Staff Report of the
California Regional Water Quality Control Board
Central Valley Region

Water Quality of the Lower San Joaquin River: Lander Avenue to Vernalis October 1994 to September 1995

(Water Year 1995)

DECEMBER 1996

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3443 Routier Road, Suite A
Sacramento, California 95827-3098

Phone: (916) 255-3000

The staff involved in the
preparation of this report are:

Ross A. Steensen, Associate Land and Water Use Analyst
Jeanne Chilcott, Associate Land and Water Use Analyst
Thomas Burns, Assistant Environmental Specialist

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SUMMARY

As part of our program to measure compliance with Basin Plan water quality objectives (CVRWQCB, 1988), the Agricultural Unit of the Central Valley Regional Water Quality Control Board (Regional Board) initiated a water quality monitoring program on the lower San Joaquin River in May 1985. Previous reports have been issued for data collected for Water Years (WYs) 86-94 (May 1985 through September 1994). The present report covers WY 95 (1 October 1994 to 30 September 1995); the third highest runoff year in 89 years of records (1906-1995) (DWR, 1995).

During WY 95, selected mineral and trace element constituents were measured for total recoverable concentrations at seven monitoring sites along a 60-mile section of the San Joaquin River extending from near Stevinson at Lander Avenue to near Vernalis at Airport Way. Water quality samples were collected weekly at seven sites and analyzed for electrical conductivity (EC), boron, selenium, temperature, and pH. In addition, all samples were analyzed for chloride, sulfate, and hardness monthly. Selected sites were also analyzed for molybdenum, copper, chromium, lead, nickel, and zinc on a monthly basis, until February 1995, and quarterly thereafter.

The general trend in constituent concentrations along the San Joaquin River study area during WY 95 continues to be that the lowest concentrations of measured constituents occur at the upstream ("background") and downstream (southern Delta boundary) study end points: Lander Avenue and Airport Way (Vernalis), respectively. Concentrations were highest just downstream of Lander Avenue below the Salt Slough and Mud Slough (north) confluences at Fremont Ford and Hills Ferry Road, respectively. Salt Slough and Mud Slough (north) are the two major sources of subsurface agricultural drainage to the San Joaquin River. Downstream of the Hills Ferry Road site, concentrations decreased as each of the three east side rivers provided dilution water for the San Joaquin River.

The three major constituents of concern from agricultural and subsurface drainage are selenium, boron, and salt. Total annual flow weighted boron, and salt concentrations (measured at Patterson) were the lowest on Regional Board record in WY 95. As a measure of salt concentration, median EC ranged from 238 to 1,180 μmhos/cm upstream of the Merced River inflow, and from 429 to 716 μmhos/cm downstream of the inflow. Selenium flow weighted concentrations for WY 95 were the lowest since WY 86. Dilution provided by the Merced River inflow before the Patterson site appeared to mitigate the higher concentrations seen upstream at Hills Ferry.

Compliance monitoring for selenium and boron objectives adopted by the Board in 1988, occurs on the San Joaquin River at the Crows Landing Bridge site. The Crows Landing Bridge site is downstream of the Merced River inflow. The water quality objectives depend on the water year type. Section III of the Third Edition, the Sacramento River Basin and San Joaquin River Basin Water Quality Control Plan (CRWQCB, 1995) describes Water Year classifications as wet, above normal, below normal, dry, and critical.

During WY 95, a wet water year, the monthly mean boron objective adopted by the Board (1.0 mg/L) was exceeded in February 1995 at the Crows Landing Bridge site. The monthly mean selenium water quality objective adopted by the Board (5 μg/L monthly mean) was exceeded during February and March at the Crows Landing Bridge site during WY 95. The period of elevated concentrations occurred during the typical period of pre-irrigation and crop irrigation.

Molybdenum water quality objectives are delineated by location of the site with respect to the Merced River. Water quality objectives (WQO) for molybdenum from Sack Dam to the mouth of the Merced River inflow are 50 μg/L maximum and 19 μg/L monthly mean. The molybdenum WQO from the Merced River inflow to Vernalis are 15 μg/L maximum and 10 μ/L monthly mean. Only one site, Lander Avenue, the single site upstream of the drainage inflows, exceeded the water quality objectives for molybdenum. The noncompliance during WY 95 was a result of natural conditions, as no waste discharges occur upstream of Lander Avenue.

The U.S. Environmental Protection Agency (EPA) did not approve the selenium water quality objectives adopted by the Board in 1988 for the San Joaquin River. In December 1992, the EPA promulgated a 5 μg/L four-day average criteria for the San Joaquin from Sack Dam to Vernalis and a 20 μg/L maximum criteria for the San Joaquin River from Sack Dam to the Merced River. These criteria apply in all water year types. Data collected during this program is insufficient to calculate a four-day average concentration but a comparison can be made with weekly grab sample concentrations. During WY 95, at the Crows Landing site downstream of the Merced River inflow, the continuous 5 μg/L selenium criteria was exceeded in five of the fifty-three samples collected. These exceedences occurred between 9 February 1995 and 9 March 1995. The highest concentration recorded was 12 μg/L which does not exceed the Federal maximum criteria of 20 μg/L.

In contrast to the lower concentrations seen as compared to water years 86-94, WY 95 saw the highest annual salt, boron, and selenium loads since the monitoring began in 1986. Selenium loads peaked in March (3115 lbs), corresponding to maximum San Joaquin River flows and record precipitation. The lowest monthly selenium loads (238 lbs) occurred in October. A total selenium load of 14,291 (lbs) was measured at the Patterson site during WY 95.

A review of total copper, chromium, nickel, lead, and zinc concentrations reported on a monthly basis indicated no potential water quality concerns. The conclusion was based on low overall trace element concentrations in conjunction with high hardness concentrations.

INTRODUCTION

The Agricultural Unit of the Central Valley Regional Water Quality Control Board initiated a water quality monitoring program on the lower San Joaquin River in May 1985. Water quality samples were collected at eight monitoring sites along a 60-mile section of the River extending from near Stevinson in Merced County to Airport Way near Vernalis in San Joaquin County (Figure 1). The purpose of this monitoring program was to compile an on-going database for selected inorganic constituents found in San Joaquin River water. This database is used to assess the effects of agricultural drainage water on the quality of the San Joaquin River. A long-term database is essential to assess the effects of the implementation of regional agricultural drainage reduction programs on overall river water quality. This report contains monitoring data collected from October 1994 through September 1995. This period comprises Water Year 1995 (WY 95). A WY extends from 1 October of one calendar year to 30 September of the following calendar year. Reports have been issued for data collected from May 1985 through September 1994 (WYs 86-94) (James, *et al.*, 1988; Westcot, *et al.*, 1989a, 1990, 1991, and 1992; Karkoski and Tucker, 1993, and Chilcott, *et al.*, 1995). This monitoring program was designed to compliment monitoring programs conducted by other state, federal, and local agencies.

STUDY AREA

The study area consists of the 60-mile section of the San Joaquin River extending from Lander Avenue (Highway 165) near Stevinson to Airport Way near Vernalis. Monitoring sites are near each of the eight river overcrossings on this section of the River (Figure 2).

There are five major tributaries to the San Joaquin River within this study area: Salt Slough, Mud Slough (north), and the Merced, Tuolumne, and Stanislaus Rivers. Salt Slough and Mud Slough (north) drain the Grassland Area of western Merced County and discharge to the San Joaquin River in the southern portion of the study area (Figure 2). These two sloughs are the major source of agricultural subsurface drainage water discharges to the San Joaquin River. They carry a varying mixture of surface and subsurface agricultural drainage, operational spillage from irrigation canals, and seasonal drainage from duck ponds flooded each winter for waterfowl habitat. The Merced, Tuolumne, and Stanislaus Rivers are east side streams which drain the Sierra Nevada. All three streams receive some agricultural return flows in their lower reaches upstream of the San Joaquin River; however, overall water quality remains relatively high.

In addition to the five major tributaries, there are also a number of smaller tributaries, as well as surface and subsurface agricultural drains, that discharge to the San Joaquin River within the study area. The significant inflows and their locations, referenced by river mile are listed in Table 1. The monitoring sites are also identified in this table. A full description of the inflow points that occur in this 60-mile section of the river is in James, *et al.*, (1989).

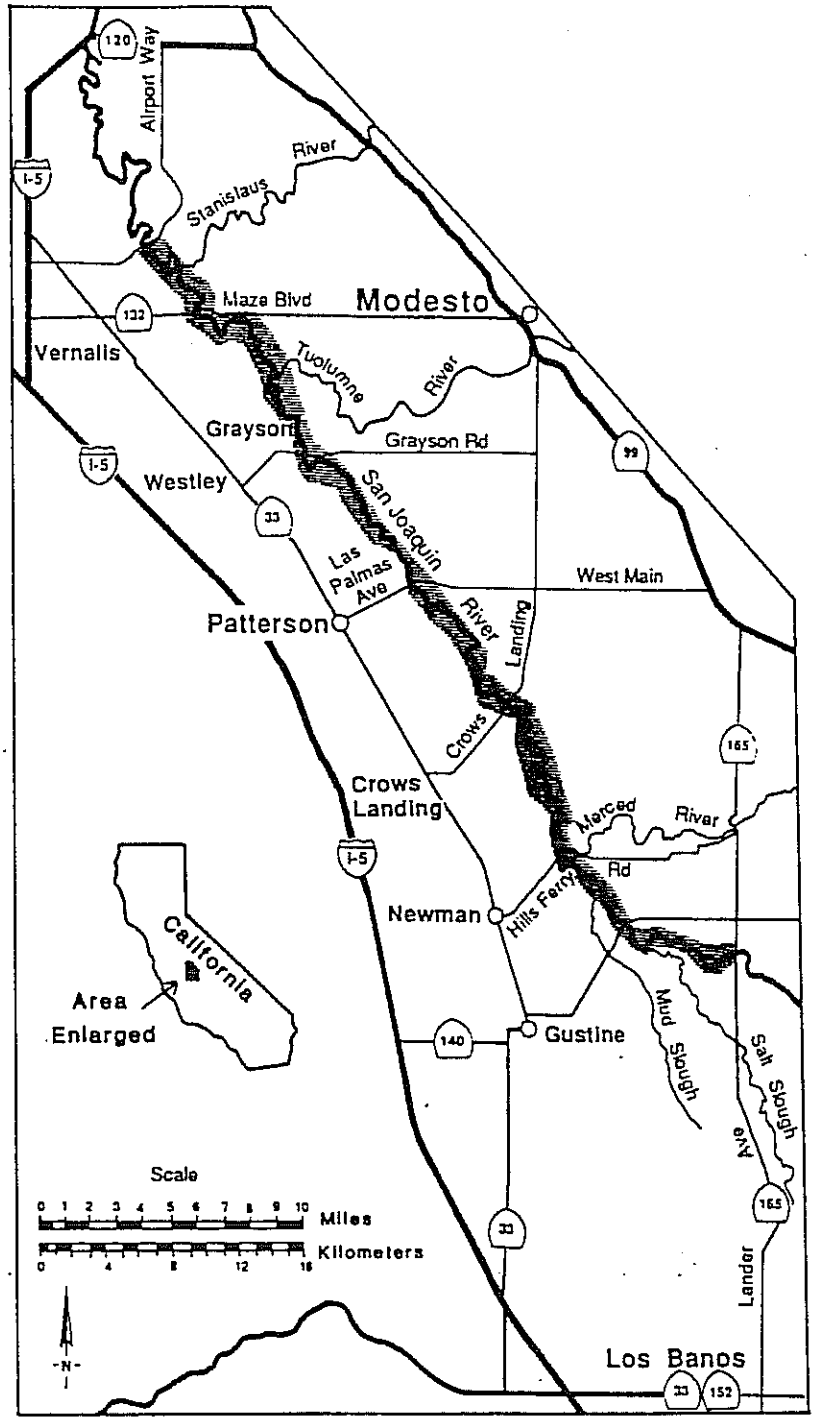

Fig.1. Location Map

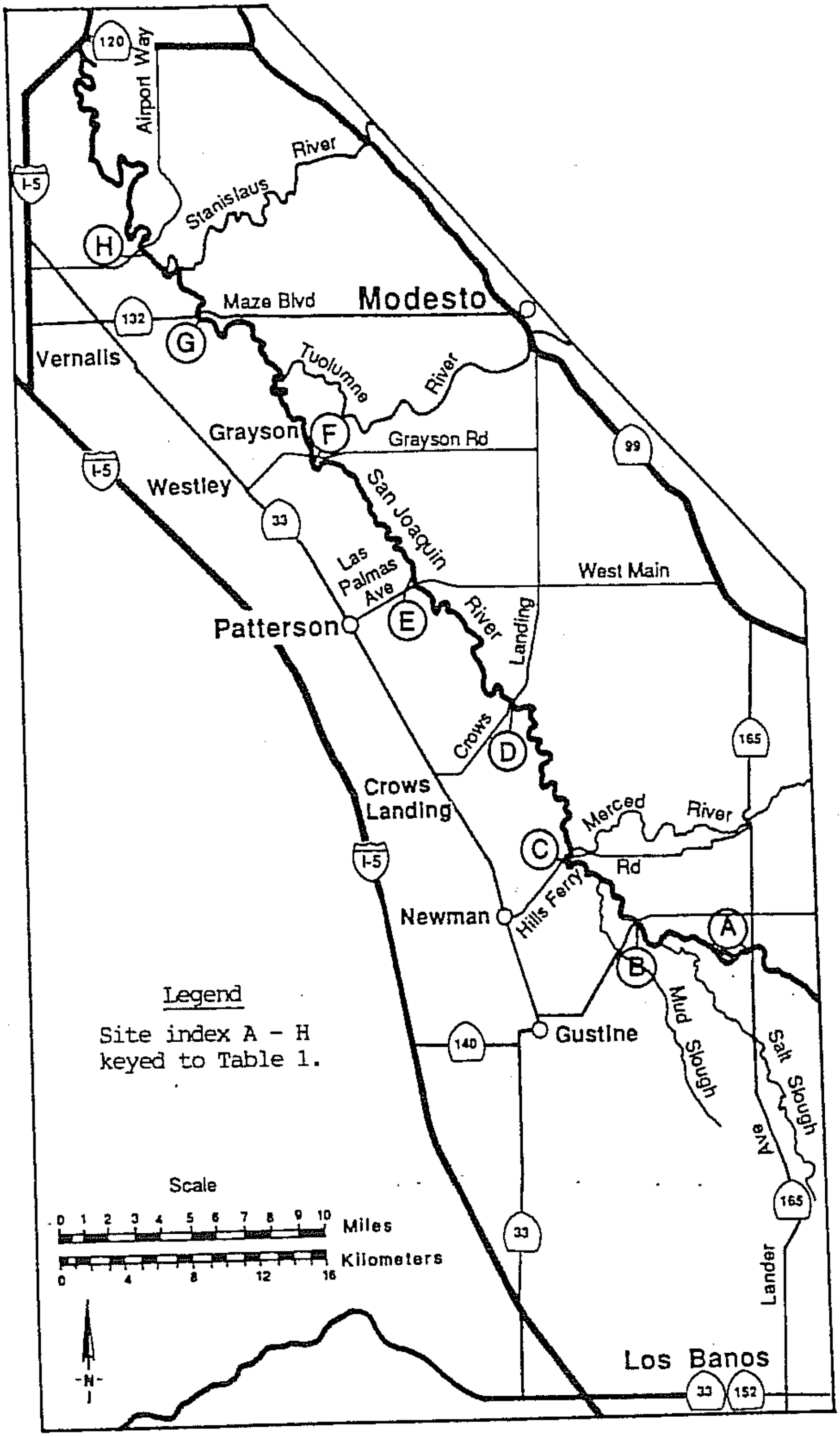

Fig. 2. Index Map

Table-1 Tributaries and Drains to the San Joaquin River Between Monitoring Station Lander Avenue and Airport Way

River Mile	*Description*	*Water Make-up*
132.9	**Lander Avenue (Site A)**	
129.7	Salt Slough	T,S
125.1	**Freemont Ford (Site B)**	
121.2	Mud Slough	T,S
119.6	Newman Wasteway	O,S
119.5	Newman Drainage District Collector Line A	T
119.1	Hills Ferry Road Drain	S
118.8	**Hills Ferry Road (Site C)**	
118.2	Merced River	N
117.5	Newman Drainage District Lateral Line 1	T
117.2	Azevedo Road Drain	S
113.4	Frietas Road Drain and South of Frietas Road Drain	S
112	Turlock Irrigation District Lateral 6	S,O
109	Orestimba Creek	N,S
107.2	**Crows Landing Road (Site D)**	
105	Spanish Grant, Marshell Road., Moran Rd. Drain	S,T
103.5	Turlock Irrigation District Lateral 5	S
100	Ramona Lake Main Drain	S,T
98.6	Patterson Water District Main Drain	S,T
98.4	**Las Palmas Launching Facility (Patterson) (Site E)**	
97.6	Olive Avenue Drain	S
97.3	Lemon Avenue Drain	S
97	Eucalyptus Avenue Drain	S
95.2	Turlock Irrigation District Lateral 3	S
92.9	Del Puerto Creek	N,S
91.4	Houk Ranch Drain	S,T
90.3	Turlock Irrigation Lateral 4	S
89.1	**Grayson Road (Site F)***	
87	Old San Joaquin River Channel	S
83.7	Tuolomne River	N
81.1	Merced Irrigation District Lateral 4	S
79.9	Hospital/Ingram Creeks	S,T
78.9	Center Road Drain	S
77.6	Blewett Drain	S,T
77.4	Blewett Drain	S
77.3	**Maze Boulevard (Site G)**	
74.9	Stanislaus River	N
73.6	**Airport Way (Site H)**	

LEGEND

S Surface Agriculture Drain
T Subsurface Agriculture Drain
N Natural Stream
O Operation Spillage
* Deleted from monitoring program after WY93

TEMPORAL VARIATIONS IN STREAMFLOW

A water year (WY) extends from 1 October of one year to 30 September of the following year. The Sacramento River Index, as described in the Third Edition, the Sacramento River Basin and the San Joaquin River Basin Plan (CRWQCB, 1995) is used to classify water year type in the Sacramento and San Joaquin River Basins. WY 85 was classified as a dry water year. Water Year 86 was a wet year and WYs 87-92 were classified as critical water years. Water Year 93 was the first above normal water year following the six consecutive critically dry years. Water Year 94 was classified as a critical water year. Water Year 95 was classified as a wet water year with San Joaquin River unimpaired runoff roughly 214% of average making it the third highest runoff year since the record began in 1906 (California Department of Water Resources, 1994). San Joaquin River unimpaired runoff for WY 1995 was superceded only by WYs 1986 and 1906.

During WY 95, 73% of the total precipitation (measured at Kesterson Reserve Station #92) fell from January to March. This wet season is not uncommon, but the total precipitation that fell during March was unusually high. Compared to the 1990-1995 historical record, March 1995 had the highest total precipitation. The total rainfall during March was 4.53 inches, with most of the month's precipitation occurring between the 9th and 11th (3.19 inches). This heavy precipitation during March caused flood flows to overtop the San Luis Drain (a concrete channel which formerly carried subsurface agricultural discharge to Kesterson Reservoir). Flood waters entering the drain were discharged into Mud Slough (north) and ultimately the San Joaquin River between 15 March and 29 March 1995.

During WY 95, releases from the Friant and McSwain dams were much higher than normal and Kings River water flowed north through the Fresno Slough for the first time since 1986 (Ed Dittenbir, Kings River Water Association, personal communication, 1996). A total of 6,637 acre-feet flowed from the Kings River through the sloughs to the Mendota Pool from 15 to 29 March 1995. The Mendota Pool is on the San Joaquin River upstream of Lander Avenue.

Friant Dam creates the Millerton Lake Reservoir, and controls San Joaquin River flows entering the study area. Friant Dam flood control releases began on 13 February and ended 5 August 1995. The peak flood release from Friant occurred on 13 March, with 15,997 acre-feet released to the San Joaquin River.

McSwain Dam is a coffer dam below the New Exchequer Dam, which creates Lake McClure Reservoir. Both dams control flows on the Merced River, which flows into the San Joaquin River downstream of the Hills Ferry sampling site. The peak release period for McSwain dam occurred from 25 to 31 March, with a total release of 7,932 acre-feet. The McSwain Dam was actually overtopped during the spring of 1995, and released water via the hydroelectric turbines and ungated spillway. This type of release is a rare occurrence, with the only similar release occurring during 1982-1983 (Tom Stevens, Bureau of Reclamation, personal communication, 1996).

Daily flow rates for the San Joaquin River at Patterson and Vernalis are listed in Figure 3. Peak flow rates occurred during January and from March-July. The impact of heavy precipitation, and flood control releases from various reservoirs is reflected in the increased flows in the San Joaquin River. Total flows for the San Joaquin River in March gauged at Vernalis and Patterson topped 50,000 acre-feet and 30,000 acre-feet, respectively.

Mud Slough (north) and Salt Slough are the main waterways that drain the Grasslands area on the west side of the San Joaquin River. Flows in both sloughs peaked during March, discharging about 46,000 acre-feet to the river. The two sloughs contributed a combined total of 263,769 acre-feet to the river, upstream of Hills Ferry during WY 95. Land use in the Grasslands area is primarily a combination of irrigated agriculture and wetland habitat.

Many of the creeks and sloughs draining the coastal range and flowing west into the San Joaquin River also overtopped their banks during peak run-off periods, further contributing water to the San Joaquin River.

METHODS

The Regional Board monitoring program for the San Joaquin River began in May 1985 and continued through WY 95. During WY 95, grab samples were collected on a weekly basis at seven sites. Water temperature, pH, electrical conductivity (EC), and sample time were recorded in the field. Laboratory analyses for total recoverable selenium, boron, and EC[1] were performed on all samples. On a monthly basis, samples from all sites were also analyzed for chloride, sulfate and hardness, while samples from Hills Ferry and Crows Landing were also analyzed monthly for total recoverable molybdenum, copper, chromium, lead, nickel and zinc. Hills Ferry was analyzed monthly for dissolved copper, chromium, lead, nickel and zinc and quarterly for carbonate, bicarbonate, total alkalinity, calcium, potassium, sodium, and total dissolved solids. The extended chemical analysis was done at Crows Landing and Hills Ferry to determine compliance with WQO downstream of agricultural drainage inflows from Mud Slough (north) and Salt Slough. Due to their potential adverse effects on waterfowl and agriculture, the major elements of concern in the monitoring program are selenium and boron.

Water samples were collected in polyethylene bottles. The selenium and trace element sample bottles were washed and rinsed with dilute nitric acid in the laboratory before use. All sample bottles, and their respective caps, were rinsed three times with the water to be sampled prior to sample collection.

Selenium, boron, and trace element samples were preserved to a pH less than two with reagent grade nitric acid within 24 hours of collection. Potential contamination from the acid was evaluated by submitting a ten-fold increase in the amount of acid used to control pH in a deionized water matrix and analyzing for the trace elements of concern. All reported recoveries were below the analytical detection limit. All samples were kept on ice after collection and until processing. Mineral samples were kept on ice until submittal to the laboratory for analysis.

A quality control and quality assurance program was conducted with blind split and spiked samples. Samples were randomly split at 10 percent of the sites with 50 percent of the splits spiked for the laboratory quality assurance program. The reported results fall within the quality assurance tolerance guidelines shown in Table 2.

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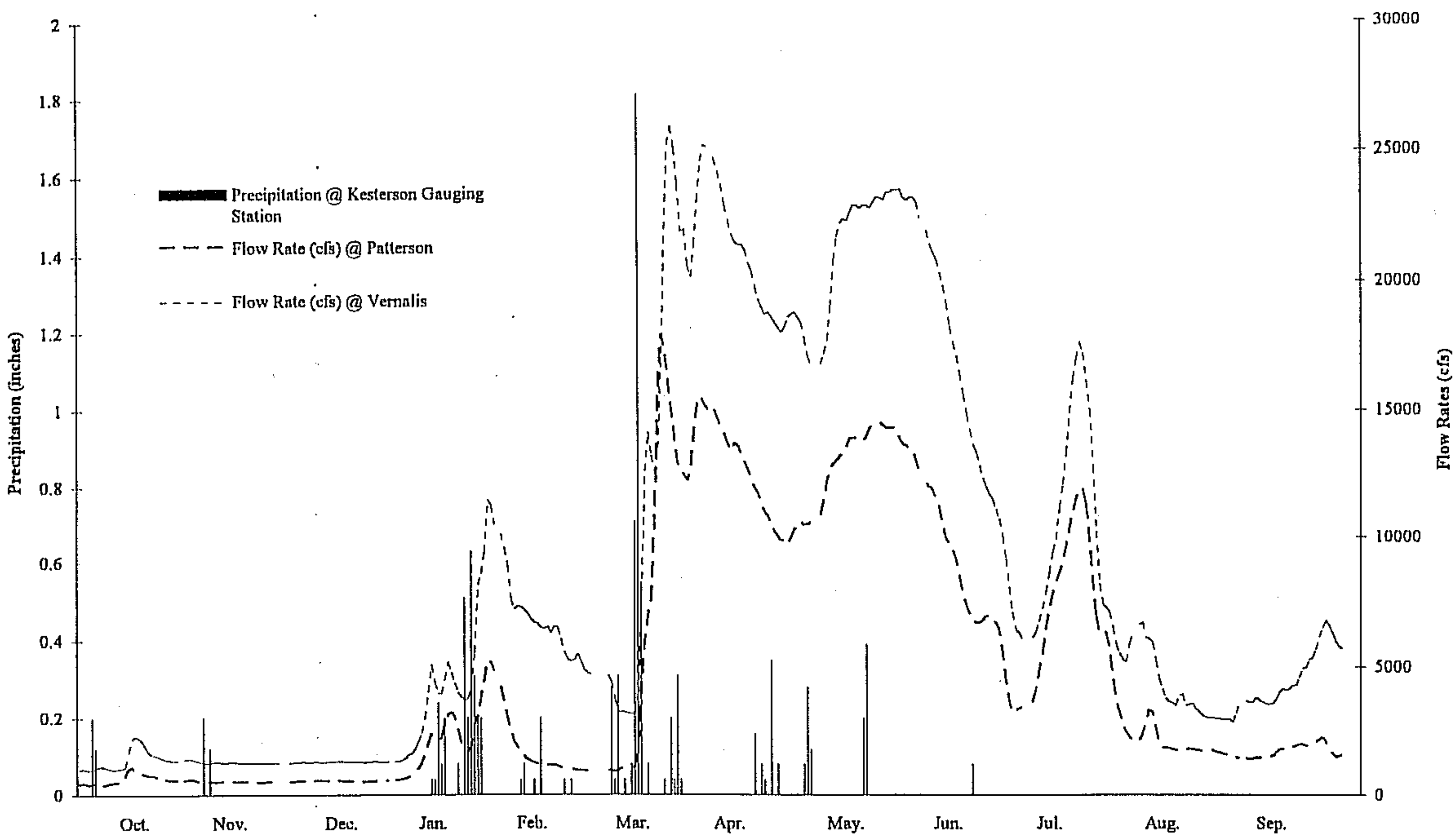
[1] Electrical conductivity values reported in the Appendix are laboratory EC values.

Figure-3
Precipitation vs. Flow Rates at Select Sites Along the San Joaquin River



All samples were collected as grab samples within six feet of the river bank. As such, these samples represent a snapshot concentration at a particular location and not a continuous measurement of overall river concentration. During WY 95, the Regional Board began using automated composite samplers at selected monitoring sites. This data will be available in future reports.

TABLE 2

Quality Assurance Tolerance Guidelines

Constituent	Recovery Range at Low Levels (μg/L)*	Acceptable Blind Split/ Spike Recovery Range
Copper	1-20 +/- 5	> 20 70-130%
Chromium	1-20 +/- 5	> 20 70-130%
Lead	5-25 +/- 8	> 25 60-140%
Molybdenum	1	90-110%
Nickel	5-25 +/- 6	>25 65-135%
Selenium	0.4	90-110%
Zinc	1-20 +/- 6	> 20 70-130%
Boron	50	85-115%
Chloride	5000	85-115%

* For certain constituents, recovery is expressed as an absolute value rather than a percentage at low levels. For example, if the result of copper analysis for a particular sample is 10 μg/L, a duplicate analysis must fall between 5 μg/L and 15 μg/L. If the sample is greater than 20 μg/L, recovery is expressed as a percent and must be between 70 and 130%. If a recovery range is not shown at low levels, the detection limit is given.

RESULTS

The following results are from WY 95 and are presented by site in the order of the site's location on the San Joaquin River (SJR). The first site is the furthest upstream (Lander Avenue) and the subsequent sites discussed are downstream from this site.

Tables 3 and 4 summarize annual median, maximum and minimum values for selenium, molybdenum, EC, and boron for WYs 85-95. All the data gathered during WY 95 for each site is included in Appendix A of this report.

Table 3 Ranges of Selenium and Molybdenum Concentration by Water Year (WY) for Monitoring Sites Along Along the Lower San Joaquin River. (Data taken from James, et al. 1988, Westcot, et al. 1989, 1990, 1991 and 1992, and Karkoski and Tucker, 1993)

WATER YEAR/TYPE		AIRPORT WAY	MAZE BLVD	GRAYSON ROAD	LAS PALMAS AVENUE	CROWS LANDING	HILLS FERRY	FREMONT FORD	LANDER AVENUE
WY 1985 DRY									
Se (μg/L)	Minimum	1	1	1	<1	1	1	<1	<1
	Median	1	2	2	3	3	4	4	<1
	Maximum	2	3	3	4	4	8	7	1
	# Samples	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(5)
WY 1986 WET									
Se (μg/L)	Minimum	0.6 (<1)	0.8 (<1)	0.9 (<1)	<1	<1	<1	<1	0.2 (<1)
	Median	1	1.5	2.2	2	2	4	1.7	0.3
	Maximum	4	2.4	4	5	4	8	9	5
	# Samples	(19)	(19)	(16)	(18)	(19)	(19)	(19)	(19)
Mo (μg/L)	Minimum	0.6 (<1)	<1	<1	<1	<1	2.6 (<5)	2.9 (<5)	<1
	Median		<5	<5	<5	<5	5.1	<5	<5
	Maximum	1.6 (<5)	8	13	12	14	14	17	5
	# Samples	(16)	(15)	(12)	(17)	(14)	(16)	(16)	(15)
WY 1987 CRITICAL									
Se (μg/L)	Minimum	0.9	1.4	3.4	3.4	3.6	6.6	4.3	0.4
	Median	2.3	3.3	4.6	4.8	5.6	11	10	0.7
	Maximum	3.2	5.8	9.3	10	12	21	26	1.8
	# Samples	(15)	(11)	(11)	(11)	(15)	(15)	(14)	(15)
Mo (μg/L)	Minimum	1 (<5)				4 (<5)	<5		4 (<5)
	Median	2 (<5)				4	7		7
	Maximum	2 (<5)				5	12		14
	# Samples	(11)				(10)	(11)		(10)
WY 1988 CRITICAL									
Se (μg/L)	Minimum	0.8	1.9	2.4	2.0	0.8	1.0	1.3	0.2
	Median	2.7	5.1	5.8	6.2	7.4	10	12	0.7
	Maximum	6.5	6.5	8.5	9.1	12	20	23	1.4
	# Samples	(41)	(13)	(12)	(14)	(42)	(41)	(40)	(38)
Mo (μg/L)	Minimum	2				3	4		3
	Median	3				5	6		15
	Maximum	4				7	11		22
	# Samples	(6)				(35)	(30)		(35)
WY 1989 CRITICAL									
Se (μg/L)	Minimum	1.4	3.2	3.5	3.0	3.4	2.8	3.4	0.3
	Median	2.9	4.4	5.8	6.0	6.9	9.8	12	0.5
	Maximum	6.8	8.0	12	14	17	23	32	1.3
	# Samples	(46)	(14)	(13)	(13)	(47)	(46)	(47)	(46)
Mo (μg/L)	Minimum	1				2	3		1
	Median	2				4	6		16
	Maximum	5				7	11		30
	# Samples	(44)				(46)	(46)		(47)
WY 1990 CRITICAL									
Se (μg/L)	Minimum	0.8	1.7	2.9	1.7	1.6	2.7	4.4	<0.2
	Median	2.4	4.0	5.0	4.6	7.2	11	14	0.4
	Maximum	9.6	9.8	10	10	13	26	33	1.7
	# Samples	(49)	(35)	(12)	(12)	(49)	(49)	(49)	(49)
Mo (μg/L)	Minimum	1	1			2	3	4	3
	Median	2	4			5	8	8	20
	Maximum	5	6			8	18	14	59
	# Samples	(46)	(20)			(48)	(48)	(26)	(48)

Table 3 continued:

WATER YEAR/TYPE			AIRPORT WAY	MAZE BLVD	GRAYSON ROAD	LAS PALMAS AVENUE	CROWS LANDING	HILLS FERRY	REMONT FORD	LANDER AVENUE
WY 1991 CRITICAL										
	Se (ug/L)	Minimum	0.5	0.8	1.0	0.6	0.7	1.0	0.9	0.2
		Median	1.9	2.7	4.3	4.9	6.1	9.5	13	0.4
		Maximum	4.8	5.6	7.3	8.3	11	24	30	0.8
		# Samples	(54)	(54)	(38)	(38)	(53)	(53)	(52)	(52)
	Mo (ug/L)	Minimum	1				0.6	1	1	0.3
		Median	2				6	12	12	22
		Maximum	4				9	19	35	74
		# Samples	(45)				(42)	(44)	(36)	(43)
WY 1992 CRITICAL										
	Se (ug/L)	Minimum	0.4	0.4	0.6	0.5	0.5	1.0	0.8	0.1
		Median	1.5	2.1	3.3	3.2	4.6	8.6	11	0.3
		Maximum	4.4	5.4	7.2	8.2	11	19	25	0.6
		# Samples	(57)	(57)	(53)	(54)	(57)	(58)	(58)	(48)
	Mo (ug/L)	Minimum	1				3	5	7	6
		Median	2				5	10	11	34
		Maximum	5				10	15	15	50
		# Samples	(9)				(17)	(10)	(9)	(17)
WY 1993 ABOVE NORMAL										
	Se (ug/L)	Minimum	0.20	0.50	0.30	0.20	0.20	0.60	0.60	0.10
		Median	1.9	2.3	1	3.5	3.8	11	13	0.50
		Maximum	6.1	4.9	1.3	6.7	8.5	23	29	1.3
		# Samples	(50)	(50)	(6)	(50)	(50)	(50)	(50)	(50)
	Mo (ug/L)	Minimum	1				2	2	6	2
		Median	2				3	10	10	11
		Maximum	3				8	18	14	55
		# Samples	(11)				(11)	(12)	(9)	(11)
WY 1994 CRITICAL										
	Se (ug/L)	Minimum	0.4	0.2		0.2	0.3	1.2	1.2	<0.2
		Median	2.6	3.6		5.1	6.1	13	19	0.5
		Maximum	6.3	7.0		14	13	28	35	1.8
		# Samples	(50)	(51)		(51)	(52)	(52)	(52)	(52)
	Mo (ug/L)	Minimum	1				1	2	2	1
		Median	2				5	9	8	10
		Maximum	3				15	19	13	17
		# Samples	(10)				(11)	(11)	(9)	(10)
WY 1995 WET										
	Se (ug/L)	Minimum	0.40	<.4		<.4	0.50	0.70	<.4	<.4
		Median	1.3	1.2		2.0	2.3	4.3	5.0	<.4
		Maximum	3.5	3.9		11	12	20	25	0.8
		# Samples	[48]	[44]		[47]	[51]	[48]	[47]	[16]
	Mo (ug/L)	Minimum	1				1	1	1	4
		Median	2				5	10	12	13
		Maximum	4				7	13	15	28
		# Samples	[5]				[4]	[5]	[3]	[4]

Table 4 Ranges of Electrical Conductivity and Boron Concentration by Water Year (WY) for Monitoring Sites Along the Lower San Joaquin River. (Data from James, et al. 1988, Westcot, et al. 1989, 1990, 1991, Karkoski, et al. 1992 and Chilcott et al. 1993 and 1994.)

WATER YEAR/TYPE		AIRPORT WAY	MAZE BLVD	GRAYSON ROAD	LAS PALMAS AVENUE	CROWS LANDING	HILLS FERRY	FREMONT FORD	LANDER AVENUE
WY 1985	DRY								
EC μmhos/c	Minimum	480	620	690	640	630	730	640	192
	Median	540	860	1000	1050	995	1325	1150	700
	Maximum	680	900	1050	1200	1200	2200	1900	1300
	# Samples	(6)	(6)	(5)	(6)	(6)	(6)	(6)	(5)
B (mg/L)	Minimum	0.20	0.25	0.38	0.26	0.27	0.45	0.33	<0.01
	Median	0.27	0.43	0.48	0.62	0.64	1.1	0.93	0.10
	Maximum	0.45	0.60	0.78	0.86	0.85	1.6	1.2	0.36
	# Samples	(6)	(6)	(5)	(6)	(6)	(6)	(6)	(5)
WY 1986	WET								
EC μmhos/c	Minimum	180	200	280	240	270	410	94	73
	Median	540	700	960	870	815	1100	905	400
	Maximum	980	1100	1700	1800	1700	2600	2300	930
	# Samples	(18)	(17)	(15)	(18)	(18)	(18)	(18)	(18)
B (mg/L)	Minimum	0.10	0.13	0.17	0.11	0.14	0.29	0.09	<0.01
	Median	0.22	0.39	0.57	0.56	0.59	0.91	0.65	0.10
	Maximum	0.7	0.70	1.2	1.7	1.2	2.2	1.8	0.61
	# Samples	(17)	(17)	(15)	(18)	(18)	(18)	(18)	(18)
WY 1987	CRITICAL								
EC μmhos/c	Minimum	340	490	1200	1200	1200	1600	1330	650
	Median	804	1100	1300	1360	1320	1720	1730	1200
	Maximum	930	1420	1890	1960	1990	2600	2880	1650
	# Samples	(13)	(9)	(9)	(9)	(13)	(10)	(12)	(13)
B (mg/L)	Minimum	0.18	0.30	0.59	0.70	0.67	0.53	0.81	0.10
	Median	0.43	0.64	0.88	0.95	0.94	1.6	1.6	0.21
	Maximum	0.62	1.1	1.6	1.8	1.9	3.0	3.2	0.35
	# Samples	(15)	(11)	(11)	(11)	(15)	(13)	(14)	(15)
WY 1988	CRITICAL								
EC μmhos/c	Minimum	650	1010	1300	750	1180	1380	1260	320
	Median	900	1400	1580	1600	1600	1990	1950	1550
	Maximum	1450	1600	1950	2150	2150	3100	2950	2100
	# Samples	(43)	(13)	(12)	(14)	(43)	(41)	(42)	(40)
B (mg/L)	Minimum	0.28	0.50	0.66	0.48	0.46	0.57	0.41	0.03
	Median	0.50	0.90	1.0	1.2	1.2	1.7	1.8	0.30
	Maximum	0.95	1.1	1.5	3	2	3.1	2.8	0.47
	# Samples	(43)	(13)	(12)	(14)	(43)	(41)	(42)	(40)
WY 1989	CRITICAL								
EC μmhos/c	Minimum	720	880	1160	1220	1000	1360	1300	380
	Median	980	1290	1480	1490	1520	1930	2010	1500
	Maximum	1510	1740	2100	2220	2210	3350	3300	1990
	# Samples	(46)	(14)	(13)	(13)	(47)	(46)	(47)	(47)
B (mg/L)	Minimum	0.37	0.60	0.64	0.76	0.68	0.69	0.67	0.06
	Median	0.54	0.80	0.9	1.0	1.2	1.7	1.8	0.32
	Maximum	1.0	1.2	1.6	1.8	1.9	3.0	3.3	0.54
	# Samples	(45)	(14)	(13)	(13)	(46)	(46)	(46)	(46)
WY 1990	CRITICAL								
EC μmhos/c	Minimum	600	930	1250	1060	1180	1120	1180	440
	Median	920	1340	1430	1530	1710	2490	2400	1500
	Maximum	1380	1640	1900	2160	2030	4120	3070	2940
	# Samples	(49)	(35)	(12)	(12)	(49)	(46)	(49)	(48)
B (mg/L)	Minimum	0.31	0.55	0.66	0.67	0.67	0.88	0.82	0.09
	Median	0.50	0.79	0.91	1.1	1.2	2.1	2.0	0.33
	Maximum	1.1	1.2	1.2	1.5	1.7	3.2	3.3	0.69
	# Samples	(49)	(35)	(12)	(12)	(49)	(48)	(49)	(49)

Table 4 (continued):

WATER YEAR/TYPE		AIRPORT WAY	MAZE OULEVAR	GRAYSON ROAD	LAS PALMAS AVENUE	CROWS LANDING	HILLS FERRY	REMONT FORD	LANDER AVENUE
WY 1991 CRITICAL									
EC mhos/c	Minimum	410	530	600	560	560	750	600	150
	Median	990	1280	1670	1740	1720	2620	2620	2240
	Maximum	1680	1750	2310	2450	2490	4360	4290	3420
	# Samples	(54)	(54)	(38)	(38)	(53)	(53)	(52)	(52)
B (mg/L)	Minimum	0.20	0.28	0.31	0.28	0.30	0.46	0.37	0.08
	Median	0.46	0.64	0.92	1.0	1.1	1.9	2.0	0.43
	Maximum	1.2	1.3	1.7	1.9	2.1	3.4	4.4	0.75
	# Samples	(54)	(54)	(38)	(38)	(53)	(53)	(52)	(52)
WY 1992 CRITICAL									
EC mhos/c	Minimum	389	410	895	880	670	880	820	100
	Median	925	1260	1530	1570	1570	2630	2670	2200
	Maximum	1450	1540	1950	2060	2180	3620	3800	3990
	# Samples	(58)	(58)	(53)	(54)	(58)	(58)	(58)	(53)
B (mg/L)	Minimum	0.16	0.20	0.25	0.24	0.23	0.34	0.28	0.038
	Median	0.44	0.61	0.74	0.86	1.0	1.9	1.9	0.46
	Maximum	0.93	1.1	1.4	1.5	1.8	3.2	4.9	0.98
	# Samples	(58)	(58)	(53)	(53)	(57)	(56)	(57)	(52)
WY 1993 ABOVE NORMAL									
EC mhos/c	Minimum	360	380	690	410	330	430	210	130
	Median	708	881	1400	1090	980	2250	2120	1230
	Maximum	1420	1620	1580	2000	1940	3650	3710	4060
	# Samples	(50)	(50)	(6)	(50)	(50)	(50)	(50)	(50)
B (mg/L)	Minimum	0.01	0.17	0.23	0.21	0.17	0.27	0.1	0.04
	Median	0.38	0.48	0.50	0.67	0.66	1.8	1.7	0.28
	Maximum	0.83	0.92	1.3	1.3	2.1	3.0	3.5	1.1
	# Samples	(50)	(50)	(6)	(50)	(50)	(50)	(50)	(50)
WY 1994 CRITICAL									
EC mhos/c	Minimum	217	211		249	209	1030	1110	204
	Median	845	1040		1450	1440	2280	2430	1190
	Maximum	1270	1510		2030	2040	3670	3590	1950
	# Samples	(50)	(51)		(51)	(52)	(52)	(52)	(51)
B (mg/L)	Minimum	0.07	0.08		0.11	0.11	0.61	0.67	<0.05
	Median	0.49	0.64		0.97	1.1	1.9	2.1	0.29
	Maximum	0.95	1.0		1.8	1.9	5.0	4.0	0.65
	# Samples	(49)	(51)		(51)	(52)	(52)	(52)	"(52)
WY 1995 WET									
EC mhos/c	Minimum	123	125		146	143	258	64	46
	Median	429	447		696	716	1180	1190	238
	Maximum	1020	1220		2120	2060	3050	3030	2450
	# Samples	[46]	[43]		[45]	[48]	[49]	[45]	[45]
B (mg/L)	Minimum	0.06	<.05		0.08	0.05	0.17	<.05	<.05
	Median	0.25	0.28		0.43	0.40	0.88	0.87	0.08
	Maximum	0.56	0.67		1.8	1.7	2.8	3.0	0.6
	# Samples	[48]	[45]		[46]	[50]	[48]	[46]	[16]

Water Year 1995

The sampling site furthest upstream on the San Joaquin River is at Lander Avenue. During WY 95, the water at this site contained low concentrations of selenium (annual median concentration less than 0.4 µg/L) and boron (annual median concentration equal to 0.08 mg/L). The annual median electrical conductivity (EC) at this site was 238 µmhos/cm. In contrast to the relatively low concentrations of boron and selenium, this site had the highest concentration of molybdenum at 28 µg/L. Because the molybdenum concentration found in the upper San Joaquin River is primarily a function of groundwater seepage and not agricultural drainage, monthly molybdenum monitoring was discontinued and is now conducted quarterly. All other San Joaquin River sites downstream of Lander Avenue consistently remained below 20 µg/L molybdenum.

The next downstream site sampled on the San Joaquin River was at Fremont Ford, which is downstream of the confluence with Salt Slough. Salt Slough carries a combination of agricultural surface and subsurface drainage, storm water runoff from surrounding lands and the city of Los Banos, and seasonal releases from duck clubs. With the exception of pH and molybdenum, constituent concentrations at the Fremont Ford site were elevated over the concentrations reported upstream at Lander Avenue during WY 95. In particular, median EC, boron and selenium values were reported at 1190 µmhos/cm, .87 mg/L and 5.0 µg/L, respectively. The highest recorded concentration of boron (3.0 mg/L) and selenium (25 µg/L) found in the river during WY 95 was at Fremont Ford.

The Hills Ferry Road site is the next downstream sampling site on the San Joaquin River, and is just downstream of the confluence with Mud Slough (north) but upstream of the Merced River inflow. Mud Slough (north), as with Salt Slough, can carry agricultural return flows, storm water, and wetland releases. Drainage flows can readily be switched between the two sloughs through a series of diversion structures so that either slough is able to carry runoff from the other's watershed. Although the majority of agricultural drainage flowed through Salt Slough during WY 95, flood flow was discharged into Mud Slough (north) from the San Luis Drain between 15 and 29 March 1995 (Steensen et al., 1996).

During WY 95, the Hills Ferry Road site had the highest median concentration for copper, boron, chlorine, sulfate and hardness. This same site had the highest recorded EC (3,050 µmhos/cm) for the river.

Crows Landing is the first site monitored downstream of the Merced River inflow. The effect of the inflow from the east side tributary on water quality can be seen by the sharp decline in median constituent concentrations at this site. Electrical conductivity reached a maximum of 2,060 µmhos/cm in late February, with a median EC of 716 µmhos/cm for WY 95.

Downstream of the Crows Landing Bridge site, the San Joaquin River receives inflow from two additional eastside tributaries: the Tuolumne and Stanislaus Rivers. Salt, boron and selenium concentrations are very low in these tributaries and improve the water quality in the San Joaquin River accordingly.

Annual median selenium concentrations moving downstream from Patterson to Maze, and finally to Vernalis were 2.0, 1.2, and 1.3 µg/L, respectively. Annual median EC for the same sites were 696, 447, and 429 µmhos/cm, respectively.

DISCUSSION

Boron and Selenium

Figures 4 and 5 compare annual median boron and selenium concentrations respectively, for the Hills Ferry Road and Crows Landing Bridge sites from WY 85 through WY 95. Concentrations for both elements are higher at the Hills Ferry Road site as compared to the Crows Landing Bridge site. The San Joaquin River at the Hills Ferry Road monitoring site is dominated by flows from Mud Slough (north) and Salt Slough and reflects the quality of water flowing through those channels. Between Hills Ferry Road and the Crows Landing Bridge, the river receives inflows from a number of drains and operational spills as well as the Merced River (refer to Table 1). Although these inflows contain agricultural discharges, the overall boron and selenium concentrations when combined with Merced River inflows are lower than those from Mud Slough (north) and Salt Slough as is reflected in the decreasing river concentrations.

Median annual boron concentrations remained relatively constant at the Hills Ferry Road monitoring site between WY 90 and WY 94, with values near 2 mg/L. Little influence from the above normal rainfall in WY 93 is apparent. Considerable leaching of the soil took place in 1993 and early 1994 as the result of more water becoming available for irrigation, heavy precipitation during the winter of 1993 and increased irrigated crop acreage. Record precipitation and increased dilution water may explain the dramatic decrease in boron concentrations which occurred in WY 95. Median boron concentrations at the Crows Landing Bridge site remained near 1.0 mg/L between WYs 87 and 92 but responded to increased inflow from the Merced River during WYs 93 and 95, recording a low annual median concentration of 0.40 mg/L in WY 95.

Median annual selenium concentrations have fluctuated at both the Hills Ferry Road and Crows Landing Bridge sites since WY 86 (Figure 5). During WY 95, median selenium concentrations sharply decreased at the Hills Ferry Road site. A similar decrease at the Crows Landing Bridge is also recorded. These decreases may reflect the record precipitation that fell during WY 95 and increased dilution flows. The annual median selenium concentration at the Hills Ferry Road site of 4.3 µg/L is the lowest recorded since monitoring began in WY 85. The WY 95 median concentration at the Crows Landing Bridge site (2.3 µg/L) is the lowest median concentration since WY 86 (2.0 µg/L).

Loads of Pollutants in the San Joaquin River

Karkoski and Tucker (1993) showed that significant selenium and boron load reductions to the San Joaquin River from the Grassland Area occurred between WY 87 and WY 92. These load reductions were credited with the less severe and less frequent exceedance of water quality objectives in the San Joaquin River. The most significant reductions occurred during the six consecutive critically dry years, WY 87 through WY 92. The reduction in loads can be attributed to better water and land management practices implemented by farmers in the Grasslands watershed area and reduced water supplies during the six critical water years.

Figure 4 Annual Median Boron Values for Crows Landing Bridge and Hills Ferry Road Monitoring Sites: WYs 85-95

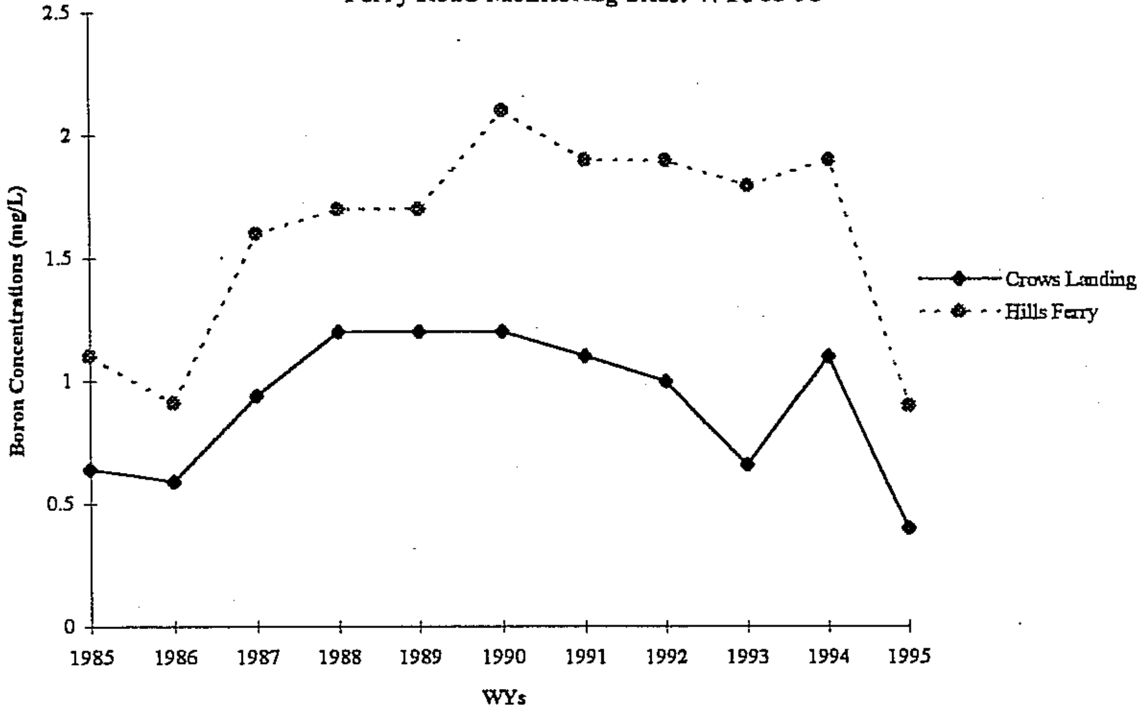
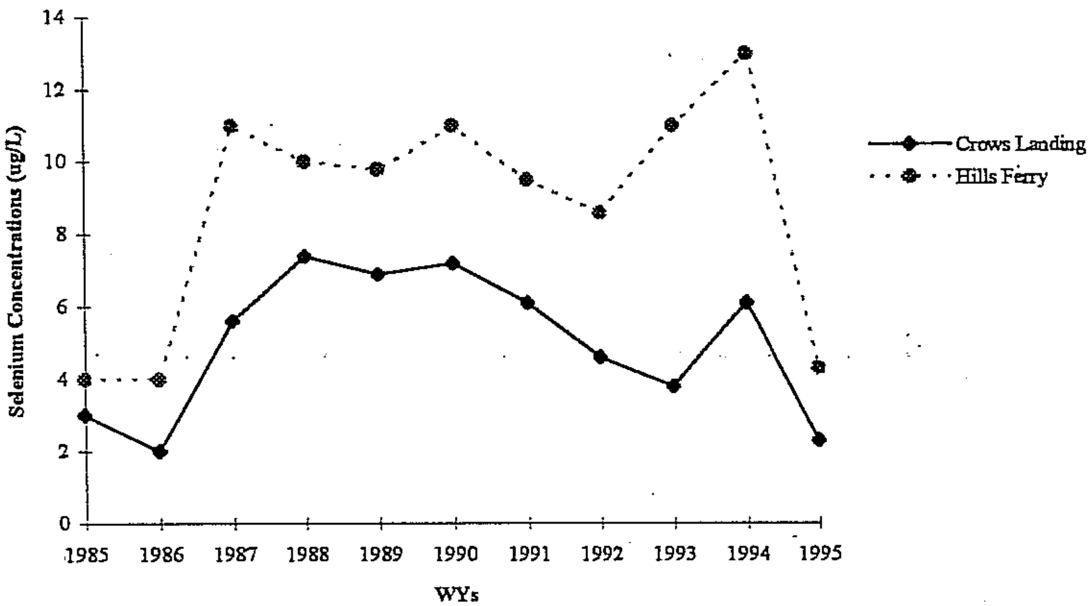


Figure 5 Annual Median Selenium Values for Crows Landing Bridge and Hills Ferry Road Monitoring Sites: WYs 85-95



During WY 95, loads to the San Joaquin River increased dramatically over previous years. After five years of decreases in salt, boron, and selenium loads (WYs 88 through 92), loads began to increase in WY 93, corresponding to the first above normal runoff year following six consecutive drought years. A slight decrease in loads occurred in WY 94, a critically dry water year. The sharp increase in loads entering the San Joaquin River during WY 95, mark the highest loads recorded since monitoring began in 1986. Figures 6, 7 and 8 compare the annual loads for salt (in terms of TDS), selenium, and boron, respectively, with their average flow weighted concentrations. The annual loads presented are the sum of each WY's 12 calculated monthly loads while the flow weighted average annual concentration was computed by dividing the total annual load by the total annual discharge. Methodology for calculating the loads is discussed in Grober, et al. (1996 draft).

Water year 95 was the first wet water year since 1986, and third highest runoff year since 1906 (superceded by WY 86). The load increases observed in WY 95, are likely due to extremely high flows flushing accumulated salts from irrigated lands. Figure 9 depicts the monthly selenium loads and monthly San Joaquin River flows recorded at Patterson for WY 95. Approximately 45% of the total annual load occurred from February to April, a time period that corresponds to 50% of the total annual runoff for WY 95. The selenium loads peaked in March at 3,115 lbs, although the highest total river flow occurred in May (800,000+ acre-feet). The March peak selenium load at Patterson coincided with an elevated monthly mean selenium concentration of 7.0 μg/L (Table 6).

Although, annual loads increased, annual mean selenium, boron, and salt flow weighted concentrations substantially decreased during WY 95. While the effect of water conservation has been to increase average annual concentrations in agricultural return flows, concentrations in the river are influenced by the amount of dilution provided by the Merced River along with discharges from the sloughs. Years of high loads can be mitigated by high Merced River flows, as previously recorded in WYs 86 and 93. The mitigating effect of Merced River flows is less pronounced in critically dry years with higher loads generally corresponding to higher constituent concentrations.

Comparisons can be made to WY 86, the only other WY that was classified as wet. Crows Landing (which is the first sampling site downstream of the Merced River inflow) data shows that the annual median selenium concentration of 2.3 μg/L in WY 95, is similar to selenium data seen in WY 86 (2.0 μg/L). During the critical water years (WYs 85, 87-92, and 94), the median selenium concentrations were consistently at least double the median values for WYs 86 and 95.

Comparison to Water Quality Objectives

Monthly mean and maximum boron water quality objectives (WQOs) on the San Joaquin River (Table 5) from Sack Dam to the mouth of the Merced River are 2.0 mg/L and 5.8 mg/L, respectively (15 March-15 September). Monthly mean WQOs for boron from the mouth of the Merced River to Vernalis are .8 mg/L (15 March-15 September) and 1.0 mg/L (16 September-14 March). Maximum boron WQOs are 2.0 mg/L (15 March-15 September) and 2.6 mg/L (16 September-14 March).

Figure-6
Salt Concentrations and Loads at the Patterson Site: WYs 86-95

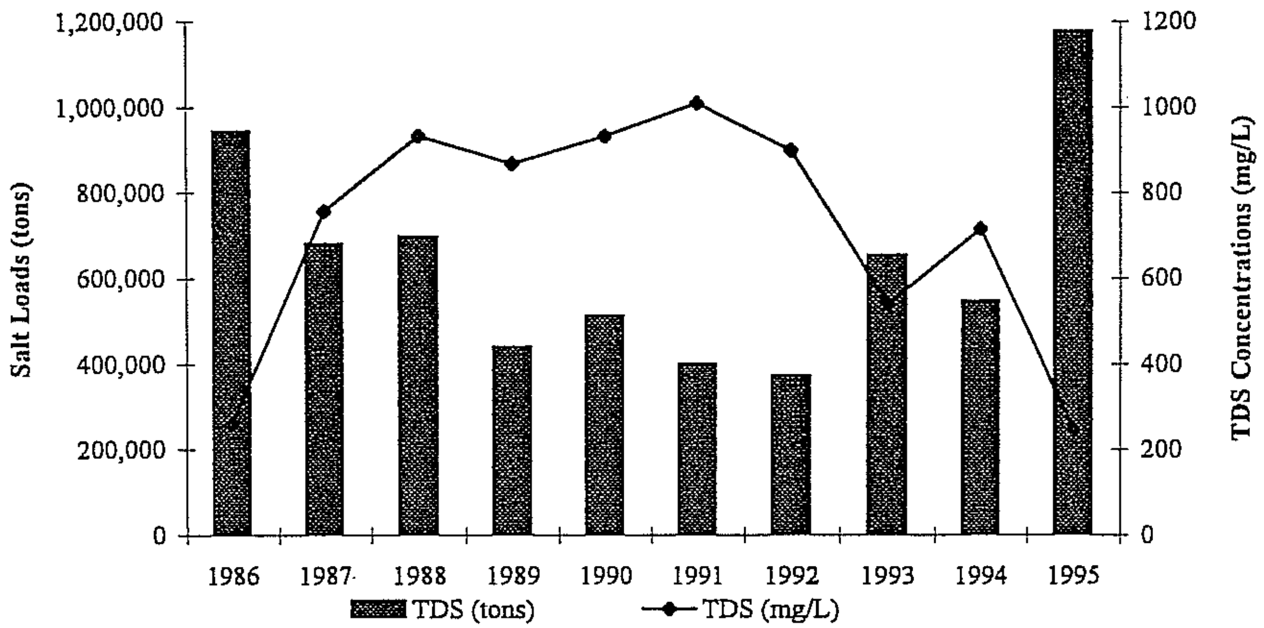
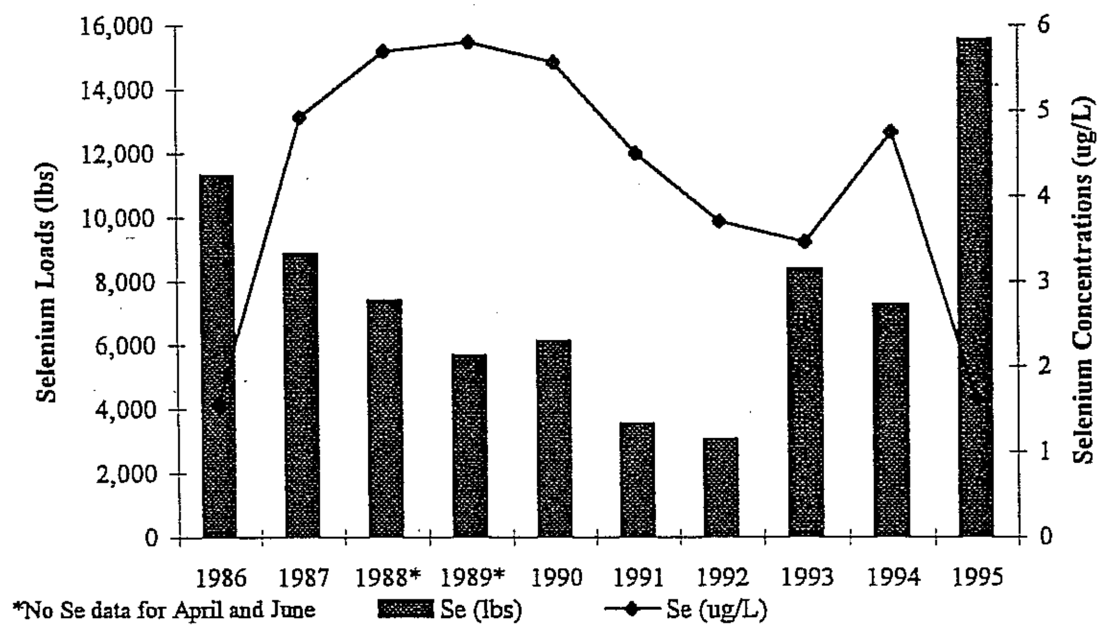


Figure-7
Selenium Concentrations and Loads at the Patterson Site: WYs 86-95



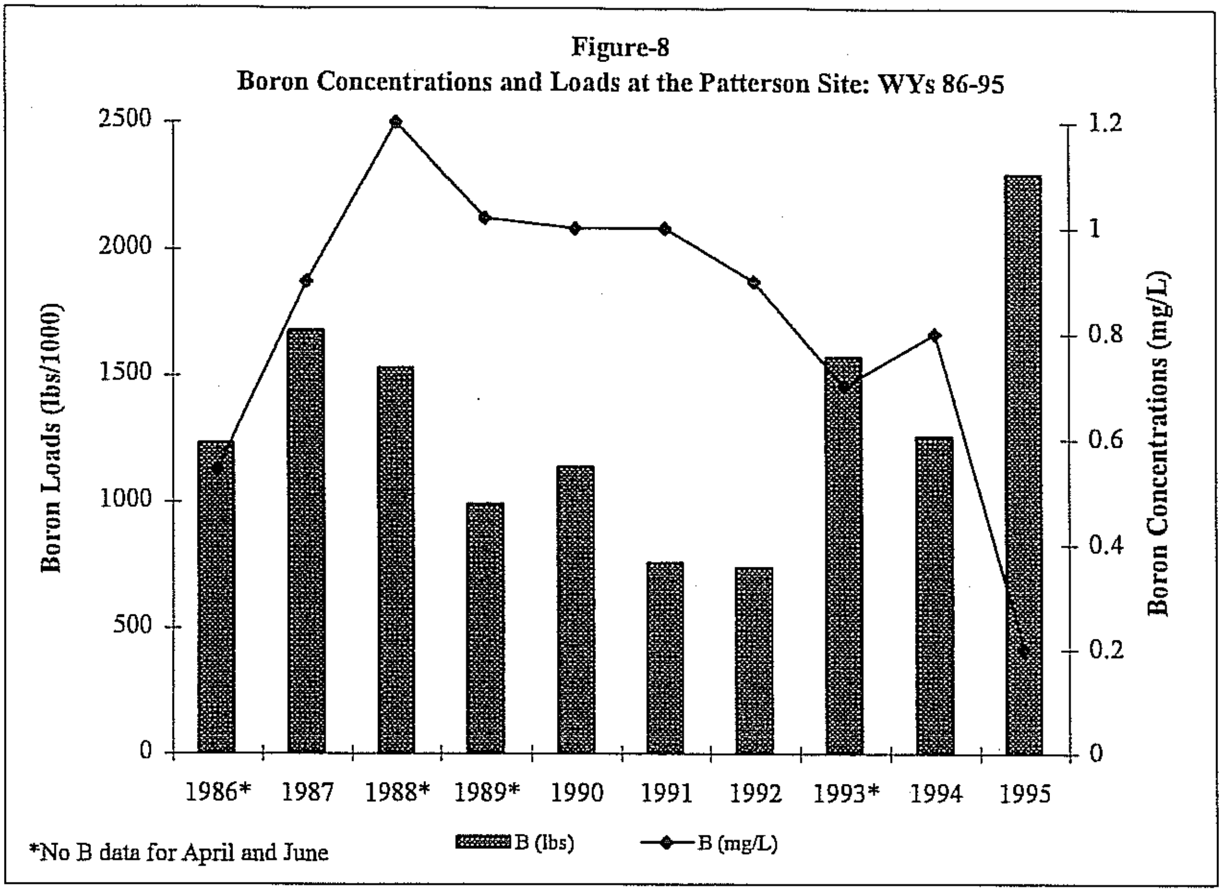


Figure-8
Boron Concentrations and Loads at the Patterson Site: WYs 86-95
Boron Loads (lbs/1000)
Boron Concentrations (mg/L)
2500
2000
1500
1000
500
0
1.2
1
0.8
0.6
0.4
0.2
0
1986*
1987
1988*
1989*
1990
1991
1992
1993*
1994
1995
*No B data for April and June
B (lbs)
B (mg/L)

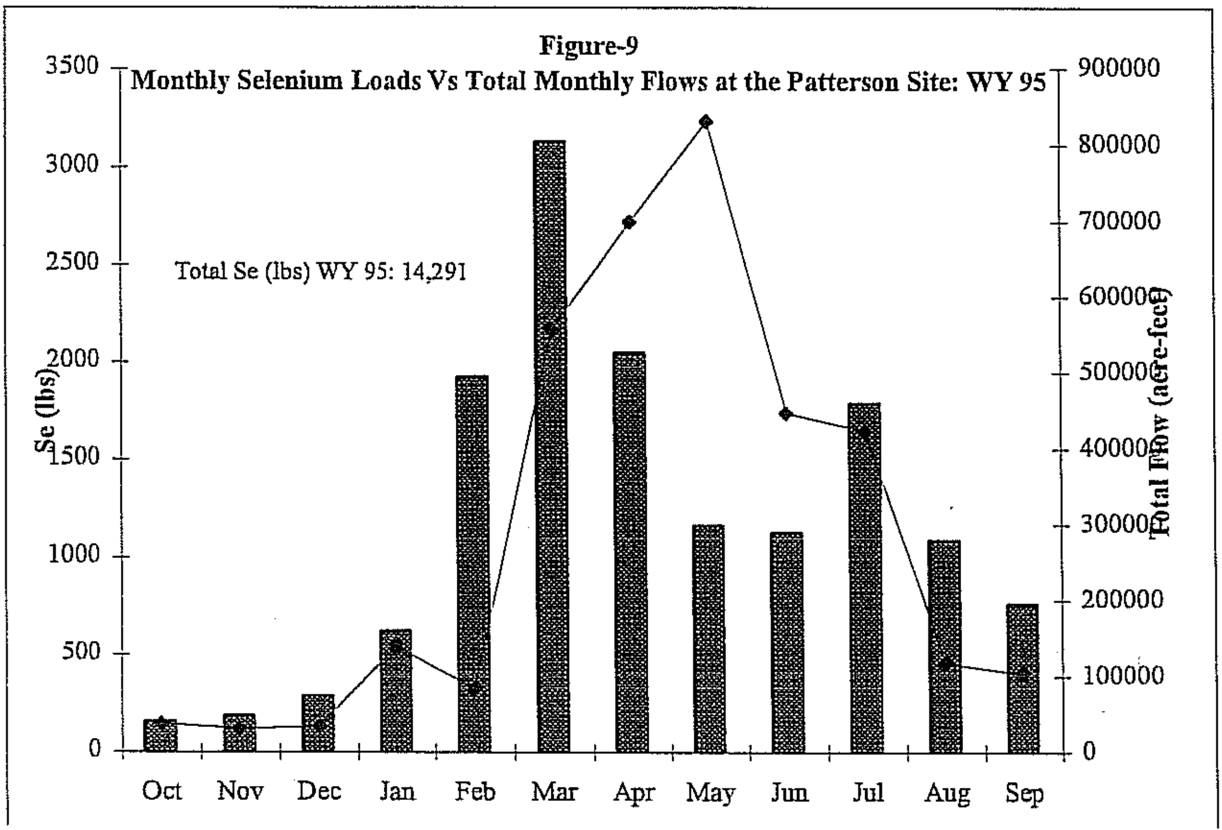


Figure-9
Monthly Selenium Loads Vs Total Monthly Flows at the Patterson Site: WY 95
Total Se (lbs) WY 95: 14,291
Se (lbs)
Total Flow (acre-feet)
3500
3000
2500
2000
1500
1000
500
0
900000
800000
700000
600000
500000
400000
300000
200000
100000
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep

In 1988, the Central Valley RWQCB adopted selenium WQOs for the lower San Joaquin River from the Sack Dam to Vernalis (Resolution #88-195). These WQO were approved by the SWRCB through Resolution #89-88 in 1989. In December 1992, the USEPA promulgated a 5μg/L 4-day average and 20 μg/L maximum selenium criteria for the San Joaquin River. This promulgation effectively superseded all but the 12μg/L maximum selenium objective adopted by the RWQCB for the San Joaquin River from the mouth of the Merced River to Vernalis. These promulgated objectives can be used to regulate point source discharges through NPDES permits, but only provide guidance for the regulation of non-point source discharges, including agricultural.

A summary of monthly mean selenium and boron concentrations measured at various points along the San Joaquin River in WY 95 are shown in Tables 6 and 7, respectively. Data below the detection limits were assumed to be at one quarter of the detection level for the purpose of calculating monthly means. Monthly mean boron and selenium concentrations at the Hills Ferry Road site for WY 95 are depicted in Figures 10 and 11. Monthly mean selenium concentrations at the Hills Ferry Road site closely resemble trends seen for the monthly mean boron concentrations. The mean concentrations varied throughout the WY, with peak boron and selenium concentrations occurring in February 1995, with concentrations of 2.3 mg/L and 12μg/L, respectively. This sharp increase from January is most likely due to heavier than usual precipitation and pre-irrigation in the agricultural areas that contribute drainage water to the San Joaquin River. January precipitation (2.72 inches) was the first large pulse of rainfall during WY 95. This pulse likely combined with pre-irrigation to flush out Mud Slough (north), Salt Slough, surrounding agricultural lands, and various tributaries to the San Joaquin River. The peak February monthly mean selenium concentration may be attributed to this runoff. Continued rainfall through February, and heavy precipitation during March (4.53 inches) contributed to record amounts of run-off during WY 95. As a result, there was an increase in the quantity of dilution water that flowed to the San Joaquin River, causing the monthly mean selenium concentration to sharply decline in April.

The monthly mean boron WQO (2.0 mg/L from 15 March to 15 September) was not exceeded at Hills Ferry during WY 95. The Basin Plan monthly mean selenium WQO (10 μg/L) was exceeded during February and March at the Hills Ferry site. Mean selenium concentrations peaked at 12 μg/L in February and dropped to 11 μg/L in March.

As specified in the San Joaquin River Basin Plan (December 1988), compliance monitoring for selenium and boron WQO occurs on the San Joaquin River at the Crows Landing Bridge site. The Crows Landing Bridge site is downstream of the Merced River inflow and also receives water from agricultural return flows and ground water seepage. As shown in Table 5, the boron and selenium WQOs adopted for the river at the Crows Landing Bridge site depends on the water year type. Slightly relaxed boron objectives are implemented during critical water years reflecting the lack of good quality dilution flows from excess tailwater and/or flows from the eastside tributaries.

TABLE 5

Water Quality Objectives (WQO) as Adopted in 1988 by the Central Valley Regional Board for the San Joaquin Basin (5C) and in Effect During WY95.*

Constituent	Water Quality Objectives (WQO)		Compliance Date
San Joaquin River, mouth of the Merced River to Vernalis (Delta Inflow)			
Selenium	5 μg/l monthly mean	12 μg/l max.	Oct. 1, 1991
	8 μg/l monthly mean (critical year only)		Oct. 1, 1991
Molybdenum	10 μg/l monthly mean	15 μg/l max.	Jan. 1, 1990
Boron	0.8 mg/l monthly mean (15 March-15 Sept)	2.0 mg/l max.	Oct. 1, 1991
	1.0 mg/l monthly mean (16 Sept-14 March)	2.6 mg/l max.	Oct. 1, 1991
	1.3 mg/l monthly mean (critical year only)		Oct. 1, 1991
Salt Slough, Mud Slough (north), San Joaquin River, Sack Dam to mouth of the Merced River			
Selenium	10 μg/l monthly mean	26 μg/l max.	Oct. 1, 1993
Molybdenum	19 μg/l monthly mean	50 μg/l max.	Jan. 1, 1990
Boron	2.0 mg/l monthly mean (15 March-15 Sept)	5.8 mg/l max.	Oct. 1, 1993

* Selenium 5 μg/L (four-day average) WQO amendment pending for WY96.

Table-6 Summary of WY 95 Monthly Mean Selenium Concentrations (µg/L).

	LOCATION: San Joaquin River at:						
Month	Lander Ave	Freemont Ford	Hills Ferry Rd	Crows Landing	Las Palmas Ave	Maze Blvd	Airport Way
Oct-94	<.4	6.4	4.7	2.2	1.5	1.3	.9
Nov-94	<.4	8.9	6.5	2.9	2.2	1.8	1.5
Dec-94	.7	**12**	6.9	3.6	3.2	2.5	2.2
Jan-95	.4	**3.6**	2.7	2	1.9	1.1	1.3
Feb-95	.5	**21**	**12**	8.0	8.9	2.1	2.2
Mar-95	.8	**12**	**11**	5.4	5.7	2.9	2.2
Apr-95	<.4	.8	2.1	1.0	1.1	.7	.8
May-95	<.4	<.4	1.7	.6	.5	.6	.5
Jun-95	.4	3.9	3.1	1.3	1.1	.7	.9
Jul-95	<.4	3.1	1.7	1.6	1.9	1	1.1
Aug-95	<.4	8.1	6.8	3.7	3.6	1.9	1.7
Sep-95	<.4	6.4	6.3	3.4	2.8	1.5	1.3
WQO*	10µg/L			12µg/L			

Bold numbers indicate exceedance of the 1988 adopted monthly mean water quality objectives.

Table-7 Summary of WY 95 Monthly Mean Boron Concentrations (mg/L).

	LOCATION: San Joaquin River at:						
Month	Lander Ave	Freemont Ford	Hills Ferry Rd	Crows Landing	Las Palmas Ave	Maze Blvd	Airport Way
Oct-94	.50	1.2	1.1	.44	.32	.34	.28
Nov-94	.16	1.7	1.5	.71	.61	.51	.43
Dec-94	.32	2.2	1.8	.88	.83	.61	.51
Jan-95	**	.71	.79	.49	.49	.30	.31
Feb-95	.10	2.6	2.3	**1.3**	**1.5**	.30	.28
Mar-95	.06	1.3	1.4	.64	.80	.41	.20
Apr-95	<.02	.04	.38	.16	.15	.10	.09
May-95	<.05	<.02	.26	.08	.09	.05	.06
Jun-95	.10	.51	.49	.19	.20	.13	.14
Jul-95	<.05	.47	.22	.17	.21	.14	.15
Aug-95	<.05	.97	1	.54	.56	.28	.26
Sep-95	<.05	.71	.75	.35	.64	.17	.16
WQO*	2.0mg/L (15 Mar-15 Sept)			8mg/L (15 Mar-15 Sept), 1.0mg/L (16 Sept- 14 Mar)			

*Water quality objectives for above normal runoff year

** No analysis done

Bold numbers indicate exceedance of the 1988 adopted monthly mean water quality objectives.

Figure-10
Monthly Mean Boron Concentrations in the San Joaquin River at the Hills Ferry Site: WY 95

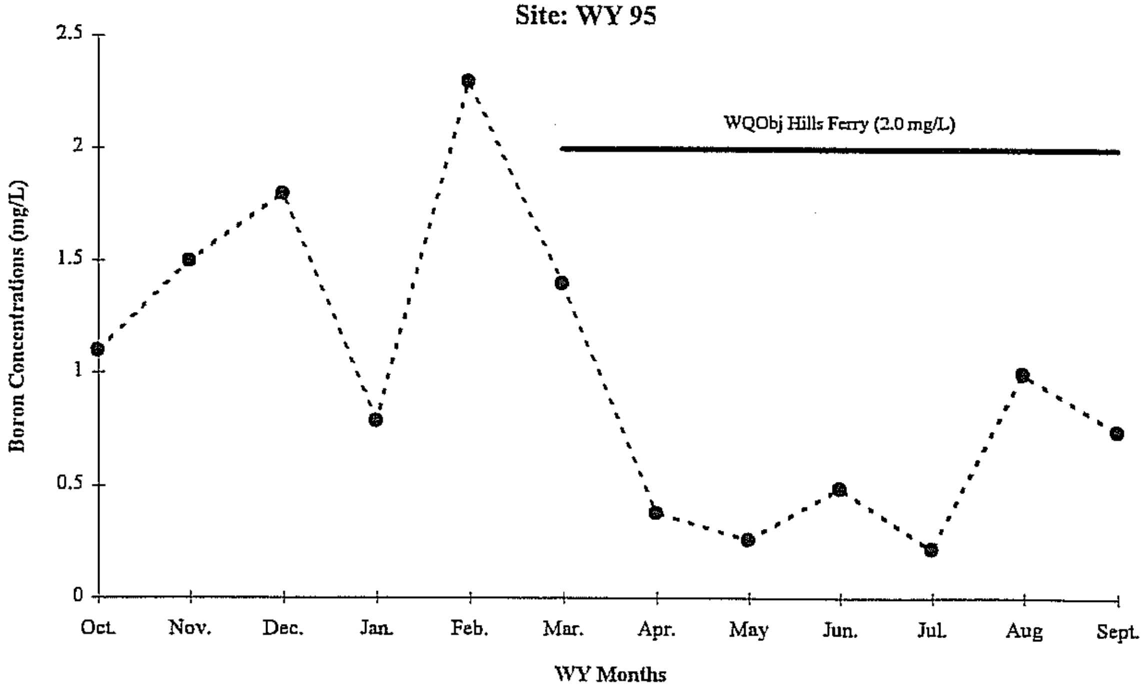
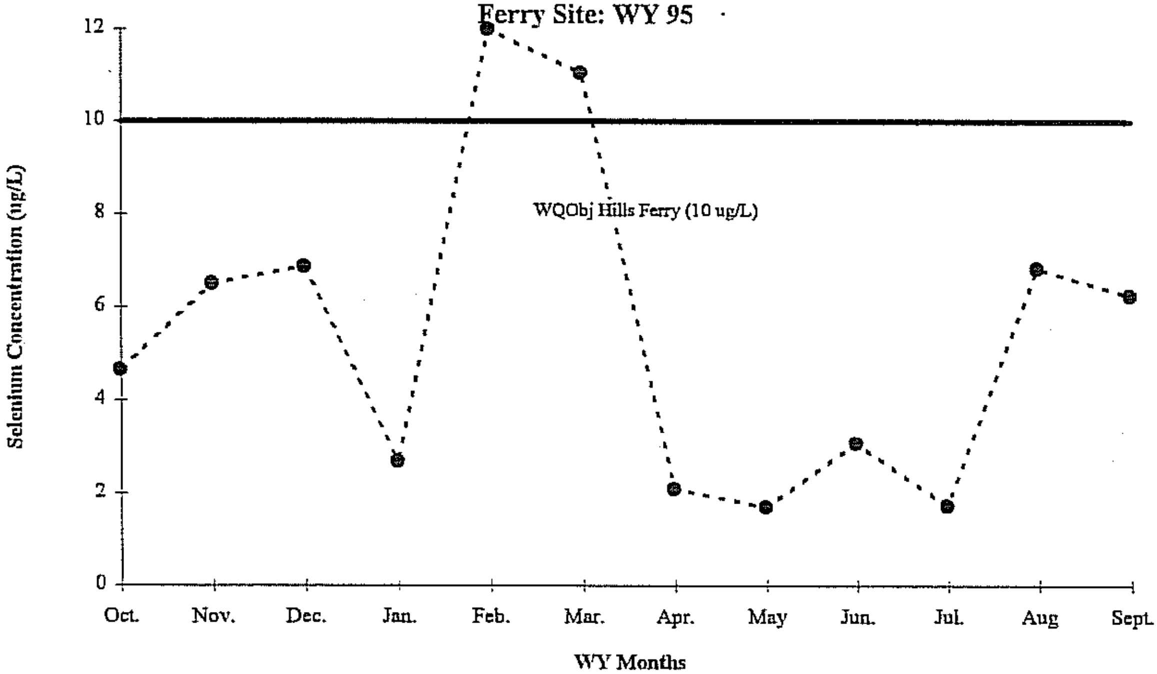


Figure-11
Monthly Mean Selenium Concentrations in the San Joaquin River at the Hills Ferry Site: WY 95



There were six years of drought between WYs 86 and 95, with WY 93 being the first above normal WY. This was followed by the critically dry WY 94 and then the third highest runoff year since 1906 (WY 95). Figure 12 shows the monthly mean boron concentrations at Crows Landing during WY 95. During WY 95, the boron WQO was exceeded in February (1.3 mg/L) at the Crows Landing Bridge site. Pre-irrigation during the late fall and early winter, coupled with a pulse of rainfall during the end of January may account for the increased concentrations during February 1995.

Figure 13 shows the average monthly mean selenium concentration at the Crows Landing Bridge site during WY 95. Seasonal patterns of selenium concentrations are evident, with peak concentrations occurring in February and again in August. The February selenium peak concentration is likely the result of pre-irrigation and heavy rainfall at the end of January 1995.

The monthly mean selenium WQO (5 μg/L) was exceeded during both February and March, with concentrations recorded at 8.0 μg/L and 5.4 μg/L, respectively. These elevated concentrations correspond to periods of extremely high runoff as discussed earlier. Monthly mean selenium concentrations for the remainder of WY 95 were below 4 μg/L.

Since WY 86, time periods of selenium WQO exceedance at the Crows Landing Bridge site appear to be centered between February and April, as well as June and July (Table 8). These two time periods correspond to typical periods of heavy precipitation, pre-irrigation and intensive crop irrigation.

Data collected during this monitoring program is not sufficient to calculate a continuous four-day average concentration which is the basis of the U.S. EPA promulgated criteria. For the sake of comparison, however, the once per week grab sample selenium concentration at the Hills Ferry Road and Crows Landing Bridge sites were compared to both the continuous and maximum federal criteria (Figure 14).

Comparing the once per week grab sample selenium data to the four-day average federal criteria (5 μg/L) at the Hills Ferry Road site shows that the federal criteria was exceeded in 20 of the 48 samples collected (42% of the time). The maximum criteria (20 μg/L) was reached at the end of February and early March but was never exceeded.

At the Crows Landing site downstream of the Merced River inflow, the continuous 5 μg/L selenium criteria was exceeded in five of the fifty-one samples collected between 7 October 1994 and 28 September 1995. The highest concentration recorded was 12 μg/L in March 1995, which does not exceed the Federal maximum criteria of 20 μg/L.

Figure-12 Monthly Mean Boron Concentrations in the San Joaquin River at Crows Landing Bridge Site: WY95

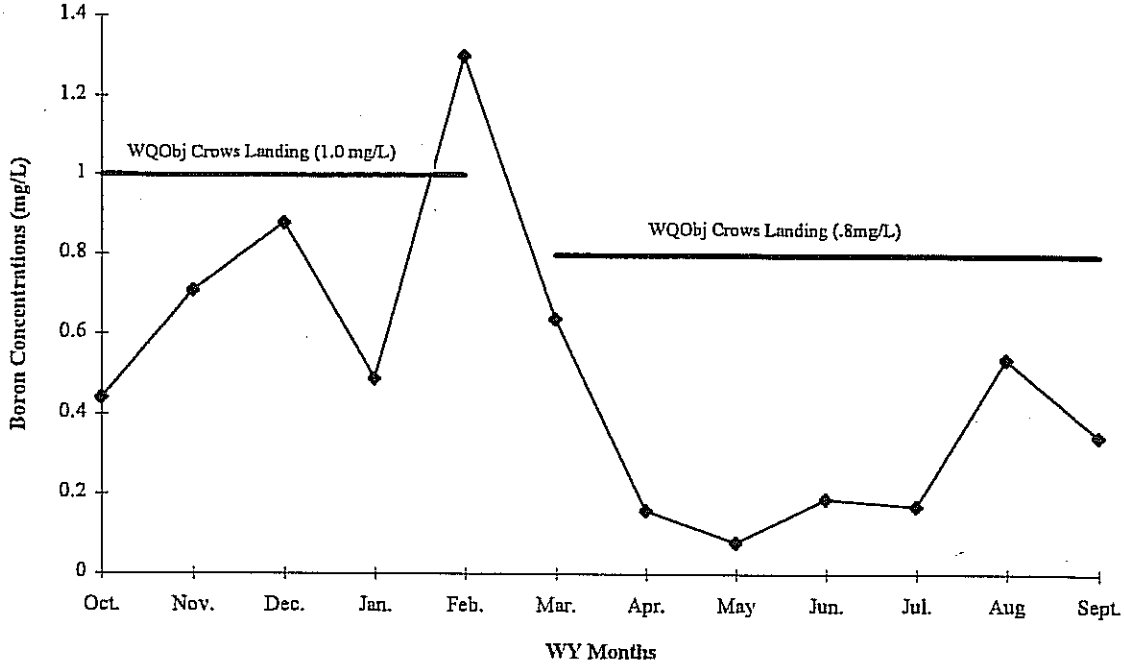


Figure-13
Monthly Mean Selenium Concentrations in the San Joaquin River at Crows Landing Bridge Site: WY95

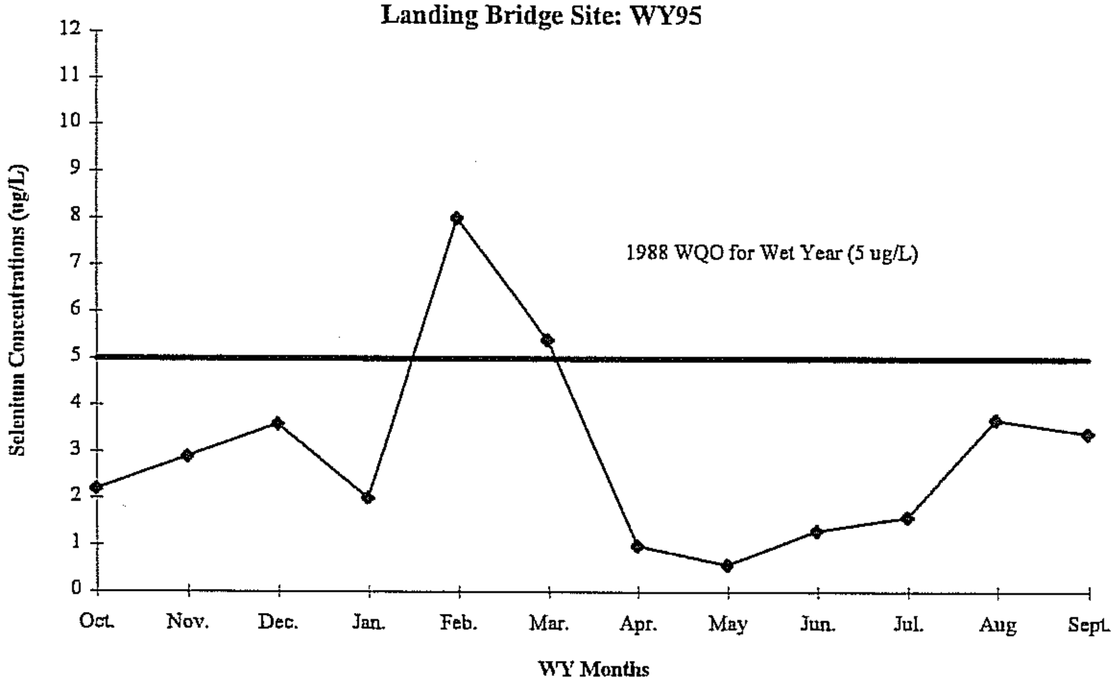


Figure-14

Comparison of Weekly Selenium Concentrations at Crows Landing and Hills Ferry to U.S. EPA Criteria: WY 95

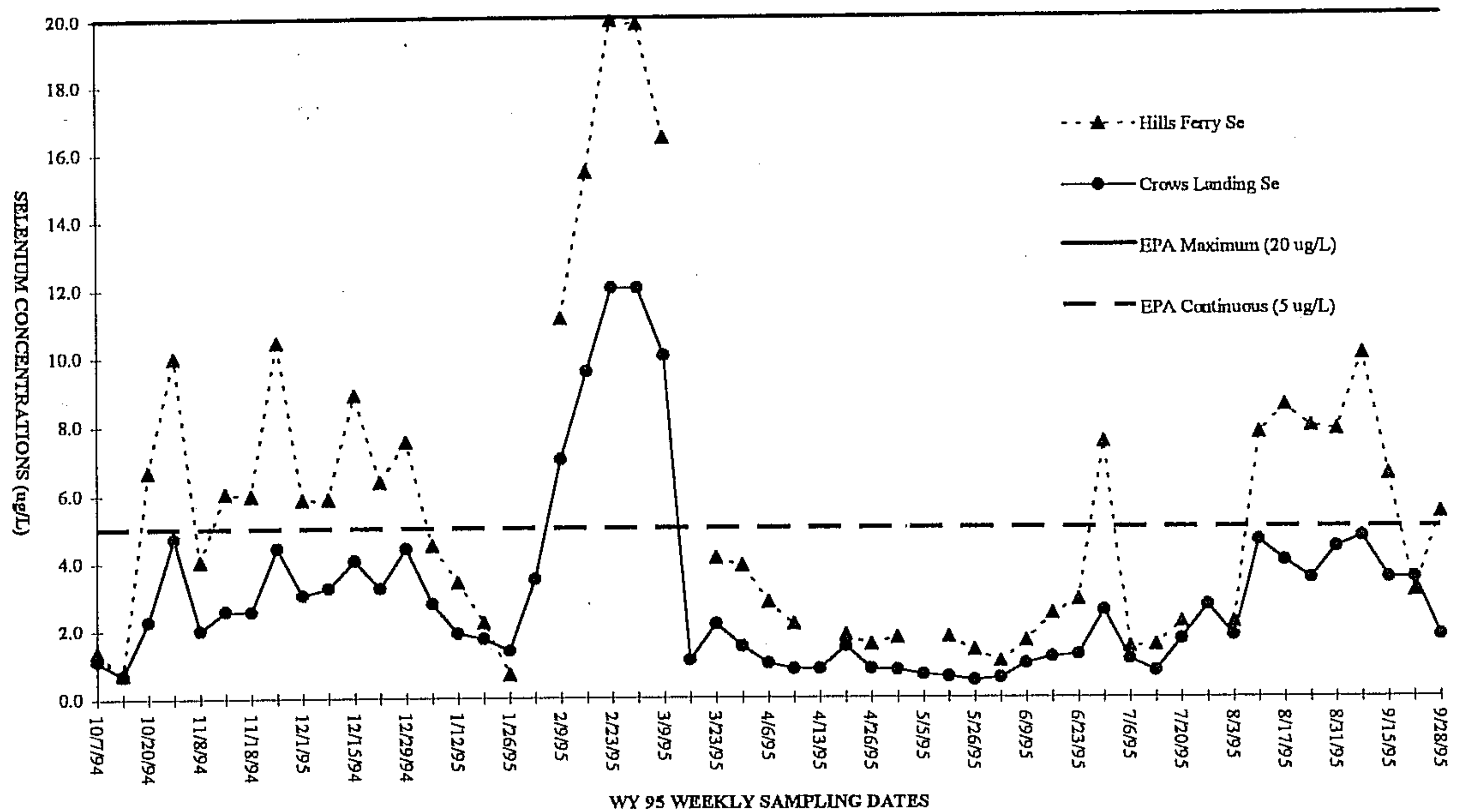


Table-8 Mean Monthly Selenium Water Quality Objective Exceedances in the San Joaquin River at Crows Landing: WYs 86-95

Water Year	Type	Se (ug/L) WQObj†	Monthly Mean Water Quality Objective Exceedances											
			Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.
1986*	Wet	5												
1987*	Critical	8							░					
1988**	Critical	8						░				░		
1989**	Critical	8					░	░			░			
1990**	Critical	8				░	░	░		░				
1991**	Critical	8							░					
1992**	Critical	8							░					
1993**	Above Normal	5						░				░		
1994**	Critical	8						░			░	░		
1995**	Wet	5					░	░						

*Samples were collected once a month

**Samples were collected weekly and the concentrations averaged

░ Exceedance of Objectives

† WQObjs shown were adopted in 1988.

Other Elements of Concern

During WY 95, laboratory analysis for molybdenum was performed quarterly through April 1995. Data collected shows that molybdenum exceeded the 19 μg/L monthly mean WQO once. The exceedance occurred on the San Joaquin River at Lander Avenue. That exceedance occurred in October with a concentration of 28 μg/L. Molybdenum concentrations at Lander Avenue ranged from 4 to 28 μg/L, with an annual median concentration of 13 μg/L.

Diversion of the San Joaquin River head waters into the Friant-Kern Canal and a lack of agricultural return flows upstream of this site result in low river flows at Lander Avenue. Molybdenum levels in the groundwater near the sampling site can range up to 1,000 μg/L (SJVDP, 1990). Since river flows are low and ground water molybdenum levels are high, the high levels of molybdenum found at the Lander Avenue site are considered background levels, and are likely due to groundwater accretions.

Total recoverable chromium, copper, lead, nickel, and zinc were analyzed at the Lander Avenue, Fremont Ford, Hills Ferry Road, Crows Landing Bridge, and Airport Way sites on a quarterly basis. Copper, lead, nickel, and zinc water quality criteria for protection of aquatic organisms vary with hardness (Marshack, 1995). Toxicity is not expected to occur from these four elements due to the combination of high median hardness (197 to 448 mg/L) in the San Joaquin River water and the low levels of the four elements measured at these sites. Total recoverable chromium was analyzed to determine whether potential problems related to hexavalent chromium exist. Total chromium values exceeded the USEPA ambient water quality chronic criteria for freshwater aquatic life of hexavalent chromium (10 μg/L) once at Crows Landing, Hills Ferry, and Airport Way, with concentrations of 15, 14, and 16 μg/L respectively. These exceedances all occurred on 26 January 1995. No measurements for hexavalent chromium are available.

The San Joaquin River between Sack Dam and Vernalis contains a high suspended sediment load. Therefore, in addition to sampling for total recoverable trace elements, monthly water samples for total dissolved trace elements were also collected at the Hills Ferry Road site to distinguish between constituent concentrations in the water column and concentrations associated with the suspended material. Table 9 shows the comparison of total vs. dissolved trace elements for the Hills Ferry Road site. In almost all cases, the filtered samples used for dissolved analysis, show no detectable levels of the element of concern. All but one of the dissolved chromium concentrations were reported below the analytical detection limit of 1 μg/L, even when total chromium concentrations reached 14 μg/L. Hexavalent chromium exists in an aqueous form under natural stream conditions, therefore, dissolved chromium concentrations should be equal to or over estimate the amount of hexavalent chromium present. Since the majority of chromium in the water column appears to be attached to suspended material, hexavalent chromium should not be of concern in this system.

Table-9 Total Recoverable vs. Dissolved Trace Element Concentrations for the San Joaquin River at the Hills Ferry Road Site: WY 95

	Concentrations (ug/L)									
	Cr		Cu		Pb		Ni		Zn	
Date	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
10/27/94	10		4		<5		8		12	
11/22/94	3	<1	6	2	<5	<5	<5	<5	13	NA
12/29/94	5		3		<5		<5		7	
1/26/95	14	<1	11	7	<5	6	11	<5	20	NA
2/23/95	9	<1	7	4	<5	<5	11	8	12	NA
3/28/95	<1	<1	3	4	<5	<5	<5	<5	3	NA
4/26/95	3	<1	5	6	<5	<5	<5	8	<2	NA
5/26/95	3		6		<5		<5		4	
6/28/95	8	3	6	3	<5	<5	8	<5	15	<2
7/27/95	28		18		12		22		46	
8/31/95	14		7		<5		12		17	
9/28/95	9		5		<5		8		10	

N/A= No Analyses

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APPENDIX A

MINERAL AND TRACE ELEMENT DATA FOR THE LOWER SAN JOAQUIN RIVER

LEGEND OF ABBREVIATIONS

Abbreviation	Abbreviation Explanation
EC	Electric Conductivity
Se	Selenium
Mo	Molybdenum
Cr	Chromium
Cu	Copper
Ni	Nickel
Pb	Lead
Zn	Zinc
B	Boron
Cl	Chlorine
SO_4	Sulfate
HDNS	Hardness

San Joaquin River at Lander Avenue (State Highway 165) (MER522)

Location: Latitude 37°17'43", Longitude 120°51'01". In NE 1/4, NE 1/4, Sec. 27, T.7S., R.10E. East Bank,

50 ft West of Lander Avenue (Highway 165), 2.3 mi. south of Stevinson. River Mile 132.9

Date	Time	Temp °F	pH	EC µmhos/cm	Se	Mo	Cr	Cu	Ni	Pb	Zn	B	Cl	SO_4	HDNS
					ug/L							mg/L			
10/7/94	1130	70	8.1	2020	<.4							0.47			
10/12/94	1010	61	8.0	2010	0.6							0.49			
10/20/94	1150	66	8.2	2070	<0.4							0.05			
10/27/94	900	63	7.6	2260	<.4	28	<1	<1	<5	<5	4	0.55	460	94	160
11/8/94	1045	54	8.1	2450											
11/10/94	1005	56	8.3												
11/18/94	1110	52	7.9	802											
11/22/94	1140	52		839	<0.4	9						0.16	160	42	99
12/9/94	1130	47		1500											
12/15/94	1226	47		1420											
12/21/94	1257	48		1270											
12/29/94	1109	49	8.2	1340	0.7	17						0.32	220	63	140
1/5/95	1003	49	8.1	1430											
1/12/95	1145	54	7.1	135											
1/19/95	1240	50	7.3	147											
1/26/95	1510	51	8.2	126	0.4										
2/9/95	1235	56	8.3	604											
2/17/95	1320	56	8.2	530											
2/23/95	1130	61	8.1	830	0.5	4						0.10	120	59	200
3/3/95	755	60	8.0	1030											
3/9/95	1045	58	8.1												
3/23/95	1005	55	7.5	236											
3/29/95	1320	67	8.8	186	0.8							0.06	10	19	62
4/6/95	1015	65	9.2	101											
4/13/95	1700	65	7.9	86.7											
4/21/95	1305	60	8.7	96.6								<.02			
4/26/95	845	65	8.1	78.5	<0.4							0.02	3.1	5.1	23
5/3/95	1125	67	8.0	81.0	<.4							<.02			
5/12/95	1240	62	8.6	66.8											
5/26/95	1000	67	7.8	65.0	<.4							<.05	3	3	21
6/2/95	1110	64	7.9	211											
6/9/95	1345	69	8.1	93.7											
6/16/95	1110	64	8.0	120											
6/23/95	1050	78	8.5	142											
6/28/95	1100	78	7.7	507	0.4							0.1	78	39	110
7/6/95	1205	76	8.4	61.0											
7/13/95	1015	71	8.4	46.0											
7/20/95	1205	77	8.4	72.6											
7/27/95	1330	82	8.1	302	<0.4		6	4	7	<5	13	<.05	27	16	65
8/10/95	1140	80	8.2	430											
8/17/95	1210	78	8.3	343											
8/24/95	1320	82	8.5	297											
8/31/95	1040	73	8.4	238	<0.4							<.05			
9/7/95	1150	78	8.5	325											
9/15/95	1136	75	8.45	156											
9/22/95	1249	78	8.4	117											
9/28/95	1100	73	7.45	151	<0.4							<.05	13	6.9	41
Count		47	43	45	16	4	2	2	2	2	2	16	10	10	10
Min		47	7.1	46	<0.4	4	6	4	7	<5	4	<.02	3	3	21
Max		82	9.2	2450	0.8	28	6	4	7	<5	13	0.6	460	94	200
Mean		64	8.1	609	0.3	15	3	2	4	<5	9	0.18	109	35	92
Geo Mean		63	8.1	309	0.2	11	1	1	3	<5	7	0.06	37	21	72

San Joaquin River at Freemont Ford (MER538)

Location: Latitude 37°18'34", Longitude 120°55'45". In NW 1/4, NW 1/4, Sec. 24, T.7S., R.9E. West Bank at Freemont Ford State Recreation Area, 50ft. south of Highway 140. 5.4 miles NE of Gustine. River Mile 125.2

Date	Time	Temp °F	pH	EC µmhos/cm	Se (µg/L)	Mo (µg/L)	Cr (µg/L)	Cu (µg/L)	Ni (µg/L)	Pb (µg/L)	Zn (µg/L)	B (mg/L)	Cl (mg/L)	SO_4 (mg/L)	HDNS (mg/L)
10/7/94	1140	68	8.1	2030	1.3							0.76			
10/12/94	1025	60	8.1	2610	1.0							0.96			
10/20/94	1210	66	8.1	1990	8.2							1.3			
10/27/94	840	62	7.2	2060	15		9	4	5	<5	12	1.6	340	370	430
11/8/94	1100	52	8.1	2070	5.0							1.4			
11/10/94	950	54	8.0	2650	11							1.8			
11/18/94	1125	52	7.7	2490	6.5							1.5			
11/22/94	1315			3010	13	15						2.1	490	580	550
12/9/94	1124	48		2450	9.6							1.9			
12/15/94	1241	48		2930	16							2.4			
12/21/94	1312	49		3030	10							2.2			
12/29/94	913	46	7.4	2850	11	12						2.2	450	540	630
1/5/95	1027	49	7.7	2530	11							1.9			
1/12/95	1150	55	7.4	453	1.3							0.26			
1/19/95	1200	50	7.3		1.4							0.59			
1/26/95	1310	53	8.4		0.8	1						0.08	20	20	70
2/9/95	1220	56	8.2	2360	16							2.3			
2/17/95	1335	55	7.8	2620	23							2.5			
2/23/95	1145	60	7.8	2980	25							3.0	440	710	710
3/3/95	740	58	7.7	2830	25							2.7			
3/9/95	1100	58	8.0	2490	19							2.1			
3/23/95	950	55	7.4	477	2.9							0.27			
3/29/95	1335	67	8.6	228	1.1							0.08	14	28	64
4/6/95	1030	65	9.2	121	0.6							<.02			
4/12/95	1650	69	8.0	143	0.6							0.06			
4/21/95	1325	60	8.4	245	1.4							0.07			
4/26/95	900	65	7.8	107	0.4							0.03	5.8	8.2	30
5/3/95	1140	69	8.2	92	<0.4							<.02			
5/12/95	1250	64	8.2	74.7	<0.4							<.02			
5/26/95	945	67	8.2	64	<.4							<.05	2	32	21
6/2/95	1120	71	8.1	77.3	<0.4							<.05			
6/9/95	1120	69	8.1	284	2.0							0.22			
6/16/95	1100	66	7.8	517	3.1							0.41			
6/23/95	1100	78	8.3	631	4.5							0.59			
6/28/95	1110	78	7.7	1570	10							1.3			
7/6/95	1220	76	8.3	264	1.7										
7/13/95	1000	70	8.7	113	0.7							0.08			
7/20/95	1215	79	8.0	276	2.1							0.23			
7/27/95	1355	84	7.8	1130	7.7							1.1	220	310	300
8/10/95	1150	80	8.0	1260	9.5							1.0			
8/17/95	1225	77	8.1	1190	8.2							1.1			
8/24/95	1335	82	8.1	1200	9.1							1.0			
8/31/95	1155	74	8.2	895	5.5							0.77	110	160	200
9/7/95	1200	78	8.1	1342	11							1.2			
9/15/95	1150	75	7.89	857	7.1							0.71			
9/22/95	1305	78	7.8	662	4.1							0.5			
9/28/95	1045	74	7.5	765	3.4							0.43	98	120	150
Count		46	43	45	47	3	1	1	1	1	1	46	11	11	11
Min		46	7.2	64	<0.4	1	9	4	5	<5	12	0.031	2	8.2	21
Max		84	9.2	3030	25	15	9	4	5	<5	12	3.0	490	710	710
Mean		65	8.0	1360	6.9	9	9	4	5	<5	12	1.0	199	262	287
Geo Mean		64	8.0	784	3.4	6	9	4	5	<5	12	0.43	72	120	166
Median		66	8.0	1190	5.0	12	9	4	5	<5	12	0.87	110	160	200

San Joaquin River at Hills Ferry Road (STC512)

Location: Latitude 37°20'33", Longitude 120°58'38". In NE 1/4, SE 1/4, NE 1/4, Sec. 9, T.7S., R.9E. West Bank, 0.9 mi. SE of Hills Ferry Road at an abandoned tallow factory, immediately upstream of Merced River inflow, 3.3 mi. NE of Newman. River Mile 118.1

Date	Time	Temp °F	pH	EC µmhos/cm	Se (µg/L)	Mo (µg/L)	Cr (µg/L)	Cu (µg/L)	Ni (µg/L)	Pb (µg/L)	Zn (µg/L)	B (mg/L)	Cl (mg/L)	SO_4 (mg/L)	HDNS (mg/L)	TDS (mg/L)	CO3 (mg/L)	HCO3 (mg/L)	T Alk (mg/L)	CA (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Dis Cr (Dissolved, µg/L)	Dis Cu (Dissolved, µg/L)	Dis Ni (Dissolved, µg/L)	Dis Pb (Dissolved, µg/L)	Diss Zn (Dissolved, µg/L)
10/7/94	1230	69	8.1	2000	1.4							0.82																
10/12/94	1130	63	8.0	2360	0.7							0.88																
10/20/94	1300	65	8.0	1910	6.6							1.3																
10/27/94	1105	64	7.7	1850	10	8	10	4	8	<5	12	1.3	300	320	400	1200	<1	220	180	83	46	260	6					
11/8/94	1120	51	7.9	1940	4.0							1.2																
11/10/94	925	54	7.9	2430	6.0							1.5																
11/18/94	1150	50	7.9	2410	6.0							1.6	420	430	460					94	54							
11/22/94			8.2	2700	10	13	3	6	<5	<5	13	1.8	410	470	510	1700	<1	280	230	110	58	380	5	<1	2	<5	<5	15
12/1/94	1145	46		2440	5.8							1.7	400	450	500					100	60							
12/9/94	1209	45		2230	5.8							1.6	350	390	420					86	50							
12/15/94	1310	48		2510	8.9							1.9																
12/21/94	1338	49		2550	6.3							1.8	440	490	530					110	62							
12/29/94	1250	48	7.5	2460	7.5	10	5	3	<5	<5	7	1.8	390	440	500					100	61							
1/5/95	1121	49	7.7	2070	4.5							1.4	330	350	400					81	48							
1/12/95	1230	55	7.6	1110	3.4							0.82	130	180	230					48	26							
1/19/95	1230	49	7.4	863	2.2							0.68	100	140	180					37	21							
1/26/95	1115	52	7.7	520	0.7	1	14	11	11	<5	20	0.27	51	60	120	350	<1	120	99	23	15	59	6	<1	7	<5	6	14
2/9/95	1205	56	8.1	2390	11							2.0	340	470	480					100	56							
2/17/95	1410	56	7.9	2600	15							2.2	370	550	550					120	61							
2/23/95	1630	59	7.8	3050	20	10	9	7	11	<5	12	2.8	440	660	690					150	76			<1	4	8	<5	12
3/3/95	1345	64	8.0	2960	20							2.4	440	657	600					130	68							
3/9/95	1140	58		2590	16							2.1																
3/23/95	820	53	7.3	884	4.1							0.63																
3/28/95	1420	67	7.5	785	3.9		<1	3	<5	<5	3	0.55	77	150	170					40	18			<1	4	<5	<5	14
4/6/95	1100	67	8.4	710	2.8							0.57																
4/12/95	1530	69	7.4	542	2.2							0.44																
4/21/95	1500	61	8.4	427	1.8							0.23																
4/26/95	1200	68	7.9	352	1.5		3	5	<5	<5	<2	0.29	35	53	78	200	<1	61	50	18	7.8			<1	6	8	<5	230
5/3/95	1245	72	8.4	397	1.8							0.28																
5/12/95	1325	66	7.7	351	1.8							0.25																
5/26/95	845	68	7.4	305	1.4		3	6	<5	<5	4	0.26	28	48	68					17	6.3							
6/2/95	1240	64	7.9	285	1.0							0.22																
6/9/95	1055	69	8.3	327	1.6							0.25																
6/16/95	1030	67	7.3	540	2.5							0.38																
6/23/95	1155	78	8.4	579	2.9							0.48																
6/28/95	1300	81	8.1	1430	7.5		8	6	8	<5	15	1.1	200	280	290					64	31			<1	3	<5	<5	<2
7/6/95	1243	77	8.1	327	1.5							0.17																
7/13/95	1035	71	8.2	258	1.5							0.20																
7/20/95	1240	79	7.9	336	2.2							0.28																
8/3/95	1515	86	8.1	441	2.2																							
8/10/95	1210	80	8.0	1340	7.7							0.97																
8/17/95	1250	77	8.0	1390	8.5							1.2																
8/24/95	1400	82	8.3	1200	7.9							0.9																
8/31/95	912	74	7.9	1160	7.8		14	7	12	<5	17	1.1	140	210	260					61	25							
9/7/95	1223	78	8.1	1388	10							1.2																
9/15/95	1219	78	7.9	929	6.5							0.72																
9/22/95	1330	78	8	724	3.1							0.45																
9/28/95	848	71	7.4	1054	5.4		9	5	8	<5	10	0.63	150	200	200					44	22							
Count		47	43	48	48	5	11	11	11	11	11	47	21	21	21	4	4	4	4	21	21	3	3	6	6	6	6	6
Min		45	7.3	258	0.7	1	3	3	8	<5	3	0.17	28	48	68	200	<1	61	50	17	6.3	59	5	<1	2	8	6	12
Max		86	8.4	3050	20	13	14	11	12	<5	20	2.8	440	660	690	1700	<1	280	230	150	76	380	6	<1	7	8	6	230
Mean		64	7.9	1380	5.7	8	7	6	6	<5	10	1.0	264	333	364	863	<1	170	140	77	41	233	6	<1	4	4	2	48
Geo Mean		63	7.9	1060	4.1	6	5	5	4	<5	8	0.78	200	263	306	615	<1	146	120	65	34	180	6	<1	4	2	2	13
Median		66	7.9	1180	4.3	10	8	6	8	<5	12	0.88	330	350	400	775	<1	170	140	83	48	260	6	<1	4	1	1	14

San Joaquin River at Crows Landing Road (STC504)

Location: Latitude 37°25'55", Longitude 121°00'42". In Section 8 T.6S., R.8E. West Bank, 100 yards south of Crows Landing Road Bridge, 4.2 miles northeast of Crows Landing. River Mile 107.1

Date	Time	Temp °F	pH	EC µmhos/cm	Se	Mo	Cr	Cu	Ni	Pb	Zn	B	Cl	SO4	HDNS
					◄			µg/L			►	◄	mg/L		►
10/7/94	1250	68	8.1	1050	1.1							0.39			
10/12/94	1155	64	8.3	926	0.6							0.31			
10/20/94	1325	65	8.2	696	2.3							0.39			
10/27/94	1125	64	7.7	1056	4.7	4	2	2	<5	<5	4	0.66	160	150	220
11/8/94	1135	53	8.0	1020	2.0							0.57			
11/10/94	905	53	8.1	1260	2.6							0.68			
11/18/94	1205	52	8.1	1260	2.5							0.71			
11/22/94	1245	52		1440	4.4		3	<1	<5	<5	9	0.89	220	240	260
12/1/94	1117	47		1350	3.0							0.78			
12/9/94	1228	46		1370	3.2							0.84			
12/15/94	1334	48		1440	4.0							0.91	210	230	300
12/21/94	1400	49		1440	3.2							0.91			
12/29/94	1324	49	7.5	1470	4.4	5	2	2	<5	<5	4	0.95	220	240	290
1/5/95	1156	50	7.7	1320	2.8							0.75			
1/12/95	1250	55	7.4	635	1.9							0.43			
1/19/95	1245	50	7.3		1.7							0.51			
1/26/95	1040	51	8.5		1.4	1	15	15	14	<5	30	0.28	50	65	120
2/3/95	1530	58	8.1	1000	3.5							0.76			
2/9/95	1120	58	8.2	1650	7.0							1.3			
2/17/95	1450	57	8.0	1850	9.6							1.5			
2/23/95	1600	59	7.9	2060	12	7	5	7	8	<5	9	1.7	290	420	430
3/3/95	1655	64	8.1	2030	12							1.3			
3/9/95	1500	58		1800	10							1.3			
3/15/95	915	61			1.1							0.14			
3/23/95	745	53	6.9	502	2.2							0.28			
3/28/95	1445	61	7.5	373	1.5		<1	2	<5	<5	<2	0.19	27	55	87
4/6/95	1120	65	8.6	299	1.0							0.19			
4/12/95	1510	67	7.6	282	0.8							0.17			
4/13/95	1645	62	7.83	261	0.8										
4/21/95	1520	59	8.2	264	1.5							0.14			
4/26/95	1220	68	7.8	223	0.8		3				<2	0.12	22	28	52
5/3/95	1300	69	8.2	178	0.8							0.07			
5/5/95	1440				0.6							0.07			
5/12/95	1355	66	7.8	162	0.6							0.08			
5/26/95	812	66	7.6	169	0.4		3				<2	0.09			
6/2/95	1255	62	8.0	191	0.6							0.1			
6/9/95	1410	68	8.4	216	1.2							0.15			
6/16/95	1000	65	7.4	278	1.2							0.16			
6/23/95	1210	72	8.5	271	1.2							0.18			
6/28/95	1330	74	8.1	551	2.5							0.38			
7/6/95	1305	78	8.0	209	1.1							0.05			
7/13/95	1440	70	7.9	143	0.8							<05			
7/20/95	1255	79	8.0	312	1.7							0.21			
7/27/95	955	76	7.3	564	2.7		9				24	0.4			
8/3/95	1451	82	8.2	438	1.8							0.25			
8/10/95	1250	78	7.9	880	4.6							0.57			
8/17/95	1315	72	8.2	773	4.0							0.53			
8/24/95	1430	82	8.5	735	3.5							0.49			
8/31/95	849	71	8.1	884	4.4						9	0.58			
9/7/95	1255	78	8.3	798	4.7		9					0.59			
9/15/95	1241	73	8.0	537	3.5							0.34			
9/22/95	1350	76	8.1	537	1.4							0.19			
9/28/95	826	70	7.2	639	1.8		5	3	4	<5	5	0.28	85	94	130
Count		51	44	48	51	4	11	7	7	7	11	50	9	9	9
Min		46	6.9	143	0.5	1	2	2	4	<5	4	0.05	22	28	52
Max		82	8.6	2060	12	7	15	15	14	<5	30	1.7	290	420	430
Mean		63	7.9	824	3.0	4	5	5	4	<5	9	0.51	143	169	210
Geo Mean		63	7.9	629	2.2	3	4	3	3	<5	4	0.35	102	126	175
Median		64	8.0	716	2.3	5	3	2	1	<5	5	0.4	160	150	220

San Joaquin River at Las Palmas Launching Facility (Patterson) (STC507)

Location: Latitude 37°29'52", Longitude 121°04'54". In SW 1/4, NW 1/4, SW 1/4, Sec. 15, T.5S., R.8E. West Bank, 0.3 mi. N of Patterson Bridge at NE corner of Las Palmas Launching Facility parking lot, 3.2 mi. NE of Patterson. River Mile 98.6.

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	B (mg/L)	Cl (mg/L)	SO_4 (mg/L)	HDNS (mg/L)
10/7/94	1310	68	7.9	993	0.9	0.34			
10/12/94	1215	64	8.4	885	0.5	0.31			
10/20/94	1340	66	7.9	693	1.1	0.34			
10/27/94	1145	66	7.6	1080	3.4	0.58	150	160	230
11/8/94	1150	54	7.8	1040	2.0	0.56			
11/10/94	845	54	8.1	1180	2.2	0.59			
11/18/94	1225	52	7.5	1330	2.9	0.69			
11/22/94	1310	53		1200	1.7	0.60	180	160	220
12/9/94	1251	47		1370	3.7	0.75			
12/15/94	1354	49		1310	2.6	0.73			
12/21/94	1421	49		1520	3.3	0.99			
12/29/94	1345	51	8.0	1360	3.2	0.83	190	220	260
1/5/95	1229	51	7.6	1230	3.0	0.73			
1/12/95	1400	54	7.4		1.6	0.44			
1/19/95	1320	50	7.3		1.3	0.45			
1/26/95	1500	54	7.8	606	1.8	0.34	61	79	140
2/9/95	945	54	8.1	1610	6.7	1.1			
2/23/95	1830	59	7.9	2120	11	1.8	280	420	500
3/3/95	1520	64	7.9	2020	11	1.5			
3/9/95	1325	58		1760	8.7	1.2			
3/23/95	725	53	6.8	519	2.0	0.29			
3/29/95	1600	71	8.8	356	1.2	0.19	28	59	86
4/6/95	1135	67	8.5	330	0.9	0.21			
4/12/95	1430	63	7.8	570	1.3	0.17			
4/21/95	1535	62	8.0	278	1.1	0.10			
4/26/95	1240	68	7.7	211	0.9	0.13	19	28	52
5/3/95	1315	70	7.6	193	0.7	0.12			
5/12/95	1415	65	7.7	172	0.6	0.08			
5/26/95	755	64	7.6	154	<0.4	0.08	12	19	40
6/2/95	1310	62	8.0	166	<0.4	0.08			
6/9/95	1020	66	7.6	221	0.9	0.12			
6/16/95	800	61	7.1	302	1.1	0.19			
6/23/95	1230	72	8.8	306	1.1	0.20			
6/28/95	1340	76	7.7	687	2.5	0.42	81	120	140
7/6/95	1325	78	7.7	212	0.9	0.11			
7/13/95	1055	68	7.9	146	0.7	0.08			
7/20/95	1310	79	7.7	391	3.0				
7/27/95	800	75	7.6	570	3.0	0.44	67	110	150
8/3/95	1425	80	8.1	644	2.1	0.35			
8/10/95	1310	80	7.8	1190	4.3	0.65			
8/17/95	1340	76	7.9	853	4.0	0.61			
8/24/95	1450	82	8.3	830	3.5	0.48			
8/31/95	818	72	7.7	995	3.9	0.69	110	170	230
9/7/95	1312	79	8.2	834	4.1	0.54			
9/15/95	1305	45	7.83	696	3.0	0.42			
9/22/95	1420	76	8	611	1.8	0.31			
9/28/95	800	70	7.25	736	2.3	0.97	130	110	160
Count		47	42	45	47	46	12	12	12
Min		45	6.8	146	<0.4	0.08	12	19	40
Max		82	8.8	2120	11	1.8	280	420	500
Mean		64	7.8	811	2.6	0.5	109	138	184
Geo Mean		63	7.8	631	1.9	0.4	77	103	150
Median		64	7.8	696	2.0	0.43	96	115	155

San Joaquin River at Maze Blvd. (State Highway 132) (STC510)

Location: Latitude 37°38'31", Longitude 121°13'40". In SW 1/4, NW 1/4, SW 1/4, Sec. 29, T.3S., R.7E.

West Bank, 400 ft S of Maze Blvd Bridge upstream of Blewett Drain, 5.7 mi. NW of Grayson. River Mile 77.2

Date	Time	Temp °F	pH	EC µmhos/cm	Se µg/L	B (mg/L)	Cl (mg/L)	SO_4 (mg/L)	HDNS (mg/L)
10/7/94	1340	70	7.8	931	0.8	0.31			
10/12/94	1250	64	8.1	962	0.7	0.32			
10/20/94	1410	68	7.9	606	0.7	0.25			
10/27/94	1225	66	7.6	912	2.9	0.46	120	120	190
11/8/94	1215	54	7.8	915	1.6	0.43			
11/10/94	819	54	7.8	1030	1.9	0.50			
11/18/94	1300	54	7.9	1080	1.8	0.54			
11/22/94	1345	52		1100	1.8	0.56	170	150	220
12/9/94	1323	47		1050	2.1	0.56			
12/15/94	1427	50		1090	2.4	0.57			
12/21/94	1456	50		1220	2.9	0.67			
12/29/94	1430	51	7.9	1190	2.7	0.62	180	170	240
1/12/95	1439	54	7.3		1.1	0.33			
1/19/95	1350	50	7.2		1.2	0.36			
1/26/95	1530	53	7.8	385	1.0	0.21	38	44	99
2/9/95	905	52	8.1	451	1.7	0.30			
2/23/95	1740	57	8.4	482	2.4	0.30	56	74	100
3/3/95	1555	59	8.2	835	3.7	0.50			
3/9/95	1400	58		861	3.9	0.53			
3/23/95	700	52	6.9	347	1.2	0.19			
4/6/95	1215	63	8.7	239	0.7	0.14			
4/12/95	1350	64	8.0	206	0.6	0.11			
4/21/95	1605	59	8.3	192	0.8	0.04			
4/26/95	1320	64	7.7	174	0.6	0.09	15	20	45
5/3/95	1405	68	7.6	206	0.6	0.03			
5/12/95	1450	62	7.8	142	0.5	0.06			
5/26/95	715	63	7.7	125	0.7	0.06	10	12	34
6/2/95	1345	70	8.1	139	0.4	0.06			
6/9/95	945	63	7.5	142	0.5	0.08			
6/16/95	715	60	7.1	197	0.5	0.11			
6/23/95	1320	71	8.6	215	0.9	0.12			
6/28/95	1425	76	7.6	500	1.6	0.29	58	71	110
7/6/95	1405	78	7.7	198	0.8	0.09			
7/13/95	1120	68	7.8	129	0.5	0.05			
7/27/95	715	74	7.6	416	1.8	0.29	49	69	110
8/3/95	1606	78	8.0	284	1.2	0.16			
8/10/95	1335	78	7.9	630	2.3	0.32			
8/17/95	1415	75	8.0	631	2.4	0.36			
8/24/95	1520	78	8.5	586	1.9	0.30			
8/31/95	741	66	7.9	442	1.6	0.26			
9/7/95	1342	76	8.2	483	2.6	0.26	45	61	96
9/15/95	1336	73	8.0	377	1.5	0.21			
9/22/95	1504	73	8.0	377	1.1	0.11			
9/28/95	730	68	7.26	254	0.7	0.10	27	31	60
Count		44	39	42	44	44	11	11	11
Min		47	6.9	125	0.4	0.032	10	12	34
Max		78	8.7	1220	3.9	0.67	180	170	240
Mean		63	7.9	541	1.5	0.28	70	74	118
Geo Mean		63	7.8	426	1.2	0.21	49	57	100
Median		64	7.9	447	1.2	0.28	49	69	100

San Joaquin River at Airport Way (SJC501)

Location: Latitude 37°40'32", Longitude 121°15'51". In SE 1/4, SW 1/4, NW 1/4, Sec. 13, T.3S., R.6E.

West Bank, south of Airport Way Bridge, 3.2 miles NE of Vernalis River Mile 72.3.

Date	Time	Temp °F	pH	EC µmhos/cm	Se (µg/L)	Mo (µg/L)	Cr (µg/L)	Cu (µg/L)	Ni (µg/L)	Pb (µg/L)	Zn (µg/L)	B (mg/L)	Cl (mg/L)	SO_4 (mg/L)	HDNS (mg/L)
10/7/94	1405	70	7.8	842	0.9							0.28			
10/12/94	1305	66	8.3	853	0.5							0.29			
10/20/94	1430	69	6.6	460	0.5							0.18			
10/27/94	1240	68	7.6	755	1.7	2	8	4	9	<5	20	0.36	110	92	170
11/8/94	1235	56	7.7	751	1.1							0.35			
11/10/94	754	52	8.0	890	1.6							0.42			
11/18/94	1310	52	7.9	942	1.3							0.43			
11/22/94	1405	52		995	1.9	4						0.52	140	140	200
12/9/94	1340	47		913	2.3							0.48			
12/15/94	1446	50		950	1.8							0.49			
12/21/94	1514	50		1013	2.5							0.56			
12/29/94	1450	50	7.8	1020	2.1	4						0.51	140	140	200
1/5/95	1313	51	7.5	902	2.2							0.50			
1/12/95	1456	54	7.2		1.2							0.25			
1/19/95	1415				1.0							0.28			
1/26/95	1600	53	7.7	351	0.8	<1	16	15	17	<5	28	0.19	34	40	93
2/9/95	845	52	8.2	436	1.7							0.28			
2/17/95	1615	52	8.4	430	2.6							0.25			
2/23/95	1755	56	8.3	488	2.2	1						0.31	56	74	110
3/3/95	1605	58	8.2	762	3.2							0.45			
3/9/95	1410	58		785	3.5							0.47			
3/23/95	645	52	6.9	349	1.2							0.18			
3/29/95	1645	59	8.7	258	0.7							0.12	19	34	63
4/6/95	1225	63	8.5	238	0.8							0.13			
4/12/95	1323	63	7.5	204	0.6							0.10			
4/21/95	1624	59	8.0	210	1.2							0.06			
4/26/95	1335	66	7.7	143	0.6		3	3	<5	<5	<2	0.08	16	21	47
5/3/95	1345	67	7.6	199	1.1							0.06			
5/12/95	1500	62	7.6	141	0.4							0.07			
5/26/95	700	64	7.8	123	0.6							0.06	9	12	33
6/2/95	1355	70	8.1	132	0.4							0.07			
6/9/95	935	64	6.9	177	0.6							0.08			
6/16/95	645	60	6.1	303	0.7							0.15			
6/23/95	1330	70	8.9	226	1.4							0.13			
6/28/95	1410	76	7.7	481	1.4							0.27	53	65	110
7/6/95	1420	78	7.6	208	0.8							0.09			
7/13/95	1140	69	7.4	132	0.5							0.06			
7/20/95	1355	79	7.9	241	1.3							0.16			
7/27/95	700	74	7.6	428	1.6							0.28	48	65	110
8/3/95	1621	76	7.9	285	1.1							0.16			
8/10/95	1345	78	7.8	620	2.0							0.31			
8/17/95	1430	74	7.9	581	2.2							0.33			
8/24/95	1535	78	8.5	542	1.7							0.27			
8/31/95	724	65	8.1	420	1.8							0.25	45	58	100
9/7/95	1354	76	8.4	446	1.9							0.23			
9/15/95	1354	74	7.9	350	1.5							0.18			
9/22/95	1523	70	8	214	0.9							0.11			
9/28/95	718	67	7.29	245	0.8							0.10	25	29	60
Count		47	42	46	48	5	3	3	3	3	3	48	12	12	12
Min		47	6.1	123	0.4	1	3	3	9	<5	20	0.06	9	12	33
Max		79	8.9	1020	3.5	4	16	15	17	<5	28	0.56	140	140	200
Mean		63	7.8	488	1.4	2	9	7	9	<5	16	0.23	58	64	108
Geo Mean		62	7.8	400	1.2	2	7	6	6	<5	7	0.20	42	51	94
Median		64	7.8	429	1.3	2	8	4	9	<5	20	0.25	47	62	105