**Cahaba River:**
**Biological and Water Quality Studies**
**Birmingham, AL**
**March/April, July and September, 2002**

**Science and Ecosystem Support Division**
**Ecological Assessment Branch**
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## CONTENTS

## ACKNOWLEDGMENTS

Rapid bioassessments, *in situ* water quality measurements, and habitat evaluations were conducted by Hoke S. Howard, Lonnie Dorn, Ron Weldon, Morris Flexner and Joe W. Compton of the USEPA Region 4, Science and Ecosystem Support Division (SESD), Athens, Georgia. Bob Quinn of the USEPA Region 4, SESD, Athens, Georgia and Dr. Ronald L. Raschke of RLR Associates, Athens, Georgia conducted periphyton and algal growth potential studies. Sediment characterization studies were conducted by Morris Flexner, SESD, and Chris McArthur and Hudson Slay of the USEPA Region 4 Water Management Division (WMD), Wetlands, Coastal and Watersheds Branch. Ed Decker of the USEPA, Region 4, WMD, Standards, Monitoring, and TMDL Branch provided the Introduction and Background sections and input to editing of the report. Hoke S. Howard, Morris C. Flexner, Bob Quinn, and Ronald L. Raschke co-authored the final report. Chemical analyses were conducted by the Analytical Support Branch of the USEPA Region 4,SESD, Athens, Georgia. Staff of the Alabama Department of Environmental Management, specifically, Lynn Sisk, Vickie Hulcher, and Bill Lott, provided valuable information on past studies, site access, and NPDES discharge location and information. Pat O'Neil and staff of the Geological Survey of Alabama conducted under contract to EPA, Region 4 an ichthyological survey of the Cahaba River; their report is provided within. Don Norris, Donnie Williams, and Trudy Stiber of the USEPA Region 4, SESD, Office of Quality Assurance and Data Integration provided GIS mapping capabilities and land use data. Peer input was provided by John Marlar, USEPA Region 4, WMD and Mark Koenig of the USEPA Region 4, SESD, Athens, Georgia, Dave Melgaard of the USEPA Region 4, WMD and Vickie Hulcher of the Alabama Department of Environmental Management.

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## SUMMARY OF FINDINGS

! Excessive sedimentation and nutrient enrichment are affecting the biology of the Cahaba River watershed. Deleterious effects of sediment deposition on the fish and benthic macroinvertebrate communities were evident in the mainstem Cahaba River below Trussville to below Helena and at several tributaries to the Cahaba (unnamed tributary to Little Cahaba Creek, Little Cahaba River, and Buck Creek). Excessive nutrient inputs (nitrogen and phosphorus) to the Cahaba system from both point and non-point sources have allowed the excessive and widespread growths of filamentous algae.

! Past studies of the Cahaba River watershed (Onorata et al. 2000) in the Birmingham area have documented the decline in pollution-intolerant fish species with a concomitant increase in pollution-tolerant fish species. Data from an ichthological survey conducted under contract for the 2002 EPA studies (O'Neil 2002) reveals this same pattern. Endangered species such as the gold-line darter and the Cahaba shiner have been adversely affected. O'Neil (2002) suggests possible causes for disruptions to the fish community from nutrient loading (point and non-point sources), possible nitrogen deposition originating from the high automobile density in the immediate airshed, sediment bedload and perhaps runoff of toxics and other associated non-point sources.

! The filamentous green alga, <u>*Cladophora*</u>, often associated with nutrient enrichment and nuisance conditions, was predominant and widespread during the study.

! Total phosphorus and total nitrogen ranged from 12 to 960 µg/L and 230 to 21,094 µg/L, respectively. The upper reaches of the Cahaba were generally phosphorus limited, followed by nitrogen limitation in the middle segment, and then tending toward phosphorus limitation again in the lower reaches.

! Cahaba waters of 12 µg/L TP and 230 µg/L TN maintained as a monthly mean should restore the Cahaba system to maximum use by reducing nuisance excursions of over 40% periphyton cover and over 100 mg/m$^2$ chlorophyll *a* biomass.

! The mainstem Cahaba from below Trussville to Helena contains excessive amounts of sediments that have degraded the habitat and altered the benthic community structure and species diversity within this section of the river. Sediment characterization studies documented a shift from coarser substrates at the upper Cahaba River stations to finer substrates at the Cahaba River stations below Trussville and the heavily developed middle reach of the Cahaba. The literature documents that the preferred substrates of pollution-sensitive benthic macroinvertebrates, such as the Ephemeroptera, Plecoptera, and Trichoptera, are the coarser substrates (gravels, pebbles, cobbles) whereas fine particle substrates (sand, silt) are preferred by pollution-tolerant benthic macroinvertebrates (chironomids and other burrowing forms). EPT fauna, common in the coarser substrates, are more readily available as forage for fish than the benthic macroinvertebrates common to the finer substrates.

! GIS land change analysis for the Cahaba River watershed documented dramatic increases in the "disturbed" land use class since 1990. As of 1998, over 38% of the watershed falls into the "disturbed' land use class; this is up from 8.8% in 1990. Land use analysis of Buck Creek, a major tributary to the Cahaba River, indicates that over 63% of that watershed falls into the "disturbed" land use class. With the large amount of both impervious and disturbed lands in the watershed, storm-generated runoff, laden with sediments and/or nutrients, represents potential impacts to both water quality and biology of the Cahaba system.(Welch, E.B. 1992; Waters, T.F. 1995)

! Results of studies by EPA in 2001 and 2002 raise an issue concerning listing under the state's §303(d) list (1998; 2000). The issue involves that section of the Cahaba River above US 280 to I-59 which is now listed for siltation. It is apparent, based on current EPA studies, that the §303(d) listing of this section of the mainstem Cahaba River should be reevaluated to possibly include nutrients.

! An examination of a Permit Compliance System (PCS) retrieval file of the major discharges (>1 mgd) to the Cahaba River and associated tributaries revealed incidences of NPDES permit violations, for nutrient or nutrient related parameters, over the last several years.(Permit Compliance System, Database retrieval, 10/15/2002) Compliance issues within the Cahaba watershed need to be addressed.

## INTRODUCTION

In order to characterize the present biology and water quality, the U.S. EPA Region 4, Water Management Division (WMD) requested staff of the Science and Ecosystem Support Division (SESD) to conduct studies of the Cahaba River and associated tributaries during the spring and summer of 2002. Studies were conducted in March /April, July and September of 2002 and focused on the causes of impairment in the Cahaba River. The objective of these studies was and is to provide supporting information for determination of an appropriate target for the development of a Total Maximum Daily Load (TMDL) for the §303(d) listed segments of the Cahaba River.

Under §303(d) of the Clean Water Act, states are required to compile a list of impaired waters and submit that list to EPA for approval. Impaired waters are those which do not meet applicable state water quality standards, i.e., do not support their designated use(s). These waters are then scheduled for development of a TMDL, which provides a plan that can be implemented to restore the designated use of the water. Federal regulations require that states consider all existing and readily available information when compiling a §303(d) list. EPA considers the formal listing process under the Endangered Species Act to be readily available information, and the loss of use of a water by a listed aquatic species due to degradation of water quality and/or aquatic habitat to be evidence of impairment. Consequently, such waters must be included on state §303(d) lists and addressed by TMDLs designed to restore conditions suitable for the endangered species. States have responsibility for the development of TMDLs, which are subject to EPA approval. (Note: In this case, the Alabama Department of Environmental Management (ADEM) is working with EPA to determine an appropriate target for this TMDL. The applicable water quality criteria in this case is narrative, ADEM Administrative Code, Rule 335-6-10-.06(c) under Minimum Conditions Applicable to All State Waters. Therefore, the process of developing a target for this TMDL will require a numeric translation of a narrative water quality criteria to reflect a level of nutrients that would protect the aquatic habitat for the species of concern.

## BACKGROUND

The U.S. Fish and Wildlife Service (USFWS) has listed several threatened or endangered aquatic species (2 fish and 8 mollusks) whose historical range included the Cahaba River and its tributaries. These species are now seriously threatened or extirpated there, and USFWS has concluded the main cause is habitat degradation resulting from excess nutrients and sediments. Consequently, Alabama's 1998 §303(d) list (and subsequent lists) includes portions (listed in several segments) of the mainstem of the Cahaba River, i.e., (1) a portion of the Cahaba River mainstem, impaired due to nutrients, from the Highway 280 bridge to the Highway 82 bridge at Centreville, and (2) a larger portion of the Cahaba River mainstem, impaired due to siltation, from the I-59 bridge to the Highway 82 bridge at Centreville. These two mainstem Cahaba reaches are depicted in Figure 1 which provides the study reach and sampling stations.

Field biologists of the USFWS have characterized the degradation of essential habitat caused by excess nutrient enrichment more specifically as an overabundance of attached filamentous green algae, which variously covers, coats, and fills-in substrate, rendering those surfaces and crevices either unavailable or unuseable by the listed species for subsistence and reproduction, during critical periods of their life cycle. This condition has resulted from a shift in algal periphyton community structure from historical diatom domination to a filamentous algae domination. This change, coupled with the effect of excess sedimentation, has had adverse affects on feeding, physical attachment, and reproduction for all the listed species.

The undesirable shift in algal community structure is presumed to be a response to elevated concentrations of phosphorus, and possibly nitrogen, above historical levels in this segment of the Cahaba River. The levels of instream phosphorus/nitrogen which drive this undesirable shift appear to be much lower than the extremes commonly seen in more classical excess eutrophication problems and the associated depletion of instream dissolved oxygen. Since the desired levels of TP/TN can be reasonably assumed to be significantly below that which would trigger eutrophication driven dissolved oxygen crashes, traditional eutrophication modeling with dissolved oxygen endpoints would not likely be an effective tool in this situation, i.e., to restore essential habitat for these species. The approach, in this case, will require accurate prediction of management levels of total phosphorus/nitrogen in ranges that capture the relationship between algal community structure as affected by instream TP/TN concentration. A determination of the critical levels (and timing) of the TP/TN, below which the historical diatom domination of the periphyton community prevails will allow selection of an appropriate target and subsequent development of a TMDL that can prescribe nutrient loads protective of the designated use. Then implementation of that TMDL could be expected to produce load reductions that would result in a reverse shift of the recent trends and restoration of critical aquatic habitat, returning the use of the water for the affected species.

## STUDY AREA

The headwaters of the Cahaba River originate to the east of Irondale, Alabama in the Ridge and Valley ecoregion (67). The river flows through subecoregions 67f (Southern Limestone/DolomiteValleys & Low Rolling Hills), 67g (Southern Shale Valleys) and 67h (Southern Sandstone Ridges). Ecoregion 67f is composed of mixed and deciduous forests, pasture and cropland and a physiography characterized by undulating to rolling valleys with rounded hills and some steep ridges. Streams in the Southern Limestone/Dolomite Valleys and Low Rolling Hills are moderate to low gradient with bedrock, cobble, gravel, and sandy substrates (Griffith et al. 2000). The Southern Shale Valleys are composed of mixed and deciduous forests with some pasture and cropland and a physiography characterized by undulating to rolling valleys, and some low, rounded hills and knobs. Streams in the Southern Shale Valleys are moderate to low gradient with bedrock, cobble, gravel, and sandy substrates (Griffith et al. 2000). Ecoregion 67h is composed of mixed and deciduous forest and a physiography characterized by high, steep ridges, some broader ridges to the south and some narrow intervening valleys. Streams in 67h are high to moderate gradient with rock, cobble, and gravel substrates.

All study station locations are provided in Table 2 and shown on Figure 1; photos of most study stations are presented in Appendix A.  Major permitted municipal wastewater discharges are shown on Figure 1 and also provided in Table 1.

Cahaba River & Associated Tributaries, March/April 2002
Sampling Locations and Permitted Discharges

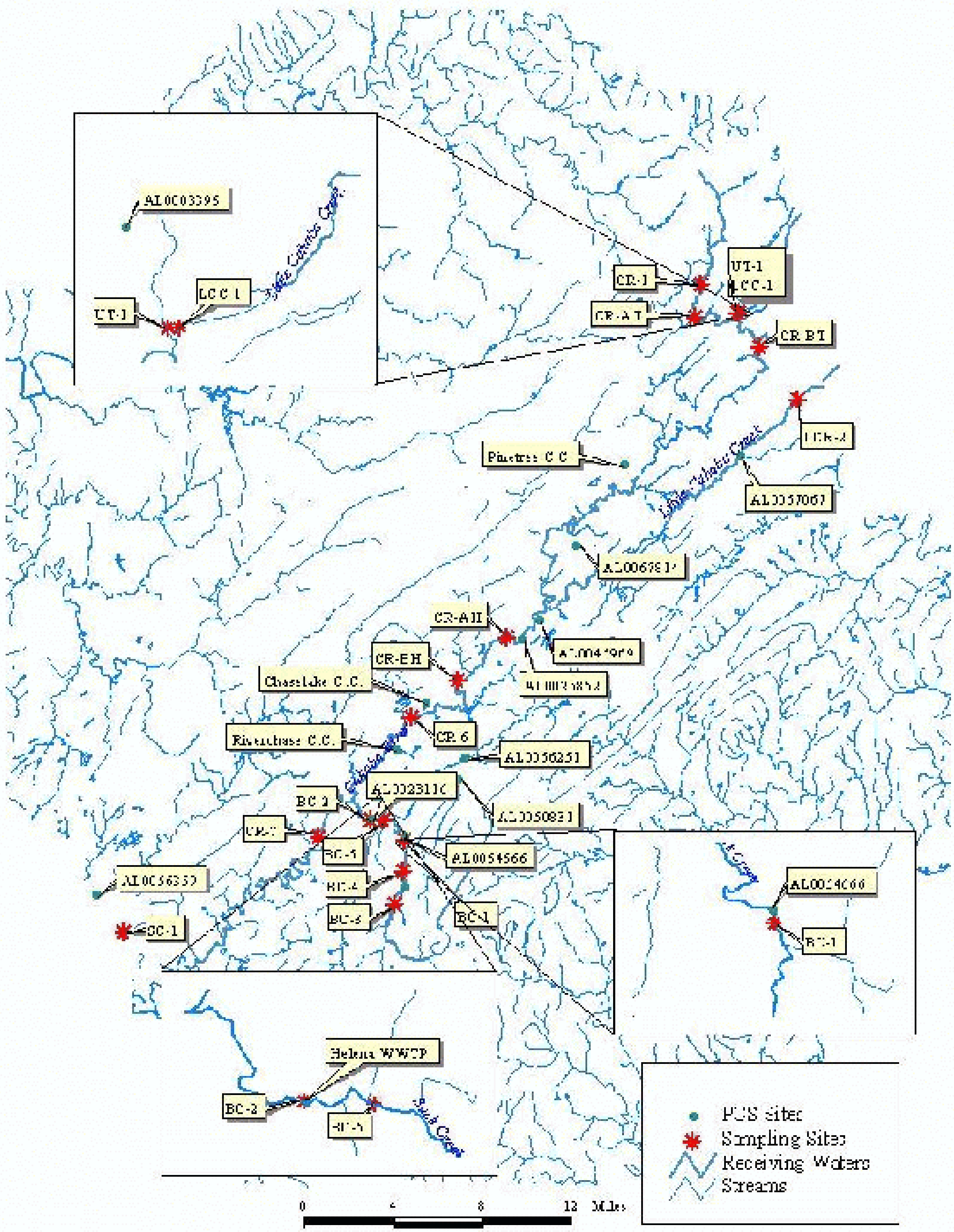


Figure 1

**Table 1. NPDES permitted discharges, Cahaba River drainage**

| Facility | NPDES | Design Flow MGD | Disinfection method |
|---|---|---|---|
| Gold Kist WWTP | AL0003395 | n/a | *Cl2/DeCl2 |
| Trussville WWTP | AL0022934 | 4 | *UV |
| Liberty Park WWTP | AL0067814 | 1.5 | Cl2/DeCl2 |
| Birmingham Riverview WWTP | AL0045969 | 1.5 | UV |
| Hoover-Inverness WWTP | AL0025852 | 1.2 | UV |
| Birmingham Hwy 411 WWTP | AL0055255 | 0.5 | UV |
| Leeds WWTP | AL0067067 | 2.0 | UV |
| Cahaba River WWTP | AL0023027 | 12.0 | Cl2/DeCl2 |
| Hoover-Riverchase WWTP | AL0041653 | 1.5 | UV |
| Alabaster WWTP | AL0025828 | 3.0 | UV |
| Pelham WWTP | AL0054666 | 4.0 | UV |
| North Shelby County WWTP | AL0056251 | 3.0 | UV |
| Oak Mountain State Park WWTP | AL0050831 | 0.94 | Cl2/DeCl2 |
| Helena WWTP | AL0023116 | 4.95 | UV |
| Tannehill State Park WWTP | AL0056359 | 0.08 | Not required |
| Centreville-Brent WWTP | AL0044857 | 1.6 | Not required |

note: Oak Mountain has 4 plants w/4 flows

* Cl2/DeCl2 = Chlorination/Dechlorination
UV = Ultraviolet radiation

**Table 2. Sampling station locations, Cahaba River and associated tributaries, March/April 2002, July 2002, and September 2002.**

| Station No. | Stream | Locale | Lat/Long |
|---|---|---|---|
| UT-1 | Unnamed trib L. Cahaba Ck | Camp Coleman Rd. | N33 37 35.2 W86 34 02.8 |
| LCC-1 | L. Cahaba Ck. | Camp Coleman Rd. | N33 37 35.4 W86 33 58.9 |
| CR-1 | Cahaba R. | CR 132 | N33 38 36.4 W86 35 48.5 |
| CR-AT* | Cahaba R. | US 11/SR 7 | N33 37 23.5 W86 36 01.0 |
| CR-BT[1] | Cahaba R. | CR 10 | N33 36 17.7 W86 32 56.8 |
| LCR-2 | L. Cahaba R. | US 411 | N33 34 20.0 W86 31 06.7 |
| CR-AH[2] | Cahaba R. | CR 29 | N33 24 56.3 W86 44 24.8 |
| CR-BH | Cahaba R. | off Old Rocky Ridge Rd; Riverford Dr. | N33 23 13.9 W86 46 39.3 |
| CR-6 | Cahaba R. | Old Montgomery Rd. (Bains Bridge) | N33 21 48.6 W86 48 46.4 |
| BC-1 | Buck Ck. | CR 52 | N33 17 08.2 W86 48 58.3 |
| BC-2 | Buck Ck. | SR 261 | N33 17 50.4 W86 50 35.0 |
| BC-3 | Buck Ck. | CR 44/ 1st Ave. | N33 14 38.0 W86 49 19.6 |
| BC-4 | Buck Ck. | Keystone Rd.; off CR 64 | N33 15 55.4 W86 48 58.6 |
| BC-5 | Buck Ck. | upstream confluence w/Prairie Ck. | N33 17 49.3 W86 50 15.4 |
| CR-7 | Cahaba R. | CR 52 | N33 17 06.4 W86 52 59.5 |
| SC-1 | Shades Ck. | CR 12, Grey Hill Rd. | N33 13 15.9 W87 01 57.6 |
| CR-9 | Cahaba R. | CR 24 | N33 05 48.2 W87 03 15.1 |
| CR-11 | Cahaba R. | US 82 nr. Centreville | N32 56 44.4 W87 08 24.8 |

* used as site control in lieu of CR-1; rains prior to sampling eliminated use of CR-1 as site control
[1]same as CR-2 in EPA August 2001 study
[2]same as CR-5 in EPA August 2001 study

## STUDY METHODS

### Benthic Macroinvertebrates

Benthic macroinvertebrates are an excellent tool for detecting stress in aquatic systems. Due to their limited mobility and relatively long life span, benthic macroinvertebrates integrate and reflect water quality effects over time. Rapid bioassessments (USEPA, 1999) of the benthic macroinvertebrate community were conducted at stations on the Cahaba and Little Cahaba Rivers.

A multi-habitat approach (USEPA Region 4, 2002) was utilized where habitats were sampled according to a strict assignment as follows:

Riffles - 3 “kicks” in the faster current and 3 “kicks” in the slower current,
Snags/Woody debris - 5 pieces washed in sieve bucket or standard biological D-frame dipnet,
Leaf packs (CPOM) - equivalent to half dipnet,
Undercut banks - 6 one meter jabs with D-frame dipnet, and
Bottom substrate - 3 sweeps or kicks (disturb sediment to 3 cm. depth).

Benthic macroinvertebrate collections were “coarse” sorted in the field to remove larger sticks, leaves, and rocks in order to keep the sample size manageable and also assure adequacy of preservation. Collections from all habitats were combined to comprise one sample per station. Sample collections were stored in plastic, one quart containers with 90% ethanol. Both inside and outside labels, with such information as station designation, stream name, project name, date/time, and sample type, were placed on sample containers.

Laboratory processing of the benthic macroinvertebrate samples involved sorting of organisms under a illuminated magnifying lamp. Following sorting, benthic macroinvertebrates were identified to the genus level and number of specimens were recorded on the laboratory bench sheets. Benthic macroinvertebrate data was evaluated through the use of biometrics utilized for analysis of the EPA August 2001 data.

### Snail Density

Herbivory by abundant populations of snails was an issue raised during the August 2001 study. Field personnel had observed large snail populations and evidence of herbivory at that time. In order to shed some light on this issue, a simple measure of snail density was conducted during the summer (July) 2002 studies. A linear 50' transect was established in the riffle/run and snails were counted from three replicate, randomly selected, square foot grids.

**Periphyton**

Sixteen stations were targeted for placement of periphytometers and measurement of periphyton percent cover in the springtime. These included all stations in Table 2 except station CR11. All periphytometers were retrieved following the incubation period. The summer strategy reduced station coverage to ten key stations for periphytometer placement and percent periphyton cover assessment. These stations were CR-1, UT-1, CR-AT, CR-BT, CR-AH, CR-BH, BC-2, CR-6, CR-7, and SC-1. Periphytometers were picked up at all of these stations except CR-BT, which was missing.

Periphytometers were placed in the open canopy of stream runs and toward the middle if possible. Where canoe traffic was expected, periphytometers were placed more toward the side of the stream. One periphytometer holding eight slides was placed at each station. Two periphytometers were placed at CR-7 for quality assurance purposes. Periphytometer incubation period for the spring and summer was expected to last four and three weeks respectively. However, rain and high flows in the springtime hindered pickup at some stations. Periphytometers at stations SC-1, CR-6, BC-1, BC-3, BC-4, and BC-5 incubated from twenty-seven to twenty-nine days. Periphytometers that remained in the water from forty-one to forty-three days included stations BC-2, CR-1, UT-1, LCC-1, CR-AT, CR-BT, LCR-1, LCR-2, and CR-AH. Stations CR-7 and CR-BH were not collected until day 70. The slides had good growths of algae on them and there were no signs of sloughing; some herbivores were on a few slides. The station UT-1 periphytometer was found sitting out of the water, and was not used for chlorophyll *a* analysis. All of the stations were processed for diatom analyses. The rationale being that those growths had reached and remained at "carrying capacity," and even though there was probably herbivory, the slide scrapings and processing would include diatom frustules in the herbivores and their excretions on the gelatinous mat of the slide. Additionally, outlier tests showed that none of the stations were outliers. During the summer, periphytometers incubated for twenty to twenty-one days or approximately three weeks.

At each station, slides were selected randomly from the periphytometers - two slides for species diversity measurement and two slides for chlorophyll measurements. One slide each for species diversity analysis were placed in two separate bottles containing 1% gluteraldehyde. One slide was analyzed, the other slide was held in reserve for backup or duplicate analysis. In the same manner two slides for chlorophyll a measurements were placed in amber bottles and put on ice immediately. One was analyzed, the other held in reserve. EPA Region 4 chain-of-custody procedures were in place in the field and the laboratory (USEPA, 2002). Ten percent of the samples held in reserve were analyzed for quality control checks.

Slides for diatom analysis were scraped on both sides with a razor blade into a receptacle. The scraped material was placed in a Waring® blender, diluted with distilled water, and broken up into a slurry for placement on cover slips. Diatoms on cover slips were incinerated to free them of organic matter and better expose the taxonomic markings on the frustules of cells. After incineration, they were mounted in HYRAX®. Over 300 frustules were identified and counted under a 1000X magnification American Optical microscope.

Slides for chlorophyll analyses were scraped on both sides with a razor blade into a beaker. Approximately 10 mL of 90% acetone solution was used in transferring the periphyton to the beaker. The periphyton/acetone mixture was then poured into a glass grinding tube and macerated for approximately one minute with a teflon tipped tissue grinder. After grinding, the sample was transferred into a disposable 50 mL screw-cap centrifuge tube and the total volume adjusted to 25 mL with 90% acetone. Samples were shaken vigorously and placed in the refrigerator at 4 $^{o}$C to steep overnight. The following day, samples were clarified by filtering through a solvent resistant disposable syringe filter into a clean 50 mL centrifuge tube. Corrected chlorophyll *a* in the periphyton samples was determined by spectrophotometric method (EPA Method 446.0).

Periphyton cover was measured using the point-intercept approach recommended in the Rapid Bioassessment Protocols (USEPA, 1999). For this measurement, emphasis was put on stream runs with the exception that three stations in the riffle habitat were included in the summer study (CR-1, CR-6, and CR-7).

At each station and habitat type, two transverse transects were selected randomly along a stretch of stream. Each transect was divided into three equidistant sections. Within each section a point was selected randomly for placement of a viewing box. The viewing box was a half meter squared plexiglass box with a 100-square grid. Growths within a square were included in the percent cover measurement. In determination of periphyton percent cover, included were algal filaments, chains, tubes, stalks, and one widespread submerged moss, *Fontinalis*, because filamentous algae were intertwined among its "leaflets." Also, its growths would contribute to the reduction of habitat space for the endangered clams and fishes. Six views or percent measures were attempted at each habitat type and station. When the water level was beyond knee deep or sediment clouds obscured the view, fewer points or subsamples were attempted. When water was deeper in the spring at some points, 4-inch or 6-inch diameter tubes were used to measure percent cover. When they were used, four sequential views were made next to each other at each point to increase area viewed. Use of the tubes was at stations CR-6, LCC-1,and UT-1. These areas were much smaller, but were included in the analysis. It is believed that the counts were conservative throughout the study, and if anything, counts erred toward smaller percentages. The periphyton growths were very heterogenous exhibiting a broad range of cover at most stations (Appendix D, tables 5 & 6). Collections of soft periphyton along the transects were preserved in 1% gluteraldehyde and identified to genus.

At three sites, CR-1, CR-6, and CR-7, periphyton samples were collected from natural substrate. At each site, three samples were collected from a known area of substrata at random points along a transect across the riffle area. Each sample was placed in a plastic container and put on ice until returned to the laboratory for later analyses. Chlorophyll *a* concentration was determined by spectrophotometric method following extraction in 90% acetone (EPA Method 446.0).
All statistical analyses were conducted with the program STATISTICA© version 6 (Statsoft). Data were, when appropriate, transformed to fit the best normal distribution using the Shapiro-Wilkes test for small sample numbers.

## Physical

The quality of the physical environ is a major determinant of biological diversity. Habitat evaluations, when compared to reference sites or site specific control sites, identify degraded conditions and the severity of such degradation. Streams in the Cahaba drainage required use of the High Gradient habitat form (USEPA, 1999) since they drain moderate to high gradient landscapes. Natural high gradient streams have substrates characterized by coarser sediment particles (i.e., gravel or larger) or frequent coarse particulate aggregations along stream reaches. Parameters considered as part of the habitat evaluation are: epifaunal substrate (available cover), embeddedness, sediment deposition, channel alteration, frequency of riffles, bank stability, and riparian zone integrity.

## Stream Geomorphology and Classification

Stream cross-sectional surveys, stream slopes, and Wolman "pebble counts," were conducted and determined according to methods prescribed by Harrelson, et. al (1994), Rosgen (1996), Leopold, (1994) and Wolman (1954) and according to the Ecological Assessment Standard Operating Procedures and Quality Assurance Manual (2002). Conventional surveying equipment (e.g., Topcon® total station) was used for the cross-sectional profiles and to calculate the channel slopes for the Cahaba River watershed stations. Slopes were surveyed from the respective edges of water within the river or creek (right or left bank from upstream to downstream) extending approximately 600-1200 ft. depending on the line-of-sight at each station. Pebble counts were collected using Wentworth size classes according to Wolman (1954). Particles smaller than 2mm were described as either very coarse, coarse, fine, or very fine sands, or "silt/clay"using a texture-by-feel method and the aid of a waterproof sand gauge. Representative riffles were sampled from bankfull to bankfull within the channel, perpendicular to flow, at nine of the seventeen study locations and an effort to collect a minimum of 100 particles at each riffle was made. Each particle that was selected from the streambed surface at each site that was >2mm was measured with a metric ruler along its median axis. A combined cumulative percent plot was calculated on a $\log_{10}$ scale to calculate the particle size distributions and median particle sizes or $D_{50}$ for each station (Appendix E). Each sample site was classified by stream type according to Rosgen (1994). Additionally, an evaluation as to which of the six stages of the channel evolution model (CEM) occurred at each site was made according to Simon (1989).

## *In situ* Water Quality

Instantaneous measurements of pH, dissolved oxygen, conductivity, and water temperature may identify water quality conditions which may affect aquatic biota. In addition, such parameters may reveal exceedance(s) of state water quality standards relative to these parameters.

*In situ* water quality measurements were made prior to biological sampling and the habitat evaluation. The field instrument utilized, a Hydrolab Quanta®, was positioned just below the water surface in an undisturbed (upstream) area of the study station. Water quality data was recorded in the field record book and included pertinent station information (station number, date, time, etc.). Field instruments used for the *in situ* water quality measurements were calibrated according to the manufacturer's instructions and USEPA Region 4, Standard Operating Procedures (USEPA, 2002).

## Water Quality Sampling

Surface water samples were collected from the 17 Cahaba River and tributary stations listed in Table 2. Sampling protocol followed SESD Standard Operating Procedures (USEPA, 2002) and/or Standard Methods (APHA, 1995). Water quality samples were collected for nutrients, chlorophyll *a*, and algal growth potential tests (AGPT). Sample containers, preservatives and methods of analysis are given in Appendix C, Table C1. The nutrient samples were preserved to pH less than 2 with 10% $H_2SO_4$ at the time of collection.

Chlorophyll samples were filtered through GF/C glass fiber filters on site. After filtration, the filters were folded in half, wrapped in aluminum foil, labeled with station name, date, time, and volume filtered on labeling tape and stored in a water-tight container on ice. Corrected chlorophyll *a* was determined using the fluorometric procedure (EPA Method 445.0).

Ten stations were sampled for algal growth potential and limiting nutrient tests. Grab samples were collected in two liter autoclavable bottles. The AGPT samples were analyzed according to the procedure described in *The Selenastrum capricornutum Printz Algal Assay Bottle Test* (Miller et al., 1978).

All water samples were stored on ice at $4^oC$ until returned to SESD laboratory for processing. Handling, custody, and transport of samples followed guidelines described in the Ecological Assessment Laboratory Operations and Quality Assurance Manual (USEPA,2002).

## Flow

During the study, estimates of stream flow were obtained from existing USGS stations or by means of stream gaging by the field team. In-stream flow measurements were accomplished by use of a standard pygmy current meter and a wading rod. Due to time constraints and the availability of USGS data, stream velocity measurements by the field team were measured at the 0.6 foot depth location and limited to quarter point locations along the stream width. Stream depth and width were determined with a wading rod and cloth/steel engineers tape.

## QUALITY ASSURANCE/QUALITY CONTROL

Field and laboratory methods utilized on this project adhered to USEPA approved guidance and methodology (USEPA, 2002). For QA/QC purposes, duplicate sampling was conducted at one of the sampling stations.

## STUDY RESULTS

### Benthic macroinvertebrates

As discussed in the EPA August 2001 study report, a valid ecoregional reference site from a biological perspective is not available for the Ridge and Valley ecoregion. Previously, station CR-1 was utilized as a site control for the August 2001 studies. However, rains prior to sampling and evidence of scouring prevented the use of CR-1 as a site control for the March/April 2002 studies. As a result, station CR-AT, approximately 1.4 miles downstream of CR-1 was utilized as a site control. An examination of March/April 2002 metric results indicated CR-AT was a suitable site control. For example, station CR-AT had the highest number of taxa collected (36) and a large number of pollution-sensitive EPT taxa (15) were present.

Although benthic macroinvertebrate samples were collected during the July 2002 (summer) sampling, extremely low water levels precluded the utility of sample analysis since comparability and representativeness would be severely affected.

Results of Rapid Bioassessments identified impairment of the benthic macroinvertebrate community at three tributaries to the Cahaba River: the unnamed tributary (UT-1), Little Cahaba River (LCR-2) and Buck Creek (BC-2). In addition, mainstem Cahaba River stations (CR-BT, CR-AH, CR-BH, CR-6 and CR-7), with the exception of CR-AT, exhibited some degree of impairment based on multimetric analysis of the benthic macroinvertebrate data. A complete summary of metric results for benthic macroinvertebrate data is presented in Table 3; habitat evaluation scores are also included in this table.

The following benthic metrics, utilized during the 2001 study, were used for the 2002 studies:

• EPT Index - summation of the total number of taxa representing the Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies),

• Taxa Richness - total taxa collected from the site,

• % EPT - percentage of the total fauna, numerically, represented by the generally pollution-sensitive Ephemeroptera, Plecoptera, and Trichoptera,

• % Ephemeroptera - percentage of the total fauna, numerically, represented by Ephemeroptera,

• Biotic Index (genus level) - overall community pollution tolerance at a site; takes into account pollution tolerance values for individual organisms and their abundance,

• % Dominant Taxon - measures the dominance of the single most abundant taxa,

• Indicator Assemblage Index (IAI) - measures change in the relative abundance of tolerant and intolerant organisms by contrasting numerical abundances of these organisms at the reference or site control to the numerical abundances of other stations. IAI is calculated as follows:
IAI = 0.50 (%EPTb / %EPTa + %CAa / %Cab),

where:

0.50 = constant
%EPTb = total relative abundances of EPT fauna at test site
%EPTa = total relative abundances of EPT fauna at site control
%CAa = total relative abundances of Chironomids and Annelids at site control
%Cab = total relative abundances of Chironomids and Annelids at test site.

Of these seven benthic metrics, six emerged as sensitive to stress and aided in identifying perturbation relative to the benthic macroinvertebrate community: **EPT Index, Taxa Richness, % EPT**, **% Ephemeroptera**, **% Dominant Taxon**, and the **Indicator Assemblage Index (IAI)**.

The **EPT Index** ranged from 4 to 13 at the test sites while the site control, CR-AT, had an EPT Index of 15 (Table 3). The EPT Index decreases in response to increasing perturbation. The lowest EPT Index values were found at UT-1 ( the unnamed tributary), BC-2 (Buck Creek), and Little Cahaba River (LCR-2); EPT Index values at these three stations were 4, 4, and 6 , respectively. The remaining mainstem Cahaba River stations had an EPT Index ranging from 7 to 11 (Table 3). Shades Creek (SC-1) had an EPT Index of 13 which is quite similar to that of CR-AT (15), the site control.

The greatest **Taxa Richness** was seen at CR-AT; 36 taxa were collected from CR-AT. Four of the six Cahaba River mainstem stations (CR-AT, CR-BT, CR-BH and CR-6) had Taxa Richness values in the range of 31 to 36; also within this range was Buck Creek station BC-4 (31). Taxa Richness decreases in response to increasing perturbation. The lowest Taxa Richness values were at UT-1 (24) and BC-2 (25). Similar Taxa Richness values ranging from 26 to 29 taxa were observed at LCC-1, LCR-2, CR-AH, CR-7, SC-1 and BC-3.

**Table 3. Summary of Metric and Habitat Evaluation Results, Cahaba River and associated tributaries, March/April, 2002.**

| Station | EPT Index | Taxa | %EPT | %Ephem | BI | %Dom Tax | IAI[1] | %Chir& Ann | Hab [4] eval. |
|---|---|---|---|---|---|---|---|---|---|
| LCC-1 | 9 | 26 | 42 | 31 | 4.25 | 38 | 1.19 | 8.9 | 155 |
| UT-1 | 4 | 24 | 41 | 2 | 6.15 | 28 | 0.72 | 20.72 | 149 |
| CR-AT* | 15 | 36 | 55 | 39 | 5.30 | 9 | n/a | 14.41 | 152 |
| CR-ATa | 13 | 37 | 44 | 24 | 5.51 | 12 | n/a | 33.84 | n/a |
| CR-BT[2] | 10 | 32 | 45 | 26 | 5.11 | 19 | 0.61 | 35.07 | 133 |
| LCR-2 | 6 | 28 | 8 | 5 | 6.68 | 44 | 1.09 | 7.58 | 85 |
| CR-AH[3] | 9 | 29 | 13 | 9 | 4.79 | 45 | 0.35 | 30.93 | 100 |
| CR-BH | 11 | 33 | 45 | 11 | 6.01 | 29 | 0.62 | 34.29 | 127 |
| CR-6 | 7 | 31 | 30 | 9 | 5.47 | 26 | 1.78 | 4.76 | 136 |
| CR-7 | 9 | 27 | 59 | 32 | 5.72 | 24 | 1.25 | 10.05 | 150 |
| SC-1 | 13 | 27 | 58 | 47 | 4.83 | 23 | 2.04 | 4.74 | 169 |
| BC-2 | 4 | 25 | 19 | 13 | 6.14 | 45 | 0.29 | 58.51 | 123 |
| BC-3 | 10 | 29 | 24 | 20 | 5.58 | 62 | 1.33 | 6.47 | 118 |
| BC-4 | 8 | 31 | 36 | 26 | 5.53 | 21 | 0.56 | 30.09 | 143 |

* used as site control in lieu of CR-1; 1.1" rain prior to spring sampling eliminated use of CR-1 as site control

[1] Indicator Assemblage Index -change in relative abundance of tolerant and intolerant organisms; Scoring criteria as follows:

IAI >0.80 No impairment
IAI 0.65 - 0.80 Minimal impairment
IAI 0.50 - 0.64 Substantial impairment
IAI <0.50 Excessive impairment

[2]same as CR-2 in EPA August 2001 study

[3]same as CR-5 in EPA August 2001 study

[4] Habitat evaluation categories:
166-200 = optimal
113-153 = suboptimal
60-100 = marginal
0-43 = poor

CR-ATa = duplicate sample

Results for the metric **%EPT** were highest at CR-7 (59), SC-1 (58), and CR-AT (55). High density of the facultative Baetid mayflies (Ephemeroptera: Baetidae) and facultative *Cheumatopsyche* caddisflies (Trichoptera) contributed 34 of the 59 %EPT at CR-7.

The metric %EPT decreases in response to increasing perturbation. Little Cahaba Creek (LCC-1), the unnamed tributary (UT-1), and two mainstem Cahaba River stations (CR-BT and CR-BH) had %EPT values in the range from 41 to 45 (Table 3). High densities of facultative benthic macroinvertebrates affected the %EPT results at LCC-1, UT-1 and CR-BH. A high density of the facultative mayfly *Stenonema* (Ephemeroptera) contributed 29 of the 42%EPT at LCC-1. The facultative Hydropsychid caddisflies (Trichoptera) contributed 39 of the 41%EPT at UT-1. Density of the facultative Hydropsychid caddisflies (Trichoptera) contributed 31 of the 45%EPT at CR-BH.

A group of six stations, LCR-2, CR-AH, CR-6, and Buck Creek stations 2, 3, and 4, exhibited a range of %EPT from 8 to 36 (Table 3). The Little Cahaba River (LCR-2), a tributary to the Cahaba had the lowest %EPT (8) followed by CR-AH (13), a mainstem Cahaba River station, and Buck Creek station BC-2 (19).

Results for the metric **%Ephemeroptera** (Table 3) revelealed Shades Creek (SC-1) as having the greatest density of pollution-sensitive mayflies (47%) followed by the site control, CR-AT (39%). Abundance of pollution-sensitive mayflies decreases with increasing perturbation. Little Cahaba Creek (LCC-1) and mainstem Cahaba River station CR-7 had 31 and 32 %Ephemeroptera, respectively. The unnamed tributary (UT-1), Buck Creek (BC-2), Little Cahaba River (LCR-2), mainstem Cahaba River stations CR-AH, CR-BH and CR-6 recorded the lowest ranges of %Ephemeroptera ranging from 2 to 13. Mid-range observations of %Ephemeroptera were seen at CR-BT (26), BC-3 (20) and BC-4 (26).

The lowest **%Dominant Taxon** of 9 was recorded at the site control, CR-AT (Table 3). The metric %Dominant Taxon increases with increasing perturbation. Values ranging from 19 to 29 %Dominant Taxon were observed for CR-BT, CR-BH, CR-6, CR-7, SC-1 and BC-4. Elevated %Dominant Taxon results were present at LCC-1 (38; *Simulium*), LCR-2 (44; *Pleurocera*), CR-AH (45; *Simulium*), BC-2 (45; Naididae), and BC-3 (62; *Pleurocera*).

The **IAI** contrasts the ratio of tolerant versus intolerant organisms (abundance) at the site control with the test sites. IAI values approaching 1.0 indicates similar community balance. IAI scores decrease with increasing perturbation. Buck Creek station BC-2 had the lowest IAI result (0.29) followed by CR-AH (0.35), BC-4 (0.56), CR-BH (0.62), and UT-1 (0.72). IAI results (Table 3) indicated SC-1, CR-6, BC-3, CR-7 and LCC-1 were most similar to the site control, CR-AT.

**Snail Density**

Snails were most abundant in the middle reach of the study area. Specifically, stations CR-AH, CR-BH and CR-6 had the greatest density with 1001, 581 and 721 individuals/$m^2$. CR-1 had the lowest snail density (32 individuals/$m^2$). Snail density at CR-2, CR-AT, CR-7 and CR-11 was

430, 387, 291 and 0 individuals/m$^2$, respectively. Table 4 (below) provides snail densities observed during the spring 2002 study.

**Table 4. Snail density (#/m$^2$)**

| STATION | DATE | #snails/m$^2$ |
|---|---|---|
| CR-1 | 7/10/02 | 32 |
| CR-AT | 7/10/02 | 380 |
| CR-BT | 7/10/02 | 430 |
| CR-AH | 7/10/02 | 1001 |
| CR-BH | 7/09/02 | 581 |
| CR-6 | 7/09/02 | 721 |
| CR-7 | 7/09/02 | 291 |
| CR-11 | 7/08/02 | 0 |

**Habitat evaluation**

Habitat evaluation scores in the "marginal" category were observed at LCR-2 (85) and CR-AH (100). Shades Creek, SC-1, had a habitat evaluation score in the "optimal" category. All other study stations were in the "suboptimal" category based on habitat evaluation scores. BC-2 and BC-3 scored in the low end of the "suboptimal" category. Sedimentation was a major factor affecting the habitat evaluation scores at all stations with the exception of SC-1. Habitat scores are provided in Table 3.

**Stream Geomorphology and Classification**

The stream geomorphology and classification data from this study is summarized in Table 5 and presented in more detail in Appendix E. Stream slopes at each of the nine stations surveyed ranged from 0.01% at CR-BH to 0.81% at LCC-1, extending over distances ranging from approximately 600 to 1200 feet. The median particle size class or $D_{50}$ at each station ranged from a very coarse sand of 1-2 mm at stations CR-BH and CR-7 to bedrock (4096 mm) at station LCC-1. The percentage of bed surface material that was measured at each site that was <2 mm (sands, silts and clays) ranged from a low of 13.89% at station CR-1 to a high of 58.96% at CR-BH. Five of the nine stations were classified as C4 stream types according to the Rosgen classification of natural rivers (Rosgen, 1994). The C4 stream type is a slightly entrenched, meandering, gravel-dominated, riffle/pool channel with a well developed floodplain with gentle gradients of less than 2%, display a high width to depth ratio and are somewhat sinuous (Rosgen, 1996). One of the nine stations, CR-BH was classified as a C5 stream type which is similar to a C4 but sand-dominated instead of gravel-dominated. Two of the stations, CR-6 and CR-7, were classified as F4 stream types. The F4 stream type is similar to the C4 stream type but is more deeply entrenched, and as a result has typically abandoned its former floodplain (Rosgen, 1996).

The remaining station, LCC-1, was classified as B1c. The B1c stream type is a moderately entrenched channel with channel slopes less than 2%, typically associated with bedrock or bedrock controlled drainage ways, faults, folds and joints. Channel materials are dominated by bedrock but can also include boulders, cobble and sand (Rosgen, 1996). Stages of the CEM were identified at each of the nine stations where stream geomorphological data was collected. Stages ranged from Class I at station LCC-1, indicating a very stable, premodified channel to Class V at stations CR-AH, CR-1, CR-AT, CR-BT and CR-BH, indicating a very unstable channel with bed aggradation, channel widening and bank slumping.

**Table 5. Summary of Stream Geomorphology and Classification Results, Cahaba River and associated tributaries, September, 2002.**

| Station | Date | Water Surface Slope | Slope Distance (ft.) | Median Particle Size ($D_{50}$) | % Sands, Silts, & Clays Particles < 2mm | Rosgen Stream Type | Simon CEM Class |
|---|---|---|---|---|---|---|---|
| CR-1 | 9/11/02 | 0.25 % | 599 | 20 mm | 13.89 | C4 | V |
| CR-AT | 9/11/02 | 0.13% | 835 | 15 mm | 29.73 | C4 | V |
| LCC-1 | 9/11/02 | 0.81% | 611 | 5000 mm | 17.54 | B1c | I |
| CR-BT | 9/11/02 | 0.24% | 732 | 12 mm | 39.64 | C4 | V |
| CR-AH | 9/10/02 | 0.07% | 949 | 20 mm | 37.76 | C4 | V |
| CR-BH | 9/12/02 | 0.01% | 1202 | 1 mm | 58.96 | C5 | V |
| CR-6 | 9/09/02 | 0.02% | 975 | 4 mm | 40.48 | F4 | IV |
| CR-7 | 9/10/02 | 0.28% | 835 | 2 mm | 50.00 | F5 | IV |
| SC-1 | 9/10/02 | 0.27% | 729 | 37 mm | 24.81 | C4 | III |

## *In situ* Water Quality

Table 6 provides a summary of all *in situ* water quality measurements made during the study periods. *In situ* water quality measurements were taken prior to any stream activity; the measurements were made just below the water's surface and were recorded in the field record.
Conductivity values for the spring 2002 sampling were lower than summer 2002 at all stations. Lowest conductivity was observed at Little Cahaba Creek, CR-1 and CR-AT; spring/summer 2002 conductivity values at these stations ranged from 143 to 242 µmhos/cm (Table 6). Elevated conductivity values were observed at the unnamed tributary (UT-1) for both the spring and summer 2002 sampling events; conductivity at UT-1 was 888 and 963 µmhos/cm for spring summer 2002, respectively.

With the exception of Little Cahaba Creek and Shades Creek, all other tributaries to the Cahaba River generally exhibited higher conductivity values for the 2002 sampling than the mainstem Cahaba River stations (Table 6). For example, Buck Creek, the unnamed tributary and the Little Cahaba River had conductivity values ranging from 364 to 963 µmhos/cm in spring/summer 2002 while mainstem Cahaba River stations had conductivity values ranging from 148 to 366 µmhos/cm (Table 6). *In situ* spring/summer 2002 measurements of pH were fairly consistent at the Cahaba River mainstem stations with the exception of summer 2002 measurements at CR-9 and CR-11 (Table 6); *in situ* pH measurements at these stations ranged from 7.29 to 7.73. Elevated pH values of 8.34 and 8.93 were observed in summer 2002 at CR-9 and CR-11, respectively.

No violations of water quality standards for dissolved oxygen were observed at any study stations. It should be noted that dissolved oxygen measurements represented instantaneous measurements at one point in time; no diel studies of dissolved oxygen were conducted as part of the spring/summer 2002 EPA studies. Lowest observed *in situ* dissolved oxygen measurements occurred at Buck Creek stations BC-1 and BC-4 and Cahaba River mainstem station CR-7 during the summer 2002 sampling; dissolved oxygen (mg/L) at BC-1 and BC-4 at this time were 6.10 and 5.85, respectively while dissolved oxygen at CR-7 was 6.15 mg/L. Little Cahaba River (LCR-2) exhibited lower dissolved oxygen values than mainstem Cahaba River stations; dissolved oxygen values were 6.94 and 6.99, respectively, during the spring and summer 2002 sampling events. Spring 2002 ranges for dissolved oxygen at Cahaba River mainstem stations ranged from 7.72 to 10.24 mg/L while the summer 2002 dissolved oxygen values ranged from 6.15 to 9.20 mg/L.

## Flow

Flow data is presented in Tables 7 and 8 and includes both USGS stream flow (cfs) during the study period and the in-stream flow measurements by the field team.

**Periphyton: Stream Runs**

The filamentous algae identified during the study included the green algae *Cladophora*, *Ulothrix*, *Spirogyra*, *Mougeotia*, *Chaetophora*, *Stigeoclonium*, and pseudoparenchyma tufts of probably *Cladophora*; blue-green algae *Shizothirx*, *Rivularia*, *Anabaena*, *Cylindrosporum*, and *Microcoleus*; diatoms *Cymbella*, *Melosira*, *Biddulphia*, *Fragilaria*; and a stream moss, *Fontinalis* (Table D7). *Cladophora* was predominant and widespread at most stations in the springtime persisting into the summer (Table D7). An examination of spring time periphytometer slides showed that green filamentous algae were present, but the growths were not obvious like those growing on natural substrates.

Distribution of filamentous periphyton at stations generally was heterogenous except at station BC-2 in the spring where 100% cover was observed at each point measured (Appendix A, Figure 15; Tables D5 and D.6). Mean percent cover ranged from 0.3% at station CR-6 in the summer to 100% at station BC-2 in the spring (Table D8). The median for all stations was 21.5% and the $25^{th}$ percentile, 10% (Appendix D, Figure1). Those stations with mean percent coverage equal to

**Table 6 . *In situ* Water Quality Measurements, Cahaba River and associated tributaries, March/April and July, 2002.**

| Station | Date/Time | pH | Conductivity (µmhos/cm) | Dissolved oxygen (mg/L) | Water temperature (°C) |
|---|---|---|---|---|---|
| LCC-1 | 3/12/02 0915 | 7.60 | 143 | n/a | 10.80 |
| LCC-1 | 7/10/02 1110 | 7.91 | 201 | 7.62 | 29.63 |
| UT-1 | 4/23/02 1035 | 7.78 | 888 | 9.09 | 17.58 |
| UT-1 | 7/10/02 1100 | 7.84 | 963 | 7.62 | 24.39 |
| CR-1 | 4/23/02 1315 | 7.65 | 148 | 9.85 | 18.79 |
| CR-1 | 7/10/02 1205 | 7.73 | 164 | 7.98 | 25.73 |
| CR-AT* | 4/23/02 0847 | 7.47 | 163 | 8.97 | 15.76 |
| CR-AT* | 7/10/02 0945 | 7.29 | 242 | 8.21 | 26.20 |
| CR-BT[1] | 4/23/02 1520 | 7.92 | 265 | 10.24 | 20.90 |
| CR-BT[1] | 7/10/02 1345 | 8.16 | 388 | 8.60 | 28.31 |
| LCR-2 | 4/24/02 0830 | 7.41 | 364 | 6.94 | 17.36 |
| LCR-2 | 7/10/02 1500 | 7.59 | 379 | 6.99 | 28.44 |
| CR-AH[2] | 4/24/02 1050 | 7.58 | 210 | 8.95 | 21.32 |
| CR-AH[2] | 7/10/02 0800 | 7.55 | 259 | 7.05 | 27.69 |
| CR-BH | 4/23/02 0805 | 7.52 | 223 | 7.78 | 19.83 |
| CR-BH | 7/09/02 1500 | 7.53 | 256 | 6.92 | 29.20 |
| BC-1 | 4/22/02 1425 | 7.59 | 365 | 6.56 | 20.68 |
| BC-1 | 7/09/02 1000 | 7.52 | 471 | 6.10 | 24.16 |
| BC-2 | 4/22/02 1525 | 7.73 | 386 | 6.74 | 21.10 |
| BC-2 | 7/09/02 1200 | 7.96 | 388 | 7.98 | 26.41 |
| BC-3 | 4/22/02 1315 | 7.80 | 417 | 7.63 | 20.18 |
| BC-3 | 7/09/02 1025 | 7.72 | 416 | 6.64 | 23.94 |
| BC-4 | 4/22/02 1355 | 7.65 | 515 | 6.28 | 20.40 |
| BC-4 | 7/09/02 1110 | 7.54 | 534 | 5.85 | 25.26 |
| BC-5 | 4/22/02 1455 | 7.81 | 331 | 6.94 | 20.45 |

**Table 6 . (continued) *In situ* Water Quality Measurements, Cahaba River and associated tributaries, March/April and July, 2002.**

| Station | Date/Time | pH | Conductivity (µmhos/cm) | Dissolved oxygen (mg/L) | Water temperature (°C) |
|---|---|---|---|---|---|
| BC-5 | 7/09/02 | 7.81 | 391 | 7.30 | 25.08 |
| CR-6 | 4/23/02 0930 | 7.55 | 246 | 8.15 | 19.88 |
| CR-6 | 7/09/02 1325 | 7.62 | 366 | 7.06 | 27.95 |
| CR-7 | 4/23/02 1330 | 7.73 | 278 | 8.59 | 20.87 |
| CR-7 | 7/09/02 0825 | 7.66 | 344 | 6.15 | 26.83 |
| CR-9 | 4/24/02 0910 | 7.63 | 225 | 7.72 | 20.78 |
| CR-9 | 7/08/02 1625 | 8.34 | 252 | 9.00 | 30.72 |
| CR-11 | 7/08/02 1435 | 8.93 | 255 | 9.24 | 30.01 |
| SC-1 | 4/23/02 1530 | 8.20 | 242 | 10.46 | 20.42 |
| SC-1 | 7/08/02 1730 | 8.07 | 276 | 8.58 | 28.40 |

**Table 7 . USGS Flow data from April 22-24, 2002 and July 7-10, 2002**

| USGS gage locale | Site number | cfs 4/22 | cfs 4/23 | cfs 4/24 | cfs 7/08 | cfs 7/09 | cfs 7/10 |
|---|---|---|---|---|---|---|---|
| Trussville | 02423130 | 22.0 | 21.0 | 19.0 | 1.20 | .63 | .70 |
| Mountain Brook | 02423380 | 93.0 | 89.0 | 80.0 | 47.0 | 25.0 | 23.0 |
| Cahaba Heights | 02423425 | 99.0 | 92.0 | 72.0 | 9.80 | 10.0 | 6.40 |
| Hoover | 02423496 | 94.0 | 93.0 | 74.0 | 12.0 | 18.0 | 22.0 |
| Acton | 02423500 | 95.0 | 96.0 | 79.0 | 26.0 | 33.0 | 32.0 |
| Helena | 02423555 | 200.0 | 194.0 | 172.0 | 52.0 | 54.0 | 54.0 |
| Centreville | 02424000 | 782.0 | 749.0 | 729.0 | 617.0 | 584.0 | 568.0 |

**Table 8. Flow (cfs) from quarter points during EPA studies in March/April, 2002.**

| Stream | Station | cfs 3/11 | cfs 3/12 | cfs 4/22 | cfs 4/23 |
|---|---|---|---|---|---|
| Little Cahaba Creek | LCC-1 | | 34.88 | | |
| Unnamed tributary | UT-1 | | 1.53 | | |
| Cahaba River | CR-1 | | 7.78 | | |
| Cahaba River | CR-BT | | 12.41 | | |
| Little Cahaba River | | | 3.80 | | |
| Cahaba River | CR-AH | 86.08 | | | |
| Cahaba River | CR-BH | | | | 51.45 |
| Buck Creek | BC-3 | 6.28 | | | |
| Buck Creek | BC-4 | 12.18 | | | |
| Buck Creek | BC-2 | | | 46.08 | |
| Shades Creek | SC-1 | | | | 39.92 |

or less than 10% included LCC-1, CR-BT, and CR-BH in the spring, and CR-1, UT-1, and CR-6 in the summer (Table D9). Figure 1 data (Appendix D) was significantly skewed (alpha 0.05) downward. A square root transformation of the data brought the skewness and kurtosis within the alpha 0.05 bounds moving the data more toward a normal curve distribution (Appendix D, Figure 2). Conversion of the transformed data gives a 21.4% and 10.0% percent median and 25$^{th}$ percentile respectively, very close or exactly the same as the median and 25$^{th}$ percentile of the raw data (Appendix D, Figure 1).

Periphyton diatom mean diversity (d-bar) was not significantly skewed and only slightly out of bounds at alpha 0.05 with respect to kurtosis. Transformations were applied to the data, but normality suffered so we used the distribution of the untransformed data (Appendix D, Figure 3). Mean diversity ranged from 1.179 at BC-2 in the summer to 4.229 at station UT-1 in the spring (Table D12 ). The median was 3.174 and the 25$^{th}$ percentile was equal to or less than 1.997 d-bar (Appendix D, Figure D3). Those stations equal to or less than 1.997 d-bar included CR-1, LCC-1, LCR-2, CR-7 in the spring, and CR-1, CR-6, and BC-2 in the summer (Table D9). Stations UT-1 and BC-5 in the spring more than doubled the 25$^{th}$ percentile d-bar of 1.997 (Table D12). Other stations encountered with high d-bars, less than 4.000 and equal to or greater than 3.000, at least once during the study, included CR-AT, CR-BT, LCR-2, CR-AH, CR-BH, CR-6, BC-1, BC-2, BC-4, SC-1, and UT-1.

During the spring study, periphyton chlorophyll *a* ranged from 5.0 mg/m$^2$ at Shades Creek (SC-1) to 67.9 mg/m$^2$ at Buck Creek (BC-5). The seven stations in the Cahaba River had an average chlorophyll *a* value of 31.8 mg/m$^2$ with a low of 11.6 at Riverford Drive (CR-BH) and a high of 59.0 mg/m$^2$ below Trussville (CR-BT). The corrected chlorophyll *a* concentrations and the number of days the periphytometers were in place are given in Table D1.

**Water Quality Sampling**

The spring results for nutrients and chlorophyll *a* in the water column are given in Table C2. Nitrate nitrogen was very high (26 mg/L) in the unnamed tributary (UT-1). In the Cahaba, nitrate ranged from 0.23 mg/L at CR-1, the most upstream station, to 3.8 mg/L at CR-BT, the first station downstream of UT-1. Total Kjeldahl Nitrogen (TKN) and ammonia ($NH_3N$) were low at all stations except Buck Creek at Helena (BC-2) where the TKN was 3.8 mg/L and the ammonia was 3.4 mg/L.

Phosphorus concentrations ranged from below the detection limit of 0.025 mg/L at CR-1 (and five other stations) to 0.91 mg/L at UT-1. The largest phosphorus concentration in the Cahaba was 0.24 mg/L at Bains Bridge (CR-6). The results of the algal assay limiting nutrient tests are listed in Table C4. Phosphorus was the limiting nutrient at the upper stations, CR-1 to CR-BT, while nitrogen was limiting from CR-AH (Caldwell Mill Road ) to CR-7 (Co. Rd. 52). At CR-9 (Hwy. 24) nitrogen and phosphorus were co-limiting. No samples were collected at CR-11 (US82 near Centreville ) during the spring study.

The chlorophyll *a* concentrations in the water column were generally low. Values ranged from 0.30 µg/L at Shades Creek to 8.4 µg/L at Little Cahaba Creek off Camp Coleman Road (LCC-1). In the Cahaba, the largest chlorophyll *a* concentration was 4.6 µg/L at CR-AH, Caldwell Mill Road (Table C2).

Results of nutrients and chlorophyll *a* analyses from water samples collected during the July study are listed in Table C3. Nitrate and phosphorus concentrations were generally higher during the summer study than in the spring. Nitrate at UT-1 was again very high at 27 mg/L. The first Cahaba River station downstream, CR-BT, had a nitrate concentration of 5.9 mg/L. Further downstream at CR-AH, Caldwell Mill Road and CR-BH, Riverford Drive, nitrate drops below 1.0 mg/L, but then increases to 6.0 mg/L at CR-6 (Bains Bridge). TKN and ammonia concentrations are low, with only one station, BC-2, having a TKN above 1.0 mg/L.

Phosphorus values for the July 2002 study ranged from below the detection limit of 0.025 mg/L at CR-1 to 1.1 mg/L at Little Cahaba River (LCR-2). The highest phosphorus concentration of the Cahaba River stations was 0.96 mg/L at Bains Bridge. The limiting nutrient experiments show phosphorus to be limiting at the upstream station, CR-1, nitrogen limiting to algal growth in the middle reach(CR-AH, Caldwell Mill Road to Bains Bridge, CR-6) and then phosphorus limiting further downstream at CR-11 (Table C4).

Chlorophyll *a* concentrations in the water column were for the most part higher during the summer study. This was especially true for the stations on the Cahaba from Caldwell Mill Road (CR-AH) downstream to CR-11. The values ranged from 0.28 µg/L at CR-1 to 13.8 µg/L at CR-9.

Untransformed total phosphorus (TP) data had a median of 143 µg/L ranging from 12 to 960 µg/L (Appendix C, Figure 4). Figure 4 data (Appendix C) shows that 75% of the measurements in the system were distributed toward lower concentrations of TP. To better fit a normal curve and correct for skewness and kurtosis, the data were transformed using a square root transformation which moved the skewness and kurtosis statistics within the alpha 0.05 bounds and improved the normal distribution of the data. The transformed data in Figure 5 (Appendix C) translates to a median of 225 µg/L and a 25$^{th}$ percentile of 27 µg/L of TP. Stations within the 27 µg/L percentile include CR-1, CR-AT, LCC-1, BC-3, and SC-1 in the spring, and CR-1, LCC-1, BC-3, and SC-1 in the summer (Table D9).

Untransformed total nitrogen (TN) had a median of 1260 µg/L with a range of 230 to 21,094 µg/L (Appendix C, Figure 6). Total nitrogen also was skewed and a natural log transformation corrected for skewness and kurtosis (Appendix C, Figure 7). The median of 7.1389 and 25$^{th}$ percentile of 6.3630 in Figure 7 converts to 1260 µg/L TN and 580 µg/L TN; the same as the untransformed data. Those stations in the TN 25$^{th}$ percentile were CR-1, CR-AT, LCC-1, and SC-1 in the spring, and CR-AT, LCC-1, and CR-BH in the summer (Table D9).

Stations CR-1 and LCC-1 were in the lower quartile for at least one of the seasons with respect to percent cover, d-bar, TP, and TN. Background station CR-1 which had a minimum mean percent cover of 8.3% also exhibited greater values of 23.2% in the spring and 21.8% at the riffles in the summer (Table D8).

Those stations in the lower TP quartile had TP values ranging from 12 to 27 µg/L and percent periphyton coverage ranging from 0.8 to 38% (Table D9; Table D10). Likewise, those stations in the lower TN quartile ranged from 230 to 580 µg/L TN with a range in percent cover from 0.8 to 38% (Table D9 ; Table D11).

## DISCUSSION

Historically, one would expect in the Cahaba tributaries and mainstem a periphytic community of predominantly diatom communities with d-bars equal to or less than 2.0 and little or no filamentous algae. Mean diversity (d-bar) is a very sensitive index reflecting community changes to small nutrient increases (Raschke 1993). Huston (1979) and Ballock et al. (1976) point out that diatoms are very sensitive to enrichment because of differences in growth rates under different concentrations rather than pollution tolerance. Increased phosphorus in relatively stable oligotrophic systems with low d-bars equal to or less than 2.0 results in some populations decreasing and others increasing because of their inate ability to adapt or utilize a new source. Peaks of production promote opportunistic migrants, which create high diversity while the resources last (Tilman, 1977; Kilham & Kilham, 1978; Washington, 1984; and Raschke, 1993). If the nutrient input continues unabated, then diversity will seek new d-bar levels of 3, 4 or greater. Apparently, this is what is happening to the periphyton and especially the diatom community of the Cahaba watershed. Excessive nitrogen and phosphorus inputs from point and non-point sources have not only driven the d-bar up in all orders of streams, but it has enabled the excessive and widespread growths of filamentous periphyton which have impaired uses of the Cahaba system. In this situation, more diversity is not good. A good example of this is station UT-1; UT-1 adjacent to LCC-1, had a diversity of 4.2. In contrast, stations CR-1 and LCC-1, both in the vicinity of UT-1, had d-bars less than 2.0 (Table D9). Station BC-5, located on Buck Creek, also had a diversity of greater than 4.0. Both stations (UT-1 and BC-5) are the recipients of high amounts of nutrients emanating from anthropogenic sources upstream. The cause for concern is not the presence of filamentous algae or other aquatic plants like mosses, but excessive growths over space and time contributing to impairment of designated uses. Generally, results and observations from this study confirm that filamentous periphytic growths are a predominant feature of the Cahaba system. One alga, Cladophora, is very prevalent, sometimes covering 100% of an area and developing strands several feet long (Tables D7 & D8; Appendix A, Figure 15 ). In the summer, the blue-green alga Shizothrix, and a diatom Melosira (Table D7) accompanied it. Study personnel noted that Cladophora and Fontinalis were very obvious residents of the streambed.

Fontinalis is an aquatic moss without a vascular system and no true roots; therefore it, like algae, absorbs nutrients from the water column. It is a widespread genus that can entirely cover a streambed and in some cases extend out two meters from its substrate. Its leaves are home for a variety of insects and algae. In general, species in this genus occur in clean water, but the same species can live in concrete ditches receiving rice paddy effluent or on substrates of enriched streams (Communication from Glime 2002). Cladophora can be found associated with Fontinalis in polluted waters (Arendt 1981).

Spatial heterogeneity varied tremendously at stations (Tables D5 & D6) where points along one transect could range from 1% to 100% cover. The same pattern of periphytic aereal coverage existed on the few riffles measured. At several points along transects there was zero percent periphyton cover, with rocks or cobble appearing smooth. While these gaps in coverage were observed, it was not apparent that their occurrence provided sufficient habitat of suitable character, location, and timeframe necessary to meet crucial requirements in the life cycles of the federally protected fish and mollusks. However, there are times, as alluded to earlier, that algal coverage may be 100%. At these times, a possibility exists that extensive algal coverage may pose a concern to fish and mollusk life cycle processes. Dr. Paul Hartfield (U.S. Fish and Wildlife Service), in a special report (2002), indicates that:

© "although the physical effects of nutrification and algal growth on mussels has not been directly addressed in the literature, field observations by Service biologists indicate a direct relationship between dense filamentous algal growth and lack of mussel recruitment in streams and loss of mussel species. Recent studies on early mussel life history indicate that heavy filamentous algal growth promoted by nutrification may physically disrupt mussel/fish interactions and/or juvenile mussel survival. In hatcheries, filamentous algae reduces mussel juvenile survival by reducing flow, increasing sedimentation, and by deleterious effects on the unicellular algal community on which the mussels feed."[a]

In personal communication (2002), Hartfield indicates that among all field malacologists he contacted, there was a clear consensus of opinion that the occurrence of excessive attached algal growth closely correlates with decline and disappearance of mussel populations. In addition to the effects on mussels discussed here, the data strongly suggests that periphyton growths also affect other uses like recreation, aesthetics, and even fishing(Table D8; Appendix A, Figure 15 ).

In addition to the periphytic growths, another finding that translates to impacts to aquatic fauna (fish and benthic invertebrates) of the Cahaba River is the excessive sedimentation that has taken place in the Birmingham area. EPA spring/summer 2002 studies of the biology and water quality of the Cahaba River and associated tributaries, as defined by a reach from I-59 near Trussville to US 82 near Centreville, revealed findings quite similar to those conducted by Onorata et. al (1998). Onorato et al. studied ichthyofaunal assemblages of the Cahaba within a similar study area to that utilized by EPA in 2002. In these studies, Onorato et al. attribute negative impacts to the ichthyofauna to the extensive urban development occurring in the watershed in the last two decades. Using remote sensing classification and GIS techniques, we performed change analysis focusing on the MRLC "disturbed" land use class as opposed to the "undisturbed" class for 1983, 1990, and 1998 (Appendix G1). The "disturbed" land use class includes land uses such as residential, commercial, industrial, transportation and bare ground. The "undisturbed" land use class is basically forested lands (deciduous, mixed, and evergreen) and grasslands. This GIS analysis reveals a remarkable increase in the "disturbed" class after 1990. For example, the percentage of the Cahaba watershed "disturbed" increased from 8.8% in 1990 to 38.7% in 1998. Wang et al. 1996 found that when urbanization exceeds 10%, the Index of Biotic Integrity scores were consistently very low. In addition, habitat was adversely affected.

Consistent with the EPA 2002 findings, Onorata et al 1998 found that the upper watershed (St. Clair County and northeastern Jefferson County) was affected primarily by sedimentation of non-point source origins while the middle reach of the Cahaba (within the urbanized Birmingham area) was affected not only by non-point sources (sediments and nutrients) but also by multiple point sources primarily originating from multiple wastewater treatment facilities. The most downstream Cahaba River station in the Onorato et al. studies, UAB-15 (over 8 miles downstream from direct impacts of Birmingham), exhibited improved ichthyofaunal assemblages. A similar finding was observed in both the 2001 and 2002 EPA studies where biological and/or water quality results yielded marked improvements at CR-11 near Centreville (over 24 miles downstream from direct impacts of Birmingham).

Recent studies of the ichthyofaunal assemblages of the Cahaba River (O'Neil 2002) found that their Altadena site, two miles downstream from the Caldwell Mill Road crossing and in the heart of the heavily developed part of the watershed, ranked "poor" based on the Index of Biotic Integrity (IBI) score. The report by O'Neil (2002) was conducted under contract to EPA, Region 4 and stands as an addendum to this report (Appendix F). Other investigators have documented biological and/or water quality degradation attributable to the intensive and extensive development of the Cahaba watershed in the Birmingham area (EPA 1995, 1997; Howell et al. 1982; Pierson et al. 1989; Davenport 1996; Onorato et al. 1998; Onorato et al. 2000). Recent studies of the historical changes in fish communities (Onorato et al. 2000) attribute the decline, and in some cases extirpation, of pollution-intolerant fish species such as the Alabama shiner (*Cyprinella callistia*), the coal darter (*Percina brevicauda*), the tricolor shiner (*Cyprinella trichoristia*), the Cahaba shiner (*Notropis cahabae*), the gold-line darter (*Percina aurolineata*), the blue shiner (*Cyprinella caerulea*), and the green-breast darter (*Etheostoma jordani*) to the extensive urbanization and resultant water quality and habitat degradation that has occurred over the last two decades. All of these fish species are affected by siltation and sedimentation (personal communication, Dr. Scott Mettee). Because of excessive sedimentation, habitat evaluation scores in the middle reach were affected and fell into the suboptimal to marginal range. Quite apparent is the filling of crevices or spaces between the natural rock substrates by sediments thus affecting both fish and benthic macroinvertebrates. A photograph taken during the sediment characterization studies provides a good example of this (Appendix E, Figure 24). The Alabama shiner and the tricolor shiner are crevice spawners (Onorato, et. al, 2000) thus the filling of the crevices in between the rocks or cobble directly impact these fish. In addition to impacts to the fish fauna, the filling of these crevices also impacts the principle fish food, the benthic invertebrates (personal communication, Dr. Robert Angus; Onorato et al. 2002). Two species of concern because of their endangered status, the gold-line darter and the Cahaba shiner, were only collected in recent fish collections (O'Neil 2002) from the lower portion of our study area. The Cahaba shiner was only collected at Centreville (US 82) while the gold-line darter was collected at Centreville (US 82), Riverbend (CR 26), and Piper Bridge (CR 24). Past studies by Howell et al. (1982) reported that siltation and pollution associated with wastewater treatment facilities were responsible for the elimination of these two species from the Cahaba River at CR 52. In contrast to the decline in intolerant fish species, recent studies (Onorato et al. 1998; O'Neil 2002) also document an increase in tolerant species such as the silverstripe shiner (*Notropis stilbius*), blacktail shiner (*Cyprinella venusta*), and riffle minnow (*Phenacobius catostomus*).

With the heavy development of the Cahaba River watershed in the last decade, nutrient enrichment originating from both point and non-point sources is also a valid concern. This enrichment, along with the previously raised concerns with periphytic growth and excessive sedimentation, has contributed to the decline in the overall ecological health of the Cahaba system.

The Trussville area constitutes the upper Cahaba portion of the spring/summer 2002 EPA studies. Although not as heavily developed as the middle or Birmingham area of the watershed, sedimentation originating from non-point sources is apparent. Stations least impacted were CR-1, CR-AT and LCC-1. Data from periphyton studies indicate that CR-1 and LCC-1 are in the lower quartile for at least one of the seasons with respect to percent cover, d-bar, TP, and TN (Table D9). Both CR-1 and LCC-1 are located upstream of the city of Trussville. LCC-1 is located on a second order stream, Little Cahaba Creek, while CR-1, located on the Cahaba River at CR 132, is a third order stream. An unnamed tributary, where station UT-1 is located, joins with the Little Cahaba Creek (downstream of LCC-1) near Camp Coleman and represents a potential source of enrichment for the Cahaba River. UT-1 receives high amounts of nutrients from the discharge of Gold Kist Corporation, a poultry processing facility. Little Cahaba Creek enters the Cahaba River upstream of station CR-BT. Station CR-BT is also downstream of the Trussville WWTP.

Like the periphyton, benthic macroinvertebrate communities above the Trussville area appeared to be in better ecological health than other Cahaba River stations. For example, CR-AT and LCC-1 had good representation of the generally pollution-sensitive EPT fauna (Ephemeroptera, Plecoptera, and Trichoptera). Almost half of the benthic macroinvertebrate fauna at these stations was comprised of EPT fauna. In addition, Shades Creek, at the lower end of our study area and prior to its confluence with the Cahaba River, also appeared to have good ecological health; EPT fauna comprised over half of the organisms collected at the Shades Creek station (SC-1). One common shared characteristic of the Cahaba watershed above Trussville and the Shades Creek station was better habitat quality as indicated by the habitat evaluation scores. Cahaba River stations above Trussville and Shades Creek station SC-1 were characterized by a benthic macroinvertebrate assemblage composed of from 30 to 50% mayflies. A noticeable finding revealed in the spring 2002 benthic macroinvertebrate studies was that the mayflies (Ephemeroptera) appeared to be the most affected by anthropogenic pollution.

Similar to the periphyton and benthic macroinvertebrate community information for the upstream most study stations, CR-1, CR-AT and LCC-1, the Wolman pebble count information that was collected to characterize the bed surface material at each of these sites yielded median particle sizes or a $D_{50}$ of 20 (coarse gravel), 15 (medium gravel) and 5000 (bedrock) mm, respectively. The $D_{50}$ for SC-1 downstream was 37mm, a very coarse gravel. These four sites all yielded the largest median particle sizes and the lowest percentages of sands, silts and clays (particles < 2mm) of the nine stations in the Cahaba River watershed where bed surface material was sampled (Table 5). The percentages of sands, silts and clays at CR-1, CR-AT, LCC-1 and SC-1 were 13.9, 29.7, 17.5 and 24.8, respectively.

Comparatively, in the assessment of water quality conditions in the Chattooga Watershed (EPA 1999), generally, small cobble to small boulder-sized particles ($D_{50}$ of 75-300 mm) were predominately associated with upper valley reference (least-impacted) reaches in the Blue Ridge physiographic province (Wharton 1978) where stream segments typically produced optimal habitat assessment scores and more robust EPT indices (15-18, mean = 16). Very coarse sand to small cobbles ($D_{50}$ of 2-80mm) were predominately associated with the more sediment-laden, impacted, lower valley reaches found in the Blue Ridge and Upper Piedmont provinces where stream segments produced suboptimal to marginal to poor habitat assessment scores and less robust EPT indices (9-15, mean = 12). The percentages of sands, silts and clays <2 mm in the reference reaches of the Blue Ridge ranged from 9-19%, with a mean of 11% whereas the sediment impaired, lower valley reaches contained sands, silts and clays ranging from 13 to 54 %, with a mean of 26%. Comparatively, the Cahaba River stations that were sampled for particle sizes contained coarse sand to bedrock-sized particles ($D_{50}$ of 1-5000 mm) and stream segments that produced habitat assessment scores from optimal to suboptimal to marginal with EPT indices ranging from 7-15, mean =11. The percentages of sands, silts and clays <2 mm at the Cahaba River stations ranged from 14 to 59%, with a mean of 35% (Table 5).

The amount of sediment that moves into a stream network from hillslopes, other land surfaces, or is eroded by fluvial systems can vary greatly among watersheds because of the numerous factors involved in erosional processes (Beschta 1996). These factors include climate (precipitation and temperature regimes), topography (terrain steepness, aspect), vegetation (type and density), soils (particle sizes and erodability), and geology (characteristics of parent material and bedrock). In addition, human perturbations and management practices that affect watersheds and stream systems can greatly augment natural rates of erosion and sediment yield (Beschta 1996). These factors should be considered when contrasting the sediment information above regarding the Cahaba and Chattooga River watersheds.

Degraded habitat is of concern below Trussville (CR-BT), the heavily urbanized middle reach of the Cahaba River, the Little Cahaba River and Buck Creek. Station CR-BT is located downstream of the Trussville WWTP and the confluence of Little Cahaba Creek. Obvious nutrient enrichment is revealed in water chemistry results for CR-BT; nitrate nitrogen concentration was 3.8 mg/L at CR-BT in spring 2002 and 5.9 mg/L in summer 2002 . As alluded to earlier, Little Cahaba Creek received wastewater from the Gold Kist Corporation via the unnamed tributary. Station UT-1, located on this unnamed tributary to Little Cahaba Creek, had a poor macroinvertebrate community; the taxa of pollution-sensitive EPT fauna at UT-1 (4) was the lowest of all study stations. As discussed earlier, this station was also characterized by elevated nitrate nitrogen levels in both the spring (26 mg/L) and summer of 2002 (27 mg/L).

At CR-BT, we begin to see a shift to a smaller median particle size of medium gravel ($D_{50}$ = 12 mm) from the coarser gravel and bedrock found at stations CR-1, CR-AT and LCC-1, respectively (Table 5). The only exception to the shift to smaller median particle sizes in the mainstem of the Cahaba from upstream to downstream occurs at station CR-AH ($D_{50}$ = 20 mm). One possible explanation for the larger median particle size at this station could be the presence of a low-head concrete dam immediately upstream of the site at the Caldwell Mill Road bridge (see photo, Figure 14, Appendix E). A significant increase in the percentage of sands, silts and clays also occurs from less than 30% at the three stations above Trussville to approximately 40% at CR-BT (Table 5). Lenat et.al. (1979) summarized the effects of sediment on benthic macroinvertebrates into two categories: 1. With small amounts of sediment, density and standing stock of the benthos may be decreased due to reduction of interstitial habitat, although structure and species richness may not change. 2. Greater sediment amounts that drastically change substrate type (i.e., from cobble-gravel to sand-silt) will change the number and type of taxa, thus altering community structure and species diversity, but often with increasing densities. Similar to what Lenat describes above, this study observed a community shift at stations CR-BT, CR-AH, and CR-BH associated with the addition of greater amounts of sediments. For example, the habitat score for CR-BT was suboptimal (133) and an increase in the percentage of tolerant chironomids and annelids to 35% also occurred (Table 3). This community structure and species diversity shift was also evident at CR-AH and CR-BH downstream, where the percentage of chironomids and annelids increased above 30% (31% and 34%, respectively) and the percentage of sands, silts and clays remained elevated (38% and 59%, respectively) compared to the stations upstream. An increase in work on the basic ecology of organism-substrate relationships confirmed the general conclusion that coarser particles (gravel, pebbles, cobbles) are preferred by EPT (the most preferred and available fish-food organisms), whereas fine-particle substrates (sand, silt) are inhabited by chironomid larvae and other burrowing forms that often are not readily available to foraging fish (Erman and Erman 1984; Minshall 1984). These are the conclusions most often reached by investigators studying the effects of sediment from anthropogenic sources, which almost invariably increase fine particle accumulations and alter the mix of invertebrate taxa (Waters, 1995).

Another tributary to the Cahaba River, Little Cahaba River, was sampled below the US 411 WWTP at the US 411 crossing. This tributary enters Lake Purdy and after exiting Lake Purdy joins the Cahaba River approximately 2 miles upstream of the US 280 crossing of the Cahaba River. The Little Cahaba River station (LCR-2) had a depauperate benthic community and poor habitat quality. The field team observed an opaque/blue-gray water color at LCR-2 often characteristic of wastewater influence. The area defined by the confluence of the Cahaba and the Little Cahaba Rivers, along with Cahaba River stations CR-AH, CR-BH, CR-6 and CR-7, lie in the heart of the heavily developed portion of the watershed study area. Multiple point sources and non-point sources originating from commercial/residential development within this area of the watershed have contributed to the water quality and biological impairment indicated by the EPA 2002 studies.

The Cahaba River stations in the heavily urbanized middle reach (CR-AH, CR-BH and CR-6) had mayflies comprising 13% or less of the benthic macroinvertebrate collections. Likewise, tributaries where impairment was indicated (unnamed tributary UT-1, Little Cahaba River and Buck Creek) also exhibited low mayfly density. In fact, the unnamed tributary (UT-1) and the Little Cahaba River had only 2% and 5% mayfly density, respectively. In regard to nutrient inputs, periphytic growths in this middle reach of the Cahaba have given rise to large populations of grazers such as the net-spinning caddisflies (Hydropsychidae) and snails (Gastropoda). Normally filterers/collectors, Hydropsychid caddisflies also will graze on periphyton (Brigham, et. al, 1982). Snails were the major source of herbivory at station CR-AH where a snail population averaging over 1000 individuals/$m^2$ resided. Grazing can be the major factor controlling accumulation of benthic algae (Jacoby1985, 1987; Lamberti et al., 1987; McCormick and Stevenson, 1989). If enrichment occurs, grazing can offset or lessen increase in biomass. Snail densities of 40 to 80 per square meter are considered intermediate (Borchardt, 1996). Periphytic growths were common in the riffle/runs of CR-AH and evidence of herbivory by the resident snail population was noted by the field team. Another grazer, the blackfly larvae *Simulium* (Diptera) was the predominant organism at CR-AH comprising 45% of the total individuals. This phenomenon follows the generalized community response to organic waste described in Klein (1962) where decreased competition and increased food supply results in a shift from mayflies (Baetidae) to blackflies (*Simulium*). Three point sources are located upstream of station CR-AH: Hoover-Inverness WWTP, Birmingham Riverview WWTP, and Liberty Park WWTP.

Further downstream of CR-AH, heavy sediment deposition was still a factor affecting habitat quality. Both stations CR-BH and CR-6 exhibited low habitat evaluation scores in the suboptimal category due to sediment related factors, unstable banks, and lack of vegetative cover. Mayflies were still affected in this reach and facultative net-spinning caddisflies (Hydropsychidae) and snails were abundant in response to food supply availability. Grazers, such as the snails, are known to increase in the immediate area of enrichment in response to increased autotrophic production (Welch, 1992). Increased abundance of net-spinning caddisflies, as observed at CR-BH, CR-6, and CR-7, is consistent with the shift in fauna from *Simulium* (predominant at CR-AH) to facultative Hydropsychid caddisflies as described by Klein (1962). In addition, snails were abundant at both CR-BH and CR-6 and evidence of grazing was apparent on natural rock substrates in the riffle/runs. Station CR-6 is approximately 2.5 miles downstream of the Cahaba River WWTP. Elevated nitrate nitrogen (6.0 mg/L) was reported in the summer 2002 water chemistry results for CR-6.

It has been demonstrated that fine sediment (<6.5 mm) in spawning gravels suffocates trout eggs and reduces macroinvertebrate populations (Bjornn and Reiser, 1991; Cordone and Kelly, 1961; Hall and Lantz, 1969). Sediment <6.5 mm above 40% levels can eliminate a trout fishery as well as many macroinvertebrate species (Everest and Harr, 1982). Sediment levels for particle sizes <6.5mm based on Wolman pebble counts were observed below 20% at stations CR-1 and LCC-1, below 30% at SC-1, and below 35% at CR-AT. Sediment levels for particle sizes <6.5 mm based on Wolman pebble counts were observed above 40% at stations CR-BT and CR-AH, above 50% at stations CR-6 and CR-7, and above 60% at station CR-BH. Additionally, CR-BH had the smallest median particle size or $D_{50}$ of 1mm (coarse sand) and the highest percentage of sands, silts and clays (59%) as well as the flattest water surface slope (0.01%) of the nine stations sampled (Table 5).

Buck Creek, another major tributary to the Cahaba River, enters the Cahaba approximately six miles downstream of station CR-6. Buck Creek has multiple point source wastewater discharges. Wastewater treatment plants at Alabaster, Pelham, and Helena discharge to Buck Creek while wastewater treatment facilities for North Shelby County and Oak Mountain State Park discharge to Cahaba Valley and Peavine Creeks, tributaries to Buck Creek. In addition to these point sources, the Buck Creek watershed is heavily developed (commercial and residential) thus affording a high potential for non-point source pollution. Impervious surfaces are a prominent feature in the Buck Creek watershed thus enhancing runoff during storm events. The most current land cover information (1998) for the Buck Creek watershed from just below the intersection of SR 119 and US 31 to Helena reveals that over 63% of the total acreage is in the class "disturbed"(Appendix G2). Because of all these factors, the ecological health of Buck Creek has been compromised. A station was selected on Buck Creek (BC-3) above most point sources and the more intensively developed area; this station (BC-3) was below the 25$^{th}$ percentile value of 27 µg/L total phosphorus in both the spring and summer 2002 sampling events. In addition, BC-3 supported a diverse EPT fauna (10 taxa). All other Buck Creek stations were impaired. Station BC-2 in Helena represents the most down gradient stream station on Buck Creek; BC-2 is approximately two miles from the confluence with the Cahaba River and less than 0.25 miles downstream of the Helena WWTP. Effects of multiple wastes sources, both point and non-point, are reflected in the spring and summer 2002 water chemistry analyses for BC-2. For example, Total Kjeldahl Nitrogen at BC-2 was 3.8 mg/L in spring 2002 and 1.0 mg/L in summer 2002 which represents the highest of all study stations. Ammonia nitrogen at BC-2 in the spring of 2002 was 3.4 mg/L; ammonia nitrogen at this level gives rise to a concern for ammonia toxicity to aquatic organisms (fish and invertebrates). In addition to the obvious water quality concerns, BC-2 is also degraded from a biological standpoint. In response to obvious nutrient enrichment, filamentous algal coverage at BC-2 in spring 2002 was 100% at each point measured. Long strands of *Cladophora* were prevalent at this time (Appendix A, Figure 15). In regard to the benthic macroinvertebrate community of BC-2, only four pollution-sensitive EPT taxa were collected. On the other hand, pollution-tolerant worms (Oligochaeta) were overly abundant (45% of total organisms) at BC-2. Station BC-2 was also the most dissimilar in the abundance ratio of tolerant and intolerant organisms as compared to the site specific control at station CR-AT. Impairment was also noted at BC-5 which is approximately 0.5 miles upstream of BC-2. BC-5 is approximately one half mile downstream of Cahaba Valley Creek (has 2 WWTP discharges) and approximately one mile downstream of the Pelham WWTP. Station BC-5 was not wadeable therefore benthic macroinvertebrates were not sampled. However, as mentioned previously, periphyton mean diversity (d bar) was elevated at BC-5 in probable response to nutrient enrichment from both point and non-point sources.

Cahaba River station CR-7, approximately three miles downstream of the confluence of Buck Creek, is nutrient enriched based on water chemistry analyses. Nutrient enrichment at CR-7 has resulted in a periphyton biomass of 200 mg/m$^2$ which exceeds a value of 150 mg/m$^2$, suggested as a level below which an aesthetic quality use will probably not be appreciably degraded by filamentous algae or its effects (though not supported as a threshold of protection for water quality and benthic habitat) (EPA, 2000). As a result of this increased food availability, grazers such as *Pleurocera* snails (Gastropoda), Baetid mayflies

(Baetidae), and *Cheumatopsyche* caddisflies (Hydropsychidae) comprise over 64% of the total benthic macroinvertebrate fauna. These three species of invertebrates are considered facultative in regard to pollution tolerance. Even though these facultative EPT taxa were numerically abundant, diversity of EPT taxa was low. Only nine EPT taxa were collected from CR-7. This is consistent with the low EPT Index observed at other Cahaba River stations within the heavily developed middle reach of our study area. The increase in numerical abundance of mayflies noted at CR-7 is attributable to the abundance of the facultative Baetid mayflies that are predominant at this station. Moderate to heavy sedimentation was indicated by the habitat evaluation process. Embeddedness was approaching 50%; as mentioned earlier in the text, the filling of the spaces or crevices of the natural substrates is detrimental to both fish and benthic invertebrates. The Wolman pebble count information collected at CR-7 confirmed the heavy sedimentation that was also indicated by the habitat evaluation process. The $D_{50}$ at CR-7 was a very coarse sand of 2 mm, and similar to the embeddedness, the percentage of sands, silts and clays measured at this site was 50% (Table 5).

As mentioned earlier in the text, studies by EPA in 2001 and others have documented improvements in water quality and/or biology in the lower reaches of the Cahaba River below Helena. EPA (2001) documented both an improved benthic macroinvertebrate community and decreased nutrient/chlorophyll a concentrations at station CR-11 near Centreville at US 82. Biological data (benthic macroinvertebrates and periphyton) are not available for stations CR-9 (Piper Bridge) or CR-11 in 2002 but nutrient analysis (specifically, nitrate and phosphorus) indicates lower concentrations of nitrogen and phosphorus at these stations than was observed from stations within the heavily developed middle reach of the Cahaba. A possible explanation to improvements in stream water quality and biology may be attributable to the increased flow in the lower reach of the Cahaba. From Helena (below station CR-7) to Centreville (US 82), twenty perennial tributaries enter the Cahaba River. A dramatic increase in the flow is evident by contrasting USGS gage data from Helena and Centreville during the spring and summer study periods. For example, flows at the USGS gage at Helena during the three days of the spring 2002 study averaged 188 cfs while the USGS gage at Centreville during the same period averaged 753 cfs. During the three days of the summer 2002 study, average flow at the Helena gage was 53 cfs while the average flow at the Centreville gage was 589 cfs.

From a national perspective two nutrients, phosphorus and nitrogen, usually limit aquatic plant growth (EPA, 2000). EPA (2002) recommends for various reasons that TP and TN be used in developing criteria to control growth of algae and macrophytes. Ambient nutrient concentrations of 8 µg/L total phosphorus and 500-700 µg/L total nitrogen may already be saturating for algal growth. (Borchardt, 1996). During the 2002 Cahaba studies, nitrates above this level were seen from CR-BT to CR-9 during the spring study, and both phosphorus and nitrate above these levels during the summer study.

Benthic algal biomass does not always relate to nutrient levels. There are several necessary conditions which must be satisfied before nutrients become a factor causing nuisance levels of algal growth in streams. These conditions include suitable substrate, light, temperature, and water velocity (Nordin, 1985). A suitable substrate is one which has relatively high surface area such as gravel and cobble as opposed to mud or sand which are poor algal substrates. Light can be growth limiting. If there is insufficient light due to riparian shading or turbidity, nutrient enrichment will have little or no effect on growth.

In enriched streams, higher biomass communities often develop in runs and pools and are usually dominated by filamentous green algae (Biggs, 1996). The highest risk of algal accumulation would be at moderate velocities (10-50 cm/s). At high stream velocity (greater than 50 cm/s) risk of accumulation is lower because of scouring and high rate of export (sloughing) which can offset high rate of growth. Cycles of sloughing and accrual can be found in streams that have a moderate frequency of flood disturbances. Time available for benthic algal accrual and nutrient supply influence the frequency and duration of benthic algal proliferation in streams (Biggs, 2000). The accumulation of biomass generally occurs during extended periods of flow stability between floods.

Both natural and artificial substrates are useful in monitoring periphyton and assessing waterbody conditions (Stevenson and Bahls, 1999). Algae in streams tend to be very patchy in their distribution as demonstrated in our periphyton percent coverage measurements. Artificial substrates are often used because of this in situ heterogeneity, particularly in upstream/down-stream work where samplers can be placed in similar physical conditions thereby reducing the effects of variables such as shading and current velocity. Most investigators agree that periphytic diatom community development on artificial substrates reflect the natural diatom community quite closely. However, algal biomass is generally lower on artificial substrates with green and blue greens often under represented possibly due to short incubation time, two weeks (Weitzel, 1979; Nordin, 1985). Most monitoring groups prefer sampling algal biomass growing on natural substrates to improve ecological applicability of information and to reduce field time (Stevenson and Bahls, 1999).

Aesthetic impairment due to algal biomass is difficult to quantify, but usually is associated with filamentous algal forms (Dodds and Welch, 2000). A biomass range of 100 to 150 $mg/m^2$ chlorophyll *a* may represent a critical level for aesthetic nuisance, below this level filamentous coverage is less than 20 percent (Welch et al, 1988). Seasonal mean and maximum chlorophyll *a* may be most relevant to those concerned with controlling stream eutrophication. Dodds defined nuisance levels of benthic algal chlorophyll *a* as mean values exceeding 100 $mg/m^2$ and a maximum value exceeding 150 $mg/m^2$ (Dodds et al., 1997). During the 2002 Cahaba studies, the periphyton chlorophyll *a* collected from the periphytometers ranged from 5 $mg/m^2$ at Shades Creek during the spring to 95 $mg/m^2$ at the unnamed tributary (UT-1) during the summer. Natural substrate samples were also collected at three stations (CR-1, CR-6, and CR-7) during the summer study. CR-6 and CR-7 both had maximum chlorophyll *a* concentrations above the 150 $mg/m^2$ maximum value suggested to be protective of aesthetic uses and CR-7 had a mean concentration of 200 $mg/m^2$, well above the 100 $mg/m^2$ mean value suggested to be protective of aesthetic uses.

Because of the limited sampling conducted in 2002, the frequency distribution approach (EPA, 2000; EPA, 1997) was used. The $25^{th}$ percentile was selected as an upper limit to begin the process of setting guidelines for the Cahaba River Basin. Background TP was a minimum of 12 µg/L (Table D9) ranging to 27 µg/L at the $25^{th}$ percentile. Total nitrogen ranged from a minimum of 230 µg/L at station LCC-1 to 580 µg/L at the $25^{th}$ percentile (Table D.9). Based on these studies, AGPT results show that phosphorus or nitrogen or both are limiting in the Cahaba system. TN:TP ratios equal to or less than 10 usually indicate, by weight, nitrogen limitation. Nitrogen in nitrogen-limited waters is usually the limiting plant growth nutrient because of an excess of phosphorus in the system. Conversely, a TN:TP ratio by weight of equal to or greater than 20 is accepted as P-limitation (EPA, 2000). Using the maximum concentrations of 580 and 27 µg/L for TN and TP respectively at the $25^{th}$ percentile equates to a TN:TP ratio (580/27) of 21.5, which is considered P-limiting (EPA Guidelines). At what we consider the site control stations, CR-1 and LCC-1, concentrations of 12.0 to 12.5 µg/L TP and 230 to 240 µg/L TN, would produce TN:TP ratios ranging from 18.4 to 20.0 indicating a tendency toward phosphorus limitation. The AGPT data confirm that CR-1 is P-limited (Table D12). No AGPT data are available for LCC-1. An examination of the system reveals a broad range of mean percent cover ranging from 0.3% to 100% (Table D8) with a 25$^{th}$ percentile of 10% cover (Appendix D, Figures 1 & 2). Stations CR-1 and LCC-1, which are in the lower TP 25$^{th}$ percentile, also were less than 10% periphyton cover except in the spring when CR-1 had a mean of 23% periphyton cover (Table D10).

EPA (2000) in the "Nutrient Criteria Technical Guidance Manual for Streams" presents the following helpful guidance in setting guidelines for the Cahaba system. The tendency for *Cladophora* to begin dominating the periphyton has been observed at TP concentrations of 10 to 20 µg/L. This general range was selected by the Clark Fork Tri-State Council to limit maximum biomass levels. Percent coverage by filamentous forms was less than 20 %, but increased in biomass and noticeably affected aesthetic quality. A provisional guideline of a maximum 40% coverage of filamentous forms was proposed for New Zealand streams to protect contact recreation. Stevenson (2001) reports that *Cladophora* growths are limited from significant accrual below TP concentrations of 18 µg/L and nuisance growths (>40% cover) generally do not occur at TP concentrations below 36 µg/L.

The 12 to 27 µg/L TP and the 230 to 580 µg/L TN are a good starting point for reducing excessive plant growths in the Cahaba system. Those stations within these ranges contained mean percent periphyton coverage ranging from 0.8 to 38 % (Tables D8 & D9). In our professional opinion, the lower values of 12 µg/L and 230 µg/L of TP and TN respectively as a monthly mean should minimize exceedances of high biomass and over 40% coverage. Although we do not have winter data, we believe it would be prudent to apply these monthly means year around because of the mild winters in the lower Temperate Zone and the ability of *Fontinalis* and many gelatinous filamentous algae to thrive in cold waters. These lower levels would reduce excess phosphorus and nitrogen driving the system to phosphorus limitation, and allowing the non-filamentous diatoms to predominate at diversity levels of 3.0 or less d-bar while maintaining periphyton chlorophyll *a* biomass below the 100 mg/m$^2$ nuisance level observed by Dodds et al. 1997.

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# APPENDIX A :

## Photos of selected sampling locations

Figure 1

Station LCC-1: Upstream

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Figure 2

Station UT-1: Upstream

Figure 3

Station UT-1: Downstream

Figure 4

Station CR-1: Upstream

Figure 5

Station CR-1: Downstream

Figure 6

Station CR-AT: Upstream

Figure 7

Station CR-AT: Downstream

Figure 8

Station CR-BT: Upstream

Figure 9

Station CR-BT: Downstream

Figure 10

Station LCR-2: Upstream

Figure 11

Station LCR-2: Downstream

Figure 12

Station CR-AH: Upstream

Figure 13

Station CR-BH: Upstream

Figure 14

Station BC-2: Upstream

Figure 15

Station BC-2: Downstream

Figure 16

Station CR-6: Upstream

Figure 17

Station CR-6: Downstream

Figure 18

Station CR-7: Upstream

Figure 19

Station CR-7: Downstream

Figure 20

Station CR-9: Upstream

Figure 21

Station CR-9: Downstream

Figure 22

Station CR-11: Upstream

Figure 23

Station CR-11: Downstream

## APPENDIX B:

## Benthic Macroinvertebrate Collections

| organism | LCC-1 | UT-1 | CR-AT | CR-ATa* | CR-BT | LCR-2 | CR-AH | CR-BH | CR-6 | CR-7 | SC-1 | BC-2 | BC-3 | BC-4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Chironomidae** | | | | | | | | | | | | | | |
| Ablabesmyia | | | | | | | | | 3 | | | 1 | | |
| Brillia | | 1 | | 1 | 2 | | | | | | | | 1 | |
| Bryophaeocladius | | | | | | 1 | | | | | | | | |
| Cardiocladius | | 1 | 2 | 4 | 1 | | | 8 | | 1 | | | | |
| Chironomidae | | | | | | | | | | | | 1 | | 1 |
| Chironomus | | | | | | | | 1 | | | | 5 | | |
| Conchapelopia | | | | | | | | | 1 | | | | | |
| Corynoneura | | | | | 1 | | 3 | | | | 1 | | | |
| Cricotopus | | 22 | | 7 | 6 | | 3 | 1 | | 2 | | 6 | 1 | 17 |
| Cryptochironomus | | 2 | | | | | | 7 | | | | | | |
| Diamesa | 1 | | | | | | 3 | | | | | | | |
| Dicrotendipes | | | | | | | | | | | | | | |
| Eukiefferiella | 13 | 1 | 6 | 2 | 1 | | 4 | | | | | | | |
| Hayesomyia | | 1 | | | | | | | 1 | | | | | |
| Hydrobaenus | | 1 | | | | | | | | | | | | |
| Meropelopia | | | | | | | 2 | 1 | | 1 | | | 2 | 1 |
| Nanocladius | 2 | | | | | | | | | | | | | |
| Orthocladius | | | | | | | 3 | 1 | | 2 | 2 | | | 26 |
| Parakiefferiella | | | | | | | | | | | | | | 1 |
| Parametriocnemus | | 1 | 3 | 6 | 1 | | | | | | | | | 1 |
| Paratanytarsus | | | | 2 | | 1 | | | | | | | | |
| Paratendipes | | | | | | | | | | | | | | 1 |

| organism | LCC-1 | UT-1 | CR-AT | CR-ATa* | CR-BT | LCR-2 | CR-AH | CR-BH | CR-6 | CR-7 | SC-1 | BC-2 | BC-3 | BC-4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Polypedilum | 2 | 3 | 6 | 11 | 15 | 3 | 27 | 36 | 1 | 6 | | 8 | 1 | |
| Potthastia | | | | | 1 | | | | | | | | 1 | |
| Procladius | | | | | | | | | | | | | | |
| Rheocricotopus | | | 2 | | 4 | | 4 | | | | | 4 | | 8 |
| Rheotanytarsus | 5 | | 5 | 24 | 40 | | 5 | 8 | | | 4 | | 5 | 8 |
| Stempellinella | | | | | | | | | | | | | | 1 |
| Stenochironomus | | | | | | | | | | 2 | | | 1 | |
| Stictochironomus | | | | | | | 2 | | | | | | | |
| Synorthocladius | | | 1 | | | | | | | | | | | |
| Tanytarsus | | | | 1 | | 1 | 1 | 1 | | | | | | 1 |
| Thienemanniella | | 1 | | | | | 1 | 1 | | 1 | | 1 | | 1 |
| Tvetenia | | | 4 | 2 | 2 | | | | | | 3 | | | |
| Xenochironomus | 1 | | | | | | | | | | | | | |
| **Trichoptera** | | | | | | | | | | | | | 1 | |
| Ceraclea | 2 | | | | | | | 1 | | | | | | |
| Cheumatopsyche | 15 | 54 | 7 | 16 | 21 | 2 | 3 | 61 | 49 | 48 | 10 | 6 | 4 | 18 |
| Chimarra | 1 | | 3 | 6 | 5 | | 2 | | | | | | 1 | 1 |
| Dolophiloides | | | | | | | | | | | | | | |
| Hydropsyche | 13 | 5 | 7 | 8 | 7 | 2 | 1 | 1 | | 5 | 4 | 6 | | |
| Hydropsychidae | | 17 | 1 | 3 | 4 | | | 5 | | | 2 | | | |
| Hydroptila | | | | | | | | | | 1 | 1 | | | |
| Micrasema | | | | | | | | | | | | | | 3 |
| Polycentropus | | | | 2 | | | | | | | | | 1 | |

| organism | LCC-1 | UT-1 | CR-AT | CR-ATa* | CR-BT | LCR-2 | CR-AH | CR-BH | CR-6 | CR-7 | SC-1 | BC-2 | BC-3 | BC-4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Triaenodes | | | 2 | | | 1 | | 2 | | | | | | |
| Trichoptera unid. | 2 | | | | | | | | | | | | | |
| **Plecoptera** | | | | | | | | | | | | | | |
| Acroneuria | | | | 1 | | | | | | | | | | |
| Amphinemura | | | | | | | 1 | | | | | | | |
| Eccoptura | | | | 1 | | | | | | | | | | |
| Isoperla | | | | | | | | | | | | | | |
| Perlesta | | | 16 | 3 | 3 | | | 2 | 1 | | 6 | | | |
| Perlidae | | | | | | | | | | | | | | |
| Taeniopteryx | | | | | | | 1 | | | | | | | |
| **Ephemeroptera** | | | | | | | | | | | | | | |
| Baetidae | 1 | 4 | 23 | 13 | 12 | | 1 | 17 | 6 | 40 | 19 | 24 | 3 | 44 |
| Caenis | | | | | | 1 | | | | | | | | |
| Ephemerella | | | 7 | 2 | | | 1 | | | | | | | |
| Eurylophella | | | 20 | 12 | | | | | 3 | | 4 | | 7 | |
| Heptageniidae | | | 2 | | | | | | 2 | | | | | |
| Isonychia | 2 | | 15 | 15 | 19 | | 4 | 2 | | 1 | 39 | | 4 | 4 |
| Serratella | | | 1 | | | | | | | | 12 | | | |
| Stenacron | 1 | | 11 | | 1 | 9 | | 1 | 3 | 15 | 1 | | 1 | 4 |
| Stenonema | 82 | | 8 | 5 | 24 | 1 | 11 | 3 | 6 | 6 | 23 | | 26 | 4 |
| Timpanoga | | | | | | | | | | | 1 | | | |
| **Odonata** | | | | | | | | | | | | | | |
| Argia | 6 | 6 | 4 | 2 | | 8 | | 6 | 5 | | 1 | 2 | 3 | |

| organism | LCC-1 | UT-1 | CR-AT | CR-ATa* | CR-BT | LCR-2 | CR-AH | CR-BH | CR-6 | CR-7 | SC-1 | BC-2 | BC-3 | BC-4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Basiaeschna | 1 | | | | | | | | | | | | | |
| Boyeria | | 2 | | | | | | | | 2 | 3 | | 1 | |
| Calopteryx | | | | 1 | 1 | | | | | | | | 1 | |
| Enallagma | | | 15 | 12 | | 17 | | 11 | 1 | | | | 2 | |
| Erpetogomphus | | | | | | | | | | | 1 | | | |
| Gomphidae | | | 5 | 2 | | 1 | | | 1 | | | | | |
| Gomphus | | | | 1 | | | | | | | | | | |
| Libellula | | | | | | 1 | | | | | | | | |
| Libellulidae | | | | 3 | | | | | | | | | | |
| Macromia | | | | | | 1 | | | | | | | | |
| Perithemis | | | | | | | | | 1 | | | | | |
| **Lepidoptera** | | | | | | | | | | | | | | |
| Pyralidae | | 1 | | | | | 1 | | | | | | | |
| **Megaloptera** | | | | | | | | | | | | | | |
| Corydalus | 3 | 2 | | 1 | 1 | | | | | | | | | |
| **Hemiptera** | | | | | | | | | | | | | | |
| Dasycorixa | | | | | | 2 | | | | | | | | |
| Rhagovelia | | | 1 | | | | | | | | | 2 | | |
| **Coleoptera** | | | | | | | | | | | | | | |
| Ancyronyx | | | | | | | | 2 | 4 | | | | 1 | |
| Cyphon | | | | | | | 2 | | | | | | | |
| Dubiraphia | | | | | | 1 | | | 2 | | 1 | | | |
| Elmidae | 2 | | | | | | | 1 | 4 | | | | | |

| organism | LCC-1 | UT-1 | CR-AT | CR-ATa* | CR-BT | LCR-2 | CR-AH | CR-BH | CR-6 | CR-7 | SC-1 | BC-2 | BC-3 | BC-4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Helichus | | | | | | | | | | | | | | |
| Macronychus | | | | | 2 | | | 1 | 9 | | 1 | | 2 | 1 |
| Microcylloepus | | | | | | | | | 1 | | | | | |
| Optioservus | | | | | | | | | | | | | | 1 |
| Peltodytes | | | | | | | | | 1 | | | | | |
| Psephenus | | | 1 | | 1 | | | | | | | | | 1 |
| Stenelmis | 5 | | 2 | | 10 | | 7 | 6 | 5 | | 3 | 1 | 2 | 3 |
| **Crustacea** | | | | | | | | | | | | | | |
| Asellus | | | 4 | | | 16 | | | | | | | | |
| Astacidae | | 55 | 8 | 6 | 1 | 7 | | | 1 | 5 | | 1 | 1 | |
| Crangonyx | | | | | | 4 | | | 1 | 3 | | 1 | 1 | 1 |
| Hyallela | | | | | | 8 | | 1 | | 3 | | | | |
| Lirceus | 2 | | 16 | 7 | | | | | | 1 | | | | |
| **Oligochaeta** | | | | | | | | | | | | | | |
| Dero | | | 1 | | | | | | | | | | | |
| Limnodrilus | | | | 2 | | 2 | | | | 1 | | | | |
| Lumbriculidae | 1 | 2 | 3 | 1 | | | | 4 | 1 | 5 | | 2 | | |
| Naididae | | | | | | | | | | | | 84 | | |
| Tubificidae | | 4 | | 4 | | 6 | 2 | 3 | 4 | | | 1 | 1 | |
| **Pelecypoda** | | | | | | | | | | | | | | |
| Corbicula | | | | | 1 | 3 | 3 | | 8 | 2 | | | | 1 |
| Musculium | | | | | | | | 1 | | | | | | 1 |
| | | | | | | | | | | | | | | |

| organism | LCC-1 | UT-1 | CR-AT | CR-ATa* | CR-BT | LCR-2 | CR-AH | CR-BH | CR-6 | CR-7 | SC-1 | BC-2 | BC-3 | BC-4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Gastropoda** | | | | | | | | | | | | | | |
| Amnicola | | | | | | 1 | | | | | | 1 | | |
| Campeloma | | | | | | | 1 | | | | 18 | | | |
| Elimia | | | | | 7 | 9 | | | 19 | | | 1 | 2 | |
| Leptoxis | | | | | 3 | | | | 26 | 2 | | | | |
| Physella | | | | | | | | | | | | 2 | | |
| Planorbula | | | | | | | | | | | | | | 1 |
| Pleurocera | 9 | | 1 | | 13 | 88 | 7 | 10 | 60 | 41 | 49 | 26 | 124 | 45 |
| **Diptera** | | | | | | | | | | | | | | |
| Antocha | 1 | | | | | | | | | | | 1 | | |
| Chelifera | 1 | | | | | | | | | | | | | |
| Limonia | | | | | | | | | | | | 1 | | |
| Muscidae | | 2 | | | | | | | | | | | | |
| Palpomyia | | | | | | 1 | | | | | | | | |
| Parydra | | 1 | | | | | | | | | | | | |
| Simuliidae | | | | | | | | | | | 1 | | | |
| Simulium | 107 | 4 | 9 | 7 | 1 | | 88 | 4 | | 3 | | | | 15 |
| Tipula | | | | 1 | | | | | 1 | | 1 | | | 1 |
| **Tot Organisms** | 281 | 193 | 222 | 197 | 211 | 198 | 194 | 210 | 231 | 199 | 211 | 188 | 201 | 216 |
| **Tot Taxa** | 26 | 24 | 35 | 37 | 31 | 28 | 29 | 32 | 31 | 26 | 26 | 24 | 28 | 30 |

* duplicate QA sample

## APPENDIX C:

## Water Quality Sampling

**TABLE C1. CAHABA RIVER STUDY**
**ANALYTICAL REQUIREMENTS**

| PARAMETER | STATIONS | TOTAL SAMPLES/QC | LABORATORY | METHOD | DETECTION LIMIT | BOTTLE/ PRESERVATIVE | HOLDING TIME |
|---|---|---|---|---|---|---|---|
| CHLOROPHYLL A | 18 | 20 | EAB | EPA 445.0 | 0.1 ug/L | 500 mL/ Filter&Freeze | 24d |
| CHLOROPHYLL A (periphyton) | 18 | 20 | EAB | EPA 446.0 | 0.2 mg/m2 | Glass Slide 4oz Amber /Freeze | 28d |
| NUTRIENTS (TP,TKN, NH3, NO2+NO3) | 18 | 20 | ASB | TP 365.1<br>TKN 351.2<br>NH3 350.1<br>NOX 353.2 | 0.025 mg/L<br>0.1 mg/L<br>0.05 mg/L<br>0.05 mg/L | 1 Liter /H2SO4 Cool $4^0$C | 28d |
| AGPT | 10 | 10 | EAB | EPA-600/9-78-018 | | 2L Nalgene/ Cool $4^0$C | |
| AGPT-NUTRIENTS | 10 | 10 | ASB | TP 365.1<br>TKN 351.2<br>NH3 350.1<br>NOX 353.2 | 0.02 mg/L<br>0.1 mg/L<br>0.05 mg/L<br>0.05 mg/L | 500 mL /H2SO4 Cool $4^0$C | 28d |
| PERIPHYTON ID | 18 | 20 | EAB/ CONTRACT | | | Glass Slide/ Glutaraldehyde | |

* Nutrient methods in Methods for Chemical Analysis of Water and Wastes (EPA-600/4-79-020)

Table C2. Nutrients and Chlorophyll Results
Cababa River - April, 2002

| Station ID | Site/Location | $NH_3$-N (mg/L) | $NO_2$+$NO_3$-N (mg/L) | TKN (mg/L) | TN (mg/L) | TPhos (mg/L) | corrChla (ug/L) |
|---|---|---|---|---|---|---|---|
| CR1 | CR at Jefferson Co Rd 132 | 0.05U | 0.23 | 0.07 | 0.30 | 0.025U | 0.57 |
| CR-AT | CR at Trussville (US11) | 0.05U | 0.25 | 0.07 | 0.32 | 0.025U | 0.65 |
| UT1 | Unnamed Tributary off Camp Coleman | 0.14 | 26 | 1.10 | 27.10 | 0.93 | 2.5 |
| LCC1 | Little Cahaba Creek off Camp Coleman | 0.05U | 0.55 | 0.24 | 0.79 | 0.025U | 8.4 |
| CR-BT | CR below Trussville (CR 10) | 0.05U | 3.8 | 0.33 | 4.13 | 0.20 | 1.0 |
| LCR2 | Little Cahaba River at US411 | 0.056 | 1.0 | 0.26 | 1.26 | 0.30 | 0.43 |
| CR-AH | CR at Caldwell Mill RD | 0.05U | 0.66 | 0.26 | 0.92 | 0.23 | 4.6 |
| CR-BH | CR at Riverford Drive | 0.05U | 0.46 | 0.25 | 0.71 | 0.11 | 2.1 |
| CR6 | CR at Bains Bridge | 0.05U | 1.2 | 0.33 | 1.53 | 0.24 | 1.0 |
| BC1 | Buck Creek at CR52 | 0.05U | 2.4 | 0.36 | 2.76 | 0.34 | 0.74 |
| BC2 | BC at CR261 (Helena) | 3.4 | 0.88 | 3.80 | 4.68 | 0.63 | 1.3 |
| BC3 | BC at CR44/1st Ave | 0.05U | 0.88 | 0.09 | 0.97 | 0.025U | 0.74 |
| BC3D | | 0.05U | 0.88 | 0.11 | 0.99 | 0.025U | |
| BC4 | BC at Keystone Rd | 0.05U | 4.4 | 0.30 | 4.70 | 0.65 | 0.51 |
| BC5 | BC at Rolling Mill (Helena) | 0.05U | 1.0 | 0.31 | 1.31 | 0.14 | 0.94 |
| CR7 | CR at Shelby Co Rd 52 | 0.086 | 1.3 | 0.34 | 1.64 | 0.22 | 0.58 |
| SC1 | Shades Creek at CR12/Grey Hill Rd | 0.05U | 0.18 | 0.15 | 0.33 | 0.025U | 0.30 |
| CR9 | Bibb Co Hwy 24 | 0.05U | 0.57 | 0.15 | 0.72 | 0.05 | 1.4 |

U - Material was analyzed for but not detected. The number is the minimum quantitation limit.

Table C3. Nutrients and Chlorophyll Results
Cahaba River - July, 2002

| Station ID | Site/Location | $NH_3$-N (mg/L) | $NO_2$+$NO_3$-N (mg/L) | TKN (mg/L) | TN (mg/L) | TPhos (mg/L) | corrChla (ug/L) |
|---|---|---|---|---|---|---|---|
| CR1 | CR at Jefferson Co Rd 132 | 0.05U | 0.23 | 0.12 | 0.35 | 0.025U | 0.28 |
| CR-AT | CR at Trussville (US11) | 0.068 | 0.076 | 0.16 | 0.236 | 0.030 | 0.87 |
| UT1 | Unnamed Tributary off Camp Coleman Rd | 0.05U | 27 | 0.92 | 27.92 | 0.55 | 11.4 |
| LCC1 | Little Cahaba Creek off Camp Coleman | 0.05U | 0.05U | 0.18 | 0.230 | 0.025U | 1.8 |
| CR-BT | CR below Trussville (CR 10) | 0.05U | 5.9 | 0.39 | 6.29 | 0.26 | 0.82 |
| LCR2 | Little Cahaba River at US411 | 0.05U | 4.2 | 0.37 | 4.6 | 1.1 | 0.38 |
| CR-AH | CR at Caldwell Mill RD | 0.05U | 0.80 | 0.27 | 1.07 | 0.31 | 10.8 |
| CR-BH | CR at Riverford Drive | 0.05U | 0.31 | 0.26 | 0.57 | 0.12 | 2.5 |
| CR6 | CR at Bains Bridge | 0.058 | 6.0 | 0.48 | 6.48 | 0.96 | 1.3 |
| BC1 | Buck Creek at CR52 | 0.088 | 3.7 | 0.43 | 4.13 | 0.57 | 0.42 |
| BC2 | BC at CR261 (Helena) | 0.88 | 1.7 | 1.10 | 2.80 | 0.51 | 1.7 |
| BC3 | BC at CR44/1st Ave | 0.05U | 0.66 | 0.097 | 0.757 | 0.026 | 0.62 |
| BC3D | BC at CR44/1st Ave | 0.05U | 0.65 | 0.085 | 0.735 | 0.025U | 0.58 |
| BC4 | BC at Keystone Rd | 0.098 | 6.0 | 0.47 | 6.47 | 0.93 | 0.60 |
| BC5 | BC at Rolling Mill (Helena) | 0.05U | 1.7 | 0.22 | 1.92 | 0.40 | 0.49 |
| CR7 | CR at Shelby Co Rd 52 | 0.087 | 2.6 | 0.35 | 2.95 | 0.44 | 1.3 |
| SC1 | Shades Creek at CR12/Easter Valley Rd | 0.05U | 0.16 | 0.19 | 0.350 | 0.027 | 0.88 |
| CR9 | Bibb Co Hwy 24 | 0.05U | 0.66 | 0.54 | 1.20 | 0.12 | 13.8 |
| CR11 | US 82 near Centreville | 0.05U | 0.45 | 0.28 | 0.730 | 0.070 | 11.6 |

U - Material was analyzed for but not detected. The number is the minimum quantitation limit.

Table C4. Algal Growth Potential Test - Limiting Nutrient Results
Cahaba River, AL 2002

| Station ID | SITE/LOCATION | AGPT SPRING | TN/TP ratio | AGPT SUMMER | TN/TP ratio |
|---|---|---|---|---|---|
| CR-1 | Cahaba River at Jefferson Co Rd 132 | P | 9.9 | P | 14.0 |
| UT-1 | Unnamed Tributary off Camp Coleman Rd | P | 29.1 | | 50.8 |
| CR-BT | CR below Trussville (CR10) | P | 20.7 | | 24.2 |
| CR-AH | CR at Caldwell Mill Rd | N | 4.0 | N | 3.5 |
| CR-BH | CR at Riverford Dr | | 6.5 | N | 4.8 |
| CR-6 | CR at Bains Bridge | N | 6.4 | | 6.8 |
| BC-2 | Buck Creek at CR261 (Helena) | | 7.4 | | 5.5 |
| BC-3 | BC at CR44/1st Ave | P | 38.9 | | 29.2 |
| BC-5 | BC at Rolling Mill (Helena) | P | 9.4 | | 4.8 |
| CR-7 | CR at Shelby Co Rd 52 | N | 7.5 | | 6.7 |
| SC-1 | Shades Creek at CR12/Easter Valley Rd | | 11.0 | P | 13.0 |
| CR-9 | CR at Bibb Co Hwy 24 | N+P | 14.4 | | 10.0 |
| CR-11 | US 82 near Centreville | | | P | 10.4 |

P - Phosphorus limited
N - Nitrogen Limited
N+P - Nitrogen and Phosphorus Co-limited

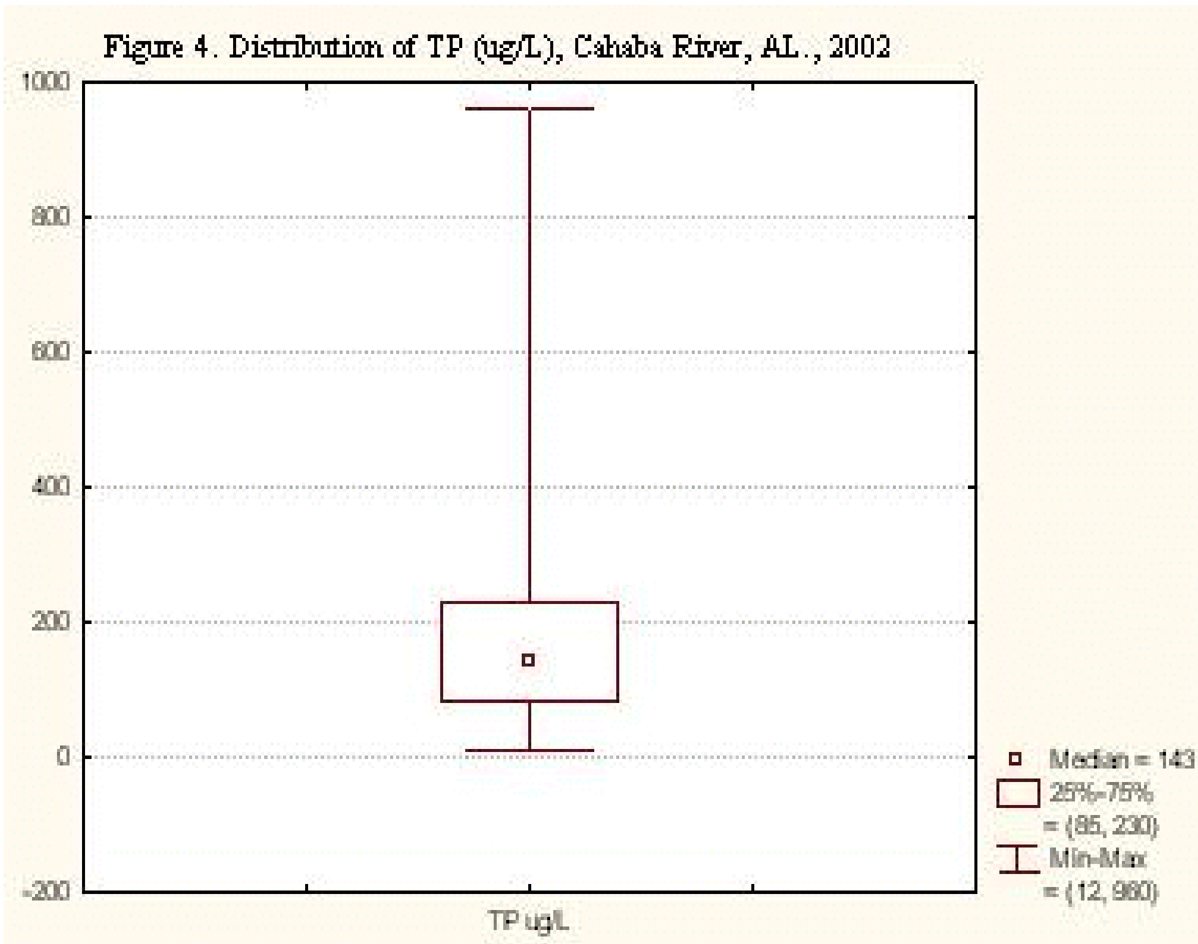


Figure 4. Distribution of TP (ug/L), Cahaba River, AL., 2002
1000
800
600
400
200
0
-200
TP ug/L
Median = 143
25%-75%
= (85, 230)
Min-Max
= (12, 960)

Figure 5. Distribution of Square Root Transformed TP (ug/L) Data, Cahaba River, AL., 2002

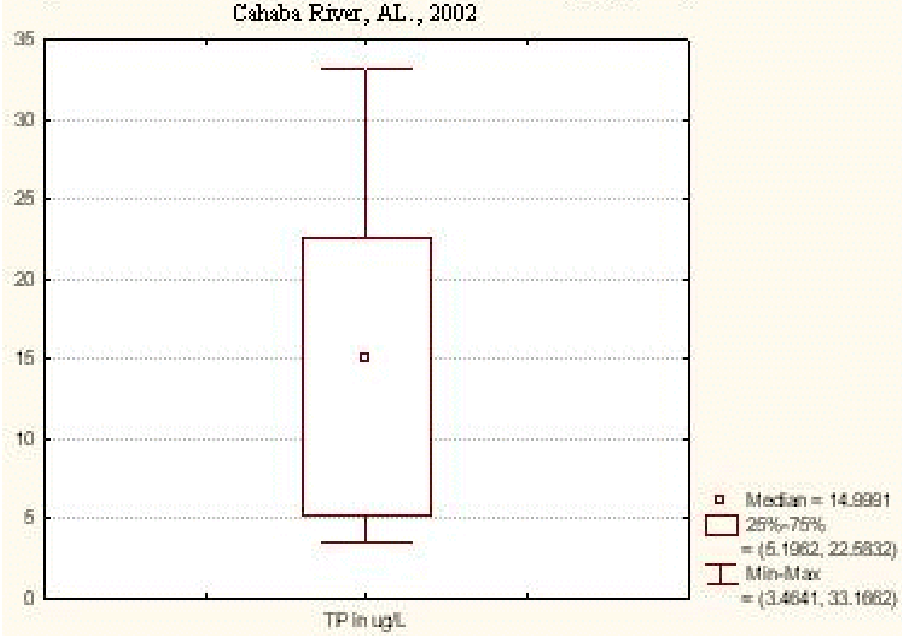


Figure 6. Distribution of TN (ug/L), Cahaba River, AL., 2002

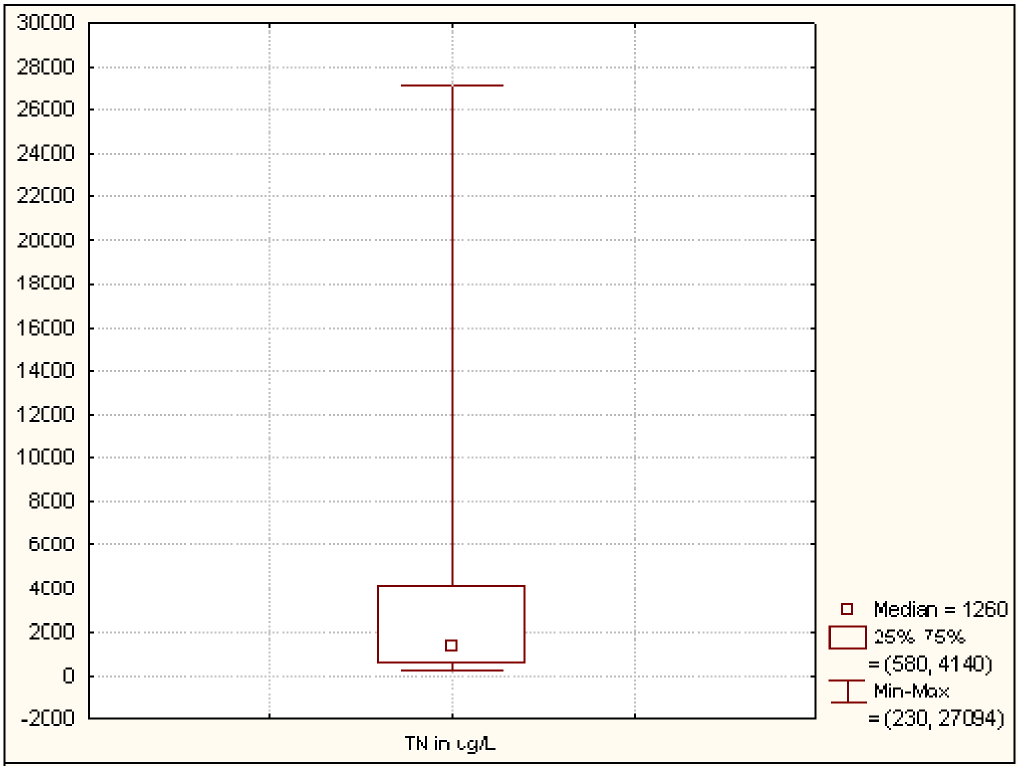
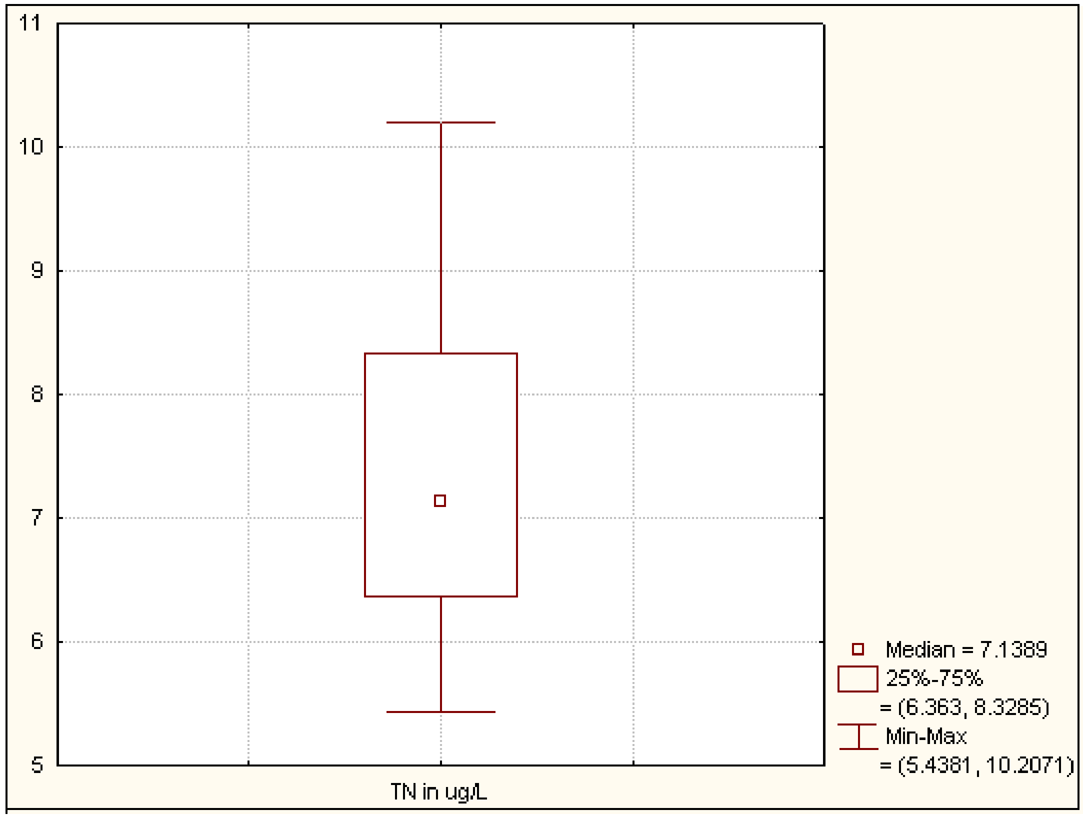


Figure 7. Distribution of Natural Log TN (ug/L), Cahaba River, AL., 2002



# APPENDIX D:

# Periphyton

## Table D1. Periphyton Chlorophyll *a* Results
## Cahaba River - Spring 2002

| Station ID | Site/Location | Days in place | corr CHLA ($mg/m^2$) | Remarks |
|---|---|---|---|---|
| CR-1 | CR at Jefferson Co Rd 132 | 41 | 20.8 | |
| CR-AT | CR at Trussville (US11) | 41 | 47.8 | |
| UT-1 | Unnamed Tributary off Camp Coleman Rd | | | Periphytometer grounded |
| LCC-1 | Little Cahaba Creek off Camp Coleman | 41 | 15.7 | |
| CR-BT | CR below Trussville (CR 10) | 41 | 59.0 | |
| LCR-2 | Little Cahaba River at US411 | 41 | 33.4 | |
| CR-AH | CR at Caldwell Mill RD | 41 | 26.2 | |
| CR-BH | CR at Riverford Drive | 70 | 11.6 | |
| CR-6 | CR at Bains Bridge | 28 | 36.4 | |
| BC-1 | Buck Creek at CR52 | 29 | 28.1 | |
| BC-2 | BC at CR261 (Helena) | 43 | 65.9 | |
| BC-3 | BC at CR44/1st Ave | 29 | 42.9 | |
| BC-4 | BC at Keystone Rd | 29 | 53.4 | |
| BC-5 | BC at Rolling Mill (Helena) | 29 | 67.9 | |
| CR-7 | CR at Shelby Co Rd 52 | 70 | 20.7 | |
| SC-1 | Shades Creek at CR12/Grey Hill Rd | 27 | 5.0 | |

**Table D2. Periphyton Chlorophyll *a* Results**
**Cahaba River - Summer 2002**

| Station ID | Site/Location | Days in place | corr CHLA ($mg/m^2$) | Remarks |
|---|---|---|---|---|
| CR-1 | Cahaba River at Jefferson Co Rd 132 | 21 | 37 | |
| CR-AT | CR at Trussville (US11) | 21 | 21 | |
| UT-1 | Unnamed Tributary off Camp Coleman Rd | 21 | 95 | |
| CR-BT | CR below Trussville (CR 10) | | | Periphytometer missing |
| CR-AH | CR at Caldwell Mill RD | 20 | 37 | |
| CR-BH | CR at Riverford Drive | 21 | 13 | |
| CR-6 | CR at Bains Bridge | 21 | 20 | |
| BC-2 | Buck Creek at CR261 (Helena) | 21 | 66 | |
| CR-7 | CR at Shelby Co Rd 52 | 20 | 31 | |
| CR-7 | CR at Shelby Co Rd 52 | 20 | 75 | 2nd periphytometer |
| SC-1 | Shades Creek at CR12/Grey Hill Rd | 20 | 45 | |

**Table D3. Periphyton Chlorophyll - Natural Substrate**
**Cahaba River - Summer 2002**

| Station ID | Site/Location | corr CHLA ($mg/m^2$) |
|---|---|---|
| CR-1A | Cahaba River at Jefferson Co Rd 132 | 41 |
| CR-1B | Cahaba River at Jefferson Co Rd 132 | 27 |
| CR-1C | Cahaba River at Jefferson Co Rd 132 | 11 |
| CR-6A | CR at Bains Bridge | 17 |
| CR-6B | CR at Bains Bridge | 170 |
| CR-6C | CR at Bains Bridge | 110 |
| CR-7A | CR at Shelby Co Rd 52 | 210 |
| CR-7B | CR at Shelby Co Rd 52 | 230 |
| CR-7C | CR at Shelby Co Rd 52 | 160 |

**Table D4. Periphyton Chlorophyll a ($mg/m^2$)**
**Natural Substrate**

| | Natural Substrate | | |
|---|---|---|---|
| Station | Avg | Max | Range |
| CR-1 | 26.3 | 41 | 11-41 |
| CR-6 | 99 | 170 | 17-170 |
| CR-7 | 200 | 230 | 160-230 |

**Table D5. Periphyton Percent Coverage**
**Cahaba River - Spring 2002**

Count / Percent Coverage

| Date | Station | | 1 | 2 | 3 | 4 | 5 | 6 | Sum | Average | Abundance |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Apr 24 | CR-1 | Run | 24 | | 52 | 0 | 40 | 0 | 116 | 23 | Common |
| Apr 24 | CR-AT | Run | 0 | 24 | 42 | 0 | 8 | 36 | 110 | 18 | Common |
| Apr 24 | UT-1 | Run | 1.5 | 1.8 | 28 | 57 | 27 | 100 | 215.3 | 36 | Abundant |
| Apr 24 | LCC-1 | Run | 0 | 0 | 0 | 0 | 0 | 4 | 4 | 1 | Rare |
| Apr 24 | CR-BT | Run | 0 | 24 | 0 | 0 | 16 | 12 | 52 | 9 | Common |
| Apr 24 | CR-AH | Run | 36 | 56 | 36 | 33 | 42 | 52 | 255 | 43 | Abundant |
| Apr 23 | CR-BH | Run | 0 | 0 | 0 | 54 | 4 | 0 | 58 | 10 | Common |
| Mar 11 | CR-6 | Run | 88 | 84 | 2 | 70 | 96 | 92 | 432 | 72 | Dominant |
| Apr 25 | BC-2 | Run | 100 | 100 | 100 | 100 | 100 | 100 | 600 | 100 | Dominant |
| Apr 25 | BC-3 | Run | 70 | 32 | 40 | 35 | 30 | | 207 | 41 | Abundant |
| Apr 24 | CR-7 | Run | 18 | 28 | 14 | | | | 60 | 20 | Common |
| Apr 25 | CR-4 | Run | 20 | 10 | 43 | 72 | 0.5 | | 145.5 | 29 | Common |
| Mar 12 | SC-1 | Run | 34 | | 36 | | | | 70 | 35 | Abundant |

Estimated Abundance: Rare (<5%), Common ( 5-30%), Abundant (30-70%), Dominant (>70%)

**Table D6. Periphyton Percent Coverage**
**Cahaba River - Summer 2002**

Count / Percent Coverage

| Date | Station | | 1 | 2 | 3 | 4 | 5 | 6 | Sum | Average | Abundance |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Jul 10 | CR-1 | Run | 14 | 8 | 4 | 12 | 6 | 6 | 50 | 8 | Common |
| Jul 10 | CR-1 | Riffle | 40 | 8 | 15 | 8 | 24 | 36 | 131 | 22 | Common |
| Jul 10 | CR-AT | Run | 8 | | 26 | | | | 34 | 17 | Common |
| Jul 10 | UT-1 | Run | 0 | 0 | 0 | 0 | 0 | 8 | 8 | 1 | Rare |
| Jul 10 | CR-BT | Run | 10 | 15 | | 30 | 24 | 22 | 101 | 20 | Common |
| Jul 9 | CR-AH | Run | 15 | 0 | 20 | 48 | 18 | 16 | 117 | 20 | Common |
| Jul 9 | CR-6 | Run | 1 | 0 | 0 | | | | 1 | 0 | Rare |
| Jul 9 | CR-6 | Riffle | 32 | 16 | 12 | 3 | 22 | 22 | 107 | 18 | Common |
| Jul 9 | BC-2 | Run | 68 | 60 | | | 5 | 42 | 175 | 44 | Abundant |
| Jul 8 | CR-7 | Run | 48 | 53 | 14 | | | | 115 | 38 | Abundant |
| Jul 8 | CR-7 | Riffle | 94 | 10 | 100 | 30 | 5 | 92 | 331 | 55 | Abundant |
| Jul 8 | SC-1 | Run | 18 | 20 | 0 | 0 | 12 | 90 | 140 | 23 | Common |

Estimated Abundance: Rare (<5%), Common ( 5-30%), Abundant (30-70%), Dominant (>70%)

## Table D7. Cahaba River, AL., Soft Filamentous Algae Collected during Percent Cover Measurement, 2002

| STATION | DATE | DIVISION | GENUS |
|---|---|---|---|
| SC1 | 3/12/02 | GREEN | Cladophora |
| BC2 | 4/25/02 | GREEN | Cladophora |
| BC3 | 4/25/02 | NONE | Moss, Fontinalis |
| BC4 | 4/25/02 | GREEN | Cladophora |
| CR7 | 4/24/02 | GREEN | Cladophora |
| CR6 | 3/11/02 | GREEN | Cladophora |
| CR6 | 4/24/02 | GREEN | Cladophora |
| CRBH | 4/23/02 | GREEN | Cladophora |
| CRAH | 4/23/02 | GREEN | Cladophora |
| CRBT | 4/24/02 | GREEN | Cladophora & Ulothrix |
| CRAT | 4/24/02 | GREEN | Cladophora |
| CRAT | 4/24/02 | DIATOM | Cymbella |
| LCC1 | 4/24/02 | GREEN | Cladophora |
| UT1 | 4/24/02 | GREEN | Cladophora |
| CR1 | 4/24/02 | GREEN | Mougeotia & Spirogyra |
| CR1 | 4/24/02 | DIATOM | Melosira |
| SC1 | 7/8/02 | GREEN | Cladophora |
| | | DIATOM | Biddulphia & Melosira |
| | | BLUE GREEN | Schizothrix |
| BC2 | 7/8/02 | GREEN | Cladophora |
| | | DIATOM | Melosira & Fragilaria |
| | | BLUE GREEN | Schizothrix |
| CR7 | 7/9/02 | GREEN | Cladophora |
| | | DIATOM | Biddulphia, Cymbella & Melosira |
| | | BLUE GREEN | Shizothrix & Rivularia |
| CR6 | 7/9/02 | GREEN | Cladophora, Stigeoclonium & Ulothrix |
| | | DIATOM | Melosira, Biddulphia & Fragilaria |
| | | BLUE GREEN | Shizothrix & Anabaena |
| CRBH | 7/9/02 | GREEN | Cladophora, Chaetophora & Ulothrix |
| | | DIATOM | Melosira & Cymbella |
| | | BLUE GREEN | Schizothrix, Rivularia & Anabaena |
| CRAH | 7/9/02 | GREEN | Cladophora |
| | | DIATOM | Melosira |
| | | BLUE GREEN | Schizothrix |
| CRBT | 7/10/02 | GREEN | Spirogyra & Cladophora |
| | | DIATOM | Melosira |
| | | BLUE GREEN | Schizothrix & Anabaena |
| CRAT | 7/10/02 | GREEN | Pseudoparenchyma |
| | | BLUE GREEN | Cylindrosporum, Rivularia & Schizothrix |
| UT1 | 7/10/02 | GREEN | Stigeoclonium, pseudoparenchyma, Cladophora & Ulothrix |
| | | DIATOM | Melosira |
| | | BLUE GREEN | Microcoleus, Rivularia & Shizothrix |
| CR1 | 7/10/02 | GREEN | Cladophora & Spirogyra |
| | | DIATOM | Melosira & Cymbella |
| | | BLUE GREEN | Rivularia & Shizothrix |

## Table D8. Summary Statistics, Percent Cover, Cahaba River AL., 2002

| Station | Season | Habitat | N | Mean | Minimum | Maximum |
|---|---|---|---|---|---|---|
| CR1 | Spring | Run | 5 | 23.2 | 0 | 52 |
| CR1 | Spring | Riffle | 0 | | | |
| CR1 | Summer | Run | 6 | 8.3 | 4 | 14 |
| CR1 | Summer | Riffle | 6 | 21.8 | 8 | 40 |
| CRAT | Spring | Run | 6 | 18.3 | 0 | 42 |
| CRAT | Spring | Riffle | 0 | | | |
| CRAT | Summer | Run | 2 | 17.0 | 8 | 26 |
| CRAT | Summer | Riffle | 0 | | | |
| UT1 | Spring | Run | 6 | 36.0 | 2 | 100 |
| UT1 | Spring | Riffle | 0 | | | |
| UT1 | Summer | Run | 6 | 1.3 | 0 | 8 |
| UT1 | Summer | Riffle | 0 | | | |
| LCC1 | Spring | Run | 5 | 0.8 | 0 | 4 |
| LCC1 | Spring | Riffle | 0 | | | |
| LCC1 | Summer | Run | 0 | | | |
| LCC1 | Summer | Riffle | 0 | | | |
| CRBT | Spring | Run | 5 | 10.4 | 0 | 24 |
| CRBT | Spring | Riffle | 0 | | | |
| CRBT | Summer | Run | 5 | 20.2 | 10 | 30 |
| CRBT | Summer | Riffle | 0 | | | |
| CRAH | Spring | Run | 6 | 42.5 | 33 | 56 |
| CRAH | Spring | Riffle | 0 | | | |
| CRAH | Summer | Run | 6 | 19.5 | 0 | 48 |
| CRAH | Summer | Riffle | 0 | | | |
| CRBH | Spring | Run | 6 | 9.7 | 0 | 54 |
| CRBH | Spring | Riffle | 0 | | | |
| CRBH | Summer | Run | 5 | 24.8 | 8 | 40 |
| CRBH | Summer | Riffle | 0 | | | |
| CR6 | Spring | Run | 6 | 72.0 | 2 | 96 |
| CR6 | Spring | Riffle | 0 | | | |
| CR6 | Summer | Run | 3 | 0.3 | 0 | 1 |
| CR6 | Summer | Riffle | 6 | 17.8 | 3 | 32 |
| BC2 | Spring | Run | 6 | 100.0 | 100 | 100 |
| BC2 | Spring | Riffle | 0 | | | |
| BC2 | Summer | Run | 4 | 43.8 | 5 | 68 |
| BC2 | Summer | Riffle | 0 | | | |
| BC3 | Spring | Run | 5 | 41.4 | 30 | 70 |
| BC3 | Spring | Riffle | 0 | | | |
| BC3 | Summer | Run | 0 | | | |
| BC3 | Summer | Riffle | 0 | | | |
| BC4 | Spring | Run | 5 | 29.2 | 1 | 72 |
| BC4 | Spring | Riffle | 0 | | | |
| BC4 | Summer | Run | 0 | | | |
| BC4 | Summer | Riffle | 0 | | | |
| CR7 | Spring | Run | 3 | 20.0 | 14 | 28 |
| CR7 | Spring | Riffle | 0 | | | |
| CR7 | Summer | Run | 3 | 38.3 | 14 | 53 |
| CR7 | Summer | Riffle | 6 | 55.2 | 5 | 100 |
| SC1 | Spring | Run | 2 | 35.0 | 34 | 36 |
| SC1 | Spring | Riffle | 0 | | | |
| SC1 | Summer | Run | 6 | 23.5 | 0 | 90 |
| SC1 | Summer | Riffle | 0 | | | |

**Table D9. Stations in the Lower 25th Percentile**
**Cahaba River, AL., 2002**

| Station | Season | Variable |
|---|---|---|
| | | |
| | | **Mean % Cover** |
| LCC1 | Spring | 0.8 |
| CRBH | Spring | 9.7 |
| CR1 | Summer | 8.3 |
| UT1 | Summer | 1.3 |
| CR6 | Summer | 0.3 |
| | | |
| | | **d-bar** |
| CR1 | Spring | 1.761 |
| LCC1 | Sping | 1.5 |
| LCR2 | Spring | 1.907 |
| CR7 | Spring | 1.825 |
| CR1 | Summer | 1.997 |
| CR6 | Summer | 1.789 |
| BC2 | Summer | 1.179 |
| | | |
| | | **TP in ug/L** |
| CR1 | Spring | 12.5 |
| CRAT | Spring | 12.5 |
| LCC1 | Sping | 12.5 |
| BC3 | Spring | 12.5 |
| SC1 | Spring | 12.5 |
| CR1 | Summer | 12 |
| LCC1 | Summer | 12 |
| BC3 | Summer | 19.2 |
| SC1 | Summer | 27 |
| | | |
| | | **TN in ug/L** |
| CR1 | Sping | 250 |
| CRAT | Spring | 260 |
| LCC1 | Spring | 240 |
| SC1 | Spring | 280 |
| CR1 | Summer | 350 |
| CRAT | Summer | 260 |
| LCC1 | Summer | 230 |
| CRBH | Summer | 580 |
| SC1 | Summer | 350 |

**Table D10 . Percent Filamentous Cover at Stations within the TP Lower 25th Percentile, Cahaba, AL., 2002.**

| Season | Station | Mean % Cover |
|---|---|---|
| Spring | CR1 | 23 |
| Spring | CRAT | 18 |
| Spring | LCC1 | 0.8 |
| Spring | BC3 | No Data |
| Spring | SC1 | 38 |
| Summer | CR1 | 8 |
| Summer | LCC1 | No Data |
| Summer | BC3 | No Data |
| Summer | SC1 | 24 |
| Summer | CR11 | No Data |

**Table D11 . Percent Filamentous Cover at Stations within the TN Lower 25th Percentile, Cahaba, AL., 2002.**

| Season | Station | Mean % Cover |
|---|---|---|
| Spring | CR1 | 23 |
| Spring | CRAT | 18 |
| Spring | LCC1 | 0.8 |
| Spring | BC3 | No Data |
| Spring | SC1 | 38 |
| Summer | CR1 | 8 |
| Summer | CRAT | 17 |
| Summer | LCC1 | No Data |
| Summer | SC1 | 24 |

# Table D12. Cahaba River, AL Multivariate Data Set, 2002

| Station | River Mile | Season | Periphyton% Cover Run | Periphyton % Cover Riffle | Periphyton Corr Chl A in mg/m2 | Diatom Mean Diversity | Corr Chl A in ug/L | AGPT in mg/L | Limiting Nutrient | N in ug/L | NH3-N in ug/L | NO2+NO3 in ug/L | TKN in ug/L | *TP in ug/L | MI HAB EVAL | Snails /m2 | MI EPT INDEX | MI TAXA | % MI EPT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CR-1 | 183.9 | Spring | 23 | | 20.8 | 1.761 | 0.57 | 1.2 | P* | 250 | 25 | 230 | 70 | 12.5 | | | | | |
| CRAT | 182.3 | Spring | 18 | | 47.8 | 3.419 | 0.65 | | NP | 260 | 25 | 250 | 70 | 12.5 | 152 | | 15 | 36 | 55 |
| UT-1 | 179.1 | Spring | 36 | | | 4.229 | 2.5 | 169 | P | 27006 | 140 | 26000 | 1100 | 930 | 149 | | 4 | 24 | 41 |
| LCC-1 | 179.1 | Spring | 1 | | 15.7 | 1.5 | 8.4 | | N | 240 | 25 | 55 | 240 | 12.5 | 155 | | 9 | 26 | 42 |
| CRBT | 175.5 | Spring | 10 | | 59 | 3.895 | 1 | 102 | P | 4140 | 25 | 3800 | 330 | 200 | 133 | | 10 | 32 | 45 |
| LCR-1 | 148 | Spring | | | 43.5 | 1.907 | | | | | | | | | | | | | |
| LCR-2 | 148 | Spring | | | 33.4 | 3.709 | 0.43 | | N | 1260 | 56 | 1000 | 260 | 300 | 85 | | 6 | 28 | 8 |
| CRAH | 144.9 | Spring | 42 | | 26.2 | 3.023 | 4.6 | 57 | N | 920 | 25 | 660 | 260 | 230 | 100 | | 9 | 29 | 13 |
| CRBH | 141.5 | Spring | 10 | | 11.6 | 2.825 | 2.1 | | N | 720 | 25 | 460 | 250 | 110 | 141 | | 11 | 33 | 45 |
| CR-6 | 136.8 | Spring | 72 | | 36.4 | 3.93 | 1 | 92 | N | 1540 | 25 | 1200 | 330 | 240 | 136 | | 7 | 31 | 30 |
| BC-1 | 130.7 | Spring | | | 28.1 | 3.902 | 0.74 | | N | 2750 | 25 | 2400 | 360 | 340 | | | | | |
| BC-2 | 130.7 | Spring | 100 | | 65.9 | 3.654 | 1.3 | | N | 4670 | 3400 | 880 | 3800 | 630 | 123 | | 4 | 25 | 19 |
| BC-3 | 130.7 | Spring | | | 42.9 | 2.396 | 0.74 | 0.4 | P | 980 | 25 | 880 | 9 | 12.5 | 118 | | 10 | 29 | 24 |
| BC-4 | 130.7 | Spring | 29 | | 53.4 | 3.917 | 0.51 | | N | 4680 | 25 | 4400 | 300 | 650 | 143 | | 8 | 31 | 36 |
| BC-5 | 130.7 | Spring | | | 67.9 | 4.009 | 0.94 | 51 | P* | 1320 | 25 | 1000 | 310 | 140 | | | | | |
| CR-7 | 127 | Spring | 20 | | 20.7 | 1.825 | 0.58 | 89 | N | 1650 | 86 | 1300 | 340 | 220 | 150 | | 9 | 27 | 59 |
| SC-1 | 103.6 | Spring | 38 | | 5 | 3.325 | 0.3 | | NP | 280 | 25 | 180 | 150 | 12.5 | 169 | | 13 | 27 | 58 |
| CR-9 | 95.8 | Spring | | | | | 1.4 | 29 | NP | 720 | | | | | | | | | |
| CR-1 | 183.9 | Summer | 8 | 22 | 37 | 1.997 | 0.28 | | P* | 350 | 25 | 230 | 120 | 12 | | | | | |
| CRAT | 182.3 | Summer | 17 | | 21 | 2.484 | 0.87 | | N | 240 | 68 | 76 | 160 | 30 | | 387 | | | |
| UT-1 | 179.1 | Summer | 1 | | 95 | 3.66 | 11.4 | | P | 27094 | 25 | 27000 | 920 | 550 | | | | | |
| LCC-1 | 179.1 | Summer | | | | | 1.75 | | N | 230 | 25 | 25 | 180 | 12 | | | | | |
| CRBT | 175.5 | Summer | 20 | | | | 0.82 | | P | 6290 | 25 | 5900 | 390 | 260 | | 430 | | | |
| LCR-2 | 148 | Summer | | | | | 0.38 | | N | 4620 | 25 | 4200 | 370 | 1100 | | | | | |
| CRAH | 144.9 | Summer | 20 | | 37 | 3.58 | 10.8 | | N | 1080 | 25 | 800 | 270 | 310 | | 1001 | | | |
| CRBH | 141.5 | Summer | 25 | | 13 | 3.57 | 2.46 | | N | 580 | 25 | 310 | 260 | 120 | | 581 | | | |
| CR-6 | 136.8 | Summer | 0 | 18 | 20 | 1.789 | 1.28 | | P* | 6530 | 58 | 6000 | 480 | 960 | | 721 | | | |
| BC-1 | 130.7 | Summer | | | | | 0.42 | | N | 4110 | 88 | 3700 | 430 | 570 | | | | | |
| BC-2 | 130.7 | Summer | 44 | | 18 | 1.179 | 1.65 | | N | 2800 | 880 | 1700 | 1100 | 510 | | | | | |
| BC-3 | 130.7 | Summer | | | | | 0.62 | | P | 750 | 25 | 660 | 90 | 19.2 | | | | | |
| BC-4 | 130.7 | Summer | | | | | 0.6 | | N | 6510 | 98 | 6000 | 470 | 930 | | | | | |
| BC-5 | 130.7 | Summer | | | | | 0.49 | | N | 1920 | 25 | 1700 | 220 | 400 | | | | | |
| CR-7 | 127 | Summer | 38 | 55 | 53 | 2.722 | 1.33 | | P* | 2950 | 87 | 2600 | 350 | 440 | | 291 | | | |
| SC-1 | 103.6 | Summer | 24 | | 45 | 2.758 | 0.88 | | P* | 350 | 25 | 160 | 190 | 27 | | | | | |
| CR-9 | 95.8 | Summer | | | | | 13.8 | | NP | 1200 | 25 | 660 | 540 | 120 | | | | | |
| CR-11 | | Summer | | | | | 11.6 | | P* | 730 | 25 | 450 | 280 | 70 | | | | | |

* Use of STATISTICA requires data entry value; it is recommended that rather than using the detection limit for TP of 0.025 mg/L that the median vcalue of 0.0125 be used

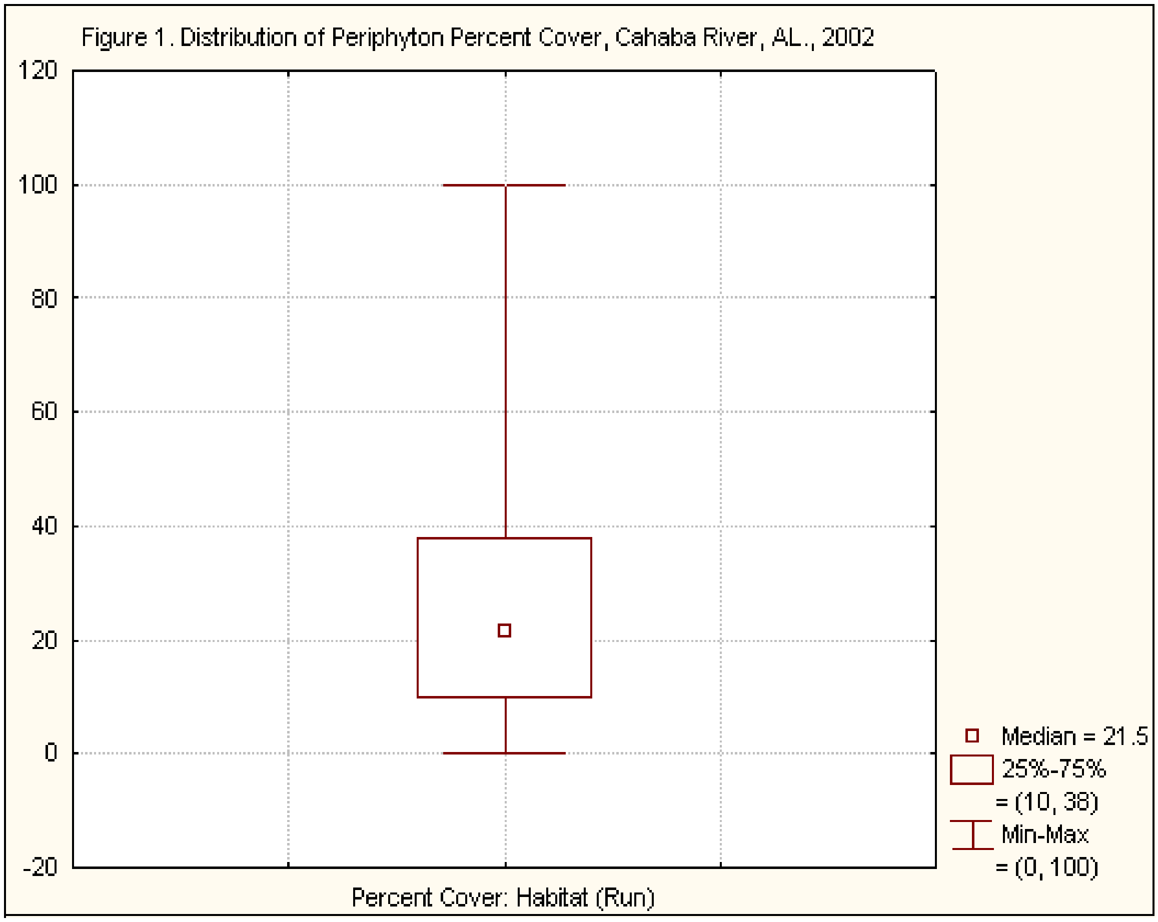


Figure 1. Distribution of Periphyton Percent Cover, Cahaba River, AL., 2002
120
100
80
60
40
20
0
-20
Percent Cover: Habitat (Run)
Median = 21.5
25%-75%
= (10, 38)
Min-Max
= (0, 100)

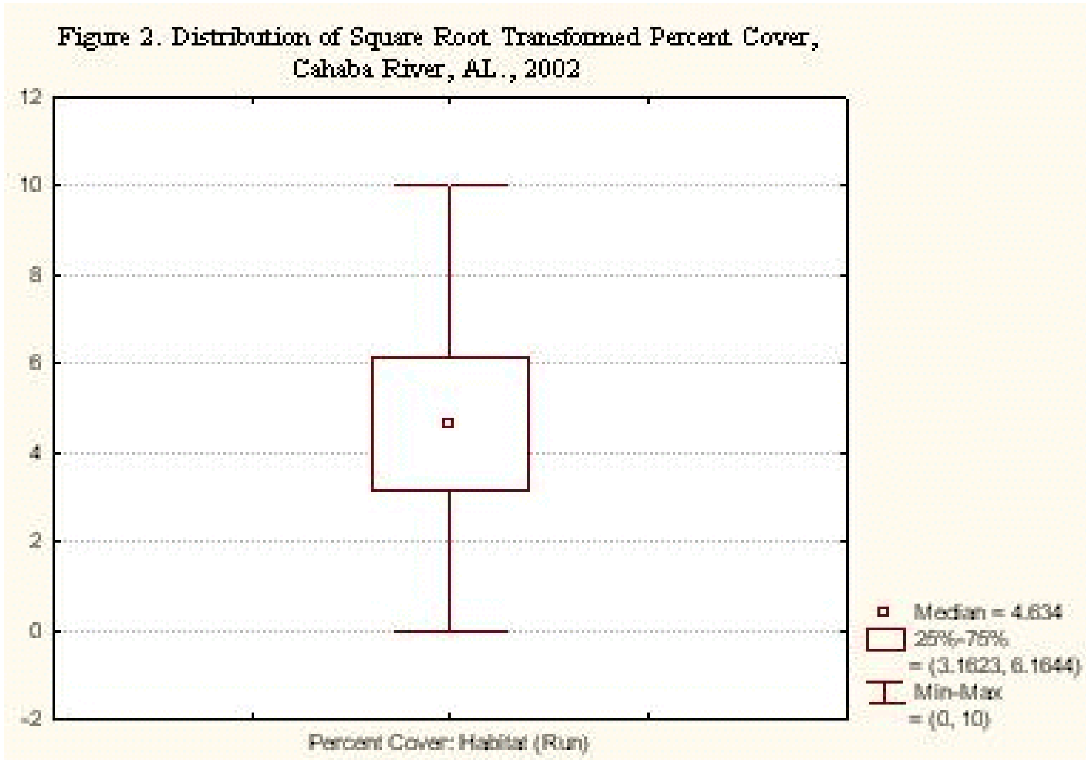
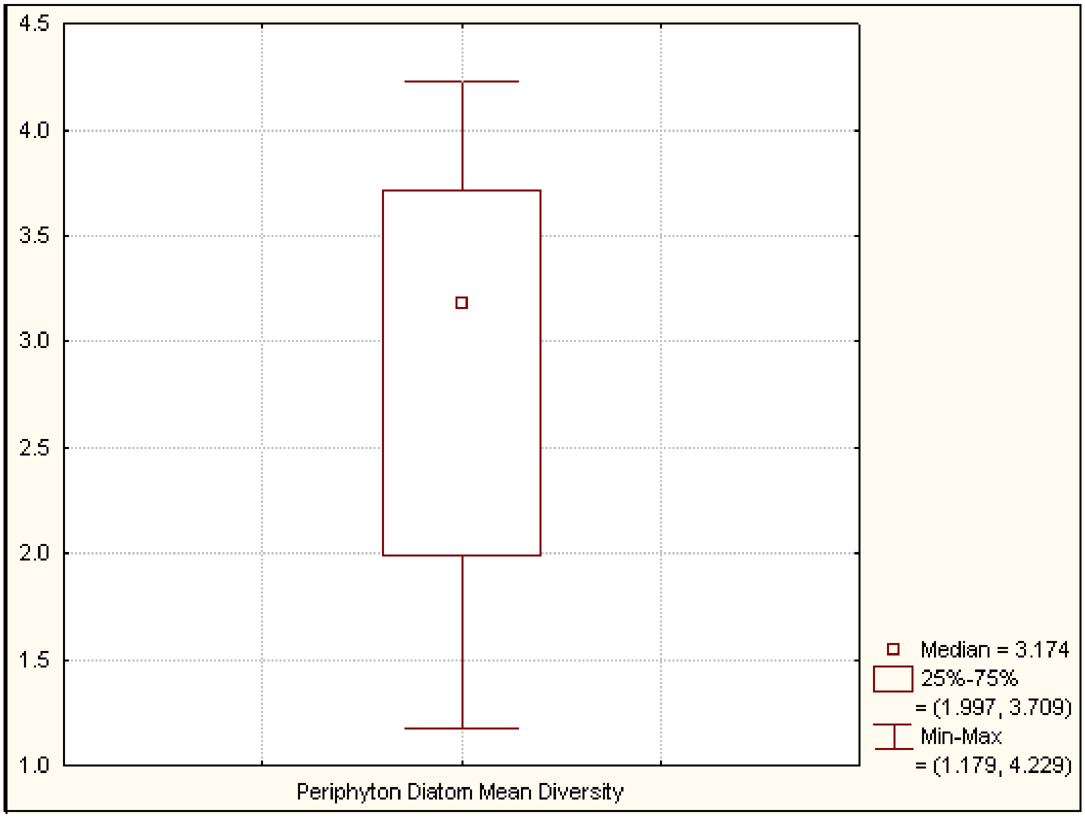


Figure 2. Distribution of Square Root Transformed Percent Cover,
Cahaba River, AL., 2002
12
10
8
6
4
2
0
-2
Percent Cover: Habitat (Run)
Median = 4.634
25%-75%
= (3.1623, 6.1644)
Min-Max
= (0, 10)

**Figure D3. Distribution of Diatom Mean Diversity, Cahaba River, AL., 2002**



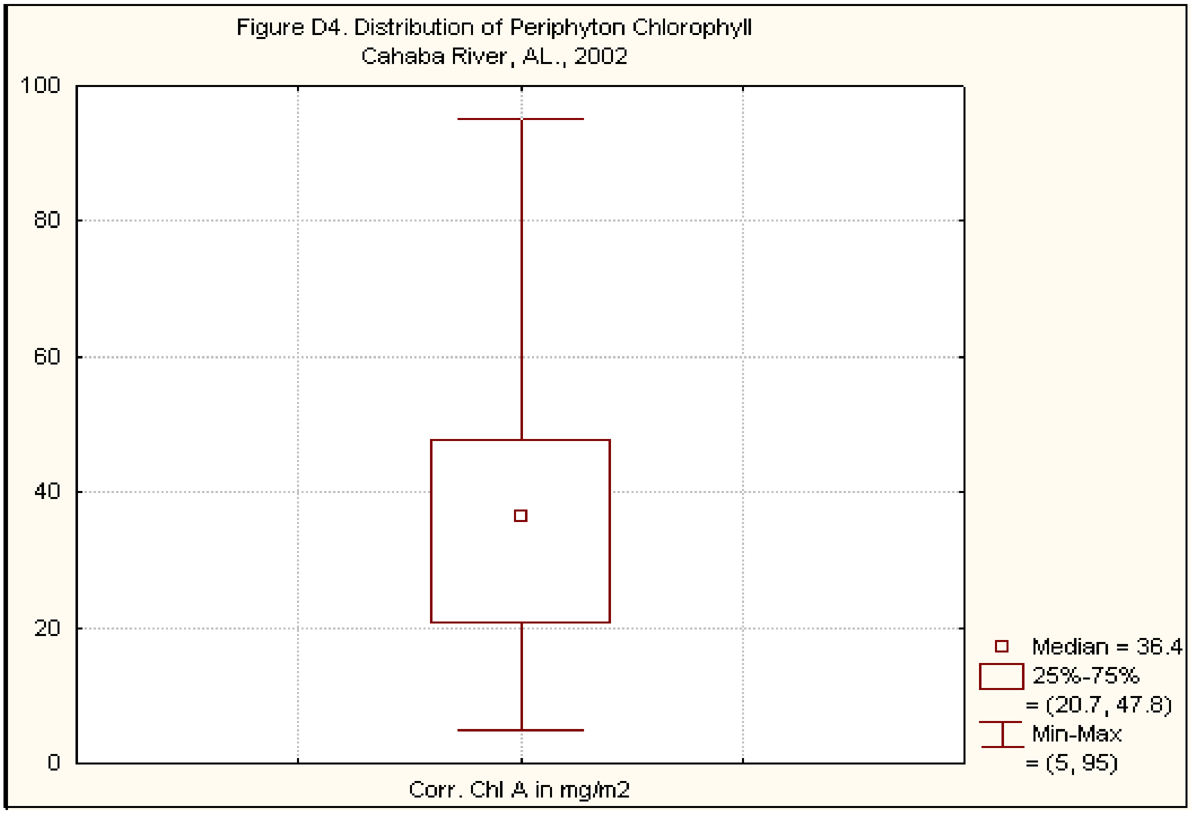


Figure D4. Distribution of Periphyton Chlorophyll
Cahaba River, AL., 2002
100
80
60
40
20
0
Corr. Chl A in mg/m2
Median = 36.4
25%-75%
= (20.7, 47.8)
Min-Max
= (5, 95)

## APPENDIX E :

**Hydraulic geometry graphs, photos of bed surface material, & particle size distribution graphs**

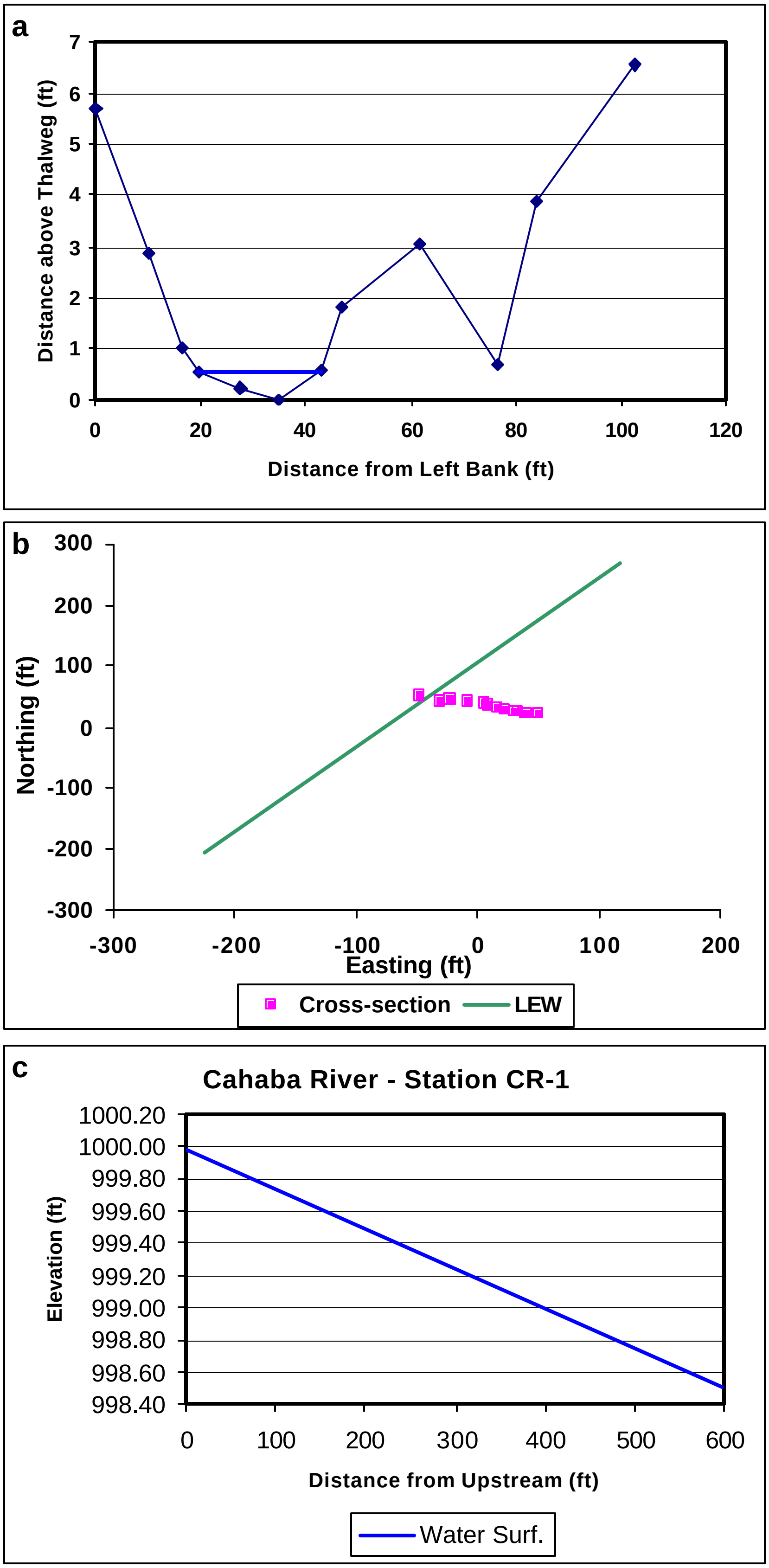



Figure 1. Hydraulic geometry at CahabaRiver Station CR-1, located at Happy Hollow Rd. near CR 132; Latitude: 33/ 38' 39"; Longitude: 86/35' 45": a. cross-section; b.planform; and c. longitudinal water-surface profile; water surface slope = 0.25%; Surveyed on 09/11/02.

Figure 2. Photograph of the bed surface material at Cahaba River Station CR-1 where a Wolman pebble count was conducted on 09/11/02.

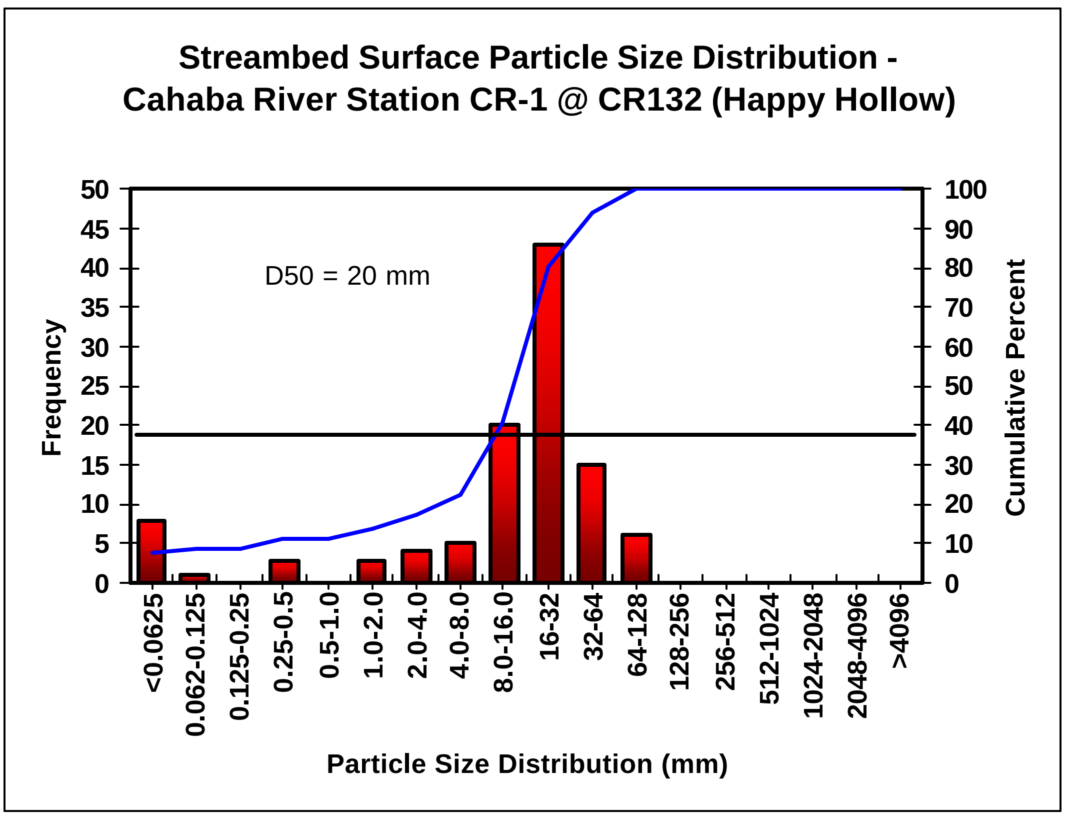



Figure 3. Graph showing the streambed surface particle size distribution at Cahaba River Station CR-1 at Happy Hollow Rd. near CR 132. The median particle size at this station or $D_{50}$ was 20 mm or coarse gravel. The dominant size classes in this sample included the 16-32 mm coarse gravel (39.8%) and the 8-16 mm medium gravel (18.5%). The percentage of sands, silts and clays at this station (particles < 2mm) was 13.89%.

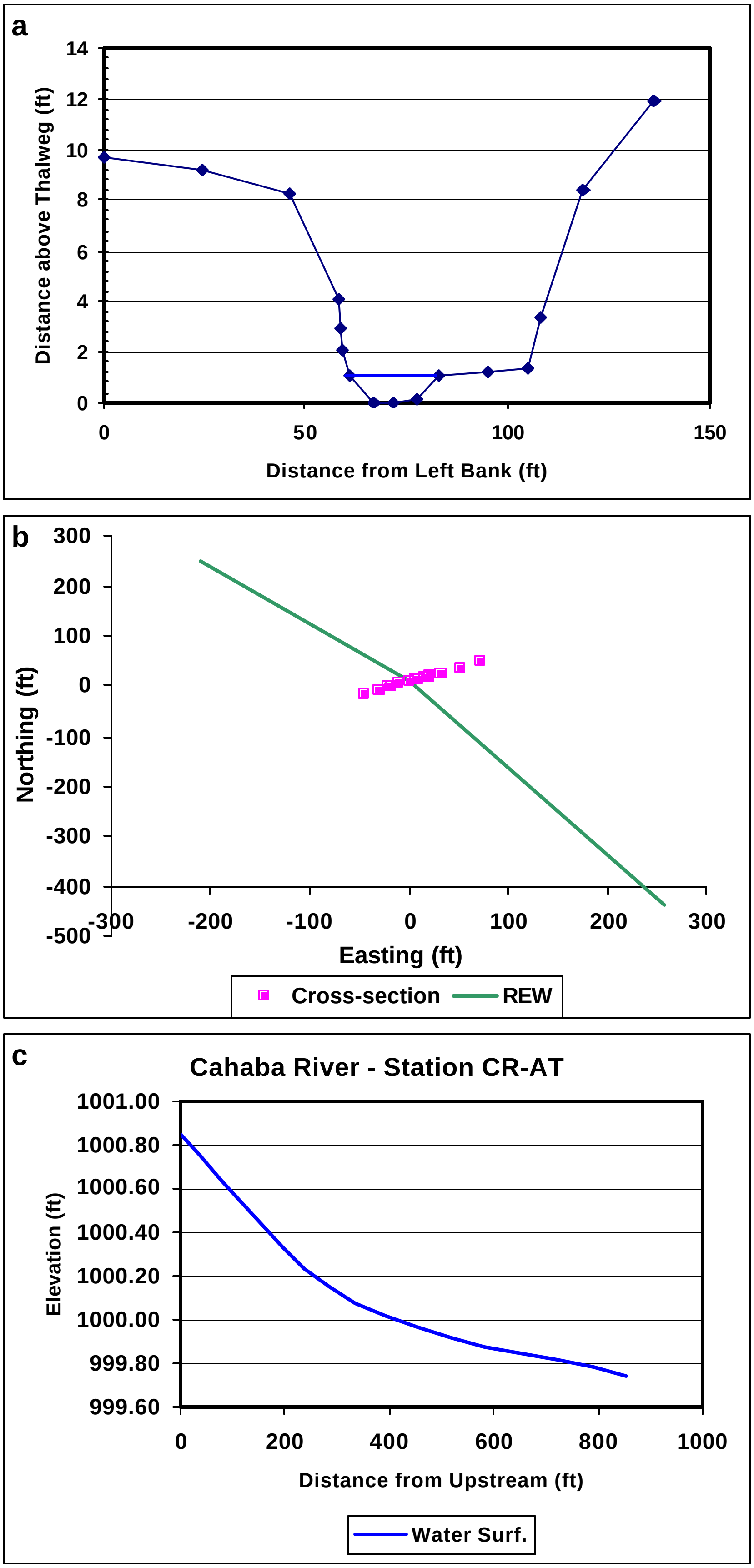



Figure 4. Hydraulic geometry at Cahaba River Station CR-AT, located at Hwy 11 above the confluence with L. Cahaba Ck. & above Trussville WWTP; Latitude: 33/ 37' 25"; Longitude: 86/36' 02": a. cross-section; b.planform; and c. longitudinal water-surface profile; water surface slope = 0.13%; Surveyed on 09/11/02.

Figure 5. Photograph of the bed surface material at Cahaba River Station CR-AT where a Wolman pebble count was conducted on 09/11/02.

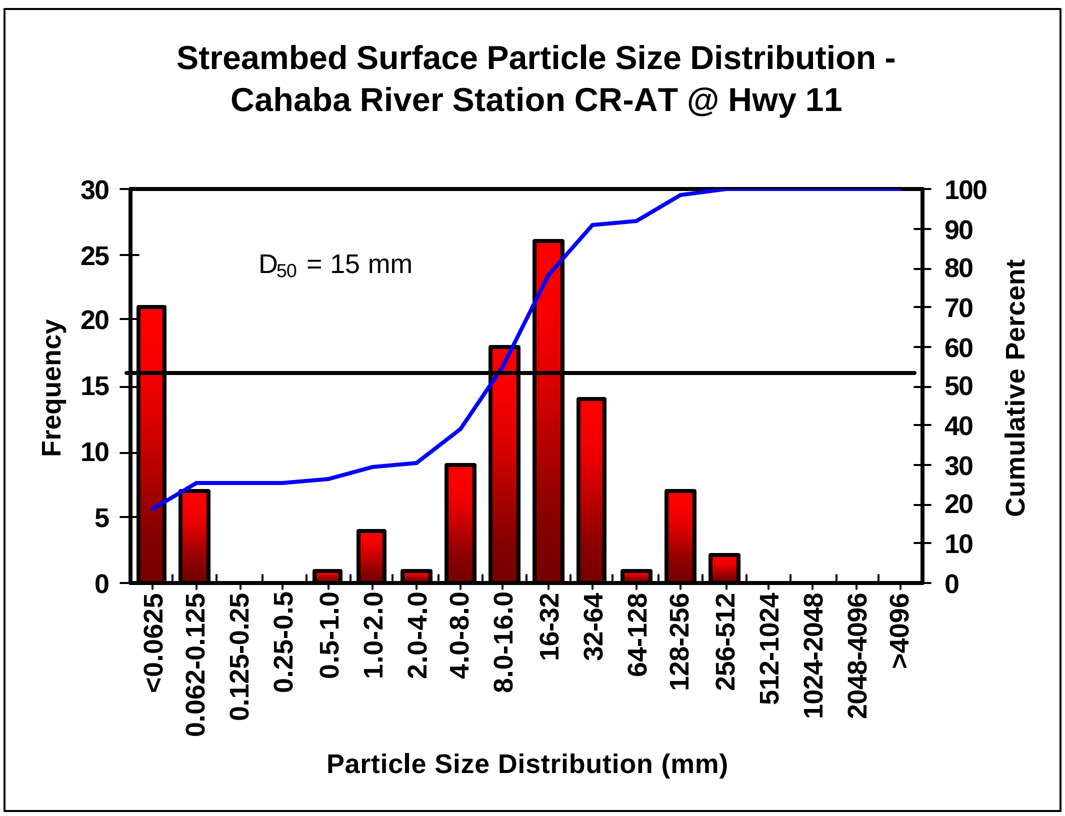



Figure 6. Graph showing the streambed surface particle size distribution at Cahaba River Station CR-AT located at Hwy 11 above the confluence with L. Cahaba Ck. & above Trussville WWTP. The median particle size at this station or $D_{50}$ was 15 mm or medium gravel. The dominant size classes in this sample included the 16-32 mm coarse gravel (23.4%), the 8-16 mm medium gravel (16.2%), and the <0.0625 mm silt/clays (18.9%). The percentage of sands, silts and clays at this station (particles < 2mm) was 29.73%.

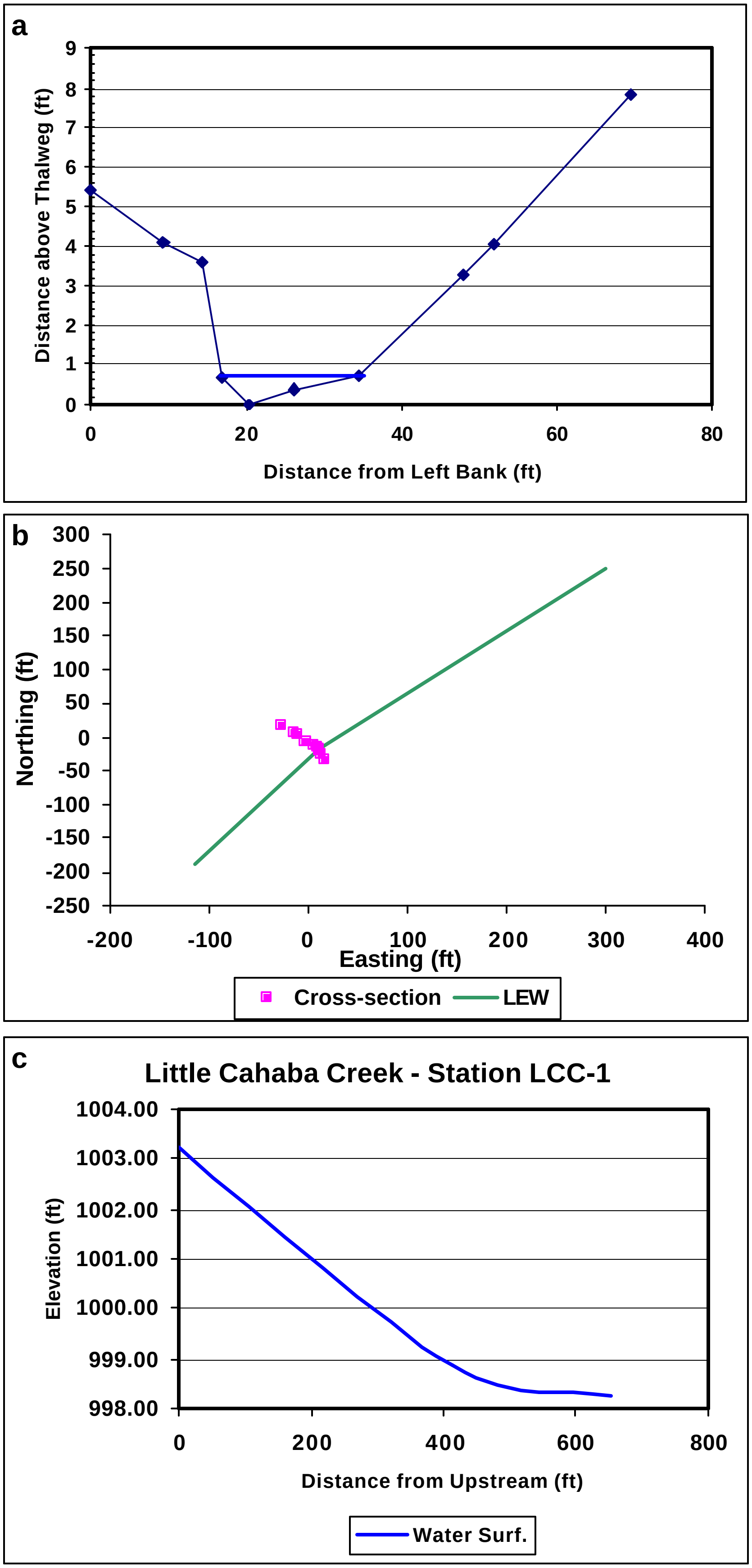



Figure 7. Hydraulic geometry at Little Cahaba Creek Station LCC-1, located at Camp Coleman Road Bridge; Latitude: 33/ 37' 34"; Longitude: 86/33' 58": a. cross-section; b.planform; and c. longitudinal water-surface profile; water surface slope = 0.81%; Surveyed on 09/11/02.

Figure 8. Photograph of the bed surface material at Little Cahaba Creek Station LCC-1 where a Wolman pebble count was conducted on 09/11/02.

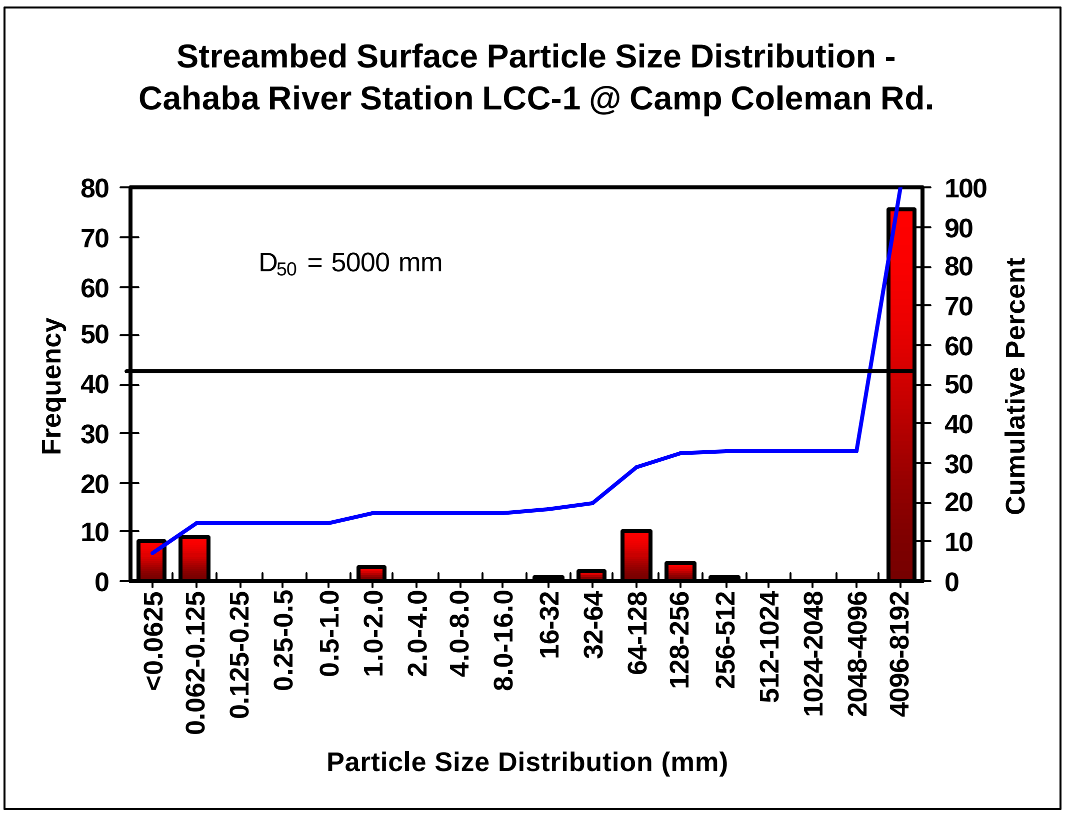



Figure 9. Graph showing the streambed surface particle size distribution at Little Cahaba Creek Station LCC-1 located at Hwy 11 at the Camp Coleman Road Bridge. The median particle size at this station or $D_{50}$ was 5000 mm (bedrock). The dominant size classes in this sample included >4096 mm or bedrock (66.7%), the 64-128 mm small cobble (8.7%), and the <0.0625-0.125 mm very fine sands (7.9%). The percentage of sands, silts and clays at this station (particles < 2mm) was 17.54%.

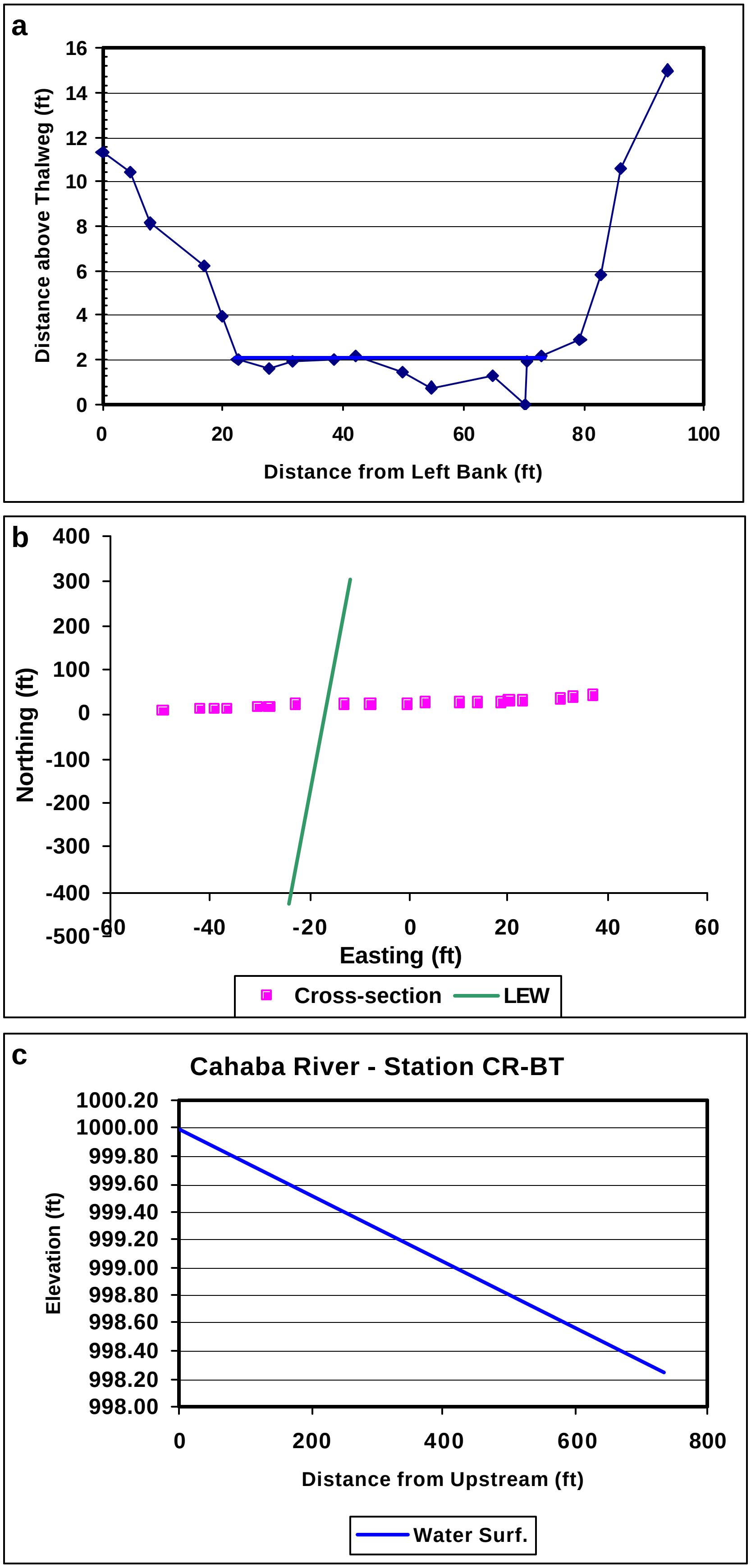



Figure 10. Hydraulic geometry at Cahaba River Station CR-BT, located at CR 10 below Trussville WWTP; Latitude: 33/ 36' 16.5"; Longitude: 86/32' 56.5": a. cross-section ; b.planform; and c. longitudinal water-surface profile; water surface slope = 0.24%; Surveyed on 09/11/02.

Figure 11. Photograph of the bed surface material at Cahaba River Station CR-BT where a Wolman pebble count was conducted on 09/11/02.

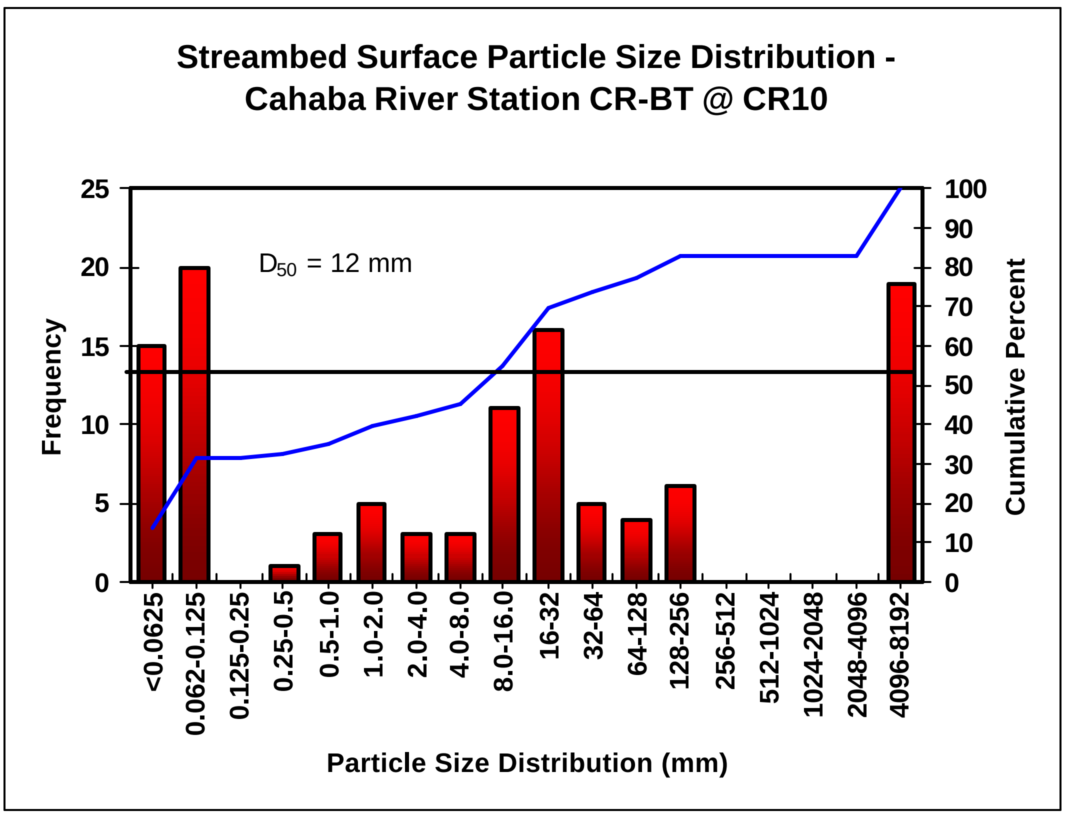



Figure 12. Graph showing the streambed surface particle size distribution at Cahaba River Station CR-BT located at CR10 below Trussville WWTP. The median particle size at this station or $D_{50}$ was 12 mm (medium gravel). The dominant size classes in this sample included <0.0625-0.125 mm or very fine sand (18.0%), >4096 mm bedrock (17.1%), and the 16-32 mm coarse gravel (14.4%). The percentage of sands, silts and clays at this station (particles < 2mm) was 39.64%.

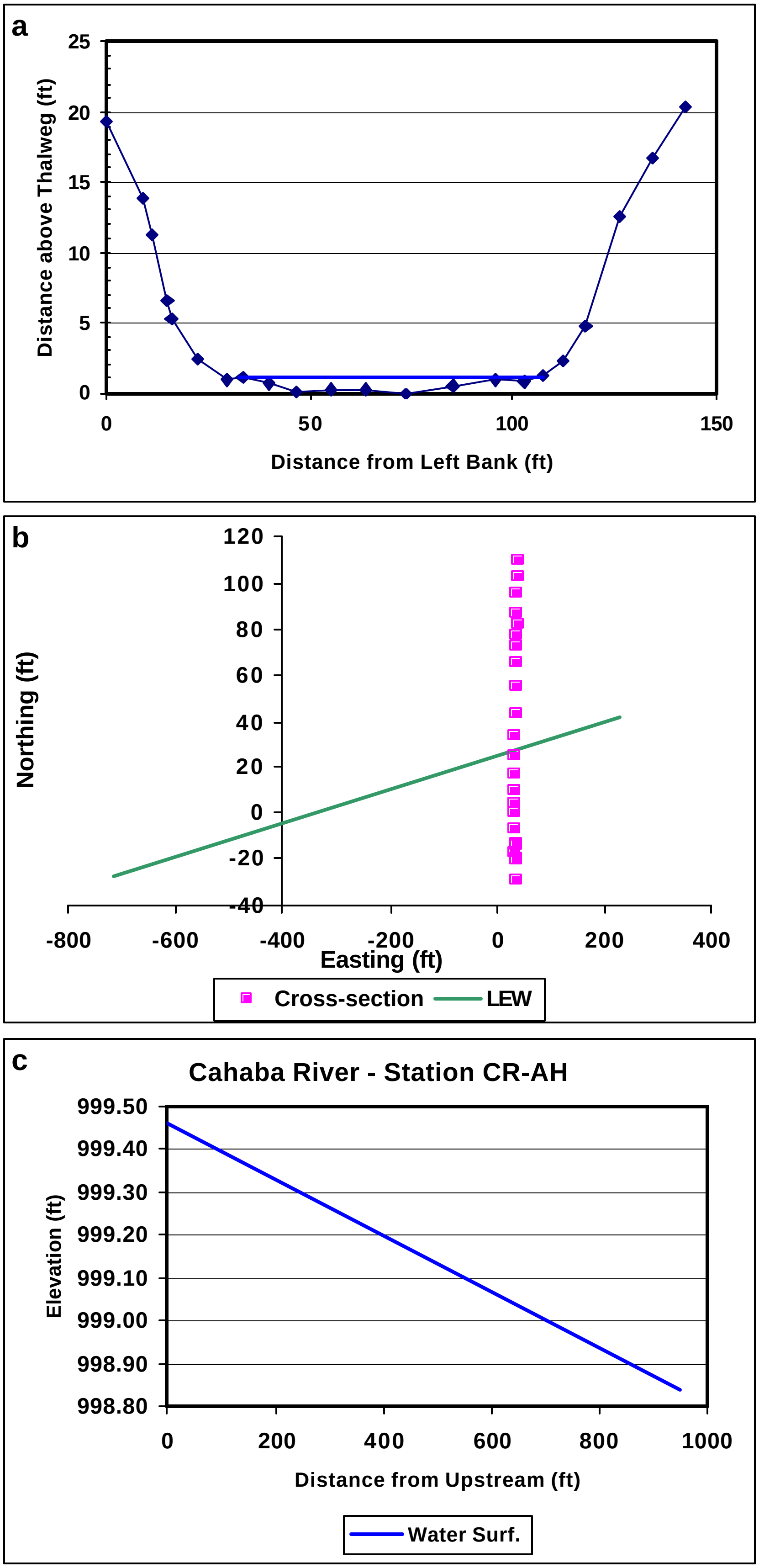



Figure 13. Hydraulic geometry at Cahaba River Station CR-AH, located at CR 29 above Hoover WWTP at Caldwell Mill Rd. Bridge; Latitude: 33/ 24' 55"; Longitude: 86/44' 28": a. cross-section; b.planform; and c. longitudinal water-surface profile; water surface slope = 0.07%; Surveyed on 09/10/02.

Figure 14. Photograph from the Caldwell Mill Rd. Bridge showing the low-head dam upstream of Cahaba River Station CR-AH taken on 9/10/02.

Figure 15. Photograph of the bed surface material at Cahaba River Station CR-AH where a Wolman pebble count was conducted on 09/10/02.

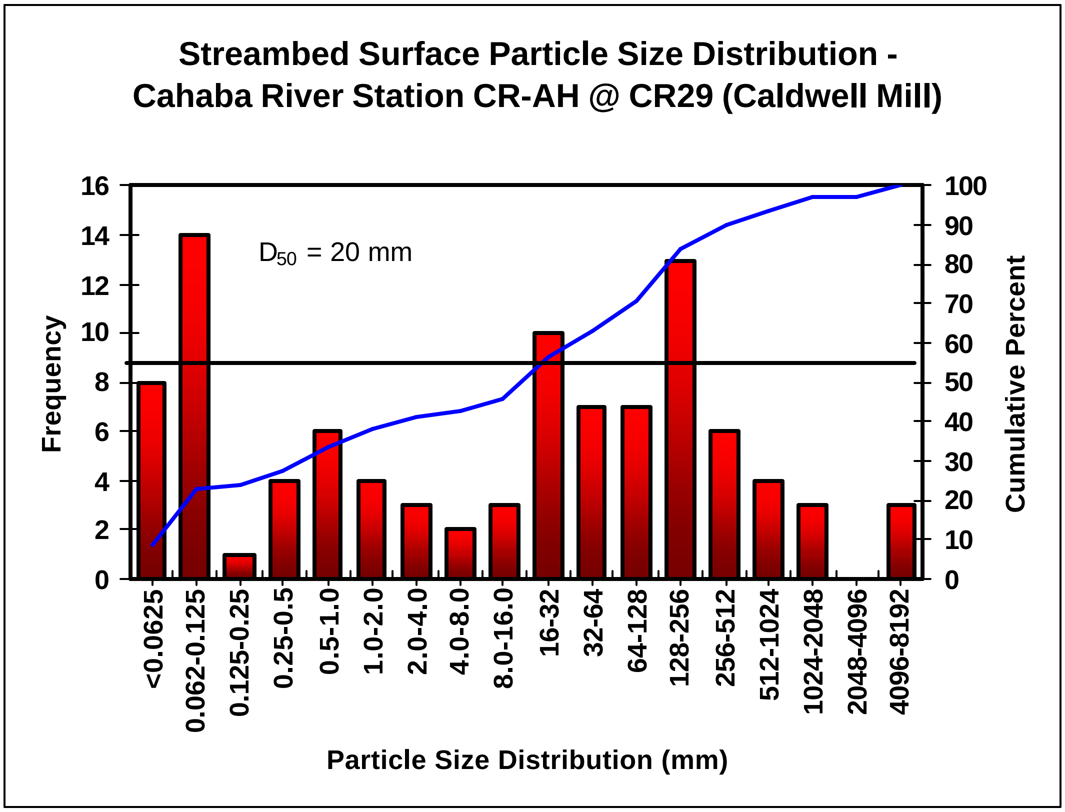



Figure 16. Graph showing the streambed surface particle size distribution at Cahaba River Station CR-AH located at CR 29 above Hoover WWTP at Caldwell Mill Rd. Bridge. The median particle size at this station or $D_{50}$ was 20 mm (coarse gravel). The dominant size classes in this sample included <0.0625-0.125 mm or very fine sand (14.3%), 128-256 mm large cobble (13.3%), and the 16-32 mm coarse gravel (10.2%). The percentage of sands, silts and clays at this station (particles < 2mm) was 37.76%.

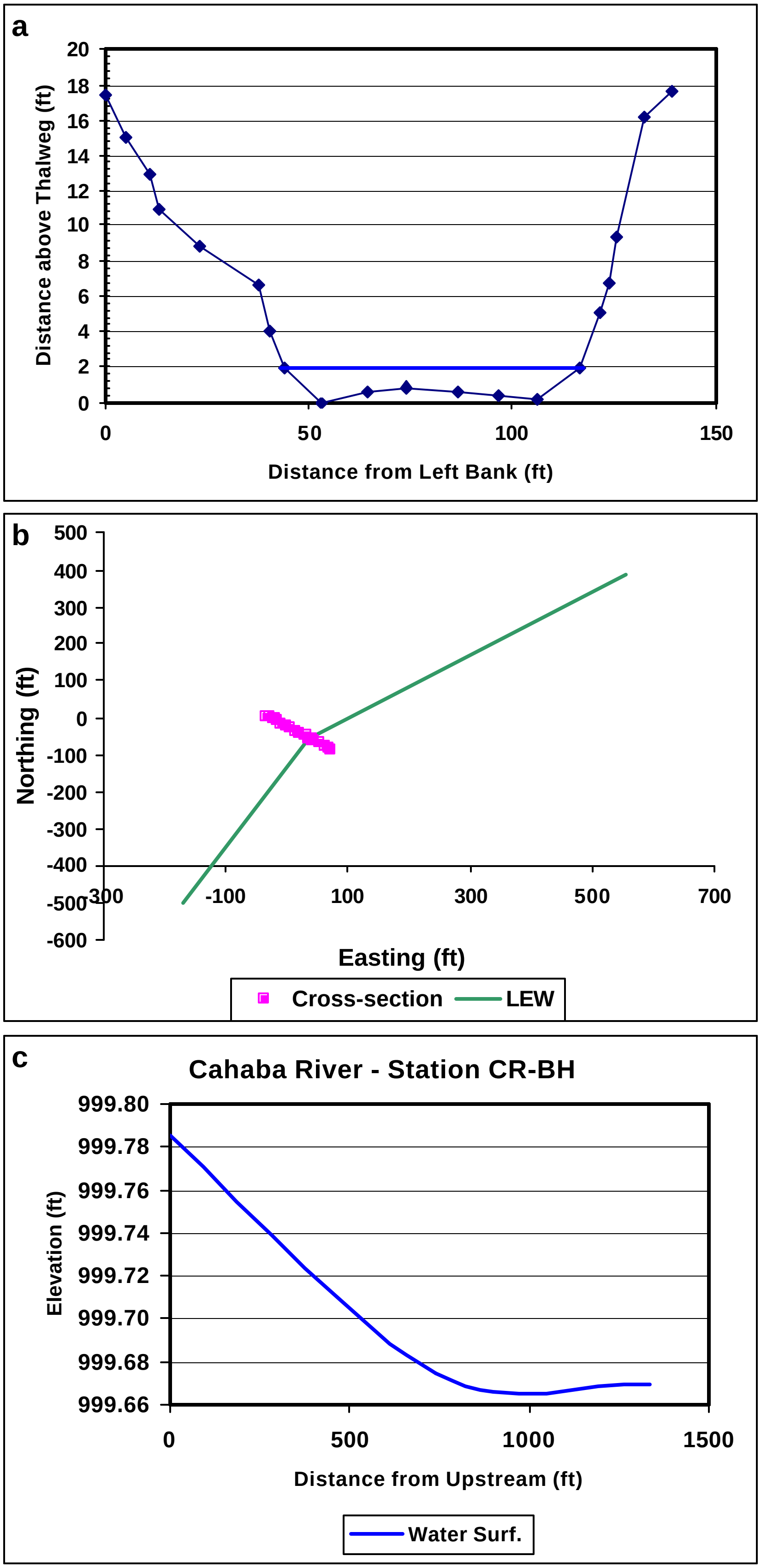



Figure 17. Hydraulic geometry at Cahaba River Station CR-BH, located off of Old Rocky Ridge Rd., in Riverford Subdivision, below the Hoover WWTP; Latitude: 33/ 23' 12"; Longitude: 86/46' 41": a. cross-section; b.planform; and c. longitudinal water-surface profile; water surface slope = 0.01%; Surveyed on 09/12/02.

Figure 18. Photograph of the bed surface material at Cahaba River Station CR-BH where a Wolman pebble count was conducted on 09/12/02.

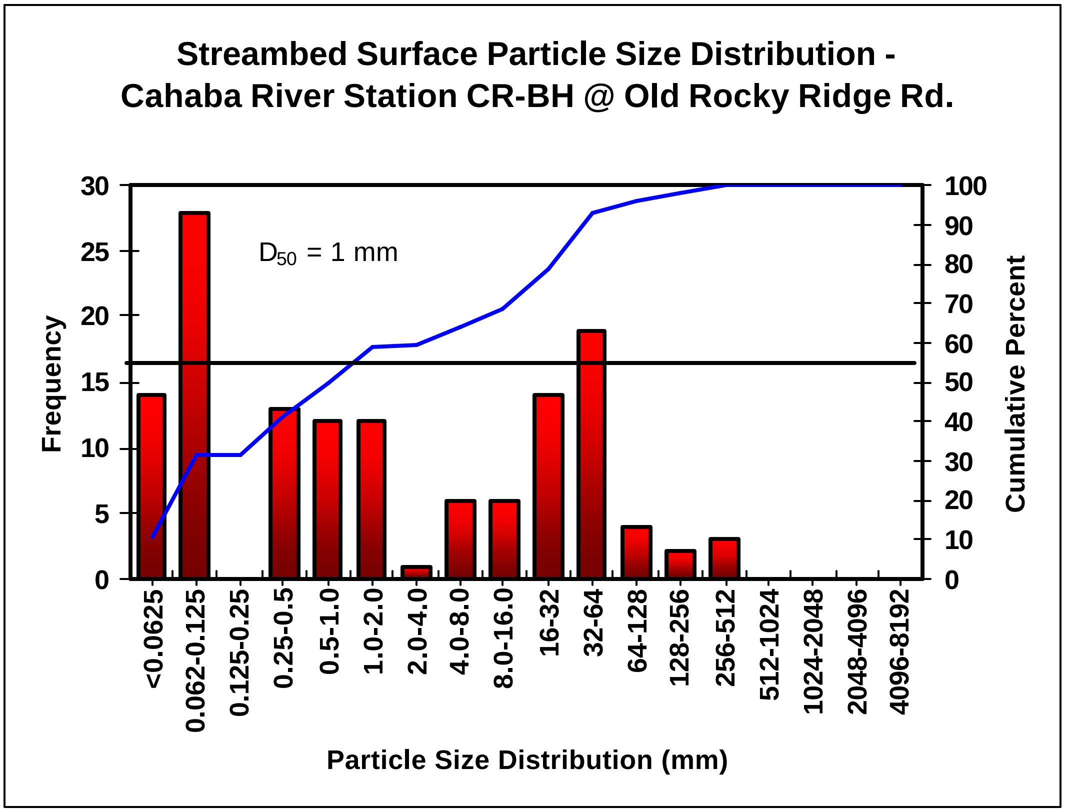



Figure 19. Graph showing the streambed surface particle size distribution at Cahaba River Station CR-BH off Old Rocky Ridge Rd. The median particle size at this station or $D_{50}$ was 1 mm or very coarse sand. The dominant size classes in this sample included the <0.0625-0.125 very fine sand (20.9%) and the 32-64 mm very coarse gravel (14.2%). The percentage of sands, silts and clays at this station (particles < 2mm) was 58.96%.

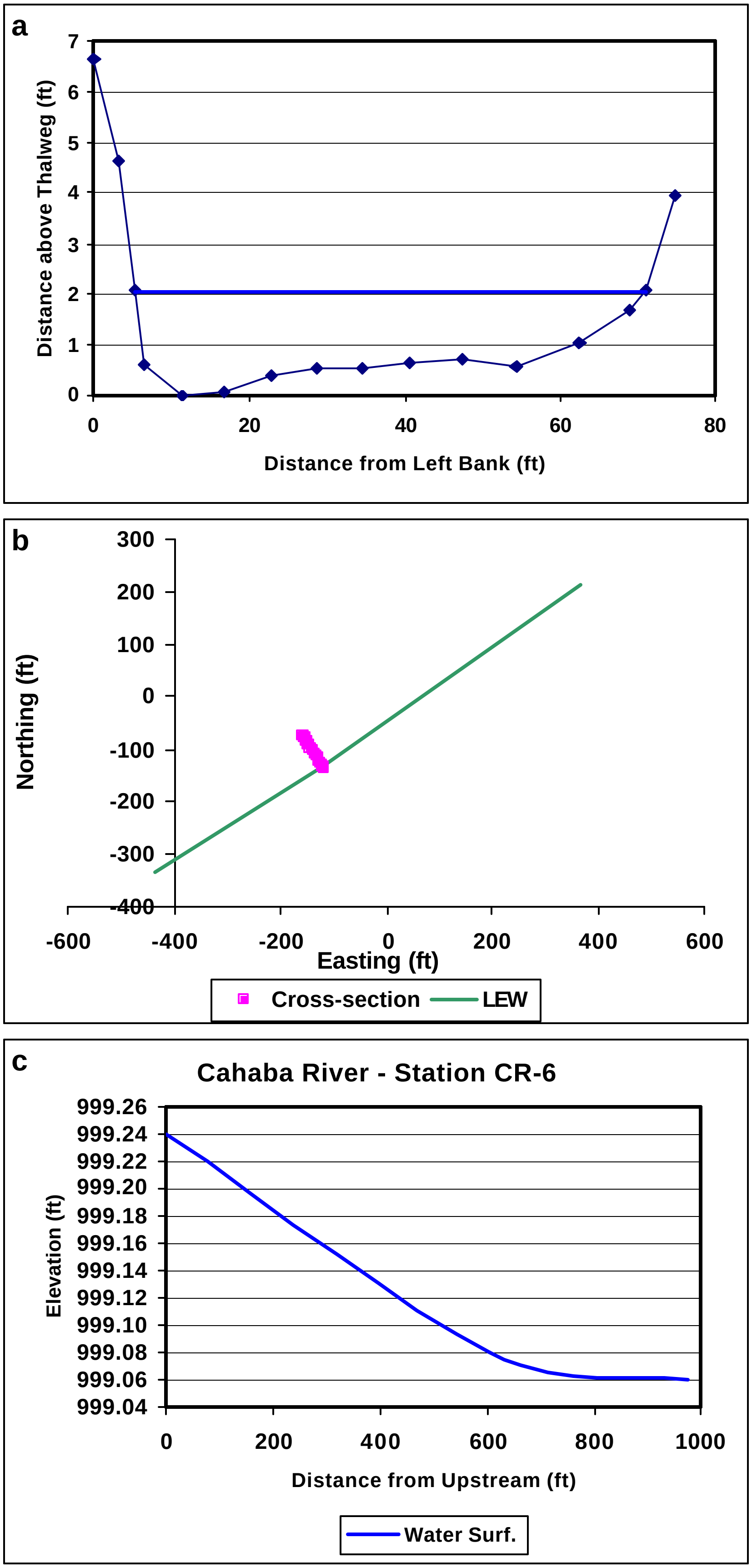



Figure 20. Hydraulic geometry at Cahaba River Station CR-6, located at the intersection of old Montgomery Hwy (Bains Bridge) above the confluence with Buck Creek; Latitude: 33/ 21' 47.8"; Longitude: 86/48' 48.8": a. cross-section; b.planform; and c. longitudinal water-surface profile; water surface slope = 0.02%; Surveyed on 09/09/02.

Figure 21. Photograph of the bed surface material at Cahaba River Station CR-6 where a Wolman pebble count was conducted on 09/09/02.

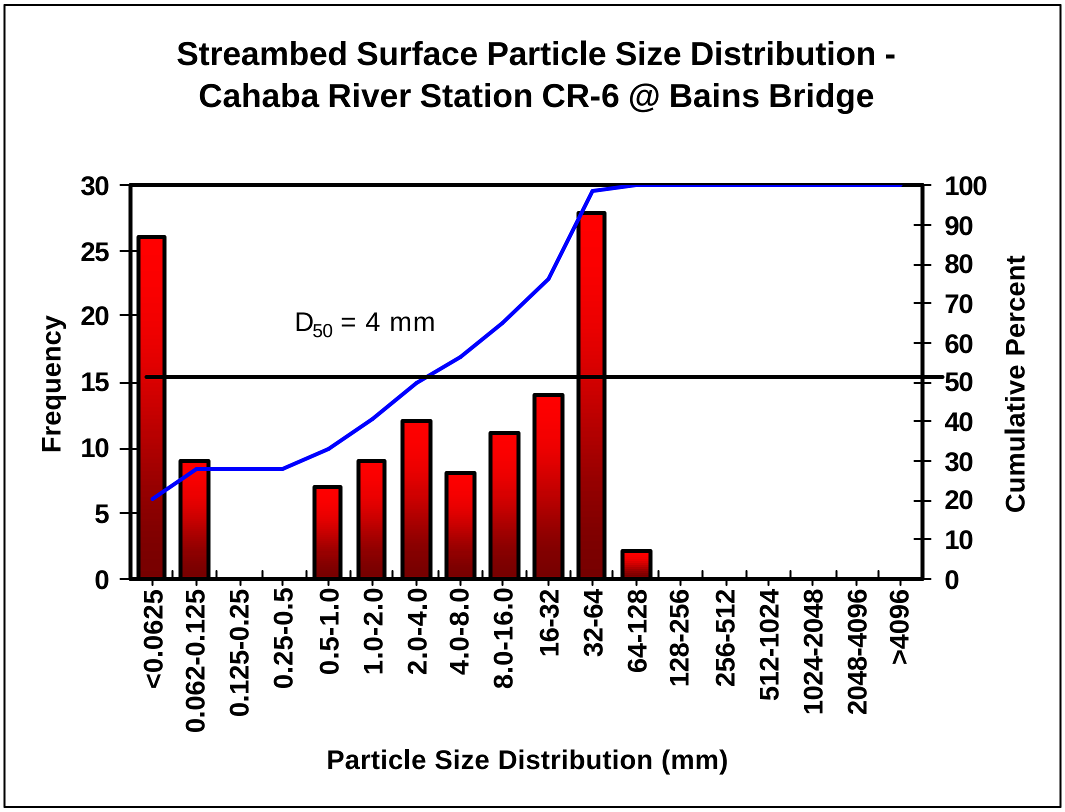



Figure 22. Graph showing the streambed surface particle size distribution at Cahaba River Station CR-6 at Bains Bridge. The median particle size at this station or $D_{50}$ was 4 mm or very fine gravel. The dominant size classes in this sample included the <0.0625 mm silt-clays (21.0%) and the 32-64 mm very coarse gravel (22.6%).

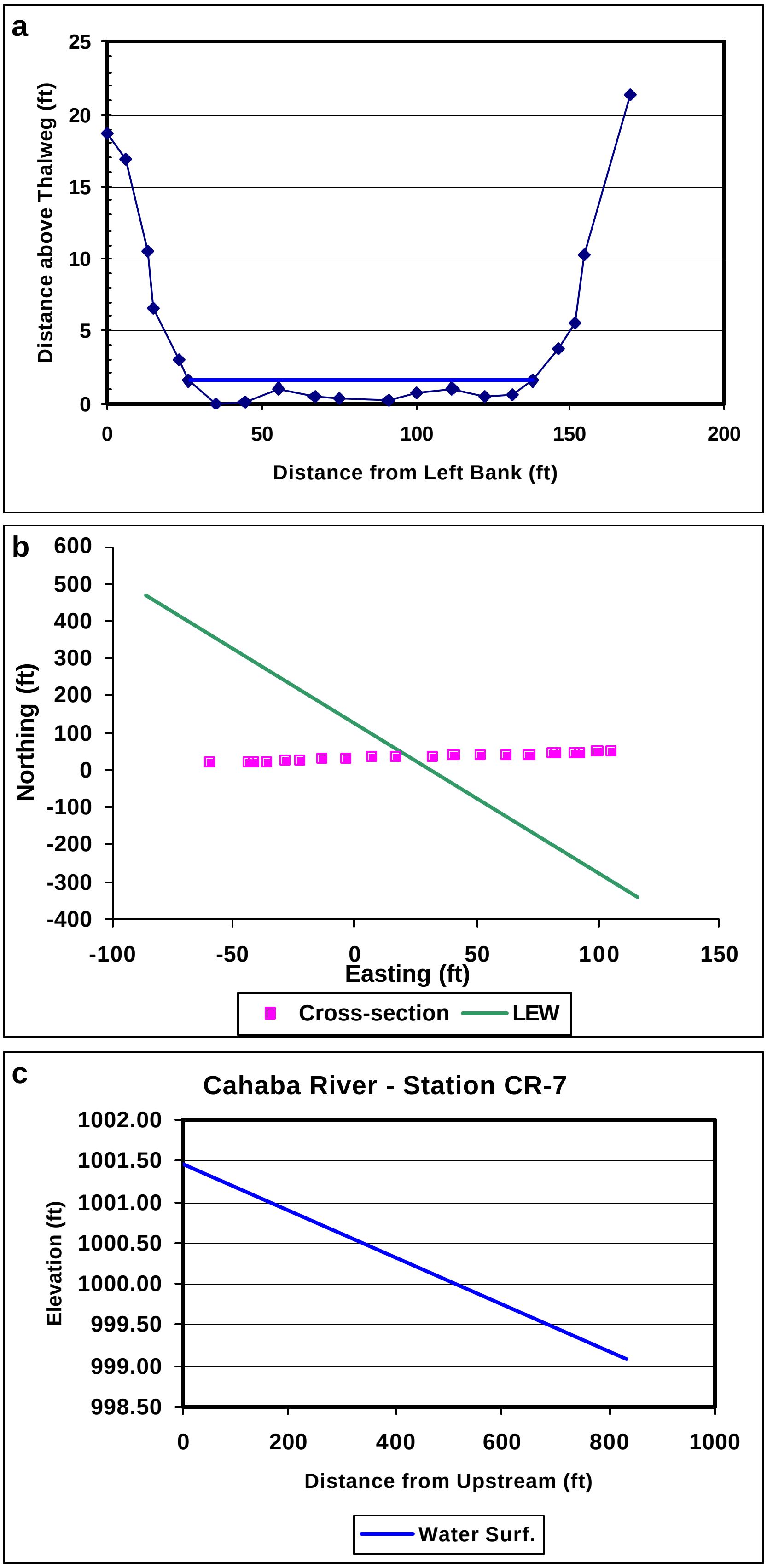



Figure 23. Hydraulic geometry at Cahaba River Station CR-7, located at Hwy 52 near Helena, AL below the confluence with Buck Creek; Latitude: 33/ 17' 02.2"; Longitude: 86/52' 53.5": a. cross-section; b.planform; and c. longitudinal water-surface profile; water surface slope = 0.28%; Surveyed on 09/10/02.

Figure 24. Photograph of the bed surface material at Cahaba River Station CR-7 where a Wolman pebble count was conducted on 09/10/02.

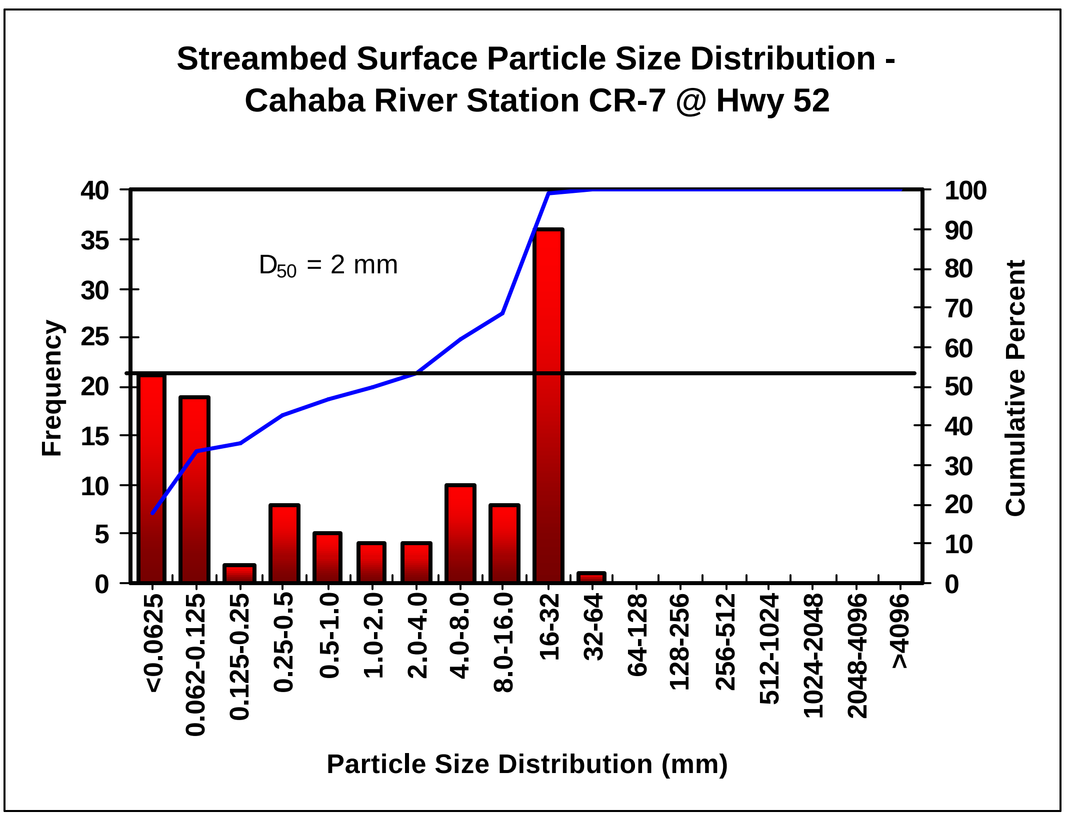



Figure 25. Graph showing the streambed surface particle size distribution at Cahaba River Station CR-7 at Hwy 52 near Helena, AL. The median particle size at this station or $D_{50}$ was 2 mm or very coarse sand. The dominant size classes in this sample included the <0.0625 mm silt-clays (17.8%), the <0.125 mm very fine sands (16.1%) and the 16-32 mm coarse gravel (30.5%).

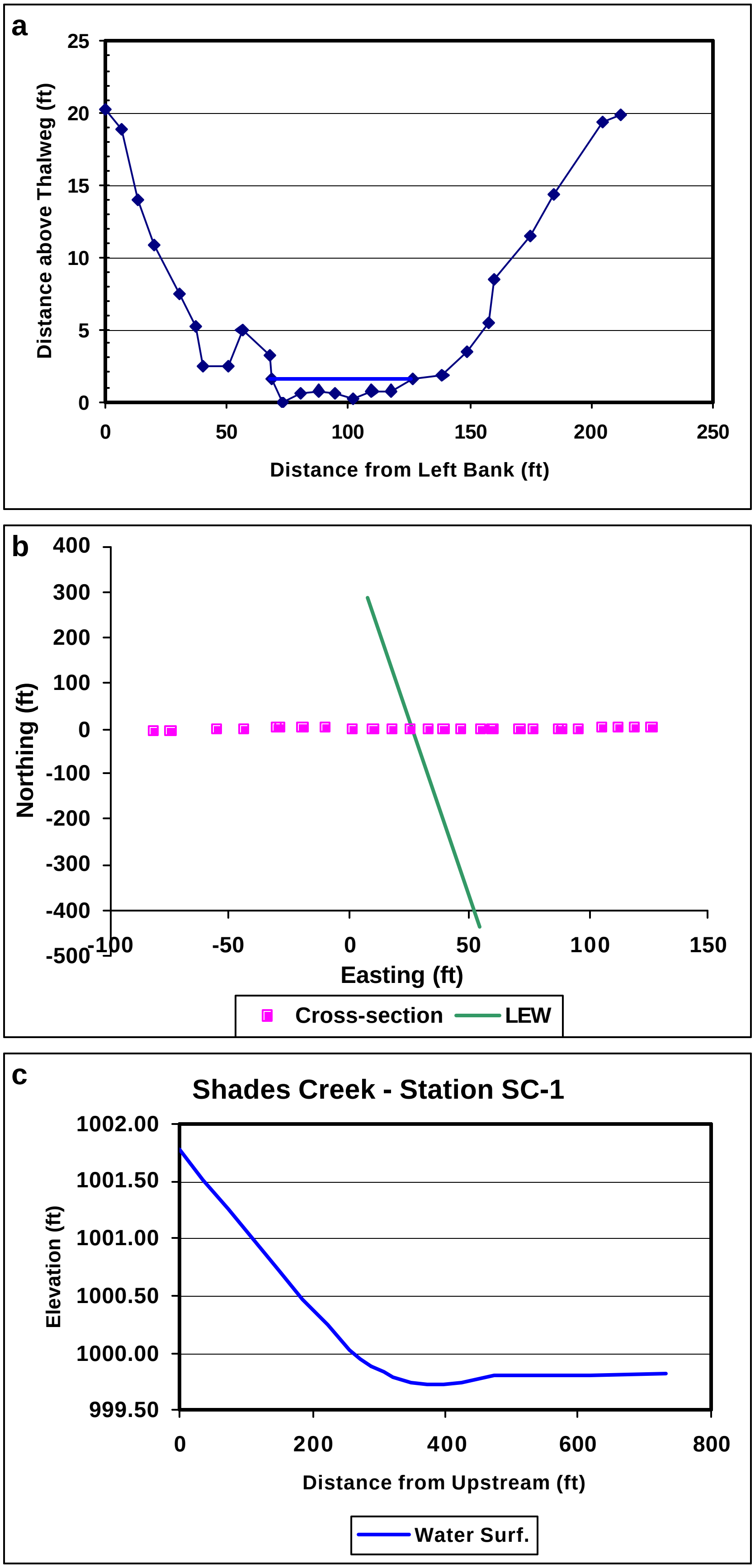



Figure 26. Hydraulic geometry at Shades Creek Station SC-1, located at CR 12/Easter Valley Rd.approx. 290 ft. downstream of the bridge; Latitude: 33/ 13' 10.3"; Longitude: 87/01' 58.9": a. cross-section; b.planform; and c. longitudinal water-surface profile; water surface slope = 0.27%; Surveyed on 09/10/02.

Figure 27. Photograph of the bed surface material at Shades Creek Station SC-1 where a Wolman pebble count was conducted on 09/10/02.

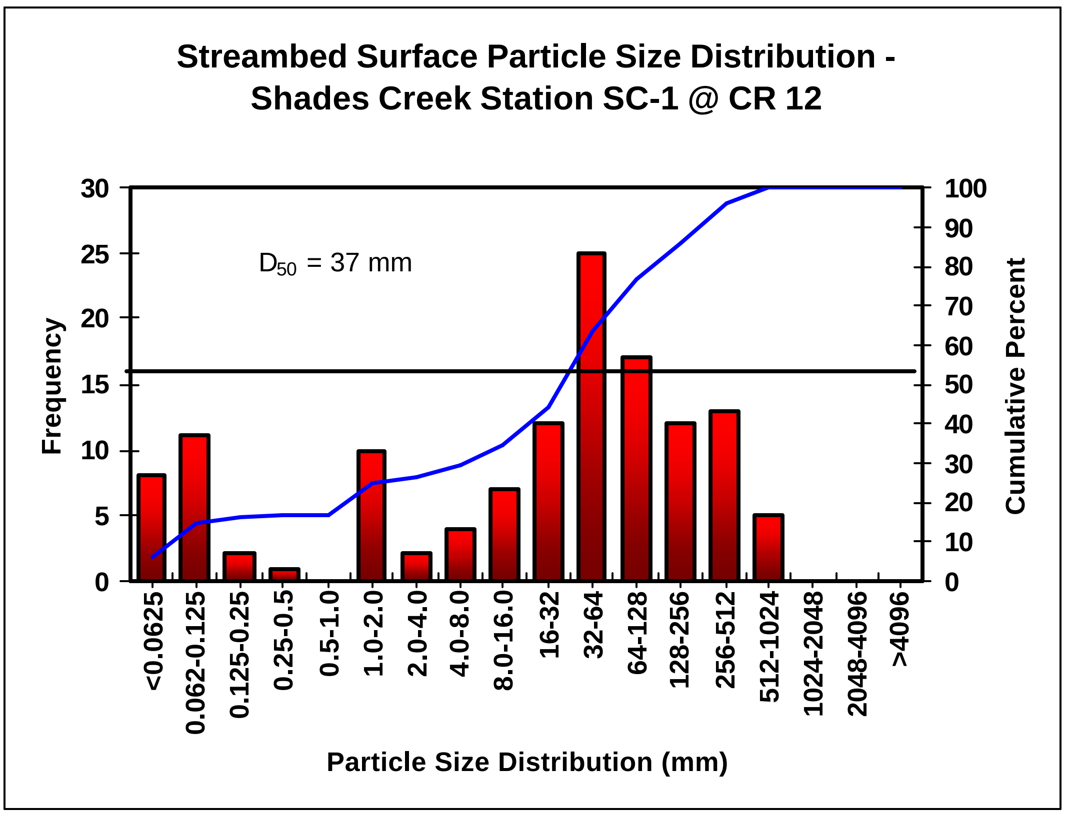



Figure 28. Graph showing the streambed surface particle size distribution at Shades Creek Station SC-1 at CR 12/Easter Valley Road. The median particle size at this station or $D_{50}$ was 37 mm or very coarse gravel. The dominant size classes in this sample included the <64mm very coarse gravel (19.4%), the <128 mm small cobble (13.2%) and the <512 mm small boulders (10.1%).

| Species | Wading samples | | | | | | | | | | | | Boat electrofishing samples | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 Centreville | 2 River Bend | 3 Piper | 4 Boothton | 5 Helena | 6 Bains Bridge | 7 Altadena | 8 Caldwell Mill | 9 Grants Mill | 10 Camp Coleman | 11 I-59 | 12 Little Cahaba | 1 Centreville | 3 Piper | 4 Boothton | 12 Little Cahaba |
| *M. salmoides* | -- | -- | -- | -- | – | -- | – | 1 | -- | -- | -- | – | 2 | 1 | -- | – |
| *Pomoxis nigromaculatus* | -- | -- | -- | -- | – | -- | -- | -- | -- | – | -- | -- | 2 | -- | -- | -- |
| PERCIDAE (darters) | | | | | | | | | | | | | | | | |
| *Etheostoma jordani* | 9 | 19 | 5 | 9 | 5 | -- | – | 1 | 18 | -- | -- | 33 | -- | -- | -- | -- |
| *E. ramseyi* | -- | -- | -- | -- | – | -- | – | 3 | -- | – | 9 | 40 | -- | -- | -- | -- |
| *E. rupestre* | 84 | 90 | 59 | 159 | 246 | 8 | – | 94 | 5 | -- | -- | 30 | -- | -- | -- | -- |
| *E. stigmaeum* | 6 | 2 | 1 | 3 | 3 | 3 | – | 1 | 1 | -- | -- | 1 | -- | -- | -- | -- |
| *E. whipplei* | -- | -- | -- | -- | – | 1 | – | -- | -- | -- | 6 | -- | -- | -- | -- | – |
| *Percina aurolineata* | 17 | 8 | 8 | -- | -- | -- | -- | – | -- | -- | -- | 2 | -- | -- | -- | -- |
| *P. brevicauda* | -- | -- | – | 4 | 1 | 2 | -- | -- | -- | -- | – | -- | -- | -- | -- | – |
| *P. kathae* | – | 3 | – | 17 | 3 | 2 | – | 7 | 6 | – | 5 | 1 | 2 | 1 | 1 | 1 |
| *P. nigrofasciata* | 47 | 27 | 25 | 39 | 39 | 15 | 8 | 27 | 23 | 11 | 15 | 22 | -- | -- | -- | -- |
| *P. shumardi* | 1 | -- | -- | -- | -- | – | -- | -- | -- | -- | – | -- | -- | -- | -- | – |
| SCIAENIDAE (drums) | | | | | | | | | | | | | | | | |
| *Aplodinotus grunniens* | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | – | 3 | 1 | 5 | – | 9 |

**APPENDIX F:**

**“A Biological Assessment of Selected Sites in the Cahaba River System, Alabama”**

**GEOLOGICAL SURVEY OF ALABAMA**

Donald F. Oltz
State Geologist

# A BIOLOGICAL ASSESSMENT OF SELECTED SITES IN THE CAHABA RIVER SYSTEM, ALABAMA

by

Patrick E. O'Neil

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# INTRODUCTION

This report presents results of a biological assessment performed in the Cahaba River main channel during the summer of 2000 by the Geological Survey of Alabama (GSA) The assessment was undertaken to assist the U.S. Environmental Protection Agency (USEPA) in characterizing present biological conditions, fish biodiversity, and the status of protected fish species listed by the U.S. Fish and Wildlife Service (USFWS). The USEPA has required the Alabama Department of Environmental Management (ADEM) to list portions of the Cahaba River main channel as impaired for nutrients and sediment under §303(d) of the Clean Water Act ultimately requiring development of a total maximum daily load (TMDL) for these parameters. The section listed for nutrient impairment extends from U.S. Hwy. 82 at Centreville upstream to U.S. Hwy. 280, and the section listed for sediment impairment extends from U.S. Hwy. 82 at Centreville upstream to Interstate Hwy. 59 at Trussville. The USFWS has listed two fish species and eight mollusk species whose historic ranges included the Cahaba River. Populations are now either extirpated or thought to be seriously threatened by degraded habitat conditions in the Cahaba River main channel due to excessive nutrients and sediment. Degradation of listed critical habitat for these species by attached filamentous green algae, smothering of stream substrates by excessive bedload sedimentation, and extreme variation of physical-chemical water quality, such as dissolved oxygen, are considered contributing factors to the poor population status of these species and one reason for listing these segments under §303(d) of the Clean Water Act.


# ACKNOWLEDGMENTS

Appreciation is extended to Ed Decker and Lonnie Dorn of the U.S. Environmental Protection Agency Region 4 for assistance with many aspects of this study: initiation of the concept, subsequent funding of field investigations, and as hard working field hands during a few hot days of sampling this summer. Tom Shepard, Stuart McGregor, Phillip Henderson, and Brett Smith of the Geological Survey of Alabama (GSA) provided expert fish sampling assistance, while Scott Mettee, also of GSA, provided his usual steady hand at the controls of our electrofishing boat. Additional field assistance was provided by personnel of the Alabama Department of Environmental Management including Fred Leslie, Lee Davis, Chris Smith, Rick Dowling, Greg Vinson, Keith Gilliland. Ashley Dumas of the University of Alabama provided expert note-taking services while sampling.

## STUDY OBJECTIVES

The objectives of this study were threefold. First was to determine biological condition of stream fish communities at selected main channel sites using the Index of Biotic Integrity (IBI). The second objective was to determine fish biodiversity and abundance at these sites. The third objective was to determine current status of two fish species listed by the USFWS for protection: the Cahaba shiner *(Notropis cahabae*--endangered) and the goldline darter (*Percina aurolineata*--threatened).

## SAMPLING SITES AND STUDY AREA

Twelve sites were sampled during this study, 11 in the Cahaba River main channel and one in the Little Cahaba River (table 1). The main channel sites extended from the U.S. Hwy. 82 bridge crossing at Centreville upstream to the Interstate Hwy. 59 bridge crossing at Trussville.

The Cahaba River is the third largest tributary to the Alabama River in the Mobile River basin. It extends for 191 miles from its headwaters in St. Clair County northeast of Birmingham to its confluence with the Alabama River southwest of Selma. The drainage area lies entirely within the state of Alabama, and encompasses approximately 1,825 square miles ($mi^2$) including portions of St. Clair, Jefferson, Shelby, Bibb, Tuscaloosa, Perry, Chilton, and Dallas Counties. Elevations in the watershed range from 1,100 feet in Shelby County to 100 feet at the confluence with the Alabama River.

The portion of the drainage in our study area extends upstream from Centreville and encompasses 1,027 $mi^2$ in Bibb, Shelby, Jefferson, and St. Clair Counties. This portion of the drainage lies within three physiographic districts in the Valley and Ridge Province (Fenneman, 1938; Sapp and Emplaincourt, 1975): the Cahaba Valley District, the Cahaba Ridges District, and the Birmingham-Big Canoe Valley District. These physiographic districts correspond to the level III ecoregion 67 (Ridge and Valley) and include the Southern Limestone/Dolomite Valleys and Low Rolling Hills (67f), Southern Sandstone Ridges (67h), and Southern Shale Valleys (67g) (Griffith and others, 2001).

Table 1. Summary information on Cahaba River sampling stations, 2002.

| Station (EPA) | Description | Location | County | Drainage Area (mi$^2$) | Gradient (ft/mile) | River Mile |
|---|---|---|---|---|---|---|
| 1 | Cahaba River @ Alt. U.S. Highway 82 (Centreville) | sec. 35,T.23 N.,R.9 E. | Bibb | 1,027 | 1.3 | 83.2 |
| 2 | Cahaba River @ Bibb Co. Hwy. 26 (River Bend) | sec. 33,T.24 N.,R.10 E. | Bibb | 919 | 3.3 | 90.0 |
| 3 | Cahaba River @ Bibb Co. Hwy. 24 (Piper) | sec. 3,T.24 N.,R.10 E. | Bibb | 593 | 5.6 | 95.8 |
| 4 | Cahaba River @ Boothton | sec. 30,T.21 S.,R.4 W. | Shelby | 367 | 2.4 | 110 |
| 5 (CR-7) | Cahaba River @ Shelby Co. Hwy. 52 (Helena) | sec. 20,T.20 S.,R.3 W. | Shelby | 335 | 2.2 | 127.1 |
| 6 (CR-6) | Cahaba River @ Jefferson Co. Hwy. 275 (Bains Bridge) | sec. 24,T.19 S.,R.3 W. | Jefferson | 230 | 2.5 | 136.8 |
| 7 | Cahaba River near Altadena | sec. 8,T.19 S.,R.2 W. | Jefferson | 207 | 2.5 | 142.2 |
| 8 | Cahaba River @ Shelby Co. Hwy. 29 (Caldwell Mill Road) | sec. 3,T.19 S.,R.2 W. | Shelby | 200 | 5.6 | 144.9 |
| 9 | Cahaba River @ Jefferson Co. Hwy. 143 (Grants Mill Road) | sec. 33,T.17 S.,R.1 W. | Jefferson | 129 | 5.8 | 161.3 |
| 10 | Cahaba River @ Camp Coleman | sec. 20,T.16 S.,R.1 E. | Jefferson | 31 | 23.3 | 179.3 |
| 11 | Cahaba River @ Interstate Hwy. 59 | sec. 12,T.16 S.,R.1 W. | Jefferson | 18 | 29.4 | 185.1 |
| 12 | Little Cahaba River @ Bibb Co. Hwy. 65 (Bulldog Bend) | sec. 13,T.24 N.,R.10 E. | Bibb | 175 | 11.7 | -- |

The Valley and Ridge Province consists of a series of parallel ridges and valleys that are underlain by highly folded and faulted rocks of Cambrian to Pennsylvanian age. The Cahaba Valley district is a topographic valley that lies between the Coosa and Cahaba Ridges. It is characterized as a faulted monoclinal fold underlain predominantly by dolomite and limestone of early Paleozoic age. The Cahaba Valley ranges in width from 2 to 3 miles in the northern end to almost 10 miles at the southern end and its length is approximately 75 miles. Ridges occur locally in the valley and are due to preferential weathering of soluble limestone and easily eroded shale, leaving the more resistant chert beds as topographically high features.

The Cahaba Ridges district is a series of parallel southwest-northeast oriented ridges formed by massive sandstone and conglomerate beds of the Pottsville and Parkwood Formations. The Cahaba Ridges district is approximately 65 miles long ranging in width from about 5 miles at the northern end to about 15 miles at the southern end. Ridges rise from 200 to 500 feet above the Cahaba Valley to the southeast and Birmingham-Big Canoe Valley to the northwest. Most of the main channel of the Cahaba River upstream of the Fall Line flows through the Cahaba Ridges district.

The northwestern and western portions of the Cahaba River system drain part of the Birmingham-Big Canoe Valley district. This district is a broad anticlinal valley and is underlain by faulted and asymmetrically folded rocks of Cambrian to Mississippian age. Downstream of the Fall Line near the town of Centreville in Bibb County, the Cahaba River enters the Coastal Plain physiographic province. Unlike the hard Paleozoic rocks of the Valley and Ridges province, the rocks of the Coastal Plain province are largely unconsolidated and tend to form broad alluvial floodplains and terraces. Stream deposits and substrates in this portion of the drainage include clay, sand, silt, and gravel.

An important feature of the upper Cahaba River is a water pumping station located about 1/4 mile upstream of a low level dam at U.S. Hwy. 280 near Cahaba Heights. The water intake draws an average of 57 million gallons per day from the impoundment. This pool is fed by flow from the Cahaba River and by water released from Lake Purdy, a water supply impoundment on the Little Cahaba River. Water released from Lake Purdy flows downstream in the Little Cahaba River to the pooled junction with the Cahaba River where it is drawn back upstream to the intake. During periods of low flow, virtually all of the discharge of the river is removed at this point with a portion returned to the river as treated wastewater near U.S. Hwy. 31. Some of the water removed at the pump station is distributed outside the Cahaba River drainage, ultimately contributing flow to the Black Warrior River.

## METHODS

The use of biological assessment tools to evaluate stream water quality has proliferated during the last 20 years since a practical definition of biological integrity was proposed by Karr and Dudley (1981). They defined biological integrity as the ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitats within a region. This definition of biological integrity is based on measurable characteristics of biological community structure and function and has provided the underlying theory for development of biocriteria for specific ecoregions in some states (Ohio EPA, 1987a).

The process of biological assessment is a systems approach for evaluating water resources which focuses on the actual condition of the resource, assessing chemical and physical water quality, biotic interactions, hydrology, energy and trophic interactions, and habitat structure. The extensively used chemical/physical and whole-effluent toxicity water regulatory approach only measures certain components of a water resource and as such are only surrogate measures for evaluating biological community integrity. Ultimately, it is the measurable performance of the natural biological system relative to a reference condition that is the goal for determining whether or not regulatory programs have successfully maintained or improved water quality. Biological assessments are one of the few ways to directly measure biological performance.

Biological assessments can now be used with some assurance for water resource evaluation for several reasons. First, support for the use of standardized techniques and methods has increased during the last decade (Karr and others, 1986; Plafkin and others, 1989; Barbour and others, 1999). Second, field and laboratory techniques have been refined and modified for application regionally and within states for use within a regulatory scheme. Third, a practical, working definition of biological integrity has been developed (Karr and Dudley, 1981) around which the process of biological assessment can be defended. And finally, the concept of using regional reference data has been incorporated into the evaluation process compensating for the natural variation inherent in biological populations and systems. Full integration of the chemical-specific, toxicity, and biological assessment approaches is essential for a broad-based, technically sound, and cost-effective system for regulating and managing water resources.

Rapid biological assessment requires the time-efficient analysis of stream conditions at a relatively low cost. Assessments must characterize the existence and severity of impairment to water-use classifications, help identify the sources and causes of water-use impairment, evaluate the effectiveness of actions to control water pollution, support water-use attainability studies, and characterize regional biotic components (Plafkin and others, 1989). In conjunction with chemical/physical water-quality measurements and analysis of habitat quality and condition, the biological assessment is an effective tool for assessing and managing water quality within the ecoregion. The most widely used approach for biological assessment is sampling and analysis of the macroinvertebrate community using the RBP-III methodology (Plafkin and others, 1989; Barbour and others, 1999) or some variation thereof. Another, though less widely used, approach for conducting bioassessments is through sampling and analysis of the fish community.

Assessing the biological condition of streams using the fish community has distinct advantages over the use of other aquatic groups.

, Fish occupy the full range of positions throughout the food chain such as herbivores, carnivores, piscivores, omnivores, insectivores, and planktivores, thereby integrating a variety of watershed functions and conditions into their community trophic structure.

, Fish are generally present in all but the most polluted waters.

, Because fish are relatively long-lived compared to macroinvertebrates and generally spawn for a confined period in a year, their population numbers and fluctuations are more stable over longer periods of time.

, Compared to diatoms and macroinvertebrates, fish are relatively easy to identify. Species identification is possible for practically all individuals collected and, if desired, individuals can be identified and released at the field site by a trained fisheries biologist. If samples are returned to the laboratory they can be sorted, identified, and data sheets prepared relatively quickly allowing several samples to be processed in a day.

, Technician training and is easier with fish than with macroinvertebrates because fish are larger and easier to see and can be identified more easily compared to macroinvertebrates. Alabama has around 300 freshwater fish species compared to several thousand macroinvertebrate species.

, Environmental requirements of fish are relatively well known for a majority of species. Life history information is extensive for many species and detailed distributional information is becoming more available with time.

, Water-quality standards, legislative mandates, and public opinion are more directly related to the status of a lake or stream as a fishery resource. One goal of the Clean Water Act is to make waters “fishable and swimmable,” a directly measurable and attainable concept. Public perception of streams, pollution, and water quality monitoring is linked closely with fish because of their value as a food source and as a recreational resource.

Various protocols have been proposed for sampling fish communities in wadeable and nonwadeable streams (Ohio EPA, 1987b; Plafkin and others, 1989; and Barbour and others, 1999) and many are accepted techniques for collecting data for use with the IBI. The Tennessee Valley Authority (TVA) has developed a depletion sampling protocol where a sample is collected according to a prescribed number of sampling units, the catch in each unit is identified and recorded on site, and sampling is continued for a series of units until no new species are collected in the last unit, termed species depletion. Depending on the size (watershed area) and biodiversity of a site, this technique may take several hours, requires on-site identification of the catch, and may require a large field crew.

Another variation of the catch-depletion protocol consists of blocking a stream reach at the upstream and downstream ends and making three depletion passes through the reach with a sampling team that stretches from bank to bank. After each pass the catch is processed and held until sampling is completed. This technique also requires on-site identification of the catch, a rather large field crew, and only about two sites can be sampled per day if they are in close proximity.

The sampling method used in this study was modified from a protocol described by O’Neil and Shepard (2000) to include more intensive sampling at each site in order to capture as many species as possible (table 2). The most effective sampling combination was a backpack

Table 2. Fish community sampling procedures used by the Geological Survey of Alabama

| | |
|---|---|
| Habitat Selection | Four basic habitat types are sampled at each site: riffles, pools, runs, and shorelines. All sampling is conducted in units called efforts. One effort is equivalent to a riffle kick with the backpack, a pool drag, a run set with the seine, or one shoreline effort. Area is determined for each effort, and the species type and number collected are determined for each effort. Habitats are sampled in relative proportion as they occur at a site. Sampling time is determined by a combination of best professional judgement and species depletion for the entire sample. |
| Sample Gear | Seine (10' wide x 6' deep or 15' wide x 6' deep; 3/16" mesh)<br>Battery- or generator-powered backpack shocker.<br>Dip nets with wood handles.<br>Hip chain (for measuring distance of shoreline samples)<br>Data recording sheet or digital data logger.<br>Plastic jar with preservative for voucher specimens. |
| Sampling Methods | Riffle kicks with and without backpack shocker.<br>Pool drags with and without backpack shocker.<br>Set downstream of and shock through runs.<br>Set below and shock through plunge pools.<br>Shoreline samples with backpack shocker and dipnets, usually 150 feet long. |
| Taxonomic Level | All collected individuals identified to species in the field. Occasional voucher specimens retained or individuals that can not be field identified. |
| QA Procedures | Field: All personnel undergo yearly assessment of sampling techniques, refine sampling method as needed for project or study.<br>Identifications: One expert fish taxonomist and(or) identifier at a minimum are present for all sampling. |
| Habitat Assessment | USEPA Physical Habitat Assessment Protocol (Barbour and others, 1999; ADEM, 1999) |
| Metrics | Species richness, catch/effort, IBI (metrics and criteria are under continual refinement until a statewide, consistent framework for scoring can be established). |

shocker in combination with a seine. In riffles, the net was set in shallow, rocky areas or deeper, swifter chutes and the backpacker walked upstream then proceeded to shock downstream through the riffle to the seine while disturbing the bottom with boots and probes. Stunned fishes in the water column were washed into the net while benthic fishes were dislodged from the bottom by kicking the substrate. Another variation was to have another crew member behind the backpacker shuffling their feet from side to side disturbing the bottom and dislodging stunned benthic fishes. Because riffles are quite often very productive areas, all microhabitats were sampled: the head, foot, middle, and sides. The sides of riffles along vegetated shoals were usually very productive areas as were head areas where riffles start to break. Plunge pools at the foot of a riffle often yielded a diverse catch of cyprinid species.

Stream runs between riffles and pools were also productive habitats and were sampled by either seining downstream or by moving from bank to bank across the stream in a downstream direction either alone or following the backpacker. Pools were generally less productive than runs and riffles but many times contained species not found in either of the other habitats. Lower velocity in pools required more effort to pull the seine through the water column. Following the electroshocker was also effective in pools and trapping fishes against the shore or in a slough at the end of a long pool was also effective. Wider seines were more effective in pools and at the larger, downstream sites.

Banks along pools can have complex structure and yield game species and larger sucker species not normally found in the basic riffle-run-pool habitats. These habitats were collected using a technique known as shoreline sampling. The shoreline technique we use was developed by TVA biologists and consisted of a crew member working the electroshocker upstream along a shoreline for a length of approximately 150 feet sampling around all structures. One or two field crew members followed closely with dip nets scooping and identifying the stunned individuals. Distance was measured with a forestry-type hip chain.

## SAMPLING GEAR

Of all available sampling equipment, the backpack electrofisher, dip net, and nylon minnow seine are the most popular sampling gear used for bioassessment studies in wadeable streams. Ohio EPA (1987b) exclusively uses electrofishing gear to collect their standardized wadeable stream samples. They have concluded that seines are too selective and inefficient while sampling effort is too variable between field crews. Because Ohio EPA has instituted biocriteria in their legal water quality regulations, collection of a sample using protocols that reduce sampling bias to a minimum and that standardize sampling effort are mandatory. This is a strong argument for using electrofishing gear exclusively when young and inexperienced field crews are dispatched to collect fish samples. On the other hand, the knowledgeable use of seines in combination with electrofishing gear can yield representative samples of the fish community for use in assessing stream water quality. As with most sampling gear and techniques, there are advantages and disadvantages to each method.

### Advantages of electrofishing:

( Electrofishing allows greater standardization of catch per unit effort.
( Electrofishing requires less time and a reduced level of effort than some sampling methods.
( Electrofishing is less selective than seining.
( If properly used, electrofishing has minimal effects on fish.
( Electrofishing is appropriate in a variety of habitats.

### Disadvantages of electrofishing:

; Sampling efficiency is affected by turbidity and specific conductance.
; Although less selective than seining, electrofishing is size and species selective. Larger species are more vulnerable to electrofishing.
; Electrofishing is a hazardous operation that may result in injury if proper safety procedures are not followed.
; Commercial electrofishing units are expensive (thousands of dollars).

### Advantages of seining:

( Seines are inexpensive, lightweight, and easily transported to sampling sites.
( Repair and maintenance are easily completed.
( Use of seines is not restricted by water clarity or quality.
( Effects on fish populations are minimal because fish are collected alive and generally unharmed.
( Seines can be effectively used as large dip nets to scoop small individuals.

**Disadvantages of seining:**

- Previous experience, sampling skill, knowledge of fish habitats and behavior, and sampling effort are more critical in seining than in the use of any other sampling gear.
- Sample effort and results for seining are more variable than sampling with electrofishing units or ichthyocides.
- Use of seines is most effective in small streams.
- Standardization of catch per unit effort to ensure data comparability can be more difficult.
- Highly mobile fishes often elude seines and nets.

Three types of sampling gear were used to sample fishes in wadeable reaches of the Cahaba River: minnow seines, dip nets, and a backpack electrofishing unit. Seines served as a complement to the electroshocker and were used to catch, scoop, or dip stunned fishes and to trap fishes in eddies and backwaters. At other times, seines were used as the primary gear for capturing fishes in pools, runs, and along shoals. Standard nylon minnow seines used during this study were 10 feet or 15 feet wide, 6 feet in height, and with a delta weave of 3/16 inch. An electrofishing boat was used at selected sites to enhance the capture of species.

The electrofishing boat was used to collect deeper pools at four sites. A holding net was tied to a tree at the downstream end of the sampled reach and served to hold all individuals collected until after the sample was completed. A 10-minute “pedal down” sample was taken along one of the shorelines and all individuals kept in a live well inside the boat. All individuals were identified and put in the holding net. This protocol was repeated midstream and again on the remaining shoreline. After three electroboat efforts the protocol is repeated starting with the original shoreline until completing an effort without collecting any new species.

## ANALYSIS OF FISH COMMUNITY DATA

Analysis of fisheries data should be done with a clear definition of questions that are to be answered by the collected information. Ecological field data involving the collection of samples which represent populations and communities is multi-variable in nature and methods of analysis should reflect this diversity and variation in both ecological and zoological characteristics. Karr and others (1986) proposed the IBI as a multi-metric bioassessment tool that has proven to be a worthy and robust measurement of stream biological integrity in relation to water-quality impairment. The IBI has become a standard analysis technique for fishery bioassessment data and some state agencies, such as Ohio EPA, have incorporated the measure into enforceable water-quality standards. The accurate assessment of biological integrity in streams requires a method that integrates biotic responses to water-quality degradation through evaluating patterns and processes of ecological organization from individual to ecosystem levels.

The IBI is considered a multi-metric analysis tool because it is an aggregation of 12 biological measures based on fish community taxonomic and trophic composition and the abundance and health of fish. The IBI approach is similar to that for evaluating economic systems where many economic measures are combined to calculate the "index of leading economic indicators" for assessing economic condition. The multi-metric approach incorporated in the IBI is useful for making objective evaluations of complex ecological systems such as streams and rivers. Another useful feature of the IBI is that it incorporates the fisheries biologists "best professional judgement" concerning the health and condition of the fish community. All too often biologists have failed to accurately and quantitatively express their valuable natural history observations about the condition of rivers and streams simply because there was no prescribed protocol for doing so. The IBI incorporates best professional judgement when creating the quantitative standards for discriminating the condition of fish communities, when selecting which metrics to use in the IBI analysis based on regional faunal components, and in establishing the scoring criteria for the metrics.

## IBI METRICS

The IBI measures 12 attributes (metrics) of the fish community which are scored 1 (worst), 3, or 5 (best) compared to values expected from an undisturbed fish community in similar streams of the same ecoregion (Karr and others, 1986). The sum of the scores for the 12 metrics varies from 12 to 60. Fish communities are assigned to one of five classes based on the final IBI score: excellent, good, fair, poor, and very poor (table 3). A "no fish" class is used when repeated sampling fails to produce any fish. Samples falling between the various classes may be assigned to an appropriate class at the discretion of a qualified fisheries biologist.

The 12 metrics are grouped into three categories: species richness and composition, trophic composition, and fish abundance and condition. The basic metrics and scoring criteria

Table 3. Total IBI scores, integrity classes, and the attributes of those classes (from Karr and others, 1986).

| Total IBI score (sum of 12 metric ratings) | | Biological integrity class | Attributes |
|---|---|---|---|
| Karr and others (1986) | Geological Survey of Alabama (O'Neil and Shepard, 2000) | | |
| 58-60 | >55 | Excellent | Comparable to the best situations without human disturbance; all regionally expected species for the habitat and stream size, including the most intolerant forms, are present with a full array of age (size) classes; balanced trophic structure. |
| 48-52 | 47-55 | Good | Species richness somewhat below expectation, especially due to the loss of the most intolerant forms; some species are present with less than optimal abundances or size distributions; trophic structure shows some signs of stress. |
| 40-44 | 38-46 | Fair | Signs of additional deterioration include loss of intolerant forms, fewer species, highly skewed trophic structure (for example, increasing frequency of omnivores and green sunfish or other tolerant species); older age classes of top carnivores may be rare. |
| 28-34 | 26-37 | Poor | Dominated by omnivores, tolerant forms, and habitat generalists; few top carnivores; growth rates and condition factors commonly depressed; hybrids and diseased fish often present. |
| 12-22 | <25 | Very poor | Few fish present, mostly introduced or tolerant forms; hybrids common; disease, parasites, fin damage, and other anomalies occur more frequently. |
| | | No fish | Repeated sampling yields no fish. |

developed by Karr and others (1986) for streams in the Midwest were modified for two streams in Alabama, the Black Warrior River (O'Neil and Shepard, 2000) and the Cahaba River (Shepard and others, 1997). The Cahaba metrics and scoring criteria presented in Shepard and others (1997) were the first ones derived for Alabama streams. Since that time, GSA biologists have acquired additional knowledge about how the IBI functions and how to improve the original metrics and scoring criteria. The IBI metrics for this study are consistent with those offered for the Black Warrior River by O'Neil and Shepard (2000) but scoring criteria were slightly modified to account for the intensive sampling regime (table 4).

## IBI SCORING CRITERIA

Several modifications of original IBI metrics were instituted to account for ecological conditions encountered in southeastern streams. Number of minnow species (Cyprinidae) was added as a species richness metric since the cyprinids are diverse and abundant in the Mobile River basin. Proportion of individuals as green sunfish was replaced with proportion of individuals as sunfish (*Lepomis*) based on our observation that several species of sunfish (rarely just green sunfish) frequently dominate the fauna at disturbed sites many times accounting for more than half of the total specimens collected. Scoring criteria for the proportion of individuals as top carnivores was lowered from Karr and others (1986) values based on our experience with the abundance of these fishes in unimpaired stream reaches in Alabama. The proportion of individuals as omnivores was altered to include omnivores and herbivores since both of these groups are typically dominant at disturbed sites. Proportion of individuals as hybrids was dropped from our list of IBI metrics because hybrids are infrequently encountered in our sampling.

The criteria proposed by Karr and others (1986) for scoring IBI metrics must usually be adjusted for stream size and regional variation in fish species diversity and community composition. Several of the IBI metrics that measure species richness and composition are strongly related to stream size with larger streams supporting more species. This relationship is in many cases drainage specific and generally holds true up to a certain critical watershed size after which species richness remains relatively constant, or declines. Regional differences in faunal composition are strongly apparent in Alabama, with distributions of many species highly correlated with physiography and (or) specific drainage basins (Mettee and others, 1996).

Table 4. Preliminary IBI metric scoring criteria for the Cahaba River system upstream of Centreville.

| Category | Metric | Watershed Size | Scoring Criteria 5 | Scoring Criteria 3 | Scoring Criteria 1 |
|---|---|---|---|---|---|
| Species Diversity and Composition | 1. Number of fish species | <10 $mi^2$ | > 13 | 7-13 | <7 |
| | | 10-250 $mi^2$ | > 18 | 9-18 | < 9 |
| | | > 250 $mi^2$ | > 22 | 15-22 | < 15 |
| | 2. Number of darter species | <10 $mi^2$ | > 2 | 1-2 | 0 |
| | | 10-250 $mi^2$ | > 3 | 2-3 | <2 |
| | | > 250 $mi^2$ | > 5 | 3-5 | < 3 |
| | 3. Number of minnow species | <10 $mi^2$ | > 5 | 3-5 | < 3 |
| | | 10-250 $mi^2$ | > 7 | 3-7 | < 3 |
| | | > 250 $mi^2$ | > 10 | 5-10 | < 5 |
| | 4. Number of sunfish species | <10 $mi^2$ | > 2 | 1-2 | 0 |
| | | 10-250 $mi^2$ | > 3 | 1-3 | 0 |
| | | > 250 $mi^2$ | > 4 | 2-4 | < 2 |
| | 5. Number of sucker species | <10 $mi^2$ | > 2 | 1-2 | 0 |
| | | 10-250 $mi^2$ | > 2 | 1-2 | 0 |
| | | > 250 $mi^2$ | > 4 | 2-4 | < 2 |
| | 6. Number of intolerant species | <500 $mi^2$ | > 2 | 1-2 | 0 |
| | | >500 $mi^2$ | > 3 | 1-3 | 0 |
| | 7. Proportion as sunfishes | all sizes | < 10% | 10-30% | > 30% |
| Trophic Composition | 8. Proportion as omnivores and herbivores | all sizes | < 5 | 5-20% | > 20% |
| | 9. Proportion as insectivorous cyprinids | all sizes | > 45% | 20-45% | < 20% |
| | 10. Proportion as top carnivores | all sizes | > 2% | 0.5-2% | <.5% |
| Abundance | 11. Number collected per hour | <100 $mi^2$ | > 350 | 150-350 | < 150 |
| | | $100 $mi^2$ | >650 | 150-650 | <150 300 |
| | 12. Percent anomalies | all sizes | < 2% | 2-5% | >5% |

## METRIC 1—TOTAL NUMBER OF INDIGENOUS FISH SPECIES

Total number of fish species is one of the best-documented measures of biological condition used to assess stream water quality. Karr and others (1986) indicated that number of species is a sensitive indicator of biological condition over the range of stream quality from poor to exceptional with biodiversity generally declining with increasing environmental disturbance throughout all types of aquatic habitats. The number of fish species is directly related to drainage area at wadeable sites up to 250 $mi^2$ but appears to level at sites with drainage areas >250 $mi^2$ in the Cahaba system.

## METRIC 2—NUMBER OF DARTER SPECIES

The presence of darter species is indicative of fair to good water quality conditions because they live, for the most part, in streams and rivers of good quality. Darters are habitat specialists, feed on benthic invertebrates, and they have complex reproductive behaviors that make them particularly sensitive to environmental degradation from siltation and those pollutants or activities that degrade stream habitat quality, particularly benthic habitat quality. Over seventy-five species of darters have been recorded from Alabama waters (Mettee and others, 1996) ranging from small intermittent headwaters, impounded rivers, swampy backwaters and oxbows, to flowing streams and rivers. This wide array of preferred habitat types make darters an excellent, regionally specific, group for assessing stream water-quality conditions.

Ohio EPA (1987b) recommends substituting the proportion of round-bodied suckers (*Hypentelium, Moxostoma, Minytrema, Erimyzon*) for this metric when the sample is collected using a boat electrofishing technique. These species comprise a substantial component of the large river fauna, much as darters do in smaller streams, and are sensitive to environmental degradation caused by high levels of siltation and poor chemical water quality. Round-bodied suckers are good indicators of acceptable to good biological condition in nonwadeable waters and future development of a boat electrofishing IBI protocol should likely incorporate the round-bodied sucker metric.

## METRIC 3—NUMBER OF MINNOW SPECIES

The Cyprinidae is a diverse group in the Southeast, particularly in Alabama where Mettee and others (1996) reported 92 species from the state. As a measure of biodiversity, the family Cyprinidae is unmatched and contains species from across the spectrum of tolerance to environmental disturbance. This measure is particularly well suited for Coastal Plain streams that are typically poor in darter species yet rich in minnow species. Coastal Plain habitats and areas of transition along the Fall Line harbor a complex mix of stream and aquatic habitats highly influenced by local geologic constraints. Sand and gravel shoals, pools, glides, log snags, and occasional hard-rock riffles are ideal habitats for supporting minnow populations. Like the percids, minnow species richness increases with watershed area.

## METRIC 4—NUMBER OF SUNFISH SPECIES

This metric is determined by counting the number of sunfish species in the family Centrarchidae, less *Enneacanthus,* which are not common throughout the state, and less the black basses, *Micropterus*. Sunfish hybrids are not included in this metric. Sunfishes thrive in structurally complex pool habitats and very often in habitats highly disturbed by sediment deposition and eroded shorelines. This metric is a measure of degradation which alters habitat complexity of pools, changes food web structure components, and physically compromises habitat quality.

O'Neil and Shepard (2000) indicated the number of sunfish species was equally high in headwater reaches and in larger streams of a river system. In contrast, the Ohio EPA (1987b) found that in headwater reaches, usually $<20$ mi$^2$ in area, the number of sunfish species was generally low, only one or two species. They attributed this condition to poor pool habitat rather than poor stream quality overall. Ohio EPA replaces the sunfish species metric with a number of headwater species metric, where headwater species are those permanent residents of small creeks that indicate stable habitat quality and low environmental stress. The headwater species metric may be applicable to other river systems in Alabama where sunfish diversity is poor.

## METRIC 5—NUMBER OF SUCKER SPECIES

All species of the family Catostomidae are included in this metric. Sucker diversity is high in Alabama, represented by 23 species, but only a few of these such as *Erimyzon oblongus*, *Hypentelium etowanum*, *Minytrema melanops*, *Moxostoma duquesnei*, *M. erythrurum*, and *M. poecilurum* are found with regularity in wadeable streams. Many sucker species enter streams to spawn and the young may linger in these areas until they reach a certain age or size before migrating back to larger waters. Suckers occur in all types of aquatic habitats and are a major portion of the total catch and biomass in many boat electrofishing samples. Suckers are generally intolerant of severe water-quality degradation and are a moderately sensitive measure of environmental quality. Suckers also have much longer life spans, compared to minnows and darters, and thereby provide a longer term assessment of past and current environmental conditions. Ohio EPA (1987b) reported that sucker diversity declined dramatically in headwater reaches and they substituted the number of minnow species for sucker species in this metric.

METRIC 6—NUMBER OF INTOLERANT SPECIES

The number of intolerant species is included as a metric in the IBI to distinguish those stream reaches of the highest quality. Many Alabama species are intolerant of a wide range of environmental changes from habitat disturbance to water quality degradation, but only those species that usually disappear first and are sensitive to a wide spectrum of environmental stress should be considered intolerant for purposes of the IBI. Species considered intolerant may be widespread in distribution, geographically restricted or infrequently captured, rarely captured, or possibly extirpated. Although endangered or threatened species are generally included in the list of intolerant species they should not automatically be considered so because their low numbers may be due to zoogeographic factors, such as relict or isolated populations, and not necessarily due to environmental stress.

If many species are included as intolerants then the usefulness of this metric declines (Karr, 1981) because intolerants are only found in good to excellent stream conditions. Karr recommended that the number of intolerants be restricted to 5 to 10 percent of species that are most susceptible to major types of degradation such as siltation, restricted flow, low dissolved oxygen, and toxic chemicals. Until a sufficient data base of systematically collected samples has been assembled, determining intolerance for Alabama fish species will remain a matter of best professional judgement supplemented by the literature and application of the IBI in other areas. Species considered intolerant for the purposes of this investigation were *Notropis chrosomus, N. cahabae, Ambloplites ariommus, Ammocrypta* spp., *Crystallaria asprella, Etheostoma ramseyi, E. jordani, Percina aurolineata*, and *P. brevicauda*.

METRIC 7—PROPORTION OF SUNFISH SPECIES

This metric is a modification of Karr’s original green sunfish proportion metric. It is designed to detect fish community trophic changes in the lower ranges of the IBI from fair to poor quality. Green sunfish are dominant at only the most impaired, usually nutrient enriched, stream reaches in Alabama. It has been our experience that several species of sunfishes can dominate the fauna in severely disturbed streams in Alabama, sometimes exceeding 50 percent of the abundance, and that limiting this metric to green sunfish would limit the value of this metric. Only species in the genus *Lepomis* are considered in the calculation.

METRIC 8—PROPORTION AS OMNIVORES AND HERBIVORES

Omnivores are defined as species that ingest substantial quantities of plant and animal matter, including detritus, and have the ability to utilize both food sources as usually indicated by a long and convoluted gut cavity. As the food base changes due to environmental degradation the predictability of specific food items becomes less reliable and the opportunistic feeding habits of omnivores allow this group to compete more successfully. We have also included herbivores in this metric to assess the presence of *Campostoma* and *Hybognathus* which can become dominant in stressed streams. Species considered omnivores and herbivores for this metric are stonerollers, *Pimephales* spp., *Hybognathus* spp., goldfish, carp, grass carp, *Dorosoma* spp., *Carpiodes* spp., and mosquitofish.

METRIC 9—PROPORTION AS INSECTIVOROUS CYPRINIDS

Insectivorous cyprinids are a dominant trophic group in southeastern streams and their abundance generally declines with increasing environmental stress. This is thought to be in response to an altered insect food supply which is in turn altered by changes in water quality, energy sources, and habitat (Karr, 1981). Thus, when the community becomes dominated by a few insect taxa, specialized insectivorous fishes will be replaced by omnivores more suited to exploit the new food base.

## METRIC 10—PROPORTION AS TOP CARNIVORES

The top carnivore metric was designed to measure biological integrity in the upper functional levels of the fish community. To be considered a top carnivore a species has to consume primarily other fish, vertebrates, or crayfish, while species that consume other items as well as fish are excluded from the list. Top carnivores include all black bass, temperate bass, crappie, rock bass, pickerel, walleye, bowfins, and gar species. The presence of top carnivores indicates a healthy and trophically diverse fish community. The criteria adopted for the Cahaba were lowered to about half of those proposed by Karr and others (1986).

## METRIC 11—NUMBER OF INDIVIDUALS COLLECTED PER HOUR

This metric evaluates population abundance and is expressed as catch per hour of sampling effort (Karr, 1981). Sites in poor biological condition are expected to have fewer individuals than higher quality sites, or in cases of enrichment more individuals than normally expected. The Cahaba River is a very productive system for fish abundance and this metric has been modified to partition these differences by watershed size. Ohio EPA (1987b) has modified this metric to individuals per unit of sampling effort less tolerant species. Their rationale is that under some environmental changes, such as canopy removal along with excess nutrification, some fishes, particularly tolerant species such as *Pimephale*s, will increase in abundance. They also presented quantitative data illustrating reduced variability in the scoring of this metric when tolerant species were removed. This modification has significant merit and should be evaluated as the IBI protocol is refined for Alabama.

## METRIC 12—PROPORTION WITH DISEASE, DEFORMITIES, LESIONS, AND TUMORS (PERCENT ANOMALIES)

Fish health is a direct concern of the public. Fish populations with excessive occurrence of disease and skin anomalies generally indicates high environmental stress resulting in poor fish health. Skin anomalies are caused by infections due to bacteria, viruses, fungus, and parasites, and exposure to toxic chemicals. Skin anomalies are most common downstream of municipal and industrial discharges and areas subject to stress from combined sewer overflows, urban runoff, and high temperature. Ohio EPA also reported this metric was a good indicator of subacute toxic stress when the community structure metrics indicated improved or good conditions.

## PROCEDURE FOR CALCULATING IBI

Calculation and interpretation of IBI values is a straightforward eight-step hierarchical process:

-Develop expectation criteria for each IBI metric

-Tabulate numbers and skin anomalies for each species

-Assign species to trophic guilds

-Assign tolerance categories to each species

-Calculate metric values and record on the IBI calculation form

-Rate each IBI metric according to the scoring criteria (table 4)

-Calculate total IBI score

-Convert IBI score to a biological integrity class (table 3)

The expectation criteria for each metric have been derived and presented in table 4. The second step is conducted in either the laboratory or field and involves sorting and identifying individuals to species, counting (and weighing) individuals, determining skin anomalies, and recording this data on an appropriate data form. The third and fourth steps are accomplished by comparing regional species lists to information presented in Mettee and others (1996) and O'Neil and Shepard (2000) which tabulates basic ecological and distributional data for Alabama freshwater fishes. Step five requires that each IBI metric is correctly calculated and added to the IBI calculation form. Step 6 involves rating the metric values according to criteria in table 4, while step seven is simply adding the 12 metric scores to yield a total IBI score. The final step involves converting the total IBI score to a biological condition class according to the criteria listed in table 3.

# RESULTS AND DISCUSSION

## SPECIES DIVERSITY AND CATCH

Fish sampling in the Cahaba River yielded a total of 9,020 individuals in 62 species and 11 families (table 5, appendix). Wade samples yielded 53 species, while 28 species were collected with the boat electrofishing unit. The most diverse wading site in the main river channel was River Bend (site 2) with 30 species followed by Centreville (site 1) with 28 species. Sites with the poorest species diversity were Camp Coleman (site 10) with 13 species and Altadena (site 7) with 16 species. The intensive sampling effort undertaken for this investigation resulted in a higher catch of species compared to collections made at the same sites in years past (table 6).

It could possibly be inferred from table 6, although falsely, that fish species diversity in the Cahaba River is actually increasing! This is not the case, however, and table 6 highlights the importance of applying a thorough and rigorous sampling technique when conducting faunal surveys or bioassessments. Further, if the boat electrofishing data are added to the results in table 6, this concept of adequate sampling becomes even more apparent. Thirteen additional species were added to site 1 bringing the total to 41 species, 10 additional species were added to site 3 for a total of 32 species, two species were added to site 4 for a total of 25 species, and five species were added to site 12 for a total of 35 species.

The maximum fish species diversity to be expected at each site was estimated using three sources and (or) techniques (table 7). One technique was to compile collection records and develop species lists. Pierson and others (1989) published a study of Cahaba River fishes and compiled records of 506 samples taken at 169 locations in the system through 1985. Data from that study was used to approximate the expected maximum species diversity at sampling sites examined during this study.

Another estimate of maximum species diversity was made by combining the data in Pierson and others (1989) with a series of fish biomonitoring samples taken at several sites in the Cahaba by Geological Survey of Alabama biologists from 1989-94 (Shepard and others, 1997), and the inclusion of data collected during this study. The repetitive and systematic sampling approach used in these investigations resulted in the addition of several species to the total species list for a given site over that reported by Pierson and others (1989)(table 7).

Table 5. Collection information for fish samples taken in the Cahaba River system, 2002.

| | | Wading samples | | | | | | | | | | | | Boat electrofishing samples | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 3 | 4 | 12 |
| | | Centreville | River Bend | Piper | Boothton | Helena | Bains Bridge | Altadena | Caldwell Mill | Grants Mill | Camp Coleman | I-59 | Little Cahaba | Centreville | Piper | Boothton | Little Cahaba |
| Date of collection | | 25 Jun 02 | 24 Jun 02 | 26 Jun 02 | 26 Jun 02 | 27 Jun 02 | 27 Jun 02 | 1Aug 02 | 1Aug 02 | 2 Aug 02 | 2 Aug 02 | 2 Aug 02 | 25 Jun 02 | 25Jun 02 | 26Jun02 | 26 Jun 02 | 25Jun02 |
| Sampling time (min) | | 250 | 240 | 135 | 130 | 110 | 90 | 95 | 110 | 95 | 55 | 70 | 125 | 50 | 60 | 30 | 50 |
| Sampling efforts | Pools | 9 | 20 | 10 | 4 | 14 | 10 | 16 | 0 | 9 | 3 | 3 | 2 | 5 | 6 | 3 | 5 |
| | Riffles | 22 | 19 | 15 | 6 | 24 | 5 | 0 | 6 | 12 | 1 | 6 | 1 | -- | -- | -- | -- |
| | Runs | 37 | 16 | 14 | 35 | 29 | 17 | 2 | 16 | 17 | 17 | 10 | 31 | -- | -- | -- | -- |
| | Shorelines | 2 | 2 | 3 | 2 | 2 | 6 | 4 | 3 | 2 | 2 | 2 | 2 | -- | -- | -- | -- |
| | Total | 70 | 57 | 42 | 47 | 69 | 38 | 22 | 25 | 40 | 23 | 21 | 36 | 5 | 6 | 3 | 5 |
| Area sampled ($ft^2$) | Pools | 1,800 | 4,020 | 1,600 | 160 | 2,240 | 1,520 | 8,145 | 0 | 3,170 | 480 | 560 | 320 | -- | -- | -- | -- |
| | Riffles | 4,105 | 3,220 | 1,800 | 720 | 2,880 | 600 | 0 | 1,160 | 1,960 | 240 | 760 | 160 | -- | -- | -- | -- |
| | Runs | 5,925 | 2,920 | 2,240 | 4,200 | 3,480 | 2,280 | 320 | 2,720 | 3,280 | 3,360 | 1,880 | 4,960 | -- | -- | -- | -- |
| | Shorelines | 600 | 600 | 900 | 600 | 600 | 1,800 | 1,200 | 800 | 600 | 600 | 600 | 600 | -- | -- | -- | -- |
| | Total | 12,430 | 10,760 | 6,540 | 5,680 | 9,200 | 6,200 | 9,665 | 4,680 | 9,010 | 4,680 | 3,800 | 5,440 | -- | -- | -- | -- |
| Total species | | 28 | 30 | 22 | 23 | 25 | 21 | 16 | 26 | 25 | 13 | 20 | 30 | 20 | 18 | 9 | 14 |
| Total individuals | | 1,288 | 1,255 | 709 | 792 | 991 | 235 | 297 | 812 | 357 | 497 | 643 | 725 | 185 | 99 | 26 | 109 |
| Catch per hour | | 309 | 314 | 315 | 366 | 541 | 157 | 188 | 443 | 225 | 542 | 551 | 348 | 222 | 99 | 52 | 131 |
| Catch per 1,000 sq ft | | 104 | 117 | 108 | 139 | 108 | 38 | 31 | 174 | 40 | 106 | 169 | 133 | -- | -- | -- | -- |

Table 6. Species diversity comparisons between this study and historical fish samples in the Cahaba River system.

| Station | | Number of species (sample size) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 2002 | | | 1994[a] | 1992-93[a] | 1989-90[a] | 1982-85[b] |
| | | wade | boat | total | | | | |
| 1 | Cahaba River-Centreville | 28 | 20 | 41 | 20 | -- | 15-21 (7) | 16 |
| 2 | Cahaba River-Riverbend | 30 | -- | 30 | 25 | -- | 15-24 (7) | 24 |
| 3 | Cahaba River-Piper | 22 | 18 | 32 | 16 | -- | -- | 17-27 (2) |
| 4 | Cahaba River-Boothton | 23 | 9 | 25 | 16 | -- | -- | -- |
| 5 | Cahaba River-Helena | 25 | -- | 25 | 21 | 8-14 (5) | 14-17 (4) | 14 |
| 6 | Cahaba River-Bains Bridge | 21 | -- | 21 | 14 | 8-12 (3) | -- | 17 |
| 7 | Cahaba River- near Altadena | 16 | -- | 16 | 7 | 1-17 (4) | -- | -- |
| 8 | Cahaba River-Caldwell Mill Road | 26 | -- | 26 | 22 | 18-19 (2) | -- | 25 |
| 9 | Cahaba River-Grants Mill Road | 25 | -- | 25 | 15 | -- | -- | 15-22 (2) |
| 10 | Cahaba River-Camp Coleman | 13 | -- | 13 | 11 | 9-13 (5) | -- | -- |
| 11 | Cahaba River-I 59 | 20 | -- | 20 | 12 | 11-15 (3) | -- | 15 |
| 12 | Little Cahaba River | 30 | 14 | 35 | 24 | 16-22 (7) | 10-22 (12) | -- |
| Month(s) of collection(s) | | Jun-Aug | | | May | Apr-Sep | Apr-Sep | Apr-Sep |

[a]- data from Shepard and others (1997)

[b]- data courtesy of J. Malcolm Pierson

Table 7. Predictions of maximum species diversity for Cahaba River main channel sites.

| Station | | Watershed area ( $mi^2$) | Maximum species diversity ( $S_{max}$ ) | | |
|---|---|---|---|---|---|
| | | | Pierson and others (1989) | All data through 2002[1] | Model prediction[2] |
| 1 | Cahaba River-Centreville | 1,027 | 74 | 82 | 63 |
| 2 | Cahaba River-River Bend | 919 | 76 | 82 | 61 |
| 3 | Cahaba River-Piper | 593 | 32 | 44 | 53 |
| 4 | Cahaba River-Boothton | 367 | 40 | 42 | 46 |
| 5 | Cahaba River-Helena | 335 | 41 | 47 | 45 |
| 6 | Cahaba River-Bains Bridge | 230 | 17 | 29 | 40 |
| 7 | Cahaba River- near Altadena | 207 | 29 | 35 | 39 |
| 8 | Cahaba River-Caldwell Mill Road | 200 | 25 | 39 | 39 |
| 9 | Cahaba River-Grants Mill Road | 129 | 22 | 30 | 34 |
| 10 | Cahaba River-Camp Coleman | 31 | 13 | 22 | 22 |
| 11 | Cahaba River-I 59 | 18 | 15 | 25 | 19 |

[1]- includes all species records in Pierson and others (1989), Shepard and others (1997), and species records from this study.

[2]- according to the model $S = 8.06A^{0.296}$ applicable only to main channel.

Species diversity is complexly correlated with a variety of environmental factors such as geology, climate, latitude, habitat, and environmental degradation. MacArthur and Wilson (1967) demonstrated that land area was a predictor of species diversity using faunal survey data collected on Pacific islands. Their work concerning island biogeography was used as a basis for a third method to predict maximum species diversity. A species-area relationship for the Cahaba River main channel is presented in figure 1. Number of species was taken from table 7 (all data through 2002) and area was equated to watershed area upstream of the sampling site (table 1). The relationship between species diversity and area is described by the relationship:

$$S = CA^z$$

where $S$ is species diversity, $C$ is a fitted constant that varies among faunal groups, $A$ is island area (watershed area in $mi^2$), and $z$ is a constant which falls generally between 0.20 and 0.35 (MacArthur and Wilson, 1967). The constants were estimated using least squares linear regression (fig. 1) to yield an equation used to model maximum species diversity ($S_{max}$) for the Cahaba River main channel:

$$S_{max} = 8.14A^{0.296}$$

$S_{\text{max}}$ was calculated for all main channel sites using the above formula and the results presented in table 7. Estimates of $S_{max}$ can be a useful frame of reference for comparison with collection data, either single or multiple samples. Species catch based on limited collection data ($S$) rarely approaches $S_{\text{max}}$, but the proportion of $S$ to $S_{max}$ can be used in a qualitative way to assess the biological integrity of a site relative to species diversity only, with little consideration of ecological function. A plot of $S / S_{max}$ ratio versus watershed area (fig. 2) revealed a relationship between these two variables. In smaller streams it is much easier to collect most, if not all, of the species occupying the stream in a single sample. Species catch in larger streams, on the other hand, rarely approaches $S_{\text{max}}$ ; in fact, it will be significantly below this number. In figure 2 a line was fitted by hand to those sites in the main channel that had high species diversity (sites 1, 2, 8, 9, and 11), were considered to have good biological condition, and that represented the maximum $S / S_{max}$ ratio to be expected in the main channel of the Cahaba. Sites falling below this line were interpreted to be under-saturated with species. Sites 7 and 10 were considered substantially under-saturated while sites 3, 4, 5, and 6 were considered moderately under-saturated relative to

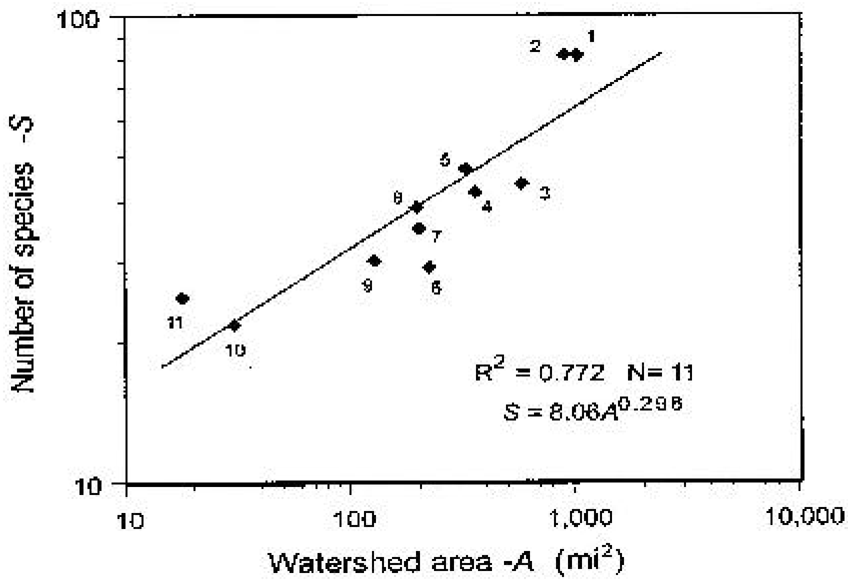



Figure 1. Species-area relationship for the upper Cahaba River.

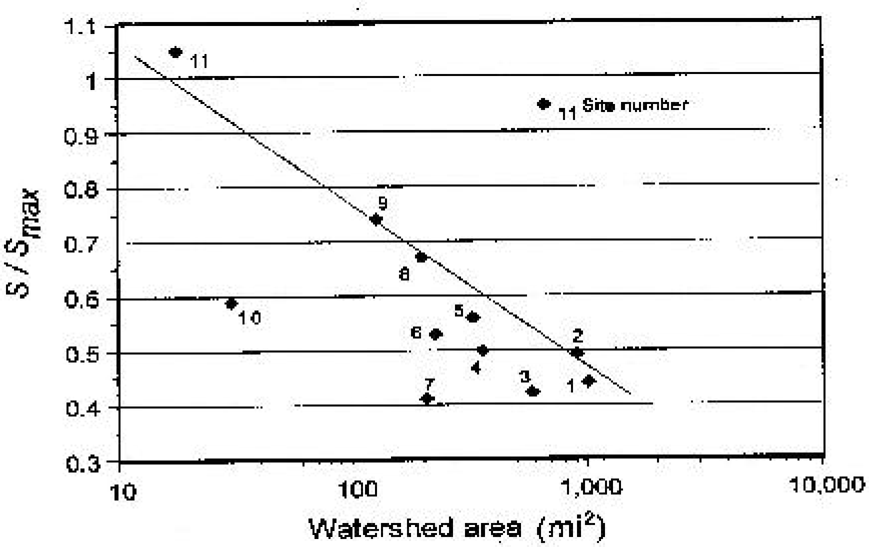



Figure 2. Relationship between the $S/S_{max}$ ratio and watershed area for sites in the upper Cahaba River.

species diversity. Results of this approach for discriminating sites with poor species diversity correspond with known habitat and(or) water quality degradation in the system (Shepard and others, 1997).

It is important to note that species diversity should not be used as the only indicator of biological integrity while conducting biological assessments. Species diversity is related to biological integrity, but diversity numbers alone can sometimes be misleading when interpreted out of context, and other components of biological integrity should always be considered together with species diversity.

Another useful parameter for analyzing collection data is catch, or yield per unit of sampling effort. Samples collected during this study allowed catch to be calculated in two ways: catch per unit time (hour) and catch per unit area (1,000 $ft^2$) (fig. 3). Catch rates are highly specific to sampling technique, sampling gear, and the effectiveness of the field crew in making the collection. Using the GSA sampling technique, “normal” catch rates generally fall in the range of 250 to 350 individuals per hour. Rates below this may indicate fish populations with less-than-normal productivity, as is the case at sites 6, 7, and 9, while rates over this range may indicate over productivity, as observed at sites 5, 8, 10, and 11. Catch rates per unit area appeard to confirm this observation with sites 6, 7, and 9 producing fewer fish while sites 8 and 11 appeared over productive.

The two measures of catch were combined into a single catch index (*CI*) calculated as follows:

$$CI = N \cdot (1{,}000 \text{ ft}^2 / a) \cdot (60 \text{ minutes / hr}) \cdot (1 / t)$$

$$CI = (N \cdot 60{,}000) / (a \cdot t)$$

$$CI = 60{,}000N / at$$

where $N$ is the total number of individuals collected in the sample, $a$ is the total area sampled in square feet, and $t$ is sample time measured in minutes. The factor 60,000 is for converting to a standard basis of 1,000 $ft^2$ and a unit time of one hour. The dimensions of this index are,

$$\text{catch (numbers of individuals)} / 1{,}000 \text{ ft}^2 \cdot \text{hr}$$

When *CI* was plotted against watershed area (fig. 3), a useful relationship resulted for discriminating sites with a low catch rate.

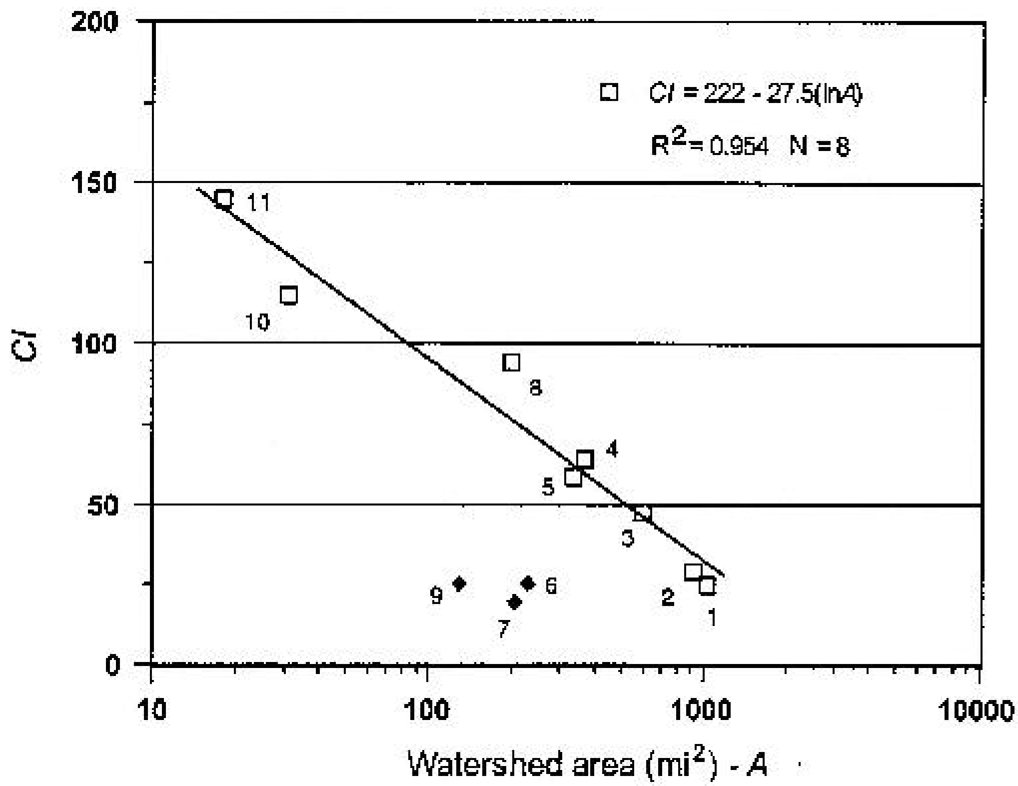



Figure 3. Relationship between the catch index (*CI*) and watershed area for sites in the upper Cahaba River.

## INDEX OF BIOTIC INTEGRITY

IBI calculations (table 8) indicate good biotic condition at sites 1 (Centreville), 2 (River Bend), 8 (Caldwell Mill), 9 (Grants Mill), 11 (Interstate 59), and 12 (Little Cahaba); fair condition at sites 3 (Piper), 4 (Boothton), 5 (Helena) and 6 (Bains Bridge); and poor condition at sites 7 (Altadena) and 10 (Camp Coleman). These results compare favorably with IBI data presented in Shepard and others (1997). Although IBI scores for this study were generally higher than scores reported in that study due to a more intensive sampling effort in 2002, a similar pattern of IBI variation in the Cahaba main channel was apparent for both studies -- fair to good scores at sites 1 and 2, poor to fair scores at sites 3 through 7, fair to good scores at sites 8 and 9, poor to fair scores at site 10, and fair to good scores at site 11. Site 12 (Little Cahaba River) had good scores for both studies.

## SITE DESCRIPTIONS

### SITE 1 - CAHABA RIVER AT CENTREVILLE

Site 1 was sampled at the new Alternate U.S. Hwy. 82 bridge approximately 1 mile upstream of the old U.S. Hwy. 82 bridge in Centreville. The area sampled was a large riffle-run complex about 200 feet wide immediately upstream of the bridge. Substrate in the riffles was predominatly cobble, large gravel, and boulders while the runs were cobble, gravel, and some sand in lower velocity runs. Extensive beds of *Justicia* covered most of the shoal area. Pools near the shoreline had a sand and gravel substrate often mixed with debris snags and occasional boulders. Sampling time for the wading effort was 250 minutes, 70 efforts were made, and 12,430 $ft^2$ of stream was sampled (table 5). The electroboat sample was taken downstream of the old U.S. Hwy. 82 bridge approximately 500 feet. Five efforts were made with the electroboat before species were depleted. Twenty-eight species were collected during the wade samples and 13 additional species were collected with the electroboat for a total of 41 species at this site. More species were collected during the wading effort compared to a 1994 sample and a series of samples collected in1989-90 (table 6). A wade sample from the early 1980s yielded only 16 species.

The largescale stoneroller, *Campostoma oligolepis*, was the most common species at 27.5 percent followed by the blacktail shiner, *Cyprinella venusta*, at 17.9 percent, the *Alabama shiner*

Table 8. IBI scores for 12 sites in the Cahaba River system, 2002.

| | IBI metric | 1-Centreville | | 2-River Bend | | 3-Piper | | 4-Boothton | | 5-Helena | | 6-Bains Bridge | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | value | score | value | score | value | score | value | score | value | score | value | score |
| 1 | Total native species | 28 | 5 | 30 | 5 | 22 | 3 | 23 | 5 | 25 | 5 | 21 | 5 |
| 2 | Total darter species | 6 | 5 | 6 | 5 | 5 | 3 | 6 | 5 | 6 | 5 | 6 | 5 |
| 3 | Total minnow species | 11 | 5 | 11 | 5 | 7 | 3 | 6 | 3 | 6 | 3 | 5 | 3 |
| 4 | Total sunfish species | 3 | 3 | 4 | 3 | 2 | 3 | 4 | 3 | 4 | 3 | 5 | 5 |
| 5 | Total sucker species | 4 | 3 | 4 | 3 | 2 | 3 | 2 | 3 | 3 | 3 | 3 | 5 |
| 6 | Intolerant species | 4 | 5 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| 7 | Percent sunfish | 2.5 | 5 | 4 | 5 | 0.8 | 5 | 4.7 | 5 | 2.6 | 5 | 48.1 | 1 |
| 8 | Percent omnivores and herbivores | 29.2 | 1 | 13.9 | 3 | 24.1 | 1 | 5.4 | 3 | 20.4 | 1 | 3 | 5 |
| 9 | Percent insectivorous cyprinids | 37.5 | 3 | 61.6 | 5 | 53.7 | 5 | 54.5 | 5 | 41 | 3 | 22.2 | 3 |
| 10 | Percent top carnivores | 2.1 | 5 | 2.8 | 5 | 3.1 | 5 | 1.6 | 3 | 1 | 3 | 1.7 | 3 |
| 11 | Catch per hour | 309 | 3 | 314 | 3 | 315 | 3 | 366 | 3 | 541 | 3 | 157 | 3 |
| 12 | Percent anomalies | 0 | 5 | 0 | 5 | 0 | 5 | 0 | 5 | 0 | 5 | 0 | 5 |
| IBI score | | – | 48 | – | 50 | – | 42 | – | 46 | – | 42 | -- | 46 |
| Biological condition | | good | | good | | fair | | fair | | fair | | fair | |

Table 8. IBI scores for 12 sites in the Cahaba River system, 2002 – Continued

| | IBI metric | 7-Altadena | | 8-Caldwell Mill | | 9-Grants Mill | | 10-Camp Coleman | | 11-Interstate 59 | | 12- Little Cahaba | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | value | score | value | score | value | score | value | score | value | score | value | score |
| 1 | Total native species | 16 | 3 | 25 | 5 | 25 | 5 | 13 | 3 | 20 | 5 | 30 | 5 |
| 2 | Total darter species | 1 | 1 | 6 | 5 | 5 | 5 | 1 | 1 | 4 | 5 | 7 | 5 |
| 3 | Total minnow species | 2 | 1 | 6 | 3 | 6 | 3 | 5 | 3 | 6 | 3 | 9 | 5 |
| 4 | Total sunfish species | 5 | 5 | 7 | 5 | 5 | 5 | 3 | 3 | 4 | 5 | 4 | 5 |
| 5 | Total sucker species | 4 | 5 | 3 | 5 | 3 | 5 | 2 | 3 | 3 | 5 | 3 | 5 |
| 6 | Intolerant species | 0 | 1 | 2 | 3 | 1 | 3 | 0 | 1 | 2 | 3 | 4 | 5 |
| 7 | Percent sunfish | 59.9 | 1 | 21.6 | 3 | 15.4 | 3 | 3.8 | 5 | 18.8 | 3 | 6 | 5 |
| 8 | Percent omnivores and herbivores | 0 | 5 | 13.8 | 3 | 5.6 | 3 | 60.8 | 1 | 26.4 | 1 | 17.9 | 3 |
| 9 | Percent insectivorous cyprinids | 19.5 | 1 | 37.7 | 3 | 48.8 | 5 | 20.3 | 3 | 30.5 | 3 | 44 | 3 |
| 10 | Percent top carnivores | 2.7 | 5 | 4.6 | 5 | 2.5 | 5 | 1.2 | 3 | 3.6 | 5 | 2.9 | 5 |
| 11 | Catch per hour | 188 | 3 | 443 | 3 | 225 | 3 | 542 | 5 | 551 | 5 | 348 | 3 |
| 12 | Percent anomalies | 0 | 5 | 0 | 5 | 0 | 5 | 0 | 5 | 0 | 5 | 0 | 5 |
| IBI score | | – | 36 | – | 48 | – | 50 | – | 36 | – | 48 | -- | 54 |
| Biological condition | | poor | | good | | good | | poor | | good | | good | |

at 7.7 percent, the banded sculpin, *Cottus carolinae*, at 6.9 percent, and the rock darter, *Etheostoma rupestre*, at 6.5 percent. Two individuals of the endangered Cahaba shiner, *Notropis cahabae*, and 17 individuals of the threatened goldline darter, *Percina aurolineata*, were found at this site. Several goldline darters were young-of-year indicating a successful spawn in the spring. Two species considered intolerant, the shadow bass, *Ambloplites ariommus*, and the greenbreast darter, *Etheostoma jordani*, were also found.

The IBI score (48) resulted in a good ranking relative to overall biological condition (table 8). Percent omnivores and herbivores was high, and scored low, indicating that productivity may be an issue at this site. Sunfish and sucker diversity were average along with percent insectivorous cyprinids and catch per hour, while all other metrics scored 5.

## SITE 2 - CAHABA RIVER AT RIVER BEND

Site 2 was sampled at a large shoal just downstream of the Bibb Co. Hwy. 26 bridge. Pools were a more common feature at this site and substrate was generally a mixture of sand and silt with some gravel. Riffles had a cobble and gravel substrate while runs had cobble, gravel, and sand. Sampling time for the wading effort was 240 minutes, 57 efforts were made, and 10,760 $ft^2$ of stream was sampled (table 5). An electroboat sample was not collected at this site because of difficult boat launching access. Thirty species were collected in 2002 compared to 25 species in 1994 and 24 species from a wade sample in the early 1980s (table 6).

The most common species at site 2 was the blacktail shiner at 21.4 percent, followed by the silverstripe shiner, *Notropis stilbius*, at 16.8 percent, the largescale stoneroller at 10.8 percent, the clear chub, *Hybopsis winchelli*, at 7.3 percent, and the rock darter at 7.2 percent. Eight individuals of the goldline darter were found while the Cahaba shiner was not collected at this site, and two intolerant species, the shadow bass and greenbreast darter, were collected. The IBI score (50) ranked as good biological condition and was the highest IBI score of all main channel sites sampled. All metrics scored either average (3) or exceptional (5).

## SITE 3 - CAHABA RIVER AT PIPER

The Piper site was sampled approximately 1 mile downstream of the Bibb Co. Hwy. 24 bridge. Both a wading sample and electroboat sample were made at this site. The wading effort was made in a large shoal dominated by bedrock outcrops. Cracked and eroded bedrock created runs throughout the shoal, whereas cobble and rubble riffles were found along both shorelines and at the foot of the shoal. Cahaba Lilies were very common throughout the sampled area. Time for the wading effort was 135 minutes, 42 efforts were made, and 6,540 $ft^2$ of stream was sampled (table 5). Just upstream of the shoal area was a long pool in which the electroboat sample was made. Six efforts were required in the pool to deplete species. Twenty-two species were collected during the wading effort and 18 during the electroboat effort for a total of 32 species at this site. Sixteen species were collected in 1994 and two wade samples made in the early 1980s yielded 17 and 27 species (table 6).

The silverstripe shiner was the most common species at 23.7 percent followed by the largescale stoneroller at 23.3 percent, the Alabama shiner at 20 percent, the rock darter at 8.3 percent, and the blacktail shiner at 7.2 percent. Eight individuals of the goldline darter were found in the riffle area on the left shoreline and the greenbreast darter was collected at this site. The IBI score (42) ranked this site as only fair biological condition. Percent omnivores and herbivores was high scoring this metric low while all of the diversity metrics scored only average.  Species diversity at site 3 was lower than expected resulting, in part, in a lower IBI score. The Piper site is also in a zone of enhanced attached and planktonic algae growth and the habitat differences between it and sites 1 and 2 are very distinct.

## SITE 4 - CAHABA RIVER AT BOOTHTON

The Boothton site is located where a concrete slab was constructed years ago over the river for hauling coal. The wading effort was made downstream of the slab in a run-riffle shoal complex. Runs were the dominant habitat feature and were either cobble, bedrock, or a bedrock-cobble mix. Riffles, when found, were typically cobble and rubble mixed with some gravel and sand. A few pools were found near the shoal head with sand-covered bedrock and some small rubble. Time for the wading effort was 130 minutes, 47 efforts were made, and 5,680 $ft^2$ of stream was sampled (table 5). The electroboat sample was made upstream of the slab and only three efforts were completed before sampling had to be stopped due to the presence of swimmers in the sample area. Twenty-three species were collected during the wading effort and nine species during the electroboat effort for a total of 25 species. Sixteen species were collected during a wade sample in 1994 (table 6).

The silverstripe shiner was the most abundant species collected at 38.5 percent followed by the rock darter at 20.1 percent, the Alabama shiner at 8.3 percent, the riffle minnow, *Phenacobius catostomus*, at 6.2 percent, and the largescale stoneroller at 5.4 percent. Two intolerant species were found at the Boothton site, the greenbreast darter and the coal darter, *Percina brevicauda*. The IBI score (46) ranked this site as fair biological condition. All metrics scored either average or exceptional and the reason for the fair score was the average scores for minnow, sunfish, and sucker diversity, and average scores for catch and top carnivore abundance. Interestingly, the percent omnivore and herbivore metric was low at 5.4 percent, scoring this metric in the average range.

SITE 5 - CAHABA RIVER AT HELENA

Site 5 was located just downstream of the Shelby Co. Hwy. 52 bridge about 300 feet in a large riffle-run shoal complex. Riffles and runs were about equally proportioned throughout the shoal with riffles of bedrock and cobble while runs had a substrate of gravel, cobble, and rubble. *Justicia* beds were common over the exposed shoal areas. Several pool efforts were also made downstream of the shoal and the pools had a substrate of sand mixed with silt and occasional detritus. Time for the wading effort was 110 minutes, 69 efforts were made, and 9,200 $ft^2$ of stream was sampled (table 5). Twenty-five species were collected in 2002 compared to 21 species in 1995, 8-14 species in 1992-93, 14-17 species in 1989-90, and 14 species in the early 1980s (table 6).

Three species were common at this site: the silverstripe shiner at 35.7 percent, the rock darter at 24.8 percent, and the largescale stoneroller at 20.2 percent, followed by fewer numbers of the blackbanded darter at 3.9 percent and the Alabama shiner at 3.2 percent. Three intolerant species were found: the shadow bass, greenbreast darter, and coal darter. Biological condition was only fair at this site with a score of 42 (table 8). Total species and darter species scored exceptional while the other diversity metrics scored only average. Total omnivores and herbivores was high resulting in a poor score for this metric while catch scored average.

SITE 6 - CAHABA RIVER AT BAINS BRIDGE

This site was sampled about 300 feet upstream and about 500 feet downstream of the bridge. The only riffle area was under the bridge and it had a substrate of limestone rip rap, sand, and gravel. Site 6 was predominantly bedrock and sand pools upstream with sand pools and gravel-sand runs downstream. Banks were heavily eroded but extensive trees and tree limb cover were present along both shorelines. Sampling time was 90 minutes, 38 efforts were made, and 6,200 $ft^2$ of stream was sampled (table 5). Twenty-one species were collected in 2002 compared to 14 species in 1994, 8 to 12 species in 1992-93, and 17 species in one wade collection from the early 1980s (table 6). Catch per hour (157) was the lowest, while catch per 1,000 $ft^2$ (38) was among the lowest of all main channel sites sampled.

Habitat at this site was very productive of sunfishes with the longear sunfish, *Lepomis megalotis*, most common at 31.5 percent followed by the silverstripe shiner at 16.2 percent, the bluegill at 14.9 percent, the blackbanded darter at 6.4 percent, and the golden redhorse at 5.5 percent. Two species considered intolerant were found: the shadow bass and the coal darter. The IBI score (46) ranked this site as fair biological condition. All diversity metrics scored 5 with the exception of minnow species which was average. Percent sunfish was high at 48.1 resulting in a poor score for this metric, while percent omnivores and herbivores was low at 3 percent resulting in an exceptional score for this metric.

## SITE 7 - CAHABA RIVER NEAR ALTADENA

Site 7 was located adjacent to a commercial sod farm just over 2 miles downstream of site 8, Caldwell Mill. Habitat was substantially impaired by bedload deposits of sand and silt mixed with some gravel and detritus. Riffle zones were present but they were covered with bedload material. The sampled reach was basically a long pool with varying depths. Banks were eroded and, like the Bains Bridge site, shorelines had extensive tree snags and limbs as instream cover. Sampling time was 95 minutes, 22 efforts were completed, and 9,665 $ft^2$ of stream was sampled (table 5). Sixteen species were collected at this site in 2002 with only seven taken in 1994. Species diversity of four wade samples made in 1992-93 ranged from 1 to 17 species (table 6).

The sunfish family was the most commonly found group at this site, with the longear sunfish most common at 30 percent, followed by the bluegill at 27 percent, the blacktail shiner at 17.9 percent, the blackspotted topminnow, *Fundulus olivaceus*, at 7.1 percent, and the golden redhorse at 3.0 percent. No species considered intolerant were collected at this site. The pooled nature of habitat and structurally complex shorelines at this site were ideal for supporting sunfish and topminnows. The IBI score was low at 36 ranking this site as poor in biological condition. Species diversity metric scores for sunfish and suckers were exceptional while the other diversity scores were average or low. The high percentage of sunfish resulted in a poor score for this metric while the absence of omnivores and herbivores resulted in an exceptional score for this metric.

## SITE 8 - CAHABA RIVER AT CALDWELL MILL

Site 8 was located between the Shelby Co. Hwy. 29 bridge and an old mill dam approximately 500 feet upstream. Habitat at this site was excellent with bedrock and rubble pools, gravel and cobble riffles, and gravel runs with *Justicia* beds along the margins. Sampling time for this site was 110 minutes, 25 sampling efforts were completed, and 4,680 $ft^2$ of stream was sampled (table 5). Twenty-six species were collected in 2002 compared to 22 species in 1994, 18 and 19 species during two samples in 1992-93, and 25 species during one wade collection in the early 1980s (table 6). Catch per hour was among the highest at 443 while catch per 1,000 $ft^2$ was the highest of all main channel sites at 174.

The Alabama shiner was the most common species collected at 26.1 percent followed by the largescale stoneroller at 13.7 percent, the rock darter and the bluegill at 11.6 percent each, and the blacktail shiner and longear sunfish at 9.1 percent each. Three species considered intolerant were collected at Caldwell Mill: the shadow bass, greenbreast darter, and Alabama darter, *Etheostoma ramseyi*. The IBI score (48) indicated good biological conditions. All diversity metrics scored 5 with the exception of minnow species which scored 3. Percent sunfish, percent omnivores and herbivores, percent insectivorous cyprinids, and catch all scored 3. The Caldwell Mill site is an exception to typical biological conditions in this middle reach of the Cahaba. The small mill dam acts as an upstream sediment trap holding bedload material. As such, the habitat structure and quality downstream is good to excellent. Additionally, the dam is an upstream barrier to fish migrations resulting in a region where fishes concentrate throughout the year. This is observed in the high catch rates, higher species diversity compared to nearby downstream sites, occurrence of unusual species like grass carp, and the high occurrence of predators (three *Micropterus* bass species) utilizing the high density of forage.

## SITE 9 - CAHABA RIVER AT GRANTS MILL

The stream reach sampled at Grants Mill extended from the Jefferson Co. Hwy. 143 bridge upstream for 600 feet. The downstream half of the sampled reach was a riffle-run area while a pool-run area was located in the upstream half. Habitat quality at this site was good to excellent with a complex riffle-run-pool structure throughout the downstream sampled reach. Riffles varied from deep, swift areas of boulders to shallow, cobble and bedrock areas. Runs were also found in the deeper parts of the stream with bedrock and boulder substrate. Shallow runs generally consisted of bedrock covered with varying amounts of sand, gravel, and cobble. Pool substrate consisted of a thin sand layer over bedrock, or sand mixed with gravel and(or) detritus. Time of sampling was 95 minutes, 40 efforts were completed, and 9,010 $ft^2$ of stream was sampled (table 5). Twenty-five species were collected at this site in 2002 compared to 15 species in 1994, and 15 to 22 species collected in two wade samples taken in the early 1980s (table 6). Catch rate per hour was comparatively low at 225 while catch per 1,000 $ft^2$ was very low at 40, similar to sites 6 and 7 downstream.

Species with the highest abundance at Grants Mill were the Alabama shiner at 23.5 percent, the silverstripe shiner at 17.9 percent, the longear sunfish at 11.5 percent, the blackbanded darter at 6.4 percent, and the blacktail shiner at 6.2 percent. Only one intolerant species was collected at this site, the greenbreast darter. The IBI score was high at 50 ranking this site in the good biological condition range. All species diversity metrics scored 5 except for one, minnow diversity, which scored 3. Percent sunfish, omnivores and herbivores, and catch were all average, while percent insectivorous cyprinids and top carnivores both scored 5. The low catch rate at this site may be an early indication that biological conditions are changing in response to deteriorating water-quality conditions upstream of the site.

## SITE 10 - CAHABA RIVER AT CAMP COLEMAN

The Camp Coleman site was sampled from the Little Cahaba Creek mouth to about 400 feet upstream. Habitat was limited to bedrock covered with a sediment-algae layer of varying thickness. Shorelines had root mats, heavy riparian cover in places, and some dead trees. The entire sampled reach was essentially a long bedrock run, but a few riffle areas were found. Sampling time at this site was 55 minutes, 23 efforts were completed, and 4,680 $ft^2$ of stream was sampled (table 5). Only 13 species were collected in 2002 compared to 11 in 1994, and from 9 to 13 species in five samples made in 1992-93 (table 6). Catch rate per hour (542) was among the highest of all main channel sites, while catch per 1,000 $ft^2$ was also high at 106.

Five species accounted for over 90 percent of the catch at Camp Coleman: the largescale stoneroller at 60.8 percent, silverstripe shiner at 11.5 percent, Alabama hogsucker at 10.1 percent, Alabama shiner at 5.2 percent, and blacktail shiner at 3.2 percent. No intolerant species were found at this site. The IBI scored a 36, in the poor biological condition range. Poor to average species diversity scores, a low score for percent omnivores and herbivores, and low numbers of insectivorous cyprinids contribute to the poor biological condition. This site is downstream of the Trussville wastewater plant and the community of Trussville.

## SITE 11 - CAHABA RIVER AT INTERSTATE HWY. 59

The most upstream site sampled on the Cahaba River main channel had good habitat quality with a predominantly cobble and gravel substrate throughout. Water at this site was very clear due to spring flows in the area. The channel was narrow, up to 25 feet wide in places, with depths varying from a few inches up to 2.5 feet in some pools below riffles. Distinct riffles and runs were formed throughout the sampled reach connected by shallow, gravel-cobble pools. Sampling time was 70 minutes, 21 efforts were completed, and 3,800 $ft^2$ of stream was sampled (table 5). Twenty species were collected in 2002 compared to 12 species in 1994, 11 to 15 species in 1992-93, and 15 species in one wade sample in the early 1980s. Catch rate per hour was the highest of all sites at 551 while catch rate per 1,000 $ft^2$ was near the highest at 169, just slightly less than the Caldwell Mill site.

The most common species was the largescale stoneroller at 26.4 percent, followed by the silverstripe shiner at 13.1 percent, the rainbow shiner, *Notropis chrosomus*, at 10.4 percent, the longear sunfish at 9.3

percent, and the Alabama hogsucker at 7.9 percent. Two intolerant species were found at this site, the rainbow shiner and the Alabama darter. The rainbow shiner is generally only found in abundance in clear streams with good water quality. The IBI score was 48, ranking this site in the good biological condition range. High diversity metric scores, high catch rates, and high carnivore percentages contribute to the good score at this site. Percent omnivores and herbivores was high at this site resulting in a low score for this metric.

## SITE 12 - LITTLE CAHABA RIVER

The wading sample reach for this site extended downstream of the Bibb Co. Hwy. 65 bridge for approximately 200 feet and upstream of the bridge for 500 feet. A large island split the stream channel into two long riffle-run complexes. Riffles in the left channel were deeper with cobble, bedrock, and gravel substrate while riffles in the right channel were shallower of cobble, rubble, sand, and gravel. Pools were found at the upstream end of the island and intermittently through the right channel. The Little Cahaba site was sampled for 125 minutes, 36 efforts were completed, and 5,440 $ft^2$ of stream was sampled (table 5). The electrofishing boat-sampled reach extended from just upstream of the island to about 600 feet upstream. Five efforts were completed before species catch was depleted. Thirty species were collected in the wade sample and 14 species in the electroboat sample for a site total of 35 species. The wade sample total is compared to 24 species collected in 1994, 16 to 22 species in 1992-93, and 10 to 22 species in 1989-90 (table 6). Total species diversity was second only to the Centreville site and wading sample species diversity (30) equalled that for site 2, River Bend.

The silverstripe shiner was most commonly found at 19.2 percent followed by the largescale stoneroller at 17.8 percent, the tricolor shiner, *Cyprinella trichroistia*, at 11.0 percent, the Alabama hogsucker at 6.5 percent, and the Alabama darter at 5.5 percent. Two individuals of the goldline darter were collected at this site along with three species considered intolerant: the shadow bass, the greenbreast darter, and the Alabama darter. The IBI score (54) was in the good biological condition range and was the highest of all sites sampled. All metrics scored 5 except the metrics percent omnivores and herbivores, percent insectivorous cyprinids, and catch which scored 3. The Little Cahaba River site historically has had a diverse fish fauna and this collection confirms that its biological status is still good to excellent.

## SUMMARY

Shepard and others (1997) presented a model for biological condition in the Cahaba River main channel and related observed biological patterns and processes to pollution mechanisms operating in the river at that time. Data collected during the current investigation of fish communities confirms many of their conclusions relative to causes of biological variation in the Cahaba and also sheds additional light on patterns of fish species diversity, population variation, and the overall status of fishes in the Cahaba River main channel.

Species diversity at the sampled sites was greater than expected compared to information developed in past investigations. Intensive sampling techniques no doubt played a role in the greater diversity and catch observed during this study.

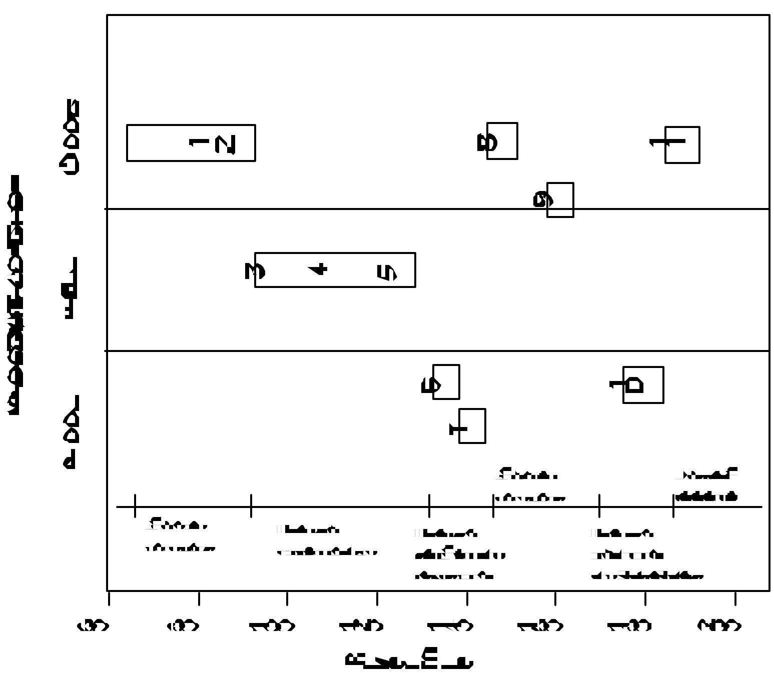
A summary of study results is presented in table 9 and figure 4 based on the three community metrics of species diversity, catch, and biological condition. Several sites in the main channel Cahaba River meet expectations relative to diversity, catch, and biological condition (sites 1, 2, 8, 11, 12). Other sites were good relative to catch but only fair relative to species diversity and biological condition (sites 3, 4, 5). We interpret these results as biological effects due to nutrient loading upstream in the watershed and from major tributaries such as Buck Creek. Nutrients in this reach of the Cahaba originate from multiple sources including wastewater treatment plants, nonpoint runoff from urban areas, and possibly nitrogen deposition originating from the high density of automobiles in the immediate airshed. Two sites (6 and 7) were poor relative to both species diversity and catch, and poor (site 7) to fair (site 6) in biological condition. We interpret these results as biological effects of sediment bedload and perhaps runoff of toxics and other associated nonpoint sources. Site 8 had good biological and habitat quality and is an example of the potential that this reach of the Cahaba River has for recovery if sedimentation and other nonpoint pollution sources were better understood and managed. Site 9 was good relative to diversity and biological condition but poor in catch. This may be an early indicator that this reach of the Cahaba is in decline. Site 10 was poor in both diversity and biological condition but good in catch. Biological conditions in this reach were interpreted as affected by a combination of pollutants from both discharged wastewaters and urban runoff from the community of Trussville. Site 11 represents the upstream reference condition and is a model for what the reach downstream of Trussville could become if pollution sources in and around Trussville were more intensively managed.

Table 9. Summary of fish community metrics for sites in the Cahaba River system, 2002.

| Station | | Community metric[1] | | |
|---|---|---|---|---|
| | | Species diversity | Catch | Biological condition |
| 1 | Cahaba River-Centreville | G | G | G |
| 2 | Cahaba River-Riverbend | G | G | G |
| 3 | Cahaba River-Piper | F | G | F |
| 4 | Cahaba River-Boothton | F | G | F |
| 5 | Cahaba River-Helena | F | G | F |
| 6 | Cahaba River-Bains Bridge | P | P | F |
| 7 | Cahaba River- near Altadena | P | P | P |
| 8 | Cahaba River-Caldwell Mill Road | G | G | G |
| 9 | Cahaba River-Grants Mill Road | G | P | G |
| 10 | Cahaba River-Camp Coleman | P | G | P |
| 11 | Cahaba River-I 59 | G | G | G |
| 12 | Little Cahaba River | G | G | G |

[1] G-good; F-fair; P-poor

Figure 4. Conceptual model of biological condition in the upper Cahaba River main channel.



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Appendix

Collection data for samples in the Cahaba River, 2002

| Species | Wading samples | | | | | | | | | | | | Boat electrofishing samples | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 3 | 4 | 12 |
| | Centreville | River Bend | Piper | Boothton | Helena | Bains Bridge | Altadena | Caldwell Mill | Grants Mill | Camp Coleman | I-59 | Little Cahaba | Centreville | Piper | Boothton | Little Cahaba |
| LEPISOSTEIDAE (gars) | | | | | | | | | | | | | | | | |
| *Lepisosteus oculatus* | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | – | -- | 1 | -- | -- | -- |
| *L. osseus* | 1 | 1 | 2 | 1 | 2 | -- | -- | -- | 1 | -- | -- | -- | -- | 3 | -- | -- |
| CLUPEIDAE (herrings and shads) | | | | | | | | | | | | | | | | |
| *Dorosoma cepedianum* | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | – | 1 | 47 | 15 | -- | 42 |
| CYPRINIDAE (minnows and carps) | | | | | | | | | | | | | | | | |
| *Campostoma oligolepis* | 354 | 135 | 165 | 43 | 200 | 7 | -- | 111 | 20 | 302 | 170 | 129 | 2 | -- | -- | -- |
| *Ctenopharyngodon idella* | -- | -- | -- | -- | -- | -- | -- | 1 | -- | -- | -- | -- | -- | -- | -- | -- |
| *Cyprinella callistia* | 99 | 68 | 142 | 66 | 32 | 8 | -- | 212 | 84 | 26 | 20 | -- | -- | -- | -- | -- |
| *C. trichroistia* | -- | -- | 1 | -- | -- | | -- | -- | -- | 2 | 24 | 80 | -- | -- | -- | -- |
| *C. venusta* | 230 | 268 | 51 | 7 | 3 | 4 | 53 | 74 | 22 | 16 | 1 | 25 | 15 | 29 | -- | -- |
| *Hybopsis winchelli* | 3 | 91 | -- | -- | -- | -- | -- | – | 2 | -- | – | 7 | -- | -- | -- | -- |
| *Lythrurus bellus* | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 10 | -- | -- | -- | -- |
| *Macrhybopsis aestivalis* | -- | 26 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| *Notropis ammophilus* | -- | -- | – | -- | -- | -- | -- | -- | -- | -- | -- | – | 1 | -- | -- | -- |
| *N. atherinoides* | 1 | -- | – | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| *N. cahabae* | 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| *N. chrosomus* | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 67 | -- | -- | -- | -- | -- |
| *N. stilbius* | 69 | 211 | 168 | 305 | 354 | 38 | 5 | 7 | 64 | 57 | 84 | 139 | -- | -- | -- | -- |
| *N. uranoscopus* | 45 | 72 | -- | – | -- | -- | – | -- | -- | -- | – | 24 | -- | -- | -- | -- |
| *N. volucellus* | 29 | 27 | 19 | 5 | 4 | -- | -- | -- | -- | -- | – | 14 | -- | -- | -- | -- |
| *Phenacobius catostomus* | 2 | 9 | – | 49 | 14 | 2 | – | 13 | 2 | -- | – | 20 | -- | -- | -- | -- |
| *Pimephales notatus* | – | 7 | – | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| *P. vigilax* | 22 | 32 | 6 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| CATOSTOMIDAE (suckers) | | | | | | | | | | | | | | | | |
| *Carpiodes cyprinus* | -- | -- | -- | -- | -- | – | -- | -- | -- | -- | -- | – | 1 | -- | -- | -- |
| *C. velifer* | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 22 | 3 | -- | 1 |
| *Hypentelium etowanum* | 46 | 9 | 6 | 16 | 21 | 3 | – | 34 | 21 | 50 | 51 | 47 | -- | -- | -- | -- |
| *Ictiobus bubalus* | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 2 | 5 | -- | -- |
| *Minytrema melanops* | -- | -- | -- | -- | -- | – | 1 | -- | -- | -- | -- | -- | -- | -- | -- | -- |

| Species | Wading samples | | | | | | | | | | | | Boat electrofishing samples | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 3 | 4 | 12 |
| | Centreville | River Bend | Piper | Boothton | Helena | Bains Bridge | Altadena | Caldwell Mill | Grants Mill | Camp Coleman | I-59 | Little Cahaba | Centreville | Piper | Boothton | Little Cahaba |
| *Moxostoma carinatum* | 2 | -- | -- | -- | -- | – | -- | -- | -- | -- | – | | 12 | 8 | | 3 |
| *M. duquesnei* | 29 | 18 | 5 | 13 | -- | – | 2 | 1 | – | -- | – | 6 | 1 | – | 5 | 16 |
| *M. erythrurum* | 39 | 22 | -- | – | 21 | 13 | 9 | – | 6 | 8 | 5 | 16 | -- | -- | -- | 18 |
| *M. poecilurum* | – | 1 | – | – | 3 | 7 | 11 | 6 | 1 | – | 1 | – | 17 | 1 | 5 | 6 |
| ICTALURIDAE (bullheads and catfishes) | | | | | | | | | | | | | | | | |
| *Ameiurus natalis* | -- | -- | -- | 2 | -- | -- | -- | -- | – | -- | 1 | -- | -- | -- | -- | – |
| *Ictalurus furcatus* | -- | -- | -- | -- | – | -- | -- | -- | – | -- | -- | -- | -- | – | -- | 1 |
| *I. punctatus* | -- | – | 2 | 5 | 2 | – | 1 | – | 12 | -- | – | 1 | 5 | 2 | 4 | 7 |
| *Noturus leptacanthus* | 6 | 4 | -- | -- | -- | -- | – | -- | -- | -- | -- | – | -- | -- | -- | -- |
| *Pylodictis olivaris* | -- | – | 17 | – | 1 | -- | -- | – | 4 | -- | -- | -- | – | 12 | 2 | -- |
| ATHERINIDAE (silversides) | | | | | | | | | | | | | | | | |
| *Labidesthes sicculus* | -- | -- | -- | -- | -- | – | -- | -- | -- | -- | – | -- | 1 | -- | -- | -- |
| POECILIIDAE (livebearers) | | | | | | | | | | | | | | | | |
| *Gambusia affinis* | -- | -- | -- | -- | 2 | -- | -- | -- | -- | – | -- | -- | -- | -- | – | -- |
| FUNDULIDAE (topminnows) | | | | | | | | | | | | | | | | |
| *Fundulus olivaceus* | – | 2 | 1 | – | – | 5 | 21 | 4 | 2 | -- | -- | 4 | -- | -- | -- | -- |
| COTTIDAE (sculpins) | | | | | | | | | | | | | | | | |
| *Cottus carolinae* | 89 | 18 | -- | -- | 1 | -- | -- | -- | -- | – | 40 | 5 | -- | -- | -- | -- |
| CENTRARCHIDAE (sunfishes) | | | | | | | | | | | | | | | | |
| *Ambloplites ariommus* | 1 | 1 | – | 5 | 2 | 1 | – | 2 | -- | -- | – | 3 | -- | – | 1 | -- |
| *Lepomis cyanellus* | -- | -- | -- | – | 1 | 1 | 4 | 2 | 1 | 1 | 29 | -- | -- | 1 | -- | -- |
| *L. gulosus* | -- | -- | -- | -- | – | -- | – | 1 | 1 | -- | -- | -- | -- | – | -- | -- |
| *L. macrochirus* | 2 | 8 | 1 | 4 | 6 | 35 | 80 | 94 | 8 | 4 | 31 | 3 | 8 | 2 | 3 | 1 |
| *L. megalotis* | 29 | 42 | 5 | 31 | 19 | 74 | 89 | 74 | 41 | 14 | 60 | 30 | 29 | 3 | 4 | -- |
| *L. microlophus* | – | 1 | -- | -- | – | 3 | 3 | 1 | -- | – | 1 | -- | – | 1 | -- | 1 |
| *L. miniatus* | -- | -- | – | 2 | -- | – | 2 | 4 | 4 | -- | -- | 11 | -- | -- | -- | -- |
| *Micropterus coosae* | -- | – | 3 | 1 | -- | – | 1 | 5 | 5 | 4 | 23 | 15 | – | 2 | -- | 1 |
| *M. punctulatus* | 24 | 33 | 17 | 6 | 6 | 3 | 7 | 32 | 3 | 2 | – | 3 | 14 | 5 | 1 | 2 |

| Species | Wading samples | | | | | | | | | | | | Boat electrofishing samples | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 3 | 4 | 12 |
| | Centreville | River Bend | Piper | Boothton | Helena | Bains Bridge | Altadena | Caldwell Mill | Grants Mill | Camp Coleman | I-59 | Little Cahaba | Centreville | Piper | Boothton | Little Cahaba |
| *M. salmoides* | -- | -- | -- | -- | – | -- | – | 1 | -- | -- | -- | – | 2 | 1 | -- | – |
| *Pomoxis nigromaculatus* | -- | -- | -- | -- | – | -- | -- | -- | -- | – | -- | -- | 2 | -- | -- | -- |
| PERCIDAE (darters) | | | | | | | | | | | | | | | | |
| *Etheostoma jordani* | 9 | 19 | 5 | 9 | 5 | -- | – | 1 | 18 | -- | -- | 33 | -- | -- | -- | -- |
| *E. ramseyi* | -- | -- | -- | -- | – | -- | – | 3 | -- | – | 9 | 40 | -- | -- | -- | -- |
| *E. rupestre* | 84 | 90 | 59 | 159 | 246 | 8 | – | 94 | 5 | -- | -- | 30 | -- | -- | -- | -- |
| *E. stigmaeum* | 6 | 2 | 1 | 3 | 3 | 3 | – | 1 | 1 | -- | -- | 1 | -- | -- | -- | -- |
| *E. whipplei* | -- | -- | -- | -- | – | 1 | – | -- | -- | -- | 6 | -- | -- | -- | -- | – |
| *Percina aurolineata* | 17 | 8 | 8 | -- | -- | -- | -- | – | -- | -- | -- | 2 | -- | -- | -- | -- |
| *P. brevicauda* | -- | -- | – | 4 | 1 | 2 | -- | -- | -- | -- | – | -- | -- | -- | -- | – |
| *P. kathae* | – | 3 | – | 17 | 3 | 2 | – | 7 | 6 | – | 5 | 1 | 2 | 1 | 1 | 1 |
| *P. nigrofasciata* | 47 | 27 | 25 | 39 | 39 | 15 | 8 | 27 | 23 | 11 | 15 | 22 | -- | -- | -- | -- |
| *P. shumardi* | 1 | -- | -- | -- | -- | – | -- | -- | -- | -- | – | -- | -- | -- | -- | – |
| SCIAENIDAE (drums) | | | | | | | | | | | | | | | | |
| *Aplodinotus grunniens* | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | – | 3 | 1 | 5 | – | 9 |

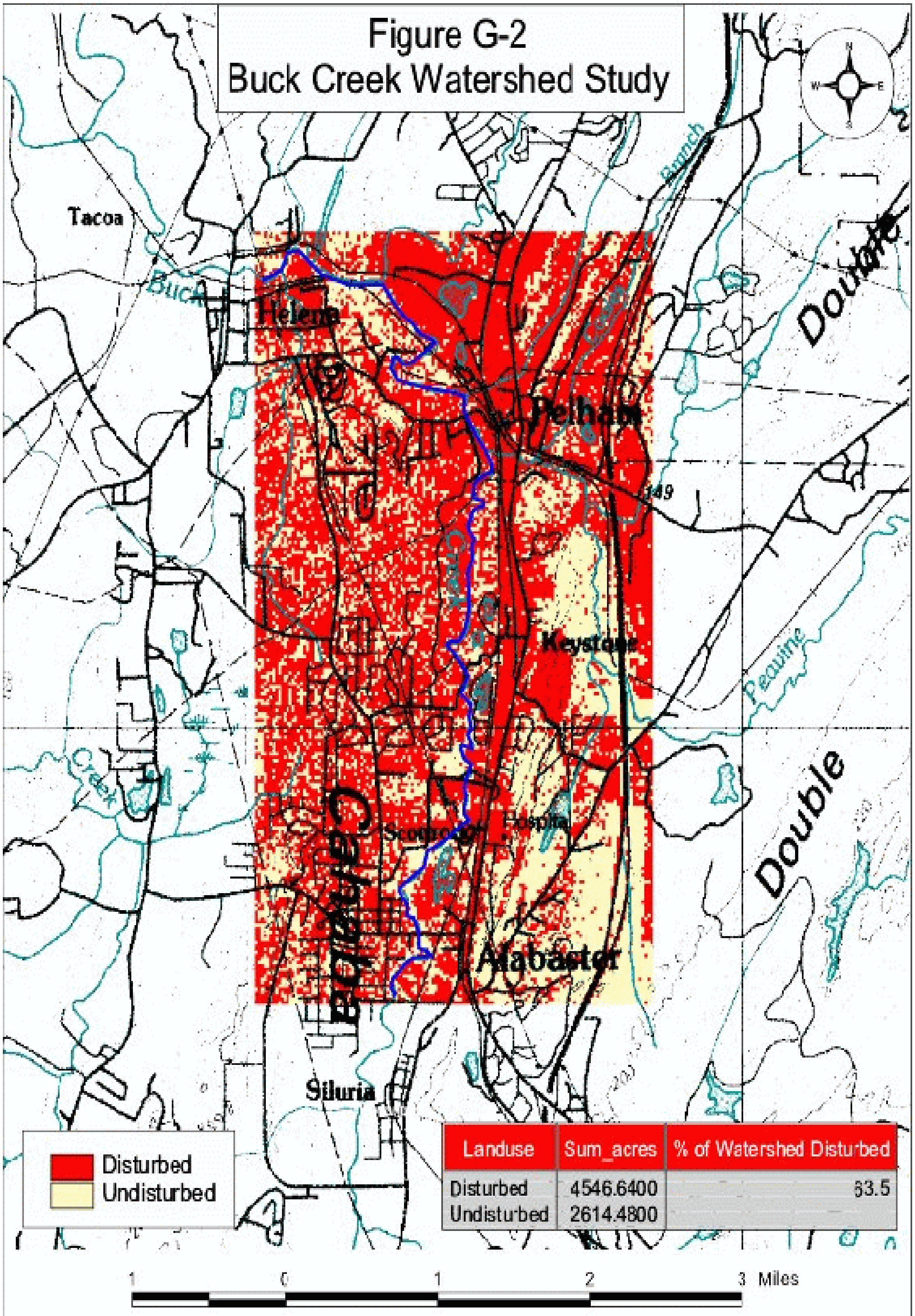
# APPENDIX G:

# GIS Land Use Analysis

Fig. G-1

"Cahaba River Watershed Study:
Disturbed vs. Undisturbed"

This figure portrays the land use changes in the watershed using GIS land change analysis for the years 1983, 1990, and 1998. GIS land change analysis focused on the "disturbed" land use class as opposed to the "undisturbed" land use class. The "disturbed" land use class includes residential, commercial, industrial, transportation, and bare ground. The "undisturbed" land use class is basically forested lands and grasslands. This figure is available in hard copy upon request; contact Hoke Howard at (706)355-8721 or email at howard.hoke@epa.gov




| Landuse | Sum_acres | % of Watershed Disturbed |
|---|---|---|
| Disturbed | 4546.6400 | 63.5 |
| Undisturbed | 2614.4800 | |

Disturbed = same data as 1998 (fig. G-1)

## APPENDIX H:

## NPDES Violations, Retrieval file, Majors in Cahaba Basin

```
                                                       MAJORS IN CAHABA BASIN
                                                             TOM MCGILL
QL
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*** QL

NPID      FNMS                           MADI RDF9   PERD     PERE     PYQS CYQS PYMS CYMS
--------- ----------------------------- ---- ------ -------- -------- ---- ---- ---- ----
   DSDG PIPQ PIAC PIDT     STRP     NRPU STSU     NSUN STSS     NSUS ILSD     ILED     MLSD     MLED     FLSD     FLED
   ---- ---- ---- -------- -------- ---- -------- ---- -------- ---- -------- -------- -------- -------- -------- --------
      LTYP PRAM                                  LQUC LQAV     LQMX     LCUC LCMN     LCAV     LCMX
      ---- -------------------------------------- ---- -------- -------- ---- -------- -------- --------
           PRAM  MLOC SEAN MODN                       LQAS     LQXS          LCMS     LCAS     LCXS
           ----- ---- ---- ----                       -------- --------      -------- -------- --------
                MVDT                             MVIO MQAV     MQMX     NODI MCMN     MCAV     MCMX     SNCE SNDE
SRCE
                --------                         ---- -------- -------- ---- -------- -------- -------- ---- --------
----

AL0003395 GOLD KIST POULTRY  TRUSSVILLE  M           12/20/01 12/31/06  ER

   001Q 2    A            10/01/94 3            0    01/28/95 3                                          09/01/94 08/31/99

      F    P/F STATRE 7DAY CHR CERIODAPHNIA                              9A   DELMON   0        DELMON
           TGP3B 1    0    0

                03/31/98                         E90                                  1
                06/30/98                         E90                                  1
                03/31/00                         E90                                  1
                12/31/00                         E90                                  1
                03/31/01                         E90                                  1

      F    P/F STATRE 7DAY CHR PIMEPHALES PROMELAS                       9A   DELMON   0        DELMON
           TGP6C 1    0    0

                03/31/98                         E90                                  1
                12/31/00                         E90                                  1

   001Q 9    A            10/01/94 3            0    01/28/95 3                                          01/01/02 12/31/06

      F    TOXICITY,           CERIODAPHNIA CHRONIC 9A   DELMON   0
           61426 1    0    0                                  SINGSAMP

                06/30/02                         E90           3
```

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0011 2 | A | | 09/01/89 1 | | 0 | 10/28/89 1 | | | | | | | | | 09/01/94 08/31/99 |
| F | BOD, 5-DAY | | | (20 DEG. C) | 26 | 270 | | 19 | | 20.0 | 30.0 | | | | |
| | 00310 1 | 0 | 0 | | | MO AVG | DAILY MX | | | MO AVG | DAILY MX | | | | |
| | | 12/31/00 | | | E90 | 170 | 851.7 | | | 27 | 96.6 | V | 03/31/01 2 | | |
| | | 01/31/01 | | | E90 | 380.6 | 1375.0 | | | 30.2 | 92.0 | T | 03/31/01 2 | | |
| | | 02/28/01 | | | E90 | 403.2 | 1107.1 | | | 32.95 | 90.3 | T | 03/31/01 2 | | |
| | | 10/31/01 | | | E90 | 154.3 | 506.1 | | | 11.9 | 37 | | | | |
| F | SOLIDS, TOTAL | | SUSPENDED | | | | | 19 | DELMON | 30.0 | 45.0 | | | | |
| | 00530 1 | 0 | 0 | | | | | | | MO AVG | DAILY MX | | | | |

MAJORS IN CAHABA BASIN
TOM MCGILL

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QL
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*** QL

NPID      FNMS                           MADI RDF9   PERD     PERE     PYQS CYQS PYMS CYMS
--------- ------------------------------ ---- ------ -------- -------- ---- ---- ---- ----
   DSDG PIPQ PIAC PIDT     STRP     NRPU STSU     NSUN STSS     NSUS ILSD     ILED     MLSD     MLED     FLSD     FLED
   ---- ---- ---- -------- -------- ---- -------- ---- -------- ---- -------- -------- -------- -------- -------- --------
      LTYP PRAM                                   LQUC LQAV     LQMX     LCUC LCMN     LCAV     LCMX
      ---- -------------------------------------- ---- -------- -------- ---- -------- -------- --------
           PRAM  MLOC SEAN MODN                        LQAS     LQXS          LCMS     LCAS     LCXS
           ----- ---- ---- ----                        -------- --------      -------- -------- --------
                MVDT                              MVIO MQAV     MQMX     NODI MCMN     MCAV     MCMX     SNCE SNDE
SRCE
                --------                          ---- -------- -------- ---- -------- -------- -------- ---- --------
----

                12/31/99                          E90                                  57       36
                12/31/01                          E90                                  34.5     78

      F    NITROGEN, AMMONIA   TOTAL (AS N)                              19                1.21     1.82
           00610 1    0    0                                                           MO AVG   DAILY MX

                01/31/99                          E90                                  .86      6.11
                03/31/01                          E90                                  .85      3.65
                12/31/01                          E90                                  0.48     2.54

      F    NITROGEN, KJELDAHL  TOTAL (AS N)       26   43.4              19                3.21     4.82
           00625 1    0    0                           MO AVG   DAILY MX               MO AVG   DAILY MX

                01/31/98                          E90  22.14    65.06                  2.4      5.83
                02/28/98                          E90  35.07    51.18                  4.25     4.75
                03/31/98                          E90  39.5     55.76                  3.36     4.71
                01/31/99                          E90  34.84    82.67                  3.40     8.40
                12/31/00                          E90  33.5     73.3                   4.48     11.1
                12/31/01                          E90  19.5     30.6                   1.86     6.33

      F     COLIFORM, FECAL    GENERAL                                   13                1000     2000
           74055 1    0    0                                                           MO AVG   DAILY MX

                01/31/99                          E90                                  1240     >6000
                06/30/01                          E90                                  1500     >6000
```

```
          11/30/01                        E90                                  >101.75  >200

0011 9    A          09/01/89 1           0    10/28/89 1                                         01/01/02 12/31/06

   F    NITROGEN, AMMONIA   TOTAL (AS N)                              19                  1.21     1.82
        00610 1    0    0                                                              MO AVG   DAILY MX

          01/31/02                        E90                                  0.09     8.0
          08/31/02                        E90                                  1.083    8.16

   F    NITROGEN, KJELDAHL  TOTAL (AS N)        26   35.89            19   DELMON      3.21     4.82
        00625 1    S    0                            MO AVG   DAILY MX                 MO AVG   DAILY MX

          08/31/02                        E90  34.61    188.80                         3.62     15.4
```

MAJORS IN CAHABA BASIN
TOM MCGILL

QL
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*** QL

```
NPID      FNMS                           MADI RDF9   PERD     PERE     PYQS CYQS PYMS CYMS
--------- ------------------------------ ---- ------ -------- -------- ---- ---- ---- ----
   DSDG PIPQ PIAC PIDT     STRP     NRPU STSU     NSUN STSS     NSUS ILSD     ILED     MLSD     MLED     FLSD     FLED
   ---- ---- ---- -------- -------- ---- -------- ---- -------- ---- -------- -------- -------- -------- -------- --------
      LTYP PRAM                                  LQUC LQAV     LQMX     LCUC LCMN     LCAV     LCMX
      ---- ---------------------------------------- ---- -------- -------- ---- -------- -------- --------
           PRAM  MLOC SEAN MODN                       LQAS     LQXS          LCMS     LCAS     LCXS
           ----- ---- ---- ----                       -------- --------      -------- -------- --------
                MVDT                             MVIO MQAV     MQMX     NODI MCMN     MCAV     MCMX     SNCE SNDE
SRCE
                --------                         ---- -------- -------- ---- -------- -------- -------- ---- --------
----
```

SUB-TOTAL QUICK LOOK PRINT LINES:     54

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                                                MAJORS IN CAHABA BASIN
                                                    TOM MCGILL
QL
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*** QL

NPID      FNMS                          MADI RDF9   PERD     PERE     PYQS CYQS PYMS CYMS
--------- ----------------------------- ---- ------ -------- -------- ---- ---- ---- ----
   DSDG PIPQ PIAC PIDT     STRP     NRPU STSU     NSUN STSS     NSUS ILSD     ILED     MLSD     MLED     FLSD     FLED
   ---- ---- ---- -------- -------- ---- -------- ---- -------- ---- -------- -------- -------- -------- -------- --------
      LTYP PRAM                                  LQUC LQAV     LQMX     LCUC LCMN     LCAV     LCMX
      ---- --------------------------------------- ---- -------- -------- ---- -------- -------- --------
           PRAM  MLOC SEAN MODN                       LQAS     LQXS          LCMS     LCAS     LCXS
           ----- ---- ---- ----                       -------- --------      -------- -------- --------
                MVDT                             MVIO MQAV     MQMX     NODI MCMN     MCAV     MCMX     SNCE SNDE
SRCE
                --------                         ---- -------- -------- ---- -------- -------- -------- ---- --------
----

AL0022934 JEFFERSON CO TRUSSVILLE WWTP   M          01/10/01 01/31/06 SSSS SSSN NNNN NNN

   001T 2    A            11/01/90 1            0    12/28/90 1                                            01/01/96 12/31/00

      F    TOXICITY,           CERIODAPHNIA CHRONIC 9A   DELMON   0
           61426 1    0    0

                08/31/98                         E90           10
                11/30/98                         E90           10

      F    TOXICITY,           PIMEPHALES CHRONIC   9A   DELMON   0
           61428 1    0    0

                08/31/98                         E90           8
                11/30/98                         E90           8

   0011 1    A            08/01/82 1            0    09/28/82 1                                            11/01/90 12/31/95

      F    BOD, 5-DAY              (20 DEG. C)      26   150      300      19   DELMON   15       22.5
           00310 1    2    1                          MO AVG   WKLY AVG               MO AVG   WKLY AVG

                03/31/95                         E90  195      525                    8.5      19.9     A    03/31/95 5

      F    SOLIDS, TOTAL       SUSPENDED            26   300      600      19   DELMON   30       45
           00530 1    2    1                          MO AVG   WKLY AVG               MO AVG   WKLY AVG
```

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 02/28/94 | | E90 | 769 | 1923 | | | 31 | 74 | A | 02/28/94 5 |
| | 03/31/95 | | E90 | 1023 | 3585 | | | 39 | 136 | A | 03/31/95 5 |
| F | NITROGEN, AMMONIA | TOTAL (AS N) | 26 | 10 | 20 | 19 | DELMON | 1.0 | 1.5 | | |
| | 00610 1 1 1 | | | MO AVG | WKLY AVG | | | MO AVG | WKLY AVG | | |
| | 06/30/95 | | E90 | 2.2 | 6.1 | | | 1.1 | 1.9 | A | 06/30/95 5 |
| F | NITROGEN, KJELDAHL | TOTAL (AS N) | 26 | 40 | 80 | 19 | DELMON | 4.0 | 6.0 | | |
| | 00625 1 2 1 | | | MO AVG | WKLY AVG | | | MO AVG | WKLY AVG | | |
| | 02/28/94 | | E90 | 65 | 147 | | | 2.7 | 5.7 | A | 02/28/94 5 |

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                                                                    MAJORS IN CAHABA BASIN
                                                                          TOM MCGILL
QL
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*** QL

NPID      FNMS                          MADI RDF9   PERD     PERE     PYQS CYQS PYMS CYMS
--------- ----------------------------- ---- ------ -------- -------- ---- ---- ---- ----
   DSDG PIPQ PIAC PIDT     STRP     NRPU STSU     NSUN STSS     NSUS ILSD     ILED     MLSD     MLED     FLSD     FLED
   ---- ---- ---- -------- -------- ---- -------- ---- -------- ---- -------- -------- -------- -------- -------- --------
      LTYP PRAM                                   LQUC LQAV     LQMX     LCUC LCMN     LCAV     LCMX
      ---- -------------------------------------- ---- -------- -------- ---- -------- -------- --------
           PRAM  MLOC SEAN MODN                        LQAS     LQXS          LCMS     LCAS     LCXS
           ----- ---- ---- ----                        -------- --------      -------- -------- --------
                MVDT                              MVIO MQAV     MQMX     NODI MCMN     MCAV     MCMX     SNCE SNDE
SRCE
                --------                          ---- -------- -------- ---- -------- -------- -------- ---- --------
----

                03/31/94                          E90  66       122                    2.8      4.9      A    03/31/94 5
                03/31/95                          E90  99       315                    3.9      11.9     A    03/31/95 5

   0011 2    A            08/01/82 1            0    09/28/82 1                                          01/01/96 12/31/00

      F    OXYGEN, DISSOLVED           (DO)                              19   6.0      DELMON   DELMON
           00300 1    0    0                                                  DAILY MN

                01/31/98                          E90                         5.5
                02/28/98                          E90                         5.1
                03/31/98                          E90                         5.7

      F    BOD, 5-DAY              (20 DEG. C)    26   70       140      19   DELMON   5.0      7.5
           00310 1    S    1                           MO AVG   WKLY AVG               MO AVG   WKLY AVG

                07/31/97                          E90  71       120                    3.7      5.7      A    07/31/97 4
                10/31/97                          E90  75       61                     5.0      4.6      A    10/31/97 4
                11/30/97                          E90  80       157                    5.0      9.2      A    11/30/97 4
                05/31/98                          E90  104      154                    6.4      9.0      A    05/31/98 4

      F    BOD, 5-DAY              (20 DEG. C)    26   150      300      19   DELMON   15       22.5
           00310 1    W    1                           MO AVG   WKLY AVG               MO AVG   WKLY AVG

                01/31/97                          E90  198.5    359.0                  8.7      14.5     A    01/31/97 4
                03/31/97                          E90  199      408                    9.0      15.3     A    03/31/97 4
```

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 12/31/97 | | E90 | 227 | 435 | | 11.9 | 26.2 | A | 12/31/97 4 |
| | 01/31/98 | | E90 | 774 | 1072 | | 30.6 | 40.7 | A | 01/31/98 4 |
| | 02/28/98 | | E90 | 937 | 1445 | | 38.6 | 54.1 | A | 02/28/98 4 |
| | 03/31/98 | | E90 | 826 | 1614 | | 37.8 | 76.6 | A | 03/31/98 4 |
| | 04/30/98 | | E90 | 498 | 960 | | 19.6 | 36.3 | A | 04/30/98 4 |
| F | SOLIDS, TOTAL | SUSPENDED | 26 | 300 | 500 | 19 | 30 | 45 | | |
| | 00530 1 S 1 | | | MO AVG | WKLY AVG | | MO AVG | WKLY AVG | | |
| | 05/31/97 | | E90 | 87 | 1400 | | 5 | 60 | P | 05/31/97 5 |
| | 06/30/97 | | E90 | 369 | 564 | | 17 | 27 | A | 06/30/97 5 |
| | 07/31/97 | | E90 | 199 | 530 | | 10 | 25 | P | 07/31/97 5 |
| | 05/31/98 | | E90 | 335 | 565 | | 21 | 33 | A | 05/31/98 5 |

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                                                        MAJORS IN CAHABA BASIN
                                                              TOM MCGILL
QL
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*** QL

NPID      FNMS                           MADI RDF9   PERD     PERE     PYQS CYQS PYMS CYMS
--------- ------------------------------ ---- ------ -------- -------- ---- ---- ---- ----
   DSDG PIPQ PIAC PIDT     STRP     NRPU STSU     NSUN STSS     NSUS ILSD     ILED     MLSD     MLED     FLSD     FLED
   ---- ---- ---- -------- -------- ---- -------- ---- -------- ---- -------- -------- -------- -------- -------- --------
      LTYP PRAM                                     LQUC LQAV     LQMX     LCUC LCMN     LCAV     LCMX
      ---- ---------------------------------------- ---- -------- -------- ---- -------- -------- --------
           PRAM  MLOC SEAN MODN                          LQAS     LQXS          LCMS     LCAS     LCXS
           ----- ---- ---- ----                          -------- --------      -------- -------- --------
                MVDT                                MVIO MQAV     MQMX     NODI MCMN     MCAV     MCMX     SNCE SNDE
SRCE
                --------                            ---- -------- -------- ---- -------- -------- -------- ---- --------
----

      F    SOLIDS, TOTAL       SUSPENDED            26   300      600      19            30       45
           00530 1    W    1                             MO AVG   WKLY AVG               MO AVG   WKLY AVG

                03/31/96                            E90  420      462                    17       18       A    03/31/96 5
                01/31/97                            E90  1041     1417                   45.3     59.4     A    01/31/97 5
                02/28/97                            E90  667      1218                   29.0     52.8     A    02/28/97 5
                03/31/97                            E90  462      2320                   22.8     98.0     A    03/31/97 5
                04/30/97                            E90  358      71                     16.3     4.8      A    04/30/97 5
                12/31/97                            E90  276      631                    15       38       P    12/31/97 5
                01/31/98                            E90  1666     2457                   66       96       A    01/31/98 5
                02/28/98                            E90  2275     2957                   91       116      A    02/28/98 5
                03/31/98                            E90  1389     3182                   64       150      A    03/31/98 5
                04/30/98                            E90  793      1783                   31       67       A    04/30/98 5

      F    NITROGEN, AMMONIA   TOTAL (AS N)         26   10       20       19            1.0      1.5
           00610 1    S    1                             MO AVG   WKLY AVG               MO AVG   WKLY AVG

                05/31/97                            E90  17       45                     1.1      2.4      A    05/31/97 5
                06/30/97                            E90  41       56                     1.9      2.6      A    06/30/97 5
                07/31/97                            E90  21       60                     1.1      2.9      A    07/31/97 5
                08/31/97                            E90  12       28                     0.9      2.2      A    08/31/97 5

      F    NITROGEN, AMMONIA   TOTAL (AS N)         26   20.0     30.0     19   DELMON   2.0      3.0
           00610 1    W    0                             MO AVG   WKLY AVG               MO AVG   WKLY AVG
```

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 01/31/98 | E90 | 45 | 64 | | 1.9 | 2.5 | T | 02/28/98 2 |
| | 02/28/98 | E90 | 55.7 | 63.2 | | 2.3 | 2.4 | T | 02/28/98 2 |
| | 03/31/98 | E90 | 36.9 | 74.8 | | 1.7 | 3.5 | T | 03/31/98 2 |
| F | NITROGEN, KJELDAHL TOTAL (AS N) | 26 | 30 | 60 | 19 | 2.0 | 4.0 | | |
| | 00625 1 S 1 | | MO AVG | WKLY AVG | | MO AVG | WKLY AVG | | |
| | 05/31/97 | E90 | 24 | 160 | | 1.5 | 6.9 | P | 05/31/97 5 |
| | 06/30/97 | E90 | 70 | 107 | | 3.1 | 4.9 | A | 06/30/97 5 |
| | 07/31/97 | E90 | 35 | 80 | | 1.8 | 3.8 | A | 07/31/97 5 |
| F | NITROGEN, KJELDAHL TOTAL (AS N) | 26 | 40 | 80 | 19 | 4.0 | 6.0 | | |
| | 00625 1 W 1 | | MO AVG | WKLY AVG | | MO AVG | WKLY AVG | | |

MAJORS IN CAHABA BASIN
TOM MCGILL

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*** QL

NPID      FNMS                           MADI RDF9   PERD     PERE     PYQS CYQS PYMS CYMS
--------- ------------------------------ ---- ------ -------- -------- ---- ---- ---- ----
   DSDG PIPQ PIAC PIDT     STRP     NRPU STSU     NSUN STSS     NSUS ILSD     ILED     MLSD     MLED     FLSD     FLED
   ---- ---- ---- -------- -------- ---- -------- ---- -------- ---- -------- -------- -------- -------- -------- --------
      LTYP PRAM                                    LQUC LQAV     LQMX     LCUC LCMN     LCAV     LCMX
      ---- --------------------------------------- ---- -------- -------- ---- -------- -------- --------
           PRAM  MLOC SEAN MODN                         LQAS     LQXS          LCMS     LCAS     LCXS
           ----- ---- ---- ----                         -------- --------      -------- -------- --------
                MVDT                               MVIO MQAV     MQMX     NODI MCMN     MCAV     MCMX     SNCE SNDE
SRCE
                --------                           ---- -------- -------- ---- -------- -------- -------- ---- --------
----

                01/31/97                           E90  89.0     126.0                  3.9      5.1      A    01/31/97 5
                02/28/97                           E90  56.0     92.0                   2.5      4.1      A    02/28/97 5
                03/31/97                           E90  84.0     154.0                  4.1      7.0      A    03/31/97 5
                04/30/97                           E90  47.0     23.0                   2.3      1.4      A    04/30/97 5
                12/31/97                           E90  58       125                    3.1      7.6      A    12/31/97 5
                01/31/98                           E90  157      231                    6.3      9.0      A    01/31/98 5
                02/28/98                           E90  210      311                    8.4      11.7     A    02/28/98 5
                03/31/98                           E90  127      282                    5.8      13.3     A    03/31/98 5
                04/30/98                           E90  54       99                     2.2      3.7      A    04/30/98 5

      F    CHLORINE, TOTAL     RESIDUAL                                   19   0.5      DELMON   DELMON
           50060 X    0    0                                                   DAILY MN

                01/31/98                           E90                         0.3
                02/28/98                           E90                         0.3
                03/31/98                           E90                         0.01

      F    CHLORINE, TOTAL     RESIDUAL                                   19   DELMON   DELMON   0.01
           50060 1    0    0                                                                     DAILY MX

                01/31/98                           E90                                           0.20

      F     COLIFORM, FECAL    GENERAL                                    13   DELMON   200      2000
           74055 1    S    0                                                            MO AVG   DAILY MX
```

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 05/31/98 | E90 | | | 83 | 2400 | | |
| F | COLIFORM, FECAL GENERAL | | 13 | DELMON | 1000 | 2000 | | |
| | 74055 1 W 0 | | | | MO AVG | DAILY MX | | |
| | 01/31/98 | E90 | | | 237 | 34000 | | |
| | 02/28/98 | E90 | | | 595 | 36000 | | |
| | 03/31/98 | E90 | | | 298 | 43000 | | |
| F | BOD, 5-DAY PERCENT REMOVAL | | 23 | 85 | DELMON | DELMON | | |
| | 81010 K 0 0 | | | MO AVG | | | | |
| | 01/31/98 | E90 | | 72 | | | T | 02/28/98 2 |

MAJORS IN CAHABA BASIN
TOM MCGILL

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*** QL

NPID      FNMS                           MADI RDF9   PERD     PERE     PYQS CYQS PYMS CYMS
--------- ----------------------------- ---- ------ -------- -------- ---- ---- ---- ----
   DSDG PIPQ PIAC PIDT     STRP     NRPU STSU     NSUN STSS     NSUS ILSD     ILED     MLSD     MLED     FLSD     FLED
   ---- ---- ---- -------- -------- ---- -------- ---- -------- ---- -------- -------- -------- -------- -------- --------
      LTYP PRAM                                   LQUC LQAV     LQMX     LCUC LCMN     LCAV     LCMX
      ---- -------------------------------------- ---- -------- -------- ---- -------- -------- --------
           PRAM  MLOC SEAN MODN                        LQAS     LQXS          LCMS     LCAS     LCXS
           ----- ---- ---- ----                        -------- --------      -------- -------- --------
                MVDT                              MVIO MQAV     MQMX     NODI MCMN     MCAV     MCMX     SNCE SNDE
SRCE
                --------                          ---- -------- -------- ---- -------- -------- -------- ---- --------
----

                02/28/98                          E90                         54                         T    02/28/98 2
                03/31/98                          E90                         63                         T    03/31/98 2

      F    SOLIDS, SUSPENDED   PERCENT REMOVAL                           23   85       DELMON   DELMON
           81011 K    0    0                                              MO AVG

                01/31/98                          E90                         67                         T    02/28/98 2
                02/28/98                          E90                         33                         T    02/28/98 2
                03/31/98                          E90                         55                         T    03/31/98 2
                04/30/98                          E90                         84                         V    04/30/98 2

                                          SUB-TOTAL QUICK LOOK PRINT LINES:     119
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                                                        MAJORS IN CAHABA BASIN
                                                              TOM MCGILL
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*** QL

NPID      FNMS                           MADI RDF9   PERD     PERE     PYQS CYQS PYMS CYMS
--------- ----------------------------- ---- ------ -------- -------- ---- ---- ---- ----
   DSDG PIPQ PIAC PIDT     STRP     NRPU STSU     NSUN STSS     NSUS ILSD     ILED     MLSD     MLED     FLSD     FLED
   ---- ---- ---- -------- -------- ---- -------- ---- -------- ---- -------- -------- -------- -------- -------- --------
      LTYP PRAM                                    LQUC LQAV     LQMX     LCUC LCMN     LCAV     LCMX
      ---- --------------------------------------- ---- -------- -------- ---- -------- -------- --------
           PRAM  MLOC SEAN MODN                         LQAS     LQXS          LCMS     LCAS     LCXS
           ----- ---- ---- ----                         -------- --------      -------- -------- --------
                MVDT                               MVIO MQAV     MQMX     NODI MCMN     MCAV     MCMX     SNCE SNDE
SRCE
                --------                           ---- -------- -------- ---- -------- -------- -------- ---- --------
----

AL0023027 JEFFERSON CO CAHABA RIVER WWTP M          09/30/00 10/31/02 PPPN NNDD       C

   001T 0    A            07/01/93 3            0    10/28/93 3                                         08/01/93 10/31/00

      F    LF P/F STATRE 7DAY CHR CERIODAPHNIA                          9A   DELMON   0        DELMON
           TEP3B 1    0    0

                02/28/98                           E90                                 1
                03/31/98                           E90                                 1                 N    05/28/98 2
                08/31/98                           E90                                 10
                11/30/98                           E90                                 10

      F    LF P/F  STATRE 7DAY CHR PIMEPHALES                           9A   DELMON   0        DELMON
           TEP6C 1    0    0

                08/31/98                           E90                                 5
                11/30/98                           E90                                 5

   0011 0    A            03/01/85 1            0    04/28/85 1                     03/01/85 10/31/00

      M    BOD, 5-DAY              (20 DEG. C)      26        167      250 19                  5      7.5
           00310 1    S    0                            30DA AVG 7 DA AVG              30DA AVG 7 DA AVG

                08/31/92                           E90  213      301                   2.60     3.50     V    08/31/92 3
                09/30/92                           E90  357      868                   2.90     4.6      T    11/30/92 3
```

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 11/30/92 | | E90 | 532 | 1006 | | 3.30 | 5.40 | T | 11/30/92 3 |
| | 03/31/93 | | E90 | 620 | 1304 | | 4 | 6.1 | T | 03/31/93 3 |
| | 05/31/93 | | E90 | 397 | 582 | | 4 | 4.0 | T | 05/31/93 3 |
| | 06/30/93 | | E90 | 291 | 381 | | 4 | 5.3 | T | 06/30/93 3 |
| | 07/31/93 | | E90 | 186 | 282 | | 3 | 4.1 | V | 07/31/93 3 |
| | 07/31/99 | | E90 | 86 | 321 | | 1 | 2 | | |
| | 03/31/00 | | E90 | 228 | 270 | | 2 | 3 | | |
| | 04/30/00 | | E90 | 276 | 719 | | 2 | 4 | | |
| M | BOD, 5-DAY | (20 DEG. C) | 26 | 267 | 400 19 | | 8 | 12 | | |
| | 00310 1 W 0 | | | 30DA AVG | 7 DA AVG | | 30DA AVG | 7 DA AVG | | |
| | 12/31/92 | | E90 | 910 | 1687 | | 5.40 | 8.50 | T | 12/31/92 3 |

MAJORS IN CAHABA BASIN
TOM MCGILL

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*** QL

NPID      FNMS                           MADI RDF9   PERD     PERE     PYQS CYQS PYMS CYMS
--------- ------------------------------ ---- ------ -------- -------- ---- ---- ---- ----
   DSDG PIPQ PIAC PIDT     STRP     NRPU STSU     NSUN STSS     NSUS ILSD     ILED     MLSD     MLED     FLSD     FLED
   ---- ---- ---- -------- -------- ---- -------- ---- -------- ---- -------- -------- -------- -------- -------- --------
      LTYP PRAM                                    LQUC LQAV     LQMX     LCUC LCMN     LCAV     LCMX
      ---- ---------------------------------------- ---- -------- -------- ---- -------- -------- --------
           PRAM  MLOC SEAN MODN                         LQAS     LQXS          LCMS     LCAS     LCXS
           ----- ---- ---- ----                         -------- --------      -------- -------- --------
                MVDT                               MVIO MQAV     MQMX     NODI MCMN     MCAV     MCMX     SNCE SNDE
SRCE
                --------                           ---- -------- -------- ---- -------- -------- -------- ---- --------
----

                01/31/98                           E90  319      1083                   2        4
                02/28/99                           E90  158      482                    2        3

      M    SOLIDS, TOTAL       SUSPENDED           26       1001     1501 19                  30       45
           00530 1    0    0                            30DA AVG 7 DA AVG               30DA AVG 7 DA AVG

                01/31/98                           E90  911      3045                   6        11

                                          SUB-TOTAL QUICK LOOK PRINT LINES:     33
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MAJORS IN CAHABA BASIN
TOM MCGILL

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*** QL

NPID      FNMS                           MADI RDF9   PERD     PERE     PYQS CYQS PYMS CYMS
--------- ------------------------------ ---- ------ -------- -------- ---- ---- ---- ----
   DSDG PIPQ PIAC PIDT     STRP     NRPU STSU     NSUN STSS     NSUS ILSD     ILED     MLSD     MLED     FLSD     FLED
   ---- ---- ---- -------- -------- ---- -------- ---- -------- ---- -------- -------- -------- -------- -------- --------
      LTYP PRAM                                LQUC LQAV     LQMX     LCUC LCMN     LCAV     LCMX
      ---- ---------------------------------------- ---- -------- -------- ---- -------- -------- --------
           PRAM  MLOC SEAN MODN                     LQAS     LQXS          LCMS     LCAS     LCXS
           ----- ---- ---- ----                     -------- --------      -------- -------- --------
                MVDT                           MVIO MQAV     MQMX     NODI MCMN     MCAV     MCMX     SNCE SNDE
SRCE
                --------                       ---- -------- -------- ---- -------- -------- -------- ---- --------
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AL0023116 HELENA CITY OF UTIL BD WWTP    M           10/06/00 10/31/05 NNPP PPPP

   001T 9    A            01/01/93 1            0    02/28/93 1                                       11/01/00 10/31/05

      F    TOXICITY,           CERIODAPHNIA CHRONIC 94   DELMON   0
           61426 1    0    0                                  SINGSAMP

                11/30/00                       E90          1
                05/31/01                       E90          1

   0011 1    A            03/01/90 1            0    02/28/93 1                                       03/01/95 02/28/00

      F    SOLIDS, TOTAL       SUSPENDED            26   312      469      19   DELMON   30.0     45.0
           00530 1    0    0                            MO AVG   WKLY AVG           MO AVG   WKLY AVG

                05/31/99                       E90  8.52     16.2                   69       1.14
                03/31/00                       E90  918      3429                   81       312

      F    SOLIDS, SUSPENDED   PERCENT REMOVAL                          23   85       DELMON
           81011 K    0    0                                                 MO AV MN

                03/31/00                       E90                           2

   0011 9    A            03/01/90 1            0    02/28/93 1                                       11/01/00 10/31/05
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| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| F | OXYGEN, DISSOLVED | (DO) | | | | | 19 | 6.0 | DELMON | DELMON |
| | 00300 1 0 0 | | | | | | | DAILY MN | | |
| | 09/30/01 | | | E90 | | | | 4.76 | | |
| | 01/31/02 | | | E90 | | | | 5.89 | | |
| F | SOLIDS, TOTAL | SUSPENDED | 26 | | 312 | 469 | 19 | DELMON | 30.0 | 45.0 |
| | 00530 1 0 0 | | | | MO AVG | WKLY AVG | | | MO AVG | WKLY AVG |
| | 01/31/01 | | | E90 | 486 | 929 | | | 32.0 | 61.7 |
| F | NITROGEN, AMMONIA | TOTAL (AS N) | 26 | | 20.8 | 31.2 | 19 | DELMON | 2.0 | 3.0 |
| | 00610 1 S 0 | | | | MO AVG | WKLY AVG | | | MO AVG | WKLY AVG |

MAJORS IN CAHABA BASIN
TOM MCGILL

QL

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*** QL

NPID      FNMS                          MADI RDF9   PERD     PERE     PYQS CYQS PYMS CYMS
--------- ----------------------------- ---- ------ -------- -------- ---- ---- ---- ----
   DSDG PIPQ PIAC PIDT     STRP     NRPU STSU     NSUN STSS     NSUS ILSD     ILED     MLSD     MLED     FLSD     FLED
   ---- ---- ---- -------- -------- ---- -------- ---- -------- ---- -------- -------- -------- -------- -------- --------
      LTYP PRAM                                      LQUC LQAV     LQMX     LCUC LCMN     LCAV     LCMX
      ---- --------------------------------------- ---- -------- -------- ---- -------- -------- --------
           PRAM  MLOC SEAN MODN                           LQAS     LQXS          LCMS     LCAS     LCXS
           ----- ---- ---- ----                           -------- --------      -------- -------- --------
                MVDT                                 MVIO MQAV     MQMX     NODI MCMN     MCAV     MCMX     SNCE SNDE
SRCE
                --------                             ---- -------- -------- ---- -------- -------- -------- ---- --------
----

                08/31/01                             E90  12.38    47.27                  0.71     2.14
                09/30/01                             E90  15.45    65.43                  0.73     2.55

      F    NITROGEN, KJELDAHL  TOTAL (AS N)          26   52.1     78.1     19   DELMON   5.0      7.5
           00625 1    S    0                              MO AVG   WKLY AVG               MO AVG   WKLY AVG

                08/31/01                             E90  31.57    79.51                  2.21     3.80
                09/30/01                             E90  35.48    110.91                 2.05     4.30

      F     COLIFORM, FECAL    GENERAL                                      13   DELMON   200      2000
           74055 1    S    0                                                              MO AVG   DAILY MX

                11/30/00                             E90                                  267      585
                06/30/01                             E90                                  231      434
                09/30/01                             E90                                  253      625

      F    BOD, CARBONACEOUS   05 DAY, 20C           26   72.9     109      19   DELMON   7.0      10.5
           80082 1    S    0                              MO AVG   WKLY AVG               MO AVG   WKLY AVG

                06/30/01                             E90  76.5     100.1                  5.84     7.00
                09/30/01                             E90  57.91    139.21                 3.76     5.60

      F    SOLIDS, SUSPENDED   PERCENT REMOVAL                              23   85       DELMON
           81011 K    0    0                                                     MO AV MN
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| | | |
|---|---|---|
| 01/31/01 | E90 | 75.3 |

SUB-TOTAL QUICK LOOK PRINT LINES: 42

MAJORS IN CAHABA BASIN
TOM MCGILL

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*** QL

NPID      FNMS                          MADI RDF9   PERD     PERE     PYQS CYQS PYMS CYMS
--------- ----------------------------- ---- ------ -------- -------- ---- ---- ---- ----
   DSDG PIPQ PIAC PIDT     STRP     NRPU STSU     NSUN STSS     NSUS ILSD     ILED     MLSD     MLED     FLSD     FLED
   ---- ---- ---- -------- -------- ---- -------- ---- -------- ---- -------- -------- -------- -------- -------- --------
      LTYP PRAM                                  LQUC LQAV     LQMX     LCUC LCMN     LCAV     LCMX
      ---- ------------------------------------- ---- -------- -------- ---- -------- -------- --------
           PRAM  MLOC SEAN MODN                       LQAS     LQXS          LCMS     LCAS     LCXS
           ----- ---- ---- ----                       -------- --------      -------- -------- --------
                MVDT                             MVIO MQAV     MQMX     NODI MCMN     MCAV     MCMX     SNCE SNDE
SRCE
                --------                         ---- -------- -------- ---- -------- -------- -------- ---- --------
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AL0024252 LAFARGE BUILDING MATERIALS INC M           04/30/01 04/30/06    E D         C

   0011 3    A            07/01/85 1            0    10/28/85 3                                           05/01/96 04/30/01

      F    SOLIDS, TOTAL       SUSPENDED                                 19   DELMON   25.0         45.0
           00530 1    0    0                                                       DAILY AV DAILY MX

                10/31/98                         E90                                   31.9     36.5

      F     COLIFORM, FECAL    GENERAL                                   13   DELMON        200      400
           74055 1    0    0                                                       DAILY AV DAILY MX

                07/31/98                         E90                                   501      2000
                04/30/01                         E90                                   625      1248

   0011 9    A            07/01/85 1            0    10/28/85 3                                           05/01/01 04/30/06

      F    SOLIDS, TOTAL       SUSPENDED                                 19   DELMON   25.0         45.0
           00530 1    0    0                                                       DAILY AV DAILY MX

                05/31/01                         E90                                   25.3     55.0     V    09/30/01 2
                07/31/01                         E90                                   35.2     41.5     T    09/30/01 2
                08/31/01                         E90                                   75.5     132      T    09/30/01 2

      F     COLIFORM, FECAL    GENERAL                                   13   DELMON        200      400
```

```
        74055 1    0    0                                                                DAILY AV DAILY MX

             05/31/01                            E90                                     145      1328
             06/30/01                            E90                                     97       1016
             07/31/01                            E90                                     61       524
             09/30/01                            E90                                     39       406

0021 3    A            07/01/85 1            0    10/28/85 3                                             05/01/96 04/30/01

   F    PH                                                                     12        6.0 DELMON        9.0
        00400 1    0    0                                                           DAILY MN         DAILY MX

             06/30/98                            E90                                8.3              9.9
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MAJORS IN CAHABA BASIN
TOM MCGILL

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*** QL

NPID      FNMS                           MADI RDF9   PERD     PERE     PYQS CYQS PYMS CYMS
--------- ------------------------------ ---- ------ -------- -------- ---- ---- ---- ----
   DSDG PIPQ PIAC PIDT     STRP     NRPU STSU     NSUN STSS     NSUS ILSD     ILED     MLSD     MLED     FLSD     FLED
   ---- ---- ---- -------- -------- ---- -------- ---- -------- ---- -------- -------- -------- -------- -------- --------
      LTYP PRAM                                  LQUC LQAV     LQMX     LCUC LCMN     LCAV     LCMX
      ---- ---------------------------------------- ---- -------- -------- ---- -------- -------- --------
           PRAM  MLOC SEAN MODN                       LQAS     LQXS          LCMS     LCAS     LCXS
           ----- ---- ---- ----                       -------- --------      -------- -------- --------
                MVDT                             MVIO MQAV     MQMX     NODI MCMN     MCAV     MCMX     SNCE SNDE
SRCE
                --------                         ---- -------- -------- ---- -------- -------- -------- ---- --------
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SUB-TOTAL QUICK LOOK PRINT LINES:     25

MAJORS IN CAHABA BASIN

TOM MCGILL

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*** QL

NPID      FNMS                          MADI RDF9   PERD     PERE     PYQS CYQS PYMS CYMS
--------- ----------------------------- ---- ------ -------- -------- ---- ---- ---- ----
   DSDG PIPQ PIAC PIDT     STRP     NRPU STSU     NSUN STSS     NSUS ILSD     ILED     MLSD     MLED     FLSD     FLED
   ---- ---- ---- -------- -------- ---- -------- ---- -------- ---- -------- -------- -------- -------- -------- --------
      LTYP PRAM                                    LQUC LQAV     LQMX     LCUC LCMN     LCAV     LCMX
      ---- --------------------------------------- ---- -------- -------- ---- -------- -------- --------
           PRAM  MLOC SEAN MODN                         LQAS     LQXS          LCMS     LCAS     LCXS
           ----- ---- ---- ----                         -------- --------      -------- -------- --------
                MVDT                               MVIO MQAV     MQMX     NODI MCMN     MCAV     MCMX     SNCE SNDE
SRCE
                --------                           ---- -------- -------- ---- -------- -------- -------- ---- --------
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AL0025828 ALABASTER CITY OF WTP          M          10/06/00 10/31/05  ENN N

   0011 3    A            02/01/90 1            0    03/28/90 1                                                06/01/95 05/31/00

      F     COLIFORM, FECAL    GENERAL                                     13   DELMON   200      2000
           74055 1    S    0                                                              MO AVG   DAILY MX

                05/31/98                           E90                                    301      1136
                06/30/98                           E90                                    238      912

   0011 9    A            02/01/90 1            0    03/28/90 1                                                11/01/00 10/31/05

      F    NITROGEN, KJELDAHL  TOTAL (AS N)        26   125      187      19   DELMON   5.0      7.5
           00625 1    W    0                            MO AVG   WKLY AVG               MO AVG   WKLY AVG

                12/31/00                           E90  124      132                      8.41     9.44     T    03/31/01 2
                03/31/01                           E90  202      627                      3.91     11.97    T    03/31/01 2

                                          SUB-TOTAL QUICK LOOK PRINT LINES:     11
```

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                                                              MAJORS IN CAHABA BASIN
                                                                    TOM MCGILL
QL
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*** QL

NPID      FNMS                         MADI RDF9   PERD     PERE     PYQS CYQS PYMS CYMS
--------- ---------------------------- ---- ------ -------- -------- ---- ---- ---- ----
   DSDG PIPQ PIAC PIDT     STRP     NRPU STSU     NSUN STSS     NSUS ILSD     ILED     MLSD     MLED     FLSD     FLED
   ---- ---- ---- -------- -------- ---- -------- ---- -------- ---- -------- -------- -------- -------- -------- --------
      LTYP PRAM                                    LQUC LQAV     LQMX     LCUC LCMN     LCAV     LCMX
      ---- ------------------------------------- ---- -------- -------- ---- -------- -------- --------
           PRAM  MLOC SEAN MODN                         LQAS     LQXS          LCMS     LCAS     LCXS
           ----- ---- ---- ----                         -------- --------      -------- -------- --------
                MVDT                               MVIO MQAV     MQMX     NODI MCMN     MCAV     MCMX     SNCE SNDE
SRCE
                --------                           ---- -------- -------- ---- -------- -------- -------- ---- --------
----

AL0025852 HOOVER INVERNESS WWTP          M          10/25/01 10/31/06 SSSS SSSS

   0011 1    A            02/01/87 1            0    03/28/87 1                                            09/01/96 08/31/01

      F    CHLORINE, TOTAL     RESIDUAL                                   19   0.5      DELMON   DELMON
           50060 X    0    0                                                   DAILY MN

                02/28/98                           E90                         0.30

      F     COLIFORM, FECAL    GENERAL                                    13   DELMON   200      2000
           74055 1    0    0                                                            MO AVG   DAILY MX

                02/28/98                           E90                                  2592     10200

   0021 1    A            09/01/96 1            0    10/28/96 1                                            09/01/96 08/31/01

      F    NITROGEN, AMMONIA   TOTAL (AS N)        26                     19   DELMON   3.0      4.5
           00610 1    0    0                            MO AVG   WKLY AVG               MO AVG   WKLY AVG

                07/31/01                           E90  23       54                     5.3      9.8
                08/31/01                           E90  42       60                     7.8      11.1     T    09/30/01 2
                09/30/01                           E90  34       45                     8.7      12.1     T    09/30/01 2
                10/31/01                           E90  45       56                     9.4      11.8     T    02/28/02 2

      F    NITROGEN, KJELDAHL  TOTAL (AS N)        26                     19   DELMON   10       15
```

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       00625 1    0    0                             MO AVG   WKLY AVG               MO AVG   WKLY AVG

            10/31/01                            E90  51       84                     10.5     11.4

0021 9    A             09/01/96 1            0    10/28/96 1                                       11/01/01 10/31/06

   F    NITROGEN, AMMONIA   TOTAL (AS N)         26                     19   DELMON   3.0      4.5
       00610 1    0    0                             MO AVG   WKLY AVG               MO AVG   WKLY AVG

            03/31/02                            E90  49.8     111.1                  6.0      11.0     T    03/31/02 2

003T 1    A             01/01/97 12           0    01/28/98 12                                      09/01/96 08/31/01

   F    LF P/F  STATRE 7DAY CHR PIMEPHALES                              9A   DELMON   0        DELMON
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                                    MAJORS IN CAHABA BASIN
                                         TOM MCGILL
QL
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*** QL

NPID      FNMS                           MADI RDF9   PERD     PERE     PYQS CYQS PYMS CYMS
--------- ------------------------------ ---- ------ -------- -------- ---- ---- ---- ----
   DSDG PIPQ PIAC PIDT     STRP     NRPU STSU     NSUN STSS     NSUS ILSD     ILED     MLSD     MLED     FLSD     FLED
   ---- ---- ---- -------- -------- ---- -------- ---- -------- ---- -------- -------- -------- -------- -------- --------
      LTYP PRAM                                    LQUC LQAV     LQMX     LCUC LCMN     LCAV     LCMX
      ---- ---------------------------------------- ---- -------- -------- ---- -------- -------- --------
           PRAM  MLOC SEAN MODN                         LQAS     LQXS          LCMS     LCAS     LCXS
           ----- ---- ---- ----                         -------- --------      -------- -------- --------
                MVDT                               MVIO MQAV     MQMX     NODI MCMN     MCAV     MCMX     SNCE SNDE
SRCE
                --------                           ---- -------- -------- ---- -------- -------- -------- ---- --------
----

           TEP6C 1    0    0

                12/31/98                           E90                                  1                 N    02/27/99 2

                                           SUB-TOTAL QUICK LOOK PRINT LINES:     26
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MAJORS IN CAHABA BASIN
TOM MCGILL

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QL
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*** QL

NPID      FNMS                           MADI RDF9   PERD     PERE     PYQS CYQS PYMS CYMS
--------- ------------------------------ ---- ------ -------- -------- ---- ---- ---- ----
   DSDG PIPQ PIAC PIDT     STRP     NRPU STSU     NSUN STSS     NSUS ILSD     ILED     MLSD     MLED     FLSD     FLED
   ---- ---- ---- -------- -------- ---- -------- ---- -------- ---- -------- -------- -------- -------- -------- --------
      LTYP PRAM                                  LQUC LQAV     LQMX     LCUC LCMN     LCAV     LCMX
      ---- ------------------------------------- ---- -------- -------- ---- -------- -------- --------
           PRAM  MLOC SEAN MODN                       LQAS     LQXS          LCMS     LCAS     LCXS
           ----- ---- ---- ----                       -------- --------      -------- -------- --------
                MVDT                             MVIO MQAV     MQMX     NODI MCMN     MCAV     MCMX     SNCE SNDE
SRCE
                --------                         ---- -------- -------- ---- -------- -------- -------- ---- --------
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AL0041653 HOOVER CITY OF RIVERCHASE WWTP M          09/30/00 10/31/02 NR X R

   001T 0    A            08/01/93 1            0    09/28/93 3                                             08/01/93 07/31/98

      F    LF P/F  STATRE 7DAY CHR PIMEPHALES                            9A   DELMON   0        DELMON
           TEP6C 1    0    0

                02/28/98                         E90                                   1
                11/30/98                         E90                                   1
                02/28/99                         E90                                   1

   0011 0    A            06/01/83 1            0    07/28/83 1                                             07/01/83 06/30/95

      F    BOD, 5-DAY             (20 DEG. C)      26   50       75       19            4        6
           00310 1    0    0                            30DA AVG 7 DA AVG               30DA AVG 7 DA AVG

                03/31/00                         E90  64.5     122                      4.7      6
                05/31/00                         E90  47       68                       4.6      6.0

      F    SOLIDS, TOTAL       SUSPENDED           26   375      563      19   DELMON         30       45
           00530 1    0    0                            30DA AVG 7 DA AVG               30DA AVG 7 DA AVG

                03/31/00                         E90  289      936                      12.7     24.9

      F    CHLORINE, TOTAL     RESIDUAL                                  19   0.5      DELMON   DELMON
```

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 50060 X 0 1 | | | | | | | DAILY MN | | | | | | |
| | 04/30/98 | | | E90 | | | | 0.0 | | | | | | |
| 0011 9 A | | 06/01/83 1 | 0 07/28/83 1 | | | | | | | | | | 11/01/00 12/31/02 | |
| F | NITROGEN, AMMONIA | TOTAL (AS N) | | 26 | 12.5 | 18.7 | 19 | DELMON | 1.0 | 1.5 | | | | |
| | 00610 1 S 0 | | | | MO AVG | WKLY AVG | | | MO AVG | WKLY AVG | | | | |
| | 08/31/01 | | | E90 | 14.1 | 27.12 | | | 0.8 | 2.1 | R | 09/30/01 2 | | |
| | 09/30/01 | | | E90 | 13.9 | 39.57 | | | 0.6 | 1.2 | R | 09/30/01 2 | | |
| F | NITROGEN, AMMONIA | TOTAL (AS N) | | 26 | 25.0 | 37.5 | 19 | DELMON | 2.0 | 3.0 | | | | |

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                                                                       MAJORS IN CAHABA BASIN
                                                                             TOM MCGILL
QL
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*** QL

NPID      FNMS                           MADI RDF9   PERD     PERE     PYQS CYQS PYMS CYMS
--------- ----------------------------- ---- ------ -------- -------- ---- ---- ---- ----
   DSDG PIPQ PIAC PIDT     STRP     NRPU STSU     NSUN STSS     NSUS ILSD     ILED     MLSD     MLED     FLSD     FLED
   ---- ---- ---- -------- -------- ---- -------- ---- -------- ---- -------- -------- -------- -------- -------- --------
      LTYP PRAM                                LQUC LQAV     LQMX     LCUC LCMN     LCAV     LCMX
      ---- ------------------------------------- ---- -------- -------- ---- -------- -------- --------
           PRAM  MLOC SEAN MODN                     LQAS     LQXS          LCMS     LCAS     LCXS
           ----- ---- ---- ----                     -------- --------      -------- -------- --------
                MVDT                           MVIO MQAV     MQMX     NODI MCMN     MCAV     MCMX     SNCE SNDE
SRCE
                --------                       ---- -------- -------- ---- -------- -------- -------- ---- --------
----

           00610 1    W    0                        MO AVG   WKLY AVG               MO AVG   WKLY AVG

                01/31/02                       E90  17.8     40.5                   1.1      1.7

      F    NITROGEN, KJELDAHL  TOTAL (AS N)    26   25.0     37.5     19   DELMON   2.0      3.0
           00625 1    S    0                        MO AVG   WKLY AVG               MO AVG   WKLY AVG

                08/31/01                       E90  27.1     23.9                   1.4      1.8
                09/30/01                       E90  14.4     41.2                   0.7      1.6

      F    NITROGEN, KJELDAHL  TOTAL (AS N)    26   50.0     75.0     19   DELMON   4.0      6.0
           00625 1    W    0                        MO AVG   WKLY AVG               MO AVG   WKLY AVG

                01/31/02                       E90  58.74    116.84                 3.67     4.90

      F    BOD, CARBONACEOUS   05 DAY, 20C     26   50.0     75.0     19   DELMON   4.0      6.0
           80082 1    S    0                        MO AVG   WKLY AVG               MO AVG   WKLY AVG

                09/30/01                       E90  41.2     120.2                  2.2      3.5

                                           SUB-TOTAL QUICK LOOK PRINT LINES:      36
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MAJORS IN CAHABA BASIN
TOM MCGILL

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QL
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*** QL

NPID      FNMS                           MADI RDF9   PERD     PERE     PYQS CYQS PYMS CYMS
--------- ------------------------------ ---- ------ -------- -------- ---- ---- ---- ----
   DSDG PIPQ PIAC PIDT     STRP     NRPU STSU     NSUN STSS     NSUS ILSD     ILED     MLSD     MLED     FLSD     FLED
   ---- ---- ---- -------- -------- ---- -------- ---- -------- ---- -------- -------- -------- -------- -------- --------
      LTYP PRAM                                      LQUC LQAV     LQMX     LCUC LCMN     LCAV     LCMX
      ---- ---------------------------------------- ---- -------- -------- ---- -------- -------- --------
           PRAM  MLOC SEAN MODN                           LQAS     LQXS          LCMS     LCAS     LCXS
           ----- ---- ---- ----                           -------- --------      -------- -------- --------
                MVDT                                 MVIO MQAV     MQMX     NODI MCMN     MCAV     MCMX     SNCE SNDE
SRCE
                --------                             ---- -------- -------- ---- -------- -------- -------- ---- --------
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AL0044857 CENTREVILLE BRENT LAGOON       M           10/16/98 10/31/03 DEEE EDXD       C

   0011 9    A            08/01/99 1             0    09/28/99 1                                          11/01/98 10/31/03

      F    BOD, 5-DAY              (20 DEG. C)      26   200      300      19   DELMON   15.0     22.5
           00310 1    0    0                             MO AVG   WKLY AVG               MO AVG   WKLY AVG

                02/29/00                             E90  279      698                    41.4     98.5     R    06/30/00 2
                04/30/00                             E90  117      243                    12.3     26.5
                05/31/00                             E90  66.7     150                    12.8     24.3
                06/30/00                             E90  115      390                    17.2     56.4     R    06/30/00 2
                09/30/00                             E90  82.1     144                    24.3     49.0     T    01/31/01 2
                11/30/00                             E90  75.0     125                    16.6     25.1     C    03/31/01 2
                12/31/00                             E90  99.3     161                    17.2     24.6     C    03/31/01 2
                01/31/01                             E90  151      281                    23.7     35.1     T    01/31/01 2
                02/28/01                             E90  151      189                    18.4     24.4     V    06/30/01 2
                03/31/01                             E90  119      246                    13.2     27.4
                04/30/01                             E90  96.2     180                    12.2     23.8
                05/31/01                             E90  80.6     112                    16.0     23.5     V    06/30/01 2
                06/30/01                             E90  198      344                    23.6     33.6     T    06/30/01 2
                07/31/01                             E90  105      143                    25.1     38.4     T    07/31/01 2
                08/31/01                             E90  120      183                    20.3     26.2     C    12/31/01 2
                09/30/01                             E90  142      172                    17.5     22.1     C    12/31/01 2
                11/30/01                             E90  73.0     95.9                   16.6     22.5     C    12/31/01 2
                01/31/02                             E90  121      258                    17.4     38.7     R    05/31/02 2
```

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 05/31/02 | | E90 | 152 | 281 | | | 20.0 | 39.8 | R | 05/31/02 2 |
| | 06/30/02 | | E90 | 81.4 | 97.2 | | | 22.5 | 25.2 | U | 06/30/02 2 |
| | 07/31/02 | | E90 | 51.5 | 74.3 | | | 19.8 | 23.5 | | |
| | 08/31/02 | | E90 | 71.0 | 140 | | | 16.4 | 28.1 | | |
| F | PH | | | | | 12 | 6.0 | DELMON | 9.0 | | |
| | 00400 1 0 0 | | | | | | DAILY MN | | DAILY MX | | |
| | 12/31/00 | | E90 | | | | 5.9 | | 8.21 | | |
| | 12/31/01 | | E90 | | | | 5.90 | | 8.04 | | |
| F | NITROGEN, AMMONIA | TOTAL (AS N) | 26 | 40.0 | 60.0 | 19 | DELMON | 3.0 | 4.5 | | |
| | 00610 1 0 0 | | | MO AVG | WKLY AVG | | | MO AVG | WKLY AVG | | |

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                                                      MAJORS IN CAHABA BASIN
                                                           TOM MCGILL
QL
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*** QL

NPID      FNMS                          MADI RDF9   PERD     PERE     PYQS CYQS PYMS CYMS
--------- ----------------------------- ---- ------ -------- -------- ---- ---- ---- ----
   DSDG PIPQ PIAC PIDT     STRP     NRPU STSU     NSUN STSS     NSUS ILSD     ILED     MLSD     MLED     FLSD     FLED
   ---- ---- ---- -------- -------- ---- -------- ---- -------- ---- -------- -------- -------- -------- -------- --------
      LTYP PRAM                                  LQUC LQAV     LQMX     LCUC LCMN     LCAV     LCMX
      ---- -------------------------------------- ---- -------- -------- ---- -------- -------- --------
           PRAM  MLOC SEAN MODN                       LQAS     LQXS          LCMS     LCAS     LCXS
           ----- ---- ---- ----                       -------- --------      -------- -------- --------
                MVDT                             MVIO MQAV     MQMX     NODI MCMN     MCAV     MCMX     SNCE SNDE
SRCE
                --------                         ---- -------- -------- ---- -------- -------- -------- ---- --------
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                10/31/00                         E90  13.5     45.2                   3.21     10.9

      F    BOD, 5-DAY PERCENT  REMOVAL                                  23   65       DELMON   DELMON
           81010 K    0    0                                                 MO AV MN

                08/31/99                         E90                         0                          R    09/30/99 2
                09/30/99                         E90                         0                          R    09/30/99 2
                10/31/99                         E90                         0
                11/30/99                         E90                         0
                12/31/99                         E90                         0
                01/31/00                         E90                         0                          R    06/30/00 2
                02/29/00                         E90                         28.4                       R    06/30/00 2
                03/31/00                         E90                         0                          R    06/30/00 2
                05/31/00                         E90                         0                          R    06/30/00 2
                06/30/00                         E90                         0                          R    06/30/00 2
                07/31/00                         E90                         62.8                       U    07/31/00 2
                05/31/01                         E90                         9.51

      F    SOLIDS, SUSPENDED   PERCENT REMOVAL                          23   65       DELMON   DELMON
           81011 K    0    0                                                 MO AV MN

                08/31/99                         E90                         0                          R    09/30/99 2
                09/30/99                         E90                         0                          R    09/30/99 2
                10/31/99                         E90                         0
                11/30/99                         E90                         0
```

| | | | | |
|---|---|---|---|---|
| 12/31/99 | E90 | 0 | | |
| 01/31/00 | E90 | 0 | R | 06/30/00 2 |
| 02/29/00 | E90 | 3.7 | R | 06/30/00 2 |
| 03/31/00 | E90 | 0 | R | 06/30/00 2 |
| 05/31/00 | E90 | 0 | R | 06/30/00 2 |
| 06/30/00 | E90 | 0 | R | 06/30/00 2 |
| 07/31/00 | E90 | 0 | R | 07/31/00 2 |

SUB-TOTAL QUICK LOOK PRINT LINES: 60

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                                                                       MAJORS IN CAHABA BASIN
                                                                             TOM MCGILL
QL
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*** QL

NPID      FNMS                          MADI RDF9   PERD     PERE     PYQS CYQS PYMS CYMS
--------- ----------------------------- ---- ------ -------- -------- ---- ---- ---- ----
   DSDG PIPQ PIAC PIDT     STRP     NRPU STSU     NSUN STSS     NSUS ILSD     ILED     MLSD     MLED     FLSD     FLED
   ---- ---- ---- -------- -------- ---- -------- ---- -------- ---- -------- -------- -------- -------- -------- --------
      LTYP PRAM                                    LQUC LQAV     LQMX     LCUC LCMN     LCAV     LCMX
      ---- -------------------------------------- ---- -------- -------- ---- -------- -------- --------
           PRAM  MLOC SEAN MODN                         LQAS     LQXS          LCMS     LCAS     LCXS
           ----- ---- ---- ----                         -------- --------      -------- -------- --------
                MVDT                               MVIO MQAV     MQMX     NODI MCMN     MCAV     MCMX     SNCE SNDE
SRCE
                --------                           ---- -------- -------- ---- -------- -------- -------- ---- --------
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AL0045969 BIRMINGHAM WWB RIVERVIEW WWTP  M          09/30/00 10/31/02 PNDD DNNN   CC C

   001T 0    A            07/01/93 3            0    10/28/93 3                                             08/01/93 07/31/98

      F    LF P/F STATRE 7DAY CHR CERIODAPHNIA                          9A   DELMON   0        DELMON
           TEP3B 1    0    1

                03/31/98                           E90                                1

      F    LF P/F  STATRE 7DAY CHR PIMEPHALES                           9A   DELMON   0        DELMON
           TEP6C 1    0    1

                03/31/98                           E90                                1
                03/31/99                           E90                                1

   001T 9    A            07/01/93 3            0    10/28/93 3                                             11/01/00 10/31/02

      F    TOXICITY,           CERIODAPHNIA CHRONIC 94   DELMON   0
           61426 1    0    0

                05/31/02                           E90           1

   0011 9    A            09/01/82 1            0    10/28/82 1                                             11/01/00 10/31/02

      F    NITROGEN, KJELDAHL  TOTAL (AS N)         26   50.0     75.0     19   DELMON   4.0      6.0
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| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 00625 1 | W | 0 | | MO AVG | WKLY AVG | | MO AVG | WKLY AVG |
| 12/31/00 | | | E90 | 48.13 | 48.13 | | 5.95 | 5.95 |

SUB-TOTAL QUICK LOOK PRINT LINES: 17

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                                                                       MAJORS IN CAHABA BASIN
                                                                             TOM MCGILL
QL
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*** QL

NPID      FNMS                           MADI RDF9   PERD     PERE     PYQS CYQS PYMS CYMS
--------- ----------------------------- ---- ------ -------- -------- ---- ---- ---- ----
   DSDG PIPQ PIAC PIDT     STRP     NRPU STSU     NSUN STSS     NSUS ILSD     ILED     MLSD     MLED     FLSD     FLED
   ---- ---- ---- -------- -------- ---- -------- ---- -------- ---- -------- -------- -------- -------- -------- --------
      LTYP PRAM                                    LQUC LQAV     LQMX     LCUC LCMN     LCAV     LCMX
      ---- ---------------------------------------- ---- -------- -------- ---- -------- -------- --------
           PRAM  MLOC SEAN MODN                         LQAS     LQXS          LCMS     LCAS     LCXS
           ----- ---- ---- ----                         -------- --------      -------- -------- --------
                MVDT                               MVIO MQAV     MQMX     NODI MCMN     MCAV     MCMX     SNCE SNDE
SRCE
                --------                           ---- -------- -------- ---- -------- -------- -------- ---- --------
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AL0054666 PELHAM CITY OF WASTEWATER PLT  M    CTG    11/19/96 11/30/01 NENN NNNN

   001T 9    A            12/01/91 1            0    04/28/92 1                                         12/01/96 11/30/01

      F    TOXICITY,           CERIODAPHNIA CHRONIC 94   DELMON   0
           61426 1    0    1

                05/31/01                           E90           1
                11/30/01                           E90           1

   0011 9    I    10/01/99 12/01/91 1            0    01/28/92 1                                         12/01/96 11/30/01

      F    SOLIDS, TOTAL       SUSPENDED           26   250.0    375.0    19            30.0     45.0
           00530 1    0    0                            MO AVG   WKLY AVG               MO AVG   WKLY AVG

                01/31/98                           E90  239.6    404.2                  12.0     18.9
                02/28/98                           E90  245      458                    11.6     20.8

      F    NITROGEN, KJELDAHL  TOTAL (AS N)        26   16.7     25.0     19            2.0      3.0
           00625 1    S    0                            MO AVG   WKLY AVG               MO AVG   WKLY AVG

                05/31/98                           E90  19.2     21.0                   1.33     1.38

      F     COLIFORM, FECAL    GENERAL                                    13            200      2000
           74055 1    0    0                                                            MO AVG   WKLY AVG
```

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 05/31/98 | | E90 | | | | | <30 | >40 | | |
| | | 06/30/98 | | E90 | | | | | <30 | >50 | | |
| | F | BOD, CARBONACEOUS | 05 DAY, 20C | 26 | 33.4 | 50.0 | 19 | | 4.0 | 6.0 | | |
| | | 80082 1 S 0 | | | MO AVG | WKLY AVG | | | MO AVG | WKLY AVG | | |
| | | 05/31/98 | | E90 | 36.8 | 48.9 | | | 2.5 | 3.2 | | |
| 0012 9 | A | 10/01/94 1 | | 0 | 11/28/94 1 | | | | | | 12/01/96 | 11/30/01 |
| | F | NITROGEN, AMMONIA | TOTAL (AS N) | 26 | 12.5 | 18.7 | 19 | | 0.5 | 0.7 | | |
| | | 00610 1 S 0 | | | MO AVG | WKLY AVG | | | MO AVG | WKLY AVG | | |

MAJORS IN CAHABA BASIN
TOM MCGILL

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QL
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*** QL

NPID      FNMS                           MADI RDF9   PERD     PERE     PYQS CYQS PYMS CYMS
--------- ----------------------------- ---- ------ -------- -------- ---- ---- ---- ----
   DSDG PIPQ PIAC PIDT     STRP     NRPU STSU     NSUN STSS     NSUS ILSD     ILED     MLSD     MLED     FLSD     FLED
   ---- ---- ---- -------- -------- ---- -------- ---- -------- ---- -------- -------- -------- -------- -------- --------
      LTYP PRAM                                     LQUC LQAV     LQMX     LCUC LCMN     LCAV     LCMX
      ---- --------------------------------------- ---- -------- -------- ---- -------- -------- --------
           PRAM  MLOC SEAN MODN                          LQAS     LQXS          LCMS     LCAS     LCXS
           ----- ---- ---- ----                          -------- --------      -------- -------- --------
                MVDT                                MVIO MQAV     MQMX     NODI MCMN     MCAV     MCMX     SNCE SNDE
SRCE
                --------                            ---- -------- -------- ---- -------- -------- -------- ---- --------
----

                08/31/00                            E90  .94      1.15                   0.8      .09

      F    NITRITE PLUS NITRATE TOTAL 1 DET. (AS N) 26   78.0     117      19   DELMON   2.4      3.5
           00630 1    0    1                             MO AVG   WKLY AVG               MO AVG   WKLY AVG

                01/31/01                            E90  67.2     85.5                   4.0      4.45     T    02/28/01 2
                02/28/01                            E90  58.5     68.7                   3.4      4.7      T    02/28/01 2
                03/31/02                            E90  57.1     81.8                   2.6      3.9

      F    PHOSPHORUS, TOTAL          (AS P)        26   71.7     107      19   DELMON   2.2      3.2
           00665 1    0    1                             MO AVG   WKLY AVG               MO AVG   WKLY AVG

                10/31/01                            E90  45.7     47.35                  2.7      2.9

                                                SUB-TOTAL QUICK LOOK PRINT LINES:     33
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                                                                        MAJORS IN CAHABA BASIN
                                                                              TOM MCGILL
QL
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*** QL

NPID      FNMS                           MADI RDF9   PERD     PERE     PYQS CYQS PYMS CYMS
--------- ----------------------------- ---- ------ -------- -------- ---- ---- ---- ----
   DSDG PIPQ PIAC PIDT     STRP     NRPU STSU     NSUN STSS     NSUS ILSD     ILED     MLSD     MLED     FLSD     FLED
   ---- ---- ---- -------- -------- ---- -------- ---- -------- ---- -------- -------- -------- -------- -------- --------
      LTYP PRAM                                     LQUC LQAV     LQMX     LCUC LCMN     LCAV     LCMX
      ---- -------------------------------------- ---- -------- -------- ---- -------- -------- --------
           PRAM  MLOC SEAN MODN                          LQAS     LQXS          LCMS     LCAS     LCXS
           ----- ---- ---- ----                          -------- --------      -------- -------- --------
                MVDT                                MVIO MQAV     MQMX     NODI MCMN     MCAV     MCMX     SNCE SNDE
SRCE
                --------                            ---- -------- -------- ---- -------- -------- -------- ---- --------
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AL0056251 SHELBY COUNTY COMM NORTH WWTP  M          10/06/00 10/31/05  NNN NNNN

   0011 0    A            10/01/94 1            0    11/28/94 1                                            03/01/94 02/28/99

      F    OXYGEN, DISSOLVED           (DO)                                 19   6.0      DELMON   DELMON
           00300 1    0    0                                                              MO AVG   WKLY AVG

                04/30/00                            E90                          5.4
                05/31/00                            E90                          5.4

      F    NITROGEN, AMMONIA   TOTAL (AS N)         26   25       37.5     19             1.0      1.5
           00610 1    0    0                             MO AVG   WKLY AVG                MO AVG   WKLY AVG

                10/31/98                            E90  5.80     21.3                    0.60     2.15

      F     COLIFORM, FECAL    GENERAL                                      13   DELMON   200      2000
           74055 1    0    0                                                              MO AVG   DAILY MX

                03/31/98                            E90                                   232      328
                05/31/98                            E90                                   240      2000
                03/31/99                            E90                                   660      240

                                                          SUB-TOTAL QUICK LOOK PRINT LINES:      14
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MAJORS IN CAHABA BASIN
TOM MCGILL

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QL
*************************************************************************************************************************
*** QL

NPID      FNMS                           MADI RDF9   PERD     PERE     PYQS CYQS PYMS CYMS
--------- ------------------------------ ---- ------ -------- -------- ---- ---- ---- ----
   DSDG PIPQ PIAC PIDT     STRP     NRPU STSU     NSUN STSS     NSUS ILSD     ILED     MLSD     MLED     FLSD     FLED
   ---- ---- ---- -------- -------- ---- -------- ---- -------- ---- -------- -------- -------- -------- -------- --------
      LTYP PRAM                                    LQUC LQAV     LQMX     LCUC LCMN     LCAV     LCMX
      ---- --------------------------------------- ---- -------- -------- ---- -------- -------- --------
           PRAM  MLOC SEAN MODN                         LQAS     LQXS          LCMS     LCAS     LCXS
           ----- ---- ---- ----                         -------- --------      -------- -------- --------
                MVDT                               MVIO MQAV     MQMX     NODI MCMN     MCAV     MCMX     SNCE SNDE
SRCE
                --------                           ---- -------- -------- ---- -------- -------- -------- ---- --------
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AL0067067 JEFFERSON CO COMM LEEDS WWTP   M           09/20/00 10/31/05      DDNR      CC

   001T 0    A           06/01/95 1            0    07/28/95 1                                             06/01/95 05/31/99

      F    P/F STATRE 7DAY CHR CERIODAPHNIA                                 9A            0
           TGP3B 1    0    0

                10/31/98                           E90                                    10

      F    P/F STATRE 7DAY CHR PIMEPHALES PROMELAS                          9A            0
           TGP6C 1    0    0

                10/31/98                           E90                                    5

   0011 9    A           06/01/95 1            0    07/28/95 1                                             11/01/00 10/31/05

      F    NITROGEN, AMMONIA   TOTAL (AS N)        26   50.0     75.0     19   DELMON   3.0      4.5
           00610 1    W    0                            MO AVG   WKLY AVG               MO AVG   WKLY AVG

                01/31/01                           E90  14.4     34.4                   2.1      5.6

                                         SUB-TOTAL QUICK LOOK PRINT LINES:      12

                                           TOTAL QUICK LOOK PRINT LINES:              482
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