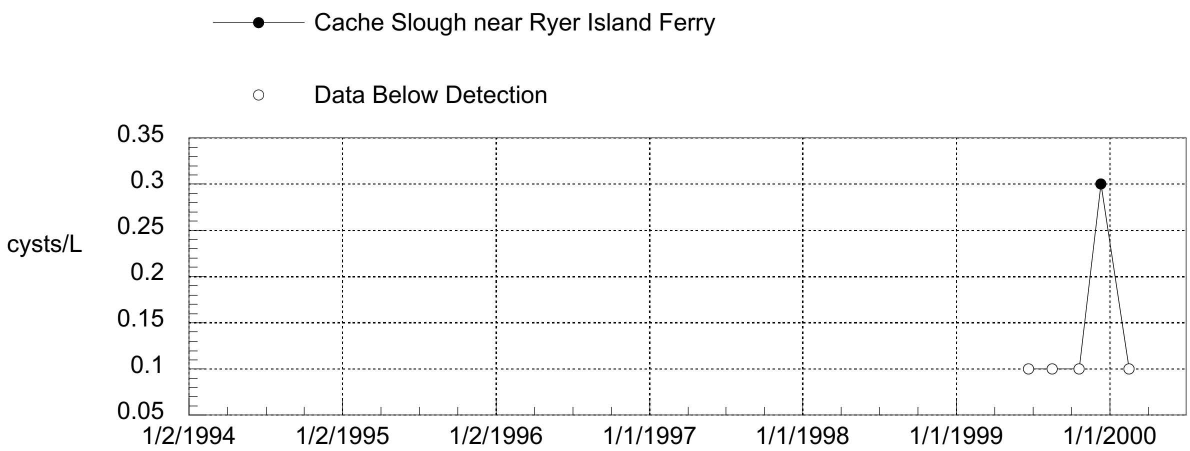


Sacramento River at Colusa
Data Below Detection
cysts/L
0
0.2
0.4
0.6
0.8
1
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000


Feather River near Nicolaus
Data Below Detection
cysts/L
0.22
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000


Sacramento River at Veterans Bridge
Data Below Detection
cysts/L
0.35
0.3
0.25
0.2
0.15
0.1
0.05
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000


Sacramento River at Freeport
Data Below Detection
cysts/L
1
0.8
0.6
0.4
0.2
0
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000



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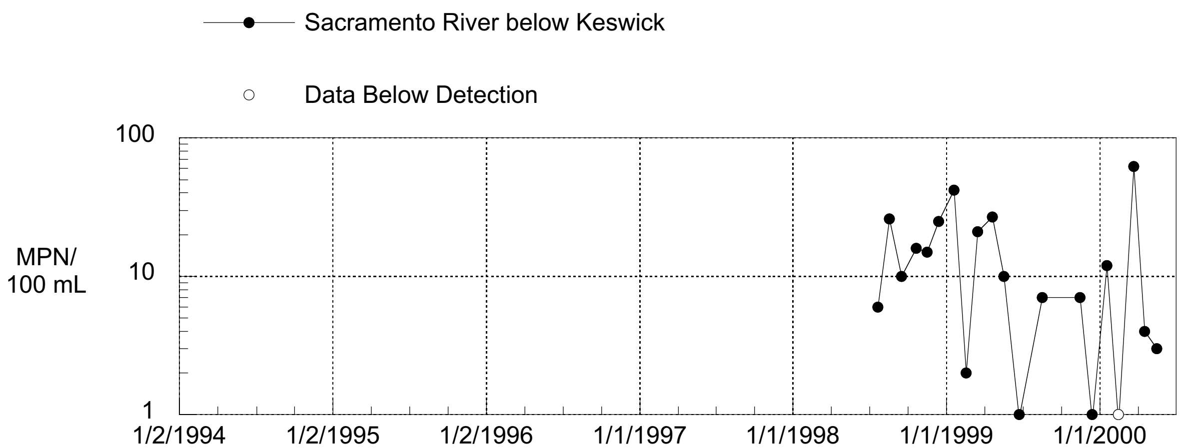
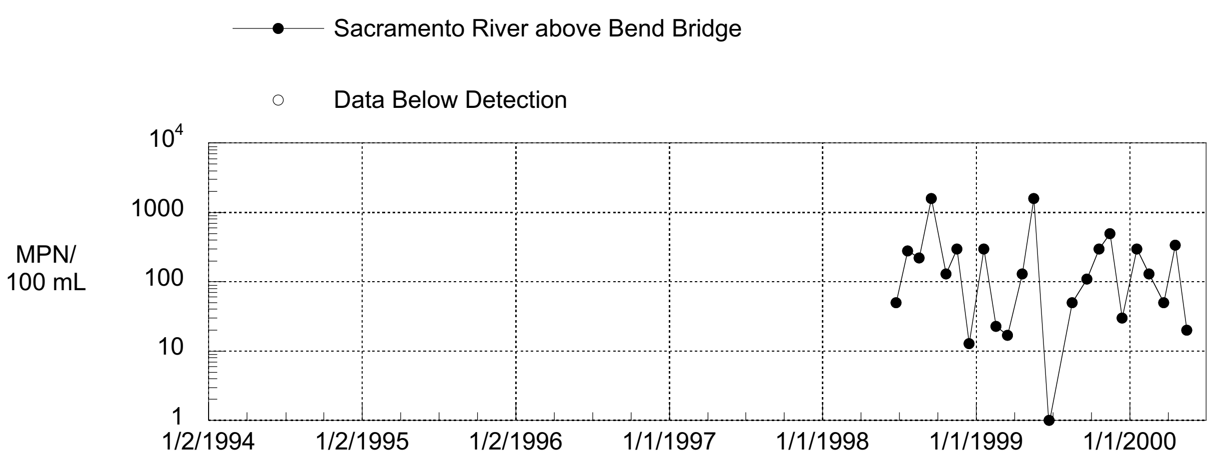
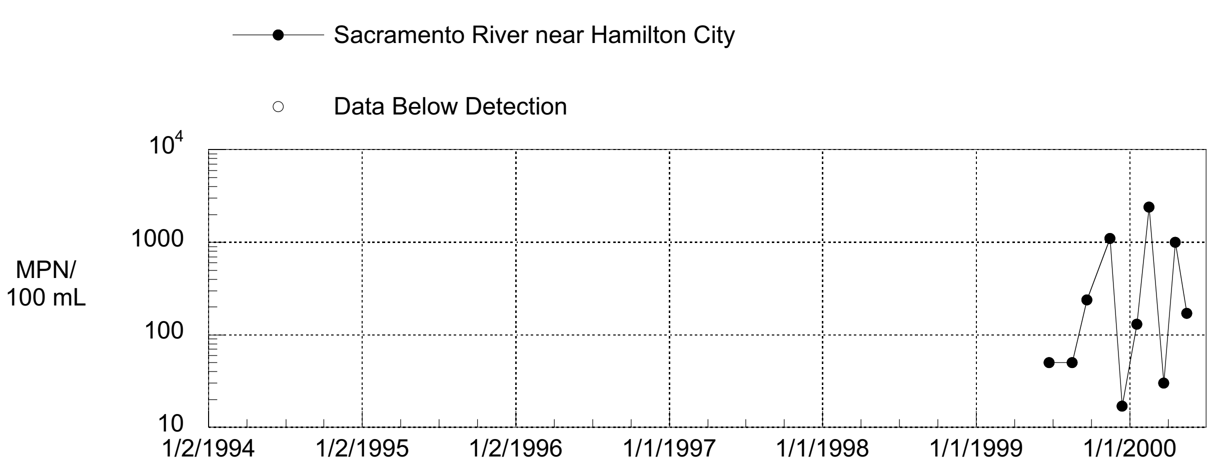
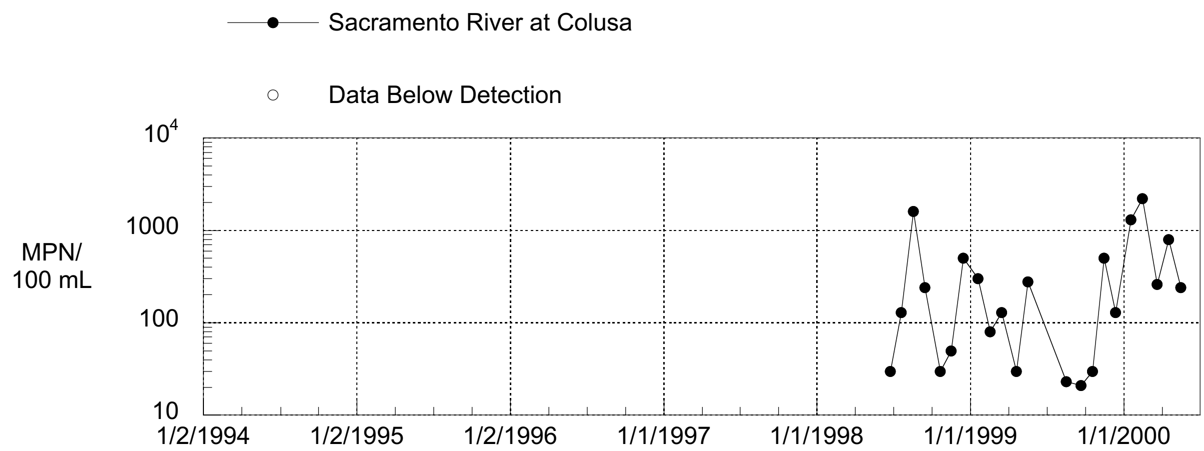
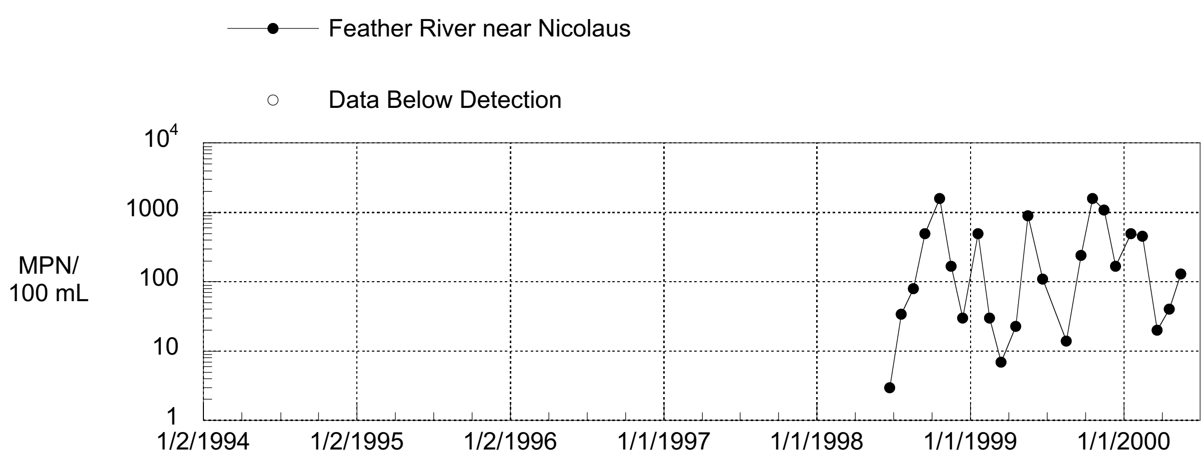
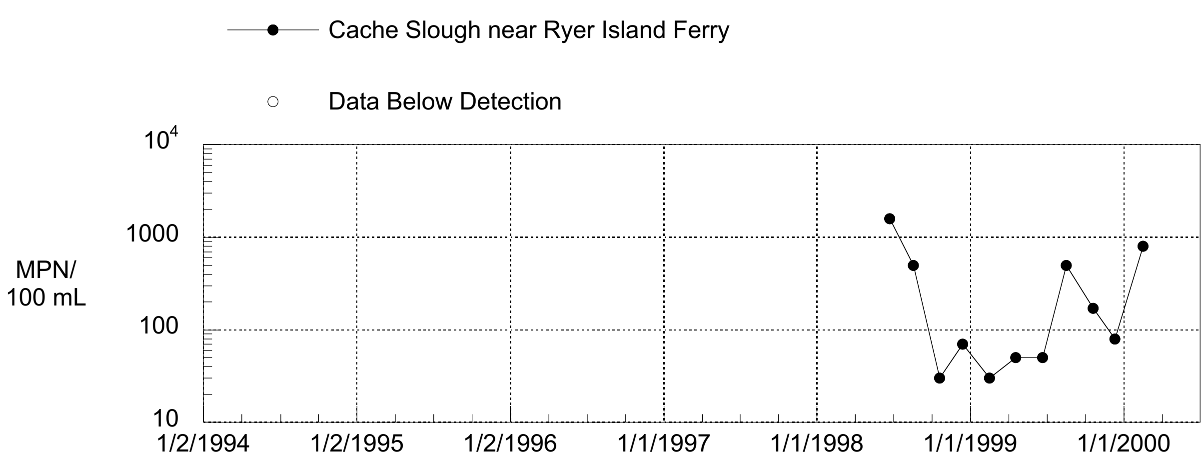

Sacramento River below Keswick
Data Below Detection
MPN/
100 mL
100
10
1
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000

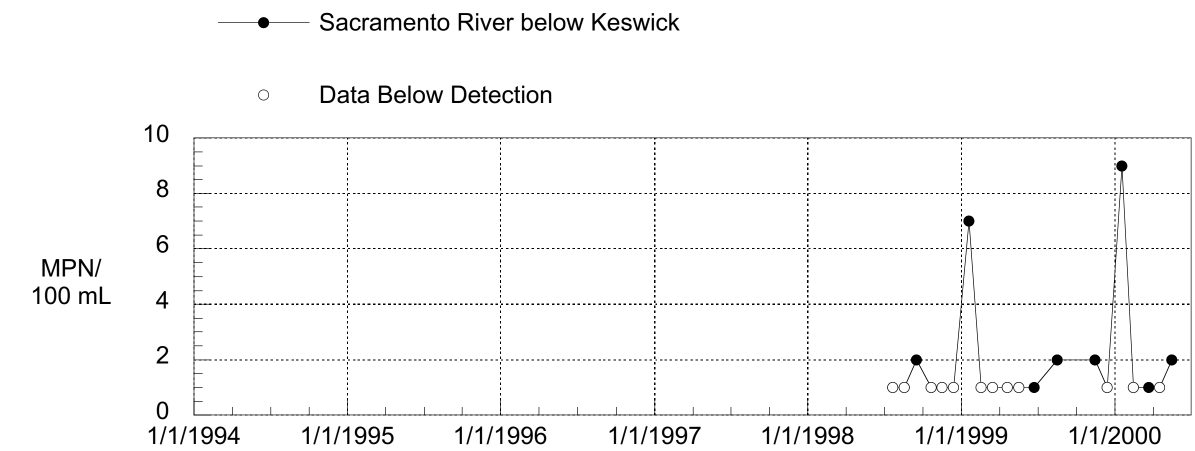

Sacramento River above Bend Bridge
Data Below Detection
MPN/
100 mL
10^4
1000
100
10
1
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000

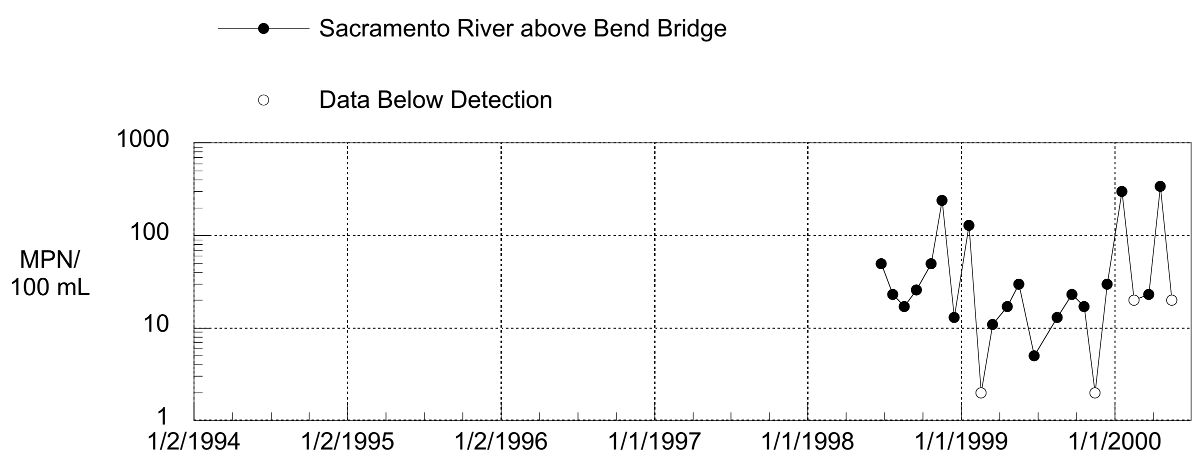

Sacramento River near Hamilton City
Data Below Detection
MPN/
100 mL
10^4
1000
100
10
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000

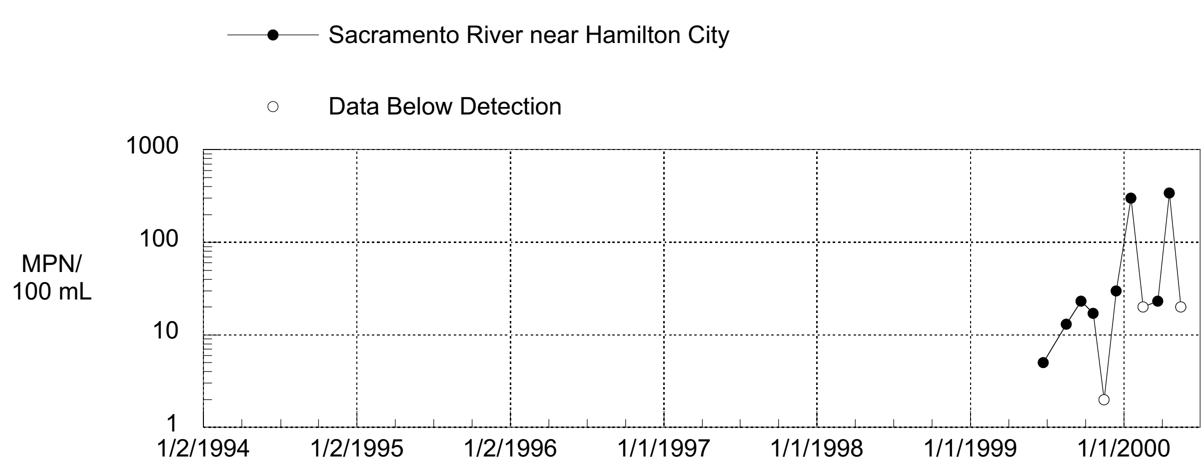

Sacramento River at Colusa
Data Below Detection
10^4
1000
100
10
MPN/
100 mL
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000

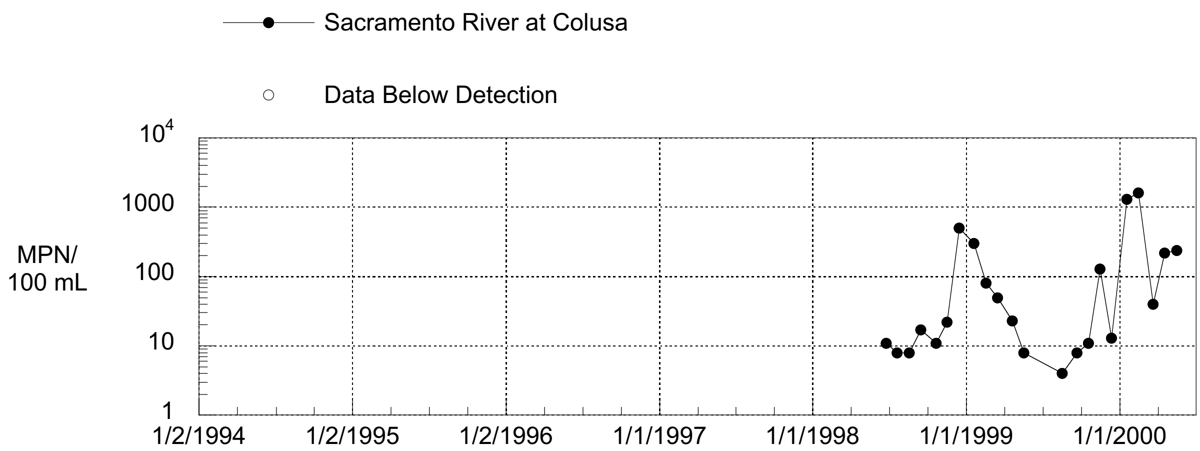

Feather River near Nicolaus
Data Below Detection
10^4
1000
100
10
1
MPN/
100 mL
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000

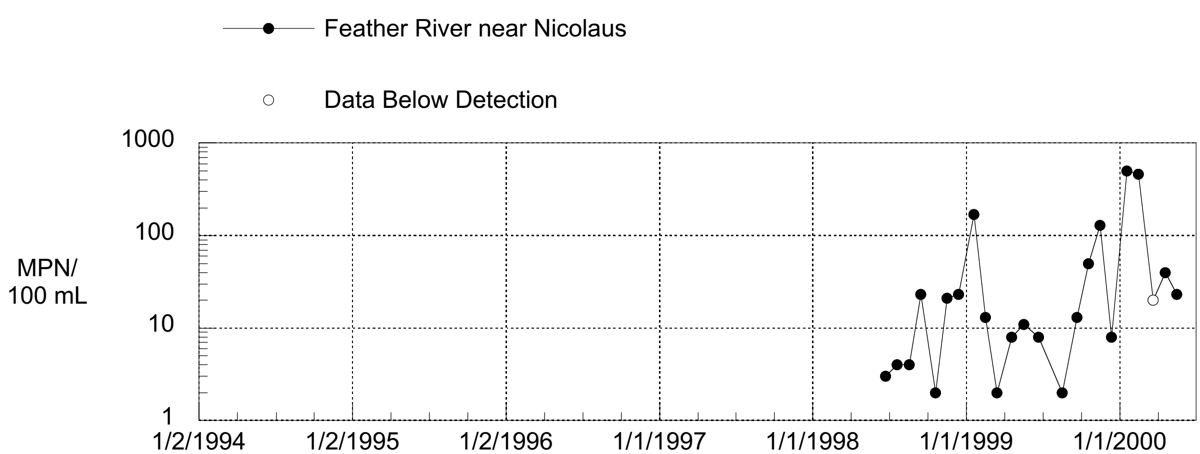

Cache Slough near Ryer Island Ferry
Data Below Detection
10^4
1000
100
10
MPN/
100 mL
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000

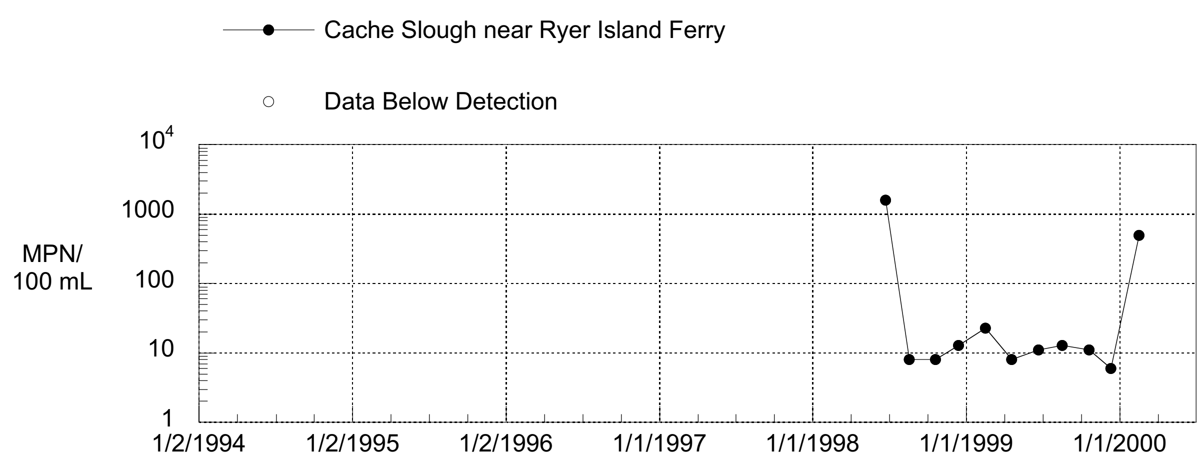

Sacramento River below Keswick
Data Below Detection
MPN/
100 mL
10
8
6
4
2
0
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000


Sacramento River above Bend Bridge
Data Below Detection
MPN/
100 mL
1000
100
10
1
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000


Sacramento River near Hamilton City
Data Below Detection
MPN/
100 mL
1000
100
10
1
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000

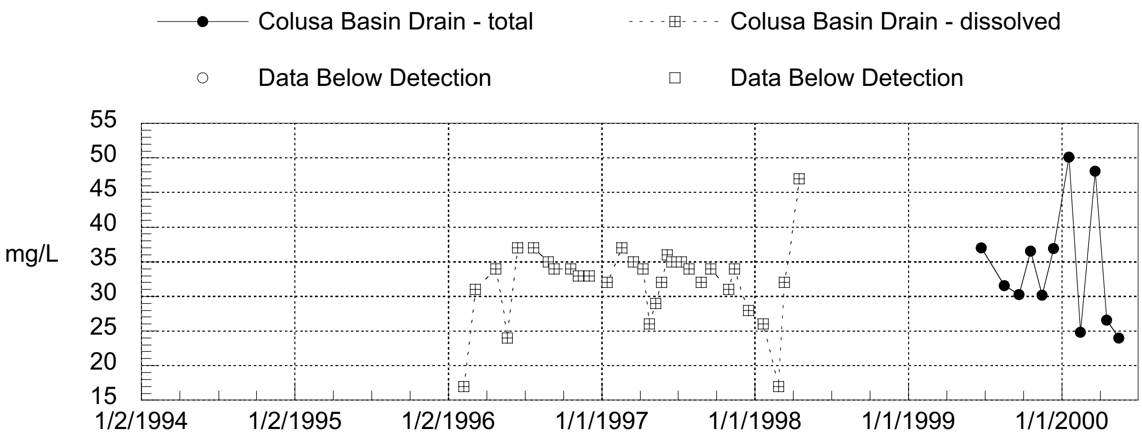

Sacramento River at Colusa
Data Below Detection
MPN/
100 mL
10^4
1000
100
10
1
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000

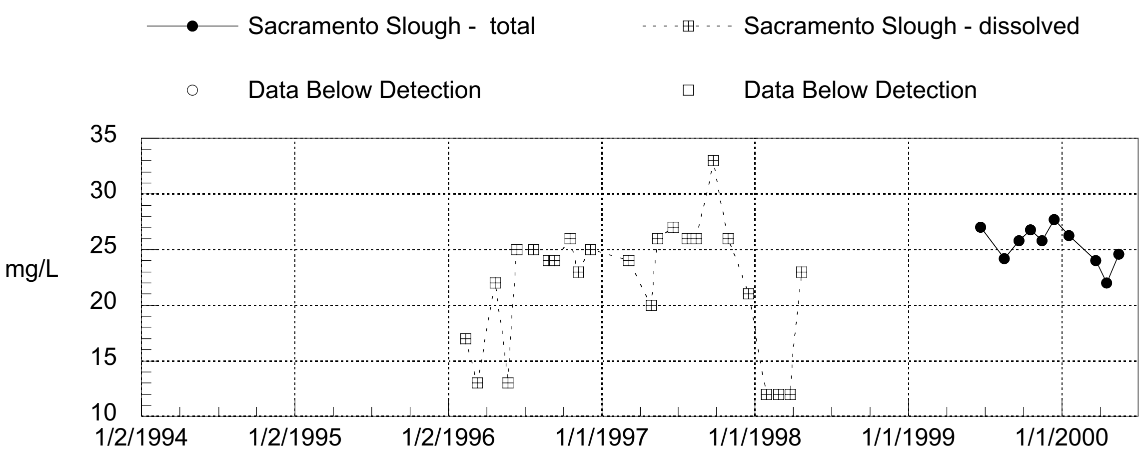

Feather River near Nicolaus
Data Below Detection
MPN/
100 mL
1000
100
10
1
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000

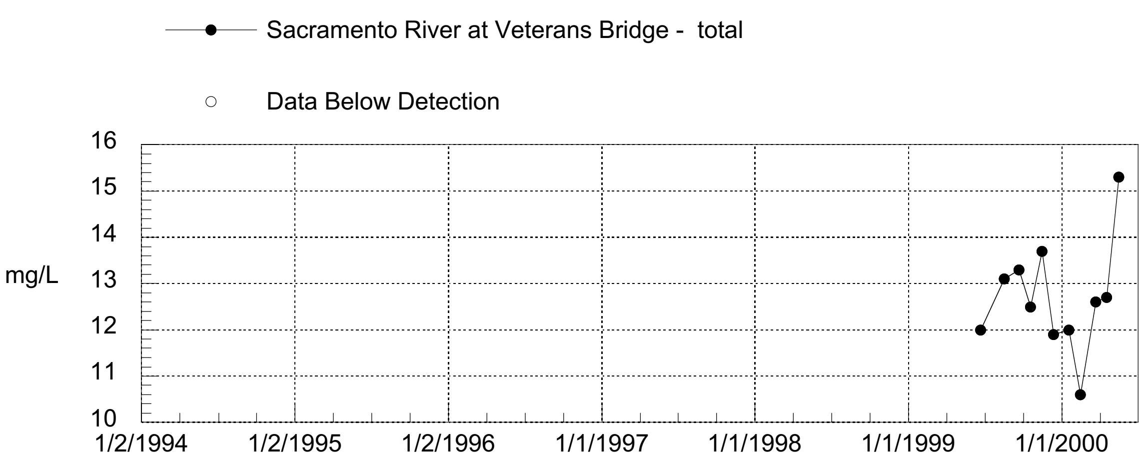

Cache Slough near Ryer Island Ferry
Data Below Detection
MPN/
100 mL
10^4
1000
100
10
1
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000

Time Series Plots of Monitoring Data: Minerals

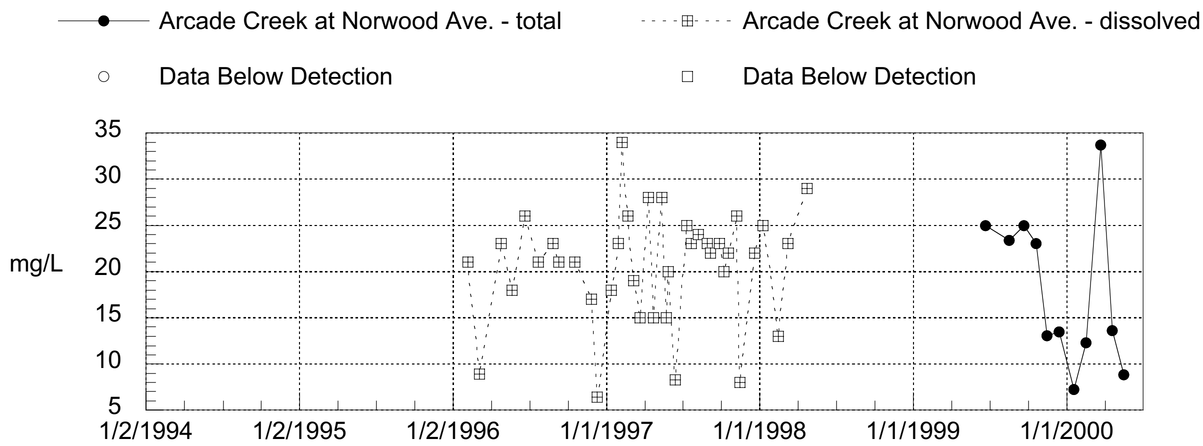
CALCIUM CONCENTRATIONS IN WATER

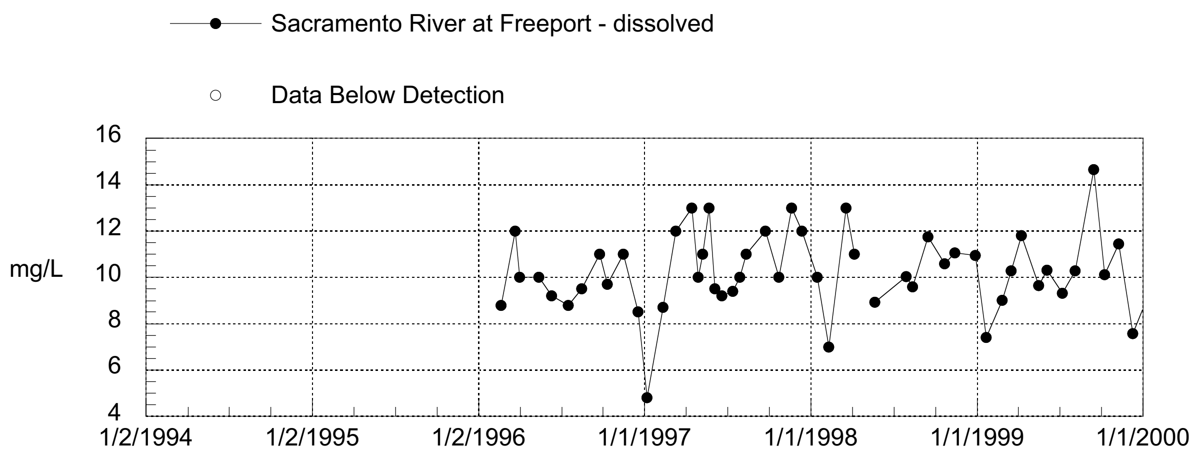


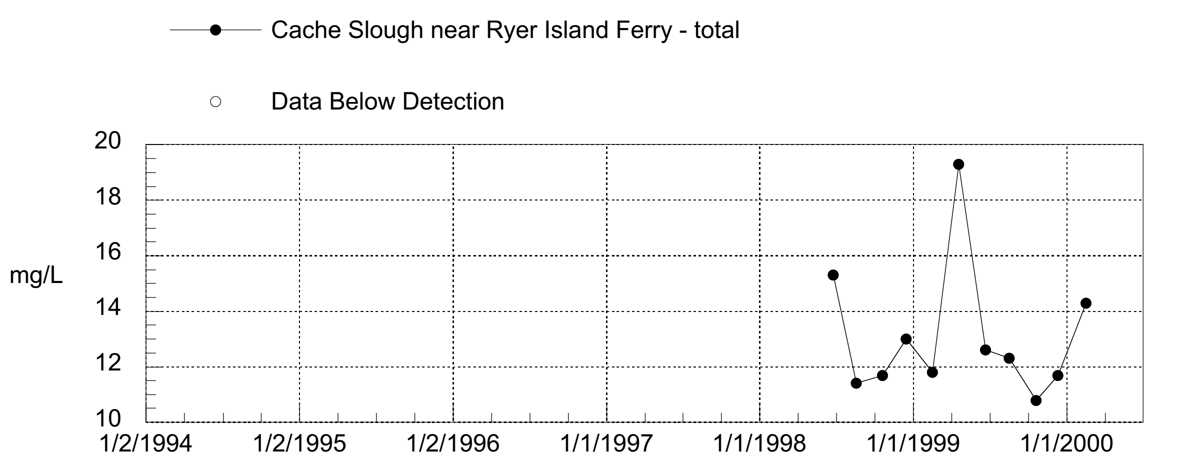




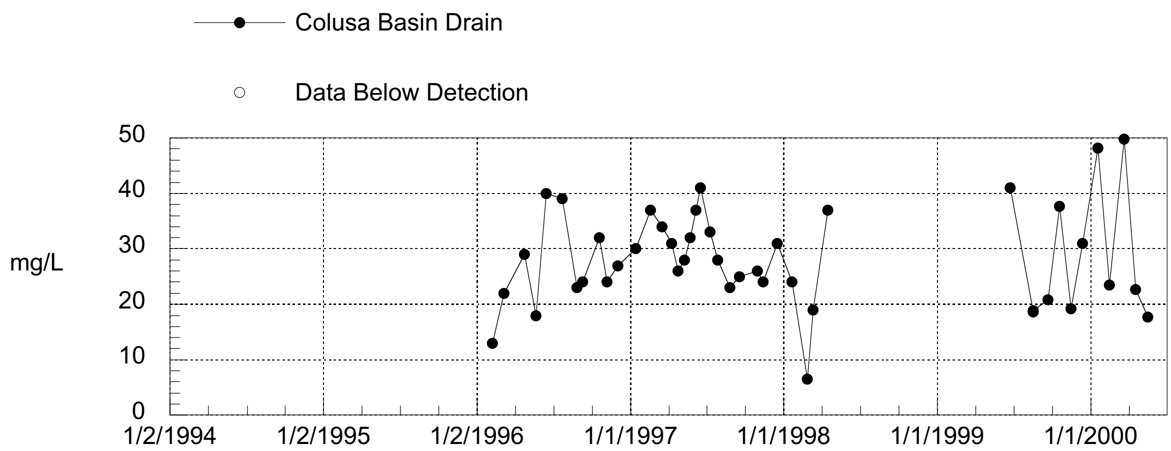
CALCIUM CONCENTRATIONS IN WATER

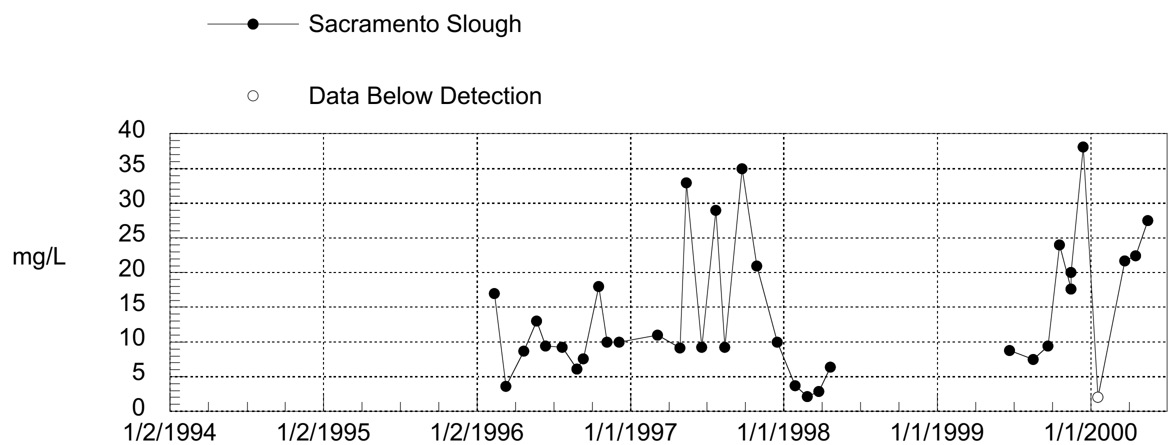


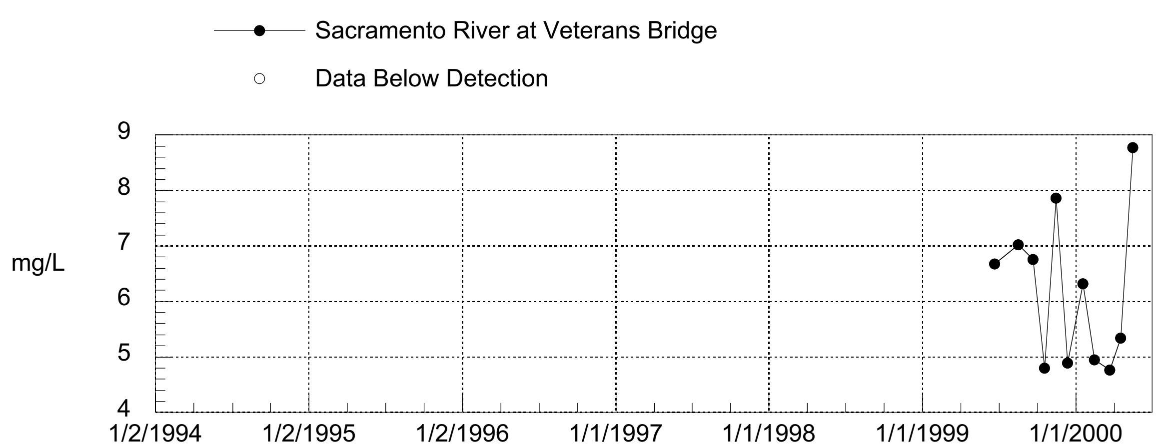




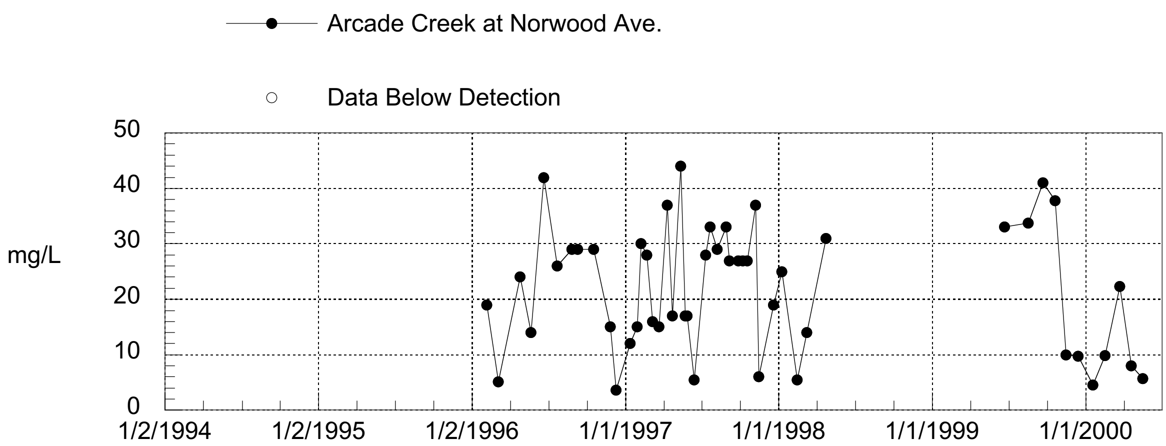
CHLORIDE CONCENTRATIONS IN WATER

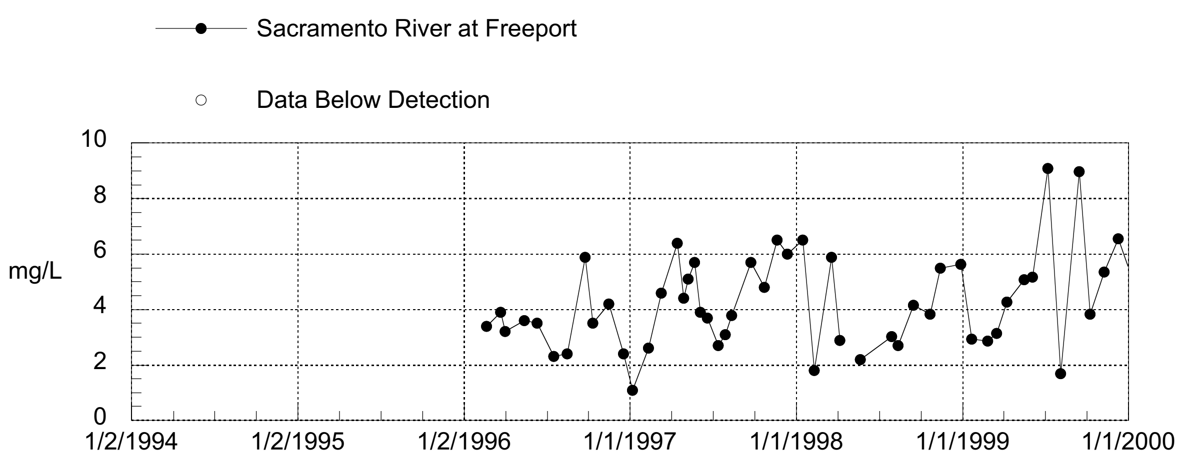


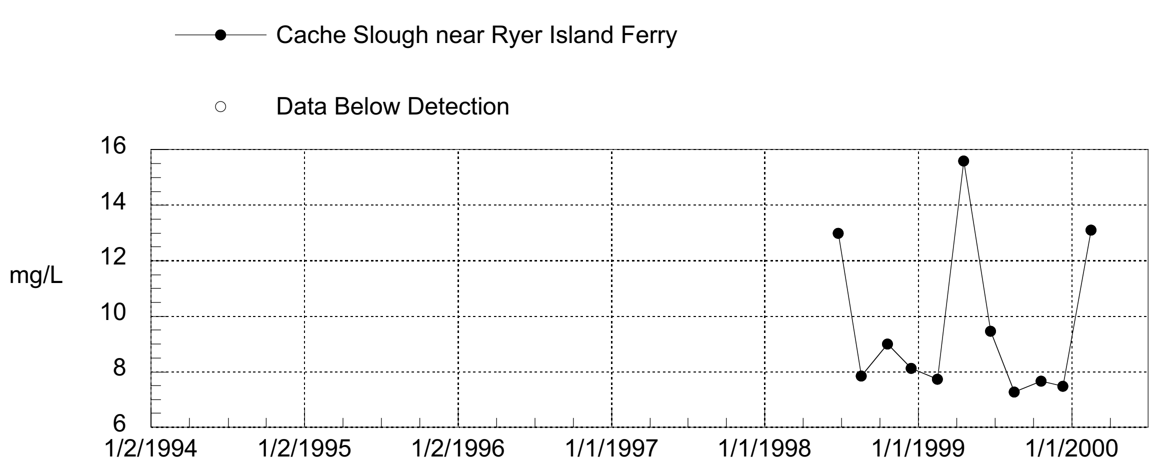




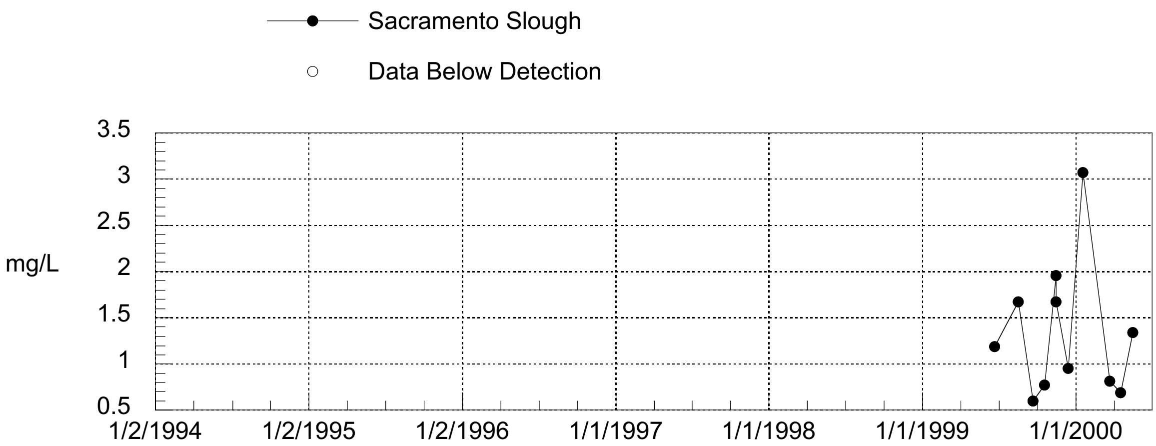
CHLORIDE CONCENTRATIONS IN WATER

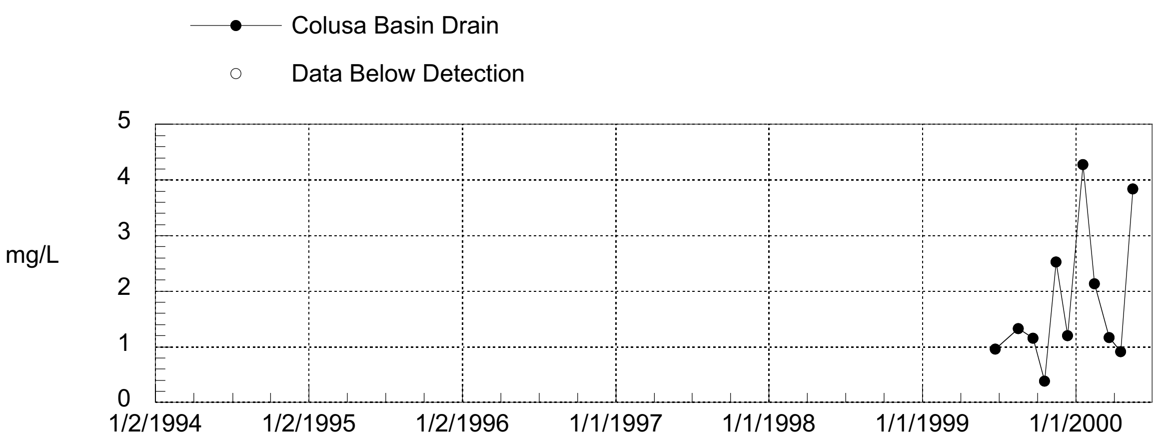


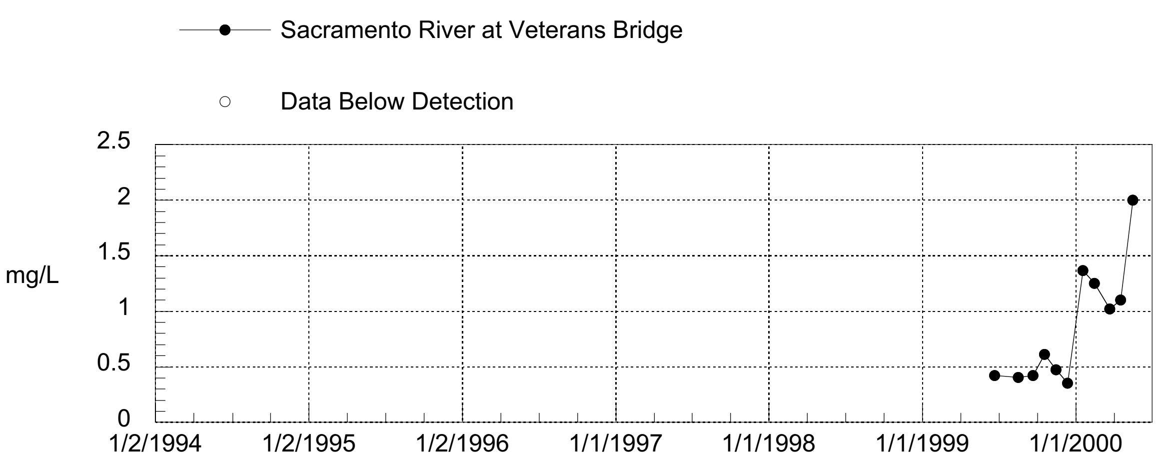




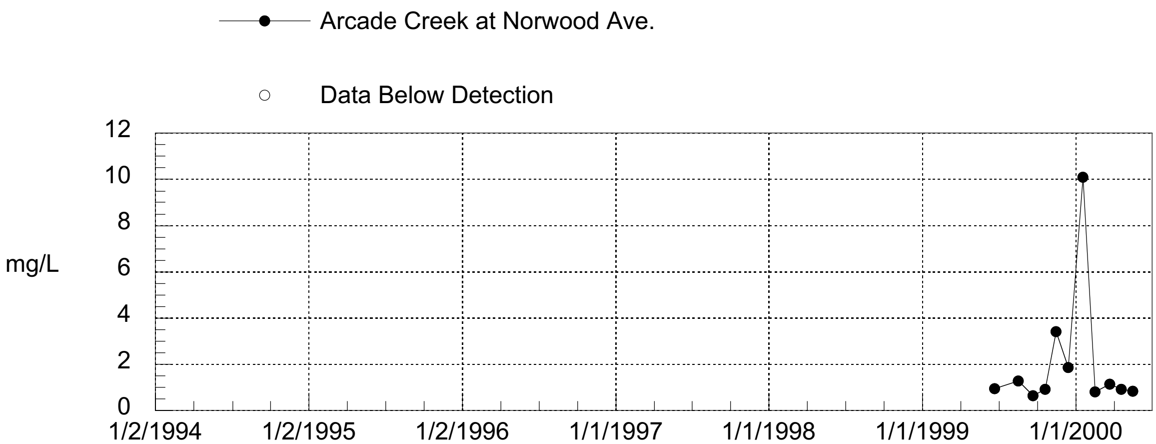
TOTAL IRON CONCENTRATIONS IN WATER

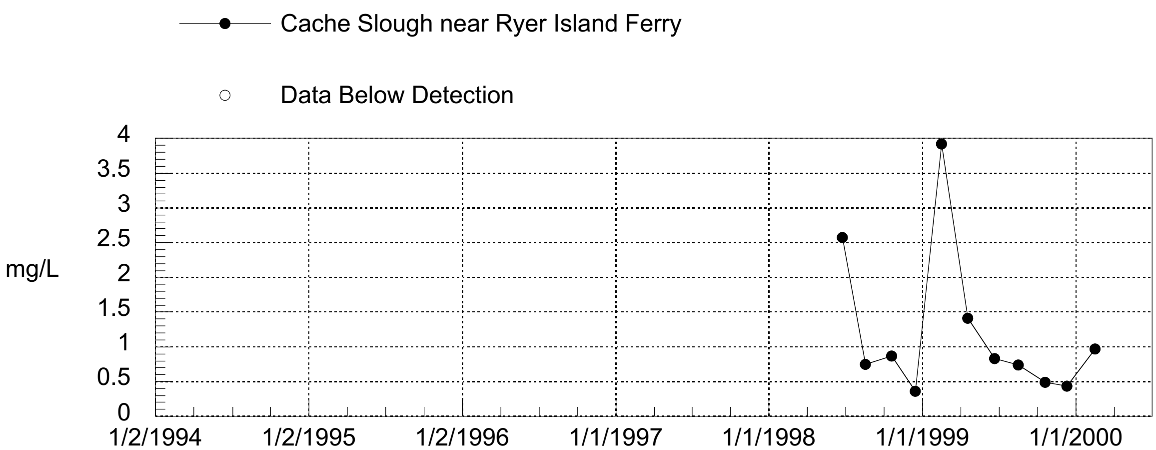






TOTAL IRON CONCENTRATIONS IN WATER





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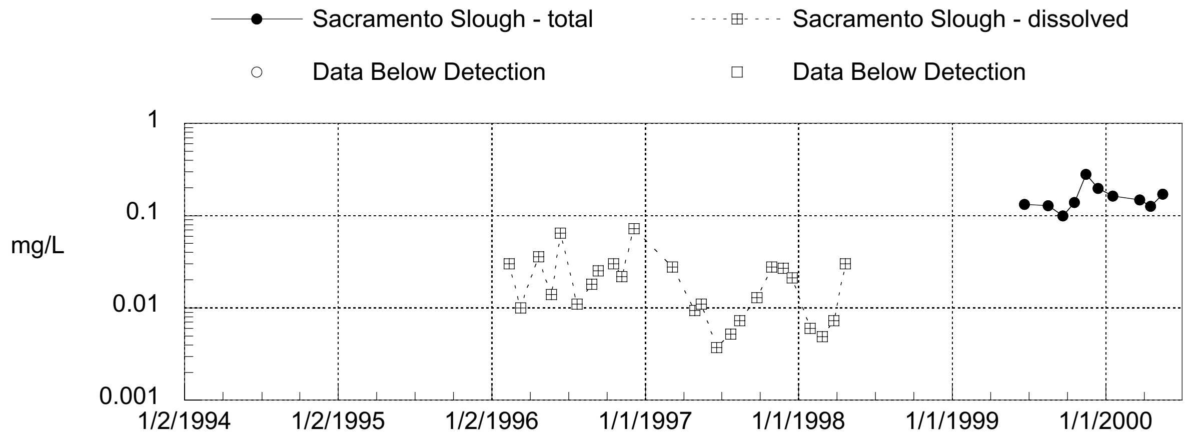
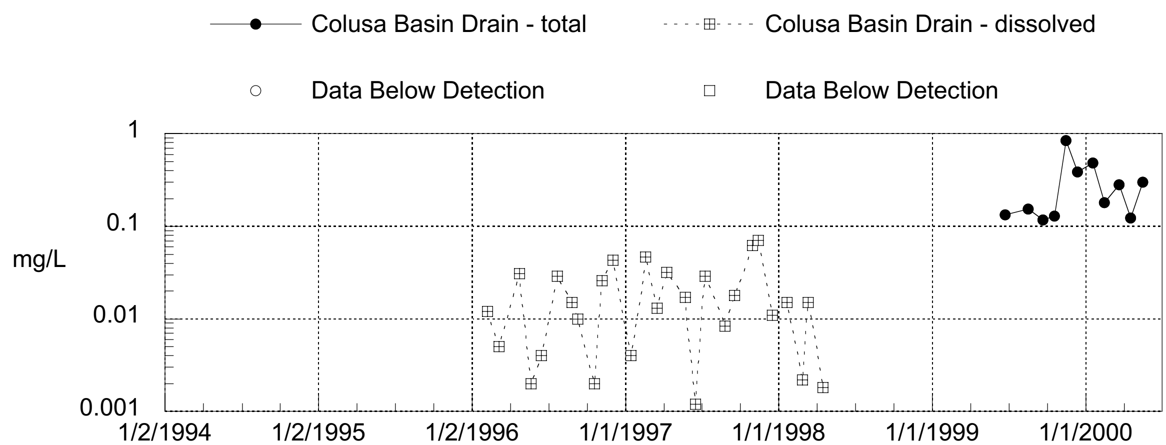
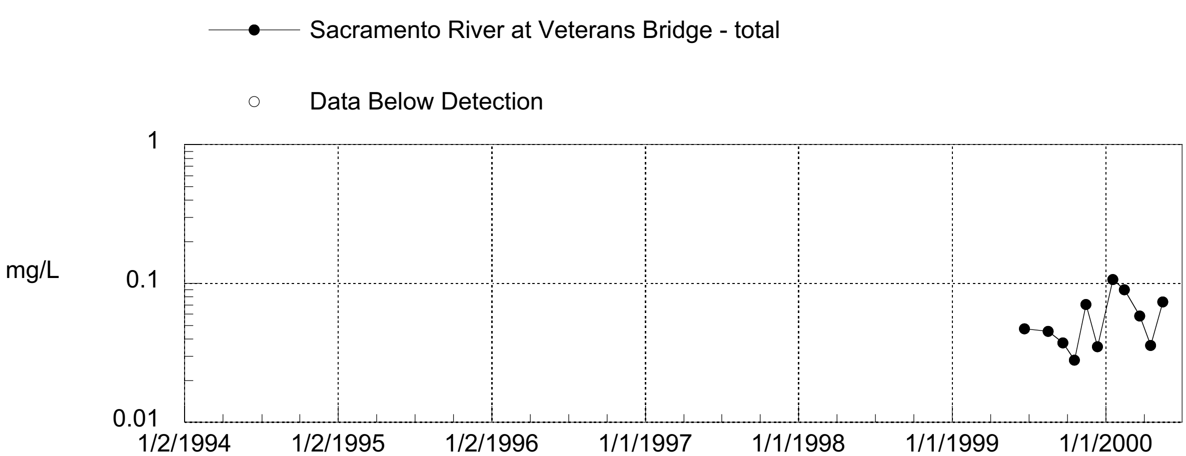
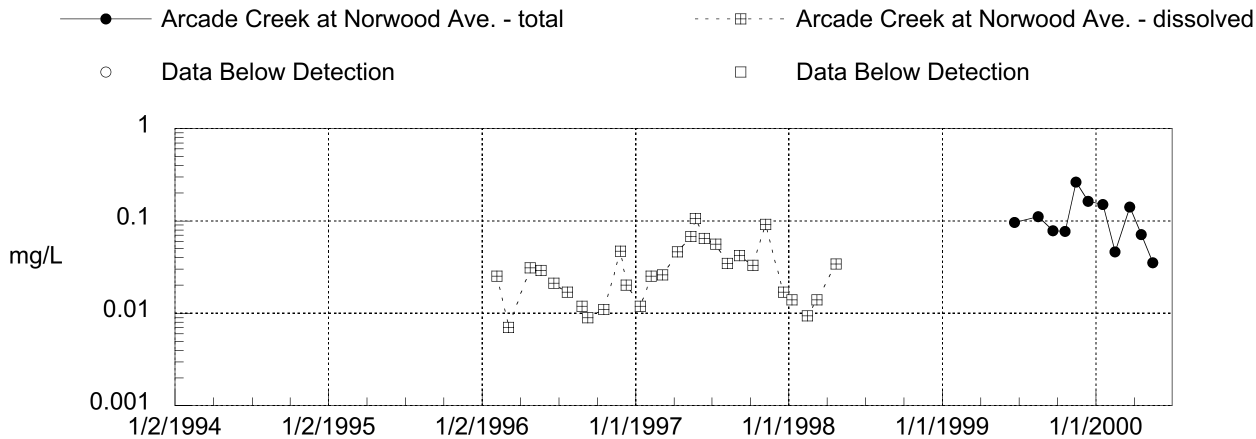
MANGANESE CONCENTRATIONS IN WATER

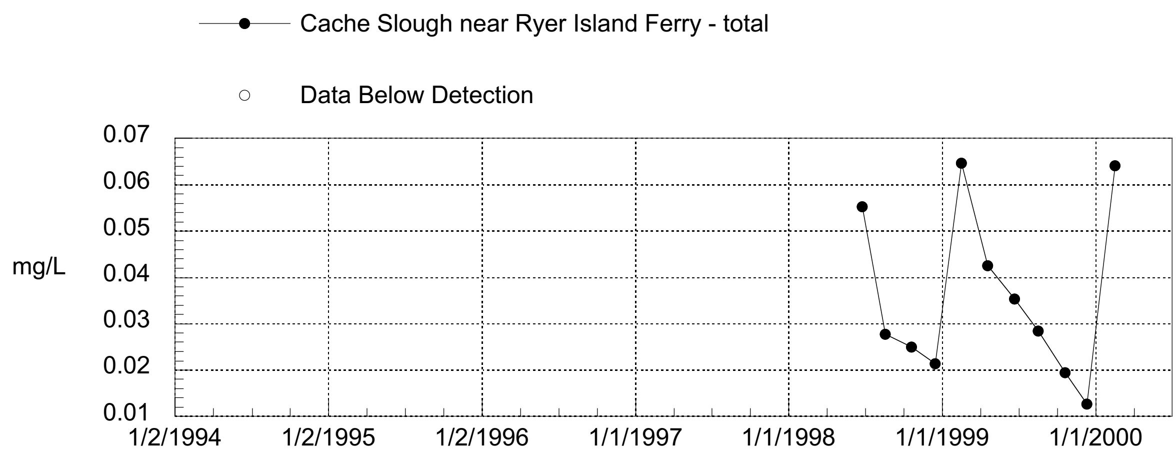






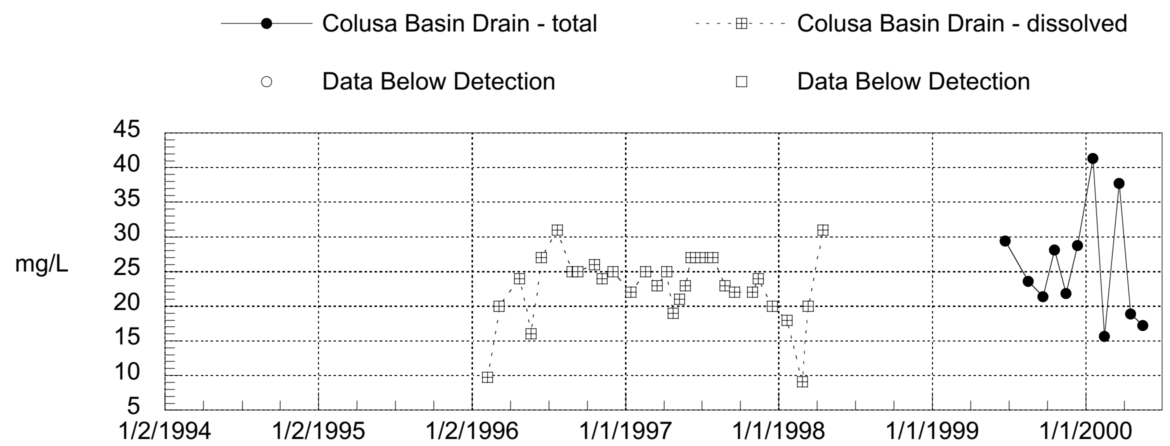
MANGANESE CONCENTRATIONS IN WATER

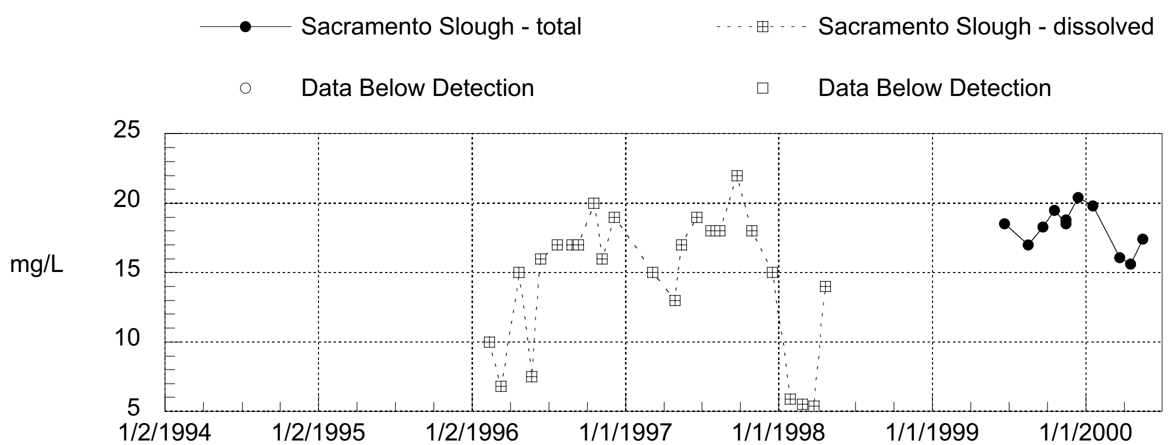


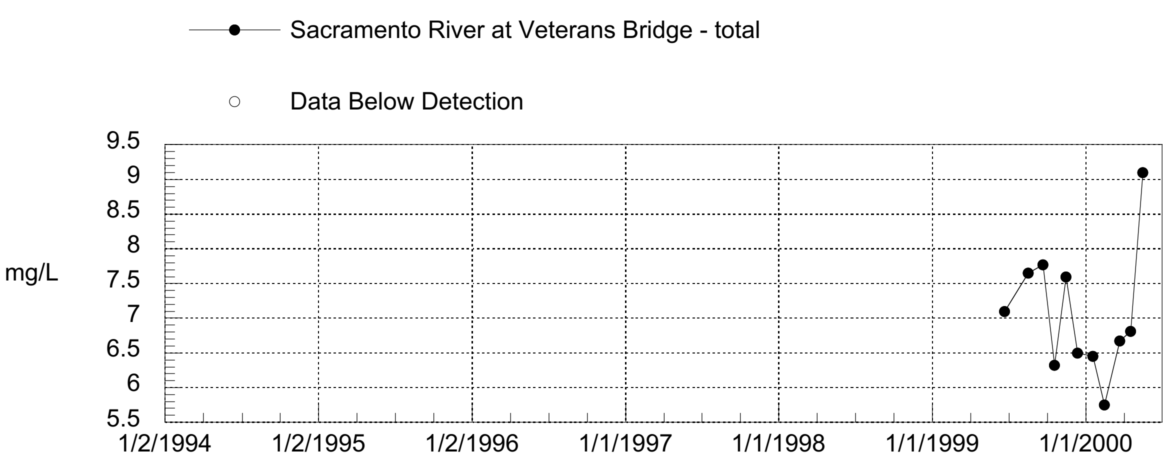


SPACE INTENTIONALLY BLANK

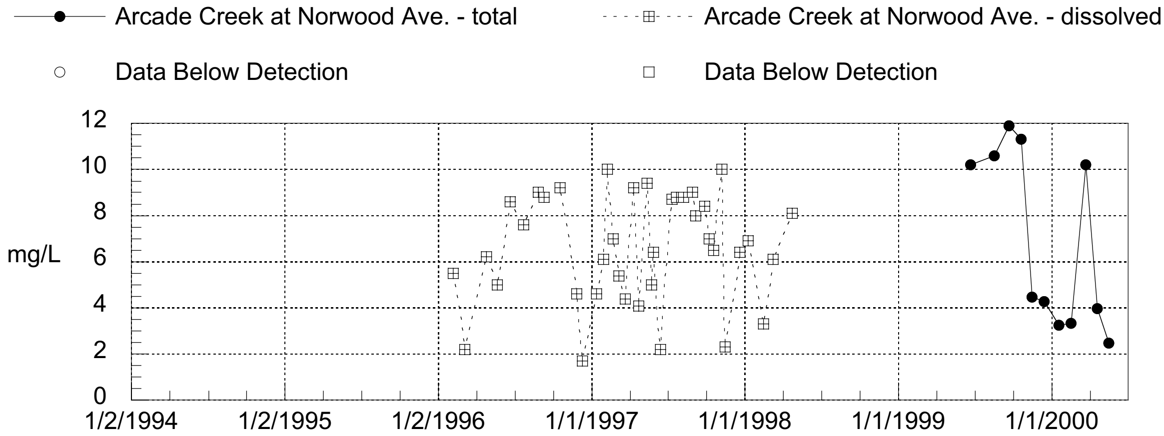
MAGNESIUM CONCENTRATIONS IN WATER

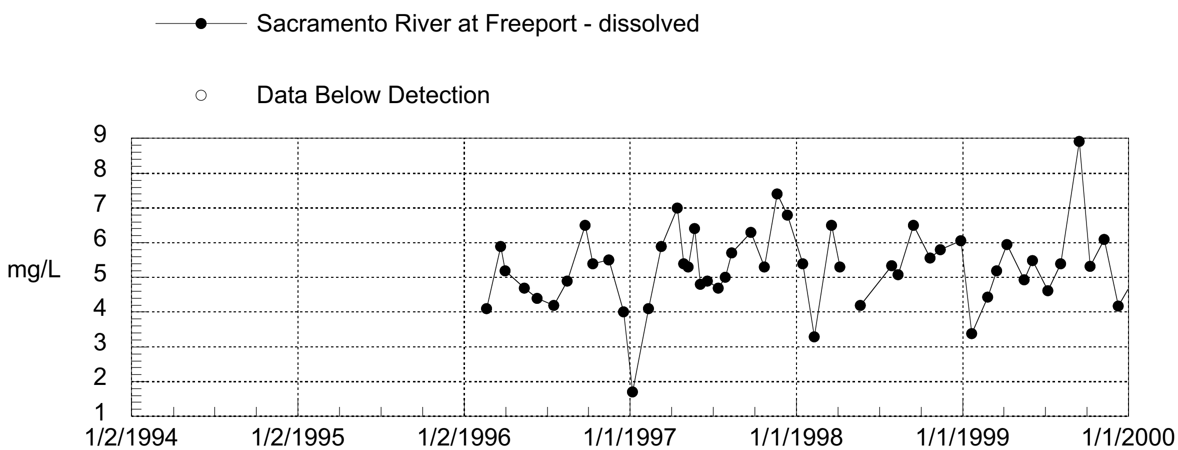


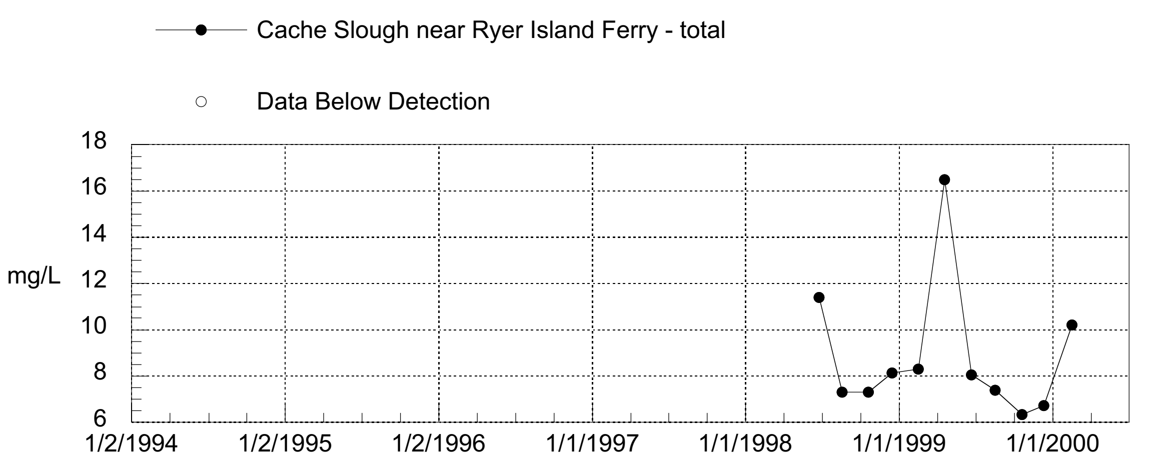




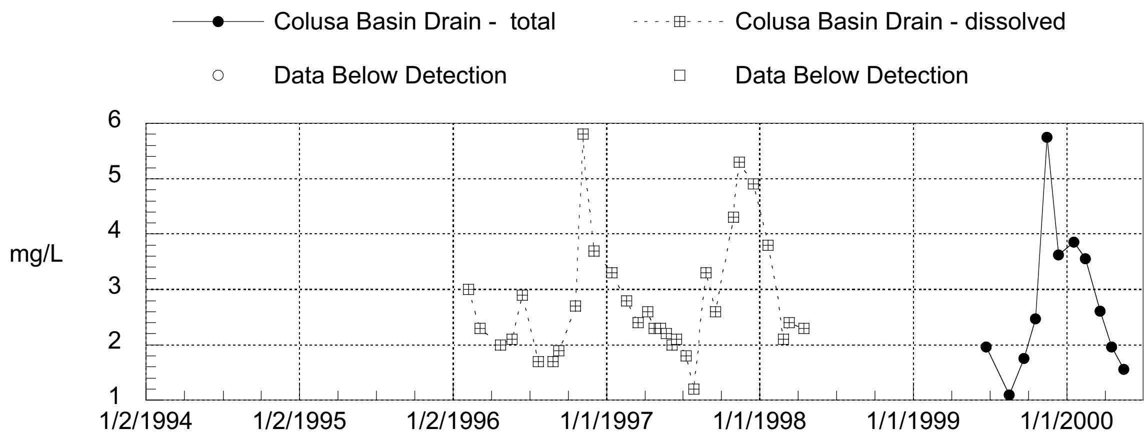
MAGNESIUM CONCENTRATIONS IN WATER

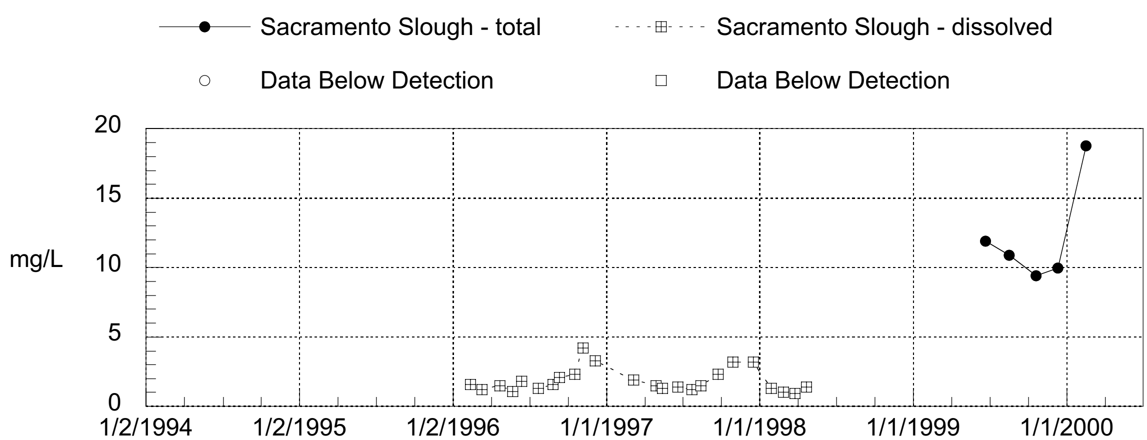


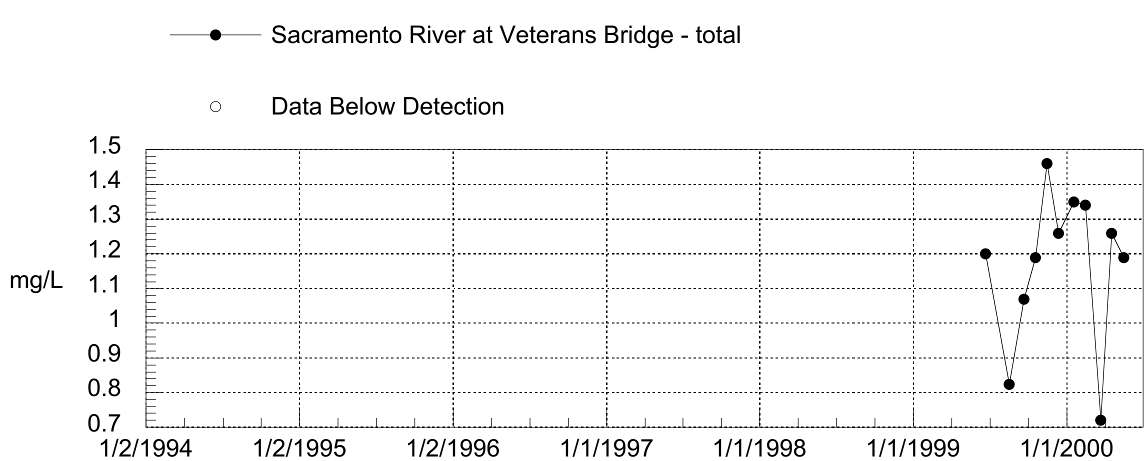




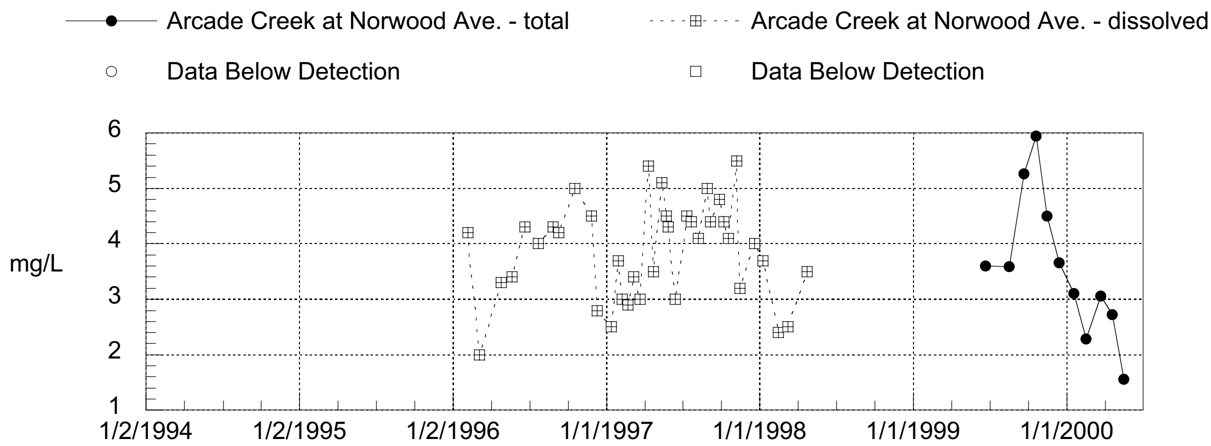
POTASSIUM CONCENTRATIONS IN WATER

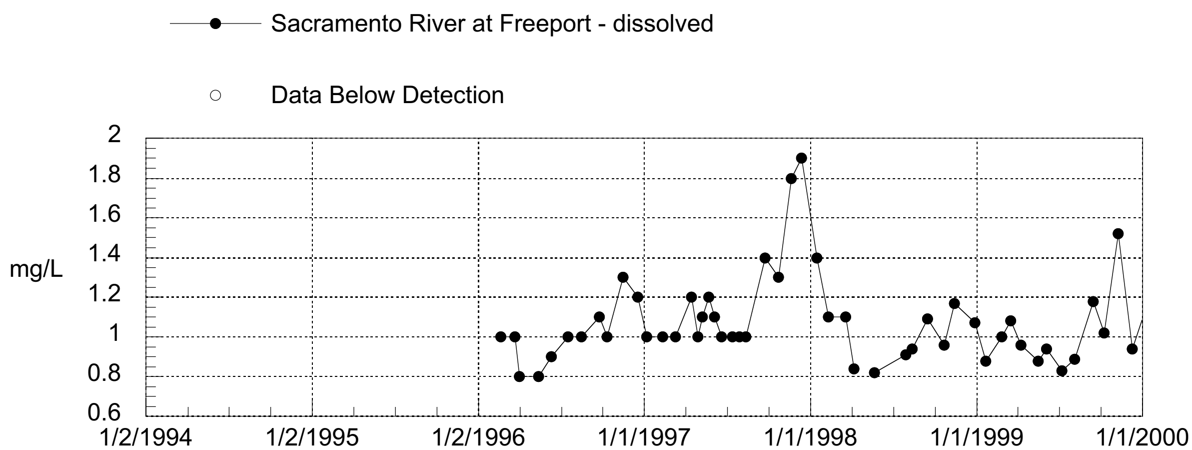


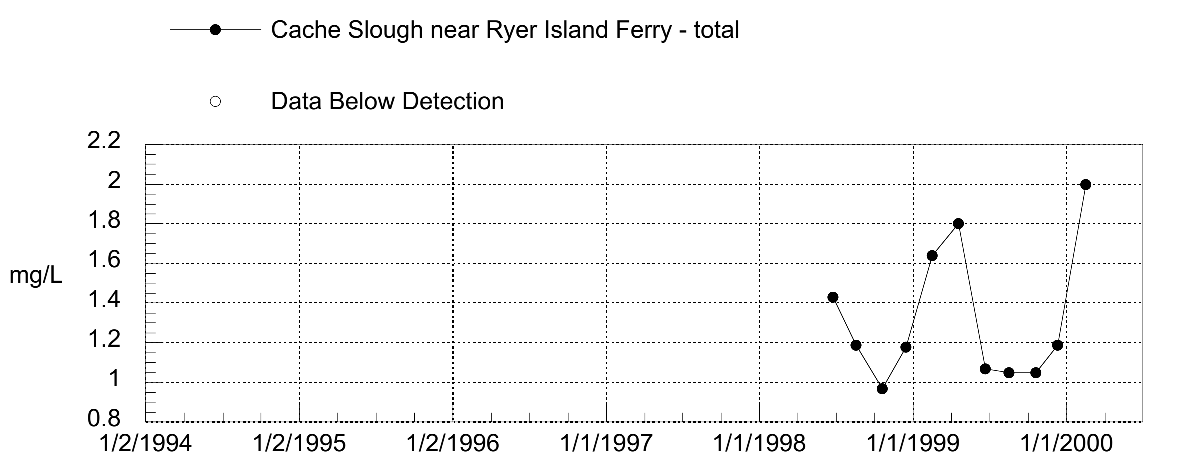




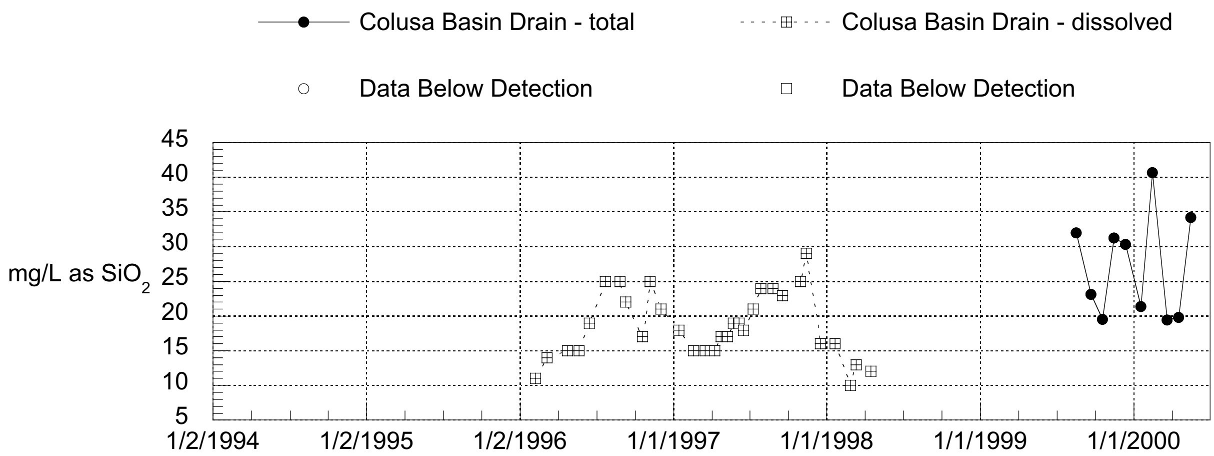
POTASSIUM CONCENTRATIONS IN WATER

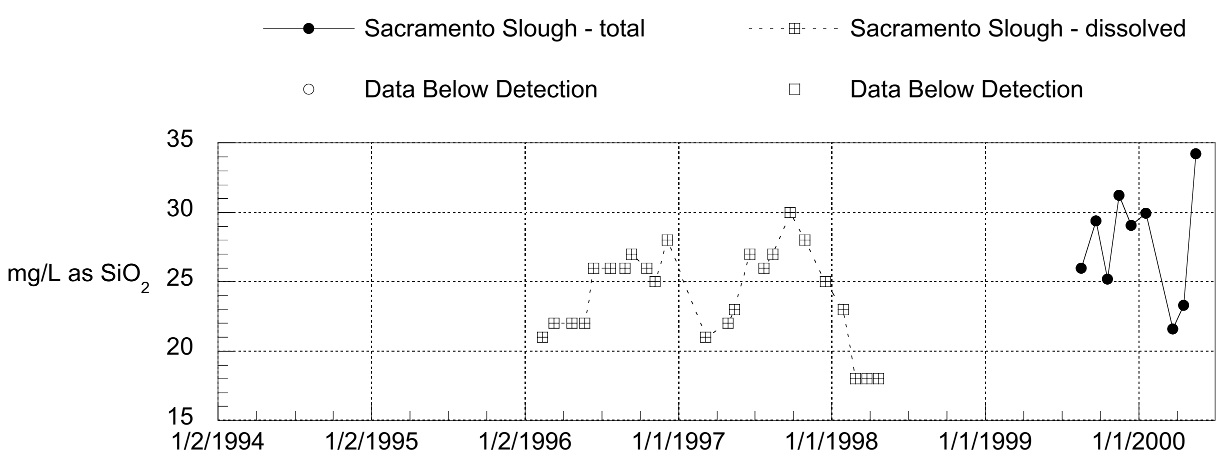


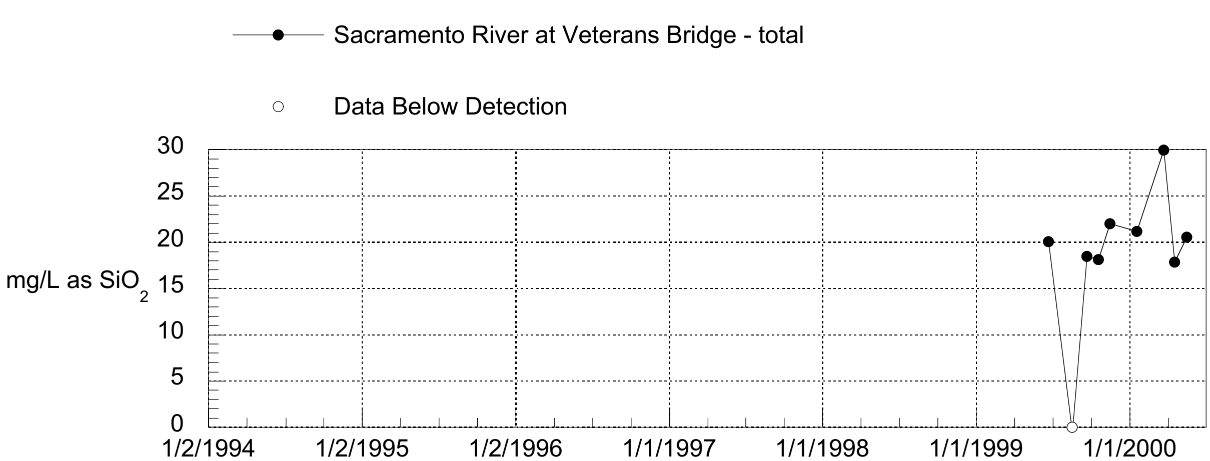




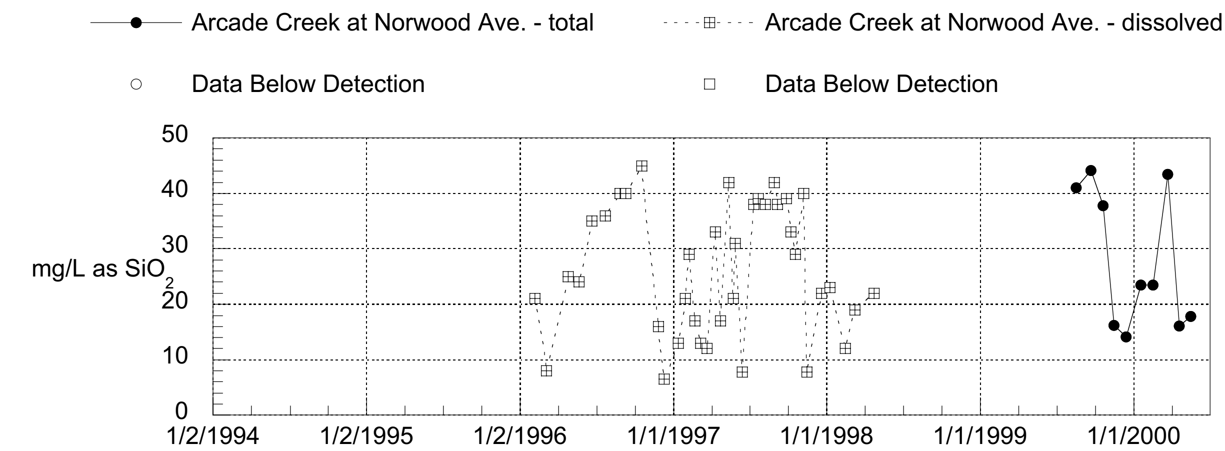
SILICA CONCENTRATIONS IN WATER

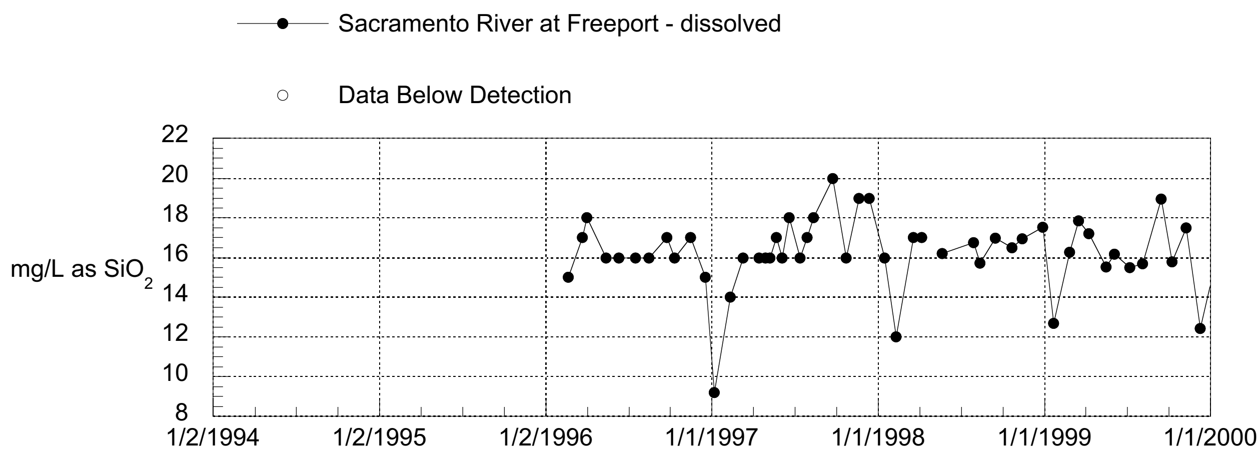


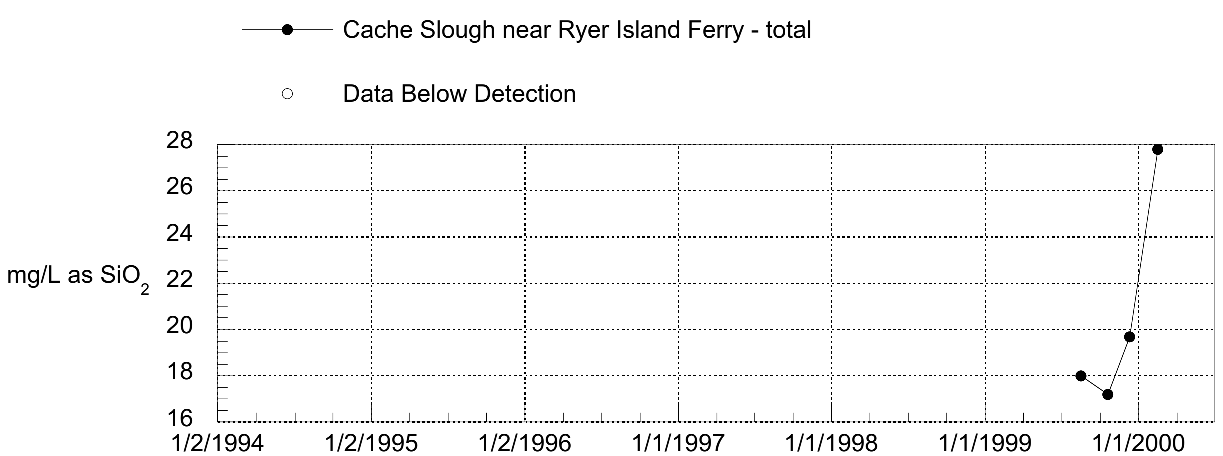




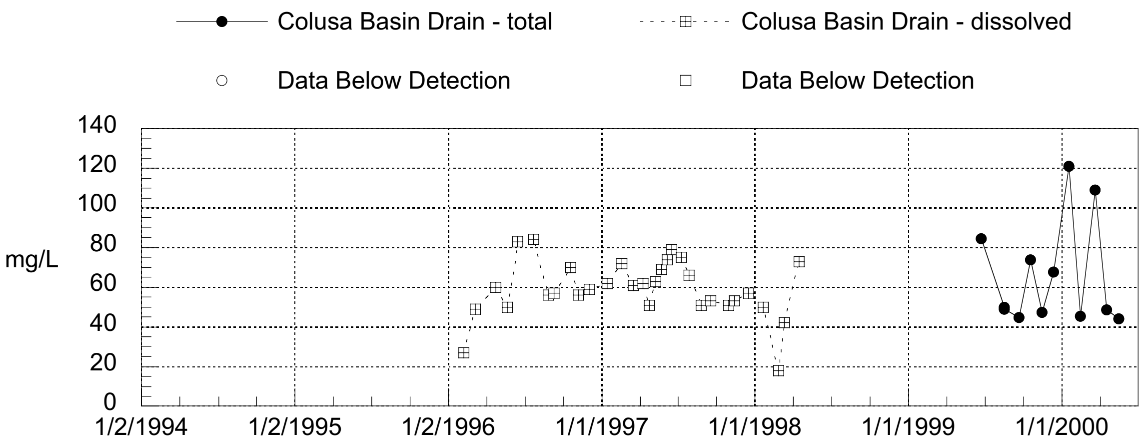
SILICA CONCENTRATIONS IN WATER

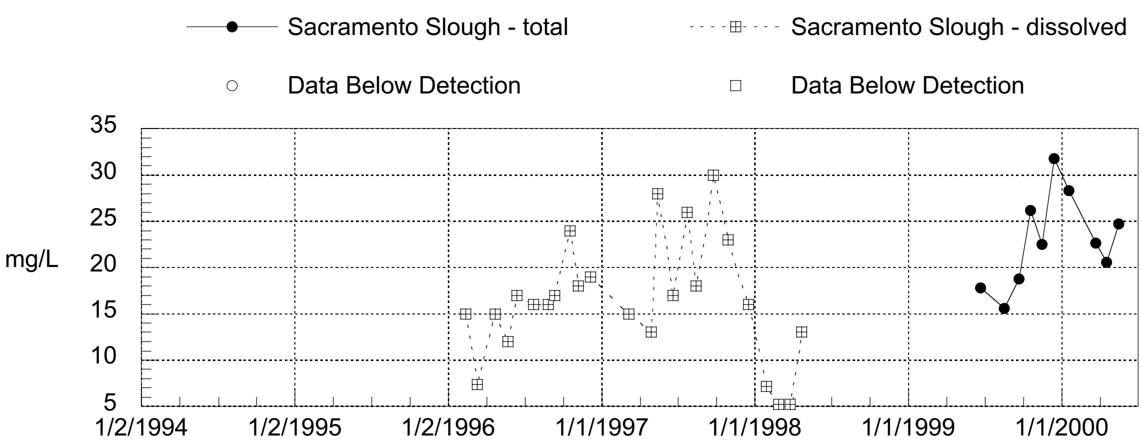


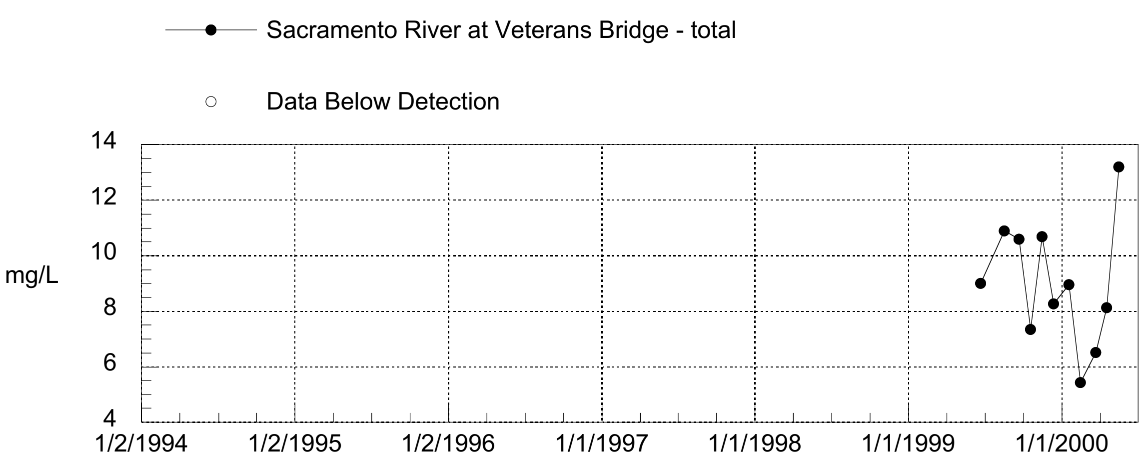




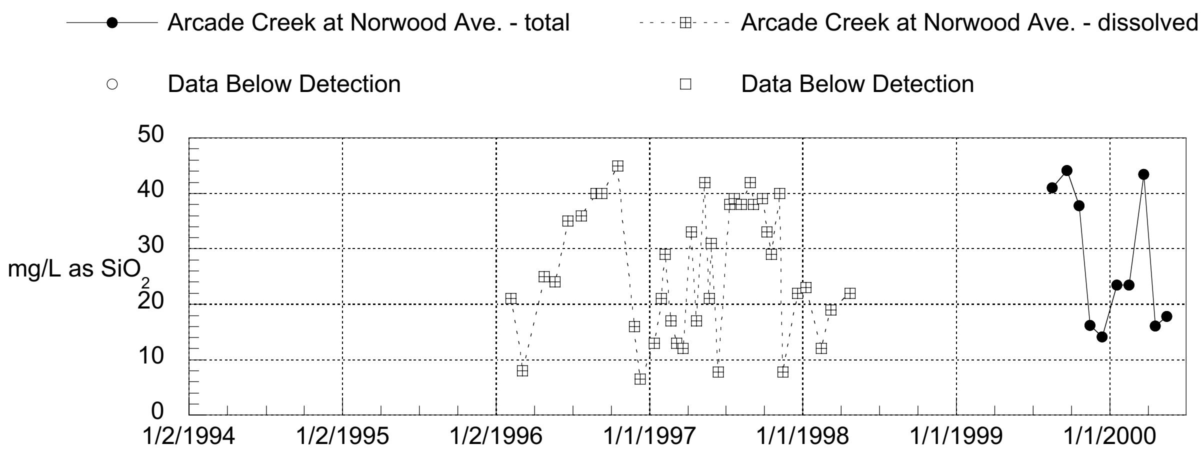
SODIUM CONCENTRATIONS IN WATER

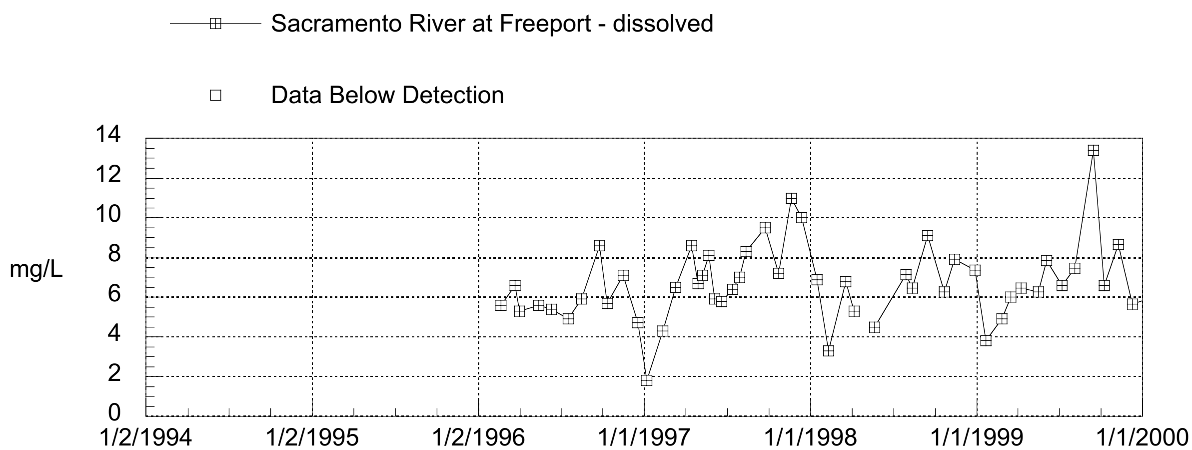


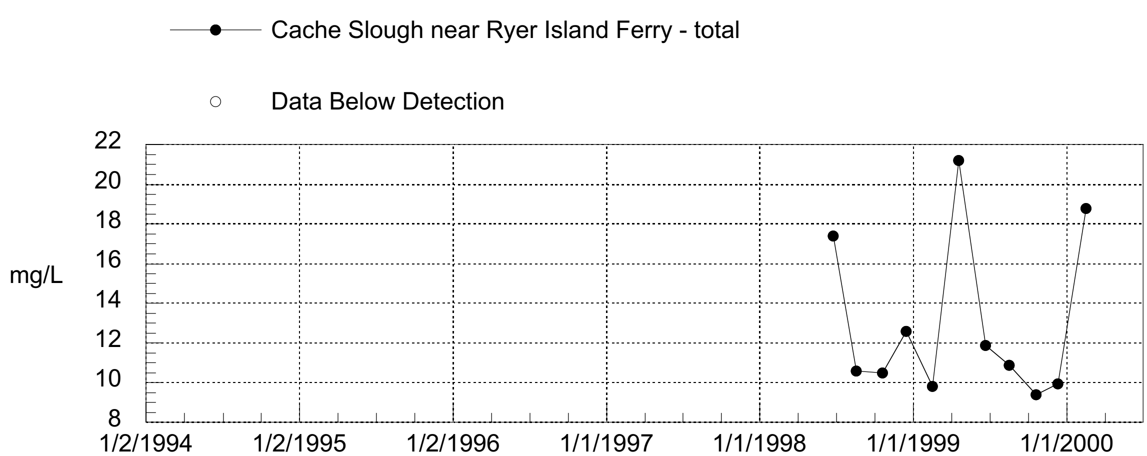




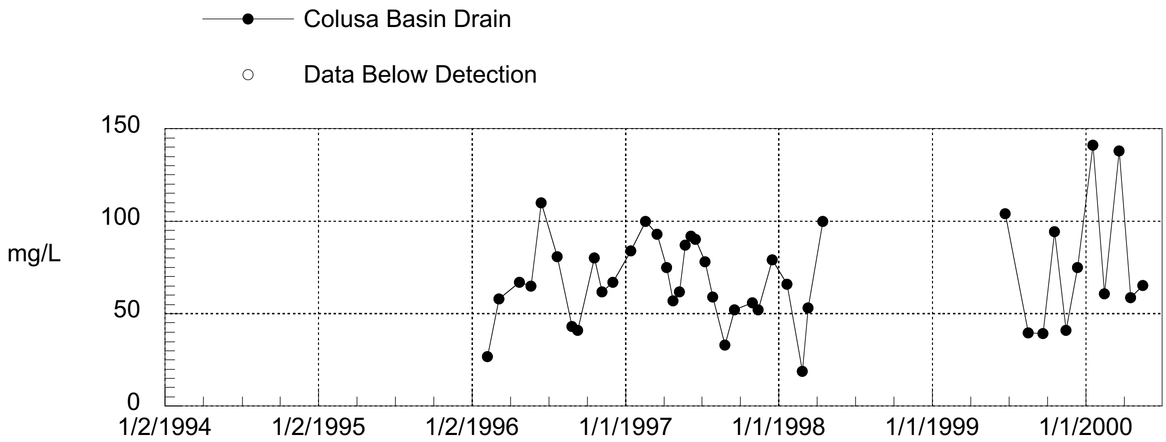
SODIUM CONCENTRATIONS IN WATER

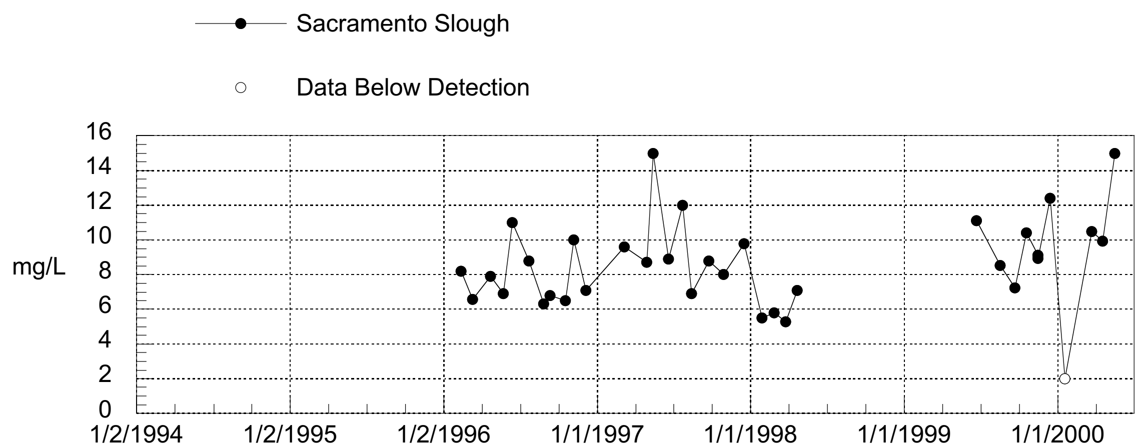


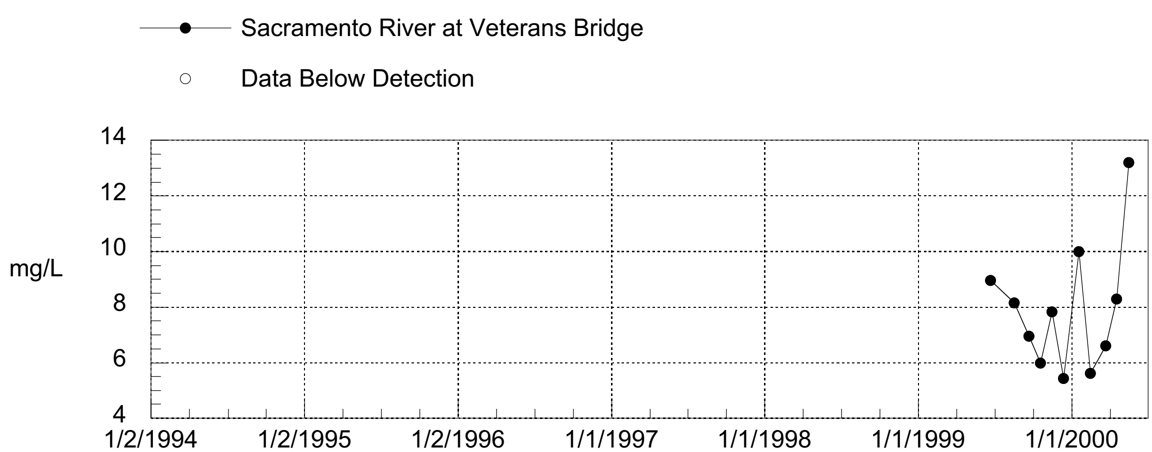


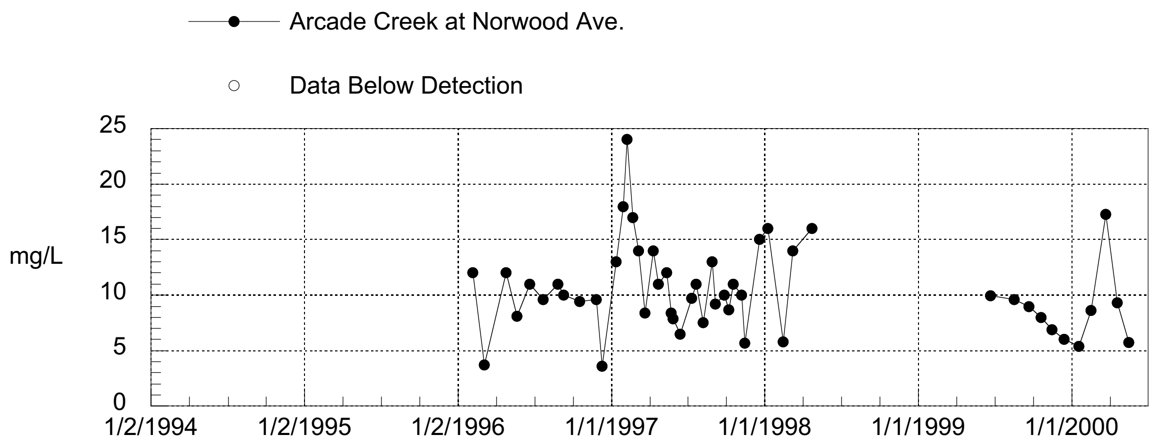


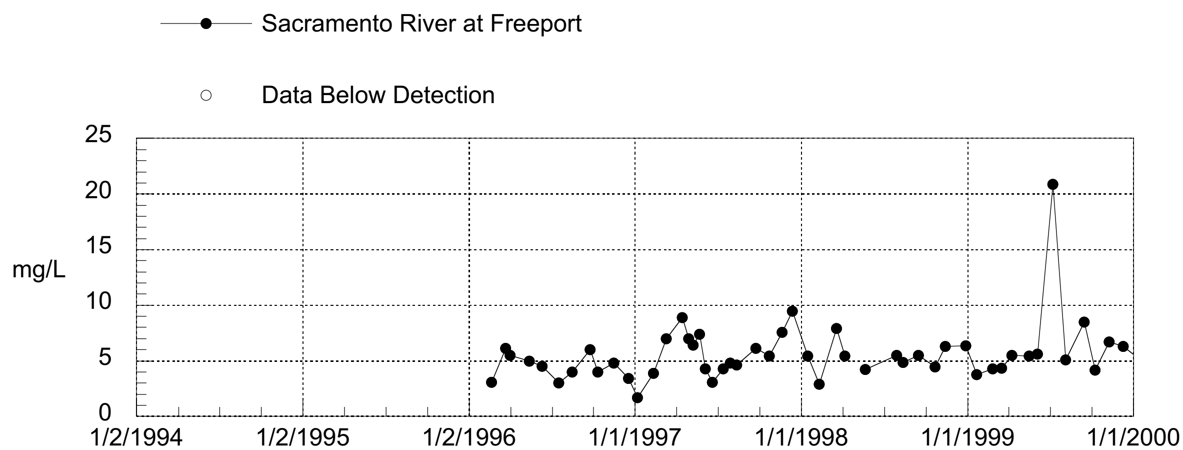
SULFATE CONCENTRATIONS IN WATER

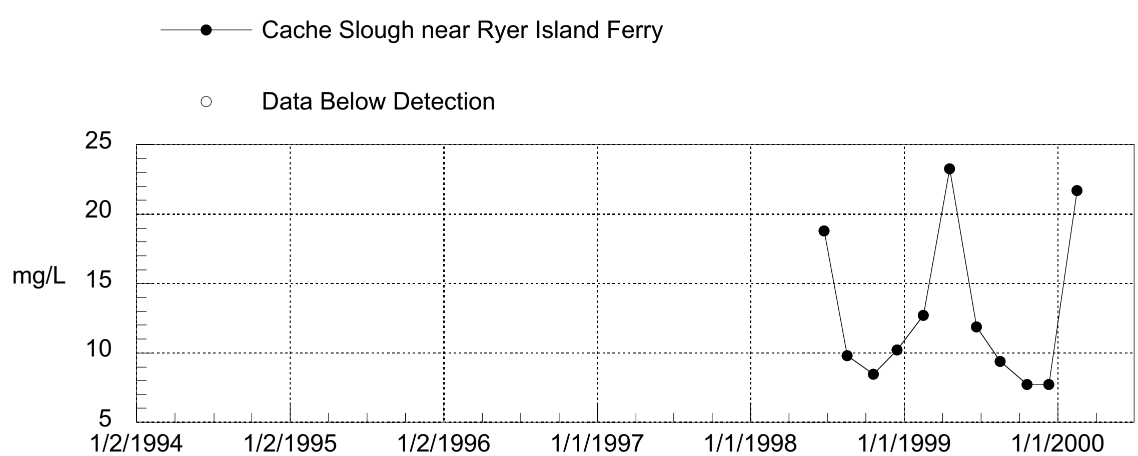




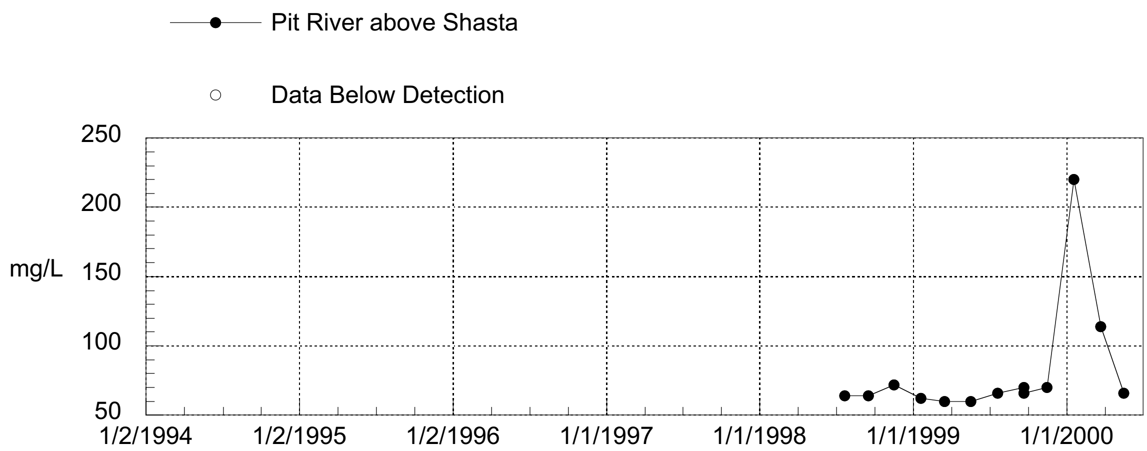


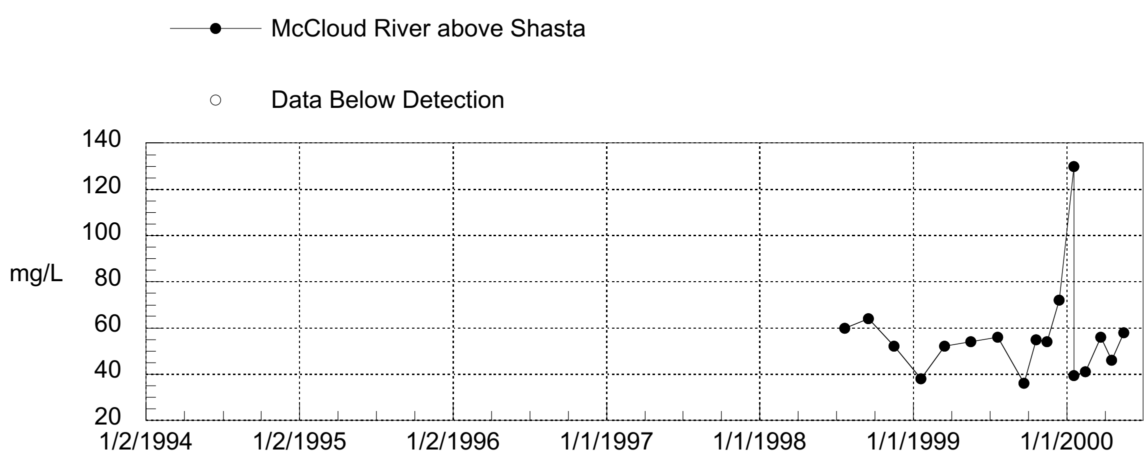

Arcade Creek at Norwood Ave.
Data Below Detection
mg/L
25
20
15
10
5
0
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000

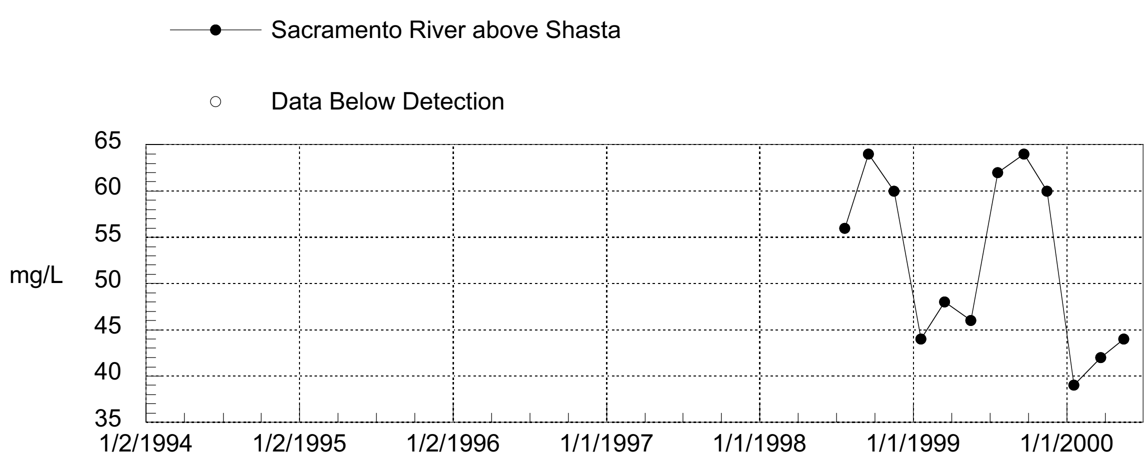

Sacramento River at Freeport
Data Below Detection
mg/L
25
20
15
10
5
0
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000

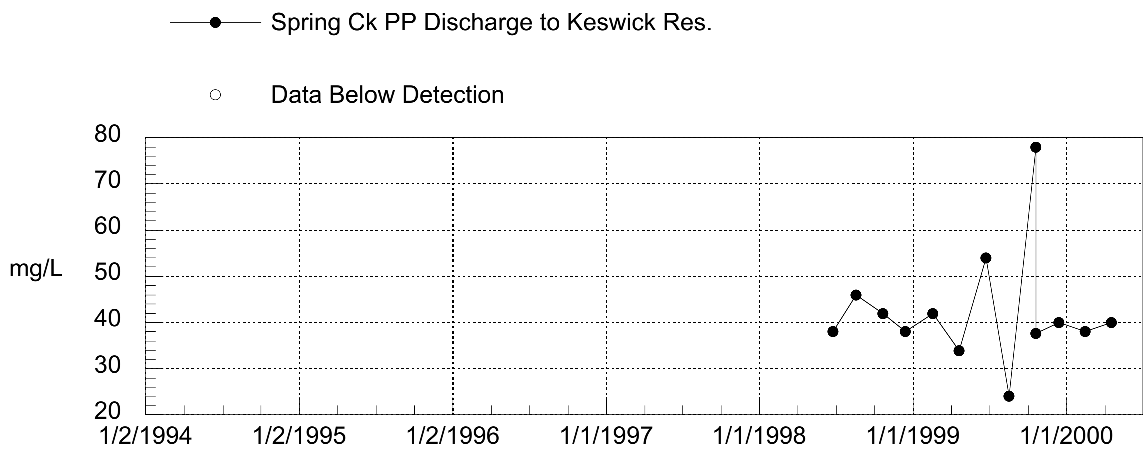

Cache Slough near Ryer Island Ferry
Data Below Detection
mg/L
25
20
15
10
5
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000

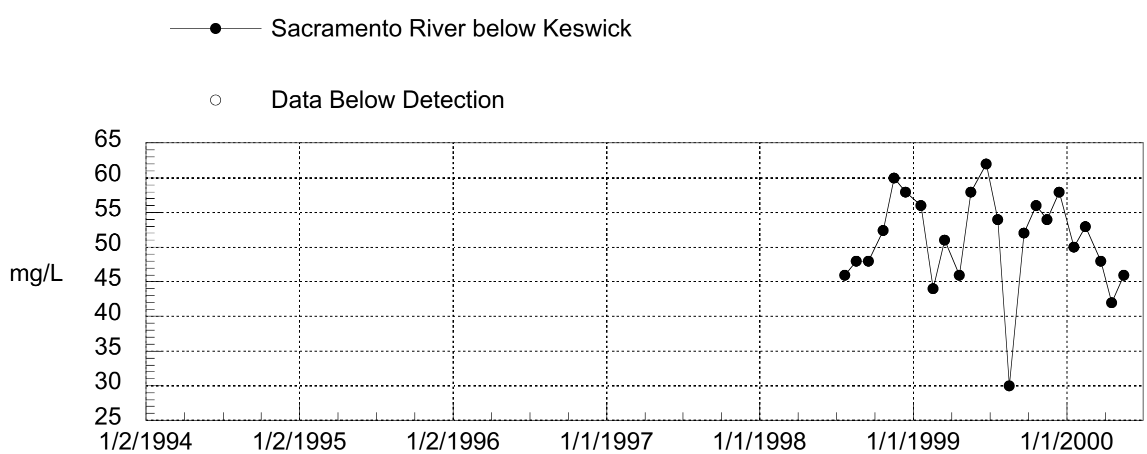
Time Series Plots of Monitoring Data: Other Conventional Water Chemistry Parameters

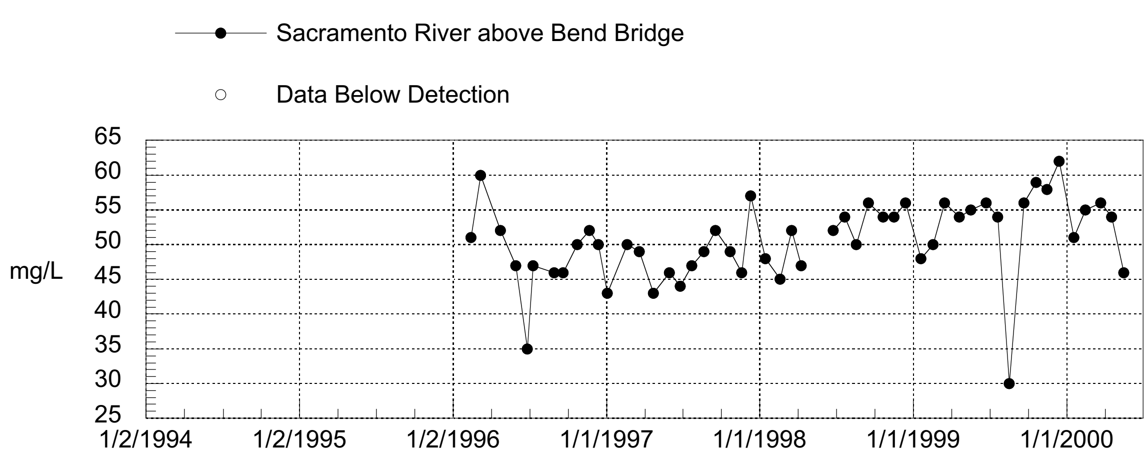

Pit River above Shasta
Data Below Detection
mg/L
250
200
150
100
50
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000

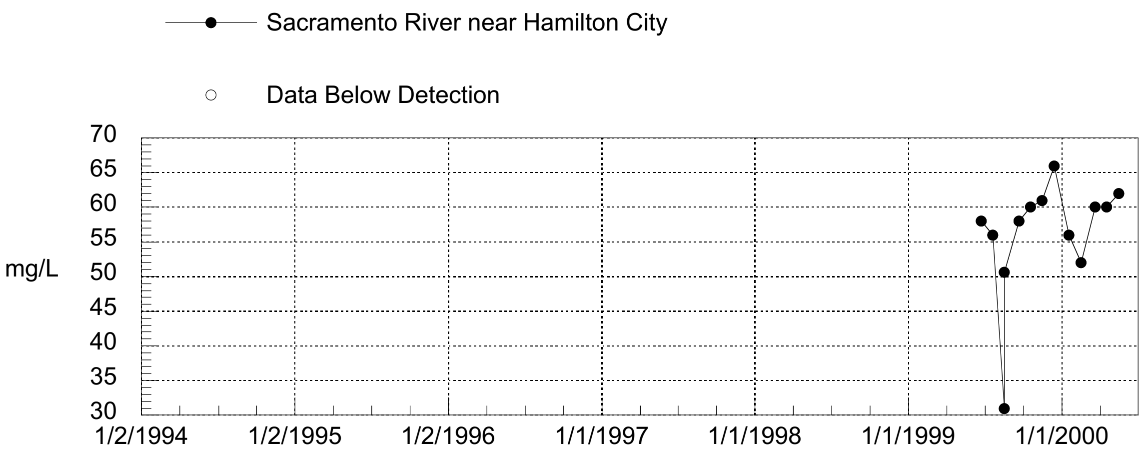

McCloud River above Shasta
Data Below Detection
mg/L
140
120
100
80
60
40
20
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000

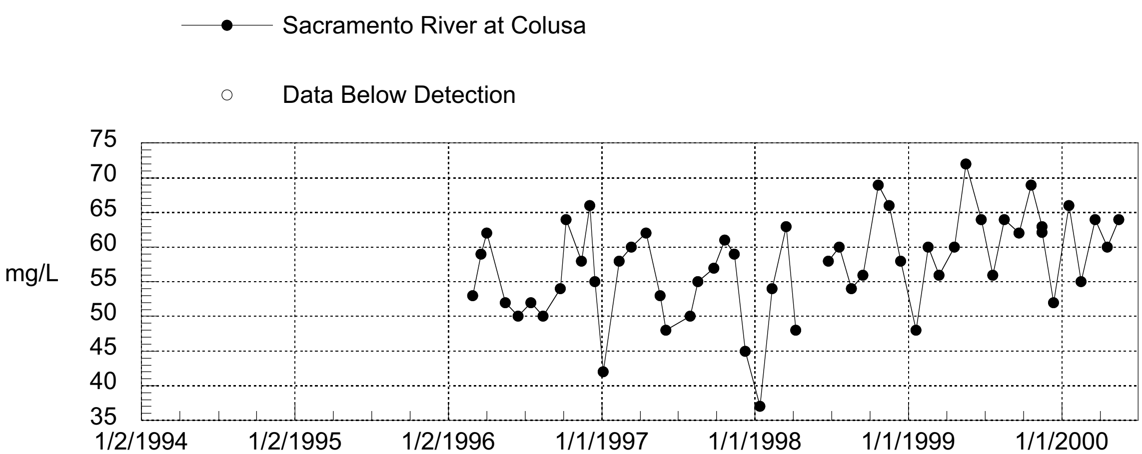

Sacramento River above Shasta
Data Below Detection
mg/L
65
60
55
50
45
40
35
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000

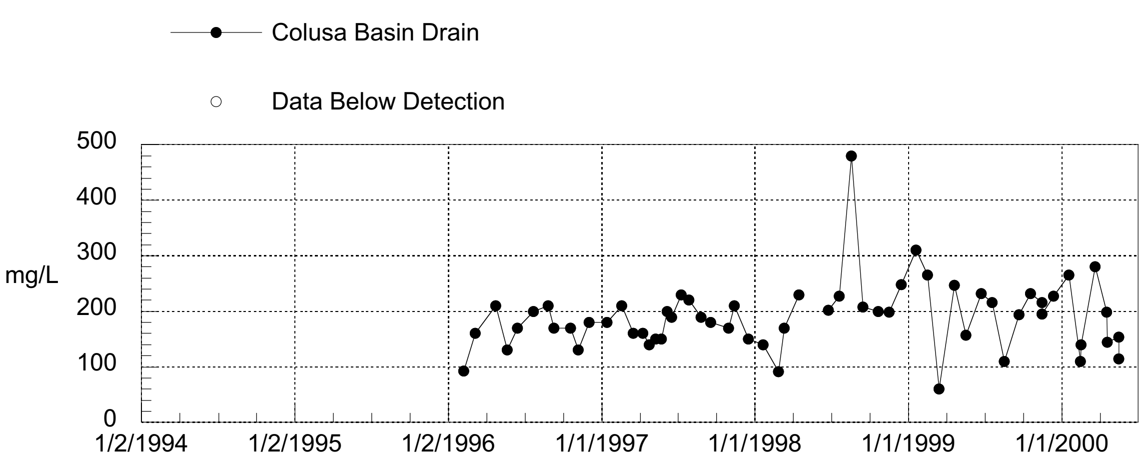

Spring Ck PP Discharge to Keswick Res.
Data Below Detection
mg/L
80
70
60
50
40
30
20
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000

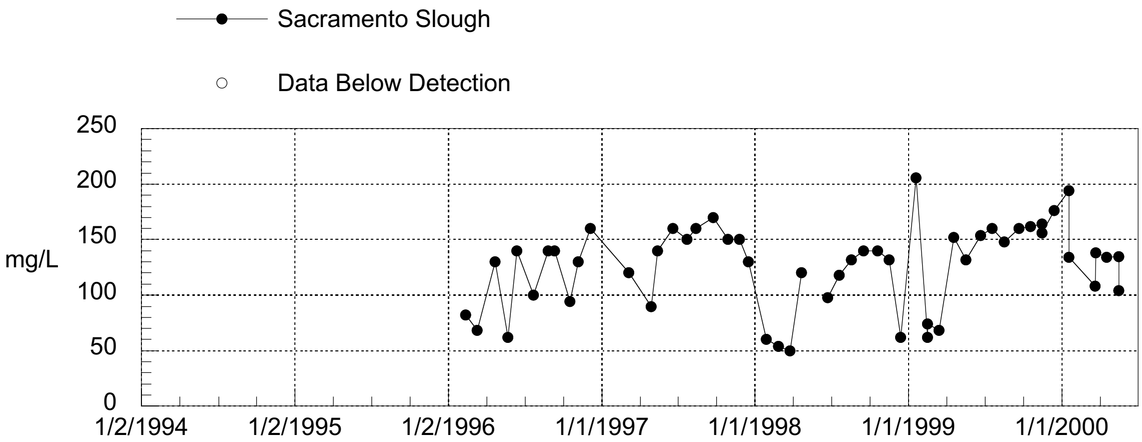

Sacramento River below Keswick
Data Below Detection
mg/L
65
60
55
50
45
40
35
30
25
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000

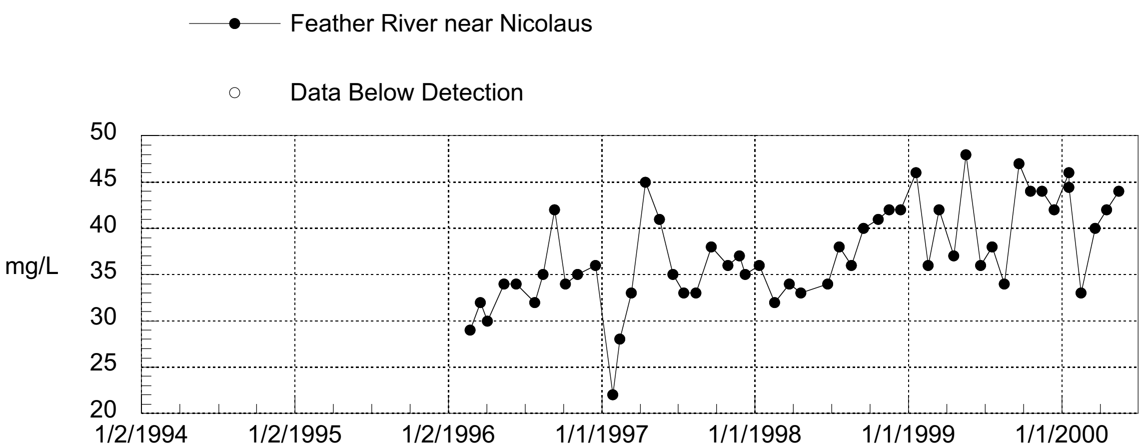

Sacramento River above Bend Bridge
Data Below Detection
mg/L
65
60
55
50
45
40
35
30
25
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000

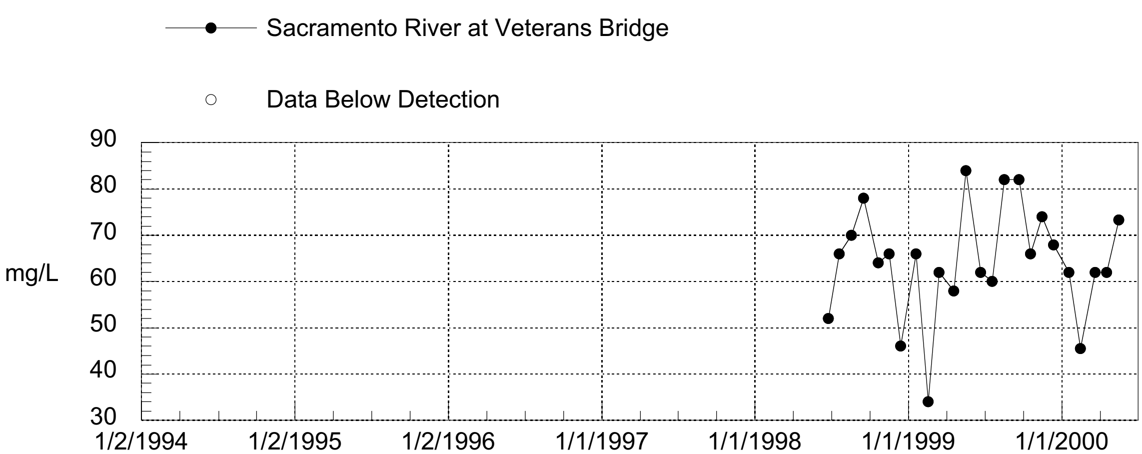

Sacramento River near Hamilton City
Data Below Detection
mg/L
70
65
60
55
50
45
40
35
30
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000

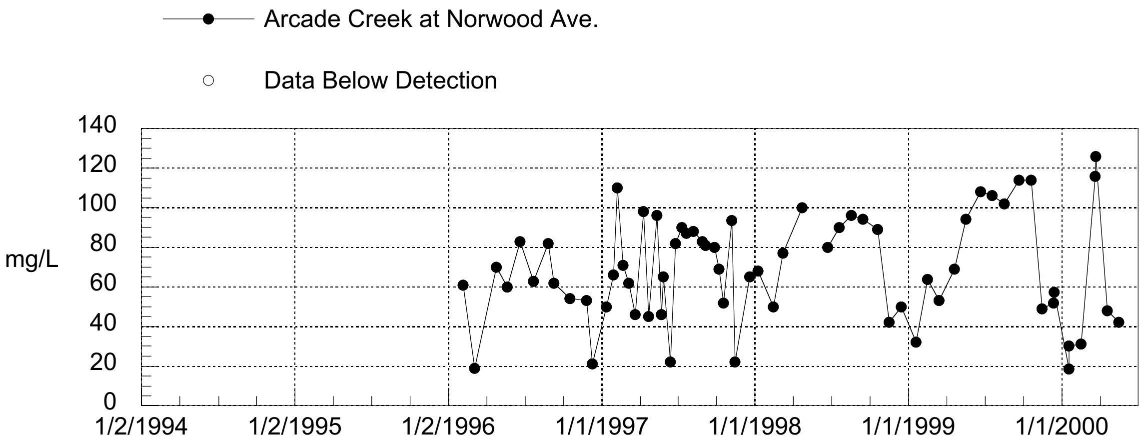

Sacramento River at Colusa
Data Below Detection
mg/L
75
70
65
60
55
50
45
40
35
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000

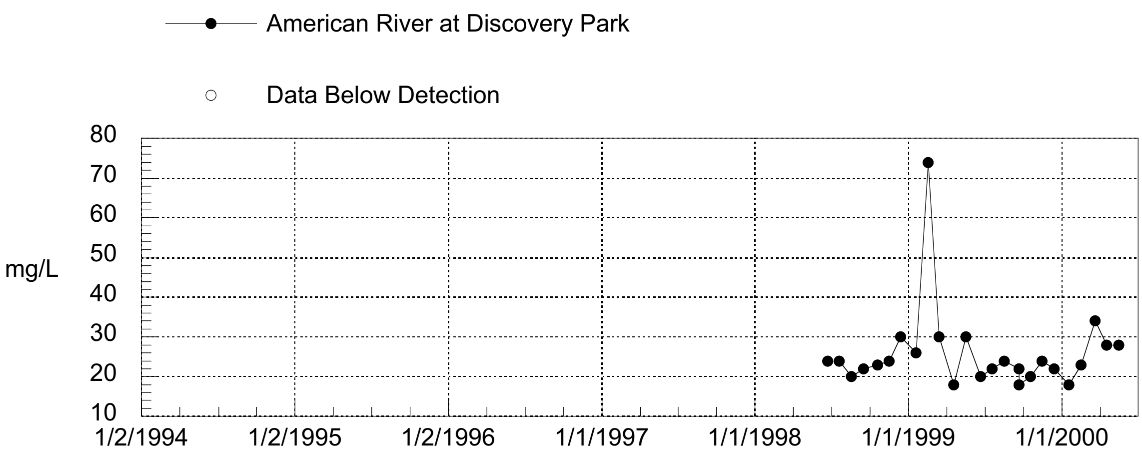

Colusa Basin Drain
Data Below Detection
mg/L
500
400
300
200
100
0
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000

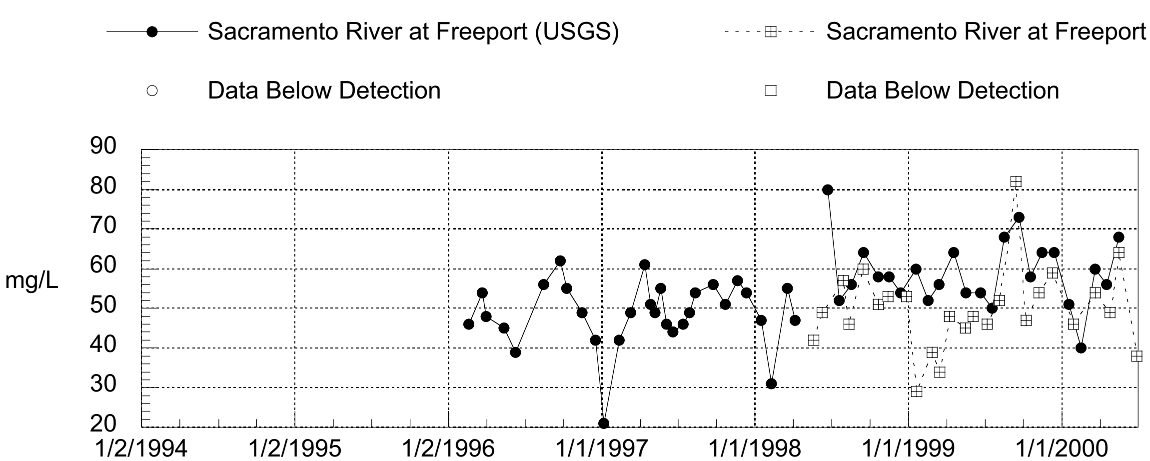

Sacramento Slough
Data Below Detection
250
200
150
100
50
0
mg/L
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000

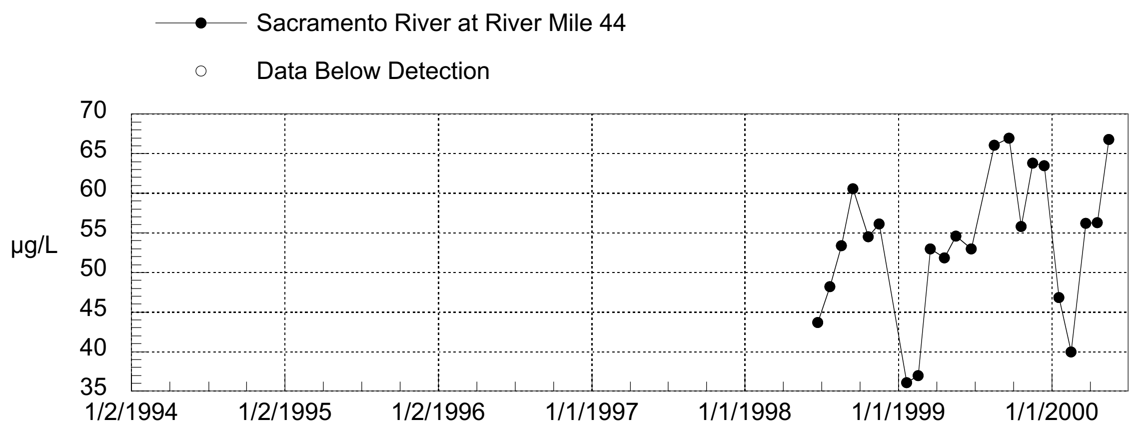

Feather River near Nicolaus
Data Below Detection
50
45
40
35
30
25
20
mg/L
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000

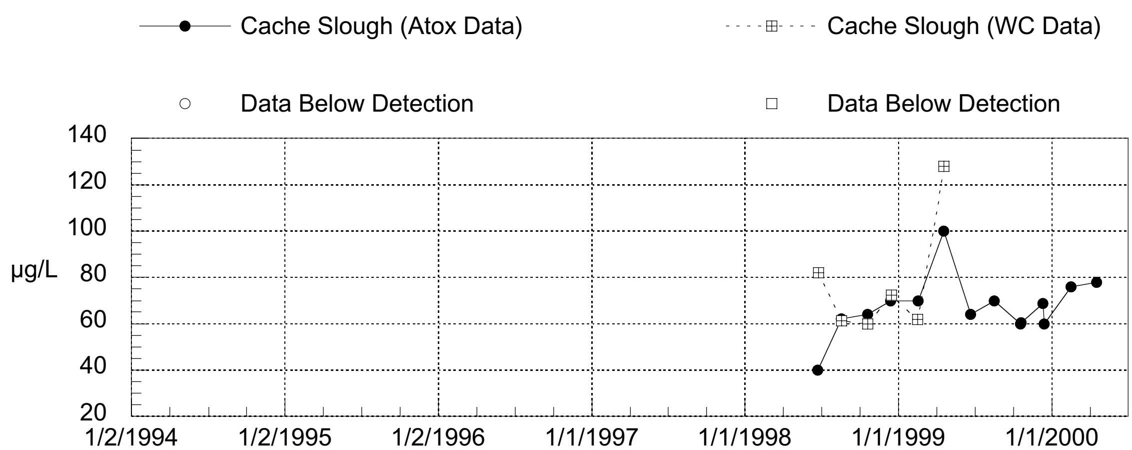

Sacramento River at Veterans Bridge
Data Below Detection
90
80
70
60
50
40
30
mg/L
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000


Arcade Creek at Norwood Ave.
Data Below Detection
mg/L
140
120
100
80
60
40
20
0
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000


American River at Discovery Park
Data Below Detection
mg/L
80
70
60
50
40
30
20
10
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000

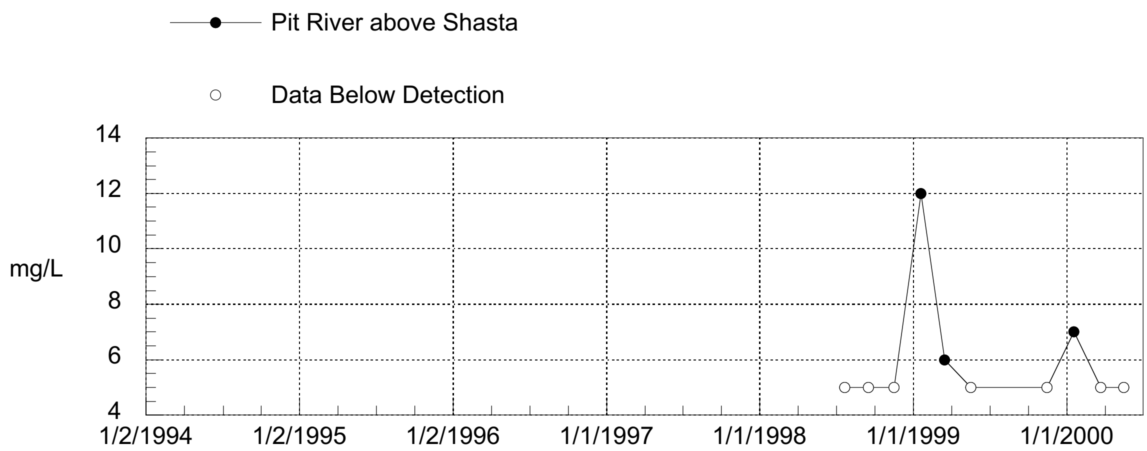

Sacramento River at Freeport (USGS)
Data Below Detection
Sacramento River at Freeport
Data Below Detection
mg/L
90
80
70
60
50
40
30
20
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000

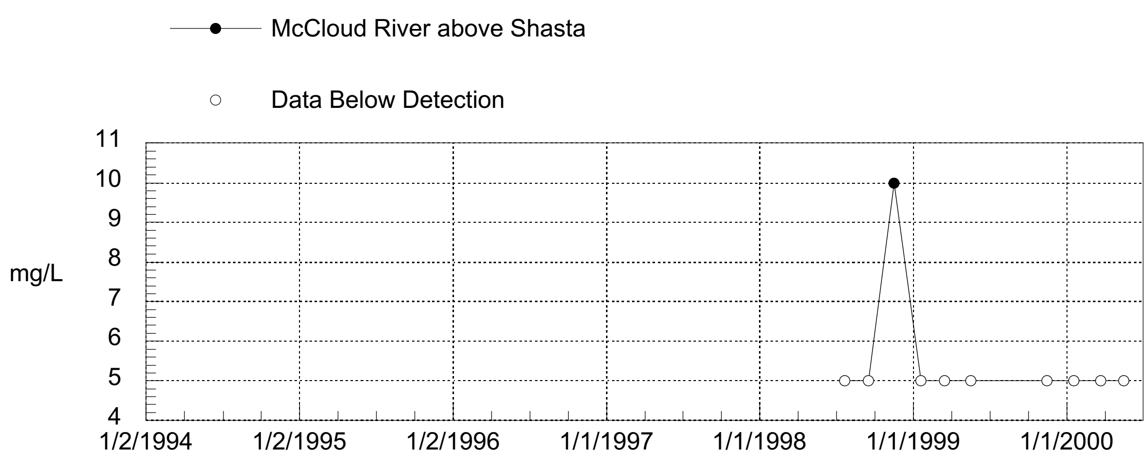


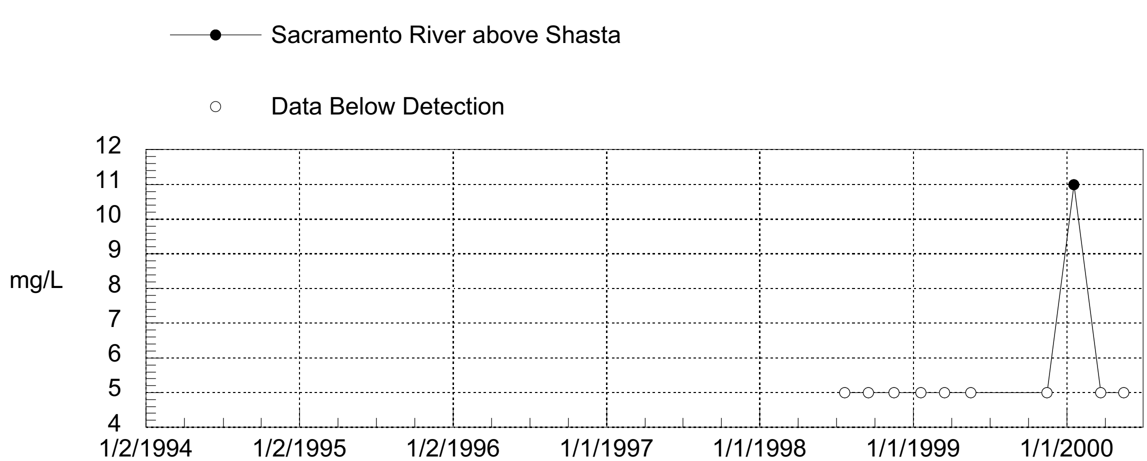


SPACE INTENTIONALLY BLANK

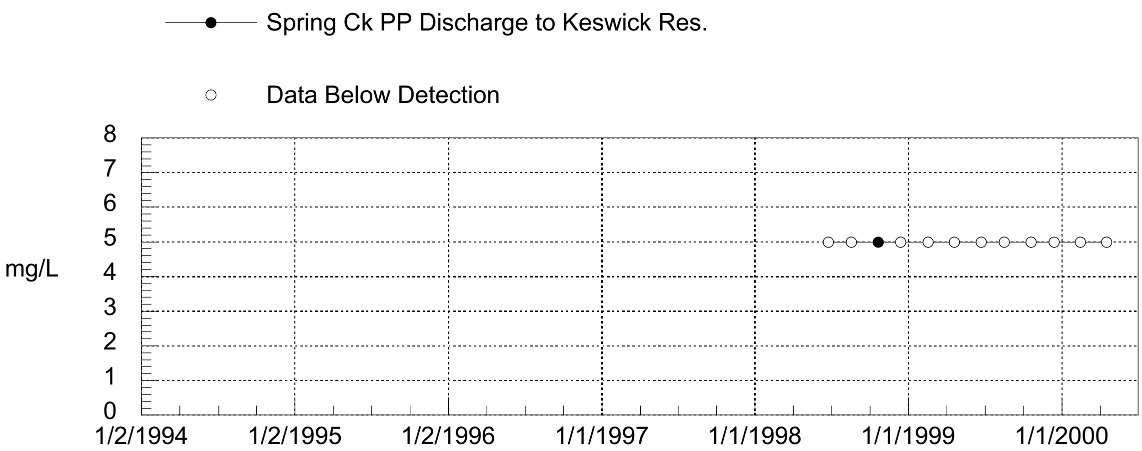
TOTAL SUSPENDED SOLIDS CONCENTRATIONS IN WATER

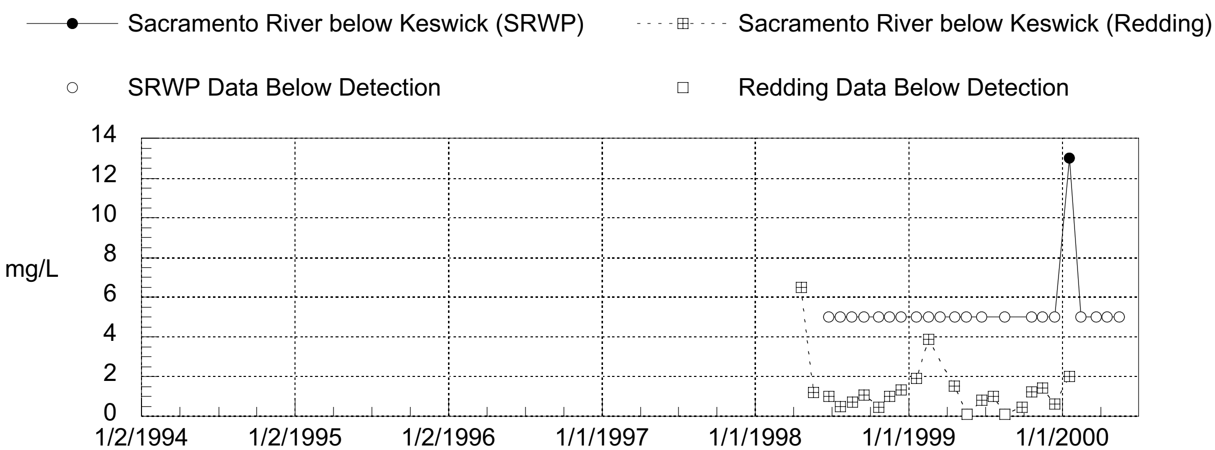


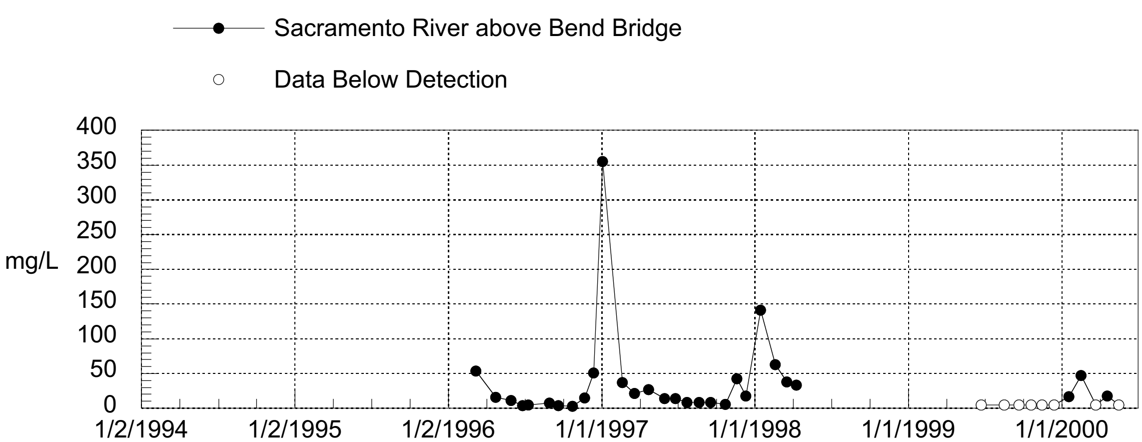




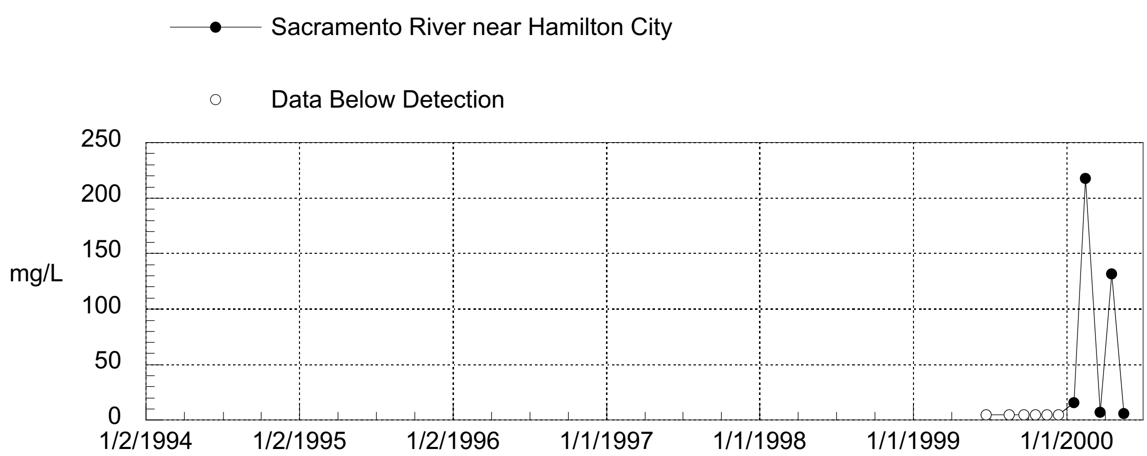
TOTAL SUSPENDED SOLIDS CONCENTRATIONS IN WATER

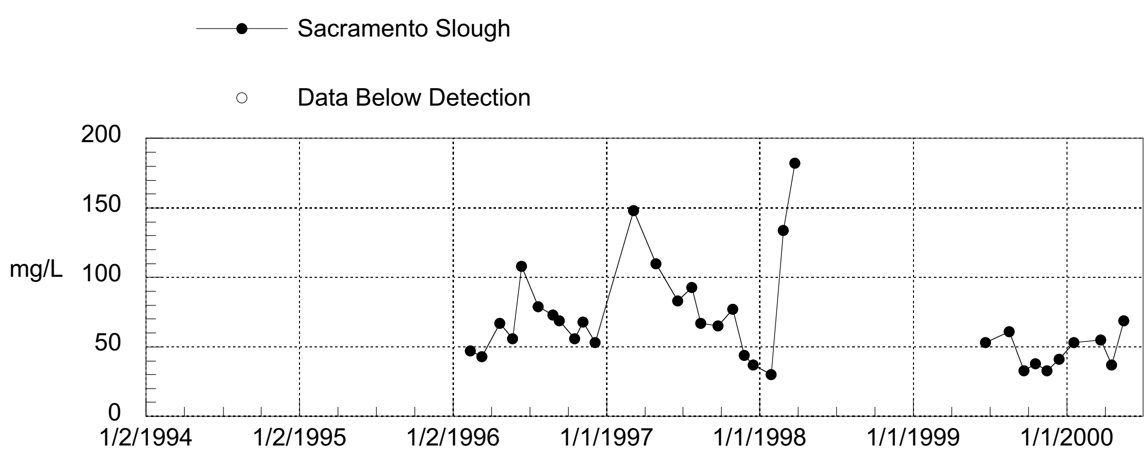


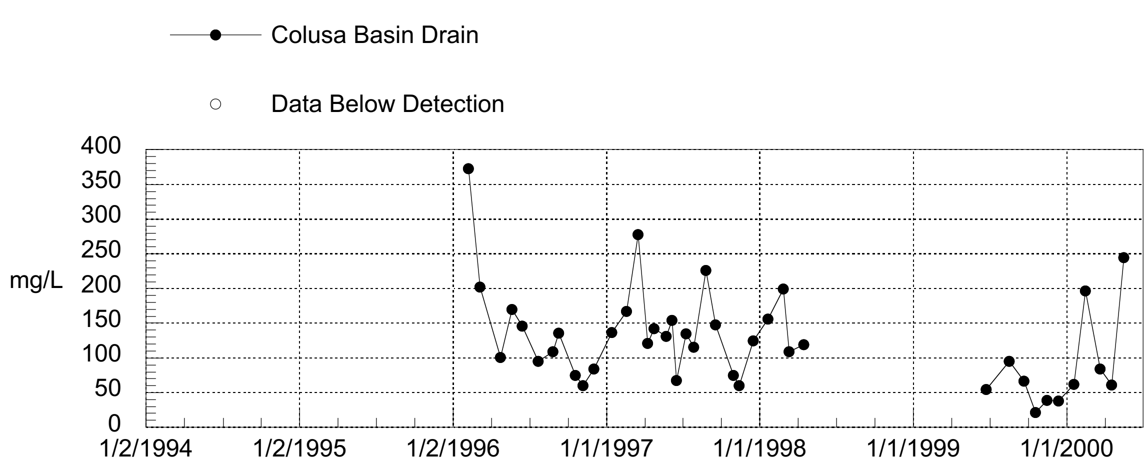




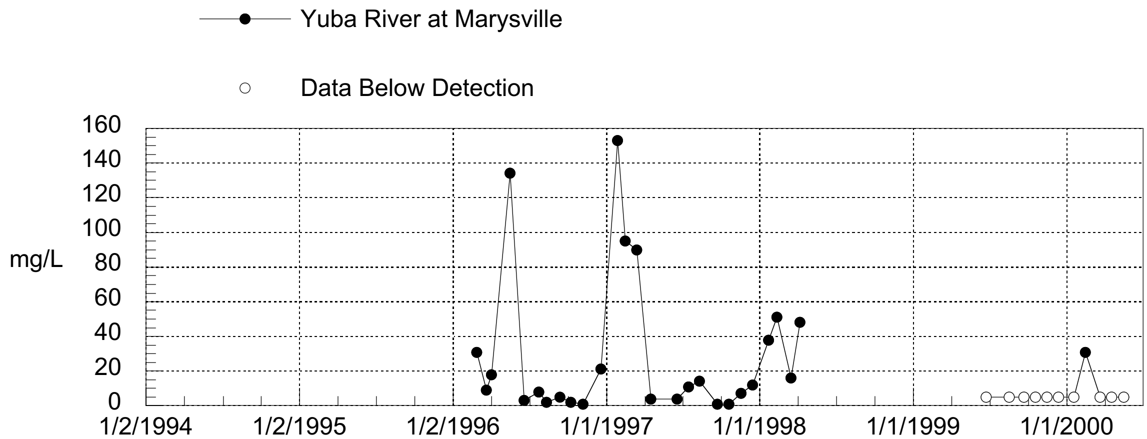
TOTAL SUSPENDED SOLIDS CONCENTRATIONS IN WATER

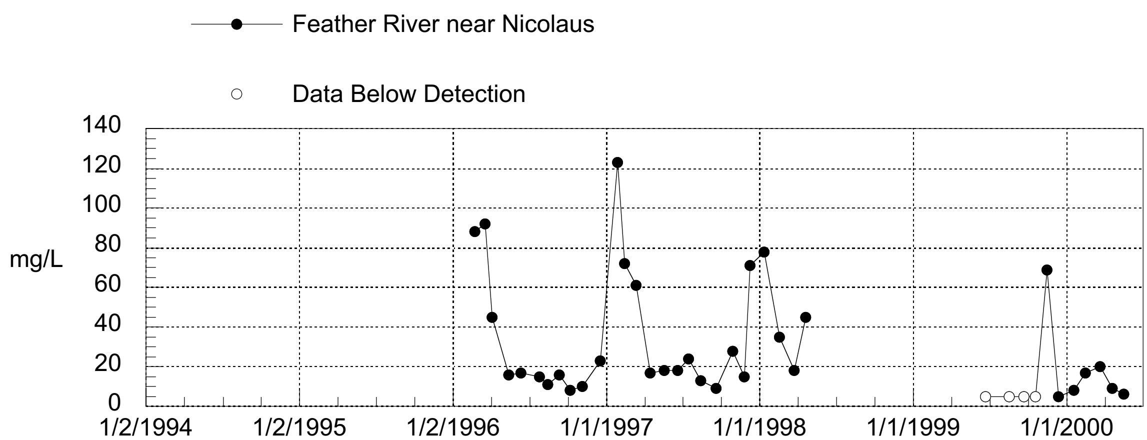


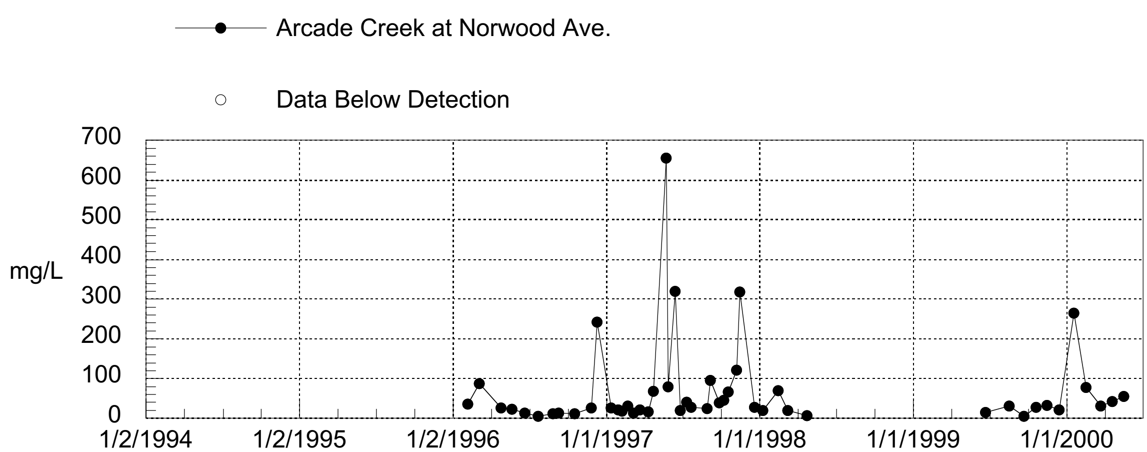




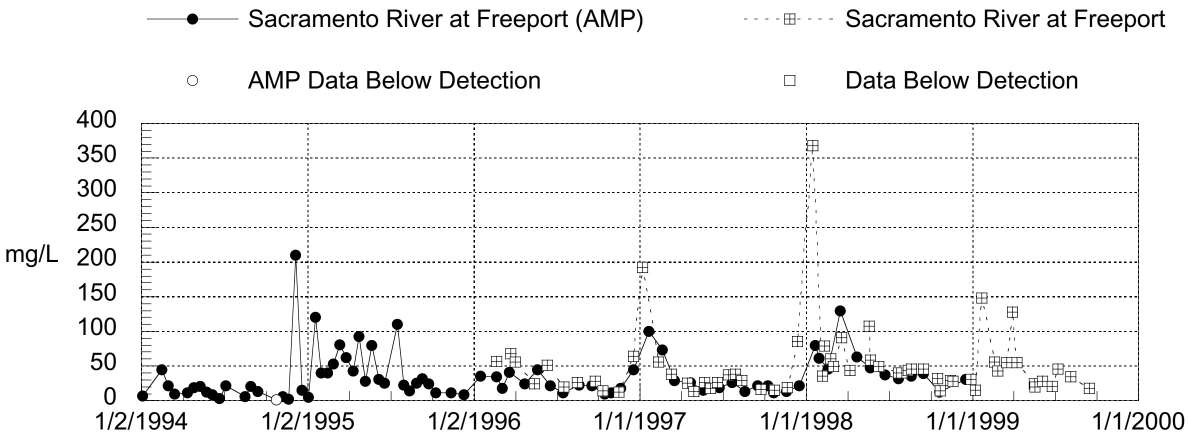
TOTAL SUSPENDED SOLIDS CONCENTRATIONS IN WATER

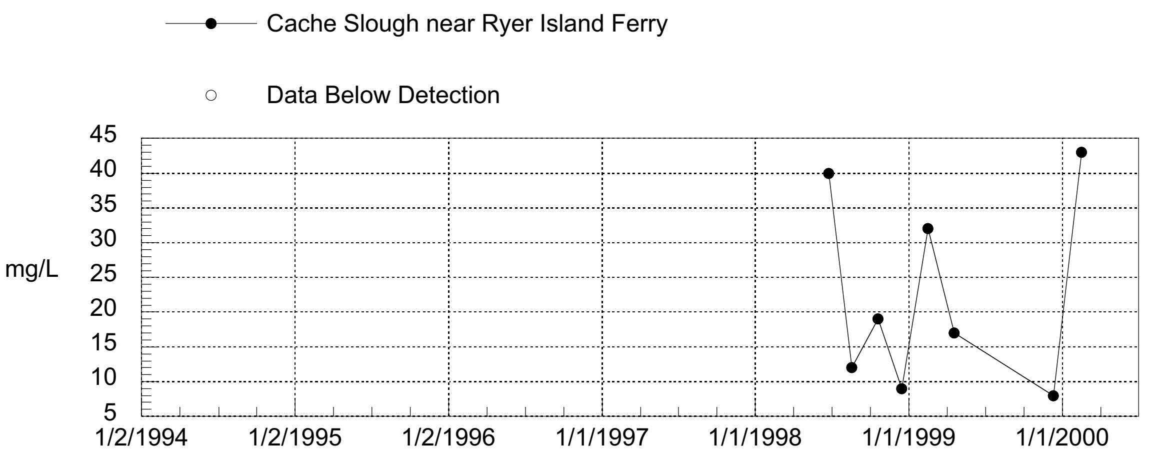






TOTAL SUSPENDED SOLIDS CONCENTRATIONS IN WATER





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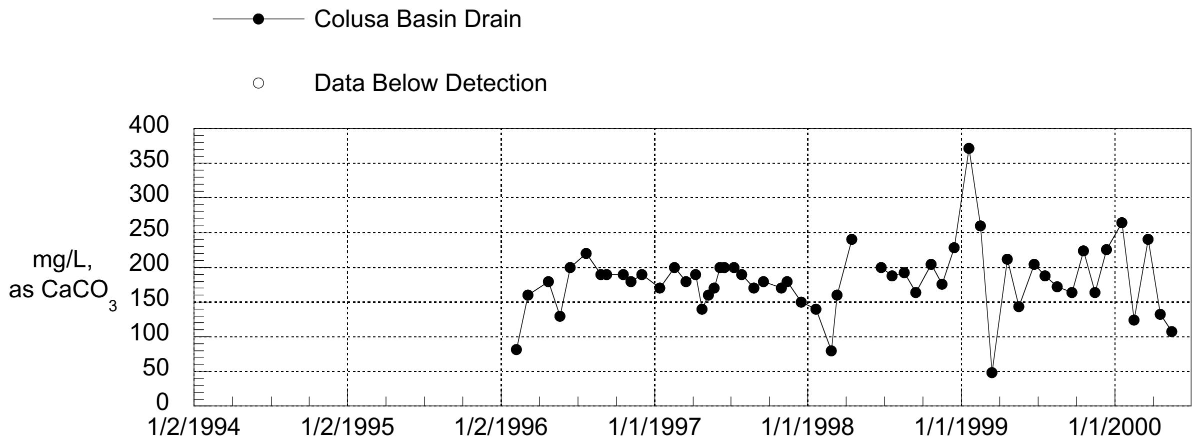
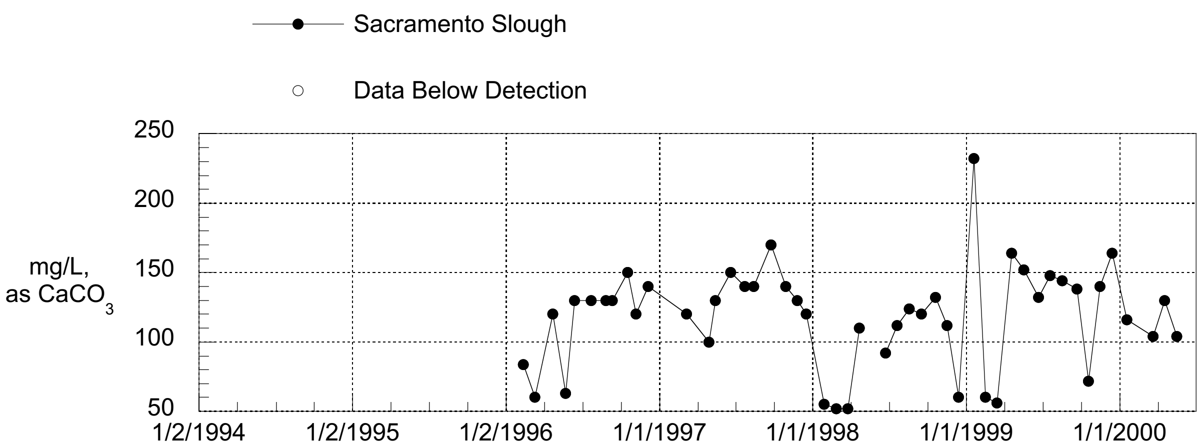
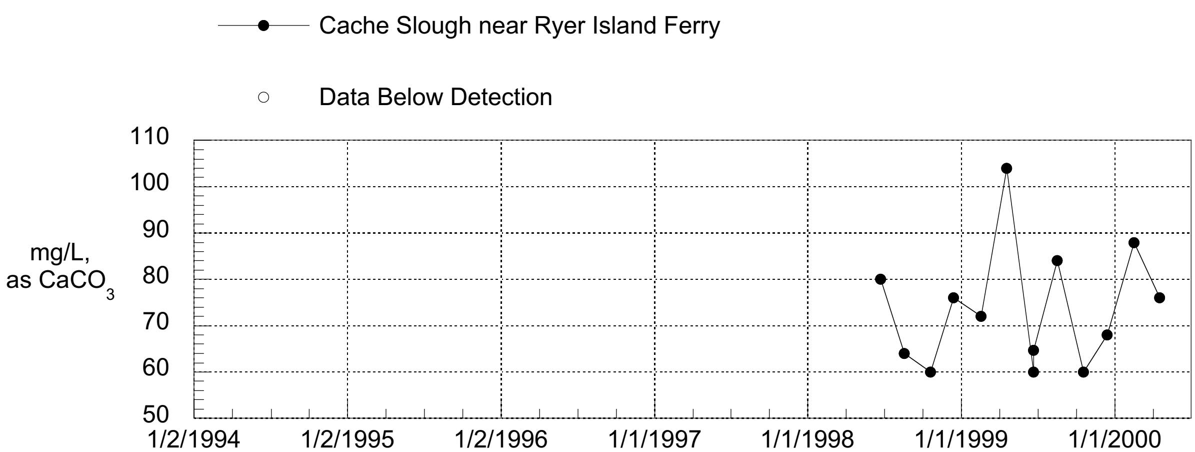

Colusa Basin Drain
Data Below Detection
mg/L,
as $CaCO_3$
400
350
300
250
200
150
100
50
0
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000


Sacramento Slough
Data Below Detection
mg/L,
as $CaCO_3$
250
200
150
100
50
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000


Cache Slough near Ryer Island Ferry
Data Below Detection
mg/L,
as $CaCO_3$
110
100
90
80
70
60
50
1/2/1994
1/2/1995
1/2/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000

APPENDIX H

Bioassessment Data

Taxonomic List Of Benthic Macroinvertebrates Identified From Samples Collected In Fall 1999 In The Sacramento River Watershed

			Arcade Creek		American River at Harrington Bar			Feather River		Yuba River at Marysville		Sacramento River at Sac. St. Park	
Transect Number:			Snag #1	Snag #2	T1	T2	T3	Snag #1	Snag #2	T1	T2	Snag #1	Snag #2
ABL Laboratory Number:			3550	3551	3552	3553	3554	3555	3556	3557	3558	3559	3560
PHYLUM ARTHROPODA	TV	FFG											
Class Insecta													
<u>Coleoptera (Adults)</u>													
Dryopidae													
Helichus sp.	5	g	-	-	-	-	-	-	-	-	-	-	-
Postelichus sp.	5	g	-	-	-	-	-	-	-	-	-	-	-
Dytiscidae													
Liodessus sp.	5	p	-	1	-	-	-	-	-	-	-	-	-
Elmidae													
Heterlimnius Koebelei	4	c	-	-	-	-	-	-	-	-	-	-	-
Optioservus sp.	4	g	-	-	-	-	-	-	-	-	-	-	-
Zaitzevia sp.	4	c	-	-	-	-	-	-	-	-	-	-	-
Hydraenidae	5	g											
Hydraena sp.	5	g	-	-	-	-	-	-	-	-	-	-	-
Ochthebius sp.	5	g	-	-	-	-	-	-	-	-	-	-	-
<u>Coleoptera (Larvae)</u>													
Elmidae													
Ampumixis dispar	4	c	-	-	-	-	-	-	-	-	-	-	-
Atractelmis sp.			-	-	-	-	-	-	-	-	-	-	-
Cleptelmis sp.	4	c	-	-	-	-	-	-	-	-	-	-	-
Dubiraphia sp.	4	c	-	-	-	-	-	1	-	-	-	-	-
Heterlimnius sp.	4	c	-	-	-	-	-	-	-	-	-	-	-
Lara sp.	4	s	-	-	-	-	-	-	-	-	-	-	-
Microcylloepus sp.	2	c	-	-	-	-	-	-	-	-	4	-	-
Narpus sp.	4	c	-	-	-	-	-	-	-	-	-	-	-
Optioservus sp.	4	g	-	-	-	-	-	-	-	-	-	-	-
Ordobrevia sp.	4	c	-	-	-	-	-	-	-	-	-	-	-
Rhizelmis nigra	1	c	-	-	-	-	-	-	-	-	-	-	-
Zaitzevia sp.	4	c	-	-	-	-	-	-	-	-	1	-	-
Psephenidae													
Acneus quadrimaculatus	4	g	-	-	-	-	-	-	-	-	-	-	-
Eubrianax sp.	4	g	-	-	-	-	-	-	-	-	-	-	-
Psephenus sp.	4	g	-	-	-	-	-	-	-	-	-	-	-
			-	-	-	-	-	-	-	-	-	-	-
<u>Diptera</u>													
Athericidae													
Atherix sp.	2	p	-	-	-	-	-	-	-	-	-	-	-
Blephariceridae													
Agathon sp.	0	g	-	-	-	-	-	-	-	-	-	-	-
Blepharicera sp.	0	g	-	-	-	-	1	-	-	-	-	-	-
Ceratopogonidae													
Bezzia sp./ Palpomyia sp.	6	p	1	-	-	-	-	-	-	-	-	-	-
Chironomidae													
Chironominae													
Chironomini	6	c	151	222	-	-	4	20	20	-	1	37	4
Tanytarsini	6	f	18	31	10	4	7	86	90	7	7	31	55
Diamesinae													
Borroheptagyia sp.		c	-	-	-	-	-	-	-	-	-	-	-
Orthocladiinae	5	c	3	8	17	39	31	29	8	51	34	53	54
Tanypodinae	6	p	-	-	-	-	-	-	1	-	-	-	-
Culicidae													
Anopheles sp.	8	c	-	1	-	-	-	-	-	-	-	-	-

			Arcade Creek		American River at Harrington Bar			Feather River		Yuba River at Marysville		Sacramento River at Sac. St. Park	
Transect Number:			Snag #1	Snag #2	T1	T2	T3	Snag #1	Snag #2	T1	T2	Snag #1	Snag #2
ABL Laboratory Number:			3550	3551	3552	3553	3554	3555	3556	3557	3558	3559	3560
Empididae													
Chelifera sp.	6	p	-	-	-	-	-	1	-	-	-	1	-
Clinocera sp.	6	p	-	-	-	-	-	-	-	-	-	-	-
Hemerodromia sp.	6	p	-	-	2	-	2	1	-	-	-	1	1
Oreogeton sp.	5	p	-	-	-	-	-	-	-	-	-	-	-
Wiedemannia sp.	6	p	-	-	-	-	-	-	-	-	-	-	-
Undetermined								5					
Psychodidae													
Maruina sp.	1	g	-	-	-	-	-	-	-	-	-	-	-
Simuliidae	6	f	-	-	1	-	-	7	8	3	-	1	1
Stratiomyidae													
Caloparyphus sp.	7	c	-	-	-	-	-	-	-	-	-	-	-
Tipulidae													
Antocha sp.	3	c	-	-	-	-	-	-	-	-	-	-	-
Dicranota sp.	3	p	-	-	-	-	-	-	-	-	-	-	-
Hexatoma sp.	2	p	-	-	-	-	-	-	-	-	-	-	-
Undetermined	3	s	-	-	-	-	-	-	-	-	-	-	-
Undetermined			-	-	-	-	-	-	-	-	-	-	-
<u>Megaloptera</u>													
Corydalidae													
Corydalus sp.	0	p	-	-	-	-	-	-	-	-	-	-	-
Orohermes sp.	0	p	-	-	-	-	-	-	-	-	-	-	-
Undetermined	0	p	-	-	-	-	-	-	-	-	-	-	-
<u>Odonata</u>													
Calopterygidae													
Hetaerina sp.	6	p	-	-	-	-	-	-	-	-	-	-	-
Coenagrionidae													
Argia sp.	7	p	-	-	-	-	-	-	-	-	-	-	-
Undetermined			-	-	-	-	-	-	-	-	-	-	-
Cordulegastridae													
Cordulegaster dorsalis	0	p	-	-	-	-	-	-	-	-	-	-	-
Corduliidae	9	p	-	-	-	-	-	-	-	-	-	-	-
Undetermined			-	-	-	-	-	-	-	-	-	-	-
Gomphidae													
Ophiogomphus sp.	1	p	-	-	-	-	-	-	-	-	-	-	-
Undetermined			-	-	-	-	-	-	-	-	-	-	-
<u>Lepidoptera</u>													
Pyralidae													
Petrophila sp.	5	g	-	-	4	-	-	-	-	-	-	1	1
<u>Ephemeroptera</u>													
Ameletidae													
Ameletus sp.	0	g	-	-	-	-	-	-	-	-	-	-	-
Baetidae													
Acentrella sp.	4	c	-	-	65	10	13	14	50	73	50	50	4
Baetis sp.	5	c	-	-	20	5	5	9	20	23	18	22	5
Diphetor sp.	5	c	-	-	-	-	-	-	-	-	-	-	-
Fallceon quilleri	4	c	-	-	-	-	-	-	-	1	-	-	-
Ephemerellidae													
Caudatella sp.	1	c	-	-	-	-	-	-	-	-	-	-	-
Drunella sp.	0	g	-	-	-	-	-	-	-	-	-	-	-
Serratella sp.	2	c	-	-	12	3	12	8	6	12	8	-	-
Undetermined	7	c	-	-	-	-	-	-	-	-	-	-	-

			Arcade Creek		American River at Harrington Bar			Feather River		Yuba River at Marysville		Sacramento River at Sac. St. Park	
Transect Number:			Snag #1	Snag #2	T1	T2	T3	Snag #1	Snag #2	T1	T2	Snag #1	Snag #2
ABL Laboratory Number:			3550	3551	3552	3553	3554	3555	3556	3557	3558	3559	3560
Heptageniidae													
Cinygma sp.	4	g	-	-	-	-	-	-	-	-	-	-	-
Cinygmula sp.	4	g	-	-	-	-	-	-	-	-	-	-	-
Epeorus sp.	0	g	-	-	-	-	-	-	-	1	14	-	-
Heptagenia sp.	4	g	-	-	-	-	-	1	-	-	-	-	-
Ironodes sp.	4	g	-	-	-	-	-	-	-	-	-	-	-
Rhithrogena sp.	0	g	-	-	-	-	-	-	-	57	21	-	-
Leptohyphidae													
Tricorythodes sp.	5	c	-	-	1	10	18	7	4	-	-	-	-
Leptophlebidae													
Paraleptophlebia sp.	4	c	-	-	-	-	-	-	-	1	1	-	-
Plecoptera													
Capniidae													
Capnia sp.	1	s	-	-	-	-	-	-	-	-	-	-	-
Undetermined	1	s	-	-	-	-	-	-	-	-	-	-	-
Chloroperlidae													
Haploperla chilnualna	1	p	-	-	-	-	-	-	-	-	1	-	-
Suwallia sp.	1	p	-	-	-	-	-	-	-	-	-	-	-
Sweltsa sp.	1	p	-	-	-	-	-	-	-	-	-	-	-
Undetermined	1	p	-	-	-	-	-	-	-	-	-	-	-
Leuctridae													
Paraleuctra sp.	0	s	-	-	-	-	-	-	-	-	-	-	-
Nemouridae													
Zapada sp.	2	s	-	-	-	-	-	-	-	-	-	-	-
Undetermined	2	s	2	-	-	-	-	-	-	-	-	-	-
Peltoperlidae													
Sierraperla sp.	1	s	-	-	-	-	-	-	-	-	-	-	-
Yoraperla sp.	2	s	-	-	-	-	-	-	-	-	-	-	-
Perlidae													
Calineuria californica	1	p	-	-	-	-	-	-	-	-	1	-	-
Claassenia sp.	3	p	-	-	-	-	-	-	-	5	1	-	-
Doroneuria baumanni	1	p	-	-	-	-	-	-	-	-	-	-	-
Hesperoperla sp.	2	p	-	-	-	-	-	-	-	-	-	-	-
Undetermined	1	p	-	-	-	-	-	-	-	-	-	-	-
Perlodidae													
Frisonia picticeps	2	p	-	-	-	-	-	-	-	1	-	-	-
Isoperla sp.	2	p	-	-	-	-	-	-	-	-	1	-	-
Megarcys sp.	2	p	-	-	-	-	-	-	-	-	-	-	-
Oroperla barbara	2	p	-	-	-	-	-	-	-	-	-	-	-
Osobenus yakimae	2	p	-	-	-	-	-	-	-	-	-	-	-
Perlinodes aureus	2	p	-	-	-	-	-	-	-	-	-	-	-
Skwala sp.	2	p	-	-	-	-	-	-	-	-	3	-	-
Undetermined	2	p	-	-	-	-	-	-	-	-	-	-	-
Pteronarcyidae													
Pteronarcys sp.	0	s	-	-	-	-	-	-	-	-	-	-	-
Pteronarcella sp.	0	s	-	-	-	-	-	-	-	-	-	-	-
Taeniopterygidae													
Taenionema sp.	2	g	-	-	-	-	-	-	-	-	-	-	-

			Arcade Creek		American River at Harrington Bar			Feather River		Yuba River at Marysville		Sacramento River at Sac. St. Park	
Transect Number:			Snag #1	Snag #2	T1	T2	T3	Snag #1	Snag #2	T1	T2	Snag #1	Snag #2
ABL Laboratory Number:			3550	3551	3552	3553	3554	3555	3556	3557	3558	3559	3560
<u>Trichoptera</u>													
Brachycentridae													
Brachycentrus sp.	1	f	-	-	-	-	-	-	-	-	-	-	-
Micrasema sp.	1	g	-	-	-	-	-	-	-	-	-	-	-
Undetermined	1	c	-	-	-	-	-	-	-	-	-	-	-
Glossosomatidae													
Anagapetus sp.	0	g	-	-	-	-	-	-	-	-	-	-	-
Culoptila sp.	0	g	-	-	-	1	-	-	-	-	-	-	-
Glossosoma sp.	0	g	-	-	-	-	1	-	-	2	-	-	-
Undetermined	0	g	-	-	-	-	-	-	-	-	1	-	-
Goeridae													
Goerita sp.	0	s	-	-	-	-	-	-	-	-	-	-	-
Helicopsychidae													
Helicopsyche sp.	3	g	-	-	-	-	-	-	-	-	-	-	-
Hydropsychidae													
Cheumatopsyche sp.	5	f	-	-	1	-	1	-	-	1	1	-	-
Hydropsyche sp.	4	f	-	-	100	3	35	74	70	34	100	76	19
Undetermined	4	f	-	-	-	-	-	-	-	-	-	15	-
Hydroptilidae													
Hydroptila sp.	6	g	-	-	12	8	14	2	-	-	-	-	-
Ithythrichia sp.	6	g	-	-	-	-	-	-	-	-	-	-	-
Leucotrichia sp.	6	g	-	-	-	-	-	-	-	-	-	-	-
Undetermined	4	g	-	-	1	-	-	4	-	-	-	-	-
Lepidostomatidae													
Lepidostoma sp.	1	s	-	-	-	-	-	-	-	-	-	-	-
Leptoceridae													
Mystacides sp.	4	c	-	-	-	-	-	-	-	-	-	-	-
Nectopsyche sp.	3	s	-	-	-	-	-	-	-	-	-	-	-
Oecetis sp.	8	p	-	-	-	-	-	-	-	-	-	-	-
Undetermined	4	c	-	-	-	-	-	-	-	-	-	-	-
Limnephillidae													
Ecclisomyia sp.	2	g	-	-	-	-	-	-	-	-	-	-	-
Philopotamidae													
Chimarra sp.	4	f	-	-	-	-	-	-	-	-	-	-	-
Dolophilodes sp.	1	f	-	-	-	-	-	-	-	-	-	-	-
Polycentropodidae													
Polycentropus sp.	6	p	-	-	-	-	-	-	-	-	-	-	-
Rhyacophilidae													
Rhyacophila sp.	0	p	-	-	-	-	-	-	-	-	-	-	-
Sericostomatidae													
Gumaga sp.	3	s	-	-	-	-	-	-	-	-	-	-	-
Uenoidae													
Neophylax sp.	3	g	-	-	-	-	-	-	-	-	-	-	-
Subphylum Chelicerata													
Class Arachnoidea													
<u>Acari</u>													
Hydryphantidae	5	p	-	-	-	-	-	-	-	-	-	-	-
Hygrobatidae	5	p	-	-	-	-	-	-	3	-	-	-	-
Lebertiidae	5	p	-	-	1	4	4	1	-	1	-	-	-
Sperchontidae	5	p	-	-	2	5	7	5	2	-	4	5	5
Torrenticolidae	5	p	-	-	-	-	2	-	-	-	-	-	-
Undetermined	5	p	-	-	-	-	3	1	-	-	-	-	-

			Arcade Creek		American River at Harrington Bar			Feather River		Yuba River at Marysville		Sacramento River at Sac. St. Park	
Transect Number:			Snag #1	Snag #2	T1	T2	T3	Snag #1	Snag #2	T1	T2	Snag #1	Snag #2
ABL Laboratory Number:			3550	3551	3552	3553	3554	3555	3556	3557	3558	3559	3560
Subphylum Crustacea													
Class Brachiopoda													
<u>Cladocera</u>													
Chydoridae	8	c	-	-	-	-	-	-	-	-	-	-	-
Daphniidae	8	c	7	1	-	-	-	-	-	-	-	-	-
Macrothricidae	8	c	1	-	-	-	-	-	-	-	-	-	-
Class Copepoda													
<u>Cyclopoida</u>	8	c	15	17	-	-	-	-	-	-	-	-	-
<u>Harpacticoida</u>	8	c	7	1	-	-	-	-	-	-	-	-	-
Class Malacostraca													
<u>Amphipoda</u>													
Gammaridae													
Gammarus sp.	4	c	-	-	1	-	-	-	-	3	14	-	-
Class Ostracoda													
<u>Ostracoda</u>													
Cyprididae	8	c	-	2	-	-	-	-	-	-	-	-	-
PHYLUM MOLLUSCA													
Class Gastropoda													
Subclass Prosobranchia													
Hydrobiidae/Pleuroceridae		g	-	-	-	-	-	-	-	-	-	-	-
Subclass Pulmonata													
Ancylidae													
Ferrissia sp.	6	g	1	2	-	-	-	-	-	-	-	-	-
Lymnaeidae													
Fossaria sp.	6	g	-	-	-	-	-	-	-	-	-	-	-
Undetermined	6	g	-	-	-	-	1	-	-	-	-	-	-
Physidae													
Physa sp./Physella sp.	8	g	-	-	-	-	-	-	-	1	1	-	-
Planorbidae													
Helisoma sp.	7	g	1	-	-	-	-	-	-	-	-	-	-
Undetermined	7	g	1	-	-	-	1	-	-	-	-	-	-
Class Bivalvia													
<u>Pelecypoda</u>													
Corbiculidae													
Corbicula fluminea	10	f	-	-	1	1	4	1	-	-	1	-	-

			Arcade Creek		American River at Harrington Bar			Feather River		Yuba River at Marysville		Sacramento River at Sac. St. Park	
Transect Number:			Snag #1	Snag #2	T1	T2	T3	Snag #1	Snag #2	T1	T2	Snag #1	Snag #2
ABL Laboratory Number:			3550	3551	3552	3553	3554	3555	3556	3557	3558	3559	3560
PHYLUM NEMATODA	5	p	-	-	-	2	-	5	3	-	-	3	7
PHYLUM TARDIGRADA		c	6	-	-	5	9	-	-	-	-	-	-
PHYLUM PLATYHELMINTHES													
Class Turbellaria													
Tricladia													
Planariidae	4	p	2	-	12	-	-	-	-	1	9	-	-
PHYLUM ANNELIDA													
Class Oligochaeta	8	c	84	9	28	182	113	12	2	13	5	5	105
PHYLUM NEMERTEA													
Class Enopla													
Tertastemmatidae													
Prostoma sp.		c	-	-	3	-	-	3	-	-	3	-	-
Total Organisms*			300	295	294	282	288	297	287	291	305	301	261

Total Bugs Recovered			300	295	294	282	288	297	287	291	305	301	261
Total Extra Bugs			2	47	103	0	64	31	238	209	64	253	126
Bugs Picked (includes extra bugs)			302	347	403	300	364	331	538	509	364	553	426
Grids Processed			3	6	4	1	3	3	2	3	3	2	2
Total Grids Possible			40	8	16	24	24	24	8	16	16	8	40
Sorted			300	294	298	308	285	289	292	299	294	297	285
Discards			4	2	0	1	0	2	2	1	0	2	2
Abundance (#/ sample)			4027	455	1580	6768	2796	2622	2059	2633	1974	2219	7412

			Butte Creek at Honey Run			Butte Creek at Doe Mill Rd.			Butte Creek Cherry Hill Camp			Big Chico Creek at Bidwell Park			Big Chico Creek at Forest Ranch			Big Chico Creek at Highway 32		
Transect Number:			T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3
ABL Laboratory Number:			3561	3562	3563	3564	3565	3566	3567	3568	3569	3570	3571	3572	3573	3574	3575	3576	3577	3578
PHYLUM ARTHROPODA	TV	FFG																		
Class Insecta																				
Coleoptera (Adults)																				
Dryopidae																				
Helichus sp.	5	g	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Postelichus sp.	5	g	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dytiscidae																				
Liodessus sp.	5	p	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Elmidae																				
Heterlimnius Koebelei	4	c	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Optioservus sp.	4	g	-	-	2	-	1	1	-	-	-	-	1	1	4	2	3	1	-	1
Zaitzevia sp.	4	c	-	-	-	-	-	-	-	-	-	-	1	-	1	2	1	-	-	-
Hydraenidae	5	g																		
Hydraena sp.	5	g	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-
Ochthebius sp.	5	g	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Coleoptera (Larvae)																				
Elmidae																				
Ampumixis dispar	4	c	-	-	-	5	2	3	-	-	-	-	-	-	2	2	-	8	11	9
Atractelmis sp.			-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	1	-
Cleptelmis sp.	4	c	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dubiraphia sp.	4	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heterlimnius sp.	4	c	-	-	-	-	-	-	4	4	5	-	-	-	-	-	-	2	-	2
Lara sp.	4	s	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	1
Microcylloepus sp.	2	c	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-
Narpus sp.	4	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Optioservus sp.	4	g	7	20	2	5	2	1	-	-	1	1	12	7	17	5	8	-	-	-
Ordobrevia sp.	4	c	-	-	-	1	-	-	-	-	-	-	-	2	-	-	-	-	-	-
Rhizelmis nigra	1	c	-	-	-	-	-	-	-	2	1	-	-	-	-	-	-	-	-	-
Zaitzevia sp.	4	c	3	-	-	11	3	5	-	-	-	1	2	2	8	7	10	-	-	-
Psephenidae																				
Acneus quadrimaculatus	4	g	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Eubrianax sp.	4	g	-	-	-	-	-	-	-	-	-	-	-	-	3	3	7	-	-	-
Psephenus sp.	4	g	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diptera																				
Athericidae																				
Atherix sp.	2	p	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-
Blephariceridae																				
Agathon sp.	0	g	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-
Blepharicera sp.	0	g	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ceratopogonidae																				
Bezzia sp./ Palpomyia sp.	6	p	-	-	-	-	1	-	-	-	-	1	-	4	-	-	-	-	1	-
Chironomidae																				
Chironominae																				
Chironomini	6	c	39	6	8	1	7	3	-	1	-	3	-	3	3	-	6	2	1	4
Tanytarsini	6	f	2	2	4	2	13	15	13	11	2	-	2	22	-	-	4	23	14	19
Diamesinae																				
Borroheptagyia sp.		c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Orthocladiinae	5	c	31	6	24	13	35	31	7	14	14	9	36	39	83	68	41	13	21	24
Tanypodinae	6	p	-	5	-	-	1	6	-	-	-	-	-	-	-	-	-	1	1	4
Culicidae																				
Anopheles sp.	8	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

			Butte Creek at Honey Run			Butte Creek at Doe Mill Rd.			Butte Creek Cherry Hill Camp			Big Chico Creek at Bidwell Park			Big Chico Creek at Forest Ranch			Big Chico Creek at Highway 32		
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ABL Laboratory Number:			3561	3562	3563	3564	3565	3566	3567	3568	3569	3570	3571	3572	3573	3574	3575	3576	3577	3578
Empididae																				
Chelifera sp.	6	p	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-
Clinocera sp.	6	p	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Hemerodromia sp.	6	p	-	1	1	-	1	-	-	-	-	1	2	-	4	1	-	-	-	-
Oreogeton sp.	5	p	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Wiedemannia sp.	6	p	-	-	-	-	2	-	-	-	-	-	-	-	-	-	1	-	1	-
Undetermined																				
Psychodidae																				
Maruina sp.	1	g	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Simuliidae	6	f	1	1	4	9	9	9	-	-	-	-	1	1	5	29	2	-	-	-
Stratiomyidae																				
Caloparyphus sp.	7	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tipulidae																				
Antocha sp.	3	c	-	1	1	3	-	1	-	1	-	-	-	1	4	3	6	2	-	-
Dicranota sp.	3	p	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Hexatoma sp.	2	p	-	4	-	-	-	4	-	-	-	-	-	-	-	-	1	-	-	-
Undetermined	3	s	-	-	-	-	1	-	-	-	-	-	-	-	1	-	-	-	-	-
Undetermined			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<u>Megaloptera</u>																				
Corydalidae																				
Corydalus sp.	0	p	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Orohermes sp.	0	p	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	1	-
Undetermined	0	p	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
<u>Odonata</u>																				
Calopterygidae																				
Hetaerina sp.	6	p	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Coenagrionidae																				
Argia sp.	7	p	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Undetermined			-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-
Cordulegastridae																				
Cordulegaster dorsalis	0	p	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Corduliidae	9	p	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undetermined			-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Gomphidae																				
Ophiogomphus sp.	1	p	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-
Undetermined			-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-
<u>Lepidoptera</u>																				
Pyralidae																				
Petrophila sp.	5	g	-	-	-	-	-	-	-	-	-	-	2	-	2	-	-	-	-	-
<u>Ephemeroptera</u>																				
Ameletidae																				
Ameletus sp.	0	g	-	-	-	-	1	1	-	8	-	-	-	-	-	-	-	1	-	-
Baetidae																				
Acentrella sp.	4	c	2	-	3	1	-	-	-	-	-	-	-	-	1	-	1	-	-	-
Baetis sp.	5	c	19	13	29	50	33	54	4	5	27	3	9	-	63	43	11	29	25	9
Diphetor sp.	5	c	-	-	-	-	-	-	1	2	-	-	-	-	-	1	1	-	1	-
Fallceon quilleri	4	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ephemerellidae																				
Caudatella sp.	1	c	-	-	-	-	-	-	2	2	5	-	-	-	-	-	-	1	1	1
Drunella sp.	0	g	-	-	-	-	-	-	2	2	-	-	-	-	1	-	-	2	-	-
Serratella sp.	2	c	36	142	98	20	31	14	12	19	18	1	2	-	20	13	6	16	14	14
Undetermined	7	c	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-

			Butte Creek at Honey Run			Butte Creek at Doe Mill Rd.			Butte Creek Cherry Hill Camp			Big Chico Creek at Bidwell Park			Big Chico Creek at Forest Ranch			Big Chico Creek at Highway 32		
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ABL Laboratory Number:			3561	3562	3563	3564	3565	3566	3567	3568	3569	3570	3571	3572	3573	3574	3575	3576	3577	3578
Heptageniidae																				
Cinygma sp.	4	g	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Cinygmula sp.	4	g	-	-	-	-	-	-	16	46	9	-	-	-	-	-	-	7	6	2
Epeorus sp.	0	g	-	-	2	26	49	65	13	9	36	-	-	-	1	41	38	43	46	48
Heptagenia sp.	4	g	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ironodes sp.	4	g	-	-	-	-	3	2	-	-	11	-	-	-	-	-	-	13	24	37
Rhithrogena sp.	0	g	4	2	37	26	2	3	51	40	42	-	-	-	1	6	8	2	1	2
Leptohyphidae																				
Tricorythodes sp.	5	c	25	7	1	-	-	-	-	-	-	1	5	11	2	-	2	-	-	-
Leptophlebidae																				
Paraleptophlebia sp.	4	c	1	1	1	3	3	5	2	21	7	-	-	-	1	2	9	16	5	5
Plecoptera																				
Capniidae																				
Capnia sp.	1	s	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undetermined	1	s	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Chloroperlidae																				
Haploperla chilnualna	1	p	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Suwallia sp.	1	p	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sweltsa sp.	1	p	-	-	1	-	-	2	7	5	4	-	-	-	7	4	3	4	-	1
Undetermined	1	p	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leuctridae																				
Paraleuctra sp.	0	s	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-
Nemouridae																				
Zapada sp.	2	s	-	-	-	-	1	-	1	8	25	-	-	-	-	1	-	3	3	15
Undetermined	2	s	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Peltoperlidae																				
Sierraperla sp.	1	s	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-
Yoraperla sp.	2	s	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	4	-	-
Perlidae																				
Calineuria californica	1	p	3	-	2	6	2	11	1	-	1	-	-	-	2	4	8	8	7	7
Claassenia sp.	3	p	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Doroneuria baumanni	1	p	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
Hesperoperla sp.	2	p	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-
Undetermined	1	p	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Perlodidae																				
Frisonia picticeps	2	p	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Isoperla sp.	2	p	5	11	13	-	-	-	-	-	-	-	1	-	1	3	-	-	2	1
Megarcys sp.	2	p	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oroperla barbara	2	p	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Osobenus yakimae	2	p	10	8	24	-	1	-	-	1	-	-	-	-	-	2	8	-	-	-
Perlinodes aureus	2	p	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	2
Skwala sp.	2	p	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Undetermined	2	p	-	-	-	-	-	-	-	-	1	-	-	-	-	3	-	-	-	-
Pteronarcyidae																				
Pteronarcys sp.	0	s	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-
Pteronarcella sp.	0	s	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Taeniopterygidae																				
Taenionema sp.	2	g	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

			Butte Creek at Honey Run			Butte Creek at Doe Mill Rd.			Butte Creek Cherry Hill Camp			Big Chico Creek at Bidwell Park			Big Chico Creek at Forest Ranch			Big Chico Creek at Highway 32		
Transect Number:			T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3
ABL Laboratory Number:			3561	3562	3563	3564	3565	3566	3567	3568	3569	3570	3571	3572	3573	3574	3575	3576	3577	3578
Trichoptera																				
Brachycentridae																				
Brachycentrus sp.	1	f	-	-	-	-	-	-	-	-	-	-	-	-	3	1	2	-	-	-
Micrasema sp.	1	g	-	-	-	56	29	10	1	1	-	-	-	-	1	-	3	53	40	16
Undetermined	1	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-
Glossosomatidae																				
Anagapetus sp.	0	g	-	-	-	-	-	-	4	1	-	-	-	-	-	-	-	-	5	7
Culoptila sp.	0	g	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Glossosoma sp.	0	g	-	2	1	7	-	8	-	-	-	-	-	-	-	1	-	-	-	-
Undetermined	0	g	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Goeridae																				
Goerita sp.	0	s	-	-	-	1	-	-	-	41	25	-	-	-	-	-	-	-	1	-
Helicopsychidae																				
Helicopsyche sp.	3	g	-	4	-	1	9	1	-	-	-	1	-	5	1	4	17	-	-	-
Hydropsychidae																				
Cheumatopsyche sp.	5	f	18	2	15	-	-	-	5	4	12	-	11	-	1	1	4	-	2	4
Hydropsyche sp.	4	f	6	7	37	16	19	6	1	2	4	2	77	4	2	11	4	28	55	50
Undetermined	4	f	-	-	-	-	-	-	-	-	-	1	9	1	-	-	-	-	-	-
Hydroptilidae																				
Hydroptila sp.	6	g	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ithythrichia sp.	6	g	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leucotrichia sp.	6	g	-	-	-	-	-	-	-	-	-	-	-	1	3	-	-	-	-	-
Undetermined	4	g	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Lepidostomatidae																				
Lepidostoma sp.	1	s	1	-	-	17	32	8	2	8	1	-	-	-	-	3	10	2	1	2
Leptoceridae																				
Mystacides sp.	4	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nectopsyche sp.	3	s	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Oecetis sp.	8	p	3	11	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-
Undetermined	4	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Limnephillidae																				
Ecclisomyia sp.	2	g	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Philopotamidae																				
Chimarra sp.	4	f	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dolophilodes sp.	1	f	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Polycentropodidae																				
Polycentropus sp.	6	p	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhyacophilidae																				
Rhyacophila sp.	0	p	-	-	-	1	-	2	6	6	4	-	-	-	-	3	-	1	1	2
Sericostomatidae																				
Gumaga sp.	3	s	-	-	-	-	-	1	-	-	-	-	-	-	2	-	3	2	1	1
Uenoidae																				
Neophylax sp.	3	g	-	-	-	-	-	-	135	-	-	-	-	-	-	-	-	-	-	-
Subphylum Chelicerata																				
Class Arachnoidea																				
Acari																				
Hydryphantidae	5	p	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Hygrobatidae	5	p	2	-	1	-	-	-	-	-	-	3	9	2	-	-	1	-	-	-
Lebertiidae	5	p	1	-	-	-	-	-	1	3	2	4	3	4	-	-	-	-	-	-
Sperchontidae	5	p	4	1	1	3	-	-	-	-	-	1	10	-	29	3	4	1	1	1
Torrenticolidae	5	p	-	1	-	-	2	-	-	-	-	5	14	1	-	3	3	-	-	-
Undetermined	5	p	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	-

			Butte Creek at Honey Run			Butte Creek at Doe Mill Rd.			Butte Creek Cherry Hill Camp			Big Chico Creek at Bidwell Park			Big Chico Creek at Forest Ranch			Big Chico Creek at Highway 32		
Transect Number:			T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3
ABL Laboratory Number:			3561	3562	3563	3564	3565	3566	3567	3568	3569	3570	3571	3572	3573	3574	3575	3576	3577	3578
Subphylum Crustacea																				
Class Brachiopoda																				
Cladocera																				
Chydoridae	8	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Daphniidae	8	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Macrothricidae	8	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Class Copepoda																				
Cyclopoida	8	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Harpacticoida	8	c	-	-	-	-	-	1	1	1	-	-	-	-	-	-	-	1	1	-
Class Malacostraca																				
Amphipoda																				
Gammaridae																				
Gammarus sp.	4	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Class Ostracoda																				
Ostracoda																				
Cyprididae	8	c	-	-	-	-	-	-	1	4	2	-	-	-	-	-	1	-	-	-
PHYLUM MOLLUSCA																				
Class Gastropoda																				
Subclass Prosobranchia																				
Hydrobiidae/Pleuroceridae		g	-	-	-	-	-	3	-	-	-	-	-	-	-	-	7	-	1	-
Subclass Pulmonata																				
Ancylidae																				
Ferrissia sp.	6	g	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lymnaeidae																				
Fossaria sp.	6	g	-	1	1	-	-	-	-	-	-	40	8	12	-	-	-	-	-	-
Undetermined	6	g	3	10	-	-	-	-	-	-	-	183	21	105	-	-	-	-	-	-
Physidae																				
Physa sp./Physella sp.	8	g	-	10	-	-	-	-	-	-	-	9	9	2	1	-	-	-	-	-
Planorbidae																				
Helisoma sp.	7	g	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undetermined	7	g	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Class Bivalvia																				
Pelecypoda																				
Corbiculidae																				
Corbicula fluminea	10	f	-	-	-	-	-	-	-	-	-	-	-	2	-	-	2	-	-	-

			Butte Creek at Honey Run			Butte Creek at Doe Mill Rd.			Butte Creek Cherry Hill Camp			Big Chico Creek at Bidwell Park			Big Chico Creek at Forest Ranch			Big Chico Creek at Highway 32		
Transect Number:			T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3
ABL Laboratory Number:			3561	3562	3563	3564	3565	3566	3567	3568	3569	3570	3571	3572	3573	3574	3575	3576	3577	3578
PHYLUM NEMATODA	5	p	-	-	-	-	-	-	-	3	1	-	-	-	-	1	9	3	1	1
PHYLUM TARDIGRADA		c	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-
PHYLUM PLATYHELMINTHES																				
Class Turbellaria																				
Tricladia																				
Planariidae	4	p	2	-	-	-	-	-	1	2	-	12	15	6	1	1	1	-	1	3
PHYLUM ANNELIDA																				
Class Oligochaeta	8	c	58	18	2	4	-	2	6	12	25	5	18	9	6	6	10	2	2	1
PHYLUM NEMERTEA																				
Class Enopla																				
Tertastemmatidae																				
Prostoma sp.		c	-	-	-	-	-	1	-	-	-	6	-	29	-	-	-	-	-	-
Total Organisms*			288	297	315	290	297	285	304	294	298	294	284	282	291	289	283	297	302	300

Total Bugs Recovered			288	297	315	290	297	282	301	294	298	294	284	282	291	289	276	297	301	300
Total Extra Bugs			37	63	114	67	1	34	66	6	19	24	55	36	5	37	2	41	1	54
Bugs Picked (includes extra bugs)			337	363	414	367	301	334	366	306	319	324	355	336	305	337	302	341	301	354
Grids Processed			1	2	4	6	4	7	4	5	4	1	3	4	3	3	8	6	5	3
Total Grids Possible			12	24	12	8	12	12	32	32	20	32	16	8	24	24	40	24	24	12
Sorted			299	302	293	300	297	290	306	298	298	292	291	284	298	301	295	297	297	299
Discards			1	1	8	0	1	2	0	2	1	5	4	5	2	0	3	0	0	0
Abundance (#/ sample)			3882	4312	1304	473	894	538	2938	1919	1584	10161	1792	632	2367	2597	1389	1350	1450	1416

			Deer Creek at Monastery			Deer Creek at Fish Screen			Deer Creek at Ponderosa			Deer Creek at Potato Patch			Sacramento River at Lamoine			McCloud River at Nature Conservancy			McCloud River at Stout's Road		
Transect Number:			T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3
ABL Laboratory Number:			3579	3580	3581	3582	3583	3584	3585	3586	3587	3588	3589	3590	3591	3592	3593	3594	3595	3596	3597	3598	3599
PHYLUM ARTHROPODA	TV	FFG																					
Class Insecta																							
Coleoptera (Adults)																							
Dryopidae																							
Helichus sp.	5	g	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Postelichus sp.	5	g	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dytiscidae																							
Liodessus sp.	5	p	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Elmidae																							
Heterlimnius Koebelei	4	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Optioservus sp.	4	g	8	-	3	-	-	1	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-
Zaitzevia sp.	4	c	-	1	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydraenidae	5	g																					
Hydraena sp.	5	g	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ochthebius sp.	5	g	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Coleoptera (Larvae)																							
Elmidae																							
Ampumixis dispar	4	c	-	-	-	-	-	-	4	9	2	6	7	4	5	-	1	-	1	1	-	-	-
Atractelmis sp.			-	-	-	-	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cleptelmis sp.	4	c	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Dubiraphia sp.	4	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heterlimnius sp.	4	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lara sp.	4	s	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Microcylloepus sp.	2	c	2	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Narpus sp.	4	c	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Optioservus sp.	4	g	15	9	2	7	3	6	14	20	11	6	7	-	13	5	1	-	-	-	-	-	-
Ordobrevia sp.	4	c	-	-	-	-	-	-	-	-	-	-	-	1	2	2	-	-	-	-	-	-	-
Rhizelmis nigra	1	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zaitzevia sp.	4	c	1	1	1	2	2	2	3	3	-	-	-	-	6	-	1	-	-	-	-	-	-
Psephenidae																							
Acneus quadrimaculatus	4	g	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eubrianax sp.	4	g	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Psephenus sp.	4	g	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diptera																							
Athericidae																							
Atherix sp.	2	p	-	-	-	1	-	-	1	1	2	-	-	-	-	-	-	-	-	-	-	-	-
Blephariceridae																							
Agathon sp.	0	g	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Blepharicera sp.	0	g	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ceratopogonidae																							
Bezzia sp./ Palpomyia sp.	6	p	-	-	-	-	-	-	-	-	-	1	1	1	-	-	-	-	-	-	-	1	-
Chironomidae																							
Chironominae																							
Chironomini	6	c	-	-	-	1	1	1	4	10	4	-	14	1	-	-	-	2	9	9	-	-	-
Tanytarsini	6	f	7	27	27	-	2	1	6	12	11	3	13	10	-	-	-	22	21	36	9	1	1
Diamesinae																							
Borroheptagyia sp.		c	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Orthocladiinae	5	c	124	53	47	63	40	28	41	51	36	15	21	37	20	14	50	45	73	86	21	14	32
Tanypodinae	6	p	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	1	-	-	-
Culicidae																							
Anopheles sp.	8	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

			Deer Creek at Monastery			Deer Creek at Fish Screen			Deer Creek at Ponderosa			Deer Creek at Potato Patch			Sacramento River at Lamoine			McCloud River at Nature Conservancy			McCloud River at Stout's Road		
Transect Number:			T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3
ABL Laboratory Number:			3579	3580	3581	3582	3583	3584	3585	3586	3587	3588	3589	3590	3591	3592	3593	3594	3595	3596	3597	3598	3599
Empididae																							
Chelifera sp.	6	p	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-	1	-	-
Clinocera sp.	6	p	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hemerodromia sp.	6	p	1	1	1	-	3	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Oreogeton sp.	5	p	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Wiedemannia sp.	6	p	-	-	-	1	-	-	2	1	-	-	-	-	-	-	-	2	4	1	-	-	-
Undetermined																							
Psychodidae																							
Maruina sp.	1	g	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Simuliidae	6	f	-	7	5	1	6	2	34	2	40	-	-	-	30	81	22	-	1	-	1	-	1
Stratiomyidae																							
Caloparyphus sp.	7	c	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Tipulidae																							
Antocha sp.	3	c	-	-	-	5	4	7	6	3	2	-	1	2	10	12	1	1	1	2	2	-	-
Dicranota sp.	3	p	-	-	-	-	-	-	-	-	-	1	1	1	-	-	-	1	-	-	-	1	-
Hexatoma sp.	2	p	-	-	-	-	-	-	2	-	3	1	3	1	-	-	-	3	-	-	-	-	-
Undetermined	3	s	-	-	-	1	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undetermined			-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Megaloptera																							
Corydalidae																							
Corydalus sp.	0	p	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Orohermes sp.	0	p	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-
Undetermined	0	p	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Odonata																							
Calopterygidae																							
Hetaerina sp.	6	p	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Coenagrionidae																							
Argia sp.	7	p	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undetermined			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cordulegastridae																							
Cordulegaster dorsalis	0	p	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Corduliidae	9	p	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undetermined			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gomphidae																							
Ophiogomphus sp.	1	p	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Undetermined			-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lepidoptera																							
Pyralidae																							
Petrophila sp.	5	g	6	1	4	8	3	3	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Ephemeroptera																							
Ameletidae																							
Ameletus sp.	0	g	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	2	-	-	-	-	-
Baetidae																							
Acentrella sp.	4	c	2	2	1	3	3	2	1	-	4	1	-	-	1	3	16	-	-	-	-	-	-
Baetis sp.	5	c	13	40	70	7	47	44	6	-	7	29	13	54	61	45	36	10	14	8	11	6	16
Diphetor sp.	5	c	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
Fallceon quilleri	4	c	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ephemerellidae																							
Caudatella sp.	1	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	2	5	-	7
Drunella sp.	0	g	-	-	-	-	-	-	-	-	2	3	2	2	-	1	-	1	1	-	16	9	22
Serratella sp.	2	c	-	1	-	25	31	42	17	28	32	74	71	29	17	13	26	37	60	54	12	2	3
Undetermined	7	c	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-

			Deer Creek at Monastery			Deer Creek at Fish Screen			Deer Creek at Ponderosa			Deer Creek at Potato Patch			Sacramento River at Lamoine			McCloud River at Nature Conservancy			McCloud River at Stout's Road		
Transect Number:			T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3
ABL Laboratory Number:			3579	3580	3581	3582	3583	3584	3585	3586	3587	3588	3589	3590	3591	3592	3593	3594	3595	3596	3597	3598	3599
Heptageniidae																							
Cinygma sp.	4	g	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Cinygmula sp.	4	g	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	13	8	1
Epeorus sp.	0	g	1	-	-	-	3	3	14	9	19	24	21	47	7	3	46	2	7	10	4	1	4
Heptagenia sp.	4	g	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ironodes sp.	4	g	-	-	-	-	-	-	-	-	-	-	2	3	-	-	-	-	-	-	-	-	8
Rhithrogena sp.	0	g	-	-	-	-	1	-	6	4	5	13	6	6	2	4	3	80	36	28	29	21	44
Leptohyphidae																							
Tricorythodes sp.	5	c	6	4	6	27	22	22	1	1	-	-	-	-	-	-	1	-	-	-	-	-	-
Leptophlebidae																							
Paraleptophlebia sp.	4	c	-	-	-	-	-	-	4	2	2	5	4	4	-	-	5	2	1	6	6	1	2
Plecoptera																							
Capniidae																							
Capnia sp.	1	s	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-
Undetermined	1	s	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chloroperlidae																							
Haploperla chilnualna	1	p	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
Suwallia sp.	1	p	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
Sweltsa sp.	1	p	-	-	-	-	-	-	7	5	3	-	-	-	-	-	-	-	1	1	7	6	5
Undetermined	1	p	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	2	-
Leuctridae																							
Paraleuctra sp.	0	s	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nemouridae																							
Zapada sp.	2	s	-	-	-	-	-	-	-	-	-	1	5	1	-	-	-	-	1	-	8	2	10
Undetermined	2	s	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Peltoperlidae																							
Sierraperla sp.	1	s	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Yoraperla sp.	2	s	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Perlidae																							
Calineuria californica	1	p	-	-	-	-	-	-	2	5	5	20	19	13	-	1	-	-	5	2	2	-	4
Claassenia sp.	3	p	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Doroneuria baumanni	1	p	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
Hesperoperla sp.	2	p	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	1	-	-	-
Undetermined	1	p	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-
Perlodidae																							
Frisonia picticeps	2	p	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Isoperla sp.	2	p	-	-	-	-	2	2	8	11	17	-	1	-	5	7	4	4	1	-	1	-	-
Megarcys sp.	2	p	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	6
Oroperla barbara	2	p	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Osobenus yakimae	2	p	-	-	-	3	1	-	-	3	-	-	1	-	2	1	-	-	1	-	-	-	-
Perlinodes aureus	2	p	-	-	-	-	-	-	-	-	-	5	7	3	-	-	-	-	-	-	2	-	-
Skwala sp.	2	p	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-
Undetermined	2	p	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pteronarcyidae																							
Pteronarcys sp.	0	s	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pteronarcella sp.	0	s	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Taeniopterygidae																							
Taenionema sp.	2	g	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-

			Deer Creek at Monastery			Deer Creek at Fish Screen			Deer Creek at Ponderosa			Deer Creek at Potato Patch			Sacramento River at Lamoine			McCloud River at Nature Conservancy			McCloud River at Stout's Road		
Transect Number:			T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3
ABL Laboratory Number:			3579	3580	3581	3582	3583	3584	3585	3586	3587	3588	3589	3590	3591	3592	3593	3594	3595	3596	3597	3598	3599
Trichoptera																							
Brachycentridae																							
Brachycentrus sp.	1	f	-	-	-	7	21	29	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Micrasema sp.	1	g	-	-	-	-	-	-	2	1	9	2	13	13	3	-	1	1	-	-	-	-	2
Undetermined	1	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Glossosomatidae																							
Anagapetus sp.	0	g	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19	79	64
Culoptila sp.	0	g	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Glossosoma sp.	0	g	-	-	-	-	4	-	2	-	7	-	-	-	21	-	-	-	-	-	25	64	11
Undetermined	0	g	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	58	1	-
Goeridae																							
Goerita sp.	0	s	-	-	-	-	-	-	-	-	-	2	4	10	-	-	-	-	-	-	-	-	1
Helicopsychidae																							
Helicopsyche sp.	3	g	3	-	-	-	1	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydropsychidae																							
Cheumatopsyche sp.	5	f	10	13	10	41	24	40	-	-	-	-	3	-	6	5	1	-	-	-	-	-	-
Hydropsyche sp.	4	f	35	26	59	7	28	45	20	5	20	36	33	8	61	98	52	2	5	13	-	1	2
Undetermined	4	f	2	7	7	4	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Hydroptilidae																							
Hydroptila sp.	6	g	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Ithythrichia sp.	6	g	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Leucotrichia sp.	6	g	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undetermined	4	g	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lepidostomatidae																							
Lepidostoma sp.	1	s	-	-	-	1	-	-	2	4	5	8	13	2	15	3	18	-	-	-	-	-	-
Leptoceridae																							
Mystacides sp.	4	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nectopsyche sp.	3	s	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oecetis sp.	8	p	1	-	-	-	-	-	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Undetermined	4	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Limnephillidae																							
Ecclisomyia sp.	2	g	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Philopotamidae																							
Chimarra sp.	4	f	-	5	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dolophilodes sp.	1	f	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polycentropodidae																							
Polycentropus sp.	6	p	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhyacophilidae																							
Rhyacophila sp.	0	p	-	-	-	-	-	-	-	-	-	-	3	2	-	1	-	2	4	4	14	5	14
Sericostomatidae																							
Gumaga sp.	3	s	-	-	-	-	-	-	-	-	-	2	1	1	-	-	-	-	-	-	-	-	-
Uenoidae																							
Neophylax sp.	3	g	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	1	4	-
Subphylum Chelicerata																							
Class Arachnoidea																							
Acari																							
Hydryphantidae	5	p	-	-	-	-	-	-	-	2	2	-	-	-	-	-	-	-	-	-	-	-	-
Hygrobatidae	5	p	-	-	-	2	-	2	-	1	-	-	-	-	-	-	1	-	1	-	-	-	-
Lebertiidae	5	p	6	-	-	2	1	-	-	1	1	-	-	4	-	1	-	-	1	-	-	1	-
Sperchontidae	5	p	5	1	1	4	3	2	5	6	1	1	-	-	-	3	2	-	-	-	-	-	-
Torrenticolidae	5	p	1	-	1	2	-	-	1	2	1	-	-	1	-	-	-	3	1	-	-	-	-
Undetermined	5	p	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-

			Deer Creek at Monastery			Deer Creek at Fish Screen			Deer Creek at Ponderosa			Deer Creek at Potato Patch			Sacramento River at Lamoine			McCloud River at Nature Conservancy			McCloud River at Stout's Road		
Transect Number:			T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3
ABL Laboratory Number:			3579	3580	3581	3582	3583	3584	3585	3586	3587	3588	3589	3590	3591	3592	3593	3594	3595	3596	3597	3598	3599
Subphylum Crustacea																							
Class Brachiopoda																							
Cladocera																							
Chydoridae	8	c	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Daphniidae	8	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Macrothricidae	8	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Class Copepoda																							
Cyclopoida	8	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Harpacticoida	8	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	4	-
Class Malacostraca																							
Amphipoda																							
Gammaridae																							
Gammarus sp.	4	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Class Ostracoda																							
Ostracoda																							
Cyprididae	8	c	7	2	-	-	-	-	-	-	-	-	-	-	-	1	-	8	3	-	-	-	-
PHYLUM MOLLUSCA																							
Class Gastropoda																							
Subclass Prosobranchia																							
Hydrobiidae/Pleuroceridae		g	-	-	-	-	-	-	2	1	1	-	-	-	-	-	-	-	-	-	-	-	-
Subclass Pulmonata																							
Ancylidae																							
Ferrissia sp.	6	g	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lymnaeidae																							
Fossaria sp.	6	g	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undetermined	6	g	1	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Physidae																							
Physa sp./Physella sp.	8	g	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Planorbidae																							
Helisoma sp.	7	g	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Undetermined	7	g	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Class Bivalvia																							
Pelecypoda																							
Corbiculidae																							
Corbicula fluminea	10	f	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

			Deer Creek at Monastery			Deer Creek at Fish Screen			Deer Creek at Ponderosa			Deer Creek at Potato Patch			Sacramento River at Lamoine			McCloud River at Nature Conservancy			McCloud River at Stout's Road		
Transect Number:			T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3
ABL Laboratory Number:			3579	3580	3581	3582	3583	3584	3585	3586	3587	3588	3589	3590	3591	3592	3593	3594	3595	3596	3597	3598	3599
PHYLUM NEMATODA	5	p	1	1	-	-	-	-	2	6	1	2	2	-	1	-	-	1	2	-	-	-	-
PHYLUM TARDIGRADA		c	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PHYLUM PLATYHELMINTHES																							
Class Turbellaria																							
Tricladia																							
Planariidae	4	p	15	28	4	5	1	-	1	1	-	-	3	-	-	1	-	7	8	5	12	7	9
PHYLUM ANNELIDA																							
Class Oligochaeta	8	c	4	21	15	50	22	3	53	3	18	7	2	5	2	-	1	29	20	28	-	22	17
PHYLUM NEMERTEA																							
Class Enopla																							
Tertastemmatidae																							
Prostoma sp.		c	14	21	3	6	1	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-
Total Organisms*			299	297	286	290	284	291	283	219	278	272	303	277	299	306	289	277	296	299	282	267	287
Total Bugs Recovered			299	297	286	290	284	291	281	218	277	272	303	277	299	306	289	277	296	299	282	267	287
Total Extra Bugs			55	64	12	17	14	23	0	35	1	9	21	16	16	58	22	2	58	106	1	31	15
Bugs Picked (includes extra bugs)			355	364	312	317	314	323	300	335	301	309	321	316	316	358	322	302	358	406	301	331	315
Grids Processed			5	3	6	4	9	6	3	4	5	7	3	23	7	3	10	9	6	4	5	5	3
Total Grids Possible			16	32	80	48	38	32	48	32	40	16	80	40	80	64	40	20	32	40	80	40	16
Sorted			302	294	290	276	278	298	280	301	293	291	297	280	299	297	289	281	293	304	290	287	298
Discards			0	1	3	1	1	2	1	1	8	5	0	2	0	1	8	2	2	1	3	0	0
Abundance (#/ sample)			1132	3844	3966	3677	1255	1671	4496	1947	2223	640	8646	507	3599	7790	1241	620	1884	4046	4527	2357	1607

Taxonomic List Of Benthic Macroinvertebrates Identified From Samples Collected from Non-Wadable Monitoring Sites In Fall 1999 In The Sacramento River Watershed

(List reflects combined taxa lists of CDFG and USGS for non-wadable sites.)

			Arcade Creek		American River at Harrington Bar			Feather River		Yuba River at Marysville		Sacramento River at Sac. St. Park	
Transect Number:			Snag #1	Snag #2	T1	T2	T3	Snag #1	Snag #2	T1	T2	Snag #1	Snag #2
ABL Laboratory Number:			3550	3551	3552	3553	3554	3555	3556	3557	3558	3559	3560
PHYLUM ARTHROPODA	TV	FFG											
Class Insecta													
Coleoptera (Adults)													
Dryopidae													
Helichus sp.	5	g	-	-	-	-	-	-	-	-	-	-	-
Postelichus sp.	5	g	-	-	-	-	-	-	-	-	-	-	-
Dytiscidae													
Liodessus sp.	5	p	-	1	-	-	-	-	-	-	-	-	-
Elmidae													
Heterlimnius Koebelei	4	c	-	-	-	-	-	-	-	-	-	-	-
Optioservus sp.	4	g	-	-	-	-	-	-	-	-	-	-	-
Zaitzevia sp.	4	c	-	-	-	-	-	-	-	-	-	-	-
Hydraenidae	5	g											
Hydraena sp.	5	g	-	-	-	-	-	-	-	-	-	-	-
Ochthebius sp.	5	g	-	-	-	-	-	-	-	-	-	-	-
Coleoptera (Larvae)													
Elmidae													
Ampumixis dispar	4	c	-	-	-	-	-	-	-	-	-	-	-
Atractelmis sp.			-	-	-	-	-	-	-	-	-	-	-
Cleptelmis sp.	4	c	-	-	-	-	-	-	-	-	-	-	-
Dubiraphia sp.	4	c	-	-	-	-	-	1	-	-	-	-	-
Heterlimnius sp.	4	c	-	-	-	-	-	-	-	-	-	-	-
Lara sp.	4	s	-	-	-	-	-	-	-	-	-	-	-
Microcylloepus sp.	2	c	-	-	-	-	-	-	-	-	4	-	-
Narpus sp.	4	c	-	-	-	-	-	-	-	-	-	-	-
Optioservus sp.	4	g	-	-	-	-	-	-	-	-	-	-	-
Ordobrevia sp.	4	c	-	-	-	-	-	-	-	-	-	-	-
Rhizelmis nigra	1	c	-	-	-	-	-	-	-	-	-	-	-
Zaitzevia sp.	4	c	-	-	-	-	-	-	-	-	1	-	-
Psephenidae													
Acneus quadrimaculatus	4	g	-	-	-	-	-	-	-	-	-	-	-
Eubrianax sp.	4	g	-	-	-	-	-	-	-	-	-	-	-
Psephenus sp.	4	g	-	-	-	-	-	-	-	-	-	-	-
Diptera													
Athericidae													
Atherix sp.	2	p	-	-	-	-	-	-	-	-	-	-	-
Blephariceridae													
Agathon sp.	0	g	-	-	-	-	-	-	-	-	-	-	-
Blepharicera sp.	0	g	-	-	-	-	1	-	-	-	-	-	-
Ceratopogonidae													
Bezzia sp./ Palpomyia sp.	6	p	1	-	-	-	-	-	-	-	-	-	-
Chironomidae													
Chironominae													
Chironomini	6	c	151	222	-	-	4	20	20	-	1	37	4
Tanytarsini	6	f	18	31	10	4	7	86	90	7	7	31	55
Diamesinae													
Borroheptagyia sp.		c	-	-	-	-	-	-	-	-	-	-	-
Orthocladiinae	5	c	3	8	17	39	31	29	8	51	34	53	54
Tanypodinae	6	p	-	-	-	-	-	-	1	-	-	-	-
Culicidae													
Anopheles sp.	8	c	-	1	-	-	-	-	-	-	-	-	-

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ABL Laboratory Number:			3550	3551	3552	3553	3554	3555	3556	3557	3558	3559	3560
Empididae													
Chelifera sp.	6	p	-	-	-	-	-	1	-	-	-	1	-
Clinocera sp.	6	p	-	-	-	-	-	-	-	-	-	-	-
Hemerodromia sp.	6	p	-	-	2	-	2	1	-	-	-	1	1
Oreogeton sp.	5	p	-	-	-	-	-	-	-	-	-	-	-
Wiedemannia sp.	6	p	-	-	-	-	-	-	-	-	-	-	-
Undetermined								5					
Psychodidae													
Maruina sp.	1	g	-	-	-	-	-	-	-	-	-	-	-
Simuliidae	6	f	-	-	1	-	-	7	8	3	-	1	1
Stratiomyidae													
Caloparyphus sp.	7	c	-	-	-	-	-	-	-	-	-	-	-
Tipulidae													
Antocha sp.	3	c	-	-	-	-	-	-	-	-	-	-	-
Dicranota sp.	3	p	-	-	-	-	-	-	-	-	-	-	-
Hexatoma sp.	2	p	-	-	-	-	-	-	-	-	-	-	-
Undetermined	3	s	-	-	-	-	-	-	-	-	-	-	-
Undetermined			-	-	-	-	-	-	-	-	-	-	-
<u>Megaloptera</u>													
Corydalidae													
Corydalus sp.	0	p	-	-	-	-	-	-	-	-	-	-	-
Orohermes sp.	0	p	-	-	-	-	-	-	-	-	-	-	-
Undetermined	0	p	-	-	-	-	-	-	-	-	-	-	-
<u>Odonata</u>													
Calopterygidae													
Hetaerina sp.	6	p	-	-	-	-	-	-	-	-	-	-	-
Coenagrionidae													
Argia sp.	7	p	-	-	-	-	-	-	-	-	-	-	-
Undetermined			-	-	-	-	-	-	-	-	-	-	-
Cordulegastridae													
Cordulegaster dorsalis	0	p	-	-	-	-	-	-	-	-	-	-	-
Corduliidae	9	p	-	-	-	-	-	-	-	-	-	-	-
Undetermined			-	-	-	-	-	-	-	-	-	-	-
Gomphidae													
Ophiogomphus sp.	1	p	-	-	-	-	-	-	-	-	-	-	-
Undetermined			-	-	-	-	-	-	-	-	-	-	-
<u>Lepidoptera</u>													
Pyralidae													
Petrophila sp.	5	g	-	-	4	-	-	-	-	-	-	1	1
<u>Ephemeroptera</u>													
Ameletidae													
Ameletus sp.	0	g	-	-	-	-	-	-	-	-	-	-	-
Baetidae													
Acentrella sp.	4	c	-	-	65	10	13	14	50	73	50	50	4
Baetis sp.	5	c	-	-	20	5	5	9	20	23	18	22	5
Diphetor sp.	5	c	-	-	-	-	-	-	-	-	-	-	-
Fallceon quilleri	4	c	-	-	-	-	-	-	-	1	-	-	-
Ephemerellidae													
Caudatella sp.	1	c	-	-	-	-	-	-	-	-	-	-	-
Drunella sp.	0	g	-	-	-	-	-	-	-	-	-	-	-
Serratella sp.	2	c	-	-	12	3	12	8	6	12	8	-	-
Undetermined	7	c	-	-	-	-	-	-	-	-	-	-	-

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Heptageniidae													
Cinygma sp.	4	g	-	-	-	-	-	-	-	-	-	-	-
Cinygmula sp.	4	g	-	-	-	-	-	-	-	-	-	-	-
Epeorus sp.	0	g	-	-	-	-	-	-	-	1	14	-	-
Heptagenia sp.	4	g	-	-	-	-	-	1	-	-	-	-	-
Ironodes sp.	4	g	-	-	-	-	-	-	-	-	-	-	-
Rhithrogena sp.	0	g	-	-	-	-	-	-	-	57	21	-	-
Leptohyphidae													
Tricorythodes sp.	5	c	-	-	1	10	18	7	4	-	-	-	-
Leptophlebidae													
Paraleptophlebia sp.	4	c	-	-	-	-	-	-	-	1	1	-	-
Plecoptera													
Capniidae													
Capnia sp.	1	s	-	-	-	-	-	-	-	-	-	-	-
Undetermined	1	s	-	-	-	-	-	-	-	-	-	-	-
Chloroperlidae													
Haploperla chilnualna	1	p	-	-	-	-	-	-	-	-	1	-	-
Suwallia sp.	1	p	-	-	-	-	-	-	-	-	-	-	-
Sweltsa sp.	1	p	-	-	-	-	-	-	-	-	-	-	-
Undetermined	1	p	-	-	-	-	-	-	-	-	-	-	-
Leuctridae													
Paraleuctra sp.	0	s	-	-	-	-	-	-	-	-	-	-	-
Nemouridae													
Zapada sp.	2	s	-	-	-	-	-	-	-	-	-	-	-
Undetermined	2	s	2	-	-	-	-	-	-	-	-	-	-
Peltoperlidae													
Sierraperla sp.	1	s	-	-	-	-	-	-	-	-	-	-	-
Yoraperla sp.	2	s	-	-	-	-	-	-	-	-	-	-	-
Perlidae													
Calineuria californica	1	p	-	-	-	-	-	-	-	-	1	-	-
Claassenia sp.	3	p	-	-	-	-	-	-	-	5	1	-	-
Doroneuria baumanni	1	p	-	-	-	-	-	-	-	-	-	-	-
Hesperoperla sp.	2	p	-	-	-	-	-	-	-	-	-	-	-
Undetermined	1	p	-	-	-	-	-	-	-	-	-	-	-
Perlodidae													
Frisonia picticeps	2	p	-	-	-	-	-	-	-	1	-	-	-
Isoperla sp.	2	p	-	-	-	-	-	-	-	-	1	-	-
Megarcys sp.	2	p	-	-	-	-	-	-	-	-	-	-	-
Oroperla barbara	2	p	-	-	-	-	-	-	-	-	-	-	-
Osobenus yakimae	2	p	-	-	-	-	-	-	-	-	-	-	-
Perlinodes aureus	2	p	-	-	-	-	-	-	-	-	-	-	-
Skwala sp.	2	p	-	-	-	-	-	-	-	-	3	-	-
Undetermined	2	p	-	-	-	-	-	-	-	-	-	-	-
Pteronarcyidae													
Pteronarcys sp.	0	s	-	-	-	-	-	-	-	-	-	-	-
Pteronarcella sp.	0	s	-	-	-	-	-	-	-	-	-	-	-
Taeniopterygidae													
Taenionema sp.	2	g	-	-	-	-	-	-	-	-	-	-	-
Trichoptera													
Brachycentridae													
Brachycentrus sp.	1	f	-	-	-	-	-	-	-	-	-	-	-
Micrasema sp.	1	g	-	-	-	-	-	-	-	-	-	-	-
Undetermined	1	c	-	-	-	-	-	-	-	-	-	-	-

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Glossosomatidae													
Anagapetus sp.	0	g	-	-	-	-	-	-	-	-	-	-	-
Culoptila sp.	0	g	-	-	-	1	-	-	-	-	-	-	-
Glossosoma sp.	0	g	-	-	-	-	1	-	-	2	-	-	-
Undetermined	0	g	-	-	-	-	-	-	-	-	1	-	-
Goeridae													
Goerita sp.	0	s	-	-	-	-	-	-	-	-	-	-	-
Helicopsychidae													
Helicopsyche sp.	3	g	-	-	-	-	-	-	-	-	-	-	-
Hydropsychidae													
Cheumatopsyche sp.	5	f	-	-	1	-	1	-	-	1	1	-	-
Hydropsyche sp.	4	f	-	-	100	3	35	74	70	34	100	76	19
Undetermined	4	f	-	-	-	-	-	-	-	-	-	15	-
Hydroptilidae													
Hydroptila sp.	6	g	-	-	12	8	14	2	-	-	-	-	-
Ithythrichia sp.	6	g	-	-	-	-	-	-	-	-	-	-	-
Leucotrichia sp.	6	g	-	-	-	-	-	-	-	-	-	-	-
Undetermined	4	g	-	-	1	-	-	4	-	-	-	-	-
Lepidostomatidae													
Lepidostoma sp.	1	s	-	-	-	-	-	-	-	-	-	-	-
Leptoceridae													
Mystacides sp.	4	c	-	-	-	-	-	-	-	-	-	-	-
Nectopsyche sp.	3	s	-	-	-	-	-	-	-	-	-	-	-
Oecetis sp.	8	p	-	-	-	-	-	-	-	-	-	-	-
Undetermined	4	c	-	-	-	-	-	-	-	-	-	-	-
Limnephillidae													
Ecclisomyia sp.	2	g	-	-	-	-	-	-	-	-	-	-	-
Philopotamidae													
Chimarra sp.	4	f	-	-	-	-	-	-	-	-	-	-	-
Dolophilodes sp.	1	f	-	-	-	-	-	-	-	-	-	-	-
Polycentropodidae													
Polycentropus sp.	6	p	-	-	-	-	-	-	-	-	-	-	-
Rhyacophilidae													
Rhyacophila sp.	0	p	-	-	-	-	-	-	-	-	-	-	-
Sericostomatidae													
Gumaga sp.	3	s	-	-	-	-	-	-	-	-	-	-	-
Uenoidae													
Neophylax sp.	3	g	-	-	-	-	-	-	-	-	-	-	-
Subphylum Chelicerata													
Class Arachnoidea													
<u>Acari</u>													
Hydryphantidae	5	p	-	-	-	-	-	-	-	-	-	-	-
Hygrobatidae	5	p	-	-	-	-	-	-	3	-	-	-	-
Lebertiidae	5	p	-	-	1	4	4	1	-	1	-	-	-
Sperchontidae	5	p	-	-	2	5	7	5	2	-	4	5	5
Torrenticolidae	5	p	-	-	-	-	2	-	-	-	-	-	-
Undetermined	5	p	-	-	-	-	3	1	-	-	-	-	-
Subphylum Crustacea													
Class Brachiopoda													
<u>Cladocera</u>													
Chydoridae	8	c	-	-	-	-	-	-	-	-	-	-	-
Daphniidae	8	c	7	1	-	-	-	-	-	-	-	-	-
Macrothricidae	8	c	1	-	-	-	-	-	-	-	-	-	-

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Class Copepoda													
Cyclopoida	8	c	15	17	-	-	-	-	-	-	-	-	-
Harpacticoida	8	c	7	1	-	-	-	-	-	-	-	-	-
Class Malacostraca													
Amphipoda													
Gammaridae													
Gammarus sp.	4	c	-	-	1	-	-	-	-	3	14	-	-
Class Ostracoda													
Ostracoda													
Cyprididae	8	c	-	2	-	-	-	-	-	-	-	-	-
PHYLUM MOLLUSCA													
Class Gastropoda													
Subclass Prosobranchia													
Hydrobiidae/Pleuroceridae		g	-	-	-	-	-	-	-	-	-	-	-
Subclass Pulmonata													
Ancylidae													
Ferrissia sp.	6	g	1	2	-	-	-	-	-	-	-	-	-
Lymnaeidae													
Fossaria sp.	6	g	-	-	-	-	-	-	-	-	-	-	-
Undetermined	6	g	-	-	-	-	1	-	-	-	-	-	-
Physidae													
Physa sp./Physella sp.	8	g	-	-	-	-	-	-	-	1	1	-	-
Planorbidae													
Helisoma sp.	7	g	1	-	-	-	-	-	-	-	-	-	-
Undetermined	7	g	1	-	-	-	1	-	-	-	-	-	-
Class Bivalvia													
Pelecypoda													
Corbiculidae													
Corbicula fluminea	10	f	-	-	1	1	4	1	-	-	1	-	-
PHYLUM NEMATODA	5	p	-	-	-	2	-	5	3	-	-	3	7
PHYLUM TARDIGRADA		c	6	-	-	5	9	-	-	-	-	-	-
PHYLUM PLATYHELMINTHES													
Class Turbellaria													
Tricladia													
Planariidae	4	p	2	-	12	-	-	-	-	1	9	-	-
PHYLUM ANNELIDA													
Class Oligochaeta	8	c	84	9	28	182	113	12	2	13	5	5	105
PHYLUM NEMERTEA													
Class Enopla													
Tertastemmatidae													
Prostoma sp.		c	-	-	3	-	-	3	-	-	3	-	-
Total Organisms*			300	295	294	282	288	297	287	291	305	301	261
Total Bugs Recovered			300	295	294	282	288	297	287	291	305	301	261
Total Extra Bugs			2	47	103	0	64	31	238	209	64	253	126
Bugs Picked (includes extra bugs)			302	347	403	300	364	331	538	509	364	553	426
Grids Processed			3	6	4	1	3	3	2	3	3	2	2
Total Grids Possible			40	8	16	24	24	24	8	16	16	8	40
Sorted			300	294	298	308	285	289	292	299	294	297	285
Discards			4	2	0	1	0	2	2	1	0	2	2
Abundance (#/ sample)			4027	455	1580	6768	2796	2622	2059	2633	1974	2219	7412