5-8

146

State of California
The Resources Agency
Department of Water Resources

CONTAMINANT ACCUMULATION IN FISH, SEDIMENTS, AND THE AQUATIC FOOD CHAIN

-

STUDY PLAN W2, PHASE 1 DRAFT REPORT

Oroville Facilities Relicensing
FERC Project No. 2100

↑Hg, PCBs↑
Sharon Copy
DFG

~~JANUARY~~ MARCH 2004

ARNOLD SCHWARZENEGGER Governor State of California	**MIKE CHRISMAN** Secretary for Resources The Resources Agency	**LINDA ADAMS** Interim Director Department of Water Resources

State of California
The Resources Agency
Department of Water Resources

CONTAMINANT ACCUMULATION IN FISH, SEDIMENTS, AND THE AQUATIC FOOD CHAIN

STUDY PLAN W2, PHASE 1 DRAFT REPORT

Oroville Facilities Relicensing
FERC Project No. 2100

This report was prepared under the direction of

Dwight P. Russell .... Chief, Northern District
Glen S. Pearson .... Chief, Special Investigations Branch, Northern District
Terry J. Mills ...... Environmental Program Manager I, Division of Environmental Services

by

Gerald L. Boles .... Chief, Water Quality and Biology Section, Northern District

Assisted by

Scott McReynolds .... Environmental Scientist Range C, Northern District
Mike Hendrick .... Environmental Scientist Range C, Northern District
Ryan Martin .... Environmental Scientist Range C, Northern District
Tom Boullion .... Environmental Scientist Range C, Northern District

Perry LeBeouf.................................. Environmental Scientist Range C, Northern District
Ira Alexander .... Fish and Wildlife Scientific Aid, Northern District
Arin Conner.. Fish and Wildlife Scientific Aid, Northern District
Tom Kraemer.. Fish and Wildlife Scientific Aid, Northern District
Scott Gregory.. Fish and Wildlife Scientific Aid, Northern District
Petra Lee .... Graduate Student Assistant
Peter Coombe... Graduate Student Assistant
Jake Nicholas .... Student Assistant

REPORT SUMMARY

Significant historic and current gold mining, hydropower generation, and industrial activities in the upper Feather River watershed could contribute metal and organic contaminants to project waters. Sediments laden with metals and organic contaminants could undergo biochemical conversion in the reservoirs, become available to biota, and subsequently bioaccumulate in the food web within project waters. A variety of wildlife, including threatened and endangered species, prey on fish from project waters, which also receive significant activity from sport fishermen. This study was undertaken to determine the significance of contamination in fish, crayfish, and sediments in project waters, and evaluate the effect to prey species and humans. The study was divided into two phases. Phase 1 evaluates contaminants in biota and sediments in the project area, while Phase 2 evaluates sources of contaminants, extent of downstream effects, and provides additional information within the project area. This report presents the results of the first phase of the study.

Eleven organic compounds, including two PCB aroclors, were detected in fish from the project area. The contaminants detected in fish include chlordanes (cis-chlordane, trans-chlordane, cis-nonachlor, and trans-nonachlor), dichloro-diphenyl-trichloroethane (DDT) breakdown products (DDD,op', DDD,p,p', DDE,p,p', and DDMU,p,p'), dieldrin, hexachlorobenzene, and polychlorinated biphenyl (PCB) arochlors 1254 and 1260 and congeners. The organophosphate chlorpyrifos was also detected. Only the DDT breakdown product DDE,p,p' and PCB arochlor 1254 were found in crayfish.

Metals detected in fish tissues include arsenic, cadmium, chromium, copper, nickel, lead, selenium, silver, zinc, and mercury. All the metals were also detected in crayfish, except arsenic, cadmium, nickel, and selenium which were not analyzed from these organisms.

Several of the organic and metal contaminants exceed various guidelines or criteria developed to evaluate the significance of contamination and protect wildlife or humans that may eat contaminated fish. Results from this phase of the study will be used to determine analyses required from sediment samples collected during Phase 1, and additional monitoring requirements upstream, within, and downstream from the project area for Phase 2 of the study.

Fish tissue results

21/28 above Hg 0.3 ppm S.V. — 3/28 above DDT tot 100ppb — 18/34 above PCB tot

50% Hg analyses on individual bass fish; organics on composites
50% Hg .. on composite other fish

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1.0 INTRODUCTION

The Environmental Work Group identified contaminant accumulation in fish, sediment, and the aquatic food chain as an issue of concern. Contamination of fish from mercury and other metals and organic contaminants is a significant issue in many areas of California, including the Feather River watershed.

Lake Oroville tributaries in the upper Feather River watershed experienced significant gold mining activity during the Gold Rush era, and continue to experience significant recreational gold mining activity. Numerous large mercury mines were developed in the Coast Range to supply mercury as an amalgam for gold extraction in the Feather River and other areas. Mercury lost to the tributaries during gold mining operations is slowly being transported downstream with sediments. Though the Gold Rush era has long since passed, significant quantities of mercury still remain in the streams tributary to Lake Oroville.

Potentially occurring anoxic conditions beneath the sediment-water interface at the bottom of project reservoirs create ideal conditions for biologically mediated liberation of methylmercury by sulfate-reducing bacteria. The redistribution of methylmercury in the water column during lake mixing in the fall and winter may facilitate bioaccumulation into the food web, including plankton, fish, and piscivorous birds and other animals, including humans.

In addition, other industrial activities in the upper Feather River watershed have contributed metal and organic contaminants, including polychlorinated biphenyls, which also have an affinity for sediments and bioaccumulate in the food web. Re-suspended sediments and recycled metals and organic contaminants in Lake Oroville can be transported downstream to other project waters, including the Diversion Pool, Thermalito Forebay and Afterbay, Oroville Wildlife Area ponds, and Feather River, where uptake and bioaccumulation in aquatic organisms can occur.

Sediments trapped behind the dam are potentially laden with metals and organic contaminants, which may bioaccumulate in the food web. Sediments carried into Lake Oroville initially deposit into the upper tributary arms. Sediment deposits are transported further into the reservoir due to natural high flow hydrologic events, reduced reservoir levels, and periodic discharge surges from upstream hydropower generation.

1.1 BACKGROUND INFORMATION

Sediments in Feather River tributaries are known to carry metal and organic contaminants. Prior to construction of Oroville Dam, sediments carried by the tributaries and the main stem of the Feather River in the reservoir footprint were transported downstream. Subsequent to completion of the dam, sediments carried by the tributaries settle into the upper arms of Lake Oroville, but are reworked by stream flows as reservoir levels drop throughout the summer and are re-deposited further into the reservoir area. Thermal stratification in the reservoir during the summer can facilitate leaching of metals and organic contaminants from the sediments into the water column, where they become available for uptake by aquatic life or release downstream. In addition, sediment dwelling organisms (e.g., crayfish, insects) ingest the sediments and can absorb contaminants. Contaminants in lower trophic levels are bioaccumulated in higher trophic level organisms, and may reach levels that are deleterious to other organisms (including listed species and humans) that ingest them.

Impoundment of the reservoir created conditions in which sediments possibly laden with contaminants are trapped, which could then allow bioaccumulation of contaminants in the food web. Water with bio-available forms of metals and organic contaminants that is released from the reservoir may contribute to bioaccumulation in downstream organisms. Bioaccumulation may not have been significant downstream from the dam prior to its construction because the metals and organic contaminants were bound to the sediment particles, not readily available for uptake, and transported out of the system with higher flows.

The California Department of Water Resources and State Water Resources Control Board had conducted limited sampling for metals in some fish from the reservoir and Feather River downstream from the dam. Analyses of the few fish from Lake Oroville and the Feather River had detected mercury at concentrations that exceed current U.S. Environmental Protection Agency and California Office of Environmental Health Hazard Assessment criteria. These data are not sufficient to determine the magnitude and extent of mercury contamination in fish and other organisms, nor the source.

A variety of wildlife species prey on fish or other aquatic species from project waters. These wildlife species could suffer adverse physiological or reproductive responses from ingestion of prey species containing elevated levels of certain contaminants. Contaminants ingested by wildlife species that prey on aquatic species from project waters can also be bioaccumulated and passed on to other predatory fish and wildlife species that in turn prey on them.

In addition, some contaminants are not strong bioaccumulators (e.g., some metals such as copper and arsenic), but may be mobilized and made available to the biota under certain environmental conditions (e.g., re-suspension of sediment deposits from the arms to the main body, depressed oxygen and pH conditions, etc.) found in the reservoir. Organisms can become re-exposed to contaminants as the lake level drops and deposited sediments are re-suspended and transported further into the reservoir. The shallow, relatively warm, organic rich waters of the Thermalito Forebay and Afterbay could contribute to the methylation of mercury and dissolution of other metals and organic contaminants. Environmental conditions such as these in project water bodies may promote mobilization of sediment bound contaminants and transport out of the "project area" where they could affect threatened and endangered species.

1.1.1 Statutory/Regulatory Requirements

Demonstration of compliance with basin plan objectives is necessary for the SWRCB to issue a water quality certification. Basin plan objectives include provisions against increases in suspended sediment discharges and deposition of material that adversely affect beneficial uses, and toxic substances that produce detrimental effects to humans, plants, animals, and aquatic life. The water quality certification is needed for license renewal with the Federal Energy Regulatory Commission.

1.1.2 Study Area

The study area is generally within the FERC project boundary, but also includes lands adjacent to the project boundary where piscivorous species may occur. The first phase of this study focused on evaluation of contaminants in project waters. Phase 2 will evaluate contamination in reservoir tributaries, additional fish species or areas within project waters, and the Feather River downstream from the project area.

1.1.2.1 Description

Water bodies sampled for Phase 1 of the study included Lake Oroville, Diversion Pool, Thermalito Forebay and Afterbay, low flow section of the Feather River, Feather River immediately downstream from the Afterbay Outlet, and two Oroville Wildlife Area ponds.

1.2 DESCRIPTION OF FACILITIES

The Oroville Facilities were developed as part of the State Water Project, a water storage and delivery system of reservoirs, aqueducts, power plants, and pumping plants. The main purpose of the SWP is to store and distribute water to supplement the needs of urban and agricultural water users in northern California, the San Francisco Bay area, the San Joaquin Valley, and southern California. The Oroville Facilities are also operated for flood management, power generation, to improve water quality in the Delta, provide recreation, and enhance fish and wildlife.

FERC Project No. 2100 encompasses 41,100 acres and includes Oroville Dam and Reservoir, three power plants (Hyatt Pumping-Generating Plant, Thermalito Diversion Dam Power Plant, and Thermalito Pumping-Generating Plant), Thermalito Diversion Dam, the Feather River Fish Hatchery and Fish Barrier Dam, Thermalito Power Canal, Oroville Wildlife Area, Thermalito Forebay and Forebay Dam, Thermalito Afterbay and Afterbay Dam, and transmission lines, as well as a number of recreational facilities. An overview of these facilities is provided on Figure 1.2-1. The Oroville Dam, along with two small saddle dams, impounds Lake Oroville, a 3.5-million-acre-feet capacity storage reservoir with a surface area of 15,810 acres at its normal maximum operating level.

The hydroelectric facilities have a combined licensed generating capacity of approximately 762 megawatts. The Hyatt Pumping-Generating Plant is the largest of the three power plants with a capacity of 645 MW. Water from the six-unit underground power plant (three conventional generating and three pumping-generating units) is discharged through two tunnels into the Feather River just downstream of Oroville Dam. The plant has a generating and pumping flow capacity of 16,950 cfs and 5,610 cfs, respectively. Other generation facilities include the 3-MW Thermalito Diversion Dam Power Plant and the 114-MW Thermalito Pumping-Generating Plant.

Thermalito Diversion Dam, four miles downstream of the Oroville Dam creates a tail water pool for the Hyatt Pumping-Generating Plant and is used to divert water to the Thermalito Power Canal. The Thermalito Diversion Dam Power Plant is a 3-MW power plant located on the left abutment of the Diversion Dam. The power plant releases a maximum of 615 cubic feet per second of water into the river.

The Power Canal is a 10,000-foot-long channel designed to convey generating flows of 16,900 cfs to the Thermalito Forebay and pump-back flows to the Hyatt Pumping-Generating Plant. The Thermalito Forebay is an off-stream regulating reservoir for the 114-MW Thermalito Pumping-Generating Plant. The Thermalito Pumping-Generating Plant is designed to operate in tandem with the Hyatt Pumping-Generating Plant and has generating and pump-back flow capacities of 17,400 cfs and 9,120 cfs, respectively. When in generating mode, the Thermalito Pumping-Generating Plant discharges into the Thermalito Afterbay, which is contained by a 42,000-foot-long earth-fill dam. The Afterbay is used to release water into the Feather River downstream of the Oroville Facilities, helps regulate the power system, provides storage for pump-back operations, and provides recreational opportunities. Several local irrigation districts receive water from the Afterbay.

The Feather River Fish Barrier Dam is downstream of the Thermalito Diversion Dam and immediately upstream of the Feather River Fish Hatchery. The flow over the dam maintains fish habitat in the low-flow channel of the Feather River between the dam and the Afterbay outlet, and provides attraction flow for the hatchery. The hatchery was intended to compensate for spawning grounds lost to returning salmon and steelhead trout from the construction of Oroville Dam. The hatchery can accommodate an average of 8,000 adult fish annually.

The Oroville Facilities support a wide variety of recreational opportunities. They include: boating (several types), fishing (several types), fully developed and primitive camping (including boat-in and floating sites), picnicking, swimming, horseback riding, hiking, off-road bicycle riding, wildlife watching, hunting, and visitor information sites with cultural and informational displays about the developed facilities and the natural environment.

There are major recreation facilities at Loafer Creek, Bidwell Canyon, the Spillway, North and South Thermalito Forebay, and Lime Saddle. Lake Oroville has two full-service marinas, five car-top boat launch ramps, ten floating campsites, and seven dispersed floating toilets. There are also recreation facilities at the Visitor Center and the Oroville Wildlife Area.

The Oroville Wildlife Area comprises approximately 11,000-acres west of Oroville that is managed for wildlife habitat and recreational activities. It includes the Thermalito Afterbay and surrounding lands (approximately 6,000 acres) along with 5,000 acres adjoining the Feather River. The 5,000 acre area straddles 12 miles of the Feather River, which includes willow and cottonwood lined ponds, islands, and channels. Recreation areas include dispersed recreation (hunting, fishing, and bird watching), plus recreation at developed sites, including Monument Hill day use area, model airplane grounds, three boat launches on the Afterbay and two on the river, and two primitive camping areas. DFG's habitat enhancement program includes a wood duck nest-box program and dry land farming for nesting cover and improved wildlife forage. Limited gravel extraction also occurs in a number of locations.

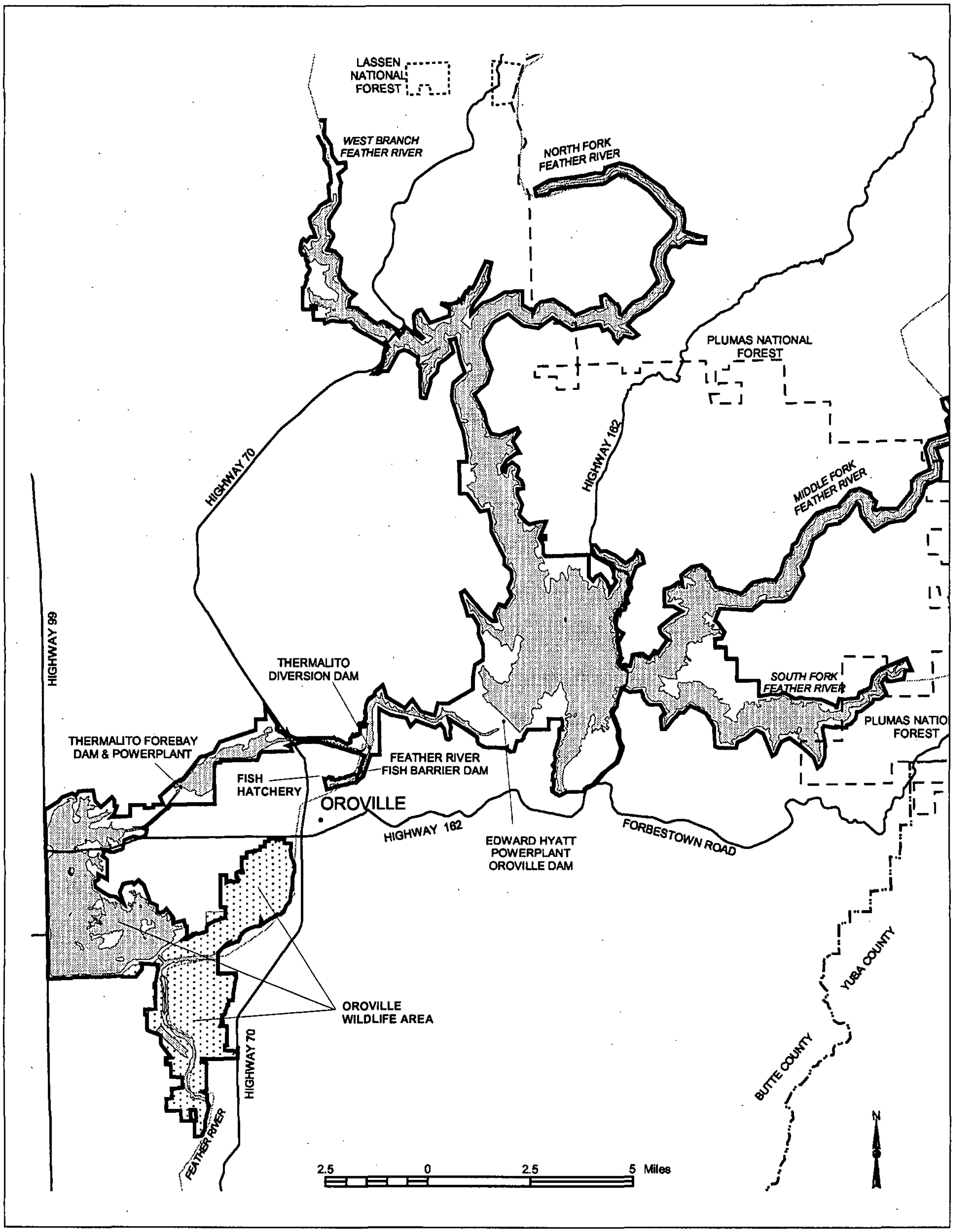


Figure 1.2-1. Oroville Facilities FERC Project Boundary

1.3 CURRENT OPERATIONAL CONSTRAINTS

Operation of the Oroville Facilities varies seasonally, weekly and hourly, depending on hydrology and the objectives DWR is trying to meet. Typically, releases to the Feather River are managed to conserve water while meeting a variety of water delivery requirements, including flow, temperature, fisheries, recreation, diversion and water quality. Lake Oroville stores winter and spring runoff for release to the Feather River as necessary for project purposes. Meeting the water supply objectives of the SWP has always been the primary consideration for determining Oroville Facilities operation (within the regulatory constraints specified for flood control, in-stream fisheries, and downstream uses). Power production is scheduled within the boundaries specified by the water operations criteria noted above. Annual operations planning is conducted for multi-year carry over. The current methodology is to retain half of the Lake Oroville storage above a specific level for subsequent years. Currently, that level has been established at 1,000,000 acre-feet; however, this does not limit draw down of the reservoir below that level. If hydrology is drier than expected or requirements greater than expected, additional water would be released from Lake Oroville. The operations plan is updated regularly to reflect changes in hydrology and downstream operations. Typically, Lake Oroville is filled to its maximum annual level of up to 900 feet above mean sea level in June and then can be lowered as necessary to meet downstream requirements, to its minimum level in December or January. During drier years, the lake may be drawn down more and may not fill to the desired levels the following spring. Project operations are directly constrained by downstream operational constraints and flood management criteria as described below.

1.3.1 Downstream Operation

An August 1983 agreement between DWR and the California Department of Fish and Game entitled, "Agreement Concerning the Operation of the Oroville Division of the State Water Project for Management of Fish & Wildlife," sets criteria and objectives for flow and temperatures in the low flow channel and the reach of the Feather River between Thermalito Afterbay and Verona. This agreement: (1) establishes minimum flows between Thermalito Afterbay Outlet and Verona which vary by water year type; (2) requires flow changes under 2,500 cfs to be reduced by no more than 200 cfs during any 24-hour period, except for flood management, failures, etc.; (3) requires flow stability during the peak of the fall-run Chinook spawning season; and (4) sets an objective of suitable temperature conditions during the fall months for salmon and during the later spring/summer for shad and striped bass.

1.3.1.1 Instream Flow Requirements

The Oroville Facilities are operated to meet minimum flows in the Lower Feather River as established by the 1983 agreement (see above). The agreement specifies that

Oroville Facilities release a minimum of 600 cfs into the Feather River from the Thermalito Diversion Dam for fisheries purposes. This is the total volume of flows from the diversion dam outlet, diversion dam power plant, and the Feather River Fish Hatchery pipeline.

Generally, the instream flow requirements below Thermalito Afterbay are 1,700 cfs from October through March, and 1,000 cfs from April through September. However, if runoff for the previous April through July period is less than 1,942,000 af (i.e., the 1911-1960 mean unimpaired runoff near Oroville), the minimum flow can be reduced to 1,200 cfs from October to February, and 1,000 cfs for March. A maximum flow of 2,500 cfs is maintained from October 15 through November 30 to prevent spawning in overbank areas that might become de-watered.

1.3.1.2 Temperature Requirements

The Diversion Pool provides the water supply for the Feather River Fish Hatchery. The hatchery objectives are 52 °F for September, 51 °F for October and November, 55 °F for December through March, 51 °F for April through May 15, 55 °F for last half of May, 56 °F for June 1-15, 60 °F for June 16 through August 15, and 58 °F for August 16-31. A temperature range of plus or minus 4 °F is allowed for objectives, April through November.

There are several temperature objectives for the Feather River downstream of the Afterbay Outlet. During the fall months, after September 15, the temperatures must be suitable for fall-run Chinook. From May through August, they must be suitable for shad, striped bass, and other warmwater fish.

The National Oceanic and Atmospheric Administration Fisheries has also established an explicit criterion for steelhead trout and spring-run Chinook salmon. Memorialized in a biological opinion on the effects of the Central Valley Project and SWP on Central Valley spring-run Chinook and steelhead as a reasonable and prudent measure; DWR is required to control water temperature at Feather River mile 61.6 (Robinson's Riffle in the low-flow channel) from June 1 through September 30. This measure requires water temperatures less than or equal to 65 °F on a daily average. The requirement is not intended to preclude pump-back operations at the Oroville Facilities needed to assist the State of California with supplying energy during periods when the California ISO anticipates a Stage 2 or higher alert.

The hatchery and river water temperature objectives sometimes conflict with temperatures desired by agricultural diverters. Under existing agreements, DWR provides water for the Feather River Service Area contractors. The contractors claim a need for warmer water during spring and summer for rice germination and growth (i.e., 65 °F from approximately April through mid May, and 59 °F during the remainder of the growing season). There is no obligation for DWR to meet the rice water temperature goals. However, to the extent practical, DWR does use its operational flexibility to accommodate the FRSA contractor's temperature goals.

1.3.1.3 Water Diversions

Monthly irrigation diversions of up to 190,000 (July 2002) af are made from the Thermalito Complex during the May through August irrigation season. Total annual entitlement of the Butte and Sutter County agricultural users is approximately 1 maf. After meeting these local demands, flows into the lower Feather River continue into the Sacramento River and into the Sacramento-San Joaquin Delta. In the northwestern portion of the Delta, water is pumped into the North Bay Aqueduct. In the south Delta, water is diverted into Clifton Court Forebay where the water is stored until it is pumped into the California Aqueduct.

1.3.1.4 Water Quality

Flows through the Delta are maintained to meet Bay-Delta water quality standards arising from DWR's water rights permits. These standards are designed to meet several water quality objectives such as salinity, Delta outflow, river flows, and export limits. The purpose of these objectives is to attain the highest water quality, which is reasonable, considering all demands being made on the Bay-Delta waters. In particular, they protect a wide range of fish and wildlife including Chinook salmon, Delta smelt, striped bass, and the habitat of estuarine-dependent species.

1.3.2 Flood Management

The Oroville Facilities are an integral component of the flood management system for the Sacramento Valley. During the wintertime, the Oroville Facilities are operated under flood control requirements specified by the U.S. Army Corps of Engineers. Under these requirements, Lake Oroville is operated to maintain up to 750,000 af of storage space to allow for the capture of significant inflows. Flood control releases are based on the release schedule in the flood control diagram or the emergency spillway release diagram prepared by the USACE, whichever requires the greater release. Decisions regarding such releases are made in consultation with the USACE.

The flood control requirements are designed for multiple use of reservoir space. During times when flood management space is not required to accomplish flood management objectives, the reservoir space can be used for storing water. From October through March, the maximum allowable storage limit (point at which specific flood release would have to be made) varies from about 2.8 to 3.2 maf to ensure adequate space in Lake Oroville to handle flood flows. The actual encroachment demarcation is based on a wetness index, computed from accumulated basin precipitation. This allows higher levels in the reservoir when the prevailing hydrology is dry while maintaining adequate flood protection. When the wetness index is high in the basin (i.e., wetness in the watershed above Lake Oroville), the flood management space required is at its greatest amount to provide the necessary flood protection. From April through June, the maximum allowable storage limit is increased as the flooding potential decreases, which allows capture of the higher spring flows for use later in the year. During September, the maximum allowable storage decreases again to prepare for the next flood season. During flood events, actual storage may encroach into the flood reservation zone to prevent or minimize downstream flooding along the Feather River.

2.0 NEED FOR STUDY

Information derived from this study will be used to demonstrate compliance with water quality standards and other appropriate requirements in the application for water quality certification. Information from the study is also needed to address DFG, U.S. Forest Service, U.S. Fish and Wildlife Service, and NOAA Fisheries concerns related to fish and wildlife species that feed on potentially contaminated aquatic organisms in the project area.

Analyses of fish tissue for mercury and other metals and organic contaminants are necessary to determine project effects and compliance with Basin Plan objectives. Since recreation, including fishing, is a major beneficial use at project facilities, analysis of fish tissues provides valuable information for fish consumption advisories.

Sediment analysis will help determine whether contamination of biota is attributable to contaminant sources located within the reservoir or upstream from the project area, and if contamination is local or widespread. Certain areas may be less contaminated than others and not warrant the same restrictions as other reservoir locations for consumption of fish. Identification of the location and extent of sediment contamination will be used to develop reservoir management practices (licensing conditions) designed to improve the overall water quality and natural and recreational resources of the reservoir. In addition, sediment contamination information will be used to focus efforts to reduce sediment loading for improvement of water quality in the reservoir.

3.0 STUDY OBJECTIVE(S)

The objectives of the study are to: 1) determine the magnitude and extent of bioaccumulation of metals and organic contaminants in aquatic organisms within the project area, 2) identify sources and potential pathways of contamination that contribute to bioaccumulation including contaminated sediments deposited as a result of project features, operations, and maintenance, and 3) provide information that could be used to develop potential protection, mitigation and enhancement measures.

3.1 APPLICATION OF STUDY INFORMATION

Information from the study will be used to determine compliance with basin plan objectives, which is necessary for the SWRCB to issue a water quality certification. The water quality certification is needed for license renewal with the FERC.

In addition, information from the study will be used to evaluate effects to fish and wildlife species that feed on potentially contaminated aquatic organisms in the project area, which is a concern to several agencies, including the CDFG, USFS, USFWS, and NOAA Fisheries.

OEHHA will use information developed from the study to determine whether risks to human health exist due to consumption of contaminated fish from affected waters. OEHHA may request additional studies to more accurately determine human health risks, or may decide to issue a health advisory suggesting that certain demographic groups limit consumption of fish from the affected waters.

The study will also provide information that may be useful in determining sources of contaminants so that the role of the project in contributing to contamination may be ascertained and remedial measures developed to improve water quality.

4.0 METHODOLOGY

The study was designed to be conducted in phases. The first phase emphasized analysis of metals and organic contaminants in fish, crayfish, and sediments in the project area. The first phase collected fish tissues and sediment samples from 16 locations in the project area, while crayfish were collected from four sites. Sediment samples have been frozen for later analysis. The Environmental Work Group will use the fish tissue and water quality data from Study Plan SPW1 to select a minimum of six sites for sediment samples to be analyzed for methylmercury, total mercury, and PCBs. Additional constituents may be analyzed from these six and any or all of the other ten sediment sampling sites based upon results from fish tissue and water quality analyses. Other sediment may be collected to augment the 16 samples.

The environmental compartments analyzed in subsequent phases, if needed, will be determined in consultation with appropriate resource and health agencies and the Environmental Work Group or Task Force. Analyses in subsequent phases in tributaries to the reservoir would provide background data needed to evaluate the role of the reservoir in bioaccumulation. Subsequent analyses of sediments and additional fish in the project area would provide information to determine the extent and sources of contamination, and species affected. The extent of project related impacts to fish, crayfish, and sediments downstream from the project area would also be analyzed in subsequent phases.

4.1 STUDY DESIGN

Water bodies sampled for Phase 1 of the study include Lake Oroville, Diversion Pool, Thermalito Forebay and Afterbay, low flow section of the Feather River, Feather River immediately downstream from the Afterbay Outlet, and two Oroville Wildlife Area ponds. Tasks undertaken in Phase 1 included sample collection, laboratory analyses, and data interpretation.

Specific fish species sampled was dependent on the types resident in the water body being investigated. Collection of newly planted fish (i.e., less than one year residency) was avoided. Fish species originally targeted from each sampling site included one larger size class of a black bass and a catfish species. Attempts were made to collect ten large bass that are a 'keepable' size as defined in the fishing regulations (i.e., greater than 15 inches in total length), and five catfish from each site. However, not all sites contained the originally targeted species, nor could the desired numbers of fish be collected at each site. The Environmental Workgroup Task Force suggested, based on similar trophic activity, that pikeminnow could be substituted for the bass species, and carp could be substituted for the catfish. The Task Force also determined that sufficient fish had been collected for analysis, though the targeted number was not caught.

Fish were collected beginning in the late spring of 2002 with electroshockers, gill nets, hooks and lines, and seines. Fish were weighed and measured, wrapped in aluminum foil, and immediately frozen for transport to the laboratory.

Crayfish were also collected from several sites within the project area at approximately the same time that the fish were collected. Larger (older) crayfish were targeted. Ten crayfish of similar size from each sampled site were composited. Crayfish were collected by hand, nets, and baited traps. Crayfish were wrapped in aluminum foil and frozen for transport to the laboratory.

Sediments were collected from sites where fish were collected. Sediments were collected with a sediment core sampler in deeper waters, and with a hand corer or teflon spoons in shallower waters following methods of the U. S. Geological Survey (USGS 1994). The top six inches of sediments in ten cores were composited and subsampled into teflon bottles. Sediments collected with teflon spoons from ten areas at shallow monitoring sites were also composited and subsampled into teflon bottles. The bottles have been frozen for later analyses (Dave Crane, DFG Water Pollution Control Laboratory, pers. comm.)

All bass were individually analyzed for total mercury. Subsequently, composites according to species were made of five of the bass and the other fish species at each site for other analyses following the protocol of OEHHA. Each composite was composed of fish with no greater than 25 percent difference in fork length between the largest and smallest individual.

4.1.1 Sampling Sites

Sampling sites for fish, crayfish, and sediments were selected from each of the water bodies associated with the Oroville Facilities. Sampling sites were selected to be representative of the particular water body.

4.1.1.1 Lake Oroville

Screening for fish contamination in Lake Oroville required multiple sampling sites in each arm and the main body due to the size of the reservoir. Fish were collected from two different sampling sites in each of the North, Middle, and South Fork arms and from both the east (Bidwell Marina arm) and west (Spillway arm) sides of the main body of the reservoir (Figure 4.1-1). Bottom sediments were collected at each of these sites. In addition, bass and catfish were collected near the Lime Saddle Marina for polynuclear aromatic hydrocarbon contamination analysis, since the marina environment is the most likely site for PAH accumulation. Fish species caught at these sites included spotted bass, channel and white catfish, and carp (Table 4.1-1).

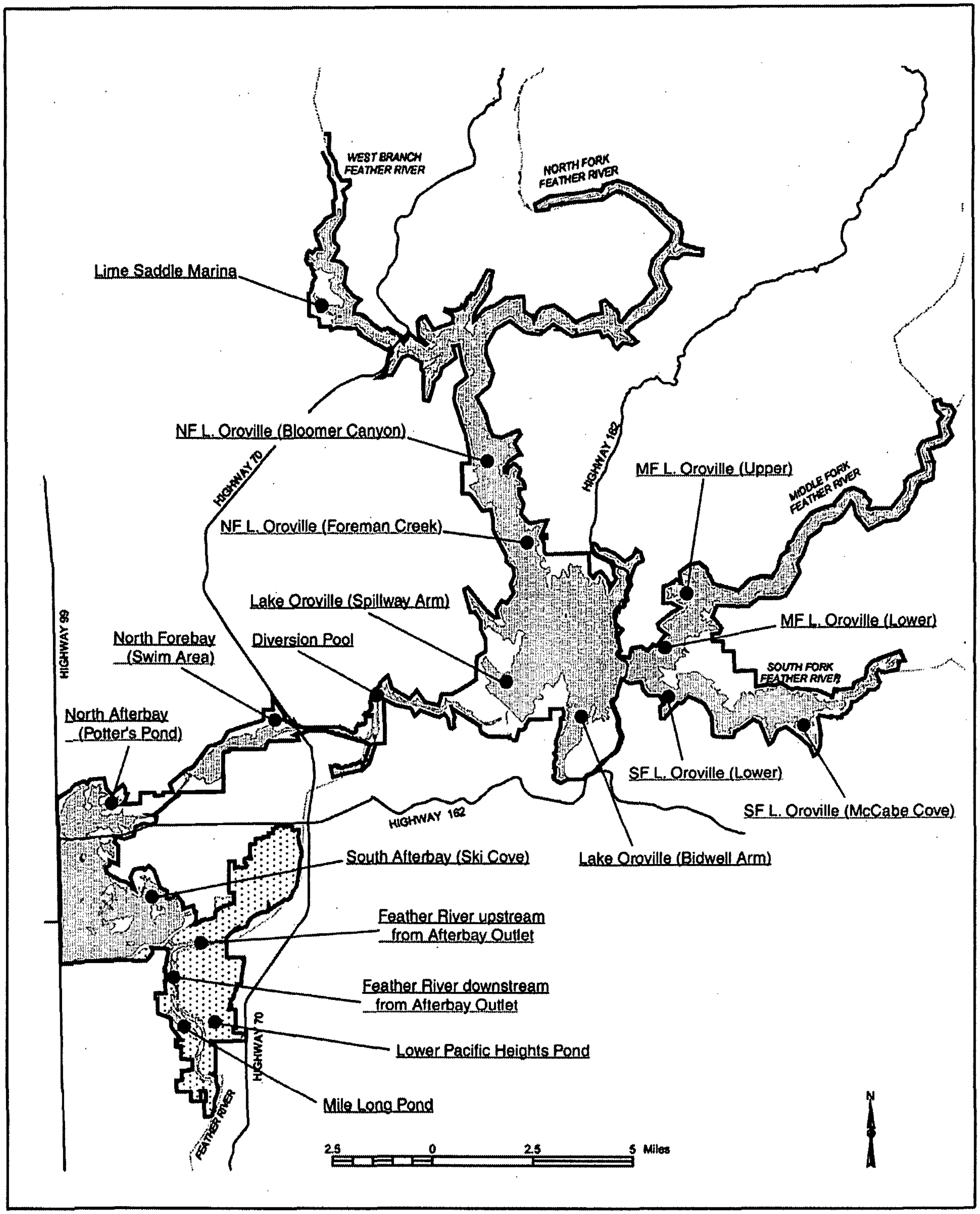

WEST BRANCH FEATHER RIVER
NORTH FORK FEATHER RIVER
Lime Saddle Marina
NF L. Oroville (Bloomer Canyon)
NF L. Oroville (Foreman Creek)
HIGHWAY 70
HIGHWAY 162
MF L. Oroville (Upper)
MIDDLE FORK FEATHER RIVER
Lake Oroville (Spillway Arm)
MF L. Oroville (Lower)
HIGHWAY 99
North Forebay (Swim Area)
Diversion Pool
SOUTH FORK FEATHER RIVER
North Afterbay (Potter's Pond)
SF L. Oroville (Lower)
SF L. Oroville (McCabe Cove)
South Afterbay (Ski Cove)
Lake Oroville (Bidwell Arm)
Feather River upstream from Afterbay Outlet
Feather River downstream from Afterbay Outlet
Lower Pacific Heights Pond
Mile Long Pond
FEATHER RIVER
2.5
0
2.5
5 Miles
N

Figure 4.1-1. Fish, Sediment, and Crayfish Sampling Sites

Table 4.1-1. Fish Collected for Contaminant Analyses from Project Waters

Sampling Location	Bass	Pikeminnow	Catfish	Carp	Crayfish
SF Lake Oroville (McCabe Cove)	9 SB		3 CHC		
SF Lake Oroville (Lower)	7 SB		5 CHC		
MF Lake Oroville (Upper)	7 SB		3 CHC		
MF Lake Oroville (Lower)	5 SB		3 CHC		
NF Lake Oroville (Bloomer Canyon)	10 SB		4 CHC	2	
NF Lake Oroville (Foreman Creek)	10 SB		5 CHC, 3 WHC		
Lime Saddle Marina (West Branch Arm)	10 SB		4 CHC		
Lake Oroville (Spillway Arm)	7 SB		4 CHC		
Lake Oroville (Bidwell Arm)	7 SB		5 CHC		
Diversion Pool					10
North Thermalito Forebay (Swim Area)		10		5	
North Thermalito Afterbay					10
North Thermalito Afterbay (Potter's Pond)	8 LM			3	
South Thermalito Afterbay	8 LM			5	10
Feather River US from Afterbay Outlet	5 LM				
Feather River DS from Afterbay Outlet	10 LM				
Feather River DS Hwy 70					10
Mile Long Pond	8 LM		4 BRB		
Lower Pacific Heights Pond			5 CHC		

SB-spotted bass, LM-largemouth bass, CHC-channel catfish, WHC-white catfish, BRB-brown bullhead

4.1.1.2 Diversion Pool

The Diversion Pool was sampled near the Diversion Dam. Though bass, catfish, carp, or pikeminnow were targeted for collection, none could be obtained. Habitat conditions in the Diversion Pool are not appropriate for the targeted species (Eric See, DWR, pers. comm.). Only crayfish were collected from this site.

4.1.1.3 Thermalito Forebay and Afterbay

Fish could not be obtained from the main Thermalito Forebay. However, collection activities in the North Forebay Recreation Area (swim area) did yield carp and pikeminnow. The Thermalito Afterbay was sampled in both the northern and southern regions, but fish could only be obtained from the south Thermalito Afterbay where largemouth bass and carp were obtained, in addition to crayfish. However, crayfish were obtained from the north Thermalito Afterbay, and largemouth bass and carp were obtained from a waterfowl brood pond, called Potter's Pond, formed in one of the fingers of the north Thermalito Afterbay.

4.1.1.4 Lower Feather River

The Feather River downstream from Oroville Dam was sampled at one site in the low flow section between the fish hatchery and Afterbay Outlet and at another site downstream from the outlet within the project boundary. Largemouth bass were collected from both sites. Crayfish were collected from the low flow section downstream from the Highway 70 bridge.

4.1.1.5 Oroville Wildlife Area

Two representative ponds were sampled in the Oroville Wildlife Area. Warmwater fish species collected from these ponds include largemouth bass and brown bullhead from Mile Long Pond, and channel catfish from the Lower Pacific Heights Pond.

4.1.2 Laboratory Analyses

Analytical procedures generally followed those used in the Toxic Substances Monitoring Program conducted by the SWRCB and DFG (SWRCB 1996). Metals, pesticides, polychlorinated biphenyls, and polynuclear aromatic hydrocarbons were analyzed from fish or crayfish tissues for this study (Table 4.1-2).

Table 4.1-2. Metals and Organic Contaminants Analyzed from Fish and Crayfish

Analyte	Reporting Limit ppb (ng/g)	Analyte	Reporting Limit ppb (ng/g)
Organochlorine Pesticides by EPA Method 8081A			
aldrin	1	dieldrin	1
alpha-BHC	1	endosulfan I	2
beta-BHC	2	endosulfan II	2
gamma-BHC	1	endosulfan sulfate	2
delta-BHC	1	endrin	2
alpha-chlordane	1	endrin aldehyde	2
gamma-chlordane	1	endrin ketone	2
alpha-chlordene	1	heptachlor	1
gamma-chlordene	1	heptachlor epoxide	1
chlorpyrifos	2	Kelthane (dicofol)	2
chlorthal (dacthal)	2	methoxychlor	10
2,4'-DDD	2	mirex	2
2,4'-DDE	2	nonachlor, cis	2
2,4'-DDT	2	nonachlor, trans	2
4,4'-DCBP	2	oxadiazon	2
4,4'-DDD	2	oxychlordane	2

Analyte	Reporting Limit ppb (ng/g)	Analyte	Reporting Limit ppb (ng/g)
4,4'-DDE	2	tetradifon (tedion)	2
4,4'-DDT	2	toxaphene	100
4,4'-DDMU	2		
Polynuclear Aromatic Hydrocarbons by EPA Method 8270C/SIM			
acenaphthene	10	fluoranthene	10
acenaphthylene	10	fluorene	10
anthracene	10	indeno(1,2,3-cd) pyrene	10
benzo(a)anthracene	10	3-methylcholanthrene	10
benzo(b, j&k)fluoranthene	10	1-methylnaphthalene	10
benzo(g,h,i)perylene	10	2-methylnaphthalene	10
benzo(a)pyrene	10	1-methylphenanthrene	70
benzo(e)pyrene	10	naphthalene	10
biphenyl	10	perylene	10
chrysene	10	phenanthrene	10
dibenzo(a,h)anthracene	10	pyrene	10
2,6-dimethylnaphthalene	10	2,3,5-trimethylnaphthalene	10
Polychlorinated Biphenyls (PCB) Congeners by GC/ECD w/congener standards			
Congener	Reporting Limit ppb (ng/g)	Congener	Reporting Limit ppb (ng/g)
8	0.6	128	0.6
15	0.6	132	0.6
18	0.6	137	0.6
27	0.6	138	0.6
28	0.6	149	0.6
29	0.6	151	0.6
31	0.6	153	0.6
44	0.6	156	0.6
49	0.6	157	0.6
52	0.6	158	0.6
66	0.6	167	0.6
70	0.6	169	0.6
74	0.6	170	0.6
77	0.6	174	0.6
81	0.6	177	0.6
87	0.6	180	0.6
95	0.6	183	0.6
97	0.6	187	0.6
99	0.6	189	0.6

Analyte	Reporting Limit ppb (ng/g)	Analyte	Reporting Limit ppb (ng/g)
101	0.6	194	0.6
105	0.6	195	0.6
110	0.6	200	0.6
114	0.6	201	0.6
118	0.6	203	0.6
123	0.6	206	0.6
126	0.6	209	0.6
Organophosphorus Pesticides by EPA Method 8141A			
chlorpyrifos	2	parathion, ethyl	2
diazinon	20	parathion, methyl	4
Metals by EPA Method 6020 (ICPMS)			
arsenic*	0.02	mercury	0.01
cadmium	0.005	nickel	0.01
chromium	0.1	selenium*	0.02
copper	0.006	silver	0.005
lead	0.007	zinc	0.06

* analysis with methanol addition

Methylmercury is assumed to be the form of mercury available for bioaccumulation in the food web. Most mercury in fish tissues is in the methylmercury fraction. Total mercury, however, is typically analyzed from fish tissue and is assumed to represent the methylmercury content of tissues. Fish muscle tissue (filet) is typically analyzed for arsenic, cadmium, nickel, mercury, and selenium, while fish liver is analyzed for copper, zinc, chromium, lead, and silver. The laboratory performed these typical analyses, as well as analyses of all the metals from most filet samples. All organic chemicals in the fish were analyzed from filets. Whole body analyses of metals and organic chemicals were performed on the crayfish. Crayfish were shelled at the laboratory prior to analysis for methylmercury. All analyses for organic contaminants were performed at the California DFG Water Pollution Control Laboratory in Rancho Cordova, while metals analyses were performed at the DFG Moss Landing Marine Laboratories in Monterey.

Bass obtained from each sampling site were individually analyzed for total mercury contamination. Subsequently, up to five fish from each site were composited following OEHHA guidelines (Margie Gassel, OEHHA, pers. comm.). The bass and catfish composites were analyzed for organic and metal contaminants. The composites of bass and catfish collected near the Lime Saddle Marina were analyzed for polynuclear aromatic hydrocarbons. The composited crayfish samples were analyzed for organic and metal contaminants.

Sediment samples from a minimum of six sites will be submitted for organic and metal contaminant analyses following review by the Environmental Work Group or Task Force of the fish and crayfish analysis results. Sediments from these six and possibly other sites will be analyzed for mercury, PCBs, and other metal or organic contaminants identified from the fish or crayfish samples at a level of concern. The sediments will be analyzed at the DFG laboratory.

4.2 DATA INTERPRETATION

Criteria and guidance values for protection of human health and wildlife from contaminant accumulation or ingestion were researched and reviewed for those contaminants identified in the fish from this study. Criteria and guidance values reviewed include numerical criteria and guidance values of the USEPA, OEHHA, SWRCB, U.S. Food and Drug Administration, Food and Agriculture Organization of the United Nations, USFWS, Environment Canada, National Academies of Sciences and Engineering, and New York Department of Environmental Conservation. Unfortunately, few criteria or guidelines have been developed for protection of predatory wildlife species from ingestion of prey containing metal or organic contaminants, though the USFWS and USEPA are beginning efforts to evaluate toxicity data, which may eventually lead to development of protective criteria (Dan Russell, Senior Environmental Contaminant Specialist, USFWS, Sacramento, pers. comm.).

4.2.1 USEPA and OEHHA

The USEPA has recommended screening values for 25 chemical contaminants that have been observed to bioaccumulate in fish tissues (Brodberg and Pollock 1999). The screening value approach is recommended by the USEPA to identify chemical contaminants in fish tissue at concentrations that may be of human health concern for frequent consumers of sport fish. Screening values are not intended to be used for issuance of health advisories, but to identify fish species and contaminants for which more intensive information is needed. The USEPA screening values were calculated for a 70 kg (155 lb.) adult with a fish consumption value of 6.5 g (0.23 oz.) per day. Screening values for use in California lakes were calculated by OEHHA according to USEPA guidance for a 70 kg adult, but using a consumption value of 21 g (0.74 oz.) per day.

As required by Section 304(a) of the Clean Water Act, the USEPA revised the water quality criteria for mercury in 2001 to reflect the latest scientific knowledge on effects to health (USEPA 2001). The USEPA determined that the major pathway for human exposure to methylmercury was through consumption of contaminated fish. Therefore, the USEPA concluded that a fish tissue residue water quality criterion for methylmercury was more appropriate than a water column based water quality criterion. The fish tissue residue criterion for protection of human health was calculated to be 0.3 mg methylmercury/kg of fish.

4.2.2 Toxic Substances Monitoring Program

The SWRCB has conducted the Toxic Substances Monitoring Program since 1976 to provide information on the occurrence of toxic substances in fish and other aquatic life. Results from the TSMP are used by the SWRCB and Regional Water Quality Control Boards in Water Quality Assessment reports to identify impaired waterbodies. The TSMP uses several "criteria" for evaluation of impairment, including the maximum tissue residue level, elevated data level, USFDA action level, NAS guideline, and median international standard.

Maximum tissue residue levels were developed by SWRCB staff from human health water quality objectives in the November 16, 1990 draft Functional Equivalent Document – Development of Water Quality Plans for Inland Surface Waters of California and Enclosed Bays and Estuaries of California, the April 9, 1991 draft Supplement to the Functional Equivalent Document, and the 1997 California Ocean Plan (SWRCB 1996). The MTRLs were calculated by multiplying the draft human health water quality criteria by the bioconcentration factor for each substance, and are an assessment tool for indicating water bodies with potential human health concerns rather than compliance or enforcement criteria. MTRLs are compared only to filet or edible tissue samples and not whole body or liver samples.

Elevated data levels are used by the SWRCB to compare results of current studies with results from previous studies. The EDL is calculated by ranking all of the results for a given chemical from the highest to the lowest concentration measured, including those records where the chemical was not detected. A cumulative distribution is constructed and percentile rankings are calculated. The 85th percentile was chosen by the SWRCB as an indication that a chemical is elevated from the median, while the 95th percentile was chosen to indicate values that are highly elevated above the mean. These measures provide a guide to determine if a chemical has been found in unusually high concentrations, and are not directly related to potentially adverse human or animal health effects.

The USFDA has established maximum concentration levels, termed action levels, for some toxic substances in human foods based on assumptions of the quantities of food consumed by humans and upon the frequency of their consumption (SWRCB 1996). The action levels are intended to protect humans from the chronic effects of toxic substances consumed in foodstuffs.

The NAS and NAE have established recommended maximum concentrations of toxic substances in freshwater fish tissues (NAS 1972). These guidelines established water quality recommendations to protect aquatic organisms as well as the predators of the organisms.

Median international standards for metals were developed from a survey by the FAO of health protection criteria used by member nations. These standards do not apply within the United States, but provide an indication of concentrations of metals that other countries have determined to be elevated in fish tissues.

4.2.3 New York Guidelines

The NYDEC developed guidelines for the protection of fish-eating wildlife. The guidelines are based on the laboratory animal toxicology database used to derive criteria for protection of human health, but were extrapolated from laboratory animals to wildlife. From all target species, the bird and mammal with the greatest ratios of daily food consumption to body weight were used to derive the wildlife criteria (Newell et al. 1987). Because several birds consume about 20 percent of their body weight per day, a generic bird, with a body weight of 1 kg (2.2 lbs.) and food consumption of 0.2 kg (7 oz.) per day, was selected. The mink, with an average body weight of 1 kg and food consumption of 0.15 kg (5.3 oz.) per day, was used to represent fish-eating mammals.

4.2.4 Canadian Tissue Residue Guidelines

Canadian tissue residue guidelines were developed by the National Guidelines and Standards Office of Environment Canada to protect wildlife that consume aquatic biota (EC 2000). The guidelines were calculated from the most sensitive of the available toxicity tests and applied to Canadian species with the largest food intake/body weight ratio, and therefore are conservative guidelines.

4.2.5 U.S. Fish and Wildlife Service

The USFWS published a series of Contaminant Hazard Reviews from 1985 to 1998. Each review evaluated hazards to fish, wildlife, and invertebrates for a specific contaminant. The reviews discuss sources and uses, chemical properties, mode of action, background concentrations, lethal and sub-lethal effects where known, and recommendations of contaminant levels in fish to protect birds and wildlife.

The USFWS also evaluated the USEPA human health criterion for mercury to determine the protectiveness for threatened and endangered wildlife in California (USFWS 2003). The USEPA in 2001 developed a recommended water criterion based on a tissue residue concentration of 0.3 mg/kg in edible portions of fish tissue to protect human health. As part of Endangered Species Act consultation for promulgation of this criterion in California, the USEPA agreed that the human health criterion should be sufficient to protect federally listed aquatic and aquatic-dependent wildlife in California. The USFWS conducted a biological evaluation of the effects of the proposed action on federally listed and proposed threatened and endangered species within California. A "wildlife value" was calculated to protect wildlife species that is analogous to the tissue residue concentration for human health protection. A wildlife value was determined for each species of concern using body weight, total daily food ingestion rate, and a protective reference dose.

5.0 STUDY RESULTS

Eleven organic compounds and two PCB aroclors were detected in fish from Phase 1 of this study (Table 5.0-1). The contaminants detected include several organochlorines, including chlordanes (cis-chlordane, trans-chlordane, cis-nonachlor, and trans-nonachlor), dichloro-diphenyl-trichloroethane (DDT) breakdown products (DDD,op', DDD,p,p', DDE,p,p', and DDMU,p,p'), dieldrin, hexachlorobenzene, and polychlorinated biphenyl (PCB) arochlors 1254 and 1260 and congeners. The organophosphate chlorpyrifos was also detected. Only the DDT breakdown product DDE,p,p' and PCB arochlor 1254 were found in crayfish.

Metals detected in fish tissues include arsenic, cadmium, chromium, copper, nickel, lead, selenium, silver, zinc, and mercury (Table 5.0-2). The metals were also detected in crayfish, except arsenic, cadmium, nickel, and selenium which were not analyzed from these organisms.

5.1 RELATIONSHIP OF RESULTS TO CRITERIA AND GUIDELINES

Organic compounds and metals detected were compared to the guidelines and criteria to determine whether elevated or harmful levels were present in fish from project area waters.

5.1.1 Organic Contaminants

5.1.1.1 Chlordane

The chlordane compounds cis-chlordane and cis-nonachlor were detected in pikeminnow and carp from the North Forebay Recreation Area swim area, carp from the south Thermalito Afterbay, and channal catfish from the Lower Pacific Heights Pond. Trans-chlordane was detected from these same fish, except those from the south Thermalito Afterbay. Trans-nonachlor was detected in channel catfish from all sampling sites in Lake Oroville, and in carp from both North Fork Arm sampling sites. Trans-nonachlor was also detected in Sacramento sucker collected from the Diversion Pool, pikeminnow and carp from the North Thermalito Forebay swim area, carp from the south Thermalito Forebay, and channel catfish from the Lower Pacific Heights Pond. No chlordane compounds were detected in bass or crayfish species from any of the project waters.

None of the individual chlordane compounds exceeded the guidance values, which consist of elevated data levels. However, the sum of the individual chlordane compounds (i.e., total chlordane) exceeded the maximum tissue residue level at each site where any chlordane compounds were detected. No other guidelines or criteria were exceeded.

Table 5.0-1. Detected Pesticides in Fish from the Oroville Facilities (Fresh Weight ppb (ng/g))

			chlordane, cis	chlordane, trans	nonachlor, cis	nonachlor, trans	chlordane (total) (e)	chlorpyrifos	DDD, o,p'	DDD, p,p'	DDE, p,p'	DDMU, p,p'	DDT (total) (f)	dieldrin	hexachloro-benzene (HCB)	Aroclor 1254	Aroclor 1260	PCB (g)	PCB (total)(h)
Maximum Tissue Residue Levels (MTRLs) (for Filets or Edible Tissues) (a)	for Carcinogens in Inland Surface Waters						1.1						32	0.65	6			2.2	
NAS Recommended Guideline for Freshwater Fish (b)	(Whole Fish)						100						1,000	100				500	
FDA Action Level for Freshwater and Marine Fish (c)	(Edible Portion)						300						5,000	300				2,000 (i)	
OEHHA Screening values and action levels in fish tissues (d)	USEPA Value						80	30,000					300	7	70			10	
	OEHHA Value						30	10,000					100	2	20			20	
Elevated Data Levels (a)	Fish Type (h)																		
	Whole Freshwater Fish Calculated Using 1978 - 1995 Data (ppb, wet weight)	EDL 85	30.7	20	16.7	44	128.8	25.4	44	254	1,570	46.4	2,393.40	46.4	3.6	120	77.1	219.6	
		EDL 95	57.9	36	27	65.7	195.1	61.9	140	893	3,490	120	5,037.70	378.5	9.1	358.5	160	472.5	
	Freshwater Fish Filets Calculated Using 1978 - 1995 Data (ppb, wet weight)	EDL 85	12	7.4	5.4	17.2	38.8	<10.0	11	77.6	540	<5.0	667.9	9.4	<2.0	<50.0	54.2	120	
		EDL 95	36.4	21	18	44	117.8	25.7	33.6	232	1,955	36	2,424.40	32.5	5	140.5	180	350	
Median International Standards (	(excludes liver)																		
New York DEC Fish Flesh Criteria	for fish-eating wildlife						500						200	120	330			110	110
Canadian Tissue Residue Guidelines													14						
USFWS Contaminant Hazard Reviews recommendation							300 (USFWS 1990)	2,000 (USFWS 1988a)										Wildlife <100, avian <3,000 (USFWS 1986a)	Wildlife <100, avian <3,000 (USFWS 1986a)
Sample Number	**Station Name**	**Species***	**chlordane, cis**	**chlordane, trans**	**nonachlor, cis**	**nonachlor, trans**	**chlordane (total) (e)**	**chlorpyrifos**	**DDD, o,p'**	**DDD, p,p'**	**DDE, p,p'**	**DDMU, p,p'**	**DDT (total) (f)**	**dieldrin**	**hexachloro-benzene**	**Aroclor 1254**	**Aroclor 1260**	**PCB (g)**	**PCB (total)(h)**
2029-2034	SF Arm Lake Oroville (McCabe Cove)	SPB	ND	<RL	<RL	<RL		ND	ND	1.10	6.40	ND	7.50	<RL	<RL	16	31	47 (j,l,m)	34.991
2038,39 2242	SF Arm Lake Oroville (McCabe Cove)	CHC	<RL	<RL	<RL	2.26	2.26 (j)	ND	ND	2.59	27.8	<RL	30.39 (n)	ND	0.312	37	97 (k)	134 (j,k,l,m,o,p)	88.777
2136-2148	Lower SF Lake Oroville	CHC	<RL	<RL	<RL	2.31	2.31 (j)	ND	<RL	3.57	24.7	<RL	28.27 (n)	<RL	<RL	37	94 (k)	131 (j,k,l,m,o,p)	85.137
2139-2236	Lower SF Lake Oroville	SPB	<RL	<RL	<RL	<RL		ND	ND	<RL	5.21	ND	5.21	<RL	<RL	18	24	42 (j,l,m)	29.33
2125-2135	Upper MF Lake Oroville	CHC	<RL	<RL	<RL	1.79	1.79 (j)	ND	ND	1.37	15.9	<RL	17.27 (n)	0.522	<RL	20	27	47 (j,l,m)	29.093
2126-2132	Upper MF Lake Oroville	SPB	ND	ND	ND	<RL		ND	ND	<RL	2.16	ND	2.16	<RL	<RL	<RL	<RL		4.664
2075-2089	Lower MF Lake Oroville	SPB	ND	<RL	ND	<RL		ND	ND	<RL	2.05	ND	2.05	<RL	<RL	10	<RL	10 (j,m)	8.655
2088-2092	Lower MF Lake Oroville	CHC	<RL	<RL	<RL	3.43	3.43 (j)	ND	ND	2.21	21.0	<RL	23.21 (n)	<RL	<RL	37	66 (k)	103 (j,l,m,p)	66.772
2045-2049	NF L. Oroville (Bloomer Cnyn)	SPB	ND	ND	ND	<RL		ND	ND	<RL	2.24	ND	2.24	<RL	ND	<RL	<RL		7.078
2188-2209	NF L. Oroville (Bloomer Cnyn)	CHC	<RL	<RL	<RL	1.72	1.72 (j)	ND	ND	1.38	15.3	ND	16.68 (n)	0.732 (j)	<RL	27	24	51 (j,l,m)	30.398
2175-2207	NF L. Oroville (Bloomer Cnyn)	CP	<RL	<RL	<RL	1.51	1.51 (j)	ND	ND	1.16	12.9	<RL	14.06 (n)	0.525	<RL	18	12	30 (j,l,m)	20.327
2150-2163	NF L. Oroville (Foreman C)	CHC	<RL	<RL	<RL	1.88	1.88 (j)	ND	ND	1.76	16.6	<RL	18.36 (n)	0.598	<RL	31	20	51 (j,l,m)	31.332
2152-2172	NF L. Oroville (Foreman C)	SPB	<RL	<RL	ND	<RL		ND	ND	<RL	2.29	ND	2.29	<RL	ND	<RL	<RL		7.299
2155-2158	NF L. Oroville (Foreman C)	WHC	<RL	<RL	ND	<RL		ND	ND	ND	3.3	ND	3.30	<RL	ND	<RL	<RL		7.473
2159-2160	NF L. Oroville (Foreman C)	CP	<RL	<RL	<RL	1.58	1.58 (j)	ND	<RL	1.37	15.2	ND	16.57 (n)	<RL	<RL	16	15	31 (j,l,m)	22.023
2064-2068	Lake Oroville Spillway arm	CHC	<RL	<RL	<RL	2.46	2.46 (j)	<RL	ND	2.72	33.7	<RL	36.42 (j)	0.775 (j)	0.710	34	32	66 (j,l,m)	42.282
2061-2073	Lake Oroville Spillway arm	SPB	ND	ND	ND	<RL		ND	ND	<RL	2.43	ND	2.43	ND	<RL	<RL	<RL		8.406
2100-2106	Lake Oroville Bidwell Arm	CHC	<RL	<RL	<RL	2.37	2.37 (j)	ND	ND	2.23	20.5	<RL	22.73 (n)	0.591	0.355	31	49	80 (j,l,m)	50.938
2105-2114	Lake Oroville Bidwell Arm	SPB	ND	<RL	ND	<RL		ND	ND	ND	<RL	ND		<RL	ND	<RL	<RL		5.596
2300-2305	Diversion Pool	SS	<RL	<RL	<RL	2.69	2.69 (j)	ND	<RL	2.13	19.2	<RL	21.33 (n)	<RL	0.832	55 (k)	34	89 (j,l,m)	66.365
5003	Diversion Pool	crayfish	ND	ND	ND	<RL		ND	ND	ND	<RL	ND		<RL	ND	<RL	<RL		3.894
2210-2216	North Thermalito Forebay (swim area)	PM	2.27	1.09	2.61	7.04	13.01 (j)	<RL	<RL	13	86.9	4.71	104.61 (j,l,n)	1.64	1.05	180 (k)	104 (k)	284 (j,k,l,m,o,p)	186.81 (o,p)
2222-2226	North Thermalito Forebay (swim area)	CP	2.86	1.17	2.40	6.64	13.07 (j)	<RL	1.57	11.1	121	3.48	137.15 (j,l,n)	0.738 (j)	0.956	166 (k)	215 (k)	381 (j,k,l,m,o,p)	281.386 (o,p)
5000	North Afterbay	crayfish	ND	ND	ND	<RL		ND	ND	<RL	5.66	ND	5.66	ND	ND	<RL	<RL		7.272
2247-2251	South Thermalito Afterbay (Ski Cove)	LMB	ND	ND	ND	<RL		ND	ND	<RL	4.99	ND	4.99	<RL	ND	<RL	<RL		112.397 (o,p)
2011-2015	South Thermalito Afterbay (Ski Cove)	CP	1.01	<RL	1.26	4.31	6.58 (j)	<RL	1.22	6.31	214	7.82 (k)	229.35 (j,l,n)	0.751 (j)	0.457	81 (k)	68 (k)	149 (j,k,l,m,o,p)	5.59
5002	South Thermalito Afterbay (Ski Cove)	crayfish	ND	ND	ND	ND		ND	ND	ND	2.11	ND	2.11	ND	ND	<RL	<RL		5.933
2183-2232B	Potters Pond	LMB	ND	<RL	ND	<RL		ND	ND	ND	<RL	ND		<RL	ND	<RL	ND		3.365
2227-2241	Potters Pond	CP	<RL	<RL	<RL	<RL		ND	ND	<RL	23.7	ND	23.7 (n)	<RL	ND	19	17	36 (j,l,m)	22.537
2182	Potters Pond	LMB	ND	<RL	ND	<RL		ND	ND	ND	<RL	ND		<RL	ND	<RL	<RL		1.937
5001	Feather R. DS from Hwy 70 #2	crayfish	ND	ND	ND	<RL		ND	ND	ND	3.01	ND	3.01	ND	ND	76 (k)	<RL	76 (j,l,m)	55.978
FR01-05	Feather R US from Afterbay Outlet	LMB	<RL	<RL	ND	<RL		ND	ND	<RL	4.98	ND	4.98	<RL	ND	22	<RL	22 (j,l,m)	15.629
2308-2322	Feather R DS Afterbay Outlet	LMB	ND	ND	ND	<RL		ND	ND	<RL	6.41	ND	6.41	<RL	<RL	24	<RL	24 (j,l,m)	15.008
2311-2320	Feather R DS Afterbay Outlet	LMB	ND	ND	ND	<RL		ND	ND	<RL	5.38	ND	5.38	<RL	<RL	21	<RL	21 (j,l,m)	11.228

Flesh? Whole fish?

Table 5.0-1. Continued.

			chlordane, cis	chlordane, trans	nonachlor, cis	nonachlor, trans	chlordane (total) (e)	chlorpyrifos	DDD, o,p'	DDD, p,p'	DDE, p,p'	DDMU, p,p'	DDT (total) (f)	dieldrin	hexachloro-benzene (HCB)	Aroclor 1254	Aroclor 1260	PCB (g)	PCB (total)(h)
Maximum Tissue Residue Levels (MTRLs) (for Filets or Edible Tissues) (a)	for Carcinogens in Inland Surface Waters						1.1						32	0.65	6			2.2	
NAS Recommended Guideline for Freshwater Fish (b)	(Whole Fish)						100						1,000	100				500	
FDA Action Level for Freshwater and Marine Fish (c)	(Edible Portion)						300						5,000	300				2,000 (i)	
OEHHA Screening values and action levels in fish tissues (d)	USEPA Value						80	30,000					300	7	70			10	
	OEHHA Value						30	10,000					100	2	20			20	
Elevated Data Levels (a)	Fish Type (h)																		
	Whole Freshwater Fish Calculated Using 1978 - 1995 Data (ppb, wet weight)	EDL 85	30.7	20	16.7	44	128.8	25.4	44	254	1,570	46.4	2,393.40	46.4	3.6	120	77.1	219.6	
		EDL 95	57.9	36	27	65.7	195.1	61.9	140	893	3,490	120	5,037.70	378.5	9.1	358.5	160	472.5	
	Freshwater Fish Filets Calculated Using 1978 - 1995 Data (ppb, wet weight)	EDL 85	12	7.4	5.4	17.2	38.8	<10.0	11	77.6	540	<5.0	667.9	9.4	<2.0	<50.0	54.2	120	
		EDL 95	36.4	21	18	44	117.8	25.7	33.6	232	1,955	36	2,424.40	32.5	5	140.5	180	350	
Median International Standards (	(excludes liver)																		
New York DEC Fish Flesh Criteria for fish-eating wildlife							500						200	120	330			110	110
Canadian Tissue Residue Guidelines													14						
USFWS Contaminant Hazard Reviews recommendation							300 (USFWS 1990)	2,000 (USFWS 1988a)										Wildlife <100, avian <3,000 (USFWS 1986a)	Wildlife <100, avian <3,000 (USFWS 1986a)

Sample Number	Station Name	Species*	chlordane, cis	chlordane, trans	nonachlor, cis	nonachlor, trans	chlordane (total) (e)	chlorpyrifos	DDD, o,p'	DDD, p,p'	DDE, p,p'	DDMU, p,p'	DDT (total) (f)	dieldrin	hexachloro-benzene	Aroclor 1254	Aroclor 1260	PCB (g)	PCB (total)(h)
2019-2025	Mile Long Pond	LMB	ND	ND	ND	ND		ND	ND	ND	<RL	ND		<RL	ND	<RL	ND		2.379
2027,28 2243,44	Mile Long Pond	BRB	ND	<RL	ND	<RL		ND	ND	ND	<RL	ND		1.67 (j)	ND	<RL	<RL		2.366
2117-2123	Lower Pacific Heights Pond	CHC	1.04	<RL	1.02	3.12	5.17 (j)	4.18	ND	2.25	56.2	<RL	58.45 (j,n)	0.836 (j)	<RL	54 (k)	27	81 (j,l,m)	48.893
2117-2123 Duplicate	Lower Pacific Heights Pond	CHC	1.03	<RL	1.01	2.94	4.98 (j)	3.97	ND	2.25	53.2	<RL	55.45 (j,n)	0.627	<RL	52 (k)	27	79 (j,l,m)	46.66

* SPB - spotted bass
CHC - channel catfish
CP - common carp
WHC - white catfish
SS - Sacramento sucker
PM - pikeminnow
LMB - largemouth bass
BRB - brown bullhead

a. From SWRCB 1995. Toxic Substances Monitoring Program, 1994-95 Data Report. State Water Resouces Control Board, Sacramento, California.
b. National Academy of Sciences-National Academy of Engineering. 1973. Water Quality Criteria, 1972 (Blue Book). U.S. Environmental Protection Agency, Ecological Research Series.
c. FDA 2000. Action Levels for Poisonous or Deleterious Substances in Human Food and Animal Feed. U.S. Food and Drug Administration. Industry Activities Staff Booklet. Washington, D.C.
d. OEHHA 1999. Prevalence of selected target chemical contaminants in sport fish from two California Lakes: Public Health Designed Screening Study. Office of Environmental Health Hazard Assessment, Sacramento, California
e. Sum of alpha and gamma chlordane, cis- and trans-nonachlor and oxychlordane
f. Sum of ortho and para DDTs, DDDs, and DDEs
g. Expressed as the sum of Aroclors
h. Expressed as sum of congeners
i. A tolerance, rather than an action level, has been established for PCBs (21CFR 109, published May 29, 1984). An action level is revoked when a regulation establishes a tolerance for the same substance and use.
j. Exceeds MTRL
k. Exceeds EDL for fish filets
l. Exceeds OEHHA screening level
m. Exceeds USEPA screening level
n. Exceeds Canadian Tissue Residue guideline
o. Exceeds New York DEC fish flesh criteria for fish-eating wildlife
p. Exceeds USFWS Contaminant Harard Review proposed criteria in diet of wildlife (based on susceptibility of mink)

3/28 above DDT SV.

18/34 above PCB SV.

Table 5.0-2. Metals Results for Fish Collected in 2002 from the Oroville Facilities (criteria and results in mg/kg (ppm))

		Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc
Maximum Tissue Residue Levels (MTRLs) (for Filets or Edible Tissues) (a)	for Carcinogens in Inland Surface Waters	0.2									
	for Non-carcinogens in Inland Surface Waters		0.64				1	28			
NAS Recommended Guideline for Freshwater Fish (b)	(Whole Fish)						0.5				
FDA Action Level for Freshwater and Marine Fish (c)	(Edible Portion)						1.0 (d)				
OEHHA Screening values and action levels in fish tissues (e)	USEPA Value	3 (f)	10				0.6 (g)		50		
	OEHHA Value	1 (f)	3				0.3 (g,n)		20		
Elevated Data Levels (a)	Fish Type (h)	All	All	All	Non / Salmo	All	All	All	All	All	All
	Fish Livers — EDL 85	0.21	0.36	0.03	12 / 170	0.1	ID (j)	<0.10 (i)	3.32	0.26	28
	Fish Livers — EDL 95	0.68	0.99	0.07	33 / 230	0.2	ID	0.2	4.74	0.76	38
	Whole Fish — EDL 85	0.41	0.12	0.23	3.3	0.2	0.11	0.21	1.4	0.02	42
	Whole Fish — EDL 95	0.88	0.19	0.54	4.3	0.46	0.22	0.56	1.9	0.04	49
	Fish Filets — EDL 85	0.14	<0.01 (i)	<0.02 (i)	0.69	<0.10 (i)	0.8	<0.10 (i)	1	<0.02 (i)	21.4
	Fish Filets — EDL 95	0.43	0.01	<0.02 (i)	0.99	<0.10	1.7	<0.10 (i)	1.8	<0.02 (i)	30.2
Median International Standards (a)	(excludes liver)	1.5	0.3	1	20	2	0.5		2		45
Canadian Tissue Residue guidelines							0.033 (y)				
USFWS Contaminant Hazard Reviews		NA (z) (USFWS 1988b)	0.1 (USFWS 1985a)	NA (z) (USFWS 1986b)	NA (z) (USFWS 1998a)	NA (z) (USFWS 1988c)	wildlife: 1.1, avian: 0.1 (USFWS 1987)	wildlife:500; avian: 200 (USFWS1998b)	NA (z) (USFWS 1985b)	6 (USFWS 1996)	300 (z) (USFWS 1993)
USFWS protection of threatened and endangered wildlife							0.3 (aa)				

Station Name	Species (k)	Type	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc
SF Arm Lake Oroville (McCabe Cove)	CHC	flesh	<0.025	<0.002	0.134 (u)	0.29	<0.002	0.876 (r,s,u,w,bb,cc,dd)	<0.002	0.11	<0.002	6.78
SF Arm Lake Oroville (McCabe Cove)	CHC	liver	0.115	0.061	0.477 (t)	4.07	0.038	0.022	0.047	1.72	0.006	18.6
SF Arm Lake Oroville (McCabe Cove)	SPB	flesh	0.188 (u)	<0.002	0.123 (u)	0.24	<0.002	0.722 (r,s,w,bb,cc,dd)	<0.002	0.27	<0.002	5.00
SF Arm Lake Oroville (McCabe Cove)	SPB	liver	0.378 (t)	0.775 (t,bb)	0.125 (t)	6.33	0.005	0.556	<0.002	0.77	0.005	22.1
SF Arm Lake Oroville (Lower)	CHC	liver			0.3 (t)	2.13	0.943 (t)				0.003	19.2
SF Arm Lake Oroville (Lower)	CHC	flesh	<0.025	<.002				1.059 (p,q,r,s,u,w,bb,cc,dd)	0.006	0.16		
SF Arm Lake Oroville (Lower)	SPB	liver			0.27 (t)	2.82	0.070				<.002	19.0
SF Arm Lake Oroville (Lower)	SPB	flesh	0.21 (o,u)	<.002				0.677 (r,s,w,bb,cc,dd)	0.007	0.28		
Upper MF Lake Oroville	CHC	liver			0.48 (t)	2.87	2.581 (t)				<.002	18.4
Upper MF Lake Oroville	CHC	flesh	<0.025	<.002				0.476 (s,bb,cc,dd)	<.002	0.12		
Upper MF Lake Oroville	SPB	liver			0.3 (t)	1.91	0.004				<.002	18.3
Upper MF Lake Oroville	SPB	flesh	0.17 (u)	<.002				0.535 (s,w,bb,cc,dd)	0.024	0.3		
Lower MF Lake Oroville	CHC	flesh	<0.025	<0.002	0.076 (u)	0.38	<0.002	1.614 (p,q,r,s,u,w,bb,cc,dd)	<0.002	0.13	0.004	6.43
Lower MF Lake Oroville	CHC	liver	0.164	0.182 (bb)	0.449 (t)	3.28	0.048	6.513	0.021	2.23	0.006	18.8
Lower MF Lake Oroville	SPB	flesh	0.189 (u)	<0.002	0.124 (u)	0.24	<0.002	0.587 (s,w,bb,cc,dd)	0.018	0.27	<0.002	4.50
Lower MF Lake Oroville	SPB	liver	0.482 (t)	0.066	0.057 (t)	6.11	0.009	0.591	<0.002	0.94	0.009	22.9
NF Arm L. Oroville (Bloomer Cnyn)	CHC	liver			0.56 (t)	2.87	0.089				<.002	18.3
NF Arm L. Oroville (Bloomer Cnyn)	CHC	flesh	0.020	0.003				0.402 (s,bb,cc.dd)	0.135 (u)	0.16		
NF Arm L. Oroville (Bloomer Cnyn)	CP	flesh	0.050	0.006				0.231 (bb,dd)	0.007	0.27		
NF Arm L. Oroville (Bloomer Cnyn)	SPB	flesh	0.242 (o,u)	<0.002	0.096 (u)	0.21	<0.002	0.394 (s,bb,cc,dd)	<0.002	0.27	<0.002	4.36

Table 5.0-2. Continued.

Guideline	Category		Arsenic	Cadmium	Chromium	Copper		Lead	Mercury	Nickel	Selenium	Silver	Zinc
Maximum Tissue Residue Levels (MTRLs) (for Filets or Edible Tissues) (a)	for Carcinogens in Inland Surface Waters		0.2										
	for Non-carcinogens in Inland Surface Waters			0.64					1	28			
NAS Recommended Guideline for Freshwater Fish (b)	(Whole Fish)								0.5				
FDA Action Level for Freshwater and Marine Fish (c)	(Edible Portion)								1.0 (d)				
OEHHA Screening values and action levels in fish tissues (e)	USEPA Value		3 (f)	10					0.6 (g)		50		
	OEHHA Value		1 (f)	3					0.3 (g,n)		20		
Elevated Data Levels (a)	Fish Type (h)		All	All	All	Non	Salmo	All	All	All	All	All	All
	Fish Livers	EDL 85	0.21	0.36	0.03	12	170	0.1	ID (j)	<0.10 (i)	3.32	0.26	28
		EDL 95	0.68	0.99	0.07	33	230	0.2	ID	0.2	4.74	0.76	38
	Whole Fish	EDL 85	0.41	0.12	0.23	3.3		0.2	0.11	0.21	1.4	0.02	42
		EDL 95	0.88	0.19	0.54	4.3		0.46	0.22	0.56	1.9	0.04	49
	Fish Filets	EDL 85	0.14	<0.01 (i)	<0.02 (i)	0.69		<0.10 (i)	0.8	<0.10 (i)	1	<0.02 (i)	21.4
		EDL 95	0.43	0.01	<0.02 (i)	0.99		<0.10	1.7	<0.10 (i)	1.8	<0.02 (i)	30.2
Median International Standards (a)	(excludes liver)		1.5	0.3	1	20		2	0.5				45
Canadian Tissue Residue guidelines									0.033 (y)				
USFWS Contaminant Hazard Reviews			NA (z) (USFWS 1988b)	0.1 (USFWS 1985a)	NA (z) (USFWS 1986b)	NA (z) (USFWS 1998a)		NA (z) (USFWS 1988c)	wildlife: 1.1, avian: 0.1 (USFWS 1987)	wildlife:500; avian: 200 (USFWS1998b)	NA (z) (USFWS 1985b)	6 (USFWS 1996)	300 (z) (USFWS 1993)
USFWS protection of threatened and endangered wildlife									0.3 (aa)				

Station Name	Species (k)	Type	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc
NF Arm L. Oroville (Foreman C)	CHC	liver			0.48 (t)	2.73	0.015				<.002	20.7
NF Arm L. Oroville (Foreman C)	CHC	flesh	0.030	<.002				0.343 (s,bb,cc,dd)	<.002	0.18		
NF Arm L. Oroville (Foreman C)	CP	flesh	0.110	0.005				0.721 (r,s,w,bb,cc,dd)	0.007	0.45		
NF Arm L. Oroville (Foreman C)	SPB	liver			0.26 (t)	1.91	<.002				<.002	18.4
NF Arm L. Oroville (Foreman C)	SPB	flesh	0.100	<.002				0.143 (bb,dd)	<.002	0.13		
NF Arm L. Oroville (Foreman C)	WHC	liver			0.63 (t)	1.85	0.005				<.002	19.3
NF Arm L. Oroville (Foreman C)	WHC	flesh	0.030	<.002				0.38 (s,bb,cc,dd)	<.002	0.15		
Lake Oroville Spillway arm	CHC	flesh	0.029	<0.002	0.175 (u)	0.10	<0.002	0.154 (bb,dd)	<0.002	0.06	<0.002	4.14
Lake Oroville Spillway arm	SPB	flesh	0.228 (o,u)	<0.002	0.073 (u)	0.24	<0.002	0.469 (s,bb,cc,dd)	<0.002	0.26	<0.002	4.68
Lake Oroville Spillway arm	SPB	liver	0.772 (t)	0.087	0.169 (t)	4.39	0.006	0.299	<0.002	1.10	<0.002	22.3
Lake Oroville Bidwell Arm	CHC	flesh	<0.025	<0.002	0.094 (u)	0.23	<0.002	0.973 (r,s,u,w,bb,cc,dd)	<0.002	0.13	<0.002	6.28
Lake Oroville Bidwell Arm	CHC	liver	0.108	0.096	0.296 (t)	3.99	0.219 (t)	2.025	<0.002	1.45	0.002	20.4
Lake Oroville Bidwell Arm	SPB	flesh	0.159 (u)	<0.002	0.141 (u)	0.21	<0.002	0.432 (s,bb,cc,dd)	<0.002	0.27	<0.002	4.85
Lake Oroville Bidwell Arm	SPB	liver	0.673 (t)	0.19 (bb)	0.024	8.36	0.012	0.845	<0.002	1.03	0.013	25.9
North Forebay (Swim Area)	CP	flesh	0.060	<.002				0.146 (bb,dd)	<.002	0.27		
North Forebay (Swim Area)	PM	flesh	0.25 (o,u)	<.002				0.543 (s,w,bb,cc,dd)	<.002	0.17		
South Thermalito Afterbay (Ski Cove)	LMB	flesh	0.080	<0.002	0.077 (u)	0.19	<0.002	0.475 (s,bb,cc,dd)	0.031	0.23	<0.002	4.78
South Thermalito Afterbay (Ski Cove)	LMB	liver	0.291 (t)	0.293 (bb)	0.074 (t)	29.5 (t)	<0.002	0.399	0.025	0.90	0.018	29.6 (t)
South Thermalito Afterbay (Ski Cove)	CP	flesh	0.126	0.007				0.234 (bb,dd)	0.014	0.18		

Table 5.0-2. Continued.

		Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc
Maximum Tissue Residue Levels (MTRLs) (for Filets or Edible Tissues) (a)	for Carcinogens in Inland Surface Waters	0.2									
	for Non-carcinogens in Inland Surface Waters		0.64				1	28			
NAS Recommended Guideline for Freshwater Fish (b)	(Whole Fish)						0.5				
FDA Action Level for Freshwater and Marine Fish (c)	(Edible Portion)						1.0 (d)				
OEHHA Screening values and action levels in fish tissues (e)	USEPA Value	3 (f)	10				0.6 (g)		50		
	OEHHA Value	1 (f)	3				0.3 (g,n)		20		
Elevated Data Levels (a)	Fish Type (h)	All	All	All	Non / Salmo	All	All	All	All	All	All
	Fish Livers EDL 85	0.21	0.36	0.03	12 / 170	0.1	ID (j)	<0.10 (i)	3.32	0.26	28
	Fish Livers EDL 95	0.68	0.99	0.07	33 / 230	0.2	ID	0.2	4.74	0.76	38
	Whole Fish EDL 85	0.41	0.12	0.23	3.3	0.2	0.11	0.21	1.4	0.02	42
	Whole Fish EDL 95	0.88	0.19	0.54	4.3	0.46	0.22	0.56	1.9	0.04	49
	Fish Filets EDL 85	0.14	<0.01 (i)	<0.02 (i)	0.69	<0.10 (i)	0.8	<0.10 (i)	1	<0.02 (i)	21.4
	Fish Filets EDL 95	0.43	0.01	<0.02 (i)	0.99	<0.10	1.7	<0.10 (i)	1.8	<0.02 (i)	30.2
Median International Standards (a)	(excludes liver)	1.5	0.3	1	20	2	0.5		2		45
Canadian Tissue Residue guidelines							0.033 (y)				
USFWS Contaminant Hazard Reviews		NA (z) (USFWS 1988b)	0.1 (USFWS 1985a)	NA (z) (USFWS 1986b)	NA (z) (USFWS 1998a)	NA (z) (USFWS 1988c)	wildlife: 1.1, avian: 0.1 (USFWS 1987)	wildlife:500; avian: 200 (USFWS1998b)	NA (z) (USFWS 1985b)	6 (USFWS 1996)	300 (z) (USFWS 1993)
USFWS protection of threatened and endangered wildlife							0.3 (aa)				

Station Name	Species (k)	Type	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc
Feather R US from Afterbay Outlet	LMB	flesh	0.039	<0.002	0.09 (u)	0.26	<0.002	0.475 (s,bb,cc,dd)	0.016	0.16	<0.002	4.45
Feather R US from Afterbay Outlet	LMB	liver	0.113	0.058	0.109 (t)	1.68	0.003	0.215	0.022	0.63	<0.002	17.4
Feather R DS from Afterbay Outlet	LMB	liver			0.22 (t)	9.23	<.002				<.002	18.0
Feather R DS from Afterbay Outlet	LMB	flesh	0.050	<.002				0.542 (s,w,bb,cc,dd)	<.002	0.20		
Mile Long Pond	BRB	flesh	<0.025	<0.002	0.126 (u)	0.32	<0.002	0.062	0.004	0.04	<0.002	3.85
Mile Long Pond	BRB	liver	<0.025	<0.002	0.111 (t)	2.08	0.008	0.005	0.14 (t)	0.16	0.005	9.23
Potters Pond	CP	flesh	0.060	0.004				0.133 (bb,dd)	0.009	0.18		
Potters Pond	LMB	liver			0.19 (t)	3.53	0.008				<.002	19.0
Potters Pond	LMB	liver			0.23 (t)	3.47	0.004				<.002	18.2
Potters Pond	LMB	flesh	<0.025	<.002				0.26 (bb,dd)	0.123 (u)	0.12		
Lower Pacific Heights Pond	CHC	liver			0.06 (t)	2.05	0.034				0.003	21.0
Lower Pacific Heights Pond	CHC	flesh	<0.025	<.002				0.355 (s,bb,cc,dd)	0.006	0.10		
Diversion Pool	crayfish (l)	crayfish			0.25 (v)	20.3 (v,w)	0.012	0.0325 (dd)			0.006	19.7
N. Afterbay	crayfish (l)	crayfish			0.25 (v)	34.3 (v,w)	0.023	0.022/0.0249			0.011	19.8
S. Afterbay	crayfish (l)	crayfish			0.32 (v)	27.6 (v,w)	0.035	0.0263			0.010	23.0
Feather R DS Hwy 70	crayfish (l)	crayfish			0.26 (v)	22.2 (v,w)	0.025	0.0416 (dd)			0.016	22.5

Table 5.0-2. Continued

a. From SWRCB 1995. Toxic Substances Monitoring Program, 1994-95 Data Report. State Water Resouces Control Board, Sacramento, California.
b. National Academy of Sciences-National Academy of Engineering. 1973. Water Quality Criteria, 1972 (Blue Book). U.S. Environmental Protection Agency, Ecological Research Series.
c. FDA 2000. Action Levels for Poisonous or Deleterious Substances in Human Food and Animal Feed. U.S. Food and Drug Administration. Industry Activities Staff Booklet. Washington, D.C.
d. as methyl mercury.

e. OEHHA 1999. Prevalence of selected target chemical contaminants in sport fish from two California Lakes: Public Health Designed Screening Study. Office of Environmental Health Hazard Assessment, Sacramento, California
f. measured as total arsenic
g. measured as total merucry
h. Non = Includes all non-salmonid species. Salmo = Family Salmonidae (trouts). All = All fish species.
i. < = EDL lies below the indicated detection limit.
j. ID = Insufficient data to calculate the EDL.
k. CHC - channel catfish, SPB - spotted bass, CP - carp, WHC - white catfish, PM - pikeminnow, LMB - largemouth bass, BRB - brown bullhead
l. Analyzed as composites
m. Duplicate
n. As methylmercury; from USEPA 2001. Water Quality Criterion for the Protection of Human Health:Methylmercury. EPA-823-R-01-001.
o. Exceeds MTRL for carcinogens
p. Exceeds MTRL for non-carcinogens
q. Exceeds FDA action level
r. Exceeds USEPA screening level
s. Exceeds OEHHA screening level
t. Exceeds EDL for fish livers
u. Exceeds EDL for fish filets
v. Exceeds EDL for whole fish
w. Exceeds MIS
x. Exceeds NAS guideline
y. As methylmercury
z. No criteria proposed
aa. USFWS 2003. Evaluation of the Clean Water Act Section 304(a) Human Health Crite-rion for Methylmercury: Protectiveness for Threatened and Endangered Wildlife in Cali-fornia. U.S. Fish and Wildlife Service. Sacramento, California.
bb. Exceeds recommended limit in USFWS Contaminant Hazard Review
cc. Exceeds recommendation of USFWS Evaluation of CWA Section 304(a) for Methylymercury
dd. Exceeds Canadian Tissue Guideline

Fish tissue
Hg 21/28 above SV.
range = 0.34–1.61

21 → 10 Bass samples
→ 11 other composite fish samples
channel & white catfish & carp

5.1.1.2 Chlorpyrifos

Chlorpyrifos was detected only in fish from the Lower Pacific Heights Pond. The concentration of chlorpyrifos in the channel catfish collected from this site did not exceed the levels of any guidelines or criteria.

5.1.1.3 DDT Isomers

DDT isomers were detected in fish from all sites except Mile Long Pond, and in all species collected except spotted bass from the Bidwell Arm of Lake Oroville, crayfish from the Diversion Pool, and largemouth bass from Potters Pond, though other species collected from these waters contained detectable levels.

Criteria or guidelines for DDT isomers consist of EDLs, which were not exceeded. Total DDT, which is the sum of the ortho and para isomers, exceeded the MTRL and Canadian tissue residue guidelines in channel catfish from Lake Oroville collected near the spillway and the Lower Pacific Heights Pond. The MTRL and Canadian tissue residue guidelines and OEHHA screening value were exceeded in pikeminnow and carp from the North Thermalito Forebay swim area and carp from the south Thermalito Afterbay. The bass and crayfish species from these same waters contained only a fraction of the level of DDT isomers that were identified in the catfish, pikeminnow, and carp.

5.1.1.4 Dieldrin

Dieldrin was detected in channel catfish, carp, pikeminnow, or brown bullhead from all of the Lake Oroville sampling sites (except those in the South Fork Arm), the North Thermalito Forebay swim area, south Thermalito Afterbay, and Mile Long and Lower Pacific Heights ponds. Dieldrin was not detected in any bass or crayfish species.

The MTRL guideline for dieldrin was exceeded in channel catfish from Lake Oroville in the Bloomer Canyon area of the North Fork Arm and near the spillway, and from the Lower Pacific Heights Pond. Dieldrin also exceeded this guideline in carp collected from the North Thermalito Forebay swim area and south Thermalito Afterbay. Brown bullhead from Mile Long Pond also had dieldrin levels that exceeded the MTRL.

5.1.1.4. Hexachlorobenzene

Hexachlorobenzene was detected in channel catfish from Lake Oroville from the South Fork Arm near McCabe Cove and from the main body near the spillway as well as the Bidwell arm. Sacramento sucker from the Diversion Pool, pikeminnow and carp from the North Thermalito Forebay swim area, and carp from the south Thermalito Afterbay also contained detectable levels of hexachlorobenzene, but none was detected in any bass or crayfish species.

None of the fish contained hexachlorobenzene at levels that exceeded any guidance values or criteria.

5.1.1.5 PCB

PCBs were detected in all fish and crayfish species from all water bodies that were sampled, while PCB Aroclors were detected in at least some fish in all water bodies (except Mile Long Pond) and in crayfish in the Feather River downstream from the Highway 70 bridge. The EDL for Aroclor 1254 was exceeded in Sacramento sucker collected from the Diversion Pool, pikeminnow and carp from the North Thermalito Forebay swim area, carp from the south Thermalito Afterbay, crayfish from the Feather River downstream from the Highway 70 bridge, and channel catfish from the Lower Pacific Heights Pond. The EDL for Aroclor 1260 was exceeded in channel catfish from both South Fork Arm collection sites and the lower Middle Fork Arm of Lake Oroville, pikeminnow and carp from the North Thermalito Forebay swim area, and carp from the south Thermalito Afterbay.

Bass contained PCBs at much lower levels than found in other fish species. However, spotted bass collected from both South Fork arms of Lake Oroville and largemouth bass collected from the Feather River both upstream and downstream from the Afterbay Outlet to the river contained total PCBs (as the sum of Aroclors) that exceeded the MTRL and screening values of the USEPA and OEHHA, while spotted bass from the lower Middle Fork Arm of Lake Oroville contained total PCBs that exceeded the MTRL and were at the same concentration as the USEPA screening value. Total PCBs (as the sum of Aroclors) exceeded the MTRL and USEPA and OEHHA screening values in channel catfish from all sites where this species was collected, which included all the Lake Oroville sampling sites and Lower Pacific Heights Pond. In addition, channel catfish from the lower Middle Fork Arm of Lake Oroville exceeded the USFWS contaminant hazard recommendation for wildlife (USFWS 1986a), while those from both South Form Arm collection sites also exceeded the EDL, New York criteria for fish-eating wildlife, and USFWS contaminant hazard recommendation for wildlife. Both pikeminnow and carp collected from the North Thermalito Forebay swim area exceeded the MTRL, EDL, USEPA and OEHHA screening values, New York criteria for fish-eating wildlife, and USFWS contaminant hazard recommendation for wildlife. Carp collected from both North Fork arms of Lake Oroville, south Thermalito Afterbay, and Potters Pond, Sacramento sucker collected from the Diversion Pool, and crayfish collected downstream from the Highway 70 bridge exceeded the MTRL and USEPA and OEHHA screening values for total PCBs as the sum of Aroclors. In addition, the EDL, New York criteria for fish-eating wildlife, and USFWS contaminant hazard recommendation for wildlife were exceeded in carp collected from the south Thermalito Afterbay.

5.1.2 Metal Contaminants

5.1.2.1 Arsenic

The MTRL for arsenic was exceeded in spotted bass from the lower South Fork Arm, Bloomer Canyon area of the North Fork Arm, and spillway arm of Lake Oroville, and in pikeminnow from the North Thermalito Forebay swim area. Arsenic was detected at levels that exceeded the EDL for filets in spotted bass from all of the Lake Oroville sampling areas, except the Foreman Creek area of the North Fork Arm, and in pikeminnow from the North Thermalito Forebay swim area. The EDL for liver was exceeded in spotted bass from the McCabe Cove area in the South Fork Arm, lower Middle Fork Arm, spillway arm, and Bidwell arm of Lake Oroville, and in largemouth bass from the south Thermalito Afterbay ski cove. Channel and white catfish and carp contained the lowest arsenic levels in tissues.

Arsenic is a relatively common element that occurs in air, water, soil, and all living tissues (USFWS 1988b). While arsenic is carcinogenic in humans, evidence of arsenic-induced carcinogenicity in other mammals is scarce. Evidence also indicates that arsenic is nutritionally essential or beneficial. Arsenic deficiency effects, such as poor growth, reduced survival, and inhibited reproduction, has been observed in mammals fed diets containing less than 0.05 mg arsenic/kg, but not in those fed diets with 0.35 mg/kg. In addition, while arsenic may be bioconcentrated by organisms, it is not biomagnified in the food chain. Criteria for the protection of wildlife have not been developed (EC 2000, Newell et al. 1987, USFWS 1988b).

Arsenic detected in fish from the South and North Fork arms and spillway area of Lake Oroville, and the North Thermalito Forebay are considered to be at levels that may pose a potential human health concern (SWRCB 1996), but did not exceed any compliance or enforcement criteria. Arsenic was present in fish from most lake sampling sites that exceeded the 85th percentile EDL, which indicates that this element is elevated from the median found in other water bodies sampled by the TSMP, but these concentrations are not directly related to potentially adverse human or animal health effects. Arsenic levels in fish filets were less than levels found to be nutritionally beneficial in mammals, which suggests that arsenic levels in fish from project area waters may not pose undue risk to wildlife. Arsenic levels in liver from some fish were elevated from the median found in other water bodies sampled by the TSMP and greater than levels found to be nutritionally beneficial. However, liver represents only a small portion of the whole fish that wildlife would consume, and thus would not be expected to be of concern.

5.1.2.2 Cadmium

Cadmium was detected in liver in spotted bass from the McCabe Cove area of the South Fork Arm of Lake Oroville that exceeded the EDL. The USFWS recommended that wildlife dietary levels exceeding 0.1 mg of cadmium/kg fresh weight of prey on a sustained basis should be viewed with caution (USFWS 1985a).

Cadmium is a relatively rare heavy metal. No evidence is available to indicate that cadmium is biologically essential, but cadmium is a known teratogen and carcinogen, a probable mutagen, and has been implicated as causing severe deleterious effects to fish and wildlife (USFWS 1985a). Freshwater aquatic organisms can accumulate measurable amounts of cadmium from water containing low levels of cadmium.

Cadmium levels in fish flesh tissue from all sampling sites were always at low levels, either below or near detection levels. However, cadmium levels in liver from spotted bass from the McCabe Cove area and Bidwell Arm, and in channel catfish from the lower Middle Fork Arm of Lake Oroville exceeded the USFWS (1985a) recommendation for cadmium levels in prey species for protection of wildlife. The recommended level for wildlife protection was also exceeded in liver in largemouth bass from the Thermalito Afterbay near the ski cove. Since liver represents only a small portion of a fish, the amount of cadmium that wildlife would ingest from eating fish from project waters should be well below the level recommended by the USFWS for their protection.

5.1.2.3 Chromium

The EDL for fish filets is less than the 0.02 detection level for chromium. All fish filets and livers from all sampling sites, except liver from spotted bass from the Bidwell Arm of Lake Oroville, exceeded EDLs. The EDL for chromium in whole fish was exceeded in crayfish from each of the four sites sampled.

Chromium is an essential trace element in humans and some species of laboratory animals, but data are incomplete to determine chromium needs of other species (USFWS 1986b). At high environmental concentrations, chromium is a mutagen, teratogen, and carcinogen. Biomagnification has not been observed in the food web, and highest concentrations are usually observed at the lowest trophic levels. One of the difficulties in establishing criteria for the protection of wildlife is that sensitivity to chromium varies widely, even amongst closely related species. Adverse effects to sensitive species of wildlife have been documented at chromium levels of 5 to 10 mg/kg of diet.

No guidelines or recommendations are available for levels of chromium to protect wildlife (EC 2000, Newell et al. 1987, USFWS 1986b). However, chromium levels detected in fish from project area waters were only a fraction of the levels identified as harmful to sensitive species of wildlife. Therefore, adverse effects to wildlife from chromium levels in fish from project area waters is not expected to result in deleterious effects.

5.1.2.4 Copper

Copper levels in fish only exceeded the EDL for liver from largemouth bass collected from the ski cove area of the Thermalito Afterbay. Copper concentrations in crayfish from all four sampling sites exceeded the EDL for whole fish as well as the median international standard.

Copper is abundant in the environment and essential for normal growth and metabolism of all living organisms (USFWS 1998a). Copper is amongst the most toxic of the heavy metals in freshwater biota, and often accumulates to levels causing harm that are just above those required for growth and reproduction. Birds and mammals, in comparison to lower forms, are relatively resistant to copper. Bioavailability and toxicity of copper to aquatic organisms is dependent upon the total copper concentration and speciation. Toxicity to aquatic life is related primarily to the dissolved cupric ion and possibly hydroxy complexes. Cupric ion accounts for less than a percent of the dissolved copper in fresh water. Numerous and disparate copper criteria have been proposed for protecting the health of agricultural crops, aquatic life, terrestrial invertebrates, poultry, laboratory white rats, and humans, but no copper criteria are available for protection of avian and mammalian wildlife.

Exceedence of the EDL in the fish and crayfish indicates that copper levels are higher than the median found in other water bodies, but is not directly related to potentially adverse human or animal health. The levels of copper found in crayfish are higher than levels that other countries have determined to be elevated in fish tissues, but this standard does not apply within the United States.

5.1.2.5 Lead

Lead was generally not detected or detected only at low levels. However, liver samples from channel catfish collected from the lower South Fork, upper Middle Fork, and Bidwell arms of Lake Oroville exceeded the EDL for lead.

Lead is neither essential nor beneficial to living organisms, and may adversely affect survival, growth, reproduction, development, behavior, learning, and metabolism (USFWS 1988c). Food web biomagnification of lead is negligible, and younger organisms are more susceptible than older individuals. Guidelines for protection of wildlife from lead levels contained in prey have not been developed (EC 2000, Newell et al. 1987, USFWS 1988c), though reduced survival has been documented in sensitive species of birds at doses of 50 to 75 mg of lead/kg of body weight. Data are unavailable for toxic and sublethal effects of lead to mammalian wildlife.

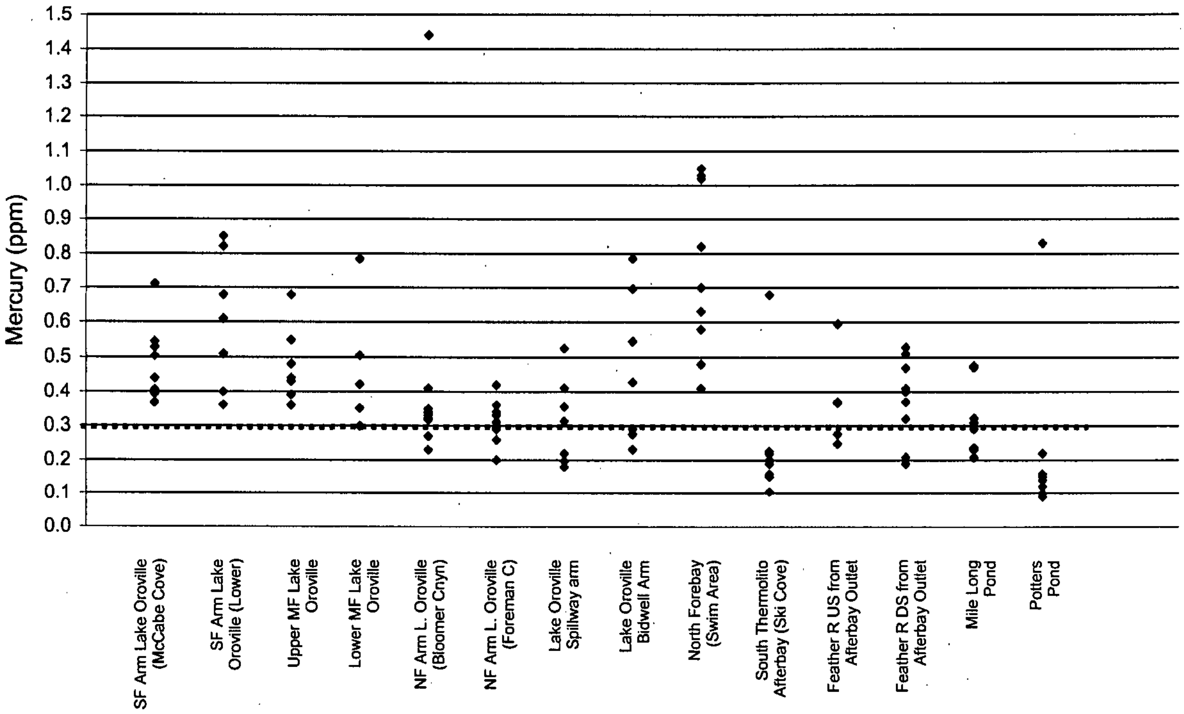
5.1.2.6 Mercury

Fish composites exceeded the OEHHA screening value or USEPA criterion for protection of human health for mercury in filets from every sampling site except Mile Long and Potter's ponds. Highest levels of mercury in fish filets, which exceeded the MTRL, were found in the lower South Fork and Middle Fork arms of Lake Oroville. The EDL was exceeded in fish from both sampling sites in the South Fork, lower Middle Fork, and Bidwell arms of Lake Oroville, while the MIS was exceeded in both of the South Fork and Middle Fork, the Foreman Creek area of the North Fork, and the Bidwell arms of Lake Oroville, the North Thermalito Forebay swim area, and the Feather River downstream from the Afterbay Outlet. Both the Canadian tissue (EC 2000) and USFWS (1987) guidelines for protection of wildlife from ingesting contaminated prey were exceeded at all stations except Mile Long Pong. The USFWS recommendation for protection of wildlife from methylmercury ingested from prey (USFWS 2003) was exceeded in fish from all sampling sites except Mile Long and Potter's ponds. Mercury levels in~~ all the~~ crayfish composites was at or exceeded ~~all the applicable guidelines and criteria, including the MTRL, NAS guideline, FDA action level, USEPA and OEHHA screening values, EDL, MIS,~~the Canadian tissue residue guideline~~, and wildlife and avian protection recommendations of the USFWS.~~ from the Diversion Pool and Feather River downstream from Highway 70. However, total mercury was analyzed from the crayfish, while the guideline is for methylmercury. While the total mercury in fish is assumed to represent methylmercury, sufficient analyses are not available to determine if a similar relationship exists in crayfish.

Analyses of mercury from individual fish show the OEHHA screening value and USEPA criterion for protection of human health was exceeded at most sampling sites, as was the recommendation of the USFWS for protection of threatened and endangered wildlife (Figure 5.1.2-1). Most fish from the Thermalito Afterbay, which was sampled in the area of the ski cove and Potter's Pond, had levels of mercury that were less than the screening value, health criterion, and protection guideline.

Mercury has no known beneficial biological function, and can be bioconcentrated in organisms and biomagnified though the food web (USFWS 1987). Mercury is a mutagen, teratogen, and carcinogen, and causes embryocidal, cytochemical, and histopathological effects. Earlier studies have indicated that total mercury concentrations in prey items for the protection of sensitive species of mammals and birds that regularly consume fish and other aquatic organisms should not exceed 0.1 mg/kg fresh weight for birds and 1.1 mg/kg for small mammals. Criteria for methylmercury in fish of 0.3 mg/kg have been developed for protection of human health (USEPA 2001). The USEPA, in consultation with the USFWS, concluded that this criterion should also be protective of federally listed aquatic and aquatic dependent wildlife species in California (USFWS 2003). However, evaluation of this criterion indicates that certain species may be protected, depending upon which trophic level analysis approach is used, but that others are still susceptible to adverse effects at concentrations of mercury less than the criterion.

Figure 5.1.2-1. Mercury levels in individual fish from project waters (species included spotted bass from Lake Oroville, pikeminnow from the Thermalito Forebay, and largemouth bass from the Thermalito Afterbay, Feather River, and ponds)



5.1.2.7 Nickel

Nickel was either not detected or detected at low levels in fish tissues, except in filets from channel catfish from the Bloomer Canyon area of the North Fork Arm of Lake Oroville and largemouth bass from the Potter's Pond brood pond in the north Thermalito Afterbay, and in liver from brown bullhead collected from Mile Long Pond. The nickel levels detected in these fish exceeded the EDL.

Nickel is abundant in the environment, and is essential for the normal growth of many species (USFWS 1998b). At high levels, nickel may be carcinogenic. Bird diets should contain at least 50 mg/kg of ration to prevent nickel deficiency but less than 200 mg/kg of ration for young birds and 800 mg/kg of ration for adults to prevent adverse effects on growth and survival. Most species of mammals evaluated had normal growth and survival during chronic exposure in diets containing 0.8 to 40 mg/kg. Sensitive species of wildlife sometimes exhibited reduced growth and survival when fed diets containing 500 to 2,500 mg of nickel/kg ration. However, further research is needed to clarify the role of nickel in mammalian nutrition and health effects. Nickel levels detected in fish from project waters were well below levels recommended for protection from ingestion of prey by avian species and levels found to be acceptable in mammals (USFWS 1998b).

5.1.2.8 Selenium and Silver

Selenium was detected in fish at low levels, while silver was either not detected or detected only at low concentrations.

Neither selenium nor silver exceeded any of the guidelines or criteria, including those developed to protect avian and wildlife predators from prey containing elevated levels of silver (USFWS 1996); predator protection guidelines have not been developed for selenium (EC 2000, Newell et al. 1987, USFWS 1985b).

5.1.2.9 Zinc

Zinc was detected in all fish samples, but only the EDL was exceeded for liver in largemouth bass from the Thermalito Afterbay ski cove.

Zinc is naturally present in the environment, but often is found at elevated levels due to anthropogenic sources (USFWS 1993). Zinc deficiency occurs in many species of plants and animals, which has severe adverse effects on all stages of growth, development, reproduction, and survival. Avian diets should contain at least 25 mg of zinc/kg of ration to prevent zinc deficiency but less than 178 mg/kg of ration to prevent marginal sublethal effects. Mammals are comparatively resistant to zinc as evidenced by tolerance to extended periods on diets containing over 100 times the minimum daily zinc requirement. The most sensitive species of mammals were adversely affected at dietary concentrations of 90 to 300 mg of zinc/kg ration.

Zinc levels found in fish were well below the guideline suggested for protection of wildlife from ingestion of prey containing zinc (USFWS 1993).

5.2 COMPARISON OF FISH TISSUE TO WATER QUALITY RESULTS

Contaminants can bioaccumulate in the aquatic food web through both water-borne and sediment-borne sources. Sediments collected for Phase 1 have not yet been analyzed for contaminants. Results from fish tissue analyses were compared to concentrations of organic compounds and metals that have been found in project area waters in Study Plan SPW1 to evaluate water-borne contaminants as a source to the food web.

Water samples for organic and metal contaminant analyses were collected from project area waters near many of the locations that were sampled for fish tissue analyses. Water quality monitoring sites that correspond to fish sampling sites include the North Fork Arm near Bloomer Canyon, upper Middle Fork Arm, South Fork Arm near McCabe Cove, and near the dam of Lake Oroville. Water samples for organic and metal contaminant analyses were also collected from the Diversion Pool, north Thermalito Forebay, north and south Thermalito Afterbay, Feather River upstream and downstream from the Afterbay Outlet, and Mile Long and Lower Pacific Heights ponds.

5.2.1 Organic Contaminants

Samples for organic analyses were collected in November 2002, and February and November 2003. Sample analyses were conducted by the DWR Bryte Chemical Laboratory in Sacramento.

Organic contaminants were not reported from any of the sampled waters at levels that exceeded the detection level.

Though potential organic contaminants were not detected in the water samples, water could still be a source of some contamination of food web organisms. Phytoplankton can accumulate low concentrations of contaminants from the surrounding water. As these organisms are eaten by other species, the low levels of contaminants assimilated by phytoplankton can bioaccumulate in the food web. Over time, sufficient bioaccumulation can occur in higher trophic levels so that even negligible concentrations of contaminants in water can become detectable in higher trophic level organisms.

5.2.2 Metal Contaminants

Metals analyses have been conducted monthly since initiation of monitoring for SPW1 in March 2002. Metals were analyzed by Frontier Geosciences in Washington and Bryte Chemical Laboratory in Sacramento.

While some metals were detected from each of the project area waters that were sampled, only arsenic, cadmium, copper, and lead were at levels in at least some of the water bodies that exceeded water quality criteria for the protection of human health or aquatic life (Appendix A).

5.2.2.1 Arsenic

Arsenic exceeded the OEHHA cancer potency factor for drinking water (CVRWQCB 2003) and USEPA (1999) water quality criteria for protection of human health through ingestion of water as well as aquatic organisms in every water sample that was collected. The highest arsenic level reported in water was 2.81 ug/L from the Lower Pacific Heights Pond, which is well below the 150 ug/L chronic criterion of the California Toxics Rule for the protection of freshwater aquatic life (CVRWQCB 2003). Arsenic in some project area waters apparently is bioaccumulating in some fish, but not to particularly elevated levels.

5.2.2.2 Cadmium

Cadmium was generally not detected or detected only at very low levels in all project area waters. However, several water bodies exhibited elevated cadmium levels in single samples. The public health goal and California Toxics Rule criterion to protect freshwater aquatic life for total recoverable cadmium (SWRCB 2003) were exceeded in one bottom sample from the Middle Fork Arm of Lake Oroville, north Thermalito Forebay, and south Thermalito Afterbay. The public health goal was also exceeded in a bottom water sample from the Diversion Pool as well as a water sample from the Feather River downstream from the Afterbay Outlet. All other analyses from each of these sites reported cadmium at non-detectable levels or levels just above the detection limit, which is well below any criterion. Cadmium was either not detected or reported at low levels in fish flesh from project area waters, except in liver from some fish collected from the Middle and South forks and Bidwell arm of Lake Oroville and the south Thermalito Afterbay, in which the recommended limit in fish tissue was exceeded. Though generally reported at very low levels in water samples, cadmium apparently is bioaccumulating in fish livers, but not to a significant amount in fish flesh. Since fish livers represent only a small portion of a fish that a predator would eat, adverse effects to wildlife from eating fish from project area waters should not pose any undue risk.

5.2.2.2 Chromium

Reported levels of chromium did not exceed any water quality criteria in project area waters. Chromium concentrations in project area waters were either below detection limits or at low levels. Since chromium does not biomagnify in the food web, adverse effects to food web organisms are not anticipated from those levels identified in project area waters.

5.2.2.4 Copper

Copper was usually reported at low levels from project area waters, but was sometimes reported at levels that exceeded the California Toxics Rule criterion to protect freshwater aquatic life in bottom water samples collected from the North, Middle, and South Fork arms of Lake Oroville, Diversion Pool, north Thermalito Forebay, and north and south Thermalito Afterbay, and mid-depth samples from Lake Oroville near the dam. The public health goal, maximum contaminant level for drinking water, agricultural goal, and California Toxics Rule for protection of human health were also exceeded in some water samples from the north Thermalito Forebay, while the public health and agricultural goal were exceeded in a bottom water sample from the South Fork Arm of Lake Oroville. Though significant concentrations of copper were reported in some water samples from many project area waters, levels in fish tissue were higher than fish from most other water bodies sampled by the TSMP only from the south Thermalito Afterbay, which may indicate that most copper found from project area waters is not in a bioavailable form.

5.2.2.5 Lead

Lead also was usually reported at low levels in water samples from project area waters. However, total recoverable lead levels exceeded the California Toxic Rule for protection of aquatic life in a bottom water sample from the Middle Fork Arm of Lake Oroville and north Thermalito Forebay, and a surface water sample from the south Thermalito Afterbay. Lead was not detected in fish at significant levels, except in liver samples from channel catfish at higher levels than most other lakes sampled by the TSMP. Generally low levels of lead in water, insignificant concentrations of lead in fish tissue, and reported negligible food web biomagnification indicate that lead is not a critical contaminant in project area waters.

5.2.2.6 Mercury

While total mercury and methylmercury levels in project area waters did not exceed any criteria, significant contamination in fish was identified. Mercury was reported in fish at levels that exceed criteria to protect human health as well as wildlife. Though levels in project area waters are low, biomagnification apparently has resulted in significant mercury concentrations in fish from all project area waters.

5.2.2.7 Nickel

Though nickel was detected from all water quality monitoring sites, no criteria were exceeded. Nickel levels in fish tissue were also generally at non-detectable or low levels, and was only elevated in a few fish compared to fish from other studies conducted by the TSMP but were still well below levels recommended for protection of predators. Nickel, therefore, is not considered to be a significant contaminant in project area waters.

5.2.2.8 Selenium, Silver, and Zinc

Selenium, silver, and zinc were all present in project area waters at low levels, and did not exceed any water quality criteria. Other than the south Thermalito Afterbay from which largemouth bass liver was at higher levels than found in other water bodies evaluated by the TSMP, these three metals also did not exceed any guidance values or criteria for the protection of human health or wildlife species. The low levels of selenium, silver, and zinc present in project area waters do no appear to be causing any adverse effects to the food web.

6.0 ANALYSES

The purpose of Phase 1 is to determine the magnitude and extent of bioaccumulation of metals and organic contaminants in aquatic organisms within the project area, and to determine the sources and potential pathways of contamination that contribute to bioaccumulation including contaminated sediments deposited as a result of project features, operations, and maintenance. A second phase is to be initiated if significant contamination is found in the biota. The purpose of Phase 2 is to determine the role of project waters in bioaccumulation by assessing contaminants in tributaries to the project, determine the distribution of contamination in project waters and extent of species affected, including other sport species (such as salmon, trout, and sunfish) and prey species eaten by other fish and wildlife (such as delta smelt, threadfin shad, and crayfish), and determine the extent of contamination in the river downstream from the project. This information could be used to develop potential protection, mitigation and enhancement measures.

Subsequent to receiving fish tissue analyses data from the DFG laboratory for mercury levels in some of the fish sampled for Phase 1, a Task Force composed of representatives from the SWRCB, NOAA Fisheries, DWR, and OEHHA met to determine the sampling regime for Phase 2. Recommendations were made to collect trout and bass species from the major tributaries to Lake Oroville, additional collection of bass and coho salmon, catfish, and sunfish from the three arms and main body of Lake Oroville, and bass and carp from the Thermalito Afterbay and Mile Long Pond. However, it was recognized that additional sampling may be necessary following receipt of the complete mercury, other metal, and organic contaminant data from the DFG laboratories. In addition, sediment samples collected as part of the Phase 1 study were preserved, pending analysis of the fish tissue samples, to determine for which parameters and from which locations sediments should be analyzed.

Therefore, following review of this report, the Task Force will convene to determine whether additional fish or locations should be sampled for Phase 2, and which sediment samples should be analyzed for which parameters. Subsequently, the data from Phase 1 and Phase 2 will be analyzed to describe existing conditions upstream from the project, within the project area, and downstream from the project, and evaluate project related effects to metal and organic compound contamination in fish.

7.0 REFERENCES

Brodberg, R.K. and G.A. Pollock. 1999. Prevalence of Selected Target Chemical Contaminants in Sport Fish from Two California Lakes: Public Health Designed Screening Study. California Office of Environmental Health Hazard Assessment. Sacramento, California.

CVRWQCB 2003. A Compilation of Water Quality Goals. Central Valley Regional Water Quality Control Board. Sacramento, California.

EC 2000. Tissue Residue Guidelines for the Protection of Wildlife Consumers of Aquatic Biota. National Guidelines and Standards Office. Environment Canada. Ottawa, Ontario. Canada.

NAS 1972. Water Quality Criteria 1972; a Report of the Committee on Water Quality Criteria. National Academy of Sciences and National Academy of Engineering. U.S. Environmental Protection Agency. EPA R3-73-033.

Newell, A.J., D.W. Johnson, and L.K. Allen 1987. Niagara River Biota Contamination Project: Fish Flesh Criteria for Piscivorous Wildlife. Department of Environmental Conservation. New York.

SWRCB 1996. Toxic Substances Monitoring Program, 1994-95 Data Report. California State Water Resources Control Board. Sacramento, California.

USEPA 1999. National Recommended Water Quality Criteria – Correction. EPA-822-Z-99-001. U. S. Environmental Protection Agency. Washington, D.C.

USEPA 2001. Water Quality Criterion for the Protection of Human Health: Methylmercury. EPA-823-R-01-001. U.S. Environmental Protection Agency. Washington, D.C.

USFWS 1985a. Cadmium Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. Biological Report 85 (1.2). U.S. Fish and Wildlife Service. Laurel, Maryland.

USFWS 1985b. Selenium Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. Biological Report 85 (1.5). U.S. Fish and Wildlife Service. Laurel, Maryland.

USFWS 1986a. Polychlorinated Biphenyl Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. Biological Report 85 (1.7). U.S. Fish and Wildlife Service. Laurel, Maryland.

USFWS 1986b. Chromium Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. Biological Report 85 (1.6). U.S. Fish and Wildlife Service. Laurel, Maryland.

USFWS 1987. Mercury Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. Biological Report 85 (1.10). U.S. Fish and Wildlife Service. Laurel, Maryland.

USFWS 1988a. Chlorpyrifos Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. Biological Report 85 (1.13). U.S. Fish and Wildlife Service. Laurel, Maryland.

USFWS 1988b. Arsenic Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. Biological Report 85 (1.12). U.S. Fish and Wildlife Service. Laurel, Maryland.

USFWS 1988c. Lead Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. Biological Report 85 (1.14). U.S. Fish and Wildlife Service. Laurel, Maryland.

USFWS 1990. Chlordane Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. Biological Report 85 (1.21). U.S. Fish and Wildlife Service. Laurel, Maryland.

USFWS 1993. Zinc Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. Biological Report 26. U.S. Fish and Wildlife Service. Laurel, Maryland.

USFWS 1996. Silver Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. Biological Report 32. U.S. Fish and Wildlife Service. Laurel, Maryland.

USFWS 1998a. Copper Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. Biological Report 33. U.S. Fish and Wildlife Service. Laurel, Maryland.

USFWS 1998b. Nickel Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. Biological Report 34. U.S. Fish and Wildlife Service. Laurel, Maryland.

USFWS 2003. Evaluation of the Clean Water Act Section 304(a) Human Health Criterion for Methylmercury: Protectiveness for Threatened and Endangered Wildlife in California. U.S. Fish and Wildlife Service. Sacramento, California.

USGS 1994. Guidelines for Collecting and Processing Samples of Stream Bed Sediment for Analysis of Trace Elements and Organic Contaminants for the National Water Quality Assessment Program. U. S. Geological Survey Open File Report 94-458.

8.0 APPENDICES

Appendix A. Summary of Total and Dissolved Metals Results from Project Area Waters

Lake Oroville North Fork -Surface (A5R93761296)

	Arsenic		Cadmium		Chromium		Copper		Lead		Mercury	Methyl Mercury	Nickel		Selenium		Silver		Zinc	
	T	D	T	D	T	D	T	D	T	D	T	T	T	D	T	D	T	D	T	D
Maximum detected	0.721	0.649	0.003	0.002	0.6	0.21	1.49	1.07	0.042	<0.015	.00111	0.000013	1.37	0.88	0.08	0.08			0.41	0.22
Minimum detected	0.3	0.226	<0.008	<0.008	<0.07	<0.07	0.67	0.53	<0.015	<0.015	<.00015	<.000025	<0.04	<0.04	<0.30	<0.30			0.07	<0.10
Number of samples	12	12	12	12	12	12	12	12	12	12	14	14	12	12	12	12	0	0	12	12
Number of samples exceeding criteria or objectives																				
Public Health Goal[1]	-	-	0	-	-	-	0	-	0	-	0	-	0	-	-	-	-	-	-	-
Primary MCL[2]	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	-	-	-	-
Secondary MCL[2]	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	0	-
Agricultural Goal[3]	0	-	0	-	0	-	0	-	0	-	-	-	0	-	0	-	-	-	0	-
Cal/EPA Cancer Potency Factor[4]	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CTR[5] Humans	-	-	-	-	-	-	0	-	-	-	0	-	0	-	-	-	-	-	-	-
CTR[5] Aquatic Life	-	0	0	0	-	0	0	0	0	-	-	-	-	-	-	-	-	-	0	0
NTR[6]	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-
NAWQC[7] Humans	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NAWQC[7] Aquatic Life	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-
USEPA IRIS Reference Dose[8]	-	-	-	-	0	-	-	-	-	-	-	0	-	-	0	-	-	-	0	-

Lake Oroville North Fork - Bottom (A5R93761296)

	Arsenic		Cadmium		Chromium		Copper		Lead		Mercury	Methyl Mercury	Nickel		Selenium		Silver		Zinc	
	T	D	T	D	T	D	T	D	T	D	T	T	T	D	T	D	T	D	T	D
Maximum detected	0.812	0.703	0.064	0.096	3.05	0.24	5.39	5.47	0.338	0.073	0.00154	0.00003	3.94	1.4	0.13	0.11			8.43	5.61
Minimum detected	0.375	0.0442	<0.008	<0.008	0.2	<0.07	0.43	0.4	<0.015	<0.015	0.00033	<.000025	0.62	0.15	<0.30	<0.30			0.19	0.11
Number of samples	12	12	12	12	12	12	12	12	12	12	13	13	12	12	12	12			12	12
Number of samples exceeding																				
Public Health Goal[1]	-	-	0	-	-	-	0	-	0	-	0	-	0	-	-	-	-	-	-	-
Primary MCL[2]	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	-	-	-	-
Secondary MCL[2]	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	0	-
Agricultural Goal[3]	0	-	0	-	0	-	0	-	0	-	-	-	0	-	0	-	-	-	0	-
Cal/EPA Cancer Potency Factor[4]	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CTR[5] Humans	-	-	-	-	-	-	0	-	-	-	0	-	0	-	-	-	-	-	-	-
CTR[5] Aquatic Life	-	0	0	0	-	0	1[9]	0	0	-	-	-	-	-	-	-	-	-	0	0
NTR[6]	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-
NAWQC[7] Humans	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NAWQC[7] Aquatic Life	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-
USEPA IRIS Reference Dose[8]	-	-	-	-	0	-	-	-	-	-	-	0	-	-	0	-	-	-	0	-

Appendix A. Continued.

Lake Oroville Middle Fork- Surface (A5R93351272)

	Arsenic		Cadmium		Chromium		Copper		Lead		Mercury	Methyl Mercury	Nickel		Selenium		Silver		Zinc	
	T	D	T	D	T	D	T	D	T	D	T	T	T	D	T	D	T	D	T	D
Maximum detected	0.868	0.925	0.002	0.001	0.63	0.25	1.24	0.97	0.373	0.039	0.00096	0.00002	1.17	0.74	<0.30	0.1			1.18	0.4
Minimum detected	0.244	0.257	<0.001	<0.001	<0.07	<0.07	0.42	0.37	<0.007	<0.007	<0.00015	<.000007	<0.04	<0.04	<0.30	<0.30			<0.10	<0.10
Number of samples	13	13	13	13	13	13	13	13	13	13	15	15	13	13	13	13	0	0	13	13
Number of samples exceeding																				
Public Health Goal[1]	-	-	0	-	-	-	0	-	0	-	0	-	0	-	-	-	-	-	-	-
Primary MCL[2]	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	-	-	-	-
Secondary MCL[2]	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	0	-
Agricultural Goal[3]	0	-	0	-	0	-	0	-	0	-	-	-	0	-	0	-	-	-	0	-
Cal/EPA Cancer Potency Factor[4]	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CTR[5] Humans	-	-	-	-	-	-	0	-	-	-	0	-	0	-	-	-	-	-	-	-
CTR[5] Aquatic Life	-	0	0	0	-	0	0	0	0	-	-	-	-	-	-	-	-	-	0	0
NTR[6]	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-
NAWQC[7] Humans	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NAWQC[7] Aquatic Life	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-
USEPA IRIS Reference Dose[8]	-	-	-	-	0	-	-	-	-	-	-	0	-	-	0	-	-	-	0	-

Lake Oroville Middle Fork - Bottom (A5R93351272)

	Arsenic		Cadmium		Chromium		Copper		Lead		Mercury	Methyl Mercury	Nickel		Selenium		Silver		Zinc	
	T	D	T	D	T	D	T	D	T	D	T	T	T	D	T	D	T	D	T	D
Maximum detected	2.03	1.27	1.408	0.054	2.98	0.35	6.18	4.29	1.721	0.318	0.00349	.000056	5.05	1.24	0.13	0.09			3.61	1.94
Minimum detected	0.361	0.293	<0.008	<0.008	<0.07	<0.07	0.4	0.41	<0.15	<0.15	.00034	<0.000025	0.07	0.15	<0.09	<0.09			0.11	<0.10
Number of samples	13	13	13	13	13	13	13	13	13	13	15	15	13	13	13	13	0	0	13	13
Number of samples exceeding																				
Public Health Goal[1]	-	-	1	-	-	-	0	-	0	-	0	-	0	-	-	-	-	-	-	-
Primary MCL[2]	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	-	-	-	-
Secondary MCL[2]	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	0	-
Agricultural Goal[3]	0	-	0	-	0	-	0	-	0	-	-	-	0	-	0	-	-	-	0	-
Cal/EPA Cancer Potency Factor[4]	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CTR[5] Humans	-	-	-	-	-	-	0	-	-	-	0	-	0	-	-	-	-	-	-	-
CTR[5] Aquatic Life	-	0	1	0	-	0	1[9]	0	1[9]	-	-	-	-	-	-	-	-	-	0	0
NTR[6]	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-
NAWQC[7] Humans	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NAWQC[7] Aquatic Life	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-
USEPA IRIS Reference Dose[8]	-	-	-	-	0	-	-	-	-	-	-	0	-	-	0	-	-	-	0	-

Appendix A. Continued.

Lake Oroville South Fork - Surface (A5R93221226)

	Arsenic		Cadmium		Chromium		Copper		Lead		Mercury	Methyl Mercury	Nickel		Selenium		Silver		Zinc	
	T	D	T	D	T	D	T	D	T	D	T	T	T	D	T	D	T	D	T	D
Maximum detected	0.533	0.604	0.002	0.003	1.29	0.26	1.5	0.78	0.407	0.019	0.00306	0.000025	1.81	0.73	<0.30	<0.30			1.97	0.35
Minimum detected	0.263	0.234	<0.008	<0.008	<0.07	<0.07	0.44	0.34	<0.015	<0.015	<.000025	<.000025	<0.04	<0.04	<0.30	<0.30			<0.05	<0.10
Number of samples	13	13	13	13	13	13	13	13	13	13	15	15	13	13	13	13	0	0	13	13
Number of samples exceeding																				
Public Health Goal[1]	-	-	0	-	-	-	0	-	0	-	0	-	0	-	-	-	-	-	-	-
Primary MCL[2]	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	-	-	-	-
Secondary MCL[2]	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	0	-
Agricultural Goal[3]	0	-	0	-	0	-	0	-	0	-	-	-	0	-	0	-	-	-	0	-
Cal/EPA Cancer Potency Factor[4]	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CTR[5] Humans	-	-	-	-	-	-	0	-	-	-	0	-	0	-	-	-	-	-	-	-
CTR[5] Aquatic Life	-	0	0	0	-	0	0	0	0	-	-	-	-	-	-	-	-	-	0	0
NTR[6]	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-
NAWQC[7] Humans	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NAWQC[7] Aquatic Life	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-
USEPA IRIS Reference Dose[8]	-	-	-	-	0	-	-	-	-	-	-	0	-	-	0	-	-	-	0	-

Lake Oroville South Fork - Bottom (A5R93221226)

	Arsenic		Cadmium		Chromium		Copper		Lead		Mercury	Methyl Mercury	Nickel		Selenium		Silver		Zinc	
	T	D	T	D	T	D	T	D	T	D	T	T	T	D	T	D	T	D	T	D
Maximum detected	0.583	0.536	0.008	0.004	1.99	0.027	222	11.7	0.349	0.022	0.0026	.000046	3	0.85	<0.30	<0.30			2.4	0.42
Minimum detected	0.312	0.283	<0.008	.002	<0.07	<0.07	0.62	0.35	<0.008	<0.008	.00011	<0.000025	0.48	<0.00	<0.30	<0.30			0.13	<0.10
Number of samples	13	13	13	13	13	13	13	13	13	13	15	15	13	13	13	13	13	13	13	13
Number of samples exceeding																				
Public Health Goal[1]	-	-	0	-	-	-	1	-	0	-	0	-	0	-	-	-	-	-	-	-
Primary MCL[2]	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	-	-	-	-
Secondary MCL[2]	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	0	-
Agricultural Goal[3]	0	-	0	-	0	-	1	-	0	-	-	-	0	-	0	-	-	-	0	-
Cal/EPA Cancer Potency Factor[4]	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CTR[5] Humans	-	-	-	-	-	-	0	-	-	-	0	-	0	-	-	-	-	-	-	-
CTR[5] Aquatic Life	-	0	0	0	-	0	5[9], 5[10]	2[9], 2[10]	0	-	-	-	-	-	-	-	-	-	0	0
NTR[6]	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-
NAWQC[7] Humans	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NAWQC[7] Aquatic Life	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-
USEPA IRIS Reference Dose[8]	-	-	-	-	0	-	-	-	-	-	-	0	-	-	0	-	-	-	0	-

Appendix A. Continued.

Lake Oroville At Dam - Surface (A5R93251286)

	Arsenic		Cadmium		Chromium		Copper		Lead		Mercury	Methyl Mercury	Nickel		Selenium		Silver		Zinc	
	T	D	T	D	T	D	T	D	T	D	T	T	T	D	T	D	T	D	T	D
Maximum detected	0.778	0.734	0.002	0.003	0.44	0.2	1.39	1.03	0.043	0.005	0.008	0.000015	1.18	0.89	0.14	0.07			0.31	0.52
Minimum detected	0.322	0.332	<0.008	<0.008	<0.07	<0.07	0.64	0.45	<0.015	<0.015	<.00002	<.000025	<0.04	<0.04	<0.30	<0.30			0.09	<0.10
Number of samples	12	12	12	12	12	12	12	12	12	12	14	14	12	12	12	12	0	0	12	12
Number of samples exceeding																				
Public Health Goal[1]	-	-	0	-	-	-	0	-	0	-	0	-	0	-	-	-	-	-	-	-
Primary MCL[2]	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	-	-	-	-
Secondary MCL[2]	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	0	-
Agricultural Goal[3]	0	-	0	-	0	-	0	-	0	-	-	-	0	-	0	-	-	-	0	-
Cal/EPA Cancer Potency Factor[4]	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CTR[5] Humans	-	-	-	-	-	-	0	-	-	-	0	-	0	-	-	-	-	-	-	-
CTR[5] Aquatic Life	-	0	0	0	-	0	0	0	0	-	-	-	-	-	-	-	-	-	0	0
NTR[6]	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-
NAWQC[7] Humans	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NAWQC[7] Aquatic Life	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-
USEPA IRIS Reference Dose[8]	-	-	-	-	0	-	-	-	-	-	-	0	-	-	0	-	-	-	0	-

Lake Oroville At Dam - Mid-depth (A5R93251286)

	Arsenic		Cadmium		Chromium		Copper		Lead		Mercury	Methyl Mercury	Nickel		Selenium		Silver		Zinc	
	T	D	T	D	T	D	T	D	T	D	T	T	T	D	T	D	T	D	T	D
Maximum detected	0.689	0.703	0.004	0.009	0.36	0.18	51.8	13.9	0.042	0.038	.00081	.000019	1.02	1.05	0.09	0.08			0.45	0.85
Minimum detected	0.376	0.345	<0.008	<0.008	<0.07	<0.07	0.82	0.6	<0.015	<0.015	<.00015	<.000025	0.05	<0.04	<0.30	<0.30			0.12	<0.10
Number of samples	11	11	11	11	11	11	11	9	11	11	13	13	11	11	11	11	0	0	11	11
Number of samples exceeding																				
Public Health Goal[1]	-	-	0	-	-	-	0	-	0	-	0	-	0	-	-	-	-	-	-	-
Primary MCL[2]	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	-	-	-	-
Secondary MCL[2]	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	0	-
Agricultural Goal[3]	0	-	0	-	0	-	0	-	0	-	-	-	0	-	0	-	-	-	0	-
Cal/EPA Cancer Potency Factor[4]	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CTR[5] Humans	-	-	-	-	-	-	0	-	-	-	0	-	0	-	-	-	-	-	-	-
CTR[5] Aquatic Life	-	0	0	0	-	0	3[9], 3[10]	1[9], 1[10]	0	-	-	-	-	-	-	-	-	-	0	0
NTR[6]	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-
NAWQC[7] Humans	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NAWQC[7] Aquatic Life	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-
USEPA IRIS Reference Dose[8]	-	-	-	-	0	-	-	-	-	-	-	0	-	-	0	-	-	-	0	-

Appendix A. Continued.

Diversion Pool US Dam - Surface (A5R93191326)

	Arsenic		Cadmium		Chromium		Copper		Lead		Mercury	Methyl Mercury	Nickel		Selenium		Silver		Zinc	
	T	D	T	D	T	D	T	D	T	D	T	T	T	D	T	D	T	D	T	D
Maximum detected	0.834	0.72	0.002	0.002	0.77	0.34	1.84	1.22	0.128	<0.015	0.00302	.000003	1.51	0.9	0.12	0.11			1.59	0.31
Minimum detected	0.364	0.316	<0.008	<0.008	0.09	<0.07	0.63	0.5	<0.015	<0.015	.0002	<.000025	0.5	0.35	<0.30	<0.30			0.06	<0.10
Number of samples	14	14	14	14	14	14	14	14	14	14	16	16	14	14	14	14	0	0	14	14
Number of samples exceeding																				
Public Health Goal[1]	-	-	0	-	-	-	0	-	0	-	0	-	0	-	-	-	-	-	-	-
Primary MCL[2]	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	-	-	-	-
Secondary MCL[2]	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	0	-
Agricultural Goal[3]	0	-	0	-	0	-	0	-	0	-	-	-	0	-	0	-	-	-	0	-
Cal/EPA Cancer Potency Factor[4]	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CTR[5] Humans	-	-	-	-	-	-	0	-	-	-	0	-	0	-	-	-	-	-	-	-
CTR[5] Aquatic Life	-	0	0	0	-	0	0	0	0	0	-	-	-	0	-	-	-	-	0	0
NTR[6]	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-
NAWQC[7] Humans	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NAWQC[7] Aquatic Life	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-
USEPA IRIS Reference Dose[8]	-	-	-	-	0	-	-	-	-	-	-	0	-	-	0	-	-	-	0	-

Diversion Pool US Dam - Bottom (A5R93191326)

	Arsenic		Cadmium		Chromium		Copper		Lead		Mercury	Methyl Mercury	Nickel		Selenium		Silver		Zinc	
	T	D	T	D	T	D	T	D	T	D	T	T	T	D	T	D	T	D	T	D
Maximum detected	0.857	0.75	0.085	0.131	0.54	0.43	94	84.5	0.075	0.002	.00184	.000034	1.35	1.02	0.34	0.64			0.52	0.29
Minimum detected	0.335	0.341	<0.008	<0.008	0.14	<0.07	0.67	0.52	<0.015	<0.015	<0.00015	<.000025	0.52	0.33	<0.30	<0.30			0.017	<0.10
Number of samples	14	14	14	14	14	14	14	12	14	14	16	16	14	14	14	14	0	0	14	14
Number of samples exceeding																				
Public Health Goal[1]	-	-	1	-	-	-	0	-	0	-	0	-	0	-	-	-	-	-	-	-
Primary MCL[2]	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	-	-	-	-
Secondary MCL[2]	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	0	-
Agricultural Goal[3]	0	-	0	-	0	-	0	-	0	-	-	-	0	-	0	-	-	-	0	-
Cal/EPA Cancer Potency Factor[4]	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CTR[5] Humans	-	-	-	-	-	-	0	-	-	-	0	-	0	-	-	-	-	-	-	-
CTR[5] Aquatic Life	-	0	0	0	-	0	4[9], 4[10]	3[9], 3[10]	0	0	-	-	-	0	-	-	-	-	0	0
NTR[6]	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-
NAWQC[7] Humans	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NAWQC[7] Aquatic Life	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-
USEPA IRIS Reference Dose[8]	-	-	-	-	0	-	-	-	-	-	-	0	-	-	0	-	-	-	0	-

Appendix A. Continued.

Thermalito Forebay, North - Surface (A5R93161366)

	Arsenic		Cadmium		Chromium		Copper		Lead		Mercury	Methyl Mercury	Nickel		Selenium		Silver		Zinc	
	T	D	T	D	T	D	T	D	T	D	T	T	T	D	T	D	T	D	T	D
Maximum detected	0.815	0.689	0.003	0.003	0.48	0.41	1.43	1.02	0.85	<0.015	0.00191	.000055	1.18	.87	0.13	0.08			0.63	0.42
Minimum detected	0.349	0.0454	<0.008	<0.008	<0.07	<0.07	0.6	0.45	<0.015	<0.015	<.00015	<.000025	0.5	0.34	<0.30	<0.30			0.07	<0.10
Number of samples	14	14	14	14	14	14	14	14	14	14	16	16	14	14	14	14	0	0	14	14
Number of samples exceeding																				
Public Health Goal[1]	-	-	0	-	-	-	0	-	0	-	0	-	0	-	-	-	-	-	-	-
Primary MCL[2]	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	-	-	-	-
Secondary MCL[2]	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	0	-
Agricultural Goal[3]	0	-	0	-	0	-	0	-	0	-	-	-	0	-	0	-	-	-	0	-
Cal/EPA Cancer Potency Factor[4]	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CTR[5] Humans	-	-	-	-	-	-	0	-	-	-	0	-	0	-	-	-	-	-	-	-
CTR[5] Aquatic Life	-	0	0	0	-	0	0	0	0	0	-	-	-	0	-	-	-	-	0	0
NTR[6]	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-
NAWQC[7] Humans	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NAWQC[7] Aquatic Life	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-
USEPA IRIS Reference Dose[8]	-	-	-	-	0	-	-	-	-	-	-	0	-	-	0	-	-	-	0	-

Thermalito Forebay, North - Bottom (A5R93161366)

	Arsenic		Cadmium		Chromium		Copper		Lead		Mercury	Methyl Mercury	Nickel		Selenium		Silver		Zinc	
	T	D	T	D	T	D	T	D	T	D	T	T	T	D	T	D	T	D	T	D
Maximum detected	0.791	0.707	3.93	0.245	0.52	0.43	1330	144	0.732	0.191	0.00191	.000024	3.6	1.88	0.07	<0.30			1.31	1.13
Minimum detected	0.354	0.321	<0.008	<0.008	0.05	<0.01	0.71	0.53	<0.015	<0.015	.00026	<.000025	0.52	0.33	<0.30	<0.30			0.16	0.13
Number of samples	14	14	14	14	14	14	14	13	14	14	16	16	14	14	14	14	0	0	14	14
Number of samples exceeding																				
Public Health Goal[1]	-	-	1	-	-	-	2	-	0	-	0	-	0	-	-	-	-	-	-	-
Primary MCL[2]	0	-	0	-	0	-	1	-	0	-	0	-	0	-	0	-	-	-	-	-
Secondary MCL[2]	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	0	-
Agricultural Goal[3]	0	-	0	-	0	-	1	-	0	-	-	-	0	-	0	-	-	-	0	-
Cal/EPA Cancer Potency Factor[4]	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CTR[5] Humans	-	-	-	-	-	-	1	-	-	-	0	-	0	-	-	-	-	-	-	-
CTR[5] Aquatic Life	-	0	1	0	-	0	4[9], 4[10]	1[9], 1[10]	1[9]	0	-	-	-	0	-	-	-	-	0	0
NTR[6]	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-
NAWQC[7] Humans	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NAWQC[7] Aquatic Life	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-
USEPA IRIS Reference Dose[8]	-	-	-	-	0	-	-	-	-	-	-	0	-	-	0	-	-	-	0	-

Thermalito Afterbay, North - Surface (A5R93011411)

	Arsenic		Cadmium		Chromium		Copper		Lead		Mercury	Methyl Mercury	Nickel		Selenium		Silver		Zinc	
	T	D	T	D	T	D	T	D	T	D	T	T	T	D	T	D	T	D	T	D
Maximum detected	0.791	0.616	0.002	0.001	0.45	0.39	1.31	0.92	0.085	.001	0.00141	.000031	1.23	0.84	0.11	0.15			0.6	0.34
Minimum detected	0.343	0.415	<0.008	<0.008	<0.07	<0.07	0.58	0.46	<0.015	<0.015	<.00015	<.000025	0.48	0.33	<0.30	<0.30			<0.10	<0.10
Number of samples	14	14	14	14	14	14	14	14	14	14	16	16	14	14	14	14			14	14
Number of samples exceeding																				
Public Health Goal[1]	-	-	0	-	-	-	0	-	0	-	0	-	0	-	-	-	-	-	-	-
Primary MCL[2]	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	-	-	-	-
Secondary MCL[2]	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	0	-
Agricultural Goal[3]	0	-	0	-	0	-	0	-	0	-	-	-	0	-	0	-	-	-	0	-
Cal/EPA Cancer Potency Factor[4]	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CTR[5] Humans	-	-	-	-	-	-	0	-	-	-	0	-	0	-	-	-	-	-	-	-
CTR[5] Aquatic Life	-	0	0	0	-	0	0	0	0	0	-	-	-	0	-	-	-	-	0	0
NTR[6]	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-
NAWQC[7] Humans	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NAWQC[7] Aquatic Life	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-
USEPA IRIS Reference Dose[8]	-	-	-	-	0	-	-	-	-	-	-	0	-	-	0	-	-	-	0	-

Thermalito Afterbay, North - Bottom (A5R93011411)

	Arsenic		Cadmium		Chromium		Copper		Lead		Mercury	Methyl Mercury	Nickel		Selenium		Silver		Zinc	
	T	D	T	D	T	D	T	D	T	D	T	T	T	D	T	D	T	D	T	D
Maximum detected	0.773	0.654	0.009	0.003	0.98	0.32	131	2.45	0.399	0.038	0.00268	.000051	1.6	0.87	0.09	0.1			2.21	17.3
Minimum detected	0.336	0.0421	<0.008	<0.008	<0.07	<0.07	0.69	0.43	<0.015	<0.015	.00033	<0.00002	0.58	0.37	<0.30	<0.30			0.07	<0.10
Number of samples	14	14	14	14	14	14	14	14	14	14	16	16	14	14	14	14			14	13
Number of samples exceeding																				
Public Health Goal[1]	-	-	0	-	-	-	0	-	0	-	0	-	0	-	-	-	-	-	-	-
Primary MCL[2]	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	-	-	-	-
Secondary MCL[2]	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	0	-
Agricultural Goal[3]	0	-	0	-	0	-	0	-	0	-	-	-	0	-	0	-	-	-	0	-
Cal/EPA Cancer Potency Factor[4]	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CTR[5] Humans	-	-	-	-	-	-	0	-	-	-	0	-	0	-	-	-	-	-	-	-
CTR[5] Aquatic Life	-	0	0	0	-	0	3[9], 3[10]	0	0	0	-	-	-	0	-	-	-	-	0	0
NTR[6]	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-
NAWQC[7] Humans	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NAWQC[7] Aquatic Life	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-
USEPA IRIS Reference Dose[8]	-	-	-	-	0	-	-	-	-	-	-	0	-	-	0	-	-	-	0	-

Appendix A. Continued.

Appendix A. Continued.

Thermalito Afterbay, South - Surface (A5R92921412)

	Arsenic		Cadmium		Chromium		Copper		Lead		Mercury	Methyl Mercury	Nickel		Selenium		Silver		Zinc	
	T	D	T	D	T	D	T	D	T	D	T	T	T	D	T	D	T	D	T	D
Maximum detected	0.707	0.62	0.003	0.003	1.54	5	1.29	0.95	1.54	0.037	.00174	.000133	2.08	0.84	0.08	0.1			0.53	0.39
Minimum detected	0.315	0.325	<0.008	<0.008	<0.07	<0.07	0.59	0.44	<0.015	<0.015	.00018	<.000025	0.47	0.34	<0.30	<0.30			0.1	<0.10
Number of samples	14	14	14	14	14	14	14	14	14	14	16	16	14	14	14	14	0	0	14	14
Number of samples exceeding																				
Public Health Goal[1]	-	-	0	-	-	-	0	-	0	-	0	-	0	-	-	-	-	-	-	-
Primary MCL[2]	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	-	-	-	-
Secondary MCL[2]	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	0	-
Agricultural Goal[3]	0	-	0	-	0	-	0	-	0	-	-	-	0	-	0	-	-	-	0	-
Cal/EPA Cancer Potency Factor[4]	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CTR[5] Humans	-	-	-	-	-	-	0	-	-	-	0	-	0	-	-	-	-	-	-	-
CTR[5] Aquatic Life	-	0	0	0	-	0	0	0	1[9]	0	-	-	-	0	-	-	-	-	0	0
NTR[6]	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-
NAWQC[7] Humans	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NAWQC[7] Aquatic Life	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-
USEPA IRIS Reference Dose[8]	-	-	-	-	0	-	-	-	-	-	-	0	-	-	0	-	-	-	0	-

Thermalito Afterbay, South - Bottom (A5R92921412)

	Arsenic		Cadmium		Chromium		Copper		Lead		Mercury	Methyl Mercury	Nickel		Selenium		Silver		Zinc	
	T	D	T	D	T	D	T	D	T	D	T	T	T	D	T	D	T	D	T	D
Maximum detected	0.768	0.58	5.77	7.97	1.43	0.38	1700	2.04	0.278	0.006	.0366	.00141	2.09	1.86	0.09	0.19			1.64	.83
Minimum detected	0.33	0.295	<0.008	<0.008	<0.07	<0.07	0.63	0.52	<0.015	<0.015	.00024	<.000025	0.49	0.35	<0.30	<0.30			0.17	0.12
Number of samples	14	14	14	14	14	14	13	11	14	14	16	16	14	14	14	14			14	14
Number of samples exceeding																				
Public Health Goal[1]	-	-	1	-	-	-	0	-	0	-	0	-	0	-	-	-	-	-	-	-
Primary MCL[2]	0	-	1	-	0	-	0	-	0	-	0	-	0	-	0	-	-	-	-	-
Secondary MCL[2]	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	0	-
Agricultural Goal[3]	0	-	0	-	0	-	0	-	0	-	-	-	0	-	0	-	-	-	0	-
Cal/EPA Cancer Potency Factor[4]	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CTR[5] Humans	-	-	-	-	-	-	0	-	-	-	0	-	0	-	-	-	-	-	-	-
CTR[5] Aquatic Life	-	0	1	1	-	0	2[9], 2[10]	0	0	0	-	-	-	0	-	-	-	-	0	0
NTR[6]	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-
NAWQC[7] Humans	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NAWQC[7] Aquatic Life	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-
USEPA IRIS Reference Dose[8]	-	-	-	-	0	-	-	-	-	-	-	0	-	-	0	-	-	-	0	-

Appendix A. Continued.

Feather R US Afterbay Outlet (A5-1695.50)

	Arsenic		Cadmium		Chromium		Copper		Lead		Mercury	Methyl Mercury	Nickel		Selenium		Silver		Zinc	
	T	D	T	D	T	D	T	D	T	D	T	T	T	D	T	D	T	D	T	D
Maximum detected	0.727	0.631	0.633	0.003	0.99	0.72	67.5	1.24	0.11	0.03	0.00253	0.00021	1.29	0.91	0.13	0.11	<0.273	<0.025	0.78	1.11
Minimum detected	0.305	0.350	<0.002	0.001	<0.06	<0.02	0.60	0.49	<0.011	<0.005	0.00032	0.000039	0.35	0.26	<0.04	<0.04	<0.273	<0.025	0.12	0.10
Number of samples	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	1	1	16	16
Number of samples exceeding																				
Public Health Goal[1]	-	-	0	-	-	-	0	-	0	-	0	-	0	-	-	-	-	-	-	-
Primary MCL[2]	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	-	-	-	-
Secondary MCL[2]	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0	-	0	-
Agricultural Goal[3]	0	-	0	-	0	-	0	-	0	-	-	-	0	-	0	-	-	-	0	-
Cal/EPA Cancer Potency Factor[4]	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CTR[5] Human	0	-	-	-	-	-	0	-	-	-	0	-	0	-	-	-	-	-	-	-
CTR[6] Aqualtic Life	-	0	0	0	-	0	0	0	0	0	-	-	-	0	-	-	0	0	0	0
NTR[7]	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-
NAWQC[8] Human	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NAWQC[9] Aquatic Life	-	-	0	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-
USEPA IRIS Reference Dose[10]	-	-	-	-	0	-	-	-	-	-	-	0	-	-	0	-	0	-	0	-

Feather R DS Afterbay Outlet (A5-1687.70)

	Arsenic		Cadmium		Chromium		Copper		Lead		Mercury	Methyl Mercury	Nickel		Selenium		Silver		Zinc	
	T	D	T	D	T	D	T	D	T	D	T	T	T	D	T	D	T	D	T	D
Maximum detected	0.633	0.597	0.074	0.008	0.99	0.65	1.47	1.05	0.157	0.032	0.00201	0.000077	1.34	0.93	0.09	0.10	<0.273	<0.025	1.47	0.61
Minimum detected	0.383	0.312	<0.002	0.001	<0.07	0.03	0.67	0.5	0.018	<0.007	0.00038	0.000025	0.44	0.27	<0.04	<0.07	<0.273	<0.025	0.18	<0.10
Number of samples	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	1	1	16	16
Number of samples exceeding																				
Public Health Goal[1]	-	-	1	-	-	-	0	-	0	-	0	-	0	-	-	-	-	-	-	-
Primary MCL[2]	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	-	-	-	-
Secondary MCL[2]	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0	-	0	-
Agricultural Goal[3]	0	-	0	-	0	-	0	-	0	-	-	-	0	-	0	-	-	-	0	-
Cal/EPA Cancer Potency Factor[4]	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CTR[5] Human	0	-	-	-	-	-	0	-	-	-	0	-	0	-	-	-	-	-	-	-
CTR[6] Aqualtic Life	-	0	0	0	-	0	0	0	0	0	-	-	-	0	-	-	0	0	0	0
NTR[7]	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-
NAWQC[8] Human	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NAWQC[9] Aquatic Life	-	-	0	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-
USEPA IRIS Reference Dose[10]	-	-	-	-	0	-	-	-	-	-	-	0	-	-	0	-	0	-	0	-

Appendix A. Continued.

Mile Long Pond (A5L92541377)

	Arsenic		Cadmium		Chromium		Copper		Lead		Mercury	Methyl Mercury	Nickel		Selenium		Silver		Zinc	
	T	D	T	D	T	D	T	D	T	D	T	T	T	D	T	D	T	D	T	D
Maximum concentration	0.77	0.75	<0.004	<0.004	1.46	0.31	0.56	0.64	0.047	0.007	0.0014	0.00006	0.7	1.41	<0.30	<0.30	<0.203	<0.011	0.48	0.89
Minimum concentration	0.18	0.17	<0.004	<0.004	<0.07	<0.07	0.09	0.07	<0.01	<0.01	0.0002	<0.00002	<0.04	<0.04	<0.30	<0.30	<0.106	<0.001	<0.1	<0.1
Number of samples	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	3	3	14	14
Number of samples exceeding																				
Public Health Goal[1]	-	-	0	-	-	-	0	-	0	-	0	-	0	-	-	-	-	-	-	-
Primary MCL[2]	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	-	-	-	-
Secondary MCL[2]	0	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0	-	0	-
Agricultural Goal[3]	0	-	0	-	0	-	0	-	0	-	-	-	0	-	0	-	-	-	0	-
Cal/EPA Cancer Potency Factor[4]	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CTR[5] Humans	-	-	-	-	-	-	0	-	-	-	0	-	0	-	-	-	-	-	-	-
CTR[5] Aquatic Life	-	0	0	0	-	0	0	0	0	0	-	-	-	0	-	-	0	0	0	0
NTR[6]	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-
NAWQC[7] Humans	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NAWQC[7] Aquatic Life	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-
USEPA IRIS Reference Dose[8]	-	-	-	-	0	-	-	-	-	-	-	0	-	-	0	-	0	-	0	-

Lower Pacific Heights Pond (A5L92551372)

	Arsenic		Cadmium		Chromium		Copper		Lead		Mercury	Methyl Mercury	Nickel		Selenium		Silver		Zinc	
	T	D	T	D	T	D	T	D	T	D	T	T	T	D	T	D	T	D	T	D
Maximum concentration	2.81	2.84	0.007	0.005	4.17	0.87	2.43	1.54	0.273	<0.01	0.0048	0.00018	2.1	1.44	0.14	0.19	<0.203	<0.011	0.81	0.61
Minimum concentration	0.09	0.07	<0.004	<0.003	<0.07	<0.07	0.48	0.40	<0.01	<0.01	0.0004	<0.00002	0.4	0.2	<0.04	<0.04	<0.106	<0.001	0.1	<0.1
Number of samples	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	3	3	14	14
Number of samples exceeding																				
Public Health Goal[1]	-	-	0	-	-	-	0	-	0	-	0	-	0	-	-	-	-	-	-	-
Primary MCL[2]	0	-	0	-	0	-	0	-	0	-	0	-	0	-	0	-	-	-	-	-
Secondary MCL[2]	0	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0	-	0	-
Agricultural Goal[3]	0	-	0	-	0	-	0	-	0	-	-	-	0	-	0	-	-	-	0	-
Cal/EPA Cancer Potency Factor[4]	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CTR[5] Humans	-	-	-	-	-	-	0	-	-	-	0	-	0	-	-	-	-	-	-	-
CTR[6] Aquatic Life	-	0	0	0	-	0	0	0	0	0	-	-	-	0	-	-	0	0	0	0
NTR[7]	-	-	-	-	0	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-
NAWQC[7]	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NAWQC[9]	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-
USEPA IRIS Reference Dose[10]	-	-	-	-	0	-	-	-	-	-	-	0	-	-	0	-	0	-	0	-

Appendix A. Continued.

Footnotes
1. California Environmental Protection Agency (Cal/EPA), Office of Environmental Health Hazard Assessment, Public Health Goals for Chemicals in Drinking Water
2. California Department of Health Services, California Code of Regulations, Title 22, Division 4, Chapter 15, Domestic Water Quality and Monitoring
3. Food and Agriculture Organization of the United Nations, 1985. Water Quality for Agriculture.
4. Cal/EPA, Office of Environmental Health Hazard Assessment, Cal/EPA Toxicity Criteria Database
5. California State Water Resources Control Board, Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California (2 March 2003)
6. U.S. Environmental Protection Agency, Federal Register, Volume 64, No. 216 (Tuesday, 9 November 1999) [National Toxics Rule revisions]
7. U.S. Environmental Protection Agency, Quality Criteria for Water, 1986 (May 1986) [The Gold Book] plus updates (various dates)
8. U.S. Environmental Protection Agency, Integrated Risk Information System [IRIS] database
9. Chronic (4 day average)
10. Acute (1 hr average)

5-8

State of California
The Resources Agency
Department of Water Resources

CONTAMINANT ACCUMULATION IN FISH, SEDIMENTS, AND THE AQUATIC FOOD CHAIN

-

STUDY PLAN W2, PHASE 1 DRAFT REPORT

Oroville Facilities Relicensing
FERC Project No. 2100

~~JANUARY~~ MARCH 2004

ARNOLD SCHWARZENEGGER
Governor
State of California

MIKE CHRISMAN
Secretary for Resources
The Resources Agency

LINDA ADAMS
Interim Director
Department of Water Resources

Table 5.0-1. Detected Pesticides in Fish from the Oroville Facilities (Fresh Weight ppb (ng/g))

			chlordane, cis	chlordane, trans	nonachlor, cis	nonachlor, trans	chlordane (total) (e)	chlorpyrifos	DDD, o,p'	DDD, p,p'	DDE, p,p'	DDMU, p,p'	DDT (total) (f)	dieldrin	hexachloro-benzene (HCB)	Aroclor 1254	Aroclor 1260	PCB (g)	PCB (total)(h)
Maximum Tissue Residue Levels (MTRLs) (for Filets or Edible Tissues) (a)	for Carcinogens in Inland Surface Waters						1.1						32	0.65	6			2.2	
NAS Recommended Guideline for Freshwater Fish (b)	(Whole Fish)						100						1,000	100				500	
FDA Action Level for Freshwater and Marine Fish (c)	(Edible Portion)						300						5,000	300				2,000 (i)	
OEHHA Screening values and action levels in fish tissues (d)	USEPA Value						80	30,000					300	7	70			10	
	OEHHA Value						30	10,000					100	2	20			20	
Elevated Data Levels (a)	Fish Type (h)																		
	Whole Freshwater Fish Calculated Using 1978 - 1995 Data (ppb, wet weight)	EDL 85	30.7	20	16.7	44	128.8	25.4	44	254	1,570	46.4	2,393.40	46.4	3.6	120	77.1	219.6	
		EDL 95	57.9	36	27	65.7	195.1	61.9	140	893	3,490	120	5,037.70	378.5	9.1	358.5	160	472.5	
	Freshwater Fish Filets Calculated Using 1978 - 1995 Data (ppb, wet weight)	EDL 85	12	7.4	5.4	17.2	38.8	<10.0	11	77.6	540	<5.0	667.9	9.4	<2.0	<50.0	54.2	120	
		EDL 95	38.4	21	18	44	117.8	25.7	33.6	232	1,955	36	2,424.40	32.5	5	140.5	180	350	
Median International Standards (	(excludes liver)																		
New York DEC Fish Flesh Criteria for fish-eating wildlife							500						200	120	330			110	110
Canadian Tissue Residue Guidelines													14						
USFWS Contaminant Hazard Reviews recommendation							300 (USFWS 1990)	2,000 (USFWS 1988a)										Wildlife <100, avian <3,000 (USFWS 1986a)	Wildlife <100, avian <3,000 (USFWS 1986a)
Sample Number	**Station Name**	**Species***	**chlordane, cis**	**chlordane, trans**	**nonachlor, cis**	**nonachlor, trans**	**chlordane (total) (e)**	**chlorpyrifos**	**DDD, o,p'**	**DDD, p,p'**	**DDE, p,p'**	**DDMU, p,p'**	**DDT (total) (f)**	**dieldrin**	**hexachloro-benzene**	**Aroclor 1254**	**Aroclor 1260**	**PCB (g)**	**PCB (total)(h)**
2029-2034	SF Arm Lake Oroville (McCabe Cove)	SPB	ND	<RL	<RL	<RL		ND	ND	1.10	6.40	ND	7.50	<RL	<RL	16	31	47 (j,l,m)	34.991
2038,39 2242	SF Arm Lake Oroville (McCabe Cove)	CHC	<RL	<RL	<RL	2.26	2.26 (j)	ND	ND	2.59	27.8	<RL	30.39 (n)	ND	0.312	37	97 (k)	134 (j,k,l,m,o,p)	88.777
2138-2148	Lower SF Lake Oroville	CHC	<RL	<RL	<RL	2.31	2.31 (j)	ND	<RL	3.57	24.7	<RL	28.27 (n)	<RL	<RL	37	94 (k)	131 (j,k,l,m,o,p)	85.137
2139-2236	Lower SF Lake Oroville	SPB	<RL	<RL	<RL	<RL		ND	ND	<RL	5.21	ND	5.21	<RL	<RL	18	24	42 (j,l,m)	29.33
2125-2135	Upper MF Lake Oroville	CHC	<RL	<RL	<RL	1.79	1.79 (j)	ND	ND	1.37	15.9	<RL	17.27 (n)	0.522	<RL	20	27	47 (j,l,m)	29.093
2126-2132	Upper MF Lake Oroville	SPB	ND	ND	ND	<RL		ND	ND	<RL	2.16	ND	2.16	<RL	<RL	<RL	<RL		4.664
2075-2089	Lower MF Lake Oroville	SPB	ND	<RL	ND	<RL		ND	ND	<RL	2.05	ND	2.05	<RL	<RL	10	<RL	10 (j,m)	8.655
2088-2092	Lower MF Lake Oroville	CHC	<RL	<RL	<RL	3.43	3.43 (j)	ND	ND	2.21	21.0	<RL	23.21 (n)	<RL	<RL	37	66 (k)	103 (j,l,m,p)	66.772
2045-2049	NF L. Oroville (Bloomer Cnyn)	SPB	ND	ND	ND	<RL		ND	ND	<RL	2.24	ND	2.24	<RL	ND	<RL	<RL		7.078
2188-2209	NF L. Oroville (Bloomer Cnyn)	CHC	<RL	<RL	<RL	1.72	1.72 (j)	ND	ND	1.38	15.3	ND	16.68 (n)	0.732 (j)	<RL	27	24	51 (j,l,m)	30.398
2175-2207	NF L. Oroville (Bloomer Cnyn)	CP	<RL	<RL	<RL	1.51	1.51 (j)	ND	ND	1.16	12.9	<RL	14.06 (n)	0.525	<RL	18	12	30 (j,l,m)	20.327
2150-2163	NF L. Oroville (Foreman C)	CHC	<RL	<RL	<RL	1.88	1.88 (j)	ND	ND	1.76	16.6	<RL	18.36 (n)	0.598	<RL	31	20	51 (j,l,m)	31.332
2152-2172	NF L. Oroville (Foreman C)	SPB	<RL	<RL	ND	<RL		ND	ND	<RL	2.29	ND	2.29	<RL	ND	<RL	<RL		7.299
2155-2158	NF L. Oroville (Foreman C)	WHC	<RL	<RL	ND	<RL		ND	ND	ND	3.3	ND	3.30	<RL	ND	<RL	<RL		7.473
2159-2160	NF L. Oroville (Foreman C)	CP	<RL	<RL	<RL	1.58	1.58 (j)	ND	<RL	1.37	15.2	ND	16.57 (n)	<RL	<RL	16	15	31 (j,l,m)	22.023
2064-2088	Lake Oroville Spillway arm	CHC	<RL	<RL	<RL	2.46	2.46 (j)	<RL	ND	2.72	33.7	<RL	36.42 (j)	0.775 (j)	0.710	34	32	66 (j,l,m)	42.282
2061-2073	Lake Oroville Spillway arm	SPB	ND	ND	ND	<RL		ND	ND	<RL	2.43	ND	2.43	ND	<RL	<RL	<RL		8.406
2100-2106	Lake Oroville Bidwell Arm	CHC	<RL	<RL	<RL	2.37	2.37 (j)	ND	ND	2.23	20.5	<RL	22.73 (n)	0.591	0.355	31	49	80 (j,l,m)	50.938
2105-2114	Lake Oroville Bidwell Arm	SPB	ND	<RL	ND	<RL		ND	ND	ND	<RL	ND		<RL	ND	<RL	<RL		5.596
2300-2305	Diversion Pool	SS	<RL	<RL	<RL	2.69	2.69 (j)	ND	<RL	2.13	19.2	<RL	21.33 (n)	<RL	0.832	55 (k)	34	89 (j,l,m)	66.365
5003	Diversion Pool	crayfish	ND	ND	ND	<RL		ND	ND	ND	<RL	ND		<RL	ND	<RL	<RL		3.894
2210-2216	North Thermalito Forebay (swim area)	PM	2.27	1.09	2.61	7.04	13.01 (j)	<RL	<RL	13	86.9	4.71	104.61 (j,l,n)	1.64	1.05	180 (k)	104 (k)	284 (j,k,l,m,o,p)	186.81 (o,p)
2222-2226	North Thermalito Forebay (swim area)	CP	2.86	1.17	2.40	6.64	13.07 (j)	<RL	1.57	11.1	121	3.48	137.15 (j,l,n)	0.738 (j)	0.956	166 (k)	215 (k)	381 (j,k,l,m,o,p)	281.386 (o,p)
5000	North Afterbay	crayfish	ND	ND	ND	<RL		ND	ND	<RL	5.66	ND	5.66	ND	ND	<RL	<RL		7.272
2247-2251	South Thermalito Afterbay (Ski Cove)	LMB	ND	ND	ND	<RL		ND	ND	<RL	4.99	ND	4.99	<RL	ND	<RL	<RL		112.397 (o,p)
2011-2015	South Thermalito Afterbay (Ski Cove)	CP	1.01	<RL	1.26	4.31	6.58 (j)	<RL	1.22	6.31	214	7.82 (k)	229.35 (j,l,n)	0.751 (j)	0.457	81 (k)	68 (k)	149 (j,k,l,m,o,p)	5.59
5002	South Thermalito Afterbay (Ski Cove)	crayfish	ND	ND	ND	ND		ND	ND	ND	2.11	ND	2.11	ND	ND	<RL	<RL		5.933
2183-2232B	Potters Pond	LMB	ND	<RL	ND	<RL		ND	ND	ND	<RL	ND		<RL	ND	<RL	ND		3.365
2227-2241	Potters Pond	CP	<RL	<RL	<RL	<RL		ND	ND	<RL	23.7	ND	23.7 (n)	<RL	ND	19	17	36 (j,l,m)	22.537
2182	Potters Pond	LMB	ND	<RL	ND	<RL		ND	ND	ND	<RL	ND		<RL	ND	<RL	<RL		1.937
5001	Feather R. DS from Hwy 70 #2	crayfish	ND	ND	ND	<RL		ND	ND	ND	3.01	ND	3.01	ND	ND	76 (k)	<RL	76 (j,l,m)	55.978
FR01-05	Feather R US from Afterbay Outlet	LMB	<RL	<RL	ND	<RL		ND	ND	<RL	4.98	ND	4.98	<RL	ND	22	<RL	22 (j,l,m)	15.629
2308-2322	Feather R DS Afterbay Outlet	LMB	ND	ND	ND	<RL		ND	ND	<RL	6.41	ND	6.41	<RL	<RL	24	<RL	24 (j,l,m)	15.008
2311-2320	Feather R DS Afterbay Outlet	LMB	ND	ND	ND	<RL		ND	ND	<RL	5.38	ND	5.38	<RL	<RL	21	<RL	21 (j,l,m)	11.228

Table 5.0-1. Continued.

			chlordane, cis	chlordane, trans	nonachlor, cis	nonachlor, trans	chlordane (total) (e)	chlorpyrifos	DDD, o,p'	DDD, p,p'	DDE, p,p'	DDMU, p,p'	DDT (total) (f)	dieldrin	hexachloro-benzene (HCB)	Aroclor 1254	Aroclor 1260	PCB (g)	PCB (total)(h)
Maximum Tissue Residue Levels (MTRLs) (for Filets or Edible Tissues) (a)	for Carcinogens in Inland Surface Waters						1.1						32	0.65	6			2.2	
NAS Recommended Guideline for Freshwater Fish (b)	(Whole Fish)						100						1,000	100				500	
FDA Action Level for Freshwater and Marine Fish (c)	(Edible Portion)						300						5,000	300				2,000 (i)	
OEHHA Screening values and action levels in fish tissues (d)	USEPA Value						80	30,000					300	7	70			10	
	OEHHA Value						30	10,000					100	2	20			20	
Elevated Data Levels (a)	Fish Type (h)																		
	Whole Freshwater Fish Calculated Using	EDL 85	30.7	20	16.7	44	128.8	25.4	44	254	1,570	46.4	2,393.40	46.4	3.6	120	77.1	219.6	
	1978 - 1995 Data (ppb, wet weight)	EDL 95	57.9	36	27	65.7	195.1	61.9	140	893	3,490	120	5,037.70	378.5	9.1	358.5	160	472.5	
	Freshwater Fish Filets Calculated Using	EDL 85	12	7.4	5.4	17.2	38.8	<10.0	11	77.6	540	<5.0	667.9	9.4	<2.0	<50.0	54.2	120	
	1978 - 1995 Data (ppb, wet weight)	EDL 95	36.4	21	18	44	117.8	25.7	33.6	232	1,955	36	2,424.40	32.5	5	140.5	180	350	
Median International Standards (	*(excludes liver)*																		
New York DEC Fish Flesh Criteria for fish-eating wildlife							500						200	120	330			110	110
Canadian Tissue Residue Guidelines													14						
USFWS Contaminant Hazard Reviews recommendation							300 (USFWS 1990)	2,000 (USFWS 1988a)										Wildlife <100, avian <3,000 (USFWS 1986a)	Wildlife <100, avian <3,000 (USFWS 1986a)

Sample Number	Station Name	Species*	chlordane, cis	chlordane, trans	nonachlor, cis	nonachlor, trans	chlordane (total) (e)	chlorpyrifos	DDD, o,p'	DDD, p,p'	DDE, p,p'	DDMU, p,p'	DDT (total) (f)	dieldrin	hexachloro-benzene	Aroclor 1254	Aroclor 1260	PCB (g)	PCB (total)(h)
2019-2025	Mile Long Pond	LMB	ND	ND	ND	ND		ND	ND	ND	<RL	ND		<RL	ND	<RL	ND		2.379
2027,28 2243,44	Mile Long Pond	BRB	ND	<RL	ND	<RL		ND	ND	ND	<RL	ND		1.67 (j)	ND	<RL	<RL		2.368
2117-2123	Lower Pacific Heights Pond	CHC	1.04	<RL	1.02	3.12	5.17 (j)	4.18	ND	2.25	56.2	<RL	58.45 (j,n)	0.836 (j)	<RL	54 (k)	27	81 (j,l,m)	48.893
2117-2123 Duplicate	Lower Pacific Heights Pond	CHC	1.03	<RL	1.01	2.94	4.98 (j)	3.97	ND	2.25	53.2	<RL	55.45 (j,n)	0.627	<RL	52 (k)	27	79 (j,l,m)	46.66

* SPB - spotted bass
CHC - channel catfish
CP - common carp
WHC - white catfish
SS - Sacramento sucker
PM - pikeminnow
LMB - largemouth bass
BRB - brown bullhead

a. From SWRCB 1995. Toxic Substances Monitoring Program, 1994-95 Data Report. State Water Resouces Control Board, Sacramento, California.
b. National Academy of Sciences-National Academy of Engineering. 1973. Water Quality Criteria, 1972 (Blue Book). U.S. Environmental Protection Agency, Ecological Research Series.
c. FDA 2000. Action Levels for Poisonous or Deleterious Substances in Human Food and Animal Feed. U.S. Food and Drug Administration. Industry Activities Staff Booklet. Washington, D.C.
d. OEHHA 1999. Prevalence of selected target chemical contaminants in sport fish from two California Lakes: Public Health Designed Screening Study. Office of Environmental Health Hazard Assessment, Sacramento, California
e. Sum of alpha and gamma chlordane, cis- and trans-nonachlor and oxychlordane
f. Sum of ortho and para DDTs, DDDs, and DDEs
g. *Expressed as the sum of Aroclors*
h. Expressed as sum of congeners
i. A tolerance, rather than an action level, has been established for PCBs (21CFR 109, published May 29, 1984). An action level is revoked when a regulation establishes a tolerance for the same substance and use.
j. Exceeds MTRL
k. Exceeds EDL for fish filets
l. Exceeds OEHHA screening level
m. Exceeds USEPA screening level
n. Exceeds Canadian Tissue Residue guideline
o. *Exceeds New York DEC fish flesh criteria for fish-eating wildlife*
p. Exceeds USFWS Contaminant Harard Review proposed criteria in diet of wildlife (based on susceptibility of mink)

3/28 above DDT sv.

18/34 above PCB sv.

Table 5.0-2. Metals Results for Fish Collected in 2002 from the Oroville Facilities (criteria and results in mg/kg (ppm))

		Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc
Maximum Tissue Residue Levels (MTRLs) (for Filets or Edible Tissues) (a)	for Carcinogens in Inland Surface Waters	0.2									
	for Non-carcinogens in Inland Surface Waters		0.64				1	28			
NAS Recommended Guideline for Freshwater Fish (b)	(Whole Fish)						0.5				
FDA Action Level for Freshwater and Marine Fish (c)	(Edible Portion)						1.0 (d)				
OEHHA Screening values and action levels in fish tissues (e)	USEPA Value	3 (f)	10				0.6 (g)		50		
	OEHHA Value	1 (f)	3				0.3 (g,n)		20		
Elevated Data Levels (a)	Fish Type (h)	All	All	All	Non / Salmo	All	All	All	All	All	All
	Fish Livers — EDL 85	0.21	0.36	0.03	12 / 170	0.1	ID (i)	<0.10 (i)	3.32	0.26	28
	Fish Livers — EDL 95	0.68	0.99	0.07	33 / 230	0.2	ID	0.2	4.74	0.76	38
	Whole Fish — EDL 85	0.41	0.12	0.23	3.3	0.2	0.11	0.21	1.4	0.02	42
	Whole Fish — EDL 95	0.88	0.19	0.54	4.3	0.46	0.22	0.56	1.9	0.04	49
	Fish Filets — EDL 85	0.14	<0.01 (i)	<0.02 (i)	0.69	<0.10 (i)	0.8	<0.10 (i)	1	<0.02 (i)	21.4
	Fish Filets — EDL 95	0.43	0.01	<0.02 (i)	0.99	<0.10	1.7	<0.10 (i)	1.8	<0.02 (i)	30.2
Median International Standards (a)	(excludes liver)	1.5	0.3	1	20	2	0.5		2		45
Canadian Tissue Residue guidelines							0.033 (y)				
USFWS Contaminant Hazard Reviews		NA (z) (USFWS 1988b)	0.1 (USFWS 1985a)	NA (z) (USFWS 1986b)	NA (z) (USFWS 1998a)	NA (z) (USFWS 1988c)	wildlife: 1.1, avian: 0.1 (USFWS 1987)	wildlife:500; avian: 200 (USFWS1998b)	NA (z) (USFWS 1985b)	6 (USFWS 1996)	300 (z) (USFWS 1993)
USFWS protection of threatened and endangered wildlife							0.3 (aa)				

Station Name	Species (k)	Type	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc
SF Arm Lake Oroville (McCabe Cove)	CHC	flesh	<0.025	<0.002	0.134 (u)	0.29	<0.002	0.876 (r,s,u,w,bb,cc,dd)	<0.002	0.11	<0.002	6.78
SF Arm Lake Oroville (McCabe Cove)	CHC	liver	0.115	0.061	0.477 (t)	4.07	0.038	0.022	0.047	1.72	0.006	18.6
SF Arm Lake Oroville (McCabe Cove)	SPB	flesh	0.188 (u)	<0.002	0.123 (u)	0.24	<0.002	0.722 (r,s,w,bb,cc,dd)	<0.002	0.27	<0.002	5.00
SF Arm Lake Oroville (McCabe Cove)	SPB	liver	0.378 (t)	0.775 (t,bb)	0.125 (t)	6.33	0.005	0.556	<0.002	0.77	0.005	22.1
SF Arm Lake Oroville (Lower)	CHC	liver			0.3 (t)	2.13	0.943 (t)				0.003	19.2
SF Arm Lake Oroville (Lower)	CHC	flesh	<0.025	<.002				1.059 (p,q,r,s,u,w,bb,cc,dd)	0.006	0.16		
SF Arm Lake Oroville (Lower)	SPB	liver			0.27 (t)	2.82	0.070				<.002	19.0
SF Arm Lake Oroville (Lower)	SPB	flesh	0.21 (o,u)	<.002				0.677 (r,s,w,bb,cc,dd)	0.007	0.28		
Upper MF Lake Oroville	CHC	liver			0.48 (t)	2.87	2.581 (t)				<.002	18.4
Upper MF Lake Oroville	CHC	flesh	<0.025	<.002				0.476 (s,bb,cc,dd)	<.002	0.12		
Upper MF Lake Oroville	SPB	liver			0.3 (t)	1.91	0.004				<.002	18.3
Upper MF Lake Oroville	SPB	flesh	0.17 (u)	<.002				0.535 (s,w,bb,cc,dd)	0.024	0.3		
Lower MF Lake Oroville	CHC	flesh	<0.025	<0.002	0.076 (u)	0.38	<0.002	1.614 (p,q,r,s,u,w,bb,cc,dd)	<0.002	0.13	0.004	6.43
Lower MF Lake Oroville	CHC	liver	0.164	0.182 (bb)	0.449 (t)	3.28	0.048	6.513	0.021	2.23	0.006	18.8
Lower MF Lake Oroville	SPB	flesh	0.189 (u)	<0.002	0.124 (u)	0.24	<0.002	0.587 (s,w,bb,cc,dd)	0.018	0.27	<0.002	4.50
Lower MF Lake Oroville	SPB	liver	0.482 (t)	0.066	0.057 (t)	6.11	0.009	0.591	<0.002	0.94	0.009	22.9
NF Arm L. Oroville (Bloomer Cnyn)	CHC	liver			0.56 (t)	2.87	0.089				<.002	18.3
NF Arm L. Oroville (Bloomer Cnyn)	CHC	flesh	0.020	0.003				0.402 (s,bb,cc,dd)	0.135 (u)	0.16		
NF Arm L. Oroville (Bloomer Cnyn)	CP	flesh	0.050	0.006				0.231 (bb,dd)	0.007	0.27		
NF Arm L. Oroville (Bloomer Cnyn)	SPB	flesh	0.242 (o,u)	<0.002	0.096 (u)	0.21	<0.002	0.394 (s,bb,cc,dd)	<0.002	0.27	<0.002	4.36

Table 5.0-2. Continued.

		Arsenic	Cadmium	Chromium	Copper		Lead	Mercury	Nickel	Selenium	Silver	Zinc
Maximum Tissue Residue Levels (MTRLs) (for Filets or Edible Tissues) (a)	for Carcinogens in Inland Surface Waters	0.2										
	for Non-carcinogens in Inland Surface Waters		0.64					1	28			
NAS Recommended Guideline for Freshwater Fish (b)	(Whole Fish)							0.5				
FDA Action Level for Freshwater and Marine Fish (c)	(Edible Portion)							1.0 (d)				
OEHHA Screening values and action levels in fish tissues (e)	USEPA Value	3 (f)	10					0.6 (g)		50		
	OEHHA Value	1 (f)	3					0.3 (g,n)		20		
	Fish Type (h)	All	All	All	Non	Salmo	All	All	All	All	All	All
Elevated Data Levels (a)	Fish Livers EDL 85	0.21	0.36	0.03	12	170	0.1	ID (j)	<0.10 (i)	3.32	0.26	28
	Fish Livers EDL 95	0.68	0.99	0.07	33	230	0.2	ID	0.2	4.74	0.76	38
	Whole Fish EDL 85	0.41	0.12	0.23	3.3		0.2	0.11	0.21	1.4	0.02	42
	Whole Fish EDL 95	0.88	0.19	0.54	4.3		0.46	0.22	0.56	1.9	0.04	49
	Fish Filets EDL 85	0.14	<0.01 (i)	<0.02 (i)	0.69		<0.10 (i)	0.8	<0.10 (i)	1	<0.02 (i)	21.4
	Fish Filets EDL 95	0.43	0.01	<0.02 (i)	0.99		<0.10	1.7	<0.10 (i)	1.8	<0.02 (i)	30.2
Median International Standards (a)	(excludes liver)	1.5	0.3	1	20		2	0.5		2		45
Canadian Tissue Residue guidelines								0.033 (y)				
USFWS Contaminant Hazard Reviews		NA (z) (USFWS 1988b)	0.1 (USFWS 1985a)	NA (z) (USFWS 1986b)	NA (z) (USFWS 1998a)		NA (z) (USFWS 1988c)	wildlife: 1.1, avian: 0.1 (USFWS 1987)	wildlife:500; avian: 200 (USFWS1998b)	NA (z) (USFWS 1985b)	6 (USFWS 1996)	300 (z) (USFWS 1993)
USFWS protection of threatened and endangered wildlife								0.3 (aa)				

Station Name	Species (k)	Type	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc
NF Arm L. Oroville (Foreman C)	CHC	liver			0.48 (t)	2.73	0.015				<.002	20.7
NF Arm L. Oroville (Foreman C)	CHC	flesh	0.030	<.002				0.343 (s,bb,cc,dd)	<.002	0.18		
NF Arm L. Oroville (Foreman C)	CP	flesh	0.110	0.005				0.721 (r,s,w,bb,cc,dd)	0.007	0.45		
NF Arm L. Oroville (Foreman C)	SPB	liver			0.26 (t)	1.91	<.002				<.002	18.4
NF Arm L. Oroville (Foreman C)	SPB	flesh	0.100	<.002				0.143 (bb,dd)	<.002	0.13		
NF Arm L. Oroville (Foreman C)	WHC	liver			0.63 (t)	1.85	0.005				<.002	19.3
NF Arm L. Oroville (Foreman C)	WHC	flesh	0.030	<.002				0.38 (s,bb,cc,dd)	<.002	0.15		
Lake Oroville Spillway arm	CHC	flesh	0.029	<0.002	0.175 (u)	0.10	<0.002	0.154 (bb,dd)	<0.002	0.06	<0.002	4.14
Lake Oroville Spillway arm	SPB	flesh	0.228 (o,u)	<0.002	0.073 (u)	0.24	<0.002	0.469 (s,bb,cc,dd)	<0.002	0.26	<0.002	4.68
Lake Oroville Spillway arm	SPB	liver	0.772 (t)	0.087	0.169 (t)	4.39	0.006	0.299	<0.002	1.10	<0.002	22.3
Lake Oroville Bidwell Arm	CHC	flesh	<0.025	<0.002	0.094 (u)	0.23	<0.002	0.973 (r,s,u,w,bb,cc,dd)	<0.002	0.13	<0.002	6.28
Lake Oroville Bidwell Arm	CHC	liver	0.108	0.096	0.296 (t)	3.99	0.219 (t)	2.025	<0.002	1.45	0.002	20.4
Lake Oroville Bidwell Arm	SPB	flesh	0.159 (u)	<0.002	0.141 (u)	0.21	<0.002	0.432 (s,bb,cc,dd)	<0.002	0.27	<0.002	4.85
Lake Oroville Bidwell Arm	SPB	liver	0.673 (t)	0.19 (bb)	0.024	8.36	0.012	0.845	<0.002	1.03	0.013	25.9
North Forebay (Swim Area)	CP	flesh	0.060	<.002				0.146 (bb,dd)	<.002	0.27		
North Forebay (Swim Area)	PM	flesh	0.25 (o,u)	<.002				0.543 (s,w,bb,cc,dd)	<.002	0.17		
South Thermalito Afterbay (Ski Cove)	LMB	flesh	0.080	<0.002	0.077 (u)	0.19	<0.002	0.475 (s,bb,cc,dd)	0.031	0.23	<0.002	4.78
South Thermalito Afterbay (Ski Cove)	LMB	liver	0.291 (t)	0.293 (bb)	0.074 (t)	29.5 (t)	<0.002	0.399	0.025	0.90	0.018	29.6 (t)
South Thermalito Afterbay (Ski Cove)	CP	flesh	0.126	0.007				0.234 (bb,dd)	0.014	0.18		

Table 5.0-2. Continued.

			Arsenic	Cadmium	Chromium	Copper	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc
Maximum Tissue Residue Levels (MTRLs) (for Filets or Edible Tissues) (a)	for Carcinogens in Inland Surface Waters		0.2										
	for Non-carcinogens in Inland Surface Waters			0.64					1	28			
NAS Recommended Guideline for Freshwater Fish (b)	(Whole Fish)								0.5				
FDA Action Level for Freshwater and Marine Fish (c)	(Edible Portion)								1.0 (d)				
OEHHA Screening values and action levels in fish tissues (e)	USEPA Value		3 (f)	10					0.6 (g)		50		
	OEHHA Value		1 (f)	3					0.3 (g,n)		20		
Elevated Data Levels (a)	Fish Type (h)		All	All	All	Non	Salmo	All	All	All	All	All	All
	Fish Livers	EDL 85	0.21	0.36	0.03	12	170	0.1	ID (j)	<0.10 (i)	3.32	0.26	28
		EDL 95	0.68	0.99	0.07	33	230	0.2	ID	0.2	4.74	0.76	38
	Whole Fish	EDL 85	0.41	0.12	0.23	3.3		0.2	0.11	0.21	1.4	0.02	42
		EDL 95	0.88	0.19	0.54	4.3		0.46	0.22	0.56	1.9	0.04	49
	Fish Filets	EDL 85	0.14	<0.01 (i)	<0.02 (i)	0.69		<0.10 (i)	0.8	<0.10 (i)	1	<0.02 (i)	21.4
		EDL 95	0.43	0.01	<0.02 (i)	0.99		<0.10	1.7	<0.10 (i)	1.8	<0.02 (i)	30.2
Median International Standards (a)	(excludes liver)		1.5	0.3	1	20		2	0.5		2		45
Canadian Tissue Residue guidelines									0.033 (y)				
USFWS Contaminant Hazard Reviews			NA (z) (USFWS 1988b)	0.1 (USFWS 1985a)	NA (z) (USFWS 1986b)	NA (z) (USFWS 1998a)		NA (z) (USFWS 1988c)	wildlife: 1.1, avian: 0.1 (USFWS 1987)	wildlife:500; avian: 200 (USFWS1998b)	NA (z) (USFWS 1985b)	6 (USFWS 1996)	300 (z) (USFWS 1993)
USFWS protection of threatened and endangered wildlife									0.3 (aa)				

Station Name	Species (k)	Type	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc
Feather R US from Afterbay Outlet	LMB	flesh	0.039	<0.002	0.09 (u)	0.26	<0.002	0.475 (s,bb,cc,dd)	0.016	0.16	<0.002	4.45
Feather R US from Afterbay Outlet	LMB	liver	0.113	0.058	0.109 (t)	1.68	0.003	0.215	0.022	0.63	<0.002	17.4
Feather R DS from Afterbay Outlet	LMB	liver			0.22 (t)	9.23	<.002				<.002	18.0
Feather R DS from Afterbay Outlet	LMB	flesh	0.050	<.002				0.542 (s,w,bb,cc,dd)	<.002	0.20		
Mile Long Pond	BRB	flesh	<0.025	<0.002	0.126 (u)	0.32	<0.002	0.062	0.004	0.04	<0.002	3.85
Mile Long Pond	BRB	liver	<0.025	<0.002	0.111 (t)	2.08	0.008	0.005	0.14 (t)	0.16	0.005	9.23
Potters Pond	CP	flesh	0.060	0.004				0.133 (bb,dd)	0.009	0.18		
Potters Pond	LMB	liver			0.19 (t)	3.53	0.008				<.002	19.0
Potters Pond	LMB	liver			0.23 (t)	3.47	0.004				<.002	18.2
Potters Pond	LMB	flesh	<0.025	<.002				0.26 (bb,dd)	0.123 (u)	0.12		
Lower Pacific Heights Pond	CHC	liver			0.06 (t)	2.05	0.034				0.003	21.0
Lower Pacific Heights Pond	CHC	flesh	<0.025	<.002				0.355 (s,bb,cc,dd)	0.006	0.10		
Diversion Pool	crayfish (l)	crayfish			0.25 (v)	20.3 (v,w)	0.012	0.0325 (dd)			0.006	19.7
N. Afterbay	crayfish (l)	crayfish			0.25 (v)	34.3 (v,w)	0.023	0.022/0.0249			0.011	19.8
S. Afterbay	crayfish (l)	crayfish			0.32 (v)	27.6 (v,w)	0.035	0.0263			0.010	23.0
Feather R DS Hwy 70	crayfish (l)	crayfish			0.26 (v)	22.2 (v,w)	0.025	0.0416 (dd)			0.016	22.5

Table 5.0-2. Continued

a. From SWRCB 1995. Toxic Substances Monitoring Program, 1994-95 Data Report. State Water Resouces Control Board, Sacramento, California.
b. National Academy of Sciences-National Academy of Engineering. 1973. Water Quality Criteria, 1972 (Blue Book). U.S. Environmental Protection Agency, Ecological Research Series.
c. FDA 2000. Action Levels for Poisonous or Deleterious Substances in Human Food and Animal Feed. U.S. Food and Drug Administration. Industry Activities Staff Booklet. Washington, D.C.
d. as methyl mercury.

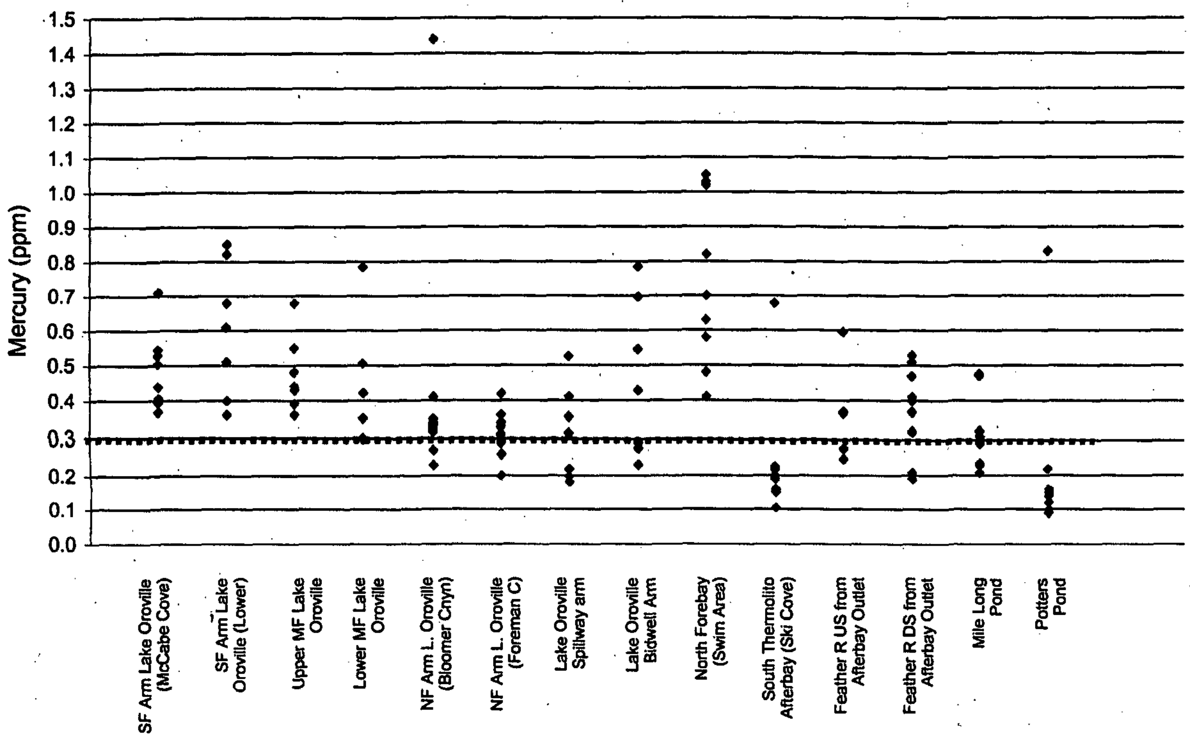
e. OEHHA 1999. Prevalence of selected target chemical contaminants in sport fish from two California Lakes: Public Health Designed Screening Study. Office of Environmental Health Hazard Assessment, Sacramento, California
f. measured as total arsenic
g. measured as total merucry
h. Non = Includes all non-salmonid species. Salmo = Family Salmonidae (trouts). All = All fish species.
i. < = EDL lies below the indicated detection limit.
j. ID = Insufficient data to calculate the EDL.
k. CHC - channel catfish, SPB - spotted bass, CP - carp, WHC - white catfish, PM - pikeminnow, LMB - largemouth bass, BRB - brown bullhead
l. Analyzed as composites
m. Duplicate
n. As methylmercury; from USEPA 2001. Water Quality Criterion for the Protection of Human Health:Methylmercury. EPA-823-R-01-001.
o. Exceeds MTRL for carcinogens
p. Exceeds MTRL for non-carcinogens
q. Exceeds FDA action level
r. Exceeds USEPA screening level
s. Exceeds OEHHA screening level
t. Exceeds EDL for fish livers
u. Exceeds EDL for fish filets
v. Exceeds EDL for whole fish
w. Exceeds MIS
x. Exceeds NAS guideline
y. As methylmercury
z. No criteria proposed
aa. USFWS 2003. Evaluation of the Clean Water Act Section 304(a) Human Health Crite-rion for Methylmercury: Protectiveness for Threatened and Endangered Wildlife in Cali-fornia. U.S. Fish and Wildlife Service. Sacramento, California.
bb. Exceeds recommended limit in USFWS Contaminant Hazard Review
cc. Exceeds recommendation of USFWS Evaluation of CWA Section 304(a) for Methylymercury
dd. Exceeds Canadian Tissue Guideline

Fish tissue
Hg 21/28 above SV.
range = 0.34-1.61

21 < 10 Bass samples / 11 other composite fish samples
channel & white catfish & carp

analysis approach is used, but that others are still susceptible to adverse effects at concentrations of mercury less than the criterion.

Figure 5.1.2-1. Mercury levels in individual fish from project waters (species included spotted bass from Lake Oroville, pikeminnow from the Thermalito Forebay, and largemouth bass from the Thermalito Afterbay, Feather River, and ponds)



5.1.2.7 Nickel

Nickel was either not detected or detected at low levels in fish tissues, except in filets from channel catfish from the Bloomer Canyon area of the North Fork Arm of Lake Oroville and largemouth bass from the Potter's Pond brood pond in the north Thermalito Afterbay, and in liver from brown bullhead collected from Mile Long Pond. The nickel levels detected in these fish exceeded the EDL.

Nickel is abundant in the environment, and is essential for the normal growth of many species (USFWS 1998b). At high levels, nickel may be carcinogenic. Bird diets should contain at least 50 mg/kg of ration to prevent nickel deficiency but less than 200 mg/kg of ration for young birds and 800 mg/kg of ration for adults to prevent adverse effects on growth and survival. Most species of mammals evaluated had normal growth and

BEFORE THE FEDERAL ENERGY REGULATORY COMMISSION

UPPER NORTH FORK FEATHER RIVER PROJECT FERC NO. 2105

APPLICATION FOR NEW LICENSE

FINAL: OCTOBER 2002

VOLUME 6 of 8

APPENDICES

PG&E

3.1.4 Fish and Crayfish Tissue Analysis

The resource agencies and NGOs in early 2001 expressed concern regarding the potential for bioaccumulation of silver (from the Licensee's cloud seeding operations, see Water Quality Section E2), methyl mercury (from historic mining operations in the Seneca Reach), and PCBs in Belden Forebay (from a landslide and spill in 1984) and in the Belden Reach below the forebay's dredge disposal pile (from remediation of the forebay following the spill). Based on these concerns, the Licensee agreed to collect fish and crayfish from both the forebay and from the Belden Reach below the dredge disposal pile for tissue analysis. Specifically, the Licensee was requested and agreed to collect and analyze Sacramento sucker and crayfish from Belden Forebay for silver, methyl mercury, and PCBs and for only PCBs in the Belden Reach below the dredge disposal pile located a short distance below Belden Dam (Figure E3.1.4-1).

Fish and crayfish were collected in Belden Forebay on the night of August 14, 2001 using two 100-foot long by 8-foot deep variable mesh gill nets, and the following day in the Belden Reach below the dredge disposal pile using backpack electrofishers. In addition to collecting and analyzing Sacramento sucker and crayfish in the forebay, the Licensee also elected to include one rainbow trout, one brown trout, and two smallmouth bass that had also been caught by the gill nets. About 12 crayfish (*Pacifasticus leniusculus*) collected as part of the gill net sampling effort were also saved for tissue analysis. In addition to collecting four Sacramento sucker and six crayfish (*P. leniusculus*) in the Belden Reach, the Licensee also collected four rainbow trout for PCB analysis. All collected fish and crayfish were identified to species, measured to the nearest mm (fork length, fish only), and wrapped in aluminum foil, each with a unique identification number (all crayfish collected at each site were composited, resulting in only two crayfish samples, one for each site). All samples were then placed in an ice chest with dry ice for transport to the laboratory for analysis. All field collection and preservation techniques followed protocols supplied by the laboratories for tissue analysis. A chain of custody form was filled out on site and was included with the samples prior to shipping.

Silver, methyl, and inorganic mercury analyses were performed by Frontier Geosciences, Seattle WA., and PCB analysis was performed by Axys Analytical Services Ltd, Sydney, B.C. using ultra-clean sample handling techniques. All fish and crayfish were analyzed as whole specimens, i.e., the entire fish or crayfish was homogenized. The tissue analysis results for collected fish and crayfish are presented in Table E3.1.4-1. Included in this table are sample criteria from various agencies, including the Food and Drug Administration (FDA), Environmental Protection Agency (EPA), and the San Francisco Estuary Institute (SFEI) for the substances analyzed in this study.

The level of silver in all of the fish and crayfish sampled ranged from a low of 0.002 parts per million (ppm) in a smallmouth bass to 0.023 ppm in the composited crayfish sample in Belden Forebay. These levels are from 5 to 50 times lower than the listed California drinking water standard maximum concentration level of 0.1 ppm.

Table E3.1.4-1

Fish and crayfish tissue analysis for silver, mercury, and PCB's in Belden Forebay and Belden Reach and Belden Reach below dredge disposal pile and various sample action, allowable, and screening levels.

SAMPLE ID	SPECIES	Length (mm)	Silver (Ag) (ppm)	Methyl Mercury (ppb)	Hg (II) (ppb)	Total Mercury (ppb)	Total PCBs (ppb)
Belden Forebay							
CA1 RT1	Rainbow Trout	229	0.014	53.5	1.1	54.5	2.60
CA1 BT1	Brown Trout	280	0.010	69.1	1.4	70.6	9.70
CA1 SS1	Sacramento Sucker	358	0.005	53.2	1.4	54.7	11.00
CA1 SS2	Sacramento Sucker	333	0.006	91.1	1.8	92.8	14.60
CA1 SS3	Sacramento Sucker	340	0.005	89.0	1.9	90.8	13.10
CA1 SB1	Smallmouth Bass	180	0.004	111.0	3.3	114.0	5.70
CA1 SB2	Smallmouth Bass	175	0.002	55.6	1.0	56.7	14.90
CA1 CF1/CF2	Crayfish	various	0.023	31.5	1.8	33.3	0.80
North Fork Feather River below dredge disposal pile							
BR1 RT1	Rainbow Trout	202					5.50
BR1 RT2	Rainbow Trout	203					5.20
BR1 RT3	Rainbow Trout	172					5.10
BR1 RT4	Rainbow Trout	295					6.70
BR1 SS1	Sacramento Sucker	365					7.30
BR1 SS2	Sacramento Sucker	360					6.40
BR1 SS3	Sacramento Sucker	425					4.70
BR1 SS4	Sacramento Sucker	418					2.30
BR1 CF1	Crayfish	various					0.20

Sample Criteria

Sample action, advisory, and screening levels	Silver (Ag) (ppm)	Methyl Mercury (ppb)	Hg (II) (ppb)	Total Mercury (ppb)	Total PCBs (ppb)
FDA Action Level	na	100			na
FDA Allowable Level		-			2,000
EPA/ODH Advisory		350			-
EPA Screening Level		-			10
SFEI Screening Level		300			20
SFEI median-largemouth bass		350			6.1
SFEI range-largemouth bass		84 - 670			2 - 112
CDWS, Secondary MCL	0.1	na			na

Legend:

CA= Caribou Afterbay BR= Belden Reach

ppm = parts per million and ppb = parts per billion

FDA Allowable Level for commercial interstate commerce.

ODH = Oregon Health Division

SFEI = San Francisco Estuary Institute, Delta Fish Contaminant Monitoring (2000)

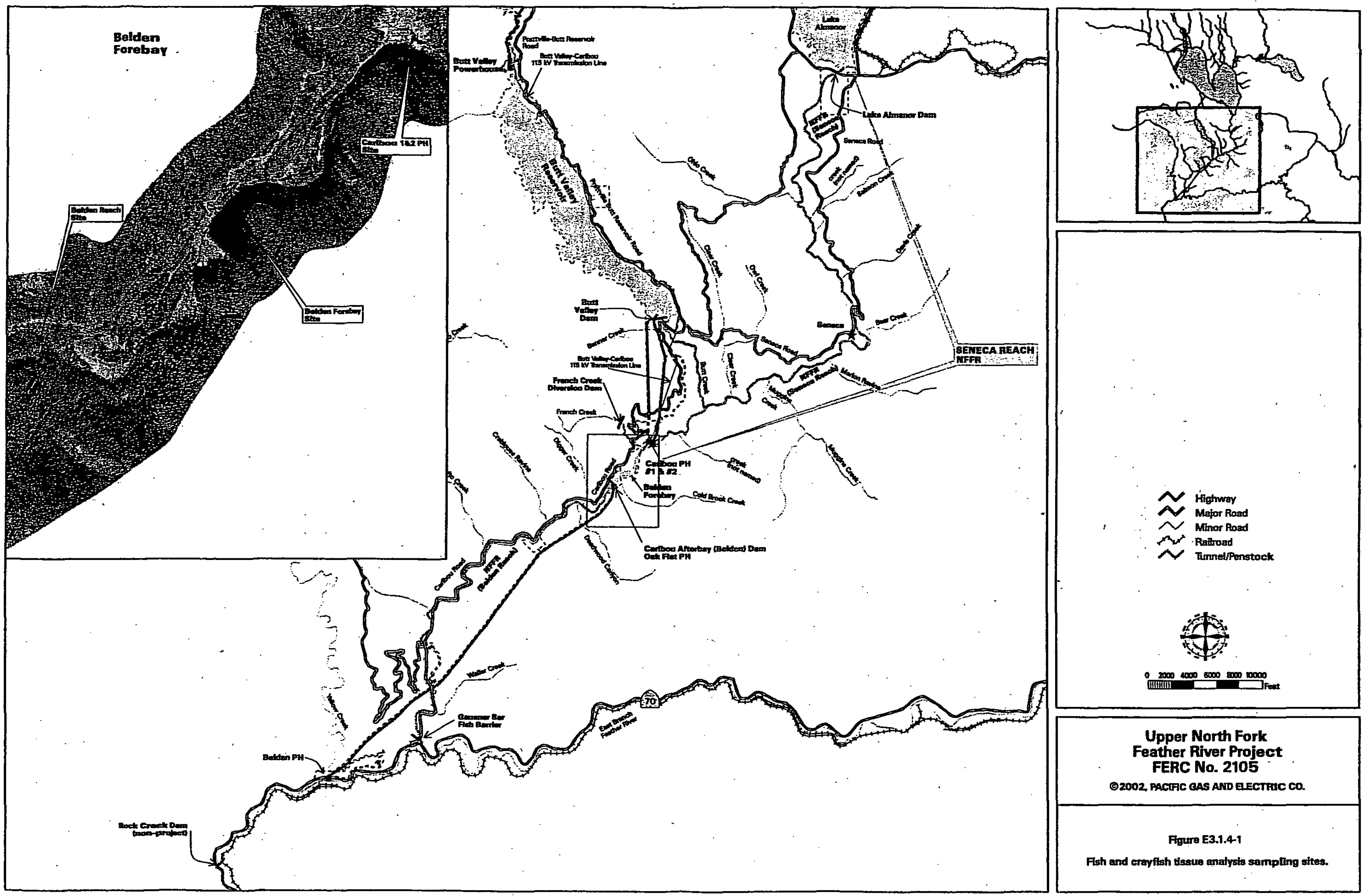
CDWS = California Drinking Water Standards; MCL = Maximum Concentration Level

Methyl mercury ranged from 31.5 parts per billion (ppb) in the composited crayfish sample to 111.0 ppb in a smallmouth bass in the Belden Forebay. With the exception of the single smallmouth bass sample, the rest of the samples were below the FDA action level of 100 ppb, and all were below the SFEI screening level of 300 ppb and the EPA advisory level of 350 ppb. Both inorganic and total mercury levels are also reported; however, there are no current criteria for these constituents.

Total PCB levels (a summation of the 209 separate congeners for each sampled organism) ranged from 0.8 ppb in the crayfish to 14.9 ppb in a smallmouth bass in the Belden Forebay and from 0.2 ppb in crayfish to 7.3 ppb in a Sacramento sucker in the Belden Reach below the dredge disposal pile. All PCB levels were below the FDA allowable level of 2000 ppb. Although four fish (all of the suckers and one smallmouth bass collected from the forebay) were above the EPA screening level of 10 ppb, they were still below the SFEI screening level of 20 ppb. Due to changes in analytical methodologies in the elapsed time between the PCB contaminated oil spill into the Belden Forebay in 1984 and this evaluation, it is not possible to directly compare the results from the fish tissue sampling conducted in 1984 and 1988 with this effort.

3.1.5 Sensitive Aquatic Species

The following section provides information on sensitive fish, amphibian, and aquatic reptile species that are either known to occur in the project vicinity or which have been identified as a sensitive species by either the Plumas National forest (PNF) and/or the



Upper North Fork Feather River Project FERC No. 2105

Figure E3.1.4-1

Fish and crayfish tissue analysis sampling sites.

SP-W1 Project Effects on Water Quality Designated Beneficial Uses for Surface Waters

October 25, 2002

1.0 Introduction/Background

The Environmental Work Group identified as an issue the effects of existing and future project operations on the physical, chemical, and biological components of water quality in the Feather River, affected tributaries, and downstream waters. The project was considered to have potential for direct and indirect water quality effects on aquatic ecosystem health, recreational opportunity, and domestic and agricultural water supply. Concern was expressed about the potential effects of the project on compliance with water quality objectives identified in the Regional Water Quality Control Board's Water Quality Control Plan (Basin Plan) (CVRWQCB 1998), and effects on designated beneficial uses of the water. The beneficial uses for the reservoir and Feather River as defined in the Basin Plan include municipal and domestic supply, agriculture irrigation, electrical power production, contact and non-contact recreation, canoeing and rafting recreation, warm and cold freshwater habitat, warm and cold fish migration and spawning, and wildlife habitat.

Some physical, chemical, and biological data have been collected from the North, Middle, and South forks of the Feather River near their confluences with Lake Oroville, from the reservoir itself, and downstream from Oroville Dam in the Feather River, Thermalito Power Canal, and Thermalito Afterbay. However, these data are not, nor were expected to be, sufficient to determine compliance of project waters with all Basin Plan objectives, goals, and criteria for protection of the designated beneficial uses. Some of the existing data also indicate potential areas of concern for adverse water quality conditions. These data are identified and summarized in the Initial Information Package for Relicensing of the Oroville Facilities (DWR 2001). Additional physical, chemical, and biological data are needed to demonstrate project compliance with Basin Plan standards.

Relicensing of the Oroville Facilities by the Federal Energy Regulatory Commission (FERC) requires certification from the State Water Resources Control Board (SWRCB) that the project complies with Section 401 of the Federal Clean Water Act. The water quality certification signifies compliance with water quality standards and other appropriate requirements for any discharge or discharges to waters of the United States resulting from an activity that requires a federal license or permit. Information required by the SWRCB for certification includes evidence of compliance with appropriate requirements of the Basin Plan.

2.0 Study Objective

The objective of the study is to evaluate the physical, chemical, and biological integrity of water quality in Lake Oroville, its tributaries, the Feather River, Diversion Pool, Thermalito Power Canal, Forebay and Afterbay, and other project-affected surface waters. Information obtained from the study will be used to determine whether project-affected waters meet Basin Plan objectives and are protective of beneficial uses designated in the Basin Plan.

3.0 Relationship to Relicensing /Need for the Study

Construction of Oroville Dam, impoundment of water to form Lake Oroville, and associated facilities of the project have affected the physical, chemical, and biological characteristics of water in the Feather River. These changes in water quality characteristics may affect beneficial uses of the water.

Prior to issuance of a new license for the project, FERC will require a water quality certification by the SWRCB or a waiver of such certification. The certification requires a determination by the SWRCB that the project complies with appropriate requirements of the CVRWQCB Basin Plan, which includes water quality objectives for protection of designated beneficial uses. The CVRWQCB has established surface water quality objectives for a variety of water quality constituents, for which both numerical and narrative standards have been developed. Numerical objectives have been established for parameters which can be measured quantitatively (such as mg/L of a chemical contaminant), while narrative objectives have been established for parameters that may not be readily quantifiable (such as toxicity). Both numerical and narrative objectives are applicable in determining impacts to beneficial uses. Demonstration of compliance with water quality standards and other appropriate requirements is needed in the application for water quality certification. While compliance with numerical objectives will be determined by comparison of data to the numerical value of the objective, compliance with narrative objectives will be determined by comparison of data to other applicable criteria or standards that are recognized as levels protective of beneficial uses. Data obtained from this study will be used to determine compliance with standards, objectives, and criteria for those factors controllable by the project.

4.0 Study Area

The study area is generally within the FERC project boundary, but also includes the Feather River downstream to the confluence with the Sacramento River for project-related effects. Specific water bodies included in the study plan are the North, Middle, and South forks of the Feather River and the West Branch and Concow Creek just above their confluences with the reservoir, Lake Oroville, Feather River downstream from Oroville Dam to the confluence with the Sacramento River, Thermalito Diversion Pool, Forebay, and Afterbay, and Oroville Wildlife Area ponds.

Study plans approved by the Environmental Work Group define the limits of the study area. If initial study results indicate that the study area should be expanded or contracted, the Environmental Work Group will discuss the basis for change and revise the study area as appropriate.

5.0 General Approach

This study will evaluate those parameters potentially affected by the project for which the CVRWQCB has established water quality objectives in the Basin Plan. These parameters include physical constituents (temperature, dissolved oxygen, pH, turbidity, electrical conductivity), chemical constituents (minerals, nutrients, and metals), pesticides, pathogens (bacteria), biostimulatory substances which promote aquatic growths (phytoplankton, periphyton), toxicity (aquatic macroinvertebrate indicators and toxicity bioassays), sediment, settleable and suspended material, color, floating material, oil and grease, and tastes and odors. The study generally relies on monthly collection of data since water quality parameters vary with environmental conditions throughout the year, though some parameters are targeted to specific times of the year due to parameter specific factors. In addition, some parameters will be collected to coincide with the first flush following significant fall rains as well as during some subsequent storm events since the higher runoff associated with these events often elevate certain parameters. Data obtained from this study will be compared to numerical or narrative objectives to determine compliance with the water quality standards for factors controllable by the project. If initial study results indicate that the methods and tasks should be modified, the Environmental Work Group will discuss the basis for change and revise the study plans as appropriate.

Task 1—Project Effects on Surface Water

Monitoring will be conducted at sites within and adjacent to the study area to assess physical, chemical, and biological water quality characteristics in major inflows, discharges, impounded waters, and ponds, and to assess effects of various land use activities within the Feather River watershed project area (Figures SPW1-1 and 2, Table SPW1-1). Monitoring sites were identified in Environmental Workgroup Task Force meetings, which included participation by federal and State agencies and members of the public. Exact monitoring sites will be determined in the field during initial sampling. Site coordinates will be obtained with hand-held GPS units, and data input into the project GIS system. Adjacent areas included in the monitoring program are primarily the tributaries entering Lake Oroville and stations on the Feather River downstream to the confluence with the Sacramento River Monitoring of these tributaries at their confluences with the reservoir will establish a baseline for determining any changes in water quality induced by the project. Additional monitoring stations may be added if data indicate the need to determine sources and effects of any detected adverse habitat or water quality conditions.

Physical, chemical, and biological components of water quality will be assessed in study area waters (Table SPW1-2). Some parameters, such as temperature, will be obtained with recording instruments, while others (such as inorganic chemistry) will be sampled during monthly visits to the monitoring site.

Water Temperature—Water temperatures in the study area will be assessed since this parameter controls the rate of chemical and biological processes, and is important in determining suitability of project waters for survival and reproduction of aquatic organisms, including anadromous fish. These data will also be necessary for development of a temperature model in other study plans. This information will be collected in Study Plan SP-W6.

Field Parameters—Basic water quality parameters, including temperature, dissolved oxygen, conductivity, pH, and turbidity, will be measured with properly calibrated field instrumentation at each visit to every monitoring station. Stream samples or measurements will be collected about one foot below the surface in flowing, well-mixed riffle or run areas. Dissolved oxygen will be measured in streams by titration (azide modification of the iodometric method). Basic water quality parameters will be measured in lentic waters (lakes and ponds) from the surface to the bottom at meter intervals when differences in individual parameters are observed between successive depths, and at three to five meter intervals when there are no differences in successive values. Temperature and dissolved oxygen in lentic waters will be measured at intervals

Figure SPW1-1. Monitoring Sites in the Project area

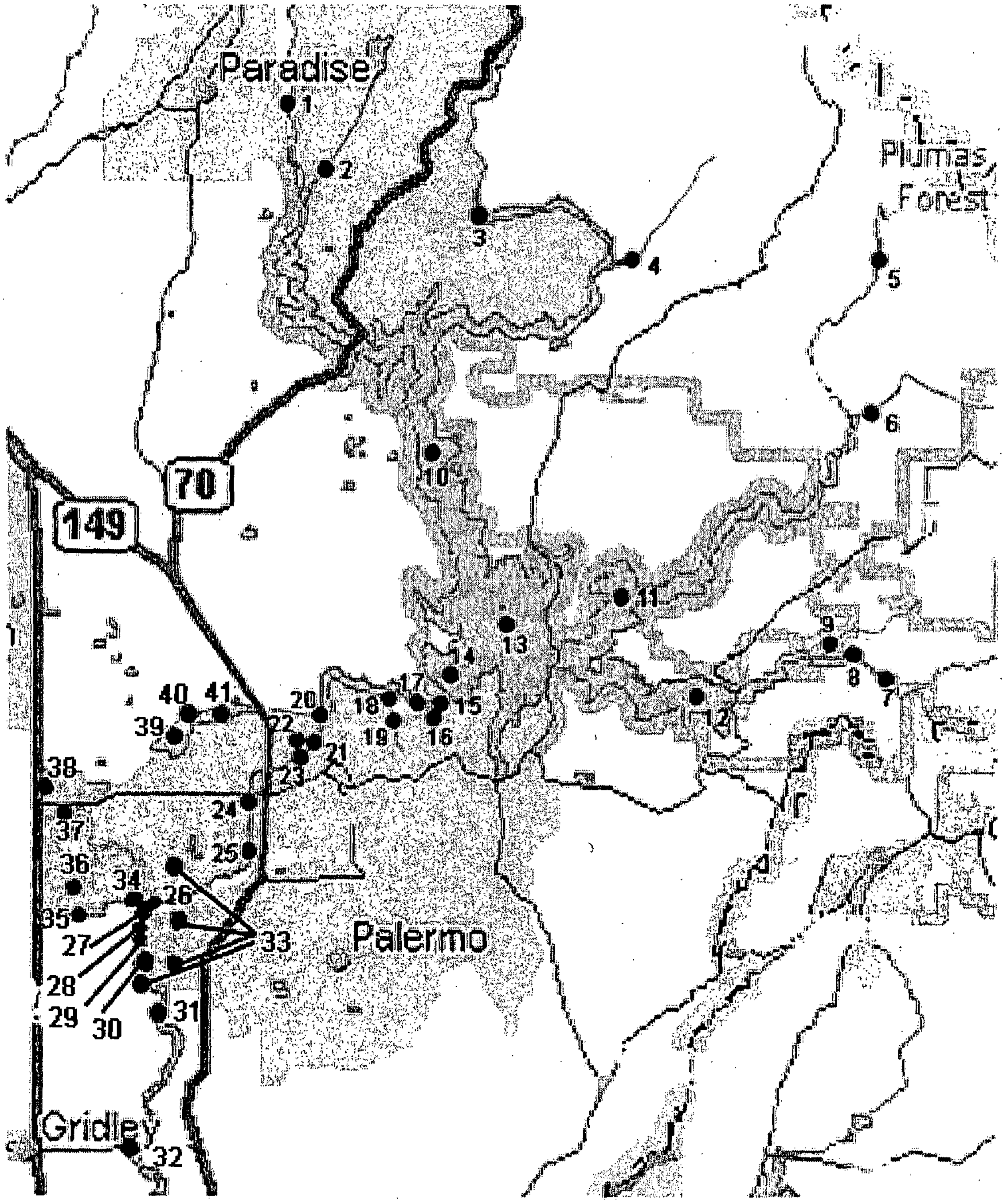


Figure SPW1-2. Monitoring Sites in the Lower Feather River

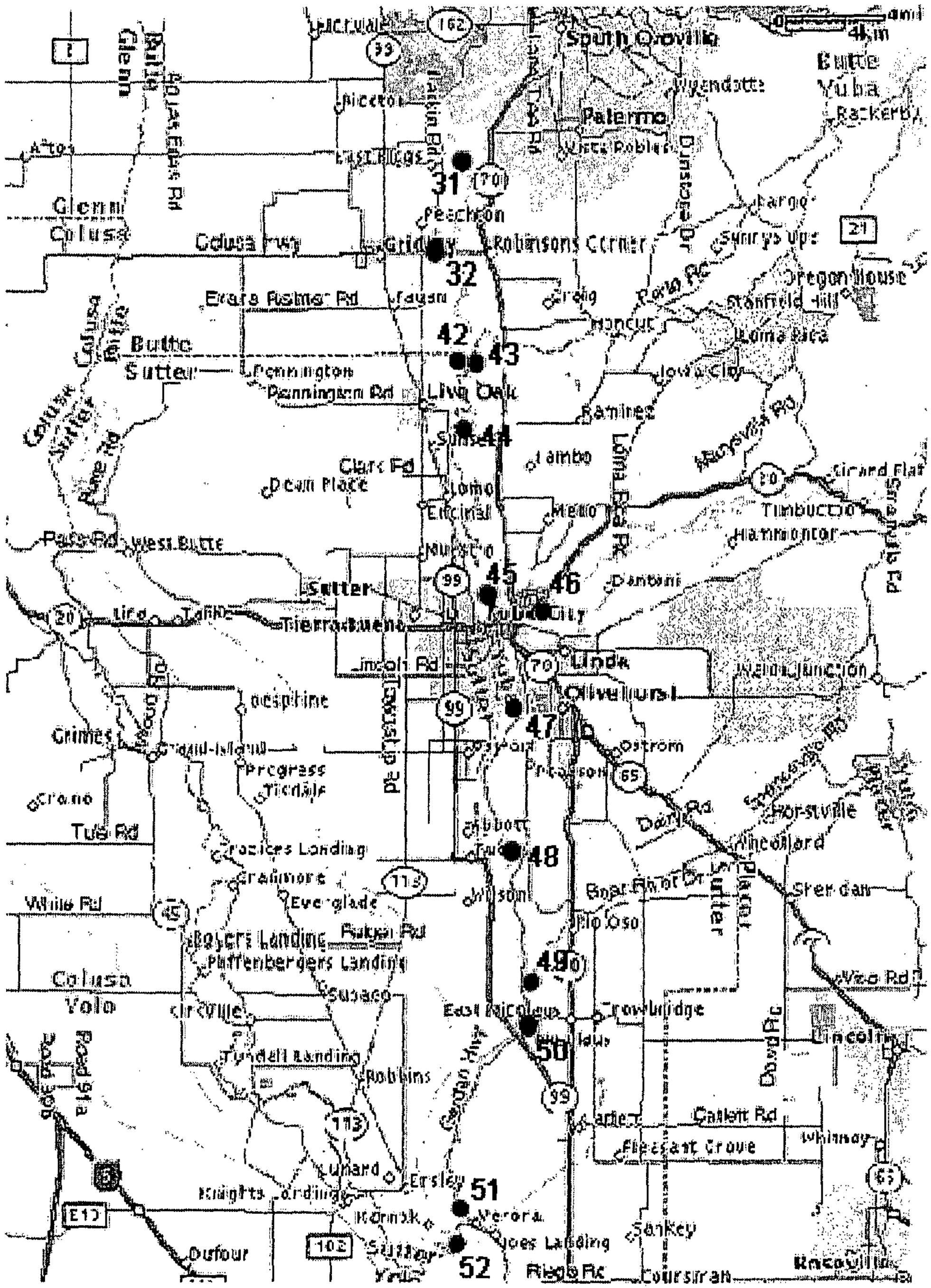


Table SPW1-1. Monitoring Site Number System for Maps

1. West Branch at Oroville Reservoir	28. Feather River downstream from Afterbay Outlet
2. Concow Creek at Jordan Hill Road	29. Feather River downstream from SCOR Outfall
3. North Fork downstream from Poe Power House	30. Feather River near Mile Long Pond
4. French Creek at Oroville Reservoir	31. Feather River downstream from Project boundary
5. Middle Fork at Milsap Bar Road	32. Feather River nr Gridley
6. Fall River upstream from Feather Falls	33. Wildlife Area ponds
7. South Fork upstream from Ponderosa Reservoir	34. Afterbay Outlet Canal to Feather River
8. Ponderosa Reservoir near Dam	35. Sutter Buttes Canal at Afterbay Outlet
9. Sucker Run near Forbestown	36. Thermalito Afterbay (south)
10. North Fork Arm Lake Oroville	37. Thermalito Afterbay (north)
11. Middle Fork Arm Lake Oroville	38. Western Canal at Afterbay Outlet
12. South Fork Arm Lake Oroville	39. Thermalito Forebay (south)
13. Lake Oroville Main Body	40. Thermalito Forebay nr Wastewater Holding Tank
14. Lake Oroville near Dam	41. Thermalito Forebay (north)
15. Diversion Pool upstream from Kelly Ridge PH	42. Feather River upstream from Honcut Creek
16. Kelly Ridge PH Discharge	43. Honcut Creek
17. Diversion Pool downstream from Kelly Ridge PH	44. Feather River near Live Oak
18. Glen Pond	45. Feather River supstream from Yuba River
19. Glen Creek	46. Yuba River at Marysville
20. Diversion Pool near Diversion Dam	47. Feather River at Shanghai Bend
21. Feather River nr Fish Barrier Dam	48. Feather River at Star Bend
22. Feather River upstream from Hatchery	49. Bear River
23. Feather River downstream from Hatchery	50. Feather River nr Nicolaus
24. Feather River downstream from Hwy 162	51. Feather River near Verona
25. Feather River at Robinson Riffle	52. Sacramento River upstream from Feather River
26. Feather River upstream from Afterbay Outlet	
27. Feather River pool at Afterbay Outlet	

using meters and membrane electrode probes calibrated at the surface using the iodometric method. Conductivity and pH will be measured with meters and probes in samples collected at intervals with a van Dorn water bottle. Turbidity will be measured with a nephelometer from samples collected using the van Dorn water bottle.

Dissolved oxygen will also be measured in pools near the sampling stations downstream from the Fish Barrier Dam to the mouth of the Feather River. Dissolved oxygen (and temperature in conjunction with SP-W6) profiles will be measured at half-meter intervals from the surface to the bottom of pools with meters and probes every other week from May through October, and monthly from November through April.

At some stations, the basic water quality field parameters may also be recorded with data loggers. Data loggers may also be installed where data indicate potential water quality degradation or where water quality parameters could be expected to experience wide diurnal variations. Logging instrumentation will be calibrated no less frequently than monthly, or more often if data indicate significant instrument drift.

Inorganic Chemistry—Water inorganic chemistry will be assessed since these parameters influence beneficial uses of water and may become elevated due to contamination, which often results in deleterious effects to aquatic life and other beneficial uses. Limnological processes in project water bodies may alter the chemical state of some parameters, and include potential release of soluble metals from bottom sediments and methylation of mercury due

Table SPW1-2. Water Quality Monitoring Schedule for the Oroville Relicensing Project

	Station	Temper -ature (a)	Field Parameters (b)	Inorganic Chemistry (c)	Pesticides (d,f)	Coliform bacteria (t)	Phyto- & Periphyton Zoo- plankton		Macro- Inverte- brates	Aquatic Toxicity
1	West Branch at Oroville Res	R	m (e)(t)	m (t)	F & W	m(t)		m	l	o
2	Concow Creek at Jordan Hill Rd	R	m (t)	m (t)	F & W	m(t)		m	l	o
3	North Fork d/s Poe Power House	R	m (t)	m (t)	F & W	m(t)		m	l	o
4	French Creek at Oroville Res	R	m							
5	Middle Fork at Milsap Bar Rd	R	m (t)	m (t)	F & W	m (t)		m	l	o
6	Fall River u/s Feather Falls	R	m (t)	m (t)	F & W	m (t)		m	l	o
7	South Fork u/s Ponderosa Res	R	m (t)	m (t)	F & W	m (t)		m	l	o
8	Sucker Run nr Forbestown	R	m (t)	m (t)	F & W	m (t)		m	l	o
9	Ponderosa Res nr Dam	P	m	m			m			
	Lake Oroville									
10	North Fork Arm	P	m	m (r)	F & W (i)	m	m			
11	Middle Fork Arm	P	m	m (r)	F & W (i)	m	m			
12	South Fork Arm	P	m	m (r)	F & W (i)	m	m			
13	Main Body	P	m	m (r)	F & W (i)	m	m			
14	Dam	P	m	m (s)	F & W (i)	m	m			
	Diversion Pool									
15	u/s from Kelly Ridge Power House	P	m	m	F & W (i)	m	m			
16	Kelly Ridge Power House discharge	R								
17	d/s from Kelly Ridge Power House	P								
18	Glen Pond	P	m	m						
19	Glen Creek	R	m	m	F & W	m		m	l	
20	Diversion Pool nr Div. Dam	P	m	m (r)	F & W (i)	m	m			
	Feather River in Project Boundary									
21	nr Fish Barrier Dam	Ru	m (g,t,u)	m (g,t)	F & W	m (t)		m (g)	l	m
22	u/s from Hatchery	Ru	m (g,u)	m (g)		m		m (g)	l	
23	d/s from Hatchery	Ru	m (g,t,u)	m (g,t)	F & W	m (t)		m (g)	l	m
24	d/s from Hwy 162 bridge	Ru	m (g,u)	m (g)		m		m (g)	l	
25	Robinson Riffle	Ru	m (g,u)	m (g)		m		m (g)	l	
26	u/s from Afterbay Outlet	Ru	m (g,t,u)	m (g,t)	F & W	m (t)		m (g)	l	m
27	pool at Afterbay Outlet	u	u							
28	d/s from Afterbay Outlet	R u	m (g,t,u)	m (g,t)	F & W	m (t)		m (g)	l	m
29	d/s from SCOR Outfall (q)	R	m (g,t)	m (g,t)	F & W	m (t)		m (g)	l	m
30	nr Mile Long Pong	Ru	m (g,t,u)	m (g,t)	F & W	m (t)		m (g)	l	
31	d/s from Project boundary	Ru	m(t,g,u)	m(g,t)	F & W	m (t)		m	l	m
32	nr Gridley	u	u							
33	Oroville Wildlife Area ponds	P	m	m	F & W (i)	m	m		l	p

	Thermalito Complex									
34	Outlet to Feather River	R	m	m	F & W (i)	m				m
35	Sutter Buttes Canal	R	m							
36	South Afterbay	P	m	m (r)	F & W (i)	m	m			
37	North Afterbay	P	m	m (r)	F & W (i)	m	m			
38	Western Canal	R	m							
39	South Forebay	P	m	m (r)	F & W (i)	m	m			
40	Forebay nr Wastewater Holding Tank					m				
41	North Forebay	P	m	m (r)	F & W (i)	m	m			
	Feather River Downstream from Project Boundary									
42	u/s from Honcut Creek	Rg,u	m(t,g,u)	m(t)	F & W	m (t)		m	l	
43	Honcut Creek	R	m(t)	m(t)	F & W	m (t)		m	l	
44	nr Live Oak	Ru	m(t,u)	m(t)	F & W	m (t)		m	l	
45	u/s from Yuba River	Ru	m(t,u)	m(t)	F & W	m (t)		m	l	
46	Yuba River	R	m(t)	m(t)	F & W	m (t)			l	
47	at Shanghai Bend	Ru	m(t,u)	m(t)	F & W	m (t)			l	
48	at Star Bend	u	u							
49	Bear River	R	m(t)	m(t)	F & W	m (t)			l	
50	nr Nicolaus	u	u							
51	nr Verona	Ru	m(t,u)	m(t)	F & W	m (t)			l	
52	Sacramento R ab FR	R	m(t)	m(t)	F & W	m (t)			l	

47

Table SPW1-2. Water Quality Monitoring Schedule for the Oroville Relicensing Project, continued

a. R = recorder, P = profile; from study plan SP-W6
b. Includes dissolved oxygen, conductivity, pH, turbidity
c. minerals (calcium, sodium, potassium, magnesium, sulfate, chloride, boron, and alkalinity), nutrients (nitrate plus nitrite, total and dissolved ammonia, dissolved orthophosphate, and total phosphorus), total and dissolved metals (aluminum arsenic, cadmium, chromium, copper, iron, lead, manganese, nickel, selenium, and zinc), total recoverable mercury, total methyl mercury, total and dissolved solids, total hardness, settleable and suspended materials (solids), color, floating material, oil and grease, taste and odor, and total and dissolved organic carbon
d. includes chlorinated organic pesticides, organic phosphorus pesticides, chlorinated phenoxy acid herbicides, volatile organic pesticides, carbamate pesticides, and glyphosate.
e. m = monthly measurement or sample collection
f. F = fall (after significant runoff), W = winter (after dormant spray season)
g. nutrients, field parameters, and periphyton at two week intervals from September through December
i. surface samples
l. benthic macroinvertebrate samples collected in September 2002
o. seasonal analysis of toxicity (July, September, first flush, February, April/May
p. spring and summer toxicity analyses
q. Sewerage Commission Oroville Region discharge 1/4 mile downstream from Afterbay Outlet
r. surface and bottom samples
s. surface, intake structure withdrawal elevation, and bottom
t. additional samples during four storm events

u. temperature and dissolved oxygen biweekly from May through October and monthly from November through April.

to warmer water and organic content in the Thermalito Afterbay. Water samples will be collected monthly for chemical analyses at the monitoring stations.

Inorganic chemical analyses will include minerals (calcium, sodium, potassium, magnesium, sulfate, chloride, boron, and alkalinity), nutrients (nitrate plus nitrite, ammonia, dissolved orthophosphate, and total phosphorus), metals (aluminum arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, and zinc), and total and dissolved organic carbon. For all metals except mercury, samples will be collected for both total recoverable and dissolved metals. Mercury will include both total recoverable and total methyl fractions. Total and suspended solids and hardness will also be analyzed from samples collected at each site. Analyses may also be conducted at other locations to determine sources of constituents found at the primary monitoring stations that may degrade the beneficial uses of the water.

Samples for chemical analyses from streams will be collected by wading into the channel and dipping sample containers to a depth of approximately one foot into the well-mixed channel flow. Mineral and nutrient samples will be collected into clean polyethylene containers. Samples for trace metals analyses at water quality criteria levels will be collected into polyethylene or glass bottles according to U.S. EPA Method 1669 (USEPA 1996). Samples for mineral, nutrient, and metal analyses from lakes and ponds will be collected from the surface by dipping an inverted container to approximately 0.5 meters below the surface. Water samples at greater depths will be collected with a van Dorn water bottle for minerals and nutrients and teflon bomb or Kemmerer style bottles for trace metals. Samples will be collected from near the surface and bottom of lakes and ponds during periods of stratification or when differences in field parameters occur between the surface and bottom, but only at mid-depth during those portions of the year when field parameters indicate uniform conditions throughout the water column in the shallower water bodies, such as Oroville Wildlife Area ponds.

Chemical analyses of minerals, nutrients, and metals will be performed at the DWR Bryte Chemical Laboratory in West Sacramento using U.S. EPA approved techniques, equipment, and methods (Appendix SPW1-1).

Pesticides—A variety of pesticides may be used within the watershed that may affect the aquatic resources in the Feather River watershed. Silviculture and agriculture pesticide uses are well regulated, but some application practices still contribute to pesticide contamination in streams and lakes. A significant source of pesticides in many areas has been identified as runoff from urbanized areas. Urban use of readily available household pesticides is unregulated and significantly more pesticides may be applied by homeowners than is applied for similar products by the regulated community.

Water samples will be collected from the monitoring stations in the fall after rains produce the first significant runoff and again during February or March. Samples will be analyzed at the Bryte Chemical Laboratory for chlorinated organic pesticides, organic phosphorus pesticides, chlorinated phenoxy acid herbicides, volatile organic pesticides, carbamate pesticides, and glyphosate.

Presently, the EPA has not approved methods for analyses of pyrethroid pesticides, though either GC-MS or HPLC methods have been used in various laboratories for their analyses. Since methods for analysis vary according to the specific pyrethroid pesticide, the Department of Pesticide Regulation will be contacted for a list of pyrethroid pesticides used within the watershed, including those that may replace diazinon and chlorpyrifos for home use by the public. Subsequently, suitable methods for analyses of these compounds will be identified and, if available, incorporated into the monitoring protocols.

Pathogens—Fecal coliform bacteria in aquatic ecosystems are indicative of fecal contamination. Though these bacteria generally do not themselves pose adverse risks, their presence indicates the possible presence of far more serious microorganisms, which may impact human health, and nutrient loading that may adversely affect the aquatic environment.

Bacteria levels will be screened monthly at the monitoring stations using membrane filter procedures for both fecal and total coliform bacteria. Analyses may be conducted at additional sites to identify sources of fecal contamination indicated by the presence of these bacteria. In addition, a focused coliform bacteria sampling program will be conducted. Selective stations at intensively used recreation areas, such as the North Forebay Recreation Area, will be monitored during a major holiday event (Independence or Labor day) according to requirements in the Basin Plan (i.e., not less than five samples for any 30-day period). This list of coliform sampling stations (approximately twelve) will be developed in consultation with SWRCB staff and other members of the Environmental Work Group.

Phytoplankton and Zooplankton—Phytoplankton form the basis of the food web in lakes and reservoirs. Phytoplankton respond to nutrient enrichment by increasing in numbers of organisms as well as type of organism dominance. Zooplankton subsequently graze on phytoplankton, and may exhibit changes in populations due to nutrient enrichment or contamination. Populations of these organisms vary throughout the year in response to environmental variables.

Both phytoplankton and zooplankton will be sampled from impounded project waters. Phytoplankton and zooplankton will be sampled with a Clark-Bumpus plankton net towed from 30 feet in depth to the surface in Lake Oroville, and from the bottom in the other impounded waters. Samples will be collected during monthly visits to the monitoring stations. Analyses of phytoplankton will include identification, enumeration, and chlorophyll determination. Zooplankton will be identified, enumerated, and measured volumetrically.

Periphyton—Periphyton are attached algae in streams that contribute to the basis of the food web along with organic input (e.g., leaves) from terrestrial sources. As with phytoplankton, periphyton also respond to nutrient enrichment by changes in types and abundance of species.

Periphyton will be sampled monthly from riffle substrates in streams. A cylindrical sampler will be used to enclose the periphyton, which will then be brushed from the substrate and aspirated into collection jars. Ten samples from each site will be composited. Analyses of the periphyton will include species identification and counts, and chlorophyll determination.

Aquatic Macroinvertebrates—Aquatic macroinvertebrates form the basis of the aquatic food web and are excellent indicators of long-term water quality conditions since specific communities develop in response to specific stream conditions and perturbations. The Department of Fish and Game modification (California Stream Bioassessment Procedure) of the U.S. EPA rapid bioassessment method (USEPA 1989) will be used to assess aquatic macroinvertebrates communities.

Decreasing reservoir levels during the summer results in exposure of former stream channels that may become habitat for fish and other aquatic organisms. Two to three riffle areas in each of these types of habitats in the major tributaries to Lake Oroville will be sampled in September of 2002 to determine the benthic community structure. Organisms will be collected using a kick screen and metal frame delineating a two square foot sampling area. Three transects will be established across each monitoring site. Three samples will be collected along each transect and combined into one sample, resulting in three samples per monitoring site. Organisms will be removed from samples using the DFG rapid bioassessment method protocols, identified to the lowest practical taxon (generally genus), and enumerated. The areas will again be sampled during the spring when the riffles are inundated to evaluate changes in aquatic macroinvertebrate composition. Spring samples will be collected with an Ekman dredge.

Habitat conditions downstream from major dams generally result in significant changes to macroinvertebrate community structure and function due to altered temperature, flow, food, and substrate regimes. Aquatic macroinvertebrates will be assessed at the monitoring stations in the Feather River upstream from Lake Oroville and downstream from the Fish Barrier Dam during September of 2002 to determine effects from Oroville Dam on community structure and function. Organisms will be collected from riffle substrate areas using a kick screen and metal frame delineating a two square foot sampling area. Two or three closely spaced riffles or one extensive riffle will be sampled at each monitoring station. Three transects will be established across each monitoring site. Three samples will be collected along each transect and combined into one sample, resulting in three samples per monitoring station. Organisms will be removed from samples following the DFG rapid bioassessment method protocols, identified to the lowest practical taxon (generally genus), and enumerated at the DWR Aquatic Macroinvertebrate Laboratory in Red Bluff.

Aquatic macroinvertebrates will be sampled in four ponds in the Oroville Wildlife Area using an Ekman dredge. Ten dredged samples will be collected from areas within a pond and composited Samples will be processed using procedures similar to those for samples collected from the Feather River.

Stream Sediments—Sedimentation is a major impairment in many streams, including those upstream from Lake Oroville. Fine sediments in gravels adversely affect salmonid reproduction and survival of aquatic macroinvertebrates and other organisms that are important as food for fish.

Stream gravels from riffle areas will be analyzed for laboratory determination of particle size distribution in study plan SP-G2, Task 2.

Aquatic Toxicity—The direct measurement of toxicity to aquatic organisms of stream water may be indicative of the ability of the stream to support aquatic life. The Basin Plan has an objective that "all waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses ... in aquatic life." The Basin Plan stipulates that "compliance with this objective shall be determined by ... biotoxicity tests." Water column toxicity assessment will be used to identify direct impacts to fish and zooplankton from toxic substances that may be either dissolved or suspended in the water column.

Water column toxicity testing will use *Ceriodaphnia* and the fathead minnow. Toxicity tests will measure survival and growth for the minnow, and reproduction and survival of Ceriodaphnia over a seven-day test period (USEPA 1994). Water samples will be analyzed during the high temperature months of July and September, following the first flush in the fall, following winter dormant spraying in February, and again during the high runoff period in April or May in tributaries to Lake Oroville. Samples will be analyzed monthly for toxicity analyses from the monitoring sites downstream from the Fish Barrier Dam to Honcut Creek. If significant toxicity is detected at these sites, identification of the causative agent for the toxicity will be attempted through toxicity identification evaluation procedures. Additional analyses will also be conducted at sites further downstream to determine the extent of project related effects. Several Oroville Wildlife Area ponds will be sampled in the spring and again in mid-summer. Toxicity tests will be conducted at the Pacific EcoRisk Laboratory or U.C. Davis Toxicology Laboratory.

Settleable and Suspended Material—Settleable and suspended materials in water may affect the beneficial uses of water and impart an aesthetically unpleasant appearance. Suspended materials may interfere with respiration of fish and other aquatic organisms, while settleable materials may smother eggs of fish and benthic organisms.

Water samples will be collected for settleable and suspended materials analyses during monthly visits to the sites designated for inorganic chemistry analyses. Setteable materials will be determined by settling the water sample in an Imhoff cone, while suspended material will be determined by filtration.

Color—Color is defined as either true or apparent color. True color in water may result from the presence of metallic ions, humus and peat materials, plankton, weeds, and industrial wastes in solution, while apparent color includes the effects from turbidity caused by suspended materials.

Water samples will be collected for color analyses during monthly visits to the sites designated for inorganic chemistry analyses. Color will be determined by comparing samples filtered to remove apparent color to calibrated glass disks (colorimetry).

Floating Material and Oil and Grease—The Basin Plan stipulates that floating material shall not be present in amounts that cause nuisance or adversely affect beneficial uses, and that oil, grease, waxes, or other materials shall not be present in concentrations that cause nuisance, result in a visible film or coating on the surface of the water or on objects in the water, or otherwise adversely affect beneficial uses.

Floating materials and oil and grease will be determined through visual observation during each visit to each monitoring site. Floating materials will be estimated as a percent cover of the water. If oil, grease, or related compound are sighted, water samples will be collected for laboratory determination of the type of compound.

Tastes and Odors—The Basin Plan states that water shall not contain taste or odor producing substances in concentrations that impart undesirable tastes or odors to domestic or municipal water supplies or to fish flesh or other edible products of aquatic origin, or that cause nuisance or otherwise adversely affect beneficial uses. Sampling water for taste requires that a sample be taken into the mouth for sensory analysis. However, raw water is not safe for taste testing due to the potential presence of bacteria, viruses, hazardous chemicals, and other factors. Therefore, water from the project area will not be subjected to taste tests. However, aquatic organisms (fish and crayfish) sampled for other studies during the spring (i.e., SP-W6) will be obtained for determination of any undesirable taste to the edible portion of these organisms.

Water can be analyzed for odor simply by smelling a sample. At least two individuals will smell water samples from each site visit to determine the presence of odors. The samplers will describe the type of any odor detected to attempt determination of the causative agent.

Specific Effects Analyses—Some aspects of the project may have water quality effects related to specific parameters or require additional monitoring for specific parameters. As these potential effects are identified in this or other studies or information from the public or other agencies, appropriate monitoring programs will be developed to evaluate their significance.

An issue that has been raised is the effect of the unnatural concentration of carcasses from over 100,000 salmon that spawn each year in the low flow section of the Feather River. Following spawning, the salmon die and begin decomposition. The decomposition process provides food for scavenger macroinvertebrates, bacteria, and other animals. Decomposition releases nutrients that may be used by periphyton and higher plants, but also may decrease oxygen levels in the water and contribute ammonia which is toxic to aquatic life, including fish eggs and fry, in sufficiently high concentration. Reduced oxygen and elevated ammonia levels may contribute to the low egg survival identified in the IIP in the upper river. Additional nutrient and periphyton monitoring will be conducted at two week intervals from September through December at the monitoring sites within the project boundary downstream from the Fish Barrier Dam to Honcut Creek to determine effects from decomposing salmon carcasses. Dissolved oxygen levels, as well as temperature, conductivity and pH, in the water and within the gravels will be measured with field instruments or recorders at several of these sites. Subsequently, the data will be reviewed by the Environmental Workgroup to determine the need to continue this monitoring past December.

Additional nutrients and other waste treatment byproducts are discharged to the Feather River a quarter mile downstream from the Afterbay Outlet by the Sewerage Commission Oroville Region, which treats sewage from the Oroville area. Monitoring of nutrients, periphyton, dissolved oxygen, temperature, conductivity, and pH in the water and within the gravels will be conducted with field instruments at monthly intervals or recorders in the Feather River upstream and downstream from the SCOR discharge.

Task 2—Project Effects on Water Quality Objectives

Data for this analysis will be obtained from Task 1. The data will be evaluated for compliance to applicable criteria and objectives for protection of beneficial uses, most of which have been summarized by the CVRWQCB (CVRWQCB 2000). The CVRWQCB has established numerical objectives for parameters which can be measured quantitatively (such as mg/L of a chemical contaminant) and narrative objectives for parameters that are not readily quantifiable. Both numerical and narrative objectives are applicable in determining impacts to beneficial uses. The criteria and objectives used for evaluating the data include:

numerical and narrative objectives identified in the CVRWQCB Basin Plan;
criteria of the U.S. EPA California Toxics Rule (USEPA 1998);
criteria of the National Recommended Water Quality Criteria (USEPA 1999);
criteria of the nutrient criteria guidance Documents (USEPA 2000a);
drinking water standards and health advisories (USEPA 2000b);
drinking water criteria (CDHS 2000a);
agriculture water quality (Ayers and Westcot 1985);
draft bacterial limits guidelines (CDHS 2000b); and
contaminant action levels established by the California Office of Environmental Health Hazard Assessment.

Task 3—Project Effects on Designated Beneficial Uses

Information for this analysis will be obtained from Task 2. Compliance with numerical and narrative water quality objectives will be evaluated to determine project effects to designated beneficial uses. Designated beneficial uses potentially affected by parameters that do not meet water quality objectives will be identified in this study. A summary table will be prepared showing designated beneficial uses, water quality criteria or objectives, and range of values obtained from the study. In addition, a report will be prepared discussing results, compliance issues, and potential mitigation.

Task 4. Effects from Future Project Operations

As the Engineering and Operations Workgroup identifies potential future operations of the project that differ from those currently experienced, potential effects to water quality and beneficial uses from those operations will be evaluated in this study.

Task 5. Progress Report—A progress report will be prepared at the conclusion of the first year of study. Interim output products will be identified through coordination with other workgroups to meet their data needs.

Task 6. Final Report—A final report will be prepared following completion of the second year of the study.

6.0 Results and Products/Deliverables

Results

Results from this study will be presented in a detailed report that evaluates effects of the project to water quality. Data obtained from this study will be compared to applicable numerical and narrative water quality objectives and criteria established for the protection of beneficial uses. Data obtained from the study will be presented in tables and graphs depicting concentrations of the various parameters and associated criteria. The graphs will illustrate variations in parameter concentrations throughout the period of collection. Parameters that exceed criteria will also be compared in graphs to concentrations of associated parameters, such as metal concentration association with turbidity levels, to help understand potential causes of elevated parameters. Temperature data from study plan SP-W6 will be summarized in tables and graphs depicting conditions in the Feather River downstream from Oroville Dam, and will illustrate daily maximum and minimum and mean daily temperature variations (based on 15-minute data collected to compute hourly values).

Compliance with water quality objectives will be used to evaluate effects on designated beneficial uses for Lake Oroville and the Feather River downstream from the Fish Barrier Dam as defined in the Basin Plan. The beneficial uses include municipal and domestic supply, agriculture, electrical power production, contact and non-contact recreation, warm-water and cold-water fish spawning, rearing and migration, warm and cold freshwater habitat, and wildlife habitat. Designated beneficial uses potentially affected by parameters that do not meet water quality objectives will be identified. Water quality data within the project area will be compared with that for waters entering the project as well as downstream from the project to determine whether the project has any affect on water quality objectives. The data from this study will also be used to evaluate effects to water quality of any proposed operational alternatives.

Aquatic macroinvertebrate data will be analyzed using various metrics to determine the health of this component of the aquatic ecosystem. Metrics used to evaluate the data will include organism abundance, taxa richness, species diversity and equitability, modified Hilsenhoff Biotic Index, ratio of scraper and filtering collector functional feeding groups, ratio of EPT (Ephemeroptera, Plecoptera, Tricoptera) and Chironomidae abundances, percent contribution of dominant taxon, and ratio of shredder functional feeding group and total number of individuals (USEPA 1989). The data will also be used to evaluate the effects of the dam on downstream community structure and function due to altered temperature, flow, and food regimes, effects of relatively sudden flow changes (ramping) on stranding macroinvertebrates and contributing to catastrophic drift, and effects of concentrated salmon spawning in the low flow section. Benthic macroinvertebrate community species composition and structure will be compared upstream and downstream from potential impacts to assess effects. Comparisons will include tables and graphs comparing various metrics used to analyze community structure. Literature information on substrate size, flow, and depth preferences will be reviewed and an assessment made for effects in the Feather River using habitat information from Study #G2 and Study #F10.

Toxicity test results will be used to identify parameters that may be adversely affecting aquatic life. The data will be presented in tables and graphs showing levels of toxicity during the monitoring period.
Information derived from this study will be used by the SWRCB to determine conditions in the water quality certification to comply with Section 401 of the Federal Clean Water Act. Information from this study will also be used by others in the Environmental, Recreation and Socioeconomics and Land Use, Land Management and Aesthetics Work Groups.

7.0 Coordination and Implementation Strategy

Coordination with Other Resource Areas/Studies

This study plan will also provide most of the data needed in study plan SP-W4 for evaluation of effects of the hatchery to water quality, and will be coordinated with water quality studies in study plan SP-W3 for evaluation of recreation facilities and activities on water quality. Temperature data from study plan SP-W6 will provide information to this study plan for evaluation of effects to water temperature beneficial use designations. This study will rely on sediment information collected in study plan SP-G2. Study plan SP-W5 will provide information for determination of project effects to groundwater.

Issues

This study plan provides the information for evaluation of Issue Statements W1 (project effects on designated beneficial uses), W2 (project effects on water quality objectives), and W3 (project effects on Feather River and tributaries), and will provide information for determination of project compliance with water quality standards and other appropriate requirements in the application for water quality certification. This study fully or partially addresses the following Stakeholder issues:

Stakeholder issues fully addressed by SP-W1 Project Effects on Water Quality Designated Beneficial Uses for Surface Waters

- WE1. Look at project effects on all designated beneficial uses of the waterway
- WE2. Water quality objectives, including levels for bacteria, chemical constituents, dissolved oxygen, pH, oil and grease, pesticides, sediment, temperature, toxicity, and turbidity will be evaluated for compliance with the Basin Plan standards
- WE3. General concerns include all parameters of water quality as flow enters the project boundaries, passes through facility features, and discharges downstream. Direct and indirect effects of the project on aquatic ecosystem health, on recreational opportunity, and on domestic and agricultural supply will be considered
- WE4. Specific issues will need to be addressed for the issuance of 401 Certification and for disclosure in the Applicant Prepared Environmental Assessment
- WE10. Maintain or improve water quality to protect beneficial uses and meet or exceed State objectives.
- WE24. Warm water release requirements for agricultural production
- WE30. Are dissolved oxygen levels in the Feather River from Thermalito Afterbay to Live Oak a problem during the spring, summer, and fall months
- WE31. How have turbidity levels been affected by project operation
- WE32. Thermalito Afterbay acts as a thermal retention basin for project water prior to delivery to water districts outside the project boundary. How do releases from this water body affect the stream temperature and dissolved oxygen content of Feather River receiving waters.
- WE33. Relationship between hatchery and water quality
- WE47. Effects of lake level changes on cultural resources due to water quality contaminants
- WE48. Macroinvertebrates as an indicator of water quality
- WE50. Conversion from lotic to lentic environment and accompanying changes in water quality

- WE53. Consider water quality downstream of Oroville facilities and the effect of low flows on dilution of contaminants entering the Feather River downstream
- FE36. Under existing conditions, does the diversity and abundance of benthic macroinvertebrates in the low-flow section and in the river downstream of Thermalito Afterbay suggest a healthy stream channel;
- FE83. Macroinvertebrates as an indicator of water quality;

Stakeholder issues partially addressed by SP-W1 Project Effects on Water Quality Designated Beneficial Uses for Surface Waters

- WE19. Is the availability of a cold-water pool in Lake Oroville adequate under present and future operational demands to meet the existing downstream cold fresh-water habitat requirements of steelhead and fall, late-fall, and spring-run Chinook salmon
- WE25. Does the present temperature model have the ability to forecast average daily water temperatures, under present and future operational demands, in the low-flow channel and in the river from the Thermalito Afterbay outlet down to Verona
- WE36. Both cold-water and warm-water habitat, spawning, and migration uses have been designated for surface waters potentially affected by the project. A determination must be made as to the specific thermal habitat that may be reasonably provided in each water body within project boundaries and downstream of the project
- WE37. Dredging of lower river to make suitable fish habitat
- WE40. Minimum level of draw-down effect on water temps
- WE46. Spawning habitat in tributaries as they relate to operations
- WE54. Impact of project structures and operations on water quality conditions necessary to sustain anadromous salmonids and their habitat. Adequacy of current project operating regimes and structures to optimize water quality conditions for anadromous salmonids and their habitats.
- F1. Effects of existing and future project operations (including power generation, water storage, ramping rates, and releases, pump-back, water levels, and water level fluctuations) during all water year types on the behavior (e.g., migration timing, microhabitat selection, vulnerability to predators), reproduction, survival and habitat of warm- and cold-water fish and other aquatic resources (e.g., macroinvertebrates), which include in project waters and tributaries within the project boundaries (Lake Oroville, Diversion Pool, Fish Barrier Pool, Forebay, Afterbay, Oroville Wildlife Area), and in project affected waters
- F6. Effects of existing and future project operations on sediment deposition, erosion, and recruitment through the system (including downstream sediment supply) and associated changes in water quality on the quantity and quality of aquatic habitats within project affected waters
- FE64. Effect of project on available upstream fishery habitat (Incorporate all project facilities)
- FE89. Impact of project structures and operations on water quality conditions necessary to sustain anadromous salmonids and their habitats;
- FE96. The lower Feather River provides habitat to support a variety of resident native and resident introduced species including coldwater species such as rainbow, brook, and brown trout, and warm water species such as bass, catfish, bluegill, green sunfish, carp and others. Potential changes in license conditions could adversely impact habitat supporting these species or upset habitat conditions

such that less desirable species are favored. Habitat investigations should evaluate the existing quality and quantity of habitat and determine alternative improvements for the various life history needs of these resident native and non-native species including flow, water temperature, instream and riparian cover, substrate and spatial area;

- FE97. The habitat for fishes in the lower Feather River is affected by the flow releases from the project. Seasonal timing, volume, and rate of release all have an affect on fish habitat conditions. Potential changes in license conditions for flow releases could adversely affect habitat conditions for one or more fish species. Fishery investigations should examine the adequacy of flows for maintaining all life history needs for anadromous and resident species. There should be evaluation of potential for flow improvements in the low-flow section. Fishery investigations should be sufficient to determine how best to meet the combined needs of the various anadromous and resident fish species;
- T1. Effects of project features, existing and future operations (including power generation, water storage and releases, ramping rates, pump-back, water levels and water level fluctuations) and maintenance on wildlife and wildlife habitat. Specific concerns include deer winter range, band-tailed pigeon winter habitat, designated emphasis and harvest species, wintering and nesting waterfowl, and other wildlife use of project and project-affected waters.

8.0 Study Schedule

Monitoring for Task 1 of the study will begin in March of 2002 and continue for two years. Subsequently, data will be analyzed for completion of Tasks 2, 3, and 4. Information developed will be presented quarterly to the Environmental Workgroup and Task Force for review to evaluate the adequacy and progress of the study. A progress report will be prepared in early 2003 after completion of the first year of monitoring. The progress report will review results, evaluate the adequacy of the monitoring program, and recommend changes to the second year of the monitoring program, which may include reduction or elimination of certain parameters and addition or increased frequency of monitoring for others. A draft final report discussing results of the two-year study will be prepared by June of 2004.

9.0 References

Ayers, R. S. and D. W. Westcot. Water quality for agriculture, Food and Agriculture Organization of the United Nations – Irrigation and drainage paper No. 29, Rev. 1

CDHS 2000a. California domestic water quality and monitoring regulations. California Code of Regulations, Title 22, Division 4, Chapter 15

CDHS 2000b. Draft guidance for fresh water beaches. California Department of Health Services, Sacramento

CVRWQCB 1998. The Water Quality Control Plan (Basin Plan) for the California Regional Water Quality Control Board, Central Valley Region, Fourth edition. The Sacramento River Basin and the San Joaquin River Basin. CVRWQCB, Sacramento

CVRWQCB 2000. A compilation of water quality goals. California Regional Water Quality Control Board, Central Valley Region

DWR 2001. Initial Information Package for Relicensing of the Oroville Facilities. Federal Energy Regulatory Commission License Project No. 2100. Department of Water Resources, Sacramento

USEPA 1989. Rapid bioassessment protocols for use in streams and rivers, benthic macroinvertebrates and fish. EPA/440/4-89/001

USEPA 1994. Short-term methods for estimating the chronic toxicity of effluents and receiving water to freshwater organisms. Third edition.. EPA-600-4-91-002

USEPA 1996. Method 1669: Sampling ambient water for trace metals at EPA water quality criteria levels. EPA-821-R-96-008

USEPA 1998. Water quality standards; establishment of numeric criteria for priority toxic pollutants for the State of California; Rule. Federal Register 40 CFR Part 131, May 2000

USEPA 1999. Compilation of national recommended water quality criteria. EPA-822-F-98-006

USEPA 2000a. Nutrient criteria technical guidance manual. Rivers and streams EPA-822-B-00-002 and Lakes and reservoirs EPA-822-B-00-001

USEPA 2000b. Drinking water standards and health advisories. EPA-822-B-00-001

10. Appendices

Appendix SPW1-1. Analytical methods and detection levels for sampling schedule in Table SPW1-2

Method	Analysis	Units	Reporting Limit
Minerals			
EPA 200 7 (D)	Dissolved Calcium	mg/L	1
EPA 200.7 (D)	Dissolved Sodium	mg/L	1
EPA 200.7 (D)	Dissolved Potassium	mg/L	0.5
EPA200.7 (D)	Dissolved Magnesium	mg/L	1
EPA 300.0 (28d hold)	Dissolved Sulfate	mg/L	1
EPA 300.0 28d Hold	Dissolved Chloride	mg/L	1
EPA 200.7 (D)	Dissolved Boron	mg/L	0.1
Std Method 2320 B	Alkalinity	mg CaCO3/L	0.1

Nutrients			
Std Method 4500-NO3-F Modified	Dissolved Nitrite + Nitrate	mg/L as N	0.05
EPA 350.1	Dissolved Ammonia	mg/L as N	0.02
Std Method 4500-NH3	Total Ammonia	mg/L as N	0.02
EPA 365.1	Dissolved Ortho-phosphate	mg/L as P	0.01
EPA 365.4	Total Phosphorus	mg/L	0.01
Metals			
EPA 1631	Total Mercury	µg/L	0.0002
EPA 1631	Total Methyl Mercury	µg/L	0.005
EPA 1631	Dissolved Methyl Mercury	ug/L	0.005
EPA 1632	Total and Dissolved Arsenic	µg/L	0.004
Std Method 3500-Fe D	Total and Dissolved Iron	µg/L	2.2
EPA 1638	Total and Dissolved Aluminum	µg/L	0.4
EPA 1638	Total and Dissolved Cadmium	µg/L	0.003
EPA 1638	Total and Dissolved Chromium	µg/L	0.03
EPA 1638	Total and Dissolved Copper	µg/L	0.01
EPA 1638	Total and Dissolved Lead	µg/L	0.005
EPA 1638	Total and Dissolved Manganese	µg/L	0.02
EPA 1638	Total and Dissolved Nickel	µg/L	0.01
EPA 1638	Total Selenium	µg/L	0.1
EPA 1638	Total and Dissolved Zinc	µg/L	0.03
Miscellaneous Parameters			
Std Method 2540 D	Total Suspended Solids (Suspended material)	mg/L	1
Std Method 2540 C	Total Dissolved Solids	mg/L	1
Std Method 2540 F	Settleable Solids (Settleable material)	Mg/L	1
Std Method 2340 B	Hardness	mg/L as CaCO3	1
Std Method 5520	Oil and Grease	mg/L	
Std Method 2550 B 1, 2	Temperature	degree Celcius	0.1
Std Method 4500-O C	Dissolved oxygen	mg/L	0.1
Std Method 4500-H+ B	pH	pH units	0.1
Std Method 2510 B	Conductivity	umhos/cm	0.1
EPA 445.0	Chlorophyll	µg/L	
EPA 600-4-91-002	Toxicity		
Std Method 2120 B	Color	Units	1

Std Method 2150/2160	Taste and Odor	-	-
EPA 415.1 (D)	Dissolved Organic Carbon		
Pathogens			
Std Method 9222 B	Total Coliform bacteria	colonies/100 mL	0
Std Method 9222 D	Fecal Coliform bacteria	colonies/100 mL	0
Table SPW1-3. Analytical methods and detection levels, continued			
Pesticides			
Chlorinated Organic Pesticides			
EPA 508	Alachlor	µg/L	0.05
EPA 508	Aldrin	µg/L	0.01
EPA 508	Atrazine	µg/L	0.02
EPA 508	BHC-alpha	µg/L	0.01
EPA 508	BHC-beta	µg/L	0.01
EPA 508	BHC-delta	µg/L	0.01
EPA 508	BHC-gamma (Lindane)	µg/L	0.01
EPA 508	Captan	µg/L	0.02
EPA 508	Chlordane	µg/L	0.05
EPA 508	Chlorothalonil	µg/L	0.01
EPA 508	Chlorpropham	µg/L	0.02
EPA 508	Chlorpyrifos	µg/L	0.01
EPA 508	Cyanazine	µg/L	0.3
EPA 508	Dacthal (DCPA)	µg/L	0.01
EPA 508	Dichloran	µg/L	0.01
EPA 508	Dicofol	µg/L	0.05
EPA 508	Dieldrin	µg/L	0.01
EPA 508	Diuron	µg/L	0.25
EPA 508	Endosulfan sulfate	µg/L	0.02
EPA 508	Endosulfan-I	µg/L	0.01
EPA 508	Endosulfan-II	µg/L	0.01
EPA 508	Endrin	µg/L	0.01
EPA 508	Endrin aldehyde	µg/L	0.01
EPA 508	Heptachlor	µg/L	0.01
EPA 508	Heptachlor epoxide	µg/L	0.01
EPA 508	Methoxychlor	µg/L	0.05

EPA 508	Metolachlor	µg/L	0.2
EPA 508	Oxyfluorfen	µg/L	0.2
EPA 508	p,p'-DDD	µg/L	0.01
EPA 508	p,p'-DDE	µg/L	0.01
EPA 508	p,p'-DDT	µg/L	0.05
EPA 508	PCB-1016	µg/L	0.1
EPA 508	PCB-1221	µg/L	0.1
EPA 508	PCB-1232	µg/L	0.1
EPA 508	PCB-1242	µg/L	0.1
EPA 508	PCB-1248	µg/L	0.1
EPA 508	PCB-1254	µg/L	0.1
EPA 508	PCB-1260	µg/L	0.1
EPA 508	Pentachloronitrobenzene (PCNB)	µg/L	0.01
EPA 508	Ronnel	µg/L	0.3
EPA 508	Simazine	µg/L	0.02
EPA 508	Thiobencarb	µg/L	0.02
EPA 508	Toxaphene	µg/L	0.4
EPA 508	Trifluralin	µg/L	0.05
Organic Phosphorus Pesticides			
EPA 508	Azinphos methyl (Guthion)	µg/L	0.05
EPA 508	Benfluralin	µg/L	0.01
EPA 508	Bromacil	µg/L	1
EPA 508	Carbophenothion (Trithion)	µg/L	0.02
EPA 508	Chlorpyrifos	µg/L	0.01
EPA 508	Cyanazine	µg/L	0.3
EPA 508	Demeton (Demeton O + Demeton S)	µg/L	0.02
EPA 508	Diazinon	µg/L	0.01
EPA 508	Dimethoate	µg/L	0.01
EPA 508	Disulfoton	µg/L	0.01
EPA 508	Ethion	µg/L	0.01
EPA 508	Malathion	µg/L	0.01
EPA 508	Methidathion	µg/L	0.02
EPA 508	Mevinphos	µg/L	0.01
EPA 508	Naled	µg/L	0.02
EPA 508	Napropamide	µg/L	5
EPA 508	Norflurazon	µg/L	5
EPA 508	Parathion (Ethyl)	µg/L	0.01

EPA 508	Parathion, Methyl	µg/L	0.01
EPA 508	Pendimethalin	µg/L	5
EPA 508	Phorate	µg/L	0.01
EPA 508	Phosalone	µg/L	0.02
EPA 508	Phosmet	µg/L	0.02
EPA 508	Profenofos	µg/L	0.01
EPA 508	Prometryn	µg/L	0.05
EPA 508	Propetamphos	µg/L	0.1
EPA 508	Ronnel	µg/L	0.01
EPA 508	s,s,s-Tributyl Phosphorotrithioate (DEF)	µg/L	0.01
EPA 508	Trifluralin	µg/L	0.01
Volatile Organics (Purgeable)			
EPA 502.2	1,1,1,2-Tetrachloroethane	µg/L	0.5
EPA 502.2	1,1,1-Trichloroethane	µg/L	0.5
EPA 502.2	1,1,2,2-Tetrachloroethane	µg/L	0.5
EPA 502.2	1,1,2-Trichloroethane	µg/L	0.5
EPA 502.2	1,1-Dichloroethane	µg/L	0.5
EPA 502.2	1,1-Dichloroethene	µg/L	0.5
EPA 502.2	1,1-Dichloropropene	µg/L	0.5
EPA 502.2	1,2,3-Trichlorobenzene	µg/L	0.5
EPA 502.2	1,2,3-Trichloropropane	µg/L	0.5
EPA 502.2	1,2,4-Trichlorobenzene	µg/L	0.5
EPA 502.2	1,2,4-Trimethylbenzene	µg/L	0.5
EPA 502.2	1,2-Dibromo-3-chloropropane (DBCP)	µg/L	0.5
EPA 502.2	1,2-Dibromoethane	µg/L	0.5
EPA 502.2	1,2-Dichlorobenzene	µg/L	0.5
EPA 502.2	1,2-Dichloroethane	µg/L	0.5
EPA 502.2	1,2-Dichloropropane	µg/L	0.5
EPA 502.2	1,3,5-Trimethylbenzene	µg/L	0.5
EPA 502.2	1,3-Dichlorobenzene	µg/L	0.5
EPA 502.2	1,3-Dichloropropane	µg/L	0.5
EPA 502.2	1,4-Dichlorobenzene	µg/L	0.5
EPA 502.2	2,2-Dichloropropane	µg/L	0.5
EPA 502.2	2-Chlorotoluene	µg/L	0.5
EPA 502.2	4-Chlorotoluene	µg/L	0.5
EPA 502.2	4-Isopropyltoluene	µg/L	0.5
EPA 502.2	Benzene	µg/L	0.5

EPA 502.2	Bromobenzene	µg/L	0.5
EPA 502.2	Bromochloromethane	µg/L	0.5
EPA 502.2	Bromodichloromethane	µg/L	0.5
EPA 502.2	Bromoform	µg/L	0.5
EPA 502.2	Bromomethane	µg/L	0.5
EPA 502.2	Carbon tetrachloride	µg/L	0.5
EPA 502.2	Chlorobenzene	µg/L	0.5
EPA 502.2	Chloroethane	µg/L	0.5
EPA 502.2	Chloroform	µg/L	0.5
EPA 502.2	Chloromethane	µg/L	0.5
EPA 502.2	cis-1,2-Dichloroethene	µg/L	0.5
EPA 502.2	cis-1,3-Dichloropropene	µg/L	0.5
EPA 502.2	Dibromochloromethane	µg/L	0.5
EPA 502.2	Dibromomethane	µg/L	0.5
EPA 502.2	Dichlorodifluoromethane	µg/L	0.5
EPA 502.2	Ethyl benzene	µg/L	0.5
EPA 502.2	Fluorobenzene	µg/L	0.5
EPA 502.2	Hexachlorobutadiene	µg/L	0.5
EPA 502.2	Isopropylbenzene	µg/L	0.5
EPA 502.2	m + p Xylene	µg/L	0.5
EPA 8260	Methyl tert-butyl ether (MTBE)	µg/L	0.5
EPA 502.2	Methylene chloride	µg/L	0.5
EPA 502.2	n-Butylbenzene	µg/L	0.5
EPA 502.2	n-Propylbenzene	µg/L	0.5
EPA 502.2	Naphthalene	µg/L	0.5
EPA 502.2	o-Xylene	µg/L	0.5
EPA 502.2	sec-Butylbenzene	µg/L	0.5
EPA 502.2	Styrene	µg/L	0.5
EPA 502.2	tert-Butylbenzene	µg/L	0.5
EPA 502.2	Tetrachloroethene	µg/L	0.5
EPA 502.2	Toluene	µg/L	0.5
EPA 502.2	trans-1,2-Dichloroethene	µg/L	0.5
EPA 502.2	trans-1,3-Dichloropropene	µg/L	0.5
EPA 502.2	Trichloroethene	µg/L	0.5
EPA 502.2	Trichlorofluoromethane	µg/L	0.5
EPA 502.2	Vinyl chloride	µg/L	0.5
Chlorinated Phenoxy Acid Herbicides			

EPA 515.1	2,4,5-T	µg/L	0.1
EPA 515.1	2,4,5-TP (Silvex)	µg/L	0.1
EPA 515.1	2,4-D	µg/L	0.1
EPA 515.1	2,4-DB	µg/L	0.1
EPA 515.1	2,4-Dichlorophenylacetic acid (DCAA)	µg/L	0.1
EPA 515.1	Dacthal (DCPA)	µg/L	0.1
EPA 515.1	Dicamba	µg/L	0.1
EPA 515.1	Dichlorprop	µg/L	0.1
EPA 515.1	Dinoseb (DNPB)	µg/L	0.1
EPA 515.1	MCPA	µg/L	0.1
EPA 515.1	MCPP	µg/L	0.1
EPA 515.1	Pentachlorophenol (PCP)	µg/L	0.1
EPA 515.1	Picloram	µg/L	0.1
EPA 515.1	Triclopyr	µg/L	0.1
Glyphosate			
EPA 547	Aminomethylphosphonic Acid (AMPA)	µg/L	100
EPA 547	Glyphosate	µg/L	100
Carbamate Pesticides			
EPA 531.1	3-Hydroxycarbofuran	µg/L	2
EPA 531.1	Aldicarb	µg/L	2
EPA 531.1	Aldicarb sulfone	µg/L	2
EPA 531.1	Aldicarb sulfoxide	µg/L	2
EPA 531.1	Carbaryl	µg/L	2
EPA 531.1	Carbofuran	µg/L	2
EPA 531.1	Formetanate hydrochloride	µg/L	100
EPA 531.1	Methiocarb	µg/L	4
EPA 531.1	Methomyl	µg/L	2
EPA 531.1	Oxamyl	µg/L	2
Pyrethrins	will be analyzed if a suitable method becomes available		