ILVER BOW CREEK

REMEDIAL INVESTIGATION FINAL REPORT
APPENDIX E, PART 2

BIOASSAY INVESTIGATION

SUBMITTED TO:

Montana Department of Health and Environmental Sciences
Helena, Montana

SILVER BOW CREEK REMEDIAL INVESTIGATION
DRAFT FINAL REPORT

BIOASSAY INVESTIGATION

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In 1983, the U.S. Environmental Protection Agency (USEPA) designated Silver Bow Creek, contiguous portions of the upper Clark Fork River, and their environs as a high priority Superfund cleanup site. The site extends from Butte to Deer Lodge, Montana, generally following the course of Silver Bow Creek and the upper Clark Fork River. Because the various mining activities interrupted the natural flow of Silver Bow Creek, the beginning of the creek for this investigation was established as the confluence of the Metro Storm Drain and Blacktail Creek, within the city limits of Butte. The site begins at the start of the Metro Storm Drain and ends at the Kohrs Bridge north of Deer Lodge.

The Silver Bow Creek Remedial Investigation (SBC RI) project consisted of coordinated individual studies to develop data on the extent and severity of contamination within the site. Results of the studies are reported in several volumes. A Summary Final Report discusses the entire project; final reports for each individual study have been issued as appendices to the Summary, as shown below:

- Surface Water and Point Source Investigation, Appendix A, Parts 1-3;
- Ground Water and Tailings Investigation, Appendix B, Parts 1-3;
- Warm Springs Ponds Investigation, Appendix C;
- Algae Investigation, Appendix D, Part 1;
- Vegetation Mapping, Appendix D, Part 2;
- Agriculture Investigation, Appendix D, Part 3;
- Macroinvertebrate Investigation, Appendix E, Part 1;
- Bioassay Investigation, Appendix E, Part 2;
- Fish Tissue Investigation, Appendix E, Part 3;
- Waterfowl Investigation, Appendix E, Part 4; and
- Laboratory Quality Assurance/Quality Control Program, Appendix F.

The Solid and Hazardous Waste Bureau (SHWB) of the Montana Department of Health and Environmental Sciences (MDHES) administered the USEPA appropriations to conduct this project. The Montana SHWB program manager was Mr. Michael Rubich. MDHES contracted with MultiTech in October 1984 to perform the SBC RI under contract No. 50341-1202503. The Project Manager at MultiTech was Mr. Gordon Huddleston.

MultiTech was assisted in the SBC RI work by Stiller and Associates of Helena and various other subcontractors. Several state and federal agencies also provided technical information and expertise, including the USEPA bioassay team, the Montana Department of Fish, Wildlife and Parks, the Montana Water Quality Bureau, and the USEPA Montana Field Office.

Information developed in the SBC RI will be used in the next phase of the project, the Feasibility Study, to evaluate options for site remediation.

EXECUTIVE SUMMARY

The fishery of the upper Clark Fork River exhibits a significant population decline related to distance downstream of the Warm Springs Ponds at Warm Springs, Montana. Metals contamination of the upper Clark Fork River has been suspected of significantly reducing fish production or recruitment in this section of the river.

The objective of the Bioassay Investigation was to document the effects of Clark Fork River water on rainbow trout recruitment. Bioassay tests were conducted in May of 1985 to observe the effects during the spring runoff period, when metal levels historically have risen. Three separate tests were performed: an eyed-egg test for 30 days, a green-egg test for 30 days, and a fingerling-trout test for 13 days. Significant mortalities were not observed in any of the tests. Lower-than-normal flow during the runoff period is postulated as a factor in limiting metal concentrations and resulting fish mortalities. Repeating the bioassay tests during a normal high flow spring runoff is recommended.

The bioassay test was performed by the Region VIII Analytical Support Branch of the Environmental Services Division of the US Environmental Protection Agency. Laboratory and logistic support, printing, and Silver Bow Creek Remedial Investigation coordination were provided by MultiTech under contract to the Montana Department of Health and Environmental Sciences.

EPA 908/3-86-001

A Thirty Day Flow-Through Bioassay Test on Copper and Zinc Toxicity in the Clark Fork River Near Deer Lodge, Montana
May 7 - June 6, 1985

by

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Abstract

Thirty-day flow-through bioassays were conducted on green eggs, eyed eggs and fingerlings of the rainbow trout with Clark Fork River water from May 7 through June 6, 1985. Dilution water was obtained from Taylor Creek, near Deer Lodge, Montana.

A two-bank vacuum diluter system was used to conduct tests with water from the Clark Fork River near Deer Lodge, Montana. The tests were started in May 1985 in order to catch predicted high spring runoff from the Silver Bow Creek Basin with concomitant high concentrations of heavy metals (primarily copper and zinc). A total of three tests were conducted at 10 $\pm$ 2 C; an eyed egg test for 30 days, a green egg test for 30 days, and a fingerling trout test for 13 days.

The expected spring runoff did not occur during the test period and resulting metals concentrations in the Clark Fork River did not produce significant mortalities in any test.

Rain events during the last half of the study period produced sharp, brief increases in metals concentrations. These increased concentrations exceeded calculated chronic and acute levels of copper that would protect aquatic life. However, the increases in copper and zinc were neither high enough nor long enough in duration to produce significant mortalities during the test period.

Additional testing is recommended during a "normal" water year when runoff would be expected to carry higher concentrations of metals.

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ACKNOWLEDGEMENTS

The assistance of the following individuals is gratefully acknowledged. Miss Maureen Martin of the Biological Sciences Section, Environmental Services Division, EPA Region 8, assisted in conducting the on-site bioassays and in data reduction. Glenn Phillips, Montana Department of Fish, Wildlife and Parks, provided information on the Clark Fork System and was instrumental in obtaining both eggs and fingerling trout for the tests. Mr. George Kirsch, Washoe Park Hatchery, Montana Department of Fish, Wildlife and Parks provided assistance in egg counting and handling during the initial phase of the tests. Mr. Ernest Hartley, Museum Director, Towe Ford Museum, provided secure space, power and water for the on-site lab. Mr. Robert Trout, Multitech, provided assistance in locating space, transporting samples, and contacting local officials in Deer Lodge, Montana. Mrs. Irma Jacobsen provided valuable secretarial assistance.

SECTION 1

INTRODUCTION

On October 24, 1983, a memo was received from the EPA Region 8 Montana Office expressing an interest in using the Region 8 Environmental Services Division mobile bioassay lab to assist with biological investigations on the Silver Bow Creek Superfund site. The memo referred to the "Silver Bow Remedial Investigation/Feasibility Study Plan". In the plan, biological investigations were recommended to assess the current ability of Silver Bow Creek and the Upper Clark Fork River to support the reproduction of brown trout. Copper was mentioned as one of the problem metals present; copper attains levels during the winter and spring that have been shown in the lab to kill incubating trout. Therefore, the study plan recommended on-site bioassays at several sites including a site on the Clark Fork River "far enough downstream to allow for complete mixing".

A statement of work for a Silver Bow Creek (SBC) Remedial Investigation (RI) bioassay study was received from the EPA Montana Office on February 14, 1985. The study called for a bioassay using eyed rainbow trout eggs through 15 days post-hatch to test the toxicity of contaminants in the Clark Fork River. Tin Cup Joe Creek was to be used as a dilution water. The tests were to be conducted in the vicinity of Deer Lodge, Montana on about April 1, 1985, Figure 1.

A reconnaissance of the area revealed that Tin Cup Joe Creek was contaminated with drainage from an old railroad yard and could not be used for dilution water. Several alternate sources were checked and Taylor Creek was finally selected as a dilution water source.

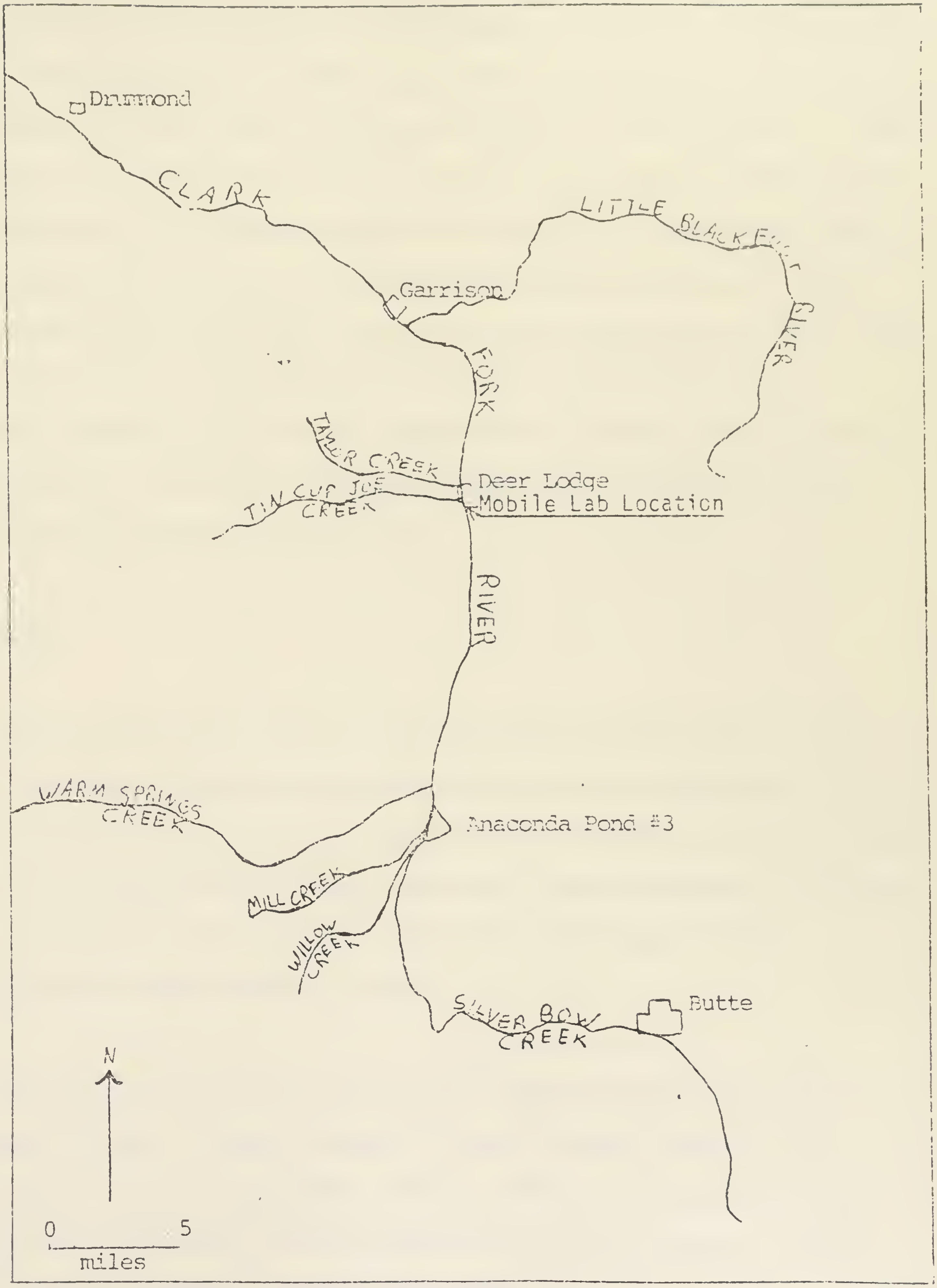

Figure 1. Map of the Upper Clark Fork River, Montana.

On April 28, 1985, an interagency agreement was received from the EPA Montana Office listing the tests to be performed. Testing was to begin on May 4 and continue until June 3, 1985. Eyed rainbow trout eggs were to be used in the bioassay since the state did not have a source of brown trout eggs. State personnel also expressed an interest in trying to determine why rainbow trout were not found in the upper Clark Fork in the vicinity of Deer Lodge, Montana, since rainbows were present in the downstream reaches of the river. Green rainbow trout eggs would also be used if a source of eggs could be found. The object of the tests was to determine the potential effects of metals (primarily copper and zinc) in the river water on trout eggs and larvae during various stages of development. The metals entered the river during spring runoff from an upstream Superfund site.

BACKGROUND

The Upper Clark Fork River has been impacted by mining wastes for over 100 years. Copper mining and processing wastes have been discharged to the system through Silver Bow Creek for about 70 years. Metallic wastes have been deposited in stream bank and flood plain areas from the headwaters to Milltown dam. During most of this time fish life in the Upper Clark Fork was essentially eliminated (Peterman, 1985).

A biological and chemical survey of the Clark Fork River from Warm Springs to Drummond, Montana, conducted from May through November 1970, revealed that the river above Deer Lodge was severely polluted with wastes from the Anaconda Company settling ponds and did not show signs of recovery until it reached Garrison, Montana (EPA, 1972).

In a memo dated July 8, 1971, Don Willems, Acting Director of the Division of Environmental Sanitation, Montana State Health Department noted a "marked improvement over the years in the Clark Fork River below the Anaconda Company ponding system". Both the Anaconda Company and State Health Department were working cooperatively to improve the quality of water in Silver Bow Creek and downstream from the Anaconda ponds. Willems also wrote that one of the basic problems remaining was the effect on the Clark Fork River, of storm runoff in the area from Butte to Warm Springs.

The Clark Fork River has currently been described as an improved system (Peterman, 1985). The river, downstream of the Anaconda ponds, supports a high trout density (1500 to 2500 trout per mile). Unfortunately, the fish population decreases from Deer Lodge to Drummond, due in part to decreasing water quality.

A study of the Clark Fork river system in 1984 revealed a number of problems. Analysis of water samples collected from 14 stations on the river upstream from Milltown dam, during an April to mid-July period, revealed that copper, iron and zinc were sometimes present at concentrations that exceeded aquatic life criteria. Copper concentrations were the highest of the three and may have been the most limiting. Conditions for aquatic life were reported to be least favorable in the stream between Deer Lodge and the confluence with Rock Creek. Fish populations were reduced in areas downstream from Deer Lodge where metals concentrations were highest. Part of the reason for the metals concentrations may have been the bypassing of untreated Silver Bow Creek water into the Clark Fork during periods of high runoff. The erosion of tailings deposited in the flood plain may also have contributed to the problem (Phillips, 1985).

An up-to-date review of copper and zinc toxicity can be found in recent publications issued by the U.S. EPA (1985a and 1985b). Copper occurs in natural waters and is a micronutrient to both plants and animals. However, concentrations of copper at levels slightly higher than micronutrient requirements have been reported as toxic to aquatic organisms. In the aquatic environment copper exists as a divalent cupric ion in both free and hydroxy complexed forms. The cupric ion in water is generally low in proportion to bound complexes and precipitates which are less toxic and tend to reduce the toxicity attributable to total copper. Increasing calcium hardness and associated carbonate alkalinity, expressed as hardness, are both known to reduce the acute toxicity of copper. As a result, copper criteria are expressed as a function of hardness in order to adjust for water quality effects. The acute toxicity of copper to rainbow trout, in water with a hardness of 30 to 32 milligrams per liter (mg/l) $CaCO_3$, ranged from 0.02 to 0.03 mg/l. In water of 194 mg/l $CaCO_3$ hardness, the toxicity of copper to rainbow trout ranged from 0.08 to 0.5 mg/l (U.S.EPA, 1985a).

Zinc is amphoteric and dissolves in both acids and bases. Zinc always has a +2 oxidation state in water and is one of the most mobile heavy metals. Low concentrations of zinc are required as a trace element by aquatic organisms. However, all forms of zinc are potentially toxic at higher concentrations if they can be sorbed or bound by biological tissues. Zinc toxicity is apparently influenced by a number of chemical factors including hardness, pH and ionic strength. The toxicity of zinc appears to be less athigh hardness in fresh water. Therefore, hardness is used as the best water quality parameter to reflect changes in toxicity caused by differences in water chemistry. For example, the 96-hour acute toxicity of zinc to juvenile

rainbow trout in water with a hardness of 170-179 mg/l $CaCO_3$ has been reported to range from 1.9 to 2.9 mg/l. Juvenile rainbows in water with a lower hardness of 44 to 47 mg/l $CaCO_3$ had a 96-hour toxicity of 0.4 to 0.7 mg/l (U.S.EPA, 1985b).

SECTION 2

METHODS AND MATERIALS

MOBILE LAB

Fish tests were conducted in a mobile bioassay lab that was set up behind the old Montana Territorial Prison/Towe Antique Car Museum property in Deer Lodge, Montana. This site provided both security and accessibility to the Clark Fork River. Flow-thru fish tests were conducted from May 7 to June 6, 1985. Methods used were adapted from Peltier (1985) and ASTM (1985).

The mobile bioassay laboratory is contained in a self-propelled 2-1/2-ton truck. Two wall mounted vacuum-siphon diluter systems mounted side by side delivered Taylor Creek water (dilution water) plus Clark Fork River water (toxicant) to 28 eight-liter aquaria, 14 aquaria per diluter, in a water bath. Aquarium temperatures are maintained at specified test temperatures by a recirculating heat/chill unit connected to the water bath. Ambient air temperature in the lab is maintained by an exterior-mounted heat pump.

The vacuum-siphon diluter system is patterned after Peltier (1985), with slight modifications. A set of glass chambers, constructed to contain specified volumes of dilution water, are mounted above a second set of

chambers that provide specified volumes of toxicant. Fluid metering pumps activated by a float switch and time-delay relays were used to deliver Taylor Creek water to the upper chambers and Clark Fork River water to the lower chambers. Vacuum siphon tubes from each chamber delivered combinations of Taylor Creek water and Clark Fork River water totaling 1000 milliliters per concentration to mixing chambers. The test concentrations were 100, 75, 56, 32, 18, 10, and 0 (control) percent Clark Fork River water. From the mixing chambers each concentration was split equally into two aquaria. Fourteen aquaria or test chambers containing the test organisms were located below the mixing chambers for each diluter system. During the 30-day test, the diluters cycled an average of 6.3 times per hour.

Two exterior-placed 1363-liter polyethylene tanks provided a reservoir for Clark Fork and Taylor Creek waters. Taylor Creek water was pumped from the creek, at a point where it left the Montana State Prison property, to 167 liter polyethylene tanks, transported to the mobile lab site, and pumped into the large (1363-liter) outside tank. Test water was continuously pumped from the Clark Fork River near the lab through a covered hose to another large tank beside the lab. A submersible pump was anchored six inches off the river bottom and covered with fiberglass screen to prevent leaves and debris from clogging the pump.

Lighting in the laboratory was provided by incandescent lights controlled by a dimmer switch. The eggs were shielded from direct sunlight, and the sac-fry and fingerlings from routine laboratory movements, by a black plastic curtain that surrounded the diluters plus the water bath containing the test aquaria.

TEST SPECIES

All trout eggs were collected from a DeSmet strain located in Willow Creek Reservoir. Eyed rainbow trout eggs were obtained from the Washoe Park Hatchery in Anaconda. The eggs were collected by State Department of Fish, Wildlife and Parks personnel on April 10. The eggs were transported to the hatchery for incubation and were approximately 27 days old when delivered to the bioassay lab. Personnel from the hatchery transported the eyed eggs and assisted in the distribution of both eyed and green eggs into the nursery baskets. Green eggs were collected at the Willow Creek area, fertilized, and immediately transported to the lab by Montana Fish, Wildlife and Parks personnel. The green eggs were less than 24 hours old when they were placed in nylon nursery baskets hung in the aquaria.

Fingerling rainbow trout were acquired from the U.S. Fish and Wildlife hatchery at Creston, Montana. Montana Fish, Wildlife and Parks personnel transported the fingerlings to the bioassay lab on May 24, 1985. The fingerlings averaged 1.6 grams in weight and 5.1 centimeters in fork length.

TEST CONDITIONS

Eyed and green eggs were placed in their respective nursery baskets constructed of a plastic frame covered with nylon webbing. The nylon webbing permitted a full exchange of test solution, thus continually exposing the eggs to any toxicant present in the aquaria. A total of 50 eggs were placed in each basket. The baskets were hung from the aquaria frames with stainless steel support hooks. Eyed eggs were placed in all 28 aquaria giving a total

of 200 eggs per concentration. Green eggs were placed in the 14 aquaria receiving test concentrations from the left diluter only, resulting in 100 eggs per concentration.

Both green eggs and eyed eggs were placed in the aquaria with hatchery water flowing through the diluters. Hatchery water was added on the sixth of May and continued until the seventh. On May 7, Taylor Creek water and Clark Fork River water were slowly added to the tanks over a seven hour period and the test was officially started at 3:30 PM. At this time any white (dead) eggs were replaced with live eggs.

Since the eyed eggs had been exposed to a fungus in the hatchery, hatchery personnel recommended a formalin treatment for all eggs. Both eyed and green eggs were treated with a 5 percent formalin solution made up in the respective concentration of dilution and test water in the aquaria. Eggs in each aquarium were exposed to the treatment for 15 minutes. After that time interval, the eggs were flushed with their particular test concentration water. This procedure was carried out on May 9 and 11. The treatment was discontinued when the first sac fry was noticed on May 12.

Fingerling trout were acclimated to the test temperature of 10 $\pm$ 2 C and placed into the 14 aquaria associated with the right diluter. Ten trout per aquarium (20 per concentration) were used, except for the controls. Five fish per aquarium were also placed in the controls for the left diluter giving a total of 30 fish for the control. The fingerling trout test was conducted for 13 days, May 24-June 6, 1985.

All tests were conducted at a temperature of 10 $\pm$ 2 C. Air was slowly bubbled to all aquaria when fingerling trout were added on May 24. Air was required for the fingerlings and was added to all aquaria to expose all eyed eggs to the same aeration conditions.

TEST PARAMETERS

The following parameters were measured daily from every aquarium: dissolved oxygen (mg/l), conductivity, temperature (C), alkalinities (mg/l Ca CO_3), and pH. Each aquarium was checked daily for mortalities and any dead eggs or fish were removed.

Samples for total copper and zinc, dissolved copper and zinc, and hardness were drawn from one concentration replicate throughout the bioassay. These samples were analyzed by Multitech, a contract laboratory in Butte. Copper and zinc were to be analyzed using ICP emission spectroscopy. Analytical methods followed those listed by EPA (1983). ICP analyses were conducted with a Perkin Elmer instrument, Model 5500-B (G. Huddleston, Multitech, Personnel Communications, 1986).

Each week a priority pollutant and an ICP metal scan sample were taken from both the Clark Fork River and Taylor Creek. These samples were analyzed at the EPA Region 8 laboratory in Denver according to the methods outlined in the EPA Chemical Methods Manual (EPA, 1983). Priority pollutant organics analyses were less than detection limits and were not reported. The results of the EPA lab ICAP metal analyses are reported in Table 1, Appendix.

In addition to the above samples, an automatic sampler was installed in the outside Clark Fork River water tank. Aliquots were taken every four hours from the same depth and location as the intake lines from the diluters. These samples were acidified and, at the end of 24 hours, filtered through a 0.45 millimicron membrane filter (EPA, 1985a).

Dissolved oxygen readings were taken with a Yellow Springs Instrument (YSI) dissolved oxygen meter, Model 58. Conductivities were measured with a YSI field/laboratory conductance meter, Model 32. An Orion Research Model 201 digital pH meter was used for all pH readings.

TEST DURATION

The green rainbow trout eggs were exposed to the test waters for thirty days. During this time they developed to the eyed stage.

The eyed rainbow trout eggs also were exposed to the test waters for thirty days. During this period the eggs hatched, absorbed the yolk sac, and began swim-up feeding.

The fingerling rainbow trout were exposed to the test waters for thirteen days.

QUALITY ASSURANCE

All direct-reading bioassay laboratory instrumentation and equipment was checked for accuracy prior to departure from Denver. Before each series of

measurements was initiated on site, the instruments were calibrated withstandardized solutions. Each test concentration in the aquaria was run in duplicates, and a control concentration was run at the same time. Samples sent to the contractor contained a duplicate and a blank. When the mobile laboratory was set up on site, each diluter was checked and recalibrated to deliver the specified amount of test and/or dilution water.

SECTION 3

DATA ANALYSIS AND INTERPRETATION

CHEMICAL ANALYSES

Averages, maximums, and minimums are reported for the chemical analyses conducted in the mobile lab during the tests. All tables of chemical data have been placed in the Appendix. Tables 2-6, Appendix list the five-day averages for the right diluter system during the 30-day test. Tables 7-11, Appendix list five-day averages for the left diluter system during the 30-day tests. Both sets of tables reflect the chemistries of the total 30-day eyed egg test. Combined data from both diluters have been summarized in Table 12, Appendix as 30-day average, maximum and minimum values per test concentration for the total test.

Average temperatures in the test aquaria ranged from 10.2C in the controls to 10.5C in the 100 percent concentrations. The maximum test temperature was 11.8C and the minimum temperature was 9.1C (Table 12, Appendix).

The average pH for the controls was 8.28. As the concentration of Clark Fork River water increased, pH decreased to an average of 7.99 in 100 percent Clark Fork River water. The maximum pH was 8.45, and the minimum pH was 7.63 (Table 12, Appendix).

Values for both conductivity and alkalinity were also higher in the controls and decreased in value as the percentage of Clark Fork River water increased (Table 12, Appendix).

Thirty-day average dissolved oxygen (D.O.) concentrations ranged from 8.2 to 8.3 parts per million (ppm) with a maximum concentration of 10.2 ppm and a minimum concentration of 6.1 ppm (Table 12, Appendix). A comparison of five-day averages in Tables 4, Appendix (right diluter) and 9 Appendix (left diluter) revealed a reduction in D.O. concentration in aquaria with the right diluter system. This difference resulted from the introduction of fingerlings on May 24 to the aquaria with the right diluter even though air was added to all aquaria to keep the D.O. from dropping below 60 percent saturation. Table 13, Appendix lists the average, maximum, and minimum concentrations for temperature, pH, conductivity, alkalinity and D.O. in the fingerling test. These values have been averaged for the 13 days that the fingerlings were tested.

Average, maximum, and minimum values are also listed in Table 14, Appendix for the green egg test. Green eggs were placed in aquaria associated with the left diluter system. Temperature, pH, conductivity and alkalinity all followed the trends evidenced in Table 12. D.O. was slightly higher with the minimum D.O. recorded being 6.5 ppm compared to 6.1 ppm in the right aquaria 100 percent concentration (Table 4, Appendix).

The hardness and metals analyses conducted by Multitech on daily samples from the test aquaria are listed in Tables 15-21, Appendix. Five-day average hardness values are listed in Tables 15 and 16, Appendix. In general, hardness follows a similar pattern to pH, conductivity, and alkalinity. Larger values are found in the control (Taylor Creek), and the values gradually decrease as Clark Fork River water increases in the test aquaria.

Five-day averages for total copper and total zinc are presented in Tables 17-18 and 19-20 Appendix respectively. Dissolved metals are not included since most of the reported values are less than the detection limits of the instrumentation used in the analyses. Thirty-day average, maximum and minimum values for hardness and total copper and zinc are listed in Table 21, Appendix.

During a pre-study meeting with EPA and Montana State personnel, the decision was made, based on previous analyses of high-flow water, that metal concentrations would be high enough to permit the use of ICP emission spectroscopy.

In the past, spring runoff in the upper river basin added metals to the Clark Fork from these sources: the Anaconda ponds, Warm Springs Creek and the Mill-Willow bypass. Untreated high water flows from Silver Bow Creek also were allowed to cut through a temporary dam at the upper end of the ponds and flow into the Mill-Willow bypass. Downstream from the Anaconda ponds, high stream flows cut into stream side deposits of tailings and added another load of metals to the upper Clark Fork (Phillips, 1985).

Because of the above events, the study was conducted in May 1985 when the high spring flows and resulting high metals concentrations were expected to occur.

Unfortunately, the snowpack in the surrounding hills was less than normal. The frequency and intensity of spring rains also was less than expected, and high sustained flows from the Silver Bow Creek basin did not occur.

Provisional flow data from a U.S. Geological Survey gauging station on the Clark Fork River at Deer Lodge, Montana, about 1/4 kilometer (0.4 miles) downstream from the study site, are listed for the May 7 to June 6, 1985 study period (Table 22, Appendix). A comparison of flow data for the May 7 to June 6 period in 1984 to the same period in 1985 shows a decrease in flows during the 1985 study (Figure 2).

A temporary staff gauge was set at the pump location for the Clark Fork River water. Readings from the gauge were used to indicate fluctuations in river level during the study. At the beginning of the test (May 7) the gauge reading for river level was 15.2 centimeters (cm) or six inches. For the following 17 days the general trend was a decrease in water level down to 1.27 cm (1/2 inch) below the gauge on May 23. Minor rain events occurred on May 26 and 30 but were not enough to breach the dam at the Anaconda ponds. During the study the only significant rain event occurred on June 1-2. Sufficient rainfall occurred to raise the Clark Fork to 19.1 cm (7 1/2 inches) on the gauge for a brief 2-3 hour period. Water flow in Silver Bow Creek was high enough to remove the temporary dam upstream from the Anaconda ponds and spill

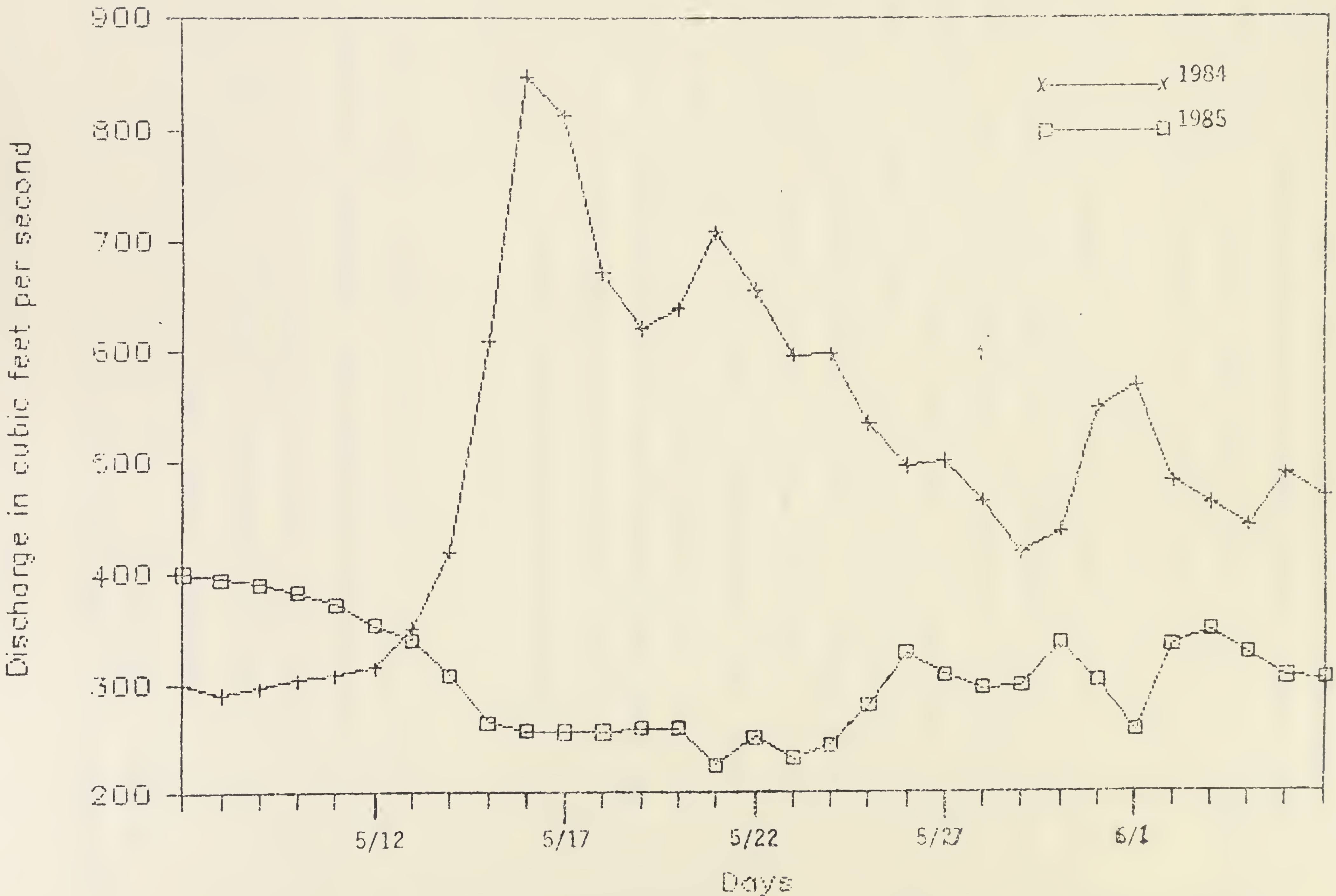

Figure 2. A Comparison of Clark Fork River water flows from May 7-June 6, 1984 to the same period of time in 1985.

untreated water into the Mill-Willow bypass. By the next morning, June 3, the Clark Fork had decreased to 14.0 cm (5 1/2 inches) on the gauge. An inspection of the dam area revealed a small amount of water flowing into the diversion canal. By June 4, water was no longer flowing into the bypass, and the Clark Fork had dropped to 11.4 cm (4 1/2 inches) on the gauge

Since the expected water flows and resulting high metals did not occur during a majority of the study period, water samples shipped to Multitech were lower in copper and zinc than expected. According to Mr. Huddleston, Environmental Services Manager - Multitech, in a letter dated July 30, 1985, "most of the samples were near or below the Silver Bow Creek Remedial Investigation recommended detection limits . . .". "Since the MDL is in effect, the 99% confidence interval for low level samples one should be cautious in assigning significance to even relatively large differences in measured analyte levels at concentrations near the MDL". As a result of the problems with the unexpectedly low metals concentrations which were near the MDL of the analytical method, copper and zinc data from the test aquaria have been included in the report, but have been used with caution in the interpretation.

Water samples, collected every four hours by automatic sampler, were sent to the EPA lab for analysis. These samples were collected from the outside large tank containing continually cycling Clark Fork River water. Analysis of these samples gave an indication of the levels of acid soluble copper and zinc that were available in the river water before it was pumped into the lab diluter system. Table 23, Appendix lists the daily average, maximum and minimum for both copper and zinc as acid soluble metal. Acid soluble metal is

listed in the "Ambient Water Quality Criteria for Copper (EPA, 1985a) as the best measurement of copper for determining aquatic life criteria. The acid-soluble method measures all forms of copper that are toxic to aquatic life or can be readily converted to toxic forms under natural conditions.

Average acid soluble copper values for each day ranged from 0.010 milligrams per liter (mg/l) on the 15th of May to 0.078 mg/l on June 3, 1985. Average acid soluble zinc ranged from 0.010 mg/l to 0.090 mg/l on the same dates (Table 23, Appendix). Figures 3 and 4 show the daily fluctuations in copper and zinc respectively. Peaks on the graphs near May 27, 30, and June 3 reflect rain events on May 26, 30 and June 1-2. The peak on May 13 was not associated with any increase in water level and remains unexplained.

BIOASSAY TESTS

Results of the flow-through bioassay tests were not conclusive. The green-egg test, which was included per the recommendations of ASTM (1985) showed no observable effects of metals in the Clark Fork River on the eggs when percent mortality in the test concentrations is compared to the controls (Table 1). The first 10 days of the test also coincided with a green-egg test recommended by Birge and Black (1982) to test the effect of metals on a critical initial development stage of the egg. Since only one mortality occurred in the 100 percent concentration during the first 10 days, any metals present in the Clark Fork had no observable effect on the eggs during the recommended test period.

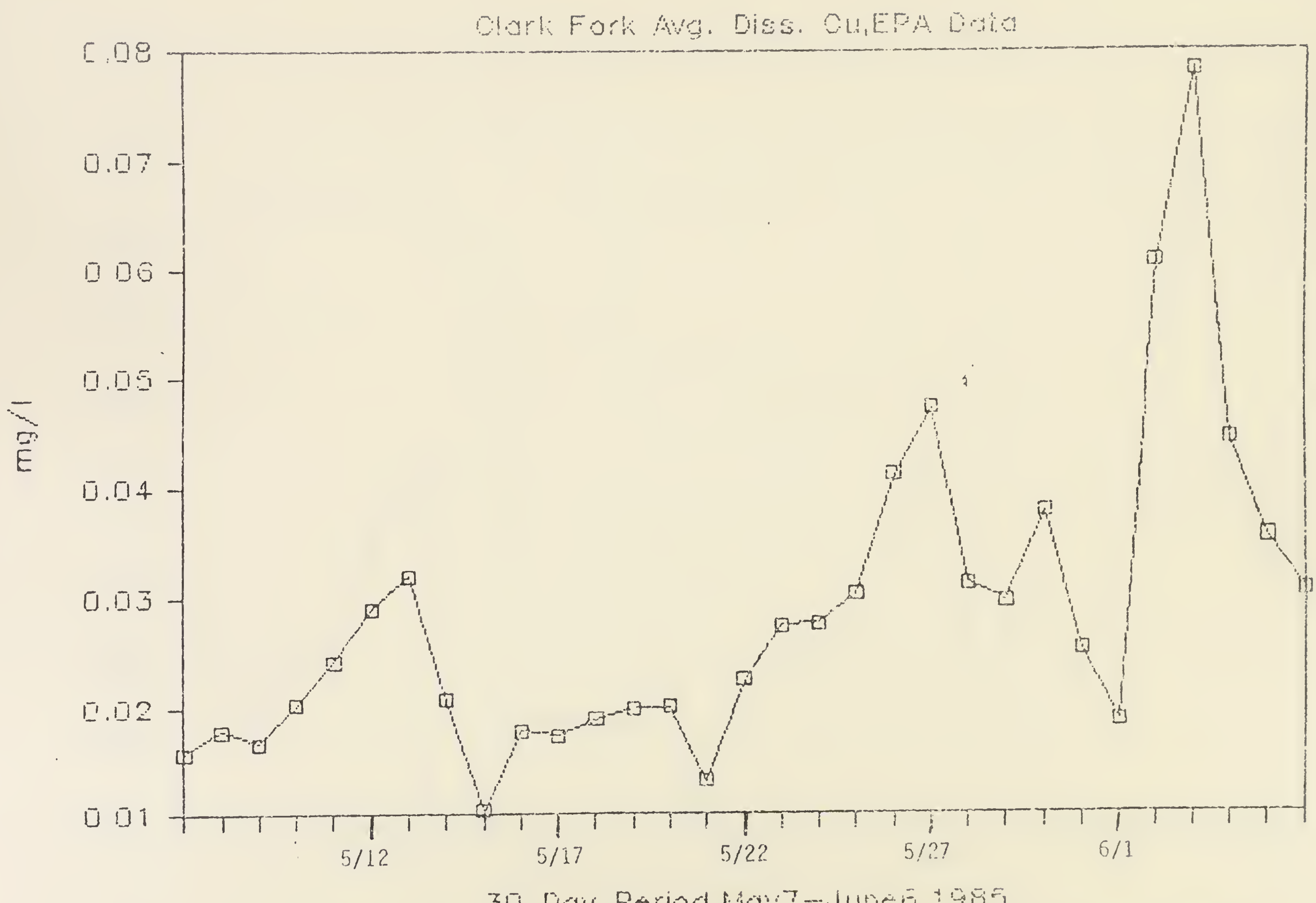

Figure 3. Average daily acid soluble copper concentrations collected by automatic sampler and analyzed by the EPA Region 8 lab.

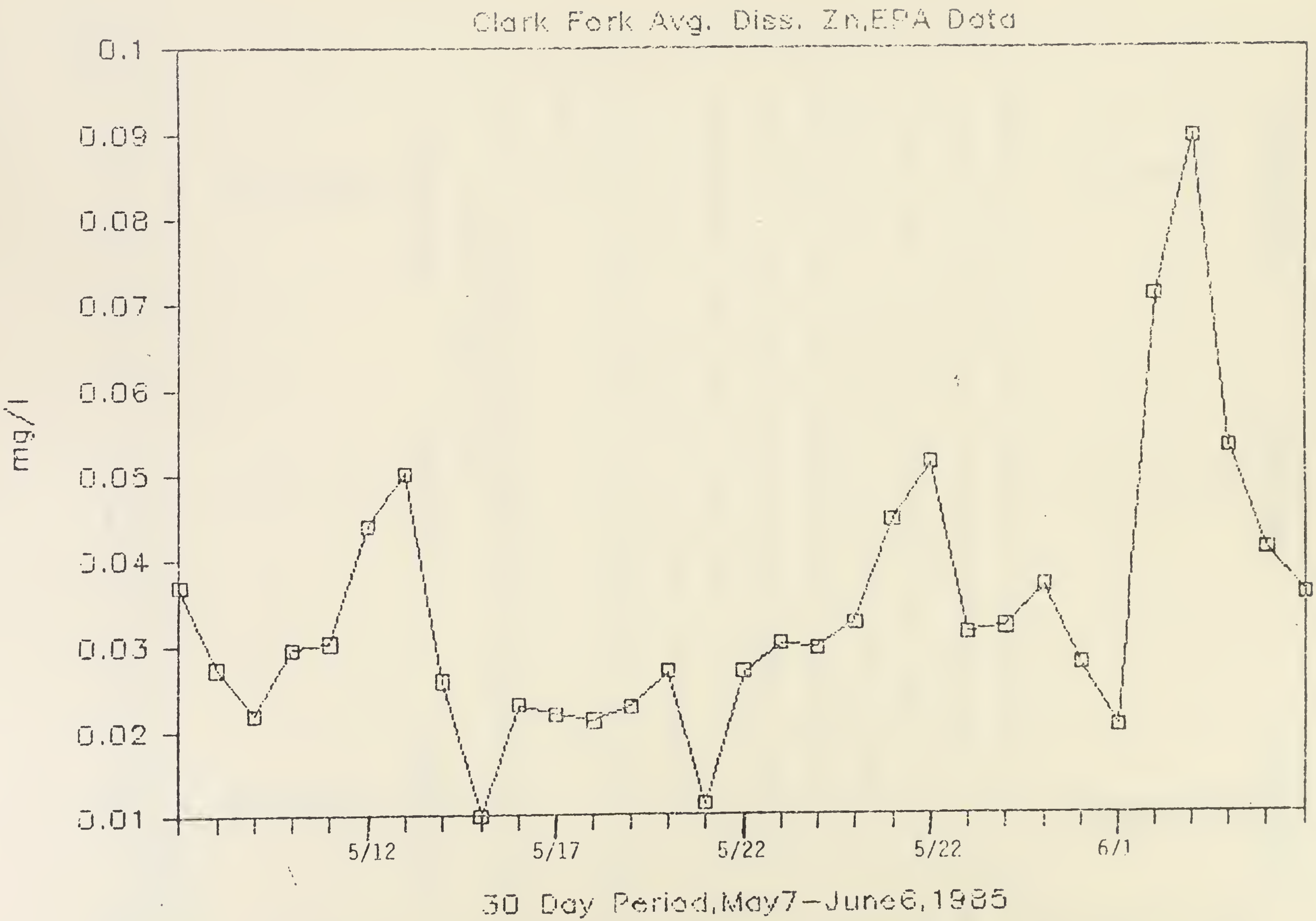

Figure 4. Average daily acid soluble zinc concentrations collected by automatic sampler and analyzed by the EPA Region 8 lab.

Table 1. Test Results for the 30-Day Rainbow Trout Green Egg Test

Concentration	Mortalities	% Mortalities
0	11	11%
10	8	8%
18	5	5%
32	5	5%
56	4	4%
75	6	6%
100	10	10%

A fingerling trout test was included at the recommendation of Mr. Patrick Davies, (Personal Communication, Patrick Davies Colorado Game, Fish and Parks, April 1985), who found fingerlings to be sensitive to copper at certain stages of their development. The fingerling trout test was inconclusive, with 7 percent mortality in the control compared to 20 percent mortality in 100 percent (Table 2). The increased mortalities may indicate a sensitivity to the increased metals in the Clark Fork River after rain events on May 26, 30, and June 1-2 (Figure 3). Fingerlings were inactive for about 12 hours following the rain event on June 1-2, but resumed active swimming and feeding the following day.

Table 2. Test Results for the 13-Day Fingerling Rainbow Trout Test (May 24 - June 6, 1985)

Concentration	Mortalities	% Mortalities
0	2	7%
10	1	5%
18	2	10%
32	1	5%
56	0	0%
75	3	15%
100	4	20%

Table 3 shows the results of the 30-day eyed egg test. Percent mortality did not exceed 14.5 percent in 100 percent Clark Fork River water, compared to 5.5 percent in Taylor Creek water. Percent hatching ranged from 98.5 to 100 percent. Percent abnormalities were extremely low, ranging from 0.5 to 1.5 percent.

Table 3. Test Results for the 30-Day Rainbow Trout Eyed Egg Test

Conc.	Mortalities	% Mortalities	% Hatch	% Abnormalities
0	11	5.5%	99.5	0.5
10	10	5%	98.5	0.5
18	12	6%	98.0	0.5
32	9	4.5%	99.0	0.0
56	13	6.5%	100.0	1.5
75	9	4.5%	100.0	0.0
100	29	14.5%	98.5	0.5

Even though mortalities were low, the percent mortality in 100 percent was almost three times the mortality in the controls. The increased mortality in Clark Fork River water indicates a possible response to metals toxicity that was not noted in lower test concentrations. Concentrations other than 100 percent Clark Fork River water may have been affected by the addition of Taylor Creek water, which would dilute the metals in the river water and increase the hardness levels. An increase in hardness would also reduce metals toxicity.

Table 4 lists chronic and acute values of copper calculated according to the recommendations in Ambient Water Quality Criteria for Copper (EPA, 1985a). Formulas for the calculations are shown in Appendix B. The calculated values are from the 100 percent concentrations of the right diluter. Both the right and left diluters used the same water sources, and hardness values are similar. Calculated values are compared to actual values of total copper as measured by Multitech, and to actual values of acid soluble copper measured by EPA. The report "Ambient Water Quality Criteria for Copper" (EPA, 1986a) notes that there is no ideal method for expressing aquatic life criteria for copper. In the past, criteria were expressed as total recoverable copper. However, the "Methods for Chemical Analysis of Water and Wastes" (EPA, 1983) requires the reporting of analyses for total and total recoverable copper as "total" copper. Both analytical techniques for

total and total recoverable copper produce essentially the same value (Personal Communication, Mr. Steve Callio, Inorganic Chemist, EPA Region 6, May 7, 1986). The measurement of total or total recoverable copper may be too rigorous in some cases and may indicate that more copper is available to aquatic organisms than actually would be available in natural situations. The analysis of acid soluble copper in water should measure all forms of copper that are toxic to aquatic life (EPA, 1986a). For this reason, updated copper criteria have been expressed as acid soluble copper. However, since the acid-soluble method has not been officially approved, the criteria may also be applied to total or total recoverable copper. The criteria recommend that calculated chronic values should not be exceeded by a four-day average concentration more than once every three years. Acute values should also not be exceeded by a one-hour average concentration more than once every three years. For purposes of general comparison, copper values have been calculated using five-day average hardness values and compared to five-day average maximum total and acid soluble copper values.

Table 4. Calculated Chronic and Acute Levels of Copper Compared to Multitech and EPA Data

	Calculated				Actual			
	Chronic		Acute		Total Cu		Acid Soluble Cu	
Date	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.
5/8-12	0.020	0.022	0.032	0.034	0.027	0.031	0.022	0.030
5/13-17	0.021	0.022	0.033	0.035	0.018	0.021	0.033	0.034
5/18-22	0.019	0.020	0.030	0.031	0.012	0.019	0.019	0.020
5/23-27	0.018	0.020	0.029	0.031	0.025	0.070	0.035	0.050
5/28-6/1	0.021	0.021	0.033	0.033	0.028	0.042	0.029	0.187
6/2-6	0.019	0.021	0.029	0.034	0.052	0.118	0.050	0.090

A comparison of chronic and acute average and maximum criteria values to the actual values in the aquaria 100 percent concentration (Multitech) reveal that significant increases in average copper concentrations over the recommended criteria occurred only during the last five-day period of the test, 0.052 mg/l compared to 0.029 mg/l respectively (Table 4). Maximum copper values exceeded maximum copper concentrations at the recommended safe levels for acute criteria by approximately 1.4 to 3.5 times during the last 15 day period of the test.

An inspection of copper values in the samples from the outside large tank containing Clark Fork River water reflect similar increases. Average acid soluble copper during the last five days reflects a significant increase in copper above recommended safe levels. Maximum values ranged from 0.050 up to 0.187 during the last fifteen days of the tests (Table 4). An inspection of Table 23 (Appendix) and Figure 3 reveals that three significant peaks in acid soluble copper occurred in the last fifteen days of the test. The copper concentrations did not remain at elevated levels long enough to produce a significant mortality. If normal spring runoff with its higher metals concentrations had occurred as predicted, mortalities would probably have increased.

When the dam was breached on June 2 and the highest levels of metals flowed passed the lab on June 3 both the fry and fingerlings were noted to be "sluggish" and not as active as usual. All fish were reacting normally by the next day. The reaction of the fish to the increase in metals was not unusual since it has been reported that "rapid excursions to near-lethal levels are more harmful than continuous low-level exposure" (EPA, 1986a).

It should be noted that acid soluble zinc reflected similar increases in concentration levels as copper on May 27 and June 3 (Figure 4). For example, when the dam was breached on June 2, the average amount of acid soluble zinc measured on June 3 was 0.09 mg/l, and the maximum amount measured was 0.157 mg/l (Table 23). Calculated water quality criteria for zinc show an average chronic value for the Clark Fork of 0.058 mg/l and an average acute value of 0.152 mg/l. (Formulas are listed in Appendix B.) Thus, concentrations of zinc in the Clark Fork at the time of the dam removal were not high enough nor sustained long enough to produce a toxic effect. Since zinc and copper have been shown to react synergistically with each other both metals may contribute to toxic problems in the Clark Fork River when spring flows and resulting metal concentrations are higher.

An examination of fry weight from the 30-day eyed egg test, as dry weight, did not reveal any significant differences in mean weights between increasing concentrations of Clark Fork River water (Table 24, Appendix). A student's t test was used to analyze the means and no significant differences were found.

Conclusions and Recommendations

Thirty-day flow-through bioassays using green and eyed rainbow trout eggs and fingerling rainbow trout were not conclusive. Expected high spring runoff with high metals concentrations did not occur in the Clark Fork River during the 30-day study period. Brief rain events flushed copper and zinc into the river system on May 27 and 30 and June 1-2. Metal concentrations in the river following the rain events exceeded calculated chronic and acute copper values for the protection of aquatic organisms, but were not high enough or present

in the river long enough to produce significant mortalities of test organisms.

Mortalities in the green-egg test 100 percent concentration, Clark Fork River, were not significantly different from control (Taylor Creek) mortalities. The 13-day fingerling trout test was also inconclusive, although an increased mortality in the Clark Fork River water compared to Taylor Creek may reflect a reaction of the fingerlings to increased metals concentrations following rain events.

The 30-day eyed egg test reflected a similar sensitivity to metals in the Clark Fork as the fingerling test. Percent hatching and abnormalities did not evidence a toxic effect. Percent mortalities were higher in the Clark Fork River water than in the controls, indicating a possible response to metals toxicity in the river during rain events that exceeded calculated chronic and acute levels predicted to protect aquatic life. If normal spring runoff with its higher metals concentrations had occurred, higher mortalities may have occurred during the test.

It is recommended that a modified series of tests be conducted during a "normal" water year when sufficient snowpack is present to produce a higher runoff than that in 1985. The green-egg test should be either shortened to 10-15 days or not conducted since the embryos appear to be relatively unaffected by changes in metal concentrations after the initial critical period suggested by Birge and Black (1982).

Trout larvae should be tested from post-hatching to 30 days or, if time is restricted, post-swim-up to 15 days with an emphasis on lethality and/or growth effects.

Literature Cited

1. ASTM, 1985. Proposed New Standard Guide For Conducting Fish Early Life-Stage Toxicity Tests. Draft. American Society for Testing and Materials. November 1985.

2. Birge, Wesley J. and Jeffrey A. Black, 1981. In Situ Acute/Chronic Toxicological Monitoring of Industrial Effluents for the NPDES Biomonitoring Program Using Fish and Amphibian Embryo-Larval Stages As Test Organisms. OWEP-82-001 USEPA Office of Water Enforcement and Permits, Wash. D.C. 121 pp.

3. EPA, 1972. A Water Quality Study of the Upper Clark Fork River and Selected Tributaries. EPA Region VIII, Dener, Colorado 1972.

4. EPA, 1983. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020. Revised March 1983. EMSL, Office of Research and Development. Cincinnati, Ohio

5. EPA, 1985a. Ambient Water Quality Criteria for Copper - 1985. EPA-440/5-84-031. Office of Water Regulations and Standards, Criteria and Standards Division, Washington, D.C. 142pp.

6. EPA, 1985b Ambient Aquatic Life Water Quality Criteria for Zinc. Draft. Office of Research and Development, Environmental Research Laboratories, Diluth, Minn.

7. Memo From Mr. Donald G. Willems, Acting Director, Division of Environmental Sanitation, Montana State Dept. of Health, July 8, 1971.

8. Peltier, William H. and Cornelius I. Weber (eds.) 1985. Method for Measuring the Acute Toxicity of Effluents to Freshwater and Marine Organisms. 3rd ed. EPA/600/4-85/013. Office of Research and Develoment, Environmental Monitoring and Support Laboratory, U.S. EPA. Cincinnati, Ohio. 216pp.

9. Peterman, Larry 1985. "The Clark Fork Legacy". Montana Outdoors, March/April 1985. p28-32.

10. Phillips, Glen R. 1985. Relationships Among Fish Populations, Metals Concentrations and Stream Discharge in the Upper Clark Fork River. Draft Report. Department of Fish, Wildlife and Parks, Helena, Montana. April 1985. 23pp.

Appendix A

TABULAR MATERIAL

Table 1. Analyses of Grab Samples of WaterCollected from the Clark Fork River During the 30-Day Bioassay

Date	5/8/85		5/22/85		5/31/85		6/6/85		6/2/85		6/3/85
Time									1845	2225	0315
Parameter[1]	CFR[2]	TC[3]	CFR	TC	CFR	TC	CFR	TC	CFR	CFR	CFR
Silver	5	5	5	5	5	5	5	5	5	5	5
Aluminum	315	358	266	335	282	164	129	278	2240	2100	1740
Arsenic	17	7	16	7	16	8	19	8	32	43	44
Barium	29	74	34	75	35	78	32	79	49	63	56
Beryllium	10	10	10	10	10	10	10	10	10	10	10
Cadmium	5	5	5	5	5	5	5	5	5	5	5
Cobalt	5	5	5	5	5	5	5	5	5	5	5
Chromium	5	5	5	5	5	5	5	5	5	5	5
Copper	35	5	33	5	35	5	30	5	177	205	215
Iron	470	354	431	310	479	154	243	250	2100	3610	2990
Manganese	156	48	125	57	119	31	72	37	654	555	465
Molybdenum	10	10	10	10	10	10	10	10	10	14	11
Nickle	30	30	30	30	30	30	30	30	30	30	30
Lead	30	30	30	30	30	30	30	30	32	37	54
Antimony	5	5	5	5	5	5	5	5	5	5	5
Selenium	5	5	5	5	5	5	5	5	5	5	5
Vanadium	10	10	10	10	10	10	10	10	10	10	10
Zinc	43	5	39	5	43	5	33	5	224	215	231
Thallium	100	100	100	100	100	100	100	100	100	100	100
Calcium (mg/l)	54.6	72.1	53.9	73.8	61.1	79.3	61.1	78.9	61.9	60.5	58.8
Manganese (mg/l)	11.9	13.5	11.5	13.5	14.1	14.6	13.5	14.1	15.0	13.8	133.0
Sodium (mg/l)	12.2	21.1	12.8	22.3	17.8	24.5	17.1	24.1	17.0	16.3	16.7

1 Parameter as ug/l unless designated otherwise.
2 Clark Fork River
3 Taylor Creek

Table 2. Five-Day Average, Maximum and Minimum Temperatures (C) per Test Concentration, for the Right Diluter System, May 8-June 6, 1985

Date	Rt	Temp avg	Max	Min
5/8-12/85	100	10.3	10.6	9.9
	75	10.1	10.7	9.8
	56	10.0	10.4	9.6
	32	9.8	10.5	9.3
	18	9.9	10.3	9.2
	10	9.8	10.4	9.1
	0	9.7	10.5	9.1
5/13-17/85	100	11.6	11.7	11.5
	75	11.4	11.5	11.3
	56	11.3	11.5	11.2
	32	11.1	11.2	11.0
	18	11.2	11.5	10.8
	10	11.1	11.3	10.6
	0	10.9	11.2	10.8
5/18-22/85	100	11.4	11.7	11.2
	75	11.2	11.6	11.0
	56	11.4	11.8	11.2
	32	11.0	11.4	10.8
	18	11.2	11.6	10.9
	10	11.2	11.6	10.8
	0	10.9	11.3	10.7
5/23-27/85	100	10.3	11.1	9.3
	75	10.3	11.1	9.4
	56	10.4	11.3	9.4
	32	10.5	11.4	9.5
	18	10.5	11.6	9.4
	10	10.5	11.5	9.4
	0	10.4	11.3	9.5
5/28-6/1/85	100	9.5	10.0	8.9
	75	9.5	9.9	8.9
	56	9.5	9.9	8.8
	32	9.5	10.0	8.8
	18	9.4	9.9	8.7
	10	9.5	10.0	8.8
	0	9.4	9.8	8.8
6/2-6/85	100	10.0	10.1	9.8
	75	9.9	10.1	9.7
	56	10.0	10.2	9.7
	32	10.0	10.3	9.8
	18	10.0	10.3	9.8
	10	10.1	10.4	9.8
	0	10.0	10.1	9.8

Table 3. Five-Day Average, Maximum and Minimum Conductivities per Test Concentration, for the Right Diluter System, May 8-June 6, 1985

5/8-12/85

Rt	Cond avg	Max	Min
100	425	445	408
75	450	466	437
56	470	482	460
32	493	503	477
18	510	517	498
10	518	523	507
0	527	531	516

5/13-17/85

Rt	Cond avg	Max	Min
100	454	463	447
75	471	475	466
56	484	487	480
32	501	503	497
18	511	515	507
10	518	521	516
0	524	528	520

5/18-22/85

Rt	Cond avg	Max	Min
100	415	426	408
75	442	449	436
56	463	469	459
32	488	492	483
18	504	507	499
10	514	518	508
0	524	528	519

5/23-27/85

Rt	Cond avg	Max	Min
100	385	391	373
75	425	432	415
56	455	465	447
32	491	500	485
18	512	521	506
10	525	534	517
0	538	548	528

5/28-6/1/85

Rt	Cond avg	Max	Min
100	449	475	412
75	474	496	444
56	495	513	472
32	519	533	503
18	534	544	521
10	542	551	533
0	551	557	545

6/2-6/85

Rt	Cond avg	Max	Min
100	462	474	453
75	485	494	478
56	503	510	499
32	525	529	521
18	537	540	533
10	545	548	540
0	553	556	547

Table 4. Five-Day Average, Maximum and Minimum Dissolved Oxygen Concentrations in mg/l, for the Right Diluter System, May 8-June 6, 1985

	Rt	DO avg	Max	Min
5/8-12/85	100	9.0	9.7	8.4
	75	8.9	9.5	8.5
	56	9.0	9.6	8.6
	32	9.1	9.9	8.6
	18	9.0	9.7	8.6
	10	8.9	9.7	8.4
	0	8.9	9.7	8.5
5/13-17/85	Rt	DO avg	Max	Min
	100	8.9	9.2	8.7
	75	9.0	9.3	8.8
	56	9.1	9.3	9.0
	32	9.1	9.5	8.9
	18	9.2	9.6	8.8
	10	9.1	9.5	8.9
	0	9.2	9.7	8.9
5/18-22/85	Rt	DO avg	Max	Min
	100	8.4	8.6	7.9
	75	8.4	8.6	8.2
	56	8.5	8.7	8.2
	32	8.5	8.7	8.3
	18	8.6	8.9	8.4
	10	8.5	8.8	8.3
	0	8.5	8.8	8.4
5/23-27/85	Rt	DO avg	Max	Min
	100	7.6	8.3	6.7
	75	7.7	8.4	6.7
	56	7.5	8.1	6.5
	32	7.8	8.3	7.0
	18	7.6	8.2	6.8
	10	7.7	8.4	6.8
	0	8.1	9.2	7.3
5/28-6/1/85	Rt	DO avg	Max	Min
	100	7.5	8.2	6.8
	75	7.5	8.1	7.2
	56	7.4	8.1	6.8
	32	7.7	8.2	7.4
	18	7.6	8.3	7.3
	10	7.5	8.3	7.2
	0	7.9	8.9	7.1
6/2-6/85	Rt	DO avg	Max	Min
	100	6.3	7.1	5.8
	75	6.7	7.1	6.3
	56	6.6	7.1	6.1
	32	6.6	7.1	6.2
	18	6.6	7.1	6.1
	10	6.4	7.0	5.9
	0	7.0	7.9	6.2

Table 5. Five-Day Average, Maximun and Minimum pH's per Test Concentration for the Right Diluter System, May 8-June 6, 1985

	Rt	pH avg	Max	Min
5/8-12/85	100	8.22	8.35	8.10
	75	8.23	8.30	8.15
	56	8.26	8.30	8.18
	32	8.31	8.35	8.20
	18	8.26	8.38	7.95
	10	8.29	8.45	7.95
	0	8.33	8.40	8.25
5/13-17/85	Rt	pH avg	Max	Min
	100	8.13	8.30	7.83
	75	8.13	8.28	7.88
	56	8.19	8.35	7.95
	32	8.26	8.38	8.05
	18	8.29	8.40	8.10
	10	8.30	8.40	8.10
	0	8.31	8.43	8.10
5/18-22/85	Rt	pH avg	Max	Min
	100	8.05	8.10	8.00
	75	8.16	8.18	8.08
	56	8.26	8.28	8.23
	32	8.34	8.35	8.30
	18	8.37	8.40	8.35
	10	8.38	8.40	8.35
	0	8.39	8.45	8.35
5/23-27/85	Rt	pH avg	Max	Min
	100	7.89	7.98	7.75
	75	8.00	8.15	7.90
	56	8.04	8.25	7.93
	32	8.11	8.35	7.95
	18	8.18	8.35	8.00
	10	8.21	8.40	8.00
	0	8.25	8.40	8.00
5/28-6/1/85	Rt	pH avg	Max	Min
	100	7.92	7.95	7.88
	75	7.95	7.95	7.95
	56	8.05	8.10	8.03
	32	8.16	8.20	8.13
	18	8.20	8.25	8.15
	10	8.24	8.25	8.20
	0	8.27	8.35	8.20
6/2-6/85	Rt	pH avg	Max	Min
	100	7.79	7.90	7.70
	75	7.87	7.90	7.85
	56	7.94	8.00	7.85
	32	8.07	8.15	7.95
	18	8.13	8.18	8.05
	10	8.18	8.25	8.05
	0	8.20	8.30	8.10

Table 6. Five-Day Average, Maximum and Minimum Alkalinities, as mg/l $CaCO_3$, for the Right Diluter System, May 8-June 6, 1985

Period	Rt	Alk avg	Max	Min
5/8-12/85	100	109	114	104
	75	134	140	130
	56	153	158	144
	32	174	180	162
	18	195	198	188
	10	204	206	200
	0	214	218	206
5/13-17/85	100	115	116	112
	75	136	138	134
	56	156	160	152
	32	178	180	176
	18	193	196	192
	10	204	206	202
	0	208	212	206
5/18-22/85	100	107	110	102
	75	131	134	126
	56	152	156	144
	32	176	178	176
	18	191	194	188
	10	201	206	198
	0	210	212	206
5/23-27/85	100	104	106	102
	75	126	134	110
	56	150	158	132
	32	178	182	174
	18	192	198	188
	10	203	208	200
	0	212	218	206
5/28-6/1/85	100	117	124	110
	75	144	158	136
	56	162	166	156
	32	186	190	180
	18	199	204	194
	10	208	212	204
	0	217	220	214
6/2-6/85	100	117	120	112
	75	142	144	138
	56	162	166	160
	32	186	188	184
	18	200	202	196
	10	211	214	210
	0	220	222	218

Table 7. Five-Day Average, Maximum and Minimum Temperatures (C) per Test Concentration, for the Left Diluter System, May 8-June 6, 1985

Date	Lt	Temp avg	Max	Min
5/8-12/85	100	10.3	10.6	10.2
	75	10.2	10.5	9.9
	56	10.0	10.6	9.6
	32	9.9	10.4	9.4
	18	9.7	10.6	9.1
	10	9.7	10.4	9.1
	0	9.8	10.4	9.2
5/13-17/85	100	11.5	11.7	11.3
	75	11.4	11.4	11.3
	56	11.2	11.2	11.1
	32	11.1	11.3	10.9
	18	10.9	11.0	10.8
	10	11.0	11.4	10.6
	0	11.0	11.1	10.9
5/18-22/85	100	11.3	11.5	11.1
	75	11.4	11.6	11.1
	56	11.0	11.3	10.8
	32	11.2	11.5	11.0
	18	11.0	11.3	10.7
	10	11.1	11.4	10.7
	0	10.9	11.3	10.4
5/23-27/85	100	10.1	11.0	9.2
	75	10.3	11.1	9.3
	56	10.2	11.0	9.4
	32	10.3	11.2	9.3
	18	10.4	11.6	9.5
	10	10.4	11.5	9.4
	0	10.3	11.2	9.5
5/28-6/1/85	100	9.5	10.0	8.9
	75	9.4	9.8	8.8
	56	9.4	9.9	8.8
	32	9.4	9.8	8.8
	18	9.3	9.7	8.7
	10	9.3	9.7	8.7
	0	9.4	9.8	8.8
6/2-6/85	100	10.0	10.1	9.8
	75	9.9	10.1	9.7
	56	9.8	10.0	9.6
	32	9.9	10.1	9.6
	18	9.8	10.1	9.6
	10	9.9	10.1	9.6
	0	10.0	10.2	9.7

Table 8. Five-Day Average, Maximum and Minimum Conductivities per Test Concentration, for the Left Diluter System, May 8-June 6, 1985

	Lt	Cond avg	Max	Min
5/8-12/85	100	423	444	401
	75	448	464	433
	56	468	480	459
	32	493	500	483
	18	509	515	499
	10	519	525	507
	0	524	531	514
5/13-17/85	Lt	Cond avg	Max	Min
	100	454	464	447
	75	470	477	465
	56	484	488	479
	32	501	502	498
	18	510	513	505
	10	518	521	515
	0	523	527	520
5/18-22/85	Lt	Cond avg	Max	Min
	100	415	426	409
	75	442	450	437
	56	463	469	458
	32	489	494	483
	18	504	508	499
	10	513	517	508
	0	524	528	519
5/23-27/85	Lt	Cond avg	Max	Min
	100	384	390	373
	75	423	431	414
	56	452	460	444
	32	488	494	482
	18	509	515	504
	10	522	528	517
	0	536	546	530
5/28-6/1/85	Lt	Cond avg	Max	Min
	100	446	473	410
	75	471	493	442
	56	490	508	466
	32	514	527	498
	18	528	539	517
	10	536	544	527
	0	551	558	544
6/2-6/85	Lt	Cond avg	Max	Min
	100	458	471	449
	75	480	490	474
	56	497	504	492
	32	517	523	513
	18	530	534	526
	10	537	540	531
	0	552	555	547

Table 9. Five-Day Average, Maximum and Minimum Dissolved Oxygen Concentrations in mg/l, for the Left Diluter System, May 8-June 6, 1985

	Lt	DO avg	Max	Min
5/8-12/85	100	8.9	9.4	8.6
	75	8.8	9.4	8.5
	56	8.8	9.4	8.5
	32	8.9	9.5	8.6
	18	9.0	9.8	8.5
	10	9.0	9.7	8.6
	0	9.0	9.3	8.8
5/13-17/85	100	8.9	9.1	8.9
	75	8.9	9.1	8.9
	56	9.1	9.4	9.0
	32	9.2	9.5	9.0
	18	9.2	9.6	9.1
	10	9.2	9.6	9.0
	0	9.3	9.8	9.1
5/18-22/85	100	8.4	8.6	8.0
	75	8.4	8.5	8.2
	56	8.5	8.7	8.2
	32	8.5	8.8	8.3
	18	8.6	8.8	8.4
	10	8.7	8.8	8.5
	0	8.7	8.9	8.4
5/23-27/85	100	8.5	9.5	7.7
	75	8.5	9.5	7.9
	56	8.6	9.7	8.1
	32	8.7	9.8	8.2
	18	8.8	10.2	8.2
	10	8.8	10.0	8.2
	0	8.6	9.6	7.3
5/28-6/1/85	100	8.2	9.0	7.7
	75	8.6	9.4	8.0
	56	8.6	9.5	8.1
	32	8.7	9.6	8.1
	18	8.8	9.7	8.2
	10	9.0	9.8	8.4
	0	7.6	7.8	7.5
6/2-6/85	100	7.4	7.9	7.2
	75	7.9	8.5	7.7
	56	8.2	8.6	8.0
	32	8.3	8.6	8.1
	18	8.4	8.7	8.2
	10	8.5	8.8	8.3
	0	6.7	7.0	6.5

Table 10. Five-Day Average, Maximum and Minimum pH's per Test Concentration for the Left Diluter System, May 8-June 6, 1985

	Lt	pH avg	Max	Min
5/8-12/85	100	8.09	8.20	8.00
	75	8.12	8.25	8.03
	56	8.17	8.30	8.08
	32	8.24	8.38	8.15
	18	8.27	8.38	8.20
	10	8.31	8.40	8.23
	0	8.18	8.35	8.05
5/13-17/85	Lt	pH avg	Max	Min
	100	8.08	8.25	7.83
	75	8.09	8.25	7.85
	56	8.16	8.30	7.93
	32	8.24	8.35	8.03
	18	8.28	8.40	8.05
	10	8.29	8.40	8.10
	0	8.24	8.40	8.10
5/18-22/85	Lt	pH avg	Max	Min
	100	8.05	8.18	7.98
	75	8.14	8.20	8.05
	56	8.21	8.25	8.15
	32	8.30	8.35	8.23
	18	8.33	8.38	8.28
	10	8.36	8.40	8.30
	0	8.37	8.43	8.30
5/23-27/85	Lt	pH avg	Max	Min
	100	7.88	8.03	7.63
	75	7.97	8.13	7.85
	56	8.08	8.15	7.90
	32	8.20	8.33	7.95
	18	8.23	8.35	7.95
	10	8.29	8.40	8.00
	0	8.30	8.45	8.00
5/28-6/1/85	Lt	pH avg	Max	Min
	100	7.94	8.00	7.85
	75	8.07	8.15	8.00
	56	8.18	8.20	8.15
	32	8.29	8.35	8.25
	18	8.33	8.35	8.30
	10	8.38	8.40	8.35
	0	8.26	8.30	8.20
6/2-6/85	Lt	pH avg	Max	Min
	100	7.86	7.95	7.78
	75	8.06	8.10	8.00
	56	8.16	8.23	8.10
	32	8.27	8.35	8.20
	18	8.33	8.40	8.25
	10	8.37	8.45	8.30
	0	8.20	8.28	8.10

Table 11. Five-Day Average, Maximum and Minimum Alkalinities, as mg/l $CaCO_3$, for the Left Diluter System, May 8-June 6, 1985

Period	Lt	Alk avg	Max	Min
5/8-12/85	100	114	118	108
	75	134	138	130
	56	154	158	148
	32	179	182	176
	18	194	198	188
	10	202	208	196
	0	214	218	206
5/13-17/85	100	115	118	112
	75	138	140	136
	56	156	158	154
	32	178	180	176
	18	192	196	188
	10	202	204	196
	0	208	212	206
5/18-22/85	100	108	110	104
	75	132	134	130
	56	153	164	146
	32	176	178	174
	18	192	196	188
	10	198	200	196
	0	210	212	205
5/23-27/85	100	103	106	100
	75	129	132	124
	56	152	158	150
	32	178	186	172
	18	193	195	188
	10	203	206	202
	0	212	218	206
5/28-6/1/85	100	116	126	106
	75	140	148	132
	56	162	168	154
	32	184	188	180
	18	200	204	196
	10	208	212	202
	0	217	220	214
6/2-6/85	100	115	118	110
	75	139	142	136
	56	161	162	160
	32	185	188	182
	18	198	200	196
	10	209	212	206
	0	220	222	218

Table 12. Thirty-Day Average, Maximum and Minimum Values, per Concentration, for Temperature, pH, Conductivity, Alkalinity and Dissolved Oxygen During the Combined (Left and Right Diluters) Eyed Egg Test

	Temp (C)		
Lt&Rt	30 day avg	Max	Min
100	10.5	11.7	8.9
75	10.4	11.6	8.8
56	10.4	11.8	8.8
32	10.3	11.5	8.8
18	10.3	11.6	8.7
10	10.3	11.6	8.7
0	10.2	11.3	8.8

	pH		
Lt&Rt	30 day avg	Max	Min
100	7.99	8.35	7.63
75	8.07	8.30	7.85
56	8.14	8.35	7.85
32	8.24	8.38	7.95
18	8.27	8.40	7.95
10	8.30	8.45	7.95
0	8.28	8.45	8.00

	Cond		
Lt&Rt	30 day avg	Max	Min
100	432	475	373
75	457	496	414
56	478	513	444
32	502	533	477
18	517	544	498
10	526	551	507
0	537	558	514

	Alk (mg/l $CaCO_3$)		
Lt&Rt	30 day avg	Max	Min
100	112	126	100
75	136	158	110
56	156	168	132
32	180	188	162
18	195	204	188
10	205	214	196
0	213	222	206

	DO (mg/l)		
Lt&Rt	30 day avg	Max	Min
100	8.2	9.7	5.8
75	8.3	9.5	6.3
56	8.3	9.7	6.1
32	8.4	9.9	6.2
18	8.5	10.2	6.1
10	8.5	10.0	5.9
0	8.3	9.8	6.2

Table 13. Average, Maximum and Minimum Values per Concentration for Temperature, pH, Conductivity, Alkalinity and Dissolved Oxygen During the 13 Day Fingerling Trout Test

Rt	Temp avg	Max	Min
100	9.7	10.5	8.9
75	9.7	10.4	8.9
56	9.7	10.5	8.8
32	9.8	10.6	8.8
18	9.8	10.7	8.7
10	9.8	10.7	8.8
0	9.7	10.8	8.8

Rt	pH avg	Max	Min
100	7.87	7.98	7.70
75	7.92	8.10	7.85
56	8.00	8.10	7.85
32	8.11	8.20	7.95
18	8.17	8.25	8.05
10	8.21	8.25	8.05
0	8.24	8.35	8.10

Rt	Cond avg	Max	Min
100	439	475	373
75	467	496	415
56	489	513	447
32	515	533	485
18	531	544	506
10	540	551	520
0	550	557	535

Rt	Alk avg	Max	Min
100	114	124	102
75	139	158	110
56	159	166	132
32	184	190	176
18	198	204	192
10	208	214	202
0	218	222	210

Rt	DO avg	Max	Min
100	7.0	8.3	5.8
75	7.2	8.4	6.3
56	7.1	8.1	6.1
32	7.3	8.3	6.2
18	7.2	8.3	6.1
10	7.1	8.3	5.9
0	7.6	9.2	6.2

Table 14. Thirty-Day Average, Maximum and Minimum Values, per Test Concentration, for Temperature, pH, Conductivity, Alkalinity and Dissolved Oxygen During the Green Egg Test

Lt	Temp (C) 30 day avg	Max	Min
100	10.5	11.7	8.9
75	10.4	11.6	8.8
56	10.3	11.3	8.8
32	10.3	11.5	8.8
18	10.2	11.6	8.7
10	10.2	11.5	8.7
0	10.2	11.3	8.8

Lt	pH 30 day avg	Max	Min
100	7.98	8.25	7.63
75	8.08	8.25	7.85
56	8.16	8.30	7.90
32	8.26	8.38	7.95
18	8.29	8.40	7.95
10	8.33	8.45	8.00
0	8.26	8.45	8.00

Lt	Cond 30 day avg	Max	Min
100	431	473	373
75	456	493	414
56	476	508	444
32	501	527	482
18	515	539	499
10	525	544	507
0	536	558	514

Lt	Alk (mg/l $CaCO_3$) 30 day avg	Max	Min
100	112	126	100
75	135	148	124
56	156	168	146
32	180	188	172
18	195	204	188
10	204	212	196
0	213	222	206

Lt	DO (mg/l) 30 day avg	Max	Min
100	8.4	9.5	7.2
75	8.5	9.5	7.7
56	8.6	9.7	8.0
32	8.7	9.8	8.1
18	8.8	10.2	8.2
10	8.9	10.0	8.2
0	8.3	9.8	6.5

Table 15. Five-Day Average, Maximum and Minimum Hardness Values ($mg/l\ CaCO_3$), per Test Concentration, for the Left Diluter System

	Lt	Hard avg	Max	Min
5/8-12/85	Lt	Hard avg	Max	Min
	100	193	252	168
	75	191	200	182
	56	201	218	192
	32	216	236	210
	18	216	220	210
	10	220	226	212
	0	227	245	218
5/13-17/85	Lt	Hard avg	Max	Min
	100	190	195	184
	75	205	232	197
	56	214	234	205
	32	213	221	209
	18	219	222	216
	10	223	228	218
	0	225	228	222
5/18-22/85	Lt	Hard avg	Max	Min
	100	173	186	165
	75	185	190	180
	56	191	197	182
	32	204	211	190
	18	219	231	207
	10	211	222	182
	0	218	224	212
5/23-27/85	Lt	Hard avg	Max	Min
	100	162	171	153
	75	177	184	168
	56	194	198	192
	32	205	211	203
	18	217	219	213
	10	228	246	221
	0	232	244	221
5/28-6/1/85	Lt	Hard avg	Max	Min
	100	182	196	166
	75	194	204	180
	56	207	214	196
	32	218	221	211
	18	224	229	218
	10	209	247	132
	0	224	241	159
6/2-6/85	Lt	Hard avg	Max	Min
	100	171	200	123
	75	220	272	190
	56	205	228	157
	32	217	230	186
	18	219	237	184
	10	201	237	153
	0	222	242	190

Table 16. Five-Day Average, Maximum and Minimum Hardness Values (mg/l $CaCO_3$), per Test Concentration, for the Right Diluter System

	Rt	Hard avg	Max	Min
5/8-12/85	100	185	201	170
	75	193	201	187
	56	203	216	196
	32	211	220	199
	18	220	233	214
	10	223	239	214
	0	227	245	218
5/13-17/85	100	195	205	187
	75	201	212	193
	56	205	207	204
	32	217	222	215
	18	219	226	212
	10	225	242	209
	0	225	228	222
5/18-22/85	100	175	183	169
	75	185	200	165
	56	194	198	190
	32	209	212	207
	18	216	232	200
	10	217	224	211
	0	218	224	212
5/23-27/85	100	167	182	161
	75	182	190	175
	56	197	203	192
	32	209	215	205
	18	218	223	213
	10	234	267	224
	0	232	244	221
5/28-6/1/85	100	191	196	178
	75	199	210	184
	56	218	258	190
	32	223	226	219
	18	221	237	184
	10	235	247	229
	0	224	241	159
6/2-6/85	100	169	198	117
	75	172	211	120
	56	204	216	171
	32	243	375	175
	18	215	232	163
	10	221	242	168
	0	222	242	190

Table 17. Five-Day Average, Maximum and Minimum Total Copper Values (mg/l), per Test Concentration, for the Left Diluter System

	Lt	T Cu avg	Max	Min
5/8-12/85	100	0.027	0.031	0.020
	75	0.022	0.029	0.016
	56	0.043	0.122	0.014
	32	0.128	0.579	0.011
	18	0.058	0.212	0.009
	10	0.019	0.054	0.007
	0	0.016	0.026	0.006
5/13-17/85	100	0.018	0.021	0.015
	75	0.015	0.017	0.012
	56	0.012	0.025	0.006
	32	0.009	0.013	0.006
	18	0.007	0.012	0.003
	10	0.005	0.007	0.003
	0	0.005	0.009	0.003
5/18-22/85	100	0.012	0.019	0.003
	75	0.012	0.018	0.003
	56	0.013	0.027	0.003
	32	0.007	0.010	0.004
	18	0.007	0.011	0.004
	10	0.004	0.008	0.001
	0	0.004	0.007	0.002
5/23-27/85	100	0.025	0.070	0.005
	75	0.013	0.023	0.004
	56	0.013	0.023	0.004
	32	0.009	0.017	0.004
	18	0.012	0.023	0.004
	10	0.006	0.013	0.004
	0	0.007	0.010	0.004
5/28-6/1/85	100	0.028	0.042	0.019
	75	0.019	0.025	0.013
	56	0.019	0.035	0.012
	32	0.017	0.028	0.008
	18	0.014	0.021	0.010
	10	0.011	0.018	0.005
	0	0.018	0.027	0.004
6/2-6/85	100	0.052	0.118	0.023
	75	0.025	0.036	0.015
	56	0.019	0.038	0.010
	32	0.021	0.031	0.010
	18	0.012	0.020	0.007
	10	0.005	0.011	0.002
	0	0.012	0.025	0.003

Table 18. Five-Day Average, Maximum and Minimum Total Copper Values (mg/l), per Test Concentration, for the Right Diluter System

	Rt	T Cu avg	Max	Min
5/8-12/85	100	0.027	0.034	0.020
	75	0.025	0.036	0.019
	56	0.023	0.035	0.016
	32	0.041	0.119	0.018
	18	0.013	0.017	0.010
	10	0.010	0.016	0.005
	0	0.016	0.026	0.006
5/13-17/85	Rt	T Cu avg	Max	Min
	100	0.019	0.024	0.015
	75	0.022	0.045	0.014
	56	0.012	0.017	0.010
	32	0.010	0.013	0.006
	18	0.006	0.009	0.003
	10	0.006	0.009	0.003
	0	0.005	0.009	0.003
5/18-22/85	Rt	T Cu avg	Max	Min
	100	0.012	0.019	0.003
	75	0.011	0.017	0.003
	56	0.040	0.175	0.003
	32	0.009	0.013	0.004
	18	0.010	0.015	0.003
	10	0.020	0.075	0.002
	0	0.004	0.007	0.002
5/23-27/85	Rt	T Cu avg	Max	Min
	100	0.018	0.029	0.004
	75	0.017	0.031	0.004
	56	0.013	0.019	0.004
	32	0.011	0.014	0.008
	18	0.010	0.016	0.008
	10	0.008	0.010	0.004
	0	0.007	0.010	0.004
5/28-6/1/85	Rt	T Cu avg	Max	Min
	100	0.028	0.033	0.021
	75	0.022	0.028	0.014
	56	0.018	0.024	0.005
	32	0.017	0.021	0.005
	18	0.015	0.023	0.005
	10	0.013	0.021	0.004
	0	0.018	0.027	0.004
6/2-6/85	Rt	T Cu avg	Max	Min
	100	0.032	0.059	0.019
	75	0.033	0.045	0.023
	56	0.022	0.034	0.010
	32	0.014	0.024	0.009
	18	0.015	0.025	0.003
	10	0.015	0.032	0.003
	0	0.012	0.025	0.003

Table 19. Five-Day Average, Maximum and Minimum Total Zinc Values (mg/l), per Test Concentration, for the Left Diluter System

5/8-12-85	Lt	T Zn avg	Max	Min
	100	0.061	0.155	0.024
	75	0.057	0.125	0.024
	56	0.059	0.125	0.017
	32	0.073	0.156	0.015
	18	0.083	0.306	0.010
	10	0.041	0.098	0.010
	0	0.061	0.098	0.007

5/13-17/85	Lt	T Zn avg	Max	Min
	100	0.030	0.040	0.016
	75	0.028	0.033	0.022
	56	0.021	0.027	0.018
	32	0.018	0.022	0.014
	18	0.012	0.015	0.008
	10	0.013	0.022	0.009
	0	0.009	0.010	0.007

5/18-22/85	Lt	T Zn avg	Max	Min
	100	0.022	0.032	0.016
	75	0.017	0.027	0.007
	56	0.029	0.083	0.007
	32	0.013	0.028	0.008
	18	0.010	0.013	0.008
	10	0.008	0.013	0.004
	0	0.006	0.009	0.004

5/23-27/85	Lt	T Zn avg	Max	Min
	100	0.024	0.032	0.014
	75	0.016	0.020	0.014
	56	0.016	0.020	0.013
	32	0.012	0.016	0.007
	18	0.012	0.024	0.006
	10	0.010	0.016	0.006
	0	0.016	0.046	0.004

5/28-6/1/85	Lt	T Zn avg	Max	Min
	100	0.045	0.130	0.021
	75	0.026	0.052	0.018
	56	0.020	0.036	0.015
	32	0.011	0.011	0.010
	18	0.011	0.015	0.010
	10	0.009	0.011	0.006
	0	0.025	0.097	0.004

6/2-6/85	Lt	T Zn avg	Max	Min
	100	0.062	0.153	0.027
	75	0.028	0.040	0.020
	56	0.024	0.032	0.015
	32	0.025	0.046	0.011
	18	0.016	0.024	0.013
	10	0.015	0.033	0.007
	0	0.008	0.010	0.005

Table 20. Five-Day Average, Maximum and Minimum Total Zinc Values (mg/l), per Test Concentration, for the Right Diluter System

	Rt	T Zn avg	Max	Min
5/8-12/85	100	0.110	0.204	0.023
	75	0.055	0.082	0.033
	56	0.183	0.688	0.020
	32	0.058	0.101	0.018
	18	0.036	0.048	0.010
	10	0.114	0.337	0.009
	0	0.061	0.098	0.007
5/13-17/85	100	0.034	0.039	0.027
	75	0.036	0.068	0.022
	56	0.021	0.025	0.016
	32	0.019	0.027	0.015
	18	0.013	0.014	0.011
	10	0.009	0.011	0.008
	0	0.009	0.010	0.007
5/18-22/85	100	0.018	0.022	0.012
	75	0.015	0.018	0.013
	56	0.054	0.219	0.007
	32	0.017	0.031	0.011
	18	0.012	0.026	0.007
	10	0.010	0.013	0.006
	0	0.006	0.009	0.004
5/23-27/85	100	0.024	0.029	0.019
	75	0.027	0.046	0.017
	56	0.020	0.031	0.013
	32	0.011	0.016	0.002
	18	0.010	0.013	0.009
	10	0.008	0.010	0.005
	0	0.016	0.046	0.004
5/28-6/1/85	100	0.025	0.028	0.021
	75	0.019	0.020	0.018
	56	0.017	0.025	0.013
	32	0.023	0.068	0.011
	18	0.012	0.023	0.008
	10	0.009	0.011	0.007
	0	0.025	0.097	0.004
6/2-6/85	100	0.033	0.053	0.022
	75	0.032	0.045	0.018
	56	0.057	0.185	0.017
	32	0.016	0.021	0.012
	18	0.011	0.013	0.010
	10	0.011	0.018	0.004
	0	0.008	0.010	0.005

Table 21. Thirty-Day Average, Maximum and Minimum Hardness, and Total Copper and Zinc (mg/l) for the Eyed Egg Test

Lt&Rt	Hardness 30 day avg	30 day Max	30 Day Min
100	179	252	117
75	192	272	120
56	203	258	157
32	216	375	175
18	218	237	163
10	221	267	132
0	225	245	159

Lt&Rt	T Cu 30 day avg	30 day Max	30 day Min
100	0.025	0.118	0.003
75	0.019	0.045	0.003
56	0.021	0.175	0.003
32	0.024	0.579	0.003
18	0.015	0.212	0.003
10	0.010	0.075	0.001
0	0.010	0.027	0.002

Lt&Rt	T Zn 30 day avg	30 day Max	30 Day Min
100	0.041	0.204	0.012
75	0.030	0.125	0.007
56	0.043	0.688	0.007
32	0.024	0.156	0.002
18	0.020	0.305	0.006
10	0.021	0.337	0.004
0	0.021	0.098	0.004

Table 22. Provisional Flow Data from U.S.G.S. Gauging Station on the Clark Fork River at Deer Lodge, Montana, May 7 to June 6, 1985[1]

Date	Flow (C.F.S.)	Date	Flow (C.F.S.)
5/7/85	400	5/23/85	231
5/8/85	395	5/24/85	244
5/9/85	390	5/25/85	279
5/10/85	383	5/26/85	327
5/11/85	372	5/27/85	308
5/12/85	352	5/28/85	295
5/13/85	340	5/29/85	298
5/14/85	308	5/30/85	337
5/15/85	264	5/31/85	302
5/16/85	257	6/1/85	257
5/17/85	256	6/2/85	335
5/18/85	256	6/3/85	348
5/19/85	259	6/4/85	327
5/20/85	259	6/5/85	306
5/21/85	226	6/6/85	305
5/22/85	251		

[1] Data obtained from Mr. Mel White, U.S.G.S. Water Research Division, Hydrologic Analysis and Research Section, Montana on 3/24/86.

Table 23. Daily Average, Maximum and Minimum Acid-Soluble Copper and Zinc Values (mg/l) Collected by Automatic Sampler and Analyzed by the Region 8 Lab

Date	Cu Daily Avg	Cu Daily Max	Cu Daily Min	Zn Daily Avg	Zn Daily Max	Zn Daily Min
5-7	0.016	0.016	0.016	0.037	0.037	0.037
5-8	0.018	0.021	0.015	0.027	0.031	0.023
5-9	0.017	0.019	0.013	0.022	0.026	0.016
5-10	0.020	0.035	0.013	0.030	0.051	0.018
5-11	0.024	0.036	0.014	0.030	0.047	0.012
5-12	0.029	0.038	0.021	0.044	0.055	0.035
5-13	0.032	0.057	0.014	0.050	0.081	0.025
5-14	0.021	0.045	0.005	0.026	0.064	0.000
5-15	0.010	0.020	0.003	0.010	0.025	0.000
5-16	0.018	0.027	0.014	0.023	0.039	0.012
5-17	0.017	0.020	0.015	0.022	0.029	0.015
5-18	0.019	0.023	0.014	0.021	0.028	0.013
5-19	0.020	0.022	0.016	0.023	0.029	0.017
5-20	0.020	0.016	0.016	0.027	0.033	0.021
5-21	0.013	0.016	0.012	0.011	0.017	0.008
5-22	0.023	0.025	0.019	0.027	0.035	0.019
5-23	0.027	0.035	0.021	0.030	0.039	0.022
5-24	0.028	0.029	0.027	0.030	0.032	0.028
5-25	0.030	0.040	0.025	0.033	0.044	0.030
5-26	0.041	0.049	0.034	0.045	0.059	0.032
5-27	0.047	0.099	0.023	0.051	0.115	0.022
5-28	0.031	0.042	0.025	0.031	0.045	0.021
5-29	0.030	0.038	0.022	0.032	0.042	0.017
5-30	0.038	0.072	0.021	0.037	0.063	0.020
5-31	0.025	0.031	0.020	0.028	0.032	0.023
6-1	0.019	0.021	0.017	0.021	0.027	0.017
6-2	0.061	0.152	0.024	0.071	0.163	0.030
6-3	0.078	0.144	0.043	0.090	0.157	0.051
6-4	0.044	0.059	0.027	0.053	0.077	0.030
6-5	0.036	0.061	0.020	0.041	0.067	0.022
6-6	0.031	0.035	0.026	0.036	0.039	0.032

Table 24. Final Mean Dry Weights of Larval Trout in Each Waste Concentration at the Termination of the 30-Day Eyed Egg Test.

Right Diluter

Conc.	Mean Dry Weights (mg)	Standard Deviations
0	16.47	2.84
10	16.94	4.07
18	16.18	3.45
32	16.70	3.59
56	15.80	3.40
75	16.27	2.52
100	16.31	3.38

Left Diluter

Conc.	Mean Dry Weights (mg)	Standard Deviations
0	16.43	2.91
10	16.71	3.39
18	16.80	3.24
32	16.62	3.45
56	17.67	3.40
75	17.02	4.03
100	16.02	3.36

Appendix B

1. Formulas for calculating copper criteria (EPA, 1985a).

Acute - one hour average concentration (in ug/l) not to exceed the numerical value given by $e^{(0.9422\,[\ln(\text{hardness})] - 1.464)}$ more than once every three years on the average.

Chronic - the four-day average concentration (in ug/l) of copper does not exceed the numerical value given by $e^{(0.8545\,[\ln(\text{hardness})] - 1.465)}$ more than once every three years on the average.

2. Formulas for calculating zinc criteria (EPA, 1985b).

Acute - one hour average concentration (in ug/l) does not to exceed the numerical value given by $e^{(0.8213\,[\ln(\text{hardness})] + 0.8141)}$ more than once every three years on the average.

Chronic - the four-day average concentration (in ug/l) of zinc does not exceed the numerical value given by $e^{(0.8213\,[\ln(\text{hardness})] - 0.1541)}$ more than once every three years on the average.