PHYSICAL, CHEMICAL AND BIOLOGICAL

ASSESSMENT OF THE

PINEY CREEK WATERSHED

JOHNSON, NEWTON AND POPE COUNTIES, ARKANSAS

ARKANSAS DEPARTMENT OF ENVIRONMENTAL QUALITY
Water Division

July, 1999
WQ-99-07-01

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INTRODUCTION

The Big and Little Piney Creeks (Piney Creek) are tributaries to the Arkansas River and are located east of Clarksville and north of Russellville in west-central Arkansas. Their headwaters are located in the Boston Mountains ecoregion, but the creeks descend out of this ecoregion and into the Arkansas River Valley ecoregion where they enter Piney Bay of Lake Dardanelle.

The Piney Creek watershed has many different public and private uses. The watershed offers year-round recreational activities, including hunting, fishing, hiking and camping, but canoeing and primary contact recreation activities seem to dominate the recreational uses. Additional watershed uses include confined animal operations, pasture land for livestock and silviculture. Most of the timberlands are managed by the Ozark National Forest. Big Piney Creek is designated in Arkansas Water Quality Standards as an Extraordinary Resource Waterbody. Both creeks have additional designated uses, including: 1) Primary Contact Recreation; 2) Secondary Contact Recreation; 3) Domestic, Industrial and Agricultural Water Supply; and 4) Boston Mountains and Arkansas River Valley Ecoregions Fishery. Piney Bay is used as a drinking water supply for the City of Clarksville. In addition, Indian Creek and Hurricane Creek are least-disturbed Boston Mountain Ecoregion reference streams.

Arkansas' 1996 Water Quality Inventory Report (305(b)) and the 1997 "Arkansas' Nonpoint Source Assessment Report" identified four stream segments of the Big Piney Creek watershed as only partially supporting the aquatic life use. The major cause of the impairment was thought to be from excessive turbidity due to silt and suspended solids loadings entering the creek during storm events. Agriculture and silviculture activities within the watershed were thought to be the major and minor sources of this impairment. In addition, silt and total suspended solids inputs during storm events from the unpaved county and forest access roads most likely add a significant load and increase instream turbidity concentrations as well.

The swim beach at Long Pool has been closed occasionally due to excessive bacteria concentrations violating National Forest bacteria standards. These closures usually occur during the low-flow, high water temperature periods of the summer months. It is probable that bacteria standards are also being exceeded during high flow events. Sources of the bacteria may include: 1) runoff from the confined animal operations within the watershed; 2) storm water runoff from grazing lands; 3) from water bodies with direct cattle access; 4) primary contact human recreation activities during periods of low flow; and 5) soil bacteria being flushed into the stream during storm events.

Piney Creek is an important water resource to the State. Therefore, addressing the nonpoint source pollution issues in the watershed was listed as a top priority in 1997 by the Nonpoint Source Pollution Support Group. This assessment survey will further refine the 1996 305(b) assessment and the 1997 "Arkansas Nonpoint Source Pollution Assessment Report" concerning nonpoint source pollution activities and impairments in the watershed and will better prioritize the subbasins within the watershed for best management practices implementation.

GOALS AND OBJECTIVES

The main objective of this survey was to assess the waters of the Piney Creek watershed to better target nonpoint source best management practices implementation by identifying areas of water quality impairment and their causes and sources.

The goals of this survey to accomplish the objectives were to:

1) procure and evaluate water quality data from all available sources relating to nonpoint pollution sources (NPS) into a useable format for analysis;

2) identify the land use activities within the watershed by utilizing GIS land use data, and ground truthing the data;

3) develop and implement a Quality Assurance Project Plan outlining the QA/QC requirements for all water quality data collected and that data obtained from other sources;

4) collect surface water quality samples from the subbasins within the watershed to: a) establish a baseline, un-impacted water quality data base; b) identify areas of impacted water quality that threatens and/or impairs the existing water quality use designations; and c) identify the causes and sources of the impairments;

5) sample macroinvertebrates from subbasins within the watershed to: a) establish a baseline macroinvertebrate data base; b) identify areas of impaired macroinvertebrate communities that threatens and/or impairs the existing designated uses: and c) identify the causes and sources of the impairments;

6) sample fish to: a) establish a baseline, fish community data base; b) identify areas with impaired fish communities that threatens and/or impairs the designated uses: and c) identify the causes and sources of impairments;

7) inventory the riparian zones, stream banks and stream channels within the watershed for stability and/or modification and evaluate those needing stabilization and enhancement;

8) prepare the Piney Creek Watershed NPS assessment identifying the level of surface water impairments, causes and sources; and

9) prioritize the subbasins for BMP implementation.

1997 ASSESSMENT SURVEY WORK PLAN

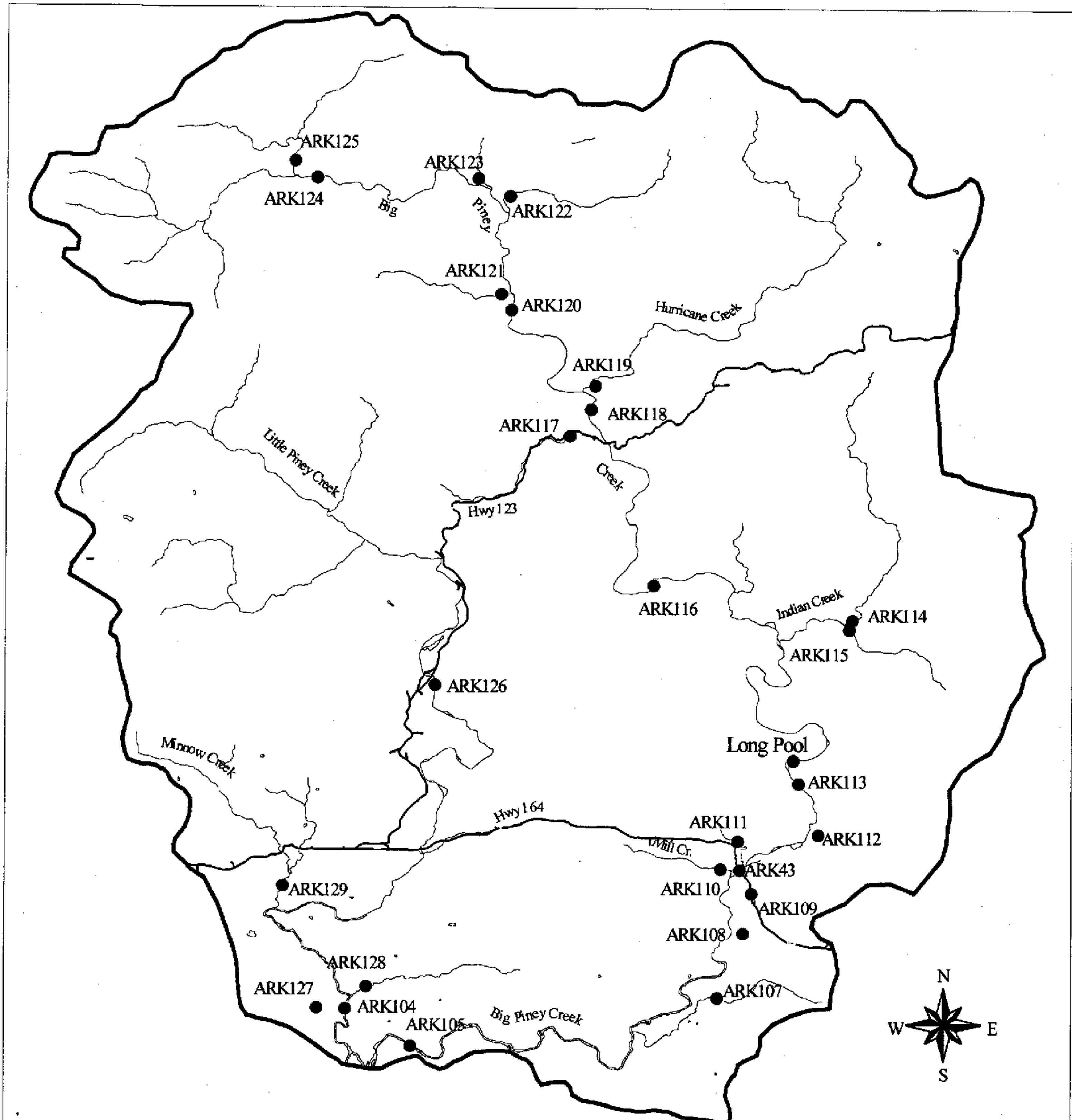
This 18 month survey initially began in the winter of 1997 with the watershed survey of Big Piney Creek. In the early summer of 1998, it was decided that the Little Piney Creek watershed needed to be added to the survey. This lengthened the survey approximately six months making the final report due in January, 1999. The outputs generated from this survey included:

1) a nonpoint source pollution assessment report of the Piney Creek watershed;
2) expanded land use data base;
3) expanded water quality data base;
4) expanded macroinvertebrate data base;
5) expanded fish community data base;
6) listing of NPS impaired and/or threatened Big Piney Creek watershed subbasins;
7) list of causes and sources of NPS impairments;
8) prioritized list of subbasins targeting best management practices implementation; and
9) an approved quality assurance project plan.

This assessment consisted of surveys of four different environmental indicators: 1) a synoptic water quality, macroinvertebrate and fish community survey; 2) an intensive, source-specific water quality, macroinvertebrate and fish community survey; 3) a stream bank, riparian zone habitat survey; and 4) a resurvey of the two least-disturbed ecoregion reference streams.

The synoptic survey sample stations, Figure 1, were located at the base of the major subbasins with additional stations located in least-disturbed reference streams and along the main stem of the Piney Creeks to determine background conditions and loadings from NPS inputs. Fish communities, macroinvertebrates, and diurnal dissolved oxygen samples were collected at selected sites (Figure 2) to obtain a representative data base throughout the watershed. Water quality storm flow samples were collected in the tributary streams upstream of the main-stem sample sites to determine tributary loadings to the main stream. Table 1 is a list of the stations, and Table 2 lists the water quality parameters analyzed during this survey.

The intensive survey consisted of sample station placement above and below NPS pollution inputs to determine the effects of the pollutants on the water quality and aquatic life. Water samples were collected at base flow conditions, when flow existed, and during storm events to quantify pollutant loadings. Fish communities and dissolved oxygen fluctuation were evaluated during the low-flow, maximum water temperature time frame. Macroinvertebrate samples were collected once during low-flow summer conditions and once again during the spring, fall and winter seasons to determine seasonal variations and/or impairments to the macroinvertebrate community. However, because there was extreme low-flow conditions in the tributaries during the summer months, many times they were dry, and because the nonpoint source inputs were so widely distributed in the lower tributaries, it was not possible to locate any upstream tributary stations above NPS inputs. Therefore, samples were only collected from the lowest downstream access point in the tributaries to determine tributary loadings to the Piney Creeks.



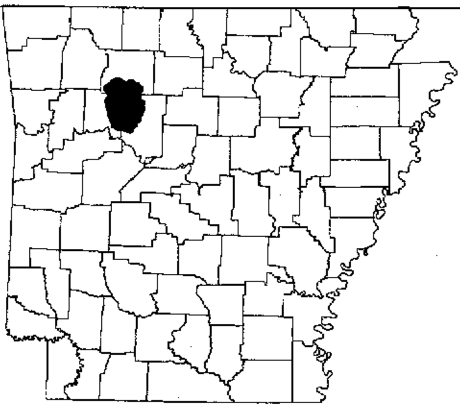


Figure 1 - Water Quality Sample Sites

● Sample Sites

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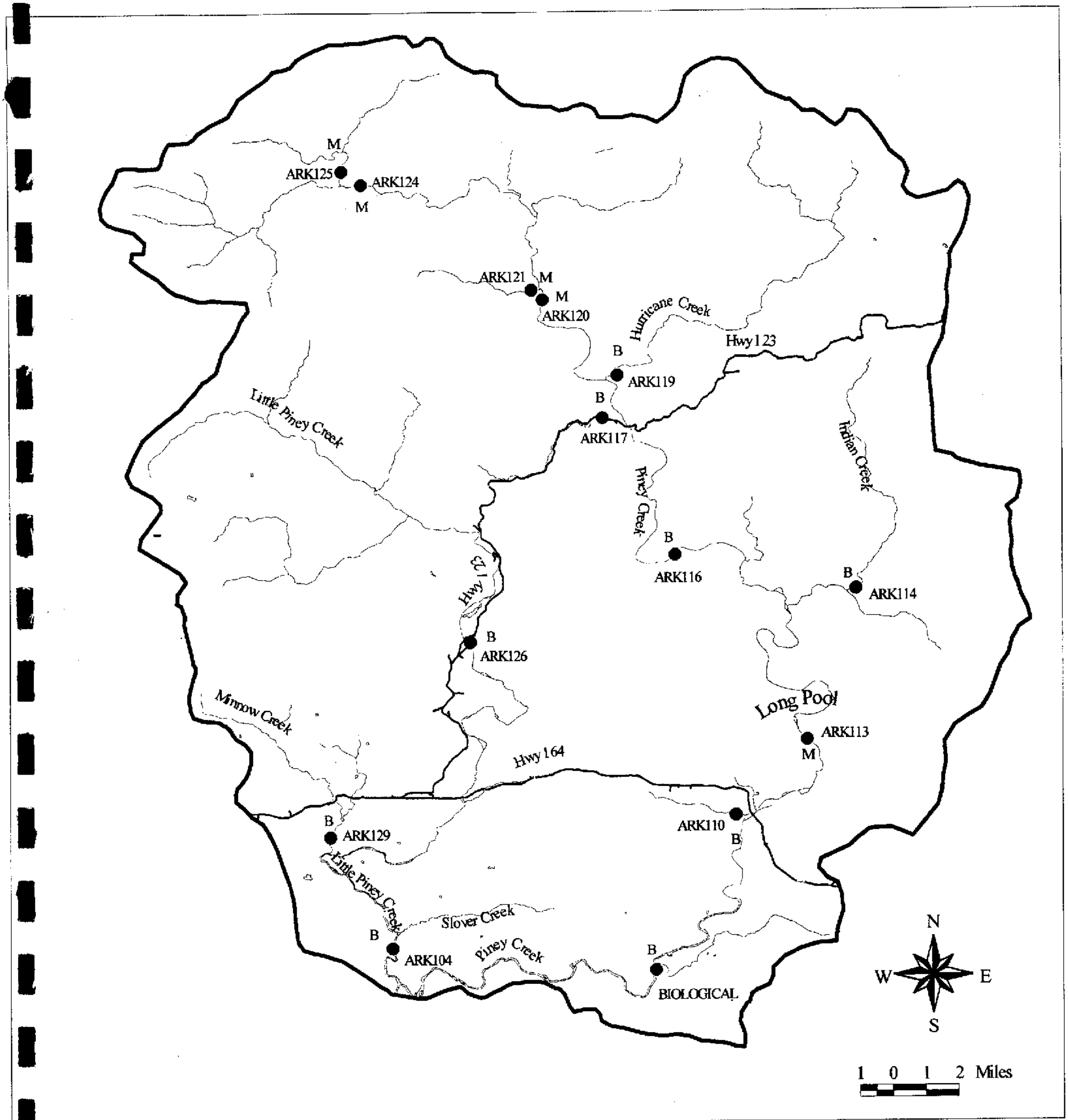

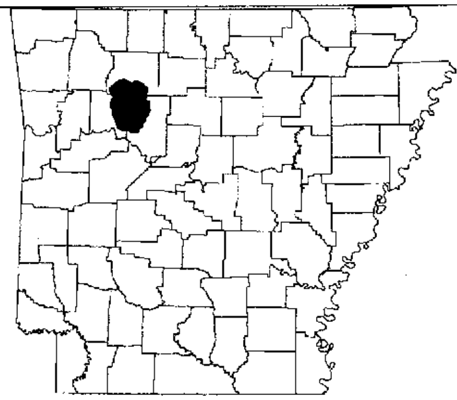

Figure 2 - Biological Sample Sites

M Macroinvetebrates Only

B Macroinvertebrates & Fish Communities

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Table 1 - Water Quality Monitoring Stations								
Name	Location Data				Samples			Lat/Long
	Stream	County	Sec. Tnsp. Rng	WS	W	M	F	
ARK126	Little Piney Creek	Johnson	Sec. 26, T11N, R22W	70	X	X	X	35 35 02.5N 93 18 15.7W
	Ar. Hwy. 123 Bridge, 5.6 miles north of Ar. Hwy. 164 jnct. near Hagarville							
ARK129	Minnow Creek	Johnson	Sec. 29, T10N, R22W	26	X	X	X	35 29 49.35N 93 21 55.26W
	at Co. Rd. 50 bridge, just off Ar. Hwy. 123, 0.8 miles south of Hagarville							
ARK127	Opossum Branch	Johnson	Sec. 9, T9N, R22W	5	X	X		35 26 51.0N 93 20 55.0W
	at Ar. Hwy. 359 bridge, 2.5 miles east of US Hwy. 64 jnct. at Lamar							
ARK128	Slover Creek	Johnson	Sec. 4, T9N, R22W	13.4	X	X		35 27 20.0N 93 20 03.0W
	at Ar. Hwy. 315 bridge, 0.4 miles north of Ar. Hwy. 359 jnct.							
ARK104	Little Piney Creek	Johnson	Sec. 9, T9N, R22W	154	X	X	X	35 26 54.4N 93 20 20.7W
	at Ar. Hwy 359 bridge 3.2 miles east of US Hwy 64 jnct. at Lamar							
ARK125	Walnut Creek	Newton	Sec. 26, T11N, R22W	19	X	X		35 47 16.5N 93 21 39.4W
	at FAS rd 1217, approx. 5 miles south of Edwards Junction off Ar. Hwy. 16							
ARK124	Big Piney Creek	Newton	Sec. 17, T13N, R22W	40	X	X		35 47 02.2N 93 20 52.5W
	at FAS rd 1458 approx. 5 miles south of Edwards Junction off Ar. Hwy. 16							
ARK123	Home Creek	Newton	Sec. 13, T13N, R22W	4	X			35 46 53.6N 93 17 08.1W
	at FAS rd 1232 west of Limestone, approx. 8 miles south of Ar. Hwy. 16							
ARK122	Curtis Creek	Newton	Sec. 13, T13N, R22W	12	X			35 46 38.8N 93 16 21.1W
	at FAS rd 1002 south of Limestone, approx. 8 miles south of Ar. Hwy. 16							
ARK121	Cow Creek	Newton	Sec. 36, T13N, R22W	12	X	X		35 44 13.9N 93 16 40.4W
	at FAS rd 1202, west of FAS rd.1002 jnct., 12 miles south of Ar. Hwy. 16							
ARK120	Big Piney Creek	Newton	Sec. 36, T13N, R22W	95	X	X		35 43 59.0N 93 16 21.9W
	at FAS rd. 1202 bridge, 12 miles south of Ar. Hwy. 16							
ARK119	Hurricane Creek	Johnson	Sec. 8, T12N, R21W	51	X	X	X	35 41 57.5N 93 14 38.2W
	at FAS rd. 1003, 2 miles north of Ar. Hwy. 123 near Ft. Douglas							

Table 1 - Water Quality Monitoring Stations

Name	Location Data				Samples			Lat/Long
	Stream	County	Sec. Tnsp. Rng	WS	W	M	F	
ARK118	Big Piney Creek	Johnson	Sec. 17, T12N, R21W	150	X	X		35 41 53.0N 93 14 36.0W
	off FAS rd. 1003 below Hurricane Creek confluence, 1.5 miles north of Ar. Hwy. 123 near Ft. Douglas							
ARK117	Haw Creek	Johnson	Sec. 20, T12N, R21W	15	X	X	X	35 40 54.4N 93 14 46.4W
	at Ar. Hwy. 123 near Ft. Douglas							
ARK116	Big Piney Creek	Johnson	Sec. 9, T11N, R21W	193	X	X		35 37 13.8N 93 12 56.2W
	at FAS rd 1802 ford, 8 miles south of Ar. Hwy. 123, south of Ft. Douglas							
ARK115	Moccasin Creek	Pope	Sec. 17, T11N, R20W	18	X	X		35 36 16.6N 93 08 23.0W
	at FAS rd. 1805 ford, at FAS rds 1805/1808 jnct. near Treat							
ARK114	Indian Creek	Pope	Sec. 17, T11N, R20W	29	X	X	X	35 36 18.3N 93 08 20.8W
	at FAS rd. 1808 bridge, at FAS rd. 1805/1808 jnct. near Treat							
ARK113	Big Piney Creek	Pope	Sec. 7, T10N, R20W	275	X	X		35 32 12.1N 93 09 10.6W
	below Long Pool Recreation Area, 4 miles north of Ar. Hwy 164							
ARK112	Levi Branch	Pope	Sec. 17, T10N, R20W	4	X			35 31 08.7N 93 08 50.3W
	at Old Hwy. 7 bridge, 2.5 miles north of Ar. Hwy 164							
ARK111	Dry Creek	Pope	Sec. 13 T10N, R21W	8	X	X		35 31 05.5N 93 10 56.5W
	at FAS rd. 1800, o.2 miles north of Ar. Hwy. 164							
ARK43	Big Piney Creek	Pope	Sec. 24, T10N, R21W	297	X	X		
	at Ar. Hwy. 164 bridge, 3.8 miles west of Ar. Hwy. 7.							
ARK110	Mill Creek	Pope	Sec. 23, T10N, R21W	10	X	X	X	35 30 24.2N 93 11 20.7W
	on county rd. 0.4 miles south of Ar. Hwy 164 near Twin Bridges.							
ARK109	Unnamed Creek	Pope	Sec. 25, T10N, R21W	2	X	X		35 34 37.0N 93 09 58.0W
	at Ar. Hwy. 164 bridge, 0.3 miles east of Old Hwy. 7							

Table 1 - Water Quality Monitoring Stations								
Name	Location Data				Samples			Lat/Long
	Stream	County	Sec. Tnsp. Rng	WS	W	M	F	
ARK108	Unnamed Creek	Pope	Sec. 36, T10N, R21W	2	X	X		35 28 31.7N 93 10 56.1W
	on county rd. 1.3 miles south of Ar. Hwy 164, 0.4 miles east of Old Hwy. 7							
ARK107	Wilson Creek	Pope	Sec. 11, T9N, R21W	2	X	X		35 27 13.0N 93 11 19.0W
	at county road 1 mile north of Piney							
Biological	Big Piney Creek	Pope	Sec. 10, T9N, R21W	325		X	X	35 27 46.0N 93 11 49.6W
	Biological site at Tate's Island Ford, off county road near Piney							
ARK105	Big Piney Creek	Johnson	Sec. 14, T9N, R22W	342	X			35 26 06.6N 93 18 49.0W
	at Ar. Hwy. 359 bridge, 6 miles east of Lamar							
APL	bacteria site located above Long Pool swimming area							
LP	bacteria site located in Long Pool swimming area at downstream end							

Sec. - Section Number Tnsp. - Township Rng. - Range
FAS - Forest Access Road
Samples: W - Water, M - Macroinvertebrates, F - Fish Community
WS - watershed size in square miles above the sample site

Table 2 - Water Quality Parameters

In-Situ & Lab Analyses	Metals, Dissolved
pH	Aluminum
Dissolved Oxygen	Barium
Temperature	Beryllium
Flow	Boron
Ammonia Nitrogen	Cadmium
Nitrate-Nitrite Nitrogen	Calcium
Total Phosphorus	Chromium
Ortho-Phosphorus	Cobalt
Chlorides	Copper
Sulfates	Iron
Total Dissolved Solids	Lead
Total Suspended Solids	Manganese
Total Hardness	Nickel
Turbidity	Potassium
Total Organic Carbon	Sodium
Fecal Coliform Bacteria	Vanadium
	Zinc

Stream bank stabilization and riparian zone habitat surveys were conducted throughout the watershed as a one-time visual and pictorial inventory to document locations of potential impairment. A second, more intensive survey was conducted on a streambank on Big Piney Creek upstream of the Hwy 64 bridge. It consisted of: 1) a full documentation of the site locality; 2) transect surveys, 3) upstream and downstream habitat surveys; 4) upstream and downstream aquatic life assessments; and 5) restoration recommendations and prioritization.

Hurricane Creek and Indian Creek, the two Boston Mountains Least-Disturbed Ecoregion reference streams were re-surveyed during this assessment. Water quality, macroinvertebrates, fish community and diurnal dissolved oxygen samples were collected from both streams. This data was then compared to the original survey data from the mid-1980s, and was used to establish guidelines for water quality of similar sized tributaries in the watershed.

The final workplan component was the development of the final assessment report and the quality assurance project plan (QAPP). The QAPP was approved by the Arkansas Soil and Water Conservation Commission and the U.S. Environmental Protection Agency Region 6 in January, 1997. The final report for the project was due in January, 1999.

HISTORICAL WATER QUALITY DATA

Water quality data has been collected from Big Piney Creek (ARK43) at the Arkansas Highway 164 bridge, 3.8 miles west of Arkansas Highway 7 in Pope County, for approximately15 years. Data from this site (Table 3) indicate, that on occasion, turbidity levels exceed the Boston Mountains ecoregion instream water quality criteria of 10 NTUs, Table 4. It should be noted that turbidity standards were established primarily for base-flow conditions. Turbidity levels have ranged from less than 1.0 NTU to 270 NTUs with an mean concentration of 9.55 NTUs. Total suspended solids concentrations range from 1.0 mg/L to 332 mg/l with an average concentration of only 5.9 mg/L. This indicates that the elevated concentrations occur infrequently, but are of high magnitude. The instream dissolved oxygen (DO) concentrations have also fallen below the Boston Mountains water quality criteria of 6.0 mg/L. The concentrations of DO at the site ranged from 3.1 mg/L to 16.5 mg/L with a mean concentration of 9.81 mg/L. In addition, chlorides and total dissolved solids concentrations occasionally exceed the Boston Mountains ecoregion criteria of 17 mg/L for chlorides and 95 mg/L for total dissolved solids. Historical maximum concentrations for these parameters are 26 mg/L for chlorides and 321 mg/L for total dissolved solids. In addition to these parameters, the mean concentrations for nitrate-nitrite nitrogen and total phosphorus were 0.07 mg/L and 0.034 mg/L, respectively, with maximum concentrations of 3.46 mg/L and 0.41 mg/L, respectively. These data, especially turbidity and total suspended solids, indicate that there could be some impairment of the aquatic life use in the stream.

Table 3 - Historical Water Quality Data From ARK43

Parameter	Mean	No. of Samples	Maximum	Minimum
Dissolved Oxygen mg/L	9.81	164	16.50	3.10
pH	7.20	156	8.21	6.11
Temperature °C	18.93	167	39.00	-4.00
Total Suspended Solids mg/L	5.90	170	332.00	1.00
NO2+NO3-N mg/L	0.07	163	3.46	0.01
Total Phosphorus mg/l	0.03	154	0.41	0.01
Total Organic Carbon mg/L	2.00	133	10.30	0.50
Total Hardness mg/L	21.44	163	52.00	11.00
Chloride mg/L	2.49	171	26.00	0.50
Sulfate mg/L	3.29	165	9.00	1.00
Total Dissolved Solids mg/L	41.08	166	321.00	13.00
Turbidity NTU	9.55	172	270.00	1.00

Table 4 - Boston Mountains Water Quality Standards and Criteria*

Temperature	31 °C	Chlorides	17.0 mg/L
Dissolved Oxygen	6.0 mg/L	Sulfates	15.0 mg/L
Turbidity	10 NTUs	Total Dissolved Solids	95.0 mg/L

Bacteria

Extraordinary Resource Waters - At no time shall the fecal coliform content exceed a geometric mean of 200/100 ml in any size watershed.

Primary Contact Waters - Between April 1 and September 30, the fecal coliform content shall not exceed a geometric mean of 200/100 ml nor shall more than 10 percent of the total samples during any 30-day period exceed 400/100 ml. During the remainder of the calender year, these criteria may be exceeded, but at no time shall the fecal coliform content exceed the level necessary to support secondary contact recreation.

Secondary Contact Waters - The fecal coliform content shall not exceed a geometric mean of 1000/100 ml, nor equal or exceed 2000/100 ml in more than 10 percent of the samples taken in any 30-day period.

Dissolved Metals

Standards for dissolved metals concentrations are based on ecoregion hardness values.

* State of Arkansas Department of Pollution Control and Ecology, Regulation No. 2, January 1998

National Forest Swim Beach Bacteria Standard

"The standard for fecal coliform is less than 200 colonies per 100 milliliters of water sample (<200col./100 ml). The standard for *E. coli* is less than 123 colonies/100 ml sample. If either of the two scheduled samples at any site failed, then the test results was negative. Two successive samples failing either standard are needed to close a beach, and two successive samples meeting the standard are necessary to re-open a site" (Ozark, 1998).[1]

1 The actual standard is, the fecal coliform content shall not exceed 200 colonies per 100 milliliters of water sample.

WATERSHED CHARACTERISTICS

LOCATION

The Big and Little Piney Creeks (Piney Creek) are located east of Clarksville and north of Russellville in west-central Arkansas (Figure 1). The Big Piney Creek headwaters are located in the Boston Mountains ecoregion in the southern portion of Newton County. The Creek flows mainly south through the northeastern portion of Johnson County past Fort Douglas and the eastern section of Pope County near Treet and Piney. It then turns westward near Augsburg back into Johnson County and enters Piney Bay in Lake Dardanelle on the Arkansas River. The creek flows out of the Boston Mountains ecoregion and into the Arkansas River Valley ecoregion before entering the lake.

The Little Piney Creek headwaters are mostly in northern Johnson County between Salus and Ozone. The creek flows southeast until turning almost due south near Mt. Levi and entering Piney Bay east of Lamar. This creek flows out of the Boston Mountains ecoregion and into the Arkansas River valley ecoregion.

LAND USE

The land use in the Big and Little Piney Creek watersheds can be divided into two distinct regions. The area north of Arkansas Highway 164 is mainly National Forest Land in the Ozark National Forest (Figure 3). There is some private land within the National Forest boundaries, the majority of which has been cleared for pasture land. The area south of the National Forest boundary is mainly used for pasture land and timber production. Almost all of the confined animal operations within both watersheds are located south of the National Forest boundary. In addition, oil and gas production also makes up a small percentage of land use south of the National Forest boundary.

Figure 4 depicts the locations of the confined animal operations (CAO), the type of operation, and the number of houses in each operation. There are 16 CAOs in the Big Piney Creek watershed. These include11 poultry operations with 23 total houses, four swine operations with 18 total houses, and one dairy operation. This equates to 0.13 CAO houses per square mile of watershed. However, because the CAOs are located south the national forest boundary within about 54 square miles of watershed, the concentration is actually closer to 0.78 houses/mi^2. The Little Piney Creek watershed has 43 CAOs which include 41 poultry operations with 121 total houses; and two swine operations with nine total houses. This equates to 0.81 houses/mi^2. Because almost all of these houses are located south of the national forest boundary, the concentration of CAOs is approximately 2.06 houses/mi^2. This illustrates that there is a greater density of CAOs in the Little Piney Creek watershed than in the Big Piney Creek watershed. Appendix A lists the CAOs in both watersheds, the subbasins where they are located and the location of each operation.

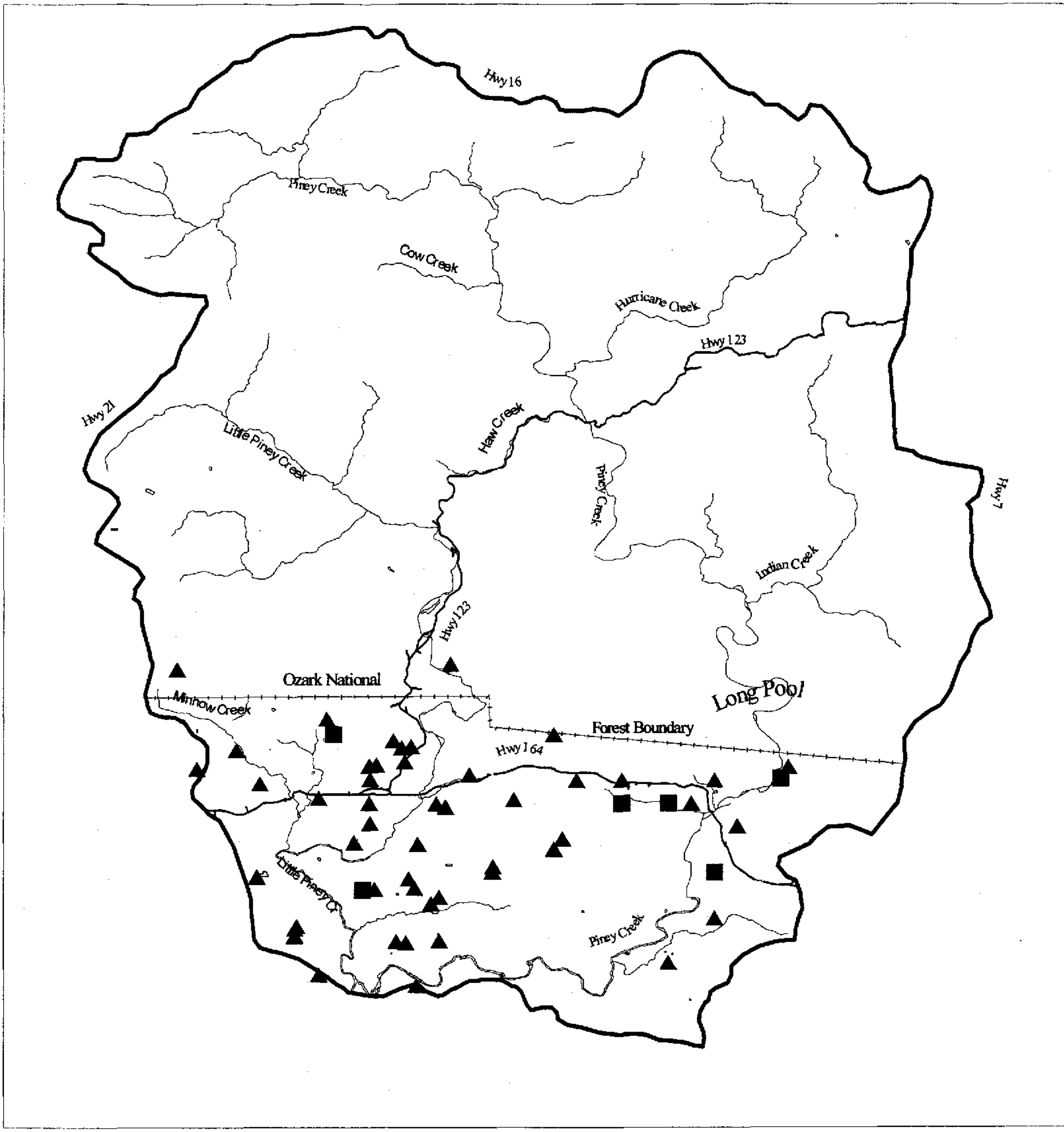

Figure 3 - Confined Animal Operations

■ Swine ▲ Poultry Dairy

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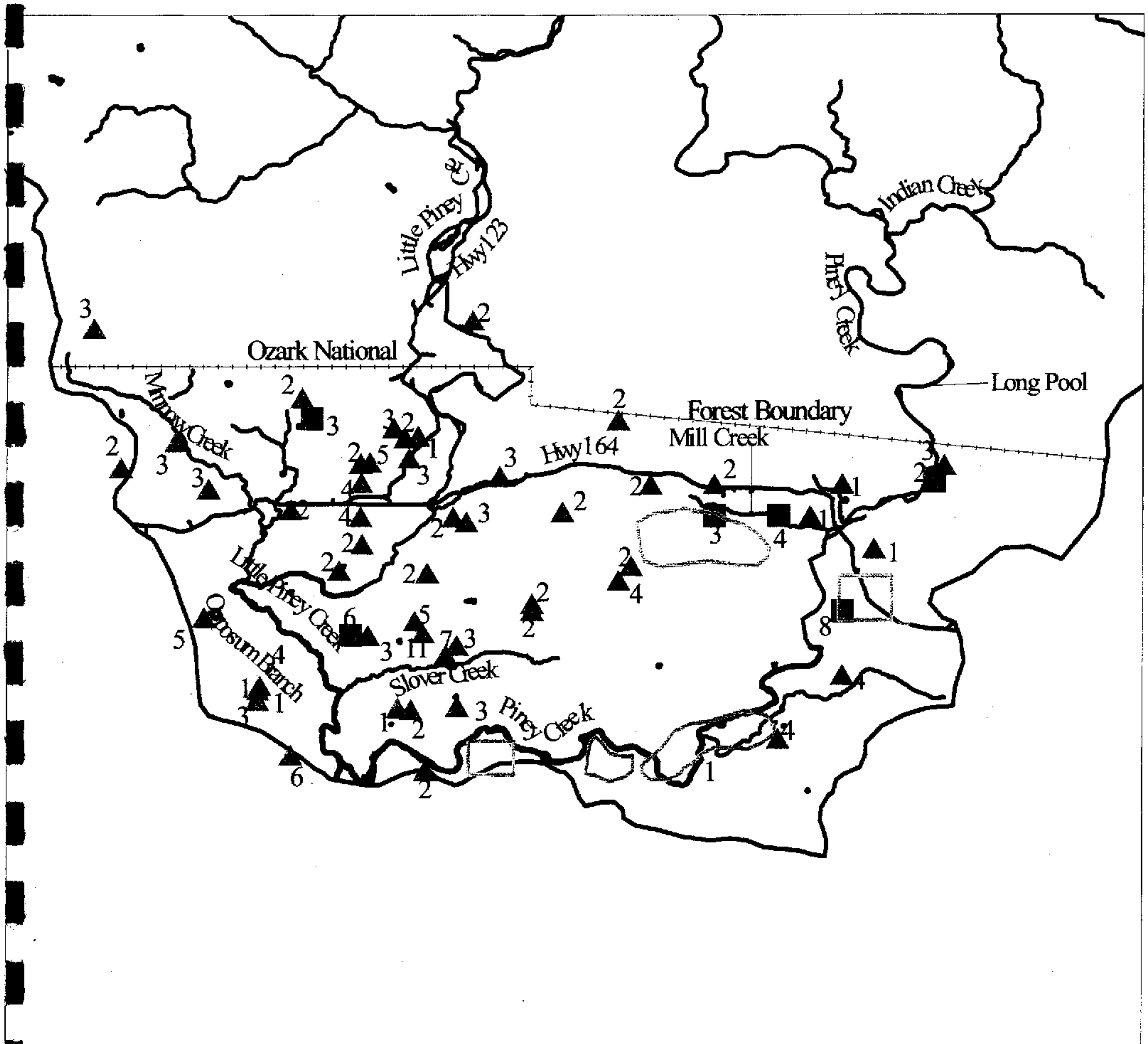

Figure 4 - Confined Animal Operations
Number of Houses

▲ Poultry
■ Swine
(X) Number of Houses
Dairy
Oil/Gas Field

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Table 5 - Confined Animal Operations				
Subbasin	Poultry		Swine	
	Growers	No. Houses	Growers	No. Houses
Big Piney Creek below Long Pool				
Dry Creek	1	1		
Mill Creek	4	6	2	7
Tributary No. 4, ARK109	1	1		
Tributary No. 3, ARK108			1	8
Wilson Creek	1	4		
Tributary No. 2, near Piney	1	4		
Tributary No. 1, near Augsburg	Dairy Operation			
Big Piney Creek near Hwy. 359	3	7	1	3
Totals: Big Piney	11	23	4	18
Little Piney Creek main stem	5	24	1	6
Dry Creek	6	11		
Minnow Creek	12	34	1	3
Granny Creek	5	16		
Oppossum Branch	5	14		
Slover Creek	6	22		
Totals: Little Piney	39	121	2	9

Note: The number of integrators does not equal the number of operations because some integrators have more than one operation.

Mill Creek has the greatest number of CAOs in the Big Piney Creek watershed with six integrators and 13 confined animal houses. This equates to 1.3 CAO houses/mi^2 of watershed. Tributary No. 3, ARK108, has an eight house swine facility, the largest in the area. This tributary has the greatest concentration of confined animal houses/mi^2 watershed at 4.0. The other tributaries in Big Piney Creek usually have only one grower and one to four confined animal houses. However, several of these operations are located in the smaller tributaries of less than two square miles of watershed which causes them to have high densities. This may be misleading since most of the animal waste applications from these facilities occurs outside of the watershed where the facility is located.

All tributaries in Little Piney Creek below the national forest boundary have concentrations of CAO houses greater than one per square mile. Minnow Creek has 12 poultry operations (34 houses) and one swine facility (3 houses). This equals 1.4 CAO houses/mi^2 of watershed. Oppossum Branch had 2.8 CAO houses/mi^2 which is the greatest ratio in Little Piney Creek basin. This is significant in this watershed because most of the watershed land use is pasture for animal waste application and cattle production. In addition, the riparian zone along Oppossum Branch is almost entirely pasture, allowing for direct run-off of storm water into the creek. In contrast, Slover Creek has a ratio of 1.7 COAs per square mile, second highest in the Little Piney Creek basin, but the land use in this tributary is split between pasture and forest lands, and there is good vegetative cover in the riparian zone along the stream. Thus, there is a greater chance of impacts from storm water runoff in Oppossum Branch as compared to Slover Creek.

GEOLOGIC SETTING

The Big Piney Creek watershed is located in the Boston Mountain region of the Ozark Plateaus physiographic province. Topography in the Boston Mountains, which are actually dissected plateaus, range in elevation from approximately 800 to 2200 feet above mean sea level. The Ozark Plateaus are defined structurally by the Ozark Uplift which is an elliptical-shaped, northeast-trending dome. Rocks to the southeast of the dome axis, which includes the Big Piney Creek watershed, dip gently to the south-southeast. Substantial faulting has occurred throughout the Ozark Plateaus. The faults generally trend east-west to northeast-southwest approximately paralleling the axis of the dome. Exposed rocks in the Ozark Plateaus of Arkansas range in age from Ordovician to Pennsylvanian and consist primarily of sandstone, shale, limestone and dolostone. Generally, rocks exposed at the surface become older from south to north. The formations outcropping in the Big Piney Creek watershed range in age from lower Mississippian to upper Pennsylvanian. The following sections were paraphrased form the Arkansas Geological Commission Information Circular 36 and detail the lithology of each of the units exposed in the watershed (McFarland, 1998).

Boone Formation

The oldest exposed unit in the watershed is the lower Mississippian-aged Boone Formation. According to geologic quadrangle maps obtained from the Arkansas Geological Commission, three small areas of the Boone Formation have been mapped in the northernmost section of the watershed near the community of Limestone. The Boone Formation consists of gray, fine- to coarse-grained fossiliferous, highly-soluble limestone interbedded with chert. The thickness of the Boone Formation ranges from 300 to 350 feet.

Hindsville Member of the Batesville Sandstone

The upper Mississippian-aged Hindsville Member of the Batesville Sandstone is a crystalline fossiliferous limestone that unconformably overlies the Boone Formation. This member also crops out in the vicinity of the Limestone community. The Batesville Sandstone, a fine- to coarse-grained, cream- to brown-colored sandstone, does not crop out in the watershed.

Fayetteville Shale

The upper Mississippian-aged Fayetteville Shale also was mapped in the area of Limestone. This unit conformably overlies the Hindsville member of the Batesville Sandstone. The Fayetteville Shale is a black, fissile, concretionary clay shale interbedded with dark-gray, fine-grained limestone.

Pitkin Limestone

The upper Mississippian-aged Pitkin Limestone conformably overlies the Fayetteville Shale in the watershed. This unit is a fine- to coarse-grained , oolitic, bioclastic limestone with some interbeds of black shale.

Cane Hill Member of the Hale Formation

The lower Pennsylvanian-aged Cane Hill Member of the Hale Formation lies unconformably over the Pitkin Limestone and marks the Mississippian-Pennsylvanian boundary. The Cane Hill Member is a dark gray silty shale interbedded with siltstone and thin-bedded, fine-grained sandstone.

Prairie Grove Member of the Hale Formation

The lower Pennsylvanian-aged Prairie Grove Member of the Hale Formation lies unconformably over the Cane Hill Member. The Prairie Grove Member consists of thin to massive, often cross bedded, frequently pitted, light-gray to dark-brown, limy sandstone or variously sandy limestone with lenses of relatively pure, crinoidal, highly fossiliferous limestone and oolitic limestone. This unit was specifically indicated on some of the field maps; however, other maps grouped this member with the overlying Bloyd Shale which was undifferentiated.

Bloyd Shale

The Lower Pennsylvanian-aged Bloyd Shale consists of several different members. These are the Brentwood Limestone member, the Woolsey Member, the Dye Shale Member, the Kessler Limestone Member, and the Trace Creek Shale Member. Most of the Arkansas Geological Commission field maps showed this unit as undifferentiated and combined with the Prairie Grove Member of the Hale Formation. One of the maps subdivided the Bloyd into the Middle Morrow and the Upper Morrow (which was combined with the Lower Atoka). No field mapping was conducted by this department to accurately define the units in the watershed.

Atoka Formation

The youngest unit exposed in the watershed and the Boston Mountains is the Atoka Formation. This unit forms the cap rock of the highest plateaus and conformably overlies the Bloyd Shale. The Atoka Formation is of marine origin and consists of tan to gray silty sandstones interbedded with grayish-black shales. Most of the watershed is located in the outcrop area of the Atoka Formation.

WATER QUALITY ASSESSMENT

SAMPLING EVENT OVERVIEWS

Eight water quality sampling events were completed from June 1997 through September 1998. Six storm events and two low flow events were sampled. Below is a synopsis of the weather conditions prior to each sampling event:

June 16, 1997 — The spring of 1997 had slightly above normal rainfall, but the three weeks prior to this sampling event were dry. During the morning of the sampling event, the lower portion of the watershed experienced localized heavy rainfall which resulted in the lower tributaries having storm flow. The upper portion of the watershed did not experience these storms and had typical flows for early June.

August 19, 1997 — The month previous to this sampling event was very dry. However, the upper portion of the watershed experienced an early morning thunder shower causing all of the upper tributaries above Fort Douglas to be flowing above low-flow conditions with storm water run off.

October 13, 1997 — From August 19, 1997 to October 3, 1997, there was no rain in the watershed. A couple of inches of rain fell in a two day period, October 3 & 4, resulting in insignificant runoff. An additional two to three inches of rain fell over another two days (October 10 & 11) throughout watershed; again resulting in insignificant runoff. Light to moderate rainfall began again on Monday, October 13, and early Tuesday morning, October 14, the rain became much heavier in the upper portion of the watershed. Very little runoff had occurred in the lower tributaries, many of which were still small standing pools. The upper watershed tributaries had noticeable runoff that had already passed. The Piney Creek sites had elevated flows. The small tributaries had the only noticeable in-stream turbidity.

January 5, 1998 — An unusually dry November and December resulted in little to no runoff in the watershed. However, very heavy rains began falling on Sunday, January 4, 1998 and continued throughout the night and into Monday morning. This storm event caused significant runoff. The upper tributaries had crested prior to sampling. Estimated bank full depths ranged from 70% to 125%. The lower tributaries and the main stem had either not yet crested or were just at the peak of the crest. Estimated bank full depths were between 100% to 115%. Stream flow was not measured at a number of sites because of the high water conditions.

January 26, 1998 — A rainfall event occurred in the watershed the night and early morning hours prior to this sampling event resulting in elevated flows in the tributaries and the main stems of the rivers. Flows were estimated to be between 70% and 90% bank full. Some of the tributary flows had peaked prior to sampling. Stream flows were unable to be measured at a number of sites because of the high water conditions.

February 10, 1998 — Little to no rainfall had occurred since the last sampling event. All flows in the watershed were estimated to be from 10% to 25% bank full. This is typical winter low flow conditions.

April 27, 1998 — Very heavy rains fell during the early morning hours of April 27, resulting in very heavy runoff. Most of the tributaries had peak flow prior to sampling. However, the flows were just peaking at the gaging stations in Little and Big Piney Creeks at the time the samples were collected. Stream flows were unable to be measured at a number of sites because of the high water conditions.

July 27, 1998 — An extended dry period occurred prior to this sampling event. Extreme low flow conditions and high air temperatures prevailed for several weeks. Many of the smaller tributaries were either completely dry, had no surface flow, resulting in intermittent pools, or had less than 0.1 cfs flows. The gage at Highway 64 on Big Piney Creek, ARK43, indicated that the stage height was less than 0.5 feet, the lowest reading recorded during the survey.

WATER CHEMISTRY DATA

Basic Parameters

Base flow conditions throughout the watershed generally occurred in the late summer to early fall months. The smaller, headwater streams also experience base flow conditions in early to mid winter. Base flows generally range from no-flow situations at the smaller tributary sites to flows of less than three cubic feet per second at the larger main stem sites. Storm flows during the survey were measured as high as 379 cfs, however, during the January 5, 1998 sampling event, the flows were so extensive that they could not safely be measured.

Water temperatures in Big Piney Creek ranged from 5.8 °C in Cow Creek in January to 31.8 °C in Big Piney Creek below Long Pool in August. The Boston Mountains ecoregion standard for maximum instream water temperature is 31.0 °C (ADPC&E, 1998). Water temperatures in the Little Piney Creek ranged from 6.5 °C in Opossum Branch in January to 27.4 °C at the upper Little Piney Creek site in August.

The Boston Mountains ecoregion standard for dissolved oxygen is 6.0 mg/L year round, except in watersheds of <10 mi^2, the dissolved oxygen standard is 2.0 mg/L during the critical season and 6.0 mg/L during the primary season (ADPC&E, 1998). Dissolved oxygen concentrations ranged from 3.6 mg/L in Opossum Branch in August, 1998, to 15.3 mg/L in Big Piney Creek in February (Figure WQ-1). Dissolved oxygen standards were not met at six sampling stations; the lower Little Piney (ARK104)[1] and lower Big Piney Creek (ARK105)[2] sites in August 1997 and August 1998; at the Big Piney Creek site below Hurricane Creek (ARK118) in August 1998; and at the Indian Creek (ARK114) and Moccasin Creek (ARK115) sites in August 1998. These concentrations ranged from 4.0 mg/L to 5.9 mg/L. All of the low dissolved oxygen concentrations occurred during one of the August sampling events during extreme low flow conditions. Several stream sites were reduced to small pools only. This could possibly account for the low dissolved oxygen concentrations taken from these sites.

The Boston Mountains ecoregion standard for turbidity is 10 NTUs, which was establish under base flow conditions. Turbidity readings ranged from 0.9 NTUs to1180 NTUs during this survey. Of the178 readings taken during the survey, 46%, were above 10 NTUs. Four readings were above 100 NTUs. All elevated readings occurred during storm events. Figure WQ-2 illustrates the maximum, minimum, and mean values for the turbidity readings taken during the survey. Only those samples taken during base flow conditions were below 10 NTUs. The sites in the lower portions of both watersheds demonstrate higher turbidity values than the upstream sites, and those sites in the middle portion of Big Piney Creek had lower turbidity values and fewer readings above 10 NTUs than the headwater sites.

The ARK108 and ARK107 sites had the highest turbidity values and the greatest number of samples above 10 NTUs. The sample taken at ARK108 during the June 1997 sampling run was taken downstream of the county road culvert just after a localized storm event. Thus, this high turbidity reading includes runoff from a county road and from a pasture and swine facility. The rest of the samples collected from this site were taken upstream of the road. The major source of the turbidity is probably from the county roads in the watershed. However, the pasture lands adjacent to the tributaries and main stems of the creeks, and the unstable streambanks throughout the watersheds are probably also contributing to the high turbidity values.

The basin wide storm event sampling that occurred during this survey did not capture the small, localized storm event effects to the creeks. Photos I and II show the effects of runoff from a localized, short duration, high intensity storm event in the lower Big Piney Creek at the Biological site. This runoff is from a watershed of approximately two square miles. The land use in the watershed included a natural gas pumping/oil catch area, timber harvest, and county roads. This type of storm event during low flow periods possibly causes more damage to the creek because the turbidity does not get flushed out of the system, but probably settles in the creek within a few hundred yards downstream of the tributary.

1 This station is in the transition zone between the Boston Mountains and Arkansas Valley ecoregions. This station met the standards for an Arkansas River Valley ecoregion stream with a watershed between 11 mi^2 and 150 mi^2 of 3 mg/L.

2 This station is in the transition zone between the Boston Mountains and Arkansas Valley ecoregions. This station met the standards for an Arkansas River Valley ecoregion stream with a watershed between 151 mi^2 and 400 mi^2 of 4 mg/L.

Figure WQ-1

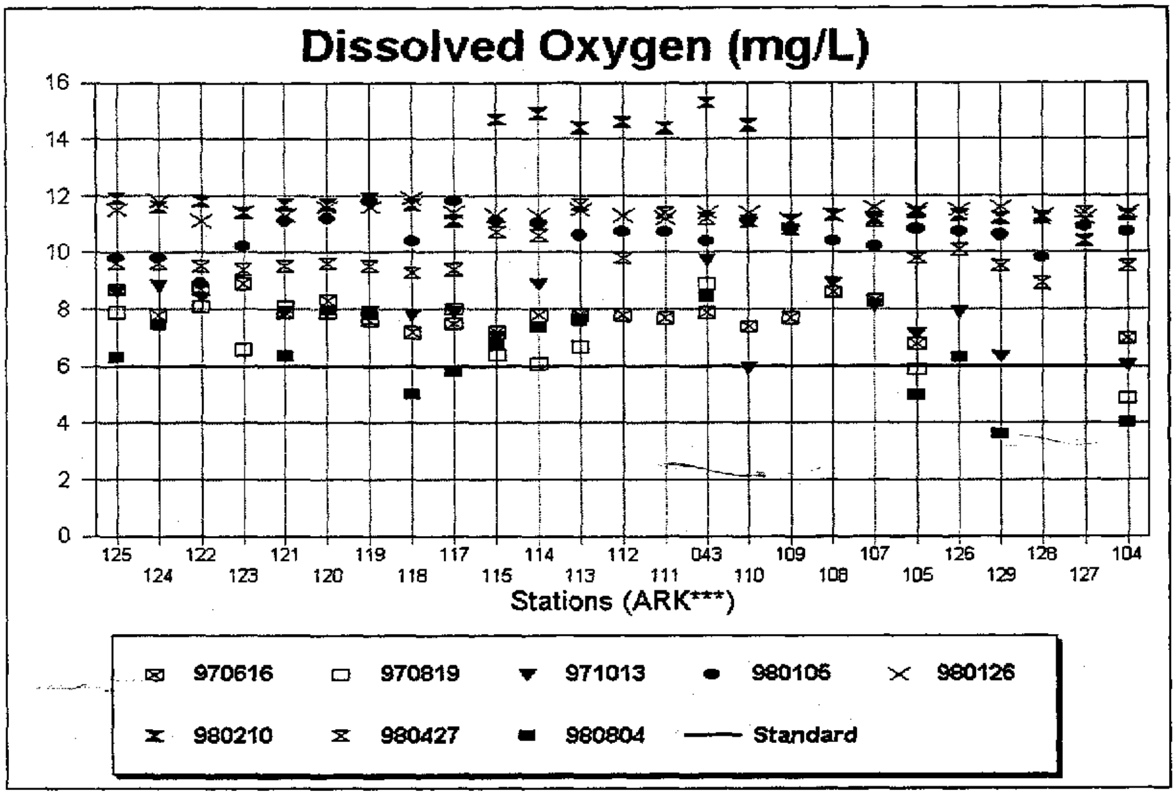

Figure WQ-2

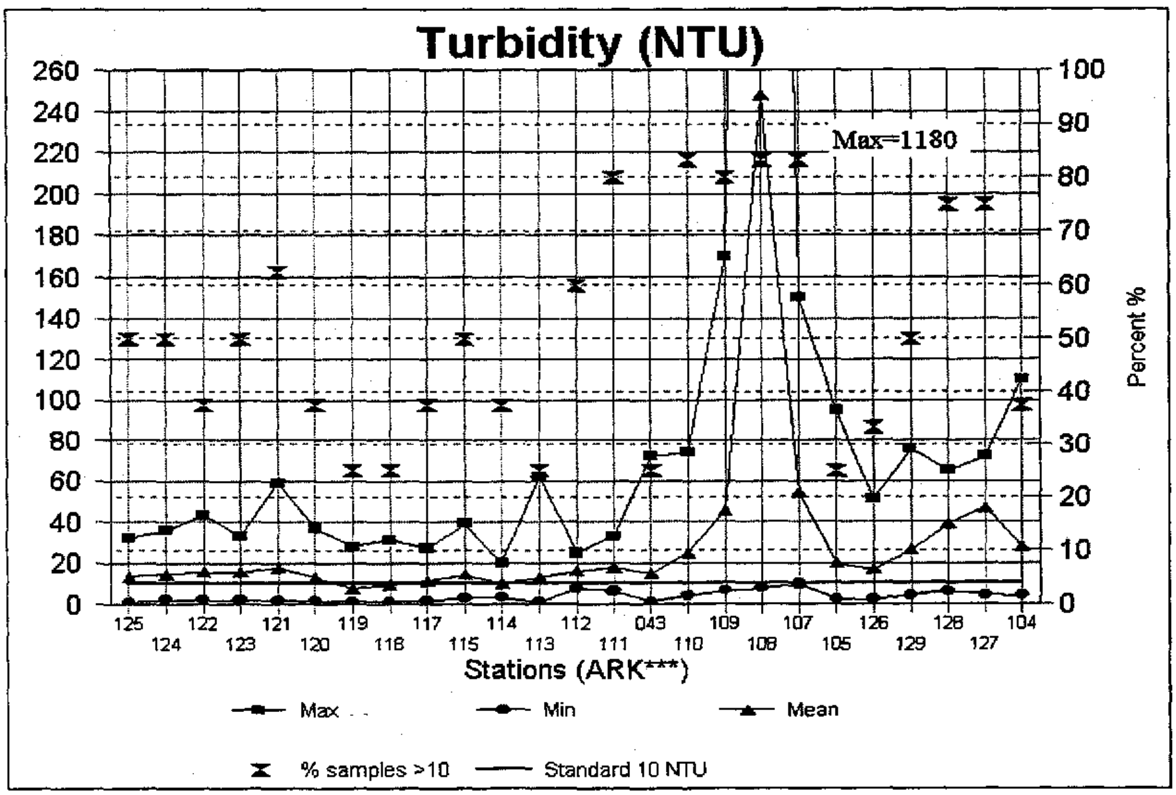

Photo I

Photo II

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The total suspended solids (TSS) concentrations reflect the turbidity values. They ranged from <1.0 mg/L at several sites to 960 mg/L at ARK108. The lower sites had higher concentrations than the upstream sites, and the sites in the middle section of Big Piney Creek had lower concentrations than the headwater sites. The Haw Creek site had only two TSS concentrations above the detection limit of 1.0 mg/L, with a maximum concentration of only 3.0 mg/L. Both of these concentrations occurred during the large January storm events. Cow Creek also had very few TSS values above the detection limit, and the maximum concentration detected from this site was only 4.5 mg/L. The Haw Creek watershed is 100% forested and the Cow Creek site is mostly forested with some pasture land in the creek valley. The 960 mg/L concentration measured at ARK108 in August 1997 was collected after a localized storm event. This sample was collected downstream of a county road, which was probably accounting for the majority of the solids in the sample. The majority of the elevated TSS concentrations throughout the watershed occurred during the first January storm event. This was an abnormally large storm event causing above bank full conditions throughout the watershed. It was also the first major storm event after a very dry summer and a fall with only a few low intensity storm events.

Instream water quality standards for chlorides, sulfates and total dissolved solids (TDS) for Boston Mountains ecoregion streams are 17, 15, and 95 mg/L, respectively. Chloride concentrations during the survey were generally less than 2.0 mg/L, but ranged from 0.63 mg/L to 31.4 mg/L. Sulfate concentrations ranged from1.49 mg/L to 46.97 mg/L. TDS concentrations ranged from 19 mg/L to 207 mg/L, with most concentrations between 20 mg/L and 60 mg/L. Figures WQ- 3 thru WQ-5 illustrates the maximum, minimum, and mean chloride, sulfate, and TDS concentrations measured during this survey. Five sites, ARK122, ARK123, ARK108, ARK105, and ARK127, experienced elevated chlorides, sulfates, and/or TDS concentrations as compared to the other sites in the survey. Three small tributaries in the upper Big Piney Creek watershed, ARK125, ARK123 and ARK122, had elevated sulfate and TDS concentrations as compared to the other headwater tributaries. These streams are located mostly in the Pitkin/Fayetteville Shale with a small outcropping of the Boone Formation. They drain mostly pasture and forest lands, but they also drain the small community of Limestone. In addition to these streams, ARK108 had the highest TDS concentration, 207 mg/L. It also had elevated concentrations of chlorides and sulfates during of the sampling events. These increases in concentrations could be caused by the swine facility or from runoff from the pasture in its watershed. The October 1997 sample at ARK105 had unusually high concentrations of chlorides, sulfates, and TDS. The cause of this is unknown. The samples taken during the February 1998 sampling event at ARK127 demonstrate the same pattern as the samples collected at ARK105 in October 1997. These samples are abnormally elevated as compared to the other samples collected at that site throughout the survey and the other samples collected from other sites collected during the same sampling run. The cause of these elevated values is also unknown. Overall, there seems to be an increase in concentrations in a downstream direction. Most of this increase may be natural due to the change in soil types and topography as the creeks traverse from one ecoregion with low soil mineral content to an ecoregion with soils of higher mineral content. However, some of this change may also be due to different land use practices; i.e. increased pasture land use, increased urban use, decreased timberlands.

Figure WQ-3

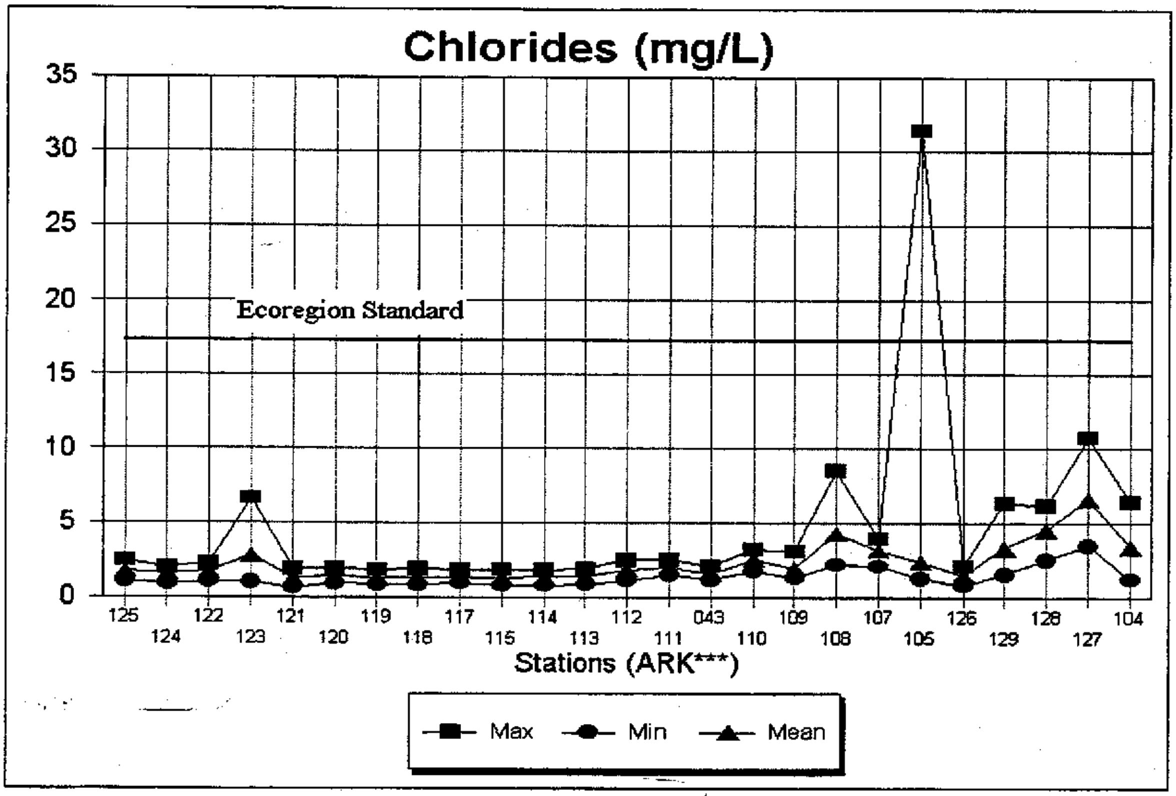


Figure WQ-4

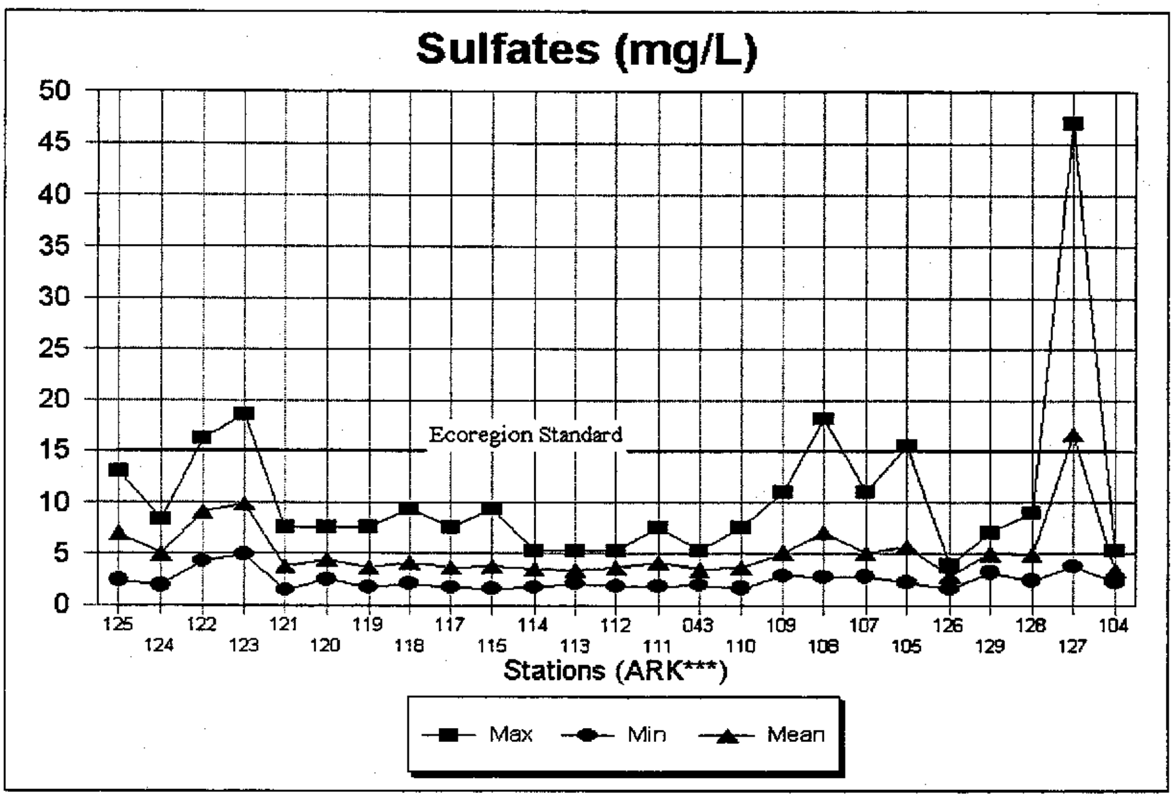


Figure WQ-5

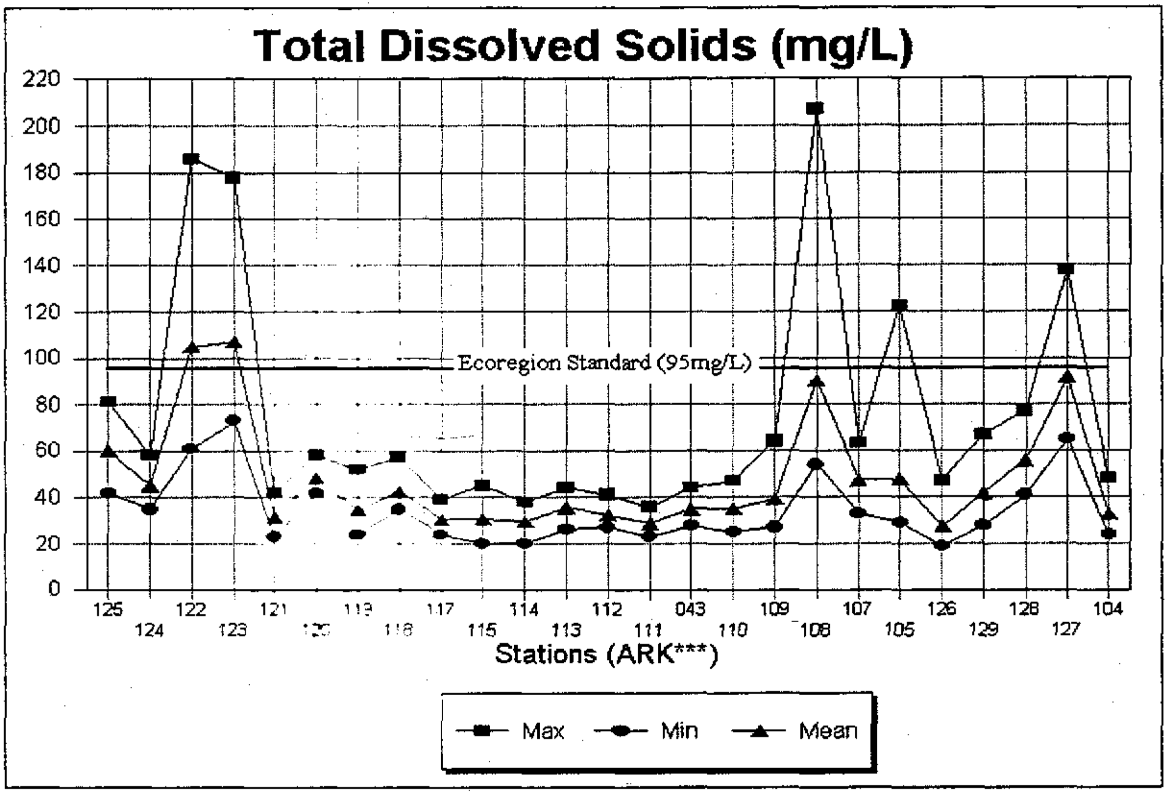
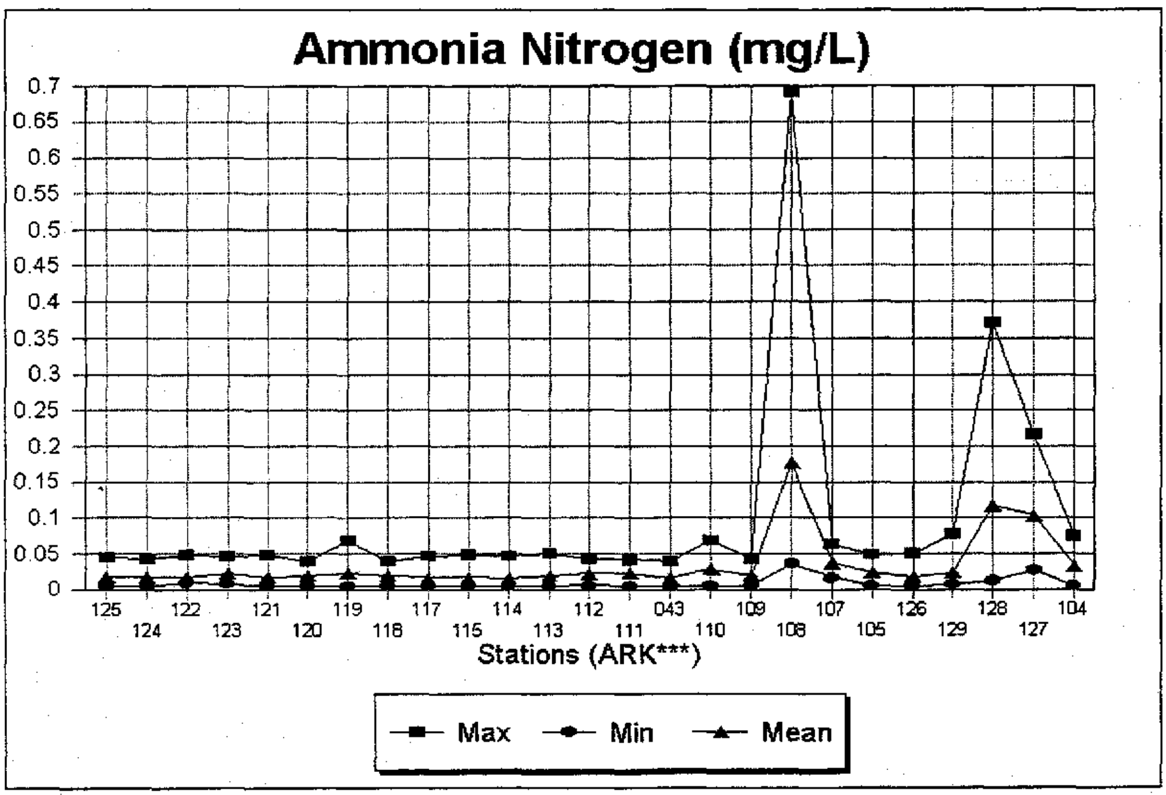


Figure WQ-6



Ammonia nitrogen concentrations were almost always below 0.05 mg/L (Figure WQ-6). Three sites, ARK108, ARK128 and ARK127, were the only sites that had concentration greater than 0.10 mg/L. The highest concentration, 0.691 mg/L, occurred at ARK108 during the August 1997 sampling event. This sample was taken shortly after a localized storm event and the sample may have been influenced from the swine facility in the watershed. Almost all of the other sites collected that day had concentrations below the 0.05 mg/L detection limit. All of the samples taken from this small tributary had elevated concentrations when compared to the other samples collected during the survey. The tributaries in the lower portions of both watersheds had higher ammonia concentrations compared to the upstream tributaries. This did not seem to be influencing the concentration at the lower Big Piney Creek site, ARK105, as compared to the upper Big Piney Creek site, ARK124. There was only a 0.005 mg/L increase in the average concentration from ARK124 to ARK105. However, there is a noticeable increase in the Little Piney Creek system from upstream to downstream. The upper Little Piney Creek site (ARK126) had an average concentration of 0.018 mg/L, and the lower Little Piney Creek site (ARK104) had an average concentration of 0.033 mg/L. Excluding the ARK108 site, each of the tributaries sampled in the Little Piney Creek watershed (ARK127, ARK128, and ARK129) had higher maximum concentrations and ARK127 and ARK128 had higher mean concentrations than the Big Piney Creek tributaries. This increase is probably due to the number of CAOs and the application of poultry litter on pasture lands located in the lower Little Piney Creek watershed.

The nutrient concentrations of nitrate + nitrite nitrogen (nitrogen), total phosphorus (TPhos) and ortho-phosphorus (OPhos) all had similar patterns of concentrations. Figures WQ-7, WQ-8, WQ-9 and WQ-10 illustrate this. Each parameter indicates that there are slightly higher concentrations in the upper portion of Big Piney Creek compared to the sample sites in the middle portion of the watershed from Cow Creek to Haw Creek. The concentrations begin to increase again beginning at Indian Creek and continue increasing throughout the lower portion of the watershed. The nitrogen and OPhos peaks are most noticeable at the tributary sites at ARK110, ARK108 and ARK107, and the TPhos peaks are most noticeable at ARK108 and the main stem sites at ARK43 and ARK105. Nitrogen concentrations are highest during low flow in the upper portion of the Big Piney Creek watershed, perhaps indicating that ground water is influencing these areas during low flow conditions (Figure WQ-8). This is also occurring at Levi Branch (ARK112) and Mill Creek (ARK110) two lower watershed tributaries.

The majority of the elevated TPhos concentrations occurred during the first January storm (Figure WQ-9). However, the TPhos concentrations during the subsequent storm flow sampling event in January did not demonstrate these same magnitudes, but the storm flow samples collected in April did. This is probably because the first January sampling event was a "first flush" event after a low rainfall period, the second January event was not as severe as the first, and the April event was a first flush event after spring litter application.

The OPhos data (Figure WQ-10) demonstrates the same pattern of higher peaks during storm flows, but the difference in the magnitude of the peaks between the storm flow data and low flow data are not as pronounced. There is also not the same decreases in concentrations between the

Figure WQ-7

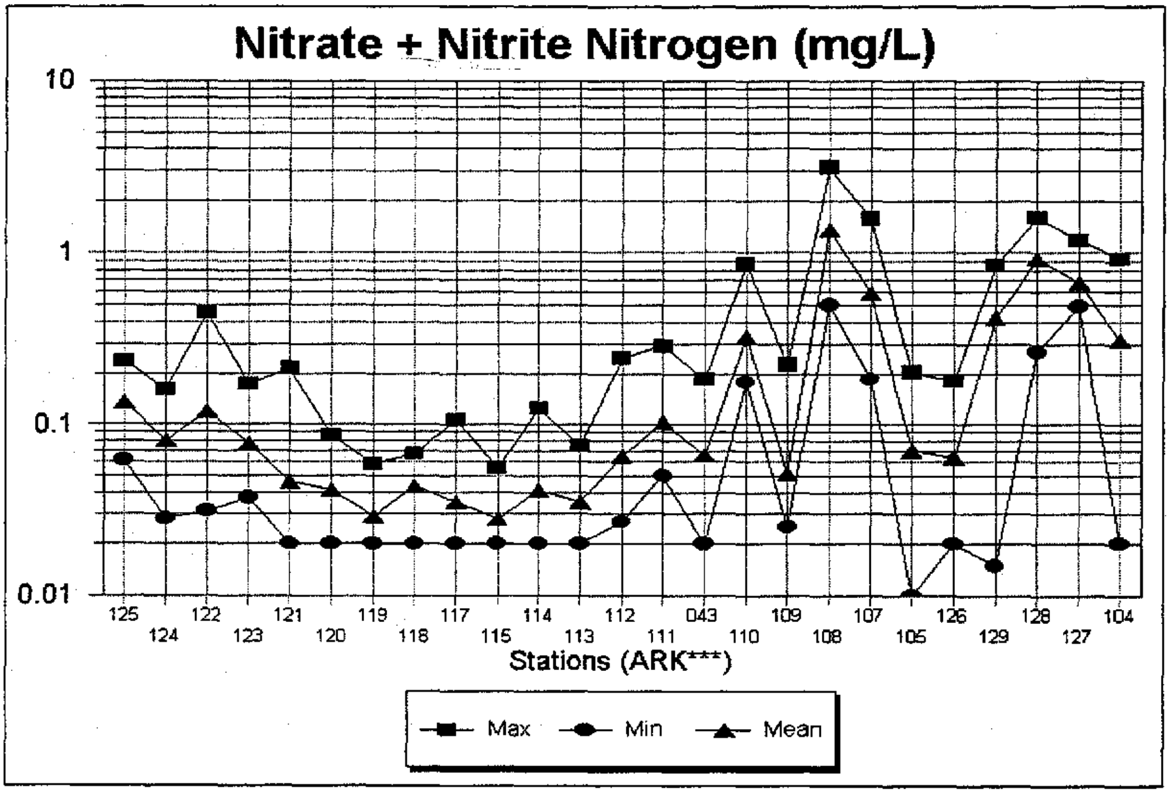


Figure WQ-8

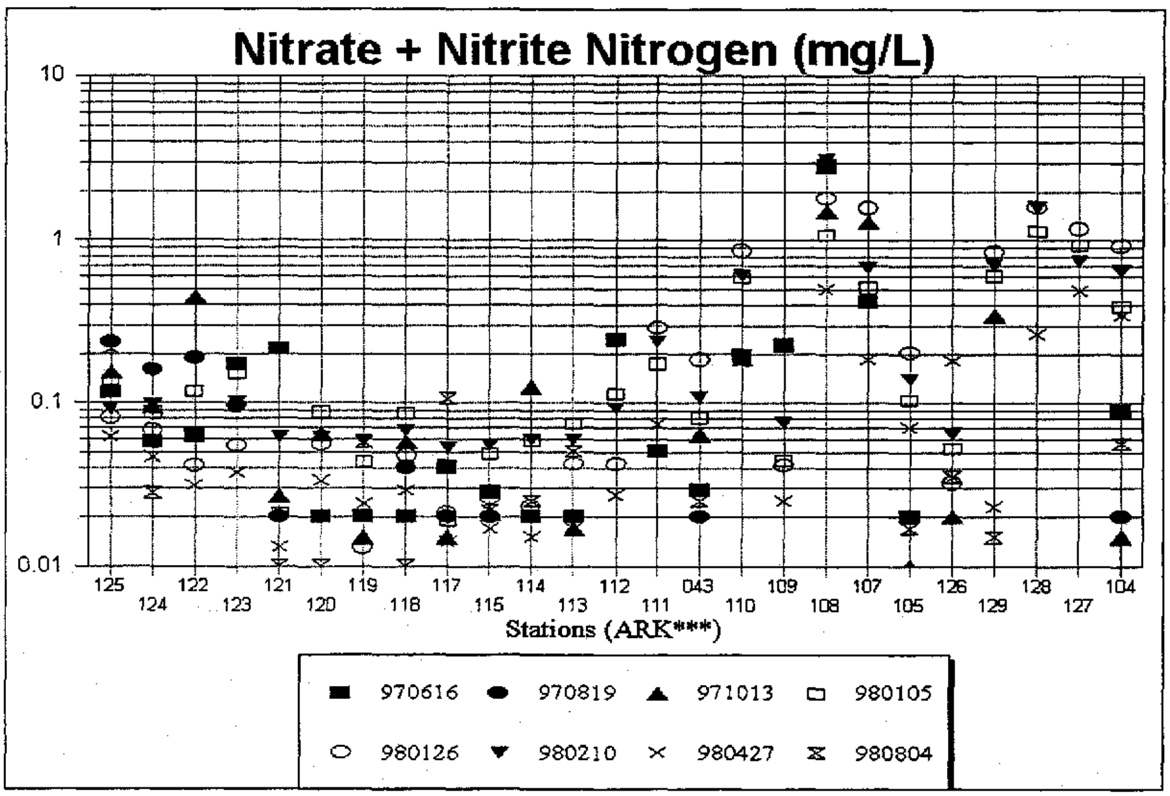


Figure WQ-9

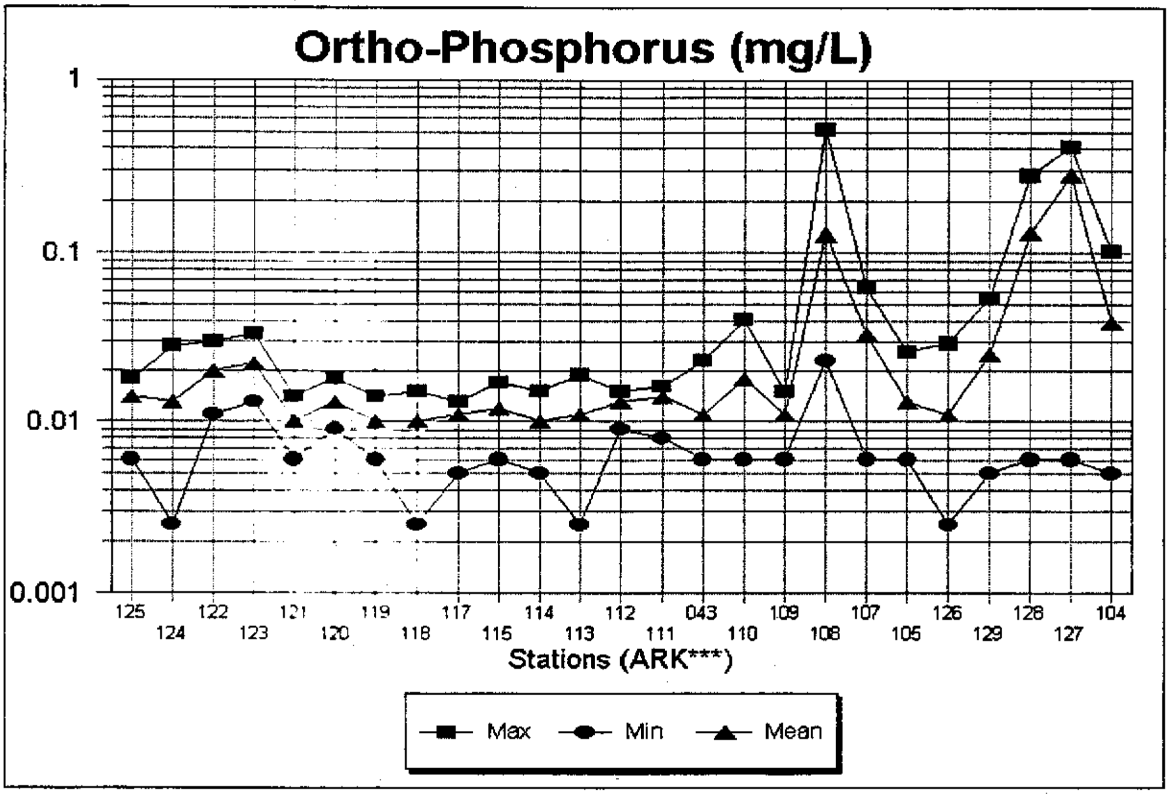
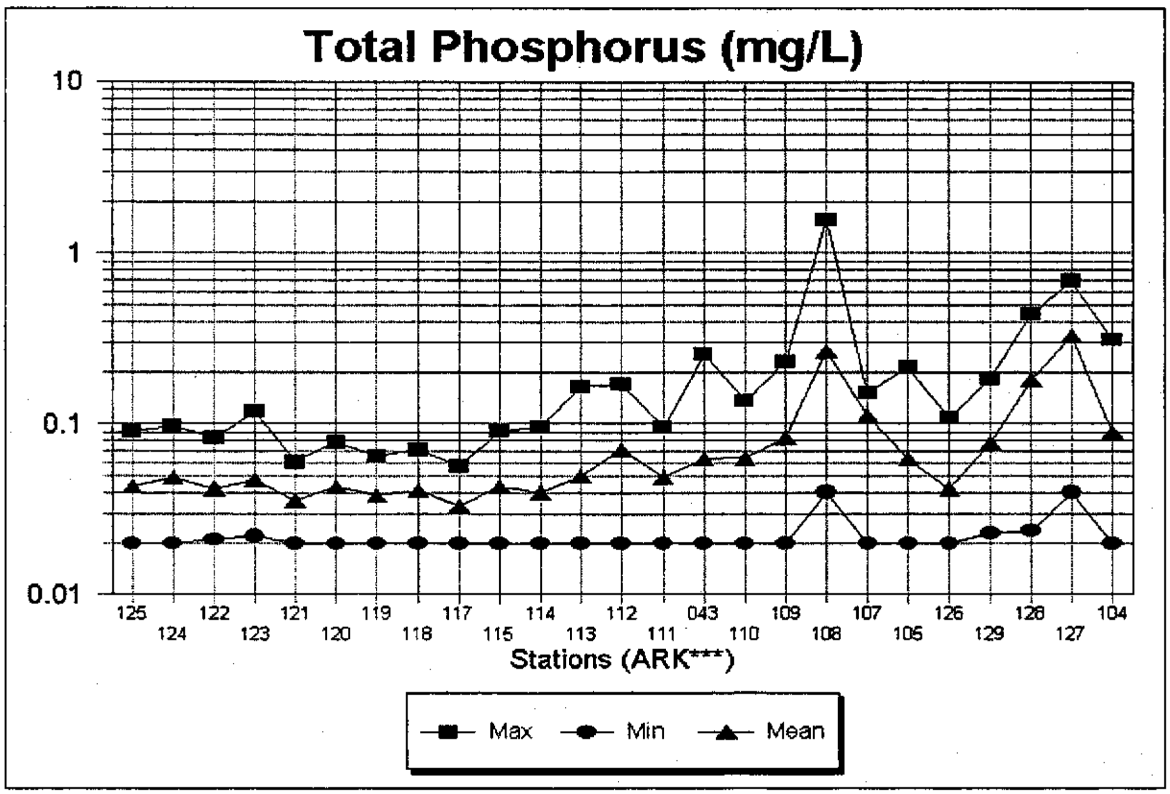


Figure WQ-10



two January sampling events. The is most likely due to the severity of the storms and that they were most likely "first flush" events. The TPhos to OPhos ratio during these events was above 3 at most sites, except at ARK108. ARK127 and ARK128. This is indicating that a greater percentage of the phosphorus is not associated with the sediment during the storm events and that there is a greater concentrations of orthophosphorus is the storm water.

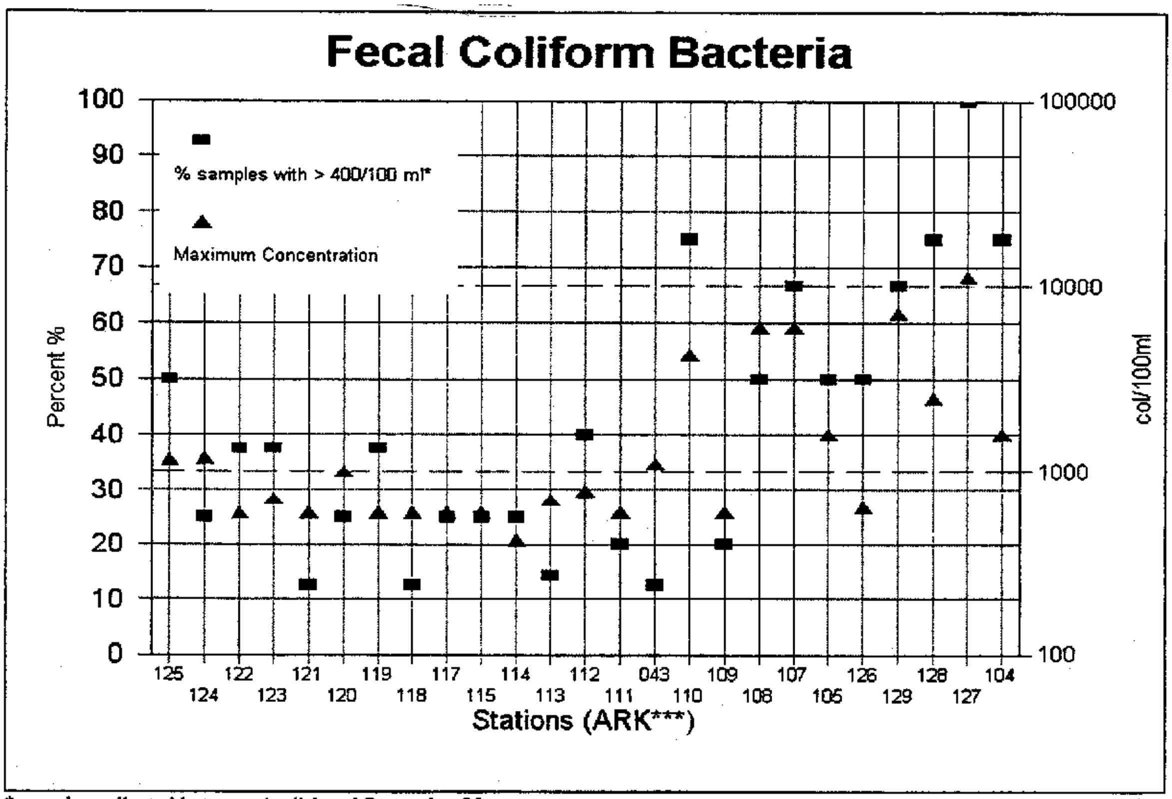
Fecal Coliform Bacteria

Fecal coliform concentrations ranged from 1 colony per 100 ml (1/100ml) of sample, to greater than 6000 col/100ml. One sample had 11, 200 col/100ml. The water quality standard for fecal coliform content to protect primary contact recreation is: "Between April 1 and September 30, the fecal coliform content ...nor shall more than 10 percent of the total samples during any 30-day period exceed 400/100ml." During the remainder of the year, "at no time shall the fecal coliform content exceed the level necessary to support secondary contact recreation." For secondary contact waters: "The fecal coliform content...nor equal or exceed 2000/100ml in more than ten percent of the samples taken during any 30-day period." ADPC&E, 1998.

Approximately 43% of the 74 samples collected during the primary contact season exceeded the standard. The concentrations in the upper most portions of the Big Piney Creek watershed were somewhat elevated as compared to those in the middle portion of the watershed. This is most likely due to the larger amount of pastureland in the upper portion of the watershed as compared to the middle portion. The lower portion of the watershed, beginning near Levi Branch, had noticeably higher concentrations than the middle or upper portions of the watershed. The percent of the samples collected during the swimming season with more than 400/100ml and the maximum concentration of colonies are displayed in Figure WQ-11. The most upstream station in the Little Piney Creek basin (ARK126) has somewhat elevated concentrations when comparing it to a like sampling station in the Big Piney Creek watershed (ARK 118). However, there is a noticeable increase in bacteria concentrations downstream both in the tributaries and the main stem of Little Piney Creek. All of the lower tributary sites in both watersheds displayed elevated bacteria concentrations as compared to upstream sites and the main stem sites. In addition, the largest and most frequent standards violations occurred during the storm flows in October, January, and April. The January and April 1998 samples have the same pattern of having higher concentrations at the upstream sites, lower in the middle portion of the watershed, and elevated concentrations in the lower portions of both watersheds. However, bacteria concentrations were elevated throughout the watershed during the October 1997 sampling event.

The elevated bacteria concentrations in the lower portions of the watersheds can perhaps be attributed to CAOs, litter application on pasture lands, and direct access to the streams by cattle. Some may be coming from the septic tanks in the area; however, there is no data to specifically link the septic tanks in the area to the elevated concentrations. The elevated concentrations that occurred during the storm flow sample events was most likely washed off the land after fall and spring litter applications had occurred. Both of these events were probably "first flush" events.

Figure WQ-11



* samples collected between April 1 and September 30

The Long Pool swim beach was sampled 23 times at two locations by the National Forest Service. As a result of the sampling, the swim beach was closed for 27 days in late May and June (NFS, 1998). Difficulty in sample scheduling may have inadvertently kept the swim beach closed longer than necessary. The bacteria source is believed to be originating near Treet where there are numerous camps, some permanent residences, and livestock which have direct access to the streams.

Metals and Other Cations

Metals concentrations below quantification levels were found for beryllium, cobalt, nickel, and vanadium. Metals found with only sporadic quantifiable levels included cadmium, chromium, and lead. Those commonly detected but usually in low concentrations were boron, barium, calcium, cadmium, copper, potassium, magnesium, manganese, sodium, and zinc. The highest concentrations were found for aluminum and iron. Most of these constituents displayed a downstream increase in concentrations, except for calcium. It was highest in the upper most section of the Big Piney Creek basin which is nearest to the Ozark Highlands geology which contains limestone. Most of the elevated metals concentrations occurred in the lower portion of the watersheds, and were usually in the tributaries.

When using the Boston Mountains ecoregion total hardness value of 25 mg/L, copper is calculated to be toxic at 4.6 ug/L. This value was exceeded at three sampling locations (ARK114, ARK128 and ARK127) during the April 1998 sampling event. Aluminum was detected at five sites at concentrations between 100 ug/L and 326.1 ug/L. None of these values were calculated to be toxic, but these values are definitely elevated as compared to the other tributary sites in the watershed. This is suggesting that there may be some sort of unnatural input of aluminum into these tributaries.

72-Hour Dissolved Oxygen Profiles

Dissolved oxygen was recorded for 72 hours during July and August at the following sites: ARK125, ARK124, ARK121, ARK120, ARK120B, ARK119, ARK117, ARK116, ARK114, ARK43, ARK126 and ARK104. Figures WQ-12 thru WQ-23 depict the data collected.

The dissolved oxygen (DO) profile from Walnut Creek (ARK125) indicates that there is possibly some elevated algae production in the stream. This is evident by the 3 mg/L change in the DO profile from 6 mg/L to 9 mg/L. Another indicator is the sharp decline in the profile once the sunlight begins to be blocked by the trees in the riparian zone. A unique feature about this profile is that the DO concentrations peaked over 9 mg/L on July 28, which was a day with overcast skies. It would be expected that the water temperature and DO concentration would both be depressed on overcast days. This was not the case for DO on that date. The cooler water temperatures, typical of the tributaries in the watershed, and the shallow, clear-water pools both help to maintain high DO concentrations throughout the day.

The DO profile at the upstream Big Piney Creek site (ARK124) indicates DO concentrations ranging between 4.6 mg/L to 7.8 mg/L. This station had a 1.6 mg/L rise in DO on July 28 and a 2.8 mg/L rise on July 29. Another indication that there was a cloud cover present on July 28 was the lower peak in temperature on that date. This profile may be indicating some elevated algae production by the sharp decline in DO on July 28.

The Cow Creek site (ARK121) had the least fluctuation of any of the sites including 1.6 mg/L for DO and only two degrees Celsius fluctuation in temperature. This station also reflects the cloud cover on July 28. The DO at this site begins to decline around 5:00 pm, which is earlier than the other sites. This is due to the steep topography in its watershed causing the loss of direct sunlight earlier in the afternoon.

The DO profile from Big Piney Creek (ARK120) downstream from Cow Creek is quite unusual. The profile fluctuates very little throughout the day of July 28, but shows a very noticeable increase in DO concentration on July 29. Two things probably occurred here. First, the overcast skies on July 28 helped to depress the DO concentrations and second, there may have been a meter malfunction.

Figure WQ-12

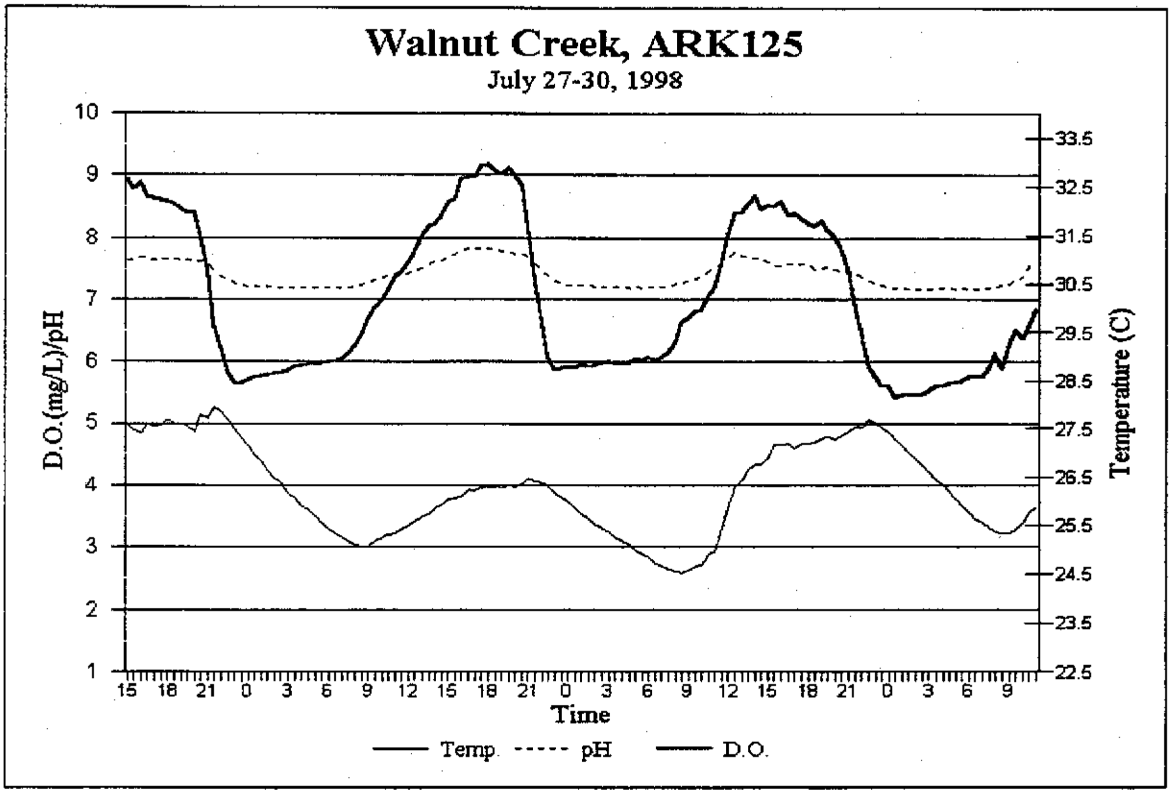


Figure WQ-13

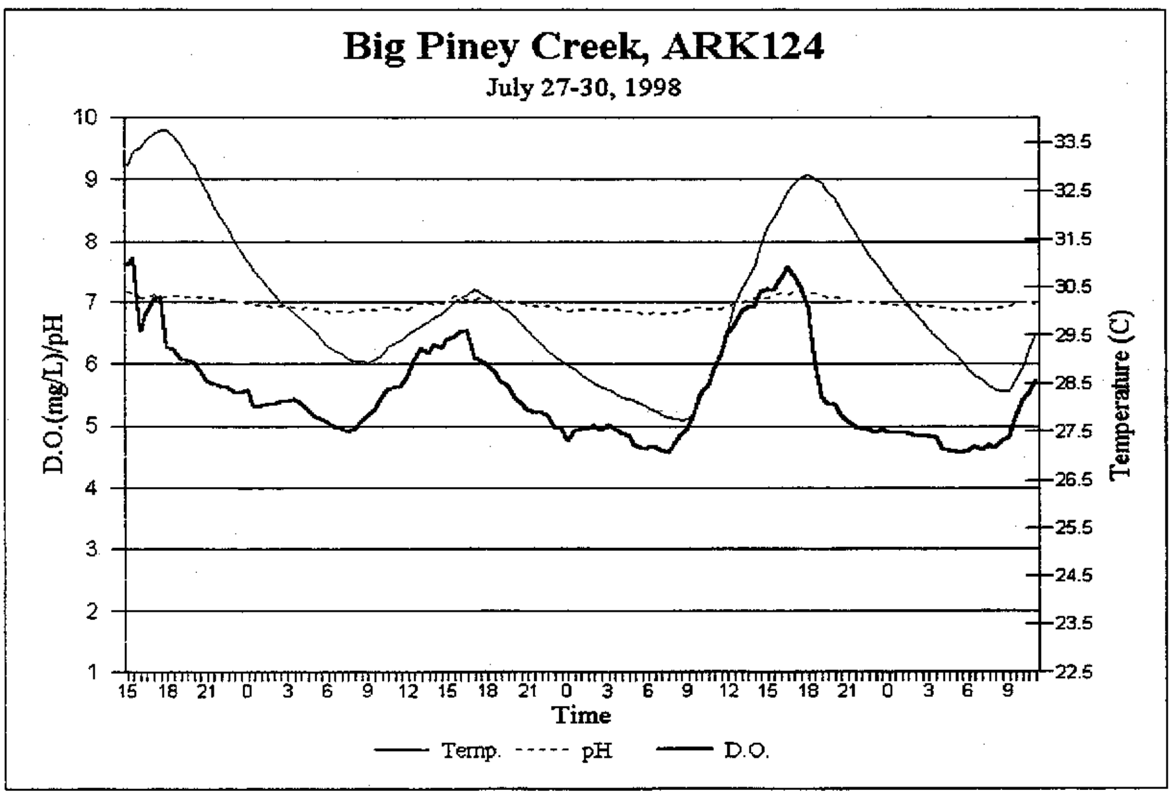


Figure WQ-14

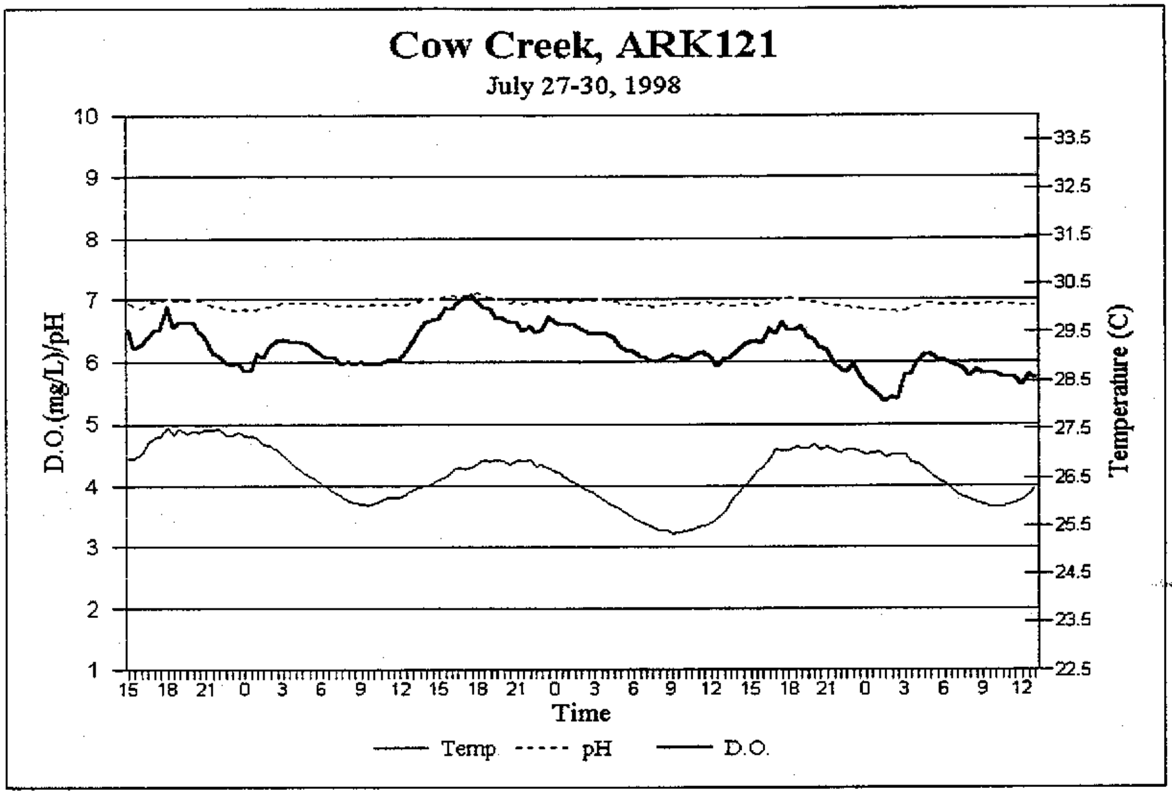
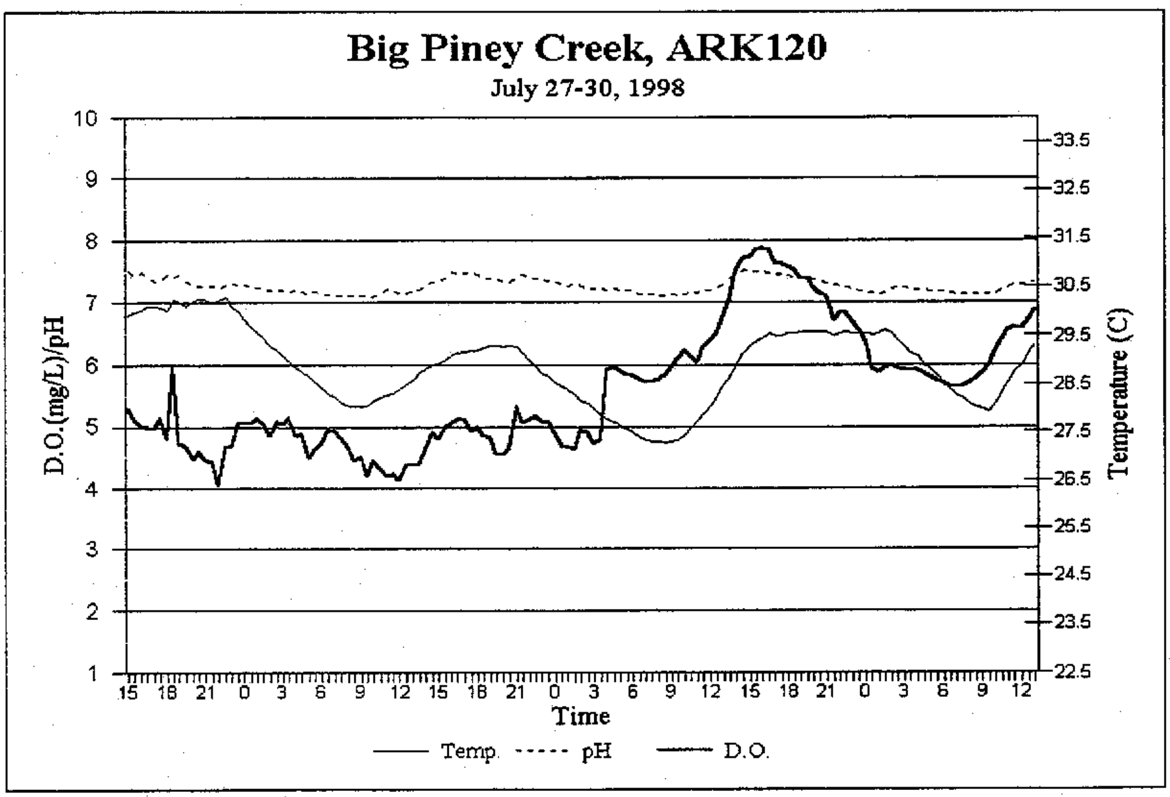


Figure WQ-15



A Hydrolab was deployed in Big Piney Creek upstream of Hurricane Creek, in an area below a pasture area where cattle have direct access to the creek. At the time of deployment, there was an unusually heavy growth of algae in this segment of the stream. This station was named ARK120B. Water quality samples collected from this site at the time of deployment did not indicate that there were any elevated concentrations of any of the constituents analyzed. There was a DO concentration fluctuation of more than 3 mg/L, but there was not a sharp decline in the DO concentration just after sunset (Figure WQ-16). However, the DO concentrations on the second and third days reached almost 97% of saturation. This is indicating that there is excessive algae growth in the stream, and that other sources of DO, upstream riffles, are helping to maintain DO concentrations throughout the night.

The DO profile for Hurricane Creek (ARK119) showed a 3 mg/L fluctuation in the DO, but there was no sharp decline in the DO concentration after sunset. The DO concentration dropped to near 5.2 mg/L each night. The ADPC&E ecoregion survey (ADPC&E 1987) indicated that DO concentrations for Hurricane Creek ranged from approximately 5.8 mg/L to approximately 7.5 mg/L, which is near the same range observed during this survey. Water temperature profiles during the ecoregion survey ranged from 21.6° C to 25.4°C. This survey indicated higher temperatures with a range from 25.5°C to 30.2° C. The summer of 1998 was abnormally hot and dry, which probably accounted for this difference.

The greatest DO fluctuation occurred in Haw Creek (ARK117). Haw Creek had a diurnal DO fluctuation of 4.5 mg/L with a range a 1.9 mg/L to 6.4 mg/L. This would perhaps indicate nutrient enrichment conditions, except that there was not the sharp decline in DO just after sunset. Factors influencing the DO profile at this site include: 1) the creek was reduced to small, clear-water pools; 2) there was maximum light penetration in the pools; and 3) direct sunlight reaching the water surface was limited by the steep topography surrounding the area to approximately nine hours a day between 7:00 am to 4:00 pm. This is typical of the small watershed, Boston Mountains streams with similar characteristics.

The Big Piney Creek site south of Fort Douglas (ARK116) had a consistent fluctuation over the three day period. Dissolved oxygen concentrations ranged from just below 6 mg/L to almost 8 mg/L. There were no sharp increases or declines in the DO concentration. Overcast skies depressed the water temperature on the second and third days producing minimal fluctuations over the three days. Temperatures ranged from near 27.5° C to about 29.5° C. This was the smallest fluctuation recorded during the survey. Higher continuous flows at this site may have helped to maintain higher DO concentrations.

The ground water influence in Indian Creek (ARK114) is obvious when examining the temperature profile (Figure WQ-20). The peak temperature was just over 25° C and the lowest was just below 23° C. This was the lowest temperature recorded during the summer period. The creek maintained only interstitial flow between isolated pools during the dry, summer period. The DO profile indicates that there is possibly some nutrient enrichment occurring. The peak DO concentration was about 5.4 mg/L and the minimum DO concentration was about 2.3 mg/L.

Figure WQ-16

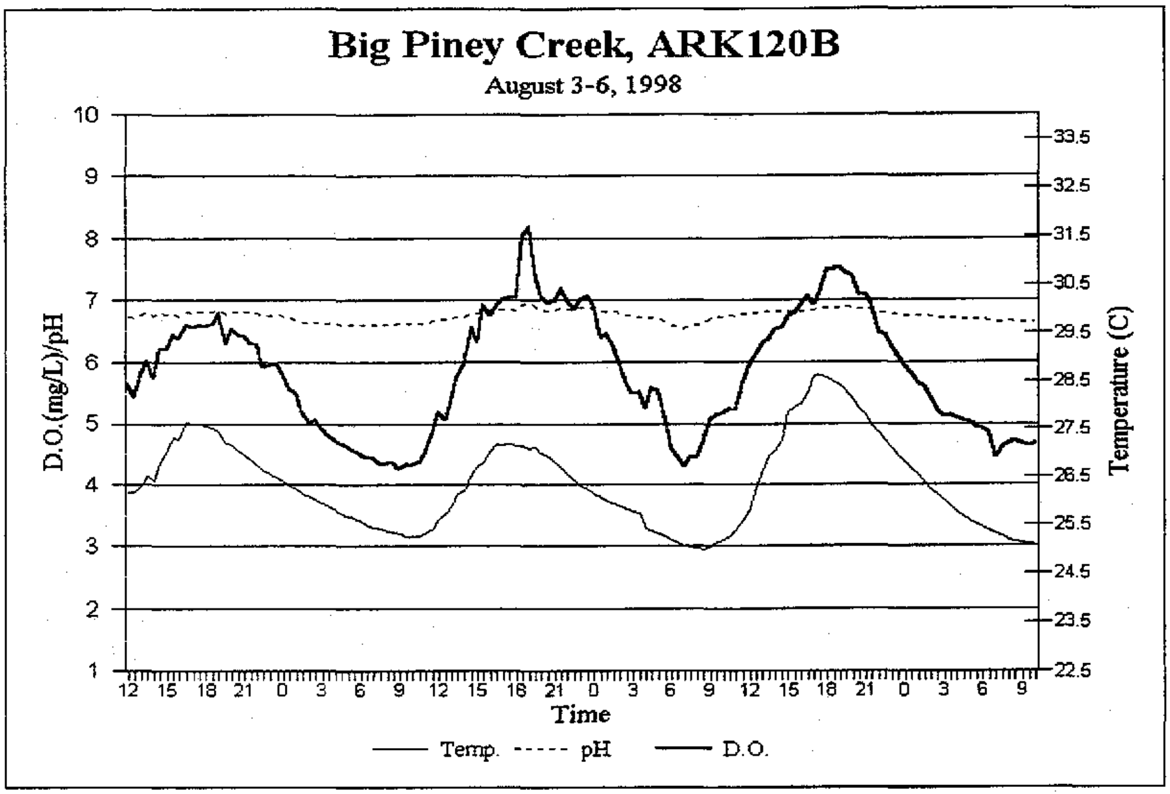


Figure WQ-17

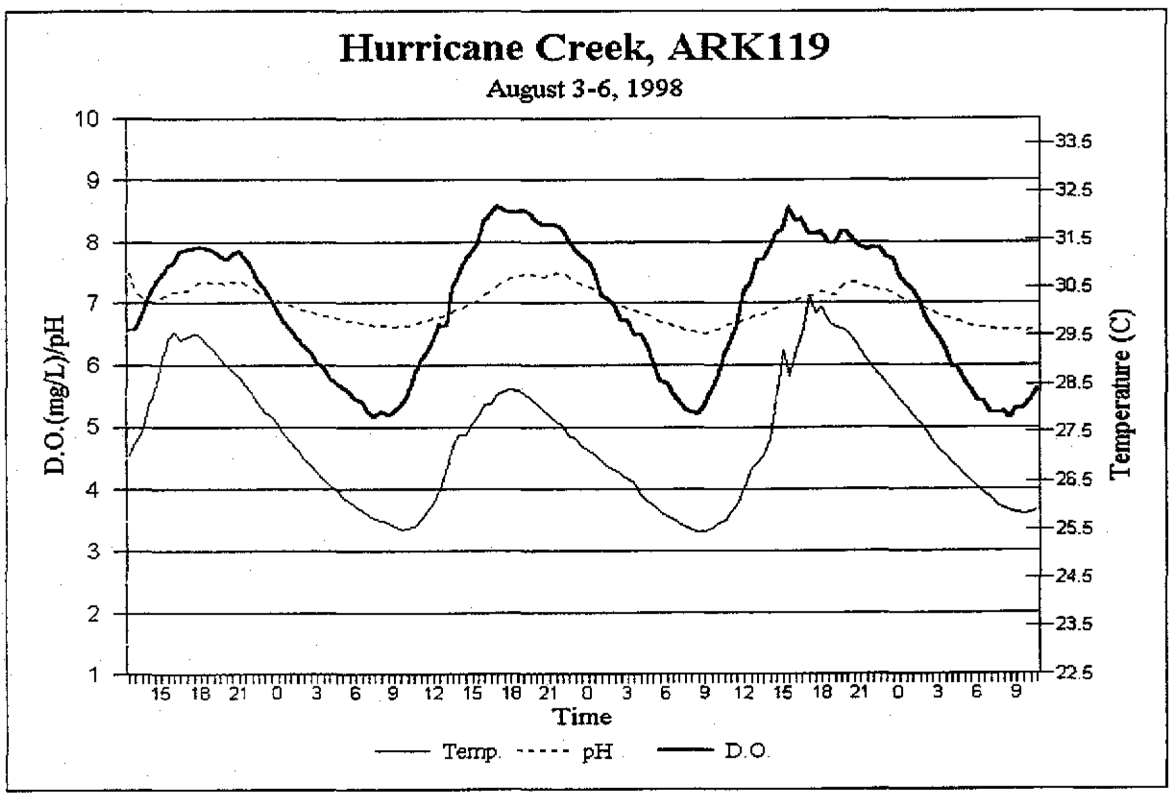


Figure WQ-18

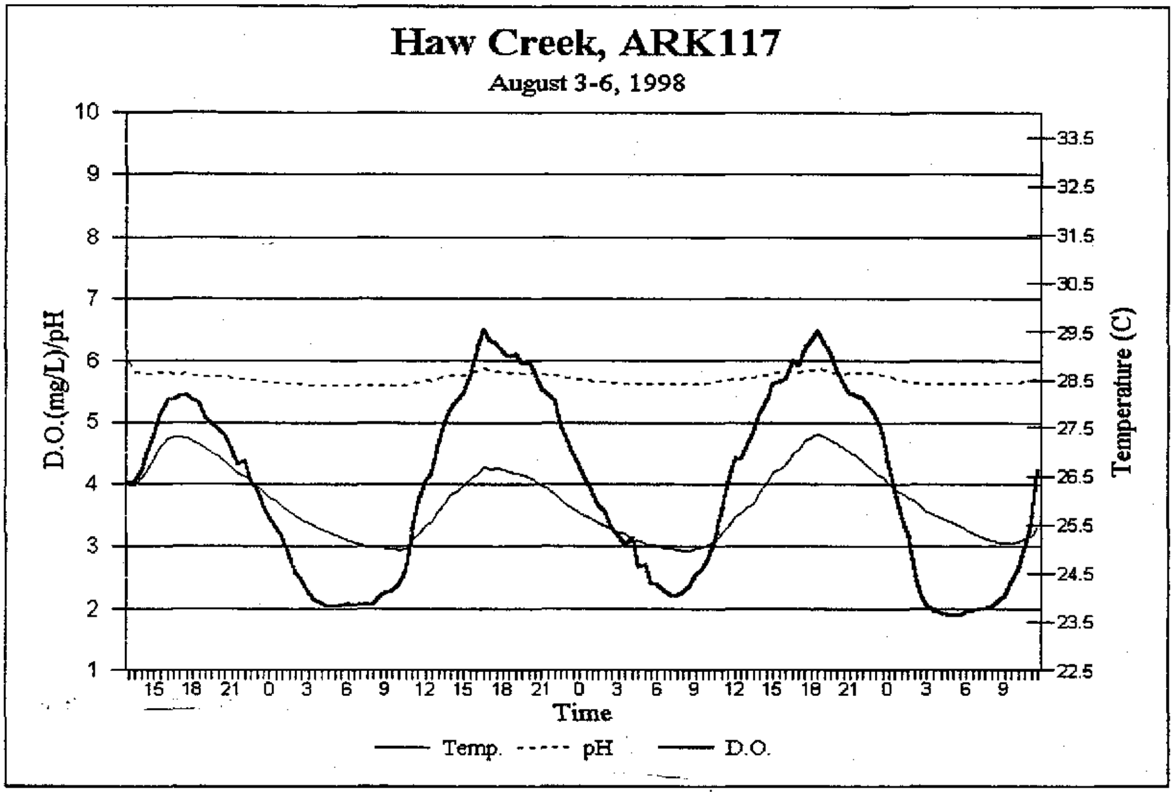
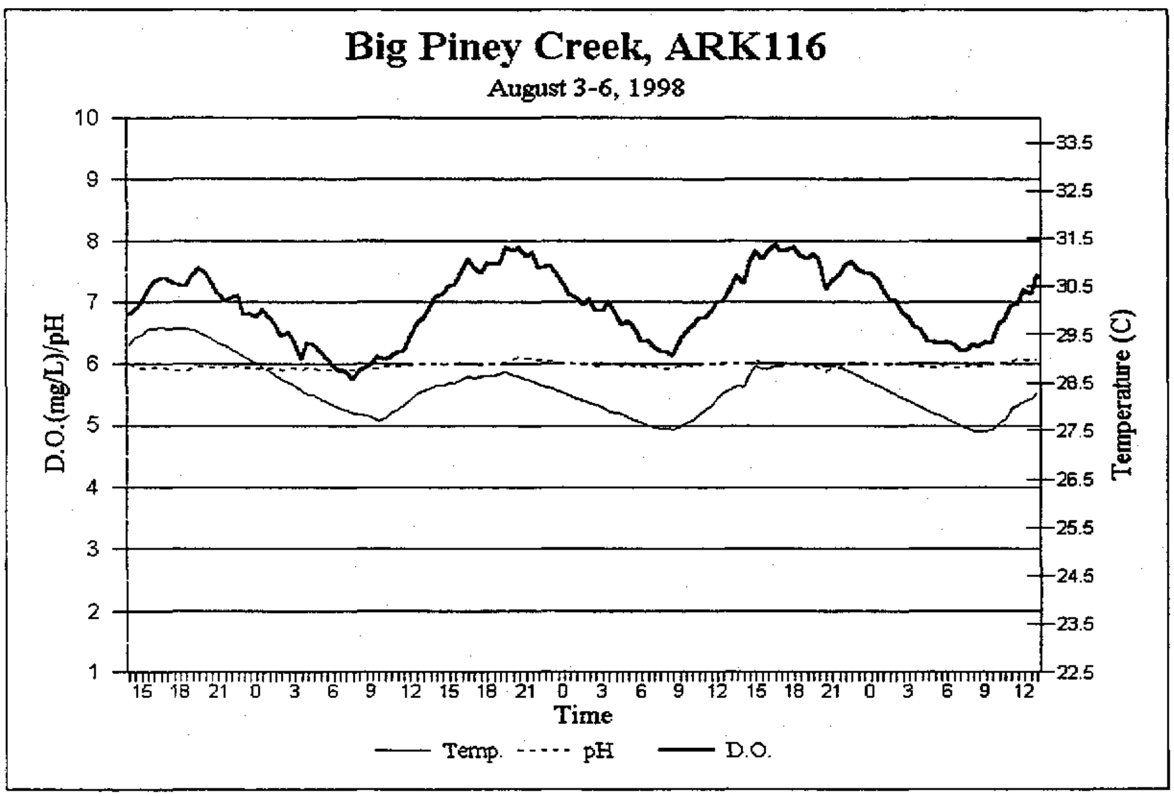


Figure WQ-19



The 3 mg/L change and the sharp decrease in DO concentrations after sunset may be indicating that there is excessive algae growth in the creek. The water quality data from this site indicates that the nutrients are elevated as compared to the upstream sites. The sources of the nutrients at this site may be from the cattle and pasture land in the lower portion of the watershed or from the septic tanks from the many cabins in the area.

The DO profile at ARK43, Big Piney Creek at the Twin Bridges, shows a daily fluctuation of only about 2.6 mg/L. The peak DO concentration was near 7.4 mg/L and minimum DO concentrations were about 4.8 mg/L. The profile also indicates that the rise and fall of the DO concentrations is gradual. The peak temperature was 37° C, the highest reading recorded during the survey. Overnight water temperatures fell to near 29° C which was an eight degree change. This site had no canopy cover which affected both the temperature and DO profiles significantly. The DO began to rise shortly after sunrise while the temperature did not begin to rise until the sunlight began to directly hit the stream at about 8:30 am. Percent saturation of 100% was reached each day by 1:00 pm and peaked each day near 112% between 4:00 pm and 4:30 pm. This DO saturation above 100% is perhaps indicating that there is some nutrient enrichment causing excessive algae production in the creek. The elevated water temperature due to a lack of canopy cover is perhaps limiting the peak DO concentration at this site.

A Hydrolab was deployed in Illinois Bayou near the Arkansas Highway 7 bridge near Dover (ARK44) for a comparison with ARK43. The temperature profile at this site does not display the same fluctuation as ARK43 profile (Figure WQ-22). The peak temperature at ARK44 was 34.5° C and the minimum temperature was 28.5° C. This represents a 2.5° C difference in the peak temperatures and about a 2° C difference in the daily fluctuations between the two sites. The DO concentration at ARK44 ranged from 4.8 mg/L to 8.4 mg/L. The percent saturation at ARK44 was about 115% each day versus a percent saturation of 112% at ARK43. There was also about a 70% canopy cover at ARK44 versus zero percent at ARK43. The canopy cover at ARK44 is probably helping to keep temperatures down and reducing the percent saturation somewhat. These differences perhaps not significant, but they do help to point out some of the effects of altered stream morphology and loss of stream canopy.

The DO and temperature profiles at the two Little Piney Creek sites were recorded during the first week of August, 1998. There was noticeable differences in the profiles between the two sites. Peak DO concentrations at ARK126 (Figure WQ-23) were near 8 mg/L with minimal concentrations near 5.8 mg/L. The concentrations began to rise around 8:00 am but did not begin to fall until about 8:30 pm each day. The riffles that were upstream of the meter may be helping to delay the fall of DO concentrations in the evenings somewhat. Temperatures ranged between 27.5° C to 29.5° C. This was one of the smallest fluctuations recorded during the survey.

Figure WQ-20

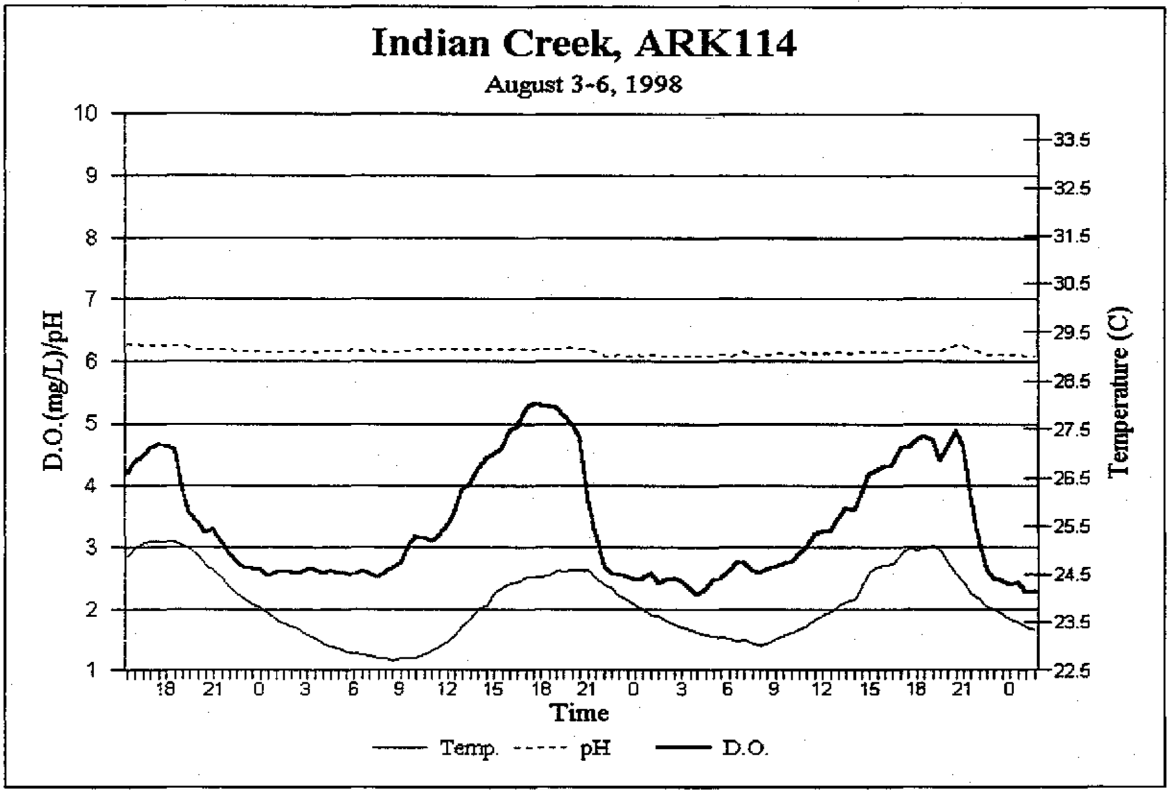


Figure WQ-21

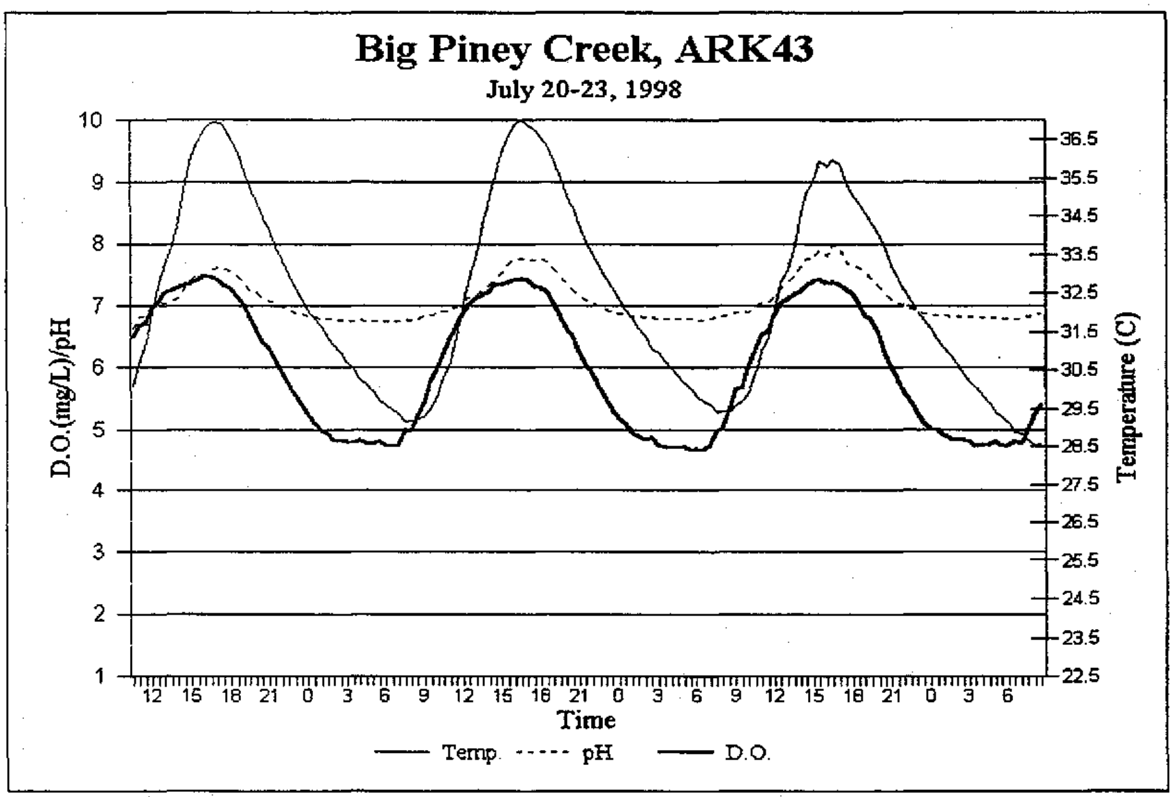
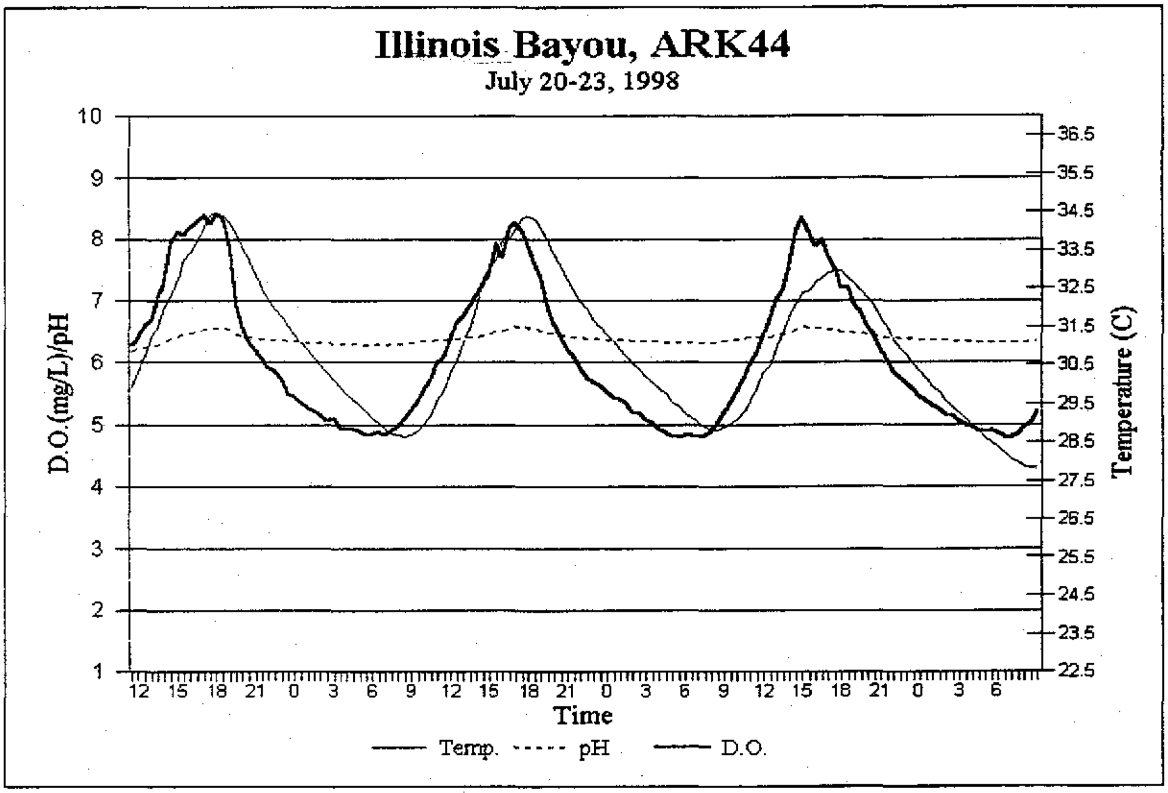


Figure WQ-22



The DO profile at the furthest downstream site in Little Piney Creek (ARK104) indicates that there is less than 2 mg/L difference between the high and low DO concentrations daily. However, during this survey the DO concentrations reached a high of only 5.1 mg/L but did not have a definite peak in concentration on the second day of sampling. This profile was probably affected by cloud cover that occurred on the first and second day of the sampling. This depressed both the DO concentrations and the water temperatures. The temperatures ranged from a low of about 27° C to a high of about 30.5° C. Both the DO concentration and the temperature increased over the survey period. Because of these factors, this is not a typical DO and temperature profile for the site. It does possibly indicate that DO concentrations can reach levels of concern during periods of limited sunlight and low flow conditions.

Figure WQ-23

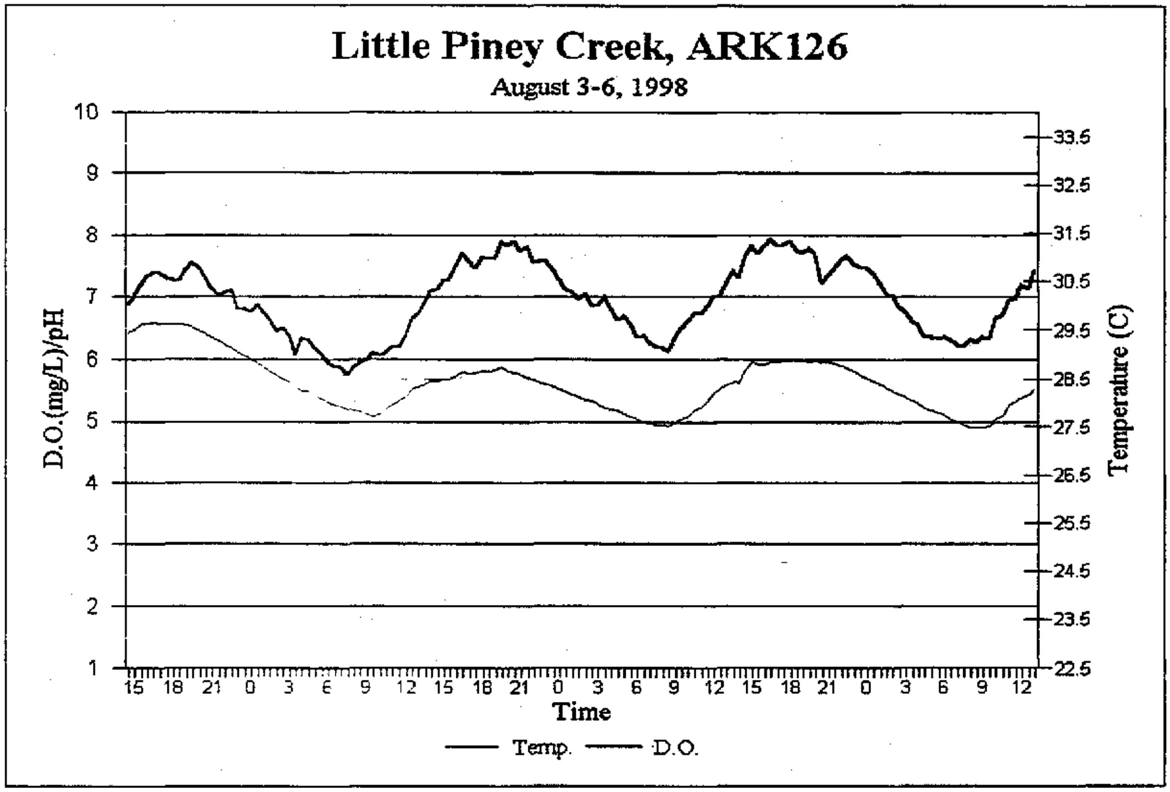
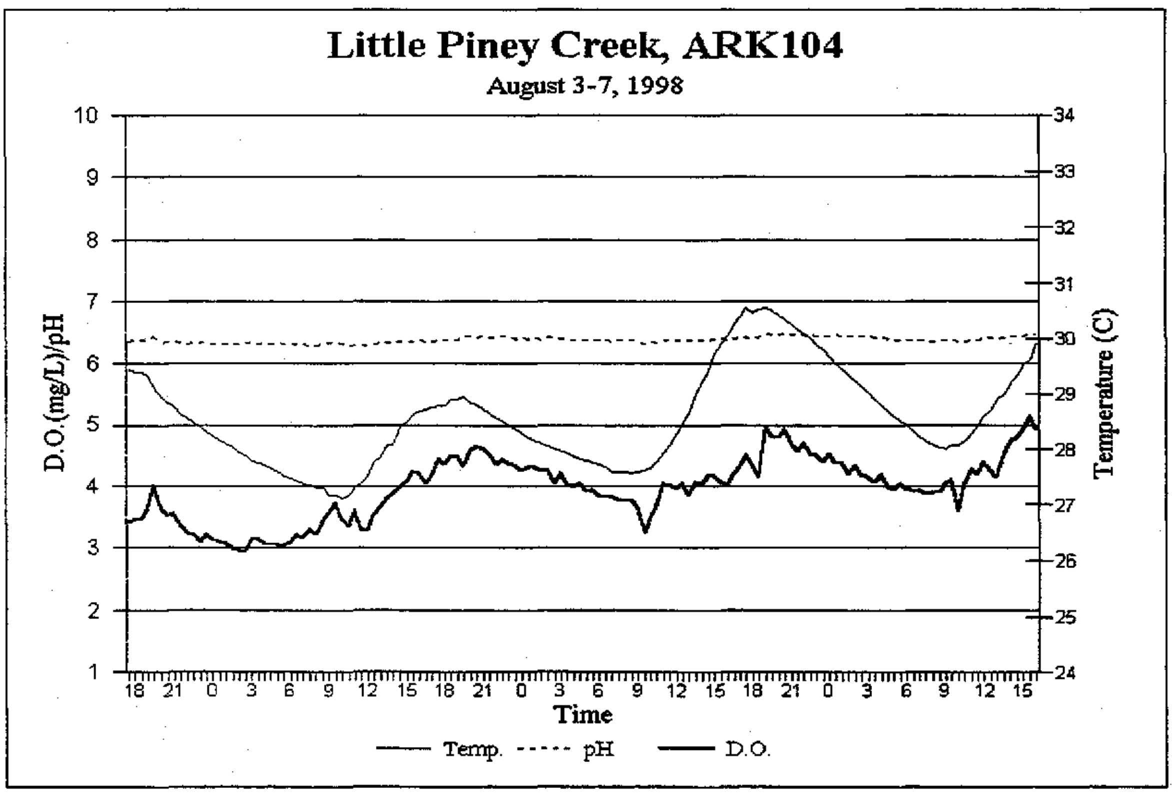


Figure WQ-24



AQUATIC MACROINVERTEBRATE ANALYSIS

COLLECTION SITES

Aquatic macroinvertebrates were collected at ARK125, ARK124, ARK121, ARK120, ARK119, ARK117, ARK116, ARK113, ARK110, ARK104, ARK 126, ARK129 and the Biological Site. For analysis, these sites were divided by watershed size into small watershed (<40 mi^2) and large watershed sites (>40 mi^2) . The large watershed sites included ARK124, ARK120, ARK119, ARK116, ARK114, ARK113, BIOL SITE, ARK126 and ARK104. Indian Creek (ARK114) and Hurricane Creek (ARK119) were placed into the large watershed site analyses since their watersheds were larger than the most upper Big Piney Creek site. Site locations are found in Table 1.

METHODOLOGY

Rapid bioassessment (RBA) techniques were employed for collection of aquatic macroinvertebrate communities in the Big Piney Creek Watershed. These techniques are described in Rapid Bioassessment Protocols for Use in Streams and Rivers (Plafkin et al, 1989). A modified version of Protocol III was utilized to determine if there were any water quality impairments.

Five minute samples were collected by placing a 30.5 cm wide D-shaped dip net randomly on the substrate and disturbing the substrate with the feet (kicking) to allow water to carry suspended materials into the net. After collecting, the sample was washed through a sieve and all large organic and inorganic debris was removed and was placed in a 1.0 L jar. The sample was preserved with 70% ethanol to be transported to the lab for identification and enumeration.

In the lab, the sample was placed into a 9" x 13" dissecting pan. The pan was swirled to evenly distribute the sample and a 4 inch (10 cm) ring randomly placed on the sample. Organisms were removed from the ring until the ring was depleted of organisms. If less than 95 organisms were encountered in the ring, the sample was swirled again and the ring randomly replaced on the sample. The same procedure was followed until a minimum of 95 organisms was removed from the sample. In cases where more than 100 organisms were encountered in a ring, the entire ring was picked to comprise the subsample. In cases where fewer than 100 organisms were collected in the sample, all organisms were removed from the sample.

Taxonomic determinations were conducted by one person to reduce bias. Organisms were identified to the lowest feasible taxonomical level using keys by Merrit and Cummins (1996). Taxa determinations were checked against regional data to ensure accurate determinations. Taxa and raw tallies were recorded on a bench sheet before enumerating and entering into a spreadsheet for further analysis. Data analyses were performed using a spreadsheet program from EPA Region 6. Modifications were made to use genus-level identifications.

Community comparisons were made using the multi-metric approach. Metrics utilized are listed in Table M-1. These were the most appropriate matrices for the Boston Mountain Ecoregion stream and have been utilized in other ADPC&E documents concerning biological integrity and water quality. Community comparison scores are made by comparing a sites score with a reference to determine a percent comparable estimate (%BCE) and determine the impairment status. The spreadsheet program scores each metric and gives it a score of 0-6. These are summed and the resulting number is divided by the reference score and reported as a percent. Impairment categories are found in Table M-2.

Table M-1 - Metrics Utilized for Determination of Water Quality Impairments

Metric	Description
Taxa Richness	Number of taxa at each site
EPT Index	Number of taxa belonging to the orders Ephemeroptera, Plecoptera and Trichoptera
Hilsenhoff Biotic Index	Index used to describe tolerance to organic pollution. It ranges from 0-5 with 5 as the most tolerant
% Contribution of Dominant Taxa	Percent of the dominant taxa at each site
Scraper/(Scraper +Filter Feeder) Abundances	Functional feeding group ratio describing the number of scrapers divided by the sum of scrapers and filter feeders

Table M-2 - Impairment Categories and Scores Used to Determine Water Quality Impairments.

Biological Condition	% Comparable to reference	Attributes
No significant impairment	> 83%	Comparable to the best situation in an ecoregion.
Slight Impairment	54-79%	Community structure less than reference site. Taxa richness lower and tolerant forms are more prevalent.
Moderate Impairment	21-50%	Obvious decline in community structure with loss of intolerant forms. EPT index reduced.
Severe Impairment	< 20%	Community dominated by 1 or 2 taxa, few taxa present.

Scores falling into the range between impairment categories are left to professional judgment to determine impairment status. Raw metric scores are utilized to determine impairment status of sites with scores falling between impairment categories (ie. 80). Raw scores and metric analysis scores are found in Appendix M-1.

Rapid bioassessments also include physical site evaluations. Physical evaluations are necessary to ensure each site can physically support the community found at the reference or "least impacted" site. Some parameters are difficult to assess and are based on the sampler's experience. Physical parameters are scored and scores are compared with the reference. A percent comparable to reference is calculated to decide comparability of stations to the reference. Percent comparable estimates and assessment categories are found in Table M-3.

Multiple factors are used to determine physical characteristics. Substrate, embeddedness and flow are the most critical factors and are conducted along a transect in the study reach. Ten points are used along the transect and intervals represent 1/10th of the width of the reach. These variables are weighted heavier than the others due to their relevance to the available habitat. These parameters are also the most consistent to determine. Channel alteration and bottom scour and deposition are weighted less but are still important in the quality and quantity of available habitats. These data are collected over a larger area than the previous three but within the sample site. Bank stability, vegetative cover and stream side cover are weighted less since they play a much smaller role in quantity and quality of habitats and these data are derived from approximately 100 m upstream and downstream of the sample site. After evaluation, the values are summed for the reference and sites in question to decide the percent physical comparable estimate (%PCE). Habitat parameter scores are found in Appendix M-2.

Table M-3 - Macroinvertebrate Habitat Criteria

Assessment Category	% Comparable to Reference
Comparable to Reference	≥90%
Supporting	75-88%
Partially Supporting	60-73%
Non-Supporting	≤58%

RESULTS

August Sampling Results

August bioassessment data revealed no significant impairments in the Big Piney Creek watershed (Table M-4) when compared to the reference site (ARK124). Only the five Big Piney Creek proper sites were sampled due to reduced flow in the tributaries. Three Little Piney Creek sites were added after this sampling event. Below Long Pool (ARK113) scored the lowest of these samples but was 88% of the reference site.

Table M-3. Impairment status of sample sites for Big Piney and Little Piney creeks.				
Small Watershed Samples				
	August	November	February	May
Stations	Status	Status	Status	Status
ARK125		Reference	Reference	Reference
ARK121		None	None	None
ARK117		Slight	None	None
ARK110		Slight	Slight	None
ARK129		Slight	Slight	Slight
Large Watershed Sample				
	August	November	February	May
Stations	Status	Status	Status	Status
ARK124	Reference	Reference	Reference	Reference
ARK120	None	None	Moderate	None
ARK119		None		None
ARK116	None	None	Slight	None
ARK114		Slight		None
ARK113	None	Slight		None
BIOL SITE	None	None		None
ARK104		None	Moderate	None
ARK126		None	Moderate	None
Shaded boxes denote no collection for that month.				

Taxa richness and taxa similarity generally declined in downstream stations. Only seven taxa were common to all sites (Appendix M-3). However, the EPT index showed a general increase downstream. ARK113 had the most EPT taxa of all stations sampled (Figure M-1). One EPT representative taxon was missing at all sites except at BIOL SITE where the number of EPT taxa was similar to the reference.

The communities at all stations were intermediate in their tolerance to organic pollution (HBI). All sites, except one, contained four functional feeding groups. Site ARK120 did not reveal the filter feeder organisms. Collectors dominated the community at each site and ranged in dominance from 18% to 30% with no connection between stream mile and percent dominance. The percent dominance by a taxon was lowest at the biological site and highest at ARK116.

Habitat data were all 100% or greater of the reference. The parameters scoring lowest were effected by flow and/or channel alteration.

November Sampling Results

Small Watershed Analysis

Data collected in tributaries for November showed slight or moderate impairment at all sites except ARK121. Slight impairment was shown at ARK117 and ARK129. Mill Creek (ARK110) was moderately impaired. Taxa richness ranged from 12 at ARK110 to 19 at ARK119. The number of EPT taxa ranged from four at ARK110 to 10 at the reference site. Tolerance to organic pollution was 2.0 at the reference and ranged up to 2.7 at ARK110. Percent contribution of dominant taxa was also highest at ARK114 (87%) and lowest at ARK125 (26%).

Both ARK110 and ARK129 had reduced taxa richness and reduced EPT taxa, resulting in low scores for these metrics. Taxa richness was lowest at ARK129 causing a low metric score. Percent contribution of dominant taxa was highest at ARK117 and ARK110 and caused metric scores for this analysis to be zero.

Habitat parameters for these sites were somewhat similar when compared to the reference. All of the sites were capable of supporting the reference community and scored higher than 75%, which is the lowest value for the supporting category (Table M-3). Two sites, ARK110 and ARK129, did not have a high percent comparison value because of the lower flow, and ARK129 received a lower value for bottom substrate. Both of these riffles were smaller than others sampled. ARK110 was also braided which further reduced area for collection of a sample.

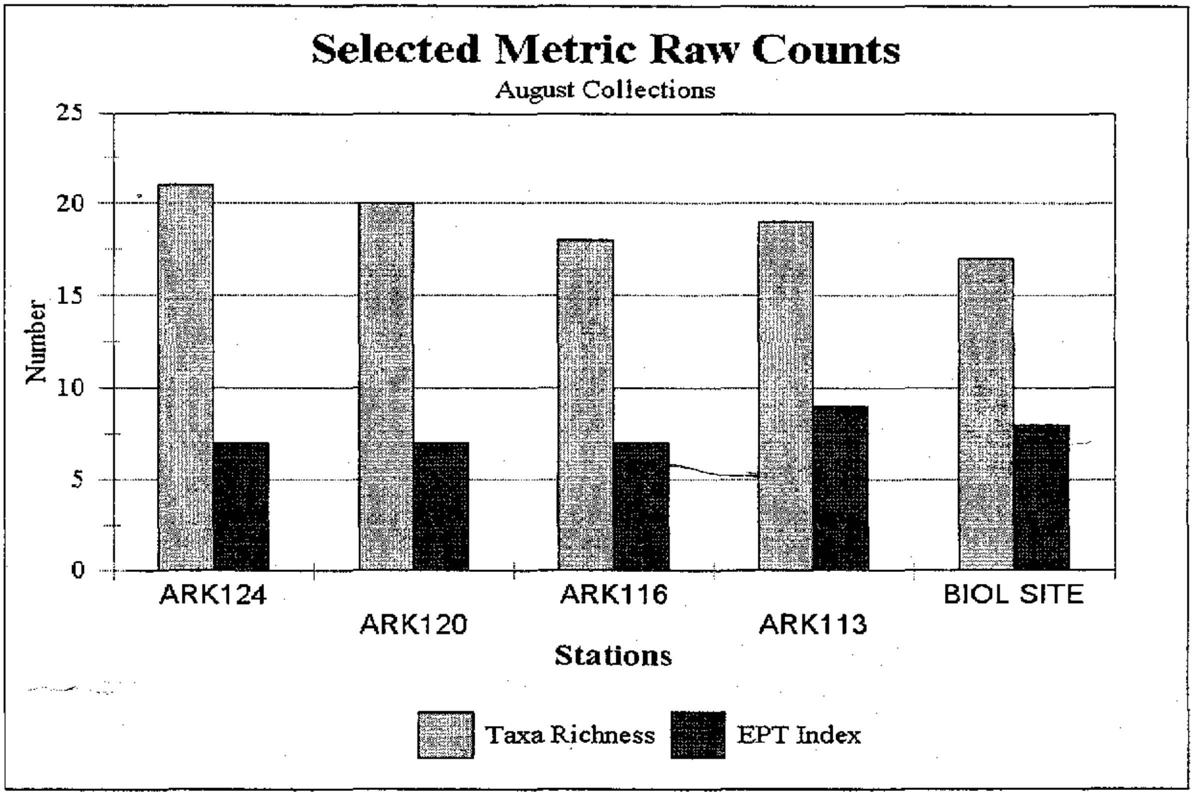
Large Watershed Analysis

No significant impairment was found for large watershed sites except at ARK114 (Indian Creek) where slight impairment was indicated. Taxa richness ranged from a high of 23 at the lowest Little Piney Creek site (ARK104) to an unusual low of six at ARK114. The EPT index was highest at ARK116 and ranged down to three at ARK114.

Pollution tolerance (HBI) was lowest at ARK114 (1.5) and highest at the lowest BIOL SITE (2.7). Indian Creek had the highest percent contribution of dominant taxa (87%) and ARK104 had the lowest value for this parameter. The Scraper/(Scraper+Filter Feeder) Abundance, which is a community balance metric, ranged from 0.74 at ARK119 to 1.0 at three other sites. Values closer to 1.0 suggest a community with fewer filter feeders which utilize mosses and filamentous algae as attachment sites. However, if aquatic vegetation is present, this number my also be below 1.0 and still maintain a healthy community balance.

Habitat Parameters for these sites were all similar and all sites were capable of supporting similar communities even though the reference scored lowest for flow.

Figure M-1



February Results

Small Watershed Analysis

Two sites were determined to have moderate impairment in February. These sites (ARK110 & ARK129) had 12 taxa each, five of which were EPT taxa. The other sites ranged from 15-17 in taxa richness and 11-14 in EPT taxa. Tolerance to pollution was lowest at ARK117 and highest at the two impaired sites with a range of 2.0-2.7. Percent contribution of dominant taxa was lowest at the reference (26%) and highest at the impaired sites. Community balance analysis of scrapers and filter feeders was lowest at ARK121 and highest at the reference and the two impaired sites.

Habitat analysis indicated that all sites, except ARK110, should be able to support similar communities. If the flow at ARK110 had been more similar to the reference, it would have scored as capable of supporting the same community structure found at the reference.

Large Watershed Analysis

All large watershed sites had some impairment during this sampling event. Slight impairment was determined at ARK116 while moderate impairment was determined at ARK120, ARK126 and ARK104. Taxa richness was 22 at the reference and ranged from 11 to 13 at the other sites. The number of EPT taxa was highest at the reference and reduced at all other sites. Pollution tolerance was lowest at the reference and ARK116 but ranged from 2.5 to 2.8 at the other sites. Percent contribution of dominant taxon was highest at ARK104 and lowest at the reference. The Scraper/(Scraper+Filter Feeder) score was lowest at ARK104 and was 1.00 at all other sites.

Habitat analysis showed all sites were more than capable of supporting similar communities. Percent comparable estimates were all greater than 100% of the reference.

May Results

Small Watershed Analysis

One site (ARK129) was determined to have slight impairment while all other sites had no significant impairment in this small watershed analysis. Taxa richness ranged from 16 to 22 and the EPT index ranged from nine to 16. The impaired site had the lowest EPT index. All sites had a lower percent contribution of dominant taxa than the reference and therefore scored higher in this metric than the reference. These percentages ranged from 16% to 45%. Scraper/(Scraper+Filter Feeder) abundances were lowest at ARK129 due to a high filter feeder verses scraper abundance causing this metric score to be zero. Habitat analysis shows all sites except ARK129 should be capable of supporting the community found at the reference. ARK129 had a much lower flow than the rest of the sites and reduced this site to partially supporting in habitat.

Large Watershed Analysis

No impairment was found at any large watershed sites during this collection event. Taxa richness was 16-22 and EPT index values were 11-13. As watershed size increased, taxa richness and EPT index values showed a declining trend. Pollution tolerance was lowest at ARK114 (HBI=1.2) and highest at ARK126 (HBI=2.2). These values show communities that are somewhat intolerant to pollution. The highest percent dominance of a taxon was found at ARK104 (29%) and the lowest at ARK116 (17%). Only BIOL SITE had a reduced metric score for the Scraper/(Scraper+Filter Feeder) abundance which was driven by the higher number of scrapers and absence of filter feeders. Habitat analysis showed all sites capable of supporting similar communities. Percent comparable estimates were from 95% to 110% of the reference.

DISCUSSION

Quarterly samples were collected for this aquatic macroinvertebrate survey. Our objective was to determine if seasonal sampling would benefit the overall knowledge of water quality in the Big Piney Creek watershed and determine efficiency of methods utilized for sampling.

Secondly, we wanted to determine if our sampling equipment could yield consistent results between seasons. Most rapid bioassessments are conducted during late summer, low-flow conditions but some are conducted during the spring season.

As described in the methods section, a D-shaped kick-net was utilized to collect all samples in this survey. This method can be limited by current velocity and water depth, which generally increase in fall and winter seasons. In February, three samples were not collected because current velocities were too high.

August collections are considered minimum flow samples. No impairments were determined for this sampling event. The communities found during low- flow conditions would be expected to be the most tolerant to environmental stresses of any seasonal community. This is expressed by the average and above average HBI values for these samples. Elevated water temperatures and lower stream flows during this season may explain the presence of a more tolerant community. Additionally, with no rainfall, non-point source pollutants are less likely to enter the stream and rapidly change water quality. Many sensitive organisms with an aquatic larval stage have left the water during this time to live their life as a terrestrial adult or they are still in an egg form.

The November and February samples were collected under hydrologic conditions that were unfavorable to the methods. Due to the net opening diameter, water would fill the net and most organisms would wash past the sides in the higher velocity portions of the riffle. To collect enough organisms to comprise a sample, kick samples were obtained by kicking for 20-30 seconds intervals and dumping the net into a temporary holding vessel until five minutes of actual sample time had elapsed. This method may have increased the number of organisms collected from areas with slow current velocity and decreased the number of fast current velocity organisms, perhaps biasing the sample toward more slower velocity organisms. Also, during higher velocities, many organisms will avoid high flows by moving deeper into the substrate to reduce the chance of being swept downstream (Merrit and Cummings, 1996). Therefore, if organisms are below the level where kicking can occur, collecting in areas with high current velocity may yield a smaller portion of high-velocity organisms, again biasing the data.

Pollution tolerance (HBI) did not differ significantly in the August samples as compared to the fall and winter samples. This parameter, while not standing alone in the analysis, is important in helping to determining the status of sites that are between impairment categories. Since fall and winter HBI values are somewhat similar to their respective reference, they may be unimpaired or not significantly impaired.

May collections revealed one impaired site. The community at ARK129 was determined to be slightly impaired due to its high dominance of one taxon and the high number of scraper feeders compared to filter feeders. While still capable of supporting the reference community, this site was physically the most different of all sites collected and may be considered as impaired due to habitat differences. This site was a short, wide riffle with a high undercut left hand bank and a wide point-bar was to the right. The substrate was consistently smaller than other sites and contained more silt between individual substrate particles.

Most of the impairment in the Big Piney Creek watershed was determined during the November and February collections. It is recommended that these collections not be used in determining water quality impairments. Current velocities were highest during these samples and sampling efficiency seems to have been limited. Future work needs to be done to determine upper and lower thresholds of our sampling gear in accordance with current velocities. These data will be utilized to determine these thresholds.

Additionally, there is no trend in the impairment of sites between seasonal collections. If sites were truly impaired, it would seem reasonable they would be impaired in all collections. This was not true in this survey. Therefore, if fall and winter collections are not utilized in this assessment, only one site (ARK129) would be considered as slightly impaired. However, this impairment may be habitat related. If more suitable riffles were available, this impairment may not have occurred.

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FISH COMMUNITY

Fish community surveys were conducted at the stations listed below:

STATION DESCRIPTION

ARK126 Upper Little Piney Creek downstream of Ar. Hwy. 123 bridge. June 8, 1998.

ARK129 Minnow Creek at Co. Rd. 50 off Ar. Hwy. 123 north of Lamar. June 4, 1998.

ARK104 Lower Little Piney Creek at Ar. Hwy. 359. July 30, 1998,

ARK119 Hurricane Creek off Co. Rd. off Ar. Hwy. 123 near Fort Douglas. July 1, 1997.

ARK117 Haw Creek upstream of Haw Creek low-water bridge off Ar. Hwy. 123. June 8, 1998.

ARK116 Piney Creek at FAS road 1808, 7 miles south of Ar. Hwy. 123. October 14, 1998.

ARK114 Indian Creek below low-water bridge near Treet. July 1, 1997.

ARK110 Mill Creek at Co. Rd. bridge off Ar. Hwy. 64 near the twin bridges. July 1, 1998.

BIOLOGICAL SITE (BS) Lower Big Piney Creek at Tate's Island Ford near Piney.
September 11, 1997

METHODOLOGY

A Smith-Root model 15-B backpack electrofishing device with pulsed DC current was used to collect fish from these sites. The device was used in the shallow pools and along the pool edges while wading upstream and dipping the stunned fishes from the water with dip nets. The riffles were collected by posting a twenty foot seine near the toe of the riffle and while working the electro fisher in a downstream direction through the riffle, the bottom substrate was overturned and the fish were herded into the seine or washed in by the current.

Fish species of all types were collected from all available habitat within the sample area until a fully representative sample of the species in the area was thought to be obtained. Larger specimens were field identified and released. The smaller specimens and those needing further identification were preserved in a ten percent formalin solution and returned to the lab.

HABITAT EVALUATION

Habitat evaluations were performed at all sites and were comprised of five parameters each consisting of three to seven variables. These parameters included: 1) habitat type; 2) habitat quantity; 3) quantity of substrate type based on fish use; 4) quantity of in stream cover; and 5) sediment on substrate. Each parameter for substrate type and in stream cover was given a score depending on its abundance. The scores given to the substrate parameters were multiplied by a factor to adjust these scores based on how they relate to fish habitat quality. Habitat type length, depth and width measurements were estimated for each habitat type and recorded in feet. The sediment on substrate parameter was scored according to the degree of embededness.

A total score for each habitat type was calculated by summing the scores for the substrate type, in stream cover and sediment on substrate. The scores from like habitat types were averaged for each sampling station. The lengths of each habitat type were also summed. The total habitat type lengths were then divided by 100 and multiplied by the average habitat type score. This score is the Ichthyofauna Habitat Index (IHI). Table F-1 summarizes the fish habitat evaluations and includes the IHI for all tributary stations sampled. Appendix F-1 outlines the habitat types and the in stream habitat ratings at each site.

Table F-1

Fish Habitat Evaluation

SITE	Riffle				Run				Pool			
	# Sam	Total Length	Average Habitat Score	IHI*	# Sam	Total Length	Average Habitat Score	IHI	# Sam	Total Length	Average Habitat Score	IHI
ARK126	7	285	43.63	124.35	5	205	45.56	93.40	4	590	56.50	333.35
ARK129	8	315	45.01	141.78	6	605	50.52	305.65	2	350	57.60	201.60
ARK104	4	130	35.15	45.70	2	120	45.80	54.96	4	460	48.13	221.40
ARK117	4	140	42.40	59.40	3	110	40.60	44.70	3	480	54.13	259.82
ARK119	5	535	44.44	237.80	3	200	49.77	99.54	5	1160	61.66	715.25
ARK116	4	220	53.85	118.87	6	510	56.00	285.60	2	280	66.40	185.92
ARK114	5	165	42.60	70.29	5	350	47.04	164.64	2	330	66.20	218.46
ARK110	4	120	49.30	59.16	2	90	48.50	53.89	3	120	45.53	54.63
BIO SITE	6	255	43.72	111.49	4	265	49.45	131.04	4	740	58.28	431.27

*- Ichthyofauna Habitat Index - Total Length of habitat in hundredths multiplied by the Average Habitat Score.

FISH COMMUNITY EVALUATION METHOD

The fish communities were evaluated by directly comparing the community structures at each site to the fish communities of least-disturbed, Boston Mountains ecoregion reference streams with approximately the same size watershed. Seventeen different parameters were compared between each of the communities and the reference streams (see Tables F-3 and F-4). A fish community structure index (CSI) was calculated using eight of these parameters and based on ecoregion reference stream data to generate the scoring criteria (Table F-2).

TABLE F-2

Fish Community Biocriteria
(Boston Mountains Ecoregion Reference Streams)

Metric (% community, except Diversity Index)	SCORE		
	4	2	0
Cyprinidae	25-60	15-25 or 60-75	<15 or >75
Ictaluridae	4-20	2-4 or 20-28	<2 or >28
Centrarchidae	10-40	6-10 or 40-55	<6 or >55
Percidae	>10	6-10	<6
Sensitive Individuals	>30	30-16	<16
Primary TFL	<35	35-45	>45
Key Individuals	>35	25-35	<25
Diversity Index	>3.15	3.15-2.85	<2.85

The CSI is determined by the sum of the scores for each metric for each fish community. The relative scores were developed from average values from the least-disturbed Boston Mountains ecoregion reference stream data. The CSI scores and corresponding degree of use support are:

Total Score	Degree of Support	Waters of Concern (✔)
25-32	Fully Supporting	No actions needed at this time.
24-17	Generally Supporting	✔ No immediate actions, continue monitoring.
16-9	Impaired	✔ Determination of cause and source; schedule corrective action.
0-8	Not Supporting	✔ Immediate actions needed; develop plan for remediation.

The final determination of support is derived by utilizing all of the indices, the overall fish community and the habitat and stream characteristics. Best professional judgement is also used in those unique situations when the metrics can not properly delineate the status of the fish communities based on the data collected.

RESULTS

Fish community samples were collected at all stations during the summer and early fall of 1998. The sample from the biological site on the lower Big Piney Creek was collected in the summer of 1997. There were 22 species of fish collected at ARK126, 18 at ARK129, 33 at ARK104, 9 at ARK119, 18 at ARK117, 24 at ARK116, 18 at ARK114, 23 at ARK110, and 29 at the biological site on lower Big Piney Creek. Appendix F-2 is a list of species collected from each site, the number of specimens per species collected, and the percent community composition of each species. Table F-3 depicts the family comparisons between sampling stations, percent and total

TABLE F-3

COMMUNITY STRUCTURE (as percent total community)									
Family	126	129	104	119	117	116	114	110	BS
Cyprinidae	33.33	61.85	43.51	48.68	66.77	27.25	53.78	40.94	53.14
Catostomidae	1.23	0.39	2.05	0.99	0.00	0.39	0.50	2.98	5.34
Ictaluridae	5.19	7.67	9.61	19.08	8.39	9.55	9.92	5.46	1.17
Centrarchidae	32.35	10.32	30.71	12.50	4.52	37.20	17.65	27.54	26.32
Percidae	25.93	15.63	11.58	17.76	19.35	18.64	16.64	17.12	11.84
Total Species	22	18	33	18	9	24	18	23	29
No. Sen. Species	9	9	14	9	4	14	9	4	17
No. Sen. Inds.	139	340	272	193	111	555	331	114	516
% Sens. Inds.	34.32	33.43	22.33	68.49	35.81	43.46	55.63	28.29	37.72
No. Primary Inds	101	426	484	41	135	115	129	104	439
% Primary Inds	24.94	41.89	39.74	13.49	43.55	9.01	21.68	25.81	32.09
No. Key Inds.	198	349	371	136	64	337	337	143	441
% Key Inds.	48.89	34.32	30.46	44.74	20.65	56.64	56.64	35.48	32.24
Diversity Index	3.38	3.01	3.36	3.40	2.40	3.49	3.16	3.56	3.50
Catch/Unit Effort	6.59	16.07	15.16	7.99	4.74	15.20	7.84	6.74	12.73

sensitive species, key species and primary trophic levels species; the diversity index (Shannon-Wiener, log base 2); and the catch per unit effort (in minutes). Key individuals are "Fishes which are normally dominant species within the important groups such as fish families or trophic feeding levels" (ADPC&E, 1998).

Table F-4 (page 57) depicts similarity indices among sample sites and between sample sites and like-size ecoregion reference streams. Comparisons are made from similarity of species present and the similarity of species relative abundances.

The upper Little Piney Creek fish community (ARK126) was dominated by the longear sunfish, bluntnose minnow and stoneroller. These species accounted for over 50% of the community. The cyprinids, centrarchids, and percids accounted for 33%, 32%, and 26% of the community, respectively. The percid family was represented by seven species and was dominated by the greenside and fantail darters. Sensitive individuals comprised 34% of the community; 49% of the community were key individuals; and 25% of the community were primary feeding individuals. The diversity index was 3.38 and the catch per unit of effort was 6.59 fish per minute. Seven riffle habitats, five run habitats and four pool habitats were sampled. The substrates varied from mostly bedrock in the lower portions of the sample area to gravel mainly in the upper riffle areas. In stream cover was moderated in the lower sample areas but was fairly abundant in the upper riffle, run and pool habitats. Overall, the in stream habitat was good.

The fish community in Minnow Creek, ARK129, was dominated by cyprinids, with the stoneroller and the bigeye shiner comprising over 36% and almost 20% of the overall community, respectively. The percids accounted for over 15% of the overall community with the orangethroat darter dominating the percid community. The centrarchids comprised ten percent of the community with the longear sunfish dominating the sunfish family. Half of the species collected were sensitivity species. They accounted for over 33% of the community. Primary feeder individuals accounted for almost 42% of the community and Key individuals accounted for over 34% of the community. The diversity index was 3.01 and the catch per unit of effort was 16.07 fish per minute. This was the highest catch rate of all of the samples. The habitat sampled at this location was comprised of eight riffles, six runs and two pools. The substrates in the sample area consisted mainly of rubble and gravel with some sand and silt in the pools and some small boulders in the riffles. In stream cover was limited in the riffles to abundant in the runs and pools. Overall, the in stream habitat was rated as excellent.

The lower Little Piney Creek site (ARK104) was comprised of 33 species. The stoneroller was the dominant species, comprising nearly 36% of the community and the longear sunfish was co-dominant, comprising 15% of the community. The cyprinids and the centrarchids accounted for 43.5% and 31% of the overall community, respectively. There were nine darter species collected comprising over 11% of the community. This is the only site where *Noturus miurus*, the brindled madtom was collected. Sensitive individuals accounted for over 22% of the community; primary feeder individuals accounted for almost 40% of the community; and Key individuals comprised over 30% of the community. The diversity index was 3.36 and the catch per unit of effort was 15.16 fish per minute. Four riffle, two run, and four pool habitats were sampled. The substrates in the habitats ranged from gravel and rubble in the riffles to gravel and sand/silt in the pools. The substrate in the runs was mainly gravel. In stream cover was mainly sparse aquatic vegetation in the riffles, but there was much greater abundance of in stream cover in the runs and pools. The overall habitat rating was moderate to good.

Hurricane Creek (ARK119), a Boston Mountains ecoregion reference stream, was the upper most site sampled in the Big Piney Creek watershed. The community was co-dominated by the cardinal shiner and the slender madtom, each comprising about 18% of the community. The cyprinid family accounted for over 48% of the overall community. Only two sunfish species were collected. The green sunfish and the longear sunfish accounted for less than 13% of the community. There were only four percids collected which accounted for almost 18% of the community. Half of the species collected at this site were sensitive species. They made up over 68% of the community. Primary trophic feeders accounted for less than 14% of the community and Key individuals accounted for almost 45% of the community. The diversity index was 3.40 and the catch per unit of effort was 7.99 fish per minute. Five riffle, three run, and five pool habitats were collected. The substrate in the riffles consisted mainly of boulders and gravel, and the substrate in the pools and runs ranged from large boulders to gravel/sand. In stream cover in the riffles was sparse, mainly limited to aquatic vegetation, but the in stream cover in the runs and pools was quite abundant and variable. The overall habitat ratings ranged from good in the riffles and runs, to excellent in the pools.

The fish community at Haw Creek (ARK117), a seasonal, small watershed stream site, was dominated by cyprinids which accounted for over 66% of the overall fish community. The stoneroller was the dominant species at the site, and the creek chub and the orangethroat darter were the next dominate species. The percids accounted for over 19% of the community. Over 35% of the community were sensitive individuals; 43.6% were primary feeders; and 20.7% were key individuals. The diversity index was only 2.40, and the catch per unit of effort was 4.74 fish per minute. Four riffle, three run, and three pool habitats were sampled. The substrate in the riffles consisted of bedrock with areas of sand and gravel. The substrate in the runs was mainly rubble and gravel with some small boulders and bedrock. The substrate in the pools ranged from bedrock and boulders to areas of gravel/sand and some silt. In stream cover in the riffles ranged from aquatic vegetation to woody debris but was sparse at best. In stream cover in the runs and pools consisted of mainly undercut banks with some woody debris and root wads. Overall the habitat scores ranged from moderate in the runs to good in the riffles and pools.

The centrarchids dominated the community at ARK116, Big Piney Creek below Ft. Douglas. The longear sunfish comprised over 30% of the community. The cyprinids comprised 27% of the community; the bigeye shiner accounted for over nine percent (9%) of the community and the stoneroller comprised only seven percent (7%) of the community. The slender madtom was the only member of the Ictalurid family collected. However, it accounted for over nine percent (9%) of the community. Seven darter species were collected which accounted for almost 19% of the community. The greenside darter was the dominant percid. More than half of the 24 species collected were sensitive species. They accounted for over 43% of the community. Also, Key individuals comprised almost 58% of the total community while primary feeders comprised only nine percent (9%). The diversity index was 3.49 and the catch per unit of effort was 15.20 fish per minute. Four riffle habitats, six run habitats and two pool habitats were sampled. The substrate in the riffles ranged from small boulders and rubble in the steeper gradient riffles to rubble/gravel in the lower gradient riffles. The substrate in the runs was mainly rubble/gravel, but there was some small boulders and bedrock. The pool substrate was mainly gravel over bedrock with some rubble and some sand/silt deposits. The in stream cover in the riffles was mostly aquatic vegetation but there was some good woody debris, root wads and undercut banks present. In stream cover in the runs and pools was mostly undercut banks and woody debris with some root wads and hanging vegetation. Overall, the in stream habitat was rated as excellent.

Indian Creek is a Boston Mountains ecoregion reference stream. The bigeye shiner dominated this fish community by making up 31% of the community. The stoneroller was a sub-dominant species, but the cyprinid family accounted for 54% of the community. The centrarchids and the percids accounted for 17% and 16% of the community, respectively. The longear sunfish was the dominant sunfish and the orangethroat darter was the dominant percid. The slender madtom was the only ictalurid collected, but it accounted for almost ten percent of the community. Half of the 18 species collected were sensitive species and they accounted for over 55% of the total community. In addition, primary feeders accounted for approximately 22% of the community, and Key individuals accounted for almost 57% of the community. The diversity index at this site was 3.16, and the catch per unit of effort was 7.84 fish per minute. Five riffle habitats, five run habitats, and two pool habitats were sampled. The substrate throughout the sample area consisted mainly of small boulders, rubble and gravel. There was some bedrock and some sand/silt deposits in the larger pools. In stream cover consisted mainly of the larger boulders and aquatic vegetation, but there was some root wads and woody debris in the runs and pools. Overall, the in stream habitat was rated as good in the riffles and runs and excellent in the pools.

The Mill Creek fish community was represented by 23 species and was dominated by the cyprinid family which comprised almost 41% of the community. The stoneroller comprised over 22% of the community and was the dominant species. The longear sunfish was a sub-dominant species, which accounted for almost 17% of the community. The centrarchids accounted for over 27% of the community, and the percids accounted for over 17% of the community. The orangethroat darter dominated the percid community. This is the only site that had a grass pickerel collected. There were only four sensitive species collected and they accounted for 28% of the community. Primary feeding individuals accounted for almost 26% of the community, and Key individuals accounted for over 35% of the community. The diversity index was 3.56 which was the highest during the survey, and the catch per unit of effort was 6.74 fish per minute. Four riffle habitats, two run habitats and three pool habitats were collected. The substrate in the lower riffle habitats was mainly bedrock with some gravel and small boulders. The upper riffle was a step-pool habitat with small boulders and gravel over bedrock. The runs and pools had some bedrock with rubble/gravel and some sand. In stream cover in the riffles consisted mainly of aquatic vegetation but there was some woody debris. The runs and pools had some undercut banks, woody debris and hanging vegetation. Overall, the habitat was rated as excellent in the riffles and good in the runs and pools.

The fish community at the biological site (BS) on Big Piney Creek included 29 species and was dominated by the cyprinid family. The stoneroller was the dominant species comprising over 29% of the community. The centrarchids comprised over 25% of the community and the longear accounted for almost 20% of the community. There were 11 darter species collected which comprised almost 12% of the community. The greenside darter was the dominant percid. This site had the lowest percentage of ictalurids collected. They comprised less than two percent of the community. More than half of the 29 species collected were sensitive species. They accounted for almost 38% of the community. Primary feeding individuals and Key individuals each accounted for over 32% of the overall community. The diversity index was 3.5, and the catch per unit of effort was 12.73 fish per minute. Six riffle habitats, four run habitats and four pool habitats were sampled at this site. The substrate in the riffles consisted mainly of gravel/rubble with a few small boulders. The habitat in the runs was similar to that of the riffles with some additional areas of sand. The pool substrates consisted mostly of gravel/rubble with areas of sand, silt/leaf packs, and some boulders and bedrock. In stream cover in the riffles consisted mainly of aquatic vegetation with some woody debris and undercut banks. The instream cover in the runs ranged from aquatic vegetation to diverse areas with undercut banks, woody debris, root wads, and hanging vegetation. The pools had the most diverse instream cover including undercut banks, woody debris, root wads, and aquatic and hanging vegetation. The riffle and run habitats were rated as good and the pool habitats were rated as excellent.

DISCUSSION

For comparisons and discussions, the fish community sites were separated into three groups based on watershed size. These sites included: 1) sites with less than a 30 square mile watershed (Haw Creek, Mill Creek, and Minnow Creeks); 2) sites with watersheds between 50 and 70 square miles (upper Little Piney Creek, Hurricane Creek, and Indian Creek); and 3) sites with watersheds greater than 150 square miles (lower Little Piney Creek, mid Big Piney Creek, and the lower Big Piney Creek). Data was not available from a small watershed, Boston Mountains ecoregion reference stream to compare with the small watershed streams. The Hurricane Creek, Indian Creek, and Illinois Bayou ecoregion data was compared to the 50 to 70 square mile watersheds, and the Lee Creek, Mulberry River and Illinois Bayou ecoregion data was compared to the 150 to 400 square mile watersheds.

The fish community in Haw Creek (ARK117) had the lowest diversity index, the lowest catch per unit of effort and the lowest number of species collected of any of the sample sites (Table F-3). In addition, the similarity indexes between this site and the other small watershed sites of Minnow Creek and Mill Creek are very low (Table F-4). This is most likely due to the habitat differences between the sites (Table F-1). Also, the community structure index for Haw Creek indicates that the fish community at this site is impaired. This community is being affected mostly by seasonal flow characteristics typical of small watershed Boston Mountain streams. In early summer, the creek ceases to flow and forms only small pools. During the driest period of summer, the creek may become completely dry. Thus, any fish species that inhabits the stream during seasonal flows must be able to tolerate these conditions or migrate in and out of the area. Downstream from this site a partial fish migration barrier exist in the form of a natural waterfall which adds to the difficulty of repopulating the stream above the falls. Therefore, this fish community is probably typical of those in less than ten square mile watersheds in the Boston Mountains.

Minnow Creek and Mill Creek fish communities are quite similar (Table F-4). Both sites are small watershed streams lying in the transition zone between the Boston Mountains and Arkansas River Valley ecoregions. The major differences between the two sites was: 1) the larger cyprinid population in Minnow Creek, which was comprised mostly of stonerollers; 2) the larger centrarchid population in Mill Creek; and 3) the higher density of fishes in Minnow Creek, as demonstrated by the greater catch per unit of effort (Table F-3). The community structure indices for the sites indicate that Mill Creek was fully supporting a typical fish community and Minnow Creek was generally supporting (Table F-5). The Ichthyofauna Habitat Indices (IHI) for the sites indicates that the habitat in Minnow Creek was much better than that in Mill Creek (Table F-1). These data indicate that the fish community in Minnow Creek may be impacted by some nutrient enrichment and turbidity which has caused shifts in the fish community.

TABLE F-4

FISH COMMUNITY SIMILARITY INDICES							
Species				Relative Abundance			
<30 square mile watersheds				**<30 square mile watersheds**			
Station	**Haw**	**Minnow**	**Mill**	**Station**	**Haw**	**Minnow**	**Mill**
Mill	50.00	87.80		**Mill**	60.46	72.12	
Minnow	59.26			**Minnow**	68.47		
50 to 70 square mile watersheds				**50 to 70 square mile watersheds**			
Station	**U. Little Piney**	**Hurricane**	**Indian**	**Station**	**U. Little Piney**	**Hurricane**	**Indian**
Indian	80.00	73.68		**Indian**	72.25	71.23	
Hurricane	76.19			**Hurricane**	67.71		
Hurricane*	74.42	76.92	76.92	**Hurricane***	69.02	66.14	72.02
Indian*	73.47	62.22	71.11	**Indian***	67.01	59.78	70.31
Illinois*	69.38	66.67	66.67	**Illinois***	69.73	57.76	63.53
150 to 400 square mile watersheds				**150 to 400 square mile watershed**			
Station	**L. Little Piney**	**Middle Big Piney**	**L. Big Piney**	**Station**	**L. Little Piney**	**Middle Big Piney**	**L. Big Piney**
L. Big Piney	90.32	90.57		**L. Big Piney**	74.90	68.15	
Lee Creek*	68.66	75.47	85.71	**Lee Creek***	66.51	63.71	73.02
Mulberry*	70.97	75.86	82.21	**Mulberry***	68.91	63.57	68.60
Illinois*	64.72	78.43	82.14	**Illinois***	53.89	66.04	67.01

* Boston Mountains Ecoregion Sites - Data collected during the 205(j) ecoregion survey, final report - 1987.
Illinois Bayou has a 125 square mile watershed.

The upper Little Piney Creek (ARK126), Hurricane Creek (ARK119) and Indian Creek (ARK114) samples were compared to the Hurricane Creek, Indian Creek and Illinois Bayou ecoregion data collected in the mid 1980s. The upper Little Piney Creek site and the current Indian Creek site were the most similar of this grouping (Table F-4). It is important to note that the similarity indexes between the collections made for this survey and the collections made for the 205(j) ecoregion survey in the mid-1980s at the Hurricane Creek and Indian Creek sites were

TABLE F-5

COMMUNITY STRUCTURE INDEX									
Family	117	119	116	114	110	BS	126	129	104
Cyprinidae	2	4	4	4	4	4	4	2	4
Ictaluridae	4	4	4	4	4	0	4	4	4
Centrarchidae	0	4	4	4	4	4	4	4	4
Percidae	4	4	4	4	4	4	4	4	4
Sensitive Inds.	4	4	4	4	2	4	4	4	2
Primary TFL	2	4	4	4	4	4	4	2	2
Key Individuals	0	4	4	4	4	2	4	2	2
Diversity Index	0	4	4	4	4	4	4	2	4
Total Score	16	32	32	32	30	26	32	24	26

in the mid-to-low 70s for the species similarity and in the low 70s to mid 60s for relative abundance similarity. This perhaps is indicating a range of similarity that can be attained between two sites. It is also important to note that the sampling methods used during the 205(j) survey were different than those used for the collections of this survey. Thus, some of the differences in the fish communities resulting in lower similarities may be attributed to sampling biases.

The upper Little Piney site had a greater percentage of primary feeders and a lesser percentage of sensitive species as compared to the other sites in this group (Table F-3). However, the upper Little Piney site had a more diverse and greater percentage of percids than the other two sites. All three sites had a CSI score of 32, indicating that they are all fully supporting their expected aquatic life use (Table 5). The differences between these three communities may be best explained by the habitat differences between the sites (Table F-1). The Indian Creek site pools up with interstitial flow between them during the later part of the summer and early fall. Hurricane Creek and upper Little Piney Creek maintain a minimal flow throughout the year. In addition, the substrate at the upper Little Piney Creek site consisted of more bedrock and rubble/gravel as compared to the boulders and cobble found at the Indian Creek and Hurricane Creek sites (Appendix F-1). This made sampling the riffle areas in Little Piney Creek much easier which perhaps produced a more abundant and diverse riffle species collection. In addition, the habitat in the riffles was more abundant and a greater amount of riffle area was sampled at Little Piney Creek site which may have also contributed to a better riffle species collection.

The lower Big Piney Creek (BS), mid Big Piney Creek (ARK116), and lower Little Piney Creek (ARK104) sites were compared to one another and to the Lee Creek, Mulberry River, and Illinois Bayou ecoregion fish collections. The lower Little Piney Creek and lower Big Piney Creek sites were the most similar based on fish species present, but the lower Big Piney and mid Big Piney sites were the most similar based on relative abundance (Table F-4). All of the sites compared well with the ecoregion sites, but the lower Big Piney site was the most similar to the ecoregion sites. All of the sites were rated as fully supporting their aquatic life use (Table F-5). However, the lower Big Piney Creek site and the lower Little Piney Creek site had CSI scores just above the generally supporting category. Both of these sites are located in the transition zone between the Boston Mountains and Arkansas River Valley ecoregions. This may partially account for the lower CSI score at these two sites. The lower Big Piney Creek site had a noticeable lack of ictalurids mainly madtoms. However, the site had a good quantity and quality of riffle habitats as reflected by the diverse and abundant percid community. This may be suggesting that there is some other parameter affecting the madtom community at this site.

The lower Little Piney Creek site had an abundant and diverse ictalurid and percid community, even though the riffle habitats had the lowest IHI score of all of the sample sites. However, this site scored low in the Key Species category, the primary feeder category and the sensitive species category. These conditions may be indicating a water quality problem which is most likely caused by nutrient enrichment and excessive turbidity.

Overall, Little Piney Creek and Big Piney Creek are fully supporting their aquatic life designated use. However, a few communities in tributary watersheds may be indicating that there are some outside influences causing shifts towards more tolerant communities. One example of this is the fish community at Haw Creek which is being affected mostly by seasonal flow patterns. The communities at the Minnow Creek and the lower Little Piney Creek sites are possibly being impacted by nutrient enrichment and excessive turbidity. This is indicated by an increase in primary feeders and a decrease of riffle species and sensitive individuals. In addition, the fish communities in Mill Creek and the lower Big Piney Creek site may be experiencing some adverse effects from excessive turbidity as reflected by the decrease in sensitive species in Mill Creek and the lack of madtoms at the lower Big Piney Creek site.

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STREAMBANK SURVEY

A streambank stability survey was conducted throughout the watershed by visually identifying streambanks that were eroding. A float trip down the main stem of Piney Creek and a watershed reconnaissance survey were used to locate the streambanks that were eroding. Twenty areas within the watershed were identified as having eroding streambanks. These areas are depicted in Figure SB-1. Table SB-1 lists the streambanks, gives the general location of each, and briefly outlines some of the key characteristics of each.

METHODOLOGY

The streambank located just upstream of the Twin Bridges, Highway 164 bridge, was chosen for a more in-depth survey. Three transects across the channel were established to help determine the degree of annual streambank erosion. Transect pins were set at each end of the transects along with pins at the toe (toe pin) of the streambanks. In addition, a pin (set pin) was set on top of the streambank at a distance far enough back from the face so as not to be lost to erosion during storm events. A temporary bench mark (TBM) was established with an arbitrary height of 100. Stream bed cross-sectional elevations, relative to the TBM, were measured along each transect. Elevations were measured to the nearest 0.01 feet with a Laser Alignment LB-2 laser level and 25 foot level rod and/or a SOKKIA SET5F Total Station . Distances from the rebar pin at the edge of the cross section were measured by a tape. Three additional pins (erosion pins), three feet in length, were driven into the face of the bank at the transect site to help determine the amount of erosion during storm events. The total length of the streambank and the thalweg were measured in addition to the distance between the corner pins on the opposite side of the streambank. Streambank profiles were established in addition to the transects. The profiles were set up by placing a set pin, top pin, and toe pin at three locations along the streambank. The profiles were located between transects one and two, two and three, and upstream of transect three. The distance from the set pin to the top pin, and from the top pin to the toe pin were measured at each profile. Three erosion pins were also installed at each profile site. The distance between each erosion pin was also measured.

At each transect, the cross-sectional area (ft^2) of the eroding bank region was calculated for each year (1997 and 1998). The cross-sectional area lost was multiplied by the distance (ft) along the bank associated with each transect and expressed as cubic feet of bank lost (ft^3). The cross-sectional area lost was divided by the average bank height (ft) to provide the average width of bank lost (ft). The cubic feet of bank lost was then converted to cubic yards.

INTENSIVE STREAMBANK SURVEY

The streambank located on the river-right of Big Piney Creek just upstream of the Arkansas Highway 164 bridge was selected for a more intensive survey. The study reach is approximately 1025 feet in length. The streambank was subdivided into three sections for discussion and evaluation, the lower 190 feet, the middle 390 feet, and the upper 440 feet.

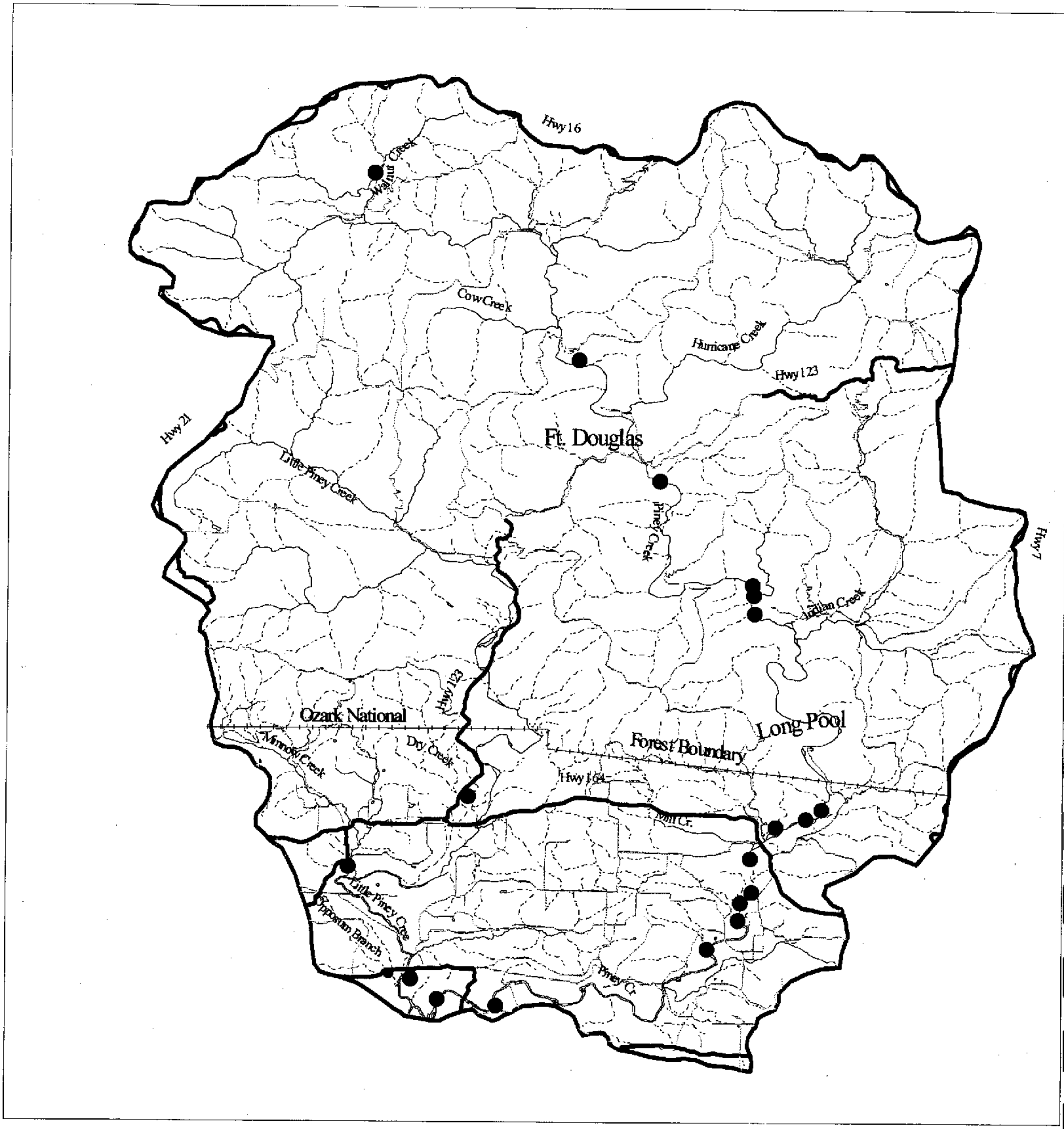


Figure SB - 1
Location of Eroding Streambanks

Table SB-1 - Eroding Streambanks					
Waterbody	County	Sec	Twn	Range	General Location
Walnut Creek	Newton	8	13N	22W	S. of Hwy 16, 3.5 mi. S. of Edwards Junction
	The creek is located in a pasture. The riparian zone is poorly vegetated riparian.				
Big Piney Creek	Johnson	7	12N	21W	2 mi. N. of Hurricane Creek
	The river-left is eroding due to loss of riparian vegetation and direct cattle access.				
Big Piney Creek	Johnson	33	12N	21W	2.5 mi. S. of Ft. Douglas
	The river is cutting into a county/Forest access road on the river-right.				
Big Piney Creek	Johnson	13	11N	21W	Near Helton's Farm. 1 mi. N. of Indian Creek.
	The river-left side is eroding due to loss of riparian vegetation, and direct cattle access.				
Big Piney Creek	Pope	24, 13	10N	21W	Above Hwy 164 bridge
	Both River-right and River-left eroding due to loss of riparian vegetation.				
Big Piney Creek	Pope	18	10N	20W	Above Hwy 164 bridge
	Instream gravel mining, construction of the Hwy 164 bridge, loss of riparian vegetation.				
Big Piney Creek	Pope	24, 25	10N	21W	Below Hwy 164 bridge
	Both sites are on river-left. Loss of riparian vegetation and cattle access.				
Big Piney Creek	Pope	35	10N	21W	Above Russian bridge
	A river-right and a river -left eroding banks. Loss of riparian vegetation.				
Big Piney Creek	Pope and Johnson				From Tate's Island Ford and Hwy 359 bridge
	Numerous stream bank erosion sites of various sizes.				
Dry Creek	Johnson	15	10N	22W	Below Hwy 123, 1 mi. N. of Hagarville
	Creek runs through a pasture, direct cattle access and some loss of riparian vegetation.				
Minnow Creek	Johnson	29	10N	22W	Below county road 59, 4 mi. N. of Lamar
	Downstream of a bridge.				
Oppossum Branch	Johnson	9	9N	22W	Below Hwy. 359, 2.5 mi. E. of Lamar
	Creek runs through a pasture, direct cattle access, loss of riparian vegetation.				
Little Piney Creek	Johnson	9	9N	22W	Below Hwy. 359, 3 mi./ e. of Lamar
	Loss of riparian vegetation next to a pasture.				

The lower section of the bank, Transect 1, has a vertical face of approximately 10 feet, then a shelf that extends out approximately 10 feet, and then another vertical face of approximately three feet before it drops off another two feet to the thalweg (Figure SB-2). The soils in the upper 10 feet of bank are mainly sand/silt/clay and the soils in the lower section are mainly cobble and sand. The total transect distance from the river-left transect pin to the river-right transect pin is 235 feet. The distance from the river-left transect pin to the toe of the river-right bank in1997 was approximately 224 feet. That distance in 1998 was approximately 232 feet, representing a streambank loss of approximately eight feet. This section of the streambank is eroding almost four times as fast as the areas around Transect 2 and Transect 3. The total cross-sectional area lost in this segment of the streambank was 110 ft^2. Multiplying this by the length of the streambank represented by Transect 1, equates to a total loss of 20,900 ft^3 (774 cubic yards) of soil.

The middle section of the streambank at Transect 2 (Figure SB-2) has a vertical face of approximately 10 feet. The bank then has a sharply sloping bank of about eight feet to the thalweg. The soils in the upper ten feet of bank are primarily clay/silt/sand. The next six feet is a layer of cobble with sand, and the lower two feet of soil is comprised of small boulders/cobble and sand. Upstream of Transect 2, the streambank protrudes out into the channel approximately five feet. This section of the bank has a vertical face of approximately 20 feet from the top of the bank to the thalweg. This section of the bank does not seem to be eroding as quickly as the sections immediately upstream and downstream. The total transect distance from the river-left transect pin to the river-right transect pin is 225 feet. The distance from the river-left transect pin to the toe of the river-right bank in 1997 was approximately 204 feet. That distance in 1998 was approximately 206 feet, a loss of approximately two feet. However, the streambank in the area around Profile 2, upstream of Transect 2, had places that lost as much as eight feet of streambank. The total cross-sectional area lost in the Transect 2 area of the streambank was 28 ft^2. Multiplying by the length of the streambank represented by Transect 2, equals to a total loss of 10,920 ft^3 (404 cubic yards) of soil.

The upper section of the streambank at Transect 3 has about an eight foot vertical face. The bank then has a sloping bank of about 10 feet to the thalweg. The soils in the upper eight feet are comprised of silt/sand, and the lower 10 feet of bank is composed of small boulders and cobble with sand. This section of the bank does not seem to be eroding as quickly as the sections downstream. The total transect distance from the river-left transect pin to the river-right transect pin is 181 feet. The distance from the river-left transect pin to the toe of the river-right bank in 1997 was approximately 159.54 feet. That distance in 1998 was approximately 161.5 feet, a loss of approximately two feet. This is typical of the loss seen in the upper 440 feet of the bank. The total cross-sectional area lost in the Transect 3 area of the streambank was 23 ft^2. Multiplying the length of the streambank represented by Transect 3, equals to a total loss of 10,120 ft^3 (378 cubic yards) of soil.

The total soil loss that occurred during a one year period from this stream bank is estimated to be 41,940 ft^3, or 1556 cubic yards.

Figure SB-2

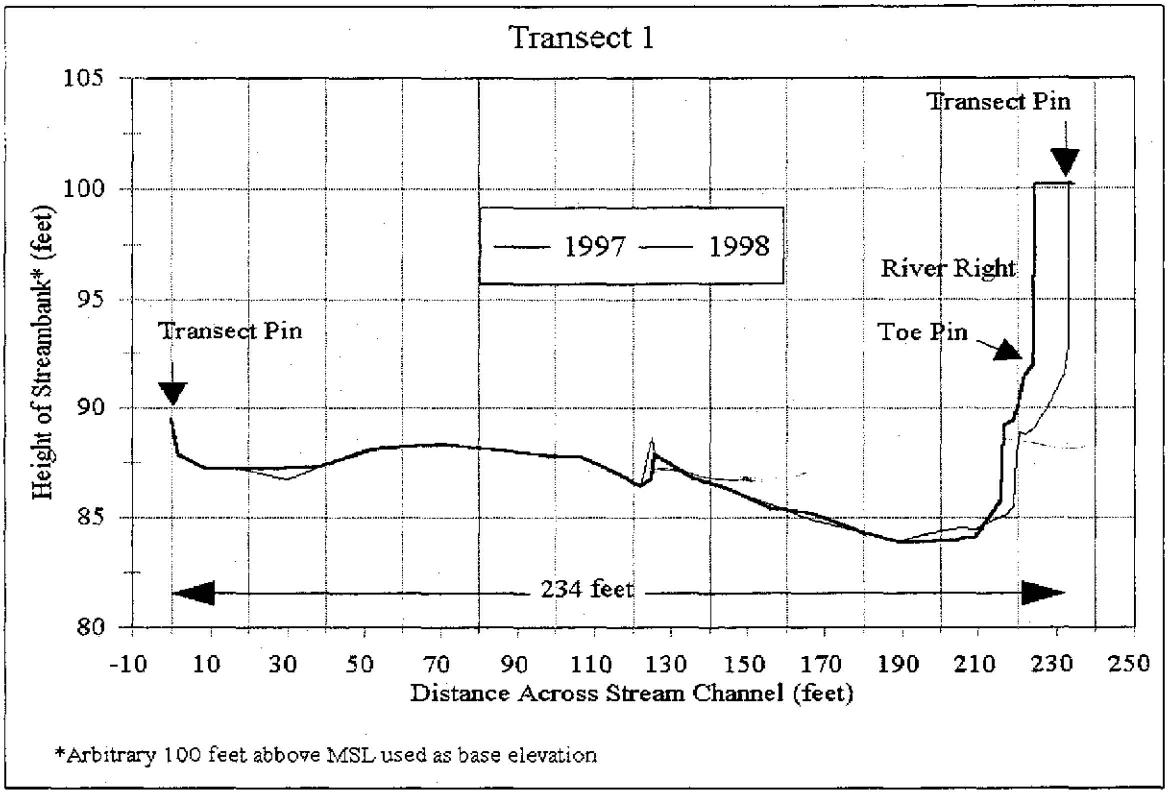


Figure SB-3

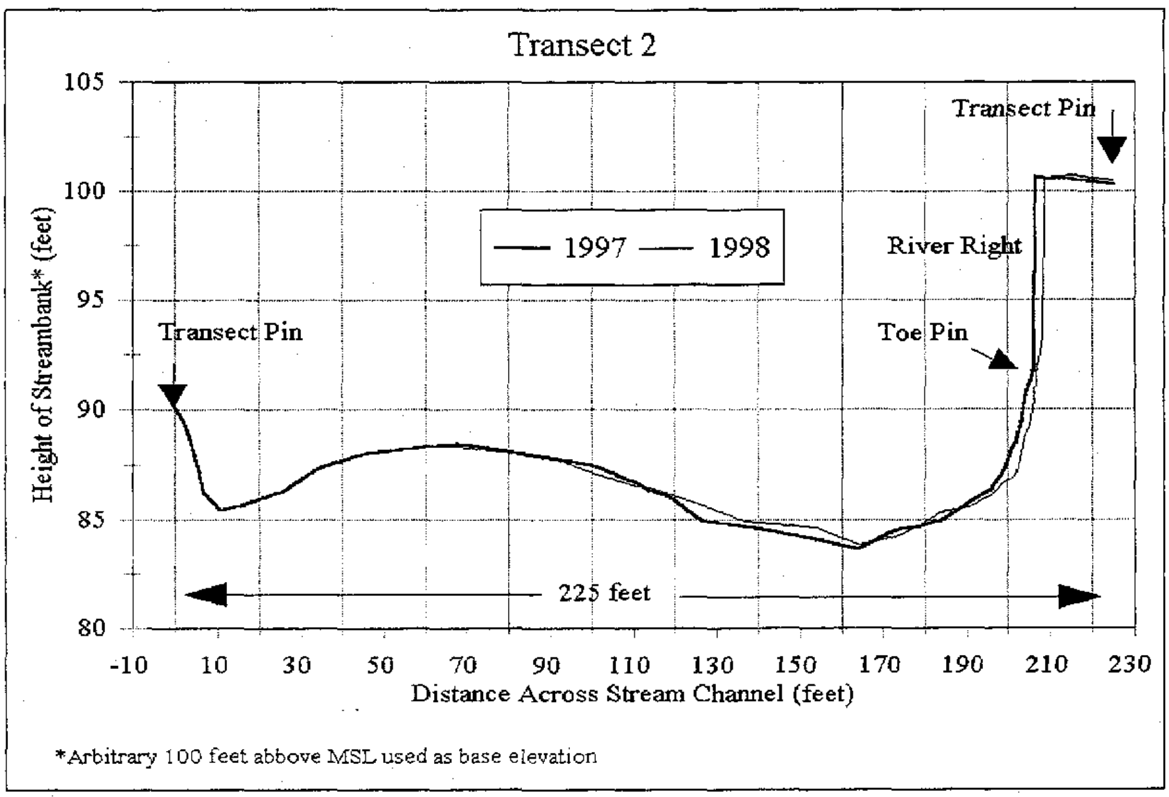
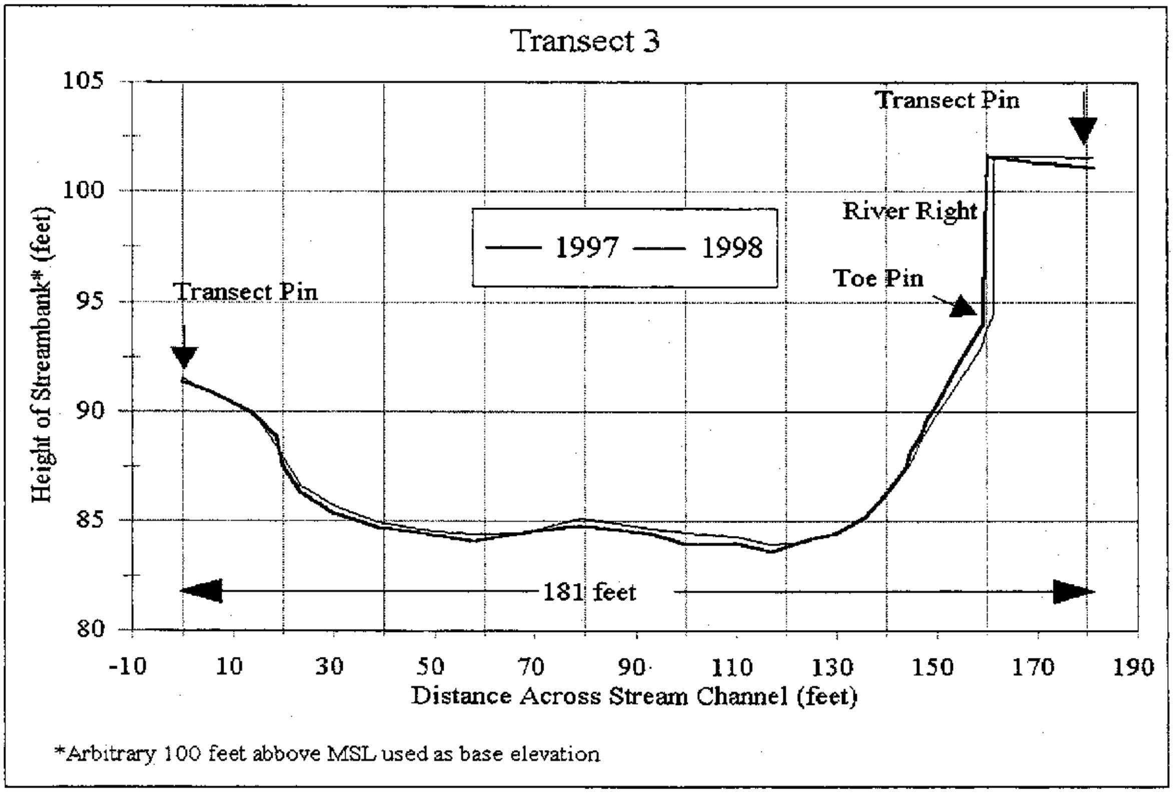


Table SB-2 - Streambank Loss Amounts						
	Width lost (ft)	Bank height (ft)	Area lost (ft^2)	Linear Distance Represented (ft)*	Total Soil Lost (ft^3)	(yds^3)
Transect 1	7.4	14.8	110	190	20,900	774
Transect 2	1.75	15.9	28	390	10,920	404
Transect 3	1.6	14.2	23	440	10,120	378
Totals			161	1020	41,940	1556

Figure SB-4



Conclusions/Recommendations

An eighteen month survey of the Piney Creeks watersheds resulted in the collection of numerous water quality, macroinvertebrate, and fish community samples as well as a comprehensive land use and streambank stability survey. It is determined that the Piney Creeks are currently meeting all designated uses and fully supporting the aquatic life use. However, there are areas of concern in both watersheds. Listed below are the main conclusions derived from this assessment survey:

1) Historical water quality data from an ambient water quality monitoring station located at Arkansas Highway 164 bridge (ARK43) indicates that there are occasionally very high values of the instream turbidity. This is most likely due to significant stream bank erosion just upstream from this site.

2) Land use in the upper portion of the watershed is mainly forest; however, there is some pasture land located adjacent to the streams and on the hill tops in this area.

3) There are 16 confined animal operations (CAOs) in the Big Piney Creek watershed below Long Pool. These include: 11 poultry operations utilizing 23 houses; four swine operations utilizing 18 houses; and one dairy operation. The concentration of CAOs below Long Pool is approximately 0.78 CAO houses/mi^2 of watershed.

4) The Mill Creek area in the Big Piney watershed has the greatest number of CAOs. It has six integrators and 13 houses within its 10 mi^2 watershed.

5) There are 43 CAOs in the Little Piney Creek watershed. These include; 41 poultry operations utilizing 121 houses; and two swine operations utilizing nine houses. Almost all of these are located south of the national forest boundary. The concentration of CAOs below the national forest is approximately 2.06 houses/mi^2 of watershed.

6) Minnow Creek has the greatest number of CAOs in the Little Piney watershed with 13 integrators and 37 houses. Oppossum Branch has the highest concentration of CAO houses at 2.8 houses/mi^2 of watershed.

7) Minimum DO concentrations were at a level of concern at six sampling stations: lower Little Piney Creek (ARK 104); lower Big Piney Creek (ARK 105); Indian Creek (ARK114); Moccasin Creek (ARK115); Haw Creek (ARK117); and Big Piney Creek at Fort Douglas (ARK118).

8) The base flow, Boston Mountains turbidity standard of 10 NTUs was exceeded in 46% of the 178 readings taken during the survey. All elevated readings occurred during storm events. The ARK108 site had the highest turbidity value recorded, 1180 NTUs. The sites in the lower part of the watershed had the highest values. The headwater sites in Big Piney Creek had higher turbidity readings than the middle watershed sites.

9) The Boston Mountains standard for instream chloride concentration of 17 mg/L was exceeded on only one occasion during the survey. The standard for instream sulfate concentration of 15 mg/L was exceeded six times during the survey. The standard for instream total dissolved solids (TDS) concentration of 95 mg/L was exceeded nine times.

10) Home Creek (ARK123) and Curtis Creek (ARK122) displayed elevated sulfate and TDS concentrations during low flow situations as compared to other headwater streams. Septic tanks may be causing the increase in minerals in these streams along with the natural geology of the area.

11) The only elevated concentrations of ammonia-nitrogen (all less than 0.7 mg/L) occurred at ARK108, ARK128 and ARK127. All three concentrations occurred during storm events. Thus, the source of ammonia-nitrogen was most likely from animal litter that was applied to the adjacent pasture lands prior to the storm event. The source of the ammonia-nitrogen at ARK108 could have come from pond overflow from the swine facility located in the watershed.

12) The nutrient concentrations in the headwaters of Big Piney Creek are slightly elevated over the concentrations found in the tributaries and in the main stem of the middle portion of the watershed. The nutrient concentrations gradually increase throughout the lower portion of the watershed.

13) Septic tanks and land use practices (pasture land) are the most probable cause of elevated nutrients in the upper portion of Big Piney Creek watershed. Land use practices (CAO and pasture land) are most likely the main cause of elevated nutrient concentrations in the lower portion of the watershed.

14) The nutrient concentrations in lower Little Piney Creek main stem and its tributaries are all elevated when compared to the upstream sampling sites. Land use practices (CAO and pasture land) are most likely the main cause of elevated nutrient concentrations.

15) The sample sites in the lower portion of both watersheds displayed elevated concentrations of fecal coliform bacteria with several sites exceeding the water quality standard for primary contact recreation of more than 25% of the time during the swimming season. Land use practices (CAO and pasture land) are most likely the main cause of the elevated fecal coliform bacteria concentrations.

16) Bacteria concentrations at Long Pool exceeded the Ozark National Forest bacteria standard and was closed to swimmers for 27 days. The source of the bacteria seems to be originating near the Treat community and was most likely from land use practices (pasture land) and/or from septic tanks in the area.

17) Copper was the only metal that was detected in potential toxic concentrations during one sampling event at ARK114, ARK128, and ARK127

18) Aluminum concentrations were detected at five sites at concentrations over 100 mg/L. The highest value was at ARK108 during one sampling event. None of these exceeded aquatic life toxicity values.

19) Diurnal dissolved oxygen profiles indicated possible nutrient enrichment at six sites. These were ARK125, ARK124, ARK120, ARK120B, ARK114, and ARK 104.

20) The macroinvertebrate community throughout both watersheds was rated as fully supporting. However, there were a few sites where the macroinvertebrate community was possibly impacted due to water quality impairments and/or habitat limitations.

21) The macroinvertebrate community in Minnow Creek seems to be impacted mainly because of a lack of quality habitat at the site selected for analysis.

22) The fish community designated use throughout both watersheds was fully supported; however, there were indications of nutrient enrichment and siltation impacts at selected sites.

23) The Minnow Creek fish community was possibly being affected by nutrient enrichment and elevated turbidity values which caused slight shifts in the fish community.

24) The fish communities in Mill Creek and the lower Big Piney Creek may have been impacted from excessive turbidity as indicated by the reduced populations of madtoms at the sample site.

25) The lower Little Piney Creek site may have experienced nutrient enrichment and turbidity impacts as indicated by the decrease in sensitive fish species and an increase in primary feeding fish.

26) Twenty areas within the watershed were identified as having problems with eroding streambanks.

27) The eroding streambank upstream of the Arkansas Highway 164 is approximately 1025 feet long and has a vertical face between eight to ten feet tall. It is losing between two to eight feet of streambank along its length, annually.

28) This streambank lost approximately 41,940 ft^3 (1556 cubic yards) of soil during the period between September 1997 and August 1998, even though during this period the stream flows were below normal. However, one large storm event during January 1998 is responsible for the majority of the streambank loss,

RECOMMENDATIONS

Nonpoint source best management practices (BMP) in the Big and Little Piney Creek watersheds should be concentrated in the areas south of the Ozark National Forest boundary. Practices to better manage nutrient runoff, increase vegetative cover on pasture lands, reduce water runoff from pasture lands and reduce livestock access to streams would all benefit the water quality in the watersheds. In addition, reducing soil runoff from the unpaved county and forest access roads and from the areas of the watershed with little or no vegetative cover would also benefit the water quality. Furthermore, addressing the streambank erosion problems and increasing the quality of the vegetative cover in the riparian zones along the eroded stream channels would help to reduce the turbidity in the streams.

To select a number one priority subbasin in the watershed to begin BMP implementation in would be very difficult because of the many different aspects associated with water quality in the watershed. However, activities should be concentrated in the subbasins with the highest concentrations of confined animal operations and the greatest percentage of pasture land. The subbasins of concern are Oppossum Branch and Minnow Creek in the Little Piney Creek watershed and Tributary No. 3 (ARK108) and Mill Creek in the Big Piney Creek watershed. Best management practice implementation for the reduction of silt and soil runoff from county and forest access roads is recommended for the entire basin. Control of fecal coliform bacteria, particularly in Big Piney Creek above Long Pool, should be a high priority. In addition, stabilization of the unstable streambanks in both watersheds, increasing the quality and quantity of vegetative cover in the riparian zones, and controlling the factors causing the destablization of the streambanks and the loss of the vegetative cover in the riparian zones is also recommended.

APPENDIX R-1

REFERENCES

Appendix R-1

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APPENDIX A

CONFINED ANIMAL OPERATIONS

Appendix A
Confined Animal Operations

Big Piney Creek Confined Animal Operations

Operation	Houses	Trib	Long	Lat	Sec	T-N	R-W
Chicken	2	Mill	93 15 13.47	35 32 10.92	8	10	21
Chicken	2	Mill	93 13 04.79	35 31 11.32	15	10	21
Chicken	1	Mill	93 14 40.25	35 31 25.07	16	10	21
Chicken	1	Dry	93 10 53.40	35 31 29.19	13	10	21
Hog	3	Piney	93 08 53.82	35 31 38.41	17	10	20
Chicken	2	Piney	93 08 53.82	35 31 38.41	17	10	20
Chicken	1	Trib #4	93 10 16.20	35 30 03.00	24	10	21
Hog	8	Trib #3	93 10 33.57	35 28 47.44	36	9	20
Hog	3	Mill	93 13 11.15	35 30 44.76	22	10	21
Hog	4	Mill	93 11 59.37	35 30 54.62	14	10	21
Chicken	1	Mill	93 11 40.45	35 30 19.11	23	10	21
Chicken	4	Trib #2	93 11 44.37	35 26 30.02	11	9	21
Chicken	4	Wilson	93 10 45.94	35 27 20.26	1	9	21
Dairy		Trib #1	93 13 56.95	35 24 53.71	21	9	21
Chicken	2	Piney	93 18 24.36	35 25 43.98	12	9	22
Chicken	3	Piney	93 17 50.35	35 27 14.80	11	9	22

Little Piney Creek Confined Animal Operations

Operation	Houses	Trib	Long	Lat	Sec	T-N	R-W
Chicken	1	Dry	93 18 58.88	35 32 03.43	10	10	22
Chicken	3	Dry	93 19 41.81	35 32 27.85	10	10	22
Chicken	1	Dry	93 19 12.13	35 32 14.71	10	10	22
Chicken	2	Dry	93 18 44.04	35 32 05.49	10	10	22
Chicken	3	Dry	93 18 54.08	35 31 41.13	15	10	22
Chicken	3	Little Piney	93 19 41.01	35 28 20.74	34	10	22
Chicken	11	Little Piney	93 18 47.54	35 28 37.47	34	10	22
Chicken	2	Little Piney	93 18 33.93	35 29 32.11	26	10	22
Chicken	3	Granny	93 17 12.50	35 31 21.34	13	10	22
Chicken	2	Granny	93 14 45.82	35 29 40.53	29	10	21
Chicken	4	Granny	93 14 59.74	35 29 33.99	29	10	21
Chicken	2	Slover	93 16 36.27	35 28 49.00	31	10	21
Chicken	2	Slover	93 16 36.03	35 28 57.34	31	10	21
Chicken	2	Granny	93 16 02.19	35 30 41.13	19	10	21

Little Piney Creek Confined Animal Operations (cont)

Operation	Houses	Trib	Long	Lat	Sec	T-N	R-W
Hog	6	Little Piney	93 20 00.39	35 28 20.63	33	10	22
Chicken	7	Slover	93 18 12.77	35 27 58.94	2	9	22
Chicken	5	Slover	93 18 38.77	35 28 23.39	35	10	22
Chicken	3	Slover	93 18 00.61	35 28 09.29	2	9	21
Chicken	2	Slover	93 18 52.28	35 26 55.89	10	9	22
Chicken	1	Slover	93 19 07.17	35 26 58.12	10	9	22
Chicken	6	Little Piney	93 21 08.04	35 26 05.59	17	9	22
Chicken	3	Oppossum	93 21 46.07	35 27 06.84	8	9	22
Chicken	1	Oppossum	93 21 45.80	35 27 18.68	5	9	22
Chicken	4	Oppossum	93 21 42.81	35 27 23.22	5	9	22
Chicken	5	Oppossum	93 22 45.29	35 28 40.87	31	10	22
Turkey	3	Minnow	93 24 49.86	35 34 07.51	35	11	23
Chicken	2	Little Piney	93 17 42.80	35 34 16.58	26	11	22
Chicken	2	Minnow	93 24 19.06	35 31 30.08	14	10	23
Chicken	3	Minnow	93 22 40.86	35 31 06.59	18	10	22
Chicken	3	Minnow	93 23 17.26	35 31 59.76	12	10	23
Chicken	2	Minnow	93 20 55.73	35 32 49.09	5	10	22
Chicken	2	Minnow	93 21 08.10	35 30 43.77	20	10	22
Chicken	4	Minnow	93 19 49.34	35 30 35.55	21	10	22
Chicken	2	Minnow	93 19 47.95	35 30 04.05	21	10	22
Chicken	2	Minnow	93 20 13.34	35 29 34.72	28	10	22
Chicken	4	Minnow	93 19 48.39	35 31 13.57	16	10	22
Chicken	5	Minnow	93 19 38.66	35 31 35.89	15	10	22
Chicken	2	Minnow	93 19 49.56	35 31 34.90	16	10	22
Chicken	1	Oppossum	93 21 45.51	35 27 06.07	8	9	22
Chicken	2	Granny	93 18.05.00	35 30 35.00	23	10	22
Chicken	3	Granny	93 17 50.00	35 30 30.00	23	10	22
Hog	3	Minnow	93 20 45.23	35 32 24.57	9	10	22

APPENDIX WQ-1

WATER QUALITY DATA

Appendix WQ-1
Water Quality Data

	Flow (CFS)							Station Number (ARK***)																
Date	125	124	122	123	121	120	119	118	117	115	114	113	112	111	43	110	109	108	107	105	126	129	128	127	104
970616	3.84	9.14	4.77	1.63	5.01	33.67	8.91	31.66	0.62	0.74	4.24	46.24	0.45	<0.05	49.90	1.31	0.32	3.31	1.08	NT*					17.68
970819	7.02	12.01	1.14	~1.50	0.90	22.21	4.94	24.32	0.55	<0.10	<0.10	4.47	DRY	DRY	4.15	DRY	DRY	DRY	DRY	NT*					1.69
971013	43.75	93.38	1.77	DRY	5.26	142.51	44.14	200.99	3.31	<1.00	7.75	2.02	DRY	DRY	0.94	0.01	DRY	0.21	<1.00	NT*	0.52	0.10	DRY	DRY	0.67
980105	NT*	NT*	NT*	99.03	NT*	NT*	NT*	NT*	NT*	NT*	NT*	NT*	NT*	NT*	NT*	NT*	46.80	NT*	NT*	NT*	NT*	NT*	NT*	NT*	NT*
980126	58.08	117.18	45.96	26.02	20.92	253.82	93.13	379.00	31.36	NT*	NT*	NT*	NT*	13.69	341.98	20.16	6.29	10.67	15.55	NT*	91.96	72.12	50.15	21.81	263.59
980210	11.76	31.13	5.77	2.46	6.41	60.19	20.47	98.89	8.44	6.94	9.10	NT*	0.95	0.91	63.98	1.48	0.68	0.74	2.46	NT*	49.41	22.75	7.94	0.85	98.08
980427	126.92	162.00	128.41	45.99	116.15	NT*	NT*	NT*	139.24	NT*	425.0^	NT*	11.99	16.80	NT*	20.46	4.25	2.21	3.04	NT*	NT*	122.33	62.40	11.46	NT*
980804	0.00	<2.00	DRY	DRY	<0.50	<3.00	<1.00	<1.00	0.00	<0.50	0.00	<2.00	DRY	DRY	<3.00	DRY	DRY	DRY	DRY	NT*	<2.00	0.00	DRY	DRY	<2.00

	Temperature (Degrees C)							Station Number (ARK***)						Boston Mountains Ecoregion Standard - 31°Celsius										
Date	125	124	122	123	121	120	119	118	117	115	114	113	112	111	43	110	109	108	107	105	126	129	128	127	104
970616	21.2	21.2	21.4	22.9	22.2	25.4	26.0	25.8	27.4	26.0	25.3	26.6	24.6	18.8	25.7	21.6	20.0	19.9	20.9	25.9					24.3
970819	22.7	22.9	21.3	25.1	23.8	25.2	25.7	25.8	25.8	26.3	24.2	27.8	DRY	DRY	27.2	DRY	DRY	DRY	DRY	28.1					26.8
971013	16.4	16.4	18.1	DRY	17.5	19.6	19.8	20.1	19.1	19.0	19.0	22.3	DRY	DRY	20.4	18.9	DRY	17.5	17.8	22.0	21.6	18.8	DRY	DRY	20.8
980105	10.8	10.5	11.1	11.1	10.6	10.6	10.7	10.7	10.6	10.8	10.9	10.8	11.3	11.3	10.9	11.4	11.8	12.3	12.7	10.9	10.7	11.5	12.0	12.7	11.0
980126	6.2	6.0	6.8	6.4	5.8	5.9	5.8	6.0	6.4	6.8	6.2	6.2	7.4	7.5	7.2	7.2	7.7	7.5	7.4	6.7	7.0	6.9	7.1	6.5	6.9
980210	7.3	7.1	7.1	7.7	6.6	7.1	6.8	7.0	7.1	7.9	7.3	7.2	8.3	8.5	7.8	8.5	8.5	8.7	8.6	7.5	7.7	8.2	8.0	8.4	8.1
980427	13.6	14.3	14.4	14.4	14.0	14.7	14.5	15.0	14.6	15.1	15.2	16.2	15.6	14.8	15.1	15.3	15.1	16.4	17.2	17.3	15.1	14.3	17.6	15.2	16.3
980804	27.8	28.5	DRY	DRY	26.1	28.5	26.0	27.7	27.0	27.2	27.1	31.8	DRY	DRY	31.7	DRY	DRY	DRY	DRY	28.9	27.4	26.4	DRY	DRY	27.1

	Dissolved Oxygen (mg/L)							Station Number (ARK***)																
Date	125	124	122	123	121	120	119	118	117	115	114	113	112	111	43	110	109	108	107	105	126	129	128	127	104
970616	8.7	7.8	8.7	8.9	7.9	8.3	7.6	7.2	7.5	7.2	7.8	7.8	7.8	7.7	7.9	7.4	7.7	8.6	8.3	6.8					7.0
970819	7.9	7.8	8.1	6.6	8.1	7.9	7.7	7.2	8.0	6.4	6.1	6.7	DRY	DRY	8.9	DRY	DRY	DRY	DRY	5.9					4.9
971013	8.6	8.8	8.4	DRY	7.9	7.9	7.9	7.8	7.9	7.0	8.9	7.6	DRY	DRY	9.7	6.0	DRY	8.9	8.1	7.1	7.9	6.4	DRY	DRY	6.0
980105	9.8	9.8	8.9	10.2	11.1	11.2	11.8	10.4	11.8	11.1	11.0	10.6	10.7	10.7	10.4	11.1	10.8	10.4	10.2	10.8	10.7	10.6	9.8	10.9	10.7
980126	11.5	11.8	11.1	11.4	11.3	11.6	11.6	11.9	11.4	11.3	11.3	11.5	11.3	11.2	11.4	11.4	11.1	11.3	11.6	11.5	11.5	11.6	11.3	11.2	11.4
980210	11.9	11.6	11.8	11.4	11.7	11.7	11.9	11.7	11.1	14.7	14.9	14.4	14.6	14.4	15.3	14.5	11.1	11.3	11.2	11.4	11.3	11.2	11.2	10.4	11.3
980427	9.6	9.6	9.5	9.4	9.5	9.6	9.5	9.3	9.4	10.7	10.6	11.7	9.8	11.4	11.2	11.1	10.8	11.3	11.1	9.8	10.1	9.5	8.9	11.4	9.5
980804	6.3	7.4	DRY	DRY	6.4	8.0	7.8	5.0	5.8	6.7	7.4	7.6	DRY	DRY	8.4	DRY	DRY	DRY	DRY	5.0	6.3	3.6	DRY	DRY	4.0

Date	pH (Standard Units)							Station Number (ARK***)																
	125	124	122	123	121	120	119	118	117	115	114	113	112	111	43	110	109	108	107	105	126	129	128	127	104
970616	7.96	7.65	7.86	8.20	7.59	8.17	7.77	7.67	7.58	EM**	EM**	EM**	EM**	EM**	EM**	EM**	EM**	EM**	EM**	7.38					6.93
970819	7.88	7.66	7.76	7.69	7.80	7.95	7.83	7.72	7.92	6.46	5.97	7.52	DRY	DRY	7.74	DRY	DRY	DRY	DRY	7.15					6.64
971013	7.68	7.67	7.72	DRY	7.59	7.66	7.50	7.70	7.15	6.74	7.16	7.40	DRY	DRY	7.26	6.93	DRY	6.97	6.75	7.17	7.16	6.65	DRY	DRY	6.82
980105	7.59	7.45	7.81	7.88	6.96	7.31	7.08	6.96	6.81	6.79	6.90	6.73	6.80	6.70	6.93	6.79	6.67	6.82	6.86	6.99	6.80	6.74	6.82	6.76	6.81
980126	7.87	7.87	8.14	8.26	7.40	7.98	7.68	7.90	7.41	6.89	7.09	7.68	7.00	6.75	6.89	6.82	6.85	6.95	7.05	7.35	6.90	7.01	6.97	7.23	7.13
980210	8.02	7.53	7.48	7.63	6.02	7.30	6.97	6.97	8.79	7.10	7.40	7.60	7.00	6.60	7.40	6.95	7.05	7.20	7.20	7.50	7.10	7.15	7.00	7.69	7.70
980427	7.41	7.38	7.76	7.94	7.46	7.52	7.24	7.34	6.94	7.10	7.17	7.34	6.79	6.91	7.15	6.89	6.80	6.97	7.17	7.14	6.96	6.83	6.91	6.79	6.88
980804	7.37	7.31	DRY	DRY	7.54	8.10	7.32	7.00	6.86	6.64	6.68	7.40	DRY	DRY	7.35	DRY	DRY	DRY	DRY	7.07	6.94	6.19	DRY	DRY	6.79

Date	Turbidity (NTUs)							Station Number (ARK***)								Boston Mountains Ecoregion Standard - 10 NTU								
	125	124	122	123	121	120	119	118	117	115	114	113	112	111	43	110	109	108	107	105	126	129	128	127	104
970616	0.9	2.5	4.8	3.0	59.0	2.7	1.1	1.4	3.3	3.0	3.5	2.0	7.8	33.0	2.0	74.0	170.0	1180.0	150.0	3.8					4.2
970819	4.1	5.8	3.8	2.1	1.9	2.5	1.1	1.7	2.1	7.0	6.3	1.4	DRY	DRY	1.3	DRY	DRY	DRY	DRY	4.5					5.3
971013	22.0	25.0	2.3	DRY	16.0	13.0	2.8	7.4	16.0	39.0	15.0	1.7	DRY	DRY	2.1	17.0	DRY	91.0	60.0	3.8	2.5	76.0	DRY	DRY	5.6
980105	26.0	29.0	26.0	25.0	20.0	37.0	20.0	25.0	20.0	20.0	20.0	62.0	20.0	16.0	72.0	20.0	21.0	76.0	34.0	95.0	34.0	40.0	65.0	59.0	110.0
980126	16.0	11.0	43.0	33.0	10.0	9.8	3.7	5.8	12.0	10.0	6.2	6.7	20.0	16.0	9.2	15.0	12.0	71.0	35.0	7.0	6.5	4.3	49.0	53.0	14.0
980210	2.9	5.6	3.0	3.2	6.8	4.2	3.3	4.3	8.8	8.1	4.6	4.8	8.2	6.4	4.9	4.2	6.6	8.0	9.8	5.7	5.6	5.4	6.2	4.4	5.8
980427	32.0	36.0	27.0	27.0	25.0	33.0	28.0	31.0	27.0	20.0	18.0	26.0	25.0	18.0	25.0	19.0	20.0	61.0	37.0	38.0	51.0	27.0	36.0	72.0	70.0
980804	3.6	2.2	DRY	DRY	2.5	1.7	1.8	1.1	1.6	7.7	7.3	0.8	DRY	DRY	2.1	DRY	DRY	DRY	DRY	2.4	2.3	6.4	DRY	DRY	7.1

Date	Total Suspended Solids (mg/L)							Station Number (ARK***)																
	125	124	122	123	121	120	119	118	117	115	114	113	112	111	43	110	109	108	107	105	126	129	128	127	104
970616	<1.0	<1.0	1.0	4.5	<1.0	<1.0	<1.0	<1.0	<1.0	3.5	0.5	2.0	10.0	8.5	1.5	36.5	53.0	960.0	105.5	4.0					4.0
970819	<1.0	<1.0	1.0	1.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	2.0	<1.0	DRY	DRY	1.5	DRY	DRY	DRY	DRY	4.0					3.0
971013	4.5	4.5	<1.0	DRY	1.0	8.0	<1.0	5.0	<1.0	1.0	1.5	<1.0	DRY	DRY	<1.0	7.0	DRY	21.0	7.5	8.0	<1.0	24.5	DRY	DRY	3.0
980105	19.0	17.5	8.5	8.0	4.5	27.5	9.5	14.0	3.0	12.0	9.5	66.5	8.5	6.0	111.0	13.5	11.5	77.0	33.0	152.5	27.5	52.0	61.5	38.0	186.5
980126	6.5	1.5	12.5	7.0	<1.0	2.0	<1.0	<1.0	2.5	<1.0	<1.0	<1.0	<1.0	1.0	1.0	2.5	1.5	22.0	13.5	2.0	<1.0	12.0	21.5	28.0	4.0
980210	<1.0	<1.0	<1.0	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	3.0	<1.0	1.0	<1.0	<1.0	<1.0	1.5	2.5	<1.0
980427	10.0	7.0	4.5	4.0	<1.0	13.5	8.0	13.5	<1.0	1.5	1.5	30.0	7.0	1.0	32.0	8.0	2.0	16.0	14.5	49.5	29.5	20.5	17.5	52.5	64.0
980804	11.5	2.0	DRY	DRY	3.5	1.5	1.5	<1.0	<1.0	23.0	4.0	<1.0	DRY	DRY	1.0	DRY	DRY	DRY	DRY	2.5	6.0	5.0	DRY	DRY	6.5

Date	Chlorides (mg/L) 125	124	122	123	121	120	119	Station Number (ARK***) 118	117	115	114	113	112	111	43	110	109	108	Boston Mountains Ecoregion Standard 17 mg/L 107	105	126	129	128	127	104
970616	1.49	1.49	1.69	2.86	1.38	1.61	1.40	1.46	1.46	1.80	1.80	1.52	2.48	2.44	1.52	3.21	3.08	8.49	3.91	1.64					2.56
970819	2.43	1.97	1.54	6.62	<1.20	1.20	<1.20	<1.20	<1.20	<1.20	<1.20	<1.20	DRY	DRY	<1.20	DRY	DRY	DRY	DRY	<1.20					<1.20
971013	1.60	1.47	2.22	DRY	1.52	1.59	1.54	1.59	1.79	1.57	1.62	1.82	DRY	DRY	2.20	3.18	DRY	3.66	3.70	11.40	1.60	6.31	DRY	DRY	6.44
980105	2.02	1.61	2.15	1.78	1.88	1.60	1.54	1.63	1.49	1.45	1.54	1.48	1.64	1.91	1.52	1.92	1.18	2.51	2.10	1.54	1.51	2.28	2.49	4.01	2.32
980126	1.07	0.86	1.04	1.00	0.63	0.92	0.82	0.85	0.96	0.78	0.77	0.88	1.13	1.47	1.18	2.09	1.29	3.17	2.60	1.25	0.79	2.88	4.51	8.09	2.68
980210	2.05	1.92	2.04	2.85	1.69	1.90	1.83	1.87	1.71	1.80	1.80	1.88	2.26	2.48	1.99	3.04	2.25	5.64	4.24	2.25	1.98	3.53	6.15	10.73	3.40
980427	1.74	1.36	1.32	1.50	1.32	1.27	1.32	1.30	1.23	1.31	1.61	1.29	1.57	1.83	1.43	1.78	1.51	2.17	2.21	1.65	2.08	1.52	4.87	3.47	2.46
980804	1.54	1.63	DRY	DRY	1.05	1.33	1.02	1.20	1.06	1.18	1.09	1.37	DRY	DRY	2.08	DRY	DRY	DRY	DRY	6.94	1.06	3.19	DRY	DRY	6.43

Date	Sulfates (mg/L) 125	124	122	123	121	120	119	Station Number (ARK***) 118	117	115	114	113	112	111	43	110	109	108	Boston Mountains Ecoregion Standard 15 mg/L 107	105	126	129	128	127	104
970616	9.40	7.60	12.40	14.90	7.60	7.60	7.60	9.40	7.60	9.40	5.30	5.30	5.30	7.60	5.30	7.60	11.00	18.20	11.00	5.30					5.30
970819	13.00	8.30	16.20	18.50	3.40	3.40	3.40	3.40	1.70	3.40	3.40	3.40	DRY	DRY	3.40	DRY	DRY	DRY	DRY	6.10					3.40
971013	8.29	5.81	15.50	DRY	5.06	6.41	3.80	4.68	3.71	3.49	4.30	3.22	DRY	DRY	3.81	2.18	DRY	8.14	3.78	15.50	2.85	7.07	DRY	DRY	2.74
980105	4.77	3.32	4.32	4.92	3.41	3.59	3.48	3.53	3.36	3.43	3.57	3.47	3.76	3.64	3.49	3.63	3.95	4.13	4.06	3.50	3.29	4.24	3.81	5.46	3.67
980126	2.43	1.96	4.47	5.98	1.49	2.54	1.76	2.18	2.55	1.61	1.80	2.10	1.88	1.84	2.03	1.67	2.90	2.80	2.84	2.20	1.62	3.64	2.45	10.10	2.30
980210	4.69	4.05	6.97	9.32	3.68	4.70	3.92	4.33	3.77	3.61	4.15	4.13	3.98	3.99	4.15	3.85	4.23	5.05	4.83	4.15	3.63	5.21	4.41	46.97	4.35
980427	4.04	3.37	4.32	5.48	3.17	3.50	3.14	3.33	3.20	3.20	3.56	3.31	3.60	3.56	3.34	3.29	3.55	4.10	4.00	3.52	3.86	3.20	8.99	3.80	3.50
980804	9.38	5.65	DRY	DRY	2.30	3.38	2.39	2.70	3.01	2.25	2.22	2.30	DRY	DRY	2.31	DRY	DRY	DRY	DRY	5.44	1.87	6.68	DRY	DRY	2.23

Date	Total Dissolved Solids (mg/L) 125	124	122	123	121	120	119	Station Number (ARK***) 118	117	115	114	113	112	111	43	110	109	108	Boston Mountains Ecoregion Standard 95 mg/L 107	105	126	129	128	127	104
970616	60	39	99	105	28	45	34	38	26	35	30	30	27	23	29	37	64	207	54	29					24
970819	81	58	155	178	34	56	52	57	35	32	31	44	DRY	DRY	40	DRY	DRY	DRY	DRY	44					25
971013	75	57	186	DRY	42	51	44	57	35	45	38	37	DRY	DRY	35	47	DRY	92	63	122	25	67	DRY	DRY	32
980105	42	37	61	73	31	42	32	35	31	30	31	42	33	32	44	35	33	54	43	46	31	41	52	65	44
980126	54	40	88	100	25	43	26	35	28	26	25	36	36	29	33	33	31	71	47	33	22	50	53	95	35
980210	50	35	75	94	23	42	28	36	24	23	25	29	25	24	31	25	27	54	33	33	21	32	41	138	27
980427	60	52	69	91	33	51	37	46	39	35	35	40	41	36	40	35	40	63	44	40	47	28	77	68	48
980804	59	42	DRY	DRY	37	58	24	37	26	20	20	26	DRY	DRY	28	DRY	DRY	DRY	DRY	35	19	32	DRY	DRY	27

Date	Total Organic Carbon (mg/L)							Station Number (ARK***)																	
	125	124	122	123	121	120	119	118	117	115	114	113	112	111	43	110	109	108	107	105	126	129	128	127	104
970616	QA	QA	QA	QA	QA	QA	QA	QA	QA	2.2	1.9	2.2	4.7	2.1	4.1	3	8.2	7.7	5.6	3.4					2.2
970819	2.6	2.3	2	2.2	1.8	2	2.6	1.9	1.6	1.8	1.5	2.8	DRY	DRY	2.7	DRY	DRY	DRY	DRY	3.7					3.2
971013	3.9	3.3	1.2	DRY	3.4	2.3	2.2	1.9	2.6	1.5	3.2	1.9	DRY	DRY	1.6	4.2	DRY	5.7	5	3.2	1.4	3.1	DRY	DRY	2.6
980105	3	2.6	3.4	3.6	2.6	3	3	2.9	2.3	3.2	2.8	4.5	4	4.1	4.8	4.4	4	4.9	4.5	6.4	3.1	5	6.6	11.9	5.4
980126	1.6	1.4	3.5	3.5	1.4	1.2	1.1	1.1	1.7	1.3	1.2	1	2.4	1.6	1.7	2.3	2	4.2	3.1	1.4	<1.0	3.4	2.7	8.9	1.5
980210	<1.0	<1.0	<1.0	1.2	1	1	<1.0	<1.0	<1.0	1	1.2	1.2	1.3	1.2	1.3	1.2	1.2	1.7	1.4	1.2	1.4	1.3	1.4	3.6	1.2
980427	4.1	4.2	3.5	4	2.6	3.7	4.8	3.7	2.7	2.4	2.5	3.3	4.6	2.9	3.7	3.3	2.7	3.4	4.4	3.3	4.8	3.4	10.6	9.4	5.6
980804	1.1	2.0	DRY	DRY	1.9	2.1	1.4	2.2	1.4	1.4	1.4	2.3	DRY	DRY	2.1	DRY	DRY	DRY	DRY	3.5	1.9	1.8	DRY	DRY	3.2

Date	Biochemical Oxygen Demand (mg/L)							Station Number (ARK***)																	
	125	124	122	123	121	120	119	118	117	115	114	113	112	111	43	110	109	108	107	105	126	129	128	127	104
970616	0.32	0.35	0.30	0.74	0.36	0.42	0.38	0.30	0.29	0.25	0.32	0.49	6.22	0.75	0.53	1.19	3.59	5.34	3.62	0.73					0.32
970819	0.10	0.20	0.20	0.60	0.50	0.30	0.30	0.40	0.10	0.60	0.30	0.60	DRY	DRY	0.50	DRY	DRY	DRY	DRY	1.30					0.70
971013	0.70	0.66	0.46	DRY	0.59	0.83	0.90	0.87	0.76	0.25	0.89	0.50	DRY	DRY	0.44	2.57	DRY	1.21	1.67	0.87	0.75	1.58	DRY	DRY	0.75
980105	0.39	0.28	0.38	0.31	0.11	0.35	0.30	0.36	0.08	0.18	0.16	0.93	0.34	0.29	1.27	0.78	0.27	0.58	0.77	1.80	0.36	0.79	1.87	2.57	1.51
980126	0.52	0.29	0.53	0.63	0.19	0.18	0.15	0.15	0.27	0.19	0.33	0.23	0.20	0.49	0.35	0.42	0.24	1.03	0.88	0.71	0.18	1.07	0.77	3.66	0.34
980210	0.15	0.11	0.17	0.27	0.16	0.24	0.17	0.05	0.11	<0.10	0.12	0.28	0.04	0.16	0.04	0.15	0.18	0.45	0.20	0.17	0.19	0.11	0.38	1.89	0.21
980427	1.24	1.23	0.46	0.63	0.27	1.04	0.77	0.88	0.21	0.36	0.30	1.44	0.57	0.43	1.57	0.82	0.32	0.85	1.55	1.61	1.72	0.83	5.88	5.91	2.99
980804	0.44	1.65	DRY	DRY	0.87	1.28	0.74	0.98	0.65	0.82	0.59	0.66	DRY	DRY	0.89	DRY	DRY	DRY	DRY	1.54	0.94	1.07	DRY	DRY	1.82

Date	Ammonia Nitrogen, NH_3-N (mg/L)							Station Number (ARK***)																	
	125	124	122	123	121	120	119	118	117	115	114	113	112	111	43	110	109	108	107	105	126	129	128	127	104
970616	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.691	0.060	<0.05					<0.05
970819	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.050	DRY	DRY	<0.05	DRY	DRY	DRY	DRY	<0.05					<0.05
971013	<0.05	<0.05	<0.05	DRY	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	DRY	DRY	<0.05	<0.05	DRY	0.046	0.017	<0.05	<0.05	0.008	DRY	DRY	0.005
980105	0.010	0.006	0.010	0.009	0.007	0.006	<0.05	<0.05	<0.05	<0.05	<0.05	0.007	0.006	0.005	0.011	0.035	<0.05	0.037	0.017	0.024	<0.05	0.014	0.030	0.061	0.027
980126	0.045	0.043	0.049	0.046	0.048	0.039	0.036	0.039	0.047	0.048	0.046	0.036	0.043	0.042	0.040	0.069	0.043	0.109	0.063	0.038	0.050	0.078	0.055	0.110	0.045
980210	0.020	0.019	0.018	0.017	0.021	0.032	0.068	0.030	0.017	0.017	0.015	0.012	0.018	0.024	0.010	0.020	0.018	0.140	0.020	0.049	0.019	0.019	0.013	0.027	0.019
980427	0.018	0.022	0.015	0.013	0.013	0.016	0.017	0.016	0.014	0.016	0.012	0.011	0.017	0.019	0.007	0.021	0.008	0.035	0.046	0.012	0.029	0.010	0.372	0.216	0.075
980804	<.005	<.005	DRY	DRY	<.005	<.005	0.005	0.018	<.005	<.005	<.005	0.008	DRY	DRY	<.005	DRY	DRY	DRY	DRY	0.005	<.005	0.007	DRY	DRY	0.041

	Nitrate+Nitrite Nitrogen, NO_3+NO_2-N (mg/L)							Station Number (ARK***)																	
Date	125	124	122	123	121	120	119	118	117	115	114	113	112	111	43	110	109	108	107	105	126	129	128	127	104
970616	0.115	0.057	0.062	0.172	0.214	<0.02	<0.02	<0.02	0.040	0.028	<0.02	<0.02	0.245	0.050	0.029	0.196	0.225	2.839	0.415	<0.02					0.088
970819	0.235	0.160	0.188	0.095	<0.02	<0.02	<0.02	0.040	<0.02	<0.02	<0.02	<0.02	DRY	DRY	<0.02	DRY	DRY	DRY	DRY	<0.02					<0.02
971013	0.154	0.094	0.449	DRY	0.027	0.064	0.015	0.057	0.015	0.021	0.124	0.017	DRY	DRY	0.063	0.191	DRY	1.497	1.302	<0.01	0.020	0.344	DRY	DRY	0.015
980105	0.137	0.086	0.116	0.152	0.021	0.086	0.043	0.085	0.019	0.048	0.058	0.074	0.112	0.173	0.080	0.584	0.044	1.071	0.511	0.103	0.052	0.605	1.140	0.935	0.392
980126	0.080	0.067	0.041	0.054	0.020	0.055	0.013	0.047	0.021	0.026	0.023	0.042	0.042	0.288	0.184	0.861	0.041	1.800	1.570	0.203	0.032	0.846	1.590	1.180	0.922
980210	0.091	0.096	0.064	0.101	0.061	0.061	0.058	0.067	0.053	0.055	0.059	0.059	0.092	0.238	0.107	0.612	0.075	3.112	0.682	0.140	0.064	0.700	1.591	0.750	0.655
980427	0.061	0.046	0.031	0.037	0.013	0.033	0.024	0.029	0.014	0.017	0.015	0.017	0.027	0.073	0.030	0.178	0.025	0.498	0.185	0.070	0.182	0.023	0.265	0.489	0.345
980804	0.214	0.028	DRY	DRY	<0.01	<0.01	0.057	<0.01	0.105	0.022	0.025	0.050	DRY	DRY	0.025	DRY	DRY	DRY	DRY	0.017	0.035	0.015	DRY	DRY	0.056

	Total Phosphorus (mg/L)							Station Number (ARK***)																	
Date	125	124	122	123	121	120	119	118	117	115	114	113	112	111	43	110	109	108	107	105	126	129	128	127	104
970616	0.040	0.040	0.050	0.070	0.040	0.040	0.040	0.040	0.040	0.050	0.030	0.040	0.170	0.060	0.040	0.130	0.230	1.540	0.290	0.050					0.050
970819	0.030	0.030	0.030	0.060	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	DRY	DRY	0.030	DRY	DRY	DRY	DRY	0.030					0.040
971013	0.060	0.060	0.060	DRY	0.060	0.060	0.050	0.060	0.050	0.060	0.050	0.030	DRY	DRY	0.030	0.070	DRY	0.200	0.150	0.050	0.040	0.120	DRY	DRY	0.040
980105	0.091	0.096	0.083	0.118	0.041	0.078	0.065	0.069	0.035	0.090	0.095	0.165	0.090	0.095	0.253	0.136	0.096	0.175	0.104	0.213	0.047	0.183	0.438	0.684	0.309
980126	<0.02	<0.02	0.021	0.022	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.056	<0.02	<0.02	<0.02	0.033	0.031	0.331	<0.02
980210	<0.02	0.021	0.024	0.030	0.024	0.026	0.021	0.023	0.024	0.022	0.026	0.023	0.023	0.021	0.023	0.025	0.022	0.040	0.024	0.022	0.020	0.023	0.024	0.040	0.021
980427	0.071	0.090	0.068	0.079	0.056	0.073	0.065	0.070	0.056	0.052	0.054	0.082	0.060	0.057	0.084	0.070	0.056	0.095	0.092	0.092	0.108	0.071	0.408	0.572	0.199
980804	0.032	0.028	DRY	DRY	0.024	0.027	0.023	0.025	0.021	0.033	0.024	0.023	DRY	DRY	0.026	DRY	DRY	DRY	DRY	0.029	0.026	0.030	DRY	DRY	0.044

	Ortho-Phosphorus (mg/L)							Station Number (ARK***)																	
Date	125	124	122	123	121	120	119	118	117	115	114	113	112	111	43	110	109	108	107	105	126	129	128	127	104
970616	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	0.509	0.062	<0.03					<0.03
970819	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	DRY	DRY	<0.03	DRY	DRY	DRY	DRY	<0.03					<0.03
971013	0.018	0.014	0.022	DRY	0.010	0.009	0.006	0.006	0.010	0.017	0.009	0.006	DRY	DRY	0.006	0.006	DRY	0.083	0.049	0.006	0.006	0.022	DRY	DRY	0.006
980105	0.015	0.014	0.026	0.030	0.007	0.018	0.011	0.012	0.011	0.010	0.010	0.019	0.011	0.015	0.023	0.040	0.012	0.042	0.024	0.026	0.014	0.052	0.191	0.369	0.055
980126	0.015	0.011	0.030	0.033	0.009	0.011	0.006	0.009	0.010	0.010	0.009	0.010	0.013	0.016	0.009	0.018	0.011	0.075	0.027	0.009	0.009	0.054	0.044	0.351	0.015
980210	0.006	0.006	0.011	0.013	0.006	0.010	0.006	0.008	0.006	0.006	0.006	0.006	0.009	0.008	0.006	0.008	0.006	0.023	0.006	0.008	0.006	0.006	0.006	0.006	0.102
980427	0.018	0.028	0.020	0.024	0.014	0.017	0.014	0.015	0.013	0.013	0.011	0.012	0.015	0.015	0.012	0.020	0.012	0.029	0.029	0.022	0.029	0.011	0.280	0.406	0.095
980804	0.011	0.005	DRY	DRY	0.005	0.005	0.006	0.005	0.005	0.006	0.005	0.005	DRY	DRY	0.005	DRY	DRY	DRY	DRY	0.006	0.005	0.005	DRY	DRY	0.005

Date	Total Hardness (mg/L) 125	124	122	123	121	120	119	Station Number (ARK***) 118	117	115	114	113	112	111	43	110	109	108	107	105	126	129	128	127	104
970616	52	29	88	90	15	36	22	32	14	9	14	27	11	7	26	10	9	16	12	25					10
970819	60	40	143	155	20	45	38	40	18	10	16	32	DRY	DRY	28	DRY	DRY	DRY	DRY	27					13
971013	51	33	176	DRY	21	37	35	46	13	11	16	27	DRY	DRY	23	27	DRY	19	13	55	11	19	DRY	DRY	13
980105	19	12	33	43	6	16	9	11	6	6	8	10	6	6	10	7	6	10	8	8	5	8	12	16	7
980126	36	23	56	68	8	28	14	23	7	6	10	17	6	7	11	8	6	14	11	16			14	33	11
980210	39	23	63	81	9	29	16	24	8	6	10	17	6	7	17	7	7	22	11	18	6	11	15	90	10
980427	27	16	36	61	6	19	9	14	6	5	9	12	6	6	11	5	6	10	9	15	7	5	21	11	8
980804	66	41	DRY	DRY	36	60	19	30	24	10	9	23	DRY	DRY	21	DRY	DRY	DRY	DRY	22	12	19	DRY	DRY	17

Date	Fecal Coliform (Colonies/100ml) 125	124	122	123	121	120	119	Station Number (ARK***) 118	117	115	114	113	112	111	43	110	109	108	107	105	126	129	128	127	104
970616	168	>240	>240	>240	220	56	44	86	~7	144	58	128	>600	>600	260	>600	>600	>1200	>600	530					>600
970819	>410	256	284	204	60	50	~27	96	~48	~11	>268	~9	DRY	DRY	~17	DRY	DRY	DRY	DRY	~12					40
971013	>600	>600	>600	>600	>600	>600	>600	>600	>600	>600	>170	NT*	DRY	DRY	240	>4300	DRY	>6000	>6000	104	>600	>7100	DRY	DRY	>410
980105	~82	220	190	200	~109	~9	~91	~73	~18	>20	>20	260	~20	~80	300	~218	~100	~173	350	~773	~40	560	>2500	11200	~885
980126	>600	300	>580	>710	~17	108	~14	~23	~9	~14	~40	~34	~20	~47	340	>600	~51	350	>600	~129	~6	3200	590	6000	420
980210	~7	~26	~9	~46	~9	~9	~20	~6	~1	~9	~9	~40	~69	116	116	~23	~41	~20	~61	224	>290	~29	160	>610	~17
980427	1160	1180	440	860	~73	1000	500	>160	460	~53	84	>700	>780	252	>1100	>1020	232	>1040	>1600	>1600	>640	>1600	>1600	>1600	>1600
980804	~9	~17	DRY	DRY	~46	~37	480	~34	~20	780	420	230	DRY	DRY	~46	DRY	DRY	DRY	DRY	>600	600	164	DRY	DRY	>600

NT - Flows were not taken due to excessive velocity and depth.
DRY - The sample site had no water.
QA - Samples were analyzed and the data did not fall within QA/QC requirements. Sample holding time was exceeded before a second analysis could occur.

Note: In December, 1997, the laboratory used during this survey installed a more sensitive analytical machine and improved on analytical methods. These changes enabled the lab to lower the detection limits of many parameters, minerals and nutrients, and improved the low-end accuracy of these parameters.

Appendix WQ-1
Metals Data

	Aluminum (ug/L)							Station Number (ARK***)																	
Date	125	124	122	123	121	120	119	118	117	115	114	113	112	111	43	110	109	108	107	105	126	129	128	127	104
970616	<16	<16	<16	<16	<16	<16	<16	<16	<16	24.9	<16	21.0	16.6	17.5	<16	28.9	96.1	326.1	53.2	24.0					25.7
970819	65.3	71.2	70.0	67.3	80.0	87.6	<16	<16	<16	72.2	62.5	40.6	DRY	DRY	31.4	DRY	DRY	DRY	DRY	<16					<16
971013	<16	<16	<16	DRY	<16	<16	<16	<16	<16	<16	<16	<16	DRY	DRY	<16	<16	DRY	38.3	40.5	<16	<16	<16	DRY	DRY	<16
980105	21.5	23.5	20.9	16.2	48.8	35.1	51.4	54.3	49.2	42.5	36.2	60.1	75.1	73.0	70.5	68.5	78.0	62.3	61.9	82.3	65.8	106.5	118.4	117.9	95.8
980126	17.2	29.9	25.0	30.9	37.0	24.4	38.3	40.6	74.3	46.1	46.0	33.8	63.7	40.7	28.8	40.3	35.1	82.8	80.2	<16			48.1	73.7	24.1
980210	19.6	20.3	18.8	<16	39.7	17.8	19.5	18.0	43.9	16.0	<16	<16	18.3	22.7	<16	<16	40.3	34.4	38.6	28.8	39.3	34.9	30.0	19.8	30.8
980427	42.6	62.1	16.5	41.8	44.2	31.3	53.6	48.5	44.6	49.9	44.1	37.9	56.6	52.9	46.0	66.5	40.7	47.2	43.8	<16	55.1	31.8	50.2	100.4	43.6
980804	<127	<127	DRY	DRY	<127	<127	<127	<127	<127	<127	<127	<127	DRY	DRY	<127	DRY	DRY	DRY	DRY	<127	<127	<127	DRY	DRY	<127

	Boron (ug/L)							Station Number (ARK***)																	
Date	125	124	122	123	121	120	119	118	117	115	114	113	112	111	43	110	109	108	107	105	126	129	128	127	104
970616	6.7	<3.0	<3.0	10.5	<3.0	<3.0	<3.0	<3.0	<3.0	6.6	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	6.0	<3.0	<3.0					<3.0
970819	8.2	7.5	6.6	19.7	6.7	6.8	9.1	8.5	7.2	9.6	8.9	7.9	DRY	DRY	8.3	DRY	DRY	DRY	DRY	10.5					21.0
971013	5.7	3.7	8.1	DRY	5.7	4.7	5.9	4.2	3.9	6.0	5.0	7.0	DRY	DRY	6.3	9.1	DRY	14.2	12.8	19.6	4.6	16.7	DRY	DRY	10.9
980105	7.6	5.3	4.5	6.2	3.6	4.1	3.3	3.1	3.9	3.2	<3.0	<3.0	3.7	4.1	3.5	3.7	3.1	6.1	5.4	5.4	3.1	4.7	6.7	7.3	6.9
980126	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	3.4	<3.0	<3.0			<3.0	10.2	4.1
980210	3.3	<3.0	<3.0	6.8	<3.0	<3.0	4.6	<3.0	3.4	3.0	3.0	<3.0	3.3	3.9	<3.0	4.5	<3.0	5.4	<3.0	<3.0	3.6	3.6	<3.0	18.8	<3.0
980427	5.1	<3.0	6.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	7.1	<3.0	<3.0	<3.0	<3.0	7.5	9.7	9.6	8.3	9.7	9.4	16.9	14.0	10.6
980804	9.4	10.1	DRY	DRY	14.8	12.4	<4.5	11.4	11.6	11.2	9.7	10.0	DRY	DRY	9.0	DRY	DRY	DRY	DRY	10.7	9.3	14.0	DRY	DRY	9.3

	Barium (ug/L)							Station Number (ARK***)																	
Date	125	124	122	123	121	120	119	118	117	115	114	113	112	111	43	110	109	108	107	105	126	129	128	127	104
970616	13.8	11.7	15.5	15.0	6.9	11.1	10.1	11.1	6.3	6.9	7.3	9.8	11.9	7.3	9.2	12.0	10.4	11.6	14.9	10.7					11.4
970819	14.1	12.0	22.8	25.3	7.3	10.8	12.5	11.2	7.3	7.6	10.7	9.5	DRY	DRY	8.6	DRY	DRY	DRY	DRY	11.2					14.0
971013	13.4	11.2	26.8	DRY	8.7	12.8	14.1	13.8	7.5	8.1	7.9	10.8	DRY	DRY	8.1	26.9	DRY	12.1	18.1	34.0	6.3	16.0	DRY	DRY	16.4
980105	8.5	7.0	7.8	8.2	5.0	8.1	7.5	7.3	5.0	4.8	4.3	5.6	6.5	6.8	5.5	12.2	7.3	6.8	11.8	7.3	5.9	12.0	21.9	17.5	8.4
980126	9.2	7.1	9.1	11.0	<4.0	8.0	7.1	7.9	4.4	4.8	5.9	6.4	6.6	8.9	9.7	14.3	7.3	12.4	16.5	9.1			23.8	25.9	13.5
980210	9.8	8.6	9.7	11.8	4.2	8.3	8.1	8.2	4.6	4.5	6.2	6.5	6.0	7.9	6.7	12.1	7.6	17.4	17.2	8.4	5.0	14.7	26.6	34.2	12.6
980427	8.2	6.5	7.1	9.1	<4.0	5.9	4.9	6.0	<4.0	<4.0	4.3	5.8	5.4	6.5	5.7	9.0	6.9	6.8	10.9	8.7	9.8	4.8	18.6	25.3	12.2
980804	18.4	18.4	DRY	DRY	14.6	17.7	9.1	14.4	10.4	<8.8	<8.8	<8.8	DRY	DRY	<8.8	DRY	DRY	DRY	DRY	13.2	<8.8	24.1	DRY	DRY	18.1

Date	Beryllium (ug/L)							Station Number (ARK***)																	
	125	124	122	123	121	120	119	118	117	115	114	113	112	111	43	110	109	108	107	105	126	129	128	127	104
970616	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0					<2.0
970819	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	DRY	DRY	<2.0	DRY	DRY	DRY	DRY	<2.0					<2.0
971013	<2.0	<2.0	<2.0	DRY	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	DRY	DRY	<2.0	<2.0	DRY	<2.0	<2.0	<2.0	<2.0	<2.0	DRY	DRY	<2.0
980105	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
980126	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0			<2.0	<2.0	<2.0
980210	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
980427	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
980804	<2.0	<2.0	DRY	DRY	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	DRY	DRY	<2.0	DRY	DRY	DRY	DRY	<2.0	<2.0	<2.0	DRY	DRY	<2.0

Date	Calcium (mg/L)							Station Number (ARK***)																	
	125	124	122	123	121	120	119	118	117	115	114	113	112	111	43	110	109	108	107	105	126	129	128	127	104
970616	18.0	9.3	31.8	32.8	3.8	12.0	6.8	10.4	3.1	1.6	3.8	9.0	2.0	1.3	8.3	1.8	1.6	2.5	2.2	7.9					2.0
970819	20.9	13.5	52.8	57.1	5.3	15.6	11.5	13.1	4.3	2.0	4.4	10.1	DRY	DRY	8.6	DRY	DRY	DRY	DRY	7.8					2.0
971013	18.0	11.0	65.3	DRY	5.2	12.0	10.8	15.2	2.8	2.0	4.2	7.8	DRY	DRY	6.9	5.3	DRY	3.0	2.2	14.7	2.0	3.1	DRY	DRY	2.0
980105	6.4	3.8	11.7	15.6	1.4	5.0	2.7	3.2	1.2	1.0	2.2	3.0	1.1	1.1	2.8	1.3	1.0	1.6	1.5	2.3	1.0	1.6	2.5	3.3	1.3
980126	12.5	7.5	20.3	24.8	1.9	9.6	4.4	7.7	1.5	1.3	2.5	5.3	1.0	1.1	4.1	1.4	0.9	2.3	1.9	4.8			2.4	6.3	1.9
980210	13.6	7.6	22.7	29.6	2.3	10.0	4.8	8.0	1.8	1.1	2.7	5.4	1.0	1.1	5.1	1.2	1.1	3.4	1.9	5.4	1.0	2.0	2.7	16.3	1.9
980427	9.6	5.2	12.8	22.5	1.4	6.2	2.6	4.5	1.2	1.0	2.3	3.7	1.0	0.9	3.1	0.9	0.9	1.7	1.6	4.5	1.3	0.9	3.9	2.1	1.6
980804	22.6	12.6	DRY	DRY	9.6	20.2	5.6	8.6	5.2	1.7	1.7	6.6	DRY	DRY	5.5	DRY	DRY	DRY	DRY	5.0	2.1	3.4	DRY	DRY	2.7

Date	Cadmium (ug/L)							Station Number (ARK***)																	
	125	124	122	123	121	120	119	118	117	115	114	113	112	111	43	110	109	108	107	105	126	129	128	127	104
970616	<0.04	0.10	<0.04	<0.04	<0.04	<0.04	0.05	0.05	0.10	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04					<0.04
970819	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	0.27	<0.04	0.08	<0.04	DRY	DRY	<0.04	DRY	DRY	DRY	DRY	0.57					0.05
971013	<0.04	<0.04	<0.04	DRY	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	0.06	0.33	DRY	DRY	<0.04	0.06	DRY	<0.04	0.40	<0.04	<0.04	0.07	DRY	DRY	0.04
980105	<0.04	0.05	<0.04	<0.04	0.05	<0.04	<0.04	<0.04	0.04	<0.04	<0.04	<0.04	0.19	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
980126	<0.04	0.14	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	0.16	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04			<0.04	<0.04	<0.04
980210	<0.04	<0.04	<0.04	<0.04	0.04	<0.04	<0.04	<0.04	<0.04	0.18	0.12	0.07	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	0.19	<0.04
980427	<0.04	<0.04	<0.04	<0.04	0.05	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
980804	<0.14	<0.14	DRY	DRY	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	DRY	DRY	<0.14	DRY	DRY	DRY	DRY	<0.14	<0.14	<0.14	DRY	DRY	<0.14

Date	Cobalt (ug/L)							Station Number (ARK***)																
	125	124	122	123	121	120	119	118	117	115	114	113	112	111	43	110	109	108	107	105	126	129	128	127	104
970616	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0					<3.0
970819	<3.0	<3.0	<3.0	<3.0	<3.0	3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	DRY	DRY	<3.0	DRY	DRY	DRY	DRY	<3.0					<3.0
971013	<3.0	<3.0	<3.0	DRY	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	DRY	DRY	<3.0	<3.0	DRY	<3.0	<3.0	<3.0	<3.0	<3.0	DRY	DRY	<3.0
980105	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
980126	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0			<3.0	<3.0	<3.0
980210	<3.0	<3.0	<3.0	<3.0	<3.0	3.2	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	3.2	<3.0	<3.0	<3.0
980427	<3.0	<3.0	<3.0	3.6	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
980804	<0.5	<0.5	DRY	DRY	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	DRY	DRY	<0.5	DRY	DRY	DRY	DRY	<0.5	<0.5	0.7	DRY	DRY	<0.5

Date	Chromium (ug/L)							Station Number (ARK***)																
	125	124	122	123	121	120	119	118	117	115	114	113	112	111	43	110	109	108	107	105	126	129	128	127	104
970616	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	0.49	<0.4	<0.4	<0.4	0.4	<0.4	<0.4	0.7	0.9	0.6	<0.4					<0.4
970819	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	DRY	DRY	<0.4	DRY	DRY	DRY	DRY	<0.4					<0.4
971013	<0.4	<0.4	<0.4	DRY	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	DRY	DRY	<0.4	<0.4	DRY	<0.4	<0.4	<0.4	<0.4	<0.4	DRY	DRY	<0.4
980105	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
980126	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4			<0.4	<0.4	<0.4
980210	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
980427	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
980804	<0.4	<0.4	DRY	DRY	<0.4	0.9	0.5	0.6	<0.4	0.6	0.7	<0.4	DRY	DRY	0.6	DRY	DRY	DRY	DRY	0.5	<0.4	<0.4	DRY	DRY	<0.4

Date	Copper (ug/L)							Station Number (ARK***)																
	125	124	122	123	121	120	119	118	117	115	114	113	112	111	43	110	109	108	107	105	126	129	128	127	104
970616	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0					<2.0
970819	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	DRY	DRY	<2.0	DRY	DRY	DRY	DRY	<2.0					<2.0
971013	<2.0	<2.0	<2.0	DRY	<2.0	<2.0	<2.0	<2.0	<2.0	2.1	<2.0	3.7	DRY	DRY	<2.0	3.3	DRY	2.6	5.6	<2.0	<2.0	2.4	DRY	DRY	<2.0
980105	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
980126	<2.0	<2.0	4.5	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0			<2.0	3.3	<2.0
980210	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
980427	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	9.1	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	16.4	13.4	2.6
980804	<0.5	<0.5	DRY	DRY	<0.5	<0.5	<0.5	1.0	<0.5	0.6	<0.5	0.6	DRY	DRY	<0.5	DRY	DRY	DRY	DRY	0.5	<0.5	<0.5	DRY	DRY	0.6

	Iron (ug/L)							Station Number (ARK***)																	
Date	125	124	122	123	121	120	119	118	117	115	114	113	112	111	43	110	109	108	107	105	126	129	128	127	104
970616	4.0	8.0	3.0	5.0	11.0	12.0	26.0	24.0	11.0	18.0	14.0	26.0	93.0	16.0	28.0	71.0	98.0	246.0	10 2.0	27.0					127.0
970819	4.6	5.4	<1.8	<1.8	6.2	11.7	18.9	15.2	7.6	8.9	38.8	14.7	DRY	DRY	55.3	DRY	DRY	DRY	DRY	16.3					112.0
971013	31.4	36.1	<1.8	DRY	53.4	23.7	37.8	25.4	59.4	27.5	33.2	13.4	DRY	DRY	72.2	168.0	DRY	120.0	132.0	3.8	64.2	45.7	DRY	DRY	60.8
980105	16.6	8.0	15.1	16.0	18.9	23.7	27.4	42.3	23.1	28.9	28.8	72.1	45.2	43.1	91.2	45.5	51.1	73.8	54.3	131.0	33.6	59.3	106.0	114.0	114.0
980126	19.5	17.3	53.6	68.0	29.1	15.0	22.4	17.9	35.0	25.2	34.0	21.9	64.5	33.2	29.3	35.5	31.6	144.0	108.0	31.3			80.7	182.0	39.8
980210	8.2	14.8	17.1	4.3	24.4	10.4	15.2	12.7	25.1	16.4	17.1	13.3	17.7	15.6	16.1	12.1	22.7	28.0	26.0	29.5	20.9	50.9	38.4	41.7	33.3
980427	151.0	66.2	27.5	62.7	44.6	38.4	69.5	66.3	45.7	53.1	57.5	65.3	64.4	62.3	61.7	72.7	62.2	137.0	121.0	71.5	138.0	44.7	253.0	232.0	141.0
980804	<15.0	50.9	DRY	DRY	63.3	<15	110.0	176.0	23.8	29.7	47.2	72.2	DRY	DRY	87.4	DRY	DRY	DRY	DRY	26.7	172.0	164.0	DRY	DRY	253.0

	Potassium (mg/L)							Station Number (ARK***)																	
Date	125	124	122	123	121	120	119	118	117	115	114	113	112	111	43	110	109	108	107	105	126	129	128	127	104
970616	1.0	1.0	1.1	0.9	1.0	0.9	0.9	1.0	1.4	1.0	0.9	1.0	1.9	0.9	0.9	1.7	1.7	6.6	2.6	0.9					1.0
970819	0.7	0.7	0.7	0.9	0.7	0.6	0.6	0.7	0.7	0.6	0.6	0.7	DRY	DRY	0.6	DRY	DRY	DRY	DRY	0.7					1.1
971013	1.0	1.0	1.1	DRY	1.1	1.1	1.1	1.1	0.9	0.9	0.9	1.1	DRY	DRY	0.9	2.8	DRY	3.4	2.9	2.0	0.9	1.9	DRY	DRY	1.5
980105	3.4	3.6	2.4	3.2	2.3	2.1	1.8	2.8	2.2	4.6	4.2	4.5	3.5	3.4	4.4	4.5	3.9	5.4	4.7	4.9	1.6	1.4	2.4	3.8	4.6
980126	1.8	1.5	0.7	1.0	0.1	0.4	<0.1	<0.1	0.3	1.5	2.2	1.8	1.8	2.0	2.0	2.2	1.4	2.7	3.0	2.2			3.0	6.0	2.6
980210	0.3	0.1	0.3	0.4	0.3	0.3	0.3	0.2	0.2	0.4	0.4	0.3	0.4	0.4	0.4	0.6	0.2	1.3	0.3	0.2	0.1	0.4	0.5	1.0	0.4
980427	0.2	0.1	0.4	0.2	0.3	0.3	0.3	0.3	0.5	0.2	0.4	0.4	0.4	0.3	0.4	0.4	0.3	0.7	0.8	0.7	0.9	0.5	3.2	2.5	1.3
980804	0.9	<0.5	DRY	DRY	1.8	0.7	0.5	0.6	1.3	1.0	0.8	2.0	DRY	DRY	1.8	DRY	DRY	DRY	DRY	2.4	1.4	2.5	DRY	DRY	2.0

	Magnesium (mg/L)							Station Number (ARK***)																	
Date	125	124	122	123	121	120	119	118	117	115	114	113	112	111	43	110	109	108	107	105	126	129	128	127	104
970616	1.6	1.4	2.1	1.9	1.5	1.5	1.3	1.4	1.5	1.2	1.1	1.2	1.5	1.0	1.2	1.3	1.3	2.3	1.6	1.3					1.3
970819	1.8	1.6	2.7	2.9	1.6	1.5	2.2	1.7	1.9	1.4	1.3	1.7	DRY	DRY	1.6	DRY	DRY	DRY	DRY	1.8					1.9
971013	1.6	1.5	3.2	DRY	1.9	1.6	1.8	1.9	1.6	1.5	1.3	1.8	DRY	DRY	1.5	3.4	DRY	2.7	1.8	4.5	1.4	2.7	DRY	DRY	2.0
980105	0.7	0.7	1.0	1.0	0.7	0.7	0.6	0.7	0.8	0.8	0.7	0.7	0.8	0.8	0.7	0.9	0.8	1.4	1.1	0.6	0.7	1.1	1.3	1.9	0.8
980126	1.1	0.9	1.4	1.5	0.8	1.1	0.8	1.0	0.8	0.8	0.8	0.9	0.9	0.9	1.0	1.1	0.9	2.0	1.5	1.1			1.9	4.1	1.4
980210	1.2	1.0	1.5	1.7	0.9	1.1	0.9	1.0	0.8	0.8	0.8	0.9	0.9	1.0	1.0	1.1	1.0	3.2	1.6	1.1	0.7	1.6	2.1	12.0	1.3
980427	0.8	0.8	1.1	1.3	0.6	0.8	0.6	0.7	0.7	0.7	0.7	0.7	0.9	0.8	0.8	0.7	0.9	1.4	1.3	0.9	1.0	0.7	2.8	1.3	1.1
980804	2.2	2.3	DRY	DRY	3.0	2.3	1.3	1.9	2.7	1.4	1.3	1.7	DRY	DRY	1.6	DRY	DRY	DRY	DRY	2.3	1.7	2.6	DRY	DRY	2.6

Date	Manganese (ug/L) 125	124	122	123	121	120	119	Station Number (ARK***) 118	117	115	114	113	112	111	43	110	109	108	107	105	126	129	128	127	104
970616	3.1	7.7	6.9	3.0	4.6	8.2	7.2	12.8	<2.0	2.2	6.2	6.1	25.5	19.5	12.8	40.9	18.7	90.7	37.5	9.6					55.7
970819	2.1	9.9	18.7	10.5	<2.0	3.7	4.4	7.0	2.4	21.8	70.8	<2.0	DRY	DRY	29.1	DRY	DRY	DRY	DRY	<2.0					77.0
971013	4.6	6.1	8.2	DRY	6.3	9.1	9.4	10.1	3.0	2.4	9.2	3.0	DRY	DRY	19.1	408.0	DRY	4.6	6.5	6.1	36.5	45.4	DRY	DRY	66.4
980105	4.2	4.6	3.1	2.5	4.6	7.0	6.8	7.9	3.6	4.4	3.8	14.5	6.6	4.5	16.8	12.0	3.5	27.1	23.9	45.5	7.1	26.6	64.4	61.7	46.5
980126	2.2	2.2	5.6	2.5	2.0	3.9	4.2	6.9	<2.0	<2.0	<2.0	4.8	2.4	2.7	10.5	5.9	<2.0	29.8	12.5	19.8			27.7	73.3	22.7
980210	<2.0	7.1	2.6	<2.0	2.4	4.1	5.4	7.0	<2.0	<2.0	<2.0	5.6	<2.0	<2.0	8.7	2.5	<2.0	23.1	6.6	20.9	3.0	17.9	23.4	83.6	19.6
980427	5.8	4.6	2.2	3.0	2.5	4.6	5.6	5.3	2.0	<2.0	2.5	8.0	4.3	5.4	11.5	8.4	2.6	15.6	20.8	25.7	18.6	4.9	96.1	54.8	32.4
980804	21.5	73.1	DRY	DRY	63.3	7.7	12.2	143.4	50.1	36.3	52.1	13.2	DRY	DRY	20.7	DRY	DRY	DRY	DRY	48.7	51.9	481.3	DRY	DRY	215.2

Date	Sodium (mg/L) 125	124	122	123	121	120	119	Station Number (ARK***) 118	117	115	114	113	112	111	43	110	109	108	107	105	126	129	128	127	104
970616	1.3	0.9	1.4	4.0	1.2	1.6	1.1	1.0	1.1	1.3	0.6	0.2	0.7	0.5	0.3	1.1	0.3	1.5	1.8	0.1					0.8
970819	3.4	1.0	1.8	5.7	2.0	1.8	1.5	1.1	2.0	1.3	1.0	1.9	DRY	DRY	2.1	DRY	DRY	DRY	DRY	3.9					2.9
971013	1.5	2.4	1.9	DRY	1.3	1.8	2.5	1.8	2.4	1.8	2.1	2.1	DRY	DRY	2.0	3.0	DRY	3.1	3.3	21.2	2.5	6.9	DRY	DRY	4.1
980105	3.1	3.1	2.6	3.3	2.9	2.6	2.5	2.7	2.4	3.1	2.9	3.0	2.8	2.4	3.0	3.2	3.0	3.6	3.1	3.1	2.2	2.4	3.1	3.6	3.0
980126	3.6	3.2	3.0	3.6	3.3	3.4	3.3	3.2	2.8	3.8	3.7	3.4	3.4	4.1	3.9	4.4	4.0	5.7	5.1	3.6			5.6	9.3	4.5
980210	0.4	0.4	1.4	2.3	0.8	0.7	1.0	0.5	0.7	1.2	1.0	0.9	1.5	1.9	1.1	1.7	1.1	4.1	1.9	0.6	0.3	1.6	3.3	11.3	1.8
980427	1.0	0.5	0.9	0.8	0.6	0.8	0.6	1.0	1.0	0.7	1.2	1.4	1.2	1.3	0.9	1.4	1.5	2.0	2.0	1.0	1.4	0.6	4.1	2.5	1.7
980804	1.8	2.1	DRY	DRY	1.8	2.1	1.5	2.0	2.1	1.9	1.8	2.1	DRY	DRY	2.6	DRY	DRY	DRY	DRY	6.4	1.8	5.2	DRY	DRY	4.7

Date	Nickel (ug/L) 125	124	122	123	121	120	119	Station Number (ARK***) 118	117	115	114	113	112	111	43	110	109	108	107	105	126	129	128	127	104
970616	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0					<5.0
970819	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	DRY	DRY	<5.0	DRY	DRY	DRY	DRY	<5.0					<5.0
971013	<5.0	<5.0	<5.0	DRY	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	DRY	DRY	<5.0	<5.0	DRY	<5.0	<5.0	<5.0	<5.0	<5.0	DRY	DRY	<5.0
980105	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
980126	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0			<5.0	<5.0	<5.0
980210	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
980427	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
980804	<2.0	<2.0	DRY	DRY	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	DRY	DRY	<2.0	DRY	DRY	DRY	DRY	<2.0	<2.0	<2.0	DRY	DRY	<2.0

Date	Lead (ug/L)							Station Number (ARK***)																	
	125	124	122	123	121	120	119	118	117	115	114	113	112	111	43	110	109	108	107	105	126	129	128	127	104
970616	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	4.2	<0.4					<0.4
970819	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	1.2	<0.4	<0.4	<0.4	DRY	DRY	<0.4	DRY	DRY	DRY	DRY	0.4					<0.4
971013	<0.4	<0.4	<0.4	DRY	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	DRY	DRY	<0.4	<0.4	DRY	<0.4	<0.4	<0.4	<0.4	<0.4	DRY	DRY	<0.4
980105	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	0.6	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
980126	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	1.5	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4			<0.4	<0.4	<0.4
980210	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
980427	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
980804	<0.4	<0.4	DRY	DRY	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	DRY	DRY	<0.4	DRY	DRY	DRY	DRY	<0.4	<0.4	<0.4	DRY	DRY	<0.4

Date	Vanadium (ug/L)							Station Number (ARK***)																	
	125	124	122	123	121	120	119	118	117	115	114	113	112	111	43	110	109	108	107	105	126	129	128	127	104
970616	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0					<5.0
970819	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	DRY	DRY	<5.0	DRY	DRY	DRY	DRY	<5.0					<5.0
971013	<5.0	<5.0	<5.0	DRY	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	DRY	DRY	<5.0	<5.0	DRY	<5.0	<5.0	<5.0	<5.0	<5.0	DRY	DRY	<5.0
980105	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
980126	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0			<5.0	<5.0	<5.0
980210	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
980427	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
980804	<1.0	<1.0	DRY	DRY	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	DRY	DRY	<1.0	DRY	DRY	DRY	DRY	<1.0	<1.0	<1.0	DRY	DRY	<1.0

Date	Zinc (ug/L)							Station Number (ARK***)																	
	125	124	122	123	121	120	119	118	117	115	114	113	112	111	43	110	109	108	107	105	126	129	128	127	104
970616	<2.0	6.2	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	8.2	2.1	3.2	<2.0	<2.0	3.4	6.7	6.9	7.0					4.1
970819	<2.0	<2.0	<2.0	4.2	<2.0	<2.0	<2.0	<2.0	<2.0	7.3	<2.0	<2.0	DRY	DRY	3.4	DRY	DRY	DRY	DRY	4.9					3.0
971013	<2.0	<2.0	2.4	DRY	<2.0	2.4	<2.0	<2.0	3.2	2.5	<2.0	2.2	DRY	DRY	<2.0	3.9	DRY	4.9	5.9	<2.0	<2.0	<2.0	DRY	DRY	<2.0
980105	<2.0	<2.0	<2.0	3.1	2.3	<2.0	<2.0	2.1	2.7	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	2.6	<2.0	2.2	3.7	4.1	4.3	<2.0
980126	2.5	10.3	10.2	9.0	<2.0	<2.0	3.2	4.9	3.9	6.6	2.9	2.1	2.1	<2.0	3.4	<2.0	2.1	3.5	5.2	<2.0			2.7	9.9	2.3
980210	<2.0	<2.0	<2.0	2.8	3.1	2.1	<2.0	6.5	8.1	<2.0	2.0	<2.0	<2.0	<2.0	<2.0	3.1	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	3.9	<2.0
980427	3.6	2.1	<2.0	3.5	<2.0	<2.0	<2.0	<2.0	2.5	<2.0	4.8	<2.0	<2.0	2.8	<2.0	2.2	2.6	4.8	4.1	2.0	2.3	<2.0	4.9	5.2	5.5
980804	3.1	<1.0	DRY	DRY	5.7	1.7	1.3	6.0	2.1	6.4	1.2	2.8	DRY	DRY	1.2	DRY	DRY	DRY	DRY	2.9	8.6	16.1	DRY	DRY	5.1

APPENDIX M-1

RAW DATA VALUES AND METRIC SCORES FOR MULTI-METRIC ANALYSIS OF COLLECTED AQUATIC MACROINVERTEBRATE SAMPLES.

Appendix M-1
Raw data values and metric scores for multi-metric analysis of collected aquatic macroinvertebrate samples.

August Raw Data Scores

	ARK124	ARK120	ARK116	ARK113	BIOL SITE
Taxa Richness	21	20	18	19	17
EPT Index	7	7	7	9	8
HBI	2.5	2.7	2.9	2.8	2.6
% Contribution of Dominant Taxa	28	22	30	31	18
Scraper / Scraper+ Filter Feeder Abundances	1.0	1.0	0.95	0.98	0.96

August Metric Scores

	ARK124	ARK120	ARK116	ARK113	BIOL SITE
Taxa Richness	6	6	6	6	6
EPT Index	6	6	6	6	6
HBI	6	6	6	6	6
% Contribution of Dominant Taxa	4	4	4	2	6
Scraper Abundance / Scraper +Filter Feeder Abundance	6	6	6	6	6
Total	34	34	32	30	34
% of Reference	Reference	100%	94%	88%	100%

November Small Watershed Raw Data Scores

	ARK125	ARK121	ARK117	ARK110	ARK129
Taxa Richness	15	19	16	12	11
EPT Index	10	9	9	4	5
HBI	2.0	2.3	2.6	2.7	2.1
% Contribution of Dominant Taxa	26	27	46	50	40
Scraper / Filterer+Scraper Abundances	1.00	0.97	0.92	1.00	1.00

November Small Watershed Metric Scores

	ARK125	ARK121	ARK117	ARK110	ARK129
Taxa Richness	6	6	6	4	4
EPT Index	6	4	4	0	0
HBI	6	6	4	4	6
% Contribution of Dominant Taxa	4	4	0	0	2
Scraper / Filterer+Scraper Abundances	6	6	6	6	6
Total	28	26	20	14	18
% of Reference		93%	71%	50%	64%

November Large Watershed Raw Scores

	ARK124	ARK120	ARK119	ARK116	ARK114	ARK113	Bio Site	ARK126	ARK104
Taxa Richness	15	18	18	21	6	13	14	23	15
EPT Index	11	10	9	13	3	8	7	9	8
HBI	2.1	2.2	1.8	2.4	1.5	1.8	2.7	2.5	2.2
% Contribution of Dominant Taxa	46	30	30	46	87	42	26	14	30
Scraper / Filterer+Scraper Abundances	1.00	0.91	0.74	1.00	1.00	0.78	0.84	0.78	0.84

November Large Watershed Metric Scores

	ARK124	ARK120	ARK119	ARK116	ARK114	ARK113	Bio Site	ARK126	ARK104
Taxa Richness	6	6	6	6	2	6	6	6	6
EPT Index	6	6	4	6	0	2	0	2	2
HBI	6	6	6	6	6	6	4	6	6
% Contribution of Dominant Taxa	0	2	4	0	0	0	4	2	2
Scraper / Filterer+Scraper Abundances	6	6	6	6	6	6	6	6	6
Total	24	26	26	24	16	20	20	22	22
% of Reference	Ref	108%	108%	100%	58%	83%	83%	92%	92%

February Small Watershed Raw Scores

	ARK125	ARK121	ARK117	ARK110	ARK129
Taxa Richness	17	15	16	12	12
EPT Index	13	11	14	5	5
HBI	2.4	2.3	2.0	2.7	2.7
% Contribution of Dominant Taxa	26	35	36	51	47
Scraper / Filterer+Scraper Abundances	1.00	0.78	0.80	1.00	1.00

February Small Watershed Metric Scores

	ARK125	ARK121	ARK117	ARK110	ARK129
Taxa Richness	6	6	6	4	4
EPT Index	6	4	6	0	0
HBI	6	6	6	6	6
% Contribution of Dominant Taxa	4	2	2	0	0
Scraper / Filterer+Scraper Abundances	6	6	6	6	6
Total	28	24	26	16	16
% of Reference	Ref	86%	93%	57%	57%

February Large Watershed Raw Scores

	ARK124	ARK120	ARK116	ARK126	ARK104
Taxa Richness	22	11	13	12	11
EPT Index	11	7	9	7	6
HBI	2.1	2.5	2.1	2.7	2.8
% Contribution of Dominant Taxa	15	50	33	72	75
Scraper / Filterer+Scraper Abundances	1.00	1.00	1.00	1.00	0.88

February Large Watershed Metric Scores

	ARK124	ARK120	ARK116	ARK126	ARK104
Taxa Richness	6	2	2	2	2
EPT Index	6	0	4	0	0
HBI	6	4	6	4	4
% Contribution of Dominant Taxa	6	0	2	0	0
Scraper / Filterer+Scraper Abundances	6	6	6	6	4
Total	30	12	20	12	12
% of Reference	Ref	40%	67%	40%	40%

May Small Watershed Raw Scores

	ARK125	ARK121	ARK117	ARK110	ARK129
Taxa Richness	16	22	19	18	17
EPT Index	11	16	12	11	9
HBI	2.2	2.2	2.3	2.1	2.3
% Contribution of Dominant Taxa	45	16	28	23	36
Scraper / Filterer+Scraper Abundances	1.00	0.88	0.94	0.76	0.19

May Small Watershed Metric Scores

	ARK125	ARK121	ARK117	ARK110	ARK129
Taxa Richness	6	6	6	6	6
EPT Index	6	6	6	6	4
HBI	6	6	6	6	6
% Contribution of Dominant Taxa	6	6	4	4	2
Scraper / Filterer+Scraper Abundances	6	6	6	6	0
Total	30	30	28	28	18
% of Reference	Ref	100%	117%	117%	75%

May Large Watershed Raw Scores

	ARK124	ARK120	ARK119	ARK116	ARK114	ARK113	Bio Site	ARK126	ARK104
Taxa Richness	20	19	22	21	16	17	16	20	21
EPT Index	13	12	13	11	11	11	13	12	12
HBI	1.7	2.0	2.0	1.8	1.2	1.3	1.8	2.2	2.0
% Contribution of Dominant Taxa	32	18	28	17	19	27	26	21	29
Scraper / Filterer+Scraper Abundances	1.00	1.00	1.00	0.65	1.00	1.00	0.45	0.90	1.00

May Large Watershed Metric Scores

	ARK124	ARK120	ARK119	ARK116	ARK114	ARK113	Bio Site	ARK126	ARK104
Taxa Richness	6	6	6	6	4	6	4	6	6
EPT Index	6	6	6	4	4	4	6	6	6
HBI	6	6	6	6	6	6	6	4	6
% Contribution of Dominant Taxa	2	6	4	6	6	4	4	4	4
Scraper / Filterer+Scraper Abundances	6	6	6	6	6	6	4	6	6
Total	26	30	28	28	26	26	24	26	28
% of Reference	Ref	115%	108%	108%	100%	100%	92%	100%	108%

APPENDIX M-2

HABITAT PARAMETERS AND METRIC SCORES OF AQUATIC MACROINVERTEBRATES

Appendix M-2
Habitat Parameters and Metric Scores of Aquatic Macroinvertebrates

August	ARK124	ARK120	ARK116	ARK113	Bio Site
Habitat Parameter					
Bottom Subs.	20	20	19	20	19
Embeddedness	20	20	20	15	19
Flow	7	13	14	13	17
Channel Alteration	11	15	15	15	8
Bot. scour/deposit	15	15	15	15	15
Bank Stability	10	10	10	5	6
Bank Vegetative Stability	8	10	9	9	9
Streamside Cover	9	8	7	8	9
Score	100	111	109	100	102
% Score	R**	111%	109%	100%	102%

November Small WS*	ARK125	ARK121	ARK117	ARK110	ARK129
Habitat Parameter					
Bottom Subs.	20	19	20	20	16
Embeddedness	19	19	19	19	18
Flow	20	14	20	5	12
Channel Alteration	15	12	15	15	14
Bot. scour/deposit	15	14	15	15	12
Bank Stability	8	8	9	9	7
Bank Vegetative Stability	9	9	9	9	9
Streamside Cover	8	8	8	10	9
Score	114	103	115	102	97
% Score	R	90%	101%	89%	85%

NovemberLarge WS	ARK124	ARK120	ARK119	ARK116	ARK114	ARK113	Bio Site	ARK126	ARK104
Bottom Subs.	20	20	20	20	20	20	19	17	20
Embeddedness	20	19	20	19	19	19	19	18	19
Flow	20	20	20	20	20	20	20	20	20
Channel Alteration	11	15	15	15	15	14	14	15	12
Bot. scour/deposit	15	15	15	15	15	15	15	10	15
Bank Stability	10	9	9	9	9	6	6	7	5
Bank Veg. Stability	8	9	9	9	10	8	8	9	8
Streamside Cover	9	8	9	8	9	8	8	9	6
Score	113	115	117	115	117	110	109	105	105
% Score	R	102%	104%	102%	104%	97%	96%	93%	93%

February Small WS	ARK125	ARK121	ARK117	ARK110	ARK129
Bottom Subs.	20	20	15	20	16
Embeddedness	20	19	20	18	18
Flow	19	16	19	5	20
Channel Alteration	15	10	15	15	11
Bot. scour/deposit	15	14	15	15	11
Bank Stability	8	9	10	7	2
Bank Vegetative Stability	9	6	9	9	9
Streamside Cover	8	9	8	10	8
Score	114	103	111	99	95
% Score	R	90%	97%	87%	83%

February Large WS	ARK124	ARK120	ARK116	ARK126	ARK104
Bottom Subs.	20	20	20	20	20
Embeddedness	19	19	19	19	19
Flow	20	20	20	20	20
Channel Alteration	11	15	15	15	14
Bot. scour/deposit	14	15	15	15	15
Bank Stability	9	8	9	9	6
Bank Vegetative Stability	6	9	9	10	8
Streamside Cover	8	8	8	9	8
Score	107	114	115	117	110
% Score	R	107%	107%	109%	103%

May Small WS	ARK125	ARK121	ARK117	ARK110	ARK129
Habitat Parameter					
Bottom Subs.	20	20	20	20	15
Embeddedness	20	19	20	18	18
Flow	16	12	12	5	6
Channel Alteration	15	10	15	15	11
Bot. scour/deposit	15	14	15	15	11
Bank Stability	8	9	10	7	2
Bank Veg.	9	6	9	9	9
Streamside Cover	8	9	8	10	8
Score	111	99	109	99	80
% Score	R	89%	98%	89%	72%

MayLarge WS	ARK124	ARK120	ARK119	ARK116	ARK114	ARK113	Bio Site	ARK126	ARK104
Bottom Subs.	20	20	19	20	20	20	19	19	20
Embeddedness	19	20	19	20	20	19	19	19	18
Flow	18	20	14	20	18	20	20	16	17
Channel Alteration	12	15	10	15	15	15	14	15	14
Bot. scour/deposit	14	15	14	15	15	15	15	10	13
Bank Stability	9	10	8	10	9	6	6	6	8
Bank Veg.Stability	6	8	9	9	10	8	8	8	8
Streamside Cover	8	8	8	8	9	8	8	9	7
Score	106	116	101	117	116	111	109	102	105
% Score	R	109%	95%	110%	109%	105%	103%	96%	99%

*WS = Watershed

**R = Reference

APPENDIX M-3

TAXA LISTS AND SUB-SAMPLE COUNTS OF AQUATIC MACROINVERTEBRATES.

Appendix M-3
Taxa lists and subsample counts of aquatic macroinvertebrates.

August Taxa List

HBI	GROUP	EPT	TAXON	ADEQ 3H-19 ARK124	ADEQ 3H-20 ARK120	ADEQ 3H-21 ARK116	ADEQ 3H-22 ARK113	ADEQ 3H-23 Bio Site
3	COL	N	*Orconectes*	2				
2	COL	Y	*Isonychia*	32	13	15	13	6
3	SCR	Y	*Stenonema*	13	14	31	33	40
3.5	COL	Y	*Caenis*	3	17	40	15	13
2.5	COL	Y	*Diphetor*				1	
2	COL	Y	*Tricorythodes*			10	2	35
0	COL	Y	*Ameletus*	2	1			
3	PRE	N	*Argia*			2	1	2
0.5	PRE	N	*Ophiogomphus*	2				
1	PRE	Y	*Plecoptera*		1			
1	PRE	Y	*Acroneuria*					1
3	PRE	N	*Corydalus*	3	10	10	5	13
1	PRE	N	*Nigronia*	2				
2	SCR	Y	*Helicopsyche*	1			1	
2	COL	Y	*Chimarra*	7	1	3	3	27
1	COL	Y	*Psychomyia*				1	
3	FIL	Y	*Cheumatopsyche*	36				2
2	COL	Y	*Hydropsyche*		24	8	15	40
3	SCR	Y	*Leucotrichia*			1		
2.5	SCR	N	*Petrophila*	2	2		1	1
2	SCR	N	*Psephenus*	10	2	1		
3	SCR	N	*Stenelmis (L)*	3	3	1	1	
3	SCR	N	*Stenelmis (A)*	1	1	2	7	14
2.5	SCR	N	*Ordobrevia (A)*	1	2	1		
2.5	SCR	N	*Ordobrevia (L)*		2	1		
3	SCR	N	*Dubiraphia (A)*		2			4
3	PRE	N	*Metrobates*	2				
3	COL	N	*Simulium*				1	
2.5	PRE	N	*Haematopota*	2	1		1	
3	PRE	N	Chironomidae 1		3			
4	PRE	N	*Ablabesmyia*	2	1	1		
4.8	COL	N	*Chironomus*	1	1	1	1	9
3.25	COL	N	*Atrichopogon*	2				
4	SCR	N	*Physa*					1
3.8	SCR	N	*Fossaria*		10	4	4	9
3	FIL	N	*Corbicula*			2	1	1
			Total	129	111	134	107	218

November Taxa List

hbi	group	ept	TAXON	ARK125	ARK124	ARK121	ARK120	ARK119	ARK117	ARK116	ARK114	ARK113	ARK110	BIOL SITE	ARK104	ARK126	ARK129
4	COL	N	Lirceus			1		2	2				45		1		36
3	COL	N	Orconectes			1		1	2		3	1	1				2
1	COL	Y	Tortopus												6		
2	COL	Y	Baetisca			1	2	1		1				1			
2	COL	Y	Isonychia	5	84	8	16	3	20	8		7		4	7	29	
0	COL	Y	Rithrogena							1							
3	SCR	Y	Stenonema	26	33	26	36	16	49	49		7		20	14	33	6
2	SCR	Y	Stenacron				15		1	7							
1	COL	Y	Leptophlebiidae						1								
0.5	COL	Y	Ephemerella							1		17					
1	COL	Y	Eurylophella			1											1
3.5	COL	Y	Caenis												3	2	
2.5	COL	Y	Baetis	4	1				1	1							
2	COL	Y	Tricorythodes							1							
0	COL	Y	Ameletus				1										
3	PRE	N	Argia		1		2	2		2					8	1	
0.5	PRE	N	Ophiogomphus			3	2	1		1					4	9	
2	PRE	N	Hagenius													1	
1.5	SHR	Y	Strophopteryx	28		11			4	2	72	48	6				4
1	SHR	Y	Taeniopteryx	3	13	9	13	36		6	2		7	15	4	3	
1.5	SHR	Y	Allocapnia		16			22									
0	SHR	Y	Perlomyia				4				4						
0	SHR	Y	Zealeuctra	4	4			10				2	14	2		1	36
1	PRE	Y	Acroneuria	1	1		2		1			1			2		
1.5	PRE	Y	Claassenia							1							
1	PRE	Y	Neoperla				1										
0.75	PRE	Y	Clioperla									2					
2	PRE	Y	Isoperla					1									
3	PRE	Y	Corydalus		2	2		2	1	4	1	1		2	4		
1	PRE	N	Nigronia	2	1	6							2				
2	COL	Y	Chimarra	4	3	2		4	10	5					6	13	
0	SCR	Y	Agapetus	1												3	
1	COL	Y	Wormaldia			8									3		

November Taxa List (cont.)

3	FIL	Y	Cheumatopsyche	3	17	2	7	9	5					2	7	8	
2	COL	Y	Hydropsyche							9		3					
2	PRE	Y	Cernotiina		1												
3	PRE	Y	Polycentropus										1	1			1
2	SCR	N	Psephenus	3		2	7	2	1	1	1		1		6	4	
2.5	PRE	N	Thermonectus														1
3	SCR	N	Stenelmis (L)			35		7					1		14		
3	SCR	N	Stenelmis (A)				1						1		1	1	2
2	SCR	N	Optioservus (L)	21	3		5		5	2							
2.5	SCR	N	Ordobrevia (A)			5										1	
2.5	SCR	N	Ordobrevia (L)							2					1		
3	SCR	N	Dubiraphia (A)						2					1			
2.3	SCR	N	Helichus			3								1	1	1	
2.5	SCR	N	Blephariceras												1		
3	COL	N	Simulium		1							21			1		
2	SHR	N	Tipula				1	2									1
1	PRE	N	Hexatoma									1					
2.5	PRE	N	Megistocera										10				
2.5	PRE	N	Pedicia										1				
2	COL	N	Antocha			3			1						1		
3	PRE	N	Chironomidae 1	1													
4	PRE	N	Ablabesmyia												4		
2.5	SCR	N	Amnicola	3						1							
4	SCR	N	Physa											3			
3.8	SCR	N	Fossaria				3	1						16			
3	FIL	N	Corbicula									2		6	4		
3.5	COL	N	Oligochaeta				2			1				4			1

February Taxa List

hbi	group	ept	TAXON	ARK 125	ARK 124	ARK 121	ARK 120	ARK 119	ARK117	ARK 116	ARK 114	ARK110	ARK126	ARK129	ARK104
4	COL	N	Caecidotea									11			
4	COL	N	Lirceus									1		14	1
3	COL	N	Orconectes		2									2	
2	COL	Y	Baetisca							1					
2	COL	Y	Isonychia	12			8		4	2			1		1
0	COL	Y	Rithrogena		4		1								
1.5	SCR	Y	Epeorus	1					2						
3	SCR	Y	Stenonema	13	17	5	12		2	16					7
2	SCR	Y	Stenacron		3										
1	COL	Y	Leptophlebiidae		4				1						
1	COL	Y	Eurylophella										1		
1	COL	Y	Seratella							8					
3.5	COL	Y	Caenis			1									
2.5	COL	Y	Baetis	29	4	3	2		4			12	4	9	3
2	COL	Y	Tricorythodes	3											
0	COL	Y	Ameletus						2						
3	PRE	N	Argia							1					
0.5	PRE	N	Ophiogomphus		1								1		
1.5	SHR	Y	Strophopteryx	13		16	21		37	35			13	9	14
1.5	SHR	Y	Allocapnia	2											
0	SHR	Y	Perlomyia	2						1					
0	SHR	Y	Zealeuctra				2					4	1		
1	PRE	Y	Acroneuria		17										1
1.5	PRE	Y	Claassenia		1										
1	PRE	Y	Hansonoperla		2										
1	PRE	Y	Haploperla						8						
0.75	PRE	Y	Plumiperla		2										
0	PRE	Y	Suwallia									4			
0.75	PRE	Y	Clioperla			1								12	
0.5	PRE	Y	Diploperla	2											
0.5	PTR	Y	Helopicus						2						
0.5	PRE	Y	Isogenoides							5					
2	PRE	Y	Isoperla	7		10	1		3				9		3

February Taxa List (cont)							120	119	117			113			
1	PRE	Y	Skwala											1	
1.5	SHR	Y	Amphinemura						2	2		2			
3	PRE	Y	Corydalus	2	1		1		1				2		
1	PRE	N	Nigronia		2										
2	COL	Y	Chimarra	1		3			3				4		
1	COL	Y	Wormaldia		1										
0	SCR	Y	Agapetus			4									
3	FIL	Y	Cheumatopsyche	1	15	4			1						
2	COL	Y	Hydropsyche							1					
3	PRE	Y	Polycentropus	1		3			1			5		4	
1	COL	Y	Setodes			5									
2	SCR	N	Psephenus		10	1							1	1	
2.5	PRE	N	Dytiscus (L)										1		
2.5	COL	N	Narpus (L)		8										
3	SCR	N	Stenelmis (A)			2									
2	SCR	N	Optioservus (L)		14										
2	SCR	N	Optioservus (A)	1											
2.5	SCR	N	Ordobrevia (A)									1			
3	COL	N	Simulium	21		33	54		31	32		44	99	50	97
2.5	PRE	N	Apatolestes		1					1					
2.5	PRE	N	Haematopota											1	
2	SHR	N	Brachypremna											2	
2	SHR	N	Tipula												1
1	PRE	N	Hexatoma									1			
2.5	PRE	N	Megistocera									1			
2	COL	N	Antocha									1			1
3	PRE	N	Chironomidae 1		1					1				2	
3	PRE	N	Chironomidae 2		3										
4	PRE	N	Ablabesmyia	1											
4.8	COL	N	Chironomus				2								
2.5	SCR	N	Amnicola				4								
3.8	SCR	N	Fossaria		2										
3	FIL	N	Corbicula												1

May *Taxa* List

hbi	group	ept	TAXON	ARK0125	ARK0124	ARK0121	ARK0120	ARK0117	ARK0116	ARK0114	ARK0113	ARK0110	Bio Site	ARK0126	ARK0129	ARK 104
4	COL	N	Caecidotea									12				
4	COL	N	Lirceus												7	3
3	COL	N	Orconectes	1	1	6	1	4	1	5		1		1	8	
2	COL	Y	Isonychia	1	1	2	14	1	14		8	1	15	20		8
2	SCR	Y	Heptageniidae							1						
0	COL	Y	Rithrogena		1		5	4	19	16	27		18	7	1	3
2	SCR	Y	Heptagenia													28
3	SCR	Y	Stenonema	2	20	15	18	24	19	2	10	6	8	21	2	5
2	SCR	Y	Stenacron	1		7	2									
1	COL	Y	Leptophlebiidae			2									1	
2	COL	Y	Leptophlebia					4				1				
1	COL	Y	Paraleptophlebia		2											
0.5	COL	Y	*Attenella*						2							
0.5	COL	Y	Ephemerella		5		1			2	2					
1	COL	Y	Eurylophella		2	4						2	1	2	1	
1	COL	Y	Seratella									1				6
3.5	COL	Y	Caenis		8	1										
2.5	COL	Y	Baetis	51	2	5	16	16	5	4	11	2	3	7	5	
2.5	COL	Y	Procleon								1					
2	COL	Y	Tricorythodes										1			
0	COL	Y	Ameletus		7	2	2			8	5	5	2	1	6	5
3	PRE	N	Argia					1	1							
0.5	PRE	N	Ophiogomphus					1						1		
0	PRE	N	Stylogomphus													1
1.5	SHR	Y	Strophopteryx	24												
1.5	SHR	Y	Allocapnia			1										
1	PRE	Y	Acroneuria		33		4	7	12	18	16		3	1		1
1	PRE	Y	Attaneuria				3	1				18				3
1.5	PRE	Y	Calineuria						1							
1	PRE	Y	Neoperla				1		3		1		1	1		1
2	PRE	Y	Perlesta		1	12			7				26	9	36	5

May Taxa List (cont)							120		116		115		B10	126		
1	PRE	Y	Haploperla	1												
0.75	PRE	Y	Plumiperla									2			5	
0	PRE	Y	Suwallia	3												
2	PRE	Y	Isoperla	15				2								
1	PRE	Y	Kogotus							1						
1.5	SHR	Y	Amphinemura			1						2				
1	SHR	Y	Paranemoura	2												
3	PRE	Y	Corydalus			3	3	2	1		2			9		2
1	PRE	N	Nigronia		1	1						1				
4	PRE	N	Sialis							1	2					
2	SCR	Y	Helicopsyche			2										
2	COL	Y	Chimarra		1	10	2	2	4	2			6	2		1
1	COL	Y	Wormaldia							12	1			5		
1	COL	Y	Wormaldia					3								
1	COL	Y	Brachycentrus										2			
3	FIL	Y	Cheumatopsyche			5		2	13			7	12	3	21	12
2	COL	Y	Hydropsyche	1	10		19			16	9					
1.5	COL	Y	Macrostemum			1										
3	PRE	Y	Polycentropus	1		2		4								
2.5	SCR	N	Petrophila					1								
2	SCR	N	Psephenus	1	2	6	7	7	1	3	1			3	1	1
2.5	PRE	N	Thermonectus									1				
2.5	PRE	N	Laccophilus													1
3	SCR	N	Stenelmis (L)						3	1			1			
3	SCR	N	Stenelmis (A)						1				1	1		
1	SCR	N	Microcylloepus				1									
2	SCR	N	Optioservus (L)		2	4									1	
2	SCR	N	Optioservus (A)	3		1									1	
2.5	SCR	N	Ordobrevia (A)									4				3
2.5	SCR	N	Ordobrevia (L)								1	12				7
2.3	SCR	N	Helichus		1									2		
3	COL	N	Phytobius						1							
3	PRE	N	Gerris												1	
3	COL	N	Simulium	5			1		1		1		1		2	
2.5	PRE	N	Apatolestes				1	1	1							
2.5	PRE	N	Haematopota											1	2	

May Taxa List (cont)																
3	PRE	N	Tabanus		1											
2	SHR	N	Brachypremna													1
1	PRE	N	Hexatoma									1				1
3	PRE	N	Chironomidae 1											2		
4	PRE	N	Ablabesmyia		1					1	2					
4.8	COL	N	Chironomus				1		3							
2.5	SCR	N	Amnicola				3									
3.8	SCR	N	Fossaria	2												
3.5	COL	N	Oligochaeta											1		

APPENDIX F-1

FISH COLLECTION SITE HABITAT ANALYSIS

APPENDIX F-1
Fish Collection Site Habitat Analysis

Upper Little Piney Creek ARK126						
No.	Riffle		Run		Pool	
	Score	Length	Score	Length	Score	Length
1	28.8	30	37.0	25	62.4	90
2	35.0	20	41.0	45	54.2	250
3	33.0	30	51.0	40	59.4	100
4	60.2	60	53.8	60	50.0	150
5	42.0	30	45.0	35		
6	61.4	100				
7	45.0	15				
Avg/Tot	43.63	285	45.56	205	56.50	590

Minnow Creek ARK 129						
No.	Riffle		Run		Pool	
	Score	Length	Score	Length	Score	Length
1	55.8	75	41.6	80	66.0	200
2	38.5	20	65.3	175	49.2	150
3	51.4	30	62.2	70		
4	41.4	20	63.4	90		
5	52.0	90	30.8	40		
6	34.0	20	39.8	150		
7	40.0	20				
8	47.0	40				
Avg/Tot	45.01	315	50.52	605	57.60	350

Lower Little Piney Creek ARK 104						
No.	Riffle		Run		Pool	
	Score	Length	Score	Length	Score	Length
1	32.4	30	37.0	70	37.8	50
2	34.4	40	54.6	50	54.0	200
3	35.4	20			48.5	130
4	38.4	40			52.2	80
Avg/Tot	35.15	130	45.80	120	48.13	460

Hurricane Creek ARK 119						
No.	Riffle		Run		Pool	
	Score	Length	Score	Length	Score	Length
1	30.2	60	59.8	50	57.2	100
2	44.2	105	32.5	80	63.0	100
3	46.0	80	57.0	70	42.1	80
4	49.0	160			93.8	800
5	52.8	130			52.2	80
Avg/Tot	44.44	535	49.77	200	61.66	1160

Haw Creek ARK 117						
No.	Riffle		Run		Pool	
	Score	Length	Score	Length	Score	Length
1	38.4	50	30.8	30	25.8	100
2	30.8	50	47.0	40	59.4	80
3	41.0	20	44.0	40	77.2	300
4	59.4	20				
Avg/Tot	42.40	140	40.60	110	54.13	480

Mid-Big Piney Creek ARK 116						
No.	Riffle		Run		Pool	
	Score	Length	Score	Length	Score	Length
1	63.8	50	47.6	30	78.6	200
2	48.4	30	54.6	140	54.2	80
3	64.2	100	61.6	100		
4	39.0	40	50.2	90		
5			70.6	50		
6			51.4	100		
Avg/Tot	53.85	220	56.00	510	66.40	280

Indian Creek ARK 114						
No.	Riffle		Run		Pool	
	Score	Length	Score	Length	Score	Length
1	43.0	20	41.0	30	62.4	80
2	43.0	30	45.0	50	70.0	250
3	45.0	40	49.0	70		
4	41.0	20	55.0	100		
5	41.0	55	45.2	100		
Avg/Tot	42.60	165	47.04	350	66.20	330

Mill Creek ARK 120						
No.	Riffle		Run		Pool	
	Score	Length	Score	Length	Score	Length
1	36.2	20	36.2	30	39.7	40
2	36.2	10	60.8	60	47.4	20
3	64.0	50			49.5	60
4	60.8	40				
Avg/Tot	49.30	120	48.50	90	45.53	120

Lower Big Piney Creek Biological Site						
No.	Riffle		Run		Pool	
	Score	Length	Score	Length	Score	Length
1	39.0	55	53.4	100	60.3	280
2	39.5	30	39.0	60	58.8	180
3	39.0	20	55.0	70	70.8	200
4	36.0	20	50.4	35	43.2	80
5	51.4	30				
6	57.4	100				
Avg/Tot	43.72	255	49.45	265	58.28	740

<u>In Stream Habitat Guide</u>

	Riffles	Runs	Pools
Excellent	>45	>50	>55
Good	45-36	50-41	55-46
Moderate	35-26	40-31	45-36
Fair	25-16	30-21	35-26
Poor	<15	<20	<25

APPENDIX F-2

FISH COMMUNITY TAXA LISTS

Appendix F-2
Fish Community Taxa Lists

FAMILY & SPECIES	COMMON NAME	SEN	TFL	KEY	Upper Little Piney ARK126		Minnow Creek ARK129		Lower Little Piney ARK104	
					Num	% Com	Num	% Com	Num	% Com
Petromyzontidae	Lampreys									
Ichthyomyzon sp.	Ammocoetes		P		1	0.25			3	0.25
Lepisosteidae	Gars									
Lepisosteus osseus	Longnose gar									
Esoxidae	Pickerels									
Esox americanus	Grass pickerel									
Cyprinidae	Minnows									
Campostoma anomalum	Central stoneroller		P		43	10.62	381	37.46	438	35.96
Cyprinella whipplei	Steelcolor shiner						2	0.20	16	1.31
Cyprinus carpio	Carp		P							
Luxilus cardinalis	Cardinal shiner	S							16	1.31
Lythrurus umbratilis	Redfin shiner								8	0.66
Notropis boops	Bigeye shiner	S		K	31	7.65	201	19.76	9	0.74
Notropis greeni	Wedgespot shiner	S			3	0.74				
Pimephales notatus	Bluntnose minnow		P		57	14.07	45	4.42	43	3.53
Semotilus atromaculatus	Creek chub	S			1	0.25				
Catostomidae	Suckers									
Erimyzon oblongus	Creek chubsucker				1	0.25	1	0.10		
Hypentelium nigricans	Northern hogsucker	S			5	1.23	3	0.29	13	1.07
Minytrema melanops	Spotted sucker								2	0.16
Moxostoma duquesnei	Black redhorse	S		K					10	0.82
Moxostoma erythrurum	Golden redhorse						1	0.10		
Ictaluridae	Freshwater catfishes									
Ameiurus natalis	Yellow bullhead						3	0.29	4	0.33
Ictalurus punctatus	Channel catfish								1	0.08
Noturus exilis	Slender madtom	S		K	21	5.19	75	7..37	107	8.78
Noturus miurus	Brindled madtom								5	0.41
Noturus nocturnus	Freckled madtom									
Pylodictis olivaris	Flathead catfish								1	0.08
Cyprinidontidae	Killifishes									
Fundulus olivaceus	Blackspotted Topminnow	S			4	0.99	28	2.75	6	0.49
Atherinidae	Silversides									
Labidesthes sicculus	Brook silverside				2	0.49	4	0.39	20	1.64
Centrarchidae	Sunfishes									
Ambloplites ariommus	Shadow bass	S								
Lepomis cyanellus	Green sunfish				21	5.19	31	3.05	55	4.52
Lepomis gulosus	Warmouth sunfish								9	0.74
Lepomis macrochirus	Bluegill sunfish						7	0.69	107	8.78
Lepomis megalotis	Longear sunfish			K	105	25.93	65	6.39	184	15.11
Micropterus dolomieu	Smallmouth bass	S		K	36	0.74			1	0.08
Micropterus punctulatus	Spotted bass				2	0.49	2	0.20	18	1.48
Micropterus salmoides	Largemouth bass						9	0.88	1	0.08

FAMILY & SPECIES	COMMON NAME	SEN	TFL	KEY	Upper Little Piney ARK126 Num	% Com	Minnow Creek ARK129 Num	% Com	Lower Little Piney ARK104 Num	% Com
Percidae	Perches									
Etheostoma blennioides	Greenside darter	S		K	38	9.38	8	0.79	60	4.93
Etheostoma flabellare	Faintail darter	S			33	8.15	41	4.03	10	0.82
Etheostoma punctulatum	Stippled darter	S			1	0.25				
Etheostoma spectabile	Orangethroat darter				26	6.42	75	7.37	14	1.15
Etheostoma stigmaeum	Speckled darter	S					1	0.10	1	0.08
Etheostoma whipplei	Redfin darter				3	0.74	21	2.06		
Etheostoma zonale	Banded darter	S			3	0.74	8	0.79	24	1.97
Percina caprodes	Logperch				1	0.25	4	0.39	27	2.22
Percina copelandi	Channel darter	S					1	0.10	2	0.16
Percina maculata	Blackside darter	S							2	0.16
Percina nasuta	Longnose darter	S								
Percina sciera	Dusky darter	S							1	0.08
Total Species//Total Numbers					22	405	18	1017	33	1218
Effort(secs)//Catch per unit effort(min)					3689	6.59	3796	16.07	4820	15.16

Appendix F-2
Fish Community Taxa Lists

FAMILY & SPECIES	COMMON NAME	SEN	TFL	KEY	Haw Creek ARK117 Num	Haw Creek ARK117 % Com	Hurricane Creek ARK119 Num	Hurricane Creek ARK119 % Com	Mid Big Piney ARK116 Num	Mid Big Piney ARK116 % Com
Ichthyomyzon sp.	Ammocoetes		P				1	0.33		
Lepisosteidae	Gars									
Lepisosteus osseus	Longnose gar									
Esoxidae	Pickerels									
Esox americanus	Grass pickerel									
Cyprinidae	Minnows									
Campostoma anomalum	Central stoneroller		P		135	43.55	32	10.53	86	6.73
Cyprinella whipplei	Steelcolor shiner						1	0.33	25	1.96
Cyprinus carpio	Carp		P							
Luxilus cardinalis	Cardinal shiner	S					53	17.43	66	5.17
Lythrurus umbratilis	Redfin shiner									
Notropis boops	Bigeye shiner	S		K	11	3.55	40	13.16	118	9.24
Notropis greeni	Wedgespot shiner	S					14	4.61	24	1.88
Pimephales notatus	Bluntnose minnow		P				8	2.63	29	2.27
Semotilus atromaculatus	Creek chub	S			61	19.68				
Catostomidae	Suckers									
Erimyzon oblongus	Creek chubsucker				3	0.97				
Hypentelium nigricans	Northern hogsucker	S							4	0.31
Minytrema melanops	Spotted sucker									
Moxostoma duquesnei	Black redhorse	S		K			2	0.66	1	0.08
Moxostoma erythrurum	Golden redhorse						1	0.33		
Ictaluridae	Freshwater catfishes									
Ameiurus natalis	Yellow bullhead						1	0.33		
Ictalurus punctatus	Channel catfish									
Noturus exilis	Slender madtom	S		K	26	8.39	57	18.75	122	9.55
Noturus miurus	Brindled madtom									
Noturus nocturnus	Freckled madtom									
Pylodictis olivaris	Flathead catfish									
Cyprinidontidae	Killifishes									
Fundulus olivaceus	Blackspotted Topminnow	S					2	0.66	38	2.98
Atherinidae	Silversides									
Labidesthes sicculus	Brook silverside								51	3.99
Centrarchidae	Sunfishes									
Ambloplites ariommus	Shadow bass	S							1	0.08
Lepomis cyanellus	Green sunfish						13	4.28	79	6.19
Lepomis gulosus	Warmouth sunfish									
Lepomis macrochirus	Bluegill sunfish								1	0.08
Lepomis megalotis	Longear sunfish			K	14	4.52	25	8.22	388	30.38
Micropterus dolomieu	Smallmouth bass	S		K					5	0.39
Micropterus punctulatus	Spotted bass								1	0.08
Micropterus salmoides	Largemouth bass									

FAMILY & SPECIES	COMMON NAME	SEN	TFL	KEY	Haw Creek ARK117		Hurricane Creek ARK119		Mid Big Piney ARK116	
					Num	% Com	Num	% Com	Num	% Com
Percidae	Perches									
Etheostoma blennioides	Greenside darter	S		K	13	4.19	12	3.95	103	8.07
Etheostoma flabellare	Faintail darter	S					11	3.62	45	3.52
Etheostoma punctulatum	Stippled darter	S								
Etheostoma spectabile	Orangethroat darter				42	13.55	28	9.21	48	3.76
Etheostoma stigmaeum	Speckled darter	S								
Etheostoma whipplei	Redfin darter				5	1.61			1	0.08
Etheostoma zonale	Banded darter	S					3	0.99	37	2.90
Percina caprodes	Logperch									
Percina copelandi	Channel darter	S								
Percina maculata	Blackside darter	S							3	0.23
Percina nasuta	Longnose darter	S							1	0.08
Percina sciera	Dusky darter	S								
Total Species//Total Numbers					9	310	18	304	24	1277
Effort(secs)//Catch per unit effort(min)					3926	4.74	2283	7.99	5042	15.20

Appendix F-2
Fish Community Taxa Lists

FAMILY & SPECIES	COMMON NAME	SEN	TFL	KEY	Indian Creek ARK114 Num	Indian Creek ARK114 % Com	Mill Creek ARK110 Num	Mill Creek ARK110 % Com	Lower Big Piney Num	Lower Big Piney % Com
Petromyzontidae	Lampreys									
Ichthyomyzon sp.	Ammocoetes		P						1	0.07
Lepisosteidae	Gars									
Lepisosteus osseus	Longnose gar								1	0.07
Esoxidae	Pickerels									
Esox americanus	Grass pickerel						1	0.01		
Cyprinidae	Minnows									
Campostoma anomalum	Central stoneroller		P		91	15.29	90	22.33	403	29.46
Cyprinella whipplei	Steelcolor shiner						17	1.24	17	1.24
Cyprinus carpio	Carp		P							
Luxilus cardinalis	Cardinal shiner	S			5	0.84	18	4.47	149	10.89
Lythrurus umbratilis	Redfin shiner						3	0.74		
Notropis boops	Bigeye shiner	S		K	185	31.09	35	8.68	52	3.80
Notropis greeni	Wedgespot shiner	S							71	5.19
Pimephales notatus	Bluntnose minnow		P		38	6.39	14	3.47	35	2.56
Semotilus atromaculatus	Creek chub	S			1	0.17				
Catostomidae	Suckers									
Erimyzon oblongus	Creek chubsucker						5.00	1.24		
Hypentelium nigricans	Northern hogsucker	S			1	0.17	12.00	2.98	41	3.00
Minytrema melanops	Spotted sucker									
Moxostoma duquesnei	Black redhorse	S		K					3	0.22
Moxostoma erythrurum	Golden redhorse				2	0.34			29	2.12
Ictaluridae	Freshwater catfishes									
Ameiurus natalis	Yellow bullhead						4	0.99	1	0.07
Ictalurus punctatus	Channel catfish								1	0.07
Noturus exilis	Slender madtom	S		K	59	9.92	18	4.47	13	0.95
Noturus miurus	Brindled madtom									
Noturus nocturnus	Freckled madtom								1	0.07
Pylodictis olivaris	Flathead catfish									
Cyprinidontidae	Killifishes									
Fundulus olivaceus	Blackspotted Topminnow	S			9	1.51	13	3.23	6	0.44
Atherinidae	Silversides									
Labidesthes sicculus	Brook silverside						3	0.74	22	1.61
Centrarchidae	Sunfishes									
Ambloplites ariommus	Shadow bass	S							14	1.02
Lepomis cyanellus	Green sunfish				37	6.22	40	9.93	34	2.49
Lepomis gulosus	Warmouth sunfish								1	0.07
Lepomis macrochirus	Bluegill sunfish						2	0.50	9	0.66
Lepomis megalotis	Longear sunfish			K	59	9.92	68	16.87	273	19.96
Micropterus dolomieu	Smallmouth bass	S		K	7	1.18	1	0.25	19	1.39
Micropterus punctulatus	Spotted bass				2	0.34			10	0.73
Micropterus salmoides	Largemouth bass						2	0.50		

FAMILY & SPECIES	COMMON NAME	SEN	TFL	KEY	Indian Creek ARK114		Mill Creek ARK110		Lower Big Piney	
					Num	% Com	Num	% Com	Num	% Com
Percidae	Perches									
Etheostoma blennioides	Greenside darter	S		K	27	4.54	21	5.21	81	5.92
Etheostoma flabellare	Faintail darter	S			16	2.69	3	0.74	8	0.58
Etheostoma punctulatum	Stippled darter	S					1	0.25		
Etheostoma spectabile	Orangethroat darter				46	7.73	42	10.42	7	0.51
Etheostoma stigmaeum	Speckled darter	S							1	0.07
Etheostoma whipplei	Redfin darter				7	1.18	2	0.5	4	0.29
Etheostoma zonale	Banded darter	S			3	0.50			32	2.34
Percina caprodes	Logperch								14	1.02
Percina copelandi	Channel darter	S							2	0.15
Percina maculata	Blackside darter	S							1	0.07
Percina nasuta	Longnose darter	S							11	0.80
Percina sciera	Dusky darter	S							1	0.07
Total Species//Total Numbers					18	595	23	403	29	1368
Effort(secs)//Catch per unit effort(min)					4555	7.84	3590	6.74	6447	12.73