

WATER QUALITY SURVEY FOR SELENIUM
IN THE SACRAMENTO RIVER AND
ITS MAJOR TRIBUTARIES

Agricultural Unit
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CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION

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SELENIUM IN THE SACRAMENTO RIVER BASIN

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SELENIUM IN THE SACRAMENTO RIVER BASIN

SUMMARY

The Central Valley Regional Water Quality Control Board has completed a stream water quality survey for selenium in the Sacramento River and its tributaries to assess whether beneficial uses are being impacted. Historically, a large number of water samples, some taken as recently as 1984, showed selenium levels exceeding 10 ug/L, the present drinking water standard. Historical selenium concentrations as high as 390 ug/L were recorded in portions of the surface water in the Sacramento River Basin. This concentration is similar to the levels found in agricultural drainage water entering Kesterson Reservoir via the San Luis Drain in the San Joaquin River Basin. This survey was designed to verify historical data and locate potential sources of selenium loading. Special emphasis was placed on evaluating the contributions of point source discharges and non-point agricultural sources.

Data obtained from the 1984-88 stream monitoring for total selenium in the Sacramento River Basin does not support historically recorded high selenium concentrations. During the current survey, measured selenium levels did not exceed the drinking water standard. Only eleven out of 366 water samples indicated concentrations exceeding 1 ug/L with a maximum of 1.6 ug/L. Monitoring also indicated that the major agricultural return flows and municipal and industrial discharges were not causing increased selenium levels in the Sacramento River or its tributaries and thus selenium levels were not adversely affecting existing or potential beneficial uses. Further evaluation of point and non-point source discharges is not needed at this time.

Limited additional sampling was undertaken within selected areas to verify historical data showing elevated levels in the water column and also to determine whether elevated selenium levels in the water column were responsible for elevated levels of selenium found in fish livers taken from these water bodies by the California Department of Fish and Game. No measurable results were reported except in the Black Butte Reservoir area where selenium concentrations in the water were reported as high as 0.8 ug/L.

INTRODUCTION

Selenium concentrations are expected to remain low in surface waterways, however even small concentrations may have harmful effects on waterfowl and other aquatic life due to bioaccumulation through the food chain. Elevated levels of selenium are being found at certain locations in the San Joaquin Valley where subsurface agricultural drainage water is discharged into surface waterways or where natural surface runoff passes over or through known high selenium shale formations of the Tertiary or Cretaceous age. Formations in the San Joaquin Valley which are known to contain high selenium are not present in the Sacramento Valley, however other formations in the Sacramento Valley may contain high selenium shales. Such formations are likely

found throughout the Coast Range. Runoff from the Coast Range along with flow from irrigated agriculture in the Sacramento Valley make up a significant portion of the Sacramento River discharge to the Sacramento-San Joaquin Delta.

Historical data on selenium concentrations in surface water of the Sacramento River Basin indicated periods of elevated selenium levels, especially from areas originating in the western portion of the basin. Selenium concentrations as high as 390 ug/L were recorded in surface water in the Sacramento River Basin. This concentration is similar to the levels found in agricultural drainage water entering Kesterson Reservoir via the San Luis Drain(USGS, 1985). Because of the concern over the effects that these selenium levels may have on aquatic life in both the River Basin and the Delta, a program of water quality monitoring was initiated to help define the sources of selenium and whether further assessment of waste discharge regulation was needed.

As the historical data proved too limited to locate potential discharges of high selenium to surface water or to define the background level in the Sacramento River and its tributaries, a water quality monitoring network was developed. The program had the following goals:

- a) Verify preliminary data showing high selenium concentrations in the Sacramento River tributaries flowing from the western part of the river basin;
- b) assess the relative significance of non-point agricultural discharges as part of the total selenium load to the River and Delta and assess whether further evaluation of non-point agricultural sources, including tile drains, in the Sacramento Valley is needed;
- c) assess whether further evaluation of point source discharges is needed; and
- d) define whether beneficial uses are being impacted by selenium concentrations in the Sacramento River, its tributaries and as it enters the Delta.

This report reviews historical data and presents the selenium levels in the Sacramento River Basin as monitored during the period April 1984 to April 1988.

BASIN DESCRIPTION

Physical Characteristics

The Sacramento River Basin is located in the northern half of the Central Valley of California. It is composed of 19 counties, covers 27,215 square miles, and produces 32% of the annual water supply for California(SWRCB, 1980). The geographical boundaries include the Cascade Range and Klamath Mountains to the North; American River and

AVERAGE ANNUAL PRECIPITATION - 51,590,000 acre-feet

AVERAGE ANNUAL RUNOFF - 22,390,000 acre-feet

IRRIGATED LAND - 2,084,000 acres

POPULATION - 1,674,000



Figure 1
SACRAMENTO BASIN--CENTRAL VALLEY

Putah Creek basins to the south; Sierra Nevada crests to the east; and North Coast Range crest to the west (Figure 1). The valley floor portion of the river basin has a Mediterranean climate with hot summers and mild winters. The average temperatures in the valley range from 44° F (January) to 80° F (July), with a mean seasonal precipitation of 23 inches, most all of which falls in the winter months.

The Sacramento River serves as the main drainage artery for the valley. Major tributary inflows below Shasta Lake include the Bear, Yuba, Feather, and American Rivers as well as numerous streams and agricultural return flows. River flow is regulated year round through the use of dams and bypasses. Major regulatory dams include Shasta and Keswick on the Sacramento River, Whiskeytown on Clear Creek, Black Butte on Stony Creek, Oroville on the Feather River, Folsom and Natomas on the American River and Englebright and Camp Far West on the Yuba and Bear Rivers, respectively. Surface water storage exceeds 10.5 million acre feet behind Whiskeytown, Folsom, Oroville and Shasta Dams alone.

The Sacramento Valley is a major agricultural area, and a significant portion of the river flow is directed through farmland with only return flows reaching the river. Water, Irrigation, and Reclamation Districts operate gates which control flow to and from these districts. Major agricultural surface drainage inflows to the Sacramento River include Butte Creek at Meridian, Reclamation District 108 Drain, Colusa Basin Drain, and the Sacramento Slough. There are very few subsurface agricultural drains in the basin.

Winter storm runoff can drastically increase river flow; e.g. from 9,400 cfs to 52,500 cfs at the City of Freeport during water year 1980-81. Areas such as the Sutter and Yolo Bypasses were developed to contain overflow. This overflow eventually finds its way back into the Sacramento River or enters directly into the Sacramento-San Joaquin Delta near Rio Vista.

Beneficial Uses

The Sacramento River provides a variety of beneficial uses as defined in the Water Quality Control Plan for the Sacramento River Basin (5A) including: municipal and domestic supply; agricultural supply; industrial supply; freshwater habitat; migration; spawning; wildlife habitat; recreation; and navigation. The major diversion for drinking water is at the City of Sacramento, supplying a population of approximately 280,000. Additional diversions occur at the cities of Redding and Red Bluff. In addition to direct diversions in the Sacramento River Basin, excess water yield from the basin is redirected through the Sacramento-San Joaquin Delta to the Delta-Mendota Canal and the California Aqueduct which supply water to agriculture and communities south of the Delta. Agriculture is the major water user in the Sacramento Basin through a highly developed system of diversions and canals. A significant use for diverted water is wildlife habitat in several federal, state and private wildlife refuges. Power development is the principal industrial use in the Sacramento River Basin. The Sacramento River and its tributaries also support a variety

of freshwater and anadromous sport fisheries. Studies conducted by the California Department of Fish and Game and the U.S. Fish and Wildlife Service have shown that the river and its tributaries are the principal migration routes and spawning grounds of White Sturgeon, Striped Bass, Chinook Salmon and American Shad.

Pre-1984 Water Quality Data

Numerous surface water analyses for selenium have been conducted in the Sacramento River Basin by various state, local and federal agencies (Table 1). The California Department of Water Resources (DWR) has compiled the most extensive data base. The U.S. Forest Service annually checks for trace elements in water sources (streams, springs, and wells) supplying their campgrounds. Selenium analyses for surface water conducted by government agencies are recorded in the U.S. Environmental Protection Agency data storage system (STORET). It should be noted that some stations report duplicate data published by both DWR and the U.S. Geological Survey (USGS).

There are 160 surface water monitoring stations recorded in STORET for the Sacramento Valley; 100 of these show only a one time analysis. Stations in the Sacramento Valley with a more continuous historical record are Greens Landing, Freeport, City of Sacramento Water Treatment Plant, and Keswick Reservoir on the Sacramento River, Nicolaus and Gridley on the Feather River, City of Sacramento Water Treatment Plant on the American River and several sites within the Stony Creek Watershed.

Different water quality monitoring agencies conducted selenium analyses under a variety of analytical methods and quality control procedures. Most samples collected before 1984 by agencies other than the USGS were not analyzed by the hydride generation technique, the currently accepted analytical technique. In 1975, the USGS began using atomic adsorption with hydride generation for low level selenium analysis. Values reported prior to 1975 may not be reliable. DWR used the colormetric method until July 1984 when the laboratory switched to hydride generation. Selenium data for low level detection and quantification as reported by DWR before July 1984 are of questionable value unless rechecked by the hydride generation technique.

Most selenium concentrations reported in surface water in the Sacramento River Basin prior to 1984 are below the drinking water standard of 10 ug/L. Stations with average concentrations approaching or exceeding this standard are listed in Table 2. In the 1700+ water samples analyzed prior to 1984, DWR reported 79 concentrations exceeding the drinking water standard of 10 ug/L for total selenium (Table 3). The maximum measured concentrations were 390 ug/L for total selenium and 30 ug/L for dissolved selenium. Locations of extreme values are scattered throughout the basin (Figure 2). Most of these values were reported by DWR after 1980 but prior to 1984. Of the previous sites showing elevated selenium values, only six were monitored after 1984 and none confirmed the original results.

TABLE 1

PUBLIC AGENCIES WHICH HAVE CONDUCTED SELENIUM
ANALYSES IN THE SACRAMENTO RIVER BASIN

Federal

U.S. Geological Survey
U.S. Bureau of Reclamation
U. S. Forest Service (El Dorado, Lassen, Mendocino, Modoc, Plumas,
Shasta-Trinity, and Tahoe National Forests)

State

Department of Water Resources
State Water Resources Control Board
Central Valley Regional Water Quality Control Board

Local

City of Sacramento (Water Treatment Plant)
County of Sacramento (Regional Wastewater Treatment Plant)

Of the samples taken prior to 1984, the highest reported selenium concentration occurred principally along the western half of the basin. Samples taken in the Stony Creek Watershed and the Clear Lake area showed consistently high values. Between 1980 and 1981, DWR conducted a trace element survey in the Stony Creek area in conjunction with the Thomes-Newville water storage project study (DWR Files). Total selenium concentrations regularly exceeded the 10 ug/L standard with the highest reported selenium at 240 ug/L. Samples taken in the Clear Lake area have shown concentrations reaching 80 ug/L for total selenium. The Colusa Basin Drain which receives runoff from the westside streams, as well as a significant amount of irrigation return flow, showed the highest concentration at 390 ug/L total selenium in 1981.

Current monthly monitoring of selenium is limited to grab samples near the confluence of the American and Sacramento Rivers by the City of Sacramento as part of its drinking water program. Monthly depth integrated, cross-sectional samples are also taken at Freeport by the USGS.

Laboratory procedures and large fluctuations in selenium concentrations make the data prior to 1984 suspect. Extremely high values, such as those reaching over 100 ug/L were never verified or incorporated into a yearly trend. Since the validity of historical data is in question, a background level for selenium in the Sacramento River or its tributaries cannot be established from the existing data record. Although overall concentrations are thought to be below 10 ug/L, instances of extremely high concentrations cannot simply be disregarded as analytical error. Their cause, whether natural or the result of

Table 2. Monitoring Stations with High Average Selenium Concentrations as Measured Prior to 1984.

LOCATION	AGENCY	TYPE ^L	SAMPLE NO.	CONCENTRATION (UG/L)		PERIOD OF RECORD
				AVERAGE	RANGE	
Cache Creek nr. Lower Lake	DWR	D	10	9	0-30	5/71-5/81
Stony Creek ab. Grindstone	DWR	T	17	20	0-150	8/80-3/82
Thomes Creek at Paskenta	DWR	T	17	15.3	0-100	8/80-3/82
Sacramento R. ab. Stony Creek	DWR	D	19	22.1	0-110	8/80-5/82
Grindstone Ck. nr. Elk Creek	DWR	T	17	24.7	0-200	8/80-3/82
Stony Creek nr. Newville	DWR	T	15	10.7	0-50	8/80-3/82
Stony Creek bl. Black Butte	DWR	T	17	21.8	0-60	8/80-3/82
Colusa Basin Drain at Knights Ldg.	DWR	T	14	42.9	0-390	3/72-3/82

^L T = total

D = dissolved

Note: Shasta Lake averaged 10 ug/L in 1983, but recorded no values exceeding 10 ug/L.

Table 3. Reported (pre-1984) selenium concentrations in the Sacramento River Basin exceeding EPA drinking water criteria (>10 ug/L).

I.D. ¹	STATION	LOCATION ²	AGENCY ³	DATE	SELENIUM CONC. (UG/L)	
					TOTAL	DISSOLVED
1	A2130000	Sacramento R A Delta	DWR	3/23/78	--	20
				3/11/80	--	20
2	A2101000	Sacramento R A Keswick	DWR	5/29/79	--	30
				3/25/80	--	20
3	A0350000	Thomes Creek A Paskenta	DWR	3/26/80	30	--
				1/22/81	20	--
				9/28/81	30	--
				12/29/81	20	--
				2/24/82	100	--
				3/31/82	40	--
4	A3117500	Stony Ck NF A Newville	DWR	1/22/81	20	--
				10/28/81	20	--
				12/29/81	50	--
5	A3130200	Grindstone Ck NR Elk Ck	DWR	6/30/81	20	--
				7/29/81	40	--
				9/28/81	30	--
				12/29/81	40	--
				2/24/82	200	--
6	A3125000	Stony Creek NR Fruto	DWR	10/22/80	30	--
				1/23/81	20	--
7	A3125300	Stony C AB Grindstone Ck	DWR	10/22/80	20	--
				1/23/81	20	--
				5/27/81	20	--
				7/29/81	20	--
				8/31/81	20	--
				9/28/81	40	--
				12/29/81	150	--
				3/31/82	20	--
8	A3R94892205	Black Butte Reservoir	DWR	6/22/81	70	--
				8/21/81	30	--
				12/23/81	30	--

Table 3. Reported (pre-1984) selenium concentrations in the Sacramento River Basin exceeding EPA drinking water criteria (>10 ug/L).

I.D. ¹	STATION	LOCATION ²	AGENCY ³	DATE	SELENIUM CONC. (UG/L)	
					TOTAL	DISSOLVED
9	A311000	Stony Ck A Black Butte Dam	DWR	10/21/80	40	--
				1/22/81	30	--
				4/28/81	20	--
				7/29/81	60	--
				9/28/81	30	--
				12/29/81	40	--
				2/24/82	60	--
				3/31/82	50	--
10	A0263000	Sacramento R A Hamilton City	DWR	5/30/79	--	30
				4/28/83	30	--
11	A0261000	Sac R AB Big Chico Creek	DWR	3/27/80	--	20
12	A026500-A	Sacramento R AB Stony Ck	DWR	10/21/80	40	--
				1/23/81	20	--
				7/29/81	110	--
				9/28/81	30	--
				11/30/81	20	--
				12/30/81	50	--
				1/29/82	--	30
				2/24/82	--	20
				3/31/82	20	--
				4/28/82	30	--
5/26/82	40	--				
13	A0516500	Feather River NR Gridley	DWR	5/25/82	--	20
14	A0615000	Yuba River NR Marysville	DWR	4/27/82	--	20
15	A8R90502322	Indian Valley Res at Dam	DWR	9/15/81	20	--
16	A8L90072417	CL23 Oaks Arm CL4	DWR	11/8/78	--	20
				9/23/82	40	--
17	A8185792406	Clear Lake Lower Arm CL3	DWR	11/8/78	--	20
				9/15/81	30	--
				9/23/82	80	--

Table 3. Reported (pre-1984) selenium concentrations in the Sacramento River Basin exceeding EPA drinking water criteria (>10 ug/L).

I.D. ¹	STATION	LOCATION ²	AGENCY ³	DATE	SELENIUM CONC. (UG/L)	
					TOTAL	DISSOLVED
18	11451000	Cache Creek NR Lower Lake	USGS	4/5/79	--	30
				9/18/80	--	20
19	A0294710	Colusa Basin Drain NR Knights Landing	DWR	7/31/81	390	--
				9/29/81	60	--
				11/24/81	60	--
				1/27/82	20	--
				3/24/82	20	--
20	A0718000	American R BL Nimbus Dam	DWR	6/14/82	--	30
21	A0714010	American R A Sac Water Treatment Plant	DWR	4/27/82	--	20
				6/14/82	--	30
22	11447810	Sacramento R A Greens Ldg	USGS	6/18/80	--	20
	B9D82071327	Sacramento R A Greens Ldg	DWR	10/21/81	--	20
				1/19/83	--	20
23	B9D81781448	Cache Slu A Vallejo Pupl	DWR	6/15/83	--	30

¹ As depicted in Figure 2.

² A = at
BL = below
AB = above
NR = near

³ DWR = Department of Water Resources.
USGS = U.S. Geological Survey

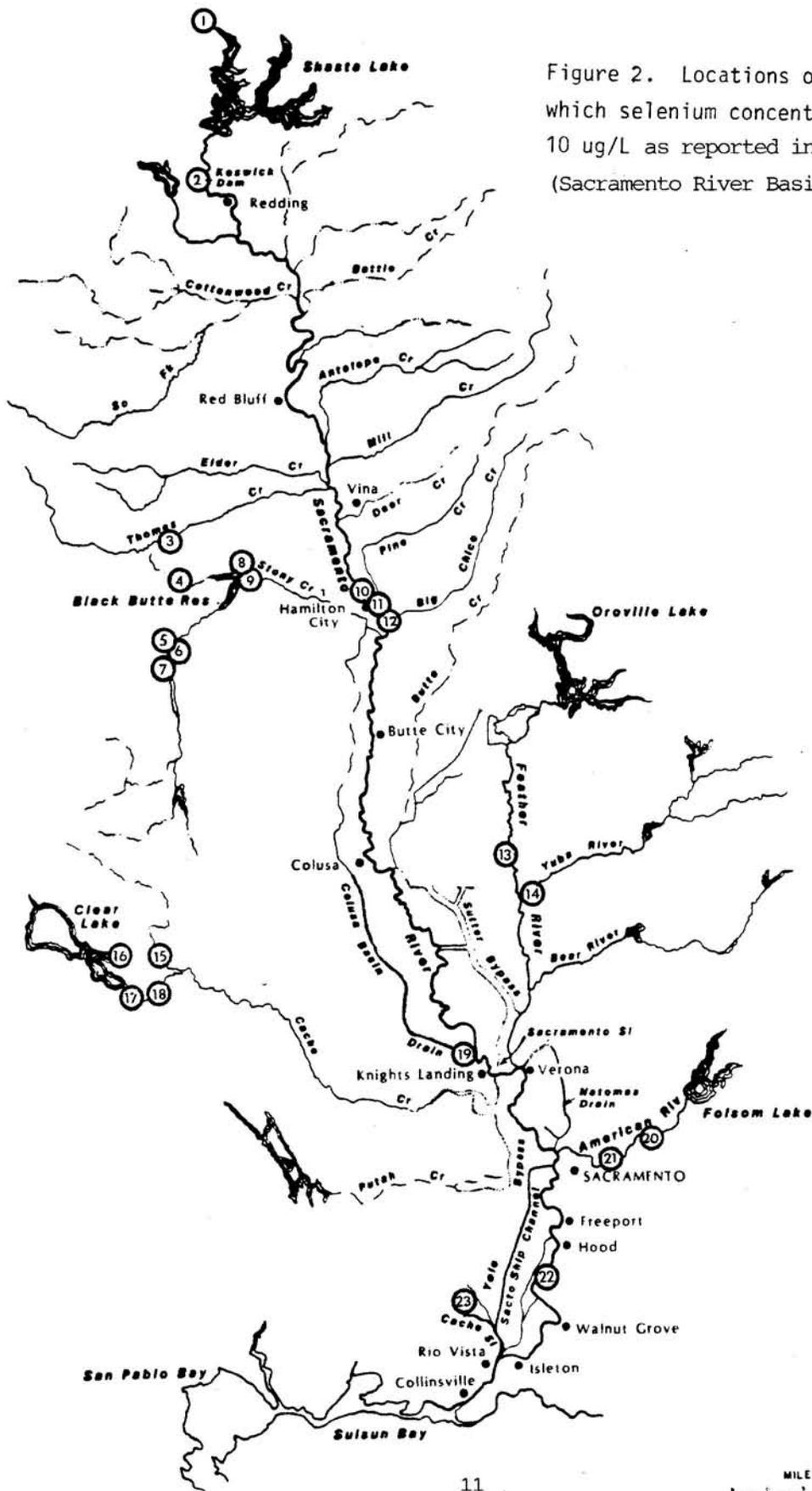


Figure 2. Locations of samples in which selenium concentrations exceeded 10 ug/L as reported in Table 3. (Sacramento River Basin 1971 - 1983)

waste discharges or agricultural practices, raises a concern for its impact on existing beneficial uses, especially those associated with wildlife habitat. The following sections of this report describe efforts to assess the validity of the available data and the potential sources of high selenium concentrations in the river basin.

STREAM MONITORING RESULTS 1984-88

Between 24 April 1984 and 12 April 1988, 366 water samples and 6 sediment composites were collected in the Sacramento Valley by Regional Board staff and analyzed for total selenium. Sampling protocol is outlined in Appendix A. Sampling locations were chosen to characterize the major tributary flows, assess levels impacting beneficial uses, as well as identify potential loading sources. Site selection considered historical data as well as site access.

Twenty-five continuous sites were located on major tributaries with four additional stations along the Sacramento River. Spot sampling was also conducted in a variety of other locations during the course of the study. Station identification and descriptions are listed in Appendix B. Locations within the basin are shown in Figure 3. Samples were split and concentrations verified by a number of different laboratories. Additional water samples were taken at 7 sites in and near Lake Berryessa. Samples were also taken in Lake Shasta and the McCloud River to determine whether elevated levels of selenium in the water column were responsible for the elevated levels of selenium found in fish livers taken from fish in this area by the California Department of Fish and Game. A special survey in Black Butte Reservoir which included composite sediment sampling was conducted in October 1986 to verify historical data that showed high values in the reservoir discharge.

The initial surveys were conducted in April, May, June, and July of 1984, and March 1985. The sampling periods were chosen to reflect pre-irrigation, irrigation, rice field drainage, and storm runoff periods. During August and September 1986, January 1987, and April 1988, four additional surveys were conducted. The January 1987 survey represented runoff after a storm event while the April 1988 survey represented flow under conditions of a critically dry year. Of the 366 analyses for total selenium conducted as part of this stream survey, only eleven values were confirmed at greater than 1 ug/L. The maximum reported value was 1.6 ug/L from a sample taken in Stony Creek above Black Butte Reservoir. Other concentrations of 1 ug/L were scattered between Stony Creek above and below Black Butte Reservoir, Kendrick's and Salt Creeks above Black Butte Reservoir, Cottonwood Creek at Interstate Highway 5, Spring Creek below the debris dam, Natomas East Main Drain at Del Paso Road, and the Sacramento River at Hood. Although no statistical analysis has been conducted, it does not appear that selenium concentrations were different between the storm-runoff survey and the survey conducted under a critically dry year conditions. Actual laboratory values are listed in Appendix C.

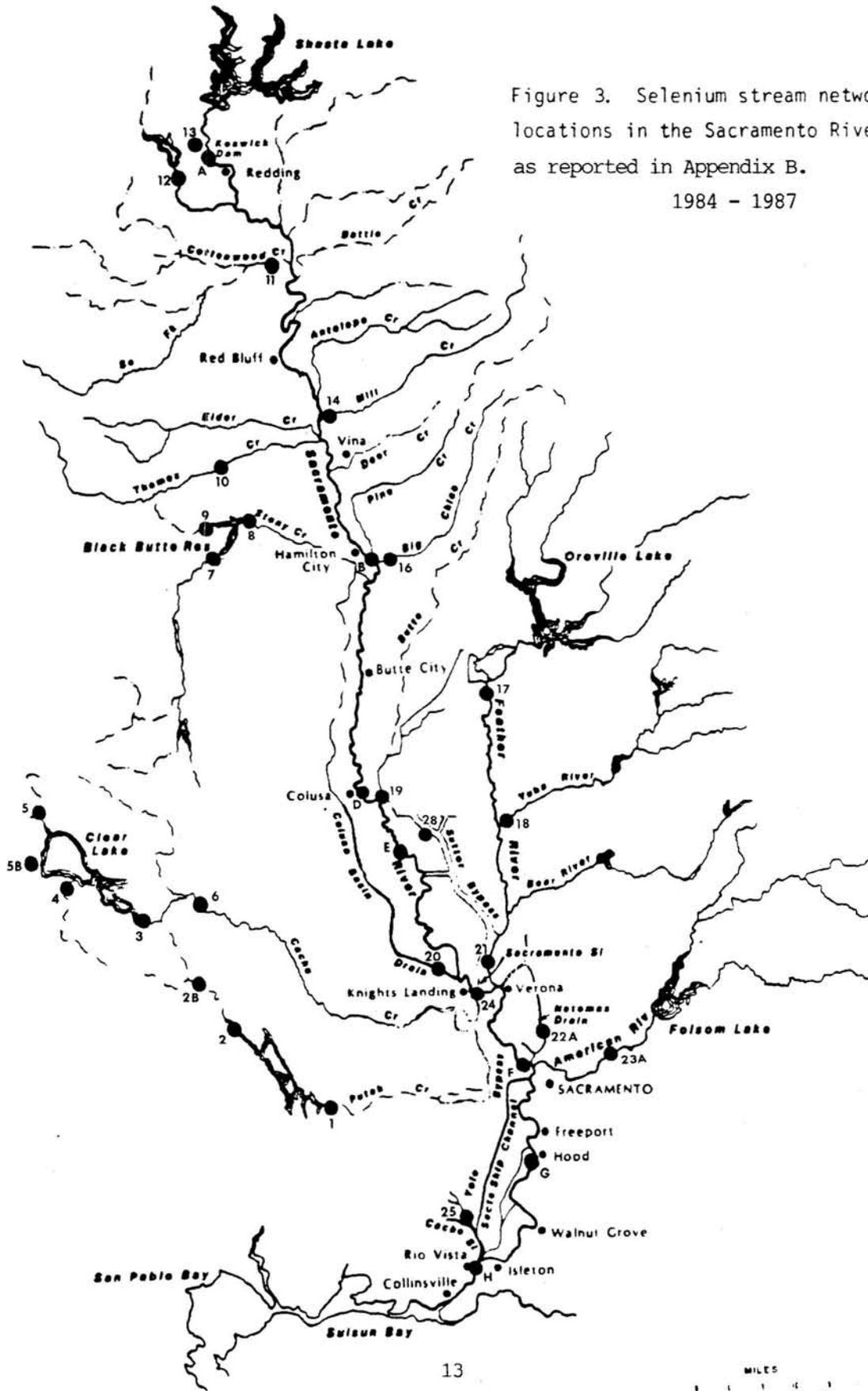
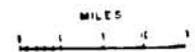


Figure 3. Selenium stream network locations in the Sacramento River Basin as reported in Appendix B. 1984 - 1987



SPECIAL SURVEYS

Additional water and sediment surveys were conducted in areas suspect of high selenium concentrations based either on historical data or relatively high concentrations detected in fish livers during the 1985 Toxics Substances Monitoring Program (SWRCB, 1986). Areas of concern included Lake Berryessa, Black Butte Reservoir, and the McCloud River.

In July 1984, additional water samples were taken by Regional Board staff in the Lake Berryessa area to verify low positive results from Putah Creek above and below the lake found during a June 1984 survey. The laboratory results for the June 1984 survey were subsequently determined to be in error. Analyses were completed by the USGS for the July 1984 samples and all results were below the 1 ug/L detection limit. Sediment samples taken during the same survey showed selenium concentrations below the detection limit of 0.10 mg/Kg.

In October 1986, sediment and water samples were taken from the Black Butte Reservoir area, to verify historical data reporting selenium levels up to 240 ug/L (DWR files) and in response to selenium levels ranging from 0.7 mg/Kg to 1.9 mg/Kg detected in fish livers by the California Department of Fish and Game during 1984 and 1985. Sediment samples were taken from Stony Creek entering the reservoir, from the dam overflow area, and from the lake behind the reservoir. Sediment concentrations ranged from 0.05 to 0.15 mg/Kg selenium. The water concentrations were 0.7 and 0.8 ug/L total selenium for Stony Creek and Black Butte Reservoir, respectively.

The 1984 Toxic Substances Monitoring Program reported high selenium concentrations (25 and 35 mg/Kg) in fish flesh collected from Kesterson Reservoir, a known selenium rich site (SWRCB, 1985). The second highest valleywide concentration, 9.1 mg/Kg in rainbow trout liver was collected in the Shasta Lake/McCloud River area. In response to high selenium levels detected in the trout liver, grab samples were collected to determine selenium concentrations in the water column for the Shasta Lake/McCloud River area. Resulting concentrations were all below the 0.6 ug/L detection limit. Additional fish flesh analyses conducted later by the California Department of Fish and Game reported selenium concentrations at less than 0.2 mg/Kg wet weight. A summary of special stream survey data is shown in Table 4.

DISCUSSION AND CONCLUSIONS

Data obtained from the 1984-88 stream monitoring for total selenium in the Sacramento River Basin does not support historically recorded concentrations. During this survey, reported concentrations never exceeded the 10 ug/L drinking water standard even though data prior to 1984 reported over 100 ug/L. The current data, based on 366 water analyses, indicates extremely low total selenium concentrations in the Sacramento River and its main tributaries. The maximum reported concentration was 1.6 ug/L.

Table 4.
Selenium in the Sacramento Valley
Special Survey Results

Location	selenium concentrations	
	water (ug/L)	sediment (mg/Kg)
LAKE BERRYESSA		
Lake Berryessa @ Steel Canyon	--	<0.10
" " @ trailer park	--	<0.10
Pope Creek @ mouth	--	<0.10
" " @ headwaters	<1	<0.10
Putah Creek @ mouth	--	<0.10
" " @ headwaters	<1 (<1)	<0.10
Capell Creek	1	--
BLACK BUTTE RESERVOIR		
Stony Creek above BBR	0.7	0.15
Black Butte Reservoir	0.8	0.05
Overflow below reservoir	--	0.10
McCLOUD RIVER/SHASTA LAKE		
McCloud River @ Shasta Lake	<0.6	--
Pit River @ Shasta Lake	<0.6	--
McCloud R. @ Fowler Campground	<0.6	--
Mud Creek @ HWY 89	<0.6	--
McCloud R. ½ mile downstream of reservoir	<0.6	--
Sacramento River @ Cypress Bridge (Redding)	<0.6	--

Additional water column data from a late 1984 survey conducted by the U.S. Bureau of Reclamation (USBR) supports the findings in this report that the Sacramento River does not carry elevated levels of total selenium. From the limited USBR data collected in the Sacramento River, selenium concentrations never exceeded 0.06 ug/L. A trend of decreasing selenium concentrations moving north from the Delta is noted in the USBR report (Brown, 1985). The USBR data and the data reported here indicate extremely low background levels of total selenium in the Sacramento River but the limited data set does not allow quantification of the selenium loading from the Sacramento River Basin to the Sacramento-San Joaquin Delta.

During the stream monitoring, average selenium concentrations were found to be less than 1 ug/L for coast range streams, Sierra streams, and surface agricultural drains. The low levels prove inconclusive as to whether any of the three general areas is a major selenium loading source. However, only samples from westside streams had concentrations reported at or greater than 1.0 ug/L, but due to the low levels detected, it is not possible to quantify selenium loadings.

Studies conducted under the Toxic Substances Monitoring Program of the State Water Resources Control Board have shown detectable levels of selenium in fish from the Sacramento Valley (Table 5). Although a follow-up water survey and fish flesh analyses indicated low selenium concentrations, data is currently not available to isolate the source for the original high levels detected in fish livers.

Current data in the San Joaquin River Basin shows agricultural subsurface drainage as a major selenium loading to both the San Joaquin River and the San Joaquin Delta. Major surface agricultural return flows in the Sacramento River Basin (i.e., the Colusa Basin Drain and Sacramento Slough) did not contain levels of selenium exceeding 1 ug/L. Subsurface drainage systems are not widespread in the Sacramento Valley, however, two areas are of special concern. The first is the open drains that serve the area upstream of the Modoc National Wildlife Refuge in the Alturas area. A survey of drainage water quality in this area is presently underway by staff of the Central Valley Regional Water Quality Control Board. The second area is in the Stony Creek-Cache Creek Fan and Interfan areas where water from the recent Tehema-Colusa Canal may cause drainage problems in some lower lying areas. Initial plans are underway for localized subsurface drainage systems in that area and initial shallow ground water samples in one area show varying selenium levels up to 32 ug/L (Boyle Engineering, 1986).

Results from this river basin survey do not indicate that point source discharges of selenium from industrial or municipal sources are impacting beneficial uses in the Sacramento River nor are they causing elevated selenium levels in surface water. A recent survey of significant municipal discharges in the river basin was conducted by staff of the Regional Board. Only two dischargers, the cities of Woodland and Davis showed selenium concentrations above the detection level of 1 ug/L but concentrations were still below the 10 ug/L drinking water standard. Follow-up surveys and monitoring are underway at these two sites (Westcot and Gonzalez, 1988).

Table 5.

Selenium in fish tissue as reported in the SWRCB
Toxics Substances Monitoring Program for
1984, 1985, and 1986

Location	selenium concentration (mg/Kg wet weight) ^{1/}					
	1984		1985		1986	
	Flesh	Liver	Flesh	Liver	Flesh	Liver
McCloud River/Shasta Lake	<0.2	9.1	0.4(0.4)	6.5(2.6)	--	--
Sac River @ Shasta Dam	--	--	--	3.1	--	--
Sac River @ Keswick	--	4	--	4.2	0.26	--
Black Butte Reservoir	--	1.3(1.9)	0.3(0.4)	0.7(0.9)	--	--
Stony Gorge Reservoir	--	--	--	1.3(2.1)	--	--
East Park Reservoir	--	--	--	--	0.38(0.37) (0.21) ^{2/}	
Rollins Reservoir	--	--	--	1.4(1.2)	--	--
Indian Valley Reservoir	--	--	--	1.3	--	--
Lake Berryessa @ Pope Creek	--	--	--	1.3	--	--
Lake Berryessa @ Putah Creek	--	--	--	1.1	--	--
Lake Berryessa @ Capell Creek	--	--	--	0.5	--	--
Feather River @ Nicolaus	--	1.2	--	--	--	--
Sacramento Slough	--	--	--	--	0.29	--
Natomas East Main Drain	--	--	--	--	0.17	--
Sac River @ Clarksburg	--	--	--	--	0.17(0.14)(0.39) ^{2/}	
Beach Lake	--	--	--	0.6(0.6)	--	--
Sac River @ Hood	--	1.5	--	1.1	--	--

^{1/} All data as reported by the California Department of Fish and Game.

^{2/} All values represent concentrations in fish flesh.

A similar survey was conducted by staff of the Regional Board for selected industrial discharges. None of those sampled showed selenium concentrations above the detection level of 1 ug/L. Because of the low levels encountered with both municipal and industrial discharges, further investigations are not warranted at this time. Certain activities however, do have a high potential for encountering selenium deposits. The most likely are the mining and geothermal activities in the coastal foothills. Periodic checks of these wastewater discharges should be conducted to ensure continued protection of beneficial uses (Westcot and Gonzalez, 1988).

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APPENDIX A

APPENDIX A

Sampling Protocol

Two methods were used for collecting water samples for total selenium analysis, direct collection from stream flow and collection using a 2.5 gallon acid-rinsed stainless steel bucket. In both cases, final samples were stored in acid-washed 6 oz. linear polyethylene plastic bottles and preserved with acid to a pH<2.

When using the bucket, water was collected from the center of a bridge on the downstream side. The bucket was rinsed two times with sample before final collection. The sample was then poured directly from the bucket to the acid-washed sampling bottle. Care was taken to avoid disturbing bottom sediments and to collect each sample as close to the center of flow as possible.

In addition to water samples taken for total selenium analysis, field data was collected for electrical conductivity (EC) and temperature. EC was measured using a Myron DS Meter, model 532 M1. Standard procedures were followed which included calibration at each site and rinsing the cell cup three times with sample before taking the reading.

A standard Fahrenheit thermometer was used to measure temperature either by direct placement into stream flow or into the bucket. Temperature measurements were taken after selenium sampling and EC analysis were completed.

In all cases, order of collection were as follows:

1. water sample for selenium analysis;
2. electrical conductivity;
3. temperature.

For each sampling run, a travel blank was prepared by filling a 6 oz. acid-washed linear polyethylene plastic container with deionized water and acidifying with acid to pH<2. At each site, the travel blank was opened and placed in the vicinity during water collection for selenium analysis. The blank was closed before EC and temperature measurements were taken.

Sediment

Most sediments were collected using a modified brass Eckman sampler. For sediments collected within lakes, the Eckman was dropped from a boat and each "sample" was a composite of four collections. Each collection consisted of approximately 100 grams from the top two inches of bottom sediment. The sampler was acid-washed and rinsed with surrounding surface water between each site.

For sediments collected in shallow streams, a modified soil auger was used. For each site, the top two inches of bottom sediment was collected in

Appendix A

acid-washed two-inch PVC pipe. Six collections taken as a random transect of the stream were composited for each site sample.

All soil samples were frozen in plastic bags until analysis by the contracted laboratory.

APPENDIX B

SELENIUM STREAM NETWORK SAMPLING SITES

ID.	Description
TB-100	Travel blank. De-ionized water taken from the CVWQCB laboratory.
SV-1	Putah Creek at HWY 128 bridge below Monticello Dam (Lake Berryessa). Sample taken from shore at northwest corner of bridge.
SV-2	Upper arm of Lake Berryessa. Taken from west bank at the end of Stage Coach Road.
SV-2B	Putah Creek at left bank of HWY 29 bridge.
SV-3	Cache Creek below Clear Lake at Dam Road Bridge (off HWY 53). Bucket sample taken from center of bridge, downstream side.
SV-4	Cole and Kelsey Creeks confluence above Clear Lake. Bucket sample taken from bridge leading to Clear Lake State Park boat launch.
SV-5	Middle Creek above Clear Lake, downstream of HWY 20. Sampled from road running along left bank of creek.
SV-5B	Scotts Creek above Clear Lake from HWY 29 bridge. Bucket sample, downstream side.
SV-6	Cache Creek from right bank at HWY 20 bridge.
SV-7	Stony Creek above Black Butte Reservoir. Bucket sample from downstream side of Black Butte Road bridge.
SV-8	Stony Creek below Black Butte Reservoir. From left bank downstream of Newville Road bridge.
SV-9	Kendricks and Salt Creeks above Black Butte Reservoir. Bucket sample, downstream side of Newville Road bridge.
SV-10	Thomes Creek at Road A9 bridge near Paskenta. Bucket sample, downstream side of Newville Road bridge.
SV-11	Cottonwood Creek near HWY 5. Left bank off dirt road leading to railroad tracks under HWY 5 bridge.

ID.	Description
SV-12	Clear Creek below Whiskeytown Reservoir. Mid-stream sample downstream of Paige Bar Road Bridge.
SV-13	Right bank of Spring Creek at Debris Dam spill.
SV-14	Mill Creek at HWY 99 bridge. Bucket sample, downstream side.
SV-15	Left bank of Big Chico Creek at 6th Street bridge in Chico.
SV-16	Big Chico Creek above the Sacramento River. Bucket sample, downstream of River Road bridge.
SV-17	Feather River near East Gridley Road. Right bank, above bridge.
SV-18	Yuba River in Marysville. Left bank above Ramirez Street Bridge.
SV-19	Butte Creek above Sacramento River. Bucket sample taken from gate release walkway off Butte Slough Road.
SV-20	Colusa Basin Drain at Road 99E. Bucket sample, downstream of bridge.
SV-21	Feather River downstream of HWY 99 bridge. Left bank.
SV-22	Natomas East Drainage Canal from Elkhorn Blvd. Bridge. Bucket sample, upstream of bridge.
SV-22A	Natomas East Drainage Canal from Del Paso Road Bridge. Bucket sample, downstream side.
SV-23	American River below Nimbus Fish Hatchery along left bank.
SV-23A	American River at Sunrise Blvd. foot bridge. Bucket sample downstream side.
SV-24	Sacramento Slough above RD 1000 discharge. Bucket sample, downstream side of bridge.
SV-25	Toe Drain above Cache Slough by boat.
SV-26	RD 108 discharge above pump house.

ID.	Description
SV-27	Feather River at West Catlett Rd.
SV-28	Sutter Bypass at Tarke Rd.
Sacramento River Sites	
SR-A	Sacramento River below Keswick Dam - right bank.
SR-B	Sacramento River below Hamilton City. Left bank where River Road becomes gravel.
SR-C	Sacramento River at Hamilton City.
SR-D	Sacramento River at Colusa.
SR-E	Sacramento River at Grimes Boat Marina from pier.
SR-F	Sacramento River at Village Marina
SR-G	Sacramento River at Hood.
SR-H	Sacramento River below Rio Vista Bridge. (By boat, mid-channel.)

APPENDIX C

SELENIUM STREAM NETWORK SAMPLING RESULTS

LOCATION	RWQCB ID	DATE	TIME	TEMP (F)	EC umhos/cm	SELENIUM CONCENTRATIONS (ug/L) *				
						ANLAB	CAL	USGS	DWR	SDSU
TRAVEL BLANK	TB100	4/24/84	1535	--	--	<2	<2	--	--	--
		5/17/84	0630	70	2	<2	--	--	--	--
		5/30/84	1900	70	2	<2	<2	--	--	--
		6/25/84	0645	68	3	<2	--	--	--	--
		7/17/84	1530	83	7	--	--	<1	--	--
		3/8/85	1500	70	5	--	--	--	<.6	--
		8/20/86	0700	--	--	--	--	--	--	<0.2
		1/5/87	0600	--	--	--	--	--	--	<0.2
PUTAH CREEK BELOW LAKE BERRYESSA	SV-1	4/25/84	0730	50	285	4	<2	--	--	--
		5/17/84	0745	52	250	<2	--	--	--	--
		5/31/84	0720	52	245	<2	<2	--	--	--
		6/25/84	0755	54	260	<2	--	--	--	--
		7/18/84	0720	53	255	--	--	<1	--	--
		3/8/85	1600	50	280	--	--	--	<.6	--
		8/20/86	0815	--	--	--	--	--	--	0.2
		1/5/87	0710	56	300	--	--	--	--	0.4
4/11/88	1113	54	300	--	--	--	--	<0.2		
UPPER ARM LAKE BERRYESSA	SV-2	4/25/84	0900	60	370	2	<2	--	--	--
		5/17/84	0850	67	365	<2	--	--	--	--
		5/31/84	0835	74	340	<2	<2	--	--	--
		6/25/84	0900	79	355	<2	--	--	--	--
		7/18/84	0830	85	370	--	--	<1	--	--
		3/8/85	1700	48	275	--	--	--	<.6	--
PUTAH CREEK ABOVE LAKE BERRYESSA	SV-2B	5/17/84	0925	60	250	<2	--	--	--	--
		5/31/84	0905	65	235	<2	<2	--	--	--
		6/25/84	0935	70	250	<2	--	--	--	--
		7/18/84	0905	76	265	--	--	<1	--	--
		3/8/85	1730	50	190	--	--	--	<.6	--
		8/20/86	0940	--	--	--	--	--	--	<0.2
		1/5/87	0835	48	215	--	--	--	--	<0.2
4/11/88	1240	73	320	--	--	--	--	0.4		
CACHE CREEK BELOW CLEAR LAKE	SV-3	4/25/84	1000	57	210	<2	<2	--	--	--
		5/17/84	0950	61	195	<2	--	--	--	--
		5/31/84	0930	71	185	<2	<2	--	--	--
		6/25/84	1005	74	190	<2	--	--	--	--
		7/18/84	0925	83	190	--	--	<1	--	--
		3/8/85	1750	48	260	--	--	--	<.6	--
		8/20/86	1000	--	--	--	--	--	--	<0.2
		1/5/87	0900	49	500	--	--	--	--	0.5
4/11/88	1310	68	300	--	--	--	--	0.5		

SELENIUM STREAM NETWORK SAMPLING RESULTS

LOCATION	RWQCB ID	DATE	TIME	TEMP (F)	EC umhos/cm	SELENIUM CONCENTRATIONS (ug/L) *				
						ANLAB	CAL	USGS	DWR	SDSU
COLE & KELSEY CREEKS	SV-4	4/25/84	1100	60	170	<2	--	--	--	--
		5/17/84	1030	65	175	<2	--	--	--	--
		5/31/84	1010	73	180	<2	--	--	--	--
		6/25/84	1045	74	175	<2	--	--	--	--
		7/18/84	0955	83	190	--	--	<1	--	--
		3/8/85	1825	49	120	--	--	--	<.6	--
		8/20/86	1035	--	--	--	--	--	--	0.2
		1/5/87	0940	46	185	--	--	--	--	0.3
		4/11/88	1400	74	260	--	--	--	--	<0.2
MIDDLE CREEK ABOVE CLEAR LAKE	SV-5	4/25/84	1215	59	170	<2	--	--	--	--
		5/17/84	1120	61	180	<2	--	--	--	--
		5/31/84	1050	65	170	<2	--	--	--	--
		6/25/84	1130	70	190	<2	--	--	--	--
		7/18/84	1035	DRY	--	--	--	--	--	--
		3/8/85	1850	50	150	--	--	--	<.6	--
		8/20/86	1115	DRY	--	--	--	--	--	--
		1/5/87	1020	50	230	--	--	--	--	0.4
		4/11/88	1455	68	250	--	--	--	--	0.2
SCOTTS CREEK ABOVE CLEAR LAKE	SV-5B	4/25/84	1230	56	230	<2	--	--	--	--
		5/17/84	1105	61	335	<2	--	--	--	--
		5/31/84	1010	73	315	<2	--	--	--	--
		6/25/84	1115	78	210	<2	--	--	--	--
		7/18/84	1025	83	220	--	--	<1	--	--
		8/20/86	1130	--	225	--	--	--	--	0.2
		1/5/87	1010	48	570	--	--	--	--	0.5
		4/11/88	1445	70	450	--	--	--	--	0.2
		CACHE CREEK AT HWY 20	SV-6	5/17/84	1210	--	--	<2	--	--
5/31/84	1135			61	200	<2	<2	--	--	--
6/15/84	1215			60	190	<2	--	--	--	--
7/18/84	1115			58	170	--	--	<1	--	--
8/20/86	1230			--	215	--	--	--	--	<.2(<.2)
1/5/87	1110			48	460	--	--	--	--	0.9
4/11/88	1540			66	250	--	--	--	--	0.2
STONY CREEK ABOVE BLACK BUTTE RESERVOIR	SV-7			4/25/84	1500	60	280	<2	<2	--
		5/17/84	1400	70	240	<2	--	--	--	--
		5/31/84	1330	71	260	<2	<2	--	--	--
		6/25/84	1415	80	280	<2	--	--	--	--
		7/18/84	1315	85	270	--	--	<1	--	--
		3/9/85	0745	44	260	--	--	--	1	--
		8/20/86	1430	--	270	--	--	--	--	0.3
		10/8/86	1400	--	390	--	--	--	--	0.7
		1/5/87	1300	52	320	--	--	--	--	1.6(1.1)
		4/11/88	1740	74	300	--	--	--	--	1.0

SELENIUM STREAM NETWORK SAMPLING RESULTS

LOCATION	RWQCB ID	DATE	TIME	TEMP (F)	EC umhos/cm	SELENIUM CONCENTRATIONS (ug/L) *				
						ANLAB	CAL	USGS	DWR	SDSU
STONY CREEK BELOW BLACK BUTTE RESERVOIR	SV-8	4/25/84	1535	58	300	<2	<2	--	--	--
		5/17/84	1430	65	260	<2	--	--	--	--
		5/31/84	1400	63	260	<2	<2	--	--	--
		6/25/84	1435	74	270	<2	--	--	--	--
		7/18/84	1335	75	275	--	--	<1	--	--
		3/9/85	0810	46	250	--	--	--	1	--
		8/20/86	1500	--	245	--	--	--	--	0.4(0.4)
		10/8/86	1515	80	390	--	--	--	--	0.8
		1/5/87	1325	50	430	--	--	--	--	0.7
4/11/88	1810	64	300	--	--	--	--	0.8		
KENDRICKS & SALT CREEKS ABOVE BLACK BUTTE RESERVOIR	SV-9	4/25/84	1600	64	500	<2	<2	--	--	--
		5/17/84	1450	76	465	<2	--	--	--	--
		5/31/84	1415	78	450	<2	<2	--	--	--
		6/25/84	1455	85	435	<2	--	--	--	--
		7/18/84	1345	DRY		--	--	--	--	--
		3/9/85	0820	45	470	--	--	--	1	--
		8/20/86	1525	--	360	--	--	--	--	0.3
		1/5/87	1340	54	600	--	--	--	--	0.6
		4/11/88	1830	72	675	--	--	--	--	0.9
THOMES CREEK AT PASKENTA	SV-10	4/25/84	1640	54	160	<2	<2	--	--	--
		5/17/84	1530	67	125	<2	--	--	--	--
		5/31/84	1445	71	155	<2	<2	--	--	--
		6/25/84	1530	84	220	<2	--	--	--	--
		7/18/84	1410	89	250	--	--	<1	--	--
		3/9/85	0845	44	145	--	--	--	<.6	--
		8/20/86	1555	--	280	--	--	--	--	0.3
		1/5/87	1405	51	220	--	--	--	--	0.6
		4/11/88	1900	68	170	--	--	--	--	0.2
COTTONWOOD CREEK AT INTERSTATE 5	SV-11	4/26/84	1015	54	230	<2	--	--	--	--
		5/17/84	1700	74	175	<2	--	--	--	--
		5/31/84	1600	73	180	<2	--	--	--	--
		6/25/84	1630	75	150	<2	--	--	--	--
		7/18/84	1500	79	140	--	--	--	--	--
		3/9/85	0950	46	220	--	--	--	<.6	--
		8/20/86	1655	--	150	--	--	--	--	<0.2
		1/5/87	1505	50	320	--	--	--	--	1.0
		4/12/88	0915	63	270	--	--	--	--	<0.2
CLEAR CREEK BELOW WHISKEYTOWN RESERVOIR	SV-12	4/26/84	0630	47	65	<2	--	--	--	--
		5/17/84	1745	60	65	<2	--	--	--	--
		5/31/84	1645	62	60	<2	--	--	--	--
		6/25/84	1720	66	65	<2	--	--	--	--
		7/18/84	1545	65	60	--	--	--	--	--

SELENIUM STREAM NETWORK SAMPLING RESULTS

LOCATION	RWQCB ID	DATE	TIME	TEMP (F)	EC umhos/cm	SELENIUM CONCENTRATIONS (ug/L) *				
						ANLAB	CAL	USGS	DWR	SDSU
CLEAR CREEK BELOW WHISKEYTOWN RESERVOIR	SV-12	3/9/85	1040	44	55	--	--	--	<.6	--
		8/20/86	1740	--	55	--	--	--	--	0.2
		1/5/87	1550	50	100	--	--	--	--	<0.2
		4/12/88	0740	48	100	--	--	--	--	0.3
SPRING CREEK AT DEBRIS DAM	SV-13	4/26/84	0900	54	1100	<2	<2	--	--	--
		5/17/84	1815	66	1200	<2	--	--	--	--
		5/31/84	1710	68	1350	<2	<2	--	--	--
		6/26/84	0935	72	1500	<2	--	--	--	--
		7/18/84	1600	88	2000	--	--	--	--	--
		3/9/85	1100	42	650	--	--	--	1	--
		8/20/86	1845	--	2300	--	--	--	--	0.6
		1/5/87	1610	50	1200	--	--	--	--	1.2
		4/12/88	0815	55	1250	--	--	--	--	1.2
MILL CREEK AT HWY 99	SV-14	4/26/84	1115	52	110	<2	--	--	--	--
		5/18/84	0700	54	100	<2	--	--	--	--
		6/1/84	0655	56	80	<2	--	--	--	--
		6/26/84	1130	68	105	<2	--	--	--	--
		7/18/84	1725	83	125	--	--	<1	--	--
		3/9/85	1230	49	110	--	--	--	<.6	--
		8/21/86	0755	--	190	--	--	--	--	0.2
		4/12/88	1010	59	160	--	--	--	--	<0.2
CHICO CREEK IN CHICO	SV-15	4/26/84	1200	52	130	<2	--	--	--	--
BIG CHICO CREEK AT RIVER ROAD	SV-16	4/26/84	1245	54	160	<2	--	--	--	--
		5/18/84	0810	63	200	<2	--	--	--	--
		6/1/84	0735	50	115	<2	--	--	--	--
		6/26/84	1220	69	105	<2	--	--	--	--
		7/18/84	1815	75	100	--	--	--	--	--
		3/9/85	1330	47	120	--	--	--	<.6	--
		8/21/86	0840	--	105	--	--	--	--	<0.2
		1/20/87	0900	--	--	--	--	--	--	0.2
4/12/88	1125	68	240	--	--	--	--	0.4		
FEATHER RIVER AT EAST GRIDLEY ROAD	SV-17	4/26/84	1400	57	70	<2	--	--	--	--
		5/18/84	1105	62	70	<2	--	--	--	--
		6/1/84	0905	65	75	<2	--	--	--	--
		6/26/84	1330	69	65	<2	--	--	--	--
		7/18/84	1900	70	70	--	--	--	--	--
		3/9/85	1430	50	60	--	--	--	<.6	--
		8/21/86	0945	--	70	--	--	--	--	<0.2
		1/6/87	0920	52	90	--	--	--	--	0.3
4/12/88	1240	63	90	--	--	--	--	0.4		

SELENIUM STREAM NETWORK SAMPLING RESULTS

LOCATION	RWQCB ID	DATE	TIME	TEMP (F)	EC umhos/cm	SELENIUM CONCENTRATIONS (ug/L) *				
						ANLAB	CAL	USGS	DWR	SDSU
YUBA RIVER AT MARYSVILLE	SV-18	4/26/84	1440	58	70	<2	--	--	--	--
		5/18/84	1145	56	65	<2	--	--	--	--
		6/1/84	0950	55	50	<2	--	--	--	--
		6/26/84	1400	64	55	<2	--	--	--	--
		7/18/84	1930	65	50	--	--	<1(<1)	--	--
		3/9/85	1450	50	60	--	--	--	<.6	--
		8/21/86	1025	--	70	--	--	--	--	0.2
		1/6/87	1000	52	100	--	--	--	--	0.2
		4/12/88	1320	63	100	--	--	--	--	0.2
BUTTE CREEK ABOVE SACRAMENTO RIVER	SV-19	4/26/84	1530	60	175	<2	<2	--	--	--
		5/18/84	1240	70	200	<2	--	--	--	--
		6/1/84	1035	75	250	<2	<2	--	--	--
		6/27/84	1055	--	--	<2	--	--	--	--
		7/19/84	0805	79	245	--	--	<1	--	--
		3/9/85	1530	51	185	--	--	--	<.6	--
		8/21/86	1100	--	240	--	--	--	--	0.2
		9/2/86	0845	74	230	--	--	--	--	0.4
		1/6/87	1040	52	210	--	--	--	--	0.3
4/12/88	1430	61	160	--	--	--	--	0.3		
COLUSA BASIN DRAIN AT ROAD 99E	SV-20	4/26/84	1630	59	420	<2	<2	--	--	--
		5/18/84	1400	69	355	<2	--	--	--	--
		6/1/84	1110	71	465	<2	<2	--	--	--
		6/27/84	1200	--	--	<2	--	--	--	--
		7/19/84	0900	73	360	--	--	<1	--	--
		3/9/85	1640	53	200	--	--	--	<.6	--
		8/21/86	1200	--	330	--	--	--	--	0.3(0.3)
		9/2/86	1020	72	330	--	--	--	--	0.6
		1/6/87	1135	--	900	--	--	--	--	0.7
4/12/88	1600	69	400	--	--	--	--	0.8		
FEATHER RIVER AT HWY 99	SV-21	4/27/84	0930	58	80	<2	<2	--	--	--
		5/18/84	1600	70	80	<2	--	--	--	--
		6/1/84	1355	68	65	<2	<2	--	--	--
		6/26/84	1440	74	--	<2	--	--	--	--
		7/19/84	1015	69	70	--	--	<1	--	--
		3/9/85	1800	51	60	--	--	--	<.6	--
NATOMAS EAST DRAIN AT ELKHORN BLVD	SV-22	4/27/84	1010	57	255	<2	<2	--	--	--
NATOMAS EAST DRAIN AT DEL PASO ROAD	SV-22A	5/18/84	1635	72	330	<2	--	--	--	--
		6/1/84	1430	77	445	<2	<2	--	--	--
		6/26/84	1515	86	455	<2	--	--	--	--
		7/19/84	1215	77	395	--	--	<1	--	--

SELENIUM STREAM NETWORK SAMPLING RESULTS

LOCATION	RWQCB ID	DATE	TIME	TEMP (F)	EC umhos/cm	SELENIUM CONCENTRATIONS (ug/L) *				
						ANLAB	CAL	USGS	DWR	SDSU
NATOMAS EAST DRAIN AT DEL PASO ROAD	SV-22A	3/9/85	1820	58	650	--	--	--	<.6	--
		8/21/86	1350	--	410	--	--	--	--	0.2
		9/2/86	1235	76	400	--	--	--	--	0.5
		1/6/87	1320	--	820	--	--	--	--	0.5
		4/12/88	1745	65	250	--	--	--	--	1.2
AMERICAN RIVER BELOW NIMBUS DAM	SV-23	4/27/84	1115	54	39	<2	--	--	--	--
AMERICAN RIVER AT SUNRISE BLVD	SV-23A	5/19/84	0930	55	39	<2	--	--	--	--
		6/1/84	1515	57	45	<2	<2	--	--	--
		6/26/84	1600	60	37	<2	--	--	--	--
		7/19/84	1250	63	32	--	--	<1	--	--
		3/13/85	0735	47	31	--	--	--	<.6	--
		8/21/86	1455	--	40	--	--	--	--	<0.2
		9/2/86	1420	72	35	--	--	--	--	0.3
		1/6/87	1405	--	60	--	--	--	--	0.2
4/11/88	0845	57	80	--	--	--	--	0.5		
SACRAMENTO SLOUGH ABOVE RD 1500 DISCHARGE	SV-24	5/18/84	1425	72	300	<2	--	--	--	--
		6/1/84	1225	76	260	<2	--	--	--	--
		6/27/84	1230	--	--	<2	--	--	--	--
		7/19/84	0920	79	300	--	--	--	--	--
		3/9/85	1655	57	325	--	--	--	<.6	--
		8/21/86	1225	--	290	--	--	--	--	0.2
		9/2/86	1050	76	280	--	--	--	--	0.3
		1/6/87	1155	--	320	--	--	--	--	0.4
4/12/88	1625	68	260	--	--	--	--	0.4		
TOE DRAIN ABOVE CACHE SLOUGH	SV-25	5/21/84	1040	68	340	<2	--	--	--	--
RD 108 DISCHARGE	SV-26	9/2/86	1000	75	450	--	--	--	--	0.4(0.6)
		4/12/88	1540	74	490	--	--	--	--	0.8
FEATHER RIVER AT WEST CATLETT ROAD	SV-27	8/21/86	1330	--	70	--	--	--	--	<0.2
		9/2/86	1200	72	70	--	--	--	--	0.4(0.8)
		1/6/87	1250	--	120	--	--	--	--	0.4
		4/12/88	1720	65	90	--	--	--	--	0.3
SUTTER BYPASS AT TARKE ROAD	SV-28	9/2/86	0910	75	240	--	--	--	--	0.3
		4/12/88	1400	69	240	--	--	--	--	0.3

* All selenium values reported as total selenium in ug/L. Laboratories conducting analyses are ANLAB (ANLAB of Sacramento), CAL (California Analytical Laboratories, Sacramento) USGS (United States Geological Survey Laboratory, Denver), DWR (California Department of Water Resour, Bryte Laboratory, Sacramento) and SDSU (South Dakota State University, Brookings).

() = duplicate sample

SELENIUM STREAM NETWORK SAMPLING RESULTS
CONCENTRATIONS IN THE SACRAMENTO RIVER

LOCATION	RWQCB ID	DATE	TIME	TEMP (F)	EC umhos/cm	SELENIUM CONCENTRATIONS (UG/L) *				
						ANLAB	CAL	USGS	DWR	SDSU
BELOW KESWICK DAM	SR-A	4/26/84	0720	46	390	<2	--	--	--	--
		5/17/84	1830	49	100	<2	--	--	--	--
		5/31/84	1720	50	100	<2	<2	--	--	--
		6/26/84	0945	50	100	<2	--	--	--	--
		7/18/84	1615	53	85	--	--	--	--	--
		3/9/85	1110	45	80	--	--	--	<.6	--
		1/6/87	1620	50	130	--	--	--	--	0.2
		4/12/88	0835	48	130	--	--	--	--	<0.2
OFF RIVER ROAD ABOVE BIG CHICO CREEK	SR-B	5/18/84	0800	58	125	<2	--	--	--	--
		6/1/84	0735	50	115	<2	<2	--	--	--
		6/26/84	1210	64	100	<2	--	--	--	--
		7/18/84	1805	64	95	--	--	<1(<1)	--	--
		3/9/85	1315	48	100	--	--	--	<.6	--
AT HAMILTON	SR-C	1/20/87	0915	--	--	--	--	--	--	0.2
		4/12/88	1100	58	140	--	--	--	--	0.2
AT COLUSA	SR-D	9/2/86	0820	--	--	--	--	--	--	0.2
AT GRIMES	SR-E	5/18/84	1315	63	120	<2	--	--	--	--
		6/1/84	1110	66	120	<2	<2	--	--	--
		6/27/84	1115	--	--	<2	--	--	--	--
		7/19/84	0830	66	105	--	--	--	--	--
		3/9/85	1600	49	100	--	--	--	<.6	--
		1/6/87	1100	--	120	--	--	--	--	0.4
		4/12/88	1500	62	140	--	--	--	--	0.4
AT VILLAGE MARINA	SR-F	9/2/86	1305	74	160	--	--	--	--	0.5
		1/6/87	1330	--	170	--	--	--	--	0.2
AT HOOD	SR-G	9/2/86	1340	75	140	--	--	--	--	1.4
		1/6/87	1455	52	160	--	--	--	--	0.5(0.2)
		4/11/88	1000	64	150	--	--	--	--	0.6
AT RIO VISTA BRIDGE	SR-H	5/21/84	1230	66	150	<2	--	--	--	--

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() = duplicate sample

