SOUTH FOURCHE LAFAVE RIVER

ARKANSAS

A

WATER QUALITY, MACROINVERTEBRATE,

AND FISH COMMUNITY

SURVEY

ARKANSAS DEPARTMENT OF POLLUTION CONTROL AND ECOLOGY

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SOUTH FOURCHE LAFAVE RIVER

A WATER QUALITY, MACROINVERTEBRATE AND FISH COMMUNITY SURVEY

INTRODUCTION

Historical water quality records from the Arkansas Department of Pollution Control and Ecology's (ADPC&E) Water Quality Monitoring Network (WQMN), station "ARK 52", indicate a trend of in-stream turbidity violations on the South Fourche LaFave River near Hollis, Arkansas. According to these data, turbidity levels greater than the 10 NTU (Nephelometric Turbidity Units) Ouachita Mountain ecoregion standard as set forth by Regulation #2 (ADPC&E 1991) have occurred in approximately sixty percent (60%) of the samples taken between November 11, 1983 and August 25, 1992. On three separate occasions, turbidity levels of 55.0 NTU, 57.0 NTU, and 65.0 NTU, were measured; and on fifteen other occasions turbidity levels were observed to be over three times that of the standard. Figure 1 is a graph depicting the turbidity levels at "Ark 52" from 1983 to 1992.

According to the ADPC&E's Water Quality Inventory Report (1992), the South Fourche LaFave River's aquatic life use is only partially supported. Excessive turbidity is stated as being the probable cause of this use impairment. However, turbidity analyses indicate an improving trend over the past eleven years.

Pasture land, confined animal operations, some row crops, timber harvesting and road maintenance and construction, dominate the land uses within the watershed and are the main causes of the excessive turbidity entering the river. Other causes for historic turbidity violations could be linked to the construction of flood control dams on the River's main tributaries and the installation of low water stream crossing structures and stream channel manipulations.

The objectives of this study were: 1) to determine the existing water quality in the South Fourche LaFave River watershed, 2) to determine the causes of the water quality violation, if any, 3) to determine the macroinvertebrate community structure within the river system, 4) and to determine the fish community structure within the river system.

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SOUTH FOURCHE LA FAVE RIVER ABOVE HOLLIS ARK 05105 ARKANSAS

P

RKANSAS RIVER VAN BUREN TO MOUTH SW LOWER MISSISSIPPI

A

82079 TURBIDTY LAB NTU

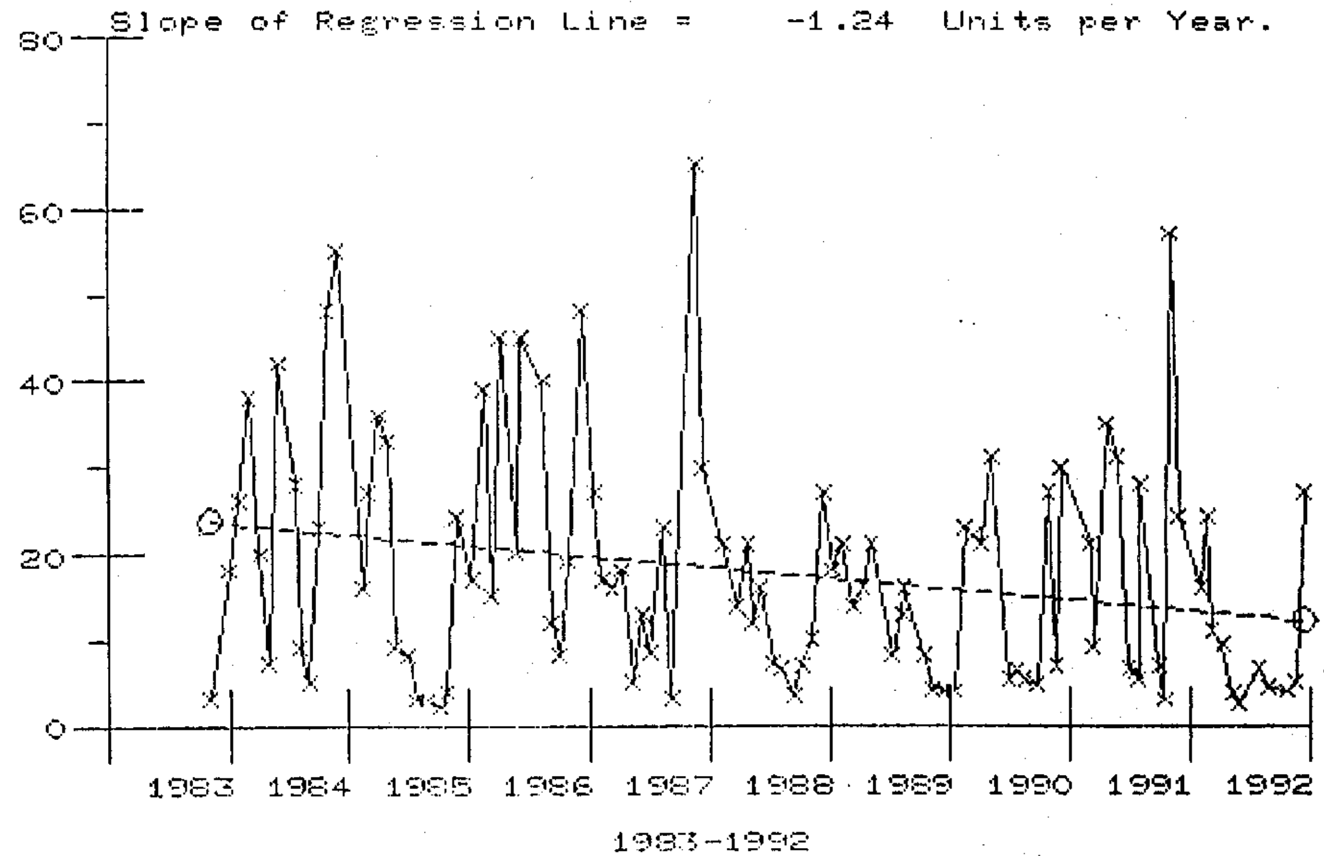


FIGURE 1

Historical Turbidity Concentration Trend Analysis

WATERSHED DESCRIPTION

The South Fourche LaFave River arises near Onyx, Arkansas, Yell County, in the Ouachita Mountain ecoregion. It flows almost due east before turning north just east of Hollis, Arkansas and entering into the Arkansas River Valley ecoregion. It then joins the Fourche LaFave River approximately ten river miles downstream of Lake Nimrod Dam (ADPC&E 1987).

The South Fourche LaFave River and most of its watershed is parallel to and overlaps the boundary of the Ouachita Mountain and Arkansas River Valley ecoregions. Although it has been placed in the Ouachita Mountain ecoregion, it is known to possess many characteristics of the Arkansas River Valley ecoregion. The river has an approximately 235 square miles watershed. The five main tributaries listed below account for 56.7% of the watershed. The four larger tributaries drain areas south of the river. The northern tributaries are mostly intermittent streams with small watersheds, with the exception of Big Cove Creek.

Graham Creek	--	17.7 mi^2
Dry Fork Creek	--	35.2 mi^2
Bear Creek	--	40.0 mi^2
Cedar Creek	--	26.5 mi^2
Big Cove Creek	--	13.7 mi^2
Total	--	133.1 mi^2

The River's main stem flows through the South Fourche LaFave River Valley and lies within the Avilla-Kenn-Clebit formation; a deep, level to gently sloping, well drained, loamy to gravelly soil, in Yell County (USDA 1988); and the Leadville-Guthrie formation, a moderately well drained to poorly drained, level to gently sloping, deep loamy soil, in Perry County (USDA 1982). It's tributaries flow from the adjacent mountain ranges which may rise six to seven hundred feet above the river bottom. Tributary soils in Yell County consist of the Carnasaw-Sherless-Clebit formation; a well drained, gently to very steep sloping gravelly and stony soil (USDA 1988). The Perry County tributaries lie in the Carnasaw-Pirum-Clebit formation; a well drained, gently to very steep sloping, deep to shallow, loamy, gravelly and stony soil (USDA 1982).

The headwaters of the tributaries and the main stem of the river arise between 800 and 900 feet mean sea level (msl) and have stream bed gradients of approximately 30 to 40 ft/mile. The gradient of the River's main stem is somewhat less, approximately 15 to 20 ft/mile in its upper portions near Onyx and 10 to 15 ft/mile near its confluence with the Fourche LaFave River. Its midsection gradient is only 5 to 10 ft/mile. This creates long, deep pools and deep riffles with slow to moderate currents (USGS Topography maps).

Site specific physical characteristics can be found in the "Materials and Methods" section, individual sampling station descriptions, of the Fish Sampling subsection of this report.

Silviculture is the dominant land use within the South Fourche LaFave drainage and it occurs mainly in the river's tributary watersheds. Timber management is primarily for a productive softwood tree forest; however, some hardwood is also harvested. An extensive road system is maintained throughout the watershed with some forest-road best management practices, concreted stream bed crossings, ditch turnouts, seeded roadbeds, etc., existing. Many low water stream crossings exist in the tributary streams.

Scattered throughout the river's main stem are small farms mostly of pasture land and/or confined animal operations. There are approximately five million broiler chickens produced in the watershed yearly (ADPC&E 1991, USDA 1991), with the majority of these farms located directly adjacent to the river's main stem. Some row crop agriculture can be found in the section of the river near its confluence with the Fourche LaFave River.

The USDA Soil Conservation Service began a watershed flood control project in early 1976. Five flood water control dams were to be constructed on four of the river's tributaries; one each on Dry Fork Creek, completed March 1977; and Big Cove Creek, completed in November 1984; one on Cedar Creek, projected construction start date sometime in the spring of 1993; and two in the Bear Creek watershed; one on Little Bear Creek, completed in December 1980, the other on Bear Creek proper, not yet slated for construction. The main objective of these structures is to control flooding.

The South Fourche LaFave River is recognized as an Ouachita Mountain ecoregion waterway and has to following designated uses assigned to it:

- Primary Contact Recreation
- Secondary Contact Recreation
- Ouachita Mountain Ecoregion Fisheries
- Domestic Water Supply
- Industrial Water Supply
- Agricultural Water Supply

MATERIALS/METHODS

Water Quality Sampling

The following equipment was used to collect water samples and take in-situ measurements:

1) 2 - Y.S.I. Model 57 portable dissolved oxygen meters
2) 2 - Orion SA Model 230 portable pH meters
3) Marsh-McBirney Model 201 flow meter
4) 1/2 gallon water sampling containers
5) Bacteria sampling containers
6) Winkler titration kit

Stream samples were collected, preserved, and analyzed according to the 16th Edition of Standard Methods for the Examination of Water and Wastewater. Analyses were conducted under ADPC&E's existing Quality Assurance Program. Table 1 list the parameters analyzed and the field data taken. The dissolved oxygen meters were calibrated prior to use with the Winkler titration kit. The pH meters were calibrated using buffer solutions of pH 4, pH 7, and pH 10, when needed. Stream flow was measured by obtaining a representative number of velocities and depths across the stream.

TABLE 1

<u>IN-SITU MEASUREMENTS</u>

Temperature
pH
Dissolved Oxygen
Flow (cfs)

<u>LAB ANALYSES</u>

Nitrogen -- Ammonia, Nitrite-Nitrate
Phosphorus -- Ortho, Total
Total Solids -- Dissolved, Suspended
Total Hardness, Turbidity
Chloride, Sulfate
Biochemical Oxygen Demand
Total Organic Carbon
Fecal Coliform Bacteria
<u>Escherichia</u> <u>coli</u>

Water Sampling Stations

The following is a list of the water quality monitoring stations identified in the South Fourche LaFave watershed. This list includes the location of the stations and its approximate watershed acreage (ws). If stream flow was recorded at the station the word "Flow" will be found. Figure 2 is a map depicting the location of these stations.

Yell County

SFR01 -- South Fourche LaFave River off Hwy 314 approx 1.5 mi. E. of Haw Creek confluence (Sec 6, T2N, R22W) WS-13,120 ac. Flow.

GRC02 -- Graham Creek just upstream of Nigger Branch confluence (Sec 7, T2N, R22W) WS-960 ac.

GRC01 -- Graham Creek approx 2 mi. E. on NFM rd., 1/2 mi. S. of Hwy 314/27 jct., (Sec 18, T2N, R22W) WS-8480 ac. Flow.

SFR02 -- South Fourche LaFave River 3/4 mi. downstream of Hutto Branch (Sec 4, T2N, R22W) WS-27,520 ac.

Perry County

SFR03 -- South Fourche LaFave River off Hwy 314 upstream of Loston Branch (Sec 31, T3N, R21W) WS-39,200 ac.

SFR04 -- South Fourche LaFave River 3/4 mi. S. on Co. Rd. 8 mi. W. of Hwy 314/7 jct (Sec 33, T3N, R21W) WS-44,320 ac.

SFR05 -- South Fourche LaFave River 1/2 mi. upstream of Dry Fork Creek on Co. Rd (Sec 36, T3N, R21W) WS-49,184 ac. Flow.

DFC01 -- Dry Fork Creek 1/2 mi. downstream of Little Creek (Sec 11, T3N, R21W) WS-19,440 ac.

SFR06 -- South Fourche LaFave River 1/2 mi. below Dry Fork Creek (Sec 30, T3N, R21W) WS-72,232 ac.

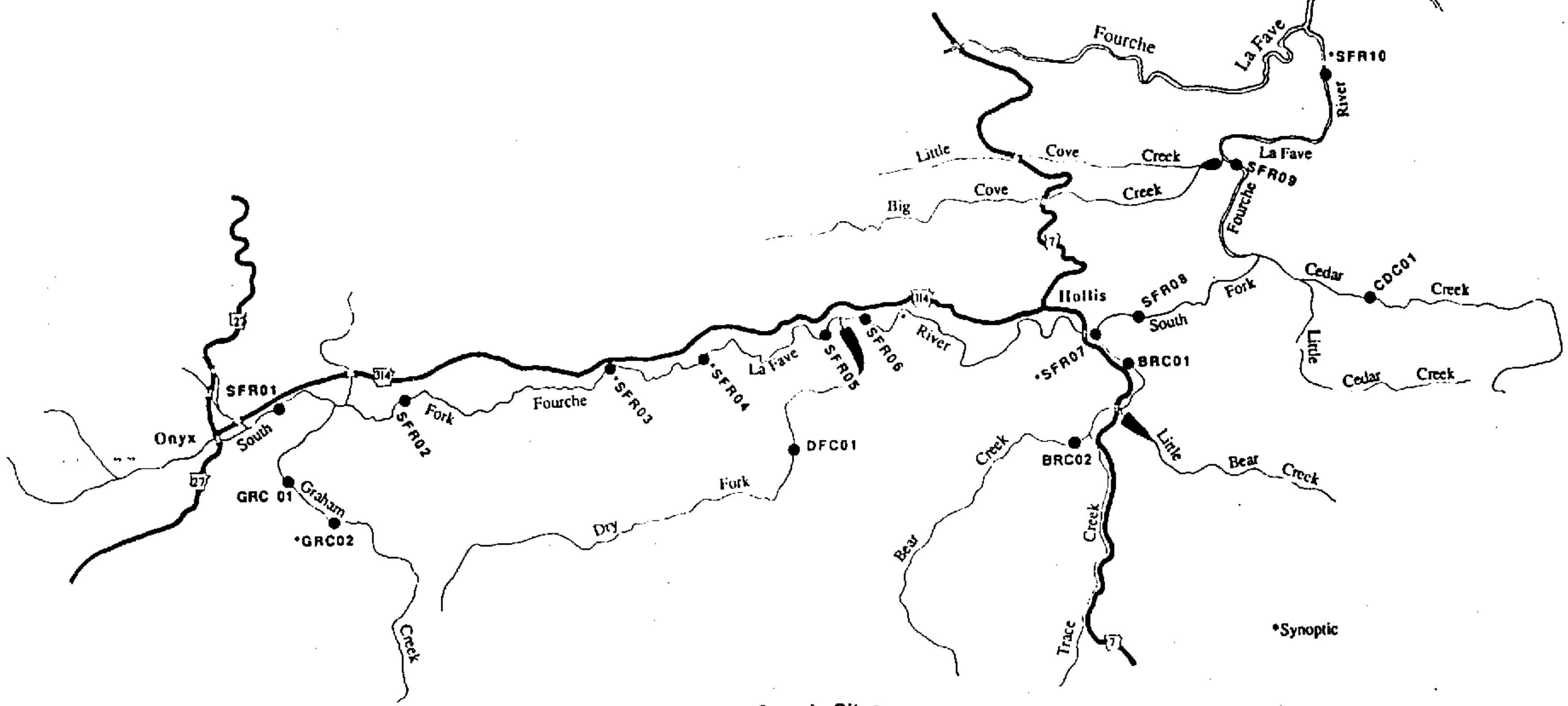
SFR07 -- South Fourche LaFave River below Hwy 7 bridge, above Bear Creek (Sec 34, T3N, R20W) WS-81,180 ac.

BRC01 -- Bear Creek at Co. Rd. bridge 1 mi. upstream of South Fourche LaFave River (Sec 35, T3N, R20W) WS-24,960 ac. Flow.

SFR08 -- South Fourche LaFave River 1 mi. downstream of Bear Creek confluence (Sec 25, T3N, R20W) WS-108,520 ac.

FIGURE 2

Survey Area



Sample Sites
South Fork Fourche LaFave River

CDC01 -- Cedar Creek 2 1/4 mi. upstream of confluence on NFM Rd. (Sec 28, T3N, R19W) WS-11,200 ac. Flow.

SFR09 -- South Fourche LaFave River upstream of Big Cove Creek on Co. Rd. (Sec 18, T3N, R19W) WS-136,320 ac.

SFR10 -- South Fourche LaFave River 1-1/4 mi. upstream of Fourche LaFave River (Sec 4, T3N, R19W) WS-149,840 ac.

Samples were collected six times during the survey at nine of the stations; one station was sampled five times. Four additional stations were sampled twice during the survey and one station was sampled three times. Survey personnel attempted to collect water samples during five climatic events; 1) summer, low flow (base flow) 2) late fall, 3) late winter flow, 4) a springtime high flow, and 5) after a summertime storm event.

Macroinvertebrate Sampling

The macroinvertebrates were collected with an indestructible Turtox benthos net, preserved in a 70% ethanol solution and returned to the lab at ADPC&E for analysis. Collecting and analyses were performed in accordance with EPA's Rapid Bioassessment Protocol II.

Macroinvertebrate Sampling Locations

Macroinvertebrates were collected at eight locations; four stations were located in the River's main stem, and one station in each of the four main tributaries. These stations and date of collection are listed below:

GRC01 -- June 17, 1992
DFC01 -- June 17, 1992
BRC01 -- June 17, 1992
CDC01 -- June 17, 1992
SFR02 -- October 17, 1991
SFR06 -- October 16, 1991
SFR08 -- October 16. 1991
SFR09 -- October 14, 1991

These eight stations were located at fish sampling stations, therefore, the habitat for each station is described in the following fish sampling Station Location/Description section.

Fish Sampling

Several different types of sampling gear were used to meet the objectives of this section of the survey. These include:

1) boat mounted, electrofishing device with pulsed D.C. current, 2500 watt A.C. Generator with hand-held electrodes
2) backpack electrofisher with pulsed D.C. current, 350 watt A.C. output

The backpack electrofisher was used to sample the riffle areas, the shallower pools, and along the shorelines which were inaccessible to the boat shocker. All tributary streams were sampled with backpack shockers. The boat mounted electrofishing device was used to sample the larger, deeper pool areas in the main stem of the river. The substrate and water condition at each sampling location dictated the type of sampling gear used.

Fish species of all types were collected from all available habitat within the sample area until all available habitat was sampled and a fully representative sample of the species in the area was obtained. Collections were made only once at each station during the survey.

Most large specimens were field identified and released. The smaller specimens, and those unidentifiable in the field, were preserved in a ten percent (10%) formalin solution and returned to the lab at ADPC&E for identification. The taxonomic keys of Robison and Buchanan (1991), Pflieger (1975), and Douglas (1974) were used in the identifications. A Relative Abundance Value (RAV) for each species collected and/or observed was determined according to Keith (1987). The values are as follows:

1 -- Rare - Species or age group represented by only one or very few individuals in the population; more than likely a remnant, migrant or a displaced species.

1.5 -- Rare to Present

2 -- Present - Species or age group collected with enough frequency to indicate the likely presence of an established population but definitely a subordinate species in the species group.

2.5 -- Present to Common

3 -- Common - Species or age group collected in most areas where such species would exist; individuals frequently seen and apparently well established in the populations; one of the more frequent species of the species group.

3.5 -- Common to Abundant

4 -- Abundant - Species or age group collected easily in a variety of habitats where species expected; numerous individuals seen with consideration of sampling gear limitations and expected abundance of such species; a dominant species of the species group.

For this survey, the young and sub-adults within each species were ranked together and given one value. The adults of each species were given a separate ranking, thus creating an eight point ranking system.

Station Location/Description

GRC01 -- Graham Creek

Graham Creek 1.5 mi. E. of St. Hwy 27 on forest service road ¼ mi. S. of St. Hwy 27 and 314 junction. (Sec 7, T2S, R22W). Yell County.

Date of Sample: October 22, 1991

Unit of Effort: Backpack shocker, pulsed-D.C.; 700v; 120 p/s

Stream Condition: Pool with mostly large boulders, some gravel and aquatic vegetation.

Quantity of Fish Habitat: Moderate

SFR02 -- South Fourche LaFave River

South Fourche LaFave River at low water crossing on TAR off Co. Rd. 130, 4 mi. E. of St. Hwy. 314 and 27 jct., on St. Hwy. 314. (Sec 4, T2S, R22W). Yell County.

Date of Sample: September 17, 1992

Unit of Effort: 3500 watt AC (220v) boat shocker in pools, 110v Backpack shocker in riffles, 10,800 secs. intermittently.

Stream Condition: Pool with aquatic and terrestrial vegetation, cobble/rubble substrate with some boulders, undercut banks, roots and logs/treetops.

Quantity of Fish Habitat: Moderate

DFC01 -- Dry Fork Creek

Dry Fork Creek at low water crossing below Marble Branch confluence, upstream ¼ mi. (Sec 2, T2N, R21W). Perry County.

Date of Sample: October 22, 1991

Unit of Effort: Pulsed D.C backpack shocker, 700v, 120 pulses/sec. 3600 secs.

Stream Condition: Pool with little aquatic vegetation, substrate mainly of boulders, some cobble/rubble, undercut banks and roots. Riffle area mainly of boulders, some cobble/rubble.

Quantity of Fish Habitat: Abundant

SFR06 -- South Fourche LaFave River

South Fourche LaFave River across private pasture approx. 1 mile below confluence of Dry Fork Creek (Sec 25, T3N, R21W). Perry County.

Date of Sample: September 23, 1991

Unit of Effort: 3500 watt boat-carried shocker; wading with hand-held electrodes shocker; 110v-AC backpack shocker in riffle, approx. 9000 secs. intermittently.

Stream Condition: Pool with logs/treetops, aquatic vegetation, some undercut banks and roots, boulders, cobble/rubble, and gravel. Riffle substrate mainly cobble/rubble with aquatic vegetation, log/treetops, boulders and gravel.

Quantity of Fish Habitat: Abundant

BRC01 -- Bear Creek

Bear Creek just above mouth, upstream approx. ¼ mi. (Sec 35, T3N, R20W). Perry County.

Date of Sample: October 1, 1991

Unit of Effort: Pulsed DC backpack shocker, 900-1100v, 120 pulses/sec., approx 3600 secs.

Stream Condition: Pool substrate mainly of boulders and cobble/rubble, some roots, undercut banks, and terrestrial vegetation. Riffle substrate mainly cobble/rubble with boulders.

Quantity of Fish Habitat: Abundant

BRC02 -- Bear Creek

Bear Creek at TAR Rd. crossing above confluence of Trace Creek, approx. ½ mi. W. of Ark. St. Hwy 7. (Sec 10, T2N, R20W). Perry County.

Date of Sample: October 1, 1991

Unit of Effort: Pulsed DC backpack shocker, 900v, 120 pulses/sec. approx. 3600 secs.

Stream Condition: Pool substrate mainly of cobble/rubble and boulders, some undercut banks, roots and gravel. Riffle substrate mainly cobble/rubble, some boulders and gravel.

Quantity of Fish Habitat: Abundant

SFR08 -- South Fourche LaFave River

South Fourche LaFave River at end of abandoned timber road, approx. 1.25 mi. below confluence of Bear Creek. (Secs 25, 26, T2N, R20W). Perry County.

Date of Sample: September 18, 1991

Unit of Effort: 3500 watt boat-carried shocker; wading with hand-held electrodes in pools and some riffles. 110v-AC backpack shocker in riffles. 10,800 secs., intermittently.

Stream Condition: Pools mainly of boulders and aquatic vegetation, some undercut banks, roots, logs/treetops. Riffle substrate mainly of cobble/rubble and boulders with some aquatic vegetation (water willow).

Quantity of Fish Habitat: Abundant

CDC01 -- Cedar Creek

Cedar Creek above and below Co. Rd. approx. 1.5 mi. upstream of Little Cedar Creek confluence, (Sec 27, T3N, R19W). Perry County.

Date of Sample: October 10, 1991

Unit of Effort: 110v-AC backpack shocker, approx. 5400 secs.

Stream Condition: Pool substrate mainly of boulders, cobble/rubble, with aquatic vegetation and some undercut banks and roots. Riffle substrate mainly of boulders, cobble/rubble and some gravel.

Quantity of Fish Habitat: Abundant

SFR09 -- South Fourche LaFave River

South Fourche LaFave River off Weyerhaeuser Rd. just upstream of Cove Creek confluence, (Secs 7, 17, 18, T3N, R19W). Perry County.

Date of Sample: September 16, 1991

Unit of Effort: Pulsed boat shocker in pools; 110v-AC backpack shocker in riffles, approx. 10800 secs.

Stream Condition: Pool substrate mainly of boulders, some cobble/rubble, a few undercut banks and roots. Riffle substrate mainly boulders, some cobble/rubble, a little gravel and terrestrial vegetation.

Quantity of Fish Habitat: Abundant

RESULTS/DISCUSSION

WATER QUALITY

Water samples were collected at 15 stations. Nine stations were collected six times, one station five times, one three times, and four stations twice each. Station SFR 07 was located near ADPC&E's ambient water quality monitoring station (ARK 52) on the downstream side of the Arkansas State Highway 7 bridge near Hollis, Arkansas. This station has been sampled monthly for over 10 years. Water temperature, pH, and dissolved oxygen were taken, in situ, at each station at each sampling, and stream flow was measured at seven of the stations (Appendix A).

Water Temperature, pH, Dissolved Oxygen

Water temperatures ranged from 29.5°C at SFR 07 to 23.5°C at SFR 01, in July 1991. On February 11, 1992, temperatures ranged from 3.5°C at GRC 01 to 5.0°C at SFR 08 (Figure 3). The maximum allowable water temperature from a man-induced cause in Ouachita Mountain (OM) ecoregion streams is 30°C. Historical water temperature records from ARK 52 since 1983 indicate a maximum temperature of 31.0°C.

Water temperature standards were not exceeded during this survey. However, because there is active land use manipulations in the watershed, water temperature could become elevated from excessive land clearing for agriculture and some types of silviculture practices.

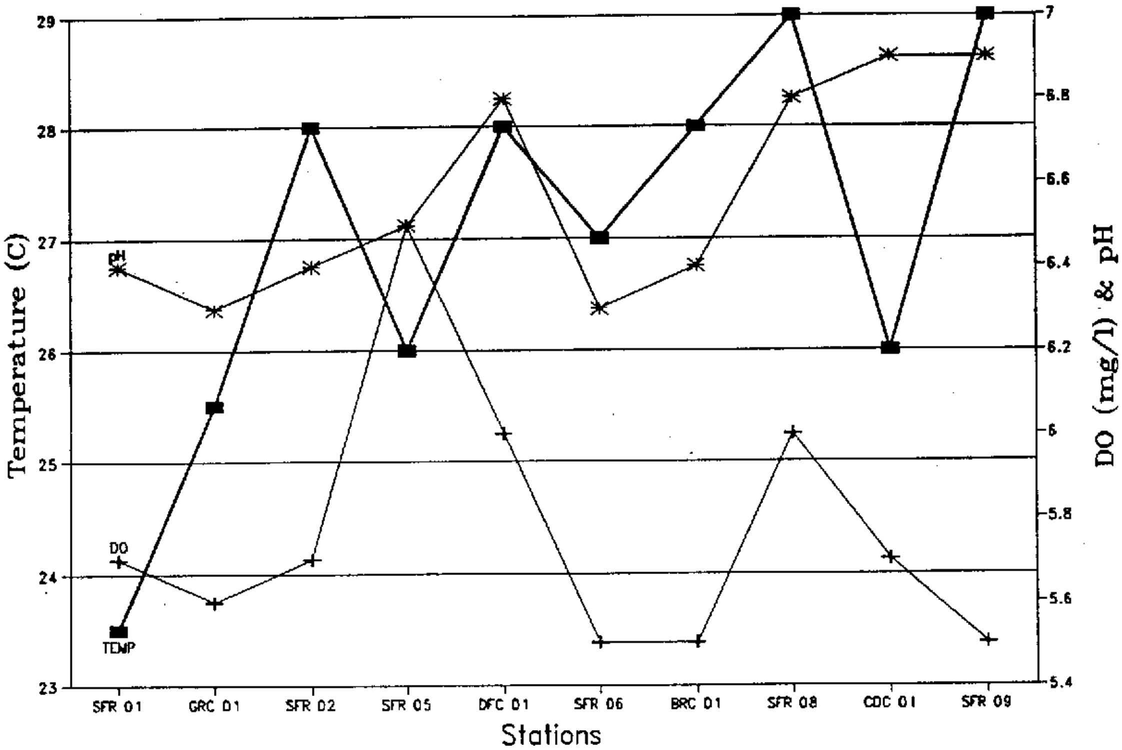
There were only small fluctuations in pH levels during this survey. Most summertime pH levels were in the 6.3 to 6.7 range, while the winter pH levels ranged from 7.1 to 7.5. The highest recorded pH was 7.8 at SFR 07 on June 3, 1992. The pH at ARK 52, from 1983 to 1992, ranged from 5.98 to 8.33 with a mean pH of 7.0. Average pH levels for OM ecoregion streams is 7.2 and 7.0 for the summer and spring seasons, respectively. There was generally less than a one unit fluctuation in pH levels during this survey (Figure 3).

The dissolved oxygen (DO) minimum standard for OM ecoregion streams with greater than a ten square mile (>10 mi^2) watershed is 6.0 mg/l. This level may be depressed by 1.0 mg/l for no more than eight hours during the critical season when water temperatures are above 22°C. The GRC 01 station had the lowest recorded DO of 5.0 mg/l on July 16, 1991. Dissolved oxygen readings above 12.0 mg/l were recorded at GRC 01, BRC 01, and SFR 08 on December 3, 1991 (Figure 3).

FIGURE 3

(WATER TEMPERATURE, pH, DISSOLVED OXYGEN)

JULY 16, 1991



SEPTEMBER 10, 1991

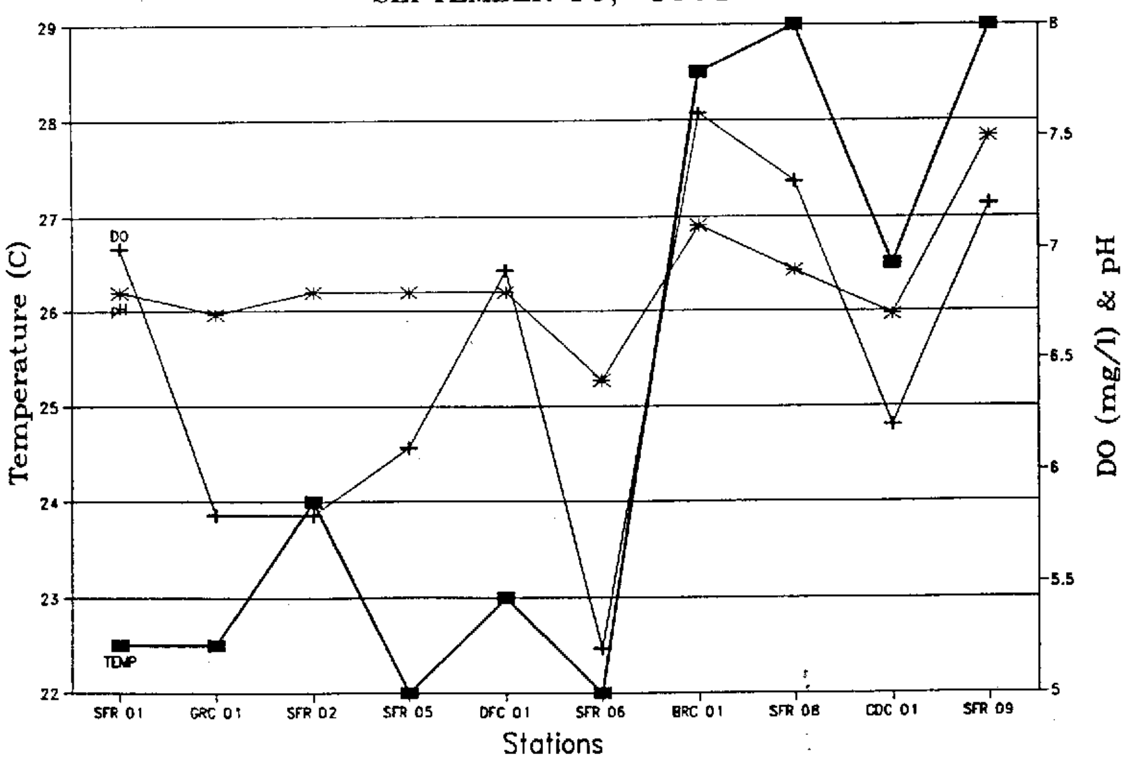
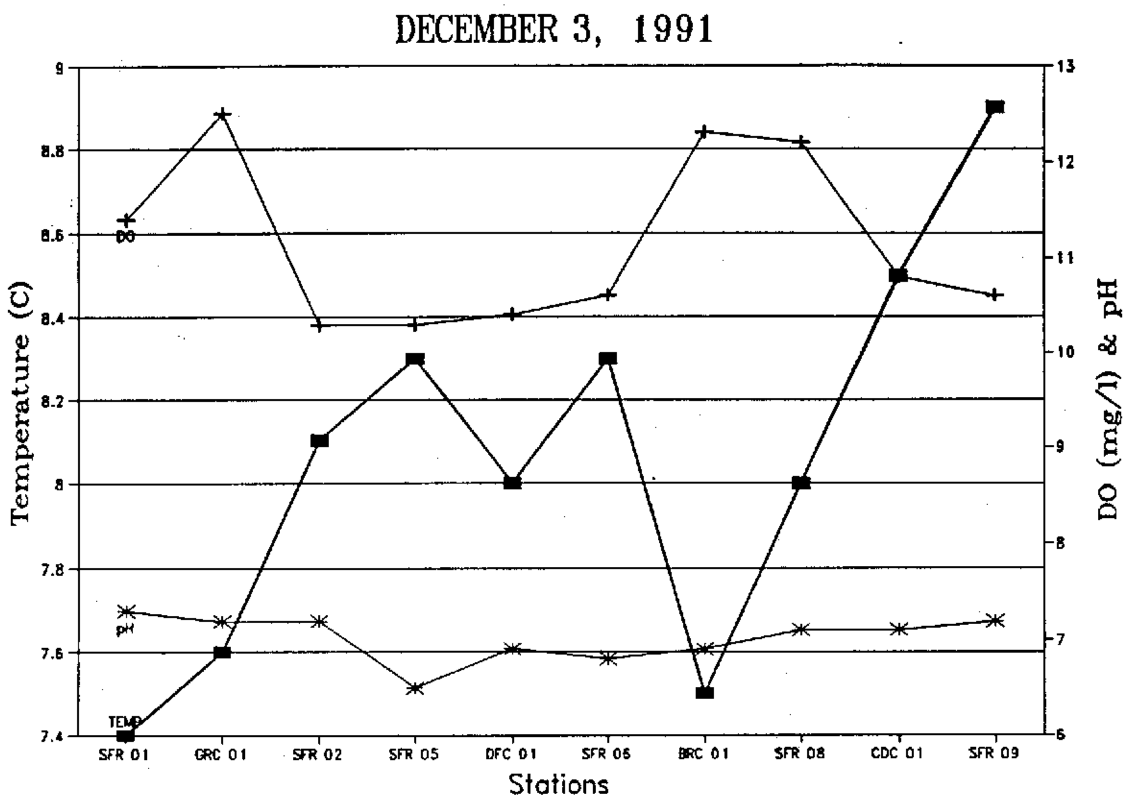


FIGURE 3, (cont)

(WATER TEMPERATURE, pH, DISSOLVED OXYGEN)



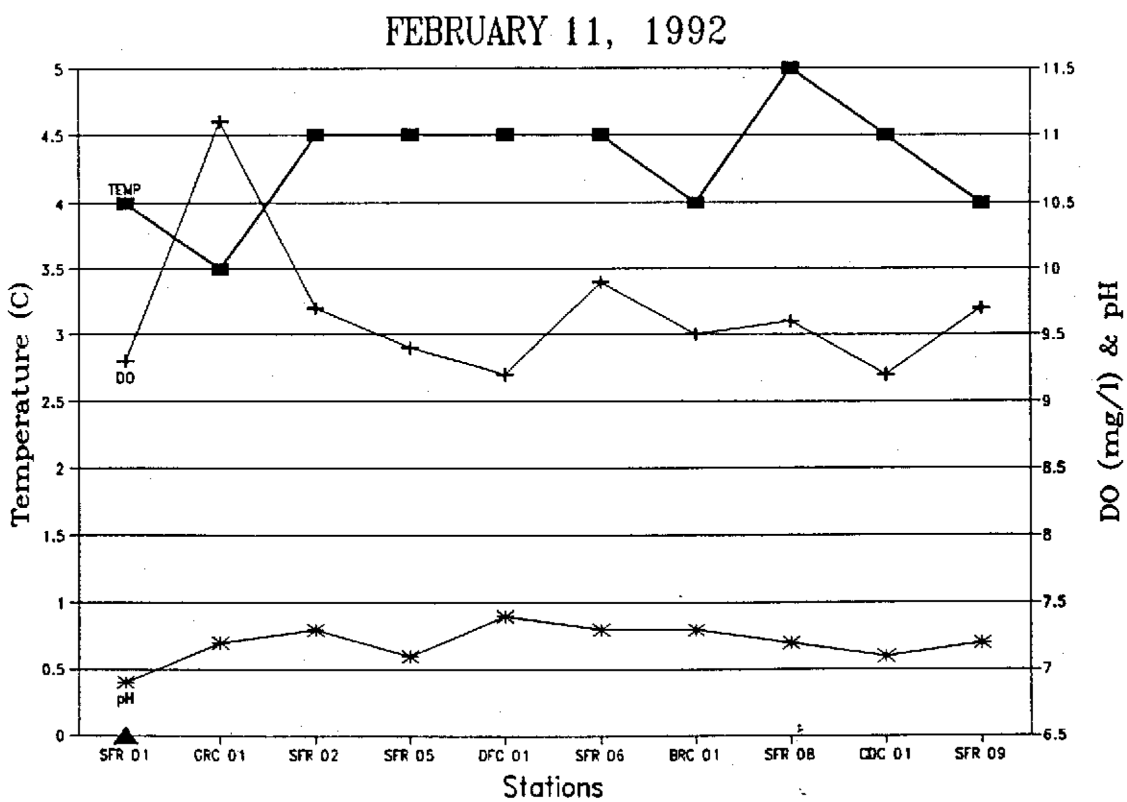
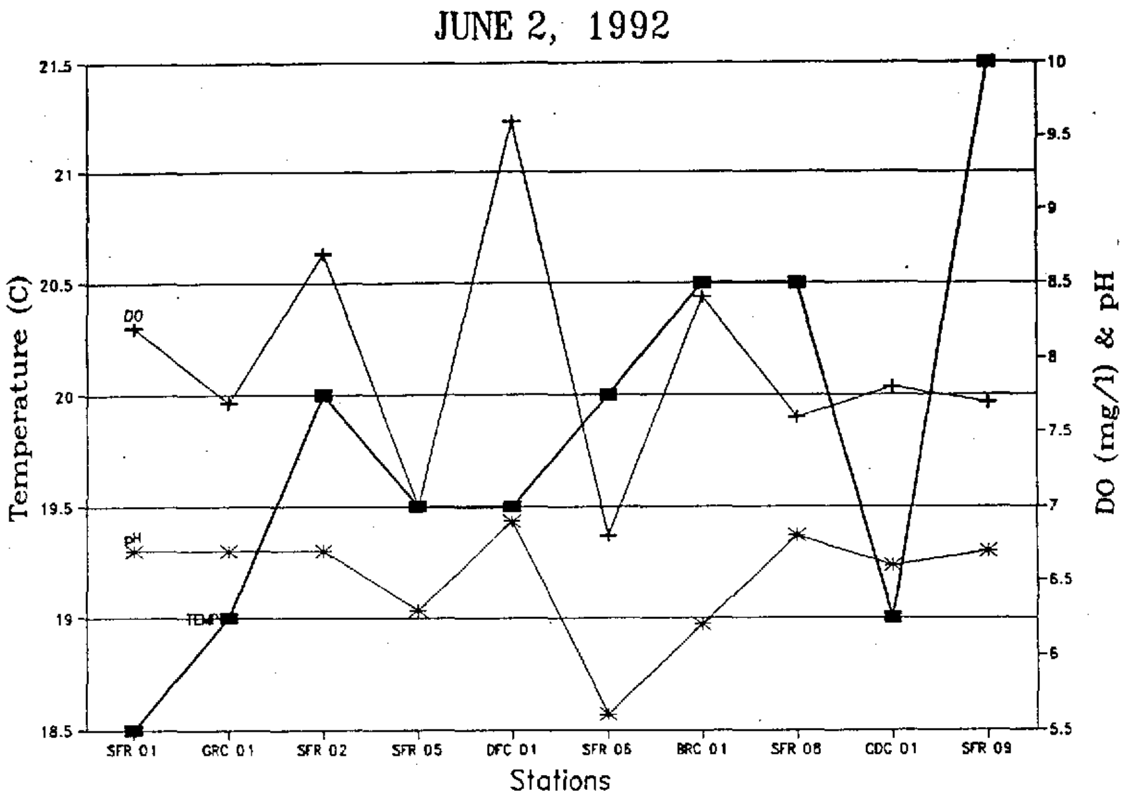


FIGURE 3 (cont)

(WATER TEMPERATURE, pH, DISSOLVED OXYGEN)



Historical DO concentrations at ARK 52 indicate a maximum concentration of 13.5 mg/l and a minimum concentration of 5.0 mg/l from 95 observations since 1984.

Because only grab samples were taken and maximum diurnal fluctuations of DO were not measured, minimmum DO values may not have been measured during this study.

<u>TSS, Turbidity, Fecal coliform, *E. coli*</u>

The in-stream turbidity standard for OM ecoregion streams is 10 NTU. During this survey, this standard was exceeded in 33 percent (33%) of the samples and historical records from ARK 52 indicate that turbidity levels have exceeded the in-stream standard in 60 percent (60%) of the 98 observations since 1983. The highest concentration recorded since 1983 was 65 NTU on November 17, 1987, at station ARK 52. During this survey the maximum turbidity recorded was 35 NTU at DFC 01 on June 3, 1992 (Appendix A).

FIGURE 4

(TSS, TURBIDITY, Fecal coliform, E. coli)

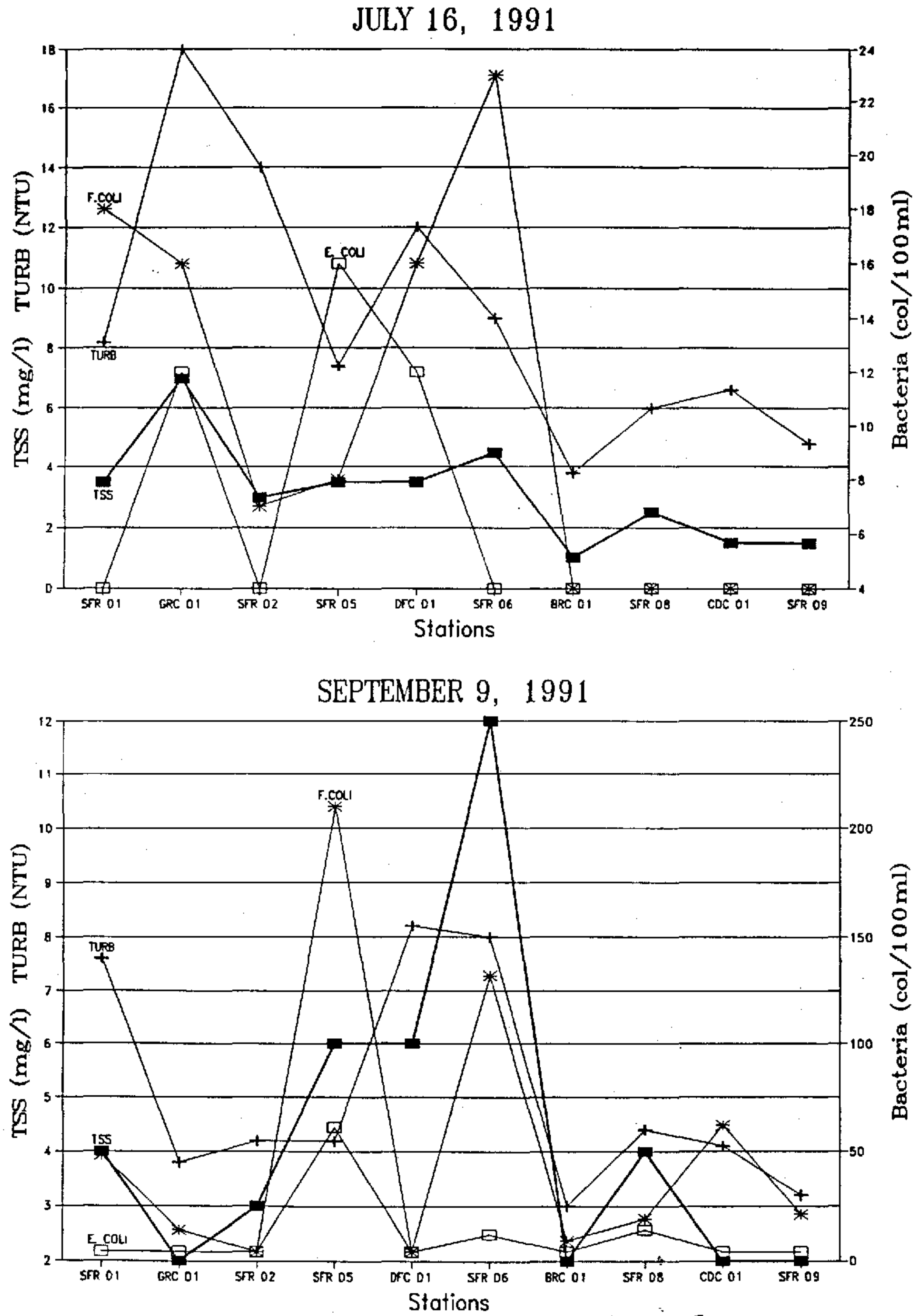
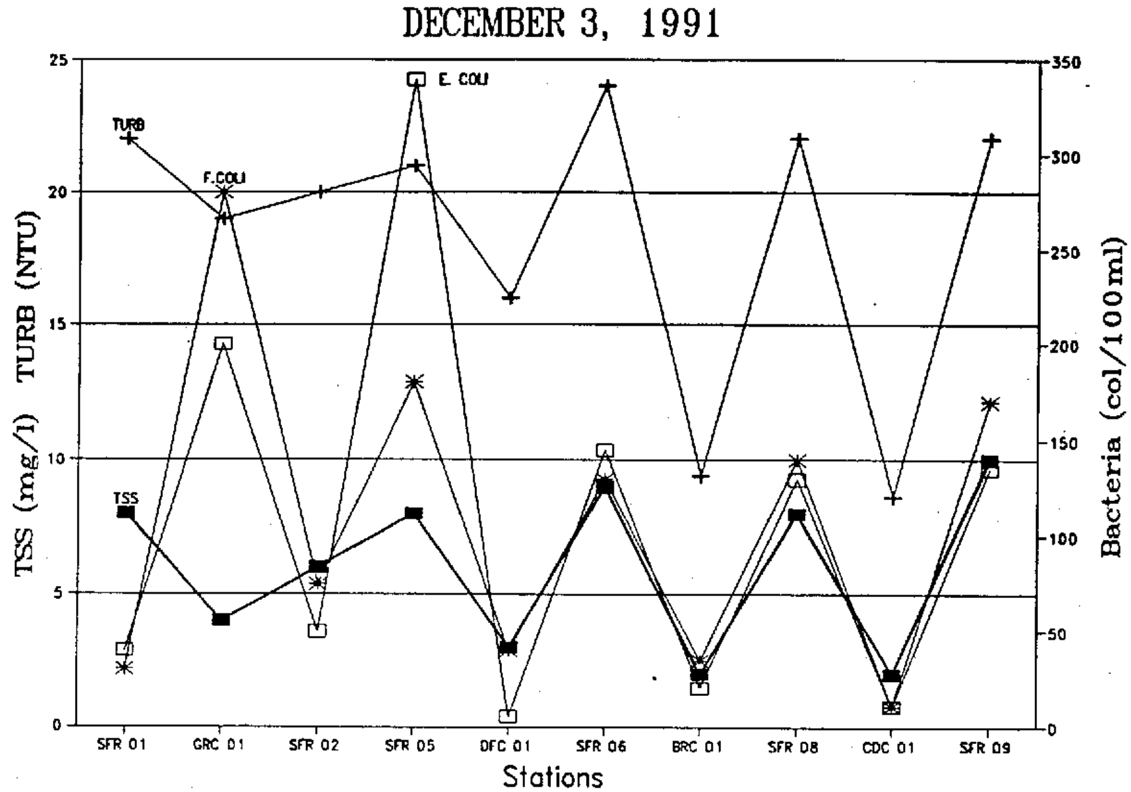


FIGURE 4 (cont)

(TSS, TURBIDITY, Fecal coliform, E. coli)



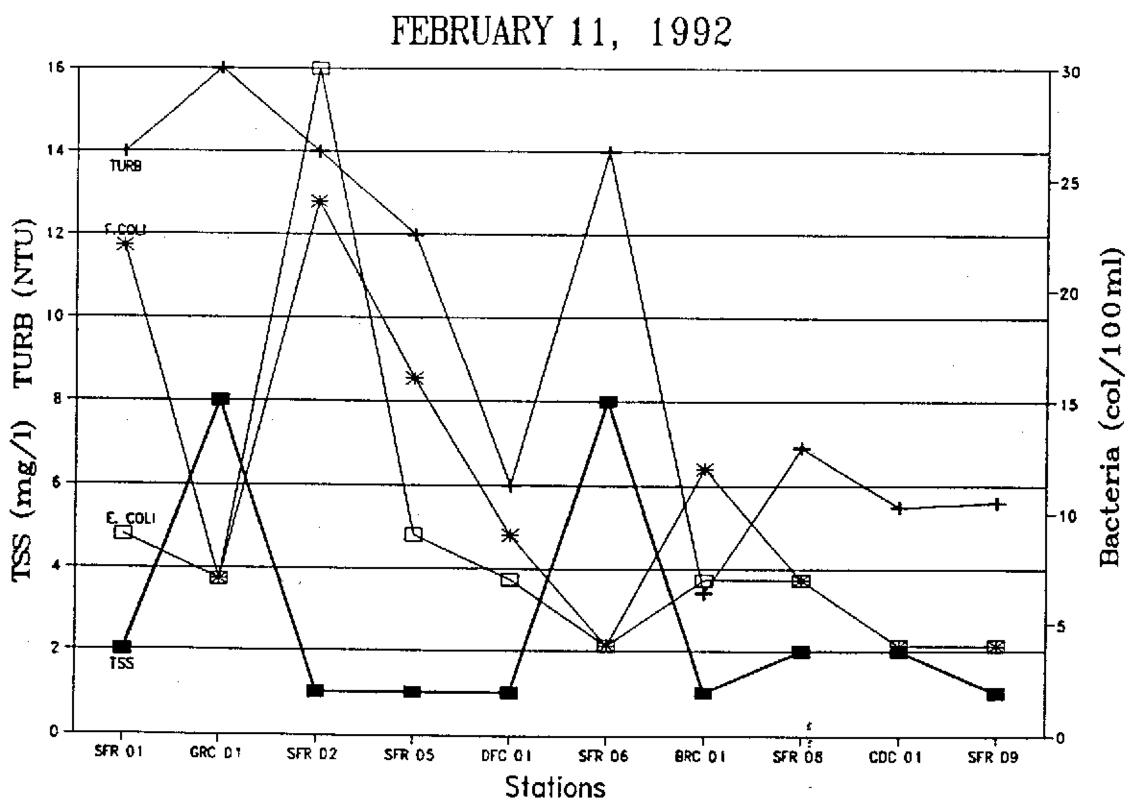
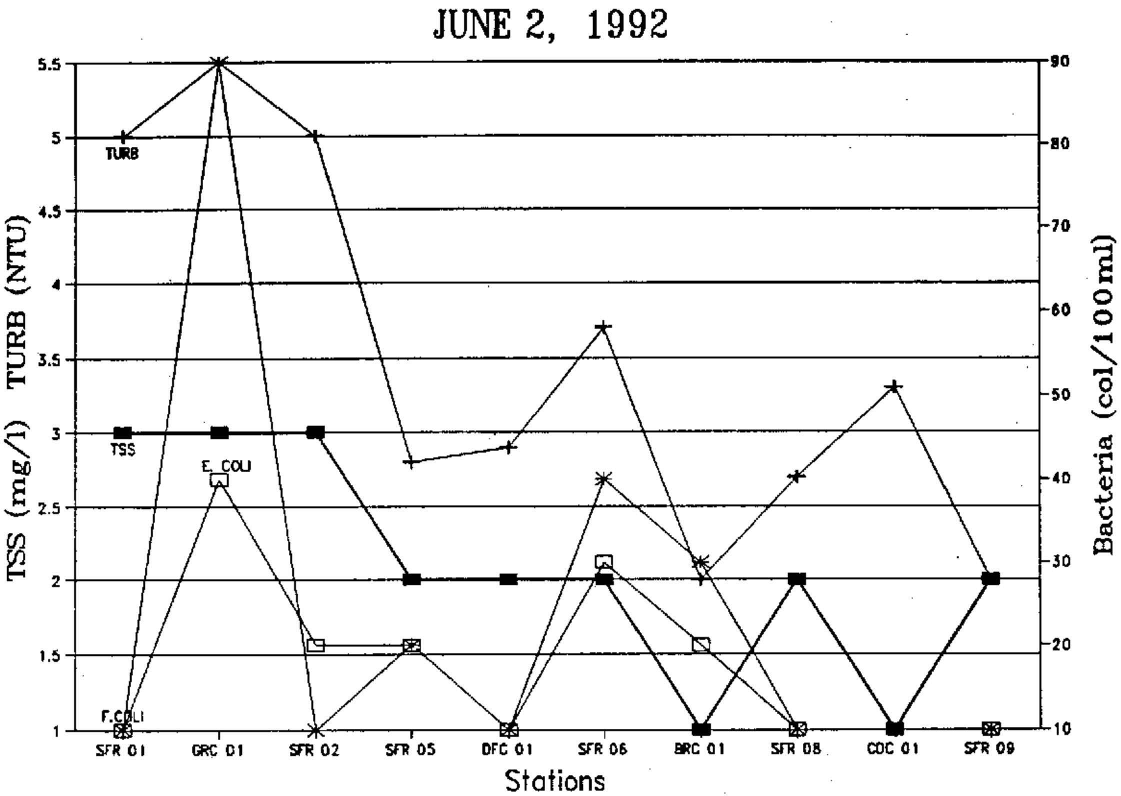


FIGURE 4 (cont)

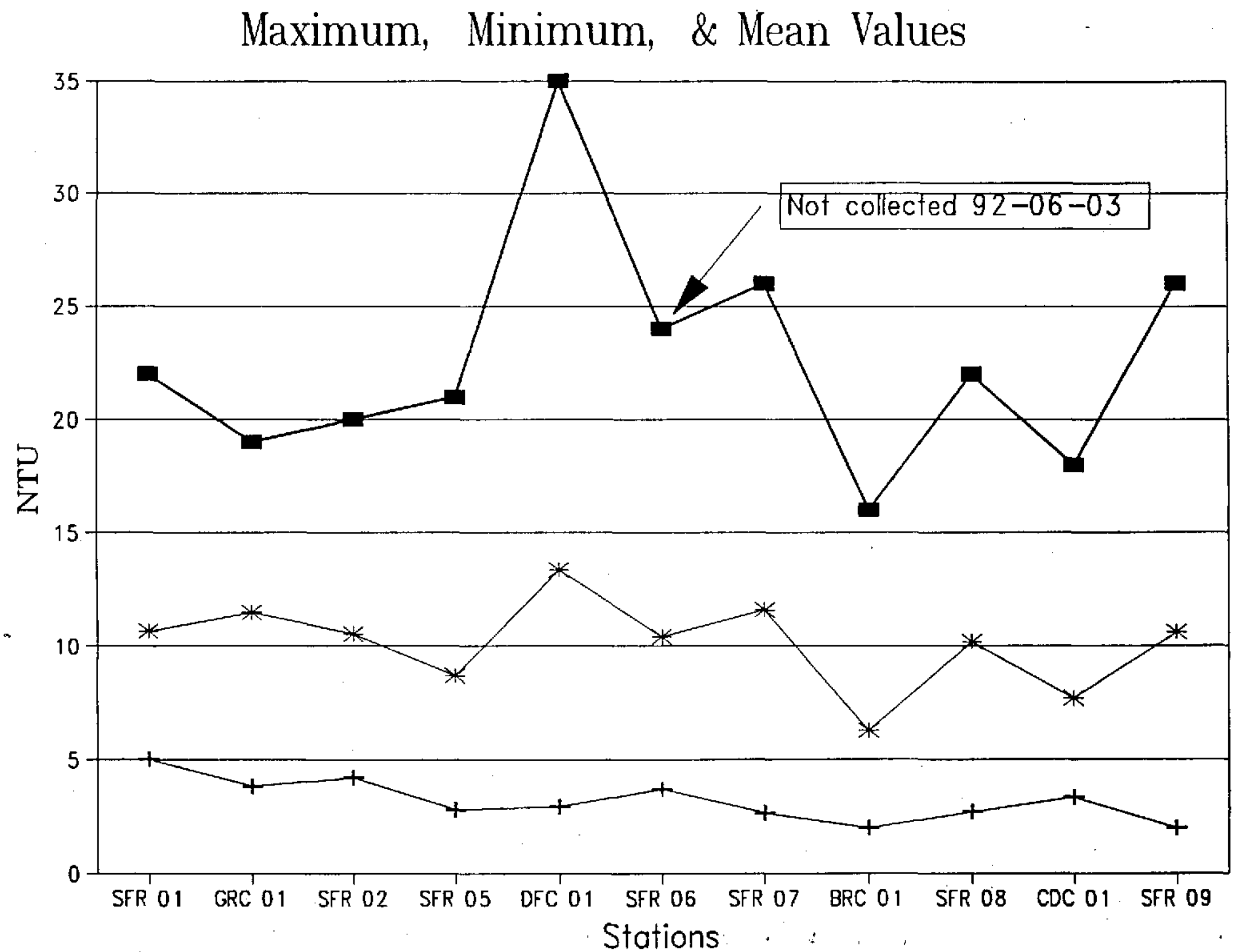
(TSS, TURBIDITY, Fecal coliform, E. coli)



The sample taken on December 3, 1992, was a few days after a major storm event in the watershed. The unusual pattern of data from this date (Figure 4) shows the strong correlation of levels of turbidity, TSS, fecal coliform and E. coli. In addition, the figure shows significantly higher values of these parameters in the main stream stations than in adjacent tributary streams. This is likely the result of the much more rapid evacuation of the flood waters from the tributary streams and a more rapid recovery to near normal conditions in the smaller watersheds. However, a plot of the maximum, average and minimum turbidity values (Figure 4A) for the entire study period indicates minimal differences in the minimum turbidity values recorded. Dry Fork Creek had the highest maximum value and normally had higher values than most other stations when elevated flows existed. Similarly, SFR 06, which is located just downstream from the confluence of Dry Fork Creek and South Fourche LaFave, normally showed elevated turbidity levels. This condition may not be accurately demonstrated in Figure 4A since SFR 06 was not sampled on June 3, 1992, which was after a major summertime storm event that produced the maximum turbidity values at DFC 01 and at SFR 07 (next downstream station from SFR 06).

FIGURE 4A

Turbidity Concentrations



The DFC 01 station is upstream from a floodwater control reservoir constructed on Dry Fork Creek just upstream from the river. Although this impoundment was not sampled, observations during this study indicate high turbidity levels during high inflow periods. In addition, severe bank erosion and channel scouring was occurring below the impoundment from reservoir discharges. These conditions are likely major contributors to elevated turbidity at stations SFR 06 and possibly SFR 07 (ARK 52).

The highest total suspended solids (TSS) concentration of 20 mg/l occurred on June 3, 1992, at SFR 07. Approximately forty percent (40%) of these samples had concentrations greater than 10 mg/l (Figure 4). These high values could be attributed to runoff from the extensive road system located in the river's watersheds, or to the agricultural practices occurring adjacent to the river's main stem. Some historical elevated values could have been caused by the construction of flood control reservoirs throughout the watershed. These structures may also be contributing to elevated turbidity levels by channel erosion from floodwater discharges from the impoundments. During high flow events, TSS concentrations increased only two to three times over low flow conditions, but turbidity concentrations increased five to nine times above low flow conditions. This may indicate that much of the turbidity in these waters is caused by very small, colloidal particles of soil which are not removed by filtration and therefore are not accounted for in the TSS analysis methodology. Soil types producing these conditions are present in several areas of both the OM and ARV ecoregion.

Fecal coliform bacteria concentrations ranged from less than 4 col/100 ml to concentrations greater than 200 col/100 ml (Figure 4). It is interesting to note in the December sample that the river's main stem bacteria count was approximately four times greater than that of the tributaries, except for the Graham Creek stations. The Graham Creek watershed contains poultry operations and cattle use areas in the lower part of the drainage basin. December's sample was taken after a major storm event which could account for the higher fecal coliform concentrations since several species of bacteria associated with soil particles can produce positive values in the fecal coliform test. However, the E. coli values are very similar to the fecal coliform values in these samples. E. coli is reported to be a better indicator of warm blood-animal fecal contamination.

E. coli concentrations of 200 col/100 ml and 340 col/100 ml were recorded on December 3, 1991, at GRC 01 and SFR 05, respectively, and on July 16, 1991, GRC 02 had a concentration of 320 col/100 ml. These stations were located downstream of animal operations allowing livestock direct access to the stream bed. Most other E. coli concentrations were at or below 40 col/100 ml except for the main stem samples taken in December.

The determination of water quality standards violations for fecal coliform is based on a minimum of not less than five samples taken over not more than a thirty (30) day period. Because this protocol was not met during this survey, standards exceedances could not be determined.

TDS, T-HARD, Cl, SO_4

The maximum naturally occurring level for chlorides, sulfates, and total dissolved solids in OM ecoregion reference streams is 6 mg/l, 15 mg/l, and 128 mg/l, respectively.

During this survey, concentrations of these parameters remained well below ecoregion values except for an unexplained sulfate value of 28 mg/l at DFC 01 on July 16, 1991. Historical data indicate chloride concentrations never exceeding 9.0 mg/l and sulfate concentrations generally below 10 mg/l. The highest TDS concentration of 326 mg/l was recorded in 1988, but most data indicate concentrations of less than 50 mg/l. Hardness concentrations were generally below 20 mg/l both historically and during this survey. These are typical values found in ARV and in most OM ecoregion streams. Figure 5 depicts these values graphically.

NH_3-N, NO_2/NO_3-N, T-PHOS, O-PHOS

The ammonia nitrogen (NH_3-N) concentrations remained low throughout this study, (0.05 mg/l), except during the summer low flow conditions. This is the period of highest organic decomposition and production of ammonia in slow moving pool environments. The highest NH_3-N concentration was 0.24 mg/l on September 10, 1991, at SFR 06. Historical concentrations at ARK 52 averaged 0.08 mg/l with the greatest concentration being 0.56 mg/l (Figure 6).

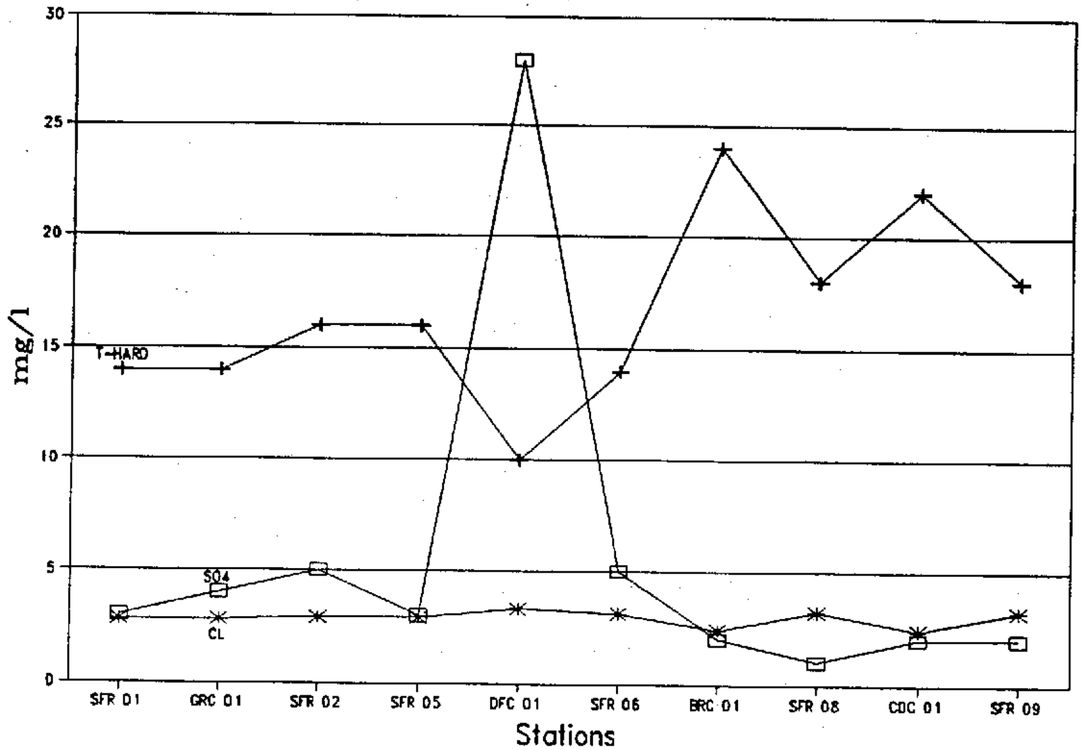
Nitrite-nitrate nitrogen (NO_2/NO_3-N) levels were usually at or below 0.03 mg/l, with the highest concentration of 0.13 mg/l occurring at SFR 05 on February 11, 1992. Historical data at ARK 52 indicate average NO_2/NO_3-N concentrations below 0.09 mg/l. The highest concentration of 0.55 mg/l occurred on May 12, 1992. It is interesting to note that most stations sampled on December 3, 1991, displayed elevated NO_2/NO_3-N concentrations of two to five times higher than other samples taken during the survey (Figure 6). Historical data displays a similar trend of early winter NO_2/NO_3-N concentrations being somewhat elevated.

With decreasing air and water temperatures and shorter daylight hours, there is less photosynthetic activity and less in-stream assimilation of nutrients. Stream side buffer zones are also dormant and are not assimilating nutrients from runoff water or from the stream. There is also a large input of organic matter

FIGURE 5

(TDS, T-HARD, Cl, SO_4)

JULY 16, 1991



SEPTEMBER 10, 1991

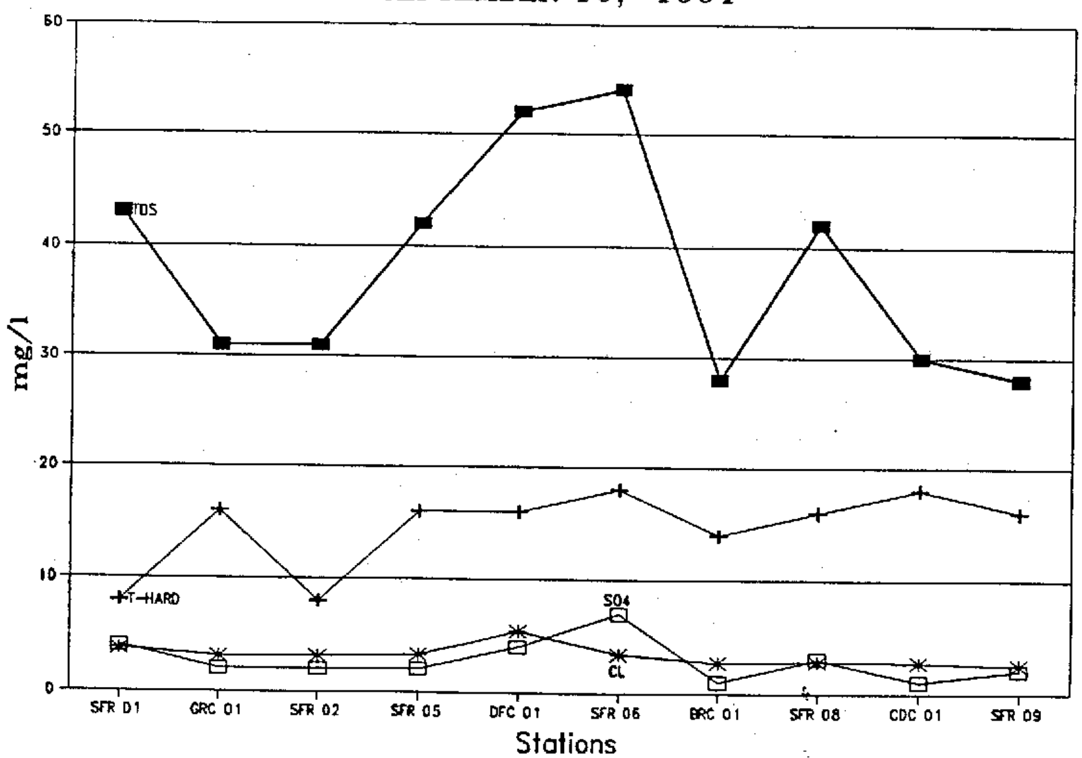
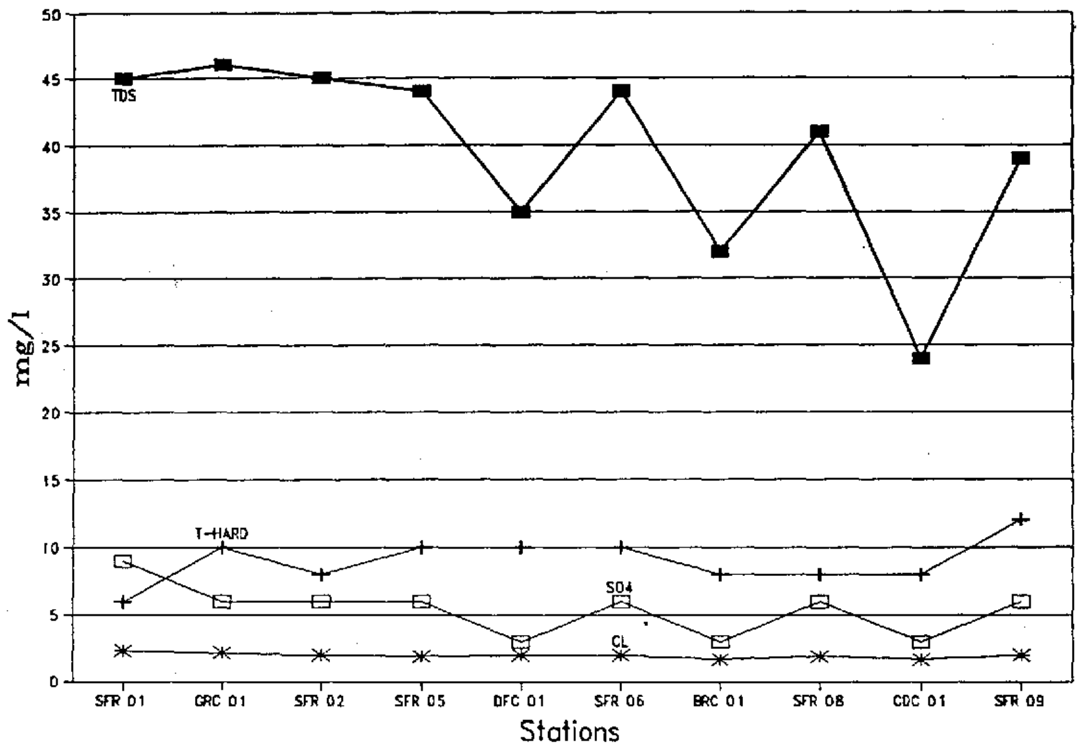


FIGURE 5 (cont)

(TDS, T-HARD, Cl, SO_4)

DECEMBER 3, 1991



FEBRUARY 11, 1992

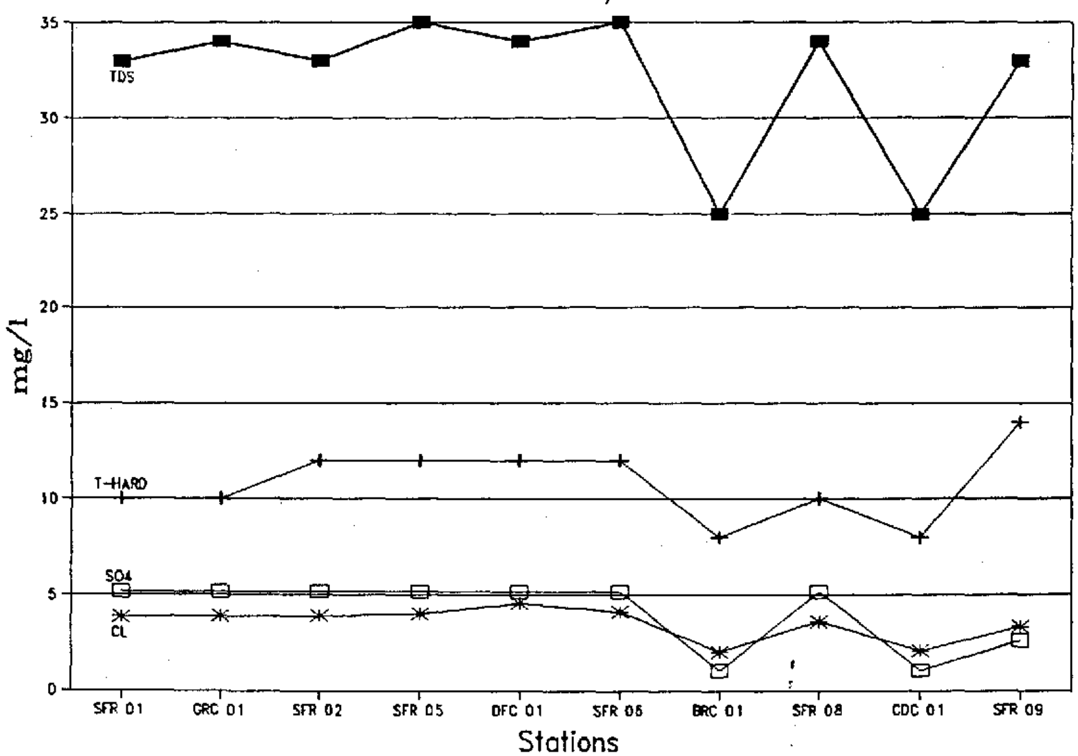
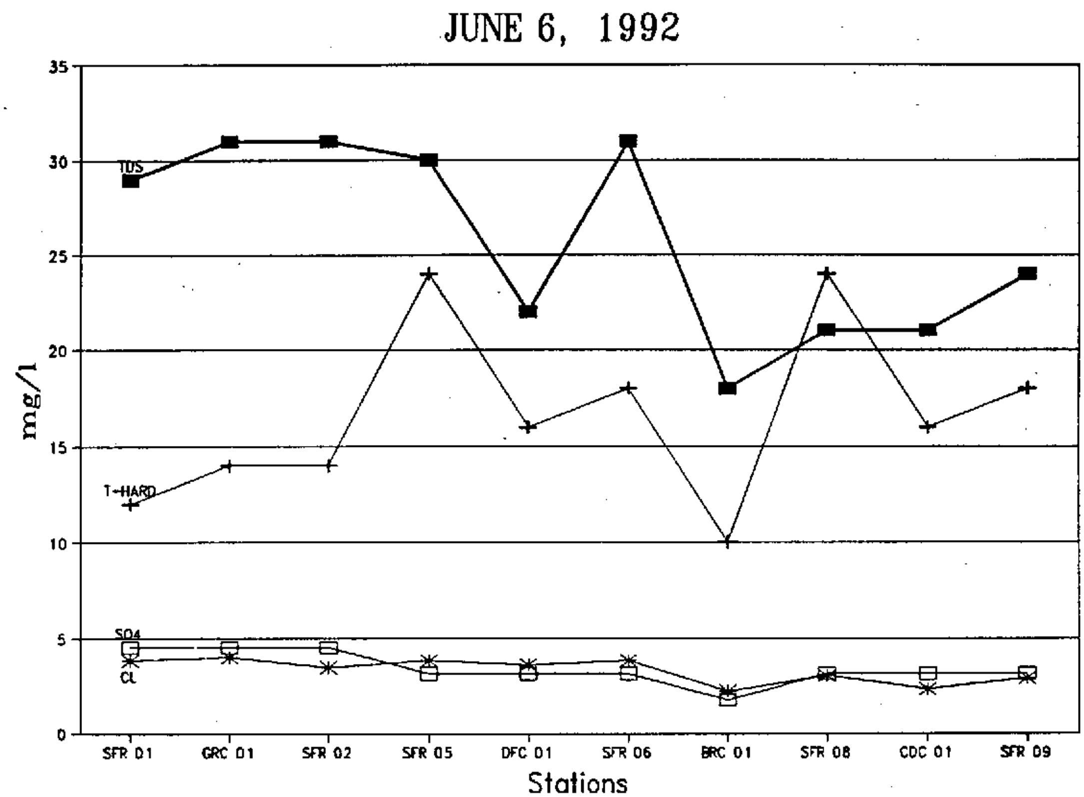


FIGURE 5 (cont)

(TDS, T-HARD, Cl, SO_4)



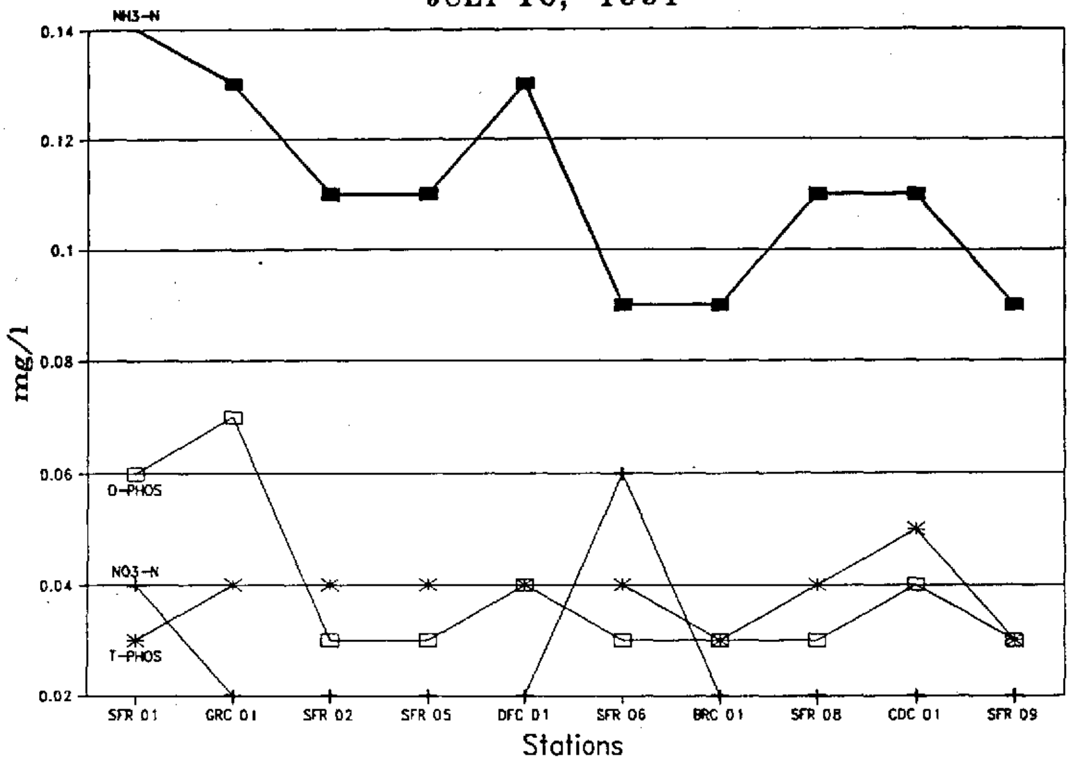
into stream systems from natural decomposition of plant and animal matter. Finally, many agricultural operations spread animal waste and other fertilizers in the early fall to prepare the ground for winter and/or to dispose of animal waste piles so there will not be a winter storage problem. These occurrences can increase the nutrient levels of waterbodies during the late fall-early winter period. It is also noted, however, that the December 3, 1991, sampling followed a major storm event and stream flows were at the highest levels during the survey period.

Total phosphorus (T-Phos) and ortho-phosphorous (O-Phos) concentrations never exceeded 0.07 mg/l and most samples had concentrations around 0.03 mg/l. Consistent increases in phosphorous concentrations occurred on the December 3, 1991, sample. These data, during a high flow period, show a pattern of more elevated levels in the main stream than in the tributaries. This is a similar pattern demonstrated by the turbidity, TSS and bacteria data. Historical T-Phos and O-Phos data indicate average concentrations of 0.06 mg/l and 0.04 mg/l, respectively. A maximum O-Phos concentration of 0.43 mg/l occurred on May 12, 1992.

FIGURE 6

(NH_3-N, NO_2/NO_3-N, T-PHOS, O-PHOS)

JULY 16, 1991



SEPTEMBER 10, 1991

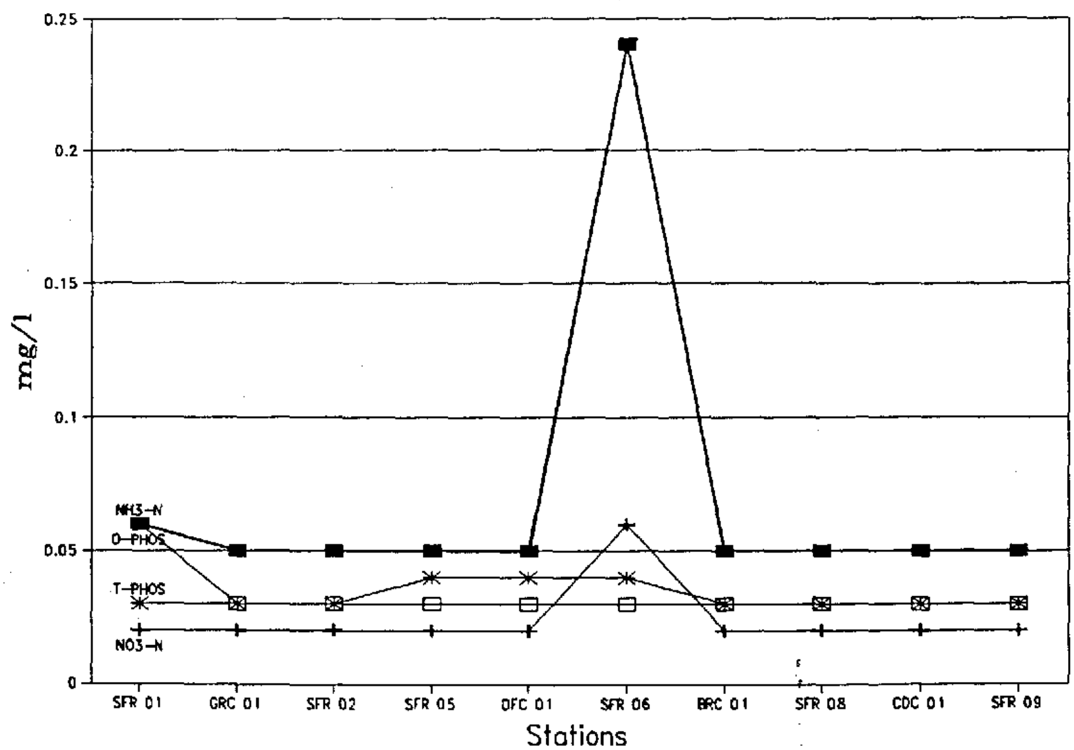
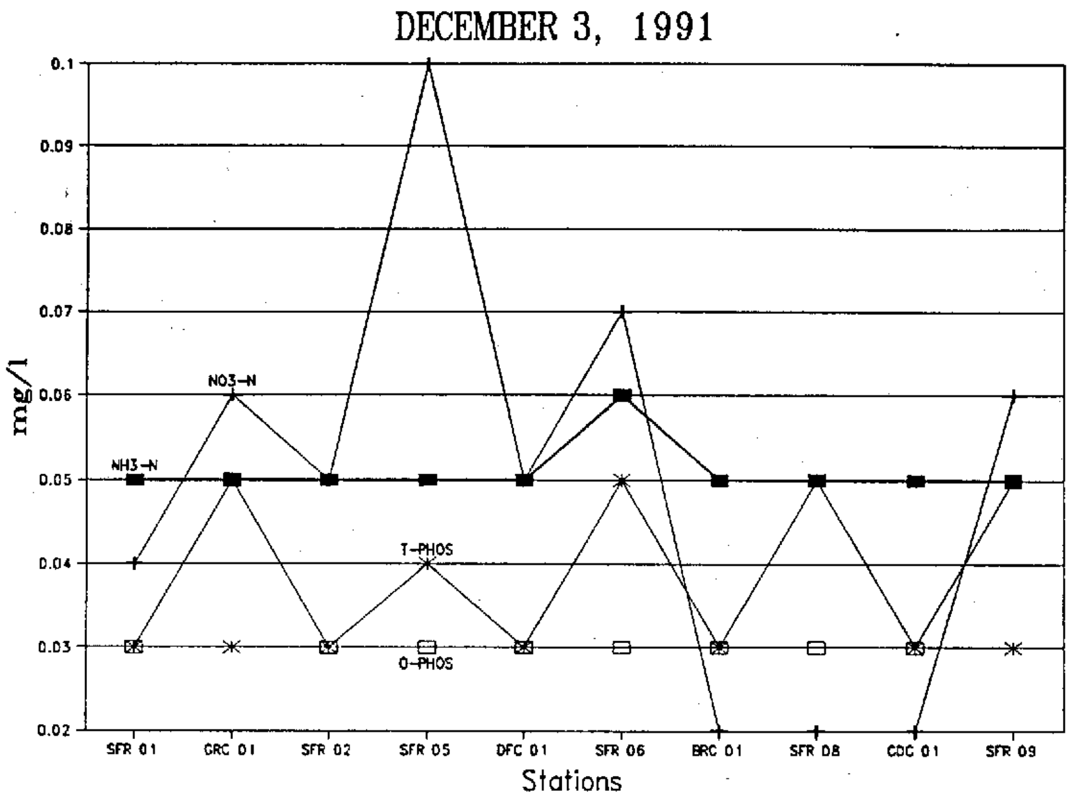


FIGURE 6 (cont)

(NH_3-N, NO_2/NO_3-N, T-PHOS, O-PHOS)



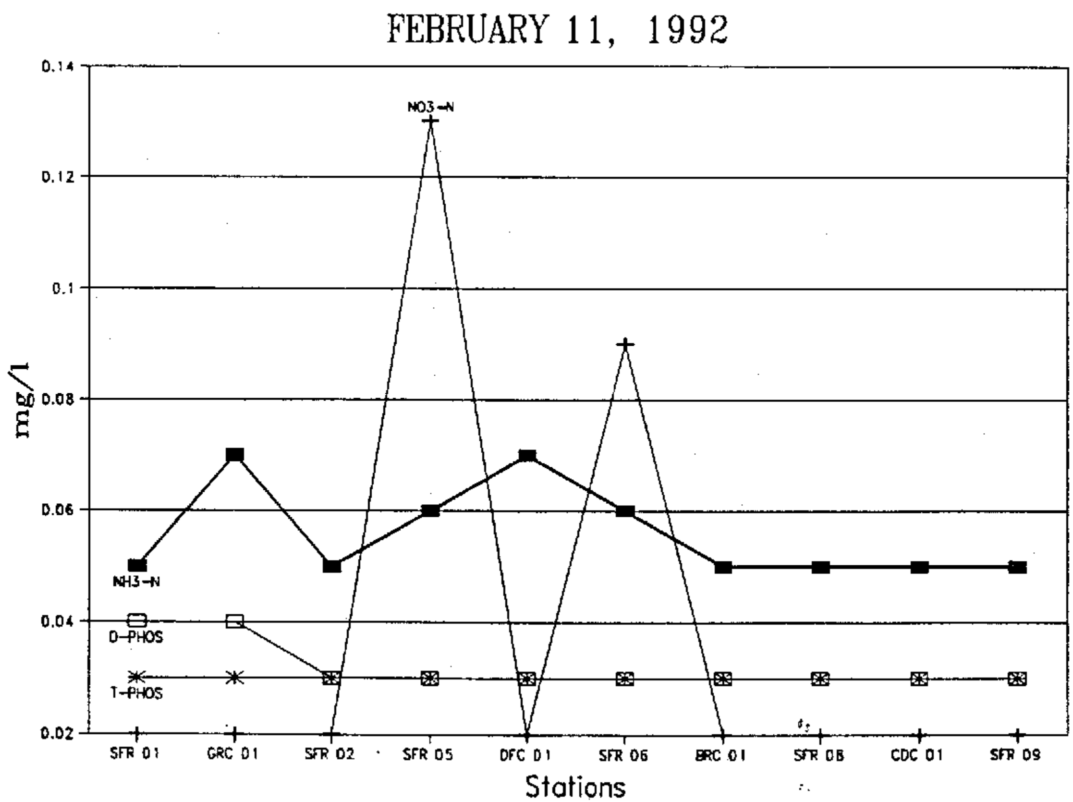
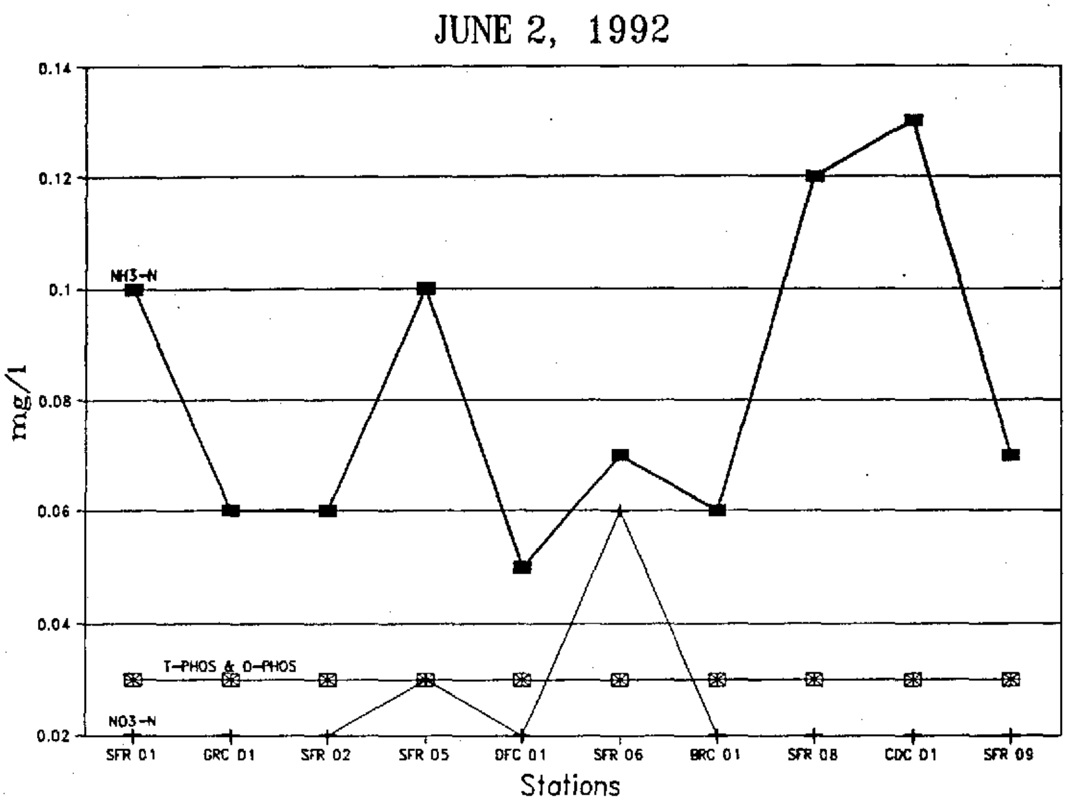


FIGURE 6 (cont)

(NH_3-N, NO_2/NO_3-N, T-PHOS, O-PHOS)



Biochemical oxygen demand (BOD) concentration remained relatively low throughout the study except during the June 2, 1992, sampling event. Stations SFR 02, SFR 03, and SFR 04 had concentrations 8.7 mg/l, 7.1 mg/l, and 7.0 mg/l, respectively. These occurred during a low flow sampling event. The total organic carbon (TOC) concentrations were generally less than 5.0 mg/l. Consistently elevated TOC concentrations occurred during the September 1991 sampling event. This was a low flow sampling event. Other elevated TOC values occurred during the December 1991, or the June 3, 1992, events; both were during high flows.

The water quality characteristics of the South Fourche LaFave River and its tributaries are similar to both the Ouachita Mountain and Arkansas River Valley ecoregion reference streams. Both types of waters have very low nutrient and mineral levels, as reflected by the nitrogen and phosphorus parameters, and the very low alkalinity and hardness values. Ouachita Mountain reference streams have slightly higher hardness and alkalinity values, particularly in larger streams. Arkansas River Valley streams generally have slightly higher nitrate and BOD values; however, the most characteristic difference in the ecoregion waters is the higher turbidity and slightly higher TSS values in Arkansas River Valley waters. In this study, there were several instances of excessive turbidity and TSS concentrations during storm events. However, base flow turbidity values were near or above the Ouachita Mountain ecoregion standard, but remained below the Arkansas River Valley ecoregion standard. Nitrogen levels from nitrite/nitrate-nitrogen were very low and characteristic of the Ouachita Mountain ecoregion, but BOD values were more characteristic of Arkansas River Valley ecoregion streams.

Appendix A is a tabulation of the water quality data collected during this survey, outlined by station, and includes the bacteria counts and flow measurements.

MACROINVERTEBRATE COMMUNITY

Community Structure

Macroinvertebrates were collected at four sites in the main stem of the river, (SFR 02, SFR 06, SFR 08 and SFR 09) and one site in each of the four main tributaries (GRC 01, DFC 01, BRC 01 and CDC 01).

The tributaries produced 18 to 20 taxa at each station with diversity indices (DI) between 3.47 to 3.82. This indicates communities rich in diversity without one single taxon dominating. This is true for the main stem stations also, except SFR 02, which had only 11 taxa collected and a DI of 2.2. The other main stem stations had 18 to 22 taxa present with DIs between 3.33 and 3.60 (Figure 7).

Adult Stenelmis, a elmid beetle, was the only taxa that ranked in the top five most abundant taxa at each main stem and tributary station. Stenonema, a mayfly, was the next most frequently occurring and abundant taxon collected. It dominated the community at the GRC 01 site and at SFR 06.

There were 19 taxa collected at GRC 01 with a diversity index of 3.47. Stenonema was the dominant taxon and Chironomidae, bloodworms, and adult and larval Stenelmis were the subdominant taxa.

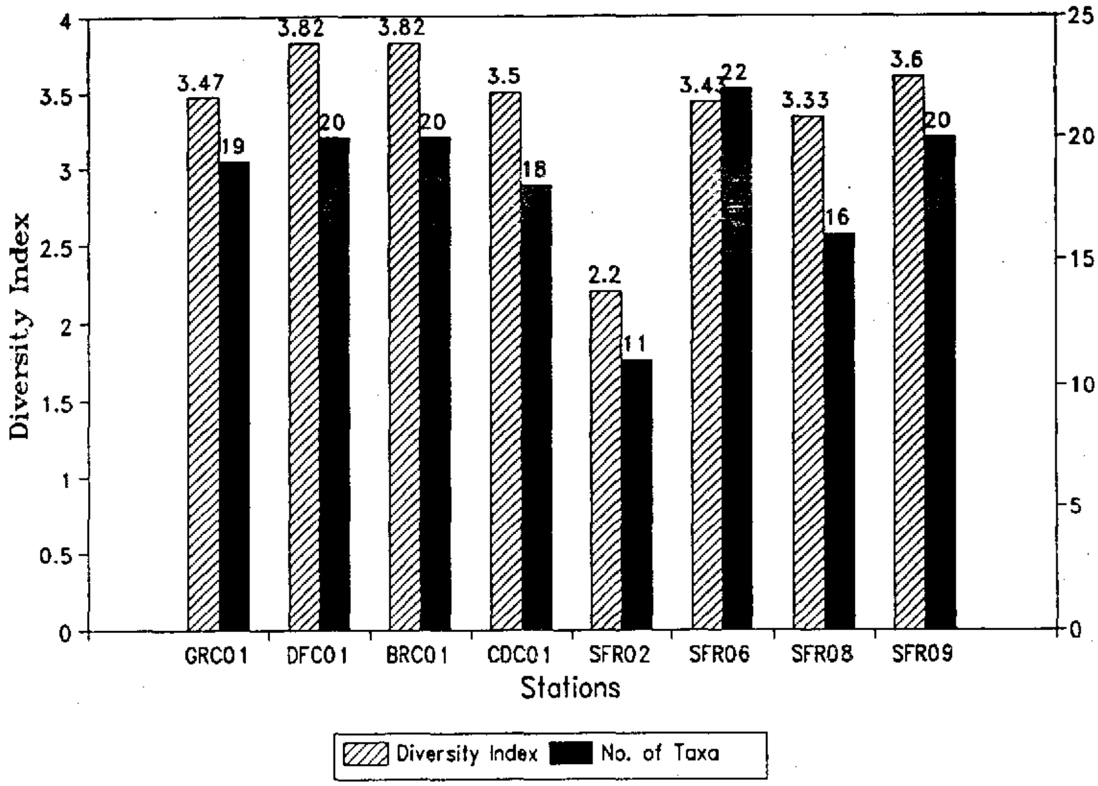
The SFR 02 site had 11 taxa collected, the least number of any station, and a diversity index of 2.2, the lowest of all stations. Cheumatopsyche and Chimarra, both caddis flies, dominated the community, making up 78 percent (78%) of the total community.

Twenty (20) taxa were present at the DFC 01 site, it had a DI of 3.82. This site had one of the highest DIs during the survey. Neoperla, a stone fly, was the dominant taxon, and adult Stenelmis was the subdominant taxon.

Figure 7

MACROINVERTEBRATE COMMUNITY

(Diversity Indices, Number of Taxa)



Stenonema dominated the community at the SFR 06 site. This site had 22 taxa collected, more than any other site, and had a DI of 3.43. Cheumatopsyche was the subdominant taxon.

The BRC 01 site had 20 taxa present and a diversity index of 3.82, one of the highest observed during the survey. Adult Stenelmis dominated the community with fourteen percent (14%) of the total, and Psephenus, a water penny, was sub-dominant, making up thirteen percent (13%) of the community. The remaining three of the top five taxa, Stenonema, Neoperla, and Simulium, a black fly larva, each comprised percent (10%) of the community. Thus, the top five taxa at this site were similar in abundance.

The SFR 08 site was dominated by stone flies, Neoperla. Sixteen (16) taxa were collected with a DI of 3.33. Both Stenonema and Corydalus, the dobsonfly larva, were subdominant taxa.

Simulium was the dominant taxon at the CDC 01 site, making up 29 percent (29%) of the community. The subdominant taxon was Heptagenia, a mayfly, making up 12 percent (12%) of the community. There were 18 taxa collected at this site with a DI of 3.5.

There were 20 taxa present of the SFR 09 site, which had a DI of 3.6. Isonychia, a mayfly, was the dominant taxon making up 29 percent (29%) of the community. Stenonema was the subdominant taxon comprising 15 percent (15%) of the community.

Figure 7 depicts the number of macroinvertebrate taxa collected at each site and their diversity indices. Table 2 is a macroinvertebrate community comparison by site, and Table 3 is a comparison of the five most frequently collected and abundant macroinvertebrates of Ouachita Mountain ecoregion reference streams and the taxa collected at each site in this study.

Ecoregion Community Structure Comparison

Ouachita Mountain ecoregion reference stream macroinvertebrate communities are primarily dominated by the order Ephemeroptera, mayflies, an indicator taxon for the ecoregion. Four sites, GRC 01, SFR 06, SFR 08, and SFR 09, demonstrated this pattern, while three other sites, SFR 02, DFC 01, and BRC 01, were all dominated by one of the two subdominant taxa of OM ecoregion reference streams, Tricoptera and Coleoptera. Only CDC 01 was dominated by the sub-dominant ecoregion indicator taxon, Diptera. Odonata, dragon flies, were present in low percentages. The five Ouachita Mountain ecoregion indicator taxa comprised at least seventy percent (70%) of the organisms collected at these sites, except the SFR 08 site, where only 49 percent (49%) of the community was comprised of these taxa. The five taxa listed above comprise approximately 80 percent (80%) of the total macroinvertebrate community in the Ouachita Mountain ecoregion.

The South Fourche LaFave River macroinvertebrate community appeared to be relatively healthy at all stream sites surveyed. The tributary sites exhibited slightly higher diversity indices than the main stem sites. This likely reflects less impairment from storm event sedimentation than seen in the main stem sites, primarily due to higher stream slopes and greater velocities in the tributary streams. Sediment loading from disruption of the watershed due to timber removal activities, and from the construction and maintenance of county and logging roads throughout the watershed appears to be the dominant impediment to an increase in biomass production within this watershed.

TABLE 2

MACROINVERTEBRATE COMPARISON (Percent Community)								
TAXA	GRC01	DFC01	BRC01	CDC01	SFR02	SFR06	SFR08	SFR09
Stenonema	23.2	9	10.3	3	4	25	10	15
Chironomidae	14.1	11	2.1	9	3	3	4	2
Stenelmis ad	14.1	13	14.4	8	4	14	9	9
Stenelmis lr	12.1	11	6.2	5	1	1	8	4
Simulium	7.1	3	10.3	29	1	0	0	0
Cheumatopsyche	0	0	0	0	39	19	4	2
Chimarra	0	3	1	1	39	1	2	3
Baetis	0	0	0	6	3	3	1	8
Neoperla	0	17	10.3	0	0	0	31	0
Argia	1	0	1	0	0	12	0	7
Corydalus	0	0	0	0	3	4	10	6
Psephenus	4	3	13.4	5	2	2	0	4
Heptagenia	3	5	0	12	0	0	0	0
Isonychia	0	4	5.2	1	0	0	5	26

Shaded areas represent five most abundant taxa at each station.
ad - adult   lr - larvae

TABLE 3

MACROINVERTEBRATE COMPARISON STATION vs. ECOREGION (Percent Community)									
ORDER	OME	GRC01	DFC01	BRC01	CDC01	SFR02	SFR06	SFR08	SFR09
Ephemeroptera	34	28	21	20	24	7	31	17	54
Odonata	10	1	0	1	0	0	12	3	7
Tricoptera	18	5	9	10	6	78	22	13	8
Coleoptera	14	16	28	34	9	3	3	8	8
Diptera	7	21	14	12	38	4	3	8	2

Shaded areas represent the most abundant taxa at each station.

FISH COMMUNITY

Community Structure

Nine fish collecting stations in the South Fourche LaFave River watershed and are described in the fish sampling station location/description section of "Materials and Methods". A single collection was made at each location during September and October of 1991.

A total of 40 species, representing 24 genera and 10 families was collected during the survey. Appendix B is a list of these species, outlined by family and includes the common name of each species. Also found in Appendix B is the Relative Abundance Value (RAV) assigned to each species at individual stations.
There were 17, 18, 21, 21, 18, 23, 24, 22 and 29 species collected at Stations GRC 01, DFC 01, BRC 01, BRC 02, CDC 01, SFR 02, SFR 06, SFR 08 and SFR 09, respectively (Figure 8).

The family Lepisosteidae was represented by only two species during the survey and was collected only in the river's main stream. This is just the opposite of the Family Esocidae, which was collected in only two of the tributaries.

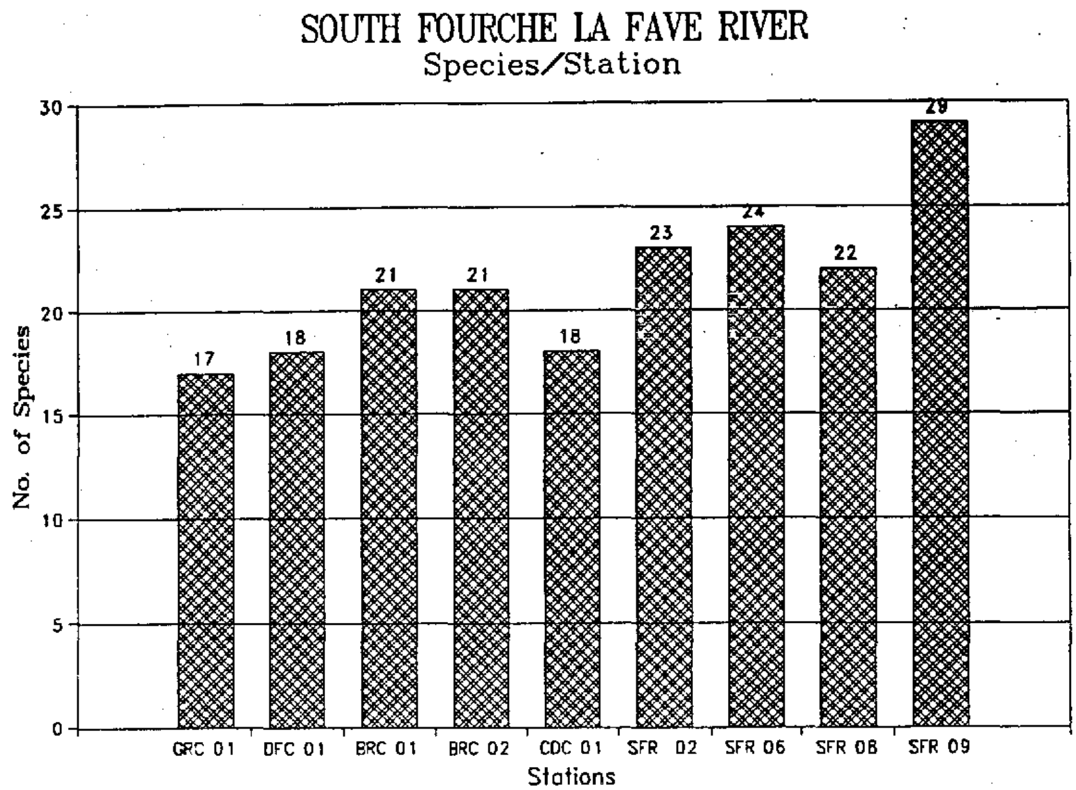
There were eight species of cyprinids collected throughout the study area. The stoneroller, Campostoma anomalum, was the most frequently and most abundant minnow collected, appearing at all nine collecting sites. Notropis boops, the bigeye shiner, and Pimephales notatus, the bluntnose minnow, were also taken from all nine collecting sites, but in lesser abundances. Notemigonus crysoleucas, the golden shiner, and Semotilus atromaculatus, the creek chub, were each taken from one location (Appendix B). The BRC 01 station had the most diverse cyprinid community with seven species, while the GRC 01 station had the least diverse community with only three species (Figure 9, Cyprinidae).

The Catostomids were sparse throughout the study area. They were represented by a single species at five stations. Three stations produced only two species. The SFR 09 station had the most diverse catostomid group with five species. Most species at all stations were reported as being rare to present (Figure 9, Catostomidae).

There were only three Ictalurid species collected during the survey. Noturus exilis, the slender madtom, was collected at all nine stations in good abundances. The flathead catfish, Polydictus olivaris, was collected only in the river's main stem lower portion with an increasing abundance in a downstream direction.

The blackspotted topminnow, Fundulus olivaceus, was collected from all nine stations at relatively the same frequency. The SFR 02 station had the lowest population of this species with an RAV ranking of "present."

FIGURE 8



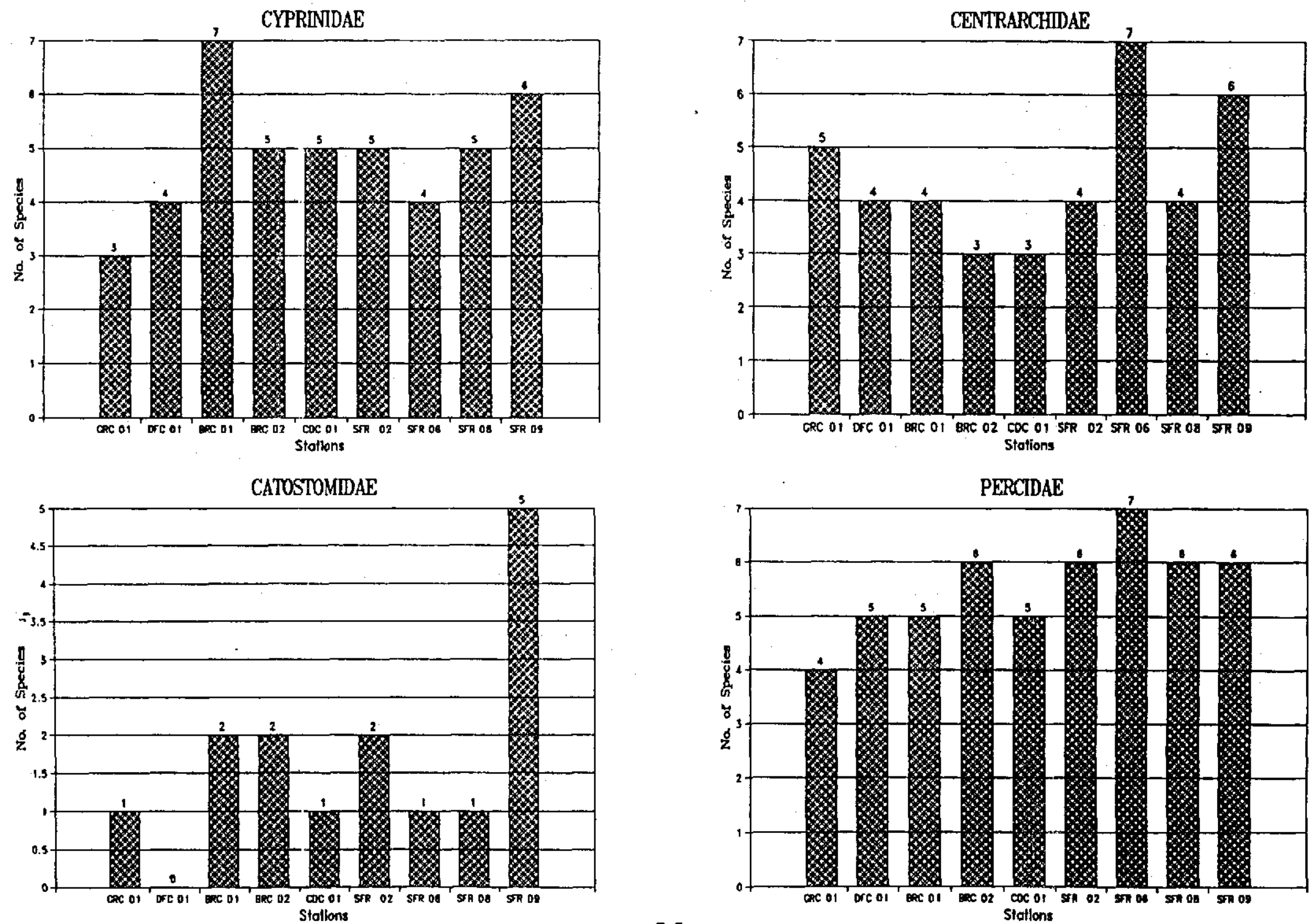
Labidesthes sicculus, the brook silverside, was collected at every station except SFR 06. It was collected in various abundances from "present" to "abundant".

The family Centrarchidae was represented by eight species throughout the survey area. The green sunfish, Lepomis cyanellus, and the longear sunfish, L. megalotis, were collected at all nine stations, the latter being the most abundant. One specimen of the orangespotted sunfish, L. humilis, was collected at SFR 06. The smallmouth bass, Micropterus dolomieu, was restricted to the lower two tributaries and the SFR 09 station. Micropterus punctulatus, the spotted bass, and M. salmoides, the largemouth bass, were collected at the river's lower three main stem stations and the BRC 01 and the GRC 01 stations. The SFR 06 station had the most diverse group of centrarchids with seven species being collected (Figure 9, Centrarchidae).

The percids were also represented by eight species throughout the study area. The orangethroat darter, Etheostoma spectabile, and the redfin darter, E. whipplei, were collected at all nine stations in varying abundances. Etheostoma blennioides, the greenside

FIGURE 9

TOTAL SPECIES COLLECTED PER FAMILY BY STATIONS



darter, was collected at all stations except GRC 01. Percina sciera, the dusky darter, was collected at the SFR 06 station and P. maculata, the blackside darter, was collected in the two most western tributaries at stations GRC 01, and DFC 01. The main stem of the river had a much more diverse and abundant percid community than the tributaries, with the SFR 06 station hosting seven species (Figure 9, Percidae).

Ecoregion Community Structure Comparison

Key species, those which are normally the dominant species within the important groups (such as fish families or trophic levels) are listed below for the Ouachita Mountain and Arkansas River Valley ecoregions.

Ouachita Mountains	**Arkansas River Valley**
Key Species	Key Species
Bigeye shiner	Bluntnose minnow
Northern hogsucker	Golden redhorse
Freckled madtom	Yellow bullhead
Longear sunfish	Longear sunfish
Orangebelly darter	Redfin darter
Smallmouth bass	Spotted bass

The key Cyprinid species are the bigeye shiner and bluntnose minnow for the Ouachita Mountain and Arkansas River Valley ecoregions, respectively. Stonerollers are not considered as a key species due to their typical dominance in a large part of the state in several different ecoregions. The bigeye shiner was the dominant or co-dominant Cyprinid in six of the nine communities sampled. The bluntnose minnow was co-dominant only at the CRC 01 site and it was the second dominant Cyprinid in three other samples.

The northern hogsucker, Hypentelium nigricans, a OM ecoregion key species, was the dominant catostomid in the Bear Creek sample. The golden redhorse, Moxostoma erythrurum, an ARV ecoregion key species, was collected in the uppermost and lowermost sites on the main stem of the river in low numbers. The most common catostomid collected in six of the nine samples was the creek chubsucker, Erimyzon oblongus. This species is normally more common in ARV ecoregion than in OM ecoregion streams.

Although the slender madtom is not listed as the key Ictalurid for either the OM or the ARV ecoregion, it is the dominant madtom in the ARV ecoregion streams. It does not occur in the Ouachita River drainage. This species was the most abundant Ictalurid at all sites in this study and was often one of the most abundant of all species.

The longear sunfish is the key Centrarchid for both ecoregions and it was the dominant sunfish at all sample sites.

The redfin darter, *Etheostoma whipplei*, the ARV ecoregion key Percid, dominated the darter communities in three of the five tributary sites. It was "present" to common in all main channel sites. The fantail darter, *E. flabellare*, was the dominant Percid in three of the four main channel sites. This species has a rather disjunct distribution in the state. It is not found in the Ouachita River drainage, but was found in one of the ARV ecoregion reference streams. The Ouachita Mountain key Percid, the orangebelly darter, *E. radiosum*, is not found outside the Ouachita and Little River drainages in Arkansas. The greenside darter, *E. blennioides*, and the banded darter, *E. zonale*, were collected in seven of the nine samples. These species are more characteristic of the OM ecoregion than the ARV ecoregion. Although demonstrating characteristics of both ecoregions, the dominant darters from the sample sites in this study indicate more similarity to the Arkansas River Valley ecoregion.

Black basses were not collected in large enough numbers to make many determinations about their distribution in this watershed. The smallmouth bass community, which apparently has a somewhat limited distribution in this watershed, appears to be more abundant in the downstream stations. Adult smallmouth were found at station SFR 09, which is the most downstream site but is in a segment of the stream that cuts through very rugged terrain that produces large broken boulders along the stream margin and large cobble in the stream bed. Some very deep pools exist, but the stream gradient increases in this segment and the riffles are faster and longer. Some sharp turns exist as the stream confronts steep, solid rock bluffs. Young-of-the-year and sub-adult smallmouth were collected in tributary streams of this segment of the river. Bear Creek and Cedar Creek appear to provide important habitat for the young smallmouth and possibly for the adults during spawning and as refuge from very high and excessively turbid flows in the main river channel.

The fish communities within this watershed appear to be generally healthy, diverse and reflective of a habitat type that does not have major disturbances. It reflects characteristics of both Ouachita Mountain and Arkansas River Valley ecoregion communities; however, fishes characteristic of the more turbid waters found in the Arkansas River Valley ecoregion appear to dominate these communities.

CONCLUSIONS

Water Quality

Historical water quality records from the South Fourche LaFave river near Hollis Arkansas, indicate that violations of the Ouachita Mountain ecoregion turbidity standard have been occurring about 60 percent (60%) of the time. Also, in 93 percent (93%) of the historical records, the total suspended solids concentrations exceeded the average of this ecoregions' reference streams. If the historical turbidity data is compared to the Arkansas River Valley ecoregion turbidity standard, less frequent exceedances occur, but they continue to occur regularly, particularly during increased runoff events.

The overall water quality of the South Fourche LaFave River during this survey was fairly good. Dissolved oxygen concentrations remained above 5 mg/l and generally maintained a saturation value of greater than seventy percent (70%). Turbidity concentrations exceeded the 10 NTU Ouachita Mountain ecoregion standard in 33 percent (33%) of the samples taken, but the Arkansas River Valley ecoregion turbidity standard of 21 NTU was only slightly exceeded during major storm events. Bacteria concentrations had several isolated peaks during this survey, the greatest occurring at the GRC 01 site and the SFR 05 site. These sites were downstream of animal operations which were adjacent to or had direct contact with the stream. Also, the bacteria concentrations were slightly higher in the river's main stem compared to its tributaries. Nutrient concentrations during this survey remained low at all stations throughout the study period. There were increases in nitrite-nitrate nitrogen and phosphorus concentrations during the late fall and during storm event sampling. The general water chemistry of the South Fourche LaFave River is characteristic of both the Arkansas River Valley and the Ouachita Mountain (OM) ecoregion since they are very similar. However, total suspended solids and turbidity levels from this watershed are most typical of Arkansas River Valley ecoregion waters.

Macroinvertebrates Community

The South Fourche LaFave River macroinvertebrate community most closely resembles that of the Ouachita Mountain ecoregion reference streams, however there some similarities to that of the Arkansas River Valley ecoregion. The community at most sites comprised approximately 70 percent (70%) of the five most commonly collected taxa from the Ouachita Mountain ecoregion. However, several sites had sub-dominate taxon related to the Arkansas River Valley ecoregion. The macroinvertebrate community appeared to be relatively healthy at all stream sites surveyed. However, sites in the main stem of the river generally showed lower species and diversities.

Fish Community

The overall fish community in this watershed appears most similar to that of the ARV ecoregion streams, although there are some similarities to the OM ecoregion communities. It is not known whether these community characteristics were developed from the natural habitat conditions within the watershed and the biotic differences between major drainage basins or from anthropogenic changes that have occurred within this watershed.

Major Concerns

The major area of concern found during this study was the excessive turbidity values which occur after storm events. The major source of this turbidity appears to be from the large network of roads within the watershed. In the steeper terrain, these roads are primarily used for access for timber harvest activities. In the flatter valley areas, the roads serve as access to private farms within the valley and are normally maintained by the county. The basic design of these roads is to move storm water as quickly as possible into the road ditches then to the nearest stream or natural drainage way. Other more specific areas of concern include the large scale pine plantation thinning and chipping operations which employs large amounts of heavy equipment, large staging areas for log storage, chipping and transportation. In addition, severe channel erosion was observed below one of the floodwater control reservoirs. This erosion is caused by high velocity discharges from the reservoir and appears to be adding significant turbidity to certain segments of the river. These problems are probably aggravated by certain soil types within the watershed. Much of the turbidity problems seem to be caused by a very fine suspended sediment. These sediments are often too fine to be captured in the filtering process for measuring total suspended solids. This is indicated by the relatively low TSS values often associated with high turbidities. After a high flow event and as the stream water levels decline, a very fine, powder-like silt covering is apparent on the stream bed. Also, these fine silt particles often go into colloidal suspension, particularly when there is continuous agitation of the water such as in a reservoir.

APPENDIX A

SOUTH FOURCHE LAFAVE RIVER

WATER QUALITY DATA (1991-1992)

SFR 01 DATE	TEMP °C	DO mg/l	pH	BOD mg/l	TOC mg/l	NH_3-N mg/l	NO_3-N mg/l	T-PHOS mg/l	O-PHOS mg/l	CL mg/l	TDS mg/l	HARD mg/l	SO_4 mg/l	TSS mg/l	TURB NTU	F. COLI col/100ml	E. COLI col/100ml	FLOW cfs
91-07-16	23.5	5.7	6.4	1.0	4.4	0.14	0.04	0.03	0.06	2.8	xx	14.0	3.0	3.5	8.2	18.0	<4.0	xxxxx
91-09-10	22.5	7.0	6.8	0.2	5.0	0.06	0.02	0.03	0.06	3.7	43	8.0	4.0	4.0	7.6	48.0	<4.0	1.46
91-12-03	7.4	11.4	7.3	0.6	4.2	0.05	0.04	0.03	0.03	2.3	45	6.0	9.0	8.0	22.0	~30.0	~40.0	53.76
92-02-11	4.0	9.3	6.9	0.3	2.0	0.05	0.02	0.03	0.04	3.8	33	10.0	5.2	2.0	14.0	~22.0	~9.0	20.91
92-06-02	18.5	8.2	6.7	0.8	4.0	0.10	0.02	0.03	0.03	3.8	29	12.0	4.5	3.0	5.0	~10.0	~10.0	1.18
92-06-03	20.0	9.0	6.9	xxx	7.3	0.06	0.02	0.03	0.03	4.4	xx	xxxx	xxx	4.0	7.0	xxxx	xxxx	xxxxx

GRC 01 DATE	TEMP °C	DO mg/l	pH	BOD mg/l	TOC mg/l	NH_3-N mg/l	NO_3-N mg/l	T-PHOS mg/l	O-PHOS mg/l	CL mg/l	TDS mg/l	HARD mg/l	SO_4 mg/l	TSS mg/l	TURB NTU	F. COLI col/100ml	E. COLI col/100ml	FLOW cfs
91-07-16	25.5	5.6	6.3	1.0	4.2	0.13	0.02	0.04	0.07	2.8	xx	14.0	4.0	7.0	18.0	16.0	12.0	xxxxx
91-09-10	22.5	5.8	6.7	0.3	4.4	0.05	0.02	0.03	0.03	3.1	31	16.0	2.0	2.0	3.8	14.0	<4.0	<0.10
91-12-03	7.6	12.5	7.2	0.4	4.3	0.05	0.06	0.03	0.05	2.1	46	10.0	6.0	4.0	19.0	280.0	200.0	48.79
92-02-11	3.5	11.1	7.2	0.3	1.8	0.07	0.02	0.03	0.04	3.9	34	10.0	5.2	8.0	16.0	~7.0	~7.0	20.74
92-06-02	19.0	7.7	6.7	1.2	4.8	0.06	0.02	0.03	0.03	4.0	31	14.0	4.5	3.0	5.5	~90.0	~40.0	0.40
92-06-03	20.5	8.0	7.0	xxx	5.0	0.09	0.02	0.03	0.03	4.5	xx	xxxx	xxx	6.0	6.5	xxxxx	xxxxx	xxxxx

GRC 02 DATE	TEMP °C	DO mg/l	pH	BOD mg/l	TOC mg/l	NH_3-N mg/l	NO_3-N mg/l	T-PHOS mg/l	O-PHOS mg/l	CL mg/l	TDS mg/l	HARD mg/l	SO_4 mg/l	TSS mg/l	TURB NTU	F. COLI col/100ml	E. COLI col/100ml	FLOW cfs
91-07-16	27.5	5.0	6.4	1.0	4.2	0.14	0.03	0.05	0.04	2.7	xx	12.0	6.0	5.5	18.0	>240.0	>320.0	xxxxx
92-06-02	18.5	9.2	6.8	1.0	2.7	0.06	0.02	0.03	0.03	3.2	24	12.0	3.0	3.0	5.0	~170.0	~90.0	xxxxx

SFR 02 DATE	TEMP °C	DO mg/l	pH	BOD mg/l	TOC mg/l	NH_3-N mg/l	NO_3-N mg/l	T-PHOS mg/l	O-PHOS mg/l	CL mg/l	TDS mg/l	HARD mg/l	SO_4 mg/l	TSS mg/l	TURB ntu	F. COLI col/100ml	E. COLI col/100ml	FLOW cfs
91-07-16	28.0	5.7	6.4	1.3	7.5	0.11	0.02	0.04	0.03	2.9	xx	16.0	5.0	3.0	14.0	7.0	<4.0	xxxxx
91-09-10	24.0	5.8	6.8	0.3	4.8	0.05	0.02	0.03	0.03	3.1	31	8.0	2.0	3.0	4.2	<4.0	<4.0	xxxxx
91-12-03	8.1	10.3	7.2	0.4	4.6	0.05	0.05	0.03	0.03	2.0	45	8.0	6.0	6.0	20.0	~75.0	~50.0	xxxxx
92-02-11	4.5	9.7	7.3	0.4	2.2	0.05	0.02	0.03	0.03	3.9	33	12.0	5.2	1.0	14.0	~24.0	~30.0	xxxxx
92-06-02	20.0	8.7	6.7	8.7	4.3	0.06	0.02	0.03	0.03	3.5	31	14.0	4.5	3.0	5.0	~10.0	~20.0	xxxxx
92-06-03	20.0	7.4	6.9	xxx	xxx	0.07	0.02	0.03	0.03	3.8	xx	xxxx	xxx	3.0	5.8	xxxxx	xxxxx	xxxxx

SFR 03 DATE	TEMP °C	DO mg/l	pH	BOD mg/l	TOC mg/l	NH_3-N mg/l	NO_3-N mg/l	T-PHOS mg/l	O-PHOS mg/l	CL mg/l	TDS mg/l	HARD mg/l	SO_4 mg/l	TSS mg/l	TURB ntu	F. COLI col/100ml	E. COLI col/100ml	FLOW cfs
91-07-16	28.0	5.6	6.5	1.4	6.7	0.10	0.03	0.04	0.03	2.6	xx	12.0	5.0	3.5	8.2	<4.0	17.0	xxxxx
92-06-02	20.0	7.1	6.6	7.1	4.6	0.07	0.02	0.03	0.03	3.8	28	18.0	4.5	2.0	2.8	~10.0	<10.0	xxxxx

APPENDIX A (cont)

SOUTH FOURCHE LAFAVE RIVER

WATER QUALITY DATA (1991-1992)

SFR 04 DATE	TEMP °C	DO mg/l	pH	BOD mg/l	TOC mg/l	NH_3-N mg/l	NO_3-N mg/l	T-PHOS mg/l	O-PHOS mg/l	CL mg/l	TDS mg/l	HARD mg/l	SO_4 mg/l	TSS mg/l	TURB NTU	F. COLI col/100ml	E. COLI col/100ml	FLOW cfs
91-07-16	29.5	5.8	6.5	2.1	6.8	0.11	0.02	0.05	0.03	2.8	xx	16.0	4.0	6.5	6.8	14.0	8.0	xxxxx
92-06-02	20.5	7.0	6.3	7.0	5.2	0.08	0.08	0.03	0.03	4.0	31	16.0	4.5	3.0	3.4	~20.0	~30.0	xxxxx

SFR 05 DATE	TEMP °C	DO mg/l	pH	BOD mg/l	TOC mg/l	NH_3-N mg/l	NO_3-N mg/l	T-PHOS mg/l	O-PHOS mg/l	CL mg/l	TDS mg/l	HARD mg/l	SO_4 mg/l	TSS mg/l	TURB NTU	F. COLI col/100ml	E. COLI col/100ml	FLOW cfs
91-07-16	26.0	6.5	6.5	1.2	4.8	0.11	0.02	0.04	0.03	2.9	xx	16.0	3.0	3.5	7.4	8.0	16.0	xxxxx
91-09-10	22.0	6.1	6.8	2.3	8.1	0.05	0.02	0.04	0.03	3.3	42	16.0	2.0	6.0	4.2	210.0	61.0	3.48
91-12-03	8.3	10.3	6.5	0.7	5.7	0.05	0.10	0.04	0.03	1.9	44	10.0	6.0	8.0	21.0	~180.0	340.0	154.24
92-02-11	4.5	9.4	7.1	0.2	2.3	0.06	0.13	0.03	0.03	4.0	35	12.0	5.2	1.0	12.0	~16.0	~9.0	88.84
92-06-02	19.5	7.0	6.3	0.8	5.3	0.10	0.03	0.03	0.03	3.8	30	24.0	3.1	2.0	2.8	~20.0	~20.0	5.31
92-06-03	20.5	7.8	6.8	xxx	5.5	0.05	0.03	0.03	0.03	3.8	xx	xxxx	xxx	4.0	4.8	xxxxx	xxxxx	xxxxx

DFC 01 DATE	TEMP °C	DO mg/l	pH	BOD mg/l	TOC mg/l	NH_3-N mg/l	NO_3-N mg/l	T-PHOS mg/l	O-PHOS mg/l	CL mg/l	TDS mg/l	HARD mg/l	SO_4 mg/l	TSS mg/l	TURB NTU	F. COLI col/100ml	E. COLI col/100ml	FLOW cfs
91-07-16	28.0	6.0	6.8	1.6	6.5	0.13	0.02	0.04	0.04	3.3	xx	10.0	28.0	3.5	12.0	16.0	12.0	xxxxx
91-09-10	23.0	6.9	6.8	0.7	8.8	0.05	0.02	0.04	0.03	5.4	52	16.0	4.0	6.0	8.2	<4.0	<4.0	1.49
91-12-03	8.0	10.4	6.9	0.8	3.5	0.05	0.05	0.03	0.03	2.0	35	10.0	3.0	3.0	16.0	~40.0	~5.0	54.00
92-02-11	4.5	9.2	7.4	0.1	1.6	0.07	0.02	0.03	0.03	4.6	34	12.0	5.2	1.0	6.0	~9.0	~7.0	30.46
92-06-02	19.5	9.6	6.9	0.8	3.1	0.05	0.02	0.03	0.03	3.6	22	16.0	3.1	2.0	2.9	<10.0	~10.0	0.40
92-06-03	18.5	8.4	6.8	xxx	8.6	0.10	0.02	0.03	0.06	4.8	xx	xxxx	xxx	14.0	35.0	xxxxx	xxxxx	xxxxx

SFR 06 DATE	TEMP °C	DO mg/l	pH	BOD mg/l	TOC mg/l	NH_3-N mg/l	NO_3-N mg/l	T-PHOS mg/l	O-PHOS mg/l	CL mg/l	TDS mg/l	HARD mg/l	SO_4 mg/l	TSS mg/l	TURB NTU	F. COLI col/100ml	E. COLI col/100ml	FLOW cfs
91-07-16	27.0	5.5	6.3	1.5	6.1	0.09	0.06	0.04	0.03	3.1	xx	14.0	5.0	4.5	9.0	23.0	<4.0	xxxxx
91-09-10	22.0	5.2	6.4	2.0	9.6	0.24	0.06	0.04	0.03	3.4	54	18.0	7.0	12.0	8.0	132.0	12.0	xxxxx
91-12-03	8.3	10.6	6.8	1.2	6.6	0.06	0.07	0.05	0.03	2.0	44	10.0	6.0	9.0	24.0	~130.0	~145.0	xxxxx
92-02-11	4.5	9.9	7.3	0.6	2.9	0.06	0.09	0.03	0.03	4.1	35	12.0	5.2	8.0	14.0	<4.0	<4.0	xxxxx
92-06-02	20.0	6.8	5.6	1.0	5.3	0.07	0.06	0.03	0.03	3.8	31	18.0	3.1	2.0	3.7	~40.0	~30.0	xxxxx

SFR 07 DATE	TEMP °C	DO mg/l	pH	BOD mg/l	TOC mg/l	NH_3-N mg/l	NO_3-N mg/l	T-PHOS mg/l	O-PHOS mg/l	CL mg/l	TDS mg/l	HARD mg/l	SO_4 mg/l	TSS mg/l	TURB NTU	F. COLI col/100ml	E. COLI col/100ml	FLOW cfs
91-07-16	29.5	5.5	6.3	1.6	5.8	0.09	0.02	0.04	0.03	3.1	xx	14.0	4.0	3.0	6.2	12.0	<4.0	xxxxx
92-06-02	20.5	6.9	6.3	1.0	4.7	0.05	0.02	0.03	0.03	3.7	29	20.0	3.1	2.0	2.6	10.0	<10.0	xxxxx
92-06-03	20.5	7.3	7.8	xxx	7.6	0.07	0.05	0.04	0.03	3.6	xx	xxxx	xxx	20.0	26.0	xxxx	xxxxx	xxxxx

APPENDIX A (cont)

SOUTH FOURCHE LAFAVE RIVER

WATER QUALITY DATA (1991-1992)

BRC 01 DATE	TEMP °C	DO mg/l	pH	BOD mg/l	TOC mg/l	NH_3-N mg/l	NO_3-N mg/l	T-PHOS mg/l	O-PHOS mg/l	CL mg/l	TDS mg/l	HARD mg/l	SO_4 mg/l	TSS mg/l	TURB NTU	F. COLI col/100ml	E. COLI col/100ml	FLOW cfs
91-07-16	28.0	5.5	6.4	0.8	1.2	0.09	0.02	0.03	0.03	2.4	xx	24.0	2.0	1.0	3.8	<4.0	<4.0	xxxxx
91-09-10	28.5	7.6	7.1	0.1	2.2	0.05	0.02	0.03	0.03	2.7	28	14.0	1.0	2.0	3.0	9.0	<4.0	0.96
91-12-03	7.5	12.3	6.9	1.0	2.7	0.05	0.02	0.03	0.03	1.6	32	8.0	3.0	2.0	9.4	~35.0	<20.0	112.30
92-02-11	4.0	9.5	7.3	0.1	1.3	0.05	0.02	0.03	0.03	2.0	25	8.0	1.0	1.0	3.4	~12.0	~7.0	80.99
92-06-02	20.5	8.4	6.2	0.8	1.8	0.06	0.02	0.03	0.03	2.2	18	10.0	1.7	1.0	2.0	~30.0	~20.0	4.32
92-06-03	20.0	8.5	6.8	xxx	4.5	0.06	0.02	0.03	0.03	2.0	xx	xxxx	xxx	4.0	16.0	xxxxx	xxxxx	xxxxx

SFR 08 DATE °C	TEMP	DO mg/l	pH	BOD mg/l	TOC mg/l	NH_3-N mg/l	NO_3-N mg/l	T-PHOS mg/l	O-PHOS mg/l	CL mg/l	TDS mg/l	HARD mg/l	SO_4 mg/l	TSS mg/l	TURB NTU	F. COLI col/100ml	E. COLI col/100ml	FLOW cfs
91-07-16	29.0	6.0	6.8	1.2	4.9	0.11	0.02	0.04	0.03	3.2	xx	18.0	1.0	2.5	6.0	<4.0	<4.0	xxxxx
91-09-10	29.0	7.3	6.9	0.5	6.3	0.05	0.02	0.03	0.03	2.8	42	16.0	3.0	4.0	4.4	19.0	14.0	xxxxx
91-12-03	8.0	12.2	7.1	1.1	5.8	0.05	0.02	0.05	0.03	1.9	41	8.0	6.0	8.0	22.0	~140.0	'130.0	xxxxx
92-02-11	5.0	9.6	7.2	0.3	2.5	0.05	0.02	0.03	0.03	3.6	34	10.0	5.2	2.0	6.9	~7.0	~7.0	xxxxx
92-06-02	20.5	7.6	6.8	0.6	3.7	0.13	0.02	0.03	0.03	3.0	21	24.0	3.1	2.0	2.7	~10.0	<10.0	xxxxx
92-06-03	20.5	8.2	6.9	xxx	5.7	0.06	0.02	0.03	0.03	2.4	xx	xxxx	xxx	9.0	19.0	xxxxx	xxxxx	xxxxx

CDC 01 DATE	TEMP °C	DO mg/l	pH	BOD mg/l	TOC mg/l	NH_3-N mg/l	NO_3-N mg/l	T-PHOS mg/l	O-PHOS mg/l	CL mg/l	TDS mg/l	HARD mg/l	SO_4 mg/l	TSS mg/l	TURB NTU	F. COLI col/100ml	E. COLI col/100ml	FLOW cfs
91-07-16	26.0	5.7	6.9	1.1	2.3	0.11	0.02	0.05	0.04	2.4	xx	22.0	2.0	1.5	6.6	<4.0	<4.0	xxxxx
91-09-10	26.5	6.2	6.7	0.3	2.5	0.05	0.02	0.03	0.03	2.7	30	18.0	1.0	2.0	4.1	62.0	<4.0	0.36
91-12-03	8.5	10.8	7.1	0.8	2.3	0.05	0.02	0.03	0.03	1.6	24	8.0	3.0	2.0	8.6	~10.0	~10.0	38.36
92-02-11	4.5	9.2	7.1	xxx	1.1	0.05	0.02	0.03	0.03	2.1	25	8.0	1.0	2.0	5.5	<4.0	<4.0	37.82
92-06-02	19.0	7.8	6.6	0.5	2.0	0.07	0.02	0.03	0.03	2.3	21	16.0	3.1	1.0	3.3	<10.0	~10.0	0.84
92-06-03	19.5	8.6	6.7	xxx	4.1	0.12	0.02	0.03	0.04	2.2	xx	xxxx	xxx	1.5	18.0	xxxxx	xxxxx	xxxxx

SFR 09 DATE	TEMP °C	DO mg/l	pH	BOD mg/l	TOC mg/l	NH_3-N mg/l	NO_3-N mg/l	T-PHOS mg/l	O-PHOS mg/l	CL mg/l	TDS mg/l	HARD mg/l	SO_4 mg/l	TSS mg/l	TURB NTU	F. COLI col/100ml	E. COLI col/100ml	FLOW cfs
91-07-16	29.0	5.5	6.9	0.9	4.5	0.09	0.02	0.03	0.03	3.2	xx	18.0	2.0	1.5	4.8	<4.0	<4.0	3.30
91-09-10	29.0	7.2	7.5	0.1	6.1	0.05	0.02	0.03	0.03	2.5	28	16.0	2.0	2.0	3.2	21.0	<4.0	12.00
91-12-03	8.9	10.6	7.2	1.0	5.5	0.05	0.06	0.03	0.05	2.0	39	12.0	6.0	10.0	22.0	~170.0	~135.0	1920
92-02-11	4.0	9.7	7.2	0.2	2.1	0.05	0.02	0.03	0.03	3.3	33	14.0	2.6	1.0	5.6	<4.0	<4.0	53.00
92-06-02	21.5	7.7	6.7	0.7	3.4	0.06	0.02	0.03	0.03	2.9	24	18.0	3.1	2.0	2.0	<10.0	<10.0	38.23
92-06-03	20.0	8.2	6.8	xxx	7.5	0.07	0.02	0.03	0.03	2.4	xx	xxxx	xxx	15.0	26.0	xxxxx	xxxxx	313.21

SFR 10 DATE	TEMP °C	DO mg/l	pH	BOD mg/l	TOC mg/l	NH_3-N mg/l	NO_3-N mg/l	T-PHOS mg/l	O-PHOS mg/l	CL mg/l	TDS mg/l	HARD mg/l	SO_4 mg/l	TSS mg/l	TURB NTU	F. COLI col/100ml	E. COLI col/100ml	FLOW cfs
91-07-16	27.0	5.5	7.2	1.1	4.3	0.09	0.02	0.03	0.03	3.0	xx	18.0	3.0	1.5	5.0	<4.0	28.0	xxxxx
92-06-02	21.0	7.3	7.2	0.7	3.4	0.06	0.02	0.03	0.03	2.9	25	20.0	1.7	1.0	1.8	~30.0	~20.0	xxxxx

APPENDIX B

FISHES FROM SOUTH FOURCHE LAFAVE RIVER (1991)

FISH FAMILY AND SPECIES		RELATIVE ABUNDANCE VALUES GRC 01	DFC 01	BRC 01	BRC 02	CDC 01	SFR 02	SFR 06	SFR 08	SFR 09
Petromyzontidae	Lampreys									
Ichthyomyzon gagei	Southern brook lamprey	-----	-----	-----	1	-----	1	-----	-----	-----
Lepisosteidae	Gars									
Lepisosteus oculatus	Spotted gar	-----	-----	-----	-----	-----	-----	1	1	-----
Lepisosteus osseus	Longnose gar	-----	-----	-----	-----	-----	1	-----	-----	3
Esocidae	Pikes									
Esox americanus	Grass pickerel	-----	4	-----	-----	4	-----	-----	-----	-----
Cyprinidae	Minnows									
Campostoma anomalum	Stoneroller	8	5	8	8	8	4	6	5	4
Cyprinella whipplei	Steelcolor shiner	-----	-----	2	-----	-----	1	1	4	5
Lythrurus umbratilis	Redfin shiner	6	7	2	3.5	1	5	-----	-----	1.5
Notemigonus crysoleucas	Golden shiner	-----	-----	1	-----	-----	-----	-----	-----	-----
Notropis boops	Bigeye shiner	-----	8	6	6	8	8	2	4	6
Notropis greeni	Wedgespot shiner	-----	-----	2	2	-----	-----	-----	5	6
Pimephales notatus	Bluntnose minnow	6	5	1.5	5	4	5	1	1	2
Semotilus atromaculatus	Creek chub	-----	-----	-----	-----	1	-----	-----	-----	-----
Catostomidae	Suckers									
Carpiodes carpio	River carpsucker	-----	-----	-----	-----	-----	-----	-----	-----	2
Erimyzon oblongus	Creek chubsucker	2.5	-----	1	2	4	1	-----	1	-----
Hypentelium nigricans	Northern hogsucker	-----	-----	1	2.5	-----	-----	-----	-----	-----
Ictiobus niger	Black buffalo	-----	-----	-----	-----	-----	-----	-----	-----	1
Moxostoma carinatum	River redhorse	-----	-----	-----	-----	-----	-----	1	-----	1
Moxostoma erythrurum	Golden redhorse	-----	-----	-----	-----	-----	1	-----	-----	2
Moxostoma macrolepidotum	Shorthead redhorse	-----	-----	-----	-----	-----	-----	-----	-----	1
Ictaluridae	Catfishes									
Ameiurus natilis	Yellow bullhead	3	2	-----	1	-----	3	4	1	1
Noturus exilis	Slender madtom	4	5	6	7	6	8	8	8	4
Polydictus olivaris	Flathead catfish	-----	-----	-----	-----	-----	-----	1	2	4.5
Cyprinodontidae	Killifishes									
Fundulus olivaceus	Blackspotted topminnow	6	6	5.5	6	6	2	6	6	6
Atherinidae	Silversides									
Labidesthes sicculus	Brook silverside	5.5	5	8	5	3.5	2	-----	2	5
Centrarchidae	Sunfishes									
Lepomis cyanellus	Green sunfish	6	5	7	6	6	6	6	6	6
Lepomis gulosus	Warmouth sunfish	2	4	-----	-----	-----	2	2	-----	-----
Lepomis humilis	Orangespotted sunfish	-----	-----	-----	-----	-----	-----	1	-----	-----
Lepomis macrochirus	Bluegill sunfish	2	2	-----	-----	-----	3	7	2	2.5
Lepomis megalotis	Longear sunfish	8	6	8	8	8	8	8	7	7
Micropterus dolomieui	Smallmouth bass	-----	-----	2	2.5	2	-----	-----	-----	3
Micropterus punctulatus	Spotted bass	-----	-----	2	-----	-----	-----	2	2	5.5
Micropterus salmoides	Largemouth sunfish	2	-----	-----	-----	-----	-----	3	-----	2
Percidae	Perches									
Etheostoma blennioides	Greenside darter	-----	3	1	6	4	8	5.5	7	4.5
Etheostoma flabellare	Fantail darter	2	-----	1	2	-----	4	8	8	6
Etheostoma spectabile	Orangethroat darter	2	4	1	4.5	5	6	5	2	2
Etheostoma whipplei	Redfin darter	1	3	4	6	5.5	4	6	6	4
Etheostoma zonale	Banded darter	-----	-----	1.5	2.5	1	5	5	7	6
Percina caprodes	Logperch	-----	5	-----	2	2.5	4	4	4	3.5
Percina maculata	Blackside darter	2	1	-----	-----	-----	-----	-----	-----	-----
Percina sciera	Dusky darter	-----	-----	-----	-----	-----	-----	2	-----	-----
	TOTAL SPECIES	17	18	21	21	18	23	24	22	29

LITERATURE CITED

Arkansas Agricultural Statistics 1990, July 1991. Report Series 320. Arkansas Agricultural Experiment Station, Fayetteville, AR 72701.

Arkansas Department of Pollution Control and Ecology. August, 1991. Arkansas Nonpoint Source Pollution Control Assessment Report, "Update".

.......June, 1987. Physical, Chemical, and Biological Characteristics of Least Disturbed Reference Streams in Arkansas' Ecoregions. Volumes I and II.

.......October, 1991. Regulation No. 2, As Amended. Regulation Establishing Water Quality Standards for Surface Waters of the State of Arkansas.

.......1992. Water Quality Inventory Report (305(b)).

Douglas, Neil H., Ph.D. 1974. Freshwater Fishes of Louisiana. Claitor's Publishing Division, Baton Rouge, LA 70821.

Pennak, Robert W. 1978. Fresh-Water Invertebrates of the United States. Second Edition. John Wiley & Sons, New York.

Pflieger, William L. 1975. The Fishes of Missouri. Missouri Department of Conservation.

Robinson, H. W., and Buchanan, T. M., 1992. Fishes of Arkansas. The University of Arkansas Press, Fayetteville, AR 72701.

United States Geological Survey, Water Resources Division, 1970. Drainage Areas of Streams in Arkansas, Arkansas River Basin.

Keith, William, E. 1987. Distribution of Fishes in Reference Streams Within Arkansas' Ecoregions. Proceedings from the Arkansas Academy of Science, Vol 41.

United States Environmental Protection Agency, May, 1989. Rapid Bioassessment Protocols for Use in Streams and Rivers, Benthic Macroinvertebrates and Fish (EPA/444/4-89-001).

United States Department of Agricultural. December 1988. Soil Survey of Yell County, Arkansas. Soil Conservation Service.

.......May, 1982. Soil Survey of Perry County, Arkansas. Soil Conservation Service. U.S. Dept. of Agricultural.

United States Department of the Interior, U.S. Geological Survey 7.5 minute topographical maps. Quadrangles -- Aplin, Onyx, Nimrod, Nimrod Dam, Nimrod SE, Nimrod SW, Steve.