Missouri Department of Natural Resources

Biological Assessment and Fine Sediment Study

Big River (lower):
Irondale to Washington State Park
St. Francois, Washington, and Jefferson Counties, Missouri

2002-2003

Prepared for:

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1.0 Introduction

At the request of the Missouri Department of Natural Resources (**MDNR**) Water Protection Program (**WPP**), the Environmental Services Program (**ESP**) Water Quality Monitoring Section (**WQMS**) conducted a macroinvertebrate bioassessment and fine sediment study of Big River in Washington, St. Francois, and Jefferson Counties.

The Big River (lower) study area included upstream near Irondale, Missouri and extended to Washington State Park, which is approximately 10 miles west of De Soto, Missouri. The study area stretched approximately 50 miles of stream in Washington, St. Francois, and Jefferson Counties. Its length included the stream's passage through Leadwood, Park Hills, Desloge, and Bonne Terre, Missouri.

Big River is a class "P" stream, which maintains permanent flow even during drought conditions. It is considered a General Warm Water Fishery (**GWWF**). Big River's designated beneficial uses are for Livestock and Wildlife Watering (**LWW**), the Protection of Warm Water Aquatic Life and Human Health-Fish Consumption (**AQL**), Whole Body Contact Recreation (**WBC**), and Boating and Canoeing (**BTG**) (MDNR 2000). Fish consumption advisories are common due to high lead levels in fish tissues and prevent uses of aquatic life in portions of Big River (Meneau 1997).

1.1 Justification

In 1998, approximately 90 miles of Big River were listed by the Missouri Clean Water Commission under section 303(d) of the Clean Water Act for excessive fine sediment deposition and high lead concentrations, presumably due to mine tailings runoff. Big River is a major drainage for what was called the "Old Lead Belt", with many lead mines in its watershed. Major lead mines and mills in the area were Leadwood, Flat River, Desloge, and Bonne Terre.

The Leadwood mines and mill began operation in 1894 and continued with little interruption until 1965. The remaining tailings ponds consist of approximately 528 acres of inactive lead mine tailings (Fluor Daniel Environmental Services 1995). Two tailings retaining structures capture drainage in the area. Whether or not they are effective is not known. Runoff from these tailing ponds may influence the aquatic communities on Eaton Branch and subsequently Big River. The Bonne Terre mines ceased operation in the early 1960's. Desloge mines were in operation between 1890 and 1958 (Fluor Daniel Environmental Services 1995). The Flat River complex of mines (Federal, National, and Elvins) was mined and ore milled from around 1890 to 1940. All have left large mine tailings piles that are potential contributors of fine sediment and heavy metals to Big River, which may impair the aquatic community.

Abandoned mines may discreetly impair aquatic communities. Water runoff during rain events is known to erode mine wastes into Big River. Tailings are generally fine sediments (ca. <2.0 mm) and have been found downstream in some portions of Big River. Fine sediments and silt clog the interstitial voids between the larger particles in the substrate and can have destructive effects on invertebrates and fish communities (Chutter 1969; Murphy et al. 1981; Berkman and Rabeni 1987; Smale et al. 1995).

Metals such as copper, iron, lead, and zinc have been detected in aquatic fauna in areas of Big River (Meneau 1997). Lead concentrations in fish tissues have resulted in fish consumption advisories. The metals composition (i.e. character) of the sediment may influence macroinvertebrate communities as well.

Lead is toxic to all phyla of aquatic biota, but its toxic action differs by species and physiological state, and by physical and chemical variables (Eisler 1988). Metals can affect aquatic organisms as toxic substances in water and sediment, or as a toxicant in the food chain (Sorensen 1991; Rainbow 1996). Clements (1991) found a lowered percent composition or elimination of Ephemeroptera and increased abundance of Chironomidae, especially Orthocladiinae and Hydropsychidae (net-spinning caddisflies), downstream from metals impacts in the absence of organic pollution. Besser et al. (1987) stated that aquatic organisms in tributaries of Big River located downstream from tailings piles contained concentrations of lead, cadmium, and other heavy metals.

The character (composition) of fine sediment may also reveal its source. Kramer (1976) and Jenett et al. (1981) reported elevated levels of lead and zinc in Flat River Creek, St. Francois County, a tributary to Big River. Concentrations of lead and zinc were elevated within algae, crayfish, and minnows from lower Flat River Creek. They believed the sources were brought to Flat River Creek via tributaries that drained Elvins and Federal tailing piles. In 2001, the MDNR, ESP, Water Quality Monitoring Section identified Elvins Tailings Pile as a potential source of lead and zinc laden sediment found in Flat River Creek (MDNR 2001).

Barite strip mines dominate the Big River watershed in Washington County downstream of St. Francois State Park. In 1975, failure of a barite settling basin dam resulted in a massive release of tailings, which resulted in impairment of macroinvertebrate and fish communities in Mill Creek and subsequently Big River (Duchrow 1978). It is not known if the barite strip mines continue to deliver fine sediments to the stream substrate.

A biological assessment and fine sediment study was conducted in 2002 on the upper reaches of Big River (Belgrade to Cedar Creek, Washington County), which is upstream of most mining influences (MDNR 2003). It appeared that Big River was relatively unimpaired and is potentially a reference quality stream upstream of Cedar Creek.

The TMDL section of Big River is considered to be a “High” priority for analysis (1998 TMDL). In 2002, a study plan was submitted to MDNR, WPP to conduct a biological assessment and fine sediment study on (lower) Big River (Appendix A). The WQMS was responsible for the proposed biological assessment and fine sediment study on Big River, Washington County. The project began in the fall of 2002 and concluded in the spring of 2003.

It was our intention to determine if the lead mine wastes impaired aquatic communities of Big River in the lower reaches where evidence of past lead mining exists. A biological assessment and fine sediment study was conducted. Comparisons were made between controls (upstream and similar size stream stations) and test stations to determine if mine tailings piles were affecting the aquatic community. A stream habitat assessment was also conducted.

1.2 Purpose

The purpose was to determine if Big River in Washington, St. Francois, and Jefferson counties was impaired by lead mine influences.

1.3 Objectives

1) Determine if the macroinvertebrate community and water quality were affected by mining influences.

2) Determine if fine sediment and heavy metals were present in Big River and determine their origin.

3) Describe habitat quality in the Big River study area.

1.4 Tasks

1) Conduct a biological assessment on Big River, Washington, St. Francois, and Jefferson Counties, a TMDL Section 303(d) listed stream, and Courtois Creek, a similar size class control stream.

2) Conduct a fine sediment assessment and characterization study on Big River.

3) Conduct a habitat assessment on Big River.

1.5 Null Hypotheses

Macroinvertebrate metrics and biological communities will be similar at the Meramec Ecological Drainage Unit (**EDU**) control (upstream and similar size) stations and test stations in Big River.

Water quality is similar between control (upstream and similar-size) stations and test stations.

No significant difference ($p>0.05$) in the sediment percentage estimates or the character of the sediment between controls and test stations.

Habitat quality will be similar between controls and test stations in Big River.

2.0 Methods

The Water Quality Monitoring Section of the Missouri Department of Natural Resources, Air and Land Protection Division, Environmental Services Program conducted this project. Kenneth B. Lister, Steve Humphrey, and the staff of the Water Quality Monitoring Section conducted the study.

2.1 Study Timing

Sampling was conducted during the fall of 2002 and spring of 2003. Fall macroinvertebrate and physicochemical water sampling were conducted on September 24, 25, 26, 2002 and October 1, 2, 3, 8, 9, 2002. Spring macroinvertebrate and physicochemical sampling occurred on April 2, 3, 2003. Fine sediment percentage estimation and characterization of sediments occurred on September 24, 25, 26, 2002 and on October 1, 2, 3, 8, 9, 2002.

2.2 Station Descriptions

Eleven stations were used in this project: nine for upstream to downstream comparisons of Big River, and two stations on Courtois Creek were used for similar size stream to stream comparisons (Table 1; Figure 1). Big River stations were situated to bracket potential mine influences and identify the extent or length of

disturbance, if any were found (Table 1; Figure 2). One station on Big River was considered an upstream control (#9). The remainders were test stations either immediately bracketing potential mine influences (#7, #6, #5, #4) or showing the downstream extent of possible impacts (#3, #2, #1). The last three stations (#3, #2, and #1) also bracketed the Mill Creek and Big River confluence, in order to identify potential influences from barite strip mines found in the Mill Creek watershed. The two remaining stations (Courtois Creek, Cc#2 and Cc#1) were considered similar-size stream control stations.

Table 1
Location and descriptive information for lower Big River and Courtois Creek stations.

Stream-Station Number	Location-Section or Survey, Township, Range	Description	County
Big River #9	SW sec. 15, T. 36 N., R. 3 E.	Upstream Control - Upstream All; Irondale, MO	Washington
Big River #8	NE sec. 3, T. 36 N., R. 4 E.	Test - Downstream Leadwood TP; MDC Leadwood CA	St. Francois
Big River #7	NE Survey 80, T. 37 N., R. 5 E.	Test - Downstream Desloge TP; Upstream Flat River; MO Hwy. 67	St. Francois
Big River #6	W ½ Survey 84, T. 37 N., R. 5 E.	Test - Downstream Flat River Confluence (Complex)	St. Francois
Big River #5	SE Survey 72 and W ½ Survey 2124, T. 37 N., R. 5 E.	Test - Upstream Bonne Terre TP; Hwy. K	St. Francois
Big River #4	NW Survey 2110, T. 38 N., R. 4 E.	Test - Downstream Bonne Terre TP; St. Francois State Park (SP)	St. Francois
Big River #3	SW sec. 17, T. 38 N., R. 4 E.	Test - Upstream Mill Creek; Private/Coles Landing	Jefferson
Big River #2	NE sec. 25, T. 39 N., R. 3 E.; SW sec. 30, T. 39 N., R. 4 E.	Test - Downstream Mill Creek; South of MO Hwy. 21	Jefferson
Big River #1	S ½ and E ½ sec. 23, T. 39 N., R. 3 E.	Test - Downstream All; Washington State Park (SP)	Washington
Courtois Creek #2	C sec. 20, T. 38 N., R. 2 W.	Similar-size Control Stream	Crawford
Courtois Creek #1	C sec. 12, T. 38 N., R. 3 W.	Similar-size Control Stream	Crawford

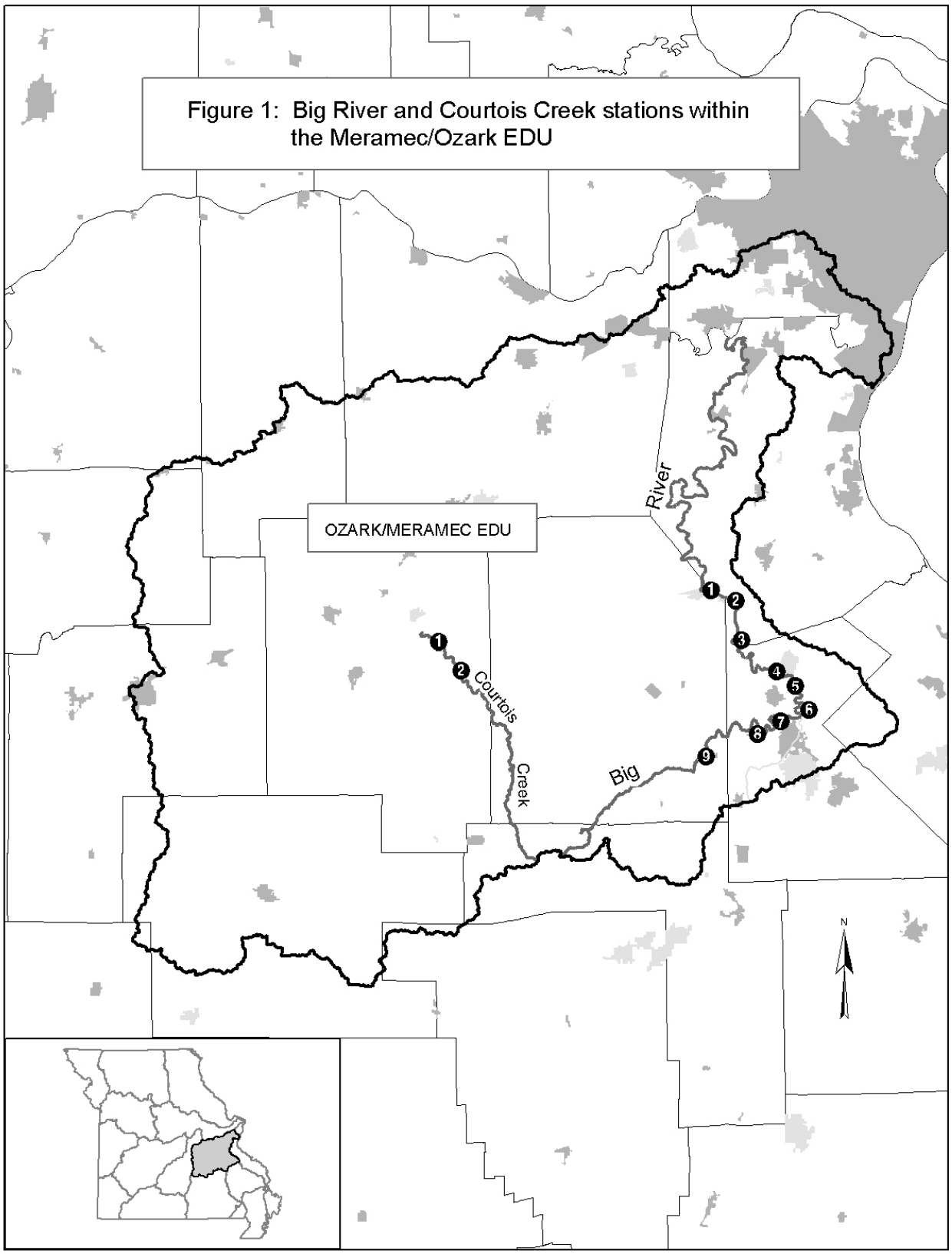

Figure 1: Big River and Courtois Creek stations within the Meramec/Ozark EDU

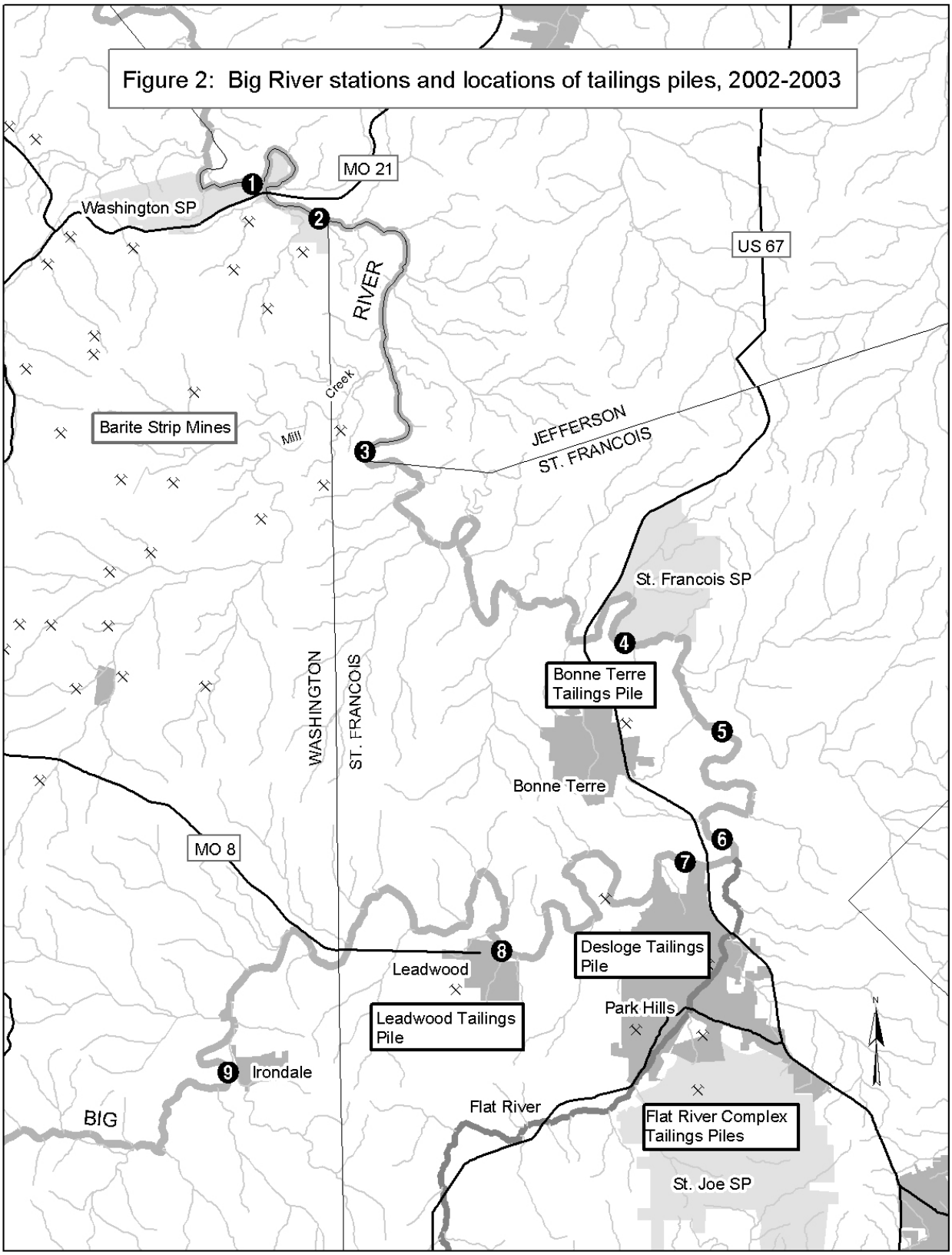

Figure 2: Big River stations and locations of tailings piles, 2002-2003

2.2.1 Ecological Drainage Unit

Big River and Courtois Creek stations are within the same Ecological Drainage Unit (Figure 1). Ecological Drainage Units are delineated drainage units that include all streams and tributaries within a major river basin. Within an EDU, aquatic communities and habitat conditions are expected to be similar between similar-size streams.

2.2.2 Land Use

Land cover throughout the entire Ozark/Meramec EDU was compared to the land cover of each station by its 14-digit Hydrological Unit (**HU**; Table 2). Percent land cover data were derived from Thematic Mapper (TM) satellite data collected between 1991 and 1993 and interpreted by the Missouri Resource Assessment Partnership (MoRAP). The implication of this comparison was that land use within the study area does not interfere with interpretation of the findings; such as comparing streams near cropland and others near forestland.

Forest dominated the land use within the EDU and was similar to the land use of most stations (Table 2). One HU that included stations #8 and #7 was slightly dominated by grassland over forest (47.9% to 44.9%). Stations #8 and #7 were approximately 20 percent higher in grassland than the Ozark/Meramec EDU (28.9%) overall. A large pasture borders station #8 and a cemetery (other urban uses) at station #7. These two stations are also downstream from two large mine tailings piles (#8 at Leadwood and #7 at Desloge), which may have been an influence. Regardless, the difference was slight, so comparisons between stations are appropriate for macroinvertebrate assemblages, physicochemical variables, and fine sediment percentage/characters.

Table 2
Comparison of land cover percentages between each stations' 14-Digit Hydrologic Unit Codes (**HUC-14**) and overall Ozark/Meramec EDU.

Stations	HUC-14	Urban	Crops	Grassland	Forest	Swamp/ Marsh
Big River 9	07140104010004	0.2	0.2	31.8	**66.1**	0.0
Big River 8, 7	07140104010006	1.2	1.5	**47.9**	44.9	0.0
Big River 6, 5, 4, 3	07140104080003	0.4	0.2	28.5	**68.9**	0.0
Big River 2, 1	07140104080004	0.0	1.3	20.6	**77.0**	0.0
Courtois Creek 2, 1	07140102040005	0.0	0.0	5.4	**94.0**	0.0
Ozark/Meramec EDU	--	1.3	1.7	28.5	**67.1**	0.0

2.3 Stream Habitat Assessment

The standardized Stream Habitat Assessment Project Procedure, MNDR-FSS-032 (**SHAPP**), was followed as described for Riffle/Pool Habitat (MDNR 2003e). Comparisons were made between scores at the control (upstream and similar-size) and test stations. According to the SHAPP, the quality of an aquatic community is based on the streams' ability to support the aquatic community on a given scale. If SHAPP

scores were ≥75% of the controls at test stations, that station was considered comparable to the control in stream quality. Stream habitat assessments were conducted on Big River (lower) and Courtois Creek stations in October 2002.

2.4 Biological Assessment

Biological assessment consisted of macroinvertebrate community and physicochemical water analyses. Biological samples were collected at nine stations on Big River and two stations on Courtois Creek in the fall of 2002. In the spring of 2003, biological samples were collected at seven stations on Big River and two on Courtois Creek. High water conditions made two stations on Big River inaccessible during the spring. However, omission of the two stations had little consequence, because of the tight bracketing strategy.

2.4.1 Macroinvertebrate Collection and Analyses

A standardized macroinvertebrate sample collection procedure was followed as described in ESP's Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (**SMSBPP**; MDNR 2003d). Metric scores are normally derived based on taxa presence and community structure in multiple habitats. However, in this project only riffle/run (coarse substrate) habitat could be consistently sampled at all stations due to the large size of the stream. Biological criteria were calculated for wadeable/perennial reference streams using only coarse substrate. These criteria were used as a comparison to the assessments made using control stations. Macroinvertebrate data were analyzed using two methods to compare results between control (upstream and similar-size) stations and test stations.

The first comparison was of individual metric scores and Stream Condition Index (**SCI**) scores between stations (MNDR 2002). Four metrics were used in the evaluation: 1) Taxa Richness (**TR**), 2) Ephemeroptera/ Plecoptera/ Trichoptera Taxa (**EPTT**), 3) Biotic Index (**BI**), and 4) Shannon Diversity Index (**SDI**). Metrics were compared to identify unusual responses or interesting trends between control stations and test stations.

An SCI is a qualitative rank measurement of a stream's aquatic biological integrity (Rabeni et al. 1997). It illustrates impairment of a stream relative to reference streams within the EDU. The SCI was refined in ESP's Biological Criteria for Perennial/Wadeable Streams (**BIOREF, or biological criteria references**) for reference streams within each EDU (MDNR 2002). All metric (TR, EPTT, BI, SDI) scores were compared to the scoring range of the BIOREF and then rank scores (5, 3, 1) were issued to each metric. Ranks for each metric were compiled per station and the total SCI was completed (see Table 2). A station's SCI score equates to the biological quality of the aquatic community. For example, an SCI of 20-16 = fully biologically supporting; 14-10 = partially biologically supporting; and 8-4 = non-supporting of the biological community.

The second analysis of the biological data was an evaluation of the dominant macroinvertebrate families (**DMF**). The predominant families within each station were identified and trends were examined between control and test stations. Individual taxa lists were also included (Appendix B).

2.4.2 Physicochemical Water Collection and Analyses

Physicochemical water samples were collected according to MDNR, ESP Standard Operating Procedures (**SOPs**) and Project Procedures (**PPs**) for sampling and analyzing physical and chemical samples. Samples

were collected according to MDNR-FSS-001 Required/Recommended Containers, Volumes, Preservatives, Holding Times, and Special Sampling Considerations (MDNR 2003c). Results are reported for physicochemical water variables in chronological order. Samples were collected and analyses conducted in the fall of 2002 and spring of 2003.

Fall (September/October) 2002 and spring (April) 2003 physicochemical variables measured in the field were pH, temperature (C^0), conductivity (uS/cm), dissolved oxygen, and discharge. Water samples collected and returned to the ESP laboratory for analyses included turbidity, hardness ($CaCO_3$), ammonia-nitrogen, nitrate/nitrite-nitrogen, Total Kjeldahl Nitrogen (**TKN**), sulfate (spring only), chloride, total phosphorus, and dissolved barium, calcium, cadmium, copper, iron, magnesium, lead, and zinc. These parameters were collected at all eleven stations on the lower Big River and Courtois Creek in the fall and at nine stations in the spring. All water samples were kept on ice for transport to the ESP laboratory. Turbidity was measured and recorded in the WQMS Biology Laboratory. All remaining samples were delivered to the ESP Chemical Analysis Section (**CAS**) in Jefferson City, Missouri for analyses.

Physicochemical data were analyzed for comparisons between the control (upstream and similar-size) and test stations. Results were also compared with acceptable limits according to Missouri's Water Quality Standards (MDNR 2000).

Interpretation of several physicochemical variables in the Water Quality Standards (MDNR 2000) is dependent on a stream's classification and beneficial-use designation. Big River was classified for the "Protection of Aquatic Life" or as a "General Warm-Water Fishery" (**GWWF**). Big River has several beneficial use designations that are needed to determine acceptable limits. These are "Livestock and Wildlife Watering (**LWW**), Protection of Warm Water Aquatic Life, Human Health-Fish Consumption (**AQL**), and Whole Body Contact Recreation (**WBC**)". Furthermore, acceptable limits within the Water Quality Standards may be dependent on the rate of exposure. These toxicity limits are based on the lethality of a toxicant given long (chronic toxicity, **c**) or short-term exposure (acute toxicity, **a**). Identification of hardness ($CaCO_3$) concentrations was necessary to further determine acceptable limits based on the solubility of heavy metals.

2.4.3 Discharge

Stream flow was measured using a Marsh-McBirney flowmeter at each station. Velocity and depth measurements were recorded to derive a discharge as cubic feet per second (**cfs**). Methodology was in accordance with SOP, MDNR-WQMS-113 Flow Measurement in Open Channels (MDNR 2003b).

2.5 Fine Sediment

In-stream deposits of fine sediment (i.e. particle size ca. <2 mm) were estimated for percent coverage per area and characterized for composition of total recoverable metals (**TR**, ug/kg). This was done once in October 2002 at all stations.

2.5.1 Fine Sediment Percentage and Characterization

The relative percentage of fine sediment (<2.0 mm) was visually estimated and the sediment was characterized for each station. The visual estimates were conducted within a metal square (**quadrat**) that was randomly located in sample areas called **grids**. Each station contained three grids.

In order to ensure sampling method uniformity, grids were located at lower margins of pools near the upper margins of riffle/run habitats. This arrangement or placement of grids was different than previous fine sediment assessment projects done by the WQMS (MDNR-WQMS Reports: Flat River 2001; Bull Creek 2002; Upper Big River 2001-2002). Higher velocities and greater depths in this larger stream made placement of the grids difficult below the riffles. This regime should still allow for estimation of short-term resident fine sediment, as did the past method. Maximum depths for placement of grids were slightly greater, yet did not exceed three feet. Water velocity was less than 1.3 feet per second (fps) which should be sufficient to allow settling of mine tailings size fine sediments (<2.0mm), according to the Hjulstrom Diagram (1939) for threshold transport and settling velocities. A Marsh-McBirney flow meter was used to ensure that water velocity of the sample area was within this range. Grids should not be placed in eddies, bends, downstream of vegetation, or large obstructions where flow is generally not laminar. The grid does not have to reach from bank to bank, so these areas may be excluded from the useable width.

Once a suitable area was identified, a virtual grid was constructed (Figure 3). A 100' tape measure anchored across the stream made up the downstream edge of a grid. The width of the useable area was measured, not including eddies, vegetation, large obstructions, and other objects that would bias the estimate. Upstream from the tape were six contiguous transects (12" x useable grid width) that traversed the stream. A retractable tape measure was held perpendicular to the 100' tape to determine the location of each transect. An individual metal square (quadrat), approximately 10"x 10", was then placed randomly on the substrate within the transect. A random number, which equated to one foot increments from the bank (or edge of the useable grid), determined where the quadrat was placed in the transect. The quadrat was placed in the transect at that distance from the bank, with its trailing edge contacting the downstream transect edge. The percent of fine sediment was estimated and recorded within the quadrat. The quadrat was then randomly placed in the next transect and so on, until all six were completed.

Two investigators then estimated the percentage of the fine sediment sized particles on the stream bottom within each quadrat. The estimates were accepted if the two observations were within a ten percent margin of error. If estimates diverged more than ten percent, the investigators repeated the process until the estimates were within the acceptable margin of error. Both estimates were recorded. The mean was later calculated and used for analyses.

Fine sediment was characterized by determining its content of total recoverable cadmium, lead, and zinc (ug/kg). One composite sample of the fine sediment was collected at each grid. Each composite consisted of three (3) two-ounce samples of fine sediment sized particles that were dredged from the substrate and placed into an eight ounce jar. Dredging depth did not exceed two inches. The flat surface of the two-ounce jar lid was used to retain the fine sediment, while the jar was retrieved through the water column. If fine sediment was not found in sufficient quantities within the grid, a representative composite collection was collected near the study grid. A total of three composite samples were collected and analyzed for each station. Samples were kept on ice and delivered to the ESP, CAS in Jefferson City, Missouri for the analyses.

2.5.2 Fine Sediment Data Analyses

The fine sediment estimates and characterization results were tested to determine if there were differences between control stations and test stations. Also, differences were more specifically identified, if they existed.

Statistical analyses were conducted on the percentage of fine sediment found in the substrate using SigmaStat, Version 2.0 (1997). Kruskal-Wallis, One-way Analysis of Variance on ranks (ANOVA on ranks) illustrated if differences between sample stations existed. If significant differences ($p<0.05$) were detected between stations, Dunn's multiple comparisons were conducted to identify the differences ($p<0.05$) between control and test stations. Dunn's comparison is generally used to identify differences with missing data. Data for all quadrats in each station (n=18 quadrats in most cases) were included in the comparison between stations. One hundred eighty-five observations were made for the eleven stations on the lower Big River and Courtois Creek study areas (13-missing).

The character of the fine sediment was analyzed using two methods. The levels of heavy metals found at all stations were compared to Probable Effects Levels (**PELs**; Ingersoll et al. 1996) and the amount of metals at control stations was compared between control and test stations for significant differences ($p<0.05$). Kruskal-Wallis ANOVA on ranks was used and Dunn's identified specific differences between stations. Data from all three composite samples for each station (n=3 in most cases) were used in the analyses. A total of 32 samples were used in the comparison (1-missing).

2.6 Quality Control

Quality control was conducted according to MDNR Standard Operating Procedures and Project Procedures.

3.0 Results and Analyses

The result section includes stream habitat assessments, biological assessments, which include a macroinvertebrate assessment with physicochemical water analyses, fine sediment coverage estimations, and fine sediment characterization by station. Variables found to have high values or that follow interesting trends are included in each section.

3.1 Stream Habitat Assessment

Stream habitat assessment (SHAPP) scores were arranged by station to assess the quality of habitat on Big River (Table 3). Two comparisons were made to assess the streams' quality.

A comparison was made between SHAPP scores at control and test stations. Both upstream (#9) and similar size stream controls (Courtois Creek #2 and #1) were assessed with higher scores than all test stations (Table 3). Habitat assessments reached their lowest score (95) at station #5, before increasing at downstream stations.

The second comparison was of all Big River stations with the mean of the similar size control stream stations. According to the Stream Habitat Assessment Project Procedure (SHAPP; MDNR 2003e) a study stream that scores greater than 75 percent of reference (control) stream conditions is considered to have habitat that is capable of fully supporting a similar biological community. Stream habitat scores at three stations (#7, #6, #5) were not considered to be supporting the aquatic community, when compared to the mean of the similar size control stream stations (Table 3). The upstream control (#9) was comparable to the similar-size control stream stations.

Table 3
Stream habitat assessment scores for Big River and Courtois Creek,
fall (September and October) 2002.

Stations	#9	#8	#7	#6	#5	#4	#3	#2	#1	Cc#2	Cc#1
Stream Habitat Score	185	162	119	118	95	132	141	141	143	172	176
Percent of Courtois Creek Mean (174)	106	93	**68**	**68**	**54**	76	81	81	82	98	101

3.2 Biological Assessment

Biological assessments consist of macroinvertebrate community and physicochemical water analyses. Macroinvertebrate data were evaluated by two methods. The first analysis was a single habitat (coarse substrate) assessment of primary metric scores, as well as comparison of wadeable/perennial biocriteria Stream Condition Index (**SCI**) scores between controls (upstream and similar-size) and the test stations. The primary metrics and SCI scores were calculated according to the Biological Criteria Development for Wadeable/Perennial Streams of Missouri (MDNR 2002). The second analysis of the macroinvertebrate assemblage included an evaluation of dominant macroinvertebrate family (**DMF**) composition and individual taxa between control and test stations.

3.2.1 Macroinvertebrate Community Analyses

All four biocriteria metrics exhibited a negative trend between controls (upstream control and similar-size) and the test stations in the fall 2002 samples (Table 4). Taxa richness, EPT taxa, BI, and the SDI metrics all declined at the first test station (#8). The decline for most metrics continued in downstream test stations and reached a low for taxa richness (17), EPT taxa (4), and SDI (0.44) at station #4. The metric scores generally started to recover at #3, which was upstream of Mill Creek's confluence.

The Stream Condition Index (SCI) was sufficient to maintain a fully biologically supporting rating at all of the controls in the fall of 2002 (Table 4). SCI scores decreased at station #8 to give a partially supporting rating. The SCI score reached a low at station #4, where that station was considered non-supporting of the aquatic community. Scores increased farther downstream and the sustainability rating increased to either partial or biologically supporting.

Table 4
Fall 2002 biocriteria metric scores and Stream Condition Index (SCI) scores (n=7) for Big River stations (control=#9; test=8,7,6…1) and Courtois Creek (Cc#; similar-size control). Coarse substrate (CS) habitat only.

Stream and Station Number	Sample No.	TR	EPTT	BI	SDI	SCI	Supporting
Cc#2a (Control)	0218136	36	15	3.97	2.02	18	Fully
Cc#2b (Control)	0218137	35	16	4.38	2.11	20	Fully
Cc#1 (Control)	0218138	44	20	3.92	2.61	20	Fully
#9 (Control)	0218084	38	16	4.76	2.46	18	Fully
#8 (Test)	0218083	**31**	**11**	**5.32**	**1.92**	**12**	**Partially**
#7 (Test)	0218131	29	8	5.82	1.72	12	Partially
#6 (Test)	0218129	37	7	5.77	1.68	14	Partially
#5 (Test)	0218130	27	6	5.49	0.68	10	Partially
#4 (Test)	0218132	**17**	**4**	**5.42**	**0.44**	**8**	**Non**
#3 (Test)	0218134	24	8	5.45	0.61	10	Partially
#2 (Test)	0218135	35	14	5.44	1.19	16	Fully
#1 (Test)	0218133	34	15	5.31	1.53	14	Partially
Score=5	--	>34	>13	<4.57	>2.10	20-16	Fully
Score=3	--	34-17	13-6	4.57-7.28	2.1-1.05	14-10	Partially
Score=1	--	<17	<6	>7.28	<1.05	8-4	Non

In the spring of 2003 (Table 5) the four biocriteria metrics scores declined between the controls (upstream and similar-sized stream) and the test stations. Taxa richness and EPT taxa decreased at the first test station (#8). At station #7, taxa richness was nearly half (39) of the control stations and the SDI reached a low (2.09). Scores (taxa richness and EPT taxa) generally reached a low at #4, in St. Francois State Park. Some recovery was apparent in the scores at #1. The BI was lowest in only one control and increased in all others and reached a high at #1. The SDI declined below all controls beginning at station #8.

The Stream Condition Index (SCI) scores decreased and the stations were less supporting of the aquatic community in most test stations in the spring of 2003 (Table 5). SCI scores at the controls were consistently in the 18-20 range, making these stations fully biologically supporting. Station #8 was also in the fully supporting, however, all metrics in that station were slightly less than the upstream control (#9). The SCI at station #7 lowered to partially supporting. SCI scores were lowest (10) at stations #6 and #4 and then increased slightly (12) at station #3. However, stations downstream did not exceed partially supporting for the remainder of the study area in the spring of 2003.

Table 5
Spring 2003 biocriteria metric scores and SCI scores (n=6) for Big River stations (control=#9; test=8,7,6…1) and Courtois Creek (Cc#; similar-size control). Coarse substrate (CS) habitat only.

Stream and Station Number	Sample No.	TR	EPTT	BI	SDI	SCI	Supporting
Cc #2 (Control)	0318672	73	**26**	4.16	3.44	20	Fully
Cc #1 (Control)	0318673	66	**27**	5.21	3.27	18	Fully
#9 (Control)	0318665	61	**23**	5.18	3.29	18	Fully
#8 (Test)	0318666	**55**	**19**	**5.57**	**3.09**	18	Fully
#7 (Test)	0318667	39	10	5.18	**2.09**	12	Partially
#6 (Test)	0318668	36	6	5.84	2.74	10	Partially
#5 (Test)	--	--	--	--	--	--	-
#4 (Test)	0318669	**35**	**5**	**5.84**	**2.62**	10	Partially
#3 (Test)	0318670	38	11	5.55	2.28	12	Partially
#2 (Test)	--	--	--	--	--	--	-
#1 (Test)	0318671	53	12	6.06	2.92	14	Partially
Score=5	--	>53	>18	<5.12	>2.78	20-16	Fully
Score=3	--	53-26	18-9	5.12-7.56	2.78-1.39	10-14	Partially
Score=1	--	<26	<9	>7.56	<1.39	8-4	Non

Several trends were apparent at the macroinvertebrate family level (Table 6) between control stations and test stations in the fall of 2002. Elmid beetles declined significantly at station #7 and remained below controls at the remaining test stations. Heptageniid mayflies were abundant in the controls, yet were absent at station #7. Their percentages remained below control levels in all remaining test stations. Baetid mayflies were present in the controls (#9; Cc#2 and Cc#1) and then absent from six of the eight remaining test stations, #8 through #3. Isonychiid mayflies decreased (8 to 2) from station #8 to #7 and were not found downstream. Also, hydropsychid caddisflies were observed in the test stations, #8 through #1, although were absent from controls. Chironomids increased in the test stations. Tricorythid mayflies were prevalent at all test stations.

Table 6
Dominant Macroinvertebrate Families (DMF) as a percentage of the total number of individuals per station, fall 2002 (Cc=Courtois Creek stations; #=Big River stations).

Station	Cc2a/b	Cc1	9	8	7	6	5	4	3	2	1
Sample Number (02-)	18136/ 18137	181 38	180 84	180 83	181 31	181 29	181 30	181 32	181 34	181 35	181 33
Tricorythidae	**38/42**	**10**	**32**	**43**	**52**	**58**	**88**	**92**	**90**	**78**	**69**
Elmidae	**8/10**	**18**	**7**	**22**	**1**	1	-	3	1	1	2
Chironomidae	1/-	5	5	**8**	**37**	**26**	7	2	4	5	9
Arachnoidea	-/4	2	-	9	2	1	-	1	1	-	-
Leptoceridae	-/-	-	-	-	1	-	<1	<1	<1	2	-
Hydropsychidae	-/-	-	-	**3**	**2**	**7**	**1**	**<1**	**1**	1	1
Ceratopogonidae	-/-	-	-	-	-	-	-	<1	-	-	-
Hydrophilidae	-/-	-	-	-	-	-	<1	<1	-	-	-
Simuliidae	-/-	-	-	-	1	4	-	-	-	-	-
Empididae	-/-	-	-	-	-	1	1	-	-	-	-
Heptageniidae	**20/16**	**29**	**19**	**8**	-	1	-	-	**1**	**4**	**8**
Gomphidae	-/-	-	-	-	-	-	<1	-	-	-	-
Corydalidae	-/-	-	-	-	-	-	<1	-	-	-	-
Coenagrionidae	-/-	-	-	-	1	-	-	-	-	-	-
Baetidae	**6/5**	**4**	**9**	-	-	-	-	-	-	2	3
Hydroptilidae	-/-	-	-	-	-	-	-	-	-	1	2
Isonychiidae	**18/12**	**16**	**8**	2	-	-	-	-	-	-	1
Pleuroceridae	4/2	8	-	-	-	-	-	-	-	-	-
Corbiculidae	1/2	-	-	-	-	-	-	-	1	-	-
Caenidae	-/-	-	8	-	-	-	-	-	-	-	-
Philopotamidae	-/-	-	4	2	-	-	-	-	-	-	-

The dominance of certain families and subsequent decline in others follows a trend from the controls through the test stations in the spring of 2003 (Table 7). Elmid beetles declined significantly between station #8 and #7 (12 to 1). Their numbers remained low throughout the downstream stations. Heptageniid mayflies were not found in station #7 or subsequent stations until station #1. Baetid mayflies followed a similar trend, in that they were found in the upstream control, yet were absent from all subsequent test stations. Tricorythid mayflies and chironomid taxa were present at most stations in the spring.

Individual taxa are listed for each station and season in Appendix B. The presence of certain species (heptageniids, baetids) in controls and absence from test stations was apparent.

Table 7
Dominant Macroinvertebrate Families (DMF) as a percentage of the total number of individuals per station, spring 2003 (Cc=Courtois Creek stations; #=Big River stations).

Station	Cc2	Cc1	9	8	7	6	5	4	3	2	1
Sample Number (03-)	18672	18673	18665	18666	18667	18668	-	18669	18670	-	18671
Chironomidae	20	26	40	47	35	41	-	40	20	-	53
Heptageniidae	**11**	**24**	**6**	**4**	-	-	-	-	-	-	4
Elmidae	-	**14**	**8**	**12**	**1**	3	-	3	4	-	6
Ephemerellidae	19	9	-	-	-	-	-	-	-	-	-
Pleuroceridae	4	8	-	-	-	-	-	-	-	-	-
Arachnoidea	10	4	5	4	1	-	-	3	1	-	4
Caenidae	-	2	8	6	-	-	-	4	3	-	4
Perlidae	-	2	5	3	2	4	-	-	-	-	-
Tricorythidae	**10**	**-**	**4**	**9**	**4**	**4**	**-**	**25**	**33**	**-**	**13**
Simuliidae	4	-	-	3	49	28	-	14	25	-	5
Corbiculidae	3	-	-	-	-	-	-	-	-	-	-
Baetidae	-	-	**9**	-	-	-	-	-	-	-	-
Ceratopogonidae	-	-	-	-	1	-	-	4	-	-	-
Empididae	-	-	-	-	1	3	-	-	-	-	-
Tubificidae	-	-	-	-	-	7	-	-	-	-	-
Lumbricidae	-	-	-	-	-	3	-	-	-	-	-
Tipulidae	-	-	-	-	-	-	-	1	-	-	-
Hydropsychidae	-	-	-	-	-	-	-	-	6	-	2
Baetiscidae	-	-	-	-	-	-	-	-	1	-	-

3.2.2 Physicochemical Water

Remarkable physicochemical water data were compared between controls (upstream and similar-size) and test stations. These were also compared to Missouri's Water Quality Standards (MDNR 2000). All unremarkable physicochemical variable data are found in Tables 8 and 9 for the fall 2002 and spring 2003, respectively.

Most physicochemical variables were unremarkable with a few exceptions in the fall of 2002 (Table 8). Dissolved barium, lead, and zinc were found in the study area of lower Big River. Dissolved barium was more than two-fold higher (275 ug/L) downstream in station #2, as was found at all stations upstream (Figure 4). Dissolved lead was below detectable levels at the controls and #8, but increased more than three-fold (6.80 ug/L) downstream in #7 (Figure 5). Dissolved zinc increased at station #8 and quadrupled at station #7 before declining (Figure 6). Zinc declined to less than detectable levels (<10 ug/L) by station #2, just upstream of Washington State Park. Although there were substantial increases from the controls to test stations, dissolved metals concentrations did not exceed Water Quality Standards (MDNR 2000) in the fall of 2002.

Physicochemical variables were generally not outstanding with several exceptions in the spring of 2003 (Table 9). Discharge reached as much as 253 cubic feet per second during the spring and as a result turbidity, nitrates, TKN, chloride, and sulfate increased slightly during the high runoff period.

Several dissolved metals exhibited an increasing trend in the spring of 2003. Dissolved barium was low (89.4 ug/L) at station #3 upstream of Mill Creek, and then increased to a high (167 ug/L) at station #1 in the spring (Table 9; Figure 4). The concentrations at station #1were higher than the upstream control (#9), however, the values were similar to the similar-size control stations on Courtois Creek. Dissolved lead increased at station #6, downstream from the Flat River confluence and reached a high at station #1 in the spring of 2003 (Table 9; Figure 5). Dissolved zinc increased at #8 and reached a high (99.5 ug/L) at #4 in the spring, which was downstream of Bonne Terre (at St.Francois State Park) and all other mining facilities in the spring of 2003 (Table 9; Figure 6). Although there were substantial increases from controls to test stations, dissolved metals concentrations did not exceed Water Quality Standards (MDNR 2000) in the spring of 2003.

3.3 Fine Sediment

The fine sediment estimation and characterization study was completed. Trends and differences between the controls (upstream and similar-size) and test stations were examined.

3.3.1 Fine Sediment Estimations

The mean fine sediment percentages increased between controls and test stations (Table 10; Figure 7). The percentage of fine sediment at control station #9 was 12.22 percent. Similar size controls (Cc#2, #1) were lower at 7.778 and 4.11 percent fine sediment. The mean fine sediment percentage increased to 29.39 percent at station #7, which was downstream of the Desloge tailings pile. The relative percentage of fine sediment nearly doubled again to 57.92 at station #6, maintained at #5, and increased again to 60.59 at station #4 (St. Francois State Park). The percentage decreased at #3 and #2, however, increased to the highest mean observed of 63.94 percent at station #1 (Washington State Park).

Kruskal Wallis ANOVA showed that there were significant differences ($H=112.792$, d.f.=10. $P<0.001$) between stations (Appendix C). The percentage of fine sediments observed at all controls were significantly less ($p<0.05$) than the estimated fine sediment at test stations #6, #5, #4, and #1.

3.3.2 Fine Sediment Character

The fine sediment character (composition; Total Recoverable ug/kg) included significant levels of cadmium, lead, and zinc. The heavy metals increased between controls and test stations. Tests showed significant differences ($p<0.05$) between several controls and test stations for each heavy metal.

Cadmium levels found in the fine sediment followed an increasing trend (Table 11; Figure 8). Sediment cadmium was nearly non-detected at the controls (ca. 500 ug/kg). Cadmium increased to a mean of 52,050 ug/kg at station #8 which was downstream of the Leadwood tailings pile. This was above the sediment cadmium Probable Effects Level (PEL, 3,200 ug/kg; Ingersoll et al. 1996). Sediment cadmium remained above acceptable levels at the remaining stations through #4, which was downstream of Bonne Terre tailings. Cadmium in the sediment decreased to acceptable concentrations at station #3, and steadily declined at the remaining stations.

Kruskal Wallis ANOVA on ranks identified significant differences ($H=30.099$, d.f.=10. $P<0.001$) in the amount of cadmium in the sediment between stations (Appendix C). The amount of cadmium in the sediment at all controls was different ($p<0.05$) from the amount found at stations #8 and #7.

Table 8
Physicochemical water variables per station, Courtois Creek (Cc) and Big River (#) in fall (September/October) 2002.
(Units mg/L unless otherwise noted; SP=State Park).

Station Variable/Date	Cc#2 Similar-size control 10-8-02	Cc#1 Similar-size control 10-9-02	#9 Irondale Upstream Control 10-2-02	#8 Down Lead-wood TP 10-1-02	#7 Down Desloge TP 10-1-02/ 9-26-02	#6 Down Flat River Complex 9-24-02	#5 Down Flat; Up Bonne Terre TP 9-25-02	#4 Down Bonne Terre TP@ St. Francois (SP) 9-26-02	#3 Up Mill Creek 10-2-02	#2 Down Mill Creek 10-3-02	#1 Down All; Washing -ton (SP) 10-1-02
Phys/Chem Sample No.	0230887	0230891	0228673	0228670	0228666/ 0230866	0230858	0230862	0230867	0230883	0230884	0230876
pH (Units)	8.1	8.2	8.3	8.7	8.2/8.0	8.2	8.1	8.2	8.4	8.2	8.2
Temperature (C^0)	15.3	16.3	21	22	21/16	19	17	17	20	20.5	21
Conductivity (uS)	405	382	393	489	568/536	459	552	545	575	552	476
Dissolved O_2	9.78	9.5	7.51	7.95	7.89/8.13	9.95	8.66	8.44	8.14	7.15	10.1
Discharge (cfs)	39.2	42.1	20.1	27.9	45/ --	108	84.9	86.6	73.2	90.4	102
Turbidity (NTUs)	<1	<1	2.87	3.21	1.81/2.74	3.51	3.56	4.73	6.21	5.59	4.14
Hardness	217	215	209	263	304/264	247	261	264	297	287	268
Ammonia-N	<0.05	<0.05	<0.05	<0.05	<0.05/<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Nitrate/Nitrite-N	<0.05	<0.05	<0.05	0.08	<0.05/0.08	0.39	0.50	0.27	0.12	0.05	0.07
TKN	<0.2	<0.2	<0.2	<0.2	<0.2/<0.2	<0.2	<0.2	<0.2	0.26	0.25	0.28
Chloride	<5	<5	5.04	7.36	7.45/6.80	8.86	11.0	9.89	14.9	12.3	11.7
Total Phosphorus	<0.05	<0.05	<0.05	<0.05	<0.05/<0.05	0.06	0.06	<0.05	<0.05	<0.05	<0.05
Barium (ug/L)-Dis.	**206**	**200**	124	128	113/108	102	103	101	130	**275**	**253**
Cadmium (ug/L)-Dis.	<1	<1	<1	<1	<1/<1	<1	<1	<1	<1	<1	<1
Calcium-Dis.	43.4	43.1	41.7	53.4	62.9/55.1	52.1	54.6	55.2	60.5	58.7	54.3
Copper (ug/L)-Dis.	<10	<10	<10	<10	<10/<10	<10	<10	<10	<10	<10	<10
Iron (ug/L)-Dis.	<10	<10	<10	<10	<10/<10	<10	<10	<10	<10	<10	<10
Lead (ug/L)-Dis.	<2	<2	<2	<2	**6.80/4.14**	**3.98**	**5.87**	**4.23**	**3.48**	**3.60**	**5.64**
Magnesium-Dis.	26.4	26.1	25.6	31.5	35.8/30.6	28.5	30.3	30.7	35.6	34.2	32.1
Zinc (ug/L)-Dis.	<10	<10	<10	**49.8**	**168/143**	108	92.9	56.6	12.0	<10	<10

Table 9
Physicochemical water variables per station, Courtois Creek (Cc) and Big River (#) in spring (April) 2003.
(Units mg/L unless otherwise noted; SP=State Park).

Station Variable/ Date	Cc#2 Similar-size control 4-3-03	Cc#1 Similar-size control 4-3-03	#9 Irondale Upstream Control 4-2-03	#8 Down Lead-wood TP 4-2-03	#7 Down Desloge TP 4-2-03	#6 Down Flat River Complex 4-2-03	#4 Down Bonne Terre @ St. Francois (SP) 4-2-03	#3 Up Mill Creek 4-3-03	#1 Down All; Washing-ton (SP) 4-3-03
Phys/Chem Sample No.	0300566	0300567	0300558	0300560	0300561	0300562	0300563	0300564	0300565
pH (Units)	8.1	8.2	8.1	8.2	8.3	8.4	8.4	8.2	8.2
Temperature (C^0)	16.7	17.6	14.5	14.6	16.3	17.4	18.0	16.7	16.9
Conductivity (uS)	314	314	292	343	387	402	426	440	435
Dissolved O_2	9.75	9.90	10.5	12	11.2	11.9	11.8	8.64	8.83
Discharge (cfs)	156	164	122	154	161	228	253	--	--
Turbidity (NTUs)	1.22	1.16	1.82	1.33	1.13	1.87	1.70	7.83	11.8
Hardness	183	187	162	192	213	228	234	229	238
Ammonia-N	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Nitrate/Nitrite-N	0.09	0.11	<0.05	<0.05	<0.05	0.08	0.11	0.07	<0.05
TKN	<0.2	<0.2	<0.2	0.22	<0.2	0.25	0.22	0.22	0.27
Chloride	<5	<5	<5	5.88	6.44	7.21	10.3	10.1	9.86
Sulfate *	14.7	13.8	16.6	26.3	44	45.5	48.3	49.4	41.6
Total Phosphorus	<0.05	<0.05	<0.05	<0.05	<0.05	0.06	0.05	0.07	0.06
Barium (ug/L)-Dis.	**155**	**153**	71.6	84.4	73.6	77.1	78.6	89.4	**167**
Cadmium (ug/L)-Dis.	<1	<1	<1	<1	<1	<1	<1	<1	<1
Calcium-Dis.	35.3	36.5	31.4	38.5	40.6	43.7	48.5	46.7	46.7
Copper (ug/L)-Dis.	<10	<10	<10	<10	<10	<10	<10	<10	<10
Iron (ug/L)-Dis.	<10	<10	<10	<10	<10	<10	<10	<10	<10
Lead (ug/L)-Dis.	<2	<2	<2	<2	<2	**4.32**	**5.25**	**4.14**	**9.96**
Magnesium-Dis.	23.0	23.2	20.4	23.4	27.1	28.8	27.4	27.2	29.4
Zinc (ug/L)-Dis.	11.7	15.3	<10	**33.1**	**80.8**	**83.4**	**99.5**	**45.2**	27.1

* Sulfate-April only.

Table 10
Percentage fine sediment per grid and quadrat for Courtois Creek (Cc) and Big River (#) stations, July 2002. (e.g. Six quadrats per grid, 18 per station).

Stream/ Station ---------- Grid-Quadrat	Cc #2	Cc #1	#9	#8	#7	#6	#5	#4	#3	#2	#1
1-1	4	1	5	15	10	-	50	60	10	14	90
1-2	5	2	5	5	5	-	38	25	18	9	80
1-3	4	9	15	20	5	-	68	71	19	25	72
1-4	2	5	10	10	20	-	42	60	25	18	67
1-5	1	13	20	5	5	-	30	36	22	8	79
1-6	7	1	25	30	10	-	22	39	25	22	75
2-1	15	1	0	10	4	65	92	50	15	5	62
2-2	16	4	10	0	10	50	88	65	42	13	42
2-3	3	1	5	10	10	45	92	60	18	6	68
2-4	4	4	0	0	95	30	84	55	65	90	72
2-5	18	1	45	30	15	70	72	40	8	18	98
2-6	4	2	5	5	25	35	96	55	14	8	38
3-1	16	1	0	-	90	40	40	82	30	58	62
3-2	20	1	5	-	5	75	18	90	20	8	75
3-3	2	2	5	-	50	68	70	91	45	45	32
3-4	4	2	10	-	95	70	9	73	6	70	42
3-5	1	11	15	-	10	58	65	78	18	40	48
3-6	14	4	40	-	65	89	38	-	66	78	49
Mean	7.78	4.11	12.22	11.67	**29.39**	**57.92**	**56.33**	**60.59**	**25.89**	**29.72**	**63.94**
S.D.	3.42	1.69	0.01	0.04	21.81	12.37	26.86	18.39	5.58	17.80	12.93

Table 11
Cadmium levels (ug/kg) in sediment per grid; means and standard deviations (s.d.) per station. Sediment cadmium Probable Effects Level (PEL)=3,200ug/kg (Ingersoll et al. 1996).

Station	Grid 1	Grid 2	Grid 3	Mean	s.d.
Courtois Cr #2	<500	<500	583	527	48
Courtois Cr #1	<500	<500	630	543	76
Big River #9	<500	<500	<500	<500	0
Big River #8	70,700	33,400	--	**52,050**	26,375
Big River #7	29,800	20,900	31,700	**27,467**	5,766
Big River #6	11,700	15,400	12,600	**13,233**	1,930
Big River #5	7,420	12,400	13,800	**11,207**	3,353
Big River #4	5,390	6,080	11,700	**7,723**	3,461
Big River #3	2,740	3,200	3,300	3,080	299
Big River #2	1,830	1,320	1,540	1,563	256
Big River #1	1,390	1,720	1,340	1,483	206

Fine sediment lead followed an increasing trend through much of the study area (Table 12; Figure 8). Sediment lead was lowest at the controls (upstream #9 and similar-size). Lead increased at station #8 to a mean of 1,320,000 ug/kg, which was above the sediment lead PEL (82,000 ug/kg; Ingersoll et al. 1996). The concentration increased nearly three-fold to 3,296,667 ug/kg at station #7, before starting a decline (Table 12; Figure 8). Lead levels in the sediment remained above the PEL for all remaining test stations.

Kruskal Wallis ANOVA on ranks identified significant differences ($H=28.348$, d.f.=10. $P=0.002$) in the amount of lead in the sediment between stations (Appendix C). The upstream #9 control and one similar-size control (Cc #2) were significantly different ($p<0.05$) from station #7 and #6 in the sediment content of lead.

Table 12
Lead levels (ug/kg) in sediment per grid; means and standard deviations (s.d.) per station.
Sediment lead Probable Effects Level (PEL)=82,000 ug/kg (Ingersoll et al. 1996).

Station	Grid 1	Grid 2	Grid 3	Mean	s.d.
Courtois Cr #2	13,900	15,600	23,700	17,733	5,237
Courtois Cr #1	19,000	21,600	26,000	22,200	3,538
Big River #9	20,100	15,800	14,700	16,867	2,853
Big River #8	1,970,000	670,000	--	**1,320,000**	919,239
Big River #7	4,430,000	2,360,000	3,100,000	**3,296,667**	1,048,920
Big River #6	1,250,000	2,180,000	6,450,000	**3,293,333**	2,773,019
Big River #5	5,800,000	866,000	2,170,000	**2,945,333**	2,556,745
Big River #4	1,990,000	4,180,000	1,320,000	**2,496,667**	1,495,805
Big River #3	459,000	657,000	437,000	**517,667**	121,167
Big River #2	389,000	297,000	370,000	**352,000**	48,570
Big River #1	374,000	486,000	299,000	**386,333**	94,108

The amount of zinc in the sediments of Big River followed a similarly interesting trend (Table 13; Figure 8). Sediment zinc concentrations were lowest in the control stations. Zinc in the sediment increased to levels above the sediment zinc PEL (540,000 ug/kg; Ingersoll et al. 1996) at station #8, which is the first test station. Zinc concentrations in the sediments decreased, yet remained above the PEL through station #5.

Kruskal Wallis ANOVA on ranks identified significant differences ($H=30.099$, d.f.=10. $P<0.001$) in the amount of zinc in the sediment between stations (Appendix C). The upstream control #9 was significantly different ($p<0.05$) from #8, #7, and #6. One of the similar size controls (Cc #2) was significantly different ($p<0.05$) from #8 and #7.

Table 13
Zinc levels (ug/kg) in sediment per grid; means and standard deviations (s.d.) per station.
Sediment zinc Probable Effects Level (PEL)=540,000 ug/kg (Ingersoll et al. 1996).

Station	Grid 1	Grid 2	Grid 3	Mean	s.d.
Courtois Cr #2	46,700	53,800	72,900	57,800	13,550
Courtois Cr #1	57,000	56,200	77,900	63,700	12,304
Big River #9	18,100	17,900	18,900	18,300	529
Big River #8	3,550,000	1,640,000	--	**2,595,000**	1,350,574
Big River #7	1,700,000	1,210,000	1,500,000	**1,470,000**	246,374
Big River #6	695,000	779,000	637,000	**703,667**	71,396
Big River #5	445,000	645,000	1,110,000	**733,333**	341,187
Big River #4	383,000	306,000	728,000	472,333	224,736
Big River #3	247,000	367,000	491,000	368,333	122,006
Big River #2	221,000	129,000	217,000	189,000	52,000
Big River #1	137,000	157,000	159,000	151,000	12,166

4.0 Discussion

Components of the study within each report section were found to be interesting or outstanding and to allow the objectives to be met. Headings within this discussion include the stream habitat assessment (SHAPP), macroinvertebrate analyses per station, physicochemical water variables per station, fine sediment and metals reactions per station, and potential effects on the macroinvertebrate community given findings of potential contamination.

4.1 SHAPP

Stream habitat assessment scores were much lower at stations #7, #6, and #5 than were found in the upstream control and the mean of the similar size control stations. Station #7 is directly downstream of the Desloge tailings pile and is within an urbanized area of Desloge Missouri, which may account for its lower score. Station #6 is directly downstream of the Flat River confluence and its riparian corridor appeared to be affected by past mining on the west banks, as well as the potential influence by Flat River Creek. Station #5, near highway K, scored the lowest. Topsoil excavation in that station's riparian corridor affected its overall score.

Habitat scores at stations #4 through #1 should support similar aquatic communities as the control stations, although they did not score as high as control stations. The available "epifaunal substrate" was of considerably higher quality at the similar-size controls than at Big River. The percentage of "sediment deposition" was much lower at the controls than the test stations. This appears to be the obvious difference between the two streams. The controls (upstream and similar size) have apparently not been subjected to the mining pressures that Big River has in the past and are of considerably higher quality. Regardless, stations #4 through #1 were "supporting" the aquatic communities based on the quality of habitat available.

A bias was discovered that may affect the usability of SHAPP at all stations. Two teams (Team 1 and Team 2) conducted SHAPPs on Big River. While conducting a QC of the SHAPPs in which both teams assessed #7, a serious difference was found between team scores. There was a nearly 30 percent difference in scores between Team 1 (119) and Team 2 (169) due to the subjectivity of the SHAPP. This is significant to the project because Team 2 conducted SHAPPs on stations #9 and #8, while Team 1 conducted SHAPP at all other stations. Scores at stations #9 and #8 should not be compared to scores at the remainder of the Big River stations. Comparing the mean of the similar size control stations with the test stations, as was done, is a more appropriate comparison. Due to inherent subjectivity, SHAPP scores in future projects should not be compared between "teams".

4.2 Macroinvertebrate Metric Analyses per Station

Metric scores and SCI scores were usually not similar between control (upstream and similar size) and test stations. Metrics at each station suggested that tailings piles may have an influence on the macroinvertebrate communities.

Macroinvertebrate metric values exhibited declining trends downstream of each tailings pile and associated urban areas in the study. Metrics generally declined downstream of Leadwood, Desloge, Flat River Complex, and Bonne Terre tailings piles. All biocriteria metrics indicated there was a level of disturbance that began at the test stations, downstream of the Leadwood tailings pile in the fall of 2002. In the fall (2002), metrics (TR, EPT taxa, SDI) declined starting at Leadwood and reached a low downstream of Bonne Terre tailings piles (at St. Francois State Park). In the spring of 2003, metrics (TR, EPT taxa, BI) declined at the Leadwood tailings pile, continued through Desloge, Flat River Complex, and again reached a low at Bonne Terre. Metrics in both seasons generally rebounded somewhat downstream of the last tailing pile.

It appears that the SCI at the controls are good for comparison and identified fully biologically supporting communities in the fall 2002 and spring 2003. It appeared that all test stations associated with tailings piles were less supporting of the aquatic community. A decline to partially supporting takes place at the test station (#8), downstream of Leadwood in the fall of 2002. In the spring of 2003, the decline was not as clear downstream of Leadwood, despite a decrease in the metric scores. The overall SCI scores declined enough to drop Desloge (#7), Flat River Complex (#6), and Bonne Terre (#4) to partially supporting during both seasons. SCI scores reach a low at station #4 (St. Francois State Park) during both seasons, and at best were considered partially supporting (spring 2003) and at worst non-supporting (fall 2002). SCI scores increased downstream of station #4 to allow for partially or fully supporting ratings at the remaining stations, which suggests the influence that caused the decline was not as prevalent. Two observations are apparent: 1) mining or another influence near mine tailings piles have had an effect on Big River; 2) St. Francois State Park was significantly impaired, probably from these upstream influences.

4.3 Physicochemical Water per Station

Most physicochemical water variables were not outstanding and are not discussed here, but may be observed in Tables 8 and 9. Dissolved barium, dissolved lead, and dissolved zinc exhibited interesting trends in test stations when compared with controls. Although there were substantial increases from controls to test stations, dissolved metals did not exceed Water Quality Standards (MDNR 2000).

Dissolved barium followed a similar pattern in the spring, as it did in the previous fall. The upstream control (#9) on Big River did not have relatively high concentrations of dissolved barium in either season. The increase in dissolved barium took place between station #3 and #2, which bracketed Mill Creek and the barite strip mine influences. Station #2 was not sampled in the spring due to high water, so station #1 at Washington State Park became the downstream test station for Mill Creek. Again, concentrations of dissolved barium were higher at the downstream test station than at all upstream stations. It appears that Mill Creek was continuously depositing dissolved barium into Big River, possibly from barite mining in its watershed. This is consistent with earlier findings (Duchrow 1978; Ryck 1974). It is also possible that this was a background level, because concentrations of barium in the similar size control (Courtois Creek) samples were

similar to the runoff of Mill Creek. It is not known if Courtois Creek had barite mining in the past, which would explain its higher concentrations of barium. Regardless, concentrations of barium were not above Water Quality Standards (MDNR 2000) during either season. Ryck (1974) believed that 10 miles of Mill Creek were seriously polluted from mine waste. A study should be conducted on Mill Creek to determine if the aquatic community in Mill Creek itself is threatened by dissolved barium concentrations or associated variables of strip mining.

Dissolved lead was found in both seasons downstream from some tailings piles. Dissolved lead was not found at the controls or at the Leadwood tailings pile in either season or at the Desloge tailings pile in the spring. However, dissolved lead was found downstream of Desloge in the fall, so it was a probable contributor. Zachritz (1978) and Czarnezki (1987) found elevated lead and zinc concentrations in Big River below Leadwood and Desloge tailings piles (Meneau 1997). These tailings piles may still contribute dissolved metals to the stream given proper conditions. The Flat River Complex and Bonne Terre tailings appeared to contribute to the dissolved lead concentrations. Flat River Creek was found with detectable dissolved lead in 2001 (MDNR 2002), as was consistently found downstream from Flat River Creek in Big River. However, Flat River Creek was not the sole contributor because dissolved lead was found upstream at Desloge in the fall. Dissolved lead was not above acceptable Water Quality Standards (MDNR 2000) during either season.

Dissolved zinc concentrations in the water column followed distinct trends in the two seasons. Controls showed no elevated levels in either season. In the fall, dissolved zinc increased at Leadwood and Desloge before following a decreasing trend over the remaining test area. This suggests that these tailings piles, or the sediment in the stream, may contribute to the dissolved fraction during low flow periods. The spring samples followed an opposite trend, in which concentrations followed an increasing trend from Leadwood, Desloge, Flat River Complex, and Bonne Terre, which suggests that all of the piles contributed dissolved zinc to the stream, probably because of higher flow/runoff. This is consistent with findings of Schmitt and Finger (1982), in which they suggested that dissolved zinc was probably transported as a liquid, especially during high flow. Dissolved zinc was not above Water Quality Standards (MDNR 2000) on Big River during this project.

4.4 Fine Sediment Percentage and Characterization per Station

Fine sediment percentage and its components (character) followed trends between controls and test stations. Possible affects on the macroinvertebrate taxa are incorporated.

4.4 .1 Fine Sediment Percentage per Station

The amount of fine sediment found on the substrate at Leadwood (#8) did not increase above controls, however, the amount increased downstream of the Desloge tailings pile. The amount increased significantly ($p<0.05$) downstream of the Flat River Complex

(#6, #5), as well as the Bonne Terre tailings (#4), before decreasing in the area downstream of St. Francois State Park. Fine sediment reached the highest percentage and was significantly higher than the controls at Washington State Park. The fine sediments found at Washington State Park were also high in lead, which suggested they were accumulated mine tailings from upstream. Fine sediment levels should be monitored downstream of each tailings pile. Efforts should be taken to keep tailings from entering Big River.

4.4 .2 Fine Sediment Character per Station

The fine sediment collected within the study area had high concentrations of heavy metals (cadmium, lead, and zinc), which suggested that it was related to mining. Total recoverable (ug/kg) cadmium, lead, and zinc were found as a greater part of the fine sediment and were significantly ($p<0.05$) greater downstream from Leadwood and Desloge tailings piles, as well as the Flat River Complex of tailings. Concentrations of cadmium in the fine sediment were above the PEL (Ingersoll et al. 1996) at all stations downstream to, and including, St. Francois State Park (#4). Lead in the fine sediment exceeded the PEL throughout the entire test area, including Washington State Park. Zinc was above the PEL to downstream of the Flat River Complex (#6, #5), however, was within acceptable limits downstream of Bonne Terre tailings. Schmitt and Finger (1982) believed that dissolved lead in the water was associated with the sediment, while zinc moved in liquid form at Big River.

Heavy metal laden sediment may also travel downstream as a pulse in Big River. Meneau (1997) suggests that fish consumption advisories will continue as the pulse of lead laden sediment from past mine waste releases moves through Big River. If it were only a part of a past pulse, sediment could have accumulated in stations #3 and #2, far from upstream influences. As it was, sediment decreased in these two stations, which suggested that the amount of sediment deposition was dependent on proximity to the upstream tailings. Increases in fine sediment metals downstream of each tailings pile suggest there was a periodic influx of fine sediment, probably during high flow. However, Washington State Park appeared to be a location where upstream mine wastes had accumulated, probably because of the stream's size and ability to carry fine sediments at that point. A fine sediment study should be conducted to see if the sediment appears to be part of a pulse or if it was being periodically renewed. These should include all seven stations, as was done in the spring of 2003.

It appeared that all of the tailings piles contributed fine sediments laden with heavy metals tailings. Runoff during rain events probably carried the mine tailings from the piles to the stream. Efforts should be made to keep the mine tailings from entering Big River. Biological studies should be conducted at St. Francois and Washington State Parks.

4.5 Potential Effects on Macroinvertebrate Communities

Results of this project suggest that several variables may be affecting the macroinvertebrate community in Big River. These potential effects are from fine sediments and metals contamination. Other interesting observations and potential sewage effects were examined.

4.5.1 Fine Sediment Effects

Several trends suggest that fine sediment may influence the presence of taxa. Several heptageniid mayflies (*Stenonema spp*.) and isonychid mayflies (*Isonychia sp*.) have been identified as sediment intolerant (Zweig and Rabeni 2001) and were missing from most test stations. Elmid coleopterans (*Stenelmis sp*.) identified as moderately tolerant (Zweig and Rabeni 2001) were also absent from most of the test stations. Interestingly, baetid mayflies were present at all controls, yet were absent for most of the test stations. However, they were a slight component in the spring.

Tricorythodes sp. were prevalent at test stations and were considered fine sediment intolerant by Zweig and Rabeni (2001), which contradicts the assertion that fine sediment was the inhibiting factor in Big River. However, Zweig and Rabeni discuss the influence of proportions of sand and silt in the fine sediment class and how differing amounts of each component may produce contradicting results. For example, sand-sized components (rather than silt) of fine sediment were prevalent in Big River, and sand may not negatively affect tricorythids. Although some of the trends were not clear-cut, it appeared that the high percentage of fine sediment may have played a role in the decline of several species and the increase in others on Big River during both seasons.

4.5.2 Metals Effects

Metals can affect aquatic organisms as compounds in water or sediment, or from the food chain (Sorensen 1991, Rainbow, 1996; Maret et al. 2003). Kiffney and Clements (1993) suggested that metals sensitivity of macroinvertebrates was related to feeding habits. Maret et al. (2003) found that several metals sensitive Ephemeroptera had a significant negative correlation with metals concentrations in water and sediment (r=-0.54 to -0.70) and were significantly lower in number at metals contaminated streams versus reference streams. Besser et al. (1987) found aquatic organisms in tributaries of Big River located downstream from tailings piles that contained concentrations of lead, cadmium, and other heavy metals, which suggests they may be inhibiting the macroinvertebrate community.

In this study, there was a clear shift in the taxa present from control to test stations, from metals sensitive to insensitive. The number of metals sensitive taxa were reduced in test stations. Low abundance of heptagneniid mayflies is one of the most useful indicators of metals pollution (Clements et al. 2000) and these mayflies were absent or less abundant at test stations than at controls. *Baetis spp.* were absent from the test stations where high levels of metals were found. This is consistent with Kiffney and Clements (1993) where *Baetis spp.* were considered intolerant of metals contamination. *Isonychia sp.* were absent from test stations. Clements et al. (1988) considers *Isonychia sp*. to be sensitive to heavy metals.

Metals concentrations in the water and sediment may have played a role in impairment of some of the test stations. The concentrations of dissolved barium, lead, and zinc increased noticeably but they did not surpass the limit for acceptable Water Quality Standards (MDNR 2000). Their effects are possible, yet not obvious. Sediment cadmium, lead, and zinc exceeded PELs and may have played a role as well. More specific work should be done to identify concentrations of heavy metals bioaccumulated in taxa that occur in Big River. Big River should be periodically monitored for levels of dissolved metals, especially barium, lead, and zinc. Monitoring should occur seasonally at these stations.

It is possible that the dissolved cadmium, lead, and zinc in the water are correlated with the amount of metals in the sediment. This is possible, however, it cannot be confirmed using these data because of different sampling locations, times, and dates. Correlation between the sediment and water fractions would be beneficial in determining the mode of delivery of the dissolved metals to the stream.

4.5.3 Unknown

In the examination of dominant macroinvertebrate families, several taxa were present in the similar size controls (Courtois Creek) and conspicuously absent from Big River. Pleurocerid snails were found in Courtois Creek, yet were absent from all Big River stations during both seasons. Ephemerellid mayflies were present in Courtois Creek in the spring, yet were absent from all Big River stations. It is possible that the sand sized fine sediment that dominated certain stations was not suitable to the snails or clinging mayflies. However, these large quantities of these particle sizes were not consistently found throughout the study area. The reason for their absence is unknown.

4.5.4 Sewage

Sewage and urban influences are a potential problem in Big River, as was noted by Ryck (1974; Meneau 1997) regarding a tributary near Bonne Terre. In this case, indicators of sewage (organic) pollution were not clearly evident. The biotic index metric trend increased, indicating that taxa which were more tolerant of organic pollution were replacing less tolerant taxa, especially in the urban areas of the test area (Tables 4 and 5). However, the BI did not increase to high levels, as would be expected if sewage was the single problem. Other indicators of sewage and urban runoff (chloride, total phosphorus) increased slightly within the test area during both seasons. However, oxygen and ammonia levels were not obviously affected. Sewage and urban runoff did not have an obvious effect on the study area.

5.0 Conclusion

Two things are apparent from the macroinvertebrate analyses and the water quality and fine sediment studies: 1) mining or another influence near mine tailings piles have had an affect on the aquatic community of Big River; 2) Big River at St. Francois State Park was significantly impaired, probably from these upstream influences.

With the exception of the upstream control at Irondale, it appears that the entire study area from #8 upstream of Leadwood to #1 in Washington State Park has been affected by the remnants of mining that took place in the past. Stations #3 and #2 appear to have recovered somewhat, probably due to their distance from the upstream influences, however, the biological criteria did not consistently reach a level of support that was comparable to the controls. It appears that the entire area should be considered impaired to some extent.

It appears that Leadwood, Desloge, Flat River Complex, and Bonne Terre tailings piles contributed to the heavy metal laden fine sediment load, and subsequently the reduction of sensitive macroinvertebrate taxa on Big River. Previous studies have also found heavy metals related to mining, in the tissue of macroinvertebrates and fish downstream of tailings piles. The amount of fine sediment was significantly greater at some test stations than control stations. Its character was made up of high amounts of cadmium, lead, and zinc, which were above PELs at most stations. This was probably the clearest cause of impairment.

Dissolved barium, lead, and zinc were also found in Big River. The dissolved fractions of lead and zinc appeared to be related to tailings from Desloge, Flat River Complex, and Bonne Terre tailings piles. Dissolved barium continuously entered Big River at the Mill Creek confluence. Dissolved metals concentrations were not above acceptable levels of the Water Quality Standards (MDNR 2000).

All null hypotheses were not accepted, regardless of season. Stream habitat was not similar between the controls and several of the test stations. The macroinvertebrate community was not similar between control and test stations. Water Quality was not similar between controls and test stations for several variables. The amount of fine sediments was not similar between controls and test stations. The character of fine sediment was not similar between controls and test stations. Results suggest that much of Big River between Irondale, Missouri and Washington State Park was affected by mining influences at the time of this study.

The objectives were met. The macroinvertebrate community appeared to be affected by mining influences. The water quality appeared to be affected by mining influences, however, not beyond acceptable levels at the time of sampling. Fine sediment and heavy metals were present in Big River, probably from tailings piles that remain from past lead mining in the area. Stream habitat was not similar between similar size controls and several stations, probably due to past mining of the area.

6.0 Recommendations:

- Different "Teams" should not conduct SHAPPs on the same stream and scores should not be compared between teams.

- Studies that identify levels of heavy metals bioaccumulated in taxa should be conducted periodically.

- A study should be conducted on Mill Creek to determine if the aquatic community in Mill Creek itself is threatened by dissolved barium concentrations or associated variables of strip mining.

- Big River should be monitored seasonally for dissolved metals, especially cadmium, barium, lead, and zinc at all stations.

- Additional fine sediment studies should be conducted to determine if fine sediment is moving in a pulse.

- Efforts should be made to keep the mine tailings from entering Big River.

- Biological and fine sediment studies should be conducted on Big River at St. Francois and Washington State Parks.

- Correlations between sediment metals and water fractions would be beneficial in understanding the mode of delivery of metals to the stream.

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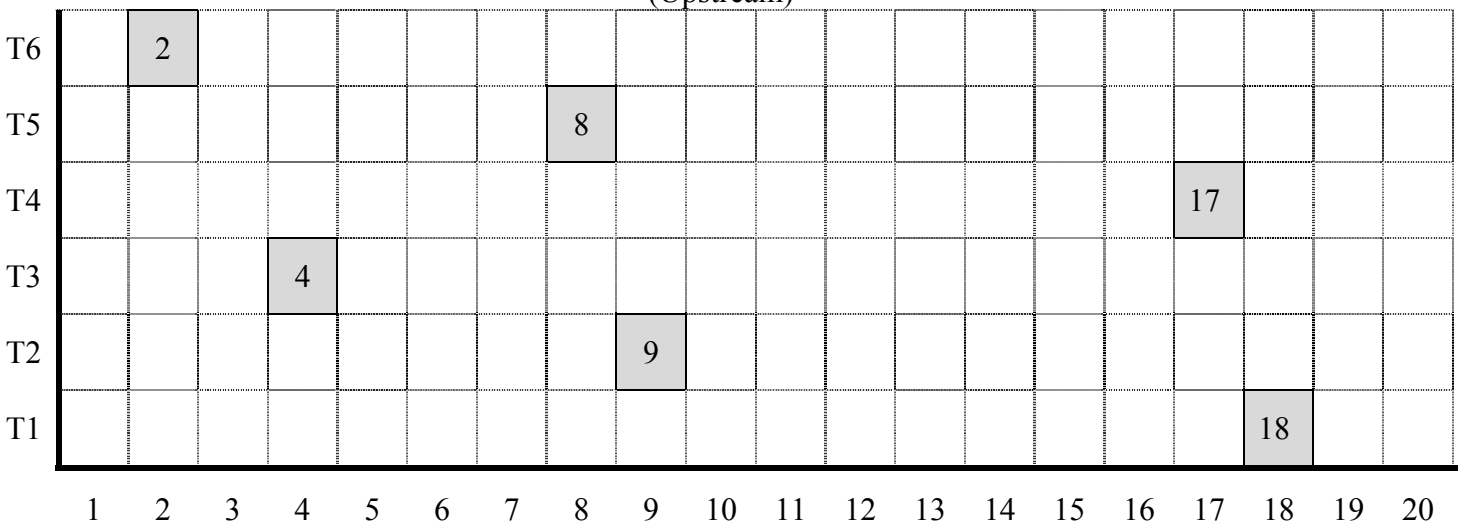
Figure 3: Virtual grid of transects (T) and quadrats (in gray, numbered) for estimating percent fine sediment. Example: stream 20' wide; quadrat placement based on random numbers (e.g. 18, 9, 4, 17, 8, 2).

RIFFLE

(Upstream)



Tape Measure Reading
(feet)

POOL

Figure 4: Dissolved barium concentrations per station

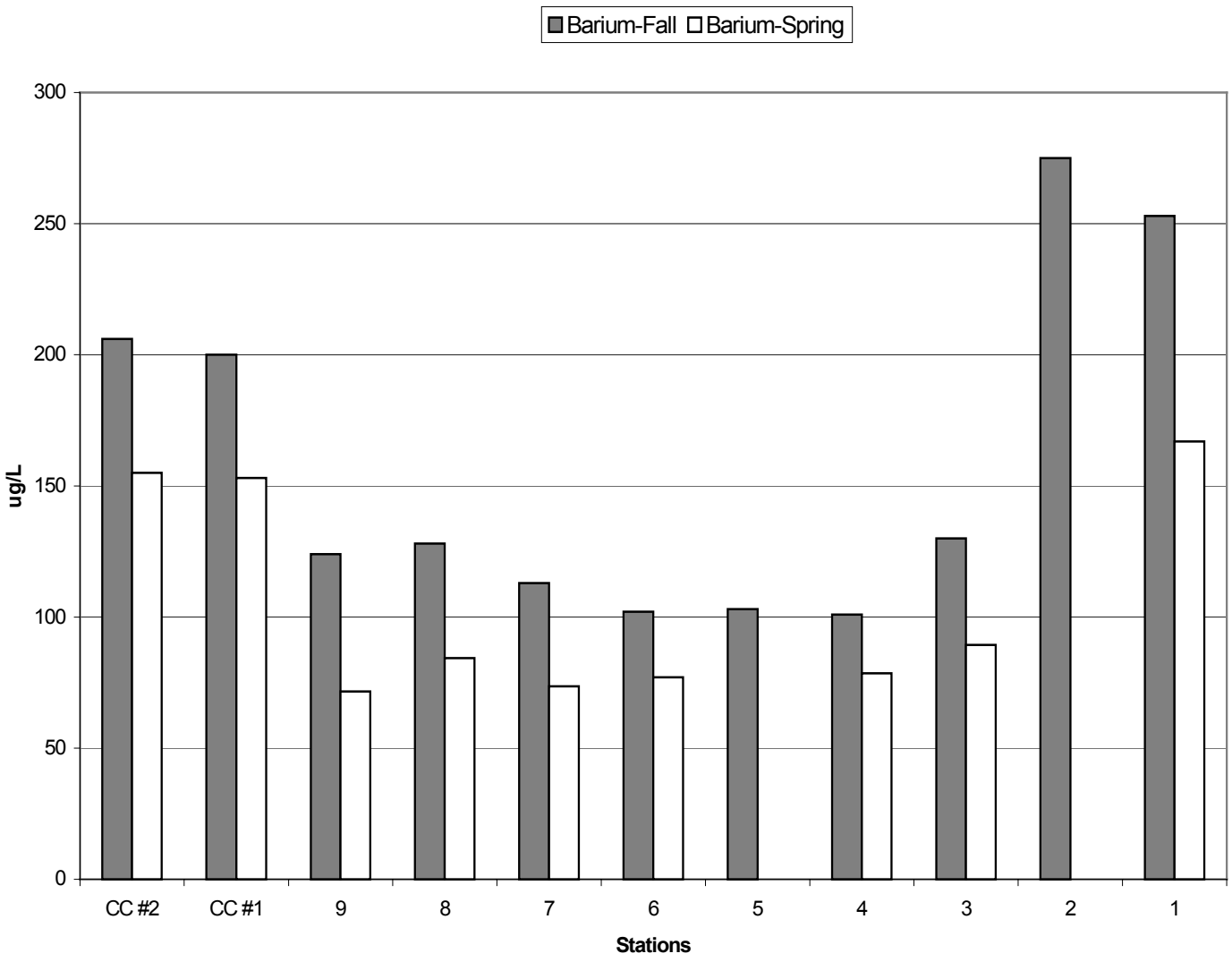


Figure 5: Dissolved lead concentrations per station

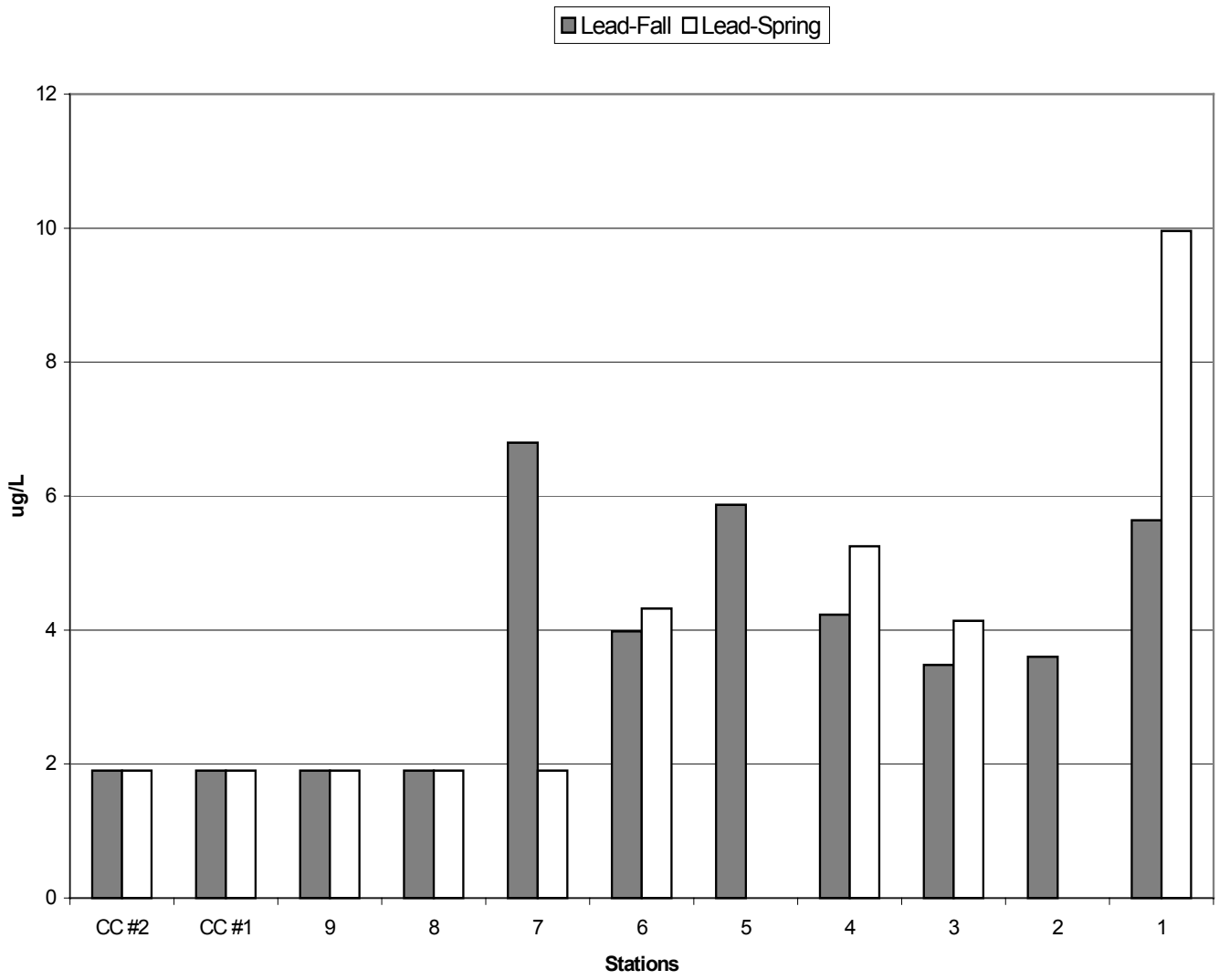


Figure 6: Dissolved zinc concentrations per station

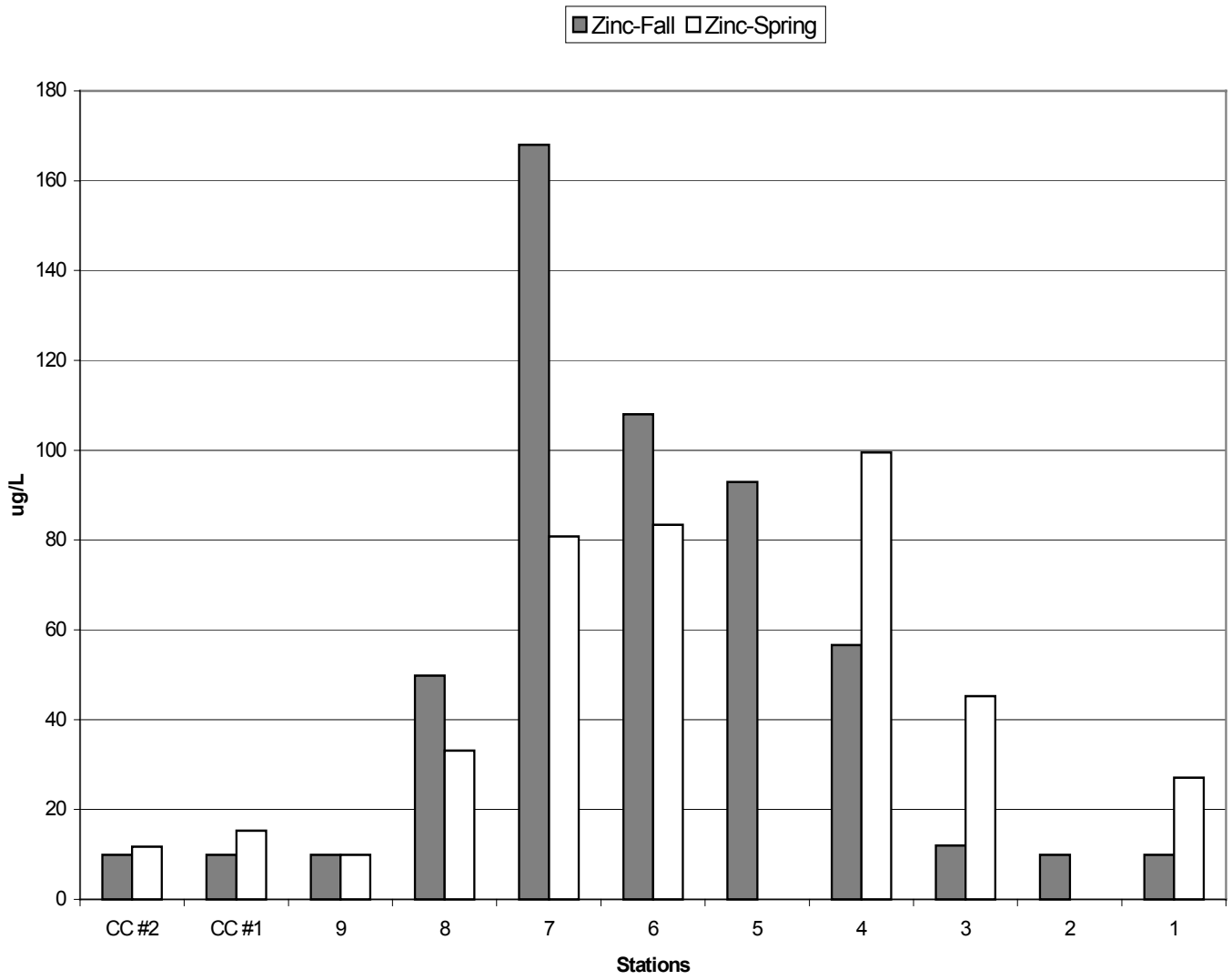


Figure 7: Big River and Courtois Creek (CC) percent fine sediment per station

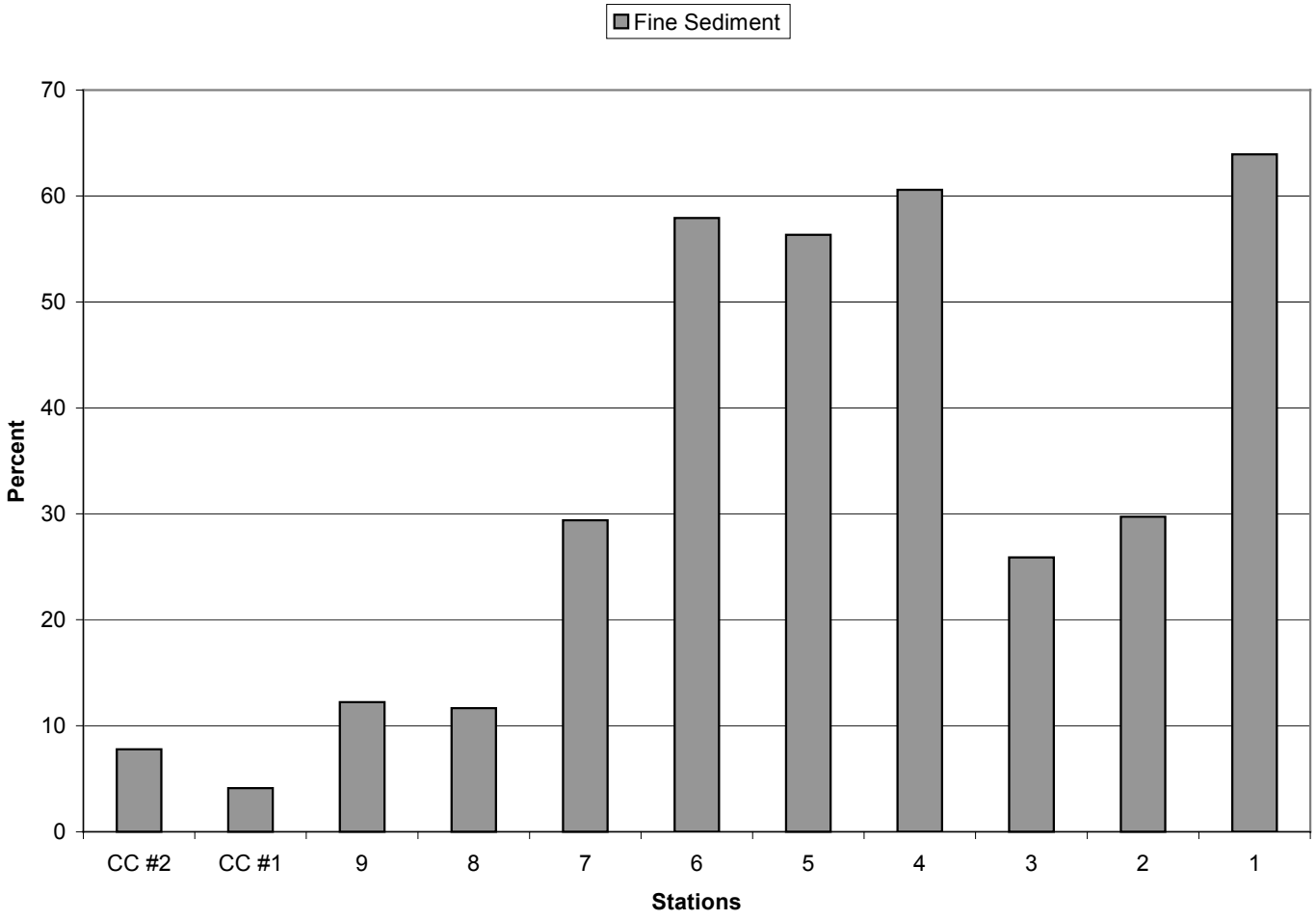
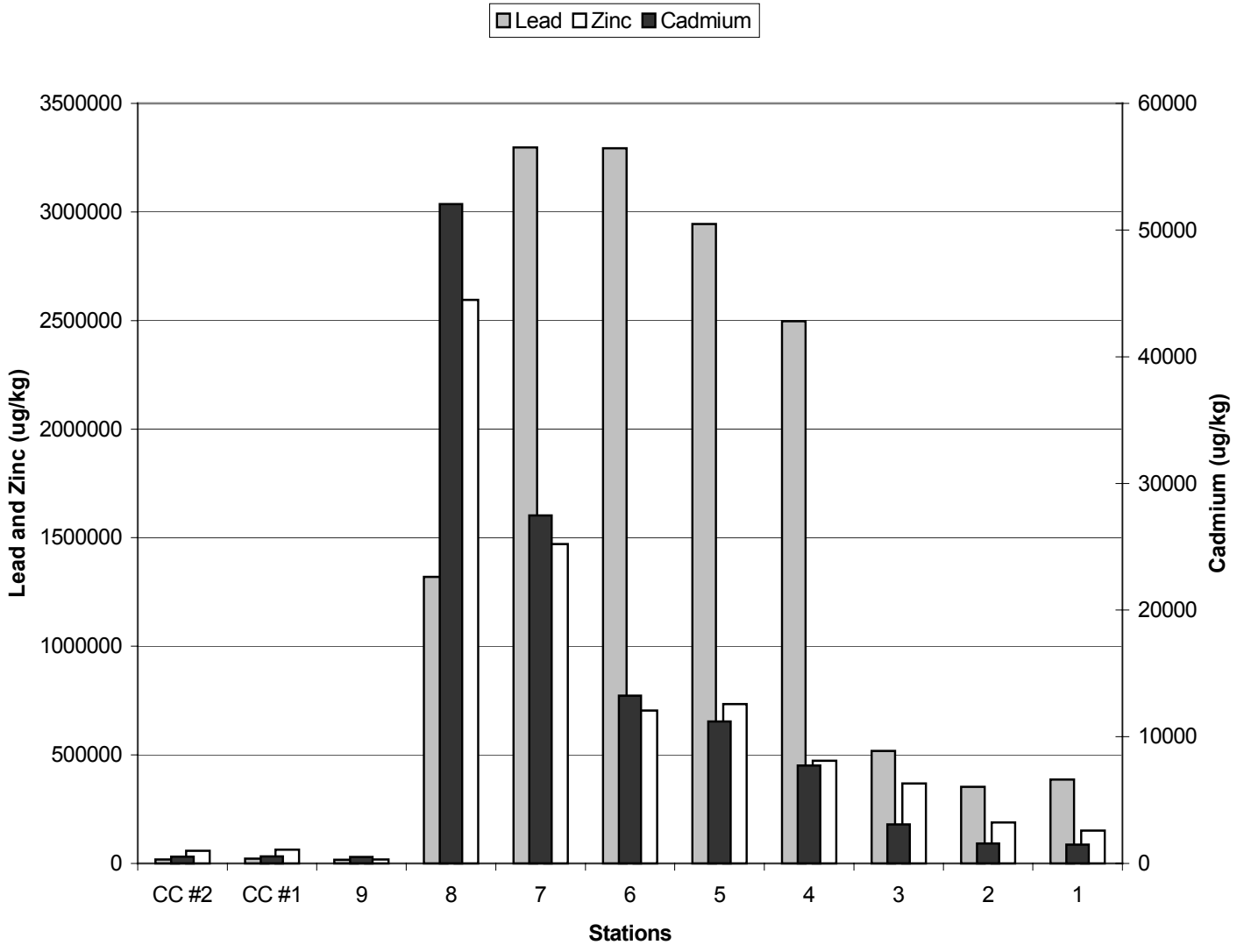


Figure 8: Big River and Courtois Creek (CC) sediment metals character per station



Submitted by: _____ _____

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Water Quality Monitoring Section	Water Quality Monitoring Section
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Date: _____

Approved by: _____

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c: John Ford, QAPP Project Manager, WPP

Appendix A

Missouri Department of Natural Resources Bioassessment and Sediment Study Proposal for Lower Big River, Washington, St. Francois, and Jefferson Counties, July 23, 2002

Missouri Department of Natural Resources
Bioassessment and Sediment Study Proposal for
Lower Big River, Washington, St. Francois, and Jefferson Counties

July 23, 2002

Purpose

The purpose is to determine if Big River in Washington, St. Francois, and Jefferson counties is impaired by mine-influences.

Objectives

1) Determine if the macroinvertebrate community and water quality is affected by mining influences.

2) Determine if fine sediment and heavy metals are present in Big River and determine their origin.

3) Describe habitat influences on Big River.

Tasks

1) Conduct a bioassessment on Big River, Washington, St. Francois, and Jefferson Counties, a TMDL 303 (d) listed stream, and a similar size class reference stream, Courtois Creek.

2) Conduct a fine sediment assessment and characterization study on Big River.

1) Conduct a habitat assessment on Flat River.

Null Hypotheses

Macroinvertebrate metrics, and biological communities will meet criteria similar to those of reference streams of the Meramec Ecological Drainage Unit (EDU).

Water quality is similar between control and test stations, as well as between Big River and the reference streams.

No significant difference ($p > 0.05$) in the sediment percentage estimates between control and test sites, as well as between Big River and the similar size reference stream.

Habitat quality will be similar from upstream to downstream, and between Big River and the similar size reference stream.

Background

Approximately 80 miles of Big River, Washington County is 303 (d) listed for excessive fine sediment deposition, high lead and zinc values. Water runoff during rain events is known to erode mine wastes that have apparently increased fine sedimentation in some lower portions of Big River. Metals such as copper, iron, lead, and zinc have been detected in aquatic fauna in areas of Big River. At least two types of mining in the Big River watershed may have contributed these potential threats.

Tailings piles from past lead mining in the upstream area of St. Francois County may or may not influence Big River. Upstream are three groups of lead-mine tailings piles, near Leadwood, Desloge, and the Flat River complex, (Elvins, National and Federal tailings piles) that may influence the river. Fine sediment has been observed downstream from tailings piles. Lead and zinc have been detected in aquatic macroinvertebrates and fish in lower Big River, which suggests that these elements were found in Big River.

Barite strip mines predominate in the Big River watershed in Washington County below St. Francois State Park. In 1975, failure of a barite settling basin dam resulted in a massive release of tailings in Mill Creek, a tributary of Big River, and impaired the macroinvertebrate and fish communities in Big River (Duchrow 1978). It is not known if the barite strip-mines continue to deliver fine sediments to the stream substrate.

It is our intention to determine if Big River in Washington, St. Francois, and Jefferson counties is impaired by mine-influences. To do this, a bioassessment and fine sediment assessment study will be conducted testing: 1) upstream to downstream; 2) between Big River and regional reference streams; 3) substrate percentage and character between Big River and a similar size class reference stream.

Study Methods

General: The study area is approximately 50 miles of Big River in Washington, St. Francois, and Jefferson Counties. The upstream boundary is north of Irondale, Missouri while its downstream boundary is the downstream edge of Washington State Park, Washington County (Figure 1). Boundaries were delineated to identify threats and extent of impacts, if any are present.

Nine stations will be sampled within the study area on Big River (Figure 1; Table 1). Each station consists of a length of twenty-times the stream's average width, with at least two riffle reaches, as outlined in MDNR-FSS-030. One station will be upstream from all known mining influences (i.e. Control Station). The eight remaining stations (i.e. Test Stations) will bracket mine influences to Big River. The control stream may be compared to the test stations, upstream to downstream. The eight test stations may be compared to regional reference streams for biometrics, physicochemical water, habitat assessments, and fine sediment percentage and characteristics.

The eight test stations may also be compared to a similar size class reference stream, chosen to identify substrate size class characteristics of larger stream substrates. The two minimally impacted stations for these references are on Courtois Creek (Table 1). These stations are within the same Ecological Drainage Unit (EDU), and are apparently minimally impacted by mining influences, although mining exists in its headwaters. Biological communities, habitat sampling, physicochemical water quality, as well as sediment percentage and characteristics may be compared between Big River Stations and Courtois Creek.

Sampling will occur in the Fall of 2002, between September 15 and October 15, 2002. Big River and Courtois Creek will be sampled during the same period.

Bioassessment: Macroinvertebrates will be sampled according to MDNR- Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (SMSBPP). Big River, Washington County is considered a "Riffle/Pool" predominant stream and habitats will be sampled accordingly. Coarse substrate habitat will be sampled due to the size of the stream. Metrics generated will be compared to regional reference streams in the Meramec Ecological Drainage Unit (EDU), which includes regional reference streams, as well as the similar size class reference stream.

Habitat Sampling: Stream flow and discharge will be measured using a Marsh-McBirney Flow Meter at all stations. Stream habitat assessments will also be conducted within the study area in accordance with MDNR Stream Habitat Assessment Project Procedure (SHAPP).

Physicochemical Water Sampling: Water samples will be collected for identification of dissolved metals and nutrients from nine Big River and two Courtois Creek stations. A one-liter (L) sample will be collected for barium, cadmium, copper, iron, lead, zinc, calcium, magnesium, and hardness analysis. This water will be filtered through a 0.45 micron filter and preserved with nitric acid in the field. A second sample (1 L) will be collected for sulfate, and chloride analysis. A third sample (1 L) will be collected for Total Kjeldahl Nitrogen (TKN), ammonia-nitrogen, nitrite plus nitrate nitrogen, and total phosphorus and preserved with sulfuric acid. In addition, two (2) 20 ml samples will be collected to measure turbidity. All samples will be kept on ice until they are delivered to the MDNR-Environmental Services Program (ESP), Chemical and Analytical Section (CAS), in Jefferson City, Missouri.

Dissolved oxygen, pH, conductivity, and temperature will be measured in stream once at the nine stations on Big River, as well as the two stations on Courtois Creek.

Fine Sediment Percentage and Characterization: To ensure sampling method uniformity, depositional areas sampled will be in-stream at the upper margins of pools and lower margins of course substrate (i.e. riffle/run) habitat. Depths of the sample areas will not exceed two (2.0) feet and water velocity will be less than 0.5 feet per second (fps). A Marsh McBirney flow meter will be used to ensure that water velocity of the sample area is within this range.

In-stream deposits of fine sediment (i.e. less than particle size ca. 2mm= sand) will be: 1) estimated for percent coverage per area and, 2) characterized by chemical analysis for total recoverable metals content (TRM).

A visual method will be used to estimate the percentage of fine sediment on the substrate within each station. Each sampling station shall be composed of three sample areas (i.e. grids) each consisting of six contiguous transects across the stream. A tape measure will be stretched from bank to bank at each transect. One sample quadrat (ca. 10 x 10 inches) will be placed directly on the substrate within each of the six transects using a random number that equates to one foot increments. The trailing edge of the quadrat will be placed on the random foot increment. Two investigators will estimate the percentage of the stream bottom covered by fine sediment within each quadrat. If the estimated percentages are within ten percent between investigators it will be accepted. If estimates diverge more than ten percent, the investigators will repeat the process until the estimates are within the acceptable margin of error. An average of these two estimates will be recorded and used for analysis.

Sediment will be characterized by determining the metals content of total recoverable metals (TRM- ug/kg) at each of the transect-grids. Specifically, sediments will be analyzed for lead and zinc content. Composite collections of sediments will be taken within each transect-grid used for fine sediment percentage estimation per area of the substrate. If there is not sufficient quantity of fine sediment within the grid (ca. 6 oz.), a representative sample will be collected from an area near the study grid. Each composite will consist of three (3) two-ounce grab samples of sediment. One (1) two-ounce glass jar will be used as a collection device to dredge the bottom to a depth within the sediment of no more than two inches. The sediment sample will be retained for transport through the water column by covering the opening with the back of the cap. Each sample will be deposited into an eight-ounce glass jar comprising a composite for each transect-grid. There will be three transect-grids per station in order to more accurately characterize and lessen potential bias. Each composite jar will be placed on ice for transport to the ESP Lab according to SOP, MDNR-FSS-001.

Laboratory Methods: Analyses of biological and chemical samples will be conducted at the MDNR Environmental Laboratory (ESP) in Jefferson City, Missouri. Biological samples will be processed and identified according to MDNR-FSS-209 Taxonomic Levels for Macroinvertebrate Identifications. The MDNR Environmental Laboratory- ESP will conduct water quality analysis for dissolved metals, as well as for Total Recoverable Metals (TRM, ug/kg) analysis on the sediment samples. Turbidity will be quantified in the Biology/Toxicology Lab at ESP.

Data Analysis: Macroinvertebrate data will be entered in a Microsoft Access database according to the MDNR Standard Operating Procedure MDNR-WQMS-214, Quality Control Procedures for Data Processing. Data analysis is automated within the Access database. Four standard metrics are calculated according to the Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (SMSBPP): Total Taxa (TT); Ephemeroptera, Plecoptera, Trichoptera Taxa (EPTT); Biotic Index; and the Shannon Diversity Index (SDI) will be calculated for each station. Additional metrics such as the Quantitative Similarity Index for Taxa (QSIT)percent Similarity of Taxa, may be employed to discern differences in taxa between control and test stations. Macroinvertebrate data from reference streams within the Meramec EDU will allow for the calculation of a 25th percentile for the four metrics in the SMSBPP. Big River will be scored against these calculations and a composite score of 16 or greater will determine non-impairment. The biological community composition will also be compared

between control and test stations, as well as between Big River and the two reference stations on Courtois Creek.

Physicochemical water variables will be analyzed to identify sources and threats to the aquatic community. Variables from the control, and the reference stations will be compared to test stations on Big River. This will be done by parametric comparisons of means, correlation, or non-parametric methods at a significant probability level ($p < 0.05$).

The percentage of fine sediment deposition will be compared between control and test stations or between grids. Additionally, Big River fine sediment deposition will be compared to the similar size class reference stream. This will be done by parametric comparisons of means, correlation, or non-parametric methods at a significant probability level ($p < 0.05$).

Character will be qualitatively compared between controls and downstream test stations, as well as between streams. Analysis of samples may identify its source and potential threats from metals contamination.

Habitats assessments will be compared between control and test stations, as well as between streams.

Ordination of communities with multiple linear regression may be used in conjunction with the biological community, habitat assessment, water quality variables, sediment percentages, as well as character of sediments in order to correlate with environmental variables.

Data Reporting: A report will be written for the Water Pollution Control Program (WPCP), which outlines and interprets the results of the study.

Quality Controls: As stated in the various MDNR Project Procedures and Standard Operating Procedures.

Attachments:
Table 1: Station Number, Legal and Descriptive Information for Big River and Regional Reference Stream, September 2002.

Figure 1: Lower Big River, Washington, St. Francois, and Jefferson Counties Sampling Stations, 2002

Table 1
Stream Name, Station Number, Legal and Descriptive Information for Big River and Regional Reference Stream, September 2002.

Stream- Station Number	Location- Section or Survey, Township, Range	Description	County
Big River # 9	S15, T36NR3E	Control- Upstream All; Irondale	Washington
Big River # 8	S3, T36NR4E	Test- Downstream Leadwood; Leadwood CA	St. Francois
Big River # 7	Surv. 80, T37NR5E	Test- Downstream Desloge; 67 Above Flat River	St. Francois
Big River # 6	Surv. 84, T37NR5E	Test- Downstream Flat River; 67 Below Flat River	St. Francois
Big River # 5	Survs. 72, 2047, T37NR5E	Test- Upstream Bonne Terre; Hwy. K	St. Francois
Big River # 4	Surv. 2110, T38NR4E	Test- Downstream Bonne Terre; St. Francois SP	St. Francois
Big River # 3	S17, T38NR4E	Test- Upstream Mill Creek; Private/ Coles Landing	Jefferson
Big River # 2	S5, T38NR4E	Test- Downstream Mill Creek; Blackwell CA (MDC)	Jefferson
Big River # 1	S23, T39NR3E	Test- Downstream All; Washington SP	Washington
Courtois Creek #2	S13, T38NR2W	Similar Size Reference	Crawford
Courtois Creek #1	S12, T38NR3W	Similar Size Reference	Crawford

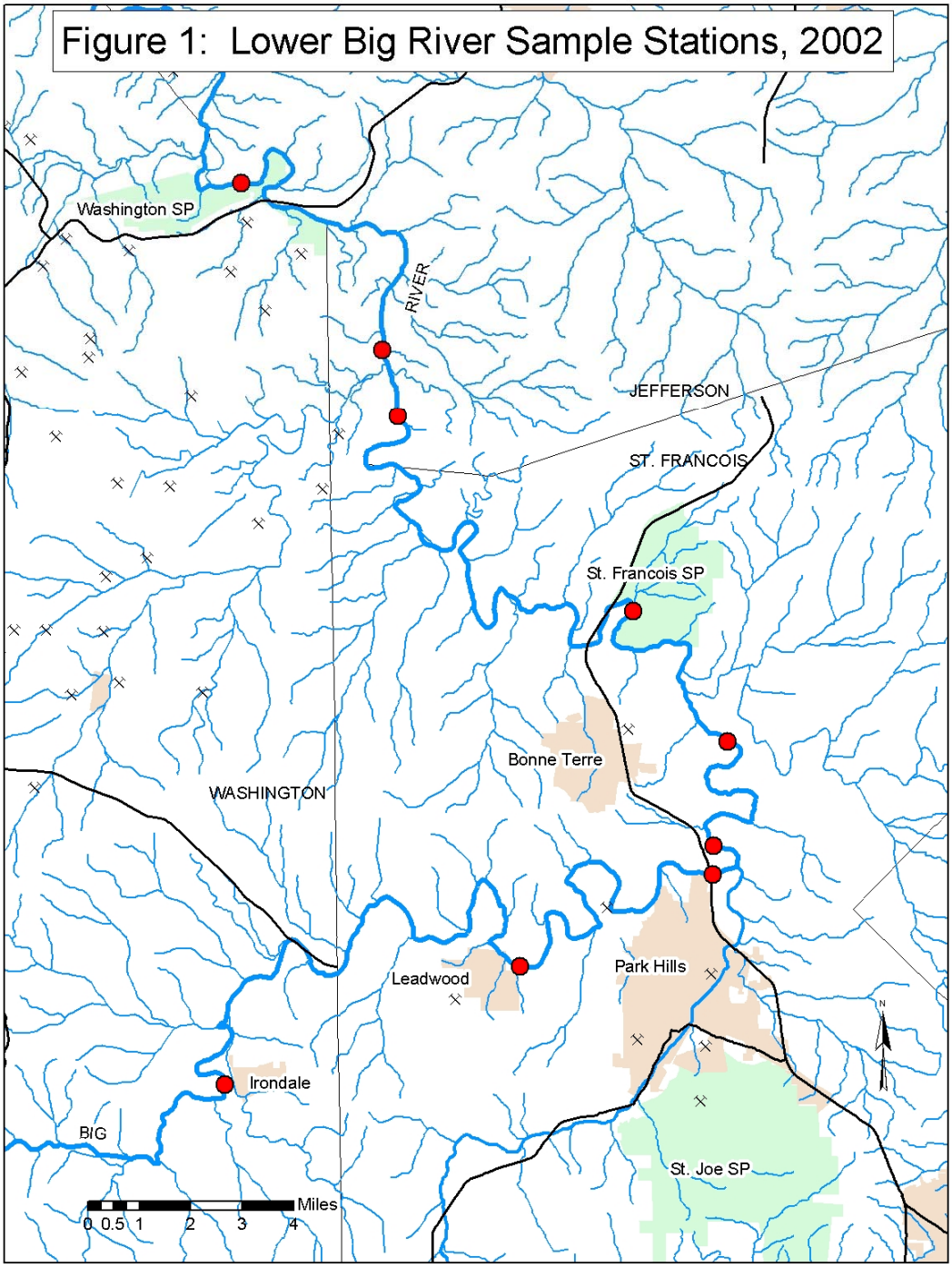
Figure 1: Lower Big River Sample Stations, 2002
Washington SP
RIVER
JEFFERSON
ST. FRANCOIS
St. Francois SP
Bonne Terre
WASHINGTON
Leadwood
Park Hills
Irondale
BIG
St. Joe SP
Miles
0 0.5 1 2 3 4

Appendix B

Macroinvertebrate Bench Sheets for Big River and Courtois Creek Stations,
Fall 2002-Spring 2003

Aquatic Invertebrate Database Bench Sheet Report
October 2, 2002 - Big R [0218084], Station #9

ORDER (Taxa)	CS	RM	SG	NF
"HYDRACARINA"				
Acarina	10			
COLEOPTERA				
Psephenus herricki	6			
Stenelmis	37			
DECAPODA				
Orconectes luteus	-99			
Orconectes medius	-99			
DIPTERA				
Simulium	1			
Nilotanypus	1			
Cricotopus bicinctus	1			
Cricotopus/Orthocladius	7			
Thienemanniella	2			
Polypedilum convictum grp	3			
Rheotanytarsus	6			
Tanytarsus	5			
Thienemannimyia grp.	2			
Cardiocladius	1			
EPHEMEROPTERA				
Acentrella	3			
Plauditus	1			
Baetis	49			
Isonychia bicolor	42			
Heptageniidae	40			
Stenacron	3			
Stenonema femoratum	1			
Stenonema mediopunctatum	57			
Stenonema pulchellum	6			
Tricorythodes	181			
Caenis anceps	43			
Caenis latipennis	1			
Baetiscidae	4			
LUMBRICINA				
Lumbricidae	1			
MEGALOPTERA				
Corydalus	-99			
MESOGASTROPODA				
Elimia	2			
ODONATA				
Hetaerina	1			
Argia	3			
Stylogomphus albistylus	1			
TRICHOPTERA				
Chimarra	25			
Oxyethira	1			
Helicopsyche	3			
VENEROIDEA				
Corbicula	10			

Aquatic Invertebrate Database Bench Sheet Report
October 1, 2002 - Big R [0218083], Station #8

ORDER (Taxa)	CS	RM	SG	NF
"HYDRACARINA"				
Acarina	63			
COLEOPTERA				
Ectopria nervosa	1			
Stenelmis	148			
DIPTERA				
Tipula	-99			
Simulium	1			
Cricotopus bicinctus	1			
Cricotopus/Orthocladius	29			
Stenochironomus	1			
Polypedilum illinoense grp	1			
Cladotanytarsus	1			
Rheotanytarsus	10			
Tanytarsus	6			
Tabanus	-99			
Atherix	-99			
Thienemannimyia grp.	1			
Cardiocladius	1			
EPHEMEROPTERA				
Acentrella	1			
Baetis	2			
Isonychia bicolor	12			
Heptageniidae	19			
Leucrocuta	1			
Stenonema femoratum	1			
Stenonema mediopunctatum	10			
Stenonema pulchellum	21			
Tricorythodes	286			
LUMBRICINA				
Lumbricidae	6			
MEGALOPTERA				
Corydalus	1			
ODONATA				
Argia	5			
TRICHOPTERA				
Chimarra	12			
Cheumatopsyche	22			
VENEROIDEA				
Corbicula	1			

Aquatic Invertebrate Database Bench Sheet Report
September 26, 2002 - Big R [0218131], Station #7

ORDER (Taxa)	CS	RM	SG	NF
"HYDRACARINA"				
Acarina	5			
COLEOPTERA				
Dubiraphia	1			
Stenelmis	3			
DIPTERA				
Simulium	3			
Nilotanypus	2			
Cricotopus bicinctus	2			
Cricotopus/Orthocladius	61			
Nanocladius	2			
Thienemanniella	1			
Dicrotendipes	2			
Cladotanytarsus	2			
Rheotanytarsus	1			
Stempellinella	12			
Tanytarsus	14			
Hemerodromia	3			
Thienemannimyia grp.	2			
EPHEMEROPTERA				
Isonychia	1			
Tricorythodes	144			
Baetiscidae	1			
LUMBRICINA				
Lumbricidae	1			
LUMBRICULIDA				
Lumbriculidae	-99			
MEGALOPTERA				
Corydalus	-99			
ODONATA				
Argia	3			
Stylogomphus albistylus	-99			
TRICHOPTERA				
Chimarra	-99			
Polycentropodidae	1			
Cheumatopsyche	5			
Nectopsyche	1			
Oecetis	2			

Aquatic Invertebrate Database Bench Sheet Report
September 24, 2002 - Big R [0218129], Station #6

ORDER (Taxa)	CS	RM	SG	NF
"HYDRACARINA"				
Acarina	4			
COLEOPTERA				
Berosus	1			
Dubiraphia	5			
Microcylloepus pusillus	1			
Stenelmis	1			
DIPTERA				
Ceratopogoninae	1			
Simulium	27			
Nilotanypus	1			
Cricotopus bicinctus	16			
Cricotopus/Orthocladius	78			
Parakiefferiella	1			
Thienemanniella	1			
Dicrotendipes	3			
Polypedilum convictum grp	1			
Pseudochironomus	1			
Cladotanytarsus	1			
Rheotanytarsus	40			
Stempellinella	2			
Tanytarsus	6			
Tabanus	-99			
Atherix	1			
Hemerodromia	6			
Thienemannimyia grp.	2			
Cardiocladius	11			
Epoicocladius	1			
EPHEMEROPTERA				
Stenonema femoratum	4			
Stenonema mediopunctatum	1			
Tricorythodes	370			
LEPIDOPTERA				
Petrophila	1			
LUMBRICINA				
Lumbricidae	1			
MEGALOPTERA				
Corydalus	-99			
ODONATA				
Hetaerina	1			
Argia	1			
TRICHOPTERA				
Chimarra	1			
Polycentropodidae	1			
Cheumatopsyche	44			
Hydropsyche	1			

Aquatic Invertebrate Database Bench Sheet Report
September 25, 2002 - Big R [0218130], Station #5

ORDER (Taxa)	CS	RM	SG	NF
"HYDRACARINA"				
Acarina	2			
COLEOPTERA				
Hydrophilidae	1			
Berosus	1			
Stenelmis	1			
DIPTERA				
Simulium	1			
Nilotanypus	1			
Cricotopus bicinctus	5			
Cricotopus/Orthocladius	16			
Parakiefferiella	1			
Dicrotendipes	2			
Stenochironomus	1			
Cladotanytarsus	7			
Stempellinella	3			
Tanytarsus	8			
Hemerodromia	8			
Thienemannimyia grp.	1			
Labrundinia	1			
EPHEMEROPTERA				
Procloeon	1			
Tricorythodes	562			
Baetiscidae	1			
MEGALOPTERA				
Corydalus	2			
ODONATA				
Gomphidae	1			
Progomphus obscurus	1			
Macromia	-99			
TRICHOPTERA				
Cheumatopsyche	6			
Nectopsyche	1			
Oecetis	1			

Aquatic Invertebrate Database Bench Sheet Report
September 26, 2002 - Big R [0218132], Station #4

ORDER (Taxa)	CS	RM	SG	NF
"HYDRACARINA"				
Acarina	4			
COLEOPTERA				
Hydrophilidae	1			
Macronychus glabratus	1			
Stenelmis	18			
DIPTERA				
Dasyheleinae	2			
Cricotopus/Orthocladius	3			
Polypedilum convictum grp	1			
Polypedilum illinoense grp	1			
Cladotanytarsus	2			
Tanytarsus	1			
Hemerodromia	1			
Thienemannimyia grp.	1			
EPHEMEROPTERA				
Tricorythodes	525			
Baetiscidae	1			
LIMNOPHILA				
Physella	1			
TRICHOPTERA				
Cheumatopsyche	3			
Oecetis	3			

Aquatic Invertebrate Database Bench Sheet Report
October 2, 2002 - Big R [0218134], Station #3

ORDER (Taxa)	CS	RM	SG	NF
"HYDRACARINA"				
Acarina	7			
COLEOPTERA				
Stenelmis	8			
DIPTERA				
Simulium	2			
Cricotopus bicinctus	5			
Cricotopus/Orthocladius	11			
Thienemanniella	1			
Polypedilum	1			
Polypedilum convictum grp	2			
Saetheria	1			
Polypedilum illinoense grp	1			
Rheotanytarsus	2			
Stempellinella	1			
Tanytarsus	17			
EPHEMEROPTERA				
Acentrella	5			
Isonychia bicolor	4			
Stenonema pulchellum	6			
Tricorythodes	898			
Baetiscidae	2			
LIMNOPHILA				
Ancylidae	1			
MEGALOPTERA				
Corydalus	1			
TRICHOPTERA				
Chimarra	-99			
Cheumatopsyche	13			
Oecetis	5			
VENEROIDEA				
Corbicula	6			

Aquatic Invertebrate Database Bench Sheet Report
October 3, 2002 - Big R [0218135], Station #2

ORDER (Taxa)	CS	RM	SG	NF
"HYDRACARINA"				
Acarina	6			
COLEOPTERA				
Berosus	1			
Dubiraphia	2			
Stenelmis	7			
DECAPODA				
Orconectes luteus	-99			
DIPTERA				
Ceratopogoninae	1			
Simulium	4			
Cricotopus trifascia	5			
Cricotopus bicinctus	7			
Cricotopus/Orthocladius	5			
Thienemanniella	1			
Cryptochironomus	1			
Rheotanytarsus	1			
Tanytarsus	11			
Hemerodromia	1			
EPHEMEROPTERA				
Acentrella	11			
Baetis	1			
Isonychia	5			
Heptageniidae	11			
Stenonema femoratum	3			
Stenonema pulchellum	13			
Tricorythodes	511			
Caenis anceps	4			
Caenis latipennis	1			
Baetiscidae	4			
LIMNOPHILA				
Ancylidae	1			
MEGALOPTERA				
Corydalus	-99			
ODONATA				
Argia	2			
Gomphidae	5			
TRICHOPTERA				
Cheumatopsyche	7			
Hydroptila	8			
Nectopsyche	1			
Oecetis	9			
VENEROIDEA				
Sphaerium	1			
Corbicula	-99			

Aquatic Invertebrate Database Bench Sheet Report
October 1, 2002 - Big R [0218133], Station #1

ORDER (Taxa)	CS	RM	SG	NF
"HYDRACARINA"				
Acarina	1			
COLEOPTERA				
Dubiraphia	1			
Stenelmis	9			
DIPTERA				
Simulium	4			
Cricotopus trifascia	8			
Cricotopus bicinctus	7			
Cricotopus/Orthocladius	13			
Thienemanniella	7			
Polypedilum convictum grp	1			
Polypedilum illinoense grp	2			
Rheotanytarsus	2			
Tanytarsus	11			
Hemerodromia	1			
EPHEMEROPTERA				
Acentrella	16			
Baetis	3			
Isonychia bicolor	6			
Heptageniidae	22			
Stenonema mediopunctatum	-99			
Stenonema pulchellum	27			
Tricorythodes	400			
Caenis anceps	3			
Caenis latipennis	1			
Baetiscidae	4			
LEPIDOPTERA				
Noctuidae	-99			
LUMBRICINA				
Lumbricidae	1			
MEGALOPTERA				
Corydalus	-99			
ODONATA				
Hetaerina	1			
Stylogomphus albistylus	1			
TRICHOPTERA				
Chimarra	1			
Cheumatopsyche	8			
Hydroptila	13			
Nectopsyche	3			
Oecetis	1			
VENEROIDEA				
Corbicula	3			

Aquatic Invertebrate Database Bench Sheet Report
October 8, 2002 - Courtois Ck [0218136], Station #2a

ORDER (Taxa)	CS	RM	SG	NF
"HYDRACARINA"				
Acarina	7			
COLEOPTERA				
Psephenus herricki	2			
Ectopria nervosa	2			
Optioservus sandersoni	23			
Stenelmis	36			
DECAPODA				
Orconectes medius	-99			
Orconectes virilis	-99			
DIPTERA				
Simulium	2			
Cricotopus/Orthocladius	1			
Thienemanniella	1			
Synorthocladius	1			
Rheotanytarsus	4			
Sublettea	2			
Tabanus	-99			
EPHEMEROPTERA				
Acentrella	1			
Baetis	42			
Isonychia bicolor	137			
Heptageniidae	37			
Stenonema mediopunctatum	120			
Stenonema pulchellum	2			
Tricorythodes	296			
Caenis anceps	1			
Caenis latipennis	1			
Baetiscidae	2			
LEPIDOPTERA				
Petrophila	1			
LIMNOPHILA				
Ancylidae	1			
MEGALOPTERA				
Corydalus	-99			
MESOGASTROPODA				
Elimia	31			
ODONATA				
Argia	-99			
PLECOPTERA				
Pteronarcys pictetii	1			
TRICHOPTERA				
Chimarra	3			
Psychomyia	2			
Cheumatopsyche	3			
Oecetis	2			
TRICLADIDA				
Planariidae	2			
VENEROIDEA				

ORDER (Taxa)	CS	RM	SG	NF
Corbicula	8			

Aquatic Invertebrate Database Bench Sheet Report
October 8, 2002 - Courtois Ck [0218137], Station #2b

ORDER (Taxa)	CS	RM	SG	NF
"HYDRACARINA"				
Acarina	37			
COLEOPTERA				
Psephenus herricki	1			
Optioservus sandersoni	21			
Stenelmis	66			
DECAPODA				
Orconectes medius	1			
DIPTERA				
Simulium	8			
Cricotopus/Orthocladius	1			
Thienemanniella	2			
Rheotanytarsus	5			
Tanytarsus	1			
Sublettea	4			
Cardiocladius	1			
EPHEMEROPTERA				
Acentrella	6			
Baetis	38			
Isonychia bicolor	106			
Heptageniidae	35			
Leucrocuta	1			
Stenacron	1			
Stenonema bednariki	1			
Stenonema mediopunctatum	90			
Stenonema pulchellum	6			
Eurylophella	2			
Tricorythodes	361			
Baetiscidae	4			
LIMNOPHILA				
Ferrissia	2			
LUMBRICINA				
Lumbricidae	2			
MEGALOPTERA				
Corydalus	1			
MESOGASTROPODA				
Elimia	22			
ODONATA				
Argia	1			
Stylogomphus albistylus	1			
PLECOPTERA				
Pteronarcys pictetii	1			
TRICHOPTERA				
Cheumatopsyche	5			
Helicopsyche	1			
Oecetis	1			
VENEROIDEA				
Corbicula	14			

Aquatic Invertebrate Database Bench Sheet Report
October 9, 2002 - Courtois Ck [0218138], Station #1

ORDER (Taxa)	CS	RM	SG	NF
"HYDRACARINA"				
Acarina	16			
AMPHIPODA				
Gammarus	1			
COLEOPTERA				
Psephenus herricki	1			
Stenelmis	117			
DIPTERA				
Dicranota	1			
Simulium	7			
Nilotanypus	1			
Cricotopus/Orthocladius	3			
Rheocricotopus	3			
Thienemanniella	3			
Dicrotendipes	1			
Polypedilum convictum grp	3			
Rheotanytarsus	9			
Stempellinella	1			
Sublettea	4			
Thienemannimyia grp.	1			
Cardiocladius	1			
EPHEMEROPTERA				
Acentrella	2			
Plauditus	6			
Baetis	15			
Isonychia bicolor	101			
Heptageniidae	70			
Leucrocuta	4			
Stenacron	11			
Stenonema bednariki	3			
Stenonema mediopunctatum	95			
Stenonema pulchellum	3			
Eurylophella	4			
Tricorythodes	64			
Caenidae	9			
Caenis latipennis	1			
LIMNOPHILA				
Ancylidae	3			
LUMBRICINA				
Lumbricidae	-99			
MESOGASTROPODA				
Elimia	48			
ODONATA				
Argia	2			
Gomphidae	1			
PLECOPTERA				
Amphinemura	2			
Pteronarcys pictetii	1			
TRICHOPTERA				

ORDER (Taxa)	CS	RM	SG	NF
Chimarra	1			
Psychomyia	4			
Helicopsyche	3			
Oecetis	4			
TRICLADIDA				
Planariidae	1			
VENEROIDEA				
Sphaerium	5			

Aquatic Invertebrate Database Bench Sheet Report
April 2, 2003 - Big R [0318665], Station #9

ORDER (Taxa)	CS	RM	SG	NF
"HYDRACARINA"				
Acarina	29			
COLEOPTERA				
Psephenus herricki	1			
Dubiraphia	1			
Microcylloepus pusillus	1			
Stenelmis	45			
DIPTERA				
Ceratopogoninae	1			
Simulium	15			
Ablabesmyia	1			
Nilotanypus	1			
Cricotopus trifascia	1			
Cricotopus bicinctus	2			
Corynoneura	1			
Cricotopus/Orthocladius	43			
Eukiefferiella	31			
Orthocladius (Euorthocladius)	2			
Nanocladius	4			
Parametriocnemus	1			
Rheocricotopus	1			
Hydrobaenus	1			
Thienemanniella	2			
Cryptochironomus	2			
Cryptotendipes	1			
Polypedilum convictum grp	6			
Cladotanytarsus	13			
Rheotanytarsus	27			
Stempellinella	11			
Tanytarsus	67			
Tabanus	1			
Hemerodromia	1			
Clinocera	8			
Thienemannimyia grp.	3			
Labrundinia	1			
EPHEMEROPTERA				
Acentrella	49			
Isonychia bicolor	3			
Heptageniidae	9			
Stenacron	2			
Stenonema femoratum	3			
Stenonema mediopunctatum	15			
Stenonema pulchellum	2			
Stenonema terminatum	2			
Ephemerellidae	2			
Ephemerella needhami	6			
Tricorythodes	24			
Caenis anceps	16			
Caenis latipennis	30			

ORDER (Taxa)	CS	RM	SG	NF
Baetisca lacustris	1			
LIMNOPHILA				
Laevapex	1			
LUMBRICULIDA				
Lumbriculidae	-99			
ODONATA				
Stylogomphus albistylus	4			
PLECOPTERA				
Leuctridae	3			
Amphinemura	13			
Neoperla	5			
Perlesta	21			
Perlinella ephyre	1			
TRICHOPTERA				
Cheumatopsyche	1			
Hydroptila	4			
Nectopsyche	1			
Oecetis	1			
TRICLADIDA				
Planariidae	3			
TUBIFICIDA				
Tubificidae	1			
VENEROIDEA				
Corbicula	9			

Aquatic Invertebrate Database Bench Sheet Report
April 2, 2003 - Big R [0318666], Station #8

ORDER (Taxa)	CS	RM	SG	NF
"HYDRACARINA"				
Acarina	27			
ARHYNCHOBDELLIDA				
Erpobdellidae	-99			
COLEOPTERA				
Berosus	3			
Ectopria nervosa	2			
Dubiraphia	36			
Stenelmis	42			
DIPTERA				
Gonomyia	1			
Simulium	20			
Corynoneura	1			
Cricotopus/Orthocladius	121			
Eukiefferiella	31			
Nanocladius	4			
Parakiefferiella	1			
Parametriocnemus	2			
Rheocricotopus	1			
Thienemanniella	2			
Cryptochironomus	1			
Dicrotendipes	4			
Polypedilum convictum grp	4			
Polypedilum illinoense grp	1			
Pseudochironomus	8			
Cladotanytarsus	16			
Paratanytarsus	5			
Rheotanytarsus	34			
Stempellinella	10			
Tanytarsus	60			
Tabanus	1			
Hemerodromia	3			
Clinocera	8			
Zavrelimyia	1			
Thienemannimyia grp.	2			
Cardiocladius	2			
EPHEMEROPTERA				
Acentrella	17			
Isonychia	3			
Stenacron	3			
Stenonema mediopunctatum	6			
Stenonema terminatum	19			
Ephemerella needhami	6			
Tricorythodes	57			
Caenis latipennis	40			
Baetisca lacustris	1			
LUMBRICINA				
Lumbricidae	1			
MEGALOPTERA				

ORDER (Taxa)	CS	RM	SG	NF
Corydalus	2			
ODONATA				
Argia	6			
Gomphus	-99			
PLECOPTERA				
Amphinemura	12			
Perlesta	22			
Isoperla	1			
TRICHOPTERA				
Chimarra	1			
Cheumatopsyche	1			
Hydroptila	3			
Oxyethira	1			
Nectopsyche	2			
Triaenodes	1			
Oecetis	2			

Aquatic Invertebrate Database Bench Sheet Report
April 2, 2003 - Big R [0318667], Station #7

ORDER (Taxa)	CS	RM	SG	NF
"HYDRACARINA"				
Acarina	7			
COLEOPTERA				
Berosus	2			
Dubiraphia	5			
Stenelmis	2			
DIPTERA				
Ceratopogoninae	8			
Simulium	286			
Nilotanypus	8			
Cricotopus trifascia	3			
Cricotopus bicinctus	22			
Corynoneura	1			
Cricotopus/Orthocladius	93			
Eukiefferiella	6			
Nanocladius	2			
Thienemanniella	2			
Tvetenia	1			
Polypedilum convictum grp	3			
Pseudochironomus	3			
Cladotanytarsus	6			
Rheotanytarsus	25			
Stempellinella	9			
Tanytarsus	17			
Hemerodromia	5			
Clinocera	3			
Thienemannimyia grp.	1			
Cardiocladius	5			
EPHEMEROPTERA				
Heptageniidae	1			
Tricorythodes	23			
Caenis latipennis	1			
LEPIDOPTERA				
Petrophila	1			
LUMBRICINA				
Lumbricidae	1			
MEGALOPTERA				
Corydalus	1			
ODONATA				
Argia	1			
PLECOPTERA				
Amphinemura	4			
Prostoia	1			
Perlesta	15			
TRICHOPTERA				
Neureclipsis	1			
Cheumatopsyche	6			
Triaenodes	1			
Oecetis	2			

ORDER (Taxa)	CS	RM	SG	NF
TUBIFICIDA				
Tubificidae	1			

Aquatic Invertebrate Database Bench Sheet Report
April 2, 2003 - Big R [0318668], Station #6

ORDER (Taxa)	CS	RM	SG	NF
COLEOPTERA				
Berosus	1			
Dubiraphia	4			
Stenelmis	1			
DIPTERA				
Simulium	43			
Prosimulium	1			
Nilotanypus	3			
Cricotopus trifascia	1			
Cricotopus bicinctus	8			
Cricotopus/Orthocladius	31			
Eukiefferiella	1			
Orthocladius (Euorthocladius)	1			
Nanocladius	2			
Thienemanniella	1			
Robackia	1			
Polypedilum convictum grp	1			
Polypedilum illinoense grp	2			
Cladotanytarsus	1			
Rheotanytarsus	5			
Stempellinella	1			
Tanytarsus	4			
Tabanus	1			
Hemerodromia	4			
Clinocera	1			
Sympotthastia	1			
Cardiocladius	1			
Diptera	2			
EPHEMEROPTERA				
Tricorythodes	7			
Baetisca lacustris	1			
LUMBRICINA				
Lumbricidae	5			
PLECOPTERA				
Amphinemura	2			
Perlesta	6			
TRICHOPTERA				
Cheumatopsyche	1			
Nectopsyche	1			
TRICLADIDA				
Planariidae	3			
TUBIFICIDA				
Tubificidae	7			
Branchiura sowerbyi	4			

Aquatic Invertebrate Database Bench Sheet Report
April 2, 2003 - Big R [0318669], Station #4

ORDER (Taxa)	CS	RM	SG	NF
"HYDRACARINA"				
Acarina	9			
COLEOPTERA				
Ancyronyx variegatus	1			
Dubiraphia	2			
Macronychus glabratus	3			
Stenelmis	3			
DIPTERA				
Tipula	1			
Gonomyia	2			
Ormosia	1			
Ceratopogoninae	12			
Simulium	41			
Nilotanypus	1			
Cricotopus trifascia	1			
Cricotopus bicinctus	29			
Corynoneura	1			
Cricotopus/Orthocladius	31			
Nanocladius	1			
Robackia	10			
Polypedilum halterale grp	1			
Polypedilum convictum grp	3			
Polypedilum illinoense grp	3			
Polypedilum scalaenum grp	1			
Cladotanytarsus	11			
Rheotanytarsus	3			
Stempellinella	2			
Tanytarsus	14			
Hemerodromia	1			
Thienemannimyia grp.	1			
EPHEMEROPTERA				
Stenonema pulchellum	1			
Tricorythodes	72			
Caenis latipennis	11			
MEGALOPTERA				
Corydalus	1			
PLECOPTERA				
Perlesta	3			
TRICHOPTERA				
Cheumatopsyche	3			
TRICLADIDA				
Planariidae	1			
TUBIFICIDA				
Tubificidae	2			

Aquatic Invertebrate Database Bench Sheet Report
April 3, 2003 - Big R [0318670], Station #3

ORDER (Taxa)	CS	RM	SG	NF
"HYDRACARINA"				
Acarina	7			
COLEOPTERA				
Dineutus	1			
Berosus	2			
Dubiraphia	12			
Macronychus glabratus	3			
Stenelmis	13			
DECAPODA				
Orconectes luteus	1			
DIPTERA				
Simulium	149			
Prosimulium	6			
Cricotopus trifascia	11			
Cricotopus bicinctus	26			
Cricotopus/Orthocladius	44			
Robackia	1			
Polypedilum convictum grp	2			
Polypedilum fallax grp	1			
Polypedilum illinoense grp	1			
Pseudochironomus	1			
Micropsectra	2			
Paratanytarsus	1			
Rheotanytarsus	1			
Stempellinella	1			
Tanytarsus	30			
Hemerodromia	2			
Thienemannimyia grp.	1			
EPHEMEROPTERA				
Heptageniidae	2			
Tricorythodes	203			
Caenis latipennis	21			
Baetisca lacustris	7			
LUMBRICINA				
Lumbricidae	1			
ODONATA				
Macromia	1			
PLECOPTERA				
Amphinemura	1			
Perlesta	1			
TRICHOPTERA				
Cheumatopsyche	31			
Hydropsyche	9			
Hydroptila	5			
Nectopsyche	3			
Oecetis	3			
VENEROIDEA				
Corbicula	4			

Aquatic Invertebrate Database Bench Sheet Report
April 3, 2003 - Big R [0318671], Station #1

ORDER (Taxa)	CS	RM	SG	NF
"HYDRACARINA"				
Acarina	23			
COLEOPTERA				
Berosus	6			
Ancyronyx variegatus	1			
Dubiraphia	31			
Macronychus glabratus	1			
Stenelmis	6			
DIPTERA				
Gonomyia	2			
Ormosia	5			
Ceratopogoninae	5			
Simulium	33			
Prosimulium	1			
Cricotopus trifascia	22			
Cricotopus bicinctus	47			
Cricotopus/Orthocladius	72			
Orthocladius (Euorthocladius)	1			
Nanocladius	1			
Paraphaenocladius	1			
Rheocricotopus	1			
Thienemanniella	1			
Tvetenia	1			
Cryptochironomus	3			
Dicrotendipes	1			
Polypedilum convictum grp	3			
Polypedilum fallax grp	1			
Polypedilum illinoense grp	3			
Cladotanytarsus	29			
Paratanytarsus	2			
Rheotanytarsus	18			
Stempellinella	5			
Tanytarsus	116			
Hemerodromia	2			
Thienemannimyia grp.	1			
Labrundinia	1			
Diptera	2			
EPHEMEROPTERA				
Acentrella	1			
Stenonema pulchellum	20			
Stenonema terminatum	4			
Tricorythodes	83			
Caenis latipennis	23			
Baetisca lacustris	10			
LIMNOPHILA				
Fossaria	1			
LUMBRICINA				
Lumbricidae	4			
ODONATA				

ORDER (Taxa)	CS	RM	SG	NF
Hetaerina	-99			
Gomphus	1			
Macromia	1			
PLECOPTERA				
Strophopteryx	1			
Perlesta	2			
TRICHOPTERA				
Cheumatopsyche	12			
Hydropsyche	2			
Pycnopsyche	-99			
Nectopsyche	7			
TUBIFICIDA				
Tubificidae	3			
VENEROIDEA				
Sphaeriidae	3			

Aquatic Invertebrate Database Bench Sheet Report
April 3, 2003 - Courtois Ck [0318672], Station #2

ORDER (Taxa)	CS	RM	SG	NF
Branchiobdellida	4			
"HYDRACARINA"				
Acarina	58			
COLEOPTERA				
Psephenus herricki	1			
Dubiraphia	5			
Macronychus glabratus	2			
Optioservus sandersoni	2			
Stenelmis	6			
DECAPODA				
Orconectes medius	-99			
DIPTERA				
Tipula	1			
Ceratopogoninae	2			
Simulium	17			
Prosimulium	5			
Cricotopus bicinctus	3			
Cricotopus/Orthocladius	13			
Eukiefferiella	2			
Parametriocnemus	1			
Thienemanniella	2			
Synorthocladius	1			
Cryptochironomus	3			
Dicrotendipes	2			
Microtendipes	3			
Polypedilum convictum grp	20			
Polypedilum illinoense grp	3			
Cladotanytarsus	2			
Paratanytarsus	1			
Rheotanytarsus	16			
Stempellinella	6			
Tanytarsus	4			
Sublettea	26			
Xestochironomus	1			
Chrysops	-99			
Hemerodromia	11			
Clinocera	1			
Thienemannimyia grp.	1			
Cardiocladius	5			
Diptera	1			
EPHEMEROPTERA				
Siphlonurus	1			
Acentrella	5			
Isonychia bicolor	3			
Heptageniidae	12			
Stenacron	9			
Stenonema femoratum	4			
Stenonema mediopunctatum	23			

ORDER (Taxa)	CS	RM	SG	NF
Stenonema pulchellum	1			
Stenonema terminatum	13			
Ephemerella invaria	71			
Ephemerella needhami	37			
Tricorythodes	57			
Caenis latipennis	11			
Ephemera	1			
LIMNOPHILA				
Ancylidae	1			
LUMBRICINA				
Lumbricidae	2			
MEGALOPTERA				
Corydalus	1			
MESOGASTROPODA				
Hydrobiidae	1			
Elimia	21			
ODONATA				
Hetaerina	-99			
Argia	3			
Enallagma	1			
Stylogomphus albistylus	2			
PLECOPTERA				
Amphinemura	11			
Prostoia	1			
Perlesta	8			
Pteronarcys pictetii	7			
TRICHOPTERA				
Psychomyia	7			
Cheumatopsyche	2			
Rhyacophila	1			
Hydroptila	1			
Oxyethira	1			
Helicopsyche	4			
Nectopsyche	2			
Oecetis	1			
TUBIFICIDA				
Enchytraeidae	1			
VENEROIDEA				
Corbicula	16			

Aquatic Invertebrate Database Bench Sheet Report
April 3, 2003 - Courtois Ck [0318673], Station #1

ORDER (Taxa)	CS	RM	SG	NF
"HYDRACARINA"				
Acarina	29			
COLEOPTERA				
Psephenus herricki	-99			
Dubiraphia	2			
Stenelmis	93			
DIPTERA				
Dicranota	-99			
Ceratopogoninae	1			
Simulium	5			
Prosimulium	1			
Ablabesmyia	2			
Procladius	1			
Cricotopus trifascia	4			
Cricotopus bicinctus	3			
Cricotopus/Orthocladius	26			
Eukiefferiella	1			
Nanocladius	1			
Parametriocnemus	4			
Hydrobaenus	1			
Dicrotendipes	6			
Paracladopelma	1			
Microtendipes	2			
Polypedilum convictum grp	5			
Cladotanytarsus	2			
Paratanytarsus	4			
Rheotanytarsus	18			
Stempellinella	16			
Tanytarsus	43			
Sublettea	3			
Hemerodromia	3			
Clinocera	1			
Thienemannimyia grp.	24			
Cardiocladius	2			
EPHEMEROPTERA				
Acentrella	4			
Isonychia bicolor	4			
Heptageniidae	8			
Rhithrogena	4			
Stenacron	45			
Stenonema femoratum	74			
Stenonema mediopunctatum	19			
Stenonema terminatum	6			
Ephemerella invaria	25			
Ephemerella needhami	14			
Eurylophella bicolor	20			
Tricorythodes	12			
Caenis latipennis	16			
Baetisca lacustris	2			

ORDER (Taxa)	CS	RM	SG	NF
Ephemera simulans	-99			
LUMBRICINA				
Lumbricidae	1			
MEGALOPTERA				
Corydalus	-99			
MESOGASTROPODA				
Hydrobiidae	1			
Elimia	54			
ODONATA				
Argia	3			
Gomphidae	1			
Hagenius brevistylus	1			
PLECOPTERA				
Amphinemura	3			
Prostoia	1			
Perlesta	13			
Pteronarcys pictetii	3			
TRICHOPTERA				
Chimarra	1			
Cheumatopsyche	1			
Hydroptila	1			
Oxyethira	5			
Pycnopsyche	-99			
Helicopsyche	3			
Nectopsyche	3			
Oecetis	3			
TRICLADIDA				
Planariidae	5			

Appendix C

Fine sediment percentage and sediment character (metals) tests:
Kruskal-Wallis ANOVA on ranks and Dunn's comparisons versus a control per station
for Big River and Courtois Creek, 2002-2003

(Key: Courtois Creek #2=Group 20; Courtois Creek #1=Group 10;
Big River #s=Groups 9,8,7…1)

Kruskal-Wallis One Way Analysis of Variance on Ranks Wednesday, December 24, 2003, 10:58:37

Data source: Fine Sediment per Station (Group)

Normality Test: Failed (P = <0.001)

Group	N	Missing	Median	25%	75%
6.000	18	6	0.615	0.425	0.700
5.000	18	0	0.575	0.380	0.840
4.000	18	1	0.600	0.475	0.742
1.000	18	0	0.675	0.480	0.750
3.000	18	0	0.195	0.150	0.300
2.000	18	0	0.180	0.0800	0.450
7.000	18	0	0.1000	0.0500	0.500
9.000	18	0	0.0750	0.0500	0.150
8.000	18	6	0.1000	0.0500	0.175
20.000	18	0	0.0400	0.0300	0.150
10.000	18	0	0.0200	0.01000	0.0500

H = 112.792 with 10 degrees of freedom. (P = <0.001)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = <0.001)

To isolate the group or groups that differ from the others use a multiple comparison procedure.

Multiple Comparisons versus Control Group (Courtois Creek #2=20); (Dunn's Method):

Comparison	Diff of Ranks	Q	P<0.05
1 vs 20	105.583	5.915	Yes
4 vs 20	100.533	5.551	Yes
6 vs 20	97.653	4.893	Yes
5 vs 20	93.361	5.230	Yes
3 vs 20	51.694	2.896	Yes
2 vs 20	50.778	2.845	Yes
7 vs 20	44.667	2.502	No
10 vs 20	15.778	0.884	Do Not Test
8 vs 20	14.361	0.720	Do Not Test
9 vs 20	13.389	0.750	Do Not Test

Note: The multiple comparisons on ranks do not include an adjustment for ties.

Kruskal-Wallis One Way Analysis of Variance on Ranks Wednesday, December 24, 2003, 11:04:05

Data source: Fine Sediment per Station (Group)

Normality Test: Failed (P = <0.001)

Group	N	Missing	Median	25%	75%
6.000	18	6	0.615	0.425	0.700
5.000	18	0	0.575	0.380	0.840
4.000	18	1	0.600	0.475	0.742
1.000	18	0	0.675	0.480	0.750
3.000	18	0	0.195	0.150	0.300
2.000	18	0	0.180	0.0800	0.450
7.000	18	0	0.1000	0.0500	0.500
9.000	18	0	0.0750	0.0500	0.150
8.000	18	6	0.1000	0.0500	0.175
20.000	18	0	0.0400	0.0300	0.150
10.000	18	0	0.0200	0.01000	0.0500

H = 112.792 with 10 degrees of freedom. (P = <0.001)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = <0.001)

To isolate the group or groups that differ from the others use a multiple comparison procedure.

Multiple Comparisons versus Control Group (Courtois Creek #1=10); (Dunn's Method):

Comparison	Diff of Ranks	Q	P<0.05
1 vs 10	121.361	6.799	Yes
4 vs 10	116.310	6.422	Yes
6 vs 10	113.431	5.684	Yes
5 vs 10	109.139	6.114	Yes
3 vs 10	67.472	3.780	Yes
2 vs 10	66.556	3.729	Yes
7 vs 10	60.444	3.386	Yes
8 vs 10	30.139	1.510	No
9 vs 10	29.167	1.634	Do Not Test
20 vs 10	15.778	0.884	Do Not Test

Note: The multiple comparisons on ranks do not include an adjustment for ties.

Kruskal-Wallis One Way Analysis of Variance on Ranks Wednesday, December 24, 2003, 11:04:44

Data source: Fine Sediment per Station (Group)

Normality Test: Failed (P = <0.001)

Group	N	Missing	Median	25%	75%
6.000	18	6	0.615	0.425	0.700
5.000	18	0	0.575	0.380	0.840
4.000	18	1	0.600	0.475	0.742
1.000	18	0	0.675	0.480	0.750
3.000	18	0	0.195	0.150	0.300
2.000	18	0	0.180	0.0800	0.450
7.000	18	0	0.1000	0.0500	0.500
9.000	18	0	0.0750	0.0500	0.150
8.000	18	6	0.1000	0.0500	0.175
20.000	18	0	0.0400	0.0300	0.150
10.000	18	0	0.0200	0.01000	0.0500

H = 112.792 with 10 degrees of freedom. (P = <0.001)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = <0.001)

To isolate the group or groups that differ from the others use a multiple comparison procedure.

Multiple Comparisons versus Control Group (Big River #9); (Dunn's Method):

Comparison	Diff of Ranks	Q	P<0.05
1 vs 9	92.194	5.165	Yes
4 vs 9	87.144	4.812	Yes
6 vs 9	84.264	4.222	Yes
5 vs 9	79.972	4.480	Yes
3 vs 9	38.306	2.146	No
2 vs 9	37.389	2.095	Do Not Test
7 vs 9	31.278	1.752	Do Not Test
10 vs 9	29.167	1.634	Do Not Test
20 vs 9	13.389	0.750	Do Not Test
8 vs 9	0.972	0.0487	Do Not Test

Note: The multiple comparisons on ranks do not include an adjustment for ties.

Kruskal-Wallis One Way Analysis of Variance on Ranks Wednesday, December 24, 2003, 11:05:59
cadmium
Data source: Sediment Cadmium per Station (Group)

Normality Test: Failed (P = <0.001)

Group	N	Missing	Median	25%	75%
20.000	3	0	499.000	499.000	562.000
10.000	3	0	499.000	499.000	597.250
9.000	3	0	499.000	499.000	499.000
8.000	3	1	52050.000	33400.000	70700.000
7.000	3	0	29800.000	23125.000	31225.000
6.000	3	0	12600.000	11925.000	14700.000
5.000	3	0	12400.000	8665.000	13450.000
4.000	3	0	6080.000	5562.500	10295.000
3.000	3	0	3200.000	2855.000	3275.000
2.000	3	0	1540.000	1375.000	1757.500
1.000	3	0	1390.000	1352.500	1637.500

H = 30.099 with 10 degrees of freedom. (P = <0.001)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = <0.001)

To isolate the group or groups that differ from the others use a multiple comparison procedure.

Multiple Comparisons versus Control Group (Courtois Creek #2=20); (Dunn's Method):

Comparison	Diff of Ranks	Q	P<0.05
8 vs 20	26.167	3.056	Yes
7 vs 20	23.667	3.090	Yes
6 vs 20	19.500	2.546	No
5 vs 20	18.333	2.394	Do Not Test
4 vs 20	15.167	1.980	Do Not Test
3 vs 20	11.667	1.523	Do Not Test
2 vs 20	7.333	0.957	Do Not Test
1 vs 20	7.000	0.914	Do Not Test
9 vs 20	1.333	0.174	Do Not Test
10 vs 20	0.333	0.0435	Do Not Test

Note: The multiple comparisons on ranks do not include an adjustment for ties.

Kruskal-Wallis One Way Analysis of Variance on Ranks Wednesday, December 24, 2003, 11:06:53

Data source: Sediment Cadmium per Station (Group)

Normality Test: Failed (P = <0.001)

Group	N	Missing	Median	25%	75%
20.000	3	0	499.000	499.000	562.000
10.000	3	0	499.000	499.000	597.250
9.000	3	0	499.000	499.000	499.000
8.000	3	1	52050.000	33400.000	70700.000
7.000	3	0	29800.000	23125.000	31225.000
6.000	3	0	12600.000	11925.000	14700.000
5.000	3	0	12400.000	8665.000	13450.000
4.000	3	0	6080.000	5562.500	10295.000
3.000	3	0	3200.000	2855.000	3275.000
2.000	3	0	1540.000	1375.000	1757.500
1.000	3	0	1390.000	1352.500	1637.500

H = 30.099 with 10 degrees of freedom. (P = <0.001)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = <0.001)

To isolate the group or groups that differ from the others use a multiple comparison procedure.

Multiple Comparisons versus Control Group (Courtois Creek #1=10); (Dunn's Method):

Comparison	Diff of Ranks	Q	P<0.05
8 vs 10	25.833	3.017	Yes
7 vs 10	23.333	3.046	Yes
6 vs 10	19.167	2.502	No
5 vs 10	18.000	2.350	Do Not Test
4 vs 10	14.833	1.937	Do Not Test
3 vs 10	11.333	1.480	Do Not Test
2 vs 10	7.000	0.914	Do Not Test
1 vs 10	6.667	0.870	Do Not Test
9 vs 10	1.667	0.218	Do Not Test
20 vs 10	0.333	0.0435	Do Not Test

Note: The multiple comparisons on ranks do not include an adjustment for ties.

Kruskal-Wallis One Way Analysis of Variance on Ranks Wednesday, December 24, 2003, 11:07:38

Data source: Sediment Cadmium per Station (Group)

Normality Test: Failed (P = <0.001)

Group	N	Missing	Median	25%	75%
20.000	3	0	499.000	499.000	562.000
10.000	3	0	499.000	499.000	597.250
9.000	3	0	499.000	499.000	499.000
8.000	3	1	52050.000	33400.000	70700.000
7.000	3	0	29800.000	23125.000	31225.000
6.000	3	0	12600.000	11925.000	14700.000
5.000	3	0	12400.000	8665.000	13450.000
4.000	3	0	6080.000	5562.500	10295.000
3.000	3	0	3200.000	2855.000	3275.000
2.000	3	0	1540.000	1375.000	1757.500
1.000	3	0	1390.000	1352.500	1637.500

H = 30.099 with 10 degrees of freedom. (P = <0.001)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = <0.001)

To isolate the group or groups that differ from the others use a multiple comparison procedure.

Multiple Comparisons versus Control Group (Big River #9); (Dunn's Method):

Comparison	Diff of Ranks	Q	P<0.05
8 vs 9	27.500	3.211	Yes
7 vs 9	25.000	3.264	Yes
6 vs 9	20.833	2.720	No
5 vs 9	19.667	2.568	Do Not Test
4 vs 9	16.500	2.154	Do Not Test
3 vs 9	13.000	1.697	Do Not Test
2 vs 9	8.667	1.132	Do Not Test
1 vs 9	8.333	1.088	Do Not Test
10 vs 9	1.667	0.218	Do Not Test
20 vs 9	1.333	0.174	Do Not Test

Note: The multiple comparisons on ranks do not include an adjustment for ties.

Kruskal-Wallis One Way Analysis of Variance on Ranks Wednesday, December 24, 2003, 11:08:33
lead
Data source: Sediment Lead per Station (Group)

Normality Test: Failed (P = <0.001)

Group	N	Missing	Median	25%	75%
20.000	3	0	15600.000	14325.000	21675.000
10.000	3	0	21600.000	19650.000	24900.000
9.000	3	0	15800.000	14975.000	19025.000
8.000	3	1	1320000.000	670000.000	1970000.000
7.000	3	0	3100000.000	2545000.000	4097500.000
6.000	3	0	2180000.000	1482500.000	5382500.000
5.000	3	0	2170000.000	1192000.000	4892500.000
4.000	3	0	1990000.000	1487500.000	3632500.000
3.000	3	0	459000.000	442500.000	607500.000
2.000	3	0	370000.000	315250.000	384250.000
1.000	3	0	374000.000	317750.000	458000.000

H = 28.348 with 10 degrees of freedom. (P = 0.002)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.002)

To isolate the group or groups that differ from the others use a multiple comparison procedure.

Multiple Comparisons versus Control Group (Courtois Creek #2=20); (Dunn's Method):

Comparison	Diff of Ranks	Q	P<0.05
7 vs 20	24.333	3.177	Yes
6 vs 20	22.333	2.916	Yes
5 vs 20	21.333	2.785	No
4 vs 20	21.000	2.742	Do Not Test
8 vs 20	17.000	1.985	Do Not Test
3 vs 20	12.333	1.610	Do Not Test
1 vs 20	9.667	1.262	Do Not Test
2 vs 20	8.000	1.044	Do Not Test
10 vs 20	3.000	0.392	Do Not Test
9 vs 20	0.000	0.000	Do Not Test

Note: The multiple comparisons on ranks do not include an adjustment for ties.

Kruskal-Wallis One Way Analysis of Variance on Ranks Wednesday, December 24, 2003, 11:09:21

Data source: Sediment Lead per Station (Group)

Normality Test: Failed (P = <0.001)

Group	N	Missing	Median	25%	75%
20.000	3	0	15600.000	14325.000	21675.000
10.000	3	0	21600.000	19650.000	24900.000
9.000	3	0	15800.000	14975.000	19025.000
8.000	3	1	1320000.000	670000.000	1970000.000
7.000	3	0	3100000.000	2545000.000	4097500.000
6.000	3	0	2180000.000	1482500.000	5382500.000
5.000	3	0	2170000.000	1192000.000	4892500.000
4.000	3	0	1990000.000	1487500.000	3632500.000
3.000	3	0	459000.000	442500.000	607500.000
2.000	3	0	370000.000	315250.000	384250.000
1.000	3	0	374000.000	317750.000	458000.000

H = 28.348 with 10 degrees of freedom. (P = 0.002)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.002)

To isolate the group or groups that differ from the others use a multiple comparison procedure.

Multiple Comparisons versus Control Group (Courtois Creek #1=10); (Dunn's Method):

Comparison	Diff of Ranks	Q	P<0.05
7 vs 10	21.333	2.785	No
6 vs 10	19.333	2.524	Do Not Test
5 vs 10	18.333	2.394	Do Not Test
4 vs 10	18.000	2.350	Do Not Test
8 vs 10	14.000	1.635	Do Not Test
3 vs 10	9.333	1.219	Do Not Test
1 vs 10	6.667	0.870	Do Not Test
2 vs 10	5.000	0.653	Do Not Test
9 vs 10	3.000	0.392	Do Not Test
20 vs 10	3.000	0.392	Do Not Test

Note: The multiple comparisons on ranks do not include an adjustment for ties.

Kruskal-Wallis One Way Analysis of Variance on Ranks Wednesday, December 24, 2003, 11:10:03

Data source: Sediment Lead per Station (Group)

Normality Test: Failed (P = <0.001)

Group	N	Missing	Median	25%	75%
20.000	3	0	15600.000	14325.000	21675.000
10.000	3	0	21600.000	19650.000	24900.000
9.000	3	0	15800.000	14975.000	19025.000
8.000	3	1	1320000.000	670000.000	1970000.000
7.000	3	0	3100000.000	2545000.000	4097500.000
6.000	3	0	2180000.000	1482500.000	5382500.000
5.000	3	0	2170000.000	1192000.000	4892500.000
4.000	3	0	1990000.000	1487500.000	3632500.000
3.000	3	0	459000.000	442500.000	607500.000
2.000	3	0	370000.000	315250.000	384250.000
1.000	3	0	374000.000	317750.000	458000.000

H = 28.348 with 10 degrees of freedom. (P = 0.002)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.002)

To isolate the group or groups that differ from the others use a multiple comparison procedure.

Multiple Comparisons versus Control Group (Big River #9); (Dunn's Method):

Comparison	Diff of Ranks	Q	P<0.05
7 vs 9	24.333	3.177	Yes
6 vs 9	22.333	2.916	Yes
5 vs 9	21.333	2.785	No
4 vs 9	21.000	2.742	Do Not Test
8 vs 9	17.000	1.985	Do Not Test
3 vs 9	12.333	1.610	Do Not Test
1 vs 9	9.667	1.262	Do Not Test
2 vs 9	8.000	1.044	Do Not Test
10 vs 9	3.000	0.392	Do Not Test
20 vs 9	0.000	0.000	Do Not Test

Note: The multiple comparisons on ranks do not include an adjustment for ties.

Kruskal-Wallis One Way Analysis of Variance on Ranks Wednesday, December 24, 2003, 11:10:47

Data source: Sediment Zinc per Station (Group)

Normality Test: Failed (P = <0.001)

Group	N	Missing	Median	25%	75%
20.000	3	0	53800.000	48475.000	68125.000
10.000	3	0	57000.000	56400.000	72675.000
9.000	3	0	18100.000	17950.000	18700.000
8.000	3	1	2595000.000	1640000.000	3550000.000
7.000	3	0	1500000.000	1282500.000	1650000.000
6.000	3	0	695000.000	651500.000	758000.000
5.000	3	0	645000.000	495000.000	993750.000
4.000	3	0	383000.000	325250.000	641750.000
3.000	3	0	367000.000	277000.000	460000.000
2.000	3	0	217000.000	151000.000	220000.000
1.000	3	0	157000.000	142000.000	158500.000

H = 29.659 with 10 degrees of freedom. (P = <0.001)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = <0.001)

To isolate the group or groups that differ from the others use a multiple comparison procedure.

Multiple Comparisons versus Control Group (Courtois Creek #2=20); (Dunn's Method):

Comparison	Diff of Ranks	Q	P<0.05
8 vs 20	25.333	2.958	Yes
7 vs 20	23.667	3.090	Yes
6 vs 20	18.333	2.394	No
5 vs 20	17.667	2.307	Do Not Test
4 vs 20	14.667	1.915	Do Not Test
3 vs 20	12.667	1.654	Do Not Test
2 vs 20	7.333	0.957	Do Not Test
1 vs 20	6.333	0.827	Do Not Test
9 vs 20	3.667	0.479	Do Not Test
10 vs 20	1.667	0.218	Do Not Test

Note: The multiple comparisons on ranks do not include an adjustment for ties.

Kruskal-Wallis One Way Analysis of Variance on Ranks Wednesday, December 24, 2003, 11:11:36

Data source: Sediment Zinc per Station (Group)

Normality Test: Failed (P = <0.001)

Group	N	Missing	Median	25%	75%
20.000	3	0	53800.000	48475.000	68125.000
10.000	3	0	57000.000	56400.000	72675.000
9.000	3	0	18100.000	17950.000	18700.000
8.000	3	1	2595000.000	1640000.000	3550000.000
7.000	3	0	1500000.000	1282500.000	1650000.000
6.000	3	0	695000.000	651500.000	758000.000
5.000	3	0	645000.000	495000.000	993750.000
4.000	3	0	383000.000	325250.000	641750.000
3.000	3	0	367000.000	277000.000	460000.000
2.000	3	0	217000.000	151000.000	220000.000
1.000	3	0	157000.000	142000.000	158500.000

H = 29.659 with 10 degrees of freedom. (P = <0.001)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = <0.001)

To isolate the group or groups that differ from the others use a multiple comparison procedure.

Multiple Comparisons versus Control Group (Courtois Creek #1=10); (Dunn's Method):

Comparison	Diff of Ranks	Q	P<0.05
8 vs 10	23.667	2.764	No
7 vs 10	22.000	2.872	Do Not Test
6 vs 10	16.667	2.176	Do Not Test
5 vs 10	16.000	2.089	Do Not Test
4 vs 10	13.000	1.697	Do Not Test
3 vs 10	11.000	1.436	Do Not Test
2 vs 10	5.667	0.740	Do Not Test
9 vs 10	5.333	0.696	Do Not Test
1 vs 10	4.667	0.609	Do Not Test
20 vs 10	1.667	0.218	Do Not Test

Note: The multiple comparisons on ranks do not include an adjustment for ties.

Kruskal-Wallis One Way Analysis of Variance on Ranks Wednesday, December 24, 2003, 11:12:05

Data source: Sediment Zinc per Station (Group)

Normality Test: Failed (P = <0.001)

Group	N	Missing	Median	25%	75%
20.000	3	0	53800.000	48475.000	68125.000
10.000	3	0	57000.000	56400.000	72675.000
9.000	3	0	18100.000	17950.000	18700.000
8.000	3	1	2595000.000	1640000.000	3550000.000
7.000	3	0	1500000.000	1282500.000	1650000.000
6.000	3	0	695000.000	651500.000	758000.000
5.000	3	0	645000.000	495000.000	993750.000
4.000	3	0	383000.000	325250.000	641750.000
3.000	3	0	367000.000	277000.000	460000.000
2.000	3	0	217000.000	151000.000	220000.000
1.000	3	0	157000.000	142000.000	158500.000

H = 29.659 with 10 degrees of freedom. (P = <0.001)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = <0.001)

To isolate the group or groups that differ from the others use a multiple comparison procedure.

Multiple Comparisons versus Control Group (Big River #9); (Dunn's Method):

Comparison	Diff of Ranks	Q	P<0.05
8 vs 9	29.000	3.386	Yes
7 vs 9	27.333	3.569	Yes
6 vs 9	22.000	2.872	Yes
5 vs 9	21.333	2.785	No
4 vs 9	18.333	2.394	Do Not Test
3 vs 9	16.333	2.132	Do Not Test
2 vs 9	11.000	1.436	Do Not Test
1 vs 9	10.000	1.306	Do Not Test
10 vs 9	5.333	0.696	Do Not Test
20 vs 9	3.667	0.479	Do Not Test

Note: The multiple comparisons on ranks do not include an adjustment for ties.