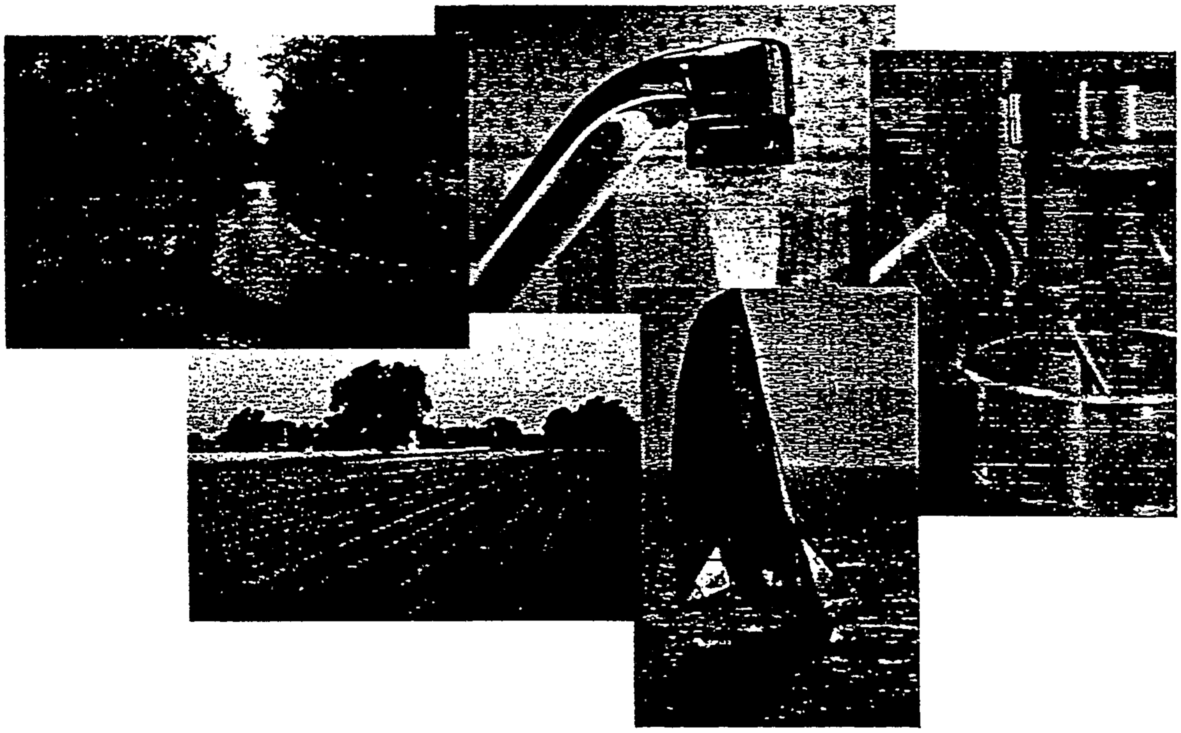
CALFED Water Quality Program



GOOD WATER QUALITY FOR ALL BENEFICIAL USES

Environmental
Agriculture
Drinking Water
Industrial
Recreational

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CALFED
BAY-DELTA
PROGRAM

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Overview E-1
Water Quality Component E-1
Geographic Scope of Water Quality Program..E-2
Water Quality Technical Report E-2
Selecting Parameters of Concern E-3
Impacts to Beneficial Uses of Water..E-5
    Drinking Water E-5
    Agriculture E-5
    Environment..E-6
    Recreation E-6
    Industrial E-6
Prioritizing Problem Areas..E-7
Identifying Sources of Problems E-8
Developing Action Strategies E-8
    Action Strategies E-8
    Performance Strategies..E-8
    Indicators of Success..E-9
Comprehensively Conducting Monitoring, Assessment, and Research E-9
Coordinating Watershed Activities..E-10

SECTION 1 - INTRODUCTION

Introduction 1-1
Water Quality Program 1-1
Geographic Scope of CALFED Water Quality Program 1-2
Stakeholder Involvement 1-3
Structure of Report.. 1-4

SECTION 2 - BACKGROUND

Background 2-1
Water Quality Issues 2-2
    Drinking Water 2-3
    Environment..2-4
    Recreation 2-4
    Industrial 2-4

SECTION 3 - PARAMETERS OF CONCERN

General Parameter Description ... 3-1
Metal and Toxic Elements ... 3-1
Organics/Pesticides ... 3-3
Other ... 3-3
Boron ... 3-3
Chloride ... 3-4
Disinfection Byproducts in Treated Drinking Water ... 3-4
Dissolved Oxygen ... 3-6
Nutrients ... 3-6
Pathogens ... 3-6
Giardia lamblia ... 3-8
Cryptosporidium parvum ... 3-8
pH ... 3-9
Sodium Absorption Ratio (SAR) ... 3-9
Salinity ... 3-9
Temperature ... 3-11
Turbidity ... 3-11
Data Available ... 3-12
Target Ranges for Parameters ... 3-12

SECTION 4 - SOURCES AND LOADINGS OF PARAMETERS

Sources of Parameters ... 4-1
Loadings of Parameters ... 4-1

SECTION 5 - Water Quality Problem Areas

Water Quality Problem Areas ... 5-1
U.S. EPA Section 303(d) Listing ... 5-1
Parameter Assessment Team Drinking Water Targets ... 5-1
Agricultural Drinking Water Targets ... 5-1
Scientific Studies ... 5-1
Impaired Water Bodies ... 5-2
Sacramento River Basin ... 5-2
San Joaquin River Basin ... 5-2
Delta ... 5-2
San Francisco Bay ... 5-2

SECTION 6 - ACTION STRATEGIES

Action Strategies ... 6-1
Summary of Action Strategies ... 6-2
Delta ... 6-2
Sacramento Basin ... 6-3
San Joaquin Basin ... 6-3

Mine Drainage 6-4
Urban and Industrial Runoff 6-5
Wastewater and Industrial Discharges 6-7
Agricultural Drainage 6-8
Water Treatment 6-10
Unknown Toxicity 6-11
Water Management 6-12

LIST OF TABLES

Table	Title	Page
Table E-1		E-4
Table 3-1	Water Quality Parameters of Concern to Beneficial Uses	3-1
Table 3-2	Principal Waterborne Bacterial Agents and Associated Health Effects	3-7
Table 3-3	Enteric Viruses and Their Associated Diseases	3-7
Table 4-1	Bromide Loadings	4-2
Table 4-2	Cadmium Loadings	4-3
Table 4-3	Copper Loadings	4-4
Table 4-4	Mercury Loadings	4-5
Table 4-5	Nitrate Loadings	4-6
Table 4-6	Selenium Loadings	4-7
Table 4-7	Selenium Loadings from the San Joaquin Tributaries	4-8
Table 4-8	Total Dissolved Solids Loadings	4-9
Table 4-9	Total Organic Carbon Loading	4-10
Table 4-10	Zinc Loadings	4-11

LIST OF FIGURES

Figure	Title	Follows Page
Figure E-1	Location of Municipal Water Intakes in Relation to Sources of Bromides, Salinity, and Total Organic Carbon	E-5
Figure E-2	Marinas Located in the Delta	E-6
Figure E-3	CALFED Impaired Water Bodies Based on CWA Section 303(D) List	E-7
Figure E-4	Potential Sources of Parameters of Concern	E-8
Figure 2-1	Location of Municipal Water Intakes in Relation to Sources of Bromides, Salinity, and Total Organic Carbon	2-3
Figure 2-2	Agriculture Diversions	2-4

CALFED
WATER QUALITY PROGRAM TECHNICAL REPORT
Executive Summary

The objective of the CALFED Water Quality Program is to provide good water quality for environmental, agricultural, drinking water, industrial, and recreational beneficial uses.

OVERVIEW

The mission of the CALFED Bay-Delta Program is to develop a long-term comprehensive plan that will restore ecosystem health and improve water management for beneficial uses of the Bay-Delta System. The Program consists of five components that address problems associated with ecosystem restoration, water quality, system integrity, water use efficiency, and water supply reliability.

All components of the CALFED Program, are being developed and evaluated at a programmatic level. The complex and comprehensive nature of a Bay-Delta solution means that it will necessarily be composed of many different programs, projects, and actions, that will be implemented over time. During the current phase of the Program, solution alternatives will be evaluated as sets of programs and projects so that broad benefits and impacts can be identified. In the next phase of the Program, more focused analysis, environmental documentation, and implementation of specific programs and actions will occur.

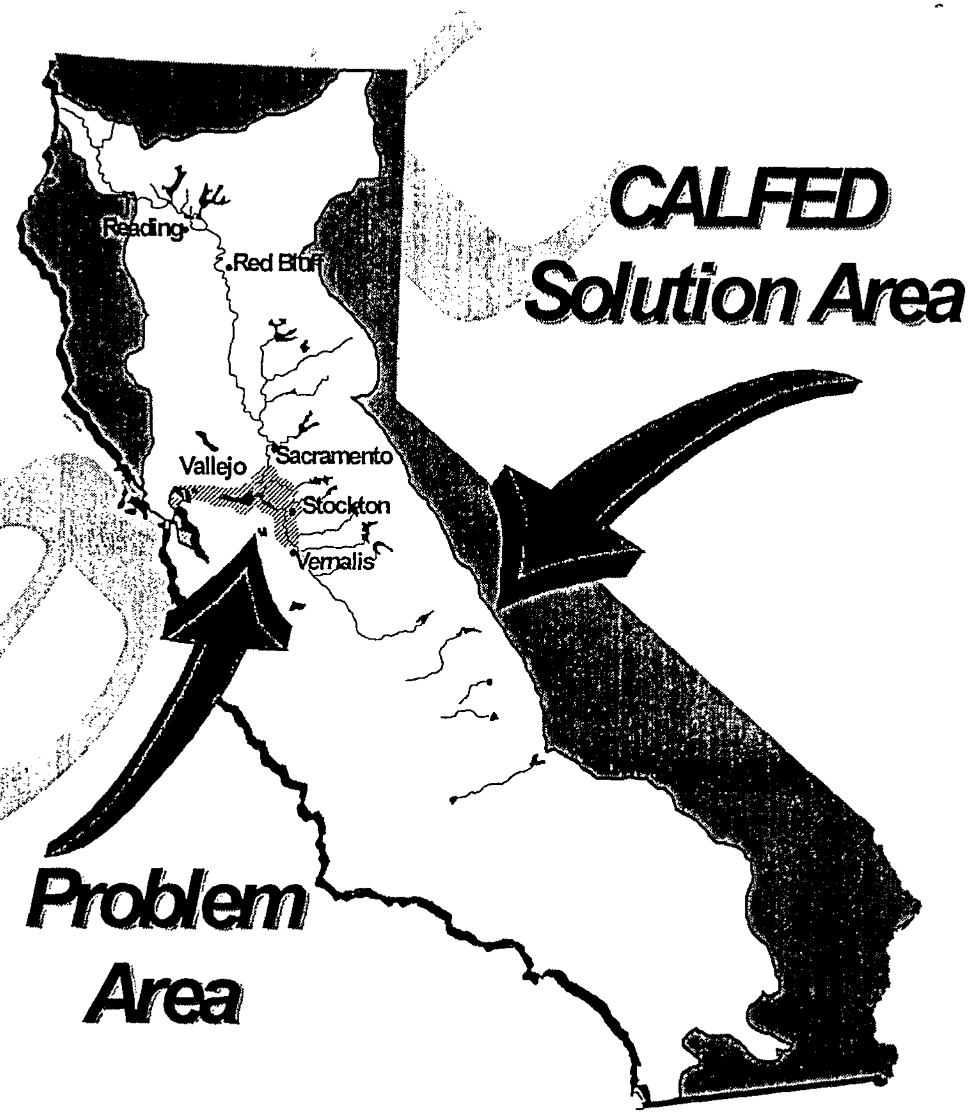
Water Quality Component

CALFED's objective for water quality is to provide good water quality for urban, agricultural, industrial, environmental, and recreational beneficial uses. This objective will be achieved through development and implementation of the CALFED Water Quality Program (WQP). The WQP will recommend action strategies that address identified parameters of concern to beneficial uses. These action strategies will have measurable performance targets and indicators of success that will be used to judge program effectiveness and facilitate adaptive management.

Adaptive Management Cycle

Geographic Scope of Water Quality Program

The geographic focus of the WQP is the Delta, which has been identified as the primary "problem" area by CALFED. This area consists of the legally defined Delta, Suisun Bay to Carquinez Strait, and Suisun Marsh. Some species (e.g., anadromous fish) that inhabit the Delta are impacted by conditions outside the Delta. Also, areas outside the Delta are sources of water quality problems affecting the Delta, its inhabitant species, and users of Delta water. In resolving the water quality problems of the Delta, the WQP recommends that actions be taken throughout the geographic solution area, as necessary.



WATER QUALITY TECHNICAL REPORT

The Water Quality Technical Report defines the basic structure of the WQP including:

- beneficial use water quality issues,
- water quality parameters of concern to beneficial uses,
- sources and loadings of parameters of concern,
- water quality beneficial use problem areas,
- existing programs to address parameters of concern,
- CALFED recommended action strategies,
- a monitoring and assessment framework to and evaluate action effectiveness, and
- a description of how CALFED's water quality activities will be coordinated with ongoing

watershed management activities.

In addition to defining the CALFED Water Quality Program information from the Water Quality Technical Report will be used to assess impacts as part of the CALFED Programmatic EIS/EIR process. Following is a summary of the main components of the Water Quality Technical Report.

SELECTING PARAMETERS OF CONCERN

The CALFED Water Quality Program has accessed and utilized a large group of water quality technical experts to assist in the development of the Water Quality Program. These stakeholders, known as the Water Quality Technical Group, represent federal, state and local agencies, environmental advisory groups, industry, (pesticide, mining, etc.), agriculture, recreation, urban water supply, and watershed interests.

Initially, three technical teams of stakeholders were formed to identify the source water quality requirements of the ecosystem, urban and agricultural water users. The ecosystem team was primarily comprised of federal and state agency representatives (California Department of Fish and Game, US Fish and Wildlife Service, US Environmental Protection Agency, California Departments of Fish and Game and Pesticide Regulation, US Fish and Wildlife Service and Environmental Protection Agency, and State and Region 2 and 5 Water Quality Control Boards). The urban team included both agency staff and urban water agency representatives. The agricultural team was represented by agency staff, farmers, and agricultural water suppliers. Using available data and technical knowledge the teams identified "parameters of concern" that were of concern to their beneficial use of water. The teams also identified actions that might be taken to reduce these parameters. CALFED then invited additional stakeholders to join in the process, specifically those who might be impacted from implementation of the recommended water quality actions.

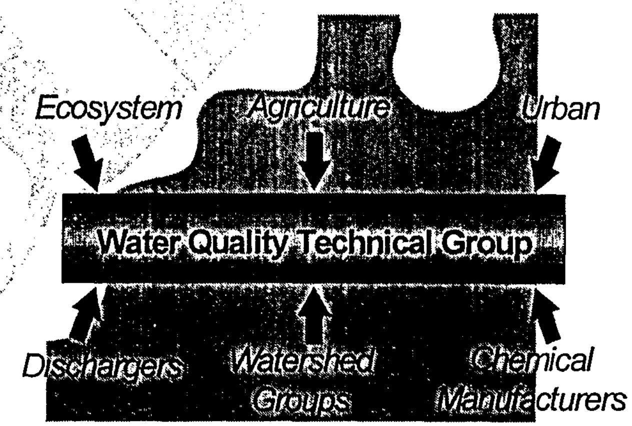


Table E-1 identifies parameters that have been identified by the Water Quality Technical Group as currently of concern to beneficial uses of water. This list may change over time in response to additional knowledge and understanding of these and other parameters.

In addition to the technical workgroup meetings CALFED has held workshops to inform the general public about the

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water quality program's activities. CALFED staff have also met with a variety of groups including the Clean Water Caucus, California Water Environment Association, and the California Urban Water Agencies. The CALFED Bay Delta Advisory Committee has been kept appraised of the water quality program's progress through informational segments at their regularly scheduled meetings.

Table E-1 Parameters of Concern to Beneficial Uses

Environmental	Drinking Water	Agriculture	Recreational	Industrial
Metals&Toxic Elements	**Disinfection By-Product Precursors**	**Other**	**Metals**	**Other**
Cadmium	Bromide	Boron	Mercury	Salinity
Copper	TOC	Chloride	**Organics/Pesticides**	pH
Mercury	**Other**	Nutrients (Nitrate)	PCBs	Alkalinity
Selenium	Pathogens	pH (Alkalinity)	DDT	Phosphates
Zinc	Turbidity	Salinity (TDS, EC)	**Other**	Ammonia
Organics/Pesticides	Salinity (TDS)	SAR	Pathogens	
Carbofuran	Nutrients (Nitrate)	Turbidity	Nutrients	
Chlordane	pH	Temperature		
Chlorpyrifos				
DDT				
Diazinon				
PCBs				
Toxaphene				
Other				
Ammonia				
Dissolved Oxygen				
Salinity (TDS, EC)				
Temperature				
Turbidity				
Unknown Toxicity*				

*Unkown toxicity refers to observed aquatic toxicity the source of which is unknown.

IMPACTS TO BENEFICIAL USES OF WATER

Drinking Water

The Delta is a source of drinking water for about 20 million, or two-thirds, of all Californians. Beneficial use of drinking water can be impacted by loadings of bromide, nutrients, salinity, organic carbon, turbidity, pathogens or changes in pH. Pathogens such as *Cryptosporidium parvum* in source water can adversely affect municipal drinking water supplies. Nutrient loading, and subsequent algae blooms, can impair the taste and odor of municipal water supplies and increase the expense of treating the water. Elevated turbidity due to suspended solids can be responsible for increasing treatment costs for municipal water supplies.

A major problem during periods of low Delta outflows is tidal mixing of salt into the Delta channels. Salts are a major concern with regard to municipal drinking water supplies because of the presence in sea water of bromide, which contributes to unwanted disinfection byproducts (DBPs). Salt can result in aesthetic problems such as salty taste, corrosion of appliances, plumbing and industrial facilities, and reduced opportunity for waste water recycling. Salts also are present in freshwater inflows to the Delta due to municipal and agricultural discharges. The most heavily concentrated sources of agricultural drainage to the Delta is the San Joaquin River.

Organic carbon in source water can adversely affect municipal drinking water supplies by combining with water treatment disinfectants to produce harmful by-products such as trihalomethanes. Of particular concern to drinking water is agricultural drainage from Delta Islands because the peat soils of the Delta contribute organic carbon to the agricultural drainage water. Delta diversions through the State Water Project H.O. Banks and North Bay Pumping Plants, the Central Valley Project Tracy Pumping Plant, and the Contra Costa Water District Pumping Plant at Rock Slough supply water for municipal purposes. Figure E-1 depicts the interaction between municipal water intakes located in the Delta and sources of bromides, salinity and organic carbon.

Agriculture

More than 1,800 agricultural diversions are located within the Delta. These diversions supply irrigation water to over 450,000 acres of fertile Delta farmlands. Irrigation water destined for use on millions of acres in the San Joaquin Valley and Southern California is also diverted in the Delta at the same intakes used for municipal water diversion. Beneficial uses of water by agriculture can be impacted by loadings of boron, salts, nutrients, pH, sodium absorption ratios, and turbidity. Excess salts can result in plant toxicity and negative effects on plant growth and crop yield.. Salts affect the ability of a plant to take up water. Salts coupled with a disproportionate amount of sodium in the water, can cause the soil surface to seal, limiting water infiltration. Excessive vegetative growth or delayed crop maturity can result from excessive nutrients and white deposits on fruit or leaves can occur due to sprinkling with high pH water. Turbidity and nutrients can also foul irrigation systems.

Environment

The Delta is the West Coast's largest estuary, one of the country's largest systems for fish production, and provides habitat for more than 120 fish species. An estimated 25 percent of all warm water and anadromous sport fishing species and 80 percent of the state's commercial fishery species either live in or migrate through the Delta. Beneficial uses of water for environmental purposes, specifically fishery resources, have been impacted due to toxic pollutants such as trace metals and synthetic organic compounds. Also, nutrients, pathogens, pH, dissolved oxygen and temperature have the potential to affect Delta species. Populations of striped bass and other species have declined significantly from historical levels. Causes of the declines are uncertain, although water quality conditions in the Bay and Delta, decreases in Delta inflow and outflow rates, habitat loss, agricultural and other instream diversions, and in-Delta exports are thought to be contributing factors. Metals, pesticides, salts, and ammonia in elevated concentrations can be toxic to early life stages of fish and invertebrate species. Mercury can bioaccumulate in the upper levels of the food chain, affecting larger fish, birds and mammals. Pathogens can adversely affect fish either acutely (lethality) or chronically (histopathological effects, impaired reproduction). Solids can increase turbidity in water bodies, reducing photosynthesis and available food for fish. Solids can also cause siltation of water bodies, burying and ruining spawning gravels that are essential fish reproduction habitat. Nutrient loading can lead to direct or indirect (abnormal algae blooms) depletion of dissolved oxygen in water bodies, which can suffocate aquatic organisms, and lead to observable fish kills. Nutrient limitations may at times limit food availability to aquatic species.

Recreation

The Delta supports about 12 million public user days a year through a variety of recreational opportunities including fishing, camping, and boating. 120 marinas, shown in Figure E-2, are located within the Delta's boundary and approximately 82,000 boaters utilize the Delta's waterways. Recreational beneficial uses in the Delta may be affected due to pathogens, metals, pesticides, solids, or nutrients. Microbial pathogens can adversely affect the health of those who are participating in water contact recreation, such as swimming, water skiing, or windsurfing. Pathogen contamination of fish or shellfish can adversely affect public health. Certain metals and pesticides, such as mercury and DDT, bioaccumulate in the food chain and can adversely affect recreational fishers who consume contaminated fish and shellfish. Solids loading can increase the turbidity of waters and interfere with the aesthetic enjoyment of these natural resources and constitute a hazard to swimmers. Solids loading is also a mechanism by which pathogens, metals, pesticides, and nutrients are transported into waters that support recreational beneficial uses. Nutrient loading can promote algal blooms that reduce water clarity and sometimes cause unsightly, odorous floating mats and fouling of boat hulls.

Industrial

The Delta supports a wide variety of industries from sugar production to oil refineries. Industrial water is diverted directly from the Delta or conveyed through the same facilities used for municipal purposes. Some industrial processes divert water from municipal systems prior to treatment and treat the raw water to the level required for their specific industrial process. Industrial uses of water may be impaired due to salinity, phosphates, ammonia and pH. Salinity has adversely affected industrial processes such as paper manufacturing through corrosion and mineral scaling of industrial equipment. For refineries, a major user of industrial water, high concentrations of phosphates can aggravate scaling concerns in cooling water systems and high levels of ammonia can cause cracking in brass cooling heat exchangers.

PRIORITIZING PROBLEM AREAS

Defining what constitutes a "problem" is a controversial and debatable issue. Very few of the parameters of concern have been studied sufficiently to understand their fate, transport and impact on beneficial uses of water. If a parameter is measured against an existing objective, criteria or standard a decision must be made 1) whether the standard is appropriate, 2) what the standard is meant to protect, and 3) what level of exceedance is relevant (e.g., duration, season, geographic location, etc.). For example, an exceedance of copper in the Upper Sacramento River during the fall-run chinook salmon juvenile outmigration period might be devastating to the population however, during other times of the year (when fall-run are not present) there may be virtually no biological impact. For some parameters such as temperature and salinity extensive data has been collected. For other parameters such as pesticides minimal information is known. Given the inherent difficulties in attempting to measure data against published standards the Water Quality Program has adopted the following approach to identifying and prioritizing beneficial use problem areas.

- For environmental and recreational beneficial uses, problem areas are primarily designated based on Section 303(d) of the Clean Water Act. This Act requires each state to develop a list, known as a 303(d) list, of water bodies that are impaired with respect to water quality and to identify the sources of impairment (e.g., mine drainage, agricultural drainage, urban and industrial runoff, and municipal and industrial wastewater discharges). Water bodies impaired by CALFED water quality parameters of concern are shown in Figure E-3.
- For drinking water beneficial uses, problem areas are determined based on the suitability of Delta drinking water sources to be treatable, at reasonable cost, to meet current and future federal and State health-based drinking water standards.
- For agricultural beneficial uses, problem areas are determined according to the impact of irrigation source water on sustainable productivity of agricultural lands.
- In addition a problem area can be defined based on scientific studies and data that indicate a potentially significant problem exists.

IDENTIFYING SOURCES OF PROBLEMS

To effectively take action to improve water quality conditions it is not sufficient to only know where a problem exists in a water body, the source of the water quality problem must also be identified. Sources of water quality parameters of concern in the Delta and its tributaries include:

- acidic drainage from inactive and abandoned mines that introduce metals such as cadmium, copper, zinc, and mercury;
- stormwater inflows and urban runoff that may contribute metals, selenium, turbidity, pathogens, organic carbon, nutrients, pesticides, petroleum and other chemical residues;
- municipal and industrial discharges that may contribute salts, metals, trace elements, nutrients, pathogens, chemical residues, oil and grease, and turbidity;
- agricultural tail water, or return flows, that may contribute salts, nutrients, pesticide residues, pathogens, and turbidity; and,
- subsurface agricultural drainage that may contribute salts, selenium and other trace elements, nutrients, and pesticides (some fungicides).

The general locations of the major sources of water quality parameters of concern are shown in Figure E-4.

DEVELOPING ACTION STRATEGIES

Action strategies have been developed to address water quality parameters of concern in the Delta and its tributaries. The strategies are recommended actions that will result in improvements to source water quality by reducing source loadings of parameters (e.g., mine drainage, agricultural drainage, urban and industrial runoff, and municipal and industrial wastewater treatment facilities); upgrading water treatment plants; or changing water management practices.

Action strategies to address water quality parameters of concern include a combination of research, pilot studies and full-scale actions. For some parameters, such as mercury, there is inadequate understanding about its sources, the bioavailability of the various sources, and the load reductions needed to reduce fish tissue concentrations to levels acceptable for human consumption. For this parameter further study is recommended before full-scale actions are taken. For other parameters, such as selenium, sources are better documented, and source control or treatment actions can be taken with a reasonable expectation of positive environmental results.

Performance targets have been established to measure the effectiveness of actions to improve water quality. Performance targets may be quantifiable reductions in loadings of parameters. For example, the target for copper in the Sacramento River is to reduce copper loadings in the Upper Sacramento River from 65,000 pounds to 10,000 pounds per year. For actions that recommend further study of a parameter the performance target may be a focussed outcome. For example, an action for mercury is further research to better understand the sources and mechanisms of mercury accumulation in the Delta estuary. The performance target is a targeted action plan that specifies selection and prioritization of the most effective mercury remediation actions.

Indicators of success are generally numerical or narrative water quality targets, or biological indicators, that have been developed for each parameter of concern. Targets relate to in-stream, sediment, or tissue concentrations of parameters. They will be used to gauge action and alternative effectiveness at protecting beneficial uses. Targets are based on Water Quality Control Plans (Basin Plans) of the Bay Area and Central Valley Regional Water Quality Control Boards or U.S. Environmental Protection Agency ambient water quality objectives (when available), standard agricultural water quality objectives, and target source drinking water quality ranges as defined by technical experts. Some parameters, such as pathogens have no regulatory objectives. In these cases indicators of success are generally a quantifiable reduction in counts before and after action is taken.

Table E-2 summarizes the Action Strategies for each parameter of concern included in the CALFED Water Quality Program.

COMPREHENSIVELY CONDUCTING MONITORING, ASSESSMENT AND RESEARCH

The Water Quality Program, and indeed all CALFED activities, must be based on the application of rigorous science. While there is some information on the existence of water quality problems in the CALFED solution area, much is yet to be learned. CALFED is developing a Comprehensive Monitoring, Assessment, and Research Program (CMARP) to address the need for adequate scientific support not only in the water quality area, but also for the system integrity, ecosystem restoration, and water supply reliability resource areas. The CMARP is central to the CALFED philosophy of adaptive management. The water quality component of the CMARP will provide for:

- Establishing a quality assurance/quality control plan to assure the scientific validity of CALFED data collection included in this plan will be recommendations for standardized data collections and handling practices to assure that all data collected for CALFED are compatible;

- Establishing the actual existence and severity of water quality problems, including evaluating the ecosystem effects of water quality parameters;

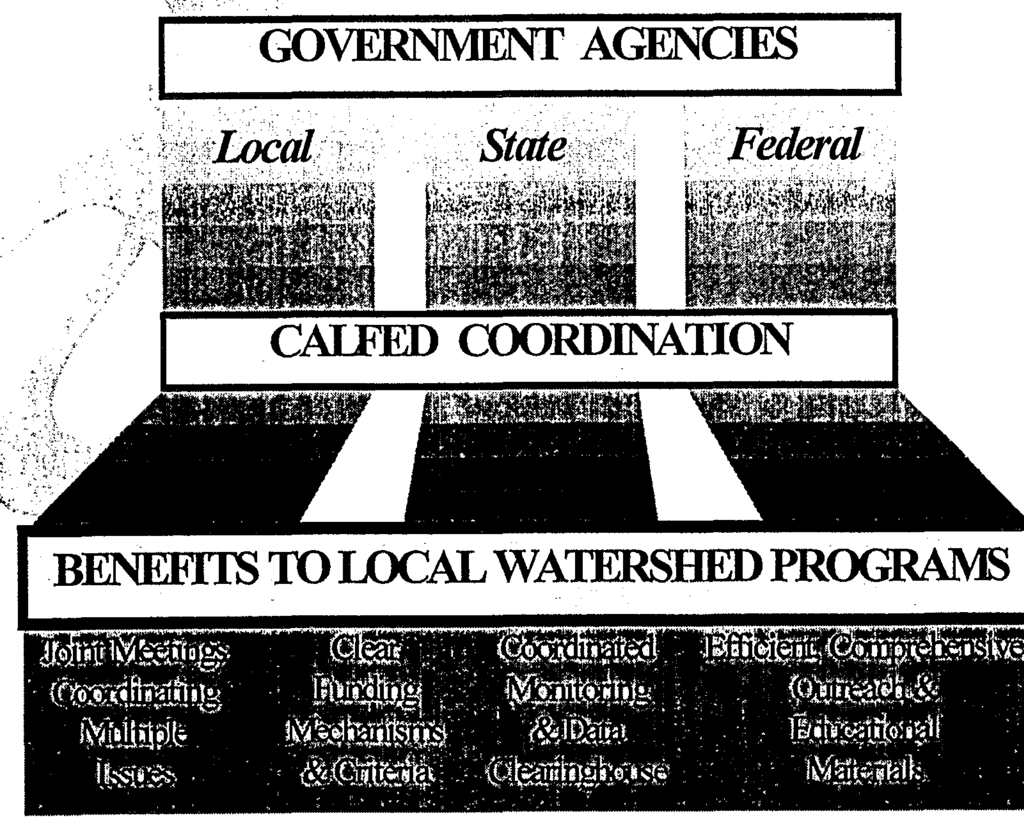
- Establishing baseline water quality conditions against which the effectiveness of CALFED actions will be measured; and,

- Evaluating the effectiveness of CALFED water quality improvement actions and identifying the need for adaptive management actions.

COORDINATING WATERSHED ACTIVITIES

CALFED may work with local agencies to assist in the formation of alliances and cooperative projects to improve water quality for beneficial uses on a larger scale than might be possible with local agencies working alone or in more narrowly scoped programs. CALFED's system-wide watershed focus on water quality will help to better integrate and coordinate State/Federal resource management programs with local watershed activities, while ensuring long-term benefits for the Bay-Delta estuary.

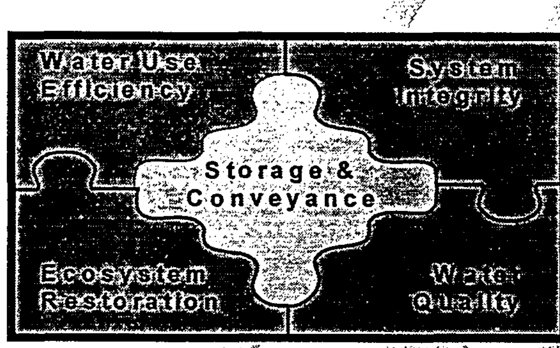
CALFED activities are being coordinated with existing or new watershed management programs affecting the Bay-Delta system including, but not limited to, the Sacramento River Watershed Program, the San Joaquin Valley Drainage Implementation Program, the San Francisco Estuary Project Comprehensive Conservation and Management Plan and the federal, State, and Regional Water Quality Control Board's Watershed Management Initiative Programs.



SECTION 1

INTRODUCTION

The mission of the CALFED Bay-Delta Program (Program) is to develop a long-term comprehensive plan that will restore ecosystem health and improve water management for beneficial uses of the Bay-Delta System. The Program addresses problems in five resource areas: ecosystem restoration, water quality, system integrity, water use efficiency and water supply reliability (i.e., storage and conveyance). The report that follows details the plans associated with the water quality component of this Program.



All components of Bay-Delta solution alternatives, are being developed and evaluated at a programmatic level. The complex and comprehensive nature of a Bay-Delta solution means that it will necessarily be composed of many different programs, projects, and actions, that will be implemented over time. During the current phase of the Program, solution alternatives will be evaluated as sets of programs and projects so that broad benefits and impacts can be identified. In the next phase of the Program, more focused analysis, environmental documentation, and implementation of specific programs and actions will occur.

Water Quality Program

The objective of the Water Quality Program (WQP) is to ensure that good water quality can be provided for urban, agricultural, industrial, environmental, and recreational beneficial uses.

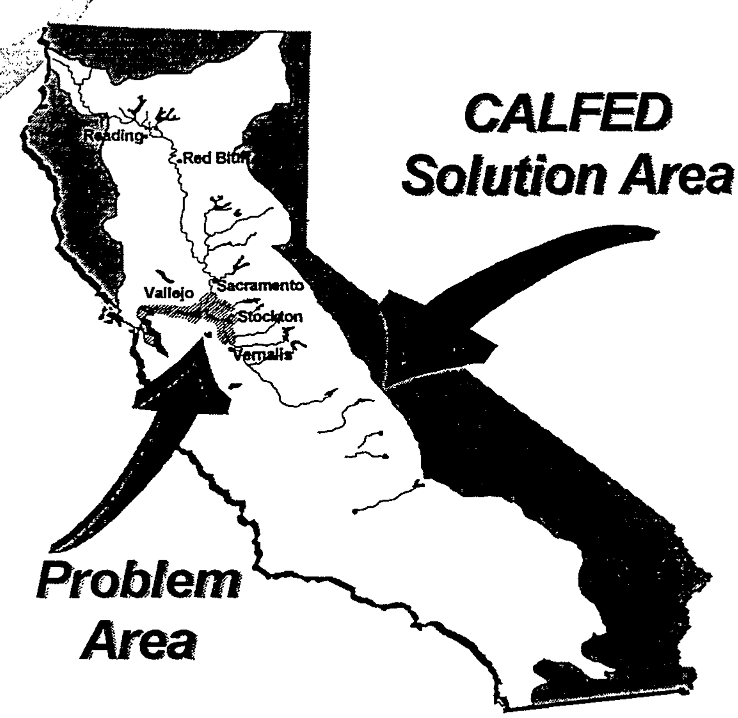
This objective will be achieved through development and implementation of a prioritized set of water quality actions that address identified parameters that are of concern to beneficial uses. These actions will have measurable performance targets and indicators of success that will be used to judge program effectiveness and facilitate adaptive management. Adaptive management is a process of testing alternative ways of meeting objectives, and adapting future management actions according to what is learned.

In developing the WQP the six CALFED solution principles were taken into account. These principles state that a Bay-Delta solution must:

- *Reduce Conflicts in the System*
  Solutions will reduce major conflicts among beneficial users of water.
- *Be Equitable*
  Solutions will focus on solving problems in all problem areas. Improvements for some problems will not be made without corresponding improvements for other problems.
- *Be Affordable*
  Solutions will be implementable and maintainable within the foreseeable resources of the Program and stakeholders.
- *Be Durable*
  Solutions will have political and economic staying power and will sustain the resources they were designed to protect and enhance.
- *Be Implementable*
  Solutions will have broad public acceptance and legal feasibility, and will be timely and relatively simple to implement compared with other alternatives.
- *Have No Significant Redirected Impacts*
  Solutions will not solve problems in the Bay-Delta system by redirecting significant negative impacts, when viewed in their entirety, within the Bay-Delta or to other regions of California.

Geographic Scope of CALFED Water Quality Program

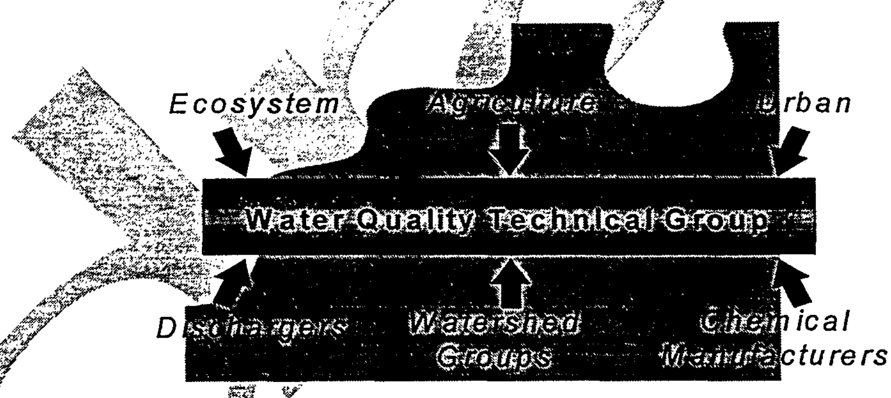
The geographic focus of the WQP is the Delta, which has been identified as the primary "problem" area by CALFED. This area consists of the legally defined Delta, Suisun Bay to Carquinez Strait, and Suisun Marsh. Some species (e.g., anadromous fish) that inhabit the Delta are impacted by conditions outside the Delta. Also areas outside the Delta are sources of water quality problems affecting the Delta, its inhabitant species, and users of Delta water. In resolving the water quality problems of the Delta, the WQP has recommended actions be taken throughout the geographic solution area, as necessary.



Stakeholder Involvement

The CALFED Water Quality Program has accessed and utilized a large group of water quality technical experts to assist in the development of the Water Quality Program. These stakeholders, known as the Water Quality Technical Group, represent federal, state and local agencies, environmental advisory groups, industry (e.g., pesticide, mining, etc.), agriculture, recreation, urban water supply, and watershed interests.

Initially, three technical teams of stakeholders were formed to identify the source water quality requirements of environment, urban and agriculture water users. The environment team was primarily comprised of federal and state agency representatives (California Department of Fish and Game, US Fish and Wildlife Service, US Environmental Protection Agency, California Departments of Fish and Game and Pesticide Regulation, US Fish and Wildlife Service and Environmental Protection Agency, and State and Region 2 and 5 Water Quality Control Boards). The urban team included both agency staff and urban water agency representatives. The agriculture team was represented by agency staff, farmers, and agricultural water suppliers. Using available data and technical knowledge the teams identified parameters that were of "concern" to their respective beneficial use of water and actions that might be taken to reduce these parameters. CALFED then invited additional stakeholders to join in the process. The stakeholders included those who might be impacted from implementation of the recommended water quality actions (e.g. parties responsible for mine drainage, agricultural drainage, urban runoff, wastewater and industrial discharges, etc.) and representatives of environment and watershed interests.



In addition to the technical workgroup meetings CALFED has held workshops to inform the general public about WQP activities. CALFED staff have met with a variety of groups including the Clean Water Caucus, California Water Environment Association, and the California Urban Water Agencies. The CALFED Bay Delta Advisory Committee has been kept appraised of the WQP's progress through informational segments at their regularly scheduled meetings.

Stakeholder involvement in CALFED water quality activities is planned to continue throughout the life of the CALFED effort. A list of the Water Quality Technical Group stakeholders can be found in Appendix A.

Structure of Report

The Water Quality Technical Report that follows discusses:

- beneficial use water quality issues,
- water quality parameters of concern to beneficial water uses,
- sources and loadings of parameters of concern,
- water quality beneficial use problem areas,
- existing programs to address parameters,
- CALFED recommended action strategies to address parameters,
- a monitoring and assessment framework to evaluate effectiveness of the WQP,
- a description of how this program will be coordinated with ongoing watershed management activities.

Additional information pertaining to the Water Quality Program can be found in the Water Quality Technical Report Appendices and the CALFED Water Quality Supplemental Information document.

SECTION 2

BACKGROUND

The Central Valley is drained by the Sacramento River system to the north and the San Joaquin River system to the south. These two river systems converge into the Delta, which encompasses approximately 680,000 acres interlaced with approximately 700 miles of waterways (Arthur and Ball, 1978). Water flows from the Delta through the Suisun, San Pablo, and San Francisco Bays to the Pacific Ocean at the Golden Gate Bridge.

The Delta supports a variety of beneficial water uses. It is the West Coast's largest estuary, one of the country's largest systems for fish production, and provides habitat for more than 120 fish species. An estimated 25 percent of all warm water and anadromous sport fishing species and 80 percent of the state's commercial fishery species either live in or migrate through the Delta. The Delta also is a source of drinking water for about 20 million, or two-thirds, of all Californians. It provides irrigation water for approximately 200 crops or 45% of the nation's produce and water supplies to major oil refineries and paper manaufacturers. The Delta supports about 12 million public user days a year through a variety of recreational opportunities including fishing, camping, and boating by 82,000 registered boaters.

Water flowing through the Delta that is not diverted by drinking water suppliers, agriculture or industries flows to the Pacific Ocean through San Francisco Bay. Freshwater outflows prevent saline water from encroaching into the Delta and degrading water quality. Delta channel geometry, inflows into and within the Delta, and tidal flows are interdependent variables that control seawater intrusion and water quality in the Delta.

Variable hydrologic conditions, seasonal demands for water diversions, and agricultural drainage flows result in considerable fluctuations in Delta water supply and water quality conditions. Periods of high inflows that result in low salinity alternate with periods of low inflow that allow greater salinity intrusion and exaggerate water quality effects of drainage. In the Delta, the distribution of dissolved and suspended materials is influenced by complex circulation patterns that are affected by channel geometry, flow volumes, pumping for Delta agricultural operations and exports, and tidal influence from the ocean. Under average hydrologic conditions, approximately 30% of Delta inflow is used for Central Valley Project (CVP) and State Water Project (SWP) exports, 10% is diverted for local uses, 20% is used for Delta outflow requirements, and 40% is additional Delta outflow that results from winter precipitation and runoff. The CVP and SWP export pumping plants exert a considerable influence on water circulation in the Delta by creating a net flow of water from northern regions of the Delta south through Old River and Middle River. During winter, inflow volumes typically exceed the export and other requirements and the Delta outflow is sufficient to repel the force of tidal encroachment. During late summer and fall, when low inflows and high agricultural pumping rates are occurring, flows can reverse direction in the central and western Delta channels. This pattern of "reverse flow" is a concern because of the potential effects on salinity.

Delta water quality, particularly the concentration of pollutants, is strongly influenced by the operation of upstream reservoirs and diversions, including the CVP and SWP. On average, approximately 75-85% of Delta inflow is from the Sacramento River, 10-15% is from the San Joaquin River, and the eastside streams (e.g., Mokelumne, Cosumnes, and Calaveras) contribute the remainder. San Joaquin River flows are often very low in late summer and fall. In contrast, the Sacramento River, the largest tributary to the Delta, has relatively good water quality because of the large amount of dilution provided by runoff from the watershed and releases from storage reservoirs. Chemical characteristics of Delta inflows are intimately tied to land use in the upstream watershed.

Water Quality Issues

Following are some of the major water quality issues recognized to be of concern in the Delta along with water quality concerns associated with particular beneficial uses.

- High-salinity water from Suisun and San Francisco Bays intrudes into the Delta during periods of low Delta outflow. Salinity adversely affects agricultural, municipal, recreational, industrial, and environmental use of water.

- Delta exports have elevated concentrations of dissolved organic carbon (DOC) which is a disinfection by-product (DBP) precursors, and the potential for formation of brominated DBPs increases along with increases in concentrations of the precursor bromide (Br^-), which originates in seawater.

- Synthetic and natural contaminants have accumulated in Delta sediments and can bioaccumulate in fish and other aquatic organisms. Synthetic organic chemicals and heavy metals (e.g., mercury) are found in Delta fish in quantities that occasionally exceed acceptable standards for food consumption.

- Agricultural drainage in the Delta contains high levels of nutrients, suspended solids, dissolved organic carbon, salinity, and may contain traces of agricultural chemicals (pesticides). The San Joaquin River delivers water of relatively poor quality to the Delta; agricultural drainage to the river is a significant source of salts and pollutants, including selenium, boron, and pesticides.

- Historical mining activities are a source of heavy metals, including cadmium, chromium, copper, mercury, and zinc.

- Populations of striped bass and other species have declined significantly from historical levels. Causes of the declines are uncertain, although water quality conditions in the Bay and Delta (e.g., toxicity), decreases in Delta inflow and outflow rates, habitat loss, agricultural and other instream diversions, and in Delta exports are thought to be contributing factors.

- The location of the estuarine salinity gradient and its associated "entrapment zone" (where biological productivity is relatively high because of the mixing and accumulation of suspended materials) is controlled by Delta outflow. The location of the entrapment zone affects the quantity and quality of habitat for estuarine species.

Drinking Water. Beneficial use of drinking water can be impacted by loadings of bromide, nutrients, salinity, organic carbon, turbidity, pathogens or changes in pH. Pathogens such as *Cryptosporidium parvum* in source water can adversely affect municipal drinking water supplies. Nutrient loading, and subsequent algae blooms, can impair the taste and odor of municipal water supplies and increase the expense of treating the water. Elevated turbidity due to suspended solids can be responsible for increasing treatment costs for municipal water supplies.

A major problem during periods of low Delta outflows is tidal mixing of salt into the Delta channels. Salts are a major concern with regard to municipal drinking water supplies because of the presence in sea water of bromide, which contributes to unwanted disinfection byproducts (DBPs). Salt can result salty taste, corrosion of appliances, plumbing and industrial facilities, and reduced opportunity for waste water recycling. Salts also are present in freshwater inflows to the Delta due to municipal and agricultural discharges. The most heavily concentrated sources of agricultural drainage to the Delta is the San Joaquin River.

Organic carbon in source water can adversely affect municipal drinking water supplies by combining with water treatment disinfectants to produce harmful by-products (e.g., trihalomethanes). Agricultural drainage is of particular concern to drinking water because the peat soils of the Delta contribute organic carbon to the agricultural drainage water. Delta diversions through the State Water Project H.O. Banks and North Bay Pumping Plants, the Central Valley Project Tracy Pumping Plant, and the Contra Costa Water District Pumping Plant at Rock Slough supply water for municipal purposes. Figure 2-1 depicts the interaction between sources of bromides, organic carbon and salinity and municipal water intakes.

Agriculture. Beneficial uses of water by agriculture can be impacted by loadings of boron, salts, nutrients, pH, sodium absorption ratios, and turbidity. Excess salts can result in plant toxicity and negative effects on plant growth and crop yield. Salts affect the ability of a plant to absorb water. Salts coupled with a disproportionate amount of sodium in the water can cause the soil surface to seal, limiting water infiltration. Excessive vegetative growth or delayed crop maturity can result from excessive nutrients and white deposits on fruit or leaves can occur due to sprinkling with high pH water. Turbidity and nutrients can foul irrigation systems. More than 1,800 agricultural diversion are located within the Delta. These diversions are shown in Figure 2-2. Irrigation water destined for use on millions of acres in the San Joaquin Valley and Southern California is diverted through the Harvey O. Banks and Tracy Pumping Plants.

Environment. Beneficial uses of water for environmental purposes, specifically fishery resources, have been impacted due to toxic pollutants such as trace metals and synthetic organic compounds. Also, nutrients, pathogens, pH, dissolved oxygen and temperature have the potential to affect Delta species. Populations of striped bass and other species have declined significantly from historical levels. Causes of the declines are uncertain, although water quality conditions in the Bay and Delta, decreases in Delta inflow and outflow rates, habitat loss, agricultural and other instream diversions, and in-Delta exports are thought to be contributing factors. Metals, pesticides, salts, and ammonia in elevated concentrations can be toxic to early life stages of fish and invertebrate species. Mercury can bioaccumulate in the upper levels of the food chain, affecting larger fish, birds and mammals. Pathogens can adversely affect fish either acutely (lethality) or chronically (histopathological effects, impaired reproduction). Solids can increase turbidity in water bodies, reducing photosynthesis and available food for fish. Solids can also cause siltation of water bodies, burying and ruining spawning gravels that are essential fish reproduction habitat. Nutrient loading can lead to direct or indirect (abnormal algae blooms) depletion of dissolved oxygen in water bodies, which can suffocate aquatic organisms, and lead to observable fish kills. Nutrient limitations may at times limit food availability to aquatic species.

Recreation. Recreational beneficial uses in the Delta may be affected due to pathogens, metals, pesticides, solids, or nutrients. Microbial pathogens can adversely affect the health of those who are participating in water contact recreation, such as swimming, water skiing, or windsurfing. Pathogen contamination of fish or shellfish can adversely affect public health. Certain metals and pesticides, such as mercury and DDT, bioaccumulate in the food chain and can adversely affect recreational fishers who consume contaminated fish and shellfish. Solids loading can increase the turbidity of waters and interfere with the aesthetic enjoyment of these natural resources and constitute a hazard to swimmers. Solids loading is also a mechanism by which pathogens, metals, pesticides, and nutrients are transported into waters that support recreational beneficial uses. Nutrient loading can promote algal blooms that reduce water clarity and sometimes cause unsightly, odorous floating mats and fouling of boat hulls.

Industrial. Industrial beneficial uses of water may be impaired due to salinity, phosphates, ammonia. Salinity has adversely affected industrial processes such as paper manufacturing through corrosion and mineral scaling of industrial equipment. For refineries, a major user of industrial water, high concentrations of phosphates can aggravate scaling concerns in cooling water systems and high levels of ammonia can cause cracking in brass cooling heat exchangers. Industrial water is diverted and conveyed through the same facilities used for municipal purposes, however for many industrial purposes water is diverted and conveyed to the industrial facility prior to treatment for municipal use purposes. Industrial facilities treat raw water to the water quality required for their industrial process.

SECTION 3

PARAMETERS OF CONCERN

Parameters identified by the Water Quality Technical Group as of concern to beneficial uses of water are identified in Table 3.1. This list of parameters may change over time in response to additional knowledge and understanding of these and other parameters.

Table 3.1 Water Quality Parameters of Concern to Beneficial Uses

ENVIRONMENT	URBAN	AGRICULTURE	RECREATION	INDUSTRIAL
Metals&Toxic Elements	**Disinfection By-Product Precursors**	**Other**	**Metals**	**Other**
Cadmium	Bromide	Boron	Mercury	Salinity
Copper	TOC	Chloride	**Organics/Pesticides**	pH
Mercury	**Other**	Nutrients (Nitrate)	PCBs	Alkalinity
Selenium	Pathogens	pH (Alkalinity)	DDT	Phosphates
Zinc	Turbidity	Salinity (TDS, EC)	**Other**	Ammonia
Organics/Pesticides	Salinity (TDS)	SAR	Pathogens	
Carbofuran	Nutrients (Nitrate)	Turbidity	Nutrients	
Chlordane	pH	Temperature		
Chlorpyrifos				
DDT				
Diazinon				
PCBs				
Toxaphene				
Other				
Ammonia				
Dissolved Oxygen				
Salinity (TDS, EC)				
Temperature				
Turbidity				
Unknown Toxicity*				

* Unknown toxicity refers to observed aquatic toxicity, the source of which is unknown.

Following is a description of the parameters of concern. More detailed information on measured concentrations of parameters (water column, sediment and tissue) throughout the water quality problem area will be available in the CALFED Water Quality Affected Environment Report. Problems associated with the parameters are described in Section 6.

General Parameter Description

Metals & Toxic Elements

Heavy metals originate primarily from rocks and minerals, mining activities, and discharges of municipal and industrial wastes. Residues from heavy metals may produce serious pollution problems in the Delta because of toxic effects on fish and other aquatic organisms and may bioaccumulate in biological tissues. These residues can be measured in water, soils, sediments, and organisms that inhabit Delta channels. The detection of a particular compound depends on its persistence and mobility in the environment, as well as its source characteristics. SWRCB has characterized cadmium, copper, mercury, and zinc as pollutants of concern because their widespread or repeated detection indicates their potential to cause adverse effects on beneficial uses in the estuary (California State Water Resources Control Board 1990).

Cadmium, Copper and Zinc. The Delta receives the majority of its metals loadings from historical mining activities in upstream watersheds. The sources of mining wastes along Spring Creek in the upper Sacramento River watershed contribute large loads of chromium, cadmium, copper, nickel, and zinc to the upper Sacramento River (California Department of Water Resources 1994a). The Iron Mountain Mine, in particular, contributes most of the cadmium, copper, and zinc transported in the Sacramento River. Urban and industrial runoff can also contribute significant loadings of copper and zinc. Urban runoff in the Central Valley and the Bay Area has exhibited toxicity to the test algal organism, Selanastrum. TIE studies with this species identified copper, zinc, and the herbicide diuron as causing toxicity.

Mercury. Large amounts of mercury were used in the processing of gold, and river flows originating in historic gold-mining areas continue to contribute mercury to Delta waterways. Natural deposits of mercury that were mined in the Cache Creek basin are suspected to contribute high loadings of mercury to Delta waters.

Mercury is of concern from an environmental and human health perspective. During a peak storm period in 1995, mercury levels at the Creek's outfall at the Yolo Bypass were measured at 695 parts per trillion. (Pers.conv. Bill Croyle, CVRWQCB). The EPA water quality criteria is 12 parts per trillion total mercury. SWRCB biennial water quality assessments list 48,000 acres of Delta waterways as impaired because of fish consumption advisories for mercury (California State Water Resources Control Board 1992, 1994). A health advisory for the consumption of striped bass from the Delta because of elevated levels of mercury in fish tissues has been in effect since the mid-1970s.

Selenium. Selenium is an inorganic constituent of soils found in alluvium derived from rocks that originate on the ocean floor. It is particularly evident in the soils of the west side of the San Joaquin River basin. Relative to irrigation water, salts containing selenium tend to concentrate by 2-5 times in agricultural drainage. Selenium is leached out of soils as a result of irrigation and concentrates further when drainage return flows are stored in surface impoundments for long periods, or when irrigated land is inadequately drained.

Selenium is primarily an environmental concern. In 1983, high rates of waterfowl death and deformity were observed in Kesterson National Wildlife Refuge and were attributed to toxic concentrations of selenium in concentrated agricultural drainage. There is continued concern over San Joaquin River selenium transport from irrigated farm lands and industrial discharges of selenium into the Delta.

Organics/Pesticides

Residues from organic pesticides and herbicides may produce serious pollution problems in the Delta because of toxic effects on fish and other aquatic organisms and may bioaccumulate in biological tissues. Similar to heavy metals, organic pesticides are detected in a variety of sample types, depending on the persistence and mobility of the particular compound. SWRCB biennial water quality assessments list Delta waterways as impaired because of elevated levels of pesticides (California State Water Resources Control Board 1992, 1994). Most parameter concentrations in fish do not exceed standards established by the U.S. Food and Drug Administration or the National Academy of Sciences for the consumption of fish tissues. The presence of pollutants in fish demonstrates, however, that organic pesticides are bioaccumulating in the Delta food webs.

Chlorpyrifos and Diazinon. Although pesticides are rarely detected in Delta water samples, data from various monitoring programs conducted by DWR and SWRCB have shown that contamination by synthetic organic chemicals is prevalent in sediment and organisms collected throughout the Delta. The Toxic Substances Monitoring Program has routinely detected chlorinated pesticides (e.g., DDT, toxaphene, and chlordane), the pesticides most resistant to chemical breakdown, in Delta sediments and biological tissue samples. Levels of these pesticides exceed identified thresholds for risk to humans, wildlife, or the biological receptors that come in contact with the pollutants (California State Water Resources Control Board 1995b).

Toxicity Identification Evaluation (TIE) studies of urban runoff have linked observed toxicity with the presence of Chlorpyrifos and Diazinon. Urban runoff in the Central Valley and the Bay Area has exhibited acute toxicity to the test organism, Ceriodaphnia. Both of these pesticides are widely available and have been detected simultaneously in urban creeks throughout the CALFED problem and solution areas. They are found in urban creeks throughout the year, but concentrations peak during the orchard dormant spray season (Foe, 1995). Ambient monitoring and composite rainfall samples suggest that the pesticides come from both urban and agricultural sources.

Other

Boron. Boron is essential in small quantities for optimum plant growth, however, minimal exceedance of the desirable limit can result in plant toxicity problems, manifested as drying and chlorosis. Climatic and soil conditions also influence boron toxicity, with boron uptake being generally higher at lower soil pH. Sensitive crops have shown toxic effects at and below 1 mg/L (Ayers and Westcot, 1985). Exceeding this limit can result in significant loss in crop yield. Boron concentrations can be reduced by various management practices similar to those for chloride. Reclaiming boron-affected soils requires leaching the boron from the root zone.

Because boron mobility is reduced by adsorption on soil particles, removing it from the soil profile requires approximately two to three times mor leaching water than is typically required for reclaiming saline soils (Hanson, 1993). Surface waters do not usually contain boron at toxic levels. Groundwater from wells or springs can contain toxic levels, especially near geothermal areas and earthquake faults. Some areas near the Delta are underlain by groundwater with high levels of boron. The average concentration in seawater is reported as 4.5 mg/L in the form of borate (EPA, 1976).

Chloride. For agriculture the most common toxic ion encountered in irrigation water supplies is chloride. Chloride is adsorbed (or retained) only slightly on soil particles. It therefore moves readily with the soil water and is taken up by the crop, accumulating in the leaves during transpiration. At toxic levels, injury symptoms develop such as leaf burning and desiccation. Continued uptake can lead to dead tissue and is often accompanied by early leaf drop or defoliation. Uptake of chloride depends on the relationship between the ability of the crop to exclude chloride, and concentrations in the soil water. Soil-water concentrations are controlled by concentrations in irrigation water and the amount of leaching that occurs. Crop tolerance of chloride is not as well documented as crop tolerance of salinity, and quantitative yield reduction relationships have not been defined. However, in general, woody plants, such as California's fruit and nut crops, tend to be more sensitive to chloride. Crops grown under overhead sprinkler irrigation can take up chloride through foliar adsorption of irrigation water into leaves during and after irrigation events. Management for chloride includes leaching in a manner similar to salinity, more frequent irrigation, selection of more tolerant crops and blending or switching to alternative water supplies. Where foliar absorption is a problem, certain management practices have been successful in minimizing effects. Some practices may require minor changes in management, while others will require more elaborate and costly changes. Some of these practices include scheduling irrigation at night, avoiding irrigation during high winds, increasing sprinkler rotation speeds, increasing application rates and increasing droplet size. (For more information on Chloride see Disinfection By-Products).

Disinfection Byproducts in Treated Drinking Water. THM compounds formed during chlorination of DOC in drinking water contain chloroform and brominated methanes. Chloroform, when administered at high doses, has been shown to increase the risk of liver and kidney cancer in mice (National Cancer Institute 1976). The suspected carcinogenic risk to humans from THMs has led some communities to study and change their methods of disinfecting drinking water. THM levels in drinking water can be reduced by using alternatives to chlorination to treat water for human consumption (e.g., ozonation or chloramination), although other potentially harmful DBP compounds (e.g., bromate) may be formed during these disinfection processes. Disinfection itself is being more carefully regulated by EPA to avoid problems involving various pathogens (e.g., bacteria, viruses, and protozoa). Reducing DOC concentrations in raw water before disinfection with flocculation or granular-activated carbon adsorption or removal of DBPs after being formed can reduce DBP levels but may be quite expensive.

Chloride and Bromide. Most of the Delta islands are as much as 10 to 15 feet below mean tide level. Tides in the Delta not only threaten the protecting levees, but bring periodic intrusion of seawater, which mixes with the inflowing Delta freshwater. Tidal currents created by the rise and fall of sea levels modify stream flow, particularly when outflows are low or when tides are high (DWR, IDHAMP, 1989). Intruded seawater is a major source of bromide, particularly in the western Delta. Bromide is a naturally occurring salt ion (halogen) of seawater origin and reacts with disinfectants to form brominated DBPs. Thus, intrusion profoundly affects Delta water withdrawn at the Contra Costa Water District, SWP and CVP intakes.

The presence of bromide in a drinking water source complicates the disinfection process. As with chlorine, bromide forms THMs in the chlorination process and these brominated THM's are also toxic to human health. Bromide is about twice as heavy as chlorine, and the THM standard is based on weight. Hence, it takes fewer molecules of brominated THMs to exceed the drinking water standard. Another method of disinfection, ozone treatment, is also complicated by the presence of bromide because it forms bromate, another undesirable DBP. Bromide contributes substantially to the formation of DBPs in treated drinking water from the Delta. Sources of Br^- in Delta water are seawater intrusion, San Joaquin River inflow containing agricultural drainage, and possibly connate groundwater (i.e., water trapped within sedimentary rocks that is often highly mineralized). It is uncertain whether there are native bromide sources in the San Joaquin Valley, or whether bromide found in the River is a result of concentration of bromides in agricultural irrigation water taken from the Delta and returned to the Delta through the River. Bromide has been measured by the MWQI program since January 1990.

Total and Dissolved Organic Carbon. Organic materials enter the water from the following sources in the Delta in decreasing order of amounts:

- natural materials, vegetation, and organics soils;
- agriculture, as vegetative organics in drainage;
- urban runoff;
- municipal and industrial wastewater discharges;
- pesticides and herbicides.

Organic carbon is one of the primary variables that influence the potential for DBP formation. Applicable drinking water standards are based on TOC concentrations; however, most of the available data for the Delta have focused on DOC. In general, most TOC in Delta waters is present in the dissolved form. The most common DBP is THM compounds formed during chlorination of DOC in drinking water supplies. These carcinogenic substances include chloroform and bromoform. MWQI studies have documented that Delta exports contain relatively high concentrations of DOC. Agricultural drainage discharges that contain natural organic matter from decomposing peat soil and crop residues are the major source of DOC in the Delta (California Department of Water Resources 1994b). Additionally, DOC is carried into the Delta from upstream inflows. Minimizing DOC concentrations in source waters is a major water quality goal for drinking water uses to meet new EPA regulations for DBPs. Utilities must undertake studies to control organic carbon in their source water if TOC exceeds 2 mg/l at the water intake.

Dissolved Oxygen. Dissolved oxygen (DO) concentrations serve as indicators of the balance between sources of oxygen (e.g., aeration and photosynthesis) and oxygen consumption (through decay and respiration processes). The capacity of water to dissolve oxygen decreases with increasing temperature and often varies with the cycle of daily photosynthetic activity of algae and plants. DO concentrations in Delta channels are not generally considered a problem, except in the waterways around Stockton and in some dead-end sloughs.

Nutrients. Nitrogen and phosphorous are the two nutrients which most often limit algal growth at low concentrations and trigger algal growth at elevated concentrations. Generally, in the presence of sufficient light and elevated temperatures, as nutrient concentrations increase algal productivity increases. A self perpetuating cycle of nutrient enrichment, plant growth, accumulation of muck, oxygen depletion, and nutrient recycling from the sediment follows. Eventually , the rate of oxygen consumption can exceed the rate of absorption, resulting in, blue-green algae blooms, odors, and eventually the death of fish and aquatic life. Drinking water taste and odor problems can occur from algae decomposition.

For agriculture excessive nutrients can result in excess vegetative growth, reduced yields, delayed or uneven maturity, or reduced quality. Algal growth stimulated by excess nutrients can increase facilities maintenance costs. In extreme cases, irrigation equipment for sprinkle and drip irrigation can plug, increasing maintenance costs. Sensitive crops may require an alternative or blended water supply, or may not be grown. Alternative, more tolerant crops can be grown, but other water quality parameters, land suitability and market conditions dictate crop selection.

Pathogens. Microbiological organisms of principal concern as agents of disease or indicators of potential contamination in drinking water include coliform bacteria, viruses and protozoan and helminth parasites. Total coliform bacteria measurements indicate the general level of urban and animal contamination of a water supply. Microbial agents have been responsible for waterborne outbreaks of infectious disease. Their presence in raw waters has been a principal thrust of water treatment technology. Waterborne diseases still occur in the United States. The Center for Disease Control (CDC) and EPA have estimated 1 million cases of illness per year and 1000 deaths per year due to waterborne diseases.

Principal waterborne bacterial agents that cause human intestinal disease are summarized in Table 3.2. Rather than attempt to analyze each of these pathogenic bacteria, water utilities routinely monitor for total and fecal coliform bacteria, an indicator organism. With few exceptions, these organisms, which originate in the intestinal tract of warm-blooded animals and other sources, are not pathogenic. Because coliforms are more abundant than pathogens in human waste by several orders of magnitude, the tests provide a margin of safety against pathogens. If coliforms are not detected, it is assumed that bacterial pathogens would not be likely to be present, or at least they are likely to be below the levels known to infect. Although the tests have limitations, they are still the most widely used indicators of bacterial water quality.

Viruses. In contrast to bacteria, enteric viruses are always assumed to be pathogenic. The prevailing theory is that only one infective unit (which may be as low as one virus) can cause infection. Because clinical symptoms do not always result from infections, because it is difficult to link infections to a waterborne source, because there are difficulties in detecting viruses, and because people are exposed to viruses from many sources, the extent of waterborne diseases due to viruses is not well quantified. The CDC estimates that of the 1 million of cases per year of illness from waterborne microorganisms, perhaps more than 50 percent are viral. Viruses of concern in drinking water are listed in Table 3.3. The enteroviruses (polio, Coxsackie A, Coxsackie B, and echoviruses), adenoviruses, reoviruses, the hepatitis viruses, and rotavirus can be detected by laboratory cell culture techniques.

Table 3.2 PRINCIPAL WATERBORNE BACTERIAL AGENTS AND ASSOCIATED HEALTH EFFECTS

Bacteria	Disease
Salmonella typhi	Typhoid fever
Salmonella paratyphi-A	Paratyphoid fever
Salmonella (other species)	Salmonellosis, enteric fever
Shigella dysenteriae, S. flexneri, and *S. sonnei*	Bacillary dysentery
Vibrio cholerae	Cholera
Leptospira sp.	Leptospirosis
Yersinia enterocolitica	Gastroenteritis
Francisella tularensis	Tularemia
Escherischia coli (specific enteropathogenic strains)	Gastroenteritis
Pseudomonas aeroginosa	Various infections
Enterobacteriacae (Edwardsiella, Proteus, Serratia, Bacillus)	Gastroenteritis
Campylobacter	Gastroenteritis

Table 3.3 ENTERIC VIRUSES AND THEIR ASSOCIATED DISEASES

Virus Group	Number of Types	Common Disease Syndromes
Enteroviruses		
Polioviruses	3	Poliomyelitis, aseptic meningitis
Coxsackieviruses A	23	Herpangina, asepticmeningitis, exanthem
Coxsackieviruses B	6	Aseptic meningitis, epidemic myalgia, myocarditis, pericarditis
Echoviruses	31	Aseptic meningitis, exanthem, gastroenteritis
Adenoviruses	31	Upper respiratory illness, pharyngitis, conjunctivitis
Reoviruses	3	Upper respiratory illness, diarrhea, exanthem
Hepatitis viruses		
Hepatitis A Virus	1	Viral hepatitis type A or infectious hepatitis
Hepatitis B Virus	4	Viral hepatitis type B or serum hepatitis
Rotavirus	2	Gastroenteritis
Norwalk agent	1	Gastroenteritis

Parasites. Eggs and cysts of parasitic protozoa and helminths (worms) excreted into the environment may enter water supplies. All can severely disrupt the intestinal tract. Two of these are *Giardia lamblia* and *Cryptosporidium parvum*. Their cysts/oocysts are far more resistant to disinfectants than bacteria or most viruses.

Giardia lamblia. *Giardia lamblia*, the intestinal protozoan most frequently found in human populations worldwide, is the most commonly identified agent of water-borne diseases in the United States (Feachem, et al., 1983). Waterborne giardiasis may be increasing in the U.S. with 95 outbreaks over the last 25 years. Over 60 percent of all *Giardia lamblia* infections are believed to be acquired from contaminated water. *Giardia lamblia* cysts are found in water contaminated by fecal material from infected humans and animals. *Giardia lamblia* forms an environmentally resistant cyst that allows the parasite to survive in surface water and treated drinking water.

Ingestion of as few as 10 cysts can cause infection (Rendtorff and Holt, 1954). Infection was measured by the excretion of cysts, and illness was not determined. The ratio of illness to infection is highly variable. *Giardia lamblia* infections with no symptoms of illness may be as high as 39 percent for children under 5 years old and 76 percent for adults in certain populations (Craft, 1981; and Wolf, 1979; as reported in Rose, et al., 1991). At the same time, symptomatic infections have been reported at a rate of 50 to 67 percent and as high as 91 percent in others (Veazie, et al., 1979, as reported in Rose, et al., 1991). In yet other groups, chronic giardiasis may develop in as many as 58 percent of an infected population.

Cryptosporidium parvum. *Cryptosporidium parvum*, an intestinal protozoan parasite, was first identified in 1907, but has been recognized to cause diarrheal disease in humans only since 1980. The first documented waterborne outbreak of cryptosporidiosis in humans occurred in the U.S. in 1985. In January 1988, EPA added *Cryptosporidium parvum* to the Drinking Water Priority List. The severe gastro-intestinal symptoms of the disease last an average of 12 days, and are self-limiting in people with normal immune function. Illness patterns vary with age, immune status, and variations in the virulence of *Cryptosporidium parvum*. Young mammals are more susceptible. For AIDS and cancer patients, cryptosporidiosis can cause mortality. The oocyst (infective stage) dose necessary to cause an infection in humans is unknown, but may be low; in a primate study, two individuals became infected after exposure to only 10 oocysts (Miller, et al. 1986). No effective treatment for the disease exists. *Cryptosporidium parvum* is transmitted between humans and warm-blooded animals, including cats, dogs, cattle, goats, mice, pigs, rats, and sheep (Fayer and Ungar, 1986, as reported in Rose, 1991). *Cryptosporidium parvum* from birds will not infect mammals, however. Common sources of *Cryptosporidium parvum* in water are wildlife in a watershed, sewage discharges, and domestic animals (including runoff from grazing lands and dairies). For example, surface water running through cattle pastures can contain up to 6,000 oocysts per liter (Madore, et al., as reported in Peeters, et al., 1989).

Cryptosporidium parvum in drinking water strongly resists chlorine disinfection. In addition, *Cryptosporidium parvum* levels do not correlate well with indicator coliform bacteria levels, so meeting standards for coliforms and turbidity (a measure of the reduction of clarity of a water by suspended particles) may not be a sufficient measure of treatment reliability for removal of *Cryptosporidium parvum*. Normal levels of chlorine in drinking water have been shown to be ineffective for inactivating *Cryptosporidium parvum*, even after 18 hours of contact. However, ozone and chlorine dioxide have been found to be more effective disinfectants (Peeters et al., 1989). Sand filtration alone reduces but does not completely eliminate oocyst concentrations. Filtration with coagulation achieves greater removals.

pH. The formation of DBPs in drinking water is dependent a variety of parameters, one of which is pH. pH of source water can affect the effectiveness of drinking water treatment technologies. For agriculture pH problems are related to potential corrosion or plugging of irrigation equipment (such as aluminum pipe and drip emitters) and precipitation of residues on plants (such as cut flowers in greenhouses). Nutritional imbalance can be caused by irrigation water with a pH outside of the normal range.

Sodium Absorption Ratio (SAR). SAR is of concern to agricultural beneficial uses. Sodium hazards in irrigation and soil waters can impair crop production. Unlike salinity, excessive sodium does not curtail the uptake of water by plants, but rather destroys soil structure and reduces the infiltration of water into the soil. Thus, plant growth can be affected by drought stress and lack of aeration. When calcium and magnesium are the predominant cations absorbed on soil particles, the soil tends to have a granular structure that is easily tilled and readily permeable. Unbalanced by other cations, large amounts of sodium can disperse soil particles, so that soil structure breaks down and hydraulic conductivity decreases. Good soil structure and adequate drainage are essential for sustainable soil and salinity management. Additional agronomic issues arising from excess sodium include soil crusting (especially over seedbeds), temporary saturation of the soil surface layer, and/or related disease, weed, root-respiratory, and nutritional problems. In extreme cases and for sensitive plants, sodium ions can be phytotoxic, much in the same manner as chloride. Management of sodium by leaching alone can be impractical because of problems with soil aeration and drainage. Sodium is generally managed by replacement with calcium through the addition of gypsum, or sulfuric acid, which reacts with soil calcium carbonate, to liberate calcium. These treatments must be followed by leaching with water of acceptable quality. In general, the benefit of a water-applied amendment is much greater when the irrigation water salinity is relatively low. The primary sources of sodium are seawater and agricultural drainage. SAR can affect crop yields and sensitive crops such as orchards and beans. It is a particular issue in the western and interior Delta.

Salinity. Salinity in of concern to municipal users because (1) bromide, a component of saline water, forms DBP precursors (bromide and total organic carbon); (2) there is a need for low salinity supplies to assure the feasibility of local wastewater reclamation and conjunctive use projects, (3) there is a need for low salinity supplies to minimize and retard the corrosion of infrastructure and appliances, (4) there is a need for low salinity supplies to improve the aesthetics of drinking water. Salinity is of concern to agricultural users because of potential plant toxicity problems. (California Urban Water Agencies (CUWA)/CALFED, 1996).

Sources of marine water include salt water intrusion into the Delta from San Francisco Bay and connate groundwater. The magnitude of saline water intrusion is influenced by Delta outflow, which defines the upstream boundary of the salinity wedge. Seawater is the primary source of salinity. Agricultural drainage from the Delta, upstream agricultural drainage from sources on the Sacramento and San Joaquin rivers, and urban runoff may also affect salinity concentrations. Urban runoff consists of dissolved minerals, whereas agricultural drainage is made up of soluble salts from irrigation water leached from the soils (CUWA, 1995).

Electrical Conductivity (EC), more correctly known as specific conductance, is the most common general measure of dissolved minerals in Delta waters. EC is generally considered a conservative parameter, not subject to sources or losses internal to a water body. Therefore, changes in EC values can be used to interpret the movement of water and the mixing of salts in the Delta. EC values increase with concentration, decrease with dilution, and may be elevated in agricultural drainage discharges and areas affected by seawater.

For agriculture, irrigation water quality affects the amount and type of salts found in soil. When water is applied as irrigation, crop uptake and evaporation remove pure water with some dissolved salts, particularly nutrient salts. However, most of the water's salt load remains in the crops root zone after uptake of water by roots. When water does not leach from the soil, but is only added to meet crop needs, the soil accumulates residual salt over time. If the frequency of leaching is too low, then salt concentrations may reach levels that stress growing plants. In general, salt influences plant growth by depriving the roots of water. Water uptake by plants is driven by differences in water content and salt concentration between the root interior and the soil. When the salt concentration of the soil increases, plants must accumulate salt themselves, or must dehydrate to continue to extract water from the soil.

Plants vary in their ability to adapt to saline conditions by these and other mechanisms; and therefore, vary in their ability to tolerate saline conditions. Even tolerant plants, though they survive, may not produce as much when grown under saline conditions. This is because extraction of water from saline soil requires more plant energy, which might otherwise be allocated for plant growth and metabolism. In addition to crop water uptake, salinity can affect agronomic system in other ways (See sodium). The major objective in selecting management practices to control salinity is to maintain adequate soil water availability to the crop. Procedures that require relatively minor changes in management are more frequent irrigation events, selection of more salt-tolerant crops, additional leaching, pre-plant irrigation events, and altered seed placement. Alternative that may require significant changes in management are changing the irrigation method, altering the water supply, land-grading, modifying the soil profile (deep ripping), and installing artificial drainage. Management practices must fit the method of irrigation. After salinization, one study showed 10 to 15 percent salt removal by leaching that should theoretically remove 50 percent of accumulated salinity (Mass & Hoffman, 1983). Field realities may influence saline land management.

Temperature. Temperature governs rates of biochemical processes and is a major environmental factor in determining organism preferences and behavior. Water temperatures in the Delta are generally a function of the weather and runoff conditions. Delta temperatures are influenced only slightly by water management activities. The most common environmental impacts associated with water temperatures are localized effects caused by discharges at substantially elevated temperatures (e.g., thermal shock). Fish growth, activity, and mortality are related to their temperature tolerances. The Delta supports fish species, such as the Chinook salmon and striped bass, that require different warm- and coldwater habitat conditions.

For agriculture temperature of irrigation water has direct and indirect effects on plant growth. Each occurs when physiological functions are impaired by excessively high or excessively low temperatures. The direct effects on plant growth from extreme temperature of the irrigation water occurs when the water is first applied, and they are less pronounced with pressure irrigation systems than with surface irrigation systems. Indirect effects of the temperature of irrigation water on plant growth occur as a result of the water's influence on soil temperature. Temperature effects are primarily related to rice seedling emergence and crop development. Rice production is concentrated in the northern San Joaquin and southern Sacramento valleys. When water is colder, irrigation facilities that spread water out for solar warming can be used, including shallow reservoirs and flooded fields. Some rice farms designate an upper part of the field for spreading and warming water, or else they accept lower productivity in parts of their farm that receive irrigation water directly from the canal.

Turbidity. Turbidity is a nonspecific measure of suspended matter such as clay, silt, organic particulates, plankton, and microorganisms. The presence of suspended solids (often measured as turbidity) is a general indicator of surface erosion and runoff into water bodies, resuspension of sediment materials, or biological productivity. Following major storms, water quality is often degraded by inorganic and organic solids and associated adsorbed contaminants (such as metals, nutrients, and agricultural chemicals) that are resuspended or introduced in runoff. Such runoff and resuspension episodes are relatively infrequent; persist for only a limited time; and, therefore, are not often detected in regular sampling programs. Large Delta inflows, sediment resuspension during dredging activities, agricultural drainage discharges, and suspended planktonic algae are the main causes of high SS concentrations.

The attenuation of light in Delta waters is controlled by SS concentrations (with some effects from chlorophyll). These concentrations are often elevated in the entrapment zone as a result of increased flocculation (i.e., aggregation of particles) in the estuarine salinity gradient. High winds and tidal currents also contribute to increased SS concentrations in the estuary. Suspended sediments tend to suppress algae growth in much of the Delta (California State Water Resources Control Board 1995a).

Turbidity is of concern in drinking water because it can render water aesthetically unacceptable to the consumer; reduce the efficiency of disinfection by shielding microorganisms; and act as a vehicle for the concentration, transport, and release of organic and inorganic toxicants, bacteria, and viruses.

From an agricultural perspective the effects of turbidity on plants and soils include the formation of crusts at the soil surface (inhibiting water infiltration and aeration, impeding seedling emergence, and hindering leaching of saline soils), and the formation of films on plant leaves (blocking sunlight and reducing photosynthesis and marketability). High colloidal content in water used for sprinkler irrigation can result in deposition of films on leafy vegetable crops such as lettuce, which affects marketability and management. Settleable matter in the water can prematurely decrease reservoir capacity, and increase maintenance requirements on delivery canals due to siltation. Turbidity also increases wear on pumping facilities. As agricultural lands in the Sacramento and San Joaquin valleys continue to be irrigated with low-volume irrigation systems like drip and micro-sprinkle, clogging, maintenance, and on-farm water management (filtration) requirements will need to be considered when selecting a new system or evaluating water supply. Filtration and maintenance requirements for turbid water for low-volume irrigation can be costly and may make the water unusable.

Data Available

Water quality and sediment data summary tables are located in Appendix B. The tables provide information on measured concentrations of water quality parameters at various locations in the Bay-Delta and Sacramento and San Joaquin Basins. The tables also detail discharge water quality data (where available), time of the study, study name, who study was prepared for and the date of the study. For this report data availability is summarized for informational purposes only. Data evaluation will be used more extensively as part of the EIR/EIS impact assessment process.

Target Ranges for Parameters

A frame of reference is required in order to understand the relevance of data regarding parameters of concern. For some parameters, particularly those affecting environmental beneficial uses, source water quality regulatory standards, objectives or criteria have been developed. In other cases, such as at municipal and agricultural water intakes, source water quality standards have not been developed. The Water Quality Technical group reviewed the existing regulatory requirements and the specific requirements of each beneficial use. Based on this review they recommended target ranges for each parameter of concern at critical locations throughout the CALFED water quality solution area. Table 3.4 summarizes the source water quality targets for each parameter of concern.

D-033621

SECTION 4

SOURCES AND LOADINGS OF PARAMETERS

Identifying the sources of a parameter is critical to developing action strategies to mitigate for problems caused by the parameter. Finding the source however, is only the first step in the process. Targeted action strategies must depend on understanding the relative importance of the source to the overall problem. Relative importance can only be understood if the forms of the parameter that impact benefical uses have been identified and the loadings of the critical forms, attributable to identified sources, have been calculated.

Sources of Parameters

Sources of water quality parameters of concern in the Delta and its tributaries include:

- acidic drainage from inactive and abandoned mines that introduce metals such as cadmium, copper, zinc, and mercury;
- stormwater inflows and urban runoff that may contribute metals, selenium, turbidity, pathogens, organic carbon, nutrients, pesticides, petroleum and other chemical residues;
- municipal and industrial discharges that may contribute salts, metals, trace elements, nutrients, pathogens, chemical residues, oil and grease, and turbidity;
- agricultural tail water, or return flows, that may contribute salts, nutrients, pesticide residues, pathogens, and turbidity; and,
- subsurface agricultural drainage that may contribute salts, selenium and other trace elements, nutrients, and pesticides (some fungicides).

Loadings of Parameters

Where information was available estimated loadings for parameters of concern were developed. These estimates are shown in Tables 4.1 to 4.10 . Source loadings of parameters are primarily due to either agricultural or mine drainage, wastewater/industrial discharges, urban/industrial runoff or flow regulation. These tables illustrate the relative loadings of parameters from four of the five CALFED study regions (e.g., Bay, Delta, San Joaquin, and Sacramento). Additional information that was used in compiling these tables can be found in Appendix C.

Table 4.1 Bromide Loadings

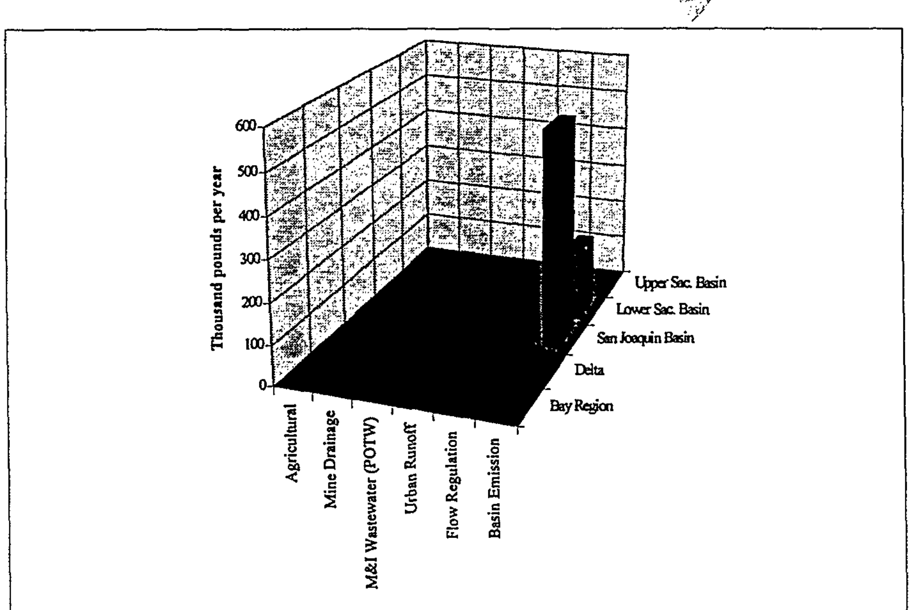
BROMIDE LOADING TABLE										
	Bromide Loading (pounds/year)									
Source	Bay Region	Note	Delta	Note	San Joaquin Basin	Note	Lower Sac. Basin	Note	Upper Sac. Basin	Note
Agricultural										
Mine Drainage										
M&I Wastewater (POTW)										
Urban Runoff										
Flow Regulation										
Total Load										
Basin Emission					535	*Com a&c*	172	*Com a&c*		

Note: Letters listed in italics under the Note column provide the background and references associated with the accompanying load

Data available; flow and concentration data available; load calculations required.

Further literature review required.

- Source does not contribute significant load of constituent in this watershed.



D-033623

D-033623

Table 4.2 Cadmium Loadings

CADMIUM LOADING TABLE										
	Cadmium Loading (pounds/year)									
Source	Delta	Note	Lower Sacramento Basin below dams	Note	San Joaquin Basin	Note	Bay Region	Note	Upper Sacramento Basin above Dams	Note
Agricultural			655	*d*						
Mine Drainage	36	*a*	96,000	*e*	36	*i*				
M&I Wastewater (POTW)	154	*b*	270	*f*	202	*j*	6394	*m*		
Urban Runoff	136	*c*	582	*g*	191	*k*	2535	*n*		
Flow Regulation										
Total Load	326		97,507		429		8929			
Basin Emission			11	*h*	2	*l*			200	o

Note: Letters listed in italics under the Note column provide the background and references associated with the accompanying load

Data available; flow and concentration data available; load calculations required

Further literature review required

- Source does not contribute significant load of constituent in this watershed

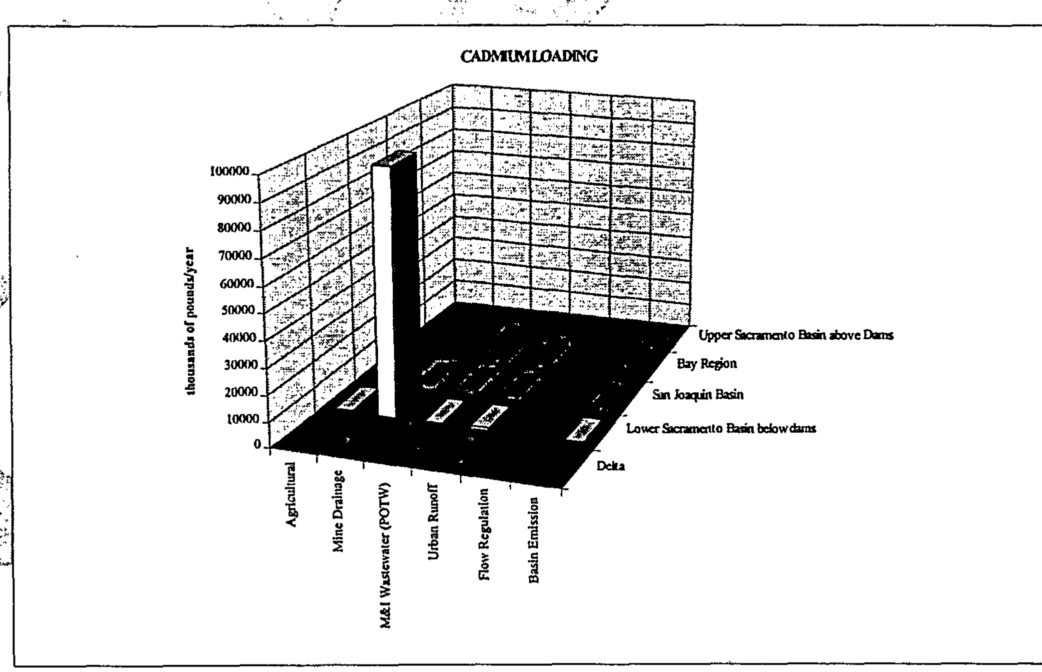


Table 4.3 Copper Loadings

COPPER LOADING TABLE										
	Copper Loading (thousands of pounds/year)									
Source	**Bay Region**	**Note**	**Delta**	**Note**	**San Joaquin Basin**	**Note**	**Lower Sacramento Basin below dams**	**Note**	**Upper Sacramento Basin above Dams**	**Note**
Agricultural							41	*e*		
Mine Drainage			4	*a*	4	*a*	274	*a*		
M&I Wastewater (POTW)	55	*g*	2	*b*			9	*b*		
Urban Runoff	73	*g*	6	*c*	9	*c*	24	*c*		
Flow Regulation										
Total Load	128		12		13		348			
Basin Emission				*d*	22	*Com a&b*	124	*Com a&b*	56	*h*

Note: Letters listed in italics under the Note column provide the background and references associated with the accompanying load

- (diagonal hatching) - Data available; flow and concentration data available; load calculations required.
- (vertical hatching) - Further literature review required.
- (dark shading) - Source does not contribute significant load of constituent in this watershed.

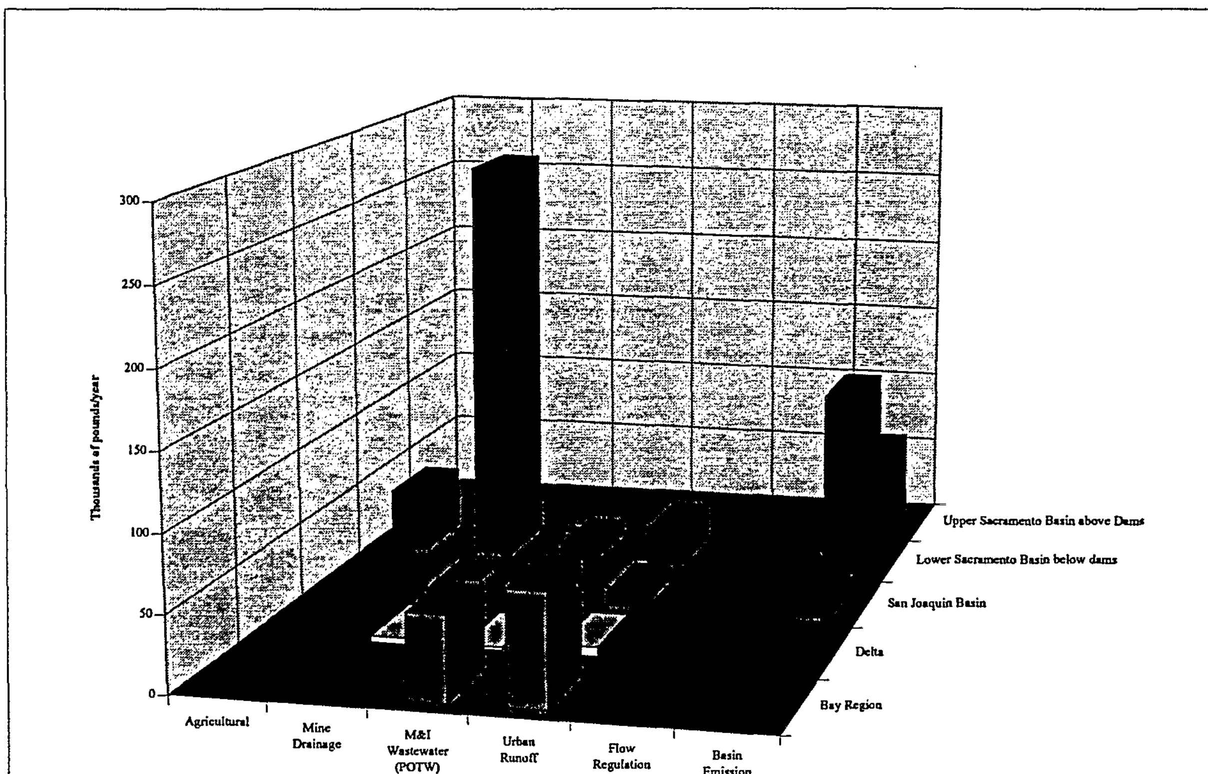


Table 4-4 Mercury Loadings

MERCURY LOADING TABLE										
	Mercury Loading (pounds/year)									
Source	**Delta**	**Note**	**Sacramento Basin**	**Note**	**San Joaquin Basin**	**Note**	**Bay Region**	**Note**	**Sacramento River above dams**	**Note**
Agricultural										
Mine Drainage										
M&I Wastewater (POTW)							1543	*a*		
Urban Runoff							330	*a*		
Flow Regulation										
Total Load							1873			
Basin Emission			2530	*Com a&b*	328	*Com a&b*			2500	*b*

Note: Letters listed in italics under the Note column provide the background and references associated with the accompanying load

- Data available; flow and concentration data available; load calculations required.
- Further literature review required.
- Source does not contribute significant load of constituent in this watershed.

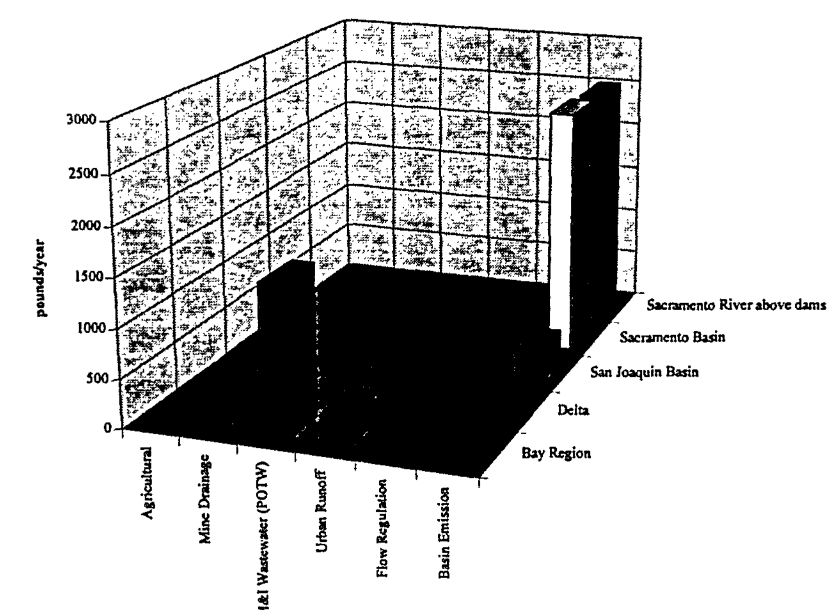


Table 4-5 Nitrate Loadings

NITRATE LOADING TABLE								
	Nitrate Loading (thousands of pounds/year)							
Source	**Delta**	**Note**	**Bay Region**	**Note**	**Sacramento Basin**	**Note**	**Sacramento River above Dams**	**Note**
Agricultural								
Urban Runoff	77	*a*	166	*a*	1790	*b*		
Flow Regulation								
Construction								
Total Load	77		166		1790			
Basin Emission								

Note: Letters listed in italics under the Note column provide the background and references associated with the accompanying load

- Data available; flow and concentration data available; load calculations required.
- Further literature review required.
- Source does not contribute significant load of constituent in this watershed.

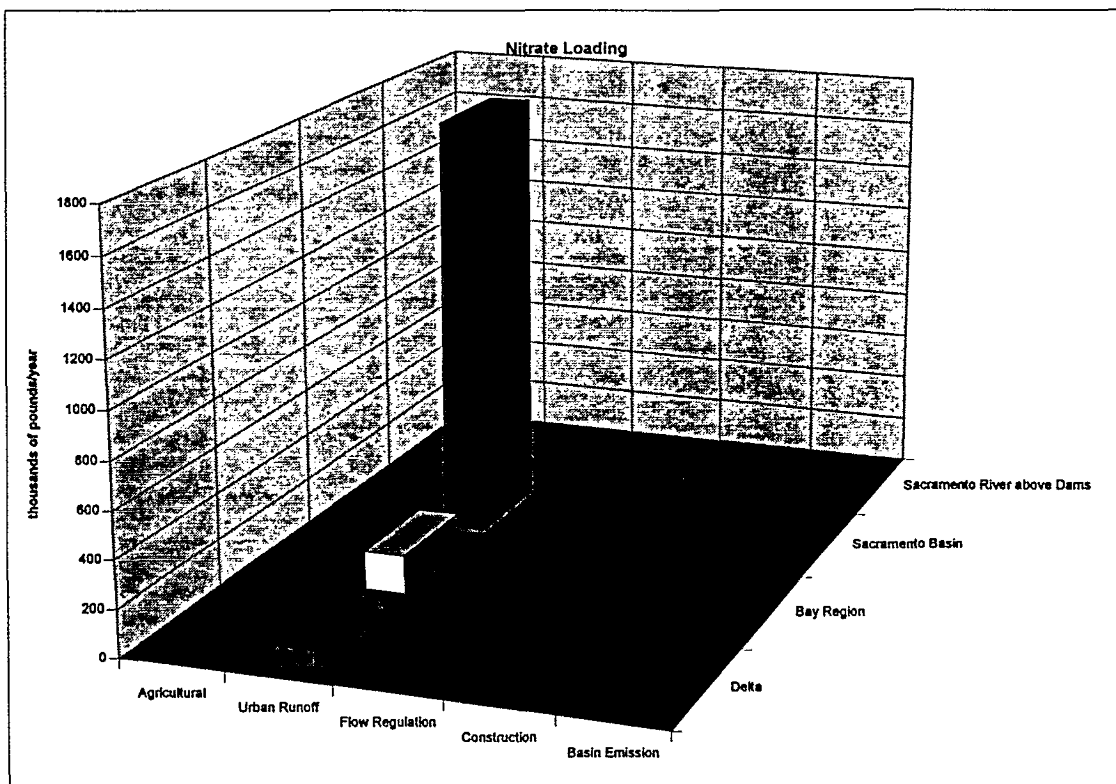
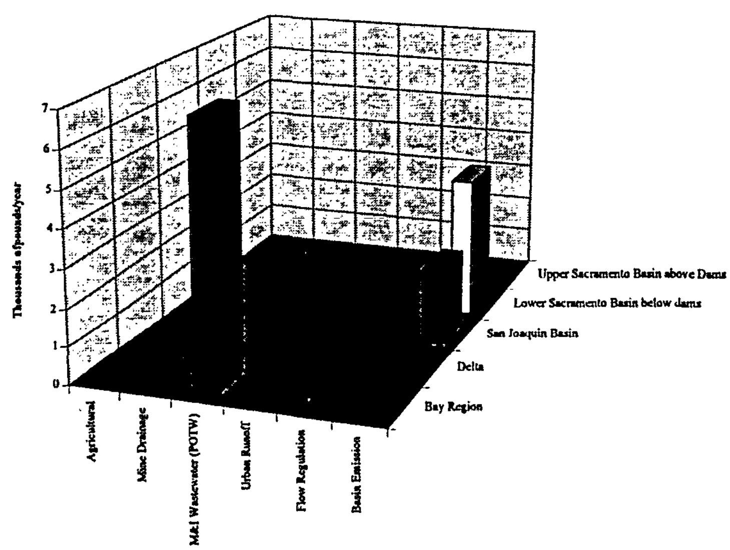


Table 4-6 Selenium Loadings

SELENIUM LOADING TABLE - 1										
	Selenium Loading (thousands of pounds/year)									
Source	**Delta**	**Note**	**Lower Sacramento Basin below dams**	**Note**	**San Joaquin Basin**	**Note**	**Bay Region**	**Note**	**Upper Sacramento Basin above Dams**	**Note**
Agricultural										
Mine Drainage										
M&I Wastewater (POTW)							7	*a*		
Urban Runoff										
Flow Regulation										
Total Load							7			
Basin Emission			4	*Com a&b*	2	*Com a&b*				

Note: Letters listed in italics under the Note column provide the background and references associated with the accompanying load
- Data available; flow and concentration data available; load calculations required.
- Further literature review required.
- Source does not contribute significant load of constituent in this watershed.



D-033628

D-033628

SELENIUM TABLE - 2	
Selenium in the San Joaquin River Tributaries	
Tributary	Dissolved Selenium Loads in Tributaries as % of those in San Joaquin River at Vernalis (1)
Stanislaus River	2
Toulumne River	3
Salt/Mud Sloughs	71
Merced River	2
San Joaquin above Salt Slough Confluence	3

Notes:

(1) Values obtained from the U.S. Geological Survey Water Resources Investigation Report 88-4186.

The dissolved selenium loads for the tributaries to the San Joaquin River do not add up to 100% of the loads in the San Joaquin River near Vernalis because some of the load at Vernalis most likely can be attributed to sources within the river, such as selenium delivered to the San Joaquin River from sources other than the listed tributaries.

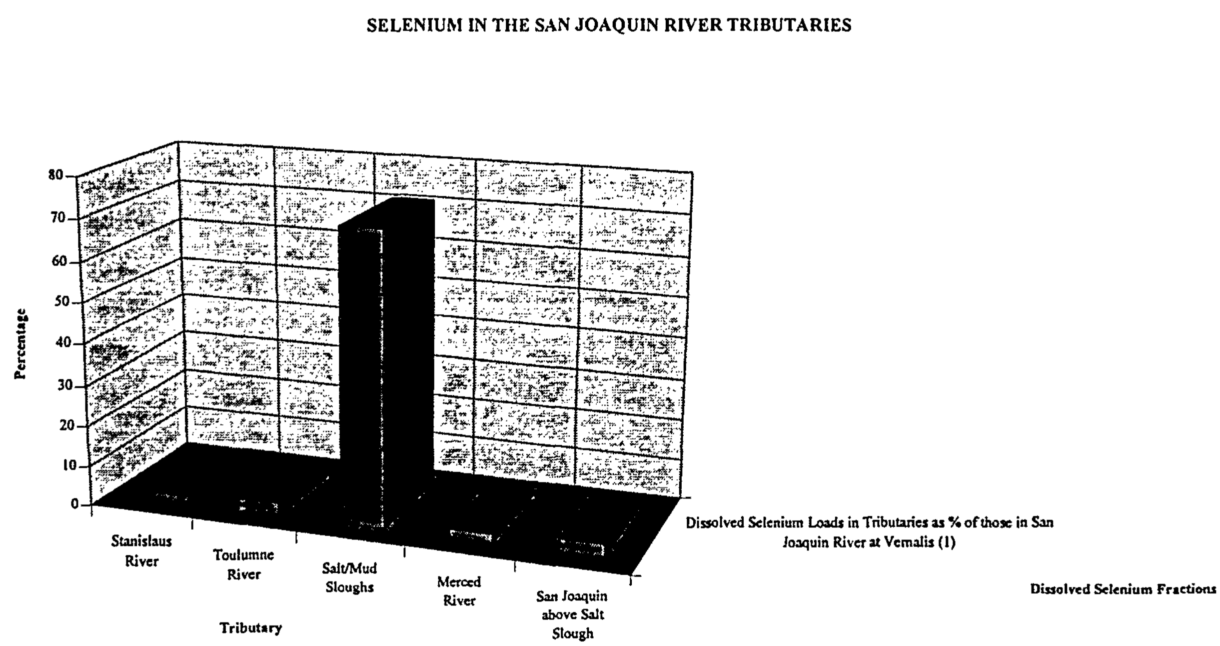


Table 4-7. Selenium Loadings from the San Joaquin Tributaries

TOTAL DISSOLVED SOLIDS (TDS) LOADING TABLE										
	Total Dissolved Solids (TDS) Loading (thousands of pounds/year)									
Source	**Delta**	**Note**	**Lower Sacramento Basin below dams**	**Note**	**San Joaquin Basin**	**Note**	**Bay Region**	**Note**	**Upper Sacramento Basin above Dams**	**Note**
Agricultural			2,651,000	*a*	2,171,000	*d*				
Mine Drainage										
M&I Wastewater (POTW)			296,000	*b*						
Urban Runoff			42,330	*c*	296	*e*				
Flow Regulation										
Total Load			2,989,330		2,171,296					
Basin Emission			901,300	*Com a&b*	722,500	*Com a&b*				

: All numbers are rounded to significant 4 digits
Note: Letters listed in italics under the Note column provide the background and references associated with the accompanying load
Data available; flow and concentration data available; load calculations required.
Further literature review required.
- Source does not contribute significant load of constituent in this watershed.

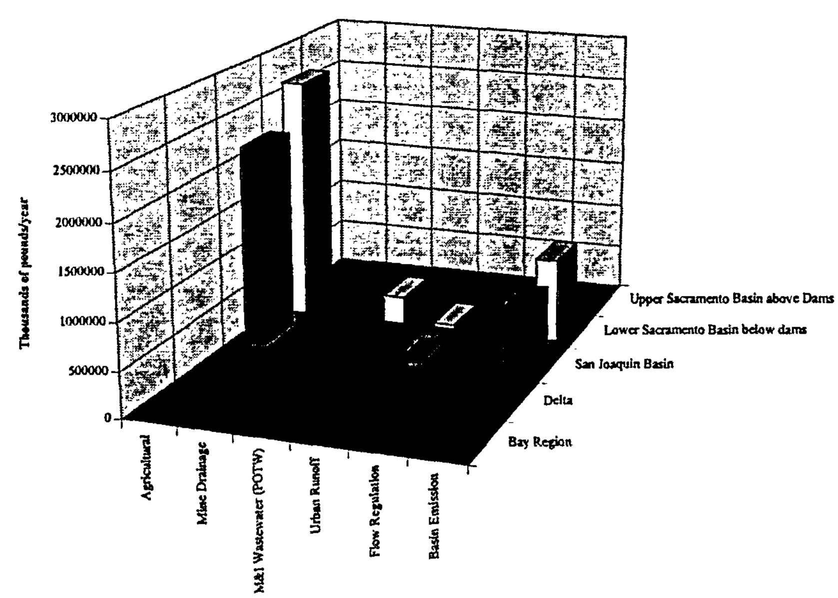


Table 4-8. Total Dissolved Solids Loadings

D-033630

Table 4-9. Total Organic Carbon Loading

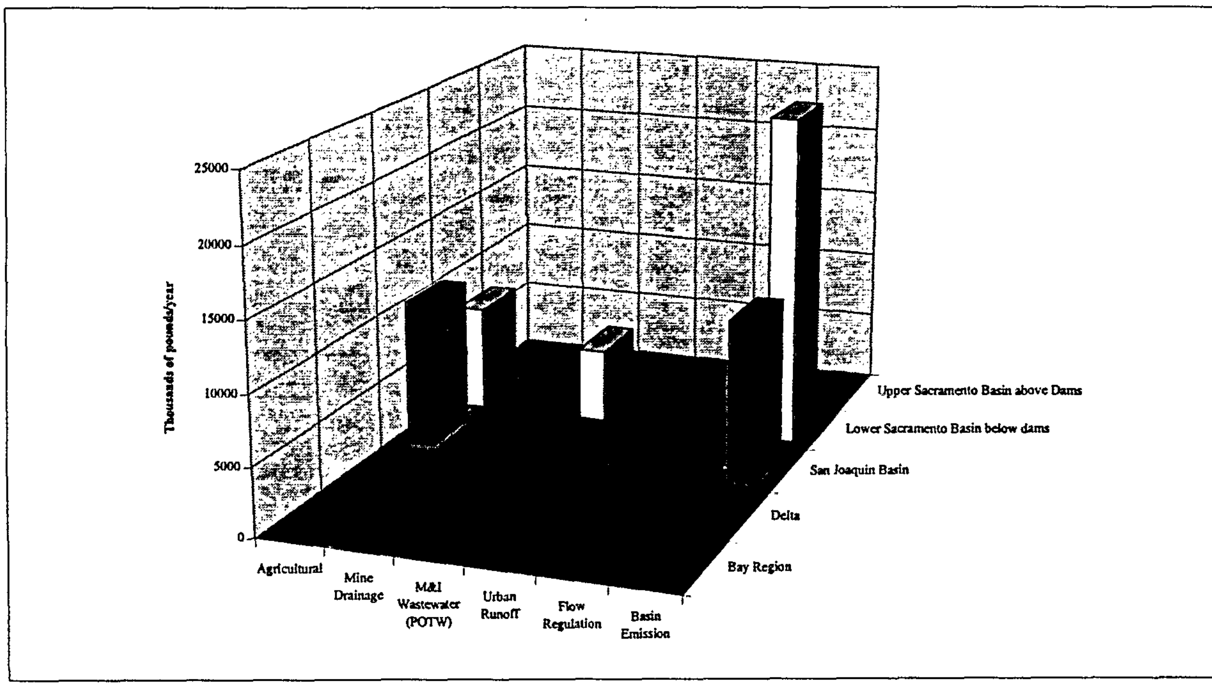
TOTAL ORGANIC CARBON (TOC) LOADING TABLE										
	Total Organic Carbon (TOC) Loading (thousands of pounds/year)									
Source	Delta	Note	Lower Sacramento Basin below dams	Note	San Joaquin Basin	Note	Bay Region	Note	Upper Sacramento Basin above Dams	Note
Agricultural			7706	*a*	10,764	*c*				
Mine Drainage										
M&I Wastewater (POTW)			5375	*b*						
Urban Runoff										
Flow Regulation										
Total Load			13,081		10,764					
Basin Emission			24,130	*Com a&c*	11,710	*Com a&b*				

Note: Letters listed in italics under the Note column provide the background and references associated with the accompanying load

(diagonal hatching) Data available; flow and concentration data available; load calculations required.

(vertical hatching) Further literature review required.

(dark shading) - Source does not contribute significant load of constituent in this watershed.



D-033631

Table 4-10. Zinc Loadings

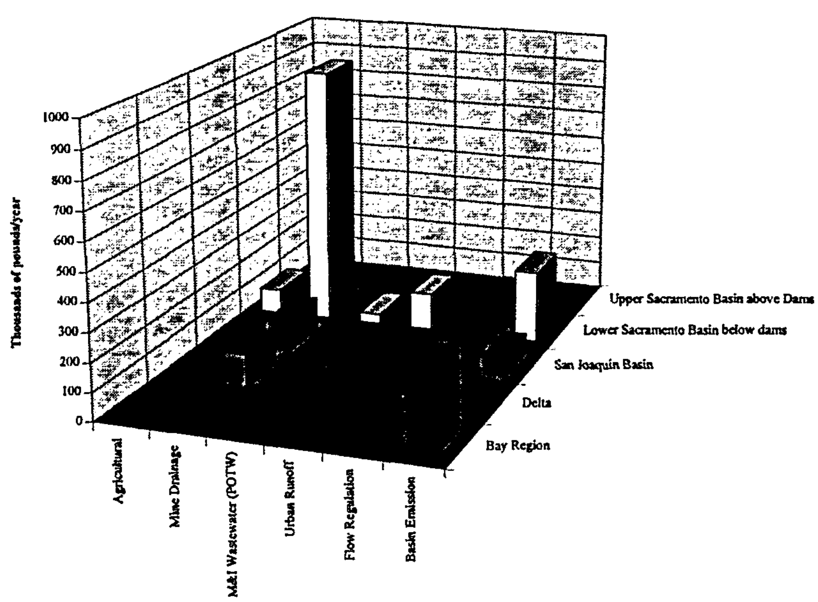
ZINC LOADING TABLE										
	Zinc Loading (thousands of pounds/year)									
Source	**Delta**	**Note**	**Lower Sacramento Basin below dams**	**Note**	**San Joaquin Basin**	**Note**	**Bay Region**	**Note**	**Upper Sacramento Basin above Dams**	**Note**
Agricultural			88	*c*						
Mine Drainage	116	*a*	930	*d*	116	*h*				
M&I Wastewater (POTW)	2	*b*	34	*e*						
Urban Runoff			131	*f*						
Flow Regulation										
Total Load	118		1183		116					
Basin Emission			255	*g*	69	*i*	279	*j*		

Note: Letters listed in italics under the Note column provide the background and references associated with the accompanying load

Data available; flow and concentration data available; load calculations required.

Further literature review required.

- Source does not contribute significant load of constituent in this watershed.



D-033632

D-033633

SECTION 5

Water Quality Problem Areas

Defining what constitutes a "problem" is a controversial and endlessly debatable issue. Very few of the parameters of concern have been studied sufficiently to understand their fate, transport and impact, particularly on biological systems. If a parameter is measured against an existing objective, criteria or standard a decision must be made of whether the standard is appropriate, what it is meant to protect, and what level of exceedance is relevant (e.g., duration, season, geographic location, etc.). For example, an exceedance of copper in the Upper SacramentoRiver during the fall-run chinook salmon juvenile outmigration period might be devastating to the population but during other times of the year (when fall-run are not present) there may be virtually no impact. For some parameters such as temperature and salinity extensive data has been collected. For other parameters such as pesticides, minimal information is known. Given the inherent difficulties attempting to measure data against published standards and the programmatic nature of the CALFED Water Quality Program, definition and prioritization of water quality problem areas have been based on one or more of the following criteria. These criteria have been developed through consultation with the Water Quality Technical Group, particularly the Parameter Assessment Team.

- **US EPA Section 303(d) Listing**
  Section 303(d) of the Federal Clean Water Act requires each state to develop a list, known as a 303(d) list, of water bodies that are impaired with respect to water quality. In addition to listing impaired water bodies the 303(d) list identifies the suspected major sources of parameters causing impairment. These sources include mine drainage, agricultural drainage, urban and industrial runoff, and municipal and industrial wastewater discharges. In compliance with Section 303(d) of the Clean Water Act the San Francisco and Central Valley Regional Water Quality Control Boards in 1996, identified all impaired water bodies in California. CALFED is using this list to make a preliminary assessment of existing water quality problems (primarily environmental & recreational) in California's Central Valley and Bay-Delta.

- **Parameter Assessment Team Drinking Water Targets**
  The ability of Delta drinking water sources to be treated at reasonable cost to meet current and future federal and State health-based drinking water standards.

- **Agricultural Drinking Water Targets**
  The ability of Delta drinking water sources to sustain the productivity of agricultural lands and prevent salt contamination of soils.

- **Scientific Studies**
  Knowledge based on scientific studies and data that indicate a potentially significant problem exists.

Impaired Water Bodies

Water bodies impaired by parameters of concern, according to the 303 (d) list are shown in Figure 5-1. More detailed information pertaining to the Section 303(d) list can be found in Appendix C.

Sacramento River Basin. Several drainages in the Sacramento Basin contain metals in concentrations that may impair environmental beneficial uses. The upper Sacramento River (Shasta Dam to Red Bluff) contains elevated copper, cadmium, and zinc. Loadings to the river in this region are predominantly from mine drainage although urban runoff does contribute a measure of mass loading of these metals to the upper Sacramento drainage.

Data collected on the lower Sacramento River (Red Bluff to the Delta) indicate that this main water body is impaired with regard to environmental and recreational beneficial uses, due to elevated mercury, diazinon, and chlorpyrifos. Both the lower American River and the lower Feather River are similarly impaired. Elevated mercury in these tributaries may pose a risk to people that catch and consume fish. Elevated levels of diazinon and chlorpyrifos have been documented in the lower Feather River. In these three water bodies, urban runoff has been identified as a source of mercury, and in the lower Sacramento and Feather rivers, urban runoff has been identified as a source of diazinon and chlorpyrifos.

Other water bodies that are influenced by urban and industrial runoff include Natomas East Main Drain and Sacramento Slough. These two water bodies contain elevated levels of diazinon and chlorpyrifos. Sources include agriculture and urban runoff. Natomas East Main Drain has elevated levels of PCBs, and Sacramento Slough has elevated mercury. These bioaccumulative substances impair recreational beneficial uses (i.e., fishing) in these areas.

San Joaquin River Basin. Urban and industrial runoff contribute to the overall mass loading of parameters of concern in the San Joaquin River Basin. However, in this basin, urban runoff is not considered a major source of diazinon or chlorpyrifos relative to agricultural sources. The principal sources of identified parameters of concern are agriculture and some mines.

Delta. Runoff from the first major storm of the year in Stockton appears to annually produce an oxygen deficit causing fish kills in adjacent Delta sloughs. The cause of the deficit is not yet known (Foe, 1995). The Delta contains elevated mercury, diazinon, and chlorpyrifos. These constituents impair environmental and recreational beneficial uses. Urban runoff from cities in the Central Valley contribute mass loading of these parameters of concern.

San Francisco Bay. Numerous waterbodies drain to the San Francisco Bay Delta Estuary, many of which are listed as impaired waterbodies under Clean Water Act Section 303(d). For example, the Napa and Petaluma rivers are conveyances for a combination of urban and agricultural runoff, and may contribute pathogens, nutrients, and turbidity to the CALFED problem area. Urban runoff from cities around San Francisco Bay and San Pablo Bay is a significant source of metals to the estuary.

D-033636

Section 6

Action Strategies

Action strategies have been developed by the Water Quality Program to address water quality problems in the Delta and its tributaries. The strategies are recommended actions that either improve source water quality by reducing loadings from the sources of water quality problems (e.g., mine drainage, agricultural drainage, urban and industrial runoff, and municipal and industrial wastewater treatment facilities), upgrade water treatment plants, or change water management practices.

Action strategies to address water quality problems include a combination of research, pilot studies and full-scale actions. For some parameters, such as mercury, there is little understood about its sources, the bioavailability of the various sources, and the load reductions needed to reduce fish tissue concentrations to levels acceptable for human consumption. For this parameter further study is recommended before full-scale actions are taken. For other parameters, such as selenium, sources are better documented, and source control or treatment actions can be taken with a reasonable expectation of positive environmental results.

Performance targets have been established to measure the effectiveness of actions in improving water quality. Performance targets may be quantifiable reductions in loadings of parameters. For example, the target for copper in the Sacramento River is to reduce copper loadings in the Upper Sacramento River from 65,000 pounds to 10,000 pounds per year. For actions that recommend further study of a parameter the performance target may be a focussed outcome. For example, an action for mercury is further research to better understand the sources and mechanisms of mercury accumulation in the Delta. The performance target is a targeted action plan that specifies selection and prioritization of the most effective mercury remediation actions.

Indicators of success are generally numerical or narrative water quality targets have been developed for each parameter of concern. These targets relate to acceptable in-stream concentrations of parameters. They will be used to gauge action and alternative effectiveness at protecting beneficial uses. Targets are based on Water Quality Control Plans (Basin Plans) of the Bay Area and Central Valley Regional Water Quality Control Boards or U.S. Environmental Protection Agency ambient water quality objectives, standard agricultural water quality objectives, and target source drinking water quality ranges as defined by technical experts.

Individual programmatic actions may vary in cost, technical feasibility, and other respects that would affect the final choices for implementation of actions. Actions will therefore be subjected to pre-feasibility analysis to determine which programmatic action are most appropriate to be carried forward toward implementation. This work has begun and will continue into Phase III of the CALFED Program. Full feasibility analysis in conjunction with project-specific environmental documentation will be performed in Phase III.

Summary of Action Strategies

Following is a summary by geographic region of some of the major strategies that make up the CALFED Water Quality Program.

Delta

Actions strategies to address water quality problems in the Delta address urban and industrial runoff, municipal and industrial wastewater, agricultural drainage, and source control and treatment. Following is a description of the main action strategies for each of these sources.

Mine drainage actions will reduce mercury loadings to the Delta from abandoned and inactive mines. These actions include source control and treatment measures. Actions for mercury occur throughout the basin and are primarily being addressed through a system-wide research-program that will attempt to identify bioavailable forms of mercury, sources of the bioavailable forms and an action plan to reduce the loadings of these forms. Pilot scale actions are recommended for mines that drain mercury to Cache Creek and the Yolo Bypass.

Urban and industrial runoff actions will help to reduce toxicity from the pesticides chlorpyrifos and diazinon, copper, and oxygen depletion in the Delta, and to reduce pathogens. Actions include both source control and treatment measures.

Municipal and industrial discharge actions will help to reduce pathogens and oxygen depletion. These actions include source control and treatment measures including improved management of boat discharges and additional source control or treatment at wastewater treatment plants.

Agricultural drainage actions will reduce toxicity from the pesticide carbofuran, chlorpyrifos, and diazinon in the Delta. Actions are primarily source control measures such as best management practices (BMPs).

Actions to improve the quality of drinking water sources include relocation of water supply intakes to avoid areas of high salinity, total organic carbon, and turbidity.

Actions to improve drinking water quality include upgrades to treatment processes to improve disinfection while reducing production of unwanted disinfection byproducts.

Actions to address unknown toxicity focus on development of a comprehensive monitoring, assessment, and research program to identify toxicities, the sources of these toxicities, and action plans to address unknown toxicity in the Delta and its tributaries.

Sacramento Basin

Action strategies in the Sacramento Basin predominantly include mine drainage actions with some agricultural drainage and urban and industrial runoff actions. Following is a description of the main action strategies for each of these sources.

Mine drainage actions will reduce mercury, cadmium, copper, and zinc loadings to the Sacramento River and its tributaries from abandoned and inactive mines. These actions include point source and non-point source measures. Actions for cadmium, copper, and zinc are focussed at mine sites that drain into the upper Sacramento River. Actions for mercury occur throughout the basin and are primarily being addressed through a system-wide research-program to identify bioavailable forms of mercury, sources of the bioavailable forms and an action plan to reduce the loadings of these forms.

Urban and industrial runoff actions will reduce toxicity of the pesticide chlorpyrifos and diazinon in the Sacramento River and its tributaries from urban areas. These actions will include implementation of pesticide usage BMPs in urban areas.

Agricultural drainage actions will reduce toxicity from the pesticides carbofuran, chlorpyrifos, and diazinon in the Sacramento River and its tributaries from agricultural areas. Actions are primarily source control measures such as best management practices (BMPs), especially from farm areas that drain to the Feather River, Colusa Basin Drain, and mainstem Sacramento River.

Actions to address unknown toxicity focus on development of a comprehensive monitoring, assessment and research program to identify toxicities, the sources of these toxicities, and action plans to address unknown toxicity in the Sacramento River and its tributaries.

San Joaquin Basin

Action strategies in the San Joaquin Basin predominantly include agricultural drainage actions with limited mine drainage actions. Following is a description of the main action strategies for each of these sources.

Subsurface agricultural drainage discharged to the San Joaquin River from the Grasslands area are perhaps the most significant cause of water quality problems, specifically selenium and salinity (TDS, chloride, bromide), in the River. CALFED agricultural drainage actions include drainage reduction and reuse, timed drainage release, drainage treatment to reduce trace elements and other contaminants, salt separation and utilization and land use changes to reduce drainage quantities. Agricultural drainage actions will reduce toxicity from the pesticides chlorpyrifos and diazinon in the San Joaquin River and its tributaries from agricultural areas. Actions are primarily source control measures such as best management practices (BMPs) particularly in farm areas that drain to Mud and Salt sloughs, and the San Joaquin River.

Actions to address mine drainage associated with loadings of cadmium and zinc to the San Joaquin Basin (specifically the Mokelumne River) have been undertaken as part of the Penn Mine Remediation Plan. However, mercury loadings continue to be a problem in the basin. Actions for mercury occur throughout the basin and are primarily being addressed through a system-wide research-program that will attempt to identify bioavailable forms of mercury, sources of the bioavailable forms and an action plan to reduce the loadings of these forms.

Actions to address unknown toxicity focus on development of a comprehensive monitoring, assessment and research program to identify toxicities, the sources of these toxicities, and action plans to address unknown toxicity in the San Joaquin River and its tributaries.

Mine Drainage

Action

Reduce toxic effects of cadmium, copper, and zinc loadings to the Delta and its tributaries by source control or treatment of mine drainage at inactive and abandoned mine sites. Action targeted at the Upper Sacramento River and tributaries to the Upper Sacramento River that are major contributors of copper, cadmium and zinc loadings.

Methods

- Source control methods include capping tailings piles, removing tailings piles, diverting water courses from metal sources, sealing mines, removing contaminated sediments, and similar measures to prevent metals from leaching or draining into water bodies.
- Treatment methods involve collecting and treating mine drainage to remove metals and neutralize acidity.

Performance measure

- Reduction in annual copper loadings (during an average water year) to the Upper Sacramento River from approximately 65,000 pounds to 10,000 pounds.

Indicator of success

Achievement of Basin Plan objectives for cadmium, copper and zinc in the Sacramento River above Hamilton City.

Action

Reduce toxic effects of mercury loadings to the Delta and its tributaries by source control and/or treatment of mine drainage at inactive and abandoned mine sites.

Methods

- Development of a system-wide research program to identify bioavailable forms of mercury, sources of the bioavailable forms and an action plan to reduce loadings of these forms to the Delta and its tributaries.
- Development of pilot scale projects to determine feasibility of mercury contaminanted sediment cleanup. Recommend action be targeted at the Cache Creek and its tributary

watersheds.

- Treatment of mercury contaminated mine drainage. Recommend action be targeted at the Cache Creek Watershed and Mt. Diablo mine areas.

Performance measures

- Improved understanding of sources and mechanisms of mercury bioaccumulation in the Delta.
- Improved understanding of the cost/benefit associated with remediation of mercury contaminated sediment.
- A targeted action plan that specifies selection and prioritization of actions to remediate mercury loadings to the Delta and its tributaries.
- Reduction in mercury loadings to Cache Creek.

Indicators of success

- Achievement of US EPA 304(a) guideline for mercury in the Delta and its tributaries.
- Removal of fish health advisories.

Urban and Industrial Runoff

Action

Reduce toxic effects of copper, zinc and cadmium loadings to the Delta and its tributaries from urban and industrial runoff

Methods

- Enforcement of existing source control regulations.
- Provision of incentives for additional source control of urban and industrial runoff, particularly those areas that have runoff associated with vehicle usage.

Performance measure

- Improved understanding of the sources and mechanisms for bioaccumulation of cadmium, copper, and zinc in the Delta.
- Reduction in copper loadings at selected stormwater monitoring stations.

Indicator of success

- For copper and zinc achievement of Basin Plan objectives in the Delta andSacramento River and its tributaries; US EPA 304(a) guidelines in the San Joaquin River and its tributaries
- For cadmium achievement of Basin Plan objectives in the Sacramento River and its tributaries and west of Antioch Bridge in the Delta, US EPA 304(a) guidelines in the San Joaquin River and its tributaries and east of Antioch Bridge in the Delta.

Action

Reduce toxicity from the pesticides chlorpyrifos and diazinon in the Delta and its tributaries through source control of urban and industrial runoff.

Methods

- Enforcement of existing source control regulations

- Provision of source control incentives, such as additional education for homeowners on pesticide usage and incentives for pesticide users to increase implementation of best management practices including integrated pest management.

Performance measure

- Improved understanding of the toxicity and sources and mechanisms of chlorpyrifos and diazinon transport into the Delta.
- Reduced toxicity at selected stormwater monitoring locations measured by improved survivability from a three-species test.

Indicator of success

- Reduced toxicity from chlorpyrifos and diazinon in the Delta and its tributaries.

Action

Reduce the toxic effects of nutrient loadings and consequently, oxygen depletion in the Delta and its tributaries through source control of urban and industrial runoff.

Methods

- Enforcement of existing source control regulations including implementation of best management practices.
- Provision of incentives for additional source control including best management practices and better planning of new developments (e.g., design of storm drainage systems that target maximum infiltration of stormwater into the ground or on-site or regional stormwater sedimentation facilities that detain the majority of stormwater for at least 8 hours,etc.) and public education.

Performance Measure

- Improved understanding of the sources and mechanisms for nutrient transport in the Delta.
- No measurable impacts to fish from low dissolved oxygen levels in the Lower San Joaquin River.

Indicator of Success

- Achievement of Basin Plan objectives for dissolved oxygen in the Delta and its tributaries, particularly in the Lower San Joaquin River.

Action

Reduce the impacts of sediment loading, and subsequent turbidity to the ecosystem of the Delta and its tributaries and to urban drinking water sources in the Delta, through source control of urban and industrial runoff.

Methods

- Better enforcement of existing source control regulations for construction sites. May include development of ordinances and other measures.
- Education of construction personnel on impacts of construction site discharges.

Performance Measure

- Decreased turbidity levels at Delta water supply intakes.
- Increased juvenile anadramous fish production in areas downstream of new developments on Delta tributaries where anadramous fish are known to spawn.

Indicator of Success

- Achievement of a 50 NTU monthly median at drinking water intakes.
- Achievement of Basin Plan objectives for turbidity.

Wastewater and Industrial Discharges

Action

Reduce the impact of domestic wastes and hence pathogens to Delta urban drinking water supplies and recreational water uses, from boat discharges within the Delta and Delta tributaries.

Methods

- More extensive enforcement of boat domestic waste discharge regulations.
- Extensive boater education campaigns.
- Installation of more extensive, better, and more economical pumpout stations.
- Installation of more public toilet facilities.

Performance Measure

- Quantifiable records from pumpout facilities that show increased usage by boaters. Usage should match expected boater domestic waste quantities.
- Number of public workshops and other outreach activities.
- Number of new pumpout and toilet facilities installed.

Indicator of Success

- Reduced bacteriological counts in marinas and other recreational areas.
- Lower pathogen levels near water supply intakes.

Action

Reduce the toxic impacts of oxygen depleting substances and copper and mercury loadings to the Delta through cost effective source control and treatment of industrial and municipal wastewater discharges. Action for oxygen depleting substances should be targeted at the Lower San Joaquin River and copper and mercury loadings at the Suisun Bay and Carquinez Straight area.

Methods

- Increased incentives for industries to pre-treatment discharges containing copper and mercury.
- Incentives for municipal wastewater effluent reclamation and reuse.
- Treatment of a portion of upstream municipal wastewater effluent in wetlands.

Performance Measures

- Reduction in nutrient loadings from Delta municipal wastewater treatment facilities.
- Reduction in copper and mercury loadings from Delta wastewater treatment plants.

Indicator of Success

- Achievement of Basin Plan objectives for dissolved oxygen in the Lower San Joaquin River.
- Achievement of applicable Basin Plan objectives or US EPA 304(a) criteria for copper and mercury in the Delta.

Action

Reduce the toxic impacts of selenium loadings to the Delta through source control and treatment of industrial discharges. Action should be targeted at industries that discharge selenium to the Suisun Bay and Carquinez Straight area.

Method

- Additional treatment of oil refinery discharges in the western Delta for selenium removal.

Performance Measure

- Reduced selenium loadings to the western Delta

Indicator of Success

- Reduced tissue bioaccumulation of selenium in aquatic organisms of the western Delta.

Agricultural Drainage

Action

Reduce the toxic effects of selenium loadings to the Lower San Joaquin River and Delta by controlling sources of selenium in agricultural sub-surface drainage.

Methods

- Change use of lands that are major sources of selenium through voluntary landowner participation and by compensated arrangements to reduce drainage volumes.
- Reduce drainage flows through increased water use efficiency.
- Treat drainage for selenium removal.

Performance Measure

- Reduced selenium loadings from the Grassland area of the San Joaquin River watershed.

Indicator of Success

- Reduced selenium concentrations in the San Joaquin River near Vernalis, where the River flows into the Delta.

Action

Reduce salinity impacts to Delta urban and agricultural source water quality through source control and treatment of agricultural surface and sub-surface drainage in the San Joaquin River watershed.

Methods

- Improved source irrigation water quality in sub-surface drainage areas.

- Concentration and safe disposal of agricultural drainage in evaporation ponds.
- Treatment of agricultural drainage by reverse osmosis, constructed wetlands, or by other means.
- Time agricultural drainage discharges to coincide with periods when dilution flow is sufficient to achieve water quality target ranges for salinity.

Performance Measures
- Reduced salinity loads entering the San Joaquin River from adjacent lands.

Indicators of Success
- Reduced salinity in the San Joaquin River near Vernalis, where the River flows into the Delta.

Action

Reduce salinity for agricultural source water in the South Delta through improved outflow patterns and water circulation in the Delta.

Methods
- Construct one or more tide gates, wiers, dams or sills at the head of Old River and possibly other southern Delta locations to manage drainage flows, tidal currents and stages in the San Joaquin and Middle River and interconnecting channels.
- Relocate Delta island drainage to more efficiently route salinity to the Bay and ocean.
- Provide dilution water for salinity control. (This measure would be considered as one possible means of mitigating salinity impacts of other CALFED actions, if such mitigation were necessary.)

Performance Measures
- Reduced salinity loads entering southern Delta channels.

Indicator of Success
- Reduced total dissolved solids in the southern reaches of the Old and Middle Rivers.

Action

Reduce the toxic effects of carbofuran, chlorpyrifos, and diazinon in the Delta and its tributaries through source control of agricultural surface drainage and Delta island drainage.

Method
- Incentives and/or enforcement of existing regulations.
- Incentives for pesticide users to increase implementation of best management practices including integrated pest management and grower education.

Performance Measures
- Reduction of toxicity in Delta channel waters.

Indicator of Success
- Improved survival of test organisms in three-species toxicity bioasssays, and indications through the toxicity identification evaluation testing that pesticides are not a significant cause of toxicity in Delta channels.

- Achievement of Basin Plan objectives for carbofuran when they are promulgated.

Action
Reduce the toxic effects of <u>ammonia</u> entering the Delta and its tributaries through source control of agricultural surface drainage.

Method
- Provide incentives for implementation of best management practices at dairies, other animal operations, and fertilized lands in the watersheds that discharge into the Delta, including the North Bay, and the lower reaches of the Sacramento and San Joaquin Rivers, and westside stream tributaries to the Delta.

Performance Measures
- Reduced toxicity due to ammonia in Delta channels and lower reaches of its tributary streams.

Indicator of Success
- Improved survival of test organisms in three-species toxicity bioasssays, and indications through the toxicity identification evaluation testing that ammonia is not a significant cause of toxicity in Delta channels.
- Achievement of US EPA 304(a) guidelines for ammonia in the Delta and its tributaries.

Action
Reduce the toxic effects of <u>ammonia</u> entering the Delta and its tributaries from waste water treatment plant discharge through improved treatment.

Method
- Provide incentives for improved waste water treatment facilities and processes.

Performance Measure
- Reduced toxicity due to ammonia in Delta channels and lower reaches of its tributary streams.

Indicator of Success
- Improved survival of test organisms in three-species toxicity bioasssays, and indications through the toxicity identification evaluation testing that ammonia is not a significant cause of toxicity in Delta channels.

Water Treatment

Action
Improve treated drinking water quality (including reduction in formation of disinfection by-products) through treatment to reduce concentrations of total organic carbon, pathogens, turbidity, and bromides.

Methods

- Incentives for the addition of enhanced coagulation, ozone, granular activated carbon filtration and/or membrane filtration facilities to the water systems treating water from the Delta.

Performance Measures

- Reliably meet current and future drinking water standards.

Indicator of Success

- Absence of waterbourne disease outbreaks and quantitative evidence of treatment success by measures such as bacteria counts, pathogen counts, and measurements of organic carbon, disinfection byproducts, and turbidity.

Action

Improve total organic carbon, pathogens, turbidity and bromides at domestic water supply intakes.

Method

- Relocate water supply intakes to areas that are not influenced by those discharges.

Performance Targets

- Total organic carbon concentrations 3.0 mg/L (quarterly average).
- Bromide concentrations of 50ug/L (quarterly average).
- Turbidity less than or equal to 50 NTU (monthly median).
- Total dissolved solids less than 220 mg/L (10 year average), or less than 440 mg/L (monthly average).
- Protozoa (Giardia, Cryptosporidium oocysts) less than 1 oocyst/100 L (annual average).

Indicators of Success

- Existing modern, well operated treatment plants can successfully and reliably meet current and future drinking water standards without the need to significantly upgrade facilities.
- Absence of waterbourne disease outbreaks and quantitative evidence of treatment success by measures such as bacteria counts, pathogen counts, and measurements of organic carbon, disinfection byproducts, and turbidity.

Unknown Toxicity

Action

Identify and implement actions to address potential toxicity to water and sediment within the Delta and its tributaries.

Method

- Conducting toxicity testing and toxicity identification evaluations and/or other appropriate methods.
- Coordinate efforts with monitoring programs being conducted by others..

Performance Measure

- Numbers of toxicity bioassays and Toxicity Identification Evaluation test conducted.

Indicator of Success

- Successful identifications of causal agents of toxicity in the channels of the Delta estuary.

Water Management

Action

Reduce the concentration of salinity entering the Delta and its tributaries during low flow periods.

Methods

- Acquiring dilution water from willing sellers.
- Provision of incentives for more efficient water management of dams, including reservoir re-operation.
- Urban water conservation. Conservation might be achieved through use of incentives for implementation of best management practices by more suppliers and water users. Implementation of the action may reduce demand for existing water and may make dilution water available (including transfers), especially on the San Joaquin River
- Greater use of reclaimed wastewater (e.g.,recharge groundwater, treated agricultural drainage, use for agricultural irrigation, recycling and treating for potable or non-potable urban, use of grey water,and storage for use in meeting X2 standards).Reclamation programs would focus on facilities that currently discharge treated wastewater to salt sinks or other degraded bodies of water that are not reusable.
- Enhanced seasonal recharge.
- Development of additional groundwater supplies.

Performance Target

- Reduced salinity loads to the Delta.

Indicator of Success

- Reduced concentrations of total dissolved solids, chloride, and bromide in the San Joaquin River near Vernalis, where the River flows into the Delta.

Section 6

Action Strategies

Action strategies have been developed by the Water Quality Program to address water quality problems in the Delta and its tributaries. The strategies are recommended actions that either improve source water quality by reducing loadings from the sources of water quality problems (e.g., mine drainage, agricultural drainage, urban and industrial runoff, and municipal and industrial wastewater treatment facilities), upgrade water treatment plants, or change water management practices.

Action strategies to address water quality problems include a combination of research, pilot studies and full-scale actions. For some parameters, such as mercury, there is little understood about its sources, the bioavailability of the various sources, and the load reductions needed to reduce fish tissue concentrations to levels acceptable for human consumption. For this parameter further study is recommended before full-scale actions are taken. For other parameters, such as selenium, sources are better documented, and source control or treatment actions can be taken with a reasonable expectation of positive environmental results.

Performance targets have been established to measure the effectiveness of actions in improving water quality. Performance targets may be quantifiable reductions in loadings of parameters. For example, the target for copper in the Sacramento River is to reduce copper loadings in the Upper Sacramento River from 65,000 pounds to 10,000 pounds per year. For actions that recommend further study of a parameter the performance target may be a focussed outcome. For example, an action for mercury is further research to better understand the sources and mechanisms of mercury accumulation in the Delta. The performance target is a targeted action plan that specifies selection and prioritization of the most effective mercury remediation actions.

Indicators of success are generally numerical or narrative water quality targets have been developed for each parameter of concern. These targets relate to acceptable in-stream concentrations of parameters. They will be used to gauge action and alternative effectiveness at protecting beneficial uses. Targets are based on Water Quality Control Plans (Basin Plans) of the Bay Area and Central Valley Regional Water Quality Control Boards or U.S. Environmental Protection Agency ambient water quality objectives, standard agricultural water quality objectives, and target source drinking water quality ranges as defined by technical experts.

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Summary of Action Strategies

Following is a summary by geographic region of some of the major strategies that make up the CALFED Water Quality Program.

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Urban and industrial runoff actions will help to reduce toxicity from the pesticides chlorpyrifos and diazinon, copper, and oxygen depletion in the Delta, and to reduce pathogens. Actions include both source control and treatment measures.

Municipal and industrial discharge actions will help to reduce pathogens and oxygen depletion. These actions include source control and treatment measures including improved management of boat discharges and additional source control or treatment at wastewater treatment plants.

Agricultural drainage actions will reduce toxicity from the pesticide carbofuran, chlorpyrifos, and diazinon in the Delta. Actions are primarily source control measures such as best management practices (BMPs).

Actions to improve the quality of drinking water sources include relocation of water supply intakes to avoid areas of high salinity, total organic carbon, and turbidity.

Actions to improve drinking water quality include upgrades to treatment processes to improve disinfection while reducing production of unwanted disinfection byproducts.

Actions to address unknown toxicity focus on development of a comprehensive monitoring, assessment, and research program to identify toxicities, the sources of these toxicities, and action plans to address unknown toxicity in the Delta and its tributaries.

Sacramento Basin

Action strategies in the Sacramento Basin predominantly include mine drainage actions with some agricultural drainage and urban and industrial runoff actions. Following is a description of the main action strategies for each of these sources.

Mine drainage actions will reduce mercury, cadmium, copper, and zinc loadings to the Sacramento River and its tributaries from abandoned and inactive mines. These actions include point source and non-point source measures. Actions for cadmium, copper, and zinc are focussed at mine sites that drain into the upper Sacramento River. Actions for mercury occur throughout the basin and are primarily being addressed through a system-wide research-program to identify bioavailable forms of mercury, sources of the bioavailable forms and an action plan to reduce the loadings of these forms.

Urban and industrial runoff actions will reduce toxicity of the pesticide chlorpyrifos and diazinon in the Sacramento River and its tributaries from urban areas. These actions will include implementation of pesticide usage BMPs in urban areas.

Agricultural drainage actions will reduce toxicity from the pesticides carbofuran, chlorpyrifos, and diazinon in the Sacramento River and its tributaries from agricultural areas. Actions are primarily source control measures such as best management practices (BMPs), especially from farm areas that drain to the Feather River, Colusa Basin Drain, and mainstem Sacramento River.

Actions to address unknown toxicity focus on development of a comprehensive monitoring, assessment and research program to identify toxicities, the sources of these toxicities, and action plans to address unknown toxicity in the Sacramento River and its tributaries.

San Joaquin Basin

Action strategies in the San Joaquin Basin predominantly include agricultural drainage actions with limited mine drainage actions. Following is a description of the main action strategies for each of these sources.

Subsurface agricultural drainage discharged to the San Joaquin River from the Grasslands area are perhaps the most significant cause of water quality problems, specifically selenium and salinity (TDS, chloride, bromide), in the River. CALFED agricultural drainage actions include drainage reduction and reuse, timed drainage release, drainage treatment to reduce trace elements and other contaminants, salt separation and utilization and land use changes to reduce drainage quantities. Agricultural drainage actions will reduce toxicity from the pesticides chlorpyrifos and diazinon in the San Joaquin River and its tributaries from agricultural areas. Actions are primarily source control measures such as best management practices (BMPs) particularly in farm areas that drain to Mud and Salt sloughs, and the San Joaquin River.

Actions to address mine drainage associated with loadings of cadmium and zinc to the San Joaquin Basin (specifically the Mokelumne River) have been undertaken as part of the Penn Mine Remediation Plan. However, mercury loadings continue to be a problem in the basin. Actions for mercury occur throughout the basin and are primarily being addressed through a system-wide research-program that will attempt to identify bioavailable forms of mercury, sources of the bioavailable forms and an action plan to reduce the loadings of these forms.

Actions to address unknown toxicity focus on development of a comprehensive monitoring, assessment and research program to identify toxicities, the sources of these toxicities, and action plans to address unknown toxicity in the San Joaquin River and its tributaries.

Mine Drainage

Action

Reduce toxic effects of cadmium, copper, and zinc loadings to the Delta and its tributaries by source control or treatment of mine drainage at inactive and abandoned mine sites. Action targeted at the Upper Sacramento River and tributaries to the Upper Sacramento River that are major contributors of copper, cadmium and zinc loadings.

Methods

- Source control methods include capping tailings piles, removing tailings piles, diverting water courses from metal sources, sealing mines, removing contaminated sediments, and similar measures to prevent metals from leaching or draining into water bodies.
- Treatment methods involve collecting and treating mine drainage to remove metals and neutralize acidity.

Performance measure

- Reduction in annual copper loadings (during an average water year) to the Upper Sacramento River from approximately 65,000 pounds to 10,000 pounds.

Indicator of success

Achievement of Basin Plan objectives for cadmium, copper and zinc in the Sacramento River above Hamilton City.

Action

Reduce toxic effects of mercury loadings to the Delta and its tributaries by source control and/or treatment of mine drainage at inactive and abandoned mine sites.

Methods

- Development of a system-wide research program to identify bioavailable forms of mercury, sources of the bioavailable forms and an action plan to reduce loadings of these forms to the Delta and its tributaries.
- Development of pilot scale projects to determine feasibility of mercury contaminanted sediment cleanup. Recommend action be targeted at the Cache Creek and its tributary

watersheds.

- Treatment of mercury contaminated mine drainage. Recommend action be targeted at the Cache Creek Watershed and Mt. Diablo mine areas.

Performance measures

- Improved understanding of sources and mechanisms of mercury bioaccumulation in the Delta.
- Improved understanding of the cost/benefit associated with remediation of mercury contaminated sediment.
- A targeted action plan that specifies selection and prioritization of actions to remediate mercury loadings to the Delta and its tributaries.
- Reduction in mercury loadings to Cache Creek.

Indicators of success

- Achievement of US EPA 304(a) guideline for mercury in the Delta and its tributaries.
- Removal of fish health advisories.

Urban and Industrial Runoff

Action

Reduce toxic effects of <u>copper, zinc and cadmium</u> loadings to the Delta and its tributaries from urban and industrial runoff

Methods

- Enforcement of existing source control regulations.
- Provision of incentives for additional source control of urban and industrial runoff, particularly those areas that have runoff associated with vehicle usage.

Performance measure

- Improved understanding of the sources and mechanisms for bioaccumulation of cadmium, copper, and zinc in the Delta.
- Reduction in copper loadings at selected stormwater monitoring stations.

Indicator of success

- For copper and zinc achievement of Basin Plan objectives in the Delta andSacramento River and its tributaries, US EPA 304(a) guidelines in the San Joaquin River and its tributaries
- For cadmium achievement of Basin Plan objectives in the Sacramento River and its tributaries and west of Antioch Bridge in the Delta, US EPA 304(a) guidelines in the San Joaquin River and its tributaries and east of Antioch Bridge in the Delta.

Action

Reduce toxicity from the pesticides <u>chlorpyrifos and diazinon</u> in the Delta and its tributaries through source control of urban and industrial runoff.

Methods

- Enforcement of existing source control regulations

- Provision of source control incentives, such as additional education for homeowners on pesticide usage and incentives for pesticide users to increase implementation of best management practices including integrated pest management.

Performance measure

- Improved understanding of the toxicity and sources and mechanisms of chlorpyrifos and diazinon transport into the Delta.
- Reduced toxicity at selected stormwater monitoring locations measured by improved survivability from a three-species test.

Indicator of success

- Reduced toxicity from chlorpyrifos and diazinon in the Delta and its tributaries.

Action

Reduce the toxic effects of nutrient loadings and consequently, oxygen depletion in the Delta and its tributaries through source control of urban and industrial runoff.

Methods

- Enforcement of existing source control regulations including implementation of best management practices.
- Provision of incentives for additional source control including best management practices and better planning of new developments (e.g., design of storm drainage systems that target maximum infiltration of stormwater into the ground or on-site or regional stormwater sedimentation facilities that detain the majority of stormwater for at least 8 hours,etc.) and public education.

Performance Measure

- Improved understanding of the sources and mechanisms for nutrient transport in the Delta.
- No measurable impacts to fish from low dissolved oxygen levels in the Lower San Joaquin River.

Indicator of Success

- Achievement of Basin Plan objectives for dissolved oxygen in the Delta and its tributaries, particularly in the Lower San Joaquin River.

Action

Reduce the impacts of sediment loading, and subsequent turbidity to the ecosystem of the Delta and its tributaries and to urban drinking water sources in the Delta, through source control of urban and industrial runoff.

Methods

- Better enforcement of existing source control regulations for construction sites. May include development of ordinances and other measures.
- Education of construction personnel on impacts of construction site discharges.

Performance Measure

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- Decreased turbidity levels at Delta water supply intakes.
- Increased juvenile anadramous fish production in areas downstream of new developments on Delta tributaries where anadramous fish are known to spawn.

Indicator of Success

- Achievement of a 50 NTU monthly median at drinking water intakes.
- Achievement of Basin Plan objectives for turbidity.

Wastewater and Industrial Discharges

Action

Reduce the impact of domestic wastes and hence pathogens to Delta urban drinking water supplies and recreational water uses, from boat discharges within the Delta and Delta tributaries.

Methods

- More extensive enforcement of boat domestic waste discharge regulations.
- Extensive boater education campaigns.
- Installation of more extensive, better, and more economical pumpout stations.
- Installation of more public toilet facilities.

Performance Measure

- Quantifiable records from pumpout facilities that show increased usage by boaters. Usage should match expected boater domestic waste quantities.
- Number of public workshops and other outreach activities.
- Number of new pumpout and toilet facilities installed.

Indicator of Success

- Reduced bacteriological counts in marinas and other recreational areas.
- Lower pathogen levels near water supply intakes.

Action

Reduce the toxic impacts of oxygen depleting substances and copper and mercury loadings to the Delta through cost effective source control and treatment of industrial and municipal wastewater discharges. Action for oxygen depleting substances should be targeted at the Lower San Joaquin River and copper and mercury loadings at the Suisun Bay and Carquinez Straight area.

Methods

- Increased incentives for industries to pre-treatment discharges containing copper and mercury.
- Incentives for municipal wastewater effluent reclamation and reuse.
- Treatment of a portion of upstream municipal wastewater effluent in wetlands.

Performance Measures

- Reduction in nutrient loadings from Delta municipal wastewater treatment facilities.
- Reduction in copper and mercury loadings from Delta wastewater treatment plants.

Indicator of Success

- Achievement of Basin Plan objectives for dissolved oxygen in the Lower San Joaquin River.
- Achievement of applicable Basin Plan objectives or US EPA 304(a) criteria for copper and mercury in the Delta.

Action

Reduce the toxic impacts of selenium loadings to the Delta through source control and treatment of industrial discharges. Action should be targeted at industries that discharge selenium to the Suisun Bay and Carquinez Straight area.

Method

- Additional treatment of oil refinery discharges in the western Delta for selenium removal.

Performance Measure

- Reduced selenium loadings to the western Delta

Indicator of Success

- Reduced tissue bioaccumulation of selenium in aquatic organisms of the western Delta.

Agricultural Drainage

Action

Reduce the toxic effects of selenium loadings to the Lower San Joaquin River and Delta by controlling sources of selenium in agricultural sub-surface drainage.

Methods

- Change use of lands that are major sources of selenium through voluntary landowner participation and by compensated arrangements to reduce drainage volumes.
- Reduce drainage flows through increased water use efficiency.
- Treat drainage for selenium removal.

Performance Measure

- Reduced selenium loadings from the Grassland area of the San Joaquin River watershed.

Indicator of Success

- Reduced selenium concentrations in the San Joaquin River near Vernalis, where the River flows into the Delta.

Action

Reduce salinity impacts to Delta urban and agricultural source water quality through source control and treatment of agricultural surface and sub-surface drainage in the San Joaquin River watershed.

Methods

- Improved source irrigation water quality in sub-surface drainage areas.

- Concentration and safe disposal of agricultural drainage in evaporation ponds.
- Treatment of agricultural drainage by reverse osmosis, constructed wetlands, or by other means.
- Time agricultural drainage discharges to coincide with periods when dilution flow is sufficient to achieve water quality target ranges for salinity.

Performance Measures

- Reduced salinity loads entering the San Joaquin River from adjacent lands.

Indicators of Success

- Reduced salinity in the San Joaquin River near Vernalis, where the River flows into the Delta.

Action

Reduce salinity for agricultural source water in the South Delta through improved outflow patterns and water circulation in the Delta.

Methods

- Construct one or more tide gates, wiers, dams or sills at the head of Old River and possibly other southern Delta locations to manage drainage flows, tidal currents and stages in the San Joaquin and Middle River and interconnecting channels.
- Relocate Delta island drainage to more efficiently route salinity to the Bay and ocean.
- Provide dilution water for salinity control. (This measure would be considered as one possible means of mitigating salinity impacts of other CALFED actions, if such mitigation were necessary.)

Performance Measures

- Reduced salinity loads entering southern Delta channels.

Indicator of Success

- Reduced total dissolved solids in the southern reaches of the Old and Middle Rivers.

Action

Reduce the toxic effects of carbofuran, chlorpyrifos, and diazinon in the Delta and its tributaries through source control of agricultural surface drainage and Delta island drainage.

Method

- Incentives and/or enforcement of existing regulations.
- Incentives for pesticide users to increase implementation of best management practices including integrated pest management and grower education.

Performance Measures

- Reduction of toxicity in Delta channel waters.

Indicator of Success

- Improved survival of test organisms in three-species toxicity bioasssays, and indications through the toxicity identification evaluation testing that pesticides are not a significant cause of toxicity in Delta channels.

- Achievement of Basin Plan objectives for carbofuran when they are promulgated.

Action
Reduce the toxic effects of ammonia entering the Delta and its tributaries through source control of agricultural surface drainage.

Method
- Provide incentives for implementation of best management practices at dairies, other animal operations, and fertilized lands in the watersheds that discharge into the Delta, including the North Bay, and the lower reaches of the Sacramento and San Joaquin Rivers, and westside stream tributaries to the Delta.

Performance Measures
- Reduced toxicity due to ammonia in Delta channels and lower reaches of its tributary streams.

Indicator of Success
- Improved survival of test organisms in three-species toxicity bioasssays, and indications through the toxicity identification evaluation testing that ammonia is not a significant cause of toxicity in Delta channels.
- Achievement of US EPA 304(a) guidelines for ammonia in the Delta and its tributaries.

Action
Reduce the toxic effects of ammonia entering the Delta and its tributaries from waste water treatment plant discharge through improved treatment.

Method
- Provide incentives for improved waste water treatment facilities and processes.

Performance Measure
- Reduced toxicity due to ammonia in Delta channels and lower reaches of its tributary streams.

Indicator of Success
- Improved survival of test organisms in three-species toxicity bioasssays, and indications through the toxicity identification evaluation testing that ammonia is not a significant cause of toxicity in Delta channels.

Water Treatment

Action
Improve treated drinking water quality (including reduction in formation of disinfection by-products) through treatment to reduce concentrations of total organic carbon, pathogens, turbidity, and bromides.

Methods

- Incentives for the addition of enhanced coagulation, ozone, granular activated carbon filtration and/or membrane filtration facilities to the water systems treating water from the Delta.

Performance Measures

- Reliably meet current and future drinking water standards.

Indicator of Success

- Absence of waterbourne disease outbreaks and quantitative evidence of treatment success by measures such as bacteria counts, pathogen counts, and measurements of organic carbon, disinfection byproducts, and turbidity.

Action

Improve total organic carbon, pathogens, turbidity and bromides at domestic water supply intakes.

Method

- Relocate water supply intakes to areas that are not influenced by those discharges.

Performance Targets

- Total organic carbon concentrations 3.0 mg/L (quarterly average).
- Bromide concentrations of 50ug/L (quarterly average).
- Turbidity less than or equal to 50 NTU (monthly median).
- Total dissolved solids less than 220 mg/L (10 year average), or less than 440 mg/L (monthly average).
- Protozoa (Giardia, Cryptosporidium oocysts) less than 1 oocyst/100 L (annual average).

Indicators of Success

- Existing modern, well operated treatment plants can successfully and reliably meet current and future drinking water standards without the need to significantly upgrade facilities.
- Absence of waterbourne disease outbreaks and quantitative evidence of treatment success by measures such as bacteria counts, pathogen counts, and measurements of organic carbon, disinfection byproducts, and turbidity.

Unknown Toxicity

Action

Identify and implement actions to address potential toxicity to water and sediment within the Delta and its tributaries.

Method

- Conducting toxicity testing and toxicity identification evaluations and/or other appropriate methods.
- Coordinate efforts with monitoring programs being conducted by others..

Performance Measure

- Numbers of toxicity bioassays and Toxicity Identification Evaluation test conducted.

Indicator of Success

- Successful identifications of causal agents of toxicity in the channels of the Delta estuary.

Water Management

Action

Reduce the concentration of salinity entering the Delta and its tributaries during low flow periods.

Methods

- Acquiring dilution water from willing sellers.
- Provision of incentives for more efficient water management of dams, including reservoir re-operation.
- Urban water conservation. Conservation might be achieved through use of incentives for implementation of best management practices by more suppliers and water users. Implementation of the action may reduce demand for existing water and may make dilution water available (including transfers), especially on the San Joaquin River
- Greater use of reclaimed wastewater (e.g.,recharge groundwater, treated agricultural drainage, use for agricultural irrigation, recycling and treating for potable or non-potable urban, use of grey water,and storage for use in meeting X2 standards).Reclamation programs would focus on facilities that currently discharge treated wastewater to salt sinks or other degraded bodies of water that are not reusable.
- Enhanced seasonal recharge.
- Development of additional groundwater supplies.

Performance Target

- Reduced salinity loads to the Delta.

Indicator of Success

- Reduced concentrations of total dissolved solids, chloride, and bromide in the San Joaquin River near Vernalis, where the River flows into the Delta.