WATER QUALITY OF THE LOWER SAN JOAQUIN RIVER: LANDER AVENUE TO MOSSDALE BRIDGE, OCTOBER 1987 TO SEPTEMBER 1988

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 nine monitoring sites along a 75-mile section of the San Joaquin River extending from near Stevinson at Lander Avenue to near Tracy at Mossdale Bridge. Water quality samples were collected on a monthly 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 for a 60-mile section of the River extending from Lander Avenue to Airport Way (Vernalis) in San Joaquin County (James, et al., 1988). The present report covers the Water Year (WY) 1988 (1 October 1987 to September 1988), a critically dry year.

The general trend in constituent concentrations along the San Joaquin River study area during WY 1988 continues to be that the lowest concentrations occur at the upstream and downstream study end points; Lander Avenue and Mossdale Bridge, respectively. Concentrations were highest just downstream of Lander Avenue below the Salt Slough and Mud Slough confluences at Fremont Ford and Hills Ferry Road, respectively. Salt and Mud Sloughs 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 and 1988 water years (WYs) constituent concentrations were routinely higher than they were during the wet 1986 WY. During WY 1988 these same constituents also show seasonal variations in concentrations with the highest levels occurring during the nonirrigation season (October to March).

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 75-mile section of the River extending from near Stevinson in Merced County to the Mossdale Bridge near Tracy 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 1987 through September 1988 (WY 88). A previous report has been issued for data collected from May 1985 through March 1988 for a 60-mile section of the River extending from Lander Avenue to Vernalis in San Joaquin County (James, et al., 1988). 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 75-mile section of the San Joaquin River extending from Lander Avenue (Highway 165) near Stevinson to Mossdale Bridge near Tracy. Monitoring sites are located near each of the nine 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, and the Merced, Tuolumne, and Stanislaus Rivers. Salt and Mud Sloughs 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 drainage 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. 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 128 inflow points that occur in this 75-mile section of the River are in James, et al., 1989.

TEMPORAL VARIATIONS IN STREAMFLOW

A 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 85-87 were given in James, et al., 1988 for each of six gaged stations within the study area. Streamflows in the 1985 and 1987 WYs were below the long-term average and in the

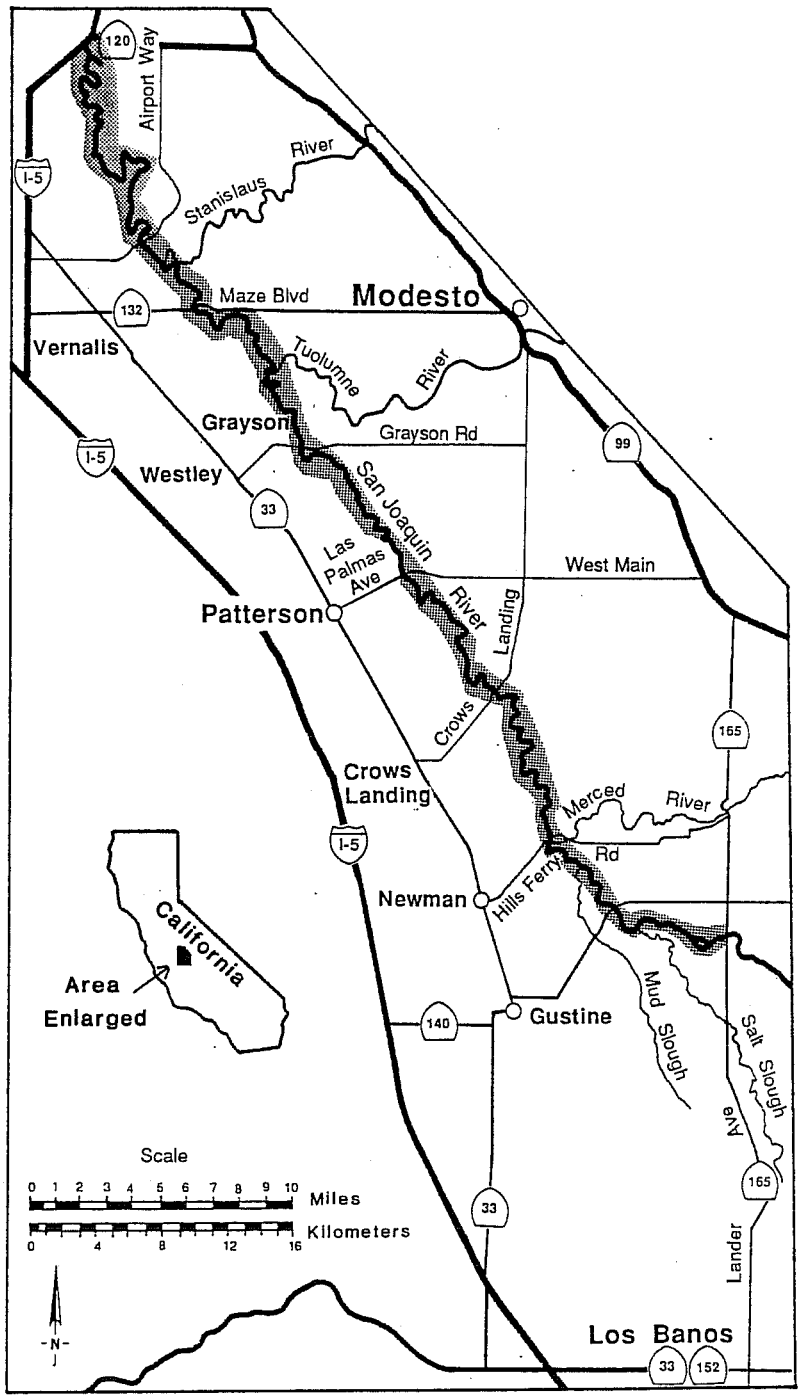

Fig.1. Location Map (modified from James et al.,1988)

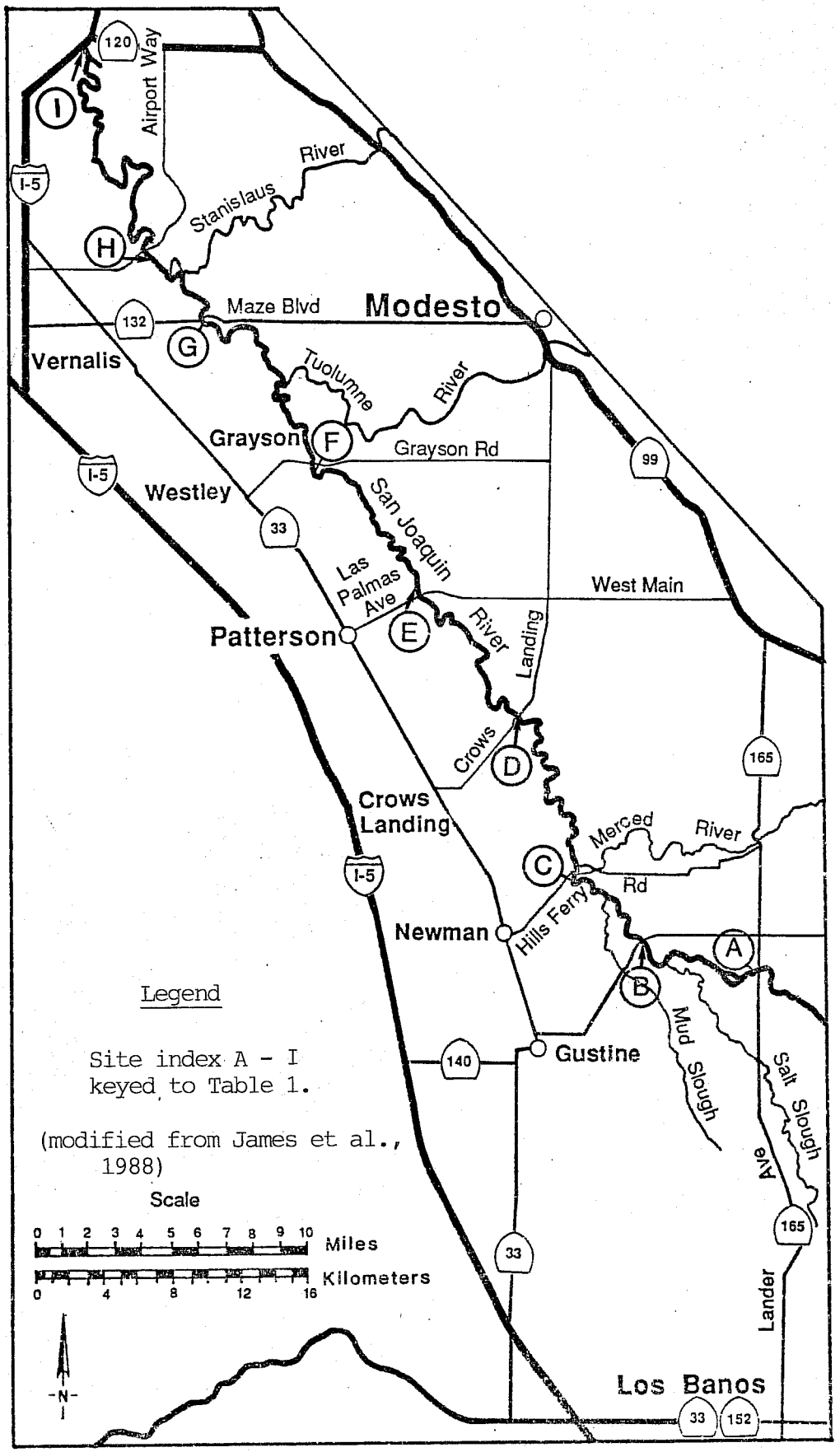

Fig. 2. Index Map

Table 1. Significant Tributaries and Drains to the San Joaquin River Between Lander Avenue and Mossdale Bridge.

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)**	
063.4	New Jerusalem Tile Drain	T
062.0	RD 2075 Drain	S
056.1	**Mossdale Bridge at Interstate 5 (Site I)**	

* LEGEND

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

1986 WY they were above average. The 1988 WY, presented in this report, was also below average. Both the WYs 1987 and 1988 were classified as critical years as described in James, et al., 1988. The 1988 WY is one of the few instances where a critical year has followed another critical year.

METHODS

The Regional Board monitoring program for the San Joaquin River began in May 1985 and was continued through the 1988 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 88, the sampling frequency was increased for four of the nine sites to biweekly 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 88 followed a consistent pattern along the San Joaquin River study area. The lowest concentrations generally occurred at the upstream study end point 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 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 and WY 87 (James, et al., 1988).

Results of water quality analysis for minerals and trace elements are listed by site in Appendix A, Tables 1A-9A. The ranges and median concentrations at each site for selected mineral constituents and selenium and boron are shown in Table 2.

The ranges and median values at each monitoring site are graphically represented for EC, chloride, sulfate, boron, molybdenum, and selenium 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

TABLE 2. SUMMARY OF SELECTED MINERAL AND TRACE ELEMENT WATER QUALITY DATA FROM THE SAN JOAQUIN RIVER FOR THE 1988 CRITICAL WATER YEAR (OCTOBER 1987 - SEPTEMBER 1988).

		MOSSDALE BRIDGE	AIRPORT WAY	MAZE BOULEVARD	GRAYSON ROAD	LAS PALMAS AVENUE	CROWS LANDING	HILLS FERRY*	FREMONT FORD	LANDER AVENUE
	Minimum	800	650	1010	1300	750	1180	1380	1260	318
EC	Median	900	900	1400	1575	1600	1600	1990	1950	1550
(µmhos/cm)	Maximum	1400	1450	1600	1950	2150	2150	3100	2950	2100
	# Samples	(13)	(43)	(13)	(12)	(14)	(43)	(41)	(42)	(40)
	Minimum	92	65	140	160	71	140	190	180	24
Cl	Median	120	120	170	215	215	210	270	250	240
(mg/L)	Maximum	170	170	210	280	300	310	430	420	380
	# Samples	(13)	(41)	(13)	(12)	(14)	(43)	(41)	(42)	(40)
	Minimum	80	73	110	170	85	120	180	150	13
SO4	Median	120	110	190	250	270	260	370	360	120
(mg/L)	Maximum	230	220	250	320	370	400	680	660	170
	# Samples	(13)	(41)	(13)	(12)	(14)	(42)	(41)	(42)	(40)
	Minimum	92	84	140	150	110	126	160	140	80
TOT ALK	Median	110	110	160	170	165	160	170	150	220
(mg/L)	Maximum	160	160	180	210	210	294	380	230	310
	# Samples	(13)	(43)	(13)	(12)	(14)	(43)	(41)	(42)	(40)
	Minimum	0.32	0.28	0.5	0.66	0.48	0.46	0.57	0.41	0.03
B	Median	0.50	0.50	0.9	1.0	1.2	1.2	1.7	1.8	0.30
(mg/L)	Maximum	0.95	0.95	1.1	1.5	3.0	2.0	3.1	2.8	0.47
	# Samples	(13)	(43)	(13)	(12)	(14)	(43)	(41)	(42)	(40)
	Minimum	1.1	0.8	1.9	2.4	2.0	0.8	1.0	1.3	0.2
Se	Median	2.7	2.7	5.1	5.8	6.2	7.4	10	12	0.7
(µg/L)	Maximum	6.6	6.5	6.5	8.5	9.1	12	20	23	1.4
	# Samples	(13)	(41)	(13)	(12)	(14)	(42)	(41)	(40)	(38)
	Minimum		1				3	4		3
Mo	Median		2				5	6		15
(µg/L)	Maximum		4				7	11		22
	# Samples		(36)				(35)	(30)		(35)

* 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.

Ferry Road site the Merced River inflows and dilutes the river so 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 located between the Merced and Tuolumne Rivers and their concentrations are essentially the same. 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 Hills Ferry Road site had the highest median EC (1710 μmhos/cm), boron (1.4 mg/L), sulfate (280 mg/L) and selenium (10 μg/L) values. These values are generally only slightly higher than those at Fremont Ford. The highest median values for molybdenum (16 μg/L) occurred at the Lander Avenue site which is upstream of the discharge of tile drainage. Because of the very dry conditions in WY 88, 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 in this flow and the very low median selenium concentration shown at the same time suggests that ground water seepage from the basin trough areas (Deveral, et al., 1984 and Chilcott, et al., 1988) may be occurring. During previous years (James, et al., 1988), median quality at this site was comparable to that at Vernalis. However, the dry WY 88 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.

Following a trend noticed in the 1986-87 WY data (James, et al., 1988), EC and boron values are generally their highest during the drier water years (including WY 88). EC and boron values for the critical 1987 and 1988 WYs were routinely higher than they were during the wet 1986 WY. As shown by James, et al., 1988 at the Hills Ferry Road site during the wet 1986 WY, the median EC value was 1100 μmhos/cm (Table 3). The median EC value increased in the critical 1987 WY to 1720 μmhos/cm. During the critical 1988 WY, EC values were even higher, ranging from 1380 to 3100 μmhos/cm with a median of 1990 μmhos/cm. Boron values followed the same trend. During the wet 1986 WY, at Hills Ferry the median boron value was 0.91 mg/L (Table 3). In the critical 1987 WY and 1988 WY, the median values were 1.6 mg/L and 1.7 mg/L, respectively. This trend was observed at all of the monitoring sites.

Selenium concentrations at the Hills Ferry site followed the same general trend observed for EC and boron with the highest concentrations occurring during the critical 1987 and 1988 WYs with median values for WY 1986, WY 1987 and WY 1988 being 4.0 μg/L, 11 μg/L, and 10 μg/L, respectively. Similar trends were observed at downstream sites. Figures 6 and 7 show the selenium concentrations with time for the various 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, the time of year patterns remain the same regardless of the water year type. One possible explanation for this relationship is that during times of low streamflow, as found in critical water years, agricultural drainage water makes up a larger proportion of the San

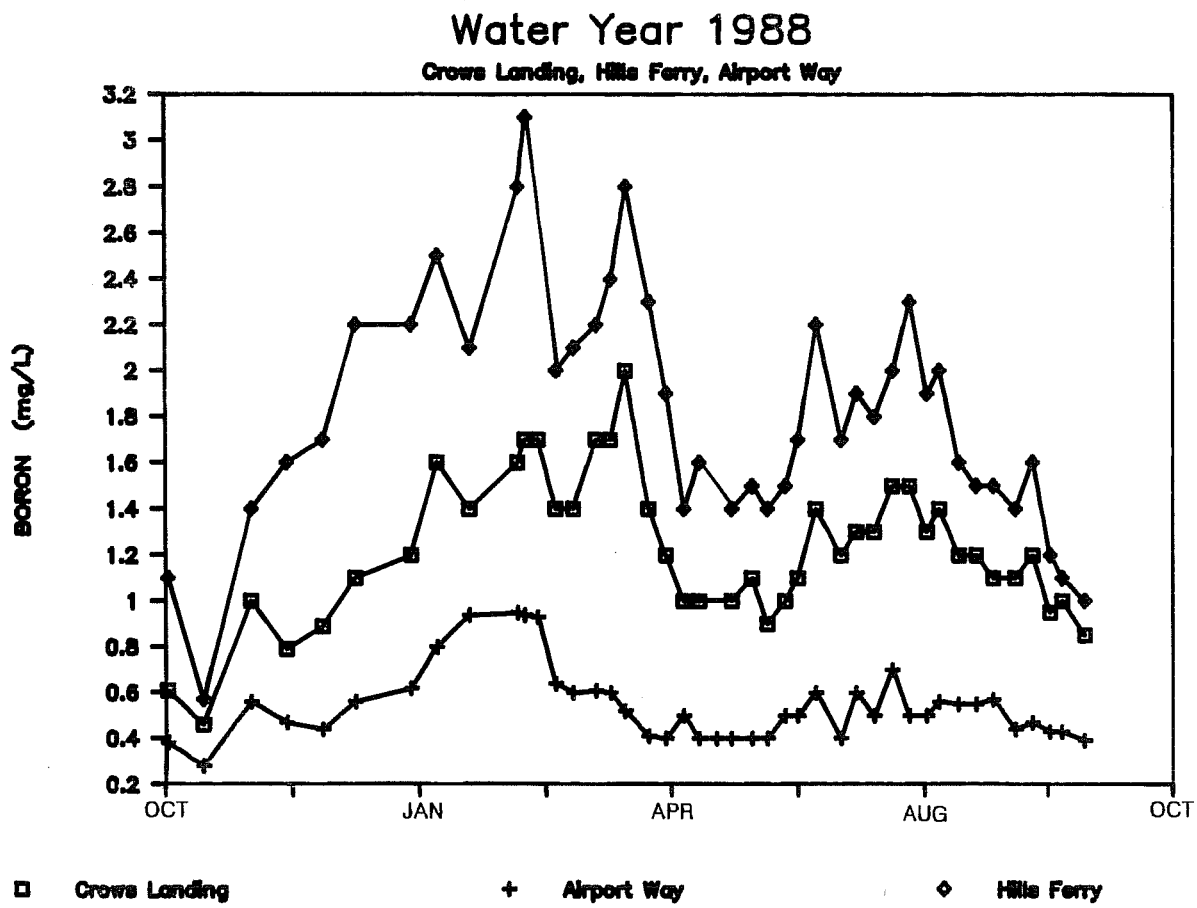

Figure 3. Boron concentrations at three monitoring sites along the lower San Joaquin River in Water Year 1988 (October 1987 through September 1988).

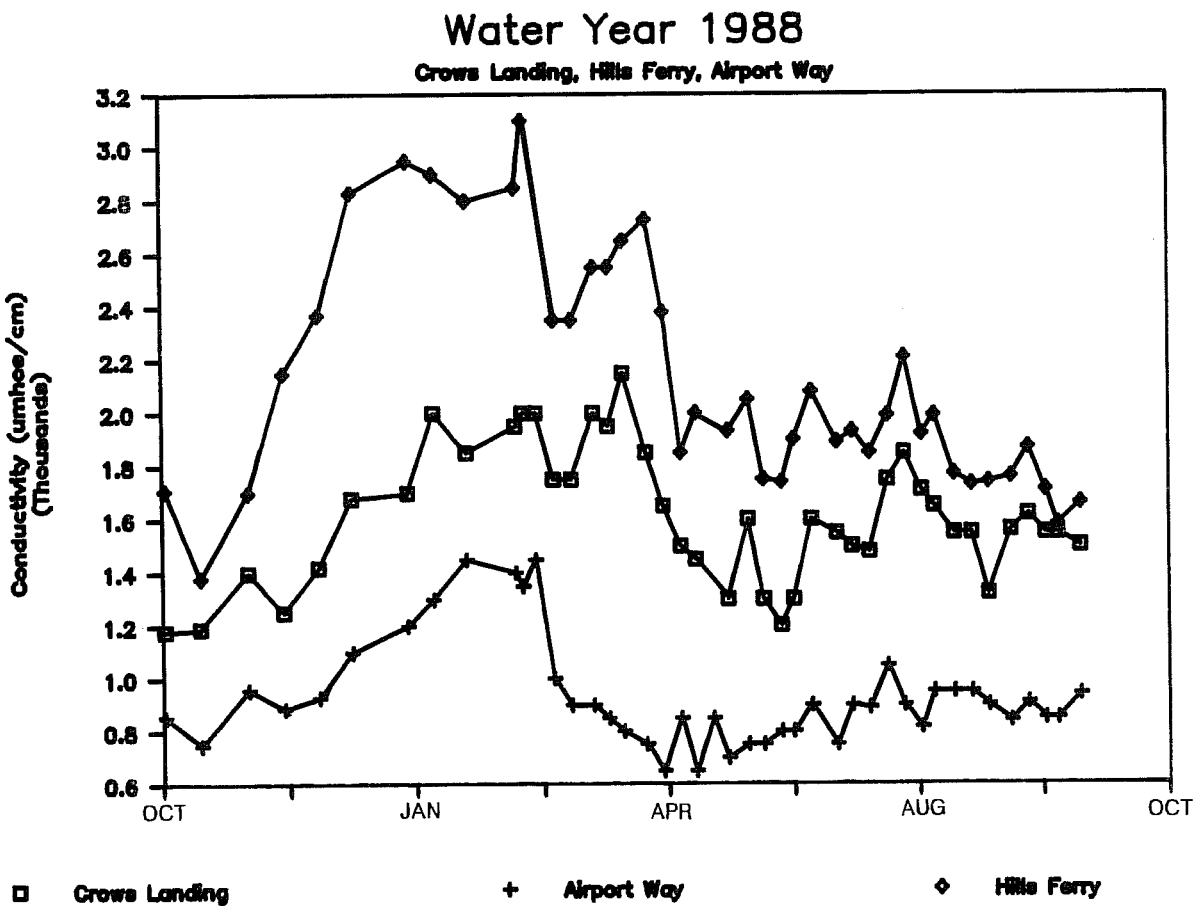

Figure 4. Electrical conductivity at three monitoring sites along the lower San Joaquin River in Water Year 1988 (October 1987 through September 1988).

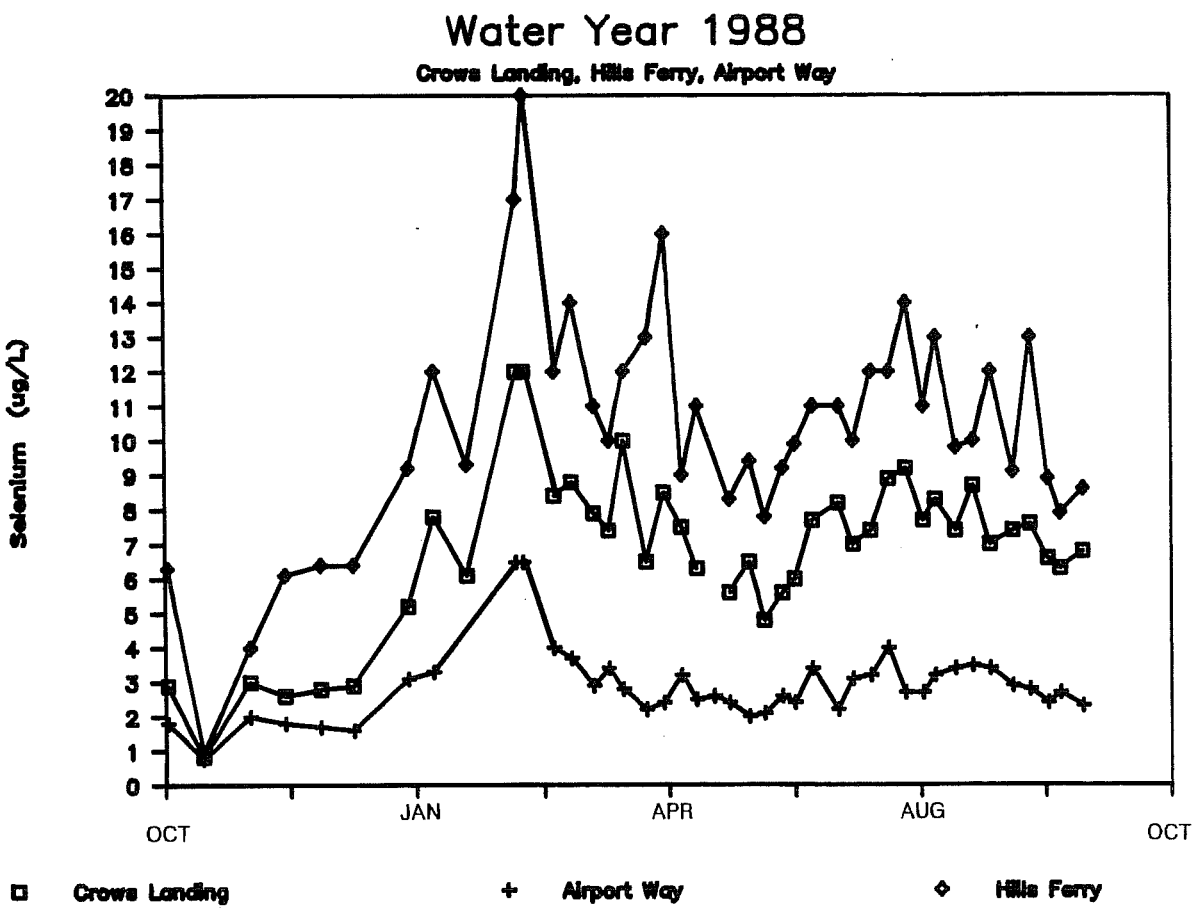

Figure 5. Selenium concentrations at three monitoring sites along the lower San Joaquin River in Water Year 1988 (October 1987 through September 1988).

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).

WY 1985 DRY		MOSSDALE BRIDGE	AIRPORT WAY	MAZE BOULEVARD	GRAYSON ROAD	LAS PALMAS AVENUE	CROWS LANDING	HILLS FERRY	FREMONT FORD	LANDER AVENUE
	Minimum	500	480	620	690	640	630	730	640	192
EC	Median	550	540	860	1000	1050	995	1325	1150	700
(µmhos/cm)	Maximum	720	680	900	1050	1200	1200	2200	1900	1300
	# Samples	(6)	(6)	(6)	(5)	(6)	(6)	(6)	(6)	(5)
	Minimum	0.30	0.20	0.25	0.38	0.26	0.27	0.45	0.33	< 0.01
B	Median	0.31	0.27	0.43	0.48	0.62	0.64	1.10	0.93	0.10
(mg/L)	Maximum	0.46	0.45	0.60	0.78	0.86	0.85	1.60	1.20	0.36
	# Samples	(6)	(6)	(6)	(5)	(6)	(6)	(6)	(6)	(5)
WY 1986 WET		MOSSDALE BRIDGE	AIRPORT WAY	MAZE BOULEVARD	GRAYSON ROAD	LAS PALMAS AVENUE	CROWS LANDING	HILLS FERRY	FREMONT FORD	LANDER AVENUE
	Minimum	240	180	200	280	240	270	410	94	73
EC	Median	600	540	700	960	870	815	1100	905	400
(µmhos/cm)	Maximum	960	980	1100	1700	1800	1700	2600	2300	930
	# Samples	(15)	(18)	(17)	(15)	(18)	(18)	(18)	(18)	(18)
	Minimum	0.13	0.10	0.13	0.17	0.11	0.14	0.29	0.09	< 0.01
B	Median	0.35	0.22	0.39	0.57	0.56	0.59	0.91	0.65	0.10
(mg/L)	Maximum	0.80	0.70	0.70	1.20	1.70	1.20	2.20	1.80	0.61
	# Samples	(14)	(17)	(17)	(15)	(18)	(18)	(18)	(18)	(18)
WY 1987 CRITICAL		MOSSDALE BRIDGE	AIRPORT WAY	MAZE BOULEVARD	GRAYSON ROAD	LAS PALMAS AVENUE	CROWS LANDING	HILLS FERRY	FREMONT FORD	LANDER AVENUE
	Minimum	320	340	490	1200	1200	1200	1600	1330	650
EC	Median	764	804	1100	1300	1360	1320	1720	1730	1200
(µmhos/cm)	Maximum	874	930	1420	1890	1960	1990	2600	2880	1650
	# Samples	(9)	(13)	(9)	(9)	(9)	(13)	(10)	(12)	(13)
	Minimum	0.18	0.18	0.30	0.59	0.70	0.67	0.53	0.81	0.10
B	Median	0.44	0.43	0.64	0.88	0.95	0.94	1.60	1.60	0.21
(mg/L)	Maximum	0.61	0.62	1.1	1.6	1.8	1.9	3	3.2	0.35
	# Samples	(11)	(15)	(11)	(11)	(11)	(15)	(13)	(14)	(15)
WY 1988 CRITICAL		MOSSDALE BRIDGE	AIRPORT WAY	MAZE BOULEVARD	GRAYSON ROAD	LAS PALMAS AVENUE	CROWS LANDING	HILLS FERRY	FREMONT FORD	LANDER AVENUE
	Minimum	800	650	1010	1300	750	1180	1380	1260	318
EC	Median	900	900	1400	1575	1600	1600	1990	1950	1550
(µmhos/cm)	Maximum	1400	1450	1600	1950	2150	2150	3100	2950	2100
	# Samples	(13)	(43)	(13)	(12)	(14)	(43)	(41)	(42)	(40)
	Minimum	0.32	0.28	0.50	0.66	0.48	0.46	0.57	0.41	0.03
B	Median	0.50	0.50	0.90	1.0	1.2	1.2	1.7	1.8	0.30
(mg/L)	Maximum	0.95	0.95	1.1	1.5	3.0	2.0	3.1	2.8	0.47
	# Samples	(13)	(43)	(13)	(12)	(14)	(43)	(41)	(42)	(40)

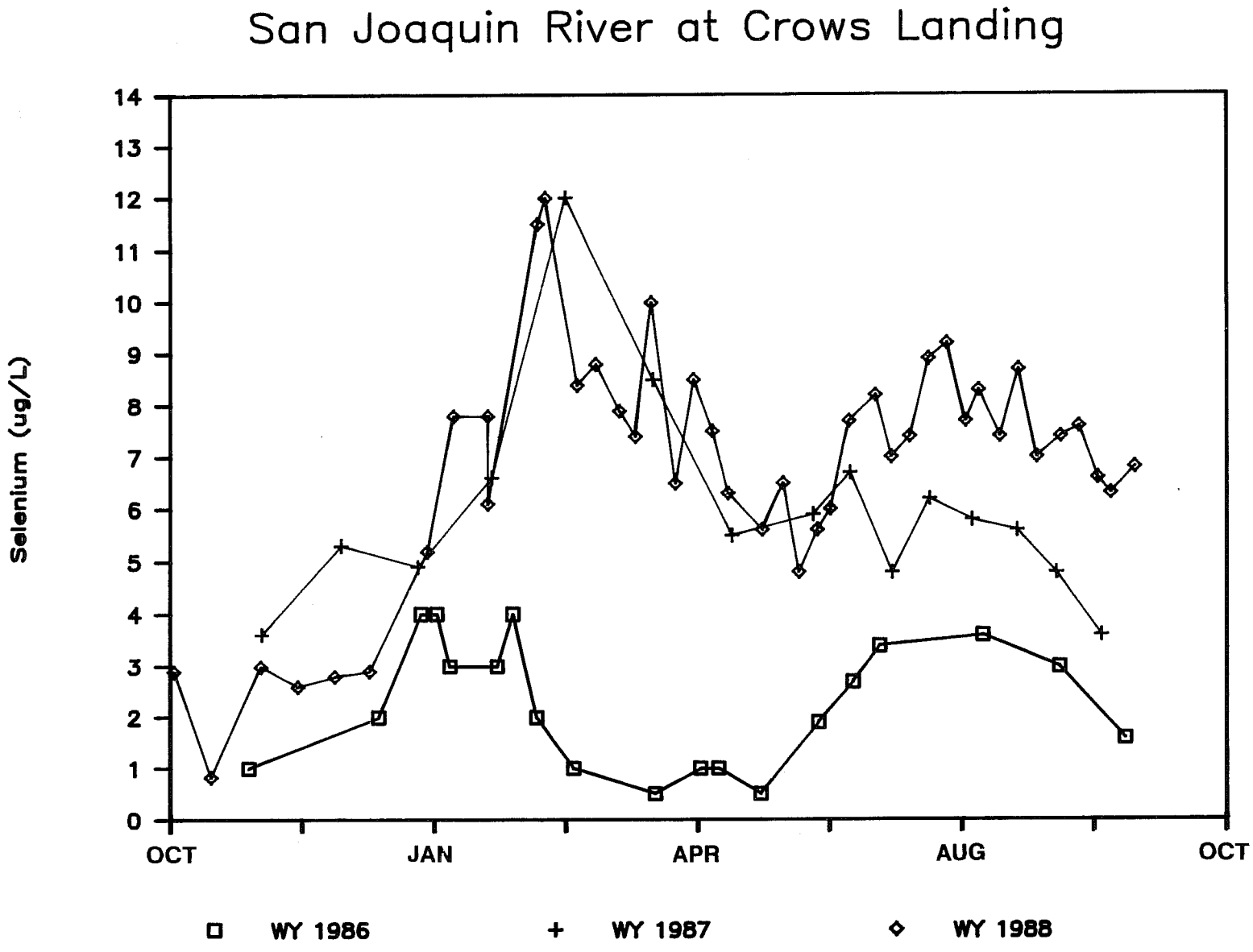

Figure 6. Selenium concentrations at Crows Landing Road along the San Joaquin River for Water Years 1986 - 1988.

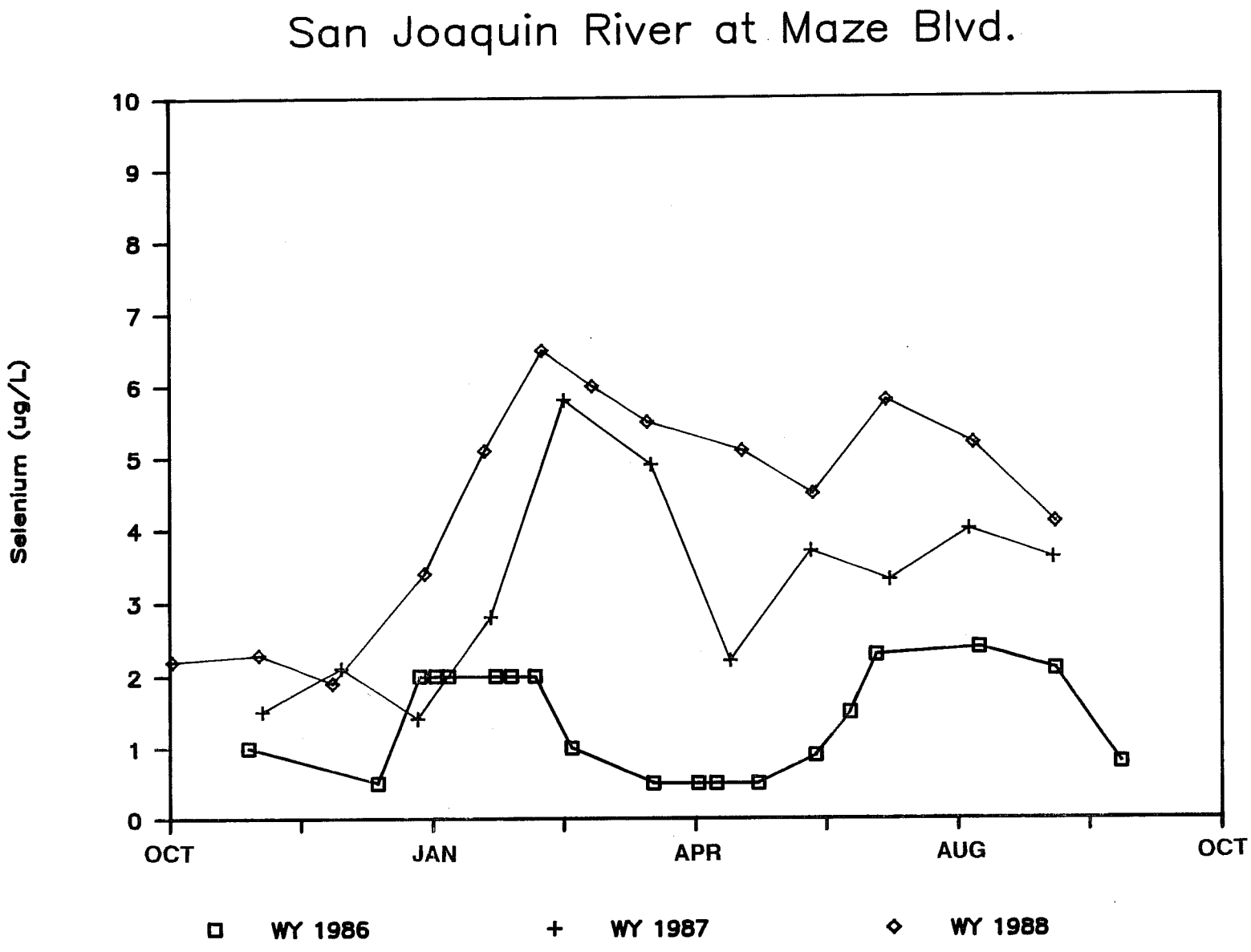

Figure 7. Selenium concentrations at Maze Road Bridge (Highway 132) along the San Joaquin River for Water Years 1986 - 1988.

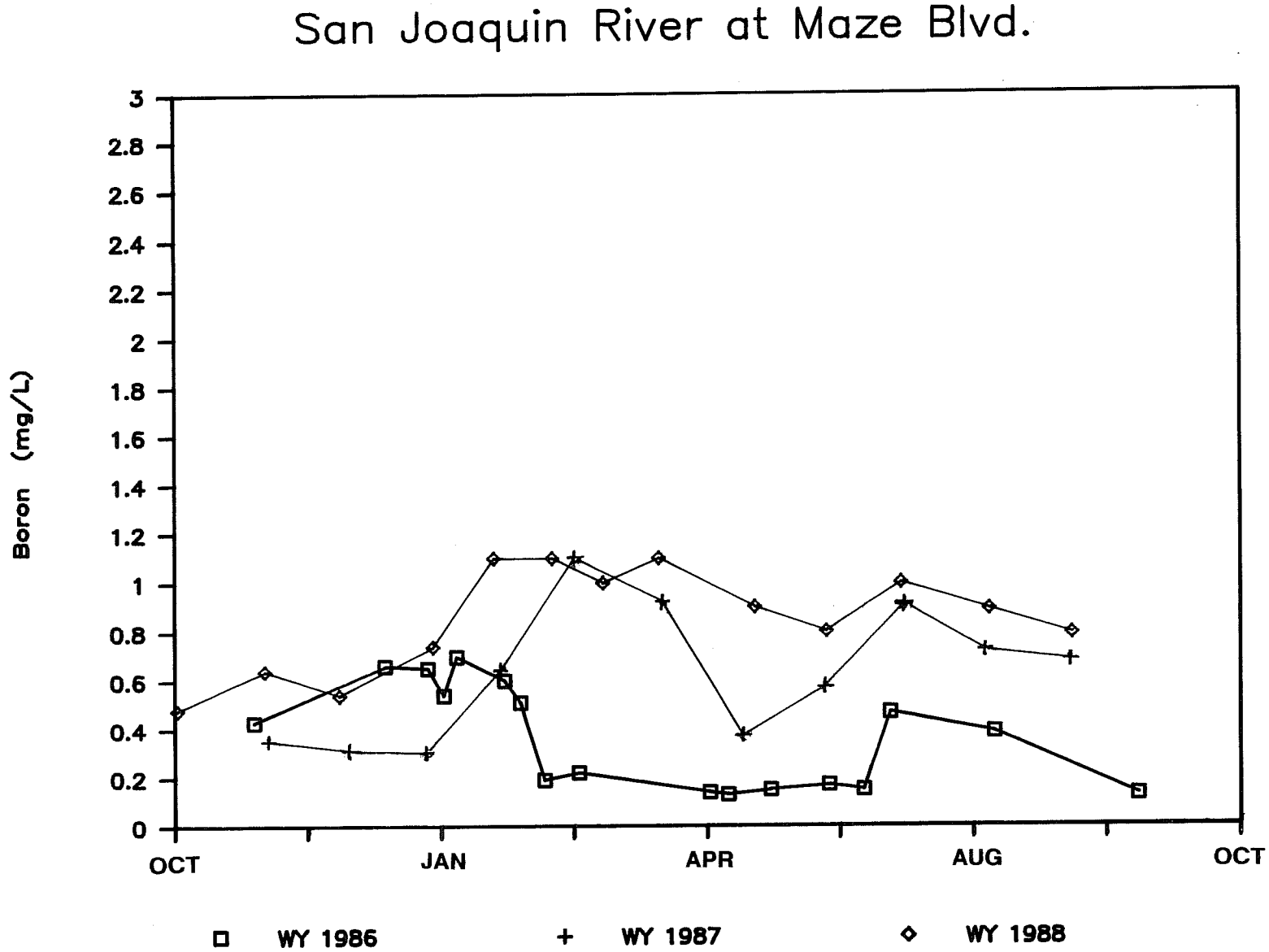

Figure 8. Boron concentrations at Maze Road Bridge (Highway 132) along the San Joaquin River for Water Years 1986 - 1988.

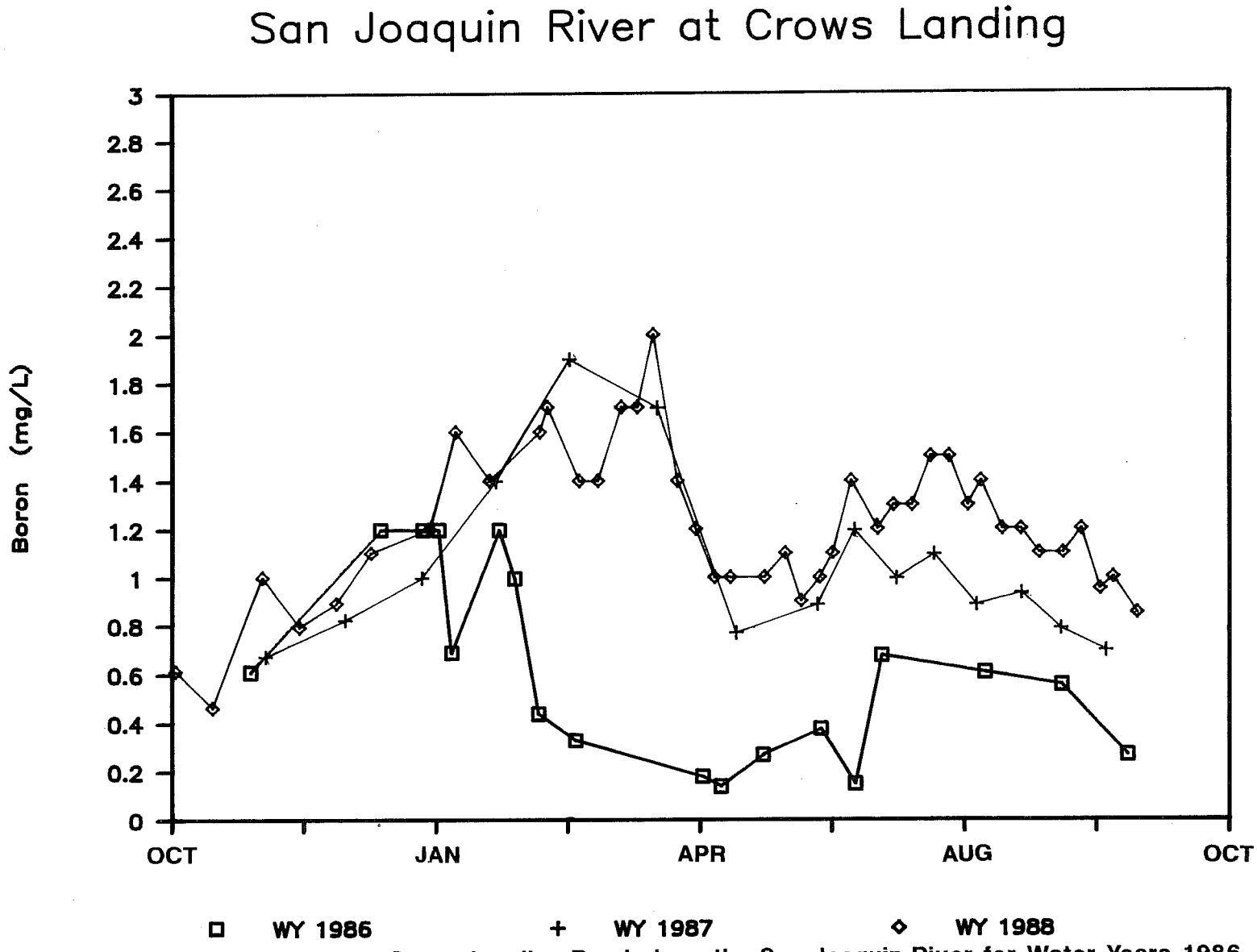

Figure 9. Boron concentrations at Crows Landing Road along the San Joaquin River for Water Years 1986 - 1988.

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).

WY 1985 DRY		MOSSDALE BRIDGE	AIRPORT WAY	MAZE BOULEVARD	GRAYSON ROAD	LAS PALMAS AVENUE	CROWS LANDING	HILLS FERRY	FREMONT FORD	LANDER AVENUE
	Minimum	< 1	1	1	1	<1	1	1	<1	<1
Se	Median	1	1	2	2	3	3	4	3.5	<1
(µg/L)	Maximum	2	2	3	3	4	4	8	7	1
	# Samples	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(5)
WY 1986 WET		MOSSDALE BRIDGE	AIRPORT WAY	MAZE BOULEVARD	GRAYSON ROAD	LAS PALMAS AVENUE	CROWS LANDING	HILLS FERRY	FREMONT FORD	LANDER AVENUE
	Minimum	< 1	0.6 (<1)	0.8 (<1)	0.9 (<1)	<1	<1	<1	<1	0.2 (<1)
Se	Median	1.4	1	1.5	2.2	2	2	4	1.7	0.3
(µg/L)	Maximum	2.0	4	2.4	4	5	4	8	9	5
	# Samples	(15)	(19)	(19)	(16)	(18)	(19)	(19)	(19)	(19)
	Minimum		0.6 (<1)	<1	<1	<1	<1	2.6 (<5)	2.9 (<5)	<1
Mo	Median			<5	<5	<5	<5	5.1	<5	<5
(µg/L)	Maximum		1.6 (<5)	8	13	12	14	14	17	5
	# Samples		(16)	(15)	(12)	(17)	(14)	(16)	(16)	(15)
WY 1987 CRITICAL		MOSSDALE BRIDGE	AIRPORT WAY	MAZE BOULEVARD	GRAYSON ROAD	LAS PALMAS AVENUE	CROWS LANDING	HILLS FERRY	FREMONT FORD	LANDER AVENUE
	Minimum	0.9	0.9	1.4	3.4	3.4	3.6	6.6	4.3	0.4
Se	Median	2.3	2.3	3.3	4.6	4.8	5.6	11	10	0.7
(µg/L)	Maximum	3.4	3.2	5.8	9.3	10	12	21	26	1.8
	# Samples	(11)	(15)	(11)	(11)	(11)	(15)	(15)	(14)	(15)
	Minimum		1 (<5)	<5	<5	<5	4 (<5)	<5	<5	4 (<5)
Mo	Median		2 (<5)	<5	<5	<5	4	7	5	7
(µg/L)	Maximum		2 (<5)	<5	<5	6	5	12	9	14
	# Samples		(11)	(3)	(3)	(3)	(10)	(11)	(3)	(10)
WY 1988 CRITICAL		MOSSDALE BRIDGE	AIRPORT WAY	MAZE BOULEVARD	GRAYSON ROAD	LAS PALMAS AVENUE	CROWS LANDING	HILLS FERRY	FREMONT FORD	LANDER AVENUE
	Minimum	1.1	0.8	1.9	2.4	2	0.8	1	1.3	0.2
Se	Median	2.7	2.7	5.1	5.8	6.2	7.4	10	12	0.7
(µg/L)	Maximum	6.6	6.5	6.5	8.5	9.1	12	20	23	1.4
	# Samples	(13)	(41)	(13)	(12)	(14)	(42)	(41)	(40)	(38)
	Minimum		2				3	4		3
Mo	Median		3				5	6		15
(µg/L)	Maximum		4				7	11		22
	# Samples		(6)				(35)	(30)		(35)

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.

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 values 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 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 1986-1988 water years.

The existing water quality guidelines and criteria for the protection of beneficial uses are shown in Table 5. 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 1988 WY median selenium values from Fremont Ford (12 μg/L) to Maze Road (Highway 132) (5.1 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.

The total recoverable trace element concentrations for copper, chromium, nickel, lead and zinc were only determined at the Hills Ferry Road site. 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, but 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 total recoverable chromium.

Median and maximum total recoverable nickel and zinc values were all below the EPA guideline for the protection of freshwater aquatic life. 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.

Table 5. 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	Other (health)	4 day average	1 hour average	None	Slight to Moderate	Severe	
	- 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	1.4	0.01			0.05
Chromium (VI)	50†			11	16	0.1			1
Copper		1000		5.4	7.5	0.2			0.5
Iron		300				5			
Lead (inorganic)	50			0.99	25	5			0.1
Mercury	2			0.012	2.4				0.01
Molybdenum			70			0.01			
Nickel				73	653	0.02			
Selenium	10			5	20	0.02			0.05
Silver	50				13				
Zinc		5000		49	54	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.)

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.

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APPENDIX A

Mineral and Trace Element Concentrations
for Sites Along the Lower San Joaquin River
in Water Year 1988
(1 October 1987 to 30 September 1988)

	Page
Lander Avenue (Hwy. 165)	A-1
Fremont Ford (Hwy. 140)	A-2
Hills Ferry Road	A-3
Crows Landing Road	A-5
Las Palmas Avenue	A-6
Grayson Road	A-7
Maze Blvd. (Hwy 132)	A-8
Airport Way	A-9
Mossdale Bridge	A-10

Table 1A .....Mineral and Trace Element Water Quality Data for San Joaquin River at Lander Avenue (site Index A) (MER522) for Water Year 1988.

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
			umhos/cm	...ug/L...		.....mg/L.....						
10/01/87	1235	7.8	357	0.4	3	0.04	24	13			100	75
10/15/87	1010	6.9	318	0.2	3	0.03	28	13			80	66
11/03/87	1215	8.8	1150	0.4	18	0.19	180	68		260	260	62
11/17/87	1210	8.2	1504	0.3	22	0.27	220	82	0	290	290	55
12/01/87	1315	7.8	940	1.4	4	0.26	150	71	0	120	120	52
12/14/87	1130	8.1	1080	1.1	6	0.26	150	90	0	180	180	42
01/05/88	1245		1150		5	0.47	110	150	0	180	180	47
01/15/88	1100	8.1	900			0.24	98	64	0	190	190	50
01/27/88	1750	8.0	1000	1.0		0.16	130	62	0	210	210	51
02/16/88	1155	8.4	1200	1.4		0.33	170	120	0	200	200	54
03/02/88	1130	8.3	1700	0.8		0.30	270	120	<1	280	280	60
03/09/88	1230		1150	0.4		0.20	160	94	<1	220	220	64
03/18/88		9.0	1650	0.7	12	0.28	240	130	<1	250	250	62
03/24/88	0910	7.2	1600	0.9	14	0.32	240	140	<1	240	240	60
03/30/88	1220	8.2	1650	1.1	14	0.29	250	160	<1	250	250	59
04/08/88	1555	8.6	1650	0.8	17	0.30	250	130	<1	260	260	64
04/15/88	1125		2100	0.7	18	0.30	230	110	<1	270	270	62
04/22/88	1050	8.1	700	0.4	4	0.10	82	55	0	130	130	63
04/28/88		8.7	900	1.2	4	0.20	120	76	<1	140	140	66
05/05/88	1430	8.4	1200	0.7	11	0.30	170	100	<1	190	190	62
05/19/88	1055	8.5	1600	0.5	15	0.30	280	140	<1	200	200	73
05/25/88	1625	8.5	1700	0.6	16	0.30	270	120	<1	270	270	82
06/01/88	1225	8.1	1550	0.6	15	0.30	230	120	<1	230	230	75
06/06/88	1300	7.2	1700	1.1	16	0.30	300	130	<1	250	250	72
06/13/88	1330	8.1	1850	0.6	18	0.30	280	130	<1	310	310	81
06/23/88	1030	7.4	1900	0.3	15	0.30	330	150	<1	250	250	76
06/29/88		8.2	2050	0.5	18	0.30	350	150	<1	270	270	73
07/06/88	1430	9.0	2060	0.6	19	0.40	380	170		230	230	80
07/13/88	1055	8.7	1750	0.7	14	0.30	320	170		170	170	79
07/20/88	0945	8.7	1750	0.6	16	0.40	330	170		150	150	81
07/27/88	1025	8.6	1900	0.8	19	0.40	290	150		230	230	86
08/01/88		8.4	1800	0.5	19	0.36	300	140		270	270	83
08/09/88		8.5	1700	0.8	17	0.32	270	140	<1	240	240	80
08/16/88	1135	8.9	1700	0.5	16	0.30	300	150	<1	170	170	77
08/23/88	1015	8.0	1430	0.9	15	0.31	290	150	<1	130	130	77
09/01/88	1300		1510	0.5	11	0.29	290	140	<1	160	160	83
09/08/88	1415		1490	0.8	15	0.33	250	130		180	180	80
09/15/88	1330		1400	0.8	16	0.31	210	120		180	180	73
09/20/88	1205		1500	0.7	18	0.28	240	110	<1	220	220	68
09/29/88	1050	8.2	1550	0.6	21	0.29	260	100	<1	260	260	70
Min		6.9	318	0.2	3	0.03	24	13	<1	120	80	42
Med		8.2	1550	0.7	15	0.30	240	120	<1	230	220	70
Mean		8.2	1417	0.7	14	0.27	221	113	<1	217	207	68
Max		9.0	2100	1.4	22	0.47	380	170	<1	310	310	86
Count		33	40	38	35	40	40	40	30	38	40	40

Table 2A .....Mineral and Trace Element Water Quality Data for San Joaquin River at Fremont Ford (site Index B) (MER538) for Water Year 1988.

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	B	Cl	SO4	CO3	HCO3	T.Alk	Temp
			umhos/cm	ug/L			mg/L				
10/01/87	1250	7.8	1640	8.8	1.1	240	270			160	76
10/15/87	0955	6.9	1260	1.3	0.41	180	150			140	63
11/03/87	1200	8.3	1850	4.7	1.9	280	330	0	170	170	57
11/17/87	1140	8.0	1966	7.5	1.7	290	360	0	180	180	54
12/01/87	1300	7.8	2340	7.6	1.8	320	410	0	190	190	53
12/14/87	1110	7.9	2870	8.2	2.3	420	510	0	220	220	40
01/05/88	1230		2950	16	2.6	390	540	0	200	200	50
01/15/88	1020	7.7	2850	17	2.7	390	660	0	210	210	50
01/28/88	1310		2850		2.1	410	500	0	230	230	54
02/16/88	1135	8.2	2700	23	2.8	360	620	0	180	180	54
02/24/88		8.1	2700		2.8	340	570	0	180	180	59
03/02/88	1115	8.1	2100	14	1.9	260	390	<1	160	160	58
03/09/88	1215		2150	14	1.8	280	450	<1	180	180	60
03/18/88		8.6	2200	12	1.8	270	390	<1	170	170	62
03/24/88	0930	7.3	2350	14	2.1	310	460	<1	180	180	60
03/30/88	1200	8.0	2500	20	2.4	330	520	<1	180	180	58
04/08/88	1620	7.8	2650	19	2.6	360	520	<1	190	190	63
04/15/88	1110		2100	18	1.8	270	380	<1	160	160	60
04/22/88	1110	7.8	1750	9.8	1.2	240	280	0	160	160	61
04/28/88		8.1	1900	12	1.6	250	360	<1	150	150	65
05/05/88	1410	8.0	2350	14	2.4	310	500	<1	160	160	62
05/11/88	1220	7.7	1700	9.9	1.6	250	370	<1	160	160	67
05/19/88	1040	8.0	1950	12	1.6	260	390	<1	160	160	70
05/25/88	1610	7.9	1800	8.8	1.4	250	310	<1	150	150	77
06/01/88	1215	7.9	1550	7.2	1.2	190	260	<1	140	140	72
06/06/88	1240	7.0	1650	8.4	1.6	220	300	<1	150	150	69
06/13/88	1315	7.8	1950	12	1.8	200	340	<1	150	150	76
06/23/88	1045	7.5	1850	11	1.8	250	360	<1	140	140	75
06/29/88		8.0	1900	11	1.9	250	350	<1	150	150	67
07/06/88	1450	8.7	1800	13	1.7	250	360	<1	140	140	78
07/13/88	1040	7.9	2050	14	2.1	250	380		140	140	76
07/20/88	1000	8.2	2250	17	2.4	280	450		140	140	79
07/27/88	1010	8.1	2200	14	2.2	260	400		150	150	82
08/01/88		8.1	2000	15	1.9	250	360	<1	140	140	80
08/09/88		8.1	1750	11	1.5	220	300	<1	140	140	78
08/16/88	1120	8.3	1800	12	1.7	240	330	<1	140	140	73
08/23/88	1000	7.7	1640	13	1.7	240	340		140	140	75
09/01/88	1245		1750	12	1.5	250	320	<1	150	150	82
09/08/88	1355		1920	14	1.8	260	360	<1	140	140	78
09/15/88	1310		1700	11	1.2	240	290	<1	140	140	72
09/20/88	1215		1600	8.6	1.2	230	260	<1	140	140	66
09/29/88	1035	7.8	1560	8.2	0.98	230	250	<1	140	140	68
Min		6.9	1260	1.3	0.41	180	150	0	140	140	40
Med		8.0	1950	12	1.8	250	360	<1	150	150	67
Mean		7.9	2042	12	1.8	274	382	<1	162	162	66
Max		8.7	2950	23	2.8	420	660	<1	230	230	82
Count		34	42	40	42	42	42	36	40	42	42

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 1988.

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	Hardness	TDS	Temp
			umhos/cm	ug/L							mg/L												
10/01/87	1350	7.7	1710	6.3		3	8	8	5	11	1.1	240	240	77	41	230	5.8	0	170	170	330	1000	76
10/15/87	0915	7.9	1380	1.0		2	6	6	<5	9	0.57	190	180	55	34	190	5.5			160	260	820	62
11/03/87	1050	7.6	1700	4.0		4	7	9	<5	12	1.4	260	260	65	32	210	7.8	0	190	190	330	1000	57
11/17/87	1040	7.9	2150	6.1		2	6	6	<5	8	1.6	300	340	89	55	250	6.7	0	200	200	410	1300	54
12/01/87	1145	7.7	2370	6.4	7	1	3	<5	<5	10	1.7	370	410	99	69	330	8.2	0	190	190	460	1400	52
12/14/87	1030	8.1	2830	6.4	11	2	2	5	14	7	2.2	420	480	110	74	380	7.1	0	250	250	510		40
01/05/88	1010	8.1	2950	9.2	11	3	5	5	<5	10	2.2	390	510	110	73	380	6.9	0	240	240	540		51
01/15/88	1215	7.9	2900	12		3	6	8	<5	9	2.5	390	600	130	76	380	7.1	0	260	260	570		50
01/28/88	1235	7.9	2800	9.3		4	7	7	<5	11	2.1	390	460	110	68	350	9.0	0	260	260	520		54
02/16/88	1055	8.1	2850	17		4	9	8	<5	12	2.8	390	600	150	71	400	5.6	0	220	220	590	1800	55
02/19/88	1645		3100	20		4	8	6	<5	8	3.1	430	680	160	85	450	6.2		220	220	660	2100	55
03/02/88	1025		2350	12		7	13	12	<5	17	2.0	320	450	120	61	290	6.1	<1	180	180	480	1400	57
03/09/88	1055		2350	14		6	12	10	<5	16	2.1	310	495	120	63	32	5.5	<1	195	195	520	1500	62
03/18/88			2550	11	8	5	6	6	<5	7	2.2	300	420	120	69	350	6.6	<1	240	240	500		61
03/24/88	1015		2550	10	8	5	8	10	<5	7	2.4	360	450	120	74	350	7.0	<1	170	170	550	1700	63
03/30/88	1105		2650	12	9	6	9	10	<10	12	2.8	400	450	120	63	360	6.9	<1	380	380	660	1800	57
04/08/88	1310	7.9	2730	13	8	6	10	9	<5	14	2.3	350	480	120	70	360	6.8	<1	200	200	580	1700	60
04/15/88	1035	7.7	2380	16	7	6	12	8	<5	17	1.9	290	420	110	61	310	6.6	<1	180	180	500	1500	60
04/22/88	1205	7.7	1850	9.0	6	4	6	7	8	10	1.4	250	330	93	50	250		0	180	180	390	1100	61
04/28/88		7.7	2000	11	6	9	13	14	8	27	1.6	260	380	98	54	260	6.0	<1	170	170	420	1200	69
05/11/88	1300	7.8	1930	8.3	8	5	10	8	<5	12	1.4	250	370	96	52	240	5.2	<1	160	160	410	1200	71
05/19/88	1000	8.0	2050	9.4	8	5	10	10	<5	12	1.5	280	380	98	58	270	6.2	<1	190	190	420	1300	68
05/25/88	1530	7.7	1750	7.8	7	6	12	6	<5	12	1.4	230	310	80	47	200	6.0	<1	160	160	380	1100	75
06/01/88	1055	7.3	1740	9.2	6	6	10	11	<5	16	1.5	230	330	84	42	220	5.7	<1	170	170	370	1100	70
06/06/88	1200	7.8	1900	9.9	7	6	9	9	<5	13	1.7	240	340	90	49	230	6.5	<1	170	170	210	1200	69
06/13/88	1245	7.3	2080	11	7	9	6	10	<5	18	2.2	210	370	110	50	270	5.5	<1	170	170	440	1300	75
06/23/88	1205	7.9	1890	11	6	6	12	11	6	20	1.7	250	360	93	42	220	5.6	<1	160	160	420	1300	76
06/29/88		7.9	1930	10	6	6	11	11	<5	16	1.9	260	370	99	44	240	6.2	<1	160	160	430	1200	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 1988. (continued)

Date	Time	pH	EC	Se	Mo	Cu	Cr	Ni	Pb	Zn	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	T.Alk	Hardness	TDS	Temp
			umhos/cm	ug/L							mg/L												
07/06/88	1525	8.0	1850	12	6	6	12	14	<5	19	1.8	250	380	94	42	230	5.5	<1	160	160	400	1200	79
07/13/88	1020	8.3	1990	12	6	7	16	16	<5	22	2.0	270	400	98	43	260	5.6	<1	170	170	440	1300	75
07/20/88	1120	7.7	2210	14	7	7	13	13	<5	18	2.3	280	440	110	49	300	5.6	<1	170	170	460	1400	80
07/27/88	1115	8.3	1920	11	6	8	15	15	<5	25	1.9	270	380	90	41	230	5.5	<1	160	160	400	1200	84
08/01/88		7.8	1990	13	5	7	16	16	<5	26	2.0	240	370	94	43	240	7.4	<1	180	180	410	1300	78
08/09/88		7.7	1770	9.8	4	7	14	15	<5	20	1.6	220	310	82	39	220	6.8	<1	160	160	370	1100	76
08/16/88	1040	7.9	1730	10	5	6	15	14	<5	19	1.5	240	300	84	37	220	5.1	<1	160	160	360	1100	72
08/23/88	1050	8.2	1740	12	5	6	10	10	<5	18	1.5	250	320	85	38	220	5.6	<1	160	160	370	1100	75
09/01/88	1130	8.2	1760	9.1		7	13	10	<5	17	1.4	270	310	81	39	230	6.2	<1	160	160	360	1100	78
09/08/88	1315	7.9	1870	13	6	7	12	14	<5	21	1.6	270	340	88	42	240	5.6	<1	160	160	390	1200	77
09/15/88	1235	8.1	1710	8.9	5	6	13	15	<5	18	1.2	260	290	76	39	200	5.7	<1	160	160	350	1100	71
09/20/88	1320	8.0	1580	7.9	5	6	9	10	<5	16	1.1	230	260	70	37	190	5.2	<1	160	160	320	960	68
09/29/88	1140	7.9	1660	8.6	5	5	6	8	<5	13	1.0	250	270	72	40	210	5.4	<1	160	160	330	1000	68
Min		7.3	1380	1.0	4	1	2	<5	<5	7	0.57	190	180	55	32	32	5.1	0	160	160	210	820	40
Med		7.9	1990	10	6	6	10	10	<5	15	1.7	270	370	96	49	240	6.0	<1	170	170	420	1200	68
Mean		7.8	2126	10	6.7	5.4	9.8	9.8	<5	15	1.8	289	386	99	53	268	6.0	0	189	188	435	1280	66
Max		8.3	3100	20	11	9	16	16	14	27	3.1	430	680	150	85	450	9.0	0	380	380	660	2100	84
Count		35	41	41	30	41	41	41	41	41	41	41	41	41	41	41	40	39	40	41	41	36	41

Table 4A .....Mineral and Trace Element Water Quality Data for San Joaquin River at Crows Landing Road (site Index D) (STC504) for Water Year 1988.

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
			umhos/cm	...ug/L...		.....mg/L.....						
10/01/87	1410	7.6	1180	2.9	4	0.61	160	150			160	74
10/15/87	0900	6.6	1190	0.8	4	0.46	150	120			160	62
11/03/87	1030	8.1	1400	3.0	5	1.0	220	200	0	160	160	57
11/17/87	1020	7.6	1252	2.6	4	0.79	170	190	0	140	140	54
12/01/87	1120	7.4	1420	2.8	4	0.89	190	240	0	140	140	51
12/14/87	1010	7.7	1680	2.9	6	1.1	210	260	0	170	170	42
01/05/88	1055		1700	5.2	6	1.2	220	280	0	160	160	49
01/15/88	1250	7.8	2000	7.8		1.6	240	380	0	180	180	50
01/28/88	1515		1850	6.1		1.4	230		0	180	180	55
01/28/88	1215		1850	7.8		1.4	240	300	0	180	180	54
02/16/88	1030	8.1	1950	12		1.6	250	380	0	170	170	56
02/19/88	1615	7.7	2000	12		1.7	250	400		170	170	56
02/24/88		7.7	2000			1.7	250	370	0	170	170	59
03/02/88	1000	7.7	1750	8.4		1.4	230	300	<1	150	150	57
03/09/88	1040		1750	8.8		1.4	240	330	<1	170	170	60
03/18/88		8.0	2000	7.9	7	1.7	240	320	<1	190	190	61
03/24/88	1035	7.5	1950	7.4	5	1.7	250	310	<1	220	220	64
03/30/88	1040	8.0	2150	10	7	2.0	310	400	<1	220	220	58
04/08/88	1245	8.0	1850	6.5	5	1.4	230	310	<1	170	170	61
04/15/88	1015		1650	8.5	5	1.2	190	260	<1	160	160	60
04/22/88	1440	7.9	1500	7.5	6	1.0	170	230	0	150	150	63
04/28/88		7.8	1450	6.3	5	1.0	160	250	<1	160	160	71
05/11/88	1320	7.6	1300	5.6	6	1.0	170	250	<1	140	140	72
05/19/88	0940	7.7	1600	6.5	6	1.1	210	300	<1	150	150	66
05/25/88	1510	7.9	1300	4.8	5	0.9	160	200	<1	140	140	74
06/01/88	1035	8.0	1200	5.6	3	1.0	140	200	<1	140	140	72
06/06/88	1130	7.1	1300	6.0	4	1.1	160	220	<1	140	140	68
06/13/88	1225	7.7	1600	7.7	5	1.4	160	250	<1	150	150	74
06/23/88	1345	7.5	1550	8.2	6	1.2	200	280	<1	160	160	78
06/29/88		7.9	1500	7.0	3	1.3	170	250	<1	150	150	68
07/06/88	1545	8.4	1480	7.4	5	1.3	200	260		110	126	78
07/13/88	1000	7.2	1750	8.9	6	1.5	220	320	<1	170	170	76
07/20/88	1300	8.2	1850	9.2	5	1.5	240	340		160	168	82
07/27/88	1135		1710	7.7	4	1.3	220	280		150	158	82
08/01/88		8.4	1650	8.3	6	1.4	210	290	<1	170	170	79
08/09/88		8.0	1550	7.4	4	1.2	180	240	<1	150	150	78
08/16/88	1015	8.1	1550	8.7	4	1.2	210	260		290	294	73
08/23/88	1110	7.8	1320	7.0	4	1.1	170	220		130	136	78
09/01/88	1115		1560	7.4	5	1.1	230	260	<1	170	170	79
09/08/88	1250		1620	7.6	5	1.2	230	270		160	168	75
09/15/88	1215		1550	6.6	4	0.95	210	240		150	165	71
09/20/88	1440		1550	6.3	5	1.0	190	200	<1	170	170	68
09/29/88	1155	8.1	1500	6.8	5	0.85	220	230	<1	160	160	68
Min		6.6	1180	0.8	3	0.46	140	120	<1	110	126	42
Med		7.8	1600	7.4	5	1.2	210	260	<1	160	160	68
Mean		7.8	1617	6.8	4.9	1.2	206	270	<1	164	165	66
Max		8.4	2150	12	7	2.0	310	400	<1	290	294	82
Count		33	43	42	35	43	43	42	33	41	43	43

Table 5A .....Mineral and Trace Element Water Quality Data for San Joaquin River north of Las Palmas Avenue (site Index E) (STC507) for Water Year 19

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

Date	Time	pH	EC	Se	B	Cl	SO4	CO3	HCO3	T.Alk	Temp
			umhos/cm	ug/L			mg/L				
10/01/87	1430	7.6	1230	3.1	0.64	180	120			160	75
11/03/87	1015	8.0	1400	3.0	3.0	210	200	0	160	160	58
12/01/87	1050	7.4	1430	3.4	0.81	200	190	0	150	150	51
12/14/87	1040	7.8	750	2.0	0.48	71	85	0	110	110	54
01/05/88	1040		1700	6.0	1.1	220	260	0	160	160	49
01/28/88	1150		1900	6.3	1.4	250	340	0	190	190	52
02/19/88	1555	7.8	1900	9.1	1.5	250	360		170	170	55
03/09/88	1020		1600	8.5	1.3	230	320	<1	170	170	60
03/30/88	1020	7.9	2150	8.6	1.8	300	370	<1	210	210	58
05/05/88	1215	7.8	1600	6.9	1.0	180	270	<1	150	150	62
06/01/88	1010	7.9	1300	5.4	1.0	160	200	<1	150	150	69
06/29/88		7.8	1600	6.9	1.3	200	280	<1	170	170	68
08/01/88		8.1	1800	7.8	1.3	230	290	<1	180	180	77
09/01/88	1050		1650	5.8	0.99	240	270	<1	180	180	78
Min		7.4	750	2.0	0.48	71	85	0	110	110	49
Med		7.8	1600	6.2	1.2	215	270	<1	165	165	59
Mean		7.8	1572	5.9	1.3	209	254	<1	165	165	62
Max		8.1	2150	9.1	3.0	300	370	<1	210	210	78
Count		10	14	14	14	14	14	12	13	14	14

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 198

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	Se	B	Cl	SO4	CO3	HCO3	T.Alk	Temp
			umhos/cm	ug/L			.....mg/L.....				
10/01/87	1445	7.9	1300	2.9	0.66	190	170			160	73
11/03/87	0955	8.0	1350	2.5	0.93	210	190	0	170	170	58
12/01/87	1030	7.4	1490	2.4	0.76	190	190	0	160	160	51
01/05/88	1015		1700	4.8	1.0	220	260	0	170	170	49
01/28/88	1125		1900	6.0	1.4	250	300	0	200	200	53
03/09/88	1000		1700	8.5	1.3	230	320	<1	170	170	60
03/30/88	0955	7.8	1950	7.9	1.5	280	320	<1	210	210	56
05/05/88	1150	7.8	1650	6.7	1.0	180	270	<1	160	160	62
06/01/88	0950	7.9	1300	5.3	0.9	160	200	<1	150	150	68
06/29/88		7.8	1450	6.7	1.1	170	240	<1	150	150	70
08/01/88		8.0	1650	7.1	1.2	230	260	<1	180	180	76
09/01/88	1015		1500	5.5	0.9	230	230	<1	170	170	76
Min		7.4	1300	2.4	0.66	160	170	0	150	150	49
Med		7.9	1575	5.8	1.0	215	250	<1	170	170	61
Mean		7.8	1578	5.5	1.0	212	246	<1	172	171	63
Max		8.0	1950	8.5	1.5	280	320	<1	210	210	76
Count		8	12	12	12	12	12	11	11	12	12

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 1988.

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	B	Cl	SO4	CO3	HCO3	T.Alk	Temp
			umhos/cm	ug/L			mg/L				
10/01/87	1510	7.9	1010	2.2	0.48	140	110			150	74
11/03/87	0935	7.8	1100	2.3	0.64	160	130	0	140	140	58
12/01/87	1005	7.4	1110	1.9	0.54	150	140	0	140	140	50
01/05/88	0955		1350	3.4	0.74	160	180	0	150	150	48
01/28/88	1100		1600	5.1	1.1	190	230	0	180	180	52
02/19/88	1105	7.7	1550	6.5	1.1	180	240		160	160	52
03/09/88	0945		1400	6.0	1.0	170	240	<1	150	150	60
03/30/88	0940	7.9	1500	5.5	1.1	210	250	<1	180	180	57
05/05/88	1130	7.8	1450	5.1	0.9	180	220	<1	170	170	62
06/01/88	0930	7.8	1250	4.5	0.8	160	180	<1	160	160	69
06/29/88		7.6	1400	5.8	1.0	170	210	<1	160	160	67
08/01/88		8.0	1450	5.2	0.9	190	190	<1	160	160	75
09/01/88	1000		1400	4.1	0.8	200	180	<1	160	160	75
Min		7.4	1010	1.9	0.5	140	110	0	140	140	48
Med		7.8	1400	5.1	0.9	170	190	<1	160	160	60
Mean		7.8	1352	4.4	0.9	174	192	<1	159	158	61
Max		8.0	1600	6.5	1.1	210	250	<1	180	180	75
Count		9	13	13	13	13	13	11	12	13	13

Table 8A .....Mineral and Trace Element Water Quality Data for San Joaquin River at Airport Way (site Index H) (SJC501) for Water Year 1988.

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	B	Cl	SO4	CO3	HCO3	T.Alk	Temp
			umhos/cm	...ug/L...		.....mg/L.....						
10/01/87	1535	7.9	855	1.8	2	0.38	110	88			130	72
10/15/87	0810		747	0.8	3	0.28	88	73			120	62
11/03/87	0920	7.8	960	2.0	3	0.56	140	100	0	130	130	58
11/17/87	0945	7.0	886	1.8	2	0.47	120	110	0	120	120	54
12/01/87	0940	7.3	930	1.7	3	0.44	130	120	0	120	120	50
12/14/87	0930	7.2	1100	1.6	4	0.56	140	140	0	140	140	43
01/05/88	0935		1200	3.1	4	0.62	140	160	0	150	150	48
01/15/88	1330	7.8	1300	3.3		0.80	160	190	0	150	150	51
01/28/88	1045		1450			0.94	170	190	0	160	160	52
02/16/88	0940	7.9	1400	6.5		0.95	160	220	0	150	150	56
02/19/88	1000	7.6	1350	6.5		0.94	170	220		150	150	59
02/24/88		7.8	1450			0.93	170	190	0	150	150	59
03/02/88	0930	7.4	1000	4.0		0.64	110	150	<1	110	110	56
03/09/88	0925		900	3.7		0.60	110	140	<1	100	100	57
03/18/88			900	2.9	2	0.61	98	110	<1	110	110	57
03/24/88	1120	7.4	850	3.4	2	0.60	110	120	<1	110	110	60
03/30/88	0920	7.7	800	2.8	2	0.52	100	100	<1	100	100	56
04/08/88	1140	7.7	750	2.2	2	0.41	92	94	<1	98	98	59
04/15/88	0930		650	2.4	2	0.40	70	78	<1	88	88	60
04/22/88	1215	8.0	850	3.2	2	0.50	87	110	0	100	100	66
04/28/88		7.9	650	2.5	2	0.40	65	83	<1	85	85	66
05/05/88	1110	7.6	850	2.6	2	0.40	91	110	<1	100	100	62
05/11/88	1440	7.8	700	2.4	3	0.40	87	110	<1	100	100	65
05/19/88	0855	7.3	750	2.0	2	0.40	96	100	<1	100	100	66
05/25/88	1000	8.0	750	2.1	2	0.40	92	92	<1	100	100	66
06/01/88	0915	7.7	800	2.6	2	0.50	92	98	<1	110	110	68
06/06/88	1050	7.0	800	2.4	2	0.50	95	96	<1	100	100	63
06/13/88	1130	7.7	900	3.4	2	0.60	100	120	<1	120	120	72
06/23/88	1610	7.9	750	2.2	2	0.40			<1	84	84	74
06/29/88		7.4	900	3.1	1	0.60	98	120	<1	110	110	66
07/06/88	1630	8.4	890	3.2	1	0.50	120	120	<1	110	110	76
07/13/88	0900		1050	4.0	2	0.70	150	150	<1	120	120	72
07/20/88	1630	8.3	900	2.7	2	0.50			<1	100	100	79
07/27/88	1215		815	2.7	2	0.50	110	110	<1	100	100	78
08/01/88		8.0	950	3.2	2	0.56	120	120	<1	110	110	
08/09/88		7.6	950	3.4	1	0.55	120	120	<1	110	110	71
08/16/88	0920	8.4	950	3.5	2	0.55	130	130	<1	110	110	70
08/23/88	1700		900	3.4	2	0.57	130	130	<1	120	120	75
09/01/88	0940		840	2.9	2	0.44	120	100	<1	96	96	73
09/08/88	1200		910	2.8	3	0.47	120	110	<1	110	110	71
09/15/88	1130		850	2.4	2	0.43	120	110	<1	100	100	67
09/20/88	1750		850	2.7	2	0.43	120	110	<1	92	92	65
09/29/88	1230	8.5	940	2.3	2	0.39	140	110	<1	120	120	68
Min		7.0	650	0.8	1	0.28	65	73	0	84	84	43
Med		7.7	900	2.7	2	0.50	120	110	<1	110	110	65
Mean		7.7	930	2.9	2.2	0.53	117	123	<1	113	114	64
Max		8.5	1450	6.5	4	0.95	170	220	<1	160	160	79
Count		30	43	41	36	43	41	41	40	41	43	42

Table 9A .....Mineral and Trace Element Water Quality for San Joaquin River at Mossdale Bridge.
(site Index I) (SJC502)

Location .....Latitude 37 47'12", Longitude 121 18'20". In SW 1/4, NW 1/4, SW 1/4, Sec. 3, T.2S., R.6E.
East bank, north of Interstate 5, at Mossdale Crossing County Park launching dock 3.1 mi. SW of Lathrop. River mile 56.1.

Date	Time	pH	EC	Se	Mo	Cu	Cr	Ni	Pb	Zn	Hg	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	T.Alk	HDNS	TDS	Temp
			umhos/cm	ug/L								mg/L												
05/02/85	1800	8.4	720	2.0								0.30	86	100										68
06/03/85	1640		660	1.0								0.46	150	95										69
07/02/85	1620	7.8	560	1.0								0.31	71	76										78
08/14/85	1330		500	1.0								0.27	62	60										70
08/29/85	1410	8.0	520	1.0								0.26	70	68										70
09/27/85	1455		540	<1								0.35	70	51										72
10/30/85	1130		570	<1								0.20	65	64										60
12/18/85	1415	8.3	960	2.0	<5	<1	1.2	2	<5	6.8	<0.2	0.49	140	110											46
01/03/86	1410	7.2	715	2.0	<5	5	2	10	<5		<0.2	0.47	87	145											53
01/09/86	1650	7.6	870	1.0	<5	<1	<1	22	<5		<0.5	0.47	100	120					0	96	96			52
01/14/86	0810		900	1.0	<5	<1	<1	<5	<5		<0.5	0.80	110	140							100			48
02/01/86	0930	8.2	760	2.0	<5	3	1	<5	<5		<0.5	0.50	94	120	36	17	89	3.8	0	100	100	180	500	54
02/07/86	1515	7.9	630	1.0	12	3	3	8	<5		<0.5	0.35	79	99	66	16	71	5.3	0	88	88	150	370	52
02/16/86	1000	8.0	600	2.0	6	5	11	44	<5		<0.5	0.48	55	77	28	16	66	5.2	0	92	92	180	380	55
03/02/86	1015	7.8	260	1.0	<5	3	1	10	<5		<0.5		35	58	12	6.8	23	2.8	0	24	24	59	150	58
04/26/86	0850	7.3	240	<1	<1	2	3	8	<5	4	<0.2	0.13	25	33	13	6	21	1.9	0	41	41	260	130	60
06/03/86	0820		310	0.8								0.15	28	47							40			67
06/26/86	0730		550	1.4	<5	4	3	<5	<5	7	<0.5	0.28	72	75							80			72
08/04/86	0910	7.0	600	1.9	<5	3	<1	<5	<5	9	<0.5	0.32	71	78							92			71
09/02/86	0930		520	1.4	<5	4	2	3	<5	6	<0.5	0.30	56	60							76			74
09/27/86	0825		440	0.6	<5	2	6	<5	<5	4	<0.5	0.18	26	26							72			61
11/04/86	1200			1.0	<5	2	2	<5	<5	<1		0.30	62	53							64			60
12/04/86	1720	7.9		1.4	<5	<1	<1	<5	<5	<1	<0.5	0.25	42	50	23	12	47	3.1	0	67	67	94	220	50
01/02/87	0850		320	0.9	<5	2	1	<5	7	2	<0.5	0.18	40	33							54			54
01/30/87	0730	7.3	610	2.3								0.45	72	83					0	120	120			53
02/27/87	0730	7.2	855	3.4								0.61	120											50
04/01/87	0720		852	3.2								0.51	100											61
05/01/87	0830		620	1.9								0.28	80											64
06/01/87	0940	7.1	764	2.4	2							0.41	110	102										69

Table 9A .....Mineral and Trace Element Water Quality for San Joaquin River at Mossdale Bridge. (site Index I) (continued)

Date	Time	pH	EC	Se	Mo	Cu	Cr	Ni	Pb	Zn	Hg	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	T.Alk	HDNS	TDS	Temp
			umhos/cm	ug/L								mg/L												
07/01/87	1515		850	2.0								0.56	100											75
07/31/87	1600	7.4	870	2.6								0.54	90	95							120			75
09/01/87	1630		874	2.3								0.44	120	110							130			78
10/01/87	1600	8.1	833	1.1								0.32	100	80							130			74
11/03/87	0900	7.2	950	1.3								0.50	140	110					0	130	130			57
12/01/87	0910		960	1.9								0.46	130	120					0	130	130			50
01/05/88	0910		1150	3.5								0.63	140	150					0	130	130			48
01/28/88	1025		1400	4.0								0.80	170	190					0	160	160			52
02/19/88	0910		1400	6.6								0.95	170	230						150	150			51
03/09/88	0905		950	3.6								0.60	110	140					<1	110	110			57
03/30/88	0900	7.8	800	2.7								0.50	100	100					<1	110	110			56
05/05/88	1045		900	2.4								0.50	93	120					<1	100	100			60
06/01/88	0850		800	2.6								0.50	92	100					<1	110	110			67
06/29/88			850	2.7								0.50	98	110					<1	92	92			69
08/01/88		8.2	900	2.5								0.53	120	120					<1	110	110			72
09/01/88	0915		910	2.9								0.44	130	120					<1	120	120			76
10/04/88	0820	8.1	1020	2.0								0.39	140	120					<1	140	140			63
11/01/88	0800	7.4	950	1.9	2							0.44	130	110						110	110			63
85 WY*	Min	7.8	500	<1								0.30	62	51										68
	Med	8.0	550	1								0.31	71	72										70
	Max	8.4	720	2								0.46	150	100										78
	# Data	3	6	6								6	6	6										6
86 WY*	Min	7.0	240	<1	<1	<1	<1	<5	<5	4	<0.2	0.13	25	26	12	6	21	1.9	0	24	24	59	130	46
	Med	7.8	600	1.4	<5	3	2	3	<5	6.4	<0.5	0.35	72	78	28	16	66	3.8	0	90	84	180	370	60
	Max	8.3	960	2	12	5	11	44	<5	9	0	0.8	140	145	66	17	89	5.3	0	100	100	260	500	74
	# Data	9	15	15	13	13	13	13	13	6	13	14	15	15	5	5	5	5	6	6	12	5	5	15
87 WY*	Min	7.1	320	0.9	<5	<1	<1	<5	<5	<1	<0.5	0.18	40	33	23	12	47	3.1	0	67	54	94	220	50
	Med	7.2	764	2.3	<5	2	1	<5	<5	<1	<0.5	0.44	90	83	23	12	47	3.1	0	94	94	94	220	61
	Max	7.9	874	3.4	2	2	2	<5	7	2	<0.5	0.61	120	110	23	12	47	3.1	0	120	130	94	220	78
	# Data	5	9	11	4	3	3	3	3	3	2	11	11	7	1	1	1	1	2	2	6	1	1	11

Table 9A .....Mineral and Trace Element Water Quality for San Joaquin River at Mossdale Bridge. (site Index I) (continued)

		pH	EC	Se	Mo	Cu	Cr	Ni	Pb	Zn	Hg	B	Cl	SO4	Ca	Mg	Na	K	CO3	HCO3	T.Alk	HDNS	TDS	Temp
			umhos/cm	ug/L								mg/L												
88 WY*	Min	7.2	800	1.1								0.32	92	80					0	92	92			48
	Med	7.5	900	2.7								0.50	120	120					<1	110	110			56
	Max	8.2	1400	6.6								0.95	170	230					<1	160	160			76
	# Data	4	13	13								13	13	13					11	12	13			13
Total	Min	7.0	240	<1	<1	<1	<1	<5	<5	<1	<0.2	0.13	25	26	12	6	21	1.9	0	24	24	59	130	46
	Med	7.8	800	1.9	<5	3	2	2	<5	4	<0.5	0.44	93	100	26	14	57	3.5	0	110	100	165	295	61
	Max	8.4	1400	6.6	12	5	11	44	7	9	<0.5	0.95	170	230	66	17	89	5.3	0	160	160	260	500	78
	# Data	23	45	47	18	16	16	16	16	9	15	46	47	43	6	6	6	6	20	22	33	6	6	47

* Water Year: Beginning on October 1 of one year and ending on September 30 of the following year.

APPENDIX B

Maximum, Minimum and Median Concentrations for Selected Mineral and Trace Elements for Sites Along the Lower San Joaquin River in Water Year 1988 (1 October 1987 to 30 September 1988)

	Page
Electrical Conductivity	B-1
Chloride	B-2
Sulfate	B-3
Boron	B-4
Selenium	B-5
Molybdenum	B-6

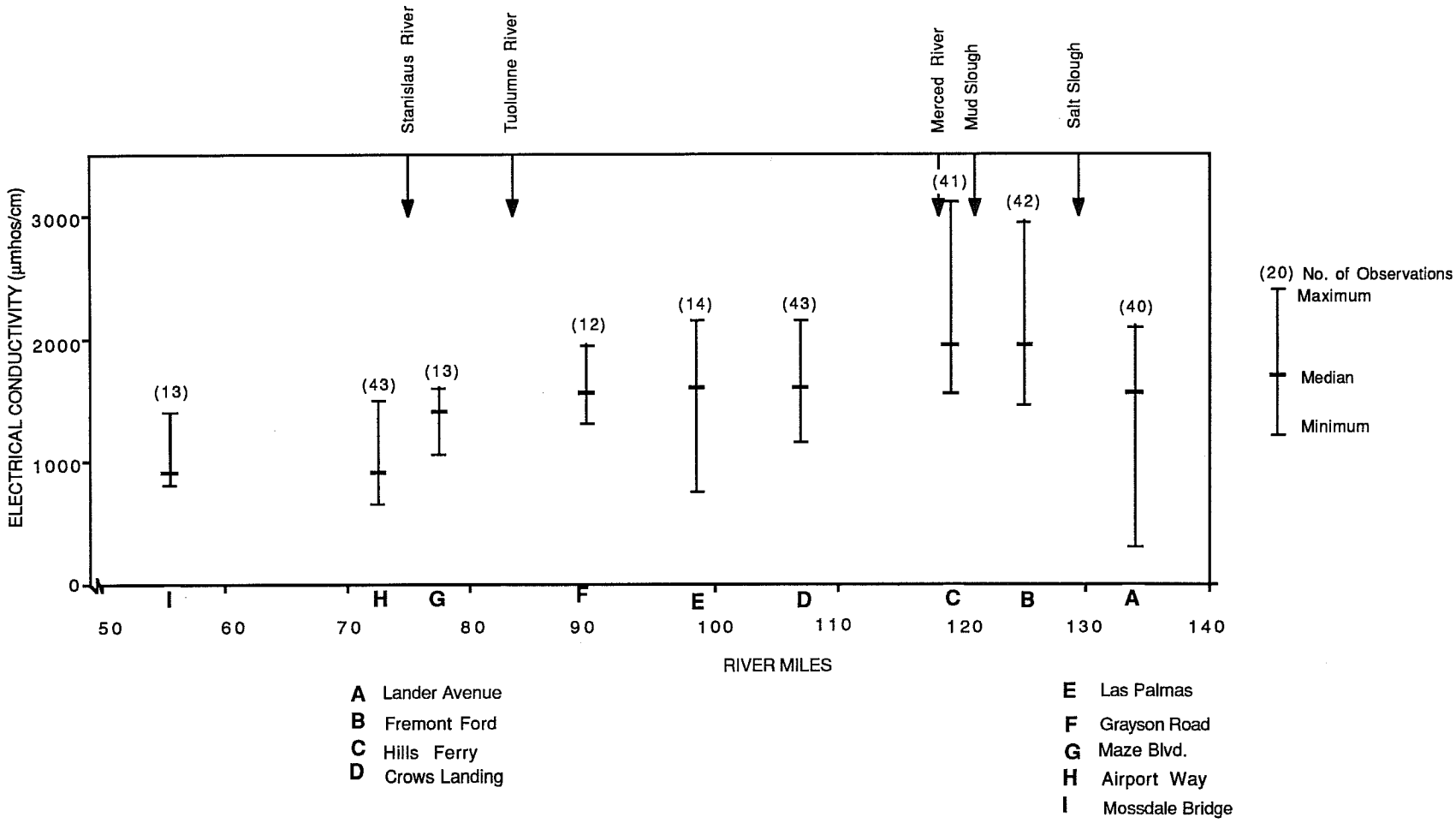

Fig. 1B. San Joaquin River Electrical Conductivity Measurements for Water Year 1988; a Critical Water Year.

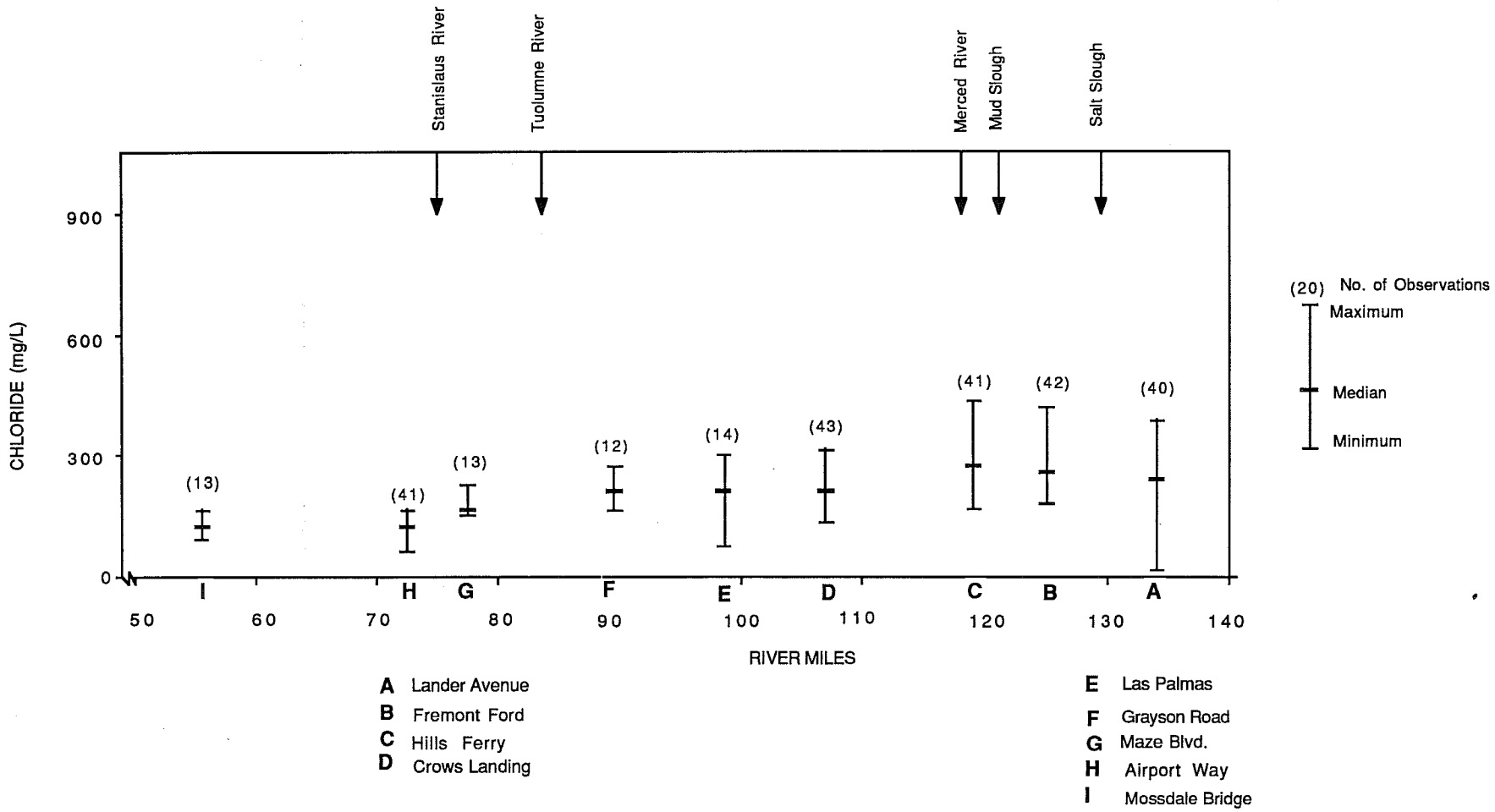

Fig. 2B. San Joaquin River Chloride Measurements for Water Year 1988; a Critical Water Year.

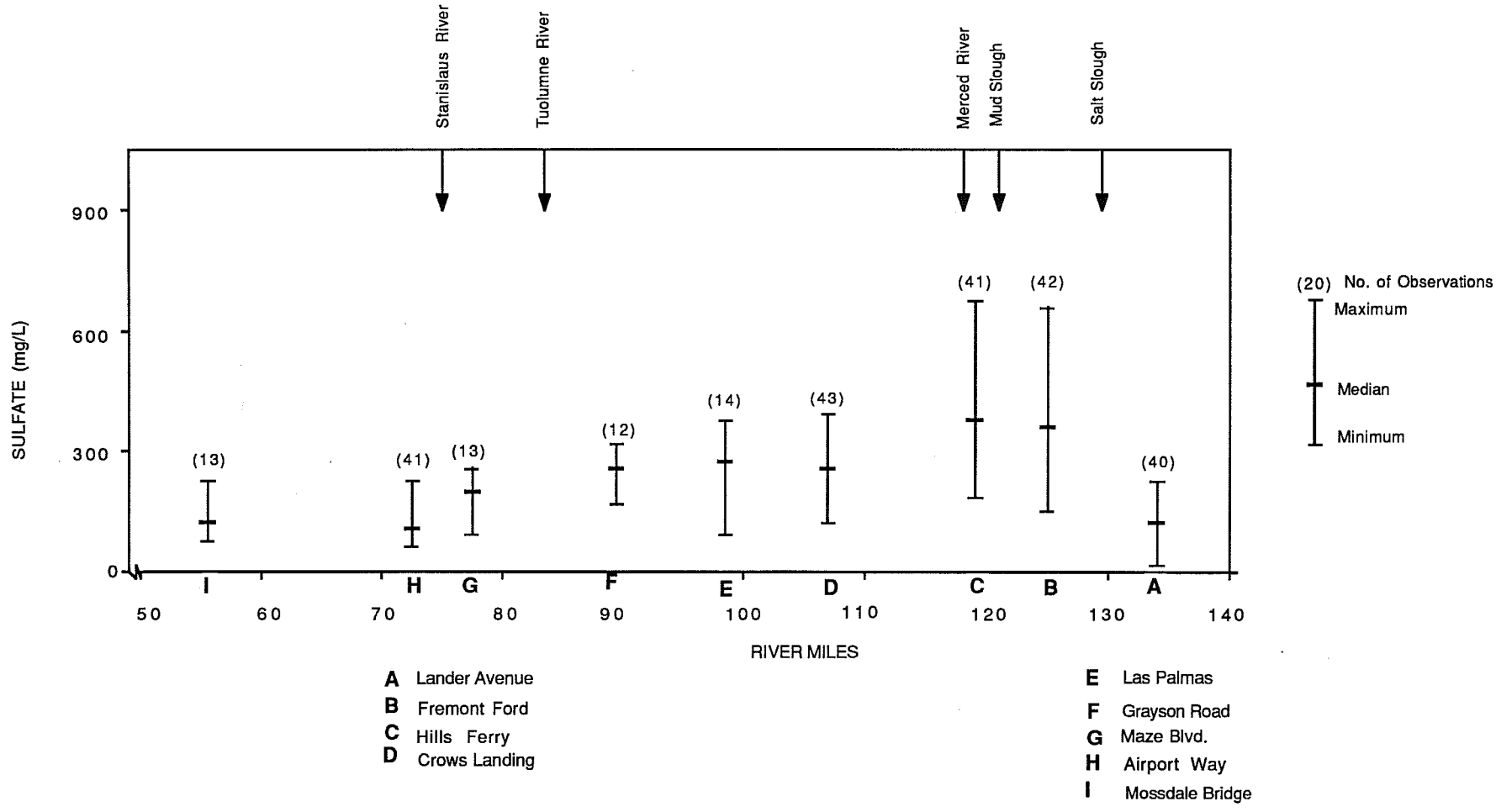

Fig. 3B. San Joaquin River Sulfate Measurements for Water Year 1988; a Critical Water Year.

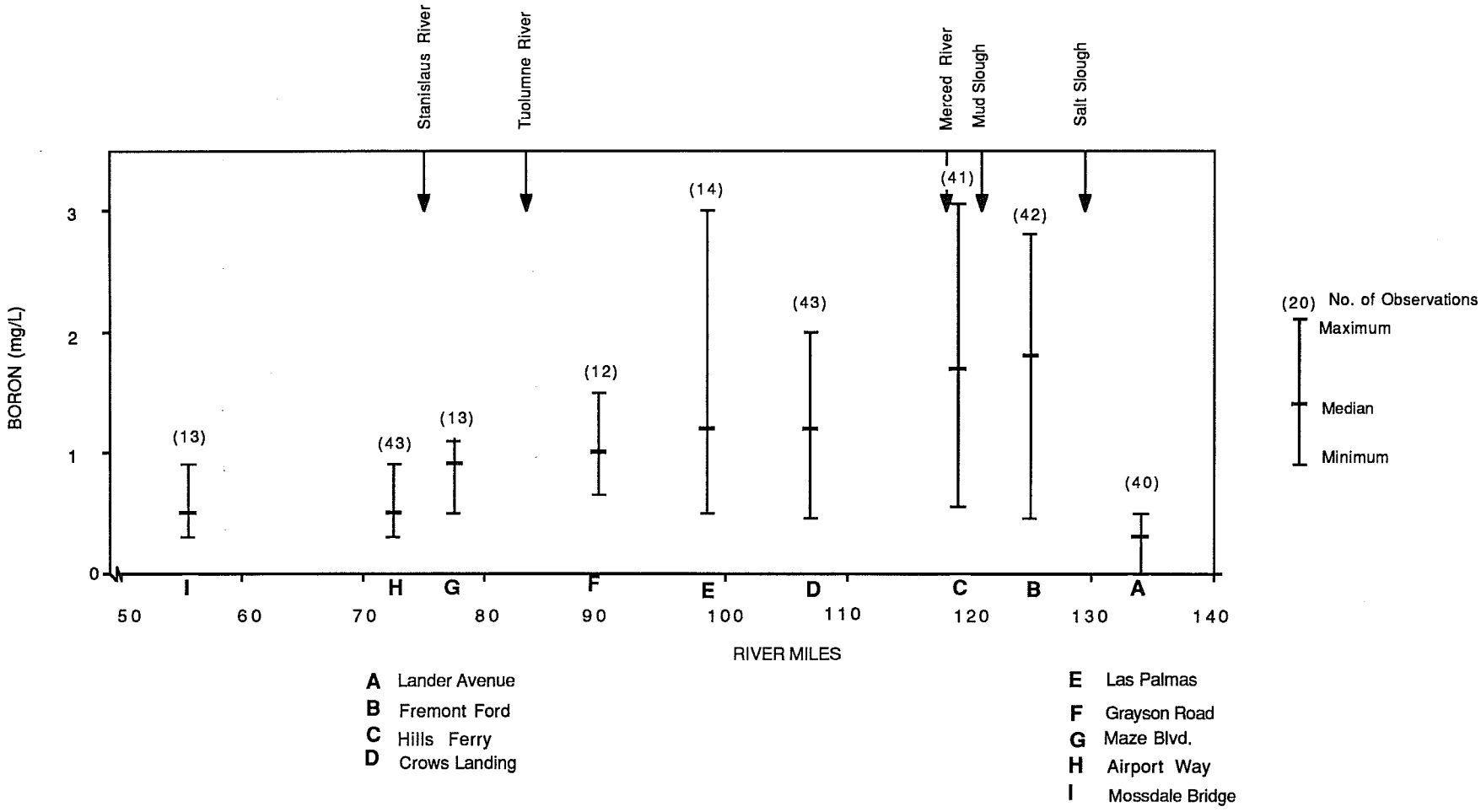

Fig. 4B. San Joaquin River Boron Measurements for Water Year 1988; a Critical Water Year.

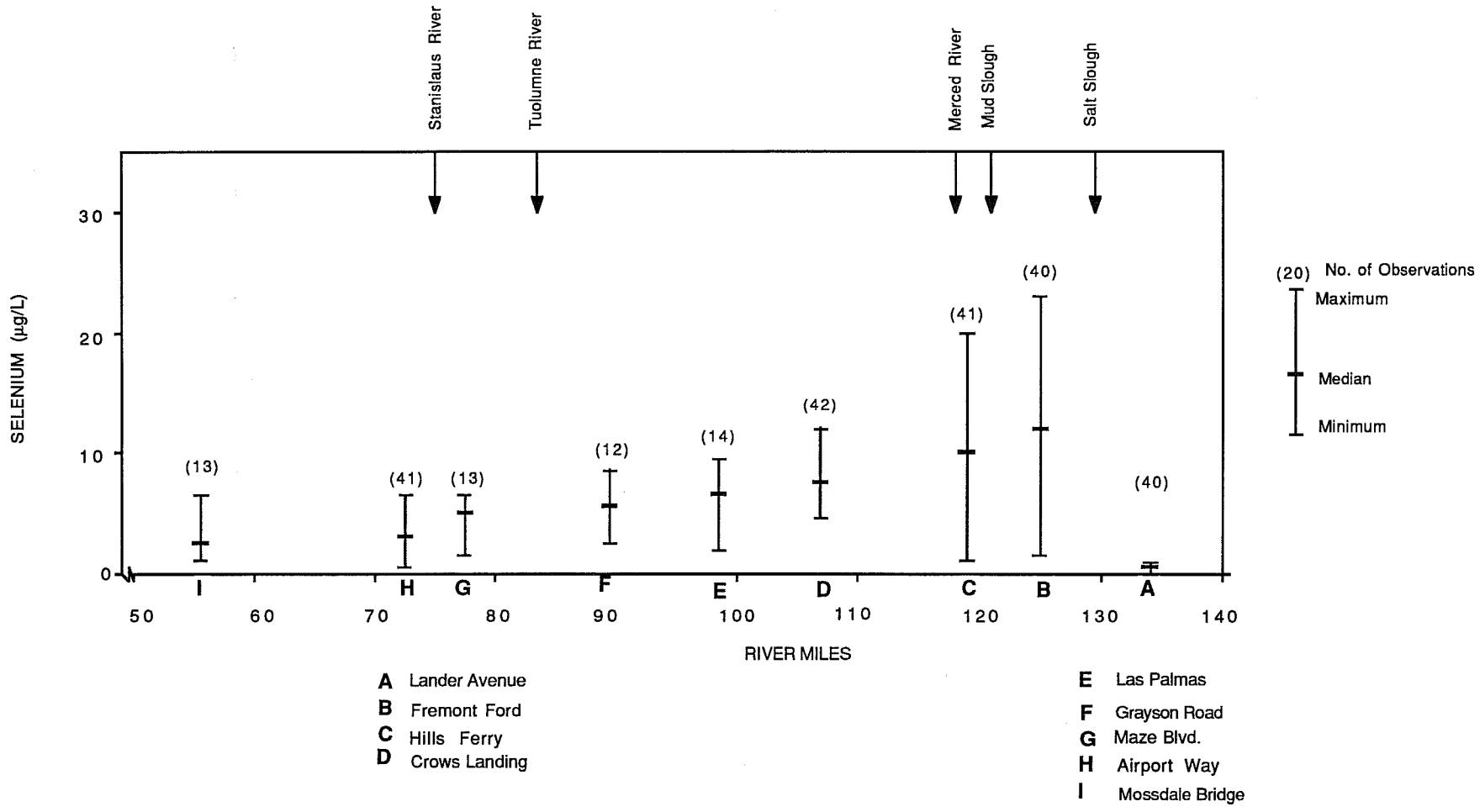

Fig. 5B. San Joaquin River Selenium Measurements for Water Year 1988; a Critical Water Year.

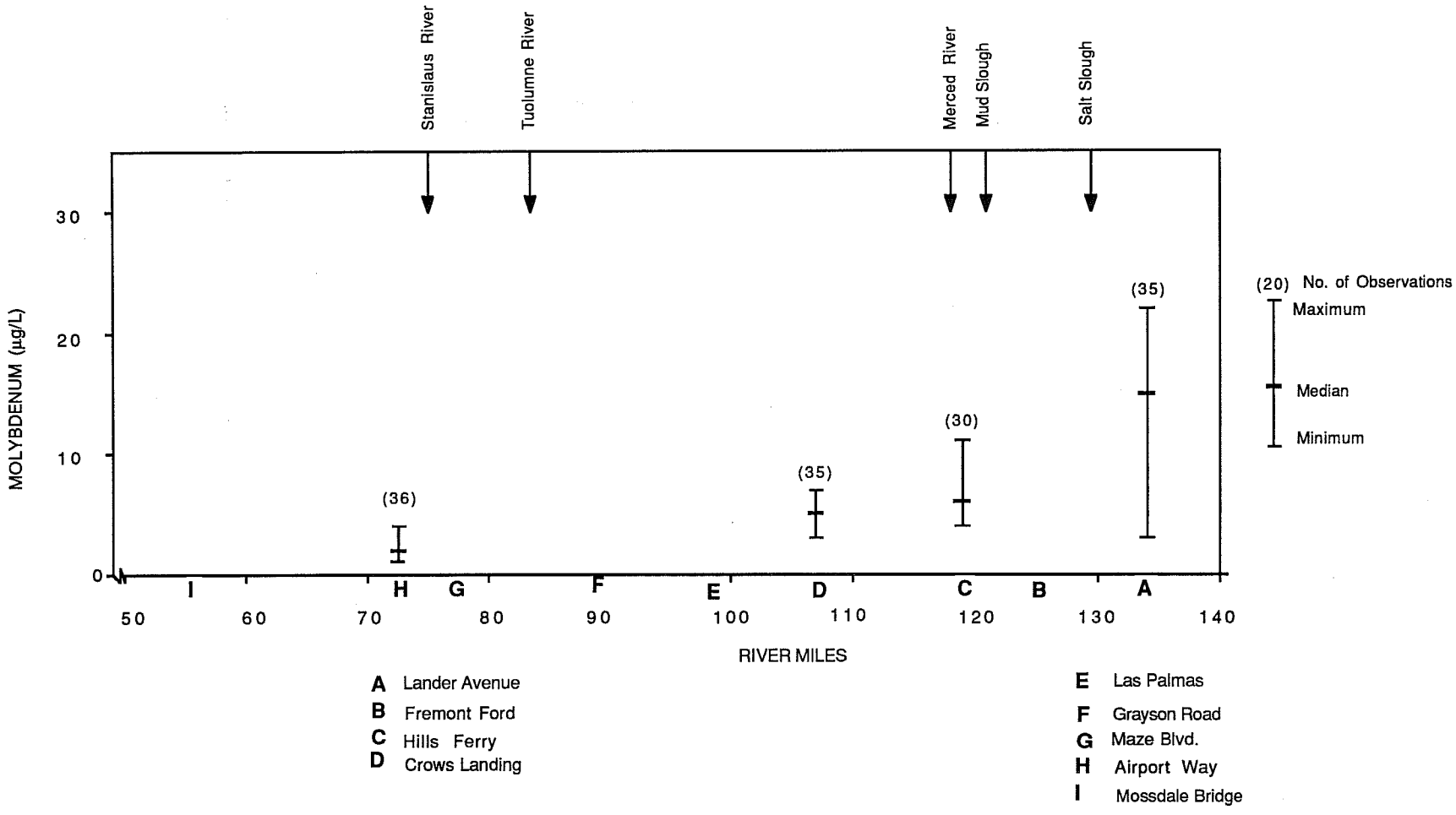

Fig. 6B. San Joaquin River Molybdenum Measurements for Water Year 1988; a Critical Water Year.