WATER QUALITY OF THE LOWER SAN JOAQUIN RIVER: LANDER AVENUE TO VERNALIS OCTOBER 1988 TO SEPTEMBER 1989

(WATER YEAR 1989)

California Regional Water Quality Control Board
Central Valley Region
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CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD

CENTRAL VALLEY REGION

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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 on a monthly basis, or at selected sites on a weekly basis, and 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). A similar report has been prepared for Water Year (WY) 1988 (1 October 1987 to 30 September 1988) (Westcot et al., 1989). The present report covers the WY 1989 (1 October 1988 to 30 September 1989), a critically dry year.

The general trend in constituent concentrations along the San Joaquin River study area during WY 89 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, and molybdenum values in the river appear to be directly related to climatic and streamflow conditions in the river basin. During the critical 1987-89 water years (WYs) constituent concentrations were routinely higher than they were during the wet 86 WY. During WY 89, 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. These objectives and associated compliance dates were approved by the State Water Resources Control Board in September 1989, the final month of WY 89. The objectives were set for molybdenum, boron, and selenium.

During WY 89, mean monthly molybdenum concentrations were consistently below the approved water quality objective (19 μg/L) for all sites except for the San Joaquin River at Lander Avenue, the single site upstream of subsurface agricultural drainage inflows. The non-compliance is the result of natural conditions and likely the result of the critically dry year. During WY 89, flows at the Lander Avenue site were very low and most resulted from ground water inseepage.

Boron water quality objectives are delineated by both location on the river, season, and water year type. Throughout WY 89, a critically dry water year, only the two sites directly downstream of subsurface agricultural drainage exceeded the approved boron objective of 2.0 mg/L. These sites were the San Joaquin River at Hills Ferry and the San Joaquin River at Fremont Ford. Compliance with the objective is to begin in 1993.

In addition to water quality objectives, milestones were also set for selenium to assess progress towards meeting the objectives. During WY 89, selenium concentrations in the San Joaquin River at both Hills Ferry and Fremont Ford exceeded the WY 93 objective but did not exceed the milestone set for upcoming WY 90. The San Joaquin River at Crows Landing did exceed both the lower objective and standard set for selenium in that downstream reach of the river although concentrations rapidly diminished farther downstream. Lack of freshwater dilution contributes to the higher concentrations found in the critically dry 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 ongoing database for selected inorganic constituents found in San Joaquin River water. This database will be used to help assess the effects of agricultural drainage water on the quality of the San Joaquin River. A long-term database is essential to assess the long-term effects of the implementation of regional agricultural drainage reduction programs. This report contains the results of this monitoring program for data collected from October 1988 through September 1989 (WY 89). A previous report has been issued for data collected from May 1985 through March 1988. (James et al., 1988). A follow-up report has been prepared for Water Year (WY) 88 (1 October 1987 to 30 September 1988 [Westcot et al, 1989]). 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 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 discharged 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 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. A list of 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).

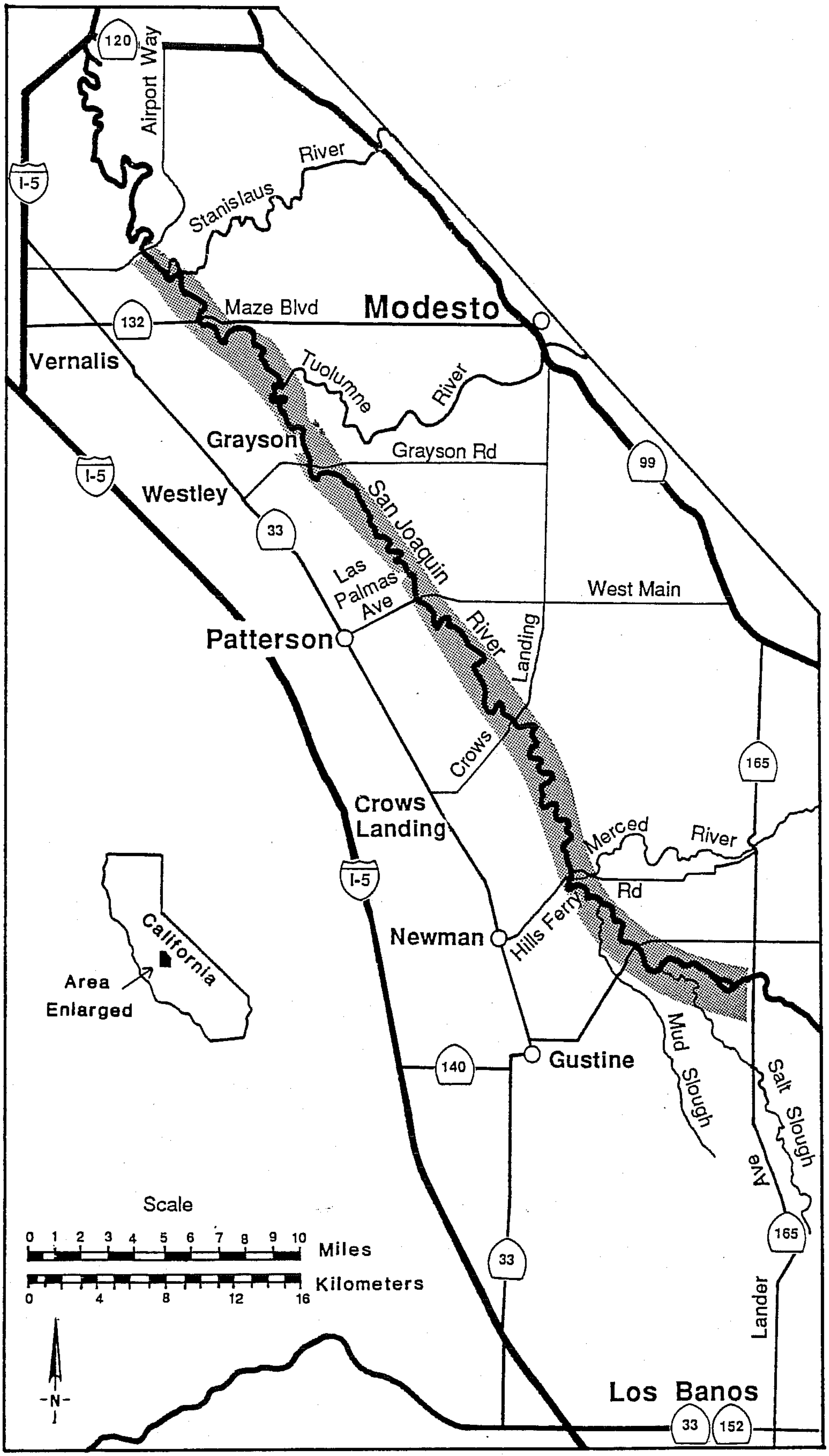


Fig. 1 Location Map

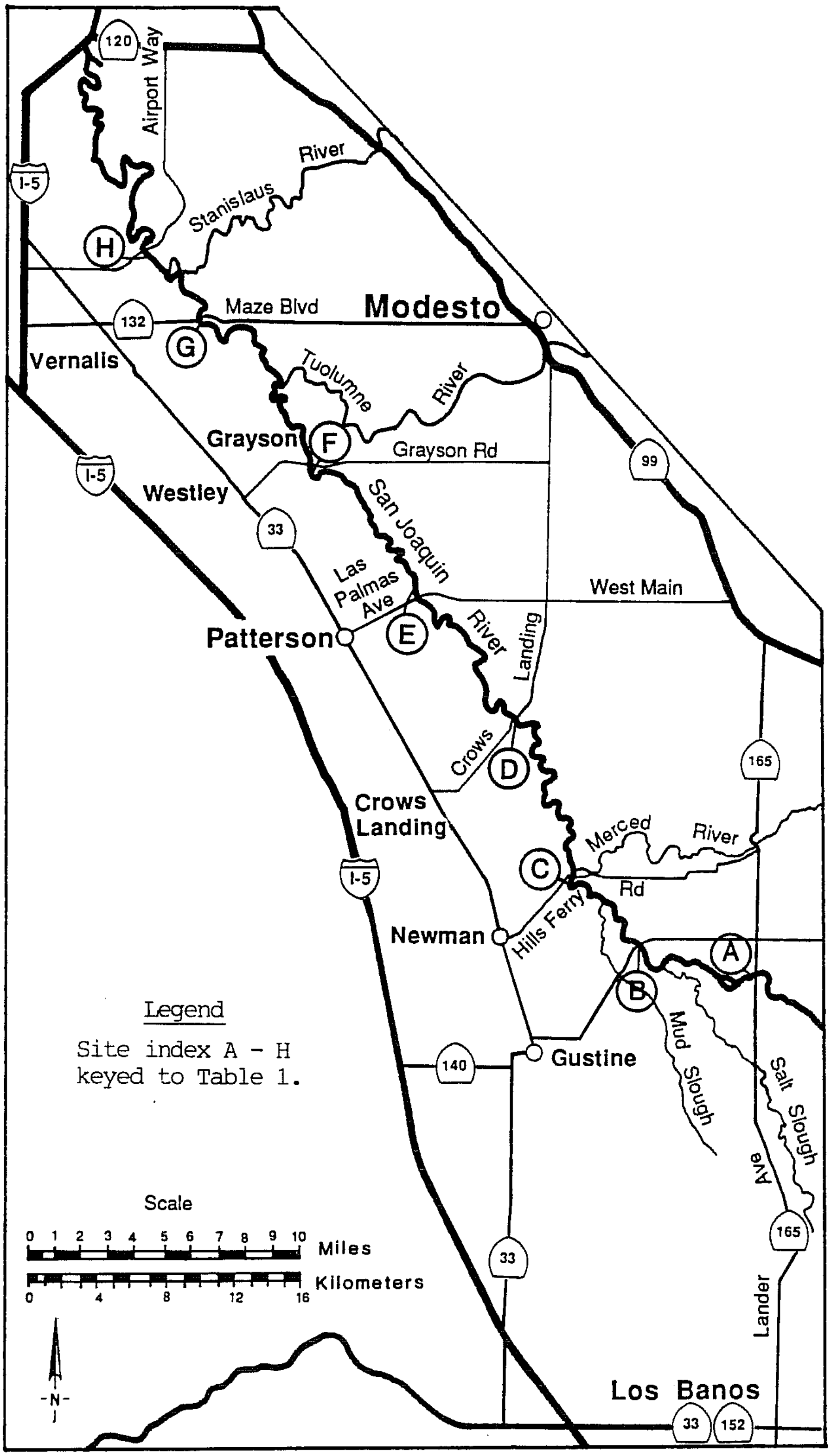


Fig. 2. Index Map

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 for the WYs 85-88 were given in James et al.(1988), and Westcot et al. (1989). Streamflows in the 85, 87, and 88 WYs were below the long-term average and in the 86 WY they were above average. The 89 WY, presented in this report, was also below average. WYs 87, 88, and 89 were classified as critically dry years as described in James et al. (1988). The 89 WY is one of the few instances where a critically dry year has followed two other critically dry years.

METHODS

The Regional Board monitoring program for the San Joaquin River began in May 1985 and has continued through the 89 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 89, the sampling frequency was increased for four of the eight sites to bi-weekly or weekly. All samples were analyzed for total recoverable selenium, boron, chloride, sulfate, total alkalinity, and EC. Selected samples were also analyzed for molybdenum. All 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. 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 the measured constituents in WY 89 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 concentrations as the Merced, Tuolumne, and Stanislaus Rivers each inflowed and diluted the San Joaquin River. These results are consistent with finding in WY 86, 87, and WY 88 (James et al., 1988 and Westcot et al., 1989).

Results of 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 1988 - September 1989).

		AIRPORT WAY	MAZE BOULEVARD	GRAYSON ROAD	LAS PALMAS AVENUE	CROWS LANDING	HILLS * FERRY RD.	FREMONT FORD	LANDER AVENUE
EC (μmhos/cm)	Minimum	720	880	1160	1220	1000	1360	1300	380
	Median	980	1285	1480	1490	1520	1930	2010	1500
	Maximum	1510	1740	2100	2220	2210	3350	3300	1990
	# Samples	(46)	(14)	(13)	(13)	(47)	(46)	(47)	(47)
Cl (mg/L)	Minimum	83	120	140	150	140	170	140	31
	Median	120	165	200	200	200	265	250	235
	Maximum	200	240	270	290	280	460	450	365
	# Samples	(45)	(14)	(13)	(13)	(46)	(46)	(46)	(46)
SO4 (mg/L)	Minimum	92	140	150	180	160	170	160	28
	Median	130	180	220	240	260	370	385	110
	Maximum	250	290	360	400	410	660	680	200
	# Samples	(45)	(14)	(13)	(13)	(46)	(46)	(46)	(46)
Total Alk. (mg/L)	Minimum	85	110	140	140	110	130	122	92
	Median	120	153	170	160	150	160	150	200
	Maximum	150	180	190	180	180	250	250	370
	# Samples	(44)	(14)	(13)	(13)	(45)	(46)	(45)	(45)
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	0.90	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)
Se (μg/L)	Minimum	1.4	3.2	3.5	3.0	3.4	2.8	3.4	0.30
	Median	2.9	4.4	5.8	6.0	6.9	9.8	12	0.50
	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			2	3		1
	Median	2	4			4	6		16
	Maximum	5	6			7	11		30
	# Samples	(44)	(4)			(46)	(46)		(47)

* Additional data ranges for Ca, Mg, Na, K, Hardness, 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 the concentrations of these selected minerals and trace elements along the entire study area. 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. Downstream of the Hills Ferry Road site the Merced River inflows and dilutes the river, thus concentrations at the next three sites downstream are lower than at Hills Ferry Road. These three sites, Crows Landing, Las Palmas Avenue, and Grayson Road, are 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).

The Fremont Ford site had the highest median EC (2010 µmhos/cm), boron (1.8 mg/L), sulfate (385 mg/L) and selenium (12 µg/L) values. These values are generally only slightly higher than those at Hills Ferry Road, the site immediately downstream. In previous water years, the highest concentrations were noted at the Hills Ferry Road site immediately upstream of the Merced River inflow. This previous finding illustrated the use of both Salt Slough and Mud Slough (north) to transport subsurface agricultural drainage water to the river. In WY 89, however, the majority of the drainage water discharges occurred through Salt Slough with the result that the highest concentrations in the river were found at Fremont Ford, the first site downstream of Salt Slough (Table 1). This trend is best illustrated using median selenium concentrations (Table 2) as greater than 95 percent of the selenium in the river comes from the discharge of subsurface agricultural drainage water.

Following a trend noticed in the 86-88 WY data (James et al., 1988 and Westcot et al., 1989), EC and boron values are generally highest during the drier water years (including WY 89). EC and boron values for the critical 87 through 89 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 critically dry 87 WY to 1720 µmhos/cm. During WY 89, the third consecutive critically dry year, EC values were even higher, ranging from 1360 to 3350 µmhos/cm with a median of 1930 µmhos/cm. Boron values followed the same trend. During the wet 86 WY, at Hills Ferry the median boron value was 0.91 mg/L (Table 3). In the critical 87 WY and 88 WY, the median values were 1.6 mg/L and 1.7 mg/L, respectively. The median boron concentration found in WY 89 was similar at 1.7 mg/L. This trend was observed at all of the monitoring sites.

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 on irrigation, but these extreme values occurred during the non-irrigation season.

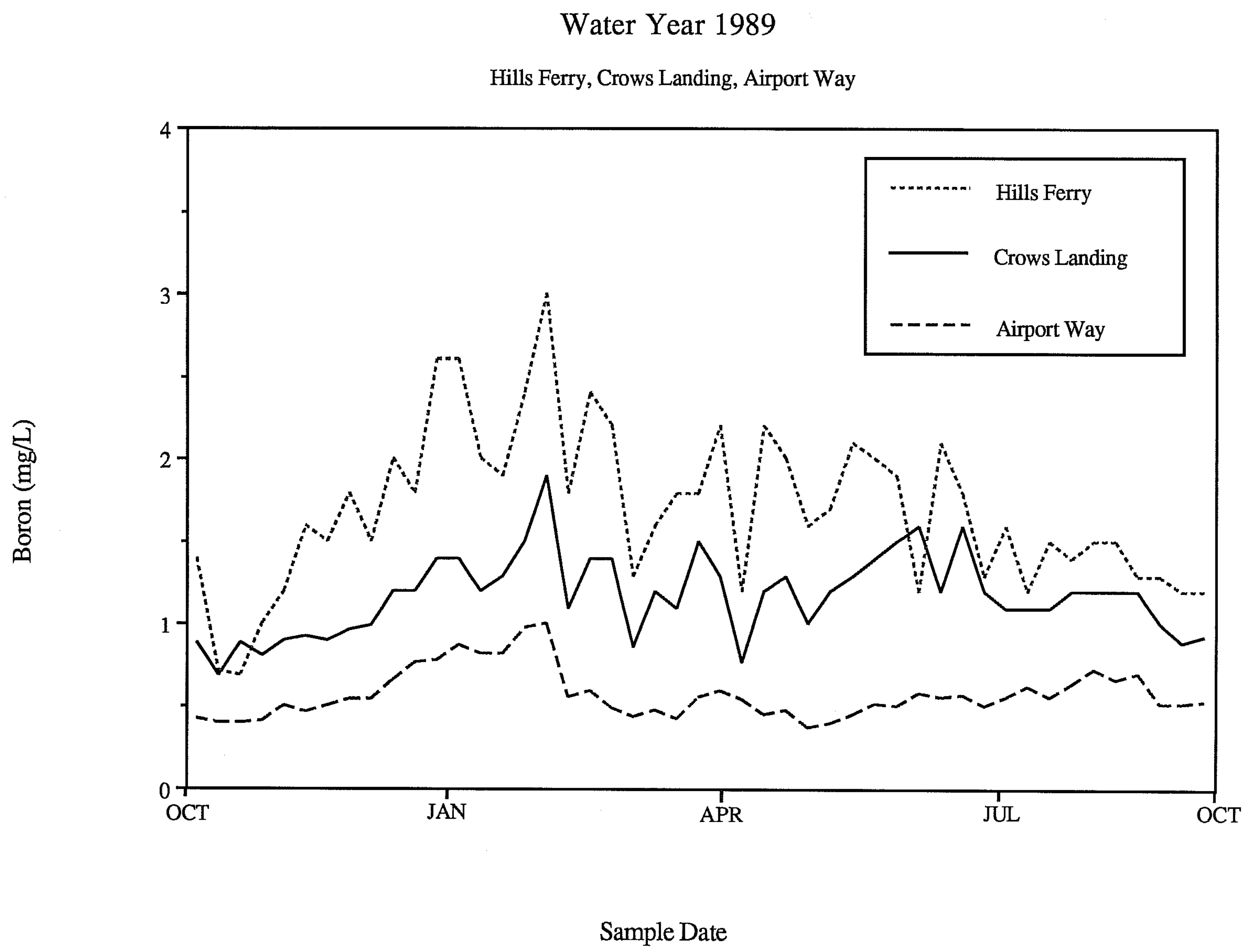


Figure 3. Boron Concentrations at Three Monitoring Sites Along the Lower San Joaquin River in Water Year 1989 (October 1988 through September 1989).

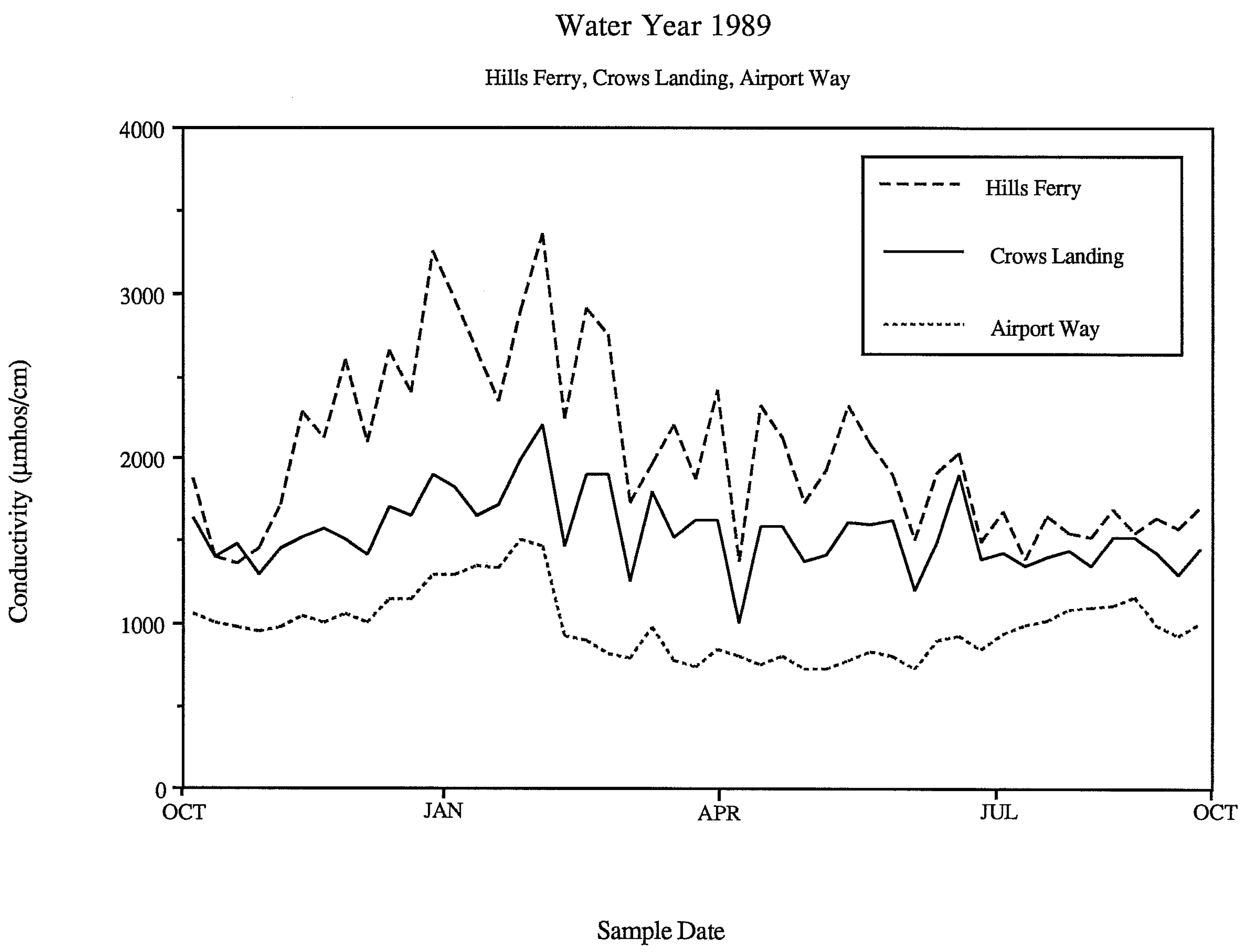


Figure 4. Electrical Conductivity at Three Monitoring Sites Along the Lower San Joaquin River in Water Year 1989 (October 1988 through September 1989).

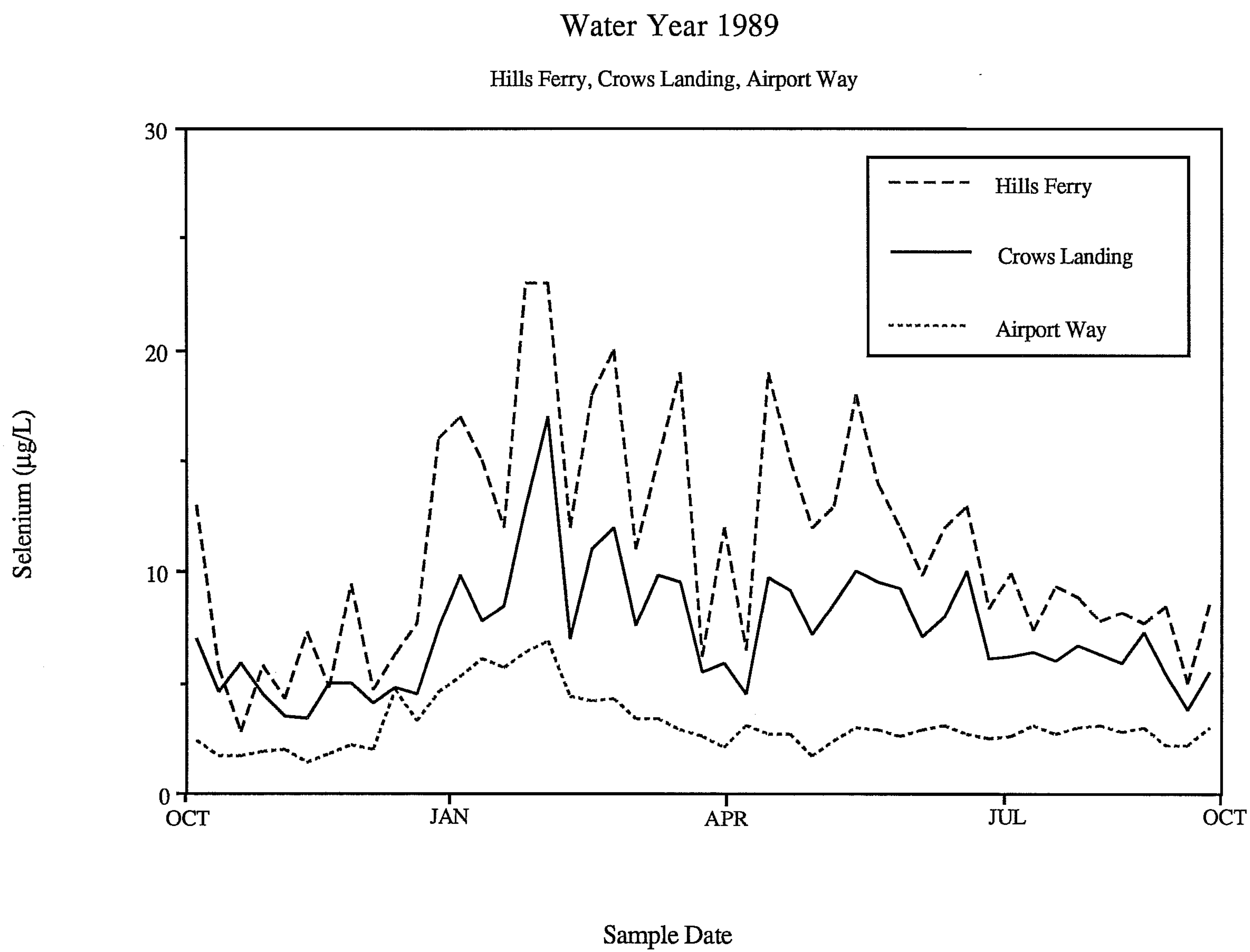


Figure 5. Selenium Concentrations at Three Monitoring Sites Along the Lower San Joaquin River in Water Year 1989 (October 1988 through September 1989).

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 taken from Westcot et al., 1989).

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)
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	1285	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	0.6	0.64	0.76	0.68	0.69	0.67	0.06
	Median	0.54	0.8	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)

Selenium concentrations at the Hills Ferry site followed the same general trend observed for EC and boron with the highest concentrations occurring during the critically dry 87 through 89 WYs with median values for WY 86-88 being 4.0 μg/L, 11 μg/L, and 10 μg/L, respectively, with WY 89 showing a median value of 9.8 μg/L. Similar trends were observed at downstream sites. Figures 6 and 7 show the selenium concentrations with time for the selected water years for the Crows Landing site (Index D) and Maze Road site (Index G). Figures 8 and 9 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. One possible explanation for this relationship 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 elevated in the River. Ranges of concentrations of selenium and molybdenum for various water years are shown in Table 4.

The Lander Avenue site is upstream of the discharge of subsurface drainage water and is considered the background site for this study. However, the highest median values for molybdenum (20 μg/L) occurred at this site. 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. During previous years (James et al., 1988), median quality at the Lander Avenue was comparable to that at Vernalis. However, contrary to that seen in WY 88 (Westcot et al., 1989), the critically dry WY 89 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 (Table 2, Figures 1B-6B in Appendix B). In WY 89, almost 40 percent of the samples collected exceeded the monthly mean for molybdenum (19 μg/L) established in the Basin Plan for the San Joaquin River. None of the samples, however, exceeded the maximum (50 μg/L) concentration established in the Plan (Table 5). (The Basin Plan objectives are discussed in detail in a later section.) Because of the very dry conditions in WY 89, flow at the Lander Avenue site was low. James et al. (1989) stated that flow at Lander Avenue in the river is often made up of a significant portion of ground water seepage into the river. The high median molybdenum 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 at Lander Avenue. (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, James et al. (1988) 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 water quality of 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 water quality. Boron, EC and selenium concentrations at those locations along the river course during the irrigation and nonirrigation

San Joaquin River at Crows Landing

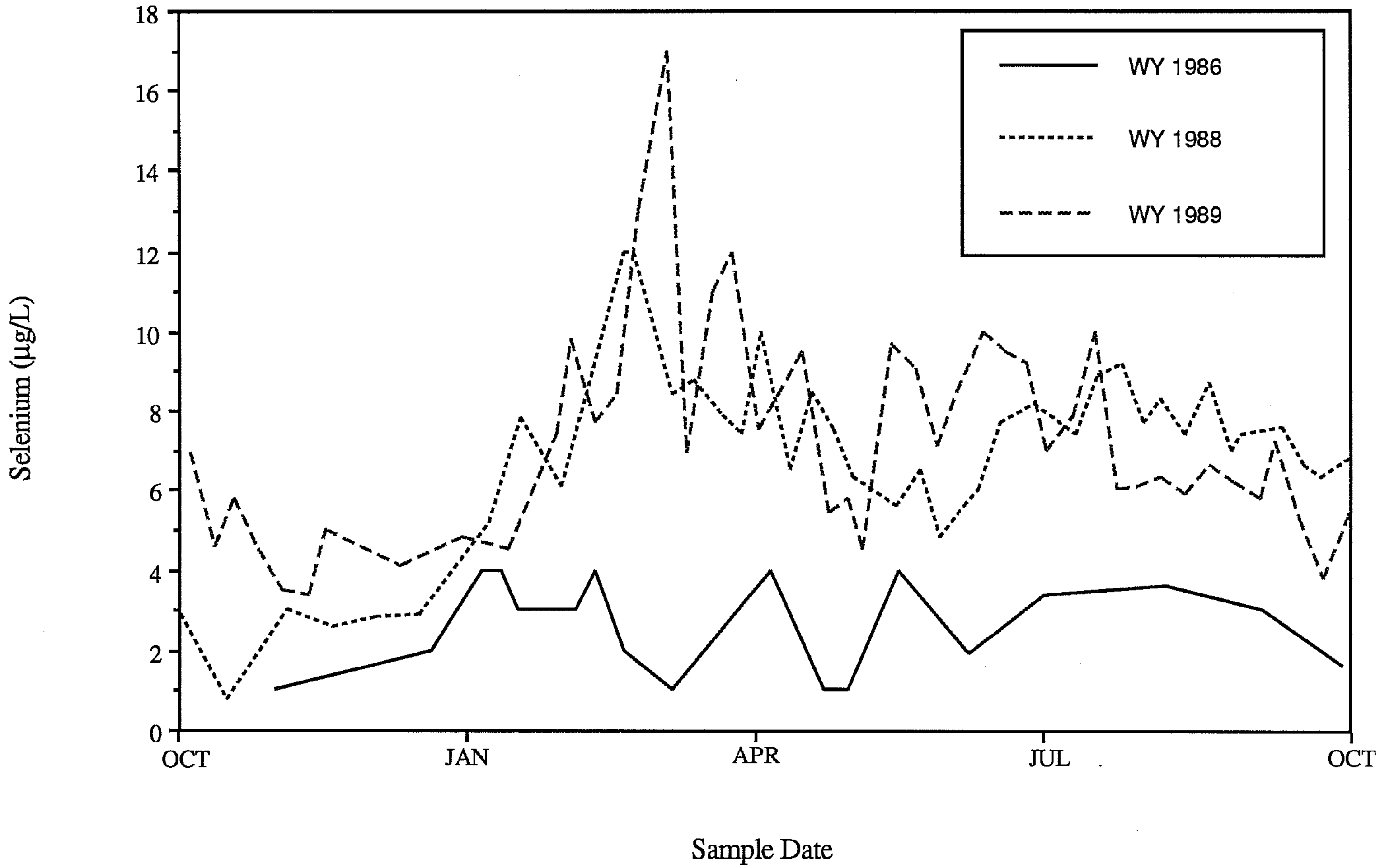


Figure 6. Selenium Concentrations at Crows Landing Road Along the Lower San Joaquin River for Water Years 1986, 1988 and 1989.

Figure 7. Selenium Concentrations at Maze Blvd. Bridge (Highway 132) Along the Lower San Joaquin River for Water Years 1986, 1988 and 1989.

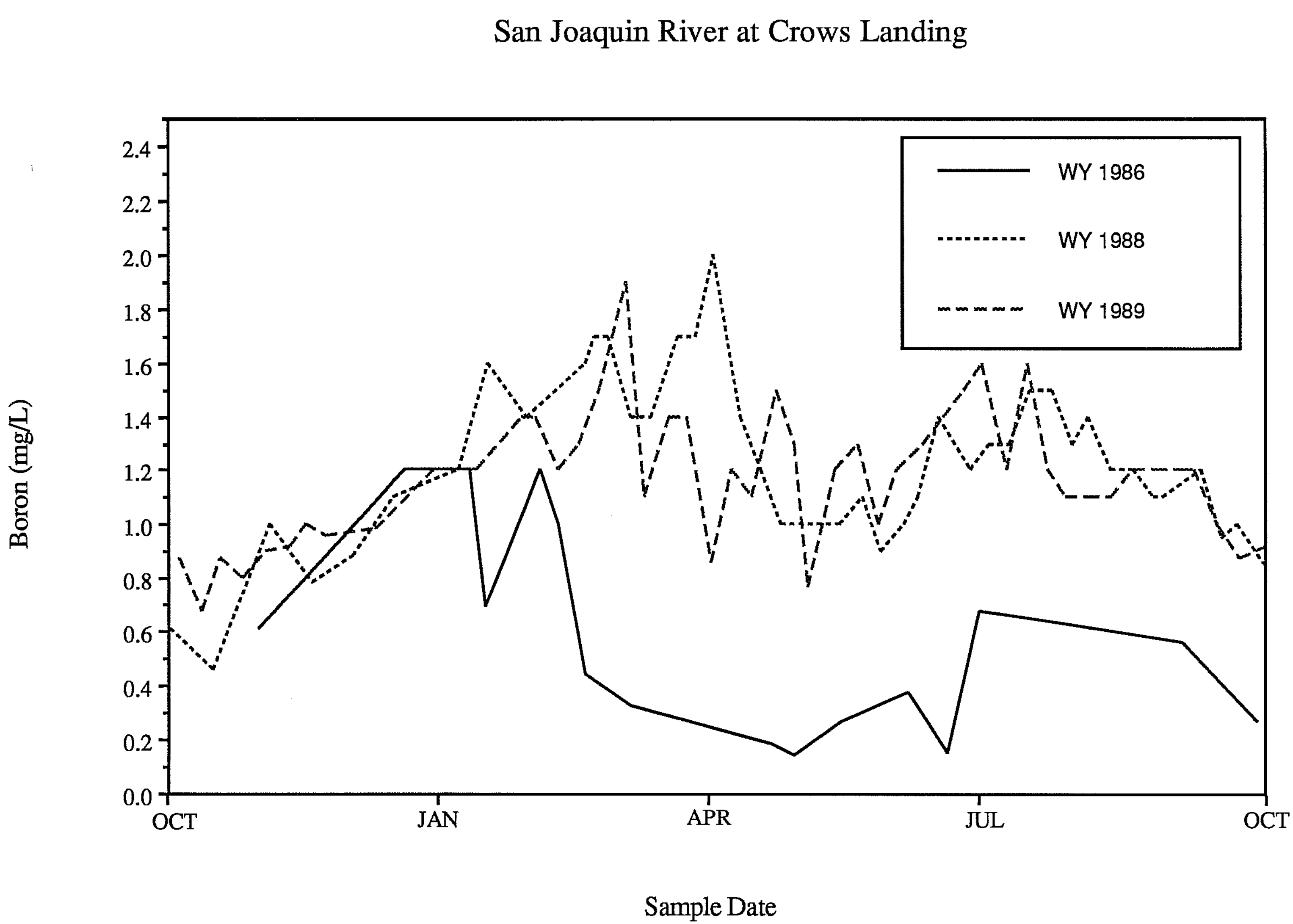


Figure 8. Boron Concentrations at Crows Landing Road Along the Lower San Joaquin River for Water Years 1986, 1988 and 1989.

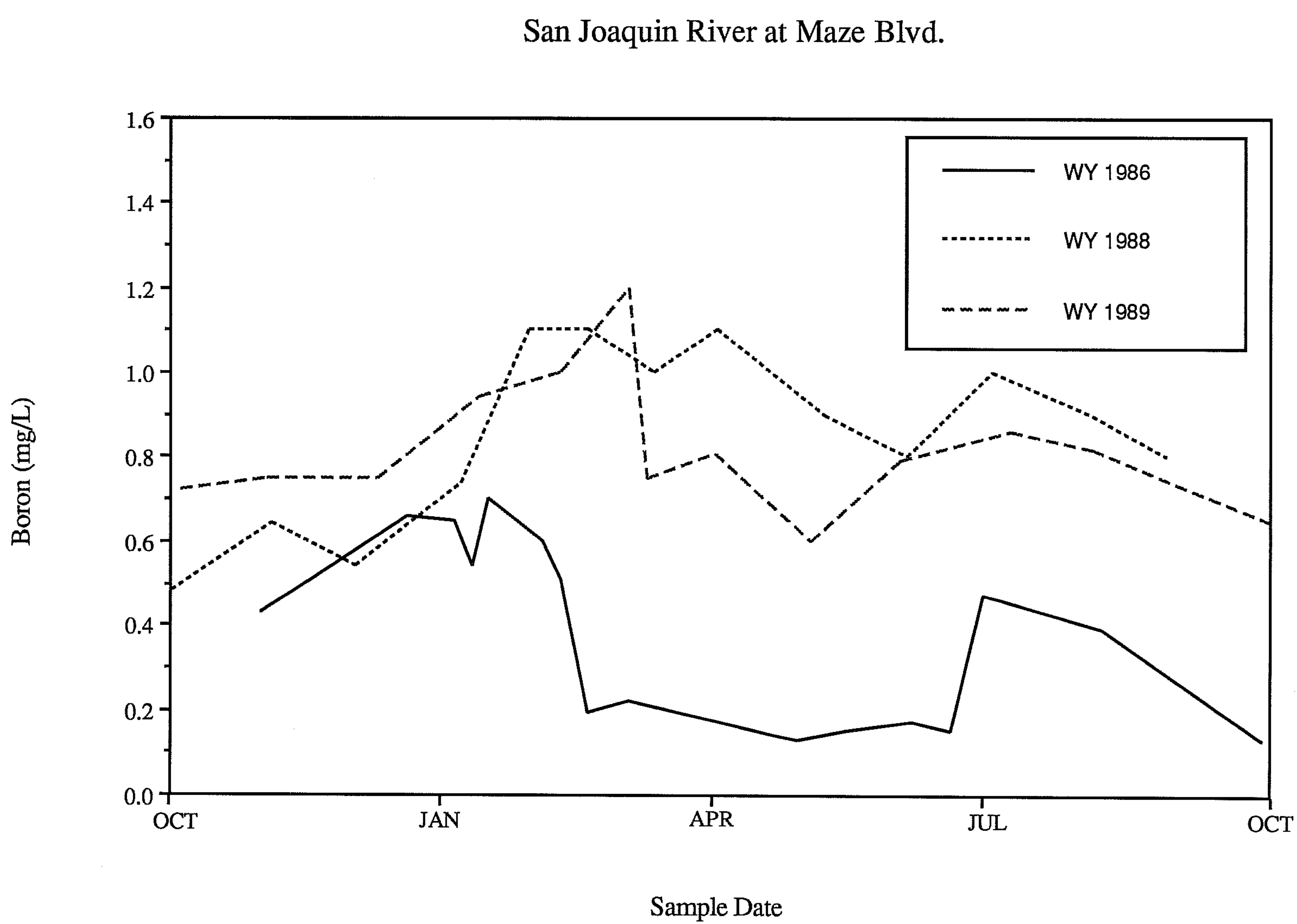


Figure 9. Boron Concentrations at Maze Blvd. Bridge (Highway 132) Along the Lower San Joaquin River for Water Years 1986, 1988 and 1989.

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 taken from Westcot et al., 1989.

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)	<5	<5	<5	4 (<5)	<5	<5	4 (<5)
	Median	2 (<5)	<5	<5	<5	4	7	5	7
	Maximum	2 (<5)	<5	<5	6	5	12	9	14
	# Samples	(11)	(3)	(3)	(3)	(10)	(11)	(3)	(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)
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			2	3		1
	Median	2	4			4	6		16
	Maximum	5	6			7	11		30
	# Samples	(44)	(4)			(46)	(46)		(47)

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	1991
	8 μg/l monthly mean (critical year only)		1991
Molybdenum	10 μg/l monthly mean	15 μg/l maximum	1990
Boron	0.8 mg/l monthly mean (15 March - 15 Sept)	2.0 mg/l maximum	1991
	1.0 mg/l monthly mean (16 Sept - 14 March)	2.6 mg/l maximum	1991
	1.3 mg/l monthly mean (critical year only)		1991
Salt Slough, Mud Slough (north), San Joaquin River, Sack Dam to mouth of the Merced River*			
Selenium	10 μg/l monthly mean	26 μg/l maximum	1993
Molybdenum	19 μg/l monthly mean	50 μg/l maximum	1990
Boron	2.0 mg/l monthly mean (15 March - 15 Sept)	5.8 mg/l maximum	1993

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

	Domestic/Municipal Drinking Water			Ambient water quality criteria to protect freshwater aquatic life		Irrigation Degree of Restriction on Use			Stock Water
	Primary	Secondary	Other (health)	4 day average	1 hour average	None	Slight to Moderate	Severe	
Constituent	- µg/l -*			- µg/l - *		- mg/l -*			- mg/l -*
Arsenic	50			190	360	0.1			0.2
Boron						< 0.7	0.7 - 3.0	> 3.0	5
Cadmium	10			0.55[a]	1.4[a]	0.01			0.05
Chromium (VI)	50†			11	16	0.1			1
Copper		1000		5.4[a]	7.5[a]	0.2			0.5
Iron		300				5			
Lead (inorganic)	50			0.99[a]	25[a]	5			0.1
Mercury	2			0.012	2.4				0.01
Molybdenum			70			0.01			
Nickel				73[a]	653[a]	0.02			
Selenium	10			5	20	0.02			0.05
Silver	50				13				
Zinc		5000		49[a]	54[a]	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; and SWRCB, 1987.)

[a] Criteria increase with increasing hardness of the water. These values are based on a hardness of 40 mg/l.

seasons are shown in Figures 3-5. Figures 6 and 7 show that the peak and low selenium concentration periods occurred at approximately the same time each year during the last two water years (WY 87 and 88) and the absence of the well-defined peaks during wet WY 86.

The existing water quality guidelines and criteria for the protection of beneficial uses are shown in Table 6. Current EPA guidelines and criteria are based on acid-soluble analyses. The more conservative total recoverable analyses values utilized in this monitoring program 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.

The 89 WY median selenium values from Fremont Ford (12 µg/L) to Grayson Road (5.8 µg/L) exceed 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.

Table 7. Dissolved Trace Element Water Quality Data for the San Joaquin River South of Hills Ferry Road (site index C) (STC512) for Water Year 1989.

Sample Date	Cr	Cu	Pb	Ni	Zn
	µg/L				
4/12/89	<1	2	<5	<5	5
4/20/89	<1	3	<5	<5	5
4/26/89	<1	2	<5	6	<1
5/1/89	<1	2	<5	5	5
5/10/89	<1	2	<5	<5	2
5/17/89	<1	2	<5	<5	2
5/24/89	<1	2	<5	<5	<1
5/31/89	<1	2	<5	<5	<1
6/7/89	<1	2	<5	<5	2
6/14/89	<1	2	<5	<5	–
6/21/89	<1	<1	<5	<5	1
6/27/89	<1	3	<5	<5	4
8/16/89	<1	2	<5	<5	<5
8/24/89	<1	2	<5	<5	<5
9/6/89	<1	1	<5	<5	<1
9/13/89	<1	2	<5	<5	<1
9/21/89	<1	2	<5	<5	<1
Minimum	<1	<1	<5	<5	<1
Median	<1	2	<5	<5	1
Maximum	<1	3	<5	6	5
Count	17	17	17	17	16

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). Extreme total recoverable chromium values at the Hills Ferry Road site have exceeded the EPA ambient water quality criteria of 11 μg/L hexavalent chromium for the protection of fresh water aquatic life almost 50 percent of the time and the median value found is 10 μg/L. Acid-soluble hexavalent chromium levels were not evaluated in this study, but are expected to be lower than total recoverable chromium. Dissolved concentrations, however, were greatly different from the total recoverable levels. As shown in Table 7, dissolved chromium levels were <1 μg/L throughout 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.

Median and maximum total recoverable nickel and zinc values were all below the EPA guideline for the protection of freshwater aquatic life. However, they were also elevated. The median and maximum value for total recoverable copper slightly exceeded the EPA guideline of 5.4 μg/L for protection of freshwater aquatic life.

Like chromium, however, the dissolved concentrations were all at or near the detection level for nickel, zinc and copper (Table 7). In no instance did the levels measured exceed the EPA guidelines for protection of freshwater aquatic life. This analysis was conducted using the conservative approach that water hardness was 50 mg/L. Table 3A in Appendix A shows that median water hardness exceeds 500 mg/L for this site. As the EPA criterion are water hardness dependent, using 50 mg/L for analysis provides a significant margin of safety.

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 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 that for chromium, copper, lead, nickel and zinc, sediment plays a key role and dissolved values may be significantly lower than the total recoverable concentrations reported. In addition, dissolved values may better represent environmental exposure in the water column.

COMPLIANCE WITH OBJECTIVES

In December of this water year, 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 approval of the objectives and compliance dates was in September 1989, the last month of WY 89.

Two different approved molybdenum objectives apply to the San Joaquin River (Table 5). One objective applies upstream of the Merced River inflow, the second applies downstream of this point. As shown in Figure 10 for the Hills Ferry Road site upstream of the Merced River inflow, monthly mean molybdenum concentrations downstream of the tile drainage discharges were consistently below the approved water quality objective of 19 μg/L and did not exceed the lower 10 μg/L objective approved for sites below the Merced River inflow. As a result, this same pattern of low concentrations can be seen at the two downstream monitoring stations (Figure 11) at Crows Landing Bridge and Airport Way. It is interesting to note that while full compliance was achieved at all the sites monitored downstream of the tile drainage discharges, the Lander Avenue site (Figure 12), which is upstream of the drainage inflows, showed the highest monthly mean concentrations. The monthly means exceeded the objective in 3 out of the 12 months. Approximately 40 percent of the samples collected in WY 89 exceeded the monthly mean for molybdenum (19 μg/L) established in the Basin Plan for the San Joaquin River. None of the samples collected, however, exceeded the maximum (50 μg/L) concentration established in the same plan (Table 5). This non-compliance is the result of natural conditions and monitoring should continue to see if these concentrations are the result of the critically dry year. During WY 89, a critically dry year, flows at the Lander Avenue site were very low and most flow resulted from ground water inseepage.

Throughout WY 89 boron concentrations never exceeded 0.54 mg/L upstream of the tile drainage inflow at the Lander Avenue site. The median of the weekly sampling was 0.32 mg/L. Downstream of the drainage inflows, the Fremont Ford and Hills Ferry Road sites showed boron concentrations that had increased significantly. Mean monthly boron concentrations at these sites frequently exceeded the approved water quality objective of 2.0 mg/L (Figure 13) although compliance with the objective is not until 1993. This comparison is made with the 1993 objective as no interim milestones are available for boron.

Downstream of the Merced River inflow, a different set of water quality objectives apply. The objectives are seasonal, as well as modified, based upon critically dry water years. WY 89 was a critically dry year; therefore, the approved water quality objective for such a year is 1.3 μg/L. Compliance with the objective is not expected until WY 92 (October 1991). Figure 14 illustrates the accomplishments in WY 89 in relation to the water quality objective to be achieved in October 1991. Only one monthly mean 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.

Figure 10. Mean Monthly Molybdenum Concentrations at Hills Ferry Road (Site Index C) for WY 89 as Compared to Adopted Water Quality Objectives for the San Joaquin River.

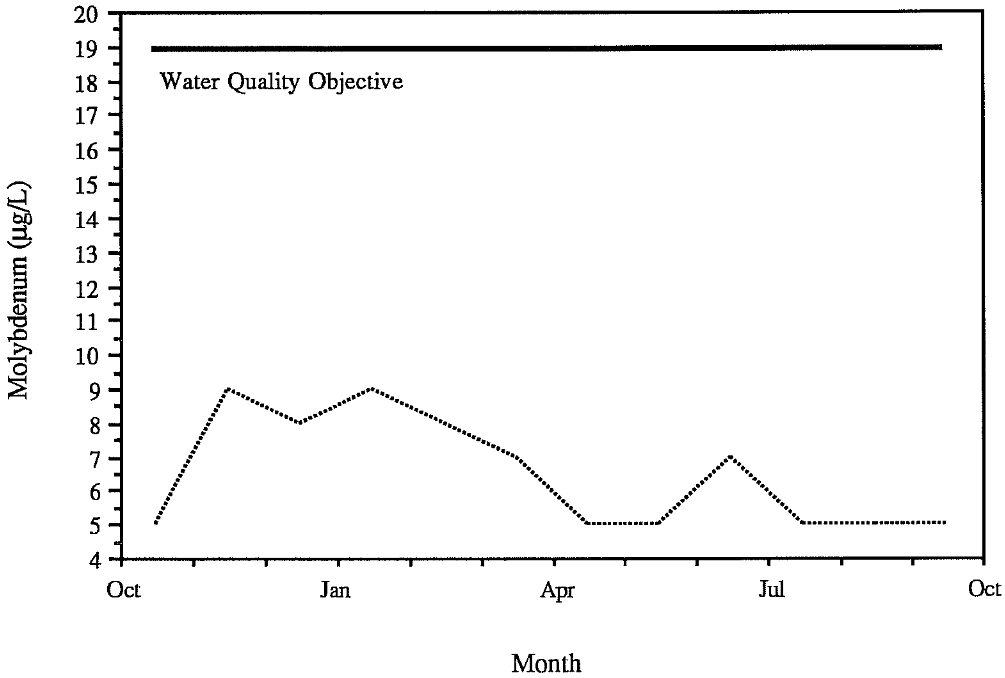


Figure 11. Mean Monthly Molybdenum Concentrations at Crows Landing Bridge (Site Index D) and Airport Way (Site Index H) for WY 89 as Compared to Adopted Water Quality Objectives for the San Joaquin River.

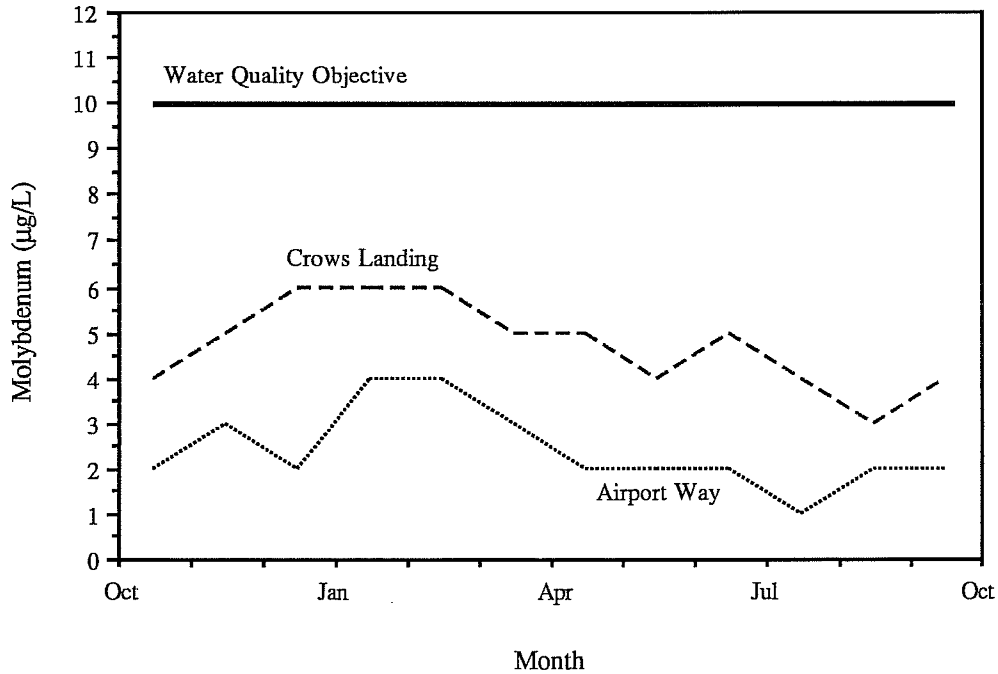


Figure 12. Mean Monthly Molybdenum Concentrations at Lander Avenue (Site Index A) for WY 89 as Compared to Adopted Water Quality Objectives for the San Joaquin River.

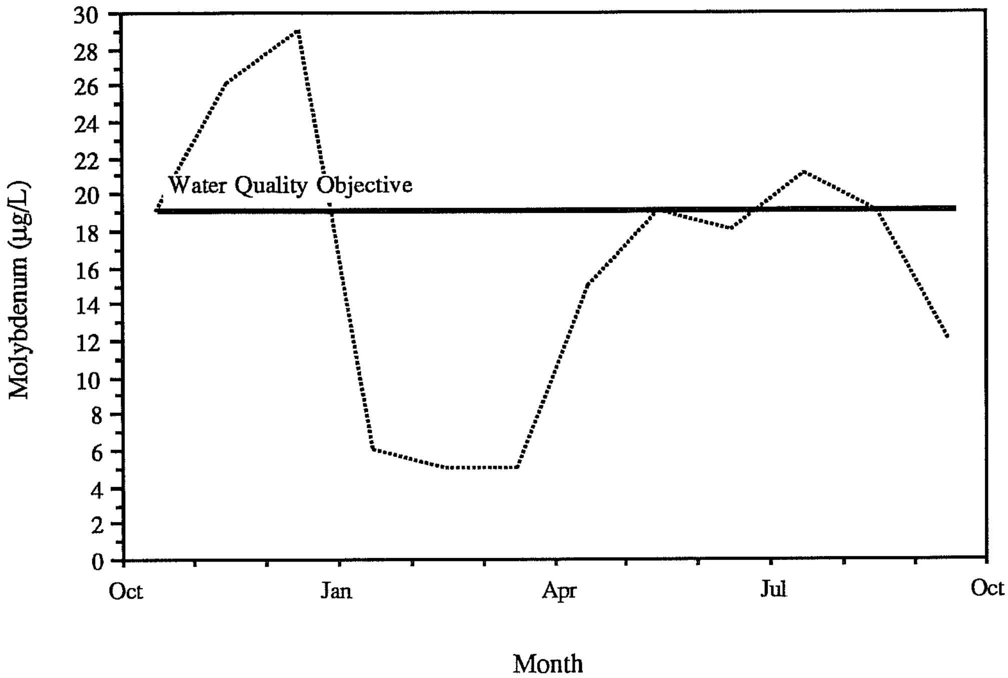


Figure 13. Mean Monthly Boron Concentrations at Freemont Ford (Site Index B) and Hills Ferry Road (Site Index C) for WY 89 as Compared to Adopted Water Quality Objectives for the San Joaquin River to be Implemented in Oct. 1993 (WY 94).

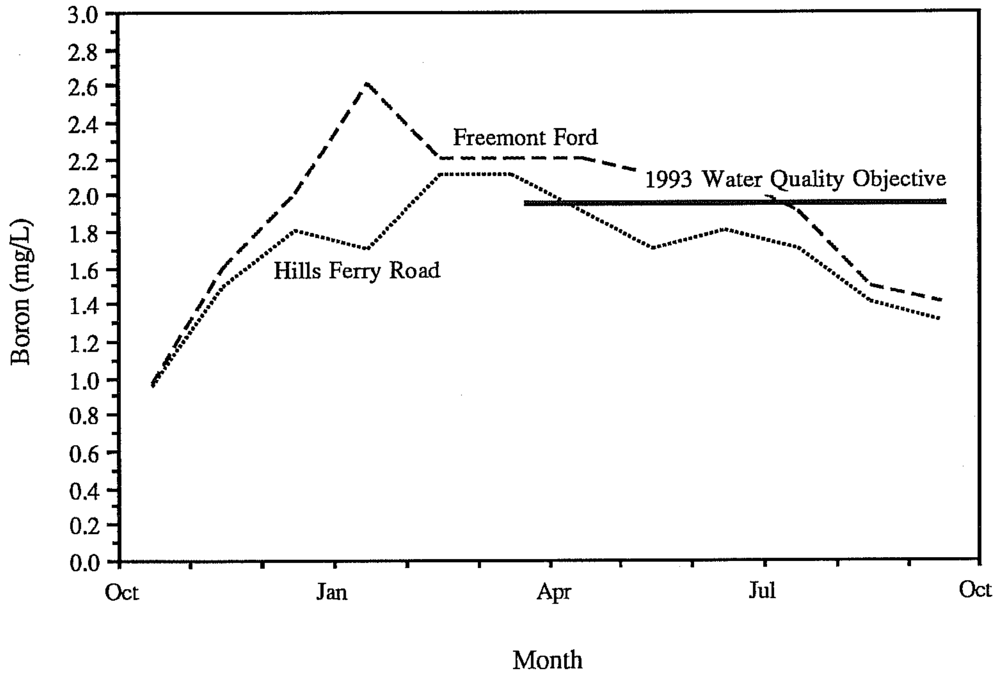


Figure 14. Mean Monthly Boron Concentrations at Crows Landing Bridge (Site Index D) and Airport Way (Site Index H) for WY 89 as Compared to the Adopted Water Quality Objectives for the San Joaquin River to be Implemented in October 1991 (WY 92).

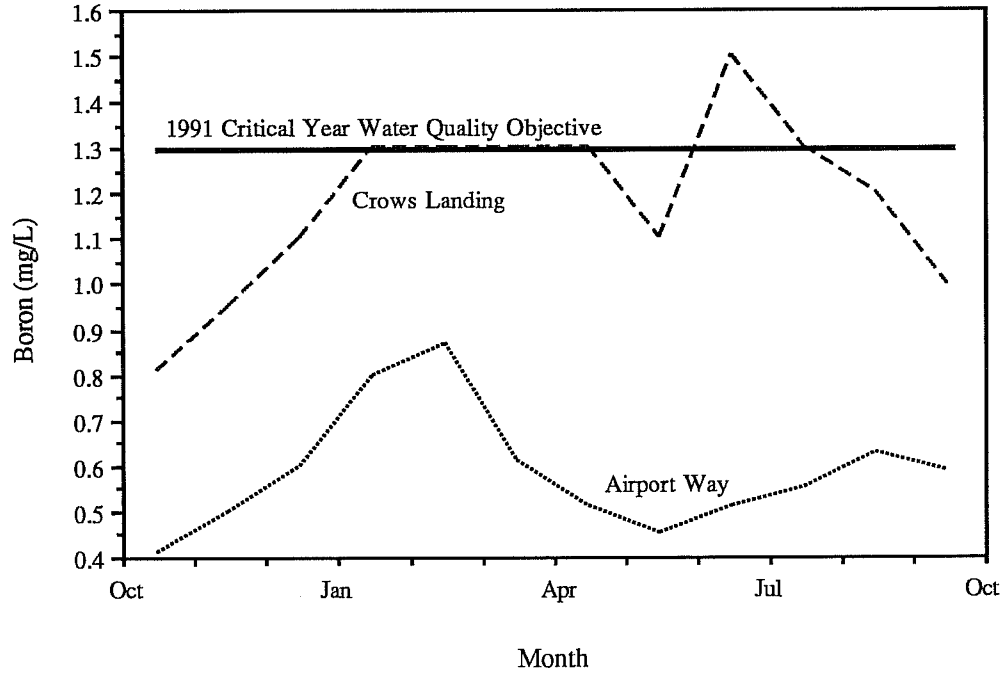
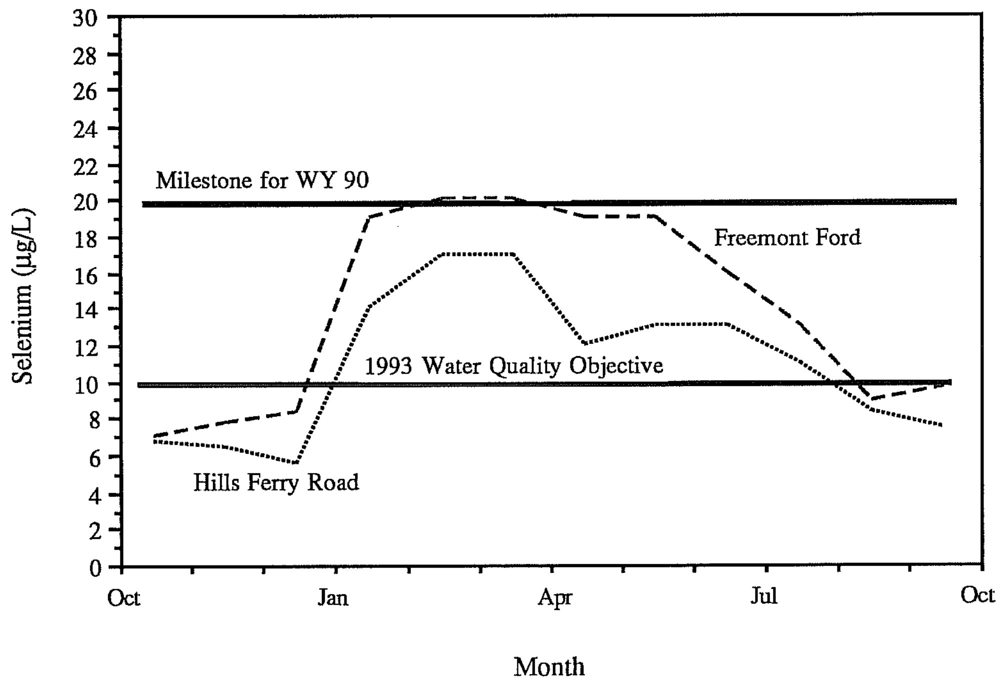


Figure 15. Mean Monthly Selenium Concentrations at Freemont Ford (Site Index B) and Hills Ferry Road (Site Index C) for WY 89 as Compared to Adopted Water Quality Objectives for the San Joaquin River to be Implemented in October 1993 (WY 94) and Milestones Used to Assess Progress Towards Meeting the Selenium Objectives.



Maximum Monthly Mean Selenium Concentrations

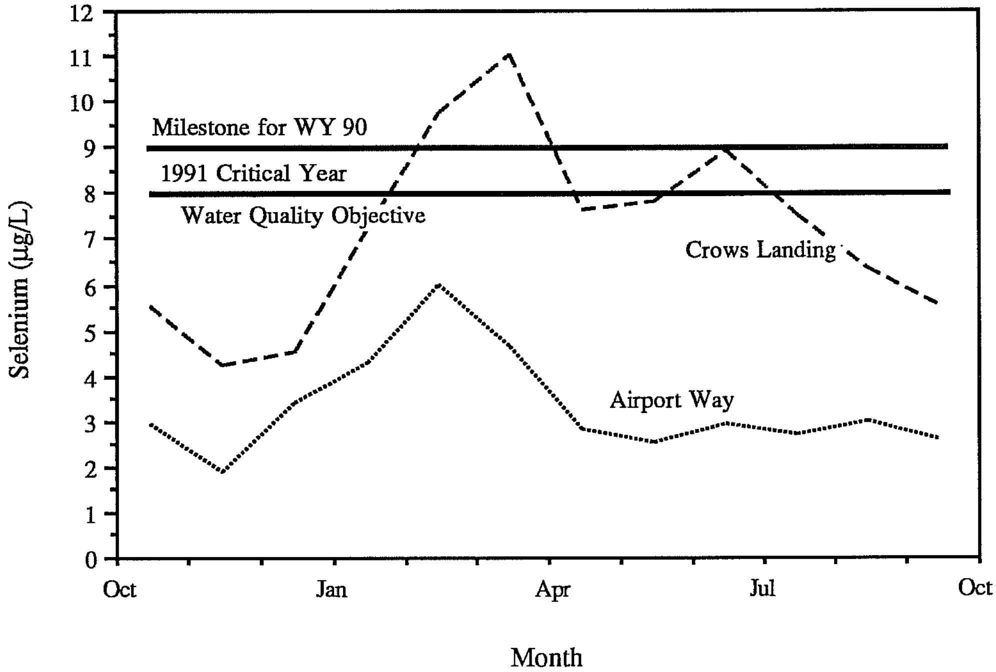
Time Period	San Joaquin River Mouth of the Merced River to Vernalis	San Joaquin River, Sack Dam to Mouth of the Merced River
WY 90 (10/89-9/90)	Dry Year* 6 µg/L Critical Year* 9 µg/L	20 µg/L
WY 91 (10/90-9/91)	Dry Year* 5 µg/L Critical Year* 8 µg/L	17 µg/L
WY 92 (10/91-9/92)	Dry Year* 5 µg/L Critical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

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

The Lander Avenue site never had selenium concentrations that exceeded 2µg/L with all monthly means less than 1 µg/L. This site is upstream of the subsurface tile drainage discharges to the river. Downstream of the discharges and prior to the Merced River inflow, both the sites at Fremont Ford and at Hills Ferry Road showed elevated selenium concentrations (Figure 15). Both sites exceeded the mean monthly selenium concentration planned for full implementation in 1993, 10 µg/L. No adjustment is planned for this objective for critically dry years such as was found in WY 89. Mean monthly concentrations at these sites, however, did not exceed 20 µg/L, the milestone value establish for the next water year (WY 90). The information is only for comparison, however, as no milestones were set for WY 89.

Downstream of the Merced River inflow, mean monthly selenium concentrations dropped as dilution flows entered from the eastside streams. Figure 16 shows monthly mean concentrations in comparison to the water quality objective for a critically dry year, 8 µg/L. This concentration will be the maximum monthly mean after October 1991 (WY 92). Also shown is the milestone for WY 90 that will be used next water year to assess progress toward meeting selenium water quality objectives in the San Joaquin River.

Figure 16. Mean Monthly Selenium Concentrations for the San Joaquin River at Crows Landing (Site Index D) and Airport Way (Site Index H) for WY 89 as Compared to the Adopted Critical Year Water Quality Objective to be Implemented in October 1991 (WY 92) and Milestones Used to Assess Progress Towards Meeting the Selenium Objectives.



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APPENDIX A

Mineral and Trace Element Concentrations
for Sites Along the Lower San Joaquin River
in Water Year 1989
(1 October 1988 to 30 September 1989)

Table 1A. Mineral and Trace Element Water Quality Data for San Joaquin River at Lander Avenue (site Index A) (MER522) for Water Year 1989.

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	B	Cl	SO4	CO3	HCO3	T. Alk.	Temp.
			µmhos/cm	µg/L		mg/L						°F
10/4/88	1125		1680	0.9	22	0.31	260	110	<1	290	290	71
10/11/88	1335	8.0	1400	0.5	18	0.20	210	94			240	70
10/17/88	1620		1370	0.5	17	0.22	190	84	9	230	239	74
10/25/88		7.8	1400	0.4	20	0.26	180	77	8	270	278	71
11/1/88	1135	8.1	1460	1.1	23	0.27	210	79	8	300	308	70
11/10/88	1305	8.1	1520	0.7	26	0.29	230	83	<1	320	320	62
11/15/88	940	8.2	1500	0.8	27	0.28	230	77	<1	310	310	58
11/22/88	1325	7.9	1550	0.6	29	0.29	220	84	9	320	329	54
12/8/88	1240		1660	0.4	30	0.32	250	79	<1	370	370	54
12/28/88	1315		1950	0.6	28	0.20	310	100	<1	360	360	43
1/11/89			750	0.9	3	0.23	100	83			110	45
1/26/89	1215		1250	1.2	7	0.54	160	180	<1	140	140	50
1/31/89	1010		1140	1.3	7	0.45	160	140	<1	160	160	50
2/7/89			1050	0.8	6							45
2/14/89	1010	8.1	550	<0.2	2	0.09	63	45	<1	120	120	48
2/21/89	1250		870	1.1	7	0.15	110	76	<1	180	180	60
3/1/89	1120	8.2	1120	0.9	9	0.23	150	100	<1	200	200	60
3/7/89	1310	7.8	380	0.6	1	0.06	31	28	<1	92	92	60
3/15/89			700	0.3	4	0.13	91	67	<1	140	140	64
3/21/89	1110		1090	0.6	8	0.22	170	110	<1	190	190	65
3/29/89	1115	7.6	530	0.3	2	0.07	62	53	<1	110	110	66
4/5/89	845	7.3	1150	0.3	12	0.22	180	93	<1	220	220	63
4/12/89	1145	7.4	1550	0.6	14	0.30	280	150	<1	200	200	75
4/20/89	945		1880	0.5	13	0.38	350	200	<1	190	190	71
4/26/89	1045	8.0	1990	0.3	21	0.37	365	185	<1	240	240	67
5/1/89	1200	8.0	1820	0.5	18	0.37	345	165	<1	235	235	71
5/10/89	1100	8.2	1790	0.3	20	0.36	300	130	<1	270	270	70
5/17/89	1140	8.4	1630	0.4	15	0.34	270	140	<1	200	200	75
5/24/89	1115	8.0	1630	0.6	18	0.37	245	140	6	200	206	70
5/30/89	1200	8.2	1760	0.6	22	0.41	310	170	8	200	208	76
6/7/89	1150	7.5	1880	0.8	21	0.40	330	150	<2	240	240	78
6/14/89	1030		1600	0.5	15	0.32	265	145	<2	190	190	75
6/21/89	1010		1540	0.5	16	0.36	270	150	<2	150	150	76
6/27/89	1430	7.0	1300	0.6	21	0.36	240	120	8	260	268	
7/5/89	1600	8.6	1690	0.7	21	0.39	270	150	8	180	188	87
7/12/89	1115	8.2	1850	0.6	18	0.38	320	160	<2	150		80
7/19/89	1110	8.7	1860	0.9	20	0.38	300	160	<2	170	170	80
7/25/89	1110	8.7	1880	0.6	23	0.39	290	120	2	210	212	84
8/1/89	1330	9.0	1960	0.3	28	0.42	270	110	18	270	288	82
8/9/89	1130	9.1	1900	0.4	21	0.40	310	160	12	160	172	82
8/16/89	1155	9.0	1450		13	0.32	250	130	<2	120	120	84
8/24/89	1500	8.5	1240	0.5	13	0.33	180	110	<2	160	160	80
9/1/89	1145	8.3	1270	0.4	13	0.34	120	120	<2	180	180	78
9/6/89	1110	8.5	1380	0.3	15	0.34	130	110	<2	190	190	75
9/13/89	1150	8.4	1160	0.3	13	0.25	180	70	<2	200	200	77
9/21/89	1100	7.7	1790	0.3	11	0.23	310	120	<2	160	160	71
9/29/89	925	7.7	940	0.3	9	0.13	150	49	<2	140	140	69
MIN		7.0	380	<0.2	1	0.06	31	28	<1	92	92	43
MED		8.1	1500	0.5	16	0.32	235	110	1	200	200	71
MAX		9.1	1990	1.3	30	0.54	365	200	18	370	370	87
COUNT		33	47	46	47	46	46	46	44	44	45	46

Table 2A. Mineral and Trace Element Water Quality Data for San Joaquin River at Fremont Ford (site Index B) (MER538) for Water Year 1989.

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 µmhos/cm	Se µg/L	B mg/L	Cl mg/L	SO4 mg/L	CO3 mg/L	HCO3 mg/L	T.Alk mg/L	Temp °F
10/4/88	1110		1790	12	1.2	250	290	<1	140	140	69
10/11/88	1320	7.5	1400	6.0	0.78	190	180			140	70
10/17/88	1640		1300	3.4	0.67	200	160	<1	150	150	72
10/25/88		7.6	1500	6.5	1.2	190	200	<1	140	140	69
11/1/88	1125	7.7	1660	6.8	1.2	240	270	<1	160	160	66
11/10/88	1245	7.8	2180	6.7	1.6	310	360	<1	180	180	60
11/15/88	930	7.9	2000	7.8	1.5	300	330	<1	180	180	56
11/22/88	1310	7.8	2550	10	1.9	360	380	7	180	187	54
12/8/88	1225		2060	5.6	1.5	280	320	<1	150	150	52
12/28/88	1300		2900	11	2.5	410	550	<1	250	250	42
1/11/89			2350	9.9	2.1	310	450			190	46
1/26/89	1145		3150	25	2.9	420	680	<1	190	190	50
1/31/89	1040		2900	23	2.9	410	660	<1	180	180	50
2/7/89			2500	20							43
2/14/89	1035	7.8	2220	17	2.0	290	470	<1	160	160	47
2/21/89	1305		2640	22	2.4	350	530	<1	160	160	60
3/1/89	1105	7.8	3300	32	3.3	450	680	<1	190	190	57
3/7/89	1245	7.7	2100	15	1.9	270	400	<1	150	150	63
3/15/89			2700	19	2.4	380	540	<1	180	180	61
3/21/89	1120		2530	22	2.2	350	580	<1	170	170	64
3/29/89	1055	7.6	1750	12	1.3	230	370	<1	140	140	64
4/5/89	825	7.0	2840	24	2.2	390	680	<1	180	180	63
4/12/89	1200	7.6	2080	19	1.7	290	440	<1	150	150	74
4/20/89	930		2300	12	2.6	330	530	<1	160	160	68
4/26/89	1120	7.8	2400	20	2.2	310	470	<1	160	160	63
5/1/89	1145	7.7	2470	27	2.5	370	570	<1	160	160	68
5/10/89	1130	7.8	2350	23	2.4	300	530	<1	160	160	66
5/17/89	1210	7.8	2010	16	2.0	265	415	<1	140	140	75
5/24/89	1140	7.9	1690	14	1.6	200	320	<2	150	150	68
5/30/89	1150	8.3	1870	14	1.9	240	390	<2	140	140	73
6/7/89	1215	7.5	2420	21	2.3	320	480	<2	150	150	76
6/14/89	930		2080	16	2.2	250	450	<2	140	140	71
6/21/89	1000		1980	14	2.2	250	430	<2	150	150	72
6/27/89	1440	7.3	1420	12	1.6	250	450	<2	140	140	
7/5/89	1620	8.0	1850	13	1.8	220	370	4	140	144	84
7/12/89	1150	7.8	2070	15	2.2	240	430	<2	150		76
7/19/89	1055	8.0	1520	10	1.6	180	270	<2	140	140	80
7/25/89	915	7.7	1690	12	1.8	180	330	<2	140	140	77
8/1/89	1400	8.8	1310	7.7	1.2	140	220	3	120	122	81
8/9/89	1150	8.9	1650	11	1.7	180	350	<2	140	140	81
8/16/89	1225	8.2	1470	8.3	1.4	170	280	4	130	128	80
8/24/89	1430	8.6	1490	8.6	1.6	170	270	3	130	133	78
9/1/89	1155	8.4	1660	10	1.6	210	320	<2	140	140	74
9/6/89	1140	8.3	1500	8.9	1.4	170	250	<2	140	140	75
9/13/89	1115	7.8	1600	11	1.4	210	270	<2	140	140	72
9/21/89	1035	7.2	1630	6.4	1.3	200	250	<2	160	160	68
9/29/89	940	7.4	1680	12	1.4	220	280	<2	140	140	67
MIN		7	1300	3.4	0.67	140	160	<1	120	122	42
MED		7.8	2040	12	1.8	250	385	<1	150	150	68
MAX		8.9	3300	32	3.3	450	680	7	250	250	84
COUNT		33	47	47	46	46	46	44	44	45	46

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 1989.

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 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	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	T.Alk	HDNS	TDS	Temp
			µmhos/cm	µg/L							mg/L												°F
10/4/88	1015	8.2	1870	13	6	4	6	7	<5	10	1.4	270	320	83	44	240	5.9	<1	170	170	380	1200	64
10/11/88	1235	7.1	1400	5.6	4	8	15	12	<5	22	0.71	220	200	56	34	180	6.2	<1	140	140	270	820	69
10/17/88	1710		1360	2.8	4	5	11	12	<5	19	0.69	200	170	54	33	180	5.5	<1	150	150	260	790	71
10/25/88		7.7	1450	5.7	4	6	8	10	<5	16	1.0	190	190	58	34	180	3.2	<1	160	160	290	840	68
11/1/88	1010	7.6	1710	4.3	7	4	10	8	6	15	1.2	260	270	71	40	200	5.4	<1	150	150	340	1000	65
11/10/88	1210	7.8	2290	7.2	9	3	5	7	<5	10	1.6	330	400	96	56	300	5.2	<1	190	190	450	1400	60
11/15/88	1010	7.9	2120	4.8	8	3	4	6	<5	7	1.5	320	340	92	55	290	5.4	<1	210	210		1300	56
11/22/88	1230	7.7	2600	9.4	10	2	4	<5	<5	6	1.8	350	420	110	61	330	5.9	<1	210	210	510	1600	53
12/8/88	1115		2100	4.7	7	3	5	6	<5	8	1.5	270	310	76	46	250	5.2	<1	190	190	400	1300	52
12/28/88	1225		2650	6.2	9	3	4	5	<5	7	2.0	340	420	100	54	370	9.4	<1	250	250	490	1600	42
1/11/89			2400	7.6	7	3	7	7	<5	8	1.8	330	390	99	58	330	6.5	<1	230	230	460	1400	45
1/26/89	1105		3250	16	11	3	4	6	<5	4	2.6	450	640	140	77	460	6.2	<1	240	240	650	2000	50
1/31/89	950		2960	17	10	4	6	8	<5	7	2.6	430	620	130	73	440	6.0	<1	230	230	620	2000	50
2/7/89	1115		2650	15	10	3	6	7	<5	5	2.0	370	520	110	61	380	5.7	<1	210	210	520	1700	41
2/14/89	945	8.0	2350	12	5	6	8	12	<5	15	1.9	310	450	110	56	320	7.0	<1	210	210	480	1400	47
2/21/89	1345		2890	23	8	4	8	9	<5	12	2.4	420	610	140	66	410	5.6	<1	190	190	610	1800	61
3/1/89	1000	7.7	3350	23	10	5	10	12	<5	14	3.0	460	660	170	82	460	6.7	<1	230	230	720	2200	56
3/7/89	1210	7.7	2250	12	7	6	7	9	<5	16	1.8	300	400	98	49	300	6.8	<1	180	180	460	1400	61
3/15/89			2900	18	9	4	7	11	<5	13	2.4	430	560	140	70	400	5.9	<1	210	210	600	1800	60
3/21/89	1145		2750	20	7	10	13	14	<5	28	2.2	410	630	140	66	360	5.7	<1	200	200	590	1800	65
3/29/89	950	7.3	1730	11	4	7	13	12	<5	17	1.3	280	400	87	42	230	4.7	<1	150	150	380	1200	64
4/12/89	1245	7.5	2200	19	6	6	8	8	<5	16	1.8	300	460	110	52	290	4.6	<1	160	160	480	1000	75
4/20/89	1020		1880	6.1	4	5	7	7	<5	9	1.8	270	330	69	42	250	6.2	<1	200	200	350	1100	70
4/26/89	1020	8.0	2410	12	6	7	14	12	<5	19	2.2	320	400	100	60	350	7.8	<1	220	220	480	1500	62
5/1/89	1030	7.3	1370	6.4	3						1.2	200	240	64	35	180	4.6	<1	140	140	280	860	66
5/10/89	1030	7.6	2330	19	7	7	11	13	<5	18	2.2	330	370	110	48	300	6.0	<1	180	180	500	1600	64
5/17/89	1110	7.6	2120	15	6	6	16	13	<5	24	2.0	270	440	110	52	280	6.3	<1	150	150	440	1300	72
5/24/89	1045	7.6	1730	12	5	7	12	12	<5	21	1.6	200	330	92	44	220	6.2	<2	160	160	400	1100	66
5/30/89	1035	7.6	1930	13	6	7	11	11	<5	17	1.7	250	400	99	44	250	6.0	<2	150	150	410	1200	70
6/7/89	1125	7.4	2320	18	7	6	11	10	<5	17	2.1	320	500	120	52	300	5.8	<2	160	160	490	1420	76
6/14/89	915		2080	14	7	6	11	12	<5	13	2.0	250	410	100	48	260	6.2	<2	150	150	440	1300	71
6/21/89	920		1900	12	6	7	14	12	<5	21	1.9	240	400	110	47	260	6.2	<2	160	160	430	1100	72
6/27/89	1515	7.8	1500	9.8	7	6	11	11	<5	18	1.2	240	380	90	42	230	6.3	<2	150	150	370	1100	
7/5/89	1730	8.2	1920	12	6	6	11	13	<5	23	2.1	230	370	97	45	280	5.5	12	150	157	395	1200	84
7/12/89	1050	7.6	2030	13	5	6	10	13	<5	25	1.8	200	370	100	46	250	5.5	14	150	164	410	1200	75
7/19/89	1005	7.8	1490	8.3	4	6	9	11	<5	22	1.3	190	240	77	36	180	5.1	<2	150	150	310	880	79
7/25/89	1140	8.1	1680	9.9	5	6	9	11	<5	24	1.6	210	340	86	39	210	5.2	<2	150	150	350	1000	80
8/1/89	1650	8.5	1380	7.3	4	8	16	15	<5	29	1.2	170	200	69	32	170	4.5	<2	130	130	280	790	80
8/9/89	1050	8.5	1650	9.3	4	8	16	15	<5	21	1.5	190	330	80	38	200	6.2	<2	150	150	350	1000	79

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 1989.

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 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	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	T.Alk	HDNS	TDS	Temp °F
				µg/L							mg/L												
8/16/89	1135	8.0	1540	8.8	5	8	8	14	<5	27	1.4	220	320	34	74	190	6.0	<2	140	140	390	910	78
8/24/89	1530	8.6	1520	7.7	5	7	13	13	<5	24	1.5	170	260	74	34	180	4.5	<2	140	140	310	920	79
9/1/89	1300	8.5	1690	8.1	5	6	10	12	<5	16	1.5	210	310	81	38	220	5.1	<2	150	150	340	1010	76
9/6/89	1050	8.1	1540	7.6	5	6	10	13	<5	17	1.3	180	280	78	35	200	5.1	<2	150	150	320	900	72
9/13/89	1220	7.9	1640	8.4	5	6	10	10	<5	15	1.3	230	280	77	40	200	5.7	<2	150	150	330	970	73
9/21/89	1130	7.6	1570	5.0	6	5	9	10	<5	11	1.2	200	250	68	35	200	6.1	<2	160	160	310	910	69
9/29/89	1025	8.0	1700	8.5	6	4	12	10	<5	15	1.2	230	280	69	38	210	5.9	<2	160	160	320	1000	66
MIN		7.1	1360	2.8	3	2	4	5	<5	4	0.69	170	170	34	32	170	3.2	<1	130	130	260	790	41
MED		7.8	1930	9.8	6	6	10	11	<5	16	1.7	265	370	94	46	250	5.9	<1	160	160	400	1200	66
MAX		8.6	3350	23	11	10	16	15	6	29	3.0	460	660	170	82	460	9.4	14	250	250	720	2200	84
COUNT		33	46	46	46	45	45	44	45	45	46	46	46	46	46	46	46	46	46	46	45	46	45

Table 4A. Mineral and Trace Element Water Quality Data for San Joaquin River at Crows Landing Road (site Index D) (STC504) for Water Year 1989.

Location: Latitude 37° 25' 55", Longitude 121° 00' 42". In SW 1/4, NW 1/4, Sec. 8, T.6S., R.8E. 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	Se	Mo	B	Cl	SO4	CO3	HCO3	T.Alk	Temp
			μmhos/cm	μg/L		mg/L						°F
10/4/88	1000	8.4	1640	6.9	5	0.88	230	250	<1	170	170	64
10/11/88	1215	5.9	1400	4.6	4	0.68	190	180			160	68
10/17/88	1740		1480	5.8	4	0.88	180	185	<1	160	160	70
10/25/88		7.8	1300	4.5	3	0.80	160	160	<1	150	150	67
11/1/88	950	7.6	1450	3.5	5	0.90	200	200	<1	160	160	64
11/10/88	1150	7.7	1520	3.4	4	0.92	210	250	<1	160	160	60
11/15/88	1030	7.7	1570	5.0	6	1.00	210	240	<1	150	150	57
11/22/88	1210	7.5	1500	5.0	5	0.96	200	230	<1	140	140	54
12/8/88	1050		1410	4.1	4	0.99	180	200	<1	150	150	54
12/28/88	1205		1700	4.8	7	1.2	220	290	<1	180	180	43
1/11/89			1650	4.5	5	1.2	230	300			160	46
1/26/89	1045		1900	7.4	6	1.4	260	350	<1	160	160	50
1/31/89	930		1820	9.8	6	1.4	250	360	<1	160	160	50
2/7/89			1650	7.7	6	1.2	200	290	<1	150	150	45
2/14/89	930	7.9	1720	8.4	6	1.3	230	330	<1	160	160	46
2/21/89	1400		2000	13	7	1.5	280	400	<1	150	150	60
3/1/89	940	7.7	2210	17	7	1.9	280	410	<1	170	170	56
3/7/89	1145	7.8	1460	6.9	4	1.1	180	230	<1	140	140	60
3/15/89			1900	11	5	1.4	250	340	<1	160	160	59
3/21/89	1205		1900	12	4	1.4	270	400	<1	160	160	62
3/29/89	930	7.4	1260	7.5	3	0.86	190	260	<1	130	130	64
4/5/89	1012	7.2	1800	9.8	5	1.2	270	390	<1	140	140	64
4/12/89	1310	7.3	1520	9.5	5	1.1	200	300	<1	140	140	72
4/20/89	1040		1620	5.4	5	1.5	230	290	<1	170	170	71
4/26/89	955	8.0	1620	5.8	4	1.3	220	260	<1	170	170	63
5/1/89	1015	7.2	1000	4.5	2	0.77	140	170	<1	110	110	66
5/10/89	1000	7.4	1590	9.7	4	1.2	200	320	<1	140	140	66
5/17/89	1040	7.5	1580	9.1	5	1.3	210	290	<1	150	150	73
5/24/89	1025	7.3	1370	7.1	4	1.0	150	220	<2	150	150	66
5/30/89	1020	7.6	1410	8.5	4	1.2	160	260	<2	130	130	70
6/7/89	1100	7.0	1610	10	4	1.3	200	295	<2	140	140	74
6/14/89	845		1600	9.5	4	1.4	210	320	<2	140	140	71
6/21/89	900		1630	9.2	6	1.5	200	315	<2	160	160	72
6/27/89	1530	7.8	1200	7.0	6	1.6	210	390	<2	140	140	
7/5/89	1750	8.1	1490	7.9	3	1.2	180	250	9	130	139	83
7/12/89	1030	7.5	1900	10	4	1.6	230	360	7	160		76
7/19/89	940	7.7	1380	6.0	4	1.2	170	250	<2	150	150	75
7/25/89	1200	7.9	1420	6.1	3	1.1	165	250	3	150	153	79
8/1/89	1715	8.4	1350	6.3		1.1	140	210	6	140	146	79
8/9/89	1030	8.9	1400	5.9	3	1.1	150	250	<2	150	150	77
8/16/89	1110	7.9	1440	6.6	4	1.2	170	240	3	150	153	77
8/24/89	1535	8.3	1340	6.2	3	1.2	150	220	6	140	146	77
9/1/89	1322	8.3	1520	5.8	4	1.2	200	260	<2	140	140	75
9/6/89	1030	8.1	1520	7.2	4	1.2	180	250	<2	160	160	71
9/13/89	1240	8.0	1420	5.3	4	1.0	190	210	<2	160	160	72
9/21/89	1145	7.7	1290	3.8	4	0.88	150	180	<2	140	140	68
9/29/89	1045	7.8	1450	5.4	5	0.92	180	220	<2	140	140	66
MIN		5.9	1000	3.4	2	0.68	140	160	<1	110	110	43
MED		7.7	1520	6.9	4	1.2	200	260	<1	150	150	66
MAX		8.9	2210	17	7	1.9	280	410	9	180	180	83
COUNT		34	47	47	46	47	47	47	44	45	46	46

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 1989.

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 Las Palmas Bridge at NE corner of Patterson. River mile 98.6.

Date	Time	pH	EC µmhos/cm	Se µg/L	B mg/L	Cl	SO4	CO3	HCO3	T.Alk.	Temp ° F
10/4/88	945	8.4	1630	6.4	0.76	240	220	<1	170	170	64
11/1/88	935	7.6	1440	3.0	0.79	200	180	<1	160	160	66
12/8/88	1030		1470	3.4	0.94	180	190	<1	150	150	54
1/11/89			1650	3.7	1.2	230	270			170	46
2/7/89			1800	8.8	1.3	230	320	<1	150	150	42
3/1/89	915	7.6	2220	14	1.8	290	400	<1	180	180	56
3/29/89	915	7.4	1470	7.3	0.87	250	280	<1	140	140	64
5/1/89	955	7.2	1220	5.2	0.88	170	200	<1	140	140	65
5/30/89	1000	7.5	1640	7.3	1.1	210	310	<2	170	170	70
7/5/89	1805	7.8	1490	6.2	1.1	170	240	<2	150	150	83
8/1/89	1730	8.3	1420	5.4	1.0	150	210	8	150	160	79
9/1/89	1340	8.2	1500	4.7	1.0	200	240	<2	170	170	77
9/29/89	1105	7.2	1460	6.0	0.84	200	200	<2	170	170	68
MIN		7.2	1220	3.0	0.76	150	180	<1	140	140	42
MED		7.6	1490	6.0	1.0	200	240	<1	150	160	65
MAX		8.4	2220	14	1.8	290	400	8	180	180	83
COUNT		10	13	13	13	13	13	1	12	13	13

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 1989.

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	B mg/L	Cl mg/L	SO4 mg/L	CO3 mg/L	HCO3 mg/L	T.Alk mg/L	Temp °F
10/4/88	920	8.0	1830	6.2	0.87	260	220	<1	190	190	66
11/1/88	910	7.4	1510	3.6	0.84	230	190		170	170	64
12/8/88	1010		1480	3.5	0.87	190	190	<1	160	160	55
1/11/89			1650	4.0	1.2	220	280			170	46
2/7/89			1850	8.1	1.2	240	310	<1	170	170	41
3/1/89	855	7.6	2100	12	1.6	270	360	<1	180	180	56
3/29/89	850	7.3	1520	8.4	0.86	260	290	<1	150	150	63
5/1/89	930	6.8	1220	5.8	0.9	170	200	<1	140	140	66
5/30/89	935	7.4	1390	6.6	1.0	170	230	<2	150	150	69
7/5/89	1825	7.8	1400	6.1	1.0	170	220	5	150	155	82
8/1/89	1800	8.3	1300	5.2	0.89	140	210	7	140	147	80
9/1/89	1400	8.2	1450	4.5	0.94	190	220	<2	170	170	76
9/29/89	1135	7.5	1160	3.7	0.64	150	150	<2	140	140	68
MIN		6.8	1160	3.5	0.64	140	150	<1	140	140	41
MED		7.5	1480	5.8	0.90	200	220	<1	165	170	66
MAX		8.3	2100	12	1.6	270	360	7	190	190	82
COUNT		10	13	13	13	13	13	2	12	13	13

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 1989.

Location: Latitude 37° 38' 31", Longitude 121° 13' 40". In SW 1/4, NW1/4, 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	B	Cl	SO4	CO3	HCO3	T.Alk	Temp
			µmhos/cm	—µg/L—		—mg/L—						°F
10/4/88	900	8.2	1620	5.6		0.72	240	220	<1	180	180	66
11/1/88	855	7.6	1330	3.3		0.75	190	170	<1	160	160	64
12/8/88	950		1310	3.2		0.75	160	160	<1	160	160	55
1/11/89			1400	3.3	4	0.94	180	210			160	46
2/7/89			1550	7.3	6	1.0	200	250	<1	150	150	41
3/1/89	835	7.4	1740	8.0		1.2	230	290	<1	170	170	55
3/7/89	1100	7.6	1140	5.4	3	0.75	140	180	<1	120	120	59
3/29/89	835	7.4	1270	6.6		0.81	190	240	<1	130	130	62
5/1/89	915	6.8	880	3.9		0.60	120	140	<1	110	110	64
5/30/89	915	7.0	1240	4.9		0.79	150	180	<2	150	150	68
7/5/89	1855	7.8	1260	4.7		0.86	150	180	3	140	143	82
8/1/89	1820	8.2	1250	4.1	2	0.82	150	190	5	150	155	78
9/1/89	1420	0.2	1300	3.5		0.80	170	180	<2	160	160	76
9/29/89	1200	7.3	1200	3.4		0.65	160	150	<2	150	150	68
MIN		0.2	880	3.2	2	0.60	120	140	<1	110	110	41
MED		7.4	1290	4.4	4	0.80	165	180	<1	150	153	64
MAX		8.2	1740	8.0	6	1.2	240	290	5	180	180	82
COUNT		11	14	14	4	14	14	14	2	13	14	14

Table 8A. Mineral and Trace Element Water Quality Data for San Joaquin River at Airport Way (site Index H) (SJC501) for Water Year 1989.

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 µg/L	Mo µg/L	B mg/L	Cl mg/L	SO4 mg/L	CO3 mg/L	HCO3 mg/L	T.Alk. mg/L	Temp. °F
10/4/88	840	8.2	1060	2.4	2	0.42	150	130	<1	120	120	62
10/11/88	1130		1000	1.7	3	0.39	140	120			130	66
10/25/88		7.5	950	1.7	2	0.41	130	110	<1	120	120	64
11/1/88	835	7.6	980	2.0		0.50	140	120	<1	120	120	63
11/10/88	1105	7.5	1040	1.4	3	0.46	140	130	<1	120	120	58
11/15/88	1345	7.9	1000	1.8	3							58
11/22/88	1125	7.4	1050	2.2	3	0.54	140	130	<1	120	120	53
12/8/88	920		1000	2.0	2	0.54	120	110	<1	120	120	55
12/28/88	1120		1150	4.7	3	0.66	150	160	<1	130	130	44
1/11/89			1150	3.3	3	0.77	160	180			140	46
1/26/89	1000		1300	4.6	4	0.78	170	200	<1	140	140	49
1/31/89	845		1300	5.2	4	0.87	180	210	<1	140	140	50
2/7/89			1350	6.0	5	0.82	160	210	<1	140	140	41
2/14/89	845	7.9	1330	5.6	3	0.82	170	220	<1	140	140	46
2/21/89	1445		1510	6.3	4	0.98	200	250	<1	140	140	60
3/1/89	820	7.3	1470	6.8	4	1.0	200	250	<1	140	140	55
3/7/89	1030	7.5	920	4.4	3	0.55	120	140	<1	110	110	56
3/15/89			900	4.2	2	0.59	120	150	<1	100	100	57
3/21/89	1255		820	4.3	2	0.49	110	140	<1	90	90	62
3/29/89	820	7.3	790	3.4	2	0.44	120	130	<1	92	92	60
4/5/89	1140	7.2	980	3.4	3	0.48	150	170	<1	110	110	62
4/12/89	1400	7.3	780	2.9	2	0.42	100	120	<1	92	92	69
4/20/89	1120		740	2.6	2	0.55	93	120	<1	85	85	68
4/26/89	915	7.9	850	2.1	2	0.59	110	120	<1	110	110	62
5/1/89	900	6.6	810	3.1	2	0.54	110	120	<1	140	140	64
5/10/89	910	6.8	750	2.7	2	0.45	94	100	<1	98	98	63
5/17/89	955	7.0	810	2.7	2	0.48	100	110	<1	97	97	68
5/24/89	935	7.0	720	1.7	2	0.37	93	92	<2	97	97	64
5/30/89	900	6.8	720	2.4	2	0.40	83	94	<2	90	90	66
6/7/89	1005	6.8	775	3.0	1	0.45	96	100	<2	90	90	69
6/14/89	745		830	2.9	2	0.51	99	110	<2	89	89	68
6/21/89	810		810	2.6	2	0.50	100	120	<2	100	100	68
6/27/89	1655	8.0	720	2.9	2	0.58	120	160	<2	110	110	
7/5/89	1910	7.8	900	3.1	2	0.56	97	120	<2	110	110	80
7/12/89	930	6.9	930	2.7	1	0.57	110	140	<2	110		73
7/19/89	845	7.6	840	2.5	1	0.50	100	110	<2	110	110	74
7/25/89	1250	7.9	940	2.6	1	0.55	120	130	2	110	112	79
8/1/89	1830	8.3	990	3.1		0.62	110	120	2	120	122	78
8/9/89	950	8.0	1020	2.7	2	0.55	120	140	<2	120	120	76
8/16/89	1030	7.9	1080	3.0	2	0.64	140	140	4	130	134	77
8/24/89	1615	8.3	1100	3.1	2	0.72	130	140	6	130	136	77
9/1/89	1430	8.2	1110	2.8	2	0.66	180	180	<2	140	140	76
9/6/89	950	8.1	1160	3.0	2	0.70	150	160	<2	150	150	70
9/13/89	1320	8.0	990	2.2	2	0.52	140	120	<2	120	120	73
9/21/89	1230	7.5	930	2.2	2	0.52	110	120	<2	120	120	70
9/29/89	1215	7.6	1000	3.0	2	0.53	130	120	<2	130	130	70
MIN		6.6	720	1.4	1	0.37	83	92	<1	85	85	41
MED		7.6	980	2.9	2	0.54	120	130	<1	120	120	64
MAX		8.3	1510	6.8	5	1.0	200	250	6	150	150	80
COUNT		33	46	46	44	45	45	45	4	43	44	45

APPENDIX B

Maximum, Minimum and Median Concentrations
for Selected Mineral and Trace Elements
for Sites Along the Lower San Joaquin River
in Water Year 1989
(1 October 1988 to 30 September 1989)

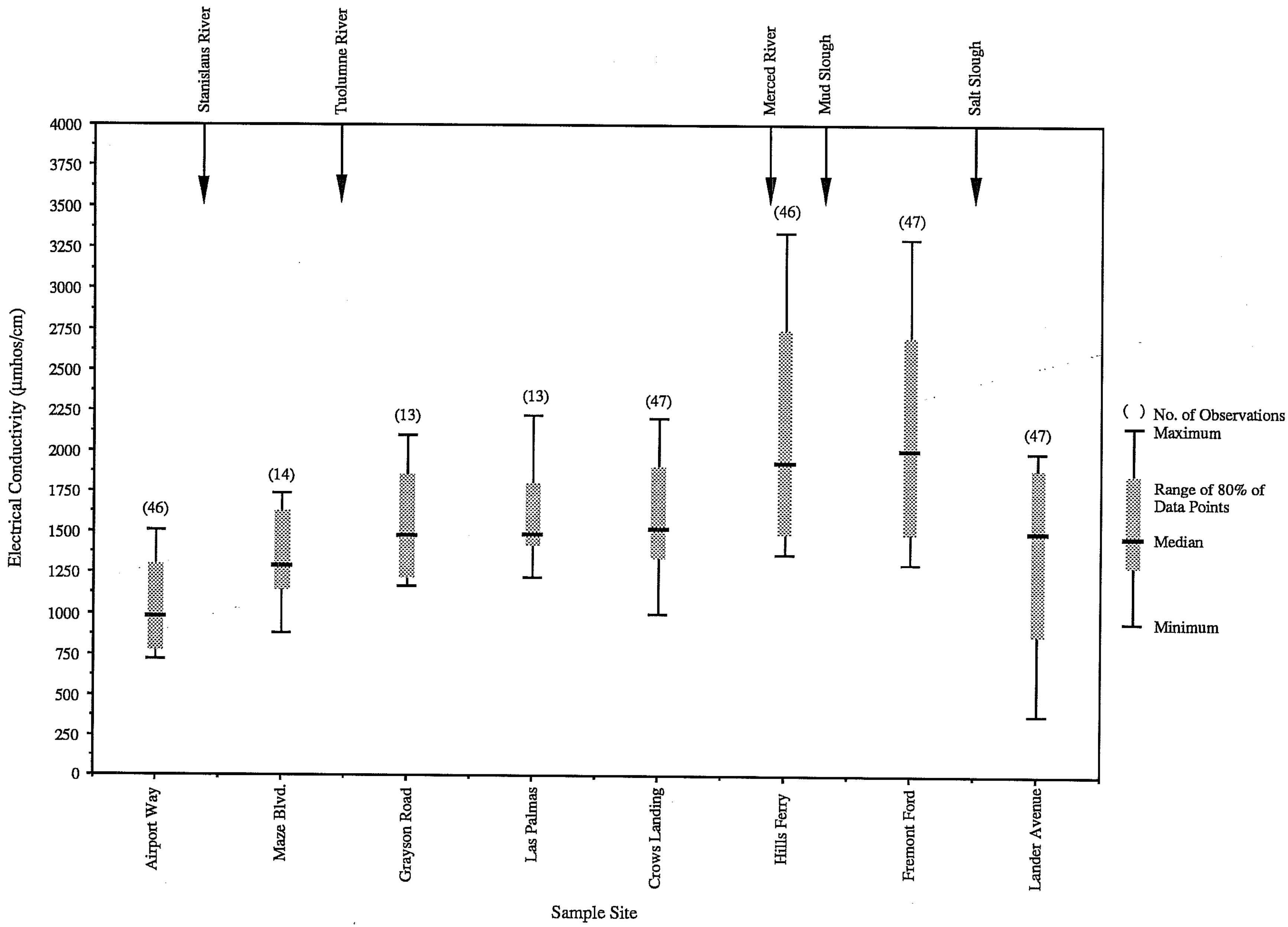

Figure 1B. San Joaquin River Electrical Conductivity Measurements for Water Year 1989; a Critical Water Year.

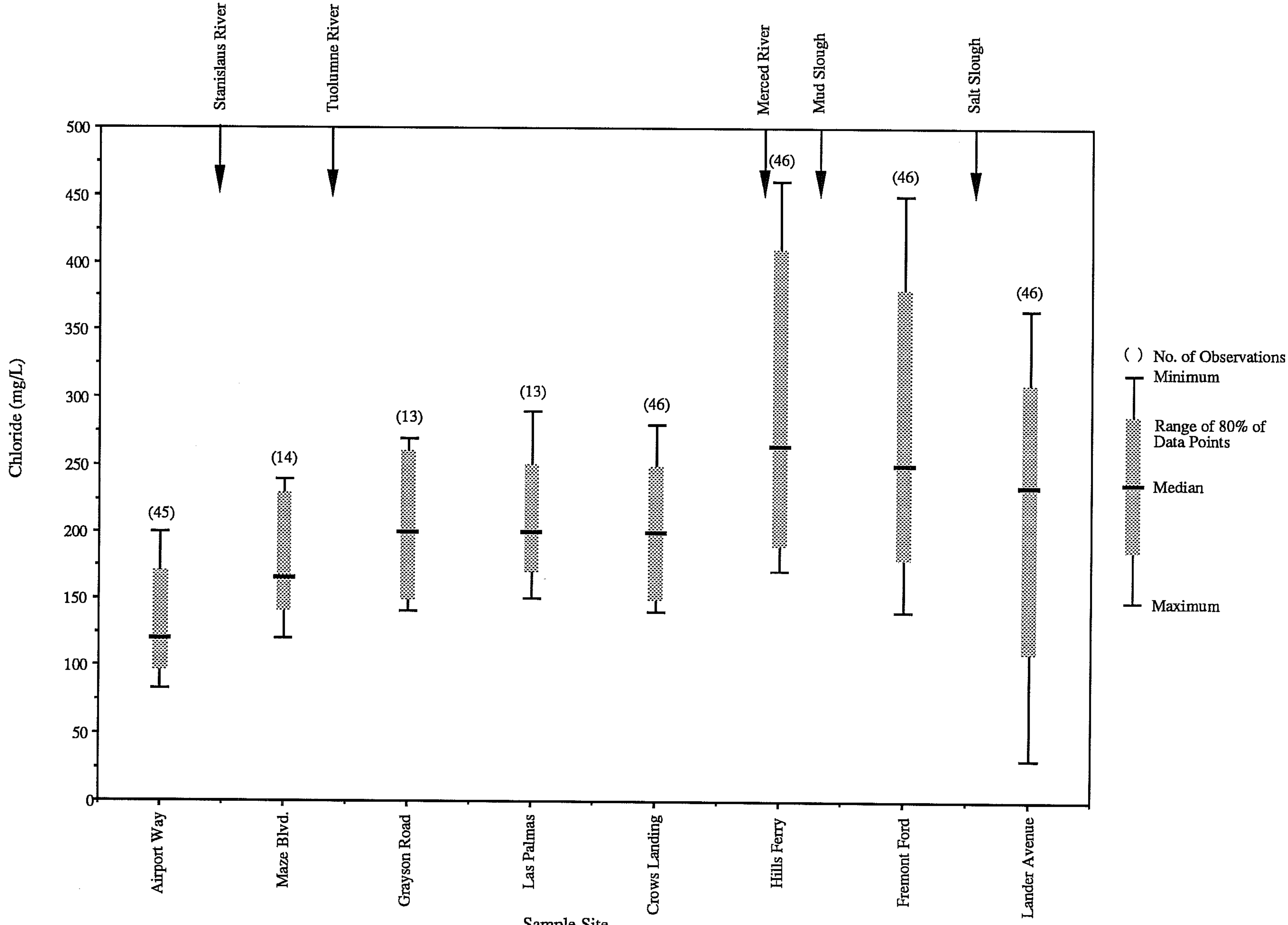

Figure 2B. San Joaquin River Chloride Measurements for Water Year 1989; a Critical Yeater Year.

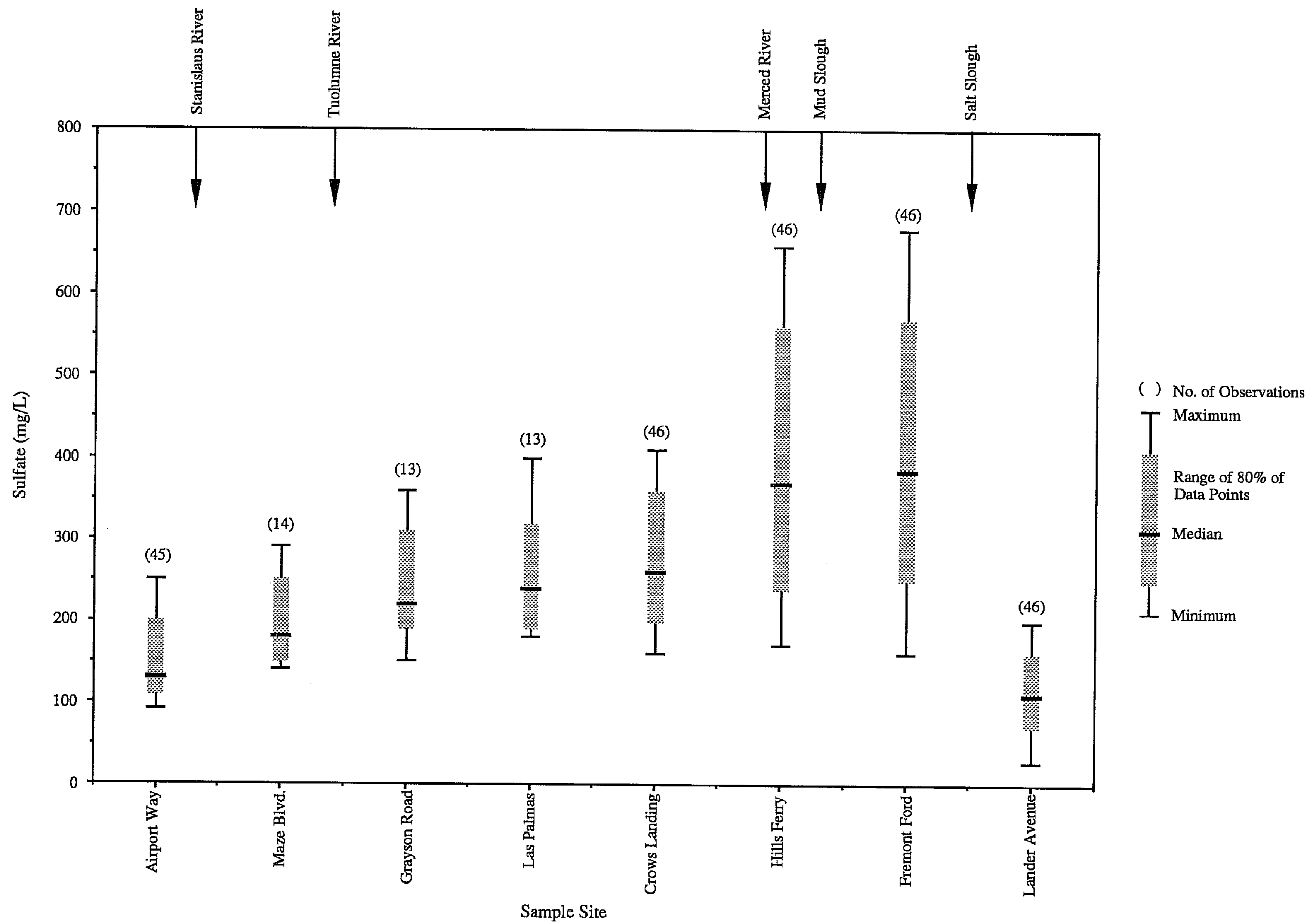

Figure 3B. San Joaquin River Sulfate Measurements for Water Year 1989; a Critical Water Year.

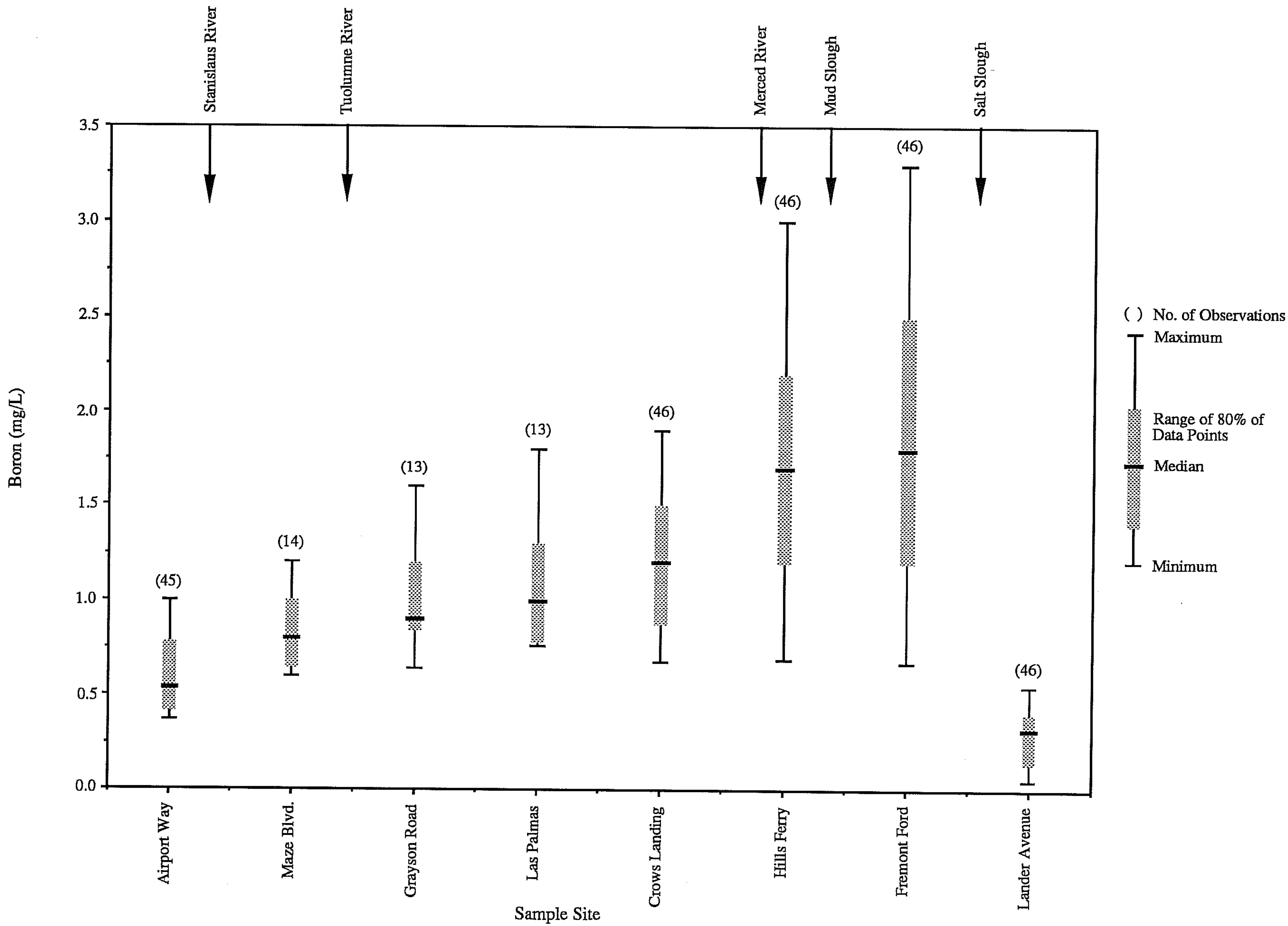

Figure 4B. San Joaquin River Boron Measurements for Water Year 1989; a Critical Water Year.

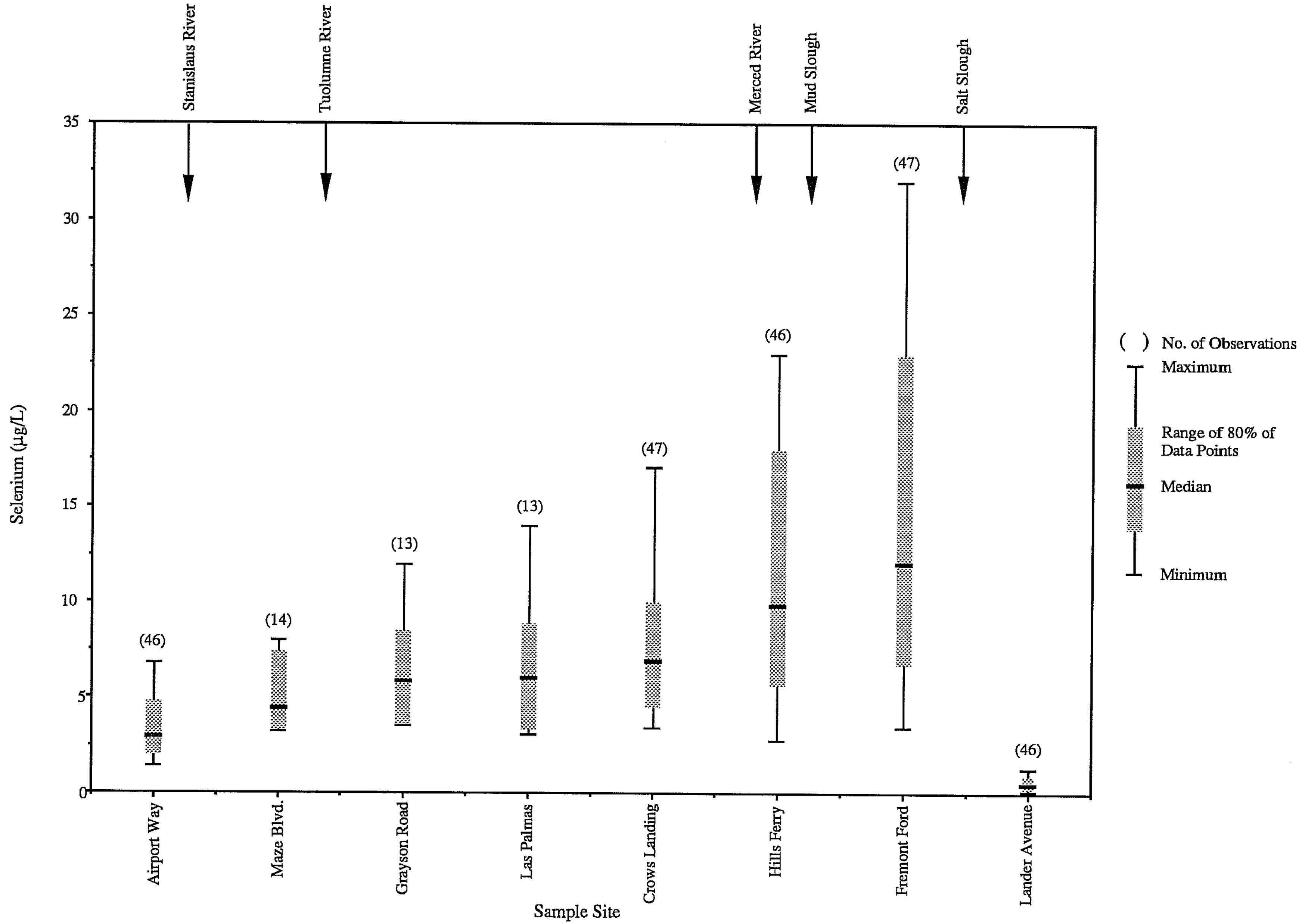

Figure 5B. San Joaquin River Selenium Measurements for Water Year 1989; a Critical Water Year.

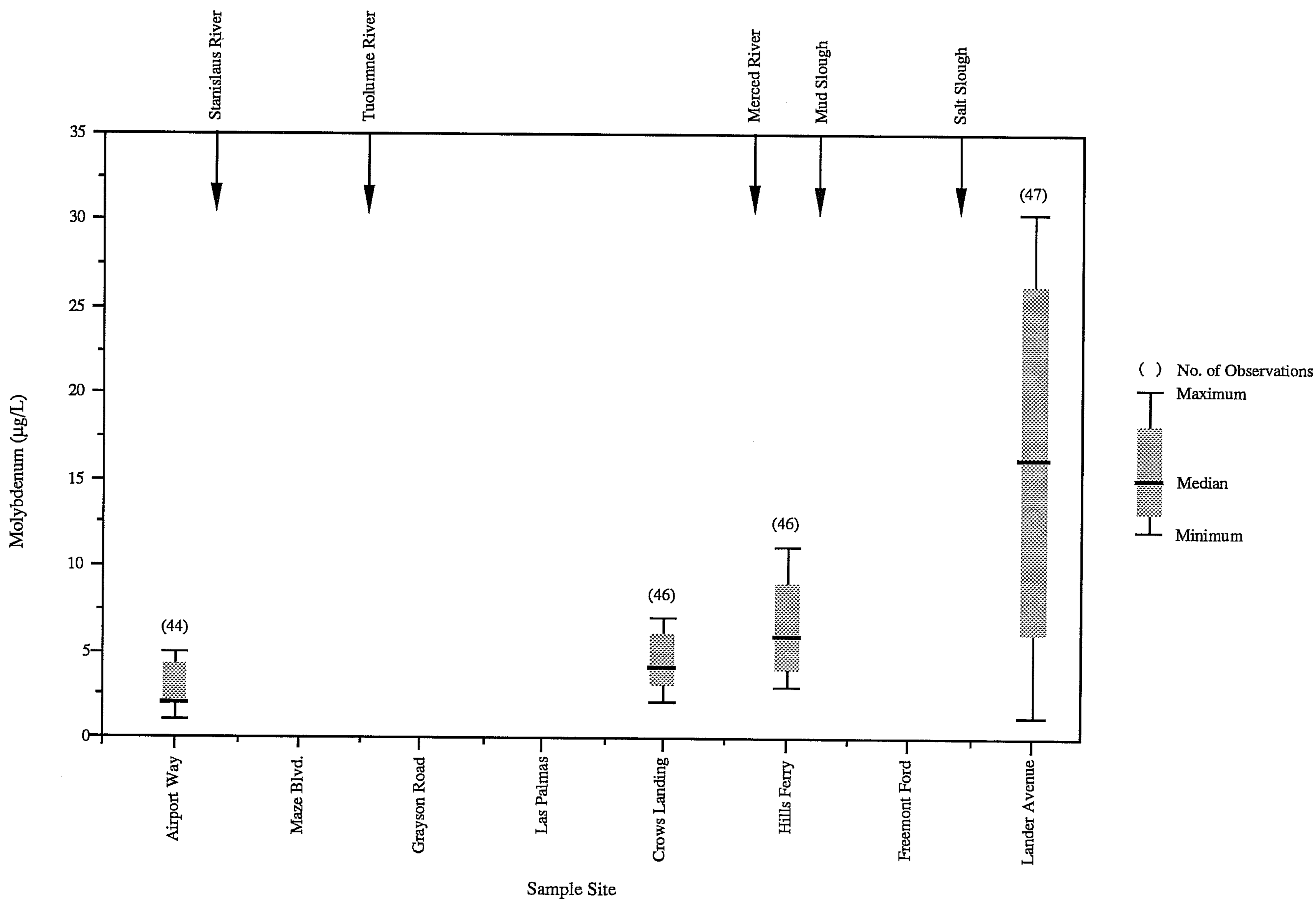

Figure 6B. San Joaquin River Molybdenum Measurements for Water Year 1989; a Critical Water Year.