Montana Bureau of Mines and Geology
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Storm-Event Monitoring on the Upper Clark Fork River Basin Silver Bow and Deer Lodge Counties

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Upper Clark Fork River Basin

Storm Event Monitoring

Introduction

The Upper Clark Fork River Basin contains the Silver Bow Creek and Anaconda Smelter Superfund sites, and has been impacted by man and mining activities for over 100 years. Due to the numerous impacts this river basin has been exposed to, a number of studies and considerable amounts of data have been collected, but much of it has been periodic in nature.

The intent of this study was to implement a monitoring and sampling network to collect data and document water quality changes, if any, in Silver Bow Creek from Butte to the Clark Fork River below the Warm Springs Ponds, during summer thunderstorm events. Realizing that thunderstorms can be spotty in the upper basin and can happen at any hour of the day and night, emphasis was placed on remote methods of collecting data when field crews were not on site. Discussions were held between the Montana Department of Health and Environmental Sciences - Solid and Hazardous Waste Bureau (MDHES-SHWB), U.S. Geological Survey (USGS), U.S. Environmental Protection Agency (EPA), and the Montana Bureau of Mines and Geology (MBMG) to discuss key areas and important water quality parameters. It was decided that, at the two existing USGS gaging stations and at the two proposed gaging stations in the upper basin, discharge, pH, specific conductance, water temperature, and dissolved oxygen would be monitored continuously, and cadmium, chromium, copper, lead, zinc, and arsenic, would be sampled as required. Iron, manganese, sulfate, and aluminum were added to the sampling list to better characterize stream water quality conditions.

Due to delays in the contract being finalized, work did not begin until the latter part of July 1988, therefore 1988 monitoring continued through October 1988. The 1989 season began in mid-March 1989 and continued through June 1989.

Monitoring and Sampling Locations

Four sites were initially identified for monitoring and sampling purposes, those being the existing USGS gaging station on Silver Bow Creek below the Colorado Tailings, a site on Silver Bow Creek near Opportunity, Stewart Street Bridge, the existing USGS gaging station on Warm Springs Creek at Warm Springs, Montana, and a site on the Clark Fork River below the Warm Springs Ponds, Perkins Lane Bridge. USGS gaging stations were installed at the two locations that did not have existing gaging stations.

During late summer 1988, the USGS and MBMG decided to relocate the Blacktail Creek gaging station that was part of their on-going cooperative program in the upper basin. This gage was relocated on Blacktail Creek just above its confluence with Silver Bow Creek. Therefore, this site was added to the sampling routine during 1989; also, samples were collected on Missoula Gulch during the 1989 sampling period. Figure 1 shows sampling and monitoring locations, while Table 1 contains those sites description.

Monitoring and Sampling Methods

To implement the remote monitoring portion of this study, Hydrolab Data Sonde continuous monitors were used at each site. These monitors have the ability to collect data at desired time intervals and for selected

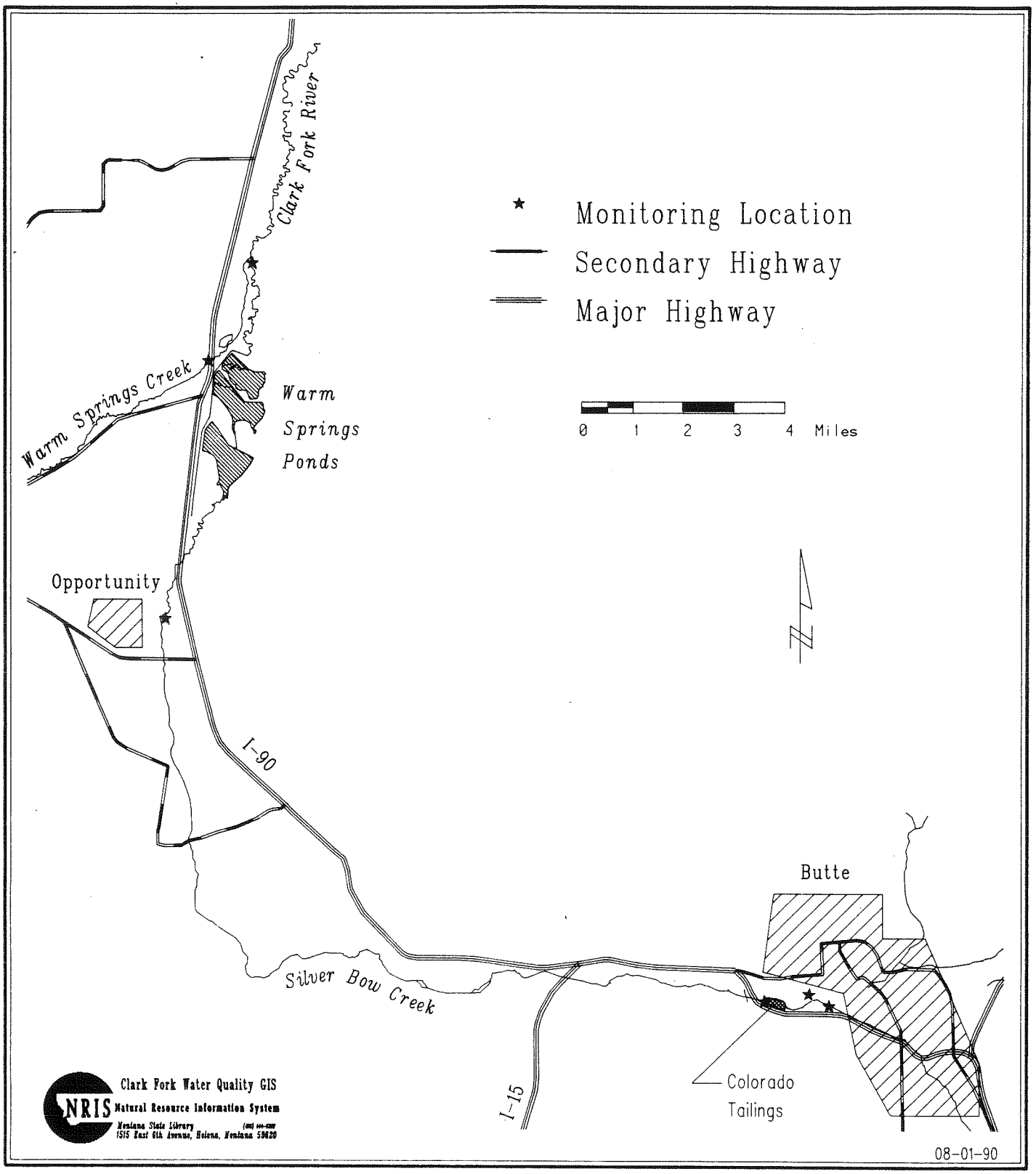

FIGURE 1 – UPPER CLARK FORK BASIN, MONITORING LOCATIONS

Table 1
U.S.G.S. Station Data

Name	U.S.G.S. Number	Drainage Area (square miles)	Datum (elevation, feet)
Blacktail Creek at Butte, MT	12323240	95.4	5430
Silver Bow Creek below Blacktail Creek at Butte, MT	12323250	103	5410.87
Silver Bow Creek at Opportunity, MT	12323600	284	4912.37
Warm Springs Creek at Warm Springs, MT	12323770	163	4811.25
Clark Fork near Galen, MT	12323800	793	4749.24

parameters. The parameters monitored by these sondes were pH, temperature, specific conductance, and dissolved oxygen.

Prior to each sondes deployment, they were calibrated in the lab, and site location, monitoring interval, and monitoring start and stop date and time were installed in the sondes memory. During the 1988 field season, the sondes were placed in the field for one week intervals, while during the 1989 field season, they were placed for seven to ten day intervals. Field parameters were measured once per week with portable field equipment as quality control (QC) checks on data sonde data. Each sonde was picked up and returned to the lab to download the collected monitoring parameter data to a computer.

An ISCO flow actuated sampler was used to collect water quality samples during storm events. During 1988, this sampler was rotated between the two

Silver Bow Creek sites, while during 1989 it was used at the Clark Fork River site only.

The flow actuated sensor was affixed to a staff gage on site at a pre-determined height above existing stream stage. Since no historical records existed at the Silver Bow Creek site at Opportunity or Clark Fork River at Perkins Lane, the height above the current stage to set the actuator was a best guess estimate. Also, since no data existed at most of the sites throughout the duration of a storm, it was uncertain at which point of the storm hydrograph (rising limb, peak or falling limb) sampling should be initiated and what time interval should be used between samples. During 1988, the time interval was 30 minutes between samples during the first sampling event at Silver Bow Creek at Opportunity and 60 minutes during the second event and 120 minutes during the third event, while the one Silver Bow Creek event at the Colorado Tailings had a 60 minute interval between samples. The 1989 sample interval at the Clark Fork River site at Perkins Lane was 60 minutes.

Field crews also collected water quality samples during some point of each storm event. The Warm Springs ponds retention time had a considerable affect on downstream response to storms, therefore samples collected during the stream-storm hydrograph of the three sites above or adjacent to the ponds was not similar to that point or the stream-storm hydrograph on the Clark Fork River site at Perkins Lane. That is, the lag-time for stream response at the Perkins Lane site was increased from start of storm to its affect on flow or stream stage, due to the routing of the storm event through the Warm Springs ponds. Most of the samples collected by field crews were depth integrated samples using a DH-48 sampler, but there were several occasions

where grab samples were collected. Table 2 contains sample date, type of sample, and collection method.

Three sample bottles were collected at each site during the 1988 field season except at sites where flow activated samples were collected; at those sites, four sample bottles were collected. Each set of samples had a 500 ml raw untreated bottle, a 250 ml filtered untreated bottle and a 500 ml filtered-acidified bottle, while the fourth sample bottle collected during automatic sampling episodes was a 250 ml raw acidified bottle.

Filtered samples were field filtered through a 0.45 um filter, while acidified samples were preserved with 1% HNO_3 acid. The raw sample was used for laboratory measurements of pH, SC, hardness and alkalinity; the filtered untreated sample was used for dissolved anion analysis, the filter acidified sample was used for dissolved trace metal and major cations and the raw acidified sample was used for bio-available trace metal and major cations analysis.

Monitoring Results

The data quality parameters pH, specific conductance, temperature and dissolved oxygen were monitored at the four primary study stations for two periods: (1) August to November, 1988, and (2) March to July, 1989. Recording intervals varied from fifteen minutes to one hour resulting in a vast data set which is available on soft media.

Typical data sets are presented below for each of the stations during two characteristic base-flow periods and one storm event. One late summer or early fall of 1988 day is tabulated and graphed followed by a spring of 1989 day. The final sets of data are a storm period and they include a four day sequence.

Table 2
Upper Clark Fork Basin Water Quality
Sampling Summary

Date	Collection Method (1)	Colorado Tailings Diss.	Bio.	TR	Stewart St. Bridge Diss.	Bio.	TR	Warm Springs Diss.	Bio.	TR	Perkins Lane Diss.	Bio.	TR
		Station Location/Type of Sample											
7/27/88	DC	X			X			X			X		
8/6/88	DC	X			X			X			X		
9/5/88	DC	X			X			X			X		
9/10-11/88	Auto				X	X							
9/11/88	DC	X			X			X			X		
9/17-18/88	Auto				X	X							
9/18/88	DC	X			X			X			X		
9/27/88	DC	X			X			X			X		
9/27-28/88	Auto				X	X							
10/17/88	DC	X			X			X			X		
11/3/88	Auto	X	X										
4/7/89	G	X	X		X	X		X	X		X	X	
4/14/89	DC	X	X		X	X		X	X		X	X	
4/21/89	DC	X	X		X	X		X	X		X	X	
4/21/89	Auto											X	
4/22/89	DC	X	X		X	X		X	X		X	X	
4/24/89	Auto										X	X	
4/28/89	DC	X	X		X	X		X	X		X	X	
5/9/89	Auto										X	X	
5/10/89	Auto										X	X	
5/12/89	DC				X	X		X	X		X	X	
5/15/89	DC	X	X		X	X		X	X		X	X	
5/15/89	DC	X	X										
5/28-29/89	DC	X	X	X	X	X	X	X	X	X	X	X	X
6/6/89	DC										X	X	
6/6/89	Auto										X	X	
6/9/89	DC	X	X	X				X	X	X	X	X	X
6/16/89	Auto										X	X	
6/27-28/89	DC	X			X			X	X		X	X	

(1) Collection Method - procedure used to collect sample:
DC - Depth Composite, using DH-48 sampler
G - Grab Sample
Auto - Sample collected by ISCO, flow activated sampler, sample collected approximately 9" above streambed.

Silver Bow Creek Below Blacktail Creek at Butte, MT

Table 3 contains a complete record of the monitoring dates, recording intervals and file names for this station. The file name was developed from a single letter for the station (C - Colorado Tailings), and two digits for the year, month and day ending the sampling period.

A typical non-storm event day (August 20, 1988) is presented in Table 4 and graphically represented in Figures 2 through 4b.

Table 3
Silver Bow Creek below Blacktail Creek at Butte, MT Monitoring Dates, Intervals and File Names

Monitoring Dates	Recording Intervals (minutes)	File Name
08/11/88 to 08/17/88	15	C880817
08/19/88 to 08/25/88	15	C880825
08/26/88 to 09/01/88	15	C880901
09/01/88 to 09/07/88	15	C880907
09/08/88 to 09/15/88	18	C880915
09/15/88 to 09/22/88	20	C880922
09/22/88 to 09/29/88	20	C880929
09/29/88 to 10/06/88	20	C881006
10/06/88 to 10/13/88	20	C881013
10/13/88 to 10/20/88	20	C881020
10/20/88 to 10/27/88	20	C881027
10/27/88 to 11/03/88	20	C881103
03/10/89 to 03/17/89	30	C890317
04/03/89 to 04/17/89	60	C890417
04/18/89 to 04/27/89	30	C890427
04/27/89 to 05/05/89	30	C890505
05/05/89 to 05/17/89	30	C890517
05/17/89 to 05/26/89	30	C890526
05/26/89 to 06/08/89	30	C890608
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06/22/89 to 07/05/89	30	C890705

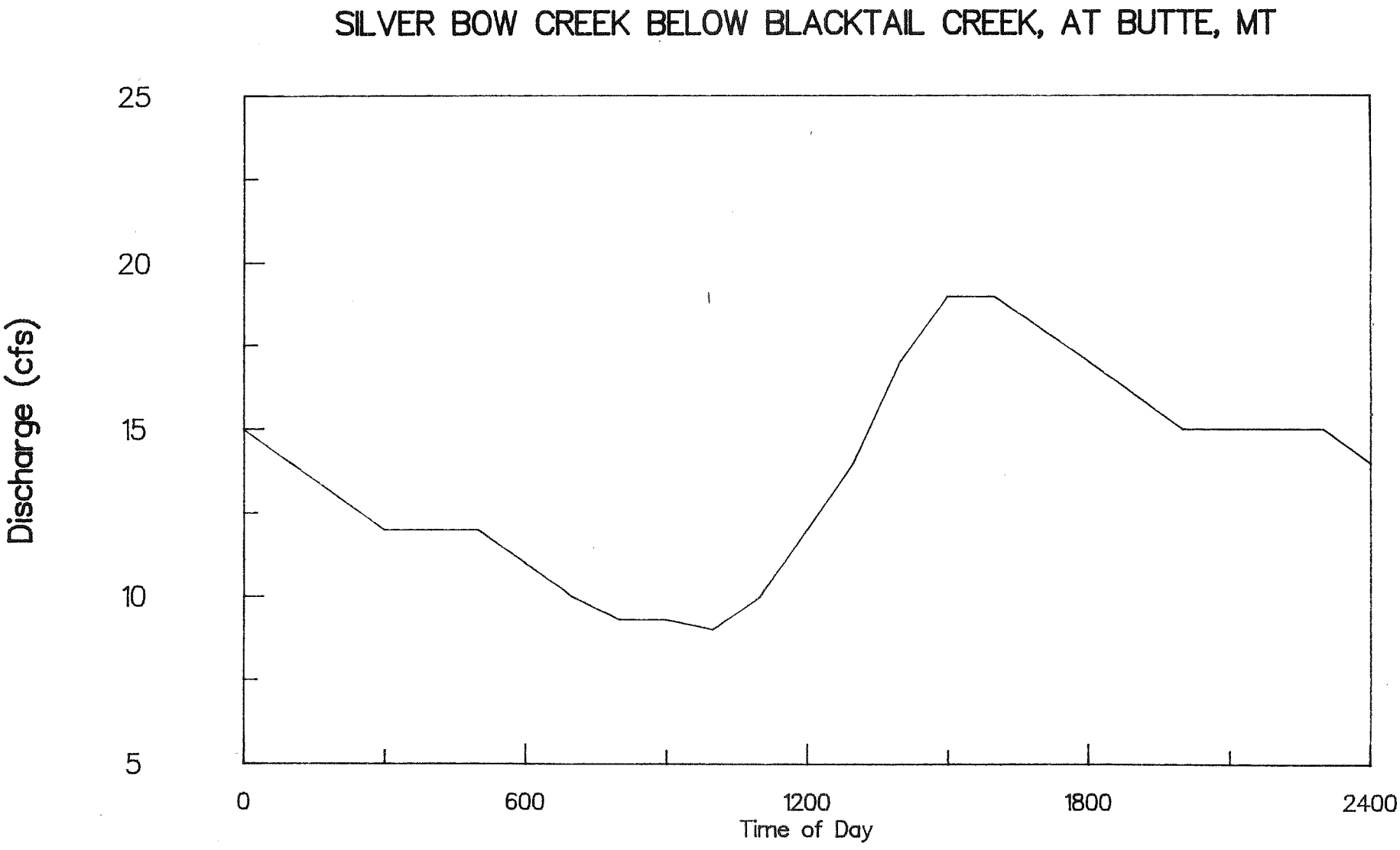
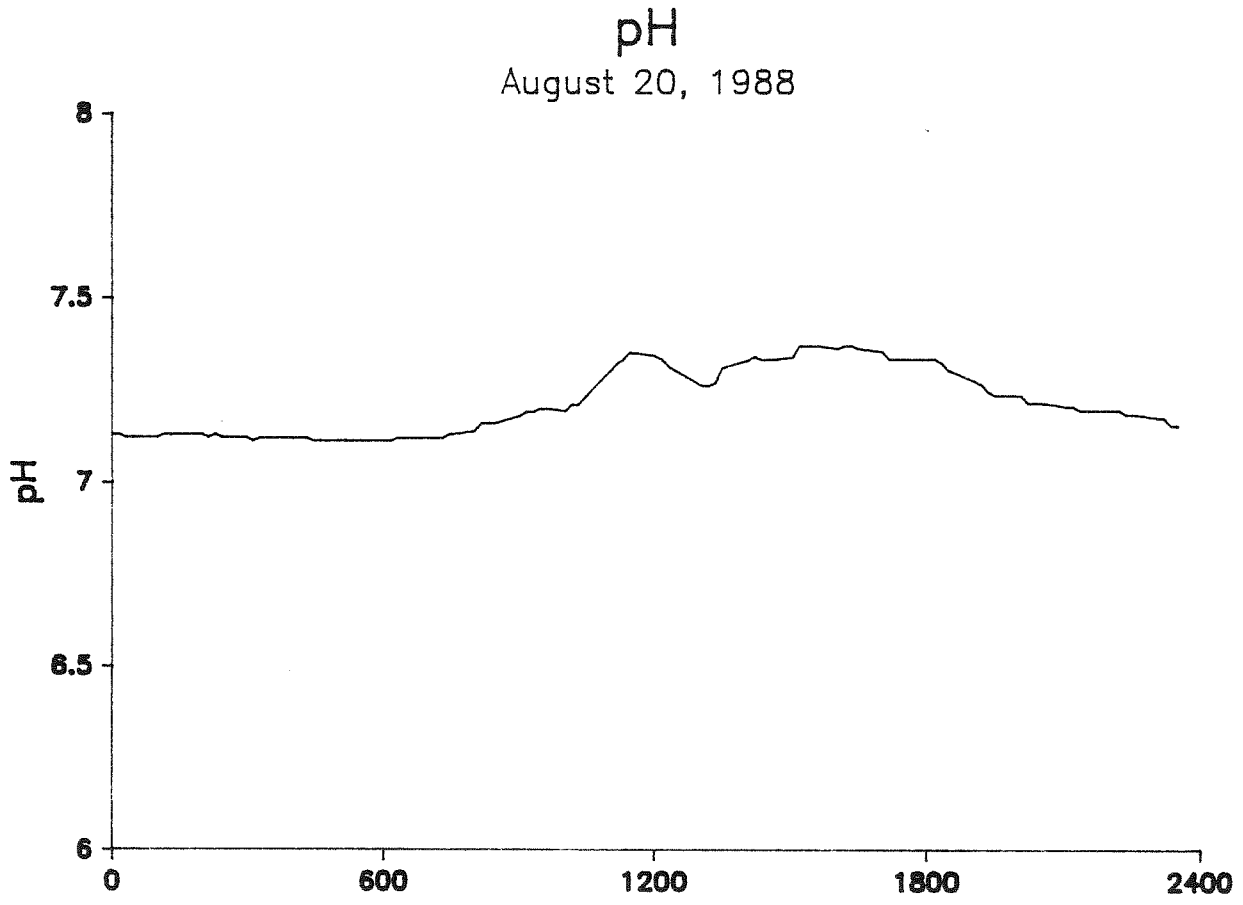


FIGURE 2 – DISCHARGE ON AUGUST 20, 1988



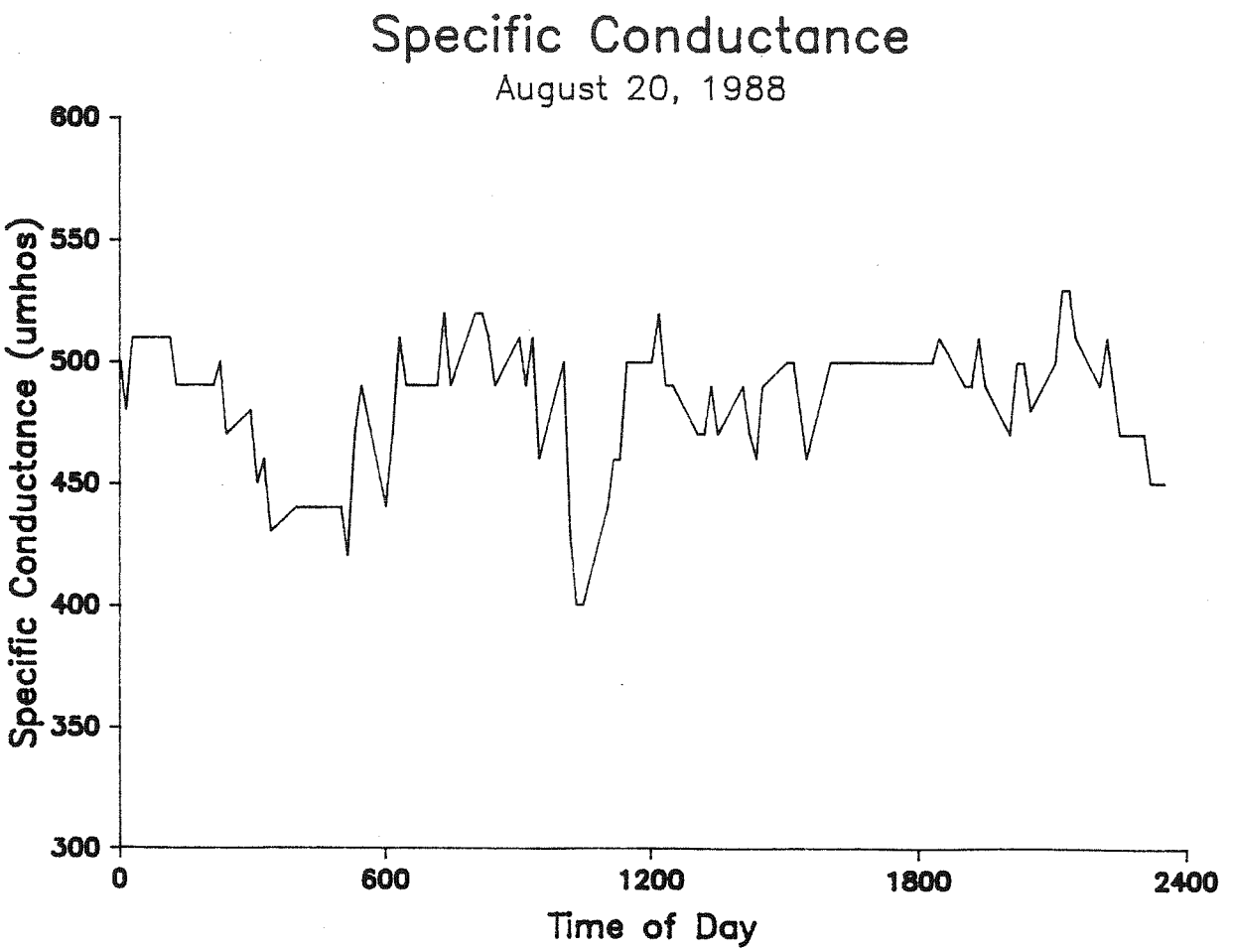
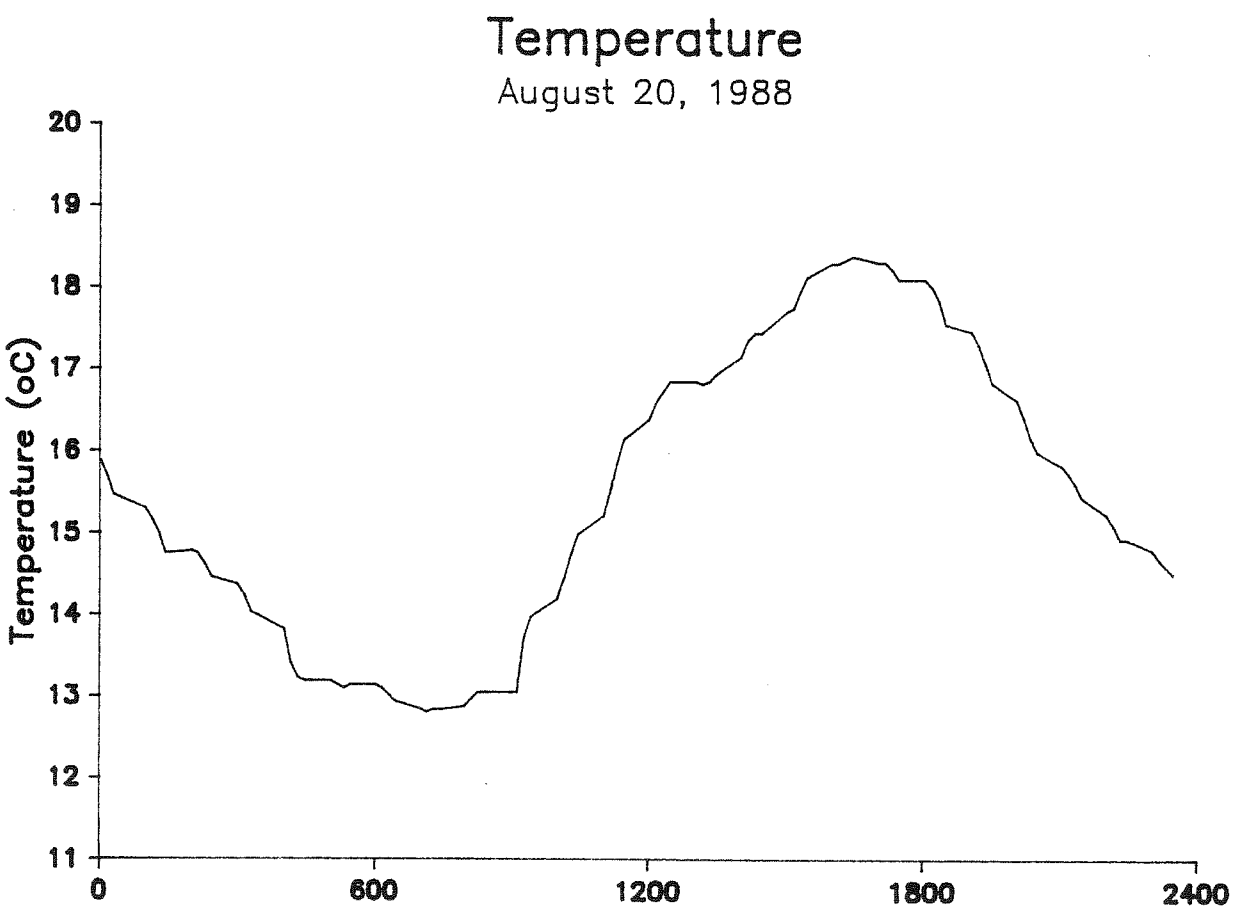


FIGURE 3 – SILVER BOW CREEK BELOW BLACKTAIL CREEK,



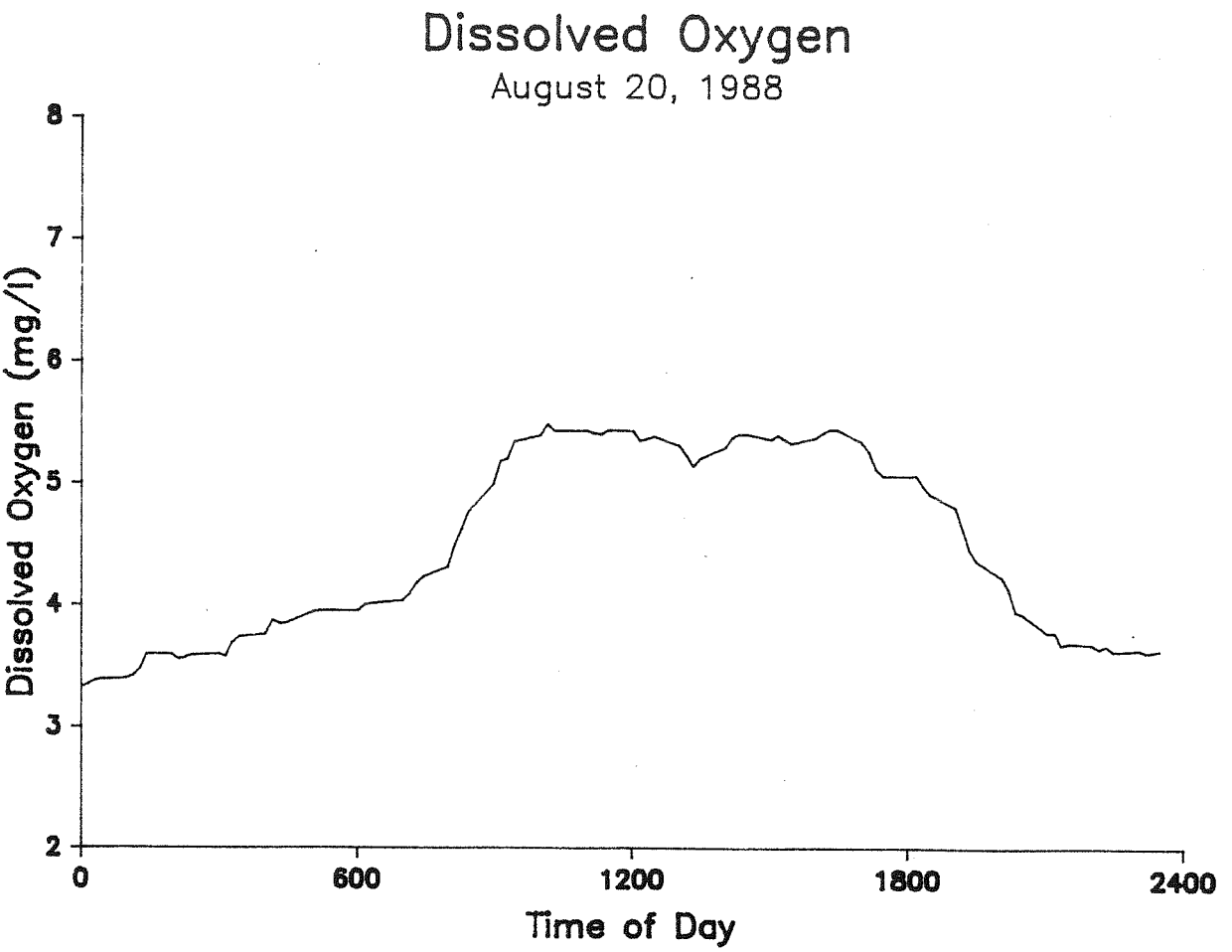


FIGURE 4 – SILVER BOW CREEK BELOW BLACKTAIL CREEK.

Table 4
Silver Bow Creek Below Blacktail Creek
at Butte, MT on August 20, 1988

	Discharge (cfs)	pH	Specific Conductance (umhos/cm @ 25° C)	Temperature (° C)	Dissolved Oxygen (mg/l)
Mean	14	7.2	483	15.4	4.5
Std. Dev.	3	0.09	27	1.8	0.8
Maximum	19	7.4	530	18.4	5.5
Minimum	9	7.1	400	12.8	3.3

Discharge at this station was strongly affected by Metro Sewer's effluent and Figure 2 shows the typical daily variation. Observed diurnal variations in pH were very small, but the afternoon rise shown in Figure 3a correlates well with the anticipated photosynthesis and the dissolved oxygen increase indicated in Figure 4a. Specific conductance was highly erratic with no apparent interpretation. Temperature (Figure 4a) showed a well behaved diurnal with a low near 0700 hours and a greater than five degrees centigrade rise to a high near 1700 hours. Dissolved oxygen (Figure 4b) was a highly variable parameter and it ranged from a nighttime low of 3.3 mg/l to a daytime high of 5.5 mg/l. Saturation values for dissolved oxygen were low at 41 to 65 percent and indicate a dominance of respiration over photosynthesis.

A typical early spring day (May 1, 1989) is tabulated in Table 5 and represented graphically in Figures 5, 6, and 7.

Table 5
Silver Bow Creek Below Blacktail Creek
at Butte, MT on May 1, 1989

	Discharge (cfs)	pH	Specific Conductance (umhos/cm @ 25° C)	Temperature (° C)	Dissolved Oxygen (mg/l)
Mean	22.8	7.1	375	9.6	8.0
Std. Dev.	2.9	0.04	3	2.6	0.4
Maximum	26	7.2	384	13.4	8.6
Minimum	18	7.0	369	6.0	7.2

Discharge (Figure 5) varied eight cfs over the 24 hour period and pH (Figure 6a) and specific conductance (Figure 6b) were basically steady at 7.1 and 375 umhos, respectively. Temperature (Figure 7a) showed a large diurnal variation of over seven degrees centigrade. Dissolved oxygen (Figure 7b) values were a maximum at a minimum temperature indicating solubility control. Observed minimum and maximum values were 7.2 mg/l and 8.6 mg/l, respectively, and the associated dissolved oxygen saturation values were 77 percent and 94 percent, respectively.

A small storm with just a trace of precipitation affected large changes in the monitored parameters on June 27, 1989 (NOAA, 1989). Discharge is given in Figure 8 and shows the rapid response typical of headwaters hydrology. The important parameter pH deviated from the diurnal cycle with a drop of 0.4 pH units (Figure 9a), and this correlated with a high specific conductance of 424 umhos/cm. Figure 9b shows that the specific conductance initially dropped to 226 umhos/cm before the rapid rise to a maximum. Storm related changes in temperature (Figure 10a) and dissolved oxygen (Figure 10b) were also detected and can easily be explained by cloud cover and cool rain.

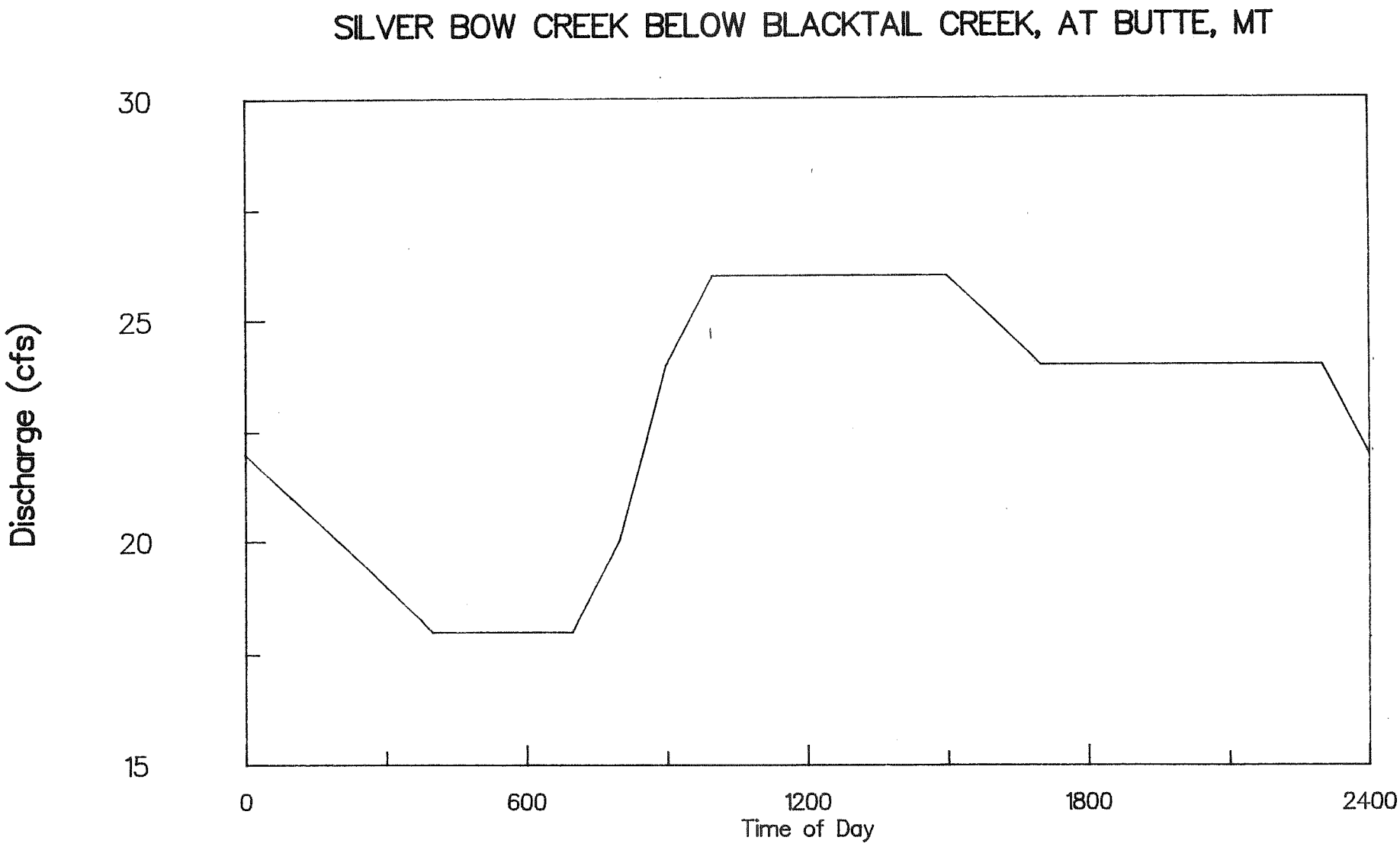
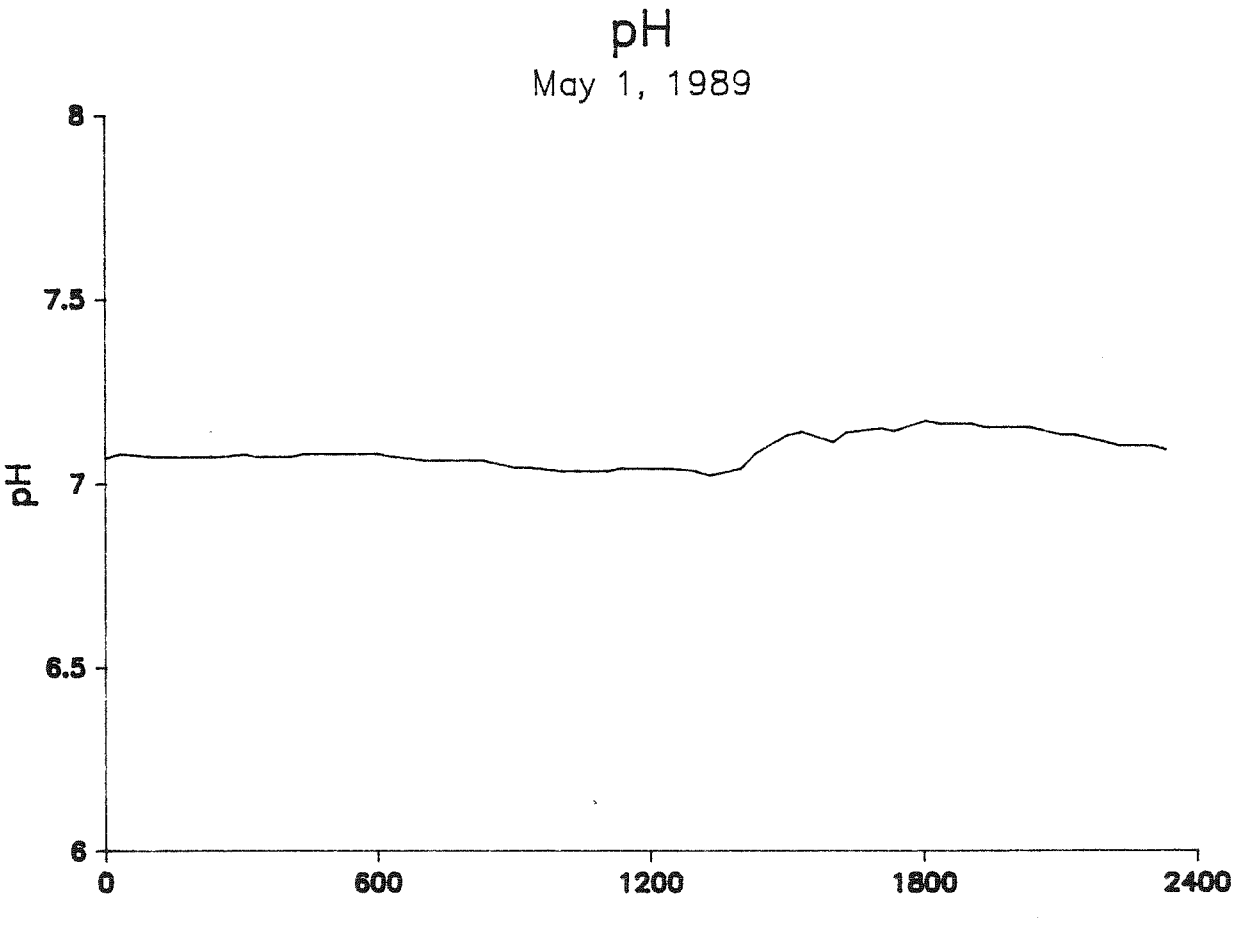


FIGURE 5 – DISCHARGE ON MAY 1, 1989



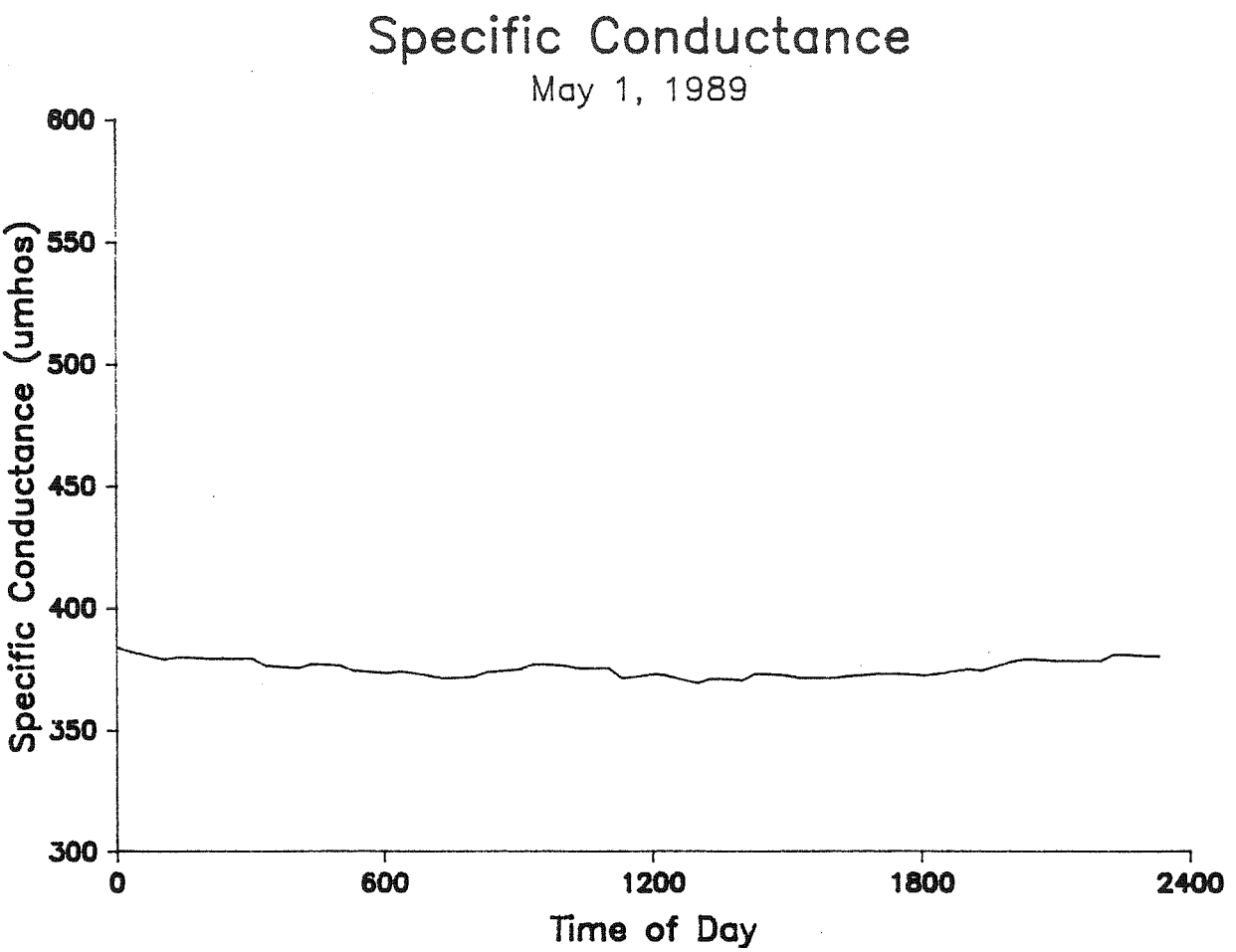
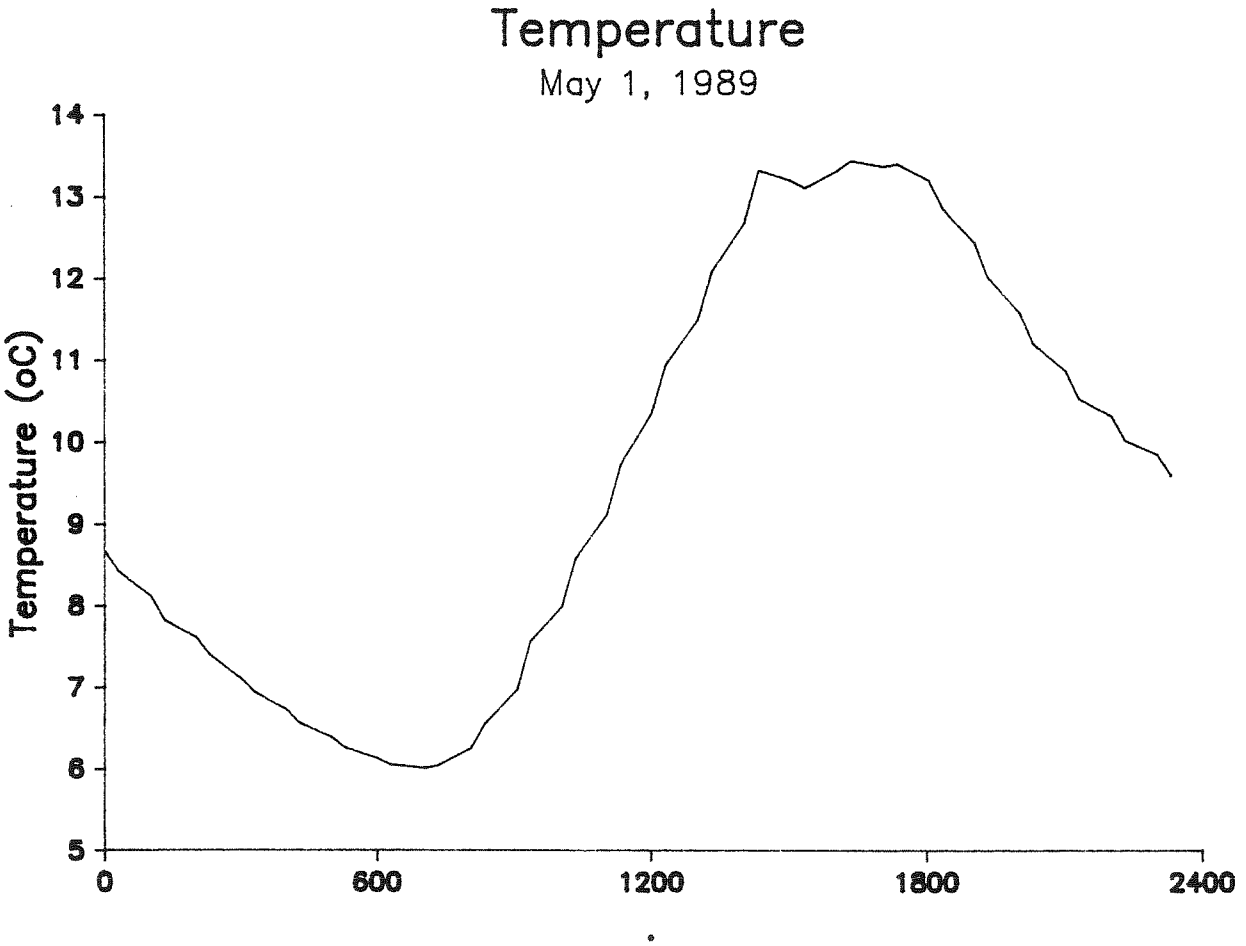


FIGURE 6 – SILVER BOW CREEK BELOW BLACKTAIL CREEK,
(a) pH (b) SPECIFIC CONDUCTANCE



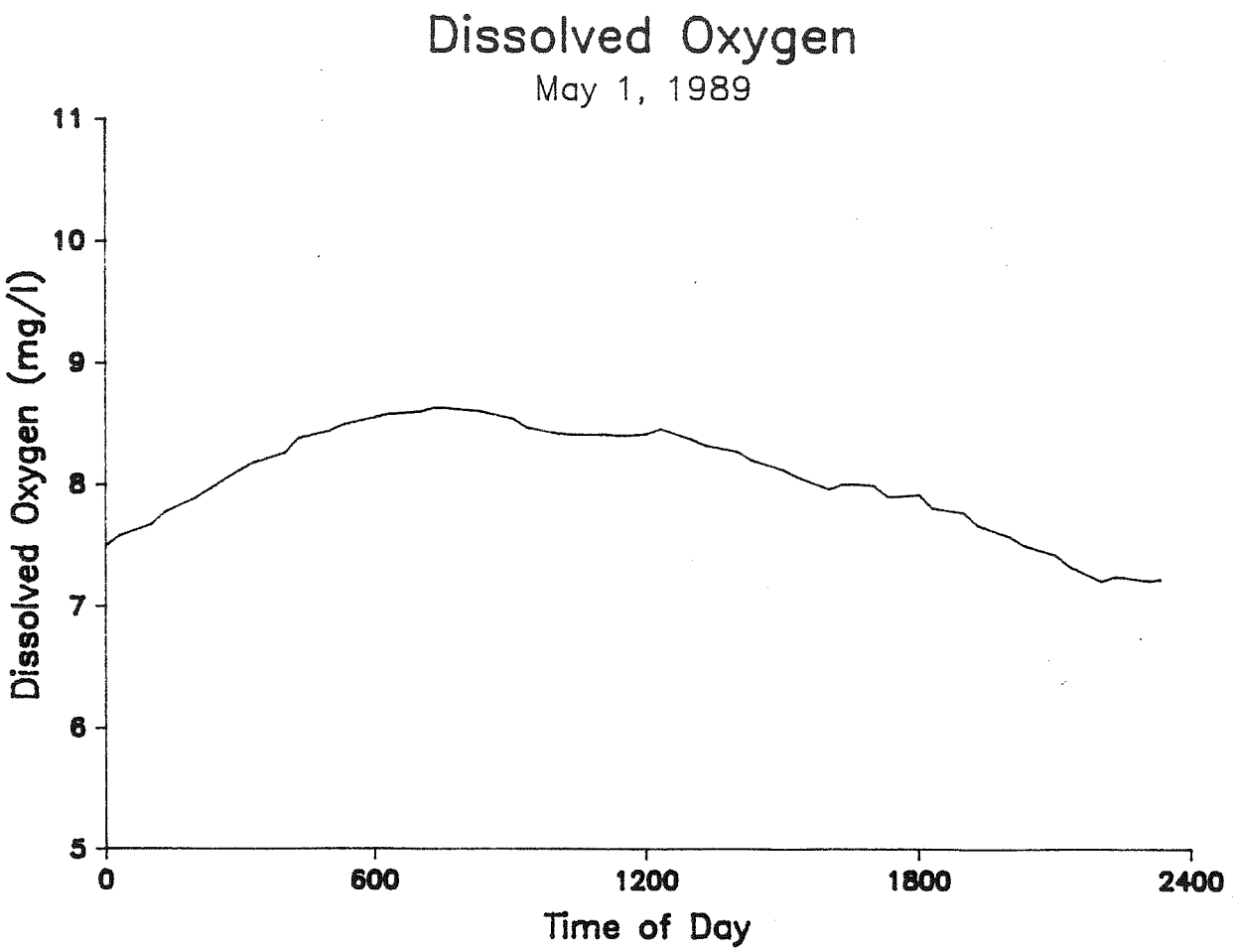


FIGURE 7 – SILVER BOW CREEK BELOW BLACKTAIL CREEK,

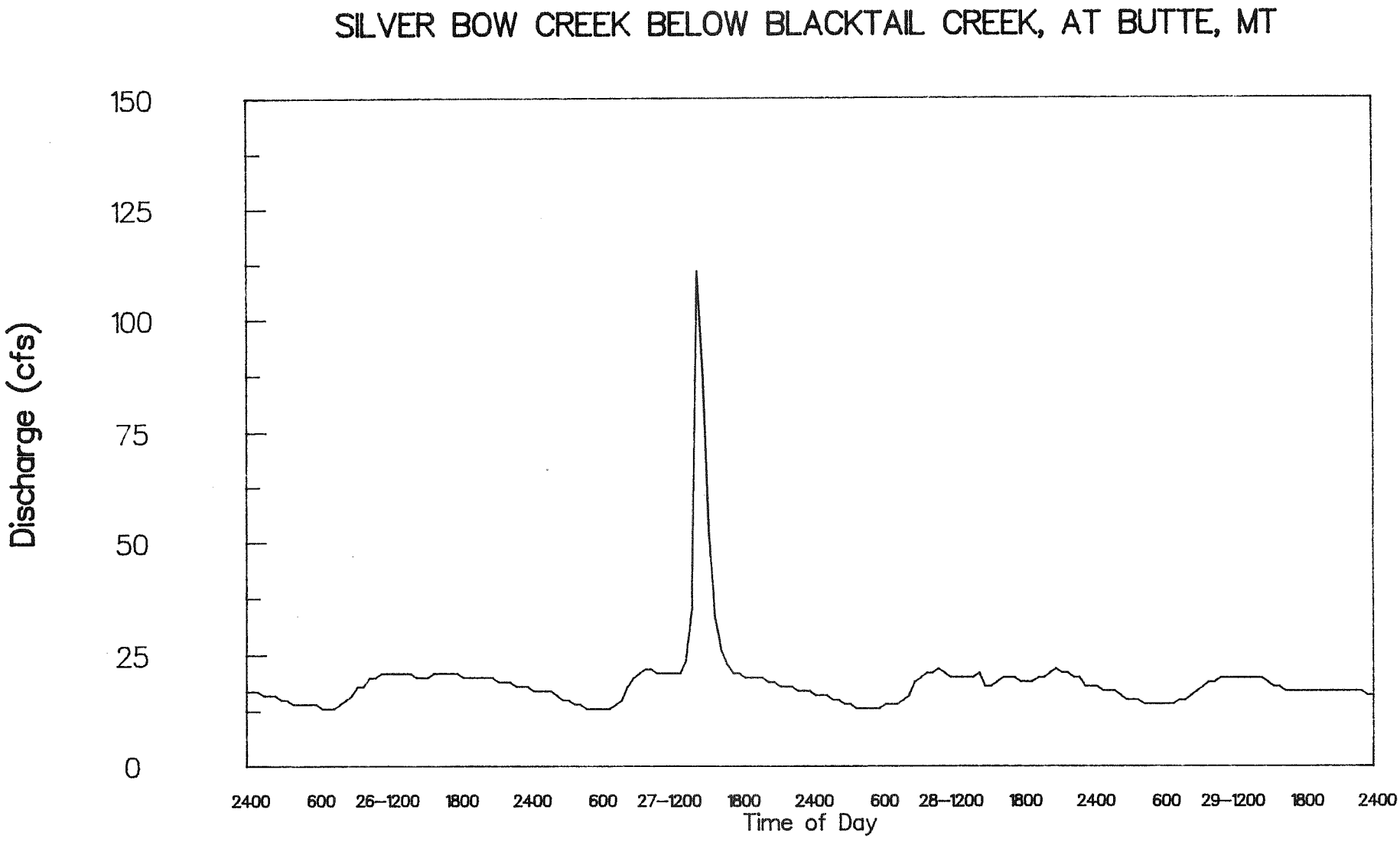
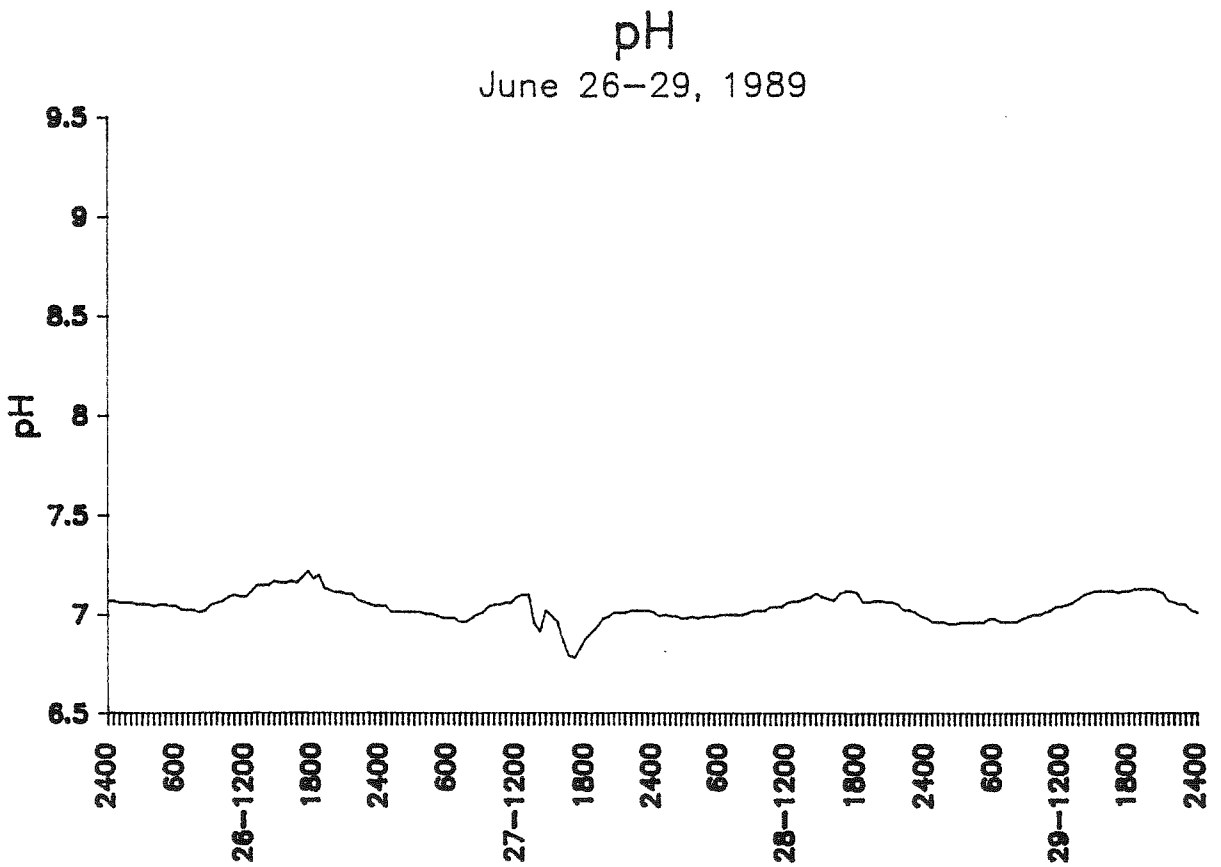


FIGURE 8 – DISCHARGE ON JUNE 26–29, 1989



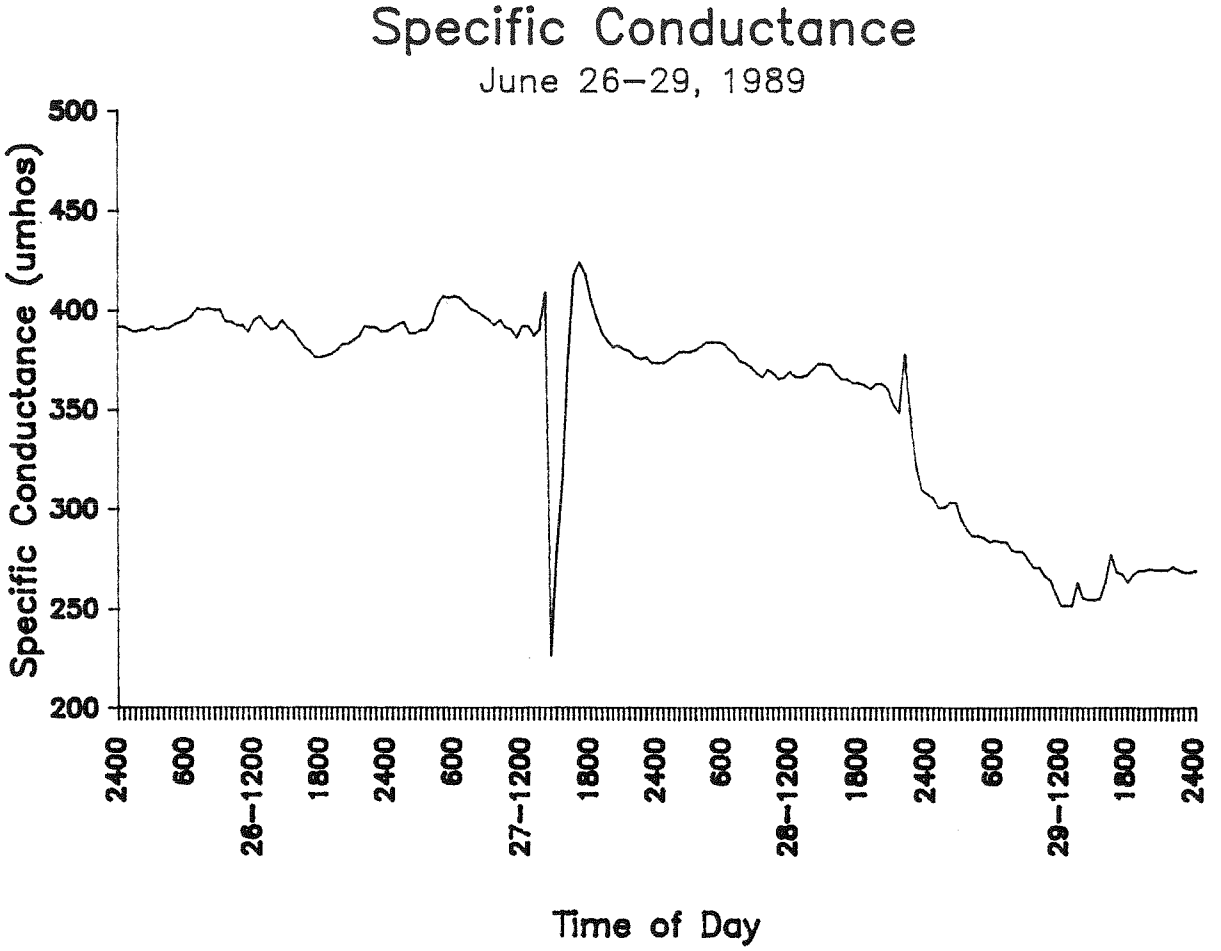
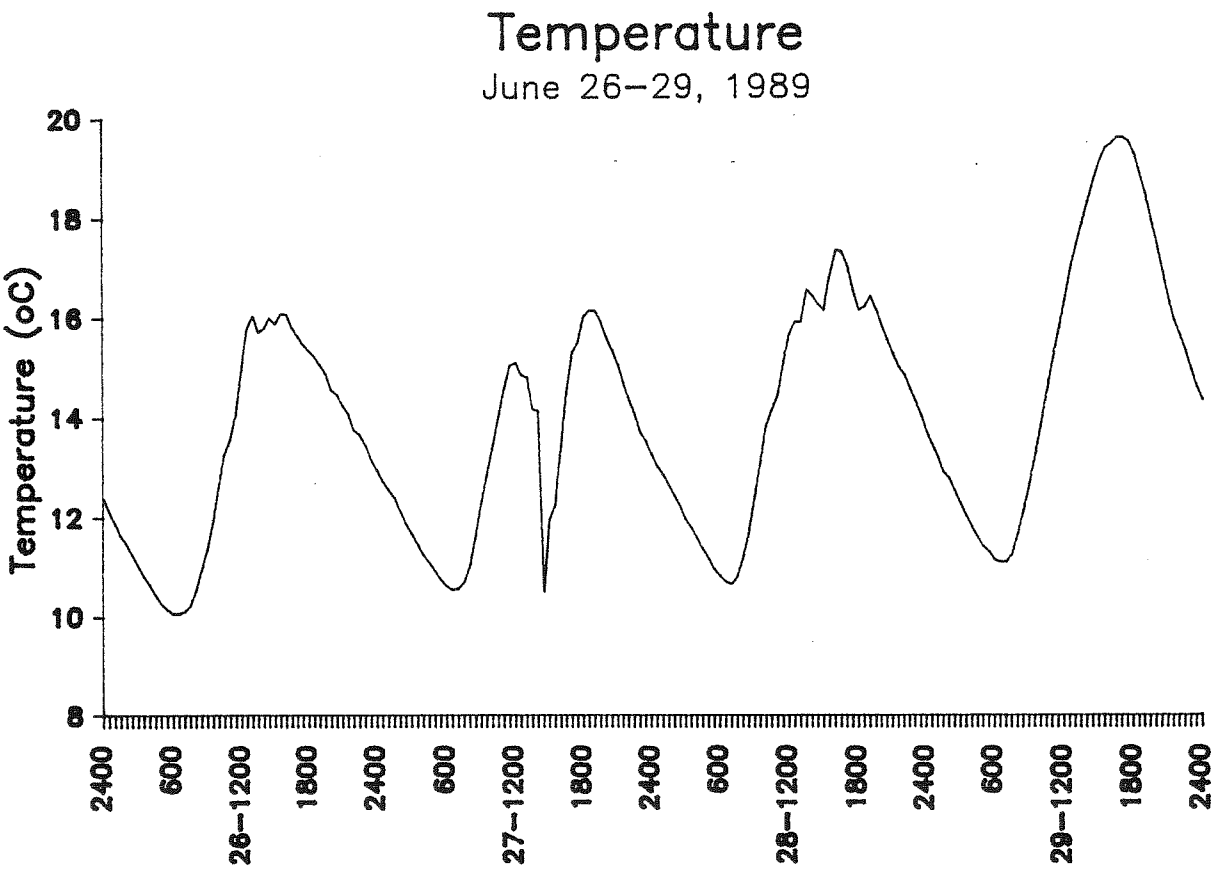


FIGURE 9 – SILVER BOW CREEK BELOW BLACKTAIL CREEK,



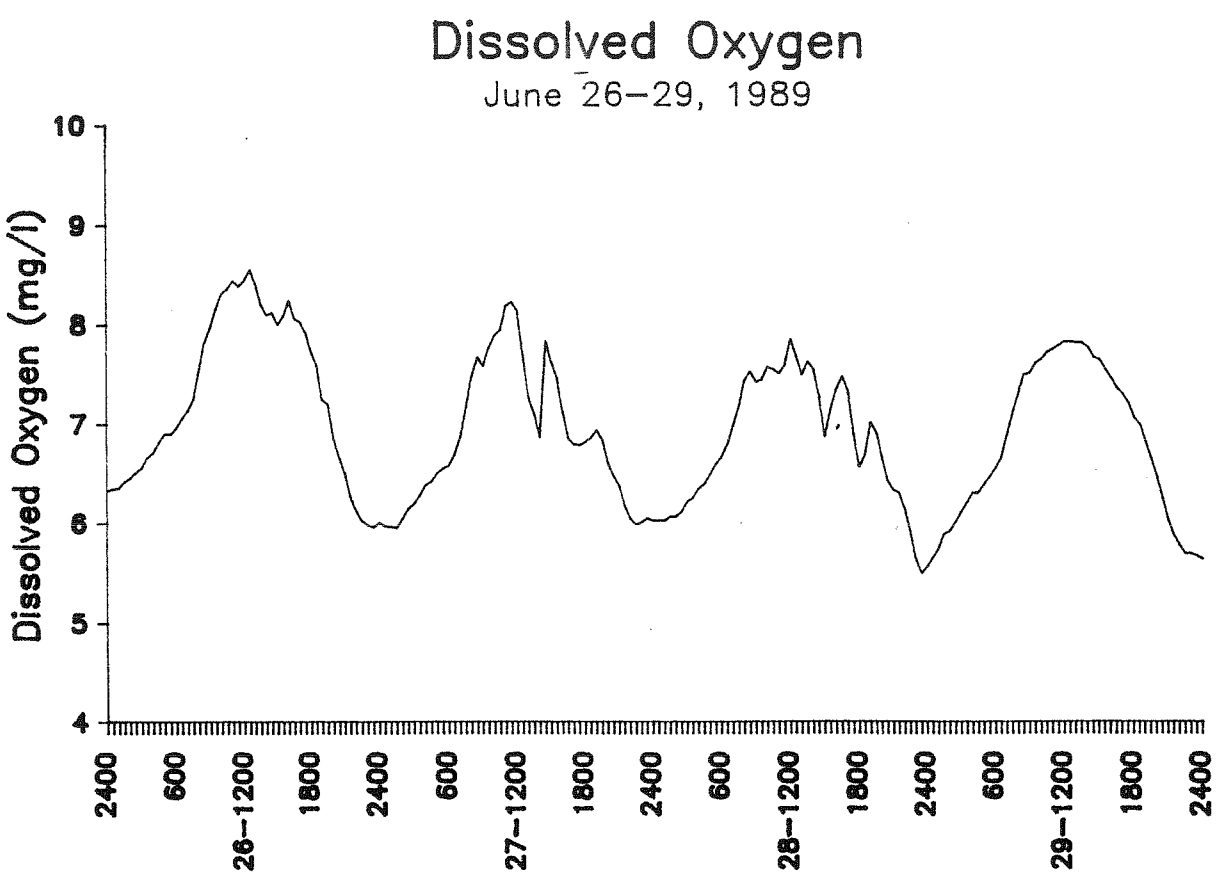


FIGURE 10 – SILVER BOW CREEK BELOW BLACKTAIL CREEK, (a) TEMPERATURE. (b) DISSOLVED OXYGEN

Silver Bow Creek at Opportunity, MT

Table 6 contains a complete record of the data available for this station. A typical late summer day is tabulated in Table 7, for August 20, 1988, but discharge data is for August 19, 1988 because of a stopped clock.

Table 6
Silver Bow Creek at Opportunity, MT
Monitoring Dates,
Intervals and File Names

Monitoring Dates	Recording Intervals (minutes)	File Name
08/12/88 to 08/17/88	15	S880817
08/19/88 to 08/25/88	15	S880825
09/01/88 to 09/07/88	15	S880907
09/08/88 to 09/15/88	18	S880915
09/15/88 to 09/22/88	20	S880922
09/22/88 to 09/29/88	20	S880929
09/29/88 to 10/06/88	20	S881006
10/06/88 to 10/13/88	20	S881013
10/13/88 to 10/20/88	20	S881020
03/13/89 to 03/27/89	60	S890327
04/14/89 to 04/25/89	30	S890425
04/25/89 to 05/04/89	30	S890504
05/04/89 to 05/16/89	30	S890516
05/16/89 to 05/25/89	30	S890525
05/25/89 to 06/06/89	30	S890606
06/06/89 to 06/20/89	30	S890620
06/20/89 to 07/05/89	30	S890705

Table 7
Silver Bow Creek at Opportunity, MT
on August 20, 1988

	Discharge* (cfs)	pH	Specific Conductance (umhos/cm @ 25° C)	Temperature (° C)	Dissolved Oxygen (mg/l)
Mean	17	9.3	437	15.3	10.3
Std. Dev.	2	0.7	29	2.9	2.7
Maximum	19	10.3	500	20.3	14.8
Minimum	14	8.1	380	11.3	7.1

*August 19, 1988

Discharge is presented in Figure 11 and the diurnal variation is probably a continued reflection of Metro Sewer's influence. Figure 12a shows a very strong pH diurnal and this combined with the dissolved oxygen variation shown in Figure 13b indicates an important photosynthesis impact. This is confirmed by dissolved oxygen saturation values which peaked at a very high value of 188 percent. Specific conductance (Figure 12b) also has a diurnal variation, but temperature (Figure 13a) has a much larger variation.

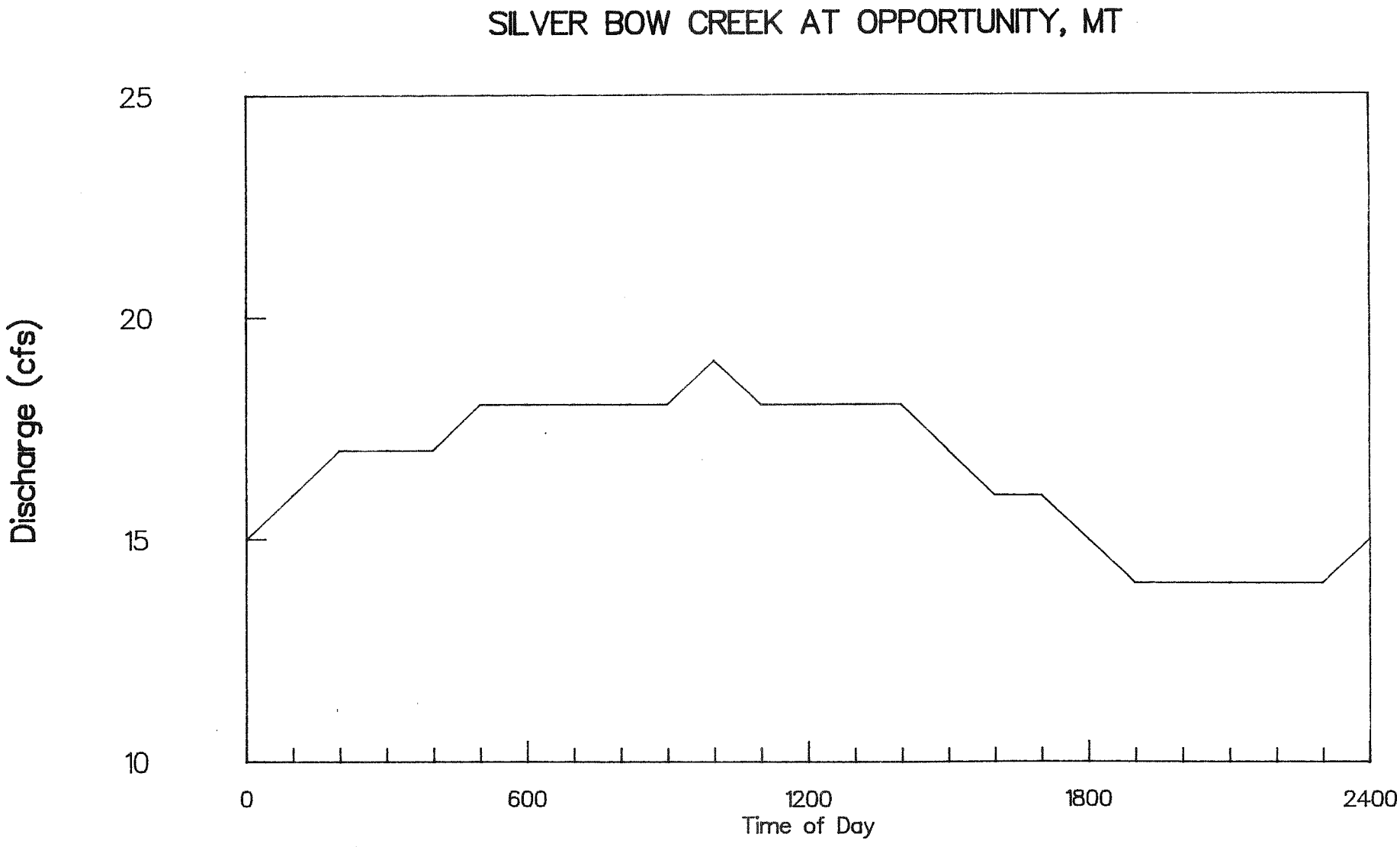
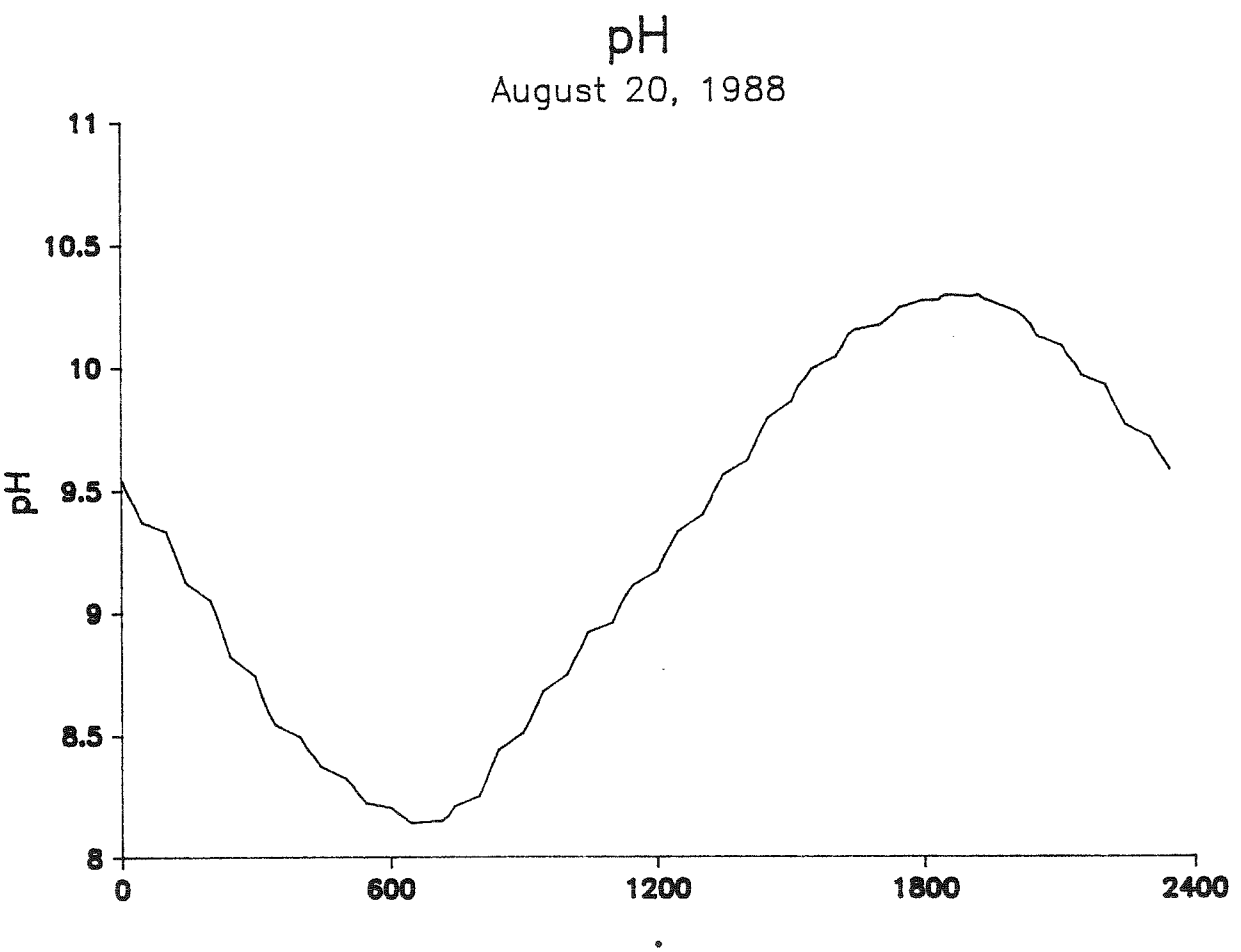


FIGURE 11 – DISCHARGE ON AUGUST 19, 1988



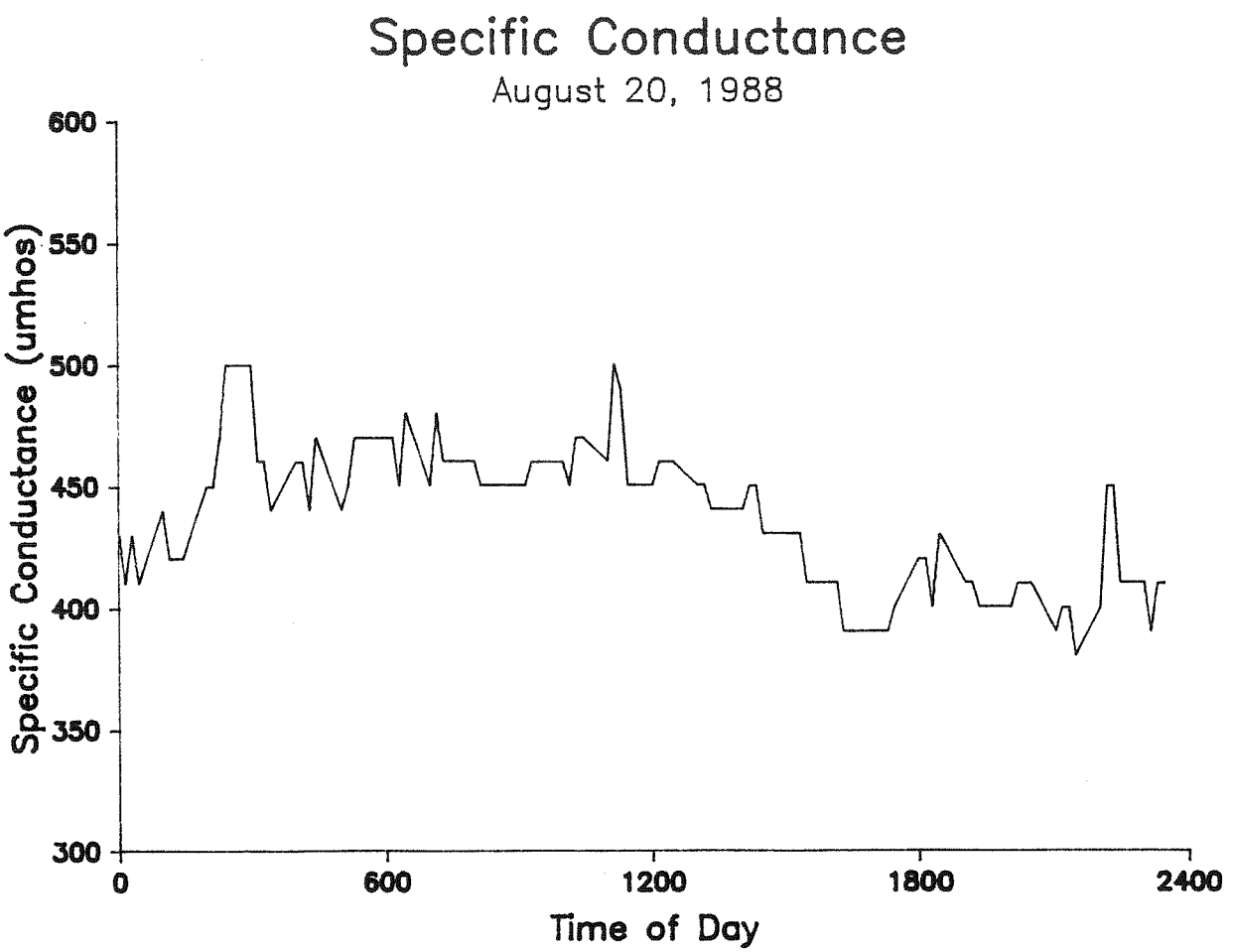
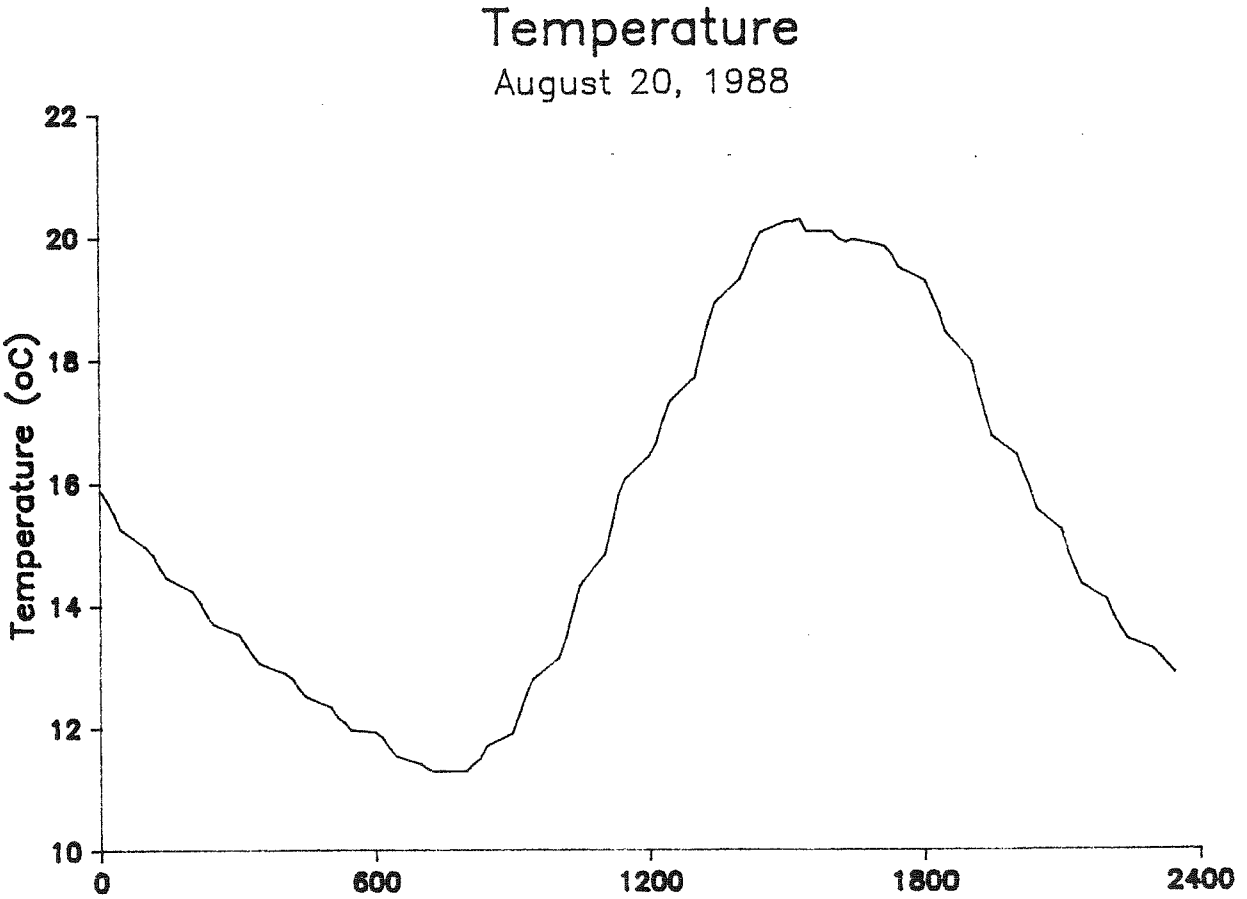


FIGURE 12 – SILVER BOW CREEK AT OPPORTUNITY, MT,
(a) pH (b) SPECIFIC CONDUCTANCE



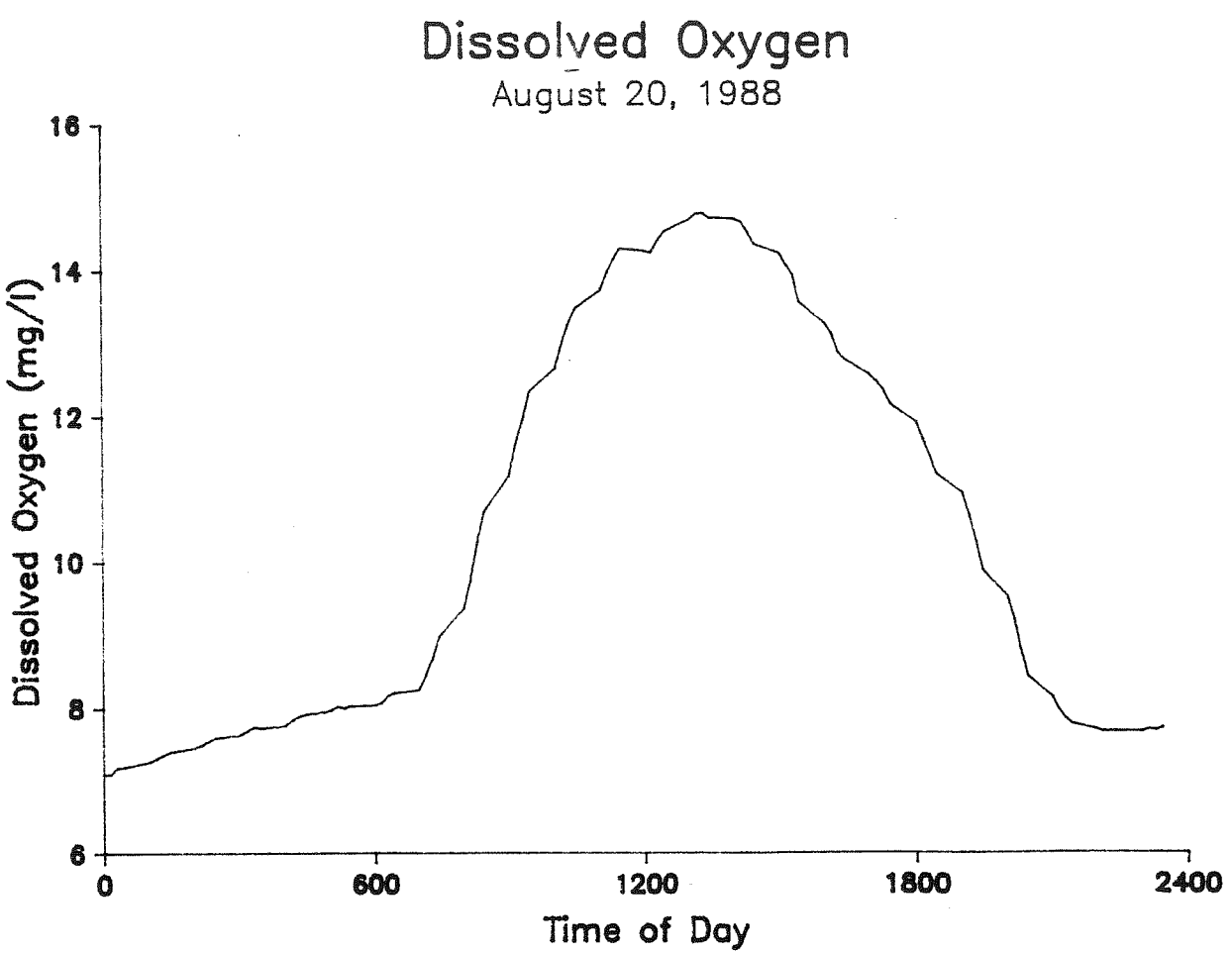


FIGURE 13 – SILVER BOW CREEK AT OPPORTUNITY, MT, (a) TEMPERATURE (b) DISSOLVED OXYGEN

May 1, 1989 is summarized in Table 8 and presented in Figures 14, 15a, 15b, 16a, and 16b which is representative of a typical spring day.

Table 8
Silver Bow Creek at Opportunity, MT
on May 1, 1989

	Discharge (cfs)	pH	Specific Conductance (umhos/cm @ 25° C)	Temperature (° C)	Dissolved Oxygen (mg/l)
Mean	72	8.0	317	9.2	10.3
Std. Dev.	5	0.2	7	2.6	0.8
Maximum	80	8.4	333	13.2	11.8
Minimum	67	7.8	302	5.0	9.2

Discharge (Figure 14) varied about ten percent above and below the mean. The pH (Figure 15a), temperature (Figure 16a) and dissolved oxygen (Figure 16b) all showed a strong, repeatable, diurnal variation. Specific conductance (Figure 15b) was very steady at about 320 umhos/cm.

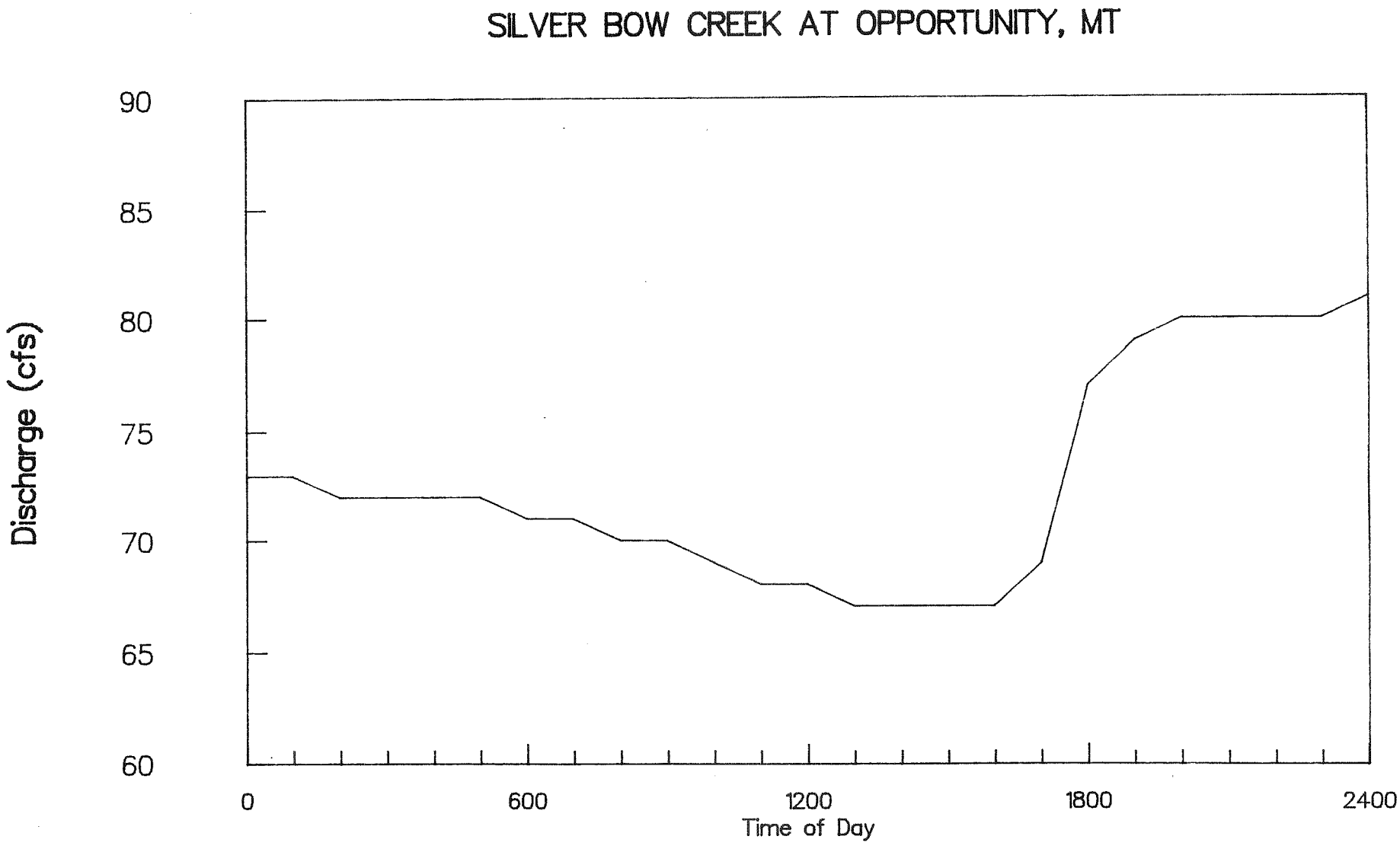
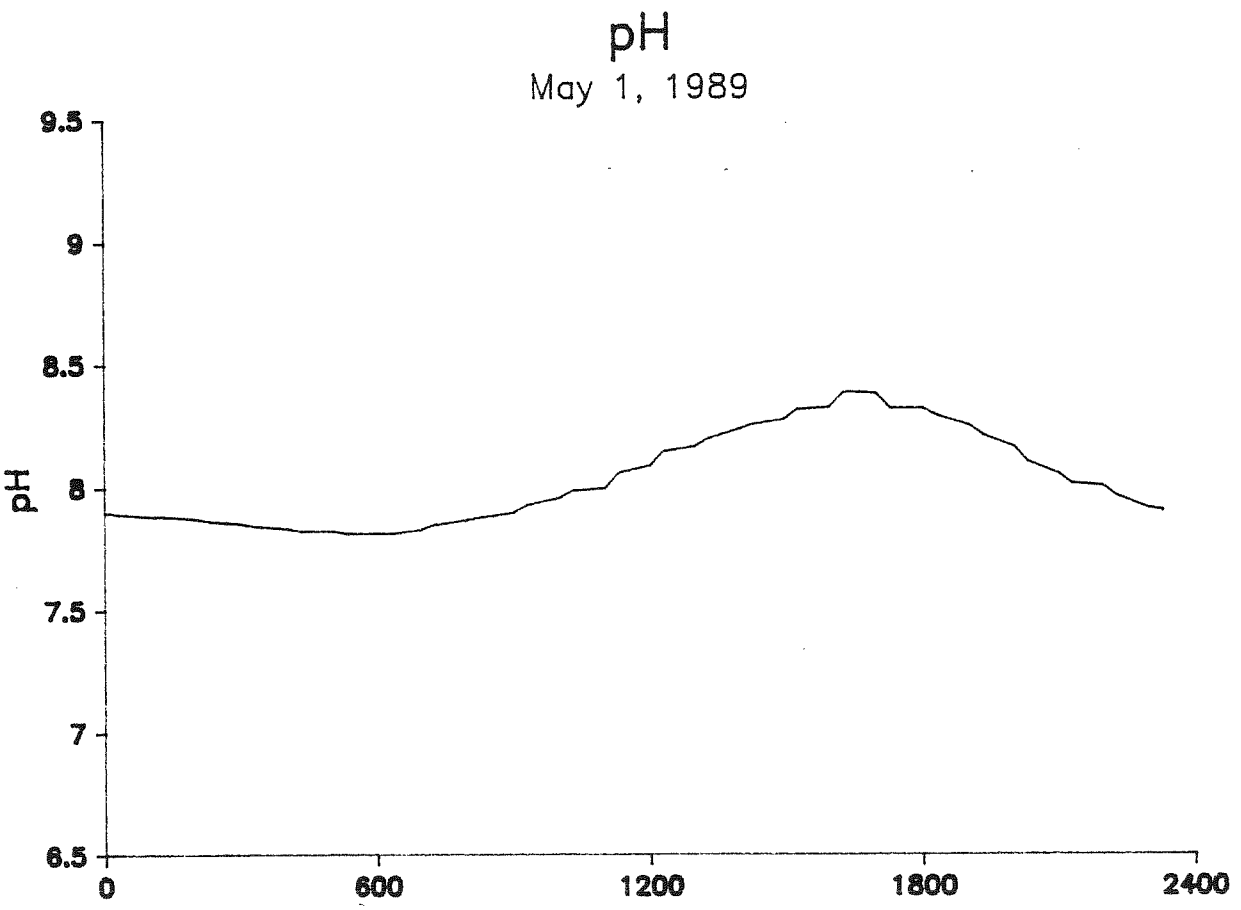


FIGURE 14 – DISCHARGE ON MAY 01, 1989



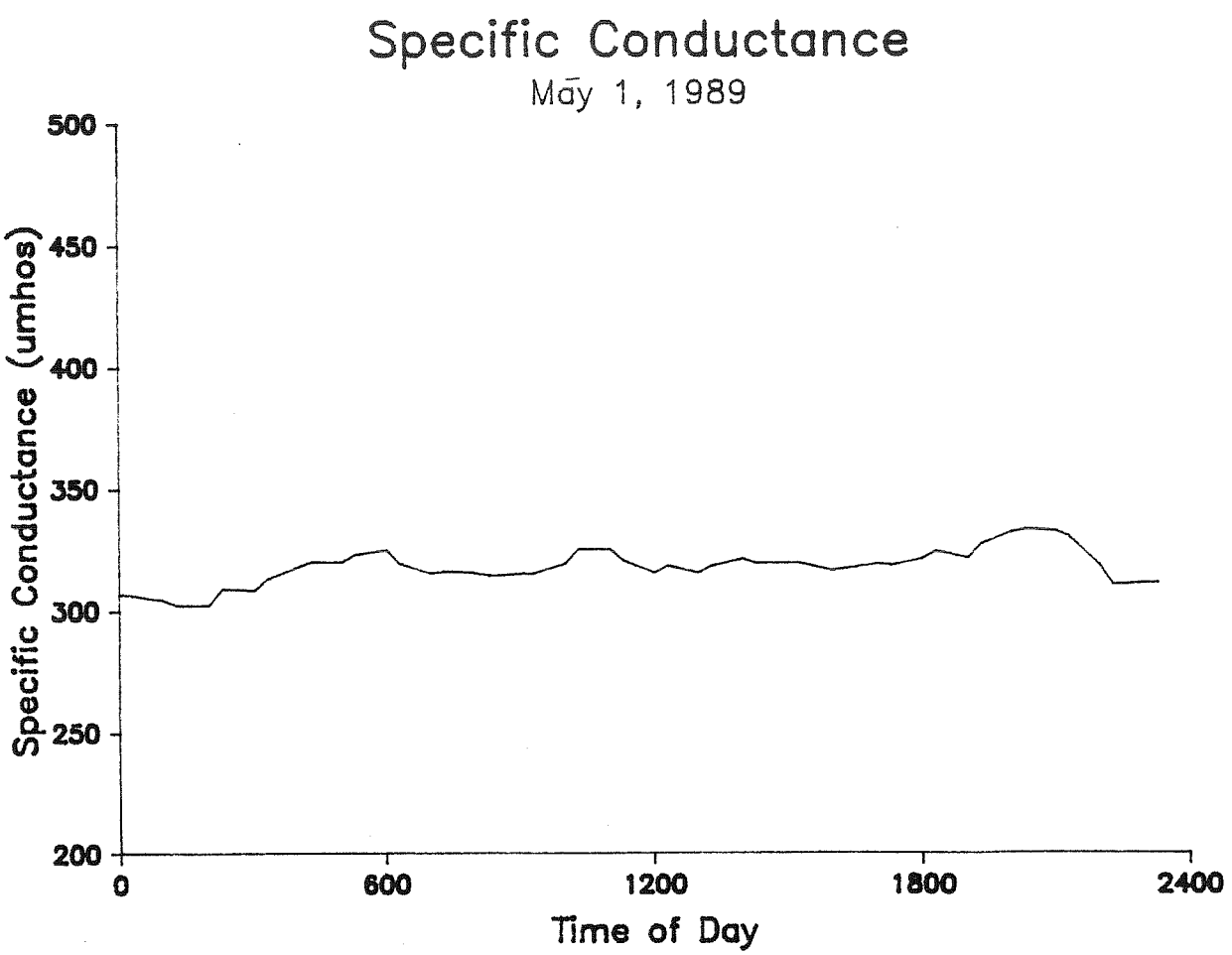
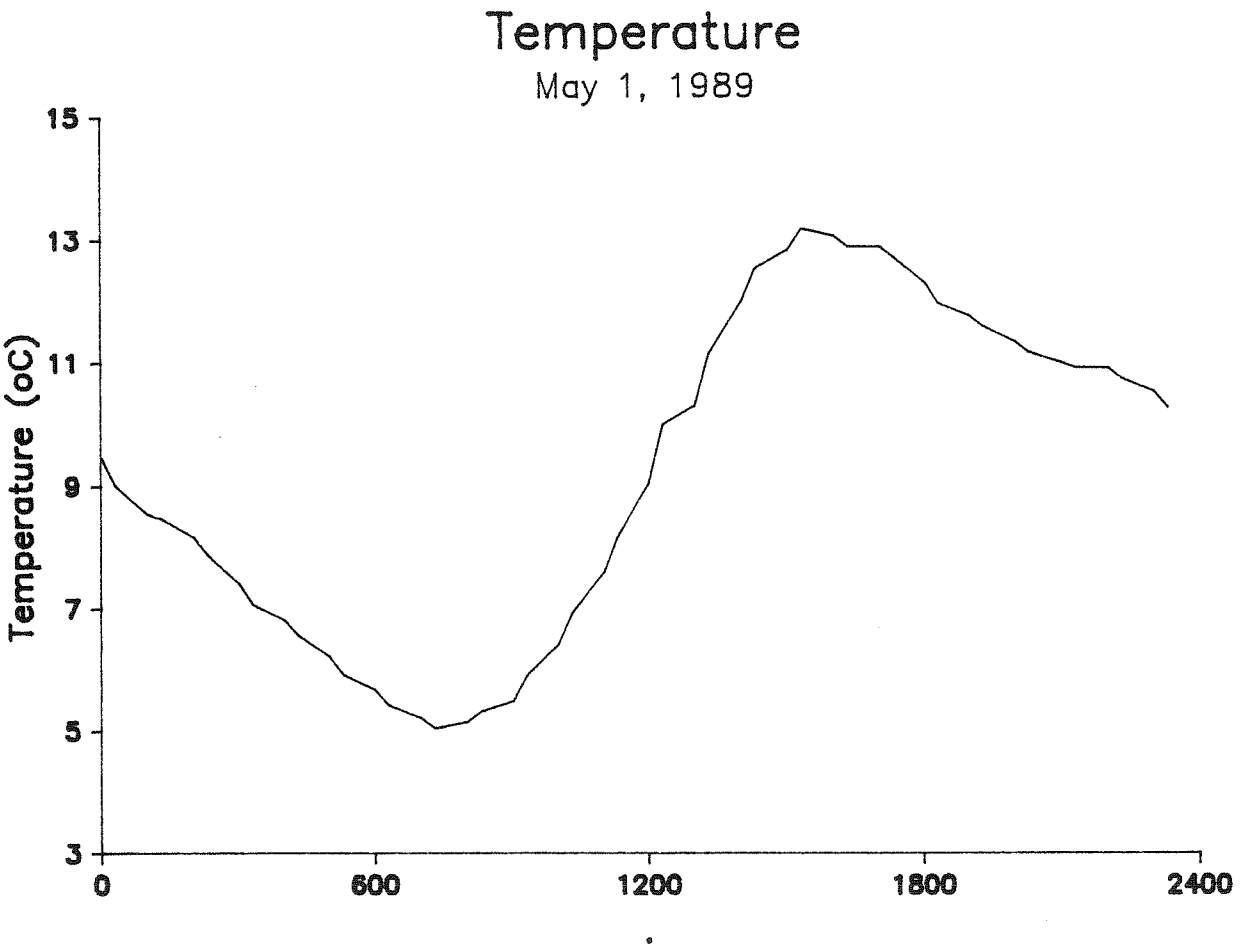


FIGURE 15 – SILVER BOW CREEK AT OPPORTUNITY, MT,
(a) pH, (b) SPECIFIC CONDUCTANCE



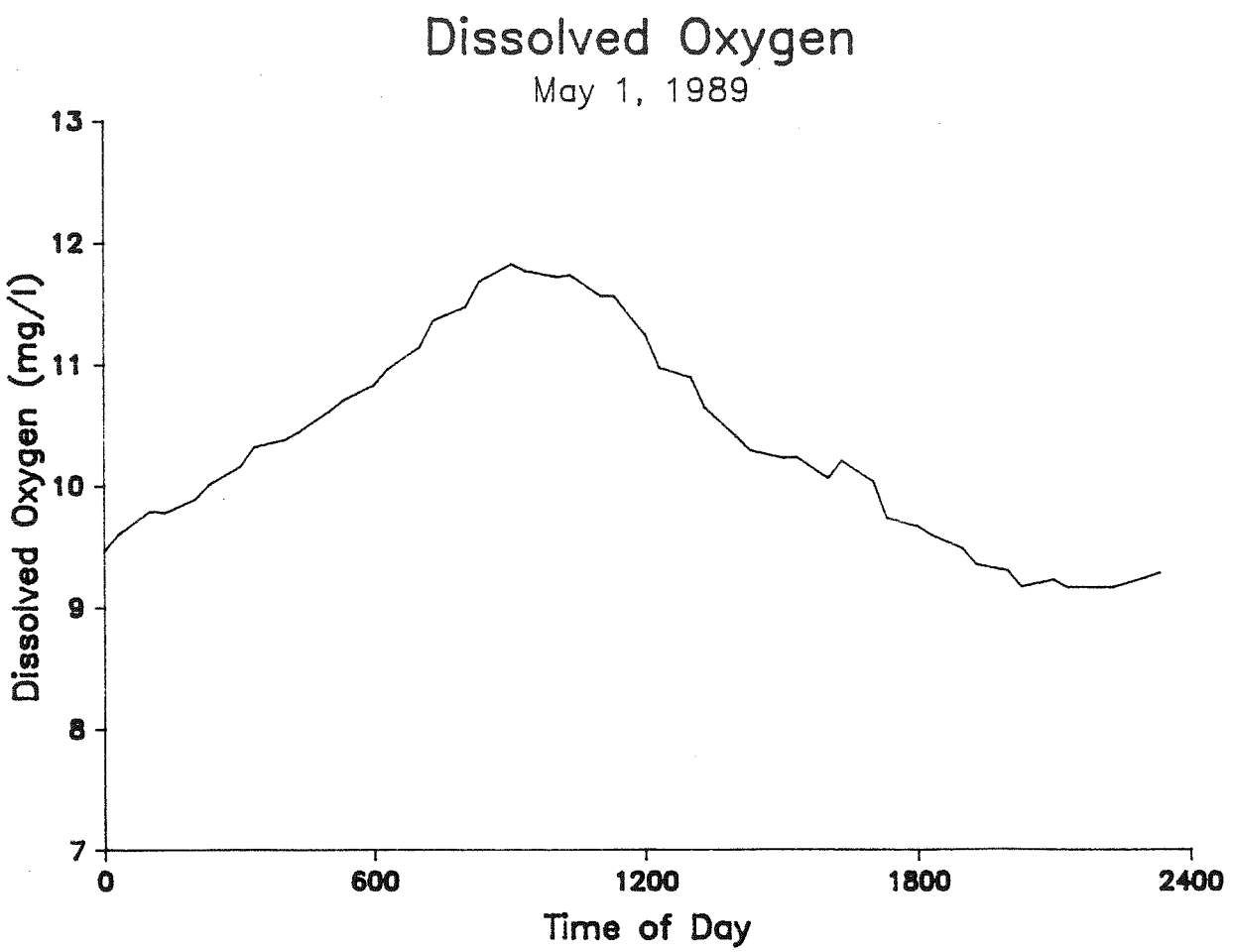


FIGURE 16 – SILVER BOW CREEK AT OPPORTUNITY, MT,
(a) TEMPERATURE (b) DISSOLVED OXYGEN

The impact of the storm of June 27, 1989 (0.03 inches, NOAA, 1989) is presented in Figures 17, 18a, 18b, 19a, and 19b. Discharge is given in Figure 17 where the diurnal cycle was briefly interrupted by the storm runoff. The pH (Figure 18a) had a very strong diurnal cycle and storm runoff depressed the pH up to 0.5 units. Typically pH was near 7.5 at 0200 hours except during the storm when pH fell to 7.0. Lower pH values and higher specific conductance values correlated daily and during the storm. The minimum pH of 7.0 and the maximum specific conductance of 502 umhos/cm occurred nearly simultaneously and lagged the peak discharge by two hours. Temperature and dissolved oxygen are presented in Figure 19a and 19b, respectively, where they appear to have been impacted more by stormy weather (lack of sun energy) than the storm discharge.

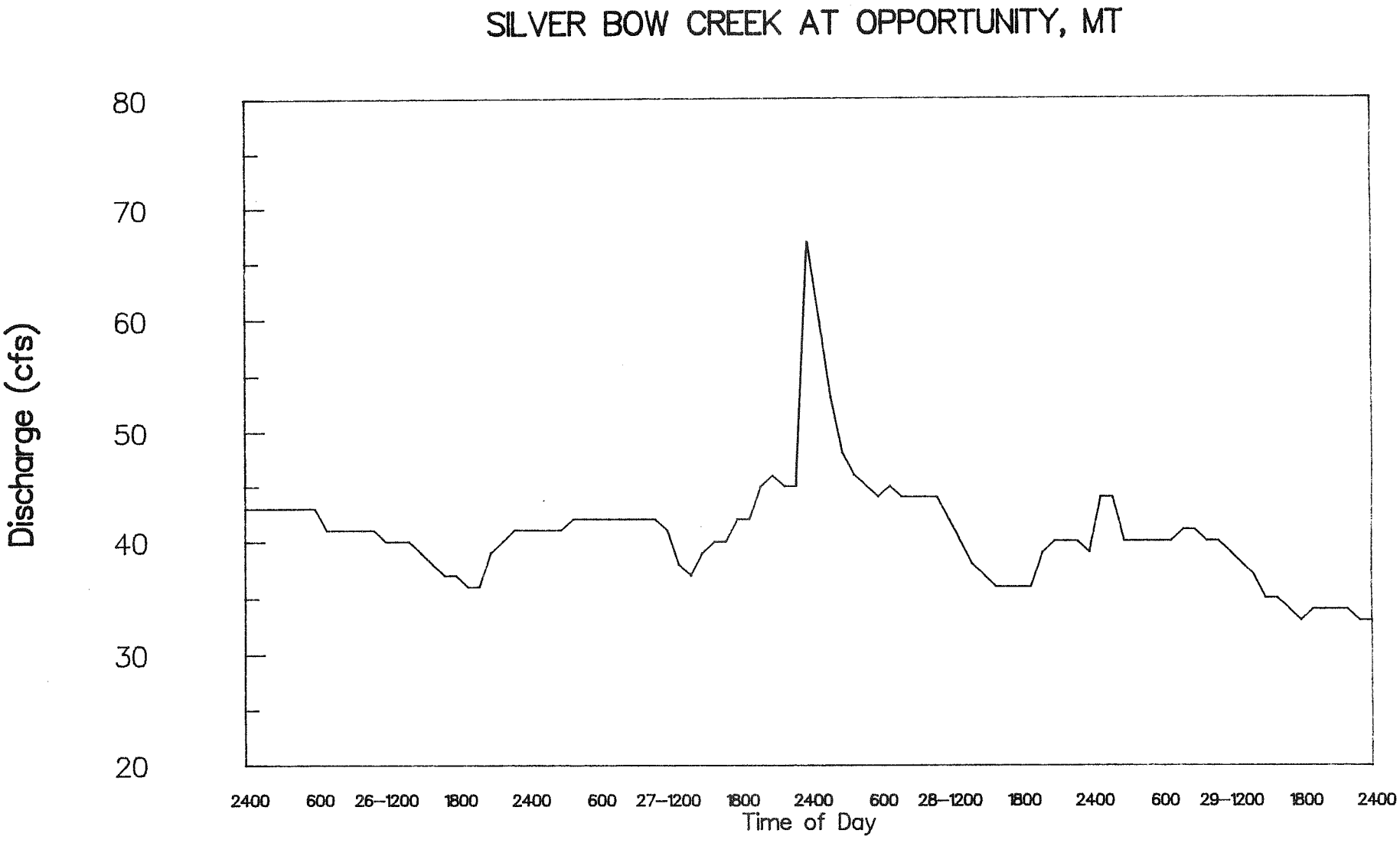
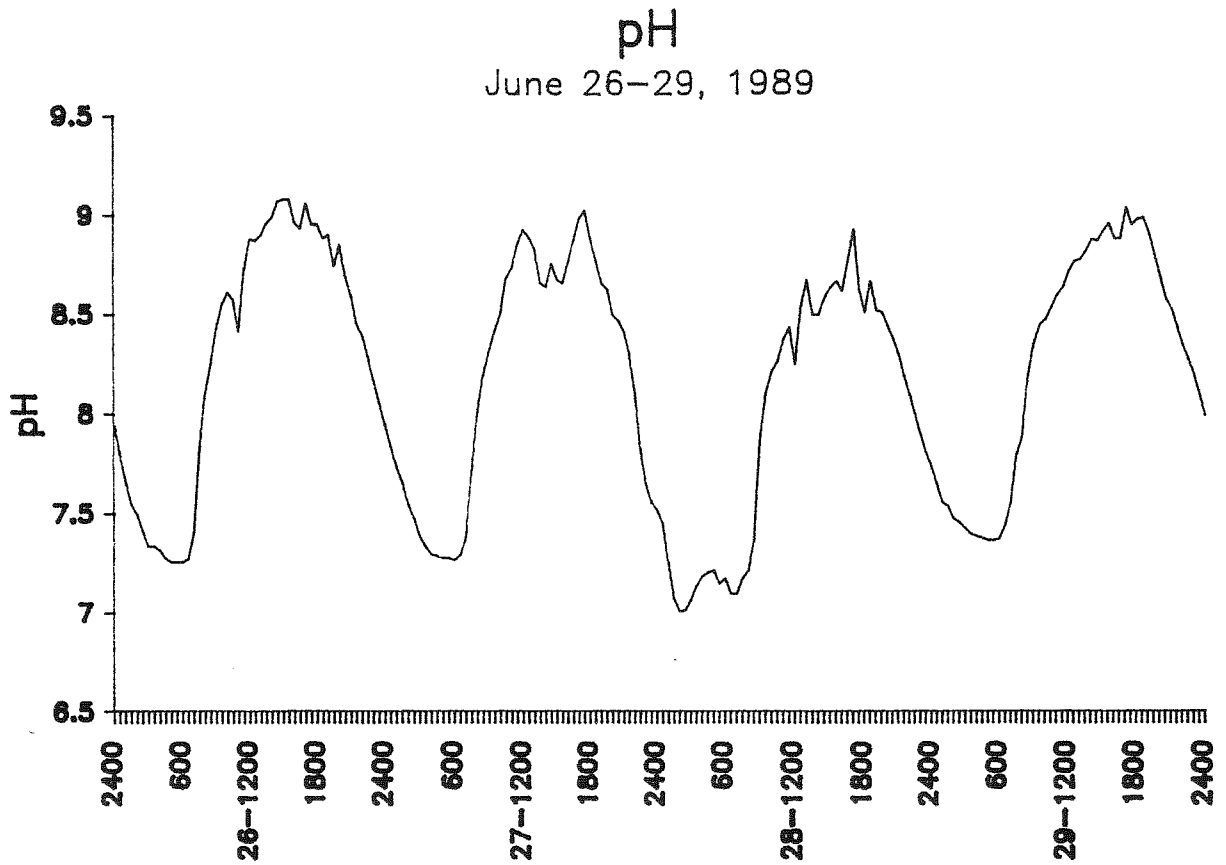


FIGURE 17 – DISCHARGE ON JUNE 26–29, 1989



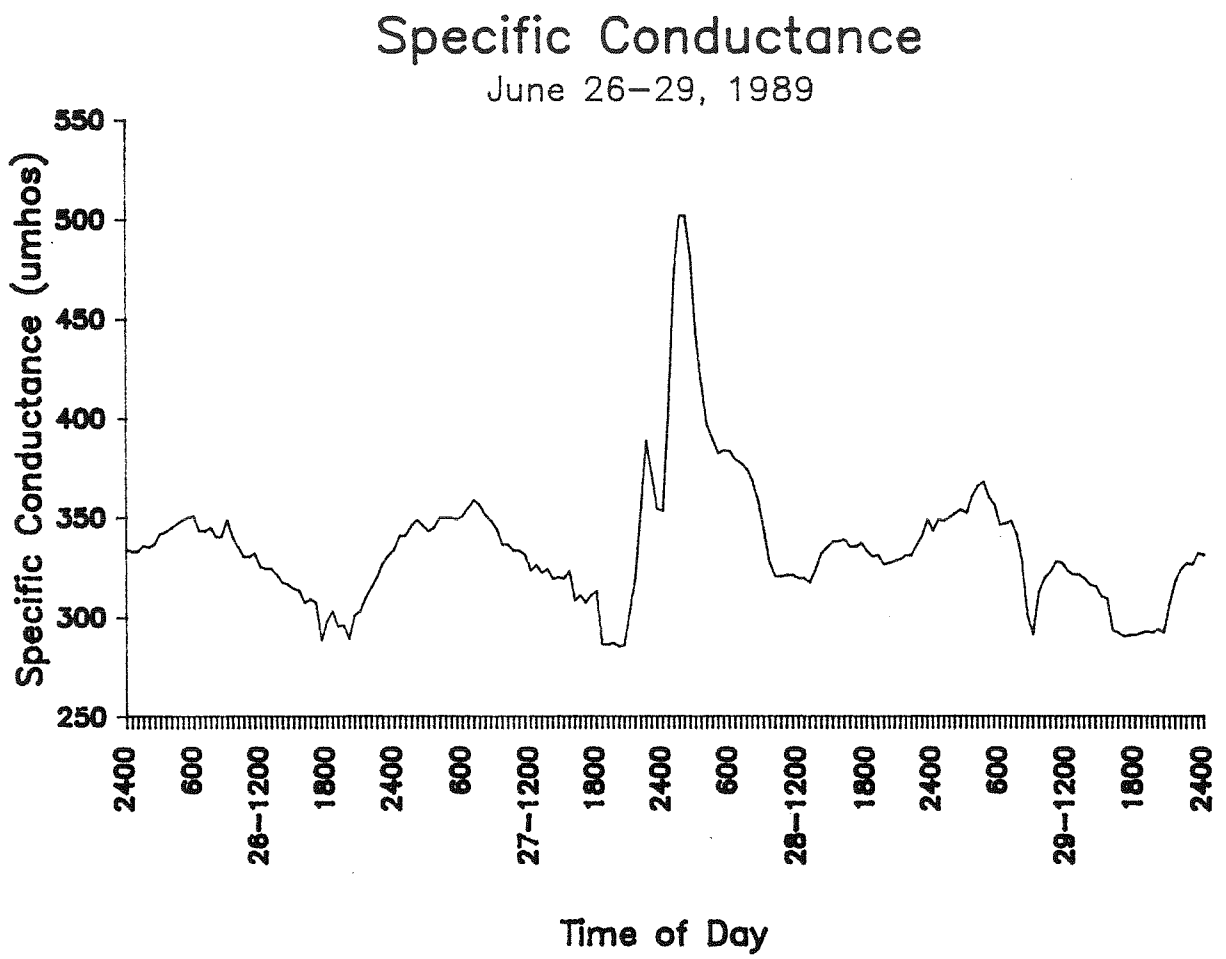
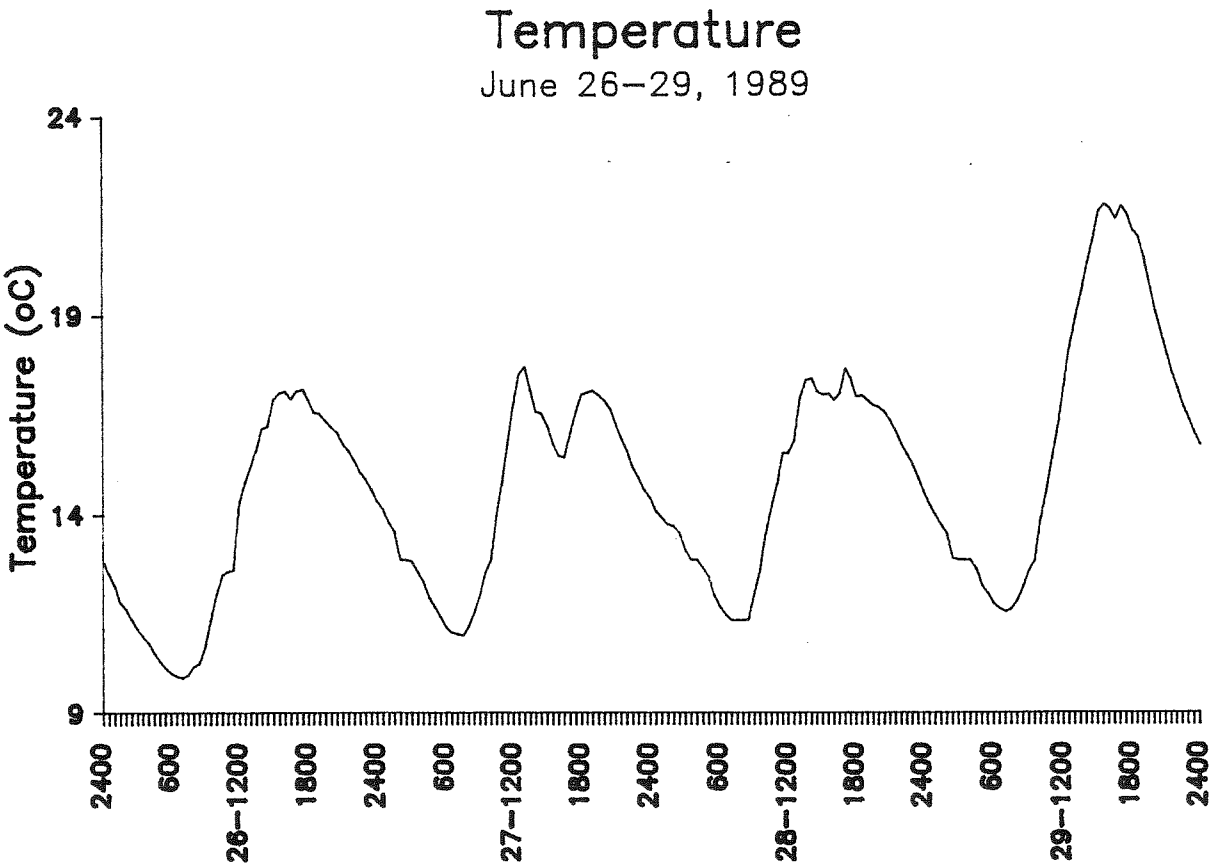


FIGURE 18 – SILVER BOW CREEK AT OPPORTUNITY, MT,



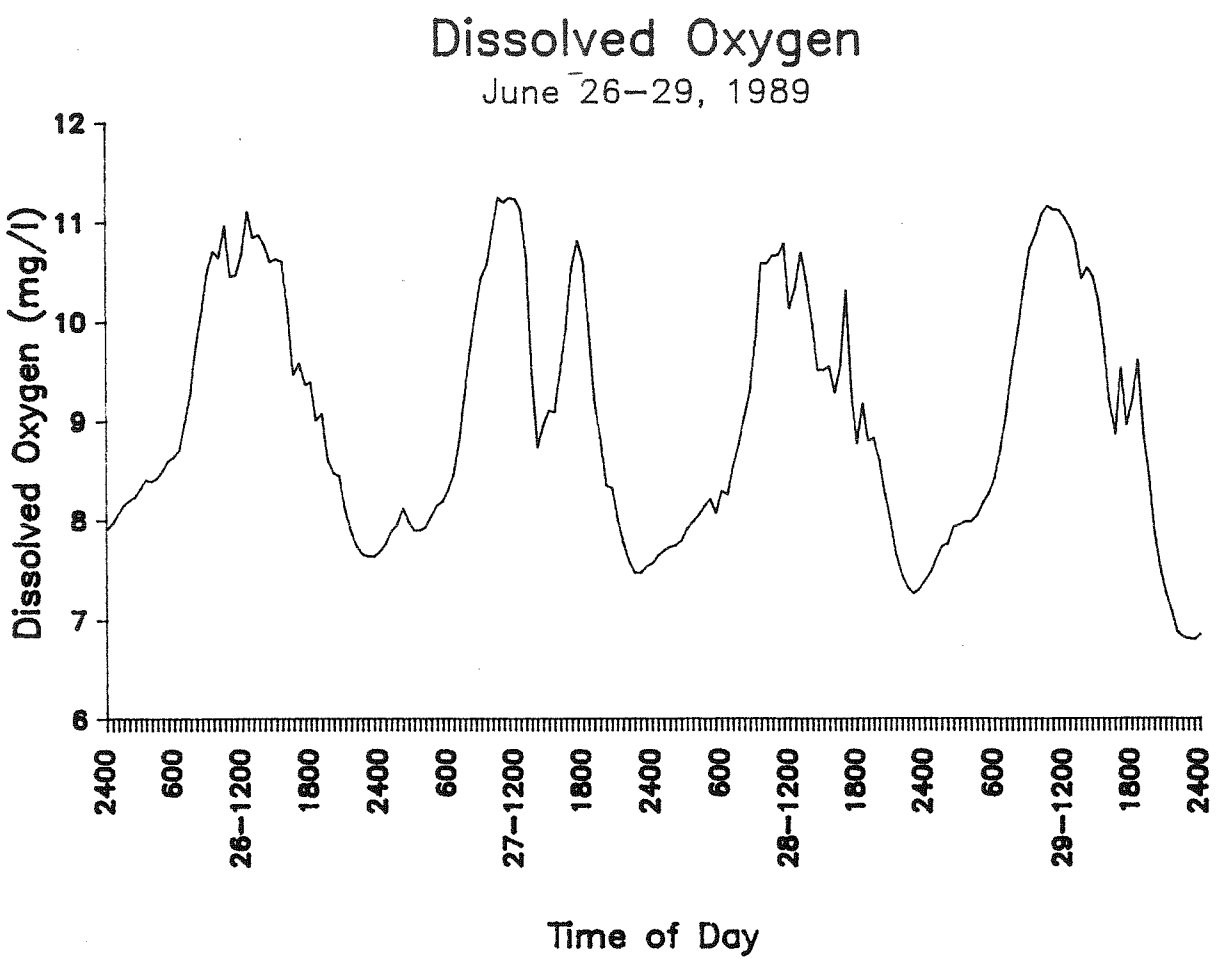


FIGURE 19 – SILVER BOW CREEK AT OPPORTUNITY, MT,

Warm Springs Creek at Warm Springs, MT

Table 9 contains a listing of the data files available for this monitoring station. Three sets of data were selected to represent typical base-flow periods (fall and spring) and a storm event. This station does not contain as complete a data set for 1988 due to the low water conditions at this site where the depth of water was not sufficient to submerge the data sondes until early October.

Table 9
Warm Springs Creek at Warm Springs, MT
Monitoring Dates,
Intervals and File Names

Monitoring Dates	Recording Intervals (minutes)	File Name
10/07/88 to 10/13/88	20	W881013
10/13/88 to 10/20/88	20	W881020
10/20/88 to 10/27/88	20	W881027
10/27/88 to 11/03/88	20	W881103
04/27/89 to 05/05/89	30	W890505
05/05/89 to 05/17/89	30	W890517
05/17/89 to 05/26/89	30	W890526
05/26/89 to 06/08/89	30	W890608
06/08/89 to 06/11/89	30	W890611

October 8, 1988 was chosen as representative of Warm Springs Creek during base flow in the late summer or fall and general statistics are tabulated in Table 10.

Table 10
Warm Springs Creek at Warm Springs, MT
on October 8, 1988

	Discharge (cfs)	pH	Specific Conductance (umhos/cm @ 25° C)	Temperature (° C)	Dissolved Oxygen (mg/l)
Mean	5.2	7.9	1301	9.9	7.1
Std. Dev.	0.2	0.1	7	1.4	0.7
Maximum	5.4	8.1	1315	12.1	8.2
Minimum	5.0	7.8	1284	7.7	6.2

The data for this day are graphically presented in Figures 20, 21a, 21b, 22a, and 22b. Discharge (Figure 20) and the specific conductance (Figure 21b), were basically stable during the twenty-four hour period. The pH (Figure 21a) and dissolved oxygen (Figure 22b) followed typical photosynthesis patterns with both rising and falling in near unison. Dissolved oxygen saturation values ranged from 67 to 88 percent. Temperature (Figure 22a) was a well behaved diurnal cycle with a peak to peak change of over four degrees centigrade.

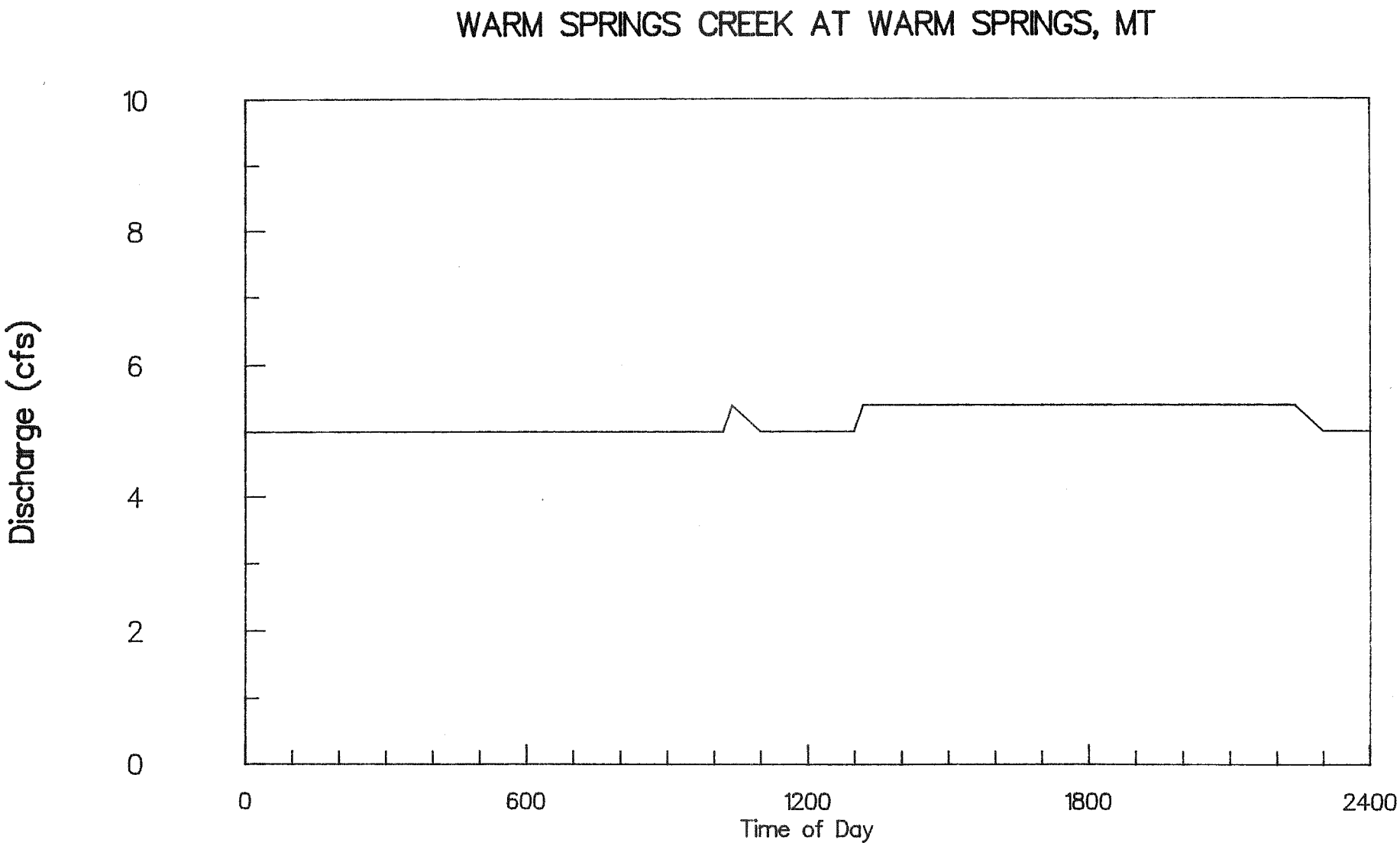
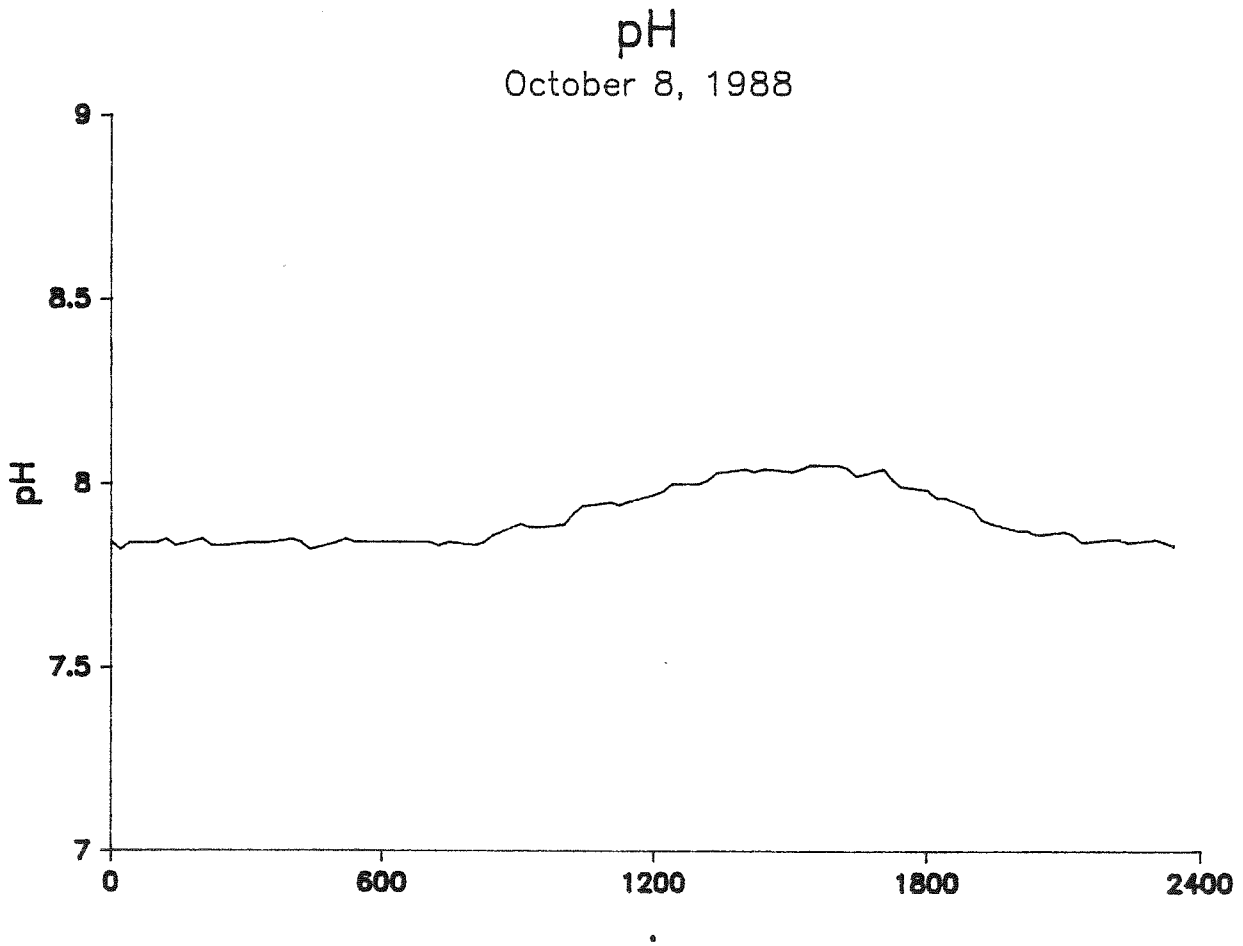


FIGURE 20 – DISCHARGE ON OCTOBER 08, 1988



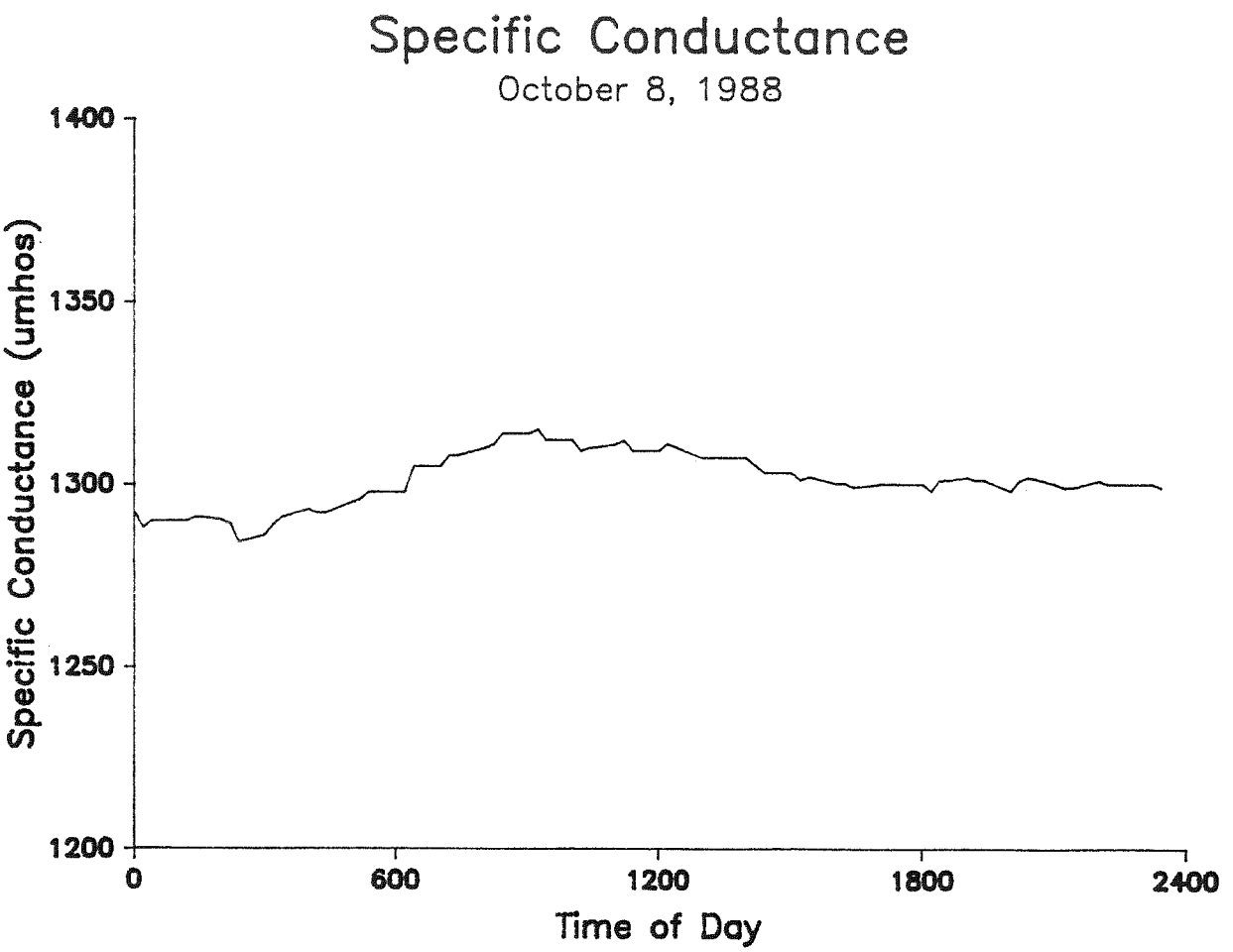


FIGURE 21 – WARM SPRINGS CREEK AT WARM SPRINGS, MT

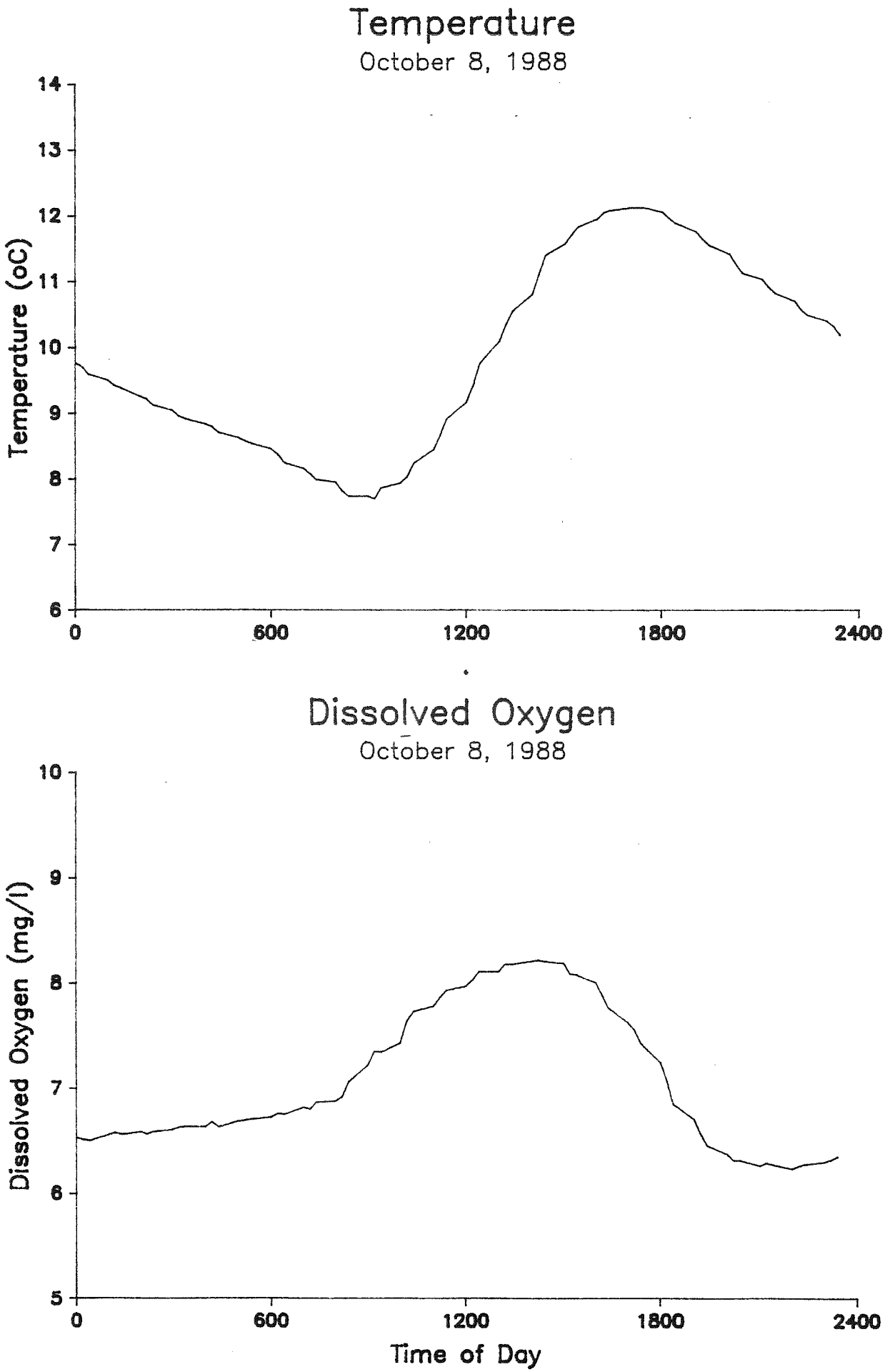


FIGURE 22 – WARM SPRINGS CREEK AT WARM SPRINGS, MT

A typical spring day was represented by May 1, 1989 and this day is tabulated in Table 11. The discharge data are presented in Figure 23 and daily variation was near ten percent. The pH (Figure 24a) had a large diurnal variation at 0.6 pH units.

Table 11
Warm Springs Creek at Warm Springs, MT
on May 1, 1989

	Discharge (cfs)	pH	Specific Conductance (umhos/cm @ 25° C)	Temperature (° C)	Dissolved Oxygen (mg/l)
Mean	45	8.2	429	9.2	10.4
Std. Dev.	1.2	0.2	13	2.0	1.2
Maximum	46	8.5	458	12.0	12.2
Minimum	41	7.9	414	5.8	8.8

Most if not all of this variation can be explained by photosynthesis. Dissolved oxygen (Figure 25b) peaks early in the day at a low temperature (Figure 25a) indicating a solubility control in the morning and photosynthesis dominance in the afternoon. This hypothesis may be substantiated by the saturation values of near 92 percent in the morning and 127 percent in the afternoon. Specific conductance (Figure 24b) had a midday low, but little daily variation.

A small storm impacted the Warm Springs Creek watershed on June 5, 1989 and the storm period is presented in Figures 26, 27a, 27b, 28a, and 28b Discharge, pH, temperature and dissolved oxygen all showed steady diurnal variations. Discharge (Figure 26) was slowly increasing while specific conductance (Figure 27b) and pH (Figure 27a) were characteristically decreasing. Figures 28a and 28b show temperature and dissolved oxygen, respectively, and no major variation was evident.

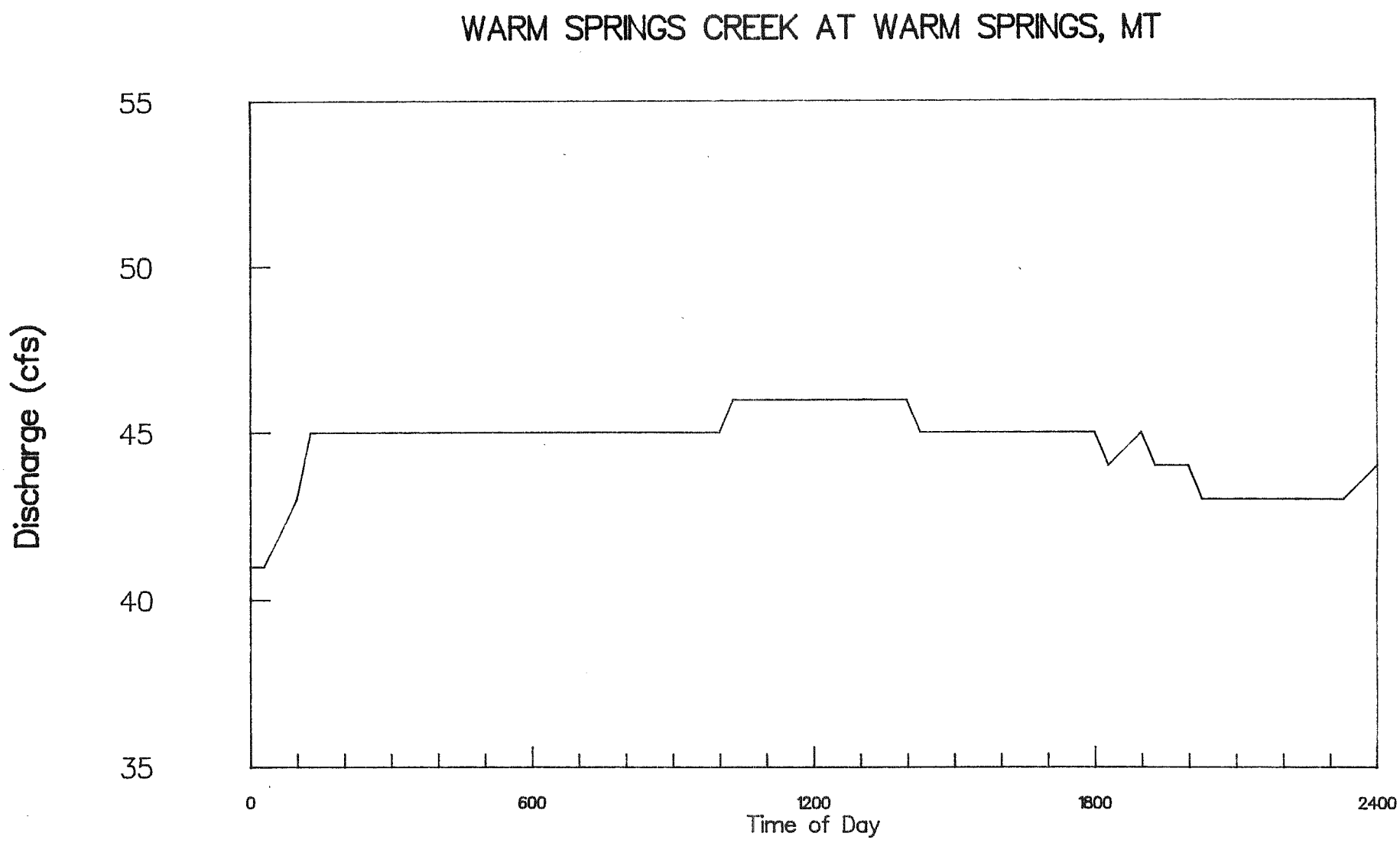
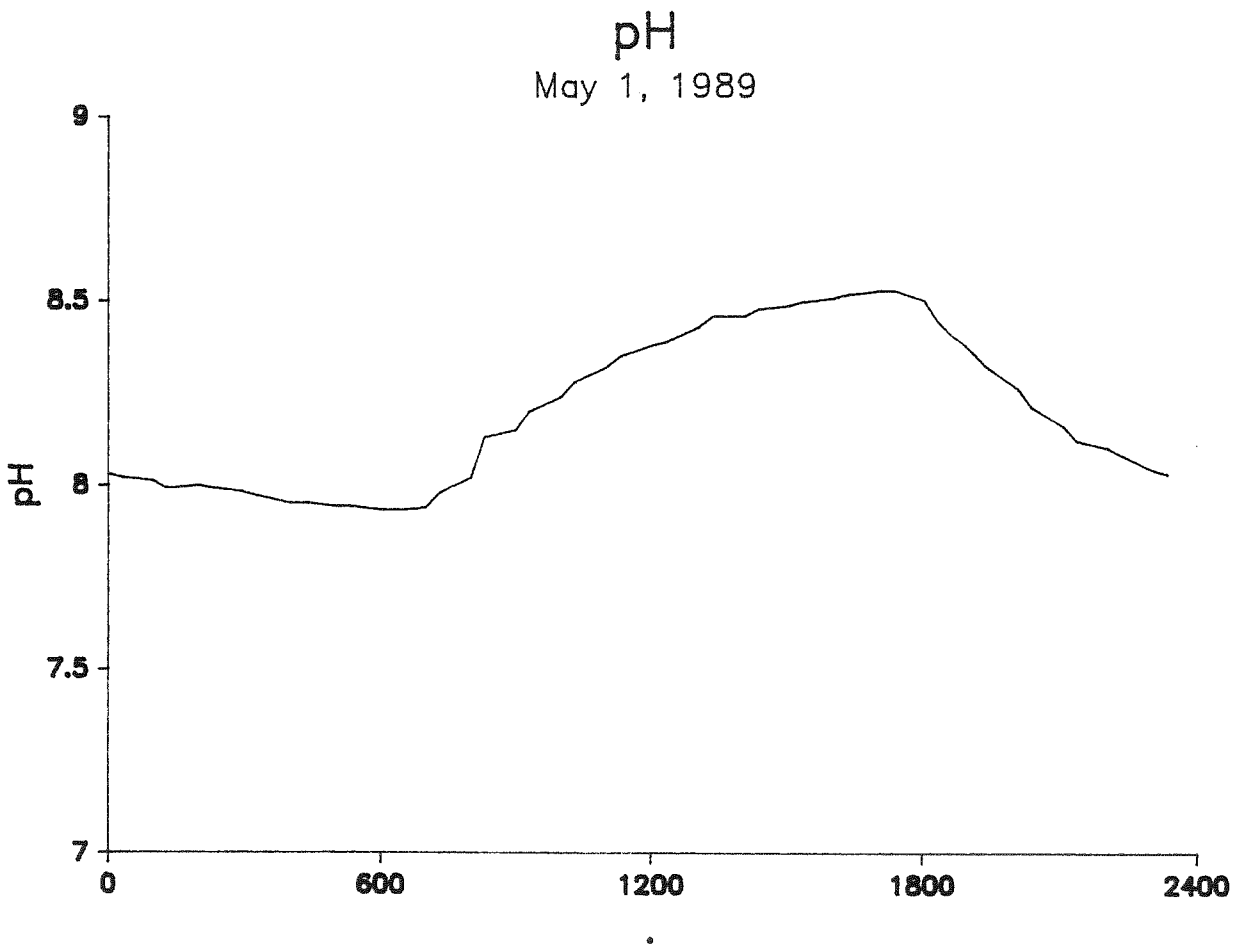


FIGURE 23 – DISCHARGE ON MAY 01, 1989



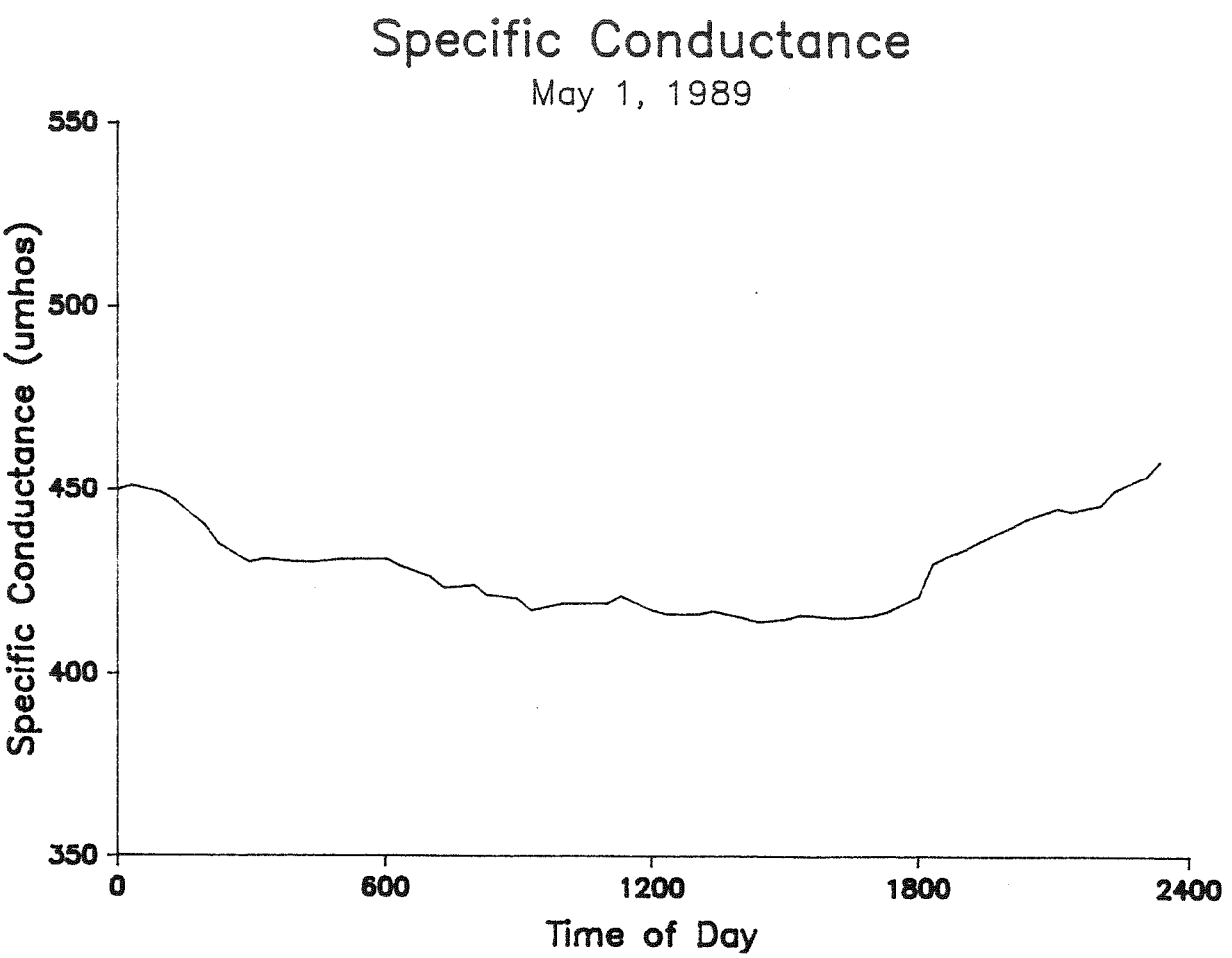


FIGURE 24 – WARM SPRINGS CREEK AT WARM SPRINGS, MT
(a) pH (b) SPECIFIC CONDUCTANCE

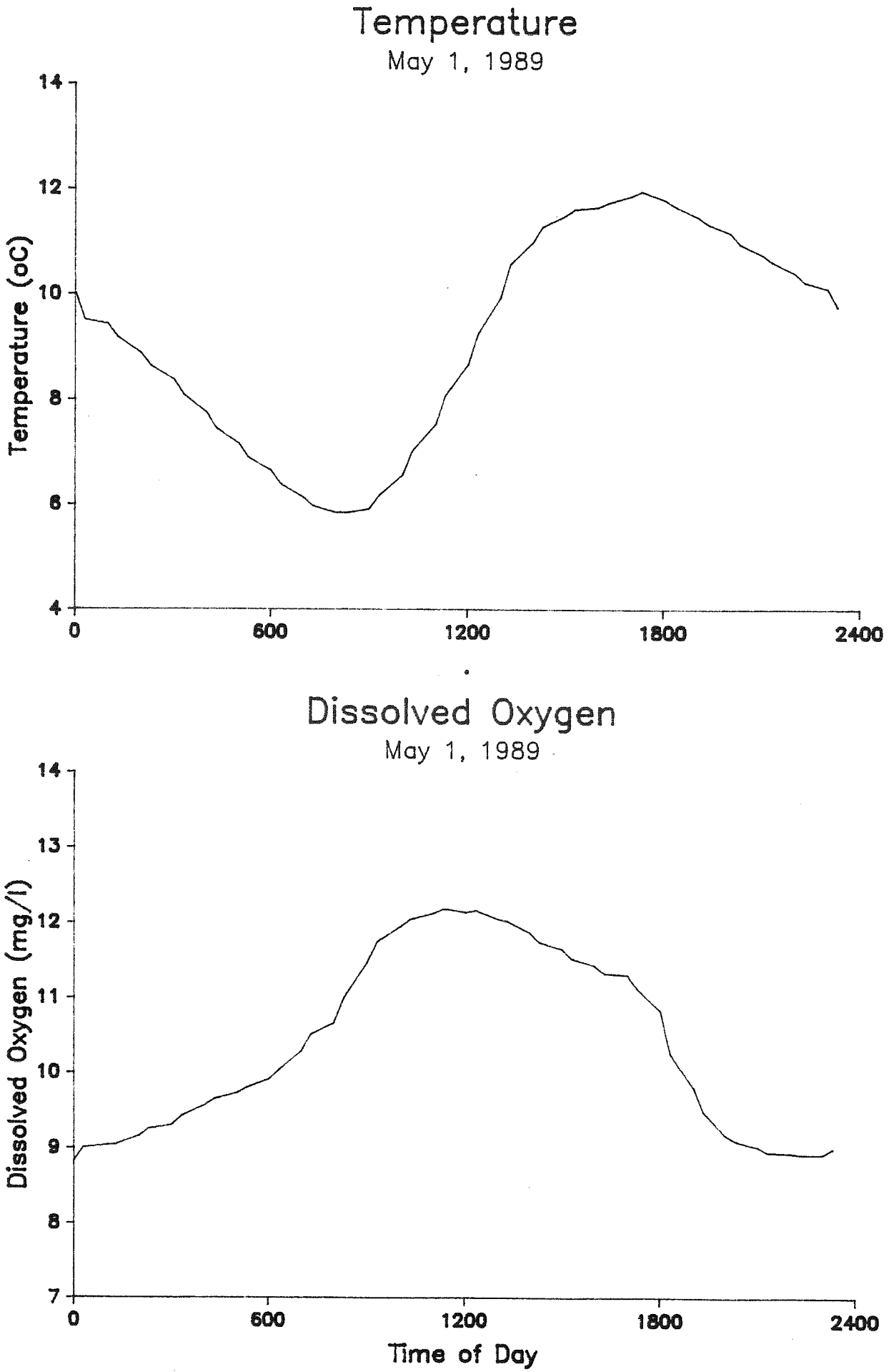


FIGURE 25 – WARM SPRINGS CREEK AT WARM SPRINGS, MT

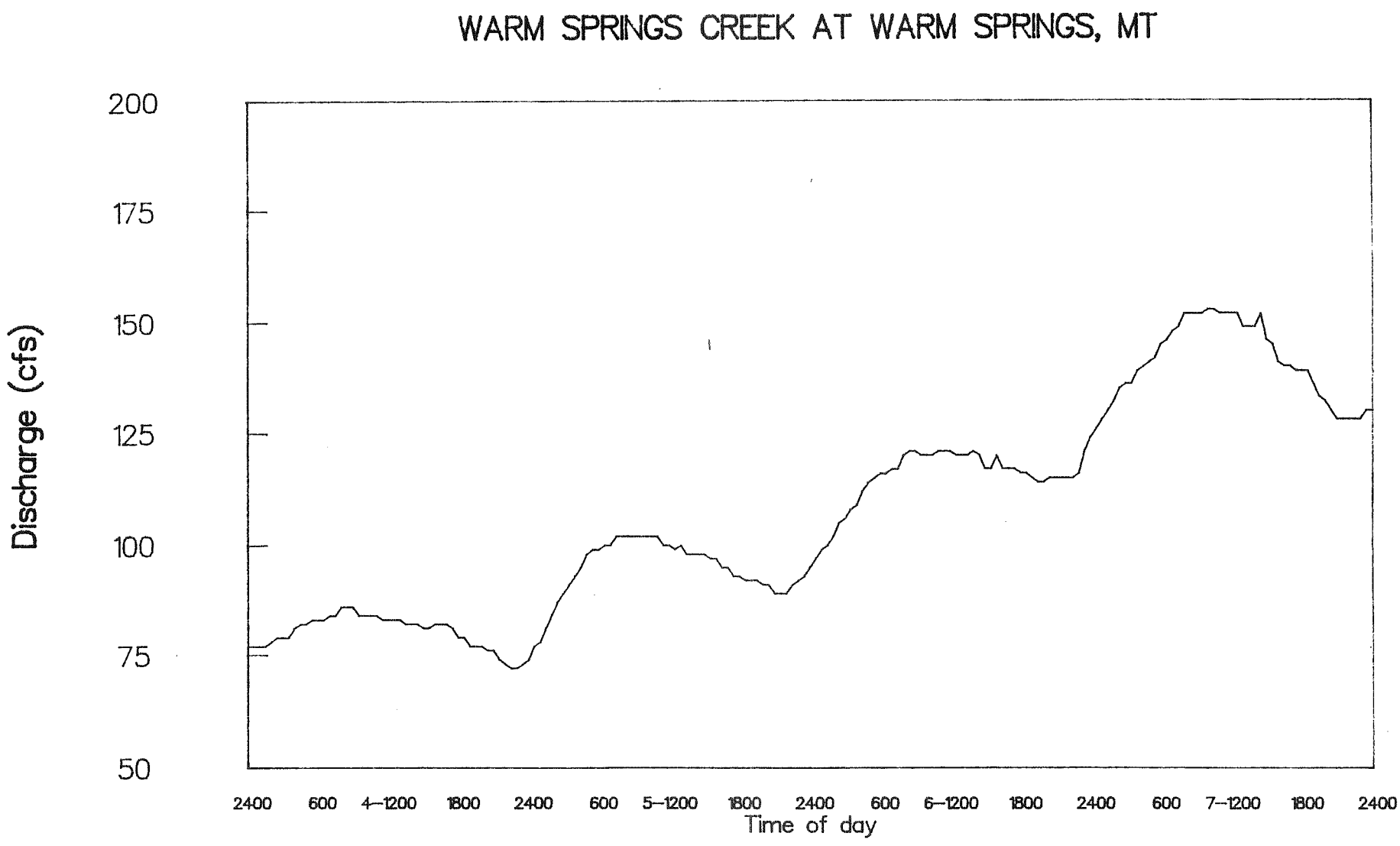
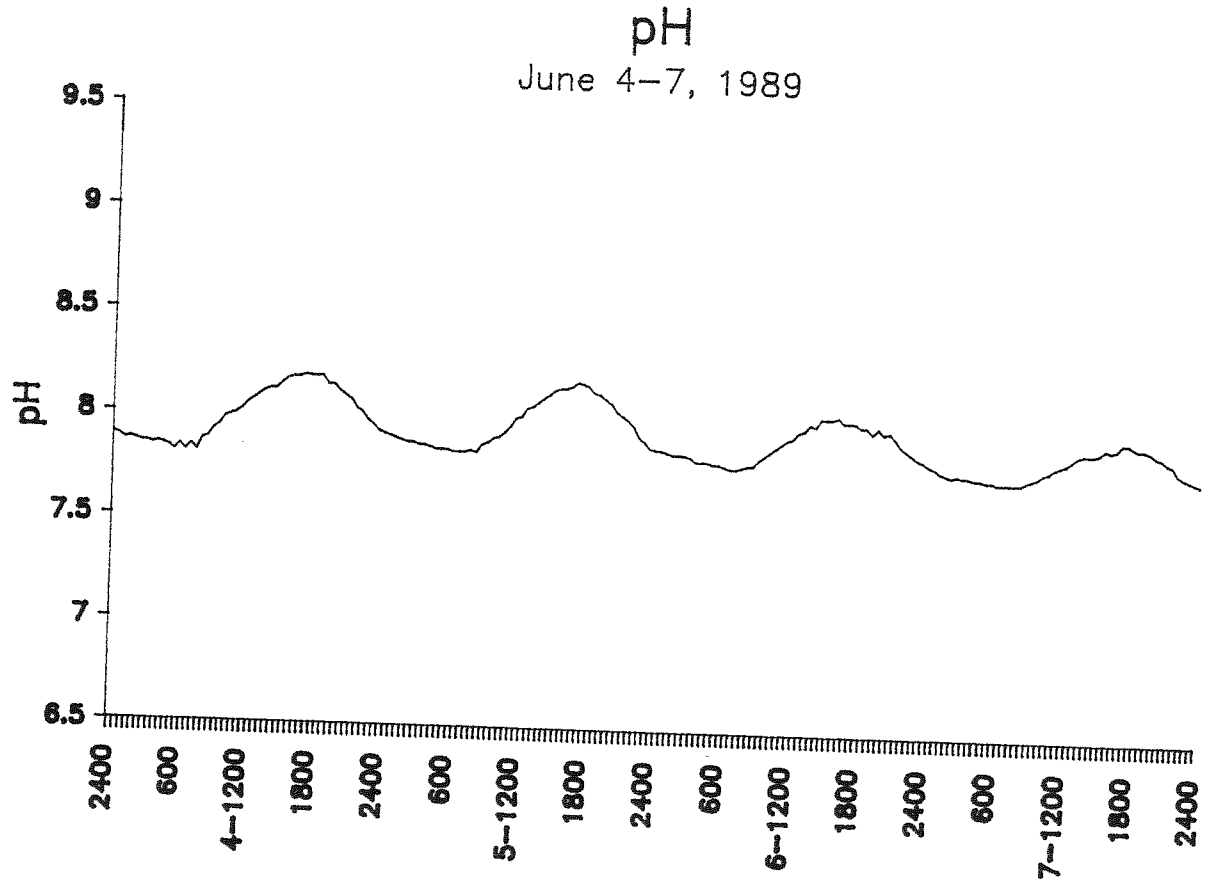


FIGURE 26 – DISCHARGE ON JUNE 04–07, 1989



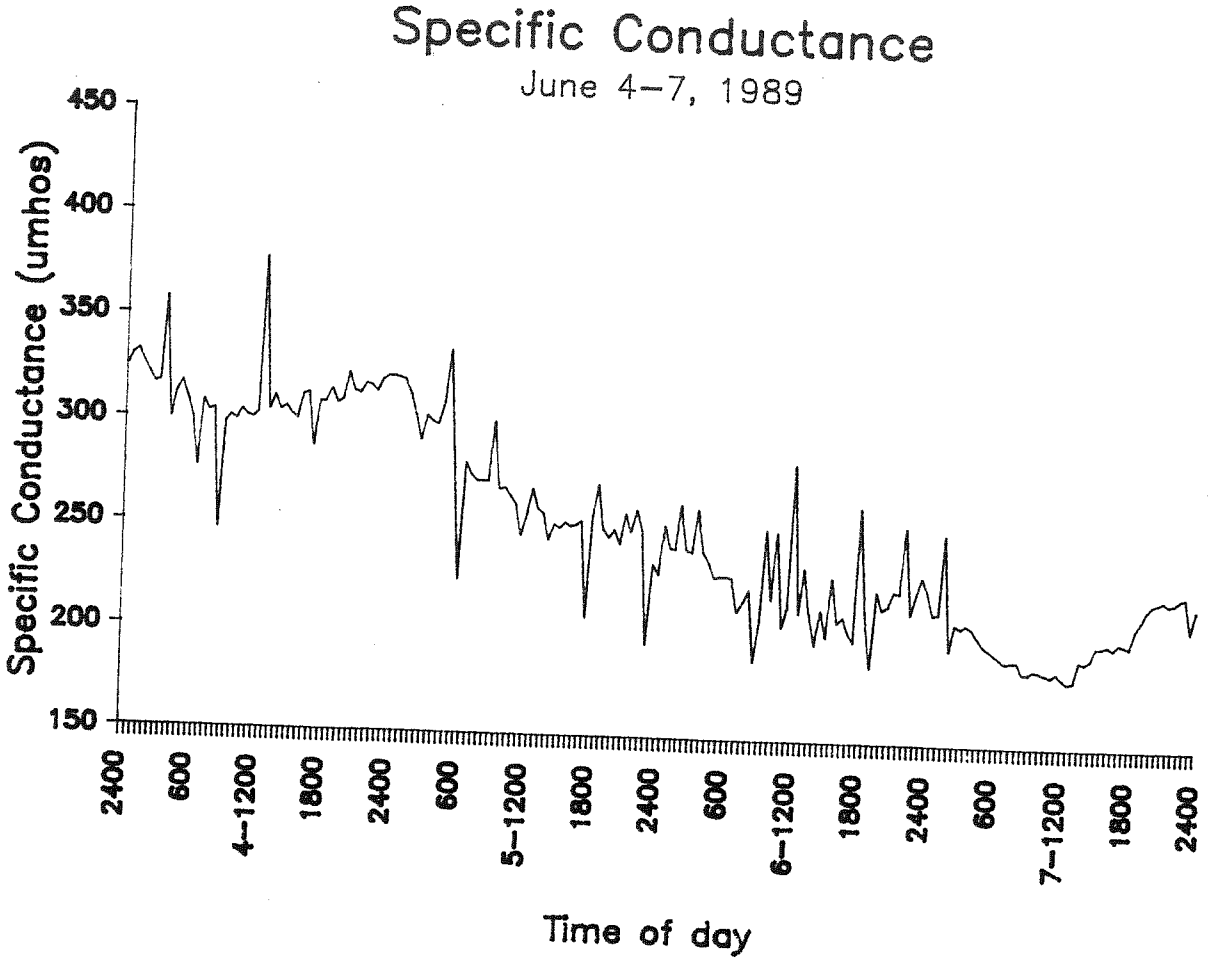
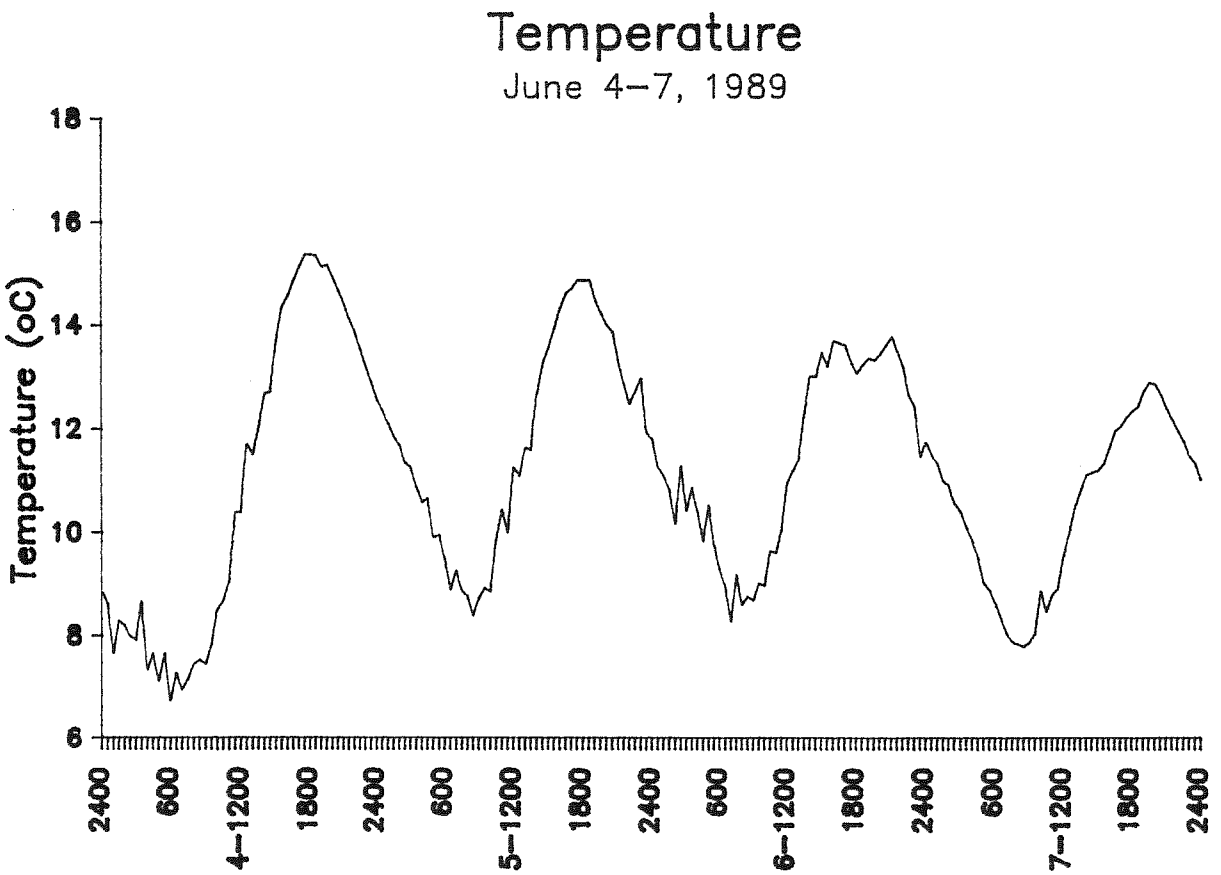


FIGURE 27 – WARM SPRINGS CREEK AT WARM SPRINGS, MT
(a) pH (b) SPECIFIC



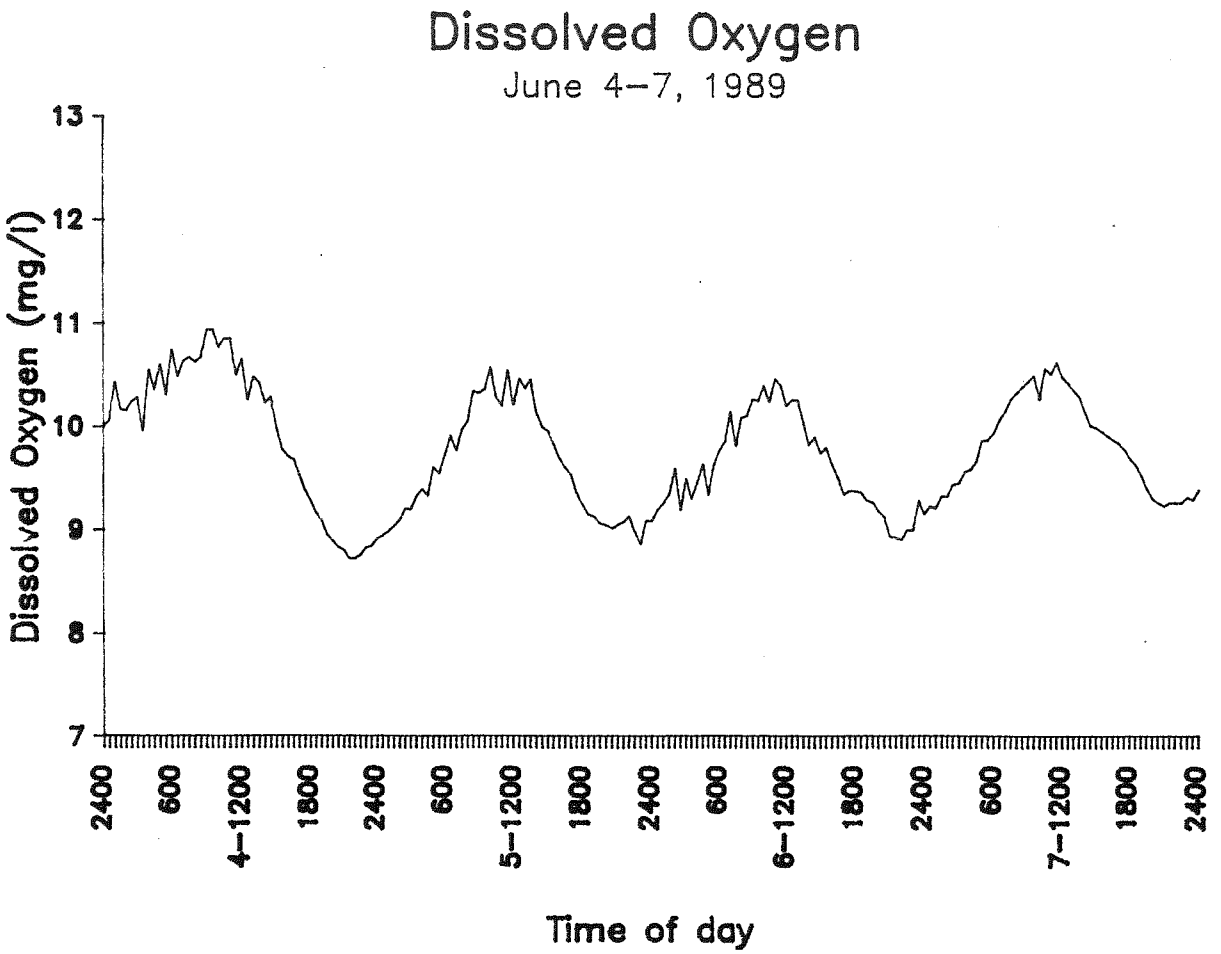


FIGURE 28 – WARM SPRINGS CREEK AT WARM SPRINGS, MT

Clark Fork Near Galen, MT

A complete listing of monitoring dates, recording intervals and file names is presented in Table 12. Two days and one storm event were selected as representative of the typical daily variations and ranges of monitoring results encountered.

Table 12
Clark Fork near Galen, MT
Monitoring Dates,
Intervals and File Names

Monitoring Dates	Recording Intervals (minutes)	File Name
08/12/88 to 08/18/88	15	P880818
08/19/88 to 08/25/88	15	P880825
08/26/88 to 09/01/88	15	P880901
09/01/88 to 09/08/88	15	P880908
09/08/88 to 09/15/88	18	P880915
09/15/88 to 09/22/88	20	P880922
09/22/88 to 09/29/88	20	P880929
09/29/88 to 10/06/88	20	P881006
10/06/88 to 10/13/88	20	P881013
10/13/88 to 10/20/88	20	P881020
10/20/88 to 10/27/88	20	P881027
10/27/88 to 11/03/88	20	P881103
03/13/89 to 03/27/89	60	P890327
03/30/89 to 04/14/89	60	P890414
04/14/89 to 04/25/89	30	P890425
04/25/89 to 05/04/89	30	P890504
05/04/89 to 05/16/89	30	P890516
05/16/89 to 05/25/89	30	P890525
05/25/89 to 06/06/89	30	P890606
06/07/89 to 06/20/89	30	P890620
06/20/89 to 07/05/89	30	P890705

August 20, 1988 was chosen as typical of base-flow conditions during late summer and the monitoring results are tabulated in Table 13.

Table 13
Clark Fork Near Galen, MT
on August 20, 1988

	Discharge (cfs)	pH	Specific Conductance (umhos/cm @ 25° C)	Temperature (° C)	Dissolved Oxygen (mg/l)
Mean	9.6	8.1	653	17.4	7.2
Std. Dev.	0.4	0.2	11	1.4	1.4
Maximum	9.9	8.4	670	20.2	9.2
Minimum	9.0	7.9	620	15.3	5.6

Discharge (Figure 29) was nearly steady at 9.6 cfs, and specific conductance (Figure 30b) was also steady with a mean value of 653 umhos/cm. In contrast, pH (Figure 30a), temperature (Figure 31a) and dissolved oxygen (Figure 31b) all showed strong diurnals. Once again, pH and dissolved oxygen appeared to be coupled by strong photosynthesis during the afternoon. The pH increased 0.5 units from 7.9 to 8.4 and dissolved oxygen increased simultaneously 3.6 mg/l from a nighttime low of 5.6 mg/l to an afternoon high of 9.2 mg/l. Dissolved oxygen saturation varied from a nighttime low of 66 percent indicating respiration was significant to an afternoon high of 119 percent also indicating significant photosynthesis.

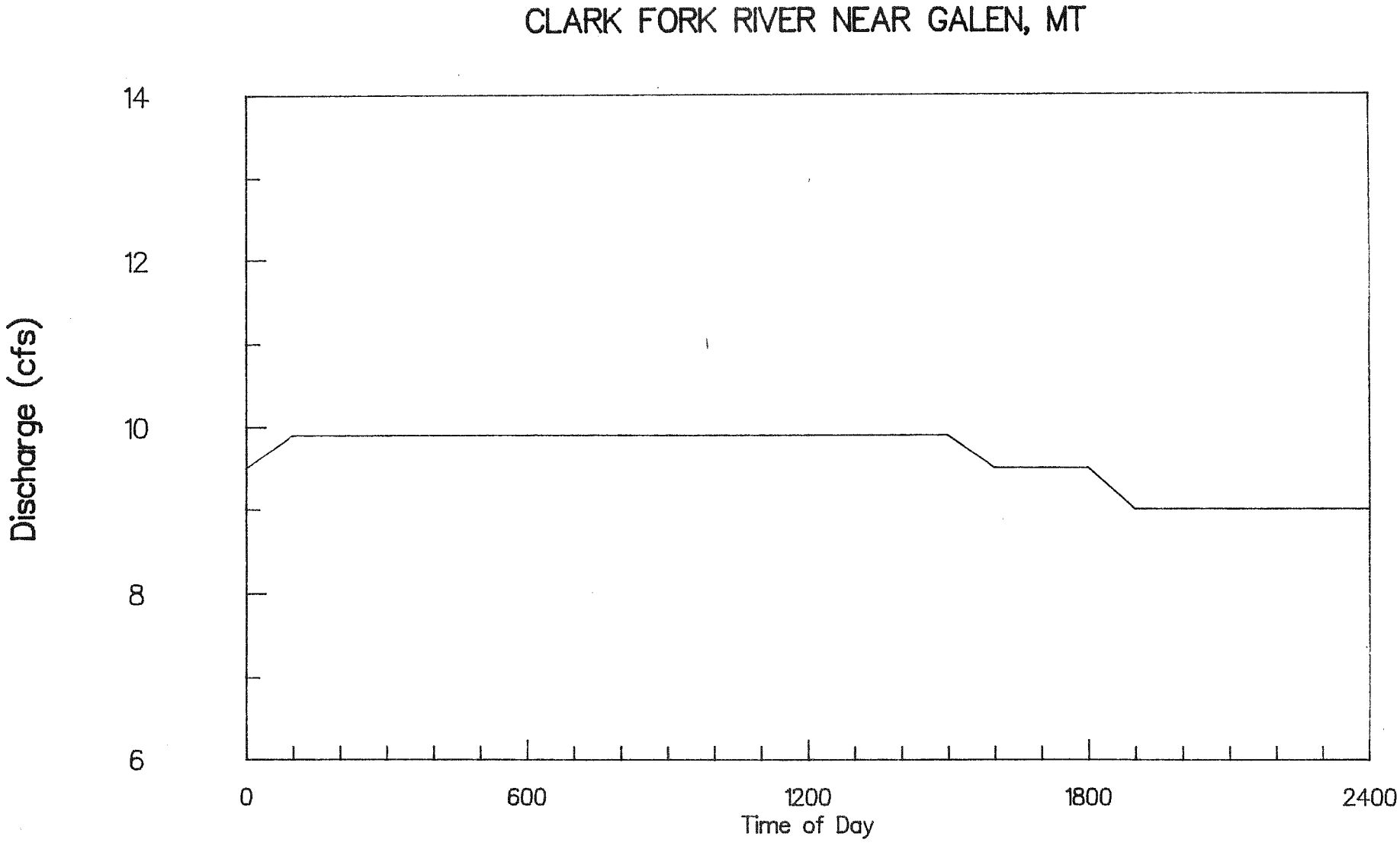
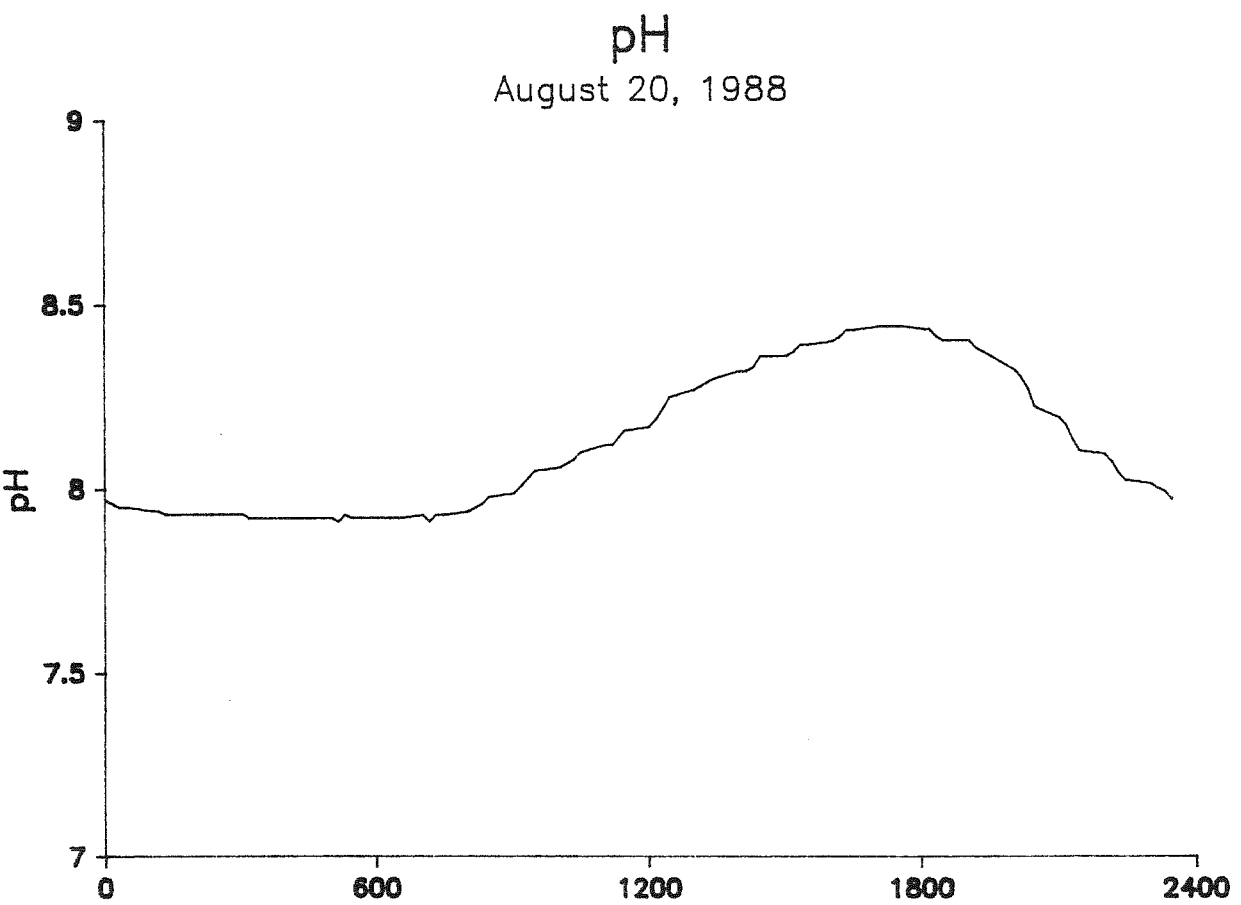


FIGURE 29 – DISCHARGE ON AUGUST 20, 1988



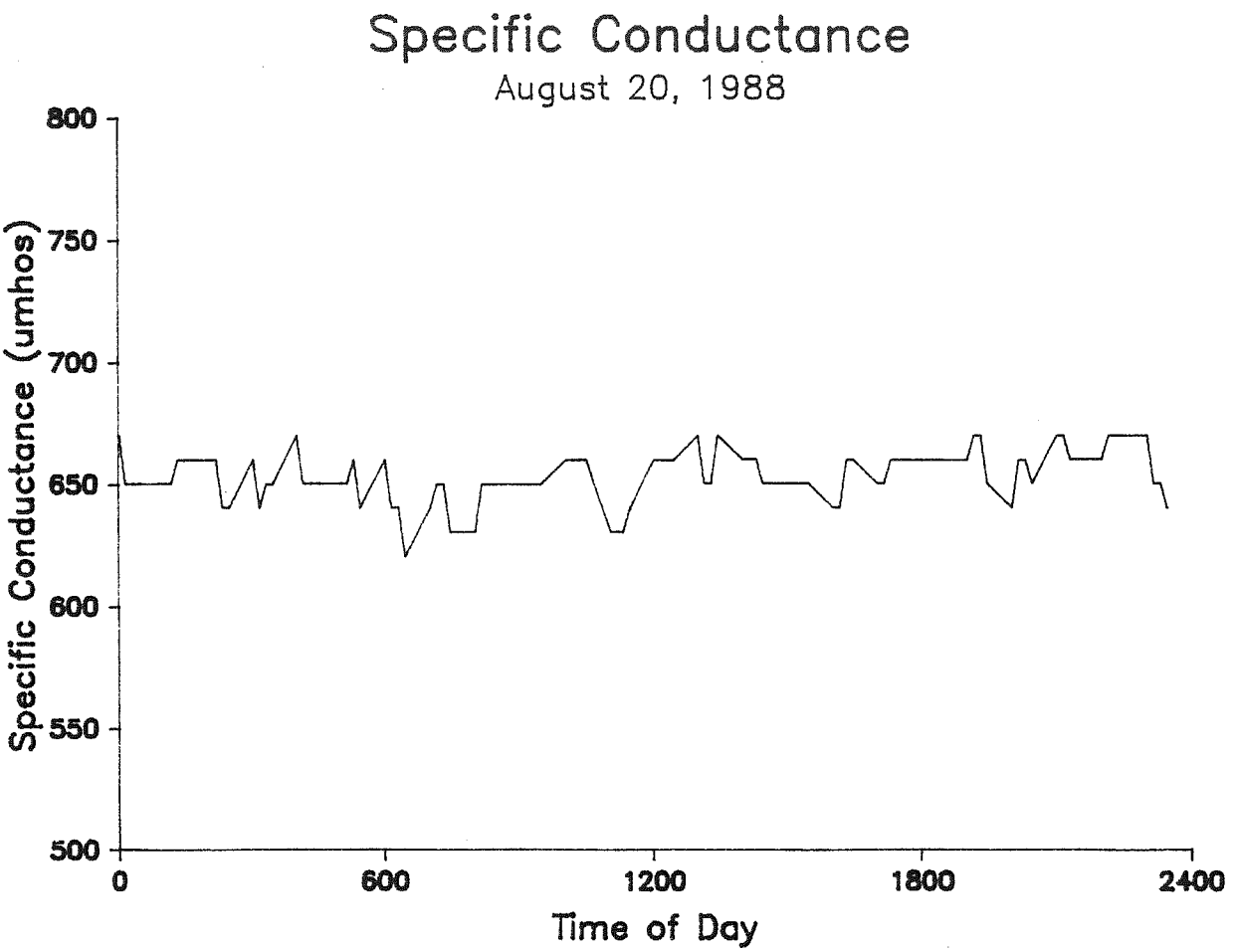


FIGURE 30 – CLARK FORK RIVER NEAR GALEN, MT

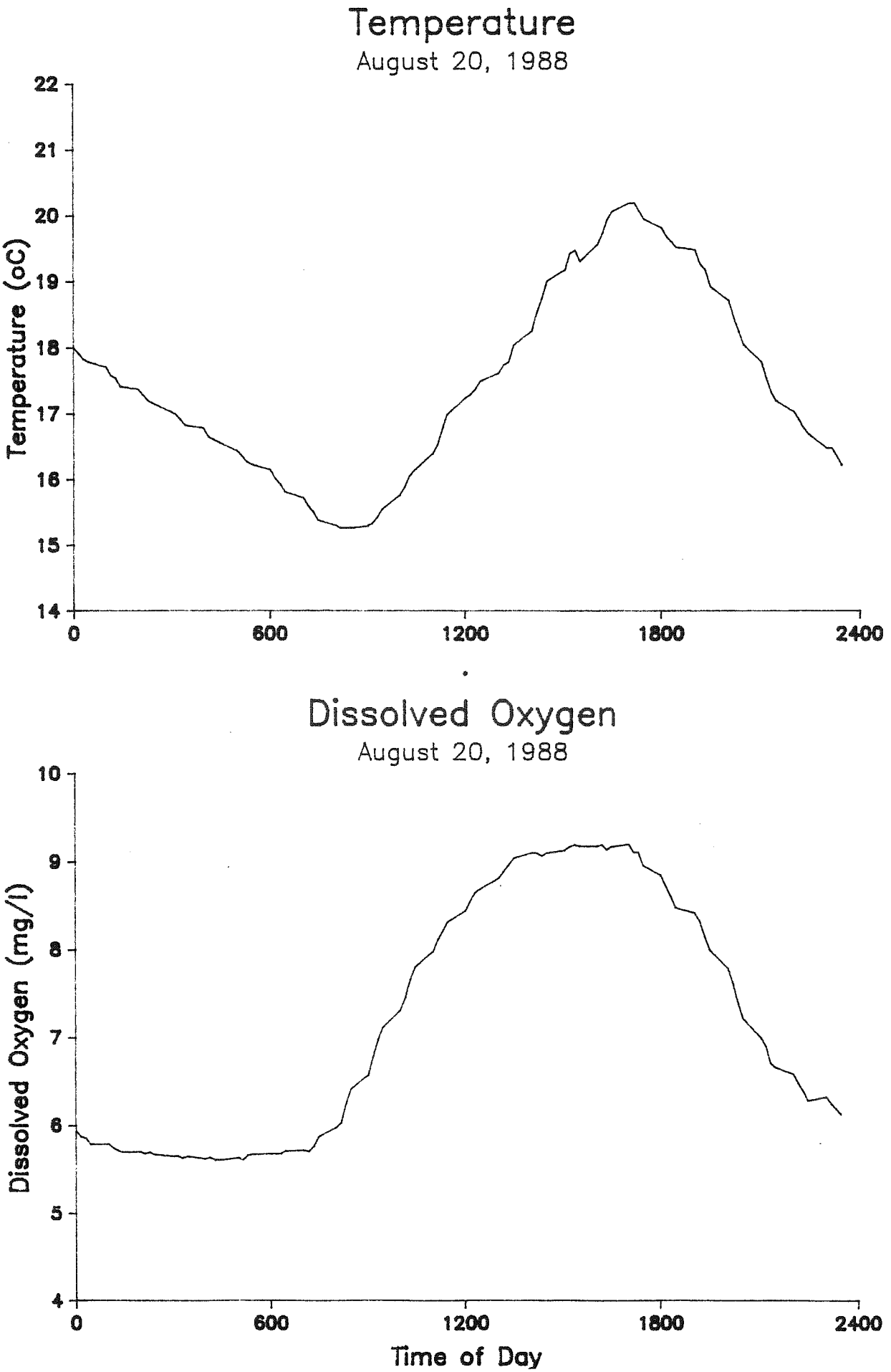


FIGURE 31 – CLARK FORK RIVER NEAR GALEN, MT

Table 14 gives the basic statistics for May 1, 1989 a typical spring day at this station.

Table 14
Clark Fork Near Galen, MT
on May 1, 1989

	Discharge (cfs)	pH	Specific Conductance (umhos/cm @ 25° C)	Temperature (° C)	Dissolved Oxygen (mg/l)
Mean	149	8.2	409	10.2	9.4
Std. Dev.	3	0.2	5	1.5	0.9
Maximum	154	8.6	418	12.5	10.7
Minimum	141	7.9	402	7.8	8.3

Discharge (Figure 32) showed a slight two percent diurnal that was consistent day to day. Specific conductance (Figure 33b) was stable near 409 umhos/cm with about a one percent diurnal. Temperature (Figure 34a) followed a strong diurnal pattern with a peak to peak change of nearly five degrees centigrade. Once again, the biological interaction between pH (Figure 33a) and dissolved oxygen (Figure 34b) was evident. Dissolved oxygen saturation was high with a minimum near 88 percent at night and a maximum of 113 percent mid to late afternoon.

This station was located just downstream of the Warm Springs Ponds and therefore storm events above the ponds were mitigated as they were routed through the ponds. Discharge (Figure 35) was affected by the 0.65 inch storm of June 15-16, 1989 (ARCO, July 1989) and nearly doubled from the base-flow rate of 220 cfs to the storm peak of 436 cfs. The pH (Figure 36a) was

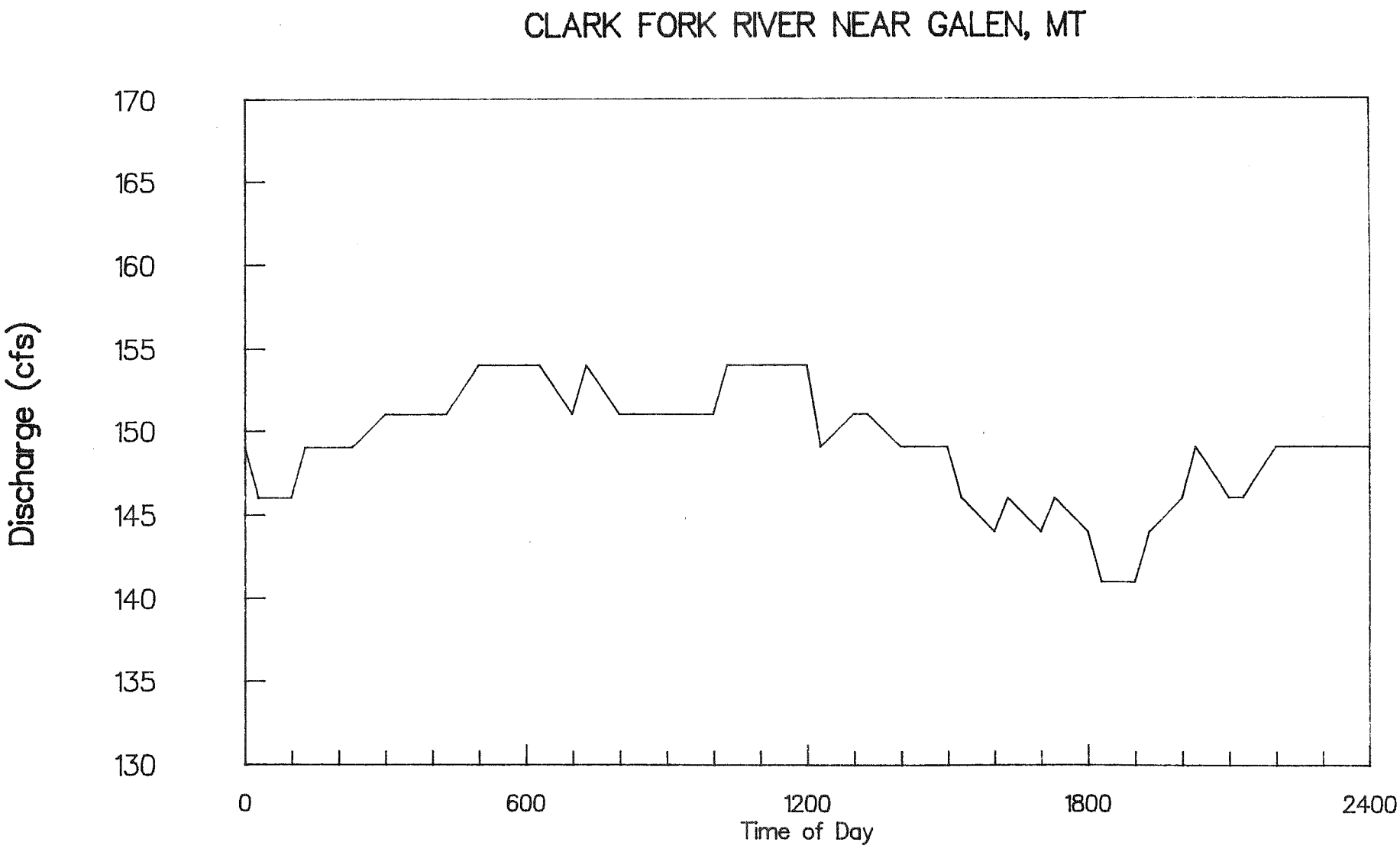
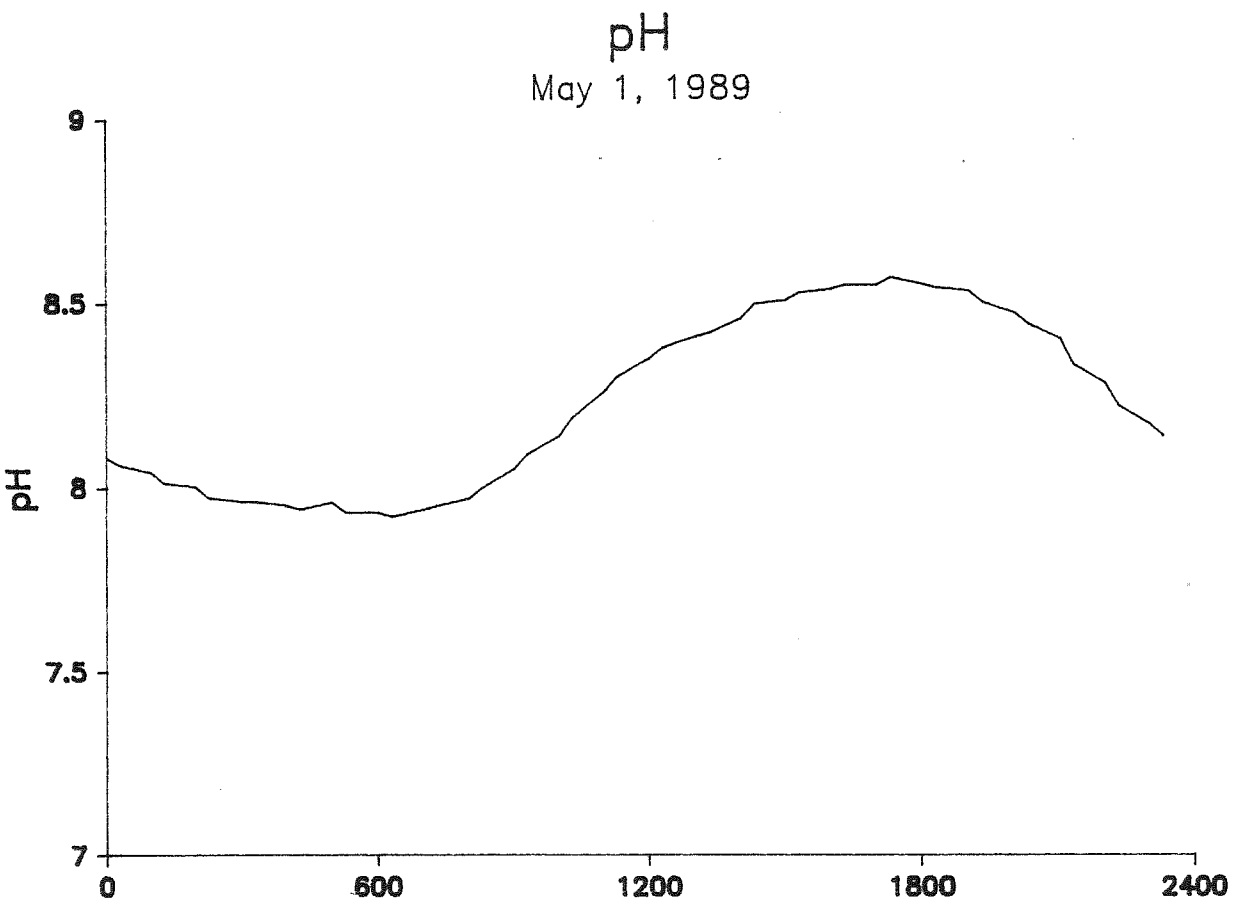


FIGURE 32 – DISCHARGE ON MAY 01, 1989



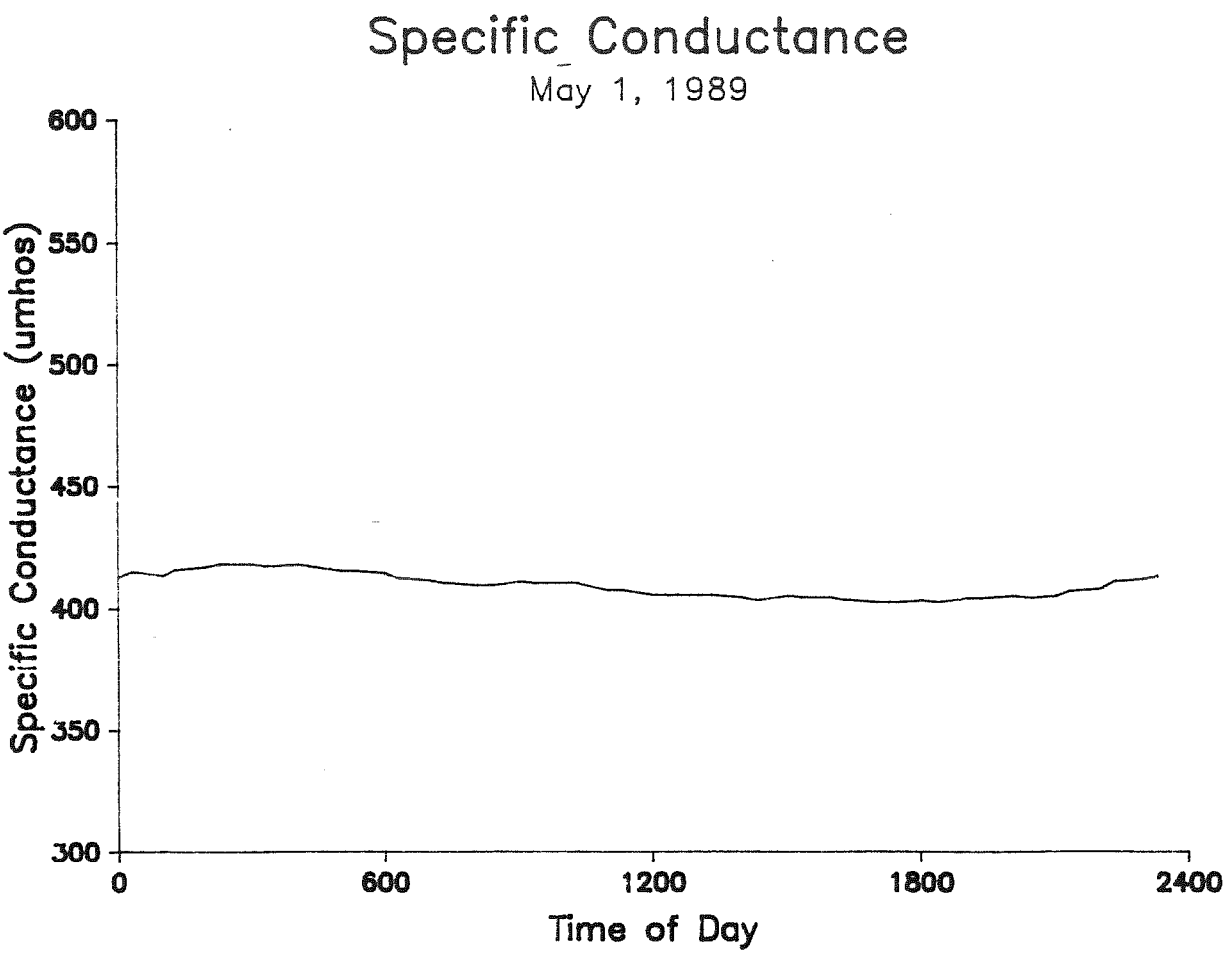
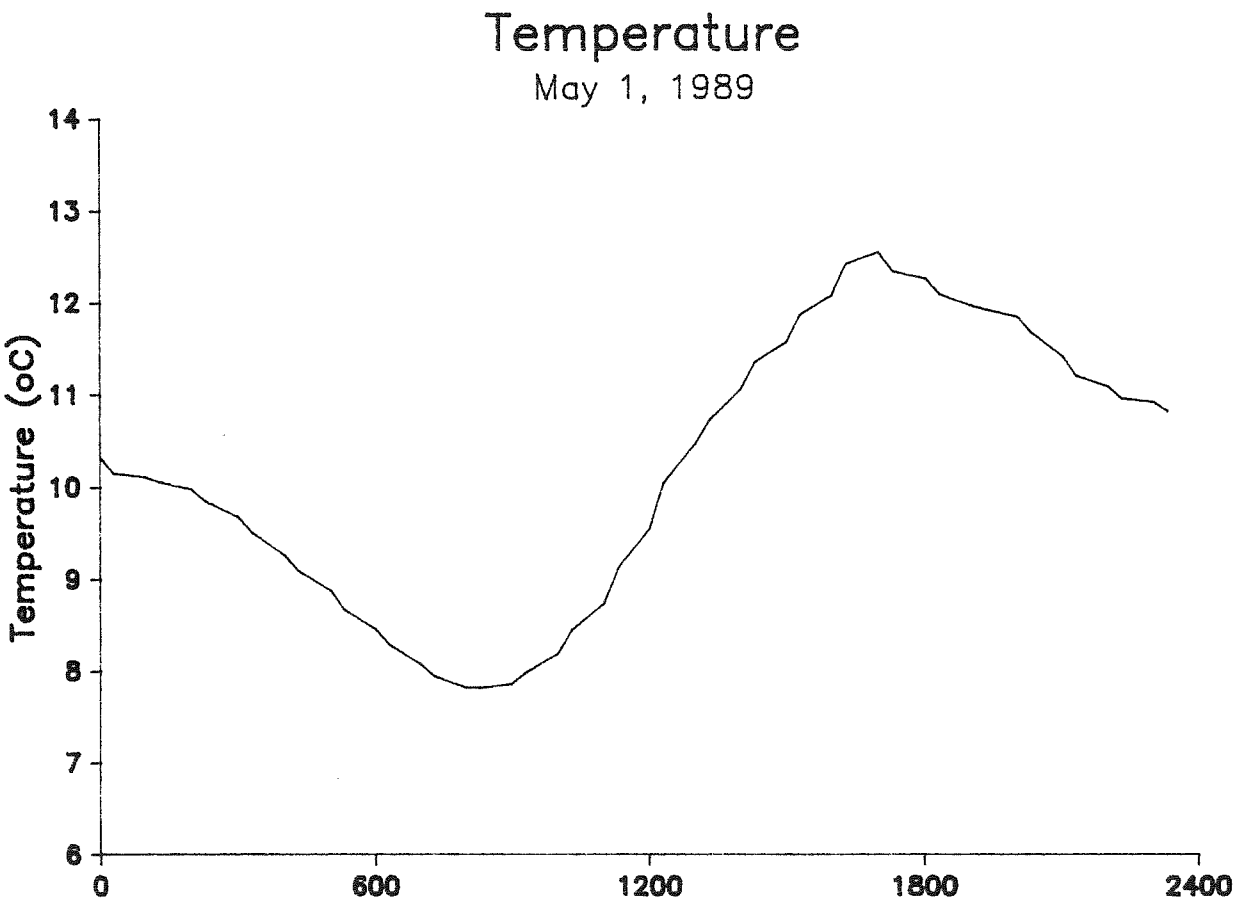


FIGURE 33 – CLARK FORK RIVER NEAR GALEN, MT



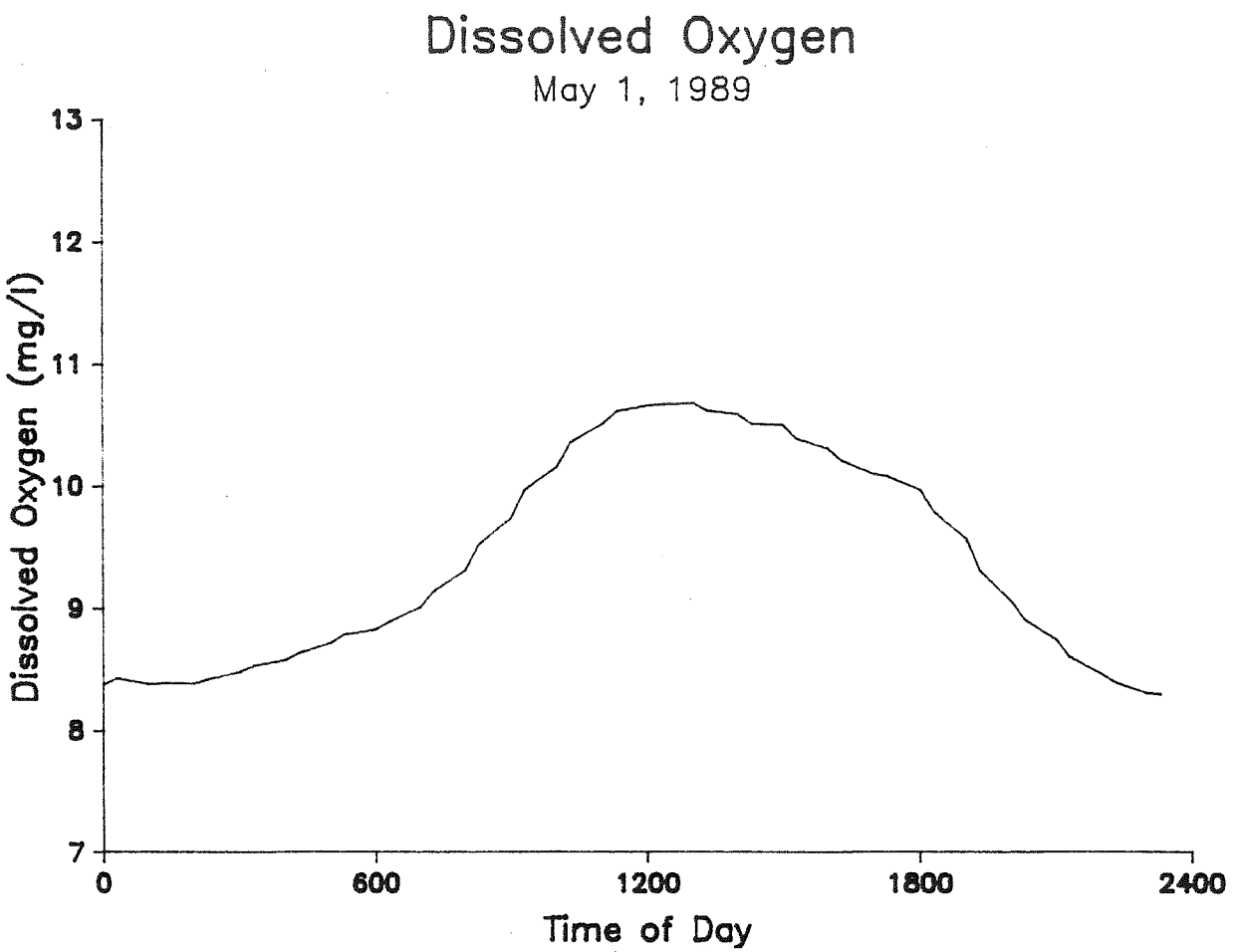


FIGURE 34 – CLARK FORK RIVER NEAR GALEN, MT

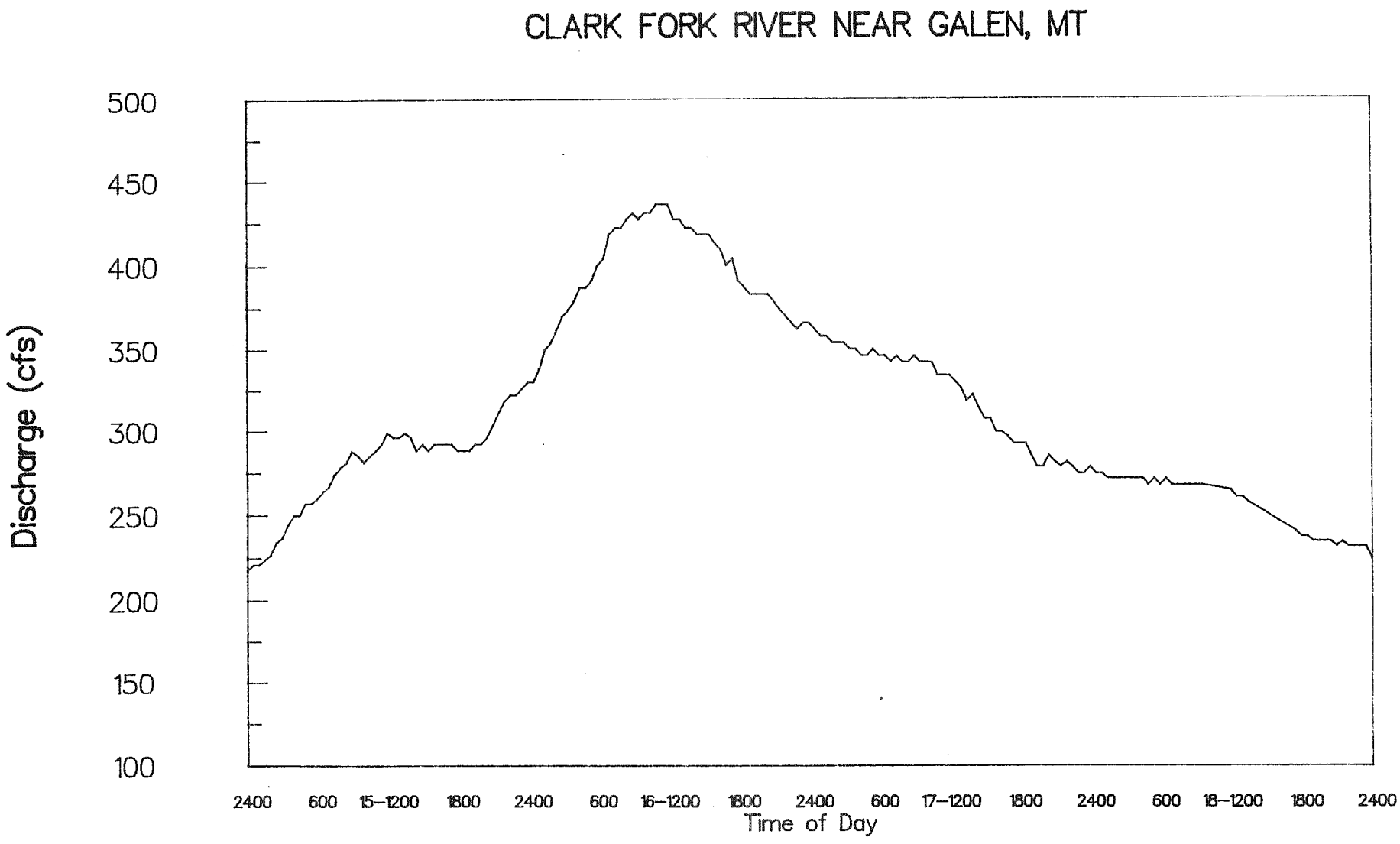
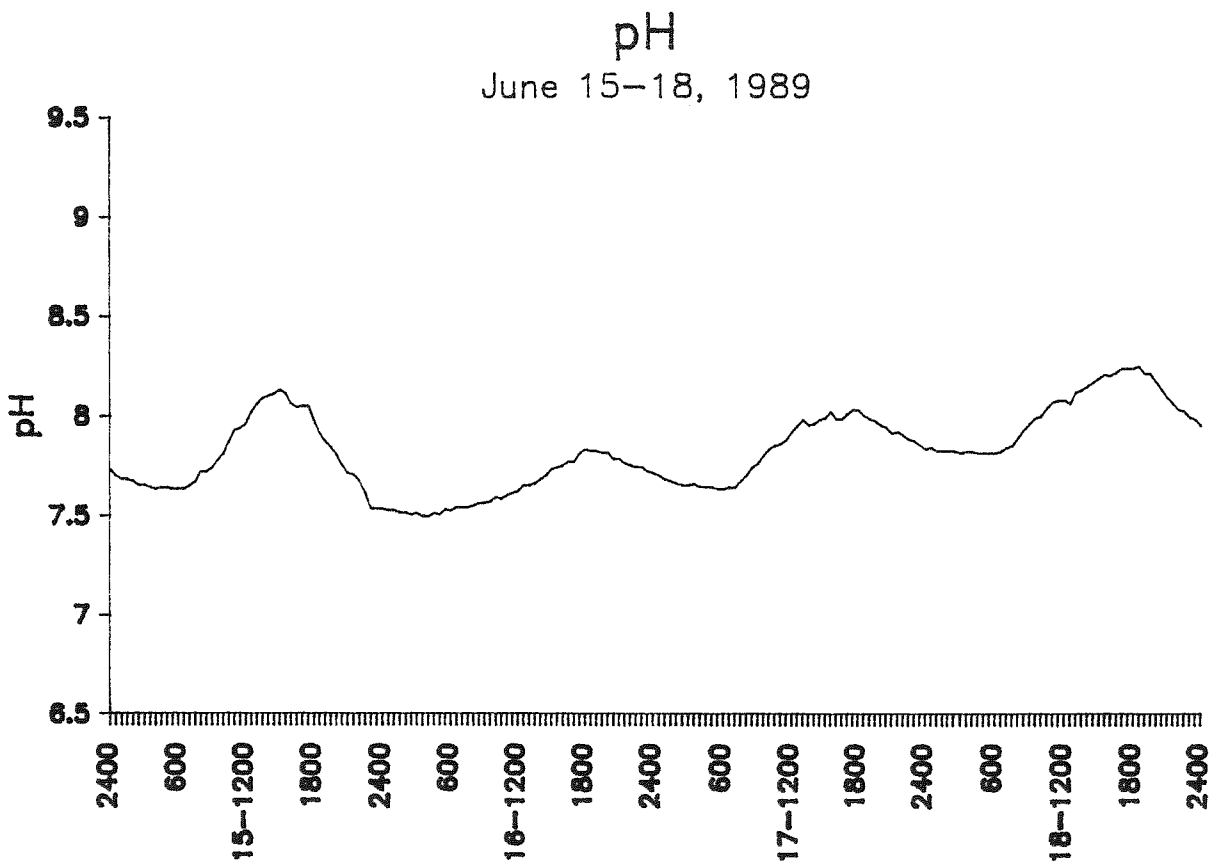


FIGURE 35 – DISCHARGE ON JUNE 15–18, 1989



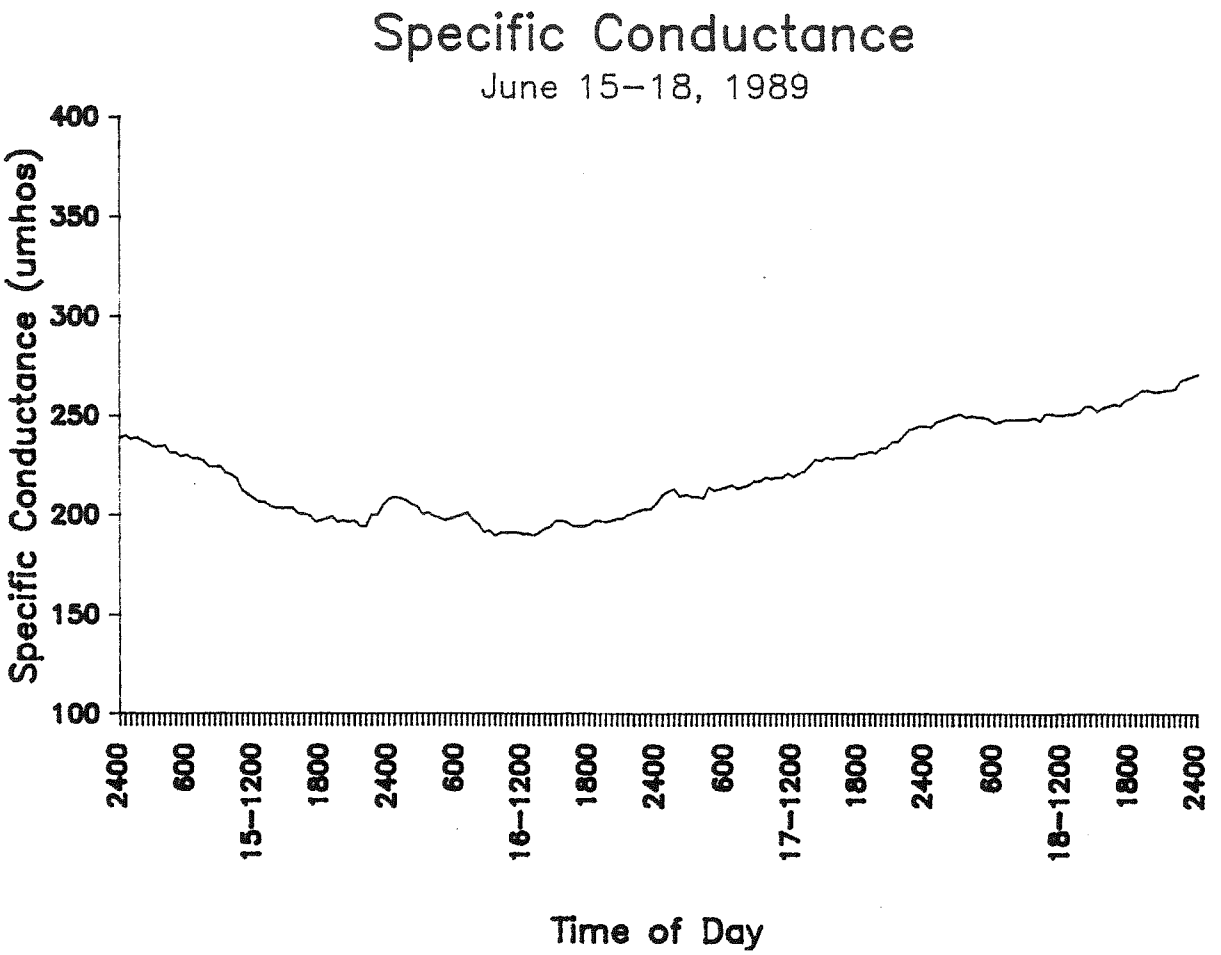


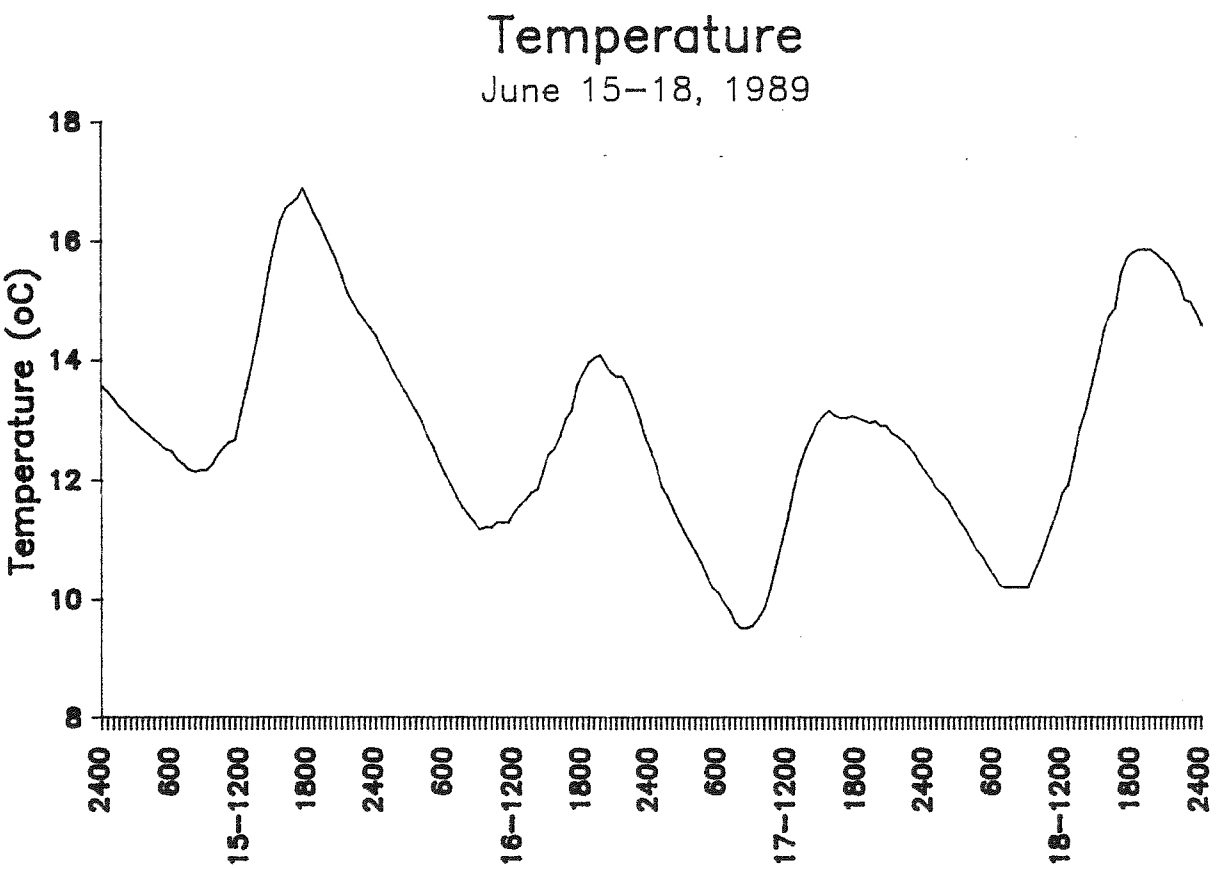
FIGURE 36 – CLARK FORK RIVER NEAR GALEN, MT

slightly depressed during the storm event and the diurnal pattern was reduced in amplitude. Specific conductance (Figure 36b) showed the characteristic inverse relationship with discharge and reached a minimum of 190 umhos/cm as the discharge peaked. Temperature (Figure 37a) and dissolved oxygen (Figure 37b) showed a pattern similar to the pH with their typical diurnal fluctuations depressed during the storm event.

Quality Control: Monitoring

Standard methods were utilized to calibrate the continuous monitors prior to placement. Once during each monitoring period and at each station an independent quality control measurement was made of all parameters. The quality control instruments were also calibrated in a standard method prior to utilization. The complete results of this quality control program may be found in Appendix A. This individual quality control data will be the most useful in assessing the validity of individual data sets.

Averaged quality control data may be useful to assess the general validity of the data sets and general conclusions that may be drawn from these data. Table 15 is a summary of the pH quality control data and the year average values were 0.31 and 0.40 for 1988 and 1989, respectively. Specific conductance is summarized in Table 16 with mean yearly values of 66 and 37 umhos/cm for 1988 and 1989, respectively. Mean temperature quality control values are presented in Table 17 with average values of 1.2° C and 1.0° C for 1988 and 1989, respectively. The final summary table (Table 18) contains dissolved oxygen data and presents yearly means of 1.3 and 1.5 mg/l for 1988 and 1989, respectively.



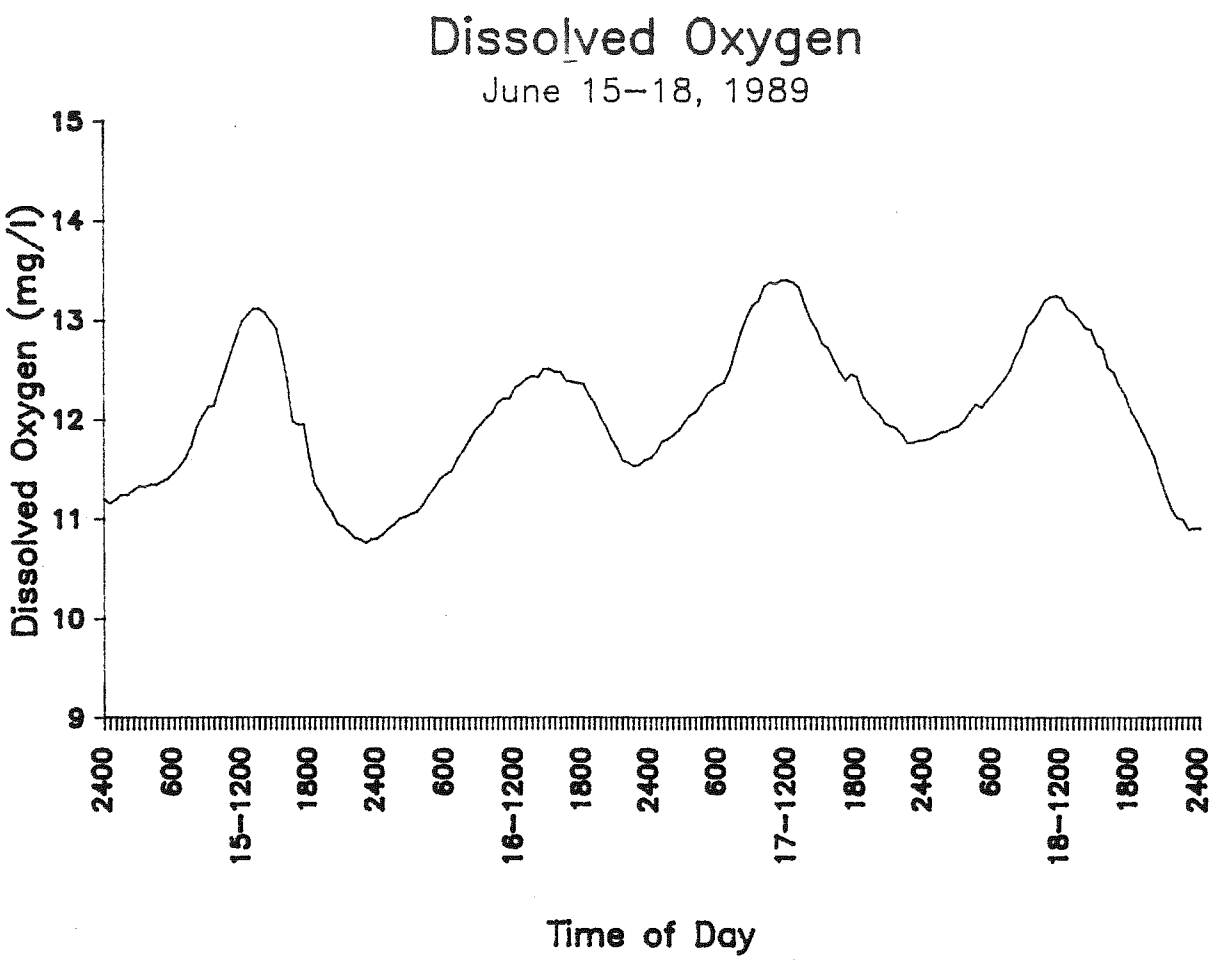


FIGURE 37 – CLARK FORK RIVER NEAR GALEN, MT

Table 15: Quality Control; Mean Absolute pH Difference

Station	1988	1989
Silver Bow Creek Below Blacktail Creek at Butte, MT	0.26	0.22
Silver Bow Creek at Opportunity, MT	0.34	0.42
Warm Springs Creek at Warm Springs, MT	0.23	0.58
Clark Fork near Galen, MT	0.41	0.37
Yearly Mean	0.31	0.40

Table 16: Quality Control; Mean Absolute Specific Conductance Difference (umhos/cm @ 25° C)

Station	1988	1989
Silver Bow Creek Below Blacktail Creek at Butte, MT	70	38
Silver Bow Creek at Opportunity, MT	47	52
Warm Springs Creek at Warm Springs, MT	53	27
Clark Fork near Galen, MT	94	31
Yearly Mean	66	37

Table 17: Quality Control; Mean Absolute Temperature Difference (Degrees Celsius)

Station	1988	1989
Silver Bow Creek Below Blacktail Creek at Butte, MT	1.3	0.9
Silver Bow Creek at Opportunity, MT	1.3	1.2
Warm Springs Creek at Warm Springs, MT	1.5	0.8
Clark Fork near Galen, MT	0.8	0.9
Yearly Mean	1.2	1.0

Table 18: Quality Control; Mean Absolute Dissolved Oxygen Difference (mg/l)

Station	1988	1989
Silver Bow Creek Below Blacktail Creek at Butte, MT	0.7	1.2
Silver Bow Creek at Opportunity, MT	1.5	1.5
Warm Springs Creek at Warm Springs, MT	2.1	1.8
Clark Fork near Galen, MT	1.0	1.4
Yearly Mean	1.3	1.5

Summary and Conclusions

Monitoring

The monitoring results indicated that the four main stations had complex base-flow diurnal fluctuations, and a majority of these fluctuations are a normal response to the sun's energy. Temperature, pH, and dissolved oxygen all rose and fell in rhythm with the sun at explainable lag times because of biological and chemical influences. Temperatures had large diurnal variations often reaching high values near 20°C during the summer. Dissolved oxygen was often super saturated during the afternoon and had nighttime levels below 6 mg/l at two stations: Silver Bow Creek below Blacktail Creek at Butte, MT and Clark Fork near Galen, MT. These nighttime lows may be a secondary effect of excess nutrients. Specific conductance was lower in the spring than summer and appeared to increase lower in the watershed. The pH increased lower in the watershed and diurnally in the afternoon.

Storm events did affect monitoring parameters. Specific conductance decreased with increasing discharge except for a sharp rise to a maximum following the discharge peak. This lagging rise in specific conductance correlated well with a decrease in pH and may provide a good parameter to trigger storm event sampling at certain locations. Because of dominant diurnal variations, a sampling trigger may have to be more of a variation from the normal trend than an absolute value.

WATER QUALITY SAMPLING RESULTS

Concentration results obtained in this study will be compared to both the acute and chronic standards for the Aquatic Life-Water Quality Criteria. Table 19 contains these standards for selected parameters.

Table 19
WATER QUALITY CRITERIA STANDARDS[1]
(Concentrations in ug/l)

Parameter	Acute[a]	Chronic[b]
Arsenic	360	190
Cadmium	6.4	1.6
Copper	27	17
Iron[c]	1000	
Lead	142	5.6
Zinc	170	154

1) Clean Water Act; 40 CFR Part 131; total recoverable metals; Table modified from CDM, 1988.

a) 1-hour average (acute); hardness = 155 mg/l

b) Four-day average (chronic); hardness = mg/l

c) Daily maximum

This is the same methodology utilized by the Water Quality Bureau in their Clark Fork Basin Monitoring program (Ingman, 1990) and previous work completed by the Montana Department of Fish, Wildlife and Parks (Phillips and others, 1987). When calculating mean and minimum values for dissolved, bio-available and total recoverable concentrations, only values above the detection limit were used. Appendix B contains selected water quality results for 1988 and 1989 sampling.

BLACKTAIL CREEK AT BUTTE, MT

This station was added to the 1989 list of monitoring stations in an attempt to categorize the quality of water entering Silver Bow Creek. At Blacktail Creek's confluence with Silver Bow Creek (SBC), Blacktail comprises the major flow of water, therefore characterizing this water was deemed important. The USGS gaging station on Blacktail Creek was moved from the upper basin to its present location (point of monitoring) during late 1988, thus providing continuous flow records.

There were nine sampling periods at this location during 1989. Flows ranged from 14 to 31 cubic feet per second (cfs) with the mean being 23 cfs. Samples represented numerous flow conditions, those being spring base flow, spring runoff (snow melt), and storm event runoff from both snow and rain storms. Table 20 contains selected analytical results at this site.

Dissolved Concentrations - 1989

Dissolved concentration (filtered-acidified) samples were collected during all nine sampling periods. Copper concentrations ranged from 7 ug/l to 28 ug/l with 14 ug/l the mean. These concentrations equalled or exceeded the aquatic life chronic standard (17 ug/l) three times, while the acute

standard (27 ug/l) was exceeded once. None of the other parameters exceeded the aquatic life standards. Arsenic concentrations ranged from 4.3 ug/l to 7.9 ug/l, with 5.7 ug/l the mean.

TABLE 20
SELECTED ANALYTICAL RESULTS AND STATISTICS
BLACKTAIL CREEK NEAR BUTTE, MT (ABOVE CONFLUENCE WITH SILVER BOW CREEK)

DISSOLVED CONCENTRATION

DATE (MM/DD/YR)	TIME (HRS)	FLOW (cfs)	Fe (ug/l)	Mn (ug/l)	Al (ug/l)	Cu (ug/l)	Pb (ug/l)	Zn (ug/l)	As (ug/l)
04/07/89	09:20	27	400	280	50	9	<40	100	7.0
04/14/89	11:46	20	340	97	<30	7	<40	29	5.2
04/21/89	11:20	16	210	100	<30	10	<40	36	5.1
04/22/89	06:45	27	200	120	<30	12	<40	54	5.9
04/28/89	12:34	14	210	150	<30	10	<40	37	5.0
05/15/89	16:10	22	130	100	78	24	<40	77	7.9
05/15/89	20:18	29	82	73	<30	28	<40	25	5.9
05/28/89	19:10	31	79	69	<30	9	<40	26	4.3
06/27/89	14:15	25	81	96	<30	17	<40	50	5.4
MEAN==>		23	192	121	64	14		48	5.7
MAX===>		31	400	280	78	28		100	7.9
MIN===>		14	79	69	50	7		25	4.3
NUMBER=>		9	9	9	2	9	0	9	9

BIOLOGICALLY AVAILABLE CONCENTRATION

DATE (MM/DD/YR)	TIME (HRS)	FLOW (cfs)	Fe (ug/l)	Mn (ug/l)	Al (ug/l)	Cu (ug/l)	Pb (ug/l)	Zn (ug/l)	As (ug/l)
04/07/89	09:20	27	1320	240	280	16	60	38	9.4
04/14/89	11:46	20	83	110	150	14	150	19	5.4
04/21/89	11:20	16	72	110	240	17	<40	33	6.2
04/22/89	06:45	27	1220	200	690	39	80	71	11.0
04/28/89	12:34	14	520	130	<30	9	<40	93	3.9
05/15/89	16:10	22	1100	210	680	72	<40	150	12.0
05/15/89	20:18	29	850	140	380	44	<40	130	10.0
05/28/89	19:10	31	1090	180	490	45	<40	119	11.0
06/27/89	14:15	25	440	130	80	101	<40	174	7.6
MEAN==>		23	900	160	374	40	97	92	8.5
MAX===>		31	1320	240	690	101	150	174	12.0
MIN===>		14	440	110	80	9	60	19	3.9
NUMBER=>		9	9	9	8	9	3	9	9

TOTAL RECOVERABLE CONCENTRATION

DATE (MM/DD/YR)	TIME (HRS)	FLOW (cfs)	Fe (ug/l)	Mn (ug/l)	Al (ug/l)	Cu (ug/l)	Pb (ug/l)	Zn (ug/l)	As (ug/l)
05/28/89	19:10	31	5110	220	4100	70	<40	135	12.0
MEAN==>		31	5110	220	4100	70		135	12.0
MAX===>		31	5110	220	4100	70		135	12.0
MIN===>		31	5110	220	4100	70		135	12.0
NUMBER=>		1	1	1	1	1	0	1	1

Bio-available Concentrations - 1898

Bio-available (raw-acidified, filtered after 24-hours) concentration samples were collected during all nine sampling periods also. Iron concentrations ranged from 440 ug/l, to 1,320 ug/l with 900 ug/l the mean. These values exceeded aquatic life standards (1000 ug/l) in four of the nine samples, while the mean concentration for iron is over four-fold the mean dissolved concentration (192 ug/l).

Copper concentrations ranged from 9 ug/l to 101 ug/l, with 40 ug/l the mean. Six of nine samples for copper equalled or exceeded the chronic aquatic life standard, while five of these six also exceed the acute standard. The mean concentration is over twice that shown for the dissolved fraction.

Zinc concentrations for bio-available analysis ranged from 19 ug/l to 174 ug/l, with 92 ug/l the mean. These concentrations exceeded the acute (170 ug/l) and chronic (154 ug/l) standards only once, but its mean concentration (92 ug/l) was almost twice that shown for the dissolved fraction (48 ug/l).

Arsenic concentrations ranged from 3.9 ug/l to 12 ug/l, with 8.5 ug/l the mean. These conscentrations once again did not exceed aquatic life standards. The mean arsenic concentration (8.5 ug/l) was 50% greater than the mean dissolved arsenic value (5.7 ug/l).

Total Recoverable Concentrations - 1989

Total recoverable samples were collected during one sampling period to compare with bio-available concentrations. Concentrations of iron and aluminum were 5,110 ug/l and 4,100 ug/l respectively.

These concentrations showed the greatest increase, with iron increasing almost five-fold, while aluminum increased over eight-fold from biologically available concentrations.

MISSOULA GULCH

This station was also added during the 1989 monitoring period. Missoula Gulch and Butte-Silver Bow's Sewage Treatment Plant are the major point source contributors to SBC in this portion of the stream, therefore it was felt the addition of this site was a pertinent addition to the monitoring network.

Flow rates were calculated by timing the filling of a 5 gallon bucket as water came out of culverts running under Centennial Avenue. Seven samples were collected at this location and flows ranged from 0.11 cfs to 1.10 cfs with 0.54 cfs being the mean. Table 21 contains concentration and statistical data for samples collected at this location.

Dissolved Concentrations - 1989

Cadmium concentrations ranged from 2 ug/l to 36 ug/l, with 11 ug/l the mean. These concentrations exceeded the acute aquatic life standard (6.4 ug/l) during 3 of the 7 sampling periods, while 6 of the 7 periods exceeded the chronic standard of 1.6 ug/l.

Copper concentrations ranged from 73 ug/l to 435 ug/l, with 145 ug/l the mean, while zinc concentrations ranged from 310 ug/l to 6720 ug/l, with 2171 ug/l the mean. All seven periods showed both the acute (27 ug/l) and chronic (17 ug/l) copper standards being exceeded by considerable amounts,

TABLE 21
SELECTED ANALYTICAL RESULTS AND STATISTICS
MISSOULA GULCH (AT CENTENNIAL AVE)

DISSOLVED CONCENTRATION

DATE (MM/DD/YR)	TIME (HRS)	FLOW (cfs)	Fe (ug/l)	Mn (ug/l)	Al (ug/l)	Cu (ug/l)	Pb (ug/l)	Zn (ug/l)	As (ug/l)
04/07/89	09:55	.22	7	1.370	<30	130	<40	2310	6.8
04/14/89	12:47	.33	20	1.330	<30	140	90	2250	6.1
04/21/89	12:00	.56	13	1.320	<30	80	<40	1700	5.7
04/28/89	13:10	.11	26	1.060	<30	76	<40	1250	4.6
05/15/89	18:00	1.10	120	.310	129	82	<40	310	11.0
05/28/89	21:15	.89	61	.340	<30	73	<40	658	5.2
06/27/89	16:30	N/A	26	4.200	140	435	<40	6720	2.6
MEAN==>		.54	39	1.419	135	145	90	2171	6.0
MAX===>		1.10	120	4.200	140	435	90	6720	11.0
MIN===>		.11	7	.310	129	73	90	310	2.6
NUMBER=>		6	7	7	2	7	1	7	7

BIOLOGICALLY AVAILABLE CONCENTRATION

DATE (MM/DD/YR)	TIME (HRS)	FLOW (cfs)	Fe (ug/l)	Mn (ug/l)	Al (ug/l)	Cu (ug/l)	Pb (ug/l)	Zn (ug/l)	As (ug/l)
04/07/89	09:55	.22	1530	1570	1080	490	100	3770	14.0
04/14/89	12:47	.33	1200	1490	880	440	190	3550	11.0
04/21/89	12:00	.56	5050	2690	3600	930	260	5300	30.0
04/28/89	13:10	.11	2050	2760	2470	730	1220	4780	18.0
05/15/89	18:00	1.10	3380	4730	708	1690	2080	8820	78.0
05/28/89	21:15	.89	580	650	510	320	140	1330	11.0
06/27/89	16:30	N/A	1750	4690	1270	670	230	8590	25.0
MEAN==>		.54	2220	2650	1503	753	603	5163	26.7
MAX===>		1.10	5050	4730	3600	1690	2080	8820	78.0
MIN===>		.11	580	650	510	320	100	1330	11.0
NUMBER=>		6	7	7	7	7	7	7	7

TOTAL RECOVERABLE CONCENTRATION

DATE (MM/DD/YR)	TIME (HRS)	FLOW (cfs)	Fe (ug/l)	Mn (ug/l)	Al (ug/l)	Cu (ug/l)	Pb (ug/l)	Zn (ug/l)	As (ug/l)
05/28/89	21:15	.89	4150	810	3210	311	130	1440	17.0
MEAN==>		.89	4150	810	3210	311	130	1440	17.0
MAX===>		.89	4150	810	3210	311	130	1440	17.0
MIN===>		.89	4150	810	3210	311	130	1440	17.0
NUMBER=>		1	1	1	1	1	1	1	1

while zinc concentrations also exceeded both the acute (170 ug/l) and chronic (154 ug/l) standards by excessive amounts.

Arsenic concentrations ranged from 2.6 ug/l to 11 ug/l, with 6 ug/l the mean. These concentrations were considerably below the aquatic life standards.

Bio-available Concentrations - 1989

Bio-available samples were collected during all seven sampling periods. Iron concentrations exceeded aquatic life criteria during 6 of the 7 periods. Iron concentrations ranged from 580 ug/l to 5050 ug/l, with a mean of 2220 ug/l. These concentrations are considerably greater than dissolved concentrations, and mean concentration is almost 200-fold (200X) greater than the mean dissolved concentration.

Cadmium concentrations ranged from 14 ug/l to 91 ug/l, with 36 ug/l the mean, while copper concentrations ranged from 320 ug/l to 1690 ug/l, with 753 ug/l the mean. These cadmium values exceeded both of the aquatic life standards during 6 of 7 sampling periods also, while copper concentrations exceeded both of the aquatic life standards by over an order of magnitude (at a minimum) during all seven sample periods. Bio-available mean copper concentrations exceeded dissolved mean concentration by five-fold.

Zinc followed the same trend as copper with all seven sampling periods having concentrations greatly exceeding standards. Zinc concentrations ranged from 1330 ug/l to 8820 ug/l, with the mean being 5163 ug/l. Bio-available mean zinc concentrations exceeded mean dissolved concentration two-fold.

Arsenic concentrations ranged from 11 ugl to 78 ug/l, with a mean of 26.7 ug/l. These concentrations were at least double the dissolved values, while still not exceeding the aquatic life criteria, but the Safe Drinking Water Act standard of 50 ug/l was exceeded on one occasion (78 ug/l).

Total Recoverable Concentrations - 1989

Total recoverable samples were collected during one sampling period (5/28/89) at this site. Iron concentration was 4,150 ug/l which exceeds the bio-available concentrations by over seven-fold. Aluminum concentration was 3,210 ug/l which is over-six fold the bio-available value. Arsenic concentration was 17 ug/l which is 50% greater than bio-available value. Copper, lead and zinc concentrations were essentially the same as bio-available concentrations collected on this same date.

SILVER BOW CREEK BELOW BLACKTAIL CREEK AT BUTTE, MT

This station was part of the 1988 and 1989 sampling program. During 1988, 14 sampling events occurred, while 10 sampling events occurred during 1989. Stream flows in 1988 varied from 14 cfs to 98 cfs, with 39 cfs being the mean, while stream flows during 1989 varied from 19 cfs to 127 cfs with 54 cfs being the mean. Stream flows represent low flow (minimum recorded by USGS for period of record), spring runoff base flow and storm event runoff flows for both melting snow and rain events. Sample results therefore represent those same conditions. Table 22 contains selected water quality results for this site.

Dissolved Concentrations - 1988

Four of the fourteen 1988 samples represent base flow conditions with one of the four collected during the all-time low flow (USGS, 1989), therefore establishing low flow concentrations. Seven of the fourteen 1988 samples were collected during one storm event via the automatic sampler.

Copper concentrations ranged from 71 ug/l, to 250 ug/l with 158 ug/l the mean. Those concentrations exceed both the acute and chronic aquatic life standards (27 ug/l and 17 ug/l, respectively). The low flow (9/5/88) concentration (71 ug/l) exceeded the acute standard by two-fold, while exceeding the chronic standard over four-fold. The maximum storm event sample concentration of 250 ug/l exceeded the acute and chronic standards by over nine-fold and fourteen-fold, respectively.

Zinc concentrations followed the same trend as exhibited by copper. Zinc concentrations ranged from 510 ug/l to 2520 ug/l, with 1121 the mean. Low flow concentrations exceeded aquatic life standards, both acute and

TABLE 22
SELECTED ANALYTICAL RESULTS AND STATISTICS
SILVER BOW CREEK BELOW BLACKTAIL CREEK AT BUTTE, MT

DATE (MM/DD/YR)	TIME (HRS)	FLOW (cfs)	DISSOLVED CONCENTRATION Fe (ug/l)	Mn (ug/l)	Al (ug/l)	Cu (ug/l)	Pb (ug/l)	Zn (ug/l)	As (ug/l)
07/27/88	15:00	15	58	550	<30	100	<40	510	6.5
08/06/88	11:05	17	64	770	<30	77	<40	840	9.7
09/05/88	10:30	14	32	730	<30	71	<40	810	9.2
09/11/88	17:10	14	64	1220	100	110	100	1700	7.8
09/18/88	04:00	29	75	830	<30	180	<40	2200	9.9
09/27/88	16:30	39	69	570	60	106	<40	1020	8.3
10/17/88	02:40	98	160	1220	140	210	<40	2520	18.0
11/03/88	09:10	56	190	680	110	150	50	800	11.0
11/03/88	09:40	50	290	540	1360	230	220	720	11.0
11/03/88	10:10	50	230	590	890	250	150	850	11.0
11/03/88	10:40	50	230	620	840	210	<40	920	10.0
11/03/88	11:10	39	240	640	340	240	80	1090	9.9
11/03/88	11:40	39	130	670	160	150	60	930	9.2
11/03/88	12:10	39	95	620	270	130	40	790	9.1
MEAN==>		39	138	732	427	158	100	1121	10.0
MAX===>		98	290	1220	1360	250	220	2520	18.0
MIN===>		14	32	540	60	71	40	510	6.5
NUMBER=>		14	14	14	10	14	7	14	14
04/07/89	10:58	56	350	460	50	97	<40	520	7.5
04/14/89	13:26	35	280	490	<30	110	<40	650	5.7
04/21/89	12:45	30	100	540	30	91	<40	630	6.4
04/22/89	07:50	58	170	490	<30	130	110	670	6.4
04/28/89	14:12	26	160	580	<30	120	<40	750	6.4
05/15/89	19:00	79	78	540	30	130	<40	920	16.0
05/15/89	20:50	127	110	560	<30	142	<40	820	13.0
05/28/89	20:25	37	87	380	<30	137	<40	589	6.8
06/09/89	13:00	19	67	610	<30	113	<40	603	9.3
06/27/89	15:15	71	49	960	<30	147	<40	1070	9.0
MEAN==>		54	145	561	37	122	110	722	8.7
MAX===>		127	350	960	50	147	110	1070	16.0
MIN===>		19	49	380	30	91	110	520	5.7
NUMBER=>		10	10	10	3	10	1	10	10

TABLE 22 (continued)
SELECTED ANALYTICAL RESULTS AND STATISTICS
SILVER BOW CREEK BELOW BLACKTAIL CREEK AT BUTTE, MT

BIOLOGICALLY AVAILABLE CONCENTRATION

	Flow (cfs)	Fe (ug/l)	Mn (ug/l)	Al (ug/l)	Cu (ug/l)	Pb (ug/l)	Zn (ug/l)	As (ug/l)
11/03/88 09:10	56	27400	2930	10100	7150	970	8320	276.0
11/03/88 09:40	50	6620	940	2530	1430	220	2210	55.0
11/03/88 10:10	50	3940	780	1710	940	110	1760	40.0
11/03/88 10:40	50	3100	760	1360	800	110	1640	35.0
11/03/88 11:10	39	2290	730	980	630	110	1490	28.0
11/03/88 11:40	39	2000	710	800	600	40	1600	27.0
11/03/88 12:10	39	1740	730	650	530	<40	1450	24.0
MEAN==>	46	6727	1083	2590	1726	260	2639	69.3
MAX===>	56	27400	2930	10100	7150	970	8320	276.0
MIN===>	39	1740	710	650	530	40	1450	24.0
NUMBER=>	7	7	7	7	7	6	7	7
04/07/89 10:58	56	1620	540	480	180	50	580	13.0
04/14/89 13:26	35	890	500	90	170	70	650	8.5
04/21/89 12:45	30	860	540	200	170	<40	670	10.0
04/22/89 07:50	58	2060	630	1170	460	80	1080	17.0
04/28/89 14:12	26	730	580	110	220	<40	900	12.0
05/15/89 19:00	79	3670	1960	2930	1040	50	3160	86.0
05/15/89 20:50	127	4010	1000	1920	1050	290	1800	54.0
05/28/89 20:25	37	2090	580	870	603	<40	1160	32.0
06/09/89 13:00	19	560	610	<30	207	<40	770	12.0
06/27/89 15:15	71	7040	2540	4860	2880	690	4910	100.0
MEAN==>	54	2350	948	1403	698	205	1568	34.5
MAX===>	127	7040	2540	4860	2880	690	4910	100.0
MIN===>	19	560	500	90	170	50	580	8.5
NUMBER=>	10	10	10	9	10	6	10	10

TOTAL RECOVERABLE CONCENTRATION

	Flow (cfs)	Fe (ug/l)	Mn (ug/l)	Al (ug/l)	Cu (ug/l)	Pb (ug/l)	Zn (ug/l)	As (ug/l)
05/28/89 20:25	37	5780	600	3675	591	<40	1120	40.0
06/09/89 13:00	19	620	610	30	200	<40	747	15.0
MEAN==>	28	3200	605	1853	396	0	934	27.5
MAX===>	37	5780	610	3675	591	0	1120	40.0
MIN===>	19	620	600	30	200	0	747	15.0
NUMBER=>	2	2	2	2	2	0	2	2

chronic, by over four-fold and five-fold, respectively, while maximum storm event concentrations exceeded acute and chronic standards by over fourteen-fold and sixteen-fold, respectively.

Arsenic concentrations were below the aquatic life standards and ranged from 6.5 ug/l to 18 ug/l, with 10 ug/l the mean.

The only occurrence of lead concentrations exceeding the acute aquatic life standards was in 2 of the 7 samples collected with the automatic sampler (flow activated). These two concentrations were 150 ug/l and 220 ug/l.

Bio-available Concentrations - 1988

Seven bio-available concentration samples were collected in 1988. These samples were collected via the flow activated sampler and had concentrations considerably greater than dissolved samples collected simultaneously. The samples were collected during one storm event (November 3, 1988).

Bio-available concentrations corresponded nicely with flow rates, that is, maximum concentrations occurred with maximum flows. Since this is different than trends exhibited by dissolved concentrations, during this event, it could be that the elevated concentrations were reflective of suspended sediment concentrations. It is logical to assume that maximum sediment loads would occur with maximum flows, therefore the suspended material must be high in metal concentrations. Figures 38-41 are examples of concentration differences during the November storm.

Iron concentrations exceeded the aquatic standard of 1000 ug/l in all seven samples, with concentrations ranging from 1740 ug/l to 27,400 ug/l, with 6730 ug/l the mean, Figure 38.

While no comparison is made for aluminum concentrations with aquatic standards, they ranged from 650 ug/l to 10,100 ug/l, with 2,590 ug/l the mean. These values, for the most part, are double the dissolved concentrations.

Copper concentrations greatly exceeded the acute and chronic aquatic standards in all seven samples. Concentrations ranged from 530 ug/l to 7,150 ug/l, Figure 39, with the mean being 1,726 ug/l.

Zinc concentrations showed similar trends, with their concentrations exceeding the aquatic standards. Concentrations ranged from 1,450 ug/l to 8,320 ug/l, Figure 40, with the mean being 2,639 ug/l.

The first arsenic sample during this storm exceeded the chronic aquatic life standard. Arsenic concentrations ranged from 24 ug/l to 276 ug/l, with the mean being 69.3 ug/l, Figure 41.

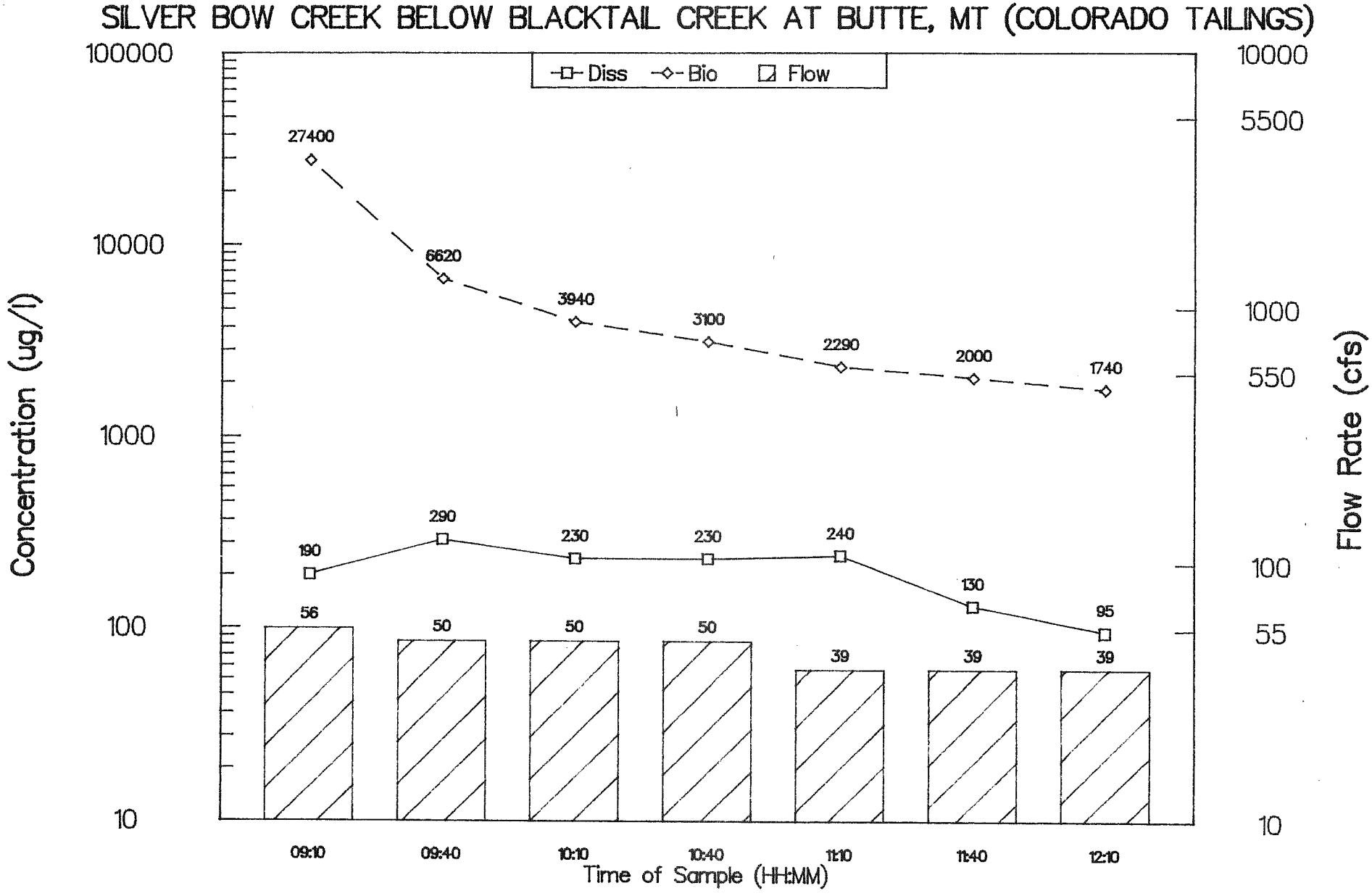


FIGURE 38 – IRON CONCENTRATION COMPARISONS, NOVEMBER 03, 1988 STORM EVENT

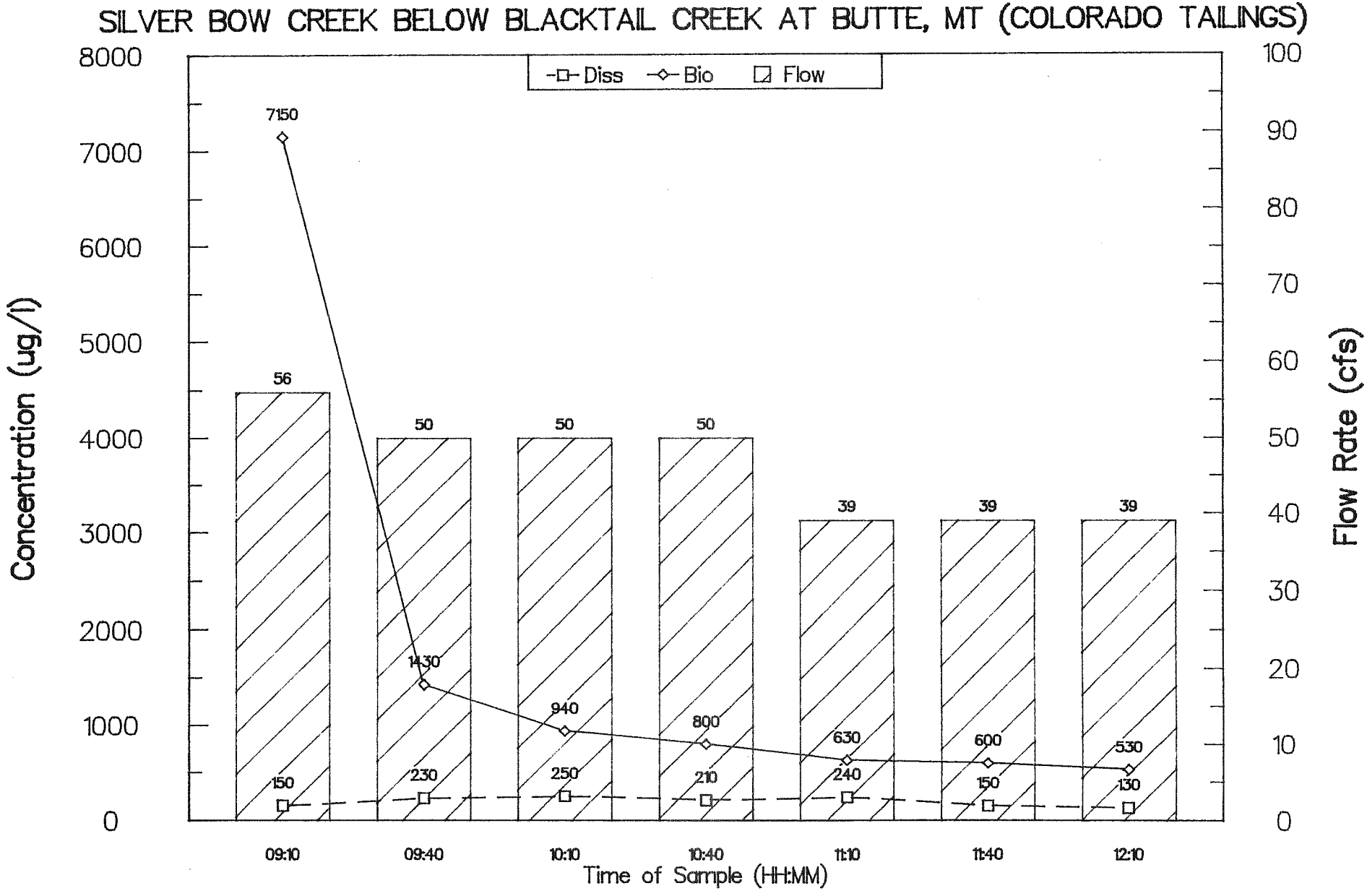


FIGURE 39 – COPPER CONCENTRATION COMPARISONS, NOVEMBER 03, 1988 STORM EVENT

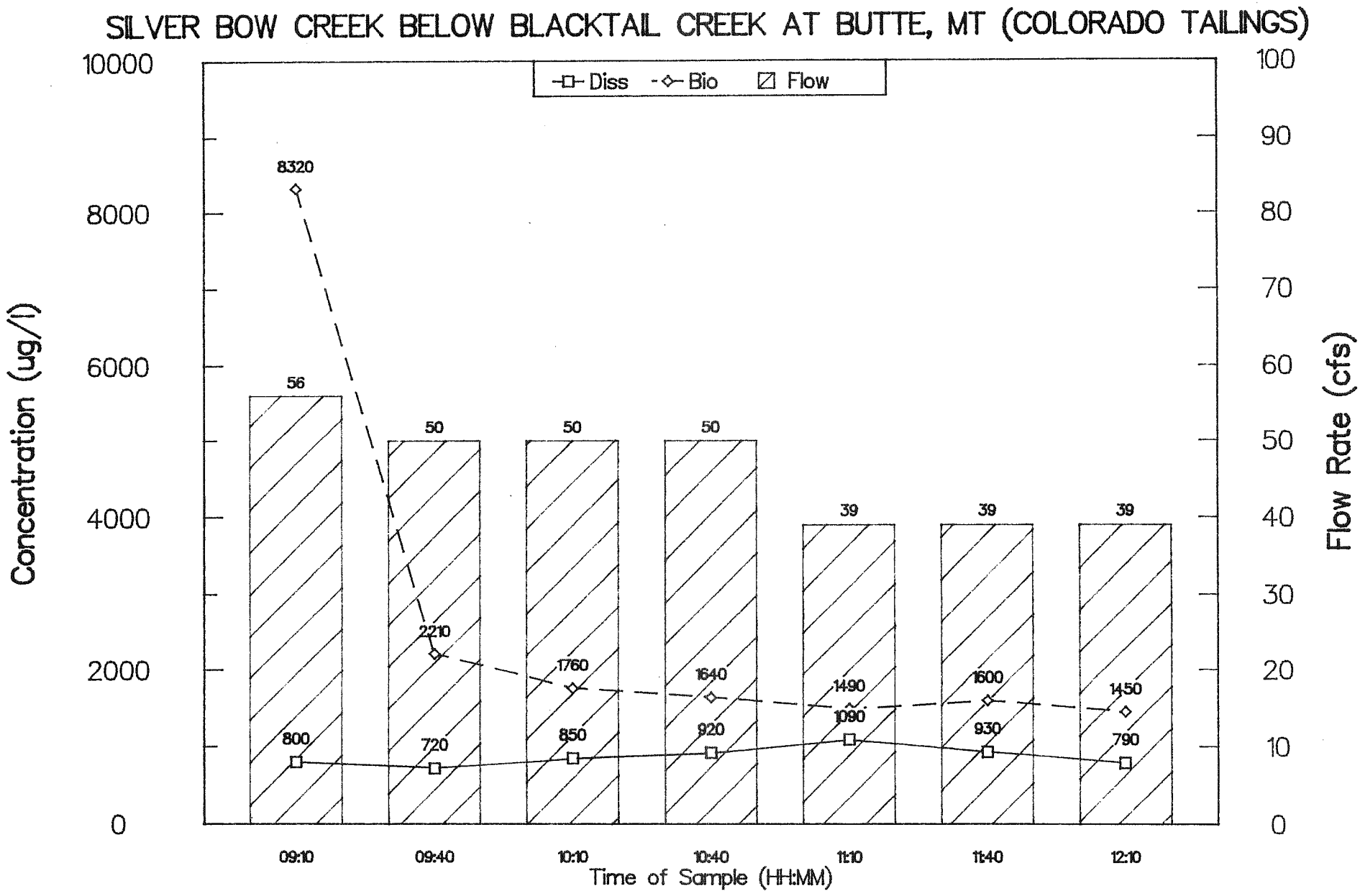


FIGURE 40 – ZINC CONCENTRATION COMPARISONS, NOVEMBER 03, 1988 STORM EVENT

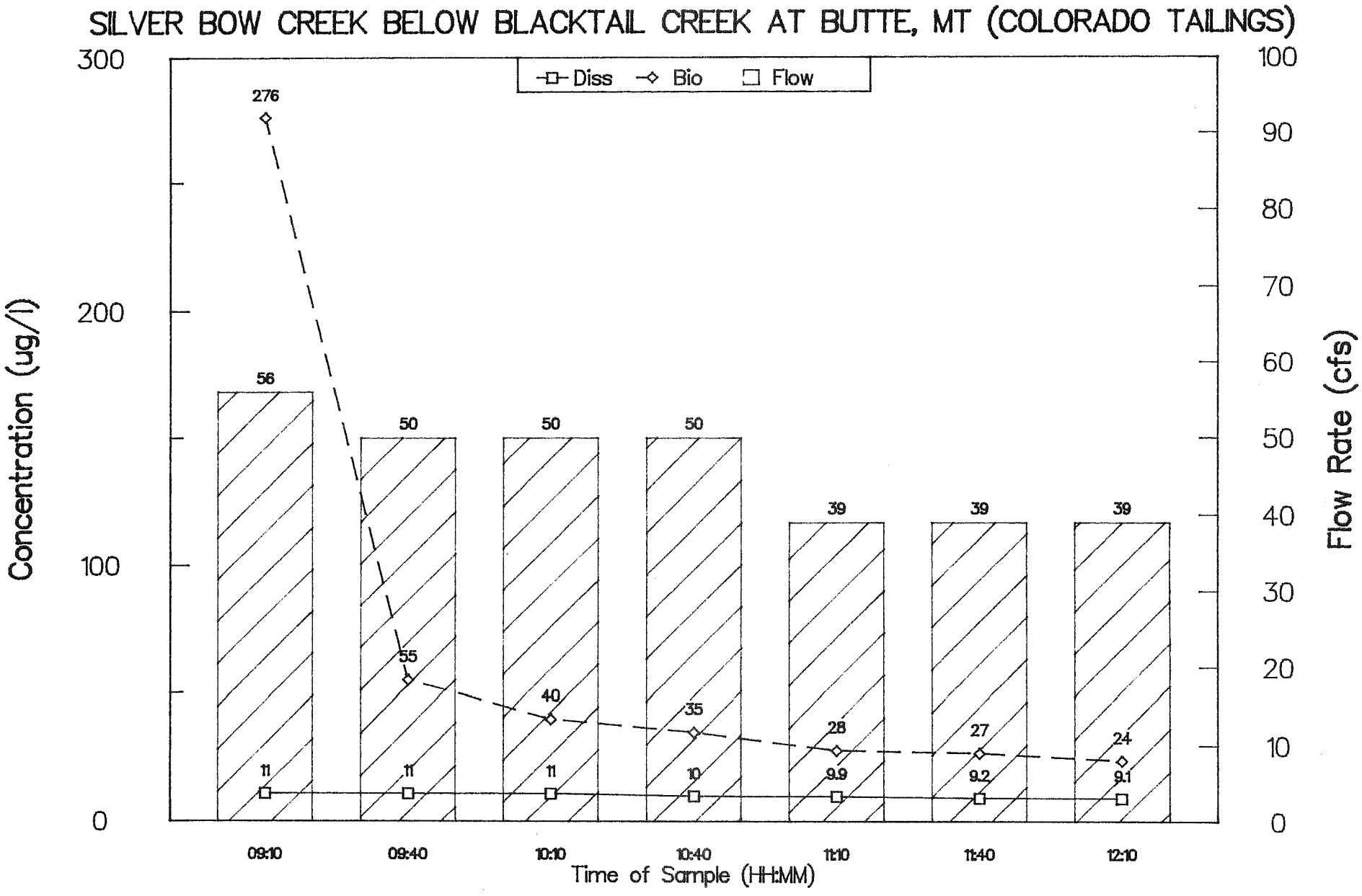


FIGURE 41 – ARSENIC CONCENTRATION COMPARISONS, NOVEMBER 03, 1988 STORM EVENT

SILVER BOW CREEK BELOW BLACKTAIL CREEK AT BUTTE, MT. (CONT).

Dissolved Concentrations - 1989

Ten sampling episodes occurred at this site during 1989. Sampling episodes occurred during spring base flow, runoff from snowmelt and storm runoff. Stream flow (cfs) varied from 19 cfs to 127 cfs, with 54 cfs the mean.

Dissolved copper concentrations ranged from 91 ug/l to 147 ug/l, with 122 ug/l the mean. These concentrations exceeded both the acute and chronic aquatic life standards by a considerable amount, at least 3-fold.

Zinc concentrations ranged from 520 ug/l to 1,070 ug/l, with 722 u/gl the mean and exceeded both the aquatic life standards during all sampling episodes.

Arsenic concentrations did not exceed any aquatic life standards. Concentrations ranged from 5.7 ug/l to 16 ug/l, with 8.7 ug/l the mean.

1989 minimum copper, zinc and arsenic concentrations closely resembled minimum 1988 concentrations, while lead concentrations varied substantially. Fifty percent of the 1988 samples had detectable lead concentrations, while only 10% of the 1989 had detectable lead.

Bio-available Recoverable Concentrations - 1989

Bio-available samples were collected during the same sampling episodes as the dissolved, Table 22. Therefore comparisons can be made between these two sample types, Figures 42-45.

Seven of the ten iron samples exceeded the aquatic life standard. Values ranged from 560 ug/l to 7,040 ug/l, with 2,350 ug/l the mean, Figure 42.

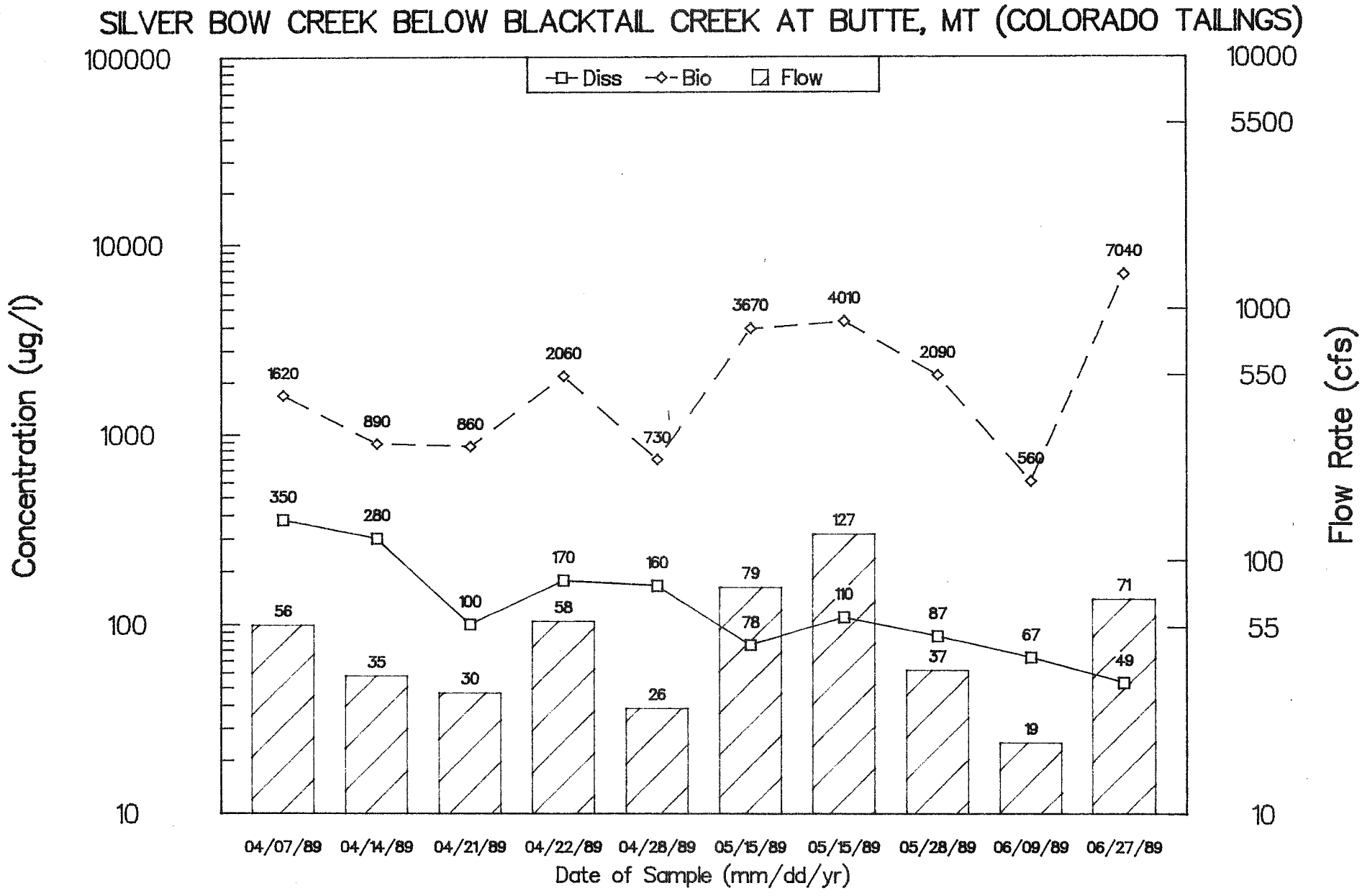


FIGURE 42 – IRON CONCENTRATION COMPARISONS, 1989

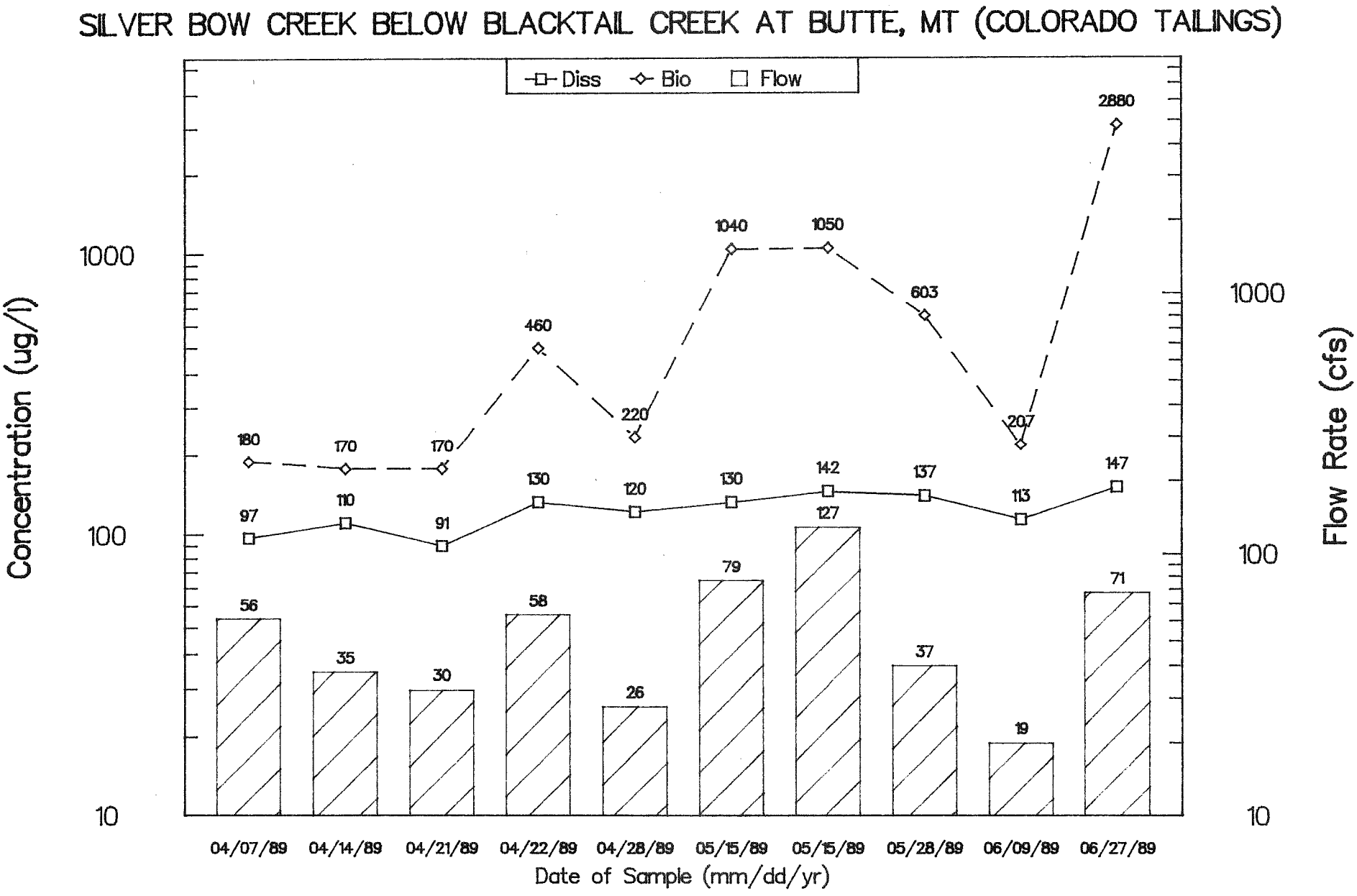


FIGURE 43 – COPPER CONCENTRATION COMPARISONS, 1989

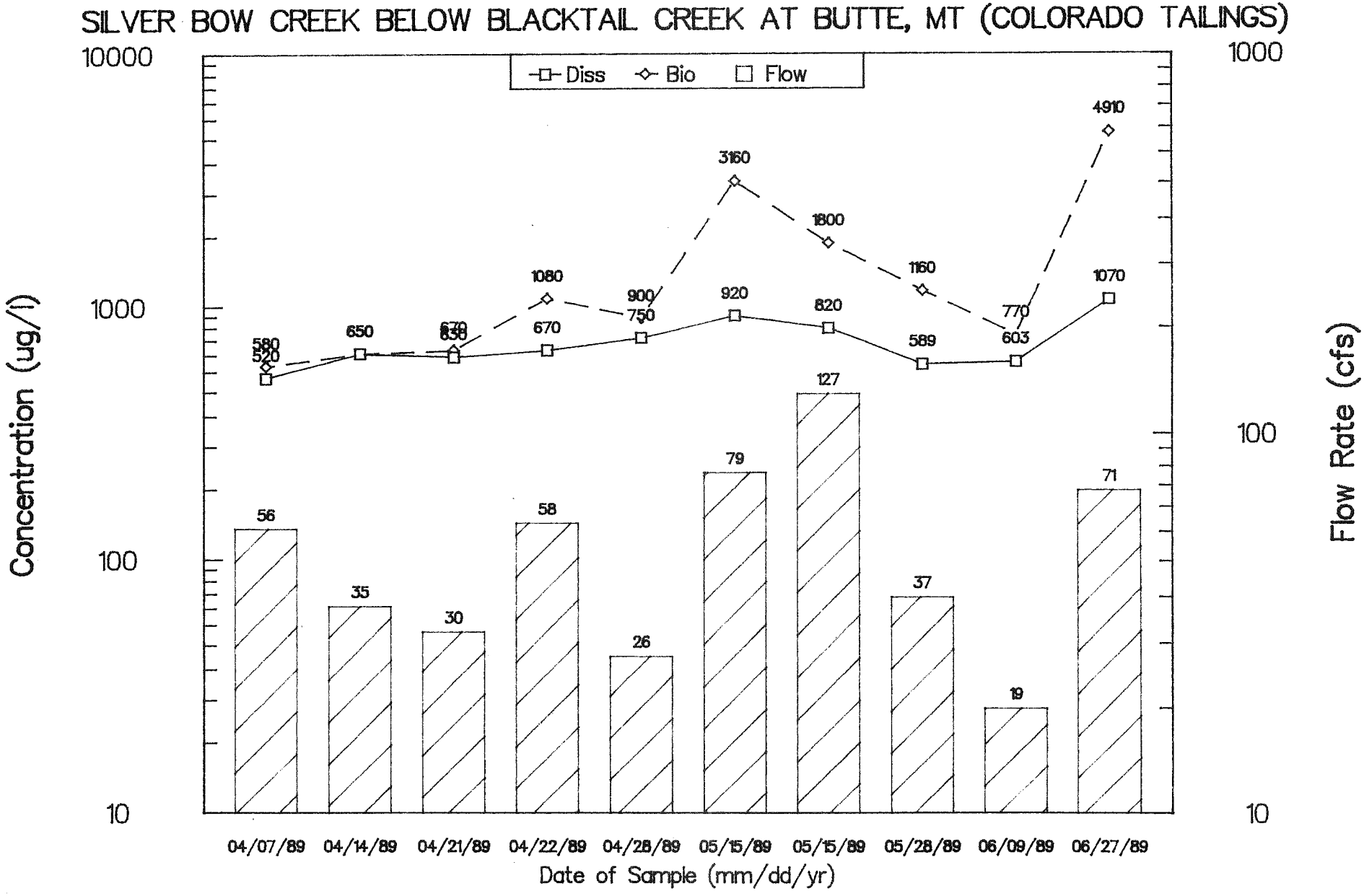


FIGURE 44 – ZINC CONCENTRATION COMPARISONS, 1989

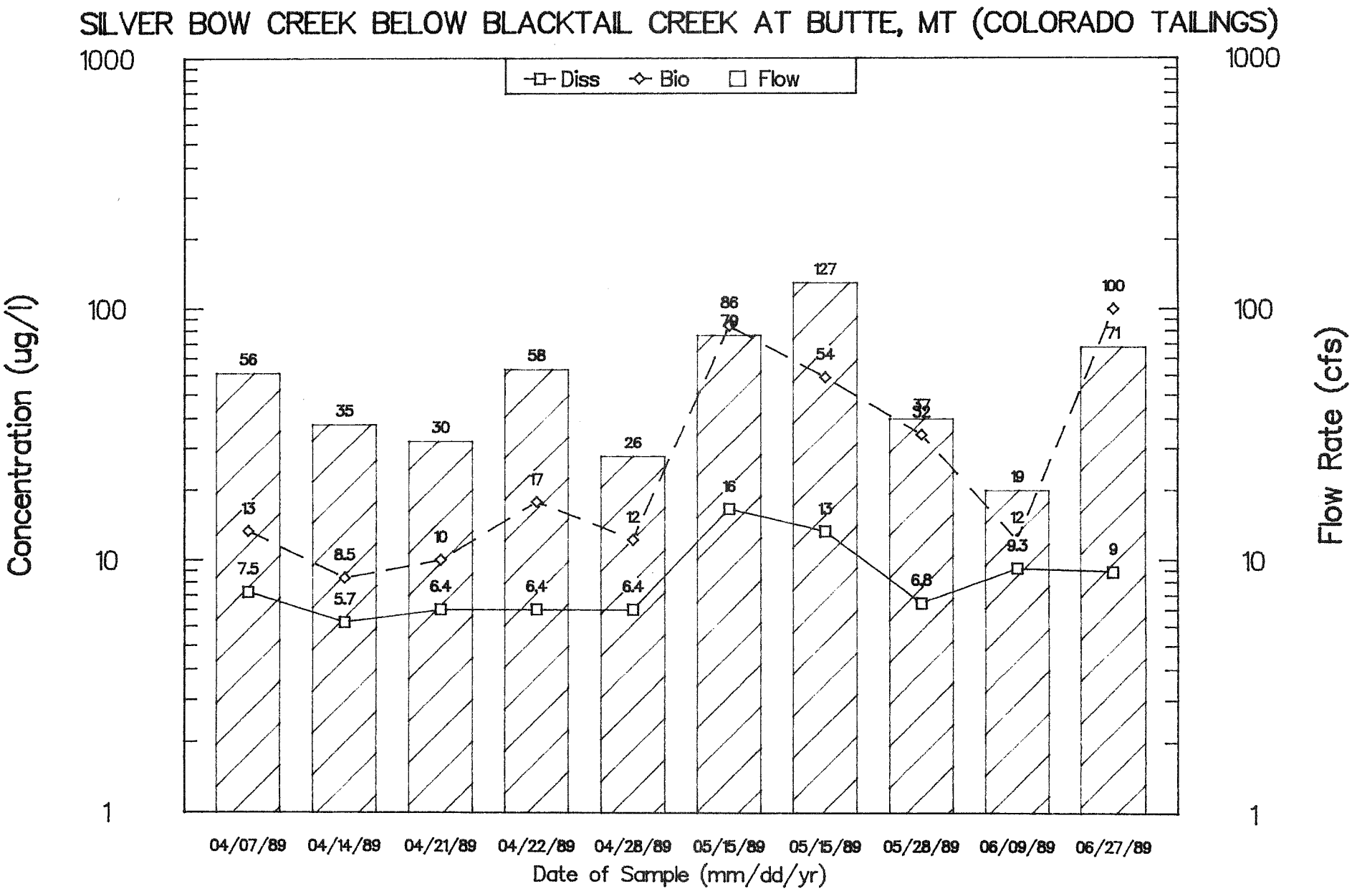


FIGURE 45 – ARSENIC CONCENTRATION COMPARISONS, 1989

Nine of the ten samples had detectable aluminum concentrations, with those concentrations ranging from 90 ug/l to 4,860 ug/l, with 1,403 ug/l the mean. This range of concentrations is from 3-fold (for minimum values), to almost 2000-fold (for maximum concentrations) in excess of dissolved aluminum concentrations.

All ten samples had detectable concentrations of copper, with concentrations ranging from 170 ug/l to 2,880 ug/l, with 698 ug/l the mean, Figure 43. All of these greatly exceed the acute (27 ug/l) and chronic (17 ug/l) aquatic life standards. These concentrations are considerably above dissolved copper concentrations previously discussed.

Zinc concentrations exceeded acute and chronic aquatic life standards in all ten samples. These concentrations ranged from 580 ug/l to 4,910 ug/l, with 1,568 ug/l the mean, Figure 44. The bio-available zinc values also greatly exceeded the dissolved concentrations.

None of the ten arsenic samples exceeded the acute (360 ug/l) or chronic (190 ug/l) aquatic life standards, but the bio-available concentrations are considerably higher than the dissolved arsenic concentrations from the same sampling episodes. Arsenic concentrations ranged from 8.5 ug/l to 100 ug/l, with 34.5 ug/l the mean, Figure 45.

Maximum bio-available concentrations occurred during the June 27, 1989 storm, which was discussed in the monitoring section. Dissolved concentrations for manganese, copper and zinc were at their maximum during this storm also. Bio-available concentrations are considerably greater than dissolved concentrations which once again can probably be attributed to higher stream flows (Figure 8) and its corresponding increased sediment load,

while the increase of several of the dissolved parameters during this storm could be attributed in part to the pH decline observed, Figure 9a.

Total Recoverable Concentrations - 1989

Total recoverable samples were collected at this location during two sampling episodes. The reasoning behind this was for comparative purposes with other sampling studies, i.e., Water Quality Bureau, which utilize different sampling and analysis procedures. These samples occurred during storm and non-storm periods. During the May 28, 1989 storm, the iron and aluminum total recoverable concentrations of 5,780 ug/l and 3,675 ug/l were significantly greater than bio-available concentrations on that same day. Total recoverable iron was almost 3-fold greater than bio-available, while aluminum concentrations were over 4-fold greater than bio-available concentrations. During the non-storm sampling on June 9, 1989, concentrations of total recoverable constituents are very similar to bio-available concentrations for those same constituents.

SILVER BOW CREEK AT OPPORTUNITY, MT (STEWART BRIDGE)

This station was part of the 1988 and 1989 sampling program. Twenty-four sampling episodes occurred during 1988 sampling, while 10 episodes occurred during 1989 sampling. Stream flows varied from 15 cfs to 54 cfs, with a mean of 33 cfs in 1988, while during 1989 they varied from 44 cfs to 129 cfs, with a mean of 79 cfs. Stream flows represent low flow, spring runoff base flows and snowmelt flows, and storm event runoff flows for both snow and rain events. Water quality results therefore represent those same conditions. Table 23 contains selected water quality results for this site.

Dissolved Concentrations - 1988

Twenty-four samples were collected during 1988, seventeen of which were collected during three storm events. The storm event samples were collected with the flow activated sampler. As was mentioned previously, this site was established by the USGS for this project, therefore it has a very short period of record. Water quality samples though, were collected on days of minimum and maximum flow periods, (USGS, 1989), for water year 1988 (October 1987 through September 1988).

Iron concentrations ranged from 17 ug/l to 1530 ug/l, with a mean of 124 ug/l. These values exceeded the aquatic life criteria once. Copper concentrations ranged from 38 ug/l to 330 ug/l, with a mean of 69 ug/l. There does appear to be an increase in concentrations during storm events. Mean concentrations during non-storm sampling was 49.3 ug/l, while mean concentrations during 3 storms (automatic sampler samples) were 56 ug/l, 92 ug/l, and 69 ug/l, respectively. All of these concentrations exceed the acute and chronic aquatice life standards.

Zinc concentrations ranged from 28 ug/l to 1750 ug/l, with a mean of 549 ug/l. Twenty-one of the twenty-four zinc samples exceeded both the acute (170 ug/l) and chronic (154 ug/l) aquatic life standards. The three samples which did not exceed standards were non-storm samples.

Non-storm mean concentrations were 40 ug/l, a 15-fold decrease. Obviously, zinc concentrations were dramatically affected by storm events. Figures 46-47 are examples of zinc concentrations during two storm events.

None of the arsenic samples exceeded aquatic standards. Concentrations ranged from 5.6 ug/l to 26 ug/l, with a mean of 12.3 ug/l. The three non-storm samples had the highest arsenic concentrations; the opposite of trends exhibited by copper and zinc and other trace metals.

The significant increase in trace metal concentrations is considerable when one compares pH trends during storm and non-storm events; pH values ranged from 6.7 to 9.5, with a mean value of 8.2. With the exception of the minimum pH of 6.7 on one instance, no other pH values were less than 7.8. Therefore the increase in concentration levels does not appear to be caused by increased metal solubility caused by depressed pH values. Evidently the metal phase of the source contamination is very soluble under non-acidic conditions, which is similar to trends reported by CH_2M Hill (1990).

Bio-Available Concentrations - 1988

Bio-available samples were collected only during the three storms, when samples were collected via the automatic sampler. As such, no comparison can be made of storm and non-storm bio-available concentrations.

Sixteen of the seventeen samples collected had iron concentrations in excess of the aquatic standard (1000 ug/l). Concentration ranged from 260 ug/l to 5820 ug/l, with a mean of 2800 ug/l. The highest iron concentrations were the first sample in each of the three sampled storm events, with sample concentrations decreasing throughout the rest of the storm event, Figure 48a. These concentrations, on the whole, are 100 times greater than those noted for the dissolved iron concentrations, a significant increase, Figure 48b; only one sample deviated from this trend.

All seventeen bio-available copper concentrations exceeded the aquatic standards. Concentrations ranged from 68 ug/l to 1420 ug/l, with a mean of 688 ug/l. Copper concentrations followed the same pattern as iron, with the first sample in each storm having the highest concentrations, Figure 49a. Bio-available concentrations were also considerably higher than the dissolved, Figure 49b, but not to the extremes seen in the iron samples. The maximum increase from dissolved copper to bio-available copper was about 30-fold, which is still significant.

Zinc concentrations followed the same pattern as iron and copper. Bio-available concentrations during the three sampled events ranged from 470 ug/l to 3420 ug/l, with a mean concentration of 1979 ug/l, Figure 50a. The maximum increase from dissolved zinc concentrations to bio-available concentration was about six-fold, 460 ug/l to 3420 ug/l, also a significant increase, Figure 50b.

Arsenic concentrations ranged from 6.3 ug/l to 55 ug/l, with a mean of 33.7 ug/l, Figure 51a, which are below the aquatic life standards. Bio-available arsenic concentrations were more scattered throughout the three storm events and did not follow the same pattern as iron, copper and zinc concentrations with the first sample of each storm having the highest concentration. However, it did follow the trend that the bio-available samples had concentration levels considerably greater than dissolved levels, Figure 51b. The maximum increase was about 6-fold, 8.9 ug/l to 55 ug/l, also a significant increase.

TABLE 23
SELECTED ANALYTICAL RESULTS AND STATISTICS
SILVER BOW CREEK AT OPPORTUNITY, MT

DISSOLVED CONCENTRATION

DATE (MM/DD/YR)	TIME (HRS)	FLOW (cfs)	Fe (ug/l)	Mn (ug/l)	Al (ug/l)	Cu (ug/l)	Pb (ug/l)	Zn (ug/l)	As (ug/l)
07/27/88	09:40	20	25	220	<30	50	40	28	22
08/06/88	14:10	16	40	230	50	56	40	42	26
09/05/88	12:00	15	90	210	80	42	<40	49	25
09/10/88	23:50	26	24	980	30	51	<40	390	13
09/11/88	00:20	26	170	900	60	64	<40	420	11
09/11/88	01:00	30	120	900	70	50	<40	359	11
09/11/88	01:30	34	130	890	<30	57	<40	377	12
09/11/88	02:00	38	120	920	60	59	<40	457	11
09/11/88	02:30	38	100	950	100	56	<40	436	12
09/11/88	03:00	29	86	940	100	55	<40	420	12
09/11/88	20:00	28	17	1160	40	54	<40	260	11
09/17/88	21:00	26	87	850	<30	53	<40	600	13
09/17/88	22:00	30	1530	1230	560	330	40	1750	12
09/17/88	23:00	31	30	890	120	42	<40	610	8.2
09/18/88	24:00	34	18	860	140	43	<40	620	10
09/18/88	01:00	35	26	950	75	50	<40	720	11
09/18/88	02:00	36	31	1060	140	50	<40	750	5.6
09/18/88	03:00	53	110	1200	180	76	<40	860	12
09/18/88	07:30	53	57	2330	80	63	70	710	12
09/27/88	15:25	28	22	530	50	38	40	120	12
09/27/88	23:50	38	37	680	40	53	60	460	8.6
09/28/88	01:50	43	24	740	<30	56	40	870	8.9
09/28/88	03:50	54	22	1300	<30	98	70	1080	6.7
10/17/88	05:00	36	68	1000	90	120	<40	780	8.3
MEAN==>		33	124	913	109	69	50	549	12.3
MAX===>		54	1530	2330	560	330	70	1750	26.0
MIN===>		15	17	210	30	38	40	28	5.6
NUMBER=>		24	24	24	19	24	8	24	24
04/07/89	12:05	129	280	600	170	130	<40	420	12
04/14/89	14:46	69	100	530	<30	75	60	290	7.9
04/21/89	14:00	88	94	400	<30	62	50	200	8.7
04/22/89	10:10	96	160	440	60	70	<40	300	8.1
04/28/89	14:57	72	92	560	60	78	<40	340	6.8
05/12/89	13:45	89	140	320	50	68	<40	170	9.3
05/15/89	10:00	76	55	380	40	55	<40	110	8.3
05/28/89	11:30	64	50	500	<30	130	<40	378	6.3
06/09/89	11:00	61	68	360	<30	25	<40	59	24.0
06/27/89	18:00	44	210	490	200	103	<40	139	9.6
MEAN==>		79	125	458	97	80	55	241	10.1
MAX===>		129	280	600	200	130	60	420	24.0
MIN===>		44	50	320	40	25	50	59	6.3
NUMBER=>		10	10	10	6	10	2	10	10

TABLE 23 (continued)
SELECTED ANALYTICAL RESULTS AND STATISTICS
SILVER BOW CREEK AT OPPORTUNITY, MT

		BIOLOGICALLY AVAILABLE CONCENTRATION						
		Fe	Mn	Al	Cu	Pb	Zn	As
		(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
09/10/88 23:50	26	4720	2900	1370	1060	110	3020	51
09/11/88 00:20	26	2800	2070	810	670	80	1960	44
09/11/88 01:00	30	2900	2170	840	700	90	2020	37
09/11/88 01:30	34	2800	2090	800	670	<40	1960	36
09/11/88 02:00	38	2730	2080	790	660	70	1940	43
09/11/88 02:30	38	2570	1990	750	610	50	1830	38
09/11/88 03:00	29	2440	1920	720	580	100	1820	32
09/17/88 21:00	26	2430	1570	1380	570	40	1850	21
09/17/88 22:00	30	1850	1400	620	450	40	1530	30
09/17/88 23:00	31	260	65	130	68	<40	470	14
09/18/88 24:00	34	2380	1590	1180	560	<40	1860	37
09/18/88 01:00	35	2110	1510	695	510	40	1715	33
09/18/88 02:00	36	1970	1540	740	490	40	1650	32
09/18/88 03:00	53	1760	1590	1430	450	40	1620	21
09/27/88 23:50	38	5820	2300	1730	1420	170	3420	6.3
09/28/88 01:50	43	4640	1940	1420	1120	140	2700	55
09/28/88 03:50	54	3410	2070	1030	1110	140	2280	43
MEAN==>	33	2800	1811	967	688	82	1979	33.7
MAX===>	54	5820	2900	1730	1420	170	3420	55
MIN===>	15	260	65	130	68	40	470	6.3
NUMBER=>	24	17	17	17	17	14	17	17
04/07/89 12:05	129	2430	890	990	580	180	900	34
04/14/89 14:46	69	1650	610	600	270	110	590	21
04/21/89 14:00	88	1280	490	610	200	<40	430	18
04/22/89 10:10	96	1070	500	390	210	50	670	18
04/28/89 14:57	72	1150	590	230	240	<50	990	14
05/12/89 13:45	89	670	360	140	140	<40	380	13
05/15/89 10:00	76	740	400	180	160	<40	420	14
05/28/89 11:30	64	770	500	<30	138	<40	513	11
06/09/89 11:00	61	1600	520	240	350	50	640	38
06/27/89 18:00	44	940	650	210	306	<40	630	18
MEAN==>	79	1230	551	399	259	98	616	19.9
MAX===>	129	2430	890	990	580	180	990	38
MIN===>	44	670	360	140	138	50	380	11
NUMBER=>	10	10	10	9	10	4	10	10

TABLE 23 (continued)
SELECTED ANALYTICAL RESULTS AND STATISTICS
SILVER BOW CREEK AT OPPORTUNITY, MT

		TOTAL RECOVERABLE CONCENTRATION						
		Fe (ug/l)	Mn (ug/l)	Al (ug/l)	Cu (ug/l)	Pb (ug/l)	Zn (ug/l)	As (ug/l)
05/28/89 11:30	64	1020	490	60	150	<40	517	10
06/09/89 11:00	61	2160	480	930	365	70	570	43
MEAN==>	63	1590	485	495	258	70	544	26.5
MAX==>	64	2160	490	930	365	70	570	43
MIN==>	61	1020	480	60	150	70	517	10
NUMBER=>	2	2	2	2	2	1	2	2

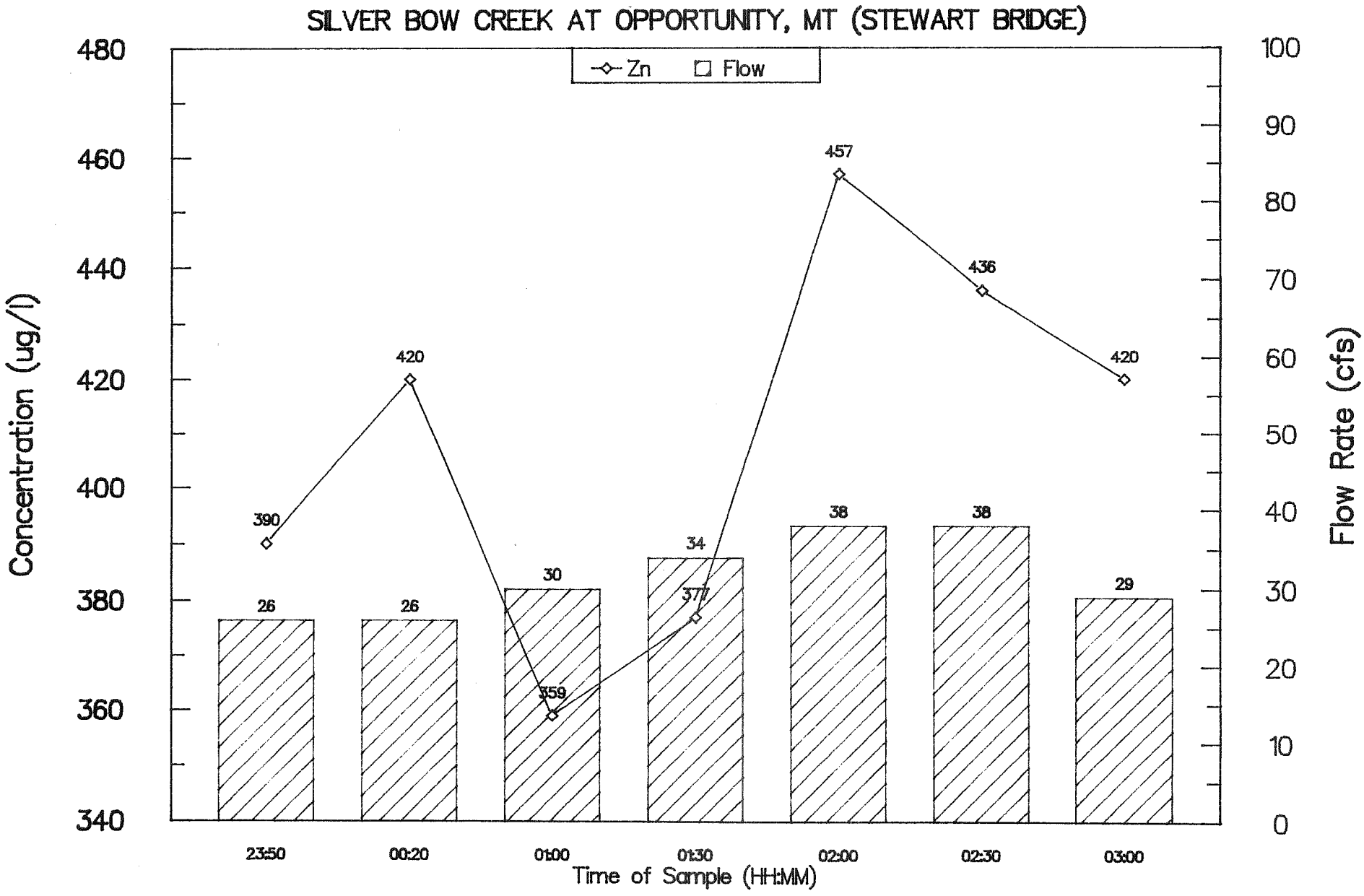


FIGURE 46 – DISSOLVED ZINC CONCENTRATIONS
SEPTEMBER 10–11, 1988 STORM EVENT

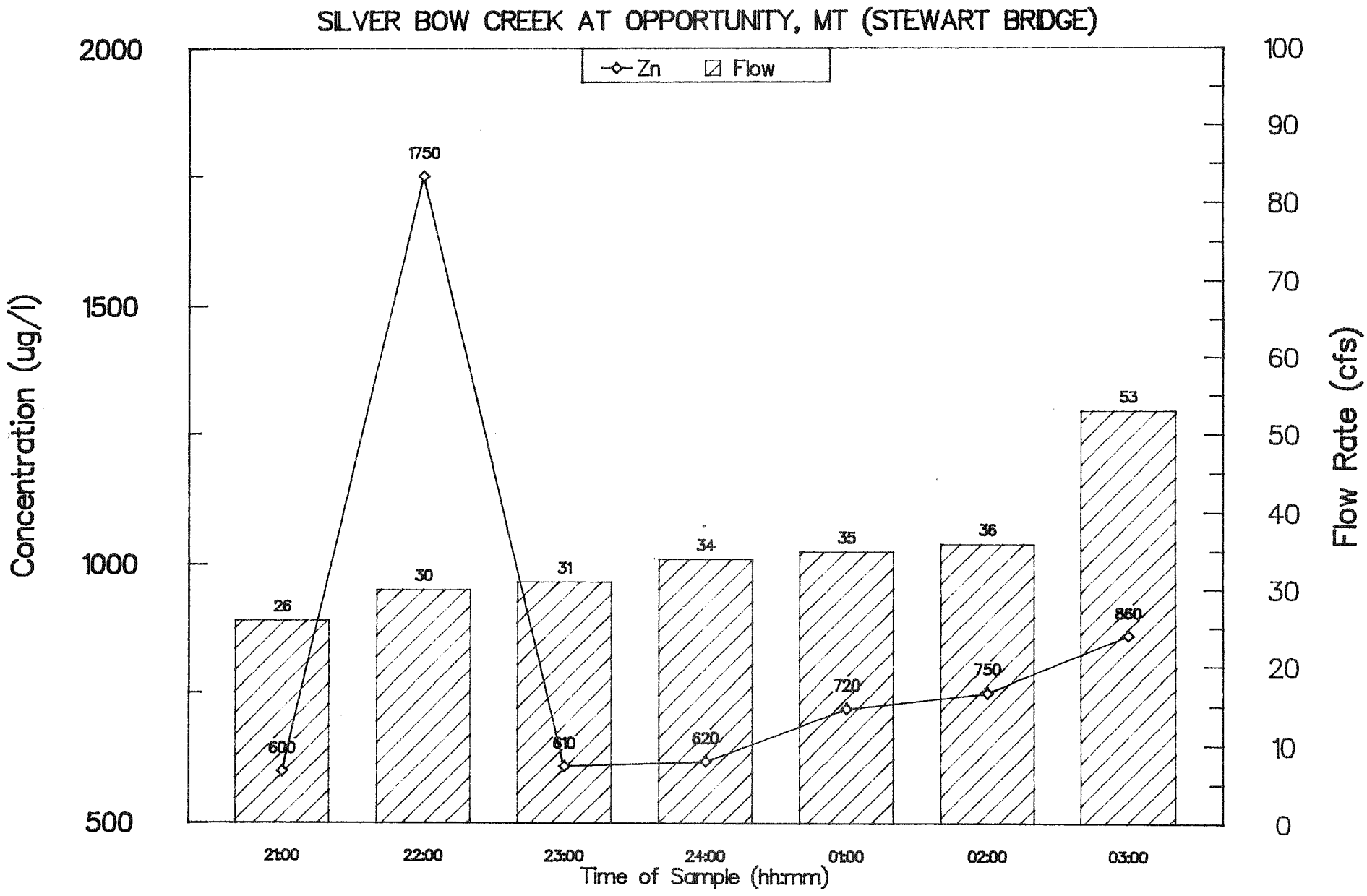


FIGURE 47 – DISSOLVED ZINC CONCENTRATIONS
SEPTEMBER 17–18, 1988 STORM EVENT

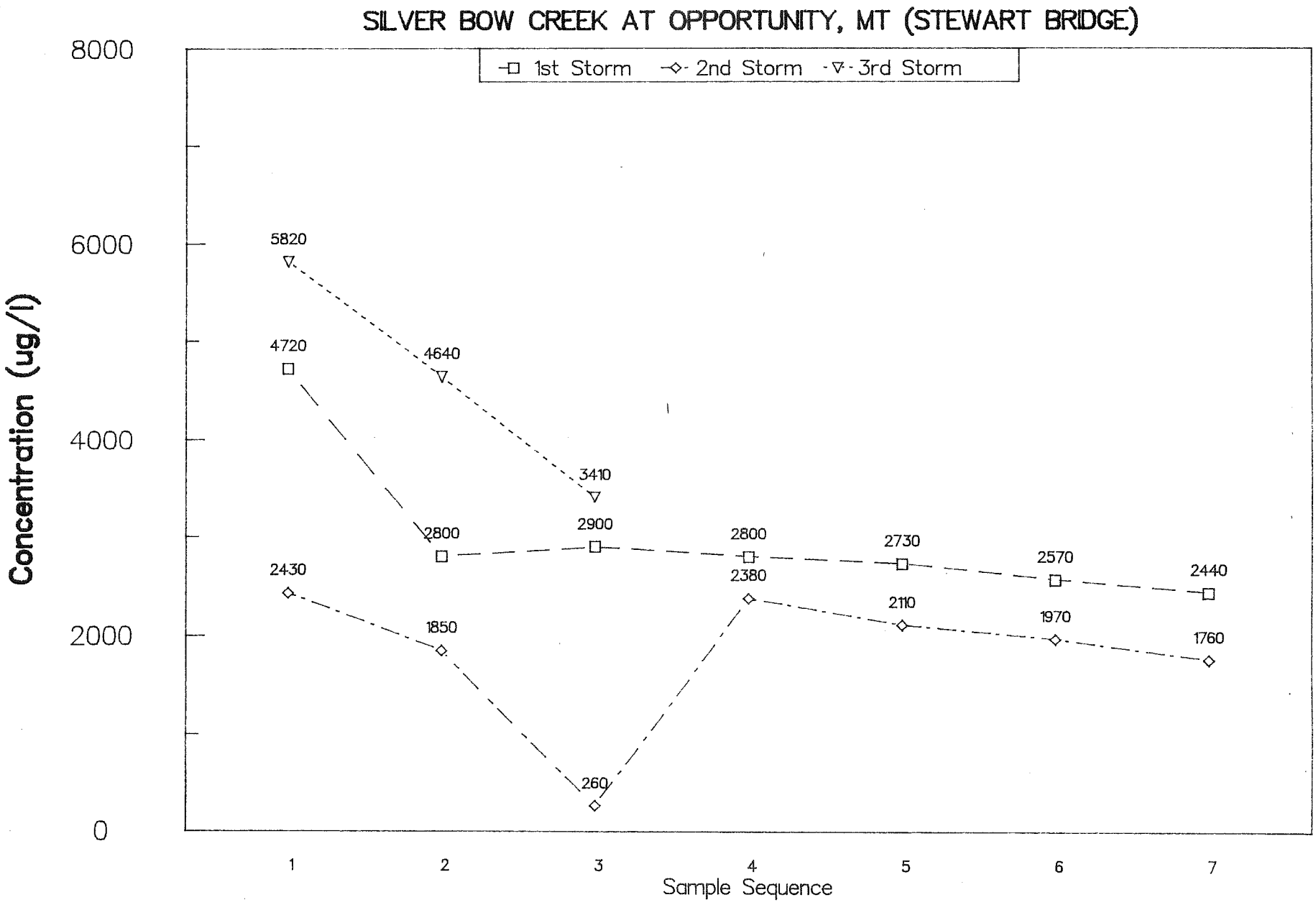


FIGURE 48a – BIO–AVAILABLE IRON CONCENTRATION COMPARISONS FOR 1988 STORM EVENTS

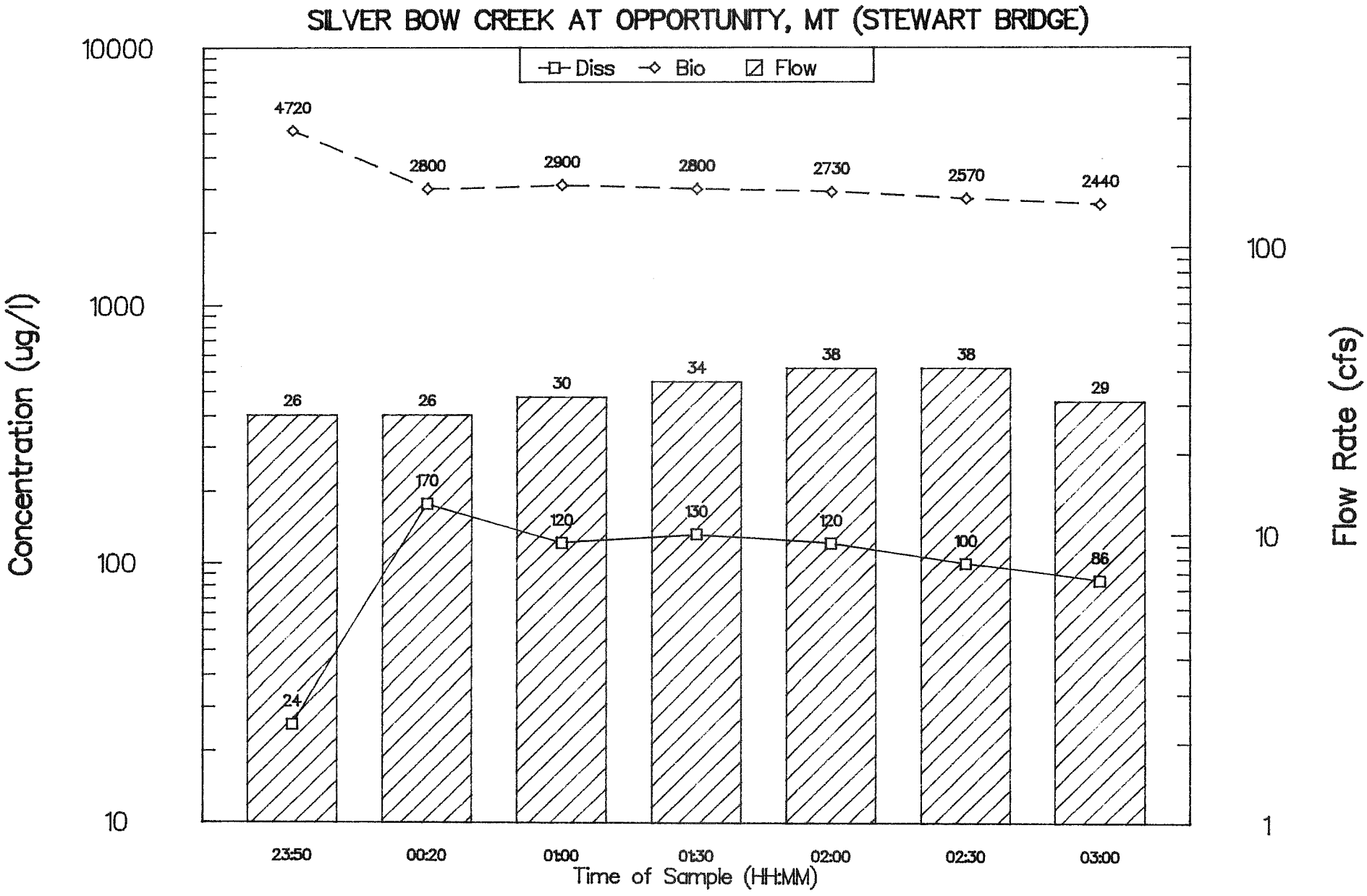


FIGURE 48b – IRON CONCENTRATION COMPARISONS, FOR SEPTEMBER 10–11, 1988 STORM EVENT

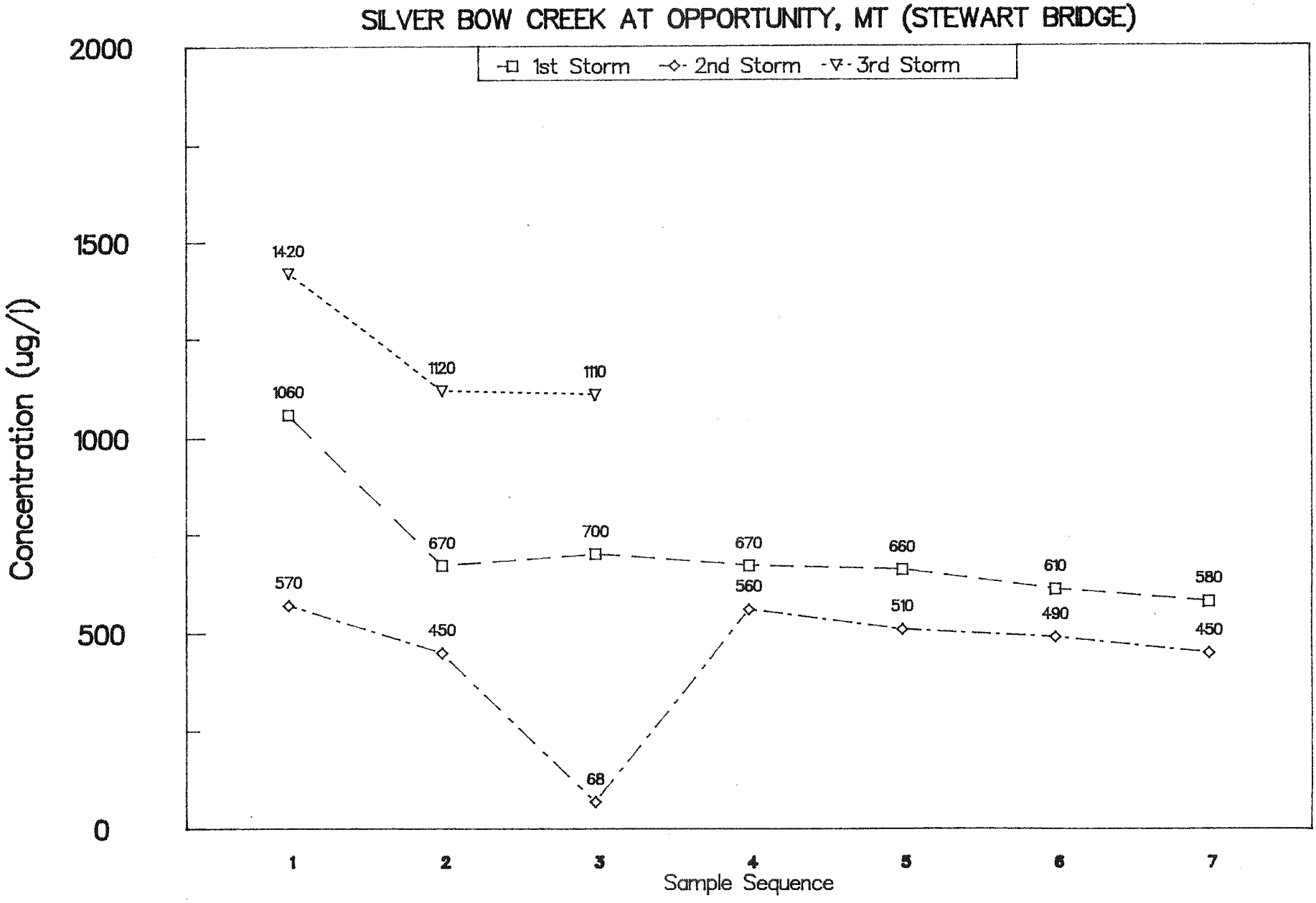


FIGURE 49a – BIO–AVAILABLE COPPER CONCENTRATION COMPARISONS FOR 1988 STORM EVENTS

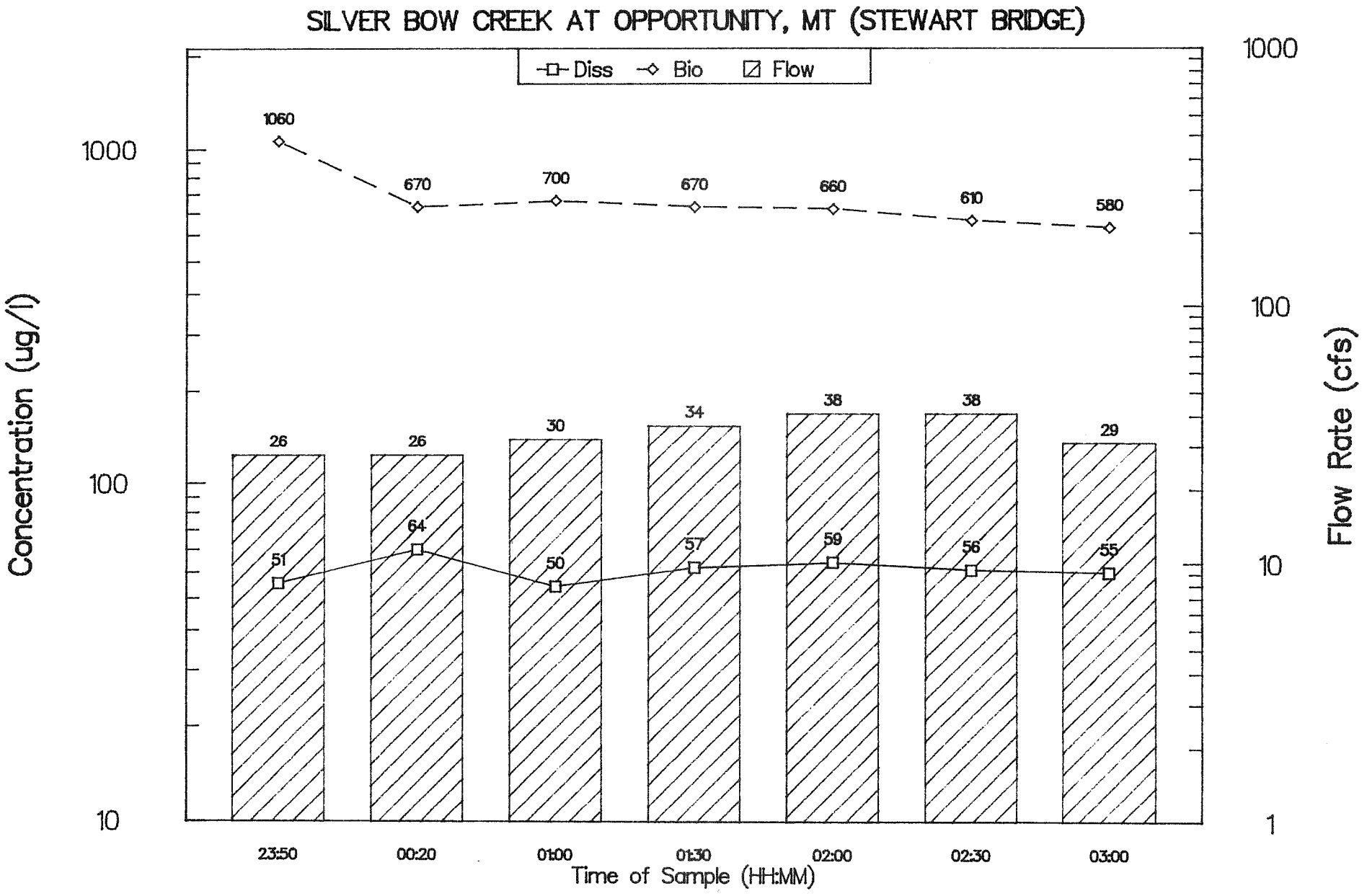


FIGURE 49b – COPPER CONCENTRATION COMPARISONS, FOR SEPTEMBER 10–11, 1988 STORM EVENT

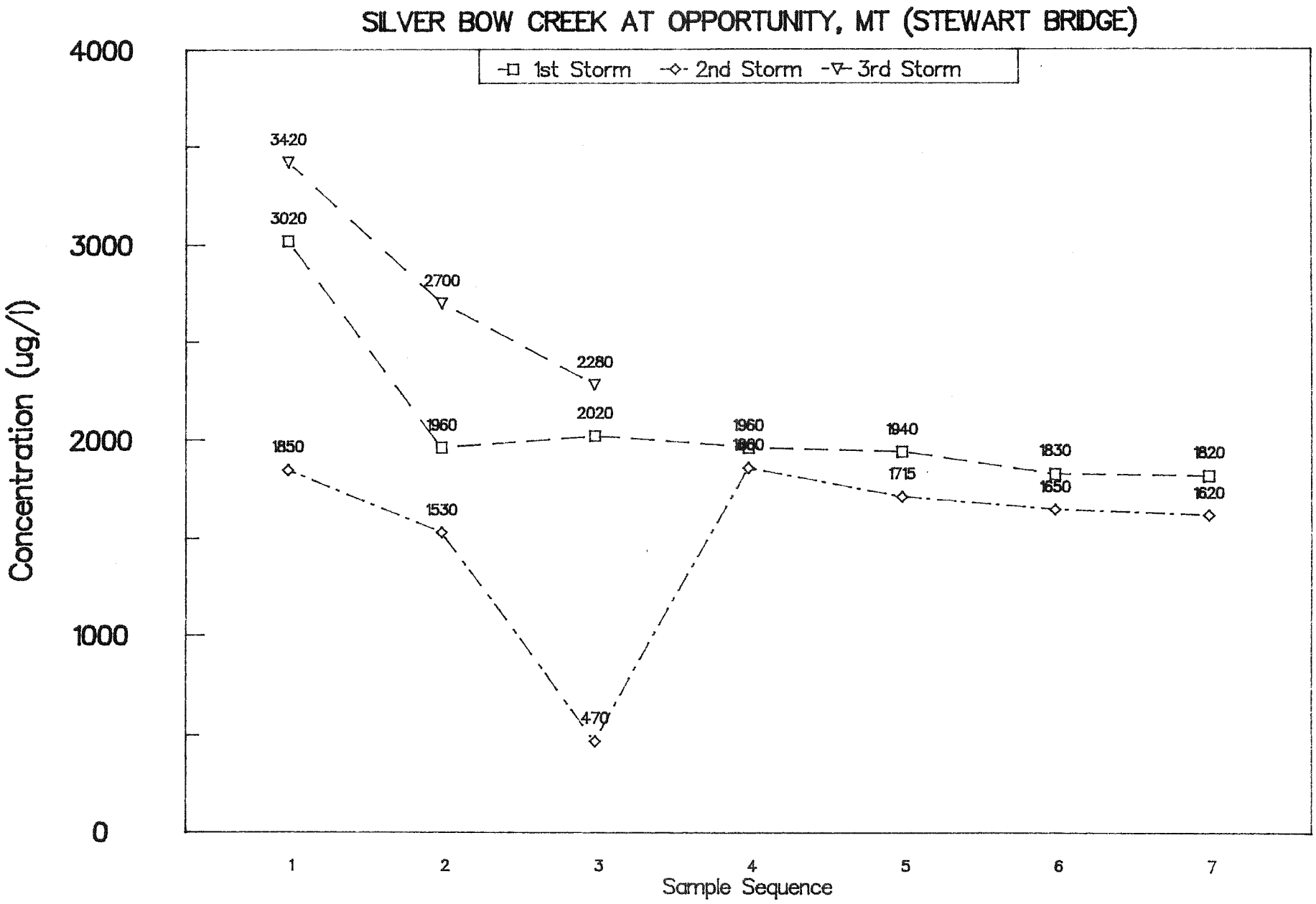


FIGURE 50a – BIO–AVAILABLE ZINC CONCENTRATION COMPARISONS FOR 1988 STORM EVENTS

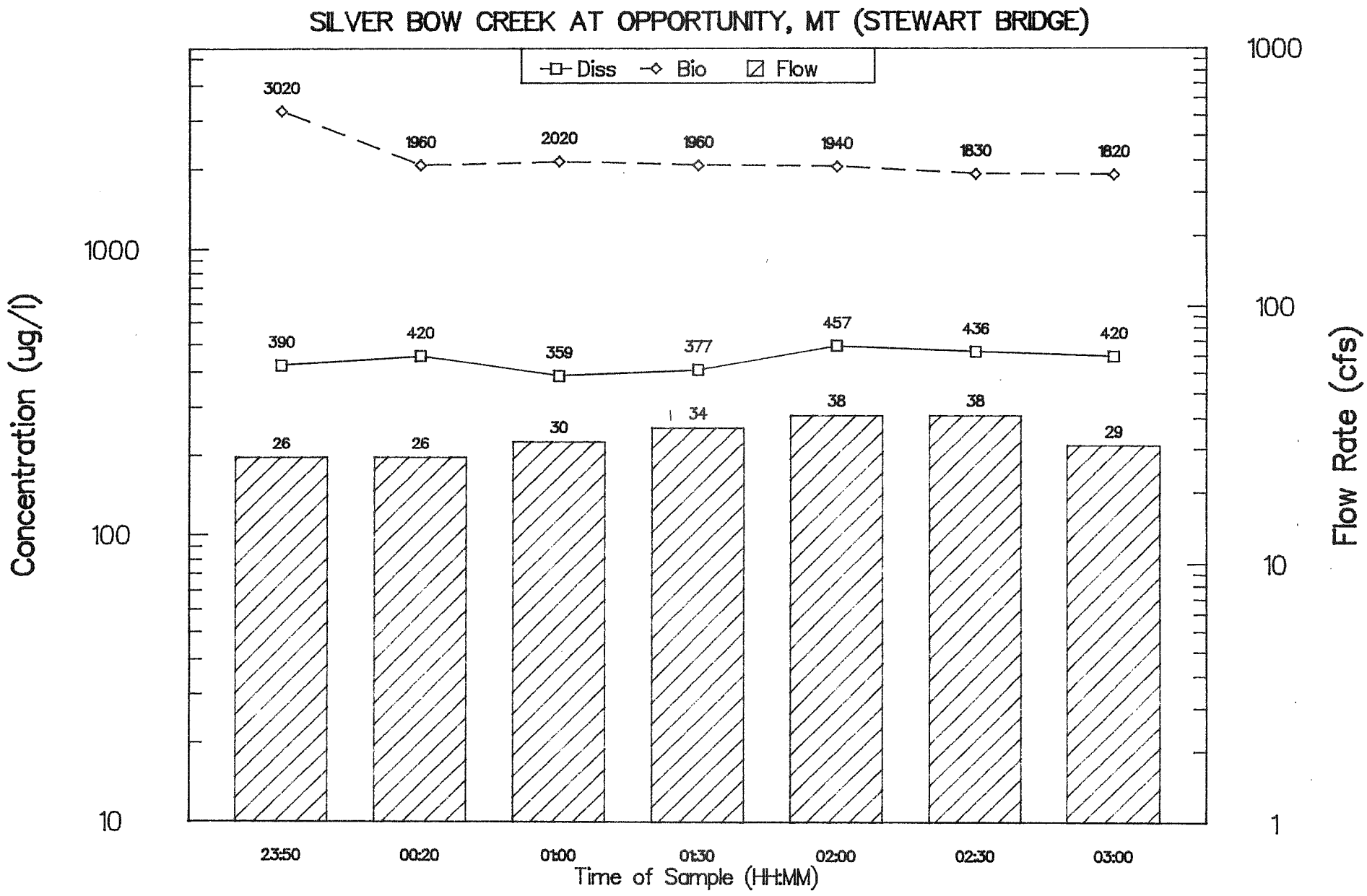


FIGURE 50b – ZINC CONCENTRATION COMPARISONS, FOR SEPTEMBER 10–11, 1988 STORM EVENT

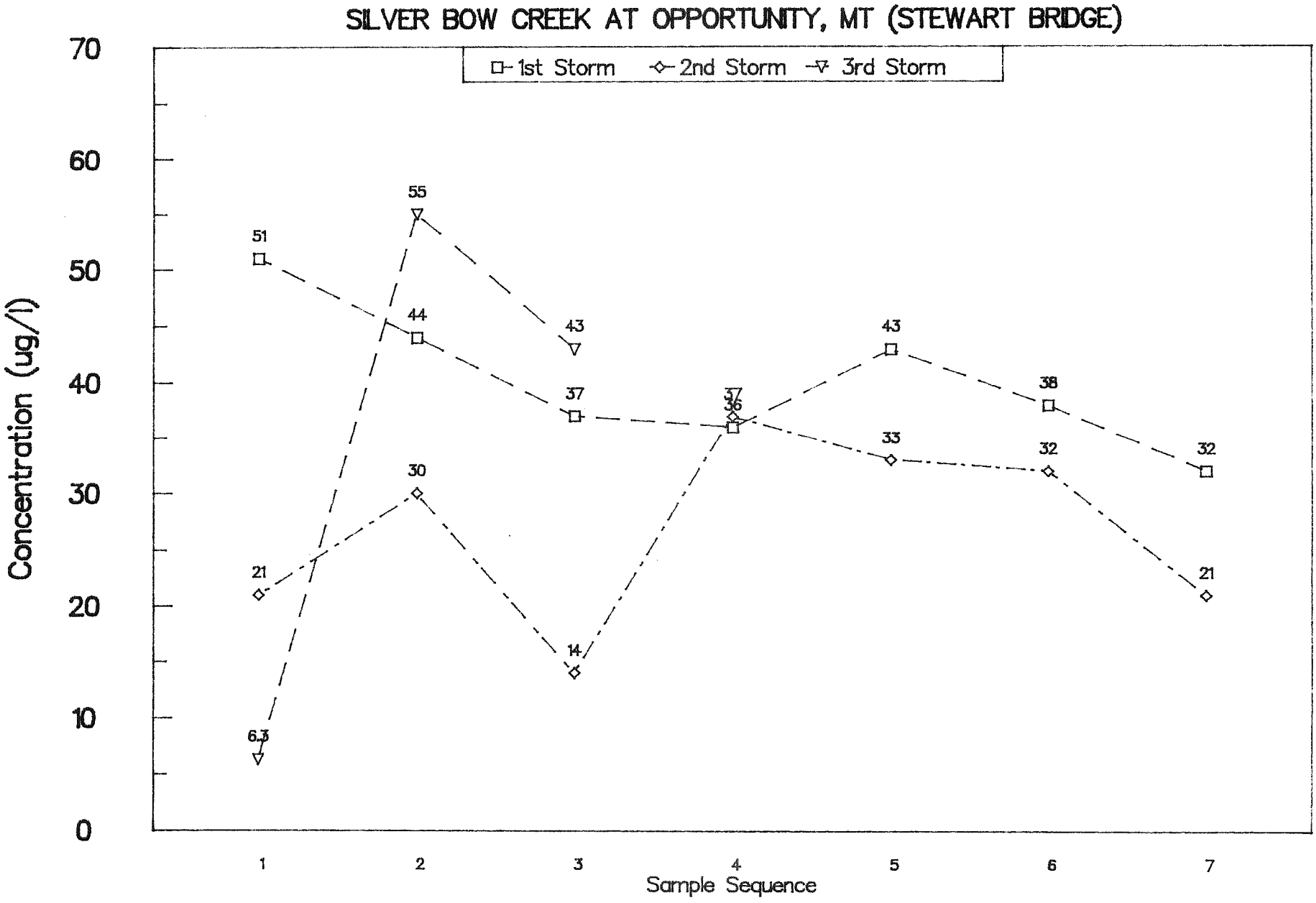


FIGURE 51a – BIO–AVAILABLE ARSENIC CONCENTRATION COMPARISONS FOR 1988 STORM EVENTS

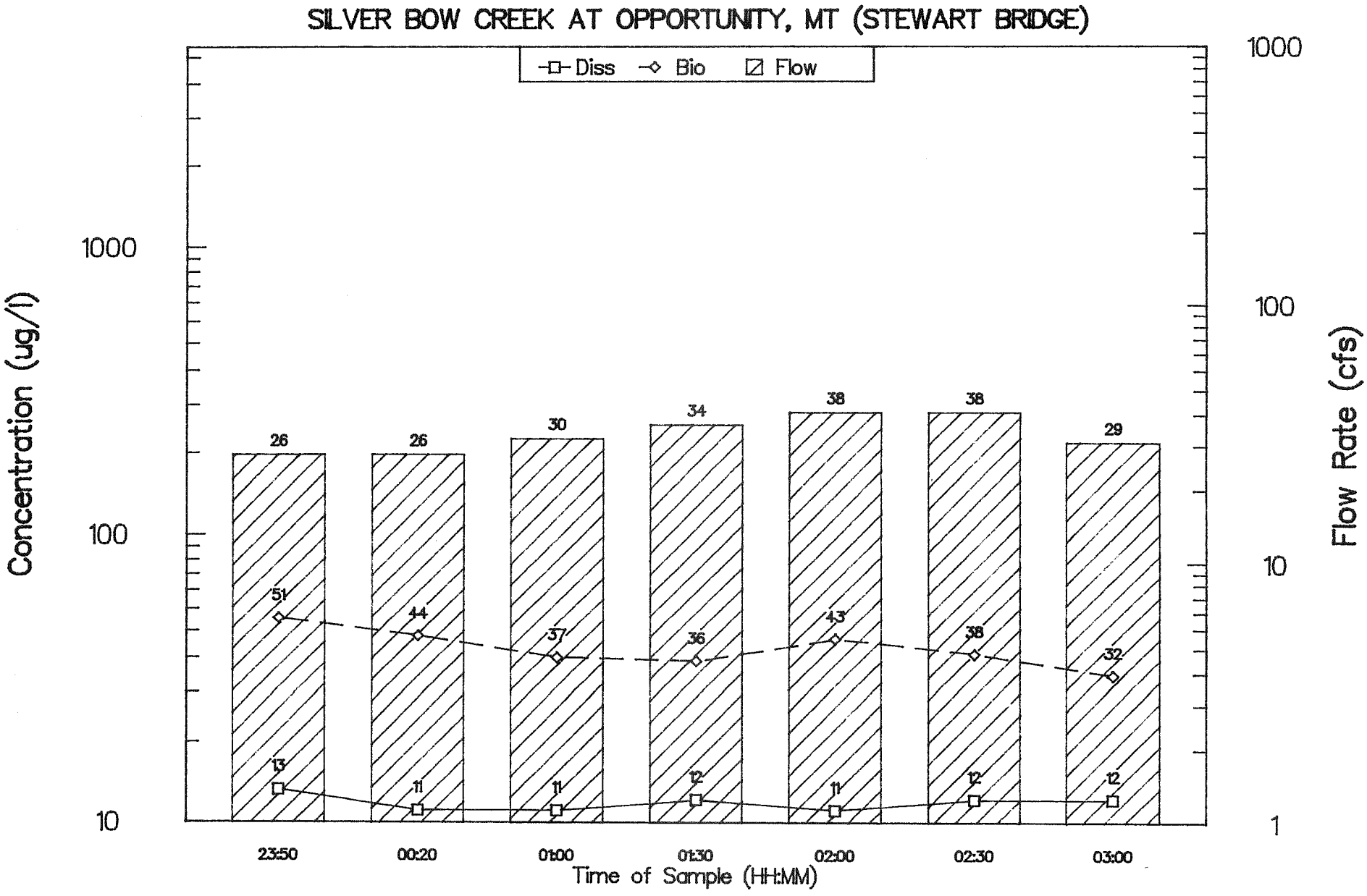


FIGURE 51b – ARSENIC CONCENTRATION COMPARISONS, FOR SEPTEMBER 10–11, 1988 STORM EVENT

SILVER BOW CREEK AT OPPORTUNITY, MT (STEWART BRIDGE)(cont.)

Dissolved Concentrations - 1989

Ten samples were collected during 1989 at this site (Table 23). Sampling occurred during spring base flow, runoff from snowmelt and storm runoff. Stream flow (cfs) varied from 44 cfs to 129 cfs, with 79 cfs the mean.

No iron concentrations exceeded aquatic life standards. Iron concentrations ranged from 50 ug/l to 280 ug/l, with a mean of 125 ug/l. Nine samples had copper concentrations in excess of the acute (27 ug/l) standard, while the chronic standard (17 ug/l) was exceeded in all ten samples. Copper concentrations ranged from 25 ug/l to 130 ug/l, with 80 ug/l the mean.

Seven of the ten samples had zinc concentrations in excess of both the acute and chronic zinc standards of 170 ug/l and 154 ug/l, respectively. Zinc concentrations ranged from 59 ug/l to 420 ug/l, with a mean of 241 ug/l.

None of the arsenic samples exceeded aquatic life standards. Concentration levels were similar to 1988 levels. Arsenic concentrations ranged from 6.3 ug/l to 24 ug/l, with a mean of 10.1 ug/l

Bio-available Concentrations - 1989

Bio-available samples were collected during all ten 1989 sampling episodes, Table 23, therefore a comparison can be made between these two sample types, Figures 52-55.

Six of the ten iron samples exceeded the aquatic life standard of 1000 ug/l. Iron concentrations ranged from 670 ug/l to 2430 ug/l, with a mean of 1230 ug/l, Figure 52.

All ten of the copper samples had concentrations in excess of both the acute and chronic aquatic life standards. Concentrations ranged from 138 ug/l to 580 ug/l, with a mean of 259 ug/l, Figure 53.

All ten zinc samples had concentrations in excess of both the acute and chronic aquatic life standards. Concentrations ranged from 380 ug/l to 990 ug/l, with a mean of 616 ug/l, Figure 54.

None of the arsenic samples had concentrations in excess of aquatic life standards, but the minimum and mean concentrations were twice the dissolved concentrations, while the maximum was 50% greater than the dissolved concentration maximum. Concentrations ranged from 11 ug/l to 38 ug/l, with a mean of 19.9 ug/l, Figure 55.

With the exception of zinc and arsenic concentrations, the maximum concentrations at this site occurred during the peak flow (129 cfs), which was during spring runoff base-flow conditions.

Total Recoverable Constrations - 1989

Total recoverable samples were collected at this location during two sampling episodes. These samples were collected during the same two episodes as at other locations and represent a storm and non-storm event. During both sampling events total recoverable iron and aluminum concentrations exceeded the bio-available concentrations by considerable amounts, while concentrations for other parameters (Mn, Cu, Zn, and As) were similar to bio-available concentrations.

WARM SPRINGS CREEK AT WARM SPRINGS, MT

This station was a part of the 1988 and 1989 sampling program also. Seven sampling episodes occurred during 1988 sampling, while 11 episodes occurred during 1989 sampling. Stream flows varied from 0.6 cfs to 35 cfs, with a mean of 7.2 cfs in 1988, and 34 cfs to 154 cfs, with the mean of 72 cfs in 1989. Stream flows represent low flow, spring runoff base flow and snowmelt flows, and storm event flows both snow and rain events. Water quality results therefore represent these same conditions. Table 24 contains selected water quality results for this site. No bio-available samples were collected at this site in 1988.

Dissolved Concentrations - 1988

Three of the seven 1988 samples represent base flow conditions, while the other four sampling episodes represent storm events. Concentrations of trace metals at this site were considerably lower than those at other sites.

None of the iron, zinc or arsenic concentrations exceeded aquatic life standards, while four of seven copper samples equaled or exceeded the chronic standard of 17 ug/l and one sample exceeded the acute standard of 27 ug/l. Copper concentrations ranged from 11 ug/l to 29 ug/l, with 17 ug/l the mean.

Dissolved Concentrations - 1989

Eleven sampling episodes occurred during 1989, representing spring base flow, spring runoff from snowmelt and storm runoff. As occurred during 1988 sampling, concentrations were considerably lower at the Warm Springs site than at other monitoring sites on Silver Bow Creek, with the exception of arsenic concentrations, which were similar to those found in Blacktail Creek.

It also appears that concentrations decrease during storm or spring runoff events, while concentrations increased during similar events at the other previously discussed stations.

No iron, zinc and arsenic concentrations exceeded aquatic life standards and only one copper sample had concentrations which exceeded either the acute or chronic standards. The one sampling episode (6/6/89) had a copper concentration of 33 ug/l, which exceeded both aquatic life standards. Copper concentrations ranged from 2 ug/l to 33 ug/l, with a mean of 10 ug/l.

Bio-available Concentrations - 1989

Bio-available samples were collected during all eleven sampling episodes, Table 24. No iron or arsenic samples exceeded aquatic standards and only one zinc sample exceeded the chronic aquatic life standard.

While none of the iron samples exceeded aquatic life standards, concentrations were over ten times greater than dissolved iron concentrations at this site, Figure 56. Bio-available concentrations ranged from 20 ug/l to 250 ug/l, with a mean of 120 ug/l.

Copper concentrations exceeded the acute aquatic standard (27 ug/l) twice and equalled or exceeded the chronic standard (17 ug/l) five times. Copper concentrations ranged from 3 ug/l to 36 ug/l, with a mean of 17 ug/l.

Total Recoverable Concentrations - 1989

Total recoverable samples were collected at this site during two sampling episodes, one base flow and one storm episode. Iron concentration was 3-fold the bio-available concentration during the non-storm (base flow) sampling period. Iron concentration increased greater than 3-fold during the storm event, but still did not exceed aquatic life maximum of 1000 ug/l.

Aluminum concentrations showed the greatest level of increase of any trace metal concentration in comparison to bio-available concentrations.

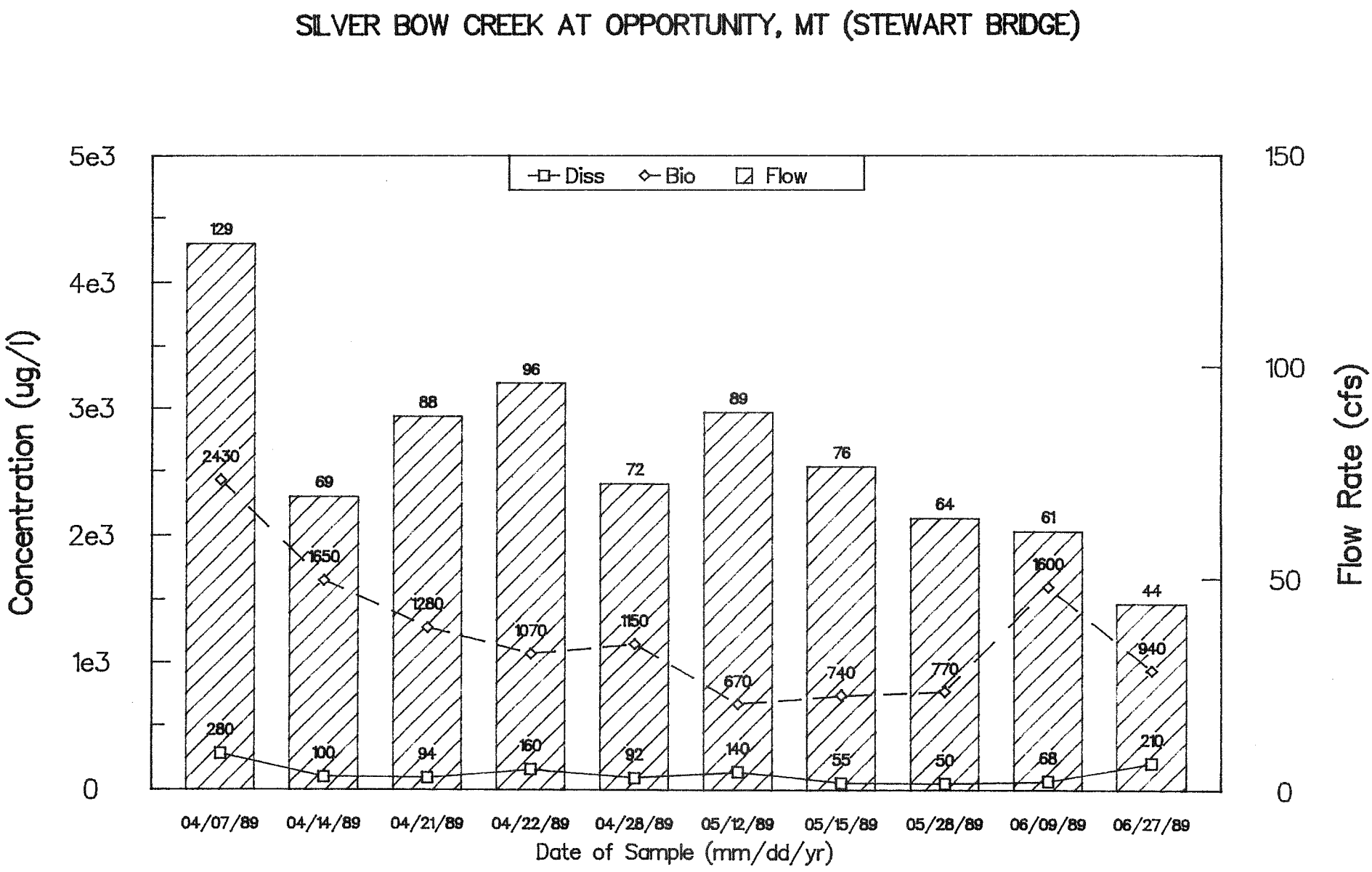


FIGURE 52 – IRON CONCENTRATION COMPARISONS, 1989

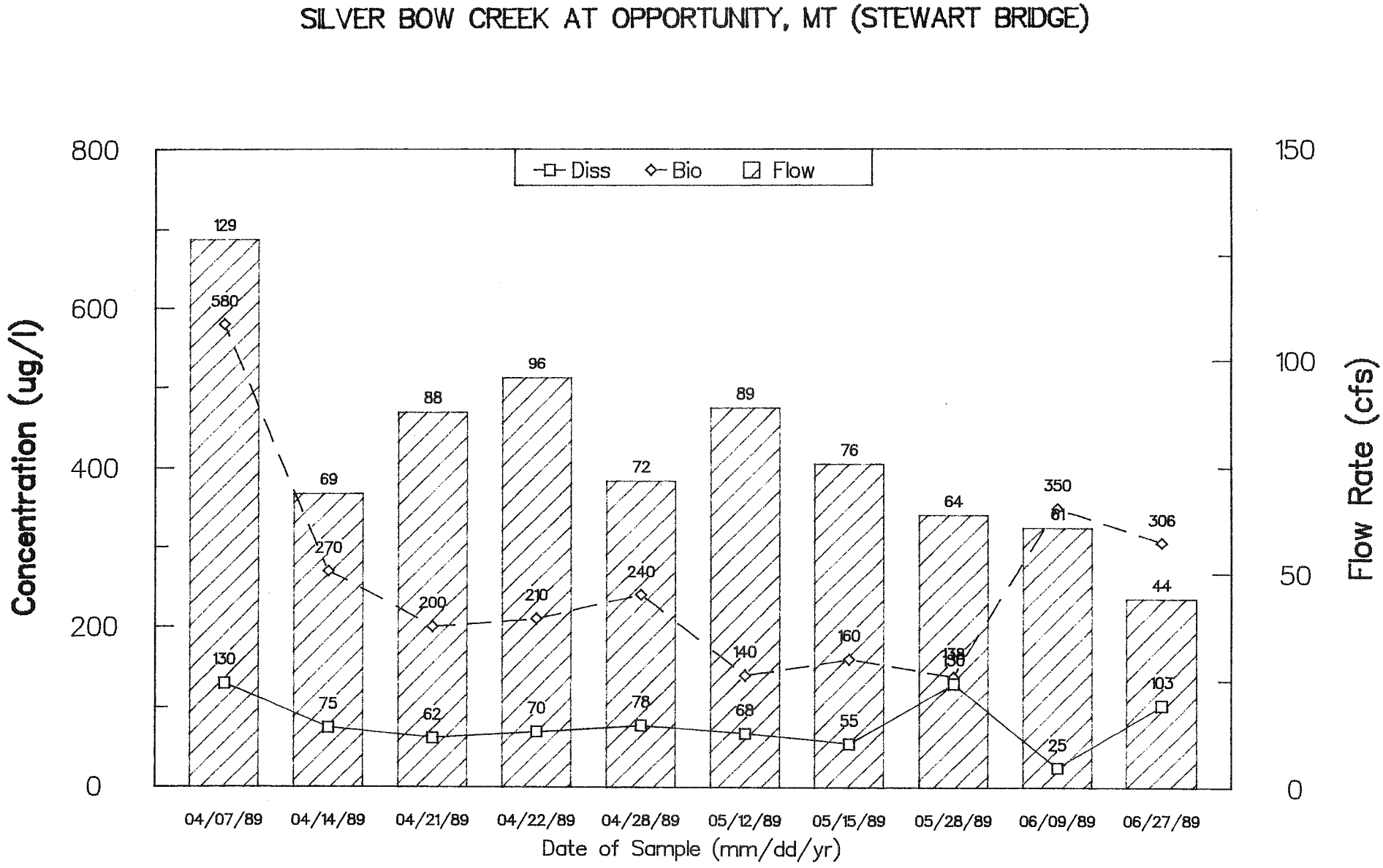


FIGURE 53 – COPPER CONCENTRATION COMPARISONS, 1989

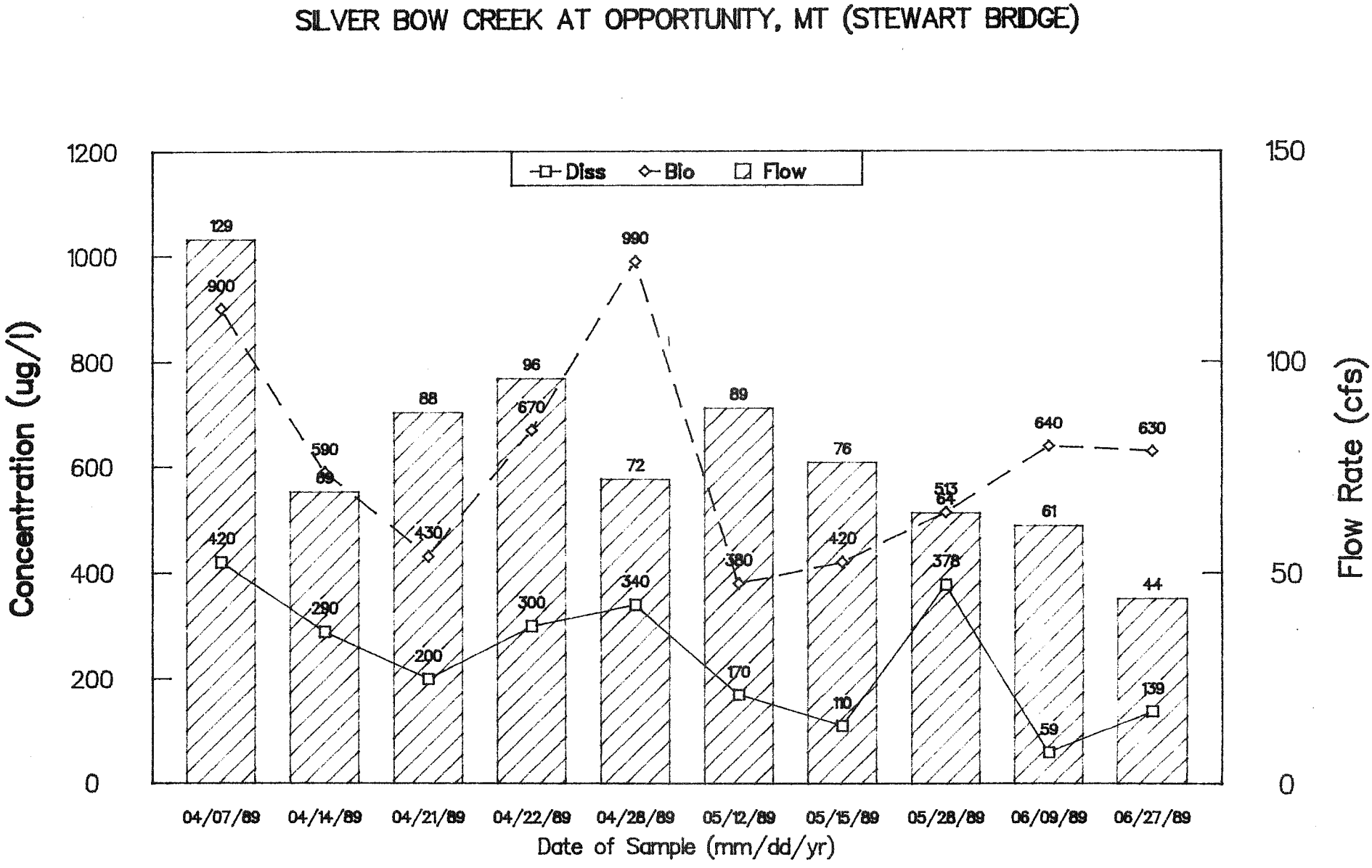


FIGURE 54 – ZINC CONCENTRATION COMPARISONS, 1989

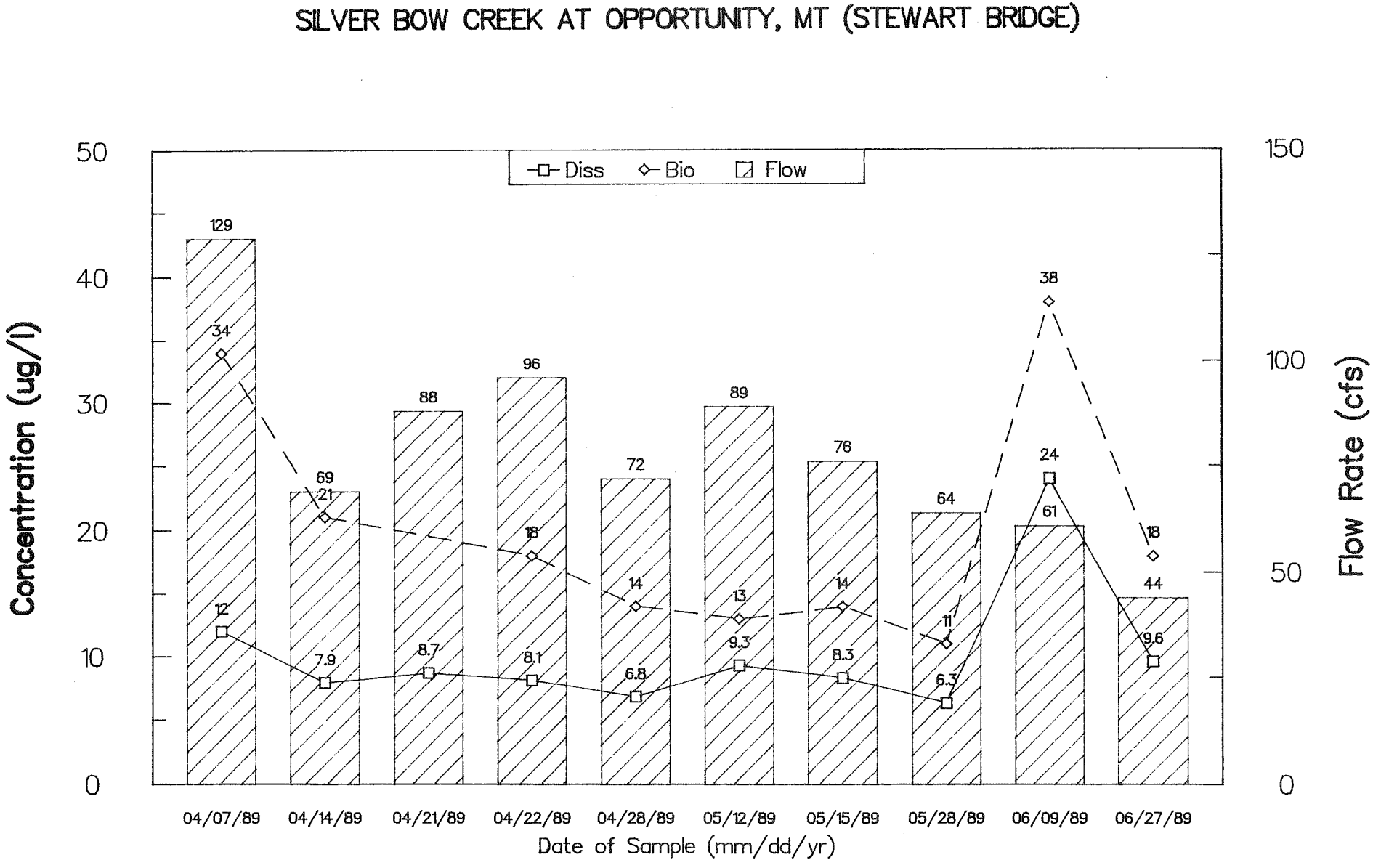


FIGURE 55 – ARSENIC CONCENTRATION COMPARISONS, 1989

TABLE 24
SELECTED ANALYTICAL RESULTS AND STATISTICS
WARM SPRINGS CREEK AT WARM SPRINGS, MT

			DISSOLVED CONCENTRATION					
DATE (MM/DD/YR)	TIME (HRS)	FLOW (cfs)	Fe (ug/l)	Mn (ug/l)	Al (ug/l)	Cu (ug/l)	Pb (ug/l)	Zn (ug/l)	As (ug/l)
07/27/88	11:30	.6	<2	33	<30	17	<40	6	4.9
08/06/88	15:10	.6	7	130	40	17	60	37	6.0
09/05/88	13:10	1.4	28	70	86	29	70	7	8.9
09/11/88	21:10	3.3	8	350	<30	16	<40	23	8.4
09/18/88	10:00	3.9	28	230	<30	12	<40	31	6.7
09/27/88	12:45	5.8	70	700	<30	11	<40	32	4.8
10/17/88	06:40	35	30	420	<30	19	<40	48	6.8
MEAN==>		7.2	29	276	63	17	65	26	6.6
MAX===>		35	70	700	86	29	70	48	8.9
MIN===>		.6	7	33	40	11	60	6	4.8
NUMBER=>		7	6	7	2	7	2	7	7
04/07/89	13:10	38	17	360	<30	9	<40	28	7.1
04/14/89	15:30	34	9	330	<30	2	50	8	5.6
04/21/89	14:45	53	19	370	<30	9	<40	22	5.2
04/22/89	10:50	59	19	380	<30	6	<40	22	6.2
04/28/89	15:41	48	<2	530	<30	4	<40	17	5.3
05/12/89	14:46	115	18	220	<30	6	70	14	3.8
05/15/89	23:10	49	6	420	<30	8	<40	25	5.2
05/29/89	00:45	62	15	270	60	10	<40	17	4.4
06/06/89	15:30	115	21	94	<30	33	<40	16	8.5
06/09/89	10:15	154	10	109	<30	6	40	6	4.0
06/27/89	18:45	68	4	280	50	12	<40	15	4.2
MEAN==>		72	14	306	55	10	53	17	5.4
MAX===>		154	21	530	60	33	70	28	8.5
MIN===>		34	4	94	50	2	40	6	3.8
NUMBER=>		11	10	11	2	11	3	11	11

TABLE 24 (continued)
SELECTED ANALYTICAL RESULTS AND STATISTICS
WARM SPRINGS CREEK AT WARM SPRINGS, MT

BIOLOGICALLY AVAILABLE CONCENTRATION

DATE (MM/DD/YR)	TIME (HRS)	FLOW (cfs)	Fe (ug/l)	Mn (ug/l)	Al (ug/l)	Be (ug/l)	Cd (ug/l)	Cr (ug/l)	Cu (ug/l)	Pb (ug/l)	Zn (ug/l)	As (ug/l)
No available data for 1988												
04/07/89	13:10	38	60	390	<30		<2	<2	8	40	3	7.3
04/14/89	15:30	34	50	350	<30		<2	<2	3	<40	4	5.5
04/21/89	14:45	53	110	470	50	2	<2	<2	14	<40	6	5.6
04/22/89	10:50	59	250	530	170		<2	<2	24	<40	11	8.8
04/28/89	15:41	48	80	550	30		<2	<2	12	<40	160	5.7
05/12/89	14:46	115	170	350	120	<2	<2	<2	28	40	24	6.9
05/15/89	23:10	49	130	480	80	<2	<2	5	24	<40	35	7.0
05/29/89	00:45	62	110	370	<30	2	<2	<2	17	<40	11	6.5
06/06/89	15:30	115	20	90	<30	<2	<2	<2	9	<40	145	3.4
06/09/89	10:15	154	220	340	80	<2	<2	2	36	<40	16	7.0
06/27/89	18:45	68	90	340	<30	<2	<2	<2	15	40	21	4.1
MEAN==>		72	120	39	88	2	N/A	4	17	40	40	6.2
MAX==>		154	250	55	170	2	N/A	5	36	40	160	8.8
MIN==>		34	20	90	30	2	N/A	2	3	40	3	3.4
NUMBER=>		11	11	11	6	2	0	2	11	3	11	11

TOTAL RECOVERABLE CONCENTRATION

DATE (MM/DD/YR)	TIME (HRS)	FLOW (cfs)	Fe (ug/l)	Mn (ug/l)	Al (ug/l)	Be (ug/l)	Cd (ug/l)	Cr (ug/l)	Cu (ug/l)	Pb (ug/l)	Zn (ug/l)	As (ug/l)
05/29/89	00:45	62	330	380	70	2	<2	4	21	<40	13	6.5
06/09/89	10:15	154	750	430	730	<2	<2	<2	33	<40	18	8.1
MEAN==>		72	540	410	400	2	N/A	4	27	N/A	16	7.3
MAX===>		154	750	430	730	2	N/A	4	33	N/A	18	8.1
MIN===.		34	330	380	70	2	N/A	4	21	N/A	13	6.5
NUMBER=>		11	2	2	2	1	0	1	2	0	2	2

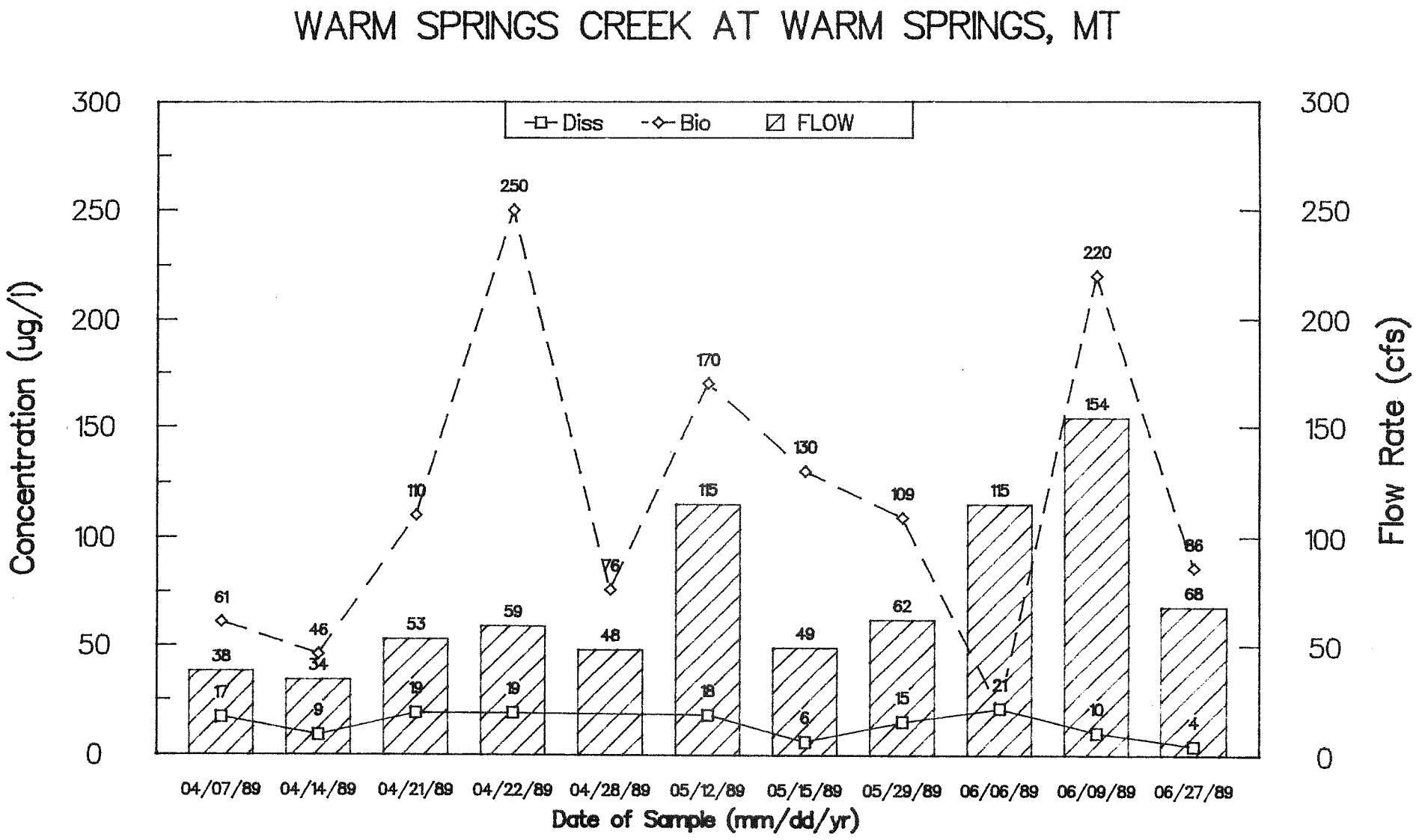


FIGURE 56 – IRON CONCENTRATION COMPARISONS, 1989

Aluminum concentrations during these two sampling episodes for bio-available concentrations ranged from <30 ug/l to 80 ug/l, while total recoverable concentrations ranged from 70 ug/l to 730 ug/l. Aluminum total recoverable concentrations increased 10-fold during the storm event when compared to the non-storm event concentration. None of the other constituents showed substantial increases from bio-available to total recoverable concentrations, nor did the total recoverable concentrations show large increases from base flow to storm runoff conditions.

CLARK FORK RIVER NEAR GALEN, MT (PERKINS LANE BRIDGE)

This station was part of both the 1988 and 1989 sampling program. There were seven sampling episodes at this site during 1988 and forty-eight sampling episodes during 1989. Stream flows ranged from 10 cfs to 63 cfs, with a mean of 24 cfs in 1988, while stream flows ranged from 125 cfs to 436 cfs, with a mean of 265 cfs in 1989. The minimum stream flow sampled was very close to the minimum at this site (10 cfs vs 9.7 cfs) for the period of record (USGS, 1989). Stream flows represent low flow, spring runoff base flow and storm event runoff flows for both snow and rain events. Water quality results therefore represent those same conditions. Tables 25 and 27 contain selected water quality results for this site. Water quality results are possibly affected by the Warm Springs Ponds just upstream of this site. Those ponds also probably affect the impact that storm events have on downstream stream flow and water quality. There were no 1988 bio-available samples collected at this site.

Dissolved concentrations - 1988

None of the dissolved samples had concentrations in excess of acute aquatic life standards for the selected constituents at this site, but copper concentrations equalled or exceeded chronic standards on two occasions.

Copper concentrations reanged from 2 ug/l to 22 ug/l, with a mean of 13 ug/l. Concentrations are therefore substantially lower than those observed just upstream of the Warm Springs Ponds. Obviously, the operation of the ponds or inputs into the ponds, or both, have a significant impact on downstream water quality.

None of the samples were collected during the minimum base flow at this site (9.7 cfs several days in August), but several were collected at flows just above this minimum, 12 cfs and 10 cfs, respectively, on July 27, 1988 and August 6, 1988. Iron was the only parameter that had its minimum concentration during one of the two low flow sampling periods (July 27, 1988), but it also had its highest concentration during the other low flow period. Iron concentrations varied from 8 ug/l to 120 ug/l, with a mean of 45 ug/l.

Maximum copper and zinc concentrations occurred during the storm event on October 17, 1988, which was also the period of highest flow at this site. It is also interesting to note that the seasonal dike on the Mill-Willow Bypass was removed just prior to this storm (Personnel Communications with Sam Stephensen, 1989). It is possible that these elevated concentrations are partially reflective of this dike's removal and less flow being routed through the Warm Springs Pond system.

While arsenic concentrations did not exceed aquatic standards at this site, its minimum and mean concentrations were similar to arsenic concentrations at the upstream sampling station, Silver Bow Creek at Opportunity, Mt. Arsenic concentrations ranged from 7.2 ug/l to 16 ug/l, with a mean of 11.3 ug/l. It therefore appears that while the ponds have a substantial affect on other constituent concentrations, it did not have as significant of an affect on dissolved arsenic concentrations at this site. Table 26 has a comparison of maximum, minimum and mean arsenic concentrations at Silver Bow Creek and Clark Fork River sites.

TABLE 25
SELECTED ANALYTICAL RESULTS AND STATISTICS - 1988
CLARK FORK RIVER NEAR GALEN, MT (PERKINS LANE BRIDGE)

			DISSOLVED CONCENTRATION						
DATE (MM/DD/YR)	TIME (HRS)	FLOW (cfs)	Fe (ug/l)	Mn (ug/l)	Al (ug/l)	Cu (ug/l)	Pb (ug/l)	Zn (ug/l)	As (ug/l)
07/27/88	09:40	12	8	120	<30	16	<40	18	12
08/06/88	16:40	10	120	210	<30	14	80	23	16
09/05/88	14:00	12	60	77	50	13	<40	8	12
09/11/88	22:30	12	13	130	<30	9	<40	30	12
09/18/88	11:30	27	49	120	<30	17	40	23	11
09/27/88	14:10	33	11	93	<30	2	<40	25	8.8
10/17/88	08:00	63	57	160	<30	22	<40	46	7.2
MEAN==>		24	45	130	50	13	60	25	11.3
MAX===>		63	120	210	50	22	80	46	16
MIN===>		10	8	77	50	2	40	8	7.2
NUMBER=>		7	7	7	1	7	2	7	7

BIOLOGICALLY AVAILABLE CONCENTRATION

No available data for 1988

Table 26
Dissolved Arsenic Concentrations Comparisons (ug/l), 1988

	Mean	Maximum	Minimum	Number Samples
Silver Bow Creek below Blacktail Creek	10	18	6.5	14
Silver Bow Creek at Opportunity, MT	12.3	26	5.6	24
Clark Fork River near Galen, MT	11.3	16	7.2	7

Dissolved Concentrations - 1989

Dissolved samples were collected during forty-two of forty-eight episodes at this site in 1989. Sampling episodes occurred during spring base flow, runoff from snowmelt, and storm event runoff. Stream flows were substantially larger than during the 1988 sampling period. Also the flow activated automatic sampler was used exclusively at this site in 1989. There were five storm event/runoff samples collected for dissolved parameters at this site. Table 27 contains selected water quality results for this location. All samples were collected prior to the re-installation of the dike in the Mill-Willow Bypass.

During 1989 no iron concentrations exceeded the aquatic life standard of 1000 ug/l, but the maximum concentration occurred during minimum stream flow, similar to 1988. Iron concentrations ranged from 14 ug/l to 900 ug/l, with a mean of 86 ug/l.

TABLE 27
SELECTED ANALYTICAL RESULTS AND STATISTICS - 1989
CLARK FORK NEAR GALEN, MT (PERKINS LANE BRIDGE)

			DISSOLVED CONCENTRATION						
DATE (MM/DD/YR)	TIME (HRS)	FLOW (cfs)	Fe (ug/l)	Mn (ug/l)	Al (ug/l)	Cu (ug/l)	Pb (ug/l)	Zn (ug/l)	As (ug/l)
04/07/89	14:18	141	14	420	<30	12	<40	46	6.1
04/14/89	16:36	125	900	230	<30	16	<40	11	8.6
04/21/89	15:30	177	22	190	<30	8	<40	9	9.8
04/21/89	15:40	175			NO DISSOLVED SAMPLE				
04/21/89	16:40	175			NO DISSOLVED SAMPLE				
04/21/89	17:40	169			NO DISSOLVED SAMPLE				
04/21/89	18:40	167			NO DISSOLVED SAMPLE				
04/21/89	19:40	167			NO DISSOLVED SAMPLE				
04/21/89	20:20	169			NO DISSOLVED SAMPLE				
04/22/89	11:56	209	73	210	<30	13	<40	21	9
04/24/89	12:40	224	45	360	<30	16	<40	53	7.9
04/24/89	13:40	224	21	320	<30	16	<40	44	7.4
04/24/89	14:40	221	30	290	<30	14	<40	39	8.6
04/24/89	15:40	221	18	270	<30	11	<40	27	7.9
04/24/89	16:40	215	22	280	<30	15	<40	37	9.2
04/24/89	17:40	212	35	330	<30	16	<40	37	9.3
04/28/89	16:40	164	25	200	<30	10	<40	21	9.6
05/09/89	10:45	267	130	220	120	33	70	270	14
05/09/89	11:45	264	35	61	<30	14	<40	23	17
05/09/89	12:45	278	60	130	50	16	50	30	18
05/09/89	13:45	278	290	400	180	63	<40	98	22
05/09/89	14:45	274	300	410	180	62	<40	79	21
05/09/89	15:45	274	580	320	130	46	<40	86	11
05/10/89	14:45	303	56	94	60	17	<40	39	18
05/10/89	15:45	299	40	100	<30	17	<40	30	19
05/10/89	16:45	303	44	110	<30	14	<40	24	18
05/10/89	17:45	299	47	120	30	13	49	17	17
05/10/89	18:45	314	69	140	<30	18	<40	23	17
05/10/89	19:45	314	49	130	<30	13	<40	24	18
05/12/89	16:02	314	69	94	<30	31	<40	20	17
05/15/89	11:55	215	40	140	<30	18	<40	37	18
05/27/89	01:50	209	47	140	<30	14	<40	21	14
06/06/89	07:15	274	48	67	<30	9	<40	382	12
06/06/89	08:15	278	18	69	<30	9	<40	174	12
06/06/89	09:15	285	26	65	<30	8	<40	61	12
06/06/89	10:15	285	24	65	<30	8	<40	41	10
06/06/89	11:15	278	21	67	<30	8	<40	21	11
06/06/89	12:15	285	22	63	<30	8	<40	27	12
06/06/89	16:50	271	25	62	<30	11	<40	6	14
06/09/89	08:05	322	28	75	<30	11	<40	17	11
06/16/89	05:15	391	42	72	<30	17	<40	15	15
06/16/89	06:15	400	40	71	<30	15	<40	15	15
06/16/89	07:15	422	44	71	<30	15	<40	11	16
06/16/89	08:15	431	48	71	<30	15	<40	14	15.5

TABLE 27 (continued)
SELECTED ANALYTICAL RESULTS AND STATISTICS
CLARK FORK NEAR GALEN, MT (PERKINS LANE BRIDGE)

DATE (MM/DD/YR)	TIME (HRS)	FLOW (cfs)	Fe (ug/l)	Mn (ug/l)	Al (ug/l)	Cu (ug/l)	Pb (ug/l)	Zn (ug/l)	As (ug/l)
06/16/89	09:15	431	51	71	<30	16	<40	15	16
06/16/89	10:15	431	51	64	<30	15	<40	22	17
06/16/89	11:15	436	43	67	<30	14	<40	14	17
06/27/89	19:15	132	20	150	34	23	<40	22	12
MEAN==>		265	86	164	98	18	56	48	13.6
MAX==>		436	900	420	180	63	70	382	22
MIN==>		125	14	61	30	8	49	6	6.1
NUMBER=>		48	42	42	8	42	3	42	42

			BIOLOGICALLY AVAILABLE CONCENTRATION						
			Fe (ug/l)	Mn (ug/l)	Al (ug/l)	Cu (ug/l)	Pb (ug/l)	Zn (ug/l)	As (ug/l)
04/07/89	14:18	141	880	530	230	60	<40	140	14
04/14/89	16:36	125	380	310	100	33	40	71	11
04/21/89	15:30	177	490	340	140	35	<40	67	12
04/21/89	15:40	175	1560	380	80	67	<40	360	15
04/21/89	16:40	175	850	310	50	40	<40	120	15
04/21/89	17:40	169	1510	300	70	44	<40	100	13
04/21/89	18:40	167	500	300	<30	39	<40	130	13
04/21/89	19:40	167	620	340	140	54	<40	110	13
04/21/89	20:20	169	2440	320	260	71	220	11	13
04/22/89	11:56	209	530	370	190	43	<40	70	16
04/24/89	12:40	224	490	520	140	91	<40	190	13
04/24/89	13:40	224	500	500	160	61	<40	210	13
04/24/89	14:40	221	630	440	130	53	<40	170	14
04/24/89	15:40	221	470	420	120	44	<40	150	12
04/24/89	16:40	215	460	440	120	16	<40	150	14
04/24/89	17:40	212	440	440	100	43	<40	120	15
04/28/89	16:40	164	450	330	150	40	<40	2200	15
05/09/89	10:45	267	720	480	260	60	<40	140	23
05/09/89	11:45	264	550	430	220	60	50	90	26
05/09/89	12:45	278	620	460	220	60	50	85	28
05/09/89	13:45	278	540	420	210	58	54	78	27
05/09/89	14:45	274	660	500	240	79	<40	100	29
05/09/89	15:45	274	590	430	180	60	<40	85	29
05/10/89	14:45	303	300	270	180	31	<40	51	23
05/10/89	15:45	299	650	560	240	77	50	260	29
05/10/89	16:45	303	630	490	200	64	167	100	27
05/10/89	17:45	299	680	510	260	69	<40	120	29
05/10/89	18:45	314	700	500	230	69	<40	100	29
05/10/89	19:45	314	700	510	217	81	<40	180	29
05/12/89	16:02	314	280	240	80	28	<40	36	21
05/15/89	11:55	215	290	270	105	36	<40	68	22

TABLE 27 (continued)
SELECTED ANALYTICAL RESULTS AND STATISTICS - 1989
CLARK FORK NEAR GALEN, MT (PERKINS LANE BRIDGE)
BIOLOGICALLY AVAILABLE CONCENTRATIONS (cont.)

DATE (MM/DD/YR)	TIME (HRS)	FLOW (cfs)	Fe (ug/l)	Mn (ug/l)	Al (ug/l)	Cu (ug/l)	Pb (ug/l)	Zn (ug/l)	As (ug/l)
05/27/89	01:50	209	270	260	<30	28	<40	45	17
06/06/89	07:15	274	350	300	<30	37	<40	157	16
06/06/89	08:15	278	370	280	<30	34	<40	64	17
06/06/89	09:15	285	320	260	<30	33	<40	44	16
06/06/89	10:15	285	310	260	<30	32	<40	41	16
06/06/89	11:15	278	290	250	<30	32	<40	38	15
06/06/89	12:15	285	290	240	<30	31	<40	29	14
06/06/89	16:50	271	260	210	<30	26	<40	37	19
06/09/89	08:05	322	250	250	<30	31	60	28	17
06/16/89	05:15	391	684	462	270	73	<40	96	20
06/16/89	06:15	400	715	482	300	71	<40	77	22
06/16/89	07:15	422	832	500	330	77	<40	80	25
06/16/89	08:15	431	875	487	370	79	<40	126	28
06/16/89	09:15	431	908	524	420	86	<40	98	27
06/16/89	10:15	431	934	545	460	87	<40	110	36
06/16/89	11:15	436	979	570	460	91	<40	92	36
06/27/89	19:15	132	150	190	<30	26	<40	30	13
MEAN==>		265	623	390	206	53	86	147	19.9
MAX==>		436	2440	570	460	91	220	2200	36
MIN==>		125	150	190	50	16	40	11	11
NUMBER=>		48	48	48	37	48	8	48	48

TOTAL RECOVERABLE CONCENTRATION

			Fe (ug/l)	Mn (ug/l)	Al (ug/l)	Cu (ug/l)	Pb (ug/l)	Zn (ug/l)	As (ug/l)
05/27/89	01:50	209	460	250	<30	30	<40	47	17
06/09/89	08:05	322	630	320	460	31	<40	23	18
MEAN==>		266	285	285	460	31	0	35	17.5
MAX==>		322	320	320	460	31	0	47	18
MIN==>		209	250	250	460	30	0	23	17
NUMBER=>		2	2	2	1	2	0	2	2

Copper concentrations ranged from 8 ug/l to 63 ug/l, with a mean of 18 ug/l. These concentrations equalled or exceeded the chronic aquatic standard (17 ug/l) eleven times and the acute aquatic standard (27 ug/l) five times.

Zinc concentrations ranged from 6 ug/l to 382 ug/l, with a mean of 48 ug/l. These concentrations exceeded both the acute (170 ug/l) and chronic (154 ug/l) aquatic life standards three times.

Once again, none of the arsenic samples exceeded any of the aquatic life standards. Arsenic concentrations ranged from 6.1 ug/l to 22 ug/l, with a mean of 13.6 ug/l, which is also similar to 1989 arsenic concentrations just above the ponds. Table 28 contains comparison of 1989 arsenic concentrations of Silver Bow Creek and Clark Fork River sites.

Table 28
Dissolved Arsenic Concentration Comparisons (ug/l), 1989

	Mean	Maximum	Minimum	Number Samples
Silver Bow Creek below Blacktail Creek	8.7	16	5.7	10
Silver Bow Creek at Opportunity, MT	10.1	24	6.3	10
Clark Fork River near Galen, MT	13.6	22	6.1	42

Bio-available Concentrations - 1989

Bio-available samples were collected during all forty-eight sampling episodes. Sampling results are representative of the same flow conditions previously discussed.

Iron concentrations during 1989 ranged from 150 ug/l to 2440 ug/l, with a mean of 623 ug/l. These concentrations exceeded the aquatic life standard of 1000 ug/l three times during 1989 sampling. All three exceedences were during the first flow activated storm/runoff event (4/21/89).

All other sampling events had concentrations considerably below this standard, with the exception of the sixth (last flow activated) sampling episode, where iron concentrations ranged from 680-980 ug/l. On the average, bio-available iron concentrations were almost ten times (10X) greater than dissolved concentrations.

Copper concentrations ranged from 16 ug/l to 91 ug/l, with a mean of 53 ug/l. Acute copper concentrations (27 ug/l) were exceeded forty-five times (94%), while chronic concentrations (17 ug/l) were exceeded forty-seven times (98%). On the average, bio-available copper concentrations were almost three times (3X) the dissolved concentrations. Figures 57a and 57b show copper concentrations during storm/runoff events number two (4/24/89) and number six (6/16/89). Both of these storms show trends similar to those previously discussed at the Silver Bow Creek below Blacktail Creek site, that is, bio-available concentrations increase with increased flow and decrease with decreased flow. Once again, this could be attributed to changes in suspended sediment loads in the stream. Dissolved concentrations remained constant throughout these two storm events.

Zinc concentrations ranged from 11 ug/l to 2200 ug/l, with a mean of 147 ug/l. Eight zinc concentrations exceeded the chronic aquatic life criteria (154 ug/l), and seven of those eight also equalled or exceeded the acute aquatic life criteria (170 ug/l). Average bio-available zinc concentrations exceed dissolved concentrations three-fold (3X).

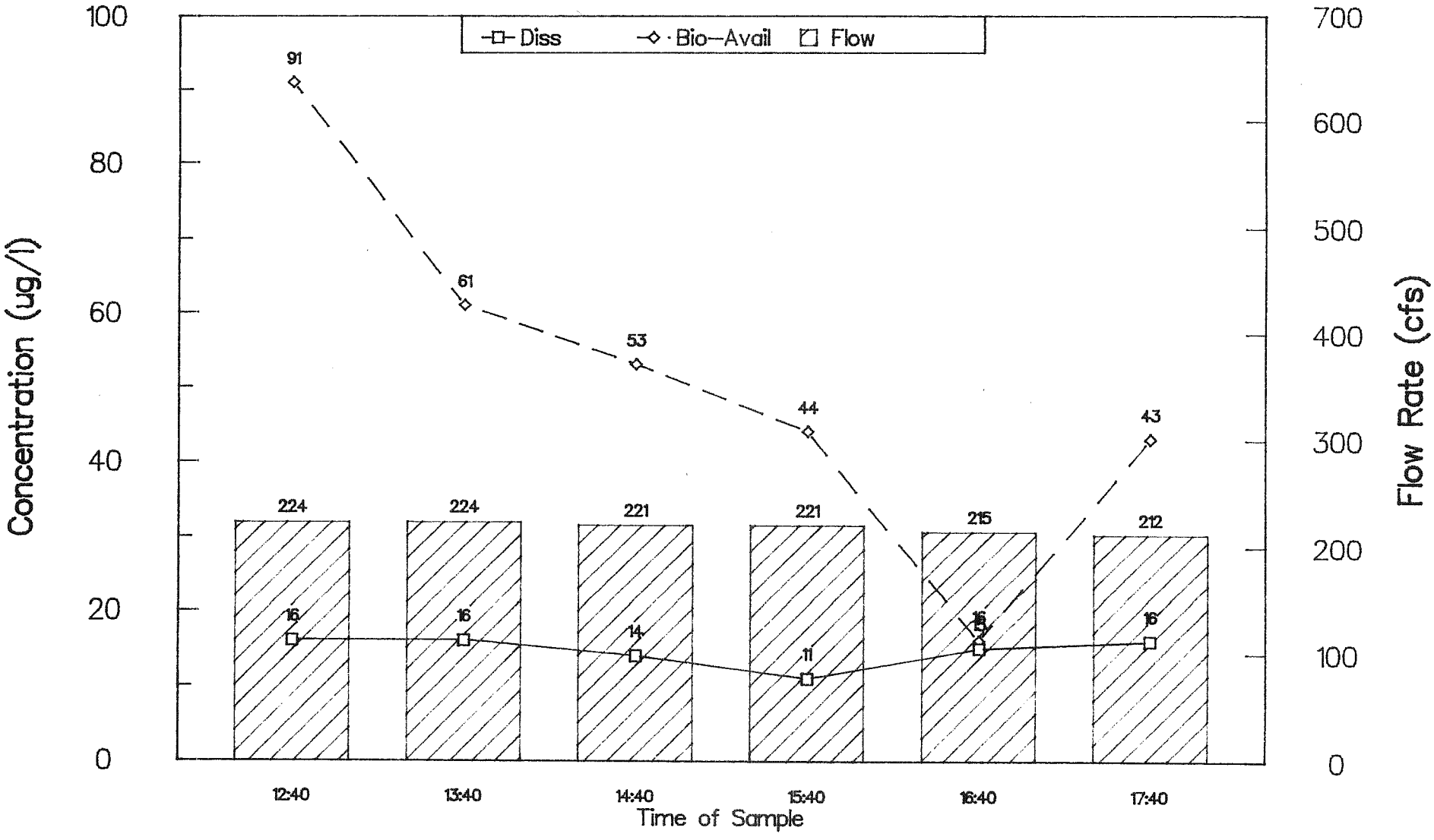


FIGURE 57a – COPPER CONCENTRATION COMPARISONS

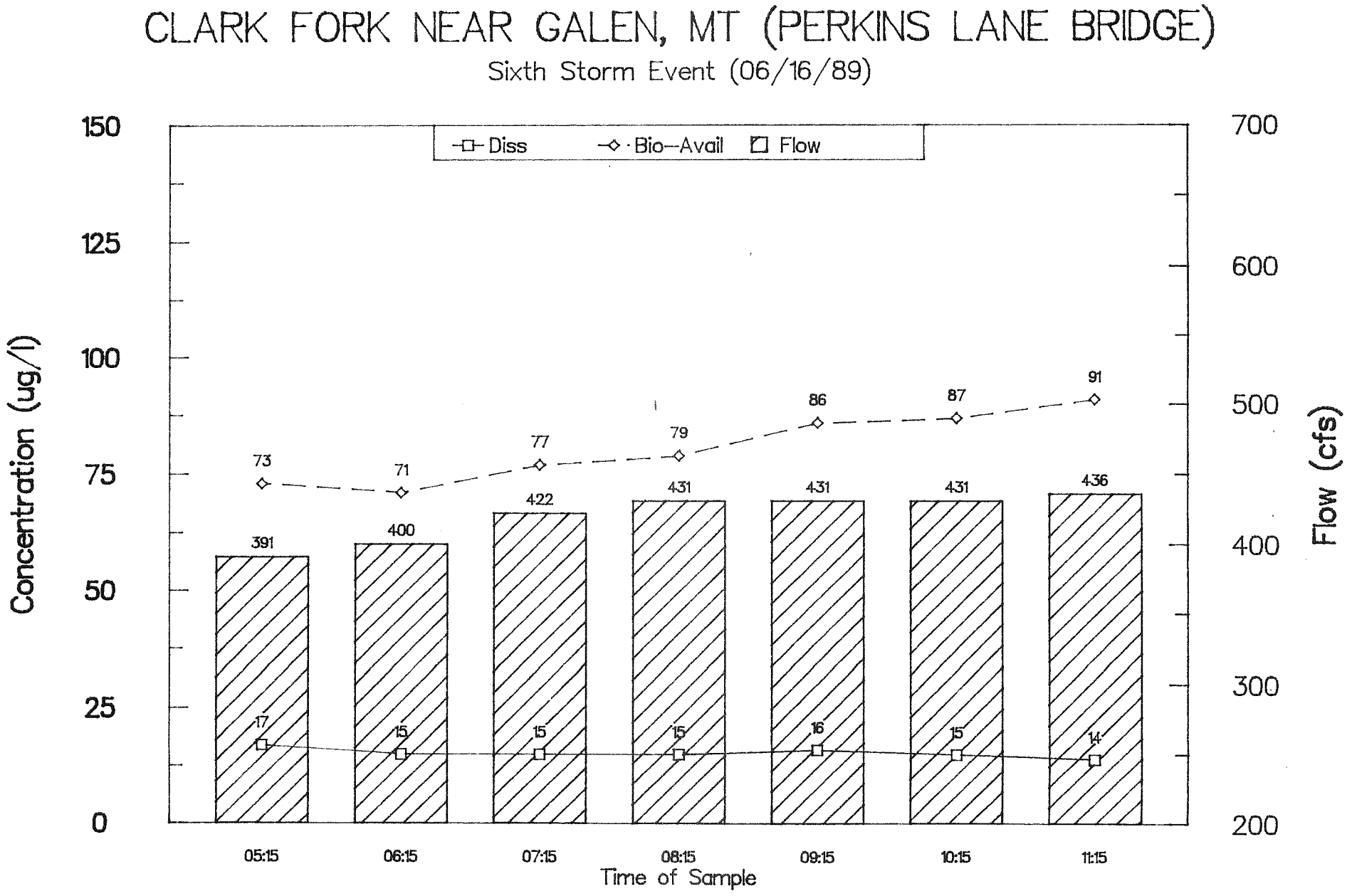


FIGURE 57b – COPPER CONCENTRATION COMPARISONS

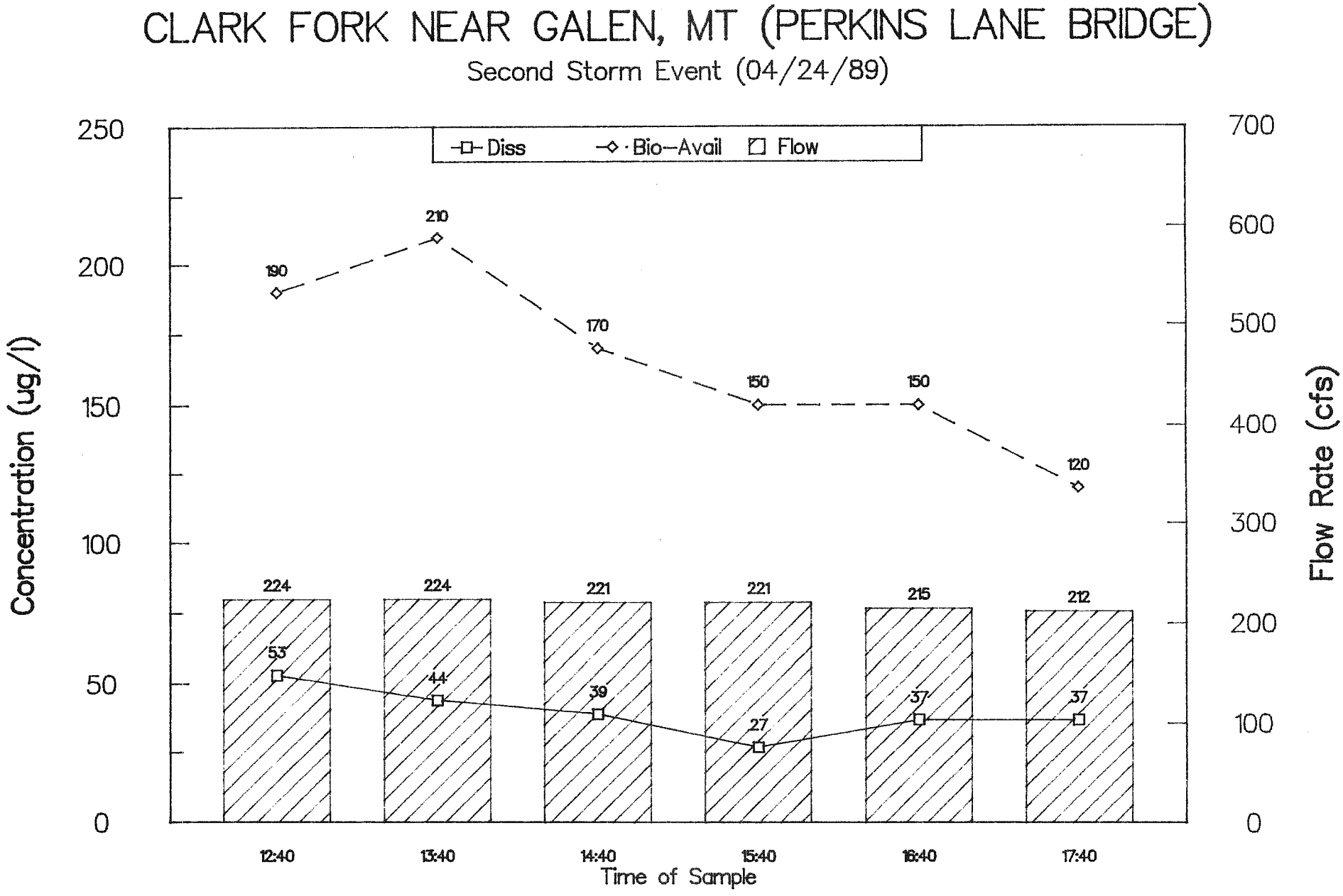


FIGURE 58a – ZINC CONCENTRATION COMPARISONS

CLARK FORK NEAR GALEN, MT (PERKINS LANE BRIDGE)

Sixth Storm Event (06/16/89)

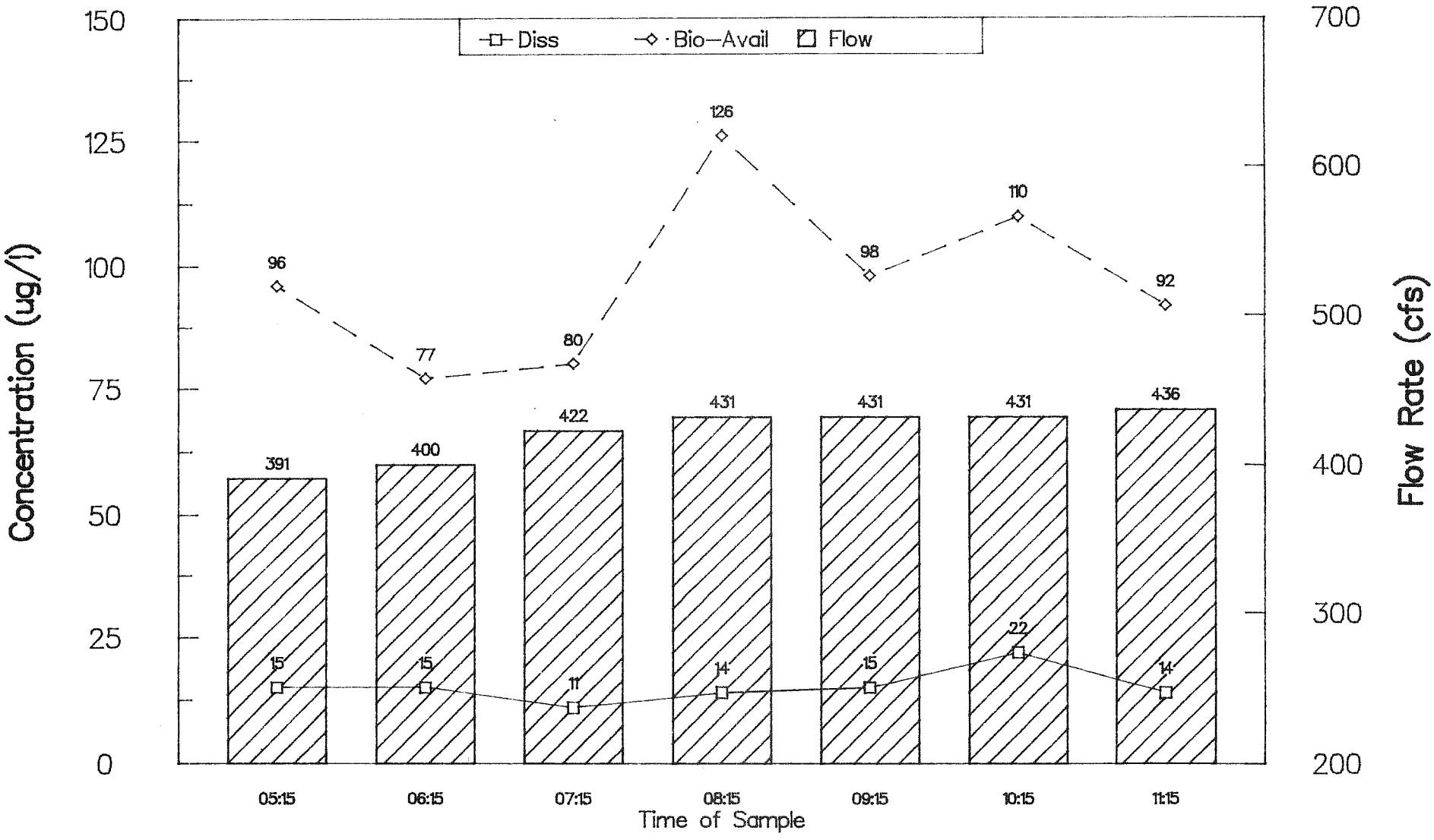


FIGURE 58b – ZINC CONCENTRATION COMPARISONS

Figure 58a shows bio-available and dissolved zinc concentrations comparisons for the 4/24/89 storm/runoff event and Figure 58b shows this comparison for the 6/16/89 event. Differences in concentrations could once again be attributed to increased suspended sediment loads, that are rich in trace metal concentrations. As was observed in copper concentrations during these two events, dissolved zinc concentrations remained fairly stable, while the bio-available zinc concentrations were more variable, which would be expected if the source of metals was the probable increased suspended sediment load being carried in the stream.

Bio-available arsenic concentrations ranged from 11 ug/l to 36 ug/l, with a mean of 19.9 ug/l. These concentrations were below aquatic life standards during all sampling episodes. Minimum and maximum concentrations occurred with minimum and maximum flows, respectively. Figure 59 shows arsenic concentration comparisons for dissolved and bio-available concentrations and change with stream flow for the 6/16/89 storm event. Mean bio-available arsenic concentrations exceed dissolved arsenic by almost 50%; this is considerably less than increases observed for iron, copper and zinc concentrations.

Total Recoverable Concentrations - 1989

Two total recoverable samples were collected during 1989 activities. One sampling episode occurred during non-storm sampling, while the other occurred during a storm/runoff event. Iron was the only constituent to show significant concentration increases during the non-storm sampling. Bio-available concentrations were 270 ug/l, while total recoverable concentrations were 460 ug/l.

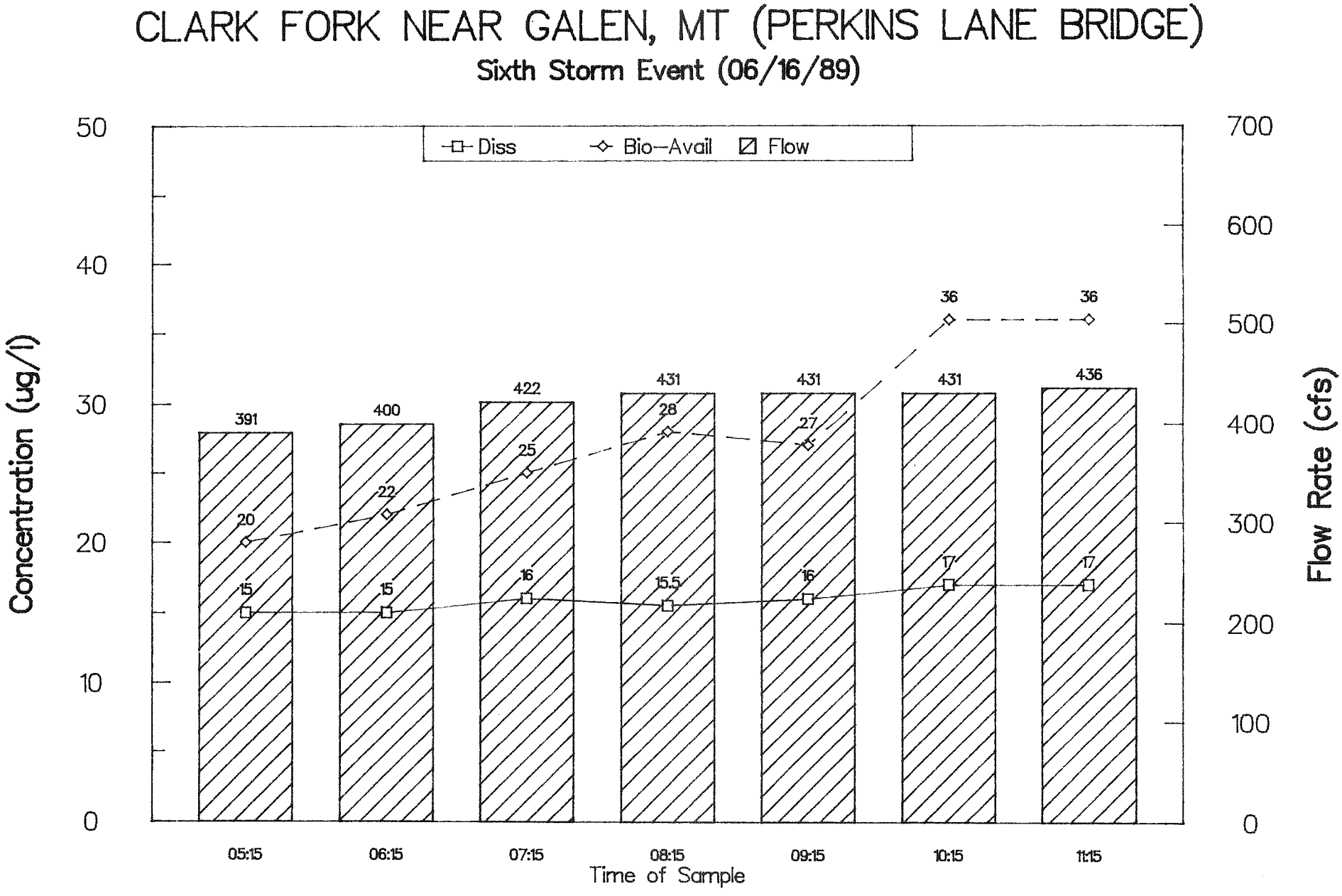


FIGURE 59 – ARSENIC CONCENTRATION COMPARISONS

During the storm/runoff sampling episode, iron and aluminum were the only constituents to show significant bio-available-total recoverable changes; concentrations ranged from 250 ug/l to 630 ug/l for iron and <30 ug/l to 460 ug/l for aluminum. These trends are similar to those observed at other locations. Total recoverable concentrations for the other constituents were very similar to bio-available concentrations during both non-storm and storm sampling events.

Summary and Conclusion

Water Quality Sampling

Water quality results indicate that the two Silver Bow Creek sites have elevated metal concentrations during both low flow and high flow conditions, while the Warm Springs Creek and Clark Fork River sites have much lower concentrations during low flow conditions (1988 sampling). The Warm Springs Creek site had lower concentrations during high flow conditions also, while the Clark Fork River site had elevated concentrations during high flow conditions. The above mentioned trends were similar for both dissolved and bio-available concentrations.

The Blacktail Creek at Butte, MT site and Warm Springs Creek at Warm Springs, MT site had the lowest mean concentrations of all sites and had concentration levels similar to each other, with the exception of iron, which was an order of magnitude higher at the Blacktail site. The Blacktail Creek site did show greater changes during 1989 storm/runoff events also.

Results from Blacktail Creek could be used to establish upper drainage background conditions. If such an assumption is made, it then appears that considerable contamination exists downstream to the Silver Bow Creek site below the Colorado Tailings, and Silver Bow Creek site at Opportunity, MT. Both dissolved and bio-available concentrations showed considerable increases during 1988 and 1989 sampling activities.

Bio-available concentrations ranged from 1.5 times greater for arsenic, to ten times greater for iron, in comparison to dissolved concentrations. Total recoverable concentrations were similar to bio-available concentrations except for iron and aluminum, during both non-storm and storm runoff events.

Storm events and runoff from spring snowmelt did affect water quality conditions at all sites, even though the Warm Springs Ponds appear to cause a lag-time effect on the downstream site (Clark Fork River near Galen, MT), and also dilutes metal concentrations.

Maximum dissolved concentrations during both 1988 and 1989 sampling (at the four main stations) occurred at the Silver Bow Creek below Blacktail Creek at Butte, MT site (below the Colorado Tailings) with the exception of arsenic concentrations which were higher at the Silver Bow Creek at Opportunity, MT site. Maximum iron concentration during 1988 was higher at this site, but the mean concentration was lower than the upstream station.

Both the maximum and maximum mean bio-available concentrations occurred at the Silver Bow Creek below Blacktail Creek site, by considerable amounts, during both 1988 and 1989 sampling. The location of this site to streamside tailings deposits possibly explains these occurrences, while increase in streamflow probably helps to dilute concentrations at downstream sites.

While the Warm Springs Ponds appear to have a positive effect (reduction in concentrationss) on trace metal concentrations, both dissolved and bio-available fractions, they do not appear to have a similar reduction on arsenic concentrations. 1989 dissolved arsenic concentrations are greater than those at the upstream site, while bio-available concentrations are essentially the same at these two sites (Silver Bow Creek at Opportunity, MT - upstream of ponds, and Clark Fork River near Galen, MT - downstream of ponds).

Prior to the start-up and following completion of this monitoring and sampling program, fish kills occurred in the vicinity of the Clark Fork River near Galen, MT site. While one of the goals of this project was to investigate remote monitoring and sampling techniques as an aid in identifying the causes of fish kills, were unanswered, it is felt that numerous changes or occurrences were documented throughout this study which should help future investigators and aid in cleanup of the Upper Clark Fork Basin.

The fall 1988 sampling, which occured during possible all time minimum (low-flow) streamflow conditions, should establish baseline concentration levels which can be used as a gauge for comparison during other flow conditions.

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Appendix A
Complete Quality Control Data for Monitoring Sites

Table A:

Silver Bow Creek Below Blacktail Creek, At Butte, MT
USGS Site 12323250
Quality Control 1988

Date (MMDDYY)	Time (HHMM)	pH QC	pH HL	pH Diff	pH Diff (%)	SC QC (umhos)	SC HL (umhos)	SC Diff (umhos)	SC Diff (%)	TEMP QC (oC)	TEMP HL (oC)	TEMP Diff (oC)	TEMP Diff (%)	DO QC (mg/l)	DO HL (mg/l)	DO Diff (mg/l)	DO Diff (%)
7/27/88	1500	7.3				488				18.0				3.7			
8/6/88	1105	6.8				536				16.0							
8/18/88	1350	7.0				511				18.0				4.9			
8/19/88	1130	6.8	7.2	.4	6	486	350	-136	-28	15.0	16.3	1.3	8	4.6	5.5	.9	19
8/25/88	1315	7.9				486				18.0				5.5			
8/26/88	1145	7.5	6.7	-.8	-10	475	450	-25	-5	16.0	16.4	.4	2	5.9	6.6	.7	12
8/29/88	1250	7.7	7.3	-.4	-6	487	410	-77	-16	16.5	16.8	.3	2	5.1	6.8	1.7	33
9/1/88	1215	6.7				511				15.5				5.9			
9/1/88	1400	6.8				385				20.0				5.1			
9/5/88	1020	7.2	7.2	.0	0	481	440	-41	-9	14.0	14.0	.0	0	6.0	7.6	1.6	26
9/8/88	1205	8.1				521				16.0				6.5			
9/8/88	1750	7.2				495				14.0				3.4			
9/11/88	1800	7.7	7.1	-.6	-7	482	470	-12	-2	11.0	12.0	1.0	9	5.8	6.3	.5	8
9/12/88	2139	7.2	7.1	-.1	-1	468	420	-48	-10	12.0	14.3	2.3	19	4.0	5.0	1.0	26
9/18/88	1715	7.1	7.1	-.1	-1	384	485	101	26	6.0	14.5	8.5	141	6.9	6.9	.0	0
9/20/88	1218	6.9	7.0	.1	2	362	488	126	35	13.0	12.5	-.5	-4	6.6	6.7	.1	2
9/27/88	1630	7.3	7.1	-.2	-3	335	348	13	4	11.0	11.5	.5	4	6.5	6.6	.1	1
10/03/88	1005	6.7	6.8	.1	1	374	421	47	13	11.0	12.0	1.0	9	6.6	6.4	-.3	-4
10/10/88	0930	7.0	7.1	.1	2	489	416	-73	-15	10.5	10.7	.2	2	5.5	6.3	.8	15
10/17/88	245	6.4	6.7	.3	5	320	233	-87	-27	9.0	9.9	.9	10	7.0	6.9	-.2	-2
10/18/88	900	7.3	7.1	-.3	-4	433	253	-180	-42	10.5	9.0	-1.5	-14	5.8	6.7	.9	16
10/24/88	1000	7.6	7.0	-.5	-7	356	407	51	14	10.3	10.8	.5	5	6.5	7.0	.6	9
10/31/88	800	7.0	7.0	.0	0	438	400	-38	-9	7.8	7.5	-.3	-4	6.3	7.7	1.4	22
		Mean====		-.1	-2			-25	-5			1	13			1	12
		Std Dev=		.3	4			81	20			2	35			1	11
		Maximum=		.4	6			126	35			8.5	141			1.7	33
		Minimum=		-.8	-10			-180	-42			-1.5	-14			-.3	-4

Table B:

Silver Bow Creek Below Blacktail Creek, At Butte, MT
USGS Site 12323250
Quality Control 1989

Date (MMDDYY)	Time (HHMM)	pH QC	pH HL	pH Diff	pH Diff (%)	SC QC (umhos)	SC HL (umhos)	SC Diff (umhos)	SC Diff (%)	TEMP QC (oC)	TEMP HL (oC)	TEMP Diff (oC)	TEMP Diff (%)	DO QC (mg/l)	DO HL (mg/l)	DO Diff (mg/l)	DO Diff (%)
4/21/89	1245	7.2	7.1	.0	0	389	362	-27	-7	10.5	10.9	.4	3	10.6	8.3	-2.3	-22
4/22/89	750	7.1	7.1	.0	0	314	288	-26	-8	6.0	7.7	1.7	28	7.8	8.3	.5	6
4/28/89	1412	7.3	7.0	-.4	-5	418	379	-39	-9	7.0	8.4	1.4	19	8.0	9.3	1.3	16
5/3/89	1715	7.1	7.1	.0	0	370	353	-17	-5	11.0	11.5	.5	4	8.0	8.1	.1	1
5/11/89	1200	6.9	7.1	.2	3	393	353	-40	-10	9.5	9.7	.2	2	8.1	8.7	.6	7
5/15/89	1900	6.6	7.0	.5	7	278	290	12	4	9.0	11.4	2.4	27	10.2	7.7	-2.5	-24
5/15/89	2050	6.8	7.0	.2	3	238	252	14	6	9.0	10.6	1.6	18	11.0	7.8	-3.2	-29
5/24/89	1450	7.1	7.2	.1	1	600	487	-113	-19	11.0	11.8	.8	8	7.6	8.6	1.0	13
5/28/89	825	6.8	7.1	.4	5	443	407	-36	-8	8.0	8.6	.6	7	8.8	9.3	.5	6
6/9/89	1200	6.7	7.1	.4	6	454	446	-8	-2	15.4	16.1	.7	4	6.8	6.1	-.7	-10
6/14/89	1745	7.2	7.2	-.1	-1	470	379	-91	-19	14.6	15.7	1.1	7	6.5	5.2	-1.3	-20
6/27/89	1515	6.5	7.0	.5	7	317	316	-1	0	11.6	12.0	.4	3	6.9	7.6	.7	10
6/28/89	1145	6.8	7.0	.2	3	430	366	-64	-15	15.2	15.1	-.1	-1	8.0	7.6	-.4	-5
	Mean====			.1	2			-34	-7			1	10			0	-4
	Std Dev=			.2	4			36	8			1	9			1	15
	Maximum=			.5	7			14	6			2.4	28			1.3	16
	Minimum=			-.4	-5			-113	-19			-.1	-1			-3.2	-29

Table C:

Silver Bow Creek at Opportunity, MT
USGS Site 12323600
Quality Control 1988

DATE (MMDDYY)	TIME (HHMM)	pH QC	pH HL	pH Diff	pH Diff (%)	SC QC (umhos)	SC HL (umhos)	SC Diff (umhos)	SC Diff (%)	TEMP QC (oC)	TEMP HL (oC)	TEMP Diff (oC)	TEMP Diff (%)	DO QC (mg/l)	DO HL (mg/l)	DO Diff (mg/l)	DO Diff (%)
7/27/88	1330	9.4				420				20.5				10.7			
8/6/88	1410	8.5				486				15.0							
8/18/88	1530	9.8				452				22.0				10.7			
8/19/88	1300	9.6	9.5	.0	0	459	480	21	5	18.5	18.9	.4	2	13.6	13.2	-.4	-3
8/25/88	0915	8.7	8.4	-.2	-3	470	440	-30	-6	13.0	12.4	-.6	-5	7.6	11.2	3.6	47
8/26/88	1255	9.5				465				18.0				12.7			
8/29/88	1950	10.2				451				20.0				9.3			
9/1/88	1615	10.1				451				18.0				9.4			
9/1/88	1900	10.2	10.2	.0	0	505	370	-135	-27	17.0	19.7	2.7	16	9.1	9.1	.0	0
9/5/88	1200	9.5	9.0	-.5	-5	478	410	-68	-14	16.8	16.9	.1	0	14.7	16.9	2.2	15
9/8/88	1045	9.8				484				11.0				12.8			
9/8/88	1830	10.1	10.0	-.1	-1	521	400	-121	-23	14.0	18.6	4.6	33	8.9	9.2	.3	4
9/11/88	2000	9.3	8.4	-.9	-9	451	390	-61	-14	4.0	6.3	2.3	57		11.5		
9/12/88	1600	9.3	9.1	-.2	-2	434	380	-54	-12	14.0	14.5	.5	4	11.5	13.9	2.4	21
9/18/88	730	8.2	8.0	-.2	-2	430	457	27	6	1.0	3.6	2.6	255	10.4	11.8	1.4	14
9/19/88	2045	8.2	8.5	.3	4	454	470	16	4	9.0	9.3	.3	4	8.5	9.4	.9	11
9/27/88	1525	8.5	8.9	.5	6	407	380	-27	-7	8.0	9.5	1.5	19	11.6	14.5	2.9	25
10/3/88	1140	8.5	8.6	.1	1	392	388	-4	-1	11.0	10.6	-.4	-4	10.5	12.8	2.3	22
10/10/88	1030	7.7	8.4	.8	10	472	388	-84	-18	7.5	7.4	-.1	-1	12.0	12.9	.9	7
10/17/88	540	6.7	7.7	1.0	15	416	415	-1	0	8.5	9.5	1.0	11	8.7	9.5	.8	10
10/19/88	1000	8.0	8.0	.0	0	383	397	14	4	7.3	6.6	-.7	-9	10.2	11.2	1.0	10
10/24/88	1100	8.7				469				6.3				9.8			
10/31/88	1000	7.7				478				4.0				11.2			
		Mean=====>		.0	1			-36	-7			1	27			1	14
		Std Dev==>		.5	6			51	10			1	65			1	12
		Maximum==>		1.0	15			27	6			4.6	255			3.6	47
		Minimum==>		-.9	-9			-135	-27			-.7	-9			-.4	-3

Table D:

Silver Bow Creek at Opportunity, MT
USGS Site 12323600
Quality Control 1989

DATE (MMDDYY)	TIME (HHMM)	pH QC	pH HL	pH Diff	pH Diff (%)	SC QC (umhos)	SC HL (umhos)	SC Diff (umhos)	SC Diff (%)	TEMP QC (oC)	TEMP HL (oC)	TEMP Diff (oC)	TEMP Diff (%)	DO QC (mg/l)	DO HL (mg/l)	DO Diff (mg/l)	DO Diff (%)
4/7/89	1205	6.9				256				4.0				10.0			
4/21/89	1400	7.8	7.9	.1	2	328	290	-38	-12	11.0	9.1	-1.9	-17	10.8	10.6	-.2	-2
4/22/89	1010	7.7	7.8	.1	2	307	279	-28	-9	6.5	7.5	1.0	16	9.3	10.9	1.6	18
4/28/89	1457	7.8	8.0	.1	2	355	329	-26	-7	4.0	4.9	.9	23	10.6	11.8	1.2	11
5/3/89	1630	8.1	8.4	.3	4	302	306	4	1	11.0	12.3	1.3	11	9.6	10.4	.8	8
5/11/89	1315	7.4	8.0	.5	7	314	251	-63	-20	8.0	8.1	.1	1	9.8	13.0	3.2	32
5/12/89	1345	7.5	8.0	.5	6	247	246	-1	0	7.0	7.5	.5	7	10.6	13.1	2.5	23
5/15/89	1000	7.7	7.8	.1	2	327	264	-63	-19	8.0	7.7	-.3	-4	10.0	13.0	3.0	30
5/24/89		7.7				400				10.0				9.6			
5/28/89	1130	6.8	8.1	1.3	19	343	184	-159	-46	4.0	7.1	3.1	76	12.0	11.5	-.5	-4
6/9/89	1110	7.6	8.6	1.0	13	423	300	-123	-29	16.4	14.8	-1.6	-10	9.9	10.3	.4	4
6/14/89	1600	8.4	9.0	.6	7	267	281	14	5	15.4	16.5	1.1	7	8.8	10.4	1.7	19
6/28/89	1030	7.8	7.9	.0	0	344	293	-51	-15	13.8	12.3	-1.6	-11	10.2	9.0	-1.2	-12
	Mean=====>			.4	6			-49	-14			0	9			1	12
	Std Dev==>			.4	6			51	14			1	24			1	14
	Maximum==>			1.3	19			14	5			3.1	76			3.2	32
	Minimum==>			.0	0			-159	-46			-1.9	-17			-1.2	-12

Table E:

Warm Springs Creek At Warm Springs, MT
USGS Site 12323770
Quality Control 1988

DATE (MMDDYY)	TIME (HHMM)	pH QC	pH HL	pH Diff	pH Diff (%)	SC QC (umhos)	SC HL (umhos)	SC Diff (umhos)	SC Diff (%)	TEMP QC (oC)	TEMP HL (oC)	TEMP Diff (oC)	TEMP Diff (%)	DO QC (mg/l)	DO HL (mg/l)	DO Diff (mg/l)	DO Diff (%)
7/25/88	1130	8.2				1475				16.5				6.5			
8/6/88	1510	7.4				1412				15.0							
8/19/88	1330	7.7				1605				15.0				6.3			
8/25/88	1105	7.8				1412				15.0				7.2			
8/26/88	1400	7.8				1415				13.0				7.1			
8/29/88	2045	8.3				1470				17.0				6.7			
9/5/88	1310	8.1				1345				19.0				8.9			
9/8/88	1000	8.2				1588				10.0				5.9			
9/11/88	2110	8.2				1331				5.5				8.6			
9/12/88	1710	8.1				1279				11.5				8.8			
9/18/88	1000	7.9				1192				6.0				8.5			
9/19/88	1850	8.2				1350				5.0				8.4			
9/27/88	1245	6.9				1279				7.0				10.1			
10/3/88	1210	7.9				1059				11.0				9.0			
10/10/88	1115	8.2	7.9	-.3	-4	1258	1310	52	4	12.2	8.4	-3.8	-31	10.2	7.6	-2.6	-25
10/17/88	640		7.8			700	702	2	0	7.0	9.0	2.0	29	8.7	10.2	1.5	18
10/19/88	1100	8.3	7.9	-.4	-5	540	590	50	9	7.8	7.1	-.7	-8	9.8	11.7	1.9	19
10/24/88	1145	8.2	8.0	-.2	-2	717	651	-66	-9	7.5	6.9	-.6	-8	9.6	11.9	2.3	23
10/31/88	930	7.9	7.9	.0	0	700	607	-93	-13	5.1	4.6	-.5	-10		12.4		
		Mean====		-.2	-3			-11	-2			-.7	-6			.8	9
		Std Dev=		.2	2			59	8			2	19			2	20
		Maximum=		.0	0			52	9			2.0	29			2.3	23
		Minimum=		-.4	-5			-93	-13			-3.8	-31			-2.6	-25

Table F:

Warm Springs Creek At Warm Springs, MT
USGS Site 12323770
Quality Control 1989

DATE (MMDDYY)	TIME (HHMM)	pH QC	pH HL	pH Diff	pH Diff (%)	SC QC (umhos)	SC HL (umhos)	SC Diff (umhos)	SC Diff (%)	TEMP QC (oC)	TEMP HL (oC)	TEMP Diff (oC)	TEMP Diff (%)	DO QC (mg/l)	DO HL (mg/l)	DO Diff (mg/l)	DO Diff (%)
4/14/89	1530	8.7				524				13.0				10.2			
4/21/89	1445	7.9	8.3	.4	5	395	395	0	0	11.3	12.1	.8	7	8.4	10.3	1.9	22
4/22/89	1050	8.4	8.2	-.2	-3	417	384	-33	-8	8.2	9.3	1.1	14	10.2	11.0	.8	8
4/28/89	1541	8.4	8.3	.0	0	414	420	6	1	6.0	6.4	.4	7	10.4	12.7	2.3	22
5/3/89	1545	7.5	8.5	1.0	14	415	402	-13	-3	11.0	11.3	.3	3	10.2	11.6	1.4	14
5/11/89	1402	7.1	7.9	.8	11	210	238	28	13	6.8	7.0	.2	3	10.0	9.9	-.1	-1
5/12/89	1446	7.3	7.0	-.3	-4	226	265	39	17	6.5	6.9	.4	6	9.8	10.2	.4	4
5/15/89	2310	7.5	8.0	.5	7	360	407	47	13	9.0	9.9	.9	10		8.6	8.6	
5/24/89	1340	7.3	8.2	.8	11	329	346	17	5	9.0	9.6	.6	7	10.2	11.2	1.0	10
5/29/89	45	7.2	7.9	.6	9	318	357	39	12	3.0	4.9	1.9	62	9.6	11.2	1.6	17
6/6/89	1530	7.3	8.0	.7	10	177	230	53	30	14.5	13.2	-1.3	-9	8.7	9.8	1.1	13
6/9/89	1015	7.0	7.8	.9	12	165	191	26	16	9.2	9.6	.4	4	9.6	8.4	-1.3	-13
6/14/89	1530	7.2				208				11.5				8.2			
6/27/89	1845	7.1				270				13.0				8.8			
6/28/89	1000	7.5				234				9.5				9.2			
		Mean====		.5	6			19	9			.5	10			1.6	10
		Std Dev=		.4	6			25	10			1	17			2	10
		Maximum=		1.0	14			53	30			1.9	62			8.6	22
		Minimum=		-.3	-4			-33	-8			-1.3	-9			-1.3	-13

Table 6:

Clark Fork Near Galen, MT
USGS Site 12323800
Quality Control 1988

DATE (MMDDYY)	TIME (HHMM)	pH QC	pH HL	pH Diff	pH Diff (%)	SC QC (umhos)	SC HL (umhos)	SC Diff (umhos)	SC Diff (%)	TEMP QC (oC)	TEMP HL (oC)	TEMP Diff (oC)	TEMP Diff (%)	DO QC (mg/l)	DO HL (mg/l)	DO Diff (mg/l)	DO Diff (%)
7/27/88	0940	8.2				707				18.5				6.7			
8/6/88	1640	8.3				711				18.0							
8/18/88	1700	8.2				788				17.0				7.6			
8/19/88	1430	8.3	8.3	.0	0	811	660	-151	-19	19.0	19.9	.9	4	7.7	9.0	1.3	17
8/25/88	1200	8.4	8.1	-.4	-4	850	660	-190	-22	17.0	16.3	-.7	-4	7.5	7.7	.2	2
8/26/88	1430	8.1	8.2	.1	1	850	720	-130	-15	17.0	17.3	.3	2	8.3	9.7	1.4	17
8/29/88	2025	8.7	8.3	-.5	-5	829	730	-99	-12	18.0	18.9	.9	5	7.5	8.0	.5	6
9/1/88	1700	8.3				861				17.0				7.8			
9/1/88	2000	8.8	8.2	-.6	-6	867	680	-187	-22	17.0	18.3	1.3	8	7.5	8.7	1.2	16
9/5/88	1400	8.3	8.5	.2	3	753	660	-93	-12	19.0	18.6	-.4	-2	10.0	11.2	1.2	12
9/8/88	0905	8.6				841				11.0				8.3			
9/8/88	1715	8.3				890				15.0				7.6			
9/11/88	2230	8.6	8.0	-.6	-7	782	750	-32	-4	5.0	8.2	3.2	65	8.7	10.1	1.4	16
9/12/88	1801	7.9	8.4	.6	7	844	780	-64	-8	13.0	13.1	.1	1	10.2	11.7	1.5	15
9/18/88	1130	8.2	8.3	.1	1	689	757	68	10	7.0	7.5	.5	7	10.2	11.3	1.1	11
9/19/88	920	8.9	8.3	-.6	-7	609	728	119	20	8.5	7.6	-.9	-11	8.4	10.2	1.8	21
9/27/88	1410	7.9	8.7	.8	10	674	667	-7	-1	8.0	9.8	1.8	23	10.5	11.0	.5	5
10/3/88	1230	7.6	8.9	1.3	17	555	673	118	21	13.0	12.5	-.5	-4	12.1	12.5	.4	4
10/10/88	1145	8.7	8.8	.1	1	710	672	-38	-5	10.5	10.7	.2	2	12.0	12.1	.1	1
10/17/88	820		7.9			500	659	159	32	7.0	9.1	2.1	30	8.8	9.3	.6	6
10/19/88	1130	8.3	8.3	.0	0	611	588	-23	-4	8.2	8.3	.1	1	11.0	11.9	.9	8
10/24/88	1200	7.8	8.4	.6	8	697	653	-44	-6	8.0	7.9	-.1	-1	11.1	13.3	2.2	20
10/31/88	1000	7.8	8.1	.2	3	686	609	-77	-11	5.2	4.9	-.3	-6	10.9	11.8	.9	8
		Mean====		.1	1			-39	-3			.5	7			1.0	11
		Std Dev=		.5	6			102	15			1.1	17			.6	6
		Maximum=		1.3	17			159	32			3.2	65			2.2	21
		Minimum=		-.6	-7			-190	-22			-.9	-11			.1	1

Table H:

Clark Fork Near Galen, MT
USGS Site 12323800
Quality Control 1989

DATE (MMDDYY)	TIME (HHMM)	pH QC	pH HL	pH Diff	pH Diff (%)	SC QC (umhos)	SC HL (umhos)	SC Diff (umhos)	SC Diff (%)	TEMP QC (oC)	TEMP HL (oC)	TEMP Diff (oC)	TEMP Diff (%)	DO QC (mg/l)	DO HL (mg/l)	DO Diff (mg/l)	DO Diff (%)
4/14/89	1636	8.9								14.0				9.5			
4/21/89	1530	8.2	8.4	.2	3	427	405	-22	-5	13.8	13.2	-.6	-4	8.8	9.7	.9	10
4/22/89	1156	8.3	8.2	-.1	-1	475	394	-81	-17	10.5	11.0	.5	5	10.0	10.0	.0	0
4/28/89	1640	8.5	8.3	-.2	-3	430	399	-31	-7	6.0	6.5	.5	8	10.4	11.4	1.0	9
5/3/89	1510	8.4	8.5	.1	1	439	394	-45	-10	10.0	11.8	1.8	18	10.6	10.4	-.2	-2
5/11/89	1421	7.5	7.7	.2	2	279	247	-32	-11	8.8	9.2	.4	4	9.4	10.3	.9	10
5/12/89	1602	8.2	7.9	-.3	-4	271	264	-7	-3	7.5	8.7	1.2	17	10.0	11.0	1.0	10
5/15/89	2355	7.6	7.8	.3	3	377	333	-44	-12	8.0	10.9	2.9	37		9.1		
5/24/89	1310	7.0	8.1	1.1	16	344	317	-27	-8	8.0	9.0	1.0	13		12.6		
5/29/89	0150	7.2	7.6	.4	6	360	332	-28	-8	6.0	6.4	.4	7	8.8	10.4	1.6	18
6/6/89	1650	7.2				217				18.0				9.0			
6/9/89	0900	7.3	7.8	.5	7	223	215	-8	-4	11.9	12.1	.2	2	9.1	12.8	3.8	41
6/14/89	1430	7.4	8.3	.9	12	203	219	16	8	14.0	14.3	.3	2	8.4	13.2	4.8	57
6/28/89	0930	7.7	7.8	.1	1	330	301	-29	-9	11.1	11.7	.6	5	9.3	8.9	-.5	-5
		Mean====		.3	4			-28	-7			.8	9			1.3	15
		Std Dev=		.4	6			23	6			.9	10			1.6	19
		Maximum=		1.1	16			16	8			2.9	37			4.8	57
		Minimum=		-.3	-4			-81	-17			-.6	-4			-.5	-5

Appendix B
Selected Water Quality Results for 1988 and 1989 Sampling
at All Sample Locations

UPPER CLARK FORK STORM EVENT MONITORING

07/19/90

DATE (MM/DD/YR)	TIME (HRS)	FLOW (cfs)	PHYSICAL PARAMETERS FIELD SC (umhos)	FIELD PH	FIELD DO (mg/l)	FIELD TEMP (C)	LAB SC (umhos)	LAB PH	HARDNESS (mg/l)	ALKALINITY (mg/l)	PERCENT meq/l Ca	Mg	Na	HCO3	CO3	SO4
USGS STATION No. 12323200			BLACKTAIL CREEK NEAR BUTTE, MT (ABOVE CONFLUENCE WITH SILVER BOW CREEK)													
04/07/89	09:20	27	220	6.9	N/A	4.2	235	6.6	93.1	64.9	55.6	22.9	17.1	56.7	.0	36.7
04/14/89	11:46	20	205	7.0	9.5	9.0	280	7.4	107.4	77.0	57.8	22.9	16.7	58.1	.0	35.2
04/21/89	11:20	16	295	6.7	9.5	9.0	290	7.6	109.9	80.0	57.5	22.9	17.2	58.6	.0	35.1
04/22/89	06:45	27	260	N/A	7.8	6.9	235	7.6	82.5	64.5	53.4	20.7	23.3	57.6	.0	33.4
04/28/89	12:34	14	275	7.2	10.0	5.0	310	7.7	120.3	85.6	56.9	22.6	17.7	57.4	.0	35.6
05/15/89	16:10	22	250		9.5	8.0	380	7.6	68.9	58.1	56.9	19.7	19.6	62.4	.0	32.0
05/15/89	20:18	29	270	6.8	10.8	9.0	300	7.5	96.1	66.0	57.9	21.4	18.0	59.0	.0	33.8
05/28/89	19:10	31	185	6.5	11.0	3.0	185	7.2	67.1	53.1	58.7	21.0	18.1	61.9	.0	30.5
06/27/89	14:15	25	290	6.8	7.6	12.0	NO RAW SAMPLE		128.9	102.0	57.5	22.5	17.7	NO ANIONS		
MISSOULA GULCH			MISSOULA GULCH (AT CENTENNIAL AVE)													
04/07/89	09:55	.22	630	7.6	N/A	7.0	595	7.2	225.6	112.4	54.3	23.6	18.3	39.3	.0	46.8
04/14/89	12:47	.33	595	7.7	8.0	15.0	605	7.7	226.1	124.5	53.2	23.6	19.8	42.6	.0	44.4
04/21/89	12:00	.56	530	7.3	8.1	12.0	520	7.7	197.9	97.3	54.5	24.5	17.7	39.5	.0	47.6
04/28/89	13:10	.11	390	7.5	9.4	7.0	475	7.6	177.2	98.4	57.2	22.1	17.0	43.8	.0	45.4
05/15/89	18:00	1.10	160	6.6	10.5	10.0	245	7.6	63.3	36.4	62.7	15.2	16.4	45.4	.0	49.3
05/28/89	21:15	.89	135	6.5	11.2	3.0	130	7.1	45.4	26.0	61.7	16.3	17.6	45.4	.0	46.3
06/27/89	16:30	N/A	665	6.6	7.2	16.1	NO RAW SAMPLE		315.9	47.0	69.8	18.7	6.5	NO ANIONS		
USGS STATION No. 12323250			SILVER BOW CREEK BELOW BLACKTAIL CREEK AT BUTTE, MT (COLORADO TAILINGS)													
07/27/88	15:00	15	485	7.3	3.7	18.0	540	7.3	160.2	116.5	48.7	19.7	27.8	52.4	.0	34.2
08/06/88	11:05	17	535	6.8		17.0	465	7.0	164.6	98.8	48.6	19.8	27.6	47.8	.0	38.4
09/05/88	10:30	14	480	7.2	6.0	17.0	495	7.2	175.7	121.1	50.0	20.9	25.4	52.3	.0	35.9
09/11/88	17:10	14	490	7.7	5.8	11.0	485	7.2	167.6	114.2	49.6	20.5	25.4	50.0	.0	38.0
09/18/88	04:00	29	385	7.1	6.9	6.0	395	6.9	144.9	87.5	51.4	20.1	23.9	46.0	.0	42.3
09/27/88	16:30	39	335	7.3	6.5	11.0	360	6.7	131.9	93.8	52.1	19.7	23.4	53.2	.0	36.5
10/17/88	02:40	98	320	6.4	7.0	9.0	340	6.5	117.5	46.3	55.9	18.2	19.1	29.3	.0	62.2
101 11/03/88	09:10	56	410	6.3	N/A	N/A	355	6.9	141.7	N/A	51.2	20.4	23.3	NO ANIONS		
102 11/03/88	09:40	50	370	6.8	N/A	N/A	355	7.1	116.2	N/A	47.3	18.4	24.7	NO ANIONS		
103 11/03/88	10:10	50	415	7.0	N/A	N/A	370	7.4	104.8	N/A	40.0	21.5	29.6	NO ANIONS		
104 11/03/88	10:40	50	415	7.1	N/A	N/A	400	7.5	131.7	N/A	47.5	18.6	26.4	NO ANIONS		
105 11/03/88	11:10	39	430	7.1	N/A	N/A	390	7.3	136.4	N/A	47.8	18.6	27.0	NO ANIONS		
106 11/03/88	11:40	39	475	7.2	N/A	N/A	410	7.3	153.2	N/A	48.2	19.4	27.5	NO ANIONS		
107 11/03/88	12:10	39	480	7.2	N/A	N/A	420	7.3	141.6	N/A	48.0	19.4	27.3	NO ANIONS		
04/07/89	10:58	56	330	7.6	8.6	7.3	325	7.1	103.8	74.6	50.0	20.0	25.1	50.0	.0	40.1
04/14/89	13:26	35	410	7.3	8.5	11.0	375	7.3	120.6	80.0	51.1	20.9	24.4	48.9	.0	40.5
04/21/89	12:45	30	415	7.2	10.6	10.6	390	7.5	126.5	80.9	50.2	20.5	25.2	46.1	.0	42.4
04/22/89	07:50	58	455	7.1	7.8	6.0	310	7.1	96.5	56.0	51.8	18.2	26.2	42.2	.0	46.2
04/28/89	14:12	26	420	7.3	8.0	7.0	420	7.4	132.8	86.3	51.4	19.6	24.9	46.5	.0	41.9
05/15/89	19:00	79	280	6.6	10.2	9.5	495	7.3	90.7	57.2	55.7	16.3	23.2	45.8	.0	44.5
05/15/89	20:50	127	240	6.8	11.0	8.5	405	7.3	100.3	98.3	56.0	16.3	23.1	72.2	.0	23.1
05/28/89	20:25	37	245	6.8	8.8	3.5	245	7.0	75.4	38.1	54.4	18.3	23.3	40.1	.0	47.8
06/09/89	13:00	19	455	6.7	6.8	15.4	430	6.7	139.2	75.2	49.5	19.3	27.3	40.6	.0	45.2
06/27/89	15:15	71	420	6.8	8.0	15.2	NO RAW SAMPLE		123.3	112.0	61.3	16.3	18.4	NO ANIONS		

UPPER CLARK FORK STORM EVENT MONITORING

07/19/90

PHYSICAL PARAMETERS

	DATE	TIME	FLOW	FIELD SC	PH	DO	TEMP	LAB SC	PH	HARDNESS	ALKALINITY	PERCENT meq/l					
	(MM/DD/YR)	(HRS)	(cfs)	(umhos)		(mg/l)	(C)	(umhos)		(mg/l)	(mg/l)	Ca	Mg	Na	HCO3	CO3	SO4
USGS STATION No. 1232600				SILVER BOW CREEK AT OPPORTUNITY, MT (STEWART BRIDGE)													
	07/27/88	09:40	20	415	9.3	10.2	18.5	410	9.6	160.2	109.6	52.7	19.7	24.4	31.1	21.4	37.5
	08/06/88	14:10	16	485	8.5	N/A	15.0	490	8.3	183.8	122.5	50.9	19.8	26.0	48.5	.0	40.8
	09/05/88	12:00	15	475	9.5	14.2	16.0	470	9.3	186.6	121.0	51.5	20.0	25.3	30.6	18.3	40.3
101	09/10/88	23:50	26	390	7.9	10.9	6.0	225	7.7	181.4	115.6	52.1	20.4	24.2	48.8	.0	40.7
102	09/11/88	00:20	26	400	7.9	11.0	5.9	395	7.2	169.8	98.8	51.7	20.2	24.3	45.0	.0	43.0
103	09/11/88	01:00	30	400	7.9	11.0	5.8	N/A	7.6	166.7	110.1	51.4	20.4	24.6	47.7	.0	42.0
104	09/11/88	01:30	34	400	7.9	11.0	5.7	N/A	7.7	166.0	104.1	51.4	20.3	24.7	46.3	.0	42.9
105	09/11/88	02:00	38	420	7.8	11.2	5.5	N/A	7.6	167.3	105.2	51.6	20.1	24.5	46.5	.0	43.1
106	09/11/88	02:30	38	430	7.9	11.2	5.3	N/A	7.5	174.7	105.6	51.5	20.3	24.4	46.2	.0	43.1
107	09/11/88	03:00	29	430	7.9	11.4	5.2	225	7.1	172.0	100.1	51.9	20.2	24.3	45.0	.0	43.6
	09/11/88	20:00	28	465	9.3	7.5	5.0	455	7.5	173.1	96.7	51.6	20.4	24.6	43.5	.0	45.5
201	09/17/88	21:00	26	450	8.8	10.0	7.8	430	7.0	172.0	102.4	51.7	20.1	24.6	46.0	.0	38.8
202	09/17/88	22:00	30	450	8.6	10.2	7.1	N/A	N/A	175.0	N/A	50.6	19.9	24.0			
203	09/17/88	23:00	31	455	8.4	10.4	6.6	N/A	7.6	170.4	83.2	51.6	19.8	24.6	38.4	.0	43.0
204	09/18/88	24:00	34	450	8.3	10.6	6.2	N/A	7.3	169.3	90.1	51.7	19.8	24.6	41.2	.0	42.9
205	09/18/88	01:00	35	450	8.2	10.7	6.2	N/A	7.3	173.5	83.1	51.8	19.9	24.5	37.3	.0	44.3
206	09/18/88	02:00	36	455	8.1	10.8	5.8	N/A	7.4	172.8	76.0	52.0	19.8	24.1	34.0	.0	44.5
207	09/18/88	03:00	53	455	8.1	10.8	5.3	335	N/A	173.9	N/A	51.8	20.1	24.2			
	09/18/88	07:30	53	430	8.2	10.4	4.0	475	6.9	174.7	97.4	52.4	20.6	23.2	41.5	.0	48.4
	09/27/88	15:25	28	410	8.5	11.6	10.0	415	8.5	160.2	111.8	51.8	19.6	25.2	50.5	1.6	37.9
301	09/27/88	23:50	38	380	8.4	12.0	6.9	460	7.3	164.6	100.9	51.7	19.6	25.1	44.3	.0	37.9
302	09/28/88	01:50	43	385	8.2	12.5	6.0	455	7.3	168.5	120.5	51.9	19.6	24.9	51.5	.0	37.2
303	09/28/88	03:50	54	390	8.1	12.6	5.5	545	7.3	173.8	94.6	52.2	20.0	24.1	40.7	.0	43.2
	10/17/88	05:00	36	420	6.7	8.7	8.5	440	7.2	165.8	97.0	52.2	19.9	24.2	44.5	.0	45.8
	04/07/89	12:05	129	235	6.9	10.0	4.0	250	6.7	84.1	53.6	50.9	18.7	22.7	46.8	.0	45.8
	04/14/89	14:46	69	375	7.9	8.8	12.0	360	7.3	127.0	75.2	55.6	19.8	21.3	46.7	.0	45.5
	04/21/89	14:00	88	330	7.8	10.8	11.0	N/A	N/A	111.8	69.5	56.7	19.3	21.6	47.2	.0	45.1
	04/22/89	10:10	96	310	7.7	9.3	6.5	295	7.4	106.4	67.2	58.2	19.5	19.4	48.9	.0	43.7
	04/28/89	14:57	72	355	7.8	10.6	3.0	360	7.8	126.1	72.0	55.7	18.7	22.1	43.6	.0	47.9
	05/12/89	13:45	89	250	7.5	10.6	10.0	430	8.1	107.0	73.8	58.8	19.2	18.9	53.0	.0	40.3
	05/15/89	10:00	76	310	7.7	10.0	8.0	495	8.0	128.7	88.9	62.1	17.9	17.3	56.4	.0	37.5
	05/28/89	11:30	64	345	6.8	12.0	3.5	335	7.7	133.3	82.0	58.5	19.2	19.5	49.0	.0	43.9
	06/09/89	11:00	61	335	7.6	9.9	16.4	300	7.1	112.7	78.7	58.5	18.9	20.0	55.0	.0	37.0
	06/27/89	18:00	44	315	8.9	10.6	17.0	NO RAW SAMPLE		129.2	115.0	57.1	18.9	20.7	NO ANIONS		

UPPER CLARK FORK STORM EVENT MONITORING

07/19/90

			PHYSICAL PARAMETERS															
			FIELD				LAB					PERCENT meq/l					
DATE	TIME	FLOW	SC	PH	DO	TEMP	SC	PH	HARDNESS	ALKALINITY								
(MM/DD/YR)	(HRS)	(cfs)	(umhos)		(mg/l)	(C)	(umhos)		(mg/l)	(mg/l)		Ca	Mg	Na	HCO3	CO3	SO4
USGS STATION No. 12323770			WARM SPRINGS CREEK AT WARM SPRINGS, MT															
07/27/88	11:30	.6	1,420	8.2	6.5	16.5	1200	8.1	724.0	184.1		74.6	22.0	2.8	24.8	.0	74.4
08/06/88	15:10	.6	1,410	7.4	N/A	14.8	1220	7.6	753.4	180.1		74.0	22.2	3.1	23.4	.0	75.7
09/05/88	13:10	1.4	1,330	8.1	8.9	16.0	1230	8.1	743.5	172.9		74.9	21.2	3.2	22.6	.0	76.6
09/11/88	21:10	3.3	1,300	8.2	N/A	N/A	1295	8.2	776.8	177.7		75.5	21.1	2.8	22.1	.0	77.1
09/18/88	10:00	3.9	1,190	7.9	8.5	6.0	1140	8.1	686.6	169.7		74.8	21.8	2.8	24.1	.0	75.1
09/27/88	12:45	5.8	1,280	6.9	10.1	9.0	1250	8.1	746.1	190.1		75.6	20.9	2.9	24.9	.0	74.1
10/17/88	06:40	35	700		8.7	7.0	700	7.8	374.9	153.1		73.8	21.7	3.5	39.1	.0	60.2
04/07/89	13:10	38	485	7.9	10.0	8.0	480	7.8	227.8	118.8		71.8	22.7	4.6	49.0	.0	50.2
04/14/89	15:30	34	525	8.6	10.2	13.0	485	8.5	244.5	140.1		71.9	23.0	4.5	53.2	.0	46.0
04/21/89	14:45	53	395	7.9	8.4	11.3	395	8.2	193.5	136.9		65.3	20.2	13.7	60.8	.0	38.4
04/22/89	10:50	59	440	8.4	10.2	8.2	385	8.1	183.6	108.8		72.4	22.0	4.8	56.6	.0	42.4
04/28/89	15:41	48	415	8.4	10.4	6.0	440	8.5	217.3	130.1		72.9	21.9	4.2	56.2	.0	43.0
05/12/89	14:46	115	220	7.3	9.8	6.5	380	8.1	119.6	80.6		73.6	21.2	4.3	64.6	.0	34.6
05/15/89	23:10	49	360	7.5	8.6	8.0	635	8.1	180.0	112.4		73.8	21.0	4.2	58.0	.0	41.0
05/29/89	00:45	62	320	7.2	9.6	4.0	295	7.8	148.3	97.6		72.9	21.8	4.3	58.7	.0	40.2
06/06/89	15:30	115	200	7.3	8.7	13.2	195	7.4	90.4	63.4		72.4	21.9	4.3	71.4	.0	27.8
06/09/89	10:15	154	150	7.0	9.6	9.3	180	7.4	81.9	58.6		73.0	21.3	4.5	68.7	.0	30.8
06/27/89	18:45	68	270	7.1	8.8	13.0	NO RAW SAMPLE		129.2	68.0		73.5	21.1	4.1	NO ANIONS		
USGS STATION No. 12323800			CLARK FORK NEAR GALEN, MT (PERKINS LANE BRIDGE)															
07/27/88	09:40	12	700	8.2	6.7	18.5	645	7.9	290.0	100.5		59.3	24.2	14.7	29.2	.0	66.0
08/06/88	16:40	10	710	8.3	N/A	17.0	680	7.6	317.5	103.3		60.3	23.8	14.0	28.6	.0	67.2
09/05/88	14:00	12	745	8.3	10.0	17.0	740	8.3	347.3	106.9		61.7	23.3	13.0	26.7	.0	69.0
09/11/88	22:30	12	775	8.6	8.7	5.0	745	8.0	361.0	104.2		62.1	23.4	12.7	24.9	.0	71.1
09/18/88	11:30	27	690	8.2	10.2	7.0	720	8.0	343.1	97.8		61.9	23.2	13.2	24.9	.0	70.3
09/27/88	14:10	33	675	7.9	10.5	8.0	700	8.6	324.4	96.9		60.4	23.5	14.2	25.1	.8	69.3
10/17/88	08:00	63	775	7.9	8.8	7.0	690	7.6	336.0	112.9		63.6	23.5	11.2	30.1	.0	66.2
04/07/89	14:18	141	550	8.0	10.6	7.4	520	7.5	227.2	108.5		63.8	21.1	12.3	39.9	.0	55.9
04/14/89	16:36	125	510	8.9	9.5	19.0	490	7.9	215.9	100.5		64.3	21.6	12.6	39.6	.0	56.6
04/21/89	15:30	177	425	8.2	8.8	13.8	420	7.7	182.9	91.0		64.3	21.7	12.4	42.5	.0	53.6
101 04/21/89	15:40	175	405	8.4	9.7	13.2	NO RAW SAMPLE		N/A	N/A		N/A	N/A	N/A	NO ANIONS		
102 04/21/89	16:40	175	400	8.4	9.4	13.5	NO RAW SAMPLE		N/A	N/A		N/A	N/A	N/A	NO ANIONS		
103 04/21/89	17:40	169	400	8.4	9.3	13.6	NO RAW SAMPLE		N/A	N/A		N/A	N/A	N/A	NO ANIONS		
104 04/21/89	18:40	167	400	8.4	9.2	13.4	NO RAW SAMPLE		N/A	N/A		N/A	N/A	N/A	NO ANIONS		
105 04/21/89	19:40	167	405	8.4	9.1	13.2	NO RAW SAMPLE		N/A	N/A		N/A	N/A	N/A	NO ANIONS		
106 04/21/89	20:20	169	410	8.3	8.8	12.9	NO RAW SAMPLE		N/A	N/A		N/A	N/A	N/A	NO ANIONS		
04/22/89	11:56	209	450	8.3	10.0	10.5	410	7.9	177.3	89.2		64.3	21.5	12.7	42.2	.0	54.1
201 04/24/89	12:40	224	400	8.1	10.9	7.5	400	8.0	184.6	86.9		64.1	21.6	12.3	40.2	.0	55.9
202 04/24/89	13:40	224	405	8.2	10.9	7.6	435	8.0	184.1	84.1		63.4	21.4	13.0	39.1	.0	56.7
203 04/24/89	14:40	221	400	8.3	10.9	7.8	440	8.0	185.3	85.6		63.4	21.5	13.0	39.5	.0	56.3
204 04/24/89	15:40	221	400	8.3	11.0	7.8	435	7.8	184.8	86.0		63.3	21.6	13.1	39.7	.0	55.8
205 04/24/89	16:40	215	405	8.3	10.9	7.7	435	7.8	186.9	85.6		63.4	21.5	12.8	39.7	.0	56.0
206 04/24/89	17:40	212	410	8.3	10.7	7.6	425	7.3	195.7	92.4		63.6	21.5	12.9	40.9	.0	54.9
04/28/89	16:40	164	430	8.5	10.4	6.0	445	7.5	191.8	92.1		64.7	21.4	12.0	41.7	.0	54.7

UPPER CLARK FORK STORM EVENT MONITORING

07/19/90

PHYSICAL PARAMETERS

	DATE	TIME	FLOW	FIELD SC	PH	DO	TEMP	LAB SC	PH	HARDNESS	ALKALINITY	PERCENT meq/l					
	(MM/DD/YR)	(HRS)	(cfs)	(umhos)		(mg/l)	(C)	(umhos)		(mg/l)	(mg/l)	Ca	Mg	Na	HCO3	CO3	SO4
USGS STATION No. 12323800				CLARK FORK NEAR GALEN, MCLARK FORK NEAR GALEN, MT (PERKINS LANE BRIDGE)													
301	05/09/89	10:45	267	290	7.9	10.1	10.3	N/A	N/A	144.3	N/A	62.5	21.0	14.1	NO ANIONS		
302	05/09/89	11:45	264	290	8.0	10.3	11.1	325	7.6	139.4	84.2	64.2	21.2	12.5	49.5	.0	46.9
303	05/09/89	12:45	278	290	8.1	10.3	12.0	430	N/A	137.1	N/A	64.3	21.0	12.6	NO ANIONS		
304	05/09/89	13:45	278	290	8.1	10.3	13.0	N/A	N/A	139.1	N/A	64.4	20.6	12.1	NO ANIONS		
305	05/09/89	14:45	274	290	8.2	10.2	14.1	295	7.8	138.6	97.3	64.5	20.8	12.2	47.5	.0	49.7
306	05/09/89	15:45	274	290	8.2	9.9	15.1	N/A	N/A	137.6	N/A	64.3	20.9	12.3	NO ANIONS		
401	05/10/89	14:45	303	290	8.0	9.3	13.6	501	7.8	N/A	N/A						
402	05/10/89	15:45	299	280	7.9	9.1	13.5	360	7.8	126.6	84.4	64.0	21.4	12.6	57.9	.0	38.1
403	05/10/89	16:45	303	280	7.9	9.1	13.8	335	8.8	N/A	N/A						
404	05/10/89	17:45	299	285	7.8	8.8	13.6	500	7.8	127.2	69.1	63.7	21.5	12.7	47.0	.0	49.5
405	05/10/89	18:45	314	280	7.8	8.9	13.7	195	9.0	125.8	61.8	63.7	21.5	12.8	37.2	7.3	51.8
406	05/10/89	19:45	314	285	7.8	8.8	13.6	450	7.8	127.3	70.1	63.9	21.2	12.9	47.3	.0	49.1
	05/12/89	16:02	314	270	8.2	10.0	10.0	420	8.0	118.0	68.0	64.0	20.7	13.6	48.6	.0	48.0
	05/15/89	11:55	215	280	7.6	10.8	8.0	615	8.0	151.9	73.9	64.6	20.8	12.7	41.7	.0	54.4
	05/27/89	01:50	209	360	7.2	8.8	4.0	335	7.7	148.0	80.5	64.1	22.0	12.4	45.1	.0	51.6
501	06/06/89	07:15	274	260	7.7	8.6	12.5	275	8.0	112.9	65.6	63.7	22.3	11.9	50.8	.0	45.7
502	06/06/89	08:15	278	250	7.7	9.0	12.1	275	8.1	113.1	65.2	63.4	22.1	12.0	50.4	.0	46.1
503	06/06/89	09:15	285	260	7.7	N/A	N/A	270	8.0	108.9	64.2	63.7	22.1	11.8	53.2	.0	41.2
504	06/06/89	10:15	285	230	8.1	N/A	N/A	260	8.1	108.6	62.3	64.1	22.2	11.8	49.6	.0	42.2
505	06/06/89	11:15	278	230	8.3	N/A	N/A	260	7.9	108.6	62.8	63.4	22.5	11.9	53.0	.0	41.6
506	06/06/89	12:15	285	230	8.1	N/A	N/A	255	8.0	106.3	61.7	64.1	22.0	11.8	49.4	.0	45.5
	06/06/89	16:50	271	240	7.2	9.0	18.0	250	7.3	102.5	60.6	64.0	22.2	11.9	51.2	.0	45.6
	06/09/89	08:05	322	220	7.3	9.1	11.9	230	7.4	92.5	54.6	64.3	22.3	11.6	51.9	.0	45.2
601	06/16/89	05:15	391	200	7.5	11.3	12.5	NO RAW SAMPLE		89.3	N/A	66.1	22.5	9.7	NO ANIONS		
602	06/16/89	06:15	400	200	7.5	11.5	12.1	NO RAW SAMPLE		87.1	N/A	65.7	22.5	9.9	NO ANIONS		
603	06/16/89	07:15	422	200	7.5	11.6	11.7	NO RAW SAMPLE		86.9	N/A	65.4	22.5	9.9	NO ANIONS		
604	06/16/89	08:15	431	195	7.6	11.8	11.4	NO RAW SAMPLE		85.9	N/A	65.1	22.7	10.0	NO ANIONS		
605	06/16/89	09:15	431	190	7.6	12.0	11.2	NO RAW SAMPLE		84.2	N/A	64.8	22.7	10.2	NO ANIONS		
606	06/16/89	10:15	431	190	7.6	12.0	11.2	NO RAW SAMPLE		79.0	N/A	64.7	22.8	10.4	NO ANIONS		
607	06/16/89	11:15	436	190	7.6	12.2	11.3	NO RAW SAMPLE		78.1	N/A	65.2	22.7	10.3	NO ANIONS		
	06/27/89	19:15	132	315	8.1	8.3	15.1	NO RAW SAMPLE		138.8	58.0	64.6	22.8	11.0	NO ANIONS		

N/A - NOT ANALYIZED

UPPER CLARK FORK STORM E

7/19/90

DISSOLVED CONCENTRATION

DATE (MM/DD/YR)	TIME (HRS)	FLOW (cfs)	Fe (mg/l)	Mn (mg/l)	SO4 (mg/l)	Al (ug/l)	Be (ug/l)	Cd (ug/l)	Cr (ug/l)	Cu (ug/l)	Pb (ug/l)	Zn (ug/l)	As (ug/l)
USGS STATION No. 12323200													
04/07/89	09:20	27	.400	.280	40	50	N/A	<2	<2	9	<40	100	7.0
04/14/89	11:46	20	.340	.097	45	<30	N/A	<2	<2	7	<40	29	5.2
04/21/89	11:20	16	.210	.100	46	<30	<2	<2	<2	10	<40	36	5.1
04/22/89	06:45	27	.200	.120	36	<30	N/A	<2	<2	12	<40	54	5.9
04/28/89	12:34	14	.210	.150	51	<30	N/A	3	<2	10	<40	37	5.0
05/15/89	16:10	22	.130	.100	29	78	<2	<2	3	24	<40	77	7.9
05/15/89	20:18	29	.082	.073	36	<30	<2	<2	<2	28	<40	25	5.9
05/28/89	19:10	31	.079	.069	25	<30	<2	<2	<2	9	<40	26	4.3
06/27/89	14:15	25	.081	.096	N/A	<30	N/A	<2	<2	17	<40	50	5.4
MISSOULA GULCH													
04/07/89	09:55	.22	.007	1.370	129	<30	N/A	5	<2	130	<40	2310	6.8
04/14/89	12:47	.33	.020	1.330	125	<30	N/A	4	<2	140	90	2250	6.1
04/21/89	12:00	.56	.013	1.320	112	<30	<2	11	<2	80	<40	1700	5.7
04/28/89	13:10	.11	.026	1.060	98	<30	N/A	8	<2	76	<40	1250	4.6
05/15/89	18:00	1.10	.120	.310	38	129	<2	2	2	82	<40	310	11.0
05/28/89	21:15	.89	.061	.340	25	<30	<2	<2	<2	73	<40	658	5.2
06/27/89	16:30	N/A	.026	4.200	N/A	140	N/A	36	<2	435	<40	6720	2.6
USGS STATION No. 12323250													
07/27/88	15:00	15	.058	.550	73	<30	1	<2	<2	100	<40	510	6.5
08/06/88	11:05	17	.064	.770	76	<30	<1	3	<2	77	<40	840	9.7
09/05/88	10:30	14	.032	.730	80	<30	<1	<2	<2	71	<40	810	9.2
09/11/88	17:10	14	.064	1.220	83	100	1	4	<2	110	100	1700	7.8
09/18/88	04:00	29	.075	.830	77	<30	<1	8	<2	180	<40	2200	9.9
09/27/88	16:30	39	.069	.570	62	60	<1	4	<2	106	<40	1020	8.3
10/17/88	02:40	98	.160	1.220	94	140	<1	7	2	210	<40	2520	18.0
101 11/03/88	09:10	56	.190	.680		110	1	5	4	150	50	800	11.0
102 11/03/88	09:40	50	.290	.540		1360	<1	7	4	230	220	720	11.0
103 11/03/88	10:10	50	.230	.590		890	<1	3	<2	250	150	850	11.0
104 11/03/88	10:40	50	.230	.620		840	<1	2	2	210	<40	920	10.0
105 11/03/88	11:10	39	.240	.640		340	1	2	4	240	80	1090	9.9
106 11/03/88	11:40	39	.130	.670		160	<1	4	<2	150	60	930	9.2
107 11/03/88	12:10	39	.095	.620		270	<1	4	<2	130	40	790	9.1
04/07/89	10:58	56	.350	.460	57	50		4	<2	97	<40	520	7.5
04/14/89	13:26	35	.280	.490	64	<30		<2	<2	110	<40	650	5.7
04/21/89	12:45	30	.100	.540	71	30	<2	2	<2	91	<40	630	6.4
04/22/89	07:50	58	.170	.490	59	<30		<2	<2	130	110	670	6.4
04/28/89	14:12	26	.160	.580	75	<30		<2	<2	120	<40	750	6.4
05/15/89	19:00	79	.078	.540	53	30	<2	5	<2	130	<40	920	16.0
05/15/89	20:50	127	.110	.560	30	<30	<2	6	3	142	<40	820	13.0
05/28/89	20:25	37	.087	.380	44	<30	2	<2	<2	137	<40	589	6.8
06/09/89	13:00	19	.067	.610	80	<30	<2	<2	<2	113	<40	603	9.3
06/27/89	15:15	71	.049	.960	N/A	<30		<2	<2	147	<40	1070	9.0

UPPER CLARK FORK STORM E

7/19/90

DISSOLVED CONCENTRATION

	DATE (MM/DD/YR)	TIME (HRS)	FLOW (cfs)	Fe (mg/l)	Mn (mg/l)	SO4 (mg/l)	Al (ug/l)	Be (ug/l)	Cd (ug/l)	Cr (ug/l)	Cu (ug/l)	Pb (ug/l)	Zn (ug/l)	As (ug/l)
USGS STATION No. 1232600														
	07/27/88	09:40	20	.025	.220	75	<30	<1	<2	<2	50	40	28	22.0
	08/06/88	14:10	16	.040	.230	99	50	<1	<2	<2	56	40	42	26.0
	09/05/88	12:00	15	.090	.210	96	80	<1	<2	<2	42	<40	49	25.0
101	09/10/88	23:50	26	.024	.980	93	30	<1	<2	<2	51	<40	390	13.0
102	09/11/88	00:20	26	.170	.900	91	60	<1	<2	<2	64	<40	420	11.0
103	09/11/88	01:00	30	.120	.900	93	70	<1	5	<2	50	<40	359	11.0
104	09/11/88	01:30	34	.130	.890	92	<30	1	4	<2	57	<40	377	12.0
105	09/11/88	02:00	38	.120	.920	94	60	1	2	<2	59	<40	457	11.0
106	09/11/88	02:30	38	.100	.950	95	100	<1	<2	<2	56	<40	436	12.0
107	09/11/88	03:00	29	.086	.940	93	100	<1	<2	<2	55	<40	420	12.0
	09/11/88	20:00	28	.017	1.160	97	40	<1	2	<2	54	<40	260	11.0
201	09/17/88	21:00	26	.087	.850	83	<30	<1	<2	<2	53	<40	600	13.0
202	09/17/88	22:00	30	1.530	1.230	96	560	<1	4	5	330	40	1750	12.0
203	09/17/88	23:00	31	.030	.890	89	120	<1	<2	<2	42	<40	610	8.2
204	09/18/88	24:00	34	.018	.860	90	140	<1	<2	3	43	<40	620	10.0
205	09/18/88	01:00	35	.026	.950	95	75	<1	<2	<2	50	<40	720	11.0
206	09/18/88	02:00	36	.031	1.060	96	140	<1	5	<2	50	<40	750	5.6
207	09/18/88	03:00	53	.110	1.200	109	180	1	<2	<2	76	<40	860	12.0
	09/18/88	07:30	53	.057	2.330	109	80	<1	7	8	63	70	710	12.0
	09/27/88	15:25	28	.022	.530	78	50	<1	2	3	38	40	120	12.0
301	09/27/88	23:50	38	.037	.680	83	40	<1	3	<2	53	60	460	8.6
302	09/28/88	01:50	43	.024	.740	84	<30	<1	2	<2	56	40	870	8.9
303	09/28/88	03:50	54	.022	1.300	97	<30	<1	5	<2	98	70	1080	6.7
	10/17/88	05:00	36	.068	1.000	96	90	<1	2	<2	120	<40	780	8.3
	04/07/89	12:05	129	.280	.600	50	170	N/A	6	<2	130	<40	420	12.0
	04/14/89	14:46	69	.100	.530	70	<30	N/A	<2	<2	75	60	290	7.9
	04/21/89	14:00	88	.094	.400	64	<30	<2	<2	<2	62	50	200	8.7
	04/22/89	10:10	96	.160	.440	58	60	N/A	<2	<2	70	<40	300	8.1
	04/28/89	14:57	72	.092	.560	76	60	N/A	<2	<2	78	<40	340	6.8
	05/12/89	13:45	89	.140	.320	54	50	<2	<2	<2	68	<40	170	9.3
	05/15/89	10:00	76	.055	.380	57	40	<2	4	<2	55	<40	110	8.3
	05/28/89	11:30	64	.050	.500	71	<30	<2	<2	<2	130	<40	378	6.3
	06/09/89	11:00	61	.068	.360	51	<30	<2	<2	<2	25	<40	59	24.0
	06/27/89	18:00	44	.210	.490		200		<2	<2	103	<40	139	9.6

UPPER CLARK FORK STORM E

7/19/90

DISSOLVED CONCENTRATION

DATE (MM/DD/YR)	TIME (HRS)	FLOW (cfs)	Fe (mg/l)	Mn (mg/l)	SO4 (mg/l)	Al (ug/l)	Be (ug/l)	Cd (ug/l)	Cr (ug/l)	Cu (ug/l)	Pb (ug/l)	Zn (ug/l)	As (ug/l)
USGS STATION No. 12323770													
07/27/88	11:30	.6	<.002	.033	530	<30	2	<2	<2	17	<40	6	4.9
08/06/88	15:10	.6	.007	.130	559	40	1	<2	3	17	60	37	6.0
09/05/88	13:10	1.4	.028	.070	563	86	1	7	7	29	70	7	8.9
09/11/88	21:10	3.3	.008	.350	595	<30	1	<2	<2	16	<40	23	8.4
09/18/88	10:00	3.9	.028	.230	507	<30	1	4	<2	12	<40	31	6.7
09/27/88	12:45	5.8	.070	.700	543	<30	2	<2	<2	11	<40	32	4.8
10/17/88	06:40	35	.030	.420	226	<30	1	3	<2	19	<40	48	6.8
04/07/89	13:10	38	.017	.360	117	<30	N/A	5	4	9	<40	28	7.1
04/14/89	15:30	34	.009	.330	116	<30	N/A	<2	<2	2	50	8	5.6
04/21/89	14:45	53	.019	.370	83	<30	2	<2	<2	9	<40	22	5.2
04/22/89	10:50	59	.019	.380	78	<30	N/A	<2	<2	6	<40	22	6.2
04/28/89	15:41	48	<.002	.530	96	<30	N/A	<2	<2	4	<40	17	5.3
05/12/89	14:46	115	.018	.220	42	<30	<2	<2	<2	6	70	14	3.8
05/15/89	23:10	49	.006	.420	76	<30	<2	<2	<2	8	<40	25	5.2
05/29/89	00:45	62	.015	.270	64	60	<2	<2	<2	10	<40	17	4.4
06/06/89	15:30	115	.021	.094	24	<30	<2	<2	2	33	<40	16	8.5
06/09/89	10:15	154	.010	.109	25	<30	<2	<2	2	6	40	6	4.0
06/27/89	18:45	68	.004	.280	N/A	50	N/A	<2	3	12	<40	15	4.2
USGS STATION No. 12323800													
07/27/88	09:40	12	.008	.120	218	<30	1	<2	<2	16	<40	18	12.0
08/06/88	16:40	10	.120	.210	233	<30	<1	<2	<2	14	80	23	16.0
09/05/88	14:00	12	.060	.077	265	50	1	3	<2	13	<40	8	12.0
09/11/88	22:30	12	.013	.130	285	<30	1	4	<2	9	<40	30	12.0
09/18/88	11:30	27	.049	.120	265	<30	1	<2	<2	17	40	23	11.0
09/27/88	14:10	33	.011	.093	249	<30	1	<2	<2	2	<40	25	8.8
10/17/88	08:00	63	.057	.160	238	<30	1	5	<2	22	<40	46	7.2
04/07/89	14:18	141	.014	.420	146	<30	N/A	<2	2	12	<40	46	6.1
04/14/89	16:36	125	.900	.230	138	<30	N/A	<2	<2	16	<40	11	8.6
04/21/89	15:30	177	.022	.190	110	<30	<2	<2	<2	8	<40	9	9.8
101 04/21/89	15:40	175	NO DISSOLVED SAMPLE										
102 04/21/89	16:40	175	NO DISSOLVED SAMPLE										
103 04/21/89	17:40	169	NO DISSOLVED SAMPLE										
104 04/21/89	18:40	167	NO DISSOLVED SAMPLE										
105 04/21/89	19:40	167	NO DISSOLVED SAMPLE										
106 04/21/89	20:20	169	NO DISSOLVED SAMPLE										
04/22/89	11:56	209	.073	.210	110	<30	N/A	<2	<2	13	<40	21	9.0
201 04/24/89	12:40	224	.045	.360	116	<30	N/A	<2	<2	16	<40	53	7.9
202 04/24/89	13:40	224	.021	.320	117	<30	N/A	<2	<2	16	<40	44	7.4
203 04/24/89	14:40	221	.030	.290	117	<30	N/A	<2	<2	14	<40	39	8.6
204 04/24/89	15:40	221	.018	.270	116	<30	N/A	<2	<2	11	<40	27	7.9
205 04/24/89	16:40	215	.022	.280	116	<30	N/A	<2	<2	15	<40	37	9.2
206 04/24/89	17:40	212	.035	.330	119	<30	N/A	<2	<2	16	<40	37	9.3
04/28/89	16:40	164	.025	.200	116	<30	N/A	<2	<2	10	<40	21	9.6

UPPER CLARK FORK STORM E

7/19/90

DISSOLVED CONCENTRATION

	DATE (MM/DD/YR)	TIME (HRS)	FLOW (cfs)	Fe (mg/l)	Mn (mg/l)	SO4 (mg/l)	Al (ug/l)	Be (ug/l)	Cd (ug/l)	Cr (ug/l)	Cu (ug/l)	Pb (ug/l)	Zn (ug/l)	As (ug/l)
USGS-STATION No. 12323800														
301	05/09/89	10:45	267	.130	.220	79	120	N/A	<2	2	33	70	270	14.0
302	05/09/89	11:45	264	.035	.061	77	<30	N/A	<2	<2	14	<40	23	17.0
303	05/09/89	12:45	278	.060	.130	77	50	N/A	<2	<2	16	50	30	18.0
304	05/09/89	13:45	278	.290	.400	88	180	N/A	<2	<2	63	<40	98	22.0
305	05/09/89	14:45	274	.300	.410	98	180	N/A	4	<2	62	<40	79	21.0
306	05/09/89	15:45	274	.580	.320	90	130	N/A	3	130	46	<40	86	11.0
401	05/10/89	14:45	303	.056	.094	88	60	N/A	<2	2	17	<40	39	18.0
402	05/10/89	15:45	299	.040	.100	53	<30	N/A	<2	2	17	<40	30	19.0
403	05/10/89	16:45	303	.044	.110	70	<30	N/A	<2	<2	14	<40	24	18.0
404	05/10/89	17:45	299	.047	.120	70	30	N/A	<2	<2	13	49	17	17.0
405	05/10/89	18:45	314	.069	.140	69	<30	N/A	<2	<2	18	<40	23	17.0
406	05/10/89	19:45	314	.049	.130	70	<30	N/A	<2	<2	13	<40	24	18.0
	05/12/89	16:02	314	.069	.094	64	<30	<2	<2	<2	31	<40	20	17.0
	05/15/89	11:55	215	.040	.140	93	<30	<2	5	<2	18	<40	37	18.0
	05/27/89	01:50	209	.047	.140	88	<30	<2	<2	<2	14	<40	21	14.0
501	06/06/89	07:15	274	.048	.067	57	<30	<2	<2	2	9	<40	382	12.0
502	06/06/89	08:15	278	.018	.069	57	<30	<2	4	<2	9	<40	174	12.0
503	06/06/89	09:15	285	.026	.065	48	<30	<2	<2	3	8	<40	61	12.0
504	06/06/89	10:15	285	.024	.065	51	<30	<2	<2	<2	8	<40	41	10.0
505	06/06/89	11:15	278	.021	.067	47	<30	<2	<2	<2	8	<40	21	11.0
506	06/06/89	12:15	285	.022	.063	55	<30	<2	<2	<2	8	<40	27	12.0
	06/06/89	16:50	271	.025	.062	52	<30	<2	<2	<2	11	<40	6	14.0
	06/09/89	08:05	322	.028	.075	46	<30	<2	<2	2	11	<40	17	11.0
601	06/16/89	05:15	391	.042	.072	N/A	<30	N/A	<2	<2	17	<40	15	15.0
602	06/16/89	06:15	400	.040	.071	N/A	<30	N/A	<2	<2	15	<40	15	15.0
603	06/16/89	07:15	422	.044	.071	N/A	<30	N/A	<2	<2	15	<40	11	16.0
604	06/16/89	08:15	431	.048	.071	N/A	<30	N/A	<2	<2	15	<40	14	15.5
605	06/16/89	09:15	431	.051	.071	N/A	<30	N/A	<2	<2	16	<40	15	16.0
606	06/16/89	10:15	431	.051	.064	N/A	<30	N/A	<2	<2	15	<40	22	17.0
607	06/16/89	11:15	436	.043	.067	N/A	<30	N/A	<2	<2	14	<40	14	17.0
	06/27/89	19:15	132	.020	.150	N/A	34	N/A	<2	3	23	<40	22	12.0

N/A - NOT ANALYZED

UPPER CLARK FORK STORM E

7/19/90

BIOLOGICALLY AVAILABLE CONCENTRATION

	DATE (MM/DD/YR)	TIME (HRS)	FLOW (cfs)	Fe (mg/l)	Mn (mg/l)	Al (ug/l)	Be (ug/l)	Cd (ug/l)	Cr (ug/l)	Cu (ug/l)	Pb (ug/l)	Zn (ug/l)	As (ug/l)
USGS STATION No. 12323200			BLACKTAIL CREEK NEAR BUTTE, MT (ABOVE CONFLUENCE WITH SILVER BOW CREEK										
	04/07/89	09:20	27	1.32	.24	280	N/A	<2	<2	16	60	38	9.4
	04/14/89	11:46	20	.83	.11	150	N/A	6	5	14	150	19	5.4
	04/21/89	11:20	16	.72	.11	240	<2	<2	2	17	<40	33	6.2
	04/22/89	06:45	27	1.22	.20	690	N/A	<2	<2	39	80	71	11.0
	04/28/89	12:34	14	.52	.13	<30	N/A	<2	<2	9	<40	93	3.9
	05/15/89	16:10	22	1.10	.21	680	<2	2	7	72	<40	150	12.0
	05/15/89	20:18	29	.85	.14	380	<2	<2	5	44	<40	130	10.0
	05/28/89	19:10	31	1.09	.18	490	<2	<2	<2	45	<40	119	11.0
	06/27/89	14:15	25	.44	.13	80	<2	<2	<2	101	<40	174	7.6
MISSOULA GULCH			MISSOULA GULCH (AT CENTENNIAL AVE)										
	04/07/89	09:55	.22	1.53	1.57	1080	N/A	14	<2	490	100	3770	14.0
	04/14/89	12:47	.33	1.20	1.49	880	N/A	19	7	440	190	3550	11.0
	04/21/89	12:00	.56	5.05	2.69	3600	<2	27	3	930	260	5300	30.0
	04/28/89	13:10	.11	2.05	2.76	2470	N/A	29	5	730	1220	4780	18.0
	05/15/89	18:00	1.10	3.38	4.73	708	3	91	9	1690	2080	8820	78.0
	05/28/89	21:15	.89	.58	.65	510	<2	<2	<2	320	140	1330	11.0
	06/27/89	16:30	N/A	1.75	4.69	1270	<2	37	<2	670	230	8590	25.0
USGS STATION No. 12323250			SILVER BOW CREEK BELOW BLACKTAIL CREEK AT BUTTE, MT (COLORADO TAILINGS										
	07/27/88	15:00	15										
	08/06/88	11:05	17										
	09/05/88	10:30	14										
	09/11/88	17:10	14										
	09/18/88	04:00	29										
	09/27/88	16:30	39										
	10/17/88	02:40	98										
101	11/03/88	09:10	56	27.40	2.93	10100	2	47	24	7150	970	8320	276.0
102	11/03/88	09:40	50	6.62	.94	2530	1	13	8	1430	220	2210	55.0
103	11/03/88	10:10	50	3.94	.78	1710	<1	8	5	940	110	1760	40.0
104	11/03/88	10:40	50	3.10	.76	1360	<1	6	4	800	110	1640	35.0
105	11/03/88	11:10	39	2.29	.73	980	1	7	3	630	110	1490	28.0
106	11/03/88	11:40	39	2.00	.71	800	<1	6	<2	600	40	1600	27.0
107	11/03/88	12:10	39	1.74	.73	650	<1	6	2	530	<40	1450	24.0
	04/07/89	10:58	56	1.62	.54	480		2	<2	180	50	580	13.0
	04/14/89	13:26	35	.89	.50	90	N/A	<2	<2	170	70	650	8.5
	04/21/89	12:45	30	.86	.54	200	<2	2	<2	170	<40	670	10.0
	04/22/89	07:50	58	2.06	.63	1170	N/A	<2	<2	460	80	1080	17.0
	04/28/89	14:12	26	.73	.58	110	N/A	2	2	220	<40	900	12.0
	05/15/89	19:00	79	3.67	1.96	2930	<2	26	12	1040	50	3160	86.0
	05/15/89	20:50	127	4.01	1.00	1920	<2	15	12	1050	290	1800	54.0
	05/28/89	20:25	37	2.09	.58	870	2	2	<2	603	<40	1160	32.0
	06/09/89	13:00	19	.56	.61	<30	<2	<2	2	207	<40	770	12.0
	06/27/89	15:15	71	7.04	2.54	4860	<2	27	20	2880	690	4910	100.0

UPPER CLARK FORK STORM E

7/19/90

BIOLOGICALLY AVAILABLE CONCENTRATION

	DATE (MM/DD/YR)	TIME (HRS)	FLOW (cfs)	Fe (mg/l)	Mn (mg/l)	Al (ug/l)	Be (ug/l)	Cd (ug/l)	Cr (ug/l)	Cu (ug/l)	Pb (ug/l)	Zn (ug/l)	As (ug/l)
USGS STATION No. 1232600			SILVER BOW CREEK AT OPPORTUNITY, MT (STEWART BRIDGE)										
	07/27/88	09:40	20										
	08/06/88	14:10	16										
	09/05/88	12:00	15										
101	09/10/88	23:50	26	4.72	2.90	1370	1	10	<2	1060	110	3020	51.0
102	09/11/88	00:20	26	2.80	2.07	810	1	9	<2	670	80	1960	44.0
103	09/11/88	01:00	30	2.90	2.17	840	<1	8	2	700	90	2020	37.0
104	09/11/88	01:30	34	2.80	2.09	800	1	11	<2	670	<40	1960	36.0
105	09/11/88	02:00	38	2.73	2.08	790	1	<2	<2	660	70	1940	43.0
106	09/11/88	02:30	38	2.57	1.99	750	<1	9	5	610	50	1830	38.0
107	09/11/88	03:00	29	2.44	1.92	720	1	8		580	100	1820	32.0
	09/11/88	20:00	28										
201	09/17/88	21:00	26	2.43	1.57	1380	1	6	9	570	40	1850	21.0
202	09/17/88	22:00	30	1.85	1.40	620	<1	<2	5	450	40	1530	30.0
203	09/17/88	23:00	31	.26	.07	130	<1	<2	2	68	<40	470	14.0
204	09/18/88	24:00	34	2.38	1.59	1180	<1	7	6	560	<40	1860	37.0
205	09/18/88	01:00	35	2.11	1.51	695	1	4	4	510	40	1715	33.0
206	09/18/88	02:00	36	1.97	1.54	740	1	7	7	490	40	1650	32.0
207	09/18/88	03:00	53	1.76	1.59	1430	1	6	10	450	40	1620	21.0
	09/18/88	07:30	53										
	09/27/88	15:25	28										
301	09/27/88	23:50	38	5.82	2.30	1730	1	15	<2	1420	170	3420	6.3
302	09/28/88	01:50	43	4.64	1.94	1420	1	10	<2	1120	140	2700	55.0
303	09/28/88	03:50	54	3.41	2.07	1030	1	8	<2	1110	140	2280	43.0
	10/17/88	05:00	36										
	04/07/89	12:05	129	2.43	.89	990	N/A	<2	<2	580	180	900	34.0
	04/14/89	14:46	69	1.65	.61	600	N/A	2	5	270	110	590	21.0
	04/21/89	14:00	88	1.28	.49	610	<2	<2	<2	200	<40	430	18.0
	04/22/89	10:10	96	1.07	.50	390	N/A	<2	<2	210	50	670	18.0
	04/28/89	14:57	72	1.15	.59	230	N/A	2	<2	240	<50	990	14.0
	05/12/89	13:45	89	.67	.36	140	<2	<2	<2	140	<40	380	13.0
	05/15/89	10:00	76	.74	.40	180	<2	2	5	160	<40	420	14.0
	05/28/89	11:30	64	.77	.50	<30	2	<2	<2	138	<40	513	11.0
	06/09/89	11:00	61	1.60	.52	240	<2	<2	<2	350	50	640	38.0
	06/27/89	18:00	44	.94	.65	210	<2	<2	<2	306	<40	630	18.0

UPPER CLARK FORK STORM E

7/19/90

BIOLOGICALLY AVAILABLE CONCENTRATION

	DATE (MM/DD/YR)	TIME (HRS)	FLOW (cfs)	Fe (mg/l)	Mn (mg/l)	Al (ug/l)	Be (ug/l)	Cd (ug/l)	Cr (ug/l)	Cu (ug/l)	Pb (ug/l)	Zn (ug/l)	As (ug/l)
USGS STATION No. 12323770	WARM SPRINGS CREEK AT WARM SPRINGS, MT												
	07/27/88	11:30	.6										
	08/06/88	15:10	.6										
	09/05/88	13:10	1.4										
	09/11/88	21:10	3.3										
	09/18/88	10:00	3.9										
	09/27/88	12:45	5.8										
	10/17/88	06:40	35										
	04/07/89	13:10	38	.06	.39	<30		<2	<2	8	40	3	7.3
	04/14/89	15:30	34	.05	.35	<30		<2	<2	3	<40	4	5.5
	04/21/89	14:45	53	.11	.47	50	2	<2	<2	14	<40	6	5.6
	04/22/89	10:50	59	.25	.53	170		<2	<2	24	<40	11	8.8
	04/28/89	15:41	48	.08	.55	30		<2	<2	12	<40	160	5.7
	05/12/89	14:46	115	.17	.35	120	<2	<2	<2	28	40	24	6.9
	05/15/89	23:10	49	.13	.48	80	<2	<2	5	24	<40	35	7.0
	05/29/89	00:45	62	.11	.37	<30	2	<2	<2	17	<40	11	6.5
	06/06/89	15:30	115	.02	.09	<30	<2	<2	<2	9	<40	145	3.4
	06/09/89	10:15	154	.22	.34	80	<2	<2	2	36	<40	16	7.0
	06/27/89	18:45	68	.09	.34	<30	<2	<2	<2	15	40	21	4.1
USGS STATION No. 12323800	CLARK FORK NEAR BALEN, MT (PERKINS LANE BRIDGE)												
	07/27/88	09:40	12										
	08/06/88	16:40	10										
	09/05/88	14:00	12										
	09/11/88	22:30	12										
	09/18/88	11:30	27										
	09/27/88	14:10	33										
	10/17/88	08:00	63										
	04/07/89	14:18	141	.88	.53	230	N/A	2	<2	60	<40	140	14.0
	04/14/89	16:36	125	.38	.31	100	N/A	<2	2	33	40	71	11.0
	04/21/89	15:30	177	.49	.34	140	<2	<2	<2	35	<40	67	12.0
101	04/21/89	15:40	175	1.56	.38	80	N/A	<2	<2	67	<40	360	15.0
102	04/21/89	16:40	175	.85	.31	50	N/A	<2	<2	40	<40	120	15.0
103	04/21/89	17:40	169	1.51	.30	70	N/A	<2	<2	44	<40	100	13.0
104	04/21/89	18:40	167	.50	.30	<30	N/A	<2	<2	39	<40	130	13.0
105	04/21/89	19:40	167	.62	.34	140	N/A	5	7	54	<40	110	13.0
106	04/21/89	20:20	169	2.44	.32	260	N/A	12	20	71	220	11	13.0
	04/22/89	11:56	209	.53	.37	190	N/A	<2	<2	43	<40	70	16.0
201	04/24/89	12:40	224	.49	.52	140	N/A	<2	<2	91	<40	190	13.0
202	04/24/89	13:40	224	.50	.50	160	N/A	<2	<2	61	<40	210	13.0
203	04/24/89	14:40	221	.63	.44	130	N/A	<2	<2	53	<40	170	14.0
204	04/24/89	15:40	221	.47	.42	120	N/A	<2	<2	44	<40	150	12.0
205	04/24/89	16:40	215	.46	.44	120	N/A	<2	<2	16	<40	150	14.0
206	04/24/89	17:40	212	.44	.44	100	N/A	<2	<2	43	<40	120	15.0
	04/28/89	16:40	164	.45	.33	150	N/A	<2	<2	40	<40	2200	15.0

UPPER CLARK FORK STORM E

7/19/90

BIOLOGICALLY AVAILABLE CONCENTRATION

	DATE	TIME	FLOW	Fe	Mn	Al	Be	Cd	Cr	Cu	Pb	Zn	As
	(MM/DD/YR)	(HRS)	(cfs)	(mg/l)	(mg/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
USGS STATION No. 12323800				CLARK FORK NEAR GALEN, MT (PERKINS LANE BRIDGE)									
301	05/09/89	10:45	267	.72	.48	260	N/A	<2	7	60	<40	140	23.0
302	05/09/89	11:45	264	.55	.43	220	N/A	3	5	60	50	90	26.0
303	05/09/89	12:45	278	.62	.46	220	N/A	<2	<2	60	50	85	28.0
304	05/09/89	13:45	278	.54	.42	210	N/A	<2	<2	58	54	78	27.0
305	05/09/89	14:45	274	.66	.50	240	N/A	4	<2	79	<40	100	29.0
306	05/09/89	15:45	274	.59	.43	180	N/A	<2	<2	60	<40	85	29.0
401	05/10/89	14:45	303	.30	.27	180	N/A	<2	2	31	<40	51	23.0
402	05/10/89	15:45	299	.65	.56	240	N/A	<2	3	77	50	260	29.0
403	05/10/89	16:45	303	.63	.49	200	N/A	2	2	64	167	100	27.0
404	05/10/89	17:45	299	.68	.51	260	N/A	2	<2	69	<40	120	29.0
405	05/10/89	18:45	314	.70	.50	230	N/A	<2	<2	69	<40	100	29.0
406	05/10/89	19:45	314	.70	.51	217	N/A	<2	<2	81	<40	180	29.0
	05/12/89	16:02	314	.28	.24	80	<2	<2	<2	28	<40	36	21.0
	05/15/89	11:55	215	.29	.27	105	<2	7	2	36	<40	68	22.0
	05/27/89	01:50	209	.27	.26	<30	<2	<2	<2	28	<40	45	17.0
501	06/06/89	07:15	274	.35	.30	<30	<2	27	<2	37	<40	157	16.0
502	06/06/89	08:15	278	.37	.28	<30	<2	<2	2	34	<40	64	17.0
503	06/06/89	09:15	285	.32	.26	<30	<2	<2	<2	33	<40	44	16.0
504	06/06/89	10:15	285	.31	.26	<30	<2	<2	2	32	<40	41	16.0
505	06/06/89	11:15	278	.29	.25	<30	<2	<2	<2	32	<40	38	15.0
506	06/06/89	12:15	285	.29	.24	<30	<2	<2	2	31	<40	29	14.0
	06/06/89	16:50	271	.26	.21	<30	<2	<2	<2	26	<40	37	19.0
	06/09/89	08:05	322	.25	.25	<30	<2	<2	2	31	60	28	17.0
601	06/16/89	05:15	391	.68	.46	270	<2	2	<2	73	<40	96	20.0
602	06/16/89	06:15	400	.72	.48	300	<2	<2	<2	71	<40	77	22.0
603	06/16/89	07:15	422	.83	.50	330	<2	<2	<2	77	<40	80	25.0
604	06/16/89	08:15	431	.88	.49	370	<2	<2	<2	79	<40	126	28.0
605	06/16/89	09:15	431	.91	.52	420	<2	<2	<2	86	<40	98	27.0
606	06/16/89	10:15	431	.93	.55	460	<2	<2	2	87	<40	110	36.0
607	06/16/89	11:15	436	.98	.57	460	<2	<2	2	91	<40	92	36.0
	06/27/89	19:15	132	.15	.19	<30	<2	<2	6	26	<40	30	13.0

N/A - NOT ANALYZED

UPPER CLARK FORK STORM E

7/19/90

TOTAL RECOVERABLE CONCENTRATION

	DATE (MM/DD/YR)	TIME (HRS)	FLOW (cfs)	Fe (mg/l)	Mn (mg/l)	Al (ug/l)	Be (ug/l)	Cd (ug/l)	Cr (ug/l)	Cu (ug/l)	Pb (ug/l)	Zn (ug/l)	As (ug/l)
USGS STATION No. 12323200													
	04/07/89	09:20	27										
	04/14/89	11:46	20										
	04/21/89	11:20	16										
	04/22/89	06:45	27										
	04/28/89	12:34	14										
	05/15/89	16:10	22										
	05/15/89	20:18	29										
	05/28/89	19:10	31	5.11	.22	4100	<2	<2	5	70	<40	135	12.0
	06/27/89	14:15	25										
MISSOULA GULCH													
	04/07/89	09:55	.22										
	04/14/89	12:47	.33										
	04/21/89	12:00	.56										
	04/28/89	13:10	.11										
	05/15/89	18:00	1.10										
	05/28/89	21:15	.89	4.15	.81	3210	2	2	3	311	130	1440	17.0
	06/27/89	16:30	N/A										
USGS STATION No. 12323250													
	07/27/88	15:00	15										
	08/06/88	11:05	17										
	09/05/88	10:30	14										
	09/11/88	17:10	14										
	09/18/88	04:00	29										
	09/27/88	16:30	39										
	10/17/88	02:40	98										
101	11/03/88	09:10	56										
102	11/03/88	09:40	50										
103	11/03/88	10:10	50										
104	11/03/88	10:40	50										
105	11/03/88	11:10	39										
106	11/03/88	11:40	39										
107	11/03/88	12:10	39										
	04/07/89	10:58	56										
	04/14/89	13:26	35										
	04/21/89	12:45	30										
	04/22/89	07:50	58										
	04/28/89	14:12	26										
	05/15/89	19:00	79										
	05/15/89	20:50	127										
	05/28/89	20:25	37	5.78	.60	3675	2	3	4	591	<40	1120	40.0
	06/09/89	13:00	19	.62	.61	30	<2	<2	<2	200	<40	747	15.0
	06/27/89	15:15	71										

UPPER CLARK FORK STORM E

7/19/90

TOTAL RECOVERABLE CONCENTRATION

	DATE (MM/DD/YR)	TIME (HRS)	FLOW (cfs)	Fe (mg/l)	Mn (mg/l)	Al (ug/l)	Be (ug/l)	Cd (ug/l)	Cr (ug/l)	Cu (ug/l)	Pb (ug/l)	Zn (ug/l)	As (ug/l)
USGS STATION No. 1232600													
	07/27/88	09:40	20										
	08/06/88	14:10	16										
	09/05/88	12:00	15										
101	09/10/88	23:50	26										
102	09/11/88	00:20	26										
103	09/11/88	01:00	30										
104	09/11/88	01:30	34										
105	09/11/88	02:00	38										
106	09/11/88	02:30	38										
107	09/11/88	03:00	29										
	09/11/88	20:00	28										
201	09/17/88	21:00	26										
202	09/17/88	22:00	30										
203	09/17/88	23:00	31										
204	09/18/88	24:00	34										
205	09/18/88	01:00	35										
206	09/18/88	02:00	36										
207	09/18/88	03:00	53										
	09/18/88	07:30	53										
	09/27/88	15:25	28										
301	09/27/88	23:50	38										
302	09/28/88	01:50	43										
303	09/28/88	03:50	54										
	10/17/88	05:00	36										
	04/07/89	12:05	129										
	04/14/89	14:46	69										
	04/21/89	14:00	88										
	04/22/89	10:10	96										
	04/28/89	14:57	72										
	05/12/89	13:45	89										
	05/15/89	10:00	76										
	05/28/89	11:30	64	1.02	.49	60	2	3	<2	150	<40	517	10.0
	06/09/89	11:00	61	2.16	.48	930	<2	<2	<2	365	70	570	43.0
	06/27/89	18:00	44										

UPPER CLARK FORK STORM E

7/19/90

TOTAL RECOVERABLE CONCENTRATION

	DATE (MM/DD/YR)	TIME (HRS)	FLOW (cfs)	Fe (mg/l)	Mn (mg/l)	Al (ug/l)	Be (ug/l)	Cd (ug/l)	Cr (ug/l)	Cu (ug/l)	Pb (ug/l)	Zn (ug/l)	As (ug/l)
USGS STATION No. 12323770													
	07/27/88	11:30	.6										
	08/06/88	15:10	.6										
	09/05/88	13:10	1.4										
	09/11/88	21:10	3.3										
	09/18/88	10:00	3.9										
	09/27/88	12:45	5.8										
	10/17/88	06:40	35										
	04/07/89	13:10	38										
	04/14/89	15:30	34										
	04/21/89	14:45	53										
	04/22/89	10:50	59										
	04/28/89	15:41	48										
	05/12/89	14:46	115										
	05/15/89	23:10	49										
	05/29/89	00:45	62	.33	.38	70	2	<2	4	21	<40	13	6.5
	06/06/89	15:30	115										
	06/09/89	10:15	154	.75	.43	730	<2	<2	<2	33	<40	18	8.1
	06/27/89	18:45	68										
USGS STATION No. 12323800													
	07/27/88	09:40	12										
	08/06/88	16:40	10										
	09/05/88	14:00	12										
	09/11/88	22:30	12										
	09/18/88	11:30	27										
	09/27/88	14:10	33										
	10/17/88	08:00	63										
	04/07/89	14:18	141										
	04/14/89	16:36	125										
	04/21/89	15:30	177										
101	04/21/89	15:40	175										
102	04/21/89	16:40	175										
103	04/21/89	17:40	169										
104	04/21/89	18:40	167										
105	04/21/89	19:40	167										
106	04/21/89	20:20	169										
	04/22/89	11:56	209										
201	04/24/89	12:40	224										
202	04/24/89	13:40	224										
203	04/24/89	14:40	221										
204	04/24/89	15:40	221										
205	04/24/89	16:40	215										
206	04/24/89	17:40	212										
	04/28/89	16:40	164										

UPPER CLARK FORK STORM E

7/19/90

TOTAL RECOVERABLE CONCENTRATION

	DATE (MM/DD/YR)	TIME (HRS)	FLOW (cfs)	Fe (mg/l)	Mn (mg/l)	Al (ug/l)	Be (ug/l)	Cd (ug/l)	Cr (ug/l)	Cu (ug/l)	Pb (ug/l)	Zn (ug/l)	As (ug/l)
USGS STATION No. 12323800													
301	05/09/89	10:45	267										
302	05/09/89	11:45	264										
303	05/09/89	12:45	278										
304	05/09/89	13:45	278										
305	05/09/89	14:45	274										
306	05/09/89	15:45	274										
401	05/10/89	14:45	303										
402	05/10/89	15:45	299										
403	05/10/89	16:45	303										
404	05/10/89	17:45	299										
405	05/10/89	18:45	314										
406	05/10/89	19:45	314										
	05/12/89	16:02	314										
	05/15/89	11:55	215										
	05/27/89	01:50	209	.46	.25	<30	<2	<2	4	30	<40	47	17.0
501	06/06/89	07:15	274										
502	06/06/89	08:15	278										
503	06/06/89	09:15	285										
504	06/06/89	10:15	285										
505	06/06/89	11:15	278										
506	06/06/89	12:15	285										
	06/06/89	16:50	271										
	06/09/89	08:05	322	.63	.32	460	<2	<2	<2	31	<40	23	18.0
601	06/16/89	05:15	391										
602	06/16/89	06:15	400										
603	06/16/89	07:15	422										
604	06/16/89	08:15	431										
605	06/16/89	09:15	431										
606	06/16/89	10:15	431										
607	06/16/89	11:15	436										
	06/27/89	19:15	132										

N/A - NOT ANALYZED