Alapahoochee River Watershed

Watershed Restoration Action Strategy

November 2007

Compiled by: **South Georgia Regional Development Center**

Mission:

To improve watershed health and water quality based upon best management practices, by identifying objectives and goals that are feasible, attainable, and beneficial to the stakeholders.

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Acknowledgement

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Secondly, I would like to thank Valdosta State University for the extensive water quality and aquatic habitat study they performed on the Alapahoochee River Watershed; the USDA—NRCS staff for their assistance in designing and implementing best management practices (BMPs) and working with the landowners; and all the stakeholders of the Alapahoochee River Watershed.

Lastly, I would like to thank the Georgia Environmental Protection Division and the U.S. Environmental Protection Agency for their continued support and dedication to protecting our natural resources. Because of the funding made available through programs such as Section 319(h) Grants, communities are able to initiate efforts that provide the needed "seed" to jump start a community's interests in the environment or simply provide that "extra" assistance to take a project to the next level. Whatever the reason may be, the fact is that the Section 319(h) program has made a huge impact in the Alapahoochee River Watershed and throughout the State of Georgia.

Sincerely,

Angela K. Wall

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Environmental Planner

Acronyms

AAS: Adopt-A-Stream

AS&WCD: Alapaha Soil & Water Conservation District

BMP: Best Management Practice

Cd: Cadmium

CSP: Conservation Security Program

Cu: Copper

CWA: Clean Water Act

CWSRF: Clean Water State Revolving Fund

DO: Dissolved Oxygen

DNR: Department of Natural Resources

DWSRF: Drinking Water State Revolving Fund

EPA: Environmental Protection Agency

EPD: Environmental Protection Division

EQIP: Environmental Quality Incentives Program

FC: Fecal Coliform

FS: Fecal sStreptococci

FEMA: Federal Emergency Management Agency

GA: Georgia

GA EPD: Georgia Environmental Protection Division

GEFA: Georgia Environmental Facilities Authority

GFC: Georgia Forestry Commission

GPS: Global Positioning System

GA S&WCC: Georgia Soil & Water Conservation Commission

Hg: Mercury

NPDES: National Pollutant Discharge Elimination System

NPS: Non—Point Source

NRCS: Natural Resource Conservation Service

NS: Not Supporting

NWF: National Wildlife Federation

NWI: National Wetland Inventory

P2AD: Pollution Prevention Assistance Division

Pb: Lead

PCS: Permit Compliance System

POTW: Publicly Owned Treatment Works

PS: Partially Supporting

RC&D: Resource Conservation and Development Council

S&WCD: Soil & Water Conservation District

SGRDC: South Georgia Regional Development Center

TMDL: Total Maximum Daily Load

UGA: University of Georgia

USCTA: Upper Suwannee Conservation Tillage Alliance

USDA: United States Department of Agriculture

USGS: United States Geological Survey

U.S. EPA: United States Environmental Protection Agency

USRWI: Upper Suwannee River Watershed Initiative

WHIP: Wildlife Habitat Incentives Program

WPCP: Water Pollution Control Plant

WRAS: Watershed Restoration Action Strategy

WRP: Wetlands Reserve Program

WQLS: Water Quality Limited Segments

Zn: Zinc

GLOSSARY

Algae – any of various chiefly aquatic, eukaryotic, photosynthetic organisms, ranging in size from single-celled forms to the giant kelp. Algae were once considered to be plants but are now classified separately because they lack true roots, stems, leaves, and embryos.

Algal bloom – a heavy growth of algae in and on a body of water as a result of high nitrate and phosphate concentrations from farm fertilizers and detergents.

Basin – the land area drained by a river and its tributaries.

Best management practices (BMPs) – an engineered structure or management activity, or combination of these that eliminates or reduces an adverse environmental effect of pollutants.

Blackwater streams – originate in swampy areas and get their names because the water that flows through them is stained dark brown, like the color of tea, by organic acids. This staining gives the appearance of "black" water.

Catch Crop - a cover crop established after harvesting the main crop and is used primarily to reduce nutrient leaching from the soil profile.

Channel – the section of the stream that contains the main flow.

Channelization – the straightening of a stream; this is often a result of human activity.

City/County Comprehensive Plan – a document that establishes a community's future goals and objectives for growth and development. In Georgia, these plans are used as a guide for local governments that incorporate information such as existing infrastructure, housing demands, population projections, economic factors, community facilities, land use, and natural/ cultural resources. Comprehensive plans typically are projected for a range of ten years.

Clarity – clearness of water. This is important in aquatic habitats. When water is not clear, it is called turbid (cloudy water).

Clean Water Act (CWA) – the Act established the basic structure for regulating discharges of pollutants into the waters of the United States and gave the U.S. EPA the authority to implement pollution control programs such as setting wastewater standards for industry, set water quality standards for all contaminants in surface waters, etc.

Clean Water Action Plan – an aggressive plan outlining the next generation of clean water protection by setting strong goals and providing states, communities and farmers with the tools and resources to meet them.

Clear cutting – the removal of all trees in a forest area.

Coastal Plain Province – a low, flat region of well—drained, gently rolling hills and poorly drained flatwoods. The Coastal Plain extends east and south of the Fall Line Hills, the old Mesozoic shoreline still marked by a line of sand hills. In Georgia, the Atlantic Ocean forms the eastern border of the Coastal Plain. The southern border of this province is formed by the Gulf of Mexico, in the State of Florida.

Cover Crop - any crop grown to provide soil cover, regardless of whether it is later incorporated.

Dendritic – a dendritic drainage pattern is the most common form and looks like the branching pattern of tree roots. Tributaries joint larger streams at acute angles (less than 90 degrees). This drainage pattern tends to develop in regions underlain by homogeneous material.

Dissolved oxygen (DO) – oxygen dissolved in water and available for living organisms to use for respiration. The concentration of DO in water is highly dependent on temperature (higher temperatures, lower DO) but pollution also tends to lower the DO.

Ecosystems – an ecological (the relationship between organisms and their environment) community together with its environment, functioning as a unit.

Glossary

Encroachment – any entry into an area not previously occupied.

Environmental steward – someone who strives to sustain natural resources and our environment for future generations.

Erosion – the wearing away of the earth's surface by running water, wind, ice, or other geological agents; processes, including weathering, dissolution, abrasion corrosion, and transportation, by which material is removed from the earth's surface.

Eutrophication – the artificial or natural enrichment of nutrients to a water body, which may lead to depleted oxygen concentrations. Eutrophication is a natural process that is frequently accelerated and intensified by human activities.

Fall Line – the imaginary line that separates the Piedmont and Coastal Plain Provinces of the State of Georgia.

Fecal coliforms (FC) – are bacteria that live in the digestive tract of warm-blooded animals (humans, pets, farm animals, and wildlife) and are excreted in the feces.

Flow – the direction or movement of a stream or river.

Homogenous – where the subsurface geology has a similar resistance to weathering so there is no apparent control over the direction the tributaries take.

Hydrology – the scientific study of the properties, distribution, and effects of water on the earth's surface, in the soil and underlying rocks, and in the atmosphere.

Impaired stream – a stream that cannot attain its use designation based on conclusions from the analysis of biological and chemical data, modeling, and/or NPS monitoring results.

Land use – the actual use of a parcel of land, typically grouped into eight general categories (residential, commercial, industrial, public / institutional, transportation / communication / utilities, parks / recreation / conservations, agriculture / forestry, and undeveloped).

National Pollutant Discharge Elimination System (NPDES) – a permit program that controls water pollution by regulating point sources that discharge pollutants into waters of the United States.

Non—Point Source (NPS) Pollution – pollution that cannot be traced to a specific point, but rather from many individual places (i.e. stormwater and agricultural runoff).

Nutrient – substance which is necessary for growth of all living things (i.e. phosphorous and nitrogen).

Paddocks – a fenced area used for grazing purposes.

Pesticide – a chemical that kills insects and rodents. Pesticides can poison aquatic life when they reach surface waters through runoff.

Phosphorus – a nutrient that is essential for plants and animals.

Point-Source Pollution – a type of pollution that can be tracked down to a specific source such as a factory discharge pipe.

Pollutant – something that makes land, water, or air dirty and unhealthful.

Pollution – any natural or manmade material that contaminates the soil, air, or water.

Riparian – of or pertaining to the banks of a body of water.

Runoff – water, including rain and snow, which is not absorbed into the ground but instead flows across the land and eventually runs into streams and rivers. Runoff can pick up pollutants from the air and land, carrying them into the stream.

GLOSSARY

Section 319 Non-point Source Management Program – this section of the Clean Water Act allows States, Territories, and Indian Tribes to receive grant money to support a wide variety of activities including technical assistance, financial assistance, education, training, technology transfer, demonstration projects, and monitoring to assess the success of specific non-point source implementation projects.

Sediment – soil, sand, and materials washed from land into waterways. Other pollutants may attach to sediment and be carried into the stream.

Sedimentary – of or relating to rocks formed by the deposition of sediment.

Sedimentation – when soil particles (sediment) settle to the bottom of a waterway.

Silviculture - the care and cultivation of forest trees; forestry.

Streambank Stabilization – the process of stabilizing the banks of a stream to minimize or eliminate erosion by either (1) reducing the force of flowing water; (2) increasing the resistance of the bank to erosion; or (3) a combination of both. No single method is appropriate in all situations, but this can be done through but not limited strictly to the following actions: the use of vegetation; soil bioengineering; the use of rock work in conjunction with plants; and conventional bank armoring.

Stormwater Runoff – the water that flows overland during a rain event.

Sub-watersheds – a sub-watershed is a smaller basin of a larger drainage area that all drains to a central point of the larger watershed.

Surface Water – precipitation which does not soak into the ground or return to the atmosphere by evaporation or transpiration and is stored in streams, lakes, wetlands, and reservoirs.

Total Maximum Daily Load (TMDL) – a calculation of the maximum amount of a pollutant that a river, stream, or lake can receive and still be safe and healthy. It is also a means for recommending controls needed to meet water quality standards.

Total Maximum Daily Load (TMDL) Implementation Plan – a plan developed after a TMDL is established to examine the probable causes of pollution and recommended strategies for correcting the problem. The process for developing these plans involves reviewing and updating land use data; visiting the affected watersheds; gathering information and input from stakeholders; and consulting with soil and water experts to determine the most effective solutions.

Water Quality Limited Segments (WQLS) – are segments of waters that do not meet their water quality standard for their designated water classification, even after point sources of pollution have installed the minimum required levels of pollution control technology.

Water Quality Standards – are limits that are established and enforced under state or federal law.

Watershed – the land area from which water drains to a particular water body.

Watershed Restoration Action Strategies (WRAS) – a document that compiles information on a particular watershed and can be used to identify potential projects and funding for implementation.

Wetlands – a lowland area, such as a marsh or swamp that is saturated with moisture, especially when regarded as the natural habitat of wildlife.

Executive Summary

The purpose of a Watershed Restoration Action Strategy (WRAS) is to serve as a master plan, while providing direction for implementation of Best Management Practices (BMPs), restoration, monitoring and education and outreach in the Alapahoochee Watershed. The WRAS integrates the Environmental Protection Agency's (EPA) nine (9) key elements to assess the conditions of the watershed. Specifically, objectives for the WRAS are to:

- Guide other community organizations and agencies in future implementation projects;
- Serve as a tool that the communities can use to improve water quality for their watershed area; and
- Address the watershed planning criteria as required for a WRAS.

As an approved WRAS, projects identified within the plan are given priority consideration for funding under the State of Georgia's Section 319(h) Grant Program, which was established pursuant to the Federal Clean Water Act. The WRAS will help identify possible non—point sources of pollution and provide management measures to help reduce the sources, all in an attempt to meet State and Federal water quality standards.

Chapter 1: Introduction of the Project

1.1. Background Information

The Clean Water Action Plan (CWAP) was released in February 1998 by the US Environmental Protection Agency (EPA), the US Department of Agriculture (USDA), and other Federal agencies. That document outlined a plan to accelerate efforts to protect and restore the nation's water resources. A central element of the plan is a set of actions that are designed to promote a renewed focus by State, Federal, Tribal, and local governments on (1) identifying watersheds that have critical water quality concerns, and (2) working together to focus resources and implement Watershed Restoration Action Strategies (WRAS) to solve these problems.

In 2004, the Seven Rivers Resource Conservation & Development (RC&D) Council entered into a Section 319(h) Grant agreement with the Georgia Department of Natural Resources (DNR) — Environmental Protection Division (EPD) for the development of a Watershed Restoration Action Strategy (WRAS) for the Alapahoochee River Watershed. A WRAS, also known as a Watershed Management Plan (WMP) or Watershed Plan (WP), is defined by the U.S. Environmental Protection Agency (EPA) as "a strategy that provides assessment and management information for a geographically defined watershed, including the analyses, actions, participants, and resources related to developing and implementing the plan." Developing a WRAS allows stakeholders and citizens of the Alapahoochee River Watershed to address water quality concerns and impacts, while increasing the understanding of a watershed development.

Located in Lowndes and Echols County, the Alapahoochee River Watershed is approximately 16 square miles. It contains approximately 274 miles of streams that flow through a wide variety of land uses that vary between agriculture, forest, wetlands, and urban. Based on the Georgia 2004 Section 303 (d) list, there are only two stream segments within the Alapahoochee Watershed that have been found "partially supporting" or "not supporting" of their designated water use, which is fishing.

1.2. Purpose of a Watershed Restoration Action Strategy (WRAS)

The purpose of developing a watershed plan is to provide a tool that demonstrates a holistic approach to watershed management. It takes into consideration the community diversity, land use trends, the overall history of the community and where it wants to be in the future.

Throughout this document you will find information on the Alapahoochee River Watershed such as geology, soil types, hydrology, land use, endangered plant and animal species, impaired stream segments, water quality threats, sources of pollution, critical areas to protect, best management practices (BMPs), public education/outreach, funding sources, and much more. Each of these areas is important to know and understand so that actions can be taken to enhance and preserve your watershed for generations to come.

Over the last couple of years, there has been a significant effort put forth to attempt to evaluate and preserve the water quality and aquatic habitats of the Alapahoochee River Watershed. The WRAS aims to identify pollutant sources, implement development techniques, increase community awareness/involvement, and implement restoration and protection opportunities.

The Alapahoochee WRAS will provide information about the Alapahoochee River Watershed's:

- Physical Description;
- Probable Causes of Impairments and Threats;
- Sources of Pollution;
- Critical Areas;
- Best Management Practices; and
- Funding Sources.

1.3. Environmental Protection Agency's (EPA) Nine (9) Key Elements

The following nine (9) key elements established by the EPA were used as guidelines to complete the WRAS for the Alapahoochee River Watershed. Descriptions of the nine (9) key elements are adopted from EPA language and include:

1. **Identification of Causes & Sources of Impairment**
   An identification of the causes and sources or groups of similar sources that will need to be controlled to achieve the pollution load reductions estimated in the WRAS.

2. **Expected Load Reductions**
   An estimate of the pollution load reductions expected for the management measures described in element #1.

3. **Proposed Management Measures**
   A description of the non-point source (NPS) management measures that will need to be implemented to achieve the pollution load reductions estimated in element #2.

4. **Technical and Financial Assistance Needs**
   An estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon, to implement management measured in element #3.

5. **Information, Education, and Public Participation Component**
   An education component that will be used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the NPS management measures and watershed restoration.

6/7 **Schedule and Milestones**
A schedule for implementing the NPS management measures identified in this plan that is reasonably expeditious. A description of interim, measurable milestones for determining whether NPS management measures or other control actions are being implemented.

8. **Load Reduction Evaluation Criteria**
   A set of criteria that can be used to determine whether load reductions are being achieved over time and substantial progress is being made towards attaining water quality standards.

9. **Monitoring Component**
   A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under element #8.

1.4. Methods

To assess the Alapahoochee Watershed, a variety of tools were utilized including: GIS analysis, water quality data, scientific documents from Valdosta State University (VSU), administration from the South Georgia Regional Development Center (SGRDC), and community input. This section is meant to describe the methods used to assess the watershed and ensuing in management recommendations.

Literature Review

The SGRDC, VSU, and EPD reviewed water quality data, stream assessments, bio-assessments and other natural resource literature as it pertained to NPS pollution and the general watershed characteristics. Documents originated from a variety of sources including: state and federal agencies, VSU, and the SGRDC.

Geographical Information System (GIS)

GIS analyses was used to assess maps for the Alapahoochee Watershed including:

- Topographic;
- Soils;
- Hydrography;
- Groundwater Recharge Areas;
- Wetlands; and
- Water Monitoring Sites.

Community Participation:

Community concerns included:

- Identification of sediment sources;
- Trash and litter in waterways;
- Lack of monitoring;
- Excessive fertilizer application from urban and agricultural use; and
- Lack of education outreach to the public.

Community members and local organizations contributed ideas to address pollutants and education projects which can be found in Chapter 6.

Chapter 2: Description of the Alapahoochee Watershed

2.1 Natural History

One of the first steps in understanding a watershed is through the discovery of its general and natural history. By having a general knowledge of its history and natural resources, this can establish an understanding and appreciation of its existence.

Lowndes County

Nearly 40 years after the State of Georgia was established, Lowndes County was created in 1825 through an act of State legislature and was named for William Jones Lowndes. In 1827, the first town was established, Franklinville, and was designated as the county seat. However, six years later in 1833, a courthouse was built in Lowndesville at the junction of the Little and Withlacoochee Rivers, which resulted in it being established as the new county seat. Approximately four years later, in honor of Georgia Governor George Troup, Lowndesville was renamed Troupville. Based off the U.S. Census, in 1840 there were 4,394 whites and 1,180 African Americans residing in the county. Almost 10 years later, the Lowndes County Commissioners purchased 140 acres to establish a new county seat in 1859. This new county seat was known as Valdosta and named after Governor Troup's plantation home, Val d'Aosta. This third and final move was so the community could connect with a railroad line from Savannah and on July 4, 1860, the first train passed through Valdosta. Today, Lowndes County is approximately 504 square miles and according to the 2000 U.S. Census Bureau had a population of 92,115.

Echols County

Echols County was created from Clinch and Lowndes counties on December. 13, 1858 by an act of the General Assembly (Ga. Laws 1858). Georgia's 132nd county was named for General. Robert Echols (1798-1847), a Georgian who died during the Mexican War. In 1859, Echols County's first courthouse, a frame building, was constructed in Statenville. Statenville, lost their municipal charter on July 1, 1995 and at that point became an unincorporated community under the jurisdiction of their county government. Today, Echols County has approximately 420.8 square miles, ranking 55th out of the 159 counties in the State of Georgia. Based on the U.S. Census bureau the population in 2000 was 3,754.

2.2 Topographic Features

A topographic map is a map that shows topography and features found on the earth's surface. These maps are important tools for studying the earth surface, not only for geologists, but for engineers, foresters, land use planners, hikers, or virtually anyone who travels outdoors. Topographic maps summarize the three dimensional topography of the earth's surface on two dimensional pieces of paper (or computer screens). Like any map, it uses symbols to represent these features. Figure 1 is a topographic map of the Alapahoochee River Watershed indicating elevation through various colors of lines known as contour lines. The color green indicates the lowest elevation, yellow indicates the mid-range of elevation, while the red indicates the highest level of elevation.

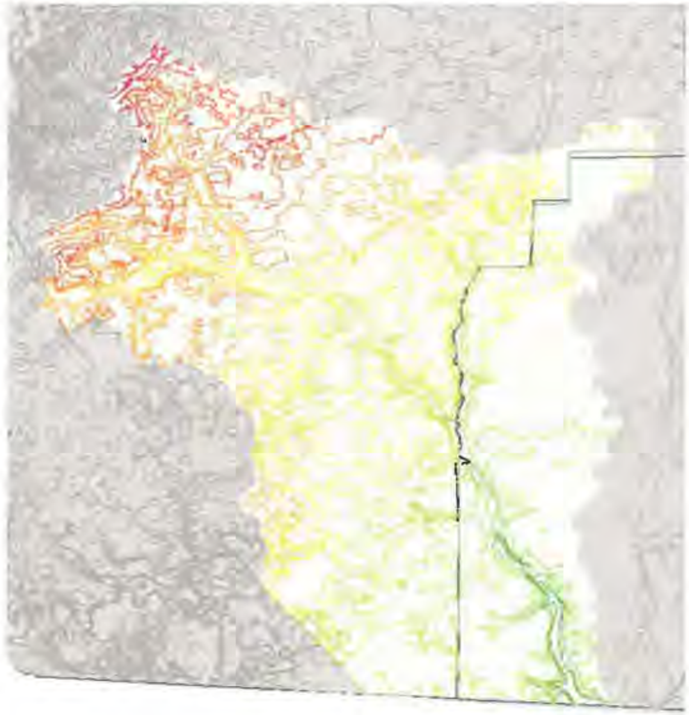


Figure 1: Topographic Map

2.3 Geology

The Alapahoochee River Watershed is located in the Coastal Plain Province of Georgia. The Coastal Plain Province is located just south of the Fall Line and consists of Cretaceous and Cenozoic sedimentary rocks and sediments. The sedimentary rocks of the Coastal Plain consist of sediment eroded from the Piedmont over the last 100 million years or so, and partly of limestone generated by marine organisms and processes at sea.

The most valuable geologic resource in this watershed is the groundwater. The Floridian aquifer provides groundwater for domestic consumption, industry, and agricultural irrigation in the Alapahoochee River Watershed (UGA). The United States Geological Survey (USGS) actively monitors water information throughout Georgia that includes conditions for *stage and stream flow*, *water quality* and *groundwater*. Currently in Lowndes County there is one groundwater site (023177483) and one stage and stream flow site (304949083165301), while Echols County has only one stage and stream flow site (02317500) (USGS, 2006).

A possible geologic hazard in the Coastal Plain Province is sinkholes. Sinkholes form in areas of limestone bedrock when subsurface dissolution of rock leads to a collapse of the earth's surface. Examples of sinkhole lakes that can be found locally include the Balboa and Ponce de Leon lakes found in Lake Park, better known as Twin Lakes.

2.4 Soil Types

Soils are considered to be the most basic and fragile natural resource and should be considered the foundation for any community. The soils within the Alapahoochee River Watershed consist primarily of deep, well drained, or excessively drained, rapidly permeable soils that formed in sandy marine sediments. The soil associations found in the Alapahoochee River Watershed are listed in Table 1.

Table 1: Alapahoochee River Watershed Soil Associations

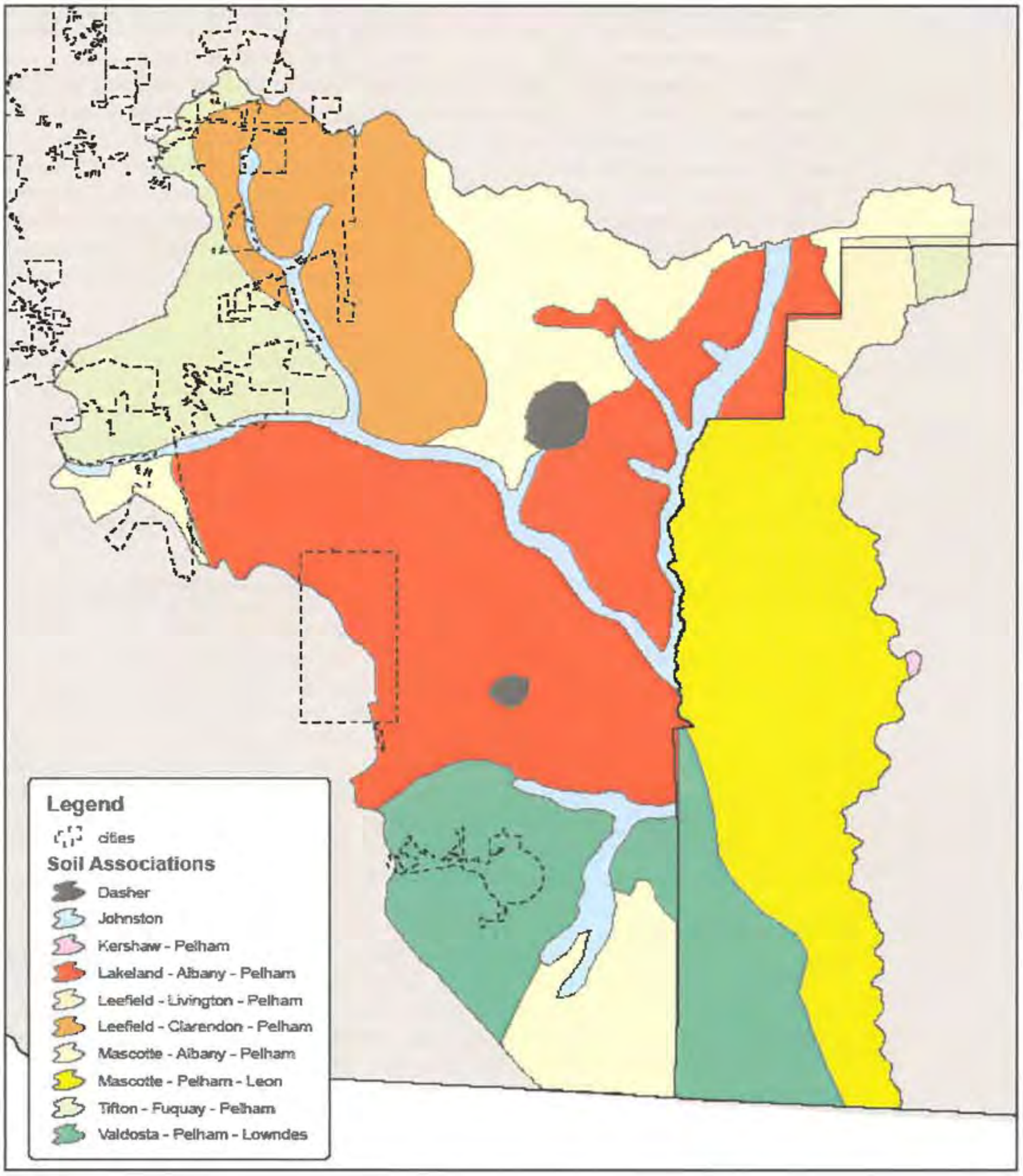
Source: USDA, *Soil Survey of Lowndes County, Georgia*, 1979

Soil Association	Description
Dasher	This association consists of soils in marshes, swamps, and drainage ways. Dasher soils are "very poorly drained". This association is under water except during dry seasons. Most of the association is in hardwood trees and aquatic plants. Because of ponding, this association is severely limited for most non-farm uses.
Johnston	This association consists of long, narrow areas of soils on bottomlands that extend for miles along the major creeks and is made up of "very poorly drained" soils. Most of this association is in hardwood trees and a few pine trees. The main concerns of management are wetness and flooding. Equipment limitations and seedling mortality are concerns in managing this association for woodland. Because of wetness and frequent flooding, limitations are severe for all non-farm uses.
Kershaw—Pelham	Thiss association consist of very deep, excessively drained, rapid permeable soils on uplands and dune-like landscapes of the Coastal Plain. The formed in thick sandy deposits. The Pelham series consists of very deep, poorly drained, moderately permeable soils that formed in unconsolidated Coastal Plain sediments. These soils are on nearly level broad flats, toe slopes, depressions and drainageways. These soils are used mostly for woodland. Native vegetation consists of turkey oak, bluejack oak, and scrub live oak with scattered longleaf pine as the overstory and scattered rosemary, palmettos, and clumps of thin grasses are in the understory.
Lakeland—Albany—Pelham	This association consists mainly of nearly level or very gently sloping soils on broad ridges and nearly level soils on flats and in depressions. Several streams originate within thee association. Lakeland soils are "excessively drained" and nearly level or very gently sloping. Albany soils are "somewhat poorly drained" and nearly level. Pelham soils are "poorly drained" and nearly level. Most of this association is wooded, but some areas are in cultivated crops. A few cleared areas have been planted to slash pine. The main concern of management is the very low available water capacity of the sandy, excessively drained soils. Wetness is the main limitation of Albany and Pelham soils. Most of this association has severe limitations for sanitary facilities because of seepage or sandiness. The Albany and Pelham soils, however, are severely limited because of wetness.
Leefield—Irvington—Pelham	This association consists of somewhat poorly drained soils. These soils have moderate permeability in the upper part of the subsoil and moderately slow permeability in the lower part. They formed in thick beds of loamy and sandy marine deposits. Pelham soils are "poorly drained" and nearly level. Some of these areas are in cultivated crops, but most of this association is wooded. The Irvington series consists of moderately well drained, slowly permeable soils with plinthite and a fragipan. They formed in loamy marine sediments on nearly level to gently sloping uplands and interstream divides. The natural vegetation consist of mixed pines and hardwoods and an understory of gallberry and wiregrass. Some drainage is needed for safe cultivation during most years.

Soil Types

Soil Association	Description
Mascotte—Albany—Pelham	This association consists of soils on broad flats and in depressions and drainage ways. Numerous intermittent ponds ranging from a few acres to many acres in size are throughout the association. Mascotte soils are "poorly drained" and are on broad flats. Albany soils are "somewhat poorly drained" and are on low flats. Pelham soils are "poorly drained" and are in depressions and drainage ways. Most of this association is in wood-land, but some is used for row crops and pasture. Most of this association requires drainage if row crops are to be grown. The drainage system is composed of sluggish intermittent streams in poorly defined channels. This association has medium potential for loblolly pine and slash pine. Equipment limitations and seedling mortality are concerns in managing this association for woodland. Because of wetness, this association has moderate or severe limitations for non—farm uses.
Mascotte—Pelham—Leon	This association consists of deep, poorly drained, moderately permeable soils that have a weakly cemented layer in the subsoil. These soils formed in sandy and loamy marine sediments. They are on low flats. The Leon series consists of very deep, poorly drained and very poorly drained, sandy soils. These soils formed in sandy marine sediments of the Atlantic and Gulf Coastal Plain. They are in areas of flatwoods, in depressions, in low areas on uplands, on stream terraces, and in tidal areas. Wiregrass and pitcher plants, some hradwoods and fair to poor growth of pine occur natively on these soils, commonly referred to as wet savannas.
Tifton—Pelham—Fuquay	This association consists of nearly level and gently sloping soils on ridge tops and hillsides and in drainage ways that dissect the ridges. Tifton and Fuquay soils are on the ridges and Pelham soils are in drainage ways and intermittently ponded depressions. Tifton soils are "well drained" and nearly level or very gently sloping. Pelham soils are "poorly drained" and nearly level. Fuquay soils are "well drained" and nearly level or very gently sloping. Most of the cultivated land in Lowndes County is in this association. Corn, tobacco, soy-beans, cotton, and peanuts are the main crops. Also, some areas are used for permanent pasture. The main concern of management is control of erosion on the gently sloping soils. Pelham soils are used mainly for producing timber, but some areas are in pasture. This association generally has slight limitations for most non-farm uses, but because of wetness and flooding, Pelham soils are severely limited.
Valdosta—Pelham—Lowndes	This association consists chiefly of nearly level to very gently sloping soils on broad ridge tops, gently sloping to sloping soils on hillsides, and nearly level soils in drainage ways. Limestone outcrops and lime sinks are in the association. This association is locally referred to as the "lake county." Valdosta soils are on ridge tops, Lowndes soils are on hillsides, and Pelham soils are in drainage ways. Valdosta soils are "well drained" or "excessively drained" and nearly level or very gently sloping. Pelham soils are "poorly drained" and nearly level. Lowndes soils are "well drained" and gently sloping or sloping. Most of this association is wooded, but some areas are used for row crops and pasture. A few areas have been planted to slash pine. The main concern of management is the low available water capacity in the sandy, excessively drained or well drained soils. Flooding and wetness are the main limitations on Pelham soils. This association generally has moderate limitations for most non-farm uses because of slope, sandiness, or seepage.

Figure 2: Alapahoochee River Watershed Soils Map (Lowndes and Echols)

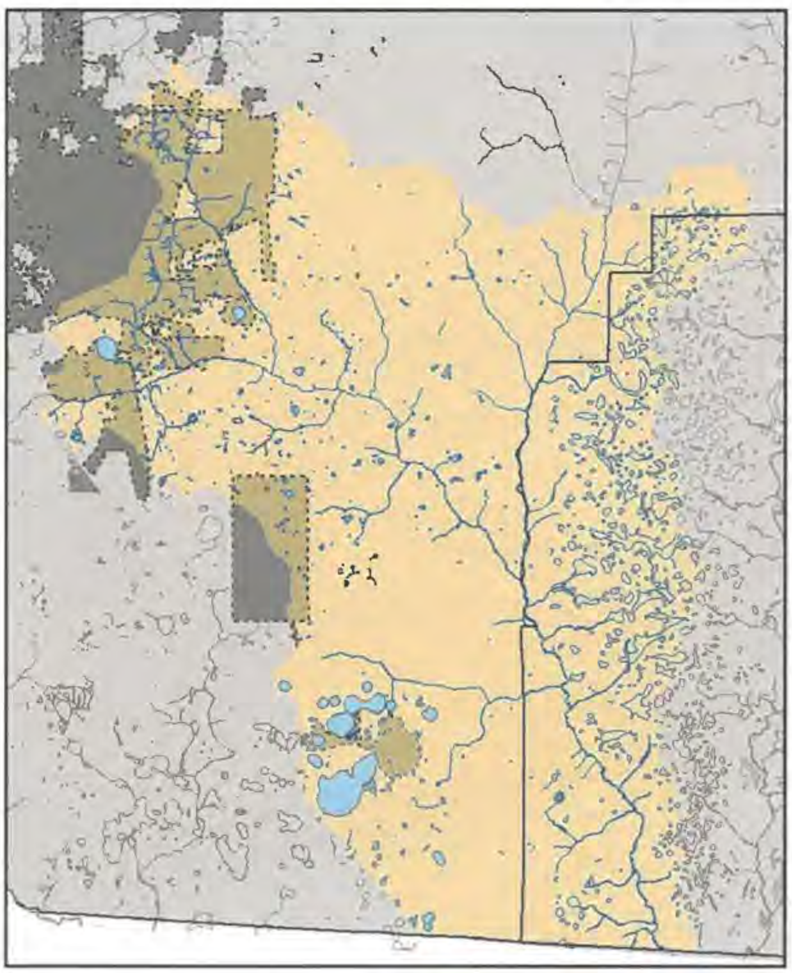


2.5 Hydrology

The Alapahoochee River Watershed has three main streams that flow throughout the year, Mud Creek, Grand Bay Creek, and the Alapahoochee River. The Alapahoochee River actually starts where Grand Bay Creek and Mud Creek join together just south of Glenn Road at the Lowndes and Echols county line. There are several small tributaries that feed into the main streams and some of those include: Enoch Creek, Knights Creek, Meetinghouse Branch, and Otter Creek. There are also numerous unnamed streams that feed into the streams of this watershed; however, many of them are wet—weather streams.

The surface drainage is directed, for the most part, by a dendritic pattern that flows generally southeastward, which ultimately empties into the Gulf of Mexico. In the urban areas of Dasher, Lake Park, and Valdosta, it is common to find that the stream channel has been channelized. In many of the urban streams, there is little vegetation or bare vertical stream banks, which can result in streambank erosion. There is also minimal if any tree buffers alongside the stream banks. In the rural areas of Lowndes and Echols county, the streams tend to be known as "blackwater streams." Due to the landscape contours and annual rain fall, the stream flows in the Alapahoochee River Watershed tend to fluctuate both seasonally and annually.

Figure 3: Alapahoochee River Watershed Map



2.6 Land Use

The Alapahoochee River Watershed is located in south—central Georgia with an elevation range of 98—240 feet. The watershed flows through Lowndes and Echols Counties and is composed of three blackwater creeks that converge to form the Alapahoochee River. The Alapahoochee Watershed drains portions of Lanier, Echols, and Lowndes Counties, with the greatest portion of the watershed lying in Lowndes County. Major terrestrial features that are or may be influencing the watershed include the urbanization of the City of Valdosta, Moody Air Force Base, and extensive lands devoted to the commercial forestry and agricultural practices. With the exception of the City of Valdosta, there are no other towns or cities within the watershed. A series of fact sheets have been completed to inform citizens about land use.

Table 2: Land Use

Type of Land Use	Average Acres
Residential	11,405
Commercial	1,826
Industrial	2,908
Public/Institutional	1,846
Transportation/Communication/ Utilities	4,601
Agriculture/Forestry	78,547
Undeveloped/Unused	3,779

Table 3: Land Use Estimates

Type of Land Use	Average Acres
Residential	17,933
Commercial	13,311
Industrial	3,617
Public/Institutional	7442
Transportation/Communication/Utilities	1,050
Agriculture/Forestry	61,778
Undeveloped/Unused	2,071

2.7 Endangered or Threatened Plant and Animal Species

The Alapahoochee River Watershed is a perceptive watershed that contains a number of endangered plant and animal species. Due to factors such as human modifications to the environment, overexploitation, and habitat loss, plant and animal species are being threatened. In 2004, the Georgia Department of Natural Resource—Wildlife Resource Division updated the list of amphibians, birds, fish, invertebrates, mammals, plants, and reptiles under the Endangered Species Act in the State of Georgia. Table 4 and 5 depicts both plants and animals that are on the "threatened" or "endangered" species list.

Table 4: Lowndes and Echols Counties
Endangered Plants

SPECIES	GEORGIA		FEDERAL	
COMMON NAME—SPECIES NAME	THREATENED	ENDANGERED	THREATENED	ENDANGERED
PLANTS				
Scale-leaf Purple Foxglove—Agalinis aphylla	X			
Florida Leadbush—Amorpha herbacea var.	X			
Savanna Milkweed—Asclepias pedicellata	X			
Leconte Wild Indigo—Baptisia lecontei	X			
Tracy's Dew-threads—Drosera tracyi	X			
Green fly Orchid—Epidendrum conopseum		X		
Southern Umbrella-sedge—Fuirena scirpoidea	X			
Southern Bog-button—Lachnocaulon bey-richianum	X			
Boykin Lobelia—Lobelia boykinii	X			
Carolina Bogmint—Macbridea caroliniana	X			
Savanna Cowbane—Oxypolis ternata	X			
Georgia Milkwort—Polygala leptostachys	X			
Bluff White Oak—Quercus austrina	X			
Yellow Flytrap—Sarracenia flava		X		
Hooded Pitcherplant—Sarracenia minor		X		

Source: Georgia Department of Natural Resources—Wildlife Resources Division—Georgia natural Heritage Program, 2004

Table 5: Lowndes and Echols Counties
Endangered/Threatened Animals

Species	Georgia		Federal	
Common Name—Species Name	Threatened	Endangered	Threatened	Endangered
Animals				
Mud Sunfish—Acantharchus pomotis	X			
American Bittern—Botaurus lentiginosus	X			
Eastern Diamondback Rattlesnake—Crotalus adamanteus	X			
Ocmulgee Shiner—Cyprinella callisema	X			
Bannerfin Shiner—Cyprinella leedsi	X			
Whitefin Shiner—Cyprinella nivea	X			
Eastern Indigo Snake—Drymarchon corais couperi	X		X	
Brown Darter—Etheostoma edwini	X			
Golden Topminnow—Fundulus chrysotus	X			
Gopher Tortoise—Gopherus polyphemus	X		X	
Florida Sandhill Crane—Grus canadensis pratensis	X			
Bald Eagle—Haliaeetus leucocephalus		X	X	
Eastern Milk Snake—Lampropeltis triangulum triangulum	X			
Migrant Loggerhead Shrike—Lanius ludovicianus migrans	X			
Alligator Snapping Turtle—Macroclemys temminckii	X			
Suwannee Bass—Micropterus notius	X			
Wood stork—Mycteria americana		X		X
Striped Newt—Notophthalmus perstriatus	X			
Yellow-crowned Night-heron—Nyctanassa violacea	X			
Black-crowned Night -heron—Nycticorax nycticorax	X			
Island Glass Lizard—Ophisaurus compressus	X			
Glossy Ibis—Plegadis falcinellus	X			
Red-cockaded woodpecker—Picoides borealis		X		X
Suwannee River Cooter—Pseudemys concinna suwannienusis	X			
Dwarf Siren—Pseudobranchus striatus	X			
Sailfin Shiner—Pteronotropis hypselopterus	X			
Striped Crayfish Snake—Regina alleni	X			
Eastern Mudminnow—Umbra pygmaea	X			

Source: Georgia Department of Natural Resources—Wildlife Resources Division

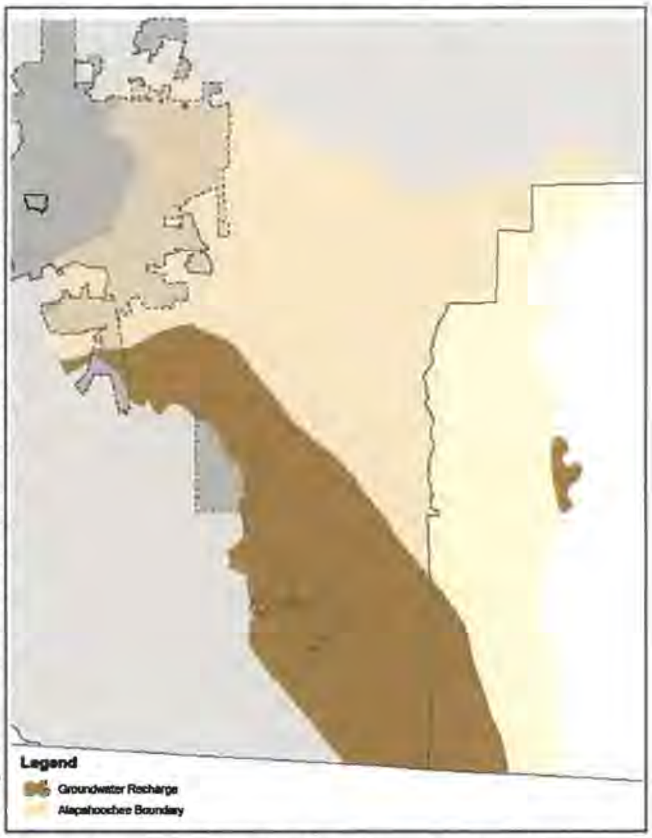
2.8 Critical Areas

Floodplains

Flood hazards along the major rivers and streams typically occur in late winter and early spring. The Federal Emergency Management Agency (FEMA) has not yet prepared official flood area maps also known as Flood Insurance Rate Maps (FIRMs) for Lowndes County. These FIRMS have been requested and will be implemented once they are received. Based on the topography and abundance of rivers and streams, flood hazards do exist in all parts of the watershed and these should be considered when making development decisions.

Groundwater Recharge Areas

Figure 4: Groundwater Recharge Area



A groundwater recharge area is any portion of the earth's surface where water infiltrates into the ground to replenish an aquifer. Groundwater recharge areas can occur at any point where the aquifer updips to become closer to the surface allowing water from streams, sink holes, and ponds to permeate through more shallow ground into the aquifer. All aquifer recharge areas are vulnerable to both urban and agricultural development. Pollutants from stormwater runoff and septic tanks in urban areas and excess pesticides and fertilizers in agricultural areas can access a groundwater aquifer more easily through these recharge areas. Once in the aquifer, pollutants can spread uncontrollably to other parts of the aquifer thereby decreasing or endangering water quality for an entire region. Therefore, development of any kind in these areas, including installation of septic tanks should be restricted.

Approximately 4,632 acres of groundwater recharge areas are found in the portion of Echols County of the Alapahoochee River Watershed. In order to protect these areas, Echols County adopted the Groundwater Recharge Area Ordinance in 2002. Groundwater pollution susceptibility rating for Echols County is predominately "High" based on, "Groundwater Pollution Susceptibility Map of Georgia", Hydrologic Atlas 20, 1992 Edition.

There are nearly 31,622 acres of groundwater recharge areas that lie within Lowndes County portion of the Alapahoochee River Watershed. Considering the impacts on these areas, Lowndes County adopted an ordinance in 2003 to protect groundwater recharge areas, known as the "Water Resource Protection District Ordinance" or WRPDO. The groundwater pollution susceptibility rating for Lowndes County is predominately "Average" based on "Groundwater Pollution Susceptibility Map of Georgia", Hydrologic Atlas 20, 1992 Edition.

Critical Areas

Wetlands

Freshwater wetlands are defined by federal law to be "those areas that are inundated or saturated by surface or ground water at frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions." Wetlands generally include bogs, marshes, wet prairies, and swamps of all kinds. Under natural conditions, wetlands help maintain and enhance water quality by filtering out sediments and certain pollutants from adjacent land uses. They also store water, reduce the speed and magnitude of floodwaters, and serve as an important and viable habitat for plant and animal species.

Wetlands play an important role in mankind's environment and should be preserved for this purpose. A National Wetland Inventory (NWI) database for the geographic extent of Echols and Lowndes Counties has been constructed by the U.S. Department of the Interior, Fish and Wildlife Service and integrated into the two counties Geographic Information System (GIS). Figure 5 depicts the location of generalized wetland areas for Echols and Lowndes Counties. These exist along the floodplains of the major rivers, but most are primarily in small pockets chained together by numerous small streams.

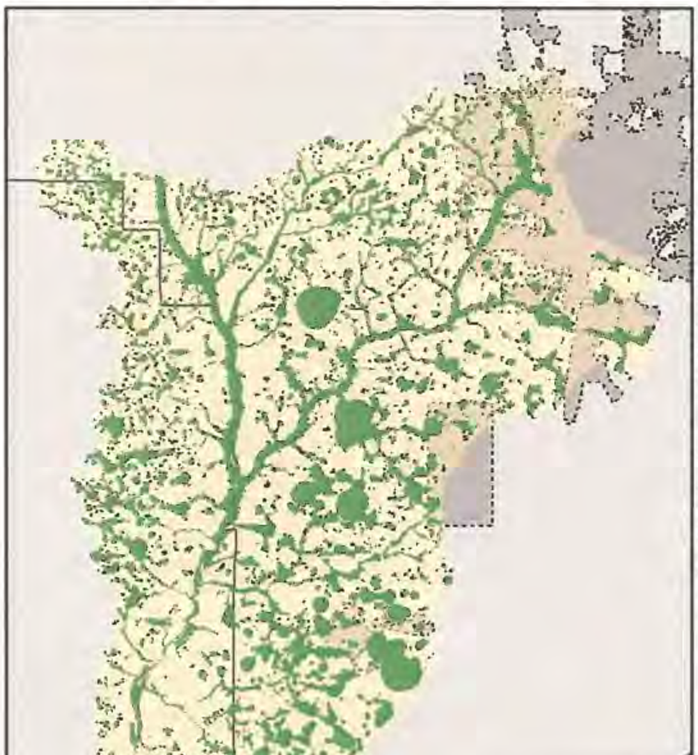


Figure 5: Wetlands

Echols County has approximately 7,532 acres of wetlands, while Lowndes County contains 21,751 acres. Over the past several decades, expansion of both agricultural and urban development in Georgia has caused a steady reduction of wetlands acreage. This has resulted in the destruction of valuable plant and animal habitats, increased magnitude of floodwaters, and the removal of natural filters for surface water drainage thereby endangering water quality throughout many areas. To ensure the protection of the wetlands, the government adopted the Local Wetlands Policy Ordinance in 2002.

Chapter 3: Measurable Milestones and Implementation Measures

3.1 Introduction

The success of the water quality assessment and enhancement program in the Alapahoochee River Watershed depend greatly upon wide—spread public support, educational outreach, and the assistance of stakeholders. The watershed is a valuable and essential source of water needed for both urban and rural communities. These issues, goals, and actions are intended as initial guidance to achieve the vision for the Alapahoochee River Watershed. This chapter will serve four main purposes:

1. Discuss types of pollution within the Alapahoochee River Watershed;
2. Identify best management practices (BMP's);
3. Identify interim measurable milestones that can be used to determine the effectiveness of selected nonpoint source pollution (NPS) management measures in the Alapahoochee Watershed; and
4. Incorporate the measurable milestones into a long—term implementation plan.

In order to identify interim measureable milestones the following methodology was applied:

1. A number of pollution problems and concerns were selected within the watershed;
2. Interim measureable milestones were identified for each pollution problem;
3. An implementation strategy was developed by subdividing the measureable milestones into short—term (within 5 years) and long—term (within 20 years) goals.

3.2 Best Management Practices (BMPs)

In order to make our water resources last as long as possible, we as citizens must help protect them. Best Management Practices (BMPs) can be a vital tool in this protection process. Implementing BMPs is a voluntary practice which preserves or enhances the quality of our soil, water, and/or air. The many different types of BMPs are all very different and can be made to target urban, rural, industrial, or agricultural practices. The USGS defines agricultural BMPs as used to minimize pollutants from agricultural activities from entering water resources (i.e. fencing, nutrient management, cover crops, irrigation water management, etc). The implementation of a BMP is only the first step: BMPs must and should be continually monitored and/or assessed to ensure that the practice is operating properly.

A thorough understanding of BMPs and the flexibility in their application are of vital importance in selecting BMPs which offer site specific control of potential nonpoint source pollution. With each situation encountered at various sites, there may be more than one correct BMP for reducing or controlling potential nonpoint source pollution. Care must also be taken to select BMPs that are practical and economical while maintaining water quality. Although it is unrealistic to expect that all sources of pollution can be eliminated, BMPs can be used to minimize the impacts we have on water quality within and surrounding the Alapahoochee Watershed.

BMPs Implemented in the Alapahoochee River Watershed

3.3 Types of Pollution

Point Source Pollution

Point source pollution includes the discharge of pollutants from a point source such as a well, pipe, ditch, etc. to U.S. waters. To combat point source pollution, the National Pollutant Discharge Elimination System permit program was established under Section 402 of the CWA, which prohibits the unauthorized discharge of point source pollutants from a point source to U.S. waters, including municipal, commercial, and industrial wastewater discharges.

Organizations discharging pollutants directly from a point source into surface waters must obtain a NPDES discharge permit from their State environmental protection agency, or the appropriate EPA regional office if a state has not received EPA permit authorization (40 CFR 122.1). Point source pollution includes direct discharges of industrial and commercial wastewater and industrial storm water discharges.

A NPDES permits establish effluent limitations for point source pollutants that determine what can be discharged into a waterway and how much. Once a NPDES permit is issued, you are required to verify compliance with permit requirements by monitoring their effluent, maintaining records, and filing periodic reports.

Non-Point Source Pollution

Defined by the Environmental Protection Agency, non—point source (NPS) pollution, unlike pollution from industrial and sewage treatment plants, comes from many diffuse sources. Non-point source pollution is caused by rainfall moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters, and even our underground sources of drinking water.

We all play a part! Non—point source pollution results from a wide variety of human activities on the land. Each of us can contribute to the problem without even realizing it.

Non—Point Source Pollution

The primary Non—Point Source (NPS) Pollution concerns of the Alapahoochee River Watershed include the following:

- Soil erosion from farmland fields as well as construction sites;
- Fertilizer runoff from both rural and urban areas;
- Pesticide runoff from both rural and urban areas;
- Animal waste management;
- Stormwater runoff;
- Paint, oil, anti-freeze, and other contaminants;
- Illegal dump sites; and
- Failing septic systems.

These concerns should be considered when implementing BMPs in and around the cities of Dasher, Lake Park, Valdosta and any agricultural area within the Alapahoochee River Watershed.

Table 6:
Ordinances To Address Water Quality

Ordinance	Description
Soil Erosion and Sedimentation Control Ordinance (E&S)	Excessive soil erosion and resulting sedimentation can take place during land disturbing activities. The application of measures and practices shall apply to all features of the site, including street and utility installations, drainage facilities and other temporary and permanent improvements. Measures shall be installed to prevent or control erosion and sedimentation pollution during all stages of any land-disturbing activity.
Water Resource Protection Districts Ordinance (WRPDO)	The intent of this ordinance is to establish minimum development standards and criteria, which will afford reasonable protection of environmentally sensitive natural resources, such as groundwater recharge areas, protected river corridor, or wetlands. Based on the Department of Natural Resources Part V Environmental Planning Standards, the Mountain and River Corridor Protection Act of 1991, it has been determined that the wise management of these resources as defined in this ordinance is essential to maintaining the health, safety, welfare and economic well being of the public, and to provide a guide for future growth and development in the water resource districts as defined.

3.4 Pollution Concern 1: Nutrients

Nutrients such as nitrogen and phosphorus are very prevalent in the Alapahocchee River Watershed and are associated with algal blooms and thus eutrophication which negatively affects the entire stream ecosystem. The high amount of agriculture in this area may be contributing to the higher nutrient loads. Sources of these nutrients may come from fertilizers and animal waste.

Measurable Milestones

1. Assure good animal waste management practices to minimize potential for runoff and groundwater contamination.
   A. Short—term implementation goal: Cover manure piles, contain, and separate waste from any permeable surfaces that increase the risk of leaching.
   B. Long—term implementation goal: Allow companies that process manure to pick up animal waste and make compost.
   C. Long—term implementation goal: Apply for funding incentives and assistance to implement management practices at animal facilities.
2. Encourage BMPs that reduces or eliminates soil loss and provide for the proper application rates of nutrients to croplands.
   A. Short—term implementation goal: Provide education and outreach to all local citizens on the importance of conservation tillage, vegetated buffer strips, diversions, waterways, etc.
   B. Long—term implementation goal: Apply for funding incentives and assistance to implement best management practices such as stream bank fencing, cover crops, field borders, stream buffers, etc.

3.5 Pollution Concern 2: Trash/Litter

Despite environmental regulations that protect the quality of streams, lakes, and wetlands, solid waste in the form of trash, litter, and garbage often ends up in these surface waters. Because surface waters collect in low-lying areas, anything that is dropped or blown into a watershed can eventually reach a drainageway. In urban areas, trash and litter (general terms for dry solid waste) often are transported by stormwater runoff. In both urban and rural areas throughout the watershed, these items sometimes are illegally dumped directly into a waterbody. Regardless of source or type, trash is a form of water pollution. Despite increased environmental awareness, some people still use local streams as a repository for unwanted items, including couches, mattresses, cars, car parts, bicycles, shopping carts, and paint cans.

The most common litter in Alapahoochee River Watershed is household trash, including plastic cups, plastic bags, wrapping materials, fast-food wrappers, plastic bottles, and other plastic containers. Local citizens have become aware of this problem and hope to decrease the amount of pollution in a proactively manner.

Measurable Milestones

1. Prevent illegal littering.
   A. Short—term implementation goal: Establish a "citizen's watch" to prevent illegal dumping.
   B. Long—term implementation goal: Increase penalties and enforcement.
2. Reduce water quality impacts from recreational use of waterways.
   A. Short—term implementation goal: Provide more trash cans along stream banks in high usage area.
   B. Long—term implementation goal: Public information campaign on sanitary practices for recreational use.
3. Increase the capacity of the community to protect and enhance stream ecosystems.
   A. Short—term implementation goal: Expand existing pollution prevention programs.
   B. Short—term implementation goal: Conduct or participate in stream cleanups to remove trash and educate public.
   C. Long—term implementation goal: Promote ongoing water quality education and organize community outreach programs centered around water quality issues.

3.6 Pollution Concern 3: Urban Runoff

Urban runoff consists of water that has drained from man—made non—porous surfaces in densely populated areas. These surfaces consist of roads, freeways, sidewalks, roofed structures, parking lots, and industrial sites found mostly in the northwestern part of the watershed. Any form of precipitation and/or irrigation can scour these surfaces, thereby washing away the materials on top of and from which the surfaces are made. Urban terrain is non—porous and does not have the ability to filter or biodegrade contaminants like natural soil does.

Measurable Milestones

1. Reduce the amount of chemicals in runoff and, therefore, streams.

   A. Short—term implementation goal: Public information campaign on proper disposal of household and animal waste.

   B. Long—term implementation goal: Funding of enforcement and higher penalties for improper use and disposal of chemicals.

2. Prevent pollutants and debris from entering streams.

   A. Short—term implementation goal: Promote the use of engineered vegetated treatment systems such as constructed wetlands or vegetated buffers along streams to filter pollutants and debris in runoff before it reaches streams.

   B. Long—term implementation goal: Continuous efforts to get funding for such projects which can be very costly.

3. Treat surface water runoff.

   A. Short—term implementation goal: Convey and treat surface water runoff with a combination of household level best management practices including rain gardens, pervious surface driveways, landscaping with native vegetation, and using dry swales to capture and treat runoff from landscaped streets and yards.

   B. Long—term implementation goal: Implement pollution prevention and education programs to reduce improper disposal of pet excrement; pick up pet waste around the yard or during walks around the neighborhood and park areas and properly dispose of the waste in garbage cans.

3.7 Pollution Concern 4: Metals

Toxic metals can be present in industrial, municipal, and rural and urban runoff, which can be harmful to humans and aquatic life. Increased urbanization and industrialization is a large contributor for the increased level of trace metals, especially heavy metals, in our waterways. There are over 50 elements that can be classified as heavy metals, 17 of which are considered to be both very toxic and relatively accessible. Toxicity levels depend on the type of metal, its biological role, and the type of organisms that are exposed to it. The heavy metals linked most often to human poisoning are lead, mercury, arsenic and cadmium. Other heavy metals, including copper, zinc, and chromium, are actually required by the body in small amounts, but can also be toxic in larger doses.

Measurable Milestones

1. Encourage proper disposal of hazardous materials.

   A. Short—term implementation goal: Provide for convenient and economic disposal of hazardous materials.

   B. Long—term implementation goal: Increase and enforce penalties for improper and illegal disposal of hazardous materials.

3. Encourage proper storage of hazardous materials.

   A. Short—term implementation goal: Use appropriate areas for storing, draining, and dispensing of toxic materials; establish procedures to contain and treat spills.

   B. Long—term implementation goal: Education of businesses and individuals who use these materials and high penalties for violators.

3.8 Pollution Concern 5: Sediments

When it rains, soil and debris from the surrounding land are eroded and washed into streams. From there, sediment particles from as small as clay to as large as boulders flow along with the water. Fast—moving water can pick up, suspend, and move larger particles more easily than slow—moving waters. This is why rivers are more muddy—looking during storms. They are carrying a lot more sediment than they carry during a low—flow period. The sediment that is being transported into our rivers and streams can carry harmful toxins from both the rural and urban areas within the watershed.

Measurable Milestones

1. Apply any combination of conservation practices and management to minimize the delivery of sediment from agricultural lands to surface waters.

   A. Short—term implementation goal: Promote the use of crop residues, low till or no till farming, cover crops, and crop rotation to minimize bare soil exposure during the rainy season.

   B. Long—term implementation goal: Reduce the amount of impermeable surfaces in the watershed, such as abandoned roads and parking lots.

2. Design and install a combination of management and physical practices to prevent sediments and associated pollutants in runoff from entering streams.

   A. Short—term implementation goal: Re-vegetate stream banks and shorelines with plants that have extensive root systems to hold soil and stabilize stream banks.

   B. Long—term implementation goal: Establish a working partnership with forestry industries and help promote best management practices for forestry.

   C. Long—term implementation goal: Provide funding and resources to create sediment detention/retention ponds and restore the function of natural wetland areas.

3. Implement construction BMPs to reduce runoff from building sites.

   A. Short—term implementation goal: Cover exposed areas that are under development during wet times.

   B. Long—term implementation goal: Ensure that developers prepare and implement an approved erosion and sediment control plan or similar administrative document.

3.9 Pollution Concern 6: Fecal Bacteria

The presence of fecal coliform bacteria in aquatic environments indicates that the water has been contaminated with the fecal material from humans or animals. At the time this occurred, the source water may have been contaminated by pathogens or disease producing bacteria or viruses which can also exist in fecal material. The presence of fecal contamination is an indicator that a potential health risk exists for individuals exposed to this water. Fecal coliform bacteria may occur in ambient water as a result of the overflow of domestic sewage or nonpoint sources of human and animal waste.

Measurable Milestones

1. Prevent sewage from entering water bodies.

   A. Short-term implementation goal: Promote to design new developments to minimize paved surfaces and ensure adequate drainage of roofs, driveways, and other impermeable surfaces; direct runoff to grassy swales and create vegetated buffers along streams.

   B. Short—term implementation goal: Organize and conduct educational programs and events.

   C. Long-term implementation goal: Conduct demonstration projects on stormwater best management practices for residential and commercial development.

   D. Long—term implementation goal: Implement TMDL plans.

3.10 General Classification of Watershed Restoration Goals

Water Quality

- Reduce pollutants of concern;
- Prevent illegal dumping/spills;
- Meet water quality standards;
- Reduce sediment contamination; and
- Protect groundwater.

Biological

- Restore aquatic diversity;
- Restore wetlands/natural areas;
- Enhance wildlife habitat;
- Remove invasive species; and
- Enhance riparian areas.

Community

- Eliminate trash/litter;
- Create greenways/waterfront access;
- Improve beautification;
- Increase citizen awareness; and
- Provide educational materials and programs.

Many different goals can be selected to guide watershed restoration: Most communities have chosen several different goals relating to water quality, biological, and community indicators.

Table 7: Potential BMPs, Cost Estimates, and Load Reduction

Type of BMP	Description	Cost	Expected Load Reduction
Rain Barrels	Barrels that capture rainwater.	$75—$250 each	Very Slight
Infiltration Trenches	Vegetated trenches containing substrates that retrieves runoff from impervious surfaces.	$30—$40 per cubic feet	Moderate
Pet Receptacles	Used to dispose of pet waste.	$110 each	Very Slight
Field/Stream Borders	Permanent vegetation at the edge of a field.	May vary but low cost	Moderate
Animal Exclusion	Confinement from bodies of water and to better manage manure.	$2.50/LF	Moderate
Urban Grassed Swales	Vegetation located in medians or along roads to improve the quality of stormwater.	May vary but low cost	Moderate
Stormwater Wetland	A man—made wetland to treat stormwater.	$90,000—$100,000	Moderate
Heavy Use Area Protection	Mulch, gravel, or concrete needed in areas in which animals use frequently.	$2.50/SF	Slight
Conservation Cover	Maintaining permanent vegetative cover.	May vary but low cost	High
Rain Garden	A planted depression that absorbs rainwater runoff.	$500	High
Permeable Pavement	Allows water to seep through the surface.	May vary but low cost	Moderate
Bioretention Cells	Uses soil, plants, and microbes to treat stormwater runoff.	$11,000+ maintenance	Moderate

* Very slight 0—1%, Slight 1—3%, Moderate 3—5%, High 5—10%.

In order to achieve the vision and goals for the Alapahoochee River Watershed, the following watershed protection and restoration tools and related actions should be considered:

Land Conservation

- Protect sensitive land, water resources, and habitats;
- Purchase key greenway and upland parcels using State and County open space funds;
- Continue research and refinement of regulations for the protection of open space, sensitive resources, and forest conservation;
- Promote forest conservation banking for forest retention and reforestation; and
- Improve land management practices and enforcement on protected lands.

Riparian Buffers

- Establish, protect, and enhance forested buffers for streams, wetlands, and lakes;
- Prioritize locations where buffers are absent;
- Continue planting buffers for green space;
- Promote habitat improvement programs to the rural and agricultural community.
- Develop and implement a strategy for control of invasive plants;
- Encourage private property owners to plant forested buffers, reduce mowing, and use BMPs in existing buffers; and
- Identify and develop funding sources for private and public buffer plantings.

Better Site Design

- Minimize impervious surfaces and maximize open space through techniques such as cluster development and conservation subdivisions;
- Develop an environmental regulations handbook for developers and citizens that explains environmental regulations, provides examples of effective design solutions, and presents the benefits of going beyond minimum requirements;
- Develop environmental agreements, conservation easements, a region greenway corridor, and transfer of development rights;
- Prepare case studies documenting successful projects that reduce impervious cover and increase open space; and
- Continue research and refinement of regulations that promote better site design.

Stormwater Best Management Practices

- Install practices to protect and maintain groundwater recharge, reduce pollutant loads, protect stream channels, and reduce flooding;
- Develop demonstration sites or case studies documenting successful projects to educate developers and engineers;
- Encourage communities, agencies, and nongovernmental organizations to convert existing dry ponds to stormwater wetlands; and
- Partner with the Utility Department to educate citizens on stormwater runoff through workshops.

Other Discharges

- Manage septic systems, sanitary sewers and industrial discharges;
- Address priority pipe outfalls, exposed pipes, and unusual conditions;
- Partner with the Health Department and ensure that problem septic areas are addressed.

Stream Channel Stabilization and Restoration

- Improve aquatic habitat and reduce sediment loads to the stream;
- Address priority erosion sites;
- Conduct an inventory of stream channels throughout the watershed to identify ditches, creeks, rivers, and streams that contribute to the overall water quality of the watershed; and
- Develop guidelines that address channel modifications in urban areas to insure channel changes are avoided or done properly.

Habitat and Wildlife Management

- Establish, protect, and enhance valuable habitat and manage wildlife to support healthy populations of native species;
- Protect and create areas of forest interior habitat, threatened and endangered species habitat, and other areas of diverse sensitive habitat;
- Develop a forest management plan to ensure forest diversity;
- Promote and encourage native plant landscaping;
- Enhance existing wetlands; and
- Endorse development of urban wildlife management studies.

Public Outreach

- Develop partnerships and coordinating efforts;
- Provide a means to communicate problems, solutions, and resources;
- Organize a book of activities and organizations in the watershed;
- Prioritize problems; and
- Develop cost estimates for specific projects, identify potential funding, and secure fund to implement projects.
- Provide educational materials such brochures, websites, factsheets, etc.

Erosion and Sediment Control

- Reduce sediment loss during construction and ensure sensitive areas are protected;
- Maintain State ordinances with the sediment and erosion control program;
- Identify occurrences of land erosion and develop a strategy to encourage stabilization and repair. Examples of such occurrences include agricultural fields lacking vegetation, and unpaved roads and trails.
- Encourage the development and implementation of soil conservation and water quality plans for agricultural lands.

Chapter 4: Technical and Financial

4.1 Financial Needs

Technical and financial support is a major component to project implementation. Several projects are listed below and are meant to provide a general guideline for implementation costs. More important perhaps than the actual cost are the various elements needed to implement a project such as project management, engineering, permitting cost, implementation (e.g. contractor, supply/materials), maintenance, monitoring and administration. Several of the projects (e.g. water quality monitoring and riparian restoration) can use the help of volunteers to off—set the cost. Each project may have additional cost and could vary from location to location.

Community Education

Educating individual landowners on implementing BMPs for small rural and urban landscaping, fertilizer use and pest control, will be important to reduce the amount of non—point source pollution. Education and outreach should include workshops/field days, door-to-door educational campaigns, mailings to strategic landowners, and outreach to local contractors for BMP education. Several important factors will need to be researched for planning the most effective educational campaign such as types of outreach, educational material/delivery method, etc. To implement an education program, the following activities are components of the budget:

- Fiscal Administration;
- Materials;
- Outreach;
- Postage;
- Printing;
- Location Cost;
- Staffing; and
- Transportation

The overall cost for community education on BMPs will vary with the intensity of community outreach, with an estimated cost of: **$45,000—75,000/year.**

Trash Clean—Up

Everyone deserves to live in a community that is healthy, safe, clean and beautiful, and we all have a role to play in achieving this goal. From trash clean—up events to sharing good ideas with other communities around the State to engaging schools, youth, yourself and others in community improvement activities. Trash clean-ups are a project which can largely be accomplished with the use of volunteers and donated services.

These costs will change depending on the number of volunteers, amount of trash, donated items/ services and number of clean—ups. However, some costs are still associated with this activity, including:

- Garbage bags;
- Gloves for volunteers;
- Transportation; and
- Miscellaneous items

The following cost is based on past projects in the Alapahoochee Watershed area: **$600/clean up effort.**

Riparian Restoration

Agriculture and urban development have a great impact on todays riparian lands. Developers tend to clear large areas of streamlines/ riparian land to build homes and establish lawns. Urban residences along rivers and streams are often concerned about floods and property damage. Therefore, flood control dams are built upstream from urban centers, which results in direct and indirect impacts on riparian habitats. Riparian restoration and associated monitoring and maintenance has many variables which affect the cost of a project such as location, size of restoration site/condition, maintenance, and monitoring. The following activities may be part of the cost:

- Fiscal Administration;
- GIS;
- Maintenance;
- Monitoring;
- Staffing;
- Supplies; and
- Transportation

The following costs are approximated at: **$11,000—15,000/acres,** but may vary year to year.

Monitoring

Monitoring for baseline water quality data and project effectiveness data is essential for long-term watershed trends. Monitoring has many variables such as the type of monitoring being conducted, monitoring equipment, sampling frequency and duration of monitoring. To implement monitoring, the following activities will be part of the budget:

- Analysis;
- Fiscal Administration;
- GIS
- Planning;
- Staffing; and
- Supplies

Cost estimates are based on baseline water quality monitoring for temperature, dissolved oxygen, nutrient, fecal coliform, and suspended solids for a one year effort: **$100,000—$150,000/year.**

Bioretention Cell

Bioretention areas function as soil and plant—based filtration devices that remove pollutants through a variety of physical, biological, and chemical treatment processes. The reduction of pollutant loads to receiving waters is necessary for achieving regulatory water quality goals. For a successful bioretention cell, little vegetation will need to be planted and the replacement of new mulch at least once a year. In order to implement this BMP, the following activities may be a part of the cost of accomplishment:

- Fiscal Administration;
- GIS;
- Planning;
- Staffing;
- Maintenance; and
- Materials

The overall cost would be roughly: **$11,000.** This cost does not include continued maintenance.

4.2 Schedule of Implementation and Estimate of Needed Resources

The planned practice schedule is based upon the consensus of prioritization. Actual implementation of practices may vary from the planned schedule due to availability of funding and future stakeholder participation.

BMPs will need to be implemented based on season, therefore if funding is approved, the implementation time will vary depending upon when approval is given. Table 8 provides an estimated time frame on potential projects if funding is available:

Table 8: Schedule of Implementation

Planning Objectives	Status
Secure future funding	Ongoing/2008
Water quality monitoring	Completed/Ongoing
Education outreach	2008—2011
Publications (fact sheets, handbooks, web-site)	2008—2011
Implement recommended BMPs	2008—2010
Field days/tours	2008—2010
Technical Assistance	Ongoing

4.3 Technical and Financial Assistance

Funding is an integral component in making a program not only happen, but successful. There are numerous funding opportunities for local governments, non-profits, and individuals from Federal, State, and local sources. This list is not exhaustive; rather it highlights some of the larger organizations/agencies which provide funding for the types of projects recommended in the WRAS. It is important to note that funding sources and opportunities change on a yearly basis, so always check for the most up-to-date information.

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA) PROGRAMS

The U.S. EPA provides grants to States, non-profits and educational institutions to support high-quality research that will improve the scientific basis for decisions on national environmental issues and help the U.S. EPA to achieve its goals. The U.S. EPA provides research grants and graduate fellowships; supports environmental education projects that enhance the public's awareness, knowledge, and skills to make informed decisions that affect environmental quality; offers information for State and local governments and small businesses on financing environmental services and projects; and provides other financial assistance through programs such as the Drinking Water State Revolving Fund, the Clean Water State Revolving Fund, and the Brownfield's Program. For more information on the U.S. EPA, go to their website, www.epa.gov.

Continuing Program Grants

The Continuing Program Grant is a baseline grant program awarded primarily to States and Tribes. These grants are available under specific statutes (such as Clean Air Act Section 105, Clean Water Act Section 106, Resource Conservation and Recovery Act Section 3011) or under a combination of these programs into a Performance Partnership Grant. The purpose of these grants is to help support ongoing State and Tribal environmental programs, such as air, water, and waste.

Project Grants

Project Grants are available to a broader range of recipients for a wide spectrum of Agency priorities such as pollution prevention, watershed planning, environmental justice, and environmental education. These project grants change from year to year and some of them are managed by the U.S. EPA HQ in Washington, DC.

Clean Water State Revolving Fund Program

Title VI of the Clean Water Act created the Clean Water State Revolving Fund (CWSRF) program. These State-run programs operate much like environmental banks that are funded with State and Federal contributions. The CWSRF provides low interest rates and flexible loan terms for funding wastewater treatment plants, non-point source pollution control and estuary protection. The CWSRF assists a variety of borrowers including municipalities, farmers, homeowners, small businesses and nonprofit organizations.

Technical and Financial Assistance

Water Pollution Control Program

The U.S. EPA provides annual grants to State water pollution control agencies and Indian Tribes to assist them in establishing and maintaining programs to prevent and control water pollution. Water Pollution Control grants are authorized by Section 106 of the Clean Water Act.

Water Quality Cooperative Agreements Program

The U.S. EPA Region 4 provides funds through a competitive process for Water Quality Agreement Grants that are authorized by Section 104(b)(3) of the Clean Water Act. The funds are available for States, Indian Tribes, interstate agencies, and other public or nonprofit organizations. The grants are used to develop, implement, and demonstrate innovative approaches relating to the causes, effects, extent, prevention, reduction, and elimination of water pollution. Awarded grants will have project periods from one to two years.

Water Quality Management Planning Program

Water Quality Management Planning Grants are awarded to States to support unified watershed assessments and watershed restoration priorities. The grants are authorized by Section 604(b) of the Clean Water Act and are generally awarded to state water quality agencies as continuing environmental program agreements. States are obligated to give 40% of the grant money to Regional Public Comprehensive Planning Organizations and Interstate Organizations.

Onsite Wastewater Management Planning Program

The U.S. EPA makes grants to States to provide wastewater operator onsite training and assistance. The program focuses on the needs of Publicly Owned Treatment Works (POTW's) under five million gallons per day that are out of compliance and attempts to bring them back into compliance. Onsite assistance is provided by wastewater professionals from either state environmental agencies or their designated state environmental training centers. The program includes small treatment system security issues. Funds for the grants are authorized by Section 104(g)(1) of the Clean Water Act.

Drinking Water State Revolving Fund Loan Program

Capitalization grants are available to each State for the purpose of establishing a Drinking Water State Revolving Fund (DWSRF) that the State can use to provide loans and other types of financial assistance to both public and private water systems. The water systems use the loans for construction and other infrastructure improvements that achieve or maintain compliance with the requirements of the Safe Drinking Water Act. A portion of each grant is also available to fund programs such as source water protection, state program administration, well head protection, and technical assistance to small systems.

Technical and Financial Assistance

Brownfields Program

The U.S. EPA's Brownfields Program provides direct funding for brownfields assessment, cleanup, revolving loans, and environmental job training. To facilitate the leveraging of public resources, the U.S. EPA's Brownfields Program collaborates with other EPA programs, Federal partners, and State agencies to identify and make available resources that can be used for brownfields activities. In addition to direct brownfields funding, EPA also provides technical information on brownfields financing matters. For more information about this program, go to www.epa.gov/brownfields/pilot.htm.

GEORGIA DEPARTMENT OF NATURAL RESOURCES (DNR) ENVIRONMENTAL PROTECTION DIVISION (EPD)

The Environmental Protection Division (EPD) is a division of the Georgia Department of Natural Resources (DNR). The mission of EPD is to help provide Georgia's citizens with clean air, clean water, healthy lives and productive land by assuring compliance with environmental laws and by assisting others to do their part for a better environment. As a result of the Clean Water Act, each year the State of Georgia receives funding from the U.S. Environmental Protection Agency to assist the State with addressing environmental issues.

Section 106 Grants

Under Section 106 of the Clean Water Act, the U.S. Environmental Protection Agency (U.S. EPA) awards grants to States and interstate agencies to assist them in administering programs for the prevention, reduction, and elimination of pollution, including enforcement directly or through appropriate State law enforcement officers or agencies.

Section 319 (h) Grants

Under Section 319(h) of the Clean Water Act, the U.S. Environmental Protection Agency (U.S. EPA) awards a Non-point Source Implementation Grant to the Georgia Environmental Protection Division (GAEPD) to fund projects in support of the Georgia Non-point Source Management Program. Each year the eligible projects vary, but in previous years projects have included Phase II Stormwater NPDES Programs, TMDL Implementation, Watershed Restoration, Technical Assistance, Education and Outreach, Technology Transfer, Monitoring and Assessment, Best Management Practices Demonstrations, Regulatory Enforcement, and Watershed Restoration Action Strategies (WRAS).

Section 604 (b) Grants

Under Section 604 (b) of the Clean Water Act, each State shall reserve each fiscal year 1 percent of the sums allotted to such State under this section for such fiscal year, or $100,000, whichever amount is greater, to carry out planning under sections 205(j) and 303(e).

Technical and Financial Assistance

USDA – NRCS CONSERVATION PROGRAMS

The U.S. Department of Agriculture – Natural Resource Conservation Service (USDA-NRCS) offers a number of funding opportunities as a result of the Farm Security and Rural Investment Act of 2002. This Act is landmark legislation for conservation funding and for focusing on environmental issues. The conservation provisions will assist farmers and ranchers in meeting environmental challenges on their land. This legislation simplifies existing programs and creates new programs to address high priority environmental and production goals.

Conservation of Private Grazing Land Program

The Conservation of Private Grazing Land Program (CPGL) is a voluntary program that helps owners and managers of private grazing land address natural resource concerns while enhancing the economic and social stability of grazing land enterprises and the rural communities that depend on them.

Conservation Security Program

The Conservation Security Program (CSP) is a voluntary program that provides financial and technical assistance for the conservation, protection, and improvement of soil, water, and related resources on Tribal and private lands. The program provides payments for producers who historically have practiced good stewardship on their agricultural lands and incentives for those who want to do more.

Environmental Quality Incentives Program

The Environmental Quality Incentives Program (EQIP) is a voluntary conservation program that promotes agricultural production and environmental quality National goals. Through EQIP, farmers and ranchers may receive financial and technical help to install or implement structural and management conservation practices on eligible agricultural land.

Farmland Protection Program

The Farmland Protection Program is a voluntary program that helps farmers and ranchers keep their land in agriculture. The program provides matching funds to State, Tribal, or local governments and non—governmental organizations with existing farmland protection programs to purchase conservation easements or other interests in land.

Resource Conservation and Development Program

The Resource Conservation and Development (RC&D) Program encourages and improves the capability of civic leaders in designated RC&D areas to plan and carry out projects for resource conservation and community development. Program objectives focus on "quality of life" improvements achieved through natural resource conservation and community development. Such activities lead to sustainable communities, prudent land use, and the sound management and conservation of natural resources.

Technical and Financial Assistance

Wetlands Reserve Program

The Wetlands Reserve Program (WRP) is a voluntary program that provides technical and financial assistance to eligible landowners to address wetland, wildlife habitat, soil, water, and related natural resource concerns on private land in an environmentally beneficial and cost-effective manner. The program provides an opportunity for landowners to receive financial incentives to enhance wetlands in exchange for retiring marginal land from agriculture.

Wildlife Habitat Incentives Program

The Wildlife Habitat Incentives Program (WHIP) is a voluntary program that encourages creation of high quality wildlife habitats that support wildlife populations of National, State, Tribal, and local significance. Through WHIP, NRCS provides technical and financial assistance to landowners and others to develop upland, wetland, riparian, and aquatic habitat areas on their property.

Chapter 5: Monitoring

Synoptic water quality monitoring, performed by Valdosta State University (VSU), started in the Summer of 2005 and was completed in the Winter of 2006. Sampling was taken at Mud Creek, Grand Bay Creek, and the Alapahoochee River.

Site selection was based on information gathered on topographical maps, aerial photos, visual surveys, and a review of impaired streams listed in Georgia's 2002 list of impaired water body's as required by Section 303(d) of the Federal Clean Water Act. Four types of studies were performed by VSU to complete this water quality analysis. They include: chemical, physiochemical, bacterial and periphyton, and macroinvertebrate analysis.

The following abbreviations are used to designate the collection sites within the Alapahoochee River Watershed:

- Mud Creek = MC
- Grand Bay Creek = GB
- Alapahoochee River = AR

Numbers, 1, 2, 3, and 4 indicate specific collection sites with 1 being upstream and 3 or 4 being furthest downstream.

The collection sites were as follows:

- MC1, Mud Creek at Clyatteville Road, Lowndes County, GA
- MC2, Mud Creek at Inner Perimeter Road, Lowndes County, GA
- MC3, Mud Creek at Vann Road, Lowndes County, GA
- GB1, Grand Bay Creek at HWY 122, Lowndes County, GA
- GB2, Grand Bay Creek at HWY 84, Lowndes County, GA
- GB3, Grand Bay Creek at Howell Road, Lowndes County, GA
- GB4, Grand Bay Creek at HWY 94, Lowndes County, GA
- AR1, Alapahoochee River at HWY 376, Echols County, GA
- AR2, Alapahoochee River at Frank J. Culpepper Rd, Echols County, GA
- AR3, Alapahoochee River at HWY 135, Echols County, GA

5.1 Chemical Analysis

During the time frame of the project no measurable concentrations of arsenic (Ar), nickel (Ni) or mercury (Hg) were detected. There were observable amounts of cadmium (Cd), copper (Cu), lead (Pb) and zinc (Zn).

Copper (Cu): Over the course of the project, only two collection dates showed any significant copper in the water samples. Three collection sites revealed measurable copper in the samples. The highest concentration was at AR 3, with a concentration of 0.465 µg/mL. AR 2 showed a lower concentration of 0.198 µg/mL and both sites were negative for copper the following test date. Also reporting positive for copper was the MC 3 site (0.139µg/mL). Like the Alapahoochee River collection sites, the Mud Creek collection site was negative for copper the following test date. Interestingly, none of these positive tests indicated any type of "wash-down" effect and there is also no evidence of residual material after the initial positive finding. The amount of copper reported is very small, falling well below the EPA maximum contaminate level for primary drinking water (1.3 µg/mL).

A second instance of copper was found with four collection sites reporting measurable concentrations of copper. In this case, two of the collection sites were at GB 3 (0.139 µg/mL) and GB 4 (0.098 µg/mL). The AR 2 (0.085 µg/mL) and MC 2 (0.134 µg/mL) also reported measurable concentrations. As with the previous instance of measurable copper, these positive results did not repeat and were well below the EPA action levels for primary drinking water.

Zinc (Zn): Zinc is the one element which consistently tested positive for essentially all collection sites for the entire project period. The concentration was very low, just above the detection limit in many cases, varying between 0.050 µg/mL to 0.010 µg/mL. There is no primary drinking water standard for zinc. The only useful value for comparison is the National Secondary Drinking Water Standard. This standard, concerned with cosmetic issues, sets zinc concentration at 5 mg/mL. Based on this, it would appear that zinc was not an issue in this watershed at this time.

Lead (Pd): For the entire year of sampling it can be concluded that there was no apparent continuing contamination of the watershed by lead, but several isolated positive tests were observed. Without discernable patterns of lead contamination, all that can be stated is that the data was correctly collected in the field, and properly processed in the laboratory. It is important to recall that the data are being compared to the EPA primary drinking water standard, a very strict standard, and this watershed is not used as a source of potable water.

Cadmium (Cd): The cadmium data also shows a measurable concentration by the UGA Analytical Laboratory. Measurable concentrations of cadmium were observed in 10 samples collected during the study. These samples were distributed across all the rivers or creeks (MC 1 and 2, GB 3 and 4, AR 1-3). The levels varied from approximately 0.020µg/mL to 0.200µg/mL. These concentrations are above the drinking water standard of 0.005µg/mL. In the instances of measurable concentrations, there is no discernable pattern to the contamination, so the probability of a release seems unlikely.

5.2 Physicochemical Analysis

Bi-weekly sampling of the collection sites were measured for temperature, pH, and electrical conductivity. Laboratory analysis included measuring concentrations of nitrite, total phosphorus as phosphate, chemical oxygen demand (COD), and total suspended solids (TSS). Before and after sampling field work, all the sampling equipment were washed and rinsed with deionized water.

Electrical Conductivity (EC): Electrical conductivity (EC) is the ability of a substance to conduct an electrical current. The presence of dissociated ions in solution renders the solution conductive. As ion concentrations increase, conductance of the solution increases; therefore, the conductance measurements provides an indication of ion concentration. Because of the longer residence times of groundwater, it has higher electrical conductivity than surface waters. Thus, streams with base flows originating from soluble rocks show higher electrical conductivity. In the study area, electrical conductivity variations are controlled by variations in groundwater contribution to the streams. In all sampling sites, electrical conductivity tends to decline after significant surface runoff caused by rainfall. Overall, samples from the Alapahoochee River show higher electrical conductivity most likely due to limestone bedrock and possible recharge from karst springs or from the Valdosta Wastewater Treatment Plant.

Relatively high average EC value for Mud Creek results from the MC 3 collection site that stands out with anomalously high values in all parameters.

	Grand Bay Creek	Alapahoochee River	Mud Creek
Maximum	129	502	1125
Minimum	7	28	9
Average	50	196	187

Total Phosphorus: There are many sources of phosphorus, both natural and human. These include soil and rocks, wastewater treatment plants, runoff from fertilized lawns and croplands, failing septic systems, runoff from animal manure storage areas, disturbed land areas, drained wetlands, and commercial cleaning preparations. Considering the agricultural and industrial land use practices in the watershed, the phosphate concentrations measured in the three stream systems are not significant. This can be explained by adsorption and uptake by riparian vegetation.

	Grand Bay Creek	Alapahoochee River	Mud Creek
Maximum	3.71	2.28	5.50
Minimum	0.01	0.03	0.07
Average	0.79	1.13	0.91

Chemical Oxygen Demand (COD): The chemical oxygen demand (COD) test is commonly used to indirectly measure the amount of organic compounds in water. It is a measure of the oxygen equivalent of the organic matter content of a sample that is susceptible to oxidation by a strong chemical oxidant. Most applications of COD determine the amount of organic pollutants found in surface water (e.g. lakes and rivers), making COD a useful measure of water quality. As shown below, Grand Bay Creek samples show a decreasing trend of COD from upstream to downstream, whereas collection sites at the Alapahoochee River had similar COD values. Samples from Mud Creek produced a generally parallel trend.

	Grand Bay Creek	Alapahoochee River	Mud Creek
Maximum	163.0	113.0	165.0
Minimum	15.0	15.5	8.5
Average	86.9	53.5	72.8

Hydrogen Ion Concentration (pH): It describes the degree of acidity or alkalinity of a solution. All but the Alapahoochee River and MC 3 waters generally show pH ranges below the minimum desired value of 6.0 for natural waters not associated with blackwater systems. These showed prevailing acidic conditions/ especially in the Grand Bay Creek and Mud Creek systems with the exception of anomalously high values of pH in MC 3. Higher pH values for the Alapahoochee River indicate potential influences from groundwater input from the limestone aquifer where groundwater acidity is buffered by the dissolution by limestone.

	Grand Bay	Alapahoochee	Mud
Maximum	6.95	7.72	8.29
Minimum	3.96	5.10	3.91
Average	4.75	6.21	6.21

Nitrite: In surface waters, nitrite it is created by bacterial oxidation of ammonia produced by fish and decomposing organic matter. Although it is less toxic than ammonia, elevated levels still present a threat to fish health. Analysis of water samples for nitrite show extremely low concentration. Thus, no graphs and discussions have been provided for nitrite.

Total Suspended Solids (TSS): Sediment is a common pollutant in many streams, but the amounts measured in this watershed were, with two exceptions, quite low. The two higher readings (78 mg/L and 164 mg/L) came from MC 1 and 3 when water levels were low and samples were difficult to obtain. If these suspect data are removed, the average value of TSS for Mud Creek becomes 6.4 mg/L, essentially the same as found in Grand Bay Creek and the Alapahoochee River.

	Grand Bay Creek	Alapahoochee River	Mud Creek
Maximum	33	30	164
Minimum	<1	<1	<1
Average	6.5	6.4	9.2

Grand Bay Creek drains an area predominantly comprised of wetlands and forests. This matched relatively high COD and acidic pH values. Water quality is not likely to be impaired by the very small spatial coverage of high density urban areas (1.0%).

Mud Creek represents an area of wider range of land use practices. Water quality parameters showed typical wetland waters. However, relatively large high density urban areas around the City of Valdosta (~7.0%) may have negative effects on the water quality of Mud Creek. Especially MC 3 samples, with their anomalous water quality parameters, could be impaired by effluents from the City of Valdosta waste water treatment plant located directly upstream from the collection site.

5.3 Bacteriological and Periphyton Analysis

At each collection site two readings of solar radiation (photosynthetic photon flux density), water temperature, and dissolved oxygen concentrations were taken. Water color and turbidity were determined at each collection site, as were cloud cover, precipitation, and wind speed.

Water Temperature and Oxygen Concentration: The temperature data reflect the annual variation in air temperature for the region and are consistent within the watershed. Oxygen concentrations generally indicated well-oxygenated waters with the exceptions of MC 1, GB 1, and during times of low water, GB 2 and GB 3. In fact, oxygen levels in MC 1 and GB 1 were consistently below the minimum standard of 4.0 mg/L designated for rivers used for fishing in the coastal plain during warm weather. The low oxygen content at these collection sites probably was the result of natural rates of decomposition within the swamps and not the result of human impacts.

Microbiological Analysis:

Escherichia coli counts were generally below 575 cfu/100 mL, the maximum allowable point measurement in waters not generally used for swimming. There are a number of small spikes above 500 cfu/100mL and a general upward trend in the numbers at all of the Alapahoochee River collection sites that cannot be accounted for. Secondly, *Enterococcus* counts in GB 1 and 2 showed anomalous increases during the Winter months. Third, the numbers of enterococci in MC 2 and 3 and in the Alapahoochee River collection sites, while highly variable, are consistently well above the suggested limit of 151 cfu/100 mL recommended for rivers not generally used for swimming. The source of these bacteria is not clear. Fecal contamination from the surrounding farms, which include herds of dairy cows, is a potential source.

5.4 Macroinvertebrate Analysis

Macroinvertebrates are invertebrates that are large enough to be seen with the naked eye. These may include aquatic insects, snails, clams, mussels, crayfish and worms. The macroinvertebrate community structure can provide information on the health of a stream. Over extended periods of time, the types of macroinvertebrates present can reflect water quality and/or habitat quality of a stream.

The results below were analyzed using Georgia Adopt-a-Stream (AAS) scores and tolerance values (TVs). Mean AAS scores for stream quality in the Alapahoochee River Watershed range from 2 to 23. Of the 67 AAS scores (Figure E1) calculated for the collection sites for each collecting period, 56.7% are ranked as poor, 35.8% are ranked as fair, 6.0% are ranked as good, and 1.5% are ranked as excellent. The lowest mean AAS scores occurred at collections sites MC 3, GB 4, and AR 1-3, those sites with higher pH values. The AAS scores examined by each creek within the watershed showed that AAS values were highest near the headwaters (Grand Bay Swamp and Mud Swamp) and declined as the creeks approached their confluence to form the Alapahoochee River, with both creeks having mean values in the poor range at the collection sites nearest their confluence. The Alapahoochee River showed a slight increase in mean AAS scores from collection sites AR 1-3, but they never rose above a ranking of poor. Looking at mean AAS scores, it might be concluded that the overall water quality in the watershed was generally poor.

A grand total of 4,110 invertebrates were collected over the course of the project representing 13 orders, 45 families and more than 69 genera, some of which were not carried out to the level of genus. Of these, tolerance values (TVs) could be assigned to 54 of the genera and a range of tolerance values could be assigned to four families for which the members were not identified to the genus level. The total number of specimens collected over the course of the project showed a decline in the total number of specimens from the headwaters of Mud Creek and Grand Bay Creek to collection sites AR 1-3 and are depicted as mean averages. Concomitantly, the number of families and genera showed a similar pattern of decline from the headwaters to the collection sites on the Alapahoochee River. Statistical analysis of these trends by collection sites consistently possessing high verses low pH values showed that total invertebrate number, families, and genera were all statistically significant.

5.5 Recommendations

The research team for this project, makes the following recommendations:

Determine the actual causes for the changes in the shift of the Alapahoochee River Watershed from a blackwater system to one resembling a limestone buffered system with higher conductivities and pH values. This would mean looking more fully into the exact sources and their proportional roles in causing the changes observed. Sources of change to specifically address would be:

1. Effluent from the City of Valdosta's wastewater treatment plant.
2. Undetermined factors causing periodic physicochemical changes at GB 4.
3. Contribution of springs and seeps at AR 1-3.

Determine what factors are contributing to the change in the biological community to include:

1. Impacts associated with changes in the physicochemical nature of the watershed.
2. Role of key predators such as *P. spiculifer*.
3. Role of changes in habitat from the headwaters to the downstream watershed in the area of AR 1-3.

Should it be learned that the City of Valdosta wastewater treatment plant is the primary contributing factor to changes in the water chemistry of the watershed, the biological watershed, then it is recommended that the parameters for effluent release from such systems be reexamined such that they match the system they are being released into rather than a broad general standard set up for the entire country.

Chapter 6: Community Outreach, Education, and Participation

6.1 Introduction

A key component to developing the Alapahoochee River Watershed WRAS is stakeholder participation. A strategy was developed to provide public participation in the growth of the Alapahoochee River WRAS. Increasing public understanding about environmental resources and better land management is important to the success of the watershed restoration effort. During the development of the WRAS, participation from citizens and partnering organizations were conducted to inform watershed residents about the WRAS and to encourage participation in the planning process. Based on existing land use within the watershed, this outreach component targets the included audiences—the residential community, the agricultural community, municipalities and the school systems located in the watershed.

6.2 Members

Each watershed should seek at a minimum membership participation from the following segments of the population:

- Interested Citizens and Community Organizations;
- Private Landowners;
- Agricultural Producers;
- County, State and Federal land management/natural resource agencies (e.g. Department of Natural Resources, Soil and Water Conservation Districts, Natural Resources of Conservation Service, Georgia Forestry Commission, etc.)
- Academia;
- Elected Officials;
- Municipalities;
- Private Industry

This cross-section of the community will ensure the watershed has balance interest represented and draw from different expertise and disciplines. Additionally, the participation of theses sectors, will facilitate the sharing of information, and limit duplication of efforts; which will maximize limited funding for watershed education, monitoring and restoration activities.

6.3 Meetings

At a minimum, quarterly meetings should be conducted with the partners within the watershed, at which time participating members are encouraged to bring concerns and issues to the table for discussion, investigation, prioritization, implementation and review. Meetings conducted should be focused on issues which are relevant for the local watershed. Meetings should be conducted where all participating members have an equal voice and vote, creating an atmosphere which encourages active dialogue and participation.

In order for this WRAS to be successful, all members must be willing to work together, have an equal voice and vote, realize the value of both public and private partnerships and forge collaboration within the various State agencies.

6.4 Staffing

To ensure the success of the implementation of the WRAS, the position of a WRAS/ Environmental Coordinators should be created. The responsibilities of the coordinator(s) should include, but are not limited to:

- Maintaining key point contact with partners within the watershed;
- Meeting facilitator;
- Partnership facilitation;
- Research project feasibility;
- Grant research and writing;
- Project implementation, management and reporting; and
- Data/ information dissemination.

Providing staff to the implementation of the WRAS relieves volunteer council members from the day-to–day administrative activities and provides continuity and institutional knowledge of projects taking place within the watersheds.

6.5 Education

Educating the public about relevant watershed issues is an important tool for a comprehensive restoration program. Educating a broad – section of the population, including K-12, college students and adults regarding local watershed issues, such as water quality/ quantity, and NPS pollution will provide opportunities for active involvement to improving long—term watershed health growth.

With the help and support of the partnerships created within the watershed, the project coordinator(s) should be able to implement the WRAS educational projects which will involve not only students that participate, but also community organizations such as the YMCA, 4-H, and FFA. Additionally, projects should include college students for more in—depth studies and data collection and/ or hands-on restoration projects.

Education should be based on local conditions, such as NPS pollution, water quality/quantity, land owner/ farm practices, forestry environment and BMP establishments. This involvement allows the public to have a greater understanding and appreciation of their local surroundings, need for stewardships and active involvement in restoration and protection of our natural resources. Various approaches and opportunities can be created to deliver environmental education. A few of these approaches are listed below:

K-12 Education

Environmental education at an early age with a sustained delivery is the best approach to improve long-term watershed health and citizen understanding of watershed issues, watershed science, active restoration and protection. Education that begins at an early age provides a foundation for understanding how to improve and protect watershed health through stewardship and hands-on learning.

College Students

Offering opportunities to college students can provide additional educational opportunities including high integrity data collection, analysis, and volunteers for on—the—ground restoration. Partnering with biology, environmental science classes, or geo-science classes on projects provide in-kind match, students for data collection, and localized environmental education.

6.6. Outreach Activities and Community Education

Outreach activities are projects that can be used to protect and improve your watershed. In order to participate, you should first find out what is going on in your watershed. There are several organizations that you can join and participate in activities and projects that are already occurring in the Alapahoochee River Watershed, such as the Upper Suwannee River Watershed Initiative (USRWI), the Upper Suwannee Conservation Tillage Alliance (USCTA), local Georgia Adopt-A-Stream groups, etc.

Watershed Field Days and Workshops

A wonderful way to bring interested citizens together and provide them with resourceful information is to assemble field days and/or workshops on specific topics of interest. The Alapahoochee River Watershed Coordinator collaborated with numerous partners to plan, organize, and hold several field days to educate local citizens on the importance of protecting our water resources in the Alapahoochee River Watershed.

Agricultural Field Days

Designed to promote BMPs, a series of three field days were held on June 13, 2007 in southern Lowndes County. The demonstration of three BMPs included: pasture planting, exclusion fencing, and low drop irrigation sprinklers. The installation of these particular BMPs will help facilitate the reduction of sediment and fecal coliform loads in streams within the Alapahoochee River Watershed. Several speakers presented from agencies such as USDA—Natural Resource Conservation Service (NRCS) and the University of Georgia (UGA).

Septic System Field Day

The fourth field day was held on July 30, 2007 at a landowners house in the northern portion of the Alapahoochee River Watershed in Lowndes County. The property consisted of a single family residence with a problem of surfacing effluent from the septic system. The Lowndes County Health Department spoke on the importance of maintaining a septic system and tips on water conservation.

"Bark in the Park"

The fifth field day was held on October 27, 2007 to promote the use of pet receptacles in local parks within and around the Alapahoochee River Watershed. "Bark In The Park," invited all pet owners to enjoy a day with their dog and learn about the importance of scooping the poop! The SGRDC partnered with the City of Valdosta and the Valdosta—Lowndes Recreation, Parks, and Community Affairs Department, and many others to make this event a huge success. Approximately 45 dogs and 60 people attended this event.

Georgia Adopt—A—Stream Program

A way to involve citizens in local activities is to get involved in your community's Adopt—A—Stream (AAS) program. The Georgia AAS is a statewide volunteer water quality monitoring program that offers many levels of involvement including: stream clean—ups at basic levels and more advanced workshops in visual, physical, chemical, and biological monitoring. The goals of Georgia ASS are to:

- Increase public awareness of the State's non—point source pollution and water quality issues;
- Provide citizens with the tools and training to evaluate and protect their local waterways;
- Encourage partnerships between citizens and their local government; and
- Collect quality baseline water quality data.

Two AAS training workshops were held in the Alapahoochee River Watershed to learn about the Biological and Chemical Stream Monitoring process. Volunteers can monitor their waterways without attending a workshop, but those who attend and pass the Quality Assurance/Quality Control (QA/QC) test will then be considered quality data collectors under the Georgia AAS Quality Assurance Project Plan (QAPP).

Over the last three years, the Alapahoochee 319 Project Coordinator worked in organizing, participating, and holding Georgia AAS workshops.

River Alive Program

Rivers Alive is Georgia's annual volunteer waterway cleanup event that targets all waterways in the State including streams, rivers, lakes, beaches, and wetlands. The mission of Rivers Alive is to create awareness of and involvement in the preservation of Georgia's water resources. Rivers Alive is held annually each October and is sponsored by the Georgia Department of Natural Resources' Georgia Adopt—A—Stream Program and the Georgia Department of Community Affairs' Keep Georgia Beautiful Program. Anyone can volunteer!

Outreach activities are projects that can be used to protect and improve your watershed. In order to participate, you should first find out what is going on in your watershed. There are several organizations that you can join and participate in activities and projects that are already occurring in the Alapahoochee River Watershed, such as the Upper Suwannee River Watershed Initiative (USRWI), the Upper Suwannee Conservation Tillage Alliance (USCTA), local Georgia Adopt-A-Stream groups, etc.

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Appendix B:
Water Quality and Aquatic Habitat Monitoring Report

Water Quality and Aquatic Habitat Assessment for the Alapahoochee Watershed

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A. Introduction

Collection Site Descriptors

The following final report is submitted as required for the Watershed Restoration Action Strategy (WRAS) Development in the Alapahoochee Watershed project. Throughout this report the following abbreviations are used to designate the collection sites within the Alapahoochee Watershed:

- Mud Creek = MC
- Grand Bay Creek = GB
- Alapahoochee River = AR
- Numbers, 1, 2, 3, 4 indicate specific collection sites with 1 being upstream and 3 or 4 being furthest downstream.

The collection sites were as follows:

- MC1, Mud Creek at Clyatteville Road, Lowndes County, GA
- MC2, Mud Creek at Inner Perimeter Road, Lowndes County, GA
- MC3, Mud Creek at Vann Road, Lowndes County, GA
- GB1, Grand Bay Creek at HWY 122, Lowndes County, GA
- GB2, Grand Bay Creek at HWY 84, Lowndes County, GA
- GB3, Grand Bay Creek at Howell Road, Lowndes County, GA
- GB4, Grand Bay Creek at HWY 94, Lowndes County, GA
- AR1, Alapahoochee River at HWY 376, Echols County, GA
- AR2, Alapahoochee River at Frank J. Culpepper Rd, Echols County, GA
- AR3, Alapahoochee River at HWY 135, Echols County, GA

Description of the Alapahoochee Watershed

The Alapahoochee Watershed (Figure C1; C7a, b; C8a, b; C9; C10) is composed of three blackwater creeks that converge to form the Alapahoochee River, which flows into the Alapaha River, which in turn flows into the Suwannee River. The Alapahoochee Watershed drains portions of Lanier, Echols, and Lowndes Counties with the greatest portion of the watershed lying in Lowndes County. Major terrestrial features that are or may be influencing the watershed include the urbanization of the City of Valdosta, Moody Air Force Base, extensive lands devoted to commercial forestry practices, and extensive agricultural lands devoted to the cultivation of warm weather crops such as tobacco, peanuts, tomatoes, peppers, eggplants, and cole crops such as lettuce and cabbage. With the exception of the City of Valdosta, there are no other towns or cities within the watershed.

Mud Creek (MC 1, 2, and 3) drains Mud Swamp, a 42.5 hectare wetlands that lies southwest of Valdosta in the west-central portion of the county. As Mud Creek drains Mud Swamp, it flows east between the regional airport and an industrial park, and after crossing Inner Perimeter Road, flows southeast until it joins Grand Bay Creek. Mud Creek is most influenced by the regional airport, a moderate sized industrial park immediately north of the airport, the sewage treatment plant operated by the City of Valdosta, and surrounding forest lands. Some agricultural and cattle ranching also occurs in its more eastern portion, but is minimal compared to other areas of the watershed. Mud Creek passes though mostly flatwoods habitat.

Knight's Creek is a small tributary which runs predominantly south until it joins Mud Creek just after it receives effluent from the sewage treatment plant. It has its origin in a wooded area on the east side of Valdosta and is most influenced by a housing development taking place immediately to the west and some timber and agricultural lands at its southern end. The creek winds through flatwoods habitat and near the headwaters has been channeled such that the creek runs in straight lines at various points and the channeled bed of the creek has filled in with a fine silt that varies from 15-60 cm deep. Sampling was not carried out on Knight's Creek, but sites MC 2 and 3 lie above and below its confluence with Mud Creek.

Grand Bay Creek (GB 1, 2, 3, and 4) drains Grand Bay Swamp, a 5,263 hectare wetlands, which lies on the northeast corner of Lowndes County and the Southwest corner of Lanier County. Moody Air Force base lies on the western edge of this large wetland. Grand Bay Creek flows south out of Grand Bay Swamp paralleling the Lowndes-Echols counties border. It flows primarily through flatwoods habitat used extensively for timberland and sod culture with smaller portions used for agriculture. At least two small creeks feed into Grand Bay Creek, one ephemeral creek just below GB 1 and the other a permanent creek whose confluence with Grand Bay Creek lies about 2.0 km below GB 2.

The Alapahoochee River (AR 1, 2, and 3) is formed by the convergence of Mud Creek and Grand Bay Creek in the east-central portion of Lowndes County close to the Echols County line. At about the point of their confluence, the habitat shifts from flatwoods to a mix of flatwoods dissected by narrow ravines that cut progressively deeper and deeper into Pleistocene limestone rock. A key aspect of the Alapahoochee River is that it is not only fed by Mud Creek and Grand Bay Creek, but also is fed by springs that issue out from the overburden above the limestone or issue form the limestone itself. The Alapahoochee River flows into Florida just south of AR 3 and then joins the Alapaha River. Large scale year-round agricultural activities involving numerous vegetable crops take place along much of the Alapahoochee River, especially near AR 2 and 3, while forest lands are somewhat more extensive around AR 1. There are several small to medium creeks that feed into the river, but their influence is seen as minimal since many are ephemeral in nature.

The collection sites MC 1 and 2 and GB 1, 2, and 3 are most deeply embedded in flatwoods habitat, and besides draining two large wetlands, have numerous smaller wetlands that lie within their drainage areas. The collection sites were typified by broad flat flood plains dominated by black gum and cypress trees. Each collection site was located at a bridge with water depths below the bridges being greater than those of the creeks. Water flow through these sites was generally slow with long retention times during heavy rains as would be expected in a flatwoods habitat. Substrate in the creeks was typified by silt and mud bottoms with areas of higher currents often having a hardpan nature. The courses of the creeks above and below the sites were often braided, especially during high water.

The MC 3 and GB 4 show moderate levels of dissection with low rolling hills mixed into areas of flatwoods habitat. With the associated dissection of the creeks into the hills and the closer proximity of the hills to the banks of the creeks, there is a considerable reduction in the width of the adjoining flood plains. There is also considerable change in the floristic nature of the area as pinelands grade into mixed deciduous forests. River substrate is typified by sand bottoms with occasional pools with mud and silt bottoms.

The AR 1, 2 and 3 show much deeper dissection into the sands and gravels overlying Pleistocene limestone. The AR 1 collection site, while showing some characteristics similar to MC 3 and GB 4, has a course more tightly constrained by hills with some moderately high nearly vertical banks appearing. Elevation above the bed of the river ranges from 3 to 4 m. The collection sites AR 2 and 3 are cut well into the Pleistocene limestone with stretches of the river above and below the collection sites being bordered by very steep banks and limestone cliffs. This area is typified by springs and seeps as well as small ephemeral and permanent creeks. Elevation above the river bed ranges from 4 to 10 m and during normal and low water conditions extensive riffles and small waterfalls can be found above and below the collection sites. The river bed is typified by numerous rocks, rocky outcrops, stretches of flat rock, and sand bottom pools.

B. Chemical Analysis

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Material and Methods

Materials. Concentrated hydrochloric and concentrated nitric acid (trace metal grade) were obtained from Fisher Scientific and used without additional purification. Certified reference standards were obtained from Inorganic Ventures. High purity water (17.5 mΩ) was obtained onsite and its purity was confirmed by aqueous conductivity.

Methods. Water samples were prepared and analyzed as described in EPA method 200.7 (revision 4.4). Analysis was performed on a Perkin Elmer Optima 3000 ICP-emission spectrometer by Valdosta State University (VSU) or a Thermo Jarrell Ash Enviro 36 ICP by the University of Georgia (UGA). In late June of 2006 the ICP at VSU failed, forcing the analysis of the remaining samples to be performed off-site. The ICP analysis was performed at the UGA Chemical Analysis Laboratory. All data reported from June 20 to the end of the collecting period were collected by UGA.

Results and Discussion

During the time of the contract no measurable concentrations of arsenic (Ar), nickel (Ni) or mercury (Hg) were detected. There were observable amounts of cadmium (Cd), copper (Cu), lead (Pb) and zinc (Zn). The details of the positive tests will be discussed separately.

Copper (Cu). Over the course of the contract, only two collection dates showed any significant copper in the water samples (Figures B1a, b, c). On 23 September 2005 three collection sites revealed measurable copper in the samples. The highest concentration was at AR 3, with a concentration of 0.465 μg/mL. AR 2 showed a lower concentration of 0.198 μg/mL and both sites were negative for copper the following test date. Also reporting positive for copper was the MC 3 site (0.139μg/mL). Like the Alapahoochee River collection sites, the Mud Creek collection sites were negative for copper the following test date. Interestingly, none of these positive test indicate any type of "wash-down" effect (i.e. a high concentration at one site followed by lower concentrations downstream) and there is also no evidence of residual material after the initial positive finding. The amount of copper reported is very small, falling well below the EPA maximum contaminate level for primary drinking water (1.3 μg/mL).

A second instance of copper was found on 20 June 2006. Four collection sites reported measurable concentrations of copper. In this case, two of the collection sites were at GB 3 (0.139 μg/mL) and 4 (0.098 μg/mL). The AR 2 (0.085 μg/mL) and MC 2 (0.134 μg/mL) also reported measurable concentrations. As with the previous instance of measurable copper, these positive results did not repeat and were well below the EPA action levels for primary drinking water.

Zinc (Zn). Zinc is the one element which consistently tested positive for essentially all collection sites for the entire contract period (Figure B2). The concentration was very low, just above the detection limit in many cases, varying between 0.050 µg/mL to 0.010 µg/mL. There is no primary drinking water standard for zinc, the only useful value for comparison is the National Secondary Drinking Water Standard. This standard, concerned with cosmetic issues, sets zinc concentration at 5 mg/mL. Based on this, it would appear that zinc was not an issue in this watershed at this time.

Lead (Pd). The lead results are problematic (Figure B3a, b, c). Early in the testing cycle, seven of the ten collection sites had measurable levels of lead (MC 1-3, AR 1, and GB 1-3). Only one site, MC 2 (0.017µg/mL) was above the EPA primary drinking water standard (0.015µg/mL). The other positive tests recorded lead concentration between 0.006µg/mL – 0.014µg/mL. The next instance of lead concentration above the EPA standard occurred on 13 December 2005. One sample collected on this date showed a lead concentration of 0.023 µg/mL. No other collection sites on Grand Bay Creek tested positive for lead and all sites were negative for lead at the following collection. Review of the standards, blanks, and fortified standards for each of the instances of positive results indicate that the ICP was operating in specified tolerances.

Data collected on the UGA Jarrell Ash instrument showed markedly higher concentrations of lead. Five samples were significantly above the EPA standard in the 20 June 2005 collection (0.109µg/mL - 0.508µg/mL). The data set for 20 June 2006 tested positive for 2 samples, the third data set for 12 July 2006 tested positive for 3 samples and the forth data set for 31 July 2006 tested positive for 2 samples. Test for lead were negative until the 4 September 2006 collection, which had a positive result for 2 samples, GB 1 (0.041µg/mL) and MC 1 (0.201µg/mL). There was no discernable pattern to this data, while the concentrations of samples decrease over time, and there were no discernable "down-stream" concentrations as would be expected. These data are significantly higher that those values reported by VSU, but like VSU's data, the standards and fortified samples are in tolerance.

For the entire year it can be concluded that there was no apparent continuing contamination of the watershed by lead, but several isolated positive tests were observed. Without discernable patterns of lead contamination, all that can be said is that the data was correctly collected in the field, and properly processed in the laboratory. With this being said, it is important to recall that the data are being compared to the EPA primary drinking water standard, a very strict standard, and this watershed is not used as a source of potable water.

Cadmium (Cd). The cadmium data (Figures B4a, b, c) also shows a measurable concentration by the UGA Analytical Laboratory. Measurable concentrations of cadmium were observed in 10 samples collected during the study. These samples were distributed across all the rivers or creeks (MC 1 and 2, GB 3 and 4, AR 1-3). The levels varied from approximately 0.020µg/mL to 0.200µg/mL. These concentrations are above the drinking water standard of 0.005µg/mL. In the instances of measurable concentrations, there is no discernable pattern to the contamination, so the probability of a release seems unlikely.

The water in the studied system is relatively free of toxic metal ions. This statement must be qualified because of the data collected at the UGA Analysis Laboratory, which reported measurable concentrations of copper, zinc, lead, and cadmium. The reason for these positive results is unclear; however, the laboratory is a reputable facility with experience running trace analysis using well maintained equipment. Since the data from UGA reveal no apparent trends in contamination, it may be that the instrumentation at UGA has a larger uncertainty in their measurements than is reported in their literature.

Figures

Figure B1a. Copper (Cu) concentrations at AR 1-3 by dates.

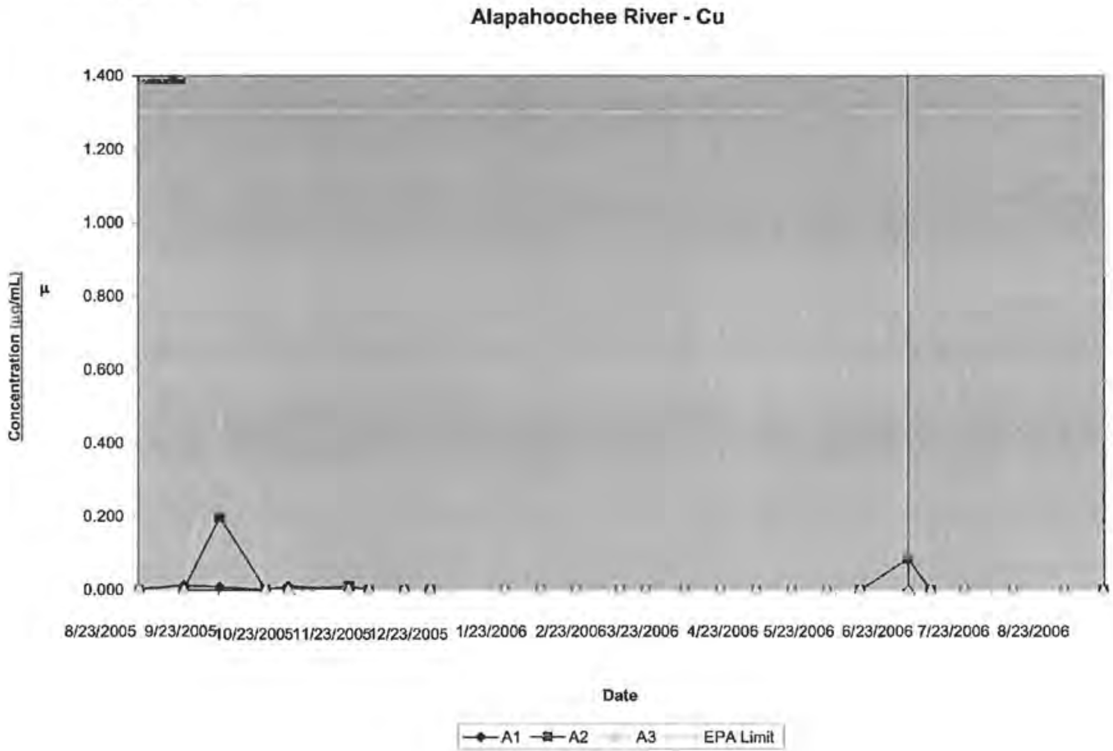


Figure B1b. Copper (Cu) concentrations at GB 1-4 by dates.

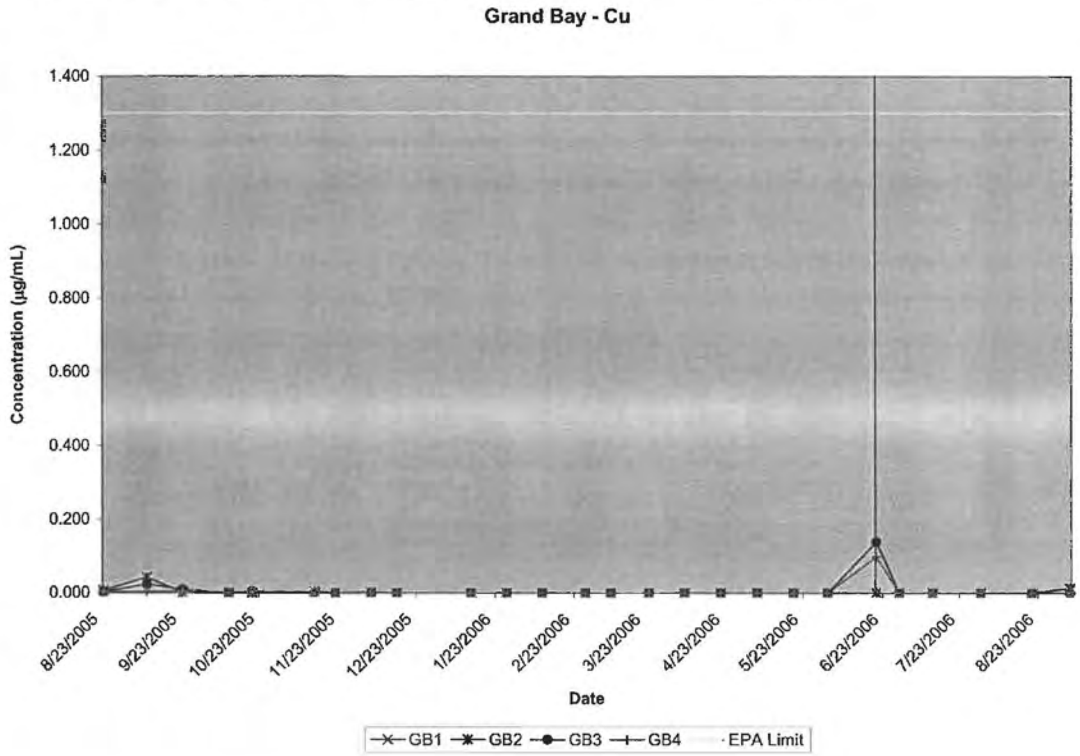


Figure B1c. Copper (Cu) concentrations at MC 1-3 by dates.

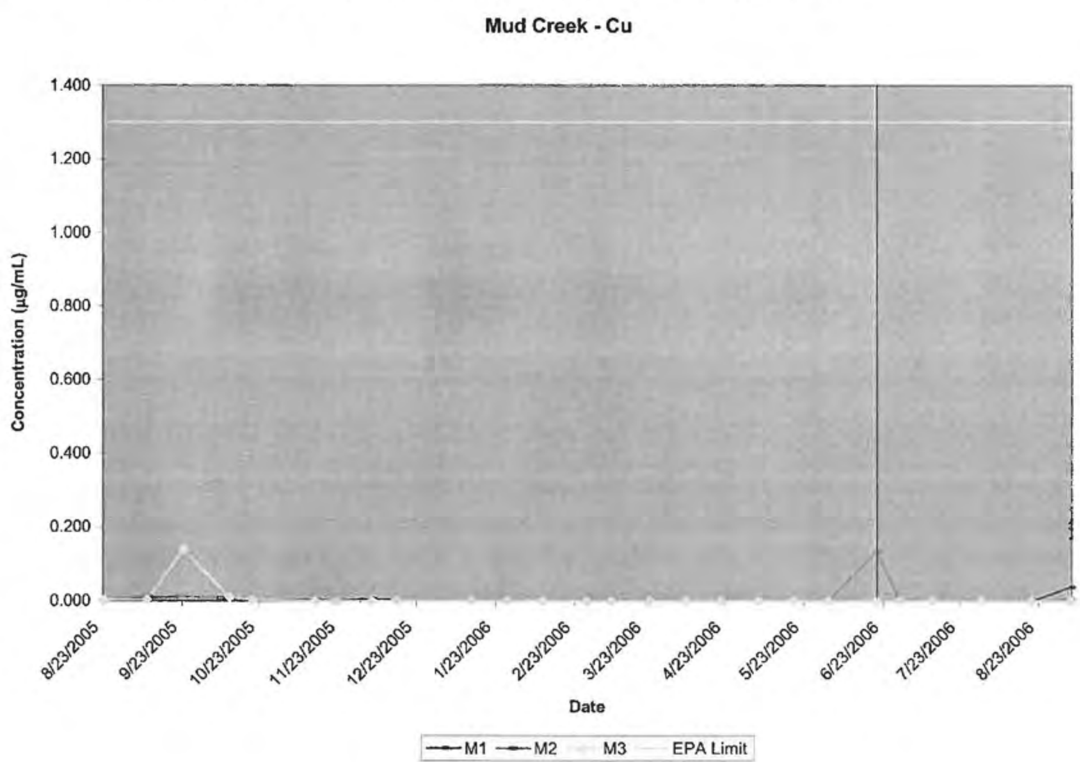


Figure B2. Zinc (Zn) concentrations at all collection sites by dates.

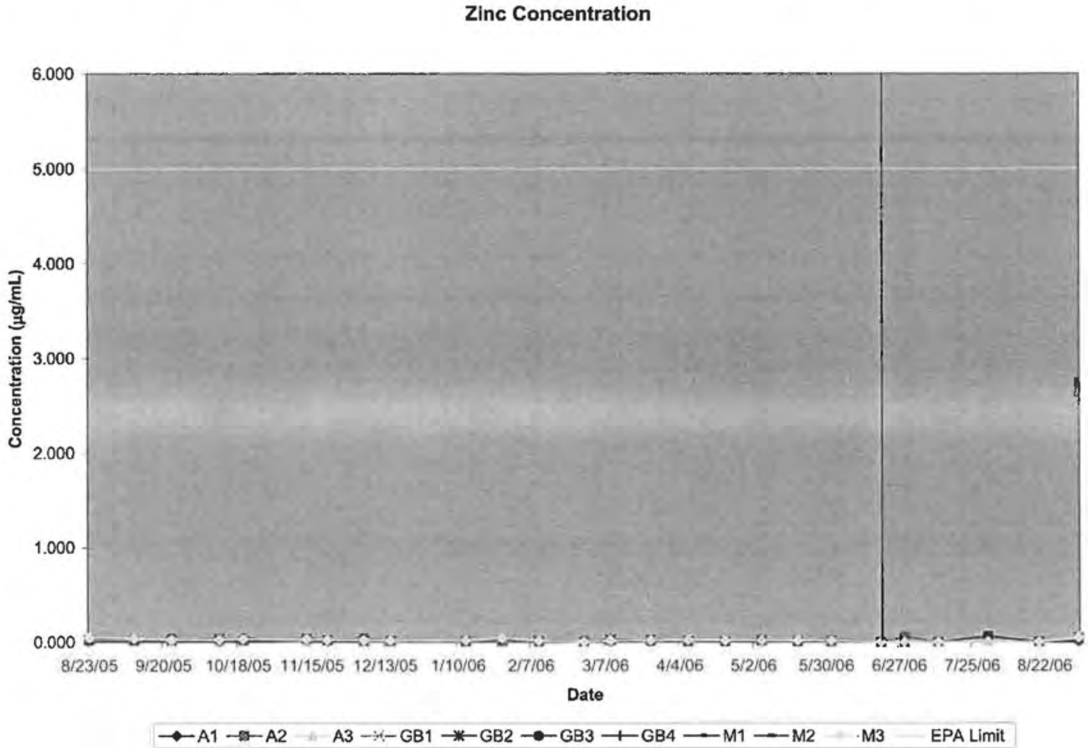


Figure B3a. Lead (Pb) concentrations at AR 1-3 by dates.

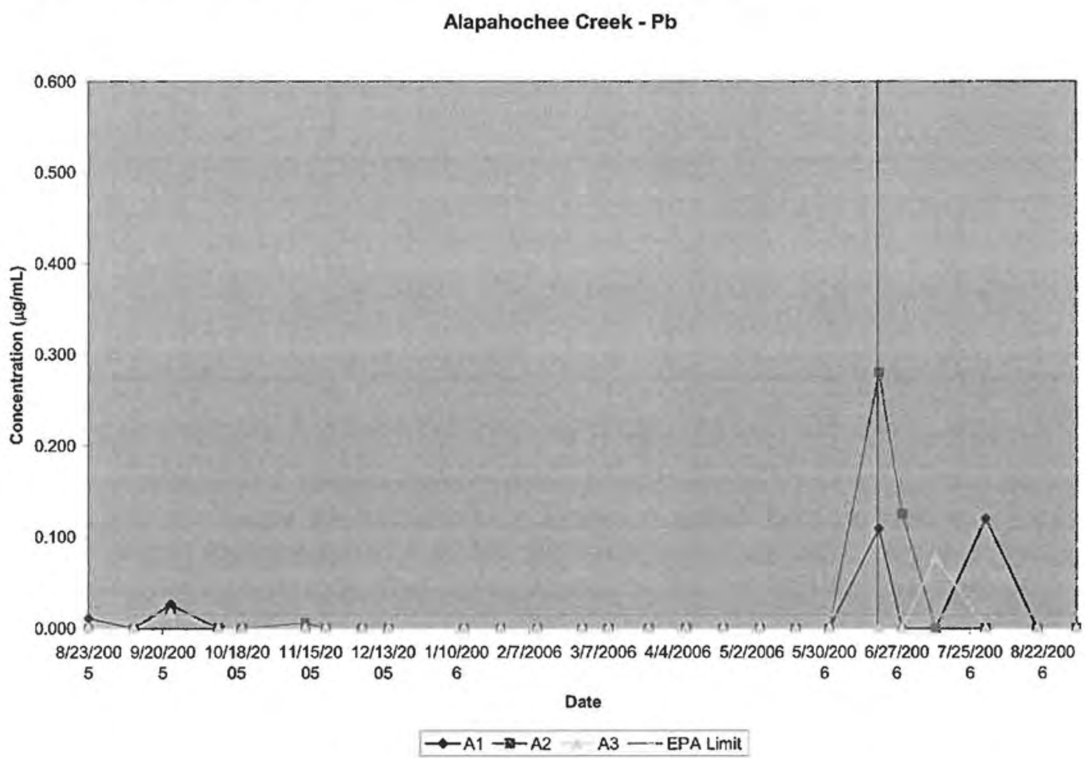


Figure B3b. Lead (Pb) concentrations at GB 1-4 by dates.

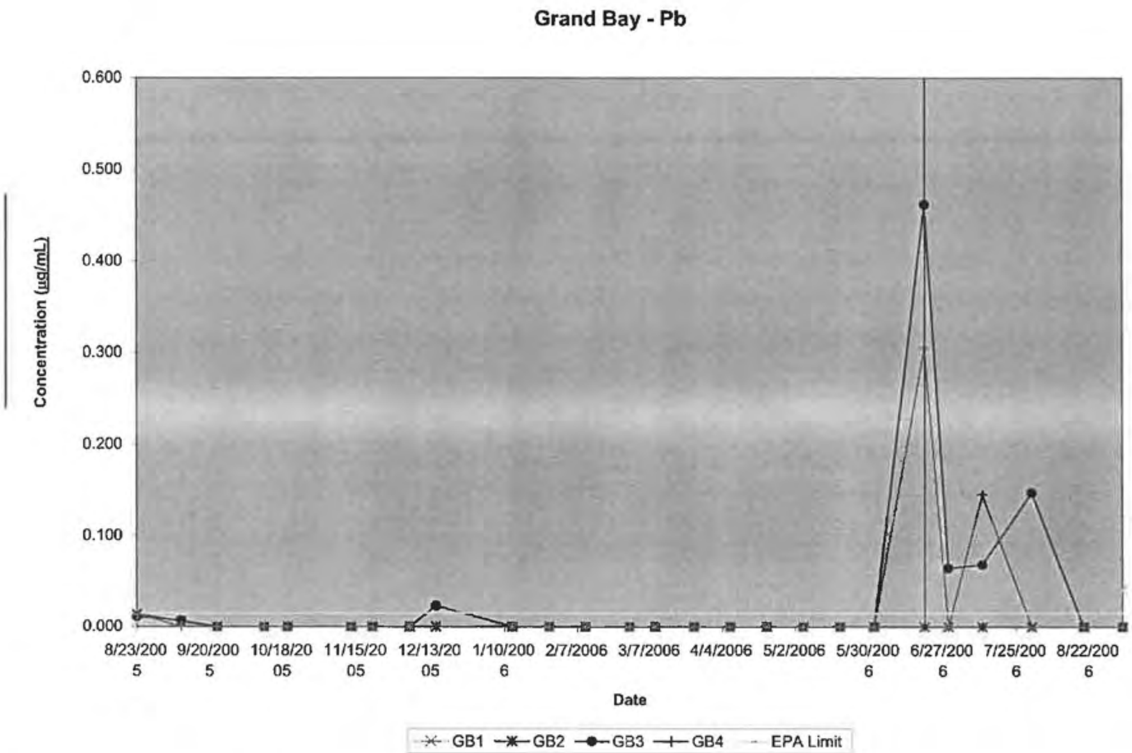


Figure B3c. Lead (Pb) concentrations at MC 1-4 by dates.

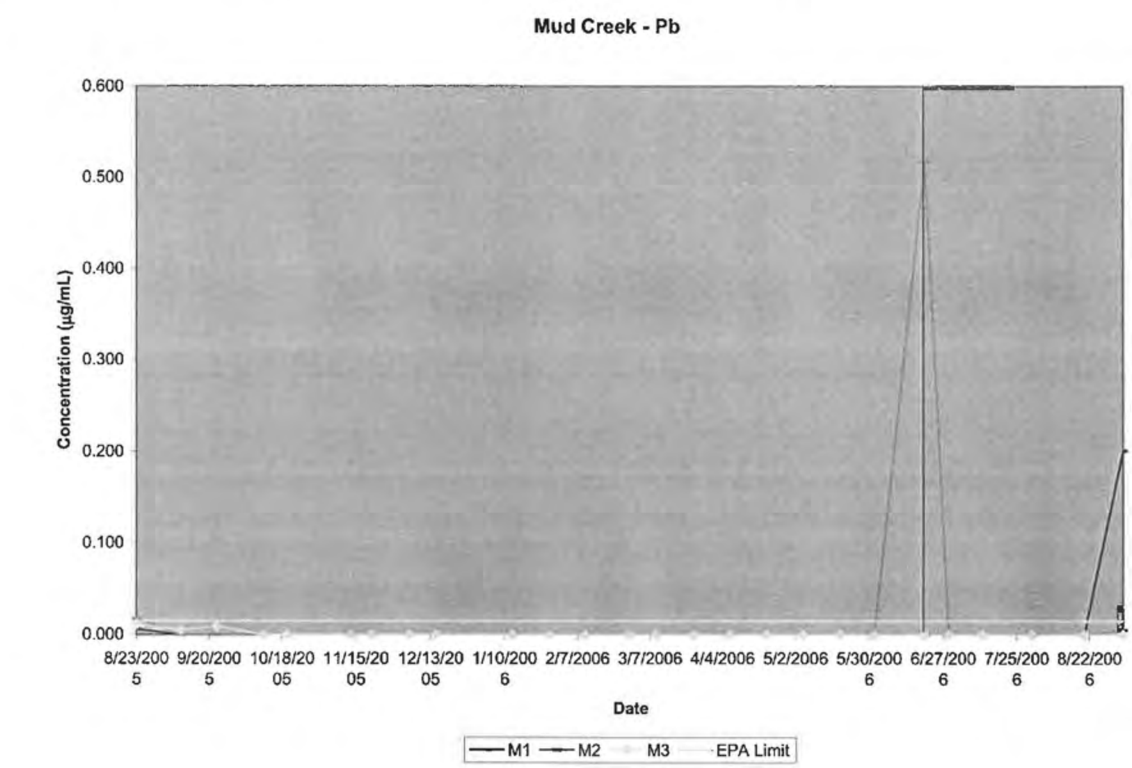


Figure B4b. Cadmium (Cd) concentrations at AR 1-3 by dates.

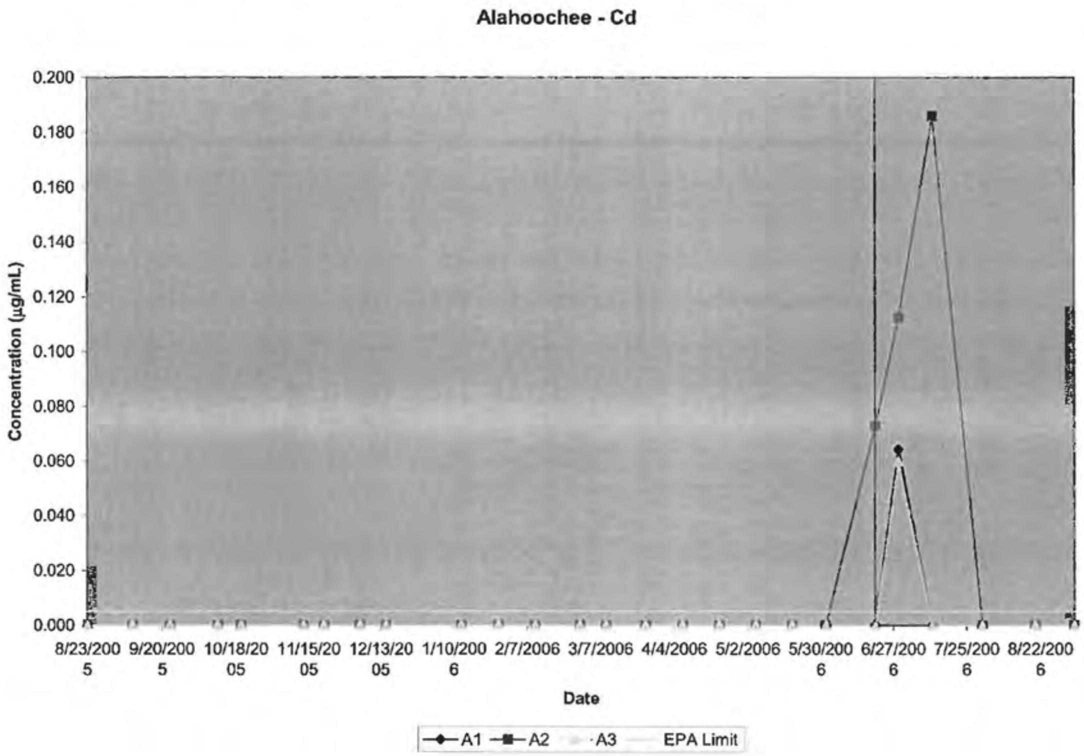


Figure B4b. Cadmium (Cd) concentrations at GB 1-4 by dates.

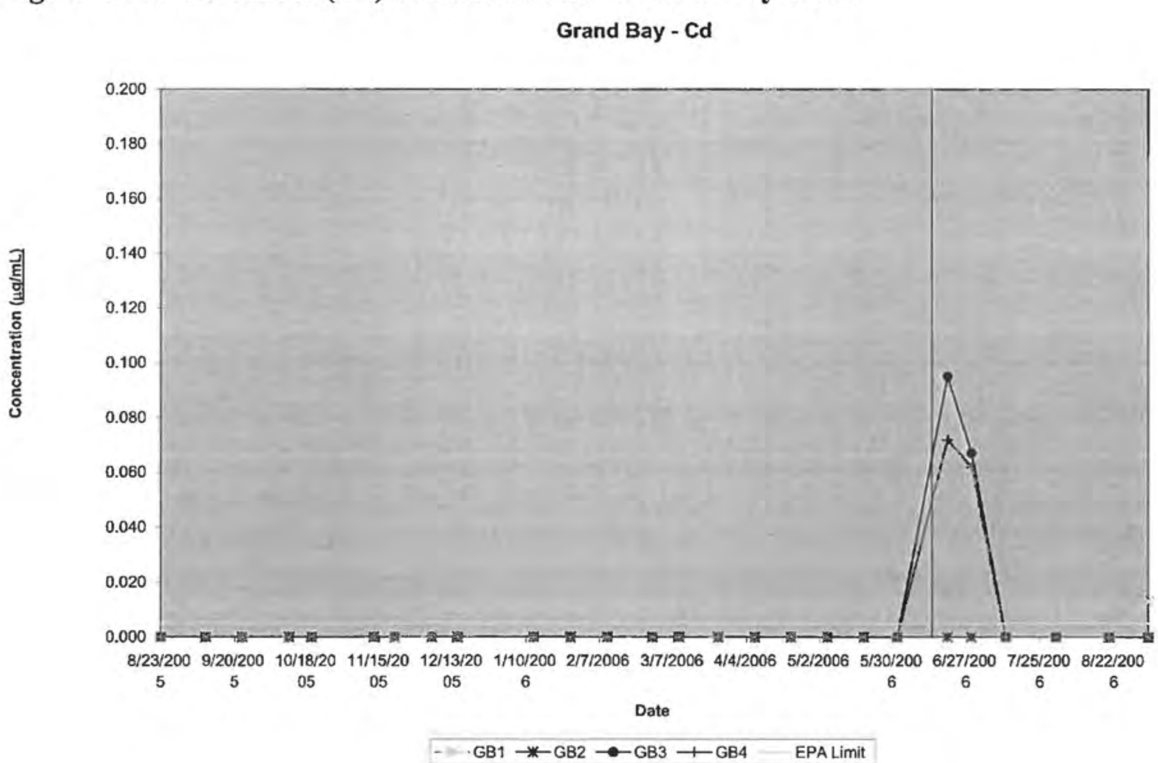
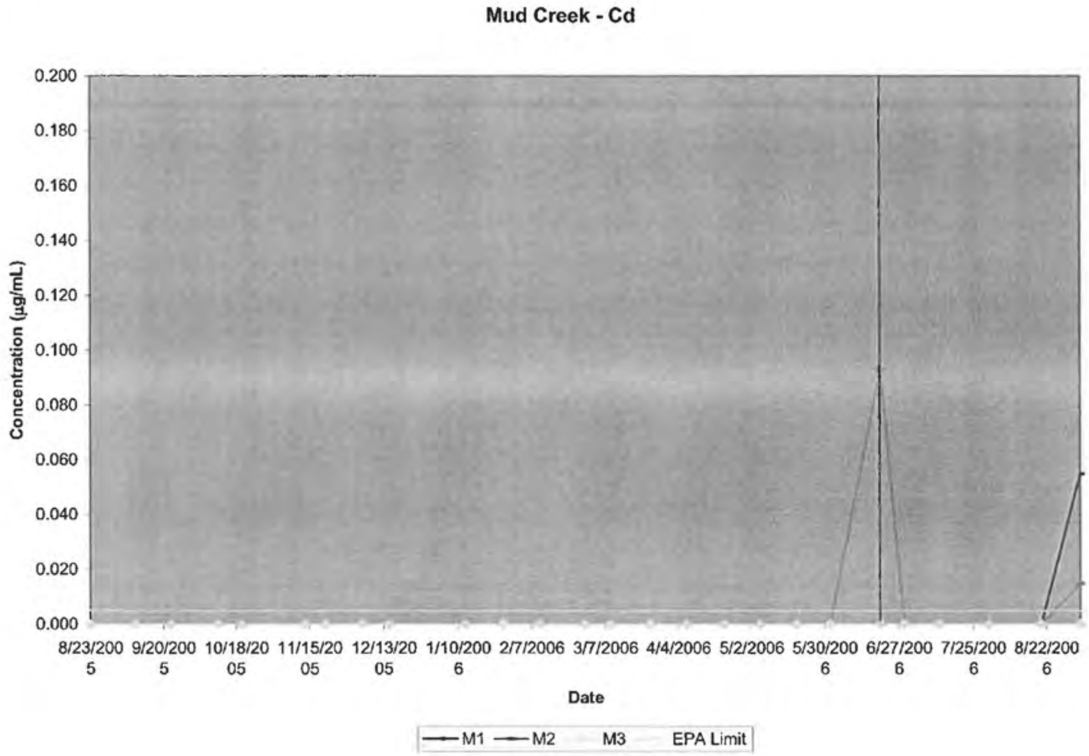


Figure B4c. Cadmium (Cd) concentrations at MC 1-3 by dates.



C. Physicochemical Analysis

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Materials and Methods

Sampling and Analysis. Bi-weekly sampling of the collection sites described above were conducted using EPA-approved protocols. Measurements of temperature, pH, and electrical conductivity were performed in the field. Laboratory analysis included measuring concentrations of nitrite, total phosphorus as phosphate, chemical oxygen demand (COD), and total suspended solids (TSS). Collection sites are shown in Figure C1.

Water quality sample collection for all analysis, except TSS, was performed by discrete sampling using a Thief Sampler and replicate samples were obtained by a cone-splitter. Samples for TSS analysis were collected with a USGS-Type DH-59 Depth-Integrating Sampler. Equipment used for sample collection and processing was field rinsed with the water to be sampled just before the water samples were collected. The purposes of the field rinsing were to condition, or equilibrate, the equipment to the sample environment and to help ensure that all solute residues had been removed before the sampling began.

Before and after sampling field work, all the sampling equipment (e.g. sampler, cone splitter, and sampling bottles) were washed and rinsed with deionized water.

Analysis of water quality parameters were performed in the field using Hach Sension 156 Portable Multi-Parameter Meter and in the laboratory using Hach DR890 Colorimeter. Temperature, pH, and electrical conductivity were measured in the field. Laboratory analysis of chemical oxygen demand, nitrite, and phosphorous (reactive phosphate) were performed using the Hach DR 890 Colorimeter. Suspended solid concentrations were determined by using the Gravimetric Method for Total Nonfilterable Residue for Water and Wastewater.

Temporal variations of the measured parameters and rainfall distribution are shown in Figures C2, C3, C4, and C5. Rainfall data were collected at the Valdosta State University Weather Station located at the Department of Physics, Astronomy, and Geosciences. The Station has been operational since the 26 October 2005. Therefore, rainfall data for the first five sampling dates are not available.

Parameters Descriptions

Electrical Conductivity. Electrical conductivity is the ability of a substance to conduct an electrical current. The presence of dissociated ions in solution renders the solution conductive. As ion concentrations increase, conductance of the solution increases; therefore, the conductance measurements provides an indication of ion concentration.

Total Phosphorus. Both phosphorus and nitrogen are essential nutrients for plants and animals that make up the aquatic food web. There are many sources of phosphorus, both natural and human. These include soil and rocks, wastewater treatment plants, runoff from fertilized lawns and croplands, failing septic systems, runoff from animal manure storage areas, disturbed land areas, drained wetlands, and commercial cleaning preparations.

Major solubility controls of phosphorus are related to coprecipitation and adsorption, as well as uptake by biota. Use of phosphorus by aquatic vegetation and perhaps adsorption of phosphate ions by metal oxides can prevent concentrations greater than a few tenths of hundreds of milligrams per liter from being present in solution in most waters (Hem, 1985).

Total phosphorus concentrations of water samples were measured with Hach DR890 Colorimeter using the Acid Persulfate Digestion Method (Method 8190) described in Hach, 2003. In this procedure, phosphate present in organic and condensed inorganic compounds is converted to reactive orthophosphate before analysis by heating sample water with acid and persulfate. The results of the reactive phosphorus test after the digestion will include the organic phosphate plus the orthophosphate and the acid-hydrolyzable (condensed) phosphate.

Chemical Oxygen Demand (COD). In environmental chemistry, the chemical oxygen demand (COD) test is commonly used to indirectly measure the amount of organic compounds in water. It is a measure of the oxygen equivalent of the organic matter content of a sample that is susceptible to oxidation by a strong chemical oxidant. Most applications of COD determine the amount of organic pollutants found in surface water (e.g. lakes and rivers), making COD a useful measure of water quality. It is expressed in milligrams per liter (mg/L), which indicates the mass of oxygen consumed per liter of solution.

The determination of COD is widely used in municipal and industrial laboratories to measure the overall level of organic contamination in wastewater. The contamination level is determined by measuring the equivalent amount of oxygen required to oxidize organic matter and chemical substances in the sample. The COD differs from Biological Oxygen Demand (BOD) in that it measures the oxygen demand to digest all organic content, not just that portion which could be consumed by biological processes.

The COD of water samples were measured with Hach DR890 Colorimeter using the Reactor Digestion Method (Method 8000) described in Hach, 2003. In this procedure, the sample is heated for two hours with a strong oxidizing agent, potassium dichromate. Oxidizable organic compounds react, reducing the dichromate ion to green chromic ion.

Hydrogen Ion Concentration (pH). The pH parameter represents the negative base-10 log of the hydrogen ion activity in moles per liter. It describes the degree of acidity or alkalinity of a solution.

Nitrite. Nitrite represents an indermediate oxidation state as part of organic solutes. In surface waters it is created by bacterial oxidation of ammonia produced by fish and decomposing organic matter. Although it is less toxic than ammonia, elevated levels still present a threat to fish health.

Nitrite concentrations of water samples were measured with Hach DR890 Colorimeter using the Diazotization Method (Method 8507) described in Hach, 2003. In this procedure, nitrite in the sample reacts with sulfanilic acid to form an intermediate diazonium salt. This couples with chromotropic acid to produce a pink colored complex directly proportional to the amount of nitrite present.

Results and Discussion

Electrical Conductivity (EC). Variations and basic statistics for EC are provided in Table C1a and Figure C2a, b, c. Because of the longer residence times of groundwater, it has higher electrical conductivity than surface waters. Thus, streams with base flows originating from soluble rocks show higher electrical conductivity. In the study area, electrical conductivity variations are controlled by variations in groundwater contribution to the streams. In all sampling sites, electrical conductivity tends to decline after significant surface runoff caused by rainfall. Overall, samples from the Alapahoochee River show higher electrical conductivity most likely due to limestone bedrock and possible recharge from karst springs.

Table C1a. Basic statistics for electrical conductivity (EC, microsiemens)

	Grand Bay Creek	Alapahoochee River	Mud Creek
Maximum	129	502	1125
Minimum	7	28	9
Average	50	196	187

Relatively high average EC value for Mud Creek results from the MC 3 collection site that stands out with anomalously high values in all parameters.

Total Phosphorus as Phosphate. Results of phosphate analysis and basic statistics are given in Table C2a and Figure C3a, b, c. Considering the agricultural and industrial land use practices in the watershed, the phosphate concentrations measured in the three stream systems are not significant. This can be explained by adsorption and uptake by riparian vegetation.

Table C2a. Basic statistics for total phosphates (mg/L)

	Grand Bay Creek	Alapahoochee River	Mud Creek
Maximum	3.71	2.28	5.50
Minimum	0.01	0.03	0.07
Average	0.79	1.13	0.91

Maximum phosphate concentration were measured at MC 3 (5.50 mg/L) on 4 September 2006. Samples collected from GB 2 on 23 September 2005 produced the lowest phosphate concentration of 0.01 mg/L.

Chemical Oxygen Demand (COD). As shown in Figure C4a, b, c, Grand Bay Creek samples show a decreasing trend of COD from upstream to downstream, whereas collection sites at the Alapahoochee River had similar COD values. Samples from Mud Creek produced a generally parallel trend. Basic statistical data for COD values are presented in Table C3a.

Table C3a. Basic statistics for COD (mg/L)

	Grand Bay Creek	Alapahoochee River	Mud Creek
Maximum	163.0	113.0	165.0
Minimum	15.0	15.5	8.5
Average	86.9	53.5	72.8

As expected, Grand Bay Creek and Mud Creek, with significant wetland areas in their watersheds, show generally higher values of COD than the Alapahoochee River. Maximum COD value was measured at MC 3 and MC 1 (165 mg/L) on 26 August 2005 and on 9 September 2005, respectively. Samples collected from MC 2 on 4 September 2006 show the lowest COD value of 8.5 mg/L.

Hydrogen Ion Concentration (pH). Variations in pH values and basic statistical data are given in Figure C5 a, b, c, and Table C4. All but the Alapahoochee River and MC 3 waters generally show pH ranges below the minimum desired value of 6.0 for natural waters not associated with blackwater systems. These showed prevailing acidic conditions especially in the Grand Bay Creek and Mud Creek systems with the exception of anomalously high values of pH in MC 3. Higher pH values for the Alapahoochee River indicate potential influences from groundwater input from the limestone aquifer where groundwater acidity is buffered by the dissolution by limestone.

Table C4a. Basic statistics for pH

	Grand Bay Creek	Alapahoochee River	Mud Creek
Maximum	6.95	7.72	8.29
Minimum	3.96	5.10	3.91
Average	4.75	6.21	6.21

The highest pH (8.29) value was measured at MC 3 on 4 September 2006. Samples collected from GB 4 on 9 March 2006 showed the lowest pH value (3.96).

Nitrite. Analysis of water samples for nitrite show extremely low concentration (mostly zero mg/L). Thus, no graphs and discussions have been provided for nitrite.

Total Suspended Solids (TSS). Sediment is a common pollutant in many streams, but the amounts measured in this watershed were, with two exceptions, quite low (Figure C6a, b, c). The two higher readings (78 mg/L and 164 mg/L) came from MC 1 and 3 in September 2005 when water levels were low and samples were difficult to obtain. If these suspect data are removed, the average value of TSS for Mud Creek becomes 6.4 mg/L, essentially the same as found in Grand Bay Creek and the Alapahoochee River. For comparison, the NPDES Permit Limits (Dorn and Rodgers, 1989) for water pollution control plants discharging TSS into the Tallapoosa and Coosa Rivers are 30 mg/L for 30-day averages. Basic statistical data for TSS values are presented in Table C5a.

Table C5a. Basic statistics for (TSS) (mg/L)

	Grand Bay Creek	Alapahoochee River	Mud Creek
Maximum	33	30	164
Minimum	<1	<1	<1
Average	6.5	6.4	9.2

Land Cover and Water Quality

Distribution of land cover in the watershed was obtained from the Georgia GIS Data Clearinghouse (Figures C7a, b; C8a, b; C9a, b; and C10). Figure C11 shows the location of the City of Valdosta wastewater treatment plant near the junction of Mud Creek and Knights Creek. The land cover dataset was prepared by the Georgia Department of Natural Resources (DNR) based on LandSat Thematic Mapper satellite imagery with a spatial resolution of 30.48 m^2 (100 ft^2). Land cover classification was performed by ERDAS, Inc. and the Georgia DNR – Wildlife Resources Division. LandSat Thematic Mapper bands 1 through 5 were used in the classification.

Grand Bay Creek drains an area predominantly comprised of wetlands and forests. This matched relatively high COD and acidic pH values. Water quality is not likely to be impaired by the very small spatial coverage of high density urban areas (1.0%).

Mud Creek represents an area of wider range of land use practices. Water quality parameters showed typical wetland waters. However, relatively large high density urban areas around the City of Valdosta (~7.0%) may have negative effects on the water quality of Mud Creek. Especially MC 3 samples, with their anomalous water quality parameters, seemed to be impaired by effluents from the City of Valdosta water treatment plant located directly upstream from the collection site (Figure C12).

The Alapahoochee River drains an area with the highest spatial coverage of cultivated/exposed earth. It is also recharged by groundwater flow from the Floridan aquifer. Most parameter values were well within limits for limestone streams or stream systems other than blackwater streams.

Figures

Figure C1. Alapahoochee Watershed

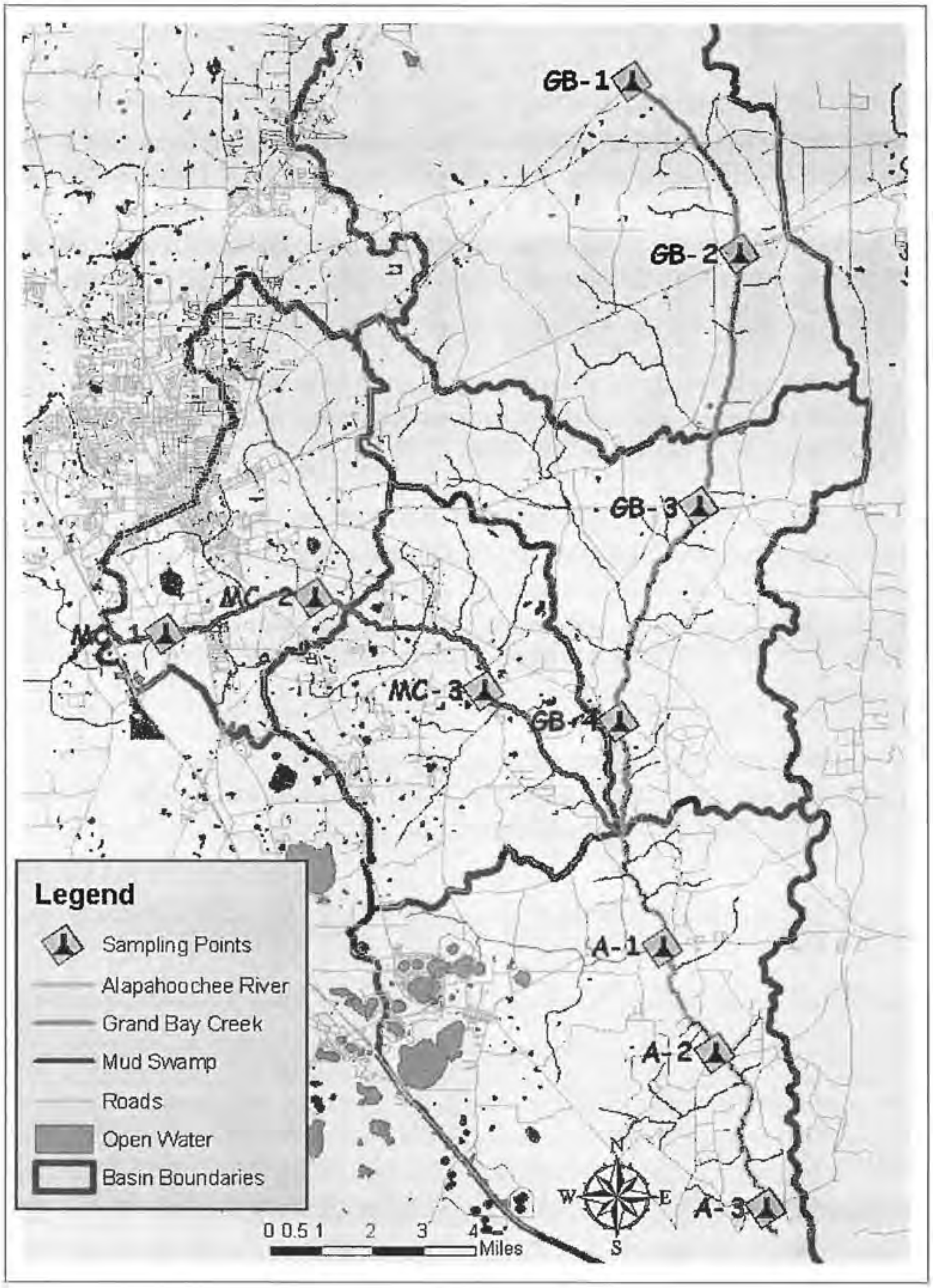


Figure C2a. Electrical conductivity at GB 1-4 by dates

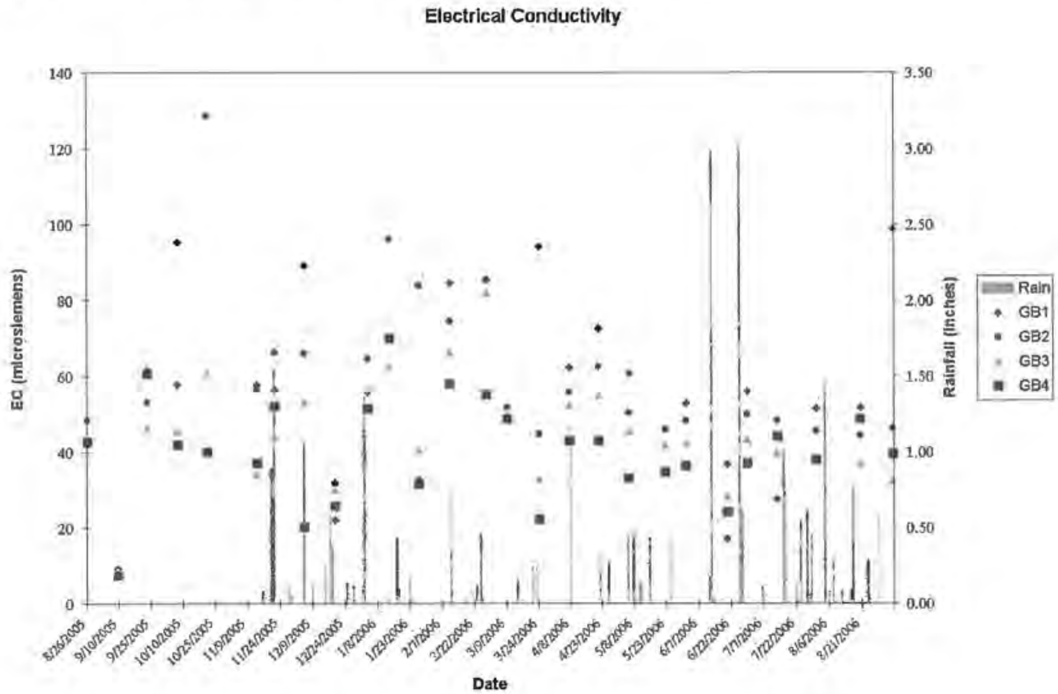


Figure C2b. Electrical conductivity at AR 1-3 by dates

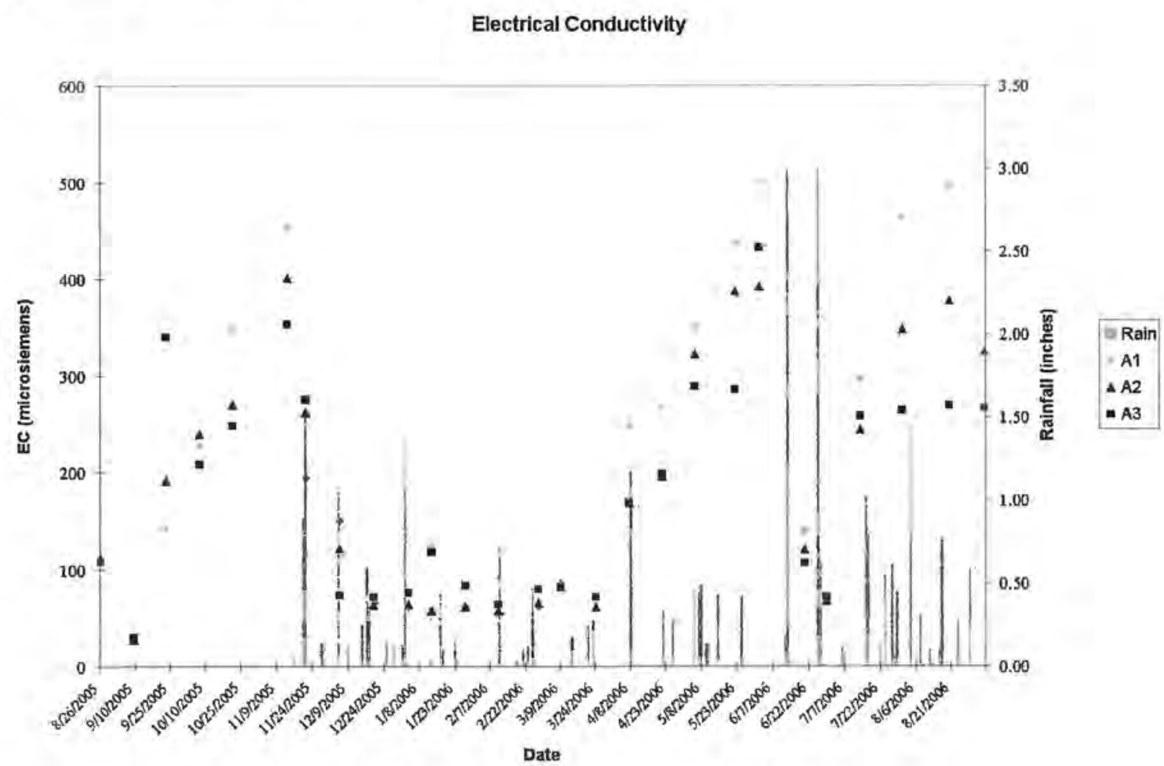


Figure C2c. Electrical conductivity at MC 1-3 by dates

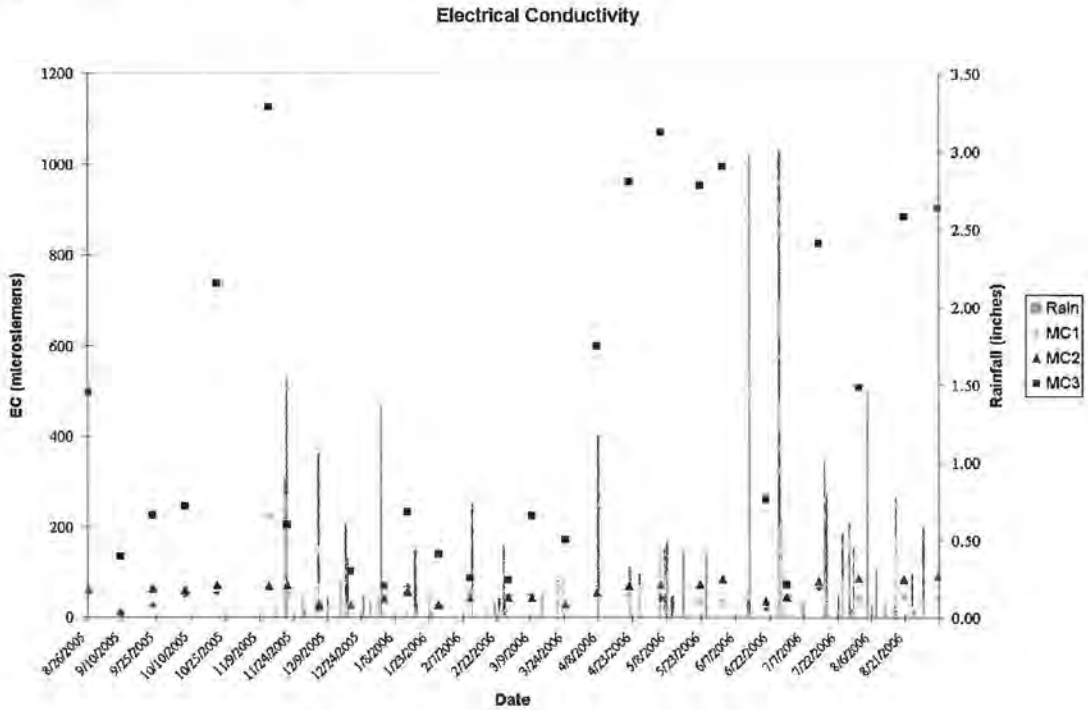


Figure C3a. Total phosphorus at GB 1-4 by date

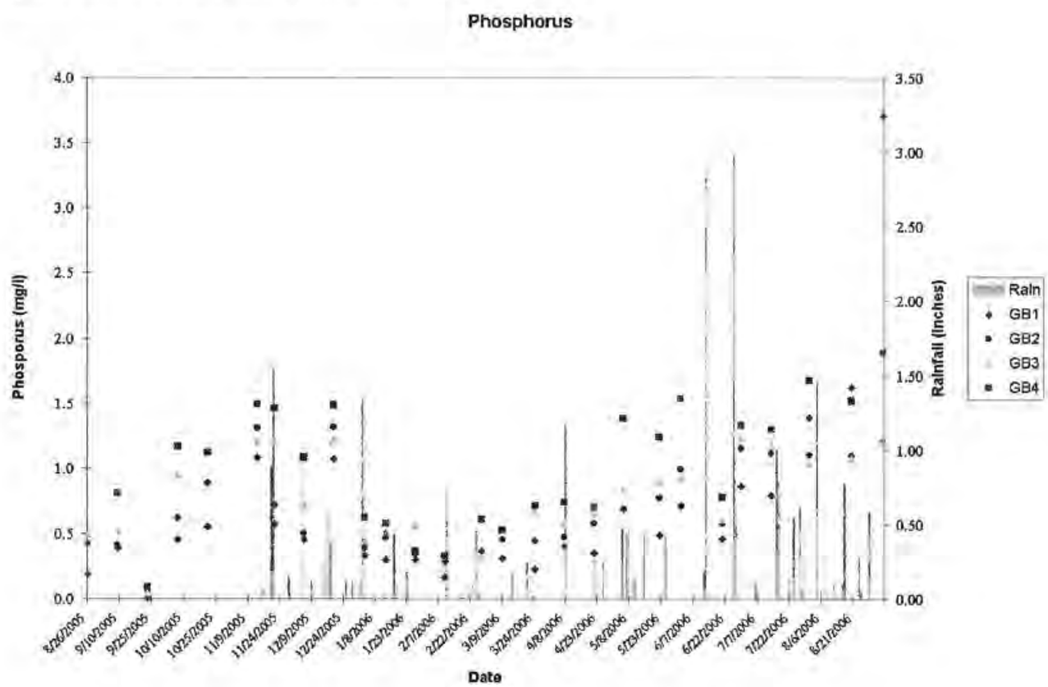


Figure C3b. Total phosphorus at AR 1-3 by date

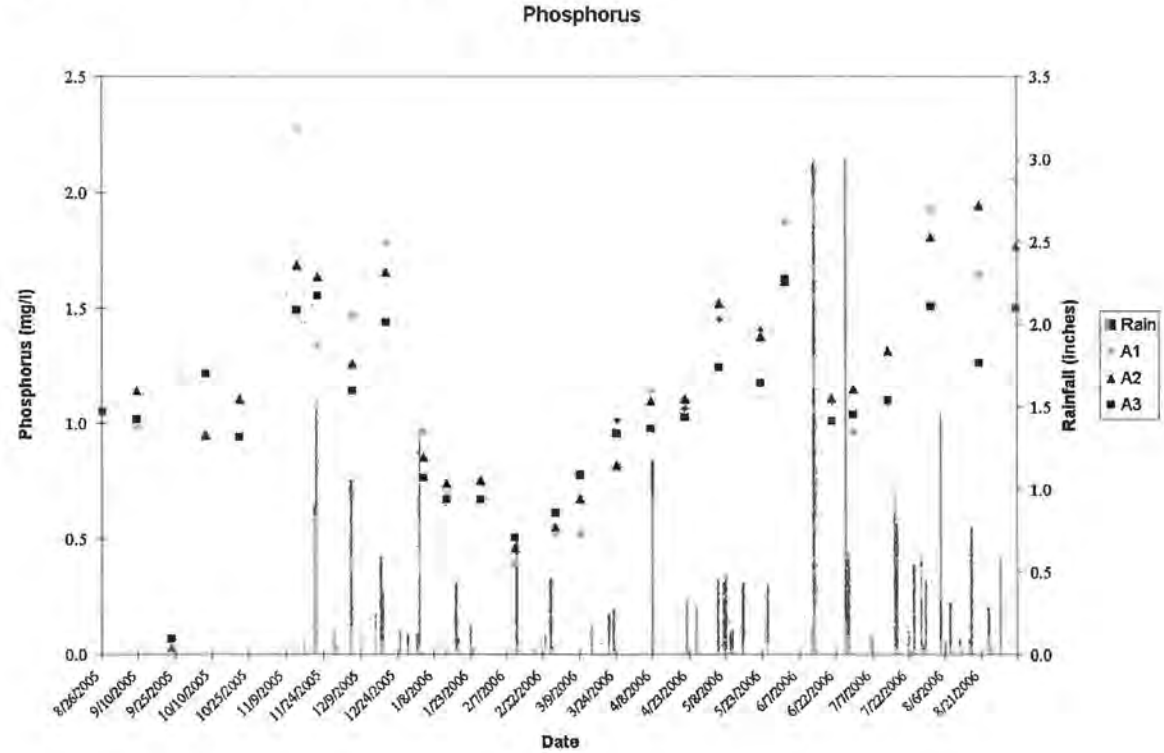


Figure C3c. Total phosphorus at MC 1-3 by date

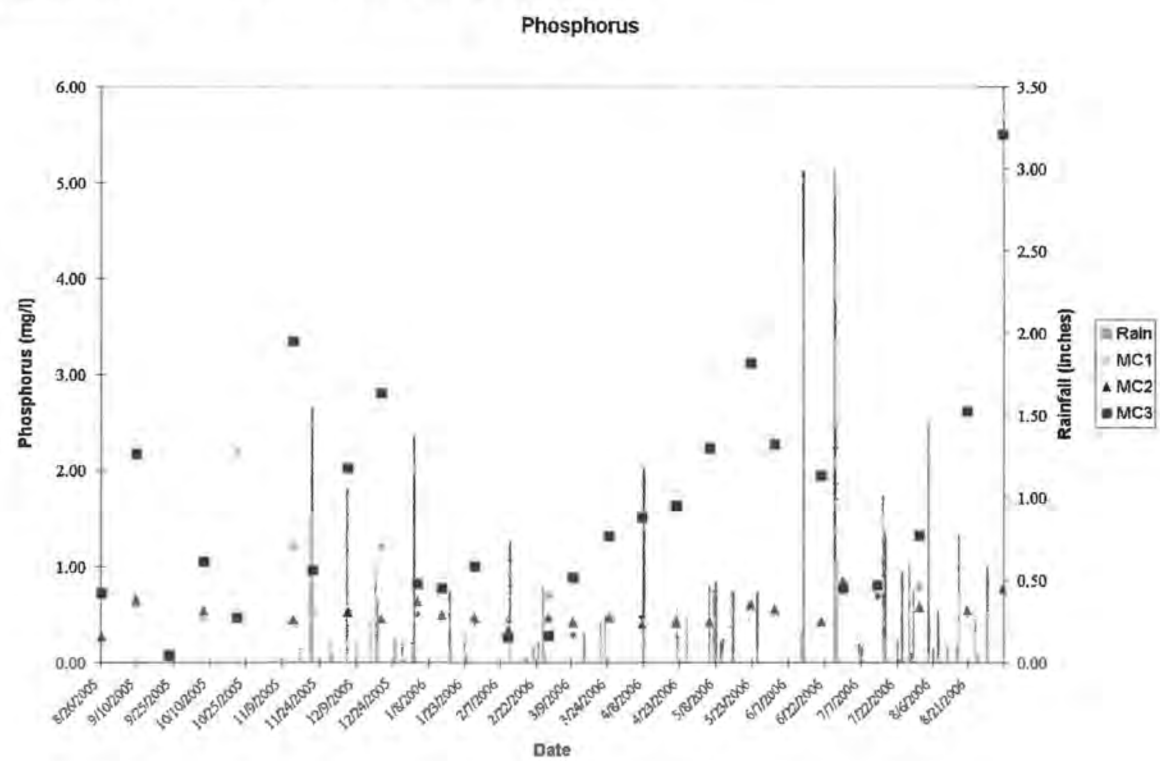


Figure C4a. COD at GB 1-4 by date

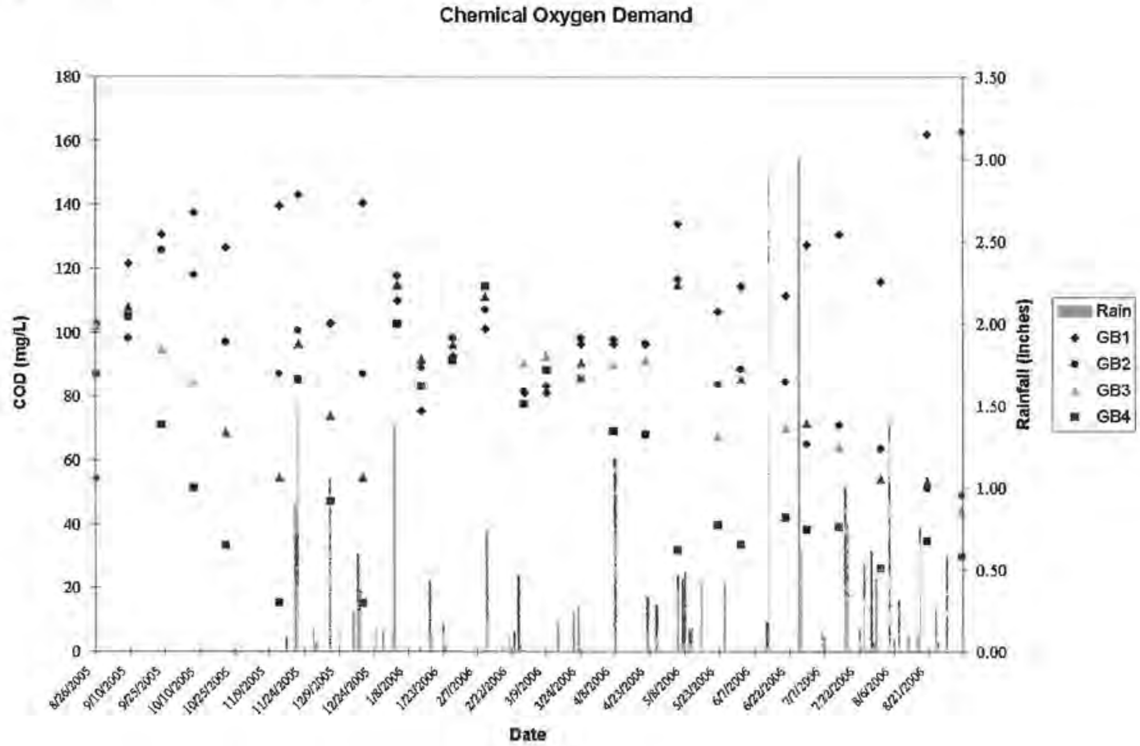


Figure C4b. COD at AR 1-3 by date

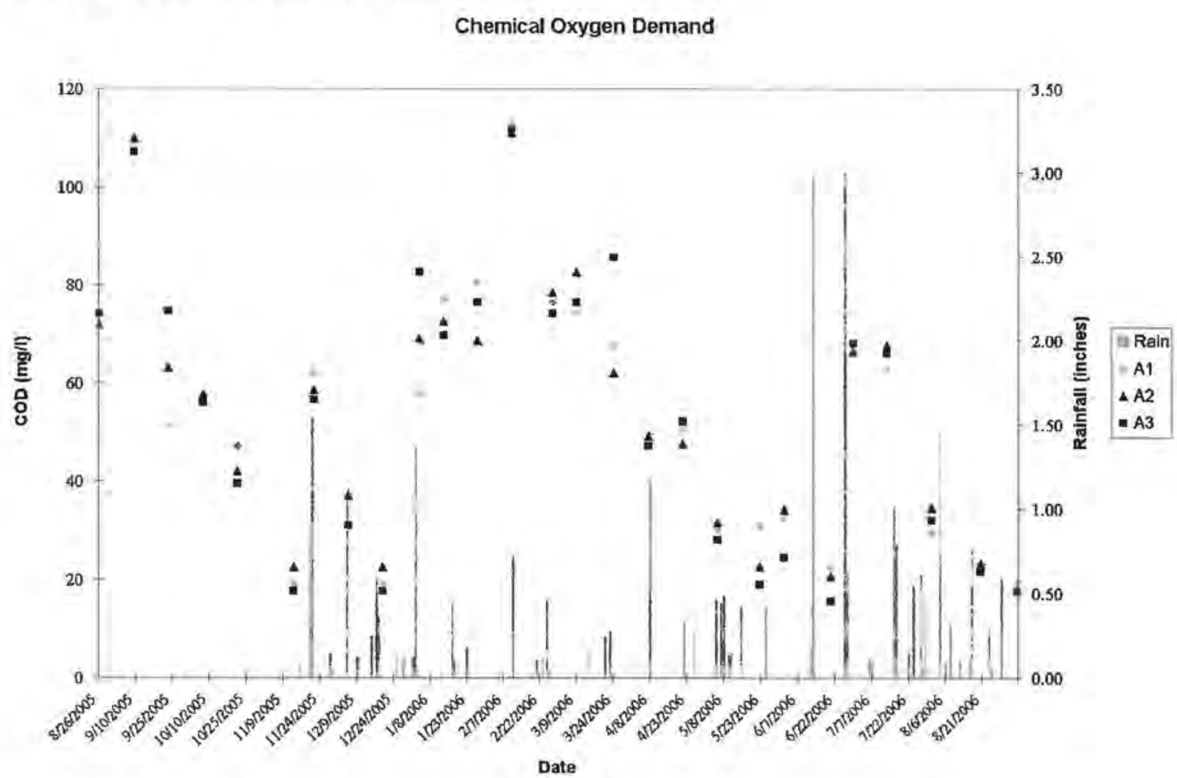


Figure C4c. COD at MC 1-3 by date

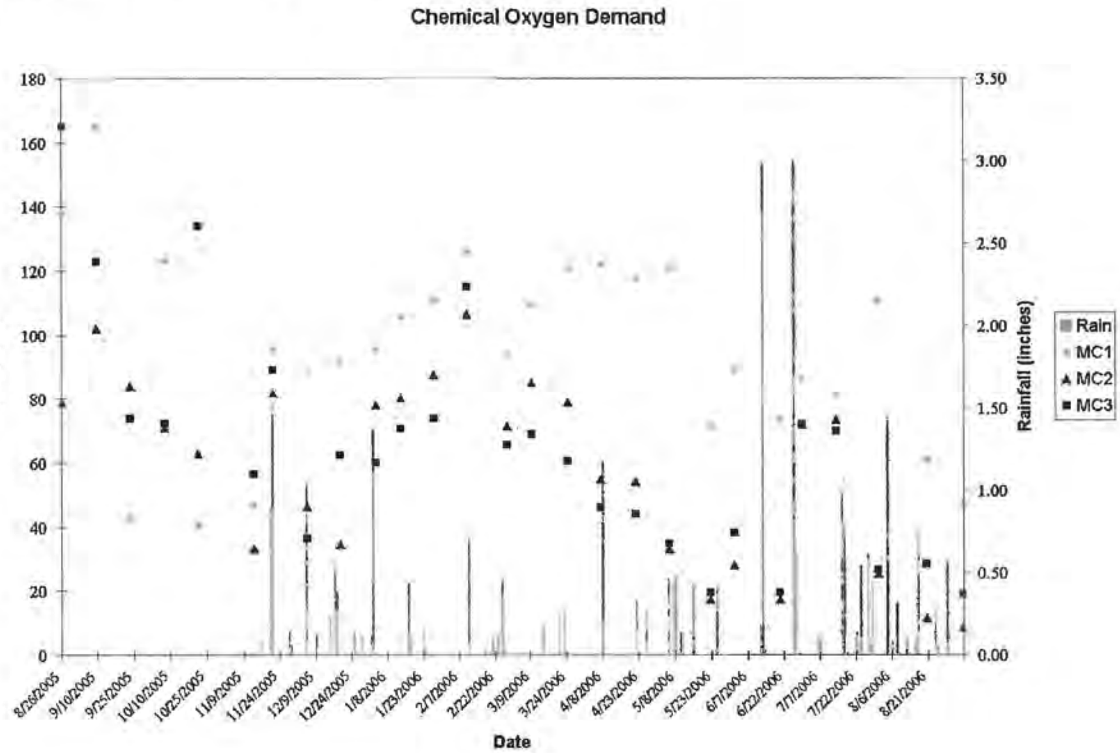


Figure C5a. pH values at GB 1-4 by date

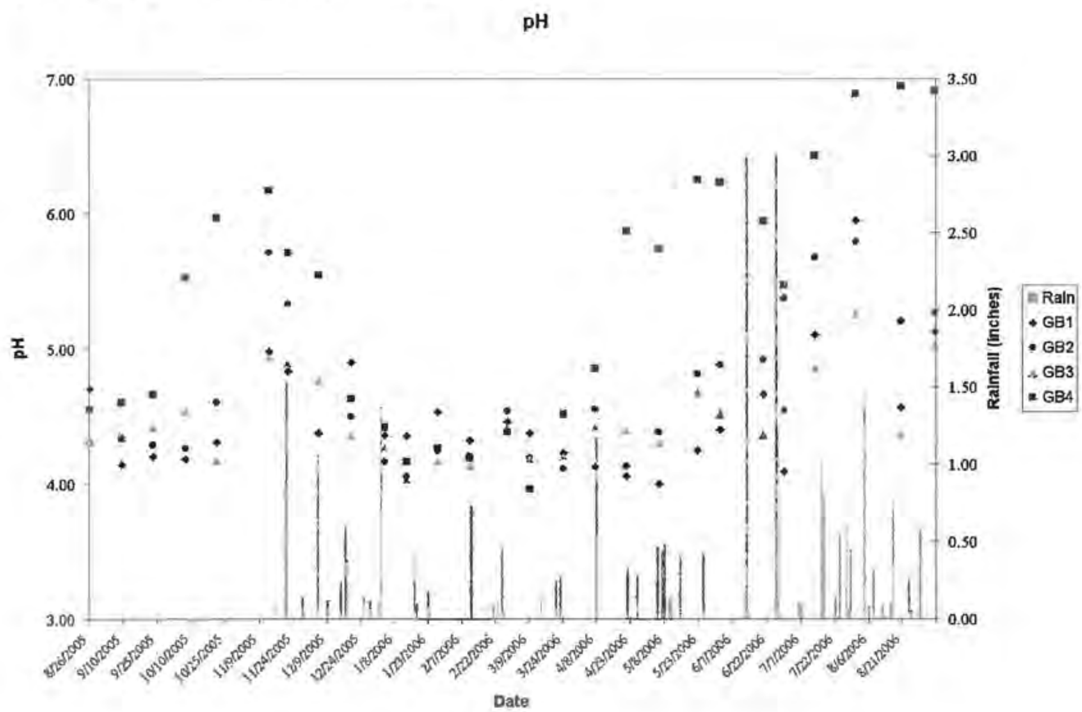


Figure C5b. pH values at AR 1-3 by date

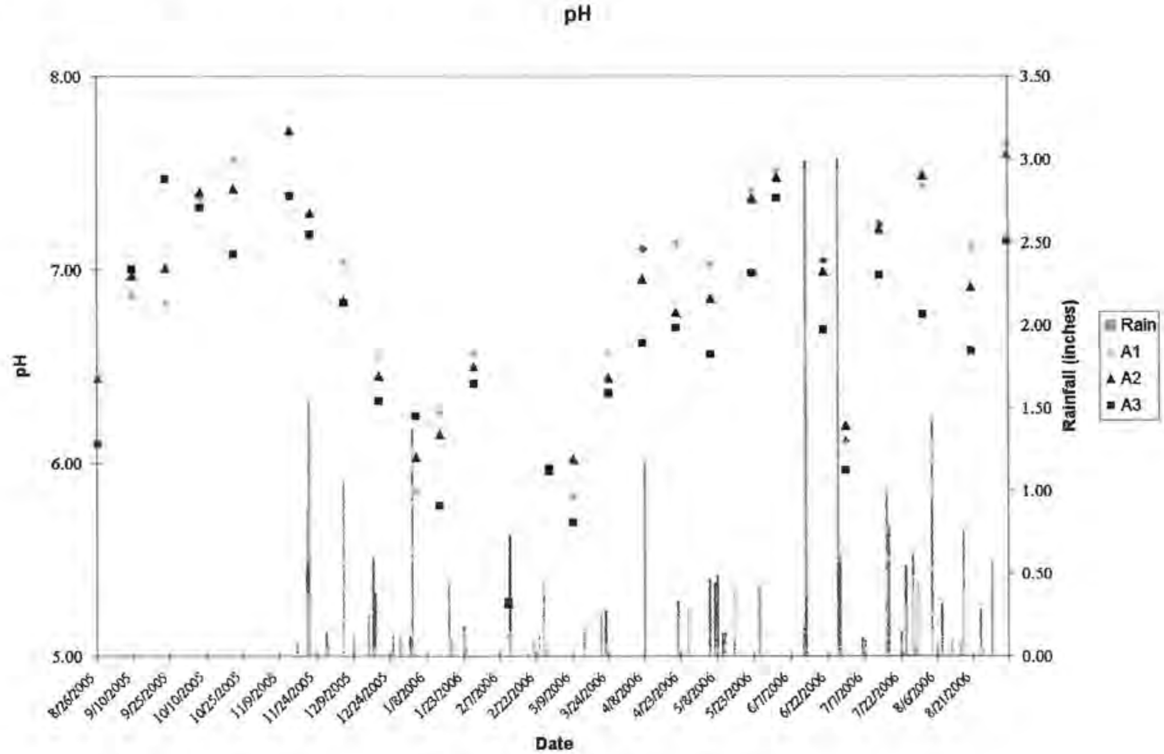


Figure C5c. pH values at MC 1-3 by date

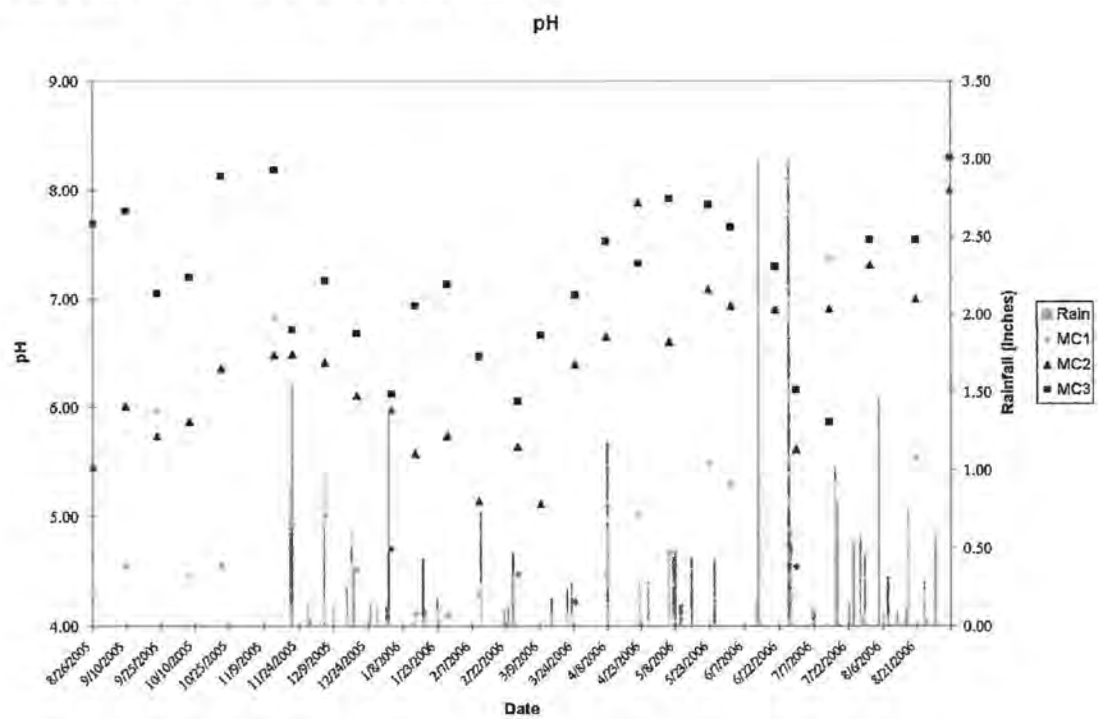


Figure C6a. TSS values at AR 1-3 by date

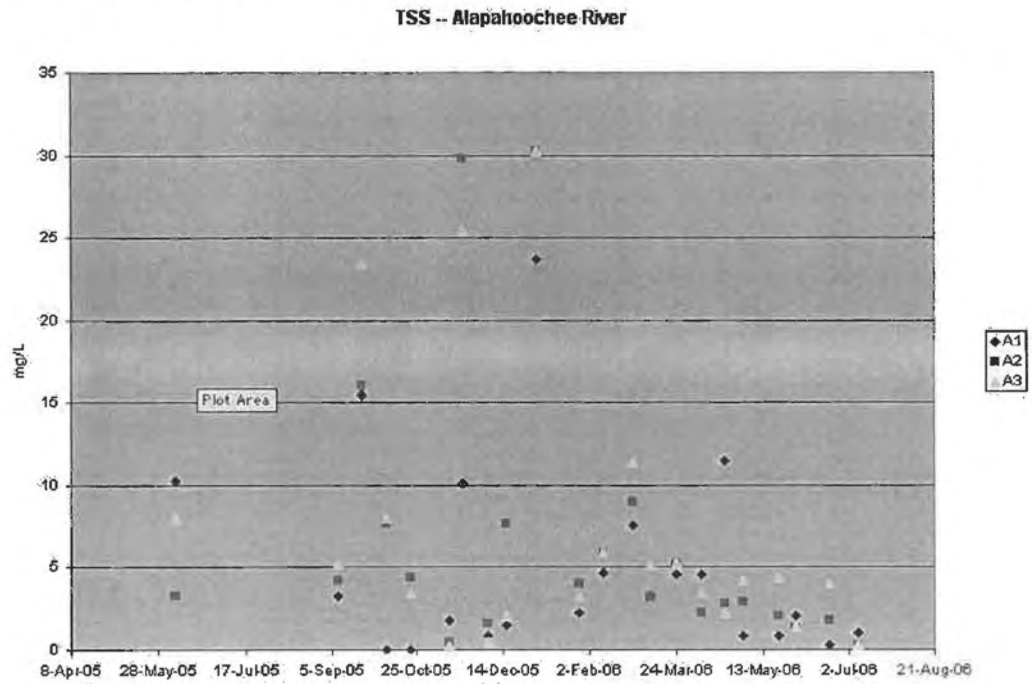


Figure C6b. TSS values at GB 1-4 by date

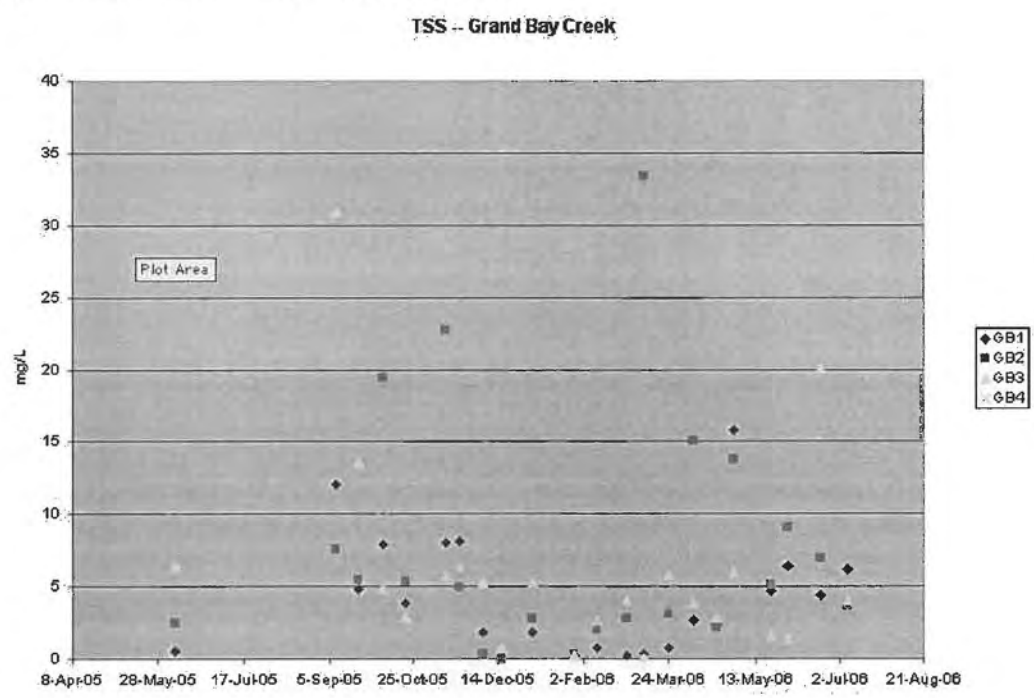


Figure C6c. TSS values at MC 1-3 by date

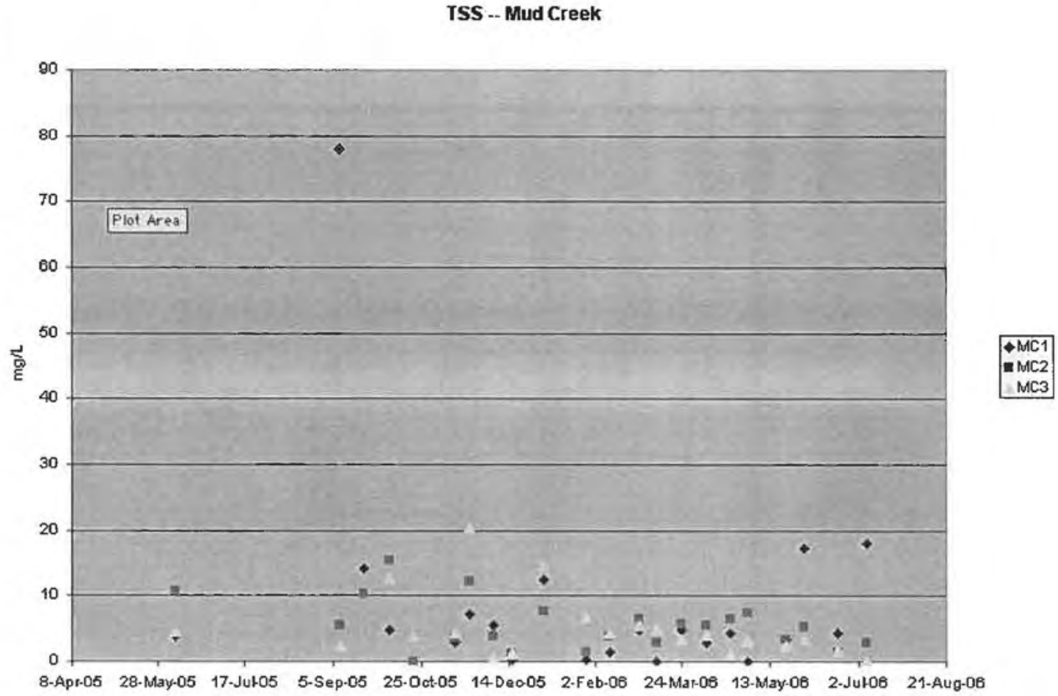


Figure C7a. Upper portion of Grand Bay Creek sub-watershed

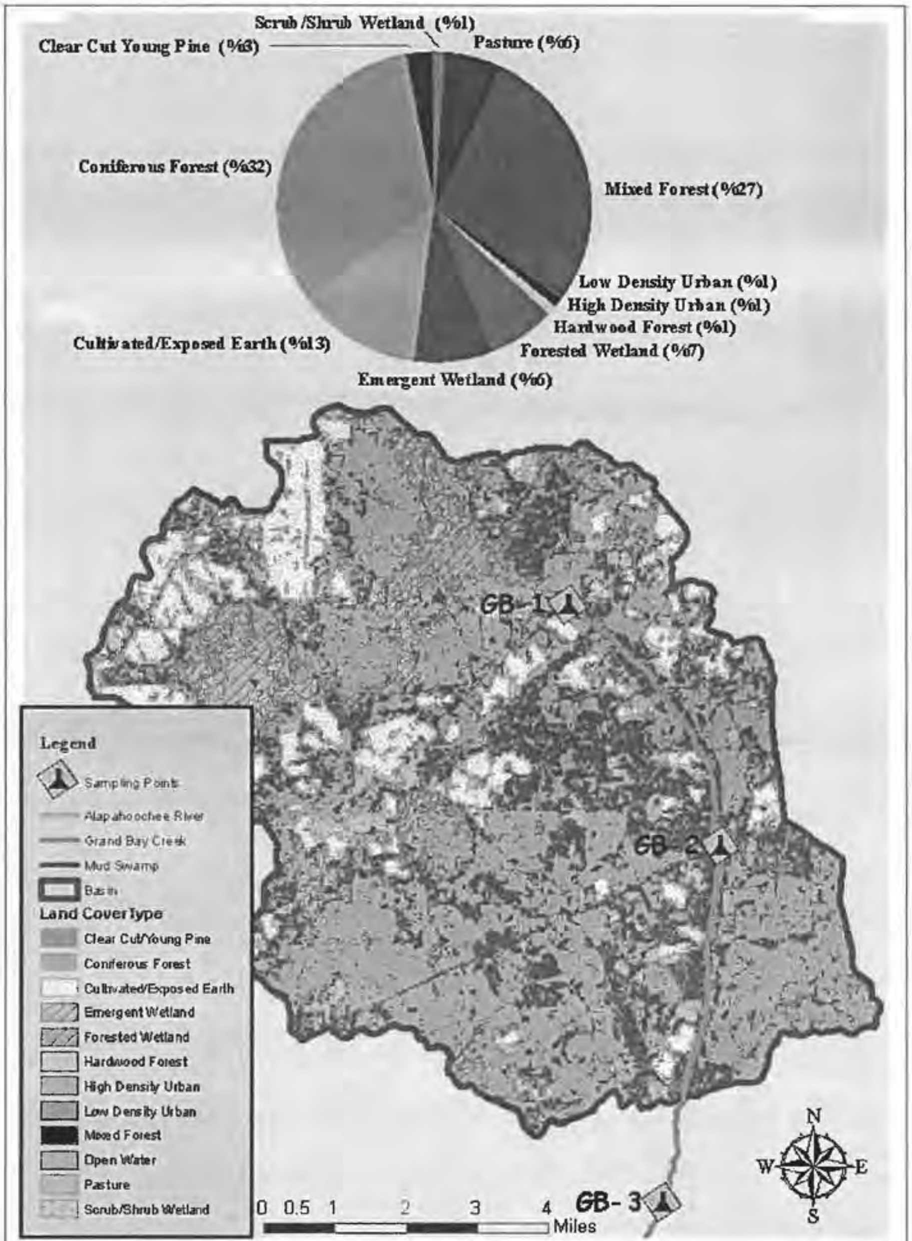


Figure C7b. Lower portion of Grand Bay Creek sub-watershed

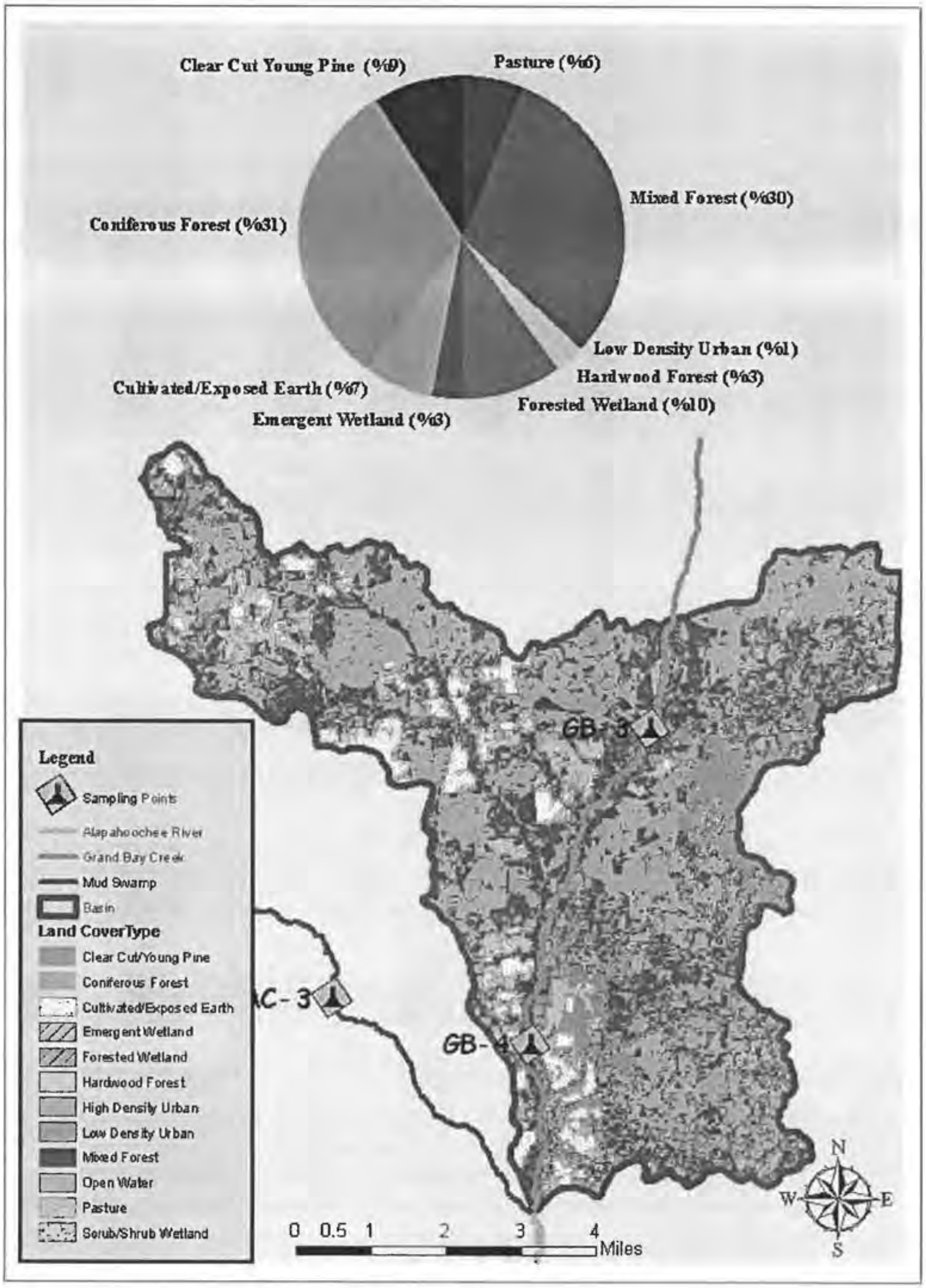


Figure C8a. Upper portion of Mud Creek sub-watershed

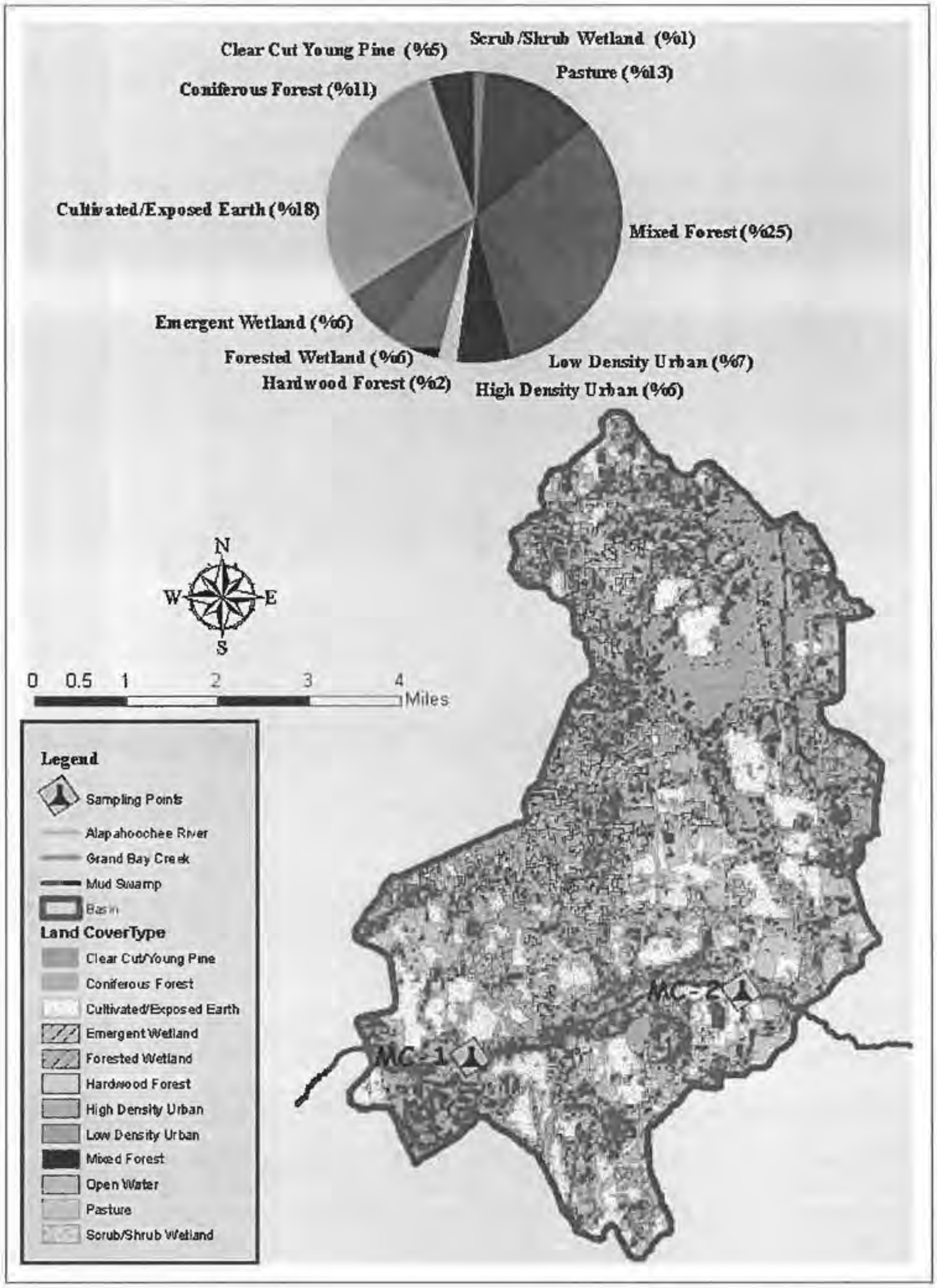


Figure C8b. Lower portion of Mud Creek sub-watershed

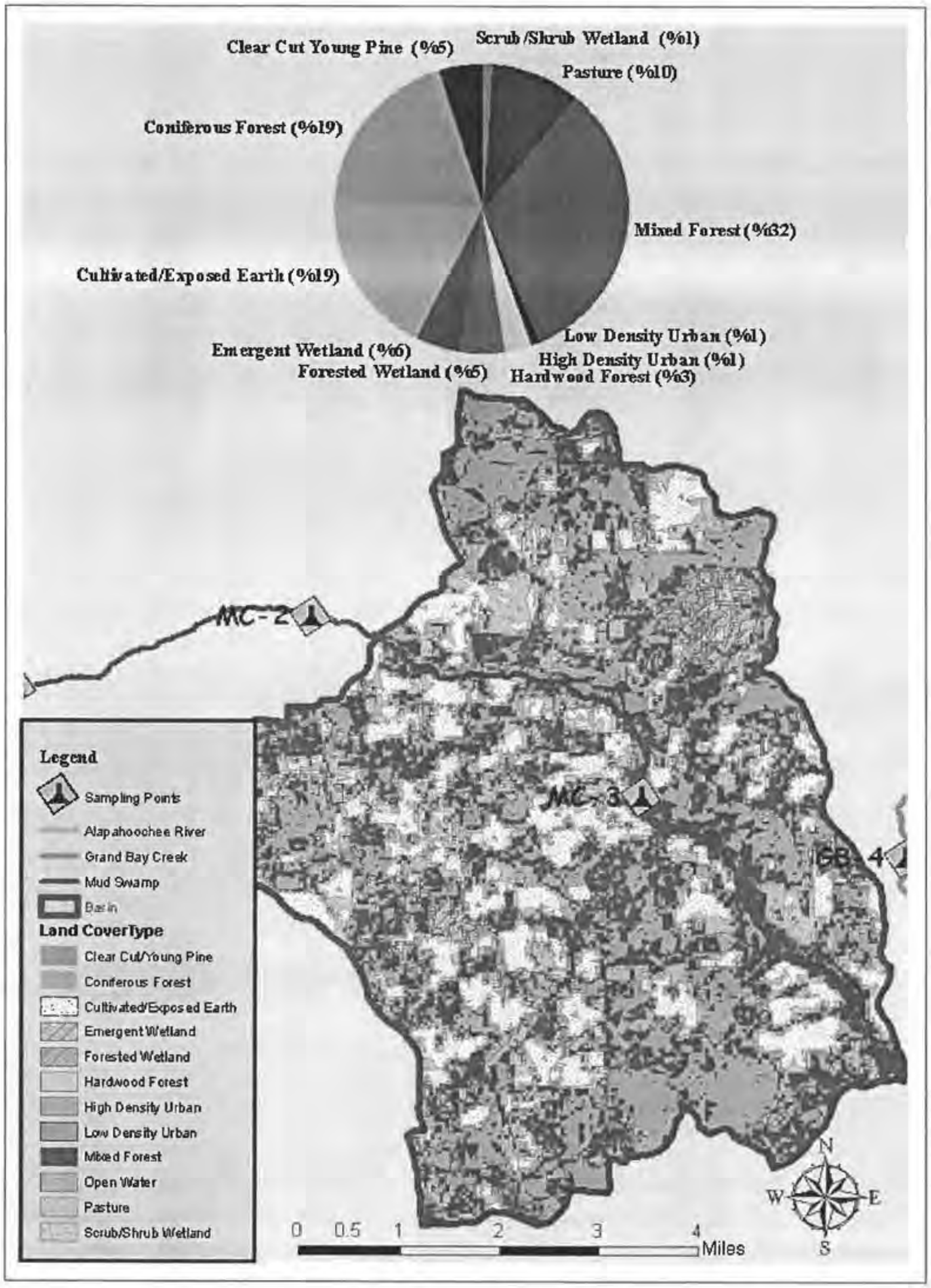


Figure C9a. Alapahoochee River sub-watershed

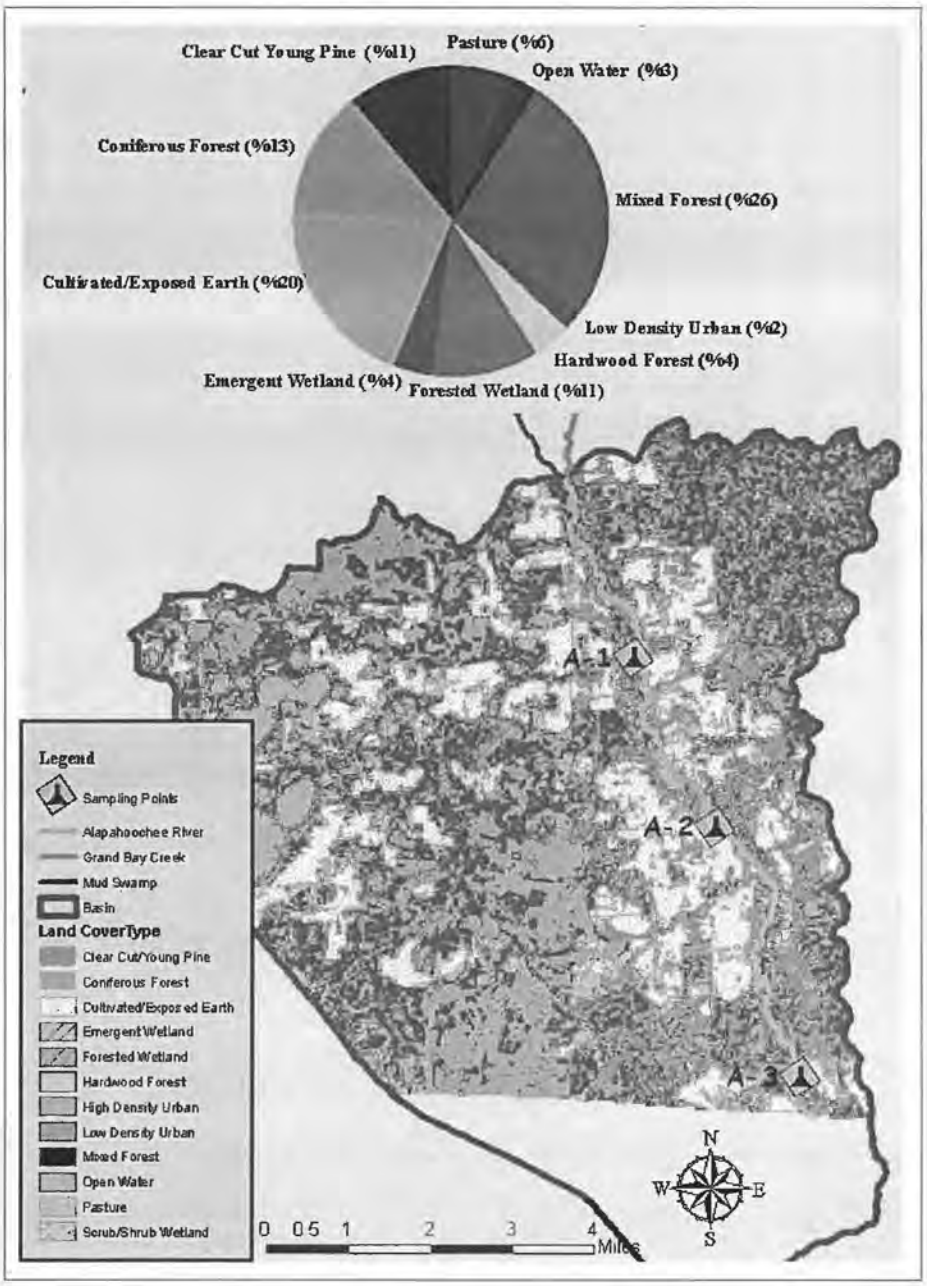
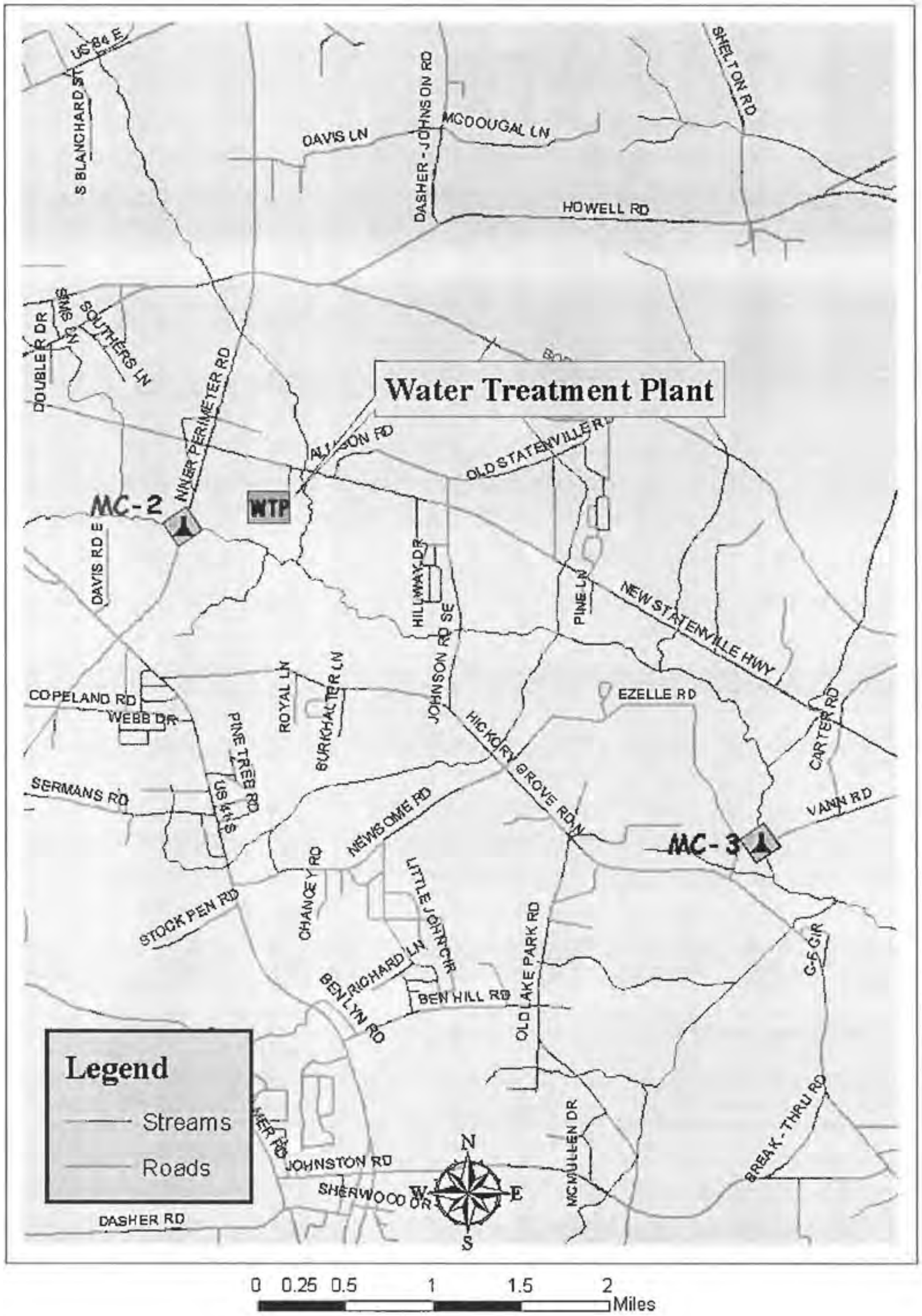


Figure C10a. Location of City of Valdosta Wastewater Treatment Plant between MC 2 and 3



D. Bacteriological and Periphyton Analysis

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Materials and Methods

Environmental Data. At each collection site two readings of solar radiation (photosynthetic photon flux density), water temperature, and dissolved oxygen concentrations were taken, one upon arrival at the collection site and one just before leaving. Light was measured with a Li-Cor quantum sensor attached to a model LI-1000 data logger and placed in direct sunlight. Water temperature and dissolved oxygen concentration were measured using a YSI model 95 dissolved oxygen meter. The probe of the meter was suspended from the bridge at approximately mid-stream and mid-depth wherever possible. To compensate for drift in oxygen readings, the probe was calibrated against water-saturated air at each collection site. Water color and turbidity were determined at each collection site, as were cloud cover, precipitation, and wind speed. The times of arrival and departure were also noted.

Sampling Protocol. One water sample, approximately 800-mL in volume, was collected from close to mid-stream at each collection site, while a second sample was collected from a randomly-selected collection sites. Samples were collected using sterile 1.0 L polypropylene bottles attached to a 2.44 m (8-foot) sampling pole. Samples were placed on ice until processed. In addition, 10 periphyton slides were collected from the periphytometer and fresh slides inserted[1]. Initially, three randomly selected slides were scraped into an amber vial and placed on ice for later chlorophyll analysis. Three additional slides, for ash-free dry weight analysis, were placed in a slide holder and allowed to air dry during transport to the laboratory. The remaining four slides were scraped into 50 mL of filtered river water and preserved with 0.5 mL of Lugol's iodine. Beginning in September 2005, the slide allocation was changed to: four slides for chlorophyll analysis (two slides scraped into each of two amber vials), three slides for ash-free dry weight, and three slides preserved with Lugol's iodine). Additional modifications were applied if slides were missing because of breakage or vandalism.

Bacterial Analysis. Bacterial enumeration began immediately upon return to the laboratory and samples not processed within six hours of collection were discarded.

Escherichia coli numbers were determined according to *Method 1603: Escherichia coli (E. coli) in Water by Membrane Filtration Using Modified membrane-Thermotolerant Escherichia coli Agar* (Modified mTEC). Three sample volumes, chosen at half-log intervals from 0.1, 0.3, 1.0, 3.0, 10.0, 30.0, and 100.0 milliliters, were assigned to each collection site on the basis of prior experience and current environmental conditions. Duplicate samples of the appropriate volumes

[1] Note that because the periphytometer holds 20 slides, by alternating collections, sets used for analysis were in place for four weeks.

were filtered through gridded 0.45 μm membranes, using a sterile filtration apparatus under house vacuum. Duplicate 100-mL aliquots of the sterile rinsing buffer were also filtered. The membranes were placed in small Petri plates containing mTEC agar and incubated for 2 hours at 35° C. At the end of this pre-incubation, the plates were sealed individually in whirl packs, placed in a water bath at 44.5° C, and incubated for 22 hours. At the end of the 22-hour incubation, magenta-colored colonies were counted with the aid of a dissecting microscope. Wherever possible, aliquots yielding counts between 20 and 80 were used to determine the number of colony forming units in 100 mL of water.

Three isolated magenta colonies were selected from each collection site for verification. These were grown on nutrient agar and in trypticase soy broth overnight. Small amounts of the slant culture were removed with a cotton swab and tested for cytochrome oxidase activity. The broth cultures were used to inoculate Simmons citrate slants, tryptone broth, and EC broth. Verified colonies showed no cytochrome oxidase activity, did not turn Simmons citrate blue within 48 hours, produced indole in tryptone broth within 48 hours, and produced gas in EC broth within 24 hours when incubated at 44.5° C.

Fifty-one bacterial isolates that were not verified as *E. coli* were examined in more detail. Each culture was streaked onto MacConkey agar and incubated for one to two days at 35° C. Selected isolated colonies were then subcultured, identified using the Enterotube II system (BD Diagnostics, Sparks, MD), and spotted onto mTEC agar.

Enterococcus numbers were determined according to *Method 1600: Enterococci in Water by Membrane Filtration* using *membrane-Enterococcus indoxyl-β-D-glucoside Agar (MEI).* Duplicate samples of the appropriate volumes (the same as used for *E. coli* enumeration) were filtered through gridded 0.45 μm membranes, using a sterile filtration apparatus under house vacuum. Duplicate 100-mL aliquots of the sterile rinsing buffer were also filtered. The membranes were placed in small Petri plates containing mEI agar and incubated at 41° C for 24 hours. At the end of the incubation period, blue-colored colonies or colonies with a blue halo were counted with the aid of a dissecting microscope. Wherever possible, aliquots yielding counts between 20 and 60 were used to determine the number of colony forming units in 100 mL of water.

Three isolated blue colonies were selected from each collection site for verification. These were grown on Brain Heart Infusion agar (BHIA) and in Brain Heart Infusion broth (BHIB) overnight. After 24 hours, growth in the BHIB tubes was used to inoculate a new tube of BHIB, a tube of BHIB containing 6.5% NaCl, and a Petri dish or slant containing Bile Esculin agar (BEA). The new tubes of BHIB were incubated at 45° C for 48 hours. The BHIB + 6.5% NaCl and the BEA cultures were incubated at 35° C for 48 hours. The original BHIA culture was Gram-stained after 48 hours and examined with the light microscope. Verified colonies contain Gram-positive cocci, grow in BHIB at 45° C, grow in BHIB + 6.5% NaCl, and produce a black pigment on BEA.

Eighteen isolates that were not verified as *Enterococcus* due to their lack of growth in BHIB plus 6.5% NaCl were studied in more detail. Each isolate was streaked onto BHIA and incubated for one to two days at 35° C. Isolated colonies were then subcultured, gram stained, spotted onto

MEI agar, and retested for their ability to grow in BHIB at 45° C and in BHIB plus 6.5% NaCl. Each isolate was identified using the Biolog MicroLog System, release 4.2 (Biolog, Inc., Hayward, CA), according to the manufacturer's specifications.

Periphyton Analysis. Chlorophyll analysis was conducted as described. A 3 mL solution of 90% acetone was added directly to the amber vials containing scrapings from the periphyton slides. The vials were then placed in an explosion-proof refrigerator and incubated at ~4° C overnight. The next day, 1.5 mL from each vial was centrifuged at high speed for 10 minutes. The supernatant was scanned between 350 and 850 nm against a 90% acetone blank using a Beckman DU 640 spectrophotometer, and the absorbance recorded. The absorbance values at 630 nm, 647 nm, 664 nm and 750 nm were used in the standard trichromatic equations to determine the concentrations of chlorophylls a, b, and c. The scan function was used instead of fixed wavelengths to verify that interfering pigments were not extracted along with the expected chlorophylls and carotenoids, a common problem in this region.

Ash-free Dry Weight. Three air-dried slides from each collection site were scraped into a tared and numbered crucible. The samples and crucible were then dried at 105° C for at least 48 hours and weighed. Samples/crucibles at constant weight were placed in an oven and ashed at 500° C for 2 hours. After cooling, the samples/crucibles were weighed again. After weighing, the samples were moistened, re-dried at 105° C overnight, and re-weighed. Ash-free dry weight was determined from the difference between the first dry weight and the final dry weight.

Diatom Community Analysis. The Lugol's iodine fixed samples were mixed thoroughly. A 25 mL aliquot of each sample was placed in each 50-mL polypropylene centrifuge tube and centrifuged at low speed for 15 minutes. The supernatant was discarded. Approximately 5 mL of 30% hydrogen peroxide (H_2O_2) was added to the pellet. The mixture was allowed to incubate at room temperature for 30 minutes. Approximately 5 mL of concentrated sulfuric acid were then added to the tube and the contents boiled at 100° C for an additional 30 to 45 minutes. The pellet was rinsed with 40 to 50 mL of de-ionized water at least 10 times. Aliquots of the cleaned material were mounted in Naphrax for viewing with light microscopy. Additional aliquots of selected samples were mounted on glass cover slips affixed to aluminum stubs and sputter-coated for viewing with scanning electron microscopy. At least one photograph of each observed taxon was taken with differential interference contrast microscopy using an Olympus BX60 microscope and Tmax 100 black-and-white film. Additional digital images were taken using a JEOL JSM-6480LV scanning electron microscope as the opportunity presented. Where possible, diatoms were identified using Patrick and Reimer (1966, 1975), Krammer and Lange-Bertalot (1986, 1988, 1991a, 1991b) and Wehr and Sheath (2003), with support from Gaiser and Johansen (2000) and Morales (2006).

Results and Discussion

Water Temperature and Oxygen Concentration. Water temperature and oxygen concentrations are presented in Figures D1a, b, c and D2a, b, c. The data include preliminary readings beginning 14 January 2005. The temperature data reflect the annual variation in air temperature for the region and are consistent within the watershed. Oxygen concentrations generally indicated well-oxygenated waters with the exceptions of MC 1, BG 1, and during times of low water, GB 2 and GB 3. In fact, oxygen levels in MC 1 and GB 1 were consistently below the minimum standard of 4.0 mg/L designated for rivers used for fishing in the coastal plain during warm weather. These collection sites were located near the outflows of large wetlands, Mud Swamp and Grand Bay Swamp, respectively. The low oxygen content at these collection sites probably was the result of natural rates of decomposition within the swamps and not the result of human impacts. This interpretation is consistent with the brown color of the water, which probably results from the presence of tannins and humic substances, with the lack of noticeable numbers of pollution tolerant microalgae and invertebrates (provided in a separate document that will be provided upon completion), and with the upward trend in oxygen content at downstream collection sites. However, both swamps have some history of human activity, which may play a contributing, but undetermined role.

Microbiological Analysis. Numbers of presumptive *Escherichia coli* and fecal enterococci are provided in Figure D3a, b, c and Figure D4a, b, c. The most obvious features present in nearly all of the graphs were spikes in counts on 3 June 2005 and 9 April 2006. These can be attributed to heavy rainstorms within the 24 hours prior to sample collection, which apparently overwhelmed all microbiology abatement procedures. By the time the next set of samples was collected, the numbers of bacteria were more or less back to normal levels. The cause of the spike at MC 2 on 7 October 2005 is not clear.

Other than the spikes in numbers noted, *Escherichia coli* counts were generally below 575 cfu/100 mL, the maximum allowable point measurement in waters not generally used for swimming. There are a number of small spikes during the Fall 2005 above 500 cfu/100mL and a general upward trend in the numbers at all of the Alapahoochee River collection sites that cannot be accounted for. However, deer carcasses were noted at a number of the collection sites during this period and the role of hunting in coliform counts may be a topic for future study.

Additional testing of 51 of the isolates that were not verified as *E. coli* by Method 1603 showed that 16 (31.4%) of them were *E. coli*. Twenty-seven (52.9%) of the isolates contained *E. coli* as well as another gram negative bacterium. The remaining eight (15.7%) of the 51 tested isolates contained gram negative bacteria other than *E. coli*. The detection of more than one type of bacteria in more than half of the 51 tested isolates most likely reflected difficulties associated with picking the colonies. For example, white, mucoid, spreading colonies sometimes grew on the plates and complicated the process of picking well-isolated, magenta-colored colonies for verification. Streaking the selected colonies for isolation before conducting the verification tests would be helpful in eliminating this problem in the future.

Enterococcus counts did not follow the same pattern as counts of *E. coli*. First, *Entercoccus* counts in the Grand Bay Creek system did not show a prominent spike on 9 April 2005, suggesting a different response to rainfall in *Enterococcus* when compared to *E. coli*. Second, GB 1 and 2 showed anomalous increases during the Winter months. This may have been, in part, due to a change in the population of *Enterococcus* during cold weather. From the end of November to the beginning of March, there was an unusual number of isolates that failed the verification tests (49 out of 270 during this period, and 13 out of 30 on 16 December 2005, compared to 57 out of 773 for the entire year). A more thorough examination of changes in the relative numbers of strains of enterococci with respect to annual temperature in natural populations may be of interest for future research. Third, the numbers of enterococci in MC 2 and 3 and in the Alapahoochee River collection sites, while highly variable, are consistently well above the suggested limit of 151 cfu/100 mL recommended for rivers not generally used for swimming. The source of these bacteria is not clear. Fecal contamination from the surrounding farms, which include herds of dairy cows, is the most probable cause. However, if this was the case, one might expect *E. coli* counts to be similarly high. The lower numbers in Grand Bay Creek and at MC 1, may have resulted from the suppression of enteroccocci by the lower pH at these collection sites. Future research into the relationship of *Enterococcus* and pH in natural systems may also be of interest.

Additional testing of 18 of the isolates that were not verified as *Enterococcus* by Method 1600 showed that three (16.7%) of them were in fact *Enterococcus* species. Interestingly, these three isolates also grew in BHIB plus 6.5% NaCl when they were re-tested. Why they did not grow in the initial test is unknown. In contrast, the remaining 15 (83.3%) of the isolates were actually *Streptococcus* species. These isolates did not grow in BHIB plus 6.5% NaCl when they were re-tested. Seventeen of the 18 isolates used in these tests were obtained from water samples collected between late November and early March—the time period during which unusual numbers of isolates were not verified as *Enterococcus*. These data suggest that additional studies of *Streptococcus* as well as *Enterococcus* bacterial species in natural waters would be helpful.

Periphyton Biomass. Chlorophyll and ash-free dry weight are presented in Figures D5a, b, c and D6a, b, c; the data include preliminary readings beginning 14 January 2005. The data represent the mount of mass accumulated in roughly four-week periods and missing data are the result of inaccessibility of slides due to flooding and loss of slides due to breakage and vandalism. In spite of the missing data, two important features can be distinguished. First, all biomass figures are relatively low. This can be accounted for, in part, by difficulties encountered trying to keep the periphytometers within the photic zone. Water levels within the watershed fluctuated markedly during the study period, with changes in depth of a meter or more during a two-week interval not uncommon, especially in the early part of the study. Because this is a black-water system, such changes severely influence the amount of light reaching the substrate and reduce the amount of growth on the slides. On the other hand, periphyton attached to the bottom or sides of the creek would encounter the same difficulty. In fact, mass growths of periphyton, metaphyton, and/or epiphyton were rare occurrences during the study period. Reports of visible growths of algae by the field crew were restricted primarily to MC 1 and the upper collection sites of Grand Bay Creek.

The autotrophic index (defined ash-free dry weight divided by chlorophyll a mass) was calculated for each collection and summary statistics are shown in Table D1. First, the numbers were generally high. As is clear from the table, the values of the index were highly variable for each collection site. This variability is due in part to the fact that small changes in the generally low values of biomass can lead to large changes in the value of the index. It is still possible to draw some conclusions. In photosynthesis-driven systems, it would be expected to see autotrophic indices in the range of 50 to 100. All of the means and all of the modes, except that of MC 1, are in excess of 400 indicating the watershed was heterotrophy-dominated for most of the study period. This is not surprising given the amount of organic matter reaching the system from the two swamps, adjoining wetlands, and the brown color and depth of the water.

However, the high autotrophic indices as indicated by both the mean and the median downstream of MC 2, when coupled with the high *Enterococcus* counts, may also be indicative of leached organic matter from the surroundings.

Table D1. Autotrophic Index

Collection Site	MC 1	MC 2	MC 3	GB1	GB2
Mean	674	3721	5975	1267	2018
Median	296	1907	4450	608	482
Maximum	3147	>10,000	>10,000	8900	>10,000
Minimum	58	43	124	9	74
Collection Site	**GB 3**	**GB 4**	**AR 1**	**AR 2**	**AR3**
Mean	5164	2475	4291	3762	4280
Median	1159	426	2967	1863	2755
Maximum	>10,000	>10,000	>10,000	>10,000	>10,000
Minimum	37	48	23	81	69

Periphyton Community Structure. Two sets of periphyton samples were selected for detailed analysis and were retrieved on 20 May 2005 and 9 September 2005. These were selected because they contained a complete set of samples with no collection sites missing and because they bracketed the assumed summer growing period. These contained a diverse assemblage with over 150 diatom taxa recognized at either the species or varietal rank (Appendix 1D). Most of these are widespread or cosmopolitan taxa, not directly linked to polluted waters.

The assemblages fall into two distinct groups. The first composed of GB 1-4 and MC 1 and 2, while the second composed of the MC 3 and all the Alapahoochee River collection sites. The first group was characterized by the predominance of *Eunotia* spp. and, to a lesser extent, *Pinnularia* spp. In some cases, *Eunotia* spp. comprise more than 99% of the valves counted. The large numbers of these two groups resulted in lower numbers of taxa encountered and lower Shannon-Wiener diversity indices and (Table D2). *Eunotia* and *Pinnularia* were still present in the second group, but formed a smaller proportion of the assemblage. Instead there was a diverse assemblage of *Navicula*, *Nitzschia*, and members of the Achnanthaceae, resulting in higher overall diversity, albeit with a lower absolute biomass and absolute numbers.

A number of factors may be involved in the change in the diatom assemblage. First, there were changes in stream morphology and flow rates within the watershed. These were most noticeable when comparing the Alapahoochee River with the upper parts of Mud Creek and Grand Bay Creek. The higher flow rates, more variable depth, and greater proportion of sandy bottoms could easily have had a negative impact on the growth of attached chain-forming taxa like *Eunotia*. Second, was the water chemistry changes downstream of MC 2 and GB 3. This was most evident in the change in pH noted previously, although changes in the concentrations of organic material (chemical oxygen demand) and nutrients occurred in other data. The change in pH could have had an adverse effect on *Eunotia* and *Pinnularia*. These genera, and many of the species identified in the present study, are generally associated with waters of lower pH (Patrick & Reimer 1966, Gaiser & Johansen 2000). The observed species of *Planothidium* and *Cocconeis*, in contrast, which show relative increases in the downstream collection sites, are generally associated with waters of pH 7 or higher. The same is true of other species present at the downstream collection sites, notably the large, distinctive forms *Gyrosigma spencerii* and *Cymbella aspera.*

Table D2. Diatom Diversity

	GB1	GB2	GB3	GB4	MC1	MC2	MC3	AR1	AR2	AR3
Total taxa (combined total = 159)	39	39	28	33	42	62	101	78	53	69
Shannon-Wiener Diversity Index										
5-20-05	1.72	0.06	1.20	1.37	1.56	2.64	3.53	3.2	0.90	3.04
9-9-05	1.99	2.20	2.41	2.86	2.50	3.50	3.75	3.61	3.44	3.79
Percent *Eunotia* and *Pinnularia*										
5-20-05	90%	99%	91%	99%	91%	63%	19%	25%	85%	24%
9-9-05	90%	36%	68%	65%	59%	49%	14%	37%	31%	25%
Composite	91%	74%	71%	79%	71%	59%	15%	33%	35%	25%

It appears that there are substantial influxes of circumneutral waters into the system below MC 2 and GB 3 that may have had an impact on the biology of the system. This was seen in the numbers of *Enterococci* and the composition of the diatom assemblage.

Figures

Figure D1a. Temperature Data for GB 1-4

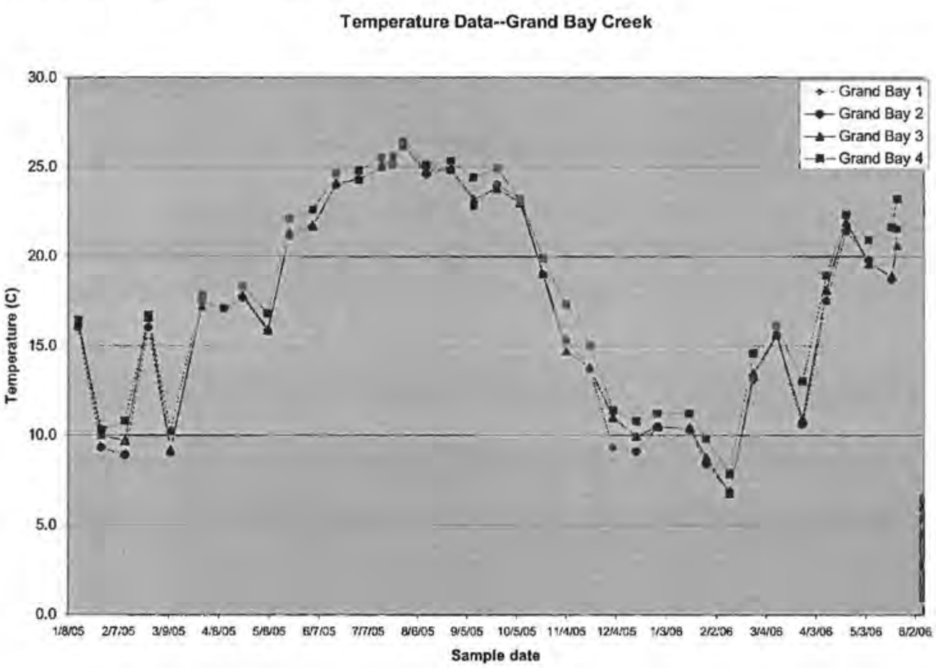


Figure D1b. Temperature Data for MC 1-3

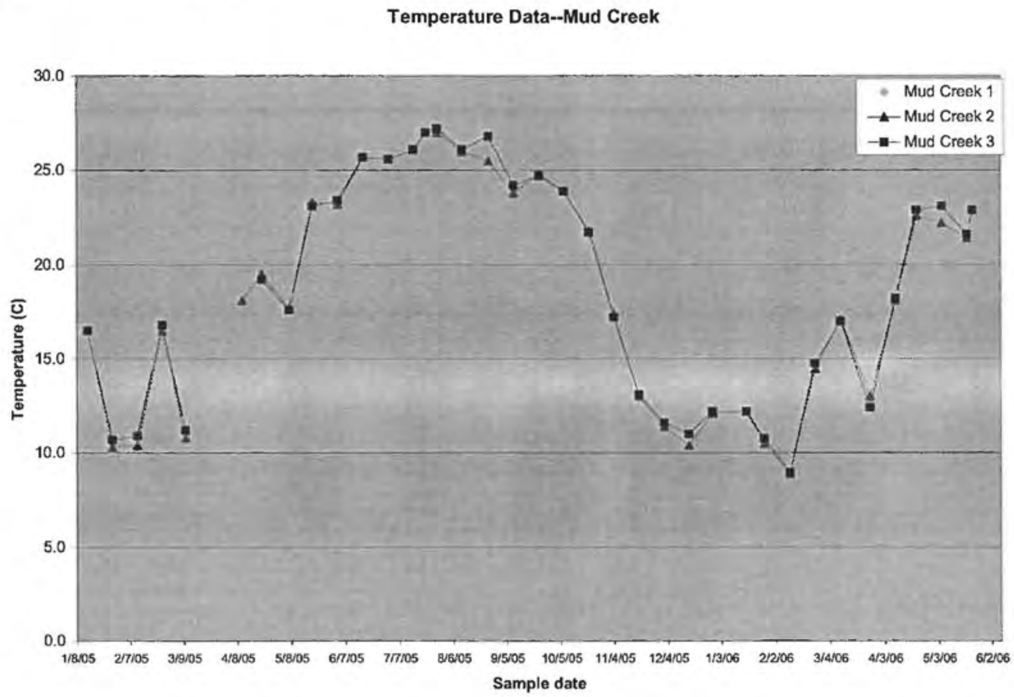


Figure D1c. Temperature Data for AR 1-3

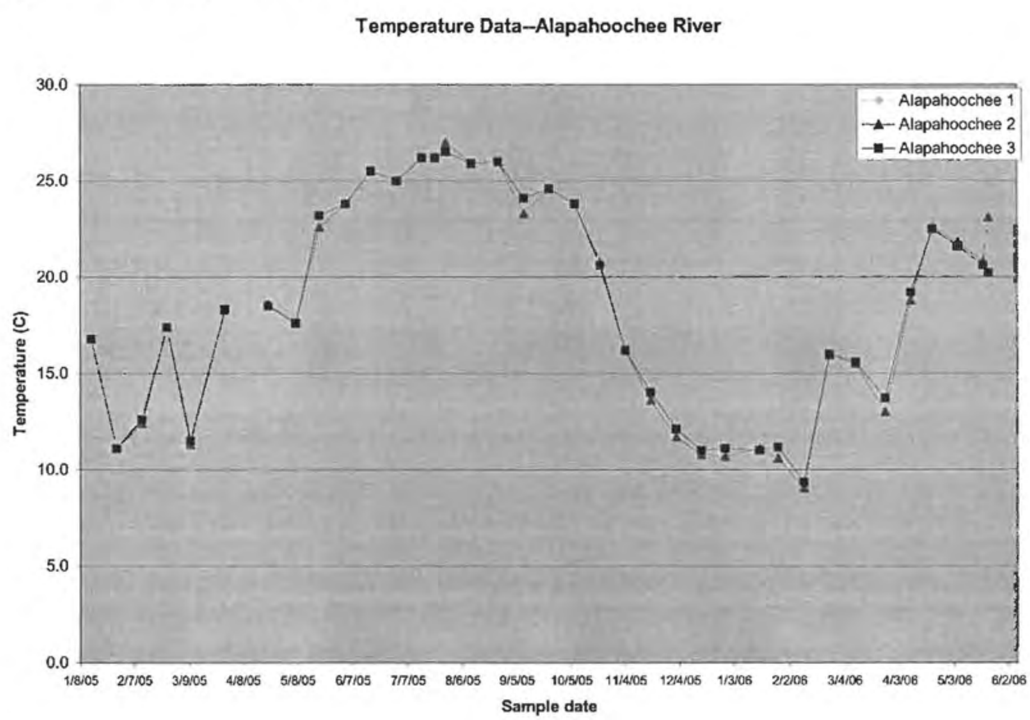


Figure D2a. Oxygen Data for GB 1-4

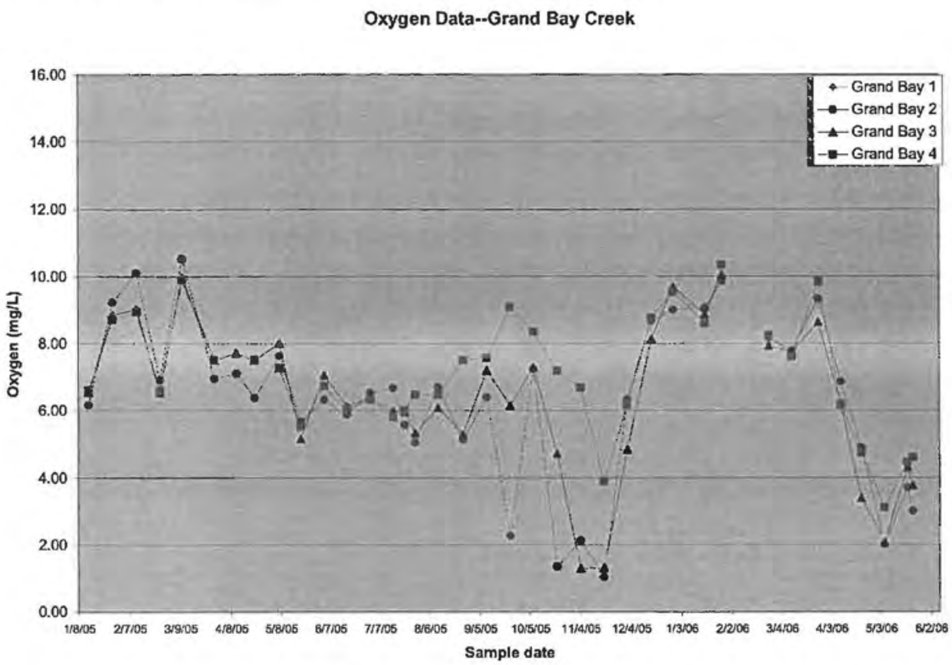


Figure D2b. Oxygen Data for MC 1-3

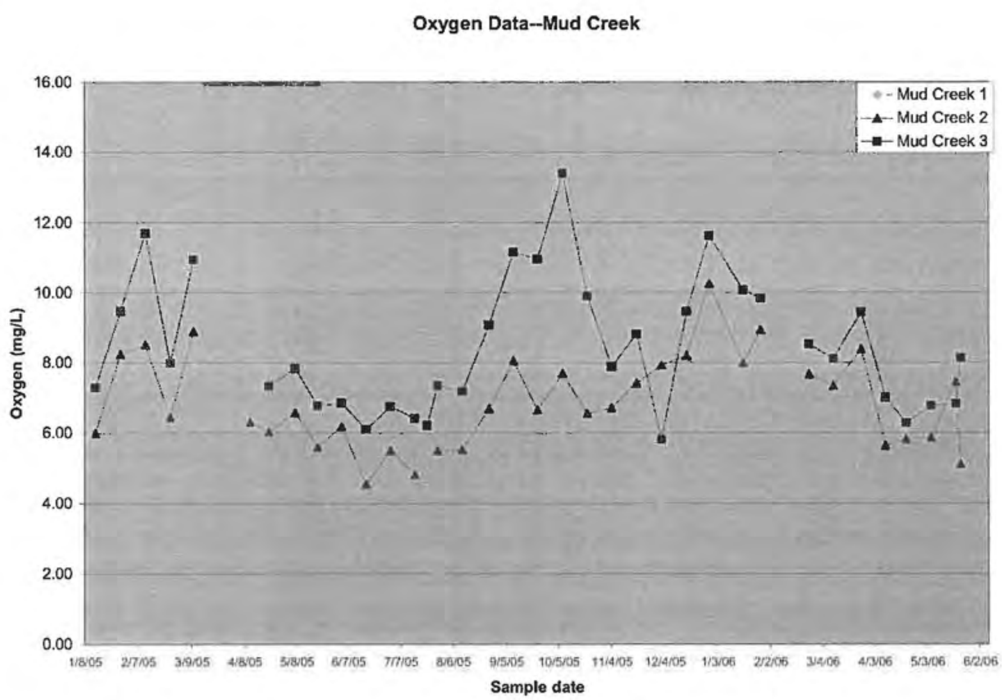


Figure D2c. Oxygen Data for AR 1-4

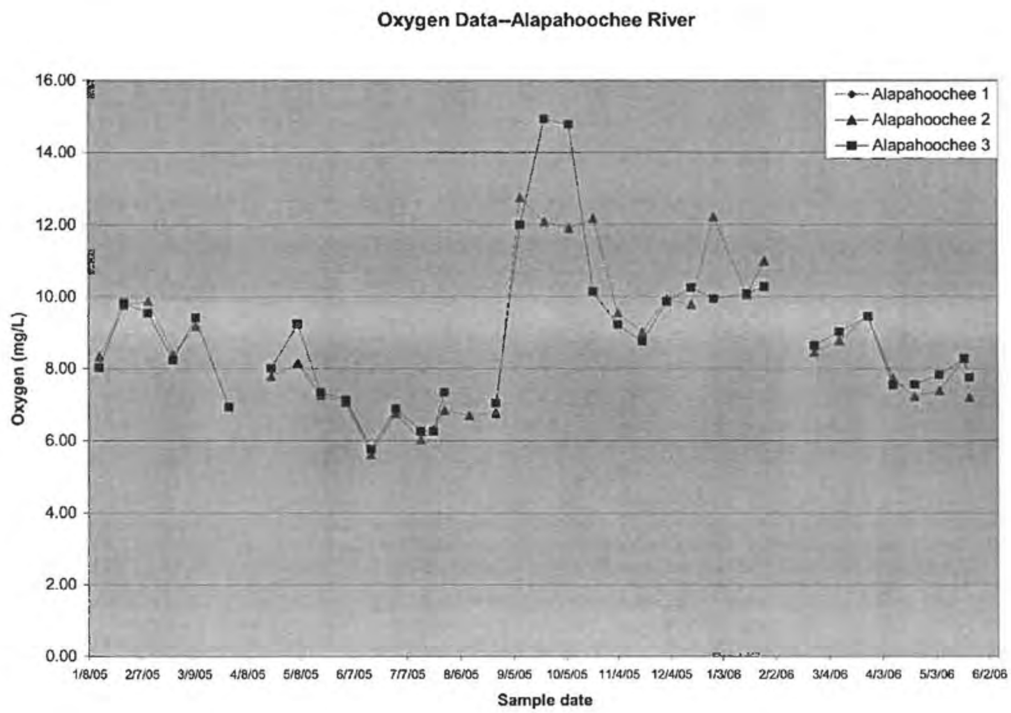


Figure D3a. ***Escherichia coli*** **counts for GB 1-4**

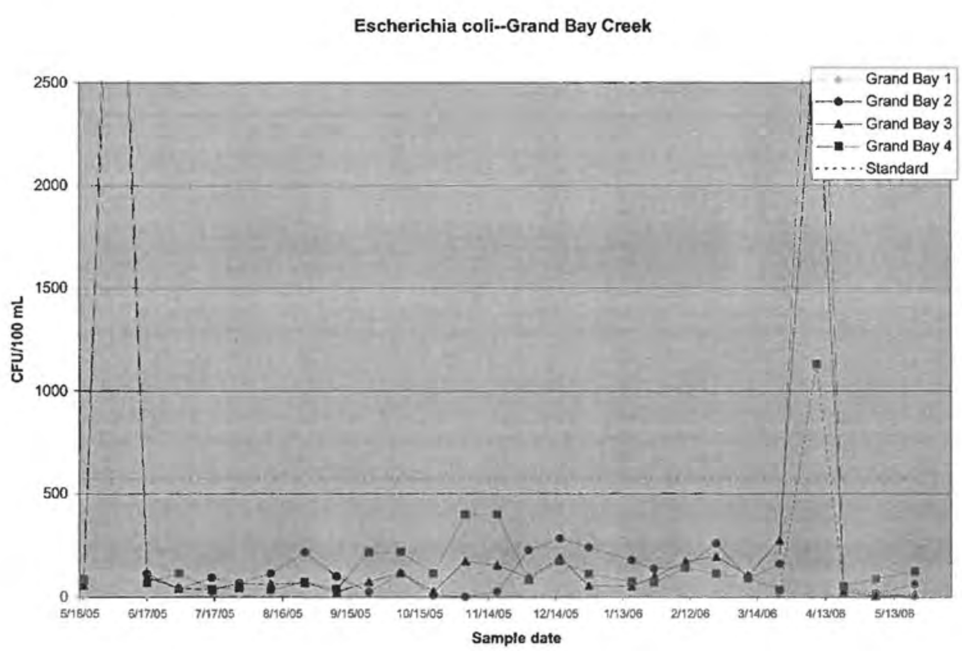


Figure D3b. ***Escherichia coli*** **counts for MC 1-3**

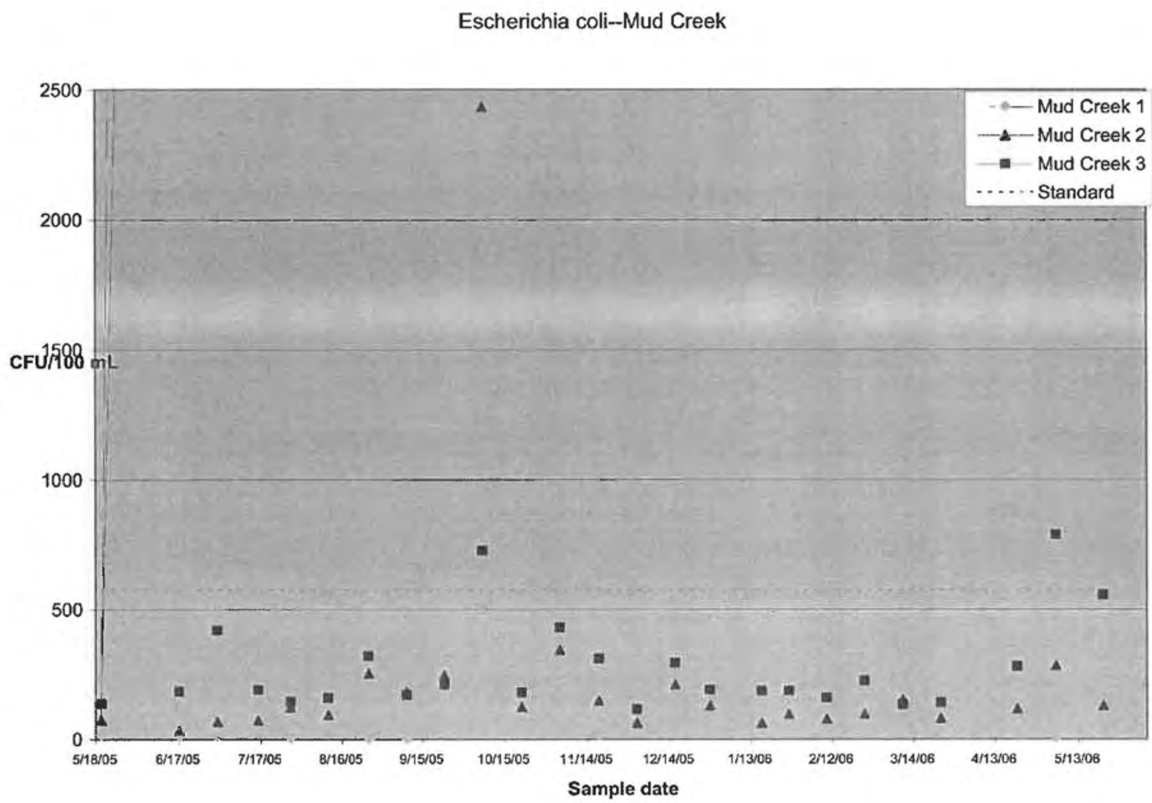


Figure D3c. ***Escherichia coli*** **counts for AR 1-3**

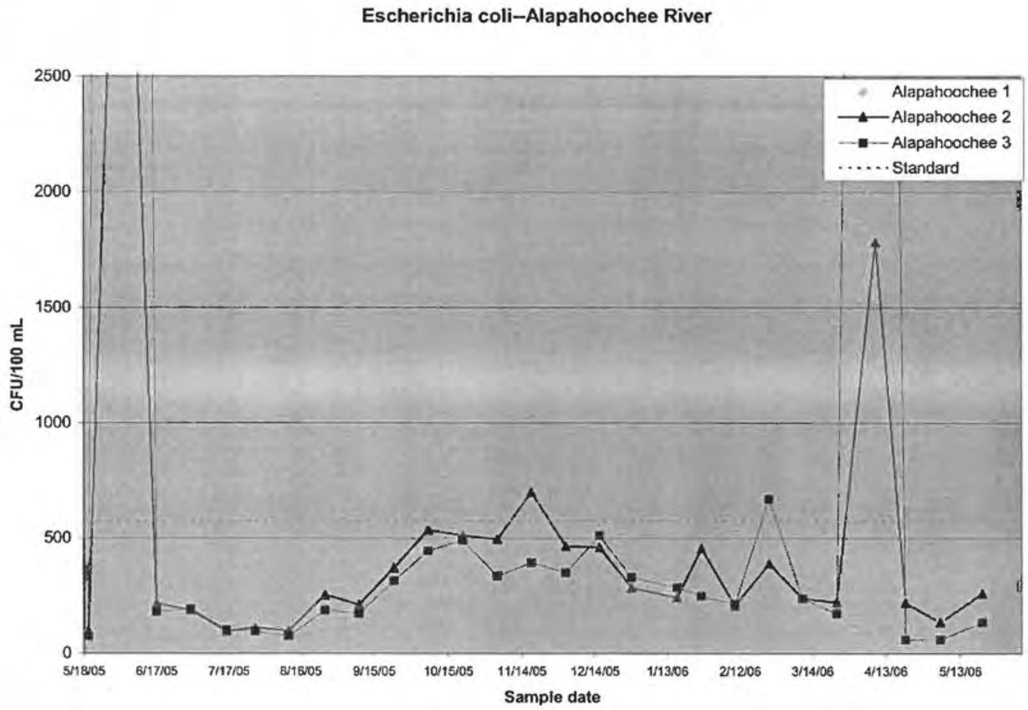


Figure D4a. ***Enterococcus*** **counts for GB 1-4**

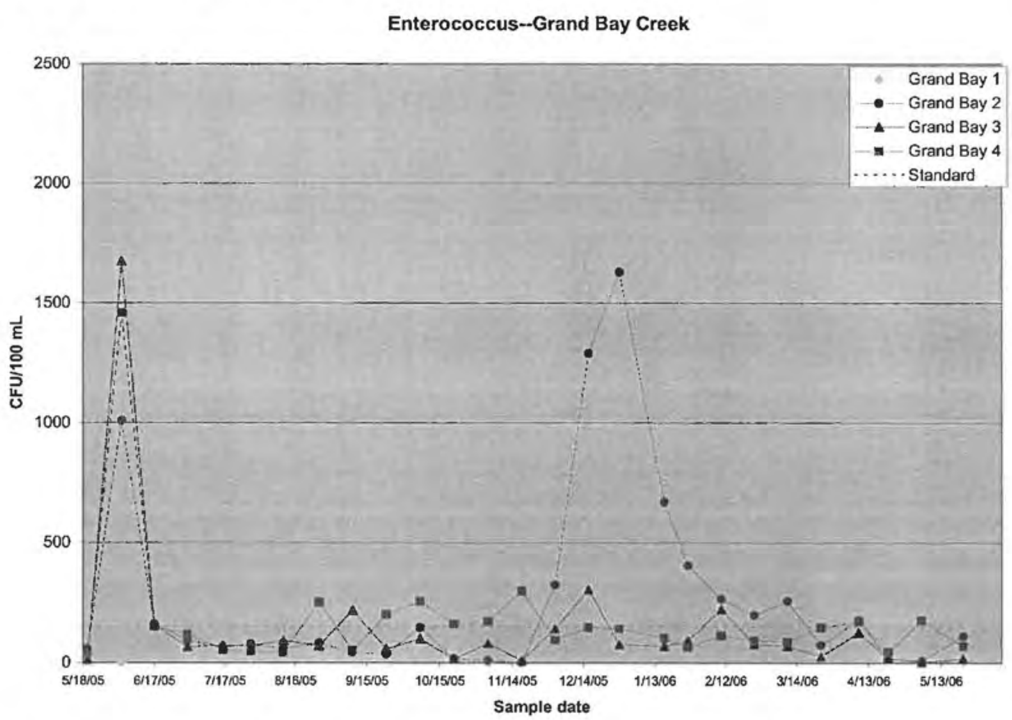


Figure D4b. ***Enterococcus*** **counts for MC 1- 3**

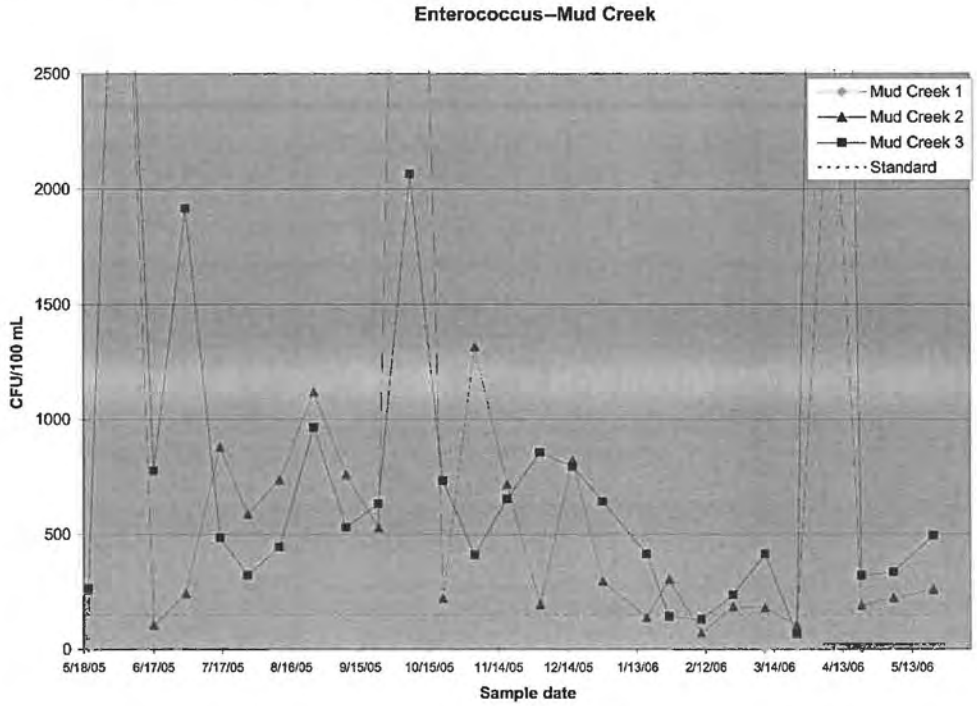


Figure D4c. ***Enterococcus*** **counts for AR 1- 3**

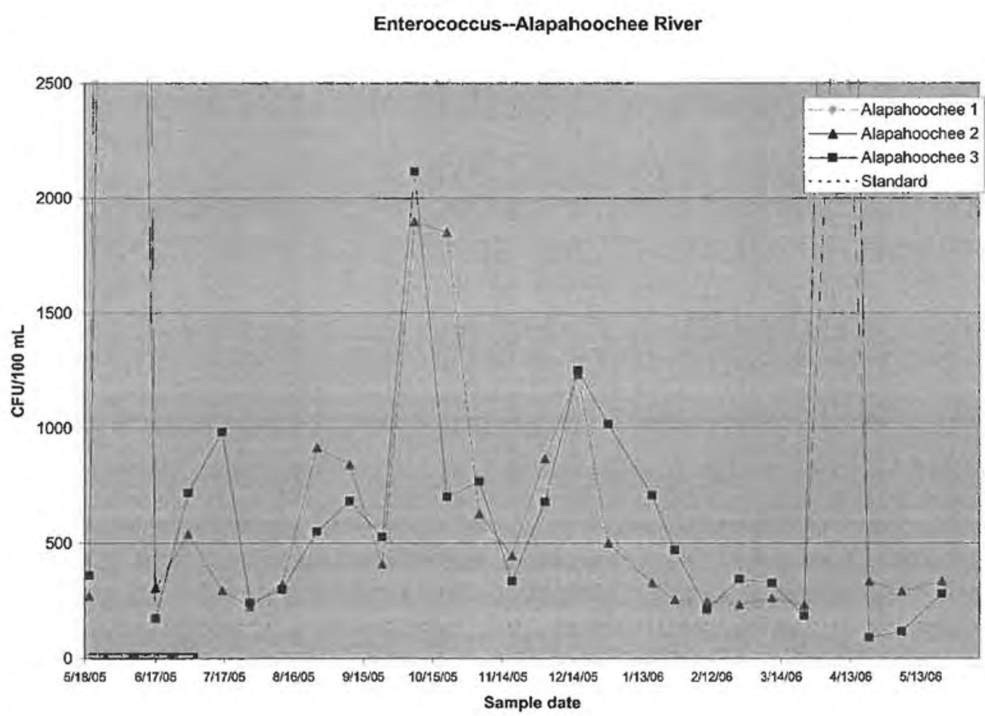


Figure D5a. Chlorophyll a for GB 1-4

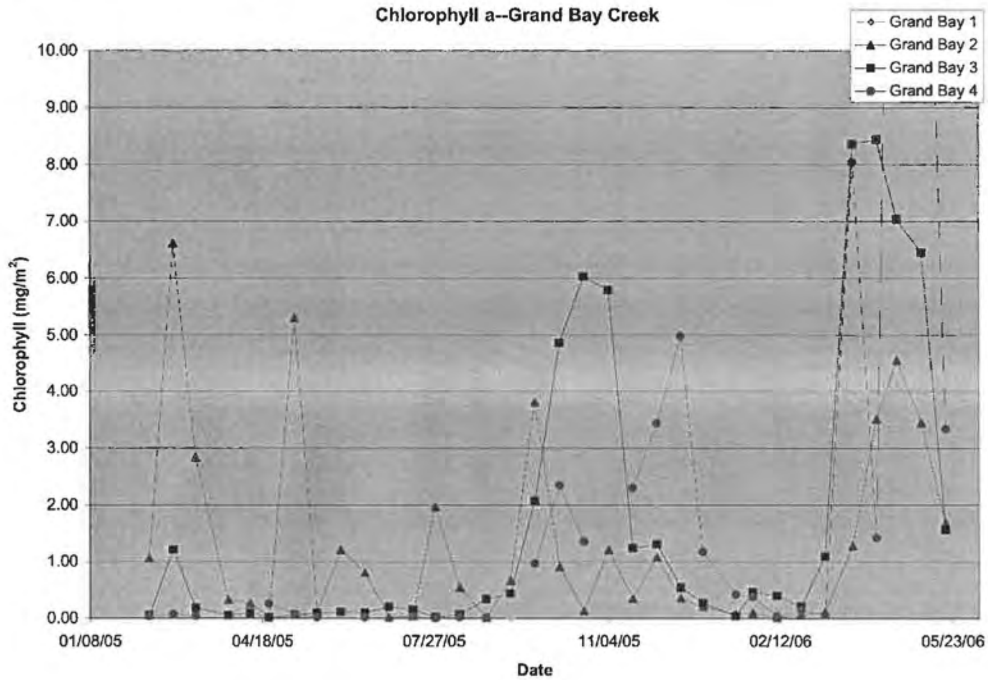


Figure D5b. Chlorophyll a for MC 1-3

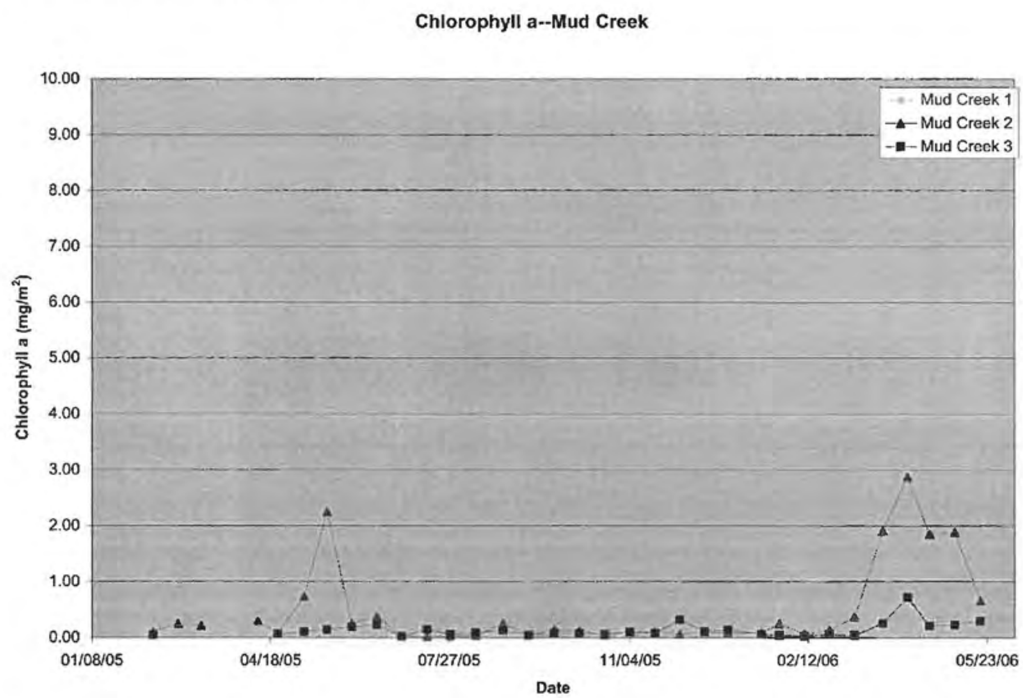


Figure D5c. Chlorophyll a for AR 1-3

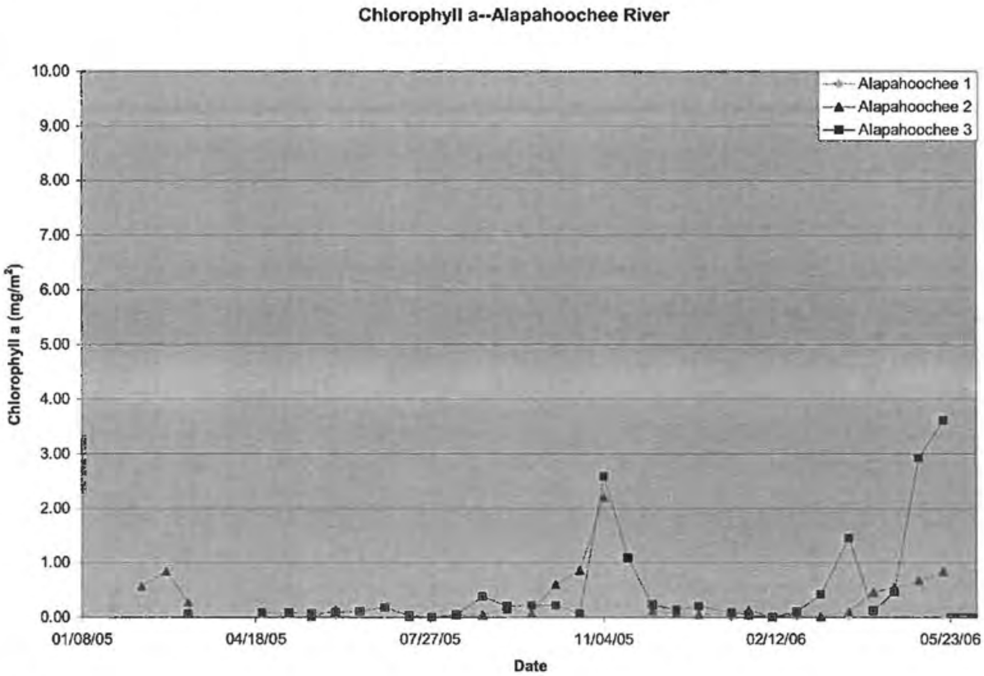


Figure D6a. Ash-free Dry Weight for GB 1-4

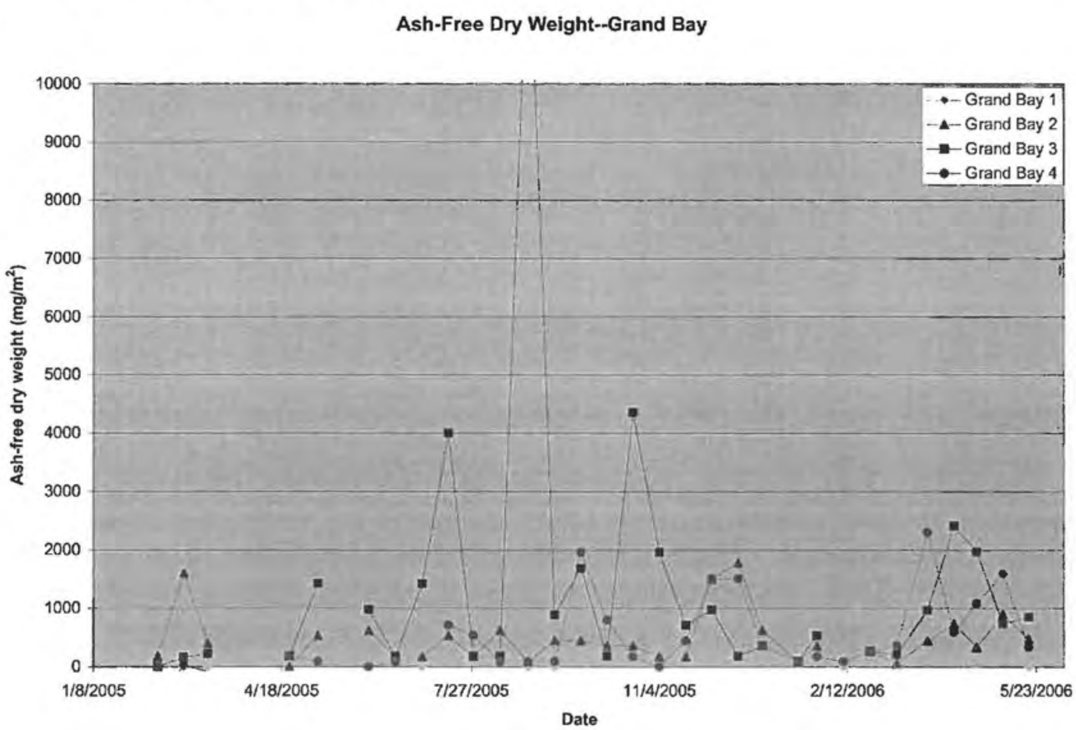


Figure D6b. Ash-free Dry Weight for MC 1-3

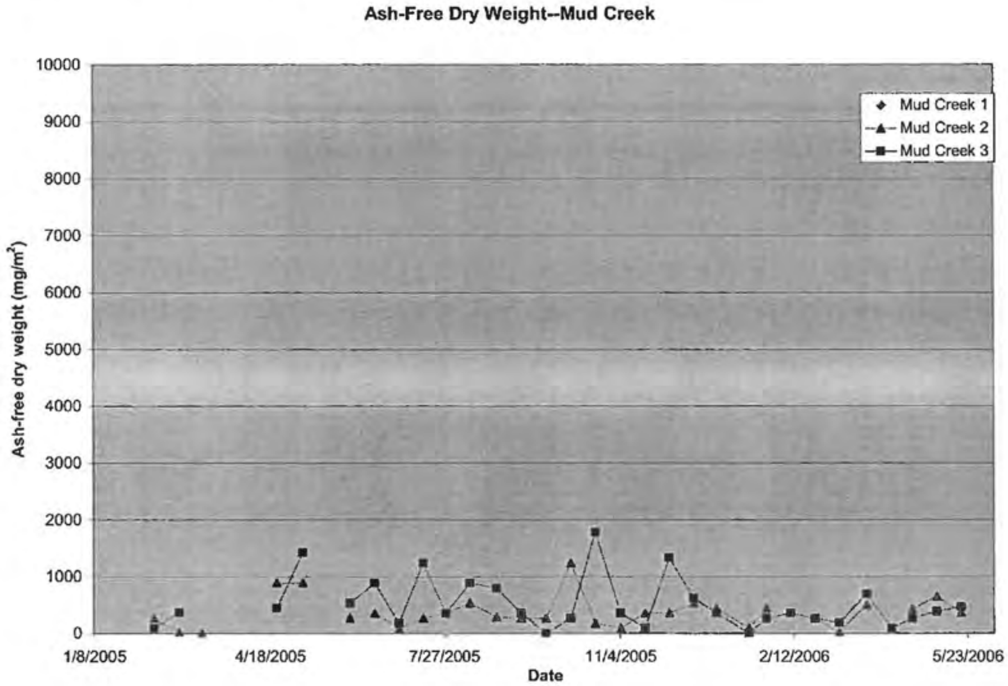
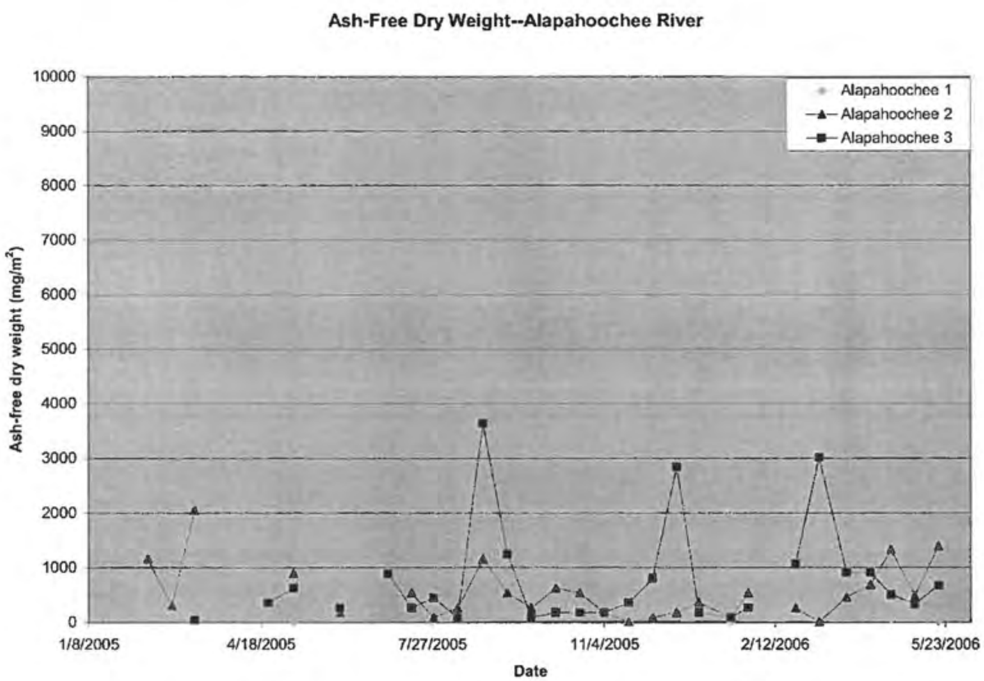


Figure D6c. Ash-free Dry Weight for AR 1-3



E. Macroinvertebrate Analysis

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Materials and Methods

Seven collections were made over a 12 month period from July 2005 to June 2006. Collections took two days to complete with the following collecting regime having been followed: 7-8 July 2005, 26-27 August 2005, 14-15 October 2005, 22-23 November 2005, 24-25 January 2006, 14-15 March 2006 and 16-17 June 2006. The original intent was to make eight collecting trips. However, the May 2006 trip was not completed. Date referred to below by month and year only refer to the specific dates listed above.

Using a D-frame net 30 cm wide by 25 cm high, the following sampling regime was followed at each sampling site when possible. Exceptions are discussed below. Three jabs 1.0 m long were preformed by pulling the D-frame net along the substrate in open water at mid stream. Three jabs 1.0 m long were made under overhanging banks as obstructions under the banks would permit. Three 3 jabs were made in and among tree roots, clusters of woody debris and snags 1.0 m long. The 1.0 m requirement was adhered to as best possible, but obstructions often made full 1.0 m jabs difficult to complete. If jabs were greatly short of 1.0 m, additional jabs were made to complete the full 3.0 m required. Three jabs 1.0 m long were made in macrophytes. No macrophytes collections were made at certain times and locations due to their total absence or drought resulting in macrophytes being out of the water. Macrophytes were always sampled at the bridges crossing over the creeks and the river as macrophytes were not found up or downstream sections, which were heavily wooded. Three grabs of leaves from the bottom of the river where made by hand or more frequently by scoping up leaves with the D-frame net. Grabs were most often made in pools by dragging the D-frame net through mats of leaves caught in quite pools or snags. By April, the decay rate of the leaves had become so great that the leaves had become quite friable without much mass left, making it difficult to collect suitable samples as compared to Fall and Winter months. In addition, the Alapahoochee River at collection sites AR 2 and AR 3 ran through narrow limestone ravines and not much wider than the river itself in many areas. During high water, which occurred during the first three collections, collections of leaves were not made beyond what could be collected along the edge of the bank. Fifteen minute periods of picking invertebrates from woody debris was made during first two collection periods. However, due to very poor returns per effort employed, this practice was ceased during the final five collections.

Collections were most often made upstream, but due to flooding, drought and other conditions, some collections were made downstream. At MC 1, beavers had a dam which made it very difficult and dangerous to collect upstream. After they raised the dam by about 30 cm, collections were made downstream as much of the water above the dam became shoulder to head deep. At GB 3, the land on either side of the creek was bordered by the Grand Bay Hunting Club. To avoid hunters, collections were made downstream to a set of railroad tracks. The MC 3 collections were made both upstream and downstream depending on the level of flooding that was occurring with downstream collections being made during high water. The AR 1 and 2 collections were always made downstream as the topography in the form of high steep banks upstream limited reasonable access to the river and habitat was less diverse than downstream.

Field collections were immediately placed in an 8.8 L bucket while collection was occurring. Upon the completion of the collection at a location, the contents of the bucket were flooded with a 99% solution of ethyl alcohol. After the first collection trip, rose Bengal dye was added to subsequent alcohol solutions to improve the visibility of animal tissue so that sorting of the invertebrates from the leaf packs could be made more efficiently. Leaf packs were sorted by Ms. Jessica Wood, student assistant. In the laboratory, invertebrates were hand sorted from the contents of the buckets by picking and the use of sieves. All invertebrates sorted per collection site were placed in individual preservation jars containing 95% ethyl alcohol until identification could be made. Identifications were made at the laboratory of Dr. William Tietjen, Department of Biology, Georgia Southwestern State University, Americus, Georgia using standard identification keys (Merritt, R. W. & K. W. Cummins 1996; Wiggins, G. B. 1996; Westfall, M. J. & M. L. May 2006; Needham, J. G., M. J. Westfall, & M. L. May 2000; Pennak, R. W. 1989). All specimens were deposited at the laboratory of William Tietjen.

Results and Discussion

The results below were analyzed using Georgia Adopt-a-Stream (AAS) scores and tolerance values (TVs). Trends in invertebrates within the Alapahoochee Watershed and specific groups of invertebrates were also analyzed as they pertain to the results of this study. Appendix E1 presents taxonomic identification and evaluation of macroinvertebrate data collected throughout the Alapahoochee Watershed by collection sites and provides TVs as found in the North Carolina Department of Environment and Natural Resources (2006). Appendix E2a-j present number of individuals of each taxa collected by collection site and date. The TVs range form 1 to 10 with low values indicating less stress tolerance in a species while higher values approaching 10 indicate high stress tolerance. For the purpose of analysis and discussion, the TVs were grouped as low (1-4), middle (5-7), and high (8-10), which are a component of and corresponds closely to the Biotic Index used by the North Carolina Department of Environmental and Natural Resources, but does not employ the abundance of organisms (NCDENR 2006). Table E1 presents collection sites by date analysis of numbers of families, genera, individuals and Ephemeroptera, Plecoptera, and Tricoptera (EPT) taxa and accompanying Georgia AAS scores. The AAS scores (1-11 poor, 12-17 fair, 18-22 good, and 23+ excellent) have been shown to be adequate for the evaluation of stream assessment (Winn, et al, 2005). This scoring system does not reflect the numbers of individuals or subtaxa within each major category. It should be noted that due to very high water conditions in July 2005 at collection sites AR 1-3, no invertebrate samples exist for these collection sites. Recognizing this, results and discussion are presented and analyzed based on the absence of these data.

Table E1. Invertebrate family, genera, total numbers, EPT taxa summary evaluation data by collection sites by month collected with means and AAS scores

Month	Jul	Aug	Oct	Nov	Jan	Mar	Jun	Mean
Collection Site AR1								
Number of families	No data	6.0	4.0	2.0	4.0	7.0	15.0	6.3
Number of genera	No data	9.0	5.0	2.0	5.0	8.0	18.0	7.8
Number of individuals	No data	14.0	20.0	2.0	10.0	32.0	92.0	28.3
Number of EPT taxa	No data	4.0	0.0	0.0	1.0	3.0	4.0	2.0
Georgia AAS Score		13.0	3.0	2.0	6.0	10.0	21.0	9.2
Collection Site AR2								
Number of families	No data	11.0	4.0	1.0	4.0	5.0	16.0	6.8
Number of genera	No data	13.0	4.0	1.0	5.0	7.0	19.0	8.2
Number of individuals	No data	51.0	9.0	4.0	24.0	38.0	137.0	43.8
Number of EPT taxa	No data	5.0	1.0	0.0	2.0	0.0	6.0	2.3
Georgia AAS Score		11.0	10.0	2.0	6.0	4.0	23.0	9.3
Collection Site AR3								
Number of families	No data	7.0	12.0	4.0	5.0	4.0	5.0	6.2
Number of genera	No data	8.0	15.0	4.0	6.0	4.0	8.0	7.5
Number of individuals	No data	29.0	114.0	8.0	17.0	4.0	49.0	36.8
Number of EPT taxa	No data	1.0	5.0	1.0	2.0	2.0	2.0	2.2
Georgia AAS Score		12.0	18.0	8.0	8.0	6.0	11.0	10.5
Collection Site GB1								
Number of families	8.0	8.0	14.0	7.0	5.0	7.0	16.0	9.3
Number of genera	8.0	10.0	17.0	7.0	5.0	9.0	19.0	10.7
Number of individuals	14.0	43.0	129.0	26.0	28.0	229.0	106.0	82.1
Number of EPT taxa	1.0	1.0	2.0	0.0	1.0	1.0	1.0	1.0
Georgia AAS Score	12.0	13.0	20.0	8.0	10.0	11.0	10.0	12.0
Collection Site GB2								
Number of families	12.0	10.0	9.0	12.0	5.0	9.0	9.0	9.4
Number of genera	13.0	12.0	12.0	14.0	5.0	12.0	11.0	11.3
Number of individuals	40.0	15.0	65.0	41.0	20.0	70.0	59.0	44.3
Number of EPT taxa	3.0	2.0	3.0	1.0	0.0	1.0	1.0	1.6
Georgia AAS Score	12.0	12.0	10.0	13.0	7.0	13.0	14.0	11.6
Collection Site GB3								
Number of families	8.0	13.0	19.0	4.0	5.0	7.0	9.0	9.3
Number of genera	9.0	14.0	22.0	4.0	5.0	9.0	11.0	10.6
Number of individuals	30.0	61.0	279.0	25.0	18.0	45.0	83.0	77.3
Number of EPT taxa	1.0	2.0	2.0	0.0	0.0	3.0	0.0	1.1
Georgia AAS Score	14.0	13.0	15.0	4.0	9.0	12.0	12.0	11.3

Table E1. (Continued)

Month	Jul	Aug	Oct	Nov	Jan	Mar	Jun	Mean
Collection Site GB4								
Number of families	3.0	9.0	3.0	5.0	5.0	11.0	9.0	6.4
Number of genera	3.0	10.0	5.0	6.0	6.0	14.0	10.0	7.7
Number of individuals	3.0	25.0	74.0	27.0	42.0	103.0	28.0	43.1
Number of EPT taxa	0.0	1.0	1.0	3.0	1.0	1.0	1.0	1.1
Georgia AAS Score	5.0	12.0	6.0	8.0	10.0	13.0	9.0	9.0
Collection Site MC1								
Number of families	6.0	6.0	13.0	6.0	10.0	8.0	15.0	9.1
Number of genera	6.0	7.0	15.0	7.0	14.0	10.0	19.0	11.1
Number of individuals	26.0	112.0	136.0	27.0	70.0	113.0	309.0	113.3
Number of EPT taxa	0.0	0.0	3.0	1.0	1.0	1.0	1.0	1.0
Georgia AAS Score	9.0	9.0	16.0	9.0	12.0	11.0	14.0	11.4
Collection Site MC2								
Number of families	7.0	11.0	7.0	2.0	11.0	14.0	10.0	8.9
Number of genera	7.0	12.0	8.0	3.0	15.0	16.0	12.0	10.4
Number of individuals	53.0	52.0	63.0	14.0	129.0	304.0	72.0	98.1
Number of EPT taxa	2.0	5.0	1.0	0.0	4.0	4.0	3.0	2.7
Georgia AAS Score	10.0	16.0	10.0	3.0	12.0	16.0	13.0	11.4
Collection Site MC3								
Number of families	1.0	10.0	11.0	2.0	8.0	9.0	4.0	6.4
Number of genera	1.0	11.0	13.0	2.0	10.0	11.0	4.0	7.4
Number of individuals	3.0	59.0	51.0	4.0	47.0	75.0	9.0	35.4
Number of EPT taxa	0.0	1.0	1.0	0.0	3.0	3.0	0.0	1.1
Georgia AAS Score	2.0	13.0	18.0	3.0	11.0	8.0	3.0	8.3

Mean AAS scores for stream quality in the Alapahoochee Watershed range from 2 to 23. Of the 67 AAS scores (Figure E1) calculated for the collection sites for each collecting period, 56.7% are ranked as poor, 35.8% are ranked as fair, 6.0% are ranked as good, and 1.5% are ranked as excellent. When mean values were computed by collecting period (Figure E2) it was possible to asses the apparent overall watershed quality for each collecting period. July and November through June mean AAS scores were ranked as poor. However, July represented a period of flooding and May and June were periods experiencing serious drought. Otherwise, all mean monthly AAS Scores were ranked as fair to good with the months of August and October ranked good. While the majority of AAS scores were ranked as poor, most of these poor scores (60.5%) were on the high end of the poor ranking scale (8-11) so were offset by the 43.3% of scores in the fair to good range.

The AAS scores analyzed by collection site (Figure E3) provide a different perspective as to the collection site by collection site quality of the watershed. The lowest mean AAS scores occurred at collections sites MC 3, GB 4, and AR 1-3, those sites with higher pH values. The AAS scores examined by each creek within the watershed showed that AAS values were highest near the headwaters (Grand Bay Swamp and Mud Swamp) and declined as the creeks approached their confluence to form the Alapahoochee River, with both creeks having mean values in the poor range at the collection sites nearest their confluence. The Alapahoochee River showed a slight increase in mean AAS scores from collection sites AR 1-3, but they never rose above a ranking of poor. A statistical analysis of collection sites with higher pH values verses those with lower values showed that no significant differences existed (Table E2).

Table E2. Mean AAS Scores comparing collection sites with low and high pH values

t-Test: Two-Sample Assuming Unequal Variances		
	pH Low	pH 7
Mean	10.94	9.67
Variance	1.19	0.53
Observations	5.00	3.00
Df	6.00	
t Stat	1.98	
P(T<=t) two – tail	0.094	
t Critical two – tail	2.45	

A grand total of 4,110 invertebrates were collected over the course of the project representing 13 orders, 45 families and more than 69 genera, some of which were not carried out to the level of genus. Of these, tolerance values (TVs) could be assigned to 54 of the genera and a range of tolerance values could be assigned to four families for which the members were not identified to the genus level. The total number of specimens collected over the course of the project showed a decline in the total number of specimens from the headwaters of Mud Creek and Grand Bay Creek to collection sites AR 1-3 on the Alapahoochee River and are depicted as mean averages (FigureE4). Concomitantly, the number of families (Figure E5) and genera (Figure E6) showed a similar pattern of decline from the headwaters to the collection sites on the Alapahoochee River. Statistical analysis of these trends by collection sites consistently possessing high verses low pH values showed that total invertebrate number, families and genera were all statistically significant (Table E3, 4, 5).

Table E3. Total number of invertebrates comparing collection sites with low and high pH values

t-Test: Two-Sample Assuming Unequal Variances		
	pH Low	pH 7
Mean	76.38	36.08
Variance	5,783.90	1,323.33
Observations	42.00	25.00
Df	63.00	
t Stat	2.92	
P(T<=t) two – tail	0.0049	
t Critical two – tail	2.00	

Table E4. Number of genera of invertebrates comparing collection sites with low and high pH values

t-Test: Two-Sample Assuming Unequal Variances		
	pH Low	pH 7
Mean	8.74	6.44
Variance	14.00	14.51
Observations	42.00	29.00
Df	60.00	
t Stat	2.51	
P(T<=t) two – tail	0.0145	
t Critical two – tail	2.00	

Table E5. Number of genera of invertebrates comparing collection sites with low and high pH values

t-Test: Two-Sample Assuming Unequal Variances		
	pH Low	pH 7
Mean	10.31	7.73
Variance	18.50	22.49
Observations	48.00	28.00
Df	52.00	
t Stat	2.37	
P(T<=t) two – tail	0.0217	
t Critical two – tail	2.01	

Invertebrates for which tolerance values could be assigned show a full range (1-10) of values at all collection sites (Appendix E1). Chironomid larvae and pupae were the most abundant invertebrates collected representing 36.4% of all the invertebrates. An average of 22.3 chironomids was collected at each collection site per month with a range of 0-144 collected at any one collection site. All other invertebrates collected, except for the crayfish *Procambarus spiculifer*, members of the orders Plecoptera (stoneflies), Ephemeroptera (mayflies), Tricoptera (caddisflies), and the Odonata (dragon and damselflies) showed low and patchy abundances and distributions throughout the watershed.

A total of 630 *P. spiculifer* were collected at all collection sites during most collecting periods with an average of 9.4 collected per site per collecting period and a range of 0-66 collected per period. Generally specimens were early instar stages to subadults and were collected from macrophytes and root masses. A current study on the life history of *P. spiculifer* has revealed that they are most easily caught when water levels are moderate in the watershed and they are most abundant in AR 1-3. During this study and that of the Hightower study, *P. spiculifer* showed strong preference for cover in macrophytes and debris with moderate currents such that they are rarely caught under other conditions. Further information learned form the study was that form I males, large form II males, and reproductively active females are primarily nocturnal and most often caught at night by trapping (Personal communication, Philip Hightower).

Members of the orders Plecoptera, Ephemeroptera, and Tricoptera (EPT taxa) were only collected at collection sites AR 1-3 (Appendices E2a, b, c). The EPT taxa have often been the focus of other studies due to the fact that they have low TVs and are thus good indicators of water quality (Whiles, et al 2000; Maxted, et al 2000). Of the Plecoptera, only five individuals from two families were collected at sites AR 1 and 2. In the Ephemeroptera, 57 individuals from four families were collected at sites AR 1-3. In the Tricoptera, 60 individuals from four families were collected at sites AR 1-3.

Odonata were represented by six families and 15 genera. While Odonata were collected at all sites during different collecting periods, they showed a pattern of decline in numbers from the headwaters to the sites on the Alapahoochee River. On Mud Creek and Grand Bay Creek, the number of Odonata specimens collected per site during the course of the project ranged from 9-79 while on the Alapahoochee River, they ranged from 1-4 specimens.

Figures

Figure E1. AAS scores by collection sites for each month

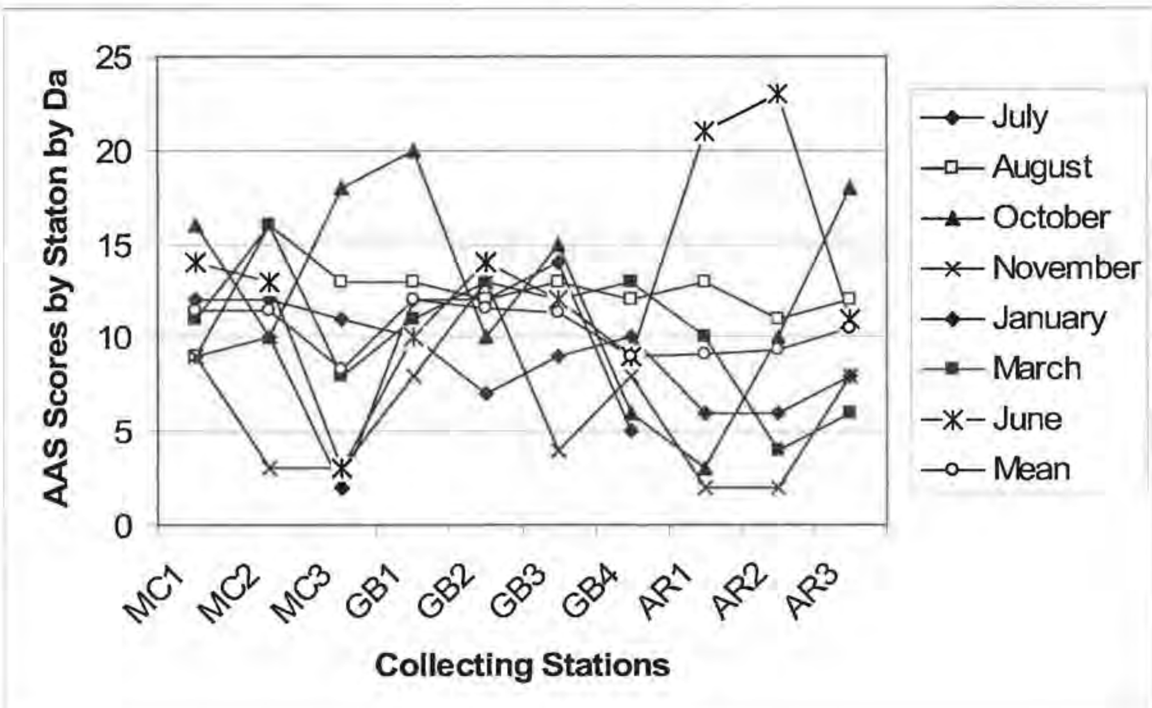


Figure E2. Mean AAS scores by collecting period

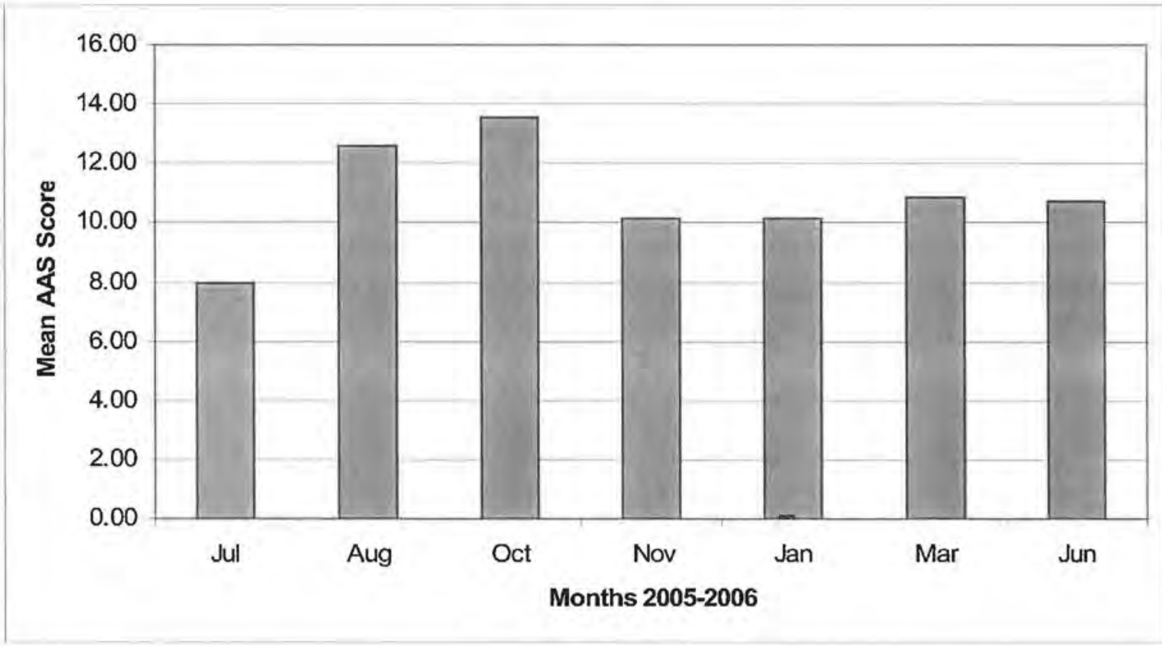


Figure E3. Mean AAS scores by collection sites

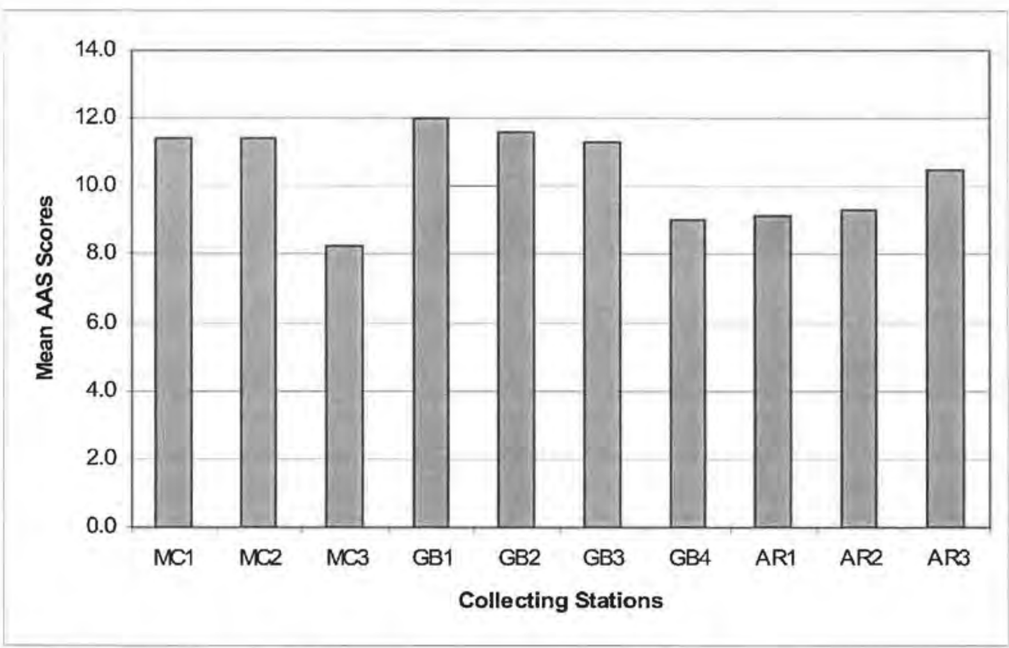


Figure E4. Mean number of invertebrates by collection sites

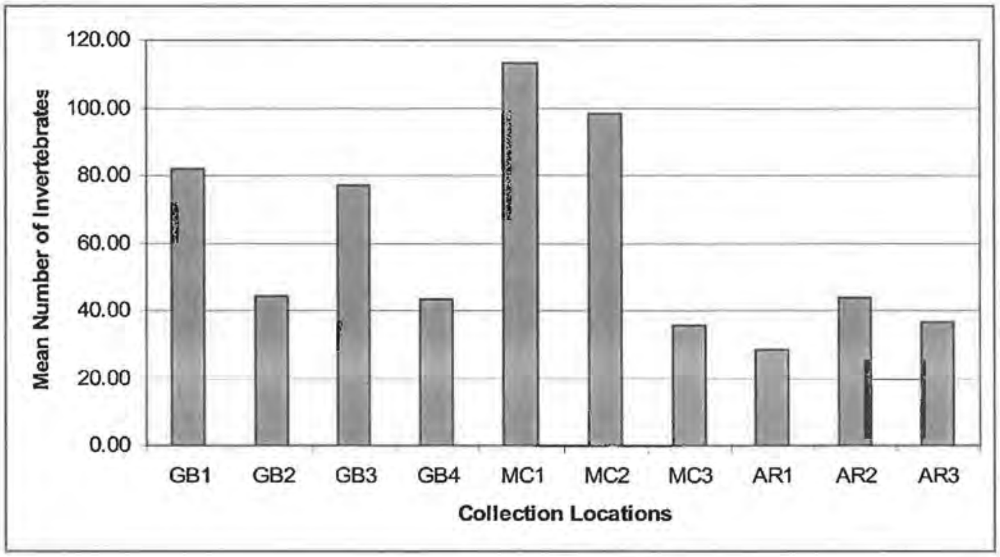


Figure E5. Mean number of families of invertebrates by collection sites

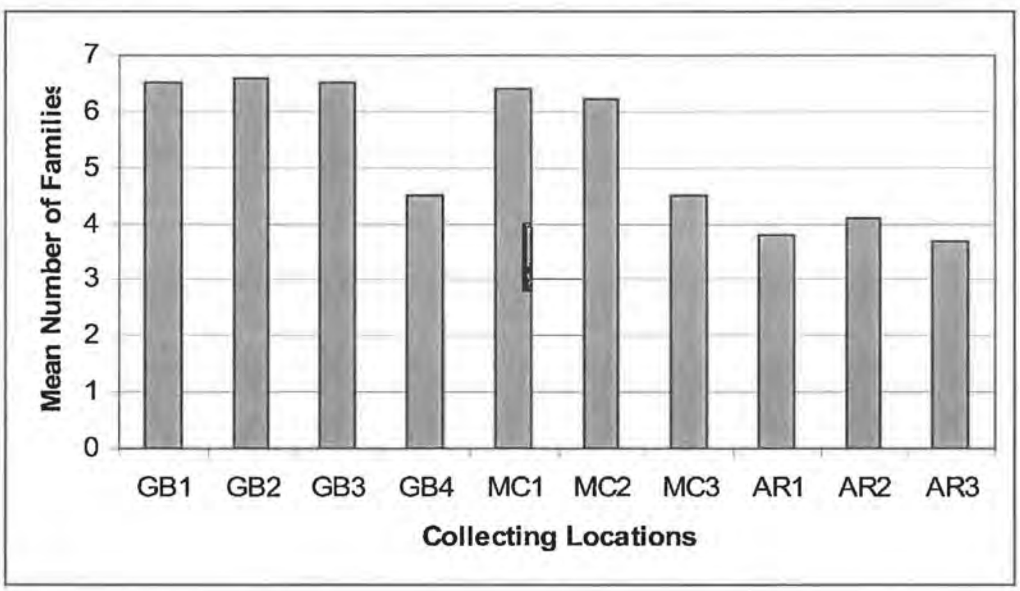
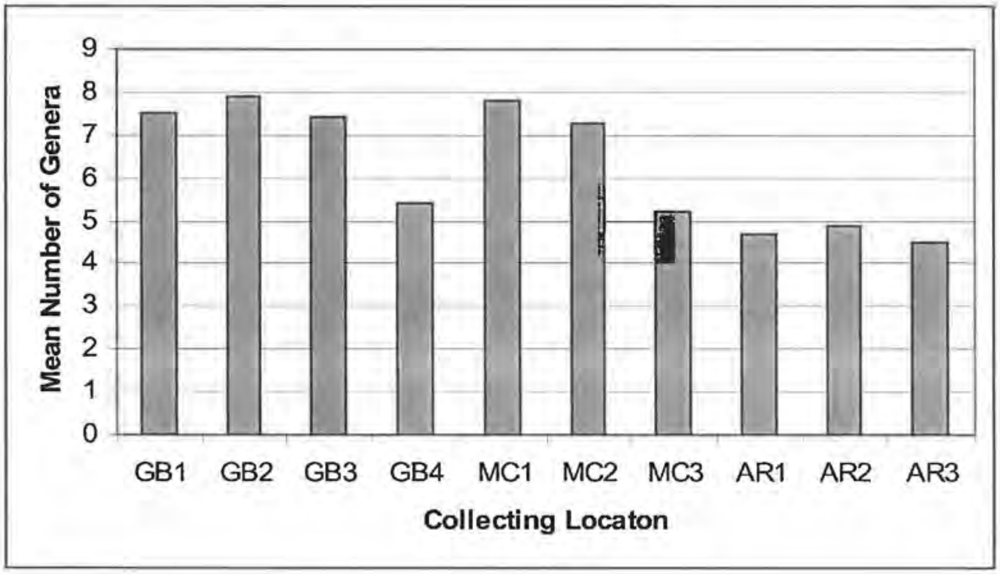


Figure E6. Mean number of genera of invertebrates by collection sites



Number of taxa with low, middle and high TVs by collection sites

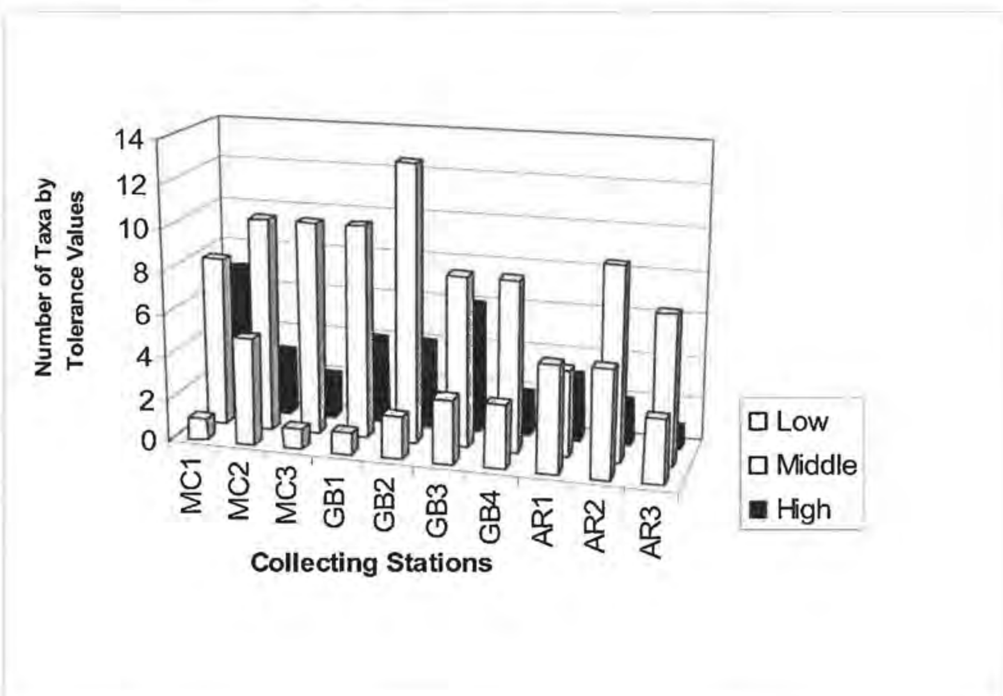
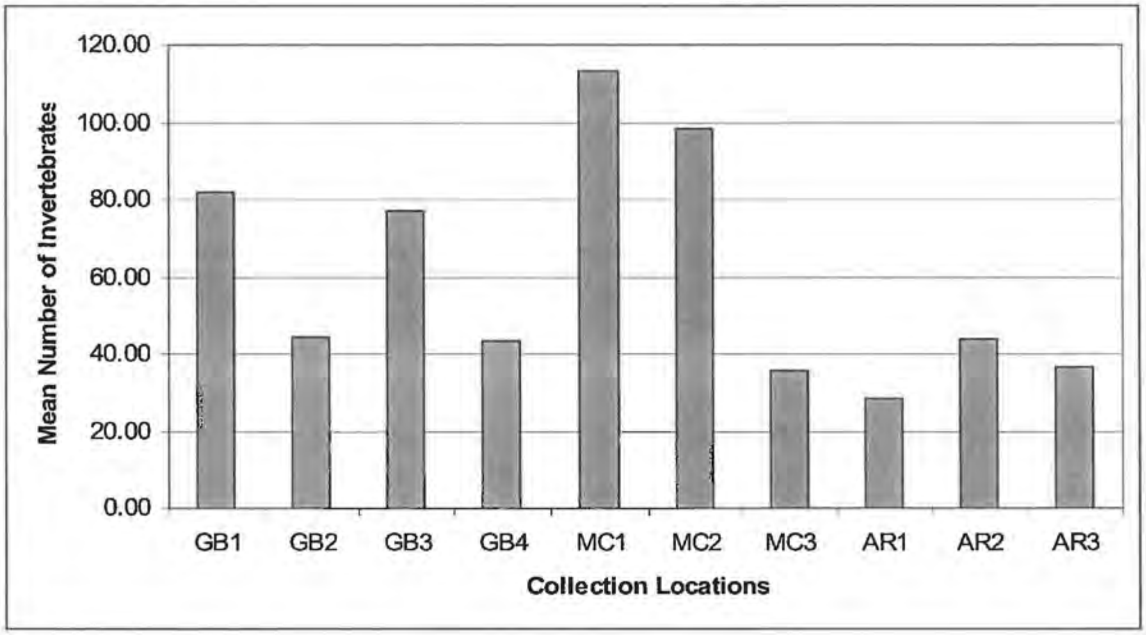


Figure E. Mean number of invertebrates by collection sites



G. Summary Discussion

Data collected presents a complex model of the Alapahoochee Watershed that consisted of apparently random or periodical events involving mostly physicochemical parameters and overlain with distinct patterns of periphyton and macroinvertebrate distributions from the headwaters to the lowest collection site, AR 3. Bacterial analysis *E. coli* showed patterns that were suggestive of control by rainfall events, but elevations in *Enteroccus* numbers did not follow the same patterns. Compounding the collection of the physicochemical and biological data was the fact that at the start of the study, the Alapahoochee Watershed was experiencing very high water conditions with the flood plains lying along the flatwoods of GB 1-3 and MC 1 and 2 being fully inundated. Downstream at the same time where the watershed has cut through the overburdens of the sand and gravels and the limestone rock of collection sites GB 4, MC 3 and AR 1-3, water was well out of the banks in many locations. By the end of the study, the watershed was experiencing a serious drought. Water levels at GB 1 and 2 were so low that the main creek channel had dried up above and below the collection sites at the bridges, MC 1 and 2 continued to flow, but at very low levels, and AR 1-3 showed a considerable drop in the level of water in the creek. During the final collection at AR 2, it was noted that some of the small seeps and springs issuing form the limestone rock were also showing signs of drying up or in some cases actually ceased to flow. As such, discussion of the findings of this report will have to take into account the hydrologic conditions in its interpretation of the data and findings presented. An exception to this flow pattern was MC 3, which receives effluent from the City of Valdosta wastewater treatment plant. Here water flow remained fairly high even during the drought.

Chaney and Bechler (2006) provide an account of the Lowndes County area noting that the eastern and northeastern portion of the county is composed of flatwoods and has a blackwater hydrologic system that reflects the flatwoods habitat. Other watersheds in the coastal plains of Georgia also are blackwater systems (Benke, et al. 1984). Denizman, Grable, Nienow, and Turco also took note of this in their field collections and data analysis in this report. Such habitats are typified by low stream gradients, slower currents, and longer retention times for water compared to regions with greater geophysical relief (Sun et al. 1996, Riekerk and Korhnak. 2000). As such it is possible that the entire Alapahoochee Watershed might be best described as a blackwater system as the blackwater from MC 1 and 2 and GB 1-3 (sometimes GB 4) feed into the Alapahoochee River. Denizman and Grable point out that the seeps and springs issuing from over and from within the limestone rock at AR 1-3 could be moderating the hydrology of the system, which would account for the higher electro conductivity and pH values reported in AR 1-3. However, MC 3, which lies in an area of mostly sands and gravels and is fed by Knights Creek, another blackwater watershed, also consistently produced high electro conductivity and pH values. A likely source of these high values is the effluent from the Valdosta wastewater treatment plant. It should be noted that Denizman and Grable reported that values are still within standards set for such effluent.

The GB 4 collection site, which was in the transition zone from flatwoods to the steeper stream gradients and contained mostly sands and gravels for substrate, also produced periodic anomalous high readings for pH at different times during the study period. It is possible that water buffered by the influence of limestone was flowing through GB 4. However, if this were occurring, then it would be expected that the variation seen in pH values would not be as great as found especially during periods of lower water flow. This suggests that undefined periodic events upstream took place such that water conditions as GB 4 were altered. The cause of such events is not known. Otherwise, the physicochemical and hydrologic regime for MC 3, GB 4 and AR 1-3 more closely resembled a system fed by limestone buffered water sources as found in the Pelham Escarpment of Southwest Georgia where limestone buffered springs and rills predominate (Entrekin, et al 1999).

With the change in the hydrologic environment of collection sites MC 3 and AR 1-3, Nienow, Turco, Tietjen, and Bechler report concomitant changes in periphyton and macroinvertebrate communities respectively. Nienow and Turco found that acidophilc species of periphyton showed reduced numbers at MC 1, GB 4 and AR 1-3, while alkaphilic species became more numerous. Tietjen and Bechler comparing data for MC 1 and 2 and GB 1-4 against data for MC 3 and AR 1-3 found significant reductions in the number of total invertebrates, families and genera downstream. They also found lower AAS scores in general, but with quite a few taxa having fair to good AAS scores in both sets of collection sites. The TV scores were mixed with high, middle and low values in both groups of collection sites when examined. Also, EPT taxa, which are often viewed as being associated with higher quality waters, were only found at AR 1-3. Looking at mean AAS scores, it might be concluded that water quality in the watershed was generally poor. However, fair to good scores were often found at each collection site throughout the year, and low TV values were found indicating that stress intolerant species were completing their life histories throughout the watershed (Benke, et al. 1984).

Key points in the above model are that the hydrology, primarily in the increased water flow of the watershed from MC 3 downstream to AR 3, is enhanced by the wastewater treatment plant and that this may have significantly contributed to the changes in the physicochemical structure of the same reach of the watershed. Overlying this were the findings that the bacterial, periphyton, and macroinvertebrate communities showed marked changes in species composition and total numbers. Addressing the changes in the biological communities, five factors or combination of factors may account for what is seen:

1. The wastewater treatment plant may be altering the flow regime and the physicochemical nature of the water such that it is also altering community structure,
2. Unidentified events at GB 4 may be periodically contributing to the downstream variation observed and thus contributing to community change,
3. The issuance of buffered limestone water may be doing the same as in numbers 1 and 2,
4. Predation by *P. spiculifer* on one or both communities (periphytes and macroinvertebrates) may be altering community structure, and
5. Differences may be due to habitat structure as substrates from the headwaters change from mud and silt to sand and gravel to limestone rocks.

Point 3 may be answered in part by the life history study currently underway. Deng, Bechler, and Lee (1993), as part of a life history study on *P. clarkii* and *P. zonangulus,* analyzed gut contents noting the types and amounts of vegetal and animal tissue. Hightower's research work on *P. spiculifer* will do the same providing possible information on how this relatively abundant crayfish may have the potential to alter community structure at sites AR 1-3.

Thus the general picture is that the Alapahoochee Watershed is in some sense a dual system with the upper reaches of the Mud Creek and Grand Bay Creek being blackwater systems and the lower reaches of the two creeks and the Alapahoochee River more inline with limestone buffered streams where higher conductivity and pH predominate. What the actual causal factors are that produce the changes in the system will require further research.

H. Recommendations

The research team for this project, recognizing the points above, makes the following recommendations:

1. Determine the actual causes for the changes in the shift of the Alapahoochee Watershed from a blackwater system to one resembling a limestone buffered system with higher conductivities and pH values. This would mean looking more fully into the exact sources and their proportional roles causing the changes observed. Sources of change to specifically address would be:

    a. Effluent from the City of Valdosta's wastewater treatment plant.
    b. Undetermined factors causing periodic physicochemical changes at GB 4.
    c. Contribution of springs and seeps at AR 1-3.

2. Determine what factors are contributing to the change in the biological community to include:

    a. Impacts associated with changes in the physicochemical nature of the watershed.
    b. Role of key predators such as *P. spiculifer*.
    c. Role of changes in habitat from the headwaters to the downstream watershed in the area of AR 1-3.

Should it be learned that the City of Valdosta wastewater treatment plant is the primary contributing factor to changes in the water chemistry of the watershed, the biological community, and that the entire system should actually be a blackwater system throughout the watershed, then it is recommended that the parameters for effluent release from such systems be reexamined such that they match the system they are being released into rather than a broad general standard set up for the entire country.

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J. Appendices

Appendix D1. Distribution of diatom taxa: composite of samples from 5-20-2005 and 9-9-2005.

+ = less than 1% of the valves recorded at the collection site
++ = 1 to 5% of the valves recorded
+++ = more than 5% of the valves recorded

Taxon	Collection Site									
	GB1	GB2	GB3	GB4	MC1	MC2	MC3	AR1	AR2	AR3
Achnanthes (Achnanthidium) cf. stolida							++			
Amphora ovalis							+		+	
Asterionella formosa					+					
Aulacoseira granulata									++	++
Aulacoseira herzogii								+	+	+
Aulacoseira islandica			+							
Aulacoseira italica				++	++	+	+	++		++
Caloneis bacillum	+	+		++		+	+	+		+
Caloneis hyalina			+			+	+	+	+	
Caloneis sp. 1						+		+		
Caloneis sp. 3						+				
Carpatogramma crucicula							+	+	++	
Cavinula cocconeiformis						+	+			+
Cocconeis cf. neodiminuta							+++		++	+++
Cocconeis placentula		+		+			+++	++	++	++
Cyclotella meneghiniana					+	+	+	+	+	+
Cyclotella stelligera						+	+	+++	++	++
Cymbella aspera							+			
Decussata placenta							+			
Desmogonium rabenhorstiana		++			++	+	+			
Diadesmis cf. gallica					+		+			+
Diploneis smithii							+	++	+	++
Encyonema minutum		+	+			+	+	+		++
Eunotia curvata	++	+	++	++	+++	++	+	+		
Eunotia monodon	+	+	+	+		+	++	+		
Eunotia naegeli	++			+	+++					
Eunotia pectinalis	+++	+++	+++			+	+		++	
Eunotia pectinalis v. minor	+++	++	+++	+++	++	+++	++	+++	++	+++
Eunotia pectinalis v. undulata	++	+	++	+++	++	++	+	+		++
Eunotia pectinalis v. ventricosa	+									
Eunotia pectinalis var. 1					+					+
Eunotia praerupta	+	+		+	+	+	+			
Eunotia praerupta v. bigibba					++	+				
Eunotia serra	+						+			
Eunotia sp. 1				+		+				

(Continued)

Taxon	Collection Site									
	GB1	GB2	GB3	GB4	MC1	MC2	MC3	AR1	AR2	AR3
Eunotia sp. 2								+		
Eunotia tautoniensis	+	+			+	+				+
Eunotia unidentified girdle view-large	++	++	++	++	++	++	+	+		
Eunotia unidentified girdle view-medium	+++	+++	+++	+++	+++	+++	++	+++	+++	++
Eunotia unidentified girdle view-small	++				+		+			
Fragilaria bicapitata	++	+	+							
Frustulia rhomboides	+	++	++		++	++	++	+		+
Frustulia rhomboids v. capitata	+	+		+	++	++	++	+	+	+
Gomphonema augur							+			+
Gomphonema gracile	+	+	+	+	+	++	++	+	+	++
Gyrosigma spencerii							+	+		
Hippodonta capitata	+	+	+			+	++	++	++	++
Hippodonta hungarica										+
Lemnicola hungarica						+	+	+	++	++
Luticola cf. mutica		+	+		+	+	+	+	++	++
Melosira varians	+				+		++	++	+	+
Meridion circulare	+					+				
Navicula cf. accomoda				+	+	+		+	+	+
Navicula arvensis	+				+	+	+	++	++	++
Navicula bacillum	+									
Navicula clementis							+	+	+	+
Navicula confervacea	+				+	+	++		+	
Navicula cf. elginensis			+		+	+	++	++	+	++
Navicula exigua				+	+	++	++	+		++
Navicula lanceolata	+						+	+	++	++
Navicula miniscula							+	+		++
Navicula pelliculosa							+			
Navicula peregrina							+	++	+	+
Navicula porifera										+
Navicula cf. radiosa	+	+	+	++	+	+	++	++	++	++
Navicula rhynchocephala	+			+		+	+	+	+	+
Navicula cf. seminulum										++
Navicula cf. subrhynchocephala	+					+	+			
Navicula cf. tenelloides							+			
Navicula cf. veneta										+
Navicula cf. viridula v. rostellata							+		+++	+
Navicula sp. 1							+	+		
Navicula sp. 3							+	+		++
Navicula sp. 5						+	++	+		+

(Continued)

Taxon	Collection Site									
	GB1	GB2	GB3	GB4	MC1	MC2	MC3	AR1	AR2	AR3
Navicula sp. 11										+
Navicula sp. 18			+				+	+	+	
Navicula sp. 24							+			
Navicula sp. 25							+			
Navicula sp. 26							++	+	+	
Navicula sp. 34		+								
Navicula sp. 38				+				+		
Navicula sp. 46						+				
Navicula sp. 60								++		
Navicula sp. 61								+		
Navicula sp. 63								+		
Navicula sp. 64								++		
Navicula sp. Skinny							+	+	+	++
Navicula unidentified girdle view				++						++
Neidium affine						+++				
Neidium affine v. amphirhynchus				+						+
Neidium affine v. 2								+	+	
Neidium affine v. longiceps						+	++			
Neidium affine v. humerus						+				+
Neidium alpinum	+	+	+++	++	+	+	++	++	++	++
Neidium densistriatum		+	+	+	+	+	+		++	+
Neidium iris	+	+	+++	+	+	+				
Neidium unidentified girdle view								+		++
Nitzschia amphibia						+	+			+
Nitzschia cf. lanceolata							+	+		
Nitzschia palea	++	+++	++	++	+++	+++	++	+++	++	++
Nitzschia cf. palea		++			+		+	+		
Nitzschia plana						+	++	+		
Nitzschia pusilla	+					+	++		+	
Nitzschia scalaris							+			
Nitzschia cf. sigmoidea							++			
Nitzschia cf. umbonata	+					++	+	+		
Nitzschia sp. 3a							+			
Nitzschia sp. 7							+			
Nitzschia sp. 8	+				+++	+				
Nitzschia sp. 10								+		
Nitzschia sp. 11							++			
Nitzschia sp. 14		+								
Nitzschia sp. 15								+		
Nitzschia sp. 21							+			
Nitzschia sp. 22							+			

(Continued)

Taxon	Collection Site									
	GB1	GB2	GB3	GB4	MC1	MC2	MC3	AR1	AR2	AR3
Nitzschia unidentified girdle view										+
Pinnularia acrosphaeria		+	+	+	+	+	+	+	++	++
Pinnularia acuminata						+				
Pinnularia braunii	++	+	++	++	++	++	+	++	++	++
Pinnularia gibba	++	++	+++	++	+++	+++	++	++	+	++
Pinnularia cf. legumen							+			
Pinnularia cf. mesolepta					+	+				
Pinnularia nobilis		+	++	++			+	+		+
Pinnularia nodosa					+	+		+		+
Pinnularia cf. obscura							+	+		
Pinnularia stomatophora						+	+	+	+	++
Pinnularia cf. sudetica	+									
Pinnularia viridis	++	+	+++	+	+	++	+	+	+	+
Pinnularia sp. Skinny							+		+	
Pinnularia sp. Small									+	
Pinnularia sp. 4				+	+				+	
Pinnularia sp. 5		+								
Pinnularia sp. 6		+								
Pinnularia sp. 10			+					+		
Pinnularia sp. 11							+	+		
Pinnularia sp. 12					+	+		+		
Pinnularia unidentified girdle view	+++	++		++	+	++	++	+++	+++	++
Planothidium cf. conspicuum		+		+		+	++	++	++	++
Planothidium cf. granum				+	+	+	++	++	++	++
Planothidium lanceolatum		+		+		+	++	+		++
Planothidium lanceolatum v. capitata					+					
Planothidium lanceolatum v. lanceolatoides							+	++	+	
Planothidium minutissimum	+	+		+	+	+	++	+++	+++	+++
Pleurosira laevis									+	
Rhopalodia gibberula			+					+		
Sellaphora cf. pupula				+		+	+	+	+++	++
Sellaphora rectangularis		+				++	++	++	+	++
Sellaphora sp. 2						+	+	+		
Sellaphora sp. 5							+	+		
Sellaphora sp. Large							+			
Sellaphora sp. Small							+			
Stauroneis anceps						+				
Stauroneis anceps v. americana						++				
Stauroneis anceps v. linearis		+				+	+	+		+
Stauroneis smithii	+					+	+	+	++	+

(Continued)

Taxon	Collection Site									
	GB1	GB2	GB3	GB4	MC1	MC2	MC3	AR1	AR2	AR3
Stauroneis sp. small							+			
Stauroneis unidentified girdle view							+			
Staurosirella sp.1								+		+
Surirella angusta		+				+				
Surirella linearis	+					+			+	+
Synedra ulna	+						+			+
Synedra ulna v. amphirhynchus										+
Tabellaria sp.		+	++		+	+				+
Thalassiosira weissflogii							+			
Tryblionella cf. gracilis							+			
Tryblionella cf. levidensis							+			
Total number of valves recorded	741	2523	582	349	2080	1298	1047	485	257	409
Total taxa (combined total = 159)	39	39	28	33	42	62	101	78	53	69

Appendix E1. Taxonomic Evaluation of Macroinvertebrate Data. Taxa are presented by collection sites and TVs are given for known taxa.

Taxa	Watershed	AR			GB				MC		
Insecta		1	2	3	1	2	3	4	1	2	3
Plecoptera											
Pteronarcyidae											
Pteronarcys sp.	1.6		x								
Perlidae											
Acroneuria sp. Nymp	1.5		x								
Neoperla sp. Nymph	1.4	x									
Ephemeroptera											
Baetidae											
Baetis sp.	5			x					x		x
Caenidae										x	
Caenis sp.	7.6	x	x	x		x			x		
Ephemerellidae											
Atrenella sp. Nym	1.5	x		x							x
Ephemerella sp. Nym	1.7										
Heptageniidae											
Heptagena sp. Nym	2.8										
Stenonema sp.	3.4	x	x	x			x	x		x	
Leptophlebiidae											
Paraleptophlebia sp.	0.9	x		x				x	x	x	x
Leptophlabia sp	6.1			x		x	x	x		x	x
Tricoptera											
Dipseudopsidae											
Phylocentropus sp.	6.2			x		x	x			x	x

(Continued)

Taxa	Waterhsed	AR			GB				MC		
Hydroptilidae											
larva	1.3 - 8.3		x				x		x		
pupa									x		
Hydropsychidae											
Cheumatopsychae sp	6.2										
Hydropsyche	4.3	x	x	x	x			x	x	x	
Leptoceridae											
unIDlarva											
Oecetis sp. Larva	5.7		x		x				x	x	x
Triaenodes sp Lar.	3.8					x				x	
Limnephilidae											
Pycnopsyche sp.	2.3						x				
Pycnopsyche type case											
Phyganeidae											
Ptilostomis sp.	6.2				x	x					
Polycentropodidae											
Polycentropus sp	6.2	x				x					
Psychomyiidae (US species)											
Lype diversa	4		x			x	x	x		x	
Rhyacophilidae											
Rhyacophilia sp.	0									x	
Megaloptera											
Corydalidae											
Corydalus sp.	5.1		x								
Sialidae											
Sialis sp.	7.2				x	x	x	x			
Coleoptera											
Dytiscidae											
Copelatus ? sp. lar	10						x				
Copelatus ? sp. Adu	10									x	
Lacaodytes sp adult	10								x		
Matus sp. Adult			x								
Elmidae	2.1 - 5.9	x	x	x		x	x	x	x	x	x
Ancyronys sp. adult											
Ancyronys sp. Larv											
Narpus sp. larva											
Oreudytes sp Larv											
Stenelmis sp. larva	5.1										
Stenelmis sp. Adult	5.1		x	x							
Gyrinidae											
Dineutus sp. Lar	5.5				x	x	x	x			
Dineutus sp. Adt	5.5		x		x	x	x			x	
Haliplidae											
Peltodytes sp. larva	8.7				x		x				
Peltodytes sp. adult	8.7					x					

(Continued)

Taxa	Watershed	AR			GB				MC		
Hydrophilidae											
Berosus sp. Larva	8.5								x		
Berosus sp. Adult	8.5						x				
Scirtidae											
Cyphon sp? (Prionocypkon?)		x									
Prionocypkon sp						x	x			x	
Odonata											
Anisoptera											
Aeshnidae											
Aeshna sp.									x		
Basiaechna sp. Nym	7.3		x								
Nasiceschna sp.	8.1				x	x					
Corullidae											
Epicardulia sp.	5.6										
Tetragoneuria sp.	8.6				x	x	x	x	x		
Macromia sp	6.2										
Gomphidae											
Gomphus sp.	5.8					x		x		x	x
Progomphus bellei	8.2	x	x								x
Libellulidae											
Libellua sp.	9.6						x		x		
Macromia sp	6.2							x		x	x
Sympetrum sp	7.7					x					
Zygoptera											
Coenagrionidae											
Agria sp. Nymph	8.2	x									
Chromagrion conditum		x		x	x	x	x	x	x	x	x
Enallagma sp.	8.9								x		
Nehalennia sp.									x		
Lestidae											
Lestes sp.	9.4								x	x	
Diptera											
Athericidae											
Atherix sp.	2.1	x	x								
Ceratopogonidae	6 - 7				x	x	x	x		x	x
Chironomidae larvae	0.9 - 10	x	x	x	x	x	x	x	x	x	x
pupae			x	x	x	x	x	x	x	x	x
Phoridae											
Simulidae											
unID larva	4.4					x	x		x		
Prosimulium sp. Lar.	4				x						
Stratomyiidae											

(Continued)

Taxa	Watershed	AR			GB				MC		
Tabanidae											
Chrysops (?)	6.7					x			x	x	x
Tabanus sp.	9.2						x				
Tipulidae	4.2 - 7.3		x		x		x		x		
Hemiptera											
Corixidae											
Tenagobia sp. (?)	5	x					x	x			
Gerridae											
Metrobates sp.	5		x		x						
Naucoridae											
Pelocoris sp. Nymp	5				x				x		
Pelocoris sp. Adult	5								x		
Nepidae											
Ranatra sp.	5									x	x
Veliidae	5		x		x						
Decapoda											
Procambridae											
Procambarus spiculifer	9.5	x	x	x	x	x	x	x		x	x
Gastropoda											
Ancylidae (Limpet)											
Ferrissia sp.	6.6			x	x	x	x		x		x
Plecypoda *(Corbicula)*	6.1		x	x							x
Annelida Oligochaeta	4 - 10			x	x		x	x	x	x	x

Appendix E2a. All Collection Site AR1 Taxa Collected by Month

Taxa				Aug	Oct	Nov	Jan	Mar	Jun
Insecta									
Plecoptera									
	Perlidae								
		Neoperla sp. lymph							3
Ephemeroptera									
	Caenidae								
		Caenis sp.							1
	Ephemerellidae								
		Atrenella sp.Nym						3	
	Heptageniidae								
		unIDnymph						1	
		Stenonema sp.		6					
	Leptophlebiidae								
		unIDnymph							5
		Paraleptophlebia sp.		6			3		

(Continued)

Taxa				Aug	Oct	Nov	Jan	Mar	Jun
Tricoptera									
	Hydropsychidae								
		Hydropsyche		1					
	Polycentropodidae								
		Polycentropus sp		1					1
Coleoptera									
	Dytiscidae								
		unIDlarva						1	
	Elmidae								
		unIDlarva			1		1		2
	Scirtidae								
		Prionocypkon sp		1					
Odonata									
Anisoptera									
	Gomphidae								
		Progomphus bellei							1
Zygoptera									
	Coenagrionidae								
		Agria sp. Nymph							2
		Chromagrion conditum					1		
Diptera									
	Athericidae								
		Atherix sp.		1					3
	Chironomidae		larvae	11	14		5	21	48
			pupae	5	2			1	3
Hemiptera									
	Corixidae								
		Tenagobia sp. (?)							5
Crustacea									
Decapoda									
	Procambridae								
		Procambarus spiculifer		14	2	1	1		4
Arachnida									
		Dolomedies sp.		1		1			
		Tetragnatha sp.		1					
Plecypoda									1
Annelida	Oligochaeta				1			1	1
	Hirudinea								1

Appendix E2b. Collection Site AR2 Taxa Collected by Month

Taxa			Aug	Oct	Nov	Jan	Mar	Jun
Plecoptera								
	Pteronarcyidae							
		Pteronarcys sp.		1				
	Perlidae							
		Acroneuria sp. Nymp						1
Ephemeroptera								
	Baetidae							
		(*Pseudocoloen*?)	1					
	Caenidae							
		Caenis sp.	1					
	Ephemerellidae							
		unIDnymph	1					
	Heptageniidae							
		Stenonema sp.	4			3		8
Tricoptera								
	Hydroptilidae							
		larva						1
	Hydropsychidae							
		Hydropsyche						48
	Leptoceridae							
		Oecetis sp. Larva						2
	Psychomyiidae							
		Lype diversa (only US species)	2					1
Megaloptera								
	Corydalidae							
		Corydalus sp.	1					
Coleoptera								
	Dytiscidae							
		unIDlarva					1	
		Matus sp. Adult						1
	Elmidae							
		unIDlarva					1	
		unID adult		1				2
		Stenelmis sp. Adult						15
	Gyrinidae							
		Dineutus sp. Adt	1					

(Continued)

Taxa			Aug	Oct	Nov	Jan	Mar	Jun
Odonata								
Anisoptera								
	Aeshnidae							
		Basiaechna sp. Nym						1
	Gomphidae							
		Progomphus bellei		1				
Diptera								
	Athericidae							
		Atherix sp.	2					12
	Chironomidae	larvae	26			18	32	31
		pupae				1	1	1
	Tipulidae						2	
Hemiptera								
	Gerridae							
		Metrobates sp.	1					
	Veliidae	nymph						1
Lepidroptera								
	Pyralidae	*unID larva*						1
Crustacea								
Decapoda								
	Procambridae							
		Procambarus spiculifer	2	6	4		1	1
Amphipoda								
	Gammaridae							
		Synurella sp.				1		
Hydracarnia								1
Plecypoda								8
Annelida								
	Hirudinea							1

Appendix E2c. Collection Site AR3 Taxa Collected by Month

Taxa			Aug	Oct	Nov	Jan	Mar	Jun
Ephemeroptera								
	Baetidae							
		Baetis sp.		6				
	Caenidae							
		Caenis sp.		1	1			
	Ephemerellidae							
		Atrenella sp. Nym					1	2
	Heptageniidae							
		Stenonema sp.	10	4		1	1	
	Leptophlebiidae							
		Paraleptophlebia sp.						1
		Leptophlabia sp				1		
Tricoptera								
	Dipseudopsidae							
		Phylocentropus sp.		2				
	Hydropsychidae							
		Hydropsyche		1				
Coleoptera								
	Dytiscidae							
		unID adult	1					
	Elmidae							
		unIDlarva		10				6
		Ancyronys sp. adult		1				
		Stenelmis sp. Adult						1
Odonata								
Zygoptera								
	Coenagrionidae							
		Chromagrion conditum	1					
Diptera								
	Chironomidae	larvae	7	48	3	8	1	29
		pupae	1	4		2		3
Decapoda								
	Procambridae							
		Procambarus spiculifer	7	21	2	2	1	
Amphipoda								
	Gammaridae							
		Synurella sp.	1	5		3		
Isopoda								
	Lcopepoda							
		Acellus sp.	1					

(Continued)

Taxa			Aug	Oct	Nov	Jan	Mar	Jun
Gastropoda								
Limpet	Ancylidae							
		Ferrissia sp.		1				
Plecypoda				2	2			7
Annelida	Oligochaeta			8				

Appendix E2d. Collection Site GB 1 Taxa Collected by Month

Taxa			Jul	Aug	Oct	Nov	Jan	Mar	Jun
Ephemeroptera									
	Baetidae								
		unIDnymph			1				
Tricoptera									
	Hydropsychidae								
		Hydropsyche	2	2					
	Leptoceridae								
		unIDlarva			1			1	
		Oecetis sp. Larva							1
	Phyganeidae								
		Ptilostomis sp.					1		
Megaloptera									
	Sialidae								
		Sialis sp.		5	1				
Coleoptera									
	Dytiscidae								
		unID adult							1
	Gyrinidae								
		Dineutus sp. Lar		2					1
		Dineutus sp. Adt				1			1
	Haliplidae								
		Peltodytes sp. larva			2				
Odonata									
Anisoptera									
	Aeshnidae								
		Nasiceschna sp.			2				6
	Corullidae								
		Tetragoneuria sp.	2		7	1			
Zygoptera									
	Coenagrionidae								
		Chromagrion conditum	1	1	2			2	13

(Continued)

Taxa				Jul	Aug	Oct	Nov	Jan	Mar	Jun
Diptera										
	Ceratopogonidae					1				
	Chironomidae		larvae	3	25	81	19	2		59
			pupae			1				1
	Culicidae									1
		unID pupa								1
	Simulidae									
		Prosimulium sp. Lar.							28	
	Tipulidae					1				
Hemiptera										
	Gerridae									
		Metrobates sp.								1
	Naucoridae									
		Pelocoris sp. Nymp								2
	Veliidae		nymph							2
Lepidroptera										
	Pyralidae	*unID larva*								1
Decapoda										
	Procambridae									
		Procambarus spiculifer		1	2	13	1	9	2	
Amphipoda										
	Gammaridae									
		Synurella sp.		1	2	9		13	39	2
Isopoda										
	Lcopepoda									
		Acellus sp.		3	4	6	2	3	20	2
Microcrusticea										present
Hydracarnia							1			10
Gastropoda										
Limpet	Ancylidae									
		Ferrissia sp.								1
Annelida	Oligochaeta			1		1	1			

Appendix E2e. Collection Site GB 2 Taxa Collected by Month

Taxa			Jul	Aug	Oct	Nov	Jan	Mar	Jun
Ephemeroptera									
	Caenidae								
		Caenis sp.				2			
	Leptophlebiidae								
		Leptophlabia sp							2
Tricoptera									
	Dipseudopsidae								
		Phylocentropus sp.	1	2					
	Leptoceridae								
		Triaenodes sp Lar.						4	
	Phyganeidae								
		Ptilostomis sp.	1	1					
	Polycentropodidae								
		Polycentropus sp			1				
	Psychomyiidae								
	Lype diversa (only US species)		1						
Megaloptera									
	Sialidae								
		Sialis sp.				2		1	
Coleoptera									
	Dytiscidae								
		unID adult				2			
		Matus sp. Adult							3
	Elmidae								
		Narpus sp. larva	1						
		Oreudytes sp Larv	1						
	Gyrinidae								
		Dineutus sp. Lar		1					
		Dineutus sp. Adt				7			
	Haliplidae								
		Peltodytes sp. adult				1			
	Scirtidae								
		Cyphon sp (Prionocypkon ?)			1				
Odonata									
Anisoptera									
	Aeshnidae								
		Nasiceschna sp.				2			
	Corullidae								
		Tetragoneuria sp.		2					
		Macromia sp							
	Gomphidae								
		Gomphus sp.	1						
	Libellulidae								1
		Sympetrum sp	1						
	Coenagrionidae								
		Chromagrion conditum		5	1				4

(Continued)

Taxa				Jul	Aug	Oct	Nov	Jan	Mar	Jun
Diptera										
	Ceratopogonidae							1	2	
	Chironomidae		larvae	7	18	24	17	2	23	30
			pupae		1				2	
	Culicidae									
		Toxorhynchites sp.				1				
	Simulidae									
		unID larva							2	
	Tabanidae									
		Chrysops (?)			1					
	Tipulidae									
Decapoda										
	Procambridae									
		Procambarus spiculifer		7	20	20	5	5	6	16
Amphipoda										
	Gammaridae									
		Synurella sp.		9	8	11	4	8	21	1
Isopoda										
	Lcopepoda									
		Acellus sp.		8	4			4	7	1
Hydracarnia							1			1
Arachnida										
		Dolomedies sp.							2	
		Tetragnatha sp.		2						
Gastropoda										
Limpet	Ancylidae									
		Ferrissia sp.					2			

Appendix E2f. Collection Site GB 3 Taxa Collected by Month

Taxa			Jul	Aug	Oct	Nov	Jan	Mar	Jun
Ephemeroptera									
	Heptageniidae								
		Stenonema sp.						1	
	Leptophlebiidae								
		Leptophlabia sp						1	
Tricoptera									
	Dipseudopsidae								
		Phylocentropus sp.		2					
	Hydroptilidae								
		larva						1	
	Leptoceridae								
		unIDlarva			2				
	Limnephilidae								
		Pycnopsyche sp.			1				
	Psychomyiidae								
		Lype diversa (only US species)	2	1					
Megaloptera									
	Sialidae								
		Sialis sp.		7	1				
Coleoptera									
	Dytiscidae								
		Copelatus ? sp. larva			1				
	Elmidae								
		unIDlarva				2			
		Ancyronys sp. adult							1
		Narpus sp. larva			2				
	Gyrinidae								
		Dineutus sp. Lar			1				
		Dineutus sp. Adt			1				2
	Haliplidae								
		Peltodytes sp. larva			1				
	Hydrophilidae								
		Berosus sp. adult			3				
	Scirtidae								
		Prionocypkon sp		2					
Odonata									
Anisoptera									
	Corullidae								
		Tetragoneuria sp.	1		5		1		33
	Libellulidae								
		Libellua sp.		1					
	Libeulid like numph, wrong antennae				2				

(Continued)

Taxa				Jul	Aug	Oct	Nov	Jan	Mar	Jun
Zygoptera										
	Coenagrionidae									
		Chromagrion conditum			2	9				25
Diptera										
	Ceratopogonidae				1					
	Chironomidae		larvae	5	30	43	14	2	23	28
			pupae			1			1	1
	Empididae									
		Hermerodromia sp.			1					
	Phoridae					92				
	Simulidae									
		unID larva							1	
	Tabanidae									
		Tabanus sp.			2					
	Tipulidae					1				
Hemiptera										
	Corixidae									
		Tenagobia sp. (?)				1				
Decapoda										
	Procambridae									
		Procambarus spiculifer		12	9	66		4		2
Amphipoda										
	Gammaridae									
		Synurella sp.		3		11	8	6	4	3
Isopoda										
	Lcopepoda									
		Acellus sp.		4	1	18		5	13	
Microcrusticea										present
Hydracarnia									1	18
Gastropoda										
Limpet	Ancylidae									
		Ferrissia sp.		1		shell		1	1	shell
Annelida	Oligochaeta			2	1	3				

Appendix E2g. Collection Site GB 4 Taxa Collected by Month

Taxa				Jul	Aug	Oct	Nov	Jan	Mar	Jun
Ephemeroptera										
	Heptageniidae									
		Stenonema sp.				2	1			
	Leptophlebiidae									
		Paraleptophlebia sp.					1			
		Leptophlabia sp						11	5	
Tricoptera										
	Hydropsychidae									
		Hydropsyche					1			
	Leptoceridae									
		unIDlarva								2
	Psychomyiidae									
		Lype diversa (only US species)			1					
Megaloptera										
	Sialidae									
		Sialis sp.			4					
Coleoptera										
	Dytiscidae									
		unIDlarva								2
	Elmidae									
		Oreudytes sp Larv							3	
	Gyrinidae									
		Dineutus sp. Lar			1					
Odonata										
Anisoptera										
	Corullidae									
		Tetragoneuria sp.			2					
	Gomphidae									
		Gomphus sp.							1	
	Libellulidae									
		Macromia sp		1						
Zygoptera										
	Coenagrionidae									
		Chromagrion conditum			2				3	1
Diptera										
	Ceratopogonidae									1
	Chironomidae		larvae	1	11	18	21	15	52	17
			pupae						2	
	Culicidae									
		unID larva								1
	Tipulidae								1	
Hemiptera										
	Corixidae									
		Tenagobia sp. (?)			1					

(Continued)

Taxa			Jul	Aug	Oct	Nov	Jan	Mar	Jun
Lepidroptera									
	Pyralidae	*Acentria sp. Larva*							1
Decapoda									
	Procambaridae								
		Procambarus spiculifer	1	2	54	3	5	2	
Amphipoda									
	Gammaridae								
		Synurella sp.		1			1	3	
Isopoda									
	Lcopepoda								
		Acellus sp.					1	30	2
Arachnida									
		Dolomedies sp.					1	1	
		Tetragnatha sp.							
Annelida	Oligochaeta								1

Appendix E2h. Collection Site MC 1 Taxa Collected by Month

Taxa				Jul	Aug	Oct	Nov	Jan	Mar	Jun
Ephemeroptera										
	Baetidae									
		Baetis sp.				2				
	Caenidae									
		Caenis sp.				2			1	
	Leptophlebiidae									
		Paraleptophlebia sp.						1		
Tricoptera										
	Hydroptilidae									
			larva			2				1
			pupa			1				
	Hydropsychidae									
		Hydropsyche					1			
	Leptoceridae									
		Oecetis sp. Larva							2	
Coleoptera										
	Dytiscidae									
		Lacaodytes sp adult				1				
	Elmidae									
		Oreudytes sp Larv								2
	Hydrophilidae									
		Berosus sp. Larva								1
	Unidentified larva (no family match)							1		

(Continued)

Taxa				Jul	Aug	Oct	Nov	Jan	Mar	Jun
Odonata										
Anisoptera										
	Aeshnidae									
		Aeshna sp.						2		
	Corullidae									
		Tetragoneuria sp.			4	1		1		8
	Libellulidae									
		Libellua sp.			1					
Zygoptera										
	Coenagrionidae									
		Chromagrion conditum				1		16		23
		Enallagma sp.						1		
		Nehalennia sp.						1		
	Lestidae									
		Lestes sp.		1				1		
Diptera										
	Chironomidae		larvae	2	13	144	15	12	28	62
			pupae			7	1		1	
	Culicidae									
		Toxorhynchites sp.				2				1
	Simulidae									
		unID larva							4	
	Tabanidae									
		Chrysops (?)								1
	Tipulidae									1
Hemiptera										
	Naucoridae									
		Pelocoris sp. Nymp		2						
		Pelocoris sp. Adult		1						
Decapoda										
	Procambridae									
		Procambarus spiculifer		16	64	30	5	8	5	23
Amphipoda										
	Gammaridae									
		Synurella sp.		2	24	15	1	9	5	95
Isopoda										
	Lcopepoda									
		Acellus sp.		2	6	19		17	67	87
Hydracarnia										1
Arachnida										
		Dolomedies sp.						1		1
Gastropoda										
Limpet	Ancylidae									
		Ferrissia sp.				2	1			
Annelida	Oligochaeta					7	3		3	

Appendix E2i. Collection Site MC 2 Taxa Collected by Month

Taxa			Jul	Aug	Oct	Nov	Jan	Mar	Jun
Ephemeroptera									
	Caenidae								
		Caenis sp.		1	1				
	Ephemerellidae								
		unIDnymph		1					
	Heptageniidae								
		Heptagena sp. Nym					9		
		Stenonema sp.	3	2			9	2	
	Leptophlebiidae								
		Paraleptophlebia sp.					1		
		Leptophlabia sp					29		2
Tricoptera									
	Dipseudopsidae								
		Phylocentropus sp.						2	1
	Hydropsychidae								
		Hydropsyche		1					
	Leptoceridae								
		Oecetis sp. Larva						2	4
		Triaenodes sp Lar.						1	
	Psychomyiidae								
		Lype diversa (only US species)		2	2				
	Rhyacophilidae								
		Rhyacophilia sp.		1					
Coleoptera									
	Dytiscidae								
		unIDlarva						2	
		Copelatus ? sp. Adult	1						
	Elmidae								
		unIDlarva						2	
	Gyrinidae								
		Dineutus sp. Adt						1	
	Scirtidae								
		Prionocypkon sp		1					
	Unidentified larva (no family match)			1					
Odonata									
Anisoptera									
	Aeshnidae								
		Arigomphus sp. Nym					1		
	Gomphidae								
		Gomphus sp.							1
	Libellulidae				1				
		Macromia sp	4						

(Continued)

Taxa				Jul	Aug	Oct	Nov	Jan	Mar	Jun
Zygoptera										
	Coenagrionidae									
		Chromagrion conditum				1		3	1	3
	Lestidae									
		Lestes sp.						1		
Diptera										
	Ceratopogonidae							1		2
	Chironomidae		larvae	1	14	15	3	29	56	36
			pupae		1	1			2	6
	Culicidae									
		Toxorhynchites sp.				1				
	Tabanidae									
		Chrysops (?)								1
Hemiptera										
	Nepidae									
		Ranatra sp.		1					1	
Decapoda										
	Procambridae									
		Procambarus spiculifer		41	16	16	11	5	3	12
Amphipoda										
	Gammaridae									
		Synurella sp.			10	27		28	221	4
Isopoda										
	Lcopepoda									
		Acellus sp.			1			13	4	
Arachnida										
		Dolomedies sp.						2		1
		Tetragnatha sp.		1						
Annelida	Oligochaeta				1					
	Hirudinea								1	

Appendix E2j. Collection Site MC 3 Taxa Collected by Month

Taxa			Jul	Aug	Oct	Nov	Jan	Mar	Jun
Ephemeroptera									
	Baetidae								
		Baetis sp.			1				
		(*Pseudocoloen*??)					2		
	Ephemerellidae								
		Atrenella sp. Nym						1	
	Leptophlebiidae								
		Paraleptophlebia sp.					6		
		Leptophlabia sp						6	
Tricoptera									
	Dipseudopsidae								
		Phylocentropus sp.		3					
	Leptoceridae								
		Oecetis sp. Larva					1	1	
Coleoptera									
	Dytiscidae								
		unIDlarva					4		
	Elmidae								
		unIDlarva			1				
Odonata									
Anisoptera									
	Gomphidae								
		Gomphus sp.					1		
		Progomphus bellei							
	Libellulidae								
		Macromia sp			1				
Zygoptera									
	Coenagrionidae								
		Chromagrion conditum		3	1		3		
Diptera									
	Ceratopogonidae			1					
	Chironomidae			14	16	3	23	58	1
				2	1		1	1	
	Stratomyiidae			1					
	Tabanidae				4			1	
		Chrysops		1					
Hemiptera									
	Nepidae								
		Ranatra sp.							1
Decapoda									
	Procambridae								
		Procambarus spiculifer	3	11	16	1	6		2
Amphipoda									
	Gammaridae								
		Synurella sp.		18	5				

(Continued)

Taxa			Jul	Aug	Oct	Nov	Jan	Mar	Jun
Isopoda									
	Lcopepoda								
		Acellus sp.			1				
Columbola	Smituridae							1	
Gastropoda									
Limpet	Ancylidae								
		Ferrissia sp.			1				
Plecypoda						shell			5
Annelida	Oligochaeta			1	3			1	

Appendix C:
Fact Sheets – Land Use and Water Quality

Water Quality Overview

Clean Water Act

Congress amended the **Clean Water Act** (CWA) in 1987 to establish the **Section 319 Non-point** Source Management Program in recognition of the need for greater federal leadership to help focus state and local non-point source (NPS) pollution efforts. Under Section 319, states, territories, and Indian Tribes are eligible to receive grant monies to support a variety of activities including technical assistance, financial assistance, education, training, technology transfer, demonstration projects, and monitoring to assess the success of specific non-point source implementation projects (U.S. EPA, 2002).

What Is Water Quality?

Water is essential to human life and to the health of the environment. As a valuable natural resource, it comprises marine, estuarine, freshwater (river and lakes) and groundwater environments, across coastal and inland areas. Water has two dimensions that are closely linked - quantity and quality. Water quality is commonly defined by its physical, chemical, biological and aesthetic (appearance and smell) characteristics. A healthy environment is one in which the water quality supports a rich and varied community of organisms and protects public health.

Water quality influences the way in which communities use the water for activities such as drinking, swimming or commercial purposes. More specifically, the water may be used by the community for:

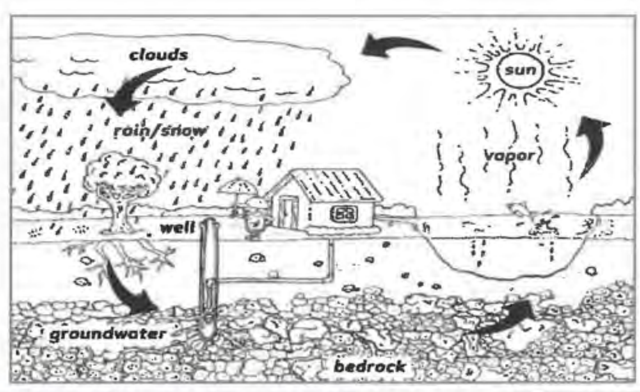
- supplying drinking water
- recreation (swimming, boating)
- irrigating crops and watering stock
- industrial processes
- navigation and shipping
- production of edible fish, shellfish and crustaceans
- protection of aquatic ecosystems
- wildlife habitats
- scientific study and education

Why Is Water Quality Important?

Our water resources are of major environmental, social and economic value and if water quality becomes degraded this resource will lose its value. Water quality is important not only to protect public health, but provides ecosystem habitats, used for farming, fishing and mining, and contributes to recreation and tourism.

If water quality is not maintained, it is not just the environment that will suffer - the commercial and recreational value of our water resources will also diminish.

How Does Water Work?



Source(s): Environmental Protection Agency. http://www.environment.nsw.gov.au/envirom/waterqual.htm. Accessed February 13, 2007.

For more information, contact the SGRDC 327 West Savannah Avenue, Valdosta, Georgia 31601 P: 229.333.5277 or F: 229.333.5312

Water Quality Overview

What Affects The Quality Our Water?

TMDL's

A **Total Maximum Daily Load** or TMDL is important because it determines the maximum amount of a **pollutant** that a river, stream, or lake can receive and still be considered safe and healthy. Once a water body exceeds the maximum amount of a pollutant allowable, it is then considered impaired and actions should be taken to improve the water quality so that the aquatic life can continue to thrive and humans can enjoy the water.

Water quality is closely linked to the surrounding environment and land use. Other than in its vapor form, water is never pure and is affected by community uses such as agriculture, urban and industrial use, and recreation. The modification of natural stream flows by dams and weirs can also affect water quality. The weather too can have a major impact on water quality, particularly in a dry areas which are periodically affected by droughts.

Groundwater is an integral part of our water supply. At times of low river flow groundwater enters the rivers, maintaining river flow. Although data on groundwater quality is limited, it is clear that, like other bodies of water, groundwater close to urban or industrial development is vulnerable to contamination.

Generally the water quality of rivers is best in the headwaters, where rainfall is often abundant. Water quality often declines as rivers flow through regions where land use and water use are intense and pollution from large towns, intensive agriculture, and industry and recreation areas increases.

There are of course exceptions to the rule and water quality may improve downstream, behind dams and weirs, at points where tributaries or better quality groundwater enter the mainstream, and in wetlands.

Rivers frequently act as conduits for pollutants by collecting and carrying wastewater from catchments and ultimately discharging it into the ocean. Stormwater, which can also be rich in nutrients, organic matter and pollutants, finds its way into rivers and oceans mostly via the stormwater drain network. Water quality may also be affected by bacteria from sewer overflows, leaking septic systems, domestic and livestock animals.

How Is Water Quality Measured?

The presence of contaminants and the characteristics of water are used to indicate the quality of water. These water quality indicators can be categorized as:

- **Biological:** bacteria, algae
- **Physical:** temperature, turbidity and clarity, color, salinity, suspended solids, dissolved solids
- **Chemical:** pH, dissolved oxygen, biological oxygen demand, nutrients (e.g. nitrogen and phosphorus), organic and inorganic compounds (e.g. toxicants)
- **Aesthetic:** odors, taints, color, floating matter
- **Radioactive:** alpha, beta and gamma radiation emitters.

Measurements of these indicators can be used to determine and monitor changes in water quality and determine whether the quality of the water is suitable for the health of the natural environment and the uses for which the water is required.

Source(s): Environmental Protection Agency. http://www.environment.nsw.gov.au/envirom/waterqual.htm. Accessed February 13, 2007.

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Land Use Overview

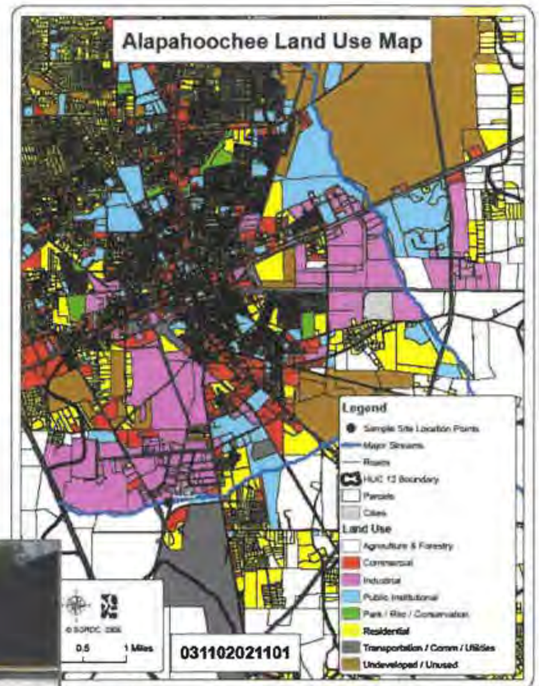
Land Use

Patterns of land use arise naturally in a culture through customs and practices, but land use may also be formally regulated by land us planning through zoning and planning permission laws, or by private agreements such as restrictive covenants. For example, the setting aside of wilderness either publicly as a Wilderness Area or privately as a Conservation Easement.

What Is Land Use?

Land Use is the activity in which the land is used.

Many communities are governed by a set of designations assigned to particular parcels of land. Each designation, known as a parcel's zoning, comes with a list of approved uses that can legally operate on the zoned parcel. These are found in a government's ordinances or zoning regulations.



Land Use Classification

- Agriculture
- Commercial
- Industrial
- Innovation
- Parks/Open Space
- Residential

What Is Land Cover?

Land cover refers to the type of feature present on the surface of the earth. For example, agricultural fields, lakes, rivers, pine forests, roads, and parking lots are all land cover types. Land cover may refer to a biological categorization of the surface, such as grassland or forest, or to a physical or chemical categorization such as concrete.

Land cover is denoted by the physical state of the land, including the type and quantity of vegetation, water and earth materials. Land cover change occurs when one land cover type is converted to another, or is modified, such as a change in agricultural composition. Land cover is continually influenced by land use due to human cultural, social, and economic activities. Understanding the significance and potential consequences of land cover changes for climate, biogeochemistry, or ecological complexity is difficult without land use information.

Source(s): US Geological Survey.
Department of Community Affairs. Guidebook For Local Community Planners.

For more information, contact the SGRDC 327 West Savannah Avenue, Valdosta, Georgia 31601 P: 229.333.5277 or F: 229.333.5312

Land Use Overview

Why Do We Plan?

One of the fundamental responsibilities of local government is planning and the preparation of plans. Planning is the word we use to describe how a community shapes and guides growth and development. The results of planning are contained in documents called "comprehensive plans" or "growth management plans."

Effective planning ensures that the future development will occur where, when, and how the community and local governments wants. There are several benefits to the entire community that result from the planning process:

- *Quality of life is maintained and improved.*
- *There is a vision, clearly stated and shared by all, that describes the future of the community.*
- *Private property rights are protected.*
- *Economic development is encouraged and supported.*
- *There is more certainty about where development will occur, what it will be like, when it will happen, and how the costs of development will be met.*

Three Questions Guide The Planning Process

While there is no universally accepted method for developing a plan, the planning process can be described as the response to these three questions:

1. *What do you have?*
2. *What do you want?*
3. *How will you get it?*

What Is Zoning?

Zoning is a term used in urban planning for a system of land use regulation. Zoning may include regulation of the kinds of activities which will be acceptable on particular lots (e.g. open space, residential, agricultural, commercial, or industrial), the densities at which those activities can be performed (e.g. low-density housing such as single family homes to high-density such as high-rise apartment buildings), the height of buildings, the amount of space structures may occupy, the location of a building on the lot (e.g. setbacks), the proportions of the types of space on a lot (e.g. how much landscaped space and paved space), and how much parking must be provided.

Land Use

To regulate what can be built where, cities create comprehensive plans and zoning ordinances to create an order to the potential uses of land within their political boundaries. A municipality will spend thousands if not hundreds of thousands of dollars to determine where best to encourage industrial growth, allow residential building and permit commercial activity. These decisions have dramatic impacts on land values, safety and community interests. With so much at stake, the process of determining what can be built where has become extremely politicized.

Source(s): Department of Community Affairs. Guidebook For Local Community Planners.

For more information, contact the SGRDC 327 West Savannah Avenue, Valdosta, Georgia 31601 P: 229.333.5277 or F: 229.333.5312

The Link Between Land Use And Water Quality

Community Actions

- Identify surface water resources.
- Identify natural features associated with water resources.
- Establish policy statements to create natural buffer zones around surface water bodies and wetlands.
- Establish policy statements to preserve and enhance natural features.
- Establish design policies to retain stormwater runoff and encourage inflow and base flow.
- Enact landscaping ordinances to require tree planting and landscaping standards for new and renovated parking lots, street right-of-ways, and new subdivisions.

Thoughtful community land use planning and development are critical components in maintaining and restoring water quality in America's streams, lakes, wetlands, estuaries and aquifers. If not carefully planned, land development projects can adversely impact water quality and quantity.

- Impervious surfaces created by the construction of roads, parking lots, rooftops and driveways can decrease groundwater infiltration of runoff and increase runoff volumes and rates. Reduced recharge of groundwater can negatively affect drinking water supplies and stream base flows. Changes in runoff volumes and rates can increase flooding, streambed erosion and sedimentation.
- Development activities typically increase pollutant loadings of pathogens, household chemicals, metals, fertilizers, pesticides, oil and grease. These increases in pollutant concentrations may impair surface and groundwater.
- Construction activities disturb soil and may release sediment and other pollutants to local streams. The EPA estimates that conversion of land produces 40 million tons per year of new sediment during construction.
- Increases in surface runoff, loss of vegetative buffers along streams, and physical alteration of waterways due to development activities can change the natural form and function of a stream. Runoff from unshaded impervious surfaces can increase stream temperatures, often crossing the threshold at which sensitive species can survive and reproduce. .

Guidelines For Building Communities That Protect Water Resources

- Establish community goals for water resources in the watershed.
- Direct development where most appropriate for watershed health.
- Minimize adverse impacts of development on watershed health.
- Promote opportunities for restoration.
- Assess and prevent unintended consequences of local, state, and/or federal decisions affecting watershed health.
- Plan for safe, adequate, and affordable water supplies as an integral part of growth.
- Consider the cumulative impacts of growth management decisions on the watershed.
- Monitor and evaluate success of initiatives.

Source(s): Environmental Protection Agency. http://www.epa.gov/smartgrowth/water_resource.htm. Protecting Water Resources with Smart Growth.

For more information, contact the SGRDC 327 West Savannah Avenue, Valdosta, Georgia 31601 P: 229.333.5277 or F: 229.333.5312

Appendix D: Educational Brochures

What is a WRAS?

The State of Georgia encourages the development of Watershed Restoration Action Strategies (WRAS) for streams and rivers that do not meet water quality standards for waters designated for fishing. The objective is to achieve and maintain good water quality in a watershed by identifying the resources necessary to control pollution.

Key elements of this project's WRAS will include:

- Water Quality and Aquatic Habitat Assessments;
- Identify potential sources of pollution;
- Identify environmental and programmatic goals;
- Outline needs to implement pollution control measures;
- Identify funding sources to implement and maintain restoration measures;
- Implement pollution control and restoration measures to achieve clean water;
- Coordinate with local, state, and federal agencies; and
- Seek and include public input.

Citizen involvement is key to the success of a WRAS. No one knows conditions in a watershed better than the residents, and no one cares more about the health and well-being of their environment than those in contact with the environment everyday. The WRAS will connect citizens with the necessary resources to improve and protect their water resources.

Project Information

Funding for this project is provided by a Section 319 (h) Grant from the

Georgia Department of Natural Resources

Environmental Protection Division

through the

Seven Rivers Resource Conservation and Development Council, Baxley GA

Collaborating Agencies

Alapaha Soil & Water Conservation District

City of Valdosta, Utilities Department

Georgia Forestry Commission

Georgia Soil & Water Conservation Commission

South Georgia Regional Development Center

UGA—Cooperative Extension

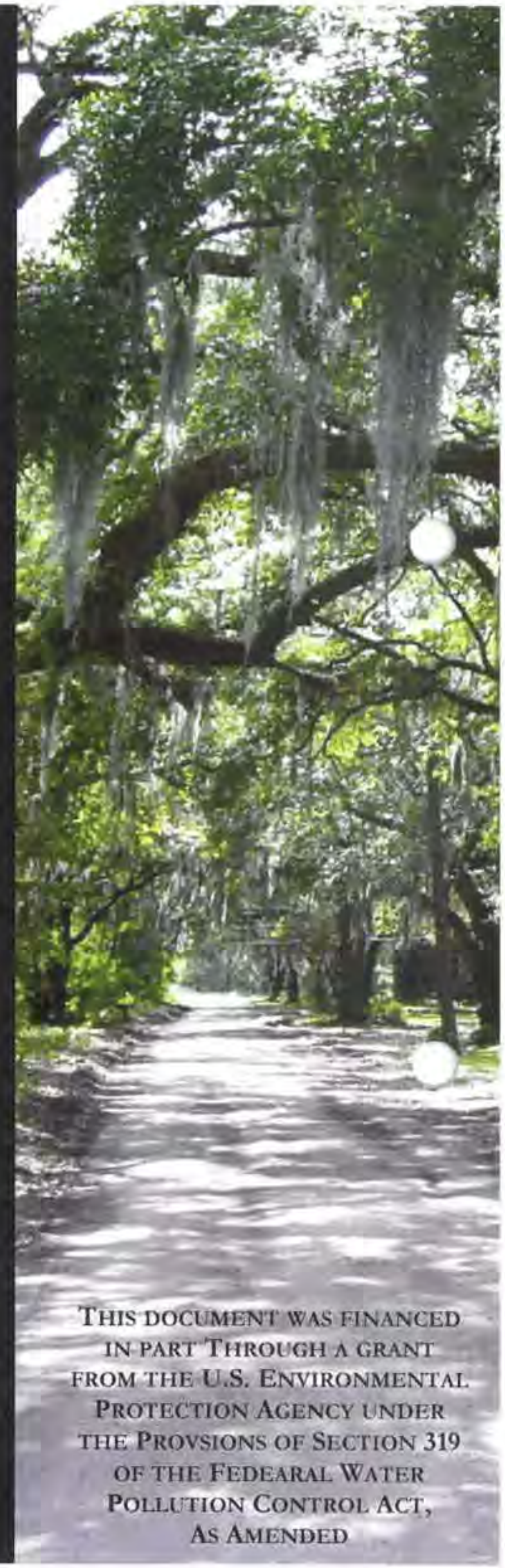
USDA—Natural Resources Conservation Service

Valdosta State University

For More Information

Angela Wall, Project Coordinator
327 West Savannah Avenue
Valdosta, Georgia 31601
229.333.5277 Ext. 222
awall@sgrdc.com

Alapahoochee Watershed



The Alapahoochee Watershed

The Alapahoochee Watershed is located in south-central Georgia in the counties of Lowndes and Echols. Of these two counties, the Alapahoochee Watershed consists of approximately 16 square miles.

In order to protect this unique watershed, we must find a balance between the natural and man-made environments that will offer a healthy place for wildlife and people to live and work.

Watershed Concerns

Over the years, citizens of the Alapahoochee Watershed have shown a strong interest in the protection of our natural resources. In recent years, concerns for our water resources have grown and community involvement has increased through public involvement activities.

In 2000, the Georgia Environmental Protection Division (EPD) identified two streams in the Alapahoochee Watershed as not meeting their designated use for fishing, the Alapahoochee River and Mud Creek. The Alapahoochee River was listed for mercury, resulting in fish consumption restrictions, while Mud Creek was listed for elevated levels of fecal coliform (FC).

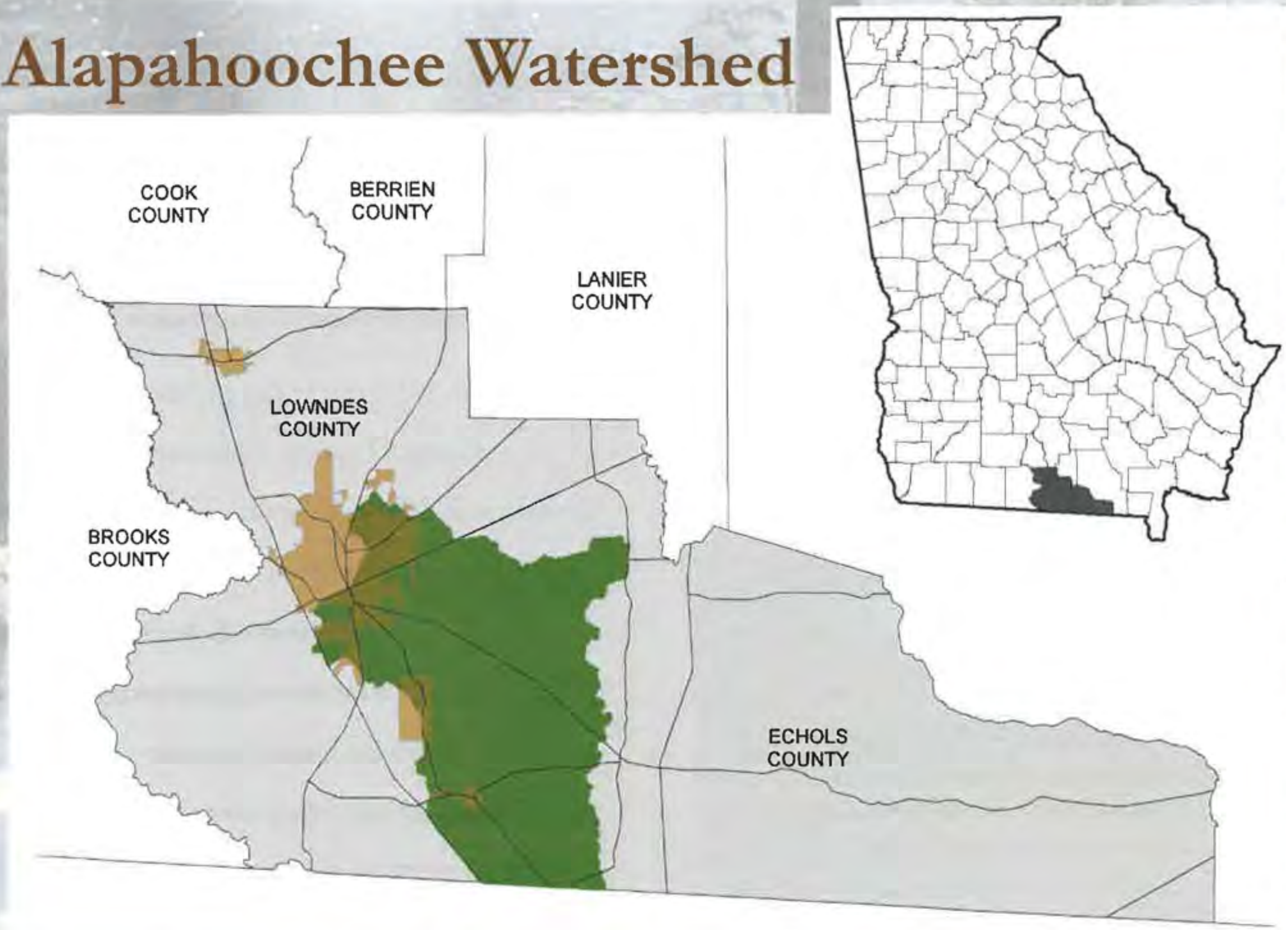
With the public being concerned about these issues, funding through a Georgia EPD Section 319(h) grant was requested to address the water quality problems, which were primarily the result of non-point source pollution.

Solutions

A watershed approach is being taken to educate citizens about water quality and connect them with resources and programs to help control and abate sources of pollution in the Alapahoochee River Watershed. Although agriculture and forestry are predominant land uses in the project area, other potential sources of pollution exist, such as urban runoff and industrial waste.

Citizen involvement, education, volunteerism, coordination, and cooperation are necessary in addressing the problems facing the watershed to ensure progress. This watershed project will involve activities such as a water quality and aquatic habitat assessment, the installation of best management practices (BMPs), educational activities such as workshops and field days, and the development of a Watershed Restoration Action Strategy (WRAS).

Alapahoochee Watershed



"Working together to restore our local waters"

Stormwater—Want to learn more?
Contact:
City of Valdosta
Stormwater Management Program
at 229.259.3592
www.valdostacity.com

Pets—Want to learn more?
Contact:
Humane Society of
Valdosta—Lowndes County
307 East Jane Street
Valdosta, GA 31601
229.247.3266
www.humanesocietyofvaldosta.org

Lowndes County Animal Shelter
337 Gil Harbin Industrial Blvd
Valdosta, GA 31601
229.671.2760
www.petfinder.com/shelters/GA53.html

PET FUN FACTS

- There are over 61 million dogs in the United States, producing approximately 7.2 billion pounds of waste per year.
- In the City of Valdosta, there are an estimated 5,911 dog-owning households totaling 9,457 dogs in our community.
- There are an estimated 5,174 cat owning households in the City of Valdosta totaling 10,867 cats.

Source: U.S. Pet Ownership & Demographics Sourcebook by the American Veterinary Medical Association.

City of Valdosta
Department of Utility Services
Stormwater Management Program
P.O. Box 1125
Valdosta, Georgia 31603
Phone: 229.259.3592
Fax: 229.333.1899
www.valdostacity.com

South Georgia Regional Development Center
327 W. Savannah Avenue
Valdosta, Georgia 31601
Phone: 229.333.5277
Fax: 229.333.5312
www.sgrdc.com

The printing of this document was financed through a grant from the U.S. Environmental Protection Agency under the Provisions of Section 319 of the Federal Water Pollution Control Act

The Scoop on Poop

A guide to safe and environmentally friendly pet waste disposal

Brought to you by
The City of Valdosta
Department of Utility Services
Stormwater Management Program

VALDOSTA
A City Without Limits...A Region of Opportunity

Did you know…

That picking up after your pet is a simple solution to water pollution? Like in many cities, the City of Valdosta's stormwater is untreated and goes directly into our local streams. When water washes over the land during a rain event, it picks up pollutants, such as pet waste, and carries them into our waterbodies. This is known as stormwater pollution or non-point source pollution.

Why is pet waste a problem?

Pet waste contains harmful bacteria, such as E. Coli and fecal coliform, so once it reaches our streams, it can make them unsafe for humans and our pets. Pet waste also contains nutrients that can cause excessive algae growth in a stream or pond, which can upset the natural balance of the waterbody.

What are the Benefits of Picking up after your Pet?

A clean yard
Protecting the environment
Hygiene / health safety
Neighborhood courtesy
Being a responsible pet owner

So What Should You Do?

Simply pick up your pet's waste! There are several options to keep your pet's waste from being washed into our local streams such as using a plastic grocery bag or pooper scooper and then disposing the waste in a garbage can. To help promote "picking up after your pet", the Recreation, Parks, and Community Affairs Department has purchased pet waste stations that can be found in various parks within the City. For locations, call 229.259.3507.

What you should <u>not</u> do:

- Do not flush pet waste down the toilet, compost it, or dump it into storm drains or ditches.
- Do not use pet waste as a fertilizer. The bacteria in pet waste can be harmful to your health and that of your pet.
- Do not leave pet waste on streets, sidewalks or other impervious (hard) surfaces where it can wash into storm drains, ditches, or waterways.

Other ways to help:

Encourage your neighbors and other pet owners to be responsible. Properly managing pet waste is something that everyone can do to make a difference in the quality of our local streams. Responsible individual actions can result in significant water quality improvement when carried out by an entire community.

Appendix E:
Field Days/Workshops

A special thanks to all the individuals and agencies that dedicated time and funding to make this field day possible. Those that assisted with the organization of this field day includes:

Alapaha Soil & Water Conservation District

DNR—Pollution Prevention Assistance Division

Georgia Environmental Protection Division

Georgia Soil & Water Conservation Commission

Seven Rivers Resource Conservation & Development Council

South Georgia Regional Development Center

The University of Georgia College of Agricultural & Environmental Sciences

US Environmental Protection Agency Region IV

USDA—Natural Resources Conservation Service

Low Drop Extension Sprinklers

South Georgia RDC
327 W. Savannah Avenue
Valdosta, Georgia 31601
P: 229.333.5277
F: 229.333.5213

Come Join Us For The...

Best Management Practices Field Day

June 13, 2007

Alapahoochee Watershed

"Working together to restore our local waters."

Exclusion Fencing

PROGRAM AGENDA

10:15—10:30 Registration

10:30—10:45 Introduction and Opening Remarks

10:45—11:30 BMP Demonstrations

- Pasture Planting
- Exclusion Fencing

11:30—11:40 Questions and comments

11:40—12:00 Travel Time

12:00—12:20 BMP Demonstration

- Low Drop Sprinkler Extension

12:20—12:30 Questions, comments, and closing remarks

12:30—1:30 LUNCH

Lunch will be provided by the Alapaha Soil & Water Conservation District and the Georgia Soil & Water Conservation Commission.

Directions To The Field Day:

Going South on I-75
- Exit I-75 at Exit # 5
- Turn left onto Hwy 376 /Lake Blvd
- Go 1.5 miles and turn right onto Hwy 41/376
- Go 1.2 miles turn left onto Hwy 376
- Go 4.4 miles turn right onto Tince Road (Stay on paved road in curve)
- Go 1.3 miles BMP site will be on the right

From Valdosta
- From East Hill Ave. (Hwy 84) turn right onto Inner Perimeter Road
- Go 4.1 miles turn left onto Hwy 41
- Go 9.3 miles turn left onto Hwy 376
- Go 4.4 miles turn right onto Tince Road. (Stay on paved road in curve)
- Go 1.3 miles BMP site will be on the right

Pasture Planting

Best management practices (BMPs), such as pasture planting, exclusion fencing, and low drop extension sprinklers helps to prevent or reduce water pollution, while maintaining economic return.

REGISTRATION FORM

Name: ____________________

Organization: ____________________

____

Address: ____________________

____

City: ____________________

State: __________ **Zip:** __________

County: ____________________

Phone number: ____________________

E-mail: ____________________

REGISTRATION IS FREE!!!

DEADLINE: JUNE 8, 2007

Continuing Credits will be available!

Please submit registration form to:

Angela Wall
327 West Savannah Avenue
Valdosta, GA 31601

For more information, please contact Angela Wall at 229.333.5277 or at awall@sgrdc.com.

Funding for this project is provided by a Section 319 (h) Grant from the

Georgia Department of Natural Resources Environmental Protection Division

through the

Seven Rivers Resource Conservation and Development Council

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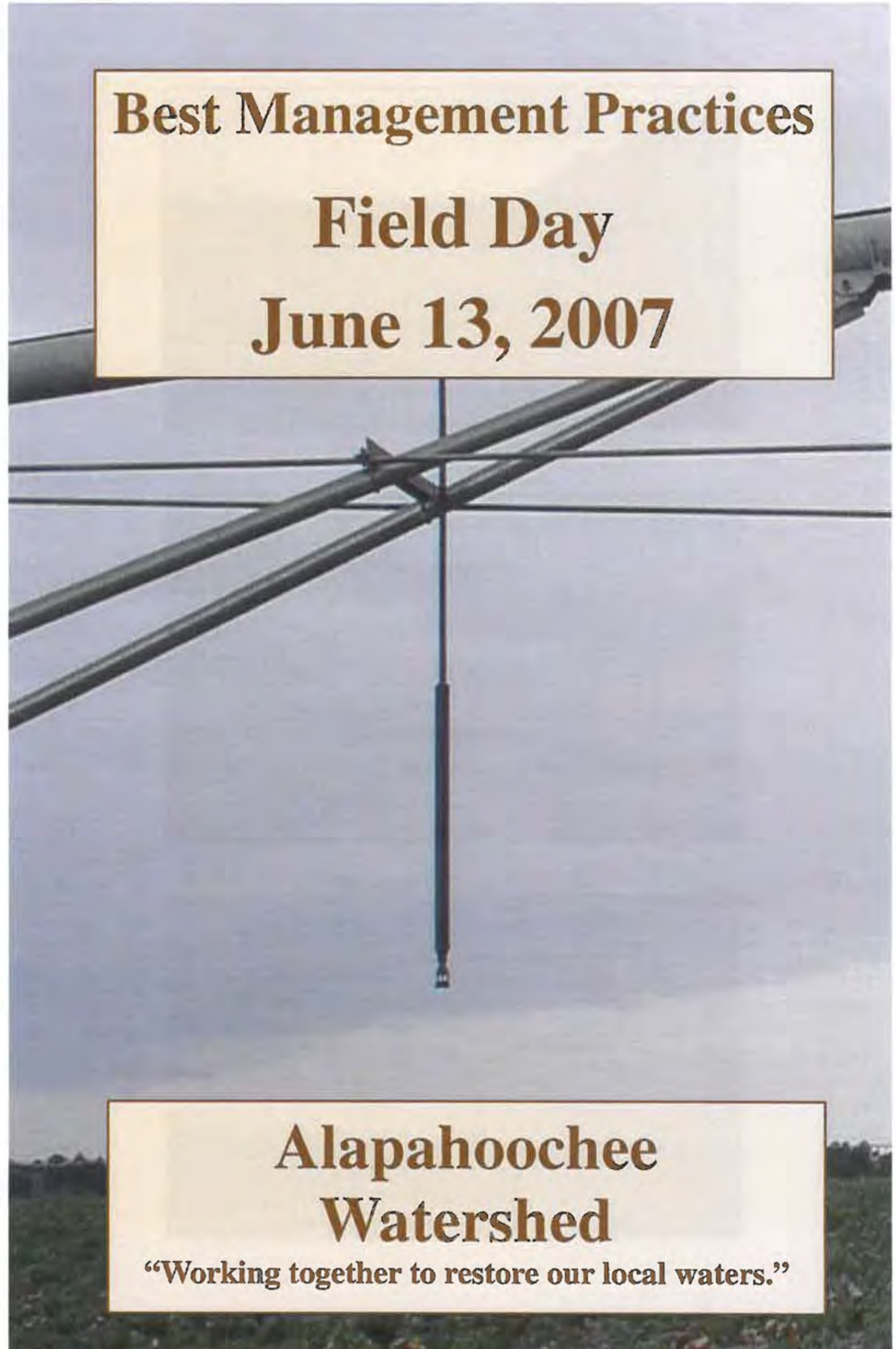
through the
Seven Rivers Resource Conservation and Development Council



Best Management Practices

Field Day

June 13, 2007

Alapahoochee Watershed

"Working together to restore our local waters."

BMP Field Day Agenda

June 13, 2007

10:15—10:30 Registration

10:30—10:45 Introduction and Opening Remarks
Speakers: O.C Prince – Alapaha S&WC District
Stan Moore – Seven Rivers RC&D Council
Hal Simpson – USDA – NRCS

10:45—11:30 BMP Demonstrations

Pasture Planting
Speakers: Stanley Corbett - Farmer
Phil Hall – USDA – NRCS

Exclusion Fencing
Speakers: Stanley Corbett – Farmer
Gary Hawkins – The University of Georgia

11:30—11:40 Questions and Comments

11:40—12:00 Travel Time

12:00—12:20 BMP Demonstration

Low Drop Sprinkler Extension
Speakers: Billy Herndon – Farmer
Calvin Perry – The University of Georgia

12:20—12:30 Questions, comments, and closing remarks
Angela Wall – South GA Regional Development Center

12:30 — 1:30 LUNCH

A very special thank you to the Alapaha Soil & Water Conservation District and the Georgia Soil & Water Conservation Commission for providing lunch today!

Learn About Your Septic System

Friday, July 30, 2007
9:30—10:00 am

Please join us for this informative field day to learn more about your septic system.

Topics to be covered will include the following: tips for operating your system, how to maintain your system and why it's important, and septic system cautions.

This field day will be held at 4020 Danube Circle. For more information about this event please contact Angela Wall at 229.333.5277 or by email, awall@sgrdc.com.

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Hosted by:

Seven Rivers Resource Conservation District & Council

South Georgia Regional Development Center

Lowndes County Health Department

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COME JOIN US FOR...

BARK IN THE PARK!

Bring your dog for a fun day in the park to play and win prizes...

Saturday, **October 27, 2007**

Drexel Park, across from Valdosta State University

10 am—12 pm

Pet Contest starts at 11 am

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Saturday, **October 27, 2007**

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City of Valdosta
Environmental Protection Division
Seven Rivers RC&D Council
South Georgia RDC
Valdosta—Lowndes Parks Department

For more information about this event please call Angela Wall or Jaime Fulmer at 229.333.5277.

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BARK IN THE PARK
Saturday, October 27, 2007
Drexel Park, across from Valdosta State University
10 am – 12 pm
Pet Contest starts at 11 am
Includes:
• Pet Owner Look Alike
• Best Costume
• Top Dog Photo (you bring)
• Best Trick
• Best Human Barker
• Overall Best Champ
For more information about this event please call
Angela Wall or Jaime Fulmer at 229.333.5277.
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Appendix F:
Adopt – A –Stream Training

FREE

2 –DAY

Georgia Adopt-A-Stream Training

- **When:** **April 15th and 16th**
- **Where:** **VSU, Nevins Hall Rm. 2111**
- **Time:** **April 15: 6pm - 9pm**

  April 16: 9am - 4pm

Material Covered:

- Getting to know your watershed
- Visual Stream Monitoring
- Biological Monitoring
- Chemical Monitoring
- How to develop a "Citizen Network"

For more details or to sign up contact Emily Perry at 229.333.5277 or eperry@sgrdc.com

Collaborating Agencies:

Alapahoochee River Watershed 319 Project
City of Valdosta, Utilities Department
Valdosta State University, Department of Physics, Astronomy, and Geosciences
GA DNR EPD

Check out the Georgia Adopt-A-Stream website:
http://www.riversalive.org/aas.htm

Get to know your watershed and become a certified chemical water quality monitoring volunteer at our

Adopt—A—Stream Workshop

Wednesday, October 17, 2007

Valdosta State University

Nevins Hall, Room 2020

From 3 pm—7 pm

REGISTRATION IS FREE!!!

For more information or to register for this workshop please contact Angela Wall at 229.333.5277 or by email at awall@sgrdc.com.

Sponsored by the Environmental Protection Division, Seven Rivers RC&D Council, South Georgia Regional Development Center, and Valdosta State University.