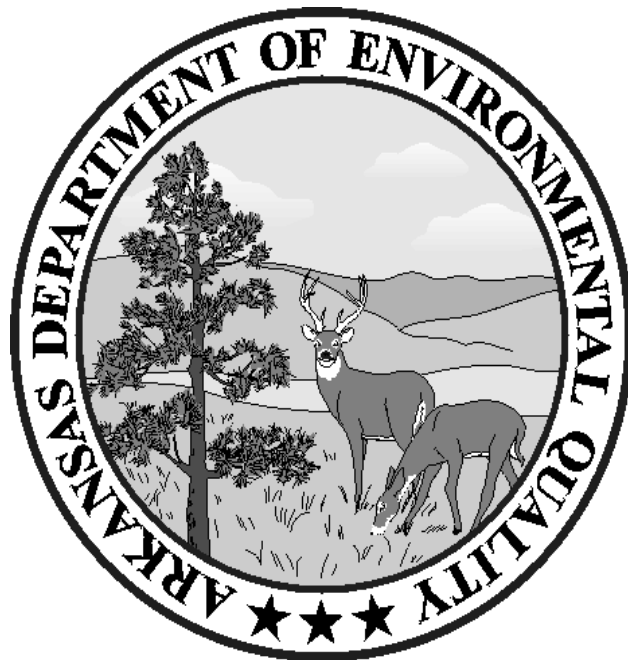


TMDL INVESTIGATION
OF
THE TYSON FOODS AND NASHVILLE
WWTP EFFLUENTS
ON
MINE CREEK
HOWARD COUNTY, ARKANSAS



MAY 2000
WQ00-05-01

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ON MINE CREEK**

INTRODUCTION

A water quality investigation was conducted on Mine Creek, the receiving stream of the Tyson Foods poultry processing facility and the Nashville municipal wastewater treatment facility in order to determine the level of impact these discharges are having on the water quality and aquatic inhabitants of the receiving stream. This investigation was conducted on September 1-4, 1997. A preliminary survey was completed on August 4 for the purpose of determining stream accessibility, the zone of impact from the effluent discharges, and potential station locations. The Tyson Foods facility is operating under NPDES permit # AR0041734 with a design flow of 1.4 MGD (million gallons per day). The Nashville STP operates under NPDES permit # AR0021776 and has a design flow of 2.3 MGD. A malfunction in the Tyson Foods treatment facility during August, 1997 resulted in elevated nutrient discharges to the stream for a period of several weeks. Due to the water quality and habitat impacts encountered during the 1997 survey, a follow-up survey was planned and conducted during September 20-22, 1998.

GENERAL DISCUSSION

Waterway Description

Mine Creek has its origin approximately five miles north of the Nashville city limits near the eastern border of Howard County. It flows south through the city limits of Nashville, then flows in a south-southwest direction for approximately 16 miles to its confluence with Millwood Lake. Mine Creek has a 92 square mile watershed at its mouth. There are approximately 26 square miles of drainage area above the Tyson Foods discharge. The Nashville municipal wastewater treatment facility discharges to Mine Creek approximately 0.75 miles below the Tyson effluent. The stream gradient in the vicinity of the study area is just over seven feet per mile. Mine Creek is highly convoluted, with log jams being prevalent, and it is dominated by pools. As a result the average velocity at base flow is around 0.1 feet/second. Stream substrate consists primarily of sand and gravel. The watershed is dominated by pasture lands, but the stream generally dissects a wooded corridor within the study area, providing canopy cover over much of the stream length. At the time of the September survey, stream flow in Mine Creek above the point source discharges was measured at 1.0 cfs (cubic feet per second); the Tyson Foods facility was discharging 2.4 cfs and the city STP was contributing an additional 2.9 cfs. USGS data has established a Q7-10 flow of less than 1 cfs for Mine Creek.

Previous Studies

In June of 1984, ADPC&E personnel conducted a wasteload assimilative capacity investigation for the purpose of determining the impact of the Tyson Foods and Nashville effluent discharges on the water quality of the receiving stream and to project future effluent limitations that would maintain the water quality standards in existence at that time. At the time of this survey, the Nashville treatment facility was receiving the Tyson Foods wastewater (comprising 35-50% of the total STP volume) and was periodically overloaded. An effluent BOD₅ of 30 mg/l and NH₃N of 18 mg/l was being discharged during the survey. This loading was consistently causing dissolved oxygen violations and habitat impairment in Mine Creek. As a result of this study Tyson Foods began treating their own wastewater and discharging approximately 0.5 miles upstream. The Nashville facility was upgraded to achieve the projected tertiary effluent limits.

During July of 1987 ADPC&E ecologists established two macroinvertebrate sampling locations designed to assess the impact of known pollutant sources on the quality of the receiving stream. The stations surveyed in 1987 coincide with two of the 1997 survey sites. The ADPC&E rapid bioassessment protocol was used in the survey, therefore a direct comparison of the benthic community can be made between the 1987 and 1997 data. The conclusions of the 1987 survey will be addressed in the results section of this report.

During July of 1991 ADPC&E personnel initiated a synoptic survey of the Millwood Reservoir watershed for the purpose of quantifying nutrient loading to the lake. As a part of the study, two stations were established on Mine Creek. The upper station coincided with the 1997 RED 0048B site. Although four sampling events were conducted during this survey, the first sample collection was performed during a low flow condition, affording a data comparison to the 1997 survey.

Land Use

Based on aerial photographs of the study area, the Mine Creek watershed is dominated by agricultural uses--primarily pasturelands for cattle grazing. Approximately 20 percent of the watershed is still forested, but in the upper portion which includes the survey area, pastureland and urban development constitute the majority of the drainage basin. Poultry and swine production houses are scattered throughout the watershed. There has been rapid growth in this industry from 1970 to 1990. There were 27.3 million broilers, 1900 swine, and 28,000 cattle in Howard County in 1970. By 1990 those numbers increased to 45.7 million broilers, 57,000 swine and 33,000 cattle. The waste products from these operations are periodically applied to pasturelands, thus enhancing the potential for nutrient loading to Mine Creek and other tributary streams of Millwood Reservoir.

Geology

The Mine Creek watershed is located in the Gulf Coastal Plain ecoregion. The geology of this drainage is characterized by Brownstown marl, Tokio formation and Alluvium and terrace deposits. Soil types in the survey area are dominated by Ruston, Ozan and Sacul series. The

Ruston and Sacul series are characterized by being deep, level to gently sloping, well-drained to moderately well-drained fine sandy loams on the upland areas. The Ozan series are deep, level poorly drained soils on the floodplains and low terraces along streams.

Water Quality Standards And Beneficial Uses

Mine Creek, which drains a 22 mi² watershed above the Tyson Foods effluent discharge, is classified as a Gulf Coastal Plains mid-size watershed perennial fishery, and as such, has an applicable dissolved oxygen standard of 3 mg/l, with a 1 mg/l diurnal fluctuation being allowed for no longer than 8 hours in a 24 hour period when the stream temperature exceeds 22 degrees Centigrade. At stream temperatures of 22 degrees C. or less, a 5 mg/l standard generally applies. The exception to this is during the March through May time frame when the stream flow exceeds 15 cfs or when the stream temperature exceeds 10° C the D.O. standard is 6.5 mg/l.

The designated beneficial uses of this stream, in addition to the previously mentioned fishery use, consist of primary and secondary contact recreation-which includes wading, boating, fishing, and swimming-as well as a source of water for industrial and agricultural uses. The domestic water supply designated use has been removed from Mine Creek from Highway 27 to its mouth.

DATA ACQUISITION

During the afternoon of August 4, 1997, ADPC&E personnel arrived at the Mine Creek area for the purpose of locating stream access points and identifying preliminary sampling stations. During this investigation apparent water quality impairments were observed in the stream below the Tyson Foods discharge. The following morning a dissolved oxygen profile was performed in order to determine the impact area and length of the zone of recovery.

The stream survey was initiated during the morning of September 1, 1997 when continuous dissolved oxygen meters were installed at four of the eight stream stations. Macroinvertebrates and fish were collected at three sites during this survey. On September 2, macroinvertebrates and fish were collected above and below the Tyson Foods discharge, with the third fish collection being completed below the Nashville STP effluent discharge. The macroinvertebrates were collected on September 3 at this location. The Mine Creek physical characterization and habitat availability was evaluated following the aquatic life sampling events. Stream flow measurements and water sampling was conducted on September 3. The water samples were returned to the central laboratory for analysis. The survey was completed on September 4 when a time of travel study was performed and the continuous dissolved oxygen meters were removed. The September 20-22, 1998 survey utilized the same stream stations and followed the same survey protocol except fish collections were not made in 1998.

Parameters

In situ stream measurements included dissolved oxygen, pH and temperature. The water samples were analyzed for fecal coliform bacteria, chlorides, bromides, fluorides, sulfates, hardness, total organic carbon (TOC), five day biochemical oxygen demand (BOD5), total suspended solids (TSS), total dissolved solids (TDS), ammonia nitrogen (NH₃N), nitrite + nitrate nitrogen (NO₂+NO₃), orthophosphorus, total phosphorus and dissolved metals. The results of the water chemistry analyses performed during both surveys are included as Appendix A.

Collection, Preservation And Measurements

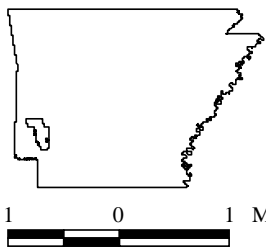
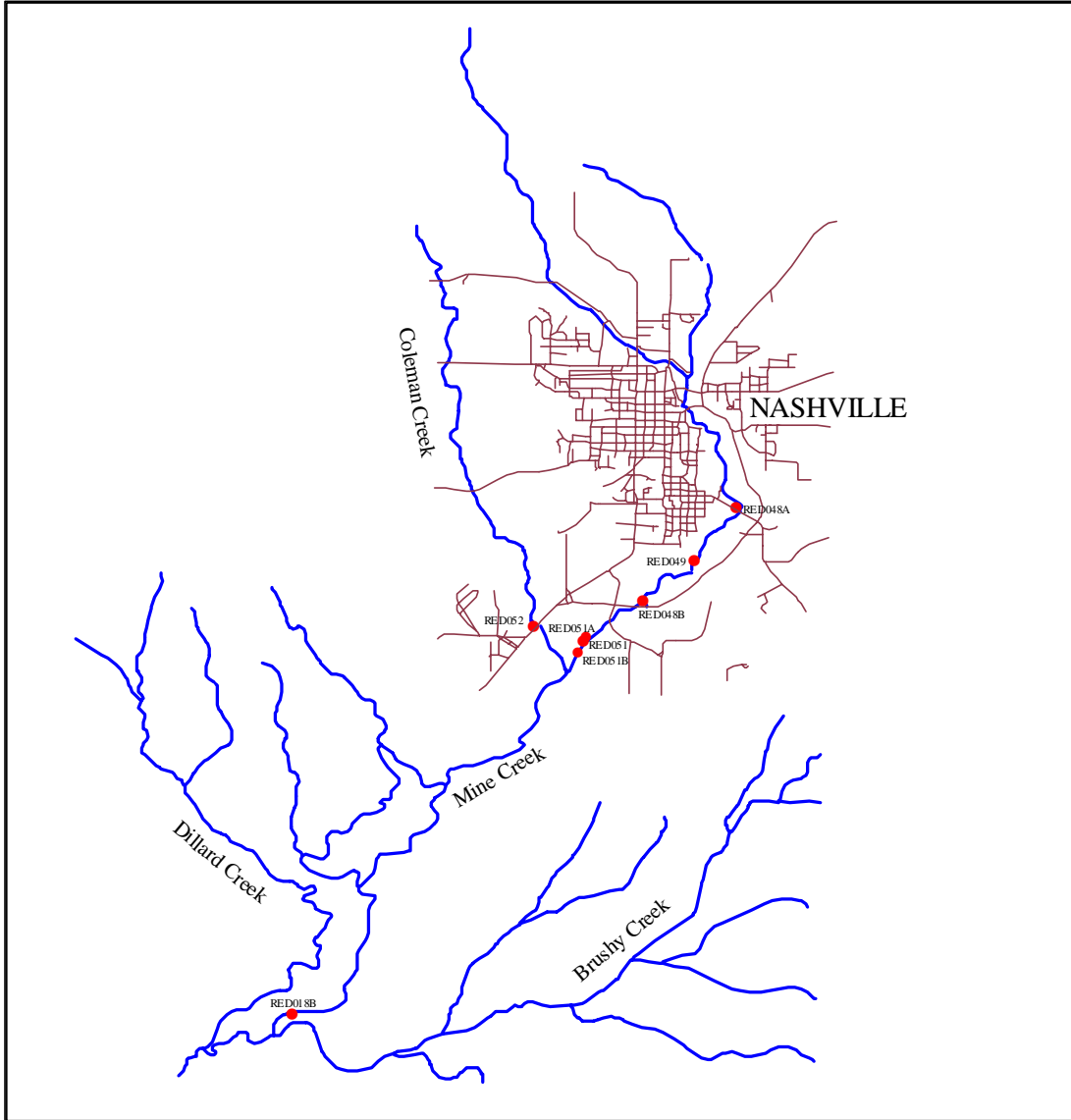
Stream samples were collected, preserved, and analyzed according to the 18th Edition of Standard Methods for Examination of Water and Wastewater. Analysis was conducted under ADPC&E's existing Quality Assurance Program. Dissolved oxygen and stream temperature during sample collection were measured by an Orion Model 840 portable dissolved oxygen meter, which was calibrated prior to use. Three Hydrolab Recorder continuous dissolved oxygen meters were used to determine diurnal variation in the dissolved oxygen concentration in Mine Creek approximately 0.25 miles above the Tyson Foods discharge, approximately one half mile below the discharge at the Highway 27 by-pass bridge, and approximately 600 yards below the Nashville STP discharge. The fourth continuous meter was installed in Coleman Creek at the Highway 27 bridge. Stream pH was analyzed by 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 Flowmate by obtaining a representative number of velocities and depths across suitable stream locations. Flows were taken in Mine Creek below the Tyson Foods outfall (Red 0048B), at the mouth of the Nashville effluent ditch (Red 0051), approximately 600 yards below Nashville (Red 0051B) and at Highway 55 (Red 0018B).

Macroinvertebrates were collected using a Turtox benthos net. An attempt was made to sample similar riffle habitats for five minutes at each site, in accordance with established protocol for rapid bioassessments. The fish community was sampled by use of a Smith-Root Model 15-A POW DC backpack electrofisher. These communities were analyzed on an upstream/downstream basis for determination of any adverse impacts from pollution sources on population diversity and density. Figure 1 provides the location of sampling stations utilized during the course of this study.

Station Description

A total of seven water chemistry stations were established on Mine Creek, with an additional station located on Coleman Creek. These stations were selected for the purpose of determining any impacts from non-point source contaminants (upstream Mine Creek site), as well as assessing the impact from the Tyson Foods and Nashville wastewater effluents on Mine Creek. Stations were spaced in order to determine any dissolved oxygen sag due to the effluent loading on this stream.

FIGURE 1. Sample Site Locations for Mine Creek, Nashville, Arkansas



The station descriptions and parameters collected at each station are as follows:

- RED0048A** Mine Creek at Hwy 4 bridge; above point source discharges. Water, macroinvertebrates, fish and D.O. profile.
- RED0049** Tyson Foods wastewater treatment facility effluent. Water only.
- RED0048B** Mine Creek at Hwy 27 bridge; below Tyson discharge. Water, macroinvertebrates, fish and D.O. profile.
- RED0051A** Mine Creek 50 yards above the Nashville STP effluent. Water only.
- RED0051** Nashville STP effluent. Water only.
- RED0051B** Mine Creek 600 yds downstream of the Nashville STP. Water, macroinvertebrates, fish and D.O. profile.
- RED0018B** Mine Creek at the Hwy 355 bridge. Water only.
- RED0052** Coleman Creek at Hwy 27 bridge. Water only.

DATA RESULTS

Dissolved Oxygen

The dissolved oxygen profile was evaluated two times with a portable meter during the 1997 survey of Mine Creek. During the preliminary investigation the dissolved oxygen concentration at the upstream site was 3.8 mg/L (46% saturation). The Tyson Foods effluent had a DO concentration of 4.4 mg/L and a saturation value of 56%. The impact of this effluent reduced the DO to 0.8 mg/L (10% saturation) at the Highway 27 bridge. Just above the Nashville STP effluent the dissolved oxygen concentration had recovered to 2.2 mg/L (27% saturation). Approximately 500 yards below the Nashville effluent, which entered the stream at a DO of 5.3 mg/L (70% sat.), the instream DO was only 2.3 mg/L. A gradual recovery to 5.1 mg/L (71% sat.) occurred prior to the Highway 355 bridge which is approximately five miles below Nashville. Stream inaccessibility prevented additional stations in this five mile reach.

The second profile occurred during the morning water chemistry sampling effort on September 3. The DO concentrations and saturation values were similar to the earlier profile indicating a continuing impact from the Tyson Foods effluent as evidenced by DO concentrations of 1.0 and 1.7 mg/L at RED 0048B and RED 0051A, respectively. Stream temperatures were in the 25-26 degree range, which were similar to the preliminary survey temperatures. Three continuous dissolved oxygen meters were used in Mine Creek to get an accurate measurement of the diurnal fluctuation in both dissolved oxygen and stream temperature. Meters were placed at RED 0048A, above the Tyson Foods effluent, and at RED 0048B, approximately 400 yards below the discharge. The third meter was installed at RED 0051B, approximately 500 yards below the Nashville STP

effluent. Figures 2-4 show the dissolved oxygen fluctuation at these sites during the September 1-3 time frame (72 hours). The upstream meter (RED 0048A) indicated a diurnal fluctuation of approximately 3 mg/L with a range of 2 to 5 mg/L, while the RED 0048B site at Highway 27 had a fluctuation of 1 mg/L with a range of 0.2 to 1.2 mg/L. The RED 0051B site below Nashville ranged from 0.6 to 4.2 mg/L. Temperature fluctuations were similar at all three stations, but the higher temperatures were recorded at the two sites below the point source dischargers; the maximum temperatures were near 28°C.

The low dissolved oxygen concentrations at the two downstream sites revealed the impact of the point source loading to the stream. During the 1997 survey dissolved oxygen standard violations were occurring 24 hours a day from the Tyson effluent downstream to the Nashville effluent confluence, and a nighttime violation occurring further downstream. Saturation values at RED 0048B ranged from 1 to 12 percent, 16 to 50 percent at RED 0051B, and although there was no continuous meter at RED 0018B, the dissolved oxygen saturation was 51% during the September 3 morning sampling event. Upstream dissolved oxygen saturation values ranged from 25 to 63 percent. This range is intermediate between typical Gulf Coastal ecoregion reference streams of similar size (10 to 30% saturation) and the spring-water influenced Gulf Coastal reference streams which had a saturation range of 60 to 80 percent. Stream volume and resulting turbulence may be the primary factor in the saturation differences between upper Mine Creek and the spring-water Gulf Coastal streams (0.5 cfs in Mine Creek compared to 5.2 cfs in the smallest spring-water ecoregion stream). Other factors influencing saturation values include the type of watershed drained (nutrient inputs) and percent canopy cover (influencing photosynthetic activity). Based on these factors, upper Mine Creek will have a wider range of saturation values due to the pastoral-urban watershed and reduced canopy cover.

The dissolved oxygen concentrations encountered in the 1998 survey were not representative of low flow critical conditions due to heavy localized rainfall in the Mine Creek basin the week prior to the survey. Due to elevated stream flows, the diurnal fluctuation at all stream sites was less than during the 1997 survey. RED 0048A had a fluctuation of 1.8 mg/L with a minimum concentration of 4.65 mg/L. RED 0048B had minimum of 3.4 mg/L and a diurnal change of 2.1 mg/L while 0051B had a diurnal fluctuation of 1.9 mg/L with a minimum of 3.8 mg/L. Figures 5-7 shows the D.O. and temperature fluctuation at these sites.

Figure 2

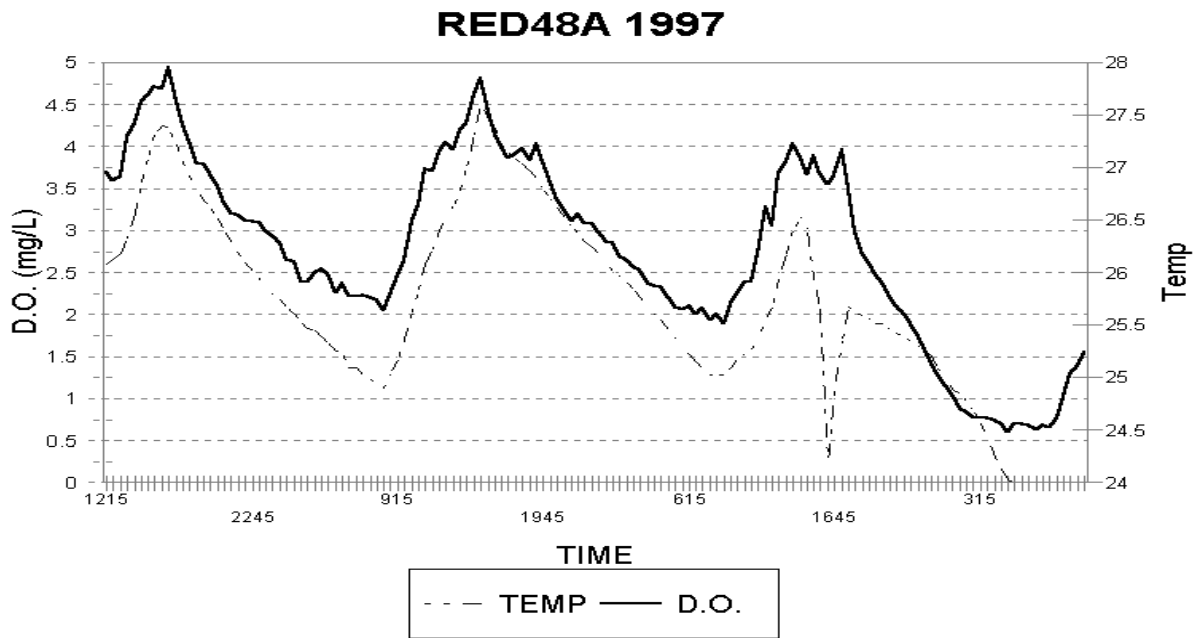


Figure 3

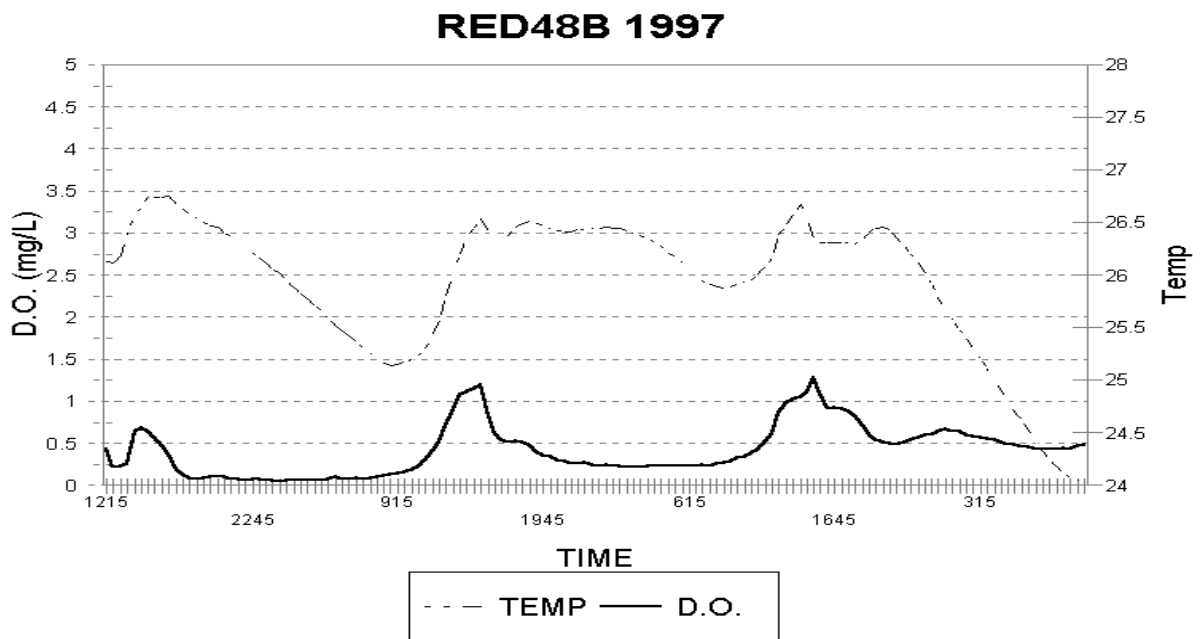


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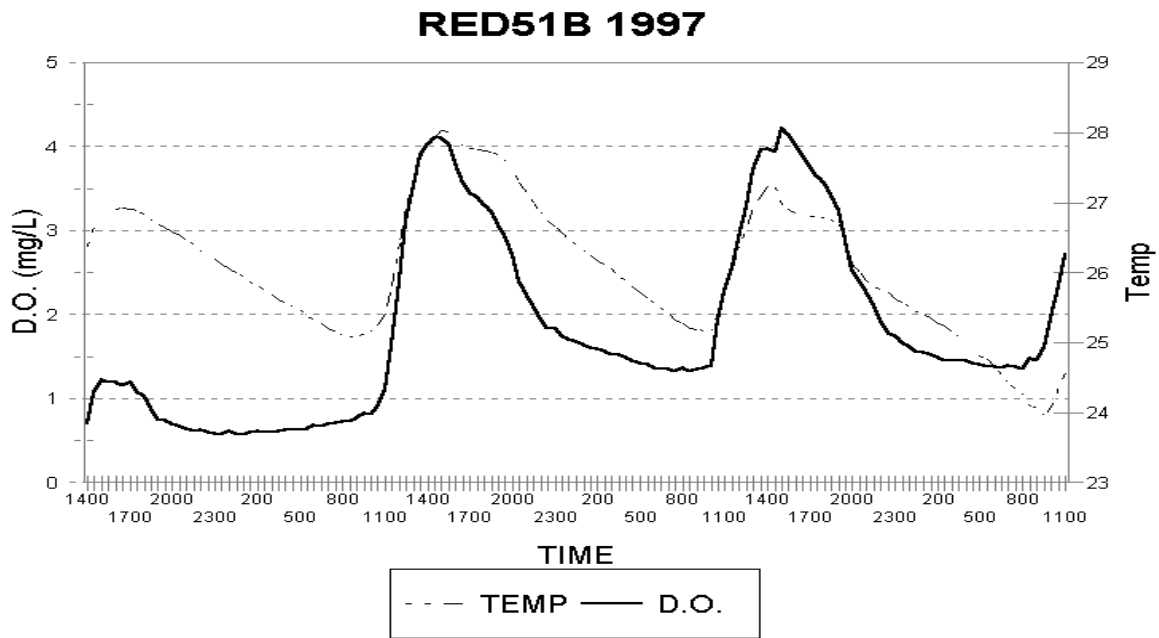


Figure 5

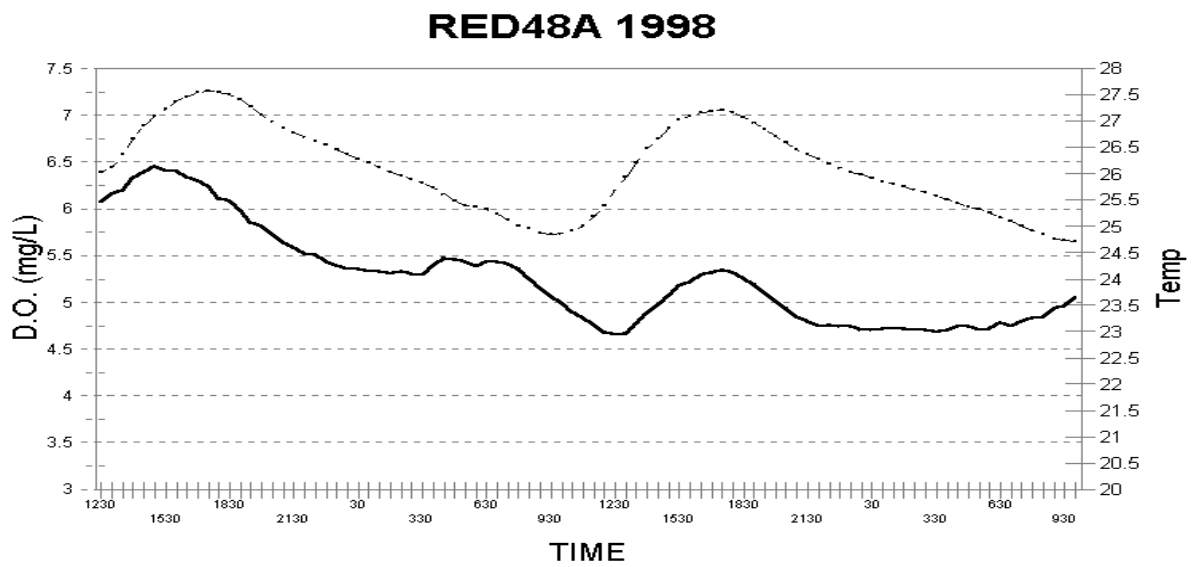
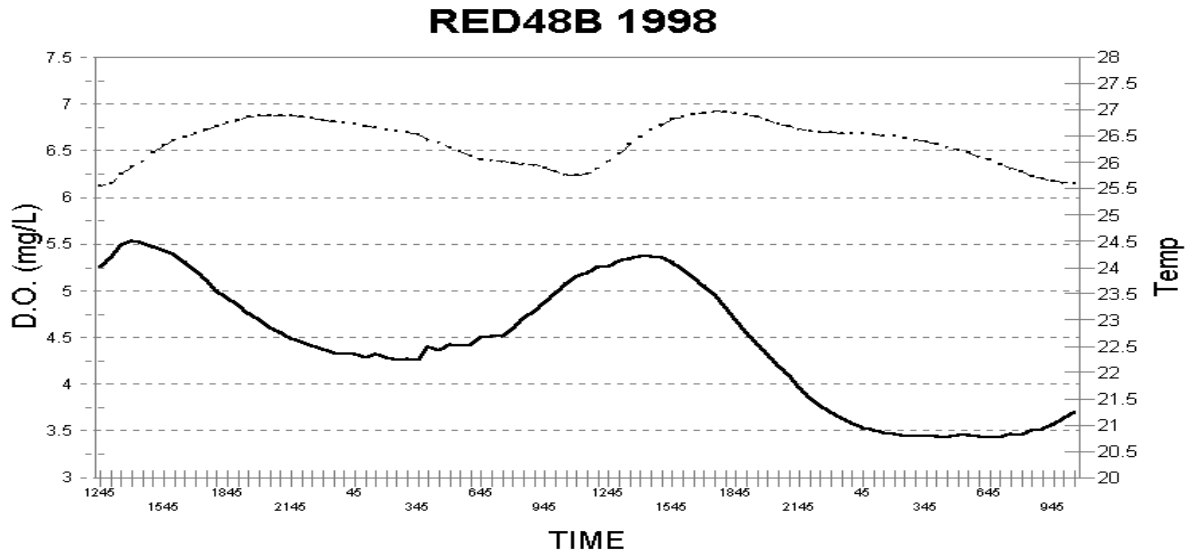
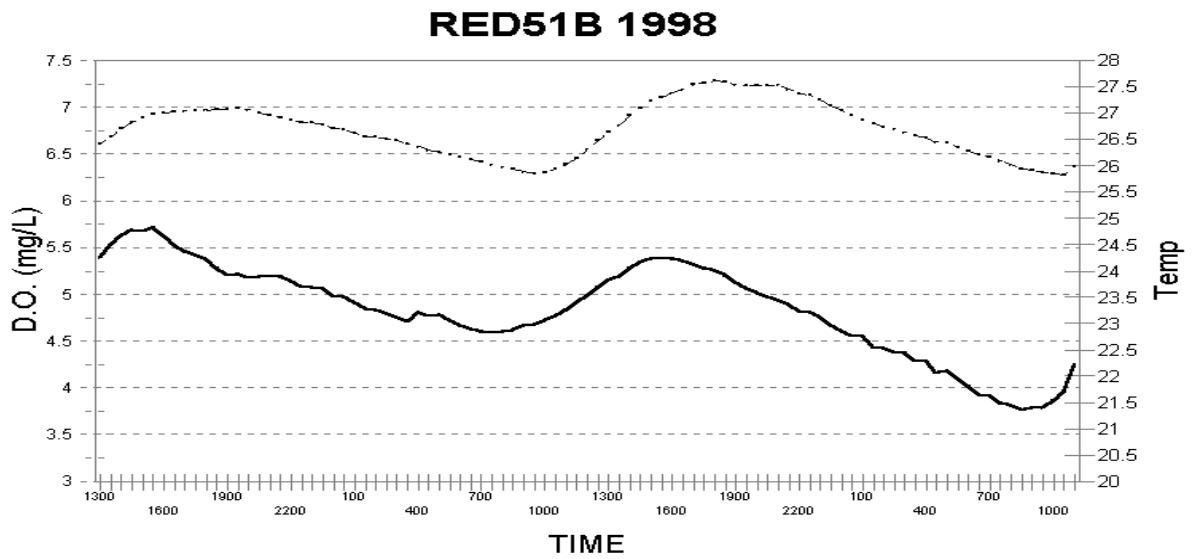


Figure 6



pH And Temperature
Figure 7



With the exception of the upstream site pH of 6.5, stream pH values measured during the 1997 survey were atypical for streams in the Gulf Coastal Plain ecoregion. The values ranged from 7.1 to 7.8, with the effluent discharges being 7.5 and 7.8 for Tyson and Nashville, respectively. The 1984 ecoregion evaluation indicated a summertime average pH of 6.8 for the typical Gulf Coastal streams. The stream temperatures measured were generally higher than those values measured in the ecoregion study (25°C average), and were also influenced by the point source discharges. The September 3 upstream Mine Creek temperature of 25.3°C was increased to 26.2°C at RED 0048B by the 30.6°C Tyson effluent. The 24.5°C RED0051A temperature (above Nashville STP) was elevated to 26.3°C by the 28.8°C Nashville STP effluent. The 1998 pH and temperature data was slightly lower but exhibited a similar pattern as the 1997 data.

Flow

According to USGS data, Mine Creek at Nashville has a Q7-10 of less than 1.0 cfs. The June 1984 WLA survey used a 0.5 cfs background flow for the critical season model, which is the same flow as was measured in the 1997 survey. Effluent discharge flows measured during the 1997 survey included 2.4 cfs from the Tyson Foods facility and 2.9 cfs from the Nashville STP. The September 1998 survey flows included a background volume of 10.3 cfs, a Tyson effluent flow of 1.5 cfs, and a Nashville effluent flow of 3.1 cfs.

Chlorides, Sulfates, And Total Dissolved Solids

As a result of the September 1997 survey, ADPC&E's ambient water monitoring network has established one new station on Mine Creek (RED 0048B at Highway 27), and re-activated an old site--at the Highway 355 bridge (RED 0018B), located about 5 miles below the Nashville STP discharge. These stations, which were established primarily for the purpose of monitoring the effects of the point source effluents on water quality, have been sampled several times since the survey. The mean value for chlorides at the Highway 27 bridge station was 31.8 mg/L, with a range from 4.8 mg/L to 77.3 mg/L. The 1984 ecoregion data indicates a "background" level of 4 mg/L for chlorides for Gulf Coastal reference streams. The 1997 survey sample collected at this station had a concentration of 67.2 mg/L, while the 1998 value was 20 mg/L, showing the effect of dilution. In contrast, the upstream Mine Creek station had a concentration of 15 mg/L in 97 and 9 mg/L in 98. The 1997 point source discharges had chloride concentrations of 112.4 and 51.3 mg/L (Tyson and Nashville, respectively), while the 1998 values were 95.5 and 39.6 mg/L. The mean value for chlorides at RED 0018B, since the survey, has been 22.7 mg/L, with a range of 4.8 to 47.7 mg/L.

Similar increases were noted in total dissolved solids. Storet data at RED 0048B had an average of 215 mg/L with a range from 60 to 503. The RED 0018B data averaged 154 mg/L with a range from 59 to 318 mg/L. TDS data from the September 1997 survey ranged from 107 mg/L at the upstream site to 307 mg/L at the lower station (RED 0018B). Tyson Foods was discharging 757 mg/L during the survey and the Nashville STP effluent concentration was 409 mg/L. Gulf Coastal ecoregion reference streams averaged 67 mg/L for this parameter.

Sulfate concentrations in the upper Mine Creek watershed were similar to ecoregion values (11.5 mg/L at RED0048A compared to 10 mg/L). The Nashville STP effluent had the highest value encountered during the survey, with a concentration of 134 mg/L. Tyson Foods discharge had a concentration of 91 mg/L. Figures 8 and 9 depict the minerals data analyzed in the 1997 and 1998 surveys, respectively.

BOD, TSS, And Nutrients

As noted earlier, the 1984 WLA survey recorded five day BOD's averaging 30 mg/L when the Tyson Foods facility was discharging to the municipal treatment plant. During the September 1997 survey Tyson Foods had an effluent BOD of 8.9 mg/L, but due to an upset in the treatment plant, an average BOD of 18.7 mg/L was being discharged during the month of August with a high of 48.7 mg/L on August 15. The impact on the stream was obvious, with near septic conditions being observed in Mine Creek during the survey. An analysis of the BOD data from RED 0048B since the survey indicated a decreasing concentration, which suggests the treatment efficiency has improved at the Tyson facility. The Nashville treatment facility had an effluent concentration of 6.9 mg/L of BOD₅ during the survey. The instream concentration had decreased to 1.9 mg/L at the RED 0018B site. The 1998 BOD concentrations were 3.6 mg/L for Tyson and 7 mg/L for the Nashville treatment facility.

Total suspended solids data generally followed the same pattern as seen in the BODs. Tyson's laboratory data for the month of August 1997 reported an average concentration of 39 mg/L with a high of 110 mg/L on August 22. September data indicated an average TSS concentration of 15 mg/L, with a high value of 53 mg/L on September 5. The Tyson effluent concentration during the survey was 8.5 mg/L and the Nashville STP effluent was 14.5 mg/L. Similar values were recorded during the 1998 stream evaluation, with 7 and 16 mg/L in the effluent streams. Both monitoring stations (RED0048B and RED0018B) indicated that TSS averages were below 10 mg/L since the surveys were completed.

An analysis of the nutrient data generated during and after the 1997 survey revealed relatively low concentrations of NH₃N and NO₃N at the stream survey stations and later at the two monitoring stations. The highest ammonia nitrogen concentrations were found at RED 0051A&B (2.4 & 2.5 mg/L, respectively)--above and below the Nashville STP effluent discharge to Mine Creek. The Tyson facility was discharging less than 1 mg/L of each nitrogen component during the survey, while the Nashville effluent contained 0.8 mg/L NH₃N and 1.3 mg/L NO₃N. In contrast, total phosphorus was extremely high in the Tyson Foods effluent during the survey. From an effluent concentration of 22.8 mg/L, the RED 0048B site had a concentration of 8.7 mg/L. At

RED 0051A the concentration was 4.1 mg/L which was diluted by the Nashville STP effluent (0.7 mg/L) to a concentration of 2.7 mg/L at RED 0051B. A concentration of 1.1 mg/L still remained at the RED 0018B site which is about six miles below the Tyson effluent. The 1998 survey nutrient data showed improvement in the Tyson effluent concentration, with 4.1 mg/L total phosphorus being recorded. The Nashville effluent had a concentration of 1.3 mg/L. Nitrate nitrogen effluent concentrations were higher during the 1998 survey, with 3.8 and 2.8 mg/L being measured from Tyson and Nashville, respectively. Figures 10 and 11 depict nutrient concentrations at all sites for the 1997 and 1998 surveys. Monitoring data generated since the surveys have shown high phosphorus concentrations during September and October of 1997 at both sites. These were 7.5 and 5.6 mg/L for these months at RED 0048B and 1.7 and 1.8 mg/L at RED 0018B. Data collected during 1999 indicated a dramatic increase in nitrate and phosphorus concentrations at these stations beginning in June 1999. The mean nitrate concentrations at RED0048B and RED0018B from July to December 1999 were 12.2 mg/L and 9.1 mg/L, respectively. The increase in the phosphorus concentration is apparent beginning in June 1999. The mean phosphorus concentrations at RED0048B and RED0018B from June to December 1999 were 3.6 mg/L and 1.9 mg/L, respectively. Figures 12 and 13 depict the nitrate and phosphorus concentrations during 1999 at stations RED0048B and RED0018B. Figure 14 depicts the ortho and total phosphorus stream loadings for the September 1997 survey and indicates the rate of uptake and utilization from the Tyson Foods effluent down to RED 0018B. Figure 15 depicts the NH_3N and NO_3N 1997 loading at each stream site.

Figure 8

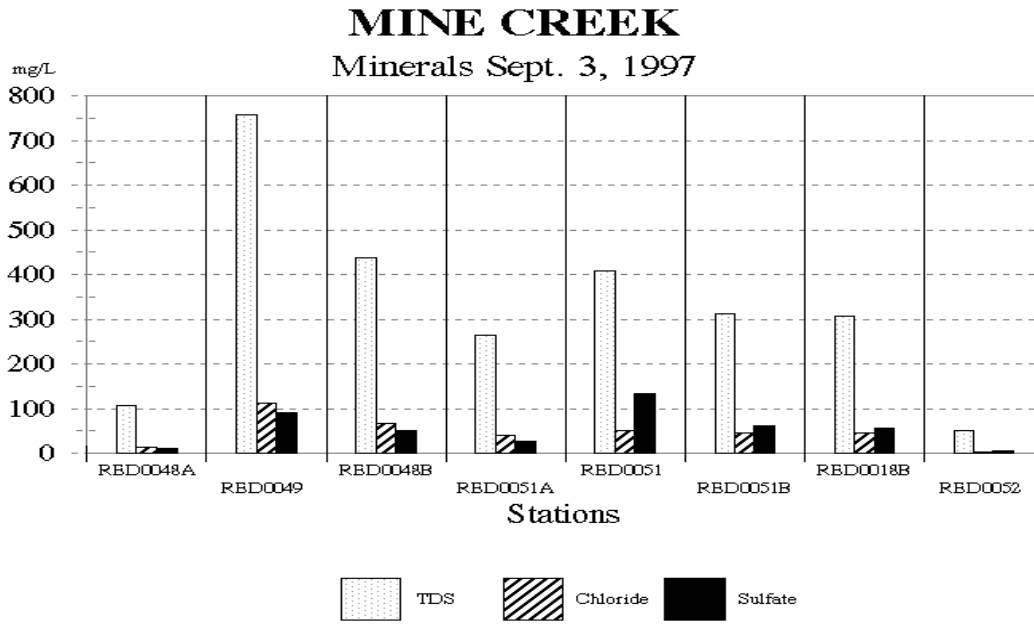


Figure 9

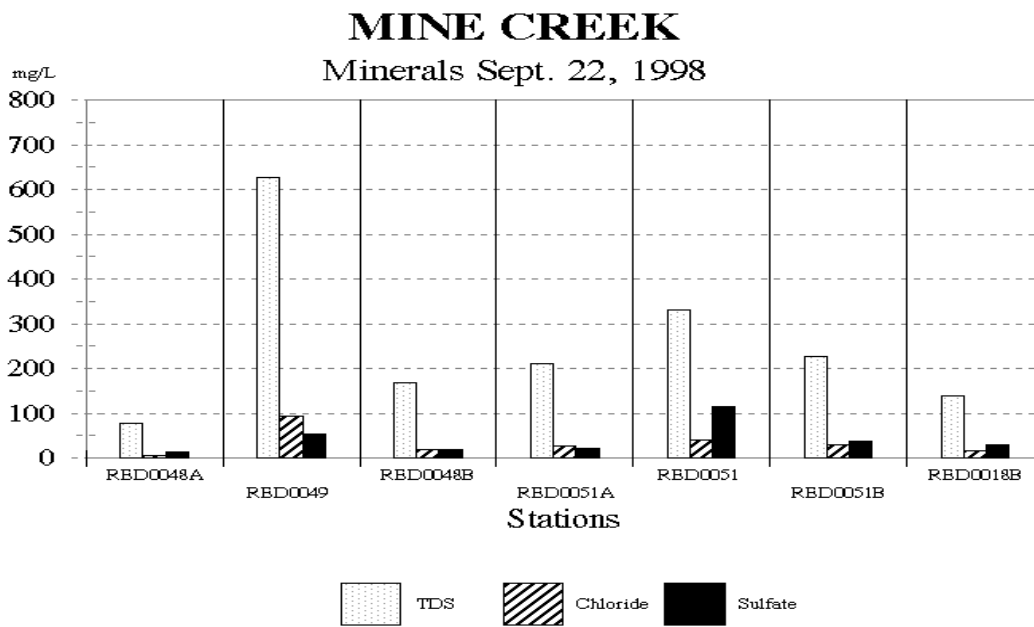


Figure 12

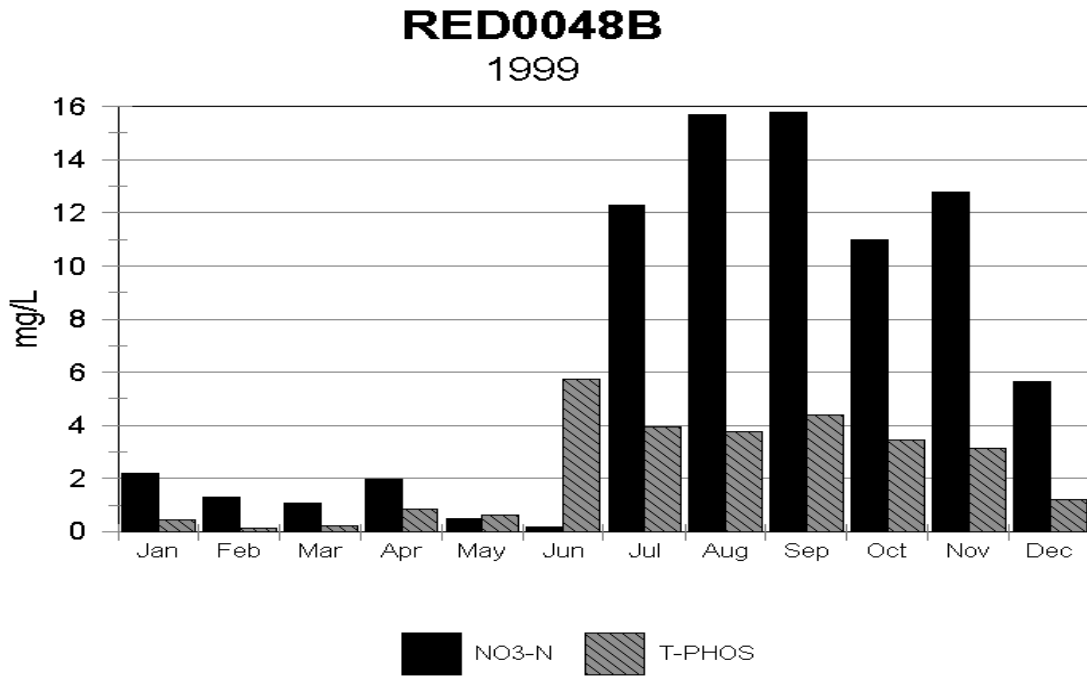


Figure 13

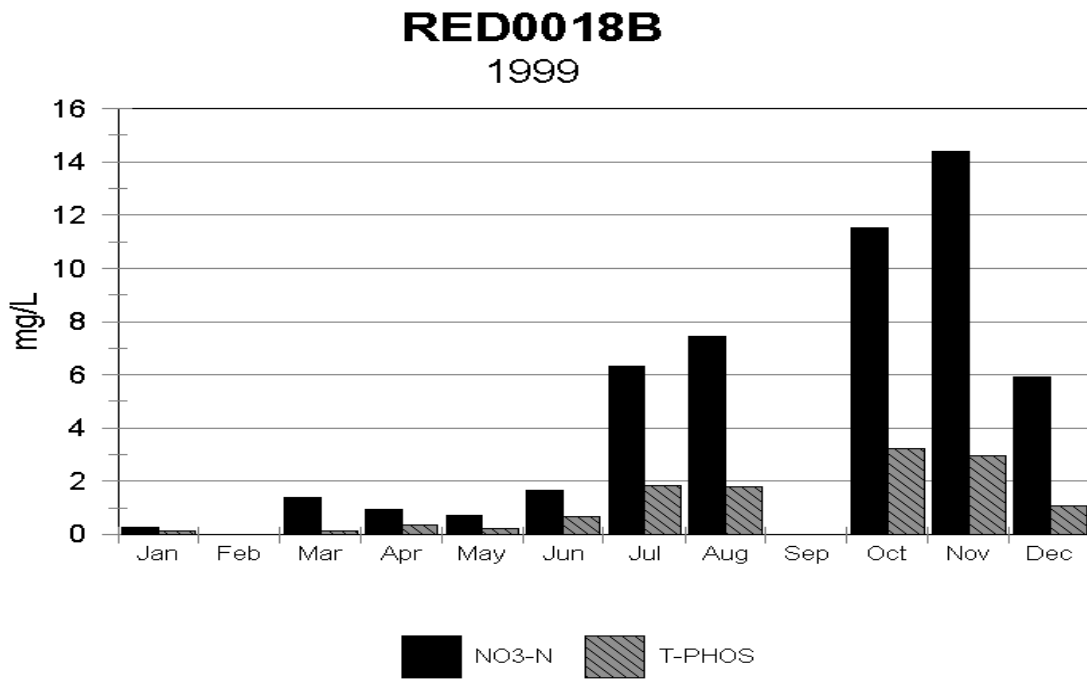


Figure 14

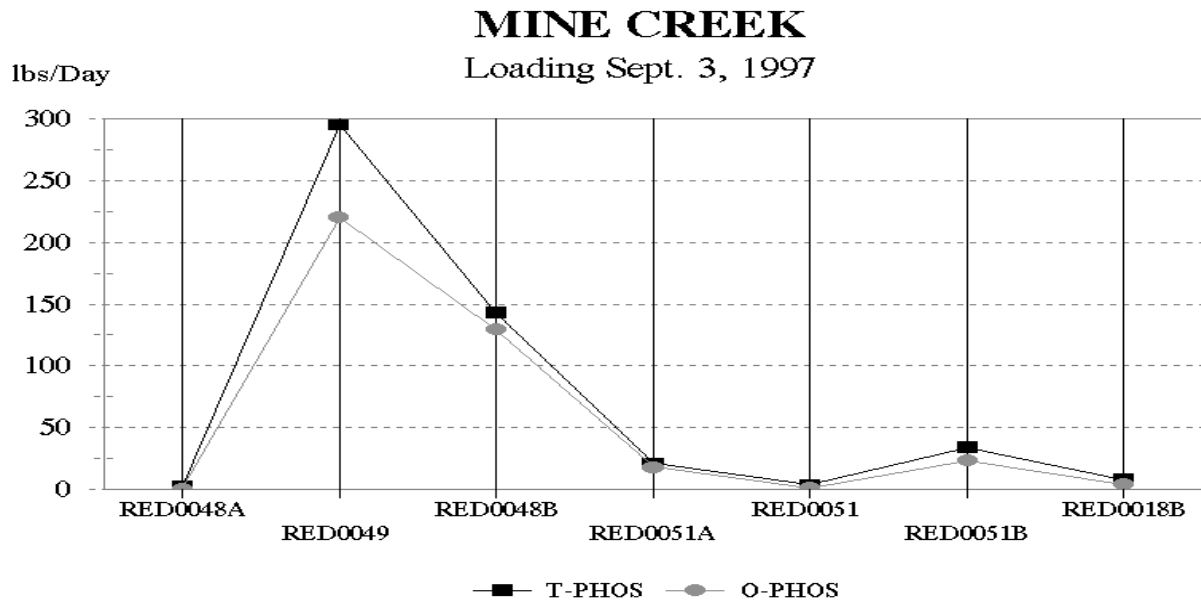


Figure 15

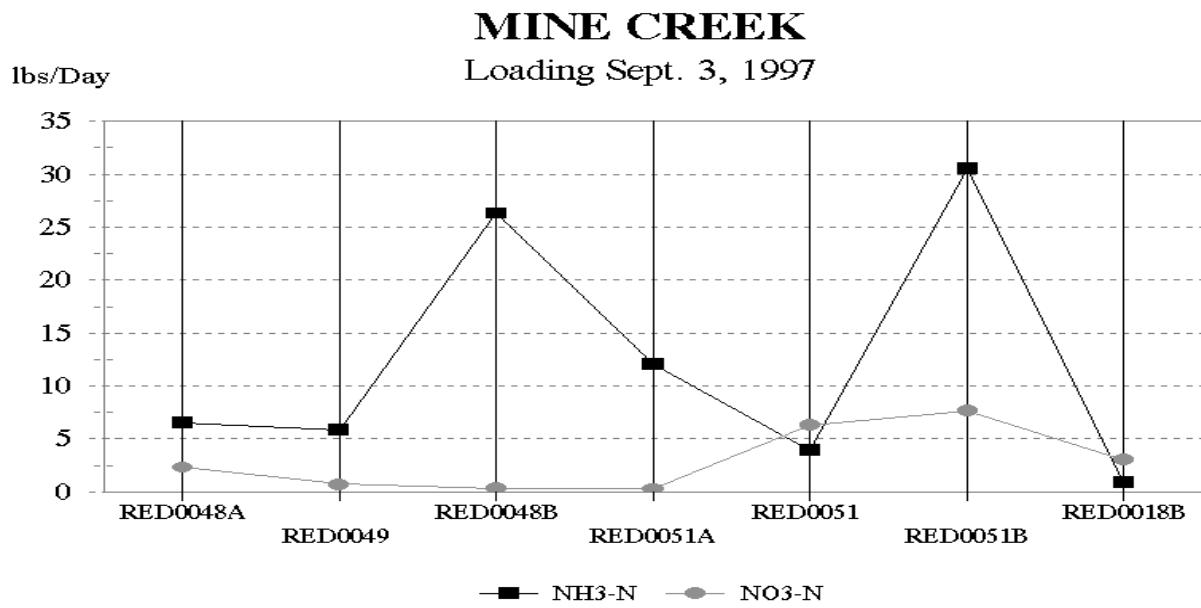
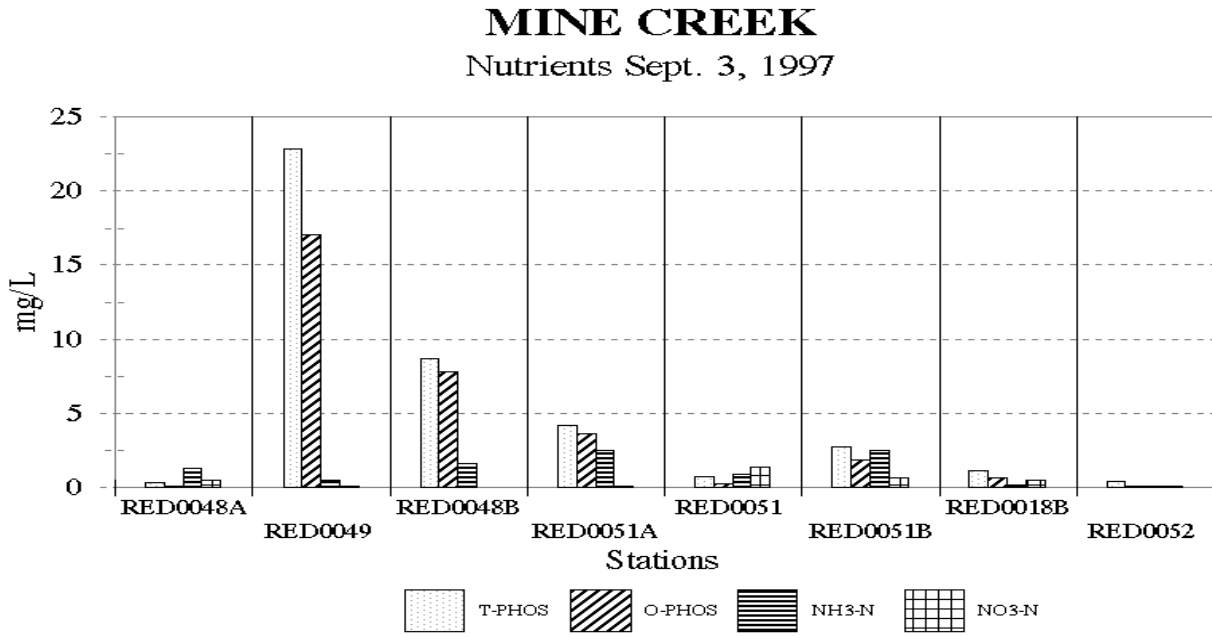
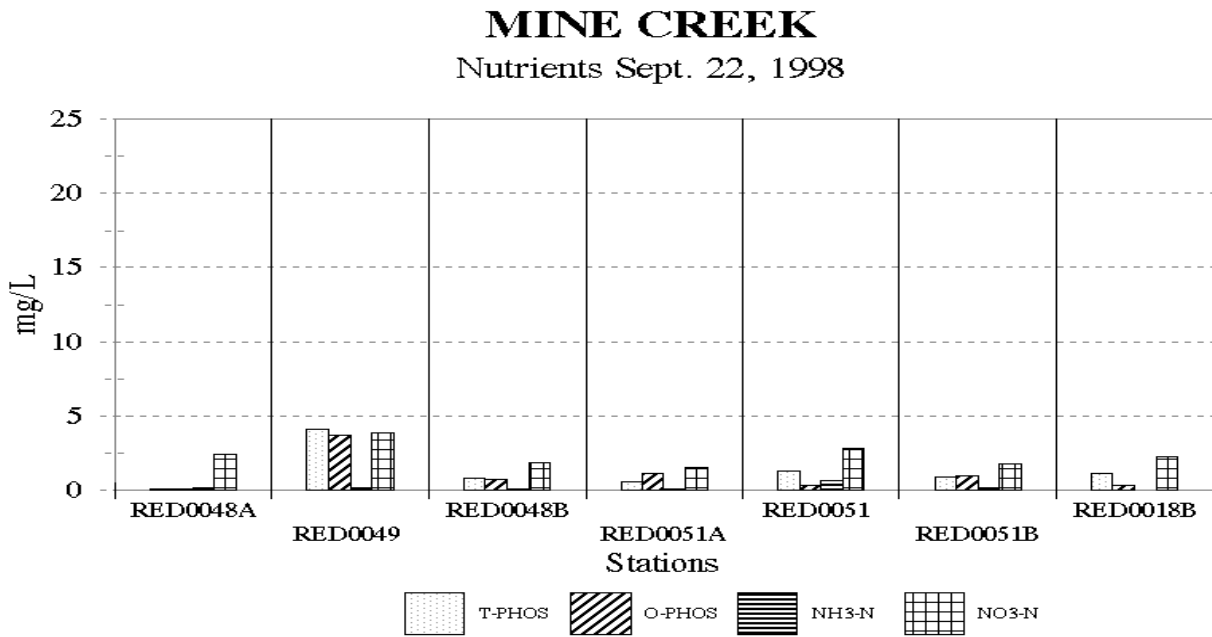


Figure 10



AQUATIC MACROINVERTEBRATE ANALYSIS

Figure 11



Aquatic macroinvertebrates were collected at three sites in Mine Creek on September 2, 1997. The upper site (RED 0048A) was above all point source discharges and was the reference site. The middle site (RED 0048B) was taken approximately 400 m below the Tyson discharge and the lowest site (RED 0051B) was approximately 400 m below the City of Nashville waste water treatment plant.

Collections of aquatic macroinvertebrates were conducted using modified protocols set forth by the USEPA that consist of disturbing the substrate, usually with the sampler's feet (kicking), and allowing the flowing water to carry all disturbed materials into a dip net. The sample was washed through a sieve, all large organic and inorganic debris removed, and placed in a 1.0 L jar and preserved with 70% ethanol to be transported to the lab for identification and enumeration.

In the lab, the sample was placed into a 9" x 13" dissecting pan. The pan was swirled to distribute the sample evenly and a 4 inch diameter (10 cm) ring was randomly placed on the sample. Aquatic macro- invertebrates were removed from the ring until the ring was depleted of organisms. If less than 100 organisms were encountered in the ring, the sample was swirled again and the ring randomly placed on the sample and the same procedure was followed until a minimum of 95 organisms was removed from the sample. In cases where more than 100 organisms were encountered in a ring, the entire ring was picked to comprise the subsample. Organisms were identified to the lowest feasible taxonomical level, usually genus, enumerated and entered into a spreadsheet for further analysis. Taxonomic determinations were conducted by one person to reduce bias in identifications.

Rapid bioassessment (RBA) scores from multi data summaries (metrics) were derived for each site. Each site's score was compared with the reference site to find a percent comparable estimate (%BCE) and determine the impairment status. Impairment categories are found in Table M-1.

Table M-1.

Biological Condition	%BCE	Attributes
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.

Table M-2 lists the metrics evaluated and raw scores calculated for impairment status.

Table M-2.

Metric	RED0048A	RED0048B	RED0051B
Taxa Richness	14	5	15
EPT Index	5	0	3
$\frac{\text{EPT Abundance}}{\text{(Chironomid +EPT Abundance)}}$.88	0	.03
$\frac{\text{Scraper Abundance}}{\text{Scraper + Filter Feeder Abundance}}$	1.0	1.0	.96
Hilsenhoff's's Biotic Index	3.1	4.7	4.2
% Contribution of Dominant Taxa	51	95	60
Community Loss Index	REFERENCE	2.4	0.7

Taxa Richness is an expression of diversity. Normally, a diverse community will be comprised of a large number of taxa. However, a community can have a high number of taxa and still contain greater than 75 percent of one taxon. EPT Taxa is another expression of taxa richness, only from the insect orders of Ephemeroptera, Plecoptera and Trichoptera. These taxa are usually considered less tolerant of pollution but tolerant EPT taxa do exist. The EPT to EPT and chironomid ratio is a metric showing the ratio of EPT taxa to the chironomid taxa and is a community balance metric. A balanced community should have all four taxa present in moderately balanced numbers. Scraper abundance to scraper + filterer feeder abundance is another community balance metric involving the feeding mechanisms of the community. An overabundance of any one feeding group reflects an unstable community.

Hilsenhoff's Biotic Index is a scoring mechanism based on tolerance to organic pollution. It's scale is from zero to five and the most tolerant organisms are near five. The Percent Contribution of Dominant Taxa is a comparison of the communities based on the percentage of the dominant taxa. Normally communities living in waters of good quality will have lower values for this metric. Community Loss Index is a metric to evaluate community similarity between sites.

This RBA also includes physical site evaluations. Physical evaluations are necessary to ensure each site can physically support the community found at the reference or "least impacted" site. Physical parameters are scored and scores are compared with the reference. A %PCE is calculated to decide comparability of stations to the reference. Percent comparable estimates and assessment categories are found in Table M-3.

Table M-3.

Assessment Category	%PCE
Comparable to Reference	\$90%
Supporting	75-88%
Partially Supporting	60-73%
Non-Supporting	#58%

Multiple factors are used to decide physical characteristics. Substrate, embeddedness, and flow are the most critical factors and are conducted along a transect in the reach. Ten points are used along the transect and intervals represent 1/10th of the width of the reach. These variables are weighted heavier than the others due to their relevance to the available habitat. Channel alteration, bottom scour and deposition and pool-riffle ratios are weighted less but are still important in the quality and quantity of available habitats. These data are calculated over a larger area than the previous three but within the sample site (except pool-riffle ratios that encompasses several hundred meters of stream). Bank stability, vegetative cover and stream side cover are weighted less since they play a much smaller role in quantity and quality of habitats and these data are derived from approximately 100 m upstream and downstream of the sample site. After evaluation, the values are summed for the reference and sites in question to decide the percent physical comparable estimate (%PCE). Physical parameters and raw scores are found in table M-4.

Table M-4.

Metric	RED 0048A	RED 0048B	RED 0051B
Bottom Substrate	17	17	18
Embeddedness	16	11	11
Flow	6	12	11
Channel Alteration	14	14	14
Bottom Scour-Deposition	14	10	14
Pool-Riffle Ratio	12	10	1
Bank Stability	9	6	2
Vegetative Cover	7	7	7
Stream side Cover	7	7	7
Total Score	102	94	85
% Similar		92	83

Results

Rapid bioassessments are not designed to be exhaustive surveys of benthic communities, only an indicator of impairment in the aquatic environment. To decide the impairment, many metrics are utilized.

No single metric is considered most accurate, but a summation of the cumulative metrics is necessary to decide impairment.

In Mine Creek, the upper site (RED 0048A) was selected as the reference site since it is above all permitted point source discharges in the stream. It had a TR of 14, the EPT taxa comprised more than 55% of the community, had a medium tolerance to organic pollution and a high EPT/(EPT+Chironomid) ratio (Table M-2). When compared with it, the middle site (RED 0048B) exhibited moderate impairment (%BCE=28) while the lower site (RED 0051B) exhibited slight impairment (%BCE=56%) (Table M-1).

RED 0048B had a reduced TR (5); no EPT taxa; a very high CLI, HBI and contribution of dominant taxa (95% Chironomidae) and a low EPT/(EPT/Chironomid) ratio since it was dominated by Chironomids (Table M-2). This site's %BCE was two percentages from being considered severely impaired (Table M-1).

RED 0051B had a greater TR (15) but a lower EPT taxa (3) than the reference. The HBI, while lower than RED0048B, was also higher than the reference. The EPT/ (EPT+ Chironomid) ratio was also near zero, due to the high number of chironomid taxa at this site. Percent contribution of dominant taxa was higher than the reference but lower than RED 0048A and the CLI was low (Table M-2). This site's %BCE was two percentages from being moderately impaired as shown in Table M-1.

The physical scores of the two sites showed that RED 0048B could sustain the same community as the reference (Table M-4). However, RED 0051B was less similar to the reference but exhibited less impairment (Table M-4).

DISCUSSION

The two sites under question showed different levels of impairment. RED 0048B showed the greatest amount of impairment while RED 0051B seems to show some improvement in water quality, although the habitat was not as "good" as the reference site.

Physical attributes of RED 0048B showed greater embeddedness, a lower pool- riffle ratio, and more bottom scour and deposition while sustaining greater flow. The substrate, however, was almost completely covered by a dense mat of filamentous algae probably due to large nutrient loads associated with some point source discharges. The site was identical to the reference except the embeddedness, filamentous algae and flow. The embeddedness averaged 47.0% versus 22.5% for the reference and the filamentous algal mat was not present at the reference. Usually, large quantities of living plant material, such as an algal mat, require DO at night when photosynthesis is not occurring. The DO taken up by the plants reduces the available DO and can stress many aquatic organisms in the vicinity. *Chironomous*, due to their blood pigments and tube burrows into which they force water around their bodies, can sustain DO levels lower than most aquatic organisms and is often the dominant macroinvertebrate in severely distressed aquatic environments.

Therefore, they could dominate the community at RED 0048B which would result in a lower RBA score, as seen in this survey.

Physical attributes of RED 0051B were somewhat different from the reference. Mine Creek appears to undergo natural, physical (hydraulic) changes in the vicinity of Nashville, Arkansas. The upper part of the creek appears to be influenced by the Ouachita Mountain hydraulics while the lower portion influenced by Gulf Coastal Plain hydraulics. This is evident by the lower pool-riffle ratio in the lower portion as well as shorter-wider riffles below RED 0048B. The lowest site, RED 0051B, had a greater percentage of cobble that increased its bottom substrate score but was more embedded than the reference, which resulted in fewer habitats. Also, the greater bank slope resulted in less bank stability than found at the reference. Due to the changes in hydraulics, this site had a lower pool-riffle ratio that reduced the available habitat for aquatic macroinvertebrates. While ample habitats to sample were present at RED 0051B, the habitat was less similar to the reference than was RED 0048A. Lower DO availability caused by upstream input(s) may have caused the increased chironomid numbers at this site and reduced the RBA score to below the reference's score.

FISH COMMUNITY

In September 1997, fish community surveys were conducted at the stations listed below:

Station Description

RED 0048A	Mine Creek above Tyson effluent at Ar. Hwy. 27B
RED 0048B	Mine Creek below Tyson effluent at Ar. Hwy. 27, above Nashville effluent.
RED 0051B	Mine Creek below Nashville effluent, above Coleman Creek confluence.

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 needing further identification were preserved in a ten percent formalin solution and returned to the lab.

Habitat Evaluation

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

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 stations sampled. Appendix F-1 outlines the habitats type by collection site and the scores received by each.

Table F-1

Fish Habitat Evaluation												
SITE	Riffle				Run				Pool			
	Number Sampled	Total Length	Average Habitat Score	IHI *	Number Sampled	Total Length	Average Habitat Score	IHI	Number Sampled	Total Length	Average Habitat Score	IHI
RED048A	7	230	37.0	85.1	3	200	42.5	85.0	7	730	44.1	321.9
RED048B	8	200	20.5	41.0	4	220	35.6	78.3	10	1130	35.9	405.7
RED051B	7	182	37.5	68.3	5	410	35.6	146.0	7	840	44.1	370.4

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

Fish Community Evaluation Method

The fish communities were evaluated by comparing the community structures at each site on an upstream-downstream community basis and to the fish community of the least-disturbed, typical Gulf Coastal ecoregion reference stream of approximately the same size watershed, Whitewater Creek. Sixteen different parameters were compared between each of the communities (see Tables F-3 and F-4). A fish community index was calculated using eight of these parameters using ecoregion reference stream data to generate the scoring criteria. These criteria are listed below in Table F-2.

Degree of impairment was defined first by determining the fish community index score for each of the communities and comparing that score to the criteria calculated from the least-disturbed Gulf Coastal ecoregion reference stream data. Those scores and the corresponding degree of impairment are:

<u>Total Score</u>	<u>Degree of Impairment</u>
25-32	Fully Supporting
24-17	Slightly Impaired
16-9	Moderately Impaired
0-8	Not Supporting

The final degree of impairment determinations were derived by analyzing all of the indices used, the fish community structures, the habitat structures and the unit of effort of each sample with some best professional judgement.

TABLE F-2

Fish Community Biocriteria
(Typical Gulf Coastal Ecoregion Reference Streams)

Metric (as % community)	4	2	0
Cyprinidae	4 - 35	<4 or 35 - 45	>45
Ictaluridae	1 - 8	0.5 - 1 or 8 - 12	>12 and >7% bullheads
Centrarchidae	28 - 47	18 - 28 or 47 - 57	<18 or >47
Percidae	>10	6-10	<6
Sensitive Individuals	>1	0.5 - 1	<0.5
Primary TFL	<15	15 - 22	>22
Key Individuals	>19	13 - 19	<13
Diversity Index	>3.89	3.65 - 3.89	<3.65

Results

Fish community samples were collected at all stations on September 2 and 3, 1997. They were evaluated by comparing different metrics and basic community structures, as described above. The sample collected at RED 0048A was used as reference site for comparison to the sites located below the wastewater treatment facilities, RED 0048B and RED 0051B. Least-disturbed, Gulf Coastal ecoregion reference streams, and other streams of similar drainage size sampled in recent years were used to develop the metrics used in Table F-2.

There were 29 species of fish collected at RED 0048A, 24 at RED 0048B, and 20 collected at RED 0051B. Appendix F-2 is a list of species collected from each site, the number of specimens per species collected, and the percent community composition of each species. Table F-3 depicts the family comparisons between sampling stations, percent and total sensitive, key and primary trophic levels species, the diversity index of each sample based on the Shannon-Wiener diversity index, and the catch per unit effort(in minutes). Table F-4 depicts similarity indices between sample sites based on species distribution between the two sites listed as percent community.

The fish community above the Tyson-Nashville discharge, RED 0048A, was comprised of 29 species and 1479 specimens. The catch per unit effort was 19.52 fish per minute. Centrarchids were represented by nine species and comprised 32% of the community. The longear sunfish accounted for over 70% of the sunfish community. There were four species of cyprinids collected comprising 52% of the community. The stoneroller and the striped shiner each comprised over 49% of the cyprinid community. There were four different sucker species collected and three species of darters were collected.

TABLE F-3

COMMUNITY STRUCTURE (as percent total community)			
Family	RED048A	RED048B	RED051B
Cyprinidae	52.33	24.75	8.30
(less stonerollers)	26.16	4.75	2.95
Catostomidae	3.45	4.75	1.11
Ictaluridae	0.74	9.18	4.43
Centrarchidae	32.45	48.36	80.44
Percidae	6.02	2.13	0.18
Total Species Collected	29	24	20
No. Sensitive Species	2	0	0
No. Sensitive Individuals	15	0	0
% Sensitive Individuals	1.01	0	0
No. Primary TFL	403	124	29
% Primary TFL	27.25	20.33	5.35
(less stonerollers)	1.08	0.33	0.00
No. Key Individuals	30	76	27
% Key Individuals	2.03	12.46	4.98
Diversity Index	2.95	3.43	2.82
Catch per Unit of Effort	19.52	7.70	6.05

Two sensitive species, the black redhorse and the northern studfish, were collected and were both represented by several specimens. Five key species were collected, including the slough darter and the grass pickerel. The primary trophic feeders comprised 27% of the community, however 96% of these were stonerollers. The diversity index was 2.95. (See Table F-3)

The habitat at RED 0048A consisted of seven riffle habitats with an average habitat score of 37 and an IHI (Ithyofauna Habitat Index) score of 85.1; three run habitats with an average habitat score of 42.5 and an IHI of 85; and seven pool habitats with an average habitat score of 44.1 and an IHI of 321.9. The riffle habitats had moderate flow, substrates of rubble/gravel and good in stream cover. The run habitats had moderate flow, substrates of mostly gravel with some rubble and sand, and good in stream cover. The pool habitats generally had little flow, substrates of mostly rubble but with occasional small boulders and some areas of sand/silt, and good in stream cover.

The site below the Tyson-Nashville discharge, RED 0048B, was comprised of 24 species and 610 specimens. The catch per unit effort was 7.70 fish per minute. The centrarchids were represented by seven species and comprised 48% of the community. The longear sunfish and the spotted sunfish accounted for 55% and 20% of the sunfish community, respectively. There were four species of cyprinids collected comprising 25% of the community. The stoneroller comprised over 81% of the

cyprinid community. There were two sucker and two darter species collected comprising less than 5% and 2% of the community, respectively. There were no sensitive species collected. Four key species were collected comprising 13% of the community and the primary trophic feeders comprised 20% of the community. The diversity index at this site was 3.43.

The habitat at RED 0048B consisted of eight riffle habitats with an average habitat score of 20.5 and an IHI score of 41; four run habitats with an average habitat score of 35.6 and an IHI of 78.3; and ten pool habitats with an average habitat score of 35.9 and an IHI of 405.7. The riffle habitats had moderate flow, substrates of gravel/sand with occasional rubble and fair in stream cover. The run habitats had moderate flow, substrates of mostly gravel with some sand, and moderate in stream cover. The pool habitats generally had little flow, substrates of mostly gravel sand/silt, and moderate in stream cover. All of the habitats, especially the more shallow areas, had extensive periphyton growth, almost to the point of totally covering the bottom substrate. There was also a noticeable black silt load in the more quite backwater areas and even in some of the run and riffle habitats.

The site below City of Nashville discharge, RED 0051B, was comprised of 20 species and 542 specimens. The catch per unit effort was 6.05 fish per minute. Centrarchids were represented by eight species and comprised 80% of the community. The longear sunfish and the bluegill sunfish accounted for over 53% and 24% of the sunfish community. There were four species of cyprinids collected comprising only 8% of the community. The stoneroller comprised over 64% of the cyprinid community. The spotted sucker was the only catostomid species collected. Only one darter species, the redfin darter, was collected and was represented by only one specimen. There were no sensitive species collected. Four key species were collected and one species from the primary feeding group was collected; each representing 5% of the community. The diversity index was 2.82.

The habitat at RED 0051B consisted of seven riffle habitats with an average habitat score of 37.5 and an IHI score of 68.3; five run habitats with an average habitat score of 35.6 and an IHI of 146.0; and seven pool habitats with an average habitat score of 44.1 and an IHI of 3709.4. The riffle habitats had moderate flow, substrates of gravel/sand, and good in stream cover. The run habitats had moderate flow, substrates of mostly gravel/sand with some silt, and moderate in stream cover. The pool habitats generally had little flow, substrates of mostly gravel with some rubble and sand/silt, and good in stream cover.

Discussion

The fish communities in Mine Creek are most similar to Gulf Coastal Plains ecoregion communities except for the stoneroller populations. These populations reflect the Ouachita Mountains ecoregion influence, best seen in the communities at the upper two sampling sites. Because of this, the stoneroller populations were not considered when scoring the communities based on the biocriteria set forth for Gulf Coastal Plains ecoregion fish communities, Table F-2.

The fish community at the RED 0048A site was dominated by three species, the stoneroller, the striped shiner, and the longear sunfish, each comprising almost 25% of the overall community.

Because of this, the diversity index for this community was only 2.95 as compared to 3.43 at the RED 0048B site. There is a distinctive decrease in the stoneroller population in a downstream direction. Much of this may be due to the habitat changes downstream. The most upper site, RED 0048A, has habitat characteristics similar to Ouachita Mountains ecoregion streams where the stoneroller is very prevalent. The habitat in the lower sites, however, are more similar to Gulf Coastal Plains ecoregion streams and much less suitable for stonerollers. This shift of species is also apparent in the sucker family. The upper site had good populations of two redhorse species, which are common in Ouachita Mountain streams, but both were totally absent from the lower sites. The lower sites did host good populations of the spotted sucker, a Gulf Coastal Plains ecoregion Key species. In addition, the striped shiner is a third species displaying this same trend. There is a large population at the upper site and a distinctive decrease in its dominance in a downstream direction. This is another species which prefers clear water with gravel bottom habitats, typical habitat of Ouachita Mountain streams but not of Gulf Coastal Plains streams.

There is a large shift in the centrarchid dominance in a downstream direction, also. The centrarchids comprised 32% of the community at the RED 0048A site, 48% at the RED 0048B site, and 80% of the community at the RED 0051B site. The major increases came in the bluegill, longear and spotted sunfish populations. In addition, there was a distinctive decrease in the percid population in a downstream direction. The percids comprised 6% of the community at the RED 0048A site, 2% at the RED 0048B site, and 0.18% of the community at the RED 0051B site.

Some of this shift in species and family compositions can be contributed to a change in habitat. There was a decrease in the riffle/pool length ratios from the upstream site to the site below Tyson effluent, 1/3.17 to 1/5.65, and then a slight decrease in the ratio again in the sample site below the City of Nashville, 1/4.6. This is also reflected in the IHI scores for each of the sites. However, some of changes may be due to some of the excessive algae growth that is occurring below the wastewater treatment facilities. This is possibly causing a decrease in the numbers of riffle and the non-tolerant species specimens and increasing the more tolerant and the pool species specimens.

The fish community at the RED 0048A site was more similar to the RED 0051B site than the site immediately downstream, RED 0048B. The lower two sites were the most similar to one another. In moving downstream, it would be expected that adjacent fish communities would be the most similar. The similarity scores may be indicating that there has been a change in the fish community structures below the discharges not fully caused by habitat changes. They may also be indicating that the community at RED 0051B has somewhat recovered but is now displaying differences in the communities due to ecoregion and/or habitat influences.

Another indication of the discharge and habitat/ecoregion influences on the fish communities is perhaps indicated in the Community Structure Index (CMI), Table F-5. The RED 0048A site scored 18 points, indicating that this site is only slightly impaired. Both of the lower sites scored 10 points indicating that these sites are moderately impaired. All three scores may be somewhat depressed because of natural habitat differences between major watersheds within the same ecoregion. However, even allowing some adjustment for this would not result in a different assessment of the lower two sites.

TABLE F-4

FISH COMMUNITY SIMILARITY INDICES					
Species			Relative Abundance		
RED	048A	048B	RED	048A	048B
048B	0.73		048B	0.63	
051B	0.83	0.86	051B	0.73	0.76

TABLE F-5*

COMMUNITY STRUCTURE INDEX			
Family	RED048A	RED048B	RED051B
Cyprinidae	2	4	2
Ictaluridae	2	0	4
Centrarchidae	4	2	0
Percidae	2	0	0
Sensitive Individuals	4	0	0
Primary TFL	4	4	4
Key Individuals	0	0	0
Diversity Index	0	0	0
Total Score	18	10	10

* Stoneroller population omitted.

Summary and Recommendations

The water quality investigation of Mine Creek implicated excess nutrient and BOD loading as the primary cause of water quality impairments in this stream. Prior to, and during, the 1997 survey the Tyson Foods plant was bypassing their treatment facility and discharging elevated concentrations of BOD and phosphorus. This loading produced near septic conditions for several hundred yards below their outfall, with dissolved oxygen concentrations ranging from 0.2 to 1.2 mg/L at station RED 0048B. This depleted D.O. pattern persisted down to site RED 0051B, with a minimum of 0.6 mg/L being observed. As verification of the persistent nature of the nutrient overload, the macroinvertebrate community at station RED 0048B consisted predominately of bloodworms—a species that can dominate an aquatic benthic habitat that is influenced by low dissolved oxygen concentrations. The 1998 survey indicated that the Tyson treatment facility was producing an effluent total phosphorus concentration of 4.1 mg/L compared with a value of 22.8 mg/L during the 1997 survey. However, an accurate evaluation of the condition of the stream during the 1998 survey was masked by an elevated stream flow due to groundwater recharge and substantial watershed runoff from a multi-day rainfall event during the week prior to the investigation. Dissolved metals analysis of samples collected during the 1997 survey revealed toxic concentrations of cadmium, 3.6 ug/L, at station RED0051A. The source of this cadmium would be the discharge of the City of Nashville, RED0051, which contained a cadmium concentration of 10.0 ug/L. Low flow conditions in the stream during the 1997 study could have allowed the upstream contamination at RED0051A due to the stations close proximity to the Nashville outfall. Cadmium concentrations upstream of RED0051A were less than 0.5 ug/L. Metals analyses performed during 1998 did not indicate toxic metal concentrations at any station. However, elevated concentrations of copper, 9.6 ug/L, present in the effluent of Tyson Foods contributed to a near toxic concentration of 5.4 ug/L at RED0048B.

It is recommended that total phosphorus and nitrate nitrogen monitoring be required for the Tyson Foods and Nashville treatment facilities in order to more accurately determine the source and degree of nutrient loads on Mine Creek. It is also recommended that both facilities initiate phosphorus reduction processes.

**APPENDIX F-1,
Collection Site Habitat Analysis**

Mine Creek Upper Site RED048A						
No.	Riffle		Run		Pool	
	Score	Length	Score	Length	Score	Length
1	50.3	60	44.2	70	46.8	300
2	32.5	60	36.0	50	44.4	100
3	32.2	40	47.4	80	46.6	80
4	37.2	15			44.5	80
5	28.0	15			54.8	40
6	32.0	20			37.0	60
7	47.0	20			34.3	70
Avg/Tot	37.03	230	42.53	200	44.06	730

Mine Creek Below Tyson RED048B						
No.	Riffle		Run		Pool	
	Score	Length	Score	Length	Score	Length
1	23.7	30	41.1	100	23.8	120
2	13.3	20	33.5	40	21.8	70
3	14.3	20	38.4	30	37.8	100
4	23.5	30	29.5	50	40.1	100
5	34.3	30			37.0	70
6	23.5	10			34.0	90
7	13.5	20			37.0	200
8	17.5	40			37.3	60
9					50.5	200
10					40.0	120
Avg/Tot	20.45	200	35.63	220	35.93	1130

APPENDIX F-1, (cont.)
Collection Site Habitat Analysis

Mine Creek Below Nashville RED051B						
No.	Riffle		Run		Pool	
	Score	Length	Score	Length	Score	Length
1	46.0	5	39.4	120	54.6	200
2	30.6	10	25.8	100	35.7	70
3	37.6	15	34.7	50	52.6	150
4	40.5	20	50.2	80	43.7	100
5	44.0	100	27.8	60	55.0	110
6	34.6	12			40.0	50
7	29.2	20			27.2	160
8						
Avg/Tot	37.50	182	35.58	410	44.11	840

In Stream Habitat Guide

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

Appendix F-2 - Fish Community

FAMILY & SPECIES	COMMON NAME	S E N	T F L	K E Y	RED048A		RED048B		RED051B	
					Num	% Com	Num	% Com	Num	% Com
Petromyzontidae	Lampreys									
<i>Ichthyomyzon sp.</i>	Emaciateds		P		16	1.08	2	0.33		
Lepisosteidae	Gars									
<i>Lepisosteus oculatus</i>	Spotted gar						1	0.16	6	1.11
Esoxidae	Pickerels									
<i>Esox americanus</i>	Grass pickerel			K	5	0.34			1	0.18
Cyprinidae	Minnows									
<i>Campostoma anomalum</i>	Central stoneroller		P		387	26.17	122	20.00	29	5.35
<i>Cyprinella venustus</i>	Blacktail shiner						3	0.49	6	1.11
<i>Luxilus chrysocephalus</i>	Striped shiner				379	25.63	22	3.61	9	1.66
<i>Lythrurus umbratilis</i>	Redfin shiner			K	7	0.47	4	0.66	1	0.18
<i>Notropis atrocaudalis</i>	Blackspot shiner				1	0.07				
Catostomidae	Suckers									
<i>Erimyzon oblongus</i>	Creek chubsucker				2	0.14	1.00	0.16		
<i>Minytrema melanops</i>	Spotted sucker			K	6	0.41	28.00	4.59	6	1.11
<i>Moxostoma duquesnei</i>	Black redhorse	S			10	0.68				
<i>Moxostoma erythrurum</i>	Golden redhorse				33	2.23				
Ictaluridae	Freshwater catfishes									
<i>Ameiurus natalis</i>	Yellow bullhead			K	11	0.74	43	7.05	19	3.51
<i>Noturus gyrinus</i>	Tadpole madtom						13	2.13	5	0.92
Aphredoderidae	Pirate perches									
<i>Aphredoderus sayanus</i>	Pirate perch				26	1.76	17	2.79	16	2.95
Cprinodontidae	Killifishes									
<i>Fundulus catenatus</i>	Northerns studfish	S			5	0.34				
<i>Fundulus notatus</i>	Blackstriped Topminnow				10	0.68	11	1.80	7	1.29
Poeciliidae	Livebearers									
<i>Gambusia affinis</i>	Mosquitofish				3	0.20	12	1.97		
Atherinidae	Silversides									
<i>Labidesthes sicculus</i>	Brook silverside				8	0.54	22	3.61		
Percichthyidae	Temperate basses									
<i>Morone mississippiensis</i>	Yellow bass				1	0.07				
Centrarchidae	Sunfishes									
<i>Lepomis cyanellus</i>	Green sunfish				27	1.83	14	2.30	19	3.51
<i>Lepomis gulosus</i>	Warmouth sunfish				1	0.07	1	0.16	5	0.92
<i>Lepomis macrochirus</i>	Bluegill sunfish				54	3.65	46	7.54	104	19.19
<i>Lepomis megalotis</i>	Longear sunfish				338	22.85	161	26.39	231	42.62
<i>Lepomis microlophus</i>	Redear sunfish				3	0.20				
<i>Lepomis punctatus</i>	Spotted sunfish				28	1.89	58	9.51	59	10.89
<i>Micropterus punctulatus</i>	Spotted bass				10	0.68	3	1.97	9	1.66
<i>Micropterus salmoides</i>	Largemouth bass				18	1.22	12	0.49	8	1.48
<i>Pomoxis nigromaculatus</i>	Black crappie				1	0.07			1	0.18
Percidae	Perches									
<i>Etheostoma gracile</i>	Slough darter			K	1	0.07	1	0.16		
<i>Etheostoma whipplei</i>	Redfin darter				87	5.88	12	1.97	1	0.18
<i>Percina caprodes</i>	Logperch				1	0.07				
Sciaenidae	Drums									
<i>Aplodinotus grunniens</i>	Freshwater drum						1	0.16		
Total Species//Total Numbers					29	1479	24	610	20	542
Effort(secs)//Catch per unit effort(min)					4546	19.52	4755	7.7	2061	6.05

Appendix M-1. Taxa list and sum of aquatic macroinvertebrates in Mine Creek TMDL survey, September 1997.

Taxa	RED0048A	RED0048B	RED0051B
Oligochaeta			5
Glossiphoniidae		3	3
<i>Branchiura</i>			5
Amphipoda		1	
<i>Hyaella</i>			1
<i>Stenonema</i>	11		1
<i>Hexagenia</i>			1
<i>Paracleodes</i>	2		
<i>Choroterpes</i>	2		
<i>Caenis</i>	57		
<i>Argia</i>			1
<i>Hetaerina</i>	3		
<i>Boyeria</i>	2		
<i>Orthemis</i>			1
<i>Corydalus</i>	1		
<i>Helicopsyche</i>			1
<i>Cheumatopsyche</i>	3		
<i>Psephenus (L)</i>	11		
<i>Stenelmis (A)</i>	3		
<i>Stenelmis (L)</i>	3	3	22
<i>Palpomyia</i>			1
<i>Hexatoma</i>	1	1	2
<i>Ablabesmyia</i>			8
Chironomidae	10		
<i>Chironomus</i>		141	81
<i>Corbicula</i>	2		1
	111	149	134
# rings	1	1	5

