1.1 Introduction

Gainesville has long been considered a desirable place to live, largely due to its abundance of natural resources. The area boasts many prominent natural features including: an extensive tree canopy, a natural creek system, and diverse wetland areas. One of the most important of Gainesville's natural resources is its creeks. The urban creek system serves vital purposes to the community and the environment by providing: (1) in-stream habitat for a variety of flora and fauna, (2) riparian areas that serve as natural buffers to reduce non-point source pollutant loading, (3) wildlife corridors, (4) recreational opportunities such as hiking and fishing, and (5) an outlet for moving stormwater runoff out of the urban area, thereby reducing flood potential. In order to preserve these important resources and functions for Gainesville's future, the creeks must be closely monitored and properly preserved, restored, and managed.

Hogtown Creek upstream of NW 34th Street.

The majority of creeks in the Gainesville area are part of the larger Orange Creek Basin (OCB), which covers approximately 600 square miles primarily within the boundaries of the St. Johns River Water Management District (SJRWMD) (Figure 1.1). The OCB is comprised of six major watersheds: Hogtown Creek, Paynes Prairie, Newnans Lake, Lochloosa Lake, Orange Lake, and Orange Creek. This report focuses on the creeks within the Hogtown Creek, Newnans Lake, and Paynes Prairie watersheds.

1.1.1 Purpose

The purpose of this report is to present the results of monthly baseflow water quality sampling, continuous storm event water quality monitoring, stream and pollutant source inventories, in-stream biological assessments (including benthic macroinvertebrate sampling), and streamflow monitoring for each creek.

From 1997 through 2002, a six-way government agency partnership supported OCB urban creek assessment activities. Partner agencies included SJRWMD, Gainesville Regional Utilities (GRU), City of Gainesville Department of Public Works (CGDPW), Alachua County Public Works Department (ACPWD), Florida Department of Environmental Protection (FDEP), and Alachua County Environmental Protection Department (ACEPD). The partnership was formed to address water quality and stormwater issues in the OCB and to coordinate and share technical and fiscal responsibilities for water quality and biological assessments. This report provides a detailed assessment of the water quality and ecosystem health of the creeks in and around Gainesville.

1.1.2 Project Approach

This project began in February 1998 as an effort to expand the monitoring of Gainesville's urban creeks. A total of 14 sam-

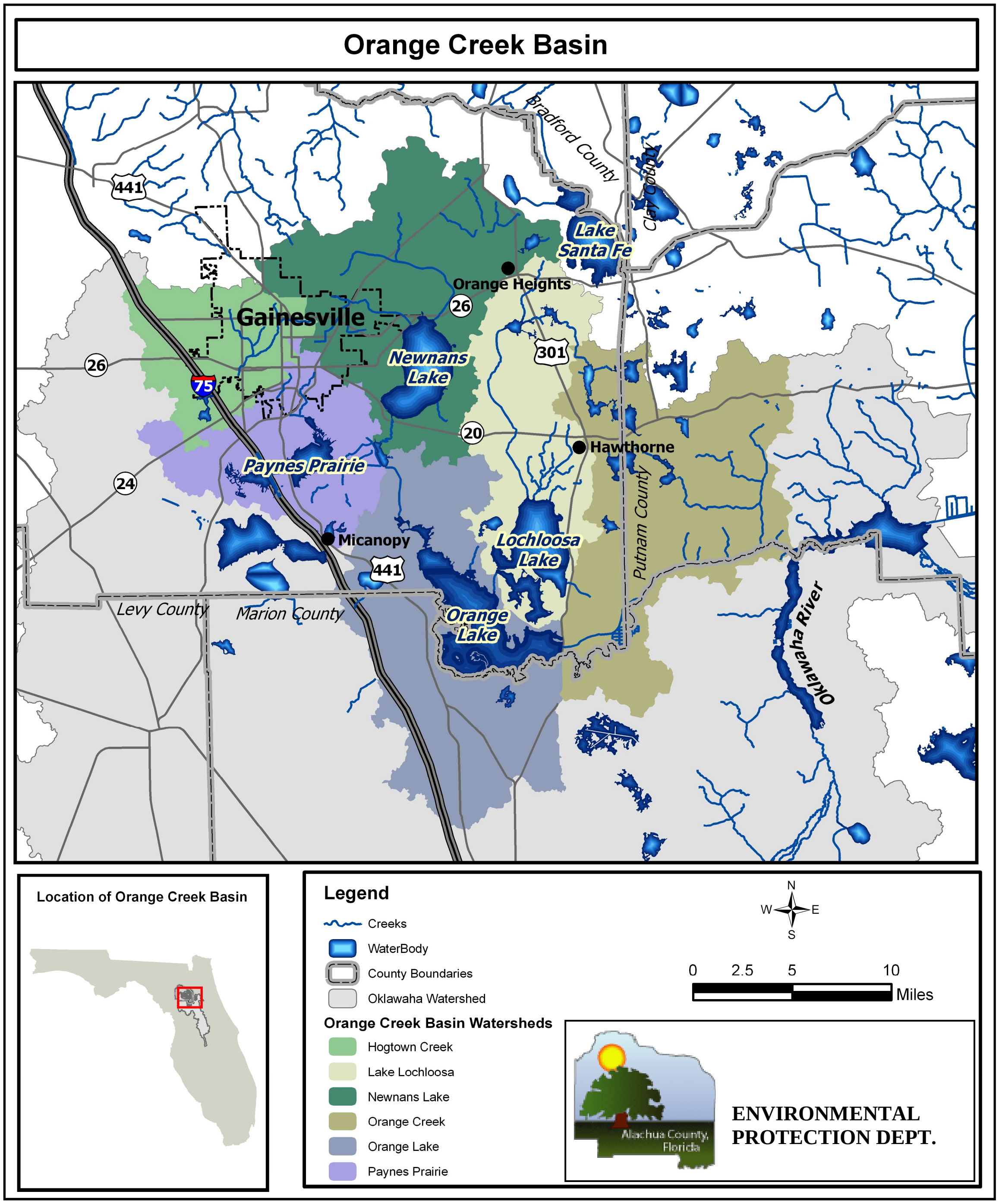

Figure 1.1 Map of the Orange Creek Basin showing major sub-basins or watersheds.

Newnans Lake (to the north) from Powers Park.

pling sites were initially selected by SJRWMD and ACEPD personnel to characterize stream water quality in each of the three major watersheds. Additional sampling sites were selected as the project progressed. Sampling locations in the Newnans Lake Watershed included three sites on Little Hatchet Creek, one site on Hatchet Creek, and one site on Lake Forest Creek. To assess the impact of these streams on water quality in Newnan's Lake, sites were selected as close to the lake as possible. Sampling locations in the Paynes Prairie Watershed included two sites on Tumblin Creek (upstream and downstream of Bivens Arm Lake) and two sites on Sweetwater Branch (upstream and downstream of the GRU Main Street Water Reclamation Facility). Sampling locations in the Hogtown Creek Watershed included one site on Possum Creek and three sites on Hogtown Creek. Baseflow water quality sampling sites are presented in Figure 1.2 and Appendix A-1.

From 1999 through 2001, the project scope expanded to include continued monthly water quality sampling, storm event water quality monitoring, in-stream biological assessments, and report preparation.

Storm event water quality monitoring was conducted at selected sites in the watersheds which are shown in Figure 1.2 and listed in Appendix A.

Stream Habitat Assessments and in-stream biological assessments were performed at selected sites. Habitat Assessments were used to determine the quality and availability of in-stream habitat suitable for aquatic macroinvertebrate use. BioRecons, short for biological reconnaissance, were used to assess the health of streams by counting the number of pollution-sensitive benthic macroinvertebrate organisms present. Benthic macroinvertebrates are commonly used as indicator species to assess in-stream biological health. Site locations for the Habitat Assessments and BioRecons are discussed in section 1.3.2 and listed in Appendix A-2.

Summaries of baseflow and stormflow water quality monitoring results, as well as in-stream biological conditions, are presented in the following sections of this chapter. Results from the water quality monitoring and stream biological health

Hogtown Creek north of NW 8th Avenue - upstream.

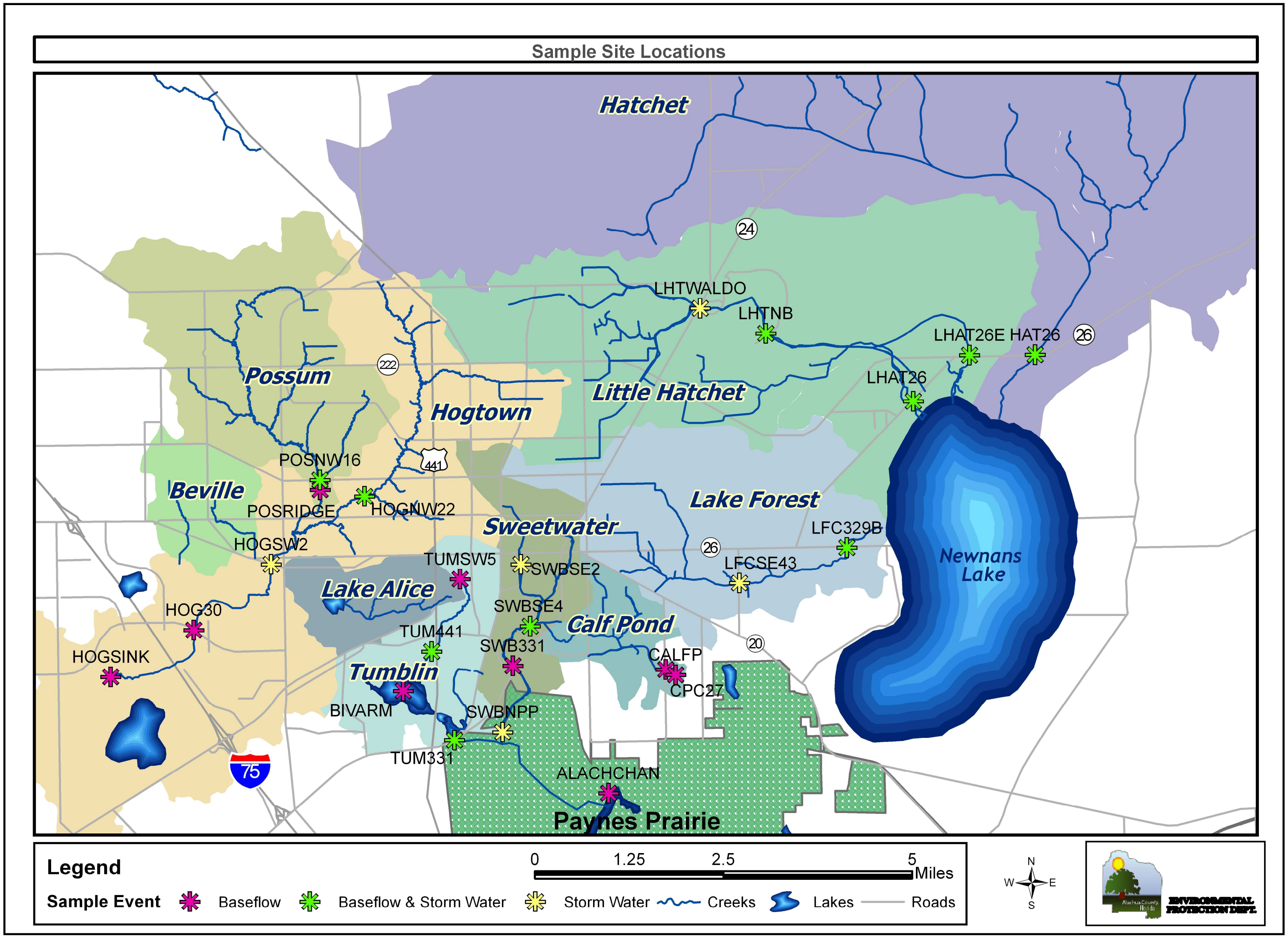

Figure 1.2 Sampling site locations for monthly baseflow and storm event water quality sampling.

assessments for the individual creeks are presented in Chapters 2 through 10 of this report.

1.2 Watershed Description

Alachua County covers an area of approximately 961 square miles in north-central peninsular Florida (Pirkle 1956). The OCB covers approximately 425 square miles in central and southeastern Alachua County. The creeks assessed as part of this study can be grouped by watershed and include: (1) Hogtown and Possum creeks in the Hogtown Creek Watershed; (2) Tumblin Creek, Sweetwater Branch and Calf Pond Creek in the Paynes Prairie Watershed; (3) Lake Forest, Hatchet, and Little Hatchet creeks in the Newnans Lake Watershed (Figure 1.2). The Blues Creek Watershed is a major urban watershed that is not within the confines of the OCB and therefore is not addressed in this report. Blues Creek is a stream to sink (internally drained) watershed which is located in northwest Gainesville.

Topographic relief in the OCB within Alachua County is moderate to high for Florida. Elevations range from less than 60 feet above the National Geodetic Vertical Datum (NGVD) of 1929 on Hogtown Prairie, Paynes Prairie, and Newnans Lake to over 175 feet in the headwaters of Hogtown Creek and the Buck Bay area. Buck Bay serves as the headwaters of Little Hatchet Creek and Hatchet Creek (excluding Bee Tree Creek).

1.2.1 Physiography

Major physiographic provinces present in the OCB include the Northern Highlands, or Plateau region, in the north and eastern areas of the basin and the Western Valley Karstic lowlands in the south and western areas (Figure 1.3). The western and southern facing feature, known as the Cody Scarp and shown by the hachured line in Figure 1.3, separates the highland plateau of the east from the lower-lying Western Valley (or plains region) and the flat-bottomed lake zone in the south-central portion of the county (Hoenstine and Lane 1991).

The scarp domain is an area of high relief. Many streams originating in the east on the Northern Highlands Plateau flow west or south and then discharge to groundwater via sinks and solution features at the toe of the slope in the lowland areas. Examples include Hogtown Creek, which flows into Haile Sink on Hogtown Prairie, and Tumblin Creek and Sweetwater Branch, which flow onto Paynes Prairie and ultimately recharge the Floridan aquifer via Alachua Sink.

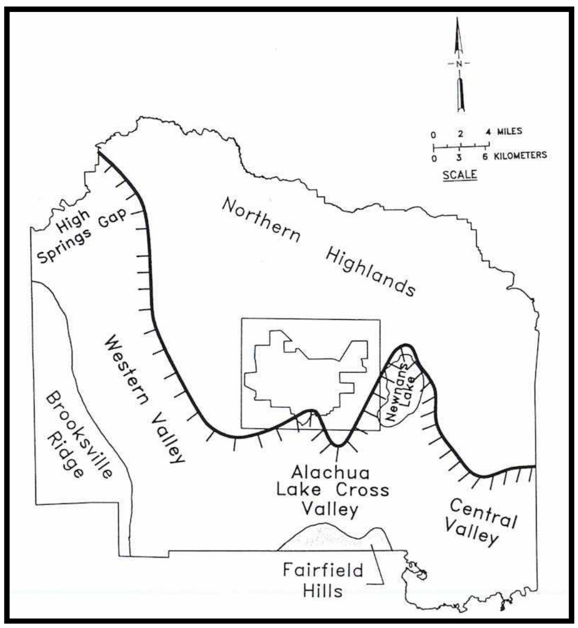

Figure 1.3 Geomorphology of Alachua County (from Hoenstine and Lane 1991).

1.2.2 Geology

The oldest geologic formation exposed at the surface in Alachua County is the Ocala Limestone. This Upper Eocene-age limestone is a white to cream colored soft, fossiliferous limestone (Cooke 1945, Williams et al 1977, Thomas et al 1985). Silicified boulders and/or lenses of chert commonly found in the upper layer of the Ocala Limestone are evidence that it was once an erosional unconformity (Williams et al 1977). In northern and northeastern Alachua County, the Ocala Limestone is covered by upwards of 100 feet of Miocene-age deposits of the Hawthorn Group formations (Clark et al 1964, Scott 1988).

The Hawthorn Group formations are extremely variable but generally consist of a series of interbedded sands, silts, clayey sands, sandy clays, carbonates (limestone and dolostone), and phosphates (Scott 1988). The Hawthorn Group (formerly the Hawthorn Formation) is comprised of three formations. From oldest to youngest the formations are the Penny Farms, Marks Head, and Coosawhatchie. In the Gainesville urban area, the upper Hawthorn Group formation (Coosawhatchie Formation) is typically observed as a stiff to soft gray-green sandy clay with phosphatic sands or nodules.

Above the Hawthorn Group formations, or directly contacting the Ocala Limestone where the sediments of the Hawthorn Group formations are absent, lie Plio-Pleistocene Terrace deposits comprised of sands and clays (Clark et al. 1964). As elevations decrease, Hawthorn Group formations, as well as younger deposits, are exposed along the creek banks and in streambeds. Clayey sands, sandy clays, and dolostones are more resistant to erosion and down cutting and are frequently observed as outcrops along streams in the Hogtown Creek and Paynes Prairie watersheds. Many of the creeks in the Gainesville area are deeply incised, due to the erosional forces of stormwater.

1.2.3 Soils

Soil types in the watersheds fall into three main groups: sandy well drained soils, sandy poorly drained soils, and sands with loamy or sandy clay subsoils that are somewhat well drained to poorly drained.

In the Paynes Prairie Watershed, major soil types in the upland areas surrounding Tumblin Creek and Sweetwater Branch include the well drained Millhopper-Urban land complex, the more poorly drained Blichton-Urban land complex, and Urban land (Thomas et al 1985). Near the creeks and in the floodplains, loamy sands and soils, such as the Blichton sand (containing ironstone and phosphatic limestone), are present.

Major soil types in the Hogtown Creek Watershed include the Millhopper sand, Kanapaha sand, Millhopper-Urban land complex, and Arredondo–Urban land complex (Thomas et al 1985). Poorly drained soils, such as Blichton sand, are present near Hogtown and Possum creeks. Such soils are indicative of their Hawthorn Group origin.

In the Newnans Lake Watershed, soils are typically sandy and poorly drained. Extensive pine flatwoods with a water table less than 10 inches below land surface for one to three months or more per year is common throughout the watershed (Thomas et al 1985). The numerous wetlands in this watershed and high water table are indicative of the nearly level terrain and the lateral continuity of the Hawthorn Group formations at depth in this area.

1.2.4 Groundwater

There are three aquifer systems present in Alachua County: the surficial aquifer system, the intermediate aquifer system, and the Floridan aquifer system (Southeastern Geological Society 1986). The Floridan aquifer system underlies all of Alachua County, while the surficial and intermediate aquifer systems occur only in the east where Hawthorn Group formations are present. It is the water from the surficial and intermediate aquifer systems that provide baseflow to Gainesville creeks. Water quality changes as the creeks flow from the Northern Highlands and approach, or cross, the Cody Scarp. Water quality changes include increased specific conductance, alkalinity, and phosphorus concentrations. These changes occur due to increased water interception (by streams) from the intermediate aquifer and exposure and erosion of the Hawthorn Group formations.

The surficial aquifer is comprised primarily of quartz sands, becoming clayey at depth. In most of eastern Alachua County the surficial aquifer exists under unconfined or "water table" conditions and discharges to streams when they intercept the surficial aquifer. Where relief is high, such as the upper reaches of the Hogtown Creek Watershed, the surficial aquifer discharges to the creeks directly as small springs and seeps or indirectly through associated small wetlands. Where relief is low, such as in some areas of the Little Hatchet Creek Watershed, water from the surficial aquifer may discharge to streams during part of the year. In these areas of low relief, the surficial aquifer may receive recharge during times of the year when surface water levels are high and conversely the surficial aquifer may discharge to the creeks when groundwater levels are high and surface water levels are low. Groundwater seepage to the creeks frequently occurs at the base of the surficial aquifer where the lower permeability Hawthorn Group clays are encountered. Groundwater flow in the surficial aquifer generally follows topography.

The surficial aquifer system is not present throughout much of western Alachua County. In this area water in the Floridan aquifer system is unconfined or very poorly semi-confined and exists under water table conditions. Areas within the OCB where a surficial aquifer may not be present include the western part of the Paynes Prairie Watershed and areas in the south and west parts of the Orange Lake Watershed. In the western portion of the OCB and the urban area of Gainesville, there are many small closed or stream-to-sink watersheds or basins. In these areas, the surficial aquifer system may not exist or only exists as an intermittent perched water table discharging via sinks or swallets to the Floridan aquifer system during periods of high rainfall. Examples of these systems include the Smith Creek and Rutledge Drain systems.

In Alachua County east of the Cody Scarp, the Hawthorn Group formations provide both a confining unit above the Floridan aquifer and discrete water bearing units collectively know as the intermediate aquifer or aquifer system. The intermediate aquifer by definition exists under confined conditions. Within the intermediate aquifer system, sands, clayey sands, carbonates (limestone and dolomite) and phosphatic materials can yield water. Through natural down cutting and dissection of the land surface by streams, these water-bearing units yield baseflow to many of the creeks. The Hawthorn Group formations are also exposed along the creek banks and streams beds as resistant beds that define the stream channels. Most water discharging from the intermediate aquifer seeps out of the banks along seepage slopes, however some springs do exist. One named spring, Glen Springs, located in the upper reaches of Hogtown Creek, discharges from the intermediate aquifer. Glen Springs is a fourth magnitude spring with a mean historical discharge, from 1941 through 1972, of 0.35 cubic feet per second (cfs) (Rosenau et al 1977).

The Floridan aquifer or aquifer system does not contribute flow to the streams in the Gainesville urban area or to the Newnans Lake tributaries. The Floridan aquifer potentiometric surface and the Ocala Limestone, which is the uppermost geologic formation that constitutes the Floridan aquifer in Alachua County, are both lower in elevation than the creeks in the Gainesville urban area and the tributaries to Newnans Lake. Instead, the creeks that cross the Cody Scarp end in swallow holes or swallets that move surface water down recharging the Floridan aquifer. Two large swallets in the area are Haile Sink, the terminus of Hogtown Creek on Hogtown Prairie, and the Primary Sink Feature at Alachua Sink on Paynes Prairie, which receives water from Alachua Lake (on Paynes Prairie), Tumblin Creek, and Sweetwater Branch. Phelps (1987) reported that surface water recharged the Floridan aquifer system from Hogtown Creek at an average rate of 19.2 cubic feet per second (cfs) via Haile Sink and 15.3 to 35.7 cfs through Alachua Sink. Surface water also discharges to the Floridan aquifer system in Orange Lake via a sinkhole complex at the southwest end of the lake in the vicinity of Heagy Burry Park located in Marion County.

1.2.5 Surface Water

Rainfall recharges surface water directly and indirectly within the OCB. Groundwater from the surficial and intermediate aquifers or aquifer systems provides the primary source of baseflow to the streams in the OCB.

The Hogtown Creek Watershed is a closed basin discharging to the Floridan aquifer system via Haile Sink on Hogtown Prairie west of the Cody Scarp. There are many tributaries to Hogtown Creek, the largest being Possum Creek. Hogtown and Possum creeks and their associated tributaries drain most of northwestern Gainesville. The direction of flow is generally south and west, although Possum Creek flows south and east to its confluence with Hogtown. Hogtown Creek flows through a series of wetlands between SW 2nd Avenue in Gainesville and its terminus at Haile Sink. The median flow in Hogtown Creek measured at CR 30, upstream of Hogtown Prairie and Haile Sink, under baseflow conditions from May 1994 through September 2002 was 9.50 cubic feet per second (cfs).

The Paynes Prairie Watershed includes two major streams; Sweetwater Branch and Tumblin Creek. The median flow in Sweetwater Branch at SR 331 from February 1994 through April 2003 under baseflow conditions was 10.74 cfs. This flow is augmented by the permitted discharge of reclaimed water from the GRU Main Street Water Reclamation Facility. The median flow in Tumblin Creek downstream of Bivens Arm Lake (Bivens Arm Outfall) at SR 331 from September 1996 through August 2002 under baseflow conditions was 1.1 cfs. Paynes Prairie also receives water from Prairie Creek via Camps Canal. On the prairie itself there are two major water bodies, Alachua Sink and the associated Primary Sink Feature and Alachua Lake, a large wetland system. The water on Paynes Prairie discharges to the Floridan aquifer system via the Primary Sink Feature at Alachua Sink. The Paynes Prairie system can hold a large volume, after the hurricanes in 2004 the surface water on the prairie covered an area twice the size of Newnans Lake (Jim Weimer, 2006).

Newnans Lake receives water from three primary sources, Hatchet Creek, Little Hatchet Creek and Lake Forest Creek. Hatchet Creek, flowing east and south, contributes the greatest volume of water to Newnans Lake and has several large tributaries including Bee Tree Creek. This tributary converges with Hatchet Creek north of SR 26 above the north end of Newnans Lake. The median flow in Hatchet Creek measured near SR 26 from May 1993 through March 2003 under baseflow conditions was 1.53 cfs. Little Hatchet and Lake Forest creeks enter Newnans Lake from the northwest and west, respectively. All three creeks are intermittently dry during drought periods. Newnans Lake discharges water to Prairie Creek on the southern side of the lake at SR 20. The water from Prairie Creek flows south toward Paynes Prairie and Orange Lake.

The primary surface water input to Lochloosa Lake is from Lochloosa Creek. Lochloosa Creek enters the lake on the north side of the lake. Lochloosa Creek flows south to Lochloosa Lake. The creek receives baseflow from large expanses of pine flatwoods and wetlands in the watershed. Smaller creeks, in the proximity to the City of Hawthorne, also flow south to the north end of Lochloosa Lake. Water exits Lake Lochloosa and enters Orange Lake through Cross Creek.

The Orange Lake Watershed is located in southeastern Alachua and northern Marion counties. The major surface water inputs to Orange Lake are from River Styx on the north side of the lake and Cross Creek, which discharges from Lake Lochloosa. Water exits Orange Lake by groundwater discharge and surface water flow. Groundwater discharge to the Floridan aquifer system occurs via a sinkhole complex at the southwest end of the lake in the vicinity of Heagy Bury Park in Marion County. Surface discharge from the lake takes place through Orange Creek via a broad crested weir east of US Hwy 301 on the southeast side of the lake.

1.3 Physical Habitat and Biology

In-stream habitat and biological assessments were conducted throughout the study area to rate the overall biological health of the streams. The assessments were conducted using Florida Department of Environmental Protection (FDEP) Habitat Assessment and BioRecon procedures (FDEP 2002a, b).

ACEPD, SJRWMD Watershed Action Volunteer (WAV) personnel and volunteers, FDEP, and a University of Florida graduate student (Line et al 2000) conducted 31 Habitat Assessments and BioRecons: 13 in the Hogtown Creek Watershed, 10 in the Paynes Prairie Watershed, seven in the Newnans Lake Watershed, and one in a non-contributory watershed Calf Pond Creek (Figure 1.4 and Appendix A).

1.3.1 Habitat Assessments

The Habitat Assessment measures the quality and quantity of available benthic macroinvertebrate habitat in a 100-meter stream segment (FDEP 2002a). Potential productive habitat for macroinvertebrates includes aquatic vegetation, aerobic leafpacks, woody debris snags, undercut banks, fine root mats, and riffles. The stream segment is given a score in the following categories: substrate (habitat) di-

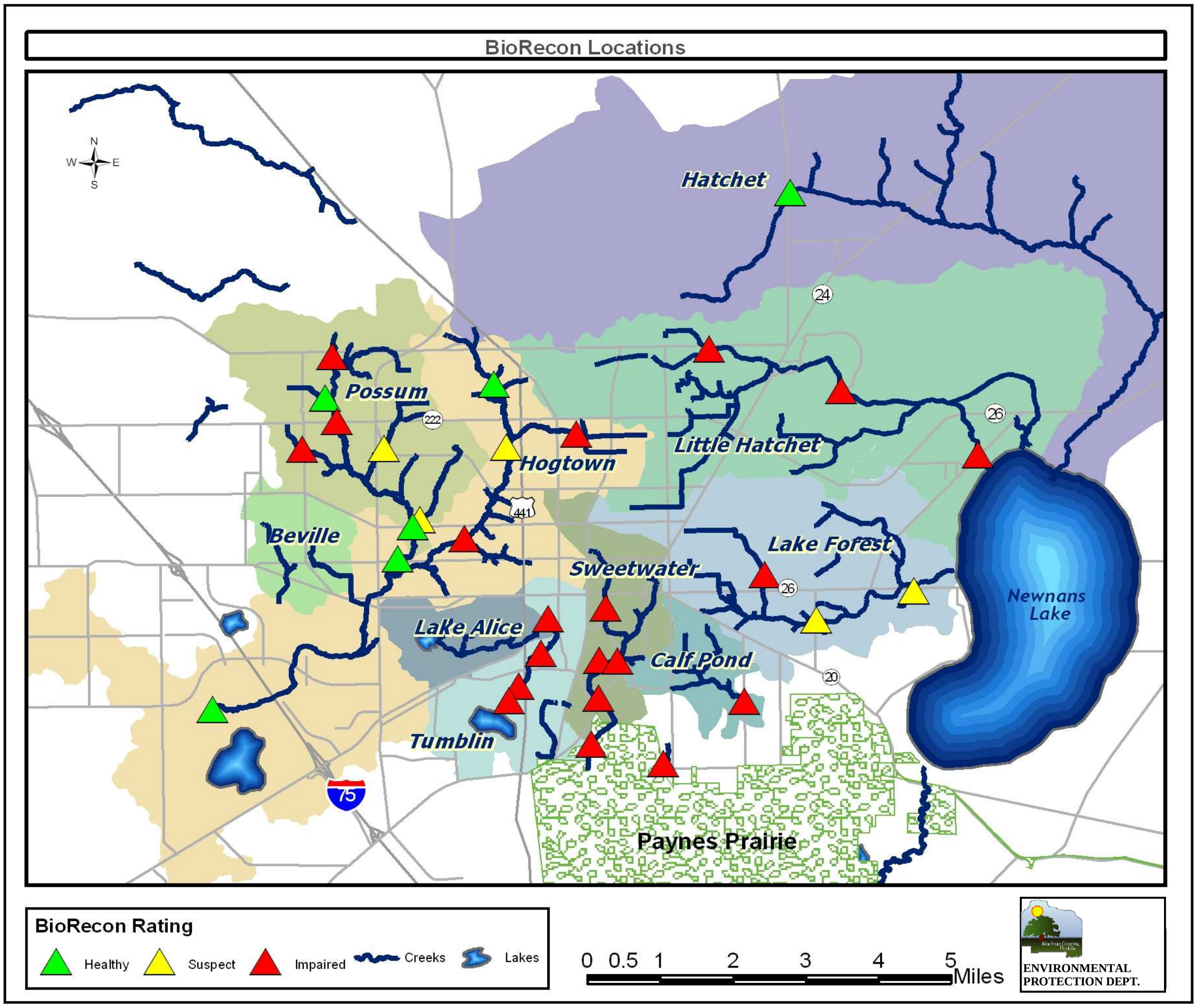

Figure 1.4 BioRecon site locations and results.

versity and availability, water velocity, habitat smothering, artificial channelization, bank stability, riparian buffer zone width, and riparian vegetation quality.

Total Habitat Assessment scores for the streams evaluated ranged from 66 to 141, out of a maximum possible score of 160 (FDEP 2002a, Appendix A). Higher scores indicate sites with ample high quality habitat. In general, the quantity, diversity, and quality of available benthic macroinvertebrate habitat was greatest in the Hogtown Creek and Newnans Lake watersheds (Figure 1.5). Scores for sites in the Paynes Prairie Watershed ranged from 80 at Tumblin Creek at US 441 (TUM441) to 120 at Tumblin Creek in the Bivens Arm floodplain, with a basin average of 96. Scores for the Newnans Lake Watershed ranged from 90 at Lake Forest Creek at Morningside Nature Center (LFCMORN) to 133 at Lake Forest Creek at SE 43rd Street (LFCSE43), with a basin average of 113. Scores for the Hogtown Creek Watershed ranged from 103 at Springstead Creek at NW 2nd Street (SPRNW2) and Possum Creek at NW 16th Avenue (POSNW16) to 141 at Hogtown Creek upstream of Haile Sink (HOGSINK), with a mean score of 117.

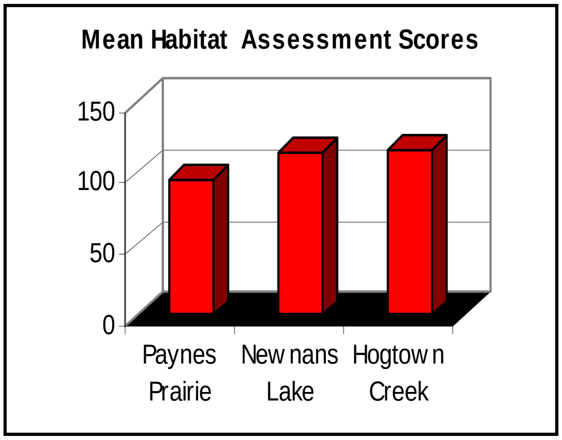

Figure 1.5 Mean Habitat Assessment scores for streams in the three major watersheds in Gainesville.

1.3.2 BioRecons

The BioRecon (FDEP, 2002b) is a screening tool used to assess the health of a surface water body by evaluation of the benthic macroinvertebrate population using three metrics: Taxa Richness, Florida Index, and EPT, an index using three orders of pollution sensitive organisms (Table 1.1). BioRecons assess the health of streams by determining the number of taxa present in a 100 meter stream transect and the number of these organism that are pollution-sensitive. These organisms are susceptible to degradation of water quality, smothering by sediment, and/or habitat quality. Macroinvertebrate organisms respond to these cumulative factors over time, and a characteristic macroinvertebrate community structure emerges. The structure reflects the nature and magnitude that environmental factors and anthropogenic impacts are having on the macroinvertebrate populations which represent the overall health of the stream system.

The Taxa Richness metric is used to measure diversity by tallying the number

Table 1.1 Target metrics for biological impairment (FDEP, 2002b).

Metric	Target Value
Taxa Richness	≥ 18
Florida Index	≥ 10
EPT	≥ 4

If 3 metric target values are met, site is Healthy
If 1 or 2 target values are met, site is Suspect
If no target values are met, site is Impaired

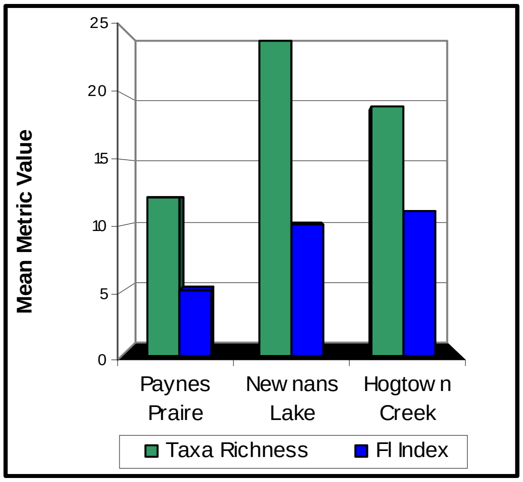

Figure 1.6 Mean Taxa Richness and Florida Index scores for three major watersheds in Gainesville.

of taxa represented in a 100-meter transect of a stream. Taxa Richness ranged overall from 8 to 32, with a metric target value of 18. Creeks within the Hogtown Creek and Newnans Lake watersheds had the highest Taxa Richness or diversity (Figure 1.6). The total number of taxa present for sites in the Paynes Prairie Watershed ranged from eight at the CSX Tributary above its confluence with Sweetwater Branch (SWBSE10) and at Tumblin Creek at SW5th Ave (TUMSW5) to 15 at Boulware Springs Run, with a mean of 12. The total number of taxa present in the Newnans Lake Watershed ranged from 12 at Little Hatchet Creek at NE 53rd Avenue (LHNB53) to 32 at Lake Forest Creek at CR329B (LFC329B), with a mean of 24. Total taxa present in the Hogtown Creek Watershed ranged from 10 at Possum Creek south of NW 39th Avenue (POSNW39) to 25 at Millhopper Creek at NW 39th Way (MILNW39), with a mean of 19.

The Florida Index metric assigns one or two points for the presence of pollution-sensitive taxa (FDEP 2002b). OCB Florida Index scores ranged from 2 to 18, with 10 and above indicating clean water (Evans 1996, FDEP 2002b). As with Taxa Richness, the sites with the highest Florida Index values were located in the Newnans Lake and Hogtown Creek watersheds (Figure 1.6 and Appendix A). Sweetwater Branch at Paynes Prairie (SWBNPP) was the only site, out of the 10 stream sites evaluated in the Paynes Prairie Watershed, that had a Florida Index value indicative of clean water. The mean score for sites in this watershed was five. In the Newnans Lake Watershed only four of the seven sites assessed had a Florida Index value of 10 or greater: LFCSE43, LFC329B, Little Hatchet Creek North Branch (LHTNB), and Hatchet Creek at CR 225 (HAT225). The mean score for the Newnans Lake Watershed was 10. In the Hogtown Creek Watershed, Florida Index values were consistent with the number of total taxa and ranged from five at Possum Creek south of NW39th Avenue (POSNW39) to 17 at Hogtown Creek at NW 45th Avenue (HOGNW45). The mean score for this watershed was 11.

The EPT index is based on the number of Ephemeroptera (Mayflies), Plecoptera

ACEPD Personnel conducting a BioRecon on Hogtown Creek.

(Stoneflies), and Tricoptera (Caddisflies) species present. Individuals in these orders tend to be pollution-sensitive and prefer a clean aquatic environment. EPT scores for the streams assessed in the OCB ranged from 0 to 12. Nine sites did not yield any individuals from the three orders. The mean number of EPT organisms found in the Newnans Lake, Paynes Prairie, and Hogtown Creek watersheds was three, zero, and three, respectively (Appendix A). No stoneflies were found during any of the BioRecons conducted as part of this assessment. The lack of these pollution-sensitive organisms in Alachua County streams, and peninsular Florida in general, is in part due to warm water conditions. Stoneflies typically thrive in the cool to cold waters of highly oxygenated fast flowing streams.

Based on the BioRecons, six of the 31 sites assessed were classified as healthy, seven sites were suspect, and 18 sites were determined to be biologically impaired (Figure 1.5 and Appendix A). The six sites determined to have healthy macroinvertebrate populations included: LHTNB, HAT225, HOGNW45, HOGSINK, POSNW16, and Possum Creek north of NW 8th Avenue (POSNW8). Sites with the most diverse populations of macroinvertebrates, 24 or more taxa, included: MILNW39, HOGNW45, HOGSINK, LFCSE43, LFC329B, LHTNB, and HAT225.

1.4 Pollution Sources

ACEPD personnel performed stream inventories for all the creeks in this study to evaluate in-stream conditions and to identify pollution sources. Inventories included assessment of current and historical land use information, extent and condition of riparian habitat, pollution sources and discharges, and physical attributes.

Landuse in the Paynes Prairie Watershed is predominately commercial and medium to high density residential. Landuse in the Hogtown Creek Watershed is generally less intense and is dominated by residential areas with relatively large lots. Residential and commercial development in the upper reaches of Little Hatchet and Lake Forest creeks has altered the hydrology within the Newnan's Lake Watershed. Hatchet Creek, also in the Newnan's Lake Watershed, is the most rural in character and has low intensity landuses.

Riparian buffers are areas of transition between the stream banks and adjacent upland areas. Although riparian zones comprise only a small proportion of the total landscape, they are diverse biological systems that provide numerous, yet often overlooked, environmental benefits. Ri-

Riparian Buffer on Hogtown Creek north of its confluence with Springstead Creek.

parian zones reduce the amount of sediments and other pollutants entering streams with stormwater runoff, provide a flood plain for storage of floodwaters, and are highly productive and diverse habitats that increase the overall biodiversity of the watershed.

To assess the riparian zones, ACEPD personnel walked along the creeks (wherever possible) and noted characteristics such as the riparian buffer zone width, the extent and quality of the riparian overstory and understory vegetation (e.g. percent cover, native, and exotic), and stream bank height and stability.

The riparian buffer was inadequate in the Paynes Prairie Watershed, due to the urban nature of Sweetwater Branch and Tumblin Creek. The Hogtown Creek Watershed had a more extensive native riparian buffer, often with a dense tree canopy and a high quality understory. The lower reaches of streams with the Newnans Lake Watershed have extensive forested wetlands buffering the creeks from adverse impacts.

ACEPD personnel also noted and evaluated any obvious pollution sources, either permitted or non-permitted, that discharged into the creeks. Two significant sources of non-permitted pollution were documented as part of this assessment. Groundwater containing petroleum constituents was discharging into Hogtown Creek in the vicinity of the Gainesville Mall. This discharge has since been remediated. Contaminated sediments were found in Springstead and Hogtown creeks downstream of the Cabot/Koppers Superfund site (Appendix B and section 9.4.1). The occurance of these sediments are still under investigation. The exposed sediments were less visible after the hurricanes of 2004, possibly due in part to sediment movement and redeposition.

Artificial channelization causes bank instability and erosion (unless the banks are armored) and can create severe downstream flooding and sedimentation problems. Stormwater moving through a straightened channel has higher velocities than a naturally sinuous (or meandering) creek. Increased velocities associated with stormwater can scour bank vegetation and cause downcutting which leads to bank instability. Further downstream in unchannelized areas, velocities decrease and sediments are deposited in the floodplain and in the stream channel. Excessive sediment which smothers habitat and scours stream channels is a pollution source affecting, to some degree, all of the OCB streams.

Creeks receive many natural and anthropogenic contributions, some of which can degrade the water quality (Miller 1993).

Sand deposited upstream of a culvert in the North branch of Little Hatchet Creek near the Airport.

Plant nutrients (mainly nitrogen and phosphorus) are transported in runoff from residential, commercial, and agricultural activities (such as pastures, golf courses, and residential turf and landscaping). Failing septic systems, leaking sanitary sewer lines and/or connections, and atmospheric deposition can also contribute high levels of water-soluble nitrogen and phosphorus compounds. These constituents, upon making their way into the surface waters, can cause excessive growth of algae and undesirable aquatic plants. This plant material eventually dies and decays, which releases nutrients to the water and depletes it of dissolved oxygen. A lack of dissolved oxygen can kill fish and other aquatic life (Manahan 1984; Miller 1993). At the present time there are no state environmental water quality standards for nutrients. There is, however, a state drinking water standard for nitrate (NO_3) of 10 milligrams per liter (mg/L). This standard is not protective of aquatic ecosystems. NO_3 is highly soluble and is readily transported to the groundwater. For those streams that discharge to sinkholes, the nutrient rich water enters our drinking water in the Floridan aquifer.

ACEPD personnel collecting water chemistry samples near Alachua Sink in Paynes Prairie State Preserve.

1.5 Baseflow Water Quality

The water quality in a creek is an indicator of the health of the creek and, to some extent, the entire watershed. The water quality in a stream also affects the receiving waterbody or wetlands. The receiving waterbodies in this study are Newnans Lake, natural wetlands (including Paynes Prairie), and the Floridan aquifer.

The stream water quality monitoring sites are summarized by four watershed categories: (1) the Newnans Lake Watershed, with streams that flow into Newnans Lake, (2) the Paynes Prairie Watershed, with streams that flow onto Paynes Prairie minus the two sites downstream from the GRU Main Street Water Reclamation Facility (WRF), (3) the two sites on Sweetwater Branch in the Paynes Prairie Watershed that are downstream from the GRU Main Street WRF, and (4) the Hogtown Creek Watershed, with both Hogtown Creek and Possum Creek. The two sites downstream from the permitted discharge of reclaimed water (treated wastewater effluent) from the GRU Main Street WRF are separated here because they have distinct differences in water quality characteristics compared to all other sites in this study.

Poor water quality for certain water quality parameters was observed at individual sites throughout the watersheds. Appendix C provides tables with mean, median, standard deviation, maximum, and minimum values for water quality constituents under baseflow conditions. The individual measurements can also be found in

Appendix C. For data that were below the reporting limit, statistical summaries were prepared using instrument response values, in accordance with SJRWMD protocols following ASTM D4210 procedures (ASTM, 1996).

Water quality varies with source materials. Surficial aquifer water contains the lowest mean concentrations of dissolved minerals of all three aquifer systems (ACEPD, 1996). The surficial aquifer receives direct recharge from rainfall and the siliceous sands and clays that comprise the surficial aquifer are not very soluble. This results is a relatively "soft water" with a low specific conductance, typically less than 100 umhos/cm (ACEPD, 1996). The mean pH is also relatively low, 4.5 to 5.8 SU (ACEPD, 1996), due in part to the absence of carbonate rocks and the presence of natural soil organic matter that produces acids as it is dissolved by the rain water directly recharging the surficial aquifer. The mean dissolved oxygen varies widely, but can be relatively high for groundwater, ranging from 0.5 to 4.5 mg/L (ACEPD, 1996). Water temperatures in all of the aquifers systems are uniform; mean values typically range from 21 to 23 ^{o}C (ACEPD, 1996). Water from the surficial aquifer directly recharges streams through springs and seeps and at the contact with the upper clay units of Hawthorn Group formations.

Groundwater entering the creeks from the intermediate aquifer system has moderate concentrations of dissolved minerals. The water is "harder" and mean specific conductance is typically higher, ranging from 20 to 200 umhos/cm, primarily due to the presence of carbonates in the aquifer matrix (ACEPD 1996). These carbonates also increase mean pH, with values ranging from 6.1 to 7.4 SU (ACEPD 1996). Mean dissolved oxygen values were variable, ranging from 2.9 to 6.3 mg/L (ACEPD 1996). Springs and seeps from the intermediate aquifer add dissolved minerals to the surface water systems. One example of an intermediate aquifer spring is Glen Springs, which discharges to Hogtown Creek. The specific conductance was reportedly 143-170 umhos/cm, pH was 7.0-7.2 SU and the temperature was 22.0 ^{o}C (Rosenau et al 1977).

The dissolved minerals in the Floridan aquifer system are present in greater concentrations than the shallower aquifer systems (surficial and intermediate) and the water is "harder." The mean specific conductance is typically higher, ranging from 300 to 400 umhos/cm or higher, except in areas of extremely high recharge where the waters are not in equilibrium with the limestone matrix. Southwest of Archer, in the area of the Brookville Ridge physiographic province where recharge is high, the mean specific conductance was 158 umhos/cm (ACEPD, 1996). As depth increases, the dissolved mineral content in the Floridan aquifer system increases, specific conductance and hardness increase with the occurrence of gypsum (calcium sulfate) in the rock matrix. The presence of these carbonates (limestone and dolostone) also increase mean pH, with values ranging from 7.1 to 7.9 SU (ACEPD, 1996). Dissolved oxygen is variable, with mean values ranging from not detectable, <0.3 mg/L, where the Floridan is confined to 7.5 mg/L where the Floridan is unconfined and aquifer recharge is high. The Floridan aquifer system does not discharge to any streams in the Gainesville urban area.

1.5.1 Field Parameters

Field parameters that were monitored include: specific conductance, dissolved oxygen (DO), pH, turbidity, and temperature (Appendix C). Average median values for these parameters are summarized for each watershed in Table 1.2 and Figure 1.7.

Specific conductance is a measure of the electrical conductivity of water, which is caused by the concentration of major inorganic ions in solution (Eaton et. al. 1995). Median specific conductance values ranged from 99 microSiemens per centimeter (µS/cm) at Hatchet Creek at SR 26 (HAT26) to 877 µS/cm at Sweetwater Branch at Williston Road (SWB331), which is downstream of the GRU Main Street WRF. Average median values for specific conductance in the four watershed categories are shown in Figure 1.7. The average median specific conductance in the Newnans Lake Watershed was 157 µS/cm, far lower than those in the other watersheds. Specific conductance values in the Hogtown Creek Watershed were the next lowest, with a mean of 256 µS/cm.

Table 1.2 Average median values for field parameters by watershed category.

Watershed Category	DO (mg/L)	pH (SU)	Turb (NTU)	Water Temp (˚C)
Newnans Lake	5.57	6.62	2.1	20.0
Paynes Prairie	7.13	7.50	4.3	21.9
Sweetwater Branch	8.97	7.49	3.4	22.9
Hogtown Creek	8.14	7.48	2.0	20.6

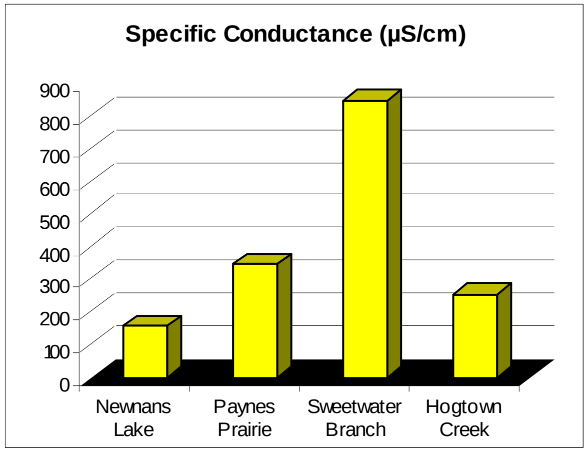

Figure 1.7 Average median values for specific conductance measurements by watershed category, during baseflow periods.

The average median specific conductance of all sites located in the Paynes Prairie Watershed, except for the two sites downstream of the GRU Main Street WRF, was 347 µS/cm. The other two sites in the Paynes Prairie Watershed, SWB331 and Alachua Channel on Paynes Prairie (ALACHCHAN), had median specific conductance values of 877 and 817 µS/cm, respectively. High conductivities at these two sites may be in part caused by the high concentration of dissolved inorganic ions in the WRF influent and effluent and/or the dechlorination process at the GRU Main Street WRF.

Dissolved oxygen (DO) is a critical parameter affecting the populations of fish, macroinvertebrates, and other biota in aquatic systems. DO levels in this study were quite variable, with median values ranging from 2.1 mg/L in Tumblin Creek at Williston Road (TUM331) to 10.9 mg/L in Bivens Arm Lake. Median DO levels were generally above 7.0 mg/L for most streams. Exceptions to this were those streams that drain or flow through wetland areas, including Hatchet and Little Hatchet creeks (3.5 to 5.5 mg/L), Hogtown Creek at SR30 (6.0 mg/L, HOG30), and TUM331 (2.1 mg/L). Low DO levels at Tumblin Creek at SW 5th Avenue (5.7 mg/L; TUMSW5) and Sweetwater Branch at NE 10th Avenue (5.5 mg/L; SWBNE10) are likely a result of groundwater discharging to the streams. In general, these relatively low DO values are representative of groundwater, slow moving surface water, or water moving through wetlands where metabolic processes and oxygen consumption are high.

pH is the measure of the acidity or alkalinity of a liquid, with a pH of 7.0 standard units (SU) being neutral. Lower numbers indicate increasing acidity while higher numbers indicate increasing alkalinity. Extreme pH values in waterbodies, both high and low, can limit the types of aquatic fauna inhabiting a system. Median pH values were generally above 7.0 SU, with only a few exceptions. The sample sites in the Newnans Lake Watershed that flow through wetland areas (HAT26, LFC329B, LHAT26, and LHAT26E) had median pH values ranging from 6.1 to 6.9 SU. The median pH at SWBNE10 was 6.6 SU, while it was 6.9 SU at TUM331. Bivens Arm Lake, with a median pH of 8.9 SU, was the only site with a median pH above 7.8 SU. This high pH reflects the high primary productivity of algae and aquatic macrophytes, which increases the pH of the lake water.

Turbidity is the amount of particles that are suspended in a water sample. The particles are generally lightweight and small in size or have a large surface area in relation to their size to allow them to remain suspended in the water column. In general terms, the higher the turbidity the lower the water clarity or transparency. The suspended material may be inorganic, such as clays, or organic, such as algal cells. Turbidity is a measurement of water clarity in which an instrument called a turbidimeter or nephelometer passes light through a representative sample of water. The more turbid the water the less light passes through the water sample and the higher the reported turbidity. Turbidity may be measured with field or laboratory instruments and the results are reported in nephelometic turbidity units or NTU. High turbidities can be caused by the input of sediment from the watershed or by high algal productivity. The median baseflow turbidity for most sites monitored in this study was less than 4.0 NTU except for Bivens Arm and ALACHCHAN. The median turbidity values at these sites, 20.0 and 5.9 NTU respectively, reflect high concentrations of algal cells in the water.

Water temperature is also an important parameter. Excessive water temperatures will limit the number and type of aquatic organisms that can inhabit a system. Cooler water allows more oxygen to be dissolved and supports more pollution sensitive taxa. Median water temperatures for stream sites in this study ranged from 19.0°C to 23.8°C.

1.5.2 Nutrients

Nutrient analyses, for nitrogen and phosphorus species, were conducted on filtered and unfiltered samples (Appendix C). For unfiltered samples the results are reported with a "T" for total after the constituent (i.e. NO_x-T for total nitrate plus nitrite). Samples that were field filtered with a

0.45µm filter prior to analyses are reported with a "D" for dissolved (i.e. NO_x-D for nitrate plus nitrite as a dissolved constituent). In the Paynes Prairie and Newnans Lake watersheds, nutrient samples were obtained for both total and dissolved constituents. In the Hogtown Creek Watershed, sampling and analyses for nutrients was more limited. In general, this report presents and discusses data as "totals" from unfiltered samples except for Hogtown and Possum creeks, where nitrate plus nitrite (NO_x), orthophosphate (PO_4), and total ammonia (NH_4) were only sampled and analyzed as dissolved constituents.

1.5.2.1 Nitrogen

Nitrogen (N) is an important nutrient for growth of plants and algae and comes from a variety of natural and anthropogenic sources. In order to evaluate nitrogen impacts to the waterbodies, a number of forms of nitrogen were tested. Nitrogen in surface waters can be found in several forms, including nitrate (NO_3), nitrite (NO_2), total ammonia (NH_4), and organic nitrogen compounds. Nitrate and nitrite are typically analyzed together as NO_x. The analyses of organic nitrogen compounds and total ammonia added together are referred to as Total Kjeldahl Nitrogen (TKN). TKN plus NO_x provides a measure of total nitrogen (TN). In highly oxygenated surface water and groundwater, NO_3 is the dominant form present. Average median values for nitrogen species in each watershed are summarized in Table 1.3.

Ammonia in aquatic systems is typically found in its unionized form as NH_3 (free ammonia) and in an ionized form as NH_4 (ammonium). Except at high pH levels and temperatures, most of the ammonia is in the ionized NH_4 form. While both forms can be toxic to fish at high concentrations, unionized (or NH_3) is more toxic. Ammonia measurements reported in this document reflect total (NH_3 plus NH_4) ammonia in water and is referred to herein as total ammonia (NH_4-T).

Table 1.3 Average median values (mg/L) for baseflow nitrogen species by watershed category. (NM = Not Measured)

Watershed Category	NOx-T	TKN-T	TN-T	NH_4-T
Newnans Lake	0.041	0.845	1.066	0.029
Paynes Prairie	0.142	0.787	1.016	0.115
Sweetwater Branch	2.399	1.217	3.990	0.058
Hogtown Creek	NOx-D 0.334	0.455	NM	NH_4-D 0.021

Total ammonia was generally low (median concentrations less than 0.040 mg/L) at most sites monitored in this study (Figure 1.8). However, several sites

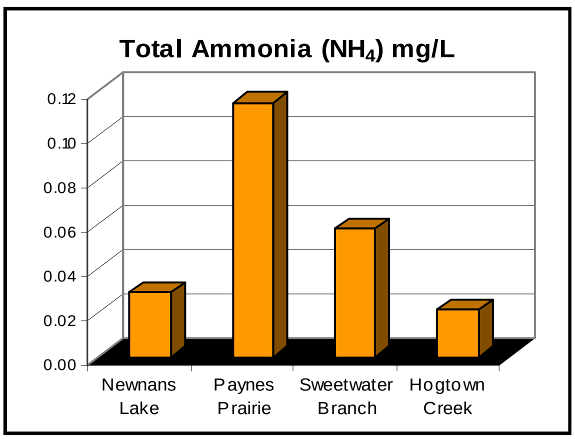

Figure 1.8 Average median values for total ammonia (NH_4) concentrations by watershed category, during baseflow periods.

had significantly higher median total ammonia (NH_4-T) concentrations: 0.460 mg/L on Sweetwater Branch at NE 10th Ave, 0.076 mg/L on Paynes Prairie (ALACHCHAN), and 0.178 mg/L on Tumblin Creek at Williston Road (TUM331). These median concentrations are well below the EPA chronic criteria for total ammonia, which at a pH of 7.0 SU and a water temperature of 30°C is 2.18 mg/L (EPA 1999). These criteria are established by the EPA to protect aquatic life, primarily young fish, from ammonia toxicity.

While total ammonia (NH_4-T) concentrations observed in this study were well below these criteria, total ammonia measurements on Tumblin Creek at Williston Road (TUM331) were above 1.0 mg/L about 13 percent of the time. This is the only site that had notable total ammonia measurements above 1.0 mg/L. Since these high concentrations were observed at summer water temperatures (which favor NH_3), there is little margin of safety for protecting aquatic life against ammonia toxicity at this site.

Total nitrate plus nitrite (NO_x-T) concentrations in the Newnans Lake Watershed streams were very low, with an average median value of 0.041 mg/L (Figure 1.9). NO_x-T concentrations at Paynes Prairie Watershed sites were higher but still relatively low, with an average median value of 0.142 mg/L. NO_x-T concentrations at the two Sweetwater Branch sites downstream from the GRU Main Street WRF were significantly higher, with an average median concentration of 2.399 mg/L. These higher NO_x-T concentrations are caused by the discharge of reclaimed water (treated wastewater effluent) from the WRF.

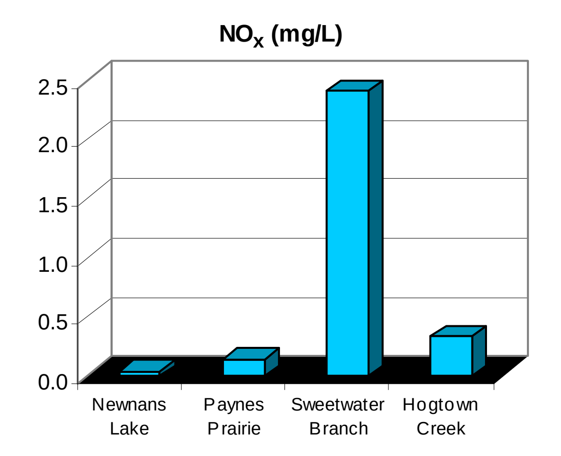

Figure 1.9 Average median values for nitrate plus nitrite (NO_x) concentrations by watershed category, during baseflow periods.

NO_x-D concentrations in the Hogtown Creek Watershed streams were also considerably higher than other streams monitored in this study, with an average median concentration of 0.334 mg/L. NO_x-D concentrations in Possum Creek (median concentration of 0.586 mg/L) were higher than those in Hogtown Creek. The high NO_x-D concentrations in Hogtown and Possum creeks are likely caused by lawn fertilizer application in the residential areas common throughout the watershed, effluent from septic tank drain fields in proximity to the creeks, and/or other anthropogenic sources.

The highest TKN-T concentrations were found in streams flowing through wetland areas, with median TKN-T concentrations of 1.120 mg/L. The median TKN concentration for streams in non-wetland areas was 0.364 mg/L. The higher TKN-T concentrations for streams in wetland areas are due to the metabolic processing of organic matter in wetlands, which results in organic nitrogen compounds that are the primary component of TKN. Bivens Arm had very high TKN-T concentrations (median of 2.160 mg/L), reflecting the significant algae populations in the lake. Algal cells contain and upon death release organic nitrogen compounds.

1.5.2.2 Phosphorus

Phosphorus (P) is an important nutrient for growth of plants and algae and comes from a variety of natural and anthropogenic sources. In order to evaluate phosphorus impacts to the waterbodies, two types of phosphorus, total phosphorus (TP) and orthophosphate (PO_4 or when field filtered also termed "soluble reactive phosphorus" or SRP) were measured. Naturally occurring minerals present in the Hawthorn Group formations in Alachua County contain water in the intermediate aquifer with elevated total phosphorus concentrations (ACDES, 1987). When streams erode these phosphatic materials through down cutting, the sediments release phosphate rich water to the creeks in the form of springs and seeps. The abrasion of the exposed phosphatic materials themselves along the creek banks and streambed also leads to mobilization of particulate inorganic phosphorus. Excess phosphorus in the environment also comes from fertilizer runoff from agricultural and residential applications, stormwater, livestock operations, animal waste, reclaimed water from domestic wastewater treatment plants, yard waste, failing septic tank systems, and domestic sewage releases from public and private wastewater infrastructure. In Alachua County phosphorus is frequently not the limiting nutrient in surface waters. Florida does not have numeric criteria for nutrients in Class III Recreation Waters, such as those evaluated in this report. However, phosphorus in excess of 0.1 mg/L or less has been found to increase excessive growth of aquatic plants and algae.

Hawthorn Group outcrop in Possum Creek north of NW 8th Avenue.

Phosphorus is present in natural waters as phosphate in the form of orthophosphate (condensed or polyphosphates) or as organically bound phosphates (Eaton et al. 1995). Orthophosphate can be utilized directly by plants and can lead to excessive algae and macrophyte growth in streams and lakes when present in sufficient quantities. Total phosphorus concentrations, which consists of all forms of phosphorus including that bound inside algal cells (organically bound phosphates), can be quite high in aquatic systems where flow and light conditions allow for algae growth.

Baseflow concentrations of orthophosphate (PO_4) varied widely across the streams in this study (Table 1.4 and Figure 1.10). The highest concentrations were observed at the two sites on Sweetwater Branch downstream from the GRU Main Street WRF, where the median dis-

Table 1.4 Average median values (mg/L) for baseflow phosphorus species by watershed category. (NM = Not Measured)

Watershed Category	TP-T	TP-D	PO_4-T	PO_4-D
Newnans Lake	0.217	0.182	0.146	0.141
Paynes Prairie	0.139	0.084	0.086	0.066
Sweetwater Branch	1.003	0.904	0.824	0.815
Hogtown Creek	0.695	NM	NM	0.579

solved orthophosphate (PO_4-D) concentration was 0.824 mg/L. Similarly, high dissolved orthophosphate (PO_4-D) concentrations (median of 0.746 mg/L) were observed in Possum Creek in the Hogtown Creek Watershed. Median dissolved orthophosphate (PO_4-D) concentrations in Hogtown Creek were less than those in Possum Creek (median of 0.511 mg/L), but still about four times higher than those in the Newnans Lake and Paynes Prairie watersheds (Figure 1.10). Orthophos-

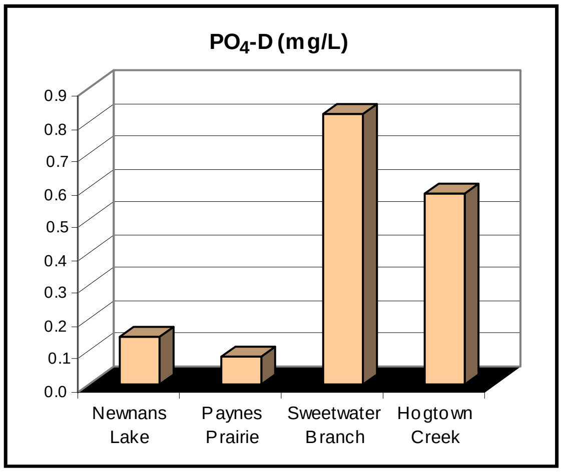

Figure 1.10 Average median values for dissolved orthophosphate (PO_4-D) concentrations by watershed category, during baseflow periods.

phates are the primary form of phosphorus in fertilizers and can be transported to streams by storm flows (Eaton et al 1995). Total phosphorus concentrations followed similar patterns as orthophosphate. The high total phosphorus and orthophosphate concentrations in Sweetwater Branch are largely due to the reclaimed water (treated wastewater effluent) discharged from the GRU Main Street WRF. The high phosphorus concentrations in Possum Creek and Hogtown Creek are likely due to residential lawn fertilizer applications and to the presence of naturally occurring phosphatic minerals from Hawthorn Group formations.

1.5.3 General Chemical Constituents

General chemical constituents, or indicator parameters, include total suspended solids (TSS), chloride (Cl), sulfate (SO_4), total organic carbon (TOC), dissolved organic carbon (DOC), total dissolved solids (TDS) and alkalinity (ALK). Summary data are presented in Appendix C. Average median values for selected constituents in each watershed are summarized in Table 1.5.

1.5.3.1 Total Suspended Solids

Total suspended solids (TSS) is a measure of the mass of particles suspended in water (Eaton et al. 1995). The particles are generally lightweight and small in size or have a large surface area in relation to their size to allow them to remain suspended in the water column. In general terms, the higher the TSS the lower the water clarity or transparency. These particles can have a mineral origin (clays and silts) or can be organic (detritus and algal cells.). Total suspended solids are measured by filtering a water sample in the laboratory and

Table 1.5 Average median values (mg/L) for baseflow total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) by watershed category.

Watershed Category	TSS	Cl	SO_4
Newnans Lake	4.60	11.63	8.68
Paynes Prairie	7.29	16.92	27.31
Sweetwater Branch	8.00	137.66	98.86
Hogtown Creek	4.71	17.78	11.79

weighing the dried material; the results are reported in mg/L. Suspended particles in high concentrations can adversely affect aquatic life and, once the particles settle out of suspension, can smother in-stream habitats. Median baseflow total suspended solids concentrations in Gainesville streams were all below 10 mg/L. However, the median total suspended solids concentrations in Bivens Arm was 21.0 mg/L, reflecting the high algal populations in the lake.

1.5.3.2 Chloride and Sulfate

Chlorides (Cl^-) and sulfates (SO_4^{-2}) are two of the major inorganic ions found in water and wastewater (Eaton et al. 1995). Chloride and sulfate can be naturally occurring or the result of permitted or illicit discharges from anthropogenic sources.

Chlorides are salts resulting from the combination of chlorine gas with a metal. Some common chlorides include sodium chloride (NaCl) and magnesium chloride ($MgCl_2$). Chlorine alone as Cl_2 is highly toxic and is often used as a disinfectant in water and wastewater treatment. When naturally occurring, chlorides are often the result of water passing through rock or soil containing chloride minerals, such as salts like sodium chloride. Chlorides may get into surface water from several sources including: rocks containing chlorides, agricultural runoff, discharge from water reclamation facilities, and road salting. While road salting is not a problem in Florida, it is a significant concern in much of United States. Freshwater fish and aquatic communities cannot survive in high levels of chlorides.

Chloride is typically found in low concentrations in fresh waters. Median baseflow concentrations in Gainesville creeks typically range from 10 to 20 mg/L (Appendix C). The two sites on Sweetwater Branch that are downstream from the GRU Main Street WRF, however, had median chloride concentrations of 130.0 and 145.3 mg/L. These elevated chloride concentrations are caused by chlorides present in the reclaimed water (treated wastewater effluent) from the GRU Main Street WRF.

Naturally occurring sulfides and sulfates are often the result of the breakdown of leaves that fall into a stream, water passing through rock or soil containing gypsum and other common sulfur containing minerals, or atmospheric deposition. Sulfur may occur in many forms, such as the familiar “rotten egg” odor that is hydrogen sulfide (a gas) or sulfate, the oxygenated mineral form (salt) of sulfur. Point sources include discharges from water reclamation facilities and other industries. Runoff from fertilized agricultural lands or residences may also contribute sulfates to water bodies.

Sulfate concentrations are also relatively low in Gainesville creeks, with median concentrations typically in the 5 to 15 mg/L range. Although several sites in the Paynes Prairie Watershed had concentrations in the 20 to 60 mg/L range. The two sites on Sweetwater Branch that are downstream from the GRU Main Street WRF had median sulfate concentrations of 94.0 and 103.7 mg/L. The elevated sulfate concentrations at the latter two sites are caused by elevated sulfate concentrations in the wastewater influent and/or the addition of sulfur dioxide as part of the dechlorination process at the GRU Main Street WRF. The elevated sulfate concentrations at other sites on Sweetwater Branch and on Tumblin Creek may be related to pollutant discharges or permitted discharges of water from the deeper portion of the Floridan aquifer, which is naturally higher in sulfate.

1.5.3.3 Organic Carbon

There are a number of methods used to estimate the amount of organic matter in natural waters. Direct measurement of organic carbon (total and/or dissolved) and indirect measurements such as biochemical oxygen demand (BOD) are used to characterize organic carbon concentrations from natural or anthropogenic sources. Total organic carbon (TOC) analysis is a method to determine the amount of organic material in a water sample. A carbon analyzer using an infrared detection system is used to measure total organic carbon. In the process, organic carbon is oxidized to carbon dioxide. Dissolved organic carbon (DOC) is also measured this way, however samples are field filtered prior to analysis. Organic carbon in surface waters may be naturally occurring due to the presence of natural organic matter that produces acids as it is dissolved by rainwater. Frequently, streams have “dark water” from naturally occurring tannins and lignans in organic matter such as leaves. This is the case in many of the Newnans Lake tributaries.

Baseflow TOC in Gainesville streams is variable. In the Newnans Lake Watershed the median baseflow TOC has an average median value of 24.54 mg/L, the highest of all the watersheds. In the Paynes Prairie Watershed the average median TOC concentration was 7.13 mg/L. In the Hogtown Creek Watershed the average median baseflow TOC concentration was 7.86 mg/L.

1.5.3.4 Total Dissolved Solids

Total dissolved solids or TDS is a measure of the total amount of materials, primarily minerals, dissolved in water. The materials that make up the dissolved solids are both natural and anthropogenic and can be inorganic or organic. Seawater has a relatively high TDS content, ~35,000 mg/L. Total dissolved solids are measured in the laboratory and reported in mg/L. The Florida drinking water standard for TDS is 500 mg/L and is based on aesthetics. The primary dissolved inorganic ions that contribute to TDS in Alachua County occur due to the dissolution of carbonate rocks. Anthropogenic contributions to TDS can come from permitted discharges of treated domestic wastewater, cooling water, or illicit discharges.

Baseflow TDS in Gainesville streams is quite variable. In the Newnans Lake Watershed the median baseflow TDS has an average median value of 130 mg/L. These waters have a relatively low alkalinity and specific conductance and relatively high levels of dissolved organic matter, which are likely reflected in the TDS of these waters. In the Paynes Prairie Watershed the average median TDS is 281 mg/L. In this watershed two stations downstream of the GRU Main Street WRF show the highest median TDS levels, 471 and 506 mg/L, of any streams evaluated as part of this study. Inorganic ions present in the domestic wastewater stream are not removed in the waste treatment process. In the Hogtown Creek Watershed the average median baseflow TDS concentration was 164.64 mg/L.

<u>1.5.3.5 Alkalinity</u>

Alkalinity is a measure of the substances in water that can resist a change in pH when an acid is added to the water. Alkalinity is usually expressed in mg/L of calcium carbonate ($CaCO_3$) because of its neutralizing ability. Water with a low alkalinity has a low buffering capacity and is susceptible to acidic contaminants, such as acid rain. Natural waters with high alkalinity or buffering capacity can neutralize acidity and tend to resist rapid changes in pH. High alkalinity protects aquatic life from rapid changes in pH. High alkalinity is often associated with hard water and high dissolved solids and poor aesthetics, but alkalinity itself does not negatively impact water quality.

The limestones and dolomites in the Hawthorn Group formations and in the Floridan aquifer can contribute significant buffering capacity or alkalinity (in terms of $CaCO_3$) to natural waters in Alachua County. In the upper reaches of the watersheds, particularly in the tributaries to Newnans Lake the surficial aquifer water contains the very low concentrations of dissolved minerals, receiving direct recharge from rainfall and the aquifer being comprised of siliceous sands and clays that are not very soluble. This results in a relatively "soft water" with a low specific conductance or amount of dissolved minerals, a low pH and a relatively low alkalinity. The lower alkalinity waters are usually higher up in the watershed, frequently associated with wetlands, before the water contacts buffering carbonate materials of the Hawthorn.

The average median baseflow alkalinity in baseflow samples from the Newnans Lake Watershed is 47.02 mg/L. This can be compared to the average median alkalinity of 111.35 mg/L of streams in the Paynes Prairie Watershed and 83.93 mg/L for streams in the Hogtown Creek Watershed.

1.5.4 Fecal Coliform Bacteria

Fecal coliform bacteria are a group of bacteria present in the gut and feces of warm-blooded animals (Eaton et al. 1995). The presence of these organisms indicates that there may be other disease causing pathogens also present. The sources of fecal coliforms in our surface waters are both natural and anthropogenic. Natural sources include warm-blooded animals. Where animals such as raccoons, possums, and rodents congregate along the streams, their feces may be a major source of fecal coliform pollution. The anthropogenic sources in the area include leaking central sewer lines and lateral connections to homes and businesses, failing septic tank systems, untreated or inadequately treated stormwater, livestock operations, pet waste, and the homeless. Once in a stream, the

Sanitary sewer line above Lake Forest Creek at SR26.

warm Florida climate may allow these bacteria to persist or increase in number.

Elevated coliform bacteria levels occur in both the rural and urban areas of the county, though the sources may be quite different. In the Orange Creek Basin, three streams in urban Gainesville (Hogtown Creek, Tumblin Creek, and Sweetwater Branch) are designated by the Florida Department of Environmental Protection (FDEP) as Impaired Waters due to elevated levels of fecal coliform bacteria. The Santa Fe River, designated an Outstanding Florida Water, has one tributary in Alachua County that has been determined by FDEP to be impaired for fecal coliform bacteria. Coliform bacteria analyses were conducted using most probable number (MPN) methodologies (Appendix C).

Surface water quality standards for Class III Recreational Waters state that fecal coliform counts shall not exceed a monthly average of 200 colony forming units (cfu)/100 mL, nor exceed 400 cfu/100 mL in 10% of the samples, nor exceed 800 cfu/100 mL on any one day. Monthly averages shall be expressed as geometric means based on a minimum of 10 samples taken over a 30 day period. (Chapter 62-302, F.A.C., FDEP 2002). Levels of fecal coliform bacteria were highest in the Paynes Prairie and Hogtown Creek watersheds, specifically in Tumblin Creek, Sweetwater Branch, and Hogtown Creek (Figure 1.11 and Appendix C). Fecal coliform bacteria levels were typically highest during or within a few days after rainfall events. One notable exception to this was raw sewage releases into a stream, which dramatically elevated baseflow levels of fecal coliform bacteria.

Samples were collected and analyzed for fecal coliform bacteria from March 2001 through December 2002 (Appendix C). Average concentrations of median fecal coliform bacteria levels in Tumblin Creek (excluding TUM331) were 1,200 CFU/100mL. Average median concentrations of fecal coliform bacteria in Sweetwater Branch were 3,300 CFU/100mL. Fecal coliform bacteria for Hogtown Creek

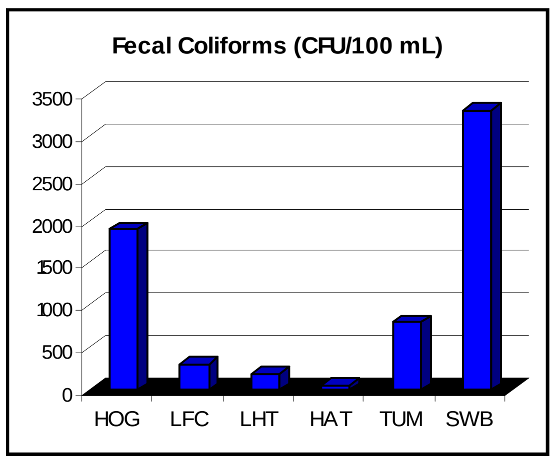

Figure 1.11 Average median values for fecal coliform concentrations in streams, from March 2001 through December 2002.

Fecal coliform bacteria sampling in Sweetwater Branch.

averaged 1,900 CFU/100mL (from March 2001 through December 2002). For this same time period, the average median concentration of fecal coliform bacteria was 50 CFU/100mL for Hatchet Creek, 300 CFU/100mL for Lake Forest Creek, and 200 CFU/100mL for Little Hatchet Creek.

ACEPD contracted with the University of South Florida Biology Department to conduct fecal coliform antibiotic resistance analysis and with Biological Consulting Services, Inc. to conduct ribotyping. Both of these studies were an attempt to determine the sources of the elevated fecal coliform bacteria in Tumblin Creek and Sweetwater Branch. The results of these studies were inconclusive as to the source of fecal coliform bacteria (Harwood 2003a and b). Additional work in this area is being conducted.

1.6 Stormwater

Water quality changes when a storm flushes large volumes of water which may carry many different pollutants into a creek. Initially, the "first flush" may have the highest concentrations of pollutants. As the rainfall event continues, the diluting effect of the rain may reduce pollutant concentrations. A hard rain after a long dry spell can wash large amounts of accumulated fertilizers and animal waste off lawns and fields and into surface water bodies.

The quantity of storm runoff flowing into a creek can be detrimental as well. Urban areas with high relief and extensive impervious surfaces can experience large volumes of stormwater runoff, which is discharged into creeks in a relatively short period of time. These storm surges rush through creeks scouring the stream bed and banks which can severely erode and destabilize stream banks. Stormflow can carry sand and debris to downstream areas, where the deposition and scouring can degrade the quality of the in-stream habitat for aquatic life.

In rural watersheds, where impervious surfaces are rare and natural riparian buffers are common, only a portion of the total rainwater runs off of surfaces directly into a stream. Gradual infiltration of rainwater occurs in the natural soils of these basins and locally recharges the

Stormflow in Little Hatchet Creek.

Erosion and bank failure on Tumblin Creek at P.K. Yonge School.

surficial aquifer. Some of the runoff that does occur is stored in natural ponds and wetlands. These infiltration and storage processes attenuate the velocity and volume of storm runoff entering a stream, thereby reducing water quality and erosion impacts.

In Gainesville, as in many cities, natural water storage areas are no longer available. Stormwater flows off of impervious surfaces directly into the creeks. Beginning in the early 1990s, stormwater treatment became mandatory for new development in order to reduce direct runoff into surface water bodies and improve water quality.

1.6.1 Stream Flows During Storms

Water depth, velocity, and stream flow volume increased during and following rainfall events monitored as part of this study. The time response to rainfall was specific to each creek. Tumblin Creek and Sweetwater Branch responded rapidly to rainfall due to their small size, large amounts of impervious area in the watersheds, lack of stormwater retention, and relatively high topographic relief. Hogtown and Possum creeks responded somewhat slower due to the increased basin size, a lower percentage of impervious area in the basin, and the presence of natural riparian buffers in many areas. The creeks in the Newnans Lake Watershed were the slowest to respond to rainfall due to the less developed nature of the watersheds, lower relief, and the presence of intact wetlands. Little Hatchet and Hatchet creeks reached their greatest depth and highest stream flow approximately 24 to 48 hours after the rainfall event began. After extended dry periods, 1 to 2 inches of rain was needed to result in observable increases of flow in Little Hatchet and Hatchet creeks.

A long duration high intensity storm event on Sweetwater Branch increased water depth by 2.3 feet at the site south of Williston Road at Paynes Prairie. Stream flow increased from a typical baseflow of 10.7 cubic feet per second (cfs) to 124.0 cfs. The increased water depth, volume, and velocity caused bank erosion, streambed scouring, sediment transport, and downstream sediment deposition.

1.6.2 Stormflow Water Quality

The highest concentrations of water quality constituents in a stream are typically observed during the early water level rises of a storm event (the “first flush”), with constituent concentrations normally decreasing as the stormflow wanes. The storm events monitored varied considerably: some were short duration high intensity while others were long duration low intensity. Stormflow water quality, therefore, had much greater variability than baseflow water quality. Appendix D provides a summary of storm event sampling. Appendix E provides statistical summaries of storm event water quality data.

1.6.3 Field Parameters

Field water quality parameters measured during storm events included specific conductance, dissolved oxygen (DO), pH, turbidity, and temperature. Generally, specific conductance was highest during the first flush and decreased over time during the storm events (Appendix E). Due to dilution from rainfall, the median specific conductance in most streams was lower in stormflow than in baseflow (Figure 1.12). However, specific conductance in the Newnans Lake Watershed streams had variable responses: some streams increased and others decreased in specific conductance. The elevated specific conductance in Lake Forest Creek during one storm event was above baseflow concentrations for the entire watershed.

Dissolved oxygen concentrations were generally lower in stormflow than baseflow, with the lowest values observed in the Newnans Lake Watershed streams. These lower DO concentrations may be related to a higher biological oxygen demand during stormflow, but may also reflect the time of year when storm events were monitored. pH values were generally similar during stormflows and baseflows.

Turbidity was generally 3 to 9 times higher during stormflows than baseflows, which reflects the sediment suspension and transport occurring as a result of the high velocity stormflows (Figure 1.13). A single turbidity measurement during a storm event on Possum Creek resulted in the very high turbidity value depicted in Figure 1.13 for the Hogtown Creek Watershed. Turbidity measurements during

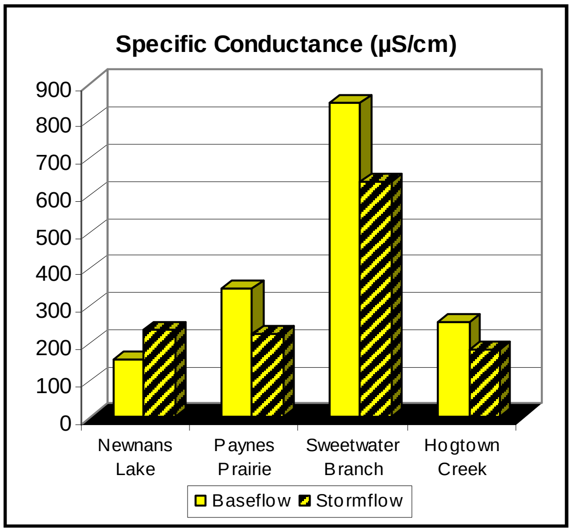

Figure 1.12 Average median values for specific conductance by watershed category, during baseflow and stormflow periods.

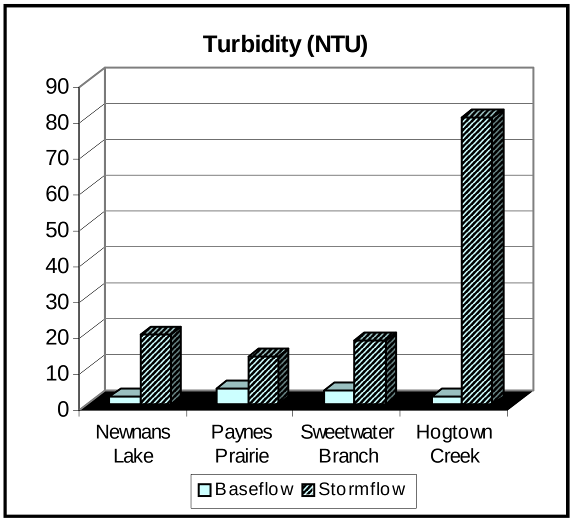

Figure 1.13 Average median values for turbidity by watershed category, during baseflow and stormflow periods.

storm events at other sites in the Hogtown Creek Watershed were similar to measurements from streams in the other watersheds.

1. 6.4 Nutrients

1.6.4.1 Nitrogen

Median total ammonia (NH_4-T) concentrations were higher for most streams during stormflow than during baseflow (Figure 1.14 and Appendix E). Concentrations more than doubled for streams in the Newnans Lake and Hogtown Creek watersheds. Median concentrations were somewhat higher during stormflows in Sweetwater Branch downstream from the GRU Main Street WRF. Median total ammonia concentrations were lower for sites in the Paynes Prairie Watershed during stormflow. This reduction is largely due to dilutions by surface runoff at the NE 10th Avenue site on Sweetwater Branch. The median baseflow total ammonia concentration at SWBNE10 is 0.46 mg/L, which is much higher than the median stormflow concentration of 0.03 mg/L further downstream at NE 6th Street.

Nitrate plus nitrite (NO_x-T) more than doubled during stormflow for streams in the Newnans Lake Watershed, while it was similar or decreased in the other watersheds (Figure 1.15). However, the stormflow NO_x values slightly lower than the baseflow values in the other watersheds. NO_x-T remained significantly higher at the two sites on Sweetwater Branch that are downstream from the GRU Main Street WRF than at all other sites in this study. NO_x-D was lower during stormflow for the streams in the Hogtown Creek Watershed, reflecting a dilution of the high baseflow NO_x-D concentrations by surface runoff.

1.6.4.2 Phosphorus

Median orthophosphate (PO_4-T) concentrations did not change dramatically during stormflow, as compared to baseflow conditions (Figure 1.16 and Appendix E). While

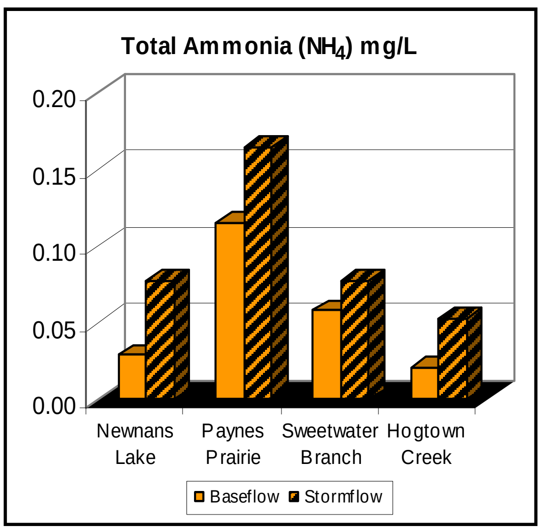

Figure 1.14 Average median values for total ammonia (NH_4) concentrations by watershed category, during baseflow and stormflow periods.

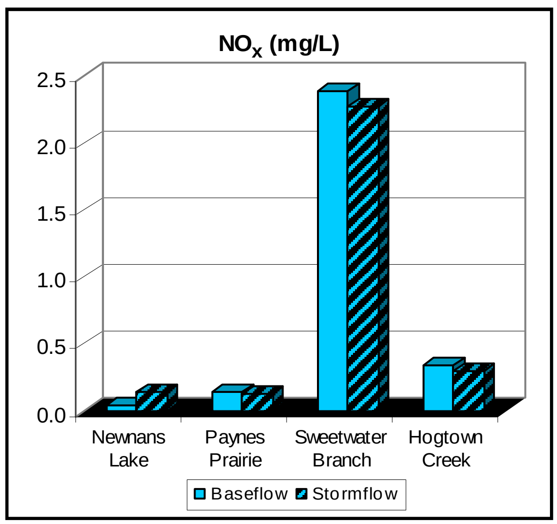

Figure 1.15 Average median values for total nitrate plus nitrite (NO_x) concentrations by watershed category, during baseflow and stormflow periods.

orthophosphate concentrations were higher during stormflow for streams in the Hogtown Creek Watershed, they were lower for the two sites on Sweetwater Branch downstream from the GRU Main Street WRF. Greater bank and streambed erosion of the phosphatic soils associated with the Hawthorn Group formations and runoff from residential yard fertilization are the likely causes for the Hogtown Creek Watershed increase. Dilution of the GRU Main Street WRF reclaimed water is the most probable cause for the decrease in orthophosphate in Sweetwater Branch. Orthophosphate concentrations increased at sites in the Paynes Prairie Watershed, while they were similar between stormflow and baseflow periods for streams in the Newnans Lake Watershed. Orthophosphate concentrations during either stormflow or baseflow periods were significantly higher for Hogtown Creek, Possum Creek, and the two sites on Sweetwater Branch downstream from the GRU Main Street WRF than at all other sites in this study.

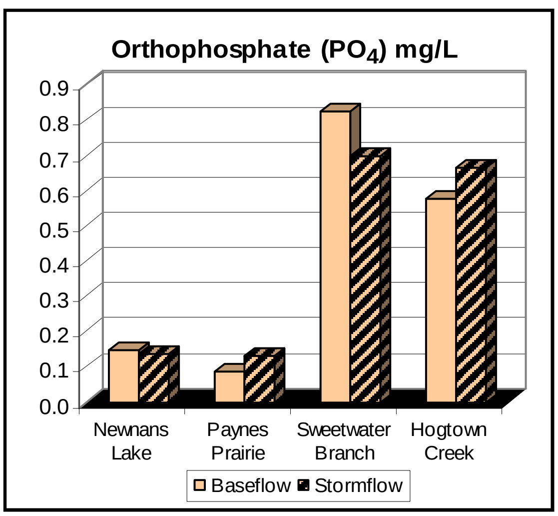

Figure 1.16 Average median values for orthophosphate (PO_4) concentrations by watershed category, during baseflow and stormflow periods.

1.6.5 General Chemical Constituents

<u>1.6.5.1 Total Suspended Solids</u>

Total suspended solids during stormflow periods were about 3 to 5 times higher than baseflow values for all streams, except those in the Hogtown Creek Watershed (Figure 1.17 and Appendix E). Total suspended solids concentrations at three of the four Hogtown Creek Watershed storm event sites were about 4 to 9 times higher than baseflow values. One of the sites on Possum Creek, had an unusually high total suspended solids concentration during one storm event (median of 504 mg/L), which is reflected in the bar graph in Figure 1.17 for the Hogtown Creek Watershed. These elevated total suspended solids concentrations were likely caused by stream bank and streambed erosion and by the input of sediments in surface runoff.

<u>1.6.5.2 Chloride and Sulfate</u>

Median chloride concentrations were generally lower during stormflows than baseflows at all streams monitored in this study (Appendix E). Chloride concentra-

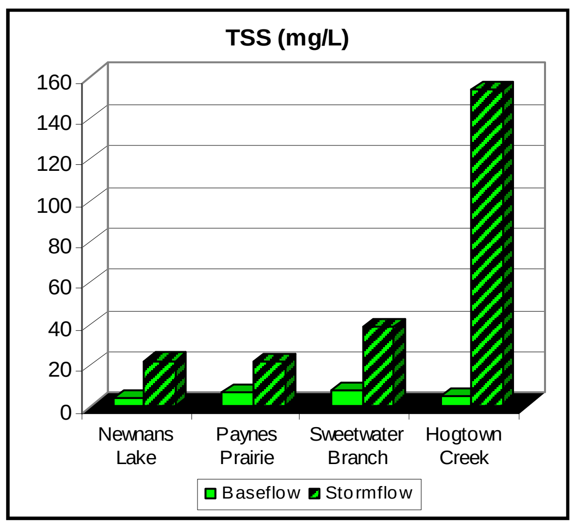

Figure 1.17 Average median values for total suspended solids (TSS) concentrations by watershed category, during baseflow and stormflow periods.

tions on Sweetwater Branch downstream from the GRU Main Street WRF, while about 43 percent lower during stormflow periods than during baseflow periods, were still significantly higher than at any other site in this study.

Sulfate concentrations were generally the same or lower during stormflow periods at most streams in this study. Sulfate concentrations were somewhat elevated for some sites in the Newnans Lake Watershed. In Lake Forest Creek, sulfate concentrations increased dramatically during a storm event in June 2000. Median sulfate concentrations during that storm event were 343.6 mg/L, compared to a median baseflow concentration of 9.5 mg/L. The cause for this single event increase is not known, but will be further investigated.

1.6.6 Fecal Coliform Bacteria

Samples for fecal coliform bacteria were not collected as part of storm event sampling. Elevated levels of fecal coliform bacteria have been reported during and after storm events in the more urbanized watersheds, specifically in Tumblin Creek and Sweetwater Branch (ACEPD 2001b). Additional work in this area is being conducted.

1.7 Ecosystem Health

During the urbanization of Gainesville, the once naturally sinuous streams have been channelized and disturbed. Tumblin Creek and Sweetwater Branch, located in the older neighborhoods of Gainesville, are the most degraded and have been extensively channelized. The upper reaches of Lake Forest and Little Hatchet creeks have also been channelized. This channelization has resulted in a loss of natural riparian buffers, loss of a floodplain or connection to the floodplain, changes in hydrology, significant in-stream erosion and sediment deposition, and the loss of in-stream biological habitat. Streams in the Hogtown Creek Watershed are less urbanized, and generally have more available in-stream biological habitat.

Channelized section of Tumblin Creek, west of US 441.

1.7.1 Biological Integrity

The width and quality of the riparian stream buffers is critical to a healthy ecosystem. A wide riparian buffer of native

Lake Forest Creek (facing south) near Morningside Nature Park south of SR 26.

tree and plant species provides a canopy to shade the stream, allows slow percolation of rainfall to recharge the surficial aquifer system, reduces rapid stormwater runoff, allows for sedimentation and nutrient uptake, provides habitat for wildlife, and generally mitigates the impact of anthropogenic activities on the stream system. All of these factors can affect biological integrity, therefore it is important to preserve the remaining forested areas in all of the watersheds for their hydrologic and wildlife values.

Tumblin Creek and Sweetwater Branch have been severely altered in many areas and have little to no natural riparian buffer. Landuse in both of the watersheds is predominantly commercial and medium to high density residential. The run-off from impervious areas, such as parking lots, is typically much warmer than water that has percolated through natural soils, and it transports sediments, nutrients, bacteria, oil, metals, and other pollutants to the streams. Elevated water temperatures and increased sediment load, which smothers available biological habitat, reduce in-stream biological diversity. Without a wooded riparian buffer there are few to no plant roots which provide a significant amount of in-stream macroinvertebrate habitat in a healthy ecosystem. In riparian areas that do have a canopy of native species, the understory vegetation is typically poor, and consists of turf grass and many non-native invasive species. The lack of good quality riparian buffers, increased stormwater flows, and sediment transport have degraded the in-stream macroinvertebrate habitat and populations. All the BioRecons performed in the Paynes Prairie Watershed showed “impaired” macroinvertebrate populations.

Landuse in the Hogtown Creek Watershed is generally less intense than in the urban areas within the Paynes Prairie Watershed. The Hogtown Creek Watershed has residential areas with relatively large lots and more extensive native riparian buffers, a denser tree canopy, and some areas with good quality understory vegetation. This provides better macroinvertebrate habitat and cooler water temperatures.

In the Newnans Lake Watershed, development in the upper reaches of Little Hatchet and Lake Forest creeks has resulted in loss of ecosystem function. The forested wetlands in these areas have been drastically altered and no longer have the hydrology to support diverse in-stream biological populations. Both creeks flow through extensive forested wetlands as they reach Newnans Lake. These forested wetlands provide significant habitat for many species of wildlife. All three of the Newnans Lake tributaries are intermittent, which likely contributes to the reduced number and diversity of species found during BioRecons. This was especially true for Little Hatchet Creek, which is frequently dry for several months of the year. The natural absence of water does not allow the longer lived aquatic larval species, such as the Odonates (dragonflies), time to complete their life cycle.

Hatchet Creek is more rural in character and has a well balanced ecosystem. Hatchet Creek at CR225 was found to have one of the most diverse populations of macroinvertebrates among all 31 of the sites biologically assessed. In general, it is dry much less frequently than Little Hatchet Creek.

1.7.2 Physical Integrity

Changes to the physical characteristics of the streams in Gainesville, primarily due to urban development, are significant. Artificial channelization and roadways alter the course of the streams. Currently, the greatest physical problem is in-stream erosion and sedimentation. Sediment transport is greatest during storm events since the lack of storage (due to impervious area) in the watershed dramatically increases the volume and rate at which water moves through the stream channels. This can be typified by a summer storm event of less than one inch of rainfall resulting in a water level increase of several feet in a stream channel. When this happens, exposed sandy soils from the stream banks collapse and are carried downstream. Tumblin Creek, Sweetwater Branch, Lake Forest Creek, Hogtown Creek, Possum Creek, and Little Hatchet Creek have severe in-stream erosion and sedimentation problems.

In-stream erosion and sedimentation are greatest in the Hogtown Creek Watershed. The erosion is most dramatic in areas of high relief along the Cody Scarp, where baseflow and stormflow water velocities are the greatest. As the relief decreases and water velocities drop, the sediments are re-deposited in the stream channel: sometimes reaching five to seven feet in thickness. Large amounts of sediment are also deposited in the floodplain near NW 8th Avenue and below the Cody Scarp. Sediment traps in the vicinity of NW 34th Street and University Avenue, installed by the Florida Department of Transportation (FDOT) to protect their infrastructure, allow routine removal of re-deposited sediments. However, the sediment traps were not designed to alleviate the problem of sediment transport within the watershed, but to protect the bridges in the area.

Other measures proposed to reduce in-stream erosion and sedimentation include greater upper basin storage of stormwater and installation of grade control structures. The City of Gainesville Public Works Department is currently planning to install grade control structures in the streambed of Sweetwater Branch as one

Sand deposited from stormflow in the Hogtown and Possum creeks floodplain north of NW 8th Avenue.

Hogtown Creek sediment trap upstream of NW 34th Street (facing west).

approach to reduce further downcutting. Our greatest challenge is to restore the urban creek system and improve the instream physical habitat and riparian buffers.

1.8 Hydrology

Creeks in the Gainesville area originate from a variety of sources, including: wetlands, springs, and seeps. Groundwater contributions are important in augmenting baseflow in the creeks as land surface elevations decrease.

Rainfall recharges surface water and groundwater within the OCB. Groundwater from the surficial and intermediate aquifers or aquifer systems provides the primary source of baseflow to the streams in the OCB. The deeper Floridan aquifer system underlies all of Alachua County at depth, but only discharges to surface waters where the potentiometric surface (water surface) is higher than the land elevation. Examples of this include the flowing wells at Magnesia Springs in the Grove Park area and potential upward seepage into Lochloosa Lake. The surficial and intermediate aquifers discharge to the creeks as elevation drops and the streams down cut through the Hawthorn Group formations east of the Cody Scarp.

Determining stream flow is an integral component in understanding water quality of surface waters. During sampling, water velocities in the streams were measured with a Marsh McBirney FlowMate 2000 digital current meter. Manual velocity measurements and the cross-sectional area of the stream allowed stream flow to be calculated. Stream flow is essential when determining loading rates of pollutants in water bodies. Some sample collection sites were co-located with stations that had permanent hydrologic monitoring equipment for continuous stage or flow measurement. Appendix F-1 contains baseflow hydrologic summary statistics and Appendix F-2 contains stormflow hydrologic data summaries. Stream hydrographs for stations with continuous hydrologic recording devices are presented in Appendix G-1 and flow exceedance curves for these stations are presented in Appendix G-2.

Water levels in the creeks vary widely. The creeks in the Newnans Lake Watershed (Hatchet, Little Hatchet, and Lake Forest creeks) are intermittent streams, with little or no flow throughout the dryer portions of the year. The outfall from Bivens Arm Lake (TUM331) that discharges onto Paynes Prairie, only flows during periods of high rainfall. Flow characteristics of the major streams in this study are provided in Table 1.6.

Table 1.6 Streamflow data for the major creeks with at least 2 years of daily flow data.

Creek and Station	Mean Flow (cfs)	Max. Flow (cfs)	Min. Flow (cfs)
Hogtown Creek (HOG30)	18.59	860.00	0.06
Sweetwater Branch (SWB331)	12.73	155.64	4.70
Hatchet Creek (HAT26)	5.87	263.48	0.00
Possum Creek (POSNW16)	4.20	44.27	0.54
Little Hatchet Creek (LHTNB)	2.02	28.43	0.00
Tumblin Creek (TUM441)	1.62	35.13	0.02

The streams with the highest mean flows are Hogtown Creek and Sweetwater Branch, followed by Hatchet Creek and Possum Creek. Mean flows in Little Hatchet Creek and Tumblin Creek are the lowest. Stormflows on Hogtown Creek, Sweetwater Branch, and Hatchet Creek are much higher than on the other creeks in this study (Table 1.6).

Some of the creeks are augmented by FDEP-permitted discharges. For example, Sweetwater Branch receives reclaimed water (treated wastewater effluent) from the GRU Main Street WRF and cooling water discharged from the GRU J.R. Kelly Generating Station. These augmentations are reflected in the 4.70 cfs minimum flow on Sweetwater Branch (Table 1.6). Little Hatchet Creek receives reclaimed water (treated wastewater effluent) from the package wastewater treatment plant at Brittany Estates Mobile Home Park.

1.9 Summary

Existing water quality data indicate elevated concentrations of nutrients and fecal coliform bacteria in Gainesville creeks. This finding is consistent with historical data collected by ACEPD. Potential sources of elevated nutrients include: stormwater runoff containing fertilizers from residential, commercial, and agricultural activities; infiltration of fertilizer-based nitrates into the surficial groundwater and subsequent stream baseflow; wild animal and/or pet waste; failing septic tank systems; leaking sanitary sewer lines and/or connections; discharges of cooling water and reclaimed water (treated wastewater effluent); and atmospheric deposition. Stormwater quality data indicate that nutrients and suspended solids increase during storm events.

A leaking manhole discharging untreated wastewater to the stormwater system.

Stormwater system design has historically focused on water quantity rather than water quality issues (Tilley and Brown 1998). As a result, stormwater design has relied on channelization and storm sewers to convey surface runoff as rapidly as possible to creeks and out of the urban area to prevent flooding. These traditional methods result in minimal pollution abatement and treatment, poor wildlife habitat, little aesthetic value, and an increase in lateral erosion and down cutting. In-stream erosion and sedimentation continues to be a severe problem in the urban creeks. Hogtown Creek, Possum Creek, Sweetwater Branch, Tumblin Creek, and Lake Forest Creek have in-stream erosion problems due to channelization and direct discharge of high volumes of stormwater.

In-stream erosion and sedimentation contribute, in large part, to the lack of good quality and quantity of aquatic habitat.

Erosion causes soil and other solid inorganic and organic materials to become suspended in water, which increases turbidity and reduces the ability of some organisms to find food and uptake oxygen (Miller 1993). Increased turbidity also reduces photosynthesis by aquatic plants, disrupts food webs, and destroys habitat for aquatic fauna. In the densely populated watersheds of Tumblin Creek and Sweetwater Branch, macroinvertebrate habitat is extremely poor which results in impaired aquatic ecosystems. Erosion and sedimentation is less of a problem in the more rural watersheds, such as Hatchet Creek.

Chemicals from road runoff and effluent from industries can be in the form of dissolved solids including acids, salts, and toxic metal compounds, such as lead and mercury (Miller 1993). High levels of such dissolved solids can harm aquatic life. Organic chemicals such as oil, gasoline, plastics, pesticides, and cleaning solvents can also threaten aquatic health.

Disease-causing agents such as bacteria, viruses, and parasitic worms can enter water from domestic sewage spills, sewer line and sewer line connection leaks, animal and pet wastes, and failing septic systems. Large populations of bacteria supported by these wastes can also deplete water of dissolved oxygen, which can kill fish and other forms of aquatic life. Excessive input of water that is heated (cooling water) results in an increase in stream water temperatures. Increased temperatures lower the dissolved oxygen content and make aquatic organisms more vulnerable to disease, parasites, and toxic chemicals (Miller 1993).

Riparian buffers frequently lack adequate native vegetation. There is an increasing trend toward dominance by invasive exotic plant species which escape from cultivation in the landscape. Many invasive plants are shade tolerant and grow well in moist soil near creeks, where they frequently form mono-cultures. The resulting reduction in diversity of native plant species contributes to reduced wildlife diversity in the riparian zone.

Wild Taro and other invasive species along Sweetwater Branch near SE 8th.

Baseflow water quality monitoring is proposed to continue. The following activities related to the water quality monitoring program should be considered:

- Re-evaluate and modify the baseflow water quality monitoring program to assess the benefits of restoration activities in the watersheds

- Further investigate the sources of fecal coliform contamination in Tumblin Creek, Sweetwater Branch, and Hogtown Creek

Aquatic macroinvertebrate education demonstration conducted by the WAV Program.

- Encourage public education and outreach activities through WAV, Current Problems, Inc./Adopt-A-River, and Gainesville Clean Water Partnership (GCWP)
- Promote healthy sustainable landscape practices by using native plants which will reduce fertilizer, pesticide, and water use

Restoration goals and strategies identified in this report are described for individual watersheds in subsequent report sections. However, there are a number of goals that apply to all watersheds. The most significant problem in the Hogtown Creek and Paynes Prairie watersheds is management of the volume and velocity of stormwater. To reduce stream bank and streambed erosion, stormwater runoff volumes and velocities must be reduced. This reduction would allow productive habitat for benthic macroinvertebrates to flourish.

Restoration goals should include:

- Decreasing in-stream erosion and sedimentation and external sediment loading
- Restoring natural riparian buffer form and function
- Providing more upper basin storage in the watersheds to reduce the rate and volume of runoff directed into the creeks
- Improving water quality with a goal of “no net nutrient increase” for surface waters discharges
- Enhancing water quality by reducing point and non-point source pollution
- Preserving and enhancing existing natural forested areas within the watersheds

Restoration strategies typically require large capital expenditures and significant recurring operation and maintenance costs. The SJRWMD, FDEP, Alachua County, and the City of Gainesville must work together in order to secure funding for these efforts. It is important to carefully plan future development in the rural areas to preserve the natural buffers and flow systems. It is also important to restore areas which have previously been degraded.