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 1990 TO SEPTEMBER 1991

(WATER YEAR 1991)

JUNE 1992

DISCLAIMER

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SUMMARY

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. The objectives of this monitoring program are:

1. to assess existing water quality conditions;
2. to provide a long-term database for assessing the effects of future regulatory actions;
3. to provide a database to assess potential long-term aquatic ecosystem impacts including in-stream biotoxicity testing being conducted by Regional Board staff; and
4. to provide a database to validate the San Joaquin River Input-Output Model (SJR10-1) described in Appendix C of the State Water Resources Control Board (SWRCB) Order No. WQ 85-1 Technical Committee Report on "*Regulation of Agricultural Drainage to the San Joaquin River*" which was released in August 1987.

Selected mineral and trace element constituents were measured for total recoverable concentrations at eight 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 six sites and monthly for the remaining two sites. Samples were analyzed for electrical conductivity (EC), boron, chloride, total alkalinity, selenium, and, at selected sites, molybdenum. A previous report has been issued for data collected from May 1985 through March 1988 (James, *et al.*, 1988). Similar reports have been prepared for the periods 1 October 1987 to 30 September 1988 (Westcot, *et al.*, 1989), 1 October 1988 to 30 September 1989 (Westcot, *et al.*, 1990a), and 1 October 1989 to 30 September 1990 (Westcot, *et al.*, 1991). The present report covers WY 91 (1 October 1990 to September 1991), a fifth consecutive critically dry year.

The general trend in constituent concentrations along the San Joaquin River study area during WY 91 continues to be that the lowest concentrations occur at the upstream and downstream 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 streams diluted the River.

Chloride, boron, sulfate, EC, selenium, molybdenum, uranium and vanadium values in the river appear to be directly related to climatic and streamflow conditions in the river basin. During the critically dry 1987-91 water years (WYs) constituent concentrations were routinely higher than they were during the wet 86 WY. During WY 91 these same constituents also show seasonal variations in concentrations with the highest levels occurring during the nonirrigation season (October to March).

In December 1988, the Regional Board adopted water quality objectives for the San Joaquin River. Objectives were set for molybdenum, boron and selenium. These objectives and associated compliance dates were approved by the State Water Resources Control Board in September 1989, the final month of WY 89.

Molybdenum water quality objectives are delineated by location on the river: upstream of the Merced River inflow (19 μg/L) and downstream of the Merced River inflow (10 μg/L). During WY 91, only one site, Lander Avenue, the single site upstream of the drainage inflows exceeded the water quality objectives for molybdenum. The noncompliance is a result of natural conditions and likely the result of the critically dry year. During WY 91, flows at the Lander Avenue site were very low and most flow resulted from ground water seepage.

Boron water quality objectives are delineated by location on the river, season, and water year type. Throughout WY 91, a critically dry year, four sites exceeded their respective approved boron objectives. Two of the sites, the San Joaquin River at Fremont Ford and the San Joaquin River at Hills Ferry, are upstream of the Merced River inflow (objective, 2.0 mg/L). Compliance with this objective begins in 1993. The other two, the San Joaquin River at Crows Landing and at Las Palmas Drive (near Patterson), are downstream of the Merced River inflow (objective 1.3 mg/L). Compliance with this objective begins October 1991.

In addition to selenium water quality objectives, milestones were also set for selenium to assess progress towards meeting the objectives. During WY 91, selenium concentrations in the San Joaquin River at both Hills Ferry and Fremont Ford exceeded the 1993 objective. The milestone set for WY 91 was also exceeded at the Fremont Ford site for 5 months out of the 12-month period. The milestone was not exceeded at the Hills Ferry site. In the downstream reach of the river, the Crows Landing site exceeded the adopted objective although it did not exceed the milestone for WY 91. Concentrations rapidly diminished farther downstream. Lack of freshwater dilution contributes to the higher concentrations found in the critically dry water years.

Water quality in the San Joaquin River will continue to be evaluated against objectives and milestones in upcoming water years.

INTRODUCTION

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. 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. This report contains the results of this monitoring program for data collected from October 1990 through September 1991. This period comprises Water Year 1991 (WY 91). Reports have been issued for data collected from May 1985 through September 1990 (WYs 86-90) (James, *et al.*, 1988; Westcot, *et al.*, 1989, 1990a, and 1991). This monitoring program was designed to complement 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 located 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 Mountains and contain relatively high quality water.

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 listed in this table. A full description of the inflow points that occur in this 60-mile section of the River are in James, *et al.*, (1989).

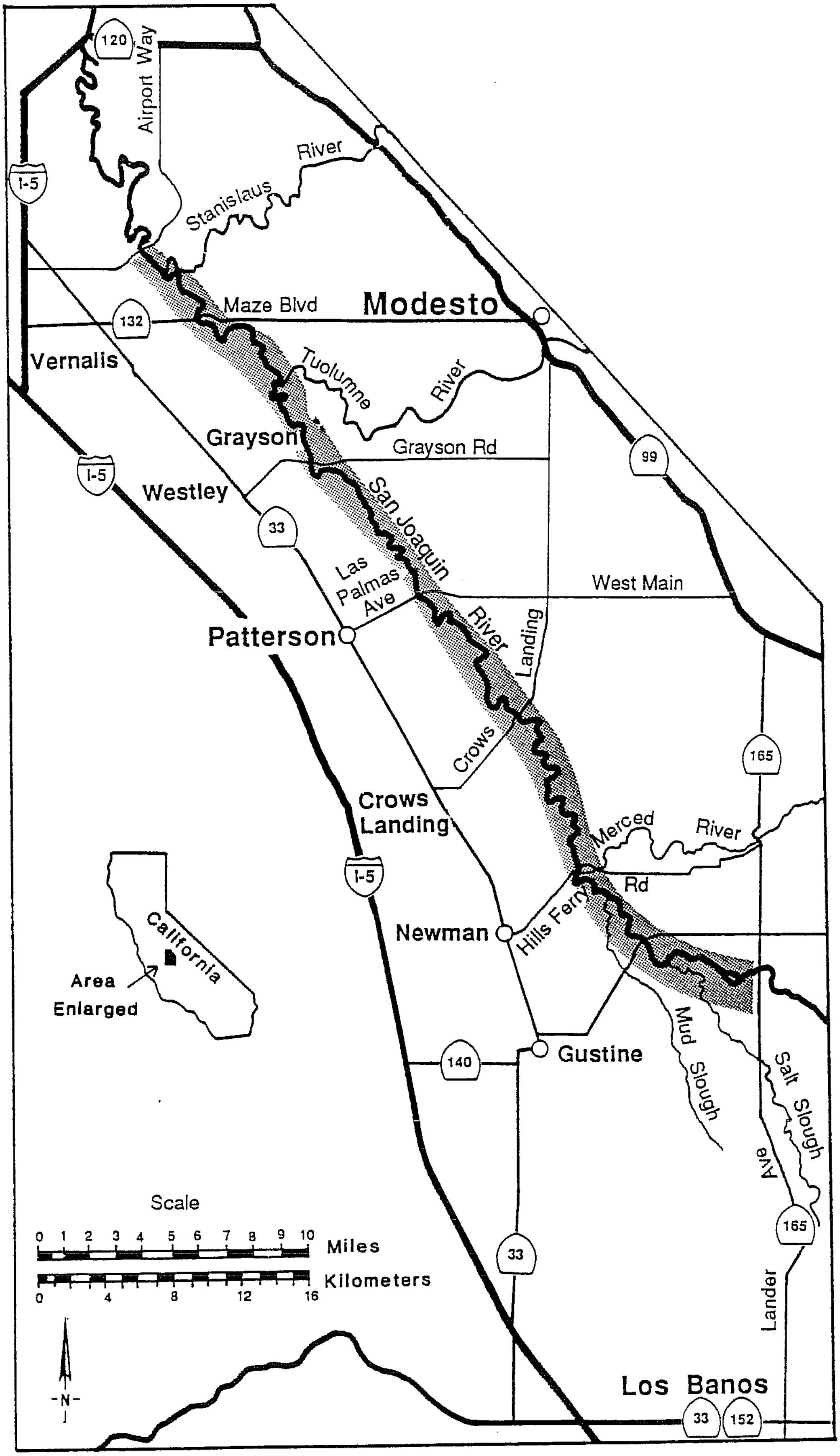


Fig. 1 Location Map

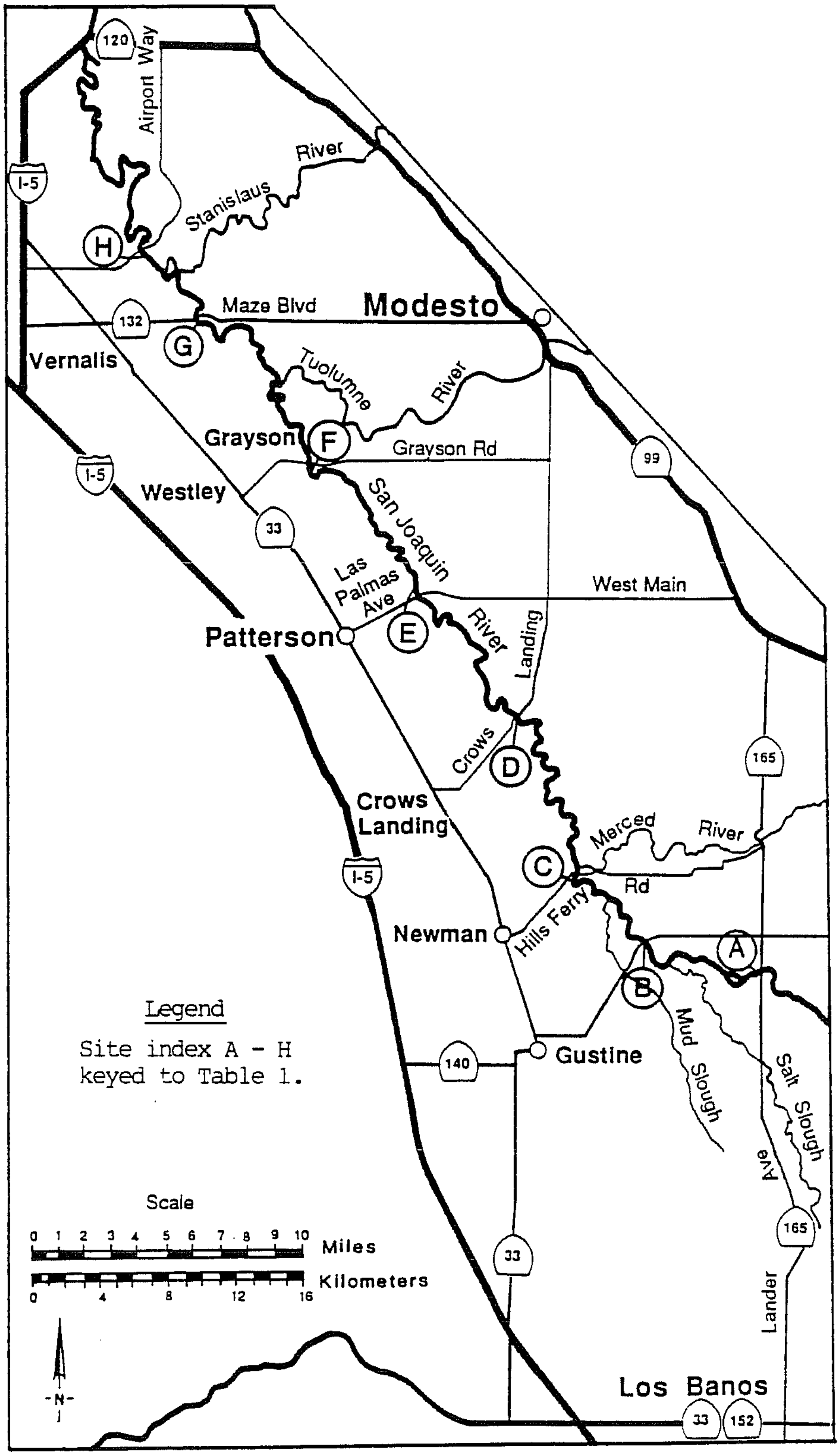


Fig. 2. Index Map

Table 1. Tributaries and Drains to the San Joaquin River Between Lander Avenue and Airport Way

River Mile	Description	Type*
132.9	**Lander Avenue (Site A)**	
129.7	Salt Slough	T,S
125.1	**Fremont 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 Collector Line I	T
117.2	Azevedo Road Drain	S
113.4	Freitas Rd. Drain + south of Freitas Rd. Drain	S
112.0	Turlock Irrigation District Lateral 6	S,O
109.0	Orestimba Creek	N,S
107.2	**Crows Landing Road (Site D)**	
105.0	Spanish Grant, Marshall Rd., Moran Rd. Drain	S,T
103.5	Turlock Irrigation District Lateral 5	S
100.0	Ramona Lake Main Drain	S,T
098.6	Patterson Water District Main Drain	S,T
098.4	**Las Palmas Launching Facility (Site E)**	
097.6	Olive Avenue Drain	S
097.3	Lemon Avenue Drain	S
097.0	Eucalyptus Avenue Drain	S
095.2	Turlock Irrigation District Lateral 3	S
092.9	Del Puerto Creek	N,S
091.4	Houk Ranch Drain	S,T
090.3	Turlock Irrigation District Lateral 2	S
089.1	**Grayson Road (Site F)**	
087.0	Old San Joaquin River Channel	S
083.7	Tuolumne River	N
081.1	Merced Irrigation District Lateral 4	S
079.9	Hospital/Ingram Creeks	S,T
078.9	Center Road Drain	S
077.6	El Solyo Drain	S,T
077.4	Blewett Drain	S
077.3	**Maze Boulevard (Site G)**	
074.9	Stanislaus River	N
073.6	**Airport Way (Site H)**	

* LEGEND

S Surface Agricultural Drain
T Subsurface Agricultural Drain
N Natural Stream
O Operational Spillage

TEMPORAL VARIATIONS IN STREAMFLOW

A water year (WY) extends from 1 October of one year to 30 September of the following year. The average yearly flows of the San Joaquin River vary considerably between WYs. Streamflows in WY 85 and WYs 87-90 were below the long-term average and in WY 86 they were above average. WY 91, presented in this report, was also below average and was classified as a critically dry year based upon the criteria described in James, *et al.*, 1988. WYs 87 through 90 were also classified as critically dry years. The 91 WY was the first instance where a critically dry year followed four previous critically dry years.

METHODS

The Regional Board monitoring program for the San Joaquin River began in May 1985 and has continued through the 1991 WY. The frequency of sample collection varies, but generally grab samples were collected on a monthly basis. However, due to the extreme dry conditions encountered in WY 91, the sampling frequency was increased. Sample collection in WY 91 began weekly for six sites and monthly for the remaining two sites. As of 15 February, all eight sites were being sampled on a weekly basis, and due to extreme drought and the low flows projected in the San Joaquin River for the late summer, the sampling frequency was increased to 2-3 times a week from 1 May until 30 September. All samples were analyzed for electrical conductivity (EC), total recoverable selenium, and boron. Selected samples were also analyzed for molybdenum, chloride, sulfate and total hardness. Samples collected at the Hills Ferry Road site were analyzed for total recoverable copper, chromium, nickel, lead, zinc, selenium, molybdenum, and a full general mineral analysis on a monthly basis. Data recorded in the field included time, temperature, pH, and EC.

Selenium and trace element samples were preserved with ultra-pure nitric acid to lower the pH of the sample to two or less. Mineral samples were kept on ice until submitted to the laboratory for analysis. A quality control and quality assurance program was conducted. Spike and duplicate samples were utilized in the laboratory. In addition, blind replicate samples were collected at 10 percent of the sites and 50 percent of the blind replicates were spiked for laboratory quality assurance. Reported results fall within quality assurance tolerance guidelines.

RESULTS

Concentrations of boron and selenium in WY 91 followed a consistent pattern along the San Joaquin River study area. The lowest concentrations generally occurred at the upstream study site at Lander Avenue while the highest concentrations occurred just downstream at Fremont Ford and Hills Ferry Road, which are located below the Salt Slough and Mud Slough (north) confluences, respectively (Figure 2). Downstream of the Hills Ferry Road site there was a progression of decreases in constituent concen-trations as the Merced, Tuolumne, and Stanislaus Rivers each inflowed and diluted the San Joaquin River. These results are consistent with findings in WY 86 through WY 90 (James, *et al.*, 1988 and Westcot, *et al.*, 1989, 1990a and 1991). Results of weekly water quality analysis for minerals and trace elements are listed by site in Appendix A, Tables 1A-8A. The ranges and median concentrations at each site for selected mineral constituents and selenium and boron are shown in Table 2.

Table 2. Summary of Selected Mineral and Trace Element Water Quality Data from the San Joaquin River for the Critical Water Year (October 1990 - September 1991).

		AIRPORT WAY	MAZE BOULEVARD	GRAYSON ROAD	LAS PALMAS AVENUE	CROWS LANDING	HILLS * FERRY RD.	FREMONT FORD	LANDER AVENUE
EC	Minimum	410	530	600	560	560	750	600	150
(µmhos/cm)	Median	990	1280	1670	1735	1720	2620	2620	2235
	Maximum	1680	1750	2310	2450	2490	4360	4290	3420
	# Samples	(54)	(54)	(38)	(38)	(53)	(53)	(52)	(52)
Cl	Minimum	74	80	110	120	120	90	160	31
(mg/L)	Median	140	170	240	260	240	460	410	480
	Maximum	180	260	360	360	360	780	730	630
	# Samples	(12)	(13)	(13)	(13)	(13)	(35)	(12)	(13)
SO4	Minimum	91	100	140	160	170	110	170	22
(mg/L)	Median	110	140	240	280	270	530	565	140
	Maximum	190	280	420	460	480	1100	1100	290
	# Samples	(12)	(13)	(13)	(13)	(13)	(35)	(12)	(13)
HDNS	Minimum	130	130	160	100	190	160	260	80
(mg/L)	Median	220	260	345	350	345	580	575	220
	Maximum	260	380	510	520	500	950	960	480
	# Samples	(12)	(13)	(13)	(13)	(13)	(35)	(12)	(13)
B	Minimum	0.20	0.30	0.30	0.30	0.30	0.50	0.40	0.10
(mg/L)	Median	0.50	0.60	0.90	1.0	1.1	1.9	2.0	0.40
	Maximum	1.2	1.3	1.7	1.9	2.1	3.4	4.4	0.80
	# Samples	(54)	(54)	(38)	(38)	(53)	(53)	(52)	(52)
Se	Minimum	0.5	0.8	1.0	0.6	0.7	1.0	0.9	0.2
(µg/L)	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	Minimum	1.0				0.6	1.0	1.0	0.3
(µg/L)	Median	2				6	12	12	22
	Maximum	4				9	19	35	74
	# Samples	(45)				(42)	(44)	(36)	(43)

* Additional data ranges for Ca, Mg, Na, K, Tot. Alk., TDS, Cu, Cr, Pb, Ni, and Zn for the Hills Ferry Road site are given in Appendix A, Table 3A.

The ranges and median values at each monitoring site are graphically represented for EC, chloride, sulfate, boron, selenium and molybdenum in Appendix B, Figures 1B through 6B, respectively. These graphs show the general trend in concentrations of these selected minerals and trace elements along the entire study area. For sulfate, boron and selenium, the lowest concentrations occurred at Lander Avenue, the upstream study end point, while the highest concentrations occurred at the next two downstream sites, Fremont Ford and Hills Ferry Road. The Lander Avenue site represents upstream background concentrations as no subsurface drainage water enters the river prior to this site. During dry and critically dry years, flow at this site is greatly reduced. The sites at Fremont Ford and Hills Ferry Road contain significant amounts of subsurface drainage water which enters upstream of these sites, but below Lander Avenue. Downstream of the Hills Ferry Road site, the Merced River inflows and dilutes the river, thus concentrations at the next three downstream sites are lower than at Hills Ferry Road. These three sites, Crows Landing, Las Palmas Avenue, and Grayson Road, are located between the Merced and Tuolumne Rivers and their concentrations do not change significantly between these sites. The concentrations were further reduced in the river downstream of the Tuolumne and Stanislaus River inflows as measured at Maze Boulevard and Airport Way, respectively. The trend of decreasing concentrations as you move downstream are shown for boron, EC and selenium in Figures 3, 4 and 5, respectively. This downstream trend was also recorded by Gilliom (1986) and Clifton and Gilliom (1988). During an above normal water year, such as was found in WY 86, the quality at Lander Avenue (upstream site) is essentially the same as that found at the downstream site at Airport Way (Vernalis) due to dilution from eastside streams. In dry or critically dry water years, the upstream site often shows consistently poorer quality water than the downstream site at Airport Way. In addition, molybdenum, chloride and EC are strongly elevated at the upstream Lander Avenue site with median concentrations approaching or exceeding those found further downstream after the discharge of subsurface drainage water. This poorer quality water at the upstream site is likely due to low flow conditions in the River at that point during WY 91.

The Fremont Ford site had the highest annual median EC (2625 μmhos/cm), boron (2.0 mg/l), sulfate (565 mg/l) and selenium (13 μg/l), though these values were only slightly higher than those at Hills Ferry Road. These high values suggest that in WY 91, the majority of subsurface drainage water discharged to the river was transported through Salt Slough. This was also the case in WY 89. In WYs 85-88 and 90, the highest median values of these constituents were found at the Hills Ferry Road site, as both Salt Slough and Mud Slough (north) were used to transport subsurface drainage water to the river.

Even though the annual median concentration for selenium was highest at Fremont Ford, the water concentrations dropped significantly beginning 24 June 1991 and lasted throughout the remainder of WY 91. This decrease coincided with a decrease in discharge of drainage water to Salt Slough. This decrease in discharge resulted from increased recycling of drainage water and diversion of drainage water to Mud Slough (north). Mud Slough (north) showed a simultaneous raise in selenium concentrations (Westcot, *et al.*, 1992). As a result of the drainage water discharge through Mud Slough (north) the concentrations at the next downstream site (Hills Ferry Road) were higher than those at the Fremont Ford site which is immediately downstream of Salt Slough. Selenium concentrations are the best illustration of the drainage inflow, as the discharge of subsurface agricultural drainage water is the source of greater than 95 percent of the selenium in the river (SWRCB, 1987).

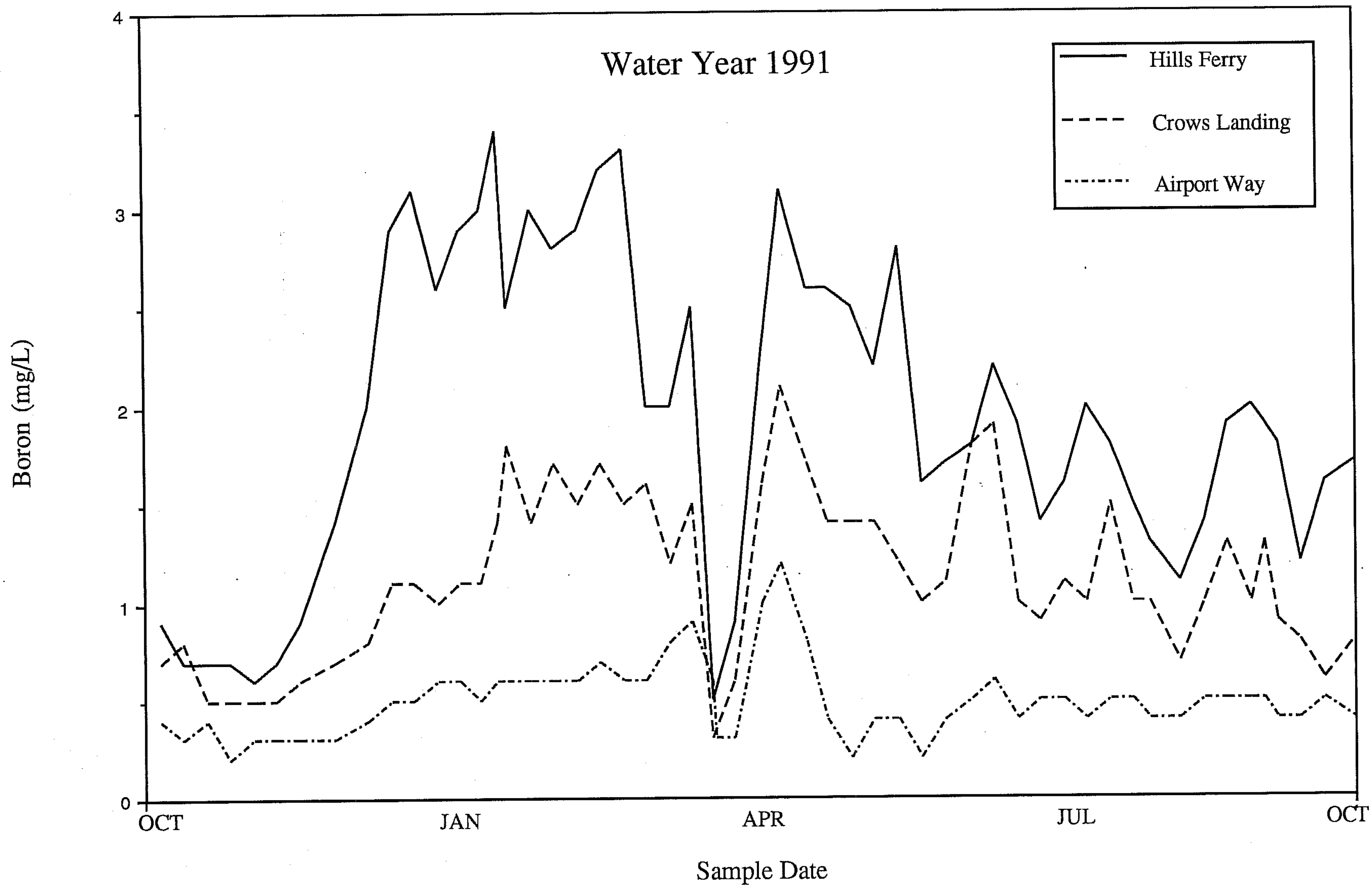


Figure 3. Boron Concentrations at Three Monitoring Locations Along the Lower San Joaquin River in Water Year 1991.

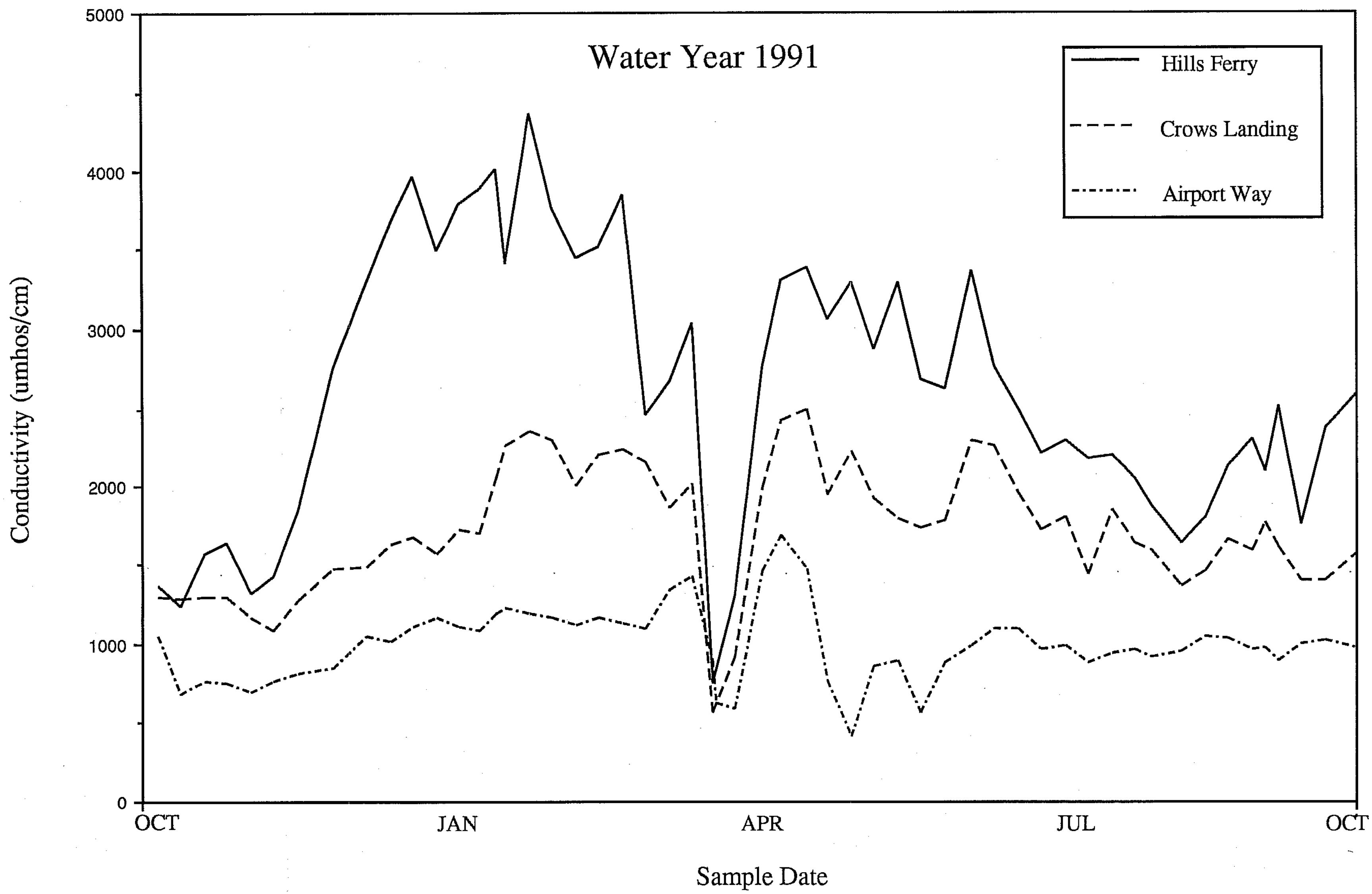


Figure 4. Electrical Conductivity at Three Monitoring Locations Along the San Joaquin River in Water Year 1991.

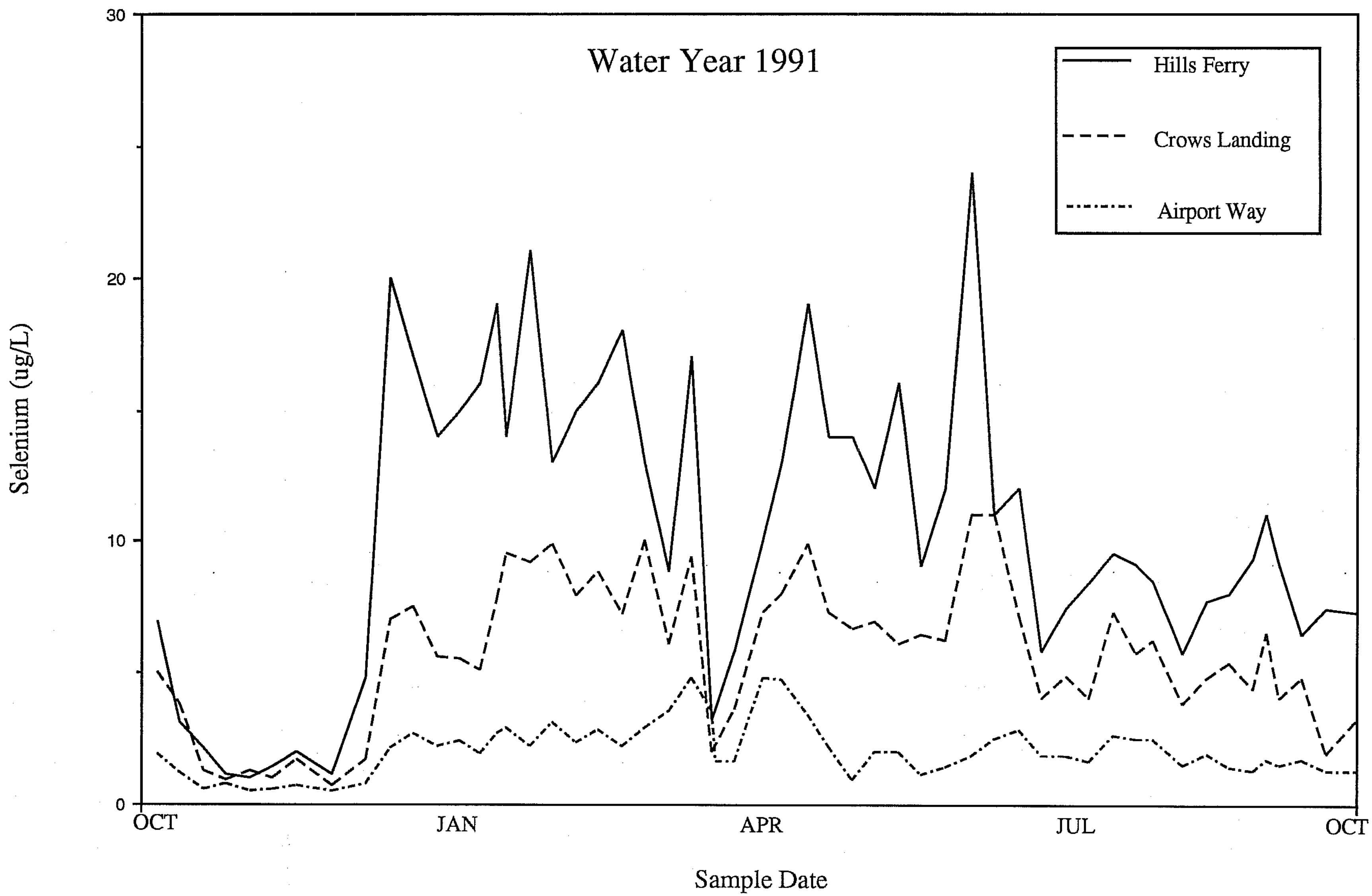


Figure 5. Selenium Concentrations at Three Monitoring Sites Along the San Joaquin River in Water Year 1991.

Following a trend noticed in the 86-90 WY data (James, *et al.*, 1988 and Westcot, *et al.*, 1989, 1990a and 1991) EC and boron values are generally highest during the drier water years (including WY 91). EC and boron values for the critical 87 through 91 WYs were routinely higher than they were during the wet 86 WY. As shown by James, *et al.*, (1988) at the Hills Ferry Road site during the wet 86 WY, the median EC value was 1100 µmhos/cm (Table 3). The median EC value increased in the critical 87 WY to 1720 µmhos/cm. During the fifth consecutive critically dry 91 WY, the median EC value was 2620 µmhos/cm (Figure 6). Boron values followed the same trend except that during the last two years, median boron concentrations appear to be leveling off. The data, however, is insufficient to make any long term trend observations.

The EC and boron values along the river do impose a slight to moderate degree of restriction on the use of river water for irrigation. Extreme EC and boron values at Fremont Ford and Hills Ferry Road have been high enough to impose severe restrictions for irrigation, but these extreme values occurred during the nonirrigation season.

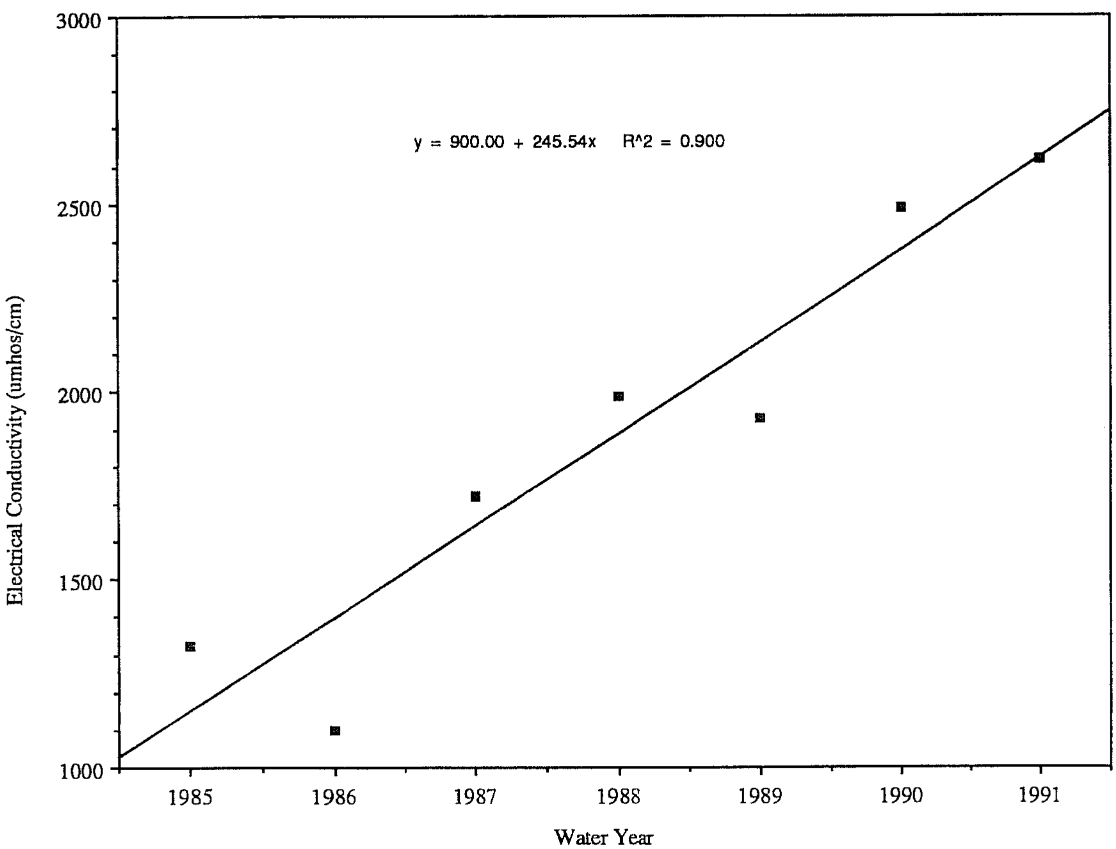


Figure 6. Median Electrical Conductivity at the Hills Ferry Road Site for Water Years 85 - 91

Table 3. Ranges of Electrical Conductivity and Boron Concentration by Water Year (WY) Type for Monitoring Sites Along the Lower San Joaquin River (Data for WY 85, WY 86, and WY 87 taken from James, et al., 1988. Data for WY 88, WY 89, and WY 90 taken from Westcot et al., 1989, 1990, and 1991).

WY 1985 DRY		AIRPORT WAY	MAZE BOULEVARD	GRAYSON ROAD	LAS PALMAS AVENUE	CROWS LANDING	HILLS FERRY	FREMONT FORD	LANDER AVENUE
EC (µmhos/cm)	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	1.10	0.93	0.10
	Maximum	0.45	0.60	0.78	0.86	0.85	1.60	1.20	0.36
	# Samples	(6)	(6)	(5)	(6)	(6)	(6)	(6)	(5)
WY 1986 WET		AIRPORT WAY	MAZE BOULEVARD	GRAYSON ROAD	LAS PALMAS AVENUE	CROWS LANDING	HILLS FERRY	FREMONT FORD	LANDER AVENUE
EC (µmhos/cm)	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		AIRPORT WAY	MAZE BOULEVARD	GRAYSON ROAD	LAS PALMAS AVENUE	CROWS LANDING	HILLS FERRY	FREMONT FORD	LANDER AVENUE
EC (µmhos/cm)	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	3.2	0.35
	# Samples	(15)	(11)	(11)	(11)	(15)	(13)	(14)	(15)
WY 1988 CRITICAL		AIRPORT WAY	MAZE BOULEVARD	GRAYSON ROAD	LAS PALMAS AVENUE	CROWS LANDING	HILLS FERRY	FREMONT FORD	LANDER AVENUE
EC (µmhos/cm)	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)

Table 3 Continued. Ranges of Electrical Conductivity and Boron Concentration by Water Year (WY) Type for Monitoring Sites Along the Lower San Joaquin River (Data for WY 85, WY 86, and WY 87 taken from James, et al., 1988. Data for WY 88, WY 89, and WY 1990 taken from Westcot et al., 1989, 1990, 1991.)

WY 1989 CRITICAL		AIRPORT WAY	MAZE BOULEVARD	GRAYSON ROAD	LAS PALMAS AVENUE	CROWS LANDING	HILLS FERRY	FREMONT FORD	LANDER AVENUE
EC (µmhos/cm)	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		AIRPORT WAY	MAZE BOULEVARD	GRAYSON ROAD	LAS PALMAS AVENUE	CROWS LANDING	HILLS FERRY	FREMONT FORD	LANDER AVENUE
EC (µmhos/cm)	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)
WY 1991 CRITICAL		AIRPORT WAY	MAZE BOULEVARD	GRAYSON ROAD	LAS PALMAS AVENUE	CROWS LANDING	HILLS FERRY	FREMONT FORD	LANDER AVENUE
EC (µmhos/cm)	Minimum	410	530	600	560	560	750	600	150
	Median	990	1280	1670	1735	1720	2620	2620	2235
	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)

Selenium concentrations at the Hills Ferry site followed the same general trend observed for EC and boron with the highest median concentrations occurring during the critically dry 87 through 91 WYs. The median value for WY 91 is 9.5 µg/L. Similar trends were observed at downstream sites. The median concentrations for selenium, like those for boron, appear to be leveling off at the upstream stations. This may be due to the extensive drainage water reuse that took place in WY 91. Figures 7 and 8 show the selenium concentrations with time for selected water years at the Crows Landing site (Index D) and the Maze Road site (Index G). Figures 9 and 10 show the boron concentrations for the same water years and sites. As can be seen in all these figures, during dry and critically dry years the time of year patterns remain the same, with the exception of a sharp dip in the WY 91 concentrations that correspond to an anomalous high rainfall event in late March 1991. One possible explanation for this consistent pattern is that during times of low streamflow, as found in critically dry water years, agricultural drainage water makes up a larger proportion of the San Joaquin River flow and consequently, constituents associated with this drainage water become the dominating influence on the River.

The upstream Lander Avenue site is considered the background water quality site for this study. However, in WY 91 the highest median values for molybdenum (22 µg/L) occurred at the Lander Avenue site which is upstream of the discharge of tile drainage (Table 4). This pattern of elevated molybdenum concentrations has been consistent throughout the five critically dry years. These levels are not caused by subsurface drainage water, as shown by the continued low concentrations of sulfate, boron, and selenium (Figures 3B, 4B, and 5B in Appendix B), all of which are chief components of the drainage water. Prior to WY 87, which was the first critically dry year (James, *et al.*, 1988), median quality at the Lander Avenue site was comparable to that at Vernalis. However, as seen in WY 88, WY 89, WY 90 (Westcot, *et al.*, 1989, 1990a and 1991) and WY 91, all critically dry years, conditions have produced a change including higher median EC levels and molybdenum concentrations and lower median selenium and boron concentrations at Lander Avenue as compared to the Vernalis site. Because of the very dry conditions in WY 91, flow at the Lander Avenue site was low. James, *et al.*, (1989) stated that flow at this point in the river is often made up of only ground water seepage into the river. The high median molybdenum concentration at this site and the very low median selenium concentration shown at the same time suggests that ground water seepage from the basin trough areas may be occurring (Deverel, *et al.*, 1984 and Chilcott, *et al.*, 1988).

James, *et al.*, (1988) also showed seasonal variations within a given water year. In their analysis, each water year was roughly divided into the irrigation and nonirrigation seasons. The irrigation season was defined to extend from April to September and the nonirrigation season from October to March. Comparing these two seasons showed the nonirrigation season generally had the higher EC, boron and selenium concentrations at each site along the river regardless of water year type. During the irrigation season surface irrigation return flows make up a large proportion of the San Joaquin River flow and these return flows have a diluting effect on the drainage water in the river. The Crows Landing site shows a steady increase in concentration each year after October, the nonirrigation season, regardless of water year type. Subsurface tile drainage lines are continuing to discharge at this time while surface irrigation return flows have ceased discharging to the river and no longer provide a diluting effect on the

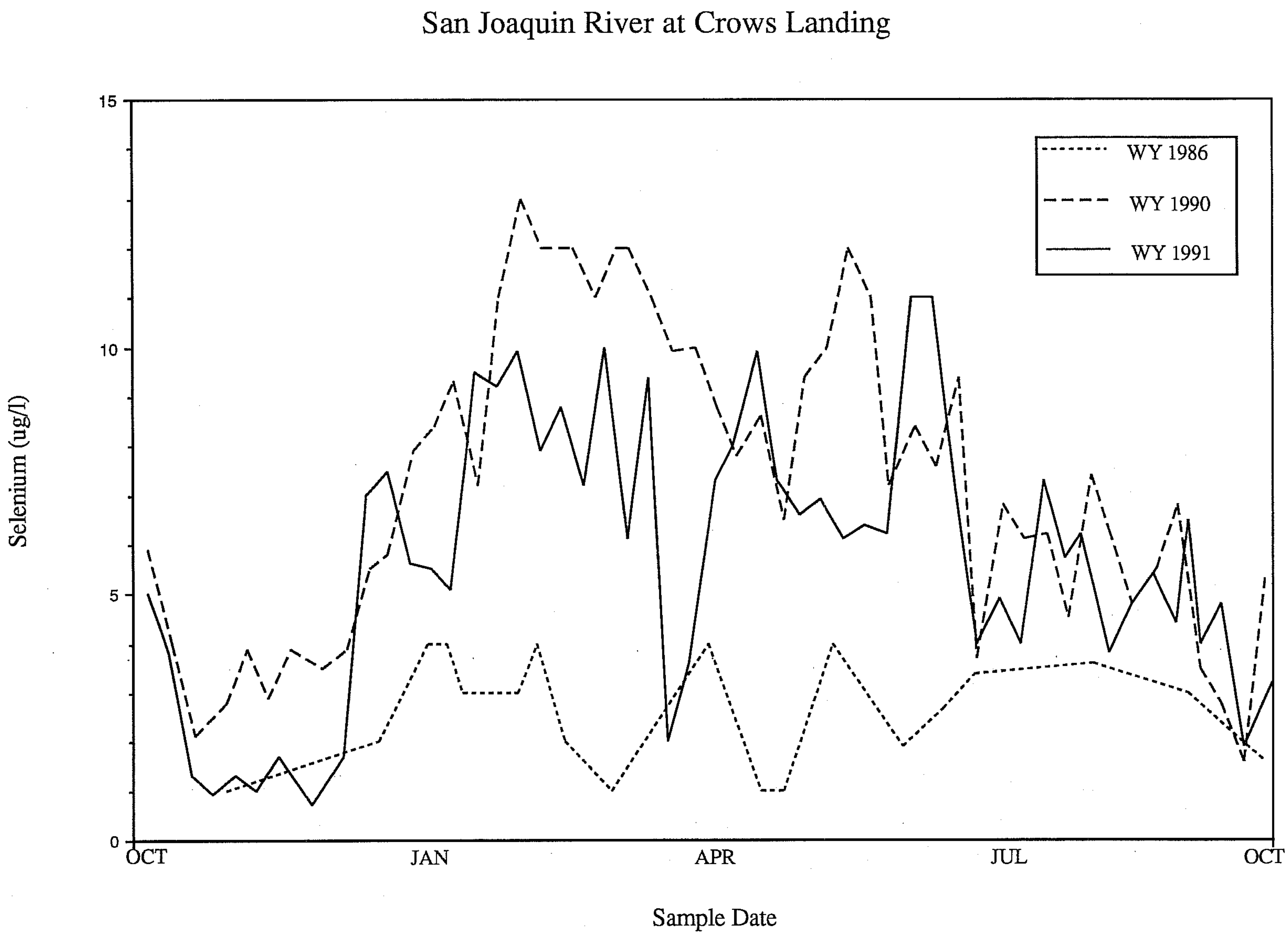


Figure 7. Selenium Concentrations at Crows Landing Road Along the Lower San Joaquin River for Water Years 1986, 1990 and 1991.

San Joaquin River at Maze Blvd.

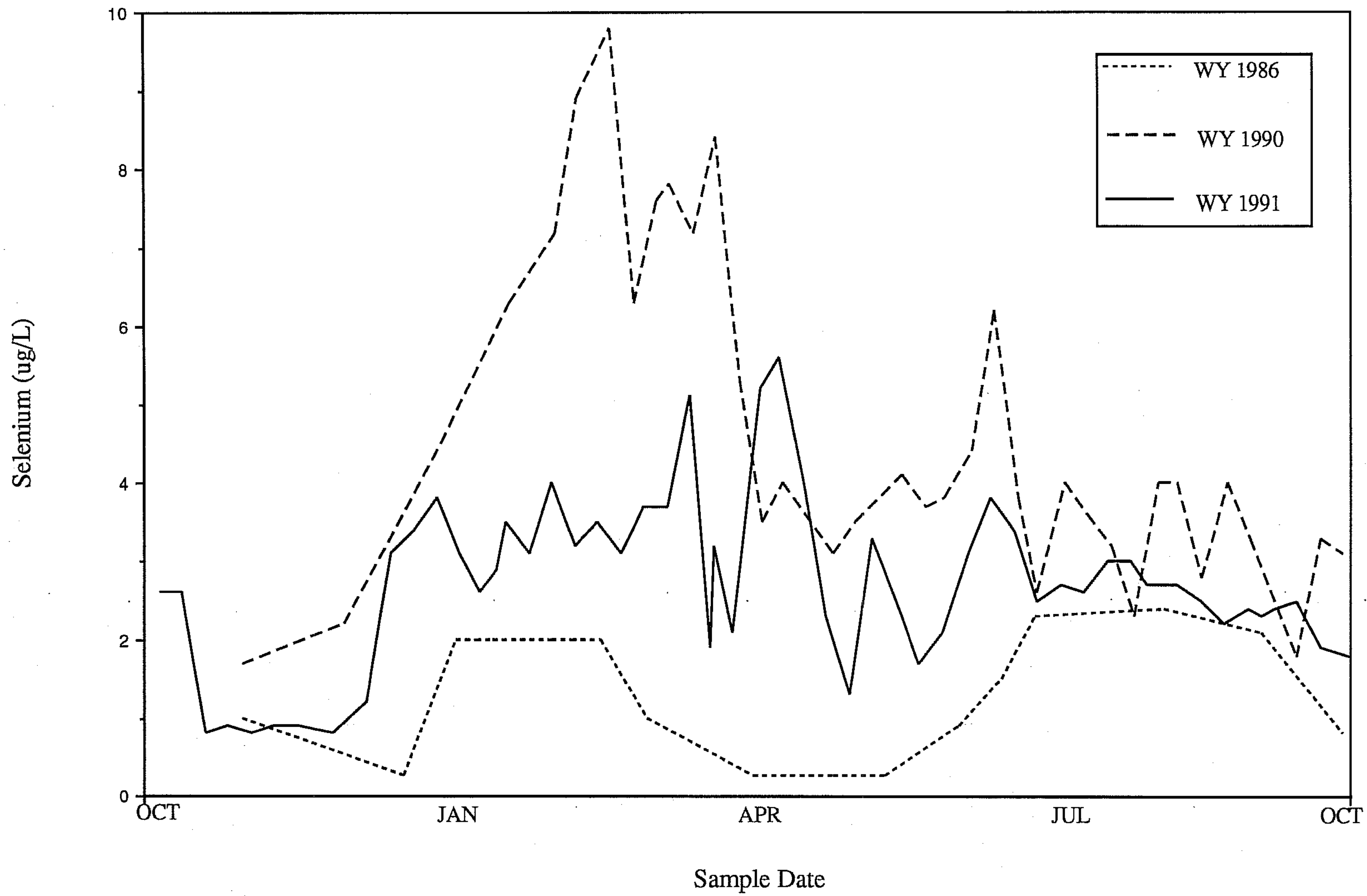


Figure 8. Selenium Concentrations at Maze Bvld. Bridge (Highway 132) Along the Lower San Joaquin River for Water Years 1986, 1990 and 1991.

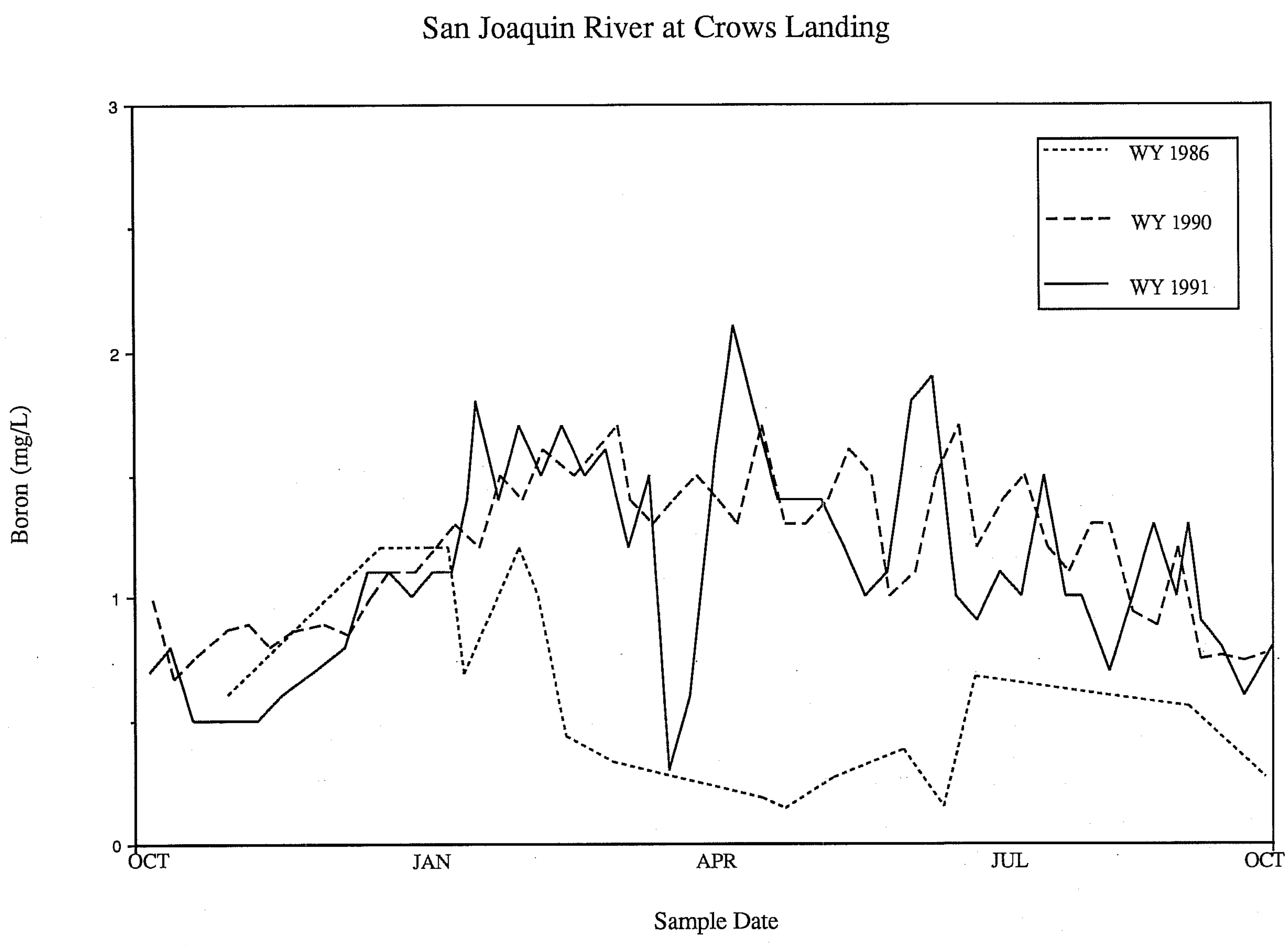


Figure 9. Boron Concentrations at Crows Landing Road Along the Lower San Joaquin River for Water Years 1986, 1990 and 1991.

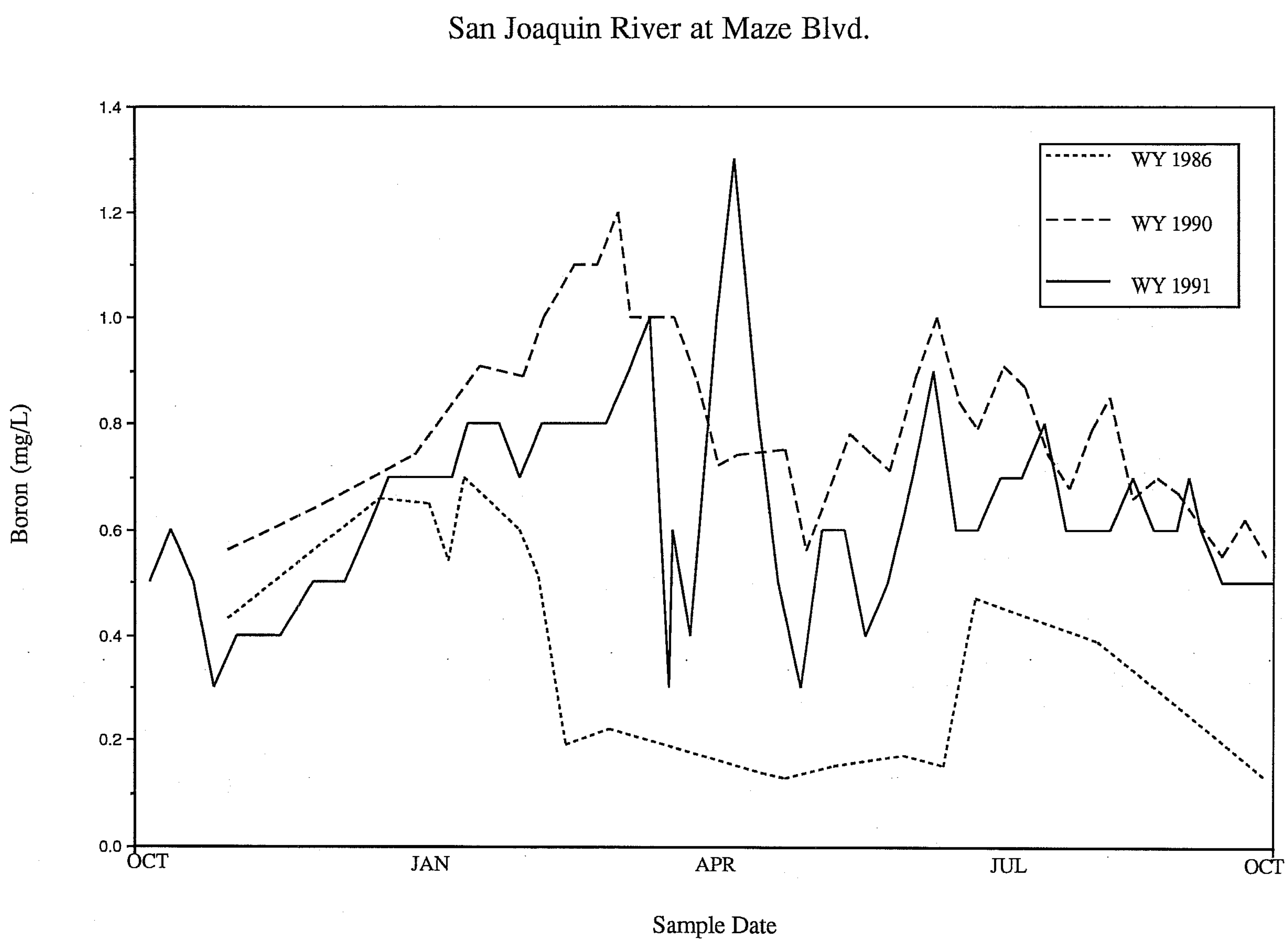


Figure 10. Boron Concentrations at Maze Blvd. Bridge (Highway 132) Along the Lower San Joaquin River for Water Years 1986, 1990 and 1991.

Table 4. Ranges of Selenium and Molybdenum Concentration by Water Year (WY) Type for Monitoring Sites Along the Lower San Joaquin River (Data for WY 85, WY 86, and WY 87 taken from James, et al., 1988. Data for WY 88, WY 89, and WY 90 taken from Westcot et al., 1989, 1990 and 1991.)

WY 1985 DRY		AIRPORT WAY	MAZE BOULEVARD	GRAYSON ROAD	LAS PALMAS AVENUE	CROWS LANDING	HILLS FERRY	FREMONT FORD	LANDER AVENUE
Se (µg/L)	Minimum	1	1	1	<1	1	1	<1	<1
	Median	1	2	2	3	3	4	3.5	<1
	Maximum	2	3	3	4	4	8	7	1
	# Samples	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(5)
WY 1986 WET		AIRPORT WAY	MAZE BOULEVARD	GRAYSON ROAD	LAS PALMAS AVENUE	CROWS LANDING	HILLS FERRY	FREMONT FORD	LANDER AVENUE
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		AIRPORT WAY	MAZE BOULEVARD	GRAYSON ROAD	LAS PALMAS AVENUE	CROWS LANDING	HILLS FERRY	FREMONT FORD	LANDER AVENUE
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		AIRPORT WAY	MAZE BOULEVARD	GRAYSON ROAD	LAS PALMAS AVENUE	CROWS LANDING	HILLS FERRY	FREMONT FORD	LANDER AVENUE
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)

Table 4 Continued. Ranges of Selenium and Molybdenum Concentration by Water Year (WY) Type for Monitoring Sites Along the Lower San Joaquin River (Data for WY 85, WY 86, and WY 87 taken from James, et al., 1988. Data for WY 88, WY 89 and WY 90 taken from Westcot et al., 1989, 1990 and 1991.)

WY 1989 CRITICAL		AIRPORT WAY	MAZE BOULEVARD	GRAYSON ROAD	LAS PALMAS AVENUE	CROWS LANDING	HILLS FERRY	FREMONT FORD	LANDER AVENUE
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		AIRPORT WAY	MAZE BOULEVARD	GRAYSON ROAD	LAS PALMAS AVENUE	CROWS LANDING	HILLS FERRY	FREMONT FORD	LANDER AVENUE
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)
WY 1991 CRITICAL		AIRPORT WAY	MAZE BOULEVARD	GRAYSON ROAD	LAS PALMAS AVENUE	CROWS LANDING	HILLS FERRY	FREMONT FORD	LANDER AVENUE
Se (µg/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 (µg/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)

water quality. Boron, EC and selenium concentrations at those locations along the river course during the irrigation and nonirrigation seasons are shown in Figures 3-5 for WY 91. Figures 7 and 8 show that the peak and low selenium concentration periods occurred at approximately the same time each year during the two critically dry water years (WY 90 and WY 91) and the absence of the well defined peaks during wet WY 86.

The water quality objectives established in the Basin Plan for the San Joaquin River are shown in Table 5. Other published water quality guidelines and criteria for the protection of beneficial uses are shown in Table 6. Current EPA guidelines and criteria, as shown in Table 6, are based on acid-soluble analyses. The more conservative total recoverable analyses values utilized in this monitoring program and used to develop Table 5 may not be directly comparable to the acid-soluble based criteria, but reliable methods for acid-soluble analyses have not been developed to date. Total recoverable data currently provides the closest comparison of water quality analyses to these protective guidelines and should provide a worst case example. A more in-depth discussion of San Joaquin River water quality during WY91 in relation to the water quality objectives outlined in Table 5 is presented in the next section on compliance.

The 91 WY median selenium values from Fremont Ford (13 μg/L) to Crows Landing Road (6.1 μg/L) equaled or exceeded the EPA ambient water quality criteria of 5 μg/L for the protection of freshwater aquatic life. Selenium concentrations at sites upstream of Hills Ferry Road routinely exceed the primary drinking water standard of 10 μg/L. A program to reduce drainage flow and river concentrations is being implemented and is expected to lower these concentrations. However, as shown in Table 5 different water quality objectives apply in critically dry years when little or no dilution flows will be available in the river.

The total recoverable trace element concentrations for copper, chromium, nickel, lead and zinc were only determined at the Hills Ferry Road site (Table 3A, Appendix A). One total recoverable chromium value at the Hills Ferry Road site exceeded the EPA ambient water quality criterion of 11 μg/L hexavalent chromium for the protection of fresh water aquatic life. The median values are well below this level. Acid-soluble hexavalent chromium levels were not evaluated in this study, but are expected to be lower than the total recoverable chromium values determined in this study. Dissolved concentrations, however, were greatly different from the total recoverable levels. As shown in Table 7, dissolved chromium levels were consistently <1 μg/L during the period of sampling. This difference between dissolved and total recoverable concentrations illustrates the need to continue to develop reliable dissolved data when total recoverable concentrations show elevated levels. The dissolved chromium values may better represent hexavalent chromium concentrations in the water column since hexavalent chromium would tend to be soluble under normal stream conditions.

Median and maximum total recoverable nickel and zinc values were all below the EPA guideline for the protection of freshwater aquatic life. The maximum value for total recoverable copper did not exceed the EPA guideline of 7.5 μg/L for a maximum nor did the median exceed the EPA guideline of 5.4 μg/L for protection of freshwater aquatic life. The EPA criteria for these elements are to be adjusted based on the hardness of the analyzed water with increasing hardness

Table 5 Water Quality Objectives as Adopted by the Central Valley Regional Board for the San Joaquin Basin (5C)

Constituent	Water Quality Objectives		Compliance Date
San Joaquin River, mouth of the Merced River to Vernalis (Delta Inflow)			
Selenium	5 µg/l monthly mean	12 µg/l maximum	WY92
	8 µg/l monthly mean (critical year only)		WY92
Molybdenum	10 µg/l monthly mean	15 µg/l maximum	WY90
Boron	0.8 mg/l monthly mean (15 March-15 Sept)	2.0 mg/l maximum	WY92
	1.0 mg/l monthly mean (16 Sept-14 March)	2.6 mg/l maximum	WY92
	1.3 mg/l monthly mean (critical year only)		WY92
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 maximum	WY94
Molybdenum	19 µg/l monthly mean	50 µg/l maximum	WY90
Boron	2.0 mg/l monthly mean (15 March-15 Sept)	5.8 mg/l maximum	WY94

increasing the criteria. Values listed in Table 6 are based on a hardness of 40 mg/L. Table 3A in Appendix A shows that median water hardness exceeds 550 mg/L at Hills Ferry. The criteria adjusted for hardness were never exceeded. Like chromium, however, the dissolved concentrations were all at or near the detection level for nickel, zinc, and copper. In no instance did the levels measured exceed the EPA guidelines for protection of freshwater aquatic life.

Table 6. Water Quality Guidelines and Criteria for the Protection of Beneficial Uses

Constituent	Domestic/Municipal Drinking Water			Ambient Water Quality Criteria to Protect Freshwater Aquatic Life			Irrigation Degree of Restriction on Use			Stock Water
	Primary	Secondary -µg/l- *	Other (Health)	4 Day Average	-µg/l- *	1 Hour Average	None	Slight to Moderate -mg/l- *	Severe	-mg/l- *
Arsenic	50			190		360	0.1			0.2
Boron							<0.7	0.7 - 3.0	>3.0	5
Cadmium	10			0.55[α]		1.4[α]	0.01			0.05
Chromium (VI)	50°			11		16	0.1			1
Copper		1000		5.4[α]		7.5	0.2			0.5
Iron		300					5			
Lead (inorganic)	50			0.99[α]		25[α]	5			0.1
Mercury	2			0.012		2.4				0.01
Molybdenum			50				0.01			
Nickel				73[α]		653[α]	0.02			
Selenium	10			5		20	0.02			0.05
Silver	50					13				
Zinc		5000		49[α]		54[α]	2			24
TDS (mg/l)		500∞					<450	450-2000	>2000	
EC							<700	700-3000	>3000	<5000

* Acid soluble metals
° Total Recoverable chromium
∞ Recommended value (Recommended level = 500 mg/l; Maximum = 1000 mg/L; Short term level = 1500 mg/l)
(References: Ayers and Westcot, 1985; EPA, 1987; EPA, 1985a; EPA 1985b; EPA, 1980; EPA, 1979; Marshack, 1987; SWRCB, 1991 and SWRCB, 1987.)
α Criteria increase with increasing hardness of the water. These values are based on a hardness of 40 mg/l.

The water quality objectives adopted for the San Joaquin River (Table 5) are based on total recoverable concentrations for boron, selenium, and molybdenum. Testing on all three trace elements in San Joaquin River water shows no difference between dissolved and total recoverable concentrations indicating that sediment plays an insignificant role in the concentrations measured by the total recoverable methods. The data presented in Table 7 and in Table 3A in Appendix A shows for chromium, copper, lead, nickel, and zinc, that sediment plays a key role in total recoverable concentrations and dissolved values may better represent environmental exposure in the water column.

Elevated uranium and vanadium concentrations have been associated with agricultural subsurface drainage discharge in the Tulare Lake Basin in California (Chilcott, *et al.*, 1990). Since the San Joaquin River may at times be heavily influenced by agricultural discharges, selected samples from the River at Lander Avenue, Hills Ferry, Crows Landing, and Airport Way were analyzed for uranium and vanadium.

Table 7. Dissolved Trace Element and Hardness Water Quality Data for the San Joaquin River South of Hills Ferry Road (site index C) (STC512) for WY 91, and Comparison With Total Recoverable Trace Element and Hardness Data

Dissolved Trace Element and Hardness Data

Sample Date	Cr	Cu	Pb	Ni	Zn	Hardness
	µg/L					mg/L
10/26/90	<1	1	<5	<5	<1	340
11/27/90	-	-	-	-	-	540
12/28/90	<1	<1	<5	<5	<1	740
1/25/91	<1	<1	<5	<5	<1	950
2/8/91	<1	<1	<5	<5	<1	730
2/22/91	<1	<1	<5	<5	<1	810
3/28/91	2	<1	<5	<5	<1	280
4/5/91	<1	<1	<5	<5	<1	570
4/25/91	<1	<1	<5	<5	<1	650
5/30/91	<1	<1	<5	<5	<1	580
6/28/91	<1	1	<5	<5	7	460
7/31/91	<1	3	<5	5	10	400
8/30/91	<1	1	<5	6	<1	480
9/30/91	<1	1.6	<5	<5	<5	490
Minimum	<1	<1	<5	<5	<1	280
Median	<1	<1	<5	<5	<1	555
Maximum	2	3	<5	6	10	950
Count	13	13	13	13	13	14

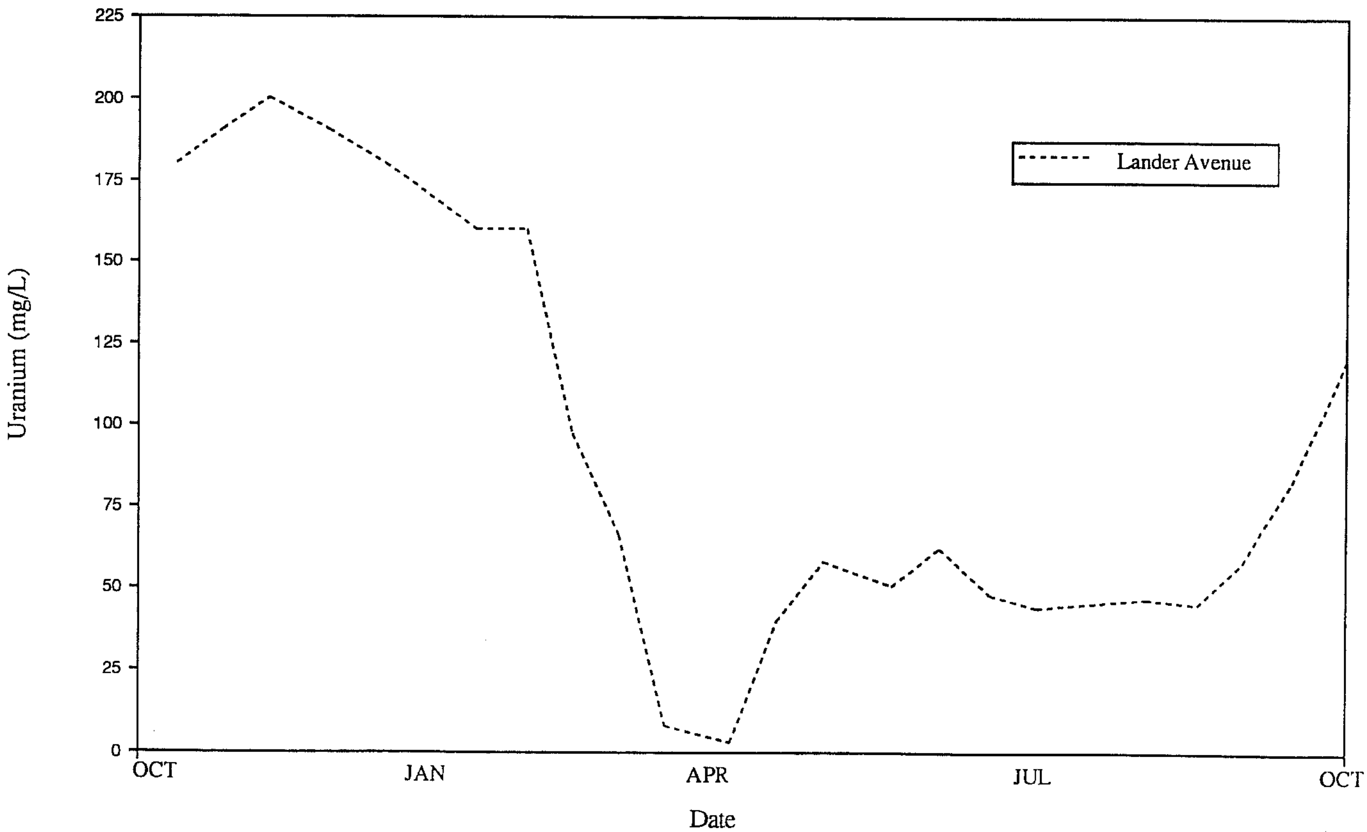
Total Recoverable Trace Element and Hardness Data (from Appendix A-5)

	Cr	Cu	Pb	Ni	Zn	Hardness
Minimum	<1	<1	<5	<5	2	160
Median	2	4	<5	3	5	580
Maximum	6	15	<5	12	11	950
Count	14	14	14	14	14	35

Overall concentrations for both elements were much lower than concentrations found in the Tulare Lake Basin. Uranium concentrations exceeded the 75th percentile concentration (4 μg/L) for California Streams as determined by Westcot, *et al.*, (1990b). Uranium concentrations for Hills Ferry, Crows Landing, and Airport Way ranged from 4 to 14 μg/L with a median concentration of 8 μg/L for each of the three sites. Samples collected from the San Joaquin River at Lander Avenue contained much higher concentrations of uranium. Only two samples from Lander Avenue, both collected during March 1991, contained uranium concentrations less than 40 μg/L, (at 3 and 8 μg/L, respectively). These low values coincided with runoff periods from major storm events. The remaining 21 samples, collected over the course of the water year, ranged in concentration from 40 μg/L to 200 μg/L with a median of 62 μg/L. Figure 11 shows the uranium concentration at Lander Avenue over time. Maximum concentrations occurred from October through January, a period of low flow due to lack of irrigation or major storm events during this fifth year of drought. The water collected at Lander Avenue during this time period is primarily made up of ground water seepage before it is influenced by any other surface flows. Surface flows, including agricultural drainage, appear to dilute the uranium concentrations as water moves downstream from Lander Avenue through the San Joaquin River Channel.

Vanadium was analyzed in selected samples collected from the San Joaquin River at Lander Avenue, Crows Landing, and Airport Way. Although samples collected at Lander Avenue did appear slightly higher in vanadium concentrations than those collected at the downstream locations, the overall range in values was low, with all reported concentrations falling between 2 μg/L and 23 μg/L. Median vanadium concentrations for Lander Avenue, Crows Landing, and Airport Way were 9 μg/L, 6 μg/L, and 6 μg/l, respectively.

Figure 11. Uranium Concentrations at Lander Avenue Along the Lower San Joaquin River.



COMPLIANCE WITH OBJECTIVES

In December 1988, the Regional Board adopted water quality objectives for the San Joaquin River. Various compliance dates were established for concentrations of selenium, molybdenum, and boron (Table 5). These objectives and compliance dates were to be effective with the Regional Board adoption and approval of the objectives by the State Water Resources Control Board, (State Board). State Board approved the objectives and compliance dates in September 1989, just prior to WY 90.

Two objectives for molybdenum apply to the San Joaquin River (Table 5). One objective applies upstream of the Merced River inflow, the second applies downstream of this point. Downstream of the Merced River inflow, as shown in Figure 12, mean monthly molybdenum concentrations were consistently below the adopted water quality objectives of 10 μg/L for this reach of the river. This same pattern of compliance can be seen at the Hills Ferry site above the Merced River inflow where the adopted water quality objective is 19 μg/L as a maximum monthly mean (Figure 13). As was also seen in WY 89 and WY 90, the maximum monthly mean was exceeded six months of WY 91 (Figure 13) at the Lander Avenue site, which is upstream of the drainage inflows. In WY 90, at the Lander Avenue site, greater than 50 percent of the samples collected exceeded the monthly mean for molybdenum (19 μg/L) established in the Basin Plan for the San Joaquin River, and in WY 91, greater than 60 percent exceeded this criterion. Approximately 35 percent of the samples exceeded the maximum (50 μg/L) concentration established in the Basin Plan (Table 5). The 50 μg/L maximum concentration in the Basin Plan is the draft EPA health advisory level (Table 6). This period of noncompliance is the result of natural conditions that may be modified as a result of WY 91 being a critically dry year, the fifth such in succession. During WY 91, flows at the Lander Avenue site were very low, and most flow resulted from ground water seepage. During the unexpected rains of late March, which resulted in high flows, molybdenum concentrations at Lander Avenue were comparable to those at the Hills Ferry Road site downstream.

In contrast to the elevated molybdenum concentrations, all monthly means for boron were less than or near 0.50 mg/L at the Lander Avenue site. Downstream of the drainage water inflows, boron concentrations at both the Fremont Ford and Hills Ferry Road sites increased significantly. Figure 14 shows the mean monthly boron concentrations as compared to the adopted water quality objective (Table 5), which is expected to be fully implemented by October 1993 (WY 94). This 2.0 mg/L objective was frequently exceeded during WY 91, although the objective only applies during the irrigation season (15 March through 15 September).

Downstream of the Merced River inflow, a different set of water quality objectives apply. These objectives are seasonal, as well as being modified, based upon critically dry water years. No provision was made for consecutive critically dry years. WY 91 is the fifth consecutive critically dry year. Figure 15 shows that the 1.3 mg/L boron objective was equaled or exceeded in 4 of the 12 months in WY 91 at Crows Landing Bridge. These high concentrations reflect the critically dry conditions in the river and the lack of dilution water for the subsurface tile drainage discharges. The current exceedences are in contrast to WY 89 where only one month exceeded the critical year objective.

Water quality objectives for selenium were also approved by the State Board. These objectives, like boron, vary with the location in the river and the type of water year (Table 5). In addition to the approved objectives the following milestones were used to assess progress towards meeting the selenium water quality objectives in the San Joaquin River.

MAXIMUM MONTHLY MEAN SELENIUM CONCENTRATIONS

Time Period	San Joaquin River Mouth of the Merced River to Vernalis		San Joaquin River, Sack Dam to Mouth of the Merced River
WY 90 (10/89-9/90)	Dry Year* Critical Year*	7 μg/L 10 μg/L	20 μg/L
WY 91 (10/90-9/91)	Dry year* Critical Year*	6 μg/L 9 μg/L	17 μg/L
WY 92 (10/91-9/92)	Dry Year* Critical Year*	5 μg/L 8 μg/L	15 μg/L

* Type of water year as defined in "Water Quality Control Plan for the San Joaquin Basin (5C)", 1975.

As with WY 89 and WY 90, in WY 91 the Lander Avenue site never had selenium concentrations that exceeded 2.0 μg/L with all monthly mean concentrations being less than 1 μg/L. This site is upstream of the subsurface tile drainage discharges to the river. Downstream of Lander Avenue, the discharges enter the river. Two monitoring sites exist below this point and prior to the Merced River inflow: they are Fremont Ford and Hills Ferry Road. Figure 16 shows the elevated selenium concentrations at these sites as compared to the adopted water quality objectives of 10 μg/l. Full implementation of this objective is not planned until 1993.

Downstream of the Merced River inflow, mean monthly selenium concentrations dropped as dilution inflows entered from the eastside streams. Figure 17 shows the monthly mean concentrations in comparison to the water quality objective for a critically dry year. This maximum monthly mean is to be fully implemented after October 1991 (WY 92). The milestones set for WY 90, as shown above, was not exceeded in WY 91. This continues to illustrate the critically dry conditions in the river for the fifth consecutive year and the need for further drainage flow reductions.

Figure 12. Mean Monthly Molybdenum Concentrations at Crows Landing (Site Index D) and Airport Way (Site Index H) for WY 91 as Compared to the Adopted Water Quality Objective for the San Joaquin River Downstream of the Merced River Inflow.

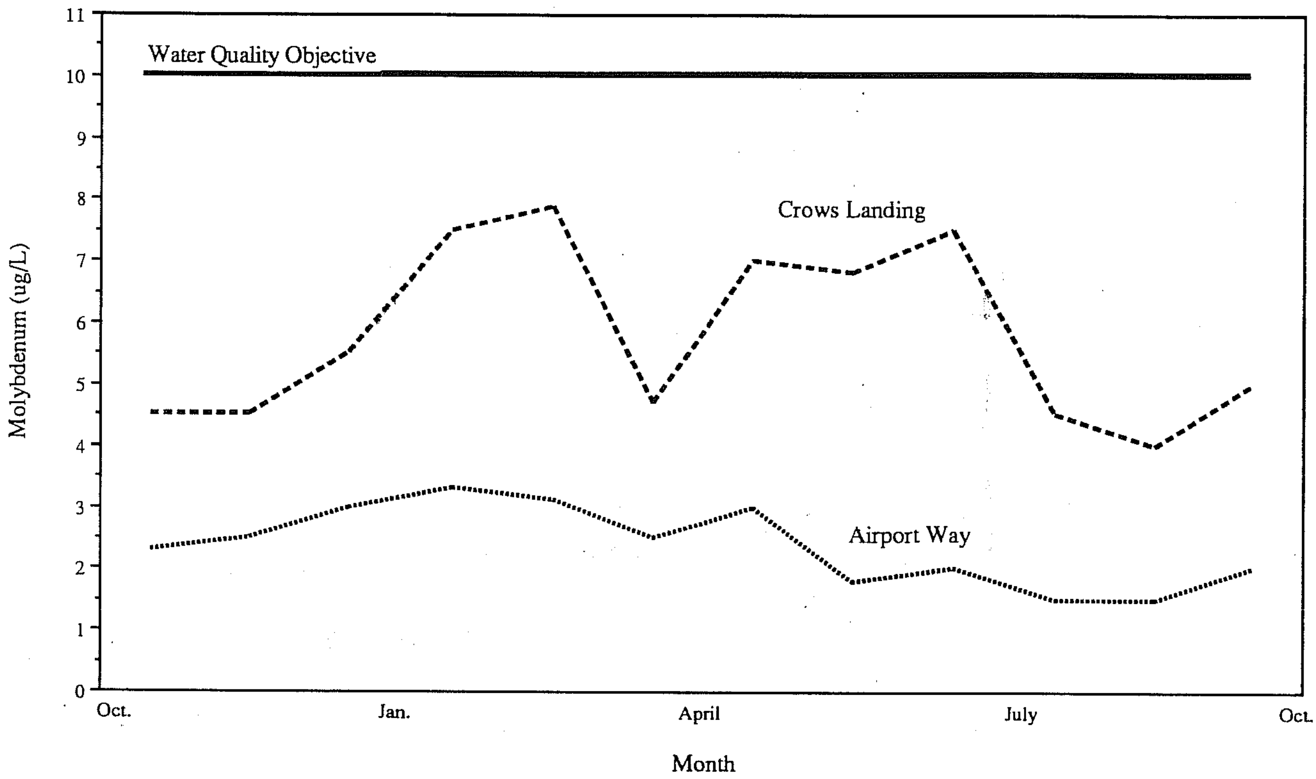


Figure 13. Mean Monthly Molybdenum Concentrations at Lander Avenue (Site Index A) and Hills Ferry (Site Index H) for WY 91 as Compared to the Adopted Water Quality Objective for the San Joaquin River Downstream of the Merced River Inflow.

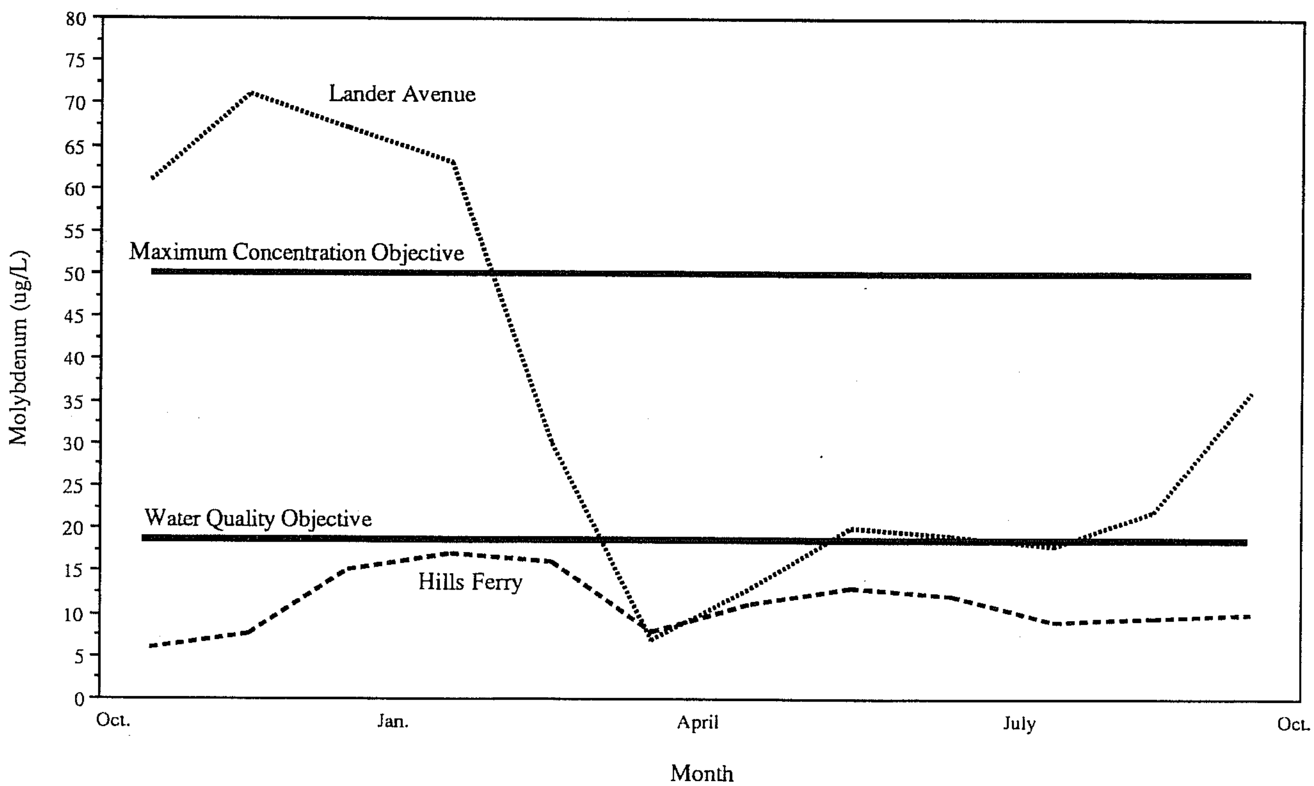


Figure 14. Mean Monthly Boron Concentrations at Fremont Ford (Site Index B) and Hills Ferry (Site Index C) for WY 91 as Compared to the Adopted Water Quality Objective for the San Joaquin River Upstream of the Merced River Inflow.

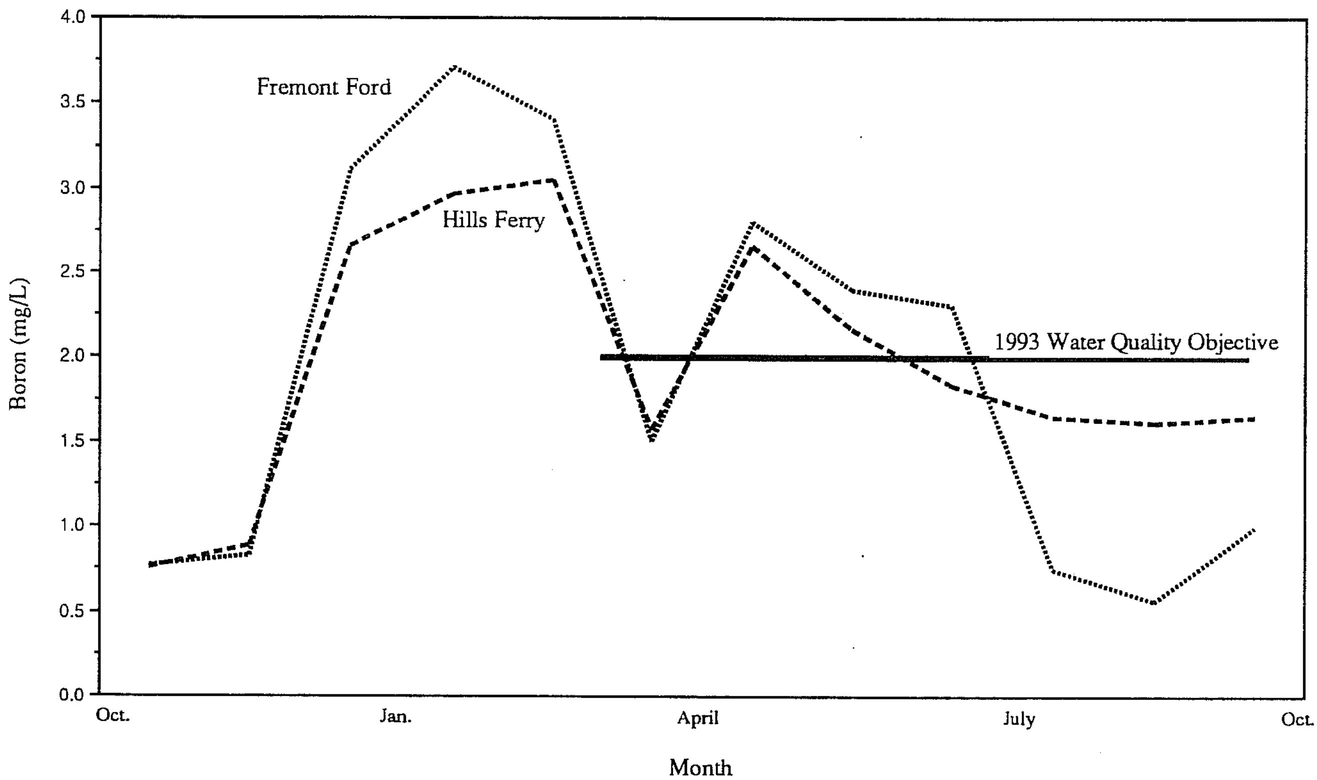


Figure 15. Mean Monthly Boron Concentrations at Crows Landing (Site Index D) and Airport Way (Site Index H) for WY 91 as Compared to the Adopted Water Quality Objective for the San Joaquin River Downstream of the Merced River Inflow.

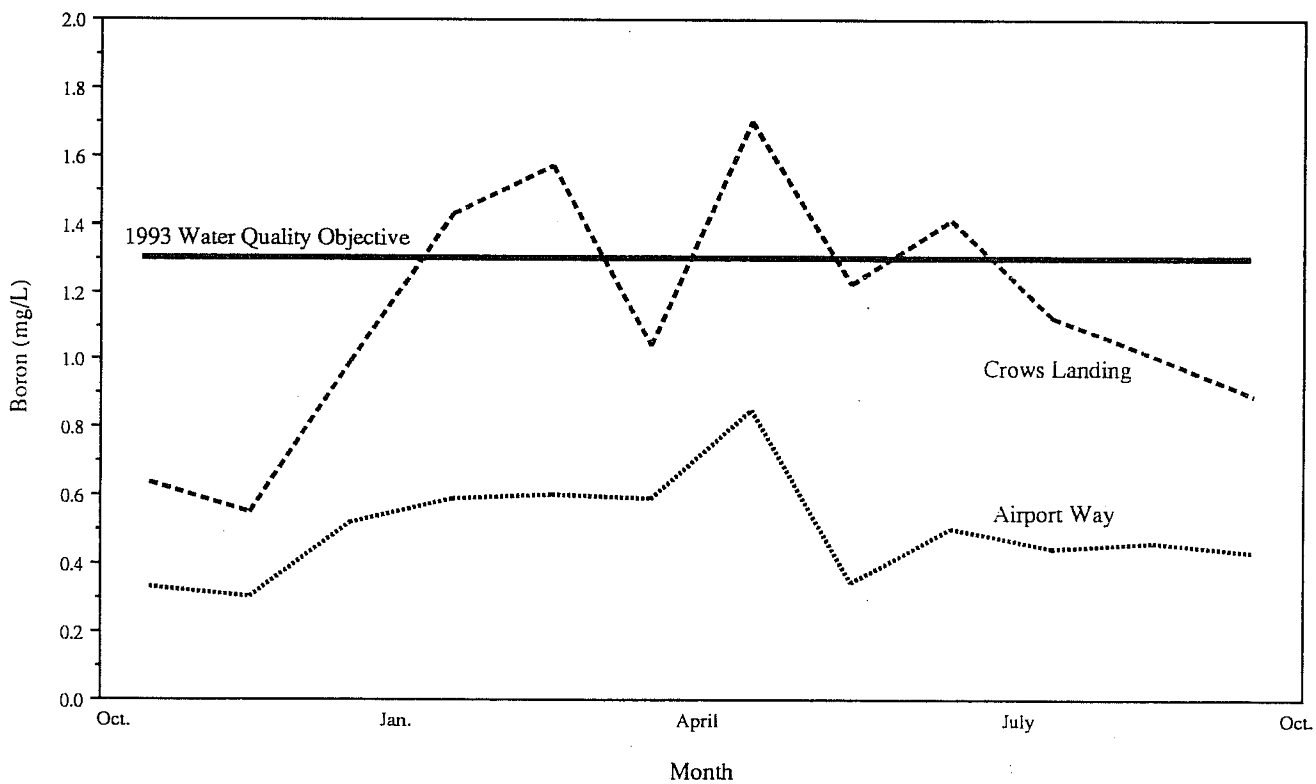


Figure 16. Mean Monthly Selenium Concentrations at Fremont Ford (Site Index B) and Hills Ferry (Site Index C) for WY 91 as Compared to the Adopted Water Quality Objective for the San Joaquin and Milestones Established to Measure Progress Toward Meeting Objectives.

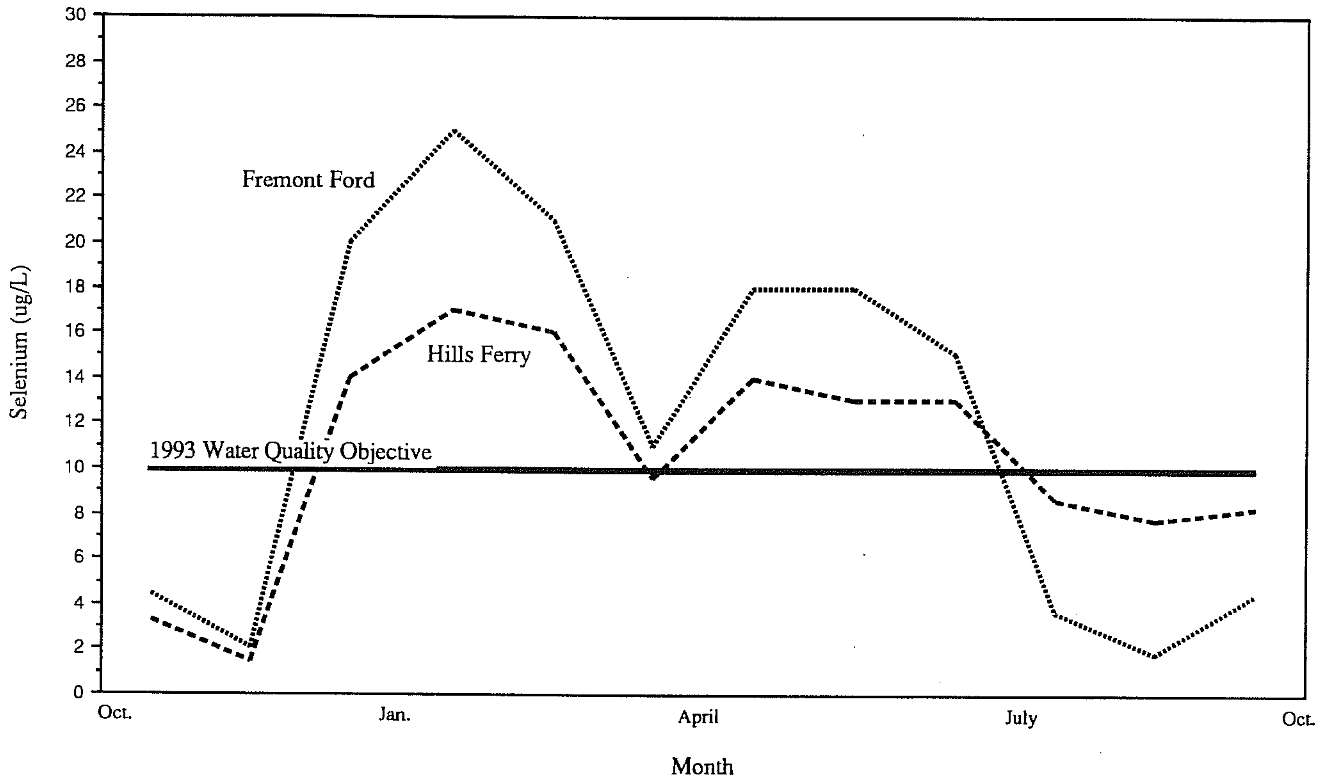


Figure 17. Mean Monthly Selenium Concentrations at Crows Landing (Site Index D) and Airport Way (Site Index H) for WY 91 as Compared to the Adopted Water Quality Objective for the San Joaquin River.

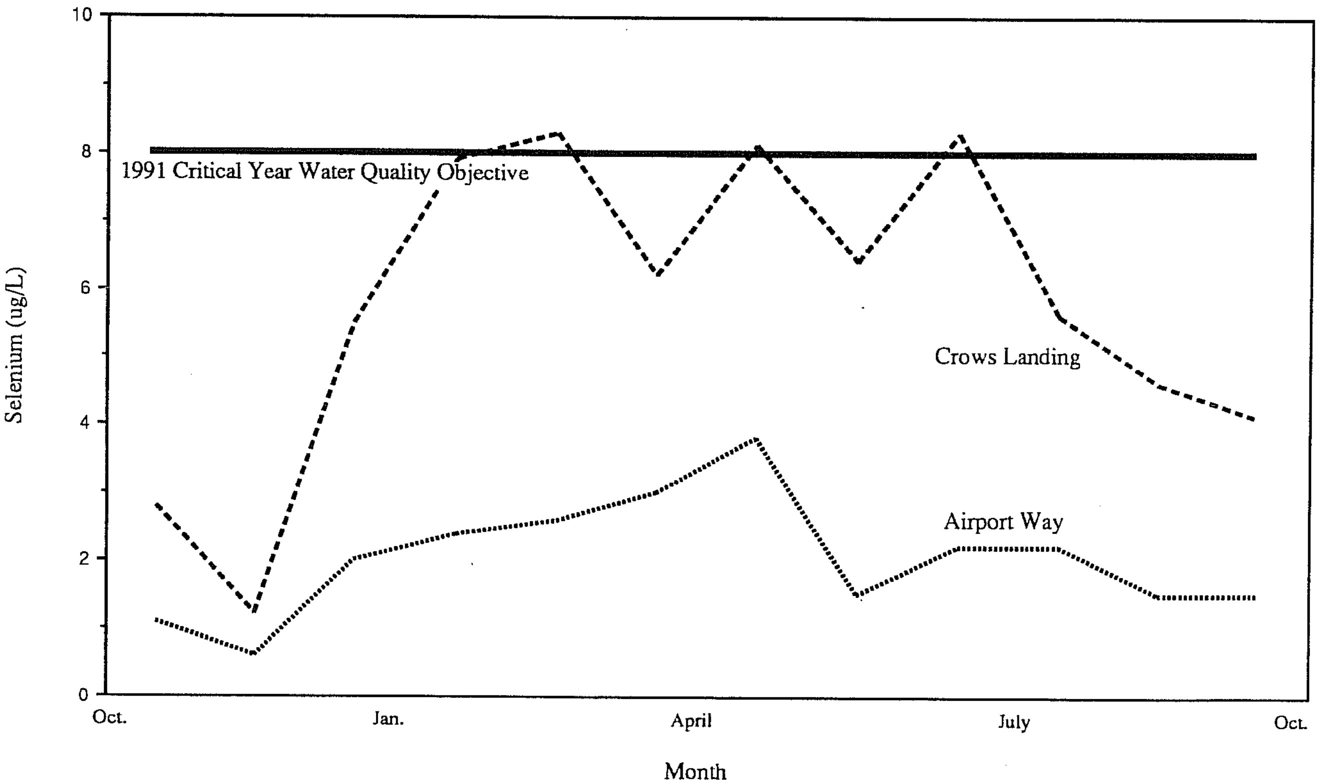
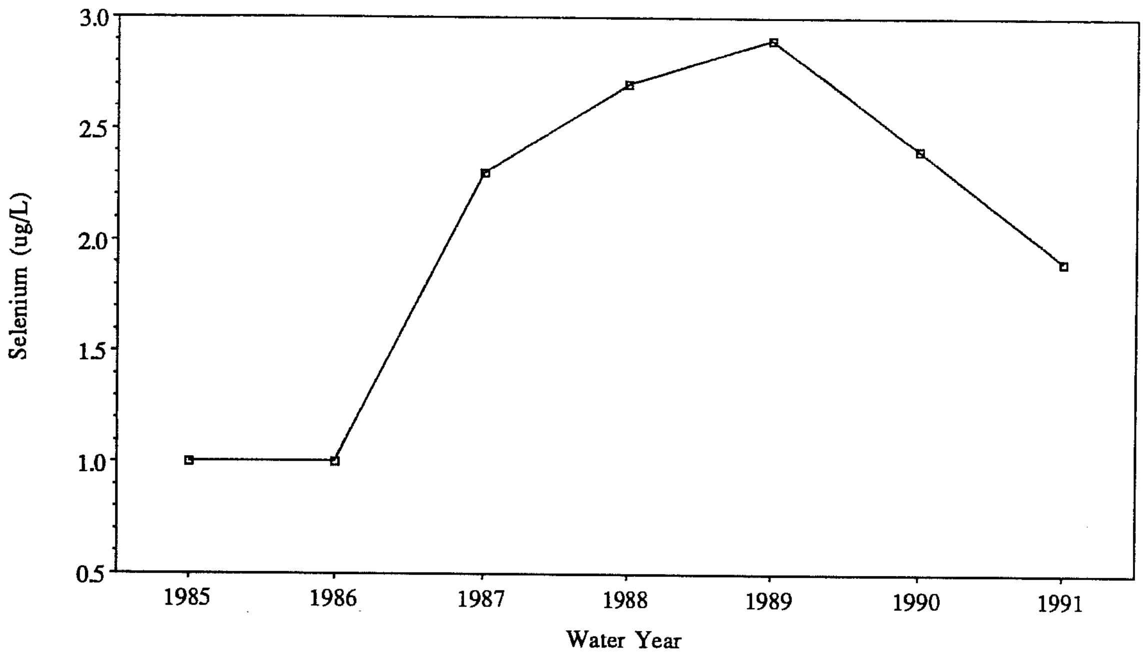


Figure 18 shows the median concentration for selenium at the Airport Way site which represents the inflow to the Delta from the San Joaquin River. Figure 18 demonstrates that as a result of the critically dry years, elevated concentrations are being found in the lower reaches of the San Joaquin. The decrease in the last two years may be explained by increased recycling of drainage water but may also be affected by the river hydrology during the different years. The data does not appear to be adequate to draw any conclusions on long-term trends during such critically dry years.

Figure 18. Median Selenium Concentrations at the Airport Way (Vernalis) Site for Water Years 85 - 91



SAMPLING FREQUENCY

The monitoring program for the San Joaquin River was conducted weekly during WY 91. The data presented in the report is based on these weekly samples. There was concern expressed that the weekly sampling would not adequately represent conditions during critically dry-low flow periods such as WY 91, a fifth consecutive critically dry year. Because of this concern and the concern that significant water quality degradation may occur, an intensified sampling program was conducted during the irrigation season (1 May - 30 September). Samples were collected at least 3 days per week during this period. Figures 19, 20, and 21 show a comparison of the weekly selenium data with that from a weekly average selenium concentration using the more frequent sampling period. For all three sites the two data sets are closely comparable. The downstream site at Maze Boulevard (Figure 21) showed the best comparison. This is likely due to hydrologic peaks and valleys being dampened out with the river travel distance and dilution flows. The low concentrations being encountered did not appear to impact the variability between the two collection frequencies. The monthly mean for this site for selenium, boron and electrical conductivity is listed in Table 8 for both data sets. The change in collection frequency did not significantly change the monthly mean at this site or at the sites further upstream.

The compliance point established in the Basin Plan Amendment of 1988 at Crows Landing achieved a similar comparison (Figure 20). The exception was in the latter part of the irrigation season when flows were very low. During this period the weekly samples underestimated those derived from the average of a more frequent sampling period. In spite of this difference, the monthly means were comparable between the two sampling frequencies (Table 8).

The site at Hills Ferry Bridge represented the River station nearest to the actual discharges. Variability was expected to be greatest at this site. Considerable variation did occur during the first 8 weeks of the season for selenium (Figure 19). The monthly mean for this site, however, did not vary greatly regardless of the sampling frequency (Table 8).

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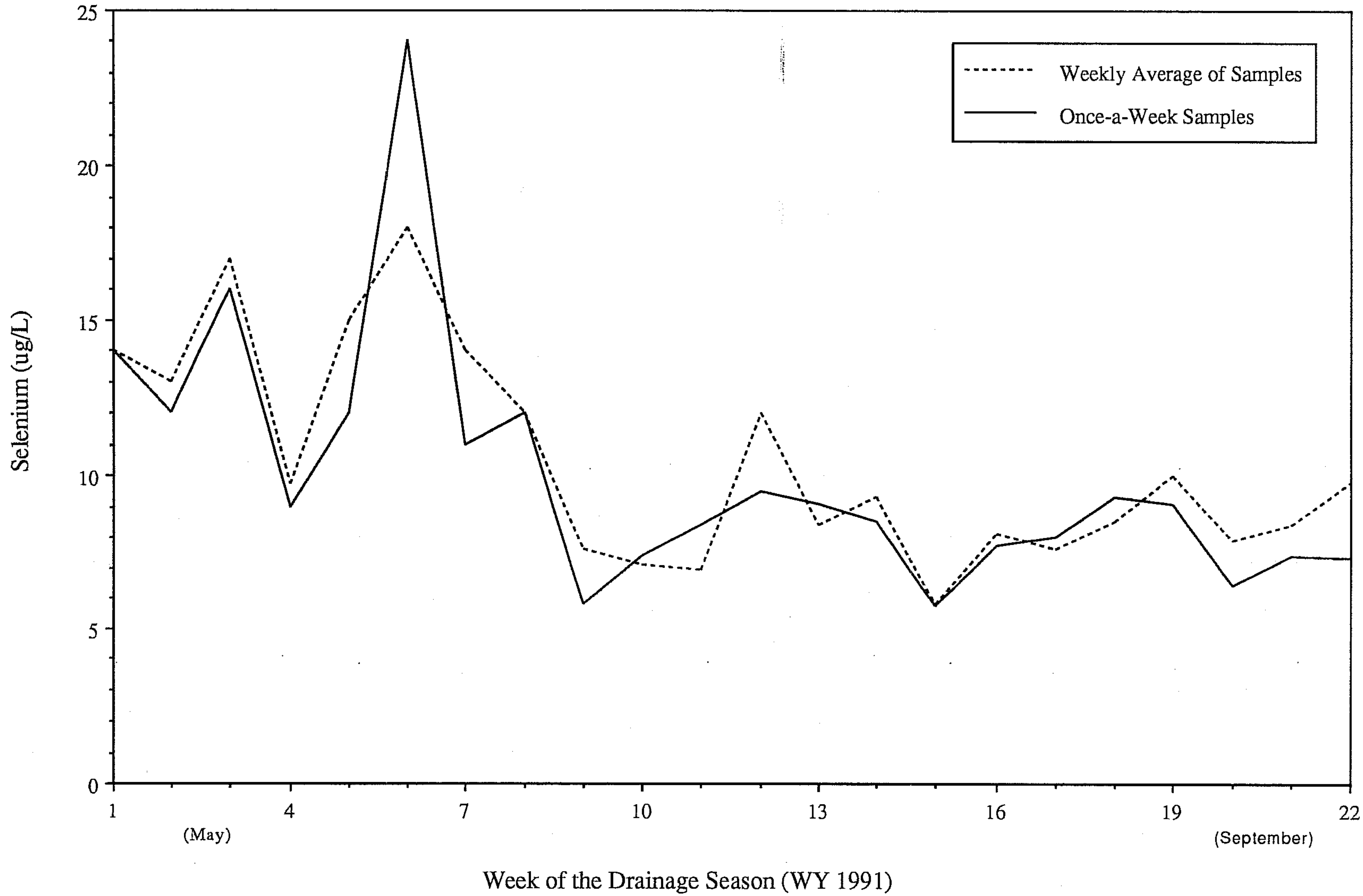

Figure 19. Selenium Concentrations at the Hills Ferry Road Bridge During the Drainage Season Collected Once-a-Week and a Weekly Average Determined From Samples Taken More Than Once-a-Week.

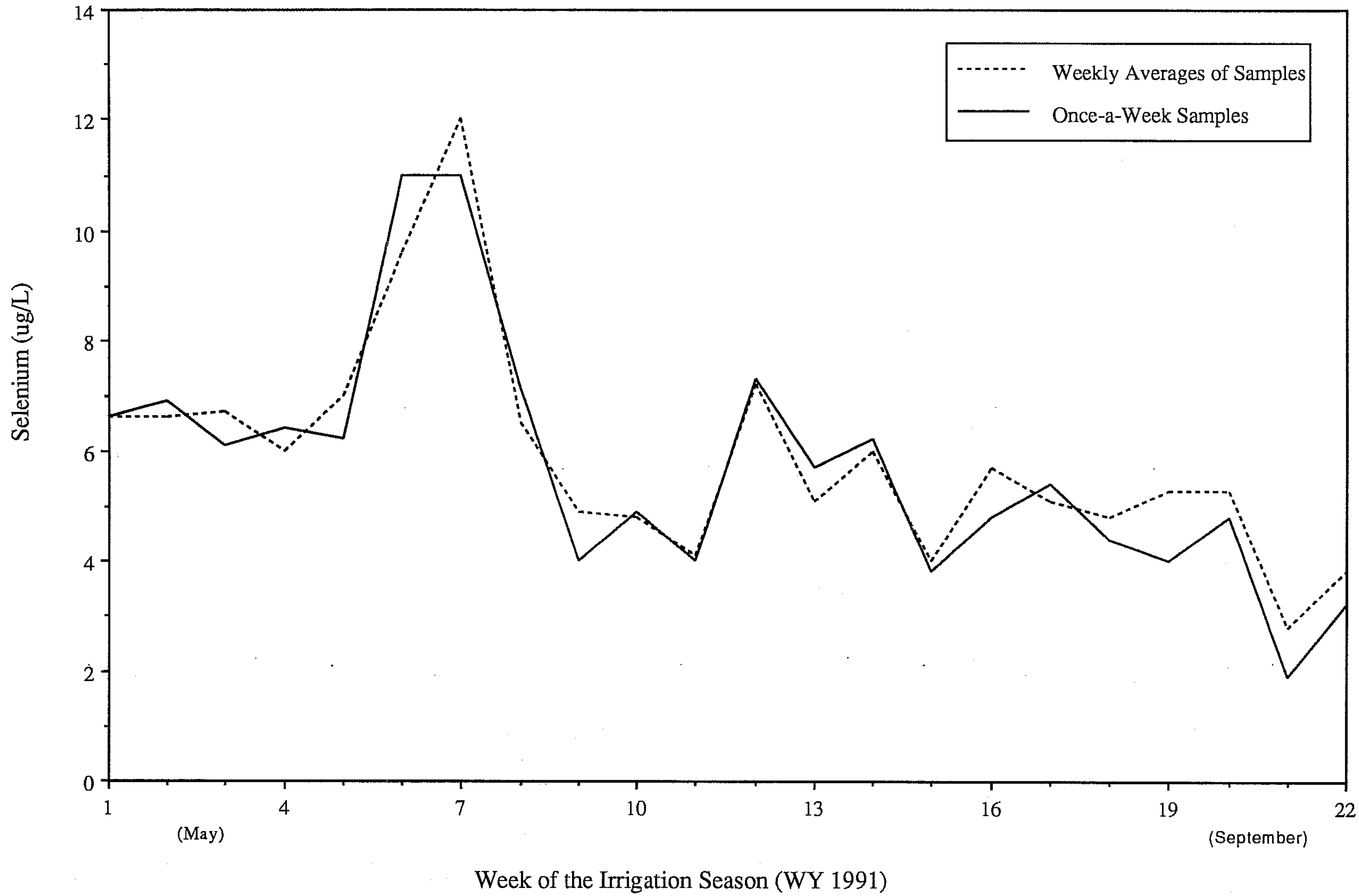

Figure 20. Selenium Concentrations at the Crows Landing Bridge During the Drainage Season Collected Once-a-Week and a Weekly Average Determined From Samples Taken More Than Once-a-Week.

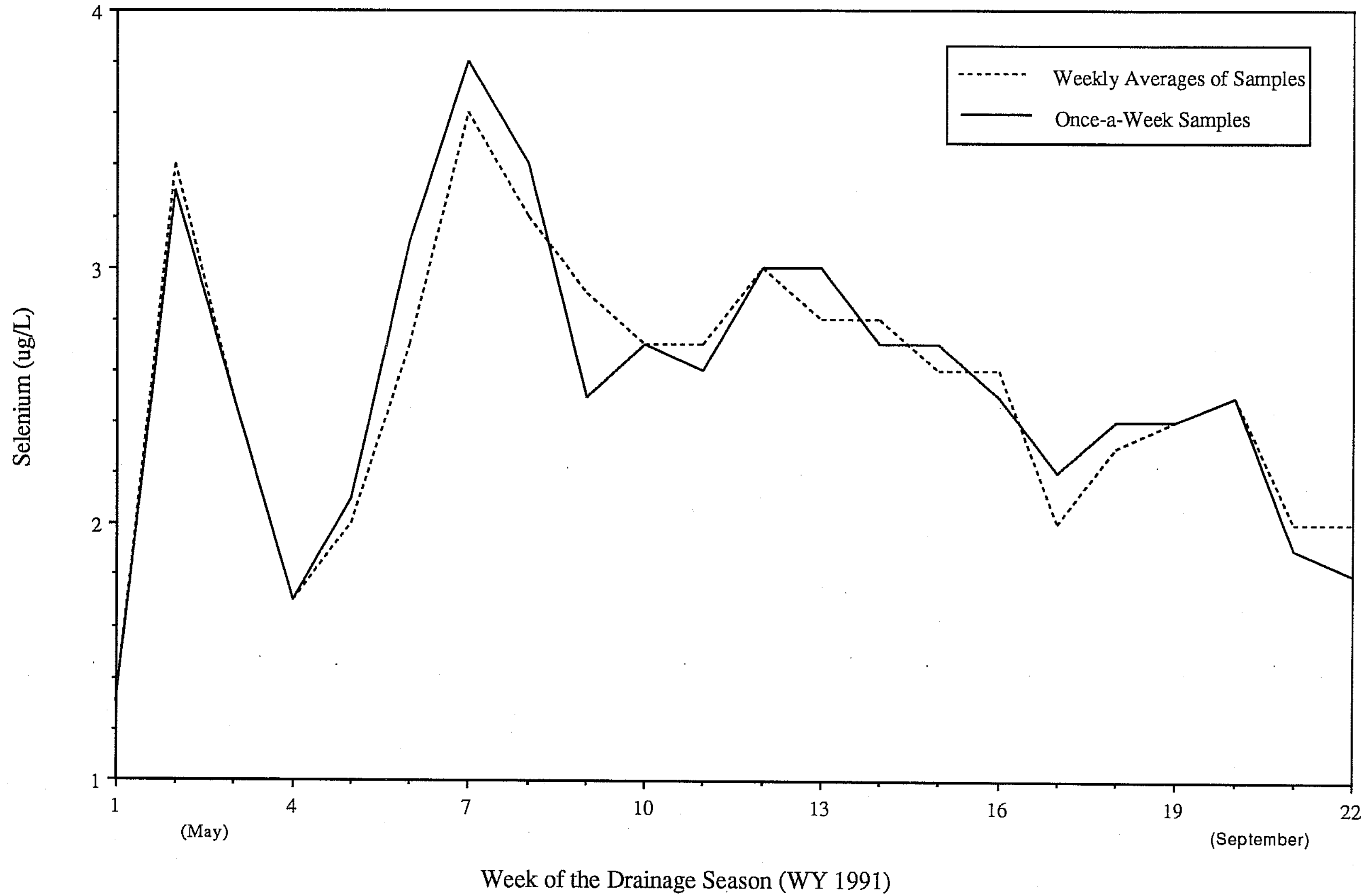

Figure 21. Selenium Concentrations at Maze Blvd (Hwy 132) During the Drainage Season Collected Once-a-Week and a Weekly Average Determined From Samples Taken More Than Once-a-Week.

Table 8. Monthly Mean Concentrations for Electrical Conductivity, Boron and Selenium Using Samples Collected Weekly as Compared to Samples Collected More Frequently for the Time Period May Through September, 1991.

Electrical Conductivity (umhos/cm)

Site	May	June	July	August	September
SJR @ Hills Ferry	2950 / 2930	2710 / 2720	2120 / 2070	1970 / 1860	2270 / 2230
SJR @ Crows Landing	1890 / 1810	2060 / 2050	1660 / 1620	1520 / 1530	1550 / 1520
SJR @ Maze	940 / 970	1450 / 1380	1320 / 1320	1280 / 1270	1220 / 1250

Boron (mg/L)

Site	May	June	July	August	September
SJR @ Hills Ferry	2.2 / 2.0	1.8 / 1.9	1.6 / 1.6	1.6 / 1.5	1.6 / 1.6
SJR @ Crows Landing	1.2 / 1.1	1.4 / 1.4	1.1 / 1.1	1.0 / 1.0	0.89 / 0.87
SJR @ Maze	0.47 / 0.45	0.72 / 0.69	0.67 / 0.65	0.63 / 0.60	0.56 / 0.57

Selenium (ug/L)

Site	May	June	July	August	September
SJR @ Hills Ferry	13 / 13	13 / 13	8.6 / 8.8	7.7 / 7.4	8.2 / 9.1
SJR @ Crows Landing	6.4 / 6.3	8.3 / 8.4	5.6 / 5.5	4.6 / 4.9	4.1 / 4.2
SJR @ Maze	2.2 / 2.2	3.2 / 3.0	2.8 / 2.8	2.5 / 2.4	2.2 / 2.2

Weekly Data / All Data

APPENDIX A

Mineral and Trace Element Concentrations for Sites Along
the Lower San Joaquin River in Water Year 1991
(1 October 1990 to 30 September 1991)

Table 1A. Mineral and Trace Element Water Quality Data for San Joaquin River at Lander Avenue (site Index A) (MER522) for Water Year 1991.

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. W of Lander Avenue (HWY 165), 2.3 mi. S of Stevinson. River mile 132.9.

Date	Time	pH	EC	Se	Mo	Cu	Cr	Pb	Ni	Zn	U	V	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	T.Alk	HDNS	TDS	Temp.
			µmhos/cm	µg/L									mg/L												°F
10/5/90	1300	8.04	2720	0.5	53								0.55												72
10/12/90	1240	8.20	2990	0.2	59						180	8.0	0.67												64
10/19/90	1310	8.08	3070	0.3	62								0.70												66
10/26/90	1110	8.11	3120	0.3	68						190	11	0.75	530	130								160		65
11/2/90	1120	8.22	3220	0.3	69								0.74												56
11/9/90	625	7.70	3270	0.3	71						200	11	0.74												52
11/16/90	1110	8.32	3250	0.3	69								0.73												56
11/27/90	1155	8.24	3420	0.5	74						190	8.0	0.72	600	140								160		52
12/7/90	1230	8.50	3220	0.3	61								0.68												50
12/14/90	800	8.60	3350	0.7	69						180	8.0	0.70												46
12/21/90	920	8.12	3370	0.6	69								0.70												38
12/28/90	1210	8.46	3330	0.5	67							8.0	0.72	610	140								160		42
1/4/91	1310	8.40	3400	0.4	65								0.75												44
1/10/91	1355	7.77	3300	0.7	64						160	7.0	0.73												50
1/18/91	950	7.80	3260	0.4	63								0.65												48
1/25/91	1200	8.80	3160	0.6	62						160	6.0	0.64	575	130								150		48
2/1/91	1100	8.30	2320	0.5	30								0.45												46
2/8/91	855	8.06	2390	0.6	30						97	6.0	0.49												51
2/15/91	1010	7.95	1910	0.6	15								0.42												59
2/22/91	1135	8.04	2190	0.4	14						66	8.0	0.42	350	140								290		58
3/1/91	1215		2150	0.3	23								0.45												58
3/8/91	1325	8.10	1720	0.5	3.0						8.0	11	0.08												62
3/15/91	1114	8.60	1110	0.4	7.0								0.17												54
3/21/91	625	7.60	150	0.5	0.3								<.02												52
3/28/91	1150	7.80	280	0.7	1.0						3.0	15	<.02	31	22								80		60
4/5/91	1020	8.03	877	0.6	6.0								0.11												69
4/11/91	1340	8.11	1580	0.6	12						40	13	0.26												60
4/19/91	1148		2130	0.6	16								0.32												64
4/25/91	910	7.62	2410	0.4	17						58	9	0.31	480	220								480		62
5/2/91	1215	7.67	2530	0.8	20								0.33												67
5/9/91	1430	7.85	2270	0.6	18								0.40												70
5/16/91	1100	8.90	1880	0.6	18						51	10	0.38												74
5/23/91	1110	8.95	1970	0.7	20								0.34												76
5/30/91	1315	9.40	2070	0.6	22						62	8.0	0.44	380	180								280		70
6/7/91	1405	8.39	2010	0.3	19								0.37												78
6/14/91	720	7.72	2010	0.4	19						48	10	0.38												74
6/21/91	920	8.60	2300	0.3	20								0.40												
6/28/91	1000	8.02	1900	0.5	16						44	11	0.39	500	180								310		72
7/5/91	1015	8.33	1750	0.4									0.28												82

Table 1A. Mineral and Trace Element Water Quality Data for San Joaquin River at Lander Avenue (site Index A) (MER522) for Water Year 1991.

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. W of Lander Avenue (HWY 165), 2.3 mi. S of Stevinson. River mile 132.9.

Date	Time	pH	EC	Se	Mo	Cu	Cr	Pb	Ni	Zn	U	V	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	T.Alk	HDNS	TDS	Temp.
			µmhos/cm	µg/L									mg/L												°F
7/12/91	1325	8.38	1960	0.3									0.37												84
7/19/91	1130	8.74	1760	0.4	16								0.36	360	290								380		80
7/26/91	1125		1770	0.3									0.33												82
7/31/91	945		1840	0.3	19						47	13	0.31	370	160								230		81
8/9/91	1115	9.00	2390	0.3									0.46												80
8/16/91	1035		1700	0.2							45	23	0.41												75
8/23/91	950		2070	0.2									0.42												74
8/30/91	1020	8.00	2100	0.3	22						58	8.0	0.47	430	150								220		76
9/7/91	1030	8.58	2200	0.3									0.49												78
9/14/91	1130	7.89	2520	0.3	31						83	7.0	0.48												78
9/21/91	1015	8.41	2900	0.3									0.60												76
9/30/91	1135	8.51	3170	0.3	41						120	6.0	0.61	630	140								210		78
Count		45	51	51	43	0	0	0	0	0	22	23	51	13	13	0	0	0	0	0	0	0	13	0	50
Min		7.60	150	0.2	0.3						3	6	0.08	31	22								80		38
Max		9.40	3420	0.8	74						200	23	0.75	630	290								480		84
Mean		8.24	2348	0.4	35						95	10	0.46	450	156								239		64
Geo Mean		8.23	2125	0.4	24						67	9	0.37	384	139								217		63
Median		8.20	2270	0.4	22						64	8	0.44	480	140								220		65

Table 2A. Mineral and Trace Element Water Quality Data for San Joaquin River at Fremont Ford (site Index B) (MER538) for Water Year 1991.

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 Fremont Ford State Recreation Area, 50 ft. S of HWY 140, 5.4 mi. NE of Gustine. River mile 125.2

Date	Time	pH	EC	Se	Mo	Cu	Cr	Ni	Pb	Zn	U	V	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	T.Alk	HDNS	TDS	Temp.
			µmhos/cm	µg/L									mg/L												°F
10/5/90	1310	8.12	1390	10	4								1.1												72
10/12/90	1230	8.10	1080	2.6	5								0.58												64
10/19/90	1325	8.20	1440	3.8	6								0.80												64
10/26/90	1125	8.23	1490	1.0	7								0.60	245	215								290		66
11/2/90	1105	8.06	1190	0.9	4								0.48												52
11/9/90	640	8.00	1390	1.7	5								0.78												50
11/16/90	1120	8.22	1660	3.7	6								0.87												56
11/27/90	1208	8.23	2450	1.5	11								1.2	390	380								480		50
12/7/90	1220	8.10	3570	19	17								3.0												47
12/14/90	815	8.25	3450	20	15								2.9												44
12/21/90	940	8.10	3840	21	12								3.3												38
12/28/90	1155	8.01	3520	20	13								3.0	530	730								770		40
1/4/91	1255	7.98	3790	19	14								3.1												46
1/10/91	1410	7.97	4100	25	17								3.6												54
1/15/91	845	7.61	4290	29	17								4.4												50
1/18/91	1005	7.97	3340	21	13								2.8												47
1/25/91	1135	8.50	4190	24	18								4.0	730	1100								960		49
2/1/91	1045	7.90	3790	19									3.1												48
2/8/91	915	8.04	3500	23	13								3.6												53
2/15/91	1020	8.06	3410	21	18								3.6												57
2/22/91	1125	7.92	3460	18	17								2.8	600	850								720		59
3/1/91	1200		2245	14	11								2.0												58
3/8/91	1310	7.90	2660	12	10								1.9												58
3/15/91	1055	8.60	2770	21	10								2.4												52
3/21/91	630	7.60	600	2.9	1								0.37												52
3/28/91	1200	7.50	1100	5.3	3								0.67	160	220								510		60
4/5/91	1030	7.71	2780	17	10								2.5												69
4/11/91	1355	7.98	3400	17	11								3.3												56
4/19/91	1134		3230	23	13								3.0												64
4/25/91	930	7.62	2615	14	12								2.3	390	560								580		61
5/2/91	1230	7.62	3060	17	14								2.5												61
5/9/91	1440	7.83	2730	15	35								2.3												68
5/16/91	1115	8.20	3200	21									2.9												72
5/23/91	1050	8.39	2630	15									1.8												74
5/30/91	1305	9.20	2920	22									2.5	430	620								680		70
6/7/91	1350	8.56	3520	30									4.2												76
6/14/91	740	7.72	2520	12									2.0												68
6/21/91	910	8.50	2800	16									2.1												
6/28/91	1025		1880	3.8	10								0.83	360	290								380		69

Table 2A. Mineral and Trace Element Water Quality Data for San Joaquin River at Fremont Ford (site Index B) (MER538) for Water Year 1991.

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 Fremont Ford State Recreation Area, 50 ft. S of HWY 140, 5.4 mi. NE of Gustine. River mile 125.2

Date	Time	pH	EC	Se	Mo	Cu	Cr	Ni	Pb	Zn	U	V	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	T.Alk	HDNS	TDS	Temp.
			µmhos/cm					µg/L											mg/L						°F
7/5/91	1000	8.32	1950	3.8									0.80												80
7/12/91	1310	8.68	1870	3.3									0.87												82
7/19/91	1115	8.77	1710	3.8	19	3	3	<5	6	3			0.82	550	1000								820		76
7/26/91	1110		1650	4.5									0.67												78
7/31/91	935		1380	2.8	5								0.54	210	170								260		77
8/9/91	1130	9.10	1250	1.3									0.40												80
8/16/91	1045		1220	1.6	5								0.47												75
8/23/91	940		1780	2.6									0.78												70
9/7/91	1015	8.55	2010	2.3									0.79												76
9/14/91	1145	8.24	1400	3.6									0.68												76
9/21/91	1000	8.31	2250	2.6									1.0												74
9/30/91	1130	8.55	2650	9.8	13								1.9	540	570								570		76
Count		44	51	51	36	1	1	1	1	1	0	0	51	12	12	0	0	0	0	0	0	0	12	0	50
Min		7.50	600	0.9	1	3	3	<5	6	3			0.37	160	170								260		38
Max		9.20	4290	30	35	3	3	<5	6	3			4.4	730	1100								960		82
Mean		8.16	2512	12	11	3	3	<5	6	3			1.9	428	559								585		62
Geo Mean		8.15	2301	8.1	9.6	3	3	<5	6	3			1.5	392	471								545		61
Median		8.10	2630	14	11.5	3	3	<5	6	3			2.0	410	565								575		63

Table 3A. Mineral and Trace Element Water Quality Data for San Joaquin River south of Hills Ferry Road (site Index C) (STC512) for Water Year 1991.

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	pH	EC	Se	Mo	Cu	Cr	Ni	Pb	Zn	U	V	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	T.Alk	HDNS	TDS	Temp.
			µmhos/cm	µg/L									mg/L												°F
10/5/90	1415	8.2	1370	6.9	4								0.90	190	210								300		74
10/12/90	1100	7.7	1240	3.1	5								0.73	170	190								270		62
10/19/90	1425	7.6	1560	2.1	7								0.71	230	210								330		64
10/26/90	1315	8.2	1640	1.1	7	1	1	<5	<5	3			0.68	260	260	64	43	220	5	<1	55	45	340	980	68
11/2/90	1000	7.5	1320	1.0	4								0.58	180	150								270		50
11/9/90	730	8.0	1420	1.4	6								0.69	220	200								290		49
11/16/90	1240	8.2	1840	2.0	8								0.86	300	280								360		56
11/27/90	1343	8.3	2750	1.1	12	2	4	<5	<5	5			1.4	420	440	99	66	370	6	<1	260	220	540	1700	52
12/7/90	855	7.4	3300	4.8	15								2.0	510	610								660		43
12/14/90	845	8.0	3670	20	15								2.9	540	770								770		43
12/21/90	1100	8.2	3960	17	16								3.1	600	860								840		40
12/28/90	1010	7.5	3500	14	13	<1	<1	<5	<5	4			2.6	510	680	140	78	460	9	<1	290	240	740	2300	38
1/4/91	1040	7.6	3790	15	16								2.9	540	690								750		44
1/10/91	1550	7.8	3880	16	17								3.0	730	1000								790		54
1/15/91	950	7.9	4010	19	18								3.4												52
1/18/91	1135	7.9	3410	14	14								2.5	580	820								730		48
1/25/91	1015	8.3	4360	21	19	<1	<1	<1	<5	<1			3.0	780	1100	190	110	550	7	<1	280	230	950	3000	44
2/1/91	930	7.4	3770	13									2.8	570	720								780		46
2/8/91	1045	8.1	3450	15	13	1	3	<5	<5	2			2.9	650	920								730		51
2/15/91	1135	8.1	3520	16	17								3.2	560	800								740		58
2/22/91	1000	7.4	3850	18	17	1	<1	<5	<5	2			3.3	560	880	170	91	520	5	<1	260	220	810	2600	56
3/1/91	1015		2460	13	12								2.0	360	520								510		56
3/8/91	1025	7.4	2670	8.8	11								2.0	380	460								520		55
3/15/91	830	8.8	3030	17	11								2.5	460	640								650		53
3/21/91	750	7.1	750	3.2	1								0.46	90	110								160		52
3/28/91	1330	7.9	1310	5.8	4	6	10	<5	10	10			0.91	190	260	63	33	140	6	<1	150	120	280	810	64
4/5/91	1230	8.2	2770	10	9	6	8	<5	11	11			2.3	380	500								570		69
4/11/91	1540	8.3	3310	13	11								3.1	490	680								690		58
4/19/91	950		3390	19	12								2.6	530	730								720		62
4/25/91	1140	7.9	3060	14	12	1	6	<5	7	8			2.6	500	680	150	76	440	8	<1	260	210	650	2000	63
5/2/91	1415	8.0	3300	14	13								2.5	550	650								710		63
5/9/91	1605	8.3	2870	12	14								2.2												70
5/16/91	1045	8.0	3290	16	14								2.8												70
5/23/91	915	7.7	2680	9	10								1.6												72
5/30/91	1050	8.6	2620	12	12	3	5	<5	5	8	7.8		1.7	400	500	120	66	360	7	<1	250	210	580	1700	67
6/7/91	1220	8.5	3360	24	15								1.8												76
6/14/91	910	8.1	2760	11	11								2.2												70
6/21/91	800	8.6	2500	12	10								1.9												
6/28/91	835		2210	5.8	10	3	3	<5	6	5	7.8		1.4	410	320	96	55	300	6	<1	220	180	460	1400	68

Table 3A. Mineral and Trace Element Water Quality Data for San Joaquin River south of Hills Ferry Road (site Index C) (STC512) for Water Year 1991.

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	pH	EC µmhos/cm	Se	Mo	Cu	Cr	Ni	Pb	Zn	U	V	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	T.Alk	HDNS	TDS	Temp. °F
				µg/L									mg/L												
7/5/91	825	8.0	2290	7.4									1.6												80
7/12/91	1120	8.0	2180	8.4									2.0												78
7/19/91	930	8.1	2200	9.5	11								1.8												74
7/26/91	930		2050	9.1									1.5												76
7/31/91	750		1870	8.5	7	6	15	<5	12	2	7.6		1.3	280	360	98	48	200	8	<1	180	150	400	1200	76
8/9/91	1255	9.0	1630	5.7									1.1												80
8/16/91	1225		1800	7.7	7								1.4												75
8/23/91	815		2130	8.0									1.9												66
8/30/91	905	8.8	2310	9.3	12	3	7	<5	7	<1			2.0	350	460	110	56	330	5	<1	220	180	480	1500	72
9/7/91	855	8.0	2520	9.1									1.8												72
9/14/91	1310	8.4	1750	6.4	8								1.2												78
9/21/91	840	7.8	2380	7.4									1.6												70
9/30/91	925	8.2	2590	7.3	12	2	2	<5	<5	6			1.7	470	530	98	69	360	7	<1	210	180	490	1600	69
Count		45	52	52	44	14	14	14	14	14	3	0	52	35	35	12	12	12	12	12	12	12	35	12	51
Min		7.1	750	1.0	1	<1	<1	<5	<5	2	7.6		0.46	90	110	63	33	140	5	0	55	45	160	810	38
Max		9.0	4360	24	19	6	15	<5	12	11	7.8		3.4	780	1100	190	110	550	9	0	290	240	950	3000	80
Mean		8.0	2647	10	11	3	5	<5	5	5	7.7		2.0	427	548	117	66	354	7	0	220	182	567	1733	62
Geo Mean		8.0	2486	8.3	10	2	2	<5	3	3	7.7		1.8	387	474	110	63	330	6	0	205	169	524	1622	61
Median		8.0	2645	9.4	12	2	4	<5	3	5	7.8		2.0	460	530	105	66	360	7	0	235	195	580	1650	63

Table 4A. Mineral and Trace Element Water Quality Data for San Joaquin River at Crows Landing Road (site Index D) (STC504) for Water Year 1991.

Location: Latitude 37° 25' 55", Longitude 121° 00' 42", Sec. 8, T.6S., R8E. West bank, 100 yds S of Crows Landing Road Bridge, 4.2 mi. NE of Crows Landing.
River Mile 107.1

Date	Time	pH	EC µmhos/cm	Se	Mo	Cu	Cr	Ni µg/L	Pb	Zn	U	V	B	Cl	SO4	Ca	Mg	Na	K mg/L	CO3	HCO3	T.Alk	HDNS	TDS	Temp. °F
10/5/90	1430	7.9	1290	5.0	4								0.73												70
10/12/90	1035	7.4	1280	3.8	4						10	10	0.75												60
10/19/90	1445	7.8	1290	1.3	5								0.54												62
10/26/90	1330	7.9	1290	0.9	5	1	1	<5	<5	3	8	6	0.52	210	200								270		64
11/2/90	950	7.3	1160	1.3	4								0.45												52
11/9/90	755	7.8	1080	1.0	4						8	6	0.47												51
11/16/90	1255	8.0	1270	1.7	5								0.59												55
11/27/90	14000	8.2	1470	0.7	5	2	3	7	<5	3	8	4	0.67	210	210								300		50
12/7/90	840	7.3	1480	1.7	5								0.75												45
12/14/90	900	8.0	1620	7.0	6						8	4	1.1												46
12/21/90	1125	8.0	1670	7.5	6								1.1												40
12/28/90	955	7.5	1570	5.6	5						7	3	1.0	210	260								310		39
1/4/91	1020	7.7	1720	5.5	6								1.1												44
1/10/91	1610	8.1	1700	5.1	7						6	3	1.1												52
1/15/91	1020	7.9	2050	7.8	7								1.4												52
1/18/91	1150	7.9	2260	9.5	8								1.8												49
1/25/91	955	8.4	2350	9.2	8	2	3	<1	<5	5	10	6	1.4	360	480								500		45
2/1/91	905	7.2	2290	9.9									1.7												46
2/8/91	1105	8.1	2000	7.9	8						10	5	1.5												53
2/15/91	1155	8.1	2200	8.8	9								1.7												58
2/22/91	950	7.4	2240	7.2	7	4	2	6	<5	6	10	7	1.5	300	400								470		57
3/1/91	940		2150	10	9								1.6												56
3/8/91	1005	7.4	1860	6.1							14	10	1.2												54
3/15/91	807	8.9	2010	9.4	7								1.5												52
3/21/91	810	7.1	560	2.0	0.6								0.30												52
3/28/91	1350	7.7	920	3.6	2	8	10	<5	11	10	6	15	0.59	120	170								190		58
4/5/91	1245	8.0	1990	7.3	6	5	7	<5	9	10			1.6												67
4/11/91	1600	8.3	2420	8.0	8						13	9	2.1												58
4/19/91	935		2490	9.9	8								1.7												62
4/25/91	1150	7.9	1945	7.3	6	2	4	<5	5	5			1.4	320	420								410		63
5/2/91	1425	8.0	2220	6.6	8								1.4												62
5/9/91	1625	8.3	1920	6.9	8								1.4												68
5/16/91	1030	8.1	1790	6.1	6								1.2												68
5/23/91	855	7.7	1730	6.4	6								1.0												70
5/30/91	1030	8.8	1780	6.2	6	4	8	<5	8	9			1.1	250	310								410		66
6/7/91	1205	8.5	2290	11	9								1.8												72
6/14/91	930	8.0	2260	11	8								1.9												70
6/21/91	750	8.6	1950	7.1	7								1.0												
6/28/91	820		1720	4.0	6	3	4	<5	8	6			0.93	250	270								400		68

Table 4A. Mineral and Trace Element Water Quality Data for San Joaquin River at Crows Landing Road (site Index D) (STC504) for Water Year 1991.

Location: Latitude 37° 25' 55", Longitude 121° 00' 42", Sec. 8, T.6S., R8E. West bank, 100 yds S of Crows Landing Road Bridge, 4.2 mi. NE of Crows Landing. River Mile 107.1

Date	Time	pH	EC µmhos/cm	Se	Mo	Cu	Cr	Ni	Pb	Zn	U	V	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	T.Alk	HDNS	TDS	Temp. °F
				µg/L									mg/L												
7/5/91	810	7.8	1800	4.9									1.1												78
7/12/91	1105	8.0	1440	4.0									0.98												74
7/19/91	915	8.0	1850	7.3	5								1.5	200	280								350		72
7/26/91	915		1630	5.7									1.0												74
7/31/91	735		1590	6.2	4	7	18	<5	16	5			1.0	240	270								330		75
8/9/91	1310	9.7	1360	3.8									0.72												80
8/16/91	1240		1460	4.8									1.0												76
8/23/91	800		1660	5.4									1.3												67
8/30/91	850	8.7	1590	4.4	4	4	11	<5	9	<1			1.0	235	250								345		70
9/7/91	840	8.1	1610	4.0									0.92												72
9/14/91	1325	8.3	1400	4.8	5								0.81												76
9/21/91	825	7.8	1400	1.9									0.61												70
9/30/91	915	8.2	1560	3.2	5	<1	<1	<5	<5	<1			0.83	260	260								320		69
Count		45	52	52	42	12	12	12	12	12	13	13	52	13	13	0	0	0	0	0	0	0	13	0	51
Min		7.1	560	0.7	0.6	<1	<1	<5	<5	<1	6	3	0.30	120	170								190		39
Max		9.7	2490	11	9.0	8	18	7	16	10	14	15	2.1	360	480								500		80
Mean		8.0	1724	5.7	6.0	4	6	2	6	5	9.1	6.8	1.1	243	291								354		61
Geo Mean		8.0	1669	4.8	5.6	3	4	1	4	3	8.8	6.1	1.0	236	279								344		60
Median		8.0	1710	5.9	6.0	4	4	1	7	5	8	6	1.1	240	270								345		62

Table 5A. Mineral and Trace Element Water Quality Data for San Joaquin River north of Patterson Bridge (Las Palmas Avenue) (site Index E) (STC507) for Water Year 1991.

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 atNE corner of Las Palmas Launching Facility parking lot, 3.2 mi. NE of Patterson. River mile 98.6.

Date	Time	pH	EC	Se	Mo	Cu	Cr	Ni	Pb	Zn	U	V	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	T.Alk	HDNS	TDS	Temp.
			µmhos/cm		µg/L								mg/L												°F
10/26/90	1345	7.7	1180	0.8									0.44	180	160								100		67
11/27/90	1415	7.8	1520	0.6									0.63	220	200								290		52
12/28/90	940	7.4	1660	5.1	6								1.0	230	270								330		40
1/25/91	935	8.2	2380	5.4									1.3	360	460								520		45
2/15/91	1210	7.8	2040	6.4									1.4												61
2/22/91	930	7.2	2340	6.5									1.4	320	400								500		57
3/1/91	915		2235	7.7									1.4												56
3/8/91	945	7.2	1820	5.7									1.2												54
3/15/91	748	8.8	1890	7.3									1.3												53
3/21/91	830	6.9	560	1.8									0.28												54
3/28/91	1405	7.6	830	4.1									0.56	120	160								170		58
4/5/91	1300	7.9	1920	6.5									1.5												69
4/11/91	1615	8.2	2350	7.6									1.9												58
4/19/91	912		2450	8.3									1.5												62
4/25/91	1210	7.8	1760	5.5									1.2	300	360								370		63
5/2/91	1445	7.9	1910	4.6									1.1												65
5/9/91	1635	8.3	1700	6.5									1.1												68
5/16/91	1015	7.9	1980	7.7									1.3												70
5/23/91	835	7.6	1770	5.3									0.94												72
5/30/91	1010	8.6	1740	6.7									1.0	260	310								410		68
6/7/91	1145	8.5	1850	5.2									1.0												74
6/14/91	950	8.1	2220	8.3									1.6												70
6/21/91	720	8.6	1800	5.8									0.92												
6/28/91	800		1660	3.0									0.79	200	280								350		68
7/5/91	750	7.7	1780	3.9									0.93												78
7/12/91	1045	7.9	1440	3.6									0.85												76
7/19/91	900	7.9	1470	4.3									0.94	310	280								400		72
7/26/91	855		1630	4.3									0.89												74
7/31/91	720		1690	6.2									0.92	260	300								380		76
8/9/91	1325	9.6	1550	3.7									0.76												80
8/16/91	1305		1470	4.1									0.92												76
8/23/91	750		1730	4.6									1.0												68
8/30/91	835	8.6	1620	3.5									0.90	240	310								330		71
9/7/91	825	8.1	1580	3.4									0.82												74
9/14/91	1340	8.2	1440	3.3									0.70												78
9/21/91	810	7.8	1420	1.6									0.54												70
9/30/91	900	8.4	1545	2.9									0.71	270	230								320		68
Count		30	37	37	1	0	0	0	0	0	0	0	37	13	13	0	0	0	0	0	0	0	13	0	36
Min		6.9	560	0.6	6								0.28	120	160								100		40
Max		9.6	2450	8.3	6								1.9	360	460								520		80
Mean		8.0	1728	4.9	6								1.0	252	286								344		66
Geo Mean		8.0	1674	4.3	6								0.95	243	273								319		65
Median		7.9	1730	5.1	6								0.94	260	280								350		68

Table 6A. Mineral and Trace Element Water Quality Data for San Joaquin River at Grayson Road, Laird Slough (site Index F) (STC511) for Water Year 1991.

Location: Latitude 37° 33' 43", Longitude 121° 09' 03". In NW 1/4, SE 1/4, NW 1/4, Sec. 25, T.4S., R.7E. Laird Park, 500 ft. S of Grayson Road Bridge, 1.5 mi. E of Grayson. River mile 89.1.

Date	Time	pH	EC µmhos/cm	Se (µg/L)	Mo (µg/L)	Cu (µg/L)	Cr (µg/L)	Ni (µg/L)	Pb (µg/L)	Zn (µg/L)	U (µg/L)	V	B (mg/L)	Cl (mg/L)	SO4 (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	CO3 (mg/L)	HCO3 (mg/L)	T.Alk (mg/L)	HDNS (mg/L)	TDS (mg/L)	Temp. °F
10/26/90	1420	7.6	1350	1.2									0.46	210	190								290		66
11/27/90	1445	7.6	1550	1.0									0.60	220	200								310		52
12/28/90	915	7.4	1710	5.7	6.0								1.0	240	280								345		40
1/25/91	915	7.8	2310	4.7									1.2	360	420								500		48
2/15/91	1230	7.7	1970	5.0									1.2												60
2/22/91	905	6.8	2310	7.0									1.4	350	420								510		59
3/1/91	900		2000	6.1									1.2												56
3/8/91	910	7.1	1760	5.2									1.1												55
3/15/91	717	9.0	1850	6.6									1.2												52
3/21/91	855	7.3	600	2.0									0.31												54
3/28/91	1430	7.4	780	2.8									0.49	110	140								160		59
4/5/91	1330	7.9	1880	6.6									1.4												67
4/11/91	1640	8.1	2260	7.3									1.7												60
4/19/91	850		2250	6.8									1.3												62
4/25/91	1240	7.8	825	2.7									0.51	130	140								180		63
5/2/91	1510	7.9	1930	5.3									1.1												64
5/9/91	1250		1730	6.2	7.0								1.1												65
5/16/91	950	7.9	1750	6.1									1.1												68
5/23/91	815	7.3	1640	3.4									0.76												68
5/30/91	930	8.4	1780	6.7									0.98	250	290								440		66
6/7/91	1115	8.5	1840	5.8									1.0												74
6/14/91	1015	8.1	1940	6.4									1.3												72
6/21/91	715	8.0	1950	6.4									0.94												
6/28/91	730		1730	3.4									0.79	310	280								400		68
7/5/91	725	7.6	1650	3.7									0.77												76
7/12/91	1020	7.8	1520	3.5									0.82												74
7/19/91	840	7.7	1430	4.2									0.91	240	180								330		72
7/26/91	825		1460	3.7									0.72												72
7/31/91	700		1690	6.5									0.96	260	300								400		76
8/9/91	1345	9.6	1470	3.6									0.69												82
8/16/91	1335		1590	4.0									0.90												76
8/23/91	730		1650	4.2									0.85												68
8/30/91	810	8.5	1640	3.5									0.82	240	240								360		72
9/7/91	800	7.8	1610	4.3									0.86												74
9/14/91	1405	8.2	1530	3.6									0.72												78
9/21/91	745	7.7	1340	2.0									0.53												70
9/30/91	840	8.2	1400	2.4									0.56	220	190								290		68
Count		29	37	37	2	0	0	0	0	0	0	0	37	13	13	0	0	0	0	0	0	0	13	0	36
Min		6.8	600	1.0	6.0								0.31	110	140								160		40
Max		9.6	2310	7.3	7.0								1.7	360	420								510		82
Mean		7.9	1667	4.6	6.5								0.93	242	252								347		65
Geo Mean		7.9	1613	4.2	6.5								0.87	230	237								330		65
Median		7.8	1690	4.3	6.5								0.91	240	240								345		68

Table 7A. Mineral and Trace Element Water Quality Data for San Joaquin River at Maze Blvd., HWY 132 (site Index G) (STC510) for Water Year 1991.

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	pH	EC µmhos/cm	Se (µg/L)	Mo (µg/L)	Cu (µg/L)	Cr (µg/L)	Ni (µg/L)	Pb (µg/L)	Zn (µg/L)	U (µg/L)	V	B (mg/L)	Cl (mg/L)	SO4 (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	CO3 (mg/L)	HCO3 (mg/L)	T.Alk (mg/L)	HDNS (mg/L)	TDS (mg/L)	Temp. °F
10/5/90	1510	7.7	1190	2.6									0.51												70
10/12/90	1008	7.1	1250	2.6									0.62												62
10/19/90	1520	7.5	980	0.8									0.51												64
10/26/90	1445	7.7	910	0.9									0.30	140	120								200		65
11/2/90	905	6.3	930	0.8									0.35												54
11/9/90	825	7.5	980	0.9									0.38												52
11/16/90	1340	7.6	1010	0.9									0.40												54
11/27/90	1510	7.7	1150	0.8									0.45	170	140								250		48
12/7/90	805	7.0	1160	1.2									0.51												46
12/14/90	930	7.8	1260	3.1									0.62												48
12/21/90	1155	8.0	1310	3.4									0.67												41
12/28/90	900	7.5	1360	3.8									0.74	200	220								280		40
1/4/91	940	8.0	1340	3.1									0.70												44
1/10/91	1650	7.7	1310	2.6									0.68												52
1/15/91	1050	7.6	1430	2.9									0.77												54
1/18/91	1230	7.7	1510	3.5									0.82												52
1/25/91	900	8.1	1700	3.1									0.80	260	280								380		45
2/1/91	820	7.0	1350	4.0									0.74												48
2/8/91	1150	7.9	1370	3.2									0.79												54
2/15/91	1250	7.7	1420	3.5									0.84												60
2/22/91	850	6.2	1460	3.1									0.79	230	220								320		56
3/1/91	830		1370	3.7									0.79												56
3/8/91	850	6.8	1500	3.7									0.92												54
3/15/91	658	9.2	1550	5.1									1.0												52
3/21/91	1230	7.2	570	1.9	3.0								0.28												54
3/22/91	1715	7.2	950	3.2									0.58												54
3/28/91	1445	7.8	630	2.1									0.37	80	100								130		58
4/5/91	1350	7.8	1550	5.2									1.0												68
4/11/91	1700	8.1	1750	5.6									1.3												58
4/19/91	835		1520	3.9									0.84												60
4/25/91	1255	7.8	760	2.3									0.45	120	120								170		63
5/2/91	1530	7.9	530	1.3									0.28												60
5/9/91	1230		1140	3.3	3.0								0.63												64
5/16/91	935	7.8	1150	2.5									0.58												68
5/23/91	750	7.0	800	1.7									0.37												66
5/30/91	910	8.3	1080	2.1									0.48	160	140								260		64
6/7/91	1050	8.2	1340	3.1									0.70												70
6/14/91	1035	8.3	1520	3.8									0.89												72
6/21/91	655	8.1	1500	3.4									0.64												

Table 7A. Mineral and Trace Element Water Quality Data for San Joaquin River at Maze Blvd., HWY 132 (site Index G) (STC510) for Water Year 1991.

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	pH	EC	Se	Mo	Cu	Cr	Ni	Pb	Zn	U	V	B	Cl	SO4	Ca	Mg	Na	K	·CO3	HCO3	T.Alk	HDNS	TDS	Temp.
			µmhos/cm	µg/L									mg/L												°F
6/28/91	705		1430	2.5									0.64	240	180								330		67
7/5/91	700	7.1	1440	2.7									0.68												74
7/12/91	1000	7.8	1380	2.6									0.69												74
7/19/91	820	7.2	1290	3.0	2.0								0.75	170	120								230		72
7/26/91	805		1280	3.0									0.64												72
7/31/91	645		1230	2.7									0.57	180	150								300		74
8/9/91	1400	9.4	1240	2.7									0.62												83
8/16/91	1350		1310	2.5	2.0								0.68												76
8/23/91	710		1270	2.2									0.58												68
8/30/91	755	7.2	1280	2.4									0.63	200	150								290		70
9/7/91	740	7.2	1240	2.4									0.60												72
9/14/91	1425	8.3	1210	2.5									0.54												78
9/21/91	725	7.4	1180	1.9									0.52												70
9/30/91	815	8.2	1160	1.8									0.47	170	130								250		68
Count		45	53	53	4	0	0	0	0	0	0	0	53	13	13	0	0	0	0	0	0	0	13	0	52
Min		6.2	530	0.8	2								0.28	80	100								130		40
Max		9.4	1750	5.6	3								1.3	260	280								380		83
Mean		7.7	1236	2.7	2.5								0.64	178	159								261		61
Geo Mean		7.6	1203	2.5	2.4								0.60	171	153								252		60
Median		7.7	1280	2.7	2.5								0.63	170	140								260		61

Table 8A. Mineral and Trace Water Quality Data for San Joaquin River at Airport Way (site Index H) (SJC501) for Water Year 1991.

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, 50 ft. S of Airport Way Bridge, 3.2 mi. NE of Vernalis. River mile 72.3

Date	Time	pH	EC µmhos/cm	Se	Mo	Cu	Cr	Ni µg/L	Pb	Zn	U	V	B	Cl	SO4	Ca	Mg	Na	K mg/L	CO3	HCO3	T.Alk	HDNS	TDS	Temp. °F
10/5/90	1525	7.69	1050	1.9	3								0.44												70
10/12/90	945	6.63	688	1.2	2						7	5	0.30												60
10/19/90	1530	7.55	770	0.6	2								0.35												64
10/26/90	1455	7.66	750	0.8	2						7	5	0.24	100	94								170		66
11/2/90	850	6.00	690	0.5	2								0.26												54
11/9/90	840	7.50	760	0.6	2						7	4	0.28												52
11/16/90	1355	7.59	810	0.7	3								0.32												55
11/27/90	1525	7.68	850	0.5	3						7	2	0.32	130	100								180		52
12/7/90	755	6.70	1050	0.8	3								0.44												46
12/14/90	945	7.67	1010	2.1	3						7	3	0.48												46
12/21/90	1215	7.71	1110	2.7	3								0.54												42
12/28/90	845	7.56	1160	2.2	3						8	4	0.60	180	190								240		39
1/4/91	920	8.50	1110	2.4	3								0.55												44
1/10/91	1705	7.61	1080	1.9	3						9	6	0.54												52
1/15/91	1115	7.71	1190	2.7	3								0.58												54
1/18/91	1240	7.58	1220	2.9	4								0.62												52
1/25/91	845	7.50	1190	2.2	3						8	5	0.60	160	170								260		44
2/1/91	810	6.90	1160	3.1									0.61												46
2/8/91	1210	7.77	1120	2.3	3						9	8	0.60												54
2/15/91	1305	7.72	1170	2.8	3								0.65												60
2/22/91	835	6.34	1130	2.2	3						10	6	0.57	150	140								250		56
3/1/91	815		1100	2.9	4								0.61												56
3/8/91	825	6.30	1340	3.5	4						11	8	0.82												52
3/15/91	641	9.10	1420	4.8	4								0.92												52
3/21/91	1700	7.20	900	3.5	1								0.57												54
3/22/91	1250	7.20	620	1.6	1								0.28												54
3/28/91	1450	7.34	590	1.6	1						4		0.31	74	91								130		58
4/5/91	1415	7.88	1460	4.8	4								0.98												67
4/11/91	1715	8.12	1680	4.7	4						12	10	1.2												58
4/19/91	825		1470	3.4	3								0.77												60
4/25/91	1310	7.66	760	2.2	1						6	10	0.44	120	130								160		64
5/2/91	1700	7.40	410	0.9	1								0.20												60
5/9/91	1220		860	2.0	3								0.44												64
5/16/91	915	7.70	900	2.0	2						7	8	0.43												68
5/23/91	730	6.30	570	1.1	2								0.24												64
5/30/91	840	8.10	880	1.4	1						8	5	0.38	130	100								220		64
6/7/91	1035	7.89	990	1.8	2								0.47												72
6/14/91	1050	8.41	1090	2.5	2						11	12	0.64												74
6/21/91	640	8.20	1100	2.8	2								0.42												

Table 8A. Mineral and Trace Water Quality Data for San Joaquin River at Airport Way (site Index H) (SJC501) for Water Year 1991.

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, 50 ft. S of Airport Way Bridge, 3.2 mi. NE of Vernalis. River mile 72.3

Date	Time	pH	EC	Se	Mo	Cu	Cr	Ni	Pb	Zn	U	V	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	T.Alk	HDNS	TDS	Temp.
			µmhos/cm					µg/L											mg/L						°F
6/28/91	650		970	1.8	2								0.46	170	120								230		66
7/5/91	645	6.61	990	1.8									0.46												74
7/12/91	945	7.51	880	1.6									0.40												72
7/19/91	800	7.04	940	2.6	2								0.48												72
7/26/91	750		960	2.5									0.46												72
7/31/91	630		920	2.5	1						9	15	0.42	140	110								210		72
8/9/91	1410	9.47	950	1.5									0.42												83
8/16/91	1405		1050	1.9	1								0.50												76
8/23/91	700		1030	1.4									0.45												68
8/30/91	740	6.70	960	1.3	2						9	10	0.47	140	110								220		70
9/7/91	720	6.85	900	1.5									0.43												72
9/14/91	1440	8.35	1000	1.7	2								0.43												78
9/21/91	710	7.18	1020	1.3									0.45												70
9/30/91	750	7.88	980	1.3	2						10	7	0.35	150	110								220		68
Count		45	53	53	45	0	0	0	0	0	20	19	53	12	12	0	0	0	0	0	0	0	12	0	52
Min		6.00	410	0.5	1						4	2	0.20	74	91								130		39
Max		9.47	1680	4.8	4						12	15	1.2	180	190								260		83
Mean		7.51	995	2.1	2						8	7	0.49	137	122								208		61
Geo Mean		7.48	966	1.8	2						8	6	0.46	134	119								204		60
Median		7.59	990	1.9	2						8	6	0.46	140	110								220		60

APPENDIX B

Maximum, Minimum, and Median Concentrations
for Selected Mineral and Trace Elements
for Sites Along the Lower San Joaquin River
in Water Year 1991
(1 October 1990 to 30 September 1991)

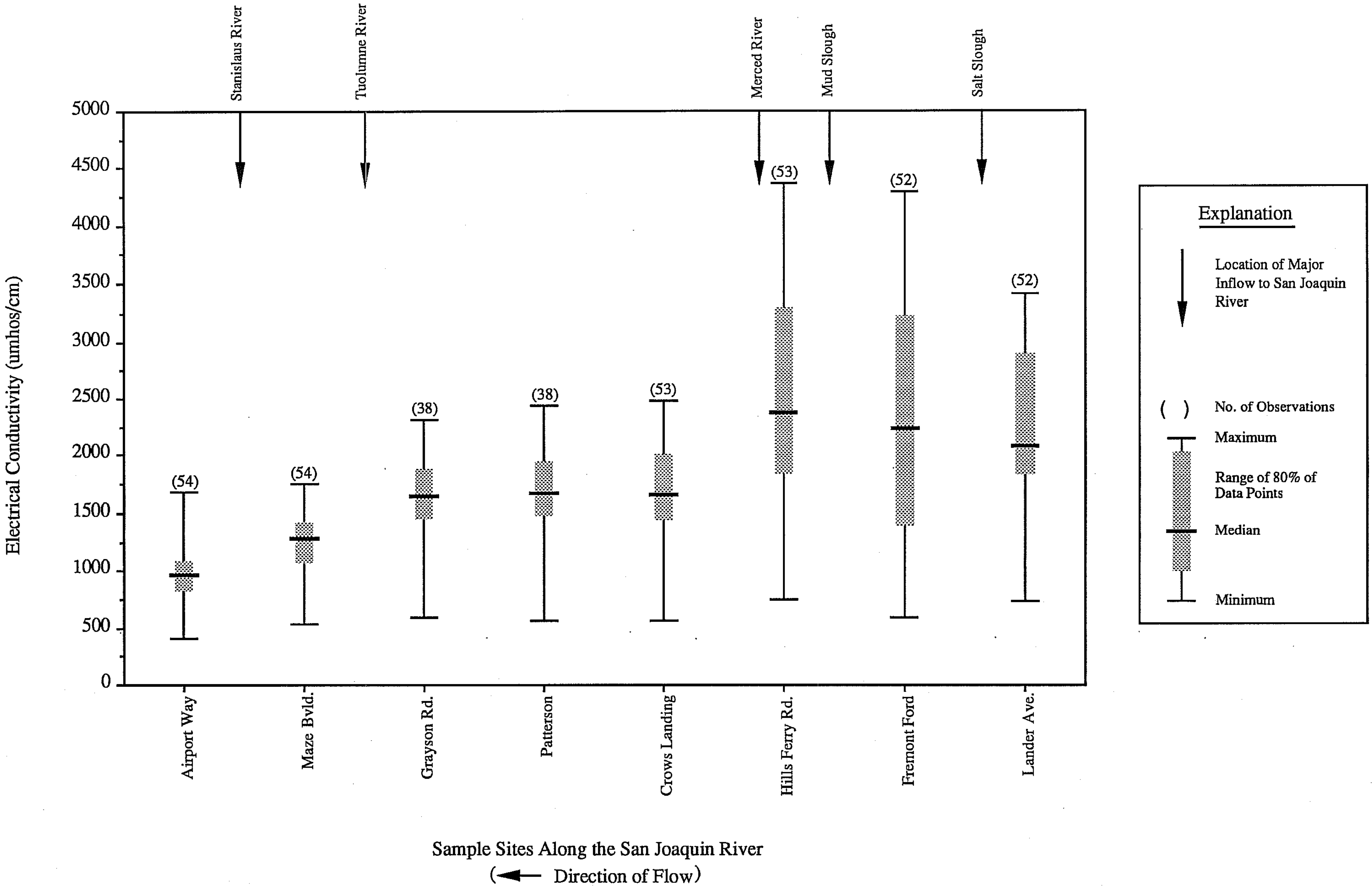

Figure 1B. San Joaquin River Electrical Conductivity Measurements for Water Year 1991; a Critical Water Year.

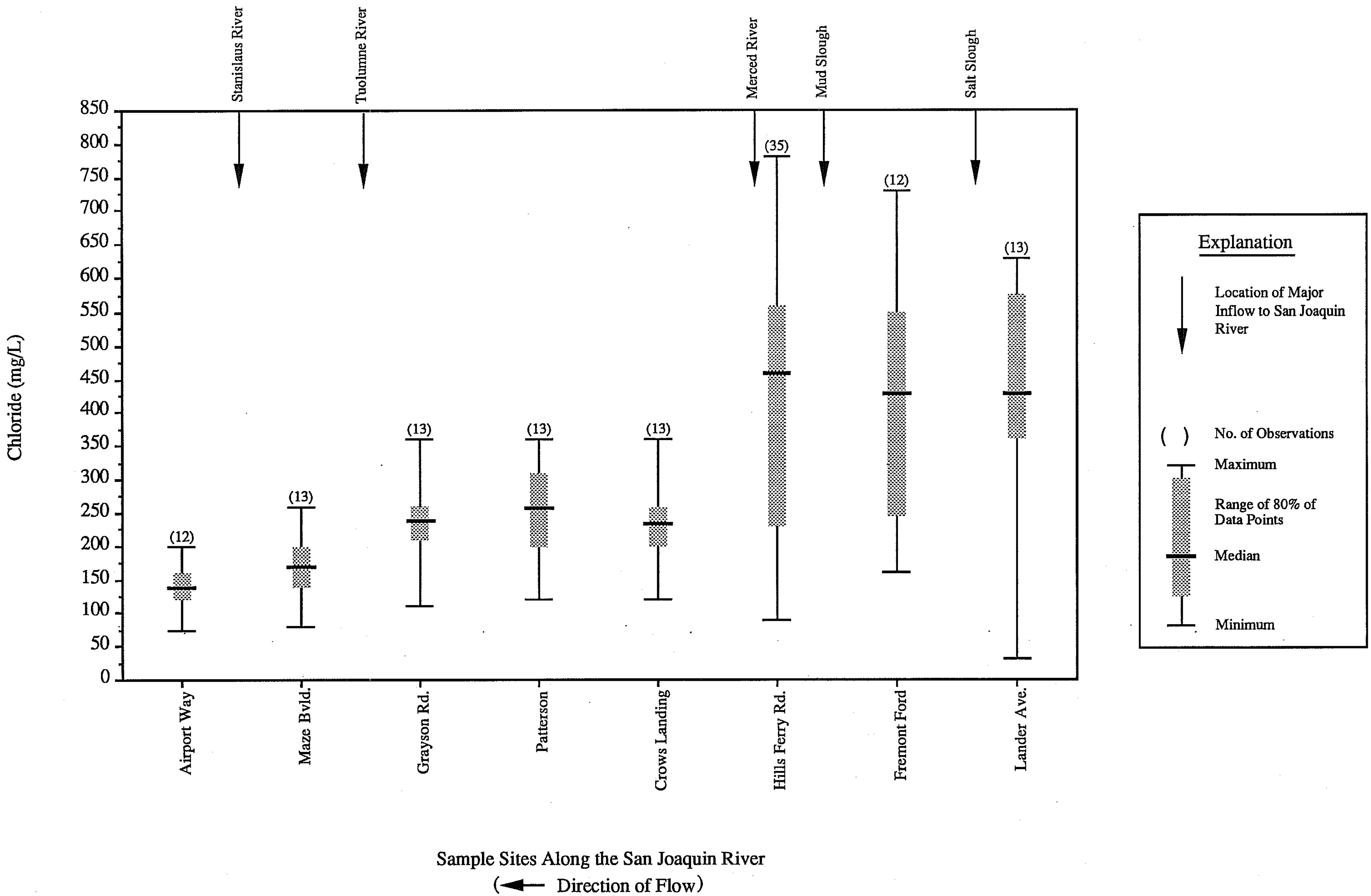

Figure 2B. San Joaquin River Chloride Measurements for Water Year 1991; a Critical Water Year.

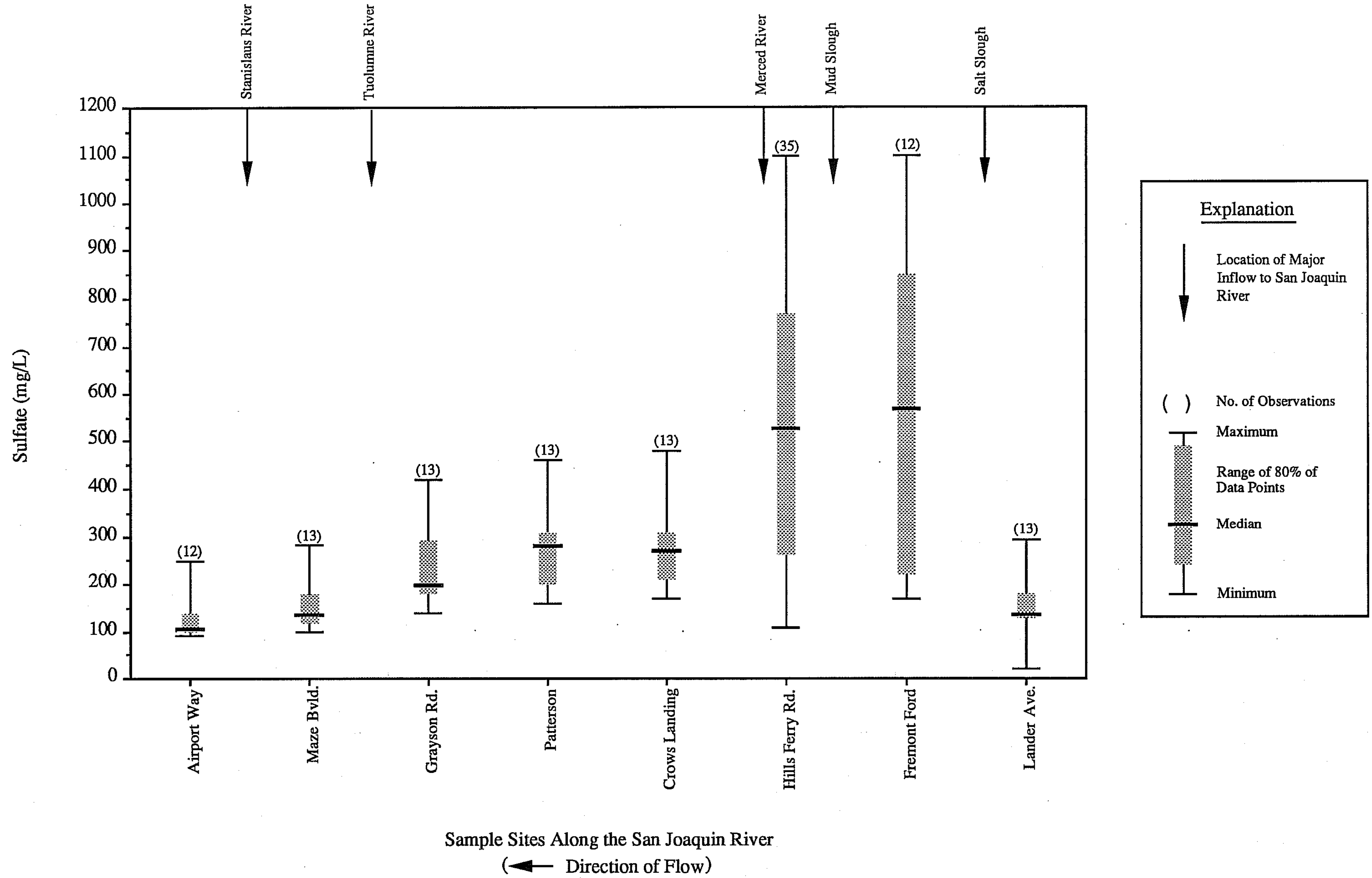

Figure 3B. San Joaquin River Sulfate Measurements for Water Year 1991; a Critical Water Year.

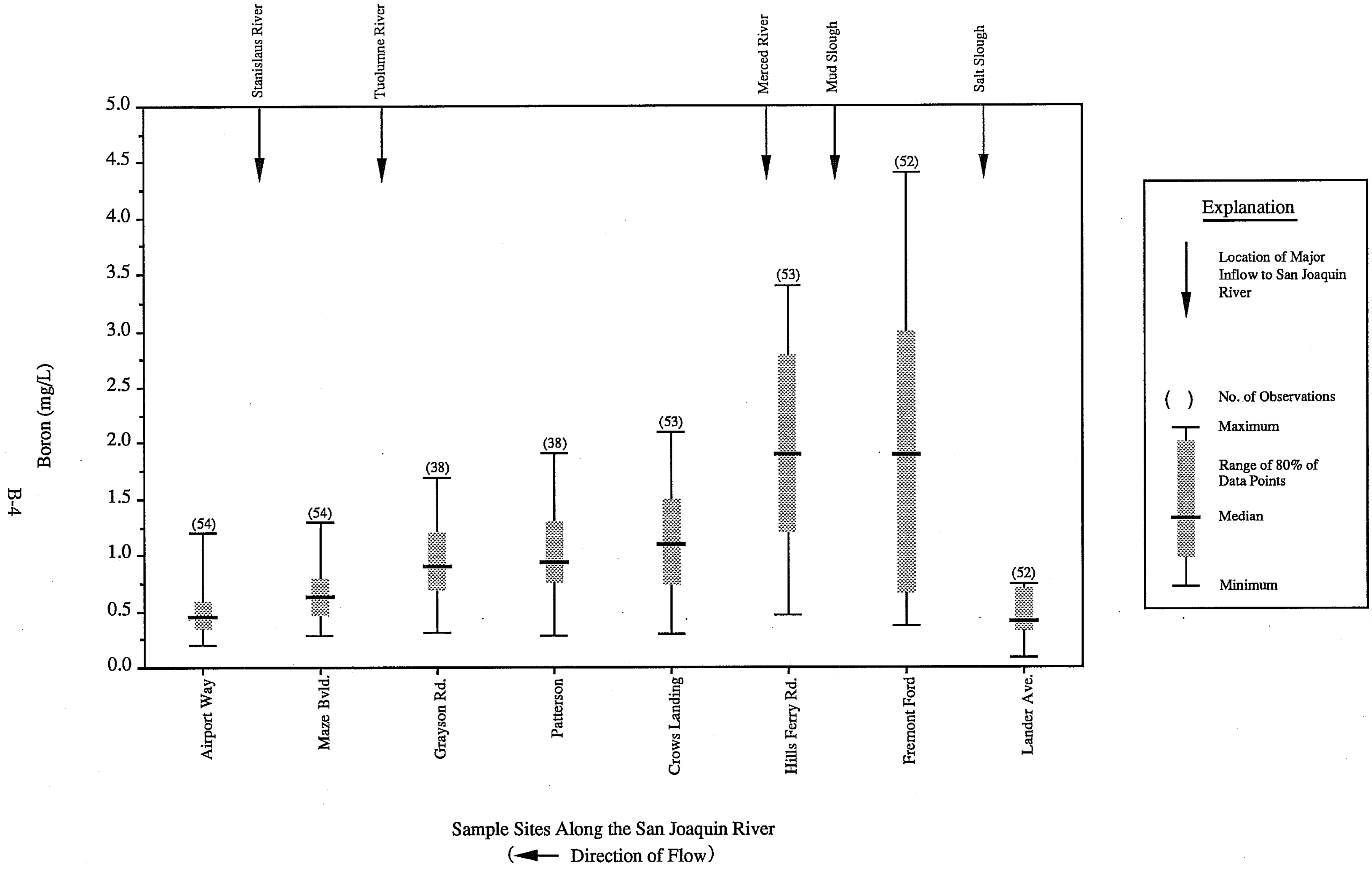

Figure 4B. San Joaquin River Boron Measurements for Water Year 1991; a Critical Water Year.

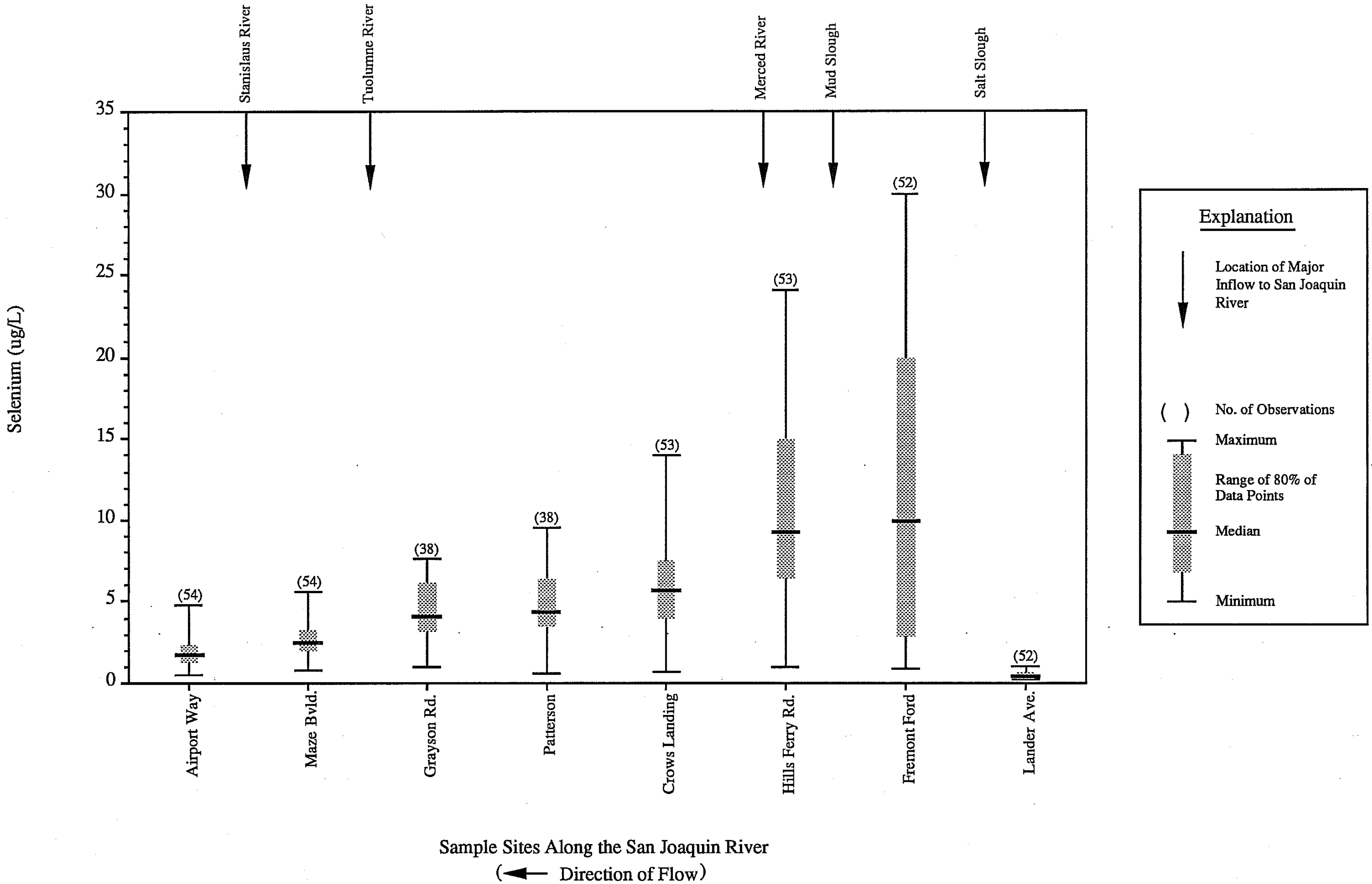

Figure 5B. San Joaquin River Selenium Measurements for Water Year 1991; a Critical Water Year.

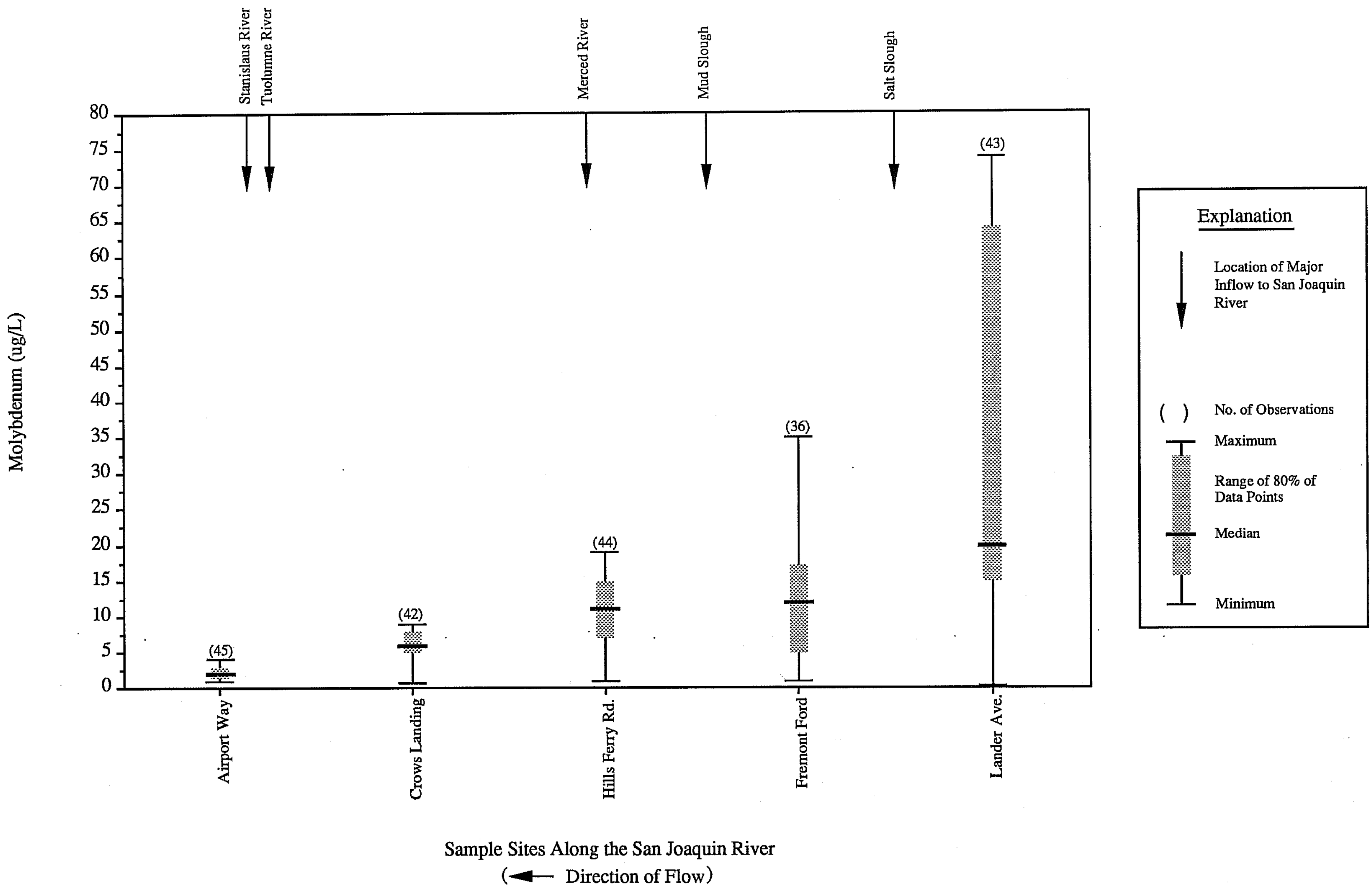

Figure 6B. San Joaquin River Molybdenum Measurements for Water Year 1991; a Critical Water Year.