SRCSD

Wastewater Treatment

Technology in balance with nature

May 15, 2001

10545 Armstrong Avenue
Mather
California
95655
Tele: (916) 876-6000
Fax: (916) 876-6160
Website: www.srcsd.com

R42-A
copy

Mr. Joe Karkoski
303(d) List Update Coordinator
California Regional Water Quality Control Board
Central Valley Region
3443 Routier Road, Suite A
Sacramento, CA 95827-3003

Subject: **Submittal of Surface Water Quality Information for Consideration in 303(d) Listing Process**

Dear Mr. Karkoski:

In response to your letter dated February 21, 2001, the Sacramento Regional County Sanitation District (SRCSD) is submitting two recent reports which describe surface water quality conditions in the Sacramento River watershed, including tributaries such as the American River. These reports include summaries and presentations of available data, a description of quality assurance procedures used in developing the data, metadata describing the timing, location, sampling methods and analytical methods for the field data, and bibliographic references.

The reports submitted today are:

- Sacramento River Coordinated Monitoring Program, 1999-2000 Annual Report, November, 2000. Prepared for Sacramento Regional County Sanitation District, City of Sacramento and County of Sacramento by Larry Walker Associates.
- Sacramento River Watershed Program Annual Monitoring Report: 1999-2000, (Administrative Draft), January 7, 2001. Prepared for SRWP by Larry Walker Associates.

It should be noted that the second report is an administrative draft of a report which is currently being finalized by the Sacramento River Watershed Program. This report is being submitted with the qualification that it has not yet been approved as a final document by the SRWP and should only be used to extract the following basic information:

- Surface Water Quality Data
- Description of Quality Assurance Procedures
- Description of sampling sites, sampling methods, and analytical methods

The final report for 1999-2000 from the SRWP will be completed and released to the public in early July, 2001. We request that the Regional Board accept the administrative draft version of the report as a placeholder for the final draft and that the Regional Board replace the administrative draft with the final report as soon as it becomes available.

For the submittal today, we are providing one hard copy of each of the reports. We can provide an additional hard copy of each report upon request. We can also provide electronic versions of selected portions of the reports or data. We would be happy to work with you or your staff to respond to your specific data needs. The volume of information in these reports is sufficiently great to merit a discussion of your needs prior to packaging and submittal of the electronic versions.

The contact person at SRCSD regarding these submittals is Andrew Frankel (916) 876-6028. His mailing address is 10545 Armstrong Avenue, Suite 101, Mather, CA 95655 and his email is frankela@saccounty.net.

We appreciate the opportunity to provide this body of information to the Regional Board for use in the 303(d) listing process. As you know, the District has be an active proponent of surface water quality monitoring in the Sacramento River watershed for the past decade.

Sincerely,

Mary James

Mary James
SRCSD

Attachments (separate cover)

R42-c

Sacramento River Coordinated Monitoring Program

1999-2000 Annual Report

Prepared for

SRCSD

Sacramento Regional County Sanitation District

City of Sacramento

County of Sacramento

STORMWATER POLLUTION SOLUTIONS

SACRAMENTO STORMWATER MANAGEMENT PROGRAM

Prepared By

Larry Walker Associates

November 2000

Table of Contents

Table of Contents Cont'd

Table of Contents Cont'd

LIST OF TABLES

LIST OF APPENDICES

ES Executive Summary

GOALS AND OBJECTIVES

In May of 1991, the Sacramento Regional County Sanitation District (SRCSD), the County of Sacramento Water Resources Division (formerly the Sacramento County Water Agency), and the City of Sacramento (City) jointly established the Sacramento Coordinated Water Quality Monitoring Program (CMP) for ongoing and future Sacramento-area water quality monitoring programs on the Sacramento and American rivers. The fundamental purpose of the CMP is to develop high-quality data to aid in the development and implementation of water quality policy and regulations in the Sacramento area.

As defined by the CMP Steering Committee in the 1997 revision of the program Mission Statement, the specific goals and objectives of the CMP include the following:

- coordination and cooperation with other monitoring programs and agencies
- communication and public education
- water quality and beneficial use assessment
- operation of a cost-effective program
- evaluation of local impacts on water quality and effective control measures
- demonstration of effective control measures.

This report summarizes CMP activities and ambient data for the period December 1992 through June 2000. The report also presents an update of current regulatory activities which may influence the CMP monitoring effort. It is intended that this report be distributed to interested parties to document the current status and findings of the CMP program. The following is a brief summary of the contents of this report.

AMBIENT MONITORING METHODS

Water quality samples for the CMP's ambient water quality monitoring program in the Sacramento and American rivers (the Ambient Program) have been obtained from sampling sites within Sacramento County since December 1992. Three sites have been sampled on the Sacramento River (at the Interstate 5 Veterans Bridge near Alamar Marina, at Freeport Marina, and at River Mile 44) (see Figure ES-1). Three sites have been sampled on the American River (at Folsom, at Nimbus, and at Discovery Park). Sampling at the Folsom site was discontinued in October 1995.

Water quality parameters which have been measured include twelve trace elements (antimony, arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc), eight conventional parameters (hardness, pH, dissolved oxygen, temperature, conductivity, total organic carbon (TOC), and dissolved organic carbon (DOC), chloride, total dissolved solids, and total suspended solids (TSS)), organophosphate and carbamate pesticides, coliform and streptococcus bacteria, cyanide, and selected trace organic compounds.

From December 1992 to September 1995, the sampling frequency was twice per month at each station. Beginning in October 1995, the sampling frequency was changed to once per month. Monitoring of four trace elements (antimony, selenium, silver, and thallium) was discontinued in October 1995, reducing the number of trace elements monitored to eight. Trace organics were monitored for five events during the 1999-2000 monitoring period, and will continue to be monitored on a quarterly basis in 2000-2001.

The sampling methods, analytical methods, and quality assurance/quality control (QA/QC) procedures for the Ambient Program are summarized in Chapter 2 of this report.

ANNUAL DATA REVIEW

Data collected by the Ambient Program between December 1992 and June 2000 are presented and evaluated in Chapter 3 of this report. The Ambient Program completed 126 sampling events during this 7.5-year period. Summaries of these evaluations follow.

Characterization of Ambient Water Quality Characteristics

Water quality characteristics in the two rivers have been characterized over a range of river flow conditions during the 7.5 year monitoring period. These data have provided a baseline for analysis of seasonal and long term annual trends.

Comparisons with Basin Plan Objectives and CTR Criteria

Comparisons with existing water quality objectives and proposed water quality criteria for the protection of freshwater aquatic life and human health were performed for the current Ambient Program sampling sites. The comparisons were primarily based on existing Basin Plan objectives and the adopted California Toxics Rule (CTR) (Federal Register, May 2000), but also considered other relevant criteria. The majority of the constituents measured by the Ambient Program indicated compliance with existing water quality objectives. Mercury concentrations in the American River and the Sacramento River are expected to achieve the current CTR human health criterion (50 ng/L total mercury), but would frequently exceed other suggested criteria values (equal to or less than 12 ng/L, the U.S. EPA's National Criterion, and also the basis for SRCSD's NPDES permit limit). Average total organic carbon (TOC) concentrations in the Sacramento River generally exceed the Disinfectant/Disinfection By-Product treatment threshold applied at drinking water treatment facility intakes, but the regulatory implications of these exceedances are not clear, since there are several other factors that affect the need for enhanced treatment for TOC removals. The CMP is evaluating additional monitoring parameters related to the issue of TOC and drinking water concerns.

SPECIAL STUDIES

In January of 1999, the CMP Steering Committee approved a CMP Special Study to evaluate trends in selected water quality characteristics and sampling frequencies required to adequately monitor long-term trends, an assessment of the importance of mass loads passing by and originating from the Sacramento metropolitan area (including the SRWTP and urban runoff), and an evaluation of the potential impacts of precipitation and urban runoff on ambient water quality in the Sacramento River and the American River. The Special Study was initiated in February 1999, and a technical memorandum presenting the results was finalized in February 2000.

COORDINATION ACTIVITIES

One of the objectives of the CMP is to encourage coordination among the numerous water quality monitoring programs in the Sacramento Region and to perform outreach to convey information to the public and other agencies. Activities performed by the CMP between January 1999 and June 2000 are described in Chapter 5. These activities included continuing communication between the CMP and other monitoring program managers in the region, participation in "Creek Week" and other educational events, and the semi-annual publication of *The Monitor*.

REVIEW OF REGULATORY ISSUES AND IMPLICATIONS

Chapter 6 of this report includes a review and update of current federal, state and regional regulatory activities pertaining to surface water quality in Sacramento. The important federal regulatory activities include the 303(d) impaired waters listing and TMDL process, promulgation of the California Toxics Rule by EPA Region IX, development and implementation of important policies, EPA criteria development, Endangered Species Act requests, and implementation of the 1996 Safe Drinking Water Act amendments. Important State activities include development and implementation of the CALFED Bay-Delta Program, and the State Implementation Policy. At the regional level, important activities include impaired waters listings, watershed management activities, the BPTCP, and health advisories for fish consumption.

ADJUSTMENTS TO THE AMBIENT PROGRAM

The principal change to the Ambient Program implemented in 1999 was the initiation of trace organics monitoring. Additionally, a change in analytical methodology for organic carbon was implemented to provide lower detection limits.

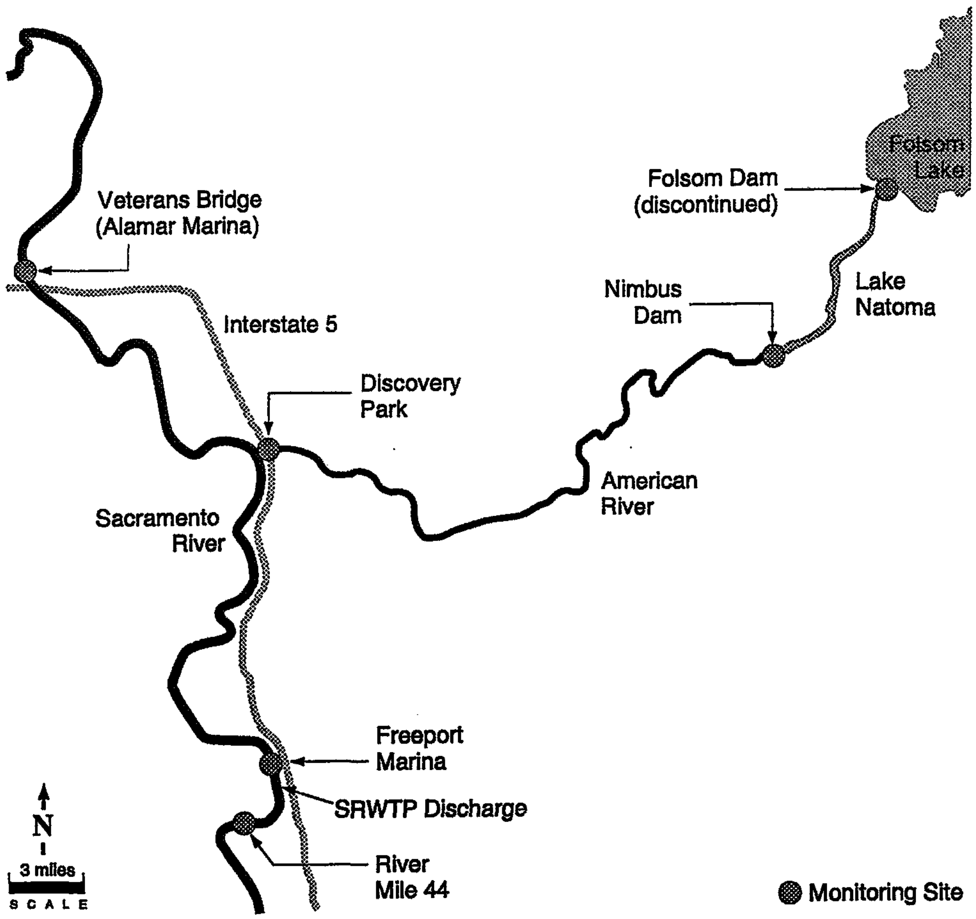


Figure ES-1.

Ambient Program Monitoring Locations

1 Introduction

GOALS AND OBJECTIVES

In May of 1991, the Sacramento Regional County Sanitation District (SRCSD), the County of Sacramento Water Resources Division (formerly the Sacramento County Water Agency), and the City of Sacramento (City) jointly established the Sacramento Coordinated Water Quality Monitoring Program (CMP) for ongoing and future Sacramento-area water quality monitoring programs on the Sacramento and American rivers. The fundamental purpose of the CMP is to develop high-quality data to aid in the development and implementation of water quality policy and regulations in the Sacramento area.

As defined by the CMP Steering Committee in the 1997 revision of the program Mission Statement, the specific goals and objectives of the CMP are as follows:

Coordination

- *Coordinate monitoring activities; schedules, long term needs and efforts among participating local agencies, and with other programs and agencies.*
- *Work cooperatively to understand and share concerns with others regarding the local surface waters in conjunction with the Sacramento River watershed.*
- *Make data easily accessible upon request.*

Communication

- *Inform and educate the public, agencies and decision makers to raise awareness, coordinate efforts and provide a basis for sharing information and resources regarding the protection of beneficial use of Sacramento Metropolitan Area watershed.*
- *Actively search for and pursue opportunities.*

Water Quality/Beneficial Use Assessment

- *Select appropriate measurements (chemical, toxicity, biological) to evaluate the Sacramento Metropolitan Area watershed.*
- *Develop and implement protocol to prioritize Sacramento's water bodies for the purpose of protection, enhancement and maximum benefits.*

- *Measure status of compliance with current regulatory standards.*
- *Investigate and develop local water quality standards.*
- *Maintain a proactive long-term ambient water quality monitoring program to collect reliable data for the purpose of identifying constituents of concern and development tools to enhance water quality.*
- *Research and implement new water quality monitoring efforts to address present and future data needs.*
- *Actively search for and pursue opportunities.*

Costs

- *Achieve the best benefit for the least cost.*
- *Quantify hard and soft costs and relative savings.*

Impacts Assessment

- *Examine the Sacramento Metropolitan Area's impact on the local surface watershed as a contributor of constituents of concern, including examining long-term affects, source loadings, and long-term trends.*
- *Prioritize constituents of concern and sources.*
- *Assist in evaluating water quality benefits of potential source control measures.*

Success Story

- *Find an opportunity to demonstrate the effectiveness of control measures.*

CONTENT OF REPORT

This annual report of the CMP presents the results of the Ambient Program sampling efforts for the period December 1992 through June 2000, a discussion of efforts to coordinate with other water quality monitoring programs, a summary of special study investigations, an update on water quality regulations, and a discussion of implemented and recommended changes to the Ambient Program for 1999, 2000, and 2001. This report consists of the following chapters:

Chapter 1. Introduction

The goals and objectives of the CMP and the contents of this annual report are described.

Chapter 2. Ambient Monitoring Program

Sampling methods and field and laboratory quality assurance/quality control (QA/QC) procedures for the CMP Ambient Program are briefly described. The goal of the Ambient Program is to collect contaminant-free, representative samples and to achieve high quality laboratory results at low analytical detection limits. The QA/QC procedures for the program are employed to verify and document the validity of the results of the Ambient Program.

Chapter 3. Annual Data Review

A QA/QC evaluation was conducted prior to evaluating the Ambient Program data to assess the accuracy and precision of the data collected. Further data analysis was only performed on data deemed acceptable under the QA/QC evaluation.

Data from the Ambient Program collected in the period from December 1992 through June 2000 are analyzed and evaluated. The primary purposes of the evaluation of the ambient data are to (1) characterize water quality conditions and identify important spatial and temporal patterns, and (2) determine compliance with projected water quality objectives.

Chapter 4. Special Studies

The CMP considers special studies in areas of potential relevance to the Ambient Program each year. A CMP Special Study was implemented in early 1999 to evaluate trends in water quality characteristics, sampling frequency requirements for monitoring long-term trends, the importance of mass loads of pollutants originating from the Sacramento metropolitan area (including the SRWTP and urban runoff), and the potential impacts of precipitation and urban runoff on ambient water quality in the Sacramento River and the American River.

Chapter 5. Coordination and Outreach Activities

Coordination efforts with other monitoring programs are described including, contacts with representatives of other monitoring programs, Creek Week activities, and the semi-annual publication of *The Monitor*, an informational newsletter.

Chapter 6. Regulatory Update and Implications

Important federal, State and regional regulatory activities are summarized, and potential impacts of these regulations on the CMP are discussed.

Chapter 7. Recommended Adjustments to the Ambient Program

Recommended adjustments to the Ambient Program for 2001 are described. Adjustments which were implemented during 1999 are also summarized.

ACKNOWLEDGMENTS

The CMP Steering Committee directs and supervises the performance of the CMP. The CMP Steering Committee is comprised of representatives from the sponsoring agencies, as follows:

Agency	Representative
Sacramento Regional County Sanitation District (SRCSD)	Robert Shanks Stan Dean Mary James Andrew Frankel Jerry Troyan Rick Johnson
County of Sacramento Water Resources Division	Terri Wegener
City of Sacramento	Larry Nash Elissa Callman Kathy Russick

The Program Manager for the CMP for 1999 and 2000 has been Andrew Frankel of the SRCSD. Mr. Frankel is responsible for management of the overall program and supervises the Ambient Program monitoring effort, including field sampling, laboratory analyses, and data management.

In addition to the agency staff, private consulting firms provide services to implement the CMP. Larry Walker Associates is the prime consultant and provides technical support in the areas of program management, data analysis, coordination activities and reporting. Harris and Company is a consultant providing technical and administrative support in the areas of outreach and project management. Several private laboratories provide analytical services for the Ambient Program.

A number of public agencies have served on the Technical Review Committee (TRC) for the CMP, providing input and guidance regarding the performance and direction of the program. The TRC member agencies have included the Central Valley Regional Water Quality Control Board, the San Francisco Bay Regional Water Quality Control Board, the U. S. Geological Survey, the San Francisco Estuary Institute, and the U. S. Fish and Wildlife Service. Because no substantial changes were considered to the CMP, the TRC was not convened during this reporting period.

2 Ambient Monitoring Methods

The field sampling methods, field quality control samples, and laboratory QA/QC procedures for the Ambient Program are summarized in this section for the period January 1999 through June 2000. Detailed Standard Operating Procedures (SOPs) for the current Ambient Program have been presented in previous Annual Reports (LWA 1996, LWA 1995).

SAMPLING METHODS

Sampling Locations

For the 1999-2000 monitoring effort, the Ambient Program collected water quality samples from three locations on the Sacramento River and two locations on the American River. Sacramento River sampling sites were located at Veterans Bridge upstream from the Sacramento urban area, near Freeport upstream from the Sacramento Regional Wastewater Treatment Plant (SRWTP), and at River Mile 44 downstream from the SRWTP. American River sampling sites were located below the Nimbus Dam discharge, and at Discovery Park near the confluence of the American River and the Sacramento River. Sampling locations are presented in Figure 2-1.

Sampling Schedule

Sampling for the Ambient Program is performed monthly. River sites were monitored for a total of eighteen sampling events for the 1999-2000 monitoring effort, including several "episodic" storm-associated events, which were coordinated with urban runoff monitoring performed by the Sacramento Stormwater Program. Dates for all sampling events from January 1999 through June 2000 (Sampling events number 109 through 126) are presented in Table 2-1.

Sample Collection

Cross-sectional composite samples were collected by boat at the Discovery Park site on the American River, and at the Veterans Bridge, Freeport, and River Mile 44 sites on the

Sacramento River. Composite samples for most analytes were collected using a peristaltic pump with acid-cleaned polyethylene tubing. Samples to be analyzed for trace organic compounds were collected using a stainless steel pump and tubing system designed by SRWTP staff. Samples collected at the Nimbus location were collected as grab samples from near the shore, either by pumping or by collecting the sample directly into a polyethylene carboy or appropriate sample containers. At all sites, samples analyzed for microbiological parameters, and for diazinon and chlorpyrifos (by ELISA), were collected as separate near-surface grabs by submerging the sample containers 6 to 12 inches below the water surface.

Samples were collected into acid-cleaned polyethylene carboys and aliquoted into glass, polyethylene, or Teflon™ sample containers appropriate for the analyses to be performed. Sample collection equipment and protocols were designed to minimize contamination, and generally conformed to EPA guidance (Method 1669; USEPA 1995) for "clean" sampling methodologies. Composite samples were comprised of sub-samples collected from three depths at each of three or five sampling points along a designated sampling transect. Details of cross-sectional composite sample collection procedures and sampling equipment for individual sites are documented in the Standard Operating Procedures for the Ambient Program, available from the Sacramento Regional County Sanitation District (SRCSD 1999).

QUALITY ASSURANCE AND QUALITY CONTROL (QA/QC)

Quality Assurance and Quality Control (QA/QC) analyses are summarized for the period January 1999 through June 2000 in Table 2-3. Details of the QA/QC procedures for the current Ambient Program have been presented previously in the 1995 Annual Report (LWA 1996) and are not repeated herein.

Field and External Laboratory Samples

Quality Control (QC) samples were prepared and submitted to the contract laboratory to characterize and evaluate potential impacts of sampling procedures and equipment on the precision and accuracy of the resulting data. QC samples submitted to the contract laboratory consisted of (1) field blanks, "Milli-Q" blanks (specially prepared blank water), and filter/bottle blanks to assess the potential for sample contamination, and (2) sample duplicates (splits of single grab or composite samples) to assess sampling and sample handling precision. Field QC samples were typically prepared and submitted at the rate of one sample of each type per sample event. External laboratory QC samples consisted of standard reference materials (SRM) and duplicate field samples submitted to the laboratory as blind samples to assess the accuracy and precision of laboratory analyses.

Internal Laboratory Quality Control Analyses

Internal laboratory QA/QC procedures were specified for the Ambient Program to ensure that high quality data were generated by the laboratory. Analysis of internal laboratory QC samples was conducted at a minimum rate of one in ten samples or at least one per analytical batch.

For most parameters, analytical accuracy was evaluated by each laboratory through analysis of (1) laboratory control samples and/or standard reference materials, and (2) matrix spikes, as appropriate for specific analyses. Analytical precision was evaluated by each laboratory through analysis of (1) duplicate samples split from a single sample in the laboratory, (2) laboratory control sample duplicates, and (3) matrix spike duplicate analyses. Potential contamination due to analytical reagents or laboratory sample processing was monitored by the laboratory through the analysis of method blanks and filter blanks.

QUALITY CONTROL DATA REVIEW PROCEDURES

A summary of the QC evaluations performed for the Ambient Program data validation is presented in Figure 2-2. The flow chart illustrates how the QC samples and the specific steps in the QC data review procedures are used to evaluate the quality of data produced by the Ambient Program. The results and discussion of the QC data review for Ambient

Program events 109–126 appear in Appendix A and are summarized in Chapter 3 (Data Review) of this report.

ANALYTICAL METHODS

Methods used to analyze Ambient Program water quality samples are presented in Table 2-3, along with program reporting limits (RLs). Reporting limits were determined based on detection limit studies conducted by the analyzing laboratories (Frontier Geosciences, City of Sacramento Water Quality Laboratory, Axys, APPL, and the SRWTP Control Laboratory).

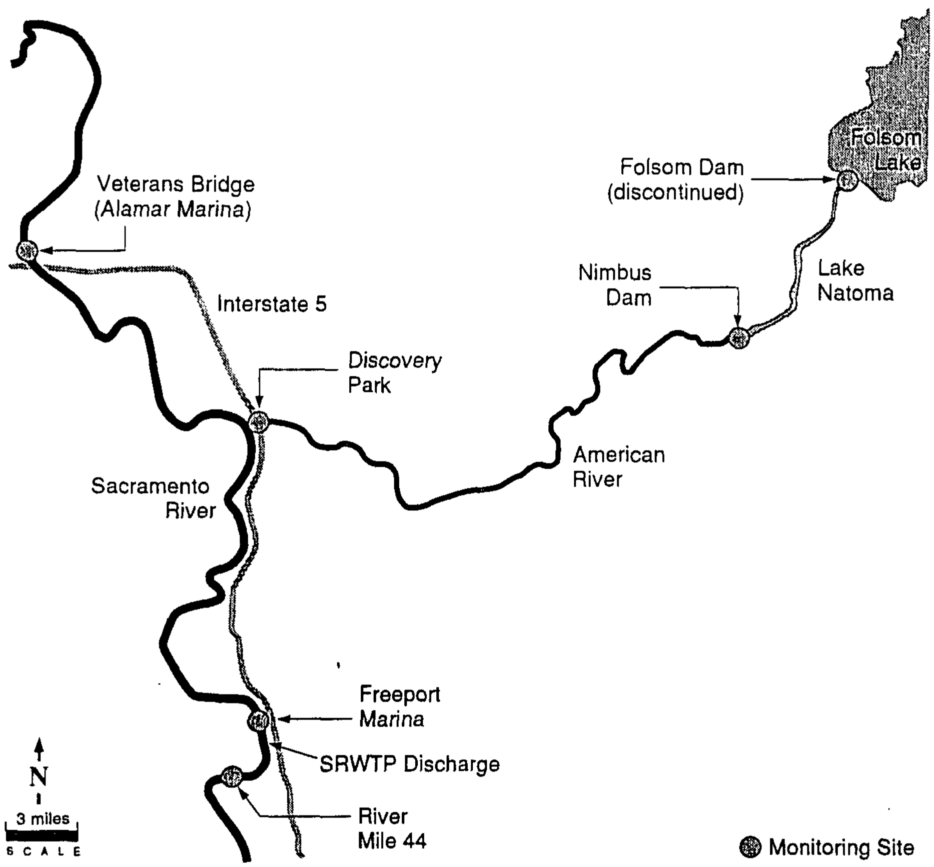


Figure 2-1

Ambient Program Monitoring Sites

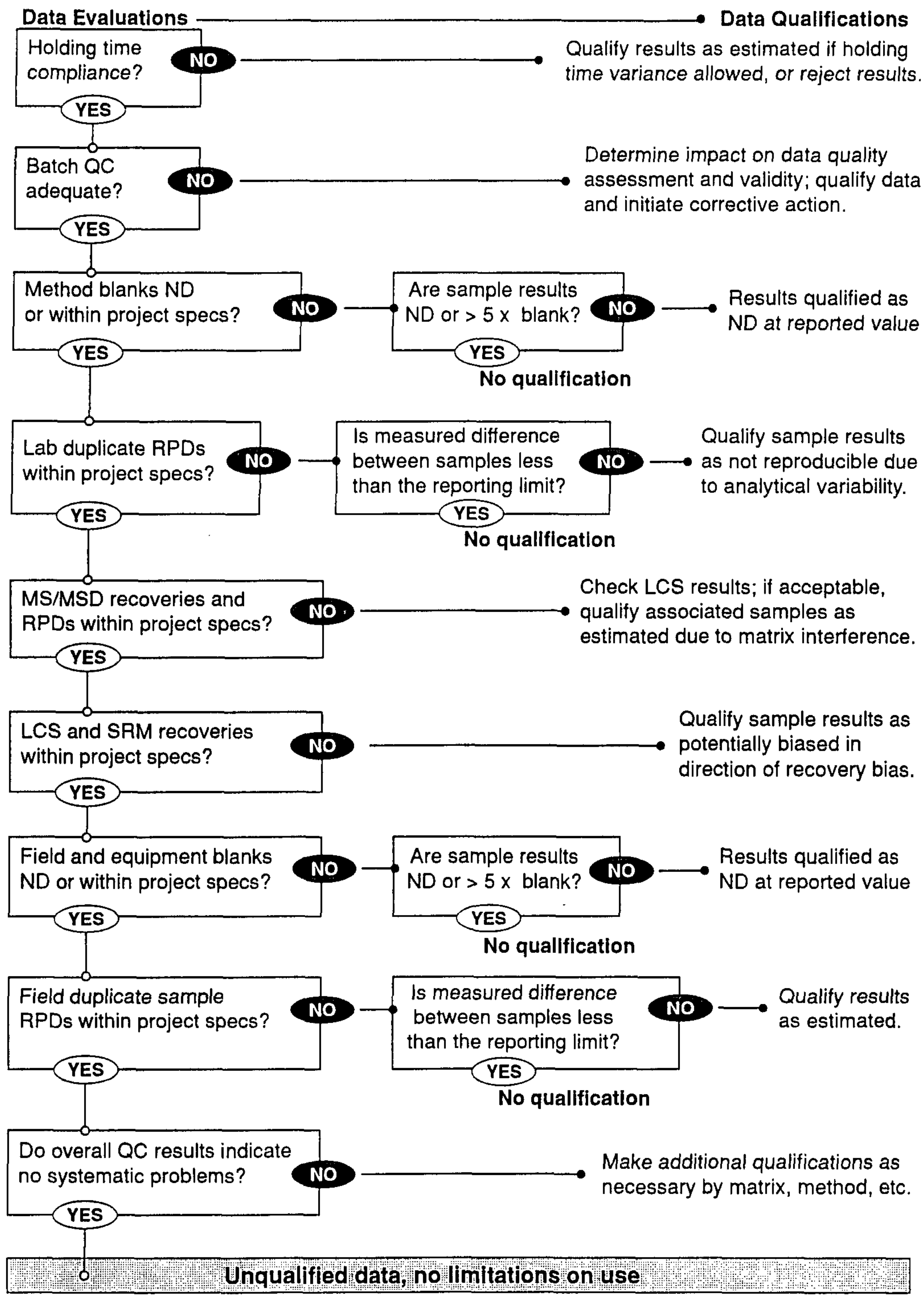


Figure 2-2

Ambient Program QA/QC Review Procedures

Table 2-1.

Ambient Program Sampling Schedule,

January 1999 through June 2000.

Ambient Program Events in 1999		Ambient Program Events in 2000	
109	January 20–22, 1999	121	January 16[a],19, 2000
110	February 17–19, 1999	122	February 15, 21[a], 2000
111	March 17–18, 1999	123	March 22–23, 2000
112	April 20–22, 1999	124	April 18–19, 2000
113	May 18–20, 1999	125	May 16–17, 2000
114	June 22–24, 1999	126	June 20–21, 2000
115	July 20–21, 1999		
116	August 18–19, 1999		
117	September 21–23, 1999		
118	October 19–20, 1999		
119	November 16–17, 1999		
120	December 13–14, 1999		

(a) Episodic event coordinated with stormwater monitoring.

Table 2-2

Summary of Quality Assurance Samples and Program Specifications Submitted for the 1999-2000 Ambient Program.

QA sample type	Parameter evaluated	Source of contamination or variation	Ambient Program QA specifications
field blanks	contamination	sampling and equipment	< reporting limit
"Milli-Q" blanks	contamination	blank water	< reporting limit
filter/bottle blanks	contamination	sample container	< reporting limit
duplicate samples (splits)	precision	sample handling	≤ 25% RPD
"blind" spikes (SRM)	accuracy	analytical	80 - 120% recovery
method blanks	contamination	analytical procedures	< reporting limit
filter blanks	contamination	analytical procedures	< reporting limit
lab control samples (LCS)	accuracy	analytical procedures	80 – 120% recovery(1)
duplicate sample and LCS analyses	precision	analytical procedures	≤ 25% RPD(1)
matrix spikes	accuracy	matrix effects	80 – 120% recovery(1)
matrix spike duplicates	precision	matrix effects	≤ 25% RPD(1)

(1) Data quality objectives for trace organic and pesticide analyses are specific to each analyte and are documented in data reports from each analyzing laboratory.

Table 2-3

Ambient Program Constituents, Analytical Methods, and Reporting Limits.

Analyte	Method	RL	Units
Arsenic	EPA 1638	0.05	µg/L
Cadmium	EPA 1638	0.01	µg/L
Chromium	EPA 1638	0.05	µg/L
Copper	EPA 1638	0.05	µg/L
Lead	EPA 1638	0.1	µg/L
Mercury	EPA 1631	0.5	ng/L
Nickel	EPA 1638	0.15	µg/L
Zinc	EPA 1638	0.1	µg/L
Dissolved Organic Carbon	EPA 415.1	1.5	mg/L
Total Organic Carbon	EPA 415.1	1.5	mg/L
Fecal coliform bacteria	SM 9221 E	2	MPN/100 mL
Total coliform bacteria	SM 9221 B	2	MPN/100 mL
Fecal streptococci	SM 9230 B	2	MPN/100 mL
Diazinon	ELISA	0.01	µg/L
Diazinon	EPA 8141	0.05-0.5	µg/L
Chlorpyrifos	ELISA	0.025	µg/L
Chlorpyrifos	EPA 8141	0.05-0.5	µg/L
Malathion	EPA 8141	0.1-0.5	µg/L
Methyl parathion	EPA 8141	0.1-0.5	µg/L
Carbofuran	EPA 8141	0.1-0.5	µg/L
PAHs	GC/MS mod 1653 (1)	Variable (1)	ng/L
Hexachlorobenzene	GC/MS mod 1653 (1)	Variable (1)	ng/L
Pentachlorophenol	GC/MS mod 1653 (1)	Variable (1)	ng/L
2,4,6-trichlorophenol	GC/MS mod 1653 (1)	Variable (1)	ng/L
Temperature	field measured	0.1	°C
Dissolved Oxygen	field measured	0.1	mg/L
pH	field measured	0.01	standard units
Conductivity	field measured	0.1	µmhos/cm @ 25°C
Hardness, as $CaCO_3$	EPA 130.2	2.0	mg/L
Total Suspended Solids	EPA 160.2	2.0–3.0	mg/L

1 Axys laboratory method. Reporting limits vary by analyte and analytical run, and are recovery-corrected.

3 Ambient Program Data Review

Water quality data collected between December 1992 and June 2000 by the Ambient Water Quality Monitoring Program (Ambient Program) are presented and evaluated in this data review. The Ambient Program has conducted a total of 126 sampling events since December 1992. Samples were collected from three sites on the American River (Folsom Dam discharge, Nimbus Dam discharge, and Discovery Park), and from three sites on the Sacramento River (Veterans Bridge, Freeport Marina, and River Mile 44; see Figure 3-1. Monitoring at the Folsom site was discontinued in October of 1995, and the results for this site are excluded from further analysis. For the 1999-2000 Ambient Program, water quality samples were analyzed for eight trace elements, hardness, total suspended solids, organic carbon, bacteria, diazinon, chlorpyrifos, and trace organics. Field measurements included temperature, dissolved oxygen, pH, and conductivity.

The scope of this data review comprises several related objectives:

- Review of quality assurance and quality control (QA/QC) data for Events 109–126;
- Characterization of ambient water quality conditions in the Sacramento and American Rivers;
- Estimation of the probability that ambient water quality will comply with applicable water quality criteria and objectives;

METHODS OF DATA ANALYSIS

Methods used to analyze data from the Ambient Program have been described in previous Annual Reports for 1993, 1994, and 1995 ("Sacramento Coordinated Water Quality Monitoring Program 1993/1994/1995 Annual Reports", prepared by Larry Walker Associates for the Sacramento Regional County Sanitation District, Sacramento County Water Agency, and City of Sacramento). Analytical methods are summarized herein and described in greater detail in the Appendices to this report.

RESULTS AND DISCUSSION OF DATA

The results and analysis of Ambient Program data are discussed in the following sections.

Quality Control Data Evaluation

Ambient Program data were evaluated to determine the ability of the program's sampling and analytical methods to produce representative and reliable water quality data for the American and Sacramento rivers. Sample results were reviewed for completeness, conformance with recommended allowable holding times for specific analyses, and for compliance with Ambient Program data quality objectives for laboratory and field quality control (QC) results. These evaluations and results are presented in detail in Appendix A. Table 3-1 summarizes the results contained in Appendix A and provides an overall assessment of the quality of data produced by the Ambient Program from January 1999 through June 2000. A brief summary of the data quality evaluations for Ambient Program Events 109 through 126 follows.

From January 1999 through June 2000, the Ambient Program successfully collected and analyzed 2041 of 2269 planned analyses for a completion rate of 90%. Of the 2041 completed analyses, data qualifications were required for 43 analytical results, leaving 1996 unqualified results for an overall analytical success rate of 97.9% for Events 109 through 126. The quality control results for Events 109 through 126 indicate that sampling and analytical methods were generally adequate to produce reliable data for the Ambient Program, with the possible exceptions of PAH and dissolved organic carbon analyses. Concerns related to filtration of dissolved organic carbon have already been addressed by the Ambient Program, and concerns related to contamination and PAH analyses are currently being investigated. Accuracy and precision generally achieved Ambient Program data quality objectives and no other systematic problems with sampling or analytical procedures were indicated. Sample results that were qualified on the basis of the quality control data are listed in Appendix A (Table A-16).

Ambient Water Quality Conditions

A primary goal of the Ambient Program is to characterize ambient water quality conditions in the CMP study area. For the purpose of this report, ambient conditions are characterized by central statistical values of the measured chemical and physical parameters, temporal variations in these parameters, and conditions associated with extreme values.

Summary Statistics Calculated

For each water quality parameter monitored by the Ambient Monitoring Program, the following statistics were calculated:

- the total number of environmental samples analyzed,
- the number of samples in which a detectable quantity was measured,
- the percent of samples in which a detectable quantity was measured,
- the minimum detected value, or the minimum detection limit if all data were below detection, and
- the maximum detected value, or "ND" if all data were below detection.

If less than 35% of the data were detected values, it was considered that insufficient data were available to reliably estimate the mean and standard deviation, and no additional statistics were calculated. If 35% or more of the data were detected values, the following additional statistics were calculated:

- geometric mean—If the data best fit a log-normal distribution, the geometric mean of all measurements is calculated using all detected data. If the distribution includes data below Ambient Program reporting limits, distribution parameters are estimated using the Robust Lognormal Regression method (see below for a discussion of Treatment of Values Below Reporting Limits). In cases where the values best fit a normal distribution (e.g., measurements for hardness, temperature, dissolved oxygen, conductivity, and pH), the arithmetic mean of all measurements is calculated.

- 95% confidence limits—The 95% confidence interval for the geometric (or arithmetic) mean is calculated using the Student's t-statistic. Lower and upper limits of the confidence interval are presented.

Treatment Of Values Below Reporting Limits

Summary statistics are computed using the Robust Lognormal Regression method (Helsel and Cohn 1988; Helsel 1990) when censored data were reported (i.e. data below program reporting limits). This method fits the detected values to a lognormal or normal distribution, using the censored data to calculate cumulative distribution values for the detected data. Distributional parameters (means and standard deviations) are calculated from the lognormal or normal distribution regression statistics. In cases where less than 35% of the values were uncensored, distributional parameters are not calculated because data are considered insufficient to accurately estimate these statistics.

Tables 3-2 through 3-6 summarize ambient conditions for the parameters monitored through the Ambient Program. Time series plots (presented in Appendix B) and frequency distribution plots (Appendix C) provide more detailed views of water quality data and variations in water quality characteristics over the period monitored by the Ambient Program.

Comparisons with Water Quality Criteria

Comparisons of ambient water chemistry with California Toxics Rule (CTR) and Central Valley Region Basin Plan (Basin Plan) water quality criteria for the protection of freshwater aquatic life and human health were performed for two American River sites and three Sacramento River sites. In addition, selected water quality characteristics are also compared to other relevant water quality limits and regulations, including Safe Drinking Water Act MCLs, California Department of Health Services Guidelines, Department of Fish and Game recommended criteria, and Stage 1 Disinfectant/Disinfection By-Products Rule treatment threshold levels. For hardness-adjusted metals criteria (cadmium, chromium, copper, lead, nickel, and zinc), the criterion used for comparison is based on the mean hardness value for each monitoring location. Mean hardness values are presented in summary statistics, Tables 3-2 through 3-6.

Statistically-based comparisons to water quality limits are performed for parameters with at least 10 detected data. The percent of time that ambient conditions are better than applicable water quality limits is estimated as the cumulative probability that the ambient concentration of a pollutant is less than the minimum applicable water quality limit. The parameters of a regression fit of the cumulative frequency distribution are used to calculate the cumulative probability that ambient concentrations are less than the criterion of interest. As a point of reference, the cumulative probability of 99.91% corresponds to EPA's allowable excursion frequency of once in three years. For the purpose of this analysis, in cases where less than 10 of the data were detected, concentrations were considered not to exceed chemical water quality objectives if (a) the detection limit was less than or equal to 0.2 times the objective, *and* (b) the maximum detected value was less than 0.2 times the objective[1]. If fewer than 10 values were detected, and the maximum detected value was greater than 0.2 times the objective but did not exceed the objective, the data were considered insufficient to evaluate the probability of exceedance. If fewer than 10 values were detected and the maximum detected value was greater than the objective, it is simply noted that the maximum value exceeds the objective (indicated as ">WQC" in Tables 3-7 through 3-11).

For the Sacramento River and American River sites currently monitored by the Ambient Program, comparisons with applicable water quality criteria and objectives are summarized in Tables 3-7 through 3-11 and are discussed briefly below. Comparisons with water quality criteria are based on data collected during a 7.5-year monitoring period representing a wide range of seasonal and annual variation in water quality and flow data. All data (including data below detection) are used in these assessments.

[1] For these comparisons with water quality limits, the level of 0.2 times the objective is used here as a conservative threshold for adequate detection limits for comparisons, and assumes that concentrations not observed to exceed this threshold are unlikely to exceed water quality limits more than once in three years. This threshold is specific to these evaluations and is not tied to any specific water quality regulation.

Comparisons with applicable regulatory limits indicate that most ambient water quality characteristics monitored by the Ambient Program consistently meet these limits at all CMP monitoring locations. In comparisons with the recently adopted CTR water quality criteria and existing Central Valley Basin Plan water quality objectives, concentrations of nearly all trace metals are estimated to be below these regulatory limits more than 99.91% of the time (i.e. they are not expected to exceed criteria more frequently than once in three years), with the exception of mercury in the Sacramento River. Concentrations of mercury are estimated to meet the current CTR criterion for mercury (50 ng/L) greater than 99.6% of the time at all three Sacramento River sites. Ambient water quality characteristics are estimated to meet Basin Plan objectives for conventional water quality parameters more than 95% of the time for most parameters. Additional discussion of these results and comparisons with other relevant water quality regulations follow.

Comparisons with Metals Criteria and Objectives

Probabilities of meeting Basin Plan and CTR water quality criteria for the protection of freshwater aquatic life and human health are consistently high for all metals monitored at the CMP monitoring locations. Ambient water quality is estimated to meet these regulatory limits more than 99.91% of the time for all dissolved metals concentrations, with the exception of lead in the American River. At both Nimbus and Discovery Park, the frequency of meeting the CTR criterion for dissolved lead (0.56 and 0.55 μg/L, respectively, based on mean hardness for each site) is estimated at 99.8%. Applicable total (or total recoverable) metals concentrations are estimated to meet regulatory limits more than 99.91% of the time at all CMP locations, with the exception of mercury in the Sacramento River at Freeport (99.8%) and River Mile 44 (99.7%).

Although the estimated frequency of meeting the adopted CTR mercury criterion (50 ng/L) was high for all CMP monitoring sites, it should be noted that this criterion is much less stringent than a number of proposed and previous criteria for mercury. USEPA national water quality criteria for total mercury for protection of human health have ranged from the current USEPA criteria value of 50 ng/l (April, 1999) (which coincides with the current CTR standard for total mercury), to the 1985 USEPA national criterion value of 12 ng/l (on which the current SRCSD NPDES permit limit is based), to the adopted Great Lakes Initiative objective of 3.1 ng/l. These criteria are aimed at the protection of sensitive individuals (pregnant women, unborn children, infants) and are based on different assumptions regarding fish consumption rates and levels in fish. It should also be noted that USEPA intends to re-evaluate and revise its Clean Water Act (CWA) 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 CWA 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, may range from 2 ng/L to 5 ng/L (Phil Woods personal communication, 1999). Total mercury concentrations have been observed to frequently exceed these levels at all CMP monitoring locations. Mercury concentrations are also of regulatory significance because mercury is cited as a cause for listing Delta waterways on the Central Valley Regional Water Quality Control Board's 1998 303(d) list of impaired California Waterbodies. Mercury is also a "constituent of concern" or target pollutant for the Sacramento Comprehensive Stormwater Management Program.

In comparisons with other relevant water quality regulatory limits, all dissolved and total metals concentrations are estimated to be below these limits more than 99.91% of the time.

Comparisons with OP and Carbamate Pesticide Regulatory Limits

Diazinon and chlorpyrifos are the only pesticides that have been detected to date by Ambient Program monitoring. Concentrations of chlorpyrifos and diazinon were compared to California Department of Fish and Game (DFG) recommended criteria for these organophosphate pesticides (Siepmann and Finlayson 2000). There are no Basin

Plan or CTR limits for these pollutants. There were insufficient detected data at all locations to rigorously compare concentrations of chlorpyrifos with the DFG Guidance level (0.014 µg/L). Although chlorpyrifos was not detected at either American River site, and was detected in only 1 of 76 Sacramento River samples, the detection limit for the majority of analyses (0.025 µg/L) was greater than the DFG recommended criterion (0.014 µg/L). Diazinon was detected in only one sample from Nimbus, and in 10 of 38 samples collected from Discovery Park. Diazinon concentrations were observed to exceed the DFG recommended criterion (0.05 µg/L) in only one Discovery Park sample, and was estimated to meet this limit greater than 95% of the time. In the Sacramento River, diazinon was detected in 7 of the 39 samples collected at Veterans Bridge, 7 of the 37 samples collected at Freeport, and 4 of 33 samples collected at River Mile 44. Diazinon concentrations exceeded the DFG recommended criterion (0.05 µg/L) in only two samples—the maximum concentrations detected at Veterans Bridge (0.16 µg/L) and Freeport (0.14 µg/L). The maximum concentrations detected at River Mile 44 did not exceed the DFG recommended criterion. These maximum concentrations were observed during storm-impacted conditions that coincided with the period when diazinon is applied as a dormant spray to orchards in the Sacramento region (and upstream). There are currently no Basin Plan or CTR limits for these pollutants. Malathion, methyl parathion, and carbofuran have not been detected in monitoring conducted by the Ambient Program.

Comparisons with Microbiological Limits

The probability of meeting the Basin Plan objective for numbers of fecal coliform bacteria (400 MPN/100mL, as a single sample maximum) is estimated to be 97% and 95% in the American River at Nimbus and Discovery Park, and about 97% and 92% in the Sacramento River at Veterans Bridge and Freeport, respectively. Numbers of bacteria were also compared to California Department of Health Services (DHS) Guidance levels (Draft, February 11, 2000) for total coliform bacteria (10,000 MPN/100 mL, single sample maximum[2]). Total coliform numbers were projected to be lower than the non-regulatory DHS Guidance level greater than 99% of the time at all of these CMP monitoring locations. Monitoring at River Mile 44 for coliform bacteria was initiated by the Ambient Program in 1999, and none of the six samples evaluated exceeded the Basin Plan objective or recommended DHS limits. While urban runoff is a potentially significant source of coliform bacteria to the American River, the slightly higher median numbers of total coliform bacteria observed at Discovery Park (314 MPN/100mL vs 101MPN/100mL at Nimbus) are also consistent with the high level of recreational use of the American River in the Sacramento metropolitan area, and with a variety of non-human sources (e.g. wildlife and pets) of coliform bacteria in the riparian zone.

Comparisons with Conventional Pollutant Regulatory Limits

In general, the probabilities of meeting applicable Basin Plan objectives for conventional parameters monitored by the Ambient Program (pH, dissolved oxygen, and conductivity) are estimated to be greater than 95%. Exceptions are discussed below.

Comparisons with Basin Plan pH Limits

In the American River at Nimbus, the probability of meeting the Basin Plan objective for pH (a range of 6.5 to 8.5 standard pH units) is estimated to be only 87%. On further inspection of the time series plots for pH at all sites, it was apparent that a number of extreme values in measured pH all occurred prior to July 1994, and that variability in measured pH decreased substantially at all monitored sites after July 1994. This pattern suggests that the extreme pH values observed at Nimbus and other sites between December 1992 and July 1994 may be artifacts of the meter used to measure pH during this period. The decrease in variability since July 1994 is most likely the result of improved equipment or

[2] The Basin Plan and DHS guidance also include lower limits expressed as geometric means for multiple samples collected over a 30 day period. Because Ambient Program coliform data consist of a single monthly samples at each location, compliance with 30-day geometric means could not be evaluated, and these data were compared only to the appropriate single sample limits.

improved equipment maintenance, rather than a real change in water quality. However, evaluation of the probabilities of compliance using only data collected since July 1994 indicate that compliance with Basin Plan pH limits at Nimbus were still about 85.5%. Most of the exceedances observed at Nimbus since July 1994 occurred between October 1995 and December 1996. The observed exceedances were all less than the 6.5 standard unit lower limit and were consistent with relatively low pH values at Discovery Park. These results suggest that exceedance of the Basin Plan pH limits in the discharge from Nimbus Dam may be a potential problem in the American River that may warrant further investigation. No similar pattern of low pH values was observed in the Sacramento River.

Comparisons with Basin Plan Temperature Limits

The probability of meeting the Basin Plan objective for temperature (a seasonal maximum of 20°C) is estimated to be 86% at Veterans Bridge. The Basin Plan temperature objective does not specifically apply to the Sacramento River at Freeport and River Mile 44, or in the American River. The Basin Plan temperature limitation is based on protection of seasonally migrating fish, and states that:

> *"The temperature shall not be elevated...above 68 °F (20 °C) in the reach from Hamilton City to the I Street Bridge during periods when temperature increases will be detrimental to the fishery."*

The Basin Plan further specifies that temperatures exceeding 20°C are not allowed April through June and September through November, and that temperatures must be below 18.9°C from January through March in this reach (which includes the Ambient Program Veterans Bridge site). Although temperatures in the Sacramento River below Lake Shasta are manipulated by cold water releases from that reservoir during periods when the fishery is most sensitive to temperature, temperatures exceeding 20°C were consistently observed in the Sacramento River during the low flows typical for June, July, and August. It should be noted that many of the observed exceedances of the 20°C maximum were observed during a period when the limit is not in effect. Temperatures did not exceed the 18.9°C limit during the periods that limit is in effect.

Comparisons with Basin Plan Dissolved Oxygen Limits

Dissolved oxygen (DO) concentrations in the American River were estimated to meet the Basin Plan minimum criterion (7.0 mg/L) approximately 94% of the time at Nimbus and 98% of the time at Discovery Park. DO concentrations in the American River were observed to drop below this limit twice between January 1999 and June 2000. The first of these was at Nimbus in September 1999 when water temperatures are high and DO is typically at a seasonal low. The second low-DO event was recorded at Discovery Park in March 2000, when DO concentrations are usually high. DO concentrations were also low at the Nimbus location during this event, but were just slightly above 7.0 mg/L, indicating that the cause of the low DO concentrations was probably due to conditions in the Nimbus Dam outflow. DO concentrations in the Sacramento River were estimated to meet the Basin Plan minimum criterion at least 95% of the time. DO concentrations were observed to drop slightly below the 7.0 mg/L limit on only one occasion—in April 2000— at all three Sacramento River locations.

Comparisons with D/DBP Rule TOC Treatment Threshold

Total organic carbon (TOC) concentrations were compared to the Disinfectants/Disinfection By-Products (D/DBP) Rule treatment threshold (2 mg/L) for TOC. The 2.0 mg/L threshold is significant because exceedance of this threshold (as a running annual average) in treatment plant water intakes may require water agencies to remove up to 35% of the TOC in the water, depending upon source water alkalinity. However, it is not clear that exceedance of this threshold will result in a requirement for additional treatment for municipal drinking water supplies or limit the drinking water supply designated use. The regulations from which the 2.0 mg/l goal was derived may not mandate such treatment if specific treatment technology requirements are met: if ozonation is utilized for disinfection, additional treatment of source water would not be required. Even if mandated, the requirement of additional treatment may not necessarily limit the water supply use. In either event, safeguards will be implemented to protect the health of end users. There are no Basin Plan or CTR limits for TOC.

Concentrations of TOC were observed to exceed the 2 mg/L D/DBP Rule threshold in only 2 of 47 samples from Nimbus, and in only 2 of 49 samples from Discovery Park. Although there were insufficient numbers of detected TOC concentrations at the American River locations to rigorously estimate the probability of exceedance of the D/DBP Rule threshold, it is apparent that the frequency of exceedance is quite low and that the average TOC concentration is lower than the 2 mg/L threshold. Data from City of Sacramento's Water Supply Lab and from the USGS NAWQA data base corroborate this conclusion (both of these programs utilize analytical methods with lower detection limits than historical CMP data[3]).

Concentrations of TOC were estimated to exceed the 2 mg/L D/DBP Rule threshold more than 50% of the time at all three Sacramento River monitoring locations. Although reliable running annual averages can not be calculated due to limitations of the current CMP TOC data, the running annual average for the Sacramento River is also expected to exceed this value. This conclusion is supported by USGS NAWQA data (collected from 1996-1998) which indicate that median and long-term average organic carbon concentrations in the Sacramento River are greater than 2 mg/L (USGS 2000).

Trace Organics Monitoring Results

The results of Ambient Program trace organic monitoring are summarized in Table 3-12. Trace organic compounds were not frequently detected and in only one case (hexachlorobenzene) exceeded relevant water quality criteria. Although there are insufficient data to accurately estimate long-term average concentrations appropriate for comparison to human health-based criteria, it appears that these average values are likely to be well below applicable criteria. Polycyclic aromatic hydrocarbons (PAHs) were detected in at least one sample at all CMP monitoring locations, but were not observed to exceed CTR human health-based criteria. Hexachlorobenzene was detected at greater

[3] CMP detection limits for TOC and DOC ranged from 1.5 mg/L to 3.0 mg/L for the monitoring period (1992-2000). Monthly monitoring for TOC and DOC with improved detection limits (~0.2 mg/L) was implemented beginning in July 2000, but TOC and DOC were not monitored in the American River for the period of 1996 through June 2000.

than the CTR human health criterion (0.75 ng/L) in one sample collected from the American River at Discovery Park, and in one sample collected from the Sacramento River at Freeport. Pentachlorophenol was not detected in any samples, and 2,4,6-trichlorophenol was detected in only one sample collected from the Sacramento River at River Mile 44.

Based on the limited number of samples collected to date, concentrations of the trace organic compounds monitored by the Ambient Program do not appear to pose a significant human health risk or compliance problem in the American River or Sacramento River. However, these are very preliminary conclusions based on limited sampling, and the CMP is continuing to monitor these constituents on a quarterly basis.

SUMMARY

Based on Ambient Program monitoring results for the period of December 1992 through June 2000, ambient water quality characteristics of the American and Sacramento rivers may be summarized by the following:

- With few exceptions, ambient water quality characteristics monitored by the Ambient Program consistently meet applicable regulatory limits in the American River and Sacramento River.
- Concentrations of trace metals in the American River and Sacramento River were estimated to meet current applicable criteria 99.8% to greater than 99.99% of the time.
- Although mercury concentrations appear to meet current regulatory limits, mercury has been identified as a potential regulatory problem in both the Sacramento River and the American River. Mercury concentrations are of regulatory significance because mercury is cited as a cause for listing Delta waterways on the Central Valley Regional Water Quality Control Board's 1998 303(d) list of impaired California Waterbodies. It is also "constituent of concern" or target pollutant for the Sacramento Comprehensive Stormwater Management Program.
- Chlorpyrifos was not detected in any samples from the American Rivers, and in only one Sacramento River sample. In the American River, diazinon exceeded the DFG recommended criterion (0.05 μg/L) in only one sample (at Discovery Park) and was detected in only one sample at Nimbus. The highest concentrations observed in the Sacramento River were collected during the orchard dormant spray season and exceeded the DFG recommended criterion (0.05 μg/L) at both Veterans Bridge and Freeport. Diazinon concentrations are of regulatory significance because diazinon is cited as a cause for listing Delta waterways and several urban runoff-affected waterbodies in the Sacramento area on the Central Valley Regional Water Quality Control

Board's 1998 303(d) list of impaired California Waterbodies. Diazinon is also is a "constituent of concern" or target pollutant for the Sacramento Comprehensive Management Program for this reason.

- Fecal coliform bacteria numbers met the Basin Plan objective (400 MPN/100 mL, as a single sample maximum) 95 – 97% of the time in the American River and 92 – 97% of the time in the Sacramento River. Total coliform bacteria numbers were below the DHS Guidance Level (10,000 MPN/100 mL, as a single sample maximum) greater than 99% of the time in the American River and the Sacramento River.
- Concentrations of total organic carbon exceeded the Disinfectant/Disinfection By-Product Rule treatment threshold value of 2.0 mg/L in more than 50% of samples from the Sacramento River. The 2.0 mg/L threshold is significant because exceedance of this threshold (as a running annual average) in treatment plant water intakes may require water agencies to remove up to 35% of the TOC in the water, depending upon source water alkalinity. However, it is not clear that exceedance of this threshold will result in a requirement for additional treatment for municipal drinking water supplies or limit the drinking water supply designated use.
- Other conventional pollutants generally met applicable water quality limits more than 95% of the time in the American and Sacramento rivers..
- Based on the limited number of samples collected to date, concentrations of the trace organic compounds monitored by the Ambient Program do not appear to pose a significant human health risk or compliance problem in the American River or Sacramento River. However, these are very preliminary conclusions based on limited sampling, and the CMP is continuing to monitor these constituents on a quarterly basis.

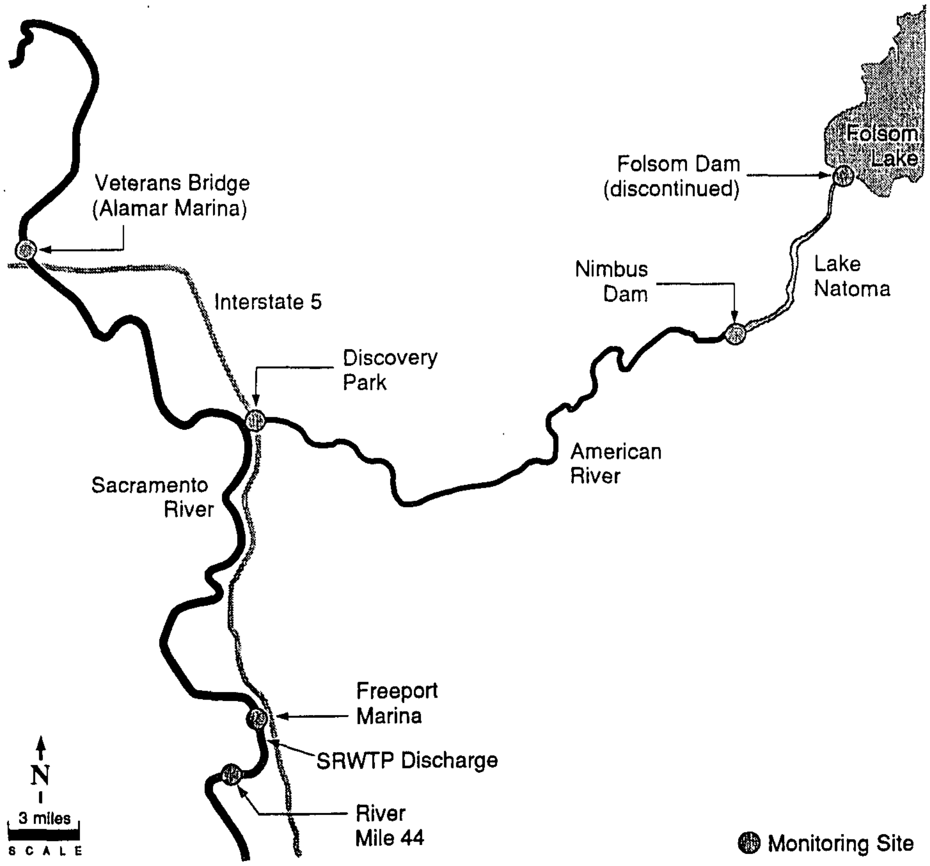


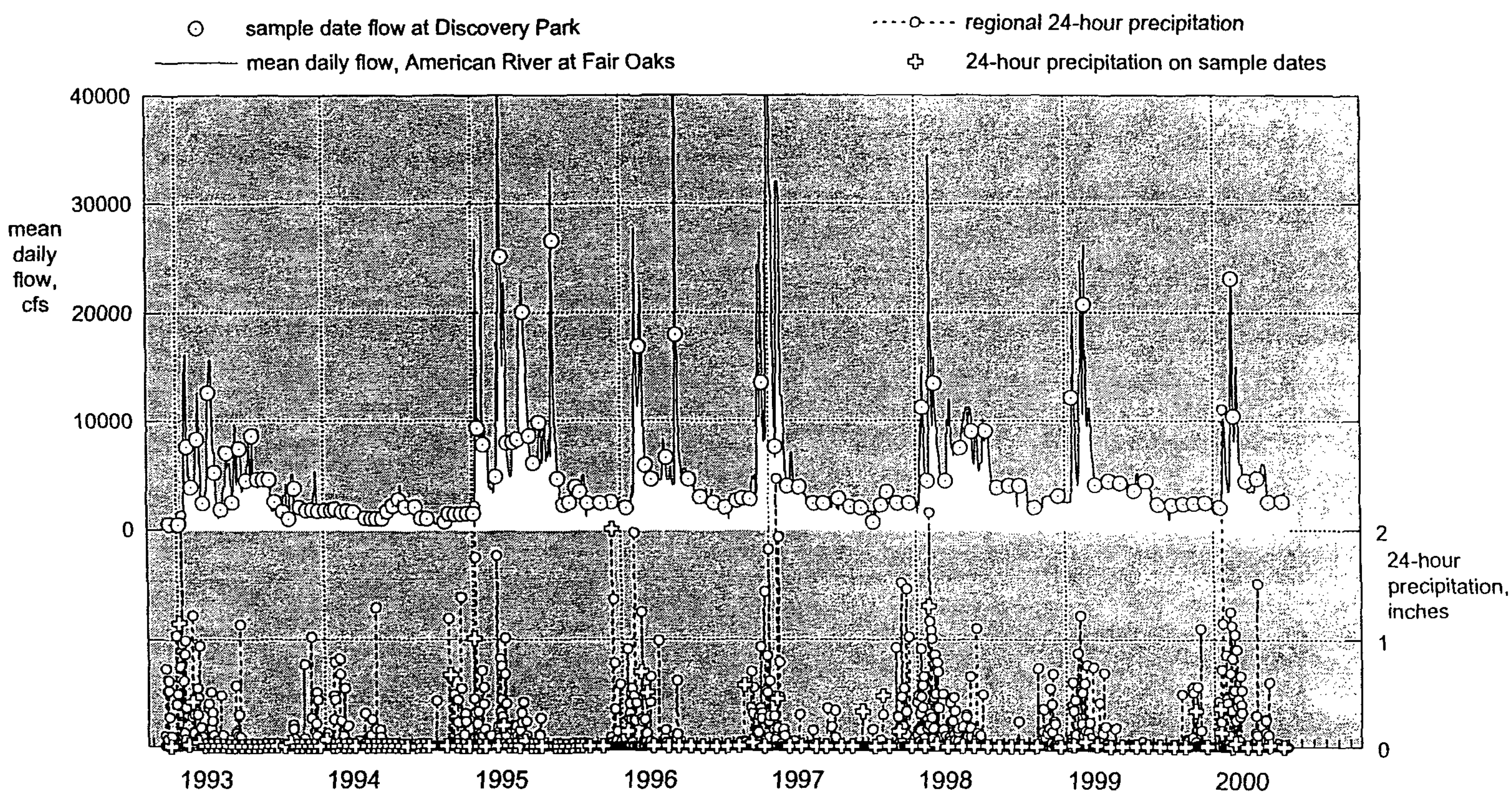
Figure 3-1

Ambient Program Monitoring Sites

Figure 3-2

Sample Events, Mean Daily River Flows, and Regional Precipitation

American River at Discovery Park



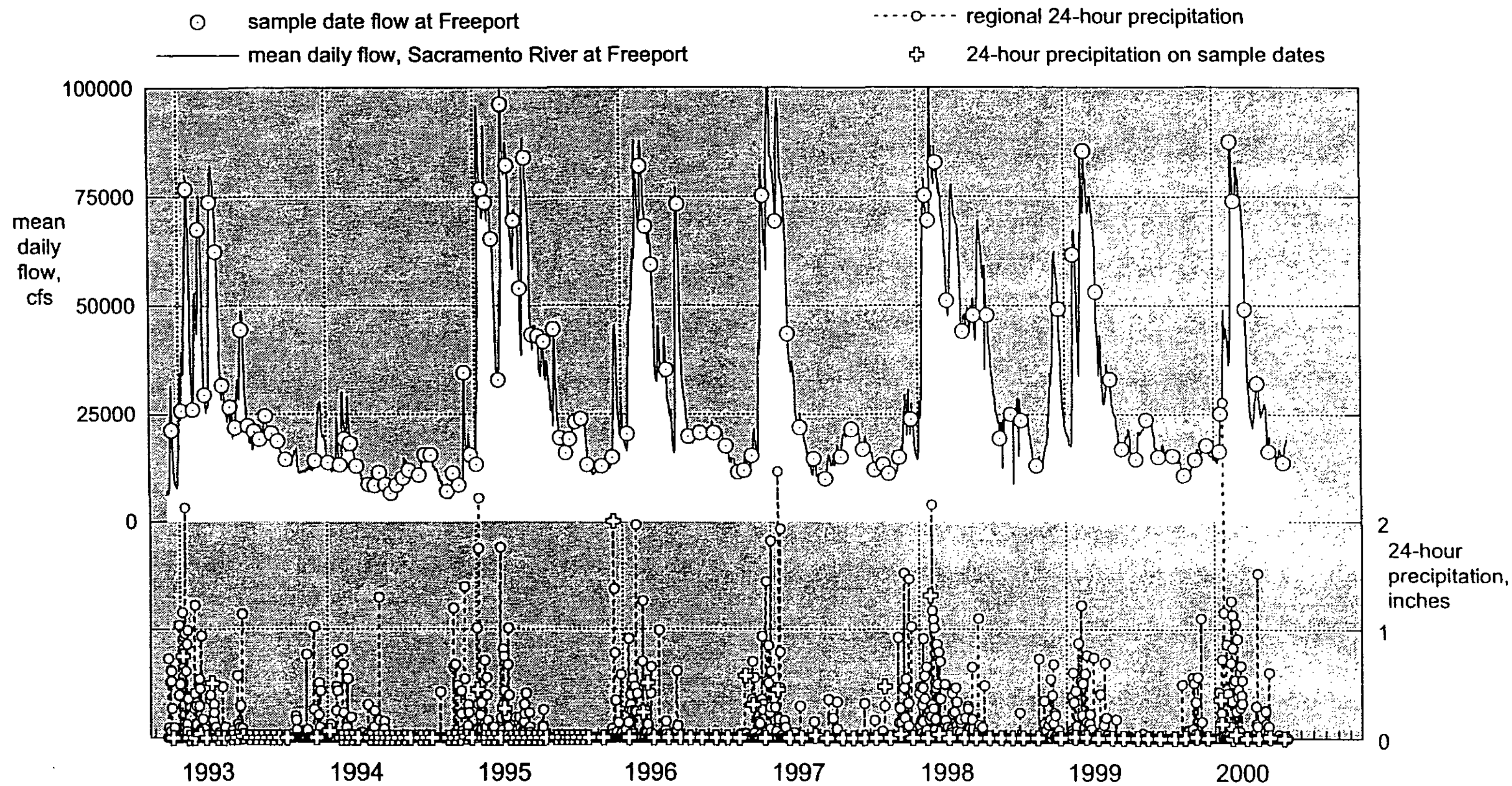


Figure 3-3

Sample Events, Mean Daily River Flows, and Regional Precipitation
Sacramento River at Freeport

Table 3-1

Summary of Quality Control Evaluation Results:

Percent Success Rates for QA Analyses for Events 109 - 126

	QA Element	Success Rate (1)
Internal Lab QA	Method Blanks	97.7%
	Filter Blanks	93.9%
	Lab Control Sample Recovery	100.0%
	Lab Control Sample Recovery Duplicates	100.0%
	Lab Duplicates	98.9%
	Matrix Spike Recoveries	99.5%
	Matrix Spike Duplicates	100.0%
Field and External Lab QA	Field Blanks	93.2%
	Milli-Q Blanks	85.7%
	Field Duplicates	90.6%
	Blind Spikes	(2)
Program QA	Completed Analyses	90.0%
	Unqualified Data	97.9%
	Holding Times	100.0%

(1) Frequency of successful results for QA analyses.
(2) No blind spikes were analyzed for this reporting period.

Table 3-2

Summary Statistics for Water Quality Data:

American River at Nimbus Dam, December 1992 - June 2000

analyte	fraction (a)	units	n (b)	number detected (c)	percent detected (d)	max (e)	min (f)	geometric or arithmetic mean (g)	95% UL (h)	95% LL (i)
antimony	dissolved	µg/L	28	0	0	ND	<3	id	id	id
antimony	total recoverable	µg/L	28	0	0	ND	<3	id	id	id
arsenic	dissolved	µg/L	54	1	2	1	<1	id	id	id
arsenic	total	µg/L	114	60	53	2.9	0.08	0.33	0.36	0.29
cadmium	dissolved	µg/L	110	20	18	0.07	0.002	id	id	id
cadmium	total recoverable	µg/L	112	35	31	5.1	0.003	id	id	id
chromium	dissolved	µg/L	57	0	0	ND	<1	id	id	id
chromium	total recoverable	µg/L	122	64	52	41	0.04	0.31	0.37	0.25
copper	dissolved	µg/L	122	95	78	1.9	0.13	0.53	0.57	0.49
copper	total recoverable	µg/L	123	113	92	4.3	0.24	0.73	0.80	0.66
cyanide	total	µg/L	38	0	0	ND	<2	id	id	id
lead	dissolved	µg/L	112	21	19	0.2	0.004	id	id	id
lead	total recoverable	µg/L	117	65	56	1.4	0.018	0.099	0.118	0.084
mercury	dissolved	ng/L	97	88	91	4.43	0.27	0.91	1.03	0.80
mercury	total	ng/L	96	96	100	15.4	0.6	2.13	2.44	1.86
nickel	dissolved	µg/L	47	9	19	1.9	0.27	id	id	id
nickel	total recoverable	µg/L	102	72	71	30	0.21	0.73	0.88	0.62
selenium	dissolved	µg/L	28	0	0	ND	<1	id	id	id
selenium	total recoverable	µg/L	29	0	0	ND	<1	id	id	id
silver	dissolved	µg/L	47	9	19	0.06	0.02	id	id	id
silver	total recoverable	µg/L	48	15	31	0.07	0.02	id	id	id
thallium	dissolved	µg/L	28	0	0	ND	<1	id	id	id
thallium	total recoverable	µg/L	28	0	0	ND	<1	id	id	id
zinc	dissolved	µg/L	122	47	39	6.8	0.07	0.24	0.31	0.19
zinc	total recoverable	µg/L	120	71	59	60	0.1	0.85	1.16	0.63
hardness	total, as $CaCO_3$	mg/L	98	98	100	64	4	25.9 A	27.8	24.0
TSS	n/a	mg/L	118	67	57	68	1	1.53	1.97	1.19
DOC	n/a	mg/L	47	1	2	2	2	id	id	id
TOC	n/a	mg/L	47	2	4	3.5	2	id	id	id
chlorpyrifos	n/a	µg/L	28	0	0	ND	<.025	id	id	id
diazinon	n/a	µg/L	36	1	0	0.012	<.01	id	id	id
fecal coliform	n/a	MPN/100mL	42	42	100	1300	4	48	67	34
total coliform	n/a	MPN/100mL	41	41	100	3000	13	101	152	67
fecal strep	n/a	MPN/100mL	4	4	100	170	8	id	id	id
temperature	n/a	°C	115	115	100	21.8	7.04	13.0 A	13.6	12.4
DO	n/a	mg/L	109	109	100	13.6	5.8	10.1 A	10.5	9.7
pH	n/a	std. units	120	120	100	8.46	5.82	7.10 A	7.19	7.01
EC	n/a	µmhos/cm	117	117	100	123	18.5	51.7 A	54.4	49.0

(a) Indicates whether values apply to total, total recoverable, or dissolved fraction.
(b) Number of samples analyzed.
(c) Number of samples in which analyte was detected.
(d) Percent of samples in which analyte was detected.
(e) Maximum detected value reported, or ND if no detected data.
(f) Minimum detected value reported or minimum detection limit.
(g) Geometric or arithmetic mean, "A" indicates arithmetic mean is reported;
Statistic reported only for analytes detected in ≥35% of samples, and n≥10;
"id" indicates insufficient data to accurately calculate statistic.
(h) 95% upper confidence limit for mean statistic.
(i) 95% lower confidence limit for mean statistic.

Table 3-3

Summary Statistics for Water Quality Data:

American River at Discovery Park, December 1992 – June 2000

analyte	fraction (a)	units	n (b)	number detected (c)	percent detected (d)	max (e)	min (f)	geometric or arithmetic mean (g)	95% UL (h)	95% LL (i)
antimony	dissolved	µg/L	28	0	0	ND	<3	id	id	id
antimony	total recoverable	µg/L	28	0	0	ND	<3	id	id	id
arsenic	dissolved	µg/L	57	2	4	1.1	0.009	id	id	id
arsenic	total	µg/L	116	59	51	1.23	0.07	0.337	0.370	0.307
cadmium	dissolved	µg/L	113	26	23	0.05	0.005	id	id	id
cadmium	total recoverable	µg/L	115	44	38	3.3	0.004	0.010	0.013	0.007
chromium	dissolved	µg/L	59	0	0	ND	<1	id	id	id
chromium	total recoverable	µg/L	124	65	52	2.25	0.03	0.34	0.39	0.29
copper	dissolved	µg/L	121	101	83	1.9	0.28	0.58	0.62	0.54
copper	total recoverable	µg/L	124	120	97	3.6	0.4	0.86	0.94	0.79
cyanide	total	µg/L	39	0	0	ND	<2	id	id	id
lead	dissolved	µg/L	115	29	25	0.5	0.01	id	id	id
lead	total recoverable	µg/L	120	103	86	1.3	0.057	0.18	0.21	0.16
mercury	dissolved	ng/L	93	88	95	3.89	0.07	1.17	1.35	1.02
mercury	total	ng/L	97	97	100	13.3	0.56	2.85	3.24	2.51
nickel	dissolved	µg/L	49	5	10	1.1	0.31	id	id	id
nickel	total recoverable	µg/L	105	76	72	8	0.18	0.77	0.88	0.67
selenium	dissolved	µg/L	29	0	0	ND	<1	id	id	id
selenium	total recoverable	µg/L	30	2	7	1.2	1	id	id	id
silver	dissolved	µg/L	49	8	16	0.2	0.02	id	id	id
silver	total recoverable	µg/L	50	18	36	0.1	0.02	0.012	0.009	0.016
thallium	dissolved	µg/L	29	0	0	ND	<1	id	id	id
thallium	total recoverable	µg/L	29	0	0	ND	<1	id	id	id
zinc	dissolved	µg/L	121	51	42	11	0.11	0.426	0.517	0.351
zinc	total recoverable	µg/L	122	77	63	230	0.18	1.29	1.67	1.00
hardness	total, as $CaCO_3$	mg/L	101	101	100	54	14	25.2 A	26.6	23.8
TSS	n/a	mg/L	118	86	73	41	1	2.66	3.30	2.14
DOC	n/a	mg/L	50	4	8	3	2	id	id	id
TOC	n/a	mg/L	49	2	4	2.9	2	id	id	id
chlorpyrifos	n/a	µg/L	24	0	0	ND	<.025	id	id	id
diazinon	n/a	µg/L	38	10	26	0.10	0.01	id	id	id
fecal coliform	n/a	MPN/100mL	41	41	100	3000	9	55	80	38
total coliform	n/a	MPN/100mL	41	41	100	50000	17	314	501	197
fecal strep	n/a	MPN/100mL	4	4	100	500	16	id	id	id
temperature	n/a	°C	115	115	100	24.4	7.6	13.9 A	14.6	13.2
DO	n/a	mg/L	114	114	100	15.21	6.18	9.9 A	10.2	9.7
pH	n/a	std. units	115	115	100	8.62	6.37	7.30 A	7.39	7.21
EC	n/a	µmhos/cm	115	115	100	100	17	52.1 A	54.8	49.4

(a) Indicates whether values apply to total, total recoverable, or dissolved fraction.
(b) Number of samples analyzed.
(c) Number of samples in which analyte was detected.
(d) Percent of samples in which analyte was detected.
(e) Maximum detected value reported, or ND if no detected data.
(f) Minimum detected value reported, or minimum detection limit.
(g) Geometric or arithmetic mean, "A" indicates arithmetic mean is reported;
Statistic reported only for analytes detected in ≥35% of samples;
"id" indicates insufficient data to accurately calculate statistic.
(h) 95% upper confidence limit for mean statistic.
(i) 95% lower confidence limit for mean statistic.

Table 3-4

Summary Statistics for Water Quality Data:

Sacramento River at Veterans Bridge, December 1992 - June 2000

analyte	fraction (a)	units	n (b)	number detected (c)	percent detected (d)	max (e)	min (f)	geometric or arithmetic mean (g)	95% UL (h)	95% LL (i)
antimony	dissolved	µg/L	31	0	0	ND	<3	id	id	id
antimony	total recoverable	µg/L	32	0	0	ND	<3	id	id	id
arsenic	dissolved	µg/L	66	45	68	2.4	1	1.23	1.33	1.14
arsenic	total	µg/L	126	117	93	3.63	0.83	1.63	1.72	1.55
cadmium	dissolved	µg/L	115	48	42	0.24	0.01	0.012	0.014	0.011
cadmium	total recoverable	µg/L	123	108	88	0.74	0.01	0.047	0.053	0.041
chromium	dissolved	µg/L	58	2	3	1.2	1.1	id	id	id
chromium	total recoverable	µg/L	126	108	86	19	0.03	1.94	2.26	1.66
copper	dissolved	µg/L	126	125	99	5	0.5	1.44	1.53	1.35
copper	total recoverable	µg/L	126	126	100	16.9	1.4	3.98	4.30	3.69
cyanide	total	µg/L	40	1	3	34	<2	id	id	id
lead	dissolved	µg/L	118	34	29	0.4	0.02	id	id	id
lead	total recoverable	µg/L	126	126	100	7.2	0.04	0.51	0.58	0.45
mercury	dissolved	ng/L	99	98	99	7.96	0.56	1.59	1.79	1.41
mercury	total	ng/L	99	99	100	34.9	3.4	8.52	9.43	7.70
nickel	dissolved	µg/L	105	72	69	2.8	0.25	0.75	0.83	0.69
nickel	total recoverable	µg/L	107	105	98	28	1	4.10	4.69	3.58
selenium	dissolved	µg/L	31	0	0	ND	<1	id	id	id
selenium	total recoverable	µg/L	32	0	0	ND	<1	id	id	id
silver	dissolved	µg/L	49	12	24	0.2	0.02	id	id	id
silver	total recoverable	µg/L	51	18	35	0.1	0.02	0.015	0.012	0.019
thallium	dissolved	µg/L	31	0	0	ND	<1	id	id	id
thallium	total recoverable	µg/L	32	0	0	ND	<1	id	id	id
zinc	dissolved	µg/L	125	61	49	23	0.23	0.63	0.78	0.52
zinc	total recoverable	µg/L	125	115	92	31	0.49	6.03	6.79	5.35
hardness	total, as $CaCO_3$	mg/L	103	103	100	90	28	57.4 A	59.7	55.1
TSS	n/a	mg/L	123	123	100	200	4	35.5	39.8	31.7
DOC	n/a	mg/L	61	23	38	10	2	2.4	2.7	2.1
TOC	n/a	mg/L	53	18	34	6	2	id	id	id
chlorpyrifos	n/a	µg/L	28	1	4	0.028	<.025	id	id	id
diazinon	n/a	µg/L	39	7	18	0.16	0.01	id	id	id
fecal coliform	n/a	MPN/100mL	42	42	100	2400	2	35	53	23
total coliform	n/a	MPN/100mL	42	42	100	5000	17	415	608	283
fecal strep	n/a	MPN/100mL	4	4	100	220	16	id	id	id
temperature	n/a	°C	110	110	100	25	7.5	15.2 A	16.0	14.4
DO	n/a	mg/L	107	107	100	12.4	6.6	9.6 A	9.9	9.4
pH	n/a	std. units	112	112	100	8.94	6.2	7.62 A	7.71	7.53
EC	n/a	µmhos/cm	116	116	100	222	37	136 A	143	129

(a) Indicates whether values apply to total, total recoverable, or dissolved fraction.
(b) Number of samples analyzed.
(c) Number of samples in which analyte was detected.
(d) Percent of samples in which analyte was detected.
(e) Maximum detected value reported, or ND if no detected data.
(f) Minimum detected value reported, or minimum detection limit if no detected data.
(g) Geometric or arithmetic mean, "A" indicates arithmetic mean is reported;
Statistic reported only for analytes detected in ≥35% of samples, and n≥10;
"id" indicates insufficient data to accurately calculate statistic.
(h) 95% upper confidence limit for mean statistic.
(i) 95% lower confidence limit for mean statistic.

Table 3-5

Summary Statistics for Water Quality Data:

Sacramento River at Freeport, December 1992 - June 2000

analyte	fraction	units	n	number detected	percent detected	max	min	geometric or arithmetic mean	95% UL	95% LL
	(a)		(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
antimony	dissolved	µg/L	18	0	0	ND	<1	id	id	id
antimony	total recoverable	µg/L	18	0	0	ND	<1	id	id	id
arsenic	dissolved	µg/L	60	37	62	2.1	0.012	0.728	0.89	0.60
arsenic	total	µg/L	119	108	91	3.6	0.78	1.45	1.52	1.38
cadmium	dissolved	µg/L	110	42	38	0.06	0.004	0.011	0.012	0.010
cadmium	total recoverable	µg/L	117	89	76	2.5	0.015	0.037	0.042	0.033
chromium	dissolved	µg/L	50	3	6	2.25	1	id	id	id
chromium	total recoverable	µg/L	118	102	86	14	0.21	1.99	2.30	1.72
copper	dissolved	µg/L	119	117	98	2.9	0.5	1.38	1.47	1.30
copper	total recoverable	µg/L	119	119	100	14.5	1.54	3.73	4.07	3.42
cyanide	total	µg/L	21	0	0	ND	<2	id	id	id
lead	dissolved	µg/L	111	32	29	1.2	0.006	id	id	id
lead	total recoverable	µg/L	119	111	93	3	0.1	0.50	0.57	0.43
mercury	dissolved	ng/L	96	95	99	14.92	0.3	1.6	1.8	1.4
mercury	total	ng/L	96	96	100	36.19	1.2	7.7	8.8	6.8
nickel	dissolved	µg/L	97	67	69	2.5	0.26	0.68	0.76	0.61
nickel	total recoverable	µg/L	100	95	95	19.5	1.2	3.6	4.18	3.10
selenium	dissolved	µg/L	25	0	0	ND	<.87	id	id	id
selenium	total recoverable	µg/L	26	0	0	ND	<.87	id	id	id
silver	dissolved	µg/L	42	1	2	0.02	0.02	id	id	id
silver	total recoverable	µg/L	43	5	12	0.03	0.02	id	id	id
thallium	dissolved	µg/L	15	0	0	ND	<1	id	id	id
thallium	total recoverable	µg/L	17	0	0	ND	<1	id	id	id
zinc	dissolved	µg/L	116	68	59	27	0.26	0.78	0.96	0.63
zinc	total recoverable	µg/L	118	104	88	29	0.93	5.34	6.09	4.68
hardness	total, as $CaCO_3$	mg/L	97	97	100	94	30	54.7 A	57.4	52.0
TSS	n/a	mg/L	116	115	99	210	2	27.3	31.9	23.4
DOC	n/a	mg/L	54	26	48	5.3	1.6	2.3	2.6	2.1
TOC	n/a	mg/L	46	20	43	6.8	1.5	2.2	2.5	2.0
chlorpyrifos	n/a	µg/L	27	0	0	ND	<.025	id	id	id
diazinon	n/a	µg/L	37	7	19	0.14	0.01	id	id	id
fecal coliform	n/a	MPN/100mL	40	40	100	8000	4	36.6	61	22
total coliform	n/a	MPN/100mL	39	39	100	8000	13	359	553	233
fecal strep	n/a	MPN/100mL	4	4	100	220	16	id	id	id
temperature	n/a	°C	110	110	100	23.1	6.2	14.9 A	15.7	14.1
DO	n/a	mg/L	106	106	100	13.1	6.9	9.6 A	9.8	9.3
pH	n/a	std. units	114	114	100	8.79	5.6	7.55 A	7.63	7.47
EC	n/a	µmhos/cm	114	114	100	254	54	133 A	140	126

(a) Indicates whether values apply to total, total recoverable, or dissolved fraction.
(b) Number of samples analyzed.
(c) Number of samples in which analyte was detected.
(d) Percent of samples in which analyte was detected.
(e) Maximum detected value reported, or ND if no detected data.
(f) Minimum detected value reported, or minimum detection limit if no detected data.
(g) Geometric or arithmetic mean, "A" indicates arithmetic mean is reported;
Statistic reported only for analytes detected in ≥35% of samples, and n≥10;
"id" indicates insufficient data to accurately calculate statistic.
(h) 95% upper confidence limit for mean statistic.
(i) 95% lower confidence limit for mean statistic.

Table 3-6

Summary Statistics for Water Quality Data:

Sacramento River at River Mile 44, December 1992 - June 2000

analyte	fraction (a)	units	n (b)	number detected (c)	percent detected (d)	max (e)	min (f)	geometric or arithmetic mean (g)	95% UL (h)	95% LL (i)
antimony	dissolved	µg/L	28	0	0	ND	<3	id	id	id
antimony	total recoverable	µg/L	28	0	0	ND	<3	id	id	id
arsenic	dissolved	µg/L	66	45	68	2.2	0.013	0.968	1.12	0.83
arsenic	total	µg/L	117	108	92	3.07	0.76	1.48	1.56	1.41
cadmium	dissolved	µg/L	111	48	43	0.18	0.004	0.012	0.015	0.011
cadmium	total recoverable	µg/L	115	95	83	0.78	0.011	0.041	0.049	0.035
chromium	dissolved	µg/L	59	2	3	1.2	1	id	id	id
chromium	total recoverable	µg/L	117	96	82	20	0.8	1.84	2.13	1.59
copper	dissolved	µg/L	119	118	99	6	0.625	1.48	1.58	1.39
copper	total recoverable	µg/L	116	116	100	16	1.2	3.80	4.16	3.47
cyanide	total	µg/L	38	0	0	ND	<2	id	id	id
lead	dissolved	µg/L	111	29	26	0.3	0.015	id	id	id
lead	total recoverable	µg/L	117	116	99	3.5	0.1	0.54	0.62	0.47
mercury	dissolved	ng/L	93	92	99	11.1	0.5	1.59	1.81	1.40
mercury	total	ng/L	94	94	100	73.41	2.74	8.12	9.31	7.08
nickel	dissolved	µg/L	97	67	69	2.3	0.28	0.72	0.79	0.65
nickel	total recoverable	µg/L	97	94	97	42	1.08	3.52	4.20	2.95
selenium	dissolved	µg/L	28	0	0	ND	<1	id	id	id
selenium	total recoverable	µg/L	29	0	0	ND	<1	id	id	id
silver	dissolved	µg/L	47	9	19	0.2	0.02	id	id	id
silver	total recoverable	µg/L	50	21	42	0.11	0.02	0.017	0.013	0.021
thallium	dissolved	µg/L	28	0	0	ND	<1	id	id	id
thallium	total recoverable	µg/L	28	0	0	ND	<1	id	id	id
zinc	dissolved	µg/L	118	62	53	18	0.12	0.84	1.00	0.70
zinc	total recoverable	µg/L	116	106	91	52	1.36	7.13	8.24	6.17
hardness	total, as $CaCO_3$	mg/L	96	96	100	94	24	57.1 A	60.2	54.0
TSS	n/a	mg/L	115	114	99	250	2	29.2	34.5	24.7
DOC	n/a	mg/L	55	19	35	8.5	2.2	id	id	id
TOC	n/a	mg/L	52	16	31	6.1	1.9	id	id	id
chlorpyrifos	n/a	µg/L	21	0	0	ND	<.025	id	id	id
diazinon	n/a	µg/L	33	4	12	0.039	0.01	id	id	id
fecal coliform	n/a	MPN/100mL	6	6	100	50	4	18.5	45.9	7.5
total coliform	n/a	MPN/100mL	6	6	100	900	130	297.0	629.7	140.1
temperature	n/a	°C	111	111	100	22.86	7.2	15.1 A	15.9	14.3
DO	n/a	mg/L	109	109	100	12.2	6.7	9.4 A	9.6	9.2
pH	n/a	std. units	115	115	100	8.83	6.14	7.46 A	7.54	7.38
EC	n/a	µmhos/cm	117	117	100	234	45	126 A	133	119

(a) Indicates whether values apply to total, total recoverable, or dissolved fraction.
(b) Number of samples analyzed; "na" indicates analyte was not analyzed.
(c) Number of samples in which analyte was detected.
(d) Percent of samples in which analyte was detected.
(e) Maximum detected value reported, or ND if no detected data.
(f) Minimum detected value reported, or minimum detection limit if no detected data.
(g) Geometric or arithmetic mean, "A" indicates arithmetic mean is reported;
Statistic reported only for analytes detected in ≥35% of samples, and n≥10;
"id" indicates insufficient data to accurately calculate statistic.
(h) 95% upper confidence limit for mean statistic.
(i) 95% lower confidence limit for mean statistic.

Table 3-7

Comparisons with Projected Water Quality Limits:

American River at Nimbus Dam

parameter	fraction (a)	units	Water Quality Limits (b) CTR	BP	Other	Minimum limit (c)	Probability of meeting limit (d)
arsenic	dissolved	µg/L	—	10	—	10	OK
arsenic	total	µg/L	150	—	50 (EPA)	50	100.00%
cadmium	dissolved	µg/L	0.82	—	—	0.82	100.00%
cadmium	total recoverable	µg/L	—	—	5 (EPA)	5.0	100.00%
chromium (III)	dissolved	µg/L	59	—	—	59	OK
chromium (III)	total recoverable	µg/L	—	—	50 (DHS)	50	100.00%
copper	dissolved	µg/L	2.8	10	—	2.8	100.00%
copper	total recoverable	µg/L	—	—	1000 (LCR)	1000	100.00%
lead	dissolved	µg/L	0.56	—	—	0.56	99.84%
lead	total recoverable	µg/L	—	—	15 (LCR)	15	100.00%
mercury	total	ng/L	50	—	2000 (EPA)	50	100.00%
nickel	dissolved	µg/L	17	—	—	17	OK
nickel	total recoverable	µg/L	—	—	100 (EPA)	100	100.00%
zinc	dissolved	µg/L	38	100	—	38	100.00%
zinc	total recoverable	µg/L	—	—	5000 (DHS)	5000	100.00%
TOC	—	mg/L	—	—	2 (D/DBP)	2	>WQC
chlorpyrifos	—	µg/L	—	—	0.014 (DFG)	0.01	OK
diazinon	—	µg/L	—	—	0.05 (DFG)	0.05	id
fecal coliform	—	MPN/100mL	—	400	400 (DHS)	400	97.02%
total coliform	—	MPN/100mL	—	—	10000 (DHS)	10000	99.97%
DO	—	mg/L	—	7	—	7	94.32%
pH	—	std. units	—	6.5-8.5	—	6.5-8.5	87.24%
EC	—	µmhos/cm	—	240	—	240	100.00%

(a) Indicates whether criterion and statistics are based on total, total recoverable, or dissolved fraction.
(b) The lowest objective or criterion for the protection of human health or aquatic life from the proposed California Toxics Rule (CTR) and the Central Valley Region Basin Plan (BP).
Other water quality limits provided for comparison include:
Safe Drinking Water Act MCLs (EPA), California Department of Health Services Guidance Levels (DHS), Lead and Copper Rule Action Levels (LCR), Department of Fish and Game Guidance Levels (DFG), and Disinfectant/Disinfection By-Product Rule (D/DBP) treatment threshold for TOC.
— indicates there is no applicable limit.
(c) Lowest applicable water quality limit.
(d) Estimated probability of meeting minimum applicable water quality limit.
One exceedance in three years is equivalent to 99.91% compliance.
Estimates are based on a lognormal distribution.
Results for parameters with less than 10 percent detected data are reported as follows:
1) "OK" when: max < 0.2 x water quality limit;
2) ">WQC" when: max > water quality limit;
3) "id" (insufficient detected data) when: 0.2 x limit < maximum detected value < water quality limit;

Table 3-8

Comparisons with Projected Water Quality Limits:

American River at Discovery Park

parameter	fraction (a)	units	Water Quality Limits (b) CTR	BP	Other	Minimum limit (c)	Probability of meeting limit (d)
arsenic	dissolved	µg/L	—	10	—	10	OK
arsenic	total	µg/L	150	—	50 (EPA)	50	100.00%
cadmium	dissolved	µg/L	0.81	—	—	0.81	100.00%
cadmium	total recoverable	µg/L	—	—	5 (EPA)	5.0	100.00%
chromium (III)	dissolved	µg/L	58	—	—	58	OK
chromium (III)	total recoverable	µg/L	—	—	50 (DHS)	50	100.00%
copper	dissolved	µg/L	2.8	10	—	2.8	100.00%
copper	total recoverable	µg/L	—	—	1000 (LCR)	1000	100.00%
lead	dissolved	µg/L	0.55	—	—	0.55	99.83%
lead	total recoverable	µg/L	—	—	15 (LCR)	15	100.00%
mercury	total	ng/L	50	—	2000 (EPA)	50	100.00%
nickel	dissolved	µg/L	16	—	—	16	OK
nickel	total recoverable	µg/L	—	—	100 (EPA)	100	100.00%
zinc	dissolved	µg/L	37	100	—	37	100.00%
zinc	total recoverable	µg/L	—	—	5000 (DHS)	5000	100.00%
TOC	—	mg/L	—	—	2 (D/DBP)	2	>WQC
chlorpyrifos	—	µg/L	—	—	0.014 (DFG)	0.01	OK
diazinon	—	µg/L	—	—	0.05 (DFG)	0.05	95.94%
fecal coliform	—	MPN/100mL	—	400	400 (DHS)	400	94.69%
total coliform	—	MPN/100mL	—	—	10000 (DHS)	10000	98.95%
DO	—	mg/L	—	7.0	—	7	97.75%
pH	—	std. units	—	6.5-8.5	—	—	94.93%
EC	—	µmhos/cm	—	—	—	240	100.00%

(a) Indicates whether criterion and statistics are based on total, total recoverable, or dissolved fraction.
(b) The lowest objective or criterion for the protection of human health or aquatic life from the proposed California Toxics Rule (CTR) and the Central Valley Region Basin Plan (BP).
Other water quality limits provided for comparison include:
Safe Drinking Water Act MCLs (EPA), California Department of Health Services Guidance Levels (DHS), Lead and Copper Rule Action Levels (LCR), Department of Fish and Game Guidance Levels (DFG), and Disinfectant/Disinfection By-Product Rule (D/DBP) treatment threshold for TOC.
— indicates there is no applicable limit.
(c) Lowest applicable water quality limit.
(d) Estimated probability of meeting minimum applicable water quality limit.
One exceedance in three years is equivalent to 99.91% compliance.
Estimates are based on a lognormal distribution.
Results for parameters with less than 10 percent detected data are reported as follows:
1) "OK" when: max < 0.2 x water quality limit;
2) ">WQC" when: max > water quality limit;
3) "id" (insufficient detected data) when: 0.2 x limit < maximum detected value < water quality limit;

Table 3-9

Comparisons with Projected Water Quality Limits:

Sacramento River at Veterans Bridge

parameter	fraction (a)	units	Water Quality Limits (b) CTR	BP	Other	Minimum limit (c)	Probability of meeting limit (d)
arsenic	dissolved	µg/L	—	10	—	10	100.00%
arsenic	total	µg/L	150	—	50 (EPA)	50	100.00%
cadmium	dissolved	µg/L	1.5	—	—	1.48	100.00%
cadmium	total recoverable	µg/L	—	—	5 (EPA)	5.0	100.00%
chromium (III)	dissolved	µg/L	113	—	—	113	OK
chromium (III)	total recoverable	µg/L	—	—	50 (DHS)	50	99.99%
copper	dissolved	µg/L	5.6	10	—	5.6	100.00%
copper	total recoverable	µg/L	—	—	1000 (LCR)	1000	100.00%
lead	dissolved	µg/L	1.4	—	—	1.37	100.00%
lead	total recoverable	µg/L	—	15	15 (LCR)	15	100.00%
mercury	total	ng/L	50	—	2000 (EPA)	50	99.98%
nickel	dissolved	µg/L	33	—	—	33	100.00%
nickel	total recoverable	µg/L	—	—	100 (EPA)	100	100.00%
zinc	dissolved	µg/L	74	100	—	74	100.00%
zinc	total recoverable	µg/L	—	—	5000 (DHS)	5000	100.00%
TOC	—	mg/L	—	—	2 (D/DBP)	2	27.22%
chlorpyrifos	—	µg/L	—	—	0.014 (DFG)	0.01	>WQC
diazinon	—	µg/L	—	—	0.05 (DFG)	0.05	>WQC
fecal coliform	—	MPN/100mL	—	400	400 (DHS)	400	96.75%
total coliform	—	MPN/100mL	—	—	10000 (DHS)	10000	99.58%
temperature	—	°C	—	20	—	20	86.09%
DO	—	mg/L	—	7.0	—	7.0	99.00%
pH	—	std. units	—	6.5-8.5	—	6.5-8.5	86.19%
EC	—	µmhos/cm	—	240	—	240	99.71%

(a) Indicates whether criterion and statistics are based on total, total recoverable, or dissolved fraction.
(b) The lowest objective or criterion for the protection of human health or aquatic life from
the proposed California Toxics Rule (CTR) and the Central Valley Region Basin Plan (BP).
Other water quality limits provided for comparison include:
Safe Drinking Water Act MCLs (EPA), California Department of Health Services Guidance Levels (DHS),
Lead and Copper Rule Action Levels (LCR), Department of Fish and Game Guidance Levels (DFG),
and Disinfectant/Disinfection By-Product Rule (D/DBP) treatment threshold for TOC.
— indicates there is no applicable limit.
(c) Lowest applicable water quality limit.
(d) Estimated probability of meeting minimum applicable water quality limit.
One exceedance in three years is equivalent to 99.91% compliance.
Estimates are based on a lognormal distribution.
Results for parameters with less than 10 percent detected data are reported as follows:
1) "OK" when: max < 0.2 x water quality limit;
2) ">WQC" when: max > water quality limit;
3) "id" (insufficient detected data) when: 0.2 x limit < maximum detected value < water quality limit;

Table 3-10

Comparisons with Projected Water Quality Limits:

Sacramento River at Freeport

parameter	fraction (a)	units	Water Quality Limits (b) CTR	BP	Other	Minimum limit (c)	Probability of meeting limit (d)
arsenic	dissolved	µg/L	n/a	10	—	10	99.97%
arsenic	total	µg/L	150	—	50 (EPA)	50	100.00%
cadmium	dissolved	µg/L	1.4	—	—	1.43	100.00%
cadmium	total recoverable	µg/L	—	—	5 (EPA)	5.0	100.00%
chromium (III)	dissolved	µg/L	109	—	—	109	OK
chromium (III)	total recoverable	µg/L	—	—	50 (DHS)	50	100.00%
copper	dissolved	µg/L	5.3	10	—	5.3	100.00%
copper	total recoverable	µg/L	—	—	1000 (LCR)	1000	100.00%
lead	dissolved	µg/L	1.3	—	—	1.30	99.92%
lead	total recoverable	µg/L	—	15	15 (LCR)	15	100.00%
mercury	total	ng/L	50	—	2000 (EPA)	50	99.79%
nickel	dissolved	µg/L	31	—	—	31	100.00%
nickel	total recoverable	µg/L	—	—	100 (EPA)	100	100.00%
zinc	dissolved	µg/L	71	100	—	71	100.00%
zinc	total recoverable	µg/L	—	—	5000 (DHS)	5000	100.00%
TOC	—	mg/L	—	—	2 (D/DBP)	2	40.38%
chlorpyrifos	—	µg/L	—	—	0.014 (DFG)	0.01	OK
diazinon	—	µg/L	—	—	0.05 (DFG)	0.05	>WQC
fecal coliform	—	MPN/100mL	—	400	400 (DHS)	400	92.33%
total coliform	—	MPN/100mL	—	—	10000 (DHS)	10000	99.56%
temperature	—	°C	—	20	—	20	87.19%
DO	—	mg/L	—	7.0	—	7.0	97.95%
pH	—	std. units	—	6.5-8.5	—	6.5-8.5	98.38%
EC	—	µmhos/cm	—	240	—	240	99.85%

(a) Indicates whether criterion and statistics are based on total, total recoverable, or dissolved fraction.
(b) The lowest objective or criterion for the protection of human health or aquatic life from
the proposed California Toxics Rule (CTR) and the Central Valley Region Basin Plan (BP).
Other water quality limits provided for comparison include:
Safe Drinking Water Act MCLs (EPA), California Department of Health Services Guidance Levels (DHS),
Lead and Copper Rule Action Levels (LCR), Department of Fish and Game Guidance Levels (DFG),
and Disinfectant/Disinfection By-Product Rule (D/DBP) treatment threshold for TOC.
— indicates there is no applicable limit.
(c) Lowest applicable water quality limit.
(d) Estimated probability of meeting minimum applicable water quality limit.
One exceedance in three years is equivalent to 99.91% compliance.
Estimates are based on a lognormal distribution.
Results for parameters with less than 10 percent detected data are reported as follows:
1) "OK" when: max < 0.2 x water quality limit;
2) ">WQC" when: max > water quality limit;
3) "id" (insufficient detected data) when: 0.2 x limit < maximum detected value < water quality limit;

Table 3-11

Comparisons with Projected Water Quality Limits:

Sacramento River at River Mile 44

parameter	fraction (a)	units	Water Quality Limits (b) CTR	BP	Other	Minimum limit (c)	Probability of meeting limit (d)
arsenic	dissolved	µg/L	—	10	—	10	99.99%
arsenic	total	µg/L	150	—	50 (EPA)	50	100.00%
cadmium	dissolved	µg/L	1.5	—	—	1.48	100.00%
cadmium	total recoverable	µg/L	—	—	5 (EPA)	5.0	100.00%
chromium (III)	dissolved	µg/L	112	—	—	112	OK
chromium (III)	total recoverable	µg/L	—	—	50 (DHS)	50	100.00%
copper	dissolved	µg/L	5.5	10	—	5.5	99.99%
copper	total recoverable	µg/L	—	—	1000 (LCR)	1000	100.00%
lead	dissolved	µg/L	1.4	—	—	1.36	100.00%
lead	total recoverable	µg/L	—	15	15 (LCR)	15	100.00%
mercury	total	ng/L	50	—	2000 (EPA)	50	99.68%
nickel	dissolved	µg/L	32	—	—	32	100.00%
nickel	total recoverable	µg/L	—	—	100 (EPA)	100	99.99%
zinc	dissolved	µg/L	73	100	—	73	100.00%
zinc	total recoverable	µg/L	—	—	5000 (DHS)	5000	100.00%
TOC	—	mg/L	—	—	2 (D/DBP)	2	27.85%
chlorpyrifos	—	µg/L	—	—	0.014 (DFG)	0.01	OK
diazinon	—	µg/L	—	—	0.04 (DFG)	0.04	id
fecal coliform	—	MPN/100mL	—	400	400 (DHS)	400	OK
total coliform	—	MPN/100mL	—	—	10000 (DHS)	10000	OK
temperature	—	°C	—	20	—	20	86.63%
DO	—	mg/L	—	7.0	—	7.0	97.72%
pH	—	std. units	—	6.5-8.5	—	6.5-8.5	97.57%
EC	—	µmhos/cm	—	240	—	240	99.68%

(a) Indicates whether criterion and statistics are based on total, total recoverable, or dissolved fraction.
(b) The lowest objective or criterion for the protection of human health or aquatic life from
the proposed California Toxics Rule (CTR) and the Central Valley Region Basin Plan (BP).
Other water quality limits provided for comparison include:
Safe Drinking Water Act MCLs (EPA), California Department of Health Services Guidance Levels (DHS),
Lead and Copper Rule Action Levels (LCR), Department of Fish and Game Guidance Levels (DFG),
and Disinfectant/Disinfection By-Product Rule (D/DBP) treatment threshold for TOC.
— indicates there is no applicable limit.
(c) Lowest applicable water quality limit.
(d) Estimated probability of meeting minimum applicable water quality limit.
One exceedance in three years is equivalent to 99.91% compliance.
Estimates are based on a lognormal distribution.
Results for parameters with less than 10 percent detected data are reported as follows:
1) "OK" when: max < 0.2 x water quality limit;
2) ">WQC" when: max > water quality limit;
3) "id" (insufficient detected data) when: 0.2 x limit < maximum detected value < water quality limit;

Table 3-12

Summary of Ambient Program Trace Organics Data, 1999 - 2000

Parameter	Statistic	American River		Sacramento River			CTR Human Health Criterion (ng/L)	Range of Detection Limits (ng/L)
		Nimbus	Discovery Park	Veterans Br.	Freeport	River Mile 44		
2,4,6-Trichlorophenol	*n*	4	4	2	4	3		
	n detected	0	0	0	0	1		
	Max detected	—	—	—	—	3.7 ng/L	2,100	0.52 - 2.1
Acenaphthene	*n*	5	4	4	5	4		
	n detected	0	0	0	1	1		
	Max detected	—	—	—	5.2 ng/L	0.43 ng/L	1,200,000	0.19 - 15
Anthracene	*n*	5	4	4	5	4		
	n detected	1	1	1	1	1		
	Max detected	0.3 ng/L	0.81 ng/L	0.2 ng/L	4.8 ng/L	0.18 ng/L	9,600	0.11 - 7.6
Benz(a)anthracene	*n*	5	4	4	5	4		
	n detected	1	2	2	1	2		
	Max detected	0.3 ng/L	1.6 ng/L	0.2 ng/L	3.1 ng/L	0.37 ng/L	4.4	0.1 - 7.6
Benzo(a)pyrene	*n*	5	4	4	5	4		
	n detected	0	1	2	1	2		
	Max detected	—	0.49 ng/L	0.3 ng/L	2.5 ng/L	0.43 ng/L	4.4	0.17 - 18
Benzofluoranthenes	*n*	5	4	4	5	4		
	n detected	1	2	1	2	2		
	Max detected	0.4 ng/L	2.6 ng/L	0.5 ng/L	3.2 ng/L	0.89 ng/L	4.4	0.21 - 11
Chrysene	*n*	5	4	4	5	4		
	n detected	1	2	2	3	2		
	Max detected	0.4 ng/L	2.2 ng/L	0.5 ng/L	2.9 ng/L	0.67 ng/L	4.4	0.16 - 7.5
Dibenz(ah) anthracene	*n*	5	4	4	5	4		
	n detected	1	1	0	1	1		
	Max detected	0.4 ng/L	0.57 ng/L	—	2.6 ng/L	0.4 ng/L	4.4	0.34 - 23
Fluoranthene	*n*	5	4	4	5	4		
	n detected	2	2	2	3	2		
	Max detected	1.2 ng/L	4.8 ng/L	1.6 ng/L	6.3 ng/L	2.1 ng/L	300,000	0.12 - 6.8
Fluorene	*n*	5	4	4	5	4		
	n detected	2	1	2	3	2		
	Max detected	1.3 ng/L	0.58 ng/L	1.3 ng/L	7.5 ng/L	1.4 ng/L	1,300,000	0.36 - 10
Hexachlorobenzene	*n*	5	4	4	5	4		
	n detected	1	1	0	2	1		
	Max detected	0.3 ng/L	$\boxed{1.3 \text{ ng/L}}$	—	$\boxed{0.9 \text{ ng/L}}$	0.28 ng/L	0.75	0.3 - 3.4
Indeno(1,2,3-cd) pyrene	*n*	5	4	4	5	4		
	n detected	1	1	1	2	1		
	Max detected	0.3 ng/L	0.64 ng/L	0.5 ng/L	2.1 ng/L	0.46 ng/L	4.4	0.18 - 7.1
N-nitrosodi-n-propylamine	*n*	5	4	4	5	4		
	n detected	0	0	0	0	0		
	Max detected	—	—	—	—	—	5.0	1.5 - 25
Pentachlorophenol	*n*	4	3	3	3	2		
	n detected	0	0	0	0	0		
	Max detected	—	—	—	—	—	280	0.83 - 5.7
Pyrene	*n*	5	4	4	5	4		
	n detected	3	2	2	3	3		
	Max detected	0.7 ng/L	5.1 ng/L	10 ng/L	5.1 ng/L	2.4 ng/L	960,000	1.0 - 7.7

Note: Outlined concentrations indicate values exceeding water quality criteria.

4 Special Studies

In January of 1999, the CMP Steering Committee approved a CMP Special Study to evaluate trends in selected water quality characteristics, sampling frequencies required to adequately monitor long-term trends, the importance of mass loads passing by and originating from the Sacramento metropolitan area (including the SRWTP and urban runoff), and the potential impacts of precipitation and urban runoff on ambient water quality in the Sacramento River and the American River. The specific questions addressed by the study are:

- Are there trends in water quality data?
- How useful is the CMP data collected to date for evaluating future trends?
- How frequently does the CMP need to sample to effectively monitor long-term trends? Can monitoring frequency be reduced and still provide adequate monitoring of trends?
- What are the average mass loads of copper, lead, mercury, TDS, and TOC to the Delta?
- What percentage of these loads are contributed by the Sacramento metropolitan area, including urban runoff and the SRWTP, and what percentage of these loads are contributed by flows from the Yolo Bypass?
- How does the relative importance of these loads change during critical water years?
- Does precipitation have a detectable effect on water quality downstream from the Sacramento urban area? Is this effect greater during certain specific flow conditions?

The approach selected for answering the questions posed by this study is to utilize the CMP monitoring data from 1992-1998 to develop multiple regression models of water quality as a function of hydrological conditions and precipitation factors. The results of these regression analyses provide the foundation and the statistical tools used to answer the study questions about trends, monitoring frequency requirements, mass loads, and precipitation effects. A diagram of the study approach is presented in Figure 4-1.

The results of this CMP Special Study were reported in a Technical Memorandum (LWA 2000). The principal findings of this study can be summarized as follows:

- The water quality data collected by the CMP ambient monitoring program between 1993 and 1998 provide an effective tool for evaluation of trends in water quality characteristics, analysis of monitoring frequency requirements, mass loading assessments, and evaluations of precipitation impacts.
- Significant decreases in the measured concentrations of several parameters at several locations (copper, mercury, fecal coliform bacteria, and conductivity) were detected over the course of the CMP monitoring program. A significant increase in total recoverable lead concentrations was observed at Veterans Bridge, but not at locations downstream.
- Continued monitoring at a monthly rate of 12 events per year would provide adequate statistical power to detect changes of 20% over twenty years in concentrations of most parameters. Changes of less than 10% over twenty years would be unlikely to be detected with monitoring frequencies of less than 24 events per year.
- Average annual mass loads can be modeled and characterized with a fairly high degree of statistical confidence (generally within 10% of the "true" average, with 95% confidence) for CMP monitoring locations.
- In general, urban runoff loads (except for lead), and SRWTP and American River loads are typically a small proportion of the total loads to the Delta.
- Differences in relative annual loads for low and high water years indicate while incremental loads are relatively constant, the potential for greatest relative effects on water quality from urban runoff and the SRWTP occurs

during years of relatively low flows and high water quality (as indicated by low measured pollutant concentrations).

- Differences in relative total loads to the Delta are largely a function of Yolo Bypass flows. Additional questions about loads to the Delta can be best answered by monitoring the Yolo Bypass. If loading to the Delta is an important issue for any pollutants, water quality characteristics and mass loads from the Yolo Bypass need to be better characterized.
- In general, precipitation appears to have little (if any) measurable additional effect on concentrations of pollutants below the Sacramento metropolitan area. This result is consistent with the relatively small percentage of most pollutant loads attributable to urban runoff. This appears to be true for the range of hydrological conditions observed during the course of the CMP monitoring effort. It is concluded that monitoring ambient receiving water is not recommended as an efficient means of evaluating the potential effects of precipitation and urban runoff in the American River and Sacramento River. More useful information for evaluating and managing potential impacts from urban runoff and precipitation is provided by direct monitoring of urban runoff, in combination with regular receiving water monitoring.

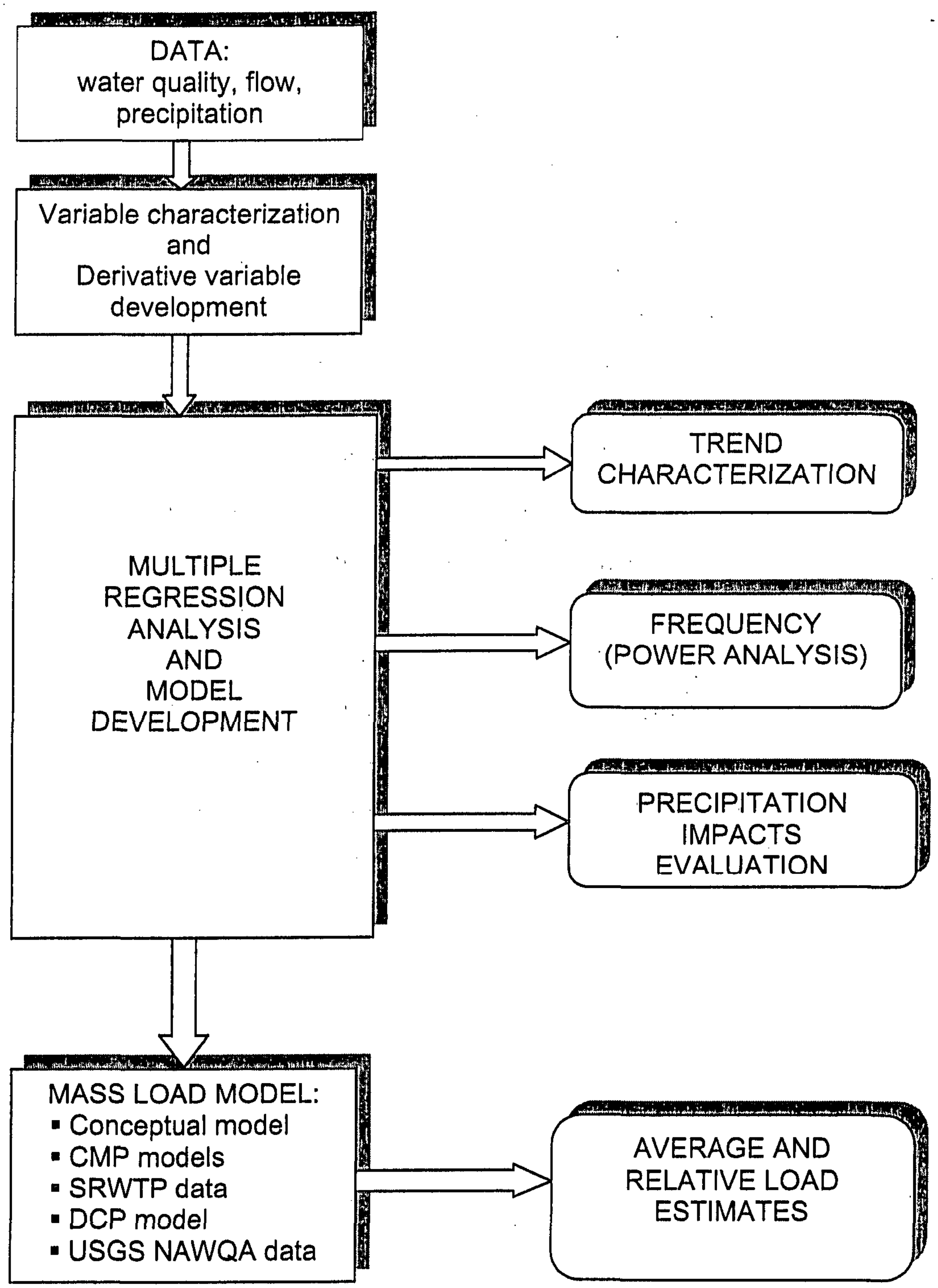


Figure 4-1

CMP Special Study Analytical Approach

5 Coordination and Outreach

In this chapter, coordination and outreach activities of the CMP are described. These activities include coordination with other monitoring programs, public outreach activities, and informational publications.

MONITORING PROGRAMS IN THE REGION

In this section, other water quality monitoring programs in the region are summarized and primary contacts are provided for each of the programs.

Sacramento River Toxic Pollutant Control Program (SRTPCP)

The Sacramento River Toxic Pollutant Control Program is a project which is funded through direct Congressional appropriations channeled through the U.S. EPA budget. The Sacramento Regional County Sanitation District (SRCSD) is the recipient of this funding. The long-term objective of this program is to bring the river into compliance with toxic pollutant standards and protect its beneficial uses through a locally-driven, watershed management approach. The primary contact for this program is Jerry Troyan at the SRCSD (916-875-9144).

The principal elements of the program include:

- Form a stakeholder group and assist in the development of a stakeholder structure.
- Develop and implement a water quality monitoring program throughout the basin to assess the condition of the watershed and to evaluate the need for action by the stakeholder group.
- Identify and evaluate alternative pollutant control options for the significant pollutant sources; and
- Develop a technically feasible, cost-effective and implementable program that will result in achievement of water quality standards in the river and its tributaries.

The stakeholder group was formed in 1996 through a series of stakeholder meetings. The stakeholder group agreed to a name for the overall program, the Sacramento River Watershed Program (SRWP). Efforts are ongoing to increase stakeholder recruitment and participation in the program. A number of subcommittees have been formed, which have become the working units for the program. These subcommittees include the following: Monitoring, Toxics, Biological and Habitat, Public Outreach and Education, and SRTPCP Grant.

The majority of the monitoring program for the watershed was implemented in June 1998 (fish tissue monitoring was initiated in 1997). The program monitors a broad array of parameters which characterize conditions in the watershed, including mercury and other trace metals, pesticides, aquatic toxicity, pathogens, nutrients, minerals, biological parameters, pollutant concentrations in fish tissue, organic matter and temperature.

CMP team members, including Steering Committee members, City and County staff and members of the consultant team are participating in essentially all aspects of the watershed program. The CMP has coordinated extensively with the watershed program from the initiation of the watershed monitoring program.

Sacramento River Basin National Water Quality Assessment Program (NAWQA)

The United States Geologic Survey (USGS) conducted a significant monitoring effort in the Sacramento River watershed from 1996 to 1998. This work was being performed as an element of the NAWQA program for the Sacramento River. The NAWQA program is based on a combination of physiography, land use, hydrology, and contaminant issues for a particular basin. NAWQA is a nation-wide program with the following objectives:

- Describe current water quality conditions for a large part of the Nation's freshwater streams, rivers, and aquifers.
- Describe how water quality is changing over time.

- Improve understanding of the primary natural and human factors that affect water quality conditions.

The primary contact for this program is Joseph Domagalski at the Sacramento USGS office (916-278-3077).

The Sacramento River Basin NAWQA Program includes a set of monitoring sites that will provide information on metals, pesticides, and urban runoff inputs to the Basin. One of the key sources of contaminants being studied was mine pollution, which is a major contributor of acid-mine drainage and trace metals, especially copper, lead and zinc, to the upper reach of the system. Agricultural drainage was also studied to determine pesticide and other contaminant inputs. The NAWQA study addressed urban runoff effects by utilizing data from the Sacramento CMP and a sampling station in Arcade Creek, in addition to the NAWQA data for the Sacramento River.

The NAWQA sampling plan included a total of 11 basic fixed sampling stations in the Sacramento River watershed. Water quality studies conducted by this program included temporal sampling at pre-determined times, synoptic studies during high and/or low flow events, and special studies designed for a particular suite of water quality constituents. Water quality parameters monitored include trace metals, pesticides and other organic contaminants. Bed sediments and aquatic organism tissue were collected for analysis of hydrophobic organic contaminants and trace elements. Water quality samples at reference sites in the Sierra Nevada and Cascade Range were collected as part of synoptic studies and/or bed-sediment, tissue sampling, and other biological studies.

The Sacramento River Basin NAWQA program is currently in a reduced-effort monitoring phase consisting of monthly sampling at two Sacramento River sites for a limited number of water quality parameters. Key staff from the USGS NAWQA program are involved in the CMP, as members of the Technical Review Committee or as participants in the State and Federal Coordinating Committee.

San Francisco Estuary Regional Monitoring Program for Trace Substances

The Regional Monitoring Program for Trace Substances (RMP) is a pollutant monitoring program funded by 63 entities, including municipal dischargers, industrial dischargers, stormwater dischargers, and dredgers, that are located in the San Francisco Bay Estuary. The RMP is managed by the San Francisco Estuary Institute (SFEI). The basic purpose of the RMP is to measure the concentration of trace substances and toxicity in the Estuary. The results of the RMP will provide information on how contaminant concentrations in the Estuary are responding to pollution prevention and other steps being taken by dischargers, and to help to make the determination whether the resources spent on these efforts are having the desired effects. The primary contact for this program is Bruce Thompson at SFEI (510-231-9539).

The principal objectives of the RMP are as follows:

- To obtain high quality baseline data describing the concentrations of toxic trace element and trace organic contaminants in the water and sediment of the San Francisco Estuary.
- To determine seasonal and annual trends in chemical and biological conditions in the Estuary.
- To determine whether water and sediment quality are in compliance with established regulatory objectives; and
- To provide a database on trace contaminants which is compatible with data being developed in other ongoing studies in the Estuary.

In 1996, more than 100 individual chemical parameters were analyzed in water, sediment, and tissue. The frequency for water, sediment and tissue sampling from the up to 25 sampling sites varied between two and three times per year. Bioassays on water and sediment samples were also conducted to determine possible toxicity to selected organisms.

Bruce Thompson of SFEI serves on the CMP Technical Review Committee. CMP consultant team staff have provided additional coordination links by serving on the RMP Program Technical Review Committee.

Central Valley Regional Water Quality Control Board Monitoring Efforts

Staff of the Central Valley Regional Water Quality Control Board (RWQCB) perform water quality monitoring throughout the Central Valley. Key staff from the Central Valley Board serve on the Technical Review Committee for the CMP and are also key participants in the SRWP. The primary contacts for these programs are Valerie Connor (916-255-3111), Christopher Foe (916-255-3113), and Jerry Bruns at the Sacramento office of the Central Valley RWQCB (916-255-3052).

Central Valley Ambient Monitoring Program

Using funding from the Bay Protection and Toxic Cleanup Program (BPTCP), the Central Valley Regional Board staff has performed monitoring in the Sacramento/San Joaquin Delta to determine if the Delta waters exceed either numerical water quality criteria for metals or narrative toxicity objectives. When data indicates exceedances of a narrative objective, follow-up work is conducted including Toxicity Identification Evaluations (TIEs) to determine the specific chemical responsible for the toxicity. In addition, more focused monitoring is undertaken to define the temporal and spatial extent of the toxicity. Results of this monitoring program may be used to identify sources of toxicity.

Sacramento River Wet Weather Mercury Mass Loading Assessment

CVRWQCB has sampled for mercury at a large number of tributaries of the Sacramento River, as well as main-stem sites along the Sacramento River. This data will be important in evaluating control strategy options for mercury within the watershed.

Sacramento Wet Weather Monitoring Program

As part of the ongoing stormwater NPDES permit requirements of the County of Sacramento and the cities of Sacramento, Folsom, and Galt, an annual wet weather monitoring program is conducted. The monitoring program is designed to characterize urban runoff quality, assist in the identification of constituents of concern, and provide information which can be used to assess the effectiveness of the stormwater management program. The primary contacts for this program are Terri Wegener at the County of Sacramento Water Resources Division (916-874-8642), and Larry Nash at the City of Sacramento offices (916-264-1434).

For the urban runoff discharge monitoring element of the program, three urban runoff sites are sampled (Sump 104, Sump 111 and Strong Ranch Slough) for up to five separate storm and dry weather events. Composite and grab samples are collected at each of these urban runoff sites using "clean" sampling techniques to minimize the introduction of contaminants into the samples. Flow-weighted composite samples are collected from the three urban runoff sites for typical storm events. For two of the storm events monitored each season (the "first flush" event and one subsequent storm), the sampling events are coordinated with Ambient Program sampling. Coordinated events include additional grab sampling for several parameters.

In addition to the urban runoff sampling portion of the study, the Sacramento and American rivers are sampled by the Ambient Program during the first flush storm and one of the four subsequent events sampled for urban runoff. Samples are collected from below Nimbus Dam and at Discovery Park on the American River, and at Veterans. Bridge and Freeport Marina on the Sacramento River. Samples are analyzed for total (or total recoverable) and dissolved metals, trace organics, conventional parameters, total and fecal coliform, fecal streptococci, diazinon, chlorpyrifos, and other pesticides.

SWRCB Toxic Substances Monitoring Program

The Toxic Substances Monitoring Program (TSMP) was initiated in 1976 by the California SWRCB to provide a uniform statewide approach to the detection and evaluation of the occurrence of toxic substances in fresh, estuarine, and marine waters of the State through the analysis of the tissues of fish and other aquatic life. The TSMP primarily targets water bodies with known or suspected water quality impairment and is not intended to give an overall assessment of the water quality of each of the State's waters. Funding for this program is determined on an annual basis and no guarantee exists that the program will continue in coming years. The primary contact for this program is Michael Perrone at the SWRCB (916-657-0660).

In the past, samples were collected each year from over 100 locations throughout the state. Samples taken by the California Department of Fish and Game (DFG) are analyzed for trace elements (metals), pesticides, and PCBs. Sampling results are compared to criteria such as Maximum Tissue Residue Levels (MTRLs), U.S. Food and Drug Administration (FDA) action levels, Median International Standards (MISs), and the National Academy of Sciences (NAS) recommended guidelines for predator protection.

The DFG reports annual sampling results to the SWRCB, which then transmits the information to the Regional Boards, and to other Federal, State, and local agencies in the form of an annual TSMP report. The TSMP reports are also routinely transmitted to the Office of Environmental Health Hazard Assessment (OEHHA) of the Cal-EPA, which has responsibility for evaluating pollutant levels based on human health concerns and issuing fish consumption health advisories, if indicated.

TSMP results are used by the State and Regional Board in the statewide Water Quality Assessment/Clean Water Strategy in which water bodies are classified from good to impaired and ranked accordingly. TSMP results are also used in the regulatory activities of the Regional Boards and the Department of Pesticide Regulation.

TSMP samples were most recently collected in the Sacramento region in 1993. During this year, mercury tissue concentrations in white catfish collected from the Sacramento River at Hood and in largemouth bass collected from the American River downstream of the Watt Avenue bridge did not exceed the MIS for mercury (0.5 mg/kg, wet weight, edible portion.) Similar levels were found in white catfish collected from the Sacramento River in 1992. However, in 1991, some of the white catfish collected from the Sacramento River at Hood and some of the Sacramento suckers collected from the American River downstream of the Watt Avenue bridge showed tissue concentrations in exceedance of the MIS for mercury. However, at both locations, the concentrations were below the FDA action level (1.0 mg/kg) wet weight edible portion.

COORDINATION WITH OTHER MONITORING PROGRAMS

Sacramento Regional County Sanitation District staff and consultant staff coordinated with other water quality monitoring programs in the Sacramento region in 1999 and 2000.

In 2000, samples were collected by the Ambient Program crew in coordination with two wet weather monitoring events for the Sacramento Stormwater Monitoring Program. This effort continued the coordination of sampling efforts with the Stormwater Program initiated in 1995.

In addition to the above, District and consultant staff attended numerous meetings of the Sacramento River Watershed Program and shared information with managers or staff of ongoing monitoring programs in the Sacramento River watershed. These other programs included water quality monitoring by the Department of Water Resources, EPA EMAP; USGS NAWQA, Department of Pesticide Regulation, Central Valley Regional Water Quality Control Board, and the Department of Fish and Game.

OUTREACH ACTIVITIES

Creek Week

Representatives from the CMP participated in the Sacramento area's Creek Week activities by exhibiting informative displays about the CMP. This annual, week-long event, involving creek clean-up and environmental education activities, is organized by the Urban Creeks Council. This year's celebration and finale was held on April 17, 2000 at the Discovery Museum Learning Center on Auburn Boulevard in Sacramento. Along with the CMP, about twenty other groups set up displays under the Center's trees to celebrate and educate people about creeks. The CMP offered a hands-on water quality sampling and testing opportunity to the kids attending this grass roots event. "I help to keep my creeks and rivers clean" stickers, which were created in 1997 were distributed to attendees as well as CMP temporary tattoos and CMP information.

Stone Lakes National Wildlife Refuge, "Walk on the Wildside"

Representatives from the CMP participated in the Stone lakes National Wildlife Refuge's "Walk on the Wildside" event in Sacramento County on Saturday, October 16, 1999. The CMP exhibit was on display and the program representatives discussed the coordinated monitoring program as well as the health of the rivers to community members. "I help keep my creeks and rivers clean" stickers, CMP temporary tattoos, and CMP information was distributed.

SUMMARY

There are a number of recently initiated and ongoing monitoring programs in the area that provide water quality data that can be used to assess potential impacts on water quality in the Sacramento River watershed. The CMP continues to carry out activities that foster coordination between the agencies and organizations that implement monitoring programs in the region. In 1999, these activities included continuing communication between the CMP and other monitoring program managers in the region, participation in "Creek Week," and participation in "Walk on the Wildside".

6 Update of Regulatory Issues

This chapter reviews the federal, state and regional regulatory activities and initiatives taken in 1999 that pertain to surface water quality management in California. Additionally, this chapter discusses how these laws, regulations, and policies may impact participating agencies in the Sacramento Coordinated Water Quality Monitoring Program (CMP).

FEDERAL LAWS

The United States Environmental Protection Agency (EPA) is the federal agency responsible for water quality management. The EPA is headquartered in Washington D.C. and includes ten regional offices. EPA Region IX, with offices in San Francisco, is responsible for water quality management in California, Nevada, Arizona, Hawaii and the Pacific territories.

Clean Water Act

The Clean Water Act (CWA, 33 U.S.C. § 1251 *et seq.*) is the federal law that governs and authorizes water quality control activities by EPA. Congress originally passed the Clean Water Act in 1972 as PL 92-500. The Act was last re-authorized and substantially amended in 1987. Although there is much speculation and discussion concerning the CWA in Congress, it is unclear when a CWA reauthorization bill will be adopted.

Section 303(d) Lists and Total Maximum Daily Loads (TMDLs)

Under Section 303(d) of the CWA, States are required to identify waters within their boundaries for which technology-based effluent limitations[1] on point sources are not stringent enough to meet the applicable water quality standard for the receiving water.

[1] The technology standards identified under this section are the Best Practicable Technology ("BPT") control standards for industrial discharges (§301(b)(1)(A)) and secondary treatment requirements for municipal discharges (§301(b)(1)(B)).

Once these waters are identified, States must then rank these waters, taking into account the severity of the pollution and the uses to be made of the identified waters.[2]

The most recent Section 303(d) list in California was issued in 1998 (SWRCB, 1998) and was approved by USEPA in May, 1999. USEPA must either approve a TMDL prepared by the State or must disapprove the State's TMDL and issue its own. NPDES permit limits for listed pollutants must be consistent with the load allocation prescribed in the TMDL. TMDLs for other listed pollutants are scheduled to be developed over the next 13 years, in accordance with the priorities contained in the 1998 303(d) list[3].

For all waters identified by States (and in this case, EPA) pursuant to the 303(d) listing process, Total Maximum Daily Loads (TMDLs) must be established for each of the listed pollutants. TMDLs set the total amount of each pollutant, which can be discharged into a particular waterbody by all sources, that will protect the applicable water quality standards, taking into account seasonal variations and a margin of safety.[4] Sacramento River watershed waterbodies on the final 1998 303(d) list for California are summarized in Table 6-1.

When implemented in the Sacramento River, the TMDL process will lead to development of wasteload allocations (WLAs)[5] and load allocations (LAs)[6]. EPA requires that an adopted WLA/LA demonstrates that the water quality standards will be achieved. The determination of WLAs/LAs will consist of a process of balancing legal constraints, equity, and cost-effectiveness in setting allowable contributions, or loads, from various sources. The WLA/LA process will establish the allowable loading of the

[2] CWA §303(d)(1)(A).

[3] California State Water Resources Control Board (SWRCB). 1998. 1998 California Section 303(d) list and TMDL Priority Schedule for impaired waters of California. California State Water Resources Control Board, Sacramento, California. May 1998.

[4] CWA 303(d)(1)(C). The "margin of safety" buffer takes into account any lack of scientific knowledge concerning the relationship between effluent limitations and water quality.

[5] A "wasteload allocation" (WLA) is the portion of the receiving water's loading capacity that is allocated to an existing or future point source of pollution. A WLA is a type of water quality-based effluent limitation. 40 C.F.R. §130.2(h).

[6] A "load allocation" (LA) is the portion of the receiving water's loading capacity that is allocated to an existing or future non-point source of pollution, or to natural background sources. 40 C.F.R. §130.2(g).

pollutants in question from all sources to the river. Accurate water quality data from the CMP and other monitoring programs will be imperative for use in the load calculation and allocation process.

Since the recent 303(d) list was adopted, probable consequences of discharging into an impaired waterbody have become apparent. In addition to undergoing the TMDL process, dischargers into impaired waterbodies may also contend with restrictions in discharge permits that limit increases in mass loading (i.e., no expanded discharges) or that eliminate dilution due to the impaired status of the receiving waters. EPA has not yet issued official guidance to permit writers that explains the requirements placed on permitted discharges prior to the adoption and implementation of TMDLs. However, EPA has informally issued guidance for performance-based Interim Mass Limits (IMLs) for 303(d)-listed pollutants. IMLs are intended to hold 303(d)-listed pollutant discharges at current mass loads until TMDL studies are completed and final waste load allocations are determined.

These regulations could impose additional restrictions, such as the requirement for offsets of any loads from new or significant expansions of existing sources of listed pollutants. For the Sacramento Regional plant, this would mean that offsets would be required if the discharges increased by 20%. At this point, it is unclear how an offset program would be run in California or whether this requirement will survive after the close of the public comment period on the TMDL regulations.

Table 6-1.

Sacramento River Watershed Waterbodies on the 1998 303(d) List

Water Body	Pollutant/ Stressor(1)	Sources(2)	TMDL Priority(3)
Sacramento River (Red Bluff To Delta)	Unknown Toxicity	Source unknown	Medium
	Mercury	Resource extraction	High
American River, Lower	Unknown Toxicity	Source unknown	Low
	Mercury	Resource extraction	Medium
	Group A Pesticides	Urban runoff/storm sewers	Low
Natomas East Main Drain	Diazinon	Agriculture Urban runoff/storm sewers	Medium
	PCBs	Industrial point sources, Urban runoff/storm sewers	Low
Arcade Creek	Chlorpyrifos	Urban runoff/storm sewers	Medium
	Diazinon	Agriculture, Urban runoff/storm sewers	Medium
Chicken Ranch Slough	Chlorpyrifos	Urban runoff/storm sewers	Medium
	Diazinon	Agriculture Urban runoff/storm sewers	Medium
Strong Ranch Slough	Chlorpyrifos	Urban runoff/storm sewers	Medium
	Diazinon	Agriculture Urban runoff/storm sewers	Medium
Elder Creek	Chlorpyrifos	Urban runoff/storm sewers	Medium
	Diazinon	Agriculture Urban runoff/storm sewers	Medium
Elk Grove Creek	Diazinon	Agriculture Urban runoff/storm sewers	Medium
Morrison Creek	Diazinon	Agriculture Urban runoff/storm sewers	Medium
Delta Waterways	Unknown Toxicity	Source unknown	Medium
	Mercury	Resource extraction	High
	Chlorpyrifos	Agriculture Urban runoff/storm sewers	High
	DDT	Agriculture	Low
	Diazinon	Agriculture Urban runoff/storm sewers	High
	Group A pesticides(4)	Agriculture	Low

(1) Cause of impairment of waterbody
(2) Source of pollutant or stressor causing impairment
(3) Priority for completing TMDLs to address impairment
(4) Group A pesticides include aldrin, dieldrin,chlordane, endrin, heptachlor, heptachlor epoxide, hexachlorocyclohexanes (including lindane), endosulfan, and toxaphene

CWA Sections 303(e) and 305(b)

Section 303(e) requires that each State have a continuing planning process (CPP) for all navigable waters within the State. The CPP must include provisions for effluent limitations and schedules of compliance, area-wide waste management plans and basin plans, TMDLs, procedures for revision, adequate authority for intergovernmental cooperation, a water quality standards implementation plan, residual waste controls, and an inventory and ranking of needed waste treatment works.

CWA section 305(b) requires in every even-numbered year that each State submit to EPA a description of the impairments found in all of the State's waters[7], an analysis of what would be required to meet desired water quality standards, the environmental and economic costs and benefits of such actions, including control of non-point sources, and the date such water quality objectives will be achieved. The purpose of this section of the Act is to provide Congress with the information needed to make a mid-course correction to the adopted "no discharge" policy, to establish a device for periodically measuring the effectiveness of the federal water pollution control program, and to serve as an important planning tool for the States. However, EPA has noted that none of the States have submitted 305(b) Reports that meet all of the requirements of section 305(b), particularly those requirements related to describing the full extent of the economic costs and benefits associated with water quality improvement.

Safe Drinking Water Act

As mandated by the Safe Drinking Water Act (SDWA, Public Law 93-523) passed in 1974, the U.S. EPA regulates contaminants of concern to domestic water supply. Contaminants of concern relevant to domestic water supply are defined as those that pose a public health threat or that alter the aesthetic acceptability of the water. EPA regulates these types of contaminants through the development of primary and secondary Maximum Contaminant Levels (MCLs). MCLs and the process for setting these

[7] Because 303(d) list submitted in 1998 by the State Board was modified by EPA and finalized in 2000, it is expected that the State Board will not submit a new 303(d) list to EPA until 2002.

standards are reviewed triennially. Amendments to the SDWA enacted in 1986 established an accelerated schedule for setting drinking water MCLs. The current edition of the SDWA and related laws was adopted January 1, 2000 (CDWP, 2000)[8].

The recent amendments require, among other things, the protection of source waters and the setting of new drinking water standards. Source water protection involves preventing entry of possible contaminants into waters that are eventually treated by drinking water systems. The source water protection approach requires states to delineate source waters, designate priority watersheds, and schedule source water monitoring and assessments in those watersheds.

In the standards setting area, EPA is required to publish, within 18 months of the enactment of the SDWA amendments, a list of potential contaminants of concern in drinking water that are not currently regulated but which may require regulation in the future. Contaminants of concern to drinking water suppliers that may adversely affect human health include pathogens (e.g. parasites, viruses, enteric bacteria), natural organic matter (precursors for disinfection by-products), and other constituents (trace organics, arsenic, etc.). After a decision has been made to regulate a contaminant, EPA has 3 years to publish a final primary drinking water standard for that contaminant.

Status of EPA's Safe Drinking Water Regulations

EPA recently redesigned key portions of the drinking water regulatory protocol to respond to Congress' adoption of the 1996 SDWA amendments. On October 6, 1997, EPA's drinking water program published a draft list of 58 chemicals and 13 microbial contaminants that are candidates for regulation. The proposed list signaled a turning point for the agency because of the list's greater emphasis on microbes. The final Drinking Water Contaminant Candidate List, required under the 1996 SDWA amendments, was published in the Federal Register by EPA on March 2, 1998 (see 63 Fed. Reg. 10273). This final list contained 10 microbiological contaminants and 50 chemical contaminants.

[8] California, State of: Drinking Water Program (CDWP). 2000. California Safe Drinking Water Act and Related Laws. 7th Edition, January 1, 2000.

As drinking water regulations become more stringent, water purveyors are looking to wastewater dischargers to improve the quality of effluent being placed into surface waters so as to lessen the treatment costs borne by drinking water providers. Pollutants such as total organic carbon (TOC), bromide, pathogens (*Cryptosporidium* and *Giardia*), disinfection by-products (DBP), and dissolved minerals (total dissolved solids (TDS) and chloride) are the main constituents of concern to drinking water sources utilizing Sacramento River and Sacramento/San Joaquin Delta waters. The CMP currently monitors TOC, TDS, conductivity (a surrogate measure for TDS), *Cryptosporidium* and *Giardia,* and pathogen indicator organisms (coliform bacteria).

In December 1998, EPA published the final Stage I Disinfection By-Products Rule (DBPR). The Rule lowered maximum contaminant levels for total trihalomethanes (chloroform, bromodichloromethane, chlorodibromomethane, and bromoform) to 80 μg/l and established new MCLs for haloacetic acids (60 μg/l), chlorite (1,000 μg/L), and bromate (10 μg/l). The Rule also establishes requirements for treatment techniques and TOC removal that are based on the TOC and alkalinity of the source water. The Rule also includes several alternative compliance criteria if the initial TOC removal criteria are not met. Although these requirements may trigger enhanced coagulation and/or other treatment steps and limit (to varying degrees) the ability of water utilities to select treatment options, the TOC removal requirements are structured so that approximately 90% of water treatment facilities are able to comply without resorting to enhanced treatment or consideration of alternative compliance criteria.

The Surface Water Treatment Rule (SWTR) became effective in December 1990. The SWTR requires all surface water treatment systems to remove (or inactivate) 99.9% of Giardia and 99.99% of viruses. These regulations will generally require municipal drinking water supply treatment systems to use disinfectants to achieve compliance with these limits. The SWTR also requires that a disinfectant residual is detectable in 95% or more of monthly distribution system samples and that the disinfectant residual leaving the treatment plant must be maintained at or above 0.2 mg/L at all times.

The Enhanced Surface Water Treatment Rule (ESWTR) proposed increases in the requirements for source water pathogen removal by municipal drinking water supply treatment systems. The rule established more stringent requirements for filtration and turbidity. The ESWTR proposed removal of up to 99.9999 % of both Giardia and Cryptosporidium, and reinforces the SWTR requirement for sanitary surveys of source waters.

Arsenic Maximum Contaminant Level Adoption

The Safe Drinking Water Act Amendments of 1996 mandate that EPA propose a primary drinking water regulation for arsenic not later than January 1, 2000, and a final regulation by January 1, 2001. EPA is proposing to change the arsenic standard in drinking water to 5 ppb to more adequately protect public health. The proposed arsenic standard is intended to protect consumers against the effects of long-term, chronic exposure to arsenic in drinking water. EPA is for the first time proposing a drinking water standard (5 ppb) that is higher than the technically feasible level (3 ppb). If this lower standard is adopted, municipal water suppliers may look to source water improvements as an alternative to installing additional treatment technologies. However, a recent budget bill extends next year's deadline for issuing a final, revised arsenic drinking water standard from January 1 to June 22. By that time, the limit may be raised to 10 ppb.

Endangered Species Act

Endangered Species Act Implementation

The Endangered Species Act (ESA, 16 U.S.C. § 1531 *et seq.*) protects species of fish, wildlife, and plants that are in danger of or threatened with extinction. The listing and proposed listing of various fish species that inhabit the receiving waters as either "threatened", "endangered", or other species of special concern may affect discharges into waters found within the critical habitat of these species. Critical habitat includes areas containing biological and physical features essential to the conservation of the designated species. Section 7 of the Act requires that before actions are taken which may adversely affect designated critical habitat, the U.S. Fish and Wildlife Service or National Marine Fisheries Service (Services) must be consulted. In order to protect listed species, NPDES permitting requirements may be adjusted to promote species recovery and protection.

Proposed ESA Memorandum of Agreement

On January 15, 1999, EPA published a Federal Register notice (64 Fed. Reg. 2742-2757) that contained the Draft Memorandum of Agreement (MOA) between the Environmental Protection Agency (EPA), Fish and Wildlife Service and National Marine Fisheries Service (Services) regarding enhanced coordination under the Clean Water Act (CWA) and the Endangered Species Act (ESA). The proposed MOA would greatly expand the role that the Services play in the national water quality criteria adoption and NPDES permitting processes. This expanded role might extend as far as giving the Services essentially "veto power" over state water quality standards and NPDES permits that might be construed as adversely affecting (i.e., jeopardizing) threatened or endangered species. This provision of power to the Services arguably was not anticipated nor sanctioned by Congress under the CWA or the ESA. It is unclear what actions will be taken by EPA and the Services to amend the MOA prior to finalization of this document. No update regarding finalization of this MOA has been found in the Federal Register.

EPA, in consultation with the Services, agreed to re-evaluate criteria for mercury and selenium. The Services' opinion is that the aquatic life criteria are not sufficiently protective of Federally listed species and should not be promulgated for the State of California. (Federal Register, Vol. 65, No. 97).

Endangered and Threatened Fish Listings

The winter run of the chinook salmon in the Central Valley was originally emergency listed by National Marine Fisheries Service (NMFS) as endangered (4/6/1990), final listed as threatened (11/30/1990), then reclassified to endangered (3/23/1994) for populations in the Sacramento River and its tributaries in California. All naturally-spawned spring-run populations from the Sacramento San Joaquin River mainstem and its tributaries were listed as threatened on December 29, 1999. The fall run of the chinook salmon in the Central Valley is not listed.

The steelhead was listed by NMFS 8/18/1997 as threatened in the Sacramento and San Joaquin Rivers, excluding San Francisco and San Pablo Bay and their tributeries. It was listed by FWS on 6/17/1998. Critical habitat is proposed to include all river reaches and estuarine areas accessible to listed steelhead in the Sacramento and San Joaquin Rivers and their tributaries in California. Also included, among other areas, are river reaches and estuarine areas of the Sacramento-San Joaquin Delta.

Lastly, the Sacramento splittail was listed as threatened on March 10, 1999. The Sacramento splittail occur in Suisun Bay and the San Francisco Bay-Sacramento-San Joaquin River Estuary (Estuary) in California. This species is primarily threatened by changes in water flows and water quality resulting from the export of water from the Sacramento and San Joaquin rivers, periodic prolonged drought, loss of shallow-water habitat, introduced aquatic species, and agricultural and industrial pollutants. Critical habitat has not been designated.

As more aquatic species that inhabit the Sacramento River, the San Francisco Bay, and the Delta system are placed on the threatened or endangered species lists, more restrictions may be placed on water quality and quantity to improve the aquatic habitat for these species. In recent years, the EPA has attempted to promulgate water quality standards to regulate the quantity of flows into the Delta in order to protect listed species. If necessary to ensure the continued survival of these species, it is conceivable that additional, more stringent effluent limitations could be imposed on entities regulated under the NPDES program. These restrictions could also include additional monitoring to determine the effects of pollutants on the endangered or threatened species.

The Magnuson-Stevens Fishery Conservation And Management Act

Among other things, the Magnuson-Stevens Fishery Conservation and Management Act of 1976 (Magnuson Act, 16 U.S.C.A. § 1801 *et seq.*) sets forth a national program for the conservation and management of the fishery resources of the United States to prevent overfishing, to rebuild overfished stocks, to ensure conservation, to facilitate long-term protection of essential fish habitats, and to realize the full potential of the Nation's fishery resources. The National Marine Fisheries Service (NMFS) has primary responsibility for implementing this Act. The emphasis of the Magnuson-Stevens Act is on coastal fisheries and anadromous fish populations. However, the Magnuson-Stevens Act has application to the inland stretches of the Sacramento River due to anadromous fish migration and spawning.

Under provisions of this Act, eight Regional Fishery Management Councils were established and required to prepare fishery management plans (FMPs) for area fisheries, both commercial and recreational, which were determined to require active Federal management. Guidelines for preparation of FMPs in conformance with national standards (§1851 of the Magnuson Act) are published in 50 C.F.R. Part 602. An environmental assessment or environmental impact statement is to be prepared for every FMP submitted. After public hearings on these plans, revised FMPs and draft regulations are submitted to the Secretary of Commerce for approval. As of January 1, 1995, these Councils had implemented 34 FMPs for various fish and shellfish resources, with 11 additional plans in various stages of development. Many of the implemented plans have undergone subsequent amendment (one has been amended more than 30 times), and three plans have been developed and implemented jointly by two or more Councils.

On October 11, 1996, the Sustainable Fisheries Act (SFA) amended the Magnuson Fishery Conservation and Management Act (renamed the Magnuson-Stevens Fishery Conservation and Management Act). SFA amendments and changes to the Magnuson Act include numerous provisions requiring science, management and conservation action by the NMFS. NMFS was mandated to implement these changes and amendments by December 1998. This Act may bring NMFS into the NPDES permit review process where discharges are deemed to have a potential to affect an "essential fish habitat." As with the ESA, this Act may also result in a tightening of wastewater discharge restrictions or additional monitoring requirements in order to protect anadromous fish in the Sacramento River and the Delta.

Coastal Zone Management Act

The Coastal Zone Management Act (CZMA, 16 U.S.C. § 1451 et seq.) regulates land and water uses that may significantly affect the quality of coastal waters and habitats. CZMA also requires the implementation of management measures for non-point sources of pollution to restore and protect coastal waters.

The 1990 amendments to the CZMA allow the definition of "coastal zone" to extend inland "to the extent necessary to control shorelands, the uses of which have a direct and significant impact on the coastal waters". This definition, when taken literally, may extend to all stretches of waterways that are tributary to coastal waters, including the Sacramento-San Joaquin Delta.

The CZMA requires federal, State, and local action. At the federal level, EPA and the National Oceanic and Atmospheric Administration (NOAA) are required to specify management measures to prevent water quality impacts from urban development, agriculture, forestry, and other land uses. At the State level, the SWRCB, in conjunction with the California Coastal Commission, is required to develop a coastal non-point source pollution control program. Furthermore, local governments are directed to implement non-point source pollution control and management measures whenever land use decisions are made. Watershed protection plans developed at the local level and implemented with the coordinated support of federal, State, and regional agencies may satisfy compliance with the CZMA.

FEDERAL REGULATIONS

NPDES Permits

The National Pollutant Discharge Elimination System (NPDES) permit system was established in the Clean Water Act of 1972 to regulate municipal and industrial discharges to surface waters of the U.S. The discharge of wastewater to surface waters is prohibited unless an NPDES permit has been issued which allows that discharge. Each NPDES permit includes the following provisions: effluent and receiving water limits on allowable concentrations and/or mass emissions of pollutants contained in the discharge, prohibitions on discharges not specifically allowed under the permit, provisions which describe required actions by the discharger, including industrial pretreatment, pollution prevention, and self-monitoring activities, as well as other regulatory requirements.

Receiving water monitoring includes at least the following constituents:

- River flow rate
- Chlorine residual
- Dissolved oxygen
- pH
- Turbudity
- Effluent/river dilution ratio
- Temperature
- Electrical conductivity
- Ammonia
- Total nitrogen
- Copper
- Bis (2-ethylhexyl) phthalate
- Lead
- Silver
- Zinc
- Mercury
- Cyanide
- Halogenated volatile organics

National Toxics Rule and California Toxics Rule

On December 22, 1992, EPA promulgated the National Toxics Rule (NTR), to establish numeric criteria for priority toxic pollutants for California and 13 other States that were not in complete compliance with Section 303(c)(2)(b) of the Clean Water Act. For California, the National Toxics Rule established water quality standards for 42 pollutants for which 304(a) water quality criteria exist, but which were not covered under California's statewide water quality regulations.

As a result of the court-ordered revocation of California's statewide water quality control plans in September 1994 (see State Regulatory Framework/Statewide Water Quality Control Plans, below), EPA Region IX initiated efforts to promulgate additional federal water quality standards for California. In May 2000, EPA issued the California Toxics Rule (CTR). The standards contained in the CTR include all priority pollutants for which EPA has issued 304(a) numeric criteria which are not already included in the December 1992 NTR.

Some of the key elements of EPA's CTR included:

- Amended the numeric criteria for 30 toxic pollutants and added new criteria for 8 toxic pollutants to protect aquatic life and human health uses;
- Criteria expressed as dissolved for most trace metals;
- Endorsed the use of translator mechanisms;
- Provided for compliance schedules (3-10 years) to provide time for permittees to meet new standards;
- Provided for mixing zones; and
- Allowed the use of interim limits in NPDES permits.

Although neither the NTR nor the CTR directly affect NPDES permit requirements, both have the potential to contribute to significant regulatory requirements. EPA regulations require that the water quality criteria contained in the CTR (and NTR) be used to set new effluent limits. These regulatory requirements are dependent on the implementation of the NTR/CTR criteria by California's regulatory agencies. Use of these criteria in California's State Implementation Policy and RWQCB permitting processes are described in the State Law section set forth later in this chapter.

EPA'S WATER QUALITY POLICIES

Additional EPA Environmental Criteria

In addition to water quality criteria, EPA has made some initial steps toward adopting other environmental criteria. For example, the Great Lakes Water Quality Initiative premiered the initial wildlife criteria. Endangered species protection is likely to drive the adoption of more such criteria, especially for constituents that tend to bioaccumulate.

The water quality criteria and standards program will fully integrate biocriteria, nutrient criteria and microbial pathogen control with improved chemical-specific criteria, whole effluent toxicity methods and possible sedimentation, flow and wildlife criteria, into criteria and standards programs to better support watershed management for the protection of human health and the maintenance and improvement of the chemical, physical and biological integrity of the Nation's waters. Future criteria initiatives for excessive sedimentation, flow and wildlife will be investigated. These criteria, once fully developed, could produce additional monitoring requirements for the CMP.

EPA's Concept of Independent Applicability

Of importance to any discussion of water quality or environmental criteria is EPA's independent applicability policy. This policy states that the failure to comply with any single criterion is cause to identify a water quality impairment, despite other evidence demonstrating compliance with the intent of the criteria. The policy presumes that all criteria are independently valid for the water body in question. For example, if toxicity tests or biological studies in a waterbody do not indicate a water quality problem, but a single chemical criterion is exceeded in the water column, the independent applicability policy says that the water body must be judged to be impaired. Thus, this policy places significant importance on each criterion proposed for a waterbody or ecosystem and places increased importance on the availability of accurate data. The future of this policy is still uncertain, but it seems to remain intact as EPA recently requested comments on the future applicability of this policy as part of its Advanced Notice of Proposed RuleMaking (ANPRM) for Water Quality Standards.[9]

Antidegradation Procedures

Differing from the two-pronged statutory definition of water quality standards (i.e., uses and criteria to protect uses), EPA defines state water quality standards as being three-pronged -comprised of water quality criteria, designated uses, and an antidegradation policy (40 C.F.R. §131.6). The federal antidegradation policy states that States shall develop and adopt a statewide policy that includes the following primary provisions:

- Existing in-stream uses and the water quality necessary to protect those uses shall be maintained and protected.

[9] see http://www.epa.gov/OST/standards/quality.html

- Where existing water quality is better than the quality necessary to support fishable and swimmable conditions, that quality shall be maintained and protected unless the State finds that allowing a lower water quality is necessary to accommodate important local economic or social development. In allowing lower water quality, the States shall assure that existing uses are fully protected.
- Where high quality waters constitute an outstanding national resource, such as waters of national and State parks, wildlife refuges and waters of exceptional recreational or ecological significance, that water quality shall be maintained and protected.

Strictly interpreted, these procedures could prohibit increased discharges to surface waters that would lower ambient water quality, in the absence of a water quality-based need to do so. EPA may consider changes to the procedures which would allow a *de minimus* change in water quality without requiring satisfaction of rigorous exception procedures. EPA may also consider less restrictive antidegradation procedures for different categories of waters. Additional guidance is expected via the TMDL regulations and guidance currently being prepared by EPA.

CALFED Bay-Delta Program

The mission of the CALFED Bay-Delta Program is to develop a long-term comprehensive plan that will restore ecological health and improve water management for beneficial uses of the Bay-Delta System. The CALFED Bay-Delta Program is managed by an interdisciplinary, interagency staff team and is assisted by technical experts from state and federal agencies as well as consultants.

The CALFED Bay-Delta Program intends to carry out a three-phase process to achieve broad agreement on long-term solutions. First, a clear definition of the problems to be addressed and a range of solution alternatives were developed. Second, to comply with the California Environmental Quality Act (CEQA) and the National Environmental Policy Act (NEPA), a first-tier Environmental Impact Statement (EIS) and

Environmental Impact Report (EIR) was prepared to identify impacts associated with the various alternatives selected[10]. Finally, a project-level or second-tier EIS/EIR will be prepared for each element of the selected alternative.

Twelve alternatives were evaluated in the March 1998 Draft Programmatic EIS/EIR. The CALFED Bay-Delta Program then developed four alternatives, which are the focus and content of the final EIS/EIR issued in July 2000:

- *Alternative 1* - Existing System Conveyance. Delta channels would be maintained essentially in their existing configuration. Several improvements would be made in the south Delta.
- *Alternative 2* - Modified Through-Delta Conveyance. Significant improvements to north Delta channels would accompany the south Delta improvements contemplated under Alternative 1.
- *Alternative 3* - Dual-Delta Conveyance. The dual-Delta conveyance alternative is formed around a combination of modified Delta channels and a new canal or pipeline, connecting the Sacramento River in the north Delta to the SWP and CVP export facilities in the south Delta.
- *Preferred Program Alternative* - Through-Delta Conveyance. The Preferred Program Alternative incorporates elements similar to some of the elements in Alternatives 1 and 2. While it includes a diversion facility on the Sacramento River and channel to the Mokelumne River, the size of tiis facility would be considerably smaller than Alternative 2. If, after additional analysis, the diversion facility is not constructed, the Preferred Program Alternative would be most similar to Alternative 1.

Anticipated beneficial impacts of chosing the preferred alternative is improved water qualify for environmental and urban or agricultural uses from reduced concentrations of many contaminates, including heavy metals, pestide residues, salts. selenium, pathogens, suspended sediments, total organic carbon, and bromides. Potential

---

[10] The complete document can be viewed at http://calfed.ca.gov/environmental_docs/july2000_eis.html.

adverse effects include increases in concentrations of bromide, salinity, total dissolved solids, and total organic carbon in the Delta; increased diversions of water from the Delta, reduced outflow to the Bay and changing Bay salinity; releases of inorganic or organic suspended solids, or toxic substances into the water column in the Delta; increased water temperature and decreased dissolved oxygen concentrations in the Delta; potential decreased instream water quality from reduced in-stream flows associated with new storage facilities; possible increases in salinity in localized areas in the central Delta. Without operation of a diversion facility on the Sacramento River, increases in salinity would be more widespread in the central Delta.

The implementation of this element may have an effect on the monitoring being performed in the Sacramento River watershed, particularly with respect to drinking water constituents of concern (See above section on Safe Drinking Water Act - Status of EPA's Safe Drinking Water Regulations).

STATE LAWS

In California, the State Water Resources Control Board (SWRCB) has broad authority over water quality control issues for the State. Regional authority for planning, permitting, and enforcement is delegated to the nine Regional Water Quality Control Boards (RWQCB).

The SWRCB consists of a full time five-member board appointed by the Governor. The lead staff position is the Executive Officer, who directs divisions responsible for water quality, legal, water rights, loans and grants, public affairs, and administration. The SWRCB is responsible for statewide water quality policy development and exercises the powers delegated to the State by the federal government under the Clean Water Act.

Each of the nine Regional Water Quality Control Boards consists of nine members appointed by the Governor. The Regional Boards are required to formulate and adopt water quality control plans for all areas within the region. Regional Boards are required to establish water quality objectives in the water quality control plans. The

RWQCB responsible for the San Joaquin River and the Sacramento-San Joaquin Delta is the Central Valley Regional Board (Region 5), headquartered in Sacramento.

Other State agencies with jurisdiction or involvement in water quality regulation in California include the Department of Health Services (drinking water regulations), the Department of Pesticide Regulation, the Department of Fish and Game, and the Office of Environmental Health and Hazard Assessment.

Porter-Cologne Water Quality Control Act

The California Legislature enacted the Porter-Cologne Water Quality Control Act (Cal. Water Code § 13000 *et seq.*) to implement federal directives requiring classification of state waters by intended use, adoption of water quality standards to ensure the intended uses were being met, and formulation of plans to achieve the adopted standards. The Porter-Cologne Act provided a comprehensive management system that relied primarily on the permitting of point sources as its control mechanism.

The Porter-Cologne Act applies to point and nonpoint discharge sources to surface and ground waters, and to waste discharges to land. The Porter-Cologne Act creates a water quality control program administered regionally yet overseen through statewide coordination and policy. The State Water Resources Control Board (SWRCB) provides program guidance and oversight to the Regional Boards through adoption of statewide regulations, plans, policies, and administrative procedures. The SWRCB and Regional Boards carry out their water protection authority through specific Water Quality Control Plans or "Basin Plans" which (1) designate beneficial uses, (2) set water quality objectives to protect beneficial uses, and (3) establish programs to achieve these objectives. Such plans may include prohibitions against the discharge of certain types of waste in specified areas under specified conditions. Discharge prohibitions may be adopted for nonpoint sources, such as surface runoff or waste discharge to land, or for direct discharges to surface or ground water. The Porter-Cologne Act also requires the SWRCB to adopt a "State Policy for Water Quality Control," including water quality objectives directly affecting water projects.

The SWRCB and Regional Boards regulate activities affecting water quality and implement water quality control plans through the issuance of Waste Discharge Requirements (WDRs). Any person discharging waste or proposing to discharge waste that could affect the quality of waters of the State, other than discharge into a community sewer system, must submit a Report of Waste Discharge to the Regional Boards unless the Regional Boards waive the filing of a report.

The Porter-Cologne Act provides Regional Boards with additional enforcement powers to address unauthorized discharges, discharges violating WDRs or prohibitions of discharge, violations of reporting or monitoring requirements, or other activities that threaten water quality. The SWRCB may use its water rights authority to enforce requirements for the protection of water quality.

Chapter 5.5 of the Porter-Cologne Act authorizes regulation of point source discharges of pollutants to surface waters through WDRs, which also serve as National Pollutant Discharge Elimination System (NPDES) permits required under the federal CWA (discussed above). Chapter 5.5 also authorizes regulation of sewage sludge use and disposal, disposal of pollutants into wells, and pretreatment of waste.

In addressing nonpoint source problems, the SWRCB and Regional Boards generally use three management approaches: (1) voluntary implementation of Best Management Practices (BMPs), (2) regulatory-based encouragement of BMPs implementation, and (3) effluent requirements. The Regional Boards decide which option(s) to use to address particular problems. The Regional Boards generally refrain from imposing effluent requirements on dischargers that implement BMPs in accordance with a SWRCB or Regional Board order.

Statewide Water Quality Control Plans

State Implementation Policy (SIP)

The SWRCB adopted its Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays and Estuaries of California on March 2, 2000. This State Implementation Policy (SIP) became effective on May 22, 2000. The SIP outlines procedures for NPDES permitting for toxic pollutant objectives that have been adopted in Basin Plans, in the National Toxics Rule and in the California Toxics Rule. The SIP contains procedures for determining which pollutants must have effluent limits, for determining the magnitude of effluent limits, for establishing mixing zones, for controlling chronic toxicity and for establishing site-specific water quality objectives.

Although issued as a "policy," the provisions of this document have full regulatory effect. The main components of this document that are of interest are the rules for establishing water quality-based effluent limitations (WQBELs) for priority pollutant criteria/objectives[11]. The following issues related to WQBELs are included:

- Selecting pollutants for regulation in NPDES permits,
- Calculating water quality-based effluent limitations (WQBELs),
- Translators for metals and selenium,
- Mixing zones and dilution credits,
- Chronic toxicity objectives,
- Ambient background concentrations, and
- Intake water credits.

The implementation procedures outlined in the State Implementation Policy require WQBELs to be established for any constituent for which the ambient or effluent concentration exceeds the lowest applicable criteria in the CTR or NTR. WQBELs are required for any constituent whose effluent concentration exceeds the ambient background concentration. Therefore, accurate assessments of the ambient background concentrations of the constituents of concern are imperative to this process.

In Phase 2 of the ISWP/EBEP re-adoption process, the SWRCB plans to develop and formally adopt the state's ISWP and EBEP. When adopted, these final statewide plans are expected to include the following:

- Incorporation by reference of existing Basin Plan beneficial uses;

[11] The State Implementation Policy explicitly states that its provisions do not apply to combined sewer overflows or stormwater discharges.

- Establishment of state-adopted water quality objectives (the CTR criteria will be included among the alternatives considered in establishing these objectives); and
- Incorporation of the Phase 1 implementation policy, with appropriate modifications, as the program of implementation.

The impact of this Phase of the State Implementation Policy on the CMP is difficult to determine, as there is no way of knowing what the final state-adopted water quality objectives will be. However, it is likely that these plans will be consistent with the criteria in the CTR. The 304(a) "criteria" adopted in the CTR are components of enforceable water quality standards.

Temperature (Thermal Plan)

The Thermal Plan was adopted by the SWRCB in January 1971, was revised in June 1972, and is currently under review to be modified by the SWRCB. The Plan restricts discharges of thermal waste or elevated temperature waste to waters of the State. As it applies to the proposed City of West Sacramento Wastewater Treatment Plant discharge, the Thermal Plan prohibits elevated temperature waste discharges which would increase ambient temperatures by more than 1 degree Fahrenheit over more than 25 percent of the stream cross section.

Bay Protection and Toxic Cleanup Program (BPTCP)

In 1989, the California Legislature codified the Bay Protection and Toxic Cleanup Program (BPTCP) at Cal. Water Code §§ 13390 - 13396.5. Under the BPTCP, "toxic hot spots" are defined as locations in enclosed bays, estuaries, or any adjacent waters in the contiguous zone or the ocean where pollution or contamination affects the interests of the State, and where hazardous substances have accumulated in the water or sediment to levels which might pose a substantial hazard to fish, wildlife (including aquatic life) or humans; or which might adversely affect the beneficial uses of the waterbody; or which causes an exceedance of the adopted water quality or sediment quality objectives.

The BPTCP has struggled over the years in its efforts to establish a policy for implementation of this program. RWQCBs issued proposed cleanup plans in December of 1997. Subsequently, the SWRCB issued a Functional Equivalent Document on the guidance for development of Regional Toxic Hot Spot Cleanup Plans in March of 1998. Issues of contention related to this guidance included the toxic hot spot definition and the criteria to rank toxic hot spots. Fundamental concerns also existed over the quality of data available to make the determinations as to what constitutes a toxic hot spot.

The final guidance was adopted by the SWRCB in the fall of 1998. Regional Boards used this guidance to formulate and adopt the final regional cleanup plans. For the waters assessed by the Central Valley RWQCB, the Delta Estuary was listed as a toxic hot spot for various pesticides (mainly diazinon and chlorpyrifos), mercury, and low dissolved oxygen. Several of these areas were later designated as high priority sites. However, the "cleanup plan" for these areas basically defers cleanup activities to be dealt with as part of the TMDL process under the Clean Water Act section 303(d).

The SWRCB compiled high priority sites from each of the regional plans into a Consolidated Toxic Hot Spots Cleanup Plan. This document, as well as the Functional Equivalent Document (FED), were released for public review and comment in April of 1999. Table 6-2 summarizes waterbodies of interest to the Sacramento watershed that have been listed by the SWRCB as high priority toxic hot spots.

The SWRCB finalized these documents to send them to the California legislature by the statutory deadline of June 30, 1999. No funding has yet been authorized for the BPTCP program at this date. Unless the BPTCP program is given statutory authority to continue, and additional funding mechanisms are authorized by the legislature, the regulatory relevance of the BPTCP is unclear. However, the statutory requirement that Waste Discharge Requirements be reevaluated 120 days after the State's Consolidated Plan is adopted still remains. Therefore, any permitted source that discharges any of the pollutants listed above into a toxic hot spot site may see revisions to permit effluent limits in order to "prevent the further pollution or creation of known toxic hot spots." *See*

SWRCB, Consolidated Toxic Hot Spots Cleanup Plan, Functional Equivalent Document, Appendix A, pg. 6 (April 1999).

Table 6-2.

SWRCB High-Priority Toxic Hot Spots

in the Sacramento River Watershed

Site	Listing Trigger	Pollutant(s)	Source(s)	Proposed Remedial Action	Estimated Cost to Remediate	Benefits of Remediation (Beneficial Uses[1])
Delta Estuary, Cache Creek	Human health impacts	Mercury	Mining, sediment resuspension, NPDES discharges	Various monitoring and studies	$3.1 million	COMM and WILD
Delta Estuary	Aquatic Life Impacts	Diazinon	Dormant sprays on orchards	Deferred to TMDL by 2005	None given	None given
Delta Estuary[2]	Aquatic Life Impacts	Diazinon & Chlorpyrifos	Urban runoff	Deferred to TMDL by 2005	None given	None given
Delta Estuary[3]	Aquatic Life Impacts	Chlorpyrifos	Agricultural use	Deferred to TMDL by 2005	None given	None given
Entire San Francisco Bay	Human Health Impacts	Mercury, PCBs, Dieldrin, Chlordane, DDT, Dioxin	Mining, industrial use of PCBs	Cleanup of New Almaden Mine and Point Potrero; Various Studies & Education	$25 to 45 million	COMM, MAR, EST, REC 1, REC 2, WILD, SHEL

(1)Beneficial Uses as defined in Basin Plans: MAR=Marine, EST=Estuarine, SHEL=Shellfish Harvesting, MUN=Municipal and domestic water supply, AGR=Agricultural water supply, IND=Indeustrial water supply, REC-1=Contact recreation, contact, REC-2= Non-contact recreation, COLD=Coldwater fish habitat, WARM=warmwater fish habitat, MIGR=Migration of anadromous fish species, SPWN=Spawning habitat, WILD=Wildlife habitat, NAV=Navigation.

(2) Specifically, Morrison Creek, Mosher Slough, Five Mile Slough, Mormon Slough & Calaveras Slough.

(3) Ulatis Creek, Paradise Cut, French Camp & Duck Slough.

REGIONAL ACTIVITIES

Basin Plans

Regional water quality control plans (Basin Plans) are required by the Porter-Cologne Act for each of the nine regions of California. The Basin Plans are used to establish beneficial uses, water quality objectives, and implementation programs for the waterbodies within each region.

Central Valley Basin Plan

The Central Valley Regional Board adopted the third edition of the Central Valley Water Quality Control Plan (Basin Plan) in December of 1994. The 1994 Basin Plan included new provisions regarding toxicity, additivity, antidegradation, and mixing zones. Amendments to this Basin Plan were made in February of 1995. The 1995 amendments included a requirement for the Regional Board to adopt site specific objectives to adequately protect threatened and endangered species.

The Basin Plan's designated existing beneficial uses of the Sacramento-San Joaquin Delta into which the SRWTP discharges include:

- municipal and domestic supply (MUN);
- agricultural supply (AGR), including irrigation and stock watering;
- industrial supply (IND), including process waters and service supply;
- contact and non-contact recreation (REC-1 and REC-2);
- cold and warm freshwater fish habitat (COLD and WARM);
- migration (MIGR) of striped bass, sturgeon, shad, salmon, and steelhead;
- spawning (SPWN) of striped bass, sturgeon, and shad;
- wildlife habitat (WILD); and
- navigation (NAV).

However, the Basin Plan notes that beneficial uses may vary throughout the Delta and will be evaluated on a case-by-case basis. The water quality objectives for the Delta are contained in Table 6-3.

Other water quality objectives contained in the Basin Plan limit the chemical constituent concentrations to not exceed the Maximum Contaminant Level (MCL) specified in Title 22 of the California Code of Regulations. Constituents limited to the MCL include: pesticides, radioactivity, inorganic chemicals, fluoride, volatile organic chemicals, and non-volatile organic chemicals. However, the Basin Plan explicitly states that the RWQCB may apply limits more stringent than MCLs to protect beneficial uses.

Currently, the Basin Plan water quality objectives and the National Toxics Rule (NTR) criteria (described above) are the only formally adopted and valid water quality criteria, since the Inland Surface Waters Plan was overturned in 1994 and the EPA's California Toxics Rule and the resultant State Implementation Plan have not yet been promulgated. Thus, the NTR criteria along with the Basin Plan numeric and narrative objectives are the criteria currently being used by the RWQCBs to set waste discharge requirements in NPDES permits. The triennial review process currently being proposed by the RWQCBs may amend the water quality objectives contained in the Basin Plans. The Central Valley RWQCB is considering adding water quality objectives to protect drinking water to the Basin Plan. Any new or amended objectives may justify amending effluent limitations based on these objectives.

Table 6-3.

Governing Basin Plan Water Quality Objectives for the Delta, Fourth Edition – 1998.

Constituent	Maximum Concentration
Arsenic	10 µg/L (a) (b)
Barium	100 µg/L (a)
Copper	10 µg/L (a) (b)
Cyanide	10 µg/L (a) (b)
Iron	300 µg/L (a)
Manganese	50 µg/L (a)
Silver	10 µg/L (a) (b)
Zinc	100 µg/L (a) (b)
Lead	15 µg/L(b)
Dissolved Oxygen	7 mg/L
Thiobencarb	1 µg/L

(a) Dissolved concentrations
(b) Limits are superceded and governed by the CTR.

Fish Consumption Advisories

The San Francisco RWQCB, along with the SWRCB and the California Department of Fish and Game, performed a pilot study to measure contaminants in edible fish tissue from species caught by anglers in the San Francisco Bay. A total of 16 geographic areas and 66 composites of fish tissue were sampled. The results showed the following 6 chemicals of concern relating to fish consumption: PCBs (total Aroclors), mercury, dieldrin, total chlordanes, total DDTs, and total dioxin/furans (TEQ). The Office of Environmental Health Hazard Assessment (OEHHA) used the results of this study to adopt fish consumption advisories for the San Francisco Bay. It should be noted that these fish advisories were the basis for listing many waterbodies as impaired under Section 303(d) of the Clean Water Act. Because of this listing, TMDLs will be required for each of the constituents of concern. OEHHA is also evaluating fish tissue data collected by the Sacramento River Watershed Program for years 1998 to 2000 to determine the need for fish consumption advisories in the Sacramento and American Rivers. They are expecting to set advisories due to mercury in tributaries (Bear-Yuba River, Putah Creek, and others) and reservoirs.

STATE WATERSHED MANAGEMENT INITIATIVE

Watershed management is an integrated holistic approach for restoring and protecting aquatic ecosystems and human health in a specific geographic area (typically, a natural hydrologic drainage basin for a stream, lake, or river. Watershed management usually involves an interest-based planning process that encourages the collaborative efforts of stakeholder groups (individuals, landowners, farmers, POTWs, industries, environmentalists, regulators) to develop a consensus on, and share responsibility for, addressing local water quality or water management problems. The goals of watershed management include:

- Increasing participation at a local level;
- Reducing the impact of sources of pollution;
- Integrating the management of all components of aquatic ecosystems;
- Moving away from command-and-control form of regulation; and
- Optimizing the cost effectiveness of point and non-point source control efforts.

As part of the SWRCB's Strategic Planning Process, the SWRCB implemented a Watershed Management Initiative (WMI) intended to support, sponsor, and facilitate water quality management on a watershed scale in partnership with local stakeholders. The SWRCB, RWQCBs, and EPA have all agreed to integrate management of federal water quality grant monies awarded to the state with the WMI beginning with the federal fiscal year 1997 grant cycle.

Sacramento River Watershed Program

One of the most prominent examples of programs under the Watershed Management Initiative is the Sacramento River Watershed Program. In 1995, Congress appropriated $490,000 to begin the Sacramento River Watershed Program. In 1996, the Sacramento

Watershed Program organized a total of eight stakeholder subcommittees to promote environmental protection and collaboration among all stakeholders for the Sacramento River and its tributaries[12]. The Sacramento River Watershed Program is an effort to bring stakeholders together to share information and resources, to work collaboratively to address all water-related issues within the watershed, and to establish a long-term water quality monitoring program in the watershed. Supplemental congressional appropriations were subsequently approved to continue work on this watershed management effort.

EFFECT OF REGULATORY ACTIVITIES ON THE CMP

The regulatory activities described above influence the monitoring effort and strategic planning for the overall CMP. A summary of specific areas affected by the CMP is provided below.

Safe Drinking Water Act and Regulations

The SDWA emphasis on source water protection in proposed SDWA amendments brings greater attention to monitoring for pathogens, natural organic matter and other drinking water constituents of concern. New EPA rules related to surface water quality as it relates to drinking water places additional pressure on drinking water purveyors to monitor for and attempt to control contaminants of concern. The CMP has added monitoring for constituents (organic carbon, TDS, chloride) related to contaminants of concern for the Sacramento-Delta areas (i.e., bromide, disinfection by-products (DBP), total dissolved solids (TDS), and chloride) to the Ambient Program. New low-level arsenic drinking water standards may mean that the Sacramento River would be listed as an impaired water for arsenic, which would require that a TMDL be prepared and implemented for arsenic.

[12] The 8 subcommittees are as follows: 1) Biological/Habitat subcommittee; 2) Coordinating Subcommittee; 3) Sacramento River Toxic Pollutant Control Program (SRTPCP) Grants Subcommittee; 4) Funding Subcommittee; 5) Toxics Subcommittee; 6) Tributary Subcommittee; 7) Education Subcommittee; and 8) Monitoring Subcommittee.

NPDES Permits

The NPDES permit for the Sacramento Regional Wastewater Treatment Plant (SRWTP) contains specific receiving water monitoring requirements. The permit specifies parameters, sampling locations, and frequencies, and allows CMP monitoring methods and results to be used in satisfaction of at least some of these requirements. The CMP currently monitors for the following parameters specified in the SRWTP NPDES permit: pH, conductivity, temperature, dissolved oxygen, trace metals, selected halogenated volatile organics, and bis(2-ethylhexl)phthtalate.

Under the NPDES permit for Sacramento's Comprehensive Stormwater Management Program (CSWMP), the permittees are required to conduct receiving water quality monitoring. However, the details of this monitoring requirement are not specified, and the CMP is not expressly mentioned in the permit. The permittees are required to submit an annual monitoring work plan specifying how they will meet their monitoring obligations for the coming year, including receiving water monitoring. In the current work plan, they have specified that the stormwater program is participating in the CMP, and that the Ambient Program monitoring will be used to substantially fulfill their receiving water monitoring requirements,.

California Toxics Rule

The adopted California Toxics Rule endorses the use of dissolved metals objectives for aquatic life protection. Thus, the California Toxics Rule supports the continued monitoring of dissolved metals under the Ambient Program. The CMP is currently also performing periodic analyses at low detection levels for trace organic pollutants of concern for which the California Toxics Rule set new limits.

Endangered Species Act (ESA)

As more aquatic species that inhabit the Sacramento River, the San Francisco Bay, and the Delta system are placed on the threatened or endangered species lists, more restrictions may be placed on wastewater discharge limits to improve the aquatic habitat for these species. The CMP participants should be aware that these limits may take the form of wildlife criteria or other criteria to protect fish and wildlife from bioaccumulative chemicals of concern.

Essential Fish Habitat

Under the National Marine Fisheries Service's interpretation of the "essential fish habitat" (EFH) requirements of the Magnuson-Stevens Fisheries and Conservation Management Act, consultation requirements are triggered for any activity "deemed to have a potential adverse effect on essential habitat for salmon, if the activity is planned for an area that is in EFH." The Service's list of covered activities includes wastewater discharges. As such, this interpretation could create a mini-ESA consultation process that could be prompted by water quality standards adoption or NPDES permit renewals.

State Implementation Policy

The State Implementation Policy supports the use of dissolved metals objectives under the California Toxics Rule. However, specific procedures in the SIP continue to place additional emphasis on total recoverable metals concentrations for the purpose of calculating effluent limits for NPDES permits. Because the SIP also requests collection of receiving water data for trace organics detected in treated wastewater effluent and stormwater discharges, it supports the CMP's current monitoring for trace organics and may support expansion of this monitoring element in the future.

SUMMARY

Federal, State, regional and local regulatory agencies are constantly reviewing and revising the regulations and policies that control water quality management. A need exists to keep up-to-date on these regulatory issues and activities to ensure that the CMP and the Ambient Program are adjusted accordingly to meet any new requirements. This chapter summarized new regulatory issues and recent regulatory activities, and discussed the effect that these activities could have, if any, on the CMP. Recommended changes in the CMP based on these issues are discussed later in this report.

7 Ambient Program Adjustments

The following elements of the Ambient Program are reviewed annually by the CMP Steering Committee:

- goals of the Ambient Program
- sampling sites
- sampling and data analysis methods
- constituents and analytical methods
- quality assurance plan
- reporting of Ambient Program results and other CMP activities.

Approved changes to the Ambient Program have typically been implemented in January of the following year.

MODIFICATIONS TO THE AMBIENT PROGRAM IN 1999 AND 2000

The most significant change to the Ambient Program for 1999 is the initiation of trace organics monitoring. The addition of trace organics to Ambient Program monitoring was considered by the Steering Committee to address several issues, including Sacramento Stormwater Program constituents of concern, organic pollutants cited as reasons for 303(d) listing of local surface water, and potential problems with attaining California Toxics Rule water quality objectives. An evaluation of these issues and a proposal for trace organic monitoring has been previously documented in an April 22, 1998 memorandum (LWA 1998). The Steering Committee approved quarterly monitoring for the following trace organic pollutants at all five Ambient Program sites: carbofuran, chlorpyrifos, diazinon, malathion, methyl parathion, polycyclic aromatic hydrocarbons (PAHs), pentachlorophenol, and 2,4,6-trichlorophenol. Monitoring for trace organics was initiated in April, 1999 and has been continued on a quarterly basis in 2000.

The CMP Steering Committee is currently considering a proposed workplan to formalize the process of evaluating the CMP monitoring program on biennial basis. If implemented, this effort would result in recommendations for monitoring to be conducted in 2001-2002.

At this time, no other changes in Ambient Program constituents, or sampling and analytical methods are recommended, and no changes in Ambient Program monitoring locations or frequency are recommended. The current CMP monitoring effort is summarized in Table 7-1.

Table 7-1.

CMP Monitoring Program, 2000-2001.

Parameter	Frequency	Location(1)	Proposed Lab	Analytical Method
Standard conventionals(2)	12X/year	All locations	SRWTP	Various
Dissolved solids, total (TDS)	12X/year	All locations	SRWTP	EPA 160.1
Organic carbon, filtered and unfiltered	12X/year	All locations	SFL	SM 5310C
Cyanide	4X/year	All locations	Frontier	EPA 355.2
Total coliforms	12X/year	All locations	SRWTP	SM 9221B
Fecal coliforms	12X/year	All locations	SRWTP	SM 9221E
E. Coli	12X/year	All locations	SRWTP	SM 9221E mod
Cryptosporidium	12X/year	All locations	BioVir	EPA 1623
Giardia	12X/year	All locations	BioVir	EPA 1623
Trace metals(3), filtered and unfiltered	4X/year	All locations	Frontier	EPA 1638
Mercury, filtered and unfiltered	12/year	All locations	Frontier	EPA 1631 mod
Methylmercury, filtered and unfiltered	12/year	All locations	Frontier	EPA 1631
Chlorpyrifos	12/year	All locations	Fairbairn Lab	ELISA
Diazinon	12/year	All locations	Fairbairn Lab	ELISA
PAHs	4X/year	All locations	AXYS	GC/MS mod EPA 8270
Chlorophenols	4X/year	All locations	AXYS	GC/MS mod EPA 1653
OP Pesticides	4X/year	All locations	APPL	EPA 8141A
Carbamate Pesticides (carbofuran)	4X/year	All locations	APPL	EPA 8321
Hexachlorobenzene	4X/year	Freeport, R-3	APPL	EPA 8260
Bis (2-ethylhexl) phthalate	4X/year	Freeport, R-3	APPL	EPA 625

(1) Locations include Nimbus and Discovery Park on the American River, and Veterans Bridge, Freeport, and River Mile 44 on the Sacramento River.

(2) hardness, suspended solids, pH, conductivity, temperature, and dissolved oxygen.

(3) Arsenic, cadmium, chromium (unfiltered only), copper, lead, nickel, and zinc.

8 References

Abacus. 1992. *StatView*, Abacus Concepts, Berkeley, CA, 1992.

Administrative Procedures Act (APA), Cal. Gov't code §11370 *et seq.*

Bay Protection and Toxic Cleanup Program (BPTCP), Cal. Water Code §§ 13390 - 13396.5.

CALFED Bay-Delta Program 1998. Draft Programmatic Environmental Impact Statement/Environmental Impact Report. March 16, 1998.

California Environmental Quality Act (CEQA), Cal. Pub. Res. Code §21000-21177.

California Toxics Rule (CTR), Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California; Final Rule. 40 CFR Part 131, Federal Register No. 97. May 18, 2000.

Clean Water Act (CWA), 33 U.S.C. §§ 1251 *et seq.*

CVRWQCB 1995. Water Quality Control Plan (Basin Plan), 3rd Edition. Central Valley Regional Water Quality Control Board (CVRWQCB). Amended, September 1995.

Drinking Water Contaminant Candidate List. 63 Federal Register 10273.

Helsel 1990. Less Than Obvious. *Environmental Science and Technology*. Vol. 24, No. 12, pp. 1766-1774.

Helsel and Cohn 1988. Estimation of Descriptive Statistics for Multiply-Censored Water Quality Data. *Water Resources Research*. Vol. 24, No. 12, pp. 1997-2004.

LWA 1995. Sacramento Coordinated Water Quality Monitoring Program 1994 Annual Report. Prepared for the Sacramento Regional County Sanitation District, Sacramento County Water Agency, and the City of Sacramento. Larry Walker Associates (LWA). March, 1995.

LWA 1996. Sacramento Coordinated Water Quality Monitoring Program 1995 Annual Report. Prepared for the Sacramento Regional County Sanitation District, Sacramento County Water Agency, and the City of Sacramento. Larry Walker Associates (LWA). February, 1996.

LWA 1997. Sacramento Coordinated Water Quality Monitoring Program 1996 Annual Report. Prepared for the Sacramento Regional County Sanitation District, Sacramento County Water Agency, and the City of Sacramento. Larry Walker Associates (LWA). December, 1997.

LWA 1998. Sacramento Coordinated Water Quality Monitoring Program 1997 Annual Report. Prepared for the Sacramento Regional County Sanitation District, Sacramento County Water Agency, and the City of Sacramento. Larry Walker Associates (LWA). July, 1998.

LWA 2000. Sacramento Coordinated Water Quality Monitoring Program Technical Memorandum: Special Study Data Analyses of Ambient Monitoring Program Water Quality Data. Prepared for the Sacramento Regional County Sanitation District, Sacramento County Water Agency, and the City of Sacramento. Larry Walker Associates (LWA). February, 2000.

Magnuson-Stevens Fishery Conservation and Management Act of 1976 (Magnuson Act). 16 U.S.C.A. §§ 1801 *et seq.*

National Toxics Rule (NTR), 40 C.F.R. §131.36.

Porter-Cologne Water Quality Control Act, California Water Code §§13000 *et seq.*

SCRSD 1999. The Ambient Monitoring Program of the CMP: Standard Operating Procedures 1999. Sacramento Regional Wastewater Treatment Plant Control Laboratory/Plant Engineering. Sacramento County Regional Sanitation District (SRCSD), Elk Grove, California.

Siepmann, S., and Finlayson, B. 2000. Water Quality Criteria for Diazinon and Chlorpyrifos. Pesticide Investigations Unit, California Department of Fish and Game, Rancho Cordova, CA.

SWRCB 1990. Pollutant Policy Document, San Francisco Bay/Sacramento-San Joaquin Delta Estuary. State Water Resources Control Board (SWRCB), Sacramento, California, June, 1990.

SWRCB 2000. Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California. California State Water Resources Control Board (SWRCB), 2000.

SWRCB 1991. California Inland Surface Waters Plan: Water Quality Control Plan For Inland Surface Waters Of California. California State Water Resources Control Board (SWRCB), 1991

SWRCB 1991. California Inland Surface Waters Plan: Water Quality Control Plan For Enclosed Bays and Estuaries Of California. California State Water Resources Control Board (SWRCB), 1991.

SWRCB 1993. Status Of The Bay Protection And Toxic Cleanup Program: Staff Report. California State Water Resources Control Board (SWRCB), Sacramento, California, November, 1993.

SWRCB 1997. Draft Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays and Estuaries of California and the Functional Equivalent Document (State Implementation Policy). California State Water Resources Control Board (SWRCB). September 1997.

SWRCB 1998. Functional Equivalent Document and Water Quality control Policy for Guidance on the Development of Regional Toxic Hot Spot Cleanup Plans. State Water Resources Control Board (SWRCB). March 1998.

USEPA 1995. Method 1669: Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels. United States Environmental Protection Agency (USEPA), Office of Water. April 1995.

USEPA 1999. National Recommended Water Quality Criteria—Correction. EPA 822-Z-99-001. U.S. Environmental Protection Agency (USEPA), Office of Water. Washington, DC. April 1999.

USEPA 1997. Proposed California Toxics Rule (CTR), Vol. 62, No. 150, Federal Register, §§42160 *et seq.*.

USEPA 2000. Final California Toxics Rule (CTR), Vol. 65, No. 97, Federal Register, §§31682 *et seq.*.

USGS 2000. Water-Quality Assessment of the Sacramento River Basin, California: Water-Quality, Sediment and Tissue Chemistry, and Biological Data, 1995-1998. U.S. Geological Survey Open-File Report 00-391. U.S. Geological Survey, Sacramento, California. 2000.

Zar 1984. *Biostatistical Analysis*, 2nd ed., Prentice-Hall, Englewood Cliffs, New Jersey, 1984.

A Review of Quality Control Data

Quality Control (QC) data for Ambient Program events 109 through 126, collected from January 1999 through June 2000 are reviewed herein. Quality Control data were evaluated using methods outlined in Chapter 2. Sample results were reviewed for conformance with recommended allowable holding times for specific analyses and for compliance with Ambient Program data quality objectives for laboratory and external QC results. Internal laboratory QC data reviewed include results for method and reagent 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 and equipment blanks, filter/bottle blanks, and blind spikes. Ambient Program specifications for data quality are summarized in Table A-1. Evaluation procedures outlined in Chapter 2 were used to assess compliance with data quality objectives for the Ambient Program. A summary of the QC checks performed for the Ambient Program data validation is presented in Figure A-1. The flow chart illustrates how QC samples and specific steps in the QC data review procedures are used to evaluate the quality of data produced by the Ambient Program. The results and discussion of the QC data review for Ambient Program events 109 through 126 are presented in the following sections.

HOLDING TIMES

Data quality objectives for holding times conformed to EPA recommendations specified for the analytical methods used for individual parameters. Allowable holding times ranged from 6 hours for microbiological analyses to 6 months for metals and hardness (after preservation). All samples collected for Ambient Program Events 109 through 126 were analyzed within acceptable holding times and no data were qualified due to violation of holding time specifications. A summary of allowable holding times and compliance for individual analytes is presented in Table A-2.

LABORATORY QC RESULTS

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 Ambient Program data quality objective for laboratory method and filter blanks was defined as below the Ambient Program 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. Mercury results were excluded from this evaluation because results reported for mercury are corrected for concentrations detected in laboratory blanks.

For Ambient Program Events 109 through 126, copper was detected at greater than program reporting limits in laboratory method blanks in one event. Copper, mercury, nickel, and zinc were detected at greater than program reporting limits in a total of 6 filter blanks. These problems were reviewed by the laboratory as they occurred, and all measures were taken to eliminate laboratory contamination. PAHs were detected in 3 of 5 laboratory method blanks analyzed. These results indicate that the analytical laboratory (Axys Analytical Services, Ltd.) may have a systematic contamination problem with. this analysis.

Additional concerns related to filter blank analyses were six cases in which dissolved organic carbon results were greater than the total organic carbon results for the same sample event. In five of these cases, the difference between the DOC and TOC results were less than the detection limit (1.5 mg/L), and therefore did not require qualification. However, the frequency of these occurances indicate a need for more filter blank analyses (only two were performed for DOC) and improved detection limits. Both of these adjustments have already been implemented by the Ambient Program.

The overall success rates for analyses of laboratory method and filter blanks was 98% and 94%, respectively. With the exceptions noted, these results indicate that laboratory contamination of water quality samples is not a significant problem for the Ambient Program. Results for laboratory method and filter blanks for events 109 through 126 are summarized in Tables A-3 and A-4.

Laboratory Control Samples

Laboratory control samples (standard reference materials) were analyzed to evaluate analytical accuracy. The Ambient Program data quality objective for laboratory control sample recoveries was defined as the range between 80% and 120% for all parameters, with the exception of trace organic compounds and pesticides, which have recovery targets specific to each individual analyte. If recoveries are outside the desired range, associated samples results are qualified as "low- or high-biased" as indicated by the control sample recovery.

Percent recovery of laboratory control samples is calculated as:

$$\%\ \text{Recovery} = 100\% \times \frac{\text{measured concentration}}{\text{expected concentration}}$$

For Ambient Program Events 109 through 126, no percent recoveries of laboratory control samples were outside project specifications. The overall success rate for analyses of laboratory control sample recoveries was 100%. These results indicate that analytical accuracy was adequate for analysis of water quality samples for the Ambient Program. Results for laboratory control sample recoveries for events 109 through 126 are summarized in Table A-5.

Laboratory Control Sample Duplicates

Analyses of laboratory control sample duplicate samples were performed to evaluate analytical precision. The Ambient Program data quality objective for laboratory control sample duplicates was defined as relative percent differences of less than or equal to

25%. If laboratory control sample duplicate results are outside this range, associated samples results are qualified as "estimated" (not reproducible) due to analytical variability. Relative percent difference (RPD) for laboratory control sample duplicates is calculated using recovered spike concentrations:

$$\text{RPD} = 100\% \times \frac{\text{absolute value of (spike 1 - spike 2)}}{\text{average of spike 1 and spike 2}}$$

where,

spike = measured spiked concentration - measured sample concentration.

For Ambient Program Events 109 through 126, all laboratory control sample duplicate RPDs were within program specifications for all analytes. No qualification was necessary based on these results. Results for laboratory control sample duplicate RPDs for events 109 through 126 are summarized in Table A-6.

Laboratory Duplicates

Analysis of duplicate samples was conducted to evaluate analytical precision. The Ambient Program data quality objective for laboratory duplicates was defined as relative percent differences (RPD) of less than or equal to 25%. If laboratory duplicate results are outside this range, associated samples results are qualified as "estimated" (not reproducible) due to analytical 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, or if matrix spike duplicate results were acceptable. Relative percent difference (RPD) of laboratory duplicate analyses is calculated, using sample results rather than spike recoveries, with the following formula:

$$\text{RPD} = 100\% \times \frac{\text{absolute value of (replicate 1 - replicate 2)}}{\text{average of replicate 1 and replicate 2}}$$

For Ambient Program Events 109 through 126, two laboratory duplicate results were outside program specification—one each for hardness and TSS). The overall success rate for analyses of laboratory control sample duplicate RPDs was 99%. These results indicate that analytical precision was adequate to produce reliable data for water quality samples for the Ambient Program. Results for laboratory duplicate analyses for events 109 through 126 are summarized in Table A-7.

Matrix Spike Recoveries

Analyses of matrix spike samples were performed to evaluate the effect of water quality sample matrix on analytical accuracy. The Ambient Program data quality objective for matrix spike recoveries was defined as the range between 80% and 120% for all parameters. When a matrix spike does not meet DQOs, associated sample results are considered "estimated" due to matrix interference. Percent recovery of matrix spikes is calculated as:

$$\% \text{ Recovery} = 100\% \times \frac{(\text{measured spiked concentration} - \text{measured sample concentration})}{\text{true spike concentration}}$$

For Ambient Program Events 109 through 126, matrix spike recoveries exceeded program specifications for only one analysis for hardness. The overall success rate for analyses of matrix spike recoveries was 99%. 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 Ambient Program. Results for matrix spike recoveries for events 109 through 126 are summarized in Table A-8.

Matrix Spike Duplicates

Analyses of matrix spike duplicate samples were performed to evaluate the effect of water quality sample matrix on analytical precision. The Ambient Program data quality objective for matrix spike duplicates was defined as relative percent differences of less than or equal to 25%. If matrix spike duplicate results are outside this range, associated samples results are qualified as "estimated" (not reproducible) due to matrix variability. Relative percent difference (RPD) for matrix spike duplicates is calculated in the same manner as for laboratory duplicates, using recovered spike concentrations instead of measured sample results:

$$\text{RPD} = 100\% \times \frac{\text{absolute value of (spike 1 - spike 2)}}{\text{average of spike 1 and spike 2}}$$

where,

spike = measured spiked concentration - measured sample concentration.

For Ambient Program Events 109 through 126, all matrix spike duplicate RPDs were within program specifications for all analytes, and the overall success rate for analyses of matrix spike duplicates was 100%. 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 Ambient Program. Results for matrix spike duplicate RPDs for events 109 through 126 are summarized in Table A-9.

FIELD QUALITY CONTROL RESULTS

Field Blanks

Field blanks were submitted and analyzed to evaluate the potential for sampling equipment and procedures to contaminate water quality samples. The Ambient Program 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 or equipment blanks, sample results were accepted without qualification if the 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 Events 109 through 126, Ambient Program analytes were detected above reporting limits in eight field blank analyses (one analysis for cadmium, five analyses for mercury, and two analyses for PAHs). No mercury data were qualified because all results were greater than 10x the field blank result. The overall success rate for analysis of field blanks was 93%. 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 Ambient Program. Results for field blanks for events 109 through 126 are summarized in Table A-10.

Milli-Q Blanks

"Milli-Q" blanks consist of "mercury-free" blank water (supplied by Frontier Geosciences) decanted directly into sample containers. Milli-Q blanks serve primarily to ensure that the field blank water is free from the analytes of interest, and do not result directly in qualification of sample results. The Ambient Program data quality objective for Milli-Q blank results was defined as below the program reporting limit, but the QA results are used primarily to support qualifications due to field blank contamination.

Fourteen Milli-Q blanks were analyzed for sample events 109 through 126. No results were qualified on the basis of analytes detected in Milli-Q blanks. Mercury concentrations greater than the program reporting limit were detected in 2 analyses. The overall success rate for analysis of Milli-Q blanks was 86%. Results for Milli-Q blanks for events 109 through 126 are summarized in Table A-11.

Filter/Bottle Blanks

Filter/bottle blanks are used to evaluate the potential for contamination due to the use of 1-liter polyethylene sample bottles for analysis of metals. The filter/bottle blanks are generated by randomly selecting an empty bottle from the lot of sample containers and submitting the bottle to the contract lab to use as a filter blank or to analyze for contamination due to the sample containers. The Ambient Program data quality objective for filter/bottle blank analyses is defined as below the program reporting limit. Sample results are generally not qualified on the basis of filter/bottle blank analyses. No filter/bottle blanks were submitted or analyzed for Ambient Program Events 109 through 126 (see Table A-12), and therefore no results were qualified on this basis.

EXTERNAL QUALITY CONTROL SAMPLES

Field Duplicates

The purpose of duplicate field samples is to measure the reproducibility (i.e. precision) of analyte concentrations in field samples split from the same composite or grab sample. The results provide a measure of the variability attributable to sample handling and aliquoting procedures after sample collection. The Ambient Program data quality objective for field duplicates (splits) 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. RPD is calculated in the same manner as described above for laboratory duplicates.

For Events 109 through 126, field duplicate RPDs exceeded program specifications for 24 sample results. The overall success rate for analysis of field duplicates was 91%. These results indicate that sample handling-generated variability in Ambient Program 1999-2000 sample results was slightly reduced in comparison to Ambient Program Events 97 through 108 (January 1998 – December 1998), and suggest that additional attention to sample handling procedures may be warranted. Results for field duplicates for events 109 through 126 are summarized in Table A-13.

BLIND SPIKES

The purpose of submitting blind spike samples is to provide an external measure of analytical accuracy achieved by the analyzing laboratory. The Ambient Program data quality objective for blind spike recoveries was between 80% and 120% for all analytes. Percent recovery of blind spikes is calculated by the same method as laboratory control sample percent recovery. Samples were typically spiked at levels of five to ten times the program reporting limit. No blind spikes were submitted for this monitoring period.

SUMMARY

From January 1999 through June 2000, the Ambient Program successfully collected and analyzed 2041 of 2269 planned analyses for a completion rate of 90%. Of the 2041 completed analyses, data qualifications were required for 43 analytical results, leaving 1996 unqualified results for an overall analytical success rate of 97.9% for Events 109 through 126. These results are summarized in Table A-15.

The quality control results for Events 109 through 126 indicate that sampling and analytical methods were generally adequate to produce reliable data for the Ambient Program, with the possible exceptions of PAH and dissolved organic carbon analyses. Concerns related to analysis of organic carbon have already been addressed by the Ambient Program. Concerns related to PAH analyses are currently being investigated by the Ambient Program. Sample results that were qualified on the basis of the quality control data are summarized in Table A-16.

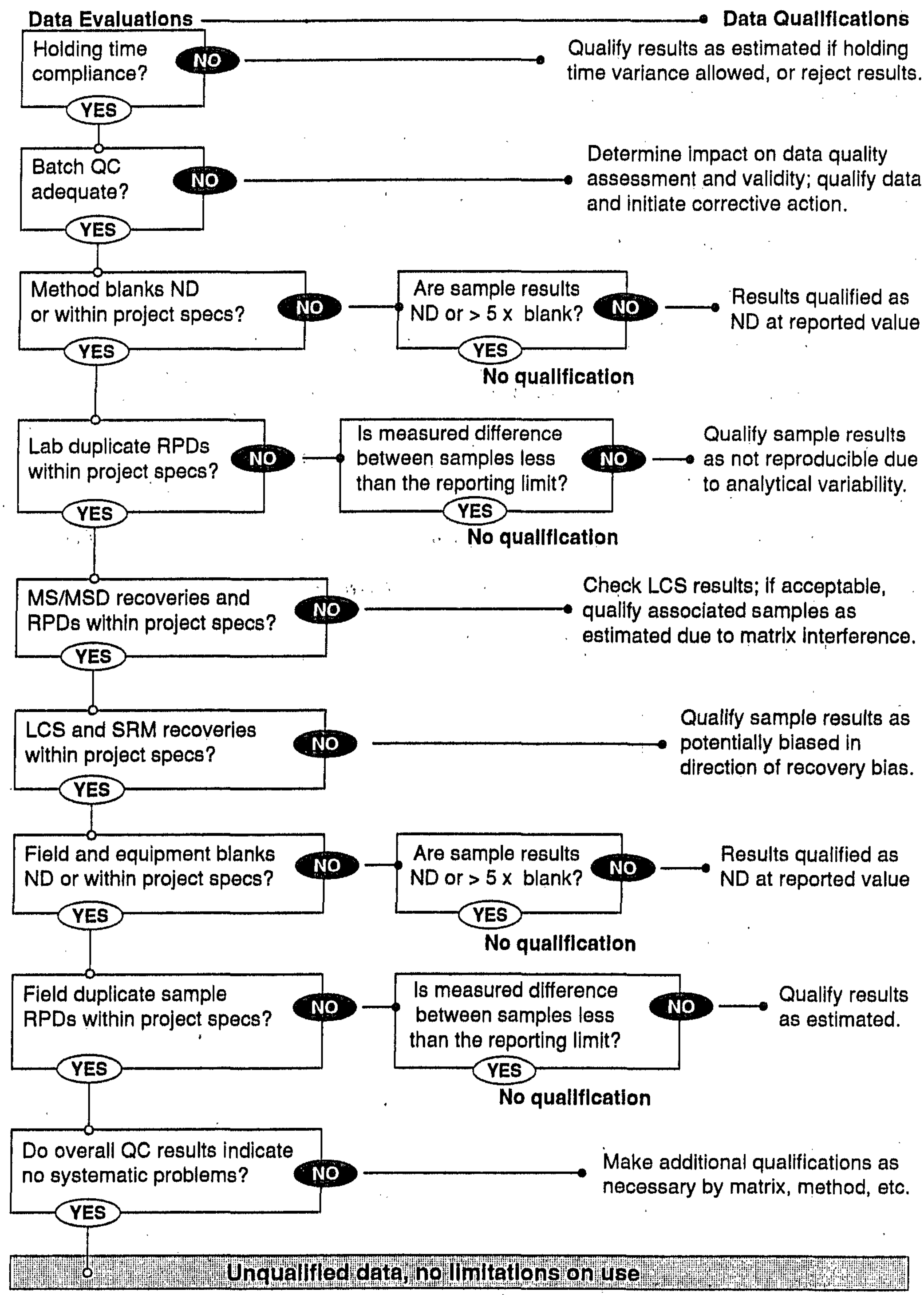


Figure A-1.

Flow Chart of QA/QC Data Evaluation Procedures for Ambient Program Events 109 through 126.

Table A-1.

Summary of Quality Assurance Samples and Program Specifications

QA sample type	Parameter evaluated	*Source of* contamination or variation	Ambient Program QA specifications
field blanks	contamination	sampling and equipment	< reporting limit
"Milli-Q" blanks	contamination	blank water	< reporting limit
filter/bottle blanks	contamination	sample container	< reporting limit
duplicate samples (splits)	precision	sample handling	≤ 25% RPD
"blind" spikes (SRM)	accuracy	analytical	80 - 120% recovery
method blanks	contamination	analytical procedures	< reporting limit
filter blanks	contamination	analytical procedures	< reporting limit
lab control samples (LCS)	accuracy	analytical procedures	80 – 120% recovery
duplicate sample and LCS analyses	precision	analytical procedures	≤ 25% RPD
matrix spikes	accuracy	matrix effects	80 – 120% recovery
matrix spike duplicates	precision	matrix effects	≤ 25% RPD

Table A-2. Summary of Compliance with Holding Times for Ambient Program Events 109 through 126

	DQO (1)	number of sample results (2)	number outside DQO (3)	% success (4)
arsenic, total	6 months	90	0	100%
cadmium, dissolved	6 months	49	0	100%
cadmium, total recoverable	6 months	73	0	100%
chromium, total recoverable	6 months	88	0	100%
copper, dissolved	6 months	89	0	100%
copper, total recoverable	6 months	89	0	100%
lead, dissolved	6 months	47	0	100%
lead, total recoverable	6 months	80	0	100%
mercury, dissolved	6 months	90	0	100%
mercury, total	6 months	89	0	100%
nickel, dissolved	6 months	56	0	100%
nickel, total recoverable	6 months	89	0	100%
zinc, dissolved	6 months	83	0	100%
zinc, total recoverable	6 months	82	0	100%
chlorpyrifos	48 hours	49	0	100%
diazinon	48 hours	73	0	100%
other OP pesticides	40 days	17	0	100%
carbofuran	40 days	19	0	100%
chlorophenols	40 days	17	0	100%
PAHs	40 days	22	0	100%
hexachlorobenzene	40 days	22	0	100%
hardness	6 months	85	0	100%
TSS	7 days	85	0	100%
DOC	28 days	12	0	100%
TOC	28 days	10	0	100%
chloride	28 days	69	0	100%
total coliform	6 hours	70	0	100%
fecal coliform	6 hours	71	0	100%
temperature	field measured	81	0	100%
dissolved oxygen	field measured	81	0	100%
pH	field measured	82	0	100%
conductivity	field measured	82	0	100%
	total for all parameters	2041	0	100%

(1) Data Quality Objectives (DQO) for holding times are as specified in EPA analytical methodology documents;
(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 A-3. Summary of Laboratory Method Blank Results for Ambient Program Events 109 through 126

	DQO (1)	n tested (2)	number outside DQO (3)	% success (4)
arsenic	< RL	18	0	100%
cadmium	< RL	18	0	100%
chromium	< RL	18	0	100%
copper	< RL	18	1	94%
lead	< RL	18	0	100%
mercury	(5)	18	0	100%
nickel	< RL	18	0	100%
zinc	< RL	18	0	100%
OP pesticides (EPA 8141)	< RL	5	0	100%
carbofuran (EPA 632)	< RL	5	0	100%
EPA 625 chlorophenols	< RL	5	0	100%
PAHs	< RL	5	3	40%
Hexachlorobenzene	< RL	5	0	100%
TOC	< RL	2	0	100%
total for all parameters		171	4	98%

(1) Data Quality Objective (DQO) for method blanks is less than the reporting limit (RL) for the parameter (see text);
(2) Total number of results for parameter;
(3) Number of results not achieving DQO;
(4) Success Rate, i.e percent of results achieving DQO;
(5) Mercury results are corrected for blank concentrations;

Table A-4. Summary of Laboratory Filter Blank Results for Ambient Program Events 109 through 126

	DQO (1)	n tested (2)	number outside DQO (3)	% success (4)
cadmium	< RL	16	0	100%
copper	< RL	16	1	94%
lead	< RL	16	0	100%
mercury	(5)	16	1	(5)
nickel	< RL	16	1	94%
zinc	< RL	16	3	81%
DOC	< RL	2	0	100%
total for all parameters		98	6	94%

(1) Data Quality Objective (DQO) for filter blanks is
less than the reporting limit (RL) for the parameter (see text);
(2) Total number of results for parameter;
(3) Number of results not achieving DQO;
(4) Success Rate, i.e percent of results achieving DQO;
(5) Mercury results are corrected for blank concentrations;

Table A-5. Summary of Laboratory Control Sample Recoveries for Ambient Program Events 109 through 126

	DQO (1)	n tested (2)	number outside DQO (3)	% success (4)
arsenic	80%–120%	18	0	100%
cadmium	80%–120%	18	0	100%
chromium	80%–120%	18	0	100%
copper	80%–120%	18	0	100%
lead	80%–120%	18	0	100%
mercury	80%–120%	18	0	100%
nickel	80%–120%	18	0	100%
zinc	80%–120%	18	0	100%
hardness	80%–120%	17	0	100%
TOC	80%–120%	1	0	100%
DOC	80%–120%	1	0	100%
OP pesticides (EPA 8141)	various	5	0	100%
carbofuran (EPA 632)	various	5	0	100%
total for all parameters		173	0	100%

(1) Data Quality Objective (DQO) for Laboratory Control Sample recoveries is 80% to 120% for all parameters.
(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 A-6. Summary of Laboratory Control Sample Duplicates for Ambient Program Events 109 through 126

	DQO (1)	n tested (2)	number outside DQO (3)	% success (4)
arsenic	≤ 25% RPD	10	0	100%
cadmium	≤ 25% RPD	10	0	100%
chromium	≤ 25% RPD	10	0	100%
copper	≤ 25% RPD	10	0	100%
lead	≤ 25% RPD	10	0	100%
nickel	≤ 25% RPD	10	0	100%
zinc	≤ 25% RPD	10	0	100%
OP pesticides (EPA 8141)	≤ 25% RPD	5	0	100%
carbofuran (EPA 632)	≤ 25% RPD	5	0	100%
	total for all parameters	80	0	100%

(1) Data Quality Objective (DQO) for Laboratory Control Sample duplicates is ≤25% for all parameters.
(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 A-7. Summary of Laboratory Duplicate Results for Ambient Program Events 109 through 126

Parameter	DQO (1)	n tested (2)	number outside DQO (3)	% success (4)
arsenic	≤ 25% RPD	18	0	100%
cadmium	≤ 25% RPD	18	1	94%
chromium	≤ 25% RPD	18	0	100%
copper	≤ 25% RPD	18	0	100%
lead	≤ 25% RPD	18	0	100%
mercury	≤ 25% RPD	18	0	100%
nickel	≤ 25% RPD	18	0	100%
zinc	≤ 25% RPD	18	0	100%
hardness	≤ 25% RPD	18	0	100%
TSS	≤ 25% RPD	16	1	94%
TDS	≤ 25% RPD	1	0	100%
DOC	≤ 25% RPD	1	0	100%
	total for all parameters	180	2	99%

(1) Data Quality Objective (DQO)
(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 A-8. Summary of Matrix Spike Recoveries for Ambient Program Events 109 through 126

Parameter	DQO (1)	n tested (2)	number outside DQO (3)	% success (4)
arsenic	80%–120%	18	0	100%
cadmium	80%–120%	18	0	100%
chromium	80%–120%	18	0	100%
copper	80%–120%	18	0	100%
lead	80%–120%	18	0	100%
mercury	80%–120%	18	0	100%
nickel	80%–120%	18	0	100%
zinc	80%–120%	18	0	100%
hardness	80%–120%	17	1	94%
DOC	80%–120%	1	0	100%
OP pesticides (EPA 8141)	various	5	0	100%
carbofuran (EPA 632)	various	5	0	100%
chlorophenols	various (5)	5	0	100%
PAHs	various (5)	5	0	100%
Hexachlorobenzene	(5)	5	0	100%
total for all parameters		187	1	99%

(1) Data Quality Objective (DQO)
(2) Total number of results for parameter;
(3) Number of results not achieving DQO;
(4) Success Rate, i.e percent of results achieving DQO;
(5) Environmental results are recovery corrected.

Table A-9. Summary of Matrix Spike Duplicate Results for Ambient Program Events 109 through 126

Parameter	DQO (1)	n tested (2)	number outside DQO (3)	% success (4)
arsenic	≤ 25% RPD	18	0	100%
cadmium	≤ 25% RPD	18	0	100%
chromium	≤ 25% RPD	18	0	100%
copper	≤ 25% RPD	18	0	100%
lead	≤ 25% RPD	18	0	100%
mercury	≤ 25% RPD	18	0	100%
nickel	≤ 25% RPD	18	0	100%
zinc	≤ 25% RPD	18	0	100%
DOC	≤ 25% RPD	1	0	100%
OP pesticides (EPA 8141)	≤ 25% RPD	5	0	100%
carbofuran (EPA 632)	≤ 25% RPD	5	0	100%
	total for all parameters	155	0	100%

(1) Data Quality Objective (DQO) for matrix spike duplicates is less than 25% Relative Percent Difference (RPD) for all parameters;
(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 A-10. Summary of Field Blank Results for Ambient Program Events 109 through 126

Parameter	DQO (1)	n tested (2)	number outside DQO (3)	% success (4)
arsenic	< RL	14	0	100%
cadmium	< RL	14	1	93%
chromium	< RL	14	0	100%
copper	< RL	14	0	100%
lead	< RL	14	0	100%
mercury	< RL	14	5	64%
nickel	< RL	14	0	100%
zinc	< RL	14	0	100%
chlorophenols	< RL	3	0	100%
PAHs	< RL	2	2	0%
Hexachlorobenzene	< RL	1	0	100%
total for all parameters		118	8	93%

(1) Data Quality Objective (DQO) for field and equipment blanks is less than the reporting limit (RL) for the parameter (see text);
(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 A-11. Summary of Milli-Q Blank Results for Ambient Program Events 109 through 126

Parameter	DQO (1)	n tested (2)	number outside DQO (3)	% success (4)
arsenic	< RL	0	0	—
cadmium	< RL	0	0	—
chromium	< RL	0	0	—
copper	< RL	0	0	—
lead	< RL	0	0	—
mercury	< RL	14	2	86%
nickel	< RL	0	0	—
zinc	< RL	0	0	—
	total for all parameters	14	2	86%

(1) Data Quality Objective (DQO) for Milli-Q blanks is less than the reporting limit (RL) for the parameter (see text);
(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 A-12. Summary of Bottle Blank Results for Ambient Program Events 109 through 126

No Bottle Blank results were provided for Events 109 through 126

Table A-13. Summary of Field Duplicate Results for Ambient Program Events 109 through 126

Parameter	DQO (1)	n tested (2)	number outside DQO (3)	% success (4)
arsenic, total	≤ 25% RPD	16	0	100%
cadmium, dissolved	≤ 25% RPD	16	0	100%
cadmium, total recoverable	≤ 25% RPD	16	2	88%
chromium, total recoverable	≤ 25% RPD	16	3	81%
copper, dissolved	≤ 25% RPD	16	0	100%
copper, total recoverable	≤ 25% RPD	16	1	94%
lead, dissolved	≤ 25% RPD	16	0	100%
lead, total recoverable	≤ 25% RPD	16	1	94%
mercury, dissolved	≤ 25% RPD	16	2	88%
mercury, total	≤ 25% RPD	16	0	100%
nickel, dissolved	≤ 25% RPD	11	0	100%
nickel, total recoverable	≤ 25% RPD	16	2	88%
zinc, dissolved	≤ 25% RPD	16	1	94%
zinc, total recoverable	≤ 25% RPD	16	3	81%
PAHs	< RL	1	0	100%
Hexachlorobenzene	< RL	1	0	100%
hardness	≤ 25% RPD	16	3	81%
TSS	≤ 25% RPD	16	5	69%
TDS	≤ 25% RPD	1	1	0%
DOC	≤ 25% RPD	1	0	100%
TOC	≤ 25% RPD	1	0	100%
	total for all parameters	256	24	91%

(1) Data Quality Objective (DQO) for field duplicates (splits) is less than 25% Relative Percent Difference (RPD) for all parameters;
(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 A-14. Summary of Blind Spike Recoveries for Ambient Program Events 109 through 126

No Blind Spike results were provided for Events 109 through 126

Table A-15. Summary of Planned and Completed Analyses for Ambient Program Events 109 through 126

	total sample analyses planned	total analyses completed	% complete-ness
arsenic, total	90	90	100%
cadmium, dissolved	51	49	96%
cadmium, total recoverable	90	73	81%
chromium, total recoverable	90	88	98%
copper, dissolved	90	89	99%
copper, total recoverable	90	89	99%
lead, dissolved	50	47	94%
lead, total recoverable	90	80	89%
mercury, dissolved	90	90	100%
mercury, total	90	89	99%
nickel, dissolved	54	56	104%
nickel, total recoverable	90	89	99%
zinc, dissolved	90	83	92%
zinc, total recoverable	90	82	91%
chlorpyrifos	90	49	54%
diazinon	90	73	81%
other OP pesticides	22	17	77%
carbofuran	22	19	86%
EPA 625 chlorophenols	22	17	77%
PAHs	22	22	100%
Hexachlorobenzene	22	22	100%
hardness	90	85	94%
TSS	90	85	94%
DOC	12	12	100%
TOC	12	10	83%
chloride	90	69	77%
total coliform	90	70	78%
fecal coliform	90	71	79%
temperature	90	81	90%
dissolved oxygen	90	81	90%
pH	90	82	91%
conductivity	90	82	91%
total for all parameters	2269	2041	90.0%
minus total qualified data		43	
unqualified data		1998	97.9%

Table A-16. Summary of Qualified Data for Ambient Program Events 109 through 126

Date [1]	Location	Parameter	Result [2]	Units	Data Qualification Code [3]
1/20/99	Discovery Park	Total suspended solids	14	mg/L	EST
1/22/99	River Mile 44	Organic carbon, dissolved	4.5	mg/L	UL
4/20/99	Veterans Br.	Hardness	44	mg/L	EST
5/18/99	Nimbus	Chromium, total recoverable	0.4	µg/L	EST
5/18/99	Nimbus	Mercury, dissolved	0.59	ng/L	EST
8/18/99	Discovery Park	Copper, total recoverable	0.42	µg/L	UL
8/18/99	Discovery Park	Zinc, dissolved	0.29	µg/L	UL
8/19/99	Freeport	Zinc, dissolved	0.34	µg/L	UL
8/18/99	Nimbus	Copper, total recoverable	0.24	µg/L	UL
8/19/99	River Mile 44	Zinc, dissolved	0.49	µg/L	UL
8/18/99	Veterans Br.	Zinc, dissolved	0.23	µg/L	UL
9/23/99	Freeport	Cadmium, total recoverable	0.029	µg/L	UL
9/23/99	River Mile 44	Cadmium, dissolved	0.011	µg/L	UL
9/23/99	River Mile 44	Cadmium, total recoverable	0.026	µg/L	UL
9/21/99	Veterans Br.	Cadmium, total recoverable	0.036	µg/L	UL
10/19/99	Discovery Park	Hardness	24	mg/L	EST
10/19/99	Discovery Park	Total suspended solids	<2	mg/L	EST
11/16/99	Discovery Park	Zinc, total recoverable	0.33	µg/L	EST
12/13/99	Discovery Park	Zinc, dissolved	0.21	µg/L	UL
12/14/99	Freeport	Nickel, dissolved	0.55	µg/L	UL
12/13/99	Nimbus	Zinc, dissolved	0.17	µg/L	UL
12/14/99	River Mile 44	Nickel, dissolved	0.55	µg/L	UL
12/14/99	River Mile 44	Zinc, dissolved	0.57	µg/L	UL
12/13/99	Veterans Br.	Chromium, total recoverable	2.51	µg/L	EST
12/13/99	Veterans Br.	Copper, total recoverable	3.62	µg/L	EST
12/13/99	Veterans Br.	Nickel, dissolved	0.52	µg/L	UL
12/13/99	Veterans Br.	Nickel, total	3.93	µg/L	EST
12/13/99	Veterans Br.	Lead, total recoverable	0.412	µg/L	EST
12/13/99	Veterans Br.	Zinc, dissolved	0.36	µg/L	UL, NR
12/13/99	Veterans Br.	Zinc, total recoverable	5.01	µg/L	EST

(table continues on following page; table notes listed at end of table)

(table A-16 continued from preceding page)

Date [1]	Location	Parameter	Result [2]	Units	Data Qualification Code [3]
2/15/00	Discovery Park	Zinc, dissolved	0.35	µg/L	UL
2/15/00	Freeport	Zinc, dissolved	1.17	µg/L	UL
2/15/00	Nimbus	Zinc, dissolved	0.41	µg/L	UL
2/15/00	River Mile 44	Zinc, dissolved	1.29	µg/L	UL
2/15/00	Veterans Br.	Hardness	56	mg/L as $CaCO_3$	EST
2/15/00	Veterans Br.	Zinc, dissolved	0.45	µg/L	UL
3/23/00	Freeport	Cadmium, total recoverable	0.067	µg/L	EST
3/23/00	Freeport	Chromium, total recoverable	4.85	µg/L	EST
4/18/00	Veterans Br.	Nickel, total	2.31	µg/L	EST
4/18/00	Veterans Br.	Total suspended solids	18	mg/L	EST, NR
4/18/00	Veterans Br.	Zinc, total recoverable	4.47	µg/L	EST
6/20/00	Discovery Park	Total dissolved solids	23	mg/L	EST
6/20/00	Discovery Park	Total suspended solids	3	mg/L	EST

(1) Ambient Program sample date
(2) Analytical result reported
(3) Codes indicate the following data qualifications apply:
UL–result is considered an "upper limit" of true concentration
LB–result is considered "low biased"
HB–result is considered "high biased"
MI–result is considered estimated due to matrix interference
NRS–result is considered not reproducible due to matrix variability
NR–result is considered not reproducible due to analytical variability
EST–result is considered estimated due to sampling variability
HT–result is considered estimated due to holding time exceedance

B Time Series and Summary Statistics

This Appendix presents the methods used to plot time series and calculate summary statistics for Ambient Program data for the period December, 1992, through June, 2000. Summary statistics are presented in Chapter 3 (Data Review). Time series plots are presented in this Appendix.

SUMMARY

Split samples submitted as part of the QA/QC program are not used to calculate summary statistics. Number of measurements, number of detected values, percent detected values, minimum, and maximum values are calculated for all water quality parameters measured by the Ambient Program. In addition, if 35% or more of the values were detected, the arithmetic or geometric mean, and 95% confidence interval about the mean are also calculated.

EVENT VALUES

In some cases, more than one measurement was made for a particular constituent during a single sampling "event." In these cases, one of the values was used and the other ignored, as follows. Duplicate samples were obtained for some sample events by splitting field samples. These duplicates were used as part of QA/QC procedures, but only the results for the "sample" were used for analysis of summary statistics. Results for "split samples" were used in QA/QC assessments, but were not included in calculation of summary statistics.

SUMMARY STATISTICS CALCULATED

For each water quality parameter measured by the Ambient Monitoring Program, the following statistics were calculated:

- number of measurements (n)

- number of measurements for which a measurable quantity was detected (*n detected*)
- percent of measurements for which a measurable quantity was detected (*percent detected*)
- minimum detected value (*min*), and
- maximum detected value (*max*).

If less than 35% of the data were uncensored, it was considered that insufficient data were available to reliably estimate the mean and standard deviation, and no additional statistics were calculated. If 35% or more of the data were detected values, the following additional statistics were calculated:

- *geometric mean*—If the data best fit a log-normal distribution, the geometric mean of all measurements is calculated using all detected data. If the distribution includes data below Ambient Program reporting limits, distribution parameters are estimated using the Robust Lognormal Regression method. (See below for a discussion of "fitted values.") In cases where the values best fit a normal distribution (e.g., hardness measurements), the arithmetic mean of all measurements is calculated.
- *95% confidence limits*—The 95% confidence limits for the geometric (or arithmetic) mean is calculated using the Student's t statistic. Lower and upper limits of the confidence interval are presented.

TREATMENT OF VALUES BELOW REPORTING LIMITS

Summary statistics are computed using the Robust Lognormal Regression method (Helsel and Cohn 1988; Helsel 1990) when censored data were reported (i.e. data below program reporting limits). This method fits the detected values to a lognormal or normal distribution, using the censored data to calculate cumulative distribution values for the detected data. The distribution type (normal or lognormal) is determined by comparison of r-squared values for distribution regressions. Geometric or arithmetic means, and 95% confidence limits are calculated from the lognormal or normal distribution regression statistics. In cases where less than 35% of the values were uncensored, the mean and 95% confidence limits are not calculated because data are considered insufficient to accurately estimate these statistics.

TIME-SERIES PLOTS

Time-series plots representing Ambient Program data from December 1992 through June 2000 were prepared for most Ambient Program parameters monitored in 1999 and 2000. Relevant regulatory limits are presented with the environmental data. For parameters with hardness-dependent criteria (cadmium, chromium, copper, lead, nickel, and zinc), these criteria are shown adjusted for the hardness measured for each sample collected. There were insufficient data to warrant preparing time series plots for the following new parameters for the Ambient Program: malathion, methyl parathion, carbofuran, PAHs, pentachlorophenol, and 2,4,6-trichlorophenol. Results for these parameters are summarized in Chapter 3 of this report.

REFERENCES

Helsel, D.R. and Cohn, T.A. Estimation of Descriptive Statistics for Multiply Censored Water Quality Data. *Water Resources Research*. Vol. 24, No. 12, pp. 1997-2004. December, 1988.

Helsel, D.R. Less Than Obvious. *Environmental Science and Technology*. Vol. 24, No. 12, pp. 1766-1774. December, 1990.

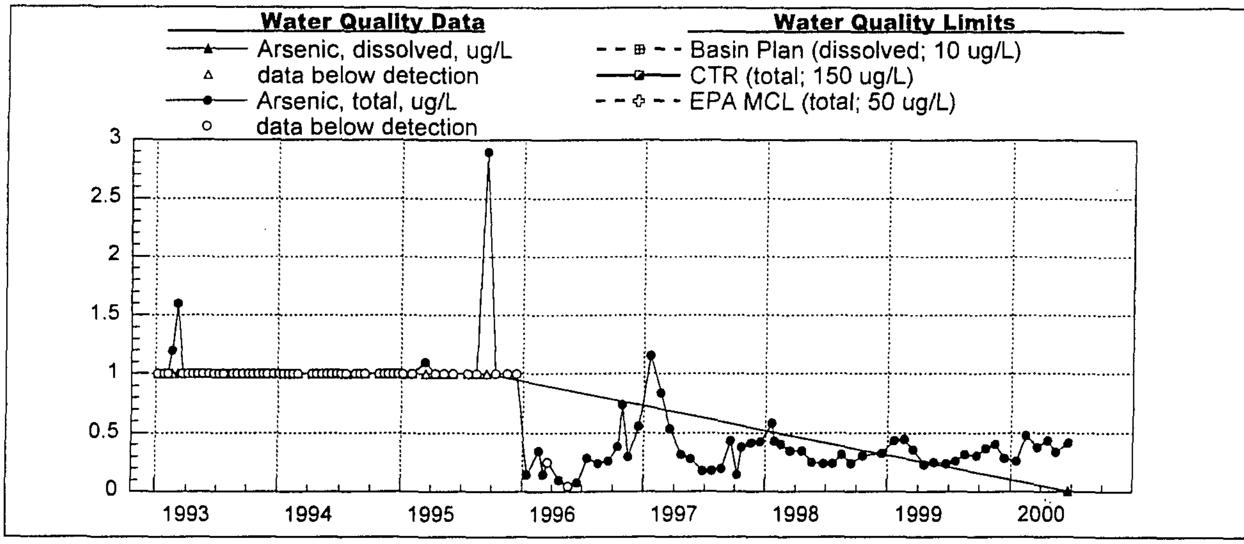
Time Series Plots:

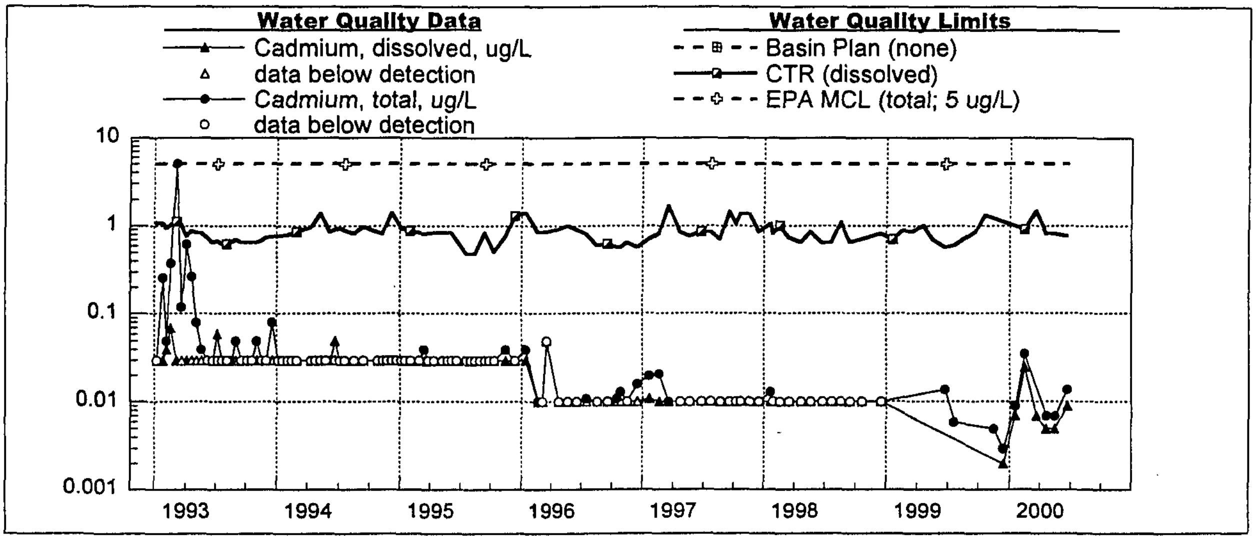
December 1992 – June 2000

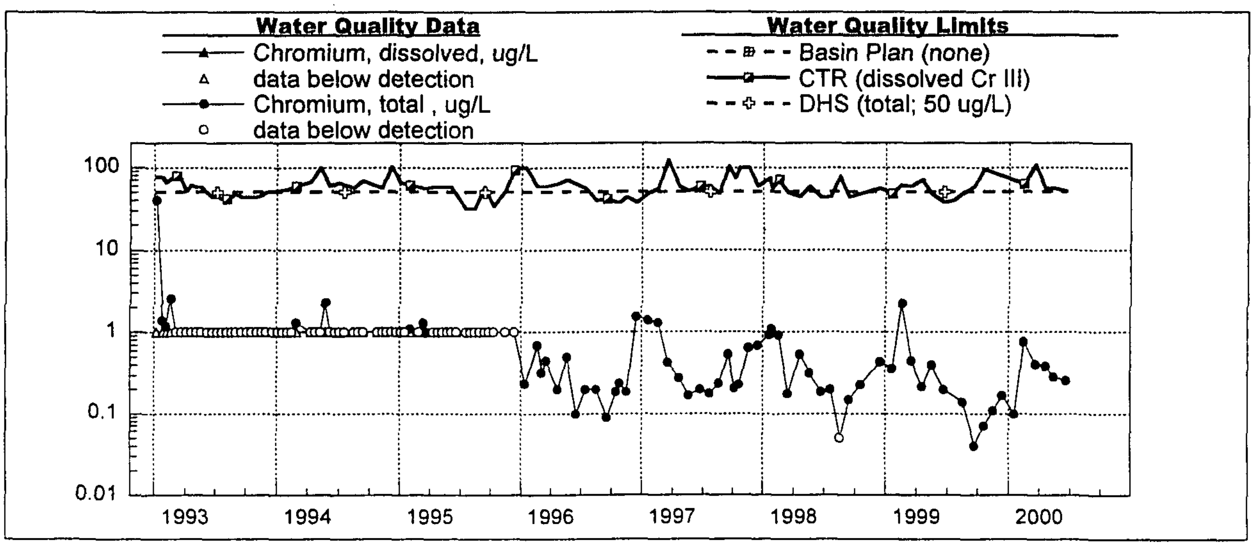
American River at Nimbus Dam

American River at Nimbus

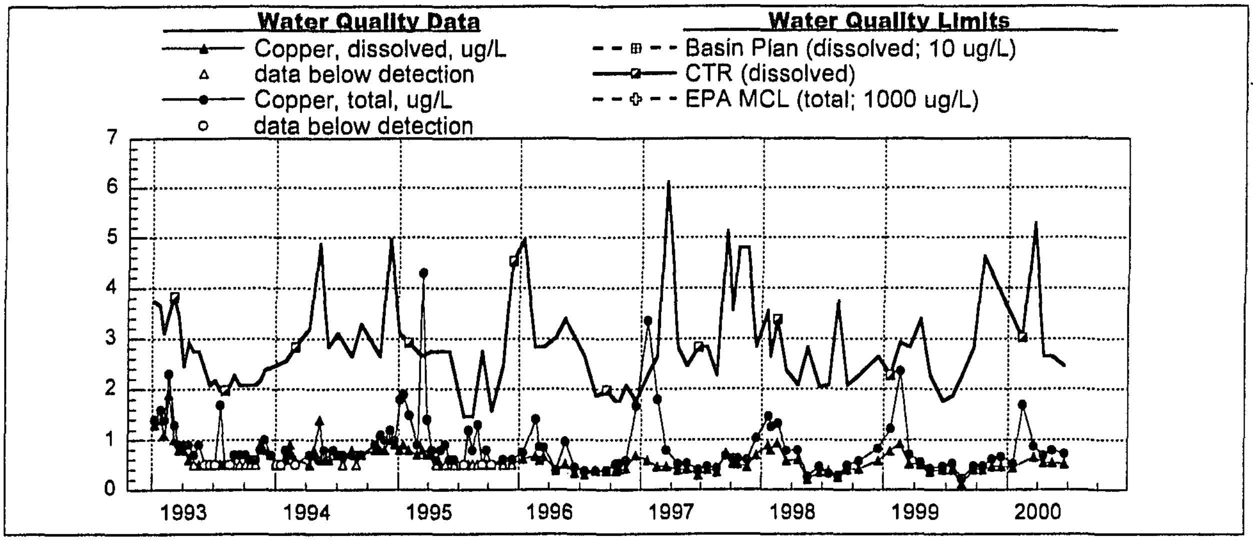
Time Series Plots of Ambient Program Data 1992-2000

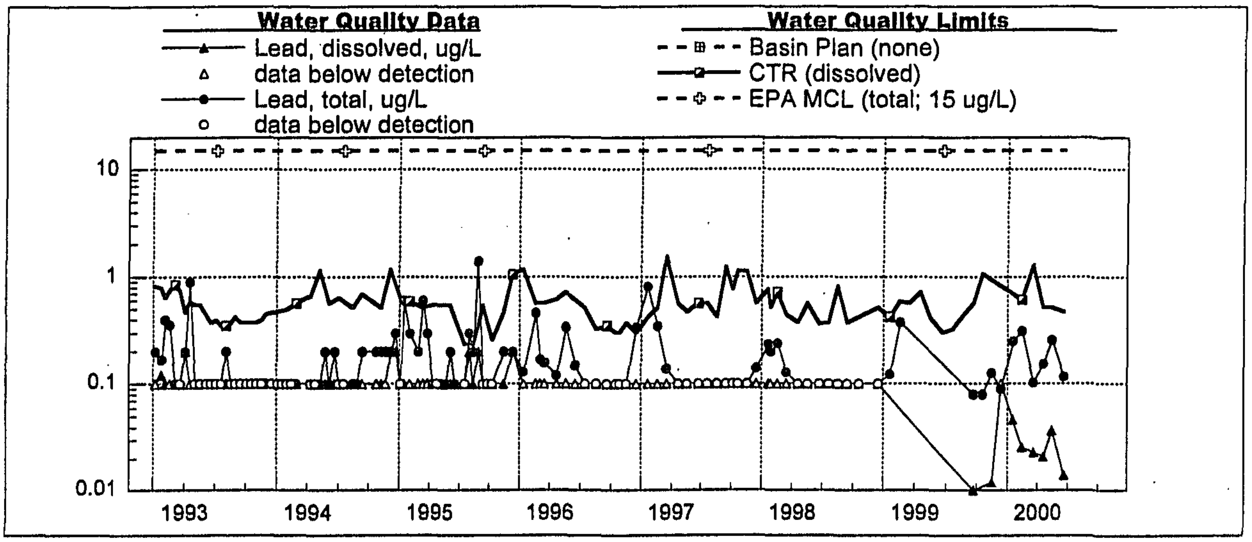


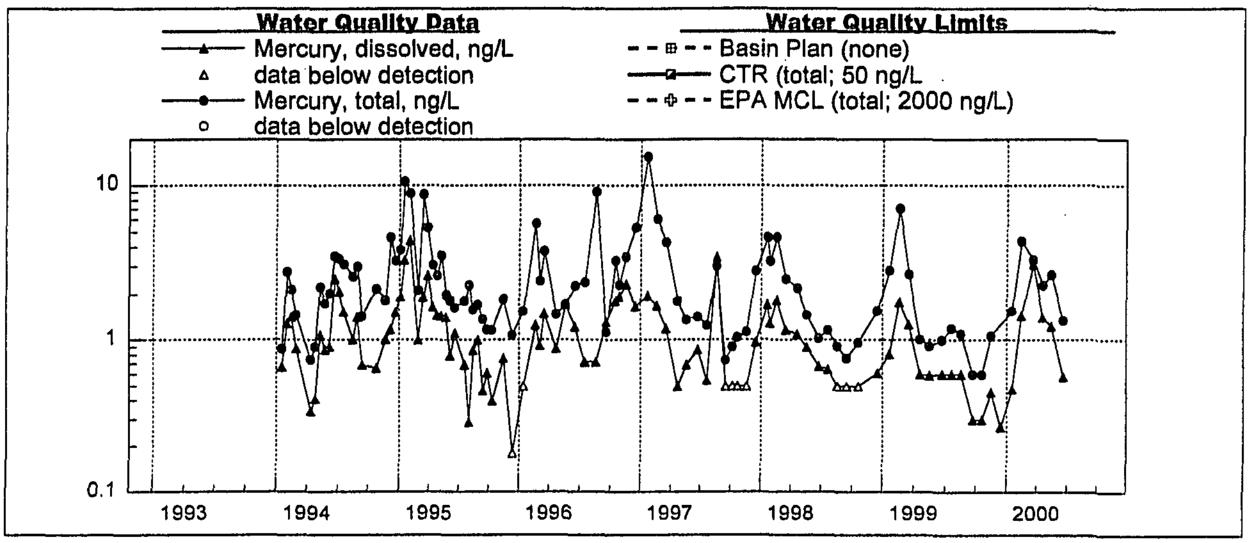


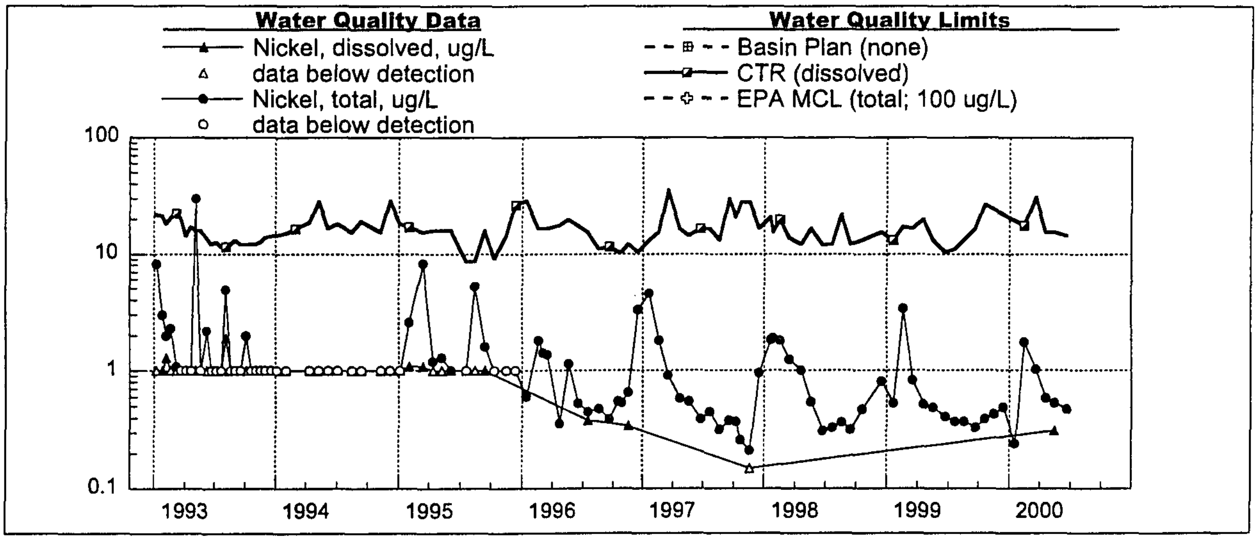


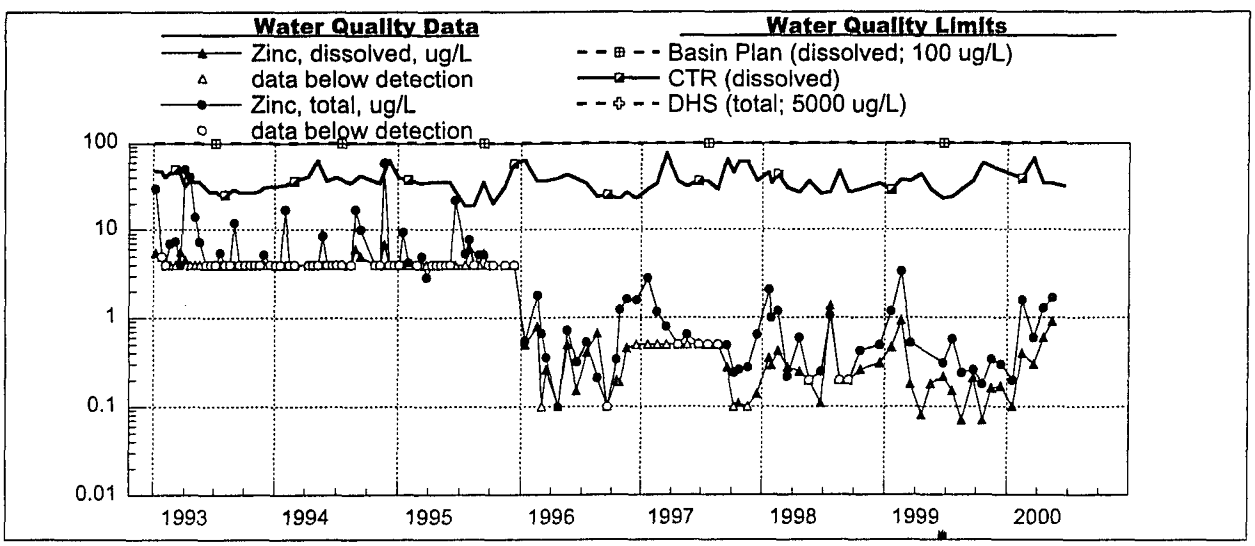
American River at Nimbus
Time Series Plots of Ambient Program Data 1992-2000



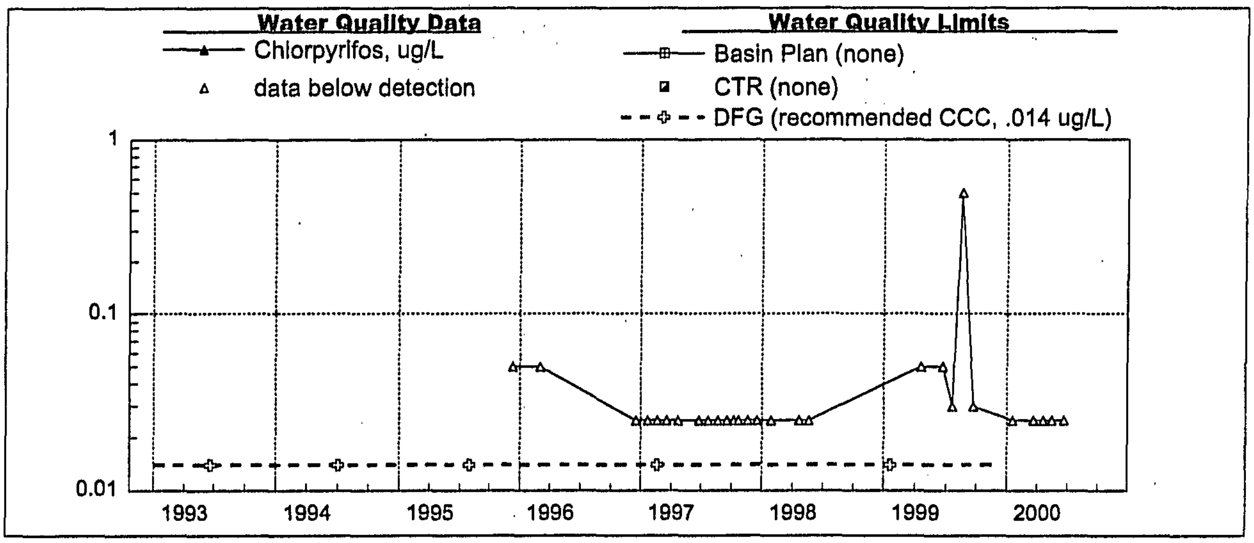


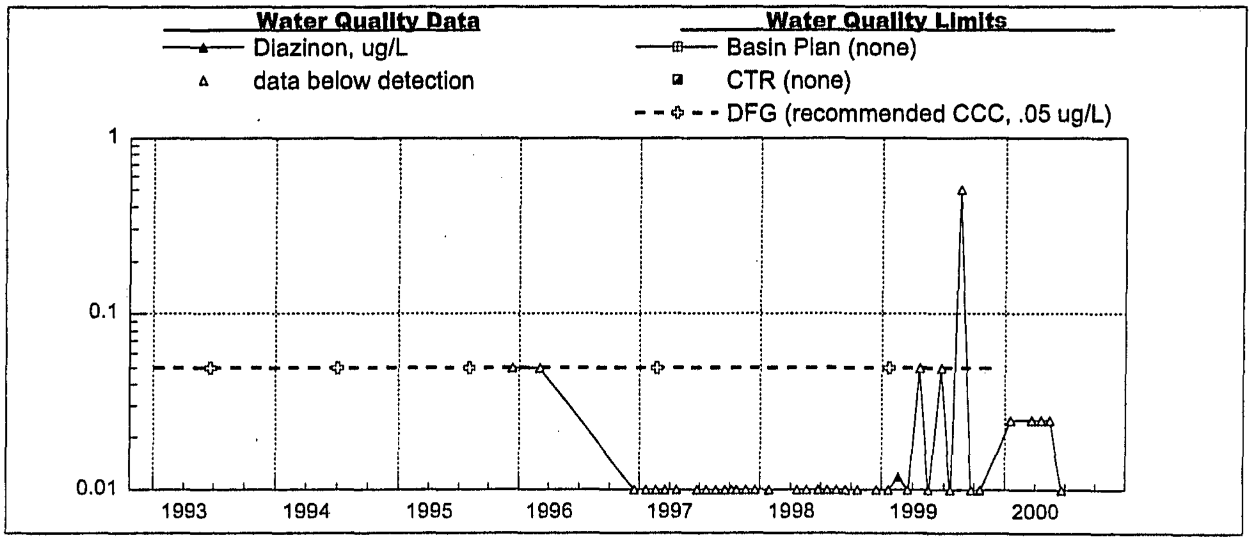



Water Quality Data
Nickel, dissolved, ug/L
data below detection
Nickel, total, ug/L
data below detection
Water Quality Limits
Basin Plan (none)
CTR (dissolved)
EPA MCL (total; 100 ug/L)
100
10
1
0.1
1993
1994
1995
1996
1997
1998
1999
2000


Water Quality Data
Zinc, dissolved, ug/L
data below detection
Zinc, total, ug/L
data below detection
Water Quality Limits
Basin Plan (dissolved; 100 ug/L)
CTR (dissolved)
DHS (total; 5000 ug/L)
100
10
1
0.1
0.01
1993
1994
1995
1996
1997
1998
1999
2000

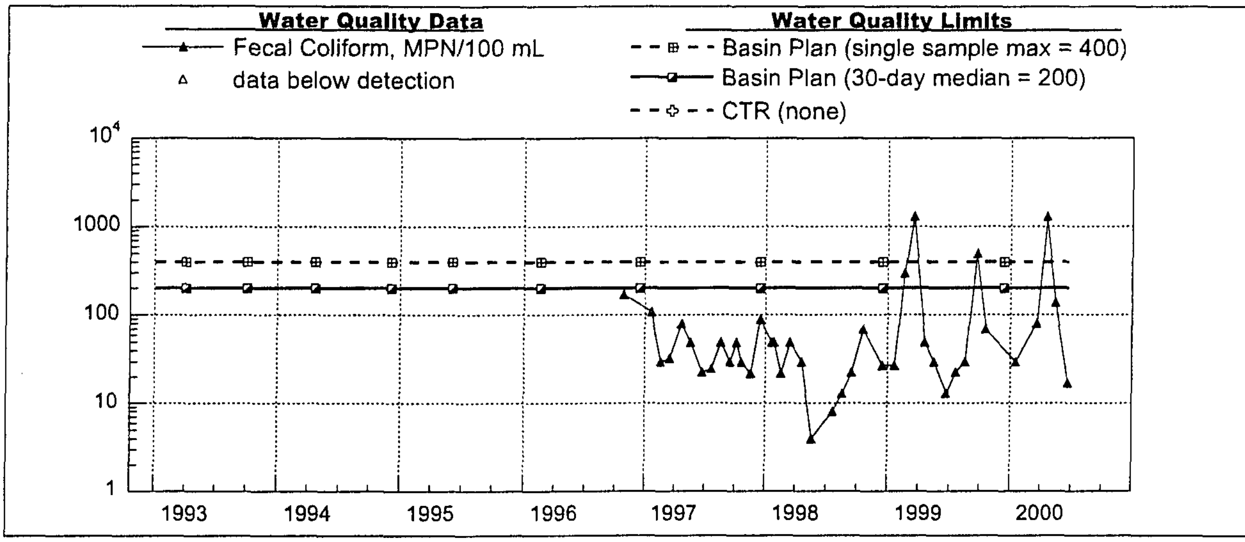
This Space Intentionally Blank

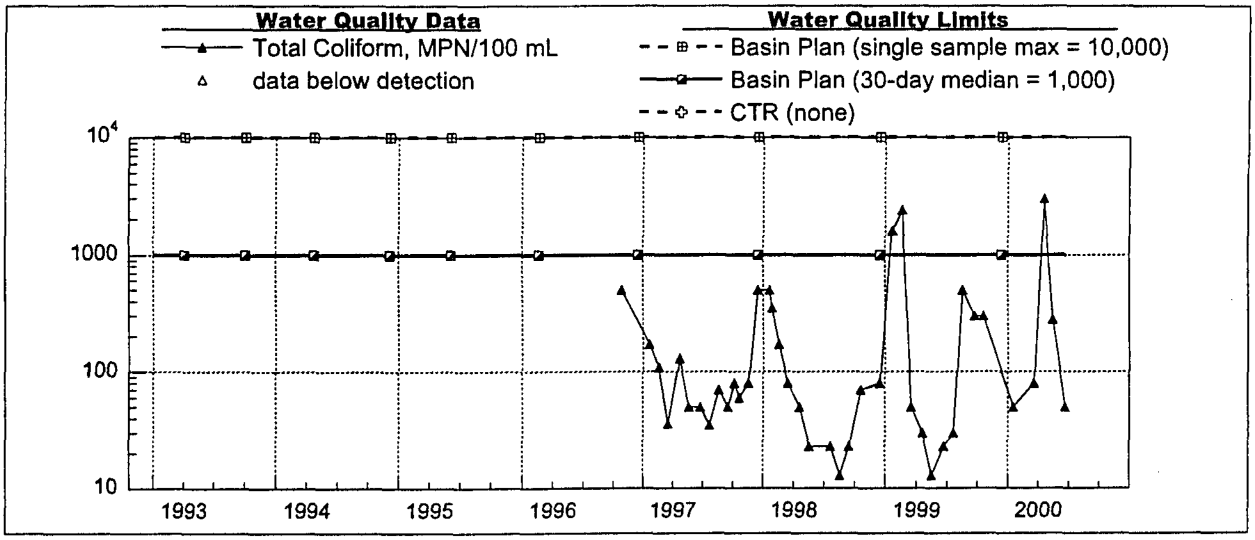


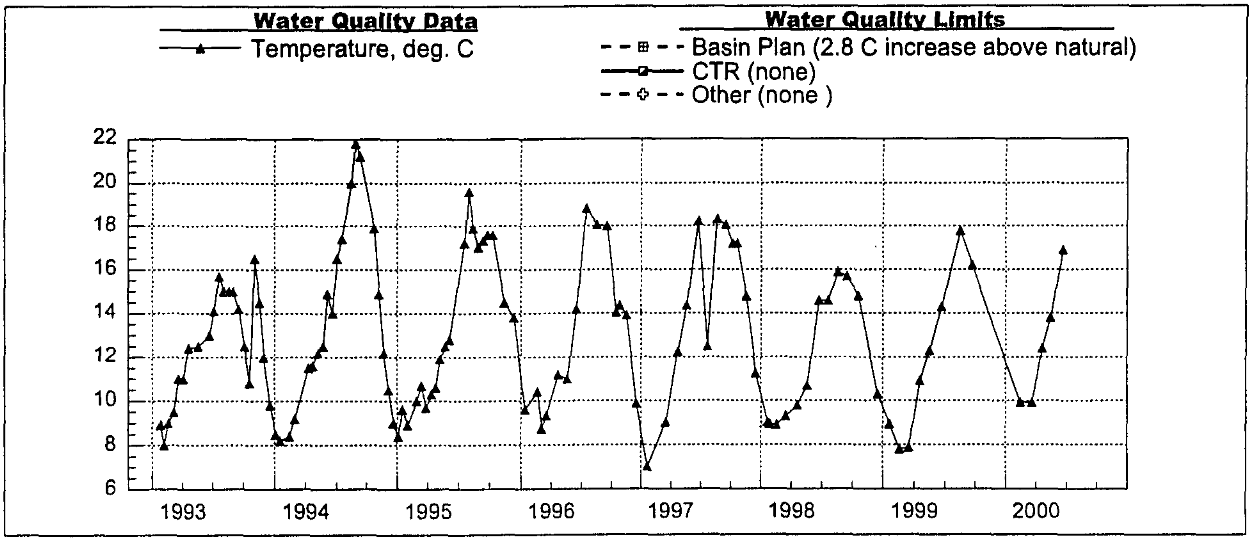


American River at Nimbus

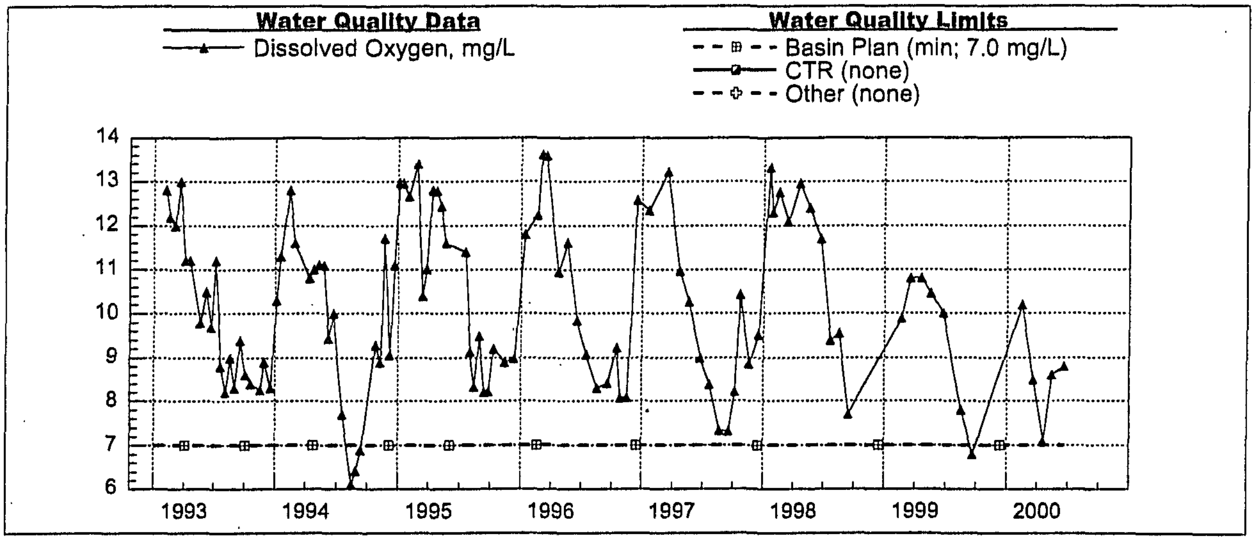
Time Series Plots of Ambient Program Data 1992-2000

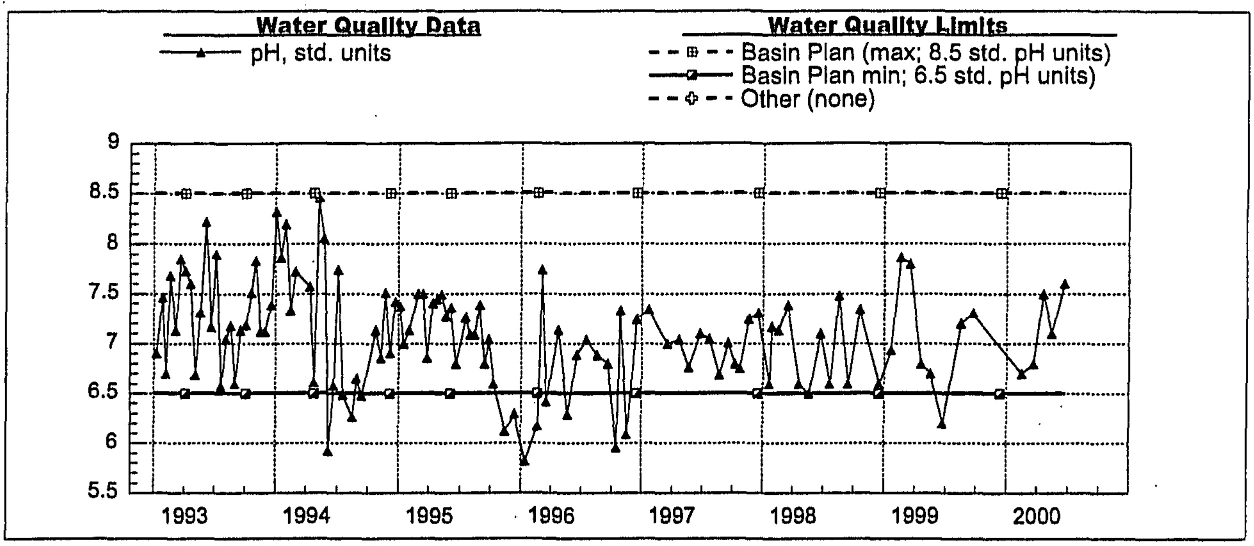


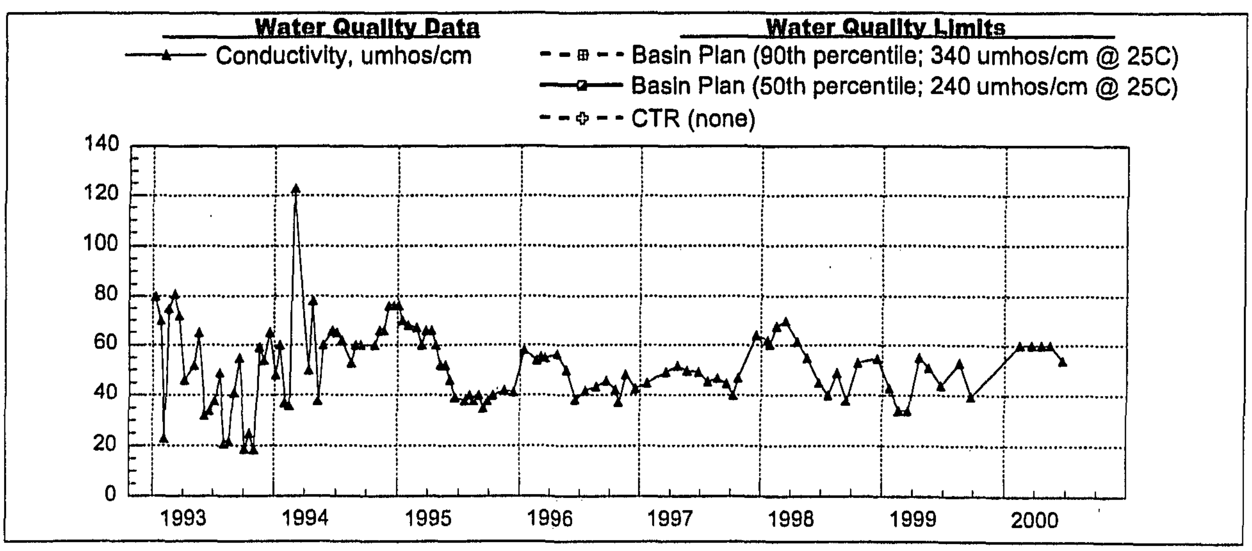


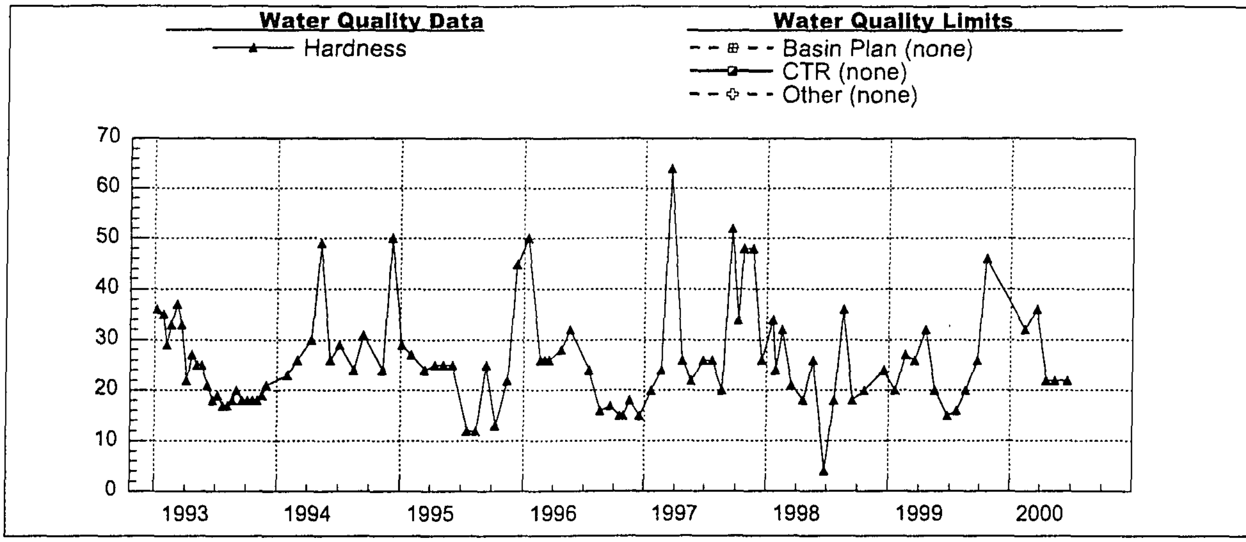


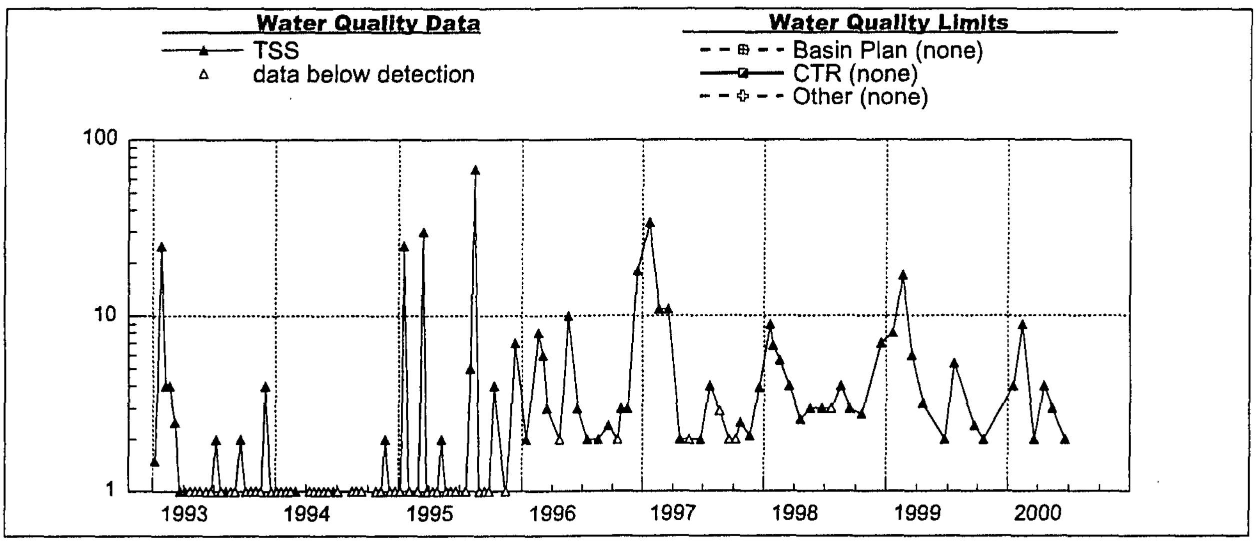
American River at Nimbus
Time Series Plots of Ambient Program Data 1992–2000

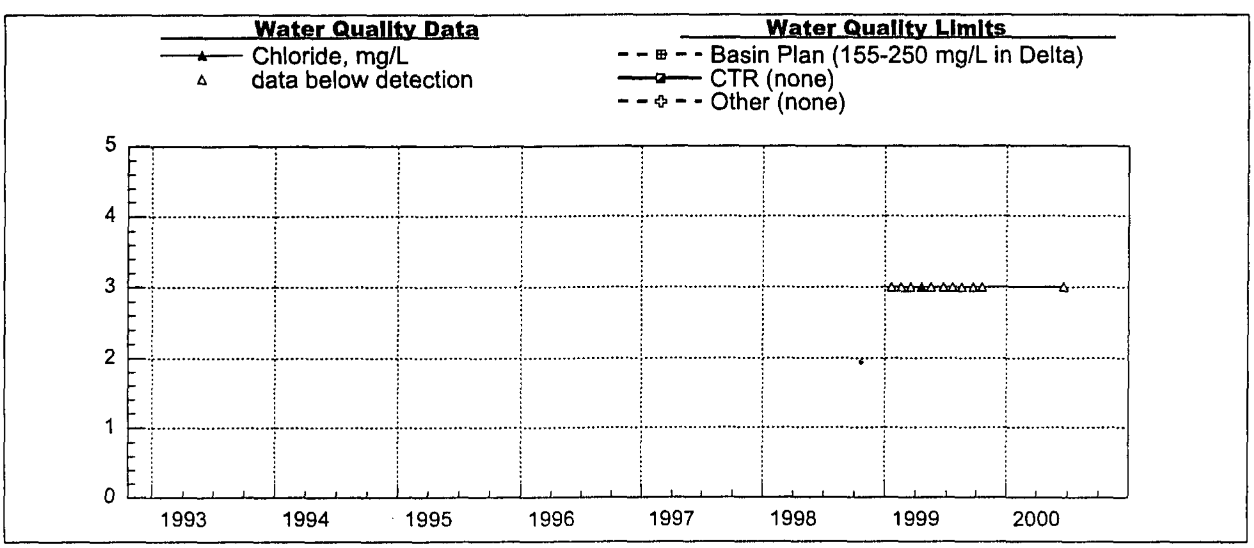






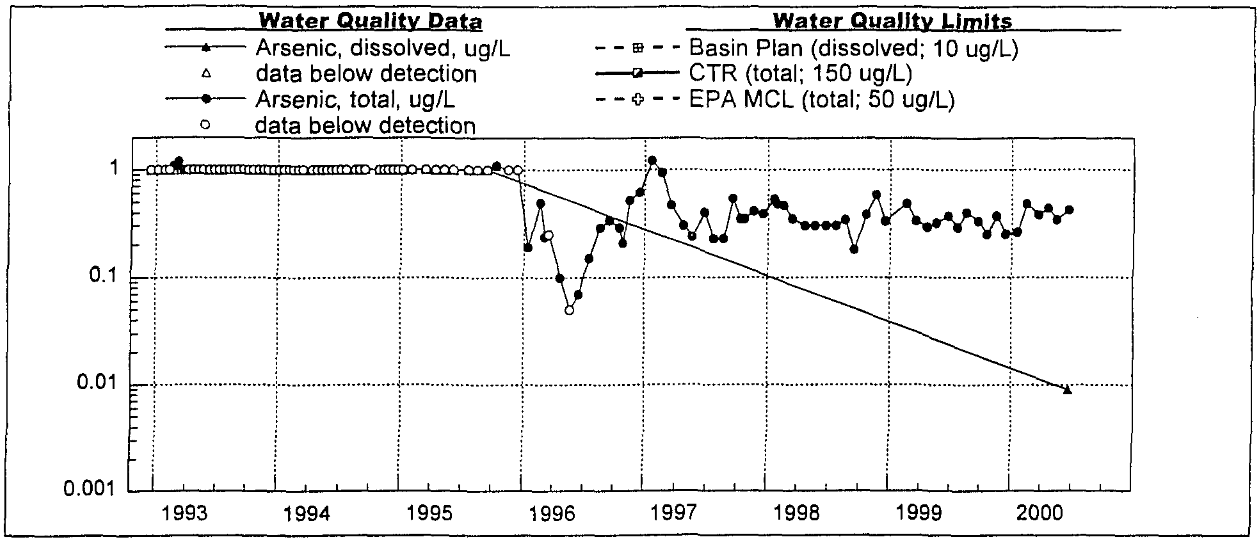

Water Quality Data
Hardness
Water Quality Limits
Basin Plan (none)
CTR (none)
Other (none)
70
60
50
40
30
20
10
0
1993
1994
1995
1996
1997
1998
1999
2000

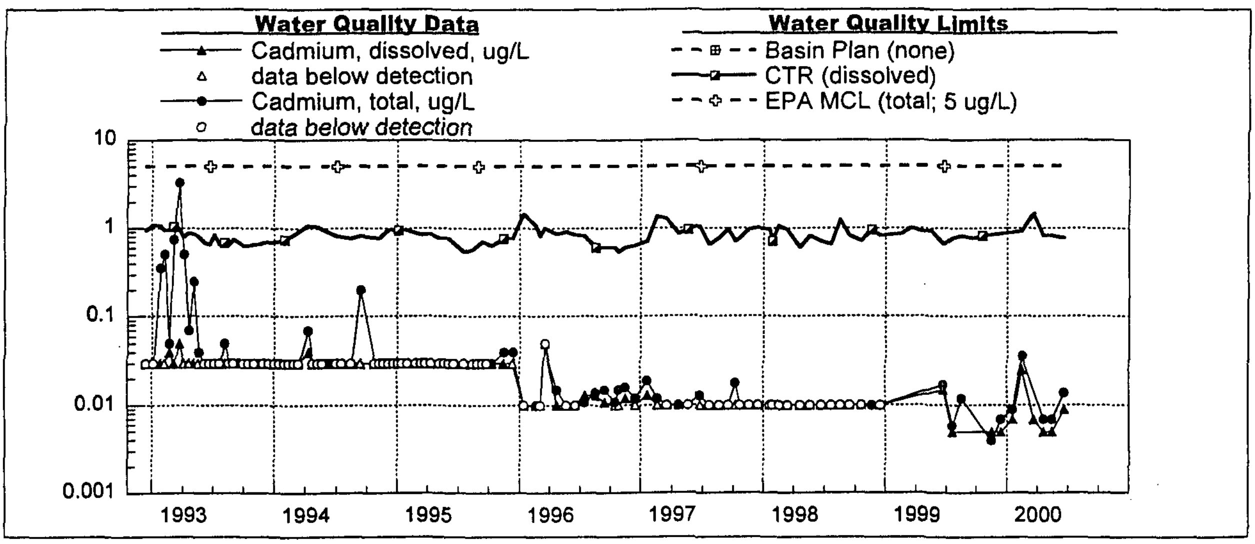

Water Quality Data
TSS
data below detection
Water Quality Limits
Basin Plan (none)
CTR (none)
Other (none)
100
10
1
1993
1994
1995
1996
1997
1998
1999
2000

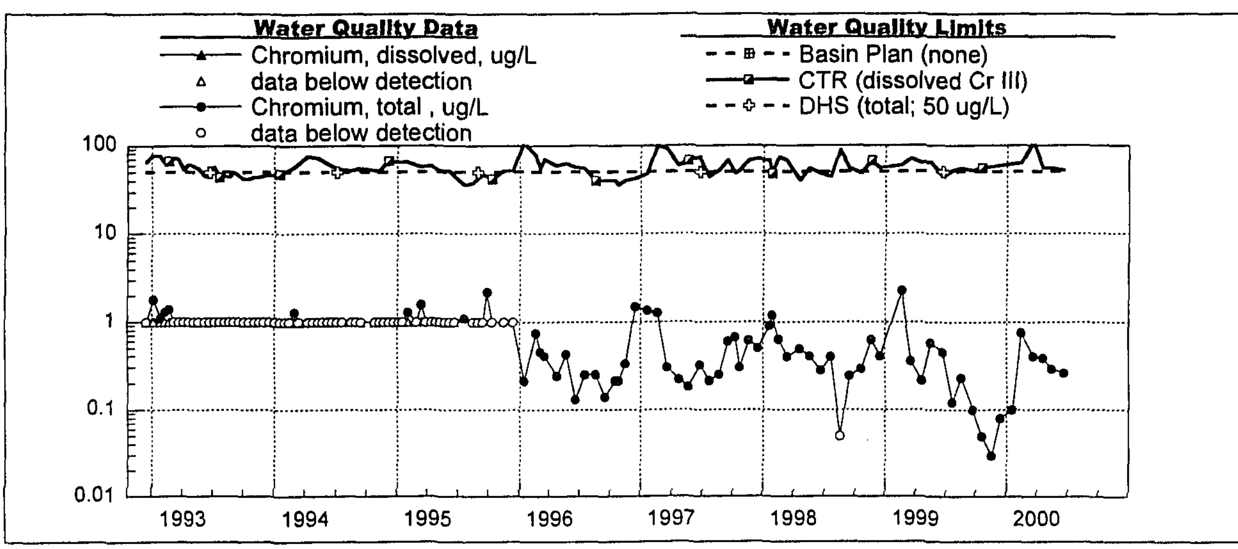

Water Quality Data
Chloride, mg/L
data below detection
Water Quality Limits
Basin Plan (155-250 mg/L in Delta)
CTR (none)
Other (none)
5
4
3
2
1
0
1993
1994
1995
1996
1997
1998
1999
2000

American River at Discovery Park

American River at Discovery Park
Time Series Plots of Ambient Program Data 1992–2000

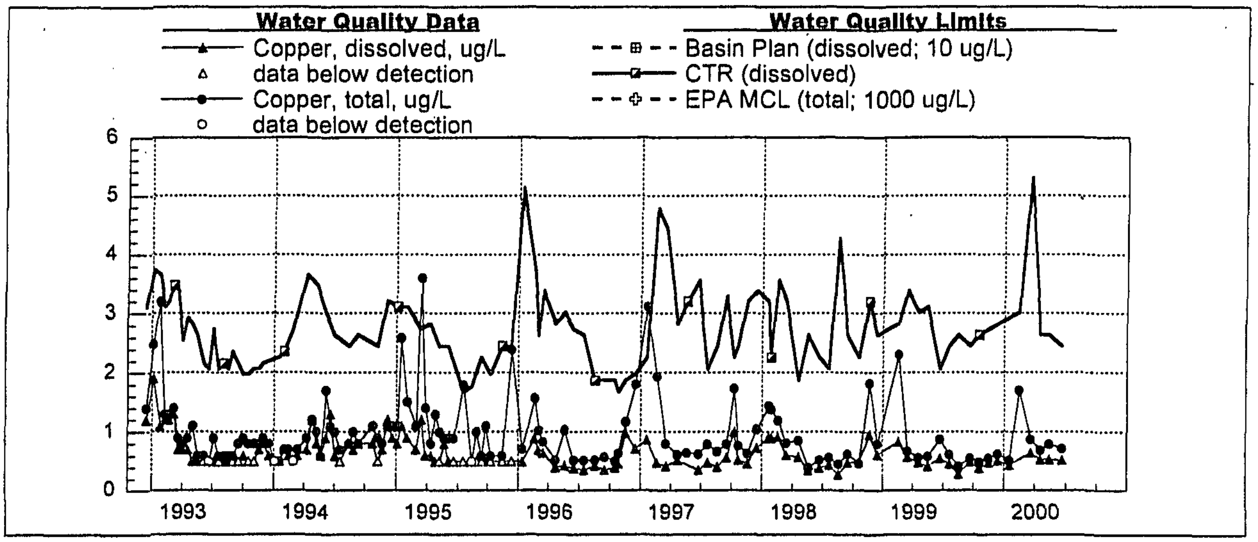


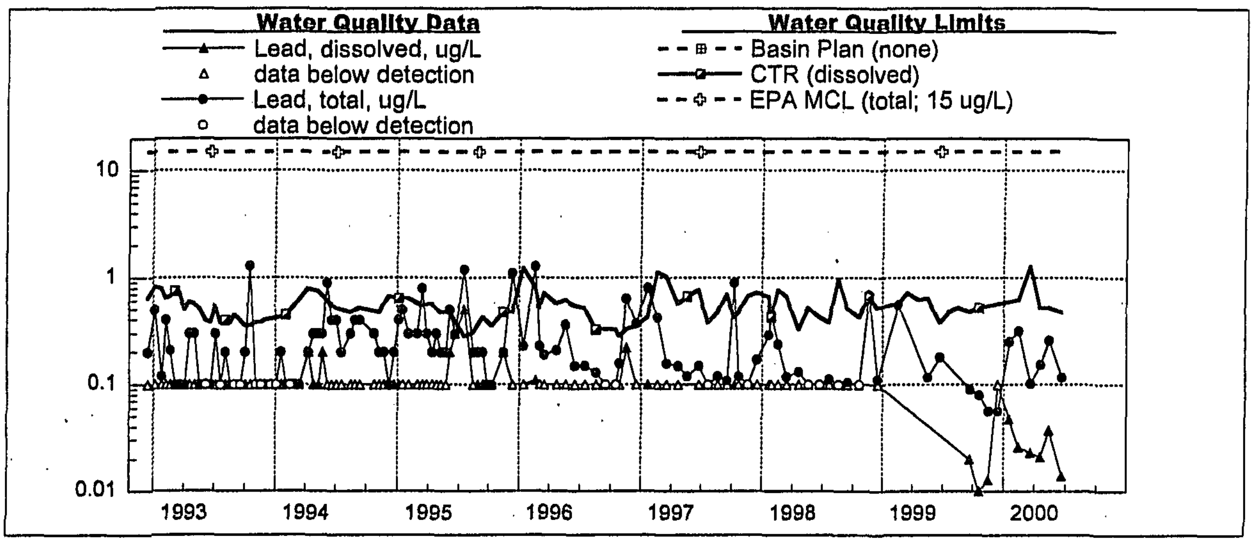


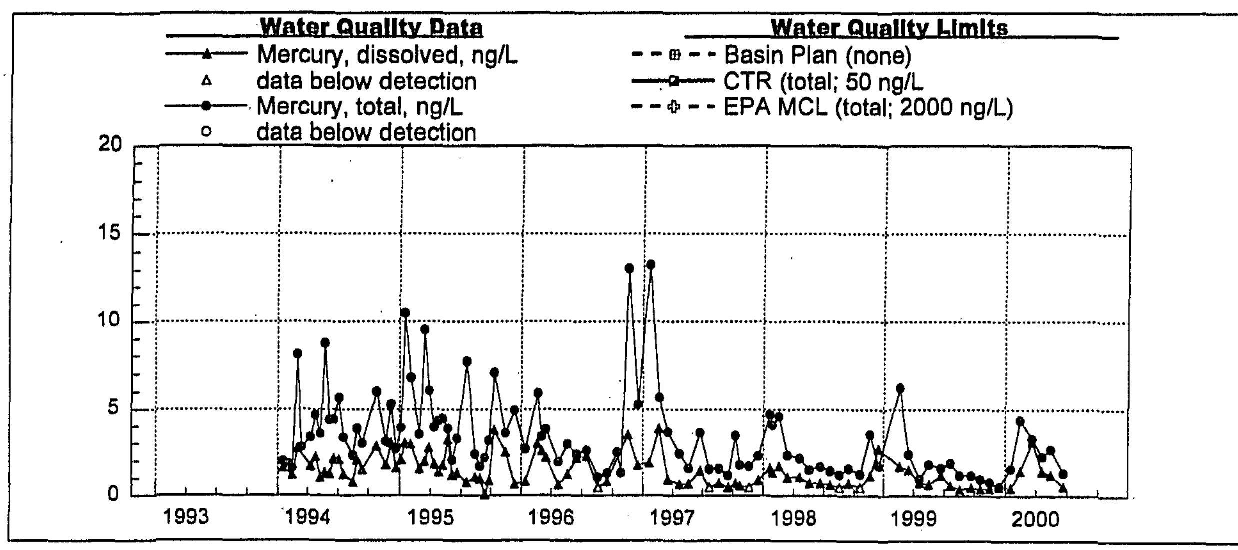


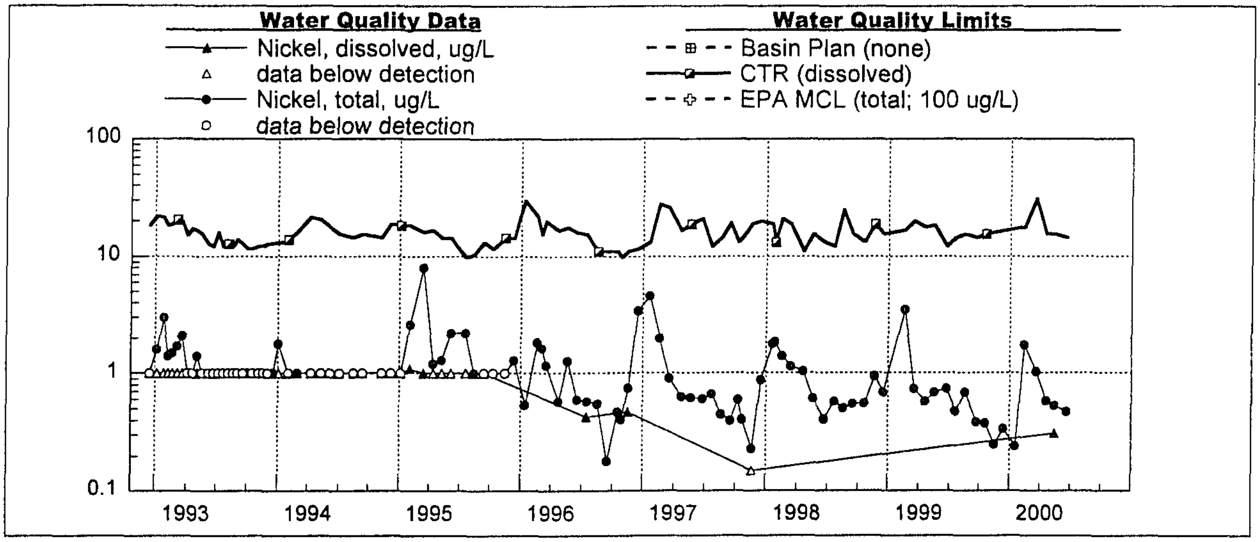
American River at Discovery Park

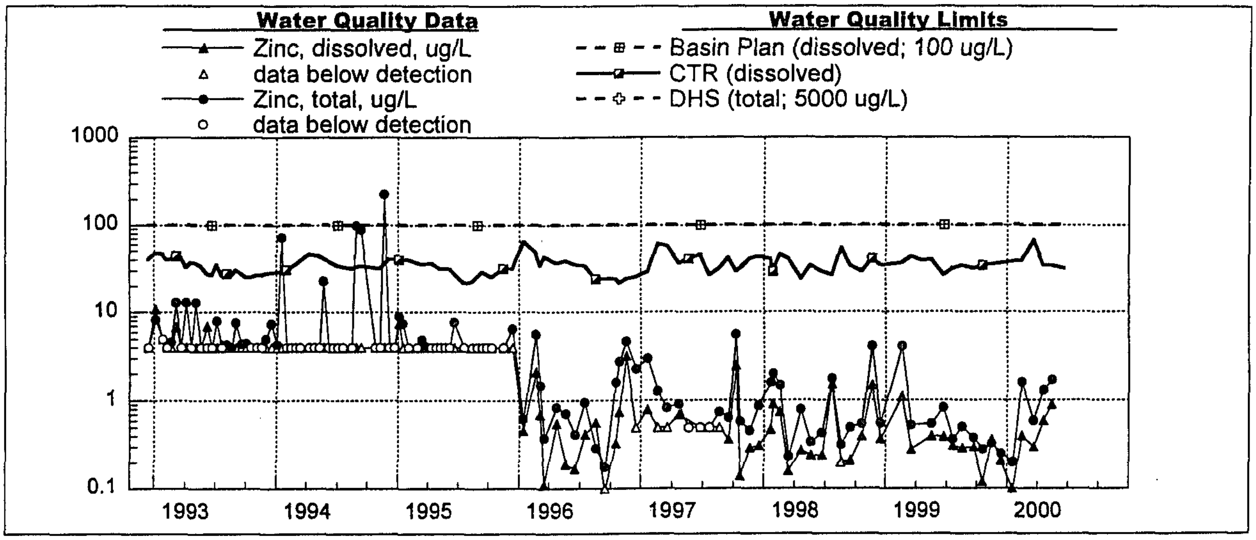
Time Series Plots of Ambient Program Data 1992-2000





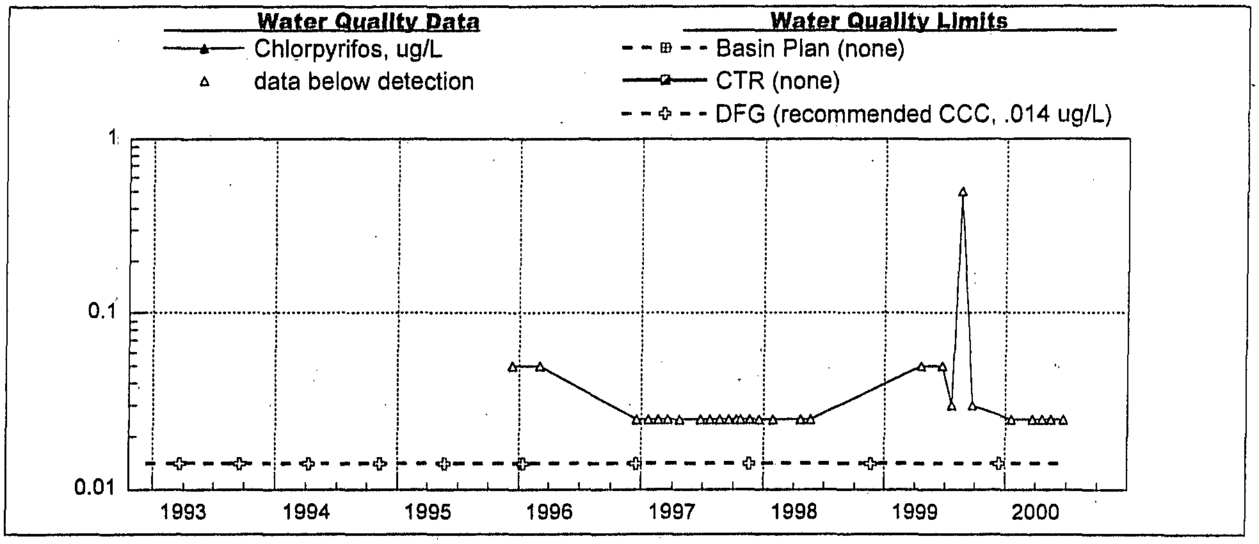


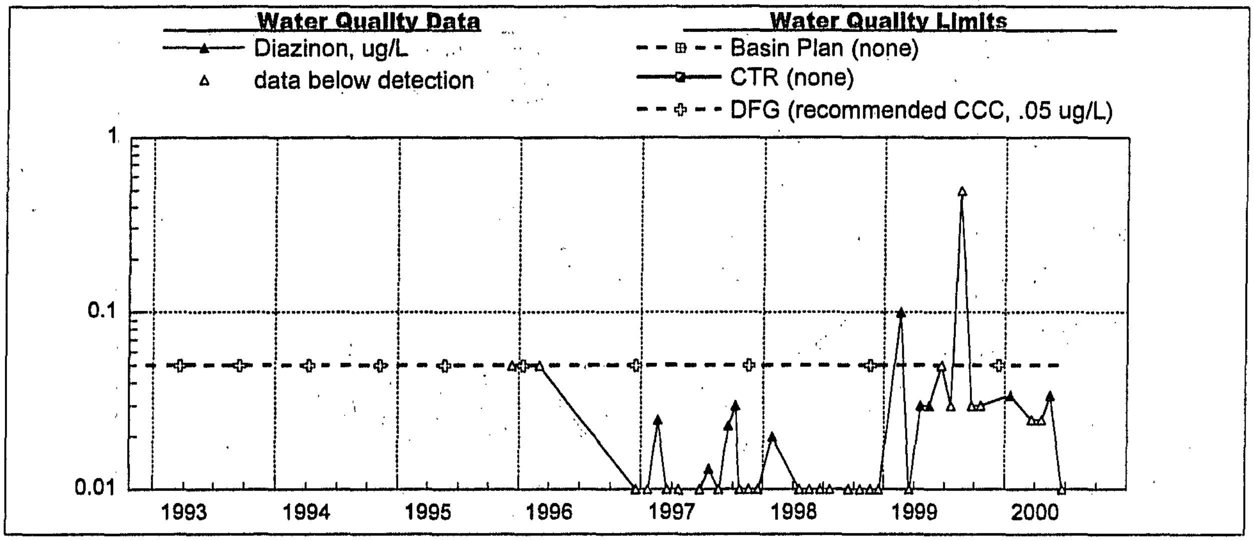


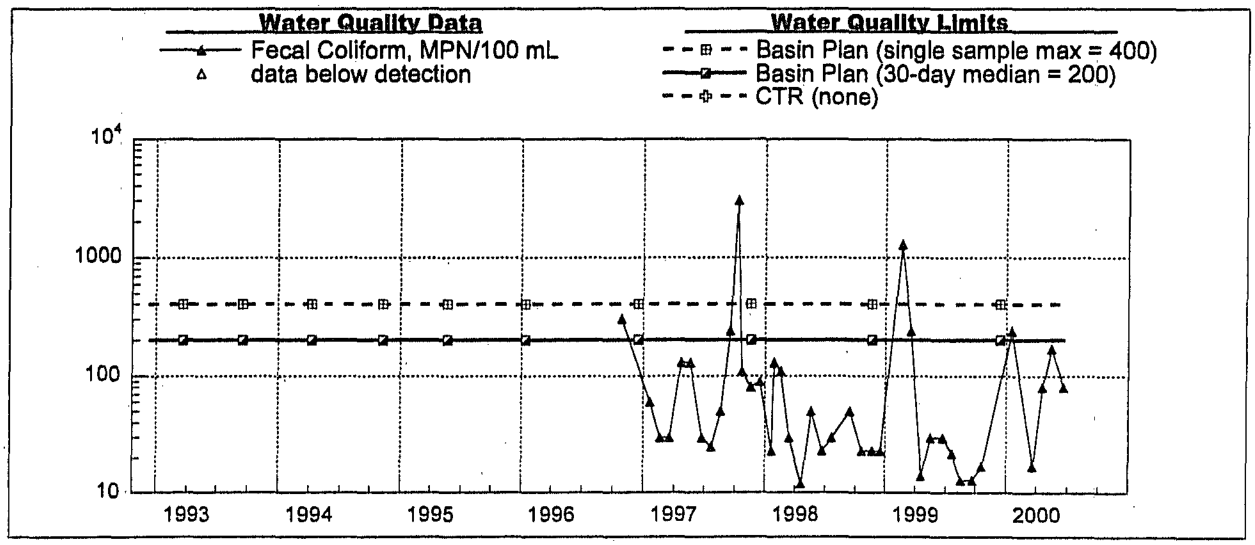


This Space Intentionally Blank

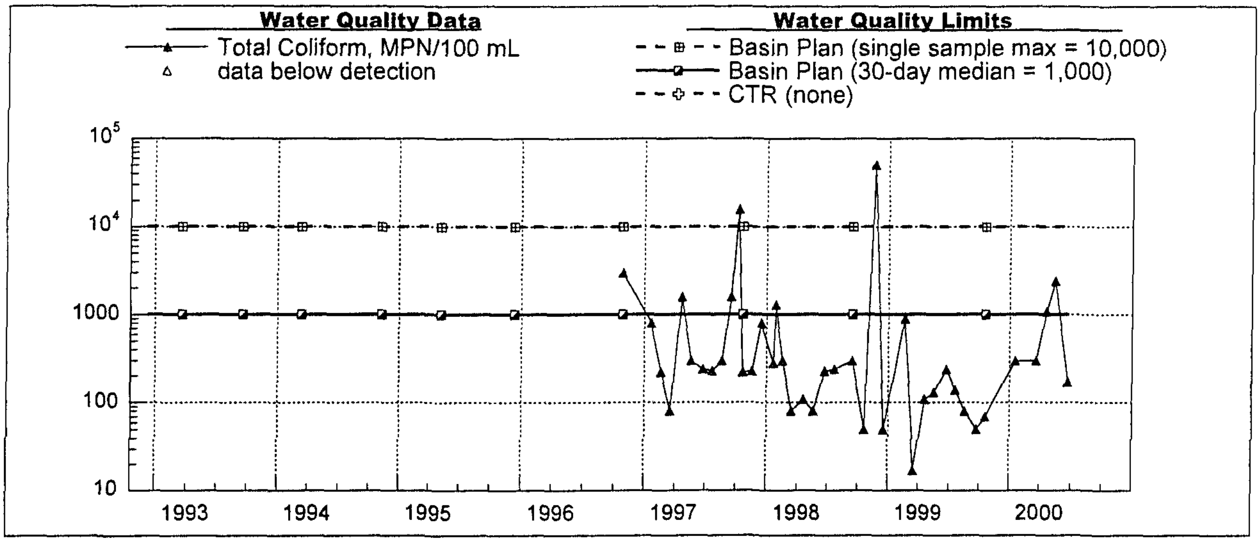
American River at Discovery Park
Time Series Plots of Ambient Program Data 1992-2000

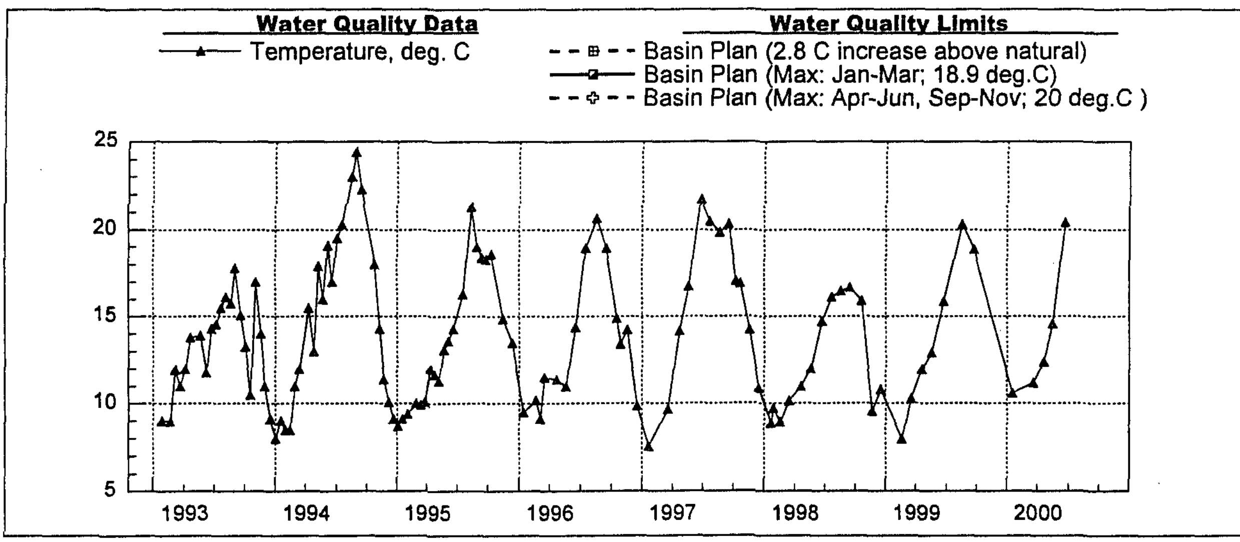


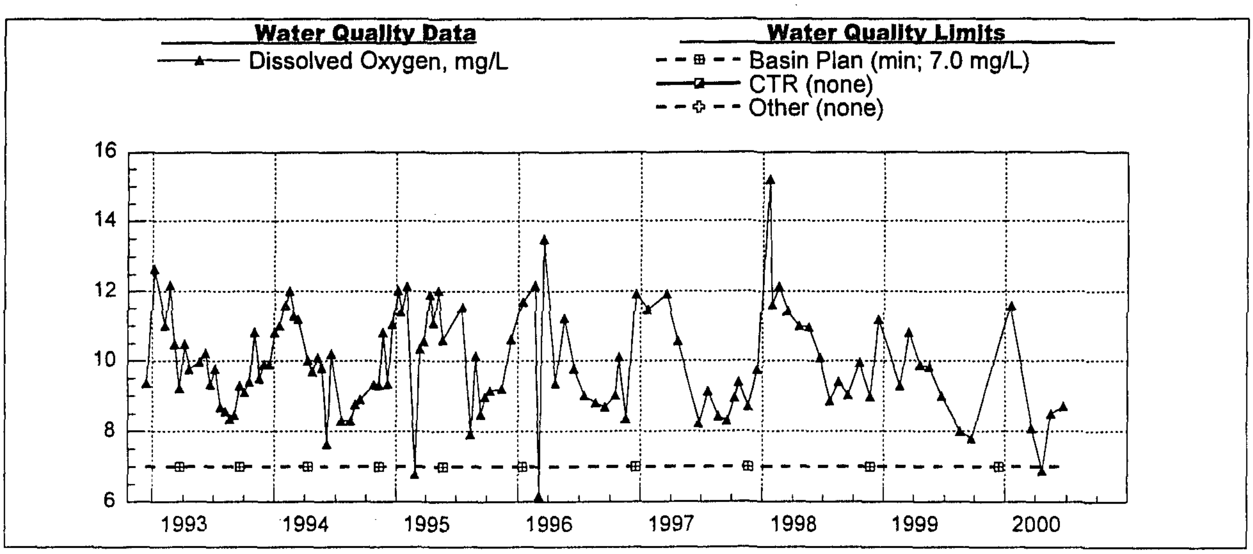




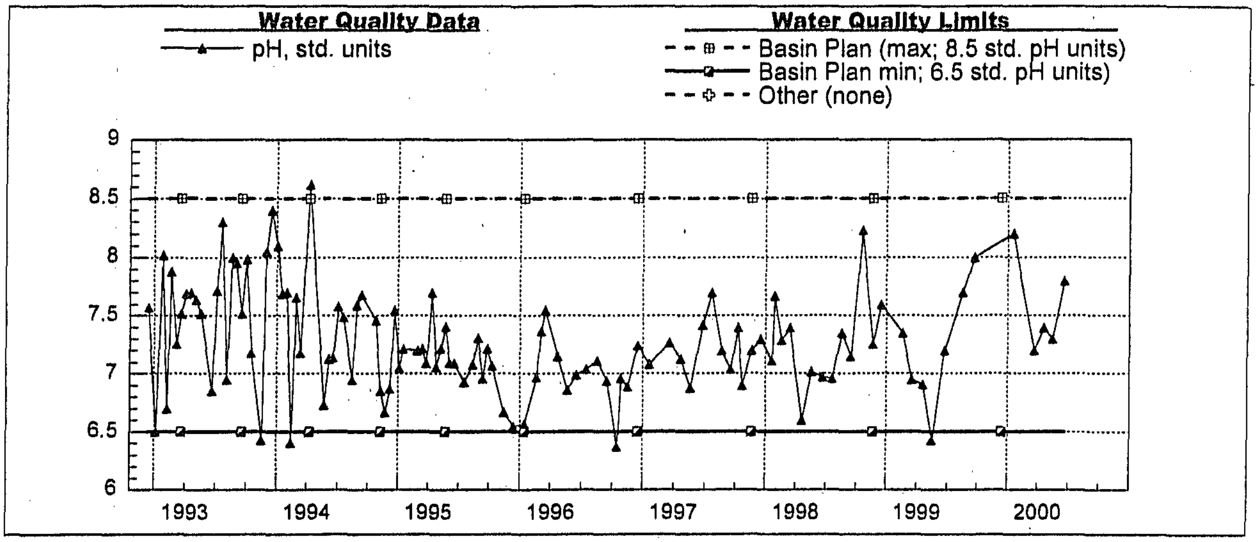
American River at Discovery Park
Time Series Plots of Ambient Program Data 1992–2000

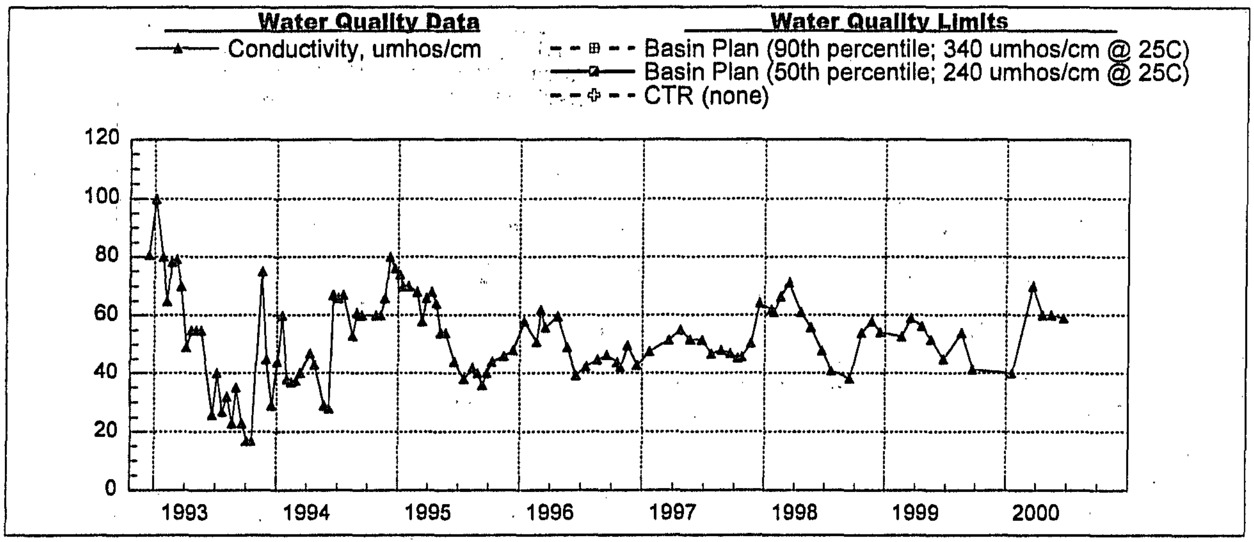


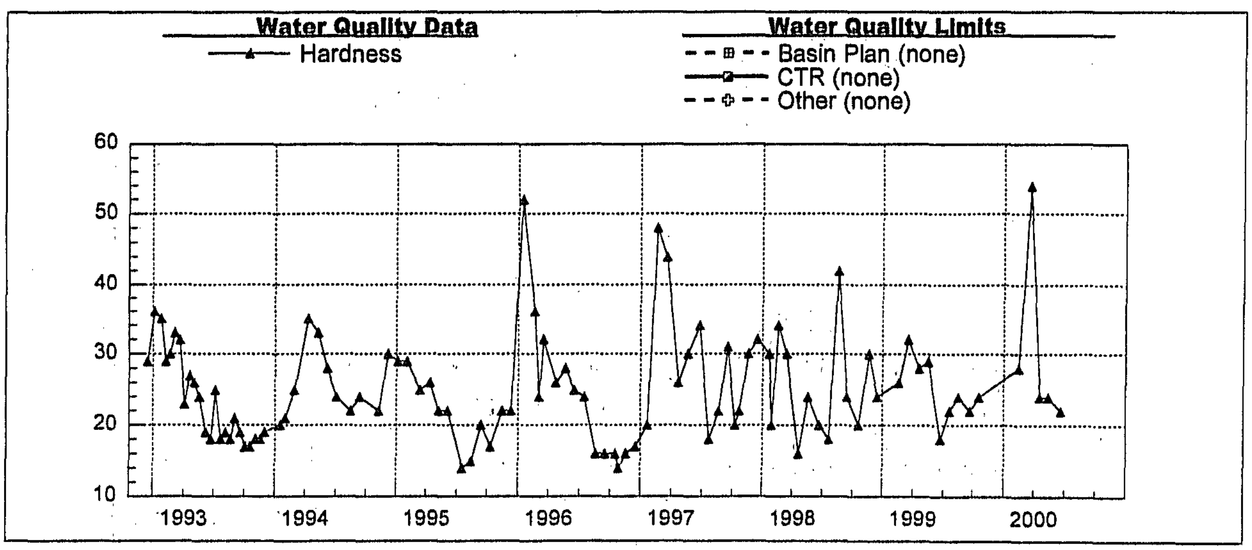




American River at Discovery Park
Time Series Plots of Ambient Program Data 1992-2000

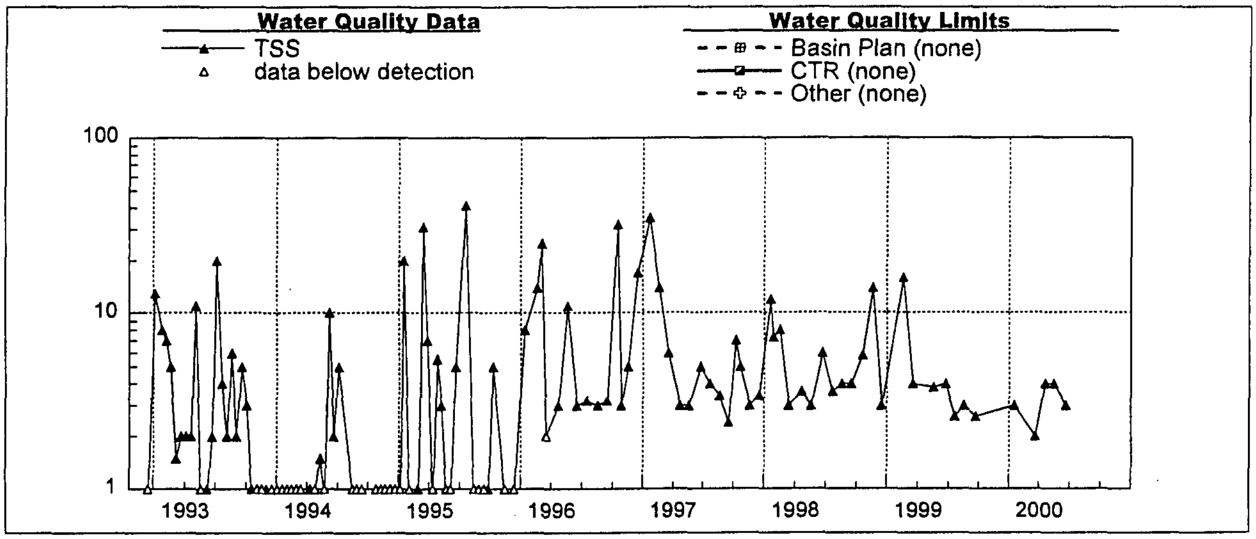


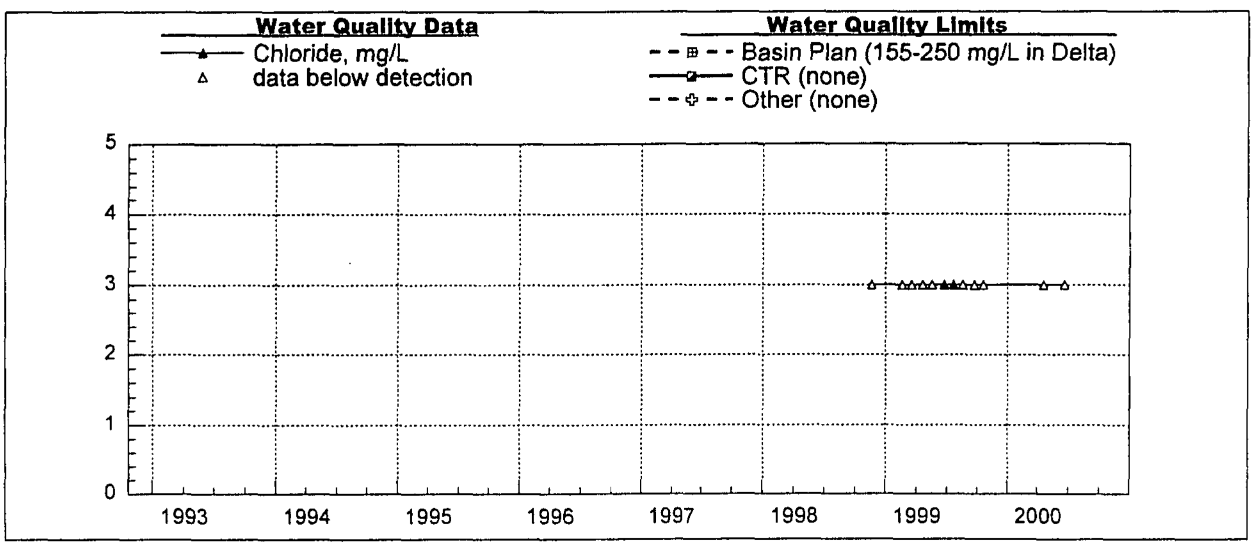




American River at Discovery Park
Time Series Plots of Ambient Program Data 1992-2000

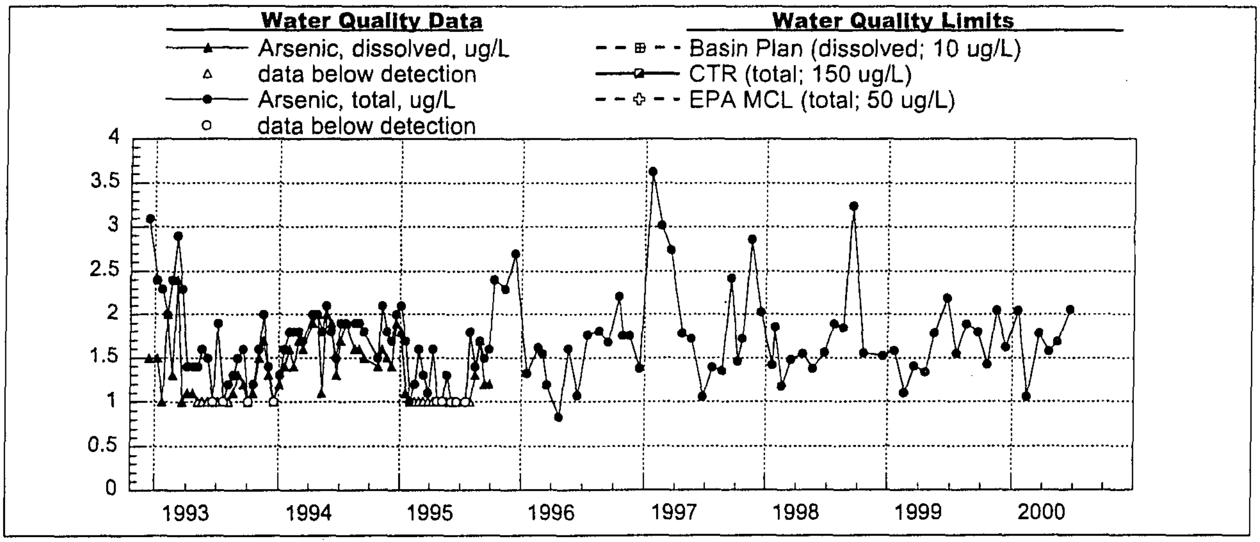
This Space Intentionally Blank

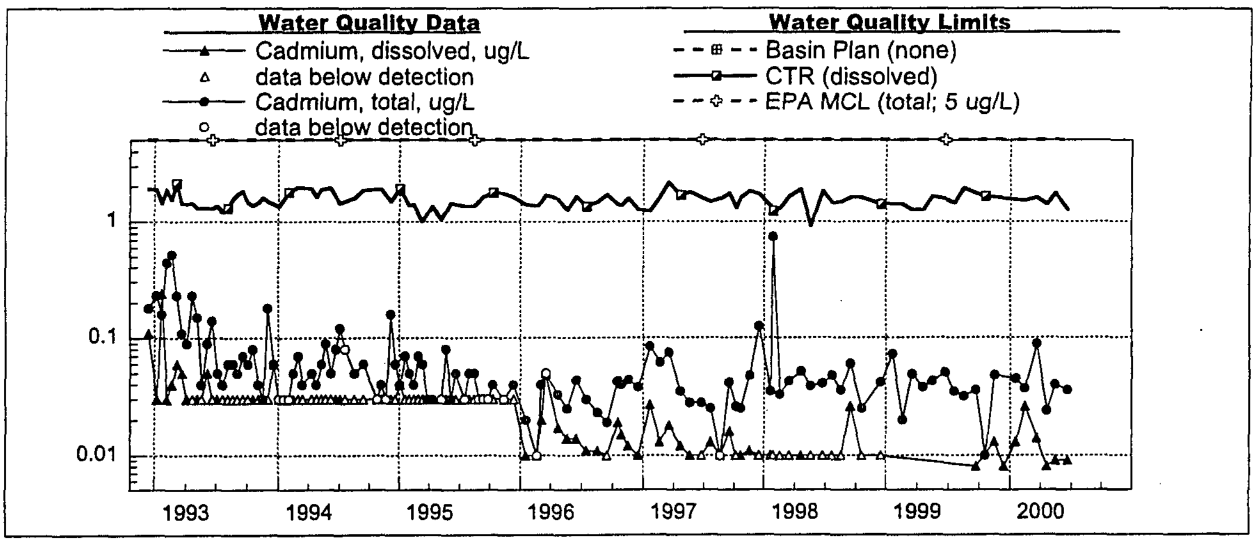


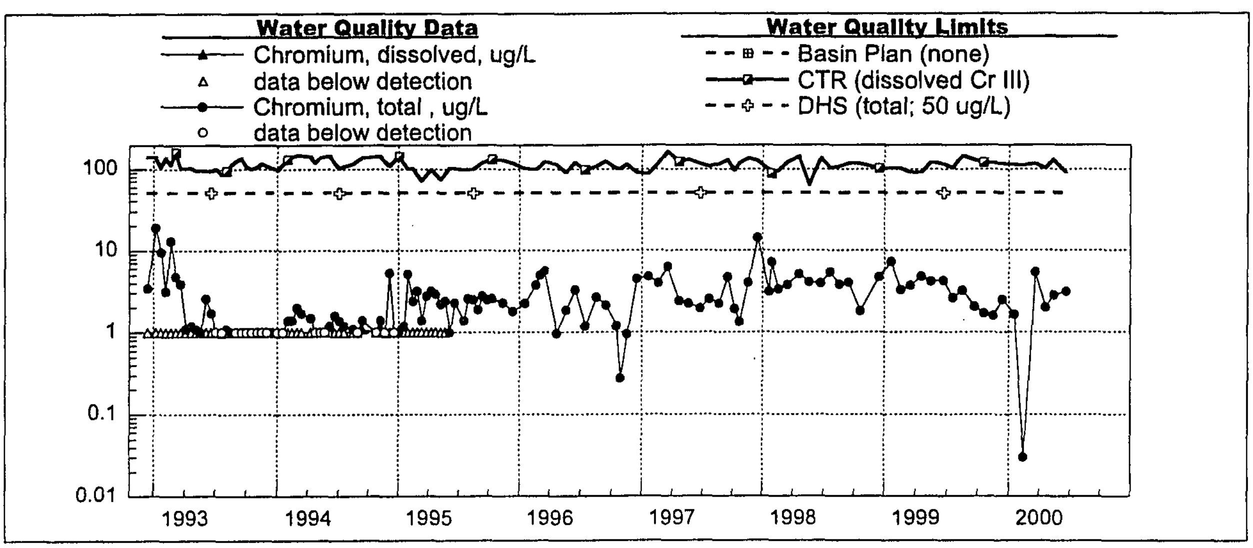


Sacramento River at Veterans Bridge

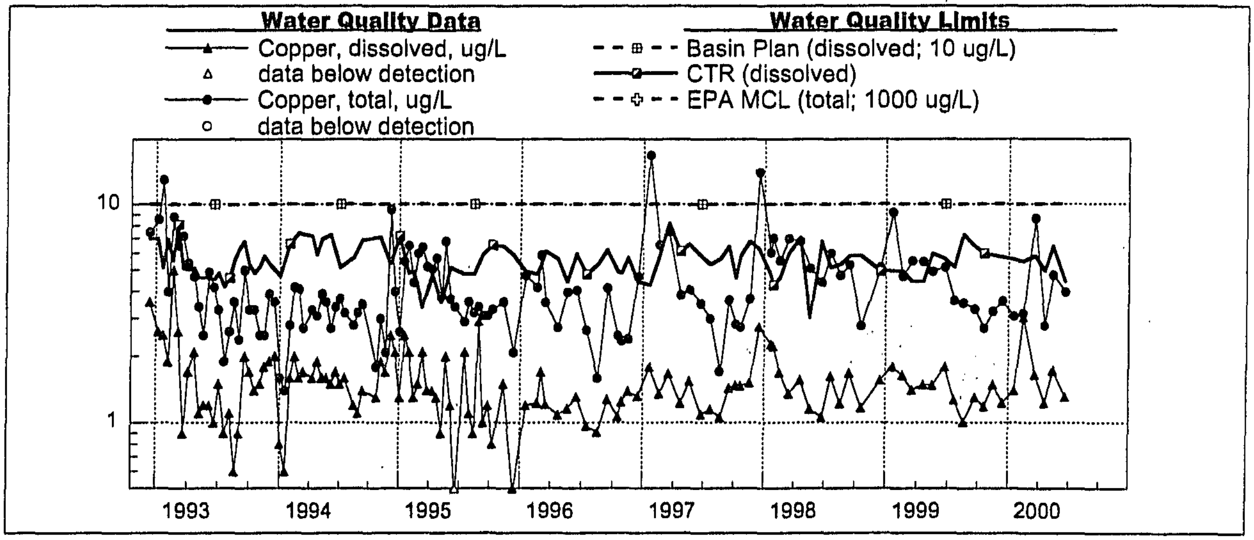
Sacramento River at Veterans Bridge
Time Series Plots of Ambient Program Data 1992-2000

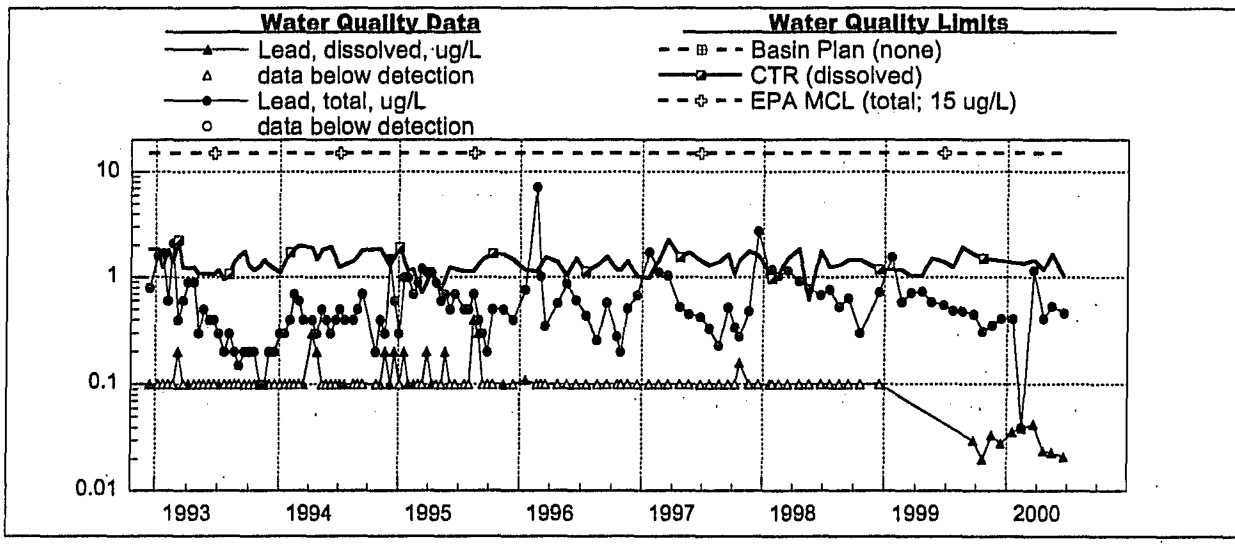


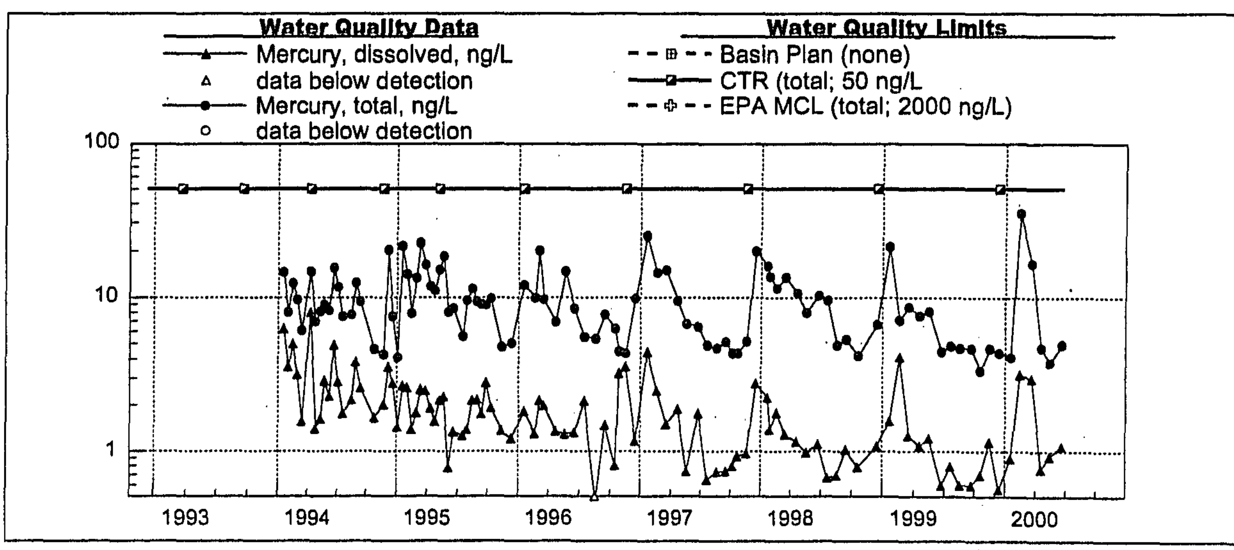




Sacramento River at Veterans Bridge
Time Series Plots of Ambient Program Data 1992-2000

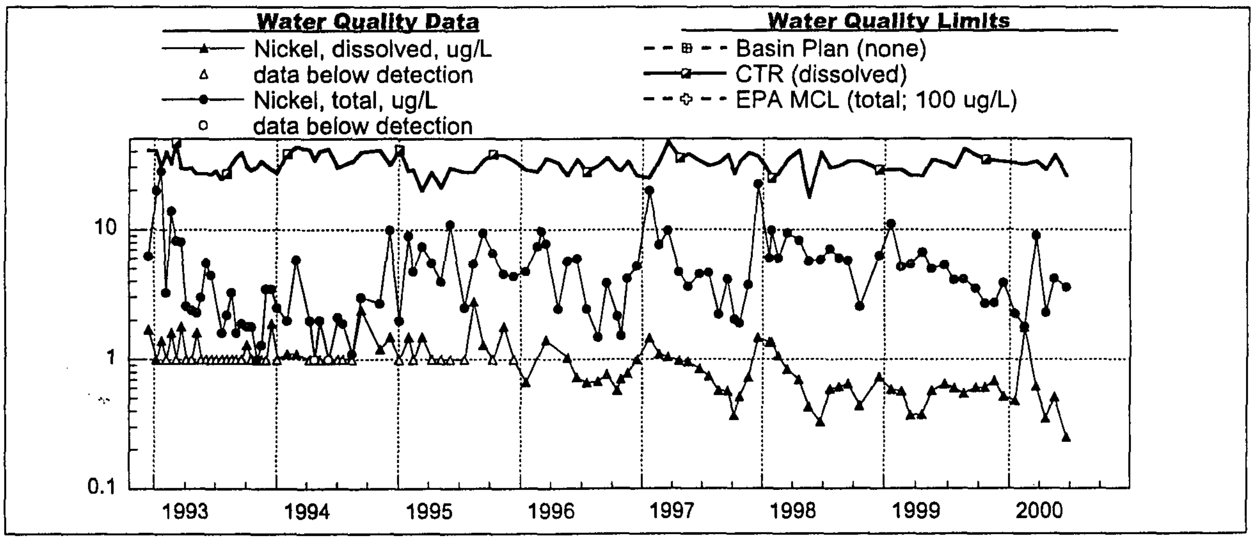


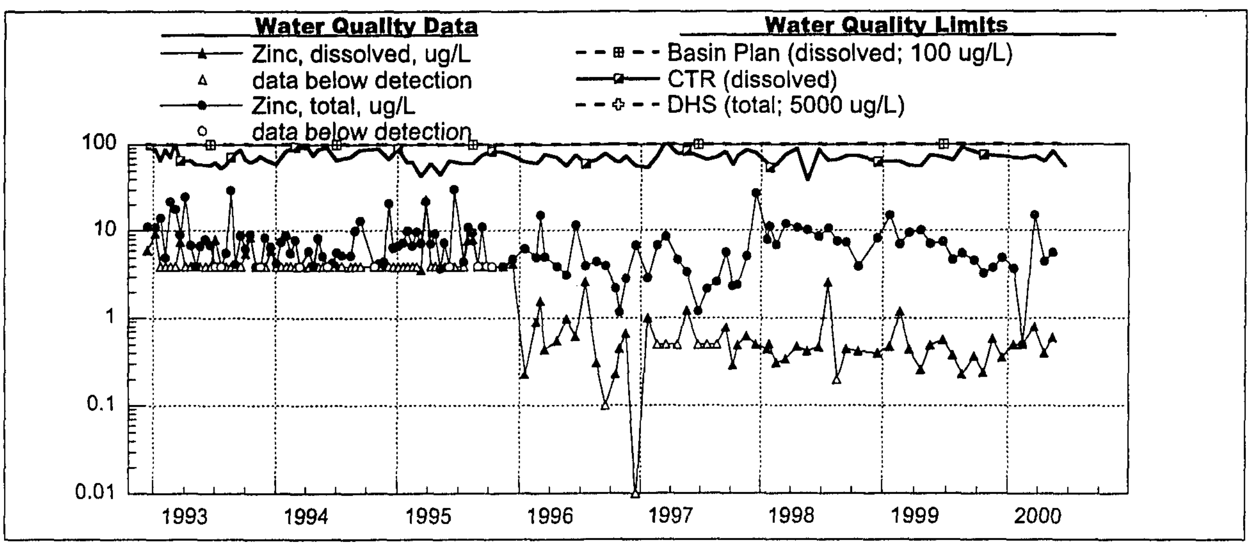




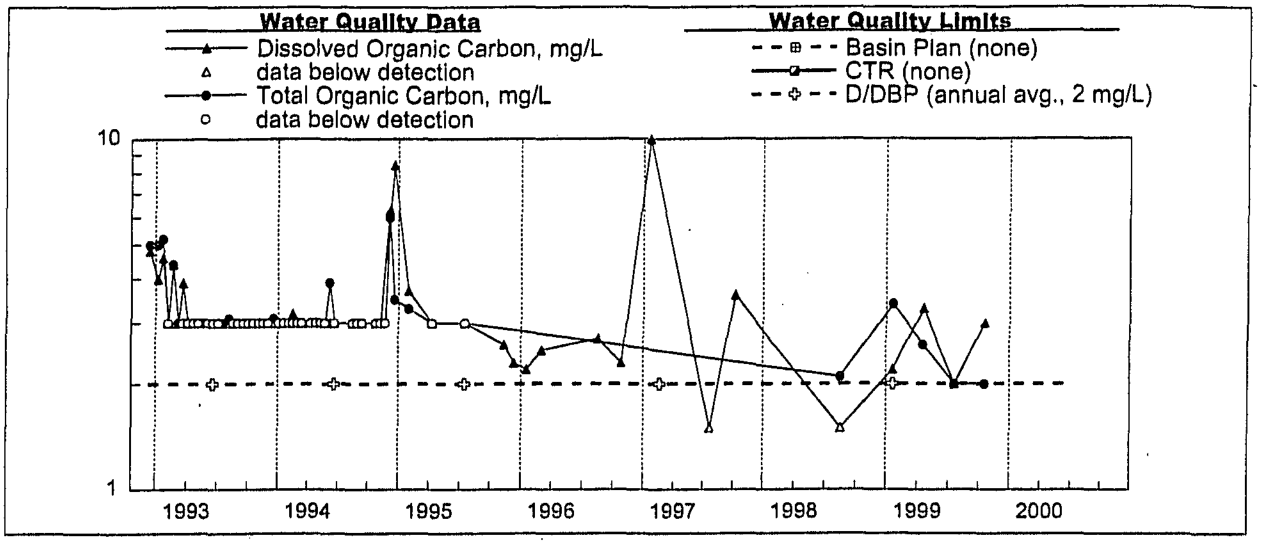
Sacramento River at Veterans Bridge
Time Series Plots of Ambient Program Data 1992–2000

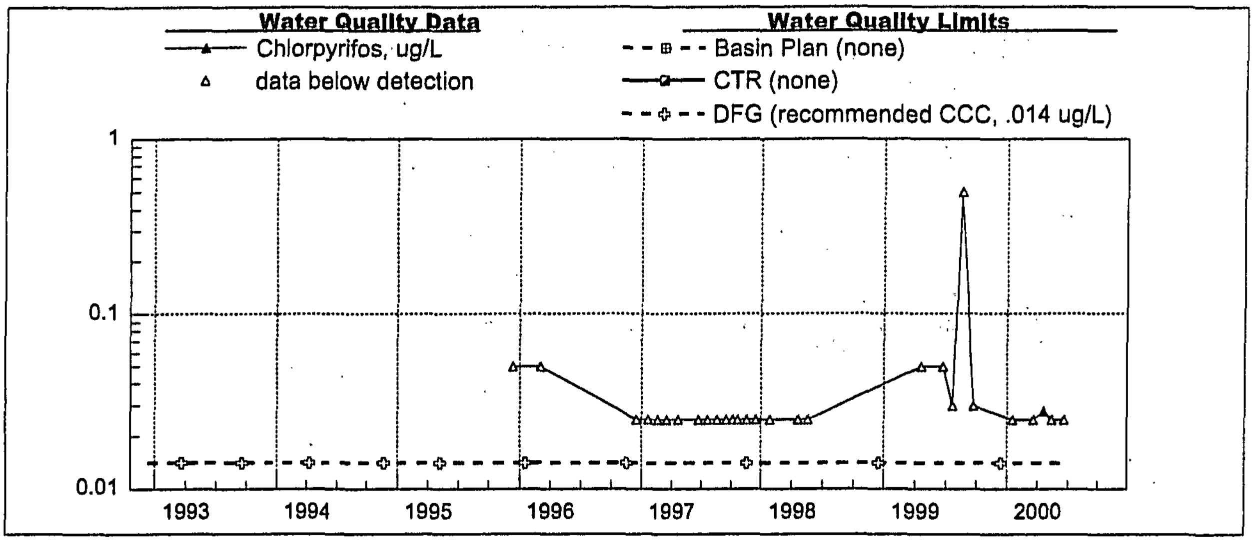
This Space Intentionally Blank

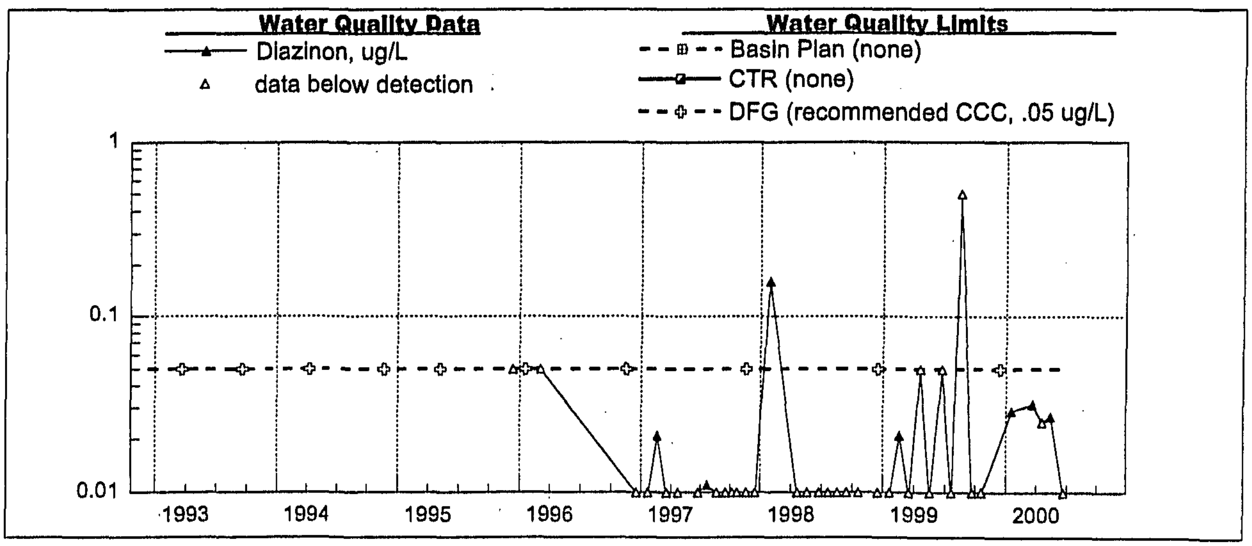




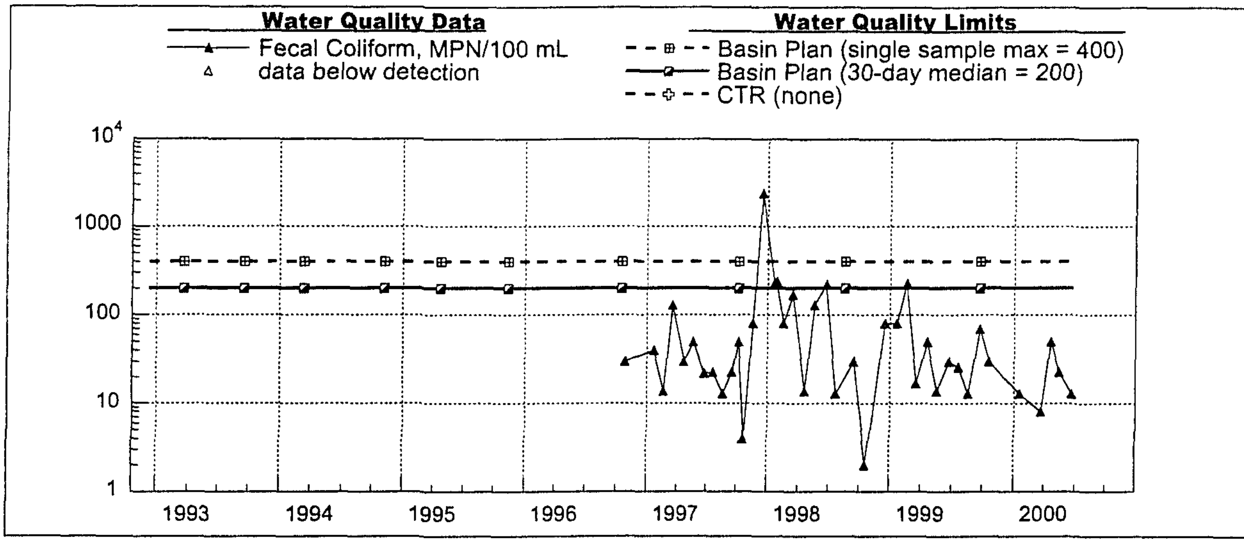
Sacramento River at Veterans Bridge
Time Series Plots of Ambient Program Data 1992–2000

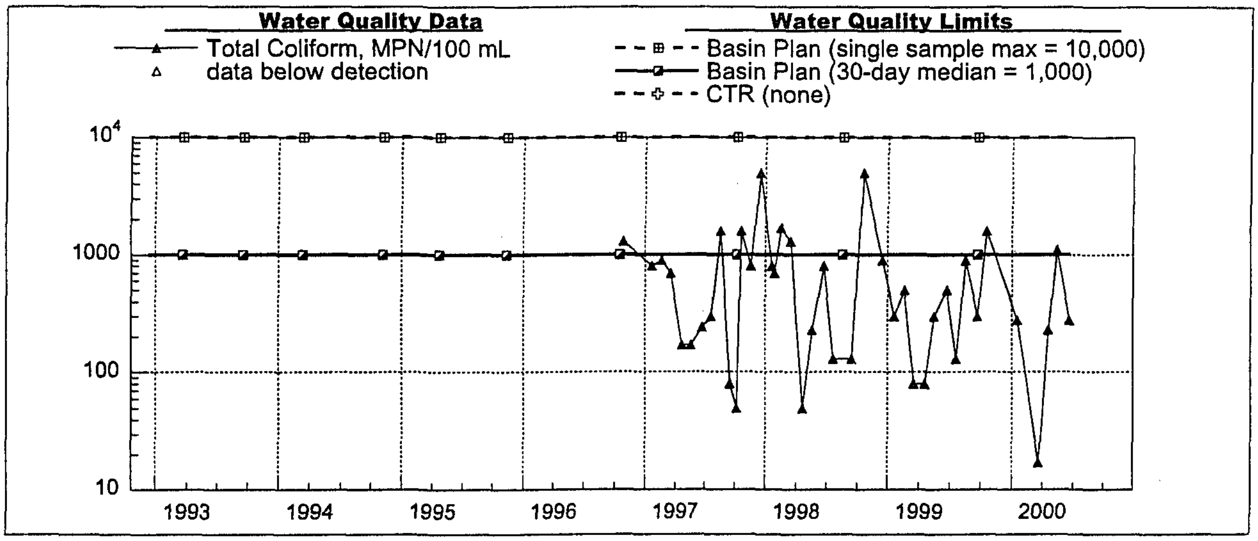


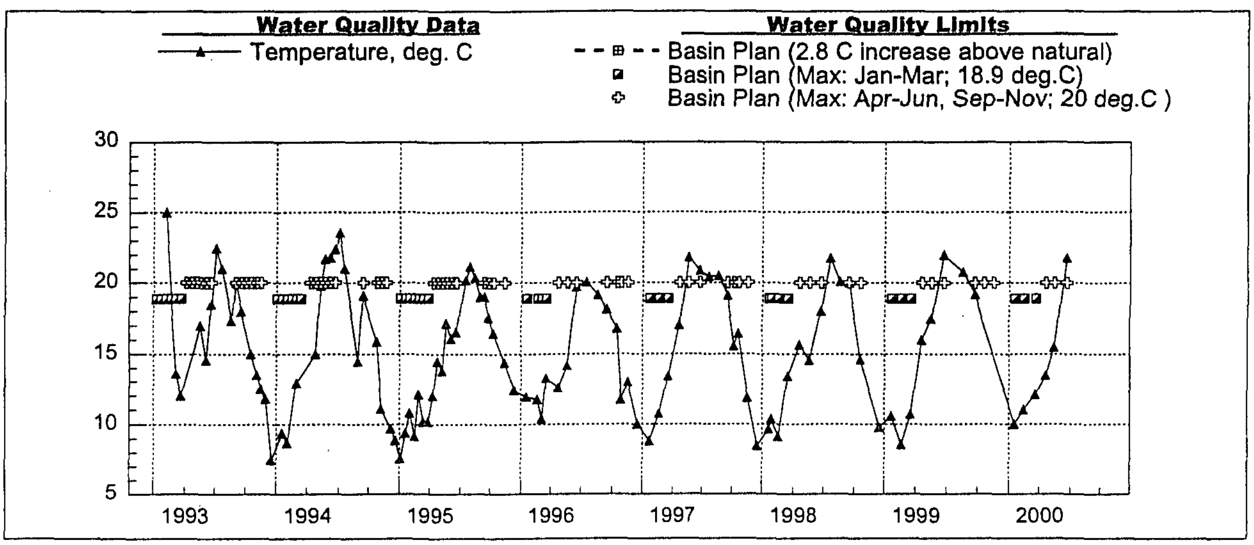




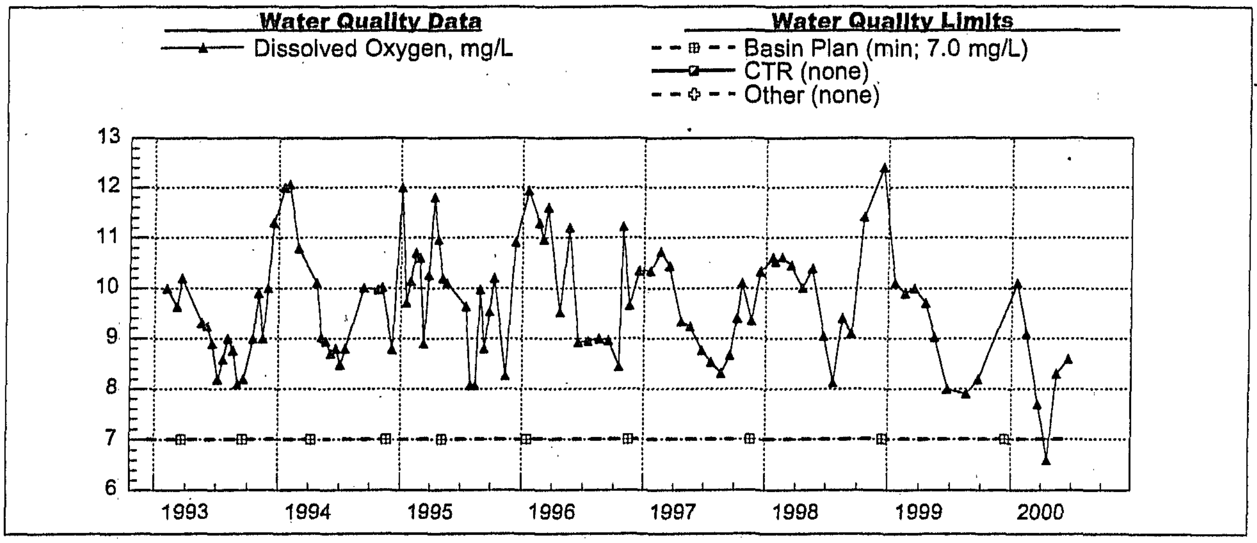
Sacramento River at Veterans Bridge
Time Series Plots of Ambient Program Data 1992–2000

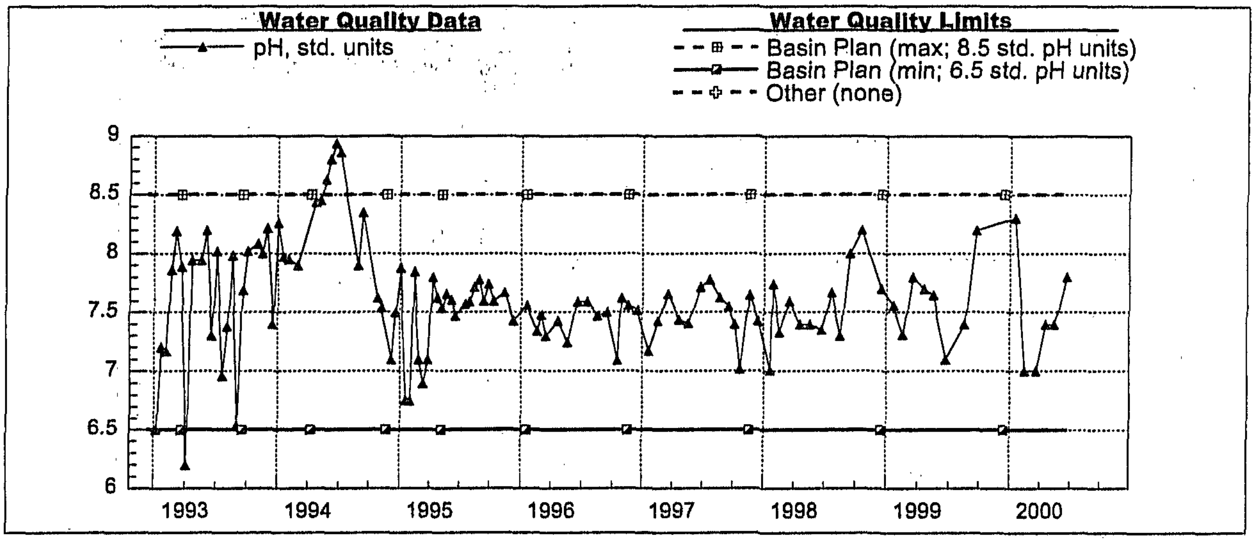


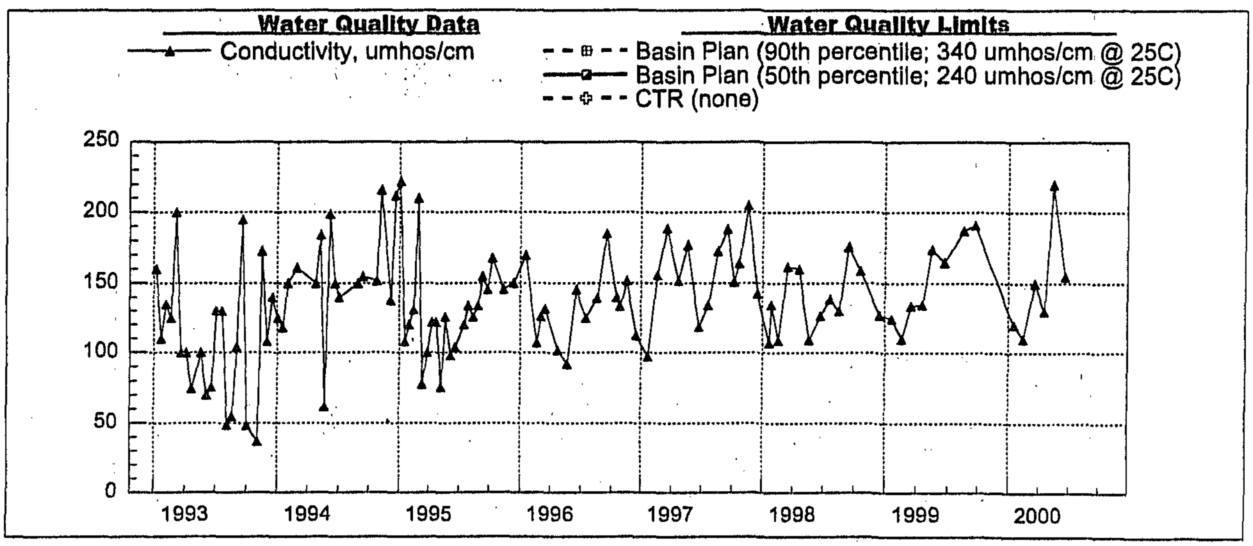




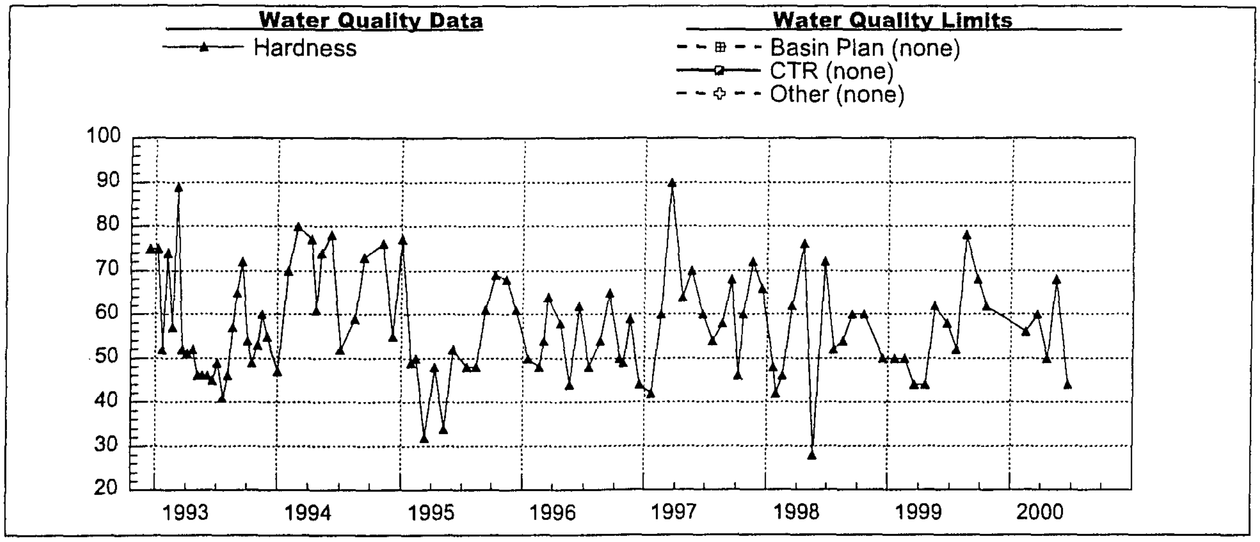
Sacramento River at Veterans Bridge
Time Series Plots of Ambient Program Data 1992-2000

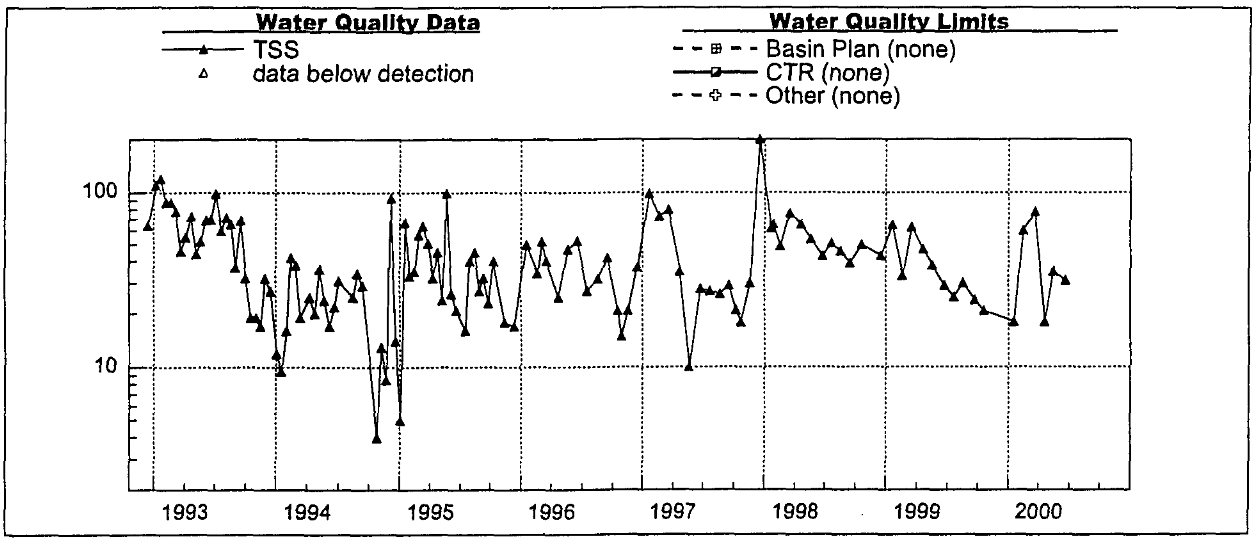


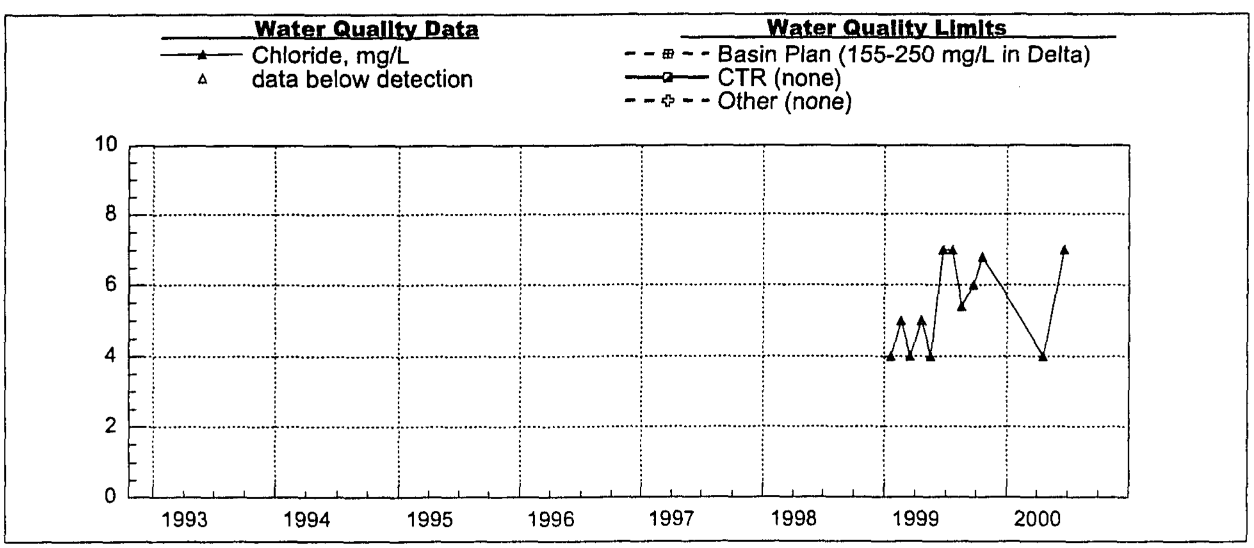




Sacramento River at Veterans Bridge
Time Series Plots of Ambient Program Data 1992–2000



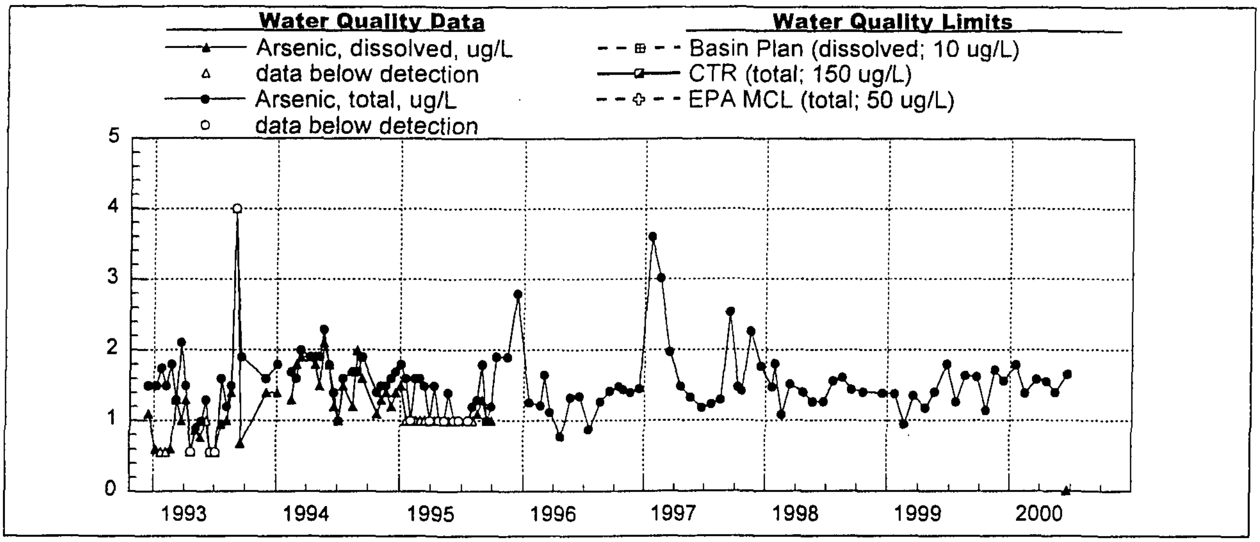


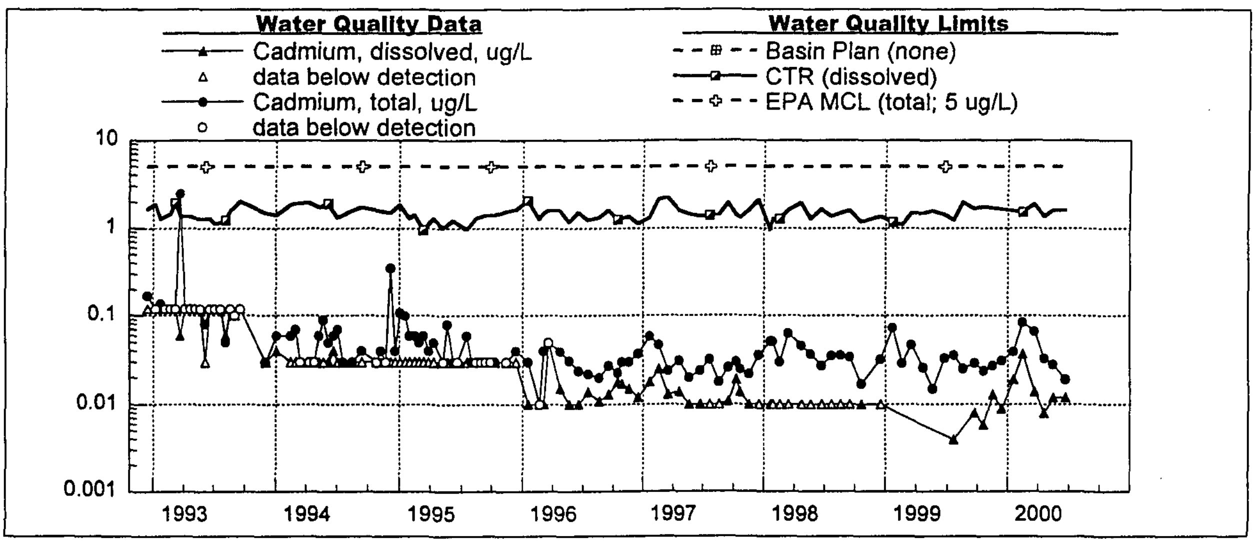


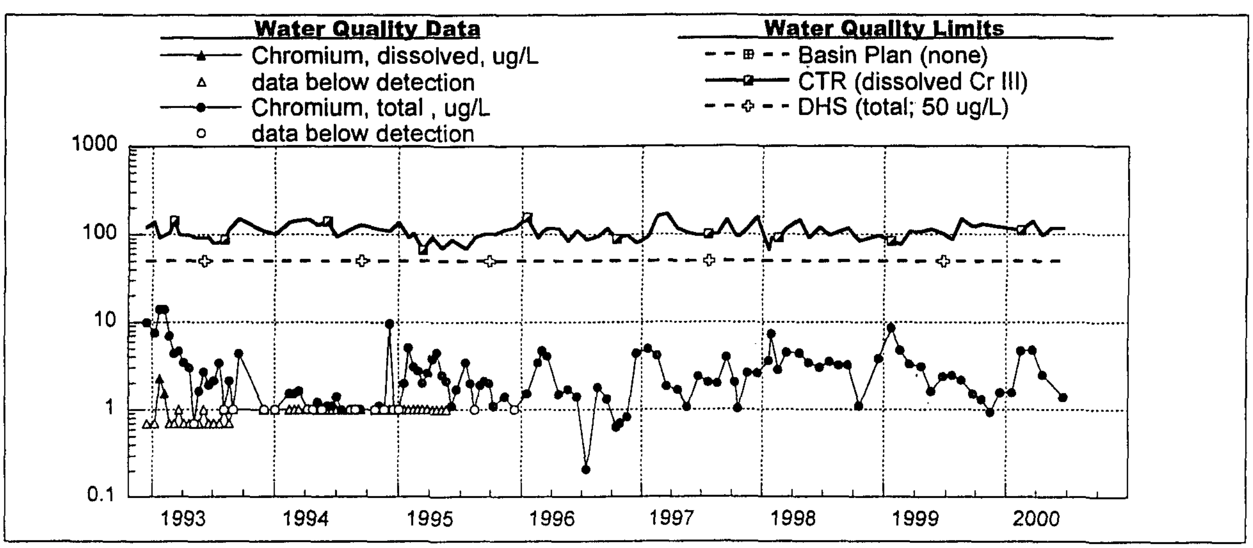
Sacramento River at Freeport

Sacramento River at Freeport

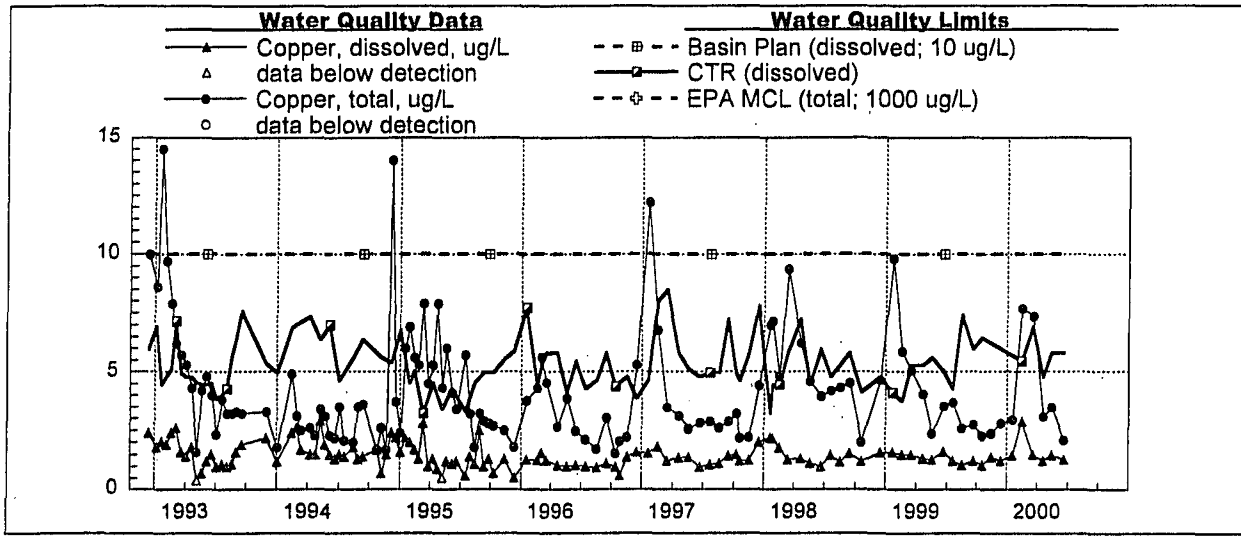
Time Series Plots of Ambient Program Data 1992-2000

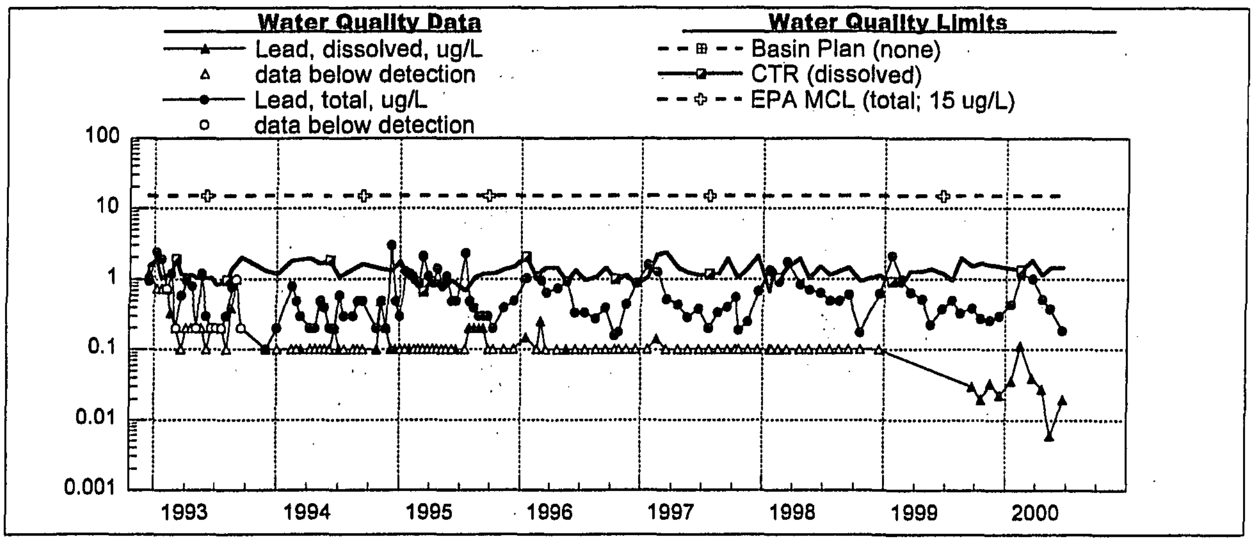


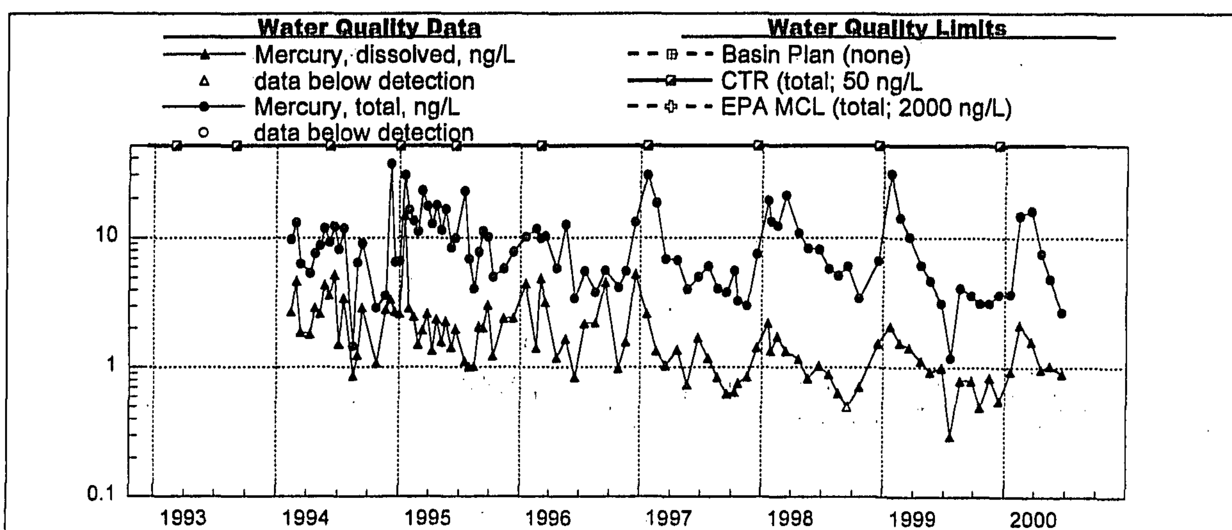




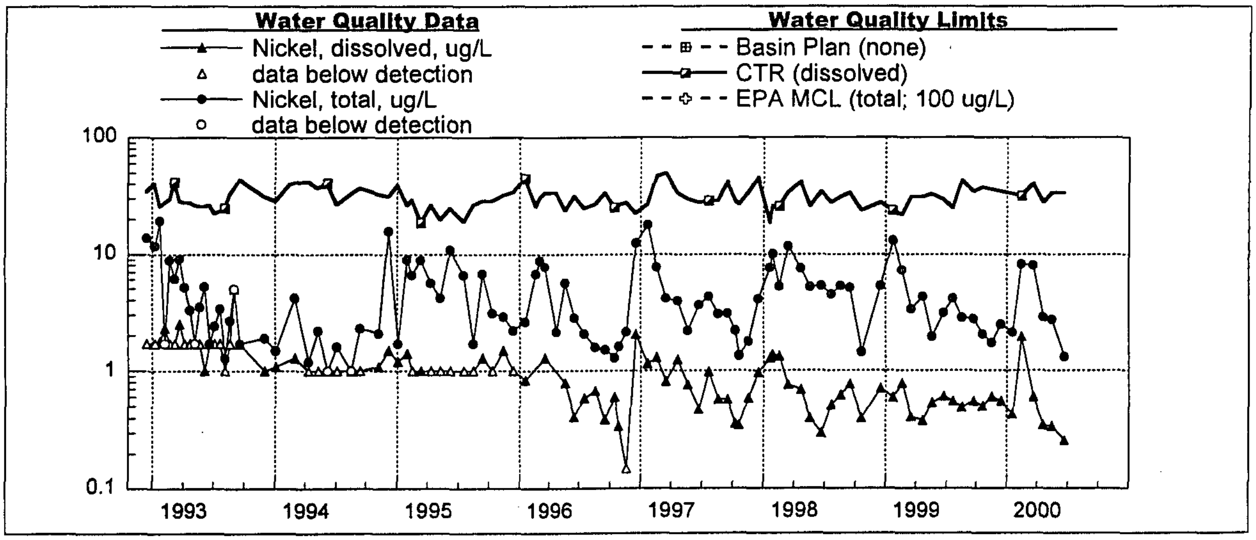
Sacramento River at Freeport
Time Series Plots of Ambient Program Data 1992–2000

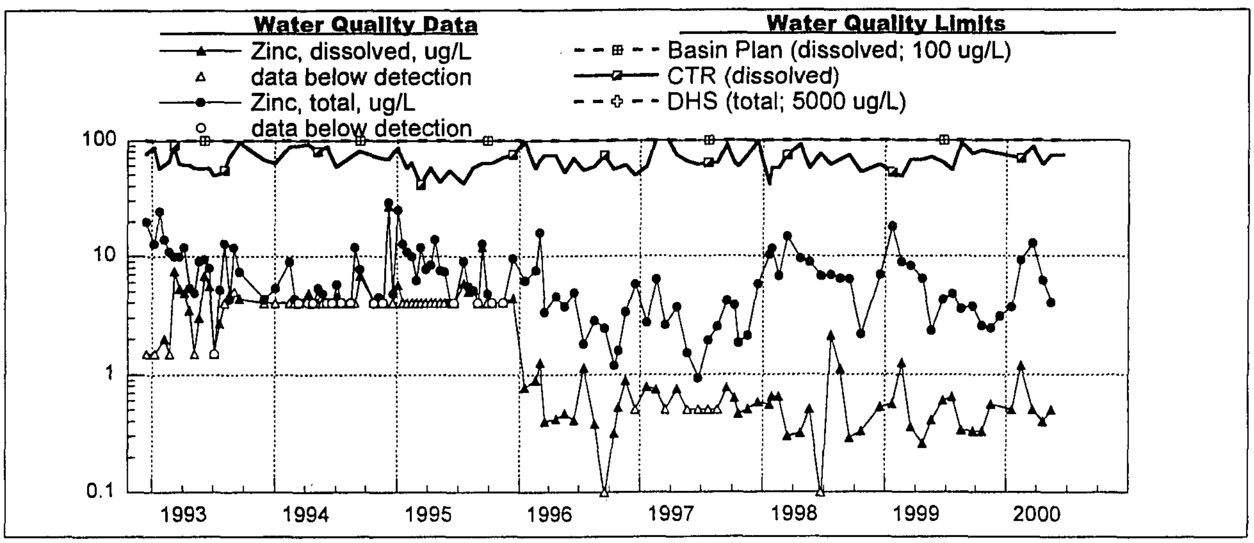






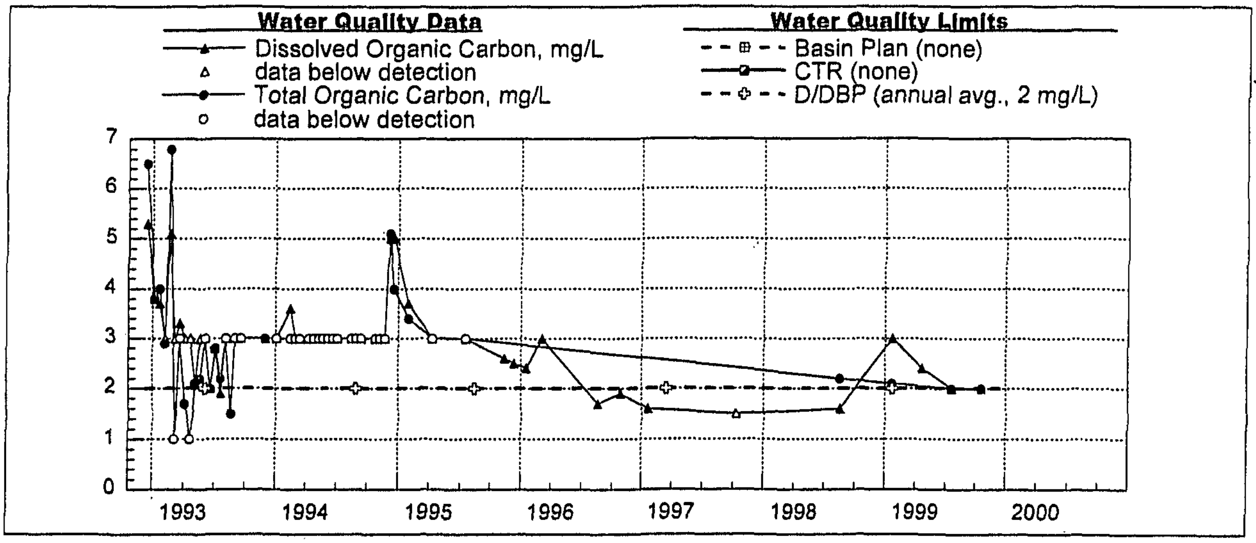
This Space Intentionally Blank

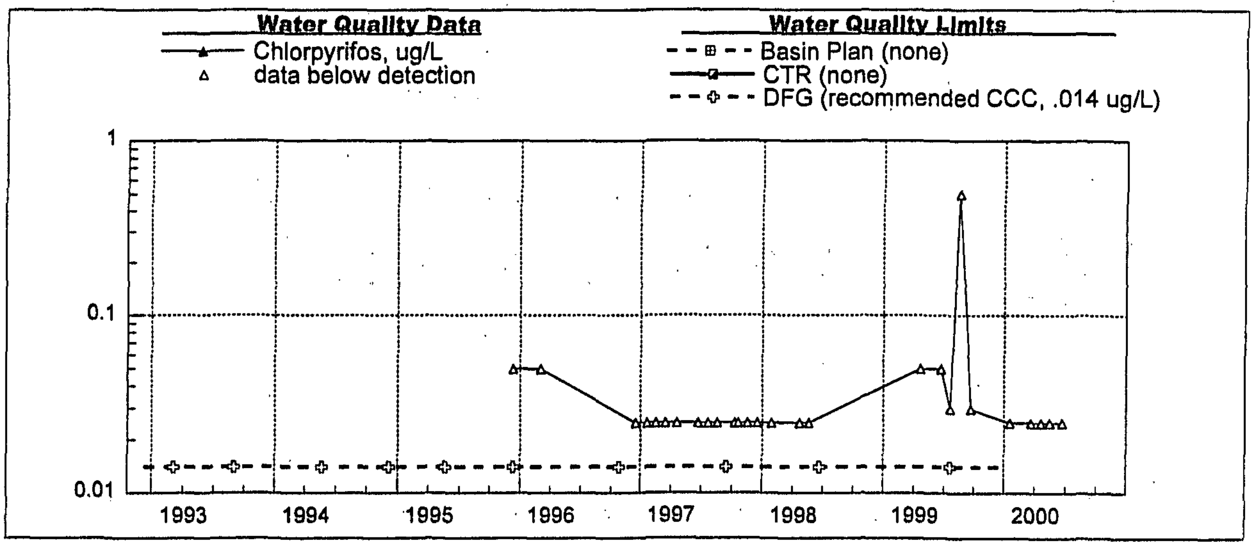


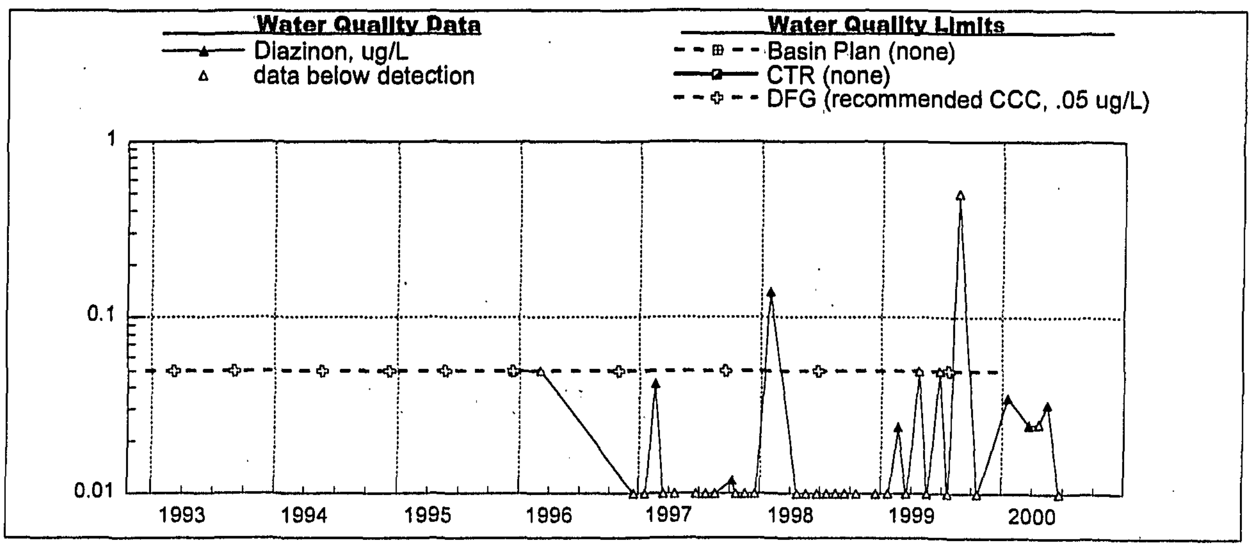


Sacramento River at Freeport

Time Series Plots of Ambient Program Data 1992–2000

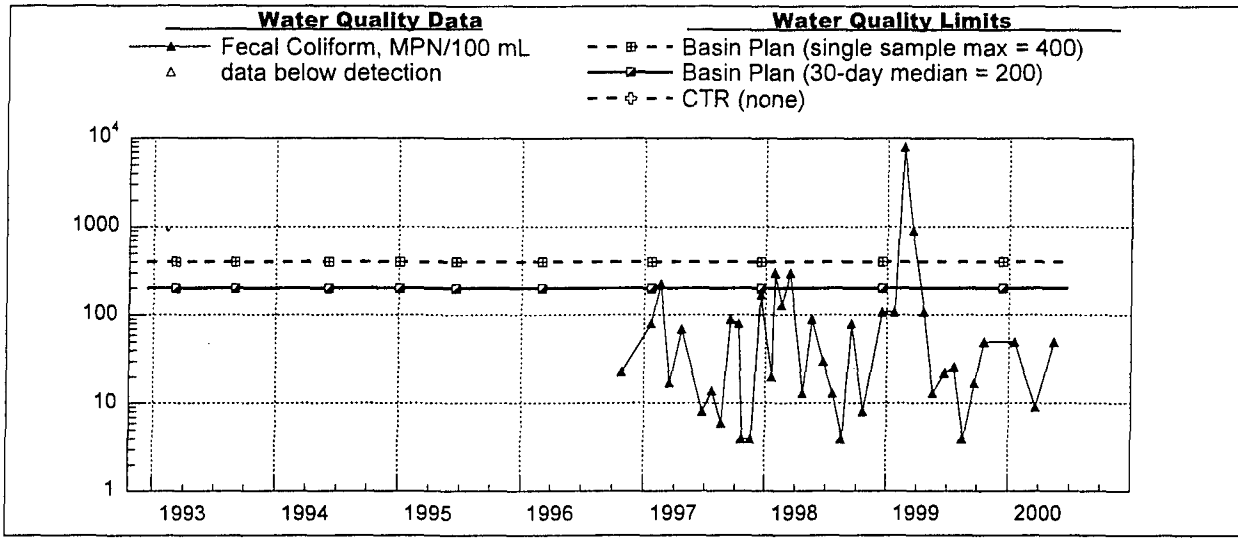


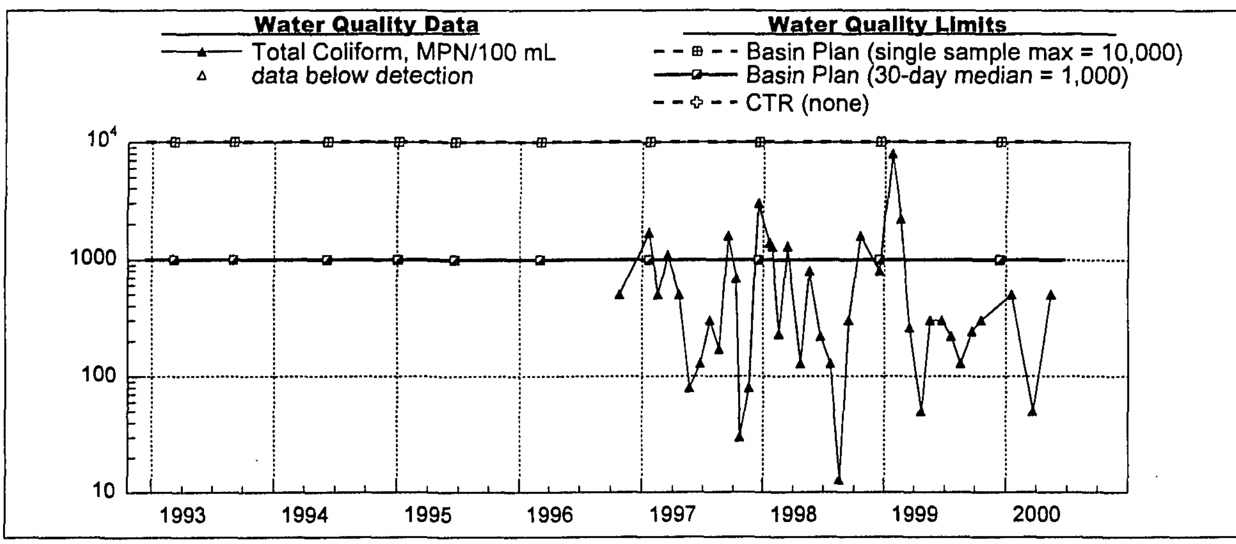


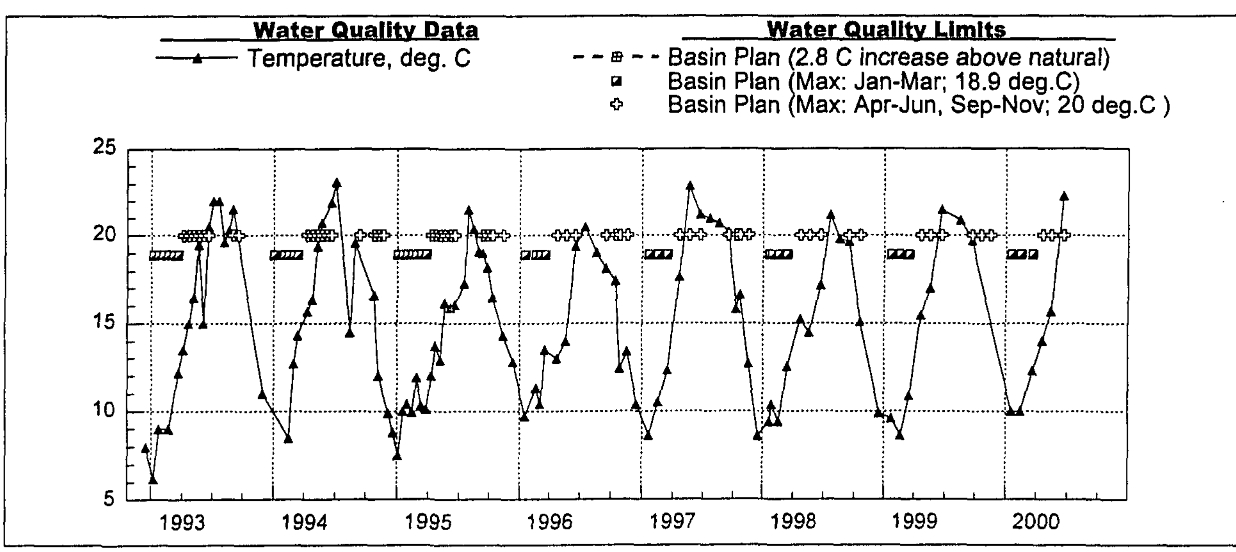


Sacramento River at Freeport

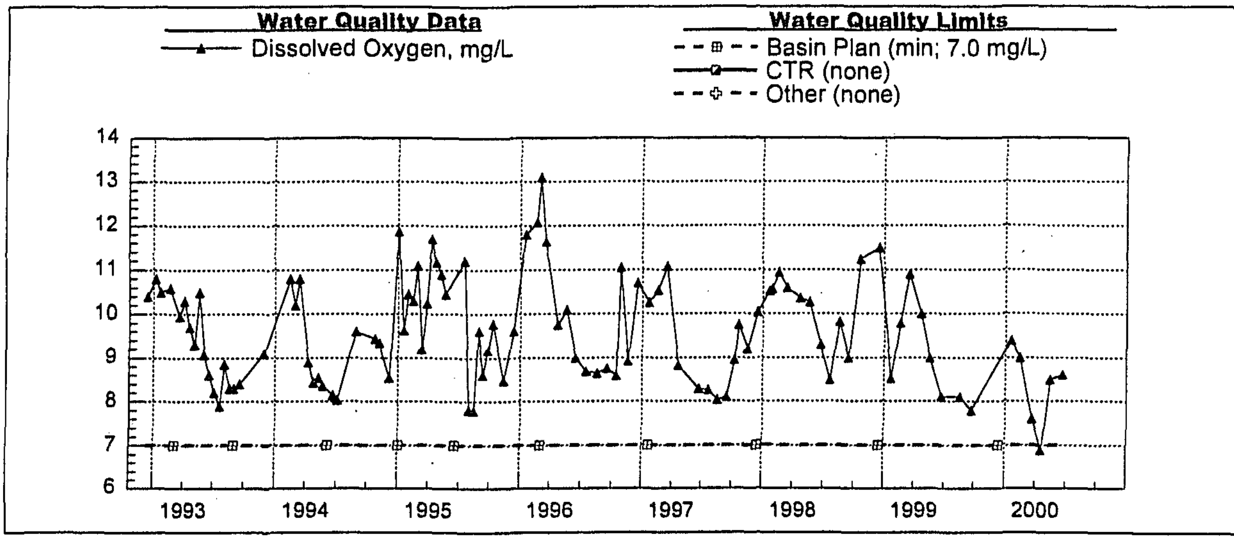
Time Series Plots of Ambient Program Data 1992-2000

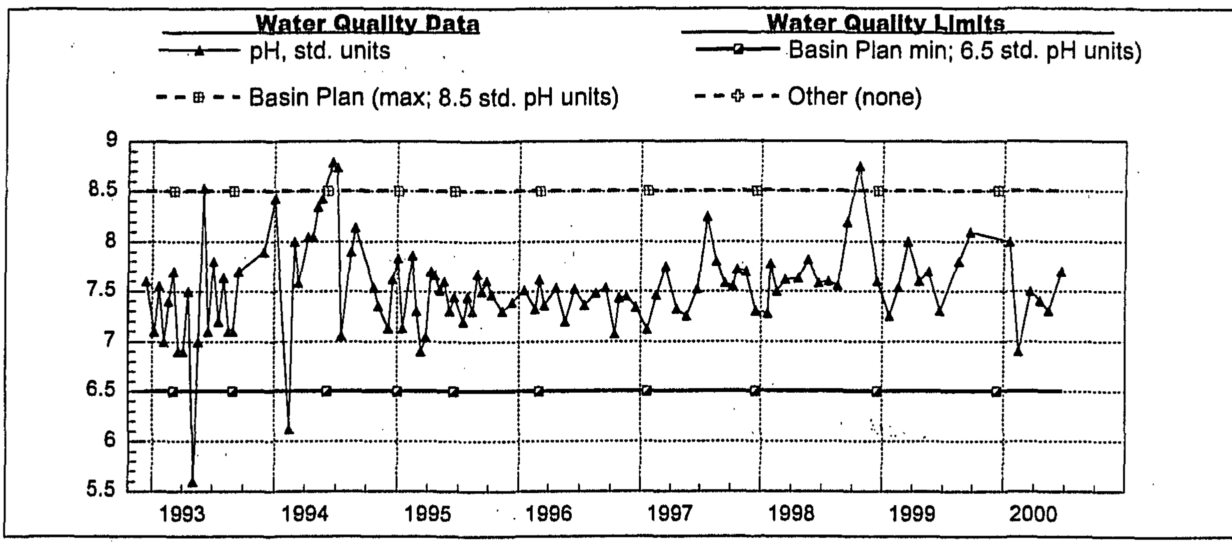


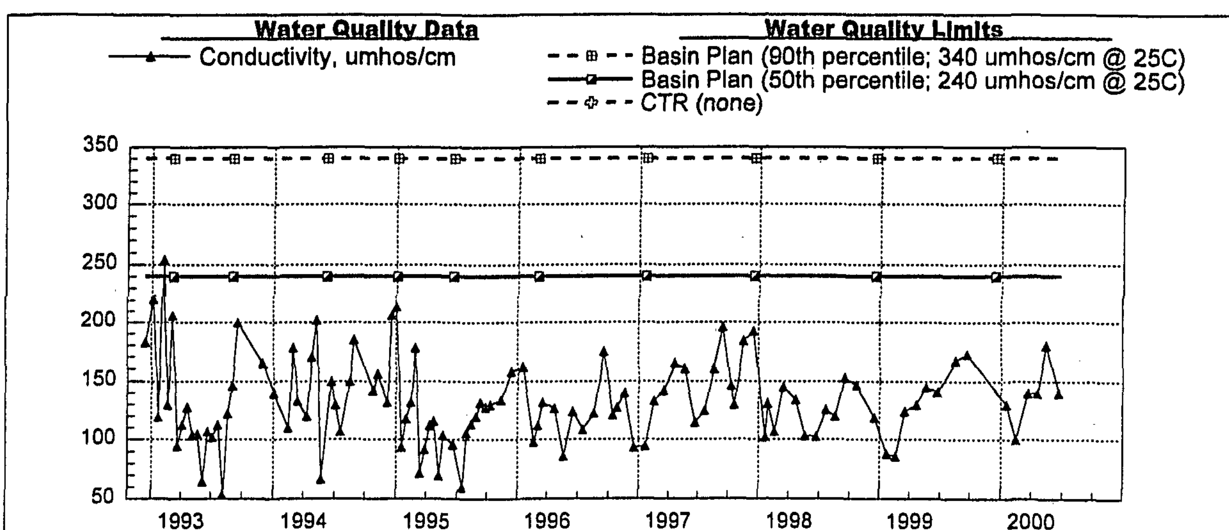




Sacramento River at Freeport
Time Series Plots of Ambient Program Data 1992-2000

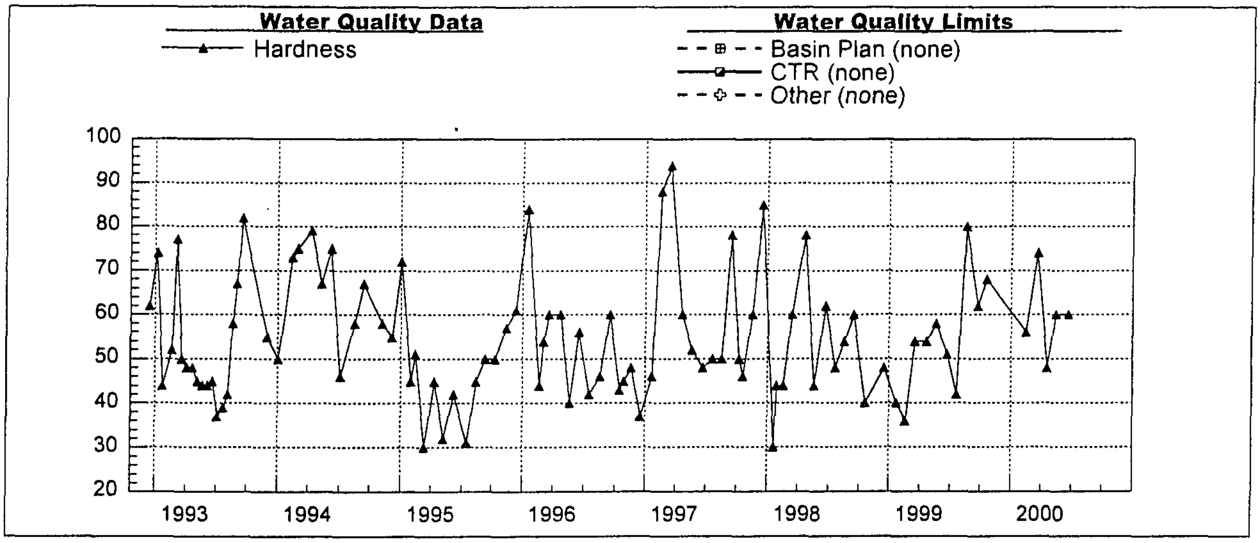


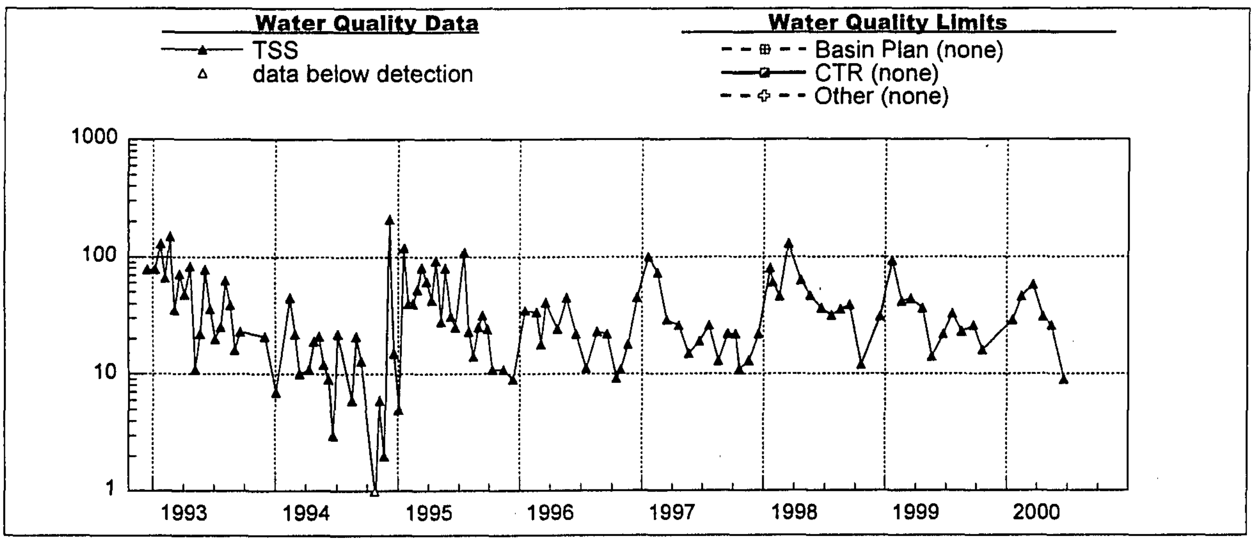


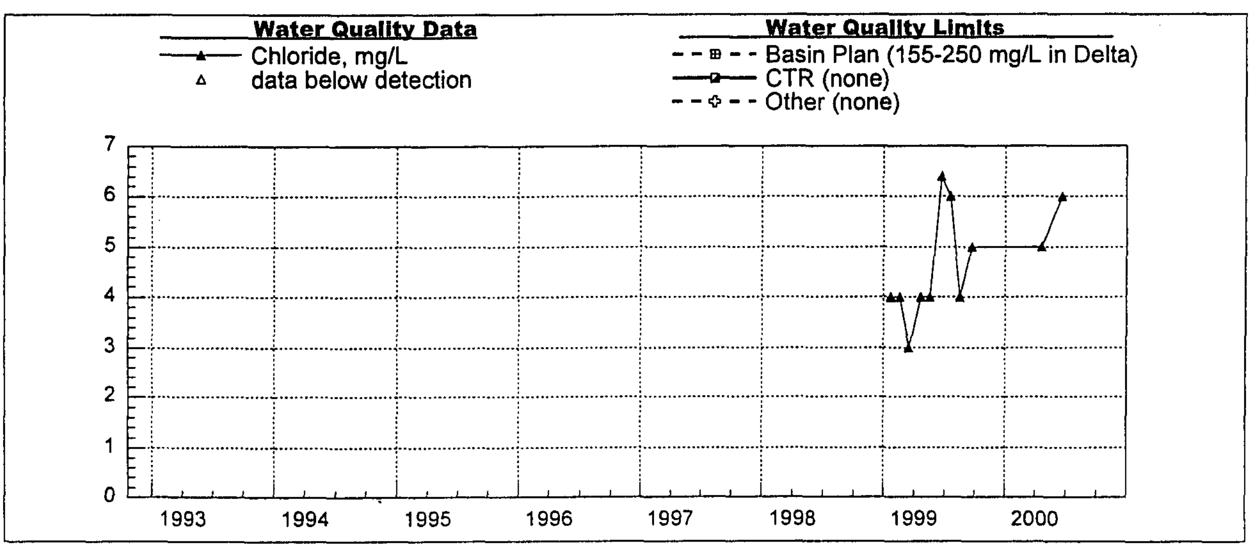


Sacramento River at Freeport

Time Series Plots of Ambient Program Data 1992–2000



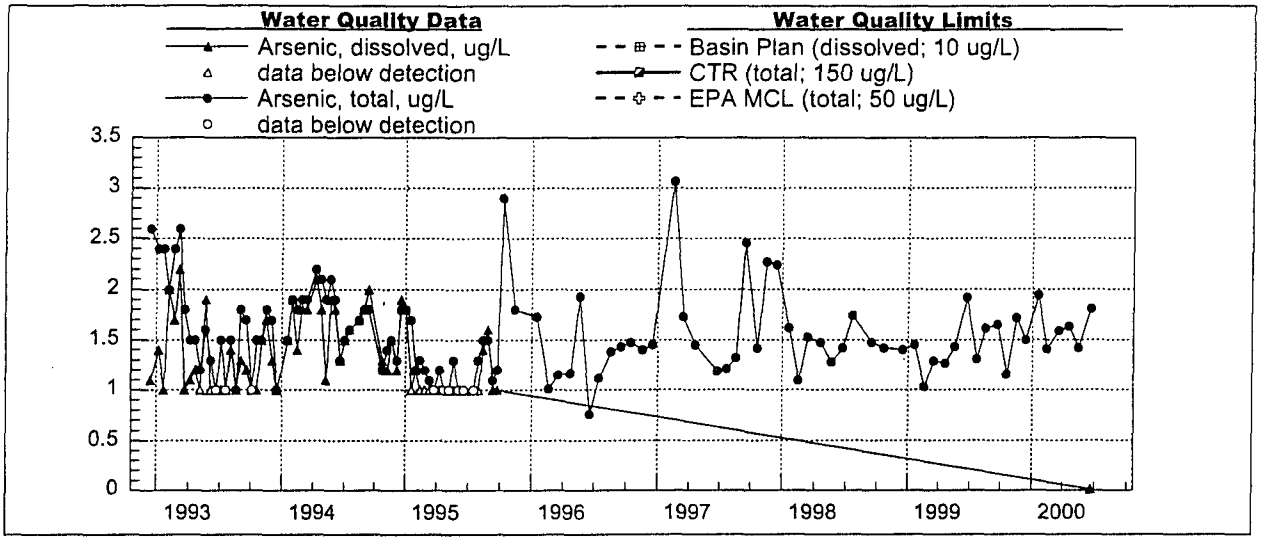


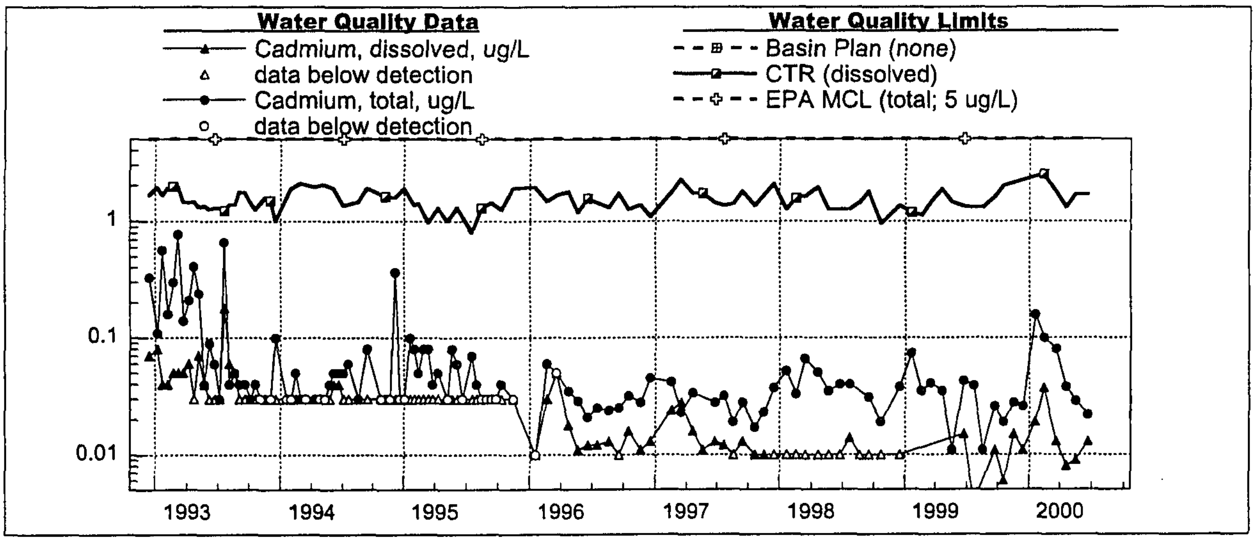


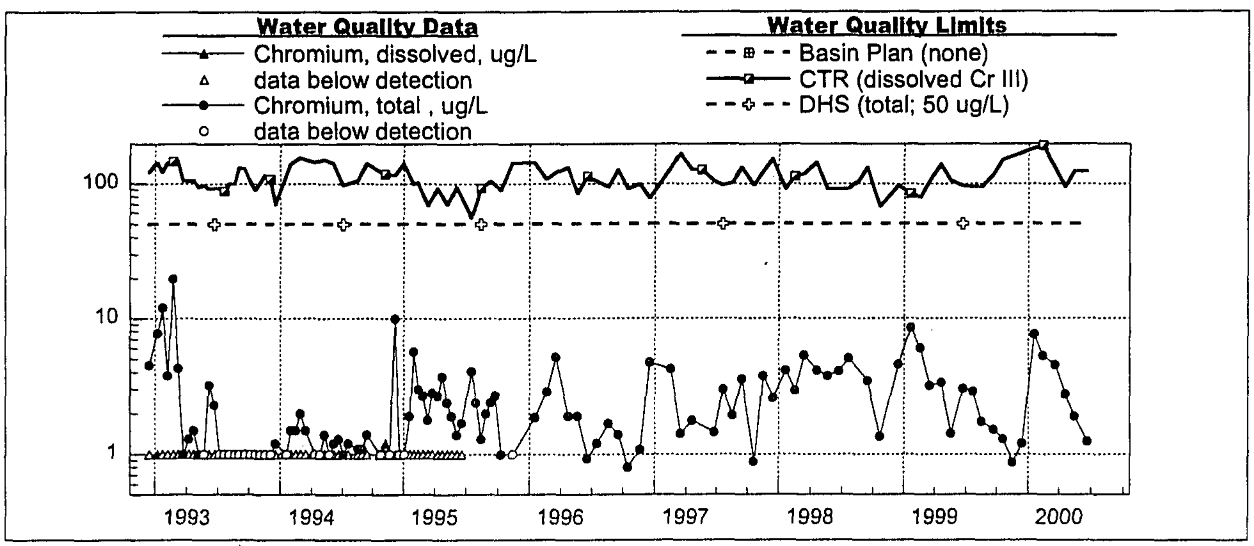
Sacramento River at River Mile 44

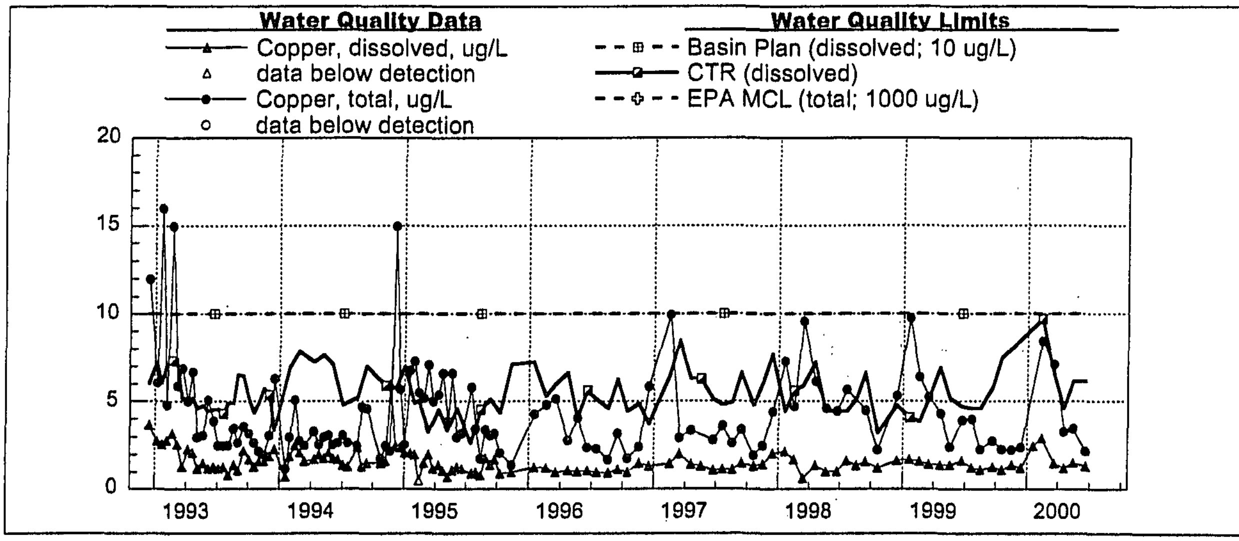
Sacramento River at River Mile 44

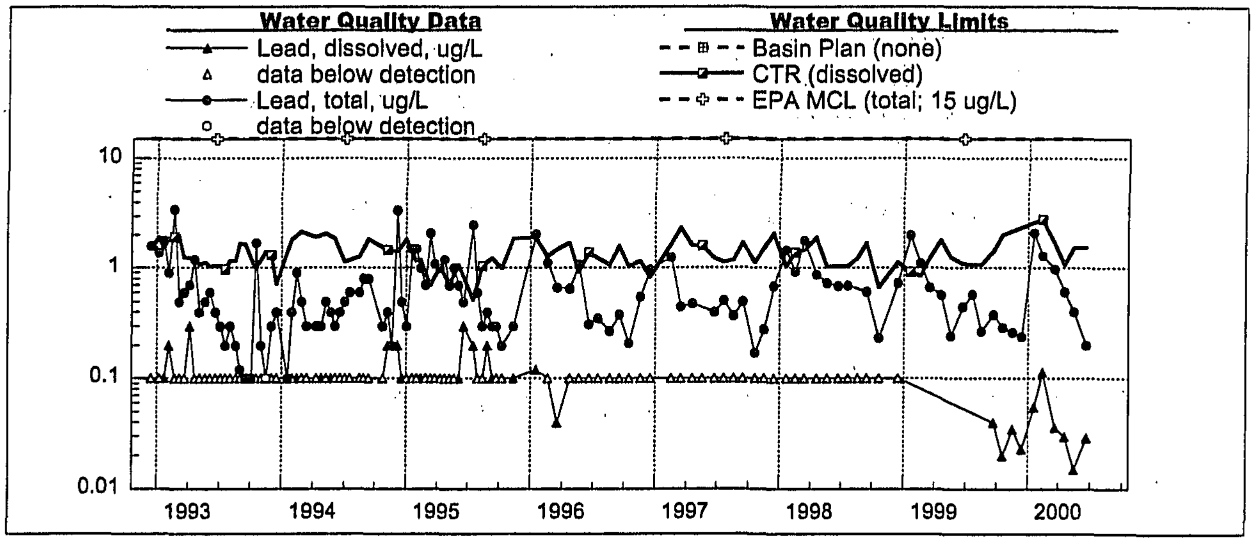
Time Series Plots of Ambient Program Data 1992–2000

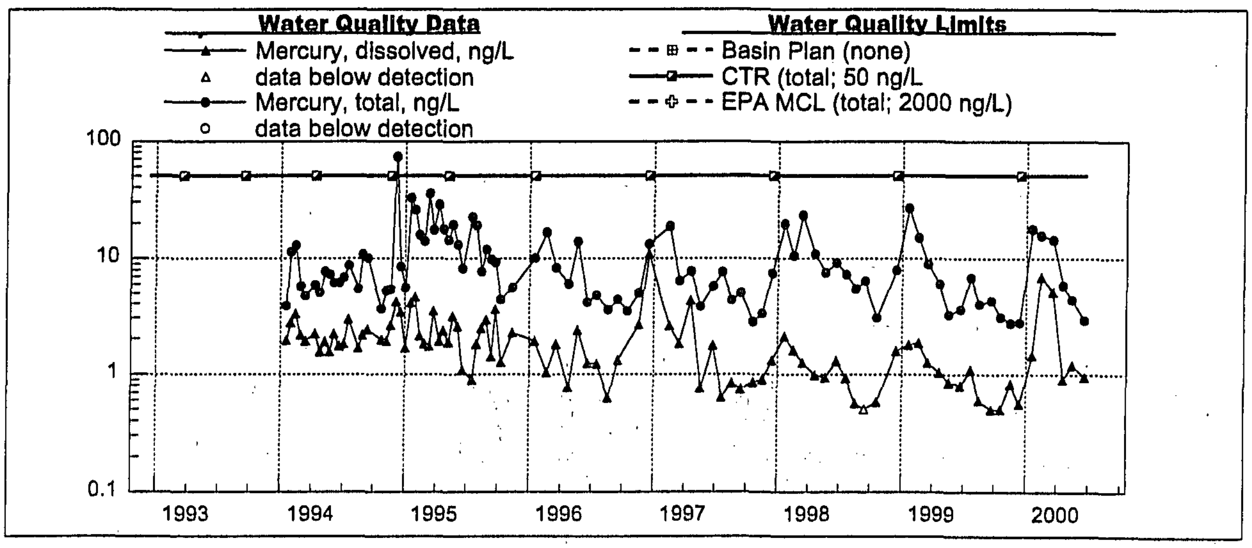




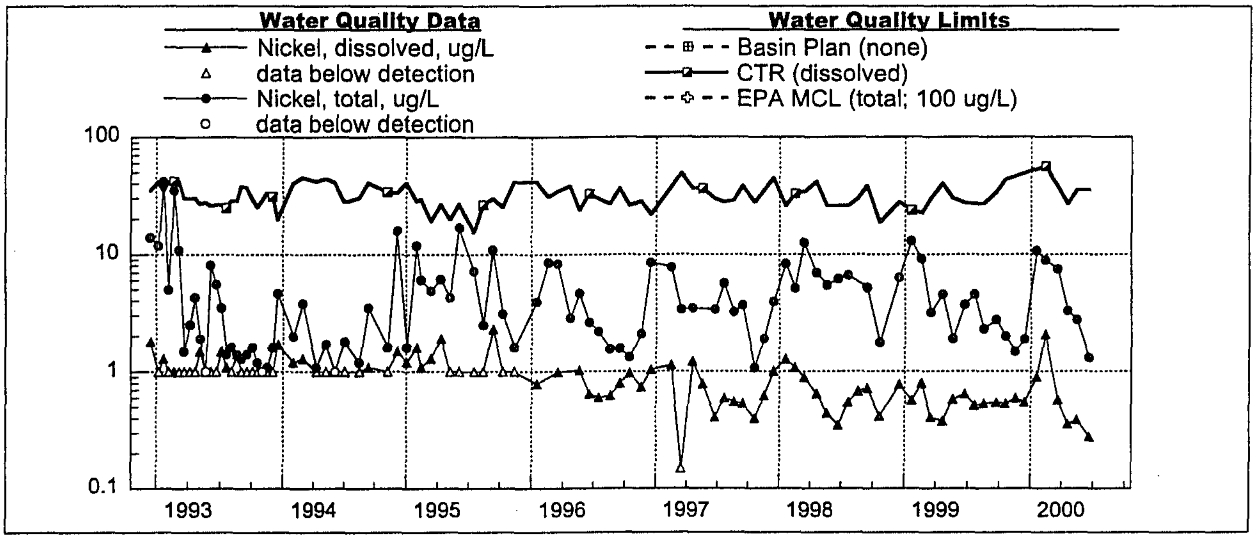


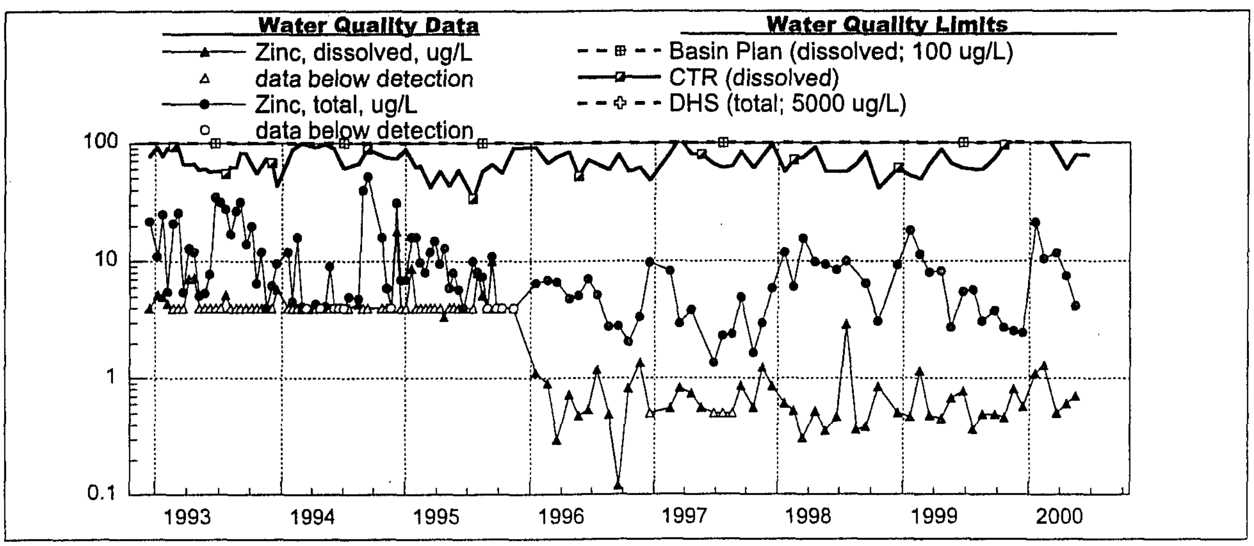

Water Quality Data
Copper, dissolved, ug/L
data below detection
Copper, total, ug/L
data below detection
Water Quality Limits
Basin Plan (dissolved; 10 ug/L)
CTR (dissolved)
EPA MCL (total; 1000 ug/L)
20
15
10
5
0
1993
1994
1995
1996
1997
1998
1999
2000


Water Quality Data
Lead, dissolved, ug/L
data below detection
Lead, total, ug/L
data below detection
Water Quality Limits
Basin Plan (none)
CTR (dissolved)
EPA MCL (total; 15 ug/L)
10
1
0.1
0.01
1993
1994
1995
1996
1997
1998
1999
2000


Water Quality Data
Mercury, dissolved, ng/L
data below detection
Mercury, total, ng/L
data below detection
Water Quality Limits
Basin Plan (none)
CTR (total; 50 ng/L
EPA MCL (total; 2000 ng/L)
100
10
1
0.1
1993
1994
1995
1996
1997
1998
1999
2000

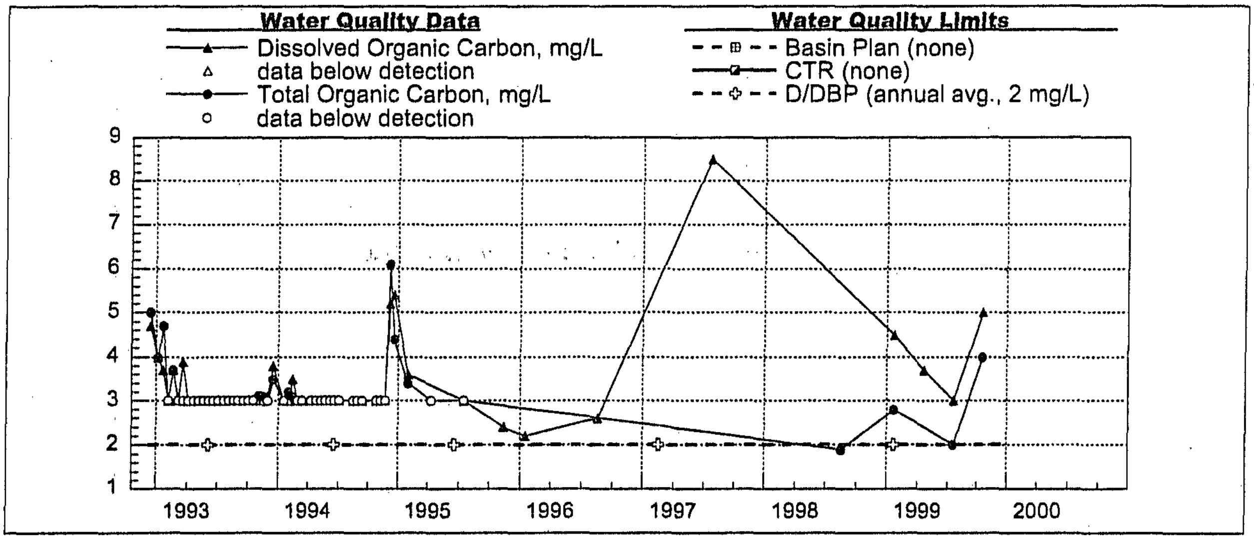
This Space Intentionally Blank

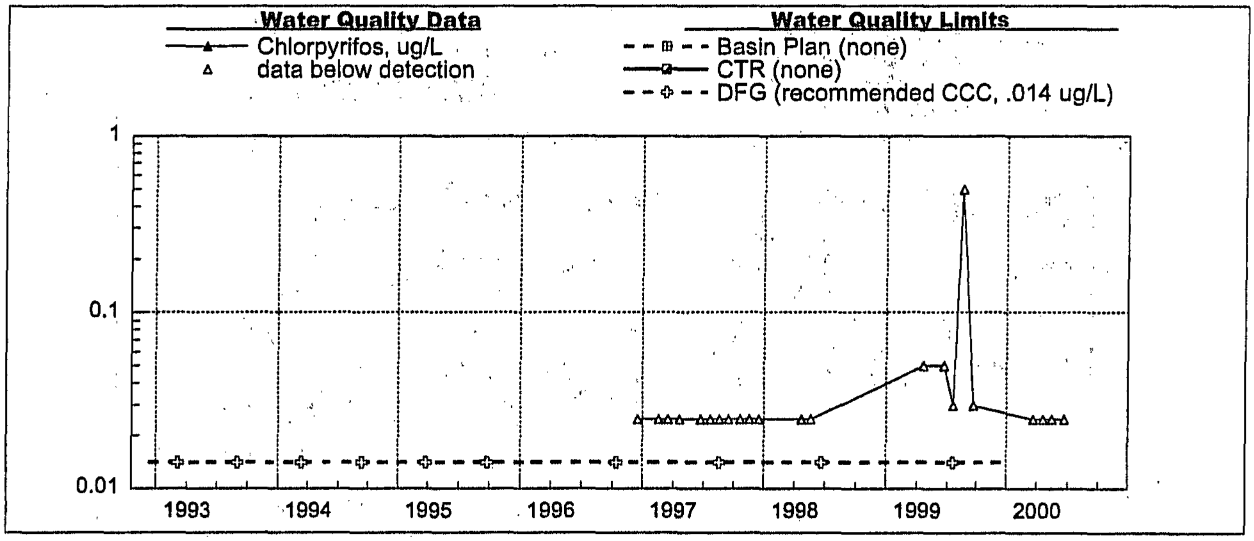


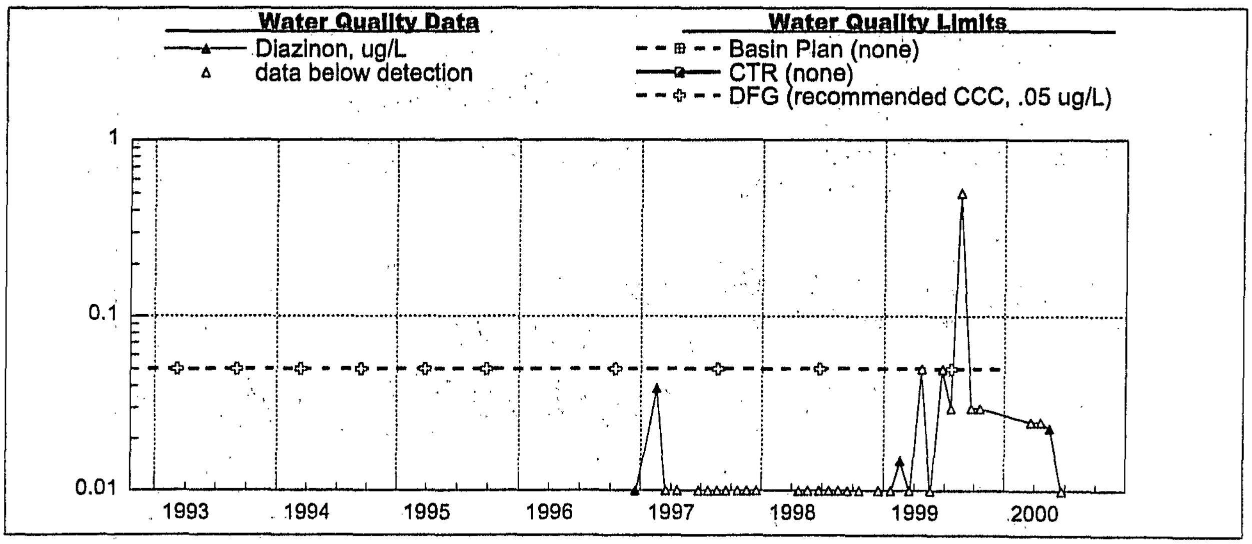


Sacramento River at River Mile 44

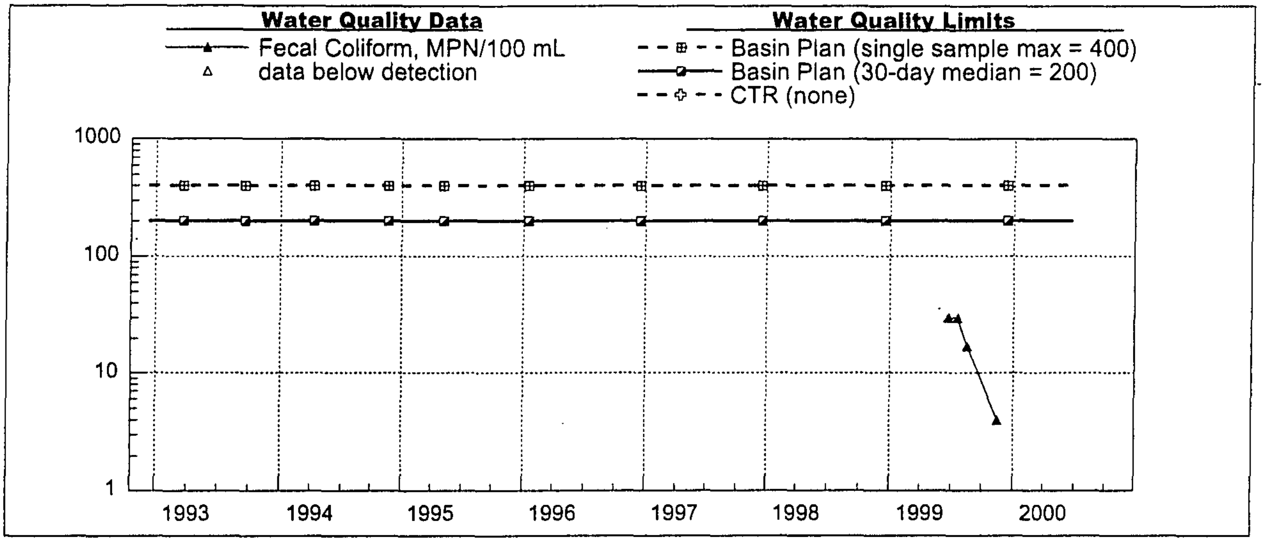
Time Series Plots of Ambient Program Data 1992-2000

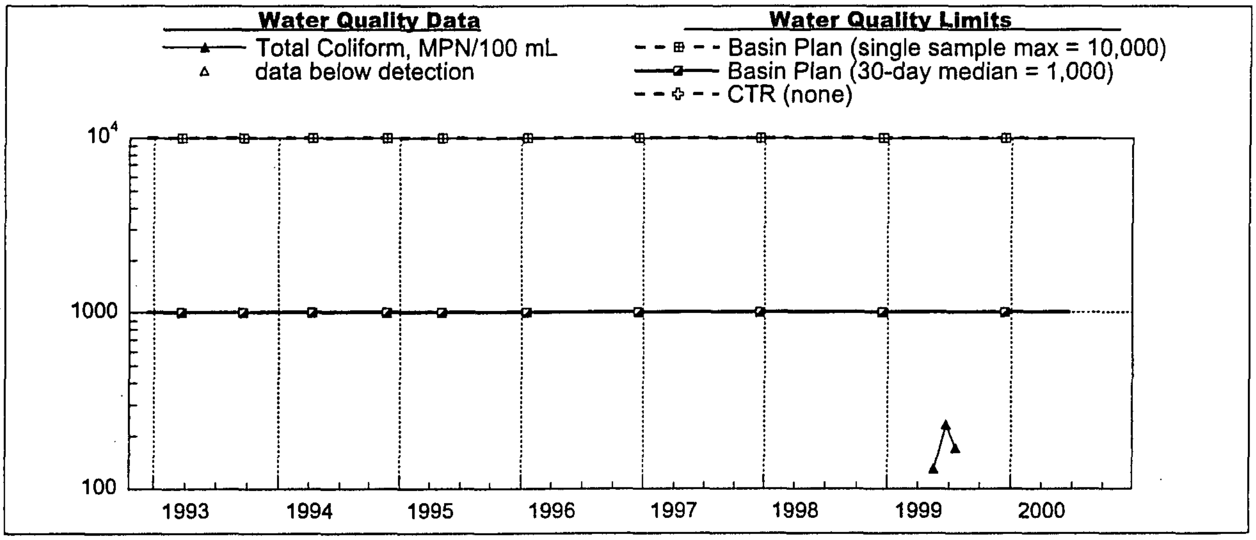


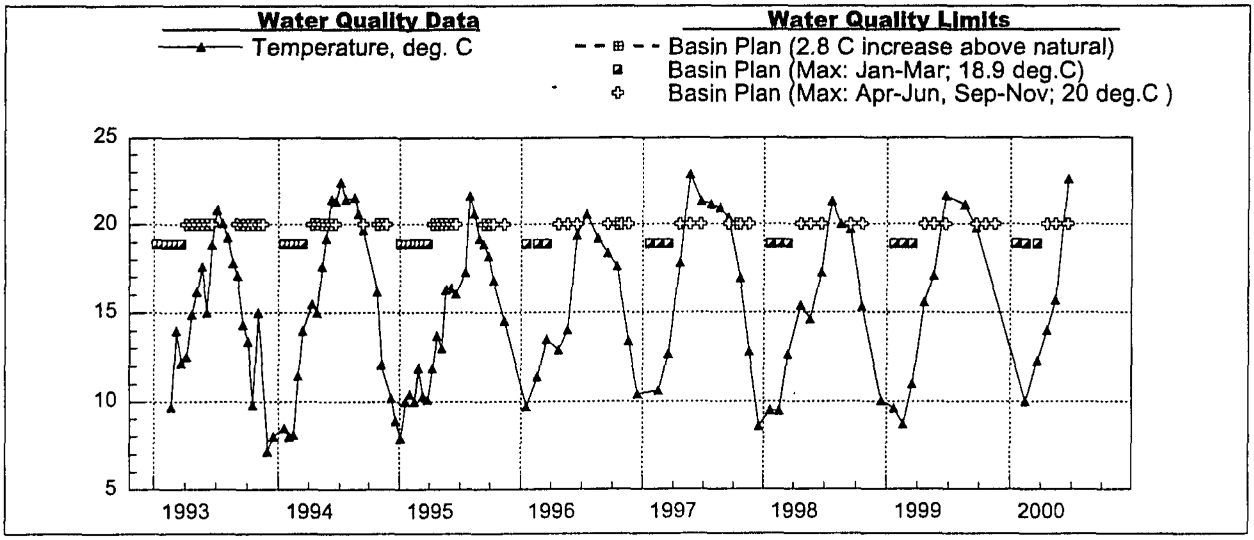




Sacramento River at River Mile 44
Time Series Plots of Ambient Program Data 1992–2000

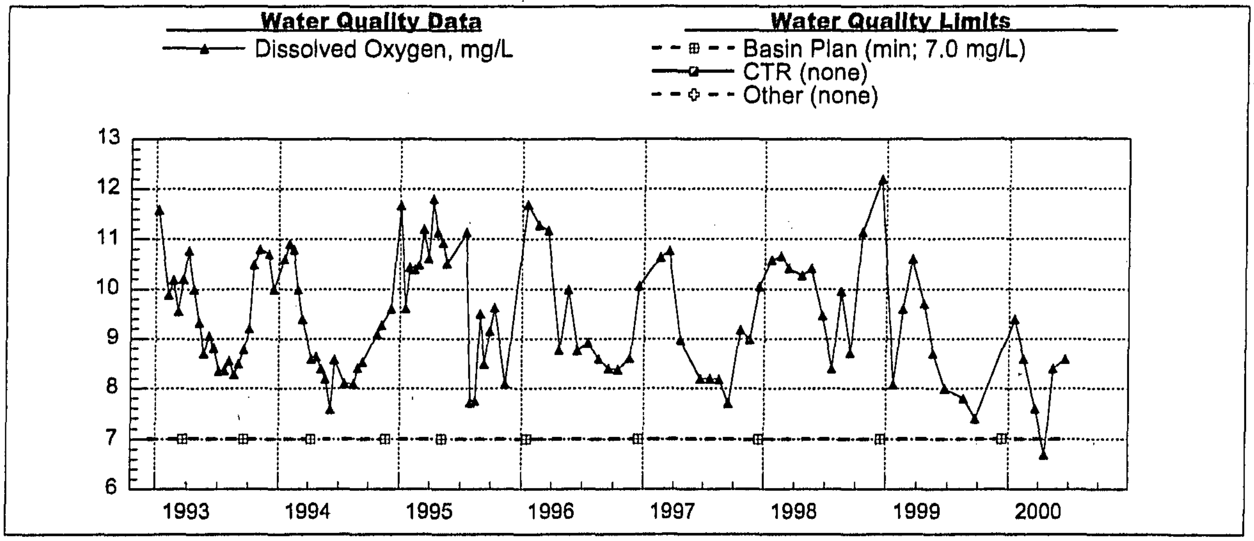


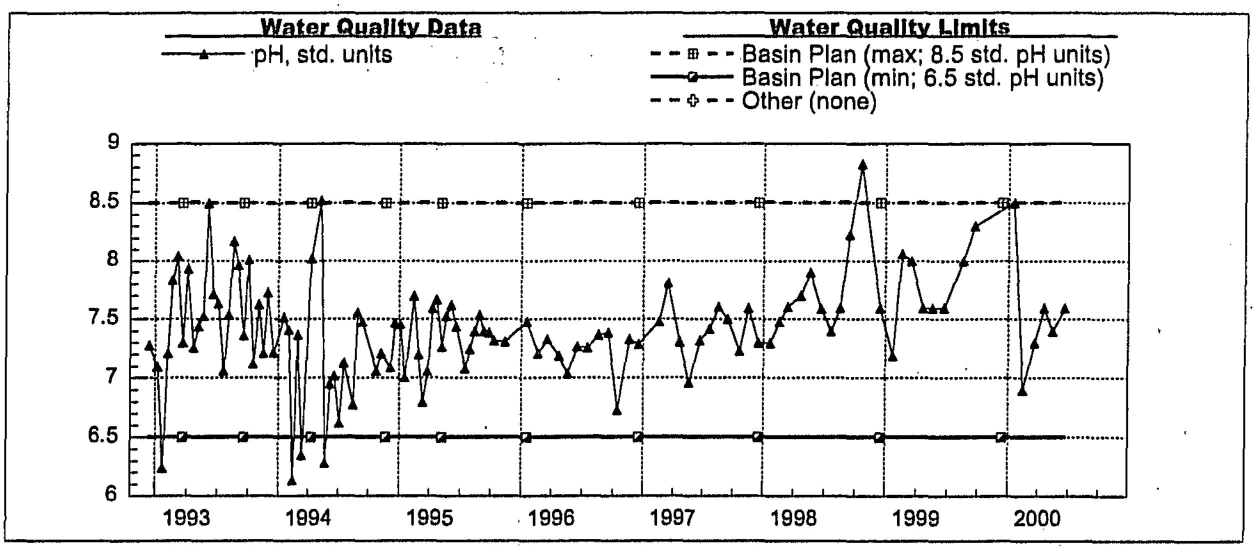


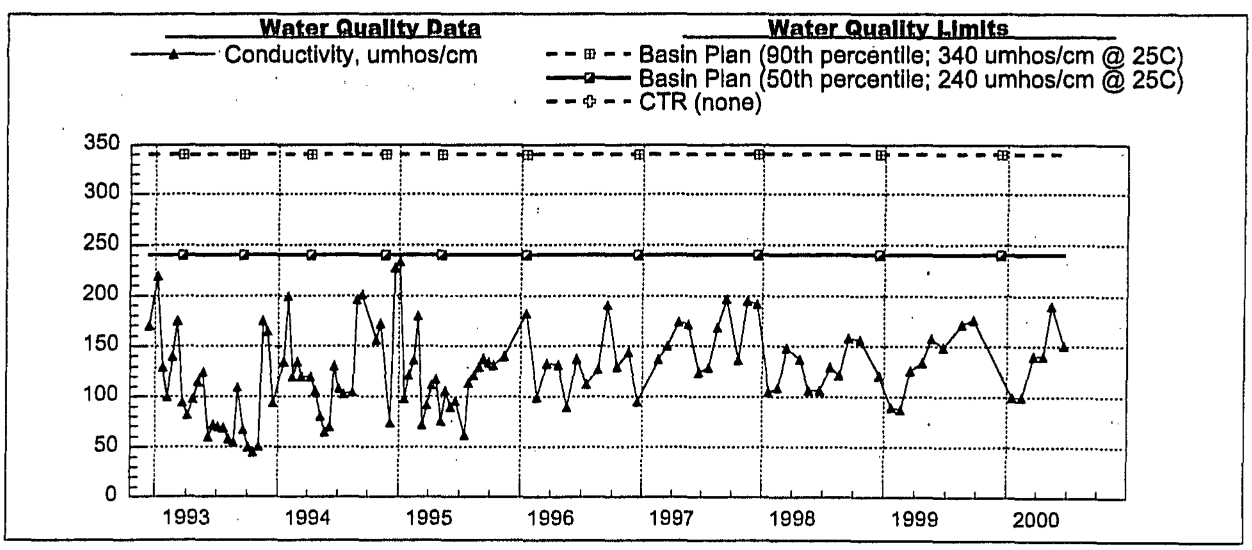


Sacramento River at River Mile 44

Time Series Plots of Ambient Program Data 1992–2000

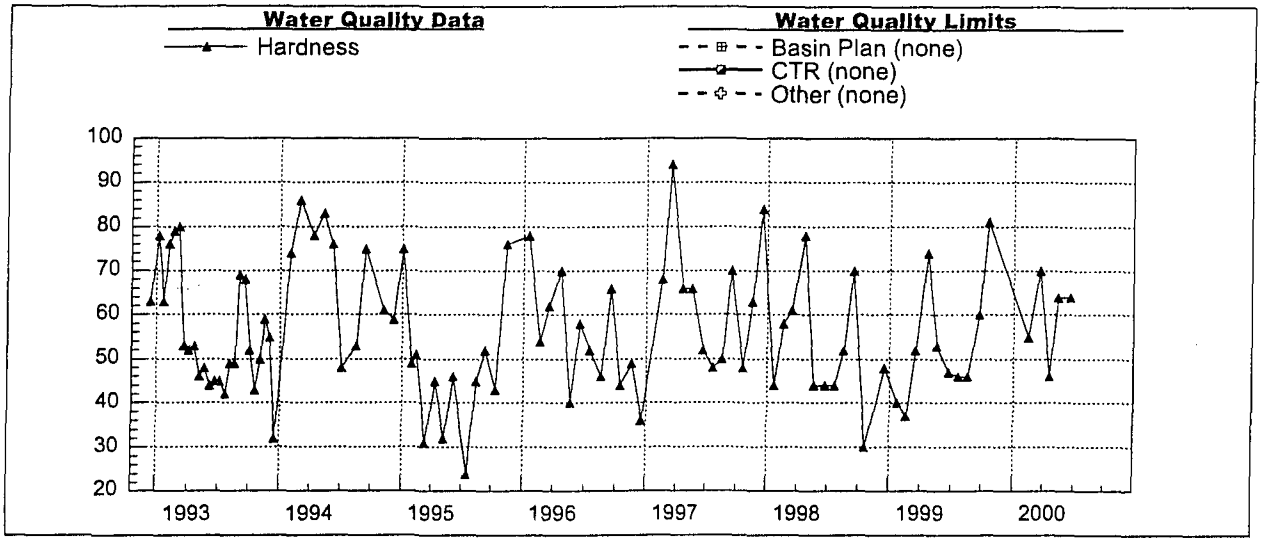


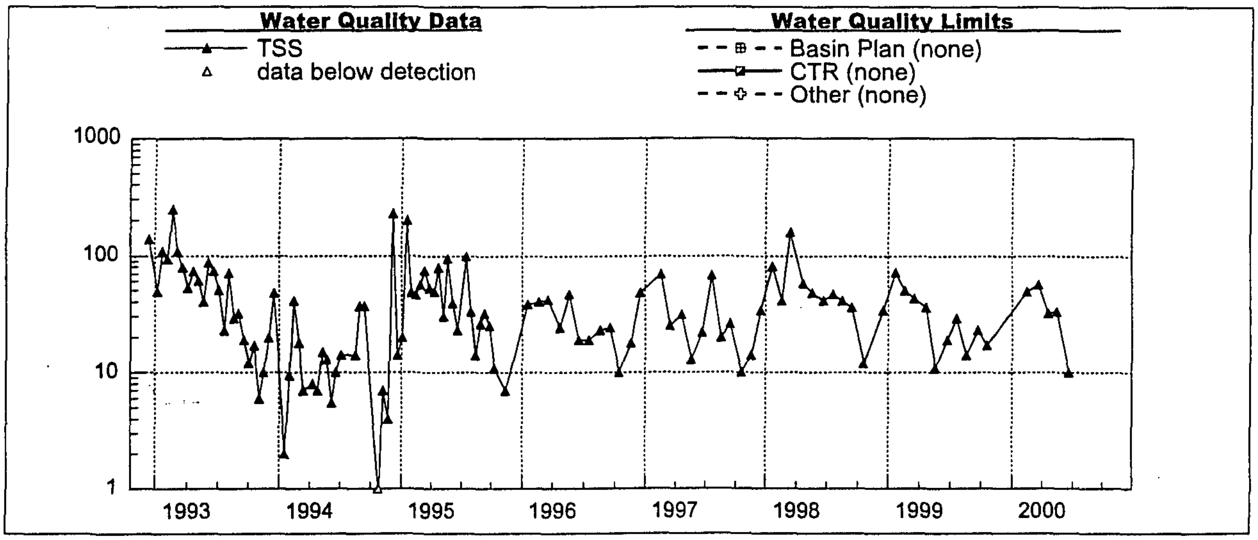


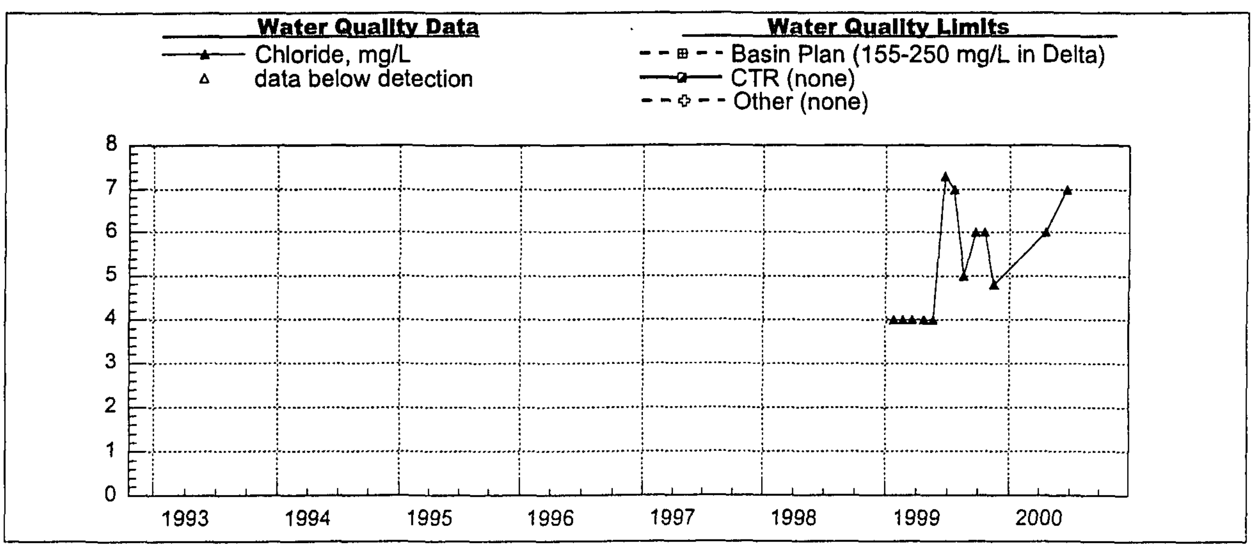


Sacramento River at River Mile 44

Time Series Plots of Ambient Program Data 1992–2000







C Comparisons With Water Quality Criteria

METHODS

Comparisons of ambient water chemistry with California Toxics Rule (CTR) and Central Valley Region Basin Plan (Basin Plan) water quality criteria for the protection of freshwater aquatic life and human health were performed for two American River sites and three Sacramento River sites. In addition, selected water quality characteristics are also compared to other water quality limits, including Safe Drinking Water Act MCLs, California Department of Health Services Guidelines, Department of Fish and Game recommended criteria, and Stage 1 Disinfectant/Disinfection By-Products Rule treatment threshold levels. Statistically-based comparisons to chemical water quality limits are performed for parameters with at least 10 detected data. The estimated percent of time that ambient conditions are better than applicable water quality limits is determined by calculating the cumulative probability that the ambient concentration of a pollutant is less than the minimum water quality limit[1]. The parameters of an best line fit of the cumulative frequency distribution are used to calculate the cumulative probability that the ambient concentration is less than the criterion of interest. As a point of reference, the cumulative probability of 99.91% corresponds to EPA's allowed excursion frequency of once in three years. For the purpose of this analysis, in cases where less than 10 of the data were detected, chemical concentrations were considered not to exceed chemical water quality objectives if (a) the detection limit was less than or equal to 0.2 times the objective, and (b) the maximum detected value was less than 0.2 times the objective.

---

[1] For criteria that are dependent on hardness (cadmium, chromium, copper, lead, nickel, and zinc), a hardness-adjusted criterion was calculated based on the mean hardness for each location for each parameter. Mean hardness data are presented in Tables 3-2 through 3-6, in Chapter 3 of this document.

RESULTS

The results of analyses comparing chemical and physical water quality characteristics to water quality regulatory limits are summarized in Tables 3-7 through 3-11, and discussed in Chapter 3 (Data Review).

Frequency distribution plots illustrating exponential line fits and probabilities of meeting water quality objectives are presented in this Appendix. Frequency distribution plots were prepared for all constituents for which at least 10% of the data were detected values. Note that all data—above and below detection limits—are used in these analyses through the Robust Lognormal Regression method (Helsel 1990, Helsel and Cohn 1988). Data below reporting limits are used to fit detected data to lognormal or normal frequency distributions, and to estimate probabilities of meeting water quality objectives. However, only detected data are plotted for the frequency distributions plots.

REFERENCES

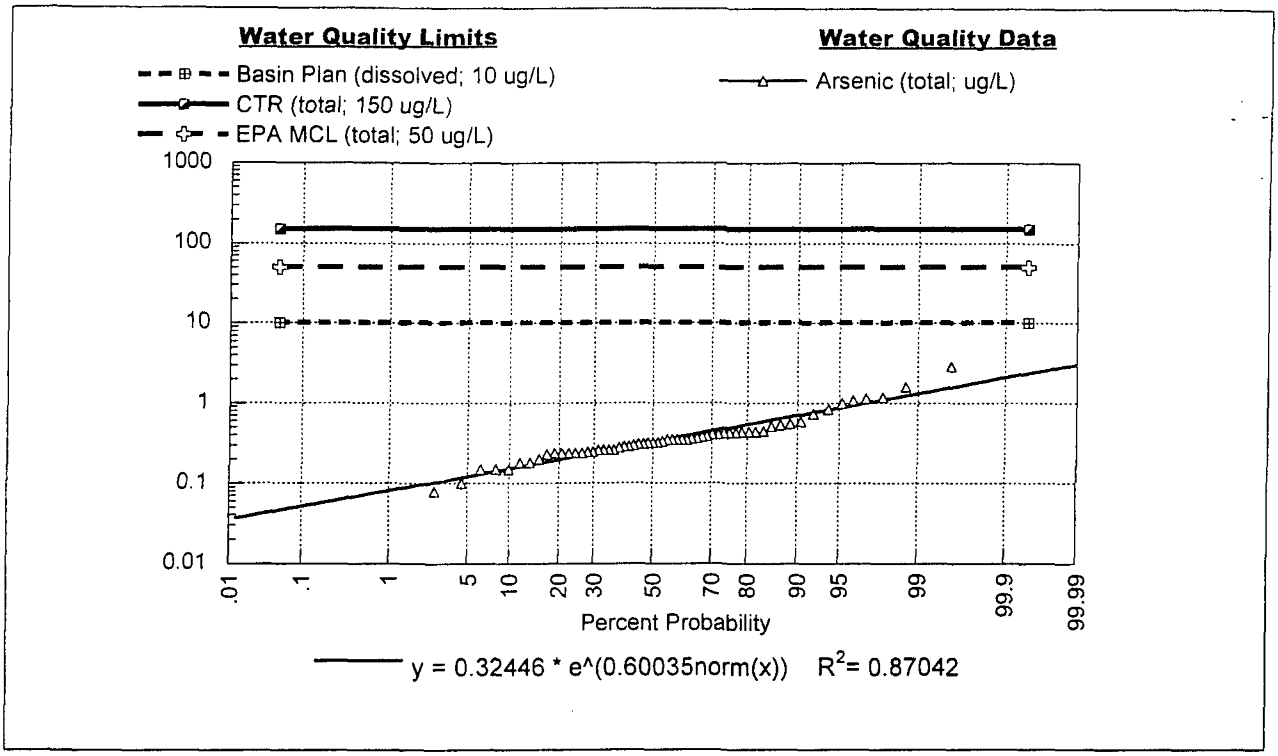
Helsel, D.R. and Cohn, T.A. Estimation of Descriptive Statistics for Multiply-Censored Water Quality Data. *Water Resources Research*. Vol. 24, No. 12, pp. 1997-2004. December, 1988.

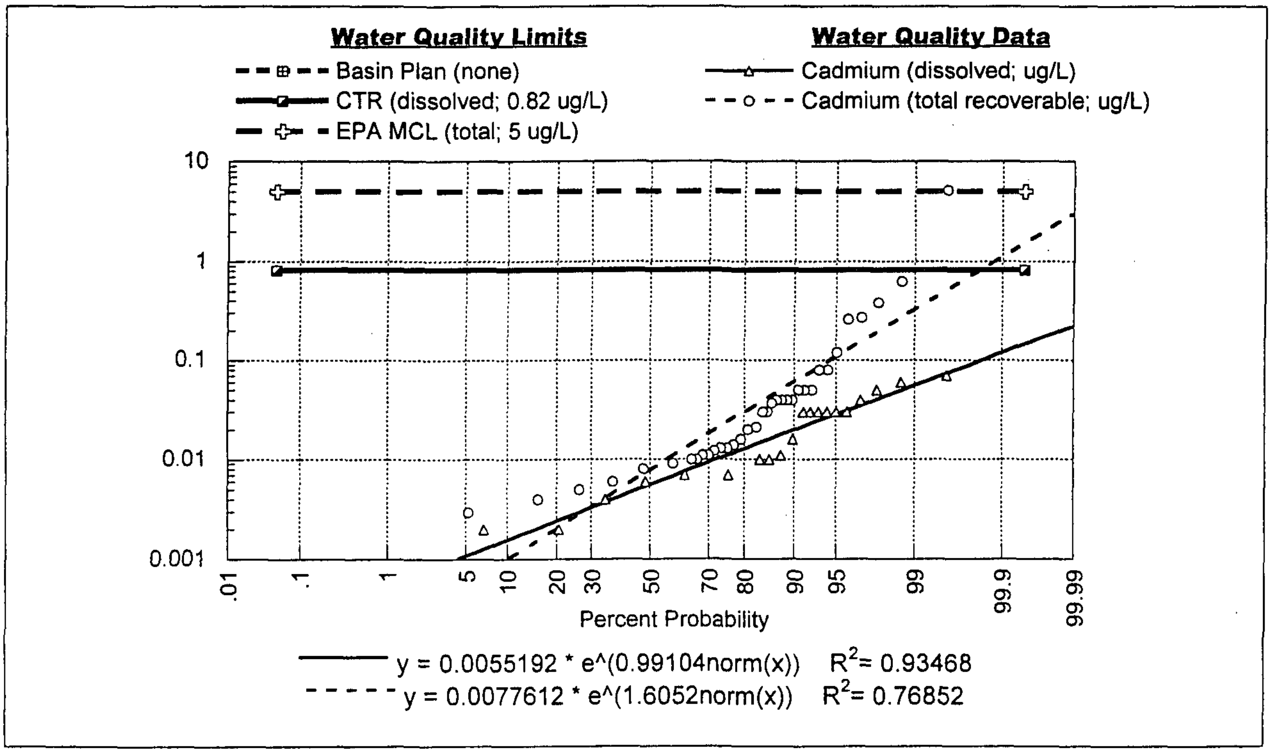
Helsel, D.R. Less Than Obvious. *Environmental Science and Technology*. Vol. 24, No. 12, pp. 1766-1774. December, 1990.

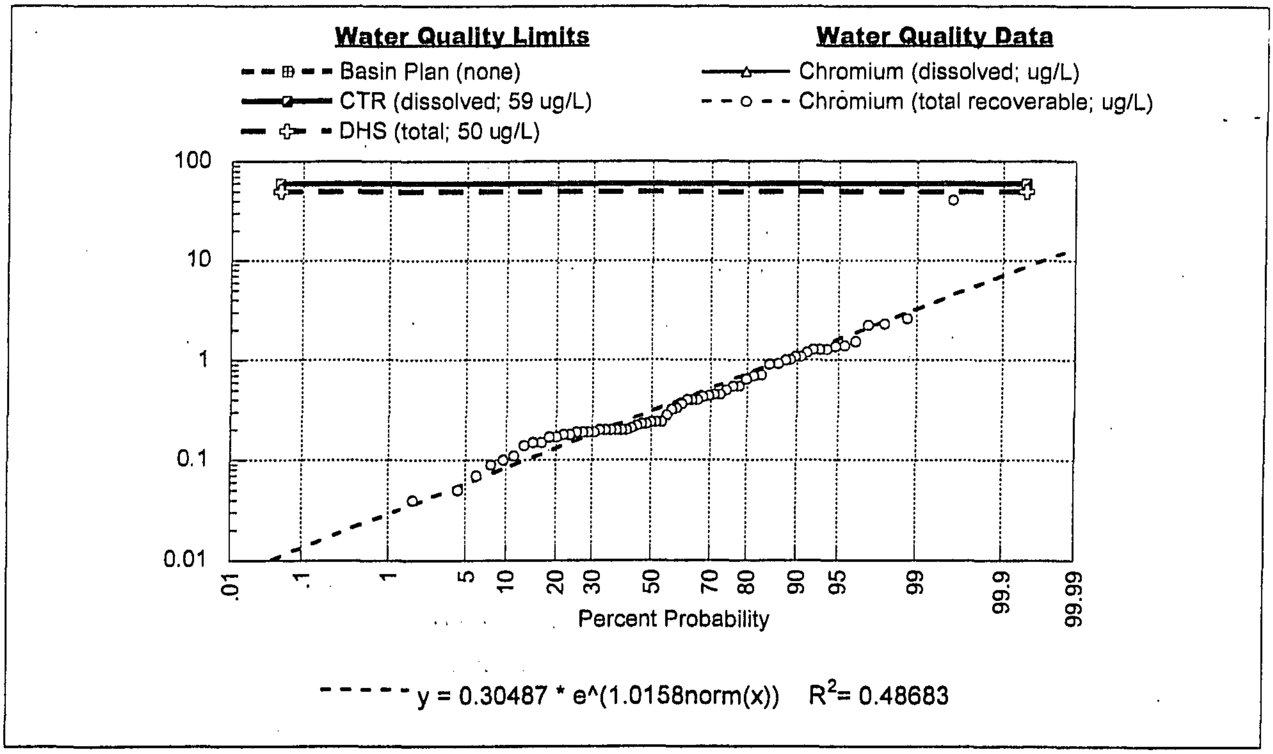
Frequency Distribution Plots

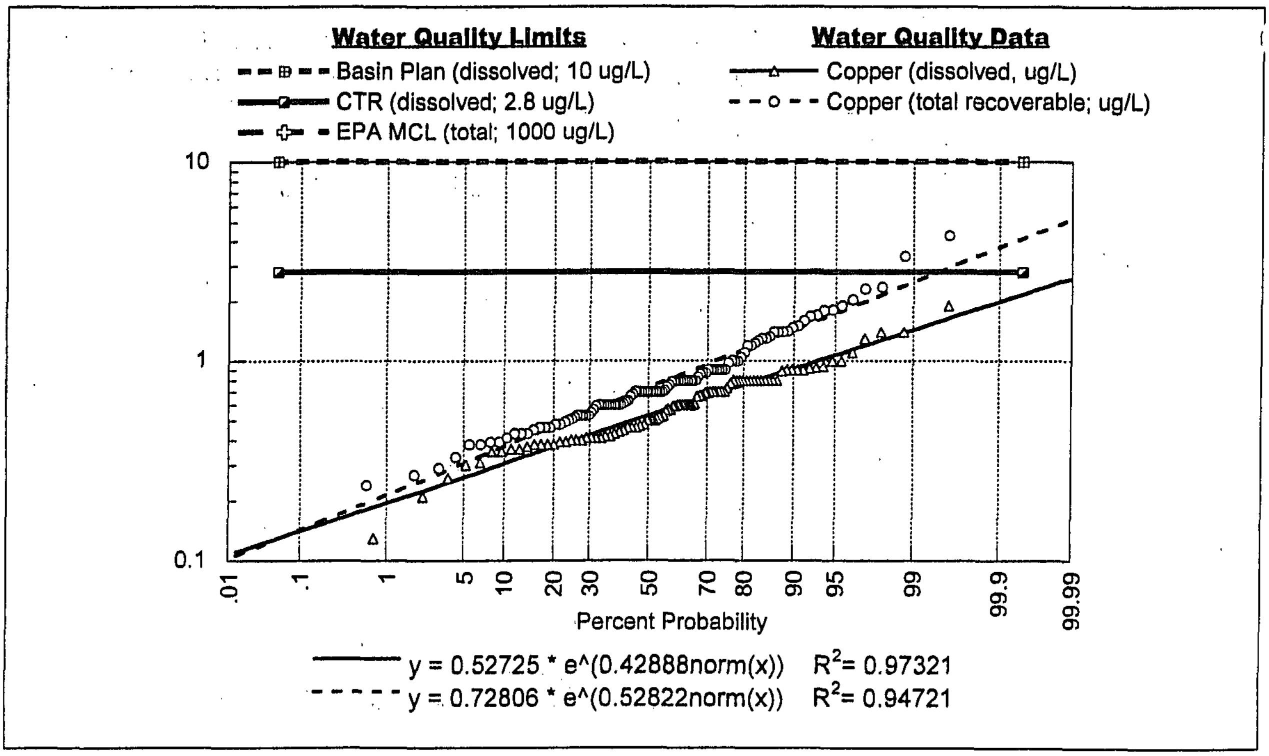
December 1992 – June 2000

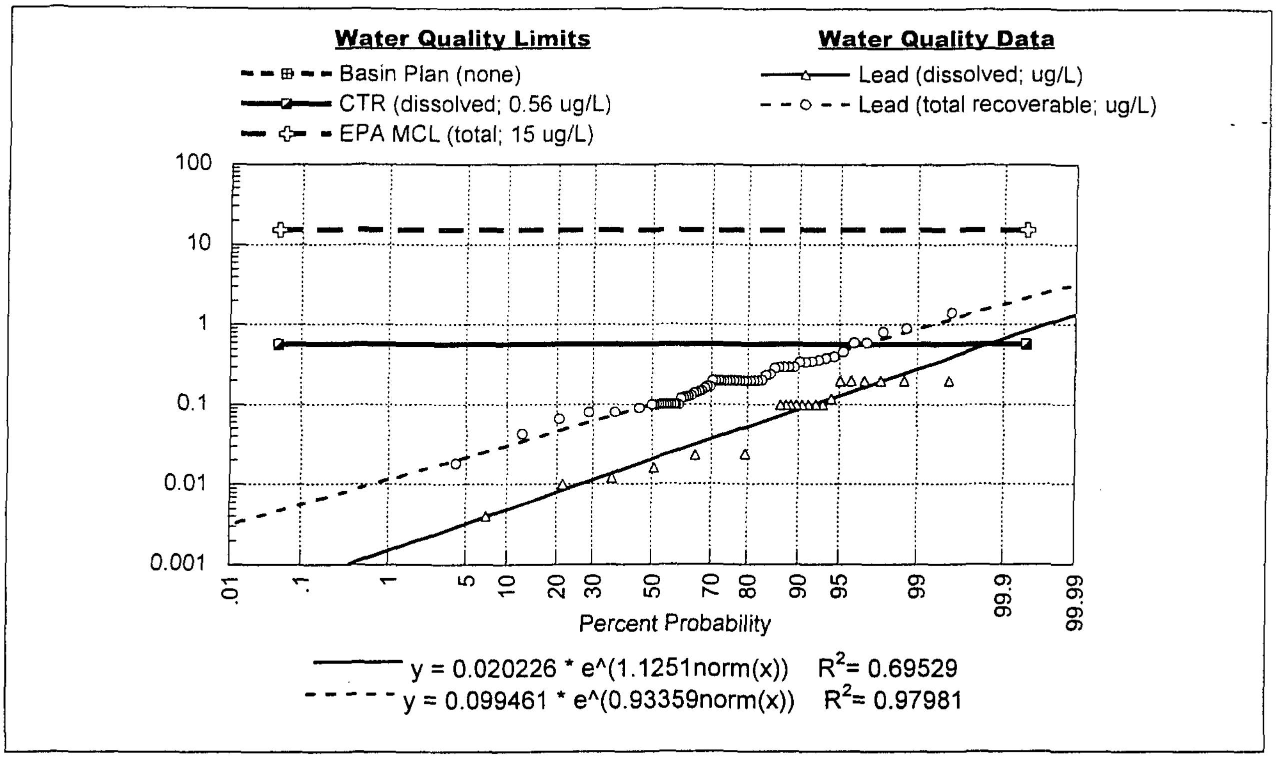
American River at Nimbus Dam

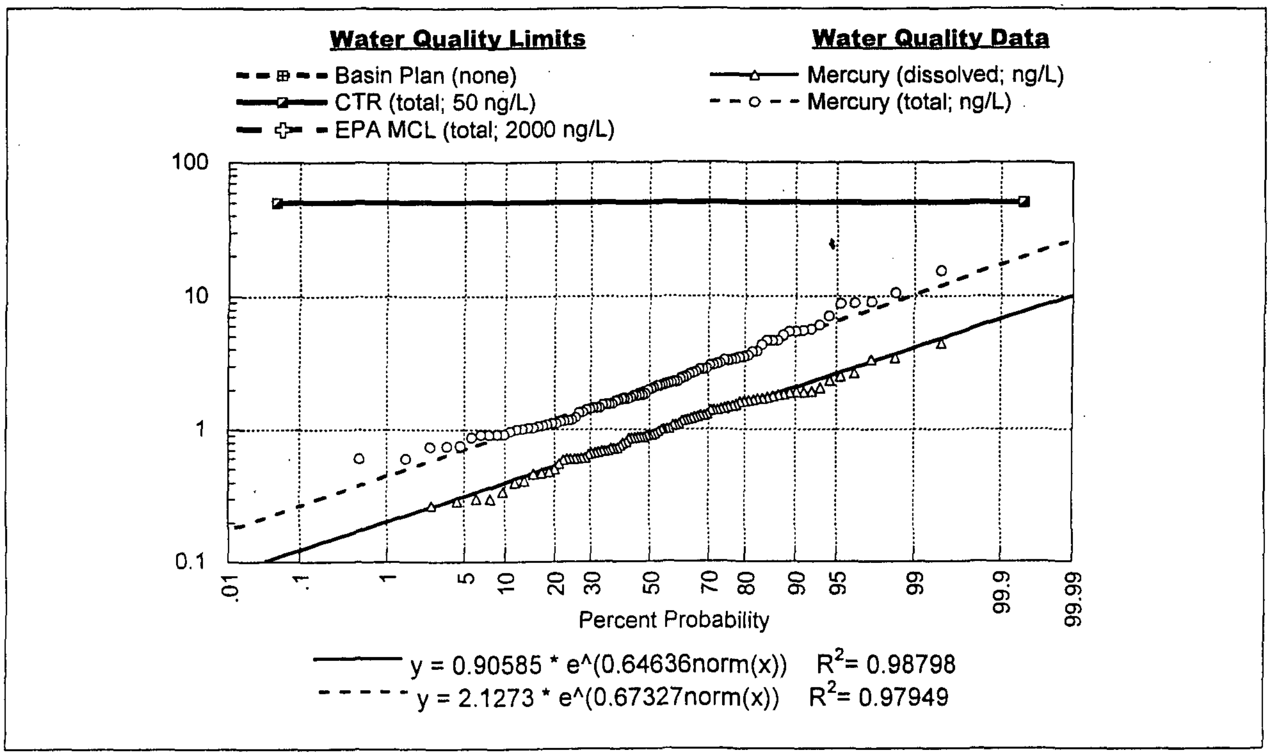

Water Quality Limits
Basin Plan (dissolved; 10 ug/L)
CTR (total; 150 ug/L)
EPA MCL (total; 50 ug/L)
Water Quality Data
Arsenic (total; ug/L)
1000
100
10
1
0.1
0.01
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 0.32446 * e^(0.60035norm(x)) R2= 0.87042

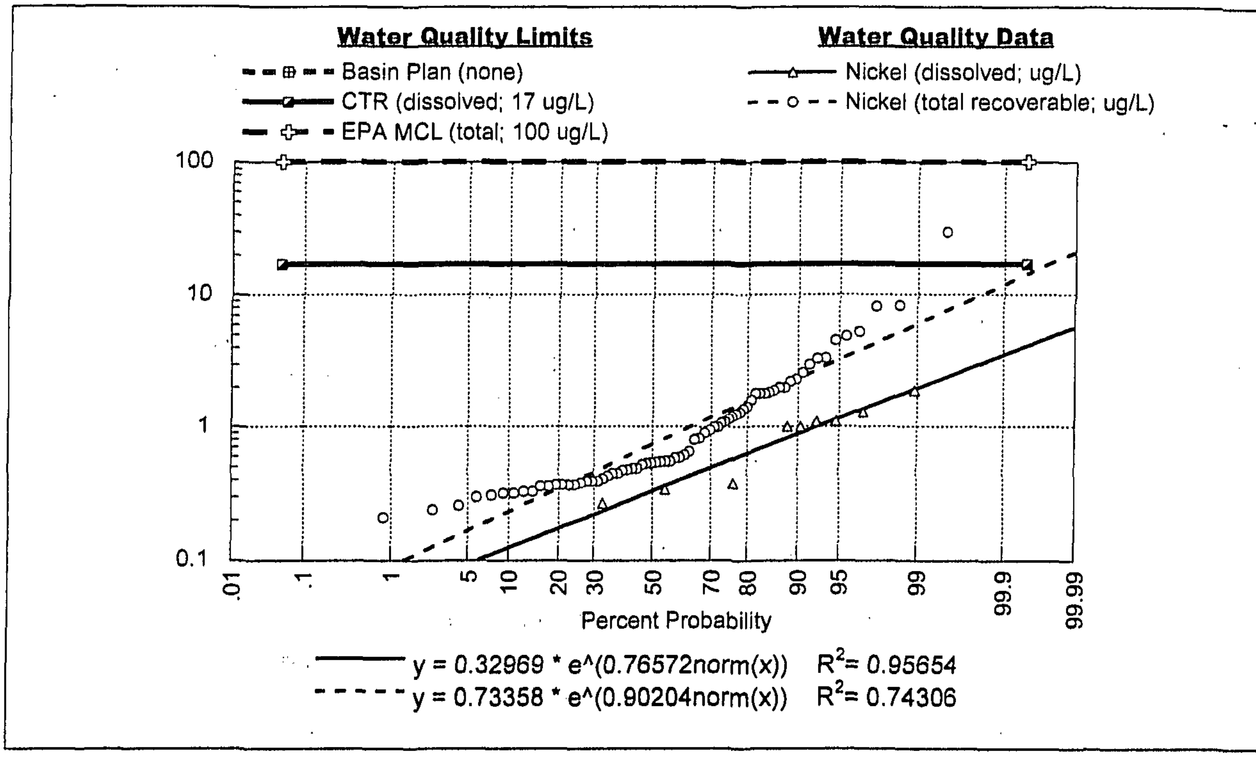

Water Quality Limits
Basin Plan (none)
CTR (dissolved; 0.82 ug/L)
EPA MCL (total; 5 ug/L)
Water Quality Data
Cadmium (dissolved; ug/L)
Cadmium (total recoverable; ug/L)
10
1
0.1
0.01
0.001
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 0.0055192 * e^(0.99104norm(x)) R2= 0.93468
y = 0.0077612 * e^(1.6052norm(x)) R2= 0.76852

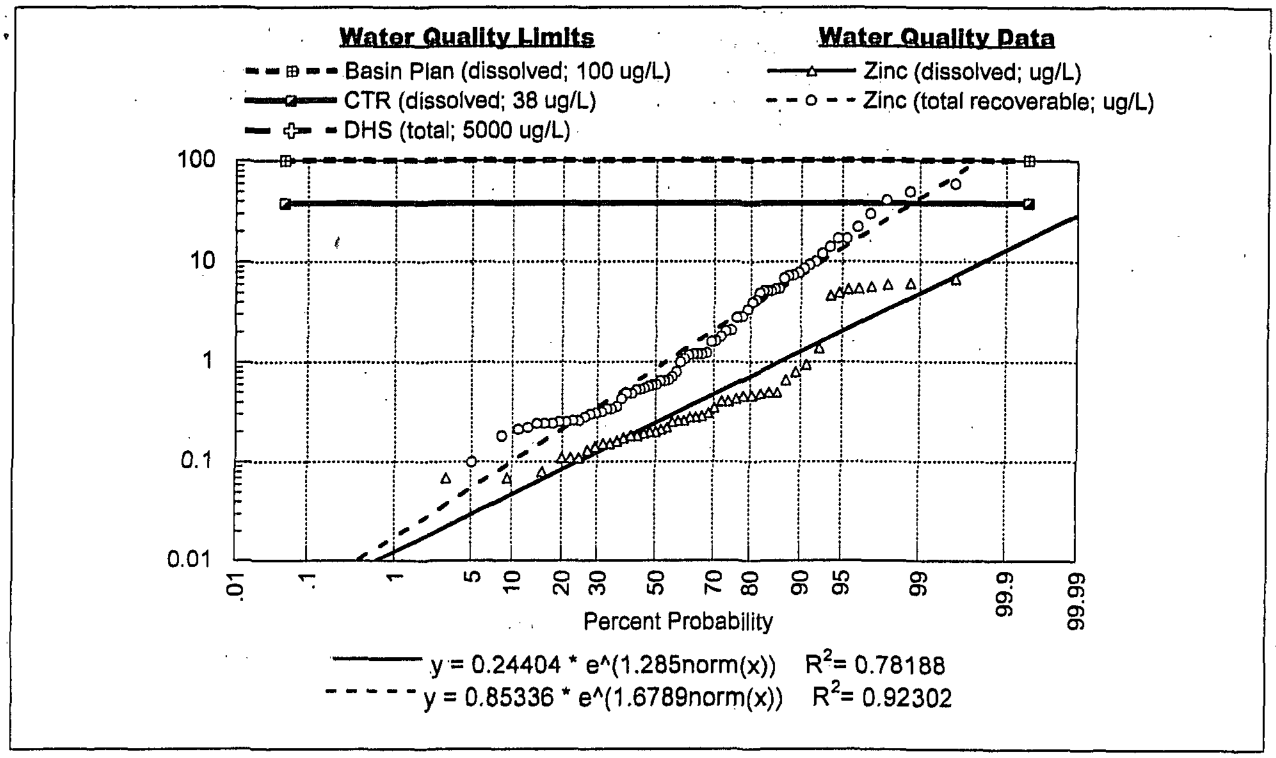

Water Quality Limits
Basin Plan (none)
CTR (dissolved; 59 ug/L)
DHS (total; 50 ug/L)
Water Quality Data
Chromium (dissolved; ug/L)
Chromium (total recoverable; ug/L)
100
10
1
0.1
0.01
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 0.30487 * e^(1.0158norm(x)) R2= 0.48683


Water Quality Limits
Basin Plan (dissolved; 10 ug/L)
CTR (dissolved; 2.8 ug/L)
EPA MCL (total; 1000 ug/L)
Water Quality Data
Copper (dissolved, ug/L)
Copper (total recoverable; ug/L)
10
1
0.1
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 0.52725 * e^(0.42888norm(x)) R2= 0.97321
y = 0.72806 * e^(0.52822norm(x)) R2= 0.94721

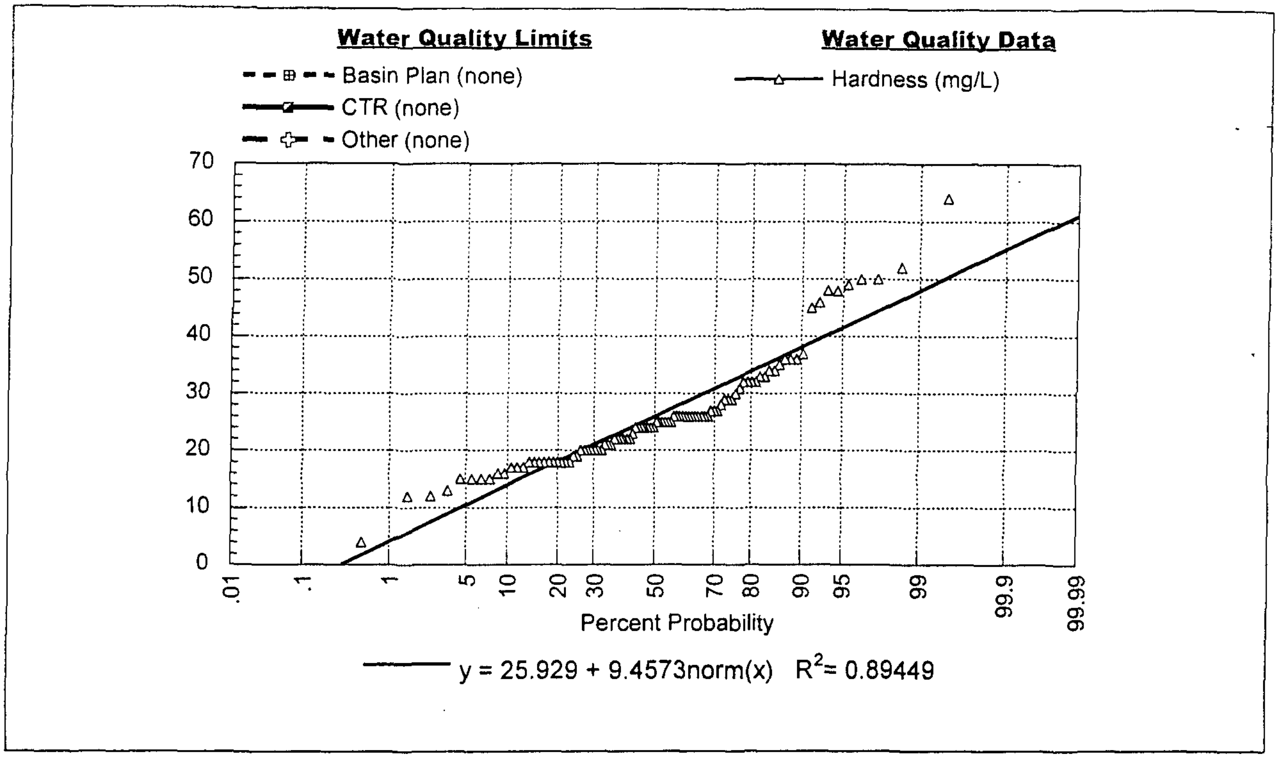

Water Quality Limits
Basin Plan (none)
CTR (dissolved; 0.56 ug/L)
EPA MCL (total; 15 ug/L)
Water Quality Data
Lead (dissolved; ug/L)
Lead (total recoverable; ug/L)
100
10
1
0.1
0.01
0.001
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 0.020226 * e^(1.1251norm(x)) R2= 0.69529
y = 0.099461 * e^(0.93359norm(x)) R2= 0.97981

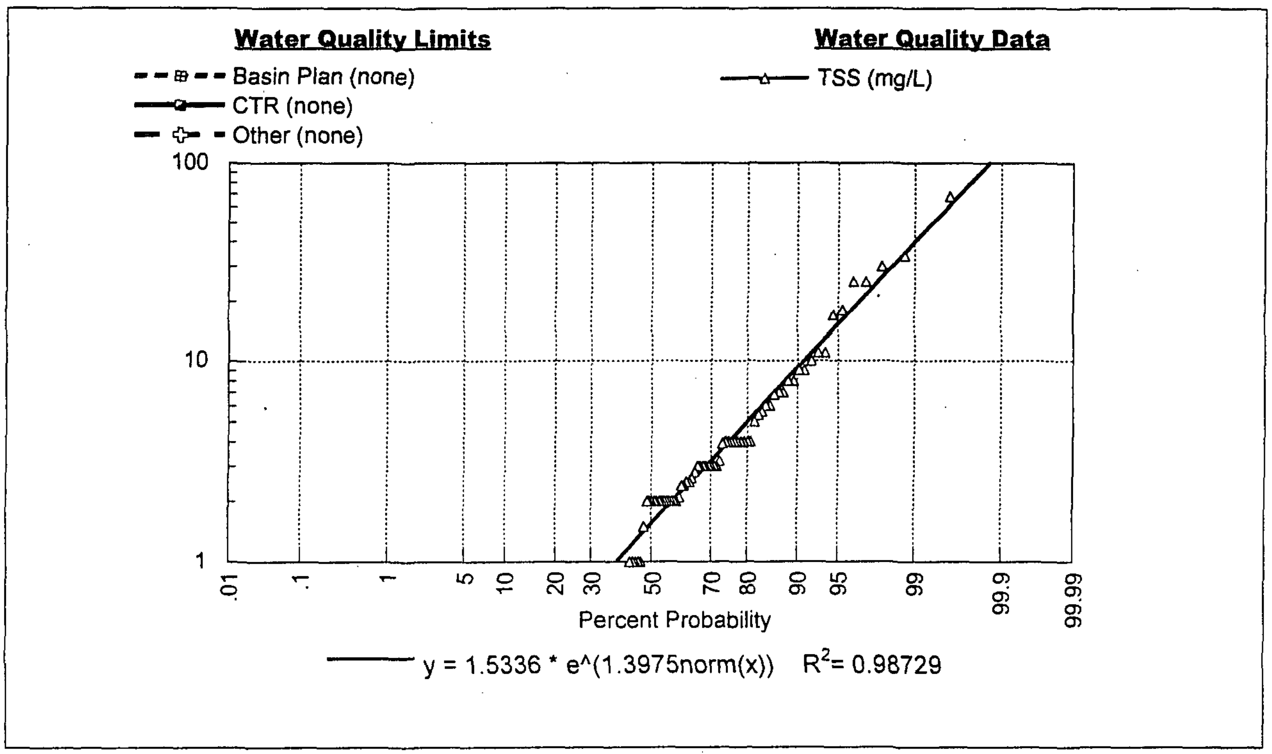

Water Quality Limits
Basin Plan (none)
CTR (total; 50 ng/L)
EPA MCL (total; 2000 ng/L)
Water Quality Data
Mercury (dissolved; ng/L)
Mercury (total; ng/L)
100
10
1
0.1
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 0.90585 * e^(0.64636norm(x)) R2= 0.98798
y = 2.1273 * e^(0.67327norm(x)) R2= 0.97949

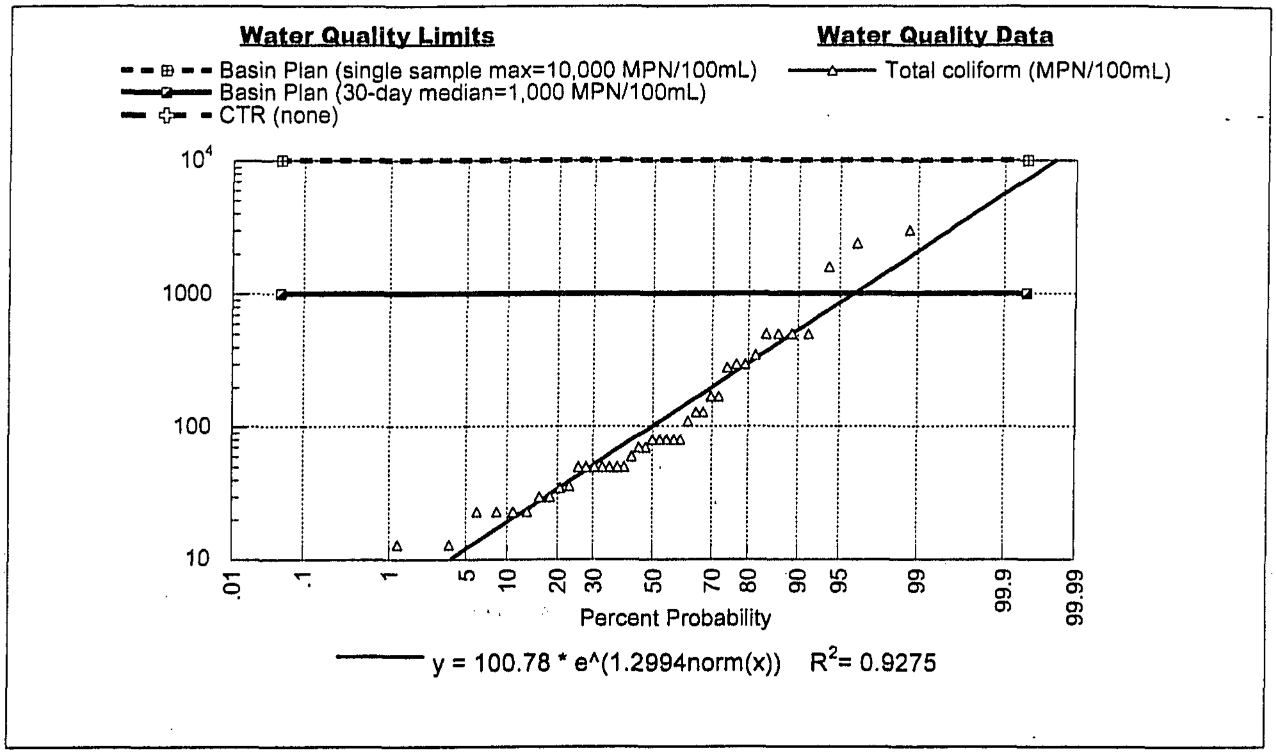

Water Quality Limits
Basin Plan (none)
CTR (dissolved; 17 ug/L)
EPA MCL (total; 100 ug/L)
Water Quality Data
Nickel (dissolved; ug/L)
Nickel (total recoverable; ug/L)
100
10
1
0.1
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 0.32969 * e^(0.76572norm(x)) R2= 0.95654
y = 0.73358 * e^(0.90204norm(x)) R2= 0.74306

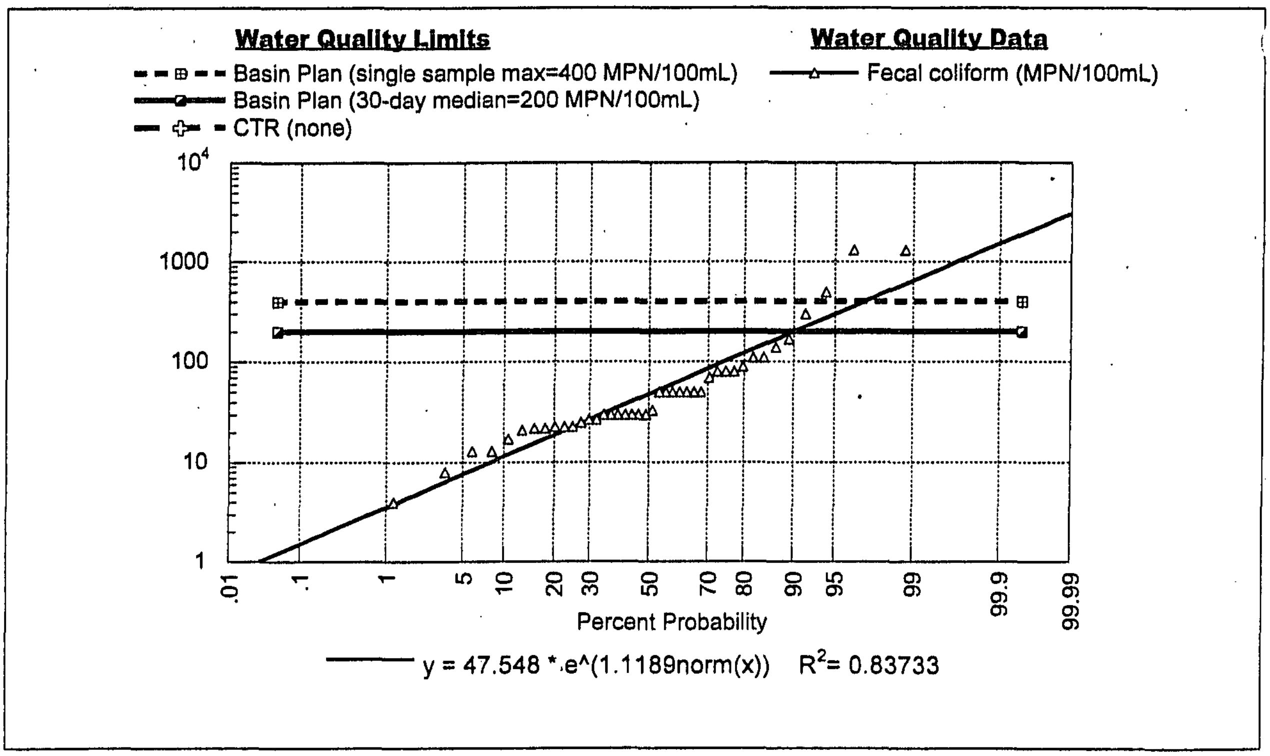

Water Quality Limits
Basin Plan (dissolved; 100 ug/L)
CTR (dissolved; 38 ug/L)
DHS (total; 5000 ug/L)
Water Quality Data
Zinc (dissolved; ug/L)
Zinc (total recoverable; ug/L)
100
10
1
0.1
0.01
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 0.24404 * e^(1.285norm(x)) R2= 0.78188
y = 0.85336 * e^(1.6789norm(x)) R2= 0.92302

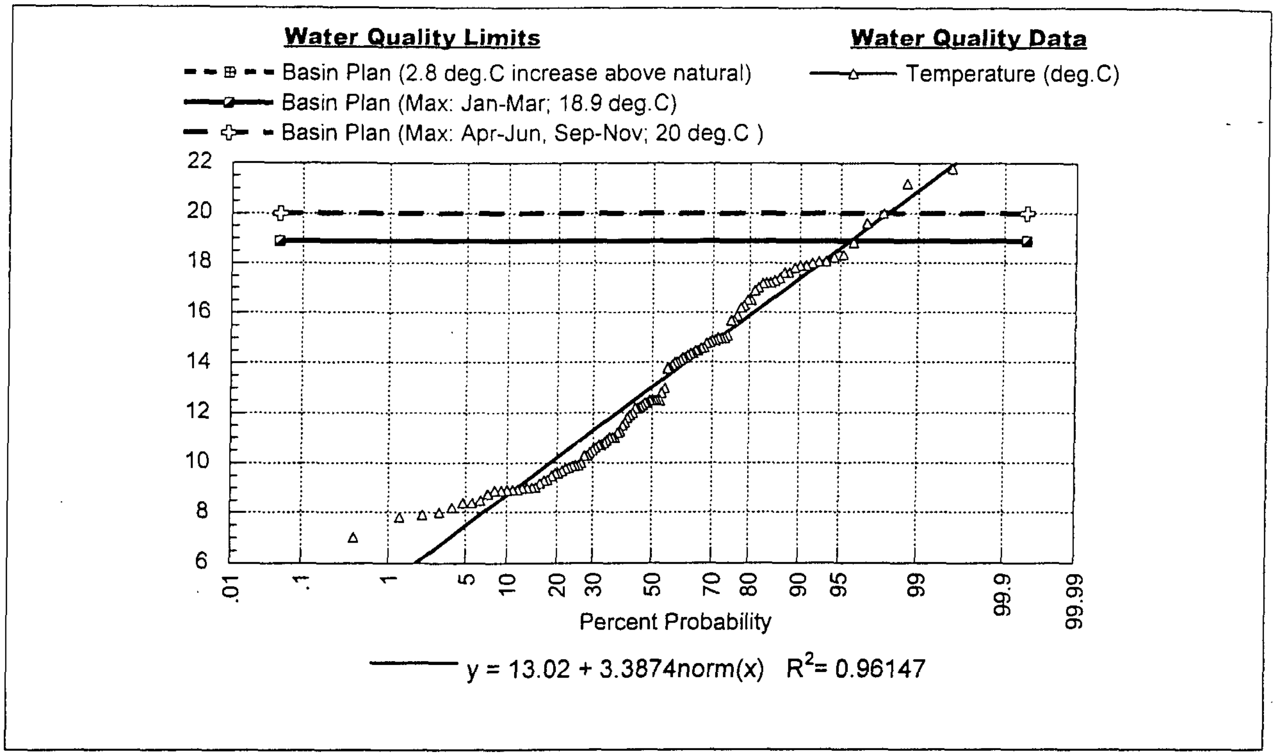
American River at Nimbus
Frequency Distribution Plots of Ambient Program Data 1992–2000

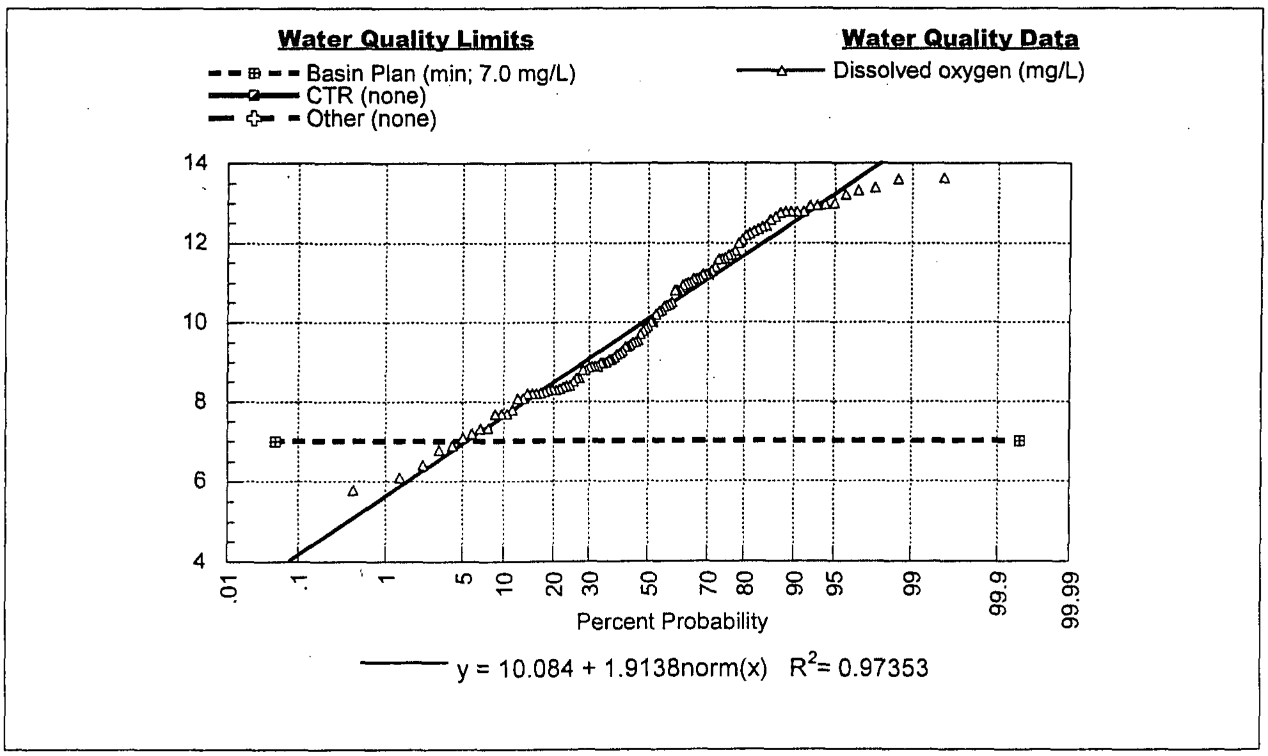


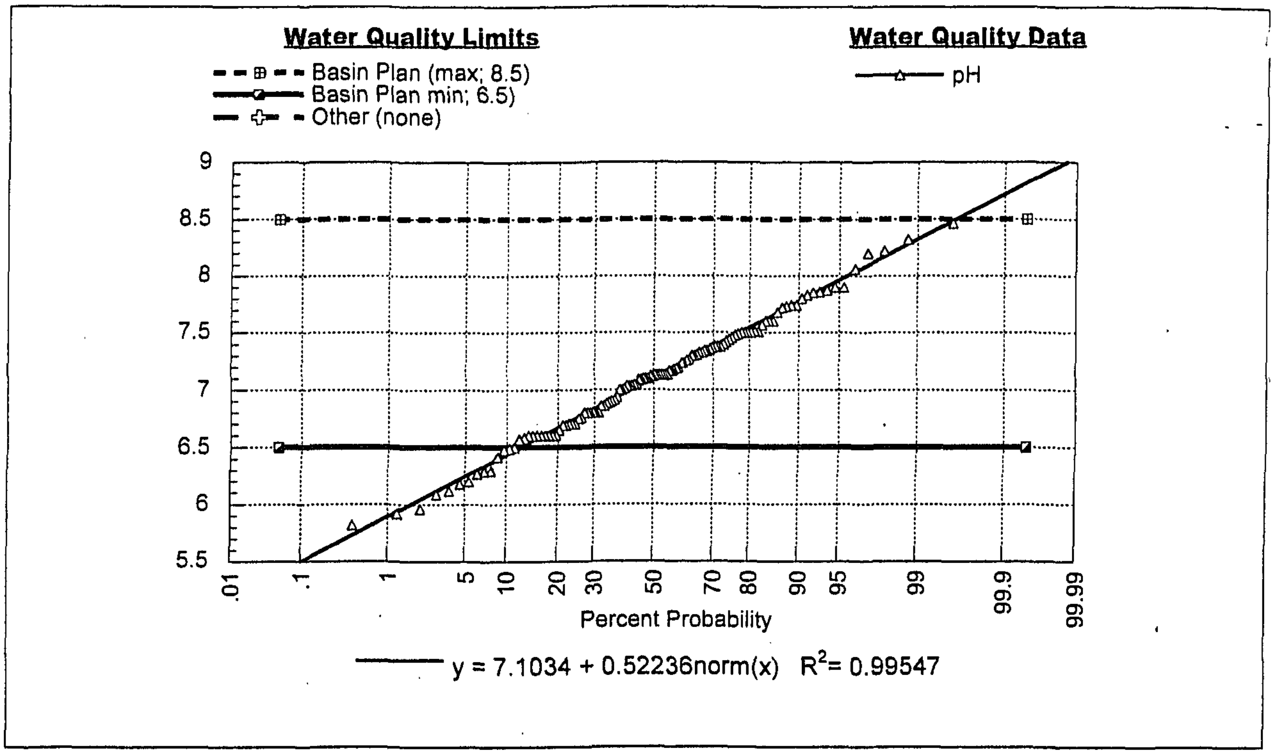


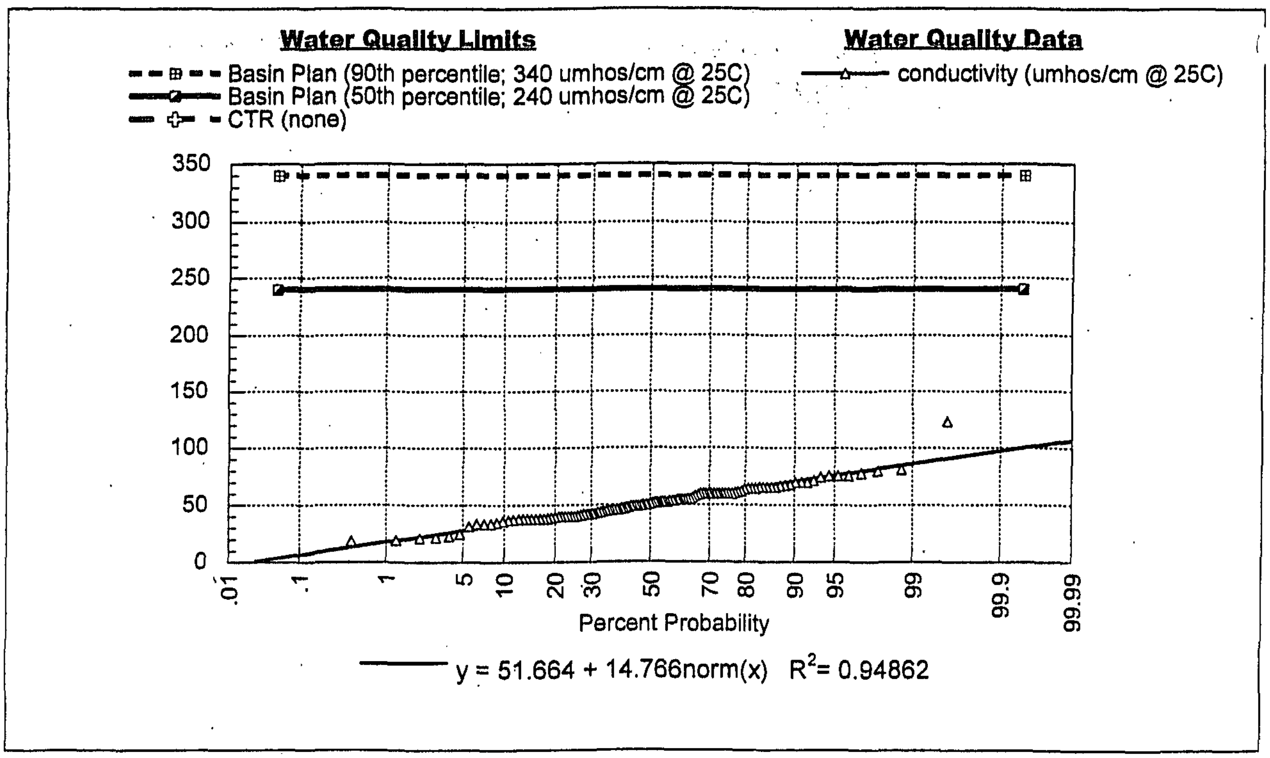

Water Quality Limits
Basin Plan (single sample max=10,000 MPN/100mL)
Basin Plan (30-day median=1,000 MPN/100mL)
CTR (none)
Water Quality Data
Total coliform (MPN/100mL)
10^4
1000
100
10
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 100.78 * e^(1.2994norm(x)) R^2= 0.9275


Water Quality Limits
Basin Plan (single sample max=400 MPN/100mL)
Basin Plan (30-day median=200 MPN/100mL)
CTR (none)
Water Quality Data
Fecal coliform (MPN/100mL)
10^4
1000
100
10
1
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 47.548 * e^(1.1189norm(x)) R^2= 0.83733

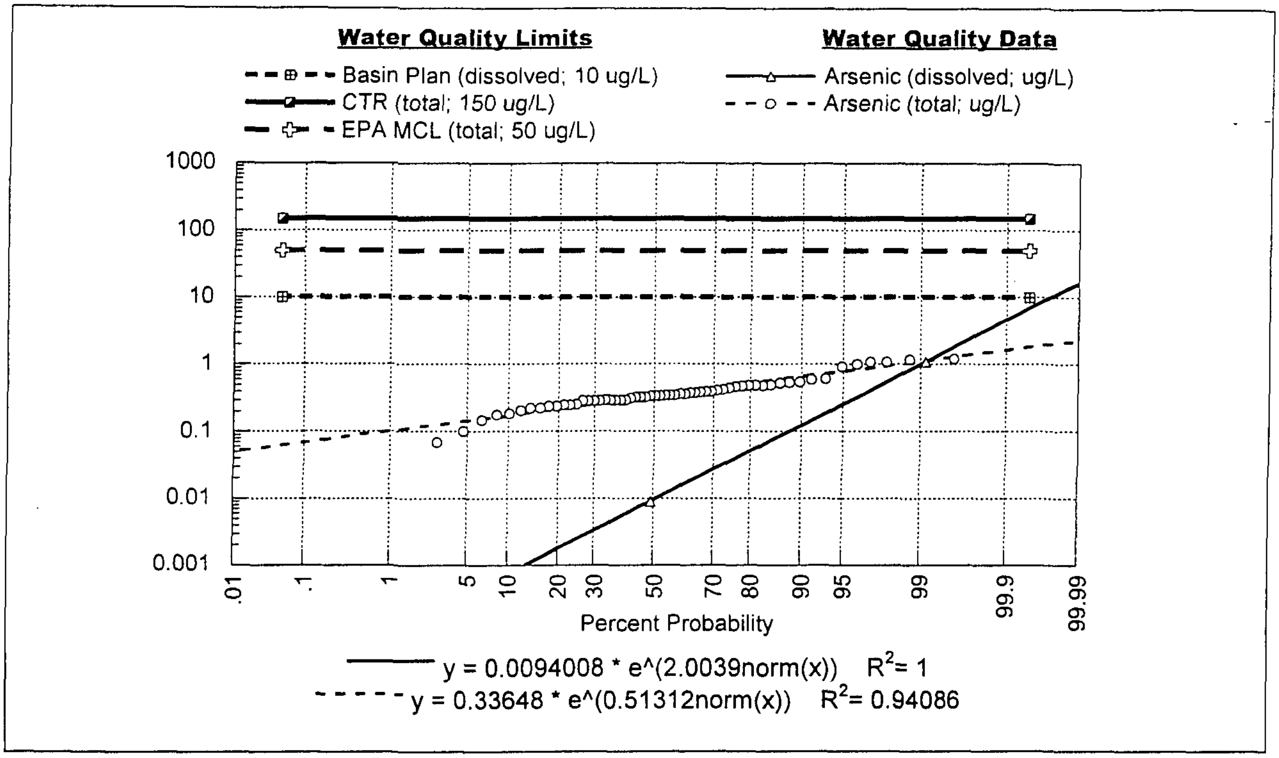

Water Quality Limits
Basin Plan (2.8 deg.C increase above natural)
Basin Plan (Max: Jan-Mar; 18.9 deg.C)
Basin Plan (Max: Apr-Jun, Sep-Nov; 20 deg.C)
Water Quality Data
Temperature (deg.C)
22
20
18
16
14
12
10
8
6
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 13.02 + 3.3874norm(x) R^2= 0.96147

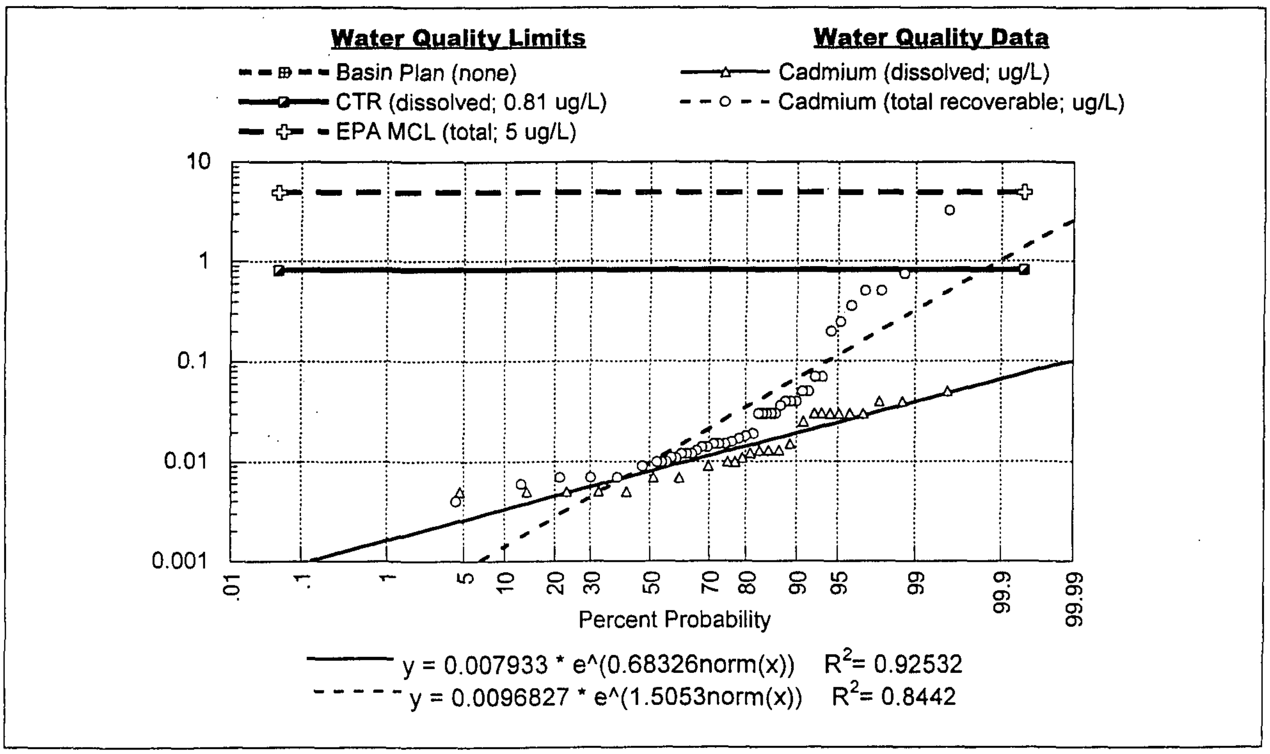

Water Quality Limits
Basin Plan (min; 7.0 mg/L)
CTR (none)
Other (none)
Water Quality Data
Dissolved oxygen (mg/L)
14
12
10
8
6
4
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 10.084 + 1.9138norm(x) R^2= 0.97353

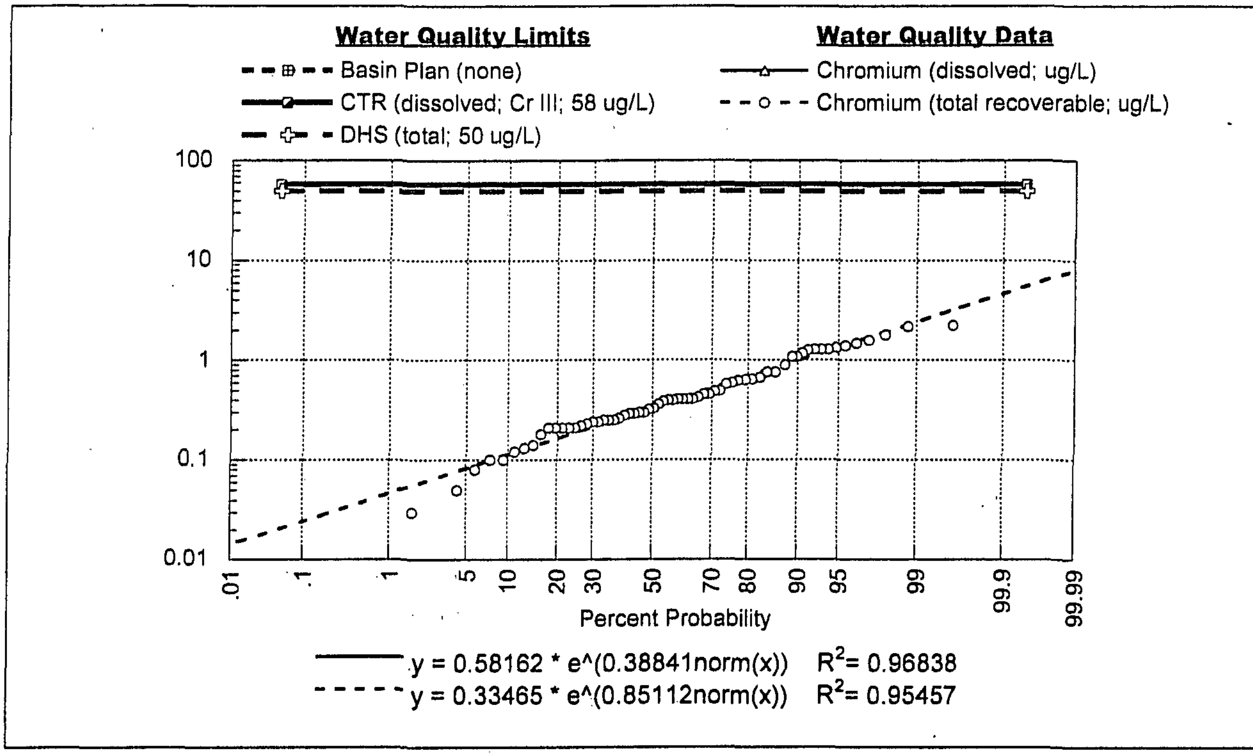

Water Quality Limits
Basin Plan (max; 8.5)
Basin Plan min; 6.5)
Other (none)
Water Quality Data
pH
9
8.5
8
7.5
7
6.5
6
5.5
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 7.1034 + 0.52236norm(x) R2= 0.99547

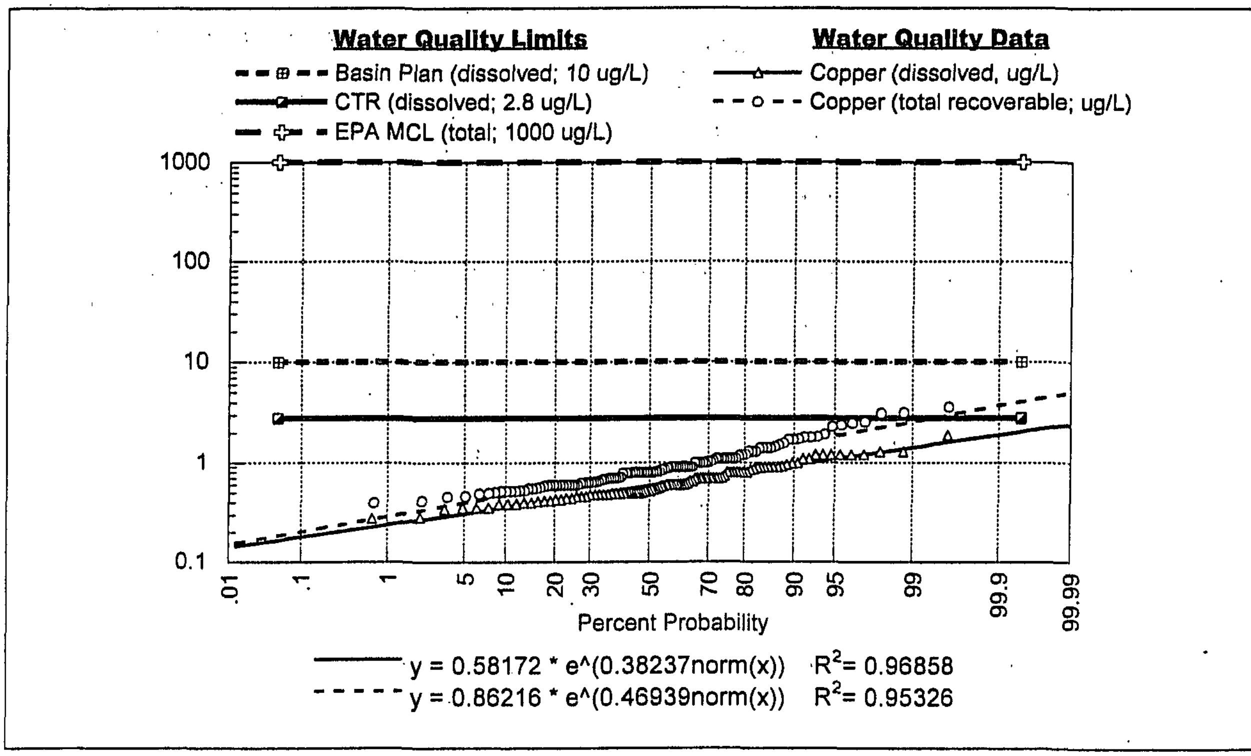

Water Quality Limits
Basin Plan (90th percentile; 340 umhos/cm @ 25C)
Basin Plan (50th percentile; 240 umhos/cm @ 25C)
CTR (none)
Water Quality Data
conductivity (umhos/cm @ 25C)
350
300
250
200
150
100
50
0
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 51.664 + 14.766norm(x) R2= 0.94862

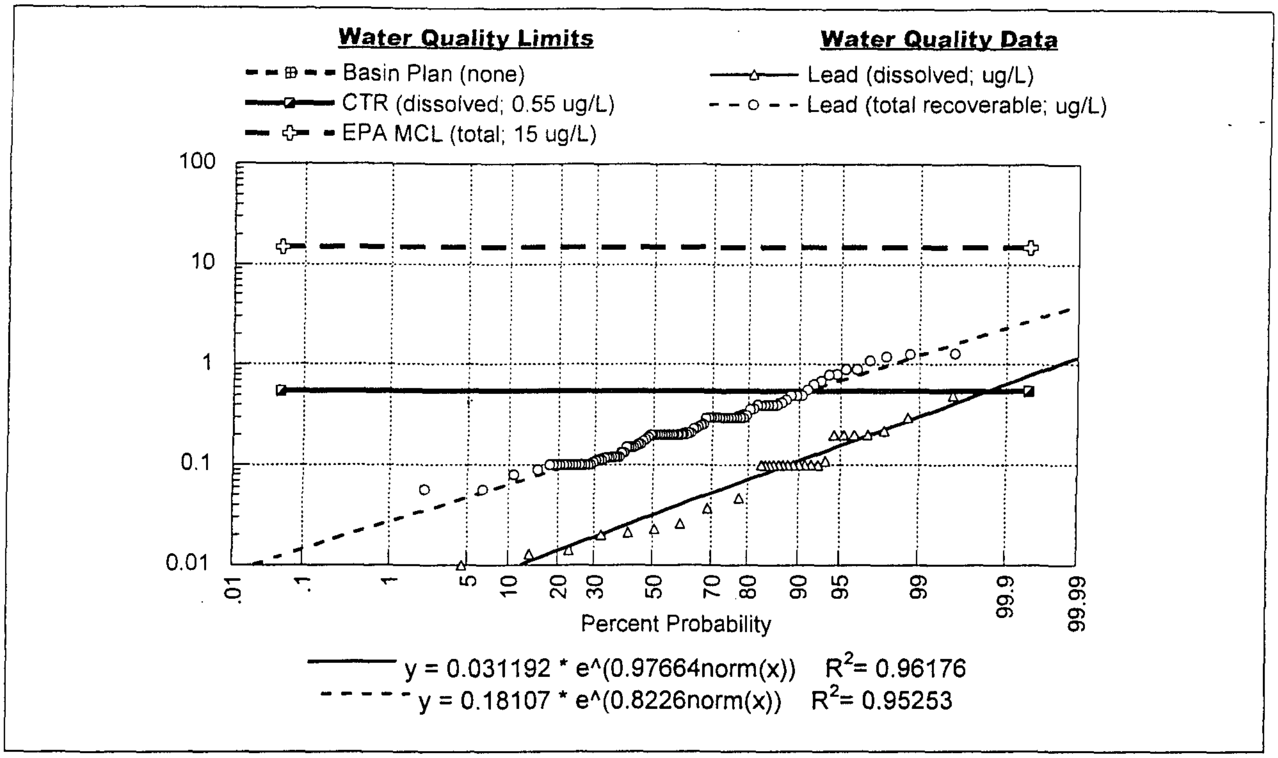
American River at Discovery Park

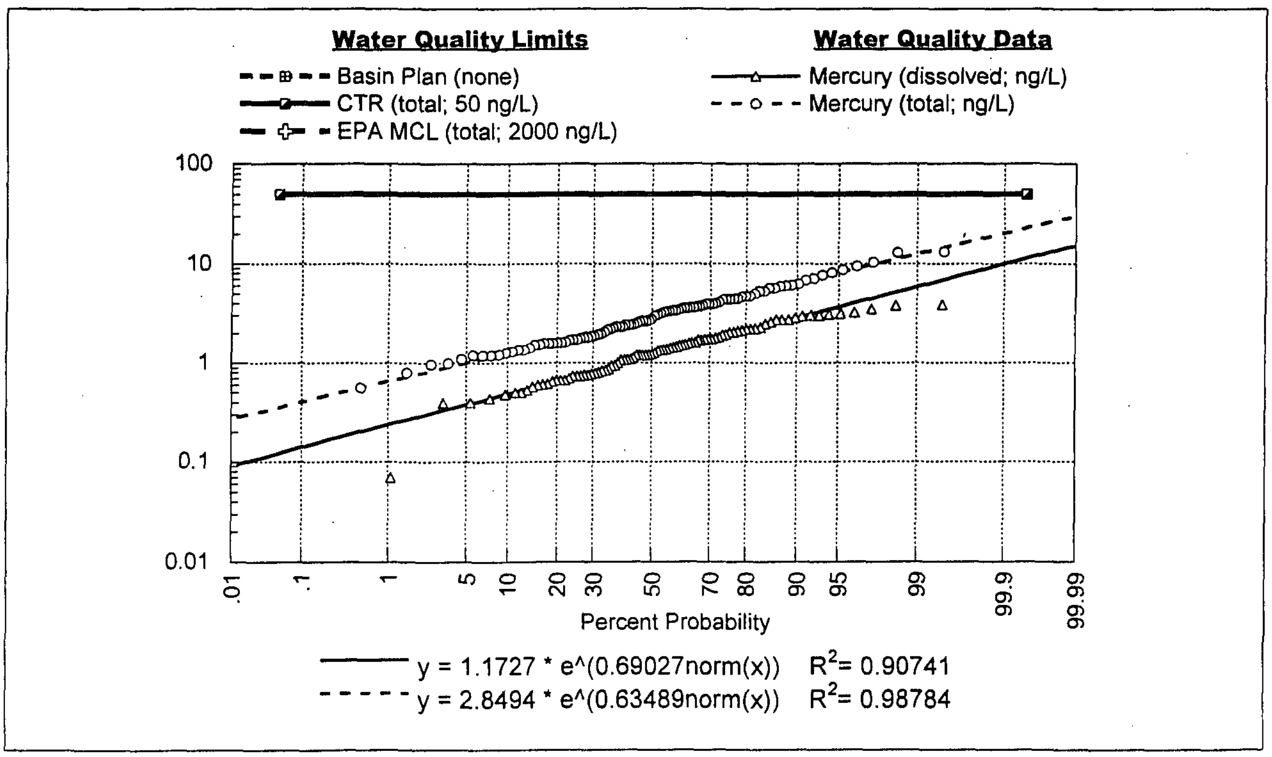

Water Quality Limits
Basin Plan (dissolved; 10 ug/L)
CTR (total; 150 ug/L)
EPA MCL (total; 50 ug/L)
Water Quality Data
Arsenic (dissolved; ug/L)
Arsenic (total; ug/L)
1000
100
10
1
0.1
0.01
0.001
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 0.0094008 * e^(2.0039norm(x)) R2= 1
y = 0.33648 * e^(0.51312norm(x)) R2= 0.94086

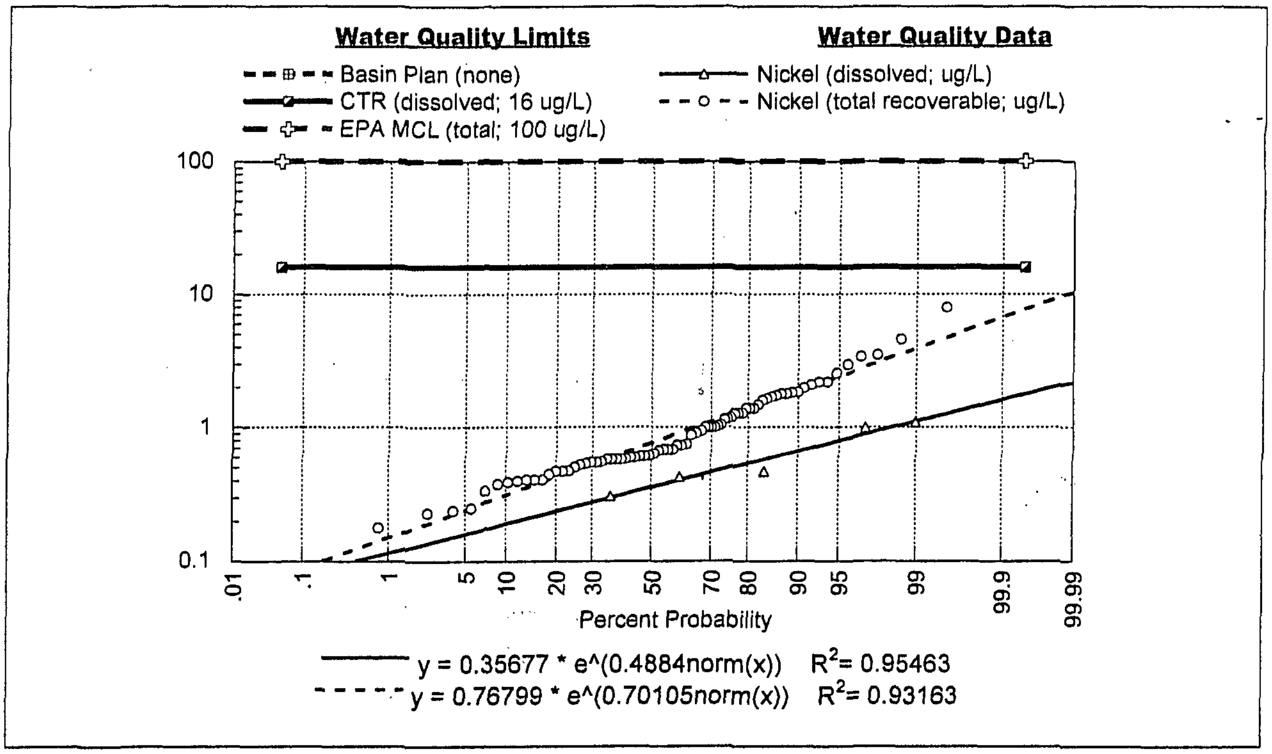

Water Quality Limits
Basin Plan (none)
CTR (dissolved; 0.81 ug/L)
EPA MCL (total; 5 ug/L)
Water Quality Data
Cadmium (dissolved; ug/L)
Cadmium (total recoverable; ug/L)
10
1
0.1
0.01
0.001
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 0.007933 * e^(0.68326norm(x)) R2= 0.92532
y = 0.0096827 * e^(1.5053norm(x)) R2= 0.8442

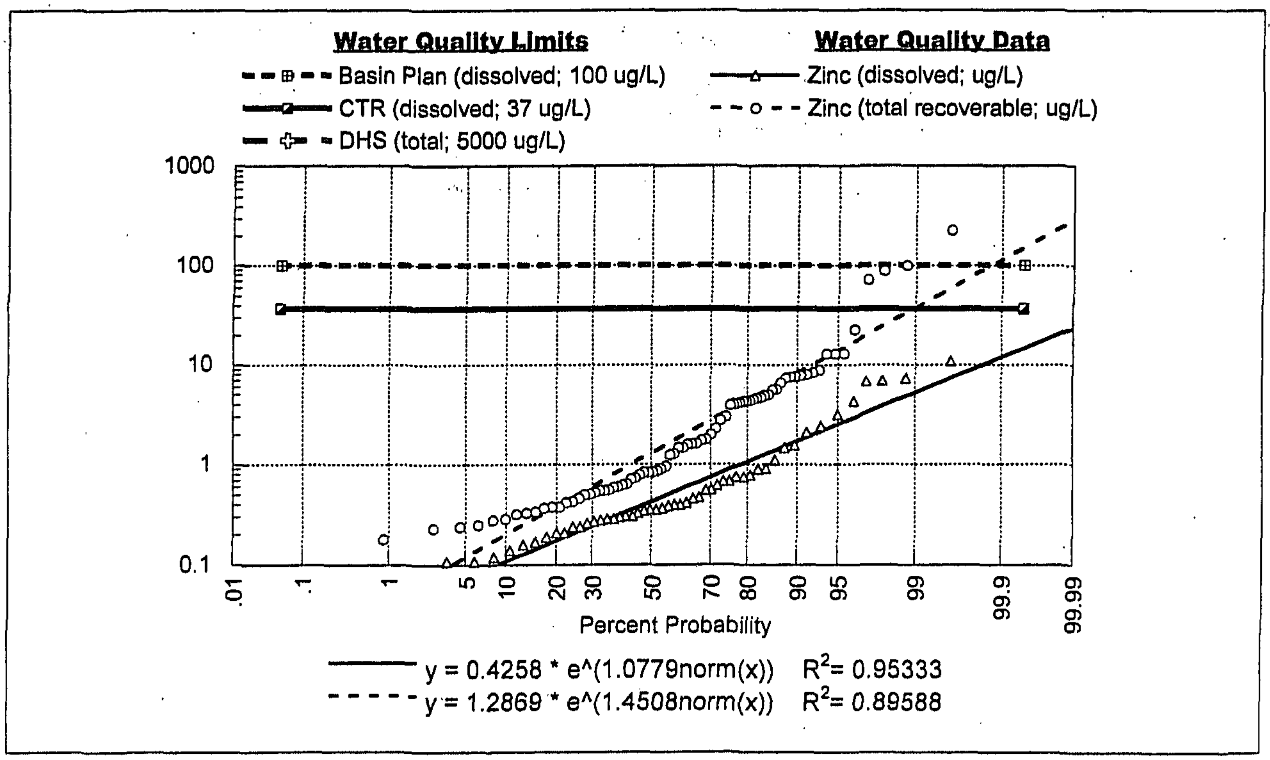

Water Quality Limits
Basin Plan (none)
CTR (dissolved; Cr III; 58 ug/L)
DHS (total; 50 ug/L)
Water Quality Data
Chromium (dissolved; ug/L)
Chromium (total recoverable; ug/L)
100
10
1
0.1
0.01
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 0.58162 * e^(0.38841norm(x)) R2= 0.96838
y = 0.33465 * e^(0.85112norm(x)) R2= 0.95457

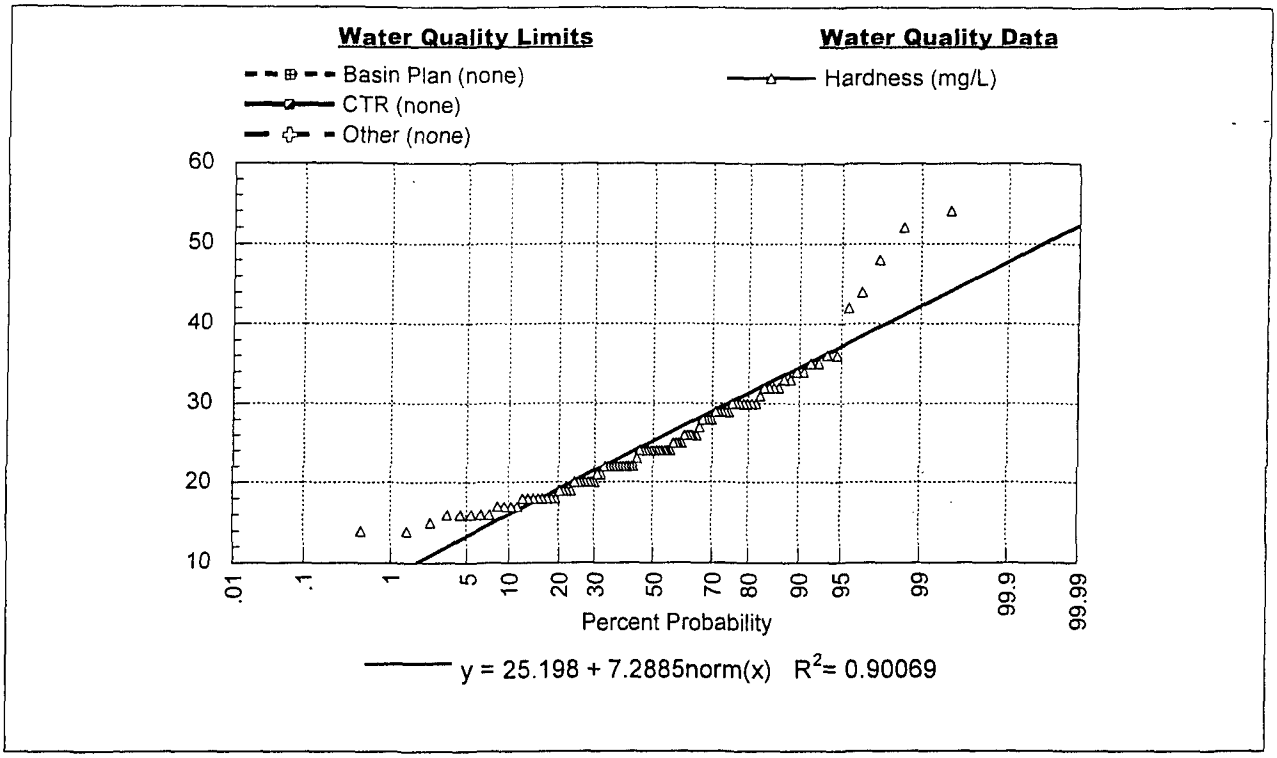

Water Quality Limits
Basin Plan (dissolved; 10 ug/L)
CTR (dissolved; 2.8 ug/L)
EPA MCL (total; 1000 ug/L)
Water Quality Data
Copper (dissolved, ug/L)
Copper (total recoverable; ug/L)
1000
100
10
1
0.1
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 0.58172 * e^(0.38237norm(x)) R2= 0.96858
y = 0.86216 * e^(0.46939norm(x)) R2= 0.95326

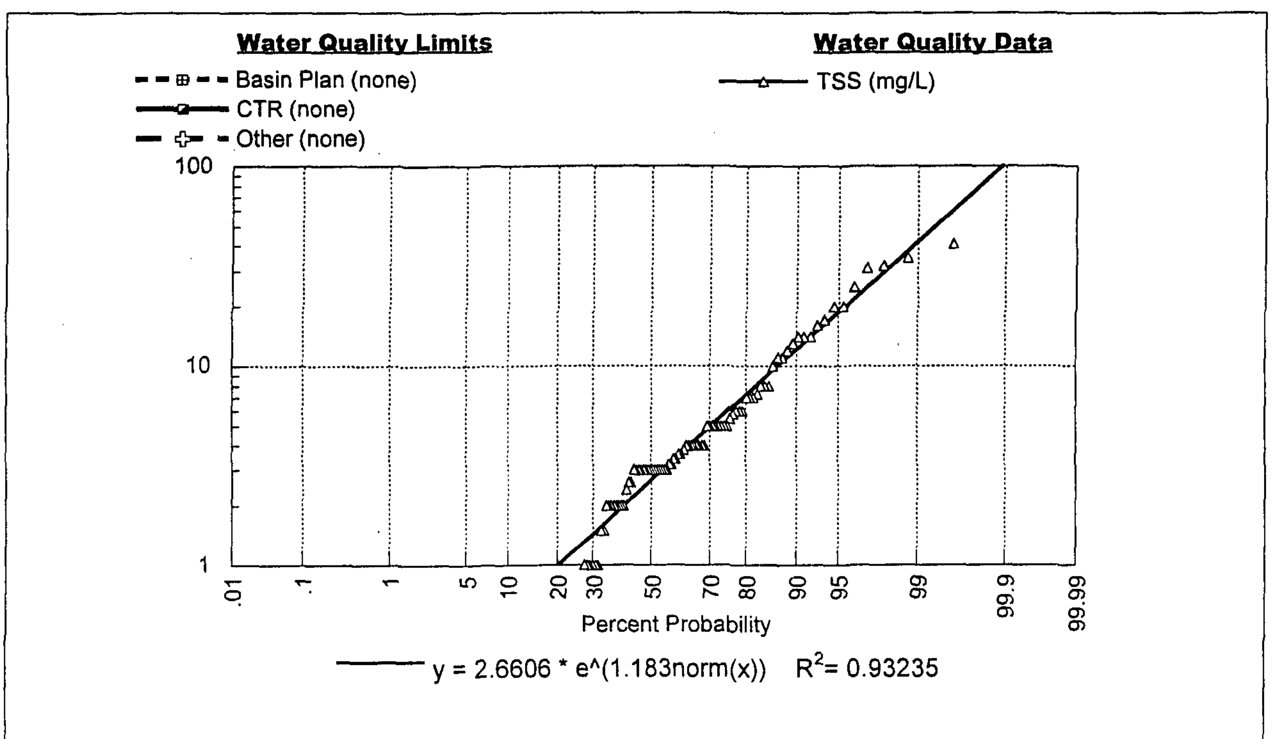

Water Quality Limits
Basin Plan (none)
CTR (dissolved; 0.55 ug/L)
EPA MCL (total; 15 ug/L)
Water Quality Data
Lead (dissolved; ug/L)
Lead (total recoverable; ug/L)
100
10
1
0.1
0.01
.01 .1 1 5 10 20 30 50 70 80 90 95 99 99.9 99.99
Percent Probability
y = 0.031192 * e^(0.97664norm(x)) R2= 0.96176
y = 0.18107 * e^(0.8226norm(x)) R2= 0.95253

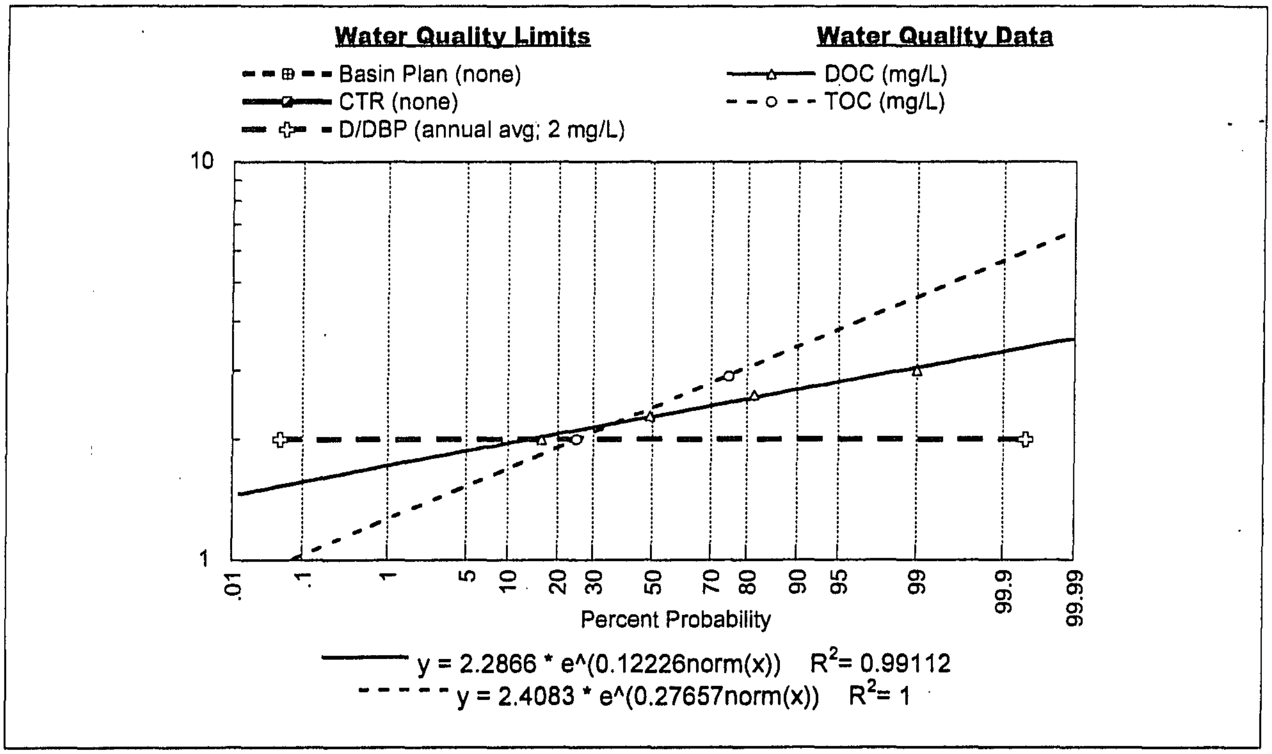

Water Quality Limits
Basin Plan (none)
CTR (total; 50 ng/L)
EPA MCL (total; 2000 ng/L)
Water Quality Data
Mercury (dissolved; ng/L)
Mercury (total; ng/L)
100
10
1
0.1
0.01
.01 .1 1 5 10 20 30 50 70 80 90 95 99 99.9 99.99
Percent Probability
y = 1.1727 * e^(0.69027norm(x)) R2= 0.90741
y = 2.8494 * e^(0.63489norm(x)) R2= 0.98784

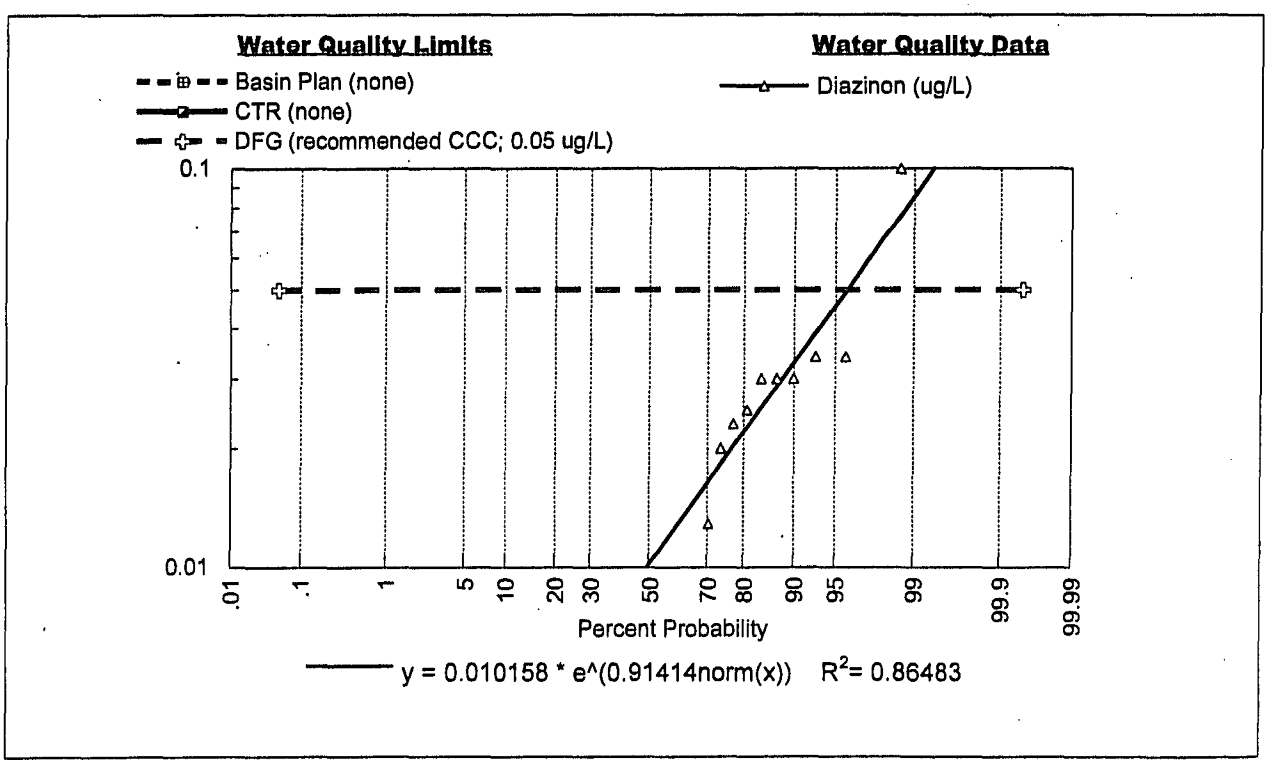

Water Quality Limits
Basin Plan (none)
CTR (dissolved; 16 ug/L)
EPA MCL (total; 100 ug/L)
Water Quality Data
Nickel (dissolved; ug/L)
Nickel (total recoverable; ug/L)
100
10
1
0.1
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 0.35677 * e^(0.4884norm(x)) R2= 0.95463
y = 0.76799 * e^(0.70105norm(x)) R2= 0.93163

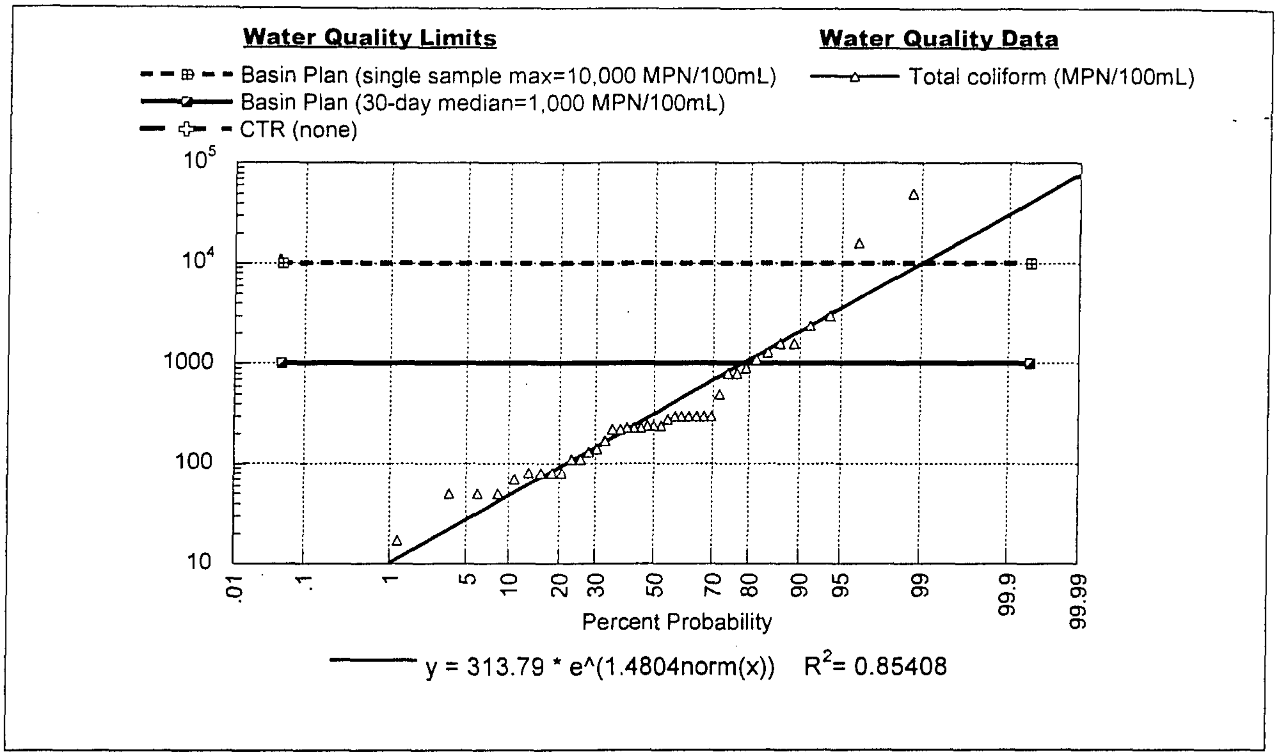

Water Quality Limits
Basin Plan (dissolved; 100 ug/L)
CTR (dissolved; 37 ug/L)
DHS (total; 5000 ug/L)
Water Quality Data
Zinc (dissolved; ug/L)
Zinc (total recoverable; ug/L)
1000
100
10
1
0.1
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 0.4258 * e^(1.0779norm(x)) R2= 0.95333
y = 1.2869 * e^(1.4508norm(x)) R2= 0.89588

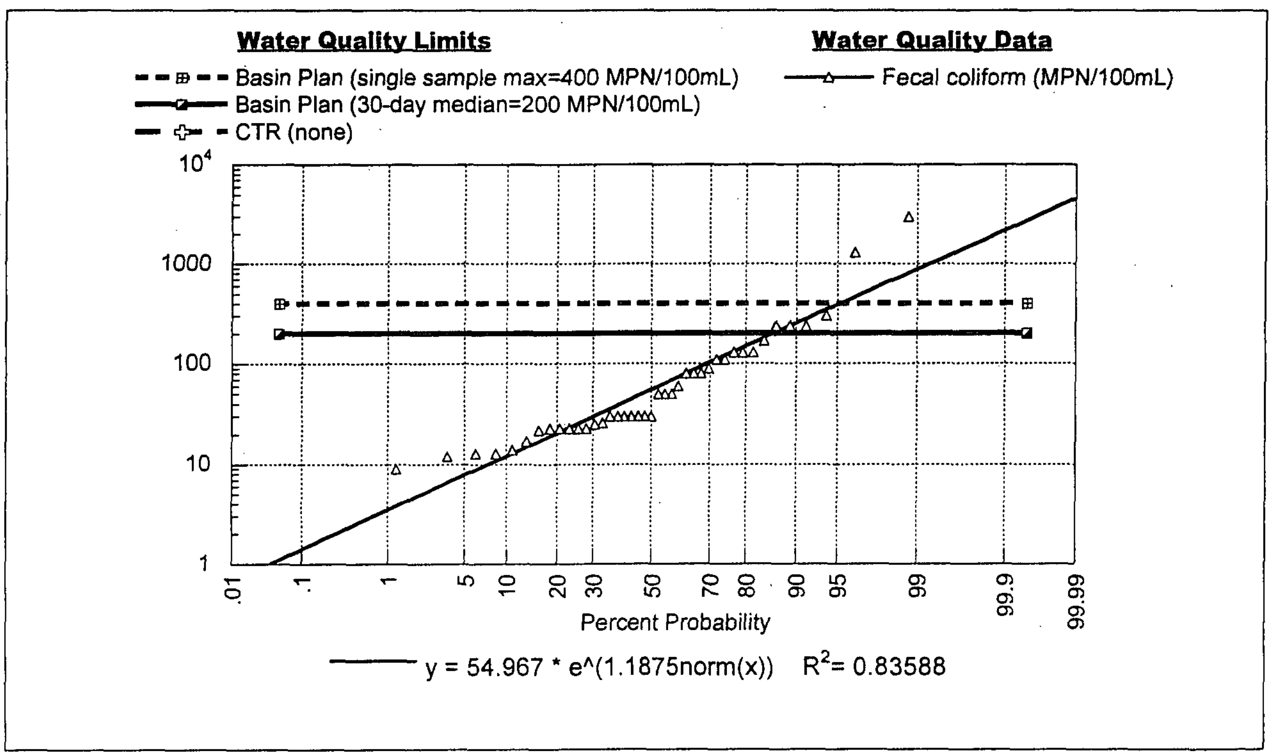

Water Quality Limits
Basin Plan (none)
CTR (none)
Other (none)
Water Quality Data
Hardness (mg/L)
60
50
40
30
20
10
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 25.198 + 7.2885norm(x) R2= 0.90069

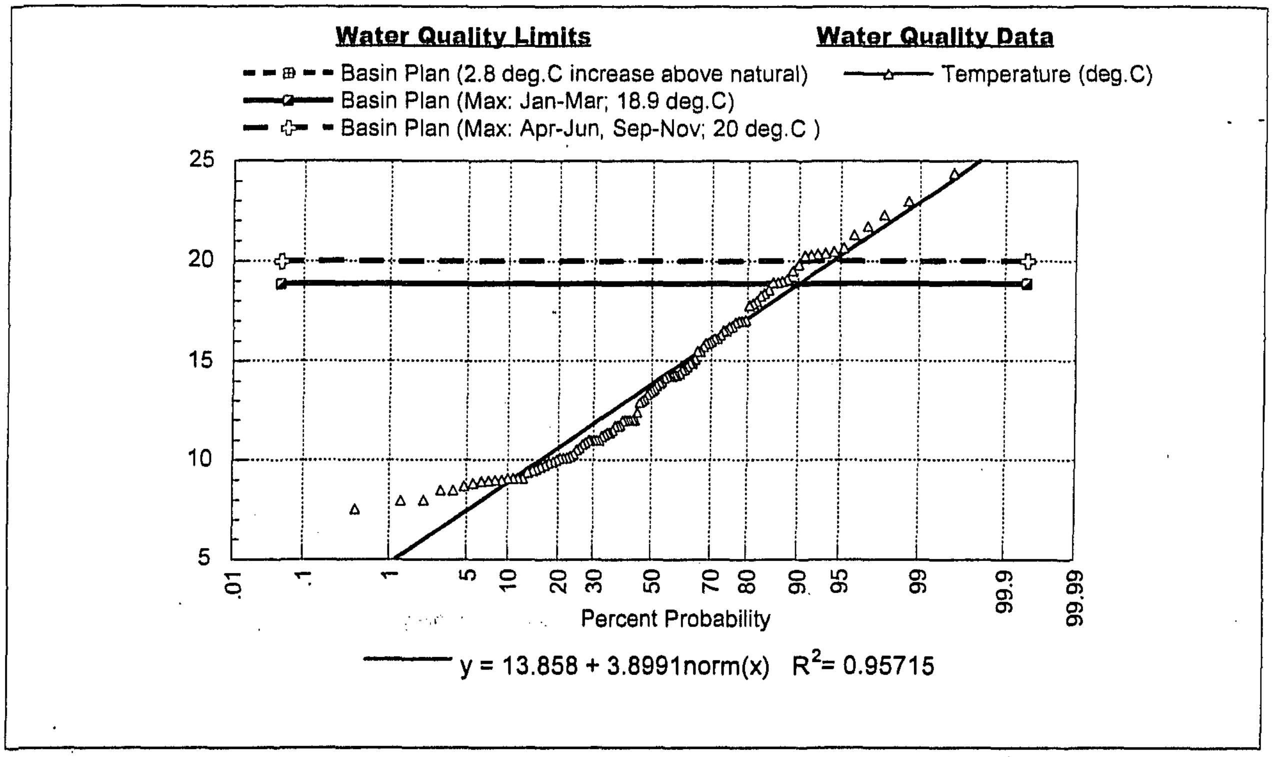

Water Quality Limits
Basin Plan (none)
CTR (none)
Other (none)
Water Quality Data
TSS (mg/L)
100
10
1
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 2.6606 * e^(1.183norm(x)) R2= 0.93235

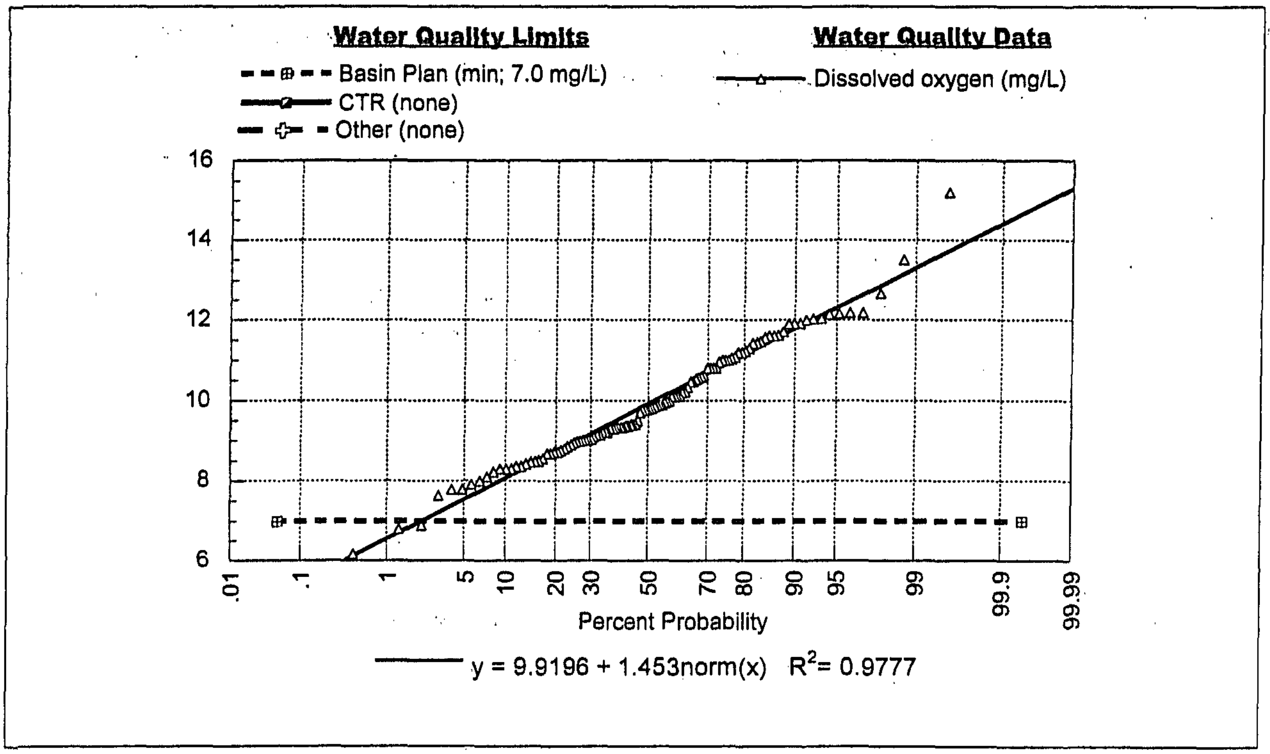

Water Quality Limits
Basin Plan (none)
CTR (none)
D/DBP (annual avg; 2 mg/L)
Water Quality Data
DOC (mg/L)
TOC (mg/L)
10
1
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 2.2866 * e^(0.12226norm(x)) R2= 0.99112
y = 2.4083 * e^(0.27657norm(x)) R2= 1

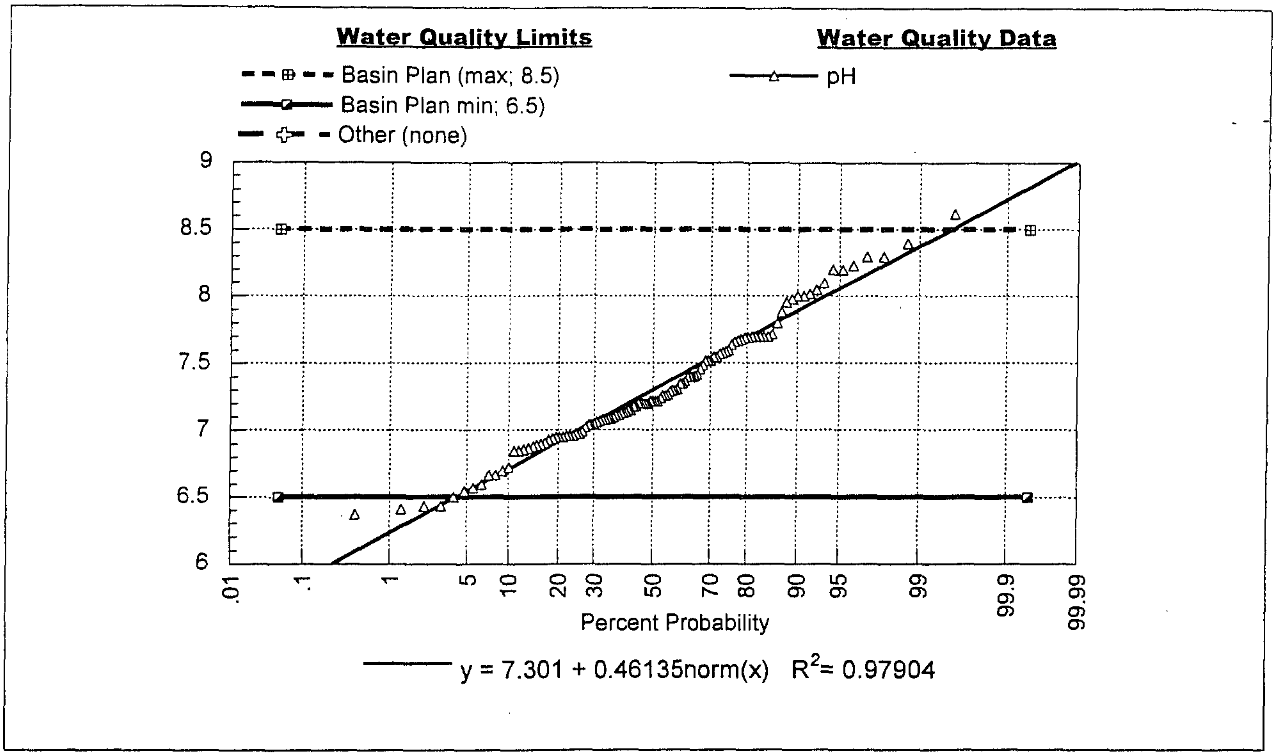

Water Quality Limits
Basin Plan (none)
CTR (none)
DFG (recommended CCC; 0.05 ug/L)
Water Quality Data
Diazinon (ug/L)
0.1
0.01
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 0.010158 * e^(0.91414norm(x)) R2= 0.86483

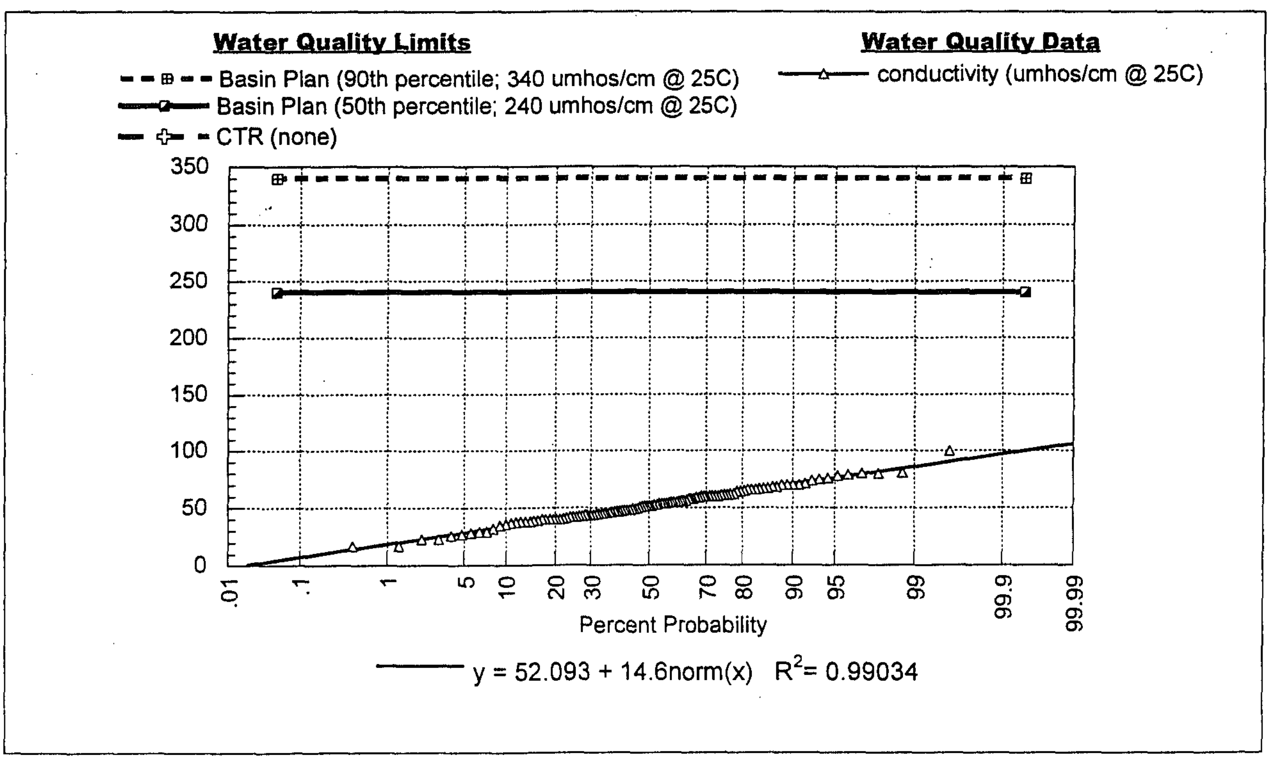

Water Quality Limits
Basin Plan (single sample max=10,000 MPN/100mL)
Basin Plan (30-day median=1,000 MPN/100mL)
CTR (none)
Water Quality Data
Total coliform (MPN/100mL)
10^5
10^4
1000
100
10
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 313.79 * e^(1.4804norm(x)) R^2= 0.85408


Water Quality Limits
Basin Plan (single sample max=400 MPN/100mL)
Basin Plan (30-day median=200 MPN/100mL)
CTR (none)
Water Quality Data
Fecal coliform (MPN/100mL)
10^4
1000
100
10
1
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 54.967 * e^(1.1875norm(x)) R^2= 0.83588

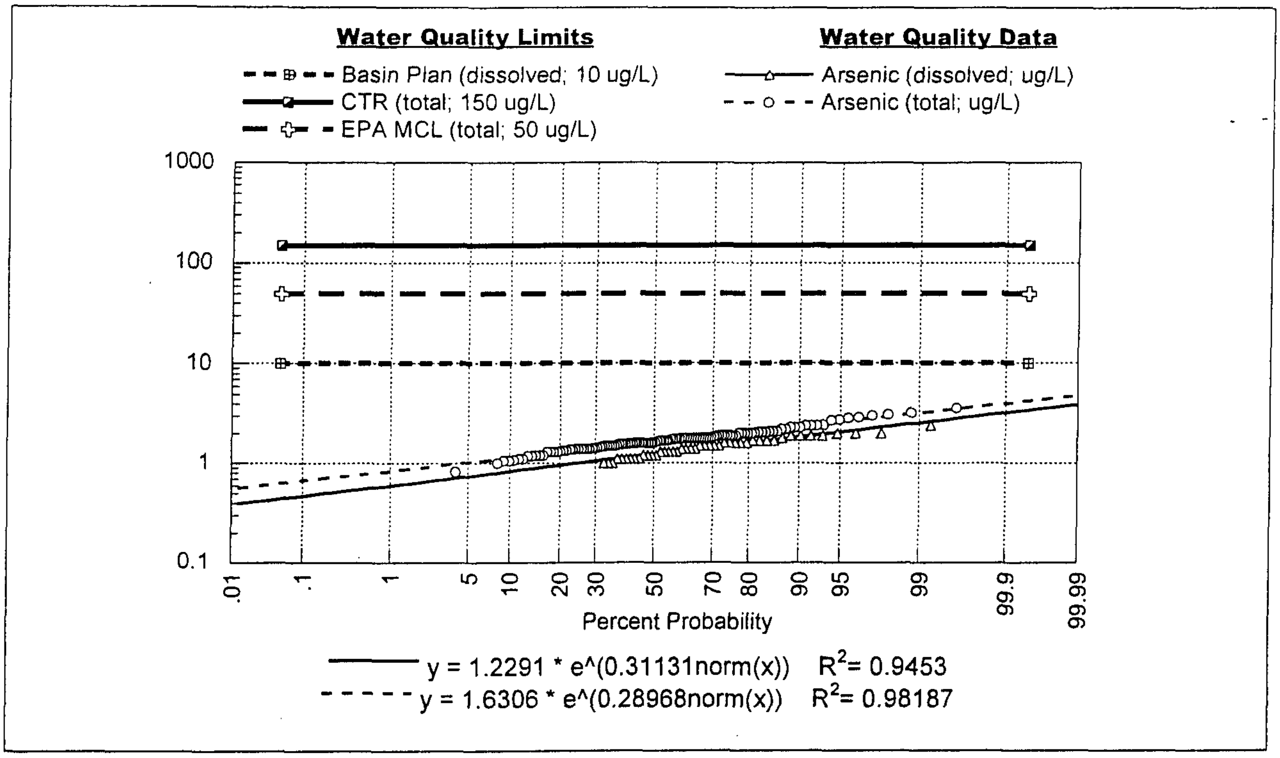

Water Quality Limits
Basin Plan (2.8 deg.C increase above natural)
Basin Plan (Max: Jan-Mar; 18.9 deg.C)
Basin Plan (Max: Apr-Jun, Sep-Nov; 20 deg.C)
Water Quality Data
Temperature (deg.C)
25
20
15
10
5
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 13.858 + 3.8991norm(x) R2= 0.95715

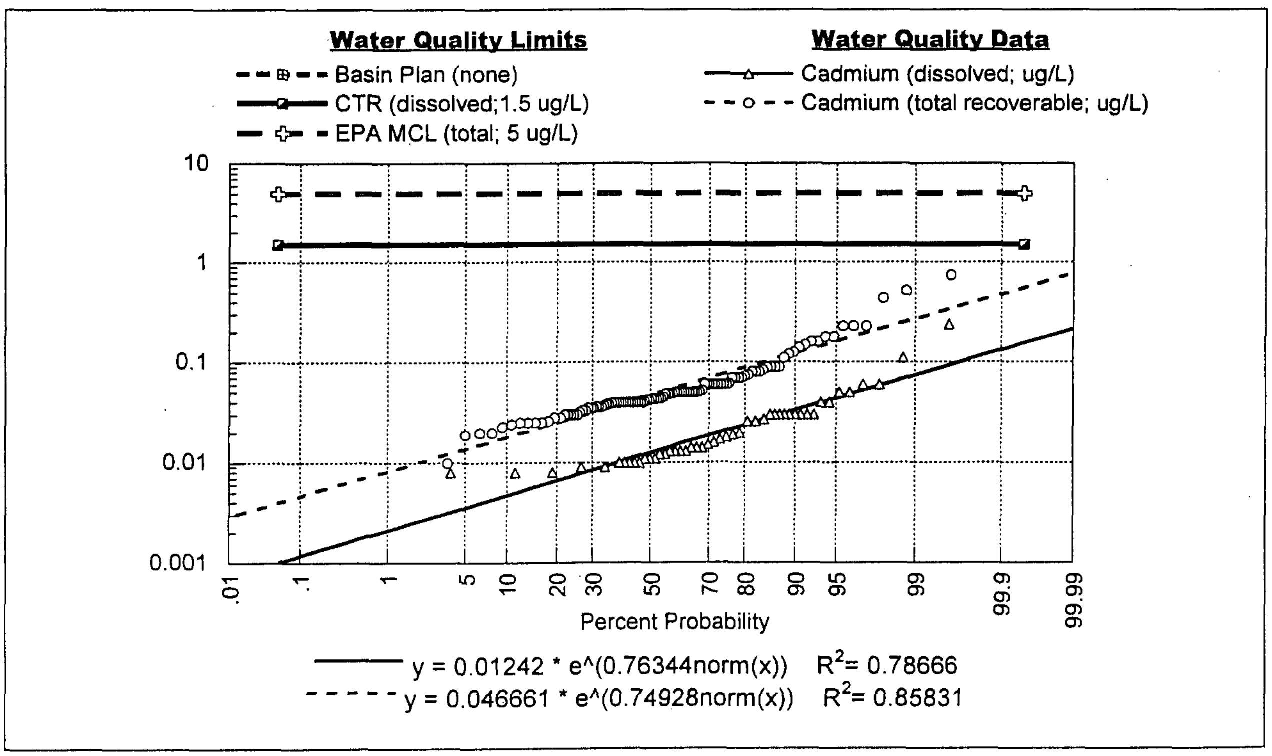

Water Quality Limits
Basin Plan (min; 7.0 mg/L)
CTR (none)
Other (none)
Water Quality Data
Dissolved oxygen (mg/L)
16
14
12
10
8
6
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 9.9196 + 1.453norm(x) R2= 0.9777


Water Quality Limits
Basin Plan (max; 8.5)
Basin Plan min; 6.5)
Other (none)
Water Quality Data
pH
9
8.5
8
7.5
7
6.5
6
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 7.301 + 0.46135norm(x) R2= 0.97904

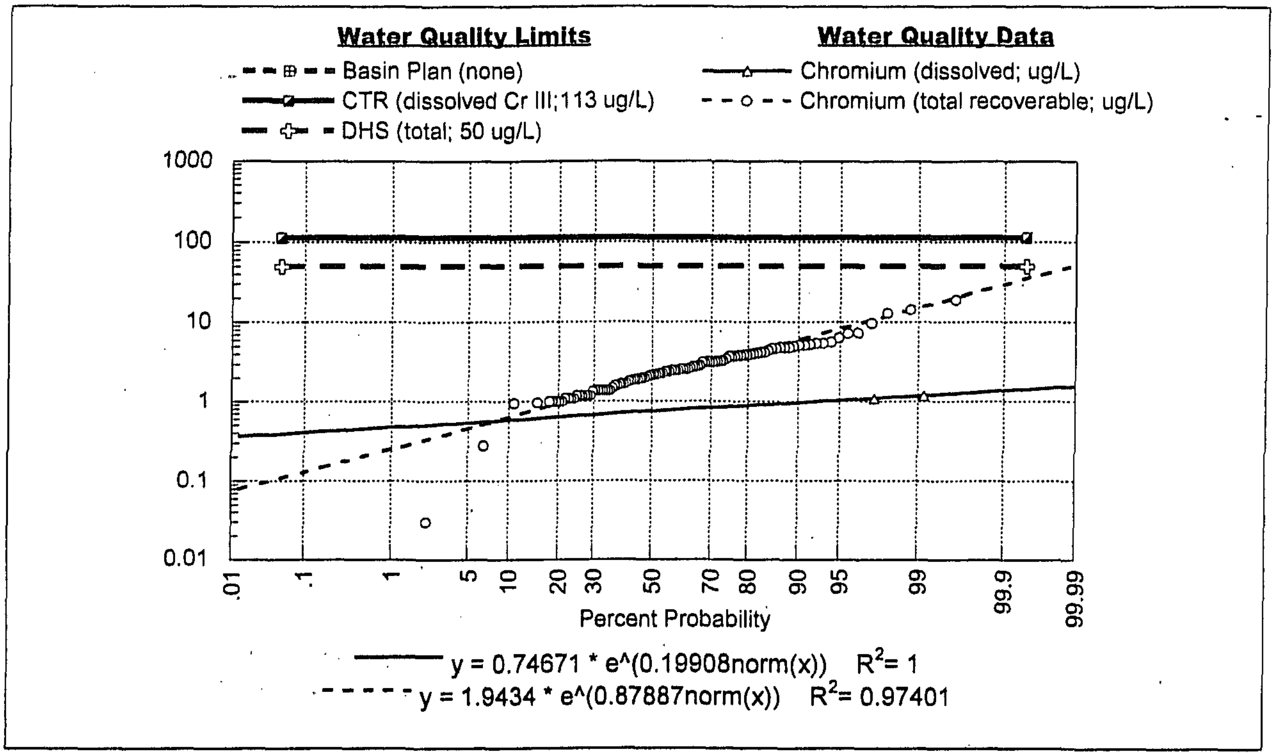

Water Quality Limits
Basin Plan (90th percentile; 340 umhos/cm @ 25C)
Basin Plan (50th percentile; 240 umhos/cm @ 25C)
CTR (none)
Water Quality Data
conductivity (umhos/cm @ 25C)
350
300
250
200
150
100
50
0
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 52.093 + 14.6norm(x) R2= 0.99034

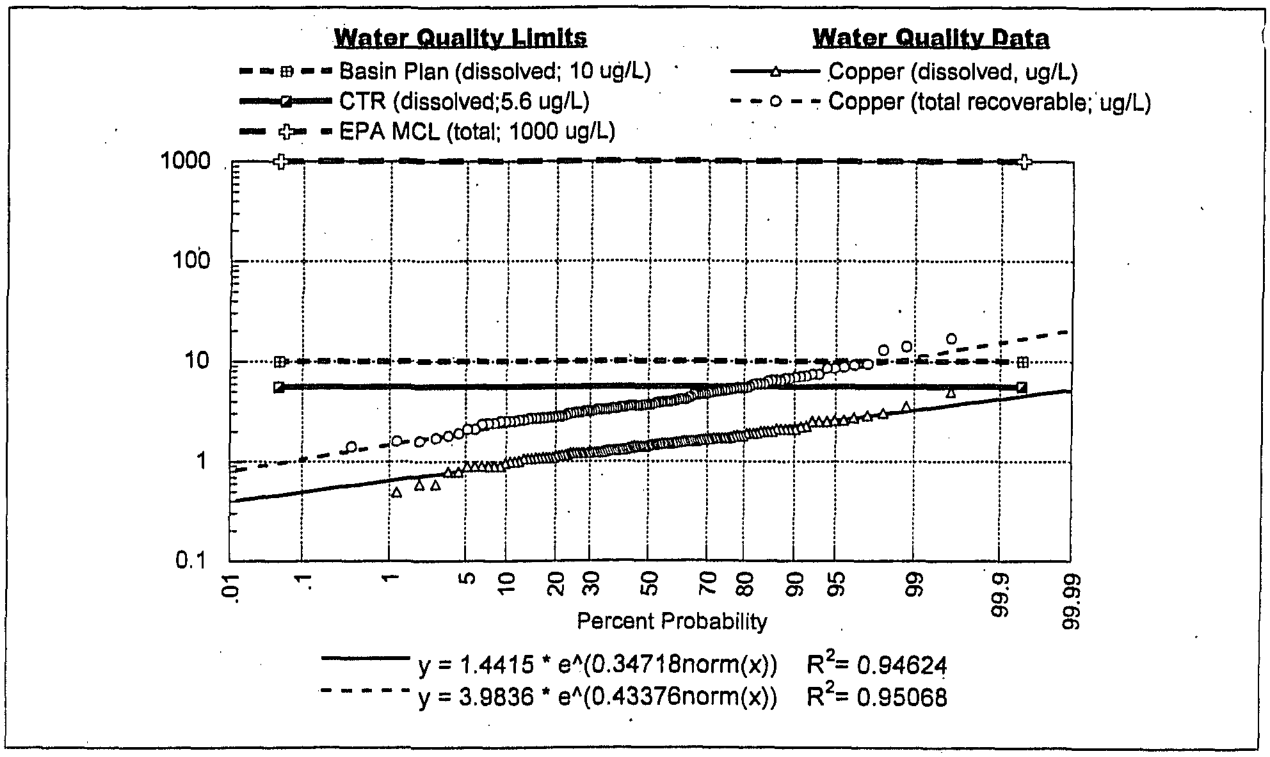
Sacramento River at Veterans Bridge

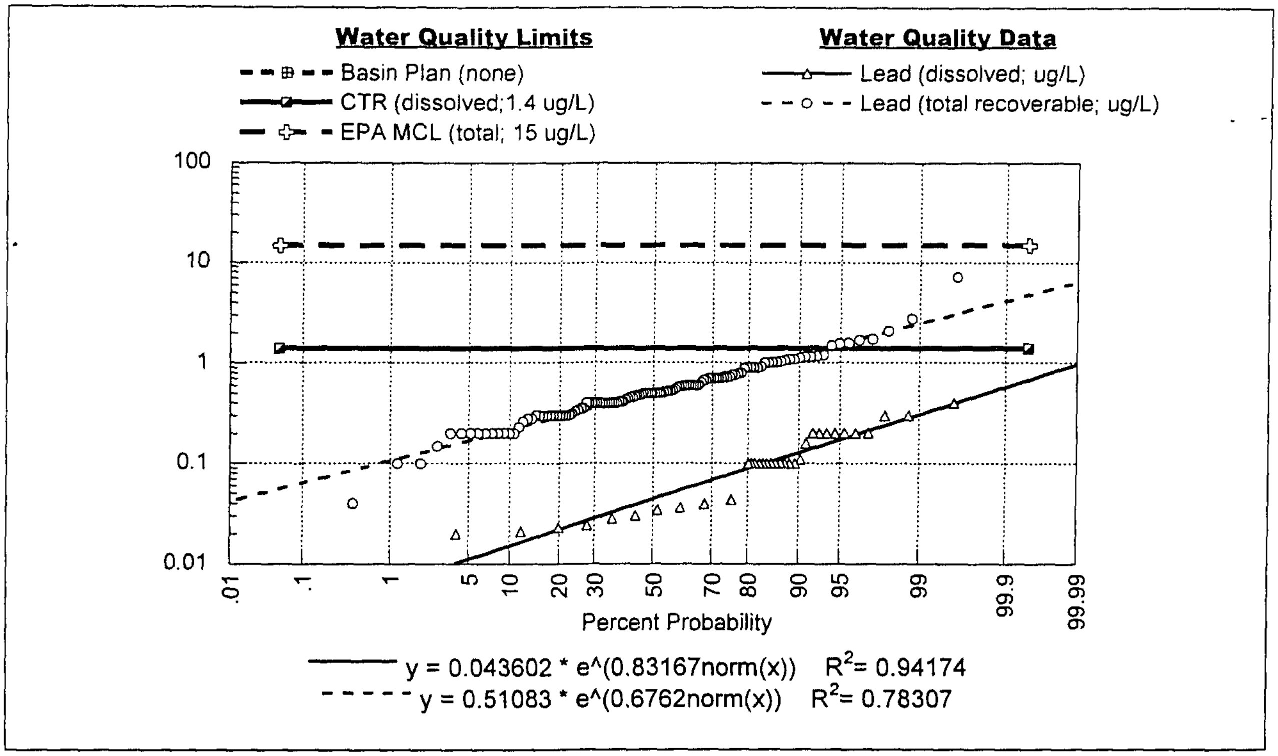

Water Quality Limits
Basin Plan (dissolved; 10 ug/L)
CTR (total; 150 ug/L)
EPA MCL (total; 50 ug/L)
Water Quality Data
Arsenic (dissolved; ug/L)
Arsenic (total; ug/L)
1000
100
10
1
0.1
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 1.2291 * e^(0.31131norm(x)) R²= 0.9453
y = 1.6306 * e^(0.28968norm(x)) R²= 0.98187

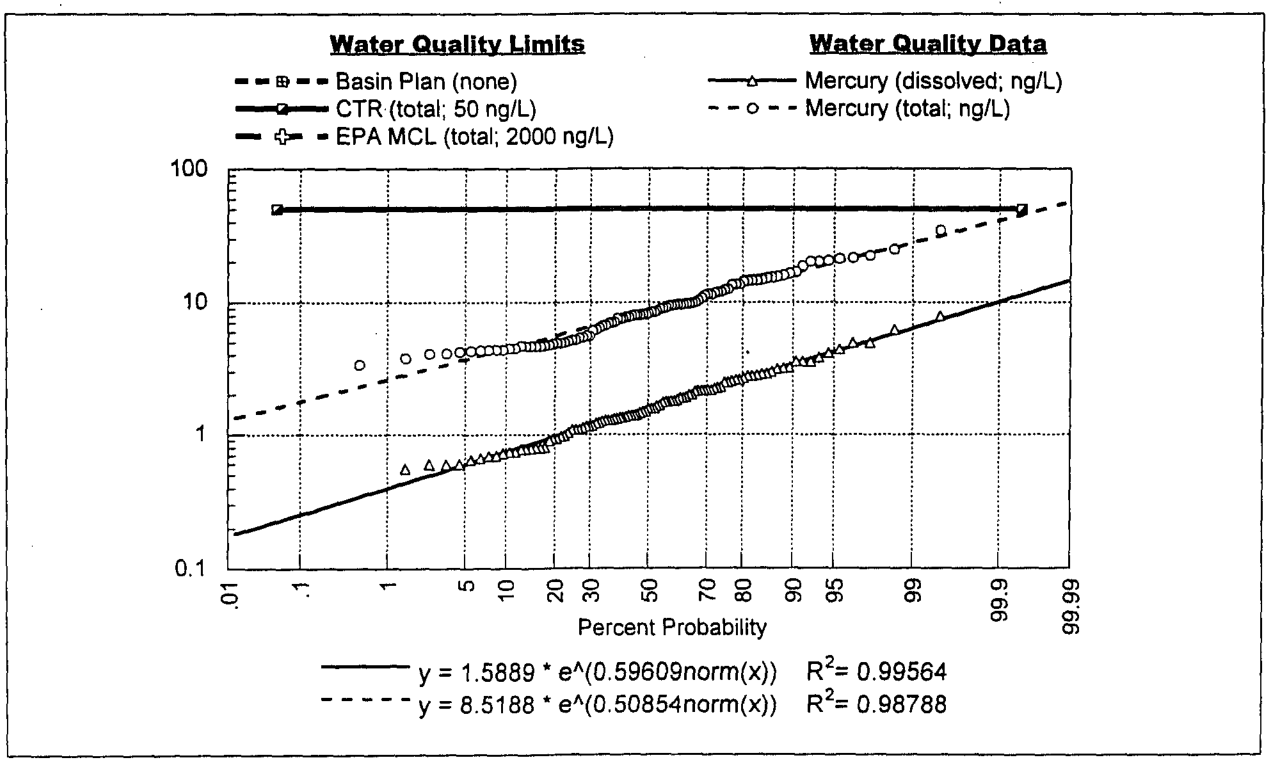

Water Quality Limits
Basin Plan (none)
CTR (dissolved;1.5 ug/L)
EPA MCL (total; 5 ug/L)
Water Quality Data
Cadmium (dissolved; ug/L)
Cadmium (total recoverable; ug/L)
10
1
0.1
0.01
0.001
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 0.01242 * e^(0.76344norm(x)) R²= 0.78666
y = 0.046661 * e^(0.74928norm(x)) R²= 0.85831

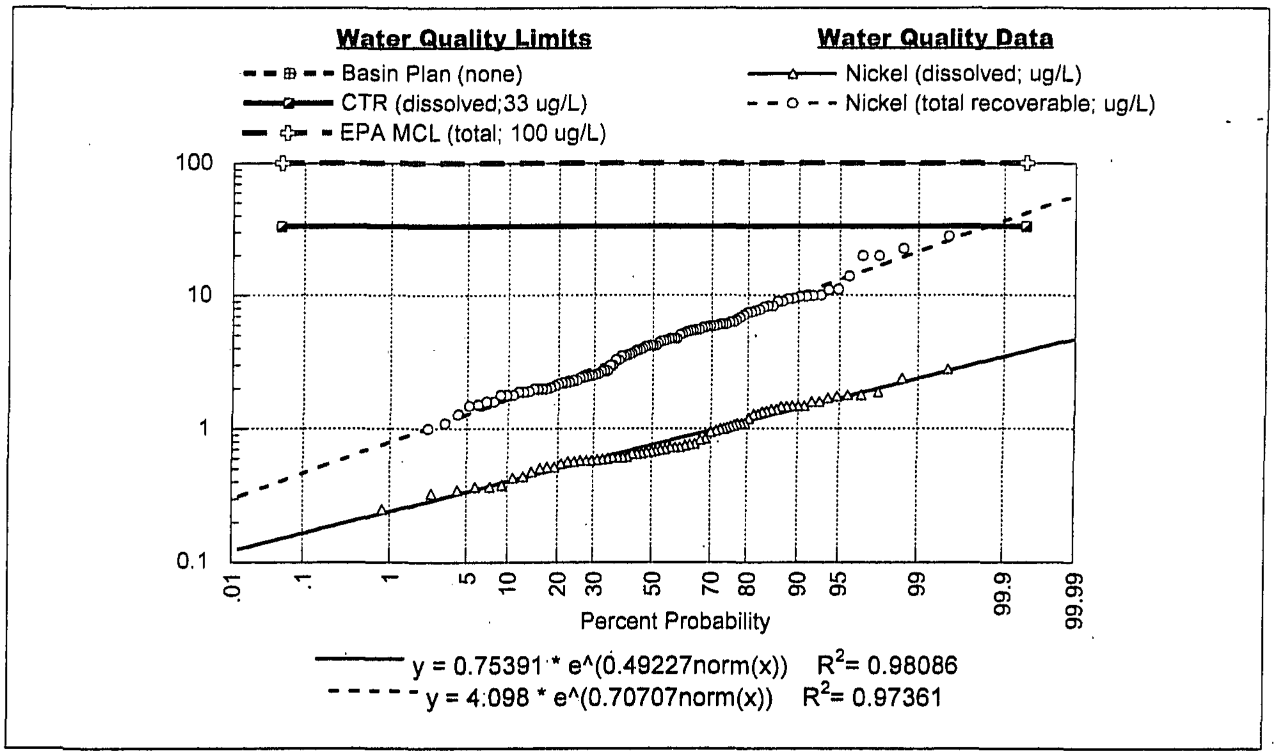
Sacramento River at Veterans Bridge
Frequency Distribution Plots of Ambient Program Data 1992-2000

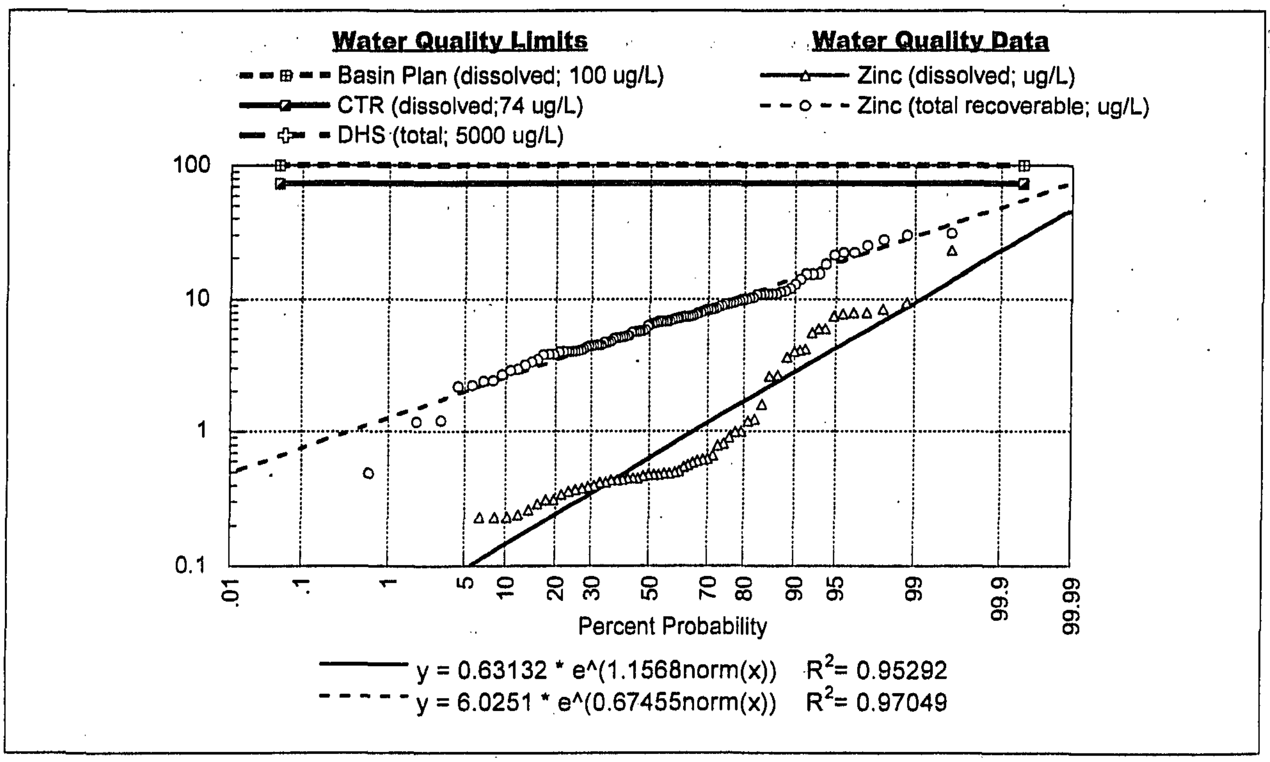


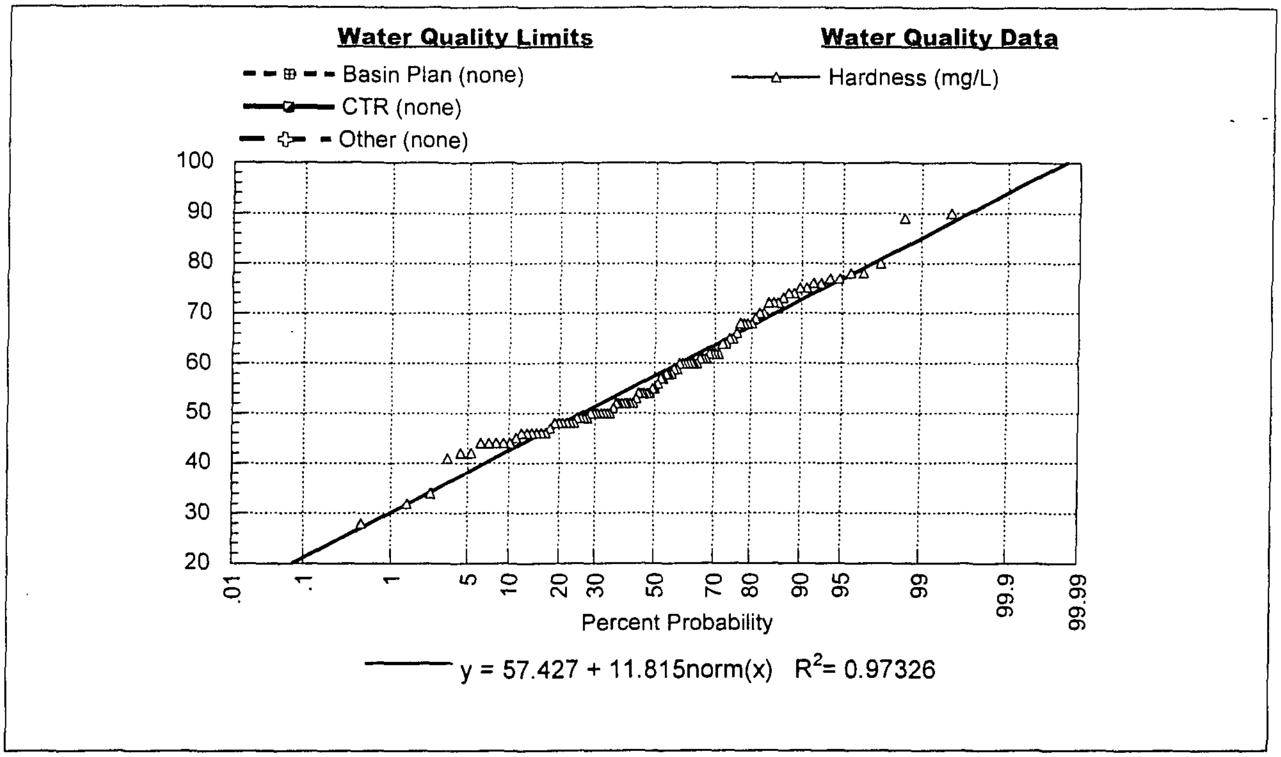


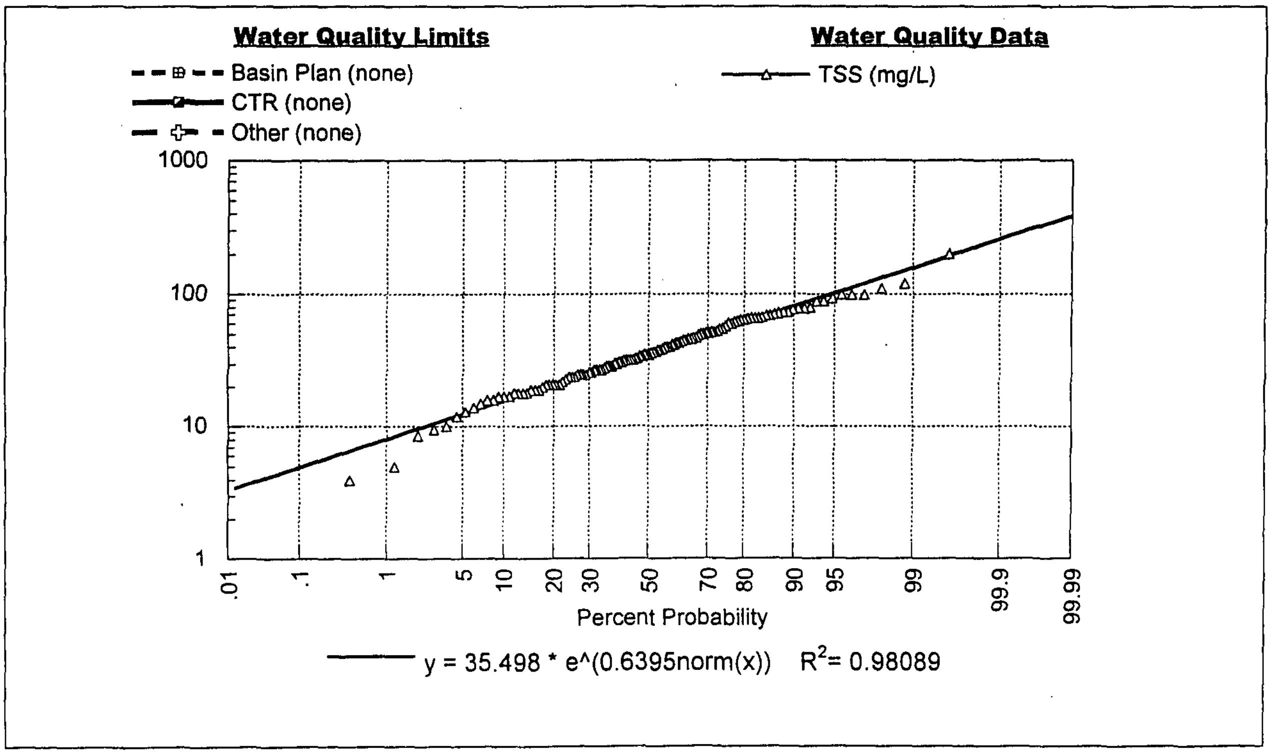

Water Quality Limits
Basin Plan (none)
CTR (dissolved;1.4 ug/L)
EPA MCL (total; 15 ug/L)
Water Quality Data
Lead (dissolved; ug/L)
Lead (total recoverable; ug/L)
100
10
1
0.1
0.01
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 0.043602 * e^(0.83167norm(x)) R2= 0.94174
y = 0.51083 * e^(0.6762norm(x)) R2= 0.78307


Water Quality Limits
Basin Plan (none)
CTR (total; 50 ng/L)
EPA MCL (total; 2000 ng/L)
Water Quality Data
Mercury (dissolved; ng/L)
Mercury (total; ng/L)
100
10
1
0.1
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 1.5889 * e^(0.59609norm(x)) R2= 0.99564
y = 8.5188 * e^(0.50854norm(x)) R2= 0.98788

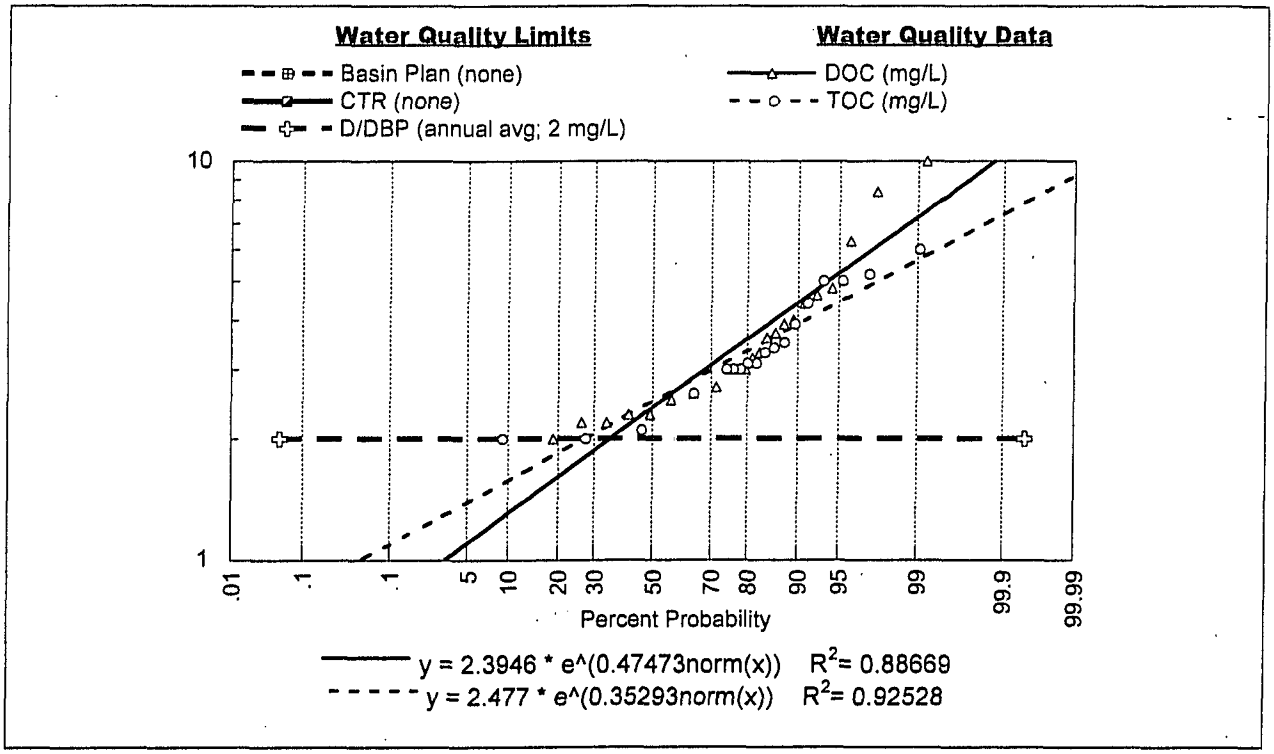

Water Quality Limits
Basin Plan (none)
CTR (dissolved;33 ug/L)
EPA MCL (total; 100 ug/L)
Water Quality Data
Nickel (dissolved; ug/L)
Nickel (total recoverable; ug/L)
100
10
1
0.1
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 0.75391 * e^(0.49227norm(x)) R2= 0.98086
y = 4.098 * e^(0.70707norm(x)) R2= 0.97361

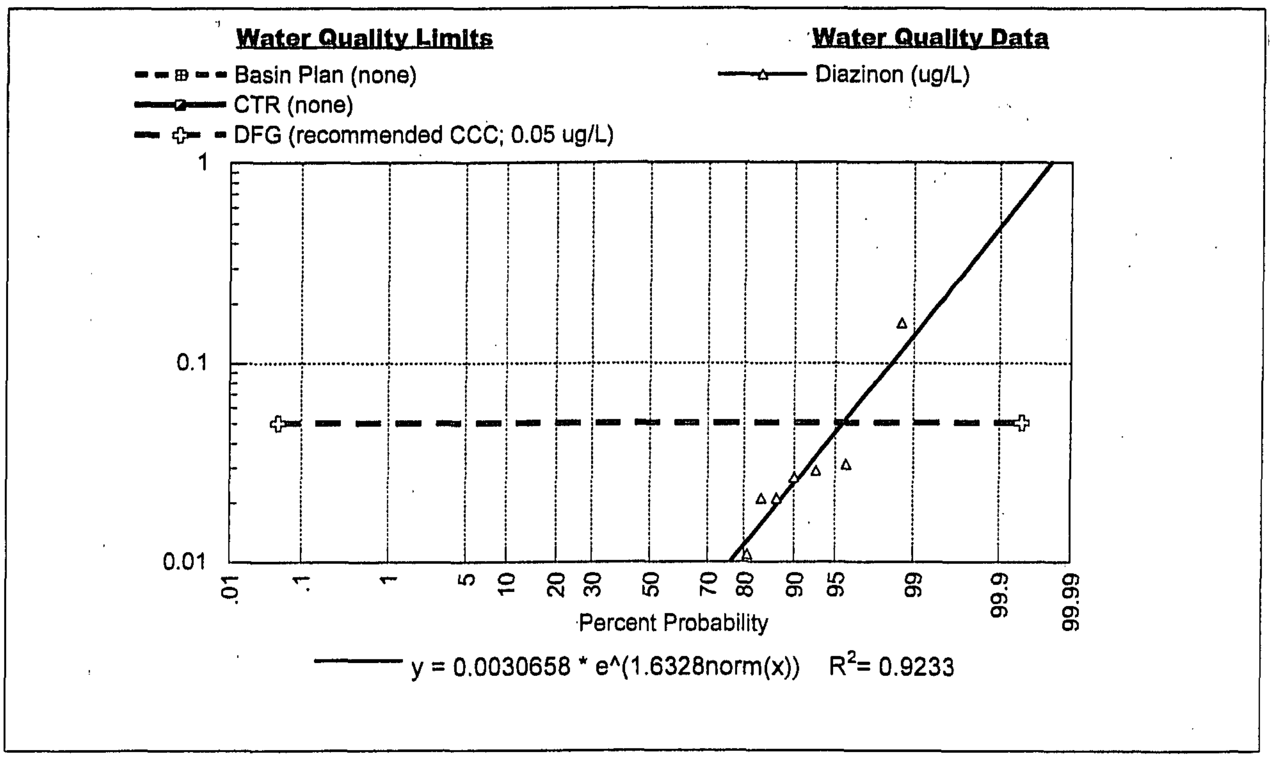

Water Quality Limits
Basin Plan (dissolved; 100 ug/L)
CTR (dissolved;74 ug/L)
DHS (total; 5000 ug/L)
Water Quality Data
Zinc (dissolved; ug/L)
Zinc (total recoverable; ug/L)
100
10
1
0.1
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 0.63132 * e^(1.1568norm(x)) R2= 0.95292
y = 6.0251 * e^(0.67455norm(x)) R2= 0.97049

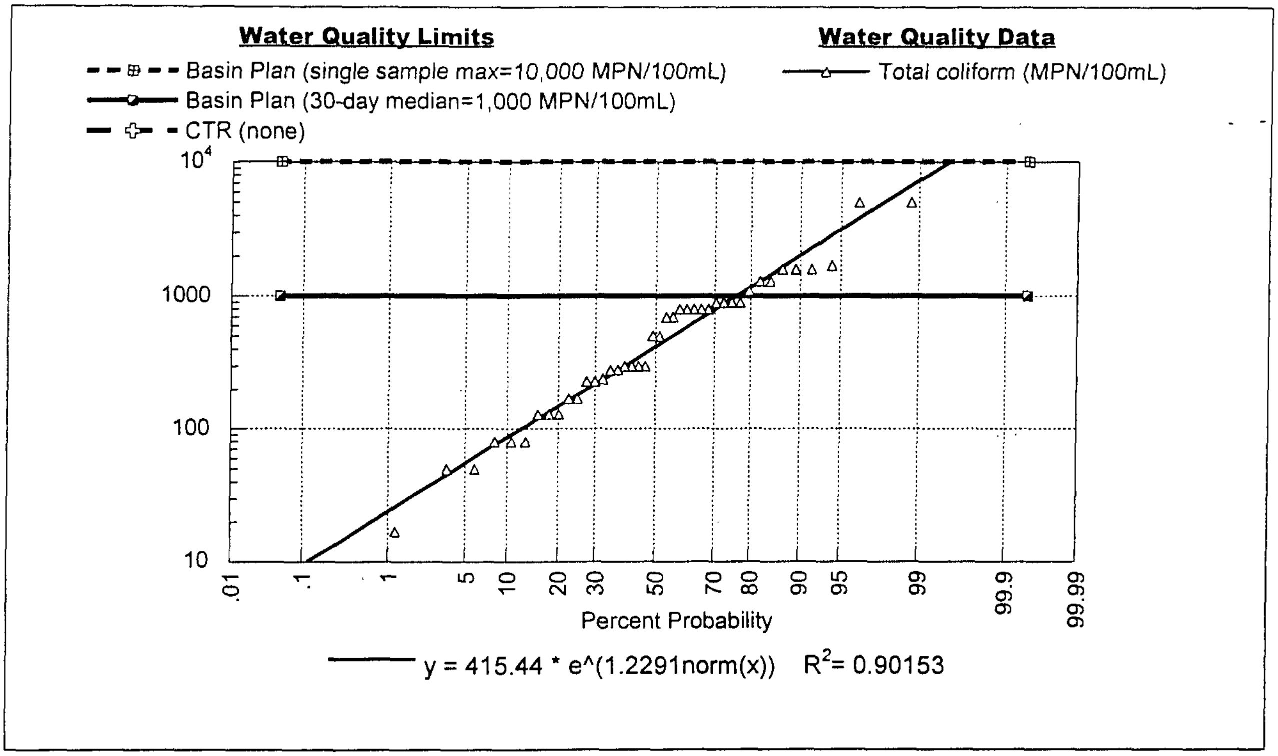

Water Quality Limits
Basin Plan (none)
CTR (none)
Other (none)
Water Quality Data
Hardness (mg/L)
100
90
80
70
60
50
40
30
20
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 57.427 + 11.815norm(x) R2= 0.97326

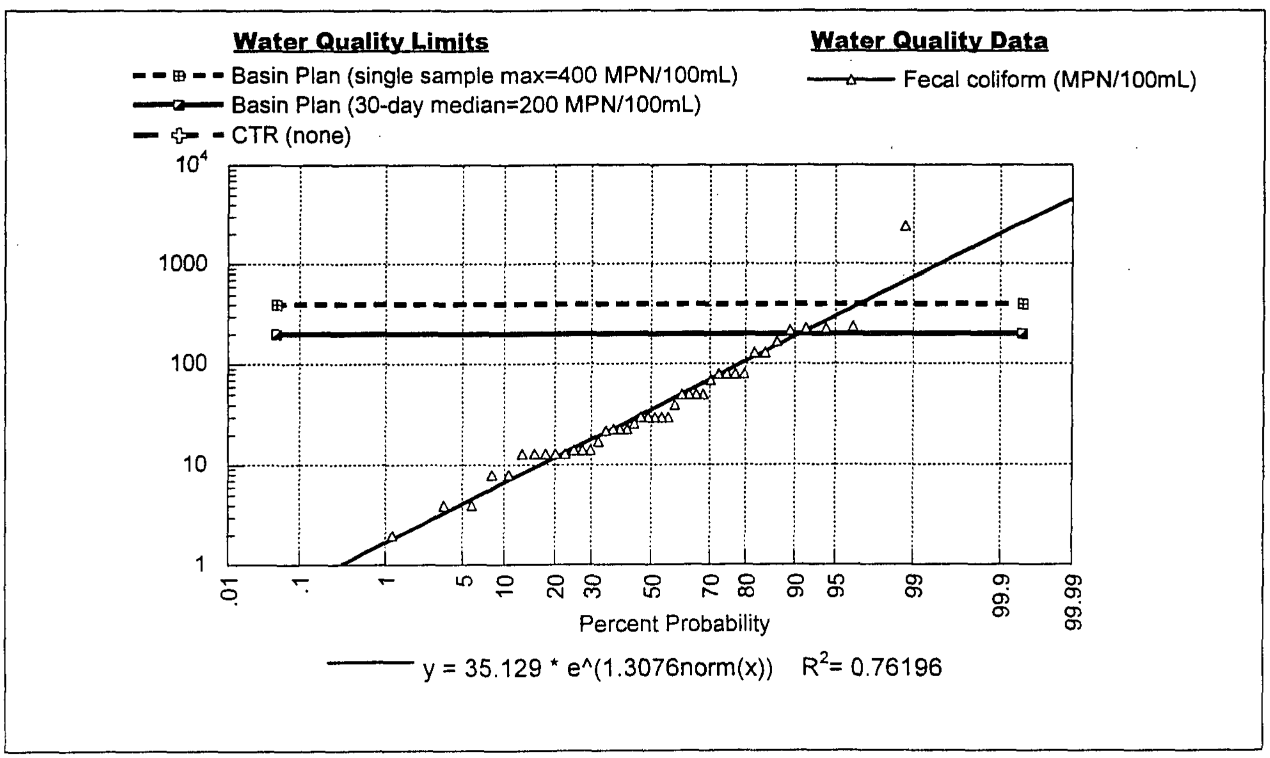

Water Quality Limits
Basin Plan (none)
CTR (none)
Other (none)
Water Quality Data
TSS (mg/L)
1000
100
10
1
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 35.498 * e^(0.6395norm(x)) R2= 0.98089

Sacramento River at Veterans Bridge
Frequency Distribution Plots of Ambient Program Data 1992-2000

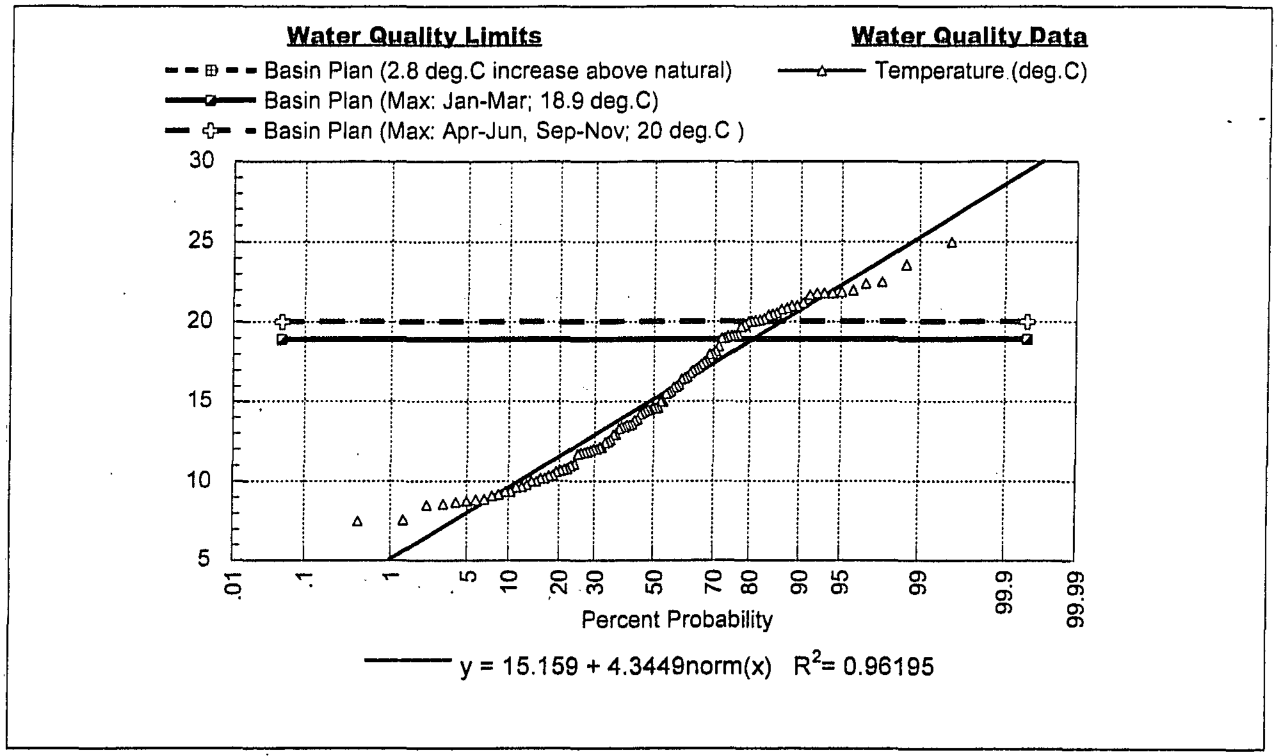


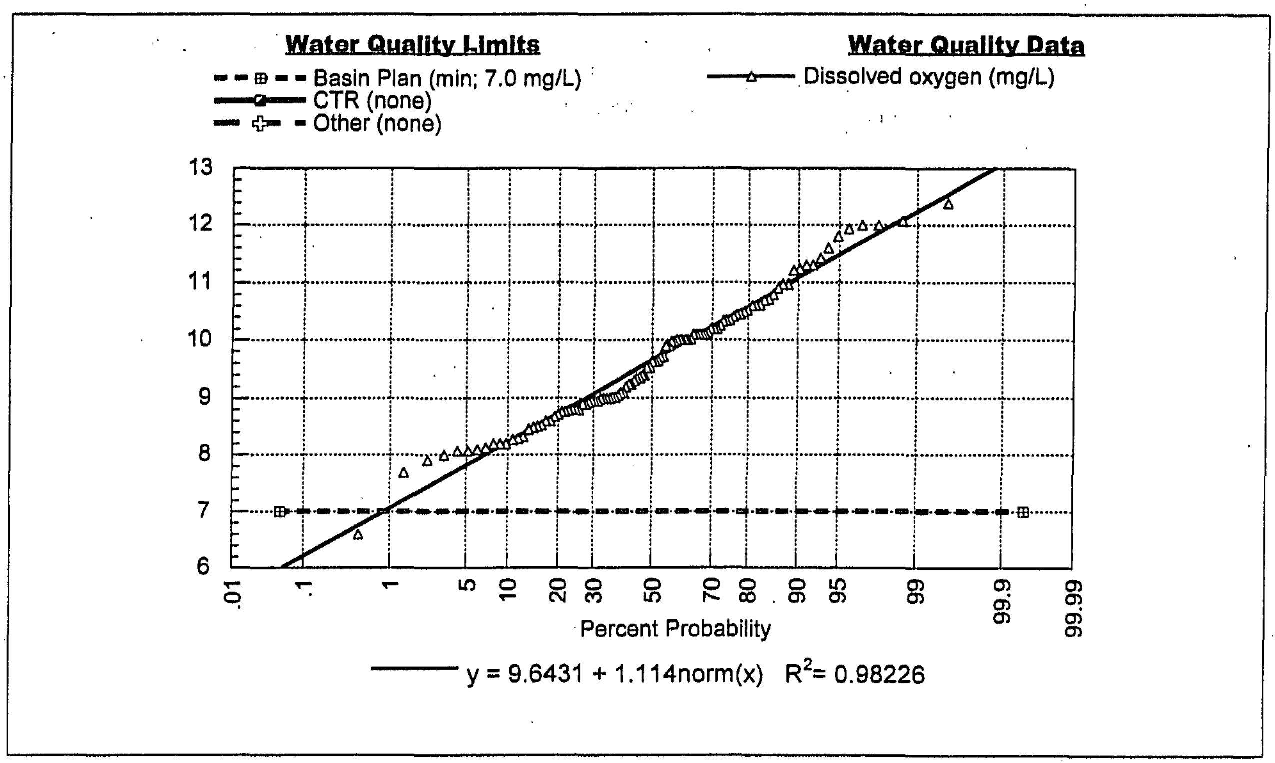



Water Quality Limits
Basin Plan (single sample max=10,000 MPN/100mL)
Basin Plan (30-day median=1,000 MPN/100mL)
CTR (none)
Water Quality Data
Total coliform (MPN/100mL)
10^4
1000
100
10
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 415.44 * e^(1.2291norm(x))
R^2= 0.90153

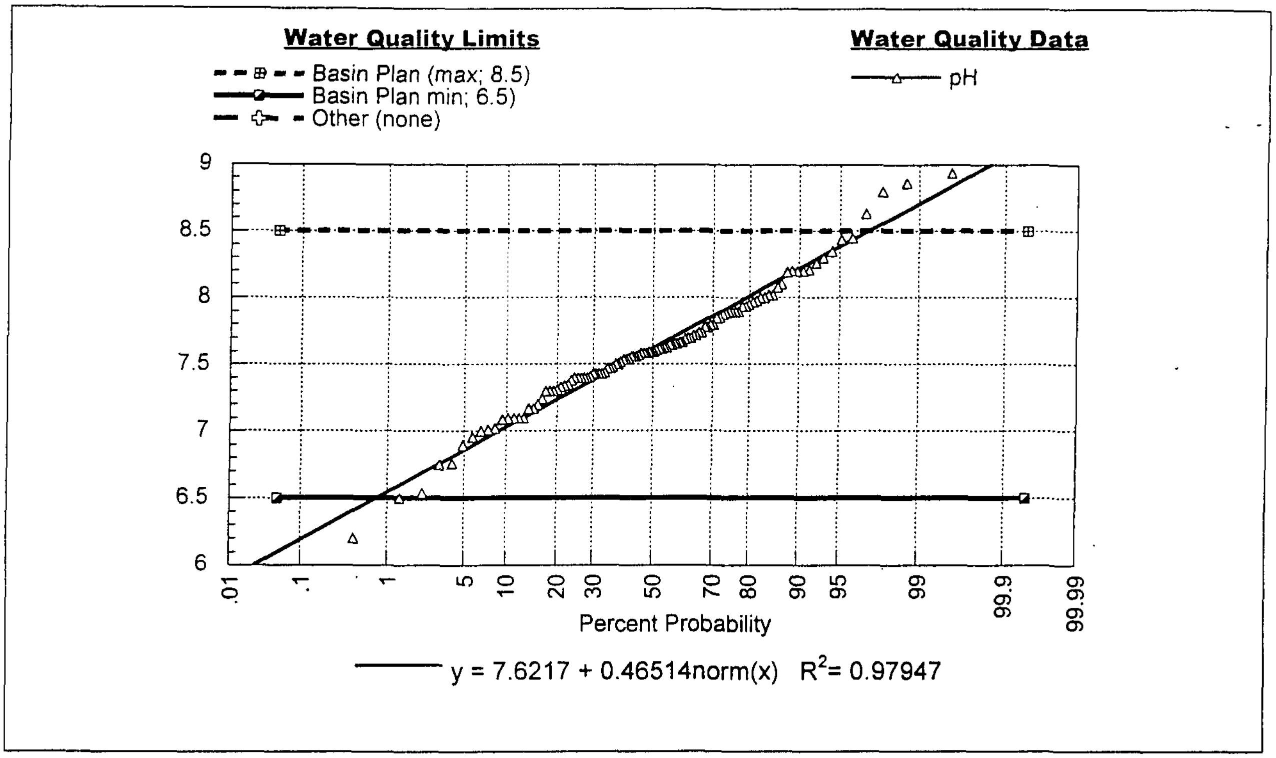

Water Quality Limits
Basin Plan (single sample max=400 MPN/100mL)
Basin Plan (30-day median=200 MPN/100mL)
CTR (none)
Water Quality Data
Fecal coliform (MPN/100mL)
10^4
1000
100
10
1
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 35.129 * e^(1.3076norm(x))
R^2= 0.76196

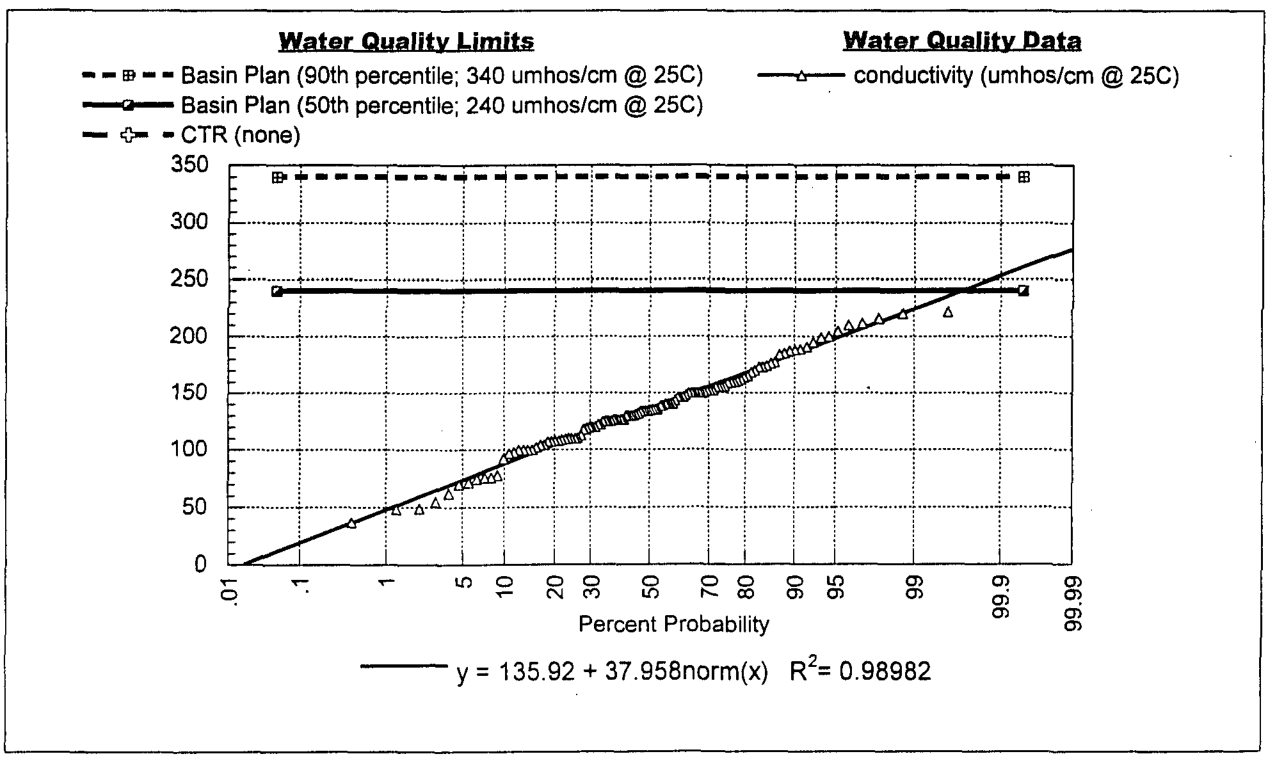
Sacramento River at Veterans Bridge
Frequency Distribution Plots of Ambient Program Data 1992-2000



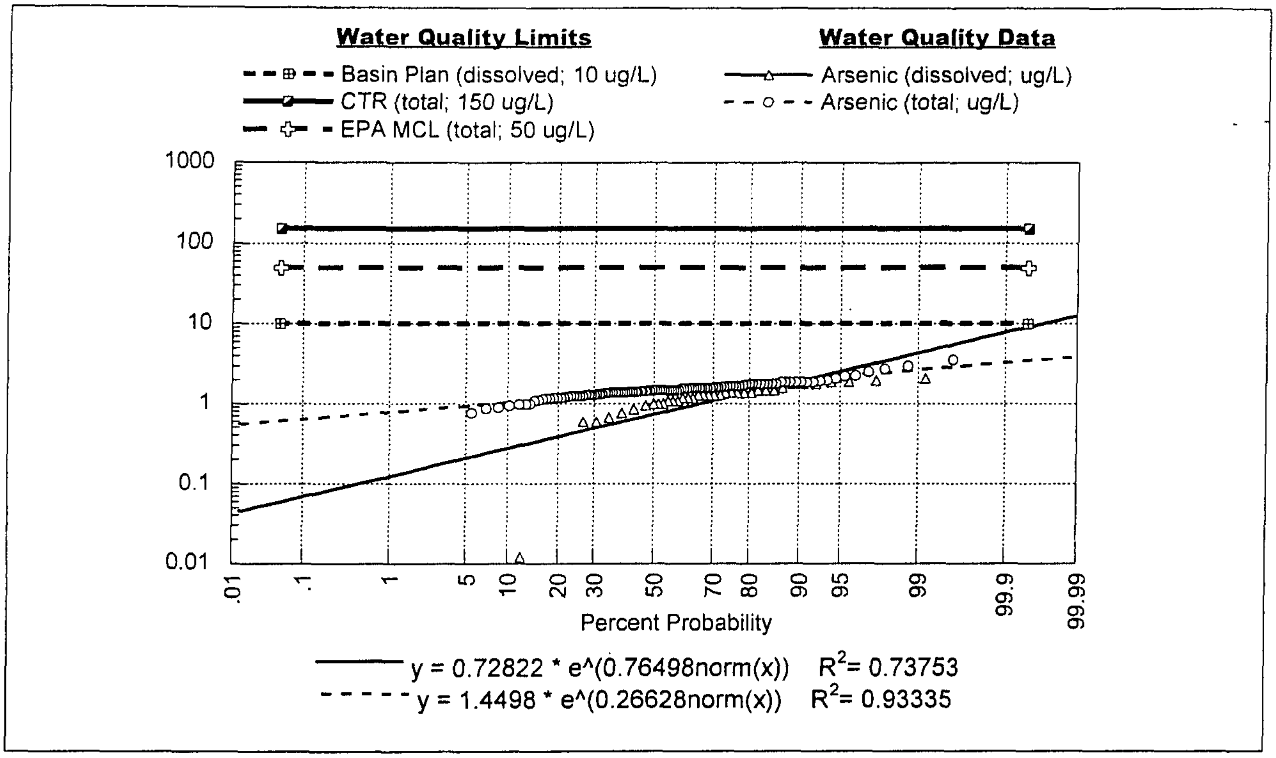


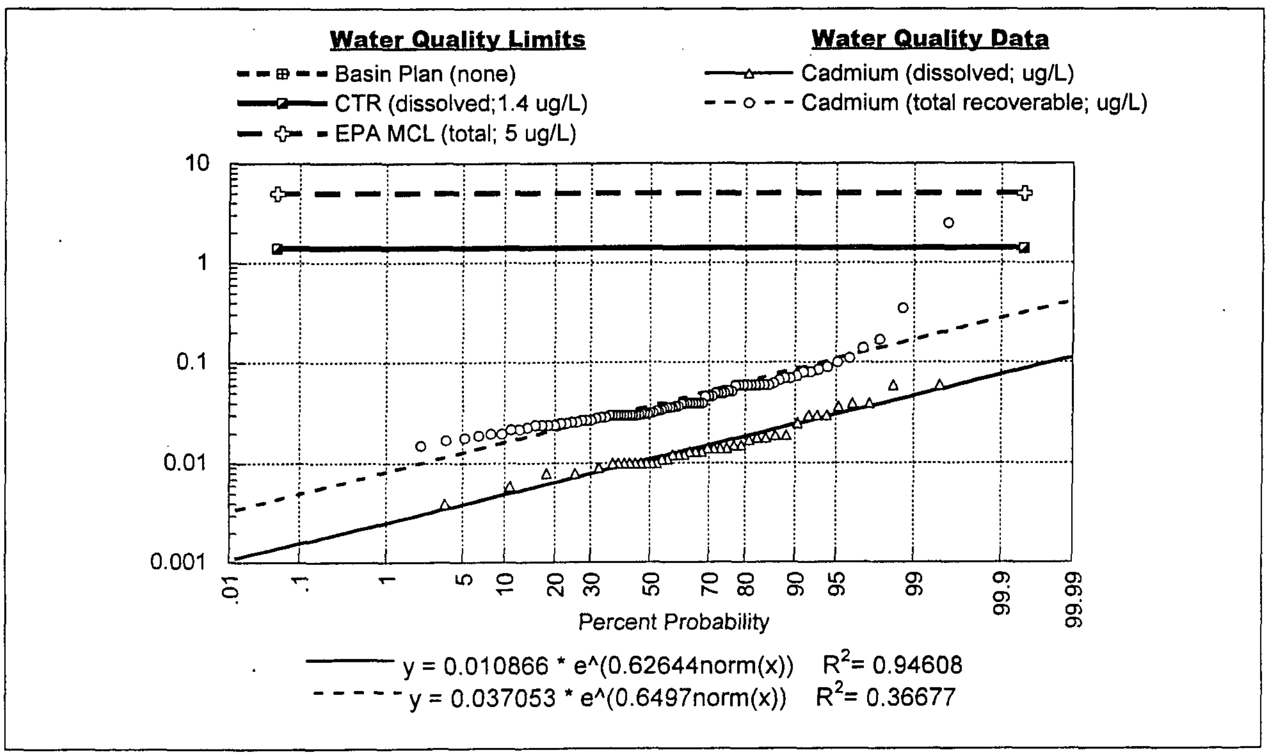
Sacramento River at Veterans Bridge
Frequency Distribution Plots of Ambient Program Data 1992-2000

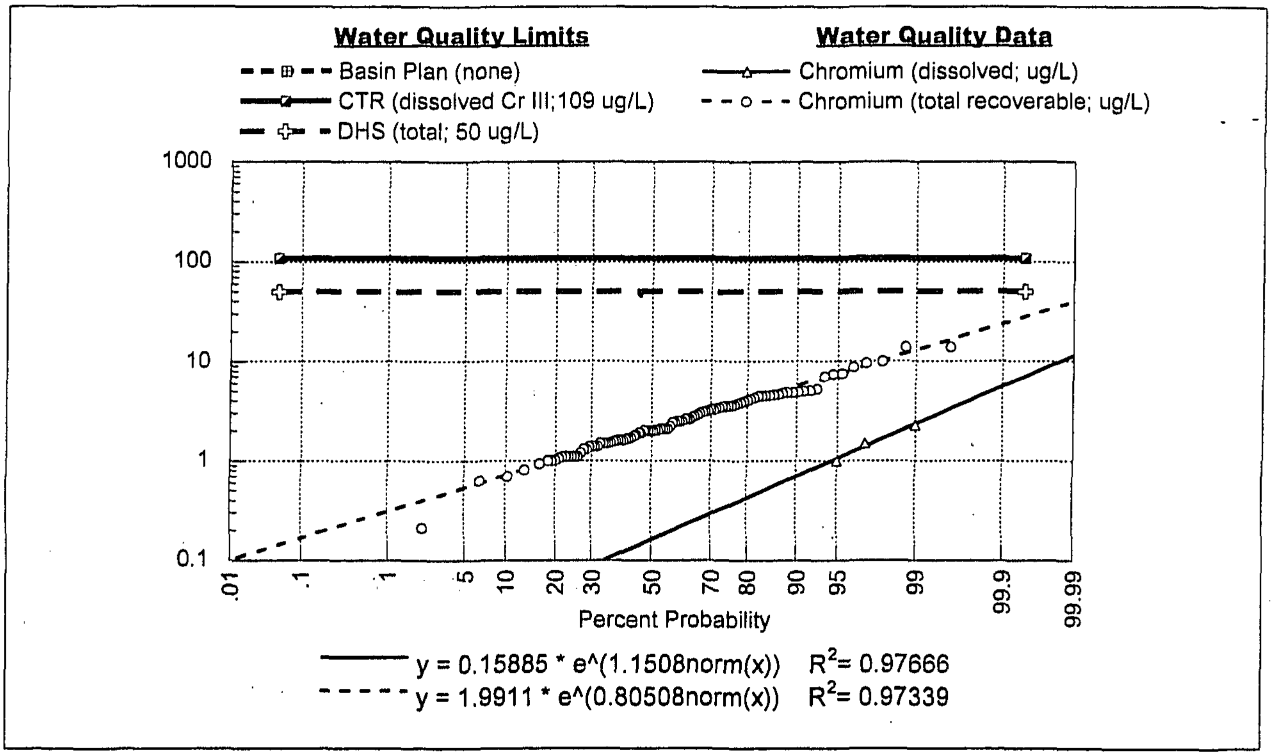


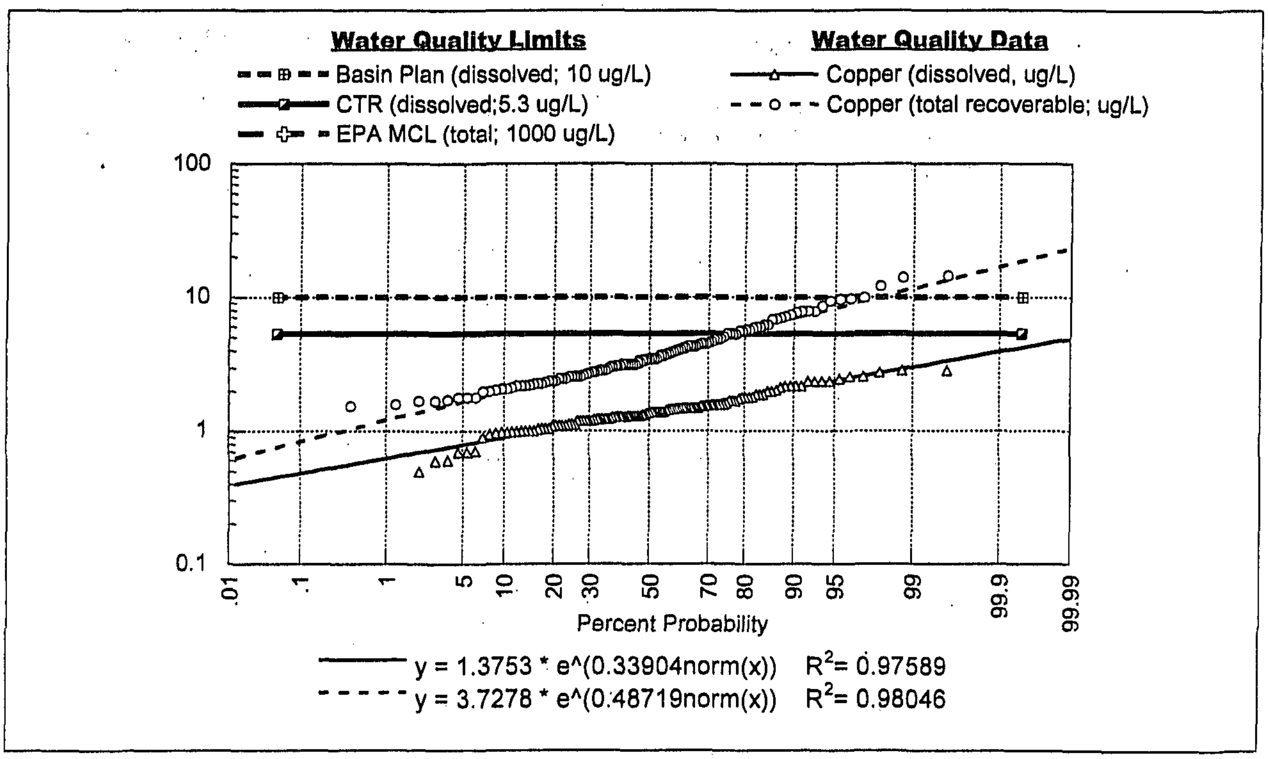


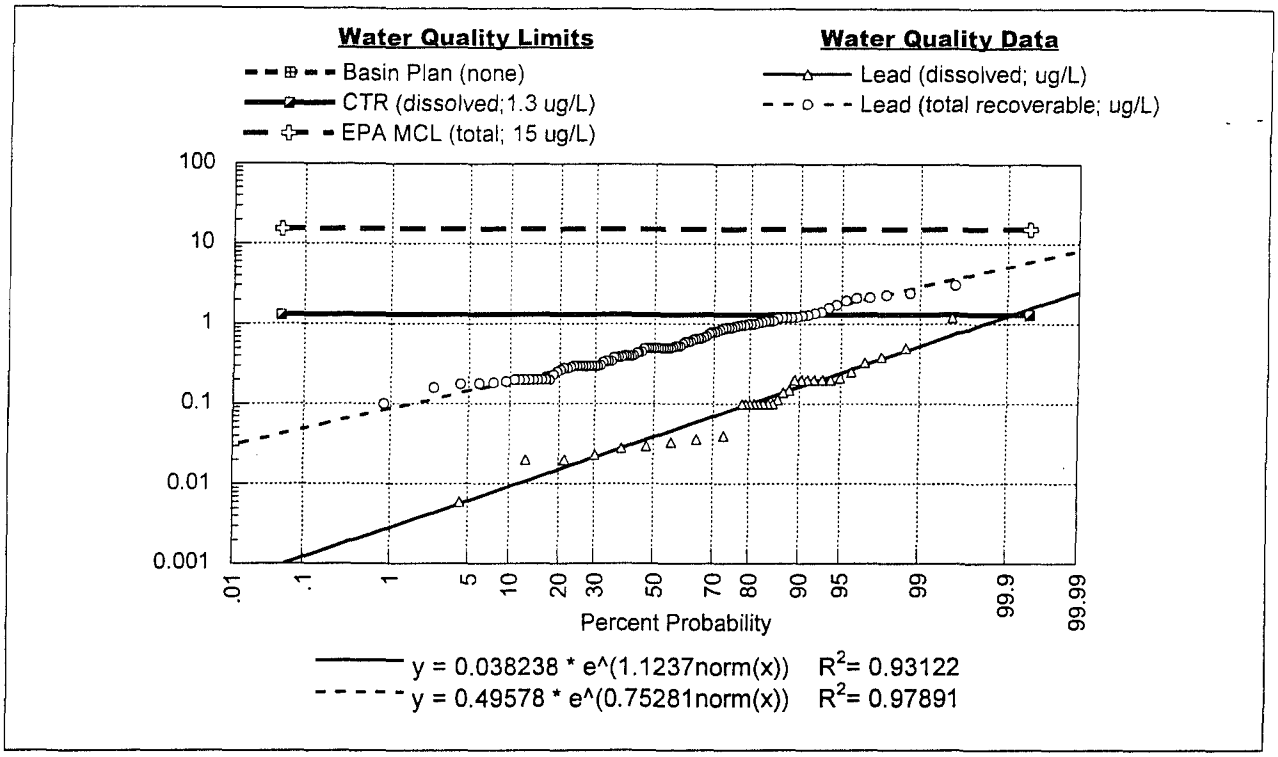
Sacramento River at Freeport

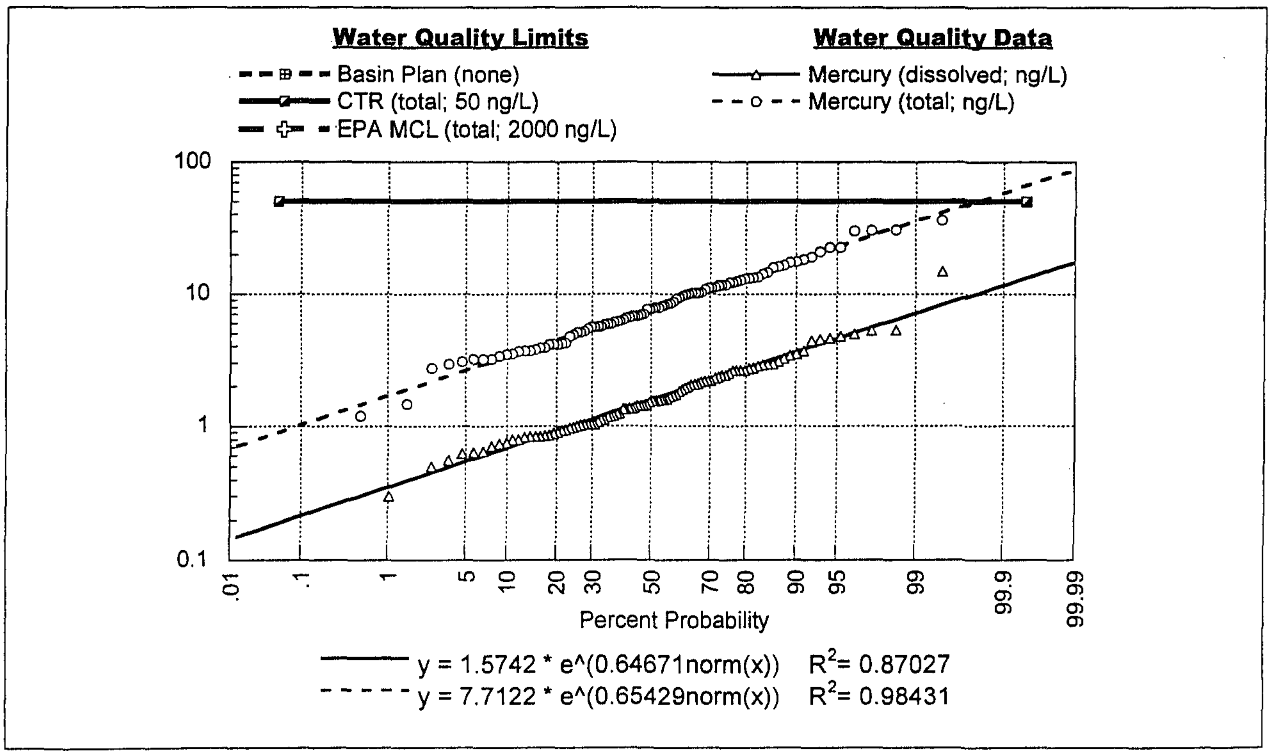

Water Quality Limits
Basin Plan (dissolved; 10 ug/L)
CTR (total; 150 ug/L)
EPA MCL (total; 50 ug/L)
Water Quality Data
Arsenic (dissolved; ug/L)
Arsenic (total; ug/L)
1000
100
10
1
0.1
0.01
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 0.72822 * e^(0.76498norm(x)) R2= 0.73753
y = 1.4498 * e^(0.26628norm(x)) R2= 0.93335

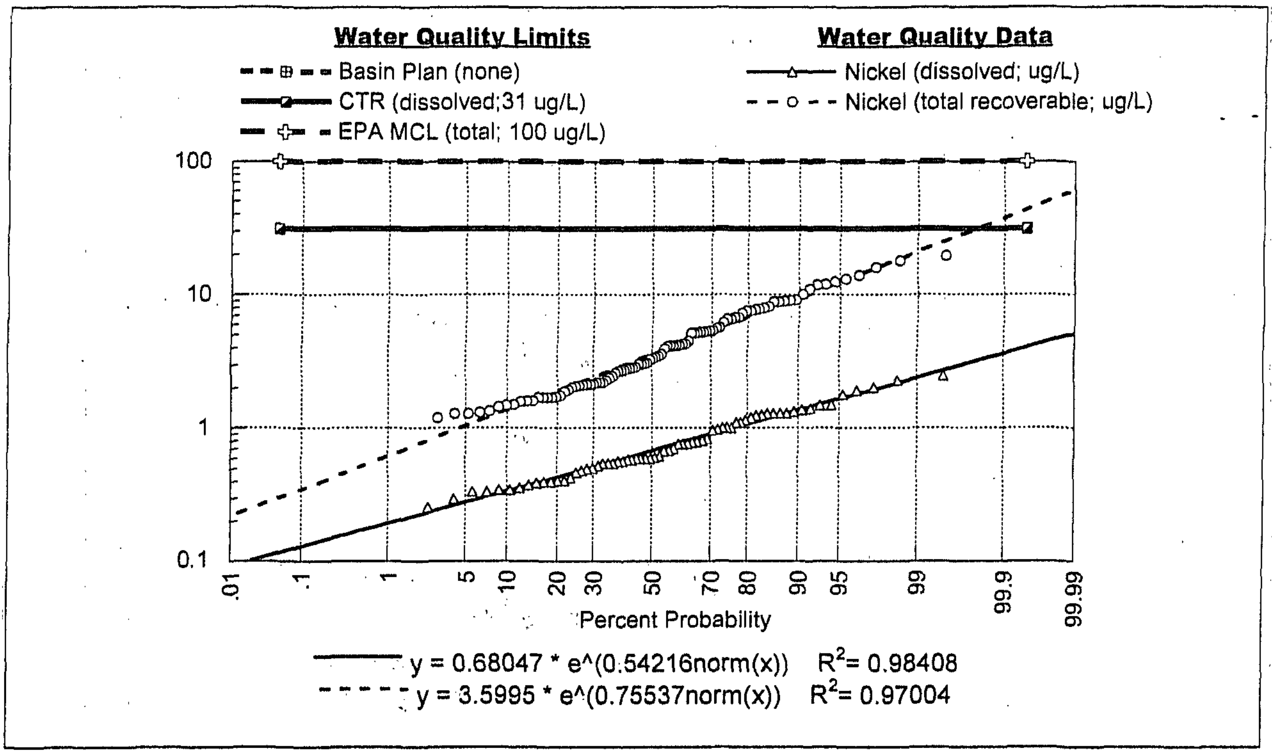

Water Quality Limits
Basin Plan (none)
CTR (dissolved;1.4 ug/L)
EPA MCL (total; 5 ug/L)
Water Quality Data
Cadmium (dissolved; ug/L)
Cadmium (total recoverable; ug/L)
10
1
0.1
0.01
0.001
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 0.010866 * e^(0.62644norm(x)) R2= 0.94608
y = 0.037053 * e^(0.6497norm(x)) R2= 0.36677

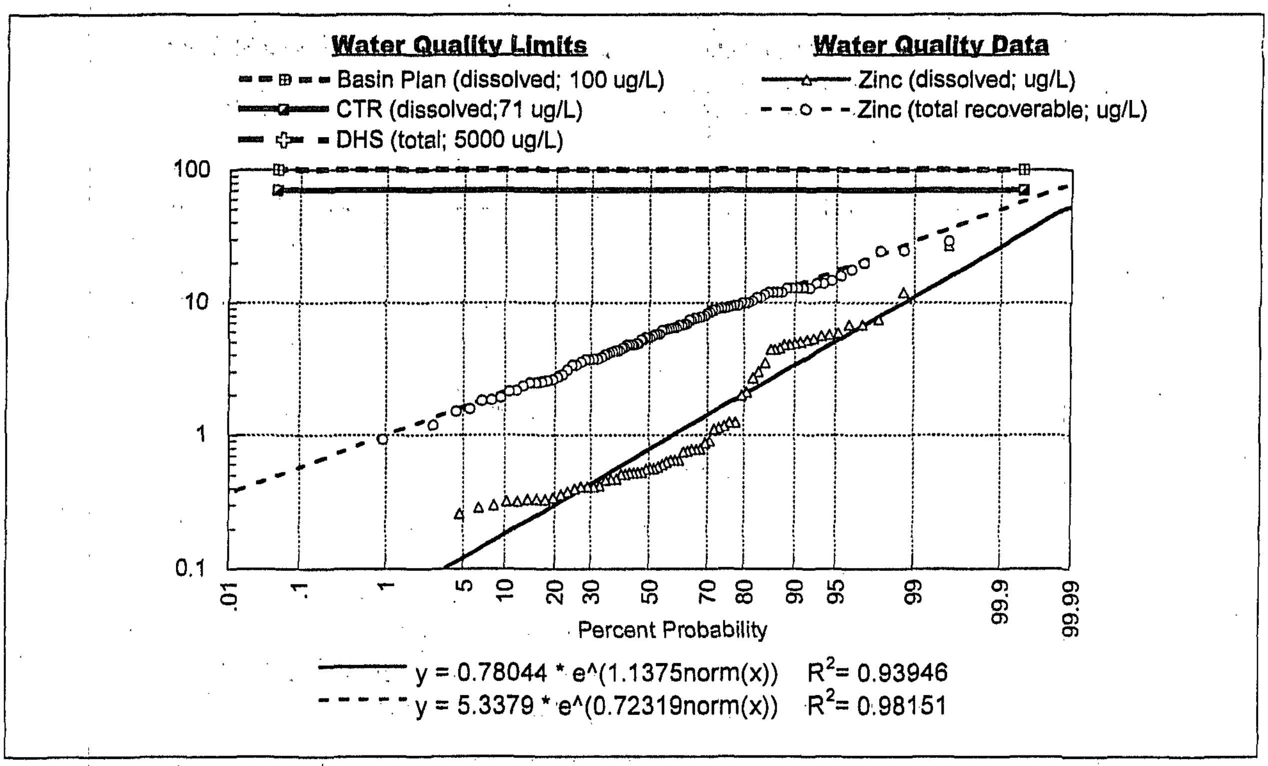

Water Quality Limits
Basin Plan (none)
CTR (dissolved Cr III;109 ug/L)
DHS (total; 50 ug/L)
Water Quality Data
Chromium (dissolved; ug/L)
Chromium (total recoverable; ug/L)
1000
100
10
1
0.1
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 0.15885 * e^(1.1508norm(x)) R2= 0.97666
y = 1.9911 * e^(0.80508norm(x)) R2= 0.97339

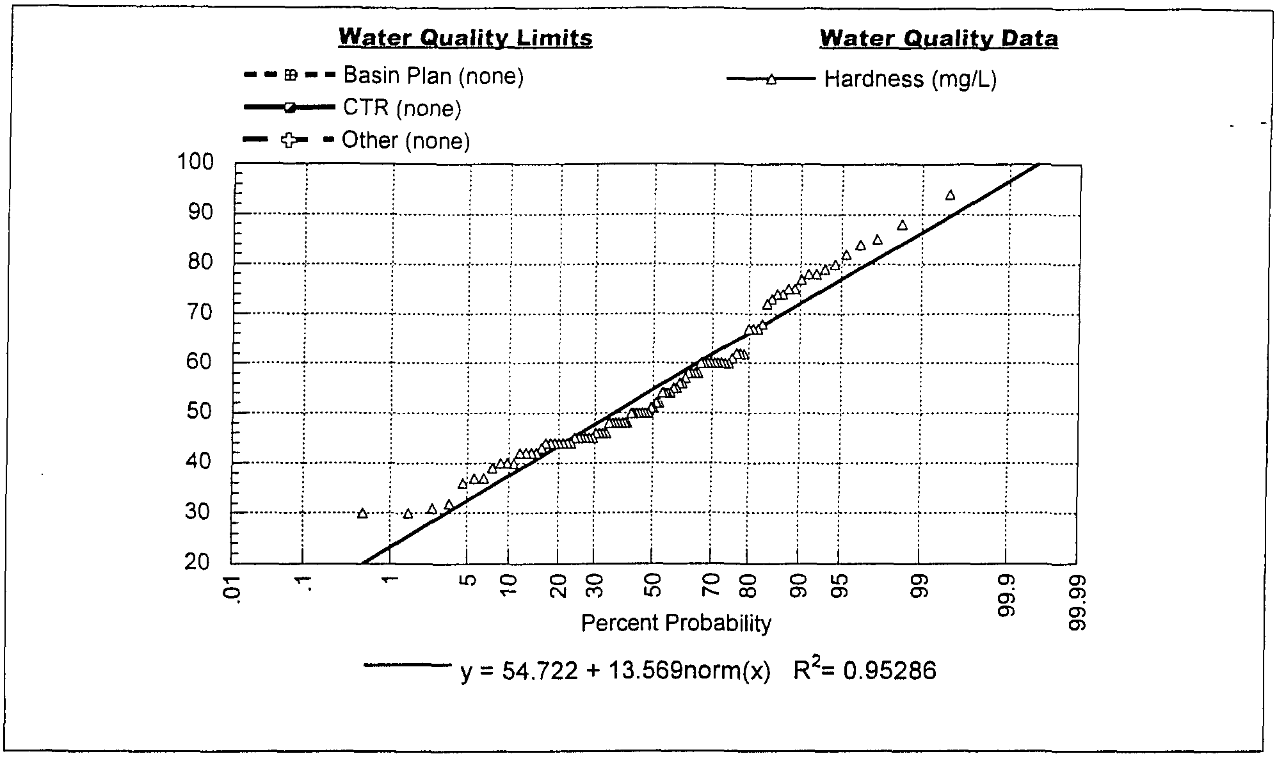

Water Quality Limits
Basin Plan (dissolved; 10 ug/L)
CTR (dissolved;5.3 ug/L)
EPA MCL (total; 1000 ug/L)
Water Quality Data
Copper (dissolved, ug/L)
Copper (total recoverable; ug/L)
100
10
1
0.1
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 1.3753 * e^(0.33904norm(x)) R2= 0.97589
y = 3.7278 * e^(0.48719norm(x)) R2= 0.98046

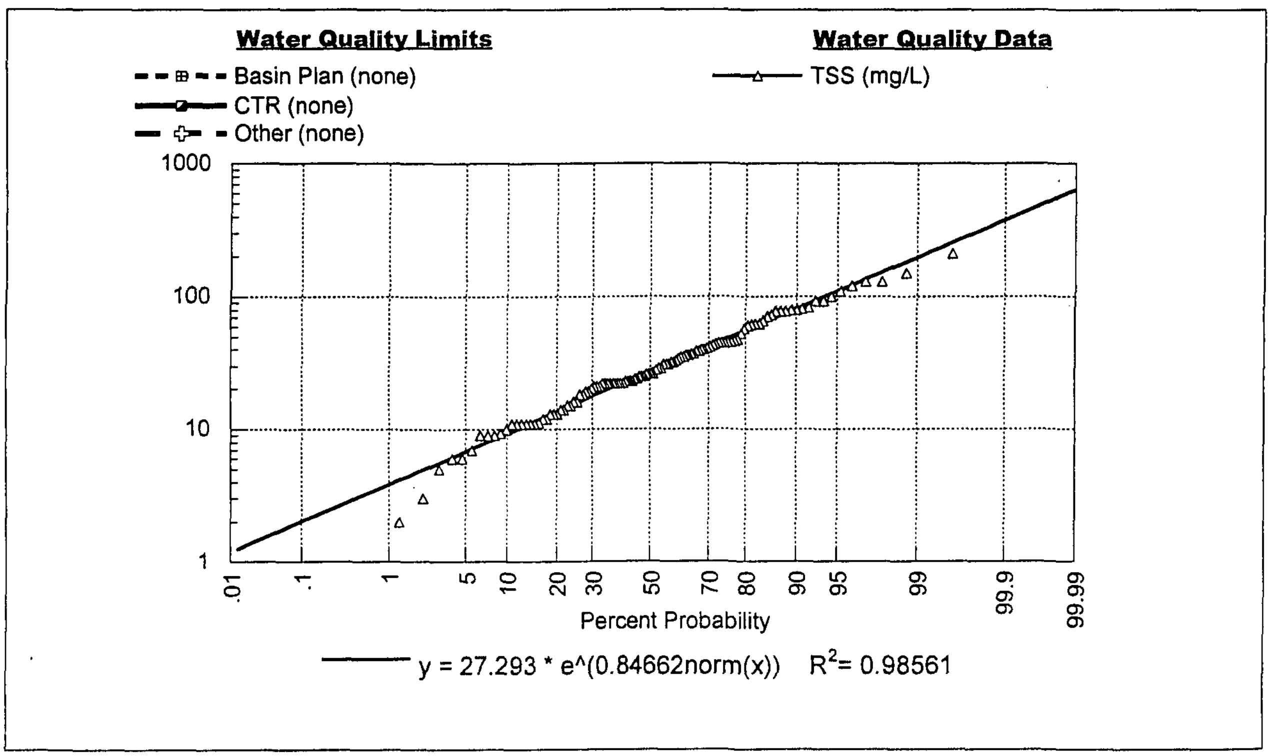

Water Quality Limits
Basin Plan (none)
CTR (dissolved; 1.3 ug/L)
EPA MCL (total; 15 ug/L)
Water Quality Data
Lead (dissolved; ug/L)
Lead (total recoverable; ug/L)
100
10
1
0.1
0.01
0.001
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 0.038238 * e^(1.1237norm(x)) R2= 0.93122
y = 0.49578 * e^(0.75281norm(x)) R2= 0.97891

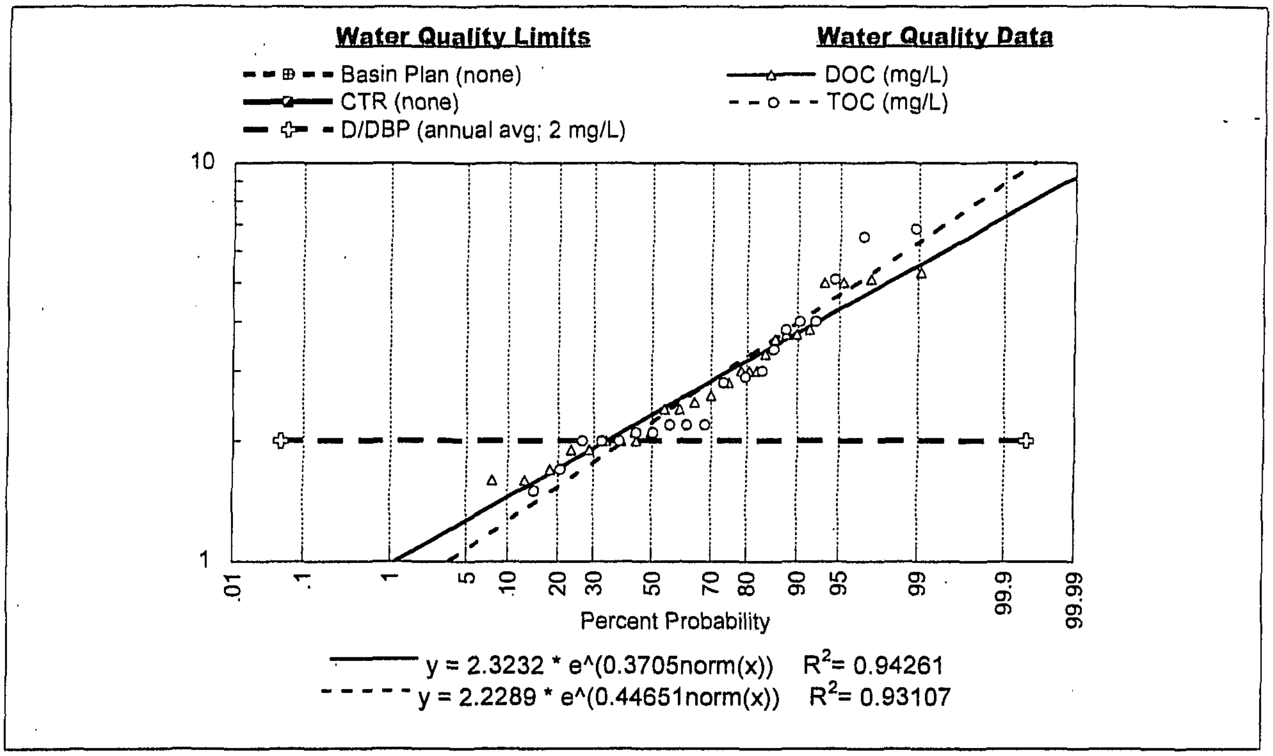

Water Quality Limits
Basin Plan (none)
CTR (total; 50 ng/L)
EPA MCL (total; 2000 ng/L)
Water Quality Data
Mercury (dissolved; ng/L)
Mercury (total; ng/L)
100
10
1
0.1
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 1.5742 * e^(0.64671norm(x)) R2= 0.87027
y = 7.7122 * e^(0.65429norm(x)) R2= 0.98431

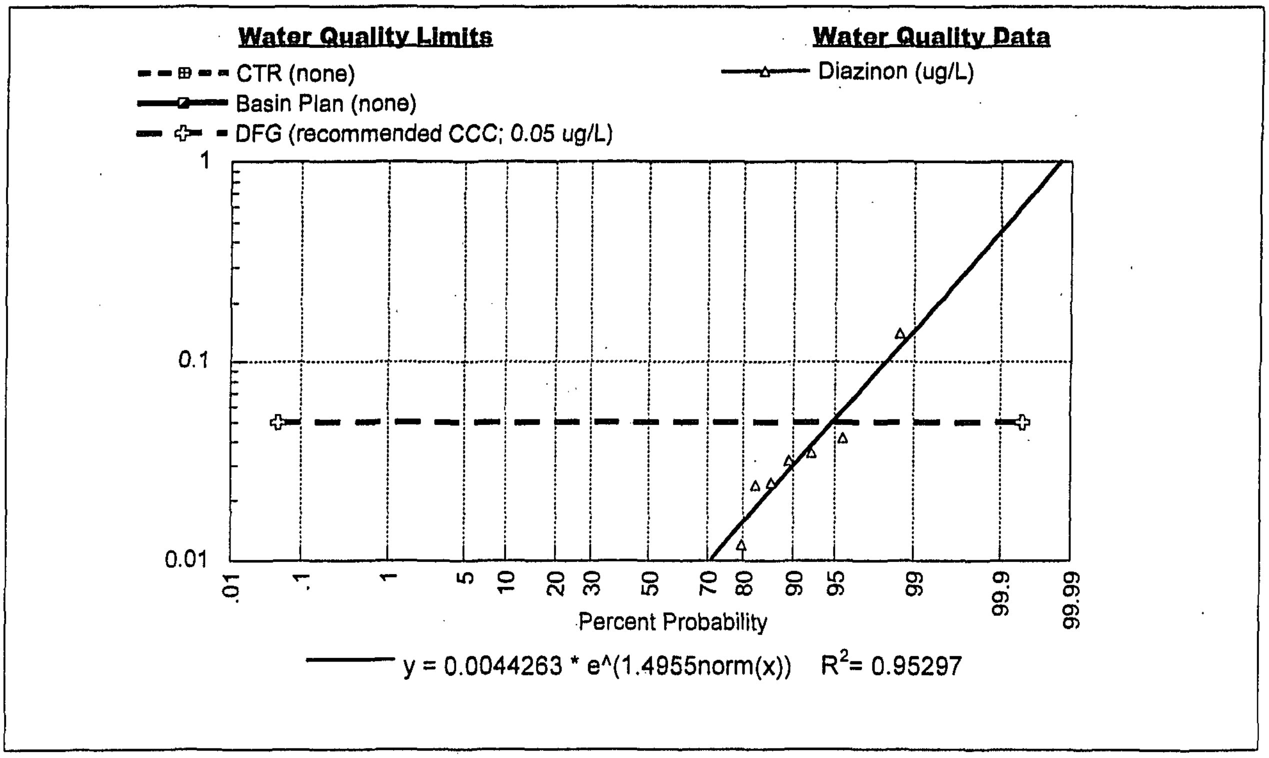

Water Quality Limits
Basin Plan (none)
CTR (dissolved;31 ug/L)
EPA MCL (total; 100 ug/L)
Water Quality Data
Nickel (dissolved; ug/L)
Nickel (total recoverable; ug/L)
100
10
1
0.1
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 0.68047 * e^(0.54216norm(x)) R2= 0.98408
y = 3.5995 * e^(0.75537norm(x)) R2= 0.97004

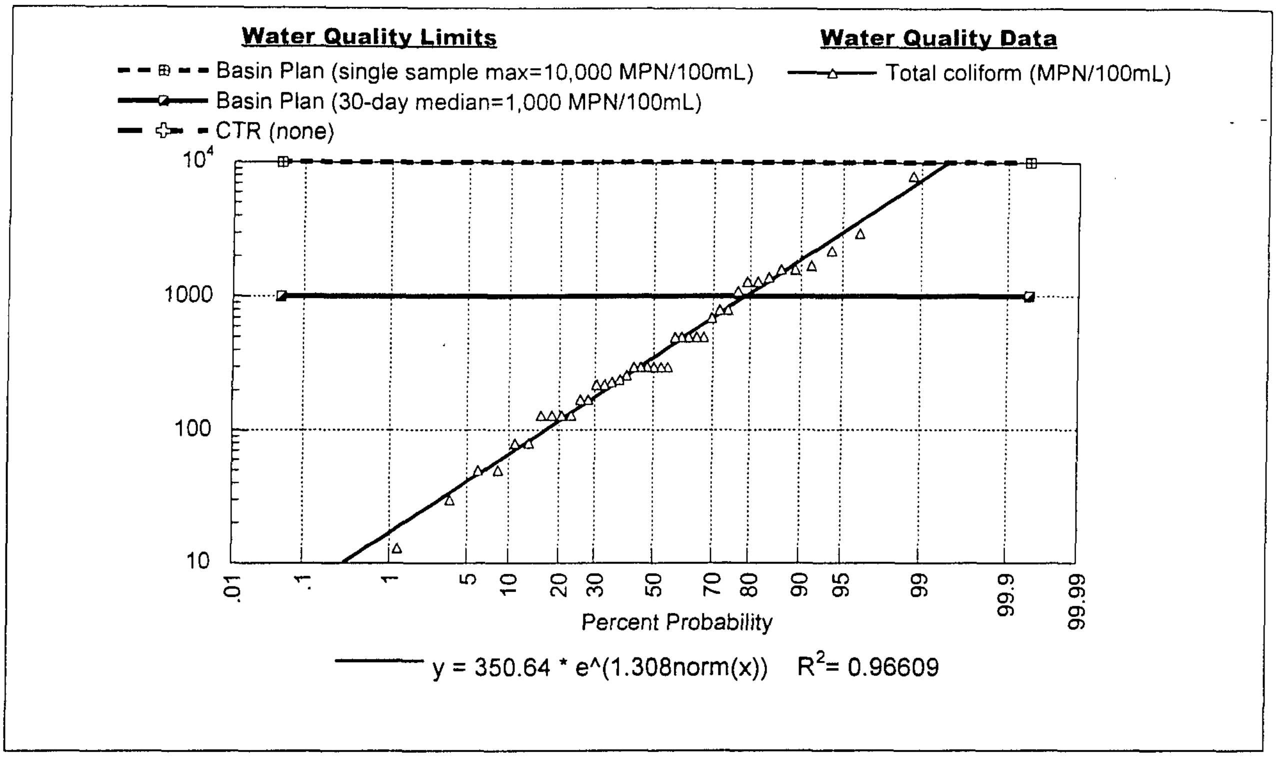

Water Quality Limits
Basin Plan (dissolved; 100 ug/L)
CTR (dissolved;71 ug/L)
DHS (total; 5000 ug/L)
Water Quality Data
Zinc (dissolved; ug/L)
Zinc (total recoverable; ug/L)
100
10
1
0.1
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 0.78044 * e^(1.1375norm(x)) R2= 0.93946
y = 5.3379 * e^(0.72319norm(x)) R2= 0.98151

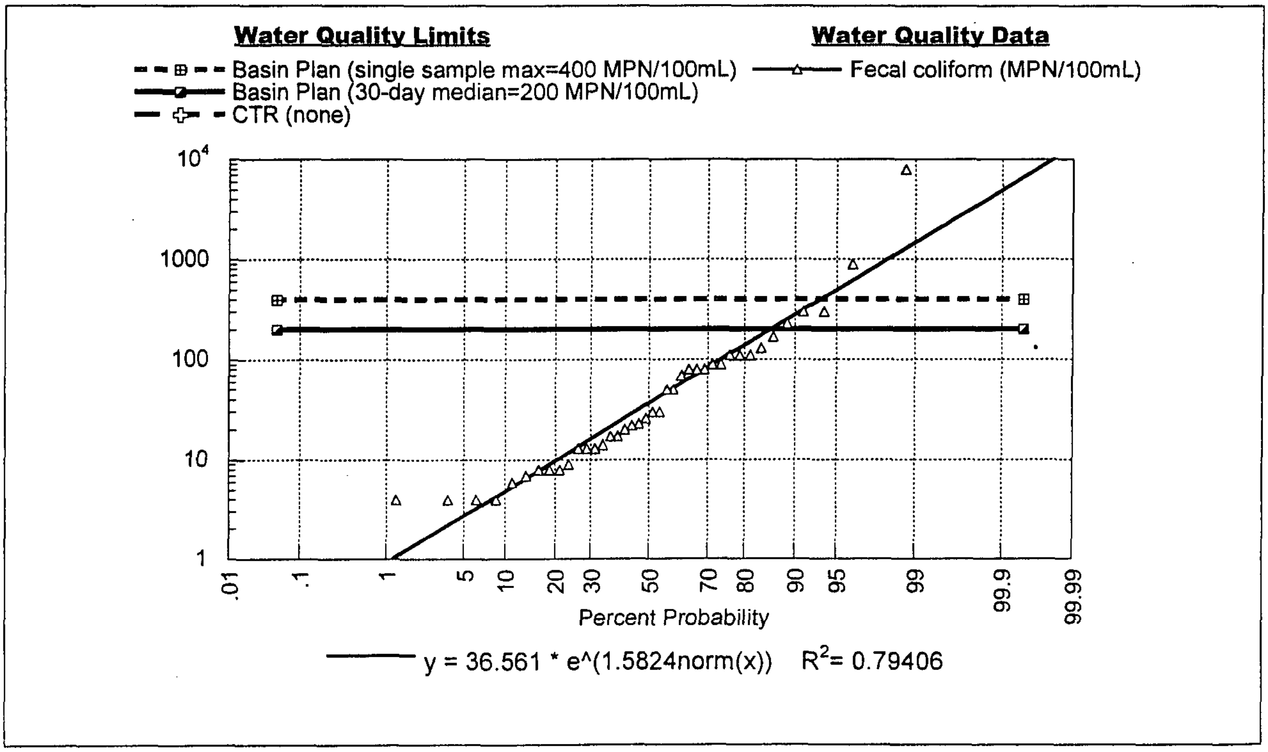

Water Quality Limits
Basin Plan (none)
CTR (none)
Other (none)
Water Quality Data
Hardness (mg/L)
100
90
80
70
60
50
40
30
20
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 54.722 + 13.569norm(x) R2= 0.95286

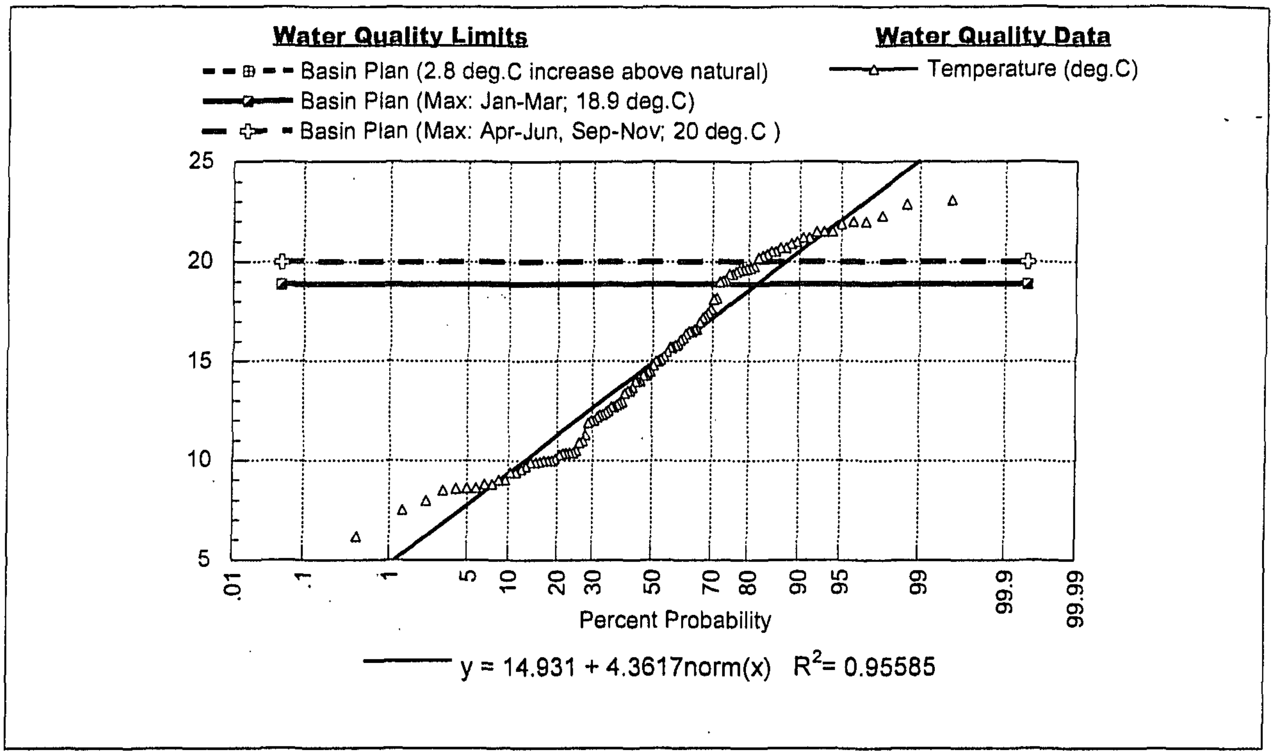

Water Quality Limits
Basin Plan (none)
CTR (none)
Other (none)
Water Quality Data
TSS (mg/L)
1000
100
10
1
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 27.293 * e^(0.84662norm(x)) R2= 0.98561

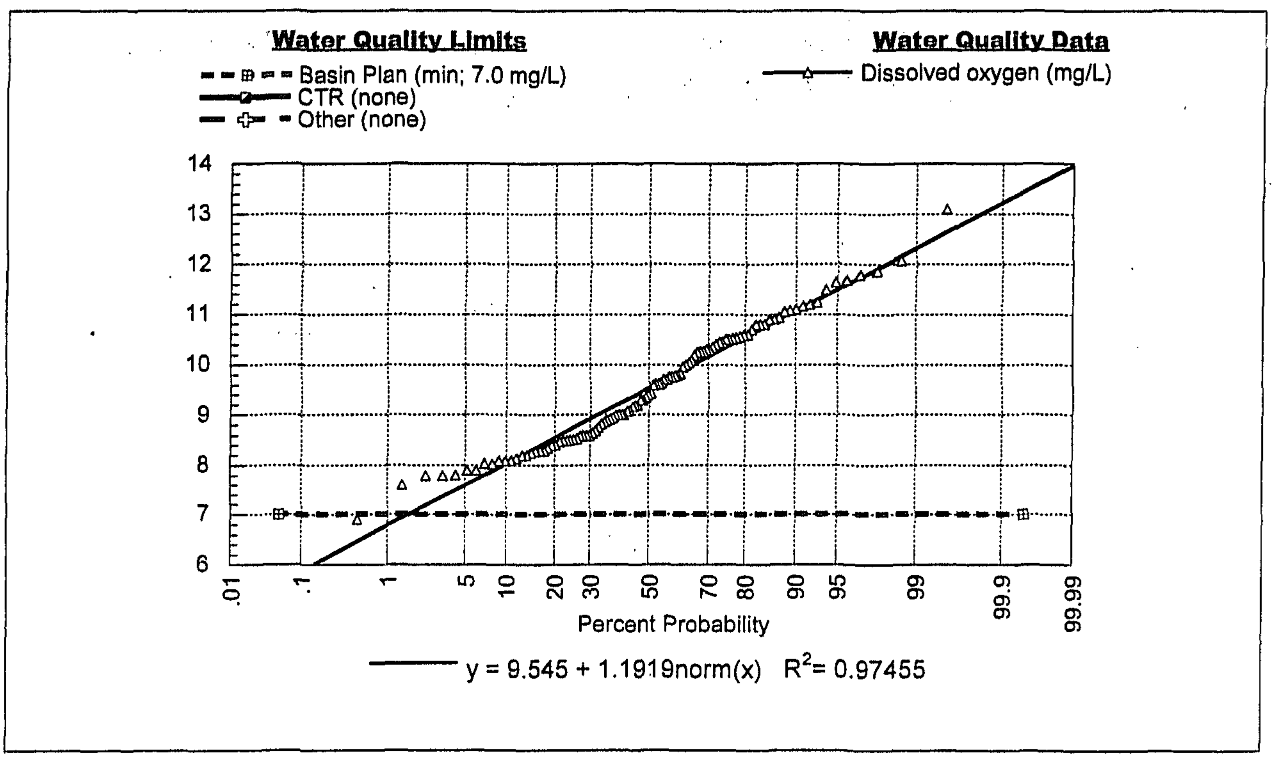

Water Quality Limits
Basin Plan (none)
CTR (none)
D/DBP (annual avg; 2 mg/L)
Water Quality Data
DOC (mg/L)
TOC (mg/L)
10
1
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 2.3232 * e^(0.3705norm(x)) R^2= 0.94261
y = 2.2289 * e^(0.44651norm(x)) R^2= 0.93107

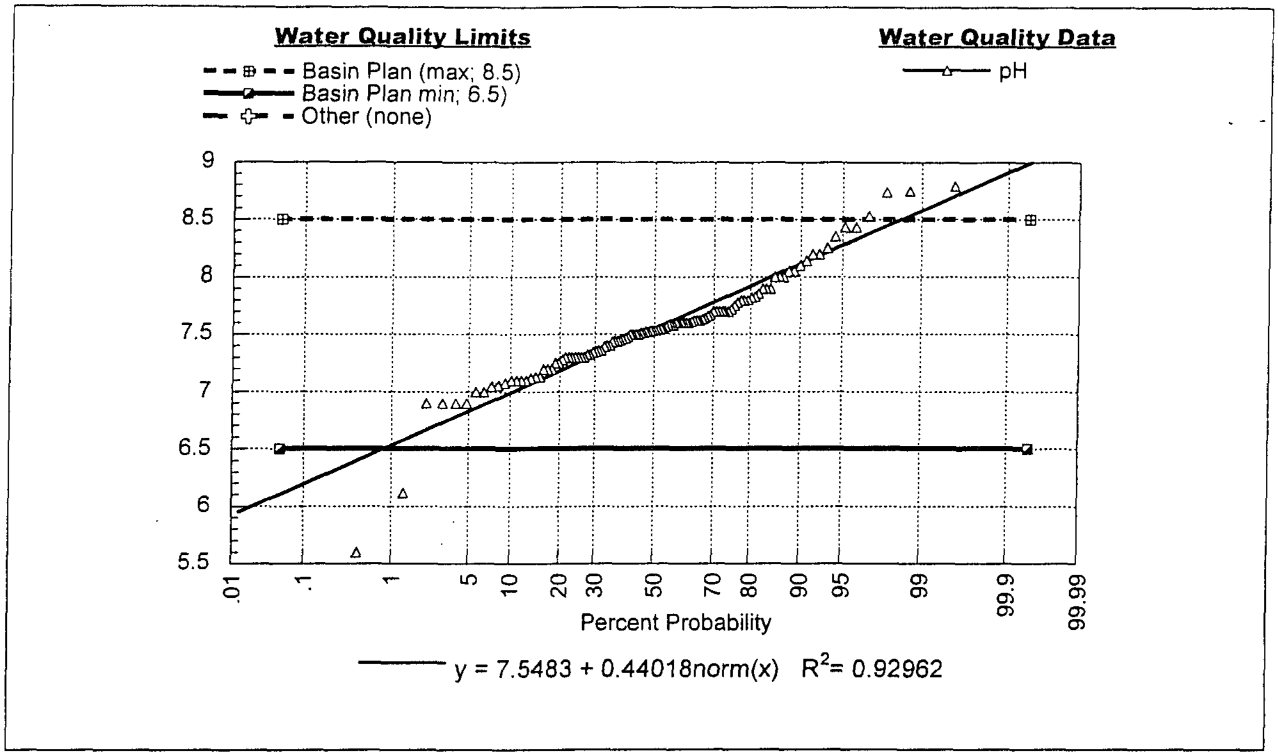

Water Quality Limits
CTR (none)
Basin Plan (none)
DFG (recommended CCC; 0.05 ug/L)
Water Quality Data
Diazinon (ug/L)
1
0.1
0.01
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 0.0044263 * e^(1.4955norm(x)) R^2= 0.95297

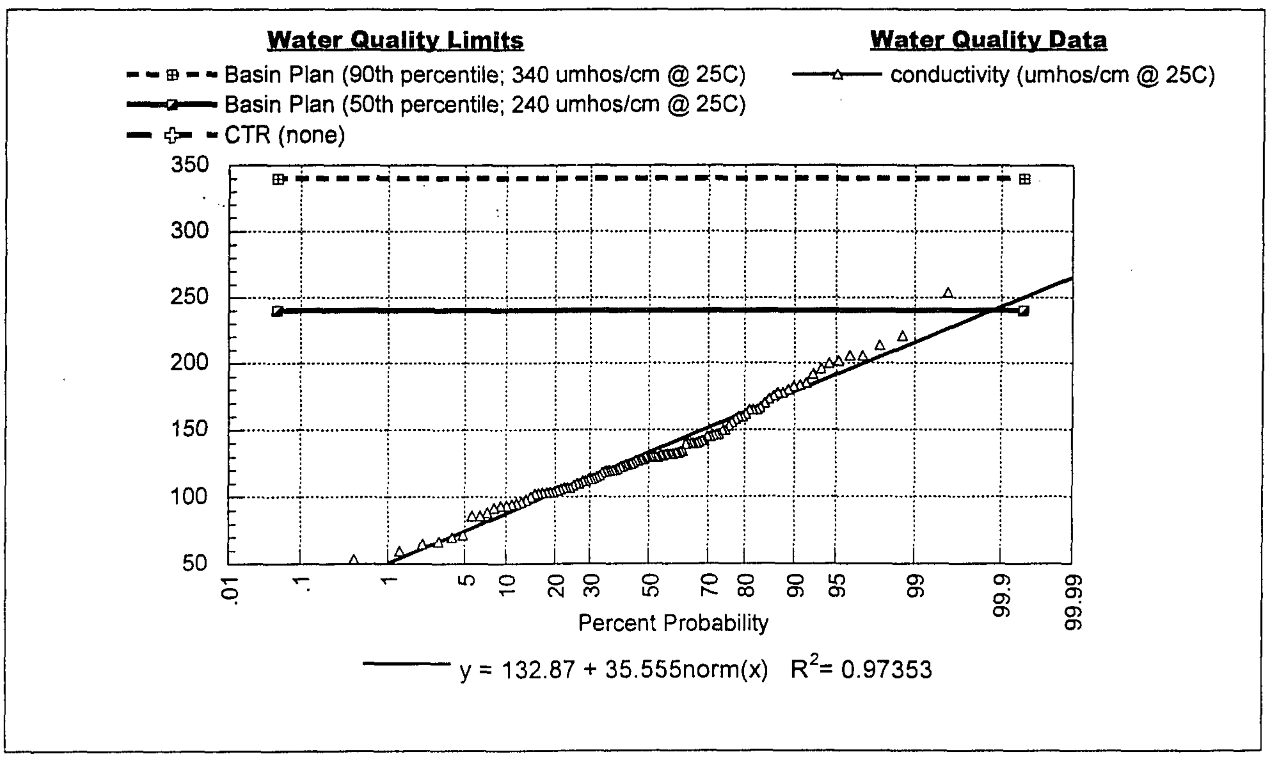

Water Quality Limits
Basin Plan (single sample max=10,000 MPN/100mL)
Basin Plan (30-day median=1,000 MPN/100mL)
CTR (none)
Water Quality Data
Total coliform (MPN/100mL)
10^4
1000
100
10
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 350.64 * e^(1.308norm(x)) R^2= 0.96609


Water Quality Limits
Basin Plan (single sample max=400 MPN/100mL)
Basin Plan (30-day median=200 MPN/100mL)
CTR (none)
Water Quality Data
Fecal coliform (MPN/100mL)
10^4
1000
100
10
1
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 36.561 * e^(1.5824norm(x)) R^2= 0.79406

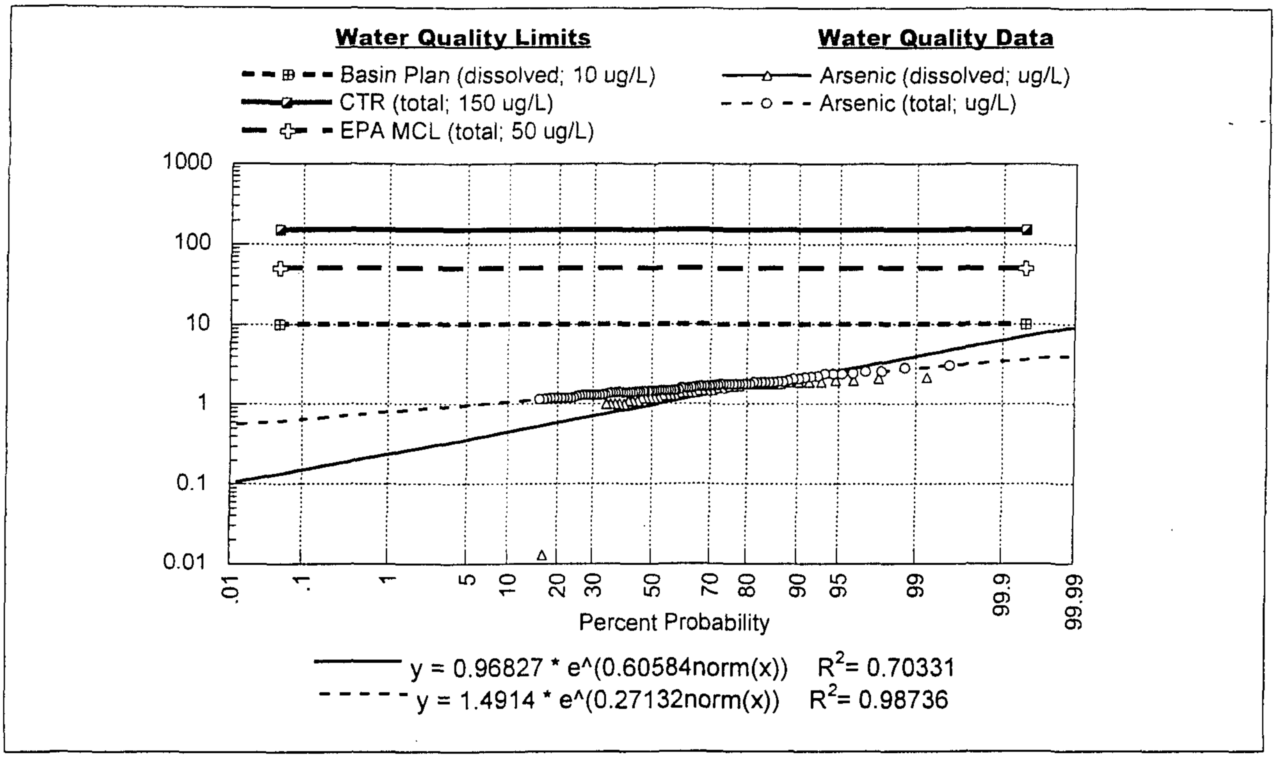

Water Quality Limits
Basin Plan (2.8 deg.C increase above natural)
Basin Plan (Max: Jan-Mar; 18.9 deg.C)
Basin Plan (Max: Apr-Jun, Sep-Nov; 20 deg.C)
Water Quality Data
Temperature (deg.C)
25
20
15
10
5
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 14.931 + 4.3617norm(x) R2= 0.95585

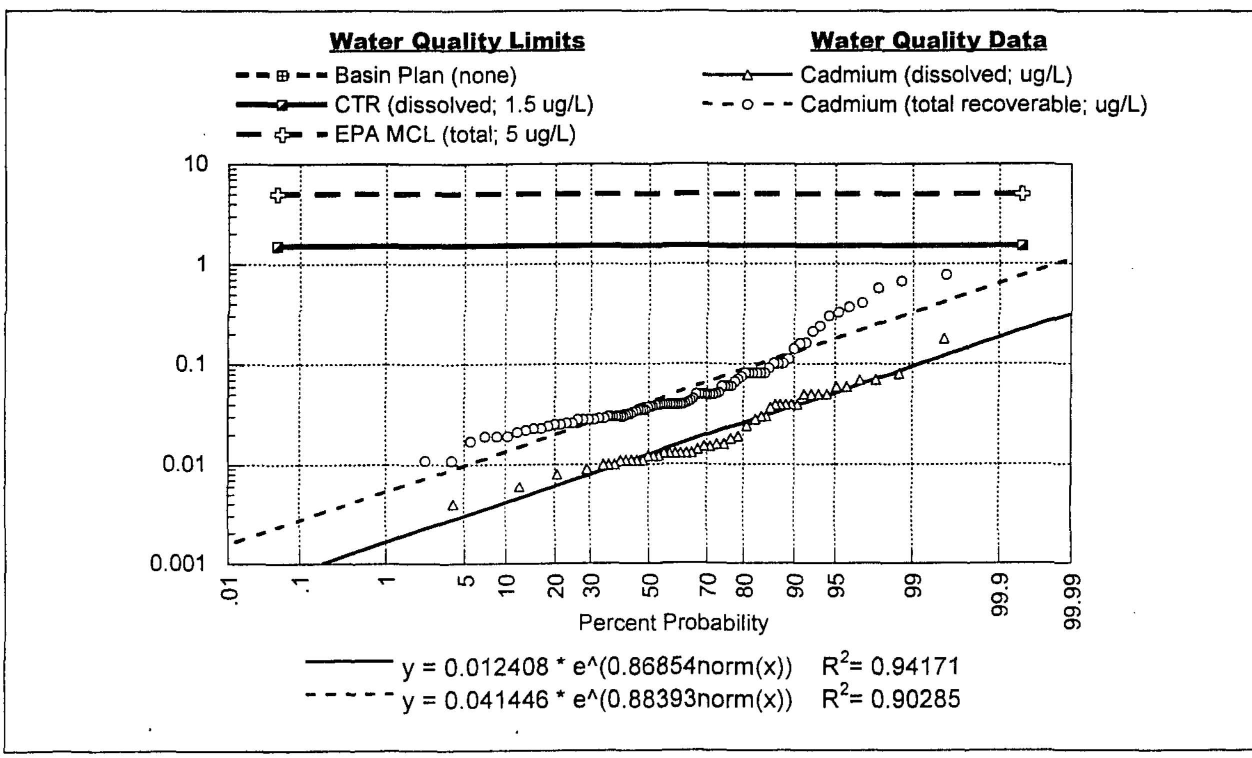

Water Quality Limits
Basin Plan (min; 7.0 mg/L)
CTR (none)
Other (none)
Water Quality Data
Dissolved oxygen (mg/L)
14
13
12
11
10
9
8
7
6
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 9.545 + 1.1919norm(x) R2= 0.97455

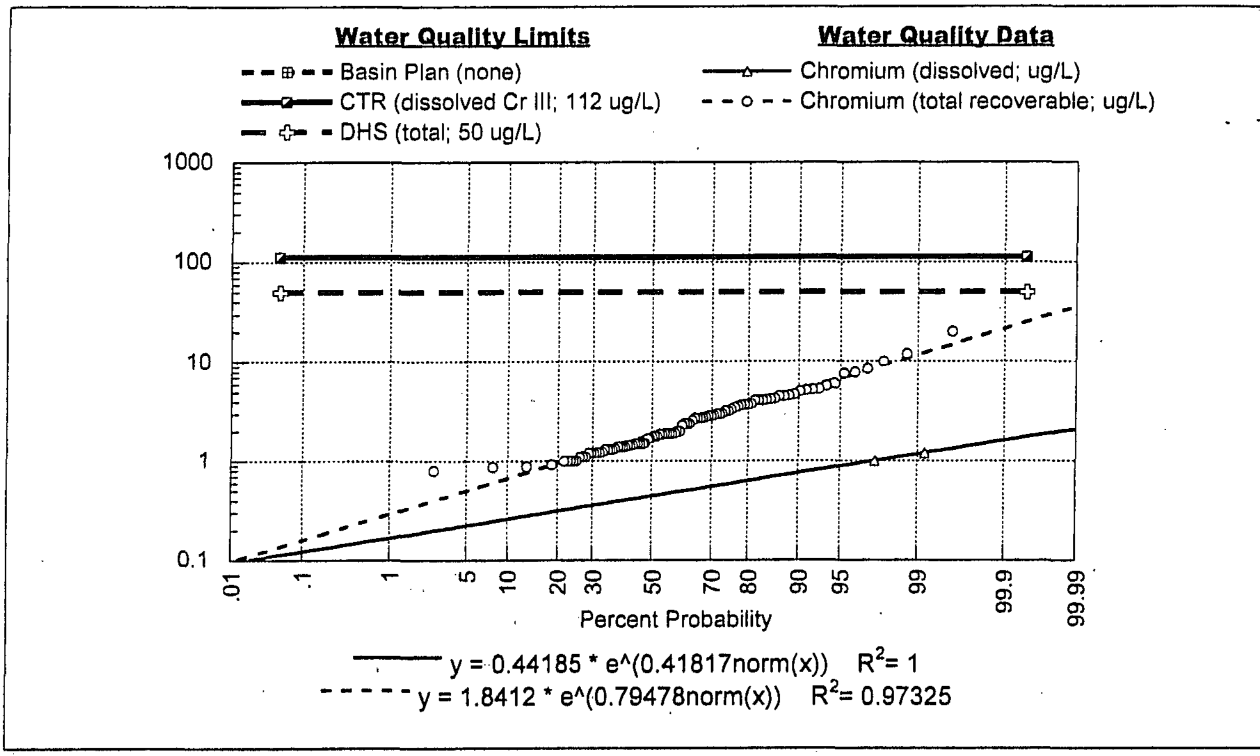

Water Quality Limits
Basin Plan (max; 8.5)
Basin Plan min; 6.5)
Other (none)
Water Quality Data
pH
9
8.5
8
7.5
7
6.5
6
5.5
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 7.5483 + 0.44018norm(x) R2= 0.92962

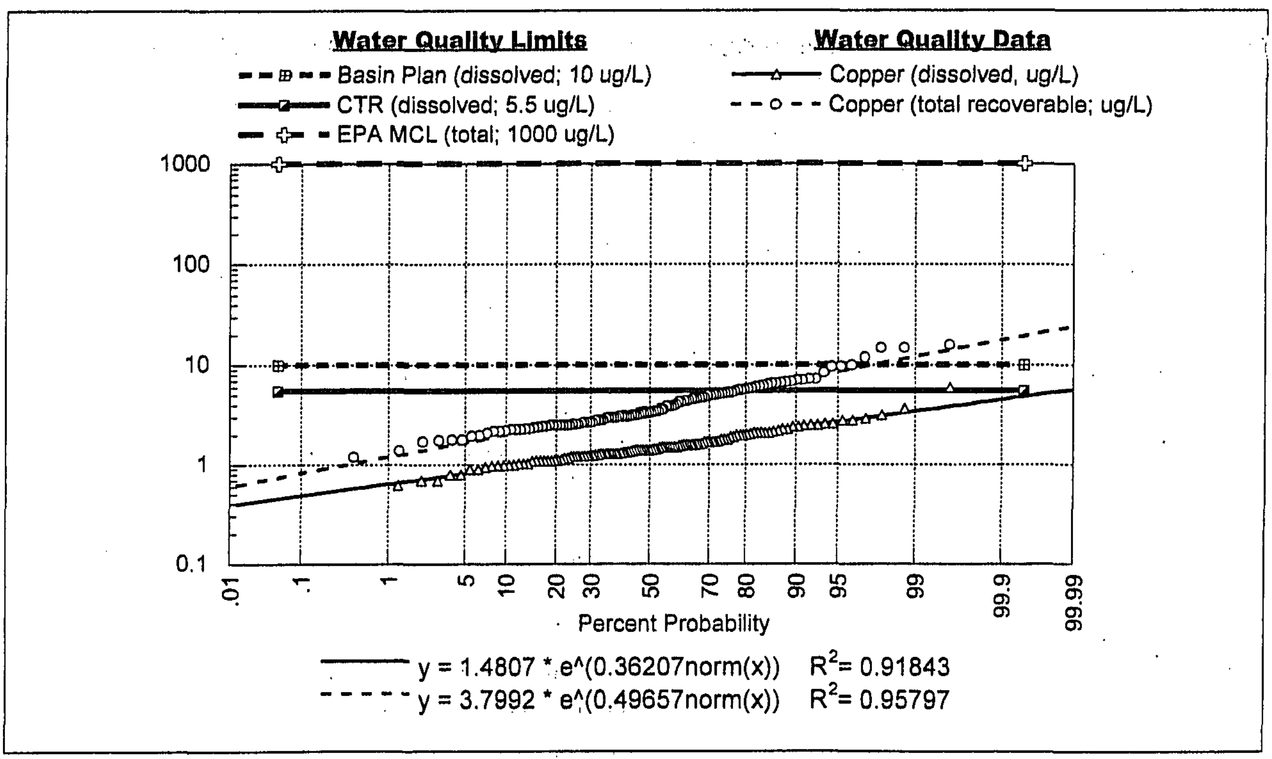

Water Quality Limits
Basin Plan (90th percentile; 340 umhos/cm @ 25C)
Basin Plan (50th percentile; 240 umhos/cm @ 25C)
CTR (none)
Water Quality Data
conductivity (umhos/cm @ 25C)
350
300
250
200
150
100
50
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 132.87 + 35.555norm(x) R2= 0.97353

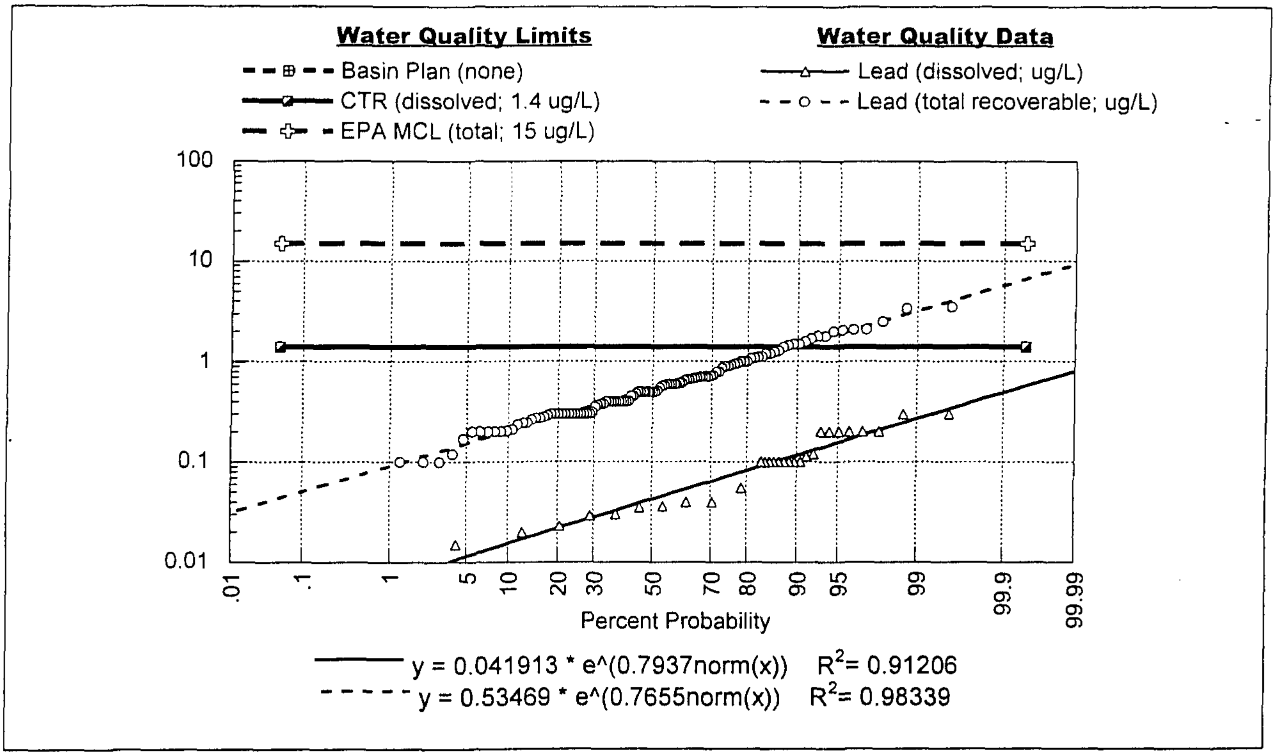
Sacramento River at River Mile 44

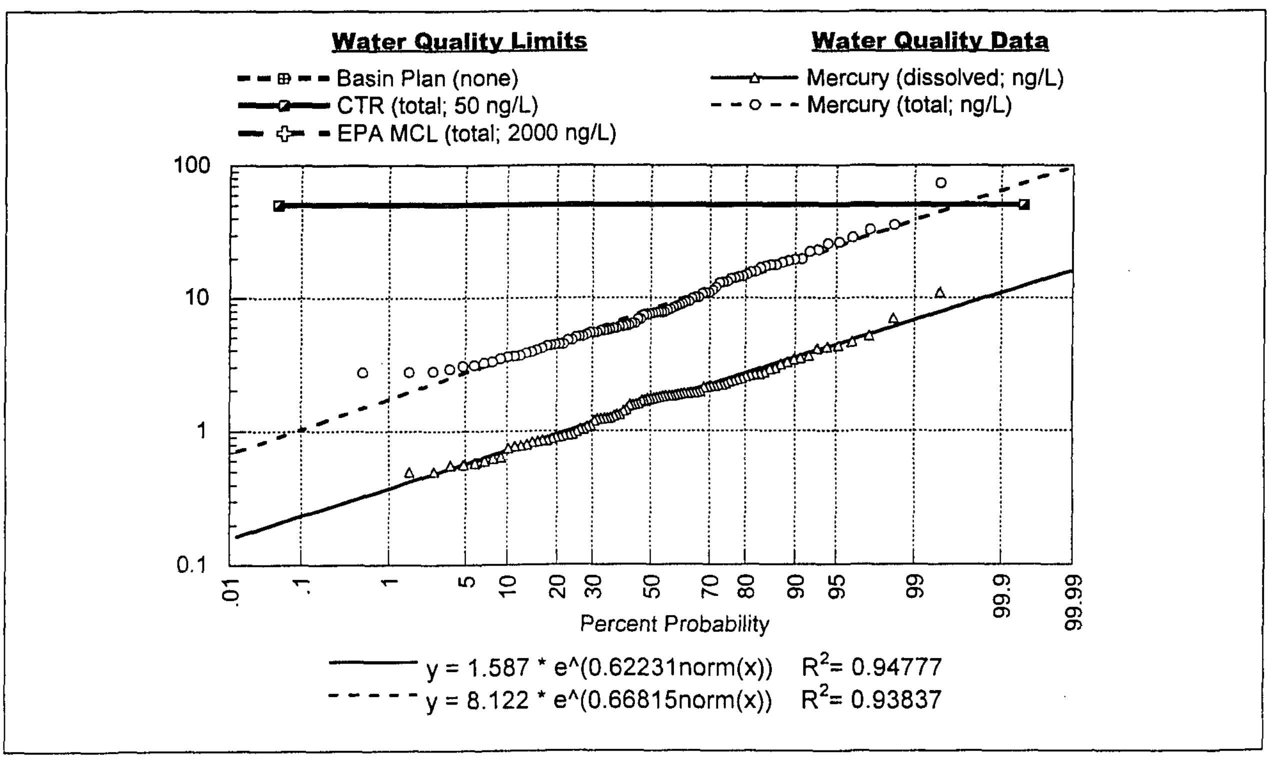

Water Quality Limits
Basin Plan (dissolved; 10 ug/L)
CTR (total; 150 ug/L)
EPA MCL (total; 50 ug/L)
Water Quality Data
Arsenic (dissolved; ug/L)
Arsenic (total; ug/L)
1000
100
10
1
0.1
0.01
.01 .1 1 5 10 20 30 50 70 80 90 95 99 99.9 99.99
Percent Probability
y = 0.96827 * e^(0.60584norm(x)) R2= 0.70331
y = 1.4914 * e^(0.27132norm(x)) R2= 0.98736

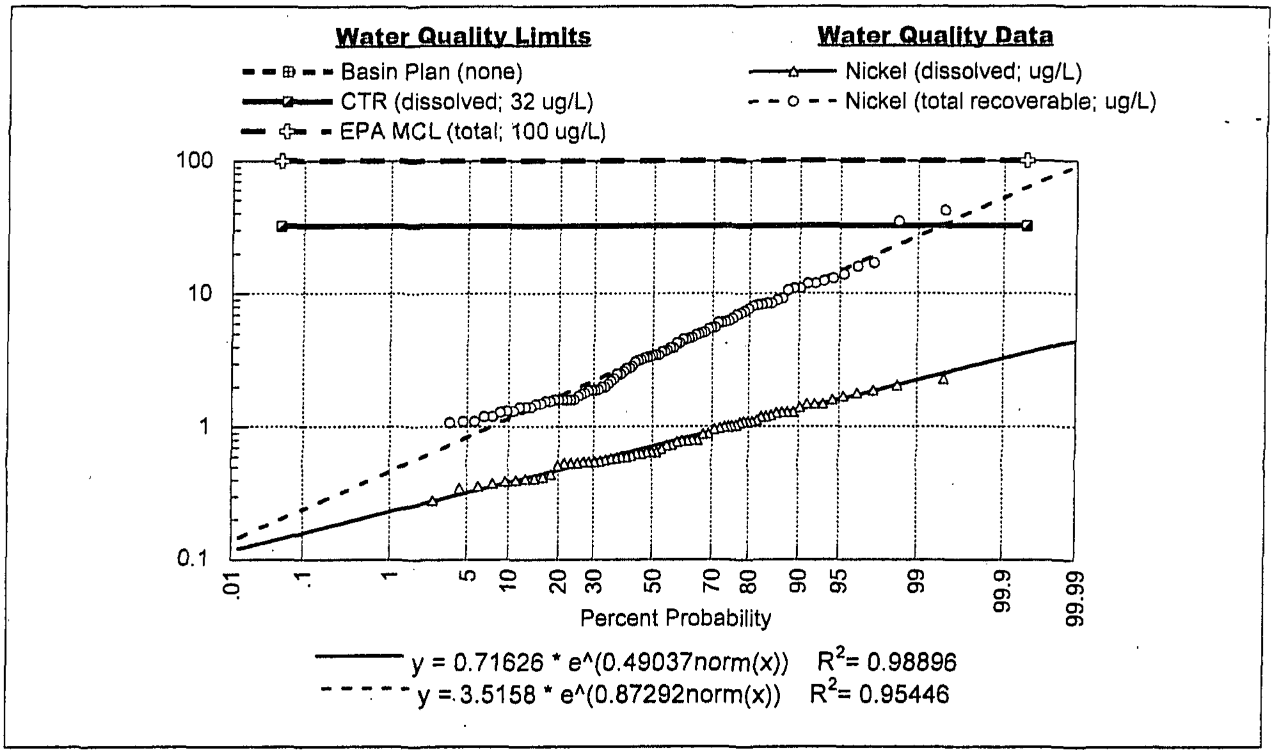

Water Quality Limits
Basin Plan (none)
CTR (dissolved; 1.5 ug/L)
EPA MCL (total; 5 ug/L)
Water Quality Data
Cadmium (dissolved; ug/L)
Cadmium (total recoverable; ug/L)
10
1
0.1
0.01
0.001
.01 .1 1 5 10 20 30 50 70 80 90 95 99 99.9 99.99
Percent Probability
y = 0.012408 * e^(0.86854norm(x)) R2= 0.94171
y = 0.041446 * e^(0.88393norm(x)) R2= 0.90285

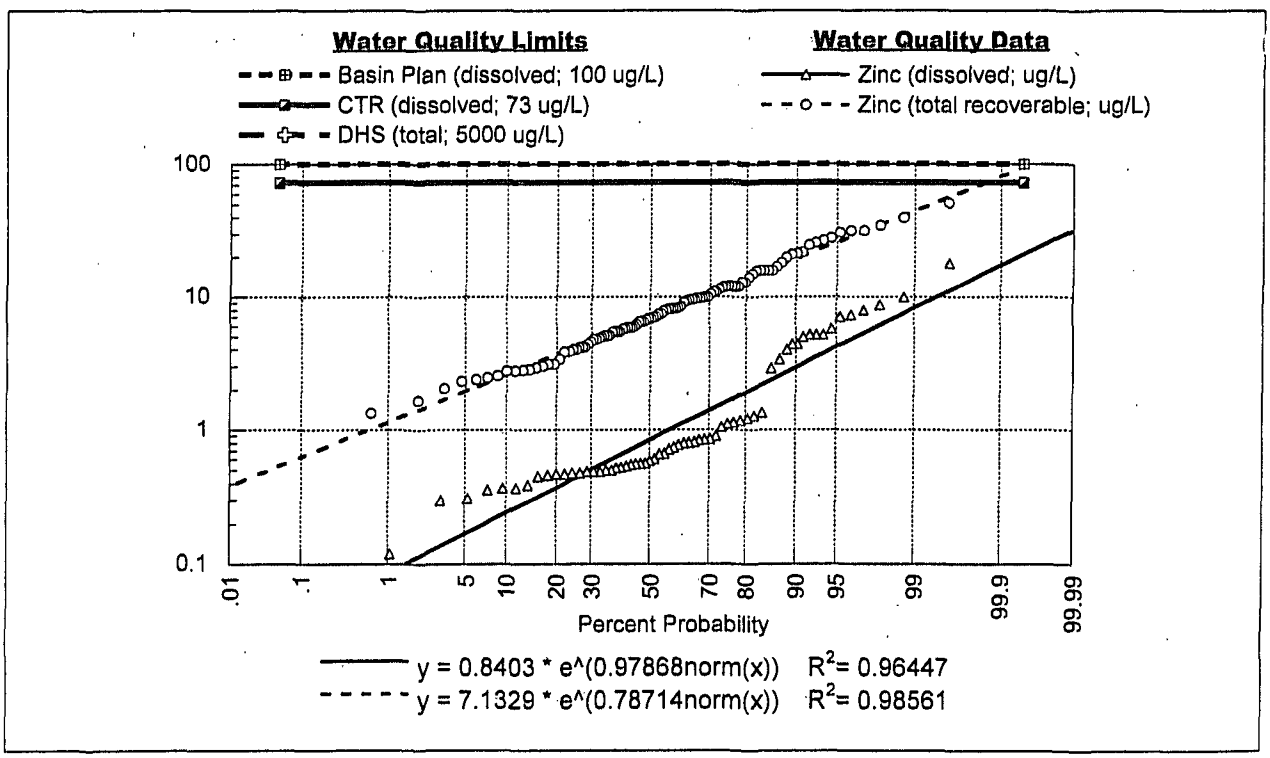

Water Quality Limits
Basin Plan (none)
CTR (dissolved Cr III; 112 ug/L)
DHS (total; 50 ug/L)
Water Quality Data
Chromium (dissolved; ug/L)
Chromium (total recoverable; ug/L)
1000
100
10
1
0.1
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 0.44185 * e^(0.41817norm(x)) R²= 1
y = 1.8412 * e^(0.79478norm(x)) R²= 0.97325

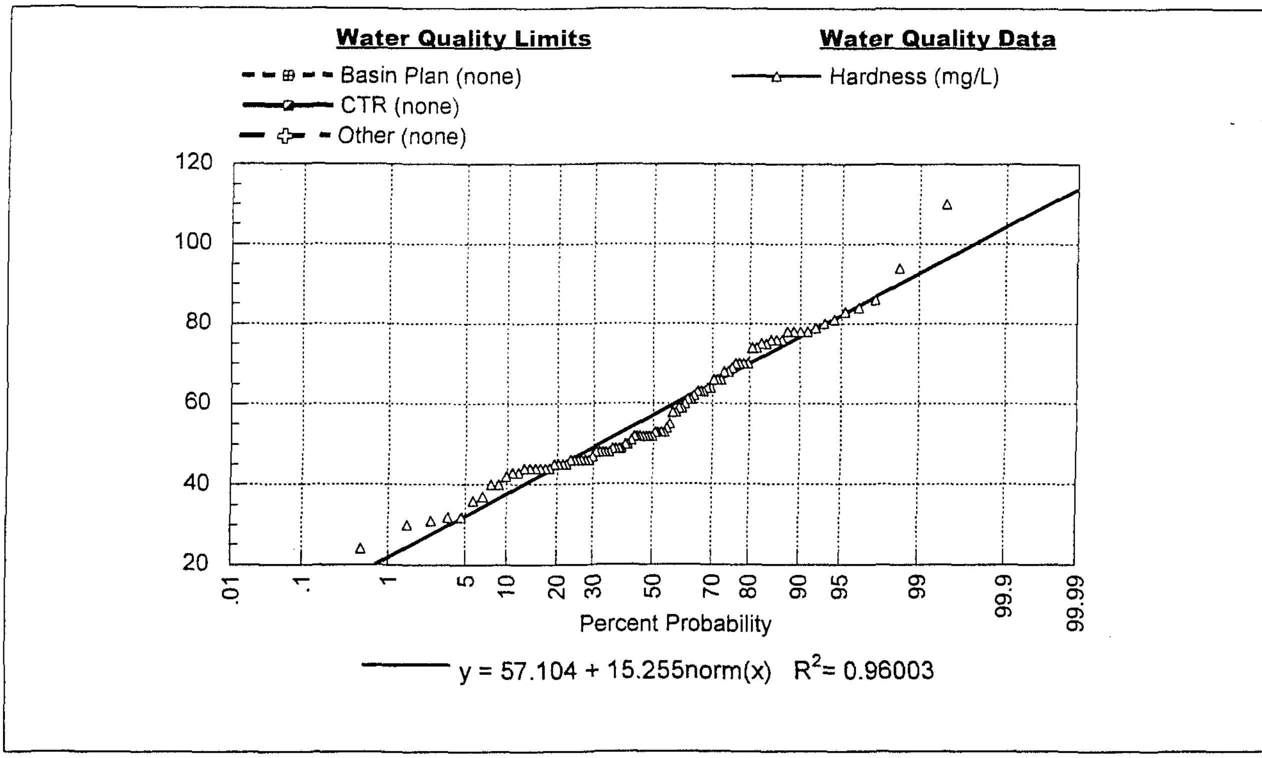

Water Quality Limits
Basin Plan (dissolved; 10 ug/L)
CTR (dissolved; 5.5 ug/L)
EPA MCL (total; 1000 ug/L)
Water Quality Data
Copper (dissolved, ug/L)
Copper (total recoverable; ug/L)
1000
100
10
1
0.1
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 1.4807 * e^(0.36207norm(x)) R²= 0.91843
y = 3.7992 * e^(0.49657norm(x)) R²= 0.95797

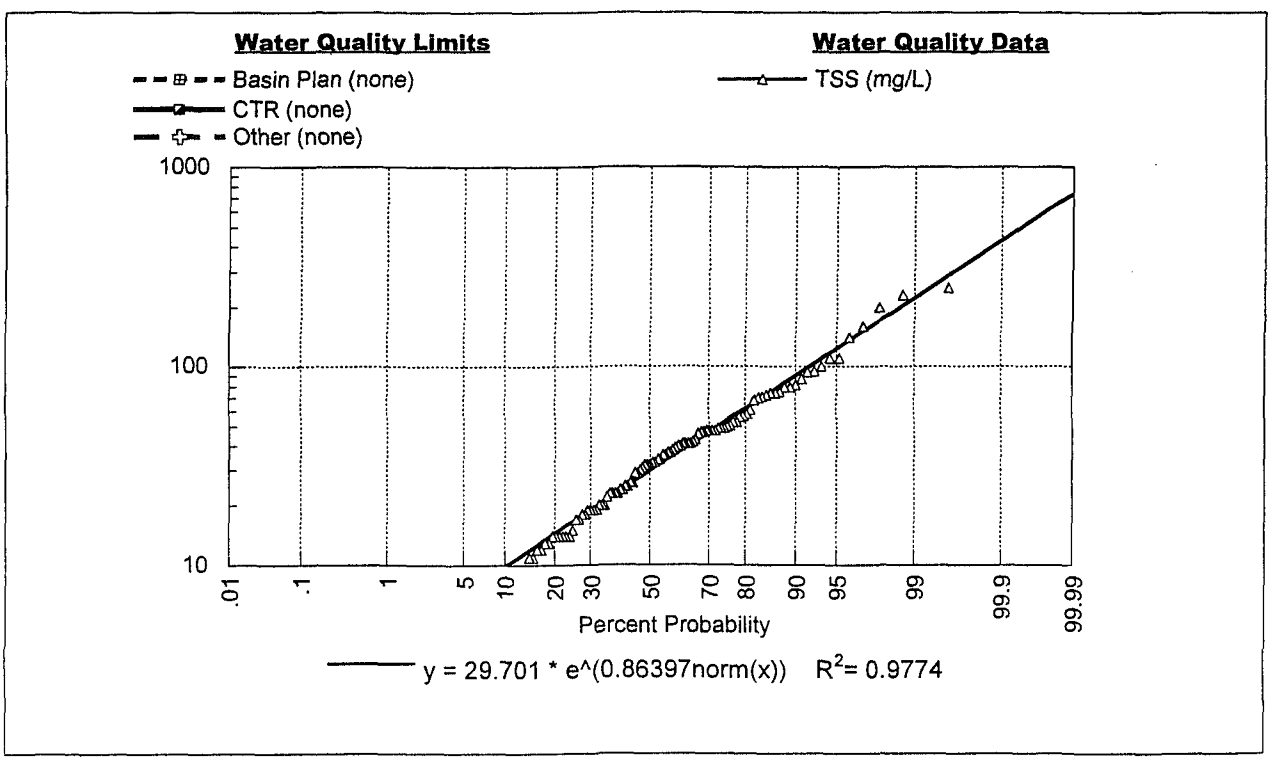

Water Quality Limits
Basin Plan (none)
CTR (dissolved; 1.4 ug/L)
EPA MCL (total; 15 ug/L)
Water Quality Data
Lead (dissolved; ug/L)
Lead (total recoverable; ug/L)
100
10
1
0.1
0.01
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 0.041913 * e^(0.7937norm(x)) R2= 0.91206
y = 0.53469 * e^(0.7655norm(x)) R2= 0.98339

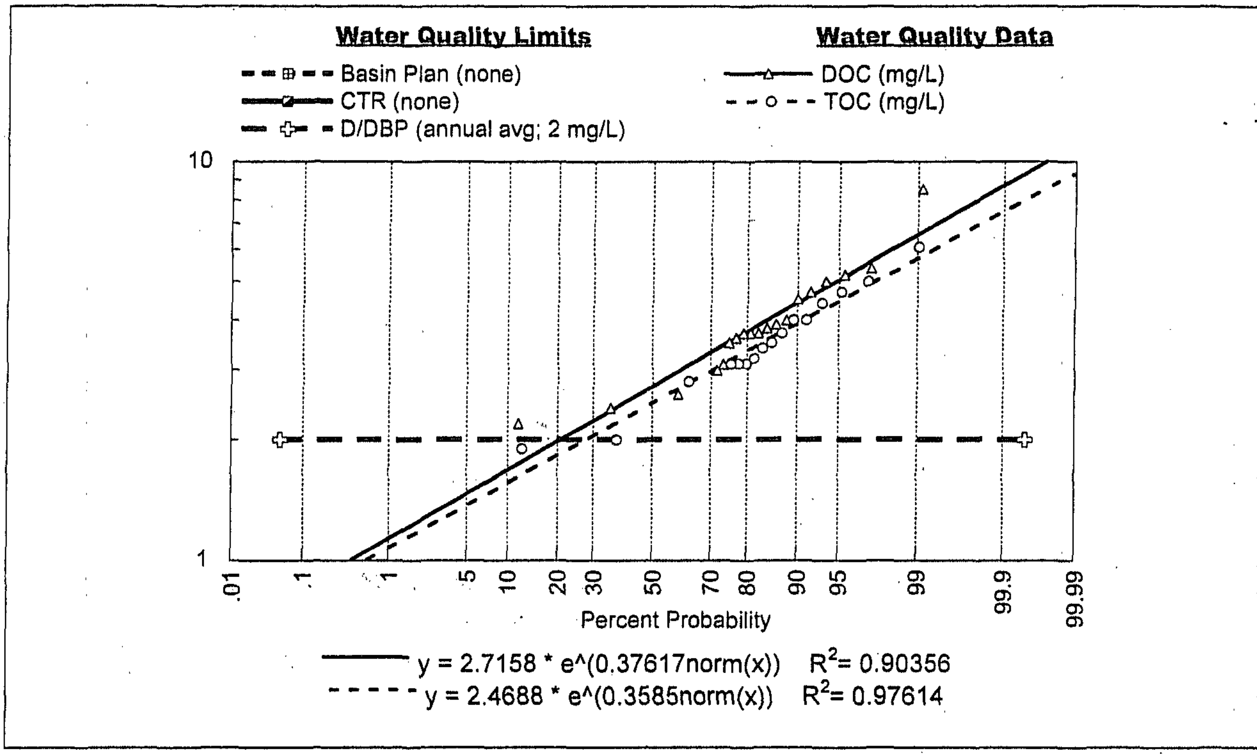

Water Quality Limits
Basin Plan (none)
CTR (total; 50 ng/L)
EPA MCL (total; 2000 ng/L)
Water Quality Data
Mercury (dissolved; ng/L)
Mercury (total; ng/L)
100
10
1
0.1
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 1.587 * e^(0.62231norm(x)) R2= 0.94777
y = 8.122 * e^(0.66815norm(x)) R2= 0.93837

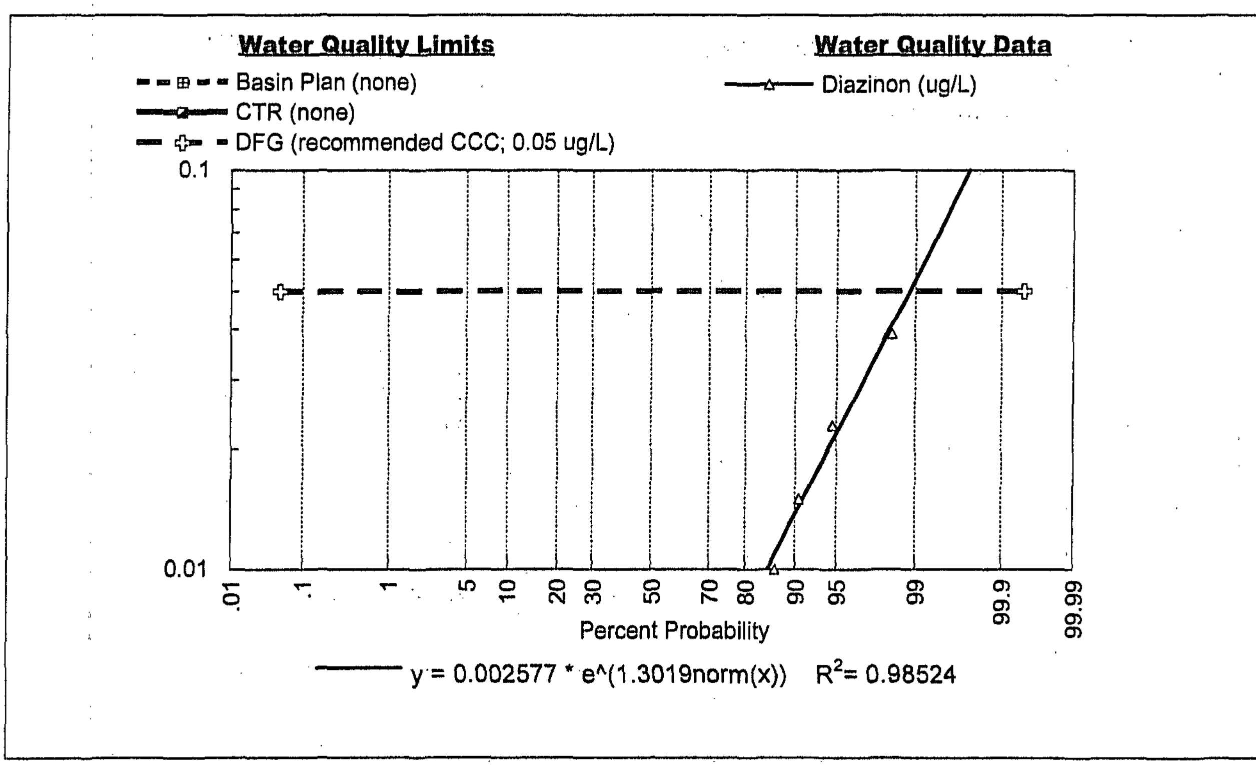

Water Quality Limits
Basin Plan (none)
CTR (dissolved; 32 ug/L)
EPA MCL (total; 100 ug/L)
Water Quality Data
Nickel (dissolved; ug/L)
Nickel (total recoverable; ug/L)
100
10
1
0.1
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 0.71626 * e^(0.49037norm(x)) R2= 0.98896
y = 3.5158 * e^(0.87292norm(x)) R2= 0.95446

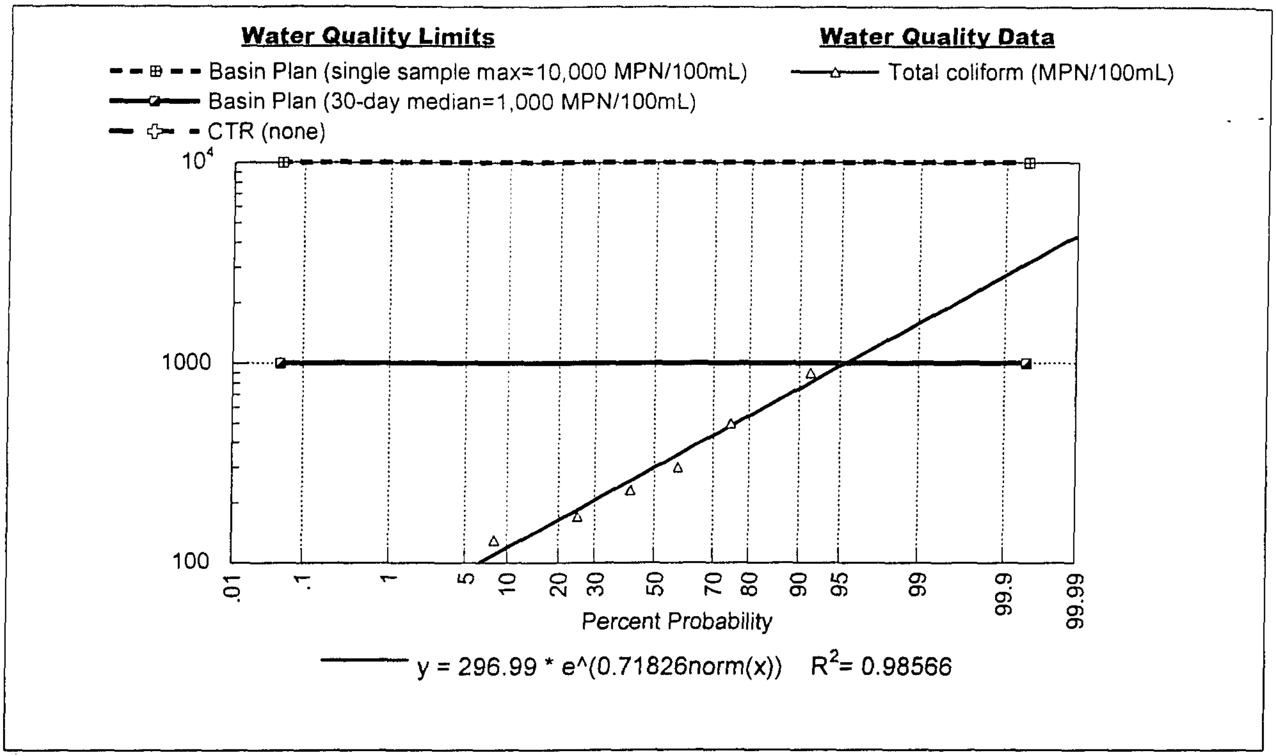

Water Quality Limits
Basin Plan (dissolved; 100 ug/L)
CTR (dissolved; 73 ug/L)
DHS (total; 5000 ug/L)
Water Quality Data
Zinc (dissolved; ug/L)
Zinc (total recoverable; ug/L)
100
10
1
0.1
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 0.8403 * e^(0.97868norm(x)) R2= 0.96447
y = 7.1329 * e^(0.78714norm(x)) R2= 0.98561

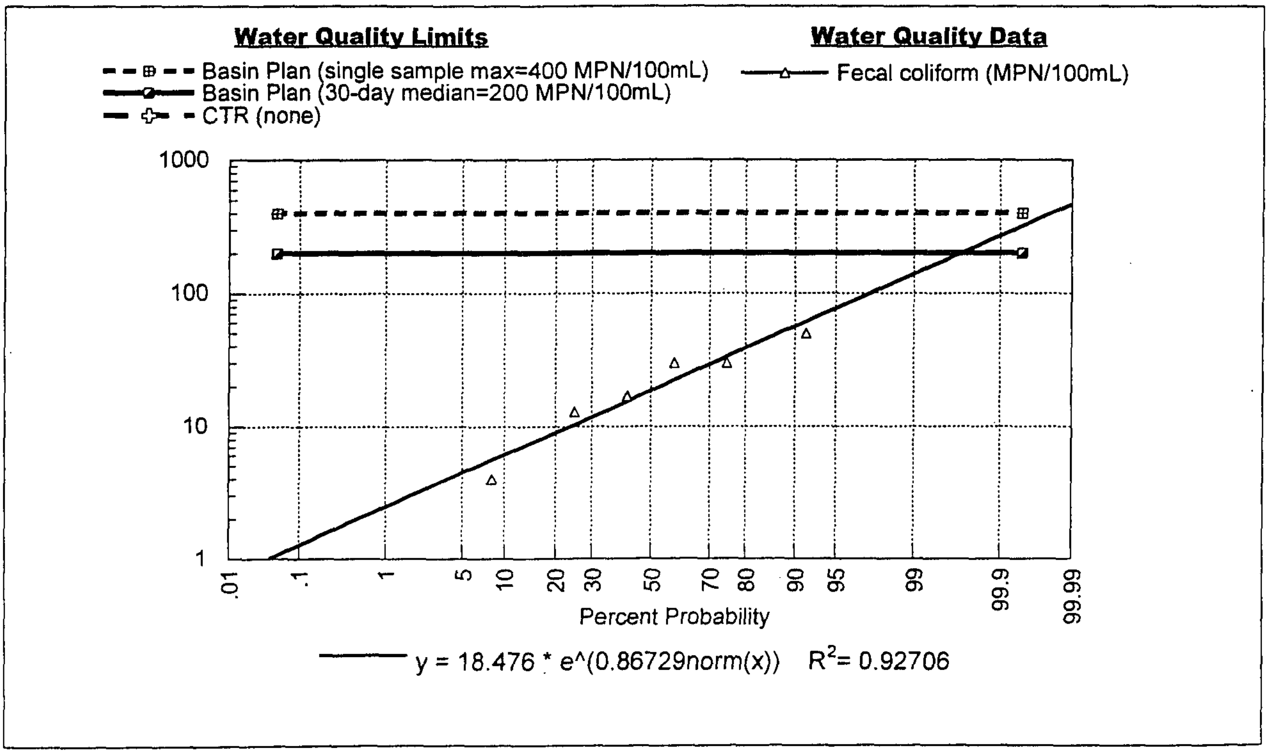

Water Quality Limits
Basin Plan (none)
CTR (none)
Other (none)
Water Quality Data
Hardness (mg/L)
120
100
80
60
40
20
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 57.104 + 15.255norm(x) R2= 0.96003

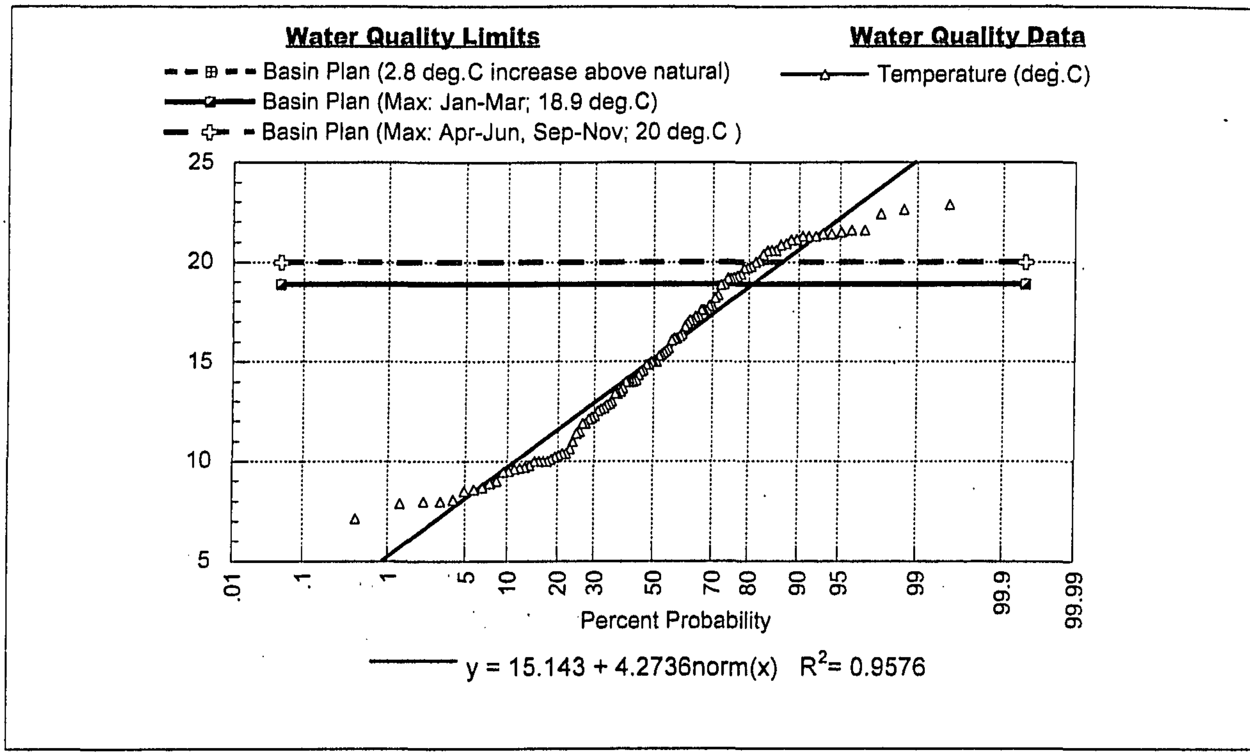

Water Quality Limits
Basin Plan (none)
CTR (none)
Other (none)
Water Quality Data
TSS (mg/L)
1000
100
10
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 29.701 * e^(0.86397norm(x)) R2= 0.9774

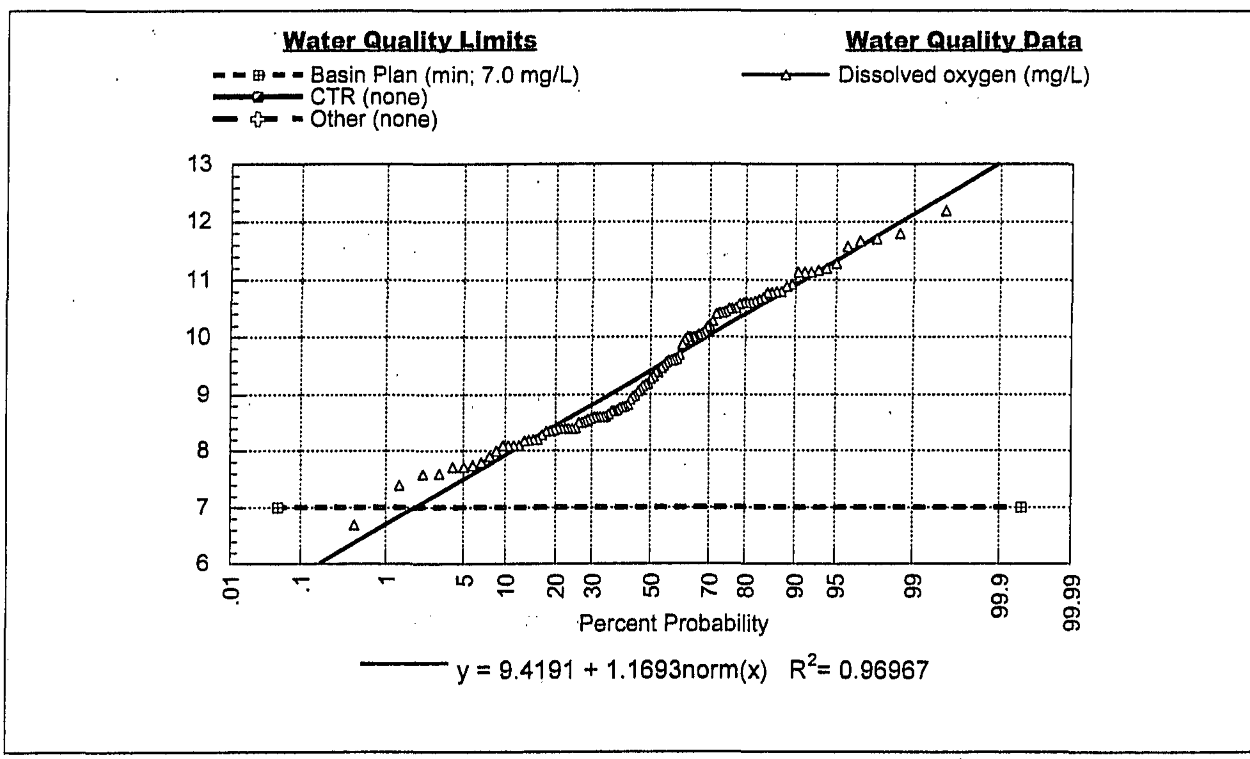

Water Quality Limits
Basin Plan (none)
CTR (none)
D/DBP (annual avg; 2 mg/L)
Water Quality Data
DOC (mg/L)
TOC (mg/L)
10
1
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 2.7158 * e^(0.37617norm(x)) R2= 0.90356
y = 2.4688 * e^(0.3585norm(x)) R2= 0.97614

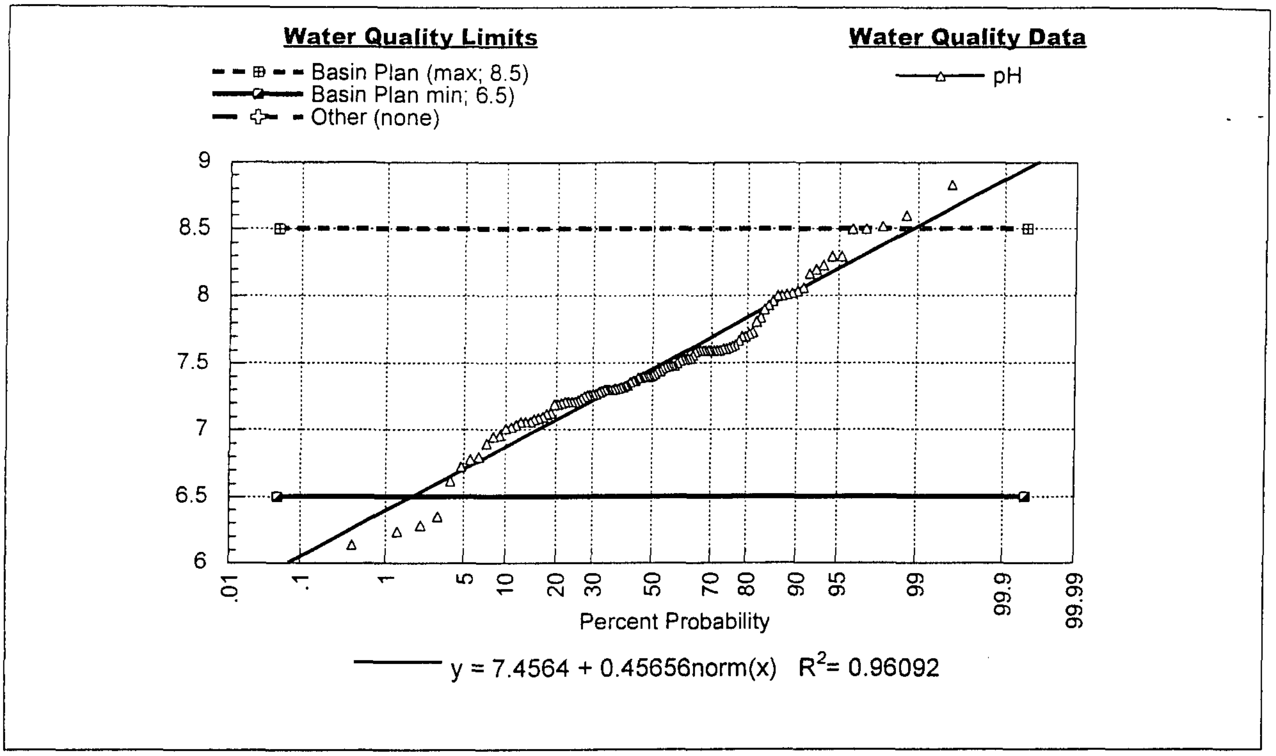

Water Quality Limits
Basin Plan (none)
CTR (none)
DFG (recommended CCC; 0.05 ug/L)
Water Quality Data
Diazinon (ug/L)
0.1
0.01
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 0.002577 * e^(1.3019norm(x)) R2= 0.98524

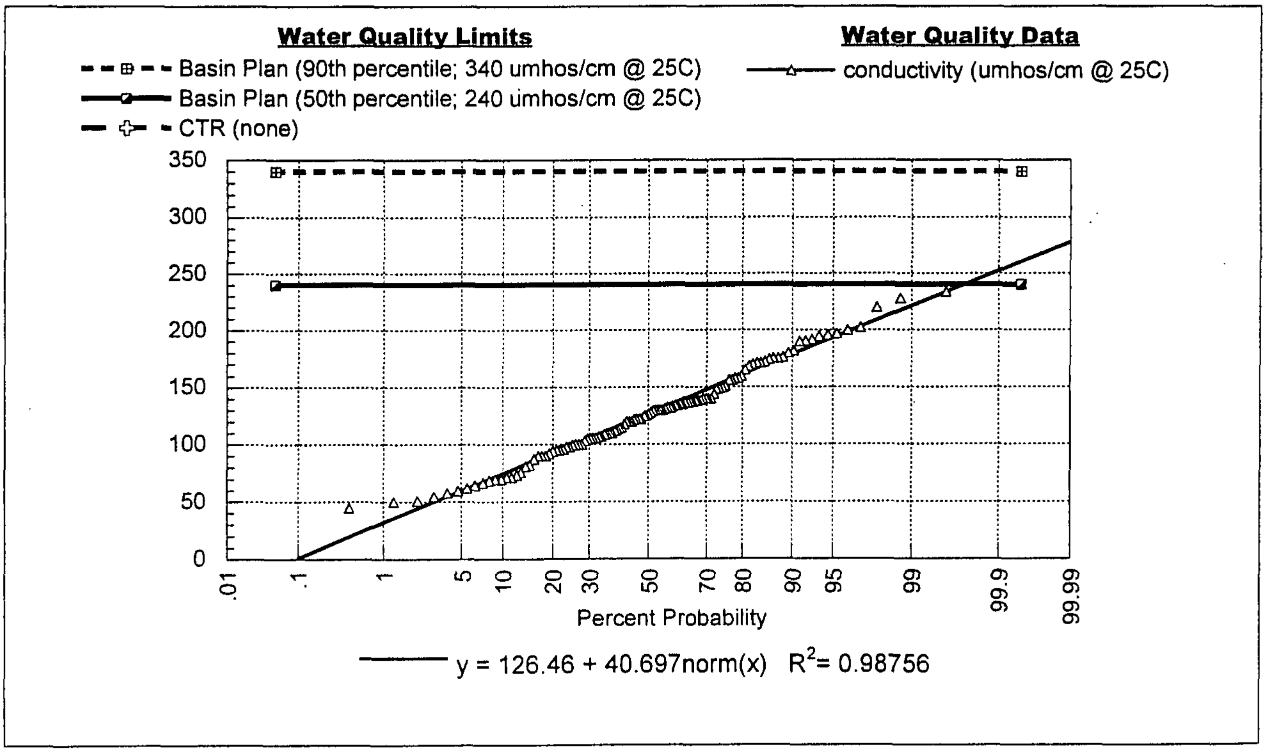

Water Quality Limits
Basin Plan (single sample max=10,000 MPN/100mL)
Basin Plan (30-day median=1,000 MPN/100mL)
CTR (none)
Water Quality Data
Total coliform (MPN/100mL)
10^4
1000
100
.01 .1 1 5 10 20 30 50 70 80 90 95 99 99.9 99.99
Percent Probability
y = 296.99 * e^(0.71826norm(x)) R^2= 0.98566


Water Quality Limits
Basin Plan (single sample max=400 MPN/100mL)
Basin Plan (30-day median=200 MPN/100mL)
CTR (none)
Water Quality Data
Fecal coliform (MPN/100mL)
1000
100
10
1
.01 .1 1 5 10 20 30 50 70 80 90 95 99 99.9 99.99
Percent Probability
y = 18.476 * e^(0.86729norm(x)) R^2= 0.92706


Water Quality Limits
Basin Plan (2.8 deg.C increase above natural)
Basin Plan (Max: Jan-Mar; 18.9 deg.C)
Basin Plan (Max: Apr-Jun, Sep-Nov; 20 deg.C)
Water Quality Data
Temperature (deg.C)
25
20
15
10
5
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 15.143 + 4.2736norm(x) R2= 0.9576


Water Quality Limits
Basin Plan (min; 7.0 mg/L)
CTR (none)
Other (none)
Water Quality Data
Dissolved oxygen (mg/L)
13
12
11
10
9
8
7
6
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 9.4191 + 1.1693norm(x) R2= 0.96967


Water Quality Limits
Basin Plan (max; 8.5)
Basin Plan min; 6.5)
Other (none)
Water Quality Data
pH
9
8.5
8
7.5
7
6.5
6
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 7.4564 + 0.45656norm(x) R2= 0.96092


Water Quality Limits
Basin Plan (90th percentile; 340 umhos/cm @ 25C)
Basin Plan (50th percentile; 240 umhos/cm @ 25C)
CTR (none)
Water Quality Data
conductivity (umhos/cm @ 25C)
350
300
250
200
150
100
50
0
.01
.1
1
5
10
20
30
50
70
80
90
95
99
99.9
99.99
Percent Probability
y = 126.46 + 40.697norm(x) R2= 0.98756

DRAFT

JANUARY 7, 2001
ADMINISTRATIVE DRAFT
DO NOT CITE

R42-b

SACRAMENTO RIVER WATERSHED PROGRAM

Annual Monitoring Report: 1999–2000

Prepared for:

Sacramento River Watershed Program

By:

Larry Walker Associates

DRAFT

Report Review Process

The review process and schedule for the 1999-2001 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, a technical peer review by a panel of three reviewers selected by the USEPA program manager for the Sacramento River Watershed Program, and review by the all SRWP stakeholders and other interested public. The Public Draft report and the Final report will be available from the SRWP website,

http://www.sacriver.org.

Comments received for the Administrative Draft (this report) will be compiled in a separate document and proposed responses will be discussed and approved by the Monitoring Sub-Committee of the SRWP. Comments received for the Public Draft of this report will be compiled, responded to, and included in the Final version. Comments should be directed by email (preferred), fax, or U.S. mail to the attention of Claus Suverkropp at the following address:

Larry Walker Associates
509 Fourth Street
Davis, CA 95616
Phone: (530) 753-6400
Fax: (530) 753-7030
email: clauss@lwadavis.com

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
	3/28//2001	Public Draft submitted to Monitoring and other Sub-Committees and Peer Reviewers. Other SRWP stakeholders notified of Public Draft AMR availability for review.
	4/25/2001	Written comments on Public Draft due from all reviewers and stakeholders.
	5/23/2001	Review and approve responses to Public Draft Peer Reviews and other major comments at May Monitoring Sub-Committee meeting (5/23/2001, tentative meeting date)
	6/20/2001	Submit Final AMR approved by Monitoring Sub-Committee in early June 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

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

Table of Contents

List of Tables

List of Tables (continued)

List of Figures

List of Figures (continued)

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 document provides a review of the Sacramento River Watershed Program monitoring effort and the data generated by the Sacramento River Watershed Program 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). Data from these programs 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. 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 being performed 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.
- Total water column mercury concentrations in the Sacramento River downstream from Colusa exceeded the 1985 USEPA mercury criterion of 12 ng/L in approximately 16 to 30% of samples. Total mercury concentrations in Cache Creek and Mill Creek exceeded the 12 ng/L limit in more than 50% of samples. Spring Creek in the upper Sacramento River watershed, Deer Creek, Big Chico Creek, the Yuba River, the Feather River, and the American River do not appear to be major sources of mercury—total concentrations rarely exceeded 12 ng/L limit (in less than 5% of samples) 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 area for total mercury. Preliminary data indicate that Cottonwood Creek and Thomes Creek drainages may also be significant mercury sources, although substantially less than the Cache Creek watershed.

Other Trace Metals

- Aquatic life uses are typically the most sensitive to trace metal concentrations. In comparisons to CTR water quality standards 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. The notable exception is that dissolved copper concentrations in individual samples continue to exceed hardness-adjusted CTR chronic standards for copper approximately 10% of the time in the Sacramento River below Keswick Reservoir. This result indicates a potential impact on sensitive aquatic life species in this reach of the Sacramento River.

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. Arcade Creek samples continue to exhibit a relatively high frequency of toxicity to *Ceriodaphnia* as compared to other lower watershed tributaries.
- The results of the 1998-99 monitoring and of previous aquatic toxicity monitoring efforts have documented that significant toxicity to bioassay test organisms occurs throughout the watershed. *Ceriodaphnia dubia* toxicity attributable to organophosphate pesticides in agricultural runoff and urban runoff has been strongly suggested by SRWP monitoring and other studies.
- The strategy of regular 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 episodic 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.

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 having 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 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 and beyond. Water supply agencies treating Sacramento River and Delta water are currently able to meet drinking water standards. 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.

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

- 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, the American River, and Cache Slough.
- 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. In either case, safeguards would be implemented to protect human health of end users.
- *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* 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 should be suspended until these analytical issues are resolved.

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 evaluating 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 indicated 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.
- Although concentrations of organochlorines did not exceed FDA Action Levels in any samples, concentrations of aroclors, DDTs, and dieldrin exceeded screening values in fish collected from eight locations, primarily in the lower watershed.
- 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 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, the available 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 available 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).
- The majority of sites evaluated had similar physical habitat characteristics and were considered to be in good to excellent condition.
- 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.

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 for the SRWP that was developed in 1996 by the participating stakeholders 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 has 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 will provide information to promote the understanding of conditions in the watershed and to assess the health of the watershed. The monitoring program will be a dynamic activity that will change over time 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.

The Monitoring Sub-committee has set the following goal for the first year of the monitoring program:

> ***SRWP Monitoring Program—First Year 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 these other monitoring programs. 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 goal for the first year monitoring effort of the SWRP 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:

- 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 (RWQCB 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 proposed California Toxics Rule (CTR)(August 1997). The adopted NTR objectives and proposed CTR criteria are summarized in Appendix C. The proposed 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.

Second Year 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 Year 1 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 Year 1 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, eastside, Sierra Nevada tributaries were selected for special studies. 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 1999-2000 (Year 2) SRWP monitoring program included sample collection at 83 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 56 sites in the 1998-99 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 1 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.

Table 1. SRWP 1998-99 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
Clear Creek (3 sites)	special 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
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

Semi-intensive monitoring (either monthly or semi-monthly) was conducted at 24 of the sites, including 7 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 one site, Sacramento River at Verona). 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 QAPP.

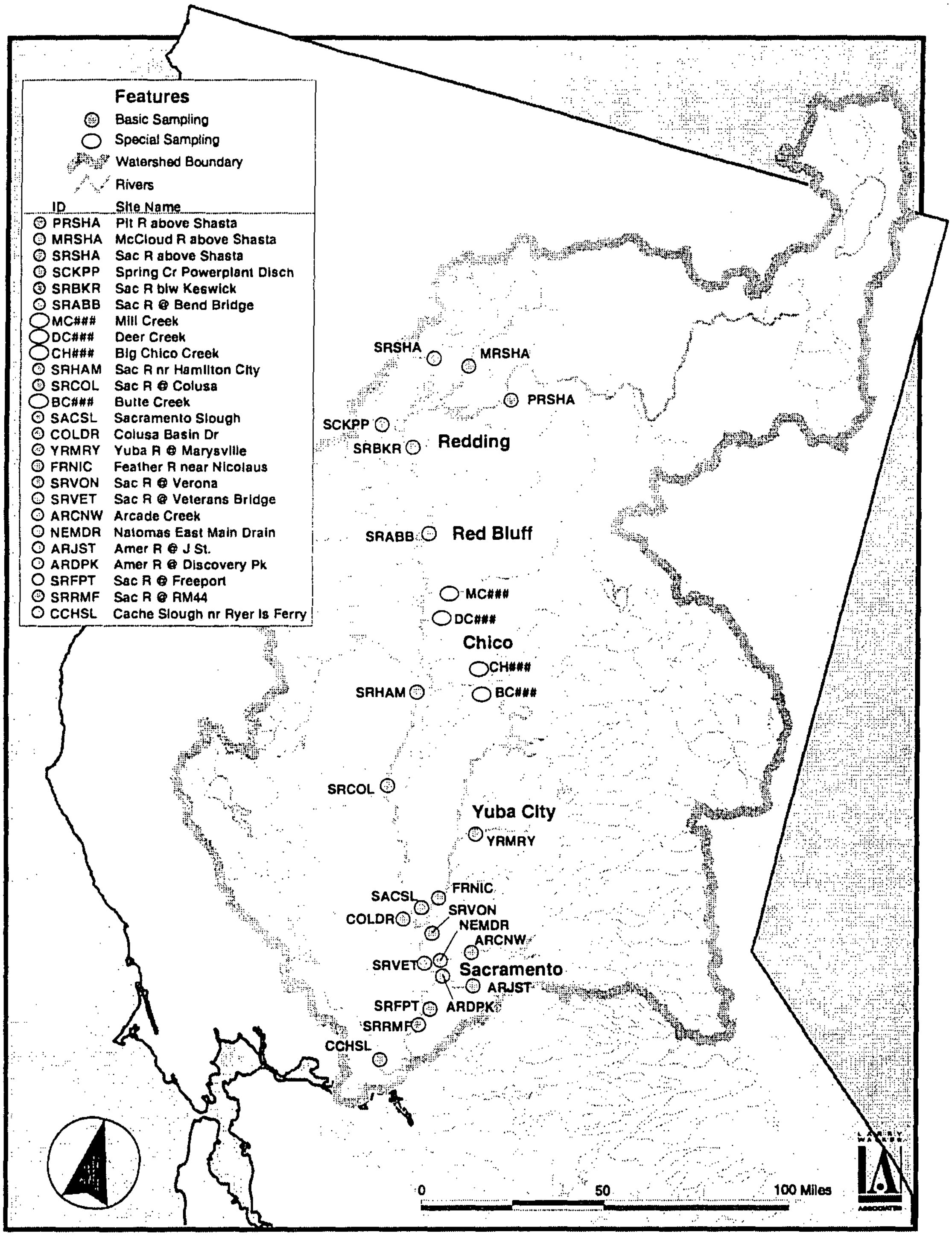


Figure 1. SRWP Monitoring Program Sampling Sites

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
- 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 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 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, 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, increased abnormalities, or increased mortality of test species. Effects may occur rapidly over a period of hours (acute toxicity) or may occur over a longer period of days or weeks (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. 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 and inactivate at least 3 logs of *Giardia* (99.9%) and 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 *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, Metropolitan Water District, and the City of Sacramento 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, with a final report expected to be released in the Summer of 2000. 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. 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.

Benthic 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 1998-99 Monitoring Program

Chemical, and Physical Water Quality Characteristics	
Trace Metals	*General Constituents*
Arsenic, total and dissolved	Alkalinity
Cadmium, total and dissolved	Chloride
Chromium (III), 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	Organophosphorus Pesticides
Nitrate & Nitrite	Carbamate Pesticides
Total Kjeldahl Nitrogen	Triazine Pesticides
Ortho-Phosphate	
Phosphate	
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 will typically be monthly for main stem sites, and monthly or semi-monthly for selected tributary sites.
- *Pathogens*—frequency of sampling is 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 is generally conducted monthly for main stem sites, and monthly or semi-monthly for tributary sites.
- *Sediment toxicity*—sampling is conducted twice annually at all sites to be monitored.
- *Fish tissue*—sampling will be conducted once annually for all sites to be monitored.
- *Bioassessment*—biota sampling and physical habitat assessment will be conducted once annually for all sites to be 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

	Water Chemistry																								Pathogens		Aquatic Toxicity		Sediment		Fish Tissue		Bioassessment (e)				
Sampling Station	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 Hyalela)	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
Deer Creek																																	10 (i)			10 (i)	12
Big Chico Creek																																	12 (j)			12 (j)	12
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	NAO		NAO	NAO	NAO	NAO	NAO	NAO	NAO	NAO	NAO	NAO	NAO	12		NAO	NAO	12	NAO	NAO	NAO	12			12	12	12		2	2	2	2		1	1	1	
Butte Creek																											6						6 (k)			6 (k)	12
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.	AMP		AMP (total)	AMP	AMP	AMP	AMP	AMP			AMP	AMP	AMP	12		AMP	AMP	12	AMP		12	12			12	AMP	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	AMP		AMP	AMP	AMP	AMP	AMP	AMP			AMP	AMP	AMP						AMP							AMP	12				2	2					
Sac. R. at Freeport	NAO		AMP	AMP	AMP	AMP	NAO	NAO	NAO	NAO	NAO	NAO	AMP	12		NAO	NAO	12	NAO	NAO	NAO	NAO	NAO	NAO	6	AMP	12		2	2							
Sac. R. at RM44	AMP		AMP	AMP	AMP	AMP	AMP	AMP			AMP	AMP	AMP	12	12	12	12	12	AMP	12						AMP					6	6					
Putah Creek																															1	1					
Cache Creek at Rumsey	GS	GS	GS	GS		GS	GS	GS			GS	GS		GS	GS	GS	GS		GS	GS	GS																
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: Text entries indicate primary coordinating data
(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) A fixed budget of $60,000 is allocated for Toxicity follow-up consisting of chemistry and TIE testing that has no fixed frequency.
(d) A fixed budget of $20,000 is allocated for Sediment Toxicity Followup consisting 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) Refer to Special Tributary Sampling Plan for monitoring details
(g) Bioassessment monitoring will be performed at 1 reach (one event) on McCloud River.
(h) Bioassessment monitoring will be performed at 6 reaches (one event each) on Mill Creek
(i) Bioassessment monitoring will be performed at 10 reaches (one event each) on Deer Creek
(j) Bioassessment monitoring will be performed at 12 reaches (one event each) on Big Chico Creek
(k) Bioassessment monitoring will be 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. The primary data considered and presented for this review were generated by the following programs:

- The Sacramento River Watershed Program (SRWP)
- The Sacramento River Coordinated Monitoring Program (CMP)
- The City of Redding NPDES monitoring program
- USGS National Assessment of Water Quality (NAWQA) for the Sacramento River
- Department of Water Resources (Northern District) Intensive Tributary Monitoring Program (Note: These data were not made available for this review)
- USGS Trace Metals and Mercury Transport Studies (Note: These data were not made available for this review)

Additionally, data were also considered and evaluated from a number of other monitoring studies, including:

- Several Regional Board studies on mercury, trace metals, OP pesticides, and toxicity
- The San Francisco Estuary Regional Monitoring Program for Trace substances (RMP)
- DWR's Municipal Water Quality Investigations (MWQI) monitoring program
- USGS National Assessment of Water Quality (NAWQA) for the San Joaquin River
- The State Water Resources Control Board's Toxic Substances Monitoring Program (TSMP).

The review of data from the 1998-99 SRWP monitoring effort is organized into the following general categories:

- Mercury in water and fish tissue
- Aquatic toxicity
- Drinking water parameters of concern (organic carbon, minerals, dissolved solids, nutrients, pathogens)
- Trace metals
- Organochlorines 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 F and Appendix H, respectively. Comparisons with applicable water quality objectives and other thresholds, and comparisons with 303(d)-listed waterbodies were performed as a preliminary evaluation of the degree to which beneficial uses of the Sacramento River watershed are attained or potentially impaired. 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.

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 E of this report.

A. *Mercury Data Summary*

Monitoring results for the Sacramento River Watershed Program (SRWP) for the period June 1999 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 F. 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
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. *Data not available for draft report*
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

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: the median mercury concentration at the Hamilton City site was 1.8 ng/L vs. 1.4 ng/L at Bend Bridge for the 1999-2000 monitoring year. 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.

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 F.

Fish Tissue

Note: 1999 SRWP final fish tissue data for mercury has not been submitted. The following discussion and evaluation of fish tissue mercury is based on the final 1997 and 1998 data and the preliminary 1999 mercury data.

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). Six fish species were sampled (depending on species present at different sites), including rainbow trout, largemouth bass, Sacramento squawfish, 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 for all sites. The average mercury concentration in Sacramento squawfish collected from four locations (from the Sacramento River above Bend Bridge to the American River at Discovery Park) was 0.24 mg/kg. White catfish and largemouth bass collected downstream from Colusa exhibited higher average mercury concentrations (0.42 mg/kg and 0.65 mg/kg, respectively). Carp were captured only at Sacramento River at Colusa and at Colusa Basin Drain (average mercury concentration of 0.12 mg/kg), and a single Sacramento sucker composite was sampled from the Sacramento River near Hamilton City with a mercury level of 0.036 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

Total mercury concentrations in the water column in the mainstem Sacramento River exhibit a strong seasonal pattern (Figure 6a). 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 absorb 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 (Figure 6b). 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 is not yet known. Ongoing methyl mercury monitoring by the SRWP monitoring program (commencing in July 2000) and continued methyl mercury monitoring by the DWR special tributary program is expected to provide valuable information to address this question.

Time series plots of water column mercury concentrations are also presented in Appendix H of this report.

iv. Attainment of Beneficial Uses and Potential Impairment

Comparisons with water quality and fish tissue criteria: Total mercury concentrations in water were compared with a variety of regulatory, screening, and advisory thresholds (Table 5).

Water Column

Human Health Thresholds

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 standard for fish consumption of 0.050 µg/L (30-day average) adopted in the May 2000 California Toxics Rule (CTR). The CTR standard 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 0.012 µg/L. The CTR standard does not reflect the approach used in the Great Lakes Initiative, where an objective of 0.0031 µg/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 0.002 µg/L to 0.005 µg/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 0.0013 µg/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 0.0006 µg/L to 0.0018 µg/L, with an average of 0.0009 µg/L for the species considered. The Mercury Report to Congress also identified a methylmercury criterion of 0.00005 µg/L (0.05 nanograms per liter (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.

Total mercury concentrations in the upper portion of the Sacramento River mainstem from Red Bluff to Keswick and in the American River were rarely observed to exceed the CTR standard for mercury. Mercury concentrations in all other major tributaries and in the Sacramento River from Colusa to River Mile 44 exceeded 0.050 µg/L in only a few samples. Mercury concentrations in Cache Creek exceeded the 0.050 µg/L limit in 22% of samples, based on data collected by USGS from 1996 through 1999. Mercury concentrations in Mill Creek exceeded the 0.050 µg/L limit in 10 to 33% of samples, based on data collected by DWR in 1998-99. Data for Deer Creek and Big Chico Creek for this same period from indicates that the CTR criterion was met in nearly every sample. A once-in-three-year exceedance frequency is equivalent to a probability of meeting the criterion approximately 99.9% of the time.

In comparison with total mercury advisory criteria in the range from 0.002 to 0.005 µg/L (as indicated by staff of USEPA Region IX) for human health protection, or at the 0.0013 µg/L levels (as has been adopted in the Great Lakes for wildlife protection), ambient water column levels of total mercury almost always exceed these values at all sites tested throughout the Sacramento River watershed. In comparison with the 0.0031 µg/L Great Lakes criterion for the protection of human health, the Sacramento River above Hamilton City exceeded this criterion in less than 40% of samples, while in the Sacramento River from Colusa to River Mile 44, the 0.0031 µg/L limit was exceeded in 73–95% of samples collected. This limit was exceeded in fewer than 20% of samples from Deer Creek and Big Chico Creek, and in nearly every sample from Mill Creek.

The Great Lakes Initiative adopted a human health-based methylmercury criterion of 0.00024 µg/L (0.24 ng/l). Methylmercury concentrations measured by USGS at three mainstem Sacramento River sites (1996–98) exceeded that value in less than 25% of samples, and methylmercury concentrations in two agricultural drain sites exceeded that value in less than 35% of samples. In comparison with the wildlife-based methylmercury advisory criterion of 0.00005 µg/L (0.05 ng/l) identified in the Mercury Report to

Congress by USEPA, USGS concentrations exceeded that value in nearly every sample collected (see Figure 6b).

The percentage of data meeting specific regulatory or advisory thresholds are summarized in Table 7.

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 standard 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 standard 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 standard (USEPA)

(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.

Fish Tissue

The levels of mercury 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".

Threshold Values

Mercury concentrations in composite fish tissue samples were compared with several different advisory thresholds 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 0.60 mg/kg (USEPA national screening value) to 0.14 mg/kg (California Department of Fish and Game screening value used in San Francisco Bay; SFRWQCB 1996). 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 screening/threshold values are risk-based advisory values against which tissue concentrations can be compared to determine whether more intensive monitoring, evaluation or management is warranted. Note that these risk-based values are based on assumed fish consumption rates for humans 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. The consumption rates associated with each limit are specified in Table 6.

Comparison with Fish Tissue Threshold Values

Fish tissue data from the SRWP monitoring effort at various locations were compared with fish tissue advisory values. SRWP data included mercury concentrations in composite samples comprised of fish of similar legal catchable size and in individual fish (Figure 5).

- 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 collected (typically from the lower Sacramento River and tributaries from Colusa to Cache Slough).
- Fish tissue mercury concentrations were greater than USEPA's human health-based screening value (0.6 mg/kg) in individual and composite largemouth bass samples collected from most locations in the lower watershed (below the confluence with the Feather River). 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. One individual white catfish, two striped bass, and one Sacramento pikeminnow (squawfish) also exceeded 1.0 mg/kg.
- None of the tissue samples collected in the Sacramento River above the confluence with the Feather River contained concentrations greater than 0.6 mg/kg, with four fish species represented. All rainbow trout from the Sacramento River at Red Bluff and Keswick and in tributaries above Lake Shasta were lower than the lowest screening value. One white catfish composite from Sacramento Slough exceeded the 0.6 mg/kg Screening Value.

Table 6. Threshold and Screening Values for Mercury in Fish Tissue

Basis for limit	Concentration in tissue, mg/kg	Description	Reference
Human Health	1.0	FDA Action Level[a]	FDA (vm.cfsan.fda.gov/~dms/)
Human Health	1.0	Corresponds to ATSDR minimum risk level assuming a 60 kg individual and 18 g/day consumption[b]	ATSDR 1999 (www.atsdr.cdc/gov/press/ma990419.html)
Human Health	0.6	USEPA Screening Value	USEPA 1995
Human Health	0.33	Corresponds to USEPA RfD assuming a 60 kg individual and 18 g/day consumption	Mercury Report to Congress, Vol. VI (USEPA 1997)
Human Health	0.14	Screening value calculated by SFRWQCB[c]	SFRWQCB 1995
Human Health	0.23	Screening value calculated by San Francisco Estuary Institute (SFEI)[d]	SFEI 1999
Wildlife[e]	0.08 0.34	Hg criterion in trophic level 3 fish Hg criterion in trophic level 4 fish	Mercury Report to Congress, Vol. VI (USEPA 1997)

(a) The FDA Action Limit is based on a consumption rate of 6.5 g/day.
(b) 60 kg is used by USEPA as the default body weight for an adult female in calculations of the RfD (USEPA 1997). 18 g/day (rounded from 17.8 g/day) is the default fish intake rate proposed by USEPA for protection of the general population and sport anglers (USEPA 1998)
(c) Screening value calculated using USEPA Guidance, and 30 g/day consumption rate.
(d) Screening value calculated using USEPA Guidance, 30 g/day consumption rate, and an updated reference dose.
(e) Lowest average criterion, based on the average for all mammalian wildlife species studied in Mercury Report to Congress.

Table 7. Comparisons With USEPA Total Mercury Water Quality Criteria for Human Health

Location [Monitoring Program]	% of data meeting USEPA criteria for protection of human health[a] 1997 USEPA 3.1 ng/L Great Lakes std	1985 USEPA 12 ng/L criterion	1999 USEPA 50 ng/L criterion
Spring Creek PP Discharge to Keswick Res.	100%	100%	100%
Sacramento River below Keswick	95%	100%	100%
Sacramento River above Bend Bridge	60%	97%	100%
Mill Creek at Mouth	14%	69%	90%
Mill Creek at Black Rock	15%	50%	80%
Mill Creek at Highway 36	0%	13%	66%
Sacramento River near Hamilton City	66%	84%	100%
Deer Creek at Mouth	100%	100%	100%
Deer Creek at Upper Diversion Dam	88%	100%	100%
Deer Creek at Ponderosa Way	94%	100%	100%
Deer Creek below Childs Meadows	100%	100%	100%
Big Chico Creek above Mud Creek	93%	100%	100%
Mud Creek above Big Chico Creek	83%	88%	98%
Big Chico Creek at Chico (Rose Ave.)	100%	100%	100%
Big Chico Creek above Salmon Hole	83%	100%	100%
Big Chico Creek at Hwy 32	100%	100%	100%
Sacramento River at Colusa	27%	78%	97%
Sacramento Slough	0%	80%	100%
Colusa Basin Drain	2%	84%	100%
Yuba River at Marysville	54%	86%	100%
Feather River near Nicolaus	8%	88%	100%
Sacramento River at Verona	5%	86%	100%
Sacramento River at Veterans Bridge	0%	74%	100%
Arcade Creek at Norwood Ave.	4%	76%	99%
American River at Discovery Park	53%	98%	100%
Sacramento River at Freeport	7%	78%	100%
Sacramento River at River Mile 44	5%	72%	99%
Cache Creek at Rumsey	4%	48%	78%
Cache Slough near Ryers Ferry	0%	84%	100%
Yolo Bypass near Woodland	0%	0%	89%

(a) See text for explanation of calculation of probabilities of meeting criteria.

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?

For mercury, the beneficial uses of greatest potential concern 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 each side of the watershed. Based on these advisories (which recommend eating limited amounts 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 these two Coast Range reservoirs.

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. While the water column data from the SRWP and other monitoring programs indicate mixed results, depending on the criteria used, mercury concentrations in fish tissue indicate that levels of mercury in certain species are at levels of potential concern. The available fish tissue data from the SRWP 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 both wet season and annual average mercury concentrations and streamflows.

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).

A wet season mass balance for mercury was developed for the Delta Tributary Mercury Council by Larry Walker Associates. This mass balance was based on available mercury concentration and stream flow data for wet weather periods. The wet season mass balance corroborates earlier findings that show that the Cache Creek watershed is the source of most total mercury in the Sacramento River watershed (approximately 80 percent). This mass load is associated with a tributary which only produces 4 percent of the annual stream flow to the Delta. The LWA estimates also indicate that Cottonwood Creek and Thomes Creek produce proportionately more mercury than would be expected based on stream flow percentages. Cottonwood Creek is estimated to contribute about 8 percent of the total mercury load, with a stream flow percentage totaling 5 percent of the total. Similarly, estimates for Thomes Creek are 4 percent of wet weather mercury loads

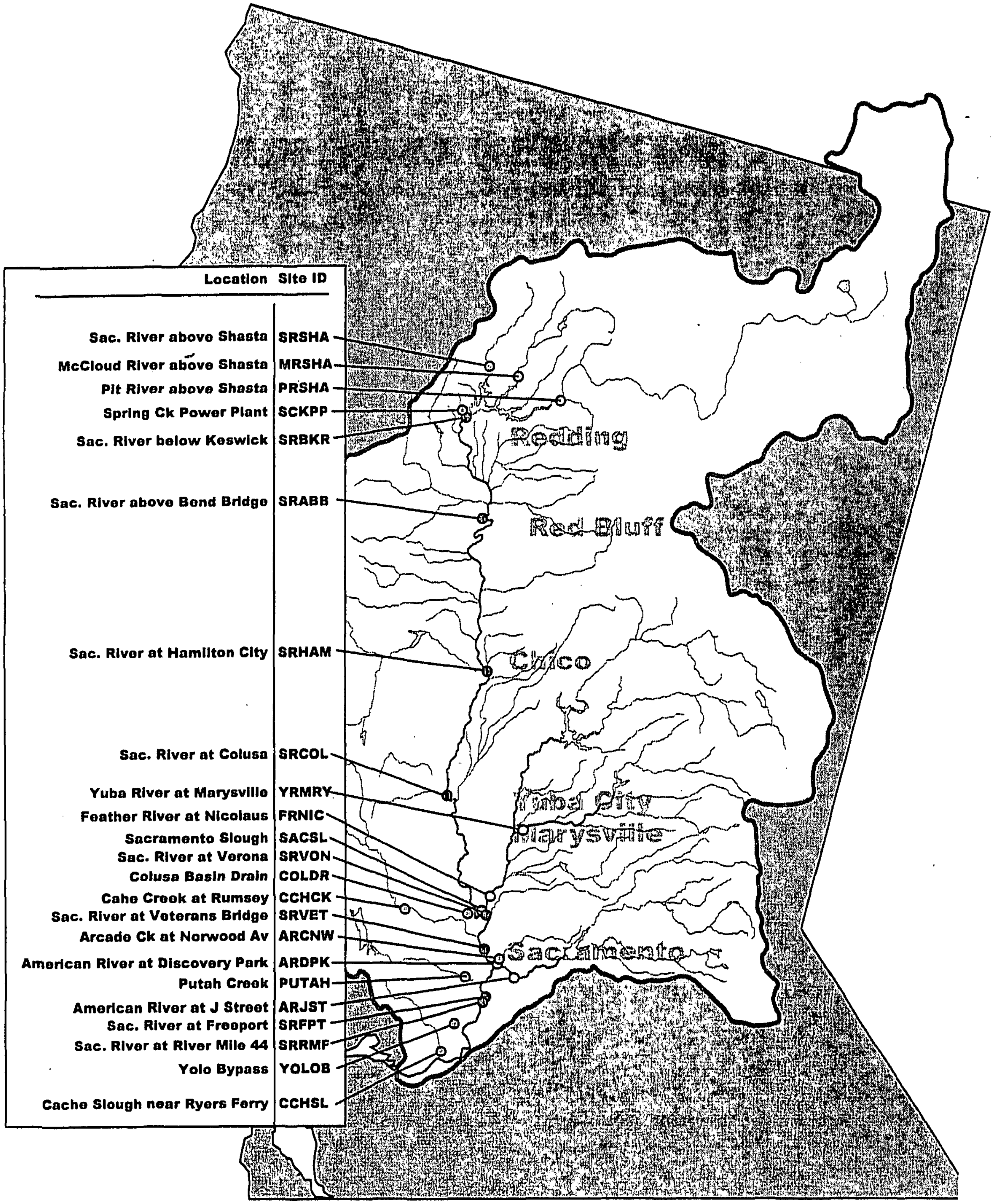


Figure 2. Mercury Monitoring Sites for the Sacramento River Watershed Program: USGS NAWQA, City of Redding, Sacramento River CMP, and SRWP

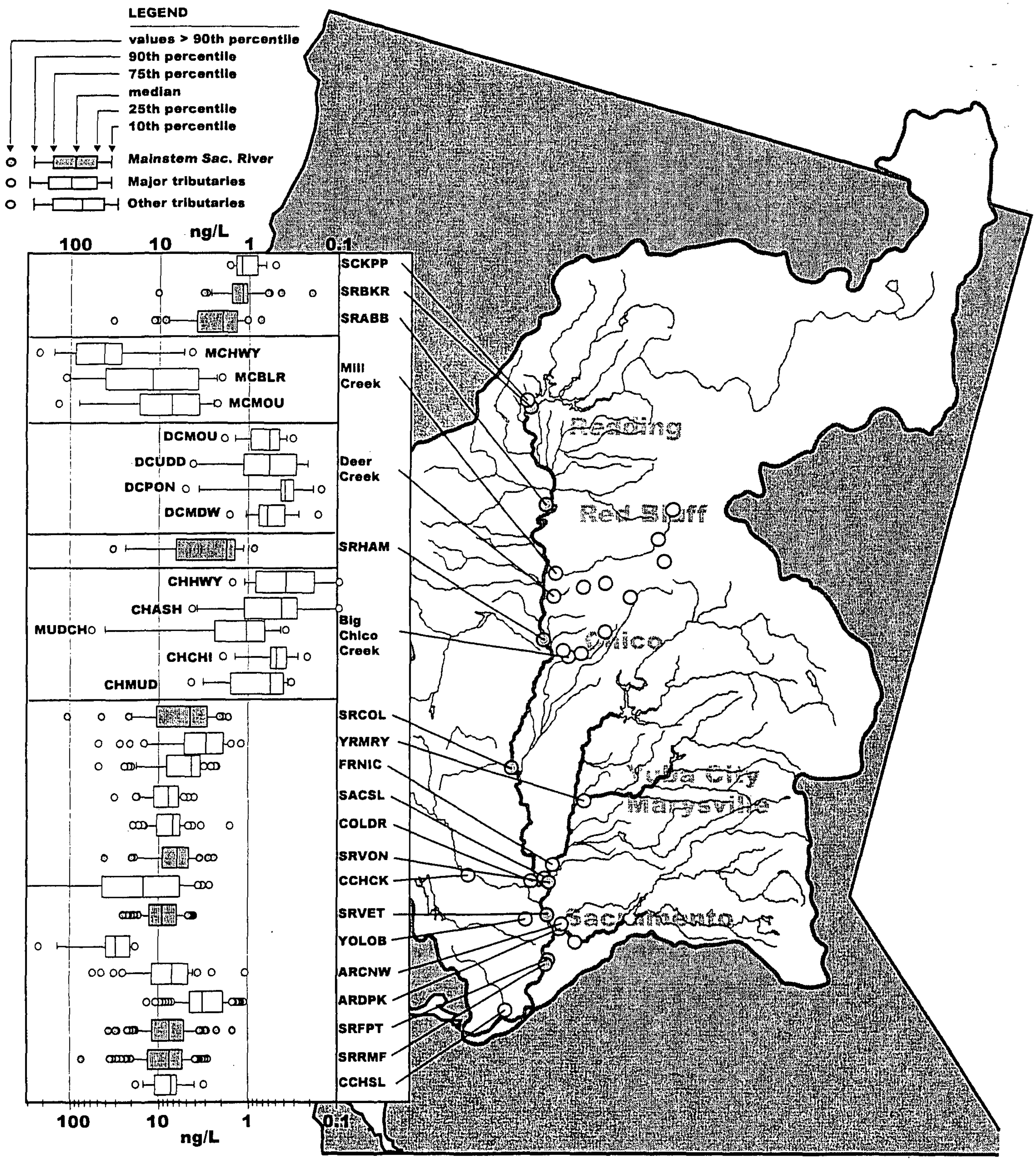


Figure 3. Mercury in the Sacramento River Watershed, *Total Mercury Concentrations in Water*

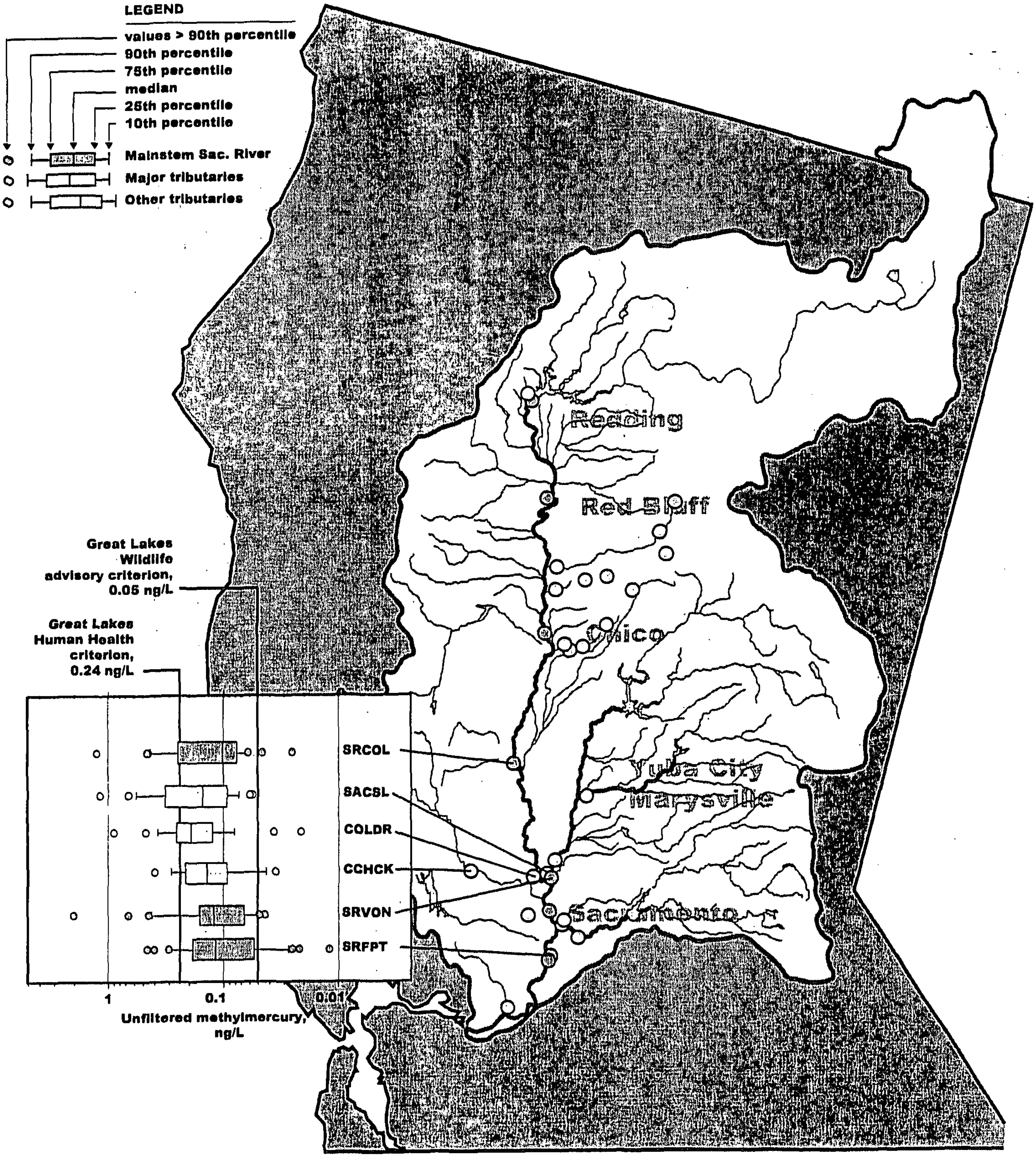


Figure 4. Methylmercury in the Sacramento River Watershed, Unfiltered Methylmercury Concentrations in Water

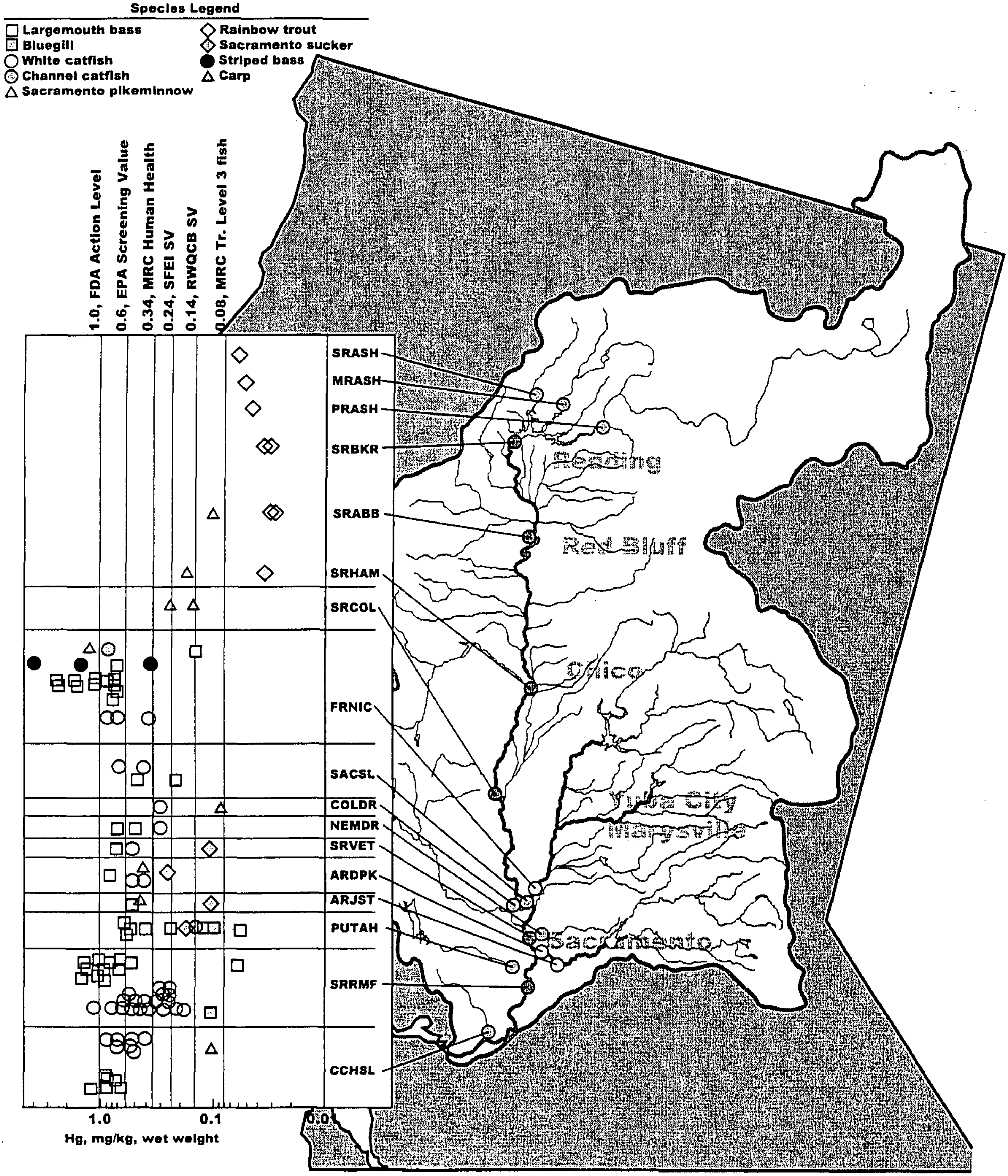


Figure 5. Mercury in Fish Tissue in the Sacramento River Watershed, SRWP Data, 1997, 1998, and 1999

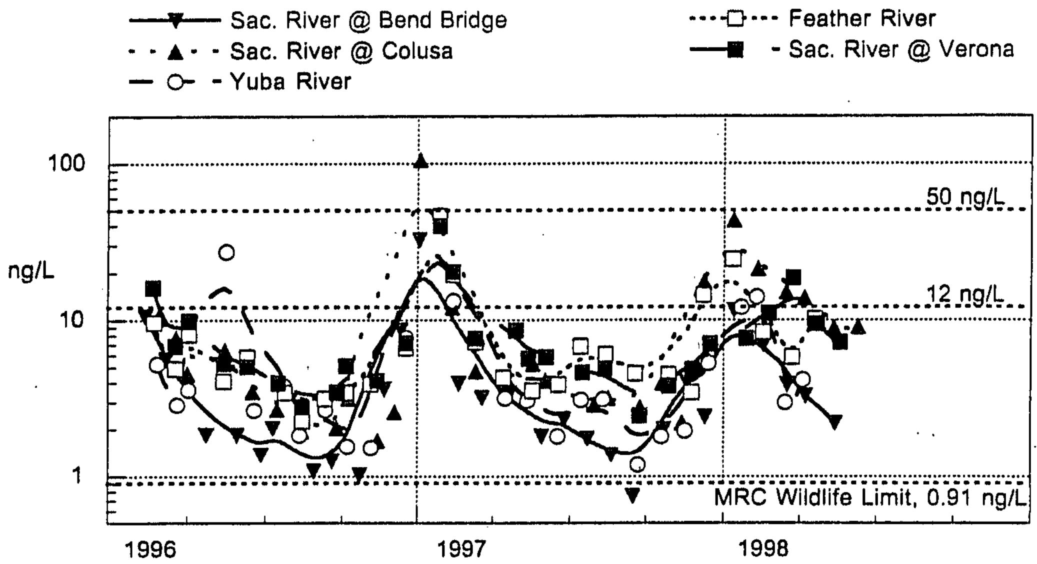


Figure 6a. Total mercury in water: USGS NAWQA data, 1996-98.

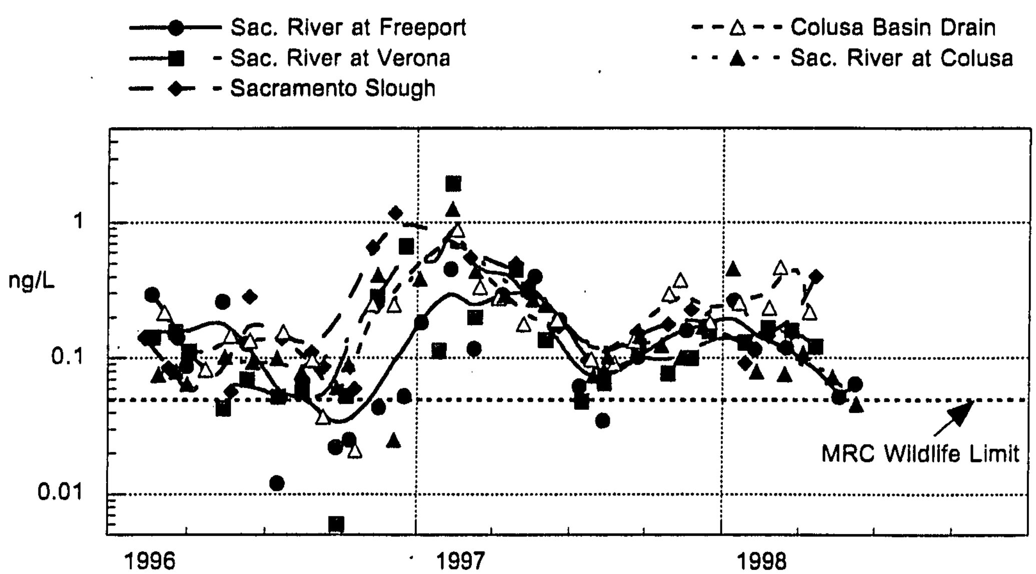


Figure 6b. Total methylmercury in water: USGS NAWQA data, 1996-98.

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 F. 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.

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 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 trace metals 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 trace metals in water	Numerous locations in Deer Ck, Mill Ck, Big Chico Ck

ii. Spatial Distribution & Patterns

Data have been evaluated for spatial trends 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 F.

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 (0.58 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 between 15 µg/L and 69 µg/L. 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 – 0.26 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 variable in the three smaller tributaries (Mill, Deer, and Big Chico creeks). The highest total arsenic concentrations observed were at Mill Creek 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 at Sacramento River at Veterans Bridge (0.74 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). 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. 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.

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 (4.8 µg/L). The median total nickel concentration in the American River (1 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 (4.0 µg/L and 3.7 µg/L, respectively). The median total concentration at Cache Slough near Ryers Ferry (7.5 µg/L) is 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 2.4 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 observed 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 main tributaries, most dissolved nickel data were below the USGS reporting limit (1 µg/L), and it is clear that dissolved nickel concentrations are lower in the main tributaries 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 6.0 µg/L for the Sacramento River at River Mile 44. The median total concentration in the American River (4.0 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 (4.9 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 was 2.8 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 1.1 µg/L and <0.5 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), Cache Creek, and the Yolo Bypass 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 H of this report.

iv. Attainment of Beneficial Uses and Potential Impairment

Comparisons with water quality criteria: Total and dissolved trace metals concentrations were compared to CTR water quality standards and Central Valley Region Basin Plan objectives (Table 11). Trace metals concentrations in the Sacramento River mainstem and in the American River were rarely observed to exceed CTR standards or other water quality objectives for trace metals. Dissolved concentrations of copper for the American

River at J Street and Arcade Creek exceeded the hardness-adjusted[1] chronic criterion in one sample for each of these locations. Dissolved copper concentrations exceeded the CTR hardness-adjusted chronic criterion (4.4 µg/L as dissolved copper at a median hardness of 37 mg/l as $CaCO_3$) in approximately 10% of the samples from Sacramento River below Keswick location, and exceeded the median hardness-adjusted Basin Plan objective (6.1 µg/L) in one sample from this site (Figures 14a and 14b). Dissolved copper concentrations were not observed to exceed CTR standard values or other applicable water quality objectives in the Sacramento River mainstem from Red Bluff to Freeport. Dissolved copper exceeded the CTR standard in only one sample below Freeport (collected in November 1994 from River Mile 44). It should be noted that CTR chronic criteria are expressed as 4-day average values, and because all samples are essentially instantaneous grabs, actual 4-day average concentrations may not have exceeded the CTR standard.

Concentrations of other trace metals were not observed to exceed CTR standards or Basin Plan objectives at any location. Since 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 standards occurred. 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 "always" meet the CTR standards (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 exception of dissolved copper concentrations in the Sacramento River below Keswick Reservoir. Compliance statistics with CTR standards 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?
With the exception of the arsenic criterion, which is based on protection of human health, CTR water quality standards for the trace metals of interest are based on the protection of aquatic life. The CTR standards define what USEPA believes to be "safe levels", rather than toxicity threshold levels. Because these standards 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 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 cadmium, copper, lead, and zinc. 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

[1] Hardness-adjusted criteria were calculated using the median hardness for the specific monitoring location.

listings for copper, nickel, and selenium for the San Francisco Bay Estuary and the Sacramento-San Joaquin Delta, attributed to a variety of sources. Observed exceedances of CTR dissolved copper standards in the Sacramento River immediately below Keswick Reservoir appears 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 standards or Basin Plan objectives for these metals (1.2 µg/L and 0.25 µg/L, respectively, as dissolved cadmium; and 59 µg/L and 31 µg/L, respectively, as dissolved zinc).

For the period monitored by 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 all major tributaries (Feather River, Yuba River, and American River), and in the two major agricultural drain monitored (Colusa Basin Drain and Sacramento Slough). However, in the Sacramento River between Shasta Dam and Red Bluff, dissolved copper concentrations may exceed levels potentially harmful to sensitive aquatic species.

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

	Arsenic, total		Cadmium, dissolved		Chromium, dissolved	Copper, dissolved		Lead, dissolved	Nickel, dissolved	Selenium, total	Silver, dissolved		Zinc, dissolved	
Location	CTR	BP	CTR	BP	CTR	CTR	BP	CTR	CTR	CTR	CTR	BP	CTR	BP
Sacramento River below Keswick	*150*	*10*	*1.2*	*0.25*	*91*	*4.4*	*6.1*	*1.0*	*26*	*5*	*0.84*	*10*	*59*	*31*
Sacramento River above Bend Bridge	150	10	1.3	0.28	98	4.8	6.6	1.1	28	5	0.98	10	63	34
Mill Ck at Mouth	150	NA	1.2	0.24	87	4.3	5.9	0.97	25	5	0.78	10	57	30
Mill Ck at Black Rock	150	NA	1.1	0.21	81	3.9	5.4	0.87	23	5	0.65	10	52	27
Mill Ck at Highway 36	150	NA	1.4	0.32	109	5.4	7.5	1.3	31	5	1.23	10	71	38
Deer Creek at Mouth	150	NA	1.7	0.43	133	6.6	9.3	1.7	38	5	1.87	10	87	49
Deer Creek at Upper Diversion Dam	150	NA	1.0	0.19	74	3.6	4.9	0.76	21	5	0.54	10	47	24
Deer Creek at Ponderosa Way	150	NA	1.4	0.3	104	5.1	7.1	1.2	30	5	1.12	10	68	36
Deer Creek below Childs Meadows	150	NA	0.63	0.09	44	2.1	2.7	0.37	12	5	0.18	10	28	13
Big Chico Ck above Mud Ck	150	NA	1.6	0.39	124	6.1	8.6	1.5	36	5	1.60	10	81	45
Mud Ck above Big Chico Ck	150	NA	1.2	0.24	87	4.3	5.9	0.97	25	5	0.78	10	57	30
Big Chico Ck at Chico (Rose Ave.)	150	NA	1.8	0.44	136	6.8	9.6	1.8	39	5	1.96	10	89	50
Big Chico Ck below Five-Mile Rec.	150	NA	1.9	0.49	145	7.2	10	1.9	42	5	2.25	10	96	54
Big Chico Ck at Golf Course	150	NA	1.8	0.46	141	7.0	9.9	1.8	41	5	2.10	10	93	52
Big Chico Ck above Salmon Hole	150	NA	1.8	0.44	136	6.8	9.6	1.8	39	5	1.96	10	89	50
Sacramento River near Hamilton City	150	10	1.4	0.32	107	5.3	7.4	1.3	31	5	1.20	10	70	38
Sacramento River at Colusa	150	10	1.4	NA	104	5.1	10	1.2	30	5	1.12	10	68	100
Sacramento Slough	150	NA	2.7	NA	221	11.2	NA	3.3	65	5	5.42	NA	148	NA
Colusa Basin Drain	150	NA	3.5	NA	288	14.8	NA	4.7	86	5	9.48	NA	194	NA
Yuba River at Marysville	150	NA	0.9	NA	66	3.2	NA	0.66	19	5	0.43	NA	43	NA
Feather River near Nicolaus	150	NA	1.1	NA	77	3.7	NA	0.81	22	5	0.60	NA	50	NA
Sacramento River at Verona	150	10	1.4	NA	107	5.2	10	1.3	31	5	1.18	10	70	100
Sacramento River at Veterans Bridge	150	10	1.5	NA	116	5.7	10	1.4	34	5	1.41	10	76	100
Arcade Ck at Norwood Ave.	150	NA	2.0	NA	154	7.7	NA	2.1	45	5	2.56	NA	102	NA
American River at J Street	150	10	0.7	NA	48	2.3	10	0.42	13	5	0.22	10	30	100
American River at Discovery Park	150	10	0.8	NA	55	2.6	10	0.52	16	5	0.30	10	35	100
Sacramento River at Freeport	150	10	1.3	NA	101	5.0	10	1.2	29	5	1.05	10	66	100
Sacramento River at River Mile 44	*150*	*10*	*1.4*	*NA*	*105*	*5.2*	*10*	*1.2*	*30*	*5*	*1.14*	*10*	*68*	*100*
Cache Slough near Ryers Ferry	150	NA	1.7	NA	133	6.6	NA	1.7	38	5	1.87	NA	87	NA

CTR criteria are California Toxic Rule (USEPA 2000) chronic criteria for protection of aquatic life.
CTR criteria for cadmium, chromium, copper, lead, nickel, silver and zinc are adjusted for median hardness.
Basin Plan values are Central Valley Region Basin Plan water quality objectives for the protection of aquatic life.
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, total CTR	Arsenic, total 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	90	99	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	T>C	T>C	T>C	100	100	T>C	T>C	100	100
Mill Ck at Black Rock	100	—	100	100	100	T>C	T>C	T>C	100	100	T>C	T>C	100	100
Mill Ck at Highway 36	100	—	100	100	100	T>C	T>C	T>C	100	100	T>C	T>C	100	100
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	100	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	100	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	96	NA	100	100	—	100	NA	100	NA
American River at J Street	100	100	100	NA	100	97	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	99.6	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

Comparisons of mass load contributions from major Delta inputs could not be adequately evaluated, 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. 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

- Aquatic life uses are typically the most sensitive to trace metal concentrations. In comparisons to CTR water quality standards 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. The notable exception is that dissolved copper concentrations in individual samples continue to exceed hardness-adjusted CTR chronic standards for copper approximately 10% of the time in the Sacramento River below Keswick Reservoir. This result indicates a potential impact on sensitive aquatic life species in this reach of the Sacramento River.

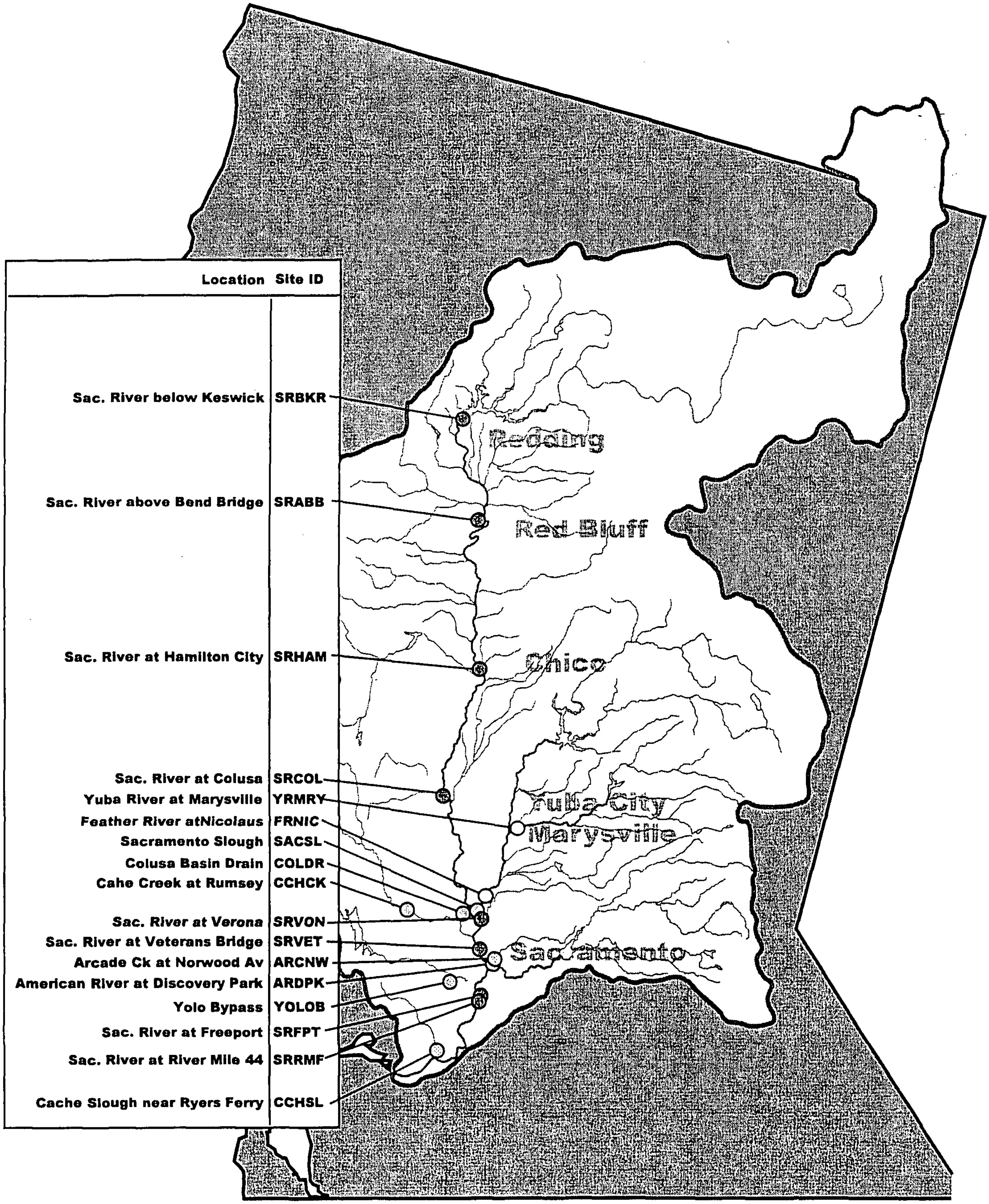


Figure 7. Trace Metals Monitoring Sites for the Sacramento River Watershed Program, USGS NAWQA, City of Redding, Sacramento River CMP, and SRWP

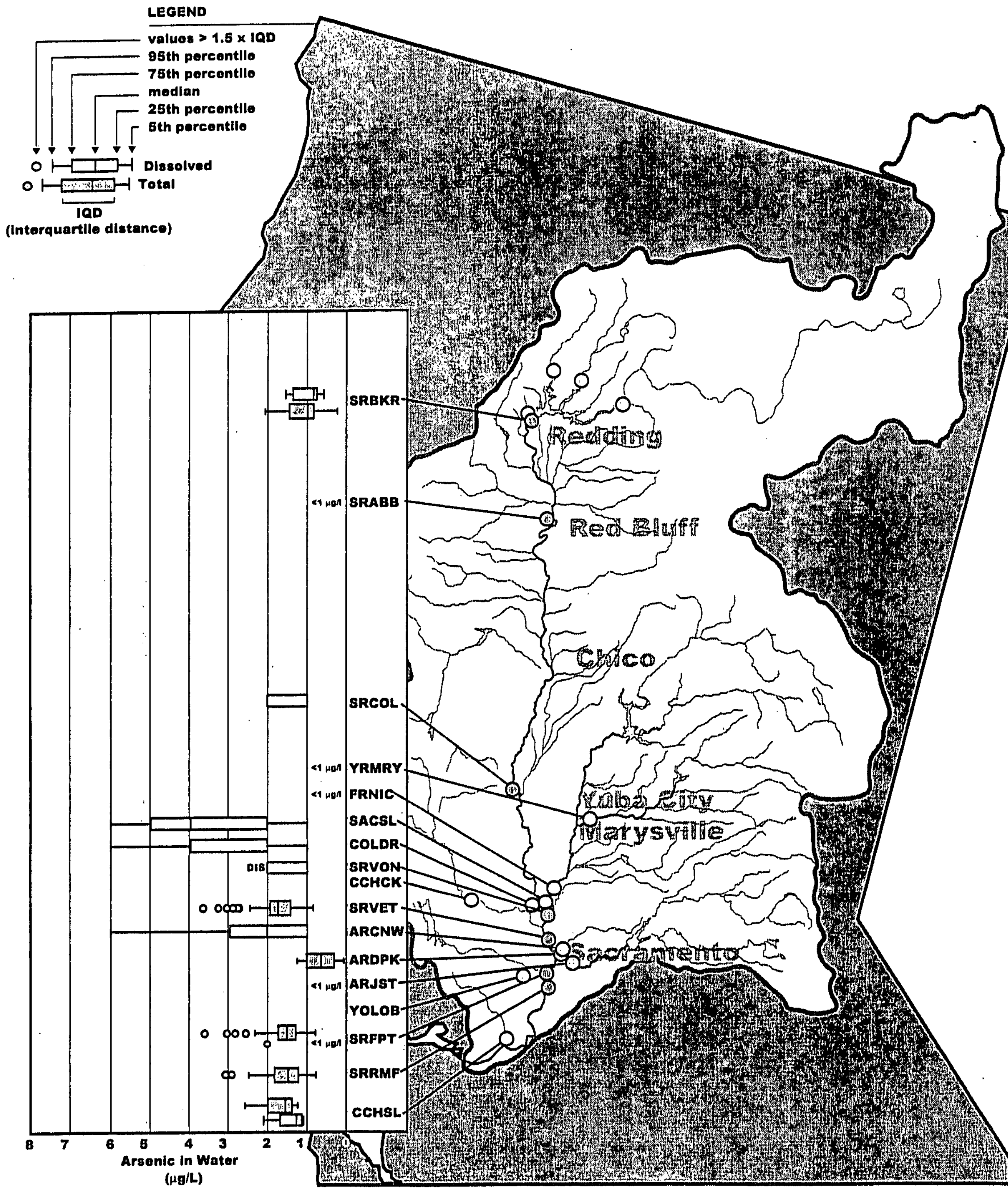


Figure 8. Distribution of Arsenic in the Sacramento River Watershed, Total and Dissolved Arsenic Concentrations, 1994-1999

TO BE UPDATED FOR PUBLIC DRAFT

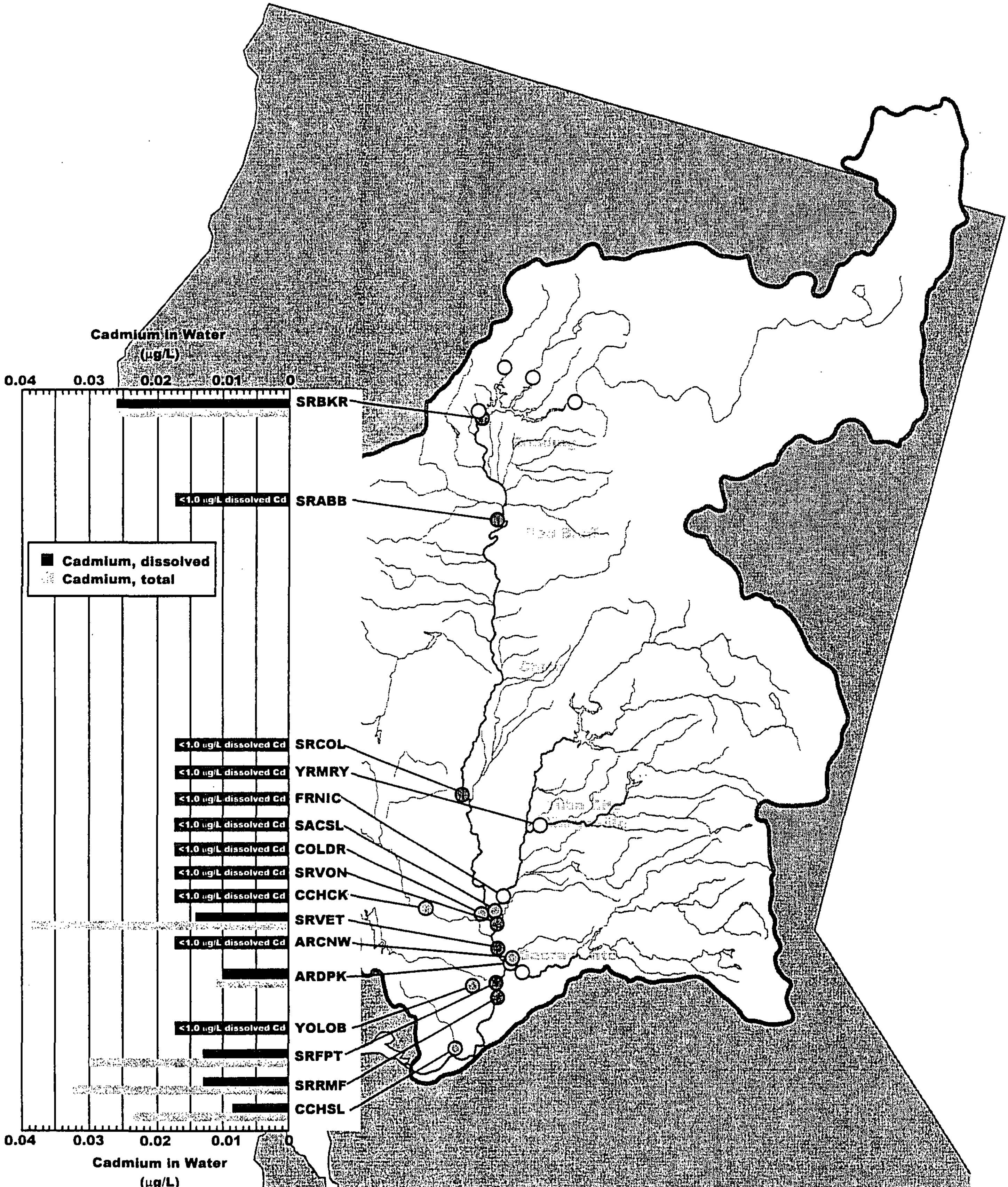


Figure 9. Distribution of Cadmium in the Sacramento River Watershed, Median Cadmium Concentrations, 1996-1999

TO BE UPDATED FOR PUBLIC DRAFT

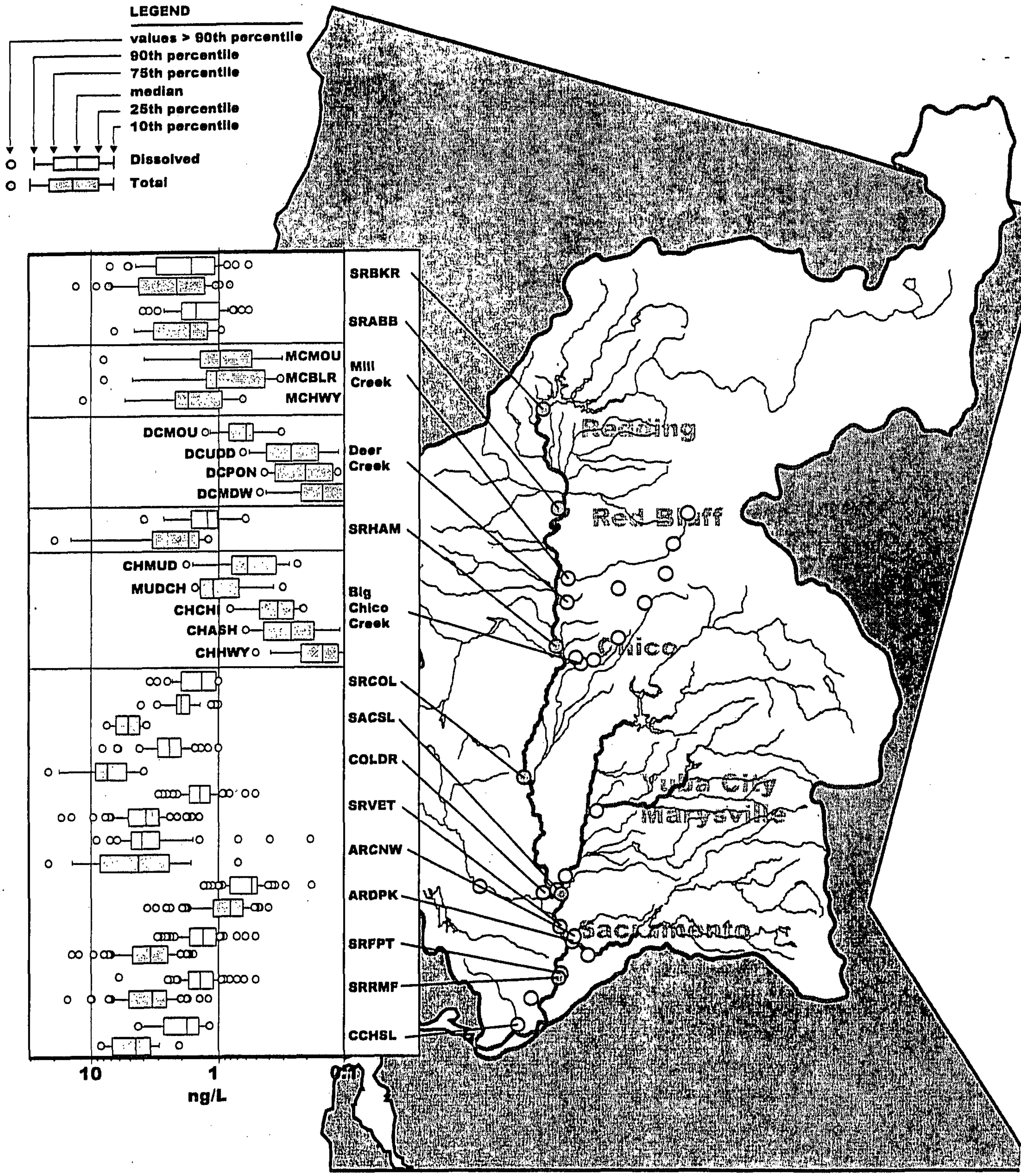


Figure 10. Distribution of Copper in the Sacramento River Watershed Total and Dissolved Copper Concentrations in Water

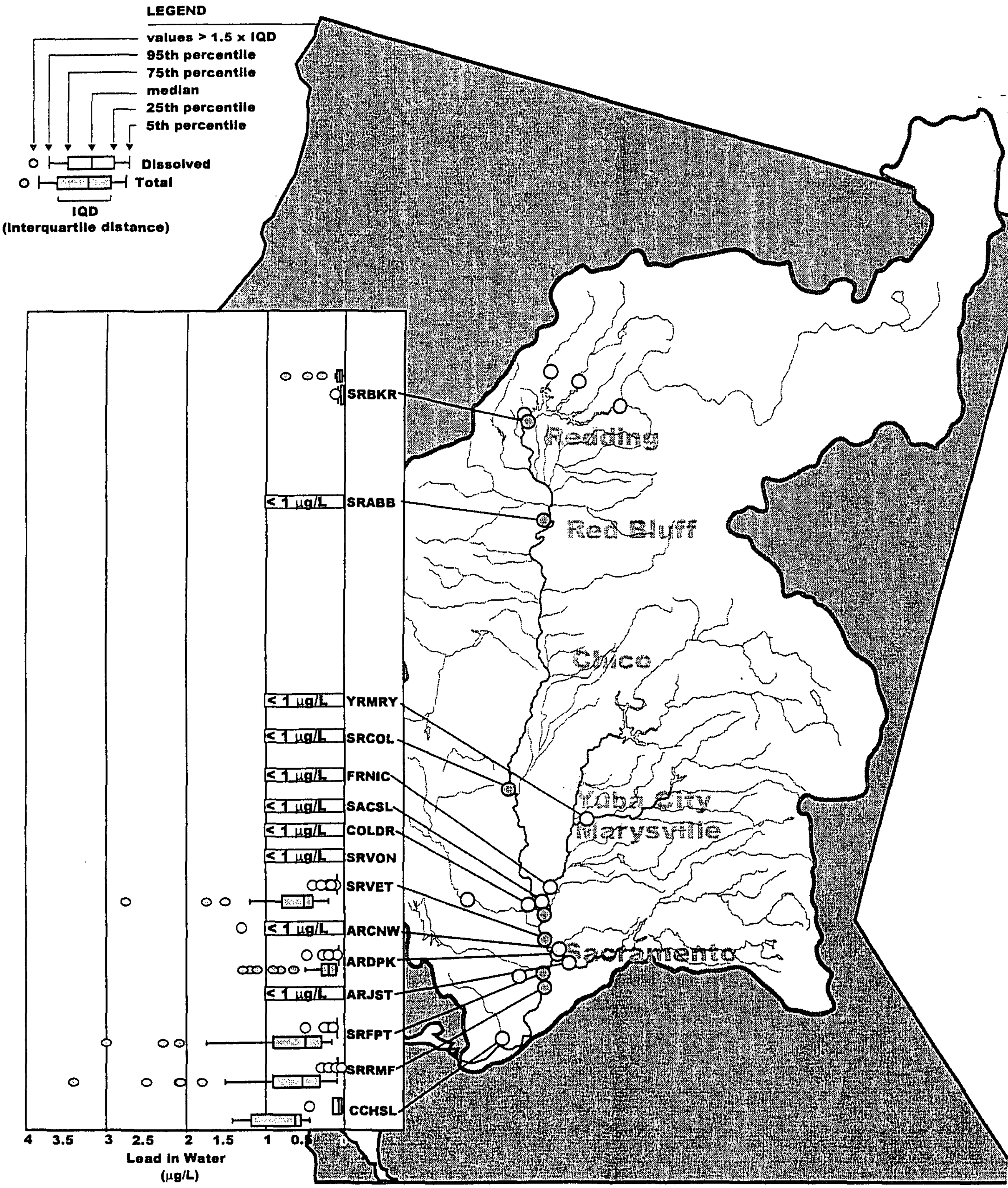


Figure 11. Distribution of Lead in the Sacramento River Watershed,
Total and Dissolved Lead Concentrations, 1994-1999

TO BE UPDATED FOR PUBLIC DRAFT

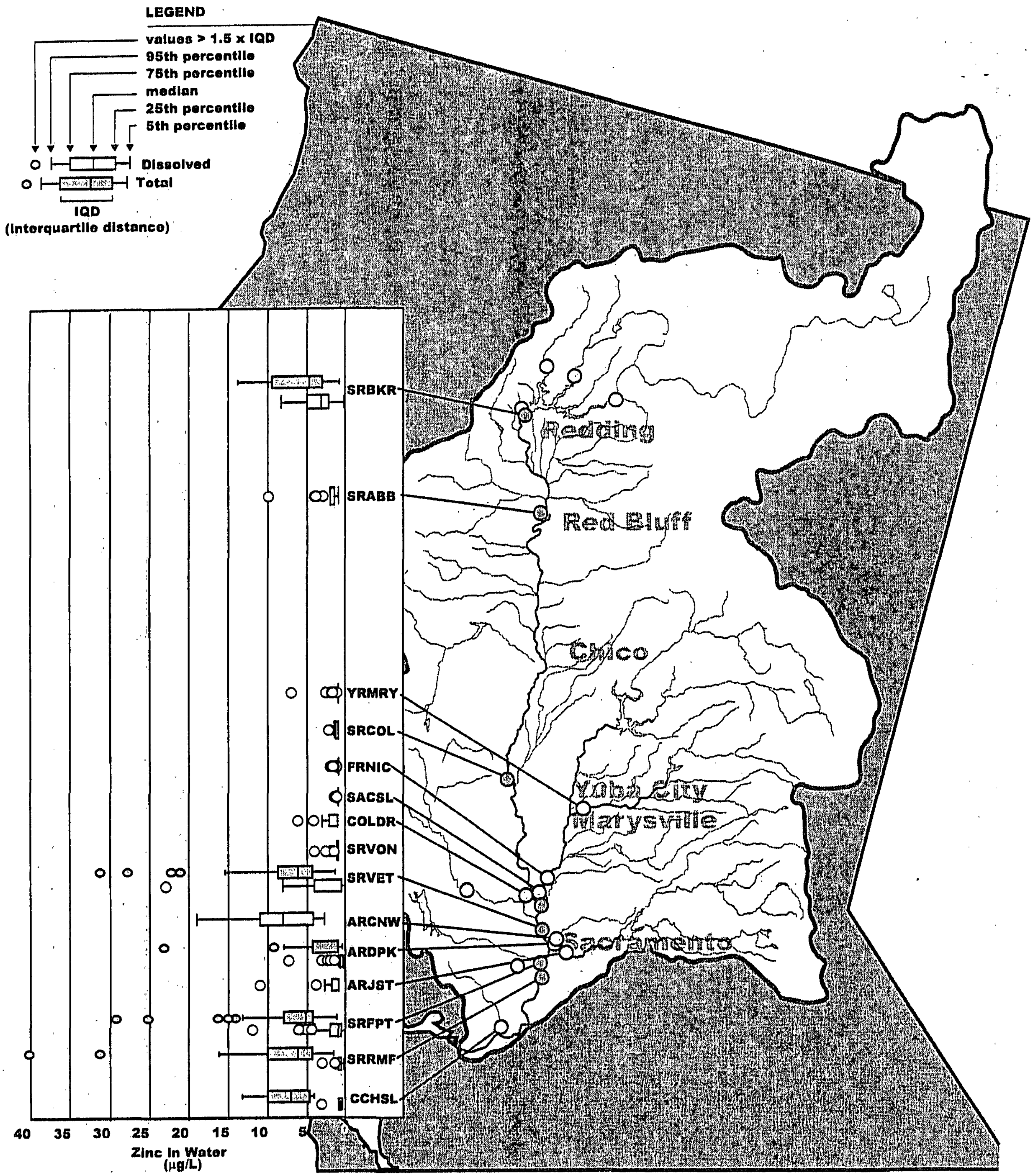


Figure 12. Distribution of Zinc in the Sacramento River Watershed, Total and Dissolved Zinc Concentrations, 1994-1999

TO BE UPDATED FOR PUBLIC DRAFT

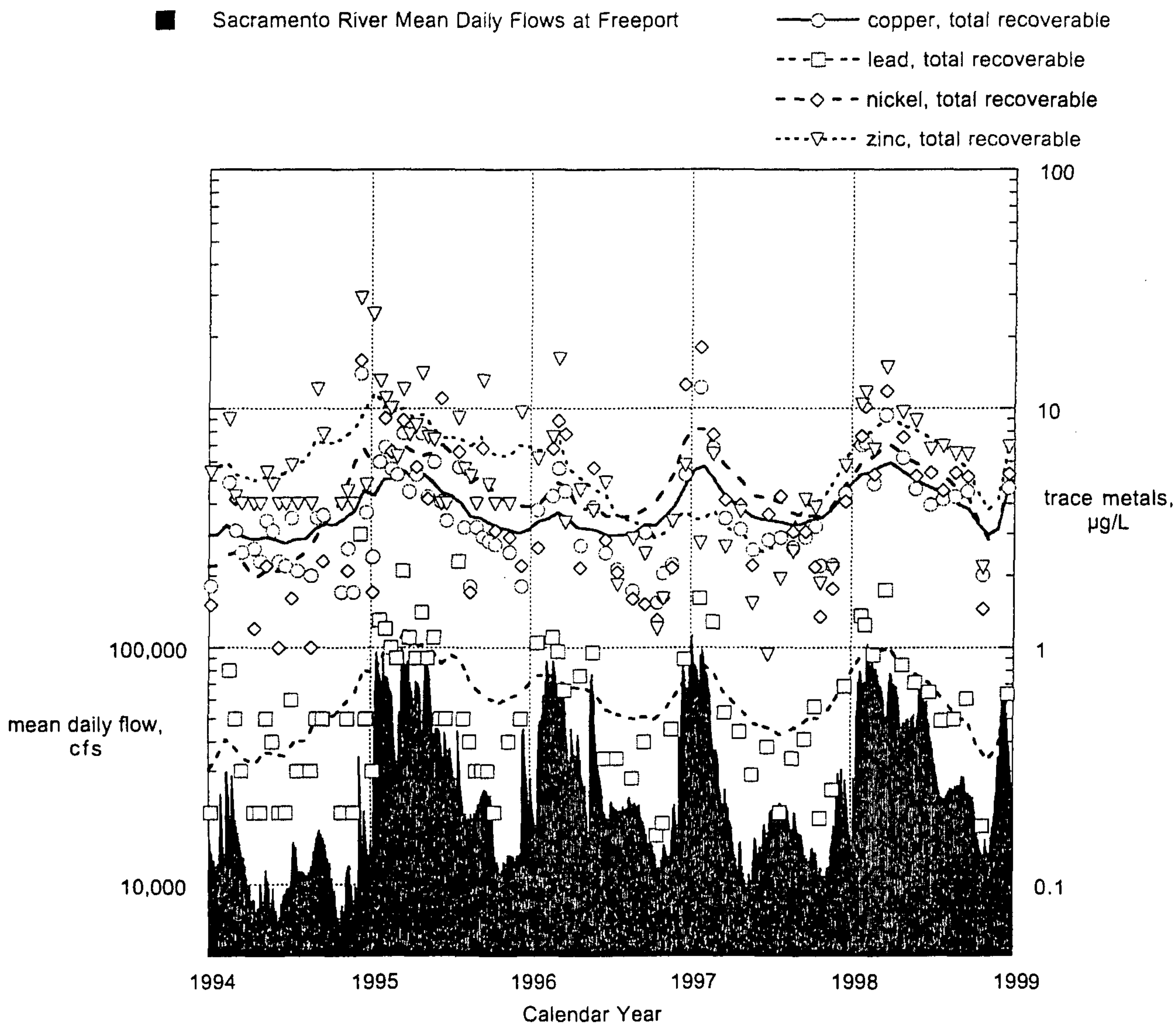


Figure 13. River flows and total recoverable trace metal concentrations, Sacramento River at Freeport, Sacramento River CMP data, 1994—1998

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 F. 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 c2. 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 C1. 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 x 1,000)	Total 1999 use[3], lbs x 1000	Number of monitoring results in DPR SW DB
Diazinon	Insecticide	Pest control[2] (346), Almonds (124), lettuce (115), walnuts (146), stonefruit[1] (110)	921	849
Carbofuran	Insecticide	Alfalfa (64), rice (29), grapes (18)	138	768
Malathion	Insecticide	Alfalfa (246), oranges (71), strawberries (76), pest control[2] (58), lettuce (46),	692	613
Methyl parathion	Insecticide	Walnut (60), stonefruit[1] (45), pears (23), apples (13)	165	584
Molinate	Herbicide	Rice (913)	913	530
Simazine	Herbicide	Oranges (214), grapes (166), almonds (56), walnuts (37)	695	481
Thiobencarb	Herbicide	Rice (734)	735	443
Atrazine	Herbicide	Forest trees (28), corn (16), sudan grass (15)	69	373
Chlorpyrifos	Insecticide	Pest control[2] (526), Almonds (203), cotton (275), landscape maintenance (158), walnuts (146), alfalfa (188), broccoli (76), stonefruit (71)	2,205	370
Carbaryl	Insecticide	Citrus crops (60), nut crops (56), stonefruit[1] (51) , apples (31), tomatoes (31), landscape maintenance (9)	386	364
Fonofos	Insecticide	Broccoli (6), beans (5), tomatoes (5)	25	349

1 apricot, nectarines, peaches, plums, prunes
2 public health and structural pest control
3 total lbs used in California in 1999 (DPR 2000)

Table C2. 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

- 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.

- 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.

- 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.

- 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.

- 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.

- 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.

- 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.

- 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 F.

Table C3. 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)	Total 1999 use[3], lbs x 1000	Number of results in DPR SW DB
Aldicarb	Insecticide	Cotton (267), sugarbeets (5), greenhouse and container grown plants (4)	280	751
Bromacil	Herbicide	Citrus crops (53), rights of way (16), landscape maintenance (3)	80	303
Carbaryl	Insecticide	Citrus crops (60), nut crops (56), stonefruit[1] (51) , apples (31), tomatoes (31), landscape maintenance (9)	386	364
Carbofuran	Insecticide	Alfalfa (64), rice (29), grapes (18), cotton (13)	138	768
Chlorpyrifos	Insecticide	Pest control[2] (526), Almonds (203), cotton (275), landscape maintenance (158), walnuts (146), alfalfa (188), broccoli (76), stonefruit (71)	2,205	370
Diazinon	Insecticide	Pest control[2] (346), Almonds (124), lettuce (115), walnuts (146), stonefruit[1] (110)	921	849
Diuron	Herbicide	Rights of way (497), citrus crops (233), alfalfa (216), landscape maintenance (39),	1,161	307
Malathion	Insecticide	Alfalfa (246), oranges (71), strawberries (76), pest control[2] (58), lettuce (46),	692	613
Prometon	Herbicide	landscape maintenance (0.0021), indoor and greenhouse-grown plants (0.0017)	0.0041	317
Propazine	Herbicide	Rights of way (0.020), greenhouse-grown flowers (0.005)	0.025	0
Prowl (pendimethalin)	Herbicide	Cotton (188), landscape maintenance and rights of way (60), nut crops (40)	415	98
Tebuthiuron	Herbicide	Rights of way (4.9), landscape maintenance (0.6)	5.6	134

1 apricot, nectarines, peaches, plums, prunes
2 public health and structural pest control
3 total lbs used in California in 1999 (DPR 2000)

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. 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.*). The lack of monitoring data for some of these relatively new pesticides (e.g. pyrethrins and pyrethroids) 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 H.

iv. Attainment of Beneficial Uses and Potential Impairment

Pesticide concentrations in water were compared with a variety of regulatory and toxicity thresholds and (Table C4). 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 in EPA's OPP Ecotoxicity database (LOEC, crustacean species). 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 C4. **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)

(1) Recommended Continuous Criterion Concentration (CCC), (CDFG 2000)
(2) EPA U.S. CCC, (USEPA 1986)

- From U.S. EPA's Environmental Fate and Effects Division of the Office of Pesticide Programs Pesticide Ecotoxicity Database, (USEPA 2000).
- "—" indicates no relevant criterion or threshold available.

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 C5.

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. Although direct effects of elevated diazinon concentrations are likely to be limited primarily to sensitive zooplankton species, these invertebrate species are important food sources for higher organisms in the ecosystem, and reduction of this resource during critical periods could impact 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 C5. 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 having 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.

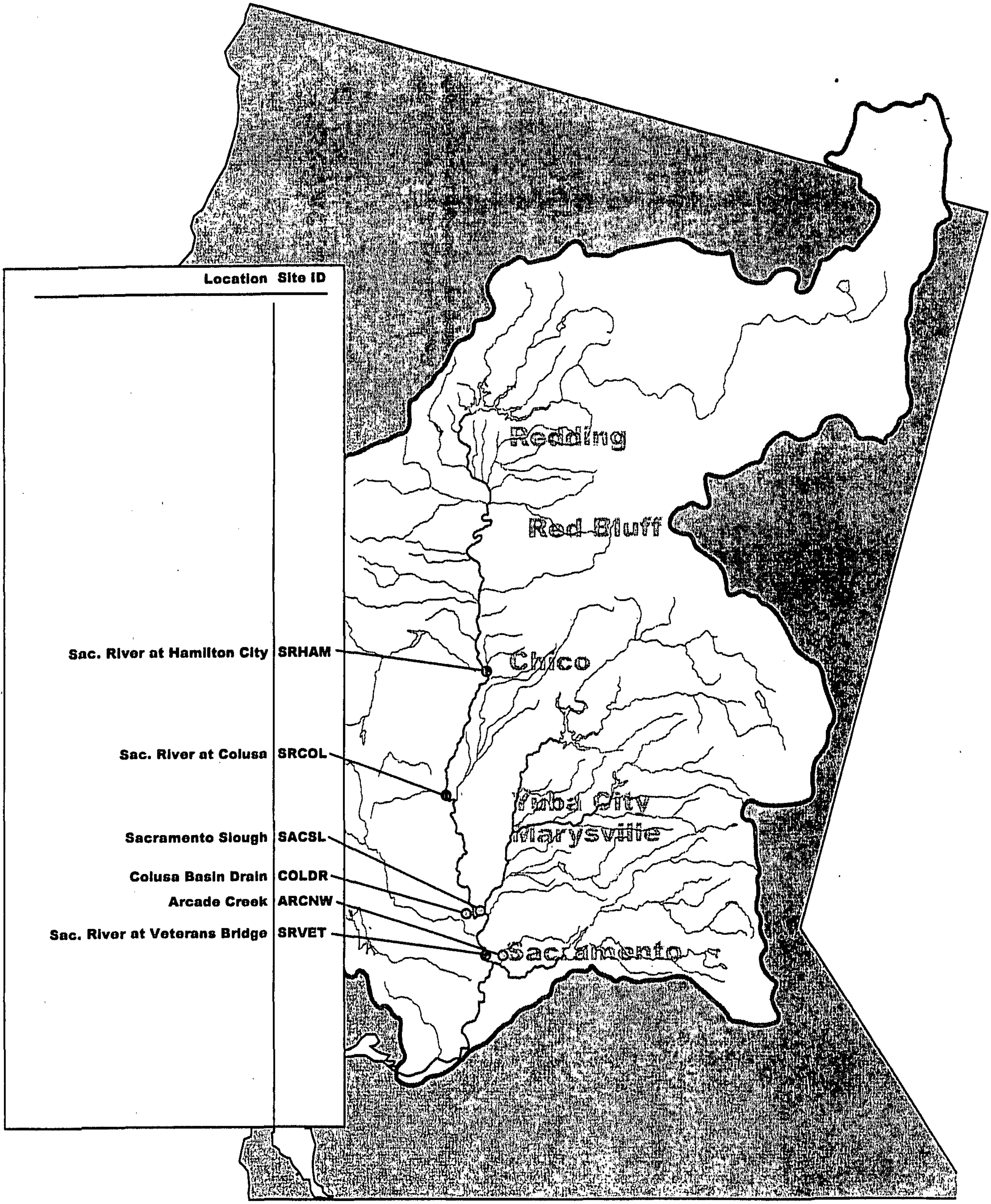


Figure 14. Pesticide Monitoring for the Sacramento River Watershed Program
1999-2000 Monitoring Locations

C. 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 14. 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 Sacramento 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—This study was focused on the occurrence of toxicity attributable to detections of dormant-spray pesticides. No significant toxicity was observed in 16 acute and 8 chronic toxicity tests of samples from Sutter Bypass and Sacramento River near Bryte. Diazinon and methidathion were the only pesticides detected (in 11 of 24 samples, and 1 of 24 samples, respectively).

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 14. Selected Aquatic Toxicity Monitoring Programs in the Sacramento River Watershed

Program	Monitoring Period and (frequency)	Parameters	# of sampling locations & geographic reference
SRWP	6/96–5/00 (monthly)	▪ 7-day *Ceriodaphnia* and 4-day *Selenastrum* toxicity tests ▪ Toxicity Identification Evaluations	21 sampling sites throughout the Sacramento River watershed
Regional Board/CalFed	6/99–5/00 (monthly)	▪ 10-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)	12/96–3/98 (weekly)	▪ 96-hour and 7-day *Ceriodaphnia* toxicity tests ▪ Dormant-spray pesticides in water	2 Sutter Bypass sampling sites, 1 sampling site at Sacramento River at Bryte
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 Figure 16, Table 15 and Tables 17-19. Summary statistics are also provided in Appendix F. 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

- Only 13 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 a metabolically-activated toxicant. 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 in the Big Chico Creek watershed. No significant mortality was observed in any of the 63 samples collected from the Sacramento River mainstem.

- Samples collected in the Sacramento River above Lake Shasta did not exhibit significant toxicity (either mortality or reproductive effects) 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. 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 holding times implemented by the rice farming industry.

- 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, only 3 of 47 samples caused significant adverse reproductive effects, with no significant toxicity observed for the Sacramento River at Colusa and Veterans Bridge. Decreases in reproduction were infrequently 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

Results for fathead minnow toxicity testing performed by the Regional Board in 1999-2000 were not available for this report.

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 43 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.) 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 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 15. Summary of 1999-2000 Toxicity Monitoring Survey Results: Percent of Samples Exhibiting Significant Toxicity

Location	% of samples exhibiting significant toxicity[a]		
	Pimephales [b]	*Ceriodaphnia*	*Selenastrum*
Pit River above Shasta		33	0
McCloud River Above Shasta		20	0
Sacramento River above Shasta		0	n/t
Clear Creek (2 sites)		33	n/t
Spring Creek PP Discharge to Keswick Res.		50	n/t
Sacramento River below Keswick Dam		25	17
Sacramento River at Bend Bridge		17	0
Mill Creek (5 sites)		15	n/t
Deer Creek (4 sites)		7	n/t
Sacramento River at Hamilton City Hwy 32		9	n/t
Mud Creek above Big Chico Creek		0	n/t
Big Chico Creek (8 sites)		10	n/t
Chico Drain (2 sites)		100	n/t
Little Chico CreeK (3 sites)		0	n/t
Lindo Drain (2 sites)		100	n/t
Sacramento River at Colusa		0	n/t
Butte Creek (4 sites)		16	n/t
Sacramento River at Veterans Bridge		0	0
Sacramento Slough		8	0
Colusa Basin Drain		27	0
Feather River near Nicolaus		33	0
Sacramento River at Alamar		0	n/t
American River at Discovery Park		8	0
Sacramento River at Freeport		17	22
Cache Slough near Ryer Island		0	n/t
Arcade Creek at Norwood Avenue		42	8

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 not available for report

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 the seasonal 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

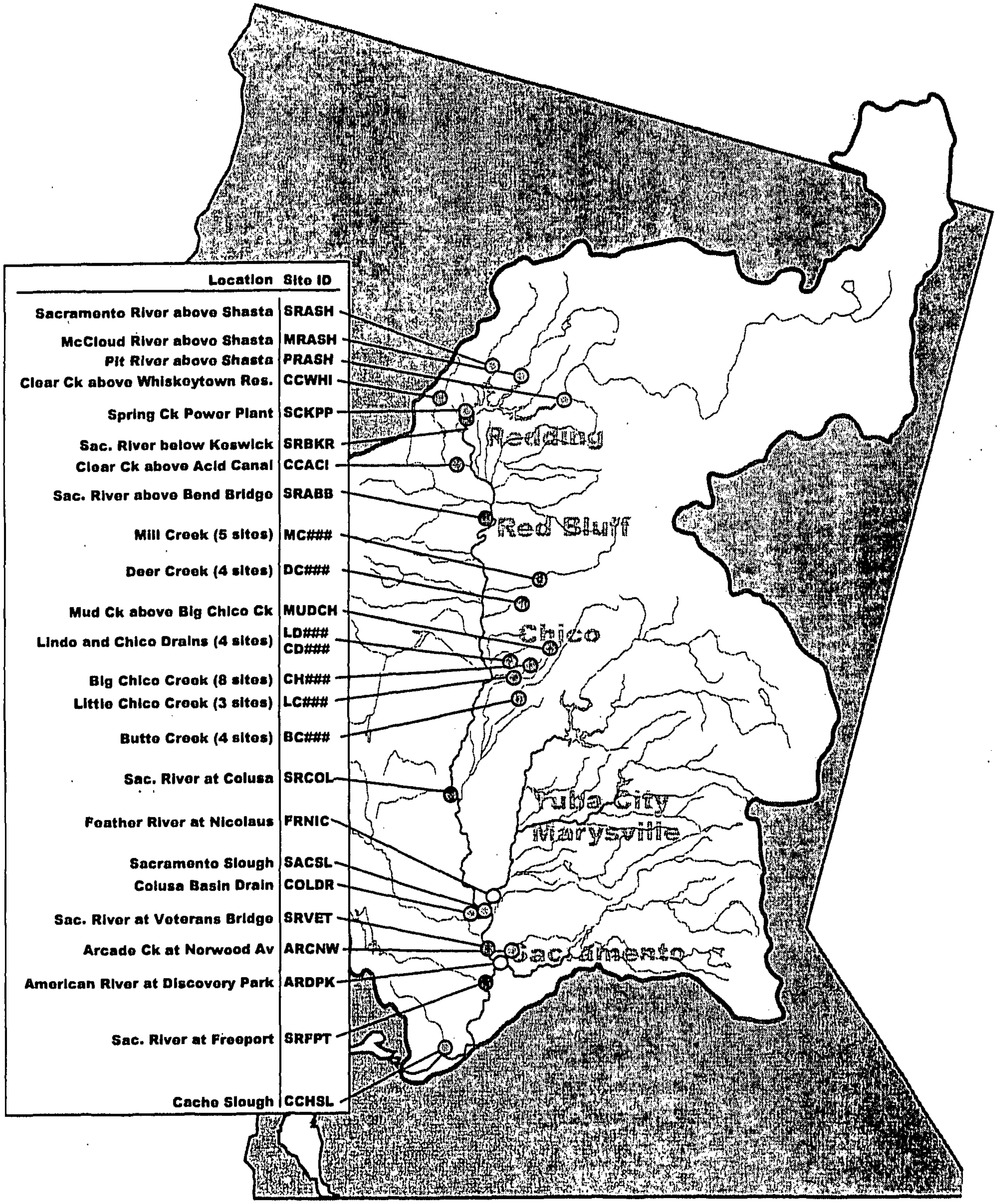


Figure 15. Aquatic Toxicity Monitoring for the Sacramento River Watershed Program, 1999-2000 Monitoring Locations

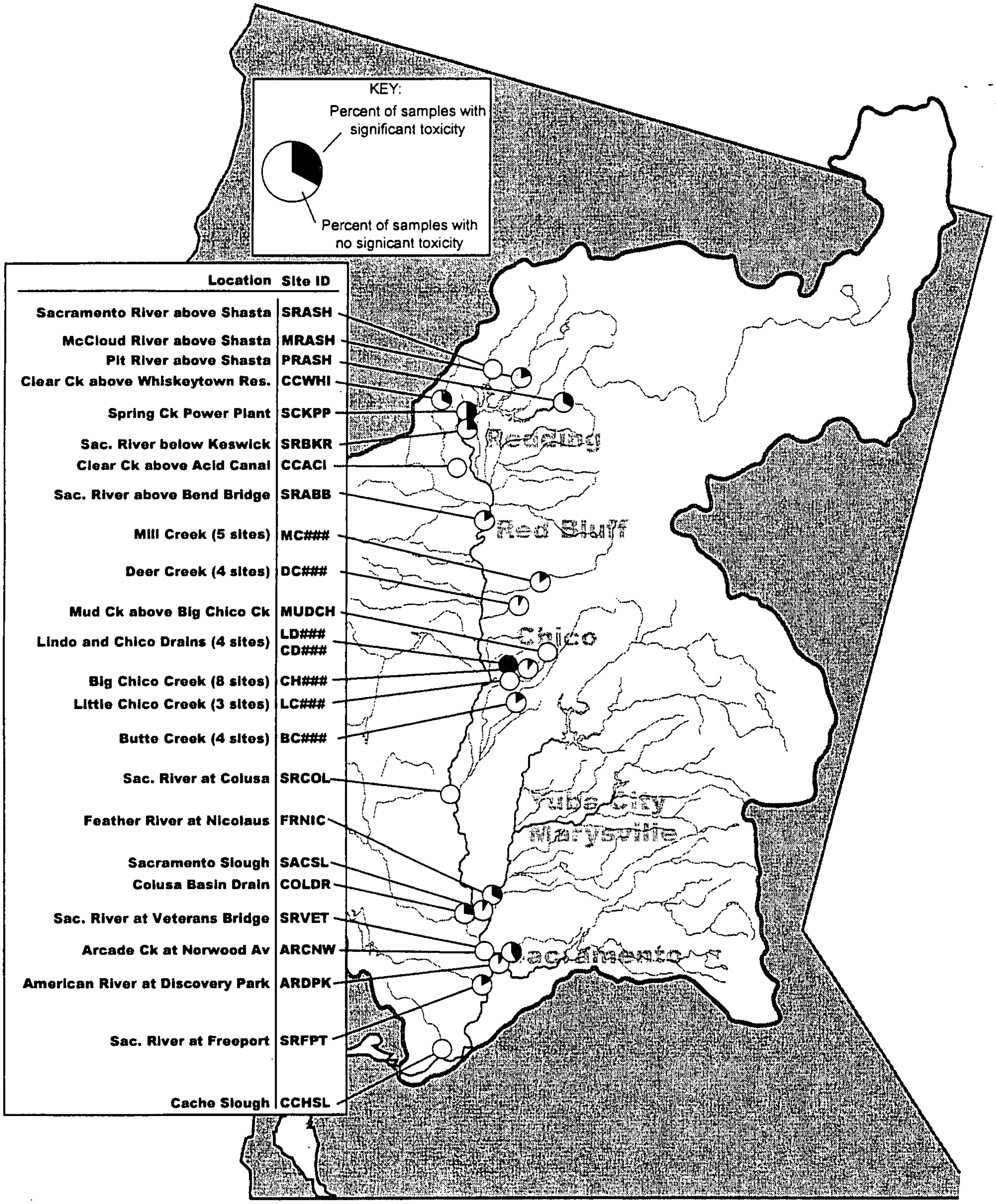


Figure 16. Percent of Samples Causing Significant Toxicity in Ceriodaphnia Toxicity Tests (1999-2000 data)

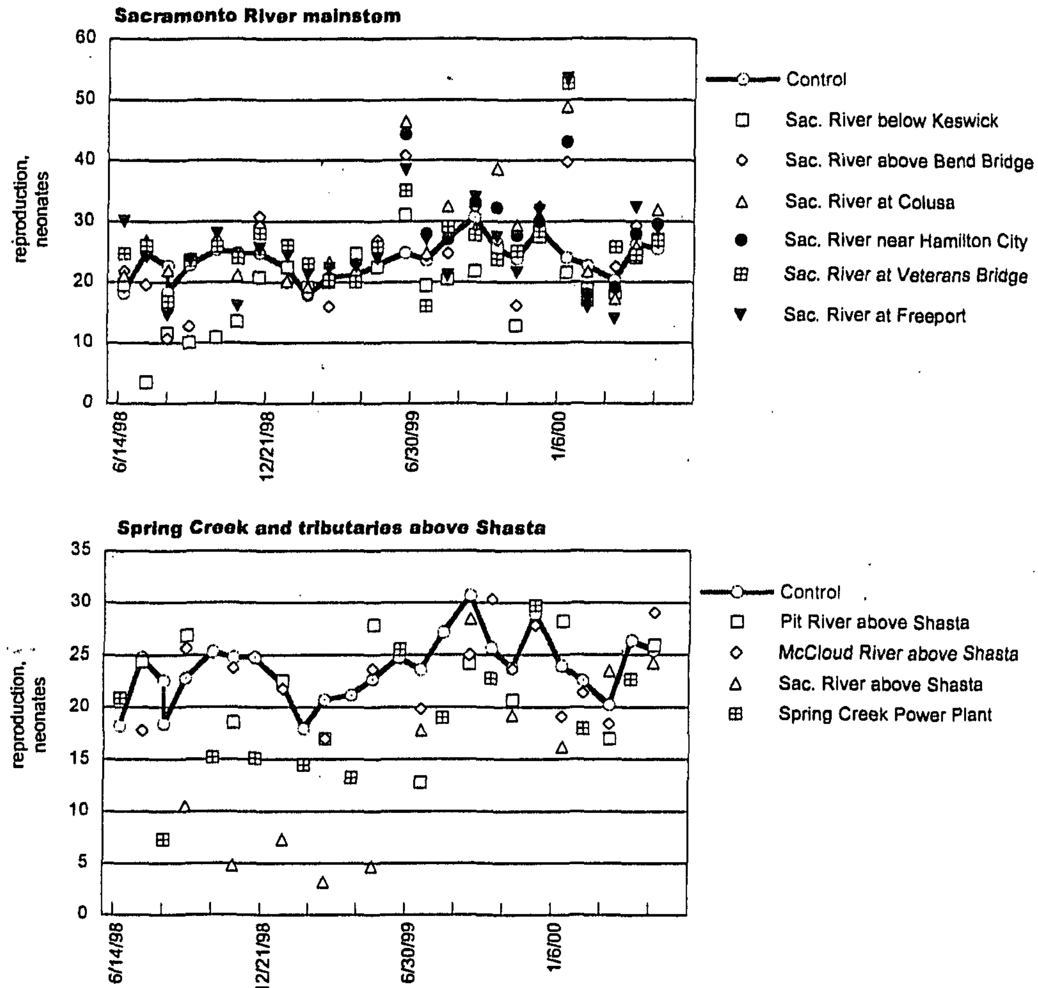


Figure 17a. *Ceriodaphnia* reproduction in bioassays of samples collected in the Sacramento River watershed.

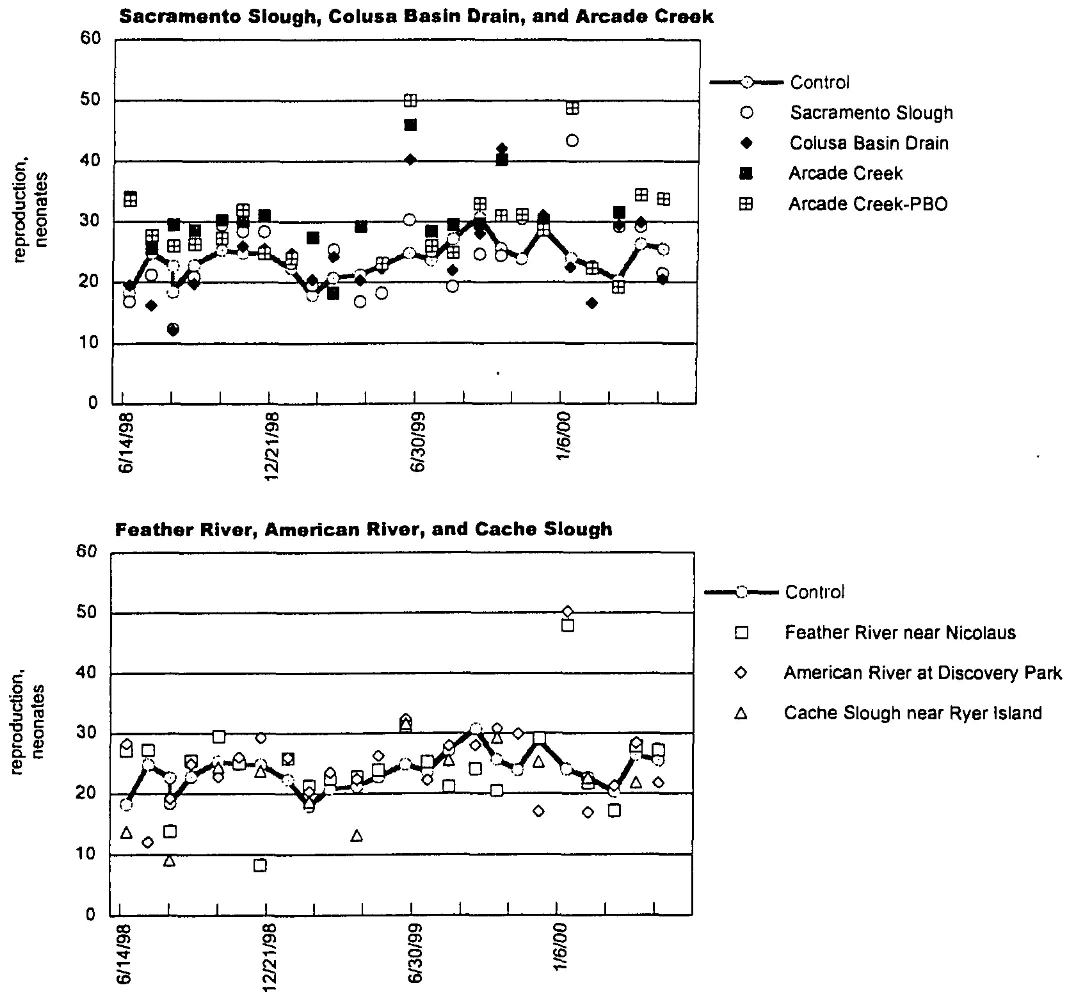


Figure 17b. *Ceriodaphnia* reproduction in bioassays of samples collected in the Sacramento River watershed.

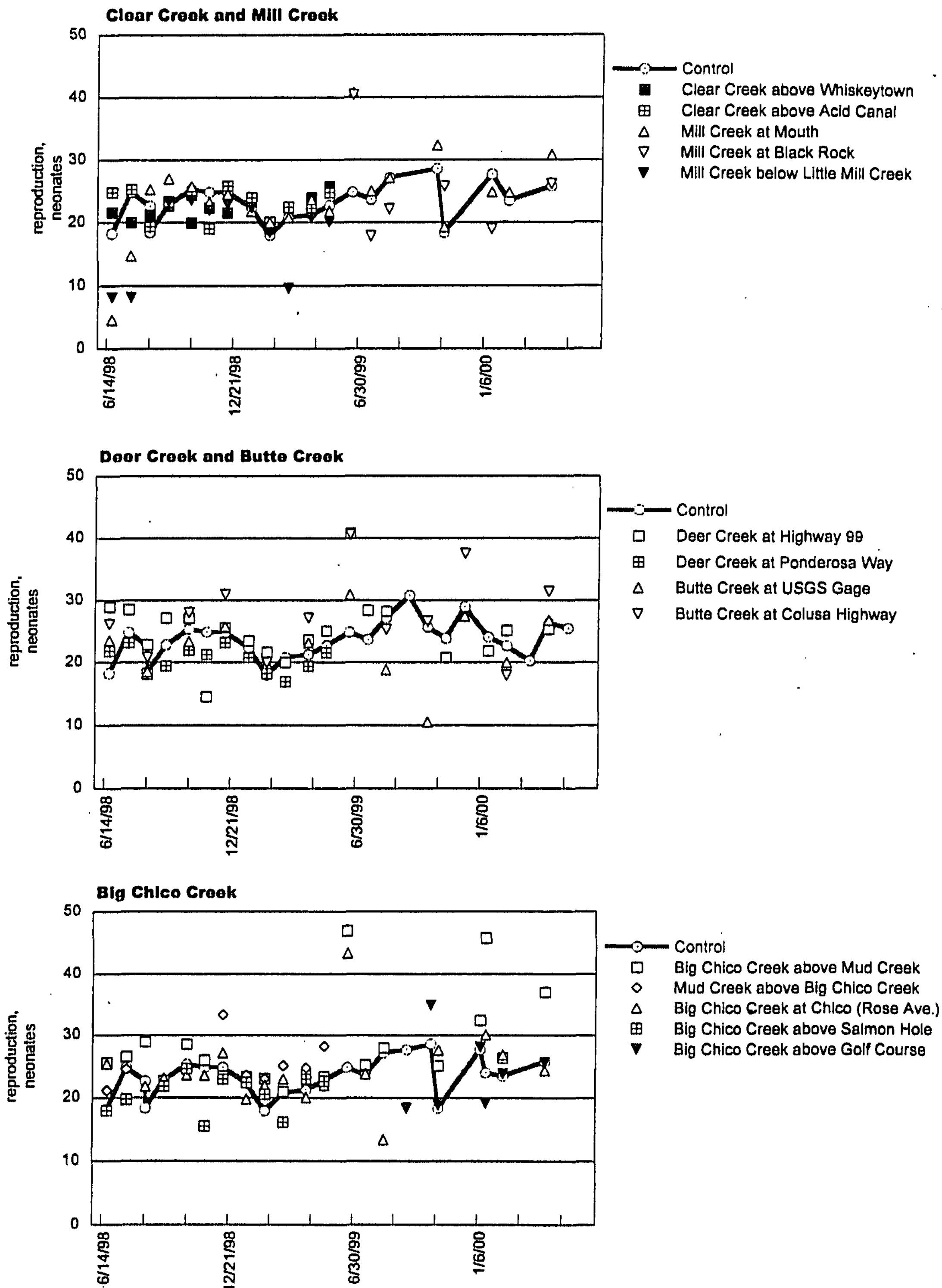


Figure 7c. *Ceriodaphnia* reproduction in bioassays of samples collected in the Sacramento River watershed.

Figure 18. ***Not used in this Administrative Draft***

Figure 19. ***Not used in this Administrative Draft***

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 F.

The sources of data utilized for this report are summarized in Table 20. 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 20.

Table 20. 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 NO_2^-; nitrate as NO_3^-; ammonia as N organic nitrogen as N; 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 NO_2 nitrate as NO_3^-; ammonia as NH_3 orthophosphate as PO_4 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 NO3; 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

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, with median concentrations ranging from 62-101 mg/L in the mainstem, and from 40–62 mg/L in major tributaries (Figure 21). 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).

b. Total and Dissolved Organic Carbon

Total and dissolved organic carbon concentrations in the mainstem Sacramento River and its tributaries have similar spatial distributions. 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 was markedly higher (2.7) than at Freeport, but was based on only nine samples collected in 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. 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 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. TOC data for the Sacramento-San Joaquin Delta were not available for analysis. However, in comparison, the median DOC concentration in Barker Slough is considerably elevated (4.1 mg/L; MWQI data 1996-98) relative to median concentrations measured in the lower mainstem Sacramento River at Freeport (1.6 mg/L) and Greene's Landing (1.8 mg/L; MWQI data). Barker Slough is located in the northwestern Delta and receives drainage from the lower western part of the Sacramento Valley and Coast Range. The distribution of organic carbon concentrations in the Sacramento River watershed are presented as DOC concentrations and illustrated in Figure 22.

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 23). 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). 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) and there remains a high degree of uncertainty associated with data for these pathogens.

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 NO_2^-) 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 NO_3^-) 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 Freeport (0.11 mg/L), but increase substantially in the lower mainstem Sacramento River, as evidenced by relatively elevated median concentrations at River Mile 44 (0.22 mg/L) and Greene's Landing (0.6 mg/L, MWQI data). 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. Nitrate data are presented as representative of the nutrient category in Figure 24.

Median concentrations of ammonia nitrogen within 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 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 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 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 phophorus 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). Comparable 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. Turbidity data are presented in Figure 25.

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 26 and 27).

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 28a). 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 28b).

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. However, data from the American River are insufficient to evaluate temporal distribution patterns. *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 21. Median Concentrations of Selected Drinking Water Parameters

Location	TDS, mg/L	TOC, mg/L[b]	DOC, mg/L	Nitrate (NO_3^-) 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
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	0.22	—	—	—	—
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] (MWQI data)	95	—	1.8	0.60	—	10	—	—
Barker Slough[c]	191	—	4.1	—	—	123	—	—
Banks Pumping Plant[c]	168	—	3	—	—	—	—	—
San Joaquin R. at Vernalis[c]	369		3.8	—	—	—	—	—

(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) Data from Municipal Water Quality Investigations data base (DWR 1999).
(d) "—" indicates parameter not evaluated at this location.

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:

> *"...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 22. 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. 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[2]. If the running average source water TOC is greater than 4.0 mg/L, water utilities may be required to remove up to 45% of the TOC in their influent. Total organic carbon concentrations

[2] 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.

occasionally exceeded the D/DBP goal at all sites evaluated (Table 23). 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. 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 infrequently 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 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 21). There are no relevant objectives for ammonia, organic nitrogen, dissolved orthophosphate, or total phosphorus. 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.

- Mineral concentrations in water are subject to several drinking water quality standards adopted by the Central Valley Basin Plan (Table 22). 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 24). 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 24). 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.

- No specific numeric criteria have been adopted for turbidity in surface waters for the Sacramento River watershed upstream from the Sacramento-San Joaquin Delta. However, 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. Comparing data for the Sacramento River watershed to the 50 NTU limit suggests that beneficial uses protected by this suggested goal 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, typical turbidity levels in Barker Slough in the North Delta come close to exceeding the suggested 50 NTU limit, with a median turbidity level of 47.2 NTU (MWQI data, 1996-98). Turbidity was observed to exceed the150 NTU turbidity limit in only one sample collected from Sacramento River at Colusa on February 15, 2000.

Table 22. 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[b]	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)	CVRWQCB Basin Plan Objective

(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.

Table 23. 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

(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.

Table 24. Comparisons with Iron and Manganese Secondary Water Quality Objectives

Location	% of Data Meeting Water Quality Objective[a] for Fe	% of Data Meeting Water Quality Objective[b] for Mn
Sacramento River at Bend Bridge	100	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 currently evaluating a work plan for the development of an effective drinking water policy 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. In either case, safeguards will be implemented to protect human health of end users. 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, the American River, and Cache Slough.
- 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. In either case, safeguards would be implemented to protect human health of end users.

- *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* 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 should be suspended until these analytical issues are resolved.

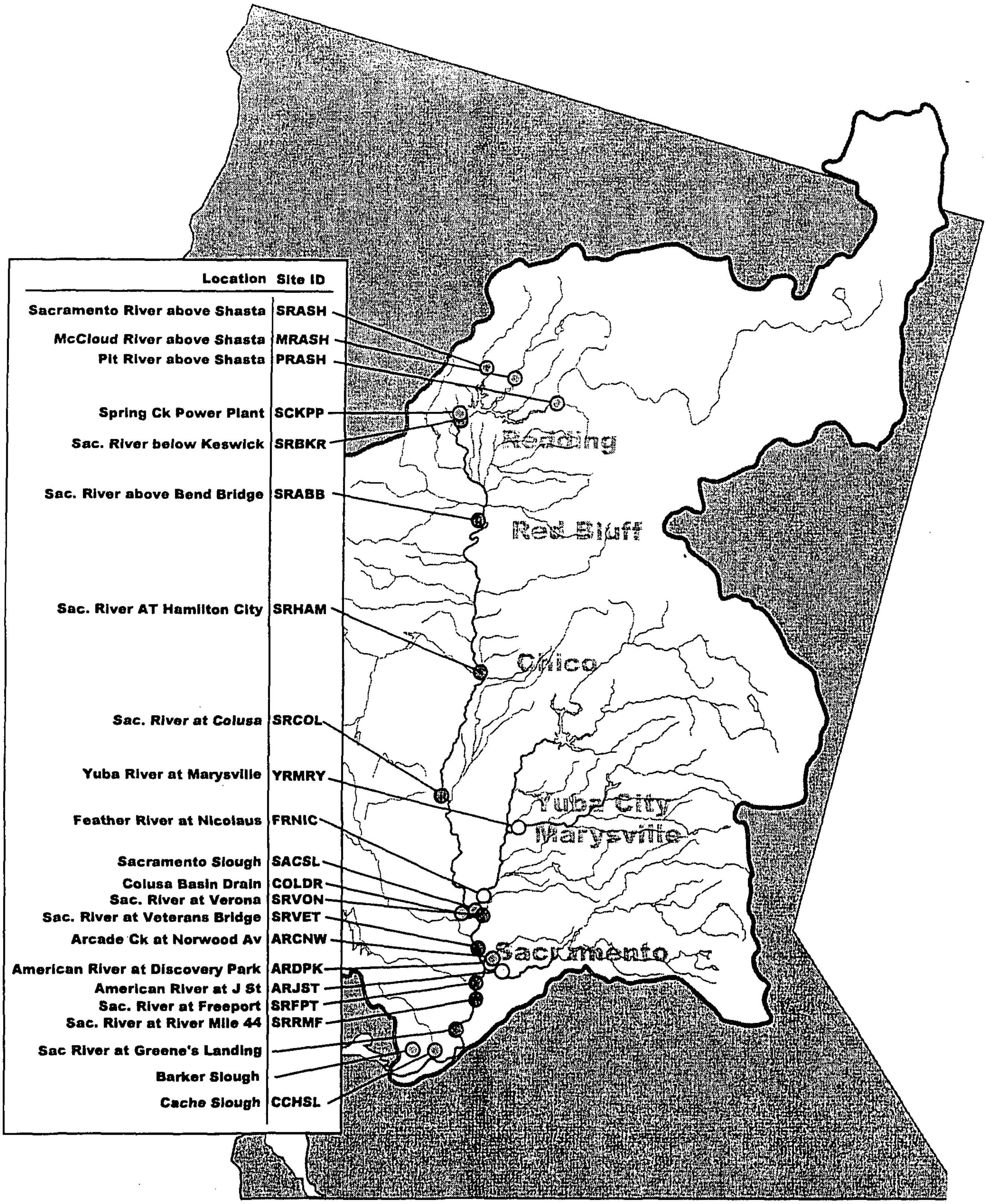


Figure 20. Drinking Water Constituent Monitoring in the Sacramento River Watershed, USGS NAWQA, Sacramento River CMP, City of Redding, DWR MWQI, and SRWP

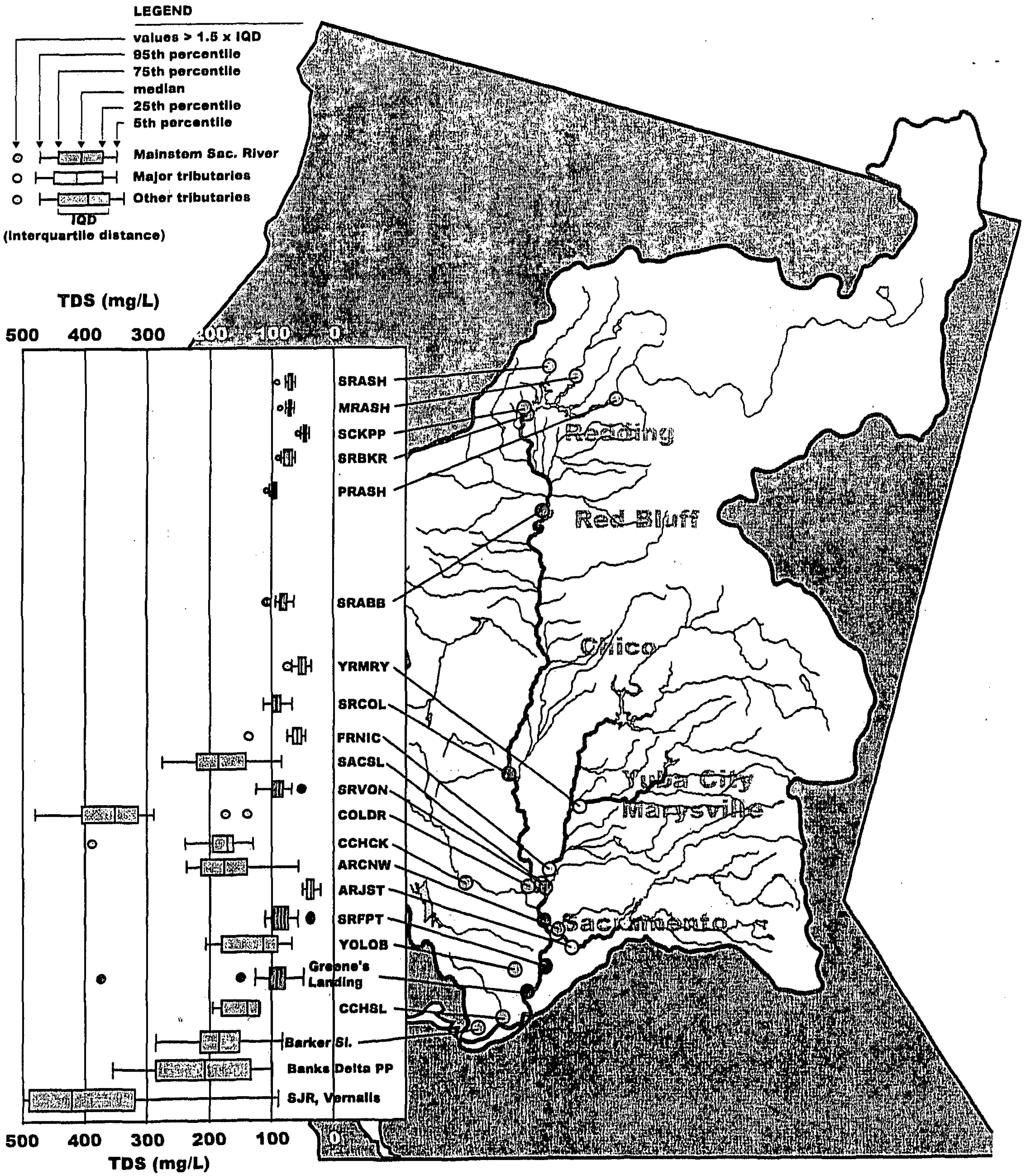


Figure 21. Total dissolved solids concentrations in the Sacramento River watershed

TO BE UPDATED FOR PUBLIC DRAFT

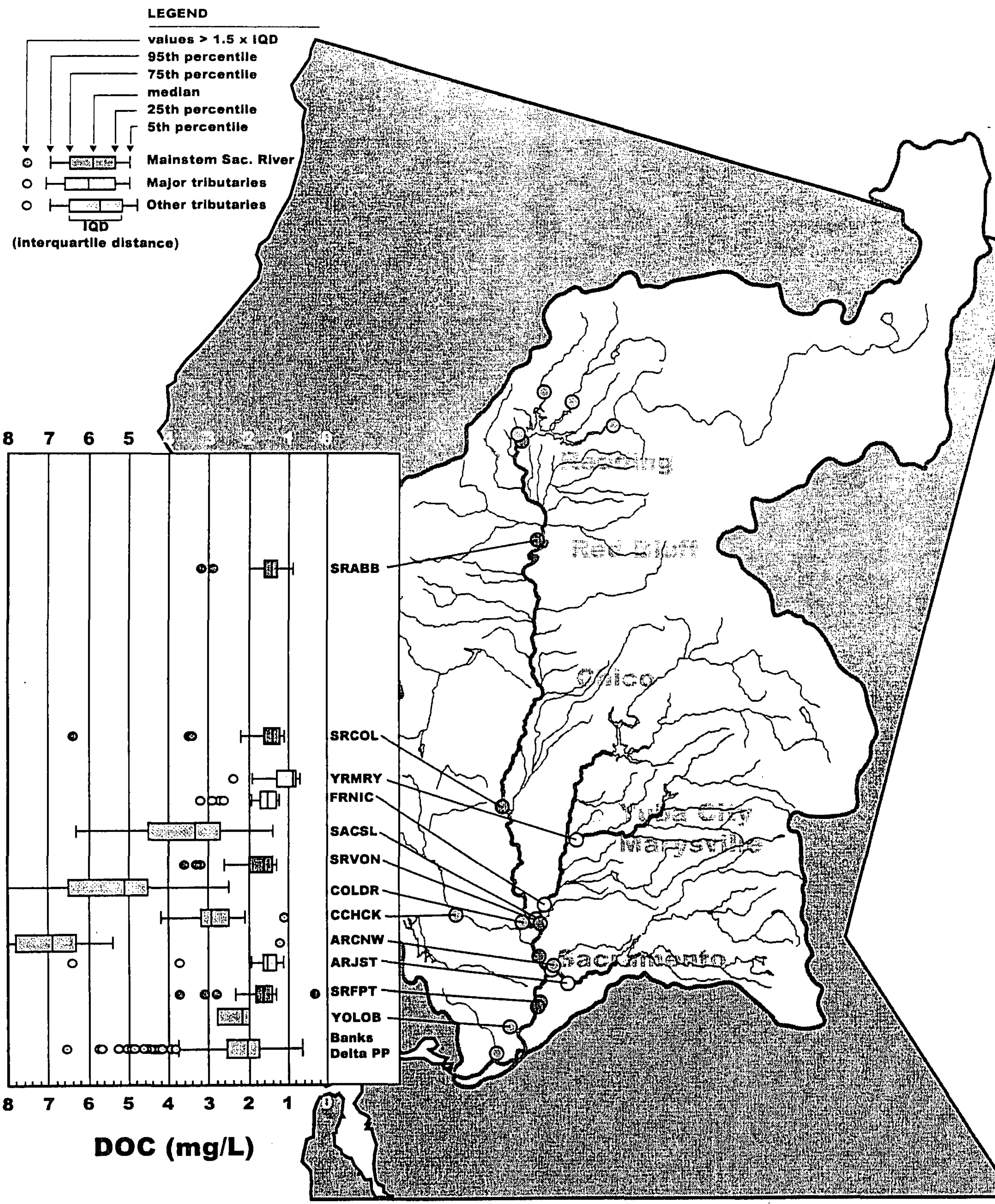


Figure 22. Dissolved organic carbon concentrations in the Sacramento River watershed

TO BE UPDATED FOR PUBLIC DRAFT

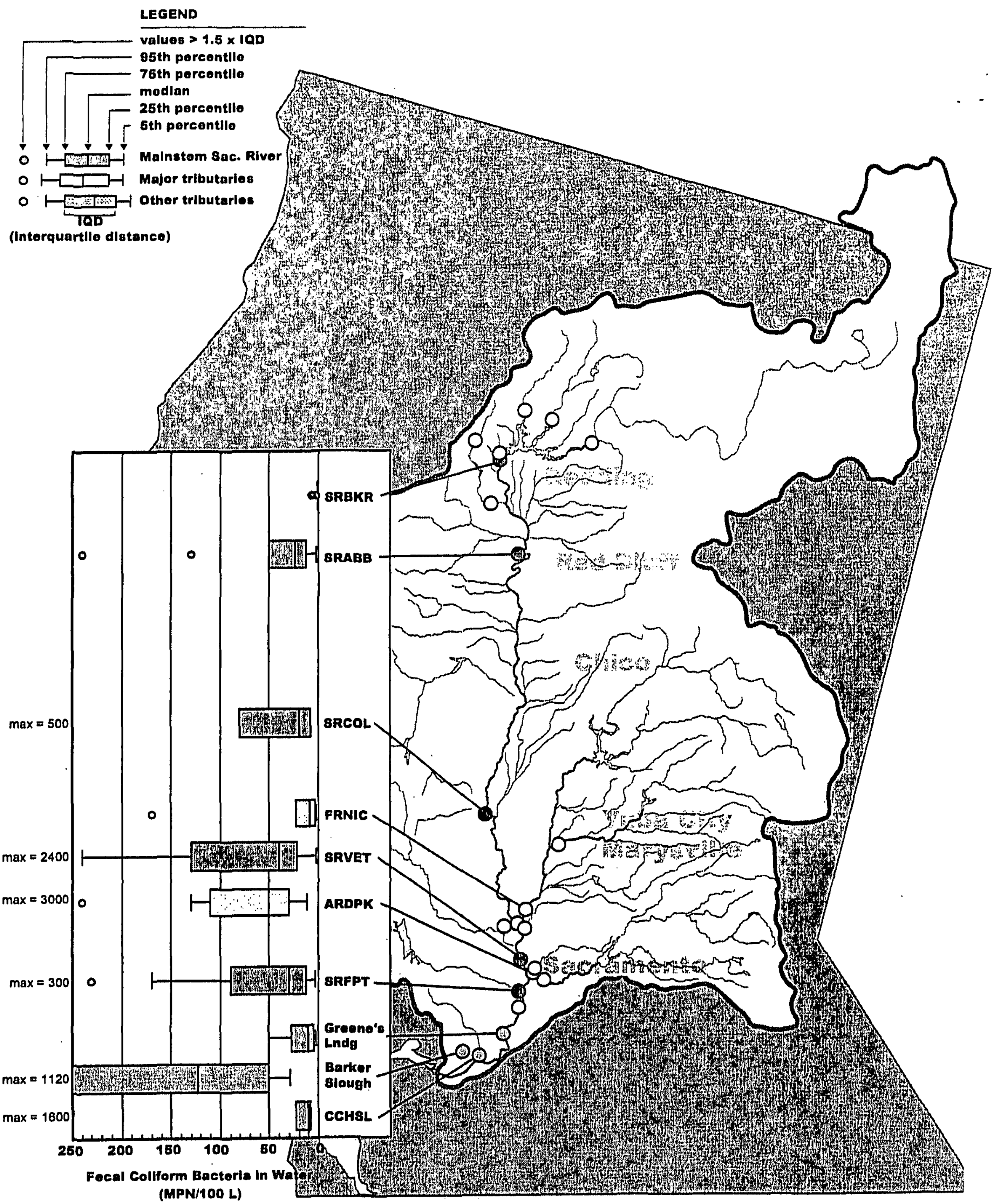


Figure 23. Fecal Coliform Bacteria in the Sacramento River Watershed

TO BE UPDATED FOR PUBLIC DRAFT

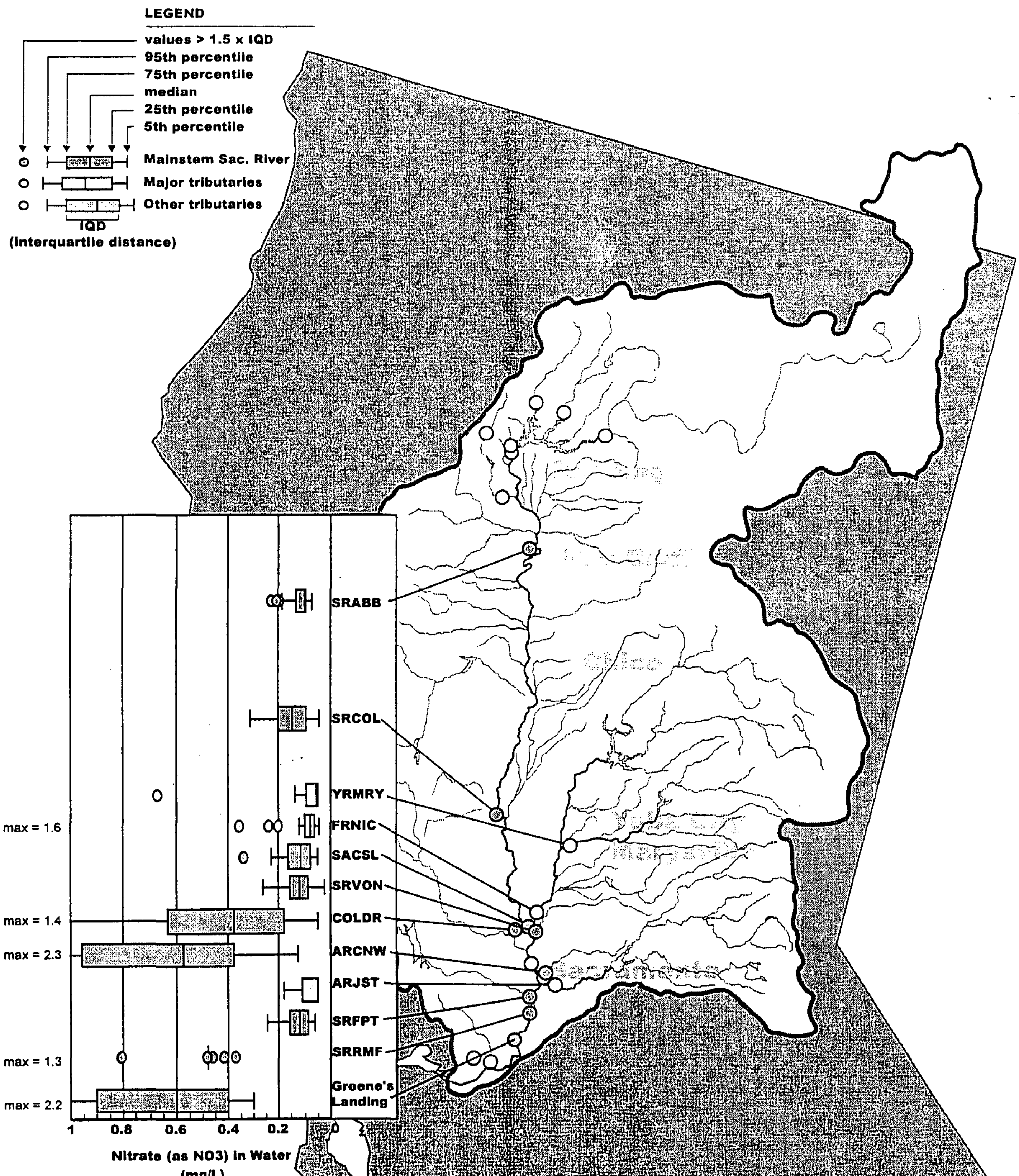


Figure 24. Nitrate in the Sacramento River Watershed: Nitrate Concentrations (as NO_3^-) in Water

TO BE UPDATED FOR PUBLIC DRAFT

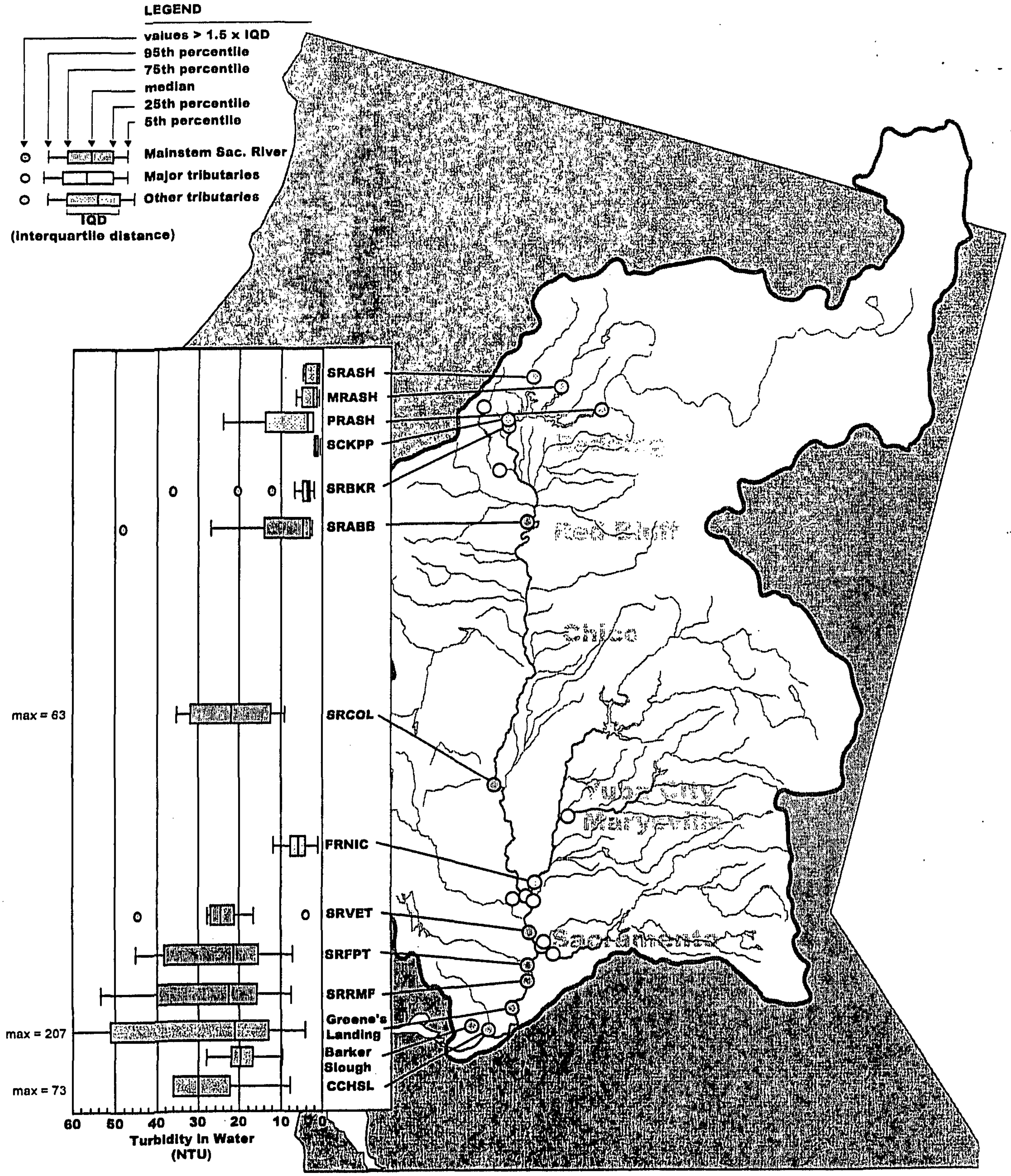


Figure 25. Turbidity in the Sacramento River Watershed: Turbidity Values (NTU) in Water

TO BE UPDATED FOR PUBLIC DRAFT

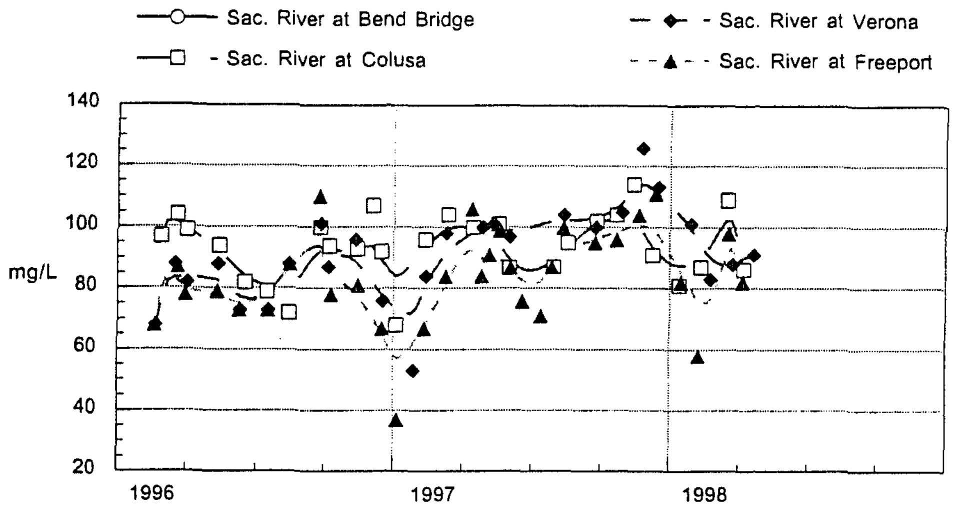


Figure 26a. Total Dissolved Solids in the Sacramento River: USGS NAWQA data, 1996-98.

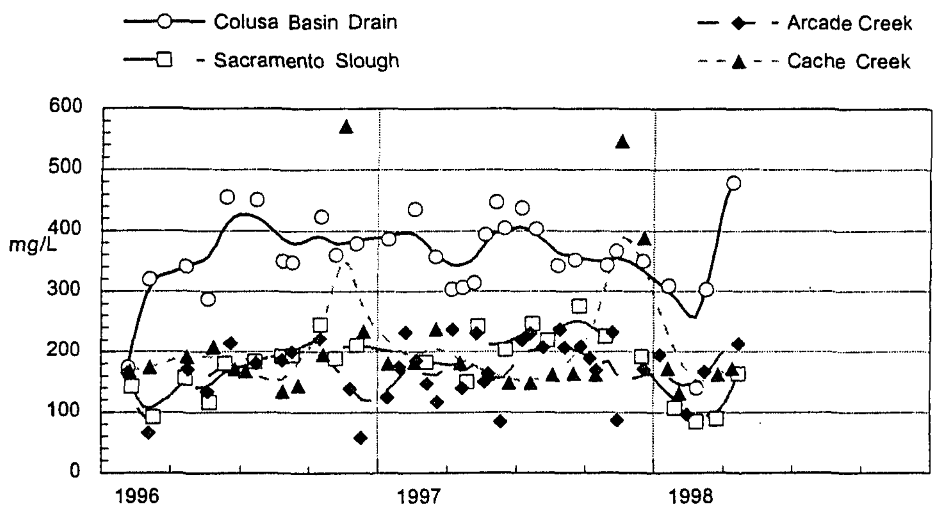


Figure 26b. Total Dissolved Solids in Agricultural Drains and Urban Runoff: USGS NAWQA data, 1996-98.

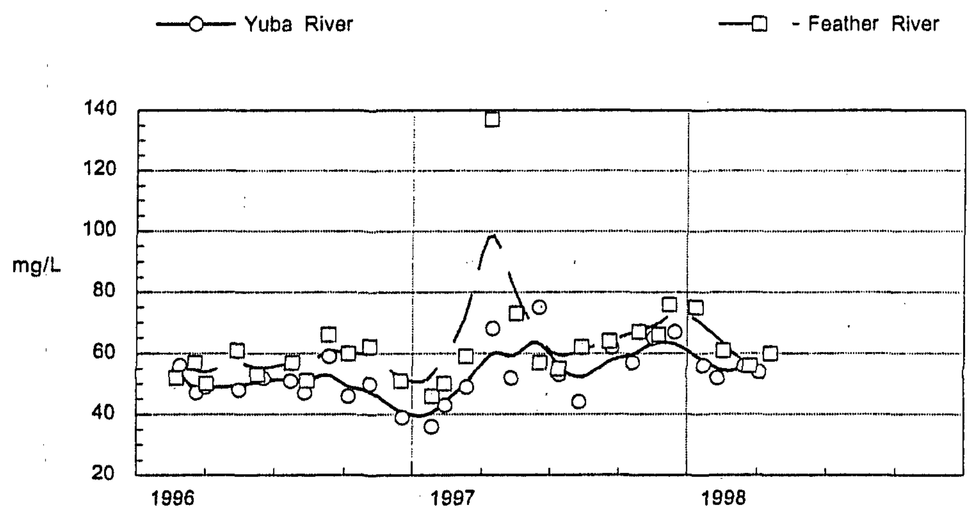


Figure 27a. Total Dissolved Solids in the Yuba and Feather rivers: USGS NAWQA data, 1996-98.

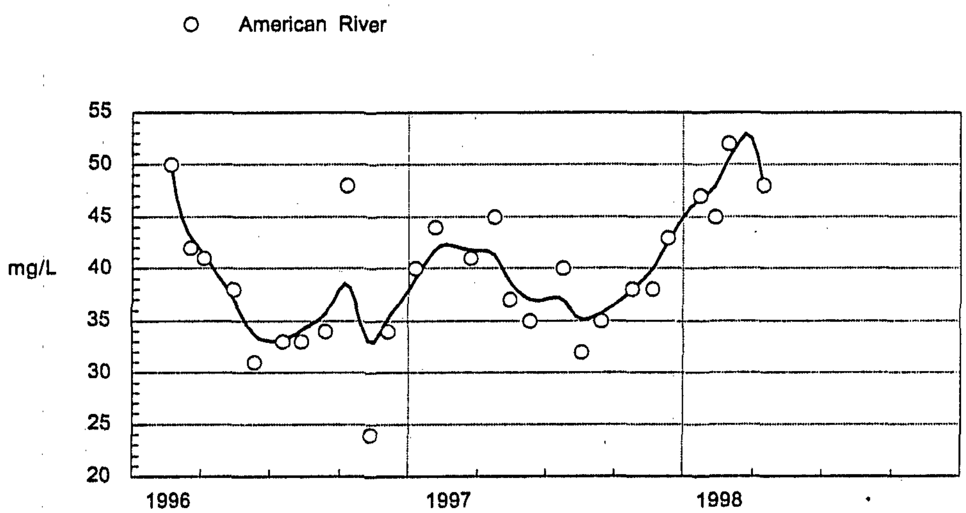


Figure 27b. Total Dissolved Solids in the American River: USGS NAWQA data, 1996-98.

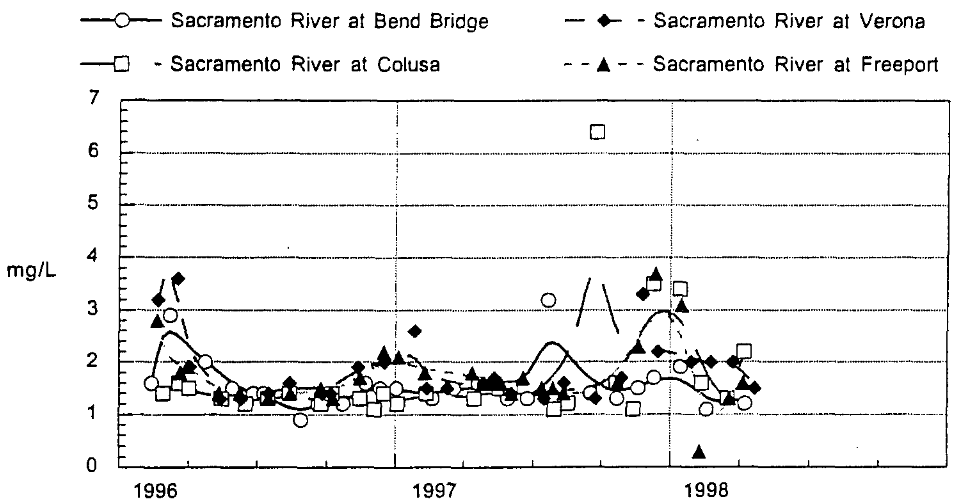


Figure 28a. Dissolved Organic Carbon in the Sacramento River: USGS NAWQA data, 1996-98.

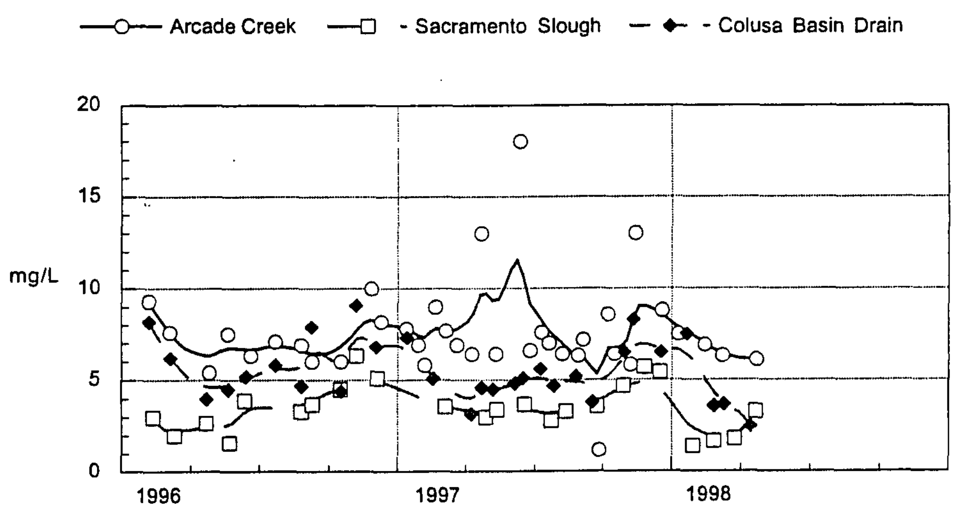


Figure 28b. Dissolved Organic Carbon in Agricultural drains and Urban Runoff: USGS NAWQA data, 1996-98.

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 (Table 25).

The locations of sites monitored in 1997–1999 by the SRWP are illustrated in Figure 29.

Table 25. 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 26 and Figure 30, and summarized below.

Aroclors: Aroclors 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 aroclors 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 to FDA Action Levels (applicable to commercially-caught fish) and 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). Exceedance of screening values is considered an indication that more intensive site-specific monitoring or evaluation of human health risks should be conducted (SFEI 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 all organochlorines in SRWP-collected fish were well below FDA Action Levels for these compounds (Table 26). Concentrations of aroclors 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 (aroclors in one Rainbow trout sample from the Sacramento River below Keswick). In general, exceedances of screening values were more frequent in the lower watershed.

There are several waterbodies included on the 1998 California 303(d) list for organochlorine compounds (Table 27). 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 indicated 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.
- Although concentrations of organochlorines did not exceed FDA Action Levels in any samples, concentrations of aroclors, DDTs, and dieldrin exceeded screening values in fish collected from eight locations, primarily in the lower watershed.
- Monitoring of organochlorine compounds in fish tissue has been continued for 2000-2001 monitoring.

Table 26. Organochlorines in Fish Tissue: Regulatory Limits, Screening Values, and Summary of SRWP Data (1997-1999)

	PCBs (Sum of 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
FDA Action Levels[b]	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 screening value	7	0	5	8
Percent of samples exceeding screening value	15%	0%	10%	16%
Species exceeding screening value	Carp, trout, white catfish	None	Carp, largemouth bass, Sacramento sucker, white catfish	Carp, largemouth bass, Sacramento pikeminnow, white catfish
Sites[(c)] exceeding screening value	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) FDA Action Level is based on a consumption rate of 6.5 g/day.
(c) 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 27. 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

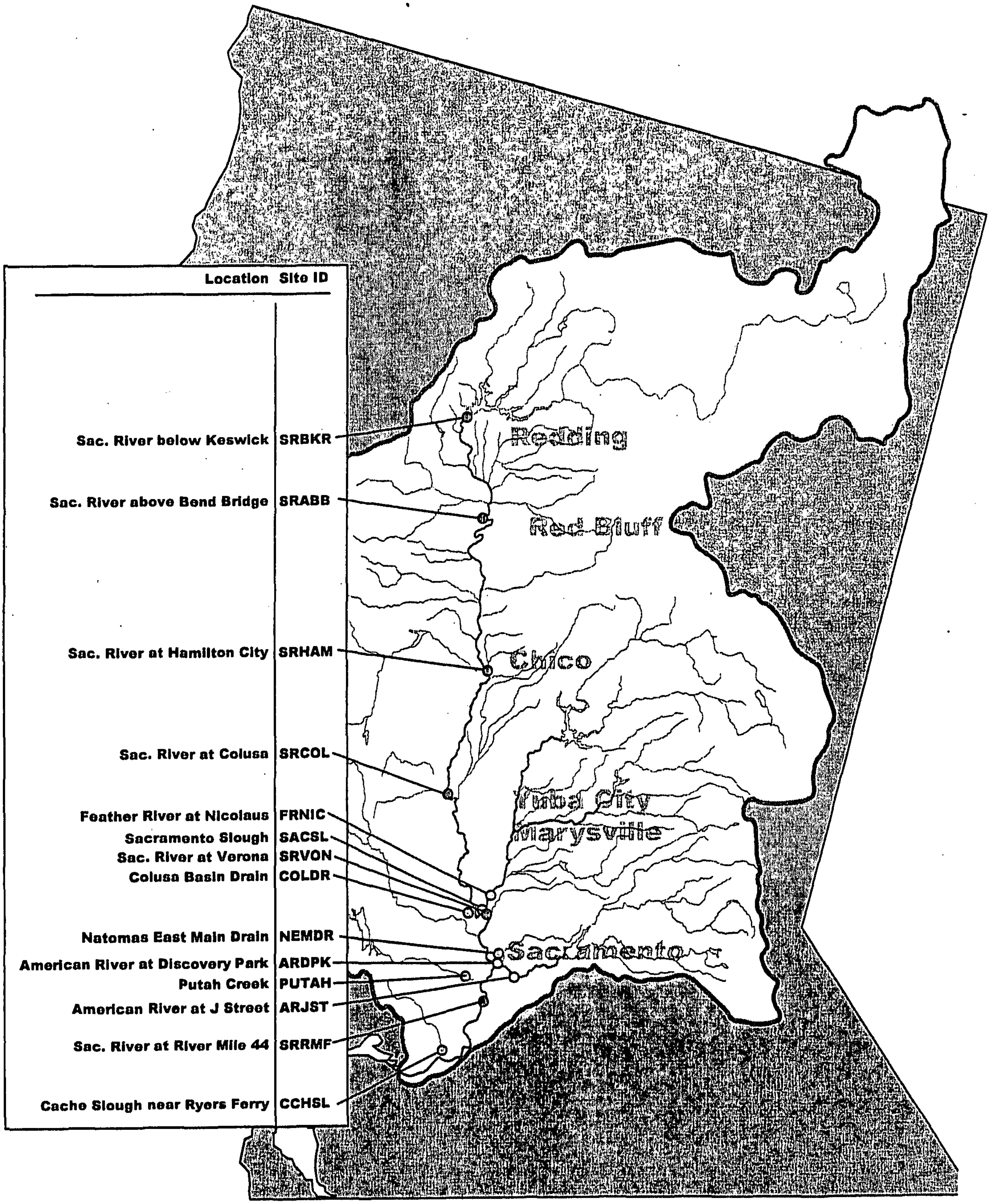


Figure 29. SRWP Monitoring for OrganoChlorines in Fish Tissue: 1997, 1998, and 1999 Monitoring Locations

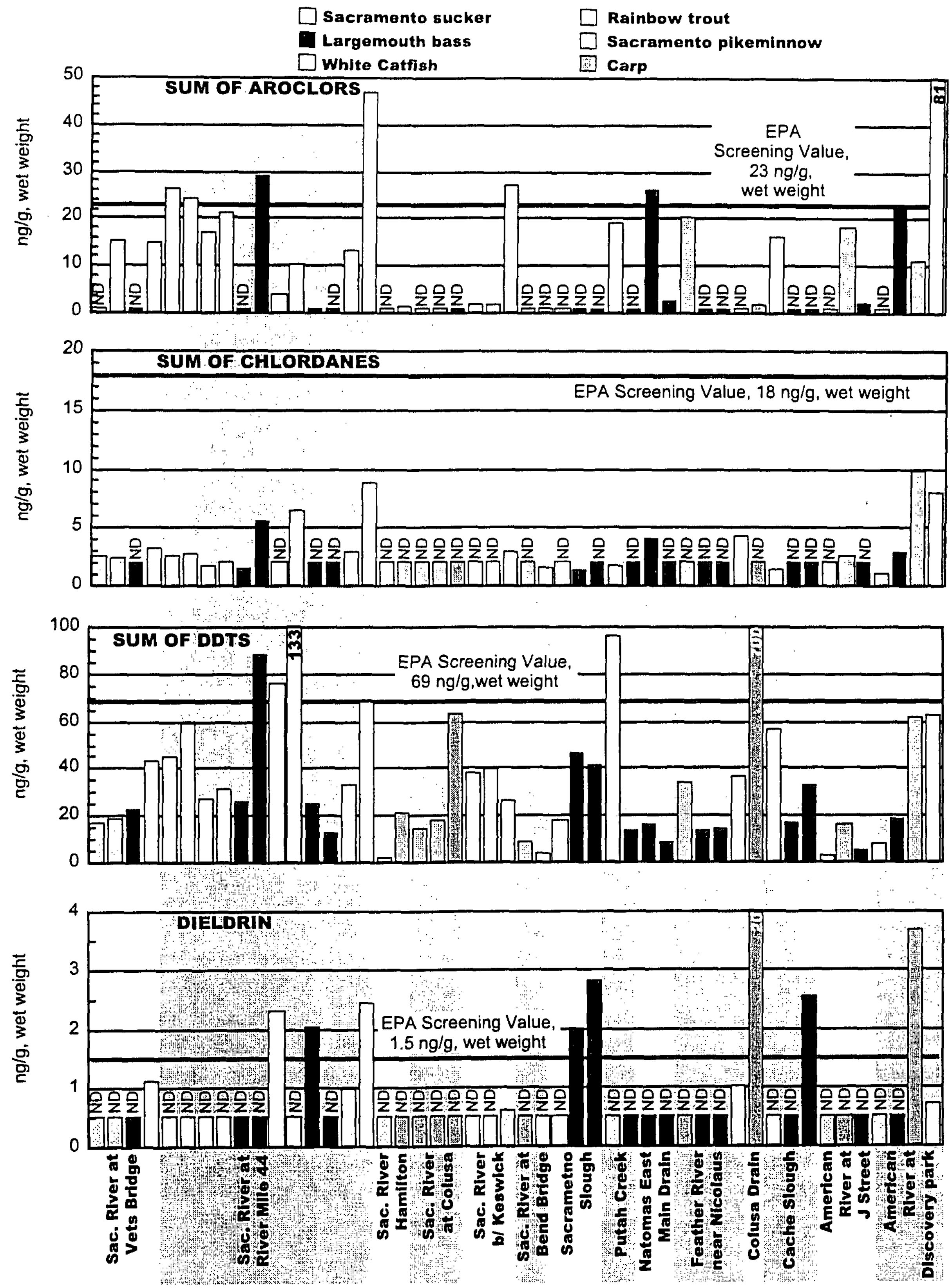


Figure 30. Organochlorines in Fish Tissue: SRWP Data, 1997 - 1999

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. 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 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 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 due to concerns regarding sediment toxicity. Because currently available data cover only a limited time period and spatial scope, they do not provide conclusive information regarding the attainment of beneficial uses 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 watershed, this result is generally consistent with the attainment of related beneficial uses, and clearly 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, the available 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 available 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.

Table 28. Summary of 1999–2000 Sediment Toxicity Monitoring Results

	November 1999		May 2000	
Ceriodaphnia bioassays	Reproduction (neonates/adult)	Test significance[a]	Reproduction (neonates/adult)	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

	November 1999		May 2000	
Hyalella bioassays	Survival (%)	Test significance[b]	Survival (%)	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.

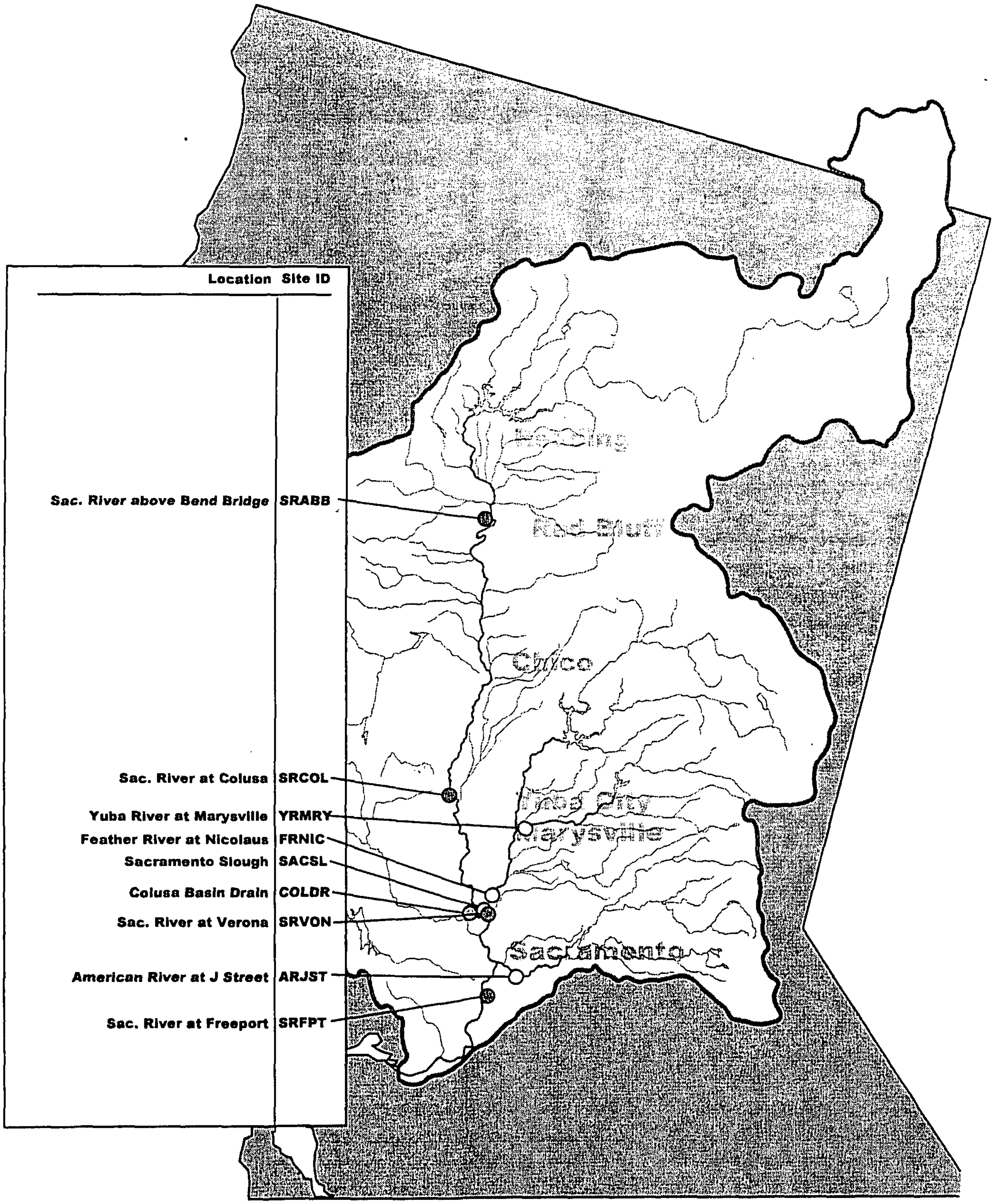


Figure 31. Sediment Toxicity Monitoring Sites for the Sacramento River Watershed Program: 1999-2000 Monitoring Locations

H. Bioassessment

Note: The report on which this section is based is being revised by CDFG. The discussion of results should be considered preliminary and will be revised to reflect the final data and report from CDFG.

I. Background

The overall objectives of the bioassessment monitoring effort was 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 1998. Results of DWR's sampling events are not currently available and will be reported in a later document.

ii. Materials and Methods

Site Selection and Reach Designation

Monitoring reach descriptions are summarized in Table 29 and a map of sampling locations is shown in Figure 32. Within the selected tributary watershed, sampling sites were selected using the procedures outlined 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 1998 using Department of Fish and Game (DFG) or 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 29. 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 The Nature Conservancy Property	MR-TNC	N41°05' 39", W122° 06' 56"
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 30.

Each of the monitoring reaches was given a relative BMI Ranking Score based on 6 of the BMI metric values (Table 30; 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 I.

Dominant BMI Taxa and General Taxonomic Notes

The five dominant taxa observed in each of the monitoring reaches are presented in Table 31.

There were 133 taxa found in the 18 sites we sampled. The macroinvertebrate communities at most sites were fairly complex, having a wide range of taxa represented. The BMI communities at almost all sites were dominated by relatively sensitive insect taxa; 54 of the taxa present at all sites were in the sensitive Ephemeroptera, Plecoptera or Trichoptera taxa.

Riffle beetles (Coleoptera: Elmidae) were common at most sites and elmid diversity was very high overall (11 genera). Although there were 21 dipteran taxa present, two families (Simuliidae and Chironomidae) were responsible for the vast majority of the individuals. True bugs (Hemiptera) were very rare; only one taxon, *Ambrysus sp.* (Hemiptera: Naucoridae) was present at any site. Lepidoptera, Megaloptera and Odonata were also rare, with only a few individuals present in the lower elevation sites.

Mayfly taxa (Ephemeroptera, especially families Heptageniidae and Baetidae), stonefly taxa (Plecoptera, especially Family Perlodidae) and caddisfly taxa (Trichoptera, especially families Hydroptilidae and Glossosomatidae) were well represented in this dataset. Although the genus Baetis was common, it rarely reached the levels of dominance common in lower elevation sites. Although there were 26 non-insect taxa found in all sites, nearly all of the non-insect abundance was accounted for by mite taxa and a few worms (Oligochaeta) and flatworms (Planariidae); the remaining non-insect taxa were rare. The distribution of non-insect taxa was much more evenly distributed in the non-wadable sites.

Table 30. 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:

- 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 I.

- 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 I 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 I.

Table 31. 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/ Sperchonitdae (4/4)
BIG CHICO CREEK BCC -H32	*Tanytarsini* (28)	Orthocladiinae (13)	*Epeorus* (8)	*Hydropsyche* (8)	*Baetis* (7)
DEER CREEK DC-M	*Hydropsyche* (24)	Orthocladiinae (13)	*Cheumatopsyche* (10)	*Fallceon* (9)	Tanytarsini (8)
DEER CREEK DC -FS	*Hydropsyche* (37)	*Baetis* (10)	Orthocladiinae (9)	*Cheumatopsyche* (8)	*Culoptila* (4)
DEER CREEK DC -PW	*Hydropsyche* (21)	Orthocladiinae (16)	*Baetis* (16)	*Rhithrogena* (7)	*Isoperla* (4)
DEER CREEK DC -PPC	Tanytarsini (11)	*Baetis* (10)	*Hydropsyche* (9)	*Serratella* (9)	Orthocladiinae (9)
SAC. RIVER SR-L	*Baetis* (33)	*Simuliidae* (16)	*Hydropsyche* (11)	*Lepidostoma* (9)	*Rhithrogena* (4)
MC CLOUD RIVER MR-TNC	Orthocladiinae (21)	*Hydropsyche* (12)	Tanytarsini (7)	*Calineuria* (7)	*Oligochaeta* (5)
MC CLOUD RIVER MR-SR	*Baetis* (49)	*Drunella* (9)	*Zapada* (9)	*Rhithrogena* (8)	Orthocladiinae (7)
			NON-WADABLE SITES		
American River AR-HB	*Acentrella* (30)	*Serratella* (17)	*Ochrotrichia* (10)	*Hydropsyche* (9)	*Sperchontidae* (4)
Sac. River, Colusa SR-SSP	*Chironomini* (16)	Tanytarsini (15)	*Baetis* (15)	*Hydropsyche* (14)	*Simuliidae* (14)
Yuba River YR-M	*Hydropsyche* (20)	*Acentrella* (17)	*Baetis* (14)	*Serratella* (7)	*Chironomini* (5)
Arcade Creek AC-DPP	Tanytarsini (38)	Orthocladiinae (16)	*Chironomini* (10)	*Oligochaeta* (7)	*Corbicula* (5)
Feather River FR-EN	Orthocladiinae (20)	*Chironomini* (19)	Tanytarsini (14)	*Hydropsyche* (9)	*Nematoda* (6)

Biological Data — Wadable and Non-wadable Sites

Richness

Average Taxonomic Richness values ranged from a low of 25 taxa to a high of 38 taxa in the wadable sites and between 14 and 25 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.

Composition Measures

Shannon Diversity values ranged from 1.9 to 2.4. EPT Index scores were high at most sites, comprising between 50 percent to 88 percent of the total abundance. Sensitive EPT taxa often made up a considerable portion of the EPT abundance. The filter-feeding caddisfly family, Hydropsychidae, was common in these samples, usually contributing less than 20 percent of the total abundance, but occasionally reaching as high as 50 percent of the total abundance. Baetid mayflies (Ephemeroptera: Baetidae) exhibited a similar pattern—in only five sites were baetids not among the top five most abundant taxa. Extreme dominance of a community by one or a few taxa was rare in this dataset, with percent dominance ranging between 26 and 38 percent. Diversity was generally lower in the non-wadable sites than the wadable sites.

Tolerance Measures

Tolerance metrics (Tolerance Value, Percent Intolerant Organisms, and Percent Tolerant Organisms) provide a measure of the degree to which the community is made up of pollution-tolerant oganisms, and by inference, whether the community has been adversely impacted by pollution. Higher numbers of intolerant organisms are an indication that the community has not been adversely affected by pollution. Tolerance measures indicated that most of the communities in this dataset were generally relatively intolerant to disturbance. The level of community tolerance was higher in the lower elevation sites, both within a watershed and at the separate non-wadable sites. Average tolerance values ranged between 2.5 and 4.3 for wadable sites and 3.5 and 6.1 in the non-wadable sites. Intolerant taxa were abundant at the higher elevation sites and less common at the lower elevation sites.

Functional Feeding Groups

All of the functional feeding groups (FFGs) were present, 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; only two sites contained more than 10% predatory taxa. 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 ranged between a low value of 1200 organisms per sample to a high of 8000 organisms per sample in the wadable sites. Abundance exhibited a greater range in the non-wadable sites, ranging between 600 and 8000 organisms. 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. Six sites scored in the low end of the "excellent" category, and seven of the sites scored in the "good" range. The only major physical habitat problem in 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.

Physical habitat quality scores are summarized in Table 32. 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 (FR, AR-HB, YR-M) ranked close to the other large river sites (SR-L, MR-TNC), 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.

There was a strong relationship between elevation and overall ranking score for some sites (Deer Creek, Big Chico Creek, Sacramento River) as higher elevation sites tended to have the highest ranks ($p<0.05$, $R^2=0.32$, Figure 34a). 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. The McCloud River site at Stout's Bridge Road was surprisingly low for an upper watershed site. Its overall score may be affected by the extreme abundance of one taxon, the mayfly *Baetis sp.* (Ephemeroptera: Baetidae).

There was a poor relationship between physical/ habitat scores and overall site rankings based on the bioassessment metrics (Figure 34b). The habitat score range of 132 to 165 provided very little range to enable discrimination of habitat quality.

Comparing USGS and DFG Riffle Methodologies

Although this project was not intended to compare the USGS and DFG methodologies and while there is not enough information to do so properly, there are some patterns in the data worth describing.

For the most part, samples collected by USGS and DFG were substantially similar. Most of the major composition metrics (Percent Dominant Taxon, Shannon, Diversity, EPT Index) differed only slightly between the two methods. However, the tolerance metrics (Sensitive EPT Index, Percent Intolerant and Percent Tolerant, but not Tolerance Value) and richness metrics (Taxa Richness, EPT Taxa) were substantially different between the USGS and DFG samples. Both of these types of metrics were higher in the DFG samples than the USGS samples.

Since the USGS Taxonomic Richness metric reflects a composite sample and the DFG taxonomic Richness Metric represents an average of two or three replicates we have included a Cumulative Taxa metric and Cumulative EPT Taxa metric to facilitate comparison. The "cumulative" metrics represent the sum of all taxa found at a site rather than the average number of taxa found at each site. Taxonomic Richness and EPT Taxa Richness were lower in the USGS datasets when compared to the same metrics calculated from DFG datasets using the cumulative method. The discrepancy is surprising because USGS metrics were based on all sampled organisms (which includes "large and rare" taxa) and DFG metrics were based on a 300-organism subsample.

In the only case where both snag and riffle samples were collected (Arcade Creek), the samples collected from snags had fewer taxa (17 vs. 30), lower diversity (1.5 vs. 2.1), and fewer intolerant taxa (1% vs. 19%) than samples collected from the riffles.

Table 32. Physical Habitat Quality Scores For Sampling Reaches In Eight Drainages Within The Sacramento River Watershed[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. Embeddedness	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

This report describes biological data from macroinvertebrate samples collected by the DFG and the USGS in 1999. The dataset for the complete 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.

It is difficult to assess the biological condition of sites with only one year of biological data, but the relative ranking technique used in this report allows us to make some statements comparing the sites evaluated here. 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 would be the best means to assess the biological integrity of these and other monitoring sites.

All of the sites considered in this report were in good to excellent biological condition. 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 an 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 such as those in Deer Creek are likely to be good reference sites in the development of an IBI.

Most of the sites were also in good to excellent physical condition. 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 sites were generally in poorer condition than the wadable sites, but were comparable to the wadable large river sites. It is difficult to compare the relative condition of wadable sites and non-wadable sites in cases where snag samples were collected.

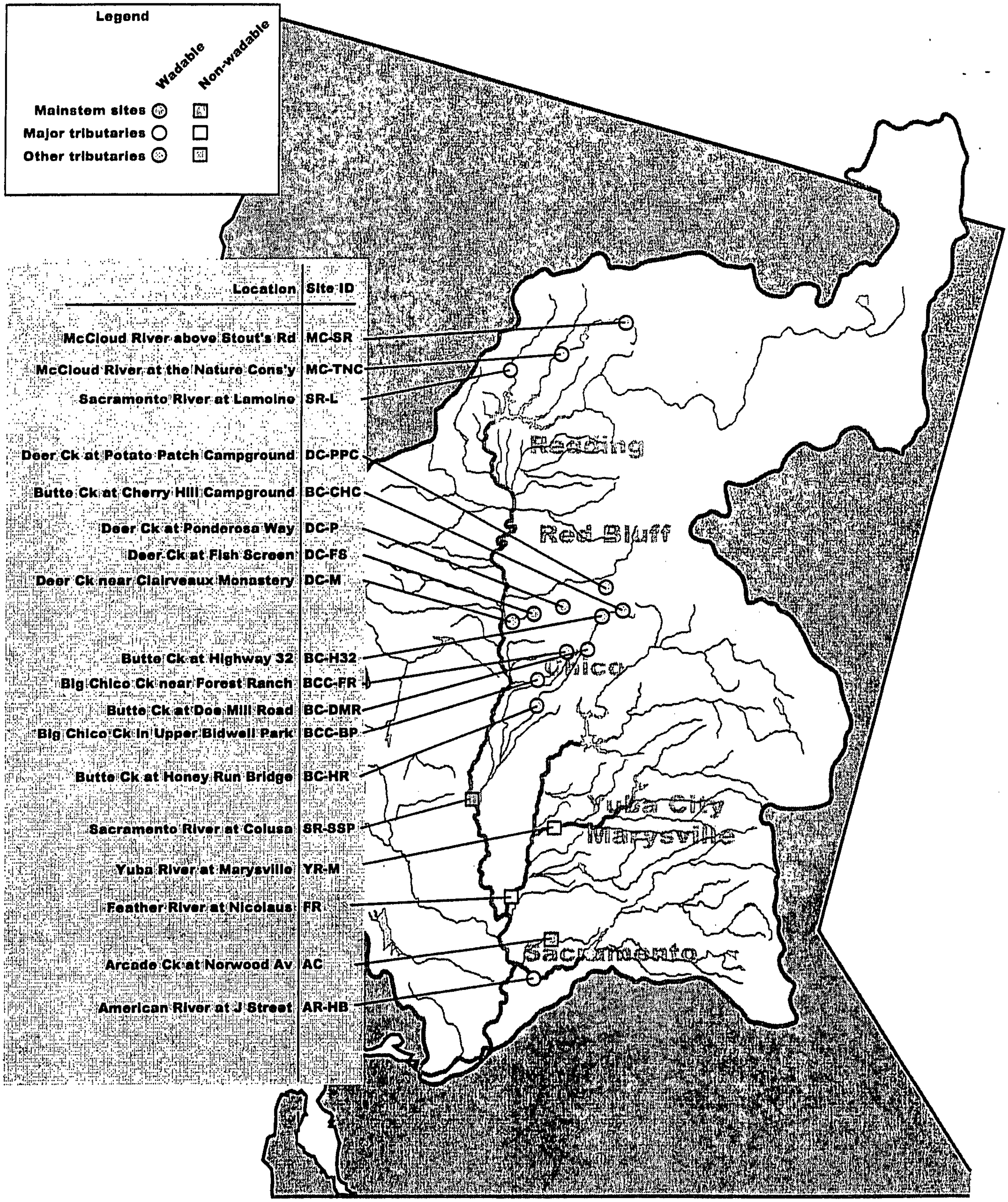


Figure 32. SRWP Bioassessment Monitoring in the Sacramento River Watershed: 1999 Macroinvertebrate Sampling Locations

Data was not available for this draft,

Figure 33. **Relative ranking scores for bioassessment sites within the Sacramento River watershed**

Data was not available for this draft,

Figure 34. **Relationships between biological ranking score and (a) physical habitat score, and (b) elevation.**

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 33. 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. When finalized, the Year 4 monitoring plan will be summarized in Table 34 in future drafts of this document.

Table 33. SRWP Monitoring for 1999-2000: Locations, Analytes, and Numbers of Annual Sample Events

Location	Water Chemistry											Path-ogens		Aquatic Toxicity		Fish Tissue		Bioassessment (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 Follow-up (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	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: 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 34. Proposed SRWP Monitoring for 2001-2002: Locations, Analytes, and Numbers of Annual Sample Events

Reserved for Final Year 4 Monitoring Plan

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, bioassay, 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.

V. References

Agency for Toxic Substances and Disease Registry (ATDSR) 1999. Toxicological Profile for Mercury. March 1999.

Alpers, C., H. Taylor, and J. Domagalski. 1998. Metal Transport in the Sacramento River, California, 1996-97: Part 1. Methods and Results (Preliminary Draft). U.S. Geological Survey Open File Report 98-___. U.S. Geological Survey, Sacramento, California. August 1998.

APHA, AWWA, and WEF 1995. Standard Methods for the Examination of Water and Wastewater, 19th Edition. American Public Health Association (APHA), American Waterworks Association (AWWA), and Water Environment Foundation (WEF). Washington, D.C., 1995.

ASTM 1995. Standard guide for conducting sediment toxicity tests with freshwater invertebrates. ASTM 1995 Annual Book of Standards Vol. 11.04, E1706-95. American Society for Testing and Materials (ASTM), Philadelphia, PA. 1995.

Bailey H, L Deanovic, E Reyes, T Kimball, K Larsen, K Cortright, V Connor, and D Hinton. 1997. Diazinon and Chlorpyrifos in Urban Waterways in Norhern California. Environmental Toxicology and Chemistry. In Press.

Bailey, H, C. DiGiorgio, K. Kroll, J. Miller, D. Hinton, and G. Starrett. 1996. Development of procedures for identifying pesticide toxicity in ambient waters: Carbofuran, diazinon, and chlorpyrifos. Environmental Toxicology and Chemistry 15: 837-845.

Barbour, M.T., J. Gerritsen, B.D. Snyder and J.B. Stribling. 1997. Revision to rapid bioassessment protocols for use in stream and rivers: periphyton, benthic macroinvertebrates and fish. EPA 841-D-97-002. U.S. Environmental Protection Agency. Washington DC.

CDFG 1990. Laboratory Quality Assurance Program Plan. California Department of Fish and Game (CDFG), Environmental Services Division. 1990.

CDFG 1996. California Stream Bioassessment Procedure for Habitat Assessment and Biological Sampling. California Department of Fish and Game, Aquatic Bioassessment Laboratory and Water Pollution Control Laboratory, Rancho Cordova, California. March 1996.

Connor, V. 1991. A Laboratory Manual for the Preparation and Use of Ion Exchange Resins to Determine the Concentration and Biotoxicity of Dissolved Trace Metals in Freshwater Samples. California Regional Water Quality Control Board (RWQCB), Central Valley Region. Sacramento, California. April 1991.

Cuffney, T. F., M.E. Gurtz, and M. R. Meador. 1993a. Methods for collecting benthic invertebrate samples as part of the national water-quality assessment program. U.S. Geological Survey, Open-File Report 93-406.

Cuffney, T. F., M.E. Gurtz, and M. R. Meador. 1993b. Guidelines for the Processing and Quality Assurance of Benthic Invertebrate Samples as Part of the National Water-Quality Assessment Program. U. S. Geological Survey, Open-File Report 93-407.

CVRWQCB 1995. The Water Quality Control Plan (Basin Plan) for the Central Valley Region, 4th Edition. California Regional Water Quality Control Board—Central Valley Region (CVRWQCB). Sacramento, California. 1994.

CVRWQCB 2000. Sacramento river Watershed Program Toxicity Testing Data Results Summary: 1998–99. California Regional Water Quality Control Board—Central Valley Region (CVRWQCB). Sacramento, California. February 2000.

Davis, W. S., B. D. Syder, J. B. Stribling and C. Stoughton. 1996. Summary of state biological assessment program for streams and wadable rivers. EPA 230-R-96-007. U.S. Environmental Protection Agency; Office of Policy, Planning and Evaluation: Washington, DC.

De Vlaming, V. V. Connor, C. DiGiorgio, H. Bailey, L. Deanovic, and D. Hinton. 2000. Application of whole effluent toxicity test procedures to ambient water quality assessment. Environmental Toxicology and Chemistry 19:42-62.

Domagalski, J. 1998. Occurrence and transport of total mercury and methyl mercury in the Sacramento River Basin, California. Journal of Geochemical Exploration 64: 277-291.

Domagalski, J. In Prep. Pesticide monitoring in the Sacramento River Basin, California, 2/96-9/98. USGS National Water-Quality Assessment Program. USGS report in preparation.

Dubrovsky, N., C. Kratzer, L. Brown, J. Gronberg, K. Burow. 1998. Water Quality in the San Joaquin-Tulare Basins, California, 1992-95. U.S. Geological Survey Circular 1159. National Water Quality Assessment Program, U.S. Geological Survey. 1998.

DWR 1997. Aquatic Invertebrate Sampling and Processing Methods (Draft). California Department of Water Resources (DWR) Northern District, Red Bluff, California. 1997.

Foe C, and R Sheipline. 1993. Pesticides in surface water from application on orchards and alfalfa during the winter and spring of 1991-92. Staff Report, Central Valley Regional Water Quality Control Board, Sacramento California.

Ganapathy, C, C Nordmark, K Bennett, A Bradley, H Feng, J Hernandez, and J White. 1997. Temporal distribution of insecticide residues in four California Rivers. Environmental Hazards Assessment Program, Environmental Monitoring and Pest

Management Branch, California Department of Pesticide Regulation, Sacramento, CA. Report EH97-06.

Gibson, G. R. 1996. Biological Criteria: Technical guidance for streams and small rivers. EPA 822-B-96-001. U.S. Environmental Protection Agency, Office of Water, Washington, D.C.

Gorder, N, J Lee, and K Newhart. 1996. Information on rice pesticides submitted to the California Regional Water Quality Control Board Central Valley Region. Environmental Monitoring and Pest Management Branch, Department of Pesticide Regulation, Sacramento, CA. December 31, 1996.

Gorder, N, J Lee, and K Newhart. 1997. Information on rice pesticides submitted to the California Regional Water Quality Control Board Central Valley Region. Environmental Monitoring and Pest Management Branch, Department of Pesticide Regulation, Sacramento, CA. December 31, 1997.

Gorder, N, J Lee, and K Newhart. 1998. Information on rice pesticides submitted to the California Regional Water Quality Control Board Central Valley Region. Environmental Monitoring and Pest Management Branch, Department of Pesticide Regulation, Sacramento, CA. December 31, 1998.

Gorder, N, K Newhart, and J Lee. 1995. Information on rice pesticides submitted to the California Regional Water Quality Control Board Central Valley Region. Environmental Monitoring and Pest Management Branch, Department of Pesticide Regulation, Sacramento, CA. December 28, 1995.

Harrington, J. M. 1996. California stream bioassessment procedures. California Department of Fish and Game, Water Pollution Control Laboratory. Rancho Cordova, CA.

Holmes R, V deVlaming, and Foe C. 1998. Sources and Concentrations of Diazinon in the Sacramento River Watershed During the 1994 Orchard Dormant Spray Season. Presented at the Northern California Society of Environmental Toxicology and Chemistry Annual Meeting, June 22, 1998.

Holmes, R, C Foe, and V de Vlaming. 1998. Sources and concentrations of diazinon in the Sacramento watershed during the 1994 orchard dormant spray season. Central Valley Regional Water Quality Control Board. Draft June 1998.

Katznelson R, and T Mumley. 1995. Diazinon in Surface Waters in the San Francisco Bay Area: Occurrence and Potential Impact. Final Report prepared for the State Water Resources Control Board, Alameda County Flood Control and Water Conservation District and Alameda Countywide Clean Water Program.

Kuivala K, and C Foe. 1995. Concentrations, transport, and biological effects of dormant spray pesticides in the San Francisco Estuary, California. Environmental Toxicology and Chemistry 14: 1141-1150.

Larsen K, L Deanovic, D Hinton and V Connor. 1998a. Sacramento River Watershed Program Toxicity Monitoring Results: 1996-1997. Staff Report, Central Valley Regional Water Quality Control Board, Sacramento California.

Larsen K, L Deanovic, D Hinton and V Connor. 1998b. Sacramento River Watershed Program Toxicity Monitoring Results: 1997-1998. Staff Report, Central Valley Regional Water Quality Control Board, Sacramento California.

LWA 1999. Sacramento Area Stormwater NPDES Permit Monitoring Program: Annual Report 1998-99. Prepared for the County of Sacramento and cities of Sacramento, Galt, and Folsom by Larry Walker Associates (LWA), Davis, California.

MacCoy, D., K. Crepeau, and K. Kuivila. 1995. Dissolved Pesticide Data for the San Joaquin River at Vernalis and the Sacramento River at Sacramento, California, 1991-94. Open-File Report 95-110. U.S. Geological Survey, Sacramento, California. 1995.

Miller, J. 2000. Results of Comparative Fathead Minnow Chronic Toxicity Tests on SRWP Samples. Presentation to the Sacramento River Watershed Program Toxics Sub-Committee. AQUA-Science, Davis, California. January 26, 2000.

Nordmark C, K Bennet, H Feng, J Hernandez, P Lee. 1998. Occurrence of Aquatic toxicity and Dormant-Spray Pesticide Detections in the Sacramento River Watershed, Winter 1996-97. California Department of Pesticide Regulation, Sacramento, California. February 1998.

Nordmark, C, K Bennett, H Feng, J Hernandez, and P Lee. 1998. Occurrence of aquatic toxicity and dormant-spray pesticide detections in the Sacramento River watershed, Winter 1996-97. Environmental Hazards Assessment Program, Environmental Monitoring and Pest Management Branch, Department of Pesticide Regulation, Sacramento, CA. Report EH98-01. February 1998.

Nordmark, C. 1998. Preliminary results of acute and chronic toxicity testing of surface water monitored in the Sacramento River watershed, winter 1997-98. Memorandum to Don Weaver, Environmental Monitoring and Pest Management, Department of Pesticide Regulation, Sacramento, California. July 31, 1998.

Nordmark, C. 1999. Preliminary results of acute and chronic toxicity testing of surface water monitored in the Sacramento River watershed, winter 1998-99. Memorandum to Don Weaver, Environmental Monitoring and Pest Management, Department of Pesticide Regulation, Sacramento, California. May 26, 1999.

Nordmark, C. In prep. Preliminary results of acute and chronic toxicity testing of surface water monitored in the Sacramento River watershed, winter 1999-00. Memorandum to Don Weaver, Environmental Monitoring and Pest Management, Department of Pesticide Regulation, Sacramento, California.

Nordmark, C., K. Bennet, H. Feng, J. Hernandez, P. Lee. 1998. Occurrence of Aquatic Toxicity and Dormant-Spray Pesticide Detections in the Sacramento River Watershed, Winter 1996-97. California Environmental Protection Agency, Department of Pesticide Regulation, Sacramento, California. February 1998.

Ogle S, and J Cooke. 2000. Water Quality Management Issue: Pesticides in Surface Water Runoff. Toxics Sub-committee, Sacramento River Watershed Program. 2000.

Plafkin, J., J. Barbour, K. Porter, S. Gross, R. Hughes. 1989. Rapid bioassessment protocols for use in streams and rivers: Benthic macroinvertebrates and fish. EPA/444/4-89-001. U.S. EPA, Office of Water. Washington, D.C. May, 1989.

Resh, V. H. and J. K. Jackson. 1993. Rapid assessment approaches to biomonitoring using benthic macroinvertebrates. In: D. M. Rosenberg and V. H. Resh, eds., Chapman and Hall, New York.

RWQCB 1991. The Use of Ion Exchange Resins to Determine the Biotoxicity and Concentration of Dissolved Trace Metals in Natural Waters. California Regional Water Quality Control Board (RWQCB), Central Valley Region. Sacramento, California. August 1991.

SFBRWQCB 1995. Contaminant Levels in Fish Tissue from San Francisco Bay. San Francisco Bay Regional Water Quality Control Board (SFBRWQCB), Oakland, California. June 1995.

SFEI 1996. Quality Assurance Project Plan: Regional Monitoring Program for Trace Substances. San Francisco Estuary Institute (SFEI), Richmond, CA. 1996.

SFEI 1998. San Francisco Estuary Regional Monitoring Program for Trace Substances: 1997 Annual Report. San Francisco Estuary Institute (SFEI), Richmond, California. 1998.

SFEI 1999a. Persistent Toxic Chemical of Human Health Concern in Fish from San Francisco Bay and the Sacramento River, CA. San Francisco Estuary Institute (SFEI), Richmond, CA.

SFEI 1999b. 1997 Annual Report: San Francisco Estuary Regional Monitoring Program for Trace Substances. San Francisco Estuary Institute (SFEI), Richmond, CA. June 1999.

SFRWQCB (San Francisco Regional Water Quality Control Board), State Water Resources Control Board, and California Department of Fish and Game, 1995. Contaminant Levels in fish tissue from San Francisco Bay: Final Report. San Francisco Regional Water Quality Control Board, Oakland, CA.

Slotton, D., S. Ayers, J. Reuter, and C. Goldman. 1995. Gold Mining Impacts on Food Chain Mercury in Northwestern Sierra Nevada Streams, Technical Completion

Report. Division of Environmental Studies and Institute of Ecology, University of California, Davis. August 1995.

Slotton, D., S. Ayers, J. Reuter, and C. Goldman. 1997. Cache Creek Watershed Preliminary Mercury Assessment, Using Benthic Invertebrates. Division of Environmental Studies, University of California Davis. June 1997.

SRWP 1999. Sacramento River Watershed Program Phase 1 Monitoring Plan. Prepared by Larry Walker Associates for the Sacramento River Watershed Program (SRWP). September 1998.

Sutter County Department of Agriculture (personal communication). 1997. Results of sampling Sutter Basin agricultural drain for suspected phenoxy compounds. June 26, 1997. (in Ogle and Cooke 2000)

U.S. Environmental Protection Agency, Integrated Risk Information System [IRIS] database, March 13, 1998.

USEPA 1979. Handbook for Analytical Quality Control in Water and Wastewater Laboratories. EPA 600-4-79-019. U.S. Environmental Protection Agency (USEPA). March 1979.

USEPA 1979. Methods for Chemical Analysis of Water and Wastes (EPA 600-4-79-020). U.S. Environmental Protection Agency (USEPA). March 1979.

USEPA 1986. Quality Criteria for Water. EPA 440-5-86-001. U.S. Environmental Protection Agency (USEPA), Office of Water. Washington DC. May 1986.

USEPA 1991. Methods for Aquatic Toxicity Identification Evaluations: Phase I Toxicity Characterization Procedures. EPA 600/6-91-003. Office of Research and Development. 1991.

USEPA 1992. Toxicity Identification Evaluation: Characterization of Chronically Toxic Effluents, Phase I. EPA 600/6-91-005F. U.S. Environmental Protection Agency (USEPA), Office of Research and Development. May 1992.

USEPA 1993. Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories: Volume 1, Fish Sampling and Analysis, Second Edition. EPA 823-R-93-002. U.S. Environmental Protection Agency (USEPA), Office of Water, Washington, DC.

USEPA 1993a. Methods for Aquatic Toxicity Identification Evaluations: Phase II Toxicity Identification Procedures for Samples Exhibiting Acute and Chronic Toxicity (EPA 600/R-92-080). U.S. Environmental Protection Agency (USEPA), Office of Research and Development. September 1993.

USEPA 1993b. Methods for Aquatic Toxicity Identification Evaluations: Phase I and III Toxicity Identification Procedures for Samples Exhibiting Acute and Chronic Toxicity (EPA 600/R-92-081). U.S. Environmental Protection Agency (USEPA), Office of Research and Development. September 1993.

USEPA 1993c. Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms. Fourth Edition, EPA-600/4-90-027F. U.S. Environmental Protection Agency (USEPA), Office of Research and Development, Cincinnatti, OH. 1993.

USEPA 1994a. Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms (EPA 600/4-91-002). U.S. Environmental Protection Agency (USEPA), Office of Research and Development. July 1994.

USEPA 1994b. Methods for Measuring the Toxicity and Bioaccumulation of Sediment-associated Contaminants with Freshwater Invertebrates. EPA-600/R-94/024. U.S. Environmental Protection Agency (USEPA), Office of Research and Development, Washington DC. June 1994.

USEPA 1995. Final Water Quality Guidance for the Great Lakes System. Final Rule. 40 CFR Parts 9,122,123,131,and 132. Federal Register. Vol. 60 No. 56. March 23. Rules and Regulations.

USEPA 1995. Guidance on the Documentation and Evaluation of Trace Metals Data Collected for Clean Water Act Compliance Monitoring. U.S. Environmental Protection Agency (USEPA), Office of Water. EPA 821-B-95-002. April 1995.

USEPA 1995. Method 1631: Mercury in Water by Oxidation, Purge and Trap, and Cold Vapor Atomic Fluorescence Spectrometry. U.S. Environmental Protection Agency (USEPA), Office of Water. EPA 821-R 95-027. April 1995.

USEPA 1995. Method 1632: Determination of Inorganic Arsenic in Water by Hydride Generation Flame Atomic Absorption. U.S. Environmental Protection Agency (USEPA), Office of Water. EPA 821-R-95-028. April 1995.

USEPA 1995. Method 1638: Determination of Trace Elements in Ambient Waters by Inductively Coupled Plasma-Mass Spectrometry. U.S. Environmental Protection Agency (USEPA), Office of Water. EPA 821-R-95-031. April 1995.

USEPA 1995. Method 1639: Determination of Trace Elements in Ambient Waters by Stabilized Temperature Graphite Furnace Atomic Absorption. U.S. Environmental Protection Agency (USEPA), Office of Water. EPA 821-R-95-032. April 1995.

USEPA 1995. National Toxics Rule. Environmental Protection Agency (USEPA), Office of Water. Promulgated in the Code of Federal Regulations, 40 CFR 131.31, December 1992, and amended in May 1995.

USEPA 1996. Drinking water Regulations and Health Advisories. U.S. Environmental Protection Agency (USEPA), Office of Water. EPA-822-B-96-002. October 1996.

USEPA 1997. Mercury Study Report to Congress. U.S. Environmental Protection Agency (USEPA), Office of Air Quality Planning and Standards and Office of Research and Development. Volumes 1–8. EPA-452/R-97-009.

USEPA 1998. 1997 National Listing of Fish Consumption Advisories. U.S. Environmental Protection Agency (USEPA), Office of Water. EPA-823-C-98-001/002.

USEPA 1998. National Primary Drinking Water Regulations: Interim Enhanced Surface Water Treatment. Final Rule. 40 CFR Parts 9, 141, and 142 Federal Register. Vol. 63 No. 241. December 16, 1988. Rules and Regulations.

USEPA 1998. U.S. EPA Iris substance file: Polychlorinated biphenyls (PCBs). U.S. Environmental Protection Agency (USEPA), Washington, DC.

USEPA 1999. National Recommended Water Quality Criteria—Correction. EPA 822-Z-99-001. U.S. Environmental Protection Agency (USEPA), Office of Water. Washington, DC. April 1999.

USGS 1999. Sacramento River Watershed NAWQA data provided by Joseph Domagalski of the U.S. Geological Survey (USGS), Sacramento, California. September 1999.

Wofford, P, and P Lee. 1995. Results of monitoring for the herbicide MCPA in surface water of the Sacramento River basin. Environmental Monitoring and Pest Management Branch, Department of Pesticide Regulation, Sacramento, CA. Report EH95-11. December 1995.

APPENDIX A

Beneficial Uses in the Sacramento River Basin (CVRWQCB 1994)

Reserved for Public Draft

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)

Reserved for Public Draft

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

Reserved for Public Draft

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

Sacramento River Watershed Program Data Collection Methods

Information in this Section is documented in the QAPP for the 1999-2000 SRWP Monitoring Program (LWA 1999)

APPENDIX E

Review of Quality Assurance Data

Reserved for Public Draft

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 inter- and intra-laboratory 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.

Algae Analysis Processing and Analysis

Accuracy of identifications and precision of enumeration of algal was assessed by analysis of split samples. Algal samples split in the field were sent to the analyzing contract laboratory and to the USGS Quality-Assurance Unit (BQUA). Split samples were submitted and analyzed at the rate of one for every ten samples. Quality criteria and corrective actions for algal sample processing, identification, and enumeration are analogous to those described by Cuffney et al. (1993).

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	$R_{log} \leq 3.27 \cdot$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 analysed 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. *[Note: this document has not yet been submitted]*

The overall completion rate was greater than the __% 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 SRWP benthic macroinvertebrate analyses have not yet been completed. The reason for the delay in completion of the QA analyses is that the Department of Water Resources laboratory responsible for analyzing approximately half of the benthic invertebrate samples has not completed the analyses and have not delivered the samples to the California Department of Fish and Game laboratory for reanalysis. In addition, results of bioassessment monitoring for algae have not been reported. The results of these QA analyses will be reported when they are completed and provided.

The overall completion rate to date is less than 50% and has not yet met the 100% objective for the program. However, it is expected that all of the samples will be analyzed and the 100% objective eventually met. Because the Quality assurance analyses have not yet been completed, it is not yet known whether this monitoring element provided data that were 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). __% of the total analyses were performed within acceptable holding times. Analyses performed outside of acceptable limits resulted in qualification of __ analytical results (for alkalinity, orthophosphate, total phosphate, TDS, TSS, and turbidity). Results for mercury analyses performed after the specified holding time were not qualified, because both the analyzing laboratory and the laboratory that developed the method felt that results were not compromised by minor exceedances of the 28-day limit. 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, lead, mercury, nickel, TDS, turbidity, and organic carbon were detected at greater than program reporting limits in laboratory method blanks for a total of __ analyses. Analytes detected in method blanks resulted in qualifications of __ analytical results. The overall success rates for analyses of laboratory method and filter blanks was __%. With the exceptions noted, 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, __ laboratory control sample recoveries were outside project specifications. 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 Table 9.

Laboratory Duplicates

Analysis of duplicate samples was conducted to evaluate analytical precision. If laboratory duplicate results were outside this range, 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, __ laboratory duplicate results were outside program specification. The overall success rate for analyses of laboratory control sample duplicate RPDs was ___%. 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 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 "estimated" due to matrix interference.

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 18 analyses. The overall success rate for analyses of matrix spike recoveries was __%. In ___cases, the matrix spike recoveries were performed on non-SRWP samples, and did not result in the qualification of any SRWP environmental data. 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 Table 11.

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 ___ analyses. In ___ of these cases, the sample matrix spiked was not an SRWP sample, and no SRWP data were qualified on the basis of these results. The overall success rate for analyses of matrix spike duplicates was ___%. 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 ___ field blank analyses: __ trace metal analyses, __ organic carbon analyses, and __ nutrient analyses. Field blank analyses resulted in the qualification of __ environmental data. The overall success rate for analysis of field blanks was ___%. 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

Mercury, total

Units = ng/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
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	5/19/99	12	12	100%	2.3	130.9	2.8	3.7	7.4	14.9	51.4	—
MCBLR	Mill Creek at Black Rock	6/23/98	5/19/99	11	11	100%	2.0	110.0	2.6	3.8	12.1	34.0	96.6	—
MCHWY	Mill Creek at Highway 36	6/23/98	5/19/99	12	12	100%	4.4	222.0	7.1	31.0	42.3	77.7	120.5	—
DCMOU	Deer Creek at Mouth	6/24/98	5/18/99	11	11	100%	0.3	1.9	0.4	0.5	0.6	0.9	1.2	—
DCUDD	Deer Creek at Upper Diversion Dam	6/24/98	5/18/99	12	12	100%	0.2	4.2	0.2	0.3	0.6	1.1	3.7	—
DCPON	Deer Creek at Ponderosa Way	6/24/98	5/18/99	8	8	100%	0.2	5.0	0.2	0.3	0.4	0.4	1.8	—
DCMDW	Deer Creek below Childs Meadows	6/24/98	5/18/99	12	12	100%	0.2	1.6	0.3	0.4	0.6	0.8	0.8	—
CHMUD	Big Chico Creek above Mud Creek	6/23/98	5/20/99	12	12	100%	0.3	4.3	0.4	0.4	0.6	1.5	2.6	—
MUDCH	Mud Creek above Big Chico Creek	6/23/98	5/20/99	8	8	100%	0.4	57.7	0.5	0.8	1.1	2.1	19.7	—
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/23/98	5/20/99	12	12	100%	0.2	2.1	0.3	0.4	0.5	0.6	1.2	—
CHASH	Big Chico Creek above Salmon Hole	6/23/98	5/20/99	12	11	92%	0.2	4.5	0.3	0.4	0.8	1.7	3.8	3
CHHWY	Big Chico Creek at Hwy 32	6/23/98	5/20/99	12	11	92%	0.2	1.6	0.2	0.3	0.5	1.0	1.6	3
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	—
SRCOL	Sacramento River at Colusa	2/28/96	6/10/98	29	29	100%	1.7	105.2	2.2	2.9	4.6	10.4	18.4	—
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	6/21/00	123	123	100%	1.2	36.2	3.4	4.2	7.2	11.5	16.5	—
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	—

Methyl Mercury, total

Units = ng/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
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	6/9/98	27	26	96%	0.01	0.46	0.03	0.06	0.12	0.19	0.30	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	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	9/15/98	32	19	59%	1	2	<RL	<RL	1.0	1.0	1.9	1
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	12	12	100%	1.11	2.09	1.1	1.2	1.5	1.6	1.7	—

Arsenic, 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
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	—
MCMOU	Mill Creek at Mouth	6/23/98	5/19/99	11	11	100%	2.0	26.8	8.5	12.3	15.0	18.8	26.1	—
MCBLR	Mill Creek at Black Rock	6/23/98	5/19/99	11	11	100%	11.3	28.8	12.6	13.4	19.6	28.2	28.7	—
MCHWY	Mill Creek at Highway 36	6/23/98	5/19/99	12	12	100%	10.8	109.0	18.7	24.8	69.7	95.5	100.6	—
DCMOU	Deer Creek at Mouth	6/24/98	5/18/99	10	10	100%	0.58	5.46	1.20	1.43	2.05	3.55	4.40	—
DCUDD	Deer Creek at Upper Diversion Dam	6/24/98	5/18/99	12	12	100%	0.68	5.46	0.97	1.48	1.98	3.60	4.82	—
DCPON	Deer Creek at Ponderosa Way	6/24/98	5/18/99	8	8	100%	0.27	19.80	0.29	0.31	0.41	0.71	6.45	—
DCMDW	Deer Creek below Childs Meadows	6/24/98	5/18/99	12	12	100%	0.13	0.46	0.15	0.18	0.25	0.33	0.35	—
CHMUD	Big Chico Creek above Mud Creek	6/23/98	5/20/99	12	12	100%	0.15	0.62	0.17	0.23	0.26	0.39	0.55	—
MUDCH	Mud Creek above Big Chico Creek	6/23/98	5/20/99	8	7	88%	0.03	0.21	<RL	0.06	0.07	0.13	0.17	0.05
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/23/98	5/20/99	12	12	100%	0.11	0.61	0.17	0.20	0.24	0.38	0.55	—
CHASH	Big Chico Creek above Salmon Hole	6/23/98	5/20/99	12	12	100%	0.07	0.65	0.16	0.18	0.26	0.38	0.58	—
CHHWY	Big Chico Creek at Hwy 32	6/23/98	5/20/99	12	12	100%	0.00	0.15	0.03	0.05	0.06	0.08	0.14	—
SRVET	Sacramento River at Veterans Bridge	1/4/94	12/16/98	83	78	94%	0.83	3.63	1.08	1.40	1.70	1.90	2.28	1
ARDPK	American River at Discovery Park	1/4/94	9/21/99	74	39	53%	0.07	1.23	<RL	<RL	0.58	1.00	1.00	0.05
SRFPT	Sacramento River at Freeport	1/4/94	12/17/98	81	74	91%	0.78	3.60	1.00	1.27	1.48	1.70	1.90	1
SRRMF	Sacramento River at River Mile 44	1/18/94	12/17/98	74	68	92%	0.76	3.07	1.04	1.20	1.45	1.80	2.05	1
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	12	12	100%	1.21	2.56	1.29	1.35	1.62	1.84	1.99	—

Cadmium, 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
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	12/16/98	81	26	32%	0.01	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	9/21/99	79	12	15%	0.004	0.04	<RL	<RL	<RL	<RL	0.03	0.01
SRFPT	Sacramento River at Freeport	1/4/94	12/17/98	111	29	26%	0.01	0.04	<RL	<RL	<RL	1.00	1.00	0.01
SRRMF	Sacramento River at River Mile 44	1/18/94	12/17/98	74	22	30%	0.01	0.04	<RL	<RL	<RL	0.03	0.03	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

Site ID	Site Description	monitoring period 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
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*	*5/19/99*	*11*	*6*	*55%*	*0.003*	*0.012*	*<RL*	*<RL*	*0.004*	*0.005*	*0.007*	*0.003*
MCBLR	Mill Creek at Black Rock	6/23/98	5/19/99	10	7	70%	0.002	0.012	<RL	<RL	0.007	0.007	0.008	0.003
MCHWY	Mill Creek at Highway 36	6/23/98	5/19/99	11	8	73%	0.006	0.023	<RL	<RL	0.008	0.010	0.014	0.003
DCMOU	Deer Creek at Mouth	6/24/98	5/18/99	10	3	30%	0.003	0.007	<RL	<RL	<RL	0.005	0.005	0.001
DCUDD	Deer Creek at Upper Diversion Dam	6/24/98	5/18/99	11	3	27%	0.001	0.004	<RL	<RL	<RL	0.004	0.005	0.001
DCPON	Deer Creek at Ponderosa Way	6/24/98	5/18/99	8	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	0.001
DCMDW	Deer Creek below Childs Meadows	6/24/98	5/18/99	11	2	18%	0.004	0.005	<RL	<RL	<RL	<RL	0.005	0.001
CHMUD	Big Chico Creek above Mud Creek	6/23/98	5/20/99	11	4	36%	0.004	0.014	<RL	<RL	<RL	0.006	0.009	0.001
MUDCH	*Mud Creek above Big Chico Creek*	*6/23/98*	*5/20/99*	*7*	*3*	*43%*	*0.003*	*0.01*	*<RL*	*<RL*	*<RL*	*0.006*	*0.008*	*0.003*
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/23/98	5/20/99	11	1	9%	0.004	0.004	<RL	<RL	<RL	<RL	<RL	0.001
CHASH	Big Chico Creek above Salmon Hole	6/23/98	5/20/99	11	2	18%	0.003	0.005	<RL	<RL	<RL	<RL	0.005	0.001
CHHWY	Big Chico Creek at Hwy 32	6/23/98	5/20/99	11	4	36%	0.003	0.005	<RL	<RL	<RL	0.005	0.005	0.001
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	—
SRVET	Sacramento River at Veterans Bridge	1/4/94	12/16/98	81	66	81%	0.019	0.74	<RL	0.030	0.040	0.050	0.080	0.01
ARDPK	American River at Discovery Park	1/4/94	9/21/99	80	21	26%	0.01	0.2	<RL	<RL	<RL	0.030	0.030	0.005
SRFPT	Sacramento River at Freeport	1/4/94	12/17/98	79	65	82%	0.017	0.35	<RL	0.030	0.032	0.050	0.061	0.01
SRRMF	*Sacramento River at River Mile 44*	*1/18/94*	*12/17/98*	*72*	*54*	*75%*	*0.017*	*0.37*	*<RL*	*0.030*	*0.032*	*0.050*	*0.070*	*0.01*
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

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	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

Chromium, 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
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	—
MCMOU	Mill Creek at Mouth	6/23/98	5/19/99	12	11	92%	0.07	7.64	0.08	0.26	0.50	0.63	0.70	0.05
MCBLR	Mill Creek at Black Rock	6/23/98	5/19/99	11	11	100%	0.12	7.74	0.18	0.20	0.48	0.62	0.88	—
MCHWY	Mill Creek at Highway 36	6/23/98	5/19/99	12	10	83%	0.21	12.75	<RL	0.27	0.37	0.69	0.80	0.05
DCMOU	Deer Creek at Mouth	6/24/98	5/18/99	11	10	91%	0.07	1.3	0.07	0.20	0.33	0.84	1.23	0.05
DCUDD	Deer Creek at Upper Diversion Dam	6/24/98	5/18/99	12	11	92%	0.08	0.72	0.08	0.11	0.23	0.31	0.40	0.04
DCPON	Deer Creek at Ponderosa Way	6/24/98	5/18/99	8	7	88%	0.07	0.66	<RL	0.10	0.26	0.35	0.46	0.06
DCMDW	Deer Creek below Childs Meadows	6/24/98	5/18/99	12	8	67%	0.12	0.38	<RL	<RL	0.13	0.33	0.36	0.04
CHMUD	Big Chico Creek above Mud Creek	6/23/98	5/20/99	12	12	100%	0.07	1.81	0.12	0.32	0.66	1.01	1.59	—
MUDCH	Mud Creek above Big Chico Creek	6/23/98	5/20/99	8	7	88%	0.14	0.99	<RL	0.20	0.44	0.78	0.89	0.04
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/23/98	5/20/99	12	11	92%	0.09	0.86	0.10	0.22	0.39	0.56	0.80	0.06
CHASH	Big Chico Creek above Salmon Hole	6/23/98	5/20/99	12	11	92%	0.1	0.84	0.10	0.24	0.38	0.51	0.67	0.05
CHHWY	Big Chico Creek at Hwy 32	6/23/98	5/20/99	12	12	100%	0.14	0.81	0.20	0.28	0.42	0.54	0.75	—
SRVET	Sacramento River at Veterans Bridge	1/4/94	12/16/98	83	74	89%	0.28	14.3	<RL	1.37	2.24	3.55	4.97	1
ARDPK	American River at Discovery Park	1/4/94	9/21/99	82	44	54%	0.13	2.2	<RL	<RL	1.00	1.00	1.18	0.05
SRFPT	Sacramento River at Freeport	1/4/94	12/17/98	81	69	85%	0.21	9.7	<RL	1.09	1.82	3.26	4.43	1
SRRMF	Sacramento River at River Mile 44	1/18/94	12/17/98	74	65	88%	0.8	10	<RL	1.20	1.84	2.96	4.19	1
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	12	12	100%	1.37	10.8	2.87	4.06	5.46	7.54	9.70	—

Summary Statistics: Trace Metals Data

Copper, dissolved

Units = µg/L

		monitoring period					min	max	percentile statistics		median			min
Site ID	Site Description	start	end	n	n det	% det	det	det	10th	25th	(50th)	75th	90th	RL
SRBKR	Sacramento River below Keswick	1/20/98	4/18/00	43	42	98%	0.57	7.03	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%	0.569	3.92	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%	0.596	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	8.04	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	12/16/98	83	82	99%	0.5	2.9	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%	0.185	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	2.8	<RL	<RL	<RL	<RL	1.7	1
ARDPK	American River at Discovery Park	1/4/94	9/21/99	80	67	84%	0.179	1.3	<RL	0.5	0.5	0.8	0.9	0.5
SRFPT	Sacramento River at Freeport	1/4/94	12/17/98	113	111	98%	0.5	3	1.0	1.1	1.3	1.7	2.2	0.5
SRRMF	Sacramento River at River Mile 44	1/18/94	12/17/98	76	75	99%	0.625	6	1.0	1.1	1.4	1.7	2.1	0.5
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	12	12	100%	1.16	4.21	1.3	1.5	1.8	2.4	3.9	—

Copper, total

Units = µg/L

		monitoring period					min	max	percentile statistics		median			min
Site ID	Site Description	start	end	n	n det	% det	det	det	10th	25th	(50th)	75th	90th	RL
SRBKR	Sacramento River below Keswick	1/20/98	4/18/00	39	39	100%	0.06	13.00	1.06	1.32	2.13	4.18	6.94	—
SRABB	Sacramento River above Bend Bridge	6/23/99	5/17/00	12	12	100%	0.93	6.53	0.99	1.27	1.70	3.10	3.82	—
MCMOU	Mill Creek at Mouth	6/23/98	5/19/99	12	11	92%	0.43	7.88	0.44	0.58	0.97	1.35	2.01	0.04
MCBLR	Mill Creek at Black Rock	6/23/98	5/19/99	11	11	100%	0.32	7.88	0.34	0.45	1.05	1.23	2.53	—
MCHWY	Mill Creek at Highway 36	6/23/98	5/19/99	12	12	100%	0.63	11.22	0.69	1.00	1.72	2.14	2.75	—
DCMOU	Deer Creek at Mouth	6/24/98	5/18/99	11	11	100%	0.31	1.25	0.32	0.54	0.61	0.82	1.10	—
DCUDD	Deer Creek at Upper Diversion Dam	6/24/98	5/18/99	12	12	100%	0.09	0.63	0.12	0.17	0.27	0.37	0.54	—
DCPON	Deer Creek at Ponderosa Way	6/24/98	5/18/99	8	8	100%	0.11	0.43	0.12	0.13	0.21	0.32	0.42	—
DCMDW	Deer Creek below Childs Meadows	6/24/98	5/18/99	12	10	83%	0.09	0.46	<RL	0.11	0.15	0.22	0.38	0.04
CHMUD	Big Chico Creek above Mud Creek	6/23/98	5/20/99	12	12	100%	0.23	1.77	0.30	0.35	0.58	0.78	1.43	—
MUDCH	Mud Creek above Big Chico Creek	6/23/98	5/20/99	8	8	100%	0.30	1.52	0.44	0.79	1.10	1.35	1.61	—
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/23/98	5/20/99	12	12	100%	0.21	0.81	0.23	0.26	0.34	0.45	0.71	—
CHASH	Big Chico Creek above Salmon Hole	6/23/98	5/20/99	12	12	100%	0.08	0.60	0.12	0.18	0.27	0.38	0.59	—
CHHWY	Big Chico Creek at Hwy 32	6/23/98	5/20/99	12	11	92%	0.09	0.50	0.09	0.11	0.15	0.22	0.32	0.04
SRHAM	Sacramento River near Hamilton City	6/23/99	5/16/00	13	13	100%	1.21	18.90	1.31	1.46	1.72	3.32	11.09	—
SACSL	Sacramento Slough	6/22/99	5/16/00	12	12	100%	3.59	7.42	4.06	4.11	5.11	6.19	6.98	—
COLDR	Colusa Basin Drain	6/23/99	5/16/00	13	13	100%	3.81	21.50	4.16	5.27	7.48	8.87	15.42	—
SRVET	Sacramento River at Veterans Bridge	1/4/94	12/16/98	83	83	100%	1.40	16.90	2.43	2.95	3.69	5.14	6.53	—
ARCNW	Arcade Creek at Norwood Ave.	6/22/99	5/17/00	12	12	100%	0.69	21.10	2.05	2.49	4.29	7.86	10.76	—
ARDPK	American River at Discovery Park	1/4/94	12/16/98	81	78	96%	0.40	3.60	0.52	0.63	0.82	1.10	1.70	0.5
SRFPT	Sacramento River at Freeport	1/4/94	12/17/98	81	81	100%	1.54	14.00	2.01	2.50	3.40	4.66	6.79	—
SRRMF	Sacramento River at River Mile 44	1/18/94	12/17/98	74	74	100%	1.20	15.00	2.13	2.60	3.34	5.15	6.60	—
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	13	13	100%	2.04	8.29	3.21	3.49	4.47	6.56	8.01	—

Lead, dissolved

Units = µg/L

		monitoring period					min	max	percentile statistics		median			min
Site ID	Site Description	start	end	n	n det	% det	det	det	10th	25th	(50th)	75th	90th	RL
SRBKR	Sacramento River below Keswick	1/20/98	4/18/00	39	30	77%	0.004	0.125	<RL	0.01	0.02	0.04	0.08	0.005
SRABB	Sacramento River above Bend Bridge	2/13/96	7/21/99	29	2	7%	0.015	0.023	<RL	<RL	<RL	<RL	<RL	1
SRCOL	Sacramento River at Colusa	2/28/96	11/16/99	33	1	3%	0.060	0.060	<RL	<RL	<RL	<RL	<RL	1
SACSL	Sacramento Slough	2/12/96	11/16/99	28	3	11%	0.049	0.130	<RL	<RL	<RL	<RL	1.00	1
COLDR	Colusa Basin Drain	2/7/96	8/18/99	30	3	10%	0.038	0.264	<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	0.088	<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	12/16/98	83	20	24%	0.100	0.400	<RL	<RL	<RL	<RL	0.19	0.1
ARCNW	Arcade Creek at Norwood Ave.	2/6/96	7/20/99	30	3	10%	1.040	1.320	<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	0.500	<RL	<RL	<RL	<RL	0.10	0.1
SRFPT	Sacramento River at Freeport	1/4/94	12/17/98	113	18	16%	0.100	0.500	<RL	<RL	<RL	<RL	1.00	0.1
SRRMF	Sacramento River at River Mile 44	1/18/94	12/17/98	76	16	21%	0.040	0.300	<RL	<RL	<RL	<RL	0.10	0.1
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	12	11	92%	0.018	0.640	0.02	0.04	0.07	0.21	0.48	0.005

Summary Statistics: Trace Metals Data

Lead, 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	36	92%	0.005	0.750	0.02	0.03	0.05	0.09	0.19	0.005
MCMOU	Mill Creek at Mouth	6/23/98	5/19/99	11	8	73%	0.026	1.282	<RL	<RL	0.05	0.19	1.01	0.009
MCBLR	Mill Creek at Black Rock	6/23/98	5/19/99	10	7	70%	0.033	1.337	<RL	<RL	0.05	0.13	0.42	0.01
MCHWY	Mill Creek at Highway 36	6/23/98	5/19/99	11	8	73%	0.029	2.562	<RL	<RL	0.05	0.19	0.36	0.009
DCMOU	Deer Creek at Mouth	6/24/98	5/18/99	10	7	70%	0.012	0.179	<RL	<RL	0.02	0.06	0.13	0.009
DCUDD	Deer Creek at Upper Diversion Dam	6/24/98	5/18/99	11	4	36%	0.020	0.059	<RL	<RL	<RL	0.03	0.05	0.009
DCPON	Deer Creek at Ponderosa Way	6/24/98	5/18/99	8	3	38%	0.019	3.250	<RL	<RL	<RL	0.02	0.99	0.009
DCMDW	Deer Creek below Childs Meadows	6/24/98	5/18/99	11	6	55%	0.013	0.060	<RL	<RL	0.02	0.03	0.05	0.009
CHMUD	Big Chico Creek above Mud Creek	6/23/98	5/20/99	11	8	73%	0.013	0.823	<RL	<RL	0.09	0.16	0.26	0.009
MUDCH	Mud Creek above Big Chico Creek	6/23/98	5/20/99	8	7	88%	0.030	0.206	<RL	0.03	0.07	0.13	0.16	0.048
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/23/98	5/20/99	11	8	73%	0.013	0.461	<RL	<RL	0.03	0.04	0.07	0.009
CHASH	Big Chico Creek above Salmon Hole	6/23/98	5/20/99	11	4	36%	0.010	0.045	<RL	<RL	<RL	0.02	0.05	0.009
CHHWY	Big Chico Creek at Hwy 32	6/23/98	5/20/99	11	4	36%	0.010	0.019	<RL	<RL	<RL	0.01	0.02	0.009
SRVET	Sacramento River at Veterans Bridge	1/4/94	12/16/98	83	83	100%	0.2	7.2	0.30	0.40	0.52	0.78	1.10	—
ARDPK	American River at Discovery Park	1/4/94	9/21/99	82	72	88%	0.071	1.28	<RL	0.11	0.20	0.30	0.50	0.1
SRFPT	Sacramento River at Freeport	1/4/94	12/17/98	81	81	100%	0.16	3	0.20	0.30	0.50	0.90	1.27	—
SRRMF	Sacramento River at River Mile 44	1/18/94	12/17/98	74	74	100%	0.1	3.4	0.29	0.32	0.53	0.89	1.41	—
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

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	5/20/99	4/18/00	15	15	100%	0.34	1.86	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	2/20/96	9/15/98	32	9	28%	1	3	<RL	<RL	<RL	1.0	1.5	1
CCHSL	Cache Slough near Ryers Ferry	6/22/99	2/16/00	6	6	100%	0.65	5.37	0.8	1.0	1.4	3.6	4.8	—

Nickel, 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%	0.51	4.71	1.03	1.25	1.53	2.54	3.07	—
MCMOU	Mill Creek at Mouth	6/23/98	5/19/99	12	11	92%	0.05	5.29	0.07	0.22	0.69	0.91	1.54	0.05
MCBLR	Mill Creek at Black Rock	6/23/98	5/19/99	11	11	100%	0.05	5.24	0.25	0.37	0.86	0.98	2.18	—
MCHWY	Mill Creek at Highway 36	6/23/98	5/19/99	12	12	100%	1.21	7.51	1.45	1.77	2.42	2.85	3.12	—
DCMOU	Deer Creek at Mouth	6/24/98	5/18/99	11	10	91%	0.01	1.43	0.01	0.22	0.54	0.70	0.94	0.01
DCUDD	Deer Creek at Upper Diversion Dam	6/24/98	5/18/99	12	5	42%	0.06	0.38	<RL	<RL	<RL	0.13	0.23	0.01
DCPON	Deer Creek at Ponderosa Way	6/24/98	5/18/99	8	3	38%	0.11	0.35	<RL	<RL	<RL	0.17	0.35	0.005
DCMDW	Deer Creek below Childs Meadows	6/24/98	5/18/99	12	5	42%	0.03	0.11	<RL	<RL	<RL	0.07	0.11	0.005
CHMUD	Big Chico Creek above Mud Creek	6/23/98	5/20/99	12	7	58%	0.23	3.12	<RL	<RL	0.29	0.94	1.93	0.005
MUDCH	Mud Creek above Big Chico Creek	6/23/98	5/20/99	8	8	100%	0.18	0.99	0.19	0.47	0.68	0.78	0.96	—
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/23/98	5/20/99	12	8	67%	0.027	0.65	<RL	<RL	0.09	0.23	0.55	0.005
CHASH	Big Chico Creek above Salmon Hole	6/23/98	5/20/99	12	7	58%	0.02	0.38	<RL	<RL	0.06	0.17	0.27	0.005
CHHWY	Big Chico Creek at Hwy 32	6/23/98	5/20/99	11	1	9%	0.03	0.03	<RL	<RL	<RL	<RL	<RL	0.005
SRVET	Sacramento River at Veterans Bridge	1/4/94	12/16/98	65	63	97%	1.1	22.5	1.95	2.46	4.76	6.60	9.68	1
ARDPK	American River at Discovery Park	1/4/94	9/21/99	63	50	79%	0.18	8.0	<RL	0.58	1.00	1.24	1.96	1
SRFPT	Sacramento River at Freeport	1/4/94	12/17/98	62	60	97%	1.2	18	1.50	2.11	4.03	6.60	9.08	1
SRRMF	Sacramento River at River Mile 44	2/1/94	12/17/98	54	53	98%	1.1	17	1.55	1.93	3.74	6.28	8.52	1
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	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	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
MCMOU	Mill Creek at Mouth	6/23/98	5/19/99	12	12	100%	0.021	13.7	0.06	0.13	0.33	0.58	1.24	—
MCBLR	Mill Creek at Black Rock	6/23/98	5/19/99	11	11	100%	0.078	15.1	0.09	0.12	0.37	0.62	1.57	—
MCHWY	Mill Creek at Highway 36	6/23/98	5/19/99	12	12	100%	0.202	24.9	0.23	0.33	0.52	0.96	1.29	—
DCMOU	Deer Creek at Mouth	6/24/98	5/18/99	10	3	30%	0.008	0.07	<RL	<RL	<RL	0.007	0.015	0.001
DCUDD	*Deer Creek at Upper Diversion Dam*	*6/24/98*	*5/18/99*	*11*	*4*	*36%*	*0.004*	*0.025*	*<RL*	*<RL*	*<RL*	*0.008*	*0.009*	*0.001*
DCPON	Deer Creek at Ponderosa Way	6/24/98	5/18/99	8	4	50%	0.001	0.058	<RL	<RL	0.005	0.013	0.043	0.002
DCMDW	Deer Creek below Childs Meadows	6/24/98	5/18/99	11	4	36%	0.004	0.023	<RL	<RL	<RL	0.008	0.008	0.001
CHMUD	Big Chico Creek above Mud Creek	6/23/98	5/20/99	11	4	36%	0.004	0.013	<RL	<RL	<RL	0.006	0.007	0.001
MUDCH	Mud Creek above Big Chico Creek	6/23/98	5/20/99	7	3	43%	0.001	0.037	<RL	<RL	<RL	0.012	0.024	0.003
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/23/98	5/20/99	11	3	27%	0.005	0.01	<RL	<RL	<RL	0.006	0.010	0.001
CHASH	Big Chico Creek above Salmon Hole	6/23/98	5/20/99	11	4	36%	0.007	0.008	<RL	<RL	<RL	0.007	0.007	0.001
CHHWY	Big Chico Creek at Hwy 32	6/23/98	5/20/99	11	5	45%	0.005	0.017	<RL	<RL	<RL	0.007	0.009	0.001
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	12/16/98	83	37	45%	0.2	23.0	<RL	<RL	<RL	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	9/21/99	81	32	40%	0.1	7.4	<RL	<RL	<RL	4.0	4.0	0.1
SRFPT	Sacramento River at Freeport	1/4/94	12/17/98	113	60	53%	0.3	27.0	<RL	<RL	1.1	4.0	4.0	0.1
SRRMF	Sacramento River at River Mile 44	1/18/94	12/17/98	76	37	49%	0.1	18.0	<RL	<RL	<RL	4.0	4.0	0.5
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	143.0	1.8	2.5	3.8	7.5	10.3	—
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	5/19/99	12	12	100%	0.2	10.2	0.4	0.5	0.9	1.3	2.4	—
MCBLR	Mill Creek at Black Rock	6/23/98	5/19/99	11	11	100%	0.4	10.8	0.4	0.6	1.1	1.6	2.9	—
MCHWY	Mill Creek at Highway 36	6/23/98	5/19/99	12	12	100%	1.4	17.3	1.9	2.4	2.8	3.1	4.8	—
DCMOU	Deer Creek at Mouth	6/24/98	5/18/99	11	10	91%	0.2	1.2	0.2	0.3	0.5	0.9	1.1	0.18
DCUDD	Deer Creek at Upper Diversion Dam	6/24/98	5/18/99	12	7	58%	0.1	5.0	<RL	<RL	0.2	0.3	0.7	0.004
DCPON	Deer Creek at Ponderosa Way	6/24/98	5/18/99	8	4	50%	0.3	0.9	<RL	<RL	0.2	0.3	0.5	0.14
DCMDW	Deer Creek below Childs Meadows	6/24/98	5/18/99	12	11	92%	0.2	1.3	0.2	0.3	0.3	0.4	0.5	0.22
CHMUD	Big Chico Creek above Mud Creek	6/23/98	5/20/99	12	11	92%	0.3	5.0	0.3	0.5	0.7	0.8	1.8	0.18
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/23/98	5/20/99	12	11	92%	0.2	2.6	0.2	0.2	0.4	0.6	0.8	0.18
CHASH	*Big Chico Creek above Salmon Hole*	6/23/98	5/20/99	12	7	58%	0.1	0.6	<RL	<RL	0.2	0.3	0.4	0.07
CHHWY	Big Chico Creek at Hwy 32	6/23/98	5/20/99	12	8	67%	0.1	0.4	<RL	<RL	0.2	0.2	0.3	0.14
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	—
SRVET	Sacramento River at Veterans Bridge	1/4/94	12/16/98	83	76	92%	1.2	31.0	3.0	4.0	5.8	8.5	11.2	4
ARDPK	American River at Discovery Park	1/4/94	9/21/99	82	49	60%	0.2	230.0	<RL	<RL	4.0	4.0	6.5	0.5
SRFPT	Sacramento River at Freeport	1/4/94	12/17/98	81	68	84%	0.9	29.0	<RL	4.0	4.9	7.8	12.0	4
SRRMF	Sacramento River at River Mile 44	1/18/94	12/17/98	74	64	86%	1.4	52.0	<RL	4.0	6.0	9.7	15.5	4
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	12	12	100%	2.1	13.2	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: Drinking Water Parameters

Organic Carbon, 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
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	8.3	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	4/7/98	29	29	100%	0.3	3.7	1.3	1.4	1.6	1.8	2.4	—
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	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	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	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	1.3	1.0	1.0	1.2	1.2	1.3	—
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	—
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	—
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	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	4/7/98	29	29	100%	0.8	4.4	1.6	1.7	2.0	2.6	3.3	—
SRRMF	Sacramento River at River Mile 44	9/22/99	5/17/00	9	9	100%	1.8	4	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	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	—
SRABB	Sacramento River above Bend Bridge	7/22/98	5/17/00	22	22	100%	60	104	69	72	85	86	94	—
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	—

Turbidity

Units = NTU

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	10	10	100%	2.0	23.9	2.3	2.5	3.8	7.0	14.8	—
MRSHA	McCloud River above Shasta	7/22/98	5/16/00	10	10	100%	0.5	6.3	0.5	0.8	1.3	3.1	5.1	—
SRSHA	Sacramento River above Shasta	7/22/98	5/16/00	10	10	100%	0.8	8.4	0.9	0.9	1.1	3.5	5.1	—
SCKPP	Spring Creek PP Discharge to Keswick Res.	6/24/98	4/18/00	12	12	100%	0.4	1.9	0.5	0.6	0.9	1.6	1.9	—
SRBKR	Sacramento River below Keswick	1/20/98	5/16/00	47	47	100%	1.3	36.1	2.1	3.0	3.4	4.1	5.8	—
SRABB	Sacramento River above Bend Bridge	6/24/98	5/17/00	23	23	100%	2.1	48.2	2.6	3.0	3.9	10.9	26.5	—
SRHAM	Sacramento River near Hamilton City	6/23/99	5/16/00	11	11	100%	2.0	140.0	2.4	2.8	4.0	17.0	89.2	—
SRCOL	Sacramento River at Colusa	6/24/98	5/16/00	23	23	100%	2.9	261.0	6.8	8.4	17.5	30.5	55.3	—
FRNIC	Feather River near Nicolaus	6/23/98	5/16/00	23	23	100%	1.1	57.0	2.2	3.7	5.3	8.1	11.7	—
SRVET	Sacramento River at Veterans Bridge	6/24/98	5/16/00	23	23	100%	3.8	81.2	8.3	19.0	24.5	27.4	44.0	—
SRFPT	Sacramento River at Freeport	6/23/98	5/17/00	23	23	100%	6.4	65.5	7.3	14.0	19.2	28.8	45.2	—
SRRMF	Sacramento River at River Mile 44	6/23/98	5/17/00	23	23	100%	5.1	58.1	7.8	12.3	19.0	31.1	50.9	—
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	11	11	100%	2.7	89.3	7.6	16.7	29.0	37.4	72.8	—

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: Nutrients Data

Nitrate as NO_3^-

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	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	0.22	0.22	0.26	0.22

Nitrite as NO_2^-

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	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

Ammonia as N

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	26	4	15%	0.02	0.09	<RL	<RL	<RL	<RL	0.02	0.015
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	0.638	<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	0.841	<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	0.955	<RL	<RL	0.11	0.15	0.20	0.1
CCHSL	Cache Slough near Ryers Ferry	2/16/00	2/16/00	1	0	0%	0	0	<RL	<RL	<RL	<RL	<RL	0.1

Nitrogen, total Kjeldahl

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	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

Orthophosphate as P, 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	26	22	85%	0.014	0.031	<RL	0.020	0.020	0.021	0.028	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	0.127	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	0.163	0.5
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	0.5

Phosphorus, 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
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	5/19/99	12	12	100%	0.03	0.26	0.03	0.03	0.04	0.05	0.13	—
MCBLR	Mill Creek at Black Rock	6/23/98	5/19/99	9	9	100%	0.01	0.15	0.02	0.02	0.03	0.04	0.06	—
DCMOU	Deer Creek at Mouth	6/24/98	5/18/99	10	10	100%	0.01	1.00	0.02	0.02	0.03	0.04	0.14	—
DCUDD	Deer Creek at Upper Diversion Dam	6/24/98	5/18/99	12	10	83%	0.01	0.03	<RL	0.01	0.02	0.02	0.03	0.01
DCPON	Deer Creek at Ponderosa Way	6/24/98	5/18/99	8	6	75%	0.01	0.04	<RL	0.01	0.02	0.02	0.03	0.01
DCMDW	Deer Creek below Childs Meadows	6/24/98	5/18/99	12	10	83%	0.01	0.04	<RL	0.01	0.02	0.03	0.03	0.01
CHMUD	Big Chico Creek above Mud Creek	6/23/98	5/20/99	12	11	92%	0.01	0.05	0.01	0.01	0.02	0.02	0.03	0.01
MUDCH	Mud Creek above Big Chico Creek	6/23/98	5/20/99	8	7	88%	0.01	0.03	<RL	0.01	0.02	0.02	0.03	0.01
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/23/98	5/20/99	12	9	75%	0.01	0.02	<RL	0.01	0.02	0.02	0.02	0.01
CHASH	Big Chico Creek above Salmon Hole	6/23/98	5/20/99	12	10	83%	0.01	0.03	<RL	0.01	0.02	0.02	0.02	0.01
CHHWY	Big Chico Creek at Hwy 32	6/23/98	5/20/99	12	9	75%	0.01	0.04	<RL	0.01	0.02	0.02	0.02	0.01
SRCOL	Sacramento River at Colusa	2/28/96	11/16/99	34	34	100%	0.01	0.29	0.02	0.03	0.04	0.08	0.15	—
SACSL	Sacramento Slough	2/12/96	5/16/00	36	36	100%	0.03	0.55	0.08	0.12	0.15	0.19	0.23	—
COLDR	Colusa Basin Drain	2/7/96	5/16/00	41	41	100%	0.02	0.56	0.12	0.15	0.22	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	28	24	86%	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	47	47	100%	0.03	1.16	0.11	0.16	0.23	0.28	0.39	—
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	22	20	91%	0.04	1.09	0.04	0.04	0.08	0.13	0.19	0.02

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 = oocysts/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	4/19/00	6	0	0%	—	—	<RL	<RL	<RL	<RL	<RL	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	5/16/00	11	5	45%	0.1	0.3	<RL	<RL	<RL	0.2	0.3	0.1
SRFPT	Sacramento River at Freeport	6/23/99	4/19/00	6	4	67%	0.1	0.3	<RL	<RL	0.1	0.175	0.25	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	28.5	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	—
CCHSL	Cache Slough near Ryers Ferry	6/23/98	2/16/00	12	12	100%	30	1600	32	50	125	500	770	—

Coliform, focal

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: 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
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	—
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	—

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%	7.22	33.7	8.8	12.7	13.6	24.2	25.0	—
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	4/8/98	27	27	100%	1.7	4.8	1.7	1.8	2.1	2.6	3.8	—
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	—
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	—

Iron, 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
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

Iron, 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
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%	1.5	154	8	24	34	96	109	27
DCPON	Deer Creek at Ponderosa Way	6/24/98	5/18/99	8	7	88%	16	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%	2.6	832	14	26	142	294	583	27
MUDCH	Mud Creek above Big Chico Creek	6/23/98	5/20/99	8	8	100%	58	451	75	106	141	328	381	—
CHCHI	Big Chico Creek at Chico (Rose Ave.)	6/23/98	5/20/99	12	11	92%	1.1	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	—
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	12	12	100%	360	3920	441	680	852	1423	2468	—

Summary Statistics: Minerals Data

Magnesium, 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%	3.9	6	4.7	4.8	5.0	5.3	5.4	—
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	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	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	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	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	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	8.93	4.2	4.7	5.3	6.0	6.6	—

Magnesium, 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%	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%	5.75	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%	2.48	11.9	3.3	3.7	4.5	10.4	11.3	—
CCHSL	Cache Slough near Ryers Ferry	6/25/98	2/16/00	12	12	100%	6.34	16.5	6.8	7.3	8.1	10.4	11.4	—

Manganese, 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
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	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	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%	1.03	10	<RL	1.7	2.4	3.1	4.0	1

Manganese, 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
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%	0.04	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	—
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	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%	0.77	1.4	0.9	1.0	1.1	1.2	1.3	—
SRCOL	Sacramento River at Colusa	2/28/96	9/16/98	31	31	100%	0.81	1.5	1.0	1.1	1.1	1.2	1.4	—
SACSL	Sacramento Slough	2/12/96	4/22/98	24	24	100%	0.96	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	0.77	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	0.9	1.0	1.1	1.3	1.5	—
ARCNW	Arcade Creek at Norwood Ave.	2/6/96	4/23/98	38	38	100%	2	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%	0.76	1.9	0.8	0.9	1.0	1.1	1.3	—

Summary Statistics: Minerals Data

Potassium, 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%	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	—
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	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	—
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	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	—
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	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	—
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	—
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: 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	24	24	100%	30	230	45	48	52	57	59	—
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	—

Summary Statistics: Other Conventional Water Chemistry Parameters

Hardness

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	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	—
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	—
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	—
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	—
CHCHI	Big Chico Ck at Chico (Rose Ave.)	6/22/99	4/17/00	7	7	100%	20	88	33	47	72	76	81	—
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

		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	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

		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	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%	7.8	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	—

pH

Units = standard 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
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	—

Specific Conductance

Units = µmhos/cm at 25°C

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	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%.

APPENDIX G

Response to Comments

This Section Reserved For A Subsequent Draft

APPENDIX H

Time Series Plots of Monitoring Data: SRWP, USGS NAWQA, Sacramento River CMP, and City of Redding

Note: Time series plots will be provided for the Public Draft

APPENDIX I

Bioassessment Data

This data is not yet available in final form.

CITY OF REDDING

PUBLIC WORKS DEPARTMENT
FIELD OPERATIONS DIVISION - STREETS, WATER, WASTEWATER
Mail: P.O. Box 496071, Redding, CA 96049-6071
Shipping: 20055 Viking Way, Building #3, Redding, CA 96003
530.224.6068 FAX 530.224-6071

May 14, 2001
W-010-450-000

R 38-A

Mr. Joe Karkoski
303(d) List Update Coordinator
California Regional Water Quality Control Board
Central Valley Region
3443 Routier Road
Sacramento, CA 95827-3003

Dear Joe:

Subject: Data for Clean Water Act Section 303(d) List Update

In response to your February 21, 2001 request for data and information regarding water quality conditions in surface waters in the Central Valley Region, we are submitting data from two locations on the Sacramento River near Redding. One site is immediately downstream of Shasta Dam; the second is at Caldwell Park, which is three miles downstream of Keswick Dam. Data for cadmium, copper and zinc are presented as graphs; all data is presented on tables following the graphs.

Introduction

This study began in 1998 after previous Local Limits monitoring yielded unreliable ambient water quality data for the Sacramento River when conventional sampling and analytical techniques were used to determine compliance with water quality criteria. The detection limits for ICP and GFAA are simply not low enough, so we began using ultra-clean techniques to build a more reliable database for Local Limits determinations and to contribute data for TMDL's and related projects. The Redding office of the RWQCB agreed to split samples to illustrate the difference in results delivered by different techniques.

Methodology

All City of Redding trace metals and mercury samples were collected using EPA Method 1669 (EPA, 1995) sampling techniques which employs the use of the "clean hands – dirty hands" sampling train and double bagged precleaned Teflon bottles for sample collection. Analyses were performed by Frontier Geosciences using modified EPA Method 1638 ICP/MS for trace metals and EPA Method 1631 CVAFS for mercury.

Monthly samples were collected approximately eight feet from the water's edge at the boat ramp at Caldwell Park from January 1998 through June 2000 when sampling was scaled back due to budget constraints. Two samples and one field blank were collected at each event. The first (sample ID SRCP198 in January 1998) was collected directly into the Teflon bottle following three rinses with river water. The sample was capped approximately two inches under the surface of the water. Beginning in March 1998, the Redding office of the RWQCB started accompanying us on sampling events and having split samples run for cadmium, copper and zinc at their contract lab (Quality Analytical (QAL) Columbia Analytical Services (CAS) and now Basic Laboratory) and at the US Bureau of Reclamation (USBR) lab at Keswick Dam. These splits (SRCP398Split for March 1998) were collected by rinsing a large amber glass or HDPE container three times with river water then splitting aliquots to containers for each lab. The Teflon bottle for ICP/MS analysis was rinsed three times with water from the larger bottle. All dissolved samples were filtered at the labs.

Sampling began downstream of Shasta Dam in April of 1998 (SRDSD498) when we started wondering how much metal would still be in the river following remediation at Iron Mountain Mine. Samples were collected from the bank approximately one mile downstream of the dam until January of 1999 when we started sampling from the bridge approximately 200 yards downstream of the dam with USBR personnel. We taped a Teflon bottle to their rope for mid-stream sampling. These samples were collected after one rinse and filtered at Frontier Geosciences following shipment by Federal Express. This sampling continued through May 2000.

Stuart Zanni and Marcia Ames, Industrial Waste Analysts for the City of Redding performed the sampling. Both hold certificates from the California Water Environment Association in Environmental Compliance Inspection and have performed wastewater sampling for Pretreatment Programs for six and seventeen years respectively.

Conclusion

It appears the use of ultra-clean techniques delivers more stable results in ambient samples and more frequently delivers dissolved values less than total values (see the Dissolved to Total Ratio charts). More importantly, these techniques have detection limits that are low enough to determine compliance with water quality criteria, as evidenced by the Dissolved Metals charts. The vast majority of data that exists for this reach of the Sacramento River have been generated with techniques that cannot adequately make this determination in waters that range from 40 to 50 mg/l hardness. Water quality criteria on these charts are calculated using hardness values at each sampling event. Cadmium and zinc are limited by Basin Plan values while copper is limited by the US Continuous 4-day average criteria.

In view of this comparison of methodologies, the City of Redding again requests the RWQCB utilize only metals data generated using EPA Method 1669 sampling techniques and analysis by techniques that consistently deliver detection limits below the water quality criteria in ambient samples when determining the need for CWA 303(d) listing and in the subsequent development of TMDL's.

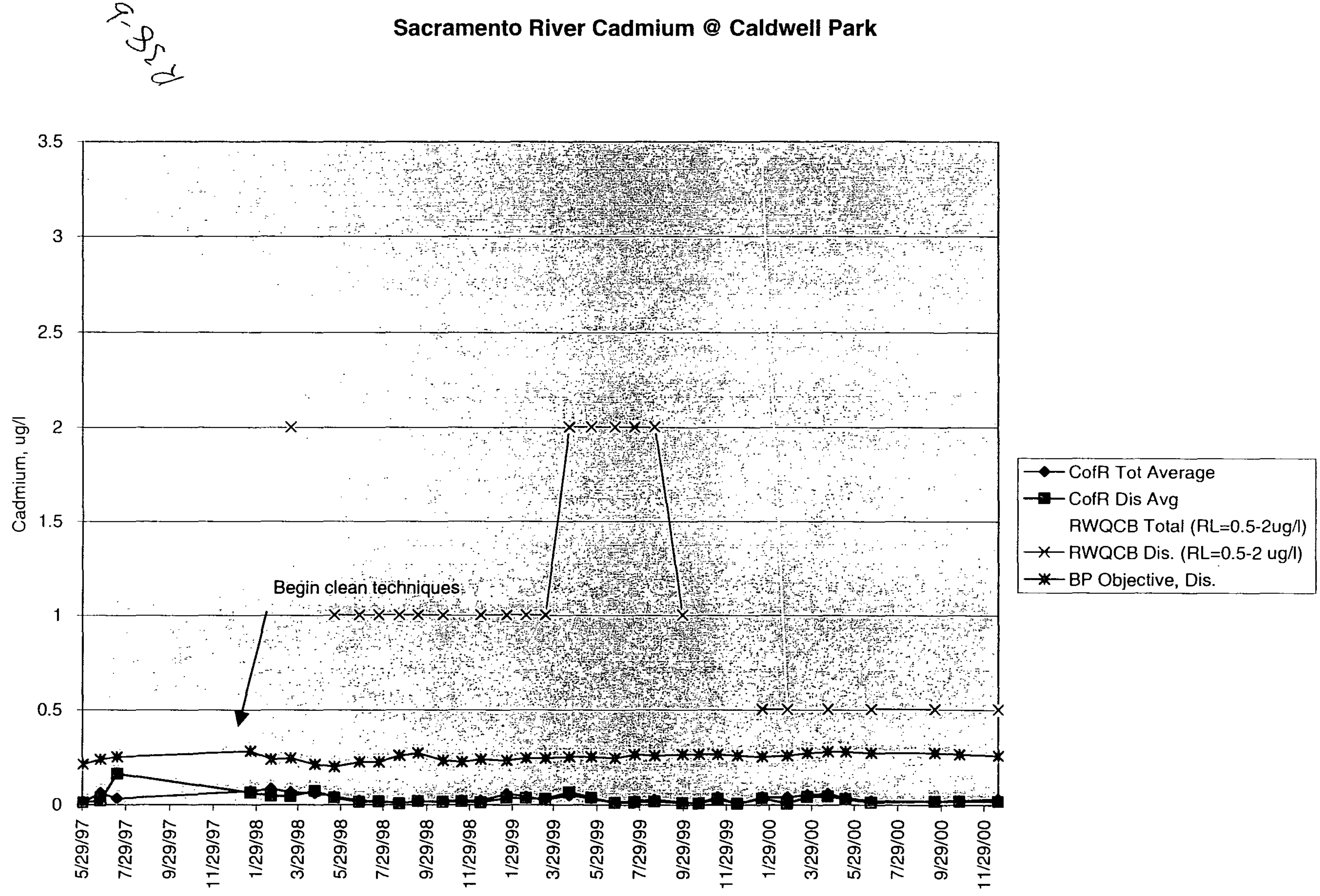
Thank you for the opportunity to submit data. Please contact me at (530) 224-6049 if you have any questions.

Sincerely,

Marcia Ames
Industrial Waste Analyst

ma/vm
attachments
c: Dennis Heiman, Environmental Specialist, CRWQCB – Redding
Nolan Randall, Water Resource Control Engineer, CRWQCB - Redding
Stephen Craig, Public Works Manager, Wastewater Utility
Richard Elliott, Public Works Supervisor - Industrial Waste
Indwaste\2001_303.doc

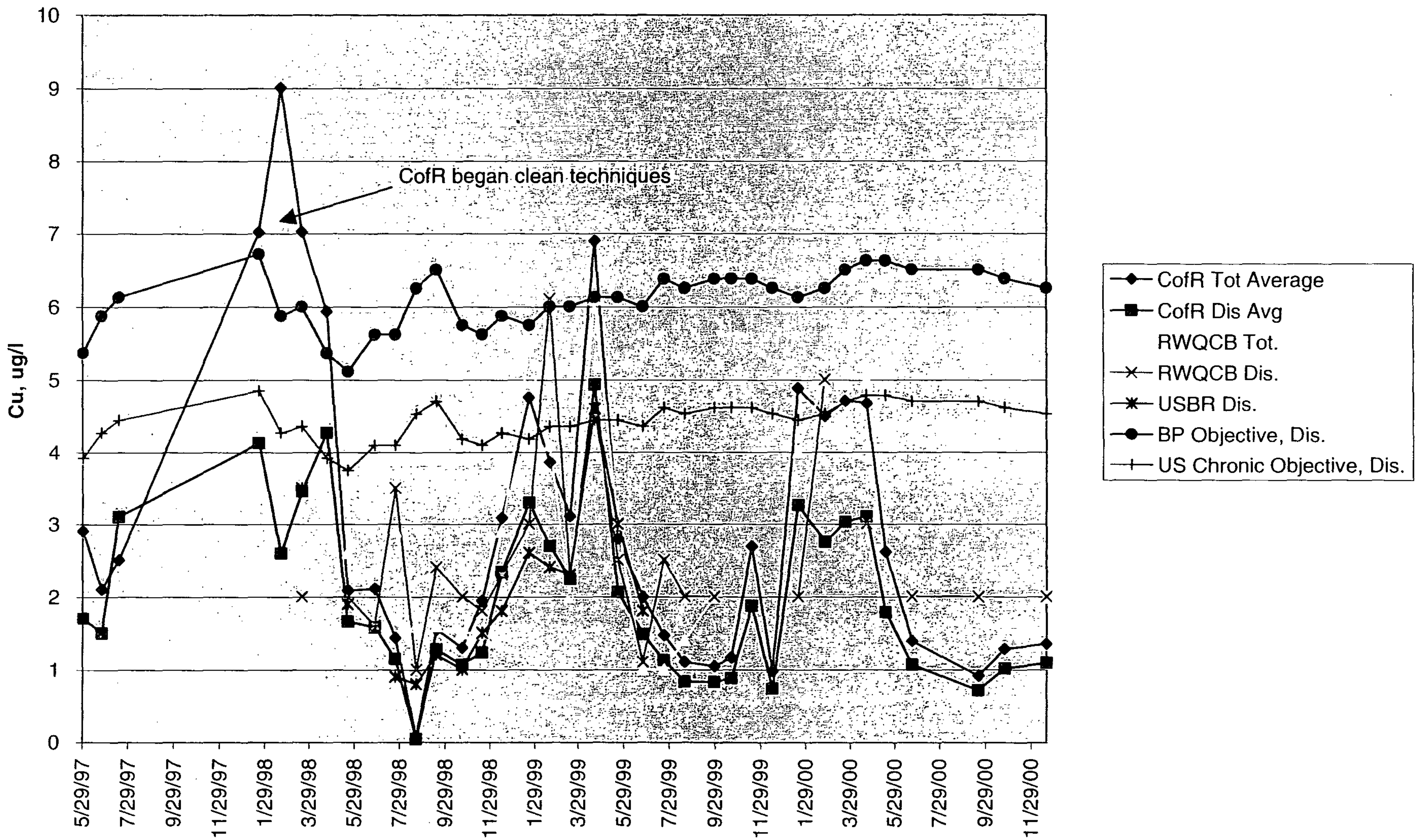
R38-b



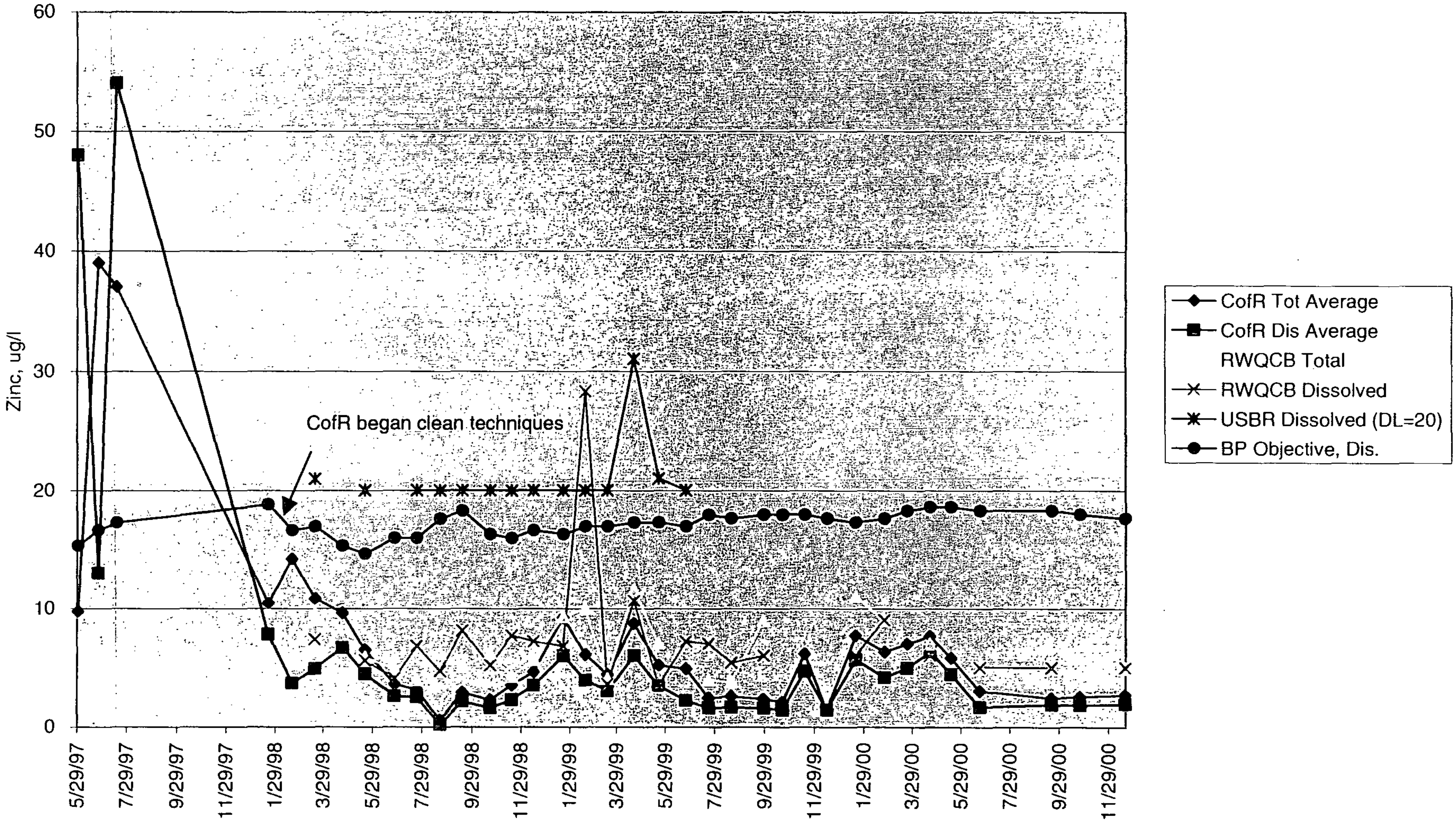
Sacramento River Cadmium @ Caldwell Park
Cadmium, ug/l
3.5
3
2.5
2
1.5
1
0.5
0
Begin clean techniques
5/29/97
7/29/97
9/29/97
11/29/97
1/29/98
3/29/98
5/29/98
7/29/98
9/29/98
11/29/98
1/29/99
3/29/99
5/29/99
7/29/99
9/29/99
11/29/99
1/29/00
3/29/00
5/29/00
7/29/00
9/29/00
11/29/00
CofR Tot Average
CofR Dis Avg
RWQCB Total (RL=0.5-2ug/l)
RWQCB Dis. (RL=0.5-2 ug/l)
BP Objective, Dis.

I

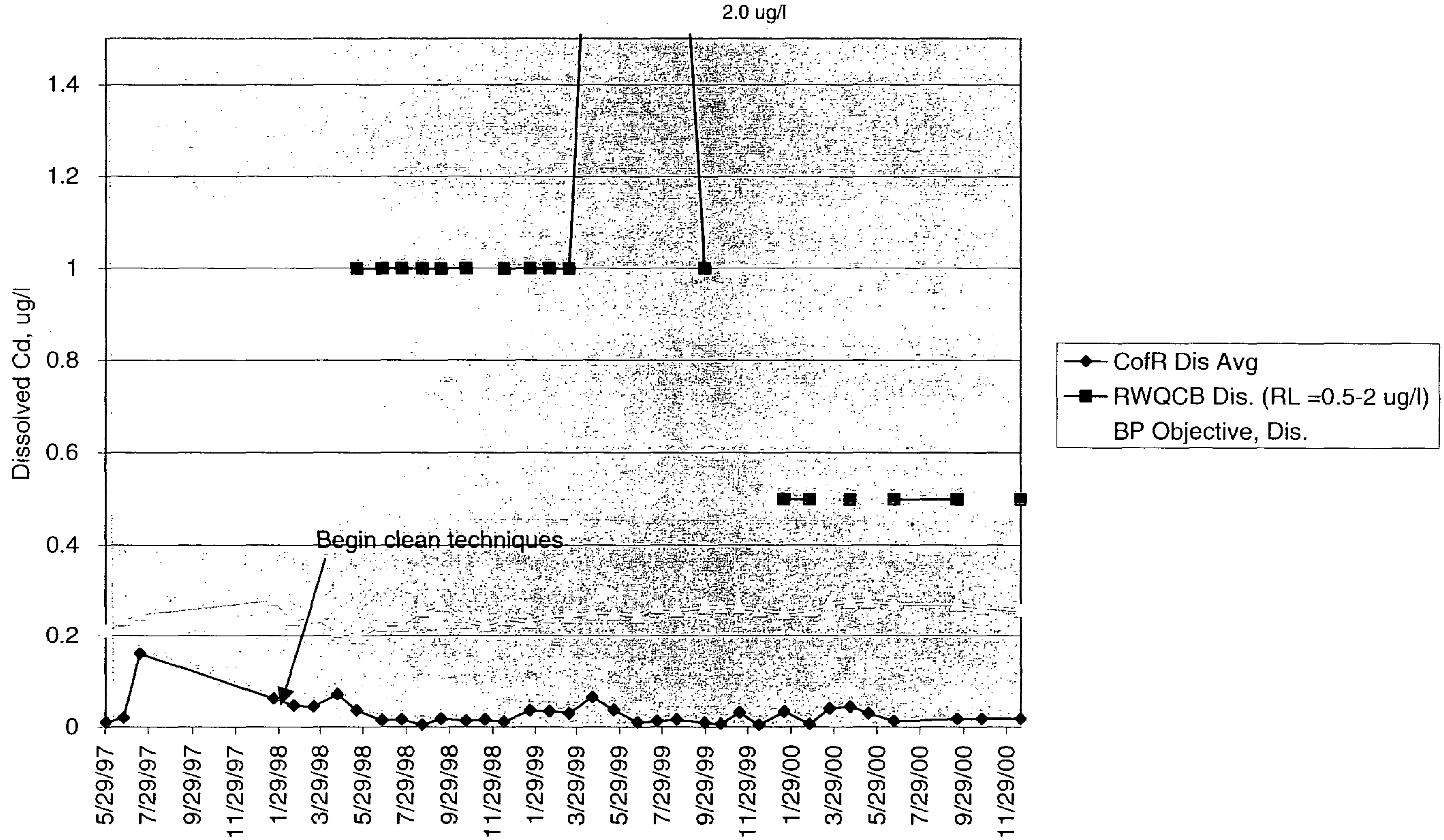
Sacramento River Copper @ Caldwell Park



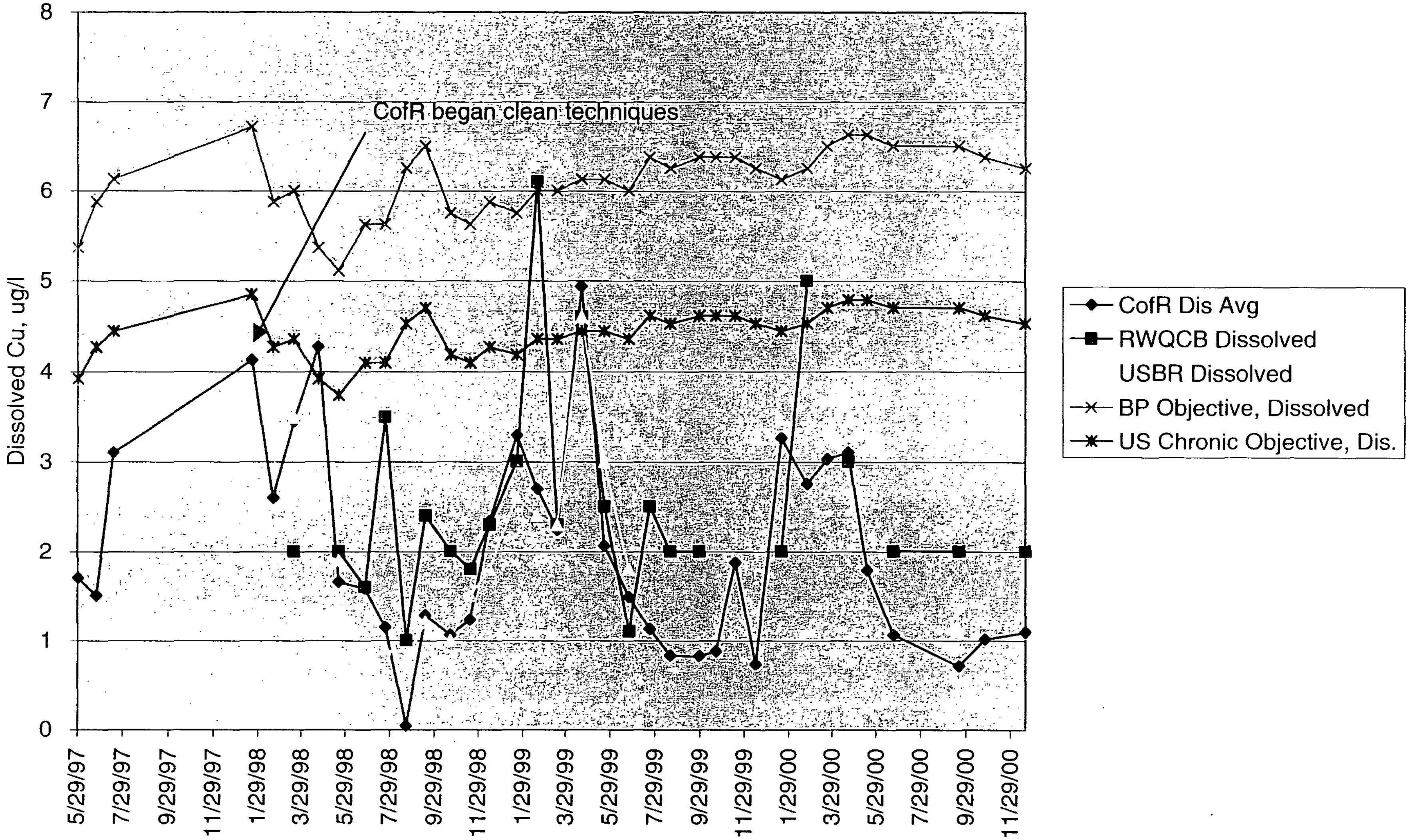
Sacramento River Zinc @ Caldwell Park

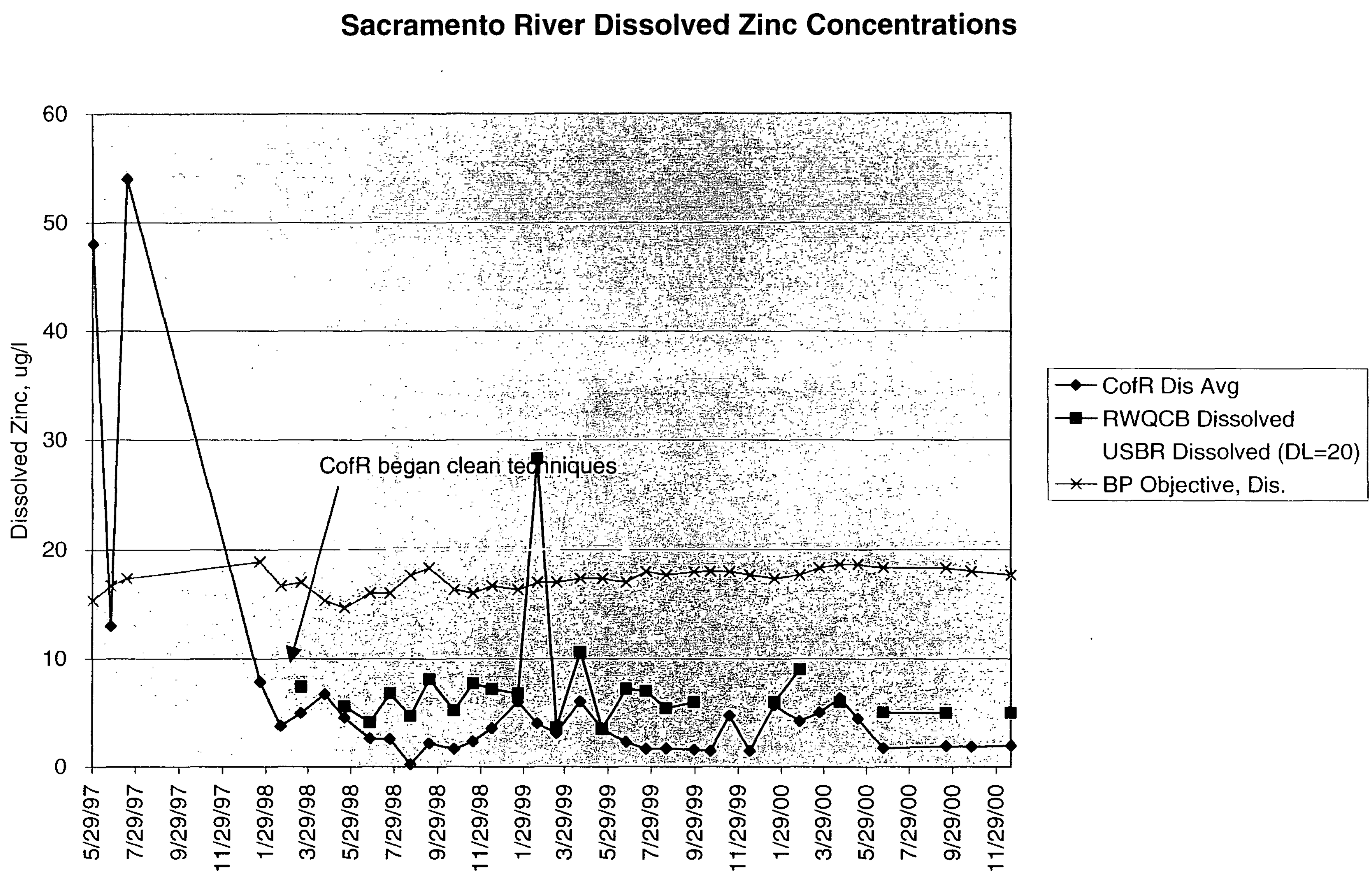


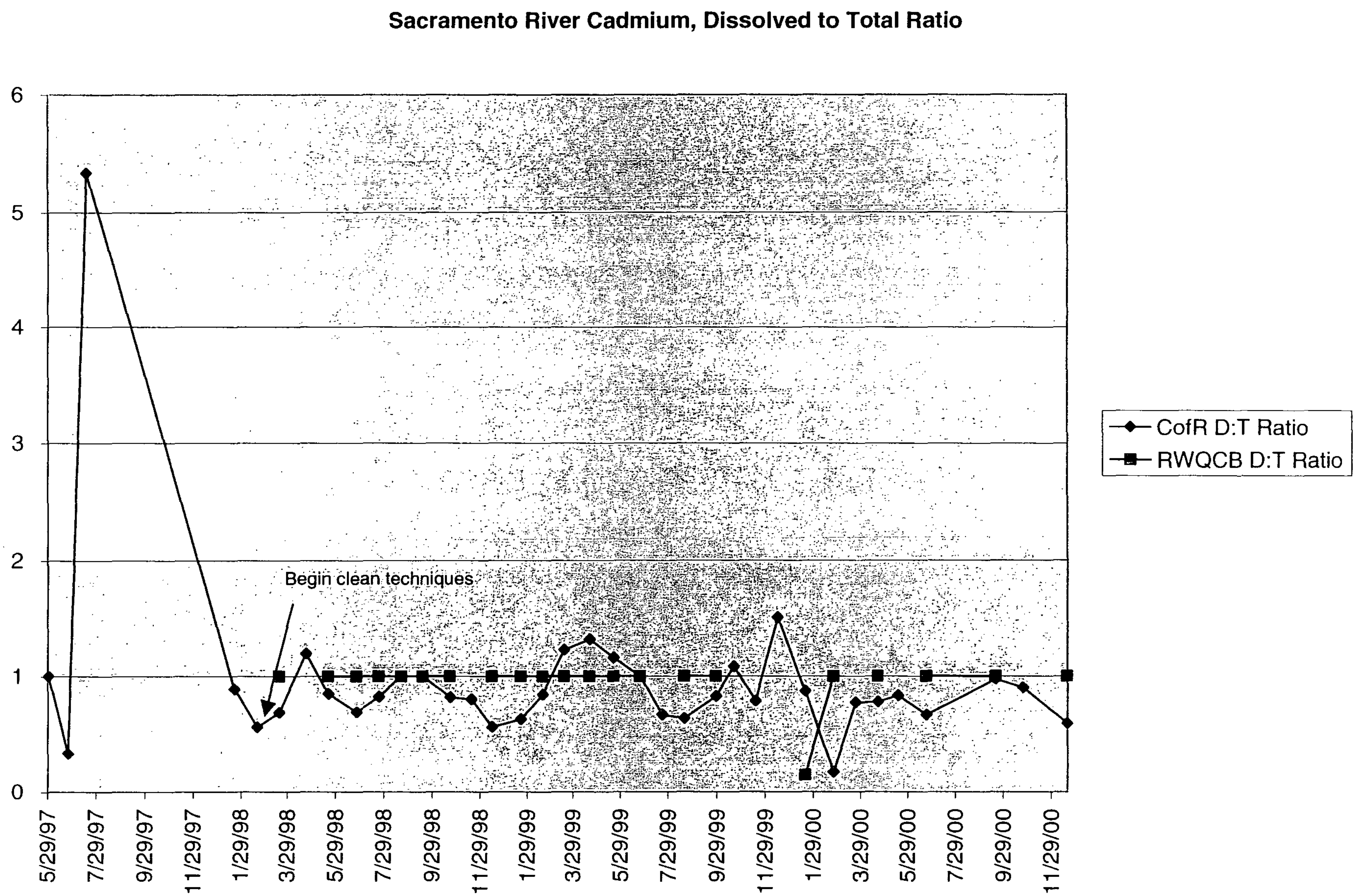
Sacramento River Dissolved Cadmium Concentrations



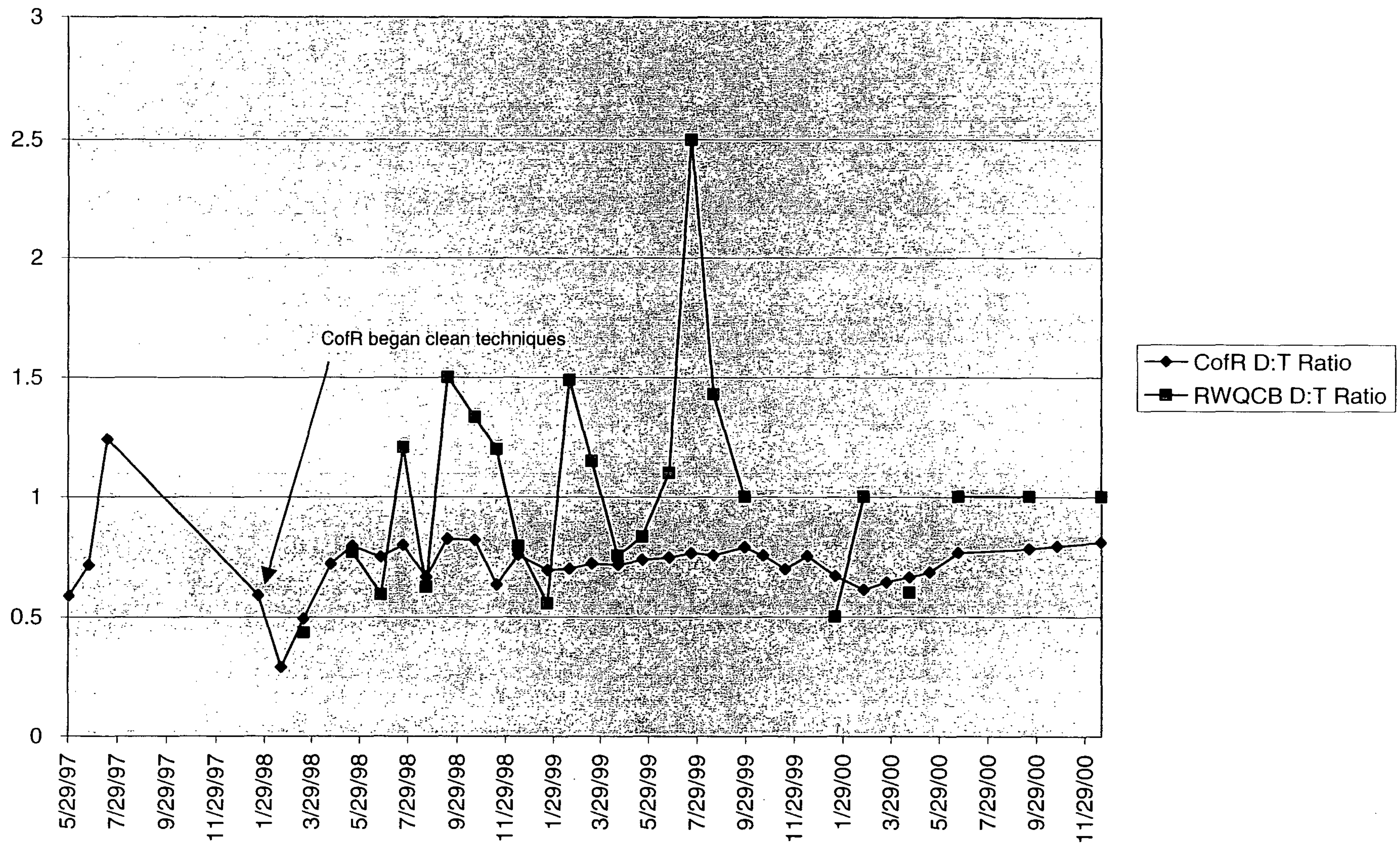
Saramento River Dissolved Copper Concentrations

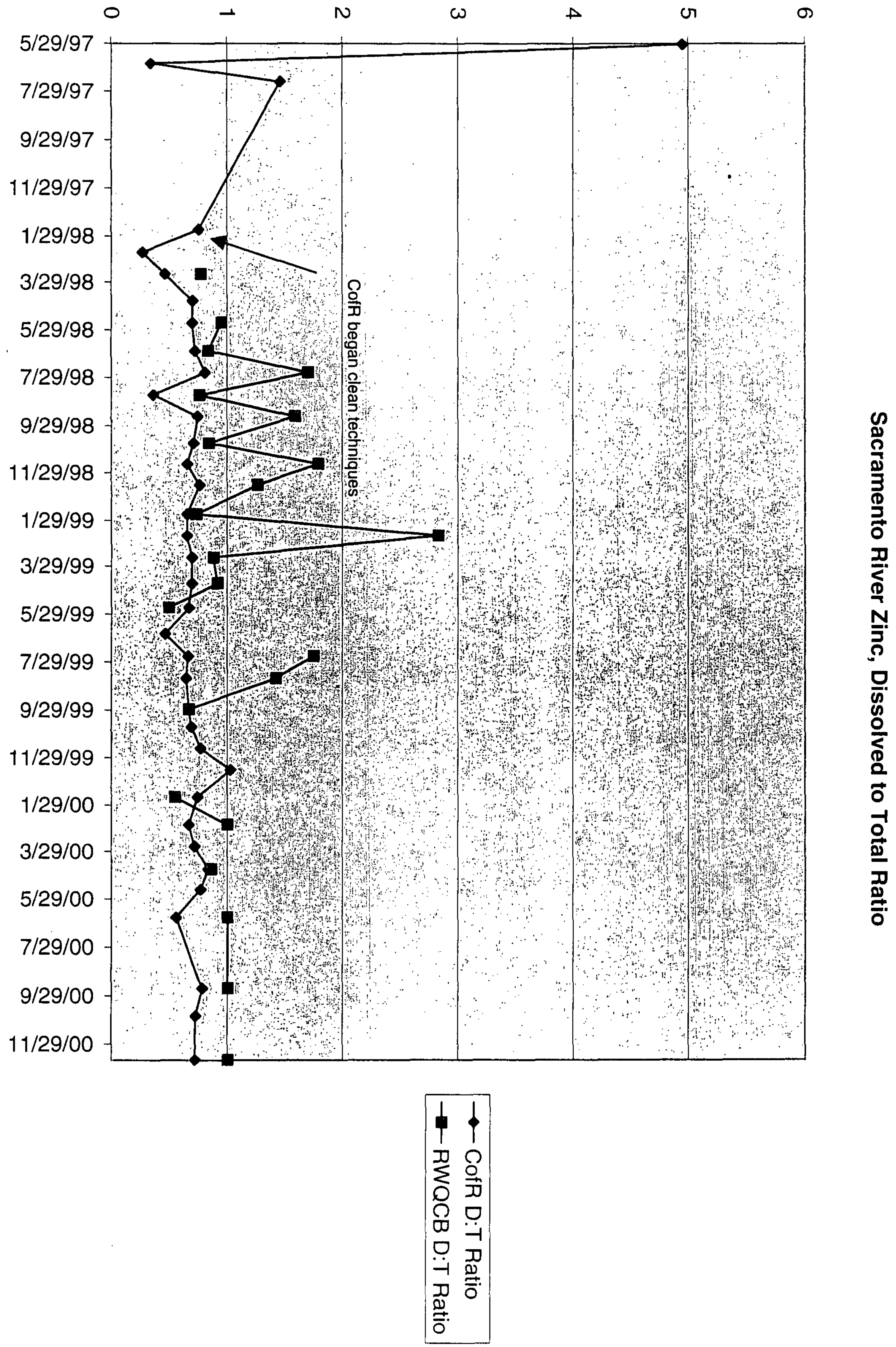



Sacramento River Dissolved Zinc Concentrations
Dissolved Zinc, ug/l
60
50
40
30
20
10
0
CofR began clean techniques
5/29/97
7/29/97
9/29/97
11/29/97
1/29/98
3/29/98
5/29/98
7/29/98
9/29/98
11/29/98
1/29/99
3/29/99
5/29/99
7/29/99
9/29/99
11/29/99
1/29/00
3/29/00
5/29/00
7/29/00
9/29/00
11/29/00
CofR Dis Avg
RWQCB Dissolved
USBR Dissolved (DL=20)
BP Objective, Dis.


Sacramento River Cadmium, Dissolved to Total Ratio
0
1
2
3
4
5
6
5/29/97
7/29/97
9/29/97
11/29/97
1/29/98
3/29/98
5/29/98
7/29/98
9/29/98
11/29/98
1/29/99
3/29/99
5/29/99
7/29/99
9/29/99
11/29/99
1/29/00
3/29/00
5/29/00
7/29/00
9/29/00
11/29/00
Begin clean techniques
CofR D:T Ratio
RWQCB D:T Ratio

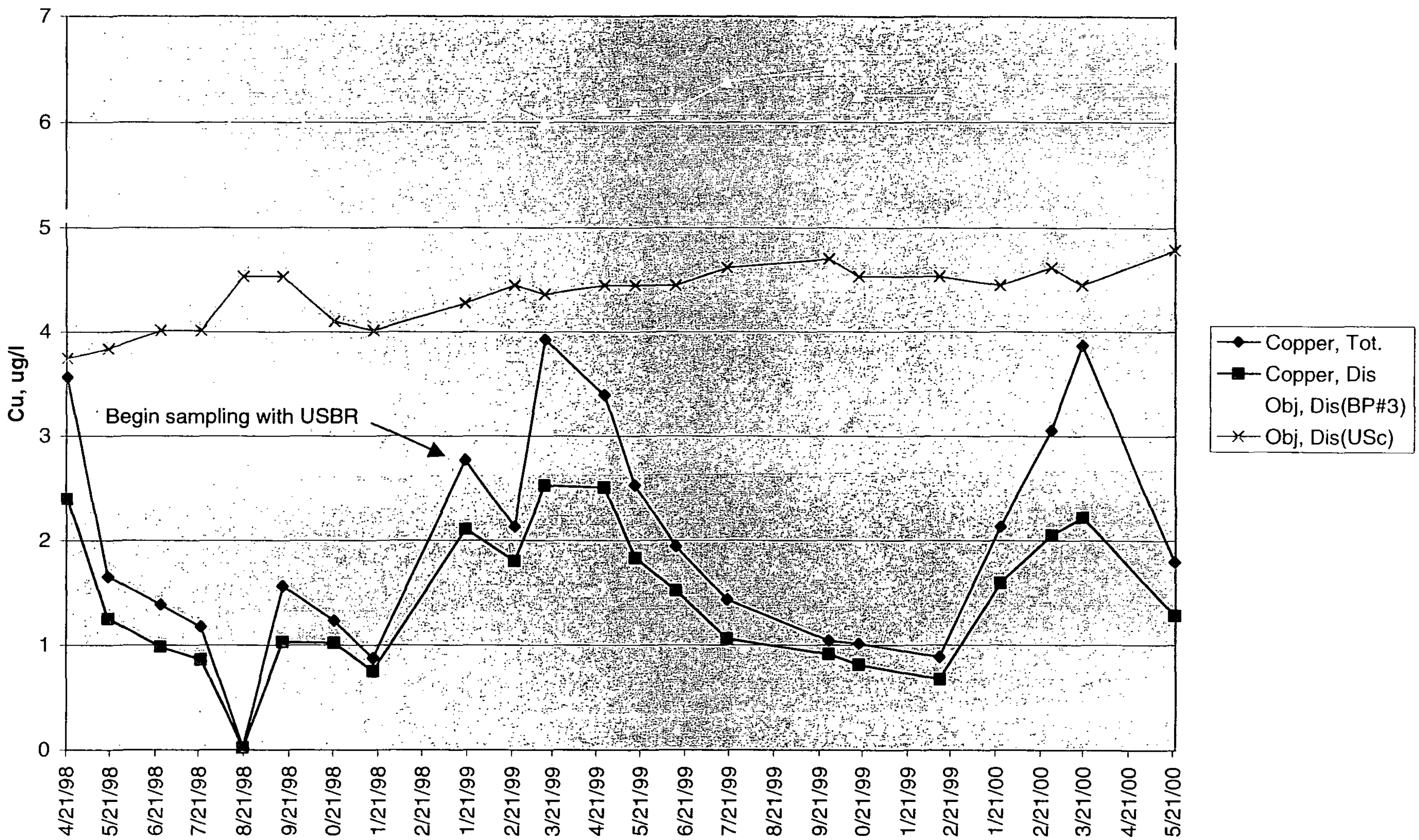
Sacramento River Copper, Dissolved to Total Ratio



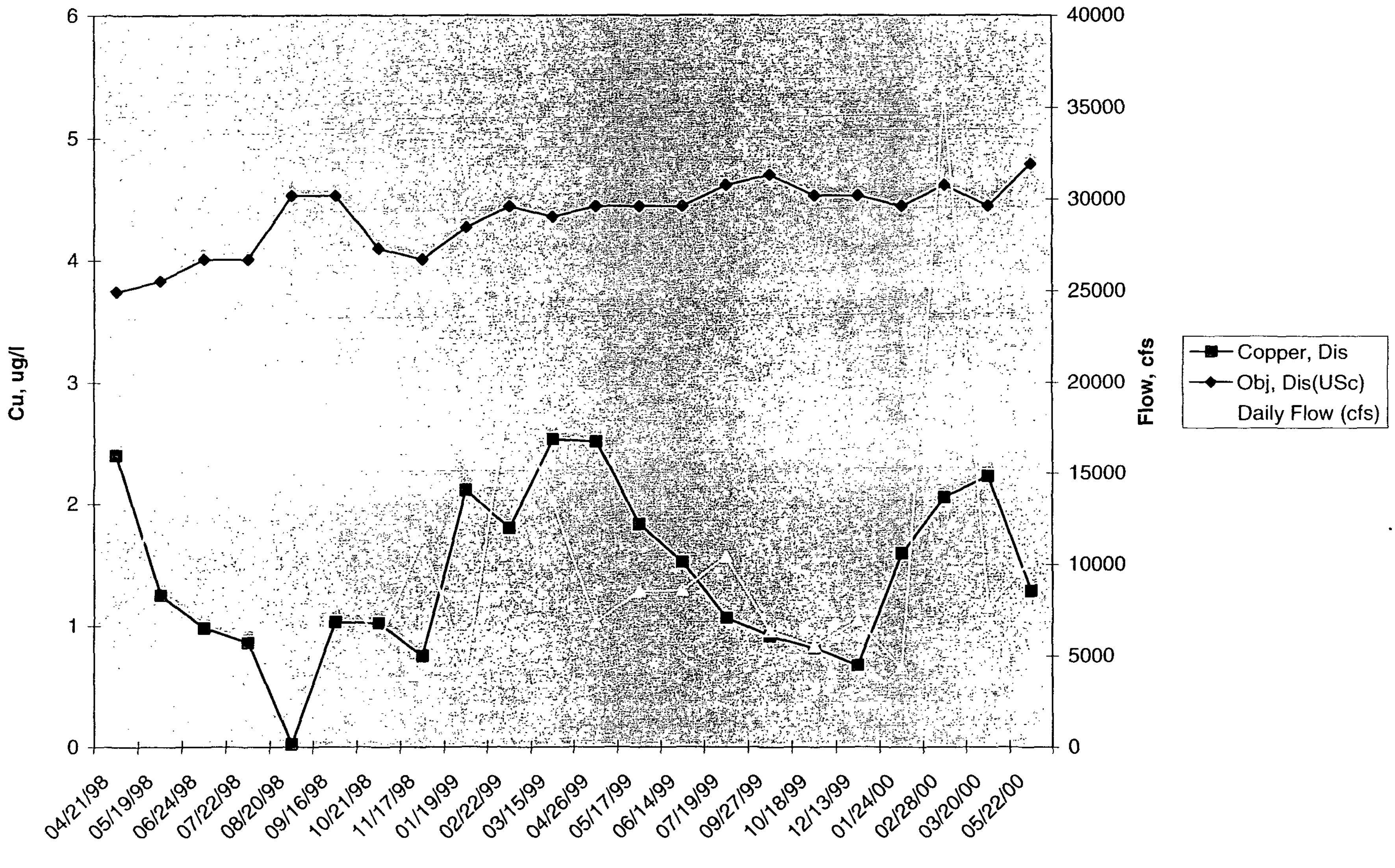


Sacramento River Zinc, Dissolved to Total Ratio
0
1
2
3
4
5
6
5/29/97
7/29/97
9/29/97
11/29/97
1/29/98
3/29/98
5/29/98
7/29/98
9/29/98
11/29/98
1/29/99
3/29/99
5/29/99
7/29/99
9/29/99
11/29/99
1/29/00
3/29/00
5/29/00
7/29/00
9/29/00
11/29/00
CofR began clean techniques
CofR D:T Ratio
RWQCB D:T Ratio

Sacramento River Copper Downstream of Shasta Dam



Sacramento River Copper Below Shasta Dam vs. Flow



CITY OF REDDING LOCAL LIMITS
SACRAMENTO RIVER SAMPLING SUMMA
DOWMSTREAM OF KESWICK DAM
@CALDWELL PARK

All figures in ug/l unless otherwise stated.
See notes on Page 7

		Arsenic(T&D)			Cadmium(T&D)				Chromium(T)			Copper(T&D)				Iron(D)			Lead(T&D)	
Sample ID	Date	T@	D	O(HH)	T	D@	O(BP#3)	O(USc)	T@	D	O(USc)	T	D@	O(BP#3)	O(USc)	T	D@	O(BP#3)	T	D@
Val's RWQCB data range	10/91-12/92	1.50-2.08	1.35-2.08	5	.049-.491	.021-.516	.28-.34		.39-.68	.39-.56	11	2.5-17.5	2.27-9.7	6.6-7.9		66-408	7-118	300	.020-.337	<.005-.049
Sac Watershed DL		0.002	0.002		0.0024	0.0024			0.1			0.024	0.024				3.0		0.0081	0.0081
CoR CC R1 1993 range	12/92-5/93	1.7-<4			<.1-.41	<.1-2.3			<1-<10			3.2-13	1.6-7.5			-	-		<1-2.7	-
Sequoia DL (ICP/MS)		0.3			0.02				0.2			0.5				5.0			0.3	
Frontier DL		0.05			0.001				0.02			0.02				0.5			0.02	
SRCP597	05/29/97	1.4	0.89	5	0.01 *	0.01 *	0.211	1.094	3.1	1.9	11	2.9	1.7	5.37	3.92	430	97	300	2.4	0.62
SRCP697	06/23/97	0.75	0.97	5	0.060	0.02	0.237	1.178	3.3	2.8	11	2.1	1.5	5.87	4.27	210	83	300	2.3	0.31
SRCP797	07/16/97	1.6	1.3	5	0.030	0.16	0.250	1.219	2.4	2.4	11	2.5	3.1	6.13	4.44	180	60	300	0.44	0.64
SRCP198 (begin clean techniqu	01/20/98	1.58	1.58	5	0.070	0.059	0.281	1.314	0.91	0.43	11	6.94	4.13	6.72	4.84	255	33.2	300	0.132	0.098
SRCP198D (duplicate)	01/20/98	1.59	1.41	5	0.070	0.065	0.279	1.308	0.90	0.50	11	7.08	4.12	6.68	4.82	249	27.2	300	0.126	0.182
SRCP298	02/18/98	2.04	1.06	5	0.082	0.049	0.237	1.178	3.65	0.96	11	8.97	2.59	5.87	4.27	1380	171	300	0.750	0.125
SRCP298D	02/18/98	1.89	1.06	5	0.084	0.044	0.237	1.178	3.47	0.72	11	9.04	2.60	5.87	4.27	1300	138	300	0.731	0.196
SRCP398	03/18/98	1.4	0.9	5	0.066	0.044	0.243	1.198	1.86	0.43	11	7.12	3.42	6.00	4.35	720	118	300	0.293	0.033
SRCP398 Split	03/18/98	1.6	1.2	5	0.064	0.045	0.243	1.198	1.84	0.43	11	6.91	3.49	6.00	4.35	786	126	300	0.312	0.029
LKRDDTCH (RWQCB)	03/18/98			5	1.0 *	1.0 *	0.243	1.198			11	4.6	1.0 *	6.00	4.35			300		
LKRDDDBR (USBR)	03/18/98			5			0.243	1.198			11		3.5	6.00	4.35			300		
LKRDDTFG (DFG)	03/18/98			5	0.1	0.1	0.243	1.198			11	6.0	5.7	6.00	4.35			300		
SRCP498	04/21/98	0.68	0.68	5	0:062	0.071	0.211	1.094	1.86		11	6.09	4.41	5.37	3.92	319	63	300	0.094	0.017
SRCP498D	04/21/98	0.57	0.57	5	0.057	0.071	0.211	1.094	1.73		11	5.78	4.13	5.37	3.92	302	57	300	0.091	0.014
SRCP598	05/19/98	0.86	0.74	5	0.042	0.032	0.198	1.051	0.77		11	2.06	1.56	5.11	3.74	198	53	300	0.026	0.0035 *
SRCP598 Split	05/19/98	0.87	0.86	5	0.043	0.040	0.198	1.051	0.83		11	2.11	1.75	5.11	3.74	208	64.9	300	0.04	0.0035 *
CALDWL (RWQCB)	05/19/98			5	0.500 *	0.500 *	0.198	1.051			11	2.6	2.00	5.11	3.74			300		
CALDWL (USBR)	05/19/98			5			0.198	1.051			11		1.90	5.11	3.74			300		
SRCP698	06/24/98	1.04	0.94	5	0.021	0.016	0.224	1.136	1.38		11	2.18	1.62	5.62	4.09	285.7	74.5	300	0.072	0.014
SRCP698 Split	06/24/98	1.02	0.93	5	0.021	0.013	0.224	1.136	1.32		11	2.04	1.54	5.62	4.09	307.4	99.6	300	0.071	0.014
CALDWL (RWQCB)	06/24/98			5	0.500 *	0.500 *	0.224	1.136			11	2.7	1.60	5.62	4.09			300		
CALDWL (USBR)	06/24/98			5			0.224	1.136			11			5.62	4.09			300		
SRCP798	07/22/98	0.22 *	0.59	5	0.020	0.018	0.224	1.136	0.90		11	1.43	1.06	5.62	4.09	284	91	300	0.051	0.016
SRCP798 Split	07/22/98	0.22 *	0.22 *	5	0.019	0.014	0.224	1.136	0.90		11	1.44	1.23	5.62	4.09	276	97	300	0.043	0.023
CALDWL (RWQCB)	07/22/98			5	0.500 *	0.500 *	0.224	1.136			11	2.9	3.50	5.62	4.09			300		
CALDWL (USBR)	07/22/98			5			0.224	1.136			11		0.90	5.62	4.09			300		
SRCP898	08/20/98	0.63	0.77	5	0.0025 *	0.0025 *	0.256	1.239	1.14		11	0.06	0.02 *	6.25	4.53	231	88.5	300	0.0045	0.0045 *
SRCP898 Split	08/20/98	0.7	0.59	5	0.0025 *	0.0025 *	0.256	1.239	1.11		11	0.06	0.02 *	6.25	4.53	232	84.2	300	0.0045	0.0045 *
CALDWL (RWQCB)	08/20/98			5	0.500 *	0.500 *	0.256	1.239			11	1.6	0.50 *	6.25	4.53			300		
CALDWL (USBR)	08/20/98			5			0.256	1.239			11		0.80	6.25	4.53			300		
SRCP998	09/16/98	0.97	0.87	5	0.014	0.018	0.270	1.280	0.77		11	1.56	1.26	6.50	4.70	211	65	300	0.043	0.021
SRCP998 Split	09/16/98	0.93	0.86	5	0.022	0.018	0.270	1.280	0.76		11	1.54	1.29	6.50	4.70	203	84	300	0.044	0.023
CALDWL (RWQCB)	09/16/98			5	0.500 *	0.500 *	0.270	1.280			11	1.6	2.40	6.50	4.70			300		
CALDWL (USBR)	09/16/98			5			0.270	1.280			11		1.20	6.50	4.70			300		
SRCP1098	10/21/98	1.26	1.21	5	0.015	0.013	0.230	1.157	0.76		11	1.3	1.05	5.75	4.18	178	79.8	300	0.0085 *	0.0085 *
SRCP1098 Split	10/21/98	1.29	1.22	5	0.018	0.014	0.230	1.157	0.78		11	1.29	1.07	5.75	4.18	174	79.8	300	0.018	0.0085 *
CALDWL (RWQCB)	10/21/98			5	0.500 *	0.500 *	0.230	1.157			11	1.5	2.00	5.75	4.18			300		
CALDWL (USBR)	10/21/98			5			0.230	1.157			11		1.00	5.75	4.18			300		
SRCP1198	11/17/98	1.18	1.06	5	0.020	0.016	0.224	1.136	0.67		11	2.13	1.25	5.62	4.09	289	60.3	300	0.059	0.08 *
SRCP1198 Split	11/17/98	1.13	1.01	5	0.020	0.016	0.224	1.136	0.60		11	1.75	1.21	5.62	4.09	238	69	300	0.035	0.08 *
CALDWL (RWQCB)	11/17/98			5			0.224	1.136			11	1.5	1.80	5.62	4.09			300		
CALDWL (USBR)	11/17/98			5			0.224	1.136			11		1.50	5.62	4.09			300		
SRCP1298	12/14/98	1.49	1.38	5	0.023	0.012	0.237	1.178	1.01		11	3.07	2.30	5.87	4.27	188	37	300	0.095 *	0.095 *
SRCP1298 Split	12/14/98	1.47	1.36	5	0.018	0.011	0.237	1.178	0.82		11	3.1	2.37	5.87	4.27	201	40	300	0.095 *	0.095 *
CALDWL (RWQCB)	12/14/98			5	0.500 *	0.500 *	0.237	1.178			11	2.9	2.30	5.87	4.27			300		
CALDWL (USBR)	12/14/98			5			0.237	1.178			11		1.80	5.87	4.27			300		
SRCP199	01/20/99	1.57	1.46	5	0.060	0.038	0.230	1.157	1.14		11	4.83	3.35	5.75	4.18	434	117	300	0.482	0.019 *
SRCP199 Split	01/20/99	1.69	1.63	5	0.053	0.033	0.230	1.157	1.08		11	4.67	3.24	5.75	4.18	424	127	300	0.505	0.019 *
CALDWL (RWQCB)	01/20/99			5	0.500 *	0.500 *	0.230	1.157			11	5.4	3.00	5.75	4.18			300		
CALDWL (USBR)	01/20/99			5			0.230	1.157			11		2.60	5.75	4.18			300		
SRCP299	02/17/99	1.44	1.44	5	0.036	0.029	0.243	1.198	0.72		11	3.69	2.71	6.00	4.35	352	65	300	0.12	0.006 *
SRCP299 Split	02/17/99	1.61	1.42	5	0.045	0.028	0.243	1.198	0.79		11	4.02	2.68	6.00	4.35	279	60	300	0.135	0.012
CALDWL (RWQCB)	02/17/99			5	0.500 *	0.500 *	0.243	1.198			11	4.1	6.10	6.00	4.35			300		
CALDWL (USBR)	02/17/99			5			0.243	1.198			11		2.40	6.00	4.35			300		
SRCP399	03/17/99	1.25	1.44	5	0.028	0.030	0.243	1.198	0.62		11	3.13	2.24	6.00	4.35	215	215	300	0.044 *	0.044 *
SRCP399 Split	03/17/99	1.20	1.41	5	0.021	0.030	0.243	1.198	0.62		11	3.08	2.24	6.00	4.35	208	208	300	0.044 *	0.044 *
CALDWL (RWQCB)	03/17/99			5	0.500 *	0.500 *	0.243	1.198			11	2.0	2.3	6.00	4.35			300		
CALDWL (USBR)	03/17/99			5			0.243	1.198			11		2.30	6.00	4.35			300		
SRCP499	04/19/99	0.93	0.90	5	0.009	0.060	0.250	1.219	0.74		11	6.95	4.94	6.13	4.44	145	51	300	0.04	0.02 *
SRCP499 Split	04/19/99	0.85	0.96	5	0.090	0.070	0.250	1.219	0.73		11	6.83	4.92	6.13	4.44	145	44	300	0.04	0.02 *
CALDWL (RWQCB)	04/19/99			5	1.0 *	1.0 *	0.250	1.219			11	6.1	4.6	6.13	4.44			300		
CALDWL (USBR)	04/19/99			5			0.250	1.219			11		4.60	6.13	4.44			300		
SRCP599	05/20/99	1.16	1.2	5	0.028	0.036	0.250	1.219	0.63		11	2.74	2.09	6.13	4.44	320	123	300	0.067	0.027
SRCP599 Split	05/20/99	1.14	1.19	5	0.036	0.038	0.250	1.219	0.64		11	2.85	2.03	6.13	4.44	323	113	300	0.067	0.027
CALDWL (RWQCB)	05/20/99			5	1.000 *	1.000 *	0.250	1.219			11	3	2.50	6.13	4.44			300		
CALDWL (USBR)	05/20/99			5			0.250	1.219			11		3.00	6.13	4.44			300	0.037	
SRCP699	06/23/99	1.09	1.04	5	0.010 *	0.010 *	0.243	1.198	0.80		11	2	1.50	6.00	4.35	291	98	300	0.031	0.004 *
SRCP699 Split	06/23/99	1.08	1.04	5	0.010 *	0.010 *	0.243	1.198	0.65		11	1.98	1.47	6.00	4.35	207	109	300		0.004 *
CALDWL (RWQCB)	06/23/99			5	1.000 *	1.000 *	0.243	1.198			11	0.5 *	1.10	6.00	4.35			300		
CALDWL (USBR)	06/23/99			5			0.243	1.198			11		1.80	6.00	4.35			300		
SRCP799	07/21/99	1.18	1.12	5	0.018	0.014	0.263	1.260	0.65		11	1.48	1.12	6.38	4.61	249	108	300	0.049	0.023
SRCP799 Split	07/21/99	1.09	1.12	5	0.021	0.012	0.263	1.260	0.65		11	1.46	1.13	6.38	4.61	243	103	300	0.053	0.028
CALDWL (RWQCB)	07/21/99			5		1.000 *	0.263	1.260			11	0.5 *	2.50	6.38	4.61			300		
CALDWL (USBR)	07/21/99			5			0.26	1.26			11			6.38	4.61			300		

CITY OF REDDING LOCAL LIMITS
SACRAMENTO RIVER SAMPLING SUMMA
DOWMSTREAM OF KESWICK DAM
@CALDWELL PARK
All figures in ug/l unless otherwise stated.
See notes on Page 7

		Arsenic(T&D)			Cadmium(T&D)					Chromium(T)			Copper(T&D)				Iron(D)			Lead(T&D)	
Sample ID	Date	T@	D	O(HH)	T	D@	O(BP#3)	O(USc)		T@	D	O(USc)	T	D@	O(BP#3)	O(USc)	T	D@	O(BP#3)	T	D@
SRCP899	08/18/99	1.23	1.14	5	0.029	0.019	0.256	1.239		0.89		11	1.13	0.85	6.25	4.53	316	136	300	0.011 *	0.011 *
SRCP899 Split	08/18/99	1.25	1.17	5	0.023	0.014	0.256	1.239		0.86		11	1.07	0.81	6.25	4.53	328	123	300	0.011 *	0.011 *
CALDWL (RWQCB)	08/18/99			5	1.000 *	1.000 *	0.256	1.239				11	1.4	2.00	6.25	4.53			300		
CALDWL (USBR)	08/18/99			5			0.256	1.239				11			6.25	4.53			300		
SRCP999	09/27/99	1.04	1.05	5	0.011	0.010	0.263	1.260		0.83		11	1.04	0.91	6.38	4.61	383	144	300	0.031	0.0045 *
SRCP999 Split	09/27/99	1.06	1.05	5	0.012	0.009	0.263	1.260		0.82		11	1.05	0.74	6.38	4.61	388	148	300	0.03	0.0045 *
CALDWL (RWQCB)	09/27/99			5	0.500 *	0.500 *	0.263	1.260				11	1 *	1 *	6.38	4.61			300		
CALDWL (USBR)	09/27/99			5			0.263	1.260				11			6.38	4.61			300		
SRCP1099	10/20/99	1.19	1.16	5	0.006	0.008	0.263	1.260		0.58		11	1.15	0.87	6.38	4.61	230		300	0.048	0.01 *
SRCP1099 Split	10/20/99	1.19	1.19	5	0.006	0.005	0.263	1.260		0.58		11	1.17	0.88	6.38	4.61	230	87.6	300	0.041	0.01 *
CALDWL (RWQCB)	10/20/99			5			0.263	1.260				11			6.38	4.61			300		
CALDWL (USBR)	10/20/99			5			0.263	1.260				11			6.38	4.61			300		
SRCP1199	11/16/99	1.42	1.31	5	0.039	0.032	0.263	1.260		0.92		11	2.71	1.92	6.38	4.61	386	147	300	0.091	0.029
SRCP1199 Split	11/16/99	1.41	1.29	5	0.040	0.030	0.263	1.260		0.91		11	2.66	1.82	6.38	4.61	382	135	300	0.088	0.026
CALDWL (RWQCB)	11/16/99			5			0.263	1.260				11			6.38	4.61			300		
CALDWL (USBR)	11/16/99			5			0.263	1.260				11			6.38	4.61			300		
SRCP1299	12/14/99	1.79	1.65	5	0.003 *	0.003 *	0.256	1.239		0.02 *		11	0.98	0.73	6.25	4.53	112	35.8	300	0.034	0.004
SRCP1299 Split	12/14/99	1.8	1.7	5	0.003 *	0.006	0.256	1.239		0.55		11	0.96	0.73	6.25	4.53	115	46.5	300	0.033	0.004
CALDWL (RWQCB)	12/14/99			5			0.256	1.239				11			6.25	4.53			300		
CALDWL (USBR)	12/14/99			5			0.256	1.239				11			6.25	4.53			300		
SRCP100	01/18/00	1.17	1.12	5	0.038	0.036	0.250	1.219		0.80		11	4.82	3.23	6.13	4.44	107	22.6	300	0.186	0.038
SRCP100 Split	01/18/00	1.11	0.92	5	0.039	0.031	0.250	1.219		0.81		11	4.94	3.29	6.13	4.44	87.4	23	300	0.176	0.039
CALDWL (RWQCB)	01/18/00			5	3.400	0.25 *	0.250	1.219				11	4	1 *	6.13	4.44			300		
CALDWL (USBR)	01/18/00			5			0.250	1.219				11			6.13	4.44			300		
SRCP200	02/23/00	1.37	1.3	5	0.037	0.007 *	0.256	1.239		0.99		11	4.64	2.66	6.25	4.53	246	41	300	0.101	0.017
SRCP200 Split	02/23/00	1.34	1.32	5	0.039	0.007 *	0.256	1.239		0.80		11	4.35	2.84	6.25	4.53	167	43	300	0.069	0.019
CALDWL (RWQCB)	02/23/00			5	0.500	0.250 *	0.256	1.239				11	5	5.00	6.25	4.53			300		
CALDWL (USBR)	02/23/00			5			0.256	1.239				11			6.25	4.53			300		
SRCP300	03/22/00	1.09	1.02	5	0.052	0.042	0.270	1.280		0.66		11	4.58	3.06	6.50	4.70	151	38	300	0.072	0.018
SRCP300 Split	03/22/00	1.14	1.01	5	0.053	0.039	0.270	1.280		0.69		11	4.84	3.00	6.50	4.70	201	33.9	300	0.075	0.017
CALDWL (RWQCB)	03/22/00			5			0.270	1.280				11			6.50	4.70			300		
CALDWL (USBR)	03/22/00			5			0.270	1.280				11			6.50	4.70			300		
SRCP400	04/20/00	0.92	0.85	5	0.056	0.044	0.276	1.300		0.05		11	4.69	3.19	6.63	4.78	117	32.3	300	0.055	0.017
SRCP400 Split	04/20/00	0.94	0.88	5	0.056	0.043	0.276	1.300		0.05		11	4.65	3.01	6.63	4.78	116	29.8	300	0.054	0.016
CALDWL (RWQCB)	04/20/00			5	0.250 *	0.250 *	0.276	1.300				11	5	3.00	6.63	4.78			300		
CALDWL (USBR)	04/20/00			5			0.276	1.300	1.300			11			6.63	4.78			300		
SRCP500	05/16/00	1.3	1.22	5	0.034	0.030	0.276	1.300		0.65		11	2.62	1.78	6.63	4.78	142	51.2	300	0.062	0.014
SRCP500 Split	05/16/00	1.28	1.23	5	0.037	0.029	0.276	1.300		0.65		11	2.6	1.79	6.63	4.78	131	43.6	300	0.059	0.015
CALDWL (RWQCB)	05/16/00			5			0.276	1.300				11			6.63	4.78			300		
CALDWL (USBR)	05/16/00			5			0.276	1.300				11			6.63	4.78			300		
SRCP600	06/21/00	1.13	1.17	5	0.018	0.019	0.270	1.280		0.28 *		11	1.37	1.08	6.50	4.70	150	56.2	300	0.043	0.011
SRCP600 Split	06/21/00	1.32	1.38	5	0.021	0.007	0.270	1.280		0.28 *		11	1.4	1.04	6.50	4.70	154	58.8	300	0.04	0.011
CALDWL (RWQCB)	06/21/00			5	0.250 *	0.250 *	0.270	1.280				11	2	1.00 *	6.50	4.70			300		
CALDWL (USBR)	06/21/00			5			0.270	1.280				11			6.50	4.70			300		
SRCP900	09/19/00	0.98	0.97	5	0.019	0.017	0.270	1.280		0.05		11	0.91	0.70	6.50	4.70	117	32.7	300	0.03	0.014
SRCP900 Split	09/19/00	1.00	1.00	5	0.017	0.018	0.270	1.280		0.05		11	0.91	0.72	6.50	4.70	97.7	29.3	300	0.024	0.0035 *
CALDWL (RWQCB)	09/19/00			5	0.250 *	0.250 *	0.270	1.280				11	1 *	1.00 *	6.50	4.70			300		
CALDWL (USBR)	09/19/00			5			0.270	1.280				11			6.50	4.70			300		
SRCP1000	10/24/00	1.28	1.29	5	0.021	0.018	0.263	1.260		0.48	0.49	11	1.27	1.01	6.38	4.61	51.2	6.1	300	0.024	0.006
SRCP1000 Split	10/24/00	1.29	1.28	5	0.019	0.018	0.263	1.260		0.48	0.45	11	1.28	1.01	6.38	4.61	50.7	6.5	300	0.053	0.007
CALDWL (RWQCB)	10/24/00			5			0.263	1.260				11			6.38	4.61			300		
CALDWL (USBR)	10/24/00			5			0.263	1.260				11			6.38	4.61			300		
SRCP1200	12/19/00	2.18	1.93	5	0.040	0.019	0.256	1.239		0.49	0.34	11	1.39	1.03	6.25	4.53	45.2	3.9	300	0.027	0.006 *
SRCP1200 Split	12/19/00	2.01	1.90	5	0.021	0.017	0.256	1.239		0.38	0.33	11	1.31	1.15	6.25	4.53	42.5	5.3	300	0.02	0.006 *
CALDWL (RWQCB)	12/19/00			5	0.250 *	0.250 *	0.256	1.239				11	1 *	1.00 *	6.25	4.53			300		
CALDWL (USBR)	12/19/00			5			0.256	1.239				11			6.25	4.53			300		
SRCP0301	03/12/01	1.34	1.23	5	0.068	0.056	0.250	1.219		0.46	0.29	11	5.59	3.45	6.13	4.44	138	13.8	300	0.124	0.016
SRCP0301 Split	03/12/01	1.35	1.28	5	0.067	0.056	0.250	1.219		0.43	0.29	11	5.38	3.48	6.13	4.44	129	14.2	300	0.126	0.02
CALDWL (RWQCB)	03/12/01			5			0.250	1.219				11			6.13	4.44			300		
CALDWL (USBR)	03/12/01			5			0.250	1.219				11			6.13	4.44			300		

Page 3 Srcpsum 5/14/01

CITY OF REDDING LOCAL LIMITS
SACRAMENTO RIVER SAMPLING SUMMA
DOWMSTREAM OF KESWICK DAM
@CALDWELL PARK

All figures in ug/l unless otherwise stated

See notes on Page 7

			Mercury(T)			Nickel(T&D)			Selenium(T)			Silver(T)			Zinc			
Sample ID	Date	O(USc)	T@	D	O(HH)	T	D@	O(USc)	T@	D	O(USc)	T@	D	O(USc)	T	D@	O(BP#3)	O(USc)
Val's RWQCB data range	10/91-12/92	1.3-1.6	-	-		.31-1.56	.25-1.56	84.7-99.5	-	-		<.001-.010	<.001-.003	1.15-1.6	5.5-64.6	3.9-56.4	18.4-21.6	
Sac Watershed DL			0.00005			0.029	0.029		0.83			0.03			0.14	0.14		
CoR CC R1 1993 range	12/92-5/93		<.2	-		<5-<50	-		-	-		<1	-		18-70	<1-31		
Sequoia DL (ICP/MS)			0.02			0.5			0.6			0.1			0.4			
Frontier DL			0.002			0.1			-			0.002			0.1			
SRCP597	05/29/97	0.87	-		0.012	8.4	3.5	22.94	-	-	5	0.05 *	0.05 *	0.653	9.7	48	15.3	52.0
SRCP697	06/23/97	0.97	0.01 *	0.01 *	0.012	4.7	2.5	24.96	0.3	0.30 *	5	0.17	0.24	0.776	39	13	16.7	56.6
SRCP797	07/16/97	1.02	0.01 *	0.06	0.012	4.4	3.2	25.97	0.84	0.86	5	0.36	0.83	0.841	37	54	17.3	58.9
SRCP198 (begin clean techniqu	01/20/98	1.14	0.00112		0.012	1.45	0.804	28.29	0.12 *	0.12 *	5	0.008	0.014	1.001	10.2	7.95	18.8	64.2
SRCP198D (duplicate)	01/20/98	1.13	0.00123		0.012	1.35	0.822	28.15	0.12 *	0.12 *	5	0.009	0.007	0.990	10.6	7.67	18.7	63.9
SRCP298	02/18/98	0.97	0.0104		0.012	4.71	1.33	24.96	0.09 *	0.09 *	5	0.029	0.023	0.776	13.5	3.76	16.7	56.6
SRCP298D	02/18/98	0.97	0.0104		0.012	4.36	1.25	24.96	0.09 *	0.09 *	5	0.056	0.005	0.776	14.9	3.68	16.7	56.6
SRCP398	03/18/98	0.99	0.0033	0.00116	0.012	2.74	1.2	25.47	0.1 *	0.1 *	5	0.014	0.009	0.808	10.9	4.92	17.0	57.8
SRCP398 Split	03/18/98	0.99	0.0032	0.00118	0.012	2.78	1.11	25.47	0.1 *	0.1 *	5	0.015	0.006	0.808	10.7	4.99	17.0	57.8
LKRDDTCH (RWQCB)	03/18/98	0.99			0.012			25.47			5			0.808	9.6	7.4	17.0	57.8
LKRDDDBR (USBR)	03/18/98	0.99			0.012			25.47			5			0.808		21 (DL	17.0	57.8
LKRDDTFG (DFG)	03/18/98	0.99			0.012			25.47			5			0.808	10 *	10 *	17.0	57.8
SRCP498	04/21/98	0.87	0.00206		0.012	4.52	2.08	22.94	0.15 *		5	0.009 *		0.653	9.95	7.05	15.3	52.0
SRCP498D	04/21/98	0.87	0.00201		0.012	4.2	1.99	22.94	0.15 *		5	0.009 *		0.653	9.24	6.34	15.3	52.0
SRCP598	05/19/98	0.81	0.00044		0.012	1.43	0.806	21.91			5	0.009		0.595	6.46	4.40	14.7	49.7
SRCP598 Split	05/19/98	0.81	0.00105		0.012	1.45	0.891	21.91			5	0.010		0.595	6.52	4.62	14.7	49.7
CALDWL (RWQCB)	05/19/98	0.81			0.012			21.91			5			0.595	5.9	5.6	14.7	49.7
CALDWL (USBR)	05/19/98	0.81			0.012			21.91			5			0.595		10 *	14.7	49.7
SRCP698	06/24/98	0.92	0.00117		0.012	2.89	1.71	23.96			5	0.009		0.713	3.63	2.75	16.0	54.4
SRCP698 Split	06/24/98	0.92	0.00121		0.012	2.75	1.59	23.96			5	0.016		0.713	3.57	2.44	16.0	54.4
CALDWL (RWQCB)	06/24/98	0.92			0.012			23.96			5			0.713	4.9	4.1	16.0	54.4
CALDWL (USBR)	06/24/98	0.92			0.012			23.96			5			0.713			16.0	54.4
SRCP798	07/22/98	0.92	0.00158		0.012	3.12	2	23.96			5	0.003 *		0.713	3.13	2.88	16.0	54.4
SRCP798 Split	07/22/98	0.92	0.00142		0.012	3.36	2.33	23.96			5	0.005		0.713	3.18	2.2	16.0	54.4
CALDWL (RWQCB)	07/22/98	0.92			0.012			23.96			5			0.713	4	6.8	16.0	54.4
CALDWL (USBR)	07/22/98	0.92			0.012			23.96			5			0.713		10 *	16.0	54.4
SRCP898	08/20/98	1.04	0.00113		0.012	2.54	1.92	26.47			5	0.016		0.874	0.51	0.2 *	17.6	60.1
SRCP898 Split	08/20/98	1.04	0.00122		0.012	2.57	1.88	26.47			5	0.007		0.874	0.61	0.2 *	17.6	60.1
CALDWL (RWQCB)	08/20/98	1.04			0.012			26.47			5			0.874	6.2	4.7	17.6	60.1
CALDWL (USBR)	08/20/98	1.04			0.012			26.47			5			0.874		10 *	17.6	60.1
SRCP998	09/16/98	1.10	0.00092		0.012	2	1.55	27.46			5	0.004 *		0.942	3.03	2.2	18.3	62.3
SRCP998 Split	09/16/98	1.10	0.00093		0.012	1.98	1.52	27.46			5	0.004 *		0.942	2.77	2.1	18.3	62.3
CALDWL (RWQCB)	09/16/98	1.10			0.012			27.46			5			0.942	5.1	8.1	18.3	62.3
CALDWL (USBR)	09/16/98	1.10			0.012			27.46			5			0.942		10 *	18.3	62.3
SRCP1098	10/21/98	0.94	0.00087		0.012	2.05	1.68	24.46			5	0.002 *		0.744	2.25	1.59	16.3	55.5
SRCP1098 Split	10/21/98	0.94	0.00074		0.012	1.99	1.7	24.46			5	0.002 *		0.744	2.32	1.64	16.3	55.5
CALDWL (RWQCB)	10/21/98	0.94			0.012			24.46			5			0.744	6.2	5.2	16.3	55.5
CALDWL (USBR)	10/21/98	0.94			0.012			24.46			5			0.744		10 *	16.3	55.5
SRCP1198	11/17/98	0.92	0.00114		0.012	1.53	1.2	23.96			5	0.006 *		0.713	3.76	2.32	16.0	54.4
SRCP1198 Split	11/17/98	0.92	0.00098		0.012	1.42	1.2	23.96			5	0.006 *		0.713	3.32	2.31	16.0	54.4
CALDWL (RWQCB)	11/17/98	0.92			0.012			23.96			5			0.713	4.3	7.7	16.0	54.4
CALDWL (USBR)	11/17/98	0.92			0.012			23.96			5			0.713		10 *	16.0	54.4
SRCP1298	12/14/98	0.97	0.00135		0.012	1.26	0.78	24.96			5	0.008		0.776	4.81	3.46	16.7	56.6
SRCP1298 Split	12/14/98	0.97	0.00143		0.012	1.23	0.79	24.96			5	0.007		0.776	4.46	3.56	16.7	56.6
CALDWL (RWQCB)	12/14/98	0.97			0.012			24.96			5			0.776	5.7	7.2	16.7	56.6
CALDWL (USBR)	12/14/98	0.97			0.012			24.96			5			0.776		10 *	16.7	56.6
SRCP199	01/20/99	0.94	0.00303		0.012	1.86	1.27	24.46			5	0.018		0.744	9.26	6.08	16.3	55.5
SRCP199 Split	01/20/99	0.94	0.00309		0.012	1.85	1.28	24.46			5	0.023		0.744	9.17	5.94	16.3	55.5
CALDWL (RWQCB)	01/20/99	0.94			0.012			24.46			5			0.744	9.3	6.8	16.3	55.5
CALDWL (USBR)	01/20/99	0.94			0.012			24.46			5			0.744		10 *	16.3	55.5
SRCP299	02/17/99	0.99	0.00180		0.012	0.94	0.64	25.47			5	0.014		0.808	5.89	4.07	17.0	57.8
SRCP299 Split	02/17/99	0.99	0.00153		0.012	1	0.64	25.47			5	0.008		0.808	6.28	3.86	17.0	57.8
CALDWL (RWQCB)	02/17/99	0.99			0.012			25.47			5			0.808	10	28.3	17.0	57.8
CALDWL (USBR)	02/17/99	0.99			0.012			25.47			5			0.808		10 *	17.0	57.8
SRCP399	03/17/99	0.99	0.00206		0.012	1.33	1.17	25.47			5	0.009 *		0.808	4.76	2.97	17.0	57.8
SRCP399 Split	03/17/99	0.99	0.00228		0.012	1.26	1.20	25.47			5	0.009 *		0.808	4.08	3.15	17.0	57.8
CALDWL (RWQCB)	03/17/99	0.99			0.012			25.47			5			0.808	4.1	3.6	17.0	57.8
CALDWL (USBR)	03/17/99	0.99			0.012			25.47			5			0.808		10 *	17.0	57.8
SRCP499	04/19/99	1.02	0.00120		0.012	1.45	1.14	25.97			5	0.100 *		0.841	8.85	6.01	17.3	58.9
SRCP499 Split	04/19/99	1.02	0.00110		0.012	1.44	1.11	25.97			5	0.100 *		0.841	8.56	6.04	17.3	58.9
CALDWL (RWQCB)	04/19/99	1.02			0.012			25.97			5			0.841	11.6	10.6	17.3	58.9
CALDWL (USBR)	04/19/99	1.02			0.012			25.97			5			0.841		31	17.3	58.9
SRCP599	05/20/99	1.02	0.00141		0.012	1.18	0.97	25.97			5	0.039	0.012	0.841	5.31	3.58	17.3	58.9
SRCP599 Split	05/20/99	1.02	0.00119		0.012	1.24	0.95	25.97			5	0.013 *	0.012	0.841	5.09	3.36	17.3	58.9
CALDWL (RWQCB)	05/20/99	1.02			0.012			25.97			5			0.841	7.1	3.5	17.3	58.9
CALDWL (USBR)	05/20/99	1.02	0.00160		0.012	1.63		25.97			5	0.030 *		0.841	3.65	21	17.3	58.9
SRCP699	06/23/99	0.99	0.00210		0.012	1.41	1.32	25.47			5	0.030 *	0.030	0.808	3.71	2.3	17.0	57.8
SRCP699 Split	06/23/99	0.99			0.012		1.22	25.47			5		0.030	0.808	6.1	2.2	17.0	57.8
CALDWL (RWQCB)	06/23/99	0.99			0.012			25.47			5			0.808		7.2	17.0	57.8
CALDWL (USBR)	06/23/99	0.99			0.012			25.47			5			0.808		10 *	17.0	57.8
SRCP799	07/21/99	1.07	0.00090		0.012	1.48	1.19	26.96			5	0.018	0.005	0.907	2.44	1.59	18.0	61.2
SRCP799 Split	07/21/99	1.07	0.00100		0.012	1.4	1.14	26.96			5	0.011	0.005	0.907	2.46	1.64	18.0	61.2
CALDWL (RWQCB)	07/21/99	1.07			0.012			26.96			5			0.907	4	7	18.0	61.2
CALDWL (USBR)	07/21/99	1.07			0.012			26.96			5			0.907			18.0	61.2

CITY OF REDDING LOCAL LIMITS
SACRAMENTO RIVER SAMPLING SUMMA
DOWMSTREAM OF KESWICK DAM
@CALDWELL PARK

All figures in ug/l unless otherwise stated.

See notes on Page 7

Sample ID	Date	Hardness (mg/l)	Hardness (ICP Ca+Mg) (mg/l)	UC Davis Toxicity	City of Redding Lab NH3-N (mg/l)	City of Redding Lab Turbidity (NTU)	City of Redding Lab Conductivity (uS/cm)	City of Redding Lab TDS (mg/l)	City of Redding Lab TSS (mg/l)	Field Conductivity (uS/cm)	Field TDS (mg/l)	Field pH (units)	Field Temp (C)	Instantaneous Keswick Release (cfs)	24 Hour Avg Keswick Release (cfs)
Val's RWQCB data range	10/91-12/92	48-58													
Sac Watershed DL															
CoR CC R1 1993 range	12/92-5/93	42-49													
Sequoia DL (ICP/MS)															
Frontier DL															
SRCP597	05/29/97	38			0.05 *	8.75	100	75		100	66	7.5	11.8	9689	
SRCP697	06/23/97	42			0.05 *	6	92	67		105	70	7.74	13.8	14459	
SRCP797	07/16/97	44			0.17	5.2	103	100		109	74	7.44	11.1	14942	
SRCP198 (begin clean techniqu	01/20/98		48.7		0.05 *	2.55	100	70		137	92	7.75	9.7	20366	22292
SRCP198D (duplicate)	01/20/98		48.4											20366	22292
SRCP298	02/18/98	42	34.4		0.05 *	20.3	86	58		252	167	8.48	9.3	54871	51667
SRCP298D	02/18/98		34.6											54871	51667
SRCP398	03/18/98	43	35.4		0.05 *	12	74	57		247	167	7.83	10.4	5821	5831
SRCP398 Split	03/18/98		35.9											5821	5831
LKRDDTCH (RWQCB)	03/18/98		35.9											5821	5831
LKRDDDBR (USBR)	03/18/98		35.9											5821	5831
LKRDDTFG (DFG)	03/18/98		35.9											5821	5831
SRCP498	04/21/98	38	34.6		0.05 *	6	88	52	6.5	85	57	7.79	12.2	10018	10016
SRCP498D	04/21/98		33.2											10018	10016
SRCP598	05/19/98	36	37.7		0.05 *	3	98	84	1.19	99	66	7.91	13.7	14962	14774
SRCP598 Split	05/19/98		37.3											14962	14774
CALDWL (RWQCB)	05/19/98													14962	14774
CALDWL (USBR)	05/19/98													14962	14774
SRCP698	06/24/98	40			0.05 *	4.6	98	74	1	104	69	8.18	12.4	14654	14731
SRCP698 Split	06/24/98													14654	14731
CALDWL (RWQCB)	06/24/98													14654	14731
CALDWL (USBR)	06/24/98													14654	14731
SRCP798	07/22/98	40			0.05 *	3.65	95	72	0.5	100	66	7.9	12.4	14962	14740
SRCP798 Split	07/22/98													14962	14740
CALDWL (RWQCB)	07/22/98													14962	14740
CALDWL (USBR)	07/22/98													14962	14740
SRCP898	08/20/98	45			0.05 *	3.45	95	90	0.7	109	74	7.55	11.6	14809	14763
SRCP898 Split	08/20/98													14809	14763
CALDWL (RWQCB)	08/20/98													14809	14763
CALDWL (USBR)	08/20/98													14809	14763
SRCP998	09/16/98	47			0.05 *	3.4	100	66.5	1.07	213	139	7.48	13.2	11026	10970
SRCP998 Split	09/16/98													11026	10970
CALDWL (RWQCB)	09/16/98													11026	10970
CALDWL (USBR)	09/16/98													11026	10970
SRCP1098	10/21/98	40			0.05 *	3.3	95	94	0.46	126	83	7.77	13.9	6033	6006
SRCP1098 Split	10/21/98													6033	6006
CALDWL (RWQCB)	10/21/98													6033	6006
CALDWL (USBR)	10/21/98													6033	6006
SRCP1198	11/17/98	40			0.05 *	2.47	100	69	1	112	111	7.26	12.4	14800	14309
SRCP1198 Split	11/17/98													14800	14309
CALDWL (RWQCB)	11/17/98													14800	14309
CALDWL (USBR)	11/17/98													14800	14309
SRCP1298	12/14/98	42			0.05 *	3.7	155	89.8	1.33	121	81	7.72	12.3	15818	16123
SRCP1298 Split	12/14/98													15818	16123
CALDWL (RWQCB)	12/14/98													15818	16123
CALDWL (USBR)	12/14/98													15818	16123
SRCP199	01/20/99	41			0.05 *	6.55	114	75	1.9	110	74	8.16	10.4	5544	9672
SRCP199 Split	01/20/99													5544	9672
CALDWL (RWQCB)	01/20/99													5544	9672
CALDWL (USBR)	01/20/99													5544	9672
SRCP299	02/17/99	43			0.05 *	4.05	140	77.7	3.87	119	79	8.58	9.2	29853	27713
SRCP299 Split	02/17/99													29853	27713
CALDWL (RWQCB)	02/17/99													29853	27713
CALDWL (USBR)	02/17/99													29853	27713
SRCP399	03/17/99	42.0			0.11	3.48	135	87.5		102	70	8.2	10.7	14330	14239
SRCP399 Split	03/17/99													14330	14239
CALDWL (RWQCB)	03/17/99													14330	14239
CALDWL (USBR)	03/17/99													14330	14239
SRCP499	04/19/99	44			0.05 *	4.1	130	77.2	1.51	104	69	8.23	11	10079	9965
SRCP499 Split	04/19/99													10079	9965
CALDWL (RWQCB)	04/19/99													10079	9965
CALDWL (USBR)	04/19/99													10079	9965
SRCP599	05/20/99	44			0.05 *	3.6	121	83	0.05 *	106	71	7.36	11.7	8964	9280
SRCP599 Split	05/20/99													8964	9280
CALDWL (RWQCB)	05/20/99													8964	9280
CALDWL (USBR)	05/20/99													8964	9280
SRCP699	06/23/99	43			0.05 *	4.05	115	51.5	0.8	109	69	7.93	14		
SRCP699 Split	06/23/99														
CALDWL (RWQCB)	06/23/99														
CALDWL (USBR)	06/23/99														
SRCP799	07/21/99	46			0.05 *	3.2	137	85.3	1	110	74	8.17	14.3	13019	12996
SRCP799 Split	07/21/99													13019	12996
CALDWL (RWQCB)	07/21/99													13019	12996
CALDWL (USBR)	07/21/99													13019	12996

CITY OF REDDING LOCAL LIMITS
SACRAMENTO RIVER SAMPLING SUMMA
DOWMSTREAM OF KESWICK DAM
@CALDWELL PARK
All figures in ug/l unless otherwise stated
See notes on Page 7

					City of Redding Lab					Field					
Sample ID	Date	Hardness (mg/l)	Hardness (ICP Ca+Mg) (mg/l)	UC Davis Toxicity	NH3-N (mg/l)	Turbidity (NTU)	Conductivity (uS/cm)	TDS (mg/l)	TSS (mg/l)	Conductivity (uS/cm)	TDS (mg/l)	pH (units)	Temp (C)	Instantaneous Keswick Release (cfs)	24 Hour Avg Keswick Release (cfs)
SRCP899	08/18/99	45			0.05 *	3.35	130	81.5	0.05 *	113	76	7.95	13.2	9466	9485
SRCP899 Split	08/18/99													9466	9485
CALDWL (RWQCB)	08/18/99													9466	9485
CALDWL (USBR)	08/18/99													9466	9485
SRCP999	09/27/99	46			0.05 *	5.15	130	81	0.45	112	75	7.79	12.6	7048	7007
SRCP999 Split	09/27/99													7048	7007
CALDWL (RWQCB)	09/27/99													7048	7007
CALDWL (USBR)	09/27/99													7048	7007
SRCP1099	10/20/99	46			0.05 *	3.2	120	79.5	1.24	113	78	7.63	14.5	6167	6006
SRCP1099 Split	10/20/99													6167	6006
CALDWL (RWQCB)	10/20/99													6167	6006
CALDWL (USBR)	10/20/99													6167	6006
SRCP1199	11/16/99	46			0.05 *	5.6	150	91.8	1.44	123	83	7.8	11.5	6245	6185
SRCP1199 Split	11/16/99													6245	6185
CALDWL (RWQCB)	11/16/99													6245	6185
CALDWL (USBR)	11/16/99													6245	6185
SRCP1299	12/14/99	45			0.05 *	2.1	145	97.5	0.61	130	88	7.28	12.5	6897	7069
SRCP1299 Split	12/14/99													6897	7069
CALDWL (RWQCB)	12/14/99													6897	7069
CALDWL (USBR)	12/14/99													6897	7069
SRCP100	01/18/00	44			0.05 *	4.5	120	89	2	112	75	7.93	10.5		4021
SRCP100 Split	01/18/00														4021
CALDWL (RWQCB)	01/18/00														4021
CALDWL (USBR)	01/18/00														4021
SRCP200	02/23/00	45			0.05 *	3.75	113	82.8	2.62	110	74	8.1	10.7		35870
SRCP200 Split	02/23/00														35870
CALDWL (RWQCB)	02/23/00														35870
CALDWL (USBR)	02/23/00														35870
SRCP300	03/22/00	47				3.35	110	85	1.1	98	66	7.54	12.4		8595
SRCP300 Split	03/22/00														8595
CALDWL (RWQCB)	03/22/00														8595
CALDWL (USBR)	03/22/00														8595
SRCP400	04/20/00	48			0.05 *	2.05	90	60	0.4	95	63	8.17	11.9		8517
SRCP400 Split	04/20/00														8517
CALDWL (RWQCB)	04/20/00														8517
CALDWL (USBR)	04/20/00														8517
SRCP500	05/16/00	48			0.05 *	2.47	107	81.8	1.33			7.79	11.6		8504
SRCP500 Split	05/16/00														8504
CALDWL (RWQCB)	05/16/00														8504
CALDWL (USBR)	05/16/00														8504
SRCP600	06/21/00	47			0.05 *	2.3	100	78.5	0.05 *			7.46	10.9		14083
SRCP600 Split	06/21/00														14083
CALDWL (RWQCB)	06/21/00														14083
CALDWL (USBR)	06/21/00														14083
SRCP900	09/19/00	47			0.05 *	2.6		82.5	0.6	109	73	7.31	14.2		8739
SRCP900 Split	09/19/00														8739
CALDWL (RWQCB)	09/19/00														8739
CALDWL (USBR)	09/19/00														8739
SRCP1000	10/24/00	46			0.05 *	1.45	100	79.5	0.83	114	76	7.54	13.3		5389
SRCP1000 Split	10/24/00														5389
CALDWL (RWQCB)	10/24/00														5389
CALDWL (USBR)	10/24/00														5389
SRCP1200	12/19/00	45			0.05 *	0.9	130	89	1.43	128	84	8.17	13	4665	4622
SRCP1200 Split	12/19/00													4665	4622
CALDWL (RWQCB)	12/19/00													4665	4622
CALDWL (USBR)	12/19/00													4665	4622
SRCP0301	03/12/01	44			0.05 *	7.4	130	69	2.29	100	65	8.15	11.5	6514	6521
SRCP0301 Split	03/12/01													6514	6521
CALDWL (RWQCB)	03/12/01													6514	6521
CALDWL (USBR)	03/12/01													6514	6521

CITY OF REDDING
SACRAMENTO RIVER SAMPLING SUMMARY
NOTES

* = Result below detection limit, 1/2 DL entered.
Fe by colorimetric method starting 1/20/98
@ = Apply criteria to this form of metal.
Criteria:
- HH = Human Health
- BP#3 = CVRWQCB Basin Plan, Table 3
- USc = USEPA Continuous (4-day avg)
- ISWP = CA Inland Surface Waters Plan
- US T&O = USEPA Taste & Odor Criteria

Keswick releases from cdec starting 1/20/98

Prepared by Marcia Ames (530)224-6049

CITY OF REDDING
SACRAMENTO RIVER
DOWNSTREAM OF SHASTA DAM

All figures in ug/l unless otherwise stated.

			Arsenic(T&D)			Cadmium(T&D)			Chromium(T)			Copper(T&D)			
Sample ID	Date	Time	T@	D	O(HH)	T	D@	O(BP#3)	T@	D	O(USc)	T	D@	O(BP#3)	O(USc)
Val's RWQCB data range	10/91-12/92		1.50-2.08	1.35-2.08	5	.049-.491	.021-.516	.28-.34	.39-.68	.39-.56	11	2.5-17.5	2.27-9.7	6.6-7.9	
Sac Watershed DL			0.002	0.002		0.0024	0.0024		0.1			0.024	0.024		
CoR CC R1 1993 range	12/92-5/93		1.7-<4			<.1-.41	<.1-2.3		<1-<10			3.2-13	1.6-7.5		
Frontier DL			0.05			0.001			0.02			0.02			
SRDSD498	04/21/98	13:50	0.56	0.62	5	0.067	0.058	0.198	0.92		11	3.56	2.40	5.11	3.74
SRDSD598	05/19/98	10:45	0.80	0.73	5	0.029	0.023	0.204	0.83		11	1.65	1.25	5.24	3.83
SRDSD698	06/24/98	9:45	1.08	1.02	5	0.016	0.010	0.217	1.39		11	1.38	0.98	5.49	4.01
SRDSD798	07/22/98	13:45	0.53	0.52	5	0.015	0.016	0.217	0.85		11	1.17	0.86	5.49	4.01
SRDSD898	08/20/98	9:50	0.78	0.76	5	0.0025	0.025	0.256	1.14		11	0.017	0.02	6.25	4.53
SRDSD998	09/16/98	15:30	0.97	0.87	5	0.023	0.01	0.256	0.82		11	1.56	1.03	6.25	4.53
SRDSD1098	10/21/98	11:15	1.3	1.25	5	0.017	0.015	0.224	0.8		11	1.23	1.02	5.62	4.09
SRDSD1198	11/17/98	14:40	1.43	1.4	5	0.01	0.009	0.217	0.53		11	0.87	0.75	5.49	4.01
SRDSD199 (sample w/USBR)	01/19/99	11:45	1.71	1.47	5	0.022	0.012	0.237	0.69		11	2.77	2.11	5.87	4.27
SRDSD299	02/22/99	9:00	2.54	1.56	5	0.021	0.016	0.250	0.56		11	2.13	1.8	6.13	4.44
SRDSD399	03/15/99	9:00	1.38	1.6	5	0.031	0.034	0.243	0.64		11	3.92	2.53	6.00	4.35
SRDSD499	04/26/99	9:00	1.05	0.98	5	0.04	0.07	0.250	0.77		11	3.39	2.51	6.13	4.44
SRDSD599	05/17/99	9:10	1.26	1.35	5	0.032	0.031	0.250	0.66		11	2.53	1.83	6.13	4.44
SRDSD699	06/14/99	9:30	1.24	1.24	5	0.01	0.01	0.250	0.95		11	1.94	1.52	6.13	4.44
SRDSD799	07/19/99	9:00	1.31	1.21	5	0.036	0.032	0.263	0.72		11	1.43	1.06	6.38	4.61
SRDSD999	09/27/99	9:15	1.04	1.05	5	0.011	0.01	0.270	0.83		11	1.04	0.91	6.50	4.70
SRDSD1099	10/18/99	9:20	1.2	1.22	5	0.022	0.015	0.256	0.62		11	1.01	0.81	6.25	4.53
SRDSD1299	12/13/99	9:30	1.75	1.89	5	0.003	0.008	0.256	0.63		11	0.88	0.67	6.25	4.53
SRDSD100	01/24/00	9:25	1.75	1.75	5	0.009	0.0035	0.250	0.57		11	2.13	1.59	6.13	4.44
SRDSD200	02/28/00	9:15	1.55	1.5	5	0.032	0.027	0.263	1.02		11	3.05	2.05	6.38	4.61
SRDSD300	03/20/00	9:25	1.28	1.24	5	0.043	0.029	0.250	0.96		11	3.86	2.22	6.13	4.44
SRDSD500	05/22/00	9:35	1.38	1.31	5	0.024	0.017	0.276	0.75		11	1.79	1.28	6.63	4.78

* = Result below detection limit, 1/2 DL entered.
Fe by colorimetric method
@ = Apply criteria to this form of metal.
Criteria:
HH = Human Health
BP#3 = CVRWQCB Basin Plan, Table 3

CITY OF REDDING
SACRAMENTO RIVER
DOWNSTREAM OF SHASTA DAM

All figures in ug/l unless otherwise stated.

		Iron(D) (colorimetric)			Lead(T&D)			Mercury(T)			Nickel(T&D)			Selenium(T)	
Sample ID	Date	T	D	O(US T&O)	T	D@	O(USc)	T@	D	O(HH)	T	D@	O(USc)	T@	D
Val's RWQCB data range	10/91-12/92	66-408	7-118	300	.020-.337	<.005-.049	1.3-1.6	-	-		.31-1.56	.25-1.56	84.7-99.5	-	-
Sac Watershed DL			3.0		0.0081	0.0081		0.00005			0.029	0.029		0.83	
CoR CC R1 1993 range	12/92-5/93	-	-		<1-2.7	-		<.2	-		<5-<50	-		-	-
Frontier DL		0.5			0.02			0.002			0.1			-	
SRDSD498	04/21/98	234	47	300	0.063	0.006	0.814	0.00142		0.012	1.95	1.04	21.9	0.15	
SRDSD598	05/19/98	242	71.7	300	0.019	0.0035	0.840	0.00106		0.012	1.66	0.985	22.4		
SRDSD698	06/24/98	293.7	109.1	300	0.06	0.017	0.891	0.00119		0.012	2.94	1.74	23.4		
SRDSD798	07/22/98	297	96	300	0.055	0.020	0.891	0.00104		0.012	2.42	1.39	23.4		
SRDSD898	08/20/98	253	98	300	0.012	0.005	1.045	0.00106		0.012	2.32	1.58	26.5		
SRDSD998	09/16/98	230	107	300	0.045	0.021	1.045	0.00092		0.012	2	1.33	26.5		
SRDSD1098	10/21/98	207	85	300	0.019	0.019	0.916	0.00085		0.012	1.65	1.36	24.0		
SRDSD1198	11/17/98	160	71.6	300	0.008	0.008	0.891	0.00074		0.012	0.58	0.51	23.4		
SRDSD199 (sample w/USBR)	01/19/99	92.4	92.4	300	0.261	0.019	0.967	0.001		0.012	1.11	0.78	25.0		
SRDSD299	02/22/99	85	24	300	0.174	0.039	1.019	0.00093		0.012	0.62	0.5	26.0		
SRDSD399	03/15/99	215	77.8	300	0.044	0.044	0.993	0.00315		0.012	0.94	0.72	25.5		
SRDSD499	04/26/99	289	119	300	0.11	0.070	1.019	0.0012		0.012	1.23	0.92	26.0		
SRDSD599	05/17/99	334	85.8	300	0.118	0.031	1.019	0.00105		0.012	1.01	0.74	26.0		
SRDSD699	06/14/99	356	166	300	0.055	0.010	1.019	0.0017		0.012	1.25	0.95	26.0		
SRDSD799	07/19/99	291	135	300	0.228	0.047	1.070	0.0009		0.012	1.17	0.89	27.0		
SRDSD999	09/27/99	383	144	300	0.031	0.005	1.096	0.0016		0.012	1.49	1.15	27.5		
SRDSD1099	10/18/99	214	95	300	0.138	0.042	1.045	0.0007		0.012	1.21	1.1	26.5		
SRDSD1299	12/13/99	117	35	300	0.067	0.010	1.045	0.00064		0.012	0.33	0.18	26.5		
SRDSD100	01/24/00	44.9	10.5	300	0.234	0.070	1.019	0.00125		0.012	0.48	0.31	26.0		
SRDSD200	02/28/00	204	56	300	0.115	0.020	1.070	0.00085		0.012	1.73	1.04	27.0		
SRDSD300	03/20/00	235	62.3	300	0.146	0.021	1.019	0.00133		0.012	1.58	0.83	26.0		
SRDSD500	05/22/00	159	51.2	300	0.099	0.033	1.122	0.00115		0.012	1.37	1.02	28.0		

* = Result below detection limit, 1/2 DL enterec
Fe by colorimetric method
@ = Apply criteria to this form of metal.
Criteria:
HH = Human Health
BP#3 = CVRWQCB Basin Plan, Table 3

2

Srdsd 5/14/01 8:17 AM

CITY OF REDDING
SACRAMENTO RIVER
DOWNSTREAM OF SHASTA DAM

All figures in ug/l unless otherwise stated.

			Silver(T)			Zinc			Hardness		City of Redding Lab					
Sample ID	Date	O(USc)	T@	D	O(USc)	T	D@	O(BP#3)	(ICP Ca+Mg) (mg/l)	UC Davis Toxicity	Hardness (mg/l)	NH3-N (mg/l)	Turbidity (NTU)	Conductivity (uS/cm)	TDS (mg/l)	TSS (mg/l)
Val's RWQCB data range	10/91-12/92		<.001-.010	<.001-.003	1.15-1.6	5.5-64.6	3.9-56.4	18.4-21.6			48-58					
Sac Watershed DL			0.03			0.14	0.14									
CoR CC R1 1993 range	12/92-5/93		<1	-		18-70	<1-31				42-49					
Frontier DL			0.002			0.1										
SRDSD498	04/21/98	5	0.009 *		0.60	10.6	7.43	14.7	33.8		36		10	92	62	1.2
SRDSD598	05/19/98	5	0.007		0.62	5.34	4.1	15.0	38		37		3.6	98	84	1.19
SRDSD698	06/24/98	5	0.0075 *		0.68	2.66	1.78	15.7			39		4.6	100	69	1
SRDSD798	07/22/98	5	0.008		0.68	2.61	1.81	15.7			39	0.05 *	4.05	100	81	0.5
SRDSD898	08/20/98	5	0.005		0.87	0.91	0.2	17.6			45	0.05 *	3.4	102	96	0.48
SRDSD998	09/16/98	5	0.013		0.87	2.12	1.43	17.6			45	0.05 *	3.4	100	78.5	0.05
SRDSD1098	10/21/98	5	0.01		0.71	2.82	2.29	16.0			40	0.05 *	3.2	95	102	0.27
SRDSD1198	11/17/98	5	0.006		0.68	1.74	1.18	15.7			39		2.02	102	91	0.78
SRDSD199 (sample w/USBR)	01/19/99	5	0.023		0.78	5.43	3.98	16.7			42		4.1	128	86.3	0.5
SRDSD299	02/22/99	5	0.0025		0.84	3.32	2.63	17.3			44		3.1	170	85.3	0.5
SRDSD399	03/15/99	5	0.022		0.81	5.92	4.26	17.0			43		3.6	115	76.5	1
SRDSD499	*04/26/99*	5	*0*		*0.84*	5.38	4.16	17.3			44		4.25	125	74	0.9
SRDSD599	05/17/99	5	0.0125		0.84	5.1	4	17.3			44		4.53	125	62	0.5
SRDSD699	06/14/99	5	0.03		0.84	3.79	2.69	17.3			44		4.7	130	88	0.2
SRDSD799	07/19/99	5	0.005		0.91	2.71	1.81	18.0			46		3.7	120	93	0.6
SRDSD999	09/27/99	5	0.014		0.94	2.38	1.52	18.3			47		4.65	120	84	0.29
SRDSD1099	10/18/99	5	0.00045		0.87	2.06	1.58	17.6			45		3.3	125	84.8	0.59
SRDSD1299	12/13/99	5	0.008		0.87	0.93	0.68	17.6			45		2.55	150	83	0.99
SRDSD100	01/24/00	5	0.008		0.84	3.02	2.37	17.3			44		1.52	145	95.7	0.33
SRDSD200	02/28/00	5	0.005		0.91	4.66	3.35	18.0			46		2.9	126	85.5	1.23
SRDSD300	03/20/00	5	0.0115		0.84	6.51	4.38	17.3			44		3.4	115	83.5	0.76
SRDSD500	05/22/00	5	0.025		0.98	3.61	2.72	18.6			48		2.46	111	78.5	0.67

* = Result below detection limit, 1/2 DL enterec
Fe by colorimetric method
@ = Apply criteria to this form of metal.
Criteria:
HH = Human Health
BP#3 = CVRWQCB Basin Plan, Table 3

Srdsd 5/14/01 8:17 AM

CITY OF REDDING
SACRAMENTO RIVER
DOWNSTREAM OF SHASTA DAM

All figures in ug/l unless otherwise stated.

Sample ID	Date	Field Conductivity (uS/cm)	Field TDS (mg/l)	Field pH (units)	Field Temp (C)	Daily Shasta Release (cfs)	Previous hrly Shasta Release (cfs)	Post hrly Shasta Release (cfs)
Val's RWQCB data range	10/91-12/92							
Sac Watershed DL								
CoR CC R1 1993 range	12/92-5/93							
Frontier DL								
SRDSD498	04/21/98	94	63	7.92	15.1	6748	5878	10131
SRDSD598	05/19/98	101	67	7.51	13.2	14240	15608	14742
SRDSD698	06/24/98	104	69	8.13	14.9	14078	13024	13532
SRDSD798	07/22/98	110	73	7.07	16.6	12116	13065	12143
SRDSD898	08/20/98	106	72	7.55	10.6	12435	8724	14733
SRDSD998	09/16/98	103	68	7.62	11.5	9338	12428	12452
SRDSD1098	10/21/98	169	112	7.67	13.3	5739	4241	6043
SRDSD1198	11/17/98	184	126	6.86	13	11353	10677	10684
SRDSD199 (sample w/USBR)	01/19/99	124	83	8.2	10.1	4235	3070	3076
SRDSD299	02/22/99	124	83	8.24	8.5	19134	19211	17470
SRDSD399	03/15/99	128	85	8.35	9.1	13534	7216	7034
SRDSD499	04/26/99	111	74	8.01	11.3	6856	3825	11920
SRDSD599	05/17/99	111	73	7.94	11.4	8521	461	13418
SRDSD699	06/14/99	112	77	7.42	15.5	8610	8453	9150
SRDSD799	07/19/99	116	77	7.96	13.6	10429	7489	9498
SRDSD999	09/27/99	113	76	7.86	12.1	6367	3234	161
SRDSD1099	10/18/99	114	76	7.78	11	5518	2484	131
SRDSD1299	12/13/99	136	91	7.19	11.2	6928	8215	8079
SRDSD100	01/24/00	132	87	7.3	10.6	4326	4057	3756
SRDSD200	02/28/00	119	79	8.57	9.7	35651	36673	36589
SRDSD300	03/20/00	109	73	7.46	10.6	7685	9391	10003
SRDSD500	05/22/00	0	0	7.8	13.3	10192	10954	11249

* = Result below detection limit, 1/2 DL enterec
Fe by colorimetric method
@ = Apply criteria to this form of metal.
Criteria:
HH = Human Health
BP#3 = CVRWQCB Basin Plan, Table 3

CITY OF REDDING LOCAL LIMITS
SACRAMENTO RIVER SAMPLING SUMMA
DOWMSTREAM OF KESWICK DAM
@CALDWELL PARK
All figures in ug/l unless otherwise stated
See notes on Page 7

			Mercury(T)			Nickel(T&D)			Selenium(T)			Silver(T)			Zinc			
Sample ID	Date	O(USc)	T@	D	O(HH)	T	D@	O(USc)	T@	D	O(USc)	T@	D	O(USc)	T	D@	O(BP#3)	O(USc)
SRCP899	08/18/99	1.04	0.00110		0.012	1.48	1.23	26.47			5	0.007	0.006	0.874	2.57	1.67	17.6	60.1
SRCP899 Split	08/18/99	1.04	0.00110		0.012	1.48	1.21	26.47			5	0.021	0.006	0.874	2.58	1.63	17.6	60.1
CALDWL (RWQCB)	08/18/99	1.04			0.012			26.47			5			0.874	3.8	5.4	17.6	60.1
CALDWL (USBR)	08/18/99	1.04			0.012			26.47			5			0.874			17.6	60.1
SRCP999	09/27/99	1.07	0.00160		0.012	1.49	1.15	26.96			5	0.014	0.004	0.907	2.38	1.52	18.0	61.2
SRCP999 Split	09/27/99	1.07	0.00140		0.012	1.5	1.17	26.96			5	0.013	0.004	0.907	2.34	1.63	18.0	61.2
CALDWL (RWQCB)	09/27/99	1.07			0.012			26.96			5			0.907	9	6	18.0	61.2
CALDWL (USBR)	09/27/99	1.07			0.012			26.96			5			0.907			18.0	61.2
SRCP1099	10/20/99	1.07	0.00070		0.012	1.24	1.01	26.96			5	0.019	0.005	0.907	2.14	1.41	18.0	61.2
SRCP1099 Split	10/20/99	1.07	0.00070		0.012	1.25	1.06	26.96			5	0.005 *	0.005	0.907	2.04	1.46	18.0	61.2
CALDWL (RWQCB)	10/20/99	1.07			0.012			26.96			5			0.907			18.0	61.2
CALDWL (USBR)	10/20/99	1.07			0.012			26.96			5			0.907			18.0	61.2
SRCP1199	11/16/99	1.07	0.00159		0.012	1.25	0.91	26.96			5	0.004 *	0.004	0.907	6.2	4.77	18.0	61.2
SRCP1199 Split	11/16/99	1.07	0.00118		0.012	1.16	0.82	26.96			5	0.009	0.004	0.907	6.1	4.65	18.0	61.2
CALDWL (RWQCB)	11/16/99	1.07			0.012			26.96			5			0.907			18.0	61.2
CALDWL (USBR)	11/16/99	1.07			0.012			26.96			5			0.907			18.0	61.2
SRCP1299	12/14/99	1.04	0.00061		0.012	0.51	0.34	26.47			5	1.790	0.003	0.874	1.36	1.08	17.6	60.1
SRCP1299 Split	12/14/99	1.04	0.00068		0.012	0.46	0.33	26.47			5	1.800	0.003	0.874	1.42	1.77	17.6	60.1
CALDWL (RWQCB)	12/14/99	1.04			0.012			26.47			5			0.874			17.6	60.1
CALDWL (USBR)	12/14/99	1.04			0.012			26.47			5			0.874			17.6	60.1
SRCP100	01/18/00	1.02	0.00234		0.012	1.16	0.92	25.97			5	0.015	0.009	0.841	7.83	5.71	17.3	58.9
SRCP100 Split	01/18/00	1.02	0.00204		0.012	1.16	0.89	25.97			5	0.011	0.006	0.841	7.57	5.65	17.3	58.9
CALDWL (RWQCB)	01/18/00	1.02			0.012			25.97			5			0.841	11	6	17.3	58.9
CALDWL (USBR)	01/18/00	1.02			0.012			25.97			5			0.841			17.3	58.9
SRCP200	02/23/00	1.04	0.00201		0.012	1.69	1.11	26.47			5	0.005 *	0.005	0.874	6.5	3.93	17.6	60.1
SRCP200 Split	02/23/00	1.04	0.00206		0.012	1.61	1.14	26.47			5	0.005 *	0.005	0.874	6.13	4.45	17.6	60.1
CALDWL (RWQCB)	02/23/00	1.04			0.012			26.47			5			0.874	9	9	17.6	60.1
CALDWL (USBR)	02/23/00	1.04			0.012			26.47			5			0.874			17.6	60.1
SRCP300	03/22/00	1.10	0.00143		0.012	1.21	0.082	27.46			5	0.012 *	0.012	0.942	6.84	5.01	18.3	62.3
SRCP300 Split	03/22/00	1.10	0.00212		0.012	1.27	0.082	27.46			5	0.012 *	0.012	0.942	7.14	4.98	18.3	62.3
CALDWL (RWQCB)	03/22/00	1.10			0.012			27.46			5			0.942			18.3	62.3
CALDWL (USBR)	03/22/00	1.10			0.012			27.46			5			0.942			18.3	62.3
SRCP400	04/20/00	1.12	0.00122		0.012	1.61	1.3	27.95			5	0.012 *	0.012	0.976	7.68	7.19	18.6	63.4
SRCP400 Split	04/20/00	1.12	0.00137		0.012	1.61	1.22	27.95			5	0.012 *	0.012	0.976	7.6	5.49	18.6	63.4
CALDWL (RWQCB)	04/20/00	1.12			0.012			27.95			5			0.976	7	6	18.6	63.4
CALDWL (USBR)	04/20/00	1.12			0.012			27.95			5			0.976			18.6	63.4
SRCP500	05/16/00	1.12	0.00124		0.012	1.39	1.1	27.95			5	0.029	0.020	0.976	5.82	4.54	18.6	63.4
SRCP500 Split	05/16/00	1.12	0.00130		0.012	1.37	1.14	27.95			5	0.011	0.028	0.976	5.78	4.33	18.6	63.4
CALDWL (RWQCB)	05/16/00	1.12			0.012			27.95			5			0.976			18.6	63.4
CALDWL (USBR)	05/16/00	1.12			0.012			27.95			5			0.976			18.6	63.4
SRCP600	06/21/00	1.10	0.00083		0.012	1.31	1.13	27.46			5	0.031	0.008	0.942	2.88	2.16	18.3	62.3
SRCP600 Split	06/21/00	1.10	0.00095		0.012	1.33	1.06	27.46			5	0.043	0.008	0.942	3.15	1.18	18.3	62.3
CALDWL (RWQCB)	06/21/00	1.10			0.012			27.46			5			0.942	2.5 *	2.5 *	18.3	62.3
CALDWL (USBR)	06/21/00	1.10			0.012			27.46			5			0.942			18.3	62.3
SRCP900	09/19/00	1.10	0.00073		0.012	1.16	1.06	27.46			5	0.013	0.020	0.942	2.34	1.8	18.3	62.3
SRCP900 Split	09/19/00	1.10	0.00069		0.012	1.16	1.06	27.46			5	0.023	0.002	0.942	2.49	1.96	18.3	62.3
CALDWL (RWQCB)	09/19/00	1.10			0.012			27.46			5			0.942	2.5 *	2.5 *	18.3	62.3
CALDWL (USBR)	09/19/00	1.10			0.012			27.46			5			0.942			18.3	62.3
SRCP1000	10/24/00	1.07	0.00002 *		0.012	1.13	1.01	26.96			5	0.002	0.004	0.907	2.51	1.87	18.0	61.2
SRCP1000 Split	10/24/00	1.07	0.00002 *		0.012	1.18	1.01	26.96			5	0.003	0.001	0.907	2.55	1.78	18.0	61.2
CALDWL (RWQCB)	10/24/00	1.07			0.012			26.96			5			0.907			18.0	61.2
CALDWL (USBR)	10/24/00	1.07			0.012			26.96			5			0.907			18.0	61.2
SRCP1200	12/19/00	1.04	0.00050		0.012	0.51	0.34	26.47			5	0.003	0.001	0.874	2.81	1.95	17.6	60.1
SRCP1200 Split	12/19/00	1.04	0.00043		0.012	0.38	0.33	26.47			5	0.002	0.009	0.874	2.58	1.90	17.6	60.1
CALDWL (RWQCB)	12/19/00	1.04			0.012			26.47			5			0.874	2.5 *	2.5 *	17.6	60.1
CALDWL (USBR)	12/19/00	1.04			0.012			26.47			5			0.874			17.6	60.1
SRCP0301	03/12/01	1.02	2.13000		0.012	1.12	0.88	25.97			5	0.003	0.001	0.841	7.68	5.33	17.3	58.9
SRCP0301 Split	03/12/01	1.02	3.25000		0.012	1.07	0.94	25.97			5	0.002	0.001	0.841	7.64	5.55	17.3	58.9
CALDWL (RWQCB)	03/12/01	1.02			0.012			25.97			5			0.841			17.3	58.9
CALDWL (USBR)	03/12/01	1.02			0.012			25.97			5			0.841			17.3	58.9