

**TMDL INVESTIGATION OF  
WATER QUALITY IMPAIRMENTS  
TO JUG CREEK**

**DALLAS COUNTY  
ARKANSAS**

*ARKANSAS DEPARTMENT OF POLLUTION CONTROL & ECOLOGY*



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# **TMDL investigation of Water Quality Impairments to Jug Creek, Dallas County, Arkansas**

## **INTRODUCTION**

Section 303(d) of the Clean Water Act (CWA) requires States to identify and rank by priority waterbodies that are not meeting applicable water quality goals. In addition, the total maximum daily load (TMDL) process is established as a tool to be used by States to aid in identifying pollutant sources and quantifying allowable loadings or other parameters in order to attain and maintain water quality standards.

Jug Creek was listed in the 1992, 1994, and 1996 303(d) list of Water Quality Limited Waterbodies. Municipal point source was identified as the major source of impairment and industrial point source was identified as the minor source of impairment. The major cause of impairment was identified as nutrients and the minor cause was attributed to minerals. In the 1996 303(d) list, Jug Creek was given a priority ranking of high.

The TMDL investigation of Jug Creek took place July 29-30, 1996. Water quality samples were collected at seven sites, diel dissolved oxygen (D.O.) and temperature was recorded at four sites, and fish and macroinvertebrate samples were collected at four sites.

## **WATERSHED DESCRIPTION**

The Jug Creek watershed encompasses approximately six square miles in the southeast corner of Dallas County. Jug Creek is an intermittent stream that without point source discharges would only flow on a seasonal basis. The stream originates near the western boundary of Fordyce, Arkansas and the flow direction is generally to the east toward Moro Creek. The headwaters region of the stream has elevation of 300 feet gradually declining to approximately 170 feet at the confluence of Jug Creek and Moro Creek. The upper portion of the stream has a slope of approximately 26 feet/mile, while the lower portion declines to approximately 5 feet/mile. The stream channel is relatively narrow ranging from 4-15 feet with an average width of 8-10 feet. The average depth of the stream upstream of the Fordyce Waste Treatment Plant (WTP) is less than one foot. Downstream of the WTP, the average depth is one foot. The stream substrate is dominated by gravel and sand from the origin to the WTP outfall, with the gravel decreasing and sandy loam dominating in the lower section of the stream.

The Jug Creek drainage lies within the eastern portion of the Gulf Coastal ecoregion of Arkansas. This region is characterized by gently rolling hills and flat lands generally covered with loblolly and shortleaf pine and bottomland hardwoods. Land use within the Jug Creek drainage is mostly silviculture with a portion of urban area in the upper watershed.

Cooks Creek north of Fordyce was chosen as a reference stream for the study. The Cooks Creek watershed encompasses approximately 10 square miles in which silviculture is the predominate land use. The creek is an intermittent stream with no point source dischargers.

## HISTORICAL DATA

Water quality data was retrieved for monthly samples collected between 1991 and 1996 from EPA STORET database for the OUA47 sampling station which is located on Cleveland St. east of Fordyce. This is the same location as the JUG04B station in this study and is located approximately 1 mile below the Fordyce WTP discharge. Graphs of total dissolved solids (TDS), minerals (chlorides and sulfates), nitrogen compounds, and phosphorus for the 1991 to 1996 time period are presented in Appendix A. TDS concentrations fluctuated widely over the time period with a slightly increasing trend. Chloride concentrations showed a similar variability with a slightly increasing trend. Sulfate concentrations were fairly constant throughout the data. Over the five year time period, nitrate nitrogen concentrations have been increasing since 1993; this coincides with a decline in ammonia-nitrogen as the denitrification process has improved. Orthophosphate and total phosphorus concentrations have also shown decreases.

Discharge Monitoring Report (DMR) data was retrieved from the Permit Compliance System data base for the Georgia Pacific plywood mill (permit # AR0036064) and the Fordyce Wastewater Treatment Plant (permit # AR0033758) for the period January, 1991 to December, 1995. Permit monitoring requirements are outlined in the Table 1. A review of the data revealed numerous excursions from the permit requirements at the Georgia Pacific 001A outfall between November, 1994 and February, 1995. The parameters exceeded were Carbonaceous Biochemical Oxygen Demand (CBOD), Nitrogen Ammonia (NH<sub>4</sub>-N), Oil and Grease, Dissolved Oxygen (D.O.), pH, and Total Suspended Solids (TSS). An additional settling basin was added to the treatment system to remedy the situation.

Previous studies in this watershed include a Stream Assimilative Capacity Study (November, 1994) and a Wasteload Allocation Report for the Georgia Pacific Discharge (December, 1995) conducted by the Arkansas Department of Pollution Control and Ecology. In addition, a Use Attainability Analysis (UAA) was prepared for Georgia Pacific by Mike McDaniel and Associates (September, 1986). As a result of the UAA, the D.O. standard of Jug Creek was amended to allow a critical season (May - October) D.O. minimum of 3 mg/L.



**Table 1**  
**Georgia Pacific NPDES Permit Effluent Limitations**

Facility/ outfall	Effluent Parameter	Mass (lb/day)		Concentration		Frequency
		Monthly Avg.	Daily Max.	Monthly Avg.	Daily Max.	
Outfall 001	CBOD (May-Oct.)	22	33	20 mg/L	30 mg/L	twice/month
	CBOD (Nov-Apr)	28	42	25 mg/L	38 mg/L	twice/month
	TSS	33	50	30 mg/L	45 mg/L	twice/month
	NH3-N	2	3	2 mg/L	3 mg/L	twice/month
	D.O.	N/A	N/A	5 mg/L	N/A	twice/month
	Oil & Grease	11	17	10 mg/L	15 mg/L	twice/month
	Temp	N/A	N/A	N/A	89.6 F	twice/month
Outfall 002	COD	N/A	N/A	50 mg/L	75 mg/L	twice/month
	TSS	N/A	N/A	35 mg/L	53 mg/L	twice/month
	Oil & Grease	N/A	N/A	10 mg/L	15 mg/L	twice/month
	BOD	N/A	N/A	Report	Report	twice/month

**Table 2**  
**Fordyce WTP NPDES Permit Effluent Limitations**

Parameter	Mass (lbs/day) Monthly Avg.	Concentration		Frequency
		Monthly Avg	7-day Avg	
CBOD (May-Oct)	70	10 mg/L	15 mg/L	three/month
CBOD (Nov-Apr)	105	15 mg/L	23 mg/L	three/month
TSS (May-Oct)	105	15 mg/L	23 mg/L	three/month
TSS (Nov-Apr)	140	20 mg/L	30 mg/L	three/month
NH3-N	49	7 mg/L	11 mg/L	three/month
D.O. (May-Oct)	N/A	7 mg/L	N/A	three/month
D.O. (Nov-Apr)	N/A	6 mg/L	N/A	three/month
Fecal Coliform (Apr-Sept)	N/A	200 col/100 ml	400 col/100 ml	twice/month
Fecal Coliform (Oct-Mar)	N/A	1000 col/100 ml	2000 col/100 ml	twice/month

## **CURRENT STUDY**

### **Data Acquisition**

The Jug Creek survey was initiated on the afternoon of July 29, 1996 when continuous dissolved oxygen meters were deployed at JUG03A, JUG04B, JUG05, and CKS01. Also on July 29, fish samples were collected at JUG02B, JUG04B and JUG05, macroinvertebrate samples were collected at JUG03A, JUG04B. On July 30, fish and macroinvertebrate samples were collected at CKS01, water quality samples were collected at all sites, and a time of travel study was conducted below the Fordyce WTP. On July 31, the hydrolab meters were retrieved and macroinvertebrate samples were collected at JUG02B.

### **Parameters**

Water samples were analyzed for D.O., temperature, pH, flow, chlorides, total organic carbon (TOC), five day biochemical oxygen demand (BOD5), total suspended solids (TSS), total dissolved solids (TDS), ammonia nitrogen ( $\text{NH}_3\text{N}$ ), nitrite + nitrate nitrogen ( $\text{NO}_2 + \text{NO}_3$ ), orthophosphate, and total phosphorus. Total and dissolved metals sampling included aluminum, boron, barium, beryllium, calcium, cadmium, cobalt, chromium, copper, iron, potassium, magnesium, manganese, sodium, nickel, lead, vanadium, and zinc. Water quality data is presented in Appendix A.

### **Collection, Preservation and Measurements**

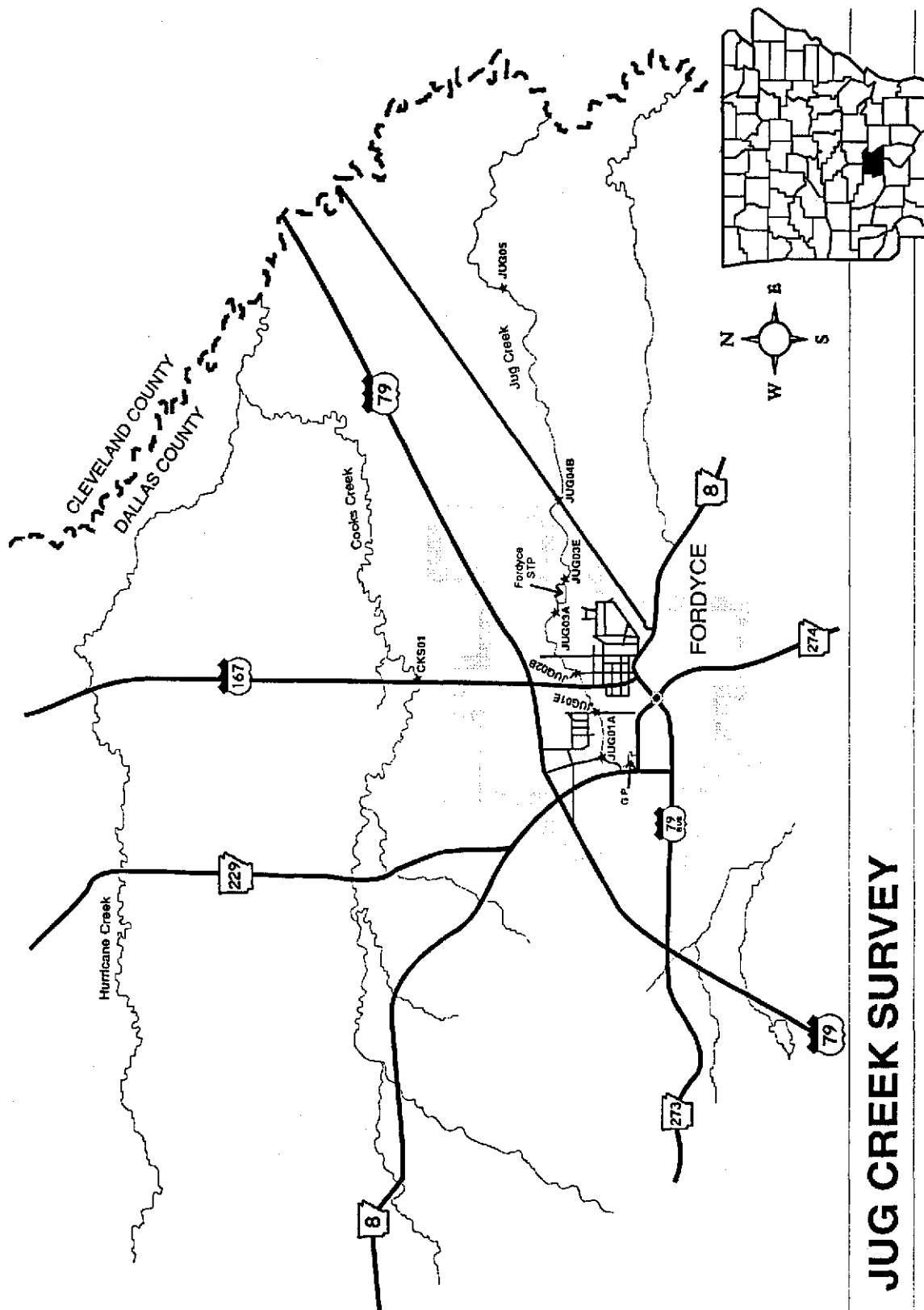
Stream samples were collected, preserved, and analyzed according to the 18th Edition of Standard Methods for Examination of Water and Wastewater. Analysis was conducted under ADPC&E's existing Quality Assurance Program. Dissolved oxygen and stream temperature was measured using an Orion Model 840 portable dissolved oxygen meter, which was calibrated according to the manufacturers instructions prior to use. Four Hydrolab continuous dissolved oxygen recorders were used to determine diurnal variation in the dissolved oxygen concentration and temperature in Jug Creek and in the reference stream. Stream pH was measured using an Orion Model 230A portable pH meter, which was calibrated using buffer solutions of pH 4 and 7. Stream flow was measured using a Marsh-McBirney Model 2000 Flow Mate meter by obtaining a representative number of velocities and depths across suitable stream locations. Macroinvertebrates were collected using a Turtox Indestructible benthos net. An attempt was made to sample similar structure and habitat at each location so that data collected would be comparable. The fish community was sampled by use of a Smith-Root Model 15-B DC backpack electrofisher. Riffle areas were sampled by driving the fish into a seine, while the fish in the pools were collected by electroshocking favorable habitat areas. The smaller specimens and those unidentifiable in the field were preserved in a ten percent (10%) formalin solution and returned to the lab for identification.

## Station Description

Seven water chemistry stations were established on Jug Creek, with an additional station located in the Cooks Creek reference stream. These stations were selected for the purpose of determining any impacts from non-point source contributors as well as assessing the impacts from the Georgia Pacific outfall and the City of Fordyce WTP effluent on Jug Creek. The station descriptions can be found in Table 3. Station locations are depicted in Figure 1.

**Table 3**  
**Sampling Stations**

Station I.D.	Location	Samples Collected*
JUG01A	Jug Creek below bridge at entrance road to Georgia Pacific plant.	Water Quality, Flow
JUG01E	Georgia Pacific discharge	Water Quality, Flow
JUG02B	Jug Creek below Georgia Pacific mill at city street east of highway 79B	Water Quality, Flow, Aquatic Life
JUG03A	Jug Creek above WTP outfall	Water Quality, Flow, Continuous D.O
JUG03E	Jug Creek WTP effluent	Water Quality, Flow
JUG04B	Jug Creek at Cleveland St. crossing	Water Quality, Flow, Aquatic Life, and Continuous D.O.
JUG05	Jug Creek at timber access road three miles south of highway 8.	Water Quality, Flow, Aquatic Life, and Continuous D.O.
CKS01	Cooks Creek at Highway 167 bridge	Water Quality, Flow, Aquatic Life, and Continuous D.O.



## JUG CREEK SURVEY

Figure 1

## WATER QUALITY

### Diel Dissolved Oxygen and Temperature

Hydrolab Recorder multi-parameter water quality sampling meters were used to measure the diel fluctuation of both D.O. and temperature. On July 29, 1996, meters were placed at Jug Creek above the Fordyce WTP (near JUG03A), at Jug Creek near the Cleveland Street crossing (JUG04B), at Jug Creek near the timber access road (JUG05), and at Cooks Creek near highway 167 (CKS01). All meters were deployed for 48 hours, collecting data in 10 minute intervals. Table WQ-1 is a summary of the temperature and D.O. data.

**Table WQ-1 - Diel D.O. and Temperature Summary**

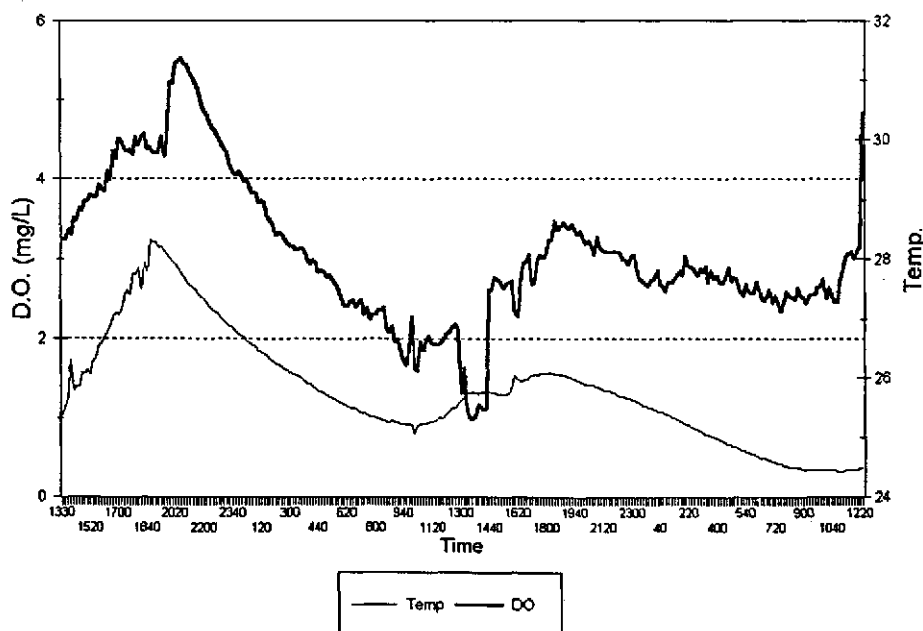
Station ID	Sample Dates	D.O.			Temperature		
		Max	Min	M.D.F.*	Max	Min	M.D.F.
CKS01	7/29-7/30	5.54	1.04	4.5	28.31	25.07	3.2
	7/30-7/31	4.83	.99	3.84	26.11	24.43	1.7
JUG03A	7/29-7/30	1.17	0.04	1.1	25.75	24.84	0.9
	7/30-7/31	2.10	0.05	2.0	25.05	24.17	0.9
JUG04B	7/29-7/30	4.55	0.2	4.4	30.90	24.2	6.7
	7/30-7/31	3.89	0.2	3.69	26.86	22.79	4.1
JUG05	7/29-7/30	2.76	0.18	2.5	29.79	26.14	3.65
	7/30-7/31	0.9	0.18	0.8	27.15	25.41	1.7

\*Maximum Daily Fluctuation

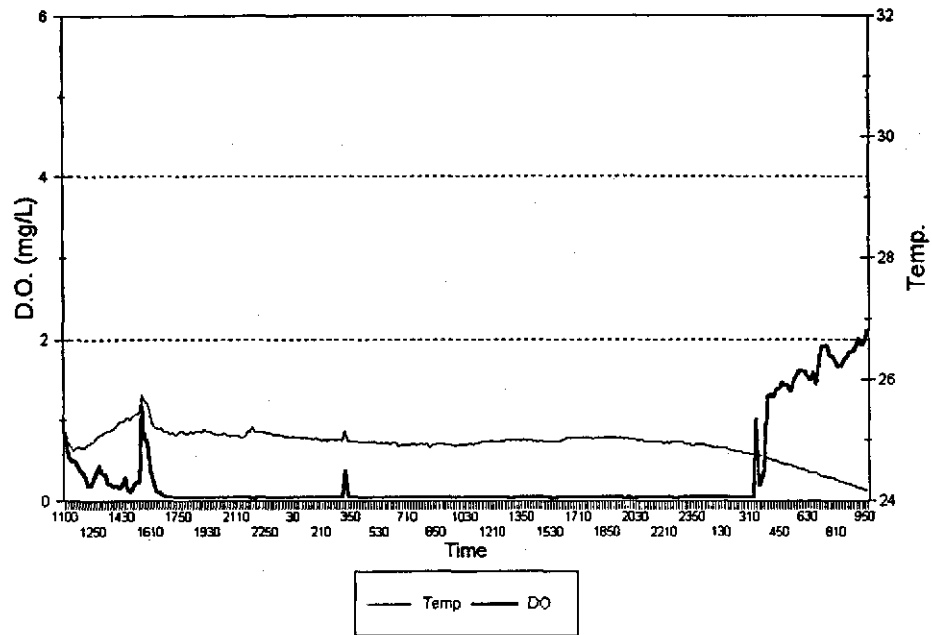
Dissolved oxygen concentrations at the Cooks Creek reference station ranged from 0.99 mg/L to 5.54 mg/L with D.O. saturation values ranging from 12.8% to 74%. Temperatures at the site ranged from 23.2 °C to 28.3 °C. Maximum daily D.O. fluctuations at the Cooks Creek site were 4.5 mg/L and 3.84 mg/L for each 24 hour period. Data collected from this site is represented in Figure WQ-1.

At JUG03A (above WTP outfall), D.O. concentrations ranged from 0.04 mg/L to 2.1 mg/L. Saturation values ranged from 0.6% to 26.2%, and temperature measurements ranged from 24.2 °C to 25.8 °C. The constant low D.O. concentrations recorded at this site are most likely due to meter malfunction. At the JUG04B site below the WTP outfall, saturation values ranged from 15.7% to 61.1%, and D.O. concentrations ranged from 1.24 mg/L to 4.55 mg/L. At the most downstream site (JUG05), D.O. concentrations ranged from 0.18 mg/L to 2.76 mg/L, and saturation values ranged from 2.4% to 37.7%. Temperatures at the site ranged from 25.4 °C to 29.8 °C. The maximum daily D.O. fluctuations for the three Jug Creek sites ranged from 1.1 mg/L at JUG03A to 4.4 mg/L at JUG04B. Figures WQ-2, WQ-3, and WQ-4 represent the D.O. and temperature data from JUG03A, JUG04, and JUG05 respectively.

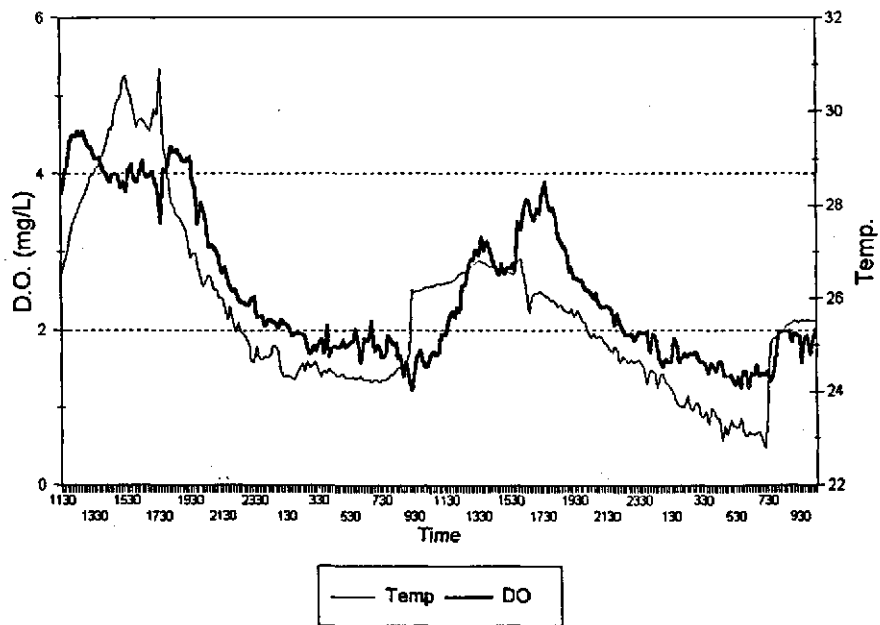
Figure WQ-1  
CKS01



**Figure WQ-2**  
**JUG03A**

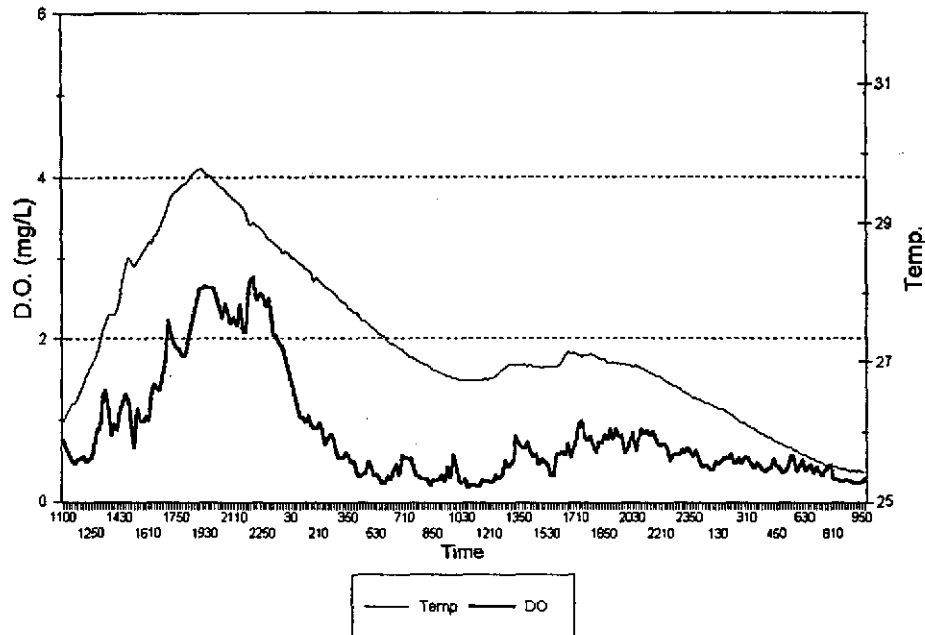


**Figure WQ-3**  
**JUG04B**





**Figure WQ-4**  
**JUG05**



### pH and Flow

The pH values measured during the study were typical for streams in the Gulf Coastal ecoregion. Values recorded ranged from 6.3 at JUG01A to 7.5 at JUG01E. A pH value of 6.4 was measured at the Cooks Creek station. Instream flows ranged from <0.1 cubic feet per second (cfs) to 1.54 cfs. Discharge flows from the Georgia Pacific facility (JUG01E) and the Fordyce WTP (JUG03E) were calculated at 0.005 cfs and 0.52 cfs respectively. A flow of 0.85 cfs was measured at the CKS01 site. Flow was not measured at JUG05.

### Chlorides, Sulfates, and TDS

Instream chloride concentrations were the highest below the treatment plant effluents. The sample from JUG03E (Fordyce WTP) had a concentration of 49.8 mg/L, and chlorides at the station immediately below the discharge (JUG04B) were measured at 45.9 mg/L. In contrast, concentrations in the most upstream site and CKS01 were 3.5 mg/L and 7.4 mg/L respectively.

Sulfate concentration ranged from 12.6 mg/L (JUG01E) to 26.8 mg/L (JUG03E). Reference stream sulfate concentration was measured at 9.3 mg/L.

A dramatic increase below the effluents was noted in total dissolved solids (TDS) concentrations. TDS concentrations from the Georgia Pacific and Fordyce effluents were 225.0 mg/L and 368 mg/L respectively. At JUG05 the concentrations had decreased to only 296.0 mg/L. Concentrations of TDS were measured at 90.0 mg/L and 88.0 mg/L at JUG01A and CKS01 respectively.

It should be noted that an increase in mineral concentrations was observed below the Georgia Pacific outfall at JUG02B. There appears to be a possible influence from domestic wastewater in the area between JUG01E and JUG02B. Figure WQ-5 depicts mineral concentrations.

### **CBOD, TSS, and Nutrients**

During the study instream CBOD concentrations ranged from 1.4 mg/L at JUG01E to 5.6 mg/L at JUG05. Above the JUG05 site, Jug Creek flows through an area where timber has been harvested. As a result, the creek substrate is made up of large amounts of woody debris, leaf litter, and other organic material. The Cooks Creek reference stream and the upstream site, JUG01A, had CBOD concentrations of 1.2 mg/L and 1.7 mg/L respectively. TSS concentrations during the study ranged from 1.0 mg/L at JUG02B to 15.5 mg/L at JUG04B. The Cooks Creek reference site had a TSS concentration of 9.0 mg/L.

Nutrient concentrations were elevated below the Fordyce WTP effluent as would be expected. Background ammonia concentration at JUG01A was below the detection limit of 0.05 mg/L. Effluent ammonia concentration at JUG03E was measured at 0.66 mg/L. The ammonia concentration increased to 2.16 mg/L at JUG04B and decreased to 1.72 mg/L at JUG05. This higher ammonia concentration approximately two miles below the WTP effluent is possibly a result of the organic substrate causing denitrification.

As with ammonia, nitrate-nitrogen concentrations were highest below the Fordyce WTP discharge. A concentration of 7 mg/L was measured at JUG03E. Concentrations decreased to 3.1 mg/L at JUG04B and then to 0.2 mg/L at JUG05. Reference stream concentration and upstream concentration were both measured at 0.1 mg/L.

Total phosphorus concentrations in Jug Creek ranged from 0.15 mg/L at the JUG01A site to 3.31 mg/L at the Fordyce effluent (JUG03E). A gradual increase was noted below the Georgia Pacific facility outfall. This trend was also noted in mineral concentrations as discussed earlier. Total phosphorus concentrations below the Fordyce effluent decreased to 2.74 mg/L at JUG04B to 2.14 mg/L at JUG05. Reference stream concentrations were 0.12 mg/L. Nutrient concentrations are represented in Figure WQ-6

## **Dissolved Metals**

Overall, metals concentrations were below detectable levels for most analytes. Aluminum was detected at JUG01A with a concentration of 79.5  $\mu\text{g/L}$  and decreased to concentrations less than the detection level farther downstream. Elevated concentrations of boron, barium, and calcium were detected in the Georgia Pacific outfall (JUG01E) and boron was also elevated in the Fordyce WTP discharge. Aluminum, iron and manganese concentrations were generally higher in background waters (above discharges and in reference stream) than in point source discharges. Instream concentrations of sodium and magnesium were slightly elevated downstream of the Georgia Pacific and Fordyce discharges. Cadmium was the only metal with concentrations exceeding water quality standards. At JUG01A, cadmium concentrations exceeded both the chronic and acute criteria. Downstream of JUG01A, cadmium concentrations were below detection levels.

Figure WQ-5  
Minerals

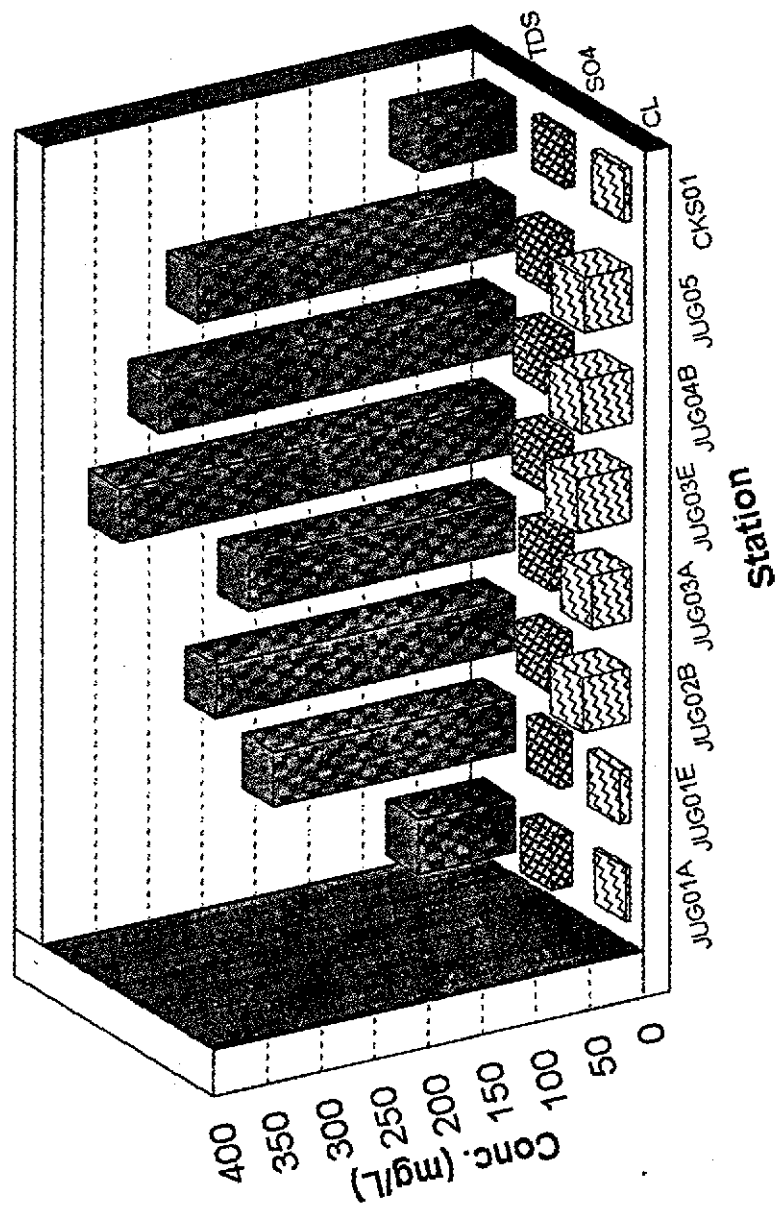
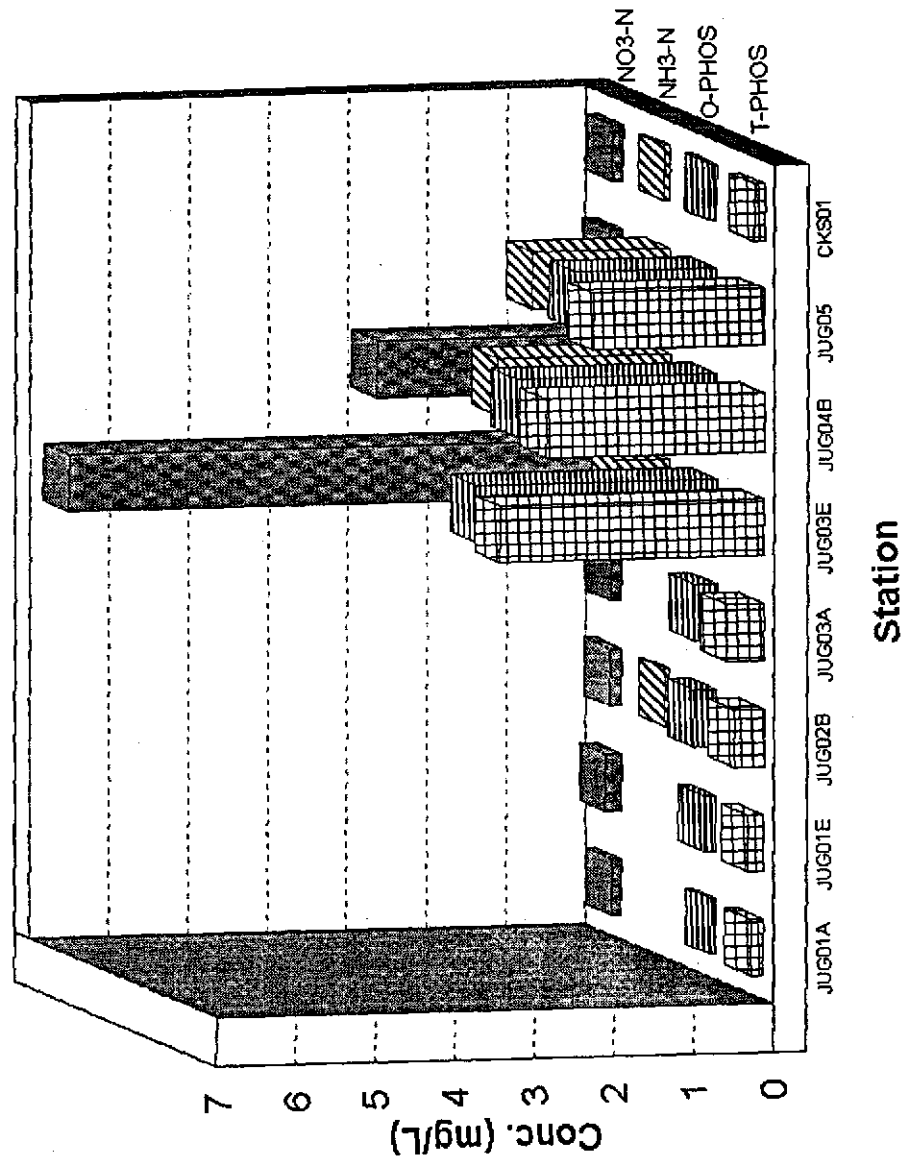


Figure WQ-6  
Nutrients



## AQUATIC MACROINVERTEBRATES

### Methods

Aquatic macroinvertebrates were collected using modified standardized protocols. These protocols call for sampling for five minutes. During the five minute collections, all available habitats within the site are sampled, to collect the maximum number of taxa from the greatest number of niches. Collections were made with an aquatic macroinvertebrate dip net. All organisms were preserved in 70% ethanol and returned to the lab for sorting and identification.

In the lab, all organisms, organic and inorganic material were placed in a dissecting pan. A 10 cm (4 in.) ring was placed in the pan to delimit a subsample and all organisms were removed from inside the ring until the ring was depleted of organisms. This process was continued until 100 organisms were removed. In cases where additional organisms remained in the ring after removal of 100 organisms, the additional organisms were placed in the subsample to prevent biasing the sample. In instances of  $\leq 100$  organisms, the entire sample was used to derive scores.

RBA scores from multi metric analysis are derived for each site. Each site's score is compared to the reference site score to determine percent comparable estimate (%CE) which determines the impairment status. Impairment categories are:

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

Scores are based on five metrics. Taxa richness, compares the number of taxa at each site, which is important to show diversity of the community. Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa abundances relate to the number of "intolerant" organisms. The Hilsenhoff Biotic Index (HBI), shows the tolerance level of the entire community to organic pollution in the water.

The Community Loss Index (CLI) relates to the number of organisms found at the reference site but not at other sites.

This form of rapid bioassessment (RBA) includes biological and physical evaluations from each site. Physical evaluations are necessary to ensure that each site can physically support the community structure found at the reference or "least impacted" site. Physical parameters are scored and scores are compared back to the reference. A %CE is calculated to determine comparability of stations to the reference. Percent comparable estimates are:

<u>Assessment Category</u>	<u>%CE</u>
Comparable to Reference	≥90%
Supporting (should contain somewhat similar community)	75-88%
Partially Supporting (community less similar than reference)	60-73%
Non-Supporting	≤58%

Two analyses were conducted on data gathered for this survey. The first analysis compared sites only in Jug Creek, where, JUG02B was the reference site and JUG04B and JUG05 compared to that site. The second analysis compared Jug Creek sites to the reference site in Cooks Creek.

## Results

For the first analysis, JUG04B should support the community found at the JUG02B, according to physical characteristics while JUG05 is comparable to the reference. Scores for physical habitat ranged from 57 (76%) at JUG04B to 89 (118.7%) at JUG05. The uppermost site, JUG02B, scored 75.

For this analysis, biological metrics were comparable to the reference and show no signs of impairment. The %CE was 93 for JUG04B and JUG05, each.

In the second analysis, physical scores were similar to the reference site in Cooks Creek. The reference site scored 54 while the Jug Creek sites scored 75 (139%), 57 (106%) and 89 (165%) for JUG02B, JUG04B and JUG05, respectively.

Biological metrics were partially impaired at JUG02B (%CE=73) but not significantly impaired at the lower two sites (%CE=93%). Individual scores were 30 (CKS01), 22 (JUG02B) and 28 (JUG04B and JUG05).

## Discussion

A RBA is not designed to be an exhaustive survey of the macroinvertebrate community of a stream. It is a tool to determine impacts to a stream and determine if more follow up work is needed. It does not determine the source of an impairment if one is occurring.

The reference site in the first analysis is above the Fordyce WTP. There was a decrease in taxa richness but an increase in EPT index while moving downstream (Table M-1). The community at the lowest site, however, was more tolerant to organic pollution than the other sites.

In the second analysis, impairment is found at JUG02B. The impairment is due to reduced EPT taxa, lower percent contribution of dominant taxa and the CLI. No trichoptera larvae were found at this site while at least one taxon was found at all other sites. However, this site contained the most taxa (19). Stream flows were very low at this site and chemical water quality indicates an unidentified discharge in this segment.

## Conclusions

The Fordyce WTP does not seem to be problematic for Jug Creek. The more organic tolerant community found at the lower site is reflective of the lowland, marsh characteristics of the lower segment and the abundance of woody debris from timber harvest activities.

The second analysis shows some problem in the vicinity of JUG02B. There may be some disturbances in the area due to the residential area adjacent to the site.

**Table M-1**  
Metrics calculated for Cooks and Jug Creek macroinvertebrates.

METRIC	CKS01		JUG02B		JUG04B		JUG05B	
	RAW	CE	RAW	CE	RAW	CE	RAW	CE
Taxa Richness	18	6	19	6	17	6	13	4
EPT Index	3	6	2	0	3	6	4	6
Hilsenhoff Biotic Index	3.0	6	3.4	6	3.4	6	2.8	6
% Contribution of Dominant Taxa	21	4	37	2	42	0	31	2
Community Loss Index	NA	6	0.8	4	0.8	4	1.0	4
RBA Scores	30	REF*	22	73	28	93	28	93

REF\* = Reference



## **FISH COMMUNITY**

In July 1996, fish community surveys were conducted at the stations listed below:

### **Station Description**

- JUG02B Jug Creek below Georgia Pacific Mill at city road off BR79, 0.1 mi. S. of US 167/US 79 intersection. Dallas County. (Sec 26, T10S, R13 W)
- JUG04B Jug Creek at Cleveland Street crossing above railroad tracks, approximately 1 mi. E. of Ark. Hwy. 8, Dallas County. (Sec 25, T10S, R13W).
- JUG05 Jug Creek 2.5 mi. N. on TAR, approx. 3 mi. S. of Ark. Hwy. 8/U.S. 167 intc. off Ark. Hwy 8, Dallas County. (Sec 20, T10S, R12W).
- CKS01 Cooks Creek at U.S. 167 bridge and upstream, approximately 0.9 mi. N. Of U.S. 167/U.S. 79 intersection. (Sec 22, T10S, R13W).

### **Methodology**

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

Fish species of all types were collected from all available habitat within the sample area until a fully representative sample of the species in the area was thought to be obtained. Larger specimens were field identified and released. The smaller specimens and those unidentifiable in the field were preserved in a ten percent (10%) formalin solution and returned to the lab for identification.

### **Habitat Evaluation**

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

Depth and width measurements were estimated for each habitat type and recorded in feet. The sediment on substrate parameter was scored according to the amount of sedimentation of the substrate.

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

**Table F-1**

<b>Fish Habitat Evaluation</b>												
<b>SITE</b>	<b>Riffle</b>				<b>Run</b>				<b>Pool</b>			
	<b>Number Sampled</b>	<b>Total Length</b>	<b>Average Habitat Score</b>	<b>IHI *</b>	<b>Number Sampled</b>	<b>Total Length</b>	<b>Average Habitat Score</b>	<b>IHI</b>	<b>Number Sampled</b>	<b>Total Length</b>	<b>Average Habitat Score</b>	<b>IHI</b>
JUG02B	9	132	42.9	56.6	3	90	46.6	42.0	9	415	60.0	249.0
JUG04B	2	60	45.8	27.5	3	230	37.5	86.4	4	525	48.5	254.6
JUG05									4	710	44.8	318.1
CKS01	1	30	52.2	15.7	2	230	48.9	112.5	3	475	43.2	205.2

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

## Results

Fish community samples were collected at all stations on July 30 and 31, 1996. They were evaluated by comparing different metrics and basic community structures. The sample collected at CKS01 was used as reference site for comparison to the sites located below the wastewater treatment facilities, JUG02B and JUG04B. In addition, the fish community from Whitewater Creek, a Gulf Coastal Ecoregion reference stream, was used to determine the likeness of the fish community in Cooks Creek to a typical Gulf Coastal Plains Ecoregion stream.

There were 5 species of fish collected at JUG02B, 13 at JUG04B and JUG05, and 26 collected at CKS01. Appendix D is a list of species collected from each site, the number of specimens

per species collected, and the percent community composition of each species. Table F-2 depicts the family comparisons between sampling stations, percent and total sensitive, key and primary trophic levels species and the diversity index of each sample based on the Shannon-Wiener diversity index. Table F-3 depicts similarity indices between sample sites based on species distribution between the two sites listed and percent community.

The fish community below the Georgia-Pacific discharge, JUG02B, was comprised of only five species and 88 specimens. Centrarchids composed nearly 56% of the community, and 96% of these were green sunfish. The mosquitofish comprised over 41% of the community. The only other species present were the redbfin darter, the pirate perch and the warmouth sunfish.

**TABLE F-2**

COMMUNITY STRUCTURE (as percent total community)					
Family	JUG02B	JUG04B	JUG05	CKS01	Whitewater
Cyprinidae	0.00	5.26	25.00	9.68	2.10
Catostomidae	0.00	0.00	0.54	2.15	4.80
Ictaluridae	0.00	2.11	25.00	3.23	0.20
Centrarchidae	55.68	46.32	40.76	61.83	53.20
Percidae	1.14	0.53	0.00	9.14	12.90
Total Species Collected	5	13	13	26	24
No. Sensitive Species	0	0	0	2	0
No. Sensitive Individuals	0	0	0	3	0
% Sensitive Individuals	0	0	0	1.61	0
No. Primary TFL	0	9	46	1	0
% Primary TFL	0	4.79	25.00	0.53	0
No. Key Individuals	0	2	21	107	112
% Key Individuals	0	1.06	11.41	57.53	26.70
Diversity Index	1.33	2.46	3.07	3.46	3.79

TABLE F-3

FISH COMMUNITY SIMILARITY INDICES							
Species				Relative Abundance			
	JUG04B	JUG05	CKS01		JUG04B	JUG05	CKS01
JUG02B	0.556	0.440	0.323	JUG02B	0.710	0.412	0.398
JUG04B		0.540	0.462	JUG04B		0.553	0.513
JUG05			0.513	JUG05			0.434
Whitewater	0.541	0.541	0.800	Whitewater	0.487	0.232	0.634

There were no Cyprinid species, primary feeders, sensitive species, or key species present. Because of this, the diversity index score for this sample was only 1.33. Also, the catch per unit effort in minutes was only 1.94.

The habitat at JUG02B was comprised of nine short riffles, three runs of approximately 30 feet long each, and nine pools with a total length of almost 415 feet. The in stream habitat was fairly good in all of the habitat types sampled. This is reflected in the IHI scores for each of the habitats of the site (Table F-1). The extensive canopy, very low flow and an unidentified discharge may be causing low dissolved oxygen concentrations. Another factor which may be influencing the fish community at this site maybe the lack of adequate year-round flow. The watershed at this particular site is less than two square miles and the Georgia-Pacific mill has a design flow of 0.13 mgd.

The JUG04B site consisted of two riffle habitats of about thirty feet long each, three runs totaling approximately 230 feet, and four pools totaling about 525 feet. In stream habitat was slightly less abundant at this site than at JUG02B; however, with the increased size of the watershed and the discharge from the City of Fordyce's wastewater treatment facility flows are substantially greater and occur there year-round. There were 184 specimens collected at this site representing 13 species. The Centrarchid family comprised 46% of the community, with seven species, but it was dominated by the green sunfish. The mosquitofish comprised 44% of the community and was the overall dominant species. Two species of cyprinids were collected, which comprised a little more than five percent (5%) of the community. The remainder of the community included bullhead catfish, topminnows, and one darter. There were no sensitive species collected and only two key species were collected comprising one percent (1%) of the community. Almost five percent (5%) of the community were primary feeders. The diversity index was 2.46 and the catch rate was 5.32 fish per minute. These are almost twice that of the upstream site (JUG02B), but the community was dominated by species tolerant of poor water quality.

The JUG05 site consisted of four pool habitats totaling about 710 feet in length. In stream cover in the pools was slightly less abundant than at JUG04B. This site was through the middle of a clear cut, thus there was very little canopy cover. In addition, there was a very large silt and fine woody debris deposit on the bottom of the creek. Also, there were several beaver dams causing the creek to become continuous pools. There were 190 specimens collected at this site representing 13 species. The Centrarchid family comprised over 40% of the community and was represented by six species. It was dominated by the spotted sunfish. The mosquitofish comprised less than three percent (3%) of this community. The one cyprinid species collected was the golden shiner which accounted for 25% of the total community. It is a primary level trophic feeder and probably an introduced species. An atypically large number of bullheads were collected which accounted for 25% of the total community. There were no sensitive species collected and two key species comprised over 11% of the community. The diversity index was 3.07 and the catch per unit effort was 4.94 fish per minute. The community was representative of a harsh environment.

The Cooks Creek reference stream site, CKS01, consisted of one riffle habitat of about 40 feet in length, two runs totaling about 230 feet in length, and three pool habitats totaling about 475 feet in total length. The in stream habitat quality in the riffle and runs was slightly better than the Jug Creek sites but the pools were of slightly lower quality. This site was also located in a timber clear cut anex; however the heavy silt load and fine woody debri did not exist in the bottom of the creek as at JUG05. There were a large number of tree tops from the timber cuts that had been deposited in the creek channel. These had caused diversions of high flows against steep-cut banks which resulted in increased bank erosion. There were 186 specimens collected representing 26 species. The Centrarchid family dominated the community and comprised almost 62% of the fish community. The Centrarchids were represented by eight species and was dominated by longear sunfish. The Cyprinids and Percids each comprised a little more than nine percent (9%) of the community and were each represented by five species. There were two sensitive species collected representing 1.6% of the community. Individuals of key species comprised 57% of the community. The diversity index of 3.46 was the highest of all sites during this study.

The fish community in Cooks Creek was most similar to the community in Whitewater Creek, a Gulf Coastal ecoregion reference stream. The relative abundance similarity index of these communities was 0.634, and the species similarity index was 0.800. This indicates a very similar species composition, but the distribution of specimens within the species is somewhat different. This demonstrates that Cooks Creek is a somewhat typical Gulf Coastal Plains ecoregion stream. However, a comparison of the similarity indices of the Cooks Creek site with the Jug Creek sites indicates very low similarities.

## Conclusions

- Historical water quality data collected at OUA47 indicates increasing trends in TDS, chlorides, and nitrate nitrogen concentrations. Declines were noted in ammonia and phosphates for the same period. There appears to have been a substantial impact on the treatment of the Fordyce waste water in late 1994, as typical ammonia levels declined noticeably (with an occasional exception). This, however, resulted in notable increases in the nitrate-nitrogen concentration. There was also a substantial improvement in the total phosphorus discharges for a short period of time; this trend seems to have been reversed over the last 12-18 months.
- Concentrations of chlorides, sulfates, phosphates, and TOC were observed to be higher at JUG02B than at the Georgia Pacific outfall (JUG01E) upstream. This is an indication of an unidentified pollutant source, possibly domestic waste from septic systems or urban runoff.
- As expected, elevated nutrient concentrations were observed below the Fordyce WTP.
- Analysis of the macroinvertebrate communities in Jug Creek compared to the communities in Cooks Creek indicate impairment at JUG02B as shown by a reduced EPT and lower percent contribution of dominant taxa. Other sites (JUG04B and JUG05) were comparable to the reference stream indicating no impact from the WTPs.
- The Jug Creek fish communities were not similar to the reference stream. The upper Jug Creek site had good fish habitat but very low flows which regularly became intermittent, and the fish community was very limited. Immediately below the Fordyce WTP, the fish community diversity increased slightly in response to additional, continuous flows, but the community was dominated by poor water quality adaptive species of fish. The fish community at the farthest downstream site on Jug Creek was surprisingly diverse for such a poor quality environment but the community was distinctively dominated by very tolerant and highly adaptive species.
- This waterbody should be removed from the 303(d)listing, but continued monitoring should be conducted to determine if future nutrient controls become necessary.

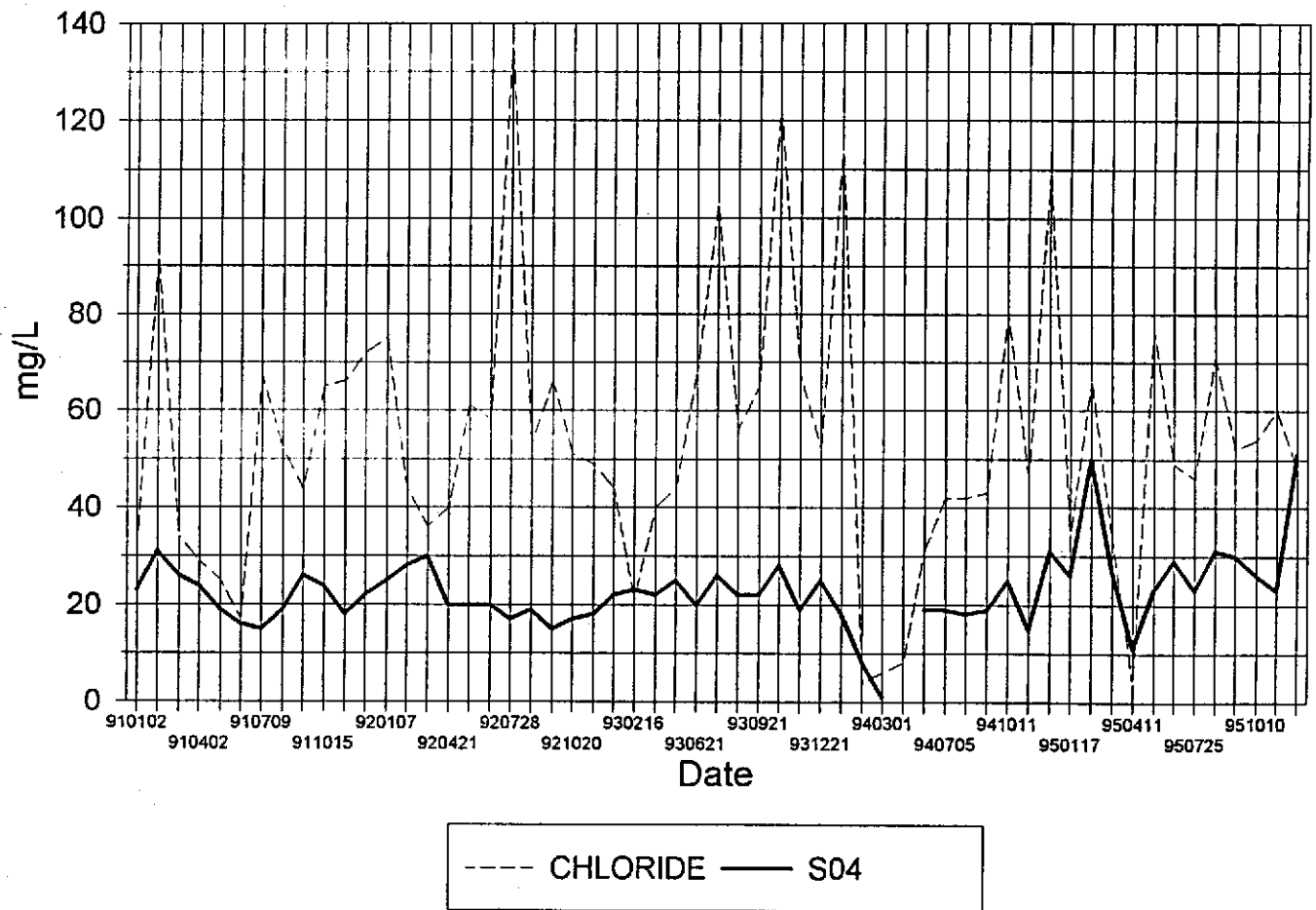
**Appendix A**  
**Historical Water Quality Data**





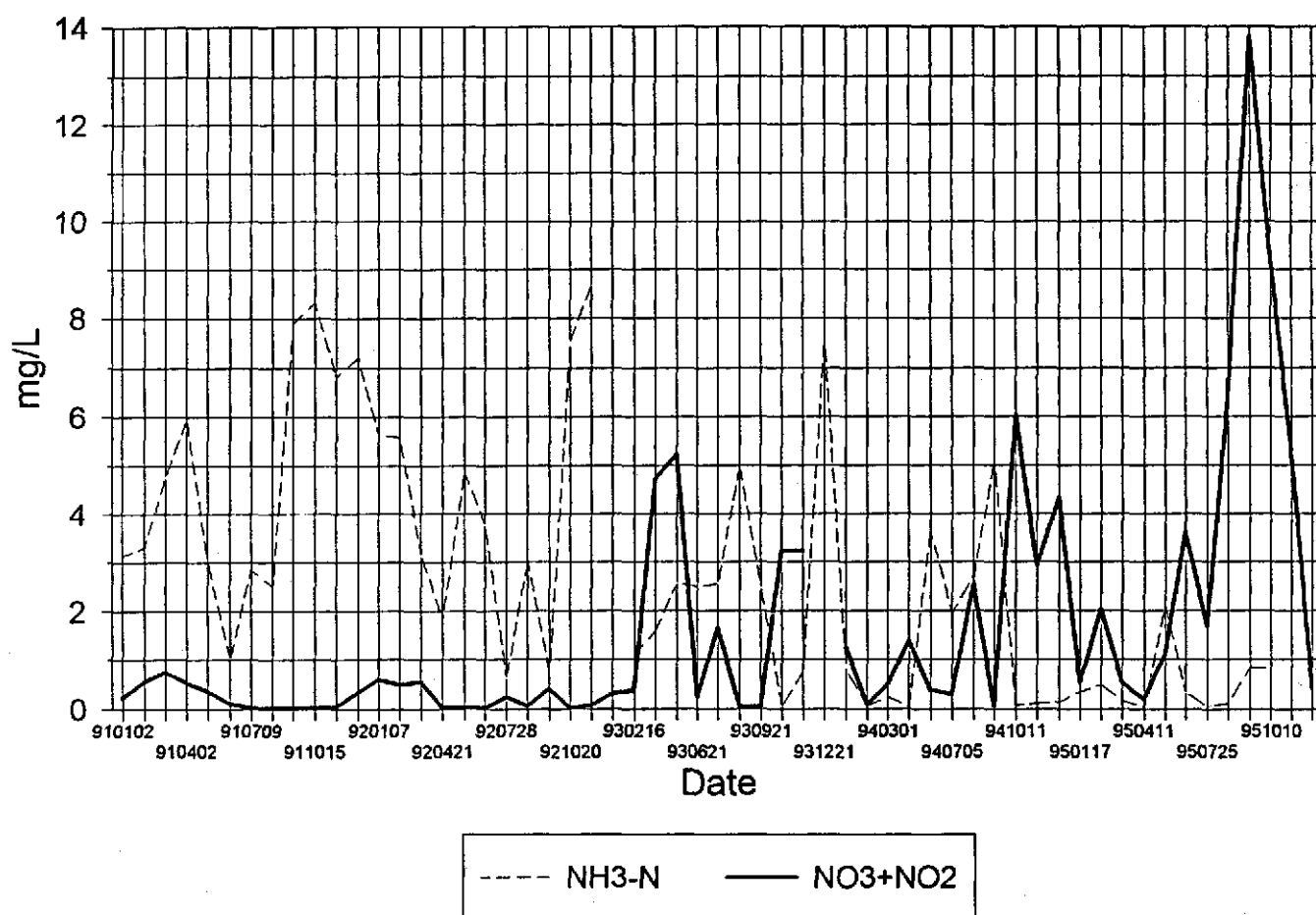
# OUA47

Minerals 1/91 - 12/95



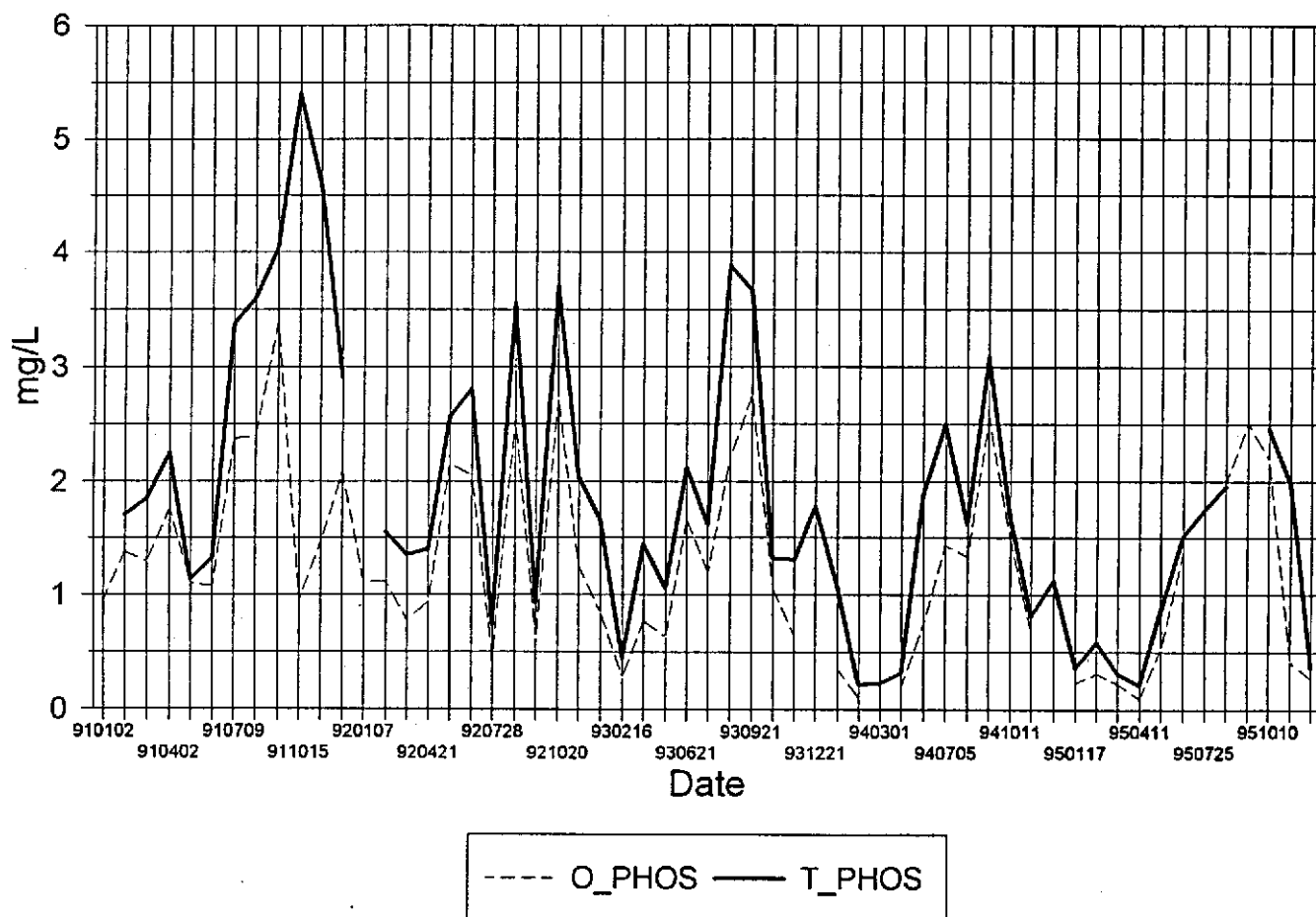
# OUA47

Nitrogen Compounds 1/91 - 12/95

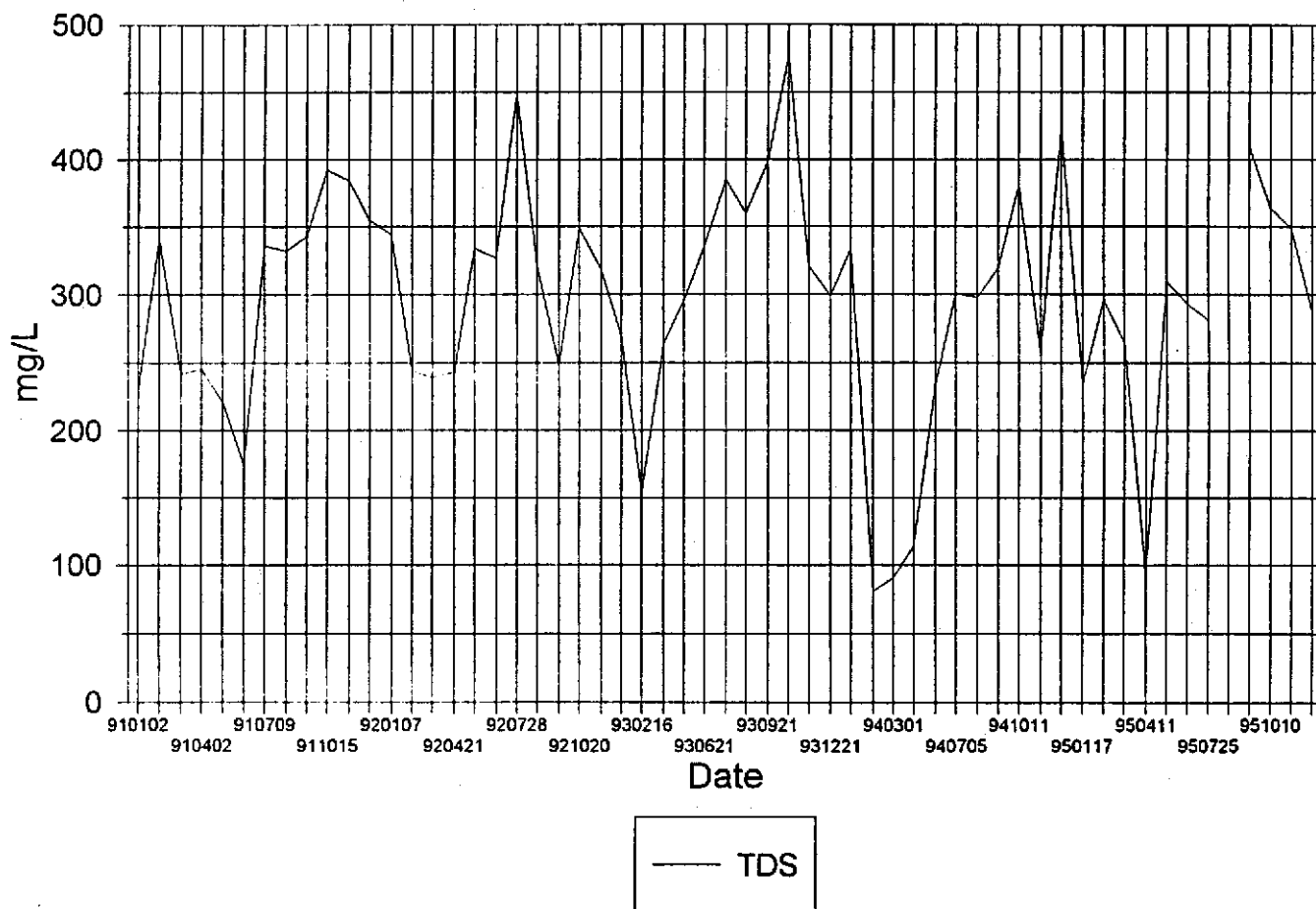


# OUA47

Phosphates 1/91 - 12/95



**OUA47**  
TDS 1/91 - 12/95



**Appendix B**  
**Water Quality Data**



# Jug Creek Survey Water Quality

July 30, 1996	JUG01A	JUG01E	JUG02B	JUG03A	JUG03E	JUG04B	JUG05	CKS01
DO (mg/L)	1.9	4.9	3.8	1.9	7.5	2.4	0.5	3.1
pH (std units)	6.32	7.53	7.28	7.18	6.75	7.43	7.38	6.44
Water Temp (C)	24.4	25.4	24.7	25.5	29.9	26.3	27.2	25.3
CBOD (mg/L)	1.7	1.4	2.1	5.4	1.5	3	5.6	1.2
NH3-N (mg/L)	<0.05	<0.05	0.053	<0.05	0.659	2.162	1.724	0.073
CL (mg/L)	3.536	9.529	44.816	35.701	49.778	45.889	43.847	7.365
NO3-N (mg/L)	0.109	0.206	0.141	0.142	6.96	3.09	0.166	0.131
O-PHOS (mg/L)	0.048	0.14	0.274	0.275	3.02	2.51	1.777	0.072
T-PHOS (mg/L)	0.152	0.193	0.357	0.459	3.31	2.74	2.14	0.122
SO4 (mg/L)	18.7	12.6	22.4	20.5	26.8	25.9	23.3	9.3
TOC (mg/L)	12.6	4	12.7	23.5	21.5	19.9	20.8	7.5
Turbidity (NTU)	6	3.4	3.5	7.9	16	11	11	18
TSS (mg/L)	3.5	1.5	1	6.5	3.5	15.5	9.5	9
TDS (mg/L)	90	225	278	248	368	331	296	88
Flow (cfs)	<0.1	0.005	0.04	0.2	0.52	1.54	Not taken	0.85





Dissolved Metals	
As	0.01
Cd	0.001
Cr	0.05
Cu	0.01
Fe	0.3
Mn	0.05
Ni	0.01
Pb	0.01
Sb	0.01
Se	0.01
Si	1.0
U	0.01
V	0.05
Zn	0.1

[illegible]



**Appendix C**  
**Taxa list from Cooks and Jug Creek**



Appendix C. Taxa list from Cooks and Jug Creek.

HBI	FEEDING GROUP	EPT	Taxa	CKS01	JUG02B	JUG04B	JUG05B
4	COL	N	Lirceus		1	1	
4	COL	N	Hyaella	1			
4	COL	N	Crangonyx		2		
3	COL	N	Paelomenetes	17		1	9
3	COL	N	Cambaridae (F)		1		
3	COL	N	Cambarus	7			
3.5	COL	Y	Siphonorus		8	5	2
3	SCR	Y	Stenonema	2			
1.8	SCR	Y	Stenacron				1
3.5	COL	Y	Caenis		36	42	36
1	PRE	N	Boyeria		1	1	
3	PRE	N	Orthemis		1		
5	PRE	N	Pachydiplax		1	3	
5	PRE	N	Perithemis		1	1	
3	PRE	N	Hetaerina		2		
3	PRE	N	Argia	1	2	1	
4	PRE	N	Enallagma		1		
4.5	PRE	N	Ischnura		5	12	
5	PRE	N	Ranatra		1		
5	PRE	N	Belastoma			1	
2.75	PIE	N	Tricocorixa				1
3	PRE	N	Buenoa		13		
3	PRE	N	Microvelia		1		
3.6	PRE	N	Sialis	13			
2.6	PRE	N	Corydalus	3			
2.5	FIL	Y	Cheumatopsyche	12		1	48
2	SHR	Y	Pycnopsyche	2			
2.5	SHR	N	Peltodytes			1	
2	PRE	N	Dineutus (L)			1	1
2	PRE	N	Dineutus (A)			1	1
3	PRE	N	Thermoncetetus (A)		1		
2.5	PRE	N	Berosus (L)			14	14
3.6	PIE	N	Laccobius (L)		1		
3	COL	N	Dubiraphia	2			
3	SCR	N	Ordobrevia (L)				1
2.5	SCR	N	Stenelmis (L)	1			37

Appendix C. continued

HBI	FEEDING GROUP	EPT	Taxa	CKS01	JUG02B	JUG04B	JUG05B
2	SHR	N	Tipulidae #1	1			
1	PRE	N	Hexatoma	1			
3	COL	N	Chironomidae #1	1		1	1
3	COL	N	Tanytarsini #1	3			
3	COL	N	Tanytarsini #2	1			
3	COL	N	Tanypodini	7			
3	COL	N	Chironomini 1	7	19	14	1
			TOTAL COLLECTED	22	21	19	7

**Appendix D**  
**Fish Community**





# APPENDIX D - FISH COMMUNITY

FAMILY & SPECIES	COMMON NAME	S E N	T F L	K E Y	JUG02B		JUG04B		JUG05		CKS01	
					Num	% Com	Num	% Com	Num	% Com	Num	% Com
Esoxidae	Pickerels											
Esox americanus	Grass pickerel			K					2	1.09	5	2.69
Cyprinidae	Minnows											
Luxilus chrysocephalus	Striped shiner										6	3.23
Lythrurus umbratilis	Redfin shiner			K			1	0.53			9	4.84
Notemigonus crysoleucas	Golden shiner			P			9	4.74	45	25.00	1	0.54
Notropis emiliae	Pugnose minnow										1	0.54
Semotilus atromaculatus	Creek chub	S									1	0.54
Catostomidae	Suckers											
Erimyzon oblongus	Creek chubsucker								1	0.54	2	1.08
Minytrema melanops	Spotted sucker			K							2	1.08
Ictaluridae	Freshwater catfishes											
Ameiurus melas	Black bullhead						4	2.11	27	14.67		
Ameiurus natalis	Yellow bullhead			K					19	10.33	5	2.69
Noturus gyrinus	Tadpole madtom										1	0.54
Aphredoderidae	Pirate perches											
Aphredoderus sayanus	Pirate perch				2	2.27			9	4.89	6	3.23
Cprinodontidae	Killifishes											
Fundulus chrysotus	Golden topminnow						3	1.58				
Fundulus olivaceus	Blackspotted Topminnow										10	5.38
Poeciliidae	Livebearers											
Gambusia affinis	Mosquitofish				36	40.91	84	44.21	5	2.72	5	2.69
Centrarchidae	Sunfishes											
Centrarchus macropterus	Flier			K							2	1.08
Elassoma zonatum	Banded pigmy sunfish						9	4.74			1	0.54
Lepomis cyanellus	Green sunfish				47	53.41	46	24.21	14	7.61	10	5.38
Lepomis gulosus	Warmouth sunfish				2	2.27			8	4.35	1	0.54
Lepomis macrochirus	Bluegill sunfish						10	5.26	14	7.61	6	3.23
Lepomis marginatus	Dollar sunfish								1	0.54		
Lepomis megalotis	Longear sunfish						1	0.53			76	40.86
Lepomis punctatus	Spotted sunfish						17	8.95	35	19.02	13	6.99
Lepomis symmetricus	Bantam sunfish						1	0.53	3	1.63		
Micropterus salmoides	Largemouth bass						4	2.11			6	3.23
Percidae	Perches											
Etheostoma chlorosomum	Bluntnose darter										1	0.54
Etheostoma collettei	Creole darter										5	2.69
Etheostoma gracile	Slough darter			K			1	0.53				
Etheostoma parvipinne	Goldstripe darter	S									2	1.08
Etheostoma proelaire	Cypress darter										1	0.54
Etheostoma whipplei	Redfin darter				1	1.14					8	4.30
	TOTAL SPECIES				5		13		13		26	
	TOTAL NUMBERS				88		190		184		186	
	Effort (sec)				2725		2144		2237		1952	
	Catch/Minute				1.94		5.32		4.94		5.72	

