

**Mokelumne River Project
FERC 137**

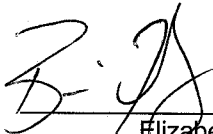
**Supplemental Water Quality
Monitoring Program
March 2002-September 2003**

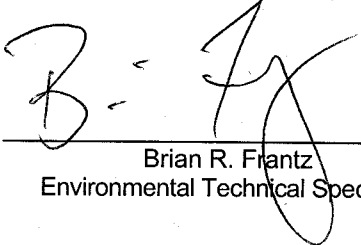
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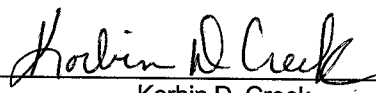
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1 INTRODUCTION

This report presents results of supplemental water quality monitoring performed from March 2002 through September 2003 at Pacific Gas and Electric Company's Mokelumne River Project, FERC Project No. 137. The supplemental water quality monitoring program was implemented to better delineate potential sources of dissolved copper upstream of the outflow from Lower Bear River Reservoir (see Photo 1). The program was later expanded to downstream locations to further delineate dissolved copper concentrations in the Bear River and Rattlesnake Creek. Water quality monitoring in 2000 and 2001, in accordance with the Project's relicensing Settlement Agreement (Pacific Gas and Electric Company 2000), detected copper levels higher than expected in the Bear River below Lower Bear River Reservoir. Consequently, the Project's Ecological Resources Committee (ERC) and the U.S. Forest Service (FS) determined that the supplemental monitoring program was needed. The supplemental monitoring plan is an addendum to the Stream Ecology Monitoring Plan (SEMP) developed collaboratively with the ERC and FS. The SEMP was approved by the ERC and the FS on May 14, 2001. The supplemental monitoring program was presented to the ERC and FS during the March 13, 2002 ERC meeting, and was finalized on March 18, 2002 (see Appendix A). The supplemental monitoring program was modified in August 2002 in consultation with the ERC and FS to focus on stations downstream of Lower Bear River Reservoir, and the duration of the study was expanded through September 2003.

The supplemental water quality monitoring program was initiated in March 2002. Data from 2002 and 2003 were collected under the interim streamflow levels (the streamflow levels that were agreed to by FERC and Pacific Gas and Electric Company during the reconstruction of the existing release structures), which represent a good faith effort to meet the new FERC license flows within the limitations of existing flow release structures. Modifications of flow release structures designed to fully meet the new FERC license flows are scheduled to be completed by 2005.

Photo 1. View of the upper Bear River below Lower Bear River Reservoir.



2 METHODS

Water samples were collected from March 2002 through September 2003. Samples were collected from various stations along Bear River, from Lower Bear River Reservoir, from two leakage weirs below Lower Bear River Reservoir Dam, from the instream flow release pipe below the dam, from the spill flow over Lower Bear River Reservoir Dam, and from various tributaries to Lower Bear River Reservoir, Upper Bear River Reservoir, and Bear River. Table 1 shows a complete list of stations that were monitored during the supplemental water quality monitoring program.

The original sample locations specified in the study plan were BR1, LBR1, SPC1, BR3, UNT1, BR4, and LBRR1 (surface, middle, and bottom) (Figure 1). Stations UNT2, UNT4, and UNT5 were added during initial field visits to better define the inflow from small tributaries (primarily due to snowmelt) located along the northwest shore of Lower Bear River Reservoir (Figure 1). Water quality sampling was discontinued at some of the original station locations between April and July, because the tributaries were dry, the flow was less than 1 cfs, or they did not represent a significant source of copper to the system (UNT1, UNT2, UNT4, UNT5, LBR1, SPC1, BR3, and BR4).

The lack of a significant dissolved copper source in the tributaries and inflow to Upper Bear River Reservoir and Lower Bear River Reservoir and in the Lower Bear River Reservoir itself resulted in an expansion of the study to include eight additional sampling locations to better characterize potential sources of copper to the Bear River below Lower Bear River Reservoir Dam. Four additional stations (BR-RSC1, BR-RSC2, RSC, and BR2) were added in August 2002 to better define conditions in the Bear River below the Lower Bear River Reservoir Dam down to Salt Springs Road (Figure 2). Two leakage weirs, UNT6 and UNT8, on the right and left abutments of the dam, respectively were added (see Photo 1 in Appendix B) during the initial field sampling early in the year (May-June 2002). Both of these leakage weirs (at the weir and at a location below the weir) were sampled, in addition to the instream flow release from the bottom of the reservoir (UNT7) and the spill flow over the dam face (UNT9) (only when the reservoir was spilling) (Figure 3 and Photo 1 in Appendix B). Gage height measurements were collected at the leakage weirs (to estimate flow) during each field visit. Preliminary flow measurements for the instream flow release, the gage at station BR1, the gage at station BR2, and Lower Bear River Reservoir storage were supplied by Bruce McGurk (Pacific Gas and Electric Company).

Table 1. Supplemental water quality sampling locations for the Mokelumne River Project (FERC 137)

Station	Location	Latitude and Longitude	Rationale
BR4	Bear River above Upper Bear River Reservoir, below its confluence with Tragedy Creek	Latitude (38° 34.40 N) Longitude (120° 12.56 W)	Defines inflow to Upper Bear River Reservoir, initial conditions in Project area
UNT5	Unnamed tributary entering midway up the west shore of Upper Bear River Reservoir	Latitude (38° 33.90 N) Longitude (120° 13.23 W)	Defines snowmelt tributary flow to the Upper Bear River Reservoir
BR3	Upper Bear River Reservoir outflow to Lower Bear River Reservoir	Latitude (38° 33.44 N) Longitude (120° 12.89 W)	Defines flow from Upper Bear River Reservoir to Lower Bear River Reservoir
UNT1	Unnamed tributary on the upper west shore of Lower Bear River Reservoir (due to snowmelt)	Latitude (38° 33.23 N) Longitude (120° 13.30 W)	Defines seasonal snowmelt tributary flow to Lower Bear River Reservoir
UNT2	Unnamed tributary on the upper west shore of Lower Bear River Reservoir (due to snowmelt)	Latitude (38° 33.21 N) Longitude (120° 13.32 W)	Defines seasonal snowmelt tributary flow to Lower Bear River Reservoir
UNT4	Unnamed tributary flow from snowmelt near Sugar Pine Creek, northwest shore of Lower Bear River Reservoir	Latitude (38° 32.81 N) Longitude (120° 14.36 W)	Defines seasonal snowmelt tributary flow to Lower Bear River Reservoir
SPC1	Sugar Pine Creek on the northwest shore of Lower Bear River Reservoir	Latitude (38° 32.74 N) Longitude (120° 14.43 W)	Defines tributary flow to Lower Bear River Reservoir
LBR1	Little Bear River on the northwest shore of Lower Bear River Reservoir	Latitude (38° 33.57 N) Longitude (120° 14.86 W)	Defines tributary flow to Lower Bear River Reservoir
LBRR1-top	Lower Bear River Reservoir near dam, surface (epilimnion) sample	Latitude (38° 32.365 N) Longitude (120° 15.162 W)	Defines conditions in the surface of Lower Bear River Reservoir near the dam
LBRR1-mid	Lower Bear River Reservoir near dam, sample collected from mid-depth when lake stratified	Latitude (38° 32.365 N) Longitude (120° 15.162 W)	Defines conditions at the middle depths of Lower Bear River Reservoir near the dam
LBRR1-bot	Lower Bear River Reservoir near dam, sample collected from bottom of lake (hypolimnion)	Latitude (38° 32.365 N) Longitude (120° 15.162 W)	Defines conditions in the bottom depths of Lower Bear River Reservoir near the dam

Table 1 (Continued)

Station	Location	Latitude and Longitude	Rationale
UNT6a	Leakage flow from the right abutment of the Lower Bear River Reservoir Dam, collected at the weir	Latitude (38° 32.30 N) Longitude (120° 15.48 W)	Defines conditions in the leakage flow as it exits the dam face on the right abutment
UNT6b	Leakage flow from the right abutment of the Lower Bear River Reservoir Dam, collected below the weir, below the spillway confluence	Latitude (38° 32.23 N) Longitude (120° 15.44 W)	Defines conditions in the leakage flow as it mixes with left abutment leakage flow and any spill flow over the dam face
UNT7	Outflow from the instream flow release pipe below Lower Bear River Reservoir Dam upstream of station	Latitude (38° 32.21 N) Longitude (120° 15.40 W)	Defines conditions in the water released from the bottom of Lower Bear River Reservoir through the outlet
UNT8a	Leakage flow from left abutment below Lower Bear River Reservoir Dam, collected at the weir	Latitude (38° 32.26 N) Longitude (120° 15.41 W)	Defines conditions in the leakage flow as it exits the dam face on the left abutment
UNT8b	Leakage flow from left abutment below Lower Bear River Reservoir Dam, collected below the weir	Latitude (38° 32.23 N) Longitude (120° 15.42 W)	Defines conditions in the leakage flow as it mixes with right abutment leakage flow and any spill flow over the
UNT9	Spill flow over Lower Bear River Reservoir Dam, collected at bottom of spillway pool (2002) and in spillway above pool (2003)	Latitude (38° 32.26 N) Longitude (120° 15.44 W)	Defines conditions in the spill flow over the face of the dam, should be representative of surface water from Lower Bear River Reservoir
BR1	Bear River below Lower Bear River Reservoir Dam, at gage M49	Latitude (38° 32.14 N) Longitude (120° 15.48 W)	Defines flow in the Bear River just below the outlet gate, combined flow from outlet and leakage weirs
BR-RSC1	Bear River above the confluence with Rattlesnake Creek	Latitude (38° 31.145N) Longitude (120° 16.008W)	Defines flow in the Bear River above the confluence with Rattlesnake Creek approximately 1.24 river miles downstream of BR1
RSC	Rattlesnake Creek (a tributary to the Bear River) at the mouth	Latitude (38° 31.089 N) Longitude (120° 16.087 W)	Defines flow in Rattlesnake Creek, a tributary to Bear River, enters approximately 1.35 river miles downstream
BR-RSC2	Bear River below the confluence with Rattlesnake Creek	Latitude (38° 31.035 N) Longitude (120° 16.105 W)	Defines flow in the Bear River below the confluence with Rattlesnake Creek, 1.46 river miles downstream of
BR2	Bear River above the gauging station near Salt Springs Road, gauging station M32	Latitude (38° 29.604 N) Longitude (120° 17.304 W)	Defines flow in the lower Bear River approximately 3.51 river miles downstream of BR1

Figure 1. Water sample stations located around the Upper Bear River Reservoir and Lower Bear River Reservoir during initial field sampling in March 2002.

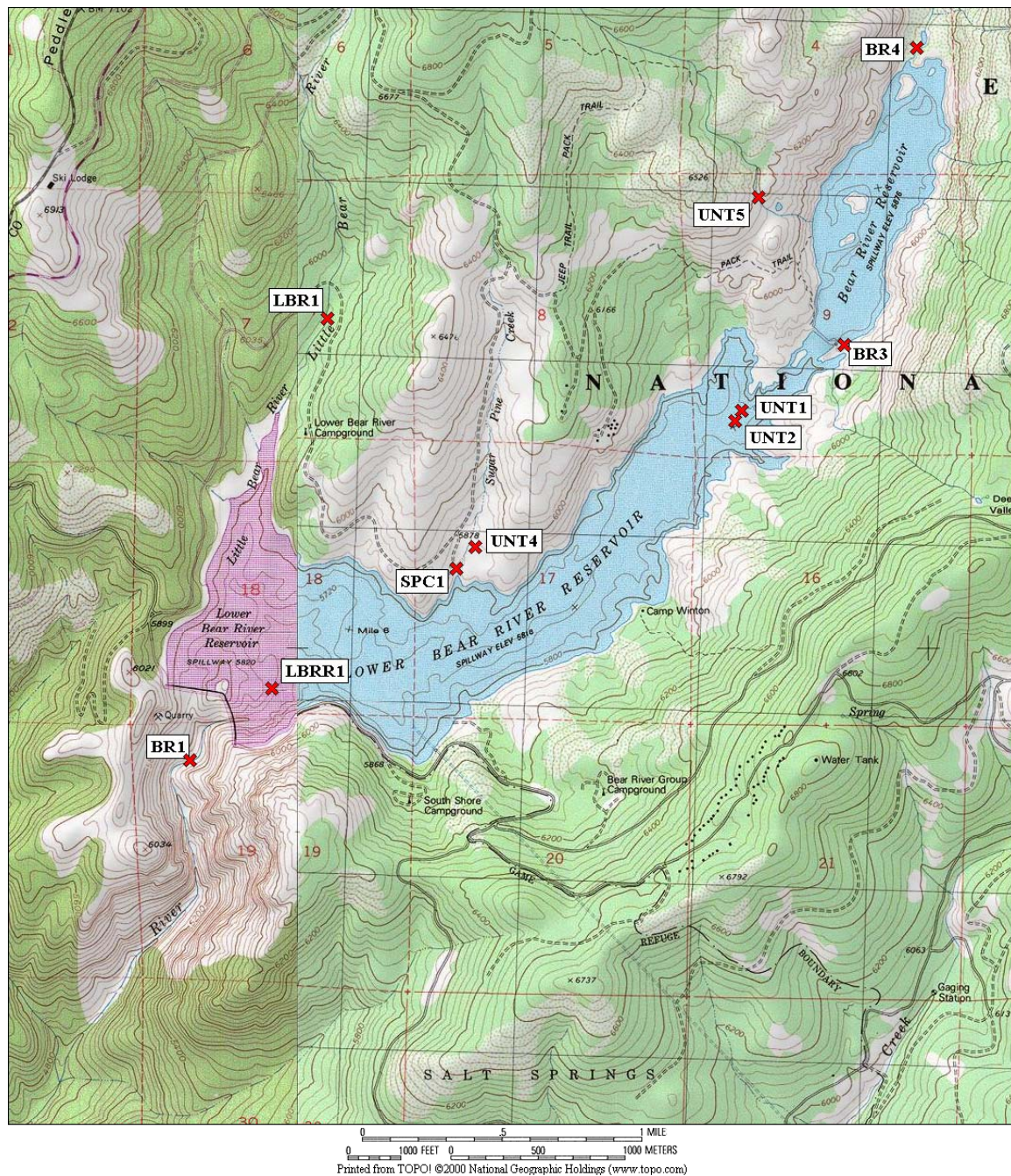


Figure 2. Additional sample stations added in August 2002 in Bear River below Lower River Reservoir and in Rattlesnake Creek.

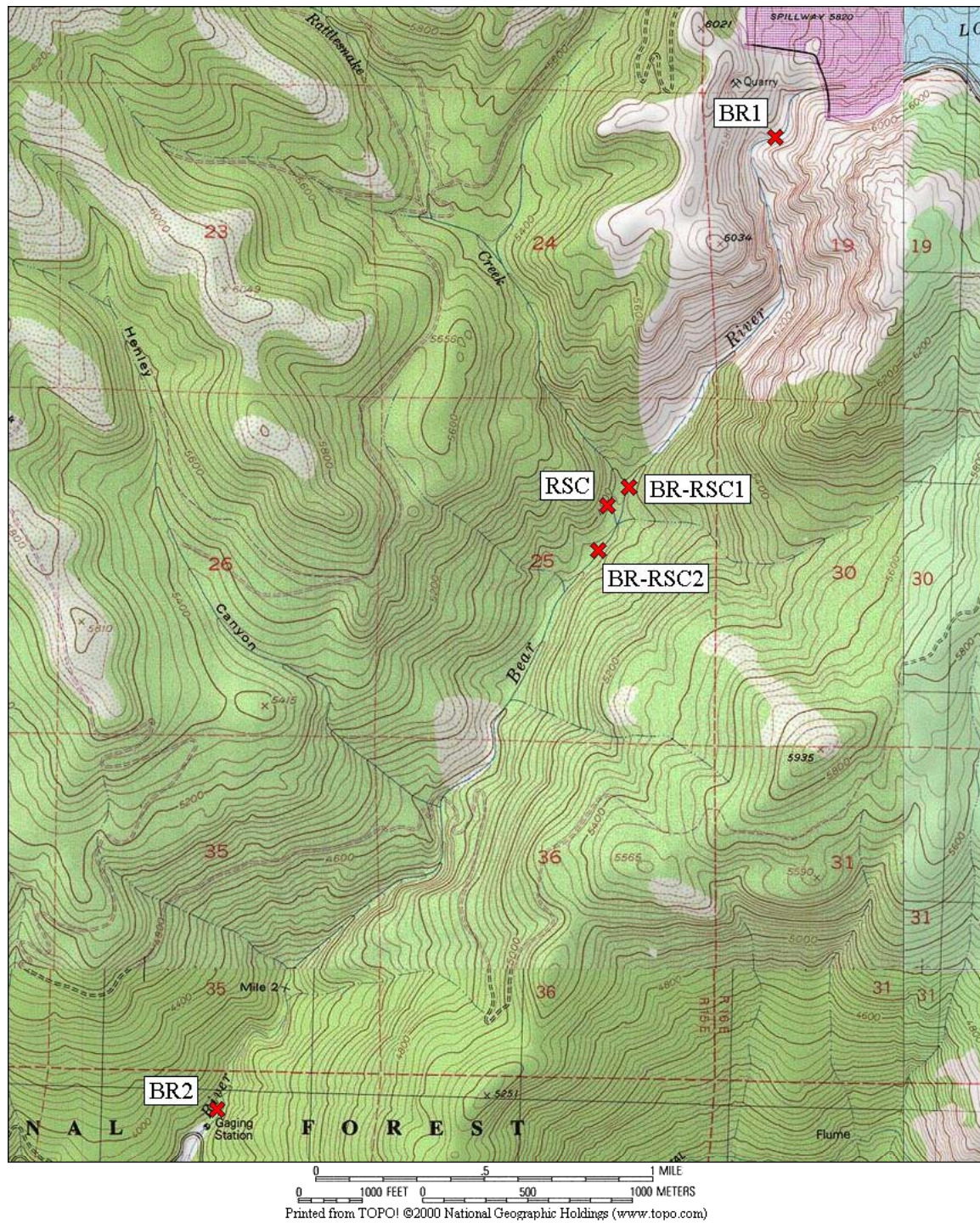
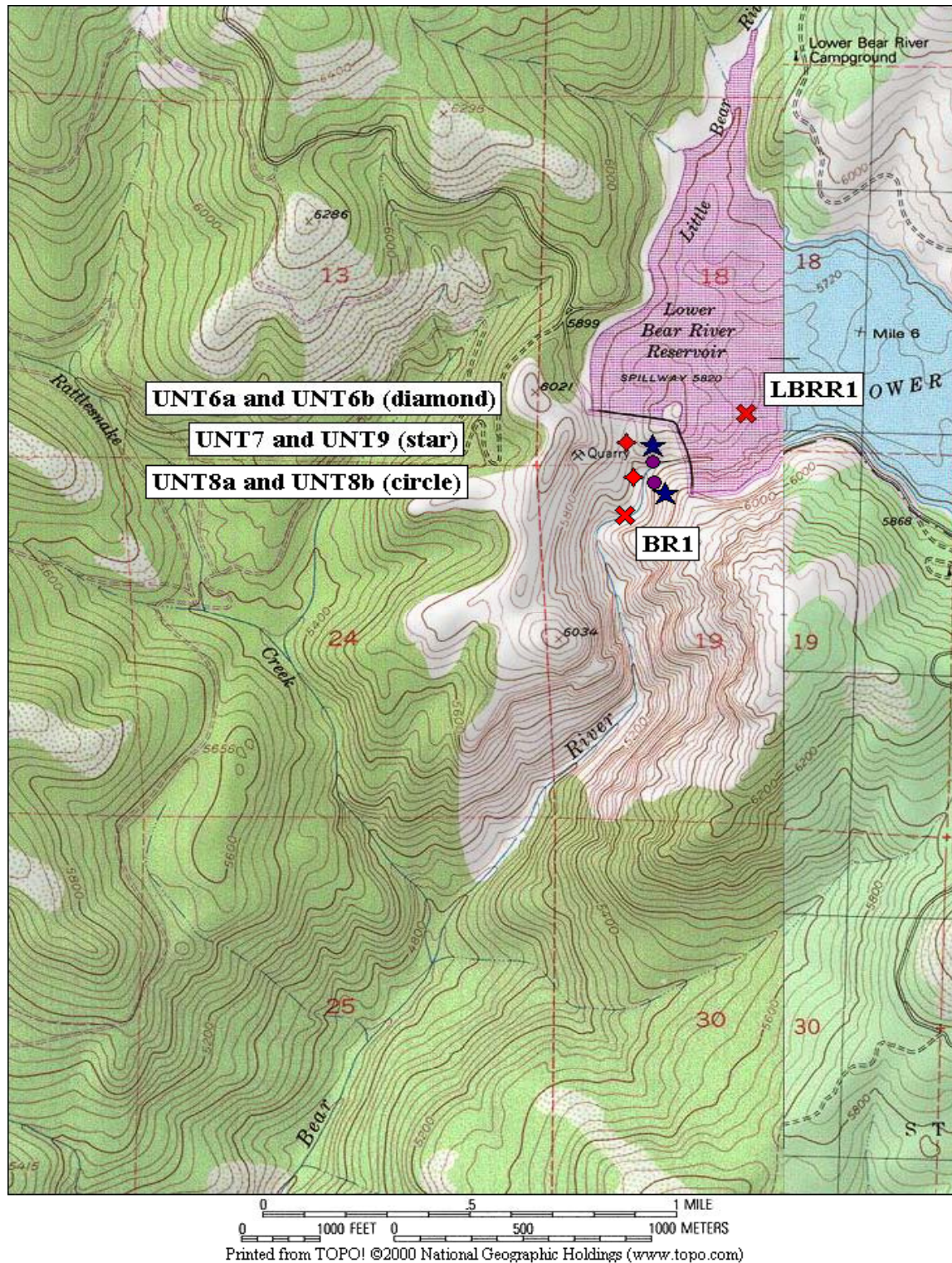


Figure 3. Location of leakage weir sampling stations (UNT6a, UNT6b, UNT8a, and UNT8b), the instream flow release sampling station (UNT7), and the reservoir spill station (UNT9) in relation to station BR1.



Prior to February 2003, all water samples were collected and analyzed for dissolved copper using standard laboratory protocol and U. S. Environmental Protection Agency (USEPA) Method 6010B (USEPA 1996a) (by Severn Trent Laboratories [STL] in Pleasanton, California). Estimated concentrations, or 'J' values were reported for samples that had dissolved copper concentrations less than the reporting limit (5 µg/L) but greater than the method detection limit (0.30 µg/L) for the period March 2002-January 2003. Although estimated, these data are provided so that comparisons can be made against those levels recommended by the California Toxics Rule (CTR) (USEPA 2000) and the USEPA National Ambient Water Quality Criteria for setting National Pollutant Discharge Elimination System permit levels for protection of freshwater aquatic life (Central Valley Regional Water Quality Control Board [CVRWQCB] 2003), and against California drinking water standards for protection of human health (California Code of Regulations [CCR] Title 26). A duplicate sample (for dissolved copper) was collected for quality control/quality assurance (QA/QC) and was analyzed by the Water Pollution Control Laboratory of the California Department of Fish and Game for all QA/QC samples collected prior to February 2003.

After January 2003, water samples for dissolved copper analysis were collected using the ultra clean field sampling techniques outlined in USEPA Method 1669: *Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels* (USEPA 1995), and copper concentrations were determined using USEPA Method 1638: *Determination of Trace Metals in Ambient Waters by Inductively Coupled Plasma – Mass Spectrometry* (USEPA 1996b). The reporting limit for the ultra clean methodology was 0.01 µg/L, and the method detection limit was 0.003 µg/L (sampled by the Marine Pollution Studies Laboratory of the California Department of Fish and Game). These lower detection limits eliminated the need for reporting 'J' flag values, which typically have approximately 60% error associated with their determination, and eliminated the need for duplicate QA/QC sampling by the California Department of Fish and Game. All dissolved copper samples were field filtered and preserved.

All samples were analyzed for hardness using Standard Method (SM) 2340C (Eaton et al 1995). Temperature, dissolved oxygen (DO), and pH were measured in the field at all stations with a HydroLab DataSonde® (3 or 4a) water analyzer. The HydroLab was calibrated in the laboratory before each use. Temperature profiles were collected using a Micom Bathythermograph in Lower Bear River Reservoir near the dam to determine if the reservoir was stratified. Water samples were collected from the reservoir at the surface, middle (only if the reservoir was stratified), and at the bottom using a Teflon Niskén™ bottle.

3 WATER QUALITY MONITORING RESULTS

Results of the *in situ* and analytical supplemental water quality monitoring are presented in Appendix C. Dissolved copper concentrations detected in the tributaries and inflow to Upper Bear River Reservoir and Lower Bear River Reservoir (at stations BR4, UNT5, BR3, UNT1, UNT2, UNT4, SPC1, and LBR1, which were all located above Project-affected waters) ranged from <0.3 to 9.9 µg/L (Appendix C). Many of these small tributaries represented seasonal flow from snowmelt (UNT1, UNT2, UNT4, and UNT5). According to a citation in the USEPA's 1985 *Ambient Water Quality Criteria*, concentrations of less than 10 µg/L are usually reported for unpolluted surface waters in the United States (USEPA 1985). Figure 4 shows dissolved copper concentrations in the tributaries and inflow to Upper Bear River Reservoir and Lower Bear River Reservoir from March-July 2002. Of the 23 samples collected at these locations, 18 had concentrations less than 2.0 µg/L; four had concentrations between 2.0 and 3.5 µg/L; and one had a concentration of 9.9 µg/L (at station BR3 during June 2002 when the both the upper and lower reservoirs were spilling). Twelve of these samples had concentrations of dissolved copper that were above the CTR and USEPA recommendations for protection of freshwater aquatic life (Appendix C). These criteria are based on a calculation that uses the sample's hardness. Hardness values ranged from 1.4 to 11 mg/L in these tributaries (Appendix C). Dissolved copper concentrations in these tributaries were well below California drinking water standards, which are applicable "at the tap," and include a Public Health Goal of 170 µg/L, a primary maximum contaminant level (MCL) of 1,300 µg/L, and a secondary MCL of 1,000 µg/L (CCR Title 26 paragraph 22-64470). Sampling locations above Lower Bear River Reservoir (above the Project) have shown dissolved copper levels that represent ambient background conditions and do not indicate a significant source of copper to the system..

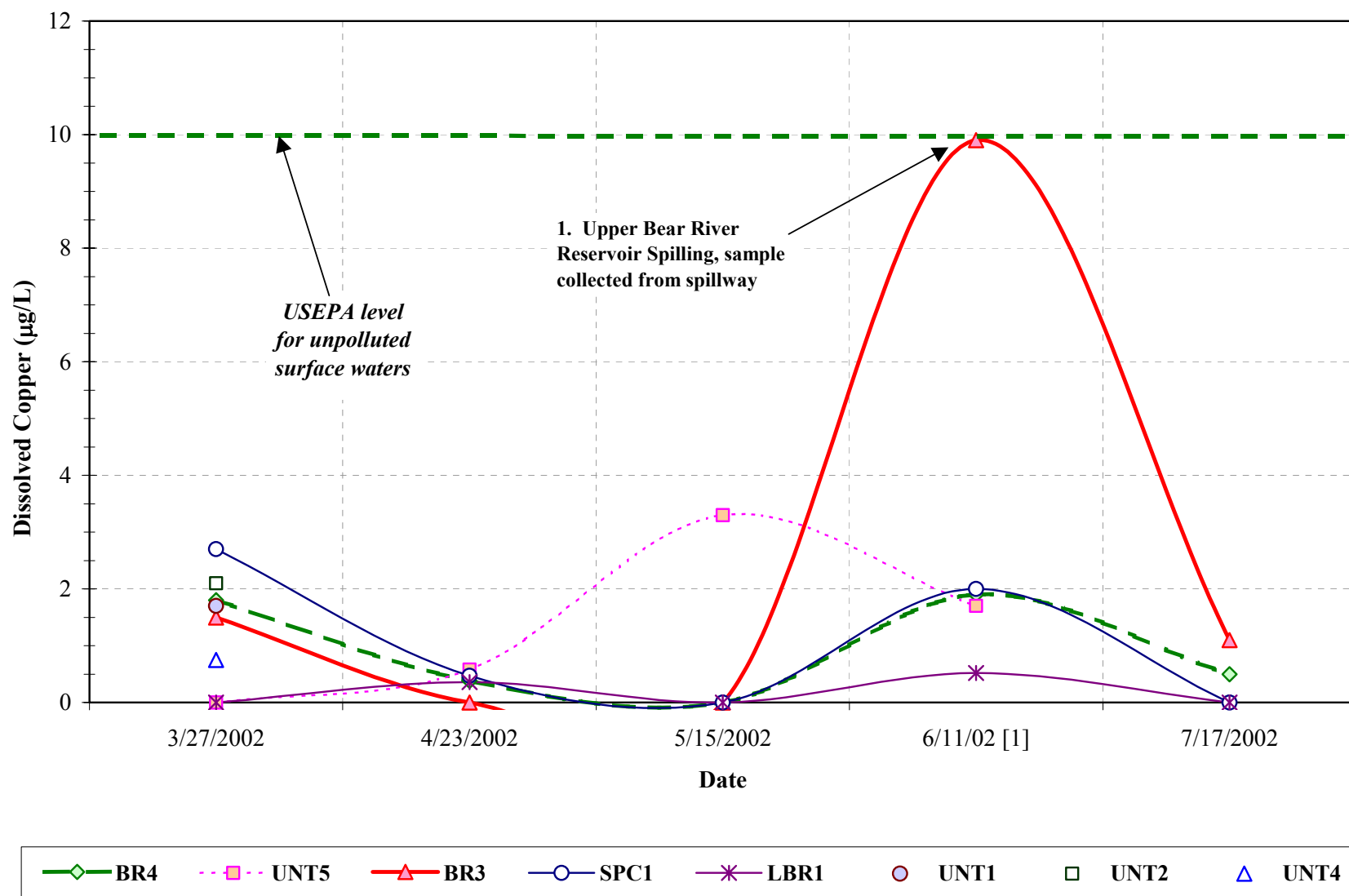


Figure 4. Dissolved copper concentrations in the tributaries and inflow to Upper Bear River Reservoir and Lower Bear River Reservoir.

Dissolved copper concentration trends in Lower Bear River Reservoir during the monitoring program are shown in Figure 5. Reservoir samples could not be collected during some winter months due to snow and ice cover. Dissolved copper concentrations in the reservoir ranged from 0.09 to 3.7 µg/L at the surface, 0.1 to 19 µg/L in the middle, and 0.13 to 1.6 µg/L at the bottom (Appendix C). The relatively high dissolved copper measurement (19 µg/L) from the middle of the reservoir on August 28, 2002 is questionable and may be due to contamination, since all of the other samples collected from the reservoir never exceeded 4.0 µg/L and a majority (71%) were below 1.0 µg/L. The concentrations of dissolved copper detected in Lower Bear River Reservoir are within the ambient background levels detected in the tributaries and inflow to the upper and lower reservoirs. These levels indicate that Lower Bear River Reservoir does not represent a significant source of copper to the system.

The concentration of dissolved copper detected at the leakage weirs followed a seasonal cycle, with concentrations increasing with increased precipitation or melting of snow in the study area. Figure 6 shows the daily average precipitation in inches for the period January 2002-September 2003 at Silver Lake (nearest location where precipitation data was available, located in the adjacent South Fork American River Drainage) and the corresponding peaks in dissolved copper concentrations at the leakage weirs. Although peaks in precipitation (in conjunction with warming conditions on sunny days after heavy snowfall) correspond to peaks in dissolved copper concentrations detected in the leakage weir samples from both the right and left abutments, the magnitude of the peak in precipitation does not correspond to the level of copper detected (Figure 6). The concentration that was detected was a function of the kind of precipitation (snow or rain) and the temperature at the time of sampling. The highest dissolved copper concentrations in the leakage weirs were detected in May 2003, when the snow from an April storm was melting and the precipitation in May was rain.

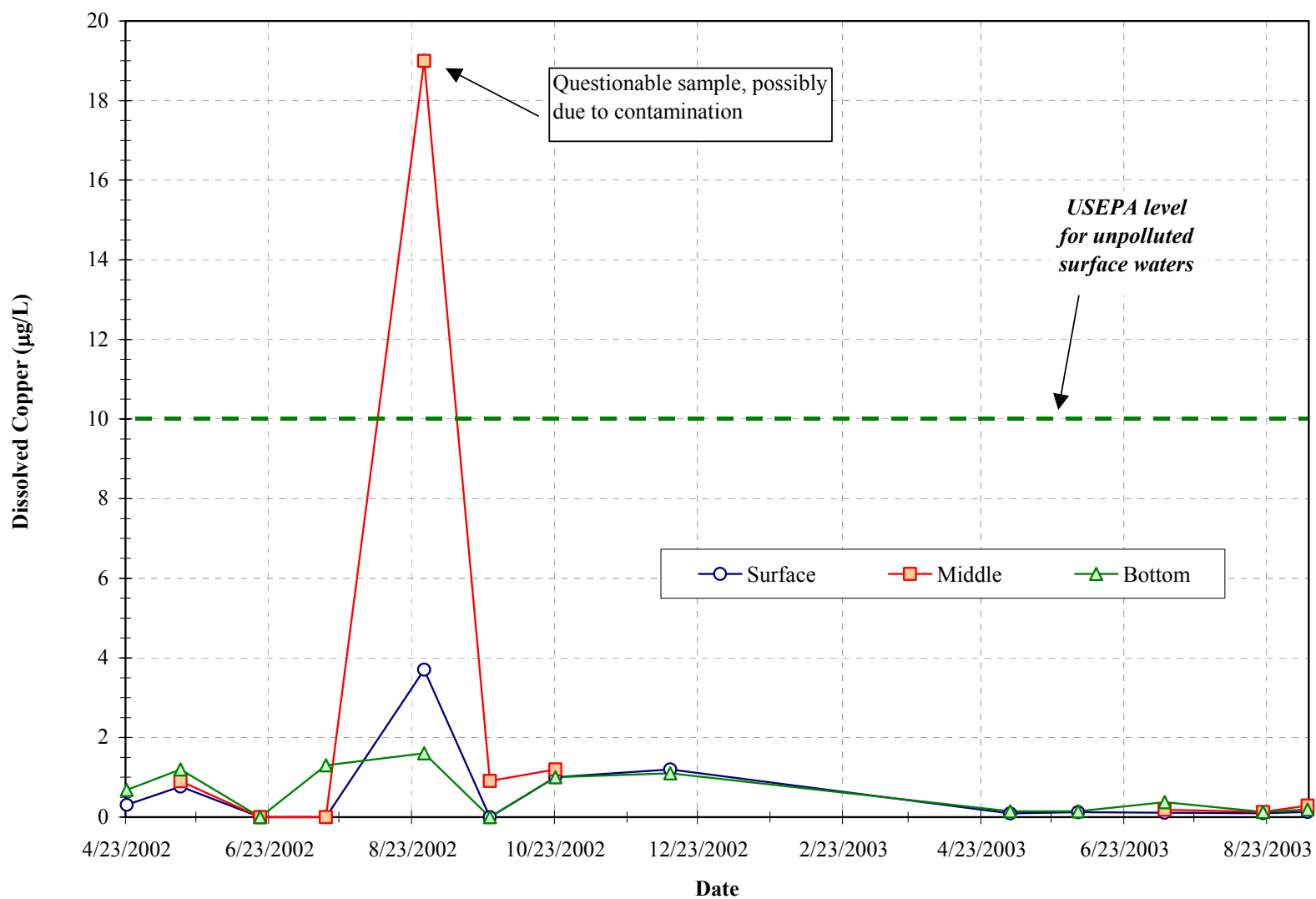


Figure 5. Dissolved copper concentrations trends in Lower Bear River Reservoir at three depths (surface, middle, and bottom) during the monitoring program.

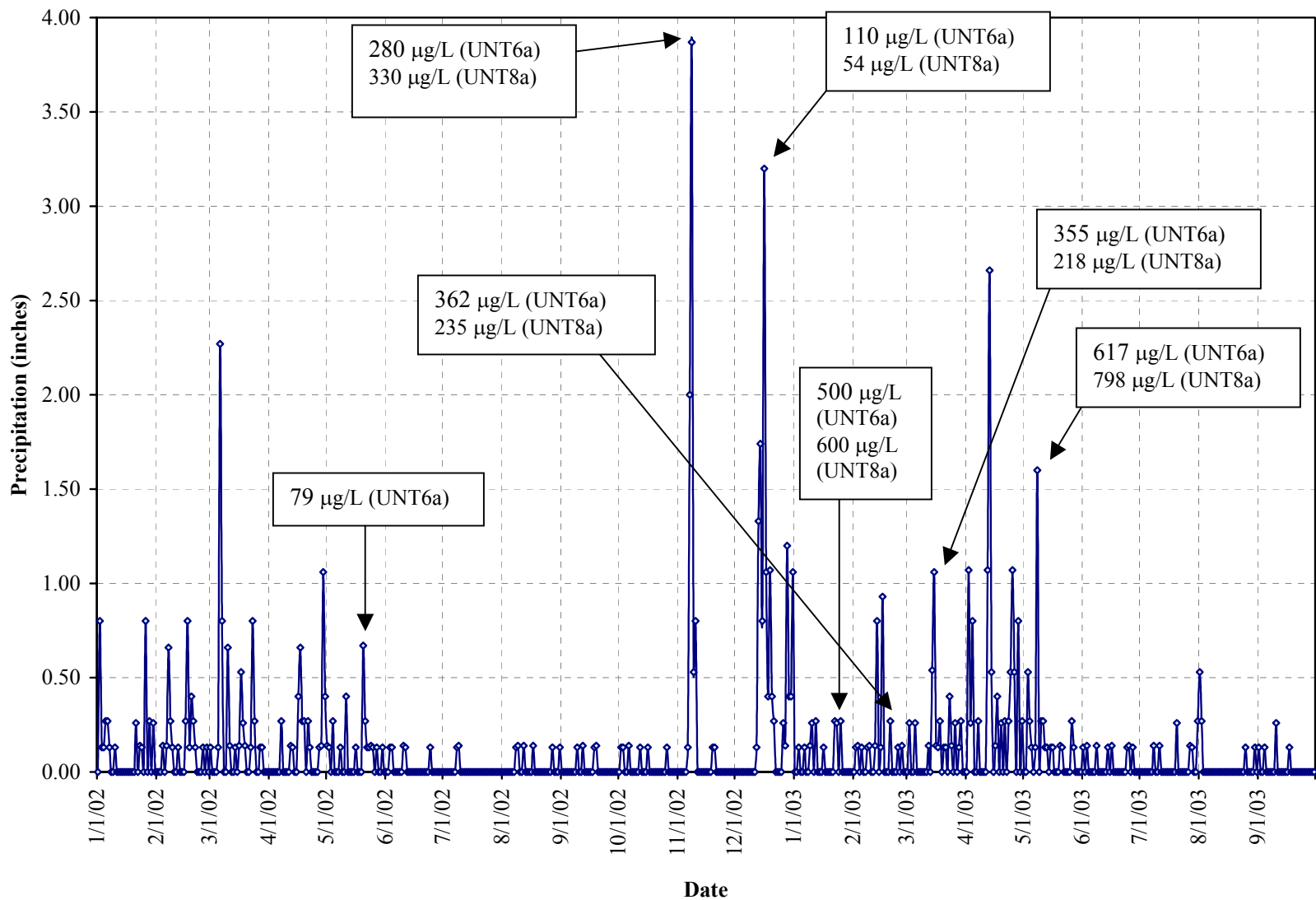


Figure 6. Daily average precipitation (inches) at Silver Lake for the period January 2002-September 2003 and corresponding peaks in dissolved copper concentrations at the leakage weirs below Lower Bear River Reservoir Dam.

The concentrations of dissolved copper detected in the leakage weir samples (UNT6a, UNT6b, UNT8a, and UNT8b) were above the levels recommended by the CTR and USEPA. Twenty-two of the 63 samples collected from the leakage weirs were above the California drinking water standard of 170 µg/L for the protection of human health (applicable “at the tap”). Hardness values ranged from 3.4 to 34 mg/L, and tended to be higher during periods of increased precipitation or snowmelt. Measurements of pH in the leakage weirs ranged from 4.7 to 7.7, and pH tended to decrease with increases in precipitation and snowmelt. The average pH of snow measured on the dam face was 5.7 during the monitoring program.

Copper is naturally occurring in the Project watershed. The Mokelumne River is located in an area known as the Foothills copper-zinc belt. It is a zone of volcanogenic massive sulfide deposits (pyrite) that extends for 400 km along the western Sierra Nevada (<http://pangea.stanford.edu/~parsons/thesis.html>). Copper mining was initiated in the Lower Mokelumne River watershed in 1861. The most famous mine, the Penn Mine (an abandoned copper-zinc mine on the shores of East Bay Municipal Utility District’s Camanche Reservoir located in the western Sierra Nevada foothills in Calaveras County, California), was mined intensively between 1899 and 1919 and closed in 1919, but was later reopened and operated intermittently between 1937 and 1956

(http://www.ebmud.com/water & environment/environmental_protection/mokelumne_environment/history/default.htm).

Given this area is known for its copper content, it appears that copper may be leaching from the rock used in the construction of the dam, from the surrounding area, and from the quarry located adjacent to the dam. The chemical process that allows this reaction to occur is pyrite weathering. Pyrite weathering is a complex series of chemical reactions that are spontaneously initiated when previously unexposed rock (spoil) material is exposed to an oxidizing environment. The products of pyrite oxidation are free acid and soluble salts. If no percolating waters are present, the acid salts generated from the limited available moisture simply reside within the spoil. When excess moisture is present, the acid weathering products are dissolved and transported with the water moving through the material (<http://www.osmre.gov/amdform.htm#chem>). This cyclic process of wetting and drying provides optimal conditions for the oxidation and subsequent leaching of pyrite and associated weathering products. Thus, the discharges from the leakage weirs in the dam face exhibit a seasonal response to precipitation and snowmelt patterns.

The concentration of dissolved copper at BR1 (the gauging station located below the leakage weirs and the instream flow release from the dam) also followed a seasonal cycle with concentrations increasing in the winter and spring and decreasing through the summer and fall. The source of water at this station is the combined flow from the leakage weirs (UNT6 and UNT8) and the instream flow release (UNT7) from the bottom of the lake. An additional source of water to this station is the spill flow (UNT9) over the dam face that only occurred when the reservoir was completely full (see Photo 1 in Appendix B which shows

location of leakage weirs, spill channel, and instream flow release pipe below the dam). Lower Bear River Reservoir spilled during two sampling events (June 11, 2002 and June 2, 2003).

The concentration of dissolved copper measured at BR1, which ranged from 0.61 to 93.8 µg/L (Appendix C) was much lower than what was measured in the leakage weirs during the monitoring program. The minimum concentration (0.61 µg/L) was measured during June 2003 when the reservoir was spilling. The maximum concentration was measured during May 2003 when the concentration of dissolved copper in the leakage weirs was at a maximum due to the melting of snow that had accumulated during a storm in April, and due to rainfall during the sampling event.

Ten of the 19 samples collected at BR1 were below 10 µg/L, which is the level usually reported for unpolluted surface waters in the United States (USEPA 1985). Six of the 19 samples were between 10 and 20 µg/L, and three samples were between 30 and 94 µg/L. Eighteen of the 19 samples collected at BR1 were at levels above the recommendations of the CTR and USEPA for protection of freshwater aquatic life. All of the samples collected at BR1 were below the California drinking water standards (applicable “at the tap”). Hardness values at BR1 ranged from 3.8 to 11.0 mg/L. The pH of the samples collected at BR1 ranged from 5.7 to 7.4. The lowest pH value (5.7) was measured in May 2003 and corresponded to the highest dissolved copper concentration at BR1.

As mentioned previously, the source of the water at BR1 was the leakage weir flow, the instream flow release originating at the bottom of the reservoir, and the spill flow (surface reservoir water). The copper in the leakage weir flow was diluted by the instream flow release and by the spill flow prior to being measured at BR1. Concentrations of dissolved copper in the instream release flow (UNT7) ranged from 0.09 to 2.3 µg/L during the monitoring program. The concentration of copper in the spill flow (UNT9) was 8.7 µg/L in June 2002 and 0.154 µg/L in June 2003. The spill flow represents water from the surface of the reservoir in 2003 and a combination of leakage weir flow and spill flow in 2002. The sample collected in June 2002 was collected in the pool below the convergence of the leakage weir flow (from UNT6a) with the spill flow. The spill flow in 2003 was collected from the spill channel prior to mixing with any other water.

Figure 7 shows the dissolved copper concentration trends at the stations in the Bear River below station BR1 and in Rattlesnake Creek during the monitoring program. The first station, BR-RSC1 (in the Bear River above the confluence with Rattlesnake Creek), was located approximately 1.24 river miles below BR1 (Figure 2). Concentrations of dissolved copper ranged from 0.80 µg/L (in June 2003) to 49.5 µg/L (in May 2003) (Appendix C). The concentration measured in May 2003 at BR-RSC1 represents a 53% decrease in the concentration measured at station BR1.

The next station below BR1 was BR-RSC2 (Bear River below the confluence with Rattlesnake Creek). This station was located approximately 1.46 river miles below BR1 (Figure 2). The concentration of dissolved copper detected at this station ranged from 0.73 µg/L (June 2003) to 17 µg/L (May 2003). The concentration of copper at this station was further reduced by the tributary inflow from Rattlesnake Creek

(RSC), which had dissolved copper concentrations ranging from 0.05 to 1.3 µg/L during the monitoring program (Appendix C).

Dissolved copper concentrations were measured 3.51 river miles below station BR1 in the Bear River at station BR2. Dissolved copper concentrations ranged from 0.80 µg/L (June 2003) to 4.3 µg/L (January 2002 and May 2003). Henley Canyon Creek enters the Bear River approximately 0.89 river miles below station BR-RSC2 and approximately 1.21 river miles above station BR2 (see Figure 2). This tributary flow further reduced the concentration of dissolved copper measured at BR2 during the monitoring program. Samples were not collected at Henley Canyon Creek during the monitoring program.

Of the thirteen samples collected at station BR-RSC1, only three had concentrations above 10 µg/L. Only one sample of the thirteen collected at station BR-RSC2 had a concentration above 10 µg/L. None of the fourteen samples collected at station BR2 had a concentration above 10 µg/L. The data indicate that for the 2.3 river miles between BR-RSC1 and BR2, 90% of dissolved copper concentrations are below the level (10 µg/L) usually reported for unpolluted surface waters (USEPA 1985).

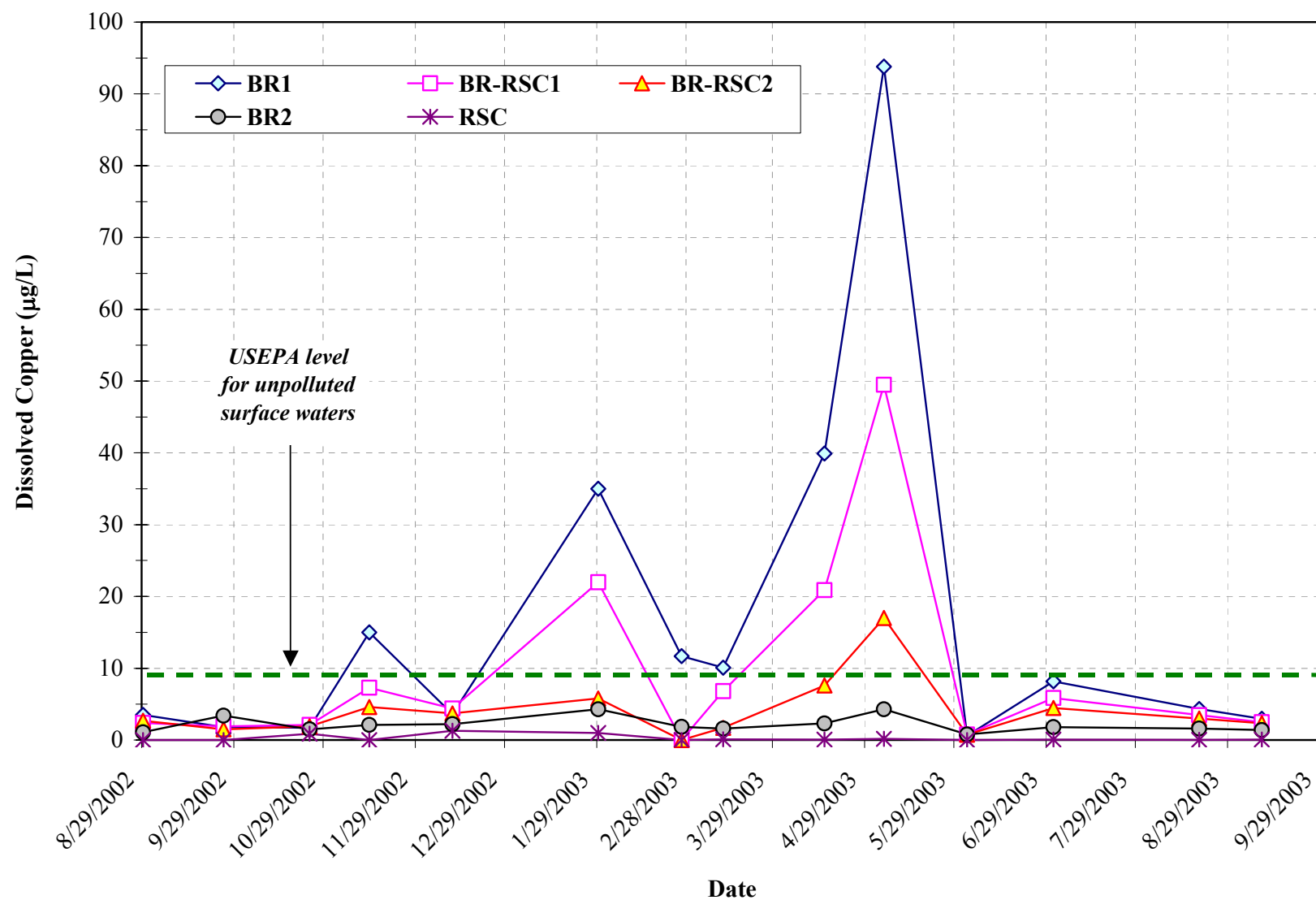


Figure 7. Dissolved copper concentration trends in the Bear River and in Rattlesnake Creek during the monitoring program.

4 SUMMARY

It appears that, as rainfall and snowmelt percolate downward through the dam, it leaches copper from the rock fill before combining with the other dam leakage. This hypothesis is supported by the data shown in Figures 8 and 9. Figure 8 shows the concentration of total and dissolved copper detected at station BR1 plotted with the concentration of dissolved copper at the right and left abutment leakage weirs, and storage data for the Lower Bear River Reservoir. Figure 9 shows the leakage weir hydrographs for both the right and left abutments plotted with storage in the Lower Bear River Reservoir. Copper concentrations at BR1 increase with the rising limbs of the leakage weir hydrographs in early winter and spring. The rising limb of the leakage weir hydrographs also precedes the rising limb of the reservoir storage plot, thus indicating that precipitation and snowmelt affect leakage weir flow, and therefore, copper concentrations that are detected in the Bear River. Interestingly, copper concentrations peak prior to peaks in leakage and reservoir elevation, which occur simultaneously. This may be the result of dilution associated with higher leakage that, as rainfall and snowmelt diminish, is primarily composed of through-dam leakage that is driven by reservoir elevation.

Copper levels in the Bear River downstream of Lower Bear River Reservoir Dam are reduced by dilution from tributary inflow. The dissolved copper concentration measured at station BR1 is reduced by an average of 65% in the first 1.24 river miles downstream. Dissolved copper concentrations in the next 2.3 river miles down to station BR2 are further reduced to levels that are typically detected in unpolluted surface waters ($<10 \mu\text{g/L}$) and therefore would not represent a significant threat to the environment (USEPA 1985). Dissolved copper concentrations that are above the level usually found in unpolluted surface waters may occasionally occur in the lower reach of the Bear River during rain on snow events at the end of winter and beginning of spring (during May).

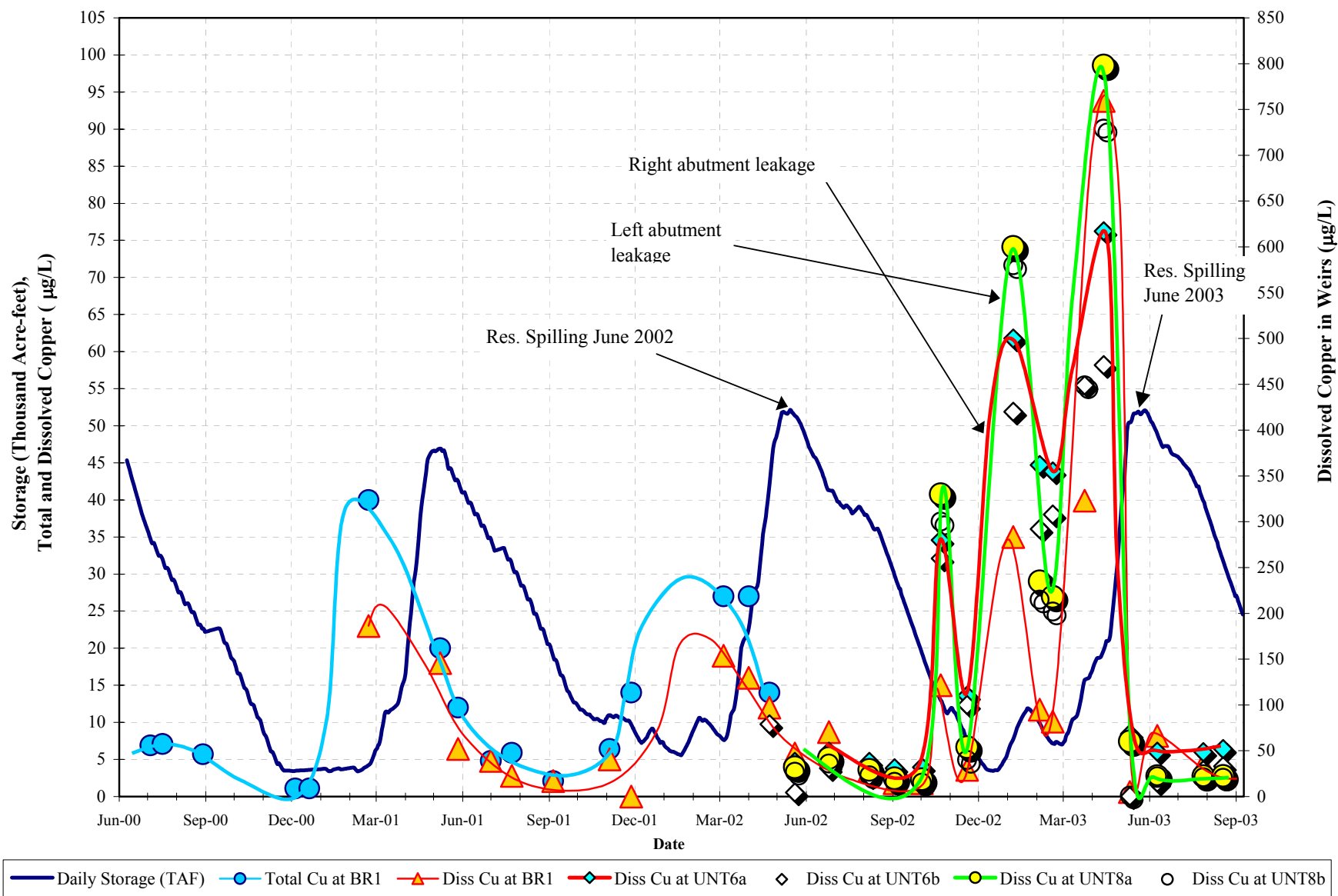


Figure 8. Concentration of total and dissolved copper detected at station BR1 plotted with the concentration of dissolved copper at the right and left abutment leakage weirs, and storage data for the Lower Bear River Reservoir during the monitoring program.

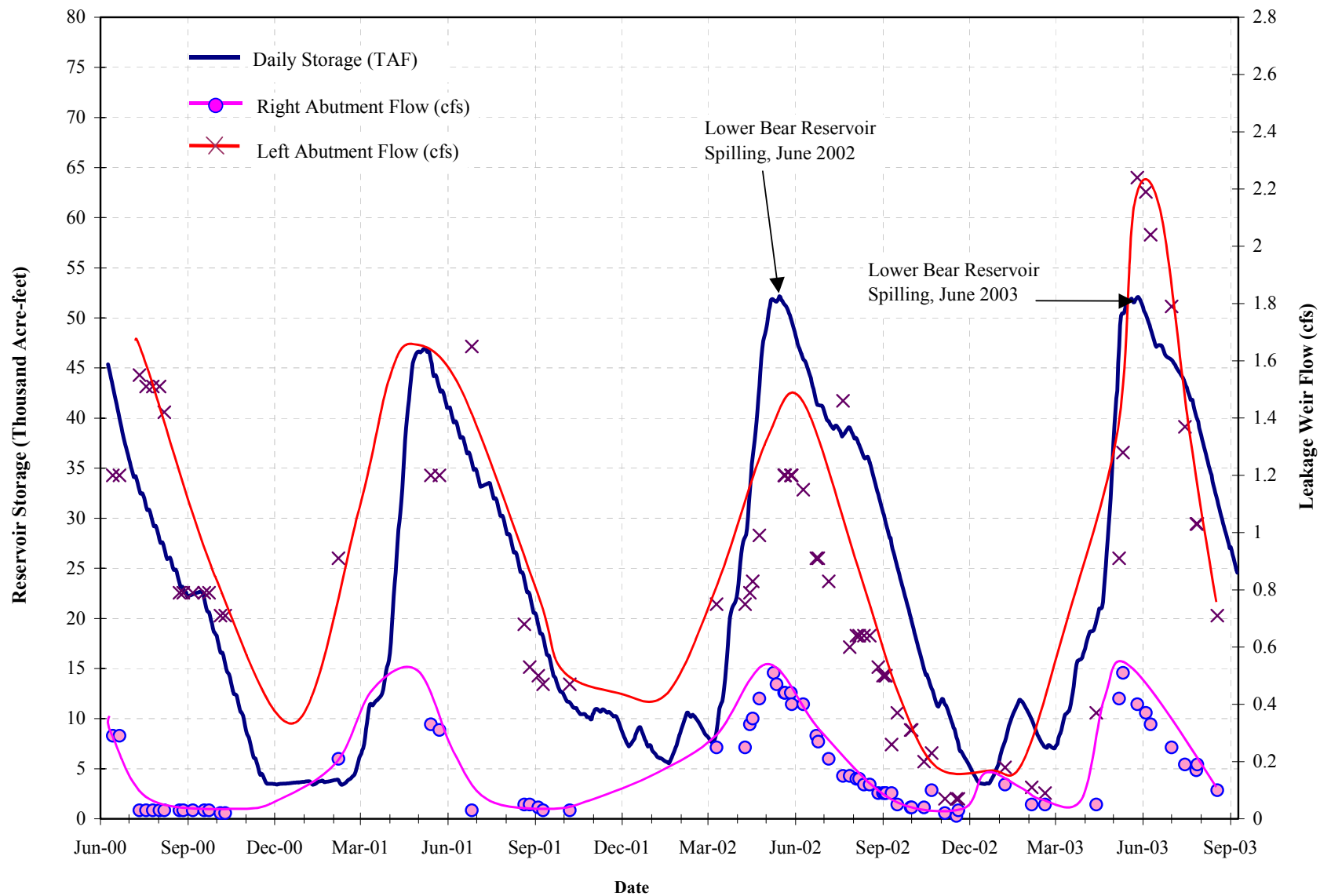


Figure 9. Leakage weir hydrographs plotted with storage in Lower Bear River Reservoir during the monitoring program.

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Appendix A
Mokelumne River Project, FERC 137,
Supplemental Water Quality Monitoring Study Plan
March 18, 2002

Appendix B

Mokelumne River Project Photographs of Stations Below Lower Bear River Reservoir Dam Taken During the Supplemental Water Quality Monitoring Program

Appendix C

Mokelumne River Project Supplemental Water Quality Monitoring Results for the Period March 2002-September 2003

Appendix D
Mokelumne River Project Analytical Laboratory Results
(See Attached CD)