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Pre-impoundment Limnological Study of the Strawberry River in Northeastern Arkansas

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A Pre- Impoundment Limnological Study of the Strawberry River In Northeastern Arkansas

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ABSTRACT

A study of pre-impoundment limnological characteristics of the Strawberry River was made from August, 1967 to June, 1968. Two collecting stations were established, one upstream which would not be inundated and a lower station which would be inundated when impoundment was complete. The Strawberry River was characterized by high alkalinity and pH, low carbon dioxide and turbidity, and adequate oxygen values. Plankton was characterized by limited numbers of **Staurastrum, Gomphonema,** and Rotatoria. Pool-riffle communities were ill-defined. Chironomidae, Oligochaeta and Ephemeroptera were dominant pool macroinvertebrates among 13 taxa collected. Of the 20 taxa collected in riffles Trichoptera, Ephemeroptera, Simuliidae and Chironomidae were the most numerous. Longitudinal zonation was characterized by an increase in species and numbers of pool benthic macroinvertebrates from headwater to downstream areas. Numerical standing crop was recorded for pools on 8 June 1968 and riffles on 30 September 1967. A total of 1979 fishes constituting 49 species were taken in this study. Station I and II pools yielded 242 and 185 fishes/ha respectively, **Dorosoma cepedianum** and **Moxostoma erythrurum** being the dominant forms. The substantial populations of **Dorosoma cepedianum** seemingly are supported by debris and allochthonous materials and not on the sparse plankton present. Station I and II riffles yielded 2896 and 1108 fishes/ha respectively, **Etheostoma caeruleum** and **Percina caprodes** being most numerous . Longitudinal zonation was characterized by decrease in number/ha and species present from headwater to downstream areas.

The Ozark Mountains and their characteristic streams are one of the greatest assets of northeastern Arkansas. Their value in supporting a bass fishery is increasing yearly. One such Ozark stream is the Strawberry River, whose course will be dammed within the next few years as part of the White River Basin Project. The proposed dam site, river mile 26.2, is on the Bell Foley farm in Sharp County, Arkansas, eight km west of Smithville, Lawrence County.

This study was undertaken to describe the pre-impoundment conditions of the Strawberry River physiochemically and biotically; to provide a comparative basis for a post-impoundment study which would determine what changes, if any, result from this action; and to provide additional information on Ozark streams, a unique habitat which is poorly known.

DESCRIPTION OF THE AREA. The Strawberry River is a spring-fed, relatively clear stream consisting of many wide, shallow pools separated by riffles flowing primarily through limestone formations in northeastern Arkansas. It arises in Ordovician Calico sandstone of lower Fulton County and winds through Cotter dolomite in Izard and Sharp counties. Midway into Lawrence County the river passes through Powell limestone, then in rapid succession through Smithville and Black Rock limestone. As it nears its confluence with the Black River, the Strawberry River is bordered by Cretaceous Nacatoch sandstone near Saffel, Arkansas. Reaching its confluence with the Black River, the Strawberry River drops into Quaternary Alluvium (Croneis, 1930). Major soils adjacent to the river are chiefly of the Huntington and Elk series (Soil Conservation Service, 1964). Mean annual rainfall is 112, 119, and 138 cm in Izard, Sharp and Lawrence Counties, respectively. Air tempertures ranges from -25 C to 40 C (Hickmon, 1941). No organic sewage is known to be dumped into the river.

MATERIALS AND METHODS. Two stations were established. The upper station, Station I, located above the proposed impoundment area at Horseshoe Bend, near Franklin, Izard County, Arkansas, S 20, T 18 N, R 7 W, will serve as a reference for post-impoundment investigations.

The lower station, Station II, located near Poughkeepsie, Sharp County, Arkansas, S 19, T 17 N, R 5 W, will be situated midway in the lake to be formed by the proposed dam. This station will allow a comparison with post-impoundment investigations.

Excluding fishes, limnological factors were determined on three occasions to provide a seasonal picture. Collections were made 30 September 1967, 20 January and 8 June 1968. Fishes were collected during the week of 7-11 August 1967.

PHYSICOCHEMICAL METHODS. On each occasion the following determinations were conducted in both pool and riffle areas, at each station. Dissolved oxygen was determined by the Sodium Azide modification of the Winkler Method (APHA, 1960). Analysis of alkalinity and carbon dioxide followed standard limnological procedures (Welch, 1948). A colormetric pH meter was used to determine the hydrogen-ion (pH) concentration. The Secchi Disc and Jackson turbidimeter were used for determination of light penetration and turbidity. Surface and water temperatures were determined with a centigrade thermometer.

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BIOLOGICAL METHODS. Samples of rooted aquatic plants were collected and classified to species.

Plankton samples were procured by a Wisconsin net with a mesh of No. 25 silk bolting cloth. Sample size was 100 1 and from the pool community only. Preservation was by 70% ethanol. Quantitative composition was determined by differential count (Welch, 1948).

Benthos was sampled at each station using the transect method to determine vertical distribution. On each collecting trip three bottom samples were collected from the pool at each station with a 15.2 cm^2 Ekman dredge. Similarly, three 0.93 m^2 samples were taken from the riffle of each station with the Surber sampler. Bottom samples were screened through a sieve of 11.8 sq/linear cm, preserved in 10% formalin, and later transferred to 70% ethanol. Keys by Pennak (1953) and Usinger (1963) were used in identification.

Fishes were taken by rotenone application and preserved in 10% formalin. Classification was according to Bailey **et al.** (1960), while Eddy (1957), Moore (1957), Hubbs and Lagler (1958) and Pflieger (1966) were used in identification.

RESULTS AND DISCUSSION. **Physicochemical Characteristics.** The Strawberry River was characterized by high pH, low carbon dioxide and turbidity, and adequate oxygen values (Tables 1, 2), which are typical of Ozark streams (Neel, 1951; Campbell and Funk, 1953; Reid, 1961; Van Kirk, 1962; Minshall and Minshall, 1966).

Physicochemical conditions in the pool and riffle areas showed only slight differences. There is no sharp demarcation of pool and riffle at either station.

Longitudinal zonation was characterized by a general increase in the amount of dissolved oxygen, alkalinity, and pH at the lower station (Tables 1, 2). The upper reaches of a spring-fed stream are typically lower in dissolved oxygen because ground waters fail to provide oxygen to the waters (Reid, 1961). The increase in alkalinity and pH at the lower station indicated that there was a change in the dissolved solids at stream junctions between the upper and lower stations. The watershed of Station I is primarily Ordovician Calico limestone, while the larger watershed of Station II encompasses Cotter dolomite, Powell, Smithville and Black Rock limestones (Croneis, 1930).

Dissolved carbon dioxide is kept low because it enters into combination with lime in the substrate to form carbonates (Reid, 1961) or is lost to the atmosphere through turbulence.

Light penetration values were generally greater at Station I than at Station II showing Station I to be less turbid on all trips. Turbidity values were less conclusive, and the Jackson Turbidimeter does not allow determinations below 25 ppm. On January 1968, however, with values above 25 ppm, Station I again proved to be the less turbid station. Low turbidity values are attributed to the nature of the watershed and concomitant absence of organic pollution.

Seasonally the amount of dissolved oxygen and carbon dioxide was highest on 20 January 1968, a period of low temperature. Oxygen values were lowest on 8 June 1968, when water temperatures were highest.

Alkalinity and pH values were lowest on 20 January 1968 and highest on 8 June 1968. The week previous to 20 January was marked by a period of heavy rainfall resulting in excessive runoff. This probably introduced a dilution factor which lowered the alkalinity. Because the carbon dioxide was highest on this sample date, it follows that the pH would be lower because pH varies inversely with the dissolved carbon dioxide concentration and directly with the bicarbonate concentration (Reid, 1961).

Further indications of the flood conditions during 20 January 1968 were the highest turbidity and lowest light pentration values on that date.

BIOLOGICAL CHARACTERISTICS. Rooted aquatic plants were limited to **Justicia americana** (L) Vahl, which bordered the riffle at Station I and a single specimen of **Nuphar luteum** (L) Sibthorp & Smith found in the pool at Station I. No rooted aquatic plants were found at Station II. Although poor substrate and swift current limits the presence of rooted aquatic plants in Ozark streams (Sullivan, 1929; Sublette, 1949; Moore and Paden, 1950; Campbell and Funk, 1953; Van Kirk, 1962) the bed of **J. americana** probably provided protection for a limited population of benthic macroinvertebrates. During 7-11 August 1967, several darters were taken from this area.

The river was characterized by a paucity of plankton. For this reason, no patterns of longitudinal or seasonal nature emerged. Rotatoria was collected twice, **Staurastrum** and **Gomphonema** once each. Numbers varied from 49-103/1. These were the only taxa observed in differential counts, although **Ceratium** was also noted in random surveys. All are typical stream forms (Reid, 1961; Hanebrink, 1965). Streams normally support a small plankton population because of current (Reid, 1961).

The pool benthic macroinvertebrate communities of Strawberry River were qualitatively and quantitatively sparse, the dominant taxa being Chironomidae, Oligochaeta and Ephemeroptera, in that order (Table 3). A sand-bottom pool habitat characteristically has few indigenous macroinvertebrates and may never possess communities because of constant shifting (Gersbacher, 1937; Kendeigh, 1961). Chironomidae has previously been found to be the dominant pool form in Ozark-type streams (O'Connell and Campbell, 1953; Van Kirk, 1962; Aggus and Warren, 1965). That clear demarcation of pool-riffle communities is absent in the Strawberry River is suggested by the fact that Ephemeroptera such as **Sten-**

onema and **Isonychia** comprised the third largest taxon in the pool communities. These forms are adapted as vigorous swimmers **(Isonychia)** or for clinging **(Stenonema)** in swift water habitats.

The riffle communities of the Strawberry River supported greater numbers and diversity of benthic macrofauna than did the pools (Table 4). At Station II the macroinvertebrate pool community was composed of fewer taxa but more total organisms than the riffle community. There was no clear demarcation of pool-riffle at Station II, therefore the riffle community approached that of the pool. In general, the greater number and diversity of macroinvertebrates in riffles are correlated with more optimal conditions such as light, food (aufwuchs) and oxygen, as well as the greater diversity of microhabitats to be found here (Kendeigh, 1961). The dominant forms of macroinvertebrates included Trichoptera **(Cheumatopsyche** and **Chimarra)**, Ephemeroptera **(Isonychia** and **Stenonema)** and Diptera (Chironomidae and Simuliidae), in that order.

Longitudinal zonation was characterized by an increase in species and numbers of the pool benthic macrofauna and a decrease in species and numbers of riffle benthic macrofauna from Station I to Station II. Armitage (1961) and Reid (1961) noted an increase in number of species of benthic macrofauna downstream correlated with increased microhabitat diversity. The data from the pool support this finding. The riffle data seem to disagree, however it must be remembered that the riffle at Station II is much less defined than the riffle at Station I, and there was a decrease in microhabitat diversity at Station II riffle.

Vertical distribution was uniform from one side to the other (Robison, 1968). Although the reason for this is not clear, it perhaps is correlated with a relatively uniform current velocity from stream bank to stream bank (Kendeigh, 1961).

A seasonal minimum for total benthic macrofauna of both stations was recorded on 20 January 1968, and a maximum for pool only on 8 June 1968 and for riffles on 30 September 1967. These figures agree with Needham (1938) and Stehr and Branson (1938) was found numerical maxima occuring in late summer and again in autumn. Winter flooding was apparently responsible for a seasonal minimum of total benthic macrofauna on 20 January 1968. Moffett (1936), Sublette (1949), Mathis (1965), and Aggus and Warren (1965) also observed a large reduction of benthic macrofauna following winter and spring floods. Because of the large decrease in biomass of benthos, floods probably have a more adverse effect than is generally known.

Fishes function as an intermediate link in the food chain betwen the benthos and man. Small forage fishes act as link between the benthos and larger fishes. Larger fishes, the predators, are the ultimate consumers in the aquatic community. The predominant predator in this study was **Micropterus punctulatus.** The most abundant forage fishes were **Dorosoma cepedianum** and **Lepomis megalotis** (Table 5).

Stream fishes can usually be divided on the basis of pool and riffle forms because of habitat preference. This separation is not absolute because of their mobility. For example, pool forms often move into the riffles to feed or in migration to other pools. The dominant pool forms were **Dorosoma cepedianum, Moxostoma erythrurum** and **Lepomis megalotis** (Table 5). Reid (1961) and Van Kirk (1962) reported Cyprinidae, Centrarchidae and Catostomidae as dominant pool forms in similar streams. Pools have been reported as supporting a larger and more diverse fish population than riffles because the current is not a limiting factor in this habitat, and food is plentiful because of drift organisms. In addition, the accumulation of debris in pools provides an ideal substrate for benthic macroinvertebrates which are more accessible to fishes. These points are seemingly emphasized in this study as 90% of the total fishes caught, 1757 of 1979, were taken from the pools.

Although only 222 fishes, 10% of those captured, were taken from the riffles, the population was greater than that for the pools on an areal basis, 3896 and 1108/ha in the riffles of Stations I and II, respectively, versus 242 and 185/ha in the pools of Stations I and II, respectively. This is understandable in that riffles are more productive of aufwuchs and benthic fauna than pools because of optimal conditions of light and oxygen, thus providing a better food supply for those fishes which are adapted to cope with the current. The dominant riffle fishes were **Etheostoma caeruleum** and **Percina caprodes,** forms which are uniquely adapted to swift waters by streamlined bodies, enlarged pectoral fins, and degenerate gas bladders (Reid, 1961). Of 14 species taken in the riffles, 7 were of the family Percidae. That fewer fish species are adapted to the riffle community is supported by the acquisition of only 15 species from the riffles, but 42 species from the pool communities.

Longitudinal zonation of the fishes was characterized by a decrease in number/ha and species (39 vs 35) present from Station I to Station II (Table 5). Thompson and Hunt (1930) found that the number of individuals decreased downstream, but the size of the fish increased, so that biomass density remained about the same. There is normally an increase in number of species, correlated with an increasingly more diverse habitat, as one moves downstream (Burton and Odum, 1945; Kendeigh, 1961; Larimore and Smith, 1963). That such was not the case in this study is due in part to the absence of a discreet riffle at Station II. Only 3 of 10 species were darters at this station, as opposed to 7 of 9 species being darters at the riffle of Station I.

Two specimens of **Noturus eleutherus** were taken at Station II. These constitute an extension of the known range for this species (Robison, 1969). The specimens are now located in the University of Minnesota Museum of Natural History.

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TABLE 1. Physicochemical Characteristics, Station I, 30 September 1967-8 June 1968.

	9-30-67		1-20-68		6-8-68	
	Pool	Riffle	Pool	Riffle	Pool	Riffle
Oxygen, ppm	7.8	7.6	10.0	9.9	6.5	6.9
Percent Oxygen Saturation	74.0	73.0	83.0	82.0	77.0	83.0
Carbon dioxide, ppm	2.3	3.0	5.0	3.5	3.3	3.2
Alkalinity, ppm	150.8	160.0	68.0	70.0	249.0	231.0
pH	7.7	7.7	7.7	7.1	7.6	7.6
Air Temperature, °C	14.4	14.4	8.5	8.4	30.5	30.5
Water Temperature, °C	13.7	13.7	7.2	7.4	25.0	25.0
Turbidity, ppm	less than 25.0	——	41.0	——	less than 25.0	——
Light penetration, cm	71.0*	——	25.0	——	36.0*	——

*Indicates a reading on the bottom

TABLE 2. Physicochemical Characteristics, Station II, 30 September 1967 - 8 June 1968. No samples taken on 1-20-68 at riffle because of flooded conditions.

	9-30-67		1-20-68	6-8-68	
	Pool	Riffle	Pool	Pool	Riffle
Oxygen, ppm	8.9	8.8	9.7	7.1	7.3
Percent Oxygen Saturation	86.0	85.0	82.0	88.0	91.0
Carbon Dioxide, ppm	3.0	3.0	5.5	0.6	1.0
Alkalinity, ppm	188.0	185.0	110.0	256.0	254.0
pH	7.8	7.8	7.4	8.0	7.9
Air Temperature, °C	16.6	16.6	11.0	27.5	27.5
Water Temperature, °C	14.1	14.1	8.1	25.5	25.0
Turbidity, ppm	less than 25.0	——	94.0	less than 25.0	——
Light penetration, cm	58.0	——	13.0	98.0	——

TABLE 3. Mean Number of Benthic Macrofauna expressed as No./M², Station I and II Pools, 30 September 1967. 8 June 1968.

	Station I			Station II		
	9-30-67	1-20-68	6-8-68	9-30-67	1-20-67	6-8-68
Oligochaeta	0	43.0	28.7	401.7	143.3	43.0
Hirudinea	0	0	0	14.3	0	7
Acarina	0	14.3	0	0	0	0
Insecta						
Ephemeroptera						
Caenis	0	0	0	14.3	14.3	14.3
Brachycercus	0	0	14.3	0	0	0
Isonychia	0	0	100.3	43.0	0	71.7
Stenonema	0	0	6.7	43.0	0	14.3
Potamanthus	0	0	0	28.7	0	0
Odonata						
Aeschnida	28.7	0	0	0	0	0
Macromia	0	0	0	0	0	14.3
Coleoptera						
Elmidae						
(larvae)	28.7	0	0	71.7	14.3	0
Diptera						
Chironomidae						
(larve)	0	43.0	1032.7	71.7	57.3	1305.7
(pupae)	71.7	0	57.3	71.7	0	200.7
Simulium	0	0	0	14.3	0	14.3
Quantitative Totals	387	301	3937	2324	688	5036
Qualitative Totals	3	3	6	10	4	8

TABLE 4. Mean Number of Benthic Macrofauna expressed as No./M², Station I and II Riffles, 30 September 1967 8 June 1968. No samples taken on 20 January 1968 at Station II because of flooded conditions.

	Station I			Station II	
	9-30-67	1-20-68	6-8-68	9-30-67	6-8-68
Oligochaeta	39.7	7.3	7.3	57.3	3.7
Turbellaria	93.3	0	3.7	0	0
Gastropoda					
Pleuroceridae	3.7	3.7	0	0	0
Insecta					
Ephemeroptera					
Ephoron	0	0	3.7	0	0
Caenis	32.3	0	0	36.0	18.0
Pseudocloeon	0	0	3.7	0	0
Isonychia	208.0	14.6	82.3	60.7	86.0
Stenonema	172.0	7.3	36.0	219.0	75.3
Potamanthus	0	0	0	61.0	3.7
Plecoptera					
Neoperla clymene	0	0	29.0	0	0
Megaloptera					
Corydalus cornutus	61.0	0	3.7	3.7	0
Trichoptera					
(Unidentified Pupae)	28.7	0	7.3	0	0
Cheumatopsyche	760.3	10.7	276.3	10.6	3.7
Chimarra	850.3	0	18.0	14.3	11.0
Coleoptera					
Elmidae (adult)	32.3	0	3.7	0	3.7
(larvae)	82.7	7.3	3.7	25.3	0
Psephenus herricki	0.3	0	11.0	0	0
Diptera					
Chironomidae (larvae)	54.0	14.3	258.3	125.7	333.3
(pupae)	7.3	0	0	25.3	75.3
Simulium	764.0	0	211.7	0	0
Tabanidae	7.3	0	0	0	0
Lepidoptera					
Elophila	3.7	0	0	0	0
Quantitative Totals	8080	193	2873	1915	1840
Qualitative Totals	18	7	16	11	10

TABLE 5. Fishes collected at Stations I and II, 7-11 August 1967.

Taxa	Station I Pool	Station I Riffle	Station II Pool	Station II Riffle
Lepisosteidae				
Lepisosteus osseus	10	0	3	0
Clupeidae				
Dorosoma cepedianum	247	0	456	0
Hiodontidae				
Hiodon tergisus	0	0	20	0
Catostomidae				
Carpiodes cyprinus	10	0	19	2
Hypentelium nigricans	12	0	5	0
Ictiobus bubalus	0	0	4	0
I. cyprinellus	3	0	5	0
I. niger	1	0	5	0
Moxostoma erythrurum	15	0	116	3
Cyprinidae				
Campostoma anomalum	32	0	0	0
Cyprinus carpio	20	0	19	0
Hybopsis amblops	0	0	65	8
Notemigonus crysoleucas	3	0	0	0
Notropis whipplei	0	0	2	1
N. chrysocephauls	15	0	0	0
N. boops	3	0	1	0
N. texanus	0	0	1	0
N. venustus	1	0	3	0
Pimephales notatus	3	0	0	0
P. tenellus	32	0	13	7
Semotilus atromaculatus	14	0	0	0
Ictaluridae				
Ictalurus natalis	2	0	0	0
I. punctatus	9	0	17	0
Noturus eleuthurus	0	0	2	2
N. exilis	12	0	0	0
N. miurus	8	0	19	0
Pylodictis olivaris	11	0	2	0

TABLE 5 (continued)

Taxa	Station I Pool	Station I Riffle	Station II Pool	Station II Riffle
Cyprinodontidae				
Fundulus olivaceous	18	0	23	0
Atherinidae				
Labidesthes sicculus	3	0	0	0
Centrarchidae				
Ambloplites rupestris	5	0	0	0
Lepomis cyanellus	42	0	0	0
L. gibbosus	0	0	7	0
L. macrochirus	45	2	10	0
L. megalotis	110	0	85	8
Micropterus dolomieui	0	0	1	0
M. punctulatus	40	0	18	0
M. salmoides	16	0	2	0
Promoxis annularis	0	0	2	0
P. nigromaculatus	7	0	2	0
Percidae				
Etheostoma blenniodes	0	9	0	0
E. caeruleum	0	72	0	12
E. euzonum	0	1	0	0
E. flabellare	0	6	0	2
E. whipplei	0	15	0	0
E. zonale	0	5	0	0
Percina caprodes	12	34	3	25
Stizostedion vitreum	0	0	1	0
Sciaenidae				
Aplodinotus grunniens	24	0	41	0
Cottidae				
Cottus carolinae	0	7	0	3
Quantitative Totals	785	151	972	71
Qualitative Totals	32	9	32	10

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Ichthyofaunal Diversification and Distribution In The Big Creek Watershed, Craighead and Greene Counties, Arkansas

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ABSTRACT

Big Creek is a relatively small deltaic stream, in northeastern Arkansas, in an area of intense cultivation. Recently it has been dredged in the interest of flood control. Lost Creek and Mud Creek are the major tributaries of Big Creek and collectively drain the Big Creek watershed. The streams were found to have relatively low alkalinity, moderate carbon dioxide, adequate oxygen values, and relatively high turbidity. Channeling of Big Creek and Lost Creek has effectively destroyed distinct pool-riffle biocies and reduced the number of acceptable spawning areas. Lost Creek, also, receives effluent from residential dwellings, a secondary treatment sewage plant, and a meat rendering plant. Mud Creek, in the absence of channeling and deleterious effects of effluents, provided a relatively greater diversity of habitat than did Big Creek or Lost Creek.

A total of 21 species were collected in the streams. Big Creek supported 17 species while Mud Creek and Lost Creek supported 14 and 11 species, respectively. Five of the 11 species collected in Lost Creek are characteristic of streams with plentiful organic debris and were not collected, in numbers, at any other station in the watershed.

Of the 2,209 fishes collected, **Notropis umbratilis, Fundulus olivaceous,** and **Leomis cyanellus** made up 63% of the total and were procured from all sations. Their relative abundance is supported by their ability to withstand high turbidity and limited competition due to depth effect.

Limited species included **Ictalurus natalis, Aphredoderus sayanus,** and **Etheostoma gracile** in Mud Creek; **Dorsoma cepedianum** in Lost Creek; and the headwater species, **Semotilus atromaculatus,** in Big Creek and Mud Creek. **Cyprinus carpio, Ictalurus melas, Gambusia affinis,** and **Notemigonus crysoleucas** were also limited, in relative numbers, to Lost Creek.

INTRODUCTION

Big Creek is a relatively small deltaic stream, in northeastern Arkansas, in an area of intense cultivation. Recently it has been dredge in the interest of flood control for surrounding farm land. Lost Creek and Mud Creek are the major tributaries of Big Creek and collectively drain the Big Creek watershed.

It is the purpose of this study to determine the qualitative variation of fish populations in the Big Creek watershed and the co-existing physicochemical conditions. Further, the effect of effluents from the Jonesboro Sewage Treatment Plant and Broadaway Meat Packing Company (Lost Creek) and intensive cultivation (the entire watershed) on the fish population will be observed.

The major soils immediately adjacent to the streams of the Big Creek watershed are of the Falaya-Collins association. These are deep, poorly to moderately well drained, moderately permeable, silty bottomed and soils washed from loess. The poorly drained Falaya soils

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