Cumberland River Biological and Water Quality Investigation
Wild River Segment

Kentucky Department of Environmental Protection
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Summary

1. The Cumberland River Wild River segment, established in 1972, is 16.1 miles long, encompasses 3,300 acres, and runs from Summer Shoals to the backwaters of Lake Cumberland. This section of the river is presently designated for warmwater aquatic habitat (WAH), primary contact recreation (PCR), secondary contact recreation (SCR), domestic water supply at the point of withdrawal, and outstanding resource water (ORW).
2. A variety of recreational activities routinely occur in the wild river corridor, including camping, fishing, hiking, boating, and sight-seeing.
3. Only three active permitted dischargers occur in the wild river corridor (Kentucky Department of Parks, Eagle Creek Elementary School, and Holiday Motor Lodge). The city of Williamsburg discharges treated wastewater just upstream of the wild river, and is the only major point source within 50 miles.
4. Past bacteriological data show that Kentucky Surface Water Standards (KSWS) for fecal coliform bacteria are occasionally exceeded. Recent bacteriological data show that the criterion is being achieved.
5. Approximately 84 percent of the drainage above the wild river is forested, 13 percent is used for agricultural operations, 2.5 percent for mining, and 0.5 percent for urban development. Though mining occurs in only a small

portion of the drainage, it has the most profound and lasting impact on the water quality of the wild river.

6. The wild river section lies in the Cumberland Plateau and drains sandstones, shales, conglomerates, and coals of the early Pennsylvanian and late Mississippian periods.

7. The annual mean discharge is 3,170 cubic feet per second (cfs) with the highest annual mean discharge of 5,196 cfs and the lowest of 1,324 cfs. The highest daily mean discharge is 57,500 cfs and the lowest is 40.0 cfs. The present 7Q10 is 23 cfs.

8. Field physicochemical data taken during this study showed that dissolved oxygen and pH did not exceed KSWS. However, pH and conductivity were elevated, probably as a result of upstream impacts.

9. STORET (1983-1993) physicochemical data show that sulfates have been elevated during the entire period of record. The annual mean for iron has exceeded KSWS chronic criterion since 1989.

10. Physicochemical data from this study, taken during a low-flow period, indicated the water quality of the wild river segment was good.

11. Elevated concentrations of conductivity, sulfates, dissolved solids, and iron are a reflection of upstream coal mining activities.

12. Sediments from all three sampling locations were generally of good quality. Station 18-3 had the greatest number of parameters that had elevated concentrations while station 18-2 had the least. Potential problem parameters are total volatile solids, manganese, oil and grease, total kjeldahl nitrogen, arsenic, cadmium, and nickel.

13. Periphyton, macroinvertebrate, and fish data were collected during this study. The periphyton and macroinvertebrate data were used to generate the biotic assessment index (BAI). This index is used to assess the biotic integrity of a stream reach. The BAI classified the upper and lower portions of the wild river segment as excellent and the middle portion as good. Therefore, the entire portion is meeting its designated uses of WAH and ORW.

14. Periphyton collections made from the Wild River segment showed that all stations had similar diatom flora. The diatom bioassessment index classified the lower portion of the wild river segment as excellent and the middle and upper portions as good. The diatom communities at the upper portion of the wild-river segment had a higher percentage of silt-tolerant species, indicating upstream land disturbance. All three stations had an abundance of Cladophora, a filamentous green alga indicative of nutrient enrichment.

15. Macroinvertebrate communities were similar throughout the wild river segment. The macroinvertebrate bioassessment index rated all three sampling locations as excellent. However, the demise of the freshwater mussel from above and below the falls indicates intermittent water quality problems have been occurring in the Cumberland River since the turn of this century.

16. Fish data were collected from all three sampling locations in the wild river segment. This data set was not used to assess biotic integrity because, due to sampling difficulties, the collections were not considered to be representative of the fish community. Members of the minnow and bass families were the only species well represented in these collections.

17. Five rare aquatic organisms have been reported from the wild river segment. None of these were observed during this study.

18. The wild river corridor serves as a refugium for both plants and animals. Protection of the corridor allows both riparian and aquatic communities to remain intact, providing an epicenter for reinvasion into areas impacted by anthropogenic activities.

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Recommendations

1. Based on the diversity of aquatic biota and aquatic habitat, it is recommended that the wild river segment of the Cumberland River continue to be designated for Aquatic Life/Warmwater Aquatic Habitat, and Outstanding Resource Water, per 401 KAR 5:026, Section 7, and the criteria applied to these classifications continue without modification.
2. Based on fecal coliform bacterial and pH data, it is recommended that the wild river segment of the Cumberland River and its tributaries continue to be designated for Primary and Secondary Contact Recreation, per 401 KAR 5:026, Section 7, and the criteria applied to these classifications continue without modification.
3. Because the wild river segment of the Cumberland River supports a diverse aquatic flora and fauna and serves as a refugia for unimpounded, large river aquatic organisms, it is recommended that the present biological and water quality monitoring program be continued.
4. Because of the close proximity of the Williamsburg wastewater treatment plant to the wild river segment of the Cumberland River, it is recommended that strict effluent permit limits be strictly enforced and that the necessity for nutrient limits be assessed.

5. Because coal mining operations are the source of the most serious impact to the wild river segment of the Cumberland River, it is recommended that the Kentucky Department for Surface Mining Reclamation and Enforcement and the Kentucky Division of Water ensure that permit limits on all coal mining operations occurring upstream, or adjacent to, the wild river corridor are enforced.

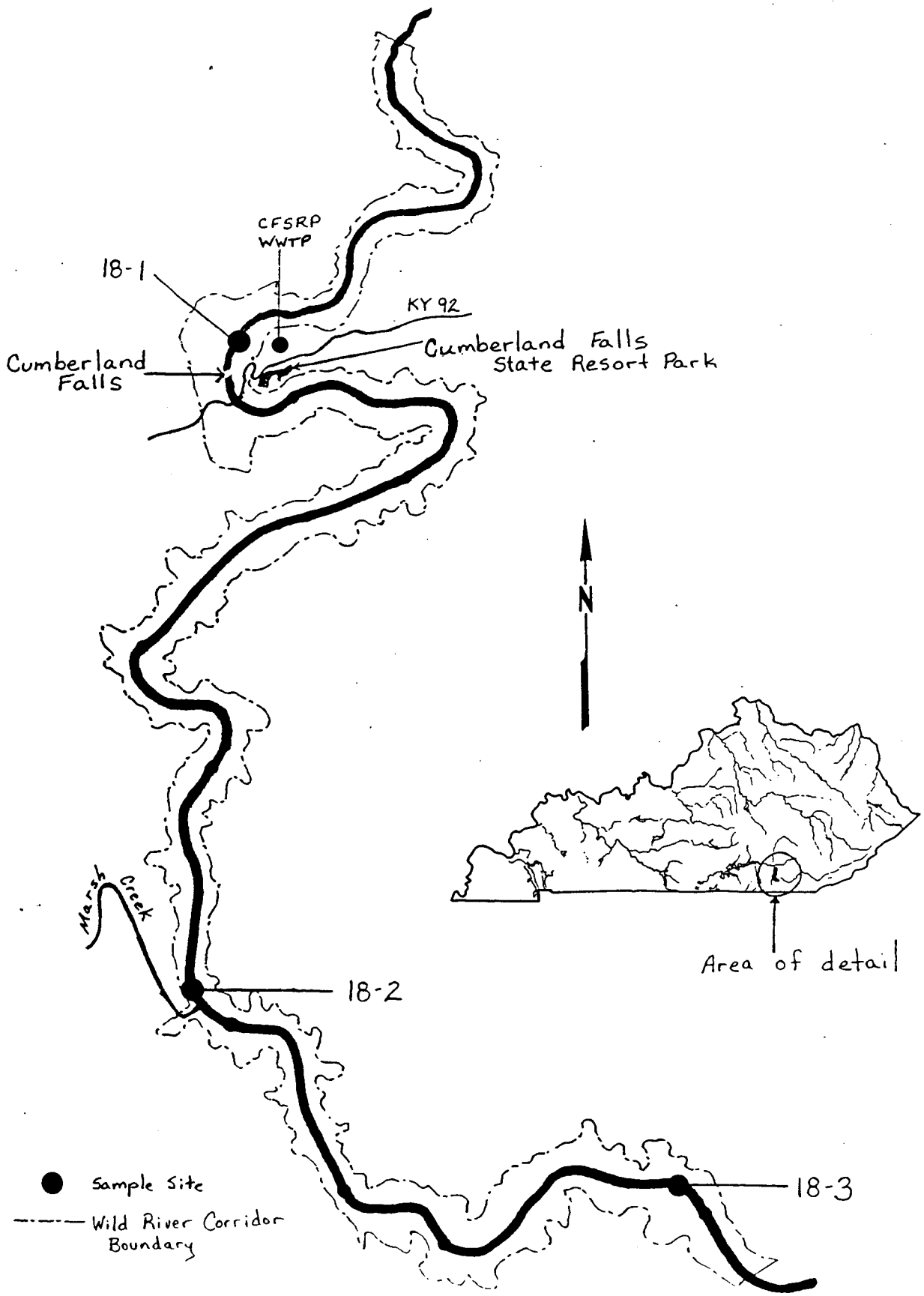
INTRODUCTION

The wild river portion of Cumberland River lies in southeastern Kentucky predominately on the McCreary-Whitley County line. This segment is located in the Daniel Boone National Forest and Cumberland Falls State Resort Park from milepoint (MP) 574.6 to MP 558.5. It is in 303e segment designated as 02 (Cumberland River), 018 (Mayes, Sudderth and Etheredge, Inc. 1975). This portion of the river is included in Kentucky waterbody segment KY 5130101-009.

This biological and water quality survey was conducted in late July and early August, 1993, by the Kentucky Division of Water (KDOW) with the help of the Kentucky State Nature Preserves Commission (KSNPC). Three stations were established in the wild river portion of the Cumberland River (Figure 1.) These three stations were sampled once during a low-flow period. The location of these stations, dates sampled, and parametric coverage are given in Appendix A.

The purposes of this investigation were to determine if this segment was meeting its designated stream uses and to compile background water quality and biological data for this segment. This section of the Cumberland River is presently designated by the Kentucky Department for Environmental Protection for warmwater aquatic habitat (WAH), primary contact recreation (PCR), secondary contact recreation (SCR), domestic water supply at the point of withdrawal (MP 562.6), and outstanding resource water (ORW) uses. The ORW designation is a reflection of the wild river status.

Figure 1. Map of the Wild River Section of the Cumberland River Depicting Sampling Locations



The 16.1 mile long wild river portion of the Cumberland River was designated by the General Assembly in 1972 with passage of KRS 146:200 to 146.360, commonly known as the "Kentucky Wild Rivers Act." It was designated in recognition of its outstanding and unique scenic, recreational, geological, fish and wildlife, botanical, historical, archaeological and other scientific, aesthetic, and cultural values.

The designated segment is located on the border of Whitley and McCreary counties and runs from Summer Shoals downstream to the backwaters of Lake Cumberland. This segment includes Cumberland Falls, one of the most visited tourist attractions in the Commonwealth. The land in the 3,300-acre wild river corridor is a mix of private and public ownership. The publicly owned land is managed by the United States Forest Service (Daniel Boone National Forest) and the Kentucky Department of Parks (Cumberland Falls State Resort Park). In addition, a portion of Cumberland Falls State Resort Park (CFSRP) has been dedicated as a Kentucky State Nature Preserve.

Literature Review

There is a limited amount of published biological information existing on the aquatic environment of the wild river section of the Cumberland River. Information on rare plants and animals occurring in the wild river corridor is available from the Kentucky Natural Heritage Program Database (KNHPD) (1993). Fish collections were made by KDOW from 1976 to 1987 from a site located above Cumberland Falls (KDOW

1988). Additional fish data on the wild river segment is presented by Jordan and Brayton (1878), Everman (1918), Lachner and Jenkins (1971), and Soil Systems, Inc. (1980). Invertebrate data consist principally of freshwater mussel collections. Unionid mussel data are presented by Wilson and Clark (1914), Neal and Allen (1964), and Stansbery (1969). Soils Systems, Inc. (1980), provides additional macroinvertebrate data on crustaceans, gastropods, and aquatic insects.

Published water quality data on the wild river segment is confined to a few sources. Kirkpatrick, et. al. (1973), Mayes Sudderth, and Etheredge, Inc. (1975), and Soil Systems, Inc. (1980), provide limited water quality information. The United States Geological Survey (1993) has flow and limited water quality data back to 1907. Kentucky Division of Water's (1992) Report to Congress on Water Quality, based on water quality and biological data collected from an ambient water quality station above Cumberland Falls, lists the wild river segment as meeting designated uses. The KDOW and National Park Service (1992) conducted a rivers assessment using ten major categories. These categories ranged from water quality based parameters to aesthetic based parameters. The wild river corridor scored highly in seven of the ten categories, reflecting the unique character of this river segment.

Stream Uses - Basin Impacts

There are a variety of recreational activities that routinely occur within the wild river corridor. Cumberland Falls, located within CFSRP, is a major Kentucky tourist

attraction. The 1,794-acre park has a variety of year-round activities (Lander 1978). According to Sehlinger's (1978) canoeing and kayaking guide, the wild river section above Cumberland Falls is Class II whitewater, while the portion below is Class III. The lower section can be paddled year around. Camping, fishing, and hiking occur throughout the corridor (Miller, Wihry, and Lee Inc. 1980). Hunting occurs in the corridor, although it is not allowed within the confines of the state park.

Only three permitted dischargers release treated domestic waste to the Cumberland River or tributary streams that flow into the wild river segment (Table 1). The Kentucky Department of Parks Wastewater Treatment Plant (WWTP) at CFSRP is the largest, with a designed flow of 192,000 gallons per day (gpd). This plant affects only the lower portion of the wild river segment because it discharges to the river approximately 0.4 mi. downstream of the falls. The city of Williamsburg, with a permitted discharge of 800,000 gpd, discharges at milepoint 589.4. This is the only major point source discharger within 50 miles of the wild river segment. Nutrients from the Williamsburg WWTP and non-point sources are believed to contribute to abundant algal growth observed at stations 18-2 and 18-3 during this study.

According to STORET (1983-1993) bacteriological data, fecal coliform contamination of the wild river segment occurs sporadically. The origin of this contamination is believed to be from point and non-point sources upstream. A recent bacteriological study conducted in July and August 1993

Table 1. List of Active Permitted Dischargers to Cumberland River 303e Segment 02018			
Name	**County**	**Designed Flow (gpd)**	**Receiving Stream**
Eagle Elementary School	McCreary	5,000 gpd	UT-Eagle Creek
KY Dept. of Parks	Whitley	192,000 gpd	Cumberland River
Holiday Motor Lodge	McCreary	6,000 gpd	Falls Branch

gpd- gallons per day

showed no fecal coliform contamination immediately upstream of the wild river segment. Thus, the wild river segment generally meets PCR and SCR criteria.

Approximately 84 percent of the Cumberland River basin from the Wild River section upstream is forested (Mayes, Sudderth, and Etheredge, Inc. 1975). Silviculture operations are common throughout the drainage. Those silviculture operations occurring in the Daniel Boone National Forest are required to employ best management practices which are designed to minimize impacts. However, logging operations on private lands are not required to follow any operational standards, and this can cause serious stream impacts.

According to Mayes, Sudderth, and Etheredge, Inc. (1975), only 2.5 percent of the watershed above the wild river is used for coal mining. Even though only a small portion of land is used for mineral extraction, coal mining is the major source of pollution in the upper Cumberland River basin, contributing large volumes of sediment to the water and causing it to

remain turbid for long periods of time (US ACOE 1976). Information presented by Mayes, Sudderth, and Etheredge, Inc. (1975), and KDOW (1981) shows that acid mine drainage is a major pollutant in the upper Cumberland River basin above the wild river section. According to Mayes, Sudderth, and Etheredge (1975) data, three acid mine degraded streams, Marsh Creek, Jellico Creek, and Clear Fork, either discharge directly to, or upstream of, the wild river section. During this study, large quantities of coal particles were observed throughout the wild river segment. Sand and sediment deposits were also common in depositional areas.

Methods

Algal, macroinvertebrate, and fish communities were collected and analyzed using the procedures described in "Methods for Assessing Biological Integrity of Surface Waters" (KDOW 1993).

Field physicochemical data were taken with a Yellow Springs Instruments Water Quality Logger, Model 3800, in accordance with manufacturer's instructions. Physicochemical samples, collected for laboratory analysis, were done so in accordance with KDOW (1993).

PHYSICAL EVALUATION

The wild river segment of the Cumberland River is a sixth-order stream (Soil Systems, Inc. 1980), which drains over 2000 mi^2 (5200 km^2) (Mayes, Sudderth, and Etheredge, Inc. 1975). Approximately 84 percent of the drainage above the wild river is forested, with about 13 percent used in some

type of agriculture operation, 2.5 percent used for mining, and 0.5 percent in urban type development (Mayes, Sudderth, and Etheredge, Inc., 1975). According to Miller, Wihry, and Lee Inc. (1980), the portion of the wild river from Summer Shoals to Cumberland Falls has an average gradient of three feet per mile. The area is characterized by long, moderately deep sluggish pools interspersed with large, shallow shoals. The stream width ranges from 65 to more than 200 feet. From Cumberland Falls downstream, the character of the stream changes dramatically. Under average flow conditions, the falls are approximately 125 feet across and drop 67 feet (Miller, Wihry, and Lee Inc. 1980). The stream below the falls narrows, ranging from 40 to 80 feet wide, and has an average gradient of 12 feet per mile (Sehlinger 1978). In this area of the river, the pools are smaller and faster flowing; riffles are steep and cascading in some locations. Large boulders are scattered throughout this reach.

The wild river section lies within the Cumberland Plateau of the Appalachian Plateaus Province (Quarterman and Powell 1978). The river drains strata of the early Pennsylvanian and late Mississippi periods (McGrain 1955). The most frequently encountered rocks are sandstones, shales, conglomerates and coals (McGrain 1955).

The United States Geological Survey (USGS) maintains a gaging station on the Cumberland River directly above Cumberland Falls. The hydrological information presented below was taken from USGS (1993).

The annual mean discharge for the period of record is 3,170 cubic feet per second (cfs). The period of record is from August 1907 to December 1911 and from October 1914 to the present. The highest annual mean discharge was 5,196 cfs in 1927. The lowest annual mean discharge of 1,324 cfs occurred during the drought of 1988. The highest daily mean discharge of 57,500 cfs occurred on January 18, 1918, while the lowest daily mean discharge of 4.0 cfs occurred on September 19, 1954. The present 7Q10 is 23 cfs (USGS 1991).

Average discharges are the greatest in the winter and spring, when they range between 3,000 to 12,000 cfs; they are the least in the summer and fall, ranging between 500 to 3,000 cfs (Miller, Wihry, and Lee Inc. 1980). The large and predominately forested watershed and local springs provide the wild river segment with good low-flow characteristics (Mayes, Sudderth, and Etheredge, Inc. 1976).

Three sites were sampled during this study (Figure 1). Site locality data are presented in Appendix A. A brief description of the sampling locations follows below.

Site Descriptions

Station 18-1

Site 18-1, located at mile point (MP) 562.1, was directly downstream of, and within sight of, Cumberland Falls. The river here was approximately 75 to 80 feet wide. Pools were 1 to 15 feet deep, and riffles were 2 inches to approximately 3 feet deep. Stream flow was low at the time of sampling; however, current velocity in the riffles was fast. The substrate consisted of large boulders and cobbles in the

riffles and boulders, cobbles, pebbles, gravel, and fine material in the pools. Two-inch and smaller-sized coal and shale pebbles and coal fines were abundant in depositional areas of the pools and along the right bank. Detrital habitats included drift piles and submerged logs. Bank stability was excellent; banks consisted of very large (10'-20') boulders and steep forested hillsides. Riparian vegetation consisted of trees and shrubs. Sandy "beach" areas along the banks were sparsely vegetated. Because of the width of the river, canopy cover was only 10-20 percent.

Station 18-2

Site 18-2 was located at MP 569.1, at the shoal below Marsh Creek. The river was approximately 100 feet wide. Pool depth ranged from one foot to greater than five feet deep, and riffle depth was two inches to two feet. Stream flow was low, and current velocity in the riffles was moderately fast. The substrate at this site consisted of boulder- and cobble-sized sandstone and bedrock in riffles; and bedrock, various-sized rocks, and sand in pools. Detrital habitats included drift piles and submerged logs. Filamentous green algae was abundant, covering the substrate in the riffles. Bank stability was excellent, and riparian vegetation consisted of a mixture of trees and shrubs. The buffer zone on the left bank was a well forested hillside and on the right bank was 10-20 feet wide. Canopy cover was about 20 percent.

Station 18-3

Site 18-3 was located at Summer Shoals at MP 573.6. The river was approximately 100 feet wide. The riffle area was shallow (two inches to two feet deep), with a substrate of sandstone bedrock ledges and boulder-cobble-sized rock. The pool below the shoals was deep (3-10 feet) with a primarily bedrock substrate. Fine sediments covered much of the bedrock in the pool. Flow was low, but current velocity in the riffle was moderately fast. Filamentous green algae was abundant in the riffle. Habitats present included undercut rock ledges, submerged logs, and drift piles. Tree roots were generally not submerged because of the low-flow conditions. Bank stability was good, and riparian vegetation consisted of trees and shrubs. Banks sloped steeply, and buffer zones were well developed on both sides of the river. A pathway along the right bank, approximately 6-10 feet from the water, was well worn by fishermen.

PHYSIOCOCHEMICAL EVALUATION

Physicochemical data were collected by KDOW in July and August 1993 during a low flow period. Analyses were conducted on 37 parameters (Table 2). These data were compared to STORET (1983-1993) physicochemical data and Kentucky Surface Water Standards (KSWS) 401 KAR:031. STORET is a national computerized management information system operated by the United States Environmental Protection Agency (US EPA). It is designed for the storage and retrieval of water quality data. In Kentucky, STORET water quality data are derived from 52 monitoring stations, 45 of which are currently active. The

TABLE 2: Physicochemical Data for the Wild River Section of the Cumberland River, July and August, 1993			
	Stations		
Parameter (mg/l)*	18-1	18-2	18-3
Acidity	ND @ 0.1	0.7	ND @ 0.1
Alkalinity	92.9	153+	102
BOD5	ND	0.9	ND
Chloride	8.5	9.8	8.2
Conductivity (umhos/cm)	544+	523+	546+
Fluoride	0.16+	0.15	0.17+
Hardness, total	13.6	153	12.9
pH (SU)	8.2+	8.1+	8.3+
Total Suspended Solids	2	ND @1	4
Total Dissolved Solids	362+	413+	361+
Sulfate	151+	130+	145+
Organic Carbon	2.9	2.8	2.9
Turbidity (NTU)	2.8	3.4	4.0
Ammonia-Nitrogen	ND @0.05	ND @ 0.05	ND @ 0.05
Total Kjeldahl Nitrogen	0.151	ND @ 0.05	0.180
Nitrate	0.063	0.562	0.133
Phosphorus, ortho	ND	ND @ 0.005	ND
Phosphorus, total	0.019	ND @ 0.005	ND @ 0.005
Calcium	35.6	33.1	32.6
Magnesium	20.3+	17.6+	18.8+
Potassium	4.01+	3.95+	3.91+
Sodium	39.6+	46.5+	44.5+
Aluminum	0.089	0.053	0.101
Arsenic	ND @0.002	ND @ 0.002	ND @ 0.002
Barium	0.044	0.052	0.044
Beryllium	ND @ 0.001	ND @ 0.001	ND @ 0.001

TABLE 2: Physicochemical Data for the Wild River Section of the Cumberland River, July and August, 1993			
	Stations		
Parameter (mg/l)*	18-1	18-2	18-3
Cadmium	ND @ 0.001	ND @ 0.001	ND @ 0.001
Chromium	0.001	0.001	0.001
Copper	0.006+	0.005	0.004
Iron	0.130	0.120	0.128
Lead	0.002	ND @ 0.002	ND @ 0.002
Manganese	0.067	0.047	0.058
Mercury	ND @ 0.0001	ND @ 0.0001	ND @ 0.0001
Nickel	ND @ 0.002	ND @ 0.001	ND @ 002
Selenium	ND @ 0.002	ND @ 0.002	ND @ 002
Silver	ND @ 0.001	ND @ 0.001	ND @ 0.001
Zinc	0.015	0.032+	0.027

*Parameters in mg/l unless otherwise stated.
+Parameters that exceeded the STORET (1983-1993) 75th percentile.
ND - Not Determined

STORET data base used in this report was from 1983 to the present. Any parameter that exceeds the STORET (1983-1993) 75th percentile or a KSWS chronic or acute criteria is considered elevated and a potential problem parameter.

The physicochemical parameters listed in Table 3 were taken in the field during this study by KDOW personnel. These data were collected in August 1993 during a low-flow period. Dissolved oxygen levels did not violate KSWS, although the percent saturation was 90 percent or less at all stations. Generally, percent saturation approaches 100 percent in lotic systems; however, the elevated water temperatures and low-flow conditions probably account for the reduced saturation values.

Table 3: Field Physicochemical Data from Wild River Segment of the Cumberland River			
	Stations		
Parameter	**18-1**	**18-2**	**18-3**
Dissolved Oxygen (mg/l)	6.6	6.8	7.0
Percent Saturation (%)	83.2	82.7	90.0
pH (SU)	8.7	8.5	8.8
Conductivity (umhos/cm)	378	508	550
Salinity (ppt)	0.2	0.2	0.3
Water Temperature (°C)	26.3	24.7	27.5
Turbidity (NTU)	18	20	28

Conductivity and pH values are considered elevated. This is probably the result of upstream activities.

Water quality data for the wild river corridor are presented by Kirkpatrick et al. (1973), Mayes, Sudderth, and Etheredge, Inc. (1975), Soil Systems, Inc. (1980), and STORET (1983-1993). The United States Geological Survey (USGS) (1993) publishes conductivity, temperature, and discharge measurements. However, with the exception of the STORET (1983-1993) data, the physicochemical data are limited and should be considered primarily for historical purposes. For the purpose of data analysis, this report will concern itself with the STORET data from 1983 to 1993 and the data collected during this study.

STORET maximum, minimum, mean, 25th percentile, 50th percentile, and 75th percentiles data from 1983 to 1993 for the Cumberland River at Cumberland Falls are found in Appendix

B. Data are presented for 30 parameters. A review of the data presented in Appendix B shows that sulfates were continually elevated above the STORET (1983-1993) 75th percentile. Since 1989, the mean annual iron values have exceeded the KSWS chronic criterion, indicating a decline in water quality from past years. Generally speaking, all parameters show seasonal fluctuations. The maximum values usually occur during the periods of high flow, i.e., winter and spring, while the minimum values generally occur during the lower flow periods of summer and fall.

Physicochemical data collected during this study indicate that at the time of collection, the water quality in the wild river segment was good. All stations had a similar number of parameters that exceeded the STORET (1983-1993) 75th percentile (Station 18-1 with 9 elevated parameters, Station 18-2 with 10, and Station 18-3 with 8). These parameters are marked with a "+" beside the concentration in Table 2. Several of these parameters (alkalinity, conductivity, pH, magnesium, potassium, and sodium) are not considered detrimental to the aquatic community at the concentrations observed. No parameter at any station exceeded KSWS.

Elevated concentrations for conductivity, dissolved solids, sulfates, and iron are a reflection of drainage activities, principally coal mining. Mayes, Sudderth, and Etheredge, Inc. (1975), U.S. Army Corps of Engineers (1976), and Soil Systems, Inc. (1980), note that coal mining is the most serious water quality impact in the upper Cumberland

River system, causing increased siltation and dissolved constituents such as sulfates and iron.

SEDIMENT EVALUATION

Sediment samples were taken from all three stations in the wild river corridor during July and August 1993. Analyses were conducted on 17 parameters (Table 4). The data were compared to U.S. EPA (1977) Great Lakes Harbor Sediment Guidelines and STORET (1979-1993) sediment data. Any parameters that met or exceeded U.S. EPA (1977) moderately or heavily polluted categories or exceeded the STORET (1979-1993) 75th percentile are considered potential problem constituents.

According to U.S. EPA (1977) guidelines, two parameters (total volatile solids and manganese) were in the heavily polluted category at all stations, while arsenic and nickel were in the moderately polluted category. Total Kjeldahl nitrogen was in the moderately polluted range at Station 18-3.

Using the STORET (1979-1983) data, the following parameters exceeded the 75th percentile at the listed stations:

oil and grease (18-1),
total volatile solids (all stations),
total Kjeldahl nitrogen (18-3),
arsenic (18-3),
cadmium (all stations), and
nickel (18-1 and 18-3).

Using the information generated from both U.S. EPA (1977) and STORET (1979-1993), Station 18-3 sediments were the most contaminated, while Station 18-2 had the least number of

TABLE 4 : Sediment Data for the Wild River Section of the Cumberland River, July and August 1993			
	Stations		
Parameter* (mg/kg)	**18-1**	**18-2**	**18-3**
Cyanide, total	ND @ 0.72	ND @ 0.85	ND @ 0.84
Oil and Grease	249.51	85.9	120.77
Total Volatile Solids %	26.5	13.0	12.7
Organic Carbon	4,490	24,900	10,500
Ammonia-Nitrogen	7.25	24.8	27.7
Total Kjeldahl Nitrogen	416	286	1,250
Aluminum	3,530	4,080	6,390
Arsenic	5.03	5.34	6.44
Cadmium	2.94	3.15	3.89
Chromium	7.80	5.78	12.4
Copper	14.2	ND @ 0.599	13.8
Iron	12,300	15,100	16,900
Lead	13.0	ND @ 4.64	17.3
Manganese	677	968	1,380
Mercury	0.083	0.077	0.089
Nickel	28.9	23.6	29.4
Zinc	55.5	44.0	64.3

*Sediment parameters in mg/kg unless otherwise stated.

elevated constituents. However, most of the sediment parameters at all three locations were below levels of concern.

BIOLOGICAL EVALUATION

Biological data was collected from three locations during this study. The location of these sites is presented in Figure 1 and Appendix A. Site descriptions are presented in the physical evaluation section of this report.

Periphyton, macroinvertebrate, and fish data were collected at each site during this study. The periphyton and macroinvertebrate data were used to generate the biotic assessment index (BAI). The BAI is used to assess the biological integrity of the wild river segment. Because of the extreme difficulties sampling the large river habitats, the fish collections made during this study were not considered to accurately represent the fish community of the wild river segment; therefore, the index of biotic integrity (IBI) was not calculated and used in the BAI.

The BAI classified the lower and upper portions of the wild river segment as excellent (Table 5) and the middle portion as good. Streams with classifications of good and excellent are considered to be supporting warmwater aquatic habitat (WAH) use designation. Therefore, the entire wild river segment (16.1 miles) is meeting the WAH use. Since the criteria for outstanding resource water (ORW) are the same as for WAH, this segment is also considered to support the ORW use.

Table 5. Biotic Assessment Index (BAI) Rankings for the Wild River Segment of the Cumberland River

	Stations		
	18-1	**18-2**	**18-3**
DBI Score	4.0	3.4	3.8
MBI Score	4.3	4.4	4.5
BAI Score	4.1	3.9	4.1
Biotic Integrity Ranking	Excellent	Good	Excellent

The wild river corridor provides a refuge for both plants and animals alike. Protection of the corridor allows riparian and large river aquatic communities to remain intact, thus providing an epicenter for reinvasion into areas disturbed by anthropogenic activities. However, the aquatic communities are subject to impacts from upstream areas. The most serious and long-lasting perturbation is coal mining. Coal mining activities are believed to be responsible for the extirpation of aquatic species from the wild river corridor.

Periphyton

The KDOW collected and identified 115 algal taxa from the Cumberland River during the 1993 survey. (Appendix C). Of these, six were green algae (Chlorophyta), four were bluegreen bacteria (Cyanophyta), and 105 were diatoms (Bacillariphyceae). Cladophora glomerata, a filamentous green alga, dominated the algal community at all three sites. Diatoms were enumerated, and the community was analyzed to assess stream biotic integrity using methods described in KDOW (1993).

Through the Biological Monitoring Program (BMP), KDOW has collected biological data, including algae, from the Cumberland River above Cumberland Falls (MP 562.4) since 1979. Historical data show a diverse algal community with high species richness indicative of good water quality. The diatom community of that site has been dominated by Achnanthes minutissima, Cocconeis placentula, and Nitzschia species, which were described as "typical stream diatoms characteristic of moderate to high dissolved oxygen levels and moderate

nutrient enrichment" (KDOW unpublished data). The algal community in 1993, at site 18-2 (closest to the BMP site), is similar to the historical data, and the same diatom species are dominant.

The three sites studied in 1993 were relatively similar to one another, with percent community similarity (PS_c) values ranging from 40-62 percent (Table 6), and total number of diatom taxa (TDNT) ranging from 67 to 77. Diatom bioassessment indices (DBI) were calculated using the following metrics: total number of diatom taxa (TNDT), diversity, pollution tolerance index (PTI), percent sensitive species (%SS), and siltation index (%NNS) (KDOW 1993). The DBI score is the mean of the individual metric score. The DBI ranks site 18-1 as excellent and 18-2 and 18-3 as good (Table 7).

Table 6. Percent Community Similarity (PS_c) Values for Diatom Data

	18-1	18-2
18-2	62.07	
18-3	40.68	47.31

TABLE 7. Diatom Community Metrics and Diatom Bioassessment Index (DBI) Scores Stations

Metric	18-1	18-2	18-3
TNDT	77 (4)	65 (4)	72 (4)
Diversity	3.66 (4)	2.47 (3)	4.49(5)
PTI	2.8 (4)	2.7 (3)	2.5 (3)
%SS	17.3 (5)	2.6 (4)	4.2 (5)
%NNS	24.4 (3)	25.6 (3)	45.6 (2)
DBI Score	4.0	3.4	3.8
biotic integrity	excellent	good	good

While all three stations supported uses, certain metrics indicated minor impairments to the algal community. The high percentage of silt-tolerant diatoms (Navicula + Nitzchia + Surirella), especially at Station 18-3, is a result of upstream land disturbance from coal mining and possibly logging operations. In addition, the abundance of Cladophora at all three sites is indicative of nutrient enrichment from a variety of upstream point and non-point sources. The continuing sedimentation and nutrient inputs to the system may result in degradation of biological integrity in the future.

Macroinvertebrates

During this study the KDOW collected and identified 120 taxa of macroinvertebrates. Annelids, mollusks, crustaceans, and aquatic insects were represented. The most diverse groups were the Diptera (flies), Trichoptera (caddisflies), and Ephemeroptera (mayflies), respectively.

Macroinvertebrate collections were made by Soil Systems, Inc., 1980; however, their identifications were primarily to the generic level, making comparison difficult. Several of the macroinvertebrate species reported by Soil Systems, Inc. (1980), are questionable, with the most notable being Orconectes placidus. They report three collections of O. placidus from above the falls. Orconectes placidus has an affinity for limestone streams and is quickly reduced or terminated with the encroachment of sandstone (Rhoades 1944). In Kentucky this species is reported only from the Cumberland

River and its tributaries from Wayne County westward (Rhoades 1944; Hobbs 1989). It is believed that Soil Systems, Inc. (1980) misidentified specimens of O. putnami, a species common to this portion of the Cumberland River, as O. placidus. They did not report O. putnami from any location in the wild river corridor.

Three papers, Wilson and Clark (1914), Neal and Allen (1964), and Stansbery (1969), report mussel data from the wild river segment. The reach below Cumberland Falls, which is equivalent to this study's 18-1, was sampled by all of the above authors. A total of 21 species are known from this area. Wilson and Clark (1914) reported 20 species, Neal and Allen (1964) found 15 species, and Stansbery (1969) observed 16 species. Stansbery (1969) noted that not only had the mussel fauna decreased since Wilson and Clark's (1914) early collections, but that the faunal composition had also changed dramatically. He attributed this change to the impacts of upstream coal mining and downstream impoundment of Cumberland River to form Cumberland Lake. Recent collections made by the KSNPC yielded only nine species (R. Cicerello, pers. com.). This loss of 12 mussel species is believed to be a result of intermittent acid mine drainage and heavy siltation arising from upstream coal mining operations and downstream impoundment. The impoundment of Cumberland River destroyed the riverine mussel fauna that flourished in the Cumberland River from the headwaters of the impoundment to the state line. This destruction of the once diverse mussel fauna precludes any recruitment from downstream areas. These twelve

species are now permanently lost from this portion of the river.

Cumberland Falls has provided a formidable barrier to the upstream movement of freshwater mussels (Neal and Allen 1964). Twenty-one species are reported from just downstream of Cumberland Falls (Stansbery 1969), while only eight species are reported from above the falls (refer to Wilson and Clark 1914, Neal and Allen 1964, Harker et al. 1980, and Call and Parmalee 1981). Recent collections by KSNPC yielded only one species from the wild river segment, Actinonaias pectorosa. The demise of the mussel fauna above the falls is the result of intermittent discharges of acid mine drainage and siltation from upstream coal operations. Juvenile mussels are known to be extremely sensitive to even slight elevations in heavy metal concentrations and siltation. These are common constituents arising from upstream coal mining operations.

According to the Kentucky Natural Heritage Program Database (KNHPD) (1993), three rare invertebrates have been reported from the wild river corridor. These include one undescribed species of caddisfly, Madeophylox sp., and two freshwater mussels, Alasmadonta atropurpurea and Villosa trabalis.

The caddisfly Madeophylax sp. is an undescribed terrestrial species. According to Dr. Gunter Schuster (pers. comm.) this trichopteran was first observed in 1983 inhabiting the Rockcastle Sandstone cliffs around seeps and damp areas in the Cumberland Falls area. Dr. Schuster notes that this caddisfly is always associated with Pennsylvanian age

sandstone cliffs. Madeophylax constructs cylindrical stone cases, which it transports with it as it feeds on periphyton. This species is considered threatened by KSNPC (1992). It presently has no federal status.

The unionid mussel Alasmadonta atropurpurea (Cumberland elktoe) is endemic to the Cumberland River system. Kentucky Natural Heritage Program Database (1993) records indicate that A. atropurpurea has been collected once from the wild river section of the Cumberland River. The sole collection was made in October, 1935, from just upstream of the falls. Call and Parmalee (1981) note that A. atropurpurea occupies various current regimes, but prefers areas of low flow in medium-sized, moderate-gradient, high-quality streams. They observed it living buried from 1/2 to 1/3 in the mud, sand, and gravel that occupies the interstitial spaces between cobble/boulder substrate. This mussel is considered endangered by KSNPC (1992) and is presently undergoing status review by the USFWS (KSNPC 1992). Williams et al. (1993) considered this mussel as endangered. This species has not been seen in the wild river corridor since 1935, thus indicating its possible extirpation from this portion of the Cumberland River.

Villosa trabalis, the Cumberland bean mussel, is known from two collections in that portion of the corridor below Cumberland Falls. The first collection was in 1910, and the other in September of 1948 (KNHPD 1993). This unionid typically inhabits medium to large streams in erosional areas (riffles and runs) laden with sand and gravel. This species is listed by both KSNPC (1992) and USFWS (1992) as endangered.

Williams et al. (1993) also considered this species as endangered. Villosa trabalis has not been collected from the wild river corridor since 1972 and is presumed extirpated from this region of the Cumberland river.

The Biological Monitoring Program has been collecting macroinvertebrate data from Cumberland River above Cumberland Falls (MP 562.4) since 1979. Those data show that this reach of the river supports a diverse macroinvertebrate fauna, including a good variety of the pollution tolerant groups, the ephemeropterans and trichopterans.

The three sites sampled during this study were relatively similar to each other, with PS_c values ranging from 45.1 to 52.9 (Table 8). Other metrics used to assess biotic integrity were also similar to one another (Table 9).

Table 8. Percent Community Similarity (PS_c) Values for Macroinvertebrate Data

Stations	18-1	18-2
18-2	45.1	
18-3	46.5	52.9

The macroinvertebrate bioassessment index (MBI) (Table 9) was used to assess biotic integrity at all three stations. The metrics used in the MBI are taxa richness (TR); total number of taxa (TNI); Ephemeroptera, Plecoptera, Trichoptera (EPT) index; dominance in common, ten (DIC_{10}); percent contribution of dominant taxa, five (PCD_5); percent community similarity (PS_c); and the Hilsenhoff Biotic Index (HBI) (KDOW 1993). The MBI score is the mean of the individual metric

Table 9. Macroinvertebrate Community Metrics and Macroinvertebrate Bioassessment Index (MBI) Scores			
	Stations		
Metrics	**18-1**	**18-2**	**18-3**
TR	68 (4)	78 (5)	73 (5)
TNI	852 (4)	1235 (5)	826 (4)
EPT	30 (5)	27 (5)	30 (5)
DIC_{10}	w/18-2 6 (4) w/18-3 6 (4)	w/18-1 6 (4) w/18-2 7 (4)	w/18-1 6 (4) w/18-2 7 (4)
PCD_5	46.7 (5)	62.5 (3)	46.5 (5)
PS_c	w/18-2 45.1 (4) w/18-3 46.5 (4)	w/18-1 45.1 (4) w/18-3 52.9 (5)	w/18-1 46.5 (4) w/18-2 52.9 (5)
HBI	4.8 (4)	4.7 (4)	4.4 (4)
MBI Score	4.3	4.4	4.5
Biotic Integrity Ranking	Excellent	Excellent	Excellent

w/ = compared with (station)

scores. The MBI classified all three sites (18-1, 18-2, and 18-3) as excellent. Excellent taxa diversity was present at all locations. However, the demise of the mussel fauna in the wild river segment indicates that there are intermittent periods of degraded water quality.

Fish

Fish data from collections taken from the wild river segment are presented in Jordan and Brayton (1878), Everman (1918), Lachner and Jenkins (1971), Soil Systems, Inc. (1980), and KDOW (1988). Data from this report is compared to Soil Systems, Inc. (1980) (Table 10).

An Index of Biotic Integrity was not calculated with this study's fish data. It was determined by KDOW staff that the

Table 10: Fishes Collected From Cumberland River				
Taxa	Soil Systems Inc. (1980)	KDOW 18-1	KDOW 18-2	KDOW 18-3
CLUPEIDAE				
Dorosoma cepedianum	X			
CYPRINIDAE				
Campostoma anomalum	X		2	3
Cyprinella spiloptera	X	66	14	39
Cyprinella whipplei	X			
Cyprinis carpio	X			
Luxilus chrysocephalus	X			6
Nocomis micropogon	X		2	6
Notropis rubellus	X	45	17	49
Notropis volucellus	X		5	29
Pimephales notatus	X		19	8
Semotilus atromaculatus	X			
CATOSTOMIDAE				
Hypentelium nigricans	X	6	3	2
Moxostoma erythrurum		1		7
Moxostoma macrolepidotum	X			
ICTALURIDAE				
Ictalurus punctatus	X			
Pylodictis olivaris		1		
SALMONIDAE				
Oncorhynchus mykiss	X			
POECILIIDAE				
Gambusia affinis	X			4
CENTRARCHIDAE				
Ambloplites rupestris	X	1	3	1
Lepomis cyanellus				2
Lepomis macrochirus	X		1	
Lepomis megalotis	X	2	5	7
Lepomis microlophus	X			
Micropterus dolomieu	X	10		4
Micropterus punctulatus	X	11	7	13
Micropterus salmoides	X			
PERCIDAE				
Etheostoma blennioides	X	1	6	2
Etheostoma kennicotti	X			1
Etheostoma stigmaeum	X			
Etheostoma baileyi	X			
Percina caprodes	X	4		

fish collections did not adequately represent the fish community of the wild river segment. Shoals were boulder-cobble dominated, making the substrate virtually impossible to move. Pools were deep and extremely difficult to properly seine.

The fish data presented in Table 10 show that Soil Systems, Inc. (1980), collected 28 species, while KDOW found only 20 species. Both groups found a good representation of minnows (Cyprinidae) and basses (Centrarchidae). Soil Systems, Inc. (1980) reported five darter species (Percidae), while KDOW found only three. Three exotic species, the carp (Cyprinis carpio), the coosae bass (Micropterus coosae), and the rainbow trout (Oncorhynchus mykiss), were reported by Soil Systems. Neither Soils Systems nor KDOW found any fish species listed by KSNPC or USFWS.

Soil Systems, Inc. (1980), reported the occurrence of Micropterus coosae, the coosae bass, from two locations in the upper portion of the wild river segment. The presence of this introduced species at these locations in the Cumberland River is extremely unlikely and should be considered a misidentification. The coosae bass was stocked in the upper reaches of Martins Fork by Kentucky Department of Fish and Wildlife Resources (KDFWR) personnel in the late 1950's or early 1960's. This species has not been reported, before or since the Soil Systems, Inc. (1980) report, in any portion of the upper Cumberland River drainage other than Martins Fork.

Two fish, the lake sturgeon (Acipenser fulvescens) and the johnny darter (Etheostoma nigrum susanae), considered

endangered by KSNPC (1992), have been reported from the wild river segment. One additional species, the blackside dace (Phoxinus cumberlandensis), considered endangered by KSWPC (1992) and threatened by USFWS (1992), may move in and out of the corridor in small tributary streams.

Acipenser fluvescens, the lake sturgeon, was observed in the portion of the corridor below Cumberland Falls in August, 1954. Distributional records indicate that the lake sturgeon occurs in large rivers with gravel and sand bottoms (Burr and Warren 1986). This species is considered endangered by KSNPC and is under status review by the USFWS (KSNPC 1992). The fluctuating water quality of the upper Cumberland River and the impoundment of the river by Wolf Creek Dam may have resulted in the extirpation of the lake sturgeon from the wild river corridor.

A subspecies of the johnny darter (Etheostoma nigrum susanae) is known only from the upper Cumberland River above Cumberland Falls (Burr and Warren 1986). The habitat preference and spawning requirements; quiet, shallow pools under rocks, logs, or other objects (Burr and Warren 1986); may indicate that E. n. susanae is not a permanent resident of the Cumberland River in the wild river corridor. This darter probably moves into the river when small tributary flows are low or non-existent. The johnny darter is considered endangered by KSNPC and is under status review by the USFWS (KSNPC 1992).

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Appendix A.
Site Information

Appendix A. Site Information

Site No: 02018001 Type Sampling: Biological
Waterbody No: KY 5130101-009 Physicochemical
Stream: Cumberland River Sediment
County: Whitley/McCreary
Location: Below Cumberland Falls
Latitude: 36-50-38
Longitude: 84-20-34
Stream Order: VI
USGS Topo Quad: Cumberland Falls, KY
DOW Map No.: 3-46
MP: 562.1
Sampling Dates: July 29, 1993

Site No: 02018002 Type Sampling: Biological
Waterbody No: KY 5130101-009 Physicochemical
Stream: Cumberland River Sediment
County: Whitley/McCreary
Location: Below the confluence with Marsh Creek
Latitude: 36-46-54
Longitude: 84-21-00
Stream Order: VI
USGS Topo Quad: Cumberland Falls, KY
DOW Map No.: 3-46
MP: 569.1
Sampling Dates: August 10, 1993

Site No: 02018003 Type Sampling: Biological
Waterbody No: KY 5130101-009 Physicochemical
Stream: Cumberland River Sediment
County: Whitley
Location: At Summer Shoals
Latitude: 36-15-34
Longitude: 84-17-25
Stream Order: VI
USGS Topo Quad: Cumberland River
DOW Map No.: 3-46
MP: 573.6
Sampling Dates: August 10, 1993

Appendix B.
STORET (1983-1992) Values for Cumberland River Ambient Monitoring Station at Cumberland Falls

Appendix B: STORET (1983-1993) Values for Cumberland River Ambient Monitoring Station at Cumberland Falls

Year/Value 1983	Water Temp. (C)	Cond. (Umhos cm)	DO (mg/l)	pH (SU)	Turb (NTU)	Alk Total (mg/l)	Cl Total (mg/l)	SO_4 Diss. (mg/l)	Susp Sol. (mg/l)	TOC (mg/l)
	Parameters									
No. of Samples	12	12	12	12	8	12	12	12	12	6
25th Percentile	6.00	195.00	7.20	7.20	0.30	36.50	3.50	49.10	4.00	4.40
50th Percentile	8.00	255.00	9.80	7.30	7.00	57.40	5.20	70.00	10.00	4.60
75th Percentile	17.00	447.00	10.40	7.80	36.00	78.60	13.10	111.00	56.00	5.10
Maximum	25.00	561.00	12.00	8.00	50.00	130.00	16.70	157.00	190.00	5.20
Minimum	5.00	179.00	6.50	6.90	0.18	31.70	3.16	45.80	2.00	4.40
Mean	13.00	323.25	9.37	7.48	19.39	63.38	8.14	88.42	44.75	4.82

Appendix B: STORET (1983-1993) Values for Cumberland River Ambient Monitoring Station at Cumberland Falls

	Parameters									
Year/Value 1984	**Water Temp. (C)**	**Cond. (Umhos cm)**	**DO (mg/l)**	**pH (SU)**	**Turb (NTU)**	**Alk Total (mg/l)**	**Cl Total (mg/l)**	**SO_4 Diss. (mg/l)**	**Susp. Sol. (mg/l)**	**TOC (mg/l)**
No. of Samples	11	11	11	11	11	10	10	10	10	10
25th Percentile	7.50	216.00	8.20	7.00	9.00	30.20	3.50	54.70	6.00	1.40
50th Percentile	13.00	297.00	9.20	7.10	24.00	36.00	6.15	65.60	37.00	2.20
75th Percentile	22.80	387.00	10.40	7.40	100.00	67.00	7.90	94.70	140.00	2.80
Maximum	24.00	534.00	11.90	7.80	100.00	98.00	52.10	174.00	266.00	11.10
Minimum	3.00	190.00	7.70	6.50	3.20	28.00	3.47	53.90	1.00	0.80
Mean	14.57	309.73	9.47	7.15	44.93	52.89	11.00	86.98	82.00	2.99

Appendix B: STORET (1983-1993) Values for Cumberland River Ambient Monitoring Station at Cumberland Falls

	Parameters									
Year/Value 1985	**Water Temp. (C)**	**Cond. (Umhos cm)**	**DO (mg/l)**	**pH (SU)**	**Turb (NTU)**	**Alk Total (mg/l)**	**Cl Total (mg/l)**	**SO_4 Diss. (mg/l)**	**Susp. Sol. (mg/l)**	**TOC (mg/l)**
No. of Samples	11	11	11	11	11	10	11	11	9	9
25th Percentile	8.50	237.00	8.50	6.80	7.60	36.40	4.10	72.10	4.00	1.20
50th Percentile	14.50	296.00	9.80	7.30	12.00	56.60	5.50	83.90	12.00	2.00
75th Percentile	24.00	298.00	12.50	7.60	36.00	74.10	6.20	91.60	19.00	2.90
Maximum	26.50	490.00	12.80	7.90	72.00	123.00	12.30	136.00	58.00	3.10
Minimum	2.00	197.00	7.20	6.40	2.60	27.90	2.61	58.10	2.00	1.10
Mean	14.91	293.64	10.14	7.19	22.32	62.80	5.62	86.57	20.67	2.02

Appendix B: STORET (1983-1993) Values for Cumberland River Ambient Monitoring Station at Cumberland Falls

Parameters										
Year/Value 1986	Water Temp. (C)	Cond. (Umhos cm)	DO (mg/l)	pH (SU)	Turb (NTU)	Alk Total (mg/l)	Cl Total (mg/l)	SO_4 Diss. (mg/l)	Susp Sol. (mg/l)	TOC (mg/l)
No. of Samples	11	11	11	11	11	11	10	11	9	11
25th Percentile	7.50	260.00	8.20	7.00	6.30	47.30	1.30	74.30	2.00	1.30
50th Percentile	14.70	315.00	8.75	7.10	13.20	60.70	5.50	83.10	12.00	2.30
75th Percentile	24.50	381.00	10.20	7.20	26.00	73.60	7.20	98.90	15.00	2.80
Maximum	28.00	409.00	12.80	7.70	96.00	150.00	9.60	114.00	92.00	5.20
Minimum	6.00	225.00	6.20	6.90	2.40	30.90	1.17	16.80	1.00	1.20
Mean	16.11	318.27	9.24	7.16	25.61	64.60	5.19	81.01	19.00	2.43

Appendix B: STORET (1983-1993) Values for Cumberland River Ambient Monitoring Station at Cumberland Falls

	Parameters									
Year/Value 1983	**Al Total (ug/l)**	**As Total (ug/l)**	**Br Total (ug/l)**	**Cd Total (ug/l)**	**Cr Total (ug/l)**	**Cu Total (ug/l)**	**Fe Total (ug/l)**	**Pb Total (ug/l)**	**Mn Total (ug/l)**	**Hg Total (ug/l)**
No. of Samples	6	12	8	12	12	12	12	12	12	12
25th Percentile	50.00	1.00	34.00	1.00	1.00	2.00	60.00	3.00	40.00	0.10
50th Percentile	67.00	1.00	50.00	1.00	2.00	12.00	360.00	8.00	110.00	0.25
75th Percentile	196.00	1.00	96.00	2.00	4.00	24.00	1020.00	10.00	240.00	0.60
Maximum	391.00	3.00	141.00	20.00	8.00	40.00	3330.00	40.00	298.00	1.20
Minimum	50.00	1.00	32.00	1.00	1.00	2.00	20.00	1.00	30.00	0.10
Mean	150.00	1.25	68.13	3.08	2.58	16.00	826.17	9.75	143.58	0.40

Appendix B: STORET (1983-1993) Values for Cumberland River Ambient Monitoring Station at Cumberland Falls

Year/Value 1984	Al Total (ug/l)	As Total (ug/l)	Br Total (ug/l	Cd Total (ug/l)	Cr Total (ug/l)	Cu Total (ug/l)	Fe Total (ug/l)	Pb Total (ug/l)	Mn Total (ug/l)	Hg Total (ug/l)
	Parameters									
No. of Samples	11	11	11	11	11	11	10	11	10	10
25th Percentile	61.00	1.00	38.00	1.00	1.00	2.00	80.00	1.00	40.00	0.10
50th Percentile	232.00	1.00	42.00	1.00	1.00	5.00	300.0	1.00	160.00	0.10
75th Percentile	829.00	1.00	46.00	1.00	3.00	6.00	1260.00	2.00	220.00	0.40
Maximum	1340.00	1.00	48.00	1.00	6.00	60.00	2870.00	9.00	660.00	2.50
Minimum	17.00	1.00	33.00	1.00	1.00	1.00	40.00	1.00	30.00	0.10
Mean	475.36	1.00	41.91	1.00	2.09	9.45	848.00	2.27	186.00	0.49

Appendix B: STORET (1983-1993) Values for Cumberland River Ambient Monitoring Station at Cumberland Falls

	Parameters									
Year/Value 1985	**Al Total (ug/l)**	**As Total (ug/l)**	**Br Total (ug/l)**	**Cd Total (ug/l)**	**Cr Total (ug/l)**	**Cu Total (ug/l)**	**Fe Total (ug/l)**	**Pb Total (ug/l)**	**Mn Total (ug/l)**	**Hg Total (ug/l)**
No. of Samples	9	8	8	9	9	9	8	9	8	10
25th Percentile	55.00	1.00	9.00	1.00	1.00	2.00	120.00	1.00	40.00	0.10
50th Percentile	166.00	1.00	29.00	1.00	1.00	3.00	380.00	2.00	110.00	0.10
75th Percentile	364.00	1.00	37.00	1.00	2.00	4.00	1090.00	2.00	130.00	0.10
Maximum	705.00	7.00	38.00	1.00	4.00	11.00	1710.00	4.00	190.00	2.70
Minimum	43.00	1.00	1.00	1.00	1.00	1.00	90.00	1.00	40.00	0.10
Mean	258.67	1.88	26.38	1.00	1.56	3.78	772.50	1.89	110.00	0.37

Appendix B: STORET (1983-1993) Values for Cumberland River Ambient Monitoring Station at Cumberland Falls

Parameters										
Year/Value 1986	Al Total (ug/l)	As Total (ug/l)	Br Total (ug/l)	Cd Total (ug/l)	Cr Total (ug/l)	Cu Total (ug/l)	Fe Total (ug/l)	Pb Total (ug/l)	Mn Total (ug/l)	Hg Total (ug/l)
No. of Samples	11	11	11	11	11	11	11	11	11	9
25th Percentile	78.00	1.00	21.00	1.00	2.00	1.00	200.00	1.00	60.00	0.10
50th Percentile	122.00	1.00	26.00	1.00	2.00	2.00	450.00	1.00	100.00	0.10
75th Percentile	281.00	2.00	34.00	1.00	4.00	4.00	640.00	2.00	160.00	0.10
Maximum	943.00	4.00	57.00	1.00	6.00	14.00	2480.00	2.00	240.00	0.30
Minimum	21.00	1.00	14.00	1.00	1.00	1.00	50.00	1.00	20.00	0.10
Mean	240.64	1.55	28.91	1.00	2.82	4.00	652.73	1.27	110.00	0.12

Appendix B: STORET (1983-1993) Values for Cumberland River Ambient Monitoring Station at Cumberland Falls

Parameters										
Year/Value 1983	**Zn Total (ug/l)**	**Ca Total (mg/l)**	**Mg Total (mg/l)**	**K Total (mg/l)**	**Na Total (mg/l)**	**Hard. Total (mg/l)**	**NH_3+ NH_4 Total (mg/l)**	**NO_2+ NO_3 Total (mg/l)**	**TKN (mg/l)**	**Phos. Total (mg/l)**
No. of Samples	12	6	6	6	6	12	12	12	12	12
25th Percentile	15.00	17.60	10.00	1.96	8.80	70.00	0.06	0.17	0.27	0.04
50th Percentile	18.00	22.00	15.60	3.86	16.00	92.20	0.09	0.31	0.32	0.05
75th Percentile	31.00	37.80	19.30	4.57	29.40	158.00	0.10	0.43	0.37	0.07
Maximum	1200.0	41.50	20.80	5.09	35.80	176.00	0.23	0.44	1.64	0.16
Minimum	2.00	17.60	10.00	1.96	8.80	66.20	0.05	0.01	0.24	0.03
Mean	1020.33	27.98	15.67	3.75	19.70	114.38	0.11	0.29	0.46	0.06

Appendix B: STORET (1983-1993) Values for Cumberland River Ambient Monitoring Station at Cumberland Falls

	Parameters									
Year/Value 1984	Zn Total (ug/l)	Ca Total (mg/l)	Mg Total (mg/l)	K Total (mg/l)	Na Total (mg/l)	Hard. Total (mg/l)	NH_3+ NH_4 Total (mg/l)	NO_2+ NO_3 Total (mg/l)	TKN (mg/l)	Phos. Total (mg/l)
No. of Samples	10	10	11	10	11	11	11	11	11	11
25th Percentile	5.00	20.50	9.08	1.90	9.10	84.00	0.05	0.22	0.23	0.03
50th Percentile	9.00	23.00	12.70	2.21	11.90	101.00	0.05	0.33	0.30	0.07
75th Percentile	20.00	27.40	18.30	3.55	24.40	159.00	0.05	0.49	0.55	0.15
Maximum	33.00	69.50	20.60	4.58	47.50	176.00	0.07	0.53	0.81	0.27
Minimum	4.00	6.70	5.28	1.85	5.60	75.00	0.05	0.14	0.08	0.01
Mean	13.50	28.62	13.23	2.82	17.02	113.87	0.05	0.33	0.39	0.09

Appendix B: STORET (1983-1993) Values for Cumberland River Ambient Monitoring Station at Cumberland Falls

Year/Value 1985	Zn Total (ug/l)	Ca Total (mg/l)	Mg Total (mg/l)	K Total (mg/l)	Na Total (mg/l)	Hard. Total (mg/l)	NH_3+ NH_4 Total (mg/l)	NO_2+ NO_3 Total (mg/l)	TKN (mg/l)	Phos. Total (mg/l)
	Parameters									
No. of Samples	8	8	8	8	8	11	11	11	11	11
25th Percentile	8.00	22.10	10.10	1.76	12.00	93.00	0.05	0.18	0.13	0.02
50th Percentile	10.00	26.50	12.40	2.22	13.90	115.00	0.05	0.43	0.21	0.03
75th Percentile	12.00	30.20	13.80	2.39	21.70	187.00	0.05	0.50	0.27	0.05
Maximum	30.00	33.20	19.40	3.81	35.60	278.00	0.05	0.59	0.46	0.07
Minimum	6.00	20.90	9.64	1.56	9.00	73.00	0.05	0.15	0.10	0.01
Mean	12.50	26.94	13.07	2.39	18.28	136.96	0.05	0.36	0.22	0.03

Appendix B: STORET (1983-1993) Values for Cumberland River Ambient Monitoring Station at Cumberland Falls

	Parameters									
Year/Value 1986	**Zn Total (ug/l)**	**Ca Total (mg/l)**	**Mg Total (mg/l)**	**K Total (mg/l)**	**Na Total (mg/l)**	**Hard. Total (mg/l)**	**NH_3+ NH_4 Total (mg/l)**	**NO_2+ NO_3 Total (mg/l)**	**TKN (mg/l)**	**Phos. Total (mg/l)**
No. of Samples	11	11	11	11	11	11	11	11	10	11
25th Percentile	12.00	22.00	11.40	1.74	13.30	101.00	0.05	0.20	0.08	0.02
50th Percentile	14.00	27.40	11.83	2.37	17.10	124.00	0.05	0.42	0.16	0.02
75th Percentile	58.00	30.00	14.60	2.76	24.60	134.00	0.05	0.44	0.37	0.03
Maximum	71.00	33.40	17.30	3.09	34.80	144.00	0.05	0.63	0.47	0.07
Minimum	5.00	17.10	10.10	1.65	9.60	77.80	0.05	0.03	0.07	0.01
Mean	26.91	26.16	12.93	2.31	18.66	116.94	0.05	0.37	0.24	0.03

Appendix B: STORET (1983-1993) Values for Cumberland River Ambient Monitoring Station at Cumberland Falls

	Parameters									
Year/Value 1987	**Water Temp. (C)**	**Cond. (Umhos)**	**DO (mg/l)**	**pH (Su)**	**Turb (NTU)**	**Alk Total (mg/l)**	**Cl Total (mg/l)**	**SO_4 (Diss) (mg/l)**	**Susp. Sol. (mg/l)**	**TOC (mg/l)**
No. of Samples	12	12	12	12	12	12	12	12	12	12
25th Percentile	8.00	246.00	7.50	7.10	3.50	42.80	3.80	80.50	5.00	1.30
50th Percentile	12.00	321.00	9.00	7.20	6.00	78.00	6.16	97.70	5.00	2.79
75th Percentile	22.00	470.00	11.00	7.40	12.00	92.00	11.30	140.00	6.00	4.30
Maximum	27.00	612.00	13.00	7.90	95.00	114.00	25.30	155.00	74.00	8.68
Minimum	0.10	185.00	6.60	7.00	2.00	30.40	3.30	63.80	1.00	1.10
Mean	15.26	363.17	9.47	7.31	18.63	72.93	9.07	109.58	10.83	3.25

Appendix B: STORET (1983-1993) Values for Cumberland River Ambient Monitoring Station at Cumberland Falls

	Parameters									
Year/Value 1988	**Water Temp. (C)**	**Cond. (Umhos)**	**DO (mg/l)**	**pH (Su)**	**Turb (NTU)**	**Alk Total (mg/l)**	**Cl Total (mg/l)**	**SO_4 (Diss) (mg/l)**	**Susp. Sol. (mg/l)**	**TOC (mg/l)**
No. of Samples	12	12	12	12	12	12	11	12	11	12
25th Percentile	1.50	255.00	8.00	7.39	4.00	44.00	3.70	66.20	5.00	1.34
50th Percentile	11.10	302.00	9.30	7.90	8.00	52.80	6.90	92.30	7.00	1.88
75th Percentile	20.20	484.00	12.40	8.20	12.00	76.50	11.20	126.00	38.00	3.00
Maximum	29.00	600.00	13.30	8.77	110.00	103.00	12.50	140.00	135.00	3.70
Minimum	0.10	155.00	6.70	6.89	2.00	33.30	3.30	64.50	1.00	1.28
Mean	13.58	367.43	9.96	7.88	21.22	63.92	7.17	102.38	25.64	2.27

Appendix B: STORET (1983-1993) Values for Cumberland River Ambient Monitoring Station at Cumberland Falls

	Parameters									
Year/Value 1989	**Water Temp. (C)**	**Cond. (Umhos)**	**DO (mg/l)**	**pH (Su)**	**Turb (NTU)**	**Alk Total (mg/l)**	**Cl Total (mg/l)**	**SO_4 (Diss) (mg/l)**	**Susp. Sol. (mg/l)**	**TOC (mg/l)**
No. of Samples	12	12	12	12	12	12	11	12	12	10
25th Percentile	8.10	206.00	7.50	7.40	7.00	37.50	2.43	52.80	9.00	1.10
50th Percentile	13.50	230.00	8.30	7.50	12.00	43.60	3.34	69.30	16.00	1.62
75th Percentile	19.00	261.00	10.70	7.90	52.00	46.90	3.82	81.80	88.00	2.50
Maximum	28.20	417.00	12.80	8.00	210.00	78.80	6.60	132.00	270.00	4.40
Minimum	0.50	148.00	5.70	7.30	3.50	14.10	0.80	50.30	3.00	1.00
Mean	15.05	241.42	9.05	7.64	49.38	44.31	3.39	76.65	71.92	2.02

Appendix B: STORET (1983-1993) Values for Cumberland River Ambient Monitoring Station at Cumberland Falls

Year/Value 1990	Water Temp. (C)	Cond. (Umhos)	DO (mg/l)	pH (Su)	Turb (NTU)	Alk Total (mg/l)	Cl Total (mg/l)	SO (Diss) (mg/l)	Susp. Sol. (mg/l)	TOC (mg/l)
	Parameters									
No. of Samples	12	12	12	12	11	12	12	12	12	12
25th Percentile	6.10	220.00	8.20	7.20	8.50	37.20	1.04	58.30	10.00	1.20
50th Percentile	15.50	317.00	9.40	7.40	14.00	56.20	3.86	66.60	15.00	2.20
75th Percentile	18.00	331.00	10.60	8.00	21.00	71.50	5.19	86.80	24.00	3.10
Maximum	26.00	490.00	14.00	8.50	130.00	94.10	46.70	133.00	125.00	4.20
Minimum	5.00	201.00	7.20	6.90	6.50	31.10	0.10	52.80	4.00	0.10
Mean	15.13	316.33	9.84	7.62	24.91	55.53	7.04	80.63	33.33	2.38

Appendix B: STORET (1983-1993) Values for Cumberland River Ambient Monitoring Station at Cumberland Falls

Parameters										
Year/Value 1987	**Al Total (ug/l)**	**As Total (ug/l)**	**Ba Total (ug/l)**	**Cd Total (ug/l)**	**Cr Total (ug/l)**	**Cu Total (ug/l)**	**Fe Total (ug/l)**	**Pb Total (ug/l)**	**Mn Total (ug/l)**	**Hg Total (ug/l)**
No. of Samples	12	12	12	12	12	12	12	12	12	12
25th Percentile	38.00	1.00	6.00	1.00	1.00	2.00	50.00	2.00	30.00	0.10
50th Percentile	88.00	1.00	23.00	1.00	1.00	3.00	220.00	3.00	60.00	0.10
75th Percentile	164.00	2.00	55.00	1.00	2.00	8.00	430.00	3.00	150.00	0.10
Maximum	1960.00	7.00	103.00	1.00	3.00	22.00	2140.00	9.00	270.00	2.30
Minimum	9.00	1.00	4.00	1.00	1.00	1.00	10.00	1.00	10.00	0.10
Mean	391.83	2.33	35.92	1.00	1.42	5.92	486.67	3.67	95.00	0.30

Appendix B: STORET (1983-1993) Values for Cumberland River Ambient Monitoring Station at Cumberland Falls

	Parameters									
Year/Value 1988	**Al Total (ug/l)**	**As Total (ug/l)**	**Ba Total (ug/l)**	**Cd Total (ug/l)**	**Cr Total (ug/l)**	**Cu Total (ug/l)**	**Fe Total (ug/l)**	**Pb Total (ug/l)**	**Mn Total (ug/l)**	**Hg Total (ug/l)**
No. of Samples	12	12	12	12	12	12	12	12	12	11
25th Percentile	42.00	1.00	30.00	1.00	1.00	2.00	100.00	2.00	60.00	0.10
50th Percentile	99.00	2.00	38.00	1.00	2.00	4.00	240.00	3.00	100.00	0.20
75th Percentile	147.00	4.00	51.00	1.00	3.00	4.00	520.00	5.00	180.00	0.30
Maximum	4410.00	18.00	84.00	1.00	5.00	8.00	3080.00	12.00	300.00	2.10
Minimum	21.00	1.00	14.00	1.00	1.00	1.00	20.00	2.00	20.00	0.10
Mean	545.33	3.75	42.83	1.00	2.58	3.75	668.33	4.50	133.33	0.40

Appendix B: STORET (1983-1993) Values for Cumberland River Ambient Monitoring Station at Cumberland Falls

	Parameters									
Year/Value 1989	**Al Total (ug/l)**	**As Total (ug/l)**	**Ba Total (ug/l**	**Cd Total (ug/l)**	**Cr Total (ug/l)**	**Cu Total (ug/l)**	**Fe Total (ug/l)**	**Pb Total (ug/l)**	**Mn Total (ug/l)**	**Hg Total (ug/l)**
No. of Samples	12	12	12	12	12	12	12	12	12	10
25th Percentile	65.00	2.00	13.00	1.00	2.00	2.00	360.00	2.00	120.00	0.10
50th Percentile	353.00	2.00	39.00	1.00	2.00	3.00	760.00	2.00	210.00	0.10
75th Percentile	1470.00	2.00	72.00	1.00	5.00	4.00	2920.00	3.00	250.00	0.10
Maximum	4810.00	8.00	98.00	1.00	8.00	9.00	1020.00	8.00	890.00	0.10
Minimum	57.00	2.00	4.00	1.00	1.00	1.00	160.00	2.00	50.00	0.10
Mean	1366.42	2.75	44.67	1.00	3.42	3.75	2526.08	3.25	277.08	0.10

Appendix B: STORET (1983-1993) Values for Cumberland River Ambient Monitoring Station at Cumberland Falls

Year/Value 1990	Al Total (ug/l)	As Total (ug/l)	Ba Total (ug/l)	Cd Total (ug/l)	Cr Total (ug/l)	Cu Total (ug/l)	Fe Total (ug/l)	Pb Total (ug/l)	Mn Total (ug/l)	Hg Total (ug/l)
	Parameters									
No. of Samples	10	11	11	10	10	11	10	12	11	12
25th Percentile	160.00	2.00	21.00	1.00	1.00	2.00	524.00	2.00	62.00	0.10
50th Percentile	389.00	2.00	30.00	1.00	2.00	3.00	670.00	2.00	89.70	0.10
75th Percentile	788.00	3.00	50.90	1.00	2.00	3.00	1060.00	4.00	143.00	0.10
Maximum	2410.00	12.00	81.00	2.00	6.00	6.00	4410.00	14.00	240.00	4.60
Minimum	48.00	1.00	8.00	1.00	1.00	1.00	140.00	2.00	50.00	0.10
Mean	668.70	3.36	37.08	1.20	2.10	2.91	1172.70	3.92	106.97	0.48

Appendix B: STORET (1983-1993) Values for Cumberland River Ambient Monitoring Station at Cumberland Falls

Parameters										
Year/Value 1987	Zn Total (ug/l)	Ca Total (mg/l)	Mg Total (mg/l)	K Total (mg/l)	Na Total (mg/l)	Hard. Total (mg/l)	NH_3+ NH_4 Total (mg/l)	NO_2+ NO_3 Total (ug/l)	TKN (mg/l)	Phos. Total (mg/l)
No. of Samples	12	12	12	12	12	12	12	12	12	12
25th Percentile	8.00	19.20	12.80	1.59	14.10	108.00	0.05	0.05	0.16	0.01
50th Percentile	13.00	31.90	14.40	2.99	26.70	121.00	0.05	0.19	0.27	0.01
75th Percentile	21.00	37.00	19.35	3.72	41.80	159.00	0.05	0.42	0.50	0.04
Maximum	125.00	47.90	23.67	4.76	50.80	188.00	0.06	0.54	0.87	0.09
Minimum	5.00	13.60	10.40	1.45	10.20	91.50	0.05	0.02	0.05	0.01
Mean	26.42	30.72	16.39	2.96	31.17	138.71	0.05	0.26	0.36	0.03

Appendix B: STORET (1983-1993) Values for Cumberland River Ambient Monitoring Station at Cumberland Falls

Parameters										
Year/Value 1988	Zn Total (ug/l)	Ca Total (mg/l)	Mg Total (mg/l)	K Total (mg/l)	Na Total (mg/l)	Hard. Total (mg/l)	NH_3+ NH_4 Total (ug/l)	NO_2+ NO_3 Total (ug/l)	TKN (mg/l)	Phos. Total (mg/l)
No. of Samples	12	12	12	12	12	12	12	12	12	12
25th Percentile	9.00	24.30	11.80	2.03	13.10	104.00	0.05	0.08	0.13	0.01
50th Percentile	14.00	30.20	14.50	2.32	17.40	133.00	0.05	0.29	0.21	0.02
75th Percentile	24.00	35.40	19.00	3.76	33.20	160.00	0.05	0.40	0.26	0.03
Maximum	70.00	44.20	21.80	4.27	63.30	183.00	0.08	0.49	0.65	0.07
Minimum	6.00	19.30	10.30	1.51	10.70	94.60	0.05	0.02	0.05	0.01
Mean	23.50	30.93	15.78	2.82	26.13	135.72	0.05	0.26	0.23	0.03

Appendix B: STORET (1983-1993) Values for Cumberland River Ambient Monitoring Station at Cumberland Falls

	Parameters									
Year/Value 1989	**Zn Total (ug/l)**	**Ca Total (mg/l)**	**Mg Total (mg/l)**	**K Total (mg/l)**	**Na Total (mg/l)**	**Hard. Total (mg/l)**	**NH_3+ NH_4 Total (mg/l)**	**NO_2+ NO_3 Total (ug/l)**	**TKN (mg/l)**	**Phos. Total (mg/l)**
No. of Samples	11	12	12	12	12	12	12	12	12	12
25th Percentile	17.00	18.80	9.78	1.78	6.70	74.70	0.05	0.19	0.07	0.01
50th Percentile	23.00	21.50	11.90	1.93	10.90	98.80	0.05	0.28	0.16	0.01
75th Percentile	49.00	27.70	15.20	2.15	15.60	116.00	0.05	0.36	0.27	0.04
Maximum	289.00	40.90	18.70	3.06	25.80	168.00	0.07	0.84	0.53	0.12
Minimum	10.00	10.90	8.80	1.58	4.00	63.20	0.05	0.12	0.05	0.01
Mean	67.73	23.91	12.74	2.09	12.66	101.68	0.05	0.32	0.22	0.03

Appendix B: STORET (1983-1993) Values for Cumberland River Ambient Monitoring Station at Cumberland Falls

	Parameters									
Year/Value 1990	**Zn Total (ug/l)**	**Ca Total (mg/l)**	**Mg Total (mg/l)**	**K Total (mg/l)**	**Na Total (mg/l)**	**Hard. Total (mg/l)**	**NH_3+ NH_4 Total (ug/l)**	**NO_2+ NO_3 Total (ug/l)**	**TKN (mg/l)**	**Phos. Total (mg/l)**
No. of Samples	10	10	10	10	11	12	12	11	12	12
25th Percentile	10.00	18.80	9.95	1.79	12.10	93.70	0.05	0.25	0.20	0.01
50th Percentile	16.00	24.80	12.70	2.63	17.40	110.00	0.05	0.38	0.23	0.01
75th Percentile	20.00	34.40	16.80	3.18	22.20	129.00	0.05	0.51	0.26	0.03
Maximum	33.00	38.00	19.60	4.05	32.10	170.00	0.05	0.60	0.44	0.06
Minimum	9.00	16.10	9.24	1.44	8.72	80.90	0.05	0.19	0.13	0.01
Mean	17.80	27.06	13.60	2.70	17.50	117.02	0.05	0.37	0.25	0.02

Appendix B: STORET (1983-1993) Values for Cumberland River Ambient Monitoring Station at Cumberland Falls

	Parameters									
Year/Value 1991	**Water Temp. (C)**	**Cond. (Umhos)**	**DO (mg/l)**	**pH (SU)**	**Turb (NTU)**	**Alk Total (mg/l)**	**Cl Total (mg/l)**	**SO_4 Diss. (mg/l)**	**Susp. Sol. (mg/l)**	**TOC (mg/l)**
No. of Samples	12	11	9	12	12	12	12	12	12	11
25th Percentile	9.20	248.00	7.50	7.40	9.00	37.90	2.80	28.80	7.00	2.20
50th Percentile	14.80	312.00	8.60	7.90	16.00	57.90	3.40	90.30	20.00	2.50
75th Percentile	25.00	403.00	9.80	8.00	45.00	88.10	6.20	97.70	46.00	3.40
Maximum	27.50	588.00	12.60	8.20	500.00	127.00	12.50	145.00	594.00	4.70
Minimum	5.10	132.00	7.10	7.30	2.60	17.70	0.20	10.20	1.00	0.90
Mean	17.42	330.45	9.11	7.81	83.93	69.63	5.43	78.59	92.25	2.73

Appendix B: STORET (1983-1993) Values for Cumberland River Ambient Monitoring Station at Cumberland Falls

Year/Value 1992	Parameters									
	Water Temp. (C)	Cond. (Umhos)	DO (mg/l)	pH (SU)	Turb (NTU)	Alk Total (mg/l)	Cl Total (mg/l)	SO_4 Diss. (mg/l)	Susp. Sol. (mg/l)	TOC (mg/l)
No. of Samples	9	9	ND	9	9	9	9	8	9	7
25th Percentile	4.00	264.00	ND	7.30	5.50	44.70	0.50	70.50	2.00	2.30
50th Percentile	22.40	284.00	ND	7.70	14.50	64.20	3.40	84.40	11.00	2.70
75th Percentile	23.50	353.00	ND	7.90	63.00	75.90	4.40	89.60	48.00	3.60
Maximum	25.50	394.00	ND	8.20	103.00	82.80	5.20	115.00	85.00	4.70
Minimum	2.70	242.00	ND	7.30	5.00	38.30	0.10	62.20	1.00	1.50
Mean	17.16	310.11	ND	7.71	32.94	62.56	2.89	86.31	25.33	2.84

Appendix B: STORET (1983-1993) Values for Cumberland River Ambient Monitoring Station at Cumberland Falls

	Parameters									
Year/Value 1991	**Al Total (ug/l)**	**Ag Total (ug/l)**	**Ba Total (ug/l)**	**Cd Total (ug/l)**	**Cr Total (ug/l)**	**Cu Total (ug/l)**	**Fe Total (ug/l)**	**Pb Total (ug/l)**	**Mn Total (ug/l)**	**Hg Total (ug/l)**
No. of Samples	10	10	11	11	11	11	11	11	11	9
25th Percentile	148.00	2.00	37.00	1.00	1.00	3.00	420.00	2.00	63.00	0.10
50th Percentile	356.00	2.00	48.00	1.00	1.00	4.00	1180.00	3.00	112.00	0.10
75th Percentile	924.00	3.00	60.00	1.00	5.00	6.00	4140.00	6.00	252.00	0.10
Maximum	12900.00	7.00	542.00	1.00	18.00	26.00	2800.00	21.00	740.00	0.20
Minimum	32.00	1.00	20.00	1.00	1.00	1.00	136.00	1.00	27.00	0.10
Mean	2185.20	2.80	90.73	1.00	4.09	6.45	4463.91	4.73	204.09	0.11

Appendix B: STORET (1983-1993) Values for Cumberland River Ambient Monitoring Station at Cumberland Falls

Year/Value 1992	Al Total (ug/l)	Ag Total (ug/l)	Ba Total (ug/l)	Cd Total (ug/l)	Cr Total (ug/l)	Cu Total (ug/l)	Fe Total (ug/l)	Pb Total (ug/l)	Mn Total (ug/l)	Hg Total (ug/l)
	Parameters									
No. of Samples	9	9	9	9	9	9	9	9	9	9
25th Percentile	73.00	2.00	25.00	1.00	1.00	1.00	356.00	2.00	39.00	0.10
50th Percentile	197.00	2.00	31.00	1.00	2.00	2.00	972.00	2.00	149.00	0.10
75th Percentile	683.00	2.00	39.00	1.00	3.00	4.00	1760.00	3.00	172.00	0.10
Maximum	1230.00	7.00	47.00	1.00	5.00	10.00	3050.00	12.00	215.00	0.10
Minimum	42.00	2.00	22.00	1.00	1.00	1.00	198.00	2.00	29.00	0.10
Mean	381.89	2.56	33.44	1.00	2.67	3.33	1190.89	3.67	129.00	0.10

Appendix B: STORET (1983-1993) Values for Cumberland River Ambient Monitoring Station at Cumberland Falls

Parameters										
Year/Value 1991	Zn Total (mg/l)	Ca Total (mg/l)	Mg Total (mg/l)	K Total (mg/l)	Na Total (mg/l)	Hard. Total (mg/l)	NH_3 + NH_4 Total (mg/l)	NO_2 + NO_3 Total (mg/l)	TKN Total (mg/l)	Phos. Total (mg/l)
No. of Samples	11	11	11	11	11	11	11	10	12	11
25th Percentile	9.00	22.70	10.90	2.20	10.80	101.60	0.05	0.07	0.13	0.01
50th Percentile	18.00	25.90	15.10	2.46	16.00	119.00	0.05	0.26	0.16	0.02
75th Percentile	35.00	34.20	17.10	3.95	29.90	139.00	0.05	0.39	0.29	0.05
Maximum	102.00	41.10	22.50	4.41	59.10	195.30	0.07	1.05	1.63	0.28
Minimum	1.00	12.40	7.39	2.15	3.80	48.20	0.05	0.01	0.05	0.01
Mean	26.64	26.94	14.66	3.01	23.22	119.14	0.05	0.36	0.35	0.05

Appendix B: STORET (1983-1993) Values for Cumberland River Ambient Monitoring Station at Cumberland Falls

	Parameters									
Year/Value 1992	Zn Total (mg/l)	Ca Total (mg/l)	Mg Total (mg/l)	K Total (mg/l)	Na Total (mg/l)	Hard. Total (mg/l)	NH_3 + NH_4 Total (mg/l)	NO_2 + NO_3 Total (mg/l)	TKN Total (mg/l)	Phos. Total (mg/l)
No. of Samples	9	9	9	9	9	9	8	8	9	7
25th Percentile	5.00	22.80	9.80	1.77	11.20	95.90	0.05	0.20	0.05	0.01
50th Percentile	19.00	23.90	12.30	1.95	14.00	114.60	0.05	0.28	0.17	0.01
75th Percentile	20.00	27.50	14.00	2.03	19.40	123.70	0.05	0.38	0.19	0.02
Maximum	75.00	31.00	14.70	3.30	21.10	135.00	0.05	0.44	0.27	0.04
Minimum	5.00	20.00	9.21	1.53	9.82	91.50	0.05	0.18	0.05	0.01
Mean	21.11	25.19	12.07	2.15	15.21	112.56	0.05	0.29	0.14	0.01

Appendix C.
Cumberland River Diatom Data,
Wild River Segment, Summer 1993

Appendix C: Cumberland River Diatom Data, Wild River Segment, Summer 1993

Species	18–1	18–2	18–3
Achnanthes exigua	*		
Achnanthes lanceolata var. dubia	0.8	0.2	0.4
Achnanthes linearis		*	
Achnanthes microcephala	3.3	0.2	
Achnanthes minutissima	43.1	57.1	13.6
Amphipleura pellucida	1.2		
Amphora ovalis var. pediculus		0.2	0.2
Amphora perpusilla	0.2		0.2
Anomoeoneis vitrea	0.2		
Bacillaria paradoxa	*	*	2.0
Biddulphia laevis			0.4
Caloneis bacillum	0.8	0.4	
Capartogramma crucicula	*	*	*
Cocconeis pediculus	0.2	1.8	2.8
Cocconeis placentula var. euglypta	2.1	8.6	15.2
Cyclotella meneghiniana	*		0.4
Cyclotella pseudostelligera	0.2	0.4	2.4
Cyclotella striata var. ambigua		*	
Cymbella affinis	0.2	0.2	*
Cymbella cuspidata	*		
Cymbella delicatula	0.4		0.2
Cymbella minuta	0.2		0.2
Cymbella prostrata	0.6		
Cymbella silesiaca		0.4	
Cymbella sp. (K)	*		0.2
Cymbella tumida	1.9	*	0.8
Cymbella turgidula	3.8	0.4	0.2
Diatoma vulgare		*	0.4
Diploneis elliptica			0.4
Diploneis oblongella	0.2		0.4
Fragilaria vaucheriae	0.2		*
Frustulia rhomboides var.amphipleuroides	*		
Gomphonema affine		*	
Gomphonema angustatum	*	*	4.2
Gomphonema clevei	0.8	0.4	0.2
Gomphonema olivaceum		*	
Gomphonema parvulum	3.1	2.0	3.8
Gomphonema rhombicum	7.9	0.2	0.8

* Present but not encountered in 500 valve count

Appendix C: Cumberland River Diatom Data, Wild River Segment, Summer 1993

Species	18–1	18–2	18–3
Gomphonema sphaerophorum	0.4	*	
Gomphonema truncatum	0.4		
Gyrosigma attenuatum	*		0.2
Gyrosigma nodiferum	1.7	0.2	2.0
Gyrosigma obtusatum		*	1.0
Gyrosigma spencerii var. curvula	0.2	0.2	0.6
Melosira varians	1.2		0.8
Meridion circulare		*	
Navicula auriculata	0.2	0.2	1.4
Navicula capitata			0.4
Navicula cryptocephala	0.6		0.2
Navicula cryptocephala var. veneta	2.3	1.0	0.6
Navicula decussis			0.2
Navicula elginensis	*		*
Navicula gregaria	0.2	*	*
Navicula menisculus var. upsaliensis	0.2		
Navicula notha	*	0.2	3.0
Navicula pelliculosa			0.2
Navicula pupula	*		0.4
Navicula radiosa var. parva	0.2		
Navicula radiosa var. tenella	3.7	0.8	0.2
Navicula rhynchocephala var. germanii	*	0.2	2.6
Navicula salinarum var. intermedia	0.2	0.2	0.6
Navicula savannahiana	*		
Navicula schroeteri var. escambia	1.0	0.6	2.6
Navicula secreta var. apiculata	*	0.6	0.2
Navicula tantula			*
Navicula tenelloides		0.2	0.2
Navicula tripunctata	0.2	*	*
Navicula tripunctata v. schizonemoides	0.8		0.2
Navicula viridula var. avenacea	*	*	*
Navicula viridula var. rostellata	0.4	0.4	1.6
Nitzschia amphibia	0.6	*	
Nitzschia angustata var. acuta	0.2	0.6	1.2
Nitzschia clausii	0.2		0.2
Nitzschia coarctata	*	*	1.4
Nitzschia dissipata	0.4	0.6	8.0
Nitzschia filiformis	*	*	0.4

* Present but not encountered in 500 valve count

Appendix C: Cumberland River Diatom Data, Wild River Segment, Summer 1993

Species	18-1	18-2	18-3
Nitzschia fonticola	5.6	16.8	12.8
Nitzschia frustulum		0.2	
Nitzschia gandersheimiensis		*	
Nitzschia gracilis	0.2	*	
Nitzschia kutzingiana	*		
Nitzschia levidensis	*	*	0.2
Nitzschia linearis			0.4
Nitzschia lorenziana var. subtilis	0.2		
Nitzschia palea	6.0	2.6	5.8
Nitzschia rautenbachiae	0.2		
Nitzschia reversa			0.2
Nitzschia sigma	0.2		*
Nitzschia sigmoidea		*	
Nitzschia spp.	0.4	*	
Nitzschia sp.1	0.2	*	0.2
Nitzschia tropica			*
Nitzschia tryblionella var. victoriae	*	0.2	
Rhoicosphenia curvata	0.4	*	0.6
Surirella linearis			*
Surirella linearis var. helvetica			*
Surirella ovata	*	*	*
Surirella robusta var. splendida			0.2
Surirella spp.	*	0.2	
Synedra famelica	*	0.2	*
Synedra fasciculata var. truncata	*	*	
Synedra pulchella		*	
Synedra rumpens var. fragilarioides		1.0	
Synedra ulna	0.6	0.2	*
Thalassiosira weissflogii		0.2	*

* Present but not encountered in 500 valve count

Appendix D.
Cumberland River Macroinvertebrate Data,
Wild River Segment, Summer 1993

Appendix D: Cumberland River Macroinvertebrate Data, Wild River Segment, Summer 1993

Order/Family	Taxa	18-1	18-2	18-3
Tricladida				
Planariidae	*unidentified species*			1
Haplotaxida				
Tudificidae	*sp. 1*		3	
	sp. 2		1	
Lumbriculida				
Lumbriculidae	*Eclipidrilus sp.*	2	9	2
Heterodonta				
Corbiculidae	*Corbicula fluminea*	19		
Mesogastropoda				
Ancilidae	*Ferrissia rivularis*		1	2
Pleuroceridae	*Elimia ebenum (?)*	1	58	121
	E. sp.		1	
Planorbidae	*Helisoma anceps*		1	
Viviparidae	*Campeloma decisum*		1	
Lymnophila				
Physidae	*Physella sp.*	1	3	
Isopoda				
Asellidae	*Lirceus fontinalis*	5		7
Decapoda				
Cambaridae	*Cambarus distans*		1	
	Orconectes putnami	1	6	13
Ephemeroptera				
Baetidae	*Acentrella sp.*	1	16	1
	Baetis intercalaris	6	95	35
	B. propinquus	1	15	3
	Centroptilum sp. 1		15	4
	C. sp. 2		12	3
	Heterocloeon curiosum	70	145	20
	Procloeon sp. 1	1		
Caenidae	*Brachycerus sp.*		1	
	Caenis hilaris	2	1	1
Heptageniidae	*Heptagenia maculipennis*	1	104	7
	Stenacron interpunctatun	15	19	8
	S. pallidum	3		
	Stenonema exiguum (?)	105	195	123
	S. mediopunctatum		1	4
	S. terminatum	2		
	S. sp.	1		
Oligoneuriidae	*Isonychia sp.*	49	215	43
Tricorythidae	*Tricorythodes sp.*	36	35	44

Appendix D: Cumberland River Macroinvertebrate Data, Wild River Segment, Summer 1993

Order/Family	Taxa	18-1	18-2	18-3
Plecoptera				
Perlidae	*Acroneuria abnormis (?)*			1
	Neoperla sp.	1		2
Pteronarcyidae	*Pteronarcys dorsata*			1
Odonata				
Calopterygidae	*Calopteryx angustipennis*	3	1	7
	C. maculata			3
	Heterina tititia	2		
Coenagrionidae	*Argia moesta (?)*	9		
	A. translata		12	6
	Enallagma exsulans		15	1
Aeshnidae	*Boyeria vinosa*	1	3	5
Cordulidae	*Cordula sp.*		1	
	Neurocordula alabamensis	10		
Gomphidae	*Dromogomphus spinosus*		6	1
	D. spoliatus	6		9
	Gomphus vastus			1
	Hagenius brevistylus		1	
	Progomphus sp.		1	1
Macromiidae	*Didymops transversa*		2	
Coleoptera				
Curculionidae	*Lixus sp.*			1
Dryopidae	*Helichus basalis*		1	2
	H. lithophilus	5	15	17
Dytisidae	*Deronectes sp.*			1
Elmidae	*Ancyronyx variegata*	2	3	
	Dubiraphia vitatta		8	3
	Macronychus glabratus	32	28	31
	Stenelmis crenata		1	
Gyrinidae	*Dineutis assimilis*	1		
	D. discolor	1		4
	D. nigrior			1
Hydrophilidae	*Tropisternis blatchleyi*		4	
Psephenidae	*Psephenus herricki*			2
Hemiptera				
Gerridae	*Metrobates hesperius*			1
Hebridae	*Merragata sp.*			1
Hydrometridae	*Hydrometra martini*		1	
Mesoveliidae	*Mesovelia mulsanti*		1	
Nepidae	*Ranatra buenoi*	1		

Appendix D: Cumberland River Macroinvertebrate Data, Wild River Segment, Summer 1993

Order/Family	Taxa	18-1	18-2	18-3
	R. nigra		2	2
Veliidae	*Rhagovelia obesa*	2	3	1
Orthoptera				
Tridactylidae	*Ellipes minuta*		1	
Megaloptera				
Corydalidae	*Corydalus cornutus*	51	37	7
	Nigronia serricornis	2	4	3
Tricoptera				
Brachycentridae	*Brachycentrus sp.*		1	14
Glossosomatidae	*Glossosoma sp.*		13	18
Helicopsychidae	*Helicopsyche borealis*		2	2
Hydropsychidae	*Cheumatopsyche sp.*	5	8	17
	Hydropsyche dicantha	2		
	H. hageni	25	7	29
	H. phalerata	13	7	70
	H. simulans	56	14	5
Hydroptilidae	*Hydroptila sp.*	1	4	15
Leptoceridae	*Oecetis avara*	3	2	2
	O. cinerascens	3		
	O. inconspicua	3		4
	Triaenodes tardus		5	8
Limnephilidae	*Pycnopsyche divergens*			1
Philopotamidae	*Chimarra aterrima (?)*	2		
	C. obscura (?)		1	
	Warmaldia sp.	1		
Polycentropididae	*Cyrnellus fraternus*	2		
	Neureclipsis sp.	29	1	
	Nyctiophylax sp.	1	3	
	Polycentropus sp.	3		
Psychomyiidae	*Lype diversa*			1
	Psychomyia nomada			1
Diptera				
Ceratopogonidae	*Atrichopogon sp.*		1	
Chironomidae	*Ablalesmyia mallochi*	10	1	1
	A. parajanta		1	
	Chironomus sp.	4		
	Conchapelopia sp.	5	3	1
	Cricotopus sp.	4		1
	Cryptochironomus fulvus gp.	1		
	Dicrotendipes neomodestus	14		2
	Eukiefferiella sp.	4	2	1

Appendix D: Cumberland River Macroinvertebrate Data, Wild River Segment, Summer 1993

Order/Family	Taxa	18-1	18-2	18-3
	Haysomia senata	2	3	
	Micropsectra sp.	3		
	Orthocladius obumbratus			1
	O. sp.	2		
	Phaenopsectra sp.		1	
	Polypedium convictum	38	5	23
	Procladius sublettei		1	
	Rheotanytarsus distinctissimus gp.	34	7	
	Stenochironomus hilaris	2	2	
	Stictochironomus divinctus	1		
	Tanytarsus sp.	6	2	5
	Thienemannimyia sp. gp.	3		2
	Tvetenia discloripes gp.		1	
Empididae	*Hemerodromia sp.*	3	1	3
Simuliidae	*Simulium tuberosum*	116	2	3
Tipulidae	*Antocha*			1