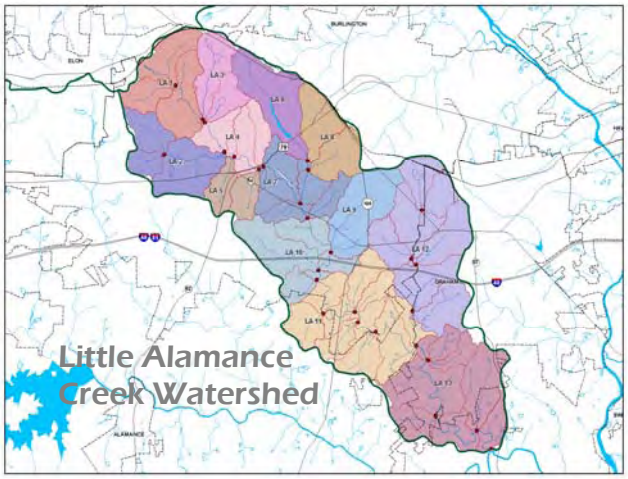
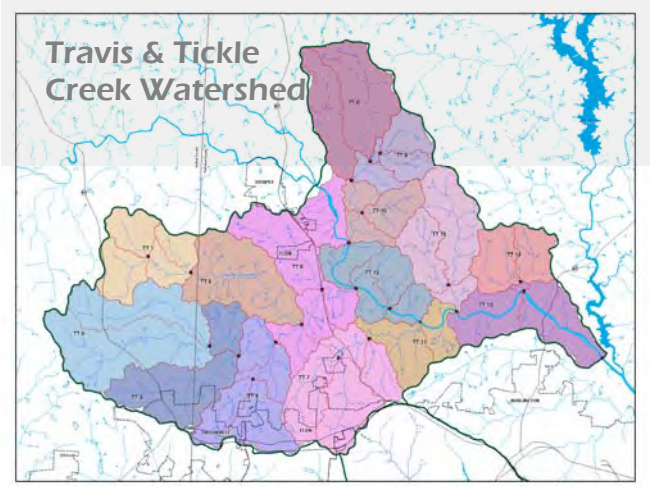


Little Alamance, Travis & Tickle Creek



Watershed Characterization

Phase 1
Final Report
March 9, 2007

Project Sponsor: North Carolina Ecosystem Enhancement Program
North Carolina Department of Environmental Resources and North Carolina Department of Transportation
Report compiled by the Piedmont Triad Council of Governments
Environmental Programs

Little Alamance, Travis and Tickle Creek

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Introduction and Background

The NC Ecosystem Enhancement Program (EEP), created in 2003, combines an existing wetlands restoration initiative by the NC Department of Environment and Natural Resources with ongoing environmental efforts by the NC Department of Transportation. The mission of the Ecosystem Enhancement Program is to "restore, enhance, preserve and protect the functions associated with wetlands, streams and riparian areas, including but not limited to those necessary for the restoration, maintenance and protection of water quality and riparian habitats throughout North Carolina" (NCEEP).

EEP provides a number of services, including:

- High-quality, cost-effective projects for watershed improvement and protection;
- Compensation for unavoidable environmental impacts associated with transportation-infrastructure and economic development; and
- Detailed watershed-planning and project-implementation efforts within North Carolina's threatened or degraded watersheds. (NCEEP)

The Piedmont Triad Council of Governments has been contracted by NC EEP to perform a Local Watershed Plan in the Little Alamance Creek Watershed (Hydrologic Unit Code 03030002040110), which flows through the City of Burlington, City of Graham, and part of Alamance County; and Travis and Tickle Creek Watershed (Hydrologic Unit Code 03030002030010) in Alamance County and a small portion of Guilford County.

The Piedmont Triad Council of Governments was responsible for facilitating stakeholder meetings and managing the local watershed planning process, which included creating meeting agendas, maintaining meeting records, and helping group members reach consensus amicably. This report details the results of work completed under Phase I, Watershed Characterization, including:

Task 1: Stakeholder Involvement
Task 2: Landowner Identification
Task 3: First Stakeholder Meeting
Task 4: Mapping
Task 5: Community Capability Assessment
Task 6: Technical Team Meetings
Task 7: Watershed Assessment Team Scoping Analysis
Task 8: Recommendation of Work
Task 9: Watershed Characterization Draft
Task 10: Second Stakeholder Meeting
Task 11: Phase I Report Submittal

Section 1: Stakeholder Process

The Piedmont Triad Council of Governments worked with partner organizations to recruit and convene a watershed stakeholder group to guide planning and facilitate other important tasks. This section summarizes the process and stakeholder group.

Local Watershed Planning Group
The project is being guided by a Local Watershed Planning Group consisting of a Community Stakeholder Group and a Technical Team. The primary purpose of the Local Watershed Planning Group is to develop watershed improvement and protection recommendations for the Little Alamance and Travis and Tickle Creek watersheds.

Community Stakeholder Group
The Community Stakeholder Group consists of members of the local community who can affect or are affected by the Local Watershed Plan. The Community Stakeholder Group includes local landowners, business people, members of environmental organizations, environmental professionals, and others who are interested in improving the quality of the community's environment. The group provides input into the process, information on issues and concerns in the watershed and ensures that the Local Watershed Planning Group considers a broad, diverse range of community interests. [See Appendix 1: Group Charter and Ground Rules, Travis/Tickle and Little Alamance Local Watershed Planning Group]

Technical Team
The technical team is responsible for carrying out the research, mapping, analysis and assessment of the watershed. The Technical Team is composed of representatives from Piedmont Triad Council of Governments, NC Division of Water Quality, and NC Ecosystem Enhancement Program. The Technical Team directly participates in the process of developing the recommendations that will create a viable Local Watershed Plan. In addition, the Technical Team organizes meeting agendas, presents relevant issues to the Community Stakeholder Group for consideration, and investigates potential projects and potential sources of agency / program funding.

Local Watershed Plan Charter
The Little Alamance and Travis and Tickle Creek Local Watershed Plan Charter, adopted by the Technical Team at its first meeting on June 20, 2006, defines the group objectives in detail and identifies the members of each specific group. The charter also outlines each group's roles and responsibilities in the process. [See Appendix 1]

Project Planning Goals
The Watershed Planning Group developed a draft set of planning goals to guide the Little Alamance and Travis and Tickle Creek Local Watershed Plan. Stakeholders agreed upon a list of initial goals at a stakeholder meeting on August 8, 2006. The group refined these goals into two major plan goals at a meeting on October 17, 2006. The Technical Team added an additional four goals and presented these to the Planning Group on December 5, 2006, upon which all attendees approved the revised goals. Summaries of these meetings are available on the project website (http://www.ptcog.org/eep/LATTC_WP.html).

The Little Alamance and Travis and Tickle Creek Local Watershed Planning goals include both short and long-term strategies to restore, manage, and protect vital functions in the watershed. The goals are listed below. These goals are based on findings and preliminary scoping during the Phase I process of characterizing the watershed.

Goal 1: Increase local government awareness of the impacts of urban growth on water resources.

Goal 2: Strengthen watershed protection standards.

Goal 3: Improve water quality through stormwater management.

Goal 4: Identify and rank parcels for retrofits, stream repair, preservation, and/or conservation.

Goal 5: Assess aquatic health to identify stressors that are the most likely causes of poor biological conditions

Goal 6: Meet requirements of outside funding sources for implementation of projects

Section 2: Watershed Characterization

2.0 Natural Features

This section comprises a general characterization of the Little Alamance Creek and Travis and Tickle Creek watersheds. This characterization describes the natural features of the watershed, including geography, geology, soils, topography, surface hydrology, floodplains and wetlands, and habitat and species. [See Map Appendix 1: Watershed Location]

2.1 Geography

The Little Alamance watershed is a 16 square mile watershed which contains over 4 perennial streams and has been delineated into 12 subwatersheds. Subwatersheds 1-9 are located in the City of Burlington; subwatersheds 12 and 13 at the lower end of Little Alamance watershed are located in the City of Graham. North Carolina's Division of Water Quality has listed Little Alamance is 303(d) as impaired for poor benthic community (NCDENR DWQ 2006a). The watershed is a built out urbanized area with some forested/agricultural area remaining in the lower portion of the watershed.

Travis and Tickle Creek watershed is a 36 square mile watershed with over 30 perennial streams. The watershed has been delineated into 15 subwatersheds. The western part of the watershed is located in Guilford County. Dry Creek is a tributary which drains into the Haw River. The towns of Elon and Gibsonville are located in Dry Creek watershed and two other urbanized subwatersheds in the southeast portion of the watershed. The largest portion of the Travis and Tickle Creek watershed is rural agricultural or forested land located in Alamance County. From GIS desktop analysis, many streams have large buffers and large forested tracts of land, especially in the areas north of the Haw River.

2.2 Geology

According to the NC Geological Survey (NCGS), in geological terms, "the state is best described in terms of geological belts; that is, areas with similar rock types and geologic history" (NCGS). The Travis and Tickle Creeks and Little Alamance Creek Watersheds lie in the Carolina Slate Belt and a small piece of the Charlotte Belt.

The NCGS describes the Carolina Slate Belt as consisting of "heated and deformed volcanic sedimentary rocks. It was the site of oceanic volcanic islands about 550-650 million years ago…. Mineral production is crushed stone for road aggregate and pyrophyllite for refractories, ceramics, filler, paint and insecticide carriers." The Charlotte Belt is described as "consisting mostly of igneous rocks such as granite, diorite and gabbro. These are 300-500 million years old. The igneous rocks are good sources for crushed and dimension stone for road aggregate and buildings" (NCGS).

Both watersheds are composed mainly of three geological types, Metamorphosed Gabbro and Diorite, Mafic Metavolcanic Rock, and Quartzite, with only a small amount of Felsic Metvolcanic Rock in the Travis and Tickle Creeks Watershed. The classifications are defined below (NCGS);

FELSIC METAVOLCANIC ROCK - Metamorphosed dacitic to rhyolitic flows and tuffs, light gray to greenish gray; interbedded with mafic and intermediate metavolcanic rock, meta-argillite, and metamudstone. Metavolcanic rock is a metamorphic rock, originally formed from volcanic rock, but recrystallized under high pressure and temperatures. The felsic character is classified as generally when it contains >75% felsic minerals; namely quartz, orthoclase and plagioclase.

QUARTZITE - Massive to well foliated; contains andalusite, kyanite, or sillimanite, chloritoid, and pyrite. Quartzite is a hard, metamorphic rock which was originally sandstone. Through heating and pressure usually related to tectonic compression within orogenic belts, the original quartz sand grains and quartz silica cement were fused into one. Pure quartzite is usually white to grey. Quartzites often occur in various shades of pink and red due to varying amounts of iron oxide. Other colors are due to impurities of minor amounts of other minerals.

MAFIC METAVOLCANIC ROCK - Metamorphosed basaltic flows and tuffs and the color is dark green to black; this rock is interbedded with felsic and intermediate metavolcanic rock and metamudstone. Metavolcanic rock is a metamorphic rock, originally formed from volcanic rock, but recrystallized under high pressure and temperatures. The mafic character is classified as such from the rock crystallizing with silicate minerals at relatively high temperatures.

METAMORPHOSED GABBRO AND DIORITE - Foliated to massive, this is considered an intrusive rock. Gabbro can be considered to be roughly the same as basalt in composition, but different in texture. With larger crystals, gabbro is typical of an intrusive rock, formed deep within the Earth. Its texture is called phaneritic, with the crystals roughly the same size. The large crystals were formed by a slow cooling process beneath the Earth's surface. Pyroxene and calcium-rich plagioclase are its major constituents.

[See Map Appendix 2: Watershed Geology]

2.3 Soils

The predominant soil series in the Little Alamance Watershed is the Mecklenburg- Elon – Cecil series, comprising almost the entire watershed south of Route 70. The Vance -Appling – Enon-Cecil series can be found north of Route 70 and encompasses the majority of the hydric soils found in the watershed.

The Mecklenburg series is formed in residuum weathered from intermediate and mafic crystalline rocks of the Piedmont uplands. Runoff is slow to medium and internal drainage is slow. Mecklenburg soils are on nearly level to moderately steep Piedmont uplands. Slope gradients are 0 to 25 percent, most commonly between 2 and 10 percent.

The Enon series consists of very deep, well drained, slowly permeable soils on ridgetops and side slopes in the Piedmont. Slope ranges from 2 to 45 percent…. Enon soils are gently sloping on ridgetops and sloping to steep on the side slopes. Slopes are generally between 4 and 10 percent but range from 2 to 45 percent. The soil formed in clayey

residuum weathered from mafic or intermediate, igneous or high-grade metamorphic rocks such as diorite, diabase, gabbro, or hornblende gneiss or schist. Runoff is medium to rapid with slow internal drainage.

The Vance series soils are on gently sloping narrow and broad ridges and sloping to moderately steep side slopes in the Piedmont. Slopes range from 2 to 25 percent. These soils formed in residuum weathered from felsic crystalline rock, primarily aplitic granite. Vance soils are well drained. Runoff is medium to rapid, and permeability is slow.

The Cecil series consists of very deep, well drained moderately permeable soils on ridges and side slopes of the Piedmont uplands. They are deep to saprolite and very deep to bedrock. They formed in residuum weathered from felsic, igneous and high-grade metamorphic rocks of the Piedmont uplands. Cecil soils are on nearly level to steep land areas. Slope gradients are 0 to 25 percent, most commonly between 2 and 15 percent. Runoff is medium to rapid runoff with moderate permeability.

The Appling series consists of very deep, well drained, moderately permeable soils on ridges and side slopes of the Piedmont uplands. They are deep to saprolite and very deep to bedrock. They formed in residuum weathered from felsic igneous and metamorphic rocks of the Piedmont uplands. Slopes range from 0 to 25 percent.

Hydric soils can be found throughout the watershed along the stream banks, but most predominantly along the Little Alamance Creek stream beds and surrounding area north of Route 70. Hydric soils are identified by examining and describing the soil to a depth of about 20 inches. Map units that are dominantly made up of hydric soils may have small areas, or inclusions, of nonhydric soils in the higher positions on the landform, and map units dominantly made up of nonhydric soils may have inclusions of hydric soils in the lower positions on the landform. (National Research Council, 1995; Hurt and others, 2002).

Soils are identified as a hydric soil if at least one of the following approved indicators is present.

1. All Histels except for Folistels, and Histosols except for Folists.
2. Soils in Aquic suborders, great groups, or subgroups, Albolls suborder, Historthels great group, Histoturbels great group, Pachic subgroups, or Cumulic subgroups that:
   a). are somewhat poorly drained and have a water table at the surface (0.0 feet) during the growing season, or
   b). are poorly drained or very poorly drained and have either:
      1. a water table at the surface (0.0 feet) during the growing season if textures are coarse sand, sand, or fine sand in all layers within a depth of 20 inches, or
      2. a water table at a depth of 0.5 foot or less during the growing season if permeability is equal to or greater than 6.0 in/hr in all layers within a depth of 20 inches, or
      3. a water table at a depth of 1.0 foot or less during the growing season if permeability is less than 6.0 in/hr in any layer within a depth of 20 inches.
3. Soils that are frequently ponded for long or very long duration during the growing season.
4. Soils that are frequently flooded for long or very long duration during the growing season.

(National Research Council, 1995; Hurt and others, 2002)

The following tables list the map unit components that are rated as hydric soils in the survey area. This list can help in planning land uses; however, onsite investigation is recommended to determine the hydric soils on a specific site.

Alamance County

The Alamance County Soil Survey identifies 8 hydric soil series in the Little Alamance and Travis and Tickle Creek watersheds. (USDA, 1959)

Table 2.3.1: Hydric Soil Types in Alamance County

Series	Description	Hydric Criteria
Chewacla	Consists of nearly level, somewhat poorly drained soils on floodplains. Formed in fine loamy material washed from upland soils. Flooded very frequently for very brief periods. Acidic.	2b 3,4
Colfax	Consists of moderately well drained to somewhat poorly drained soils, remaining wet and water-logged for long periods. Occur at heads of small drainways. Made up of sandy clay loam, heavy sandy clay, or silt loam, strongly acidic.	2b 3
Congaree	Consists of moderately well drained to well drained loamy soils on floodplains. Formed from sediments washed from upland soils. Made up of silt loam and sandy loam, often found on gentle slopes.	2b 3
Helena	Consists of somewhat poorly to moderately well drained soils on smooth upland areas. Developed from aplitic granite cut by iron and magnesium rich dikes. Permeable surface has low capacity to hold water, highly susceptible to erosion. Strongly acidic.	2b 3,4
Iredell	Consists of nearly level to sloping, moderately well drained soils on uplands. Fairly permeable surface layer capable of holding moisture. Very slow permeability in subsoil, highly susceptible to erosion.	2b 3
Local Alluvial	Consists of poorly drained areas made up of layers of sand, silt, and clay. Formed from alluvial deposits washed from upland soils.	2b 3,4
Wehadkee	Consists of nearly level, poorly drained soils on narrow flood plains. Formed in fine loamy alluvium washed from soils on uplands. Flooded very frequently for short periods. Permeability moderate. Seasonal water table at or near surface late in the winter and early in spring. Acidic.	2b 3,4
Worsham	Consists of poorly drained, strongly acidic soils occurring in low, wet depressions or in wet alluvial drainways. Made up of colluvium and alluvium, mixed with granite, gneiss, schist, and slate.	2b 3

Guilford County
The Guilford County Soil Survey identifies 6 hydric soil series in the Little Alamance and Travis and Tickle Creek watersheds. (USDA, 1977)

Table 2.3.2: Hydric Soil Types in Guilford County

Series	Description	Hydric Criteria
Chewacla	Consists of nearly level, somewhat poorly drained soils on floodplains. Formed in fine loamy material washed from upland soils. Flooded very frequently for very brief periods. Acidic.	2b 3,4
Congaree	Consists of moderately well drained to well drained loamy soils on floodplains. Formed from sediments washed from upland soils. Made up of silt loam and sandy loam, often found on gentle slopes.	2b 3
Enon	Consists of well drained, slowly permeable soils that formed in residuum weathered from dark colored rocks such as diorite, gabbro, hornblende, schist, or mixed acidic and basic rocks. Located on broad, smooth interstream divides and narrow side slopes.	2b 3
Helena	Consists of somewhat poorly to moderately well drained soils on smooth upland areas. Developed from aplitic granite cut by iron and magnesium rich dikes. Permeable surface has low capacity to hold water, highly susceptible to erosion. Strongly acidic.	2b 3,4
Iredell	Consists of nearly level to sloping, moderately well drained soils on uplands. Fairly permeable surface layer capable of holding moisture. Very slow permeability in subsoil, highly susceptible to erosion.	2b 3
Wehadkee	Consists of nearly level, poorly drained soils on narrow flood plains. Formed in fine loamy alluvium washed from soils on uplands. Flooded very frequently for short periods. Permeability moderate. Seasonal water table at or near surface late in the winter and early in spring. Acidic.	2b 3,4

[See Map Appendix 3: Watershed USDA Soils]

[See Also Map Appendix 5: Watershed Hydric Soils, Slopes, and Floodplains]

2.4 Topography

The Travis/Tickle Watershed and the Little Alamance Watershed is fairly flat. The high point in the area is located in the Northern most tip of the Travis Tickle Watershed at 830 feet. The low lying areas are generally around stream banks. The lowest point is approximately 450 feet in the southern most part of the Little Alamance Watershed.

The degree of slope throughout the planning area was calculated using topographic contour data provided by the NC Department of Transportation (DOT). This data was used to generate a topographic contour map with a contour interval of 20 feet. A 20% slope (20 feet of fall per 100

horizontal feet) was used as the threshold for defining a steep slope. Some steep slopes are scattered throughout the watersheds, generally concentrated along streambanks.

[See Map Appendix 4: Catchments with Digital Elevation Model]

[See Also Map Appendix 5: Hydric Soils, Slopes, and Floodplains]

2.5 Surface Hydrology

Alamance County has a mild year-round climate with four seasonal changes. Average rainfall is approximately 45 inches. Average annual frozen precipitation is 4.0 inches per year.

The State Climate Office of North Carolina at NC State University reports that "summer precipitation is normally the greatest, and July is the wettest month. Summer rainfall is also the most variable, occurring mostly in connection with showers and thunderstorms. Daily showers are not uncommon, nor are periods of one to two weeks without rain. Autumn is the driest season, and November the driest month. All North Carolina's rivers and streams commonly have a maximum flow in late spring, with low flow in fall. It is rare for any but the very smallest streams to be dry at any time. However, all are likely to flood. Floods covering a wider area and extending into the Piedmont are most likely in winter, when traveling weather systems bring prolonged rain to a large portion of the state" (NC State Climate Office).

2.6 Floodplains and Wetlands

Wetlands in the Little Alamance and Travis and Tickle Creek were located using National Wetlands Inventory data. Specific types of wetlands found in the study areas are described in Table 2.6.1. As stated on the National Wetlands Inventory website,

> "the data are intended for use in publications, at a scale of 1:24,000 or smaller. Due to the scale, the primary intended use is for regional and watershed data display and analysis, rather than specific project data analysis. The map products were neither designed nor intended to represent legal or regulatory products" (US Fish and Wildlife Service, 2006).

As this data is on a national scale, more accurate local wetlands data is necessary to make a firm determination of location and number of wetland areas in the watershed. This data compilation will be undertaken during field assessments in Phase II of the Local Watershed Planning process.

Table 2.6.1 Wetland Types and Size

Wetland Type	Description	Acres
Freshwater Emergent Wetland	Herbaceous march, fen, swale and wet meadow	15.9
Freshwater Forested/Shrub Wetland	Forested swamp or wetland shrub bog or wetland	53.5
Freshwater Pond	Pond	338.3
Lake	Lake or reservoir basin	24.1
Riverine	River or stream channel	147.9

Floodplain data was obtained from the North Carolina Floodplain Mapping Program and accurately represents floodplains in the watersheds under study.

2.7 Habitat and Endangered Species

There are no confirmed species, listed on the North Carolina Natural Heritage Inventory, in either the Little Alamance watershed or the Travis and Tickle Creek watershed. The Haw River, however, has large areas of forest along its riparian corridor that is valuable habitat for local terrestrial and aquatic species. Indeed, its habitat and recreational value spurred interest and funding to create the Haw River Riparian Corridor Conservation Plan (PTCOG, 2005). That report can be found online at http://www.ptcog.org/files/hawriverreport.pdf

2.8 Watershed Delineation

The GIS methodology used to create both the Travis/Tickle and Little Alamance Creeks subwatersheds incorporated several steps. First, the most accurate topography and stream data needed to be obtained. Then, a stream flow model was needed. Finally, delineation of stream catchments for each watershed occurred. These catchments were further combined into subwatersheds based on order of streams and drainage areas.

The GIS analysis was conducted using ESRI's ArcGIS 9.1 GIS software, with ArcEditor and the Spatial Analyst extension. The catchment delineation was further refined by using the ArcHydro™ extension for ArcGIS, which requires the Spatial Analyst extension as well. Arc Hydro was developed jointly by the Center for Research in Water Resources at the University of Texas at Austin headed by Dr. David Maidment, and ESRI. Methodology is described below, but more information on this tool can be found at the GIS Water Resources Consortium's web site at http://www.crwr.utexas.edu/.

The first step in delineating watersheds was obtaining the hydro-corrected Digital Elevation Models (DEMs) for the area. The DEMs for Guilford and Alamance County were published by the NC Floodplain Mapping program in 2004 based on data "collected using Light Detection and Ranging (LIDAR) technology in the spring of 2001, and processed and edited to bare earth points by January 2002 (www.ncfloodmaps.com)." The DEM cell size is 50 feet, with a vertical accuracy of 0.2 feet. The DEMs were further edited by the NC Floodplain Mapping program to hydro-correct the data in order to prevent interruption of projected stream flow by bridges or roads.

Travis/Tickle and Little Alamance were analyzed separately, as decided upon early in the process to provide a more accurate representation of each area. A 'seamless' DEM was created for each watershed using the "Mosaic" function in Spatial Analyst. This provided a seamless DEM for each watershed. This data along with the stream network was then used as the base data for use with ArcHydro™ to perform the rest of the subwatershed delineation process.

The ArcHydro™ catchment delineation began with DEM reconditioning, a process that corrects any relational errors that may occur between the DEM and the stream network. The "Agree" methodology (Maidment, 2002) ensured that the stream data correctly corresponded with the DEM topography and checked for any errors, such as sinks (i.e., depressions) that may impede the virtual stream flow analysis. Figure 2.8.1 illustrates the results of the DEM reconditioning process in the Little Alamance Creek watershed. Subsequent figures further illustrate the delineation process. The DEM reconditioning ensured that the next step, determination of the

stream flow using the “Flow Direction” tool, was accurate. The stream flow (Figure 2.8.2) was also used to derive the number of DEM cells (i.e. drainage area) draining through the virtual stream network to create the flow accumulation GIS dataset.

Figure 2.8.1 - Reconditioned DEM, using “Agree” function

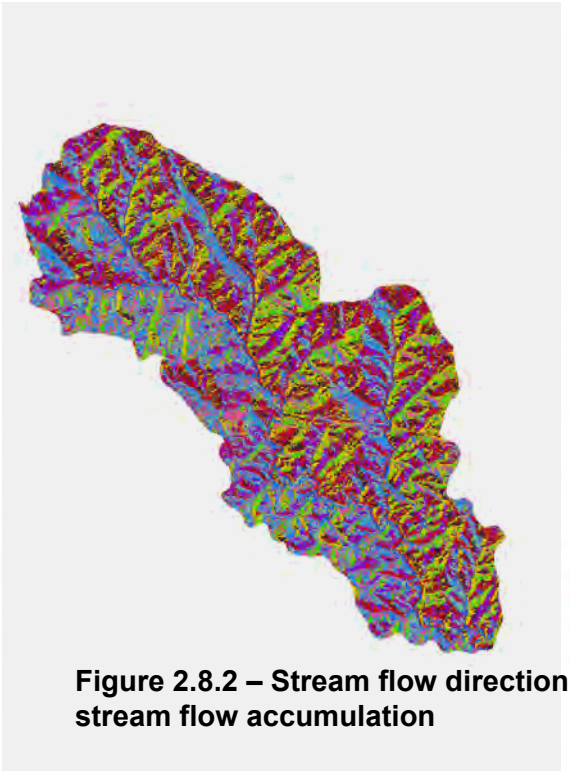


Figure 2.8.2 – Stream flow direction, stream flow accumulation

Small drainage areas, or catchments, were then identified for the study area. An important step in this process was to identify the drain points, (Figure 2.8.3) or the most downstream point in each individual drainage catchment. Drain points must be identified in order to determine where to begin delineating catchment boundaries. The end result using this analysis is subcatchment delineations such as that shown in Figure 2.8.4.

Figure 2.8.3 - Drainage areas, stream segmentation, drain points

Figure 2.8.4 Catchment polygons

The Travis and Tickle Creeks subwatershed analysis identified 45 drainage catchments, while the Little Alamance analysis produced 55 catchments. These catchments were then combined into homogeneous subwatersheds based on similar drainage, drain point locations, and land use patterns. This provided logical subwatersheds at a more manageable scale in order to further study the many aspects of both study areas. This process reduced the Travis and Tickle Creeks study area from 45 catchments to 15 subwatersheds (Figure 2.8.5), while the 55 catchments in Little Alamance Creek were combined into 13 subwatersheds (Figure 2.8.6). This process gave the watershed plan management units that will be used to summarize data, characterize conditions, and develop recommendations in the next phases of the planning process.

Figure 2.8.5
Little Alamance Watershed- Catchments and Sub Watersheds

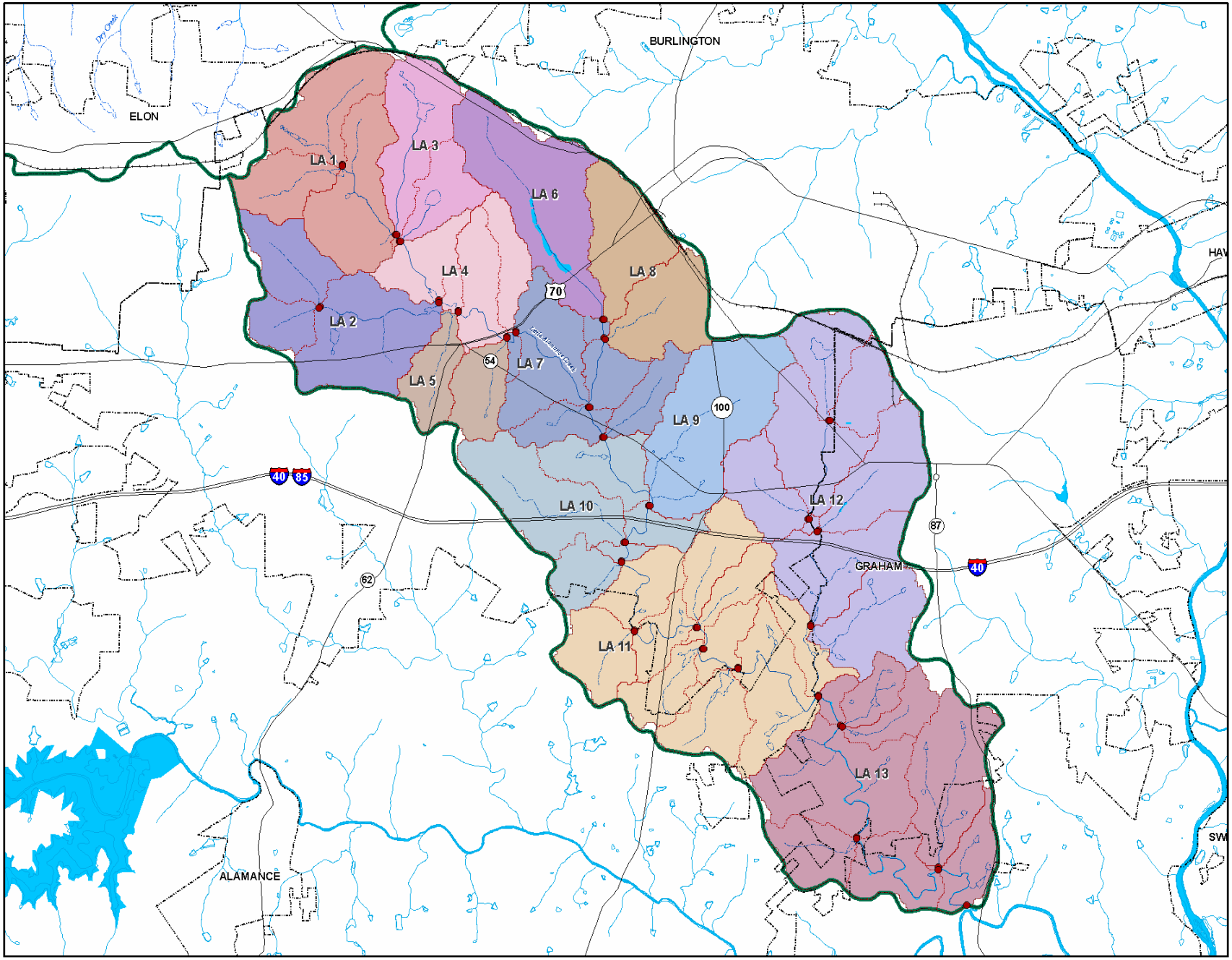
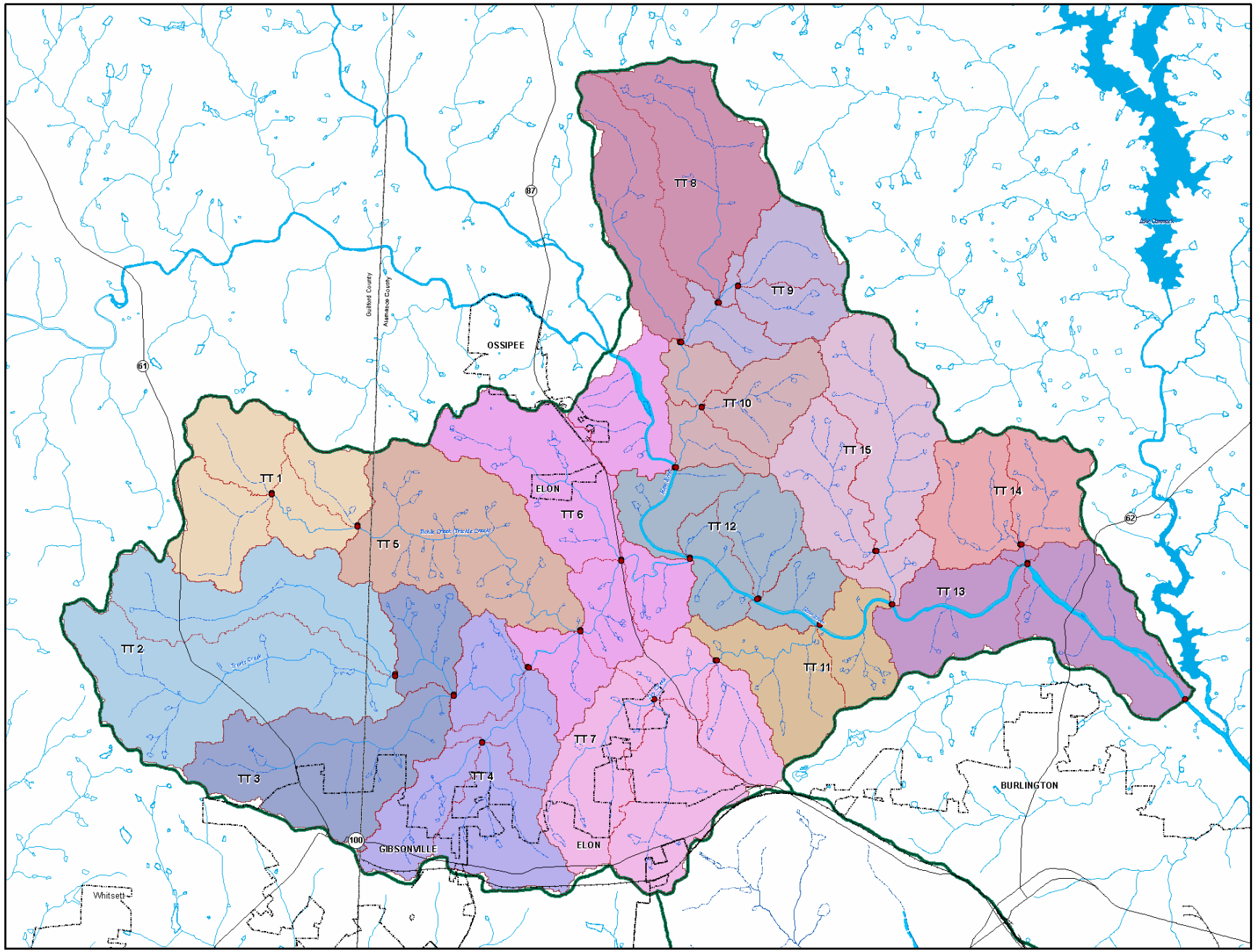


Figure 2.8.6.
Travis/Tickle Watershed- Catchments and Sub Watersheds



Section 3: NC Division of Water Quality (DWQ) Summary of Existing Monitoring Data

Little Alamance Creek is impaired because of fair and poor benthic community ratings at four sites. The stressors identified in the 2004 Cape Fear River Basinwide Assessment report are hydromodification, riparian area loss, bank erosion, sedimentation, and potential toxic impacts (NCDENR, 2004). Little Alamance Creek runs through the City of Burlington, City of Graham and part of Alamance County. The lower half of the watershed is less dense with larger undeveloped areas.

Travis and Tickle Creeks are two tributaries that flow into the Haw River. There is no data available for these stream segments. The closest monitoring station (B59) is on the Haw River immediately upstream of the confluence of the creeks and the river. A second monitoring station (B746) on the Haw River is located several miles downstream. This segment of the Haw River (approximately 10 miles) is supporting of its uses. The Cape Fear River Basinwide Water Quality Plan (2005) reports that turbidity is the major stressor on this segment of the Haw River; the source of the stressor is impervious surface area, runoff, NPDES dischargers and agriculture (NCDENR, 2005). While the Haw River is 303(d) listed, there are no impairments listed within the Travis and Tickle Creeks subwatershed.

The NC Division of Water Quality completed a review of existing monitoring data for this project and has summarized the data in a draft report. [See Appendix 2: Summary of Existing Water Quality Data for Little Alamance Creek, Travis Creek, and Tickle Creek]

3.1 Benthic Macroinvertebrates Monitoring

Biological sampling, including benthic macroinvertebrate and fish community monitoring, was conducted in Little Alamance Creek from 1985 to 2003, with most samples collected in 2003. Little Alamance has rated either Poor or Fair at all sites since 1985. Little Alamance Creek at SR 2309 was sampled three times for fish in the past. It rated Good in 2003, Fair in 1998, and Good in 1993 (See Table 3.1.1 below). Travis, Tickle, and Dry Creeks have not been sampled for benthic macro-invertebrates before thus no prior data is available. In addition, no fish community monitoring occurred in Travis, Tickle, or Dry Creeks

Table 3.1.1: Little Alamance Biological Monitoring, 1985-2003 (NCDENR, 2006)

			Bioclassification	
Waterbody	**Location**	**Date**	**Fish**	**Benthos**
L. Alamance Creek	SR 2309	6/23/2003	Full Scale	Fair
		2003	Good	No sample
		7/10/1998	No sample	Poor
		1998	Fair	No sample
		1993	Good	No sample
		7/29/1985	No sample	Fair
L. Alamance Creek	I-85 Frontage Rd.	6/23/2003	No sample	Poor
L. Alamance Creek	NC 49	6/23/2003	No sample	Poor
L. Alamance Creek	Overbrook Rd.	6/24/2003	No sample	Poor

3.2 Water Chemistry Monitoring

Very little monitoring for water chemistry parameters has been conducted in either watershed in the past. A few sites along Travis Creek were monitored from 1968 to 1978, with results obtained for nutrients, fecal coliform bacteria, water temperature, specific conductance, and dissolved oxygen. Findings revealed violations of the water quality standard for dissolved oxygen and high concentrations of fecal coliform bacteria. The NC Division of Water Quality has hypothesized that these values are due more to non-point source pollution than discharges from municipal or industrial sources. (NCDENR, DWQ, 2006b)

There is only one monitoring station on Little Alamance Creek, which is still in use and currently monitored by the Upper Cape Fear River Basin Association. Results from this station, dating back to 1978 and running through the present, also suggest that non-point sources are affecting the water chemistry in the creek, as well as point sources, including a City of Greensboro wastewater treatment plant discharging into North Buffalo Creek, outside of the watershed planning area. (NCDENR, DWQ, 2006b).

Section 4: Current Land Use

4.1 Watershed Population

According to 2000 US Census data, the Little Alamance watershed had a population of 27,581 and the Travis and Tickle watershed had a population of 11,320. The Piedmont Triad Council of Governments utilized data from its Regional Data Center to estimate population amounts in 2005; data values were 29,512 for Little Alamance and 11,852 for Travis and Tickle.

4.2 Watershed Land Uses

Land use data for both Travis and Tickle Creeks and Little Alamance Watersheds were compiled by gathering tax parcel, zoning, and when available, land use GIS layers directly from several different municipalities as well as Alamance and Guilford Counties. Land use was compiled to help characterize how parcels in the watersheds are being used. Additionally, in later planning phases, this data will be helpful in understanding how growth and policy decisions will impact parcels in the study area.

The analysis proved challenging, as each municipality has varying extents of land use data, and all have slightly different categories of use. The Travis and Tickle Creek Watershed analysis required analyzing data from Burlington, Elon, Gibsonville, Ossippee, Alamance County and Guilford County. The Little Alamance Watershed land use analysis required analyzing data from Burlington, Graham, and Alamance County.

It was decided to combine specific uses into general categories for this phase of the Watershed Plan to provide some categorical continuity among the different local governments. For example, Guilford County's Rural Single Family Residential and General Single Family Residential categories were combined into the Single Family Residential category. The general categories chosen include Agriculture, Commercial, Industrial, Institutional, Mobile Homes, Mobile Home Parks, Multifamily, Office, Open Space/Recreational, Single Family Residential, and Vacant.

4.2.1 Little Alamance Creek Watershed Land Use

The Little Alamance Creek Watershed is much more urban in nature with 59.7% of the area developed as Single Family Residential. Industrial uses make up 12.4% of the area, being second in percentage. Industrial and Commercial uses are clustered mainly around Interstate 40 and the major thoroughfares in the study area. [See Map Appendix 6: Existing Land Use]

Table 4.2.1 Little Alamance Creek Watershed Land Use

Type	Acreage	Percentage
Agriculture	318	3.6%
Commercial	565.5	6.6%
Industrial	1082.1	12.4%
Institutional	171.1	1.9%
Mobile Homes	2.9	0%
Multifamily	545.3	6.2%
Office	226.6	2.6%
Open Space / Recreational	256.9	2.9%
Single Family	5233	59.7%
Vacant	360.4	4.1%
Total Acreage in Parcels	8761.8	100%

4.2.2 Travis and Tickle Creek Watershed Land Use

The predominant land use in this watershed proves to be Agricultural, making up 40% of the study area, with Single Family Residential being a close second with 37%. Agricultural uses are mostly spread throughout Alamance and Guilford Counties, with Single Family residential being more predominant closer to the cities of Elon, Burlington, and Gibsonville. [See Map Appendix 6: Existing Land Use]

Table 4.2.2 Travis and Tickle Creeks Watershed Land Use

Type	Acreage	Percentage
Agriculture	8443.2	40%
Commercial	369.9	1.7%
Industrial	435.8	2.1%
Institutional	896.1	4%
Mobile Home Park	169	0.8%
Mobile Homes	358.6	1.7%
Multifamily	7.6	0%
Office	25.4	0.1%
Open Space / Recreational	342.1	1.6%
Single Family	7738.2	37%
Vacant	2318.2	11%
Total Area Acreage in Parcels	21104.1	100%

4.3 Future Growth and Land Use Changes in Little Alamance and Travis and Tickle Watersheds

No comprehensive land development plans have been completed in either watershed, so future growth and land use changes have not been analyzed. Analysis of developable and undevelopable land will be completed in Phase II of the planning process.

Section 5: Review of Local Government Codes, Ordinances, Rules, and Programs

Important to watershed protection are current ordinances, rules and programs that affect water quality. There are varying levels of watershed protection, depending on municipality. The combined watersheds include the following municipalities and counties: Alamance County, City of Burlington, Town of Elon, Town of Gibsonville, City of Graham, and Guilford County.

These Section and subsections summarize the key findings from the Little Alamance, Travis, and Tickle Creeks (LATT) Watershed Survey conducted in September 2006. The survey was adapted from a survey drafted by the Center for Watershed Protection. The survey explored various zoning, subdivision and development ordinances. In addition, land use, growth management, and floodplain management plans were culled for different approaches affecting water quality. Also explored were the capital improvement, transportation, parks and recreation plans when available. In addition, some municipalities had specific ordinances and plans for farmland preservation and open space protection.

While not discussed here, Everett Jordan Reservoir and all lands and waters within its watershed, including Little Alamance, Travis and Tickle Creeks, have been classified as Nutrient Sensitive Waters (NSW). As such, the State has developed requirements intended to restore and maintain nutrient-related water quality standards in the Reservoir and protect its classified uses including that as a drinking water supply. The requirements by the State are proposed to become effective in 2008. These requirements will strictly limit runoff from new and existing development, lower that from agriculture, and protect riparian buffers and wetlands. More information on the proposed requirements can be found online at http://www.ptcog.org/jordanrules.html.

The summary of watershed protection measures and ordinances are grouped into the seven categories found in Table 6.1.1 below. Municipalities and counties partially or wholly in the watershed received a survey organized into the sections found in Table 5.1 below.

Table 5.1 Watershed Protection Tools

Watershed Protection	Technique Description
Watershed Planning	The application of regulatory measures and/or planning techniques that are designed to maintain or limit future impervious cover, redirect development where appropriate, and protect sensitive areas.
Land Conservation	Programs or efforts to conserve undeveloped, ecologically sensitive areas or areas of historical, recreational, or cultural value.
Aquatic Buffers	The protection, restoration, creation, or reforestation of stream, wetland, or lake buffers.
Better Site Design	Local ordinances and codes that incorporate techniques into new and redevelopment sites to reduce impervious cover and/or direct runoff onto pervious surfaces.
Erosion and Sediment Control	The use of erosion control, sediment control, and dewatering practices at all new development and redevelopment sites.
Stormwater Management	The incorporation of structural practices into new or re-development of the existing landscape to help mitigate the impacts of stormwater runoff on receiving waters.
Non-Stormwater Discharges and Stewardship	Locating, quantifying, and controlling non-stormwater pollutant sources in the watershed. Operation and maintenance practices that prevent or reduce pollutants entering the municipal or natural drainage system (e.g. illicit discharges, sand-type wastewater filters). Education or outreach programs fostering a behavior that reduces pollution over a range of uses and activities.

For this section, the discussion of ordinances, rules and programs for the Little Alamance, Travis and Tickle Creek watersheds will be split into two sections. The first section will discuss watershed protection rules for Little Alamance Creek watershed including Alamance County, the City of Burlington and the City of Graham and the second section will discuss watershed protection for the Travis and Tickle Creek watershed including Guilford County, the Town of Gibsonville, the Town of Elon and Alamance County.

5.1 Little Alamance Creek Ordinances, Rules and Programs

Burlington contains the headwaters and the bulk of Little Alamance Creek. Lower in the watershed, it also flows through the City of Graham and Alamance County as it meanders from northwest to southeast, finally emptying into the Big Alamance Creek, then the Haw River. The development around the Creek is primarily urban, but becomes less developed as it gets closer to the Haw River.

5.1.1 Watershed Planning

This subsection will discusses the application of regulatory measures (i.e., zoning and subdivision regulations) and planning techniques (i.e., comprehensive and land development planning) that are designed to maintain or limit future impervious cover, redirect development where appropriate, and protect sensitive areas. The three jurisdictions Little Alamance Creek flows through create a patchwork pattern of regulations and ordinances protecting the watershed.

A. Comprehensive and Land Development Planning

The City of Burlington's comprehensive plan was adopted in 1991 and addressed planning up until 2000. Future land development and transportation should be addressed through an updated, but as of yet unwritten, comprehensive plan that addresses future growth. The outdated comprehensive plan evaluates and accounts for the impacts of future land use on water resources. Part II - Goals and Policies; Section 4 - Environmental Quality (p.57) of the Burlington Comprehensive Plan addresses the natural environment, water resources, floodplain and stormwater management. The policies are general, but extensive in calling for the protection of the natural environment and development's effect on water resources. The updated plan should clarify specific recommendations and regulations for development in this section, i.e. specific buffer widths adjacent to streams or a goal for the number of acres to be acquired per year for the protection of environmentally sensitive areas. (Burlington, 1991)

The City of Graham has a Growth Management Plan (GMP) for the years 2000-2020 to guide its growth in the Little Alamance Creek watershed. Section 3.3 - Development Factors in the Graham GMP has a short paragraph on watershed protection and how these watersheds should be protected. This section also indicates that there are no Water Supply Watersheds (Class I-IV) in the City of Graham, which allows for less stringent watershed protection regulations. (Graham, 2000)

Alamance County has no comprehensive plan to guide development currently, which makes future planning difficult absent a guiding document.

B. Transportation Planning

The Burlington-Graham Urban Area Metropolitan Planning Organization is the agency responsible for future transportation planning for Alamance County and all the municipalities within the county and the Town of Gibsonville in Guilford County. The 2005-2030 Burlington-Graham MPO Transportation Plan Update addresses a number of transportation issues facing the metropolitan area. The transportation plan identifies a number of roadways in the watershed that will be over capacity and require widening by the year 2030. There are two roads in the watershed that were over-capacity in 2003 and will require improvements to decrease congestion and increase the automobile level of service. (Burlington-Graham MPO, 2005)

Transportation issues are important to mention for the purposes of this study, because a number of roads are planned or are being planned for the watershed area. There are over 10 miles of road widening projects included on the State Transportation Improvement Plan currently, which does not include projects that may be proposed for the 2014-2020 STIP and beyond. (NCDOT, 2007)

C. Zoning

The Little Alamance watershed is not classified as a water supply watershed. Big Alamance Creek does supply drinking water to the City of Burlington, but Lake Mackintosh lies upstream from the convergence of Little and Big Alamance Creek. The absence of a drinking water supply watershed regulation offers little protection of open space or reductions in impervious surface cover called for under drinking watershed protection. The Little Alamance lies within the Balance of Watershed district for

Alamance County. The prohibited uses in the Balance of Watershed (BOW) district as determined by the Alamance County Watershed Ordinance are: 1) sites for land application of residuals or petroleum contaminated soils, 2) discharging landfills and 3) storage of hazardous materials unless a spill containment plan is implemented. In addition, no lots can be less than one acre and the built-upon area must not exceed twelve percent (12%) of the lot area. Any number of uses can be accommodated, but multi-family, community business or industrial purposes are required to obtain a zoning permit from the County's Zoning Administrator before a building permit is issued. (Alamance, 2004)

The City of Burlington and City of Graham have a number of different zoning districts. The City of Burlington has 6 residential, 2 multi-family, 3 business, 4 industrial, 1 office-institutional, 1 planned employment center and 6 conditional use districts, including mixed use residential and commercial. The Western Loop Planning Area is a special overlay for the area around the proposed western loop. The City of Graham has 5 different residential, 3 business, 2 industrial districts, 1 office/institutional and conditional residential, business, industrial and office/institutional and mixed use (residential and office) districts. There are two overlay districts including a planned unit development and historic district overlay.

Most of the zoning districts mentioned above for Alamance County, City of Burlington and Graham exist within the concerned watershed area.

5.1.2 Land Conservation

This subsection will discuss programs or efforts to conserve undeveloped, ecologically sensitive areas or areas of historical or cultural value. There is little protected land within the watershed, excluding some municipal parks and a handful or parcels participating in the voluntary agriculture district program. There are a number of larger parcels of land in the southern portion of the watershed, wherein open space and agricultural preservation efforts may prove cost effective.

A. Floodplain regulations

All of the jurisdictions in the Little Alamance Creek watershed participate in the National Flood Insurance Program. The City of Graham requires development to be two feet above the federal (NFIP) minimums shown on the September 6th, 2006 federal flood insurance maps.

B. Preservation of agriculture

The City of Burlington does not encourage or require the protection of agriculture. The City of Graham encourages the protection of agricultural lands with a designation in their Growth Management Plan of certain districts as rural or agricultural. Alamance County has no comprehensive plan to guide development, but does have a purchase of development rights (PDR) system and a farmland preservation fund, both set up in the fall of 2006. The County also has a Voluntary Agriculture District Program with 198 tracts and nearly 11,000 acres enrolled county-wide.

C. Steep slopes and wetlands preservation above and beyond state and federal regulations

The only jurisdiction to provide protection above and beyond state or federal regulations is the City of Burlington. With no specific slope, Burlington Erosion and Sediment Control Ordinance 31.5-5 (b) requires that "graded slopes and fills shall be no greater than the angle which can be retained by vegetative cover or other adequate erosion control devices or structures". After 21 days from grading, the slope must be demonstrated as stable and the temporary or permanent ground cover must control erosion. (Burlington)

5.1.3 Aquatic Buffers

This subsection describes the protection, restoration, creation, or reforestation of stream, wetland or lake buffers. The North Carolina State Forestry Best Management Practices guidelines offer a number strategies and management techniques to establish and maintain good quality aquatic buffers via forestation techniques.

A. Lake and stream buffer widths and restoration programs

There are varying levels of stream buffer widths required in the Little Alamance watershed. There is a 50 foot buffer requirement on all perennial and intermittent streams within the City of Graham. Greenway trails are allowed in the buffer, but only after approval by the Graham City Council. Otherwise, the buffer area must remain undisturbed. Currently the City of Burlington has no buffer requirement on the Little Alamance creek or its tributaries. The 50 foot buffer requirements for the City of Burlington and Alamance County are only for water supply watersheds. Alamance County provides for 50 feet of undisturbed buffer on all perennial streams in the County Subdivision ordinance.

The buffer of protection for water supply lakes and ponds is 100 feet for Alamance County, as mentioned above, there are no water supply lakes in the Little Alamance Creek watershed. Discussed further below, Graham's open space requirements mention 30 foot buffering from bodies of water and watercourses. The City of Burlington currently has no protection of lakes or ponds, however the Stormwater Phase II ordinance under development will have protection of lakes, ponds and streams.

5.1.4 Better Site Design

This subsection discusses local ordinances and codes that incorporate techniques into new and redevelopment sites to reduce impervious cover and/or direct runoff onto pervious surfaces. There are very few requirements for low impact design (LID) or open space designation in the two watersheds. There are some encouraging ordinances that allow for LID and open space preservation, but the ordinances only go so far as to encourage, rather than mandate open space or pervious surfaces in all developments.

A. Low impact development techniques

Low impact development techniques include regulations or ordinances such as cluster development, open space requirements or pervious surface ordinances. Allowing these development techniques is a first step, encouraging these techniques through incentives over conventional building techniques or requiring certain techniques is a more effective

and rewarding step. None of the jurisdictions employ low impact developments in their ordinance.

B. Parking lot regulations and landscaping

The Alamance County Subdivision Ordinance mentions nothing about parking lot design or the inclusion of landscaping. The City of Graham Development ordinance allows dust free, pervious surface for overflow parking and also has fairly detailed landscaping regulations. The City of Burlington allows flexibility in the materials used for overflow parking and also requires one canopy tree for every 12 parking spaces. (Alamance County Subdivision Ordinance, 2005).

C. Open space design and management

The Alamance County Subdivision Ordinance allows for cluster development to be designed and built, but the density of the overall development must remain at 1 development unit per acre (du/ac) for single family development. The minimum lot size within Alamance County is 1 acre, except when cluster development is used. (Alamance, 2005)

The City of Graham has a number of ways to incorporate open space in development. The City of Graham Development Ordinance specifies open space requirements in 3 different sections: Section 10.131 (Conditional Residential Zonings), Section 10.168 (Planned Unit Development Open Space Requirements), and Section 10.249 (Open Space for R-12, R-15, and R18 Zoning Districts). (Graham, 1999)

The Conditional Residential Zoning applies to >5 acre developments and allows for an undesignated amount of open space to be creatively incorporated into any new developments. Table 5.1.4 explains the open space requirements for Planned Unit Developments.

Table 5.1.4 Planned Unit Development Open Space Requirements (City of Graham Development Ordinance, Section-10.168)

Number of Acres in PUD	Percent of PUD in Open Space
3 to 49	5.0
51 to 75	7.5
76 to 100	10.0
101 and above	15.0

The Graham Development Ordinance open space requirements for R-12, R-15 and R18 Zoning District lots are 16,000, 13,000 and 10,000 square feet respectively. This section of the ordinance goes on to instruct the developer where open space should be preserved, for example floodplain buffers, buffers from water bodies, environmentally sensitive areas and lands that protect view sheds. (Graham, 1999)

5.1.5 Erosion and Sediment Control

This subsection discusses the use of erosion control, sediment control, and dewatering practices at all new development and redevelopment sites within the three municipalities within the watershed. The state has a fairly rigorous erosion and sediment control program, with an extensive field manual for design and implementation of controls and measures. The Division of

Land Quality in the Department of Environment and Natural Resources updates the field manual and employs inspectors to enforce rules and regulations based upon the North Carolina Sedimentation Pollution Control Act passed in 1973 and amended in 1989. (NCDENR DLQ, 1991).

A. Sediment and erosion control practices

All of the three municipalities in the watershed use the North Carolina Erosion & Sedimentation Control Design Manual when directing developers during new development or redevelopment that exceeds 1 acre. In addition to specifications and installation instructions on different erosion and sediment control practices, the Design Manual discusses the following:

- sedimentation control law;
- principles of erosion and sediment control;
- vegetation that can be used for erosion control;
- how to develop an approved erosion and sedimentation control plan; and
- inspection checklist for site evaluation and how to remedy and report deficiencies.

Developers or construction crews create a Sedimentation Control Plan prior to construction and is submitted during the site plan review process. Municipalities and their inspection staff review the Sedimentation Control Plan for accuracy and effectiveness and then a State Permit will be issued given a satisfactory Plan. The Plan will call for specific vegetation and manmade erosion and sedimentation techniques addressing steep cut and fill slopes, highly erodible soils, construction access routes, stream crossings, channels, water disposal spouts and any other critical areas. The Erosion and Sediment Control field manual will be updated with new requirements in early 2007.

B. Compliance and training efforts for erosion and sediment control

The City of Burlington uses a municipal inspector on a monthly basis to review sediment and erosion control measures. Burlington is considering trainings about erosion and sediment control for developers, contractors, engineers and inspectors in preparation for Phase II of stormwater regulations. Burlington will fine developers and withold the issuance of building permits or a certificate of occupancy when erosion and sedimentation control practices are violated.

Alamance County and the City of Graham call upon the State Division of Land Quality when there is a complaint about erosion or sediment flowing from a construction site. They levy the state minimum requirement of fines upon developers when the erosion control practices are ineffective or non-existent.

5.1.6 Stormwater Management Practices

This subsection discusses the incorporation of structural practices into new or re-development of the existing landscape to help mitigate the impacts of stormwater runoff on receiving waters. The stormwater management system for the City of Graham and Burlington is best described as a mixture of open channels and storm drains. Neither City has an affirmative handle on the percentage of each. There is an attempt to map the stormwater system in both municipalities currently. Any stormwater systems within Alamance County are best described as open channels and ditches primarily along roadways.

A. Required stormwater practices

None of the three jurisdictions currently require stormwater practices on new development in the Little Alamance Creek watershed. The City of Burlington does require stormwater practices, but only in drinking water supply watersheds. The Phase II stormwater regulations will require practices on all new development, which will affect Alamance County, Burlington and Graham in the near future.

B. Design criteria

Alamance County currently does not have any ordinances related to stormwater. The City of Graham is working on a Post-Construction and Illicit Discharge Ordinance with a consulting firm; these regulations and others will be developed and sent to City Council in the Spring of 2007. Burlington Public Works Department refers developers, construction managers and engineers to the DENR Division of Water Quality Manual of Stormwater Best Management Practices for correct field application. The Burlington strategy for stormwater management is to control the volume of runoff, incorporating more infiltration practices reducing the amount of stormwater treated mechanically. (NCDENR DWQ, 1999)

C. Inspections, maintenance, funding agreements and responsible parties

The City of Graham and Burlington inspect stormwater practices during construction. The City of Graham requires as-built drawings of all utilities before the Final Plat is recorded. In both cities, the private owner or homeowner association is responsible for the maintenance of stormwater practices. The City of Graham has included a requirement that Homeowner Associations include a note acknowledging the responsibility of maintenance to the stormwater system recorded with the Final Plat. Stormwater systems in the two cities are inspected in response to complaints.

5.1.7 Non-Stormwater Discharges and Stewardship

This subsection describes programs for locating, quantifying, and controlling non-stormwater pollutant sources in the watershed. The operation and maintenance practices that prevent or reduce pollutants entering the municipal or natural drainage system (e.g. illicit discharges, sand-type wastewater filters) is covered.

A. Sewer system structure

Alamance County has no sewer system and the extra territorial jurisdictions around the City of Graham and Burlington that lay within the concerned watershed hook into the Graham and Burlington sewer systems where available. That being said, there are a number of larger lots in the southern part of the watershed (south of Interstate 40/85) that are using septic systems. The enforcement of proper septic system function is performed by the County Health Department. Complaints will initiate a response and the Health Department may choose to fine residences whose systems are not functioning properly.

The City of Graham and Burlington both use centralized wastewater treatment plants. The main trunk lines are gravity fed where possible, following stream valleys to treatment facilities. The City of Graham uses Burlington's main trunk lines for carrying its sewer waste.

Phase II Stormwater regulations will include regulations for illicit connection detection to sewer and stormwater systems. The City of Graham is considering levying fines in response to violations for illicit discharge in the Spring of 2007 in advance of Phase II mandates.

B. Agriculture and animal feed lots

There are regulations for runoff from animal feeding lots in Alamance County and the City of Graham and Burlington defer to the County when controlling runoff from feed lots and other agricultural lands. Alamance County follows the State O200 animal regulations with regards to animal feed lots and waste regulation. The County encourages rotational grazing, off-stream water sources for drinking, exclusionary fencing to keep animals out of stream beds. The County utilizes the North Carolina Agriculture Cost Share Program and the USDA EQIP program to preserve natural resources. Participation in any benefits program requires a site specific conservation plan to preserve land and water quality.

C. Hazardous waste and spill response

Alamance County deals with hazardous waste in the City of Burlington. Once a year, all county residents can take household hazardous waste to the Burlington fire training center. The County Emergency Management Department handles spill response, prevention and clean-up. The City of Burlington also has its own city-wide spill response plan.

D. Golf course, pet and lawn care waste regulations

There are no regulations with regards to pet waste in Burlington or Alamance County. The City of Graham uses signage at its parks and provides bags to pick up pet waste at three pet waste stations. The City of Burlington attempts to minimize the use of fertilizers on its park facilities and grass medians. Excess fertilizer spilling on paved surfaces is blown back onto the grassy areas. Pesticides and herbicides are used on Burlington's athletic fields, but the use is kept to a minimum. County parks and golf courses use both pesticides and fertilizers.

5.2 Travis and Tickle Creek Ordinances, Rules and Programs

There are four jurisdictions in the Travis and Tickle Creek Watersheds. Alamance County, Guilford County, the Town of Gibsonville and the Town of Elon jurisdiction encompass the Travis and Tickle Creek Watershed area. The Tickle and Travis Creeks originate in Guilford County and flow eastward emptying into the Haw River in the north central area of Alamance County. This watershed includes perennial and intermittent streams on the northeast side of the Haw River, many of which are unnamed. A few parcels from the City of Burlington and the Town of Ossipee have intermittent streams flowing into the watershed, but are not considered in this analysis.

5.2.1 Watershed Planning

This section discusses the application of regulatory measures (i.e., zoning and subdivision regulations) and planning techniques (i.e., comprehensive and land development planning) that are designed to maintain or limit future impervious cover, redirect development where appropriate, and protect sensitive areas. The four jurisdictions that the Travis and Tickle Creek watershed contains create a patchwork pattern of regulations and ordinances protecting the watershed.

A. Comprehensive and Land Development Planning

Guilford County completed a comprehensive plan in the fall of 2006. There are five elements to the Comprehensive Plan and each element lists goals, objectives and policies. The major elements are; 1) future land use, 2) transportation, 3) housing, 4) governmental coordination and 5) natural, historic, and cultural resources element. This plan identifies a number of policies geared at protecting water resources, land management and collaboration with other municipalities on enforcing regulations to protect natural resources. Protecting natural resources, the comprehensive plan spells out well over 40 specific policies from open space preservation and infill development to speeding up the process of responding to erosion control complaints. (Guilford, 2006)

The Town of Elon completed a Land Development Plan in 2002 to address issues of future land use and future growth. Goals and policies of the Elon Land Development Plan are designed to:

- lessen congestion in the streets
- secure safety from fire, panic, and other dangers
- promote the health and general welfare
- provide adequate light and air
- prevent overcrowding of land
- avoid undue concentration of population
- facilitate the adequate provision and economic provision of transportation, water, sewerage, schools, parks, and other public requirements conserve the value of buildings
- encourage the most appropriate use of land within the Town's corporate limits and its extraterritorial planning and zoning jurisdiction.

In addition, the Land Development Plan of 2002 for Elon had four community building principles, one of which includes clustering development, while preserving open space, buffering streams and water bodies. (Elon, 2002)

The Town of Gibsonville completed a Land Development Plan in 2001. The plan looks ahead 20 years to guide the development of Gibsonville. Environment is the first goal in the list of goals to guide future development. There are two major objectives to protect natural resources: 1) protection of wetlands, waterways, slopes and floodplains and 2) encouraging the restoration of creeks and streams to control stormwater runoff. (Gibsonville, 2001)

Alamance County has no comprehensive plan to guide development currently, which makes future planning difficult absent a guiding document.

B. Transportation Planning

The Burlington-Graham Urban Area Metropolitan Planning Organization is the agency responsible for future transportation planning for Alamance County and all the municipalities within the county and the Town of Gibsonville in Guilford County. The Greensboro Metropolitan Planning Organization is responsible for planning in Guilford County, excepting Gibsonville. The 2005-2030 Burlington-Graham MPO Transportation Plan Update addresses a number of transportation issues facing the metropolitan area. (Burlington-Graham MPO, 2005)

The State Transportation Improvement Program (STIP) identifies one major road widening project in the watershed along NC-87, but this project is not fully funded in the current STIP. (NCDOT, 2007)

C. Zoning

The Travis and Tickle Creek watershed is not classified as a water supply watershed. The absence of a drinking water supply watershed regulation offers little protection of open space or reductions in impervious surface cover called for under drinking watershed protection.

Guilford County has 29 zoning districts and 7 overlay districts. The Travis and Tickle Creek watershed has no specific performance standards enumerated in the Guilford County Development Ordinance. Guilford County has two watershed overlay districts, the Watershed Critical Area (WCA) and the General Watershed Area (GWA), which is applied to 9 different watersheds, all regional drinking supply watersheds. The Travis and Tickle Creek watershed does not supply drinking water; therefore, these regulations do not apply. (Guilford, 2006)

The Town of Elon has 11 zoning districts and 3 overlay districts. There is a stream protection overlay, which provides a 50 foot buffer on perennial streams and 30 foot buffer on intermittent streams for all development.

The Town of Gibsonville has 23 zoning districts and 6 overlay districts. One of the overlay districts includes watershed protection, but there were no available details on this overlay district. Gibsonville ordinance allows cluster development, encouraging open space preservation through its zoning.

Alamance County has some regulation of development for what is called a Balance of Watershed (BOW) district. They have two other districts in their watershed protection ordinance, but all of the land in the Travis and Tickle Creek watershed is classified as BOW. The Alamance County Watershed Ordinance BOW district prohibits the following uses: 1) sites for land application of residuals or petroleum contaminated soils, 2) discharging landfills and 3) storage of hazardous materials unless a spill containment plan is implemented. In addition, no lots can be less than one acre and the built-upon area must not exceed twelve percent (12%) of the lot area. Any number of uses can be accommodated, but multi-family, community business or industrial purposes are required to obtain a zoning permit from the County's Zoning Administrator before a building permit is issued. (Alamance, 2004)

5.2.2 Land Conservation

This subsection discusses programs or efforts to conserve undeveloped, ecologically sensitive areas or areas of historical, recreational, or cultural value. There are a number of larger undeveloped parcels over 20 acres that may be considered for land conservation. A number of the agricultural landowners participate in the voluntary agricultural district program, providing some protection to land development.

A. Floodplain regulations

All of the jurisdictions in the Travis and Tickle Creek watershed participate in the National Flood Insurance Program. Guilford County requires one foot of height added above the federal base flood elevation minimum.

B. Preservation of agriculture

Guilford and Alamance County both encourage the preservation of agricultural districts and working lands. The voluntary agricultural district program is administered through the Soil and Water Conservation Offices for each county. As mentioned above Alamance County has no comprehensive plan to guide development, but the County has a purchase of development rights (PDR) system and farmland preservation fund established in the fall of 2006. Alamance also has a Voluntary Agriculture District Program with 198 tracts and nearly 11,000 acres enrolled county-wide.

The Town of Elon and Gibsonville do not have any ordinances with regards to agricultural preservation.

C. Steep slopes and wetlands preservation above and beyond state and federal regulations

The Town of Gibsonville does not allow any development in steep slope areas steeper than 2 to 1 in slope. Guilford County has regulations on steep slopes, but only in Watershed Critical Areas.

The Town of Elon is the only jurisdiction to have wetland preservation regulations above and beyond state and federal regulations. The Town requires additional buffering of wetlands during development over and above basic state requirements. The stream protection overlay mentioned above requires a 30 foot buffer along intermittent streams. The state buffer requirements are not required for intermittent streams.

5.2.3 Aquatic Buffers

This subsection discusses the protection, restoration, creation, or reforestation of stream, wetland or lake buffers. The North Carolina State Forestry Best Management Practices guidelines offer a number of strategies and management techniques to establish and maintain good quality aquatic buffers via forestation techniques. (NCDENR DFR, 2006)

A. Lake and stream buffer restoration and width requirements

There are no requirements for stream buffering above the state minimum of 30 feet in Guilford County, because the watershed does not fall into any special watershed area. If the minimum buffer is disturbed, the County requires reforestation of the buffer.

The Town of Elon, as mentioned above requires a 50 foot buffer on perennial streams and 30 feet on intermittent streams. Disturbing the buffer requires restoration of the buffer via reforestation and vegetation. There are no requirements for ponds or lakes.

The Town of Gibsonville ordinance requires that “no land disturbing activity be permitted in proximity to a lake or natural watercourse unless a buffer zone is provided…to confine visible siltation within 25% of the buffer zone nearer the land-disturbing activity”. There is

also a provision to protect stream banks and channels downstream from land-disturbing activity. (Gibsonville, 2002)

Alamance County provides for a 50 foot buffer on all perennial streams in the County Subdivision ordinance. The buffer of protection for water supply lakes and ponds is 100 feet for Alamance County, as mentioned above; there are no water supply lakes in the Travis and Tickle Creek Watersheds. (Alamance, 2005)

5.2.4 Better Site Design

This subsection discusses local ordinances and codes that incorporate techniques into new and redevelopment sites to reduce impervious cover and/or direct runoff onto pervious surfaces. There are very few requirements for low impact design (LID) or open space designation in the two watersheds. There are some encouraging ordinances that allow for LID and open space preservation, but the ordinances only go so far as to encourage, rather than mandate open space or pervious surfaces.

A. Low impact development techniques

Guilford County requires the completion of what is called a low impact development checklist in their development ordinance. The checklist, which is also found in the Town of Gibsonville's ordinance, awards points for land development design that preserves open space, reduces stormwater runoff with pervious surfaces, etc. If a certain level of points are not achieved, the development can then be reviewed by a board before moving forward.

In all of the municipalities in the Travis and Tickle Creek watersheds, clustering development is allowed, where a set aside of open space allows a density bonus for clustering the building lots in the same subdivision. Refer to each specific ordinance for the level of clustering that is allowed.

B. Parking lot regulations and landscaping

Municipalities within the Travis and Tickle Creek watershed allow pervious surfaces for parking spaces above what is required by ordinance. Alamance County does not have any requirements for parking lots or landscaping. Gibsonville has no requirements for landscaping around parking areas. Elon requires pervious parking surfaces to be dust free and has landscaping provisions for parking areas with 30 or more vehicles.

C. Open space design and management

Guilford County does allow cluster development within its jurisdiction. The open space requirements of cluster development and conventional development will vary. The Town of Gibsonville, in its Development Ordinance, requires 10% open space in standard residential development, but cluster development requires 15% when that option is utilized. The cluster development option can be used for 10 acres or more when sanitary sewer is available (Gibsonville, 2002). In the Alamance County watershed ordinance, there is a cluster development option for the Balance of Watershed (BOW) district, but the average overall density of a development must remain at one unit per acre, or in the case of multi-family residential development, the density is one building per acre (Alamance, 2004). The Town of Elon encourages cluster development and the preservation of open space. Depending on which planning district a development is in, the open space requirement can range from 15 – 30% in Elon.

5.2.5 Erosion and Sediment Control

This subsection discusses the use of erosion control, sediment control, and dewatering practices at all new development and redevelopment sites within the four municipalities within the watershed. The state has a fairly rigorous erosion and sediment control program, with an extensive field manual for design and implementation of controls and measures. The Division of Land Quality in the Department of Environment and Natural Resources (DENR) updates the field manual and employs inspectors to enforce rules and regulations based upon the North Carolina Sedimentation Pollution Control Act passed in 1973 and amended in 1989. (NCDENR DLQ, 1991)

A. Sediment control practices

Three of the four municipalities in the Travis and Tickle Watershed follow a state document for erosion and sediment control, the North Carolina Erosion & Sedimentation Control Design Manual when directing developers during new development or redevelopment. Any development or redevelopment that exceeds 1 acre. In addition to specifications and installation instructions on different erosion and sediment control practices, the Design Manual discusses the following:

- sedimentation control law;
- principles of erosion and sediment control;
- vegetation that can be used for erosion control;
- how to develop an approved erosion and sedimentation control plan; and
- inspection checklist for site evaluation and how to remedy and report deficiencies.

Developers or construction crews create a Sedimentation Control Plan prior to construction and is submitted during the site plan review process. Municipalities and their inspection staff review the Sedimentation Control Plan for accuracy and effectiveness and then a State Permit will be issued given a satisfactory Plan. The Plan will call for specific vegetation and manmade erosion and sedimentation techniques addressing steep cut and fill slopes, highly erodible soils, construction access routes, stream crossings, channels, water disposal spouts and any other critical areas. The Erosion and Sediment Control field manual will be updated with new requirements in early 2007.

Guilford County has a more rigorous set of requirements it uses for sediment control practices including more specifications on fill contents for silt fencing to reduce siltation and run-off, for example. The early 2007 requirements from a new state document will have better design guidelines for sediment traps and require the use of polymers and coagulants for soil treatment.

B. Compliance and training efforts for erosion and sediment control

Guilford County provides a brochure to developers and the general public that outlines specific guidelines with regards to erosion and sediment control practices. The County provides inspection services for all County developments. There are also trainings and education for developers and contractors in the County and in the Town of Elon, on erosion and sediment control. Gibsonville and Guilford County inspect construction sites weekly for violations and will issue fines as needed. The Town of Elon responds to compliance issues based upon complaints and will levy fines if needed.

Alamance County relies upon the State Division of Land Quality when there is a complaint about erosion or sediment flowing from a construction site. They levy the state minimum requirement of fines upon developers when the erosion control practices are ineffective or non-existent.

5.2.6 Stormwater Management Practices

This subsection discusses the incorporation of structural practices into new or re-development of the existing landscape to help mitigate the impacts of stormwater runoff on receiving waters. Many of the stormwater practices of these municipalities will be forced to change when the Phase II stormwater regulations are enforced in 2007.

A. Required stormwater practices

Alamance County is the only municipality that does not require stormwater practices. There are no stormwater ordinances in place, but Phase II stormwater requirements will require the County to set up ordinances and regulations with regards to stormwater. The other three municipalities in the Travis and Tickle Creek watershed require a stormwater plan for proposed development.

B. Design criteria

Guilford County has a Water Quality Protection Manual it shares with developers and contractors (Guilford, 2002). The State DENR Division of Water Quality has recently published a Best Management Practices (BMP) Manual on Stormwater, which will be used in the future for Guilford County. The Town of Elon and Gibsonville use the BMP Manual for design criteria. (NCDENR DWQ, 1991)

C. Inspections, maintenance, funding agreements and responsible parties

The maintenance and inspections of stormwater varies by municipality. The Town of Gibsonville has its engineering staff inspect stormwater practices during construction. Annually, the Town will inspect stormwater facilities and may require the builder to fix any problems with the stormwater management system. There is not a fine structure in place to address dysfunctional systems.

Guilford County encourages a pre-construction meeting with the owner, contractor and engineer of a development project. The engineer is responsible for setting up a stormwater management device(s) effectively. When the project is complete, Guilford County does a final inspection and records that certification with the long term maintenance program. Guilford County also inspects stormwater facilities after construction annually and in response to complaints. If the facility is not functioning properly, the owner or homeowner's association will be responsible for making the facility functional again or may face a $200/day/violation fine. The fine may be enforced through a maintenance agreement with the private owner or homeowner's association.

The Town of Elon inspects stormwater during construction and a stormwater plan needs to be recorded with the property. Privately maintained stormwater practices are inspected, but only in response to complaints. There is a fine system in place to address problems with stormwater systems, but there is no maintenance agreement to serve as record of responsibility.

5.2.7 Non-Stormwater Discharges and Stewardship

This subsection describes programs for locating, quantifying, and controlling non-stormwater pollutant sources in the watershed. The operation and maintenance practices that prevent or reduce pollutants entering the municipal or natural drainage system (e.g. illicit discharges, sand-type wastewater filters) is covered.

A. Sewer system structure

Alamance County does not have any sewer system set up. A few locations in the County have a package treatment plant, but none in the watershed. The southern part of Travis and Tickle Creek watershed provides the bulk of sewer service and all wastewater flows to the City of Burlington for processing. The sanitary system lines follow either the shortest distance or stream valleys depending upon the location. Guilford County is the only municipality in the watershed that requires an illicit connection detection program. There are fines that can be levied after a period of time to come into compliance has expired. Guilford and Alamance County Health departments conduct any inspections of privately maintained septic systems and small package system plants.

B. Agriculture and animal feed lots

Alamance County follows State O200 Animal regulation with regards to stormwater runoff from confined animal feeding lots. The other three municipalities do not have any requirements with regards to animal feeding lots. Alamance County has a number of watershed protection practices it encourages farmers to use, including rotational grazing, using off-stream water sources and exclusionary fencing around riparian buffers and streams. The county encourages and assists farmers enrolling with the North Carolina Agriculture Cost Sharing and the USDA EQIP programs.

C. Hazardous waste and spill response

All of the municipalities in the watershed have a spill response plan. Each County also has a hazardous waste program where residents can take their hazardous waste to central location to be disposed of once or twice a year. The Burlington Fire training is the Alamance County location for hazardous waste drop-off. Guilford County did not report a specific location to dispose of hazardous waste.

D. Golf course, lawn care and pet waste regulations

None of the golf courses in the four municipalities in the Travis and Tickle Creek watershed have any regulations to reduce non-point source pollution from golf courses. In Alamance County education on pesticide application and fertilizer reduction is offered through the Cooperative Extension service. There are no regulations on pet waste in this primarily rural watershed. In all four municipalities fertilizers are used on public parks and golf courses. In addition, Alamance County, Guilford County and the Town of Gibsonville use pesticides as well.

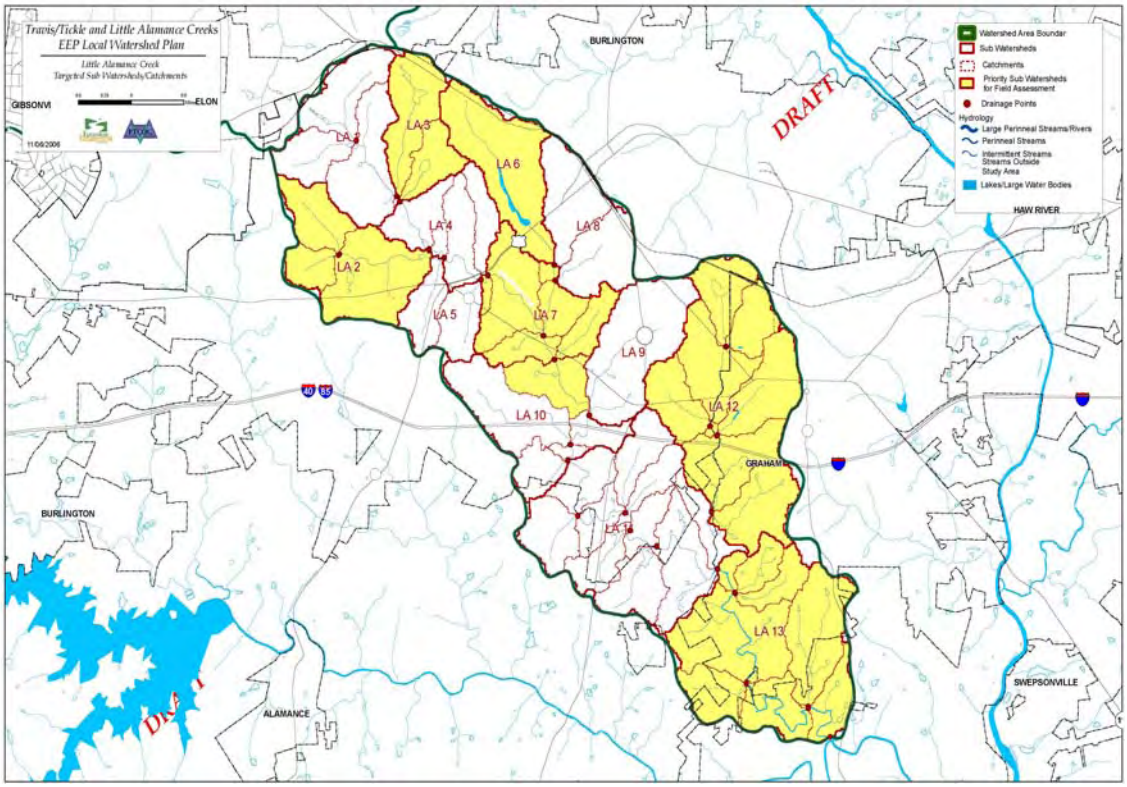
Section 6: Recommendations for Phase II Field Assessment Activities

Based on the Community Stakeholder feedback, survey of existing water quality data, and the need to address existing impairments, a number of monitoring and field activities have been proposed for Phase II of the Watershed Planning process. These include in-stream and upland field assessments using the Unified Stream Assessment (USA) and Unified Subwatersheds and Site Reconnaissance (USSR), developed by the Center for Watershed Protection, will be completed (Schueler and Kitchell, 2005). These assessments will be concentrated in priority subwatersheds as identified by stakeholders.

6.1 Little Alamance Watershed Field Assessment Activities

In the Little Alamance watershed, it is recommended that the USA and USSR be conducted in subwatersheds LA 2, LA 3, LA 6, LA 7, LA12, and LA 13 as well as a small catchment area in subwatershed LA 10 at the base of subwatershed LA 7. In stream and upland assessments in the Little Alamance Watershed will cover 17 miles of perennial and intermittent streams, and 8 square miles of upland area. This level of work covers approximately 52% of the watershed.

Map 6.1.1: Little Alamance Creek Targeted Sub Watersheds



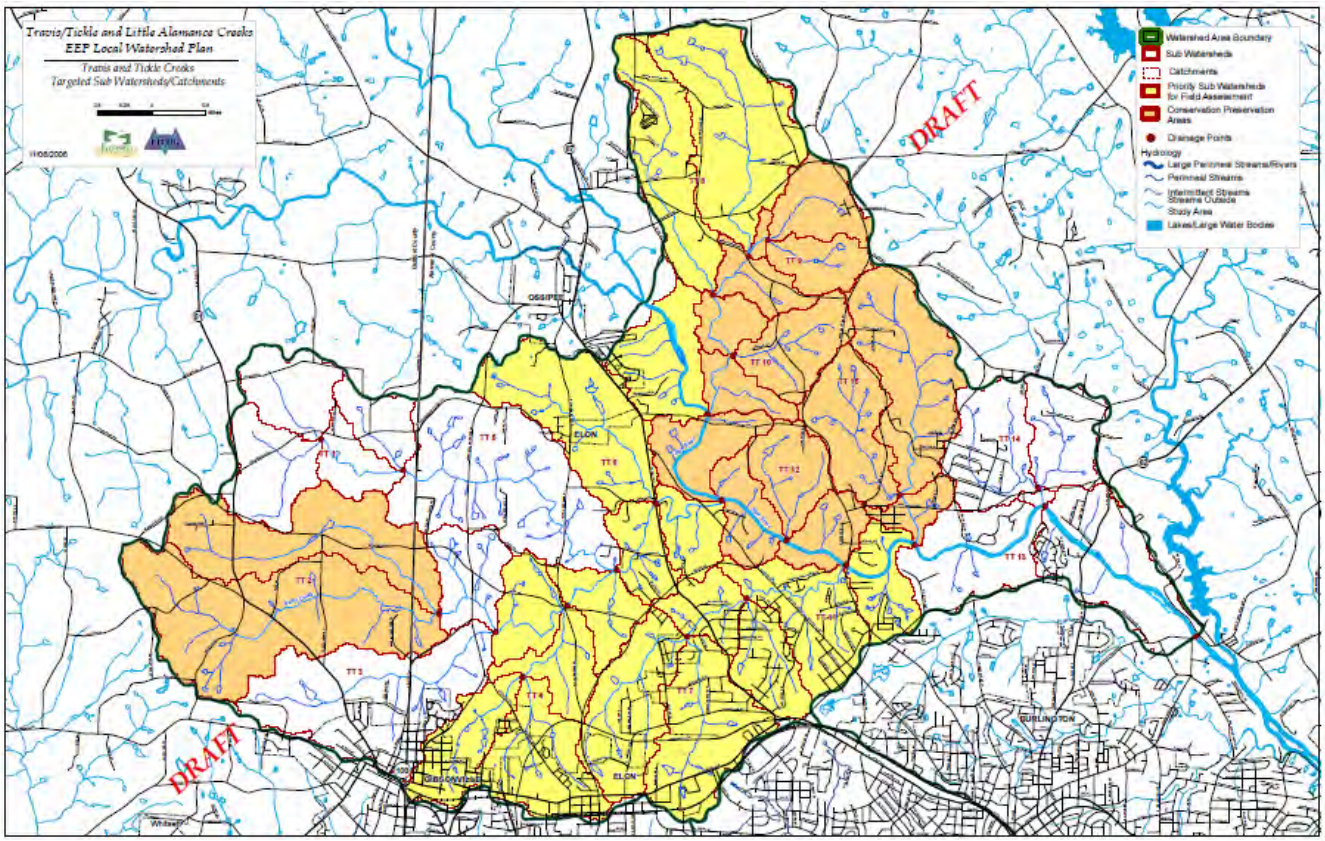
6.2 Travis & Tickle Creek Watershed Field Assessment Activities

In the Travis and Tickle Creek (TT) watershed, the USA and USSR will be conducted in subwatersheds TT 4, TT 7, TT 8, TT 11, and TT 6 to assess over 12 miles of perennial streams and 10.4 square miles of upland area.

In addition to the in-stream and upland assessments in the Travis and Tickle Creek Watersheds, subwatersheds TT 2, TT 8, TT 9, TT 10, TT 12, TT 15, totaling 13 sq. miles of upland area, have been selected for upland reconnaissance for possible preservation, conservation, reforestation, and green space opportunities. These subwatersheds were identified in Phase I as having important resources warranting conservation consideration and will undergo field verification of land cover, wetlands, and riparian buffers. When appropriate, an upland assessment of hotspots, reforestation opportunities, or restoration possibilities will be undertaken. In total, the level of effort will cover approximately 70% of the land area in Travis and Tickle Creek.

If in-stream and/or upland investigations indicate a need, field teams will expand the field assessment activities to additional intermittent/perennial streams and/or upland areas.

Map 6.2.1: Travis & Tickle Creek Targeted Sub Watersheds



6.3 DWQ Water Quality Monitoring Recommendations

The Division of Water Quality is proposing to monitor ten sites (Map 6.3.1, Table 6.3.1) in the Little Alamance, Travis and Tickle Creek (LATT) watershed. This monitoring will support the NC Ecosystem Enhancement Program's Local Watershed Planning (LWP) endeavors within these watersheds. Monitoring efforts will 1) address biological impairment of Little Alamance Creek, with the goal of identifying specific stressors that may be causing impairment, and 2) compare water quality among the several watersheds in this planning area. See Table 6.3.1 Proposed Monitoring Locations for more detailed information.

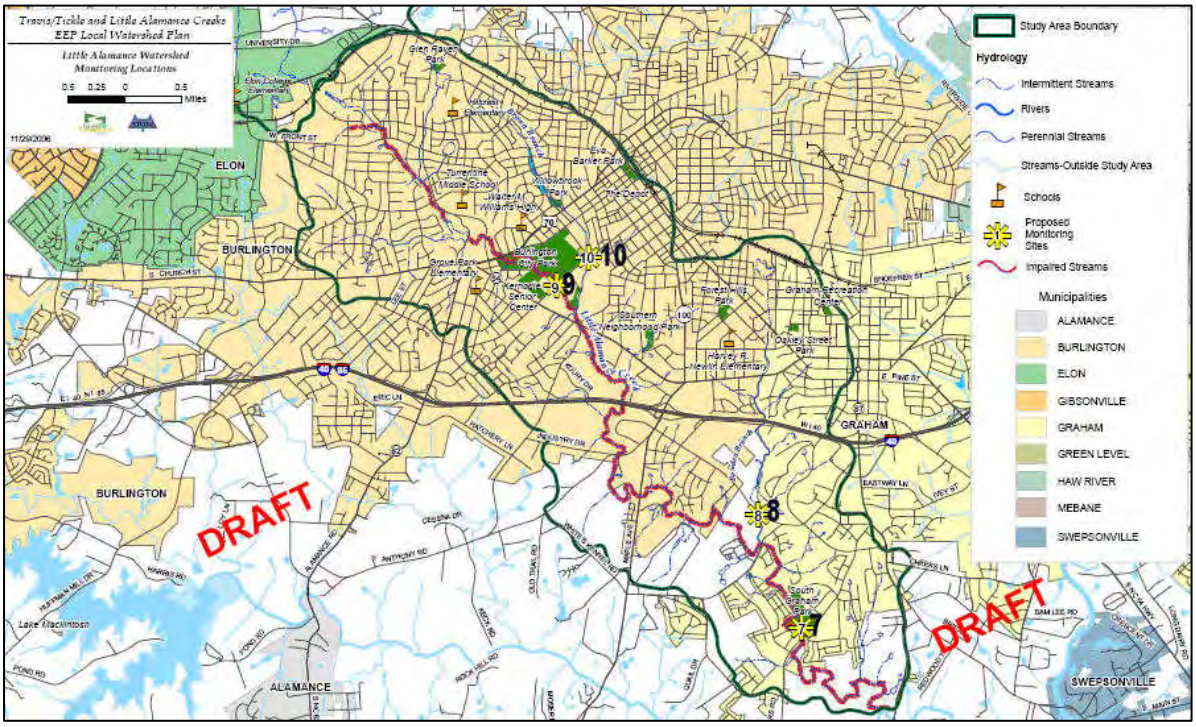
Data will be used to compare water quality among the several watersheds in this planning area and may allow comparisons of the effects of population density, land cover, construction activity, agricultural activity and other factors. This information will be useful to identify relatively unimpacted watersheds, as well as to identify water quality problems. Another objective will be to identify opportunities for stream restoration, storm water management and best management practices (BMPs).

In addition, DWQ personnel, as members of field assessment teams organized by the Piedmont Triad Council of Governments, will use the Unified Stream Assessment methodology to conduct stream corridor assessments. These assessments will cover all perennial streams in the Little Alamance subwatershed, while a subset of the Travis and Tickle Creek subwatershed will be targeted. The aim will be to identify possible stressors or other factors (e.g., upstream activities) that may be contributing to observed water quality problems. DWQ may perform additional sampling if conditions or activities warrant.

Besides providing evidence of watershed condition and stability, stream visual assessments will help to guide further field activities and assist with site identification for restoration and BMPs.

[See Appendix 4: Watershed Monitoring Plan - Phase II]

Map 6.3.1: Water quality monitoring locations in the Little Alamance Creek watershed.



Map 6.3.2: Water quality monitoring locations in the Travis/Tickle Creek watershed.

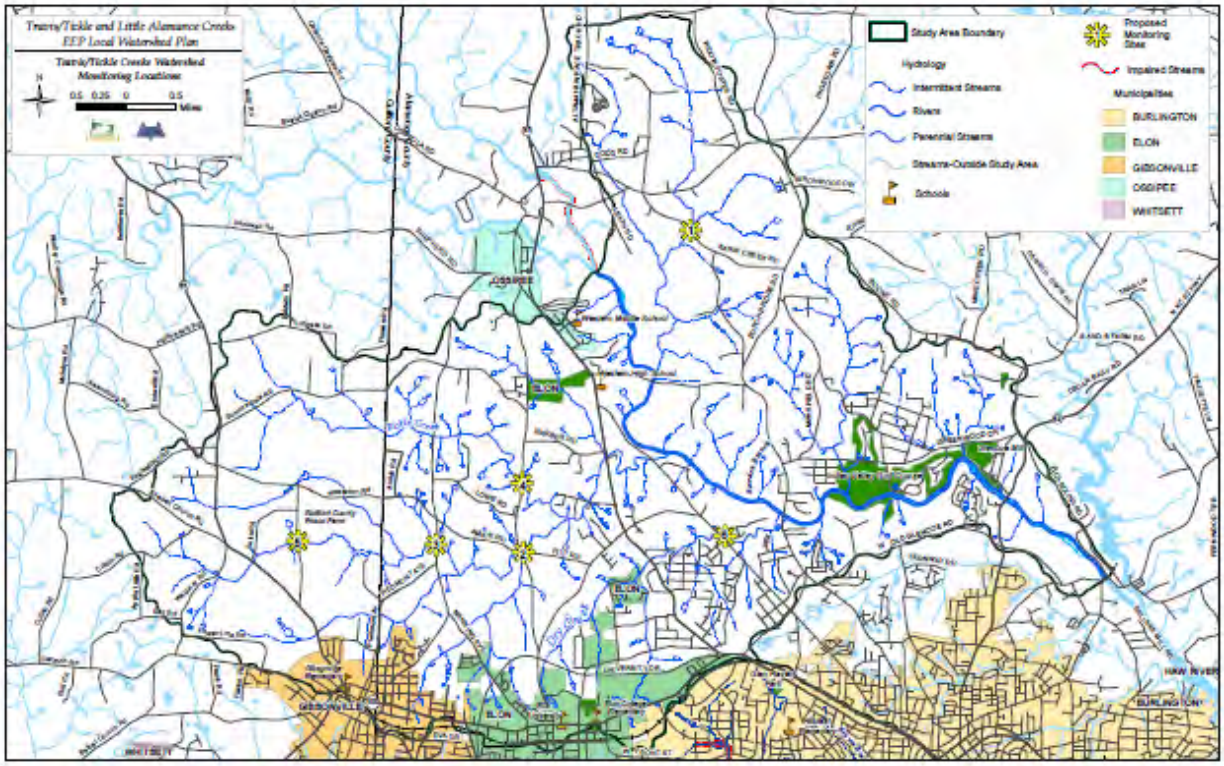


Table 6.3.1 Proposed monitoring locations

Location Number	Stream	Crossing	Drainage area (sq mi)	Land Use	Latitude (degrees North)	Longitude (degrees West)	Baseflow Chemistry	Stormflow Chemistry	Biological Sampling1
1	Basin Creek	SR 1594	2.6	Rural	36.1751	79.4827	X	.	Benthos
2	Travis Creek	SR 1504	8.4	Suburban and Rural	36.1281	79.5123	X + Metals	X	Benthos
3	Travis Creek	SR 1500	4.3	Mostly Rural	36.1291	79.5278	X	X	
4	Tickle Creek	SR 1504	3.7	Mostly Rural	36.1382	79.5125	X + Metals	X	Benthos
5	Travis Creek	SR 2741	1.6	Rural; Above County Farm	36.1296	79.5526	X	X	
6	Dry Creek	SR 1529	3.4	Suburban	36.1306	79.4763	X	.	Benthos
7	L. Alamance Creek	SR 2309	15	Urban, Suburban and Rural	36.0360	79.4091	X + Metals	X	Benthos and Fish
8	Bowden Branch	SR 2304	3.4	Urban, Suburban and Rural	36.0506	79.4161	X	.	
9	L. Alamance Creek	Mebane St - Burlington	4.1	Urban	36.0800	79.4482	X + Metals	X	
10	Willowbrook Creek	Mebane St - Burlington	1.4	Urban	36.0836	79.4432	X + Metals	X.	

[1] Biological sampling was conducted at eight sites.

References

Alamance, County of. 2004. *Alamance County Watershed Protection Zoning Ordinance*.

Alamance, County of. 2005. *Alamance County Subdivision Ordinance.*

Burlington, City of. 1991. *Comprehensive Land Use Plan*.

Burlington, City of. *Erosion and Sediment Control Ordinance*, Chapter 31.

Burlington-Graham Urban Area Metropolitan Planning Organization. 2005. *2005-2030 Burlington-Graham MPO Transportation Plan Update*.

Center for Research in Water Resources, GIS Water Resources Consortium. 2006. University of Texas at Austin, Web Site: http://www.crwr.utexas.edu/.

Elon, Town of. 2002. *Land Development Plan.*

Gibsonville, Town of. 2002. *Gibsonville Development Ordinance.*

Gibsonville, Town of. 2001. *Gibsonville Land Development Plan.*

Graham, City of. 1999. *City of Graham Development Ordinance*.

Graham, City of. 2000. *City of Graham Growth Management Plan 2000-2020.*

Guilford, County of. 2006. *Guilford County Comprehensive Plan.*

Guilford, County of. 2006. *Guilford County Development Ordinance.*

Guilford, County of. 2002. *Water Quality Protection Manual.*

Hurt, G.W., P.M. Whited, and R.F. Pringle, editors. *Version 5.0, 2002. Field indicators of hydric soils in the United States.*

Maidment, D. R., ed., 2002. *Arc Hydro: GIS for Water Resources*, ESRI Press, Redlands, Ca.

National Research Council. 1995. *Wetlands: Characteristics and boundaries*

NCDENR, Division of Water Quality, 2006b. *North Carolina Assessment and Impaired Waters List (2006 Integrated 305(b) and 303(d) Report)*, Web Site: http://h2o.enr.state.nc.us/tmdl/documents/2006IRPublicReviewDraft.pdf

NCDENR, Division of Water Quality, 2006a. *Summary of Existing Water Quality Data for Little Alamance Creek, Travis Creek, and Tickle Creek, Guilford and Alamance Counties, North Carolina*.

NCDENR, Division of Water Quality, 2004. *Cape Fear River Basin Basinwide Assessment Report*, Web Site: http://www.esb.enr.state.nc.us/Basinwide/CPF%202004%20Report%20Final.pdf

NCDENR, Division of Water Quality, 2005. *Cape Fear River Basinwide Water Quality Plan*, http://h2o.enr.state.nc.us/basinwide/draftCPFApril2005.htm

NCDENR, Division of Water Quality, 1999. *Stormwater Best Management Practices*.

NCDENR, Division of Land Quality, 1991. *North Carolina Erosion and Sediment Control Planning and Design Manual and Field Manual*, http://dlr.enr.state.nc.us/pages/manualsandvideos.html

NCDENR, Division of Forest Resources, 2006, http://www.dfr.state.nc.us/water_quality/wq_bmpeffectiveness.htm

NCDOT (Department of Transportation), 2007. *Transportation Improvement Program, 2007-2013*, Web Site: http://www.ncdot.org/planning/development/TIP/TIP/pdf/2007-2013_Draft_STIP.pdf

NC EEP (NC Ecosystem Enhancement Program), Web Site: http://www.nceep.net/

NCGS (NC Geological Survey), Web Site: Mineral Resources of North Carolina http://www.geology.enr.state.nc.us/Mineral%20resources/mineralresources.html

NC State Climate Office, NC State University, http://www.nc-climate.ncsu.edu/climate/ncclimate.html

Piedmont Triad Council of Governments (PTCOG), 2005. *Haw River Riparian Corridor Conservation Plan*.

Schueler, Tom, and Kitchell, Anne. 2005. *Methods to Develop Restoration Plans for Small Urban Watersheds*. Center for Watershed Protection, Ellicott City, MD.

USDA (United States Department of Agriculture), 1959. *Soil Survey of Alamance County, North Carolina*, National Cooperative Soil Survey, North Carolina.

USDA (United States Department of Agriculture), 1977. *Soil Survey of Guilford County, North Carolina*, National Cooperative Soil Survey, North Carolina.

U.S. Fish and Wildlife Service, 2006. *Classification of Wetlands and Deepwater Habitats of the United States*. U.S. Department of the Interior, Fish and Wildlife Service, Washington, DC. FWS/OBS-79/31.

Appendix 1: Group Charter and Ground Rules, Travis/Tickle and Little Alamance Local Watershed Planning Group

APPENDIX 2

Summary of Existing Water Quality Data

for

Little Alamance Creek
Travis Creek
Tickle Creek

Guilford and Alamance Counties
North Carolina

NC Division of Water Quality
Watershed Assessment Team
September 2006

Introduction and Background

The Ecosystems Enhancement Program (EEP) has selected Little Alamance, Tickle and Travis creek watersheds (LATT) for the development of a Local Watershed Plan (LWP). In support of this plan, the NC Division of Water Quality (DWQ) -- Watershed Assessment Team (WAT) has developed this summary of available water quality data. This summary identifies and summarizes water quality data that have been collected in the LATT LWP planning area. Data collected as part of synoptic surveys during the summer of 2006 are also summarized.

The LATT watersheds lie partially within Guilford County but primarily within Alamance County near the municipalities of Gibsonville, Elon, Burlington and Graham. Although the acronym LATT reflects the names of three streams (Little Alamance, Tickle, and Travis), others (e.g. Dry Creek) are included in the LWP planning area (Figure 1). Information on watersheds is often filed or cataloged using watershed codes. In North Carolina, two formal watershed-cataloging systems are used. The United States Geological Survey (USGS) and other federal agencies use Hydrologic Unit Codes (HUCs) extensively. The NC Division of Water Quality uses subbasin codes. The codes that are used for the LATT watersheds are provided in Table 1.

Table 1. USGS and DWQ watershed codes that include the Little Alamance, Tickle and Travis Creek (LATT) watersheds. (Eight-digit HUC codes are in **bold** font)

Watershed	14-digit Hydrologic Unit Code (HUC)[1]	DWQ Subbasin[2]	Area (mi^2) (14-digitit HUC)
Tickle, Travis	**03030002**030010	03-06-02 or CPF02	35
Little Alamance	**03030002**040110	03-06-03 or CPF03	16

[1] The United States Geological Survey designates watershed using Hydrologic Unit Codes (HUCs). Natural resource professionals often refer to 8-digit HUCs and 14-digit HUCs. The 14-digit HUCs represent smaller watersheds. All of the LATT watersheds lie within the 8-digit "03030002" HUC

[2] The DWQ uses a different numbering scheme. The DWQ scheme is useful when referring to sections or chapters within the DWQ's Basin Assessment Reports (http://h2o.enr.state.nc.us/esb/bar.html) or the Basinwide Management Plans (http://h2o.enr.state.nc.us/basinwide).

Watershed Land Uses, Geology and Point Source Dischargers

The Little Alamance Creek watershed consists mostly of urban and suburban areas, while the Travis and Tickle Creek watersheds have mostly suburban and rural land uses.

Streams within the LWP planning area are along the border between the Carolina Slate Belt, which is mostly east of the watersheds, and the mixed felsic and mafic region to the west. Streams within the Carolina Slate Belt can exhibit low flows, or even cease flowing due to natural conditions.

There are three small point-source discharges in the LWP areas (Table 2), and no agricultural animal operations with NPDES permits in these watersheds. No individual stormwater permits have been issued within these watersheds.

Table 2. NPDES point source dischargers

Permittee	Permit Number	Permitted discharge	Waterbody
Shields Mobile Home Park	NC0055271	0.006 MGD	Travis Cr
Western Alamance Middle School	NC0031607	0.015 MGD	Haw River
Western Alamance High School	NC0045144	0.0115 MGD	Haw River

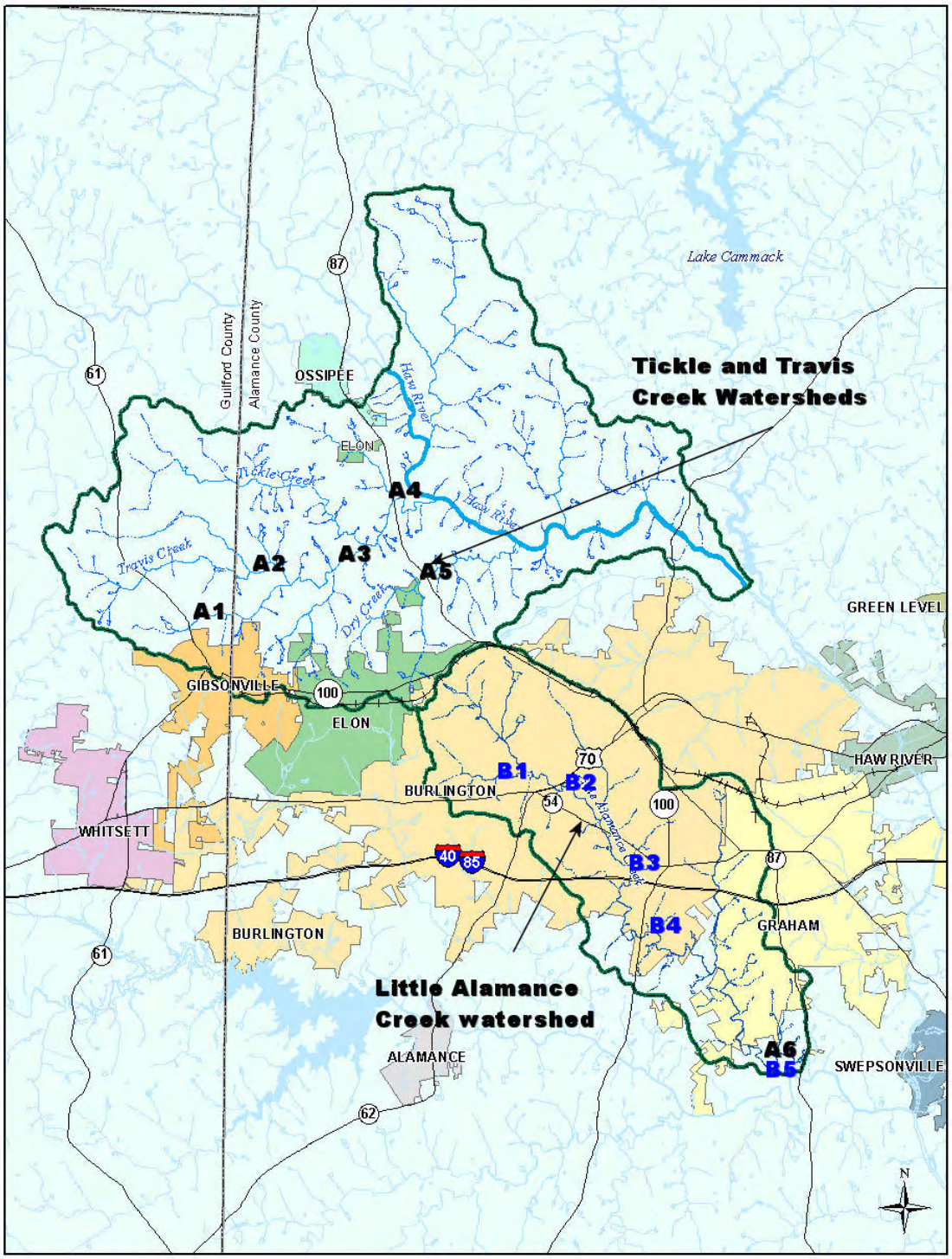


Figure 1. Boundaries of the Little Alamance, Tickle and Travis Creek (LATT) watersheds depicting the approximate locations of ambient water quality monitoring stations (A1-A6) sampled during 1968-1978 and benthic macroinvertebrate sites (B1-B5) sampled during 1984-2003

Water Chemistry

Within the LATT watershed boundaries (Figure 1) there is one currently active monitoring station along the Haw R (Haw R. and SR 1530 --Gerringer Mill Road) that is being monitored by the Upper Cape Fear River Basin Association (UCFRBA; see http://www.cfra-nc.org/ucfrba.htm). However results from this station strongly reflect influences on water quality that exist outside the LWP. An example of these influences includes the discharge of a City of Greensboro's wastewater treatment plant into North Buffalo Creek. Therefore results from this station are not presented here.

Overall, little information exists on the physical and chemical properties in the LATT watersheds. Historically a few sites were monitored between 1968 through 1978 (Table 3 and Figure 1). These were located primarily along Travis creek. However, since 1978 there has been no sustained monitoring program for physical and chemical parameters in any of the LATT watersheds except for the one UCFRBA station located on the Haw River.

Although a variety of parameters were sampled between 1968 and 1978, the greatest numbers of results were for nutrients, fecal coliform bacteria, water temperature, specific conductance and dissolved oxygen. Scatterplots of the results for these parameters are provided (Figures 2 and 3). It is important to note, that administrative procedures addressing quality assurance, and analytical techniques have improved since that time period.

Table 3. Locations of ambient water quality monitoring stations. (Latitude and Longitude are in decimal degrees.)

Map Code	STORET[1] No.	Location	Latitude	Longitude	Period
A1	B0900000	Travis Cr at Gibsonville	36.1150	-79.5420	1968-1975
A2	B0930000	Travis Cr at SR 1500 near Gibsonville	36.1250	-79.5250	1970-1975
A3	B0960000	Travis Cr. near Gibsonville	36.1290	-79.5130	1968-1975
A4	B0990000	Travis Cr. near Glen Raven	36.1400	-79.4990	1969-1978
A5[2]	B1020000	Haw R. at Hopedale[2]	36.1240	-79.4920	1968-1975
A6	B1920000	Little Alamance Cr. near Graham	36.0330	-79.4080	1968-1975

[1] A STORET number represents the station number in a the national database (STORET) for water quality data. More information is available: http://www.epa.gov/storet/

[2] The latitude and longitude for this site may be incorrect. Older geospatial data have a higher frequency of errors for latitude and longitude. The description (Haw R. at Hopedale) is likely correct.

The data obtained between 1968 and 1978 do reveal a few water quality issues. These include violations of the NC water quality standard for instantaneous values (4 mg/L) for dissolved oxygen (Figure 2). These occurred in Travis Cr. In addition, results for fecal coliform bacteria are high at most sites (Figure 2.) At this time (2006) it is difficult to make statements about what may have been responsible for these problems occurring decades ago. It appears that water chemistry in these watersheds was affected more by multiple *nonpoint* sources of pollution than by any single (or few) discharge(s) from municipal or industrial sources.

The results for all four nutrients (Figure 3) were not extremely high except for the one sample taken on 8/18/1971. On this day, results for all four measures of nutrients were very high. High values, such as these, often occur during or just after significant precipitation. The USGS National Water Information System (http://waterdata.usgs.gov/nc/nwis) was queried to determine if there were any peaks in stream flow during Aug. 1971 for the monitoring station USGS 02094500 at Reedy Fork near Gibsonville, NC. This is the closest gaging station to the LWP planning area. Results indicated mean stream flow ranged from 36 cfs on 8/17/1971 to 315 cfs on 8/18/1971. The significantly higher flow on Aug 18, 1971 was due to precipitation. The high nutrient levels were likely due to runoff since ammonia is usually quickly converted to nitrate. Flows decreased to 48 cfs on 8/19/1971.

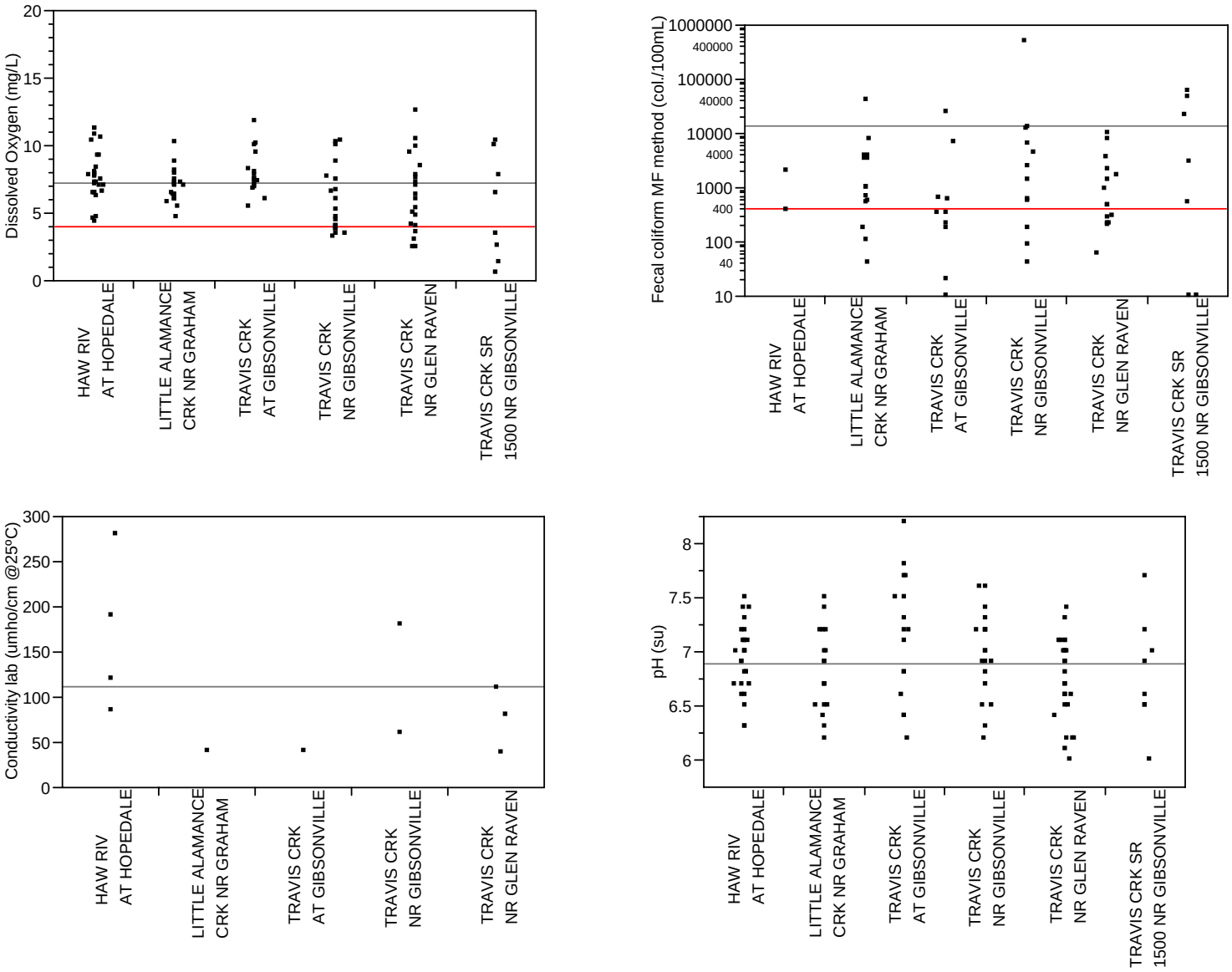


Figure 2. Ambient monitoring results for dissolved oxygen, fecal coliform bacteria, conductivity (laboratory-measured) and pH from sites monitored from 1968-1978. (Horizontal gray line is the mean for all observation. A reference line at 4.0 mg/L was added to the graph representing dissolved oxygen and 400 colonies/100 ml for fecal coliform bacteria.)

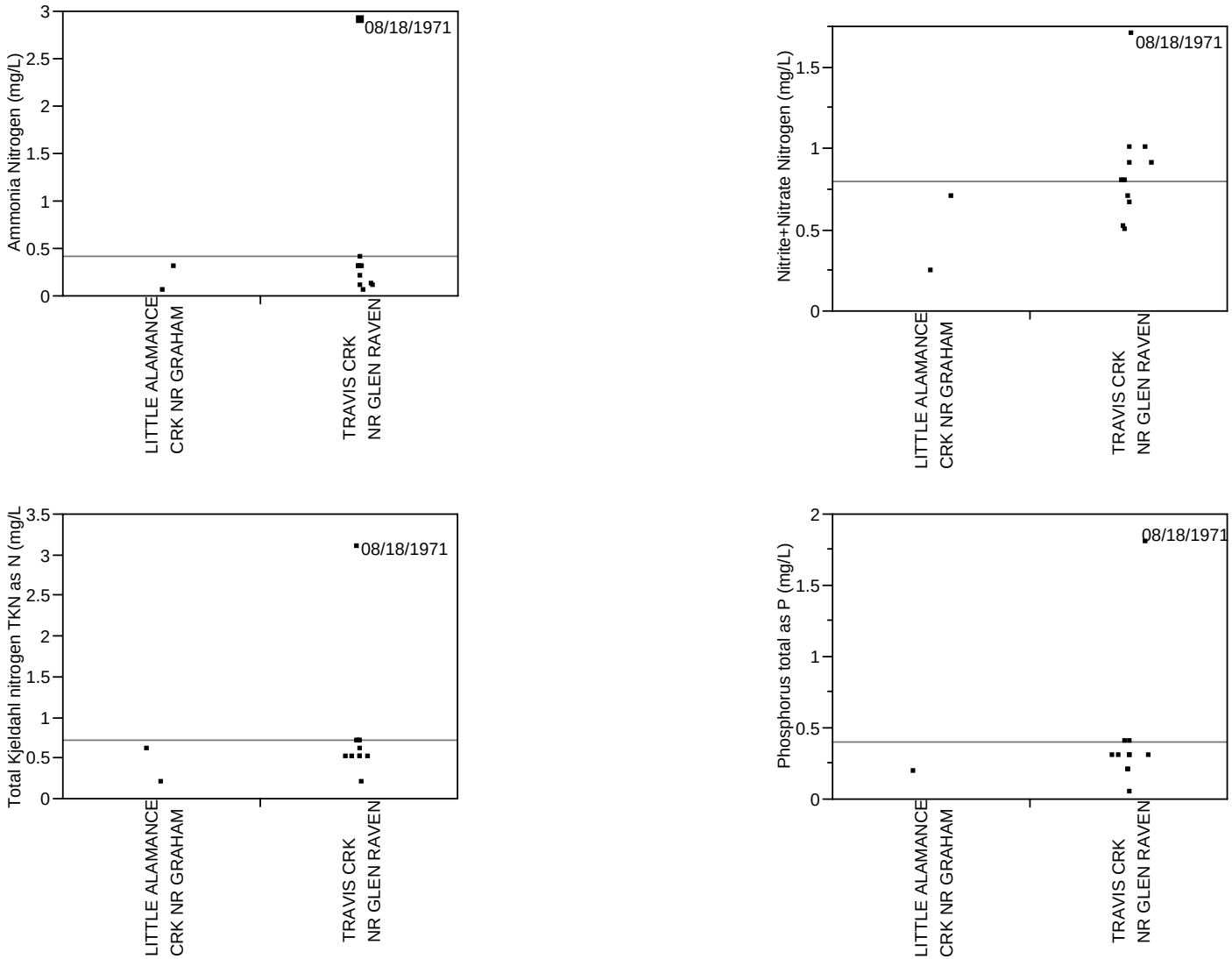


Figure 3. Ambient monitoring results for nutrients from sites monitored from 1968-1978. (Horizontal gray line is the mean for all observation.

Biological Data

Assessments of aquatic biological communities, and how well the communities reflect the ability of a stream to support aquatic life, are the focus of biological monitoring. Benthic macroinvertebrates are most often collected due to the ease in obtaining samples. Fish community assessment may be done as well. In the LATT LWP planning area, biological collections representing benthic macroinvertebrates and/or fish have been completed only in Little Alamance Creek between 1985 and 2003. (The majority of sites were sampled during 2003). By examining what species are present at a sample site, and the relative abundances of the species, biologists can provide "bioclassifications[1]," which determine how well aquatic life is being supported.

Bioclassifications for Little Alamance Creek range from Poor to Good (Table 4). The fish community was rated Good in 1993, Fair in 1998 and Good in 2003. All benthic sampling sites that have been rated have received at least one "Poor" rating. The most downstream site (B5; Figure 1) received a "Fair" rating in 2003, which is an improvement from its 1998 rating of "Poor." Additional benthic macroinvertebrate sampling in Little Alamance Creek, as well as sampling in Travis and Tickle Creeks will be conducted in September 2006 for EEP's Local Watershed Plan.

Table 4. Location of fish and benthic macroinvertebrate sample sites and bioclassification.

			Bioclassification	
Map Code	**Water Body.**	**Date**	**Fish**	**Benthos**
B1	Coble Br. at Engleman Ave.	06/24/2003	.	Not Rated[1]
B2	L. Alamance at Overbrook Rd.	06/24/2003	.	Poor
B3	L. Alamance at I-85 Frontage Rd.	06/23/2003	.	Poor
B4	L. Alamance at NC 49	06/23/2003	.	Poor
B5	L. Alamance at SR 2309	07/29/1985	.	Fair
B5	L. Alamance at SR 2309	1993	Good	.
B5	L. Alamance at SR 2309	1998	Fair	.
B5	L. Alamance at SR 2309	07/10/1998	.	Poor
B5	L. Alamance at SR 2309	2003	Good	.
B5	L. Alamance at SR 2309	06/23/2003	.	Fair

[1]Watershed too small for rating.

Summer 2006 – Watershed Assessment Team Synoptic Surveys

During the summer of 2006, DWQ personnel collected a limited amount of field data to ascertain if any water quality problems could be readily identified, and to aid in the development of a plan for additional monitoring. This monitoring included the measurements of specific conductance at many of the bridge crossings over streams in the planning area, and the deployment of equipment called datasondes that recorded temperature, pH, specific conductance, dissolved oxygen and the percent saturation of dissolved oxygen at hourly intervals between July 25 and 31, 2006.

[1] NC uses five bioclassifications: Excellent, Good, Good-Fair, Fair and Poor for benthos and fish.

Synoptic Survey – Specific Conductance at Bridge Crossings (July 19, 20, 2006)

Specific conductance is a measure of the ability of water to conduct electricity. High values can indicate geological influences or sources of pollution. Generally large differences between values within a stream or between streams within a localized area reflect point source discharges.

Results for specific conductance for streams obtained from bridge crossings within the planning area (Table 5) ranged from 119 to 226 µS/cm. The median is 157 (µS/cm). These results are typical of streams in the piedmont physiographic province of North Carolina. Within and among stream variations were not great enough to readily discern point source influences using measurements of specific conductance. Table 5 does contain a value of 403 (µS/cm) for a site influenced by point source discharges, but this stream, Reedy Fork, is not in the LWP planning area.

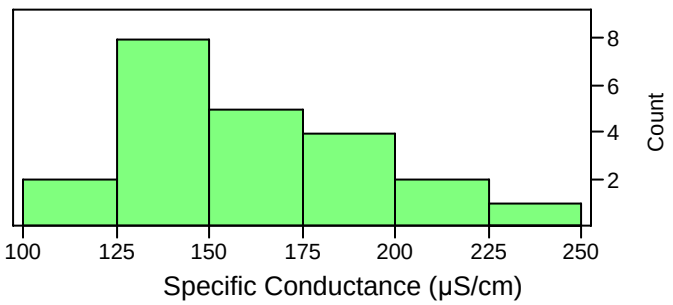


Figure 4. Distribution of specific conductance results listed in Table 5.

Table 5. Results of a survey of specific conductance conducted on July 19 and 20, 2006.

Stream[1]	**Road crossing**	**Latitude**	**Longitude**	**Specific Conductance** (µS/cm))
Stinking Quarter Cr	Bellemont-Mt Hermon Rd	36.0139	79.4318	140
Big Alamance Cr	Rogers Rd	36.0169	79.4137	143
Little Alamance Cr	Rogers Rd	36.0360	79.4091	133
Little Alamance Cr	NC 49	36.0528	79.4348	176
Little Alamance Cr	Plantation Dr (I-85 Frontage)	36.0655	79.4405	207
Little Alamance Cr	NC 54 (Tucker St)	36.0744	79.4444	203
Meadowbrook Cr	Mebane St	36.0836	79.4432	226
Little Alamance Cr	Edgewood St	36.0906	79.4679	191
Coble Brook	Engleman St	36.0863	79.4695	197
Little Alamance Cr	Woodland Ave	36.0964	79.4732	195
Reedy Fork Cr	NC 87	36.1732	79.5103	403 (not in planning area)
Haw River	NC 87	36.1826	79.5099	148
Travis Cr	Durham St Ext;-SR 1529	36.1418	79.4896	135
Travis Cr	SR 1504	36.1281	79.5123	148
Travis Cr	SR 1500	36.1291	79.5278	173
Travis Cr	County Farm; Rd; SR 2741	36.1296	79.5526	153
UT 1 Travis Cr	Barber Rd; SR 1552	36.1427	79.4981	119

Table 5. Results of a survey of specific conductance conducted on July 19 and 20, 2006.

Stream[1]	Road crossing	Latitude	Longitude	Specific Conductance (µS/cm))
Table 5. continued				
UT 2 Travis Cr	SR 1500	36.1243	79.5273	172
Tickle Cr	SR 1504	36.1382	79.5125	134
Tickle Cr	SR 1500	36.1448	79.5284	140
Dry Cr	Durham St Ext; SR 1529	36.1306	79.4763	173
Basin Cr	Basin Cr Rd; SR 1594	36.1751	79.4827	160
UT to Basin Cr	Hub Mill Rd; SR 1002	36.1808	79.4949	123

[1] UT is the abbreviation for "unnamed tributary."

Synoptic Survey – Datasonde Deployment (July 25 to 31, 2006)

Automated sampling devices (datasondes) were deployed at the most downstream bridge crossings (Table 6) to characterize five parameters among four different watersheds – Little Alamance, Tickle, Travis and Dry Creeks. Water temperature, dissolved oxygen, dissolved oxygen – percent saturation, pH and specific conductance were measured at hourly intervals between July 25 and July 31. Data obtained in both a temporal and spatial manner reveal how results vary among watersheds and over time. During this sample period, datasondes were paired at all creeks except for Dry Creek. Only one datasonde was deployed here. Datasondes were paired to provide a measure of quality assurance.

Table 6. Locations of Datasondes (Latitude and longitude are in decimal degrees)

Waters	Description	Latitude	Longitude	Datasonde Serial Numbers
Little Alamance	SR 2309 Rogers Rd	36.0360	79.4091	37710, 38966
Dry Creek	SR 1529	36.1306	79.4763	38965
Tickle Creek	SR 1504	36.1382	79.5125	37711, 38933
Travis Creek	SR 1504	36.1281	79.5123	37712, 37713

Results from the datasondes are depicted in Figures 6 and 7 and a tabular summary is provided in Table 7. Results and figures were obtained using JMP statistical software (www.jmp.com; SAS Institute). These figures depict all individual measurements and provide "overlays" that depict measures of central tendency (i.e. mean or median) and variation. Illustrations and explanations of these overlays are provided in Figure 5.

Specific conductance and pH was considerably greater at Dry Creek than the other watersheds (Figure 6.) Reasons for this are not clear and will be investigated when a more comprehensive monitoring plan is implemented. The greatest range (difference between the high and low results) occurred in the Little Alamance Creek watershed. Little Alamance creek drains an urban watershed, so it is likely the range in specific conductance reflects this.

Overall, results for dissolved oxygen were good (Figure 6). Tickle Creek had the greatest range in results and three of these (out of 270) were just below the 4.0 mg/L water quality standard. These three results occurred just before sunrise, which is often the time when low dissolved oxygen results often occur. The largest diurnal fluctuations in dissolved oxygen were observed at Tickle Creek (Figure 7). Often large daily changes in dissolved oxygen concentrations are due to releases of oxygen via photosynthesis of stream algae. It is not known why the largest daily fluctuation in oxygen is occurring in Tickle Creek and whether this pattern is due to stream algae.

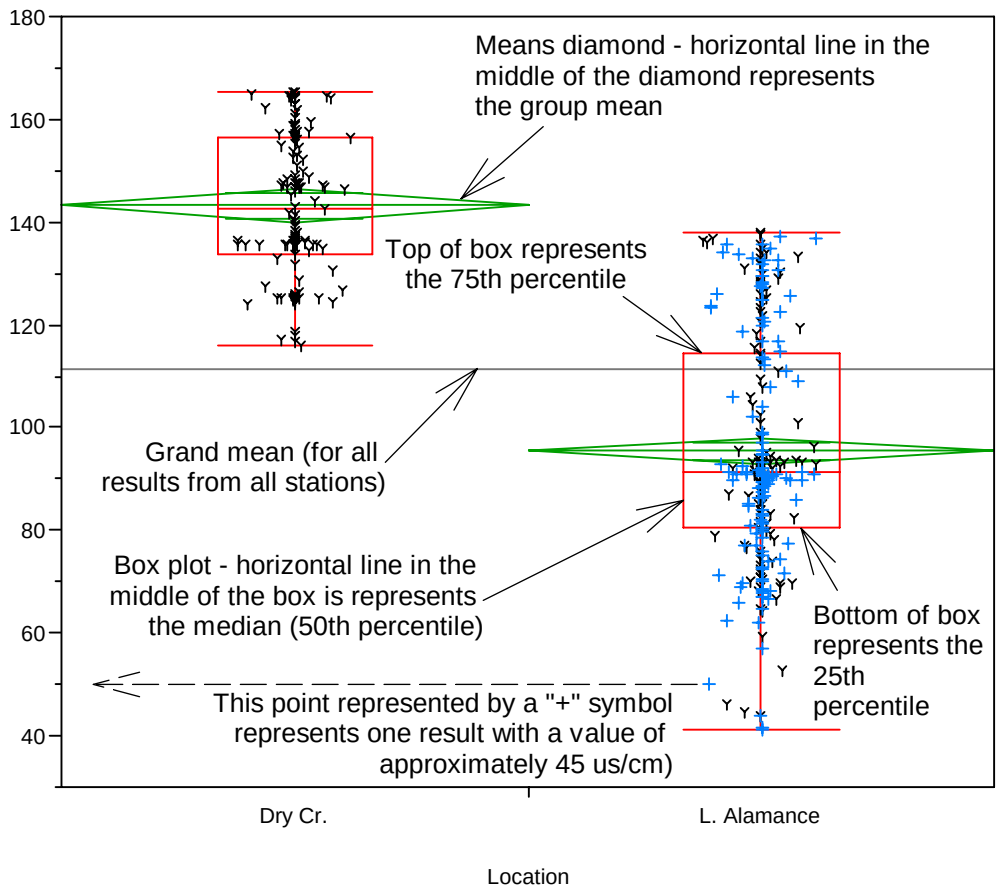


Figure 5. Interpreting box and whisker and means-diamonds plots from JMP statistical software. Data represent specific conductance results (µS/cm) for Dry and Little Alamance Creeks.

Explanations:

Two types of overlays ("means diamonds" and "box plots") can be added to displays of results to assist the reader seeing how results vary at and between each sample locations. A means diamond (green in Figure 5) illustrates a sample mean and 95% confidence interval. The line across each diamond represents the group mean. The vertical span of each diamond represents the 95% confidence interval for each group

The box plots (red in Figure 5) summarize the distribution of points at each factor level. (Factors represent groups – in this case, there are two groups: Dry Creek and Little Alamance Creek.) The ends of the box are the 25th and 75th quantiles. The difference between the quartiles is the interquartile range. The line across the middle of the box identifies the median sample value. Each box has lines, sometimes called whiskers that extend from each end. The whiskers extend from the ends of the box to the outermost data point that falls within the distances computed as upper quartile + 1.5(interquartile range) and lower quartile - 1.5*(interquartile range).*

Explanations from: JMP Statistics and Graphics Guide, Release 6. 2005. SAS Institute, Cary, NC.

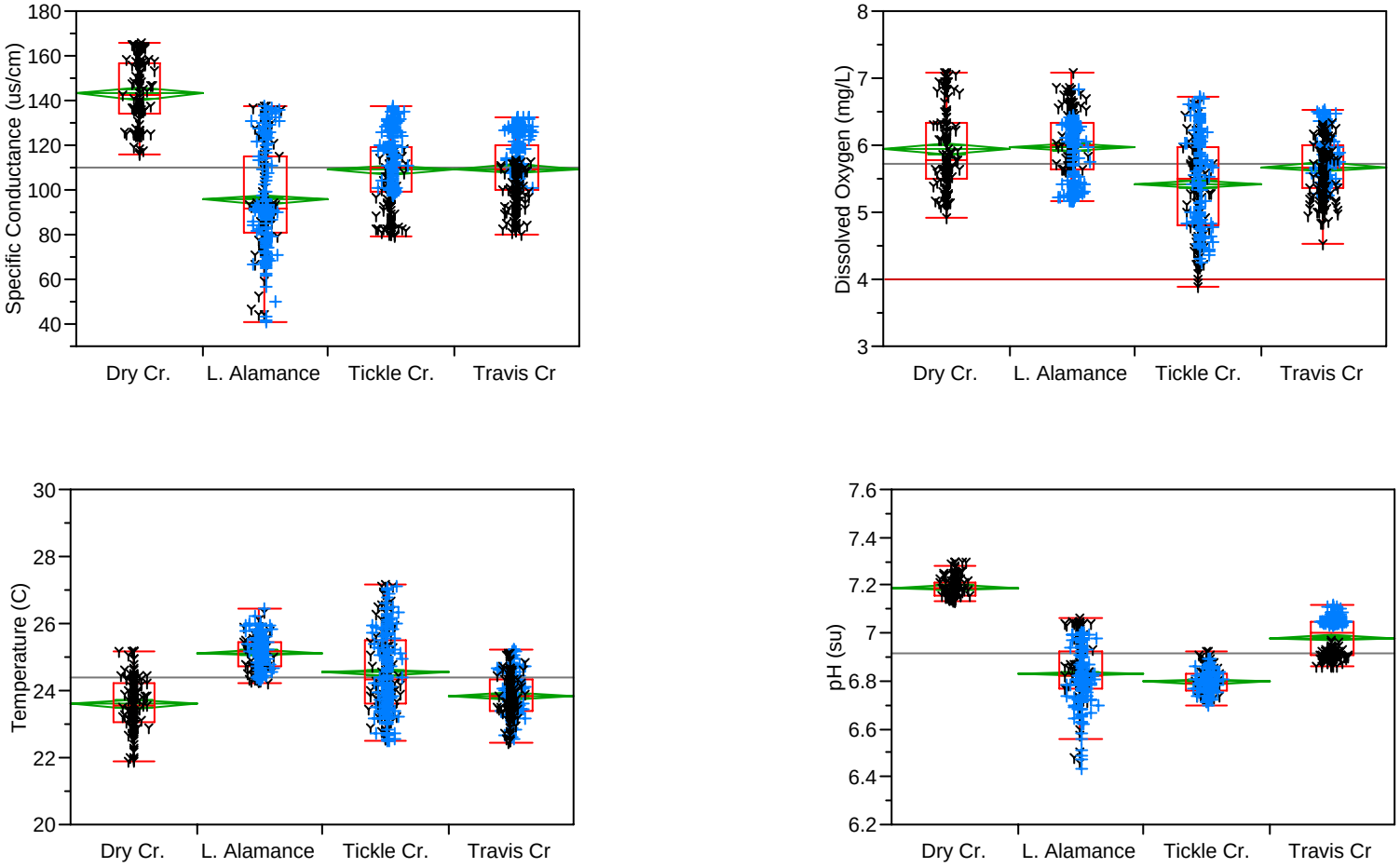


Figure 6. Results of the datasonde deployment between July 25 and 31 2006. These automated measuring devices recorded results hourly. Dry Creek had one datasonde. Datasondes at the remaining watersheds were paired (results are distinguished between datasondes at a site by a black "Y" and a blue "+". See Figure 5 for a description of the green diamonds (means diamonds) and the red boxes (box plots). The graph for dissolved oxygen has a horizontal line at 4.0 mg/L representing the NC water quality standard for instantaneous values.

Table 7. Summary statistics of measurements obtained from the use of datasondes for the period July 25 through July 31, 2006

Parameter/ Site	N[1]	Mean	95 % Confidence Interval Lower	95 % Confidence Interval Upper	Percentile Min.	10%	25%	50[a]	75%	90%	Max.
Specific Conductance (µS/cm)											
Dry Cr.	135	143.2	140.3	146.1	116	125	134	143	157	164	166
L. Alamance	270	95.4	93.4	97.5	41	69	81	91	115	131	138
Tickle Cr.	270	108.9	106.9	111.0	79	83	99	110	120	130	137
Travis Cr	270	109.5	107.4	111.5	80	90	100	109	120	129	133
Dissolved Oxygen (mg/L)											
Dry Cr.	135	5.9	5.8	6.0	4.9	5.2	5.5	5.8	6.3	6.9	7.1
L. Alamance	270	6.0	5.9	6.0	5.2	5.3	5.6	6.0	6.3	6.6	7.1
Tickle Cr.	270	5.4	5.4	5.5	3.9	4.5	4.8	5.5	6.0	6.3	6.7
Travis Cr	270	5.7	5.6	5.7	4.5	5.1	5.4	5.7	6.0	6.3	6.5
Dissolved Oxygen (%)											
Dry Cr.	135	70.5	69.4	71.6	59	62	65	70	75	81	83
L. Alamance	270	73.0	72.2	73.8	62	64	69	73	77	81	86
Tickle Cr.	270	65.5	64.7	66.3	46	53	58	66	72	78	83
Travis Cr	270	67.6	66.8	68.4	55	61	64	67	71	74	78
Temperature (C)											
Dry Cr.	135	23.6	23.5	23.7	21.9	22.7	23.1	23.6	24.2	24.5	25.2
L. Alamance	270	25.1	25.0	25.2	24.2	24.4	24.7	25.2	25.5	25.8	26.5
Tickle Cr.	270	24.5	24.4	24.6	22.5	23.2	23.6	24.3	25.5	26.3	27.2
Travis Cr	270	23.8	23.7	23.9	22.5	23.1	23.4	23.8	24.3	24.7	25.2
pH (s.u.)											
Dry Cr.	135	7.2	7.2	7.2	7.1	7.1	7.2	7.2	7.2	7.3	7.3
L. Alamance	270	6.8	6.8	6.8	6.4	6.7	6.8	6.8	6.9	7.0	7.1
Tickle Cr.	270	6.8	6.8	6.8	6.7	6.7	6.8	6.8	6.8	6.9	6.9
Travis Cr	270	7.0	7.0	7.0	6.9	6.9	6.9	7.0	7.1	7.1	7.1

[1] Only one datasonde was deployed in Dry Creek. The remaining watersheds had two datasondes. Thus sample size (N) differs by a factor of 2 between these sets.
[a] The median is also the 50th percentile.

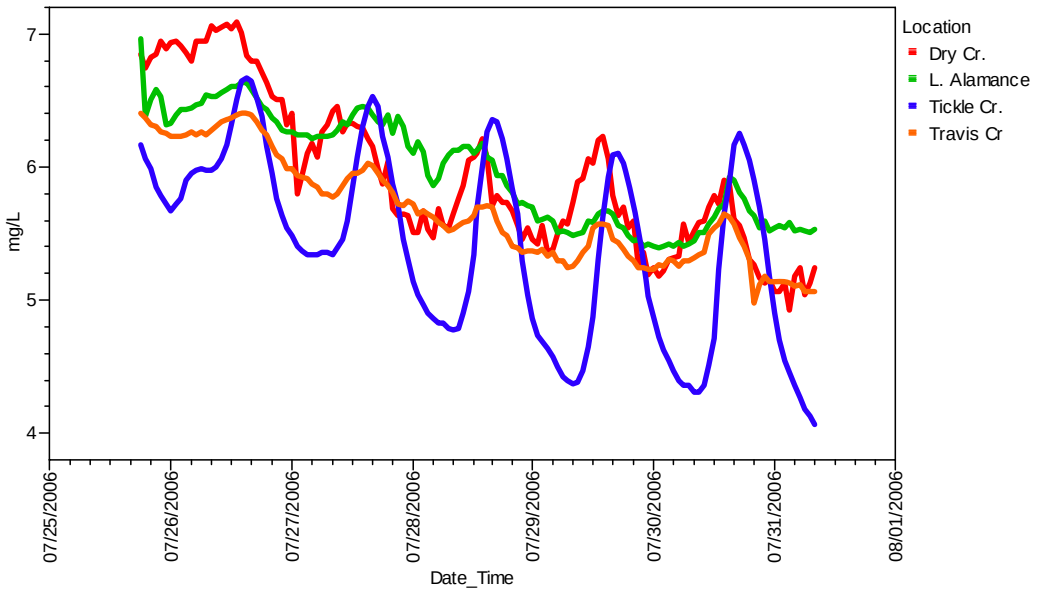


Figure 7. Daily changes in dissolved oxygen among Dry Creek, Little Alamance Creek, Tickle Creek, and Travis Creek. The graph is best observed in color. Note the larger daily fluctuations in dissolved oxygen concentrations for the station in Tickle Creek. These exceed the daily fluctuations observed at the other locations. Additional monitoring, which is being planned, may explain the reason for this large fluctuation.

Appendix 3: Little Alamance, Travis, and Tickle Creek Watershed Protection Summary

Little Alamance, Travis and Tickle Creek Watershed Protection Summary - DRAFT

Watershed Protection Tools	City of Burlington	Town of Elon	Town of Gibsonville	City of Graham	Alamance County	Guilford County
1. Watershed Planning						
Land Use or Growth Management Plan	X (expired)	X	X	X	Under development	X
# of Zoning Sub-Districts	23	11	23	19	3[1]	29
# of Overlay Districts	1	3	6	4		7
Zoning Ordinance Protects Watershed	X	X – Stream protection overlay	X – Watershed protection overlay	X - No specific ordinance	X[1]	X
2. Land Conservation						
Conservation Program					X, Voluntary ag. dist.	X, Easements, Voluntary ag. dist.
Critical Habitat Areas					X – Mussels	
Flood Regulations Above FIRM Minimum	Minimum	Minimum	Minimum	Two feet above freeboard	Minimum	one foot above freeboard
Steep Slope Restriction	X, No specific slope defined		X, no steeper than 2 to 1			X, >15% in WCAs
3. Aquatic Buffers						
Wetland Buffers for Ponds and Lakes	X, Only drinking water reservoir		X		X, Only drinking water reservoir	X, Only drinking water reservoir
4. Better Site Design						
Low Impact Design Guidelines (e.g. minimize impervious surface, redirecting runoff to pervious surfaces)						X
Open Space Design Encouraged (e.g. cluster development, flexible site design)	X	X	X	X	X	X
Pervious Spillover Parking Surfaces	X	X, dust free	X	N/A	X	X

Little Alamance, Travis and Tickle Creek Watershed Protection Summary - DRAFT

Watershed Protection Tools	City of Burlington	Town of Elon	Town of Gibsonville	City of Graham	Alamance County	Guilford County
5. Erosion and Sediment Control						
Follow a State Document	X	X	X	X	X	More regs.
Inspectors (e.g. county/municipal, state or third party)	Municipal	State	State or third party	State	State	Municipal
6. Stormwater Management Practices [2]						
Stormwater Plan Required	X	X	X	X		X
Inspections During Construction	X	X	X	X		X
Maintenance of Stormwater (e.g. HOA, owner, builder, or municipality) and Fines	Owner, HOA no fines	Owner, HOA fines	Builder no fines	Owner, HOA fines [3]		Owner, HOA fines
Stormwater System Structure (e.g. open channel, storm drain, or combo)	combo	storm drain	storm drain	combo	open channel	open channel
7. Sewer System Structure						
Sewer System Structure	Central treatment plant	Central treatment plant/ septic system	Central treatment plant/ septic system	Central treatment plant	Septic system	Central treatment plant/ septic system
Program for Illicit Connection and Fines	X, no fines			X, fines		X, fines
8. Other						
Guidelines for Hobby Farming or Agricultural Runoff			Exclusionary fencing		Rotational grazing, exclusionary fencing, others	
Restrictions on Pet Waste Management				X		

[1] Watershed Protection Ordinance has three districts, no other zoning document.
[2] In July of 2007, Phase II regulations will be in place and regulations by municipality will be updated at that time.
[3] Amendments to stormwater and sewer ordinance should be finalized by spring of 2007 and fines will be levied at that time.
Disclaimer: This summary is in draft form and is based upon municipal staff answers to a survey based upon a template from the Center for Watershed Protection about the Little Alamance, Travis and Tickle Creek Watershed.

Appendix 4: North Carolina Division of Water Quality
Surface Water Protection Section
January 17, 2007

Water Quality Monitoring Plan
Upper Cape Fear—Little Alamance, Tickle and Travis Creeks

Cape Fear River Basin

Introduction

The Division of Water Quality is proposing to monitor ten sites (Figures 1 and 2, Table 1) in the Little Alamance, Travis and Tickle Creek (LATT) watershed. This monitoring will support the NC Ecosystem Enhancement Programs Local Watershed Planning (LWP) endeavors within these watersheds. Monitoring efforts will 1) address biological impairment of Little Alamance Creek, with the goal of identifying specific stressors that may be causing impairment, and 2) compare water quality among the several watersheds in this planning area.

Data will be used to compare water quality among the several watersheds in this planning area and may allow comparisons of the effects of population density, land cover, construction activity, agricultural activity and other factors. This information will be useful to identify relatively unimpacted watersheds, as well as to identify water quality problems. Another objective will be to identify opportunities for stream restoration, storm water management and best management practices (BMPs).

Methods

Biological Surveys

Biological assessment involves the collection and identification of benthic macroinvertebrates or fish to evaluate community structure and diversity. Favorable community composition with respect to species richness, abundance and pollution intolerance reflects desirable water quality. Aquatic habitats are also assessed. Details of the protocol can be reviewed at http://www.esb.enr.state.nc.us/BAU.htm].

Benthic macroinvertebrates were collected during the week of September 11, 2006 at six sites using the Division of Water Quality's standard qualitative (Full Scale) method, and at two sites using the Qual 4 method.

Table 1. Proposed monitoring locations (See Figures 1 and 2)

Location Number	Stream	Crossing	Drainage area (sq mi)	Land Use	Latitude (degrees North)	Longitude (- degrees West)	Baseflow Chemistry	Stormflow Chemistry	Biological Sampling [1]
1	Basin Creek	SR 1594	2.6	Rural	36.1751	79.4827	X	.	Benthos
2	Travis Creek	SR 1504	8.4	Suburban and Rural	36.1281	79.5123	X + Metals	X	Benthos
3	Travis Creek	SR 1500	4.3	Mostly Rural	36.1291	79.5278	X	X	
4	Tickle Creek	SR 1504	3.7	Mostly Rural	36.1382	79.5125	X + Metals	X	Benthos
5	Travis Creek	SR 2741	1.6	Rural; Above County Farm	36.1296	79.5526	X	X	
6	Dry Creek	SR 1529	3.4	Suburban	36.1306	79.4763	X	.	Benthos
7	L. Alamance Creek	SR 2309	15	Urban, Suburban and Rural	36.0360	79.4091	X + Metals	X	Benthos and Fish
8	Bowden Branch	SR 2304	3.4	Urban, Suburban and Rural	36.0506	79.4161	X	.	
9	L. Alamance Creek	Mebane St - Burlington	4.1	Urban	36.0800	79.4482	X + Metals	X	
10	Willowbrook Creek	Mebane St - Burlington	1.4	Urban	36.0836	79.4432	X + Metals	X.	

[1] Biological sampling was conducted at eight sites.

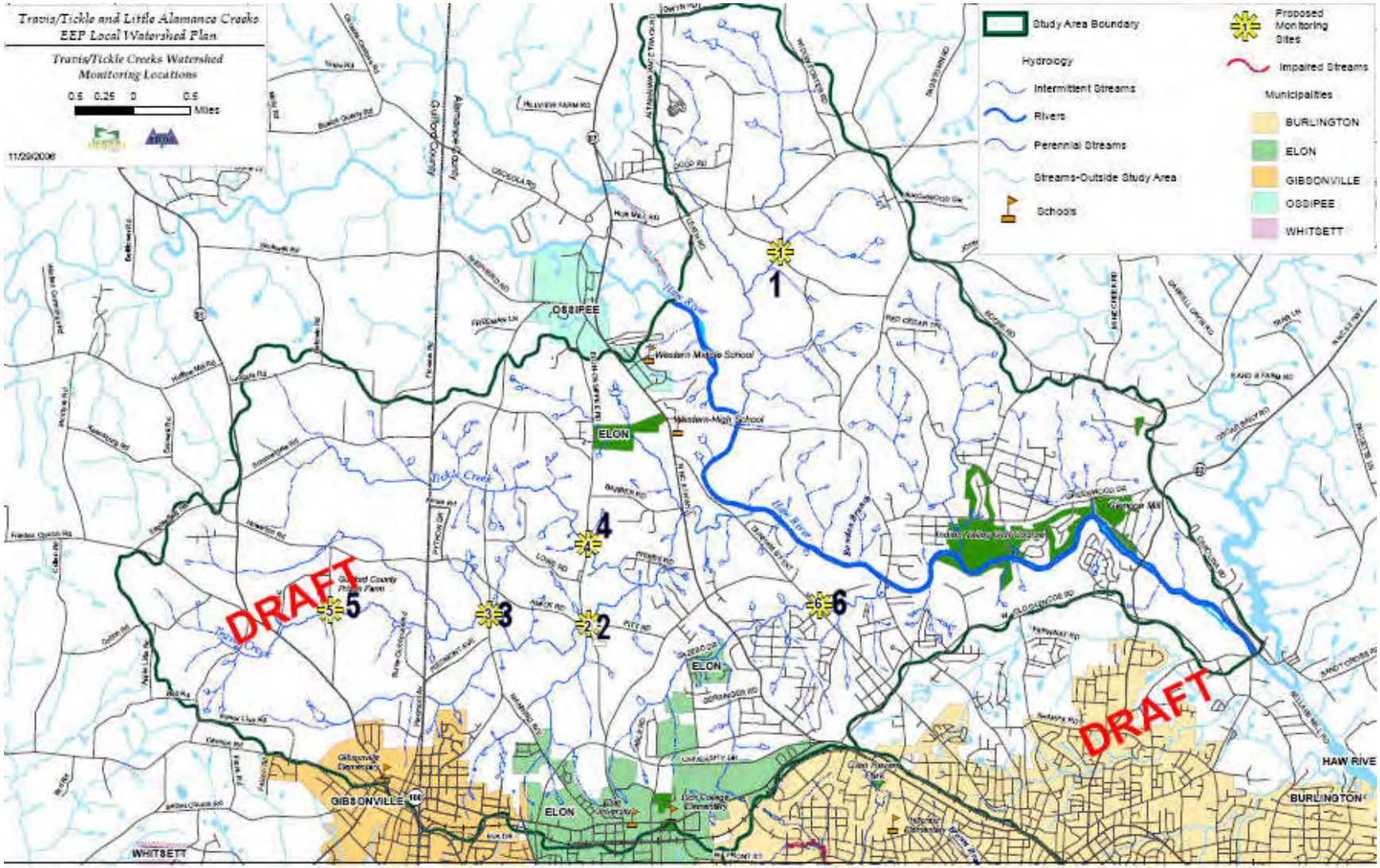


Figure 1. Water quality monitoring locations in the Tickle – Travis watersheds.

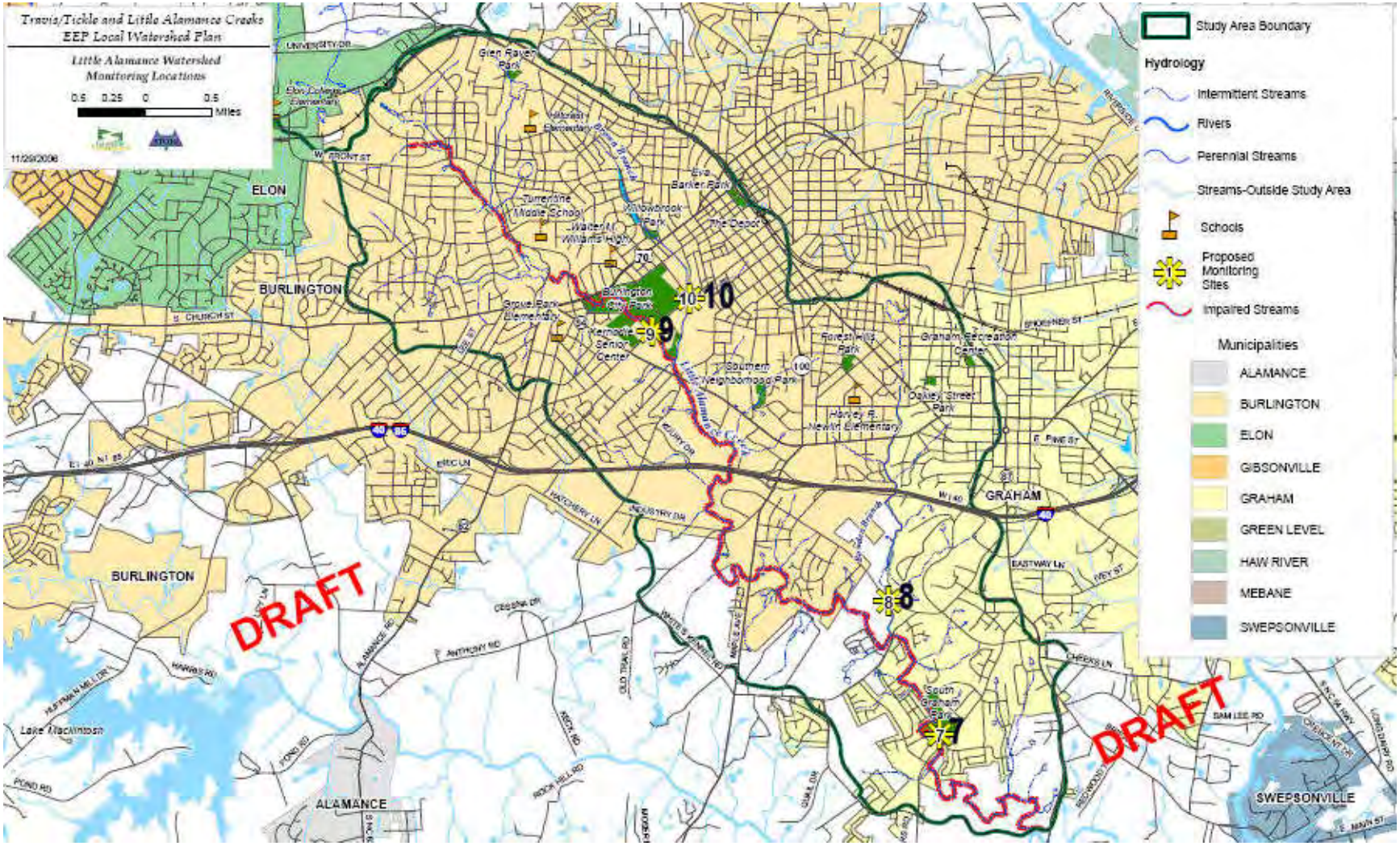


Figure 2. Water quality monitoring locations in the Little Alamance Creek watershed.

Habitat evaluations of these six sites were made using the DWQ Biological Assessment Unit's "*Habitat Assessment Field Data Sheet for Mountain/Piedmont Streams"*. These assessments assign a numerical score from 0-100 for the reach of stream sampled based on channel modification, instream habitat, bottom substrate, pool variety, riffle habitats, bank stability and vegetation, light penetration, and width of the riparian zone.

The results of the 2006 sampling, including comparisons with earlier benthic macroinvertebrate data, have been summarized in a memorandum by BAU biologists (DWQ 2006). All locations that were rated received either a Fair or Poor rating. It was noted that stream flows at the time of sampling were very low, which could have contributed to the low benthic community ratings.

Fish Community Data

Little Alamance Creek at SR 2309 (Location 7 in Table 1) was sampled three times for fish in the past (DWQ 2004). It rated Good in 2003, Fair in 1998, and Good in 1993. No fish community sites are located on Tickle, Travis, or Dry Creeks. No additional fish sampling is planned for this study.

Fish Tissue Data

No fish tissue data are available for any of the streams in the study area, nor will data of this type be collected for this study.

Ambient and Coalition Water Chemistry

Little current information exists on the physical and chemical properties of these watersheds. A few sites, primarily along Travis Creek, were monitored between 1968 through 1978. However, since 1978 there has been no sustained monitoring program of physical and chemical parameters for any of the watersheds within this LWP area.

Proposed Water Chemistry Study

Physical and chemistry sampling will be conducted at ten sites (Figures 1 and 2) during both baseflow and stormflow conditions (Table 1). Sample locations were chosen to represent the major streams and tributaries in the study area, including a cross section of urban, suburban and rural land uses. Availability of biological data at a particular location was also given consideration. Field (physical) measurements for dissolved oxygen, pH, specific conductance and temperature will be made and water samples will be collected for analysis of solids, turbidity, fecal coliform bacteria, nutrients and metals (Table 2).

Table 2. Parameters for Physical and Chemical Monitoring.

Parameters	
Field parameters	**Metals**
Dissolved oxygen (mg/L)	Aluminum (Al)
pH (su)	Arsenic (As)
Temperature (C)	Cadmium (Cd)
Specific Conductance (µS/cm)	Calcium (Ca)
Oxygen Saturation (%)	Chromium (Cr)
Bacteria	Copper (Cu)
Fecal Coliform, MF	Iron (Fe)
	Lead (Pb)
Residues (Solids)	Magnesium (Mg)
Susp. residue	Manganese (Mn)
Susp. volatile residue	Mercury (Hg)
Susp. fixed residue	Nickel (Ni)
	Silver (Ag)
Turbidity	Zinc (Zn)
	Sodium (Na)
Nutrients	Potassium (K)
NH_3 as N	
TKN as N	
NO_2+ NO_3 as N	
P total as P	

The proposed schedule is to begin water chemistry sampling in December 2006 and conclude in August 2007[1], with a final report of results by November 2007. Baseflow sampling will be conducted monthly, while stormflow sampling will be done once per season, as weather permits. Water and sediment samples may be taken for development of new toxicity assays.

Water temperature, dissolved oxygen, oxygen saturation, pH and specific conductance will be measured *in situ* using appropriate field instrumentation. Samples for other parameters will be submitted to the DWQ Laboratory Section for analysis. Chemical and physical monitoring will be conducted according to the procedures described in NCDWQ's Standard Operating Procedures (SOP) manual and the Laboratory Section's sample submission guidance (NCDWQ 2002, 2003, 2004a).

[1] The current contract between DWQ and EEP expires June 30, 2007. Any work past this date assumes that a new contract with EEP or other funding will be available.

The first set of samples will be analyzed for the complete set of parameters, including total metals. These results will be used to determine which parameters may provide useful information. Initially our current plan (Table 1) is to collect baseflow samples for metals at only five locations, on a quarterly basis. However the strategy outlined in Table 1 may be modified depending on the results as monitoring is conducted. All stormflow samples will be analyzed for metals.

Results of datasonde deployments in the summer of 2006 revealed that Dry Creek had higher values of specific conductance and pH than other sites. In addition a higher diurnal fluctuation of dissolved oxygen was observed at Travis Creek that other locations. These will be investigated further by additional deployments of datasondes and stream corridor visual assessments.

Stressor Identification

Efforts will be directed towards identifying specific stressors that may be causing biological impairment in Little Alamance Creek. These efforts will reflect those outlined in the "*Stressor Identification Guidance Document*" (Figure 3, EPA 2000). The LATT stakeholder process will be used to help identify potential stressors.

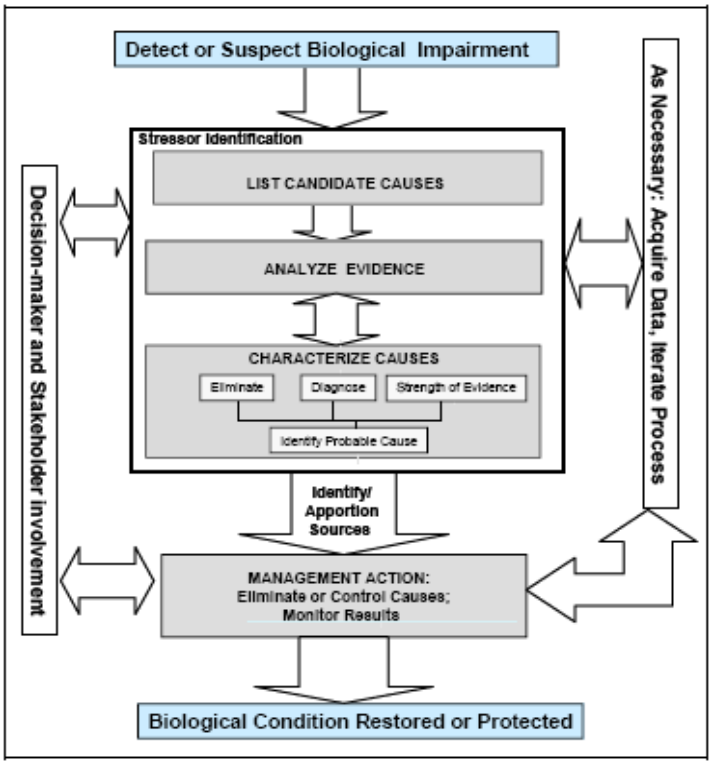


Figure 3. Stressor identification process (EPA, 2000)

Stream Corridor Visual Assessments

Stream corridor visual assessments are proposed to evaluate subwatershed condition and stream channel stability. The abundance of impervious surfaces in the study area, particularly in the Little Alamance Creek subbasin, is likely a cause of bank erosion and other possible stream channel effects. There are several methods and versions of protocols available, providing varying degrees and types of physical information (NRCS, 1998; Barbour, et al. 1999).

DWQ personnel, as members of field assessment teams organized by the Piedmont Triad Council of Governments, will use the Unified Stream Assessment methodology to conduct stream corridor assessments. These assessments will cover all perennial streams in the Little Alamance subwatershed, while a subset of the Travis and Tickle Creek subwatershed will be targeted. The aim will be to identify possible stressors or other factors (e.g., upstream activities) that may be contributing to observed water quality problems. DWQ may perform additional sampling if conditions or activities warrant.

In-stream assessments in other streams segments not previously targeted may be conducted if water quality issues or other observations indicate a need.

Besides providing evidence of watershed condition and stability, stream visual assessments will help to guide further field activities and assist with site identification for restoration and BMPs.

References

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. *Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish*. Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

EPA. 2000. Stressor Identification Guidance Document. U.S. Environmental Protection Agency. Office of Water. Washington, DC 20460 and Office of Research and Development. Washington, DC 20460. EPA-822-B-00-025 December 2000

NCDWQ. 2002. Guidance for Sample Submission. NCDWQ Laboratory Section. April. Available on-line at http://www.esb.enr.state.nc.us/lab/qa.html. Current sample preservation requirements are available on-line at http://www.esb.enr.state.nc.us/lab/qa/collpreswq.htm.

NCDWQ. 2003a. Standard Operating Procedures for Benthic Macroinvertebrates. Biological Assessment Unit. Environmental Sciences Branch. July. Available on-line at http://www.esb.enr.state.nc.us/BAU.htm]

NCDWQ. 2003b. Intensive Survey Unit Standard Operating Procedures. Environmental Sciences Branch. August. Available on-line at http://www.esb.enr.state.nc.us/isu.html

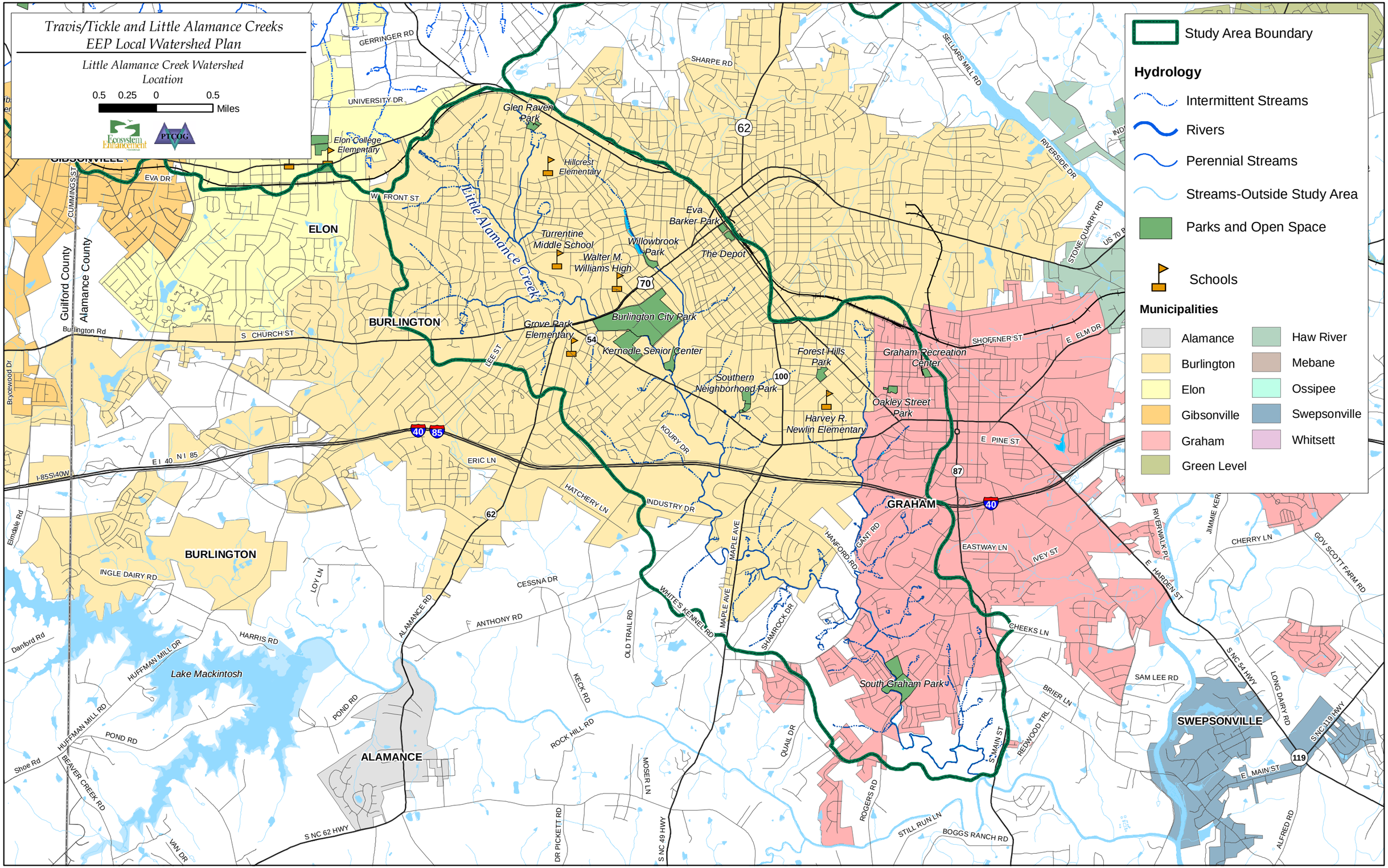
NCDWQ. 2004a. Ambient Monitoring System Quality Assurance Project Plan (QAPP). Environmental Sciences Section. http://h2o.ehnr.state.nc.us/esb/qa.html

NCDWQ 2004b. Basinwide Assessment Report—Cape Fear River Basin. August 2004.

NCDWQ 2006. Memorandum to Jimmie Overton. "Ecosystem Enhancement Program (EEP) Benthic Macroinvertebrate Report fro Little Alamance, Tickle, Travis, Basin and Dry Creeks, Cape Fear River Basin, Subbasins 2 and 3, Alamance County." November 17, 2006.

NRCS. 1998. Aquatic Assessment Workgroup. National Water and Climate Center (NWCC) Technical Note 99-1, Stream Visual Assessment Protocol.

Map Appendices: Reference, Geology, Soils, Existing Land Use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Little Alamance Creek Watershed
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Intermittent Streams
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Schools
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Alamance
Burlington
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Gibsonville
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Mebane
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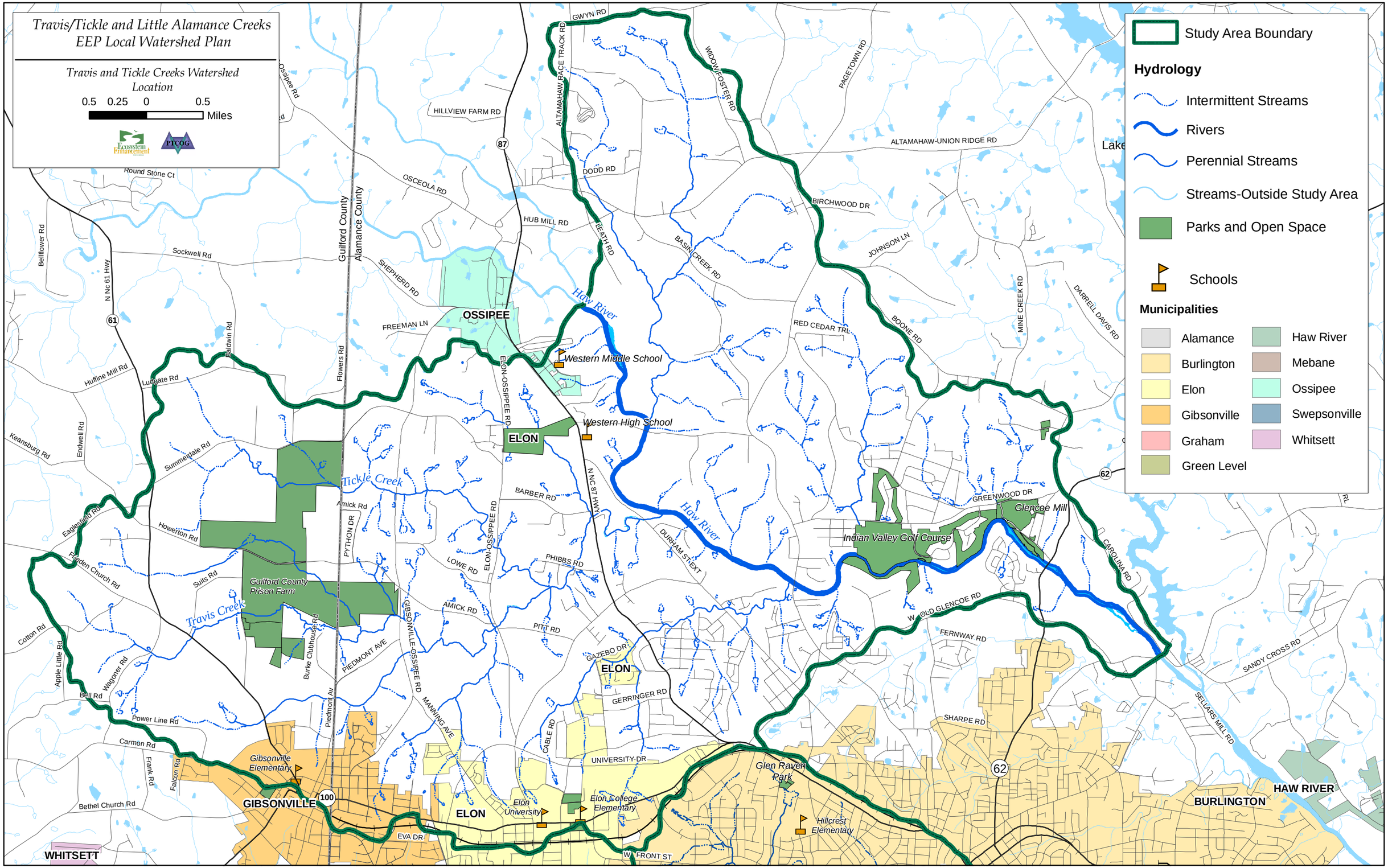
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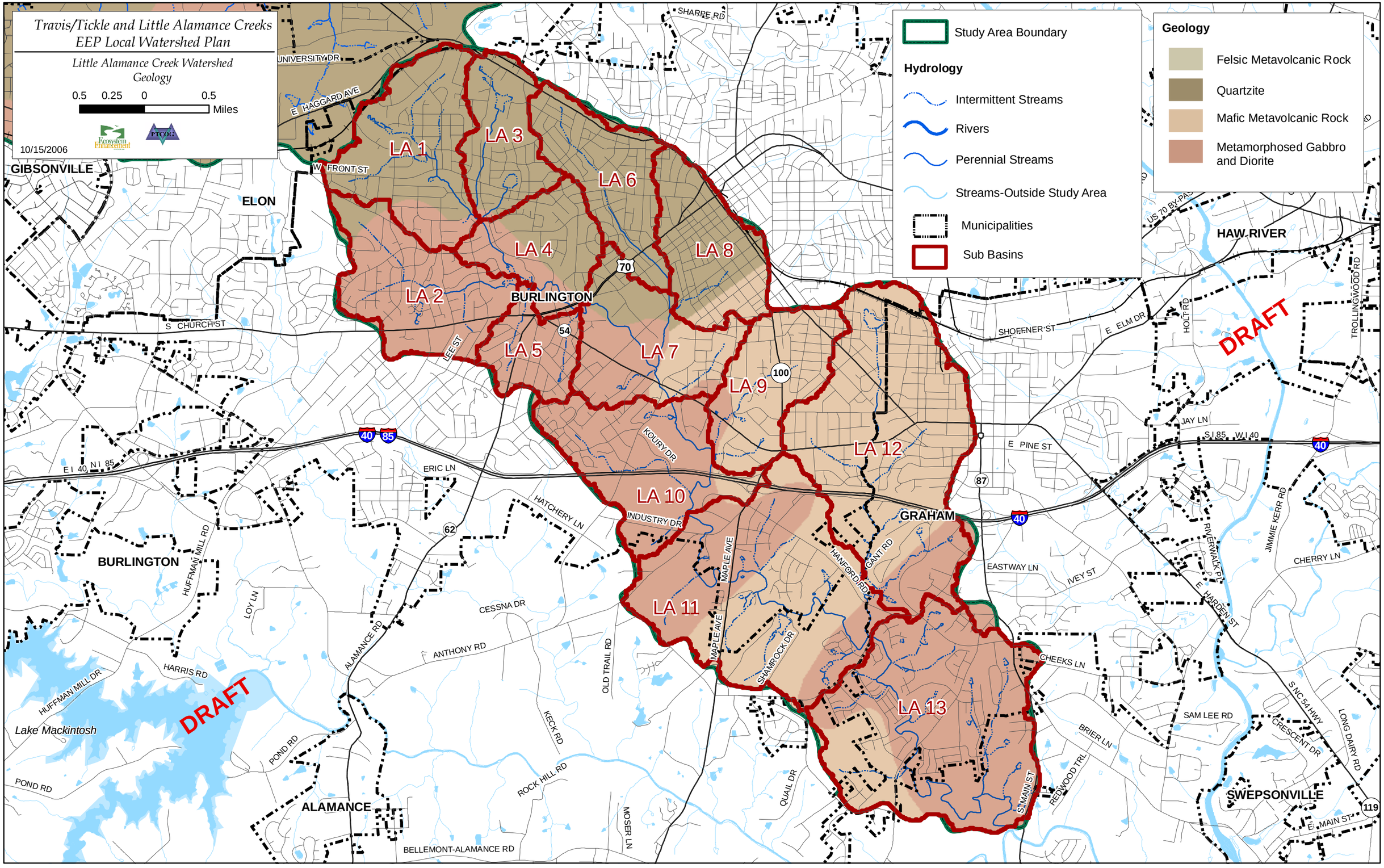
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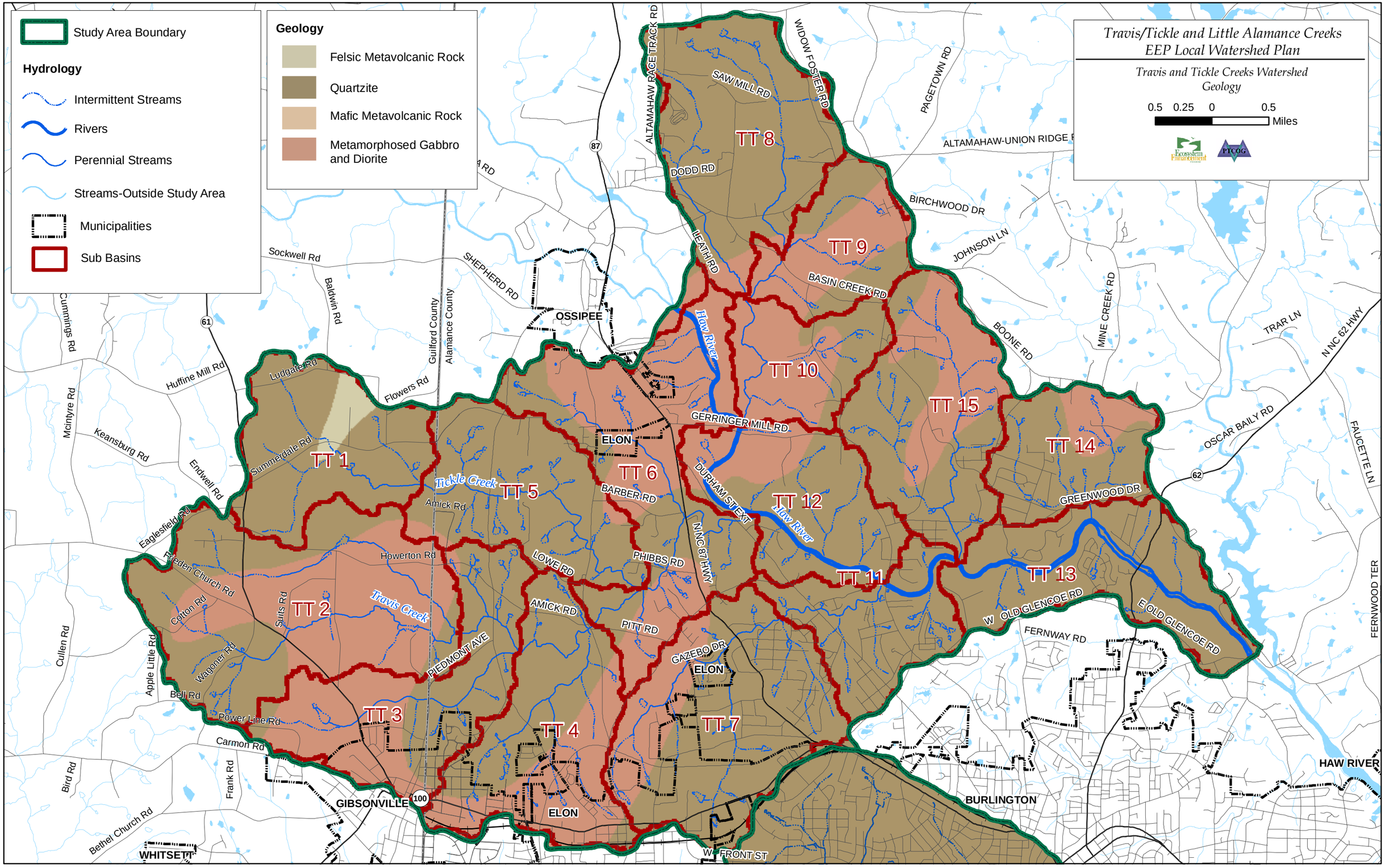
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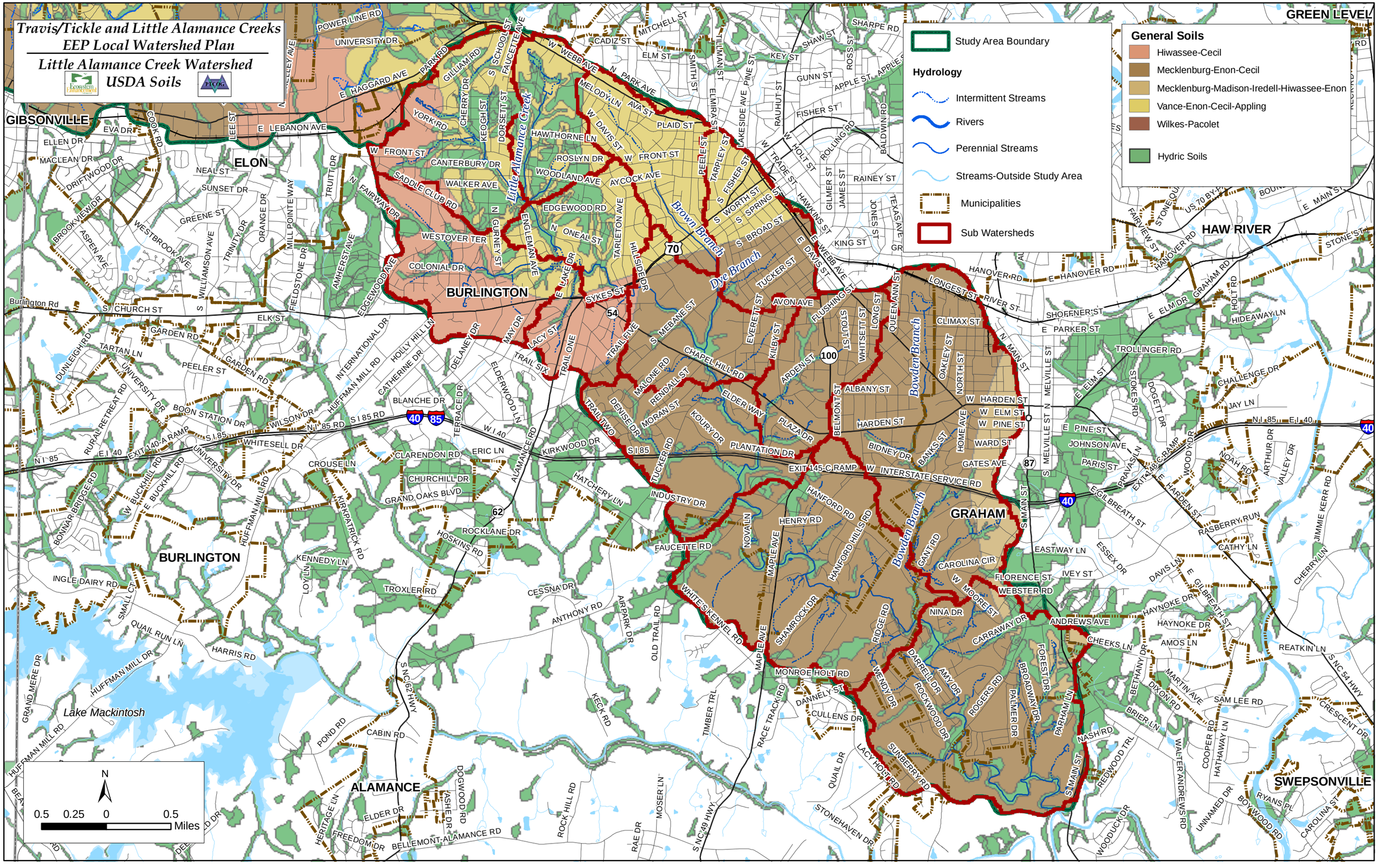
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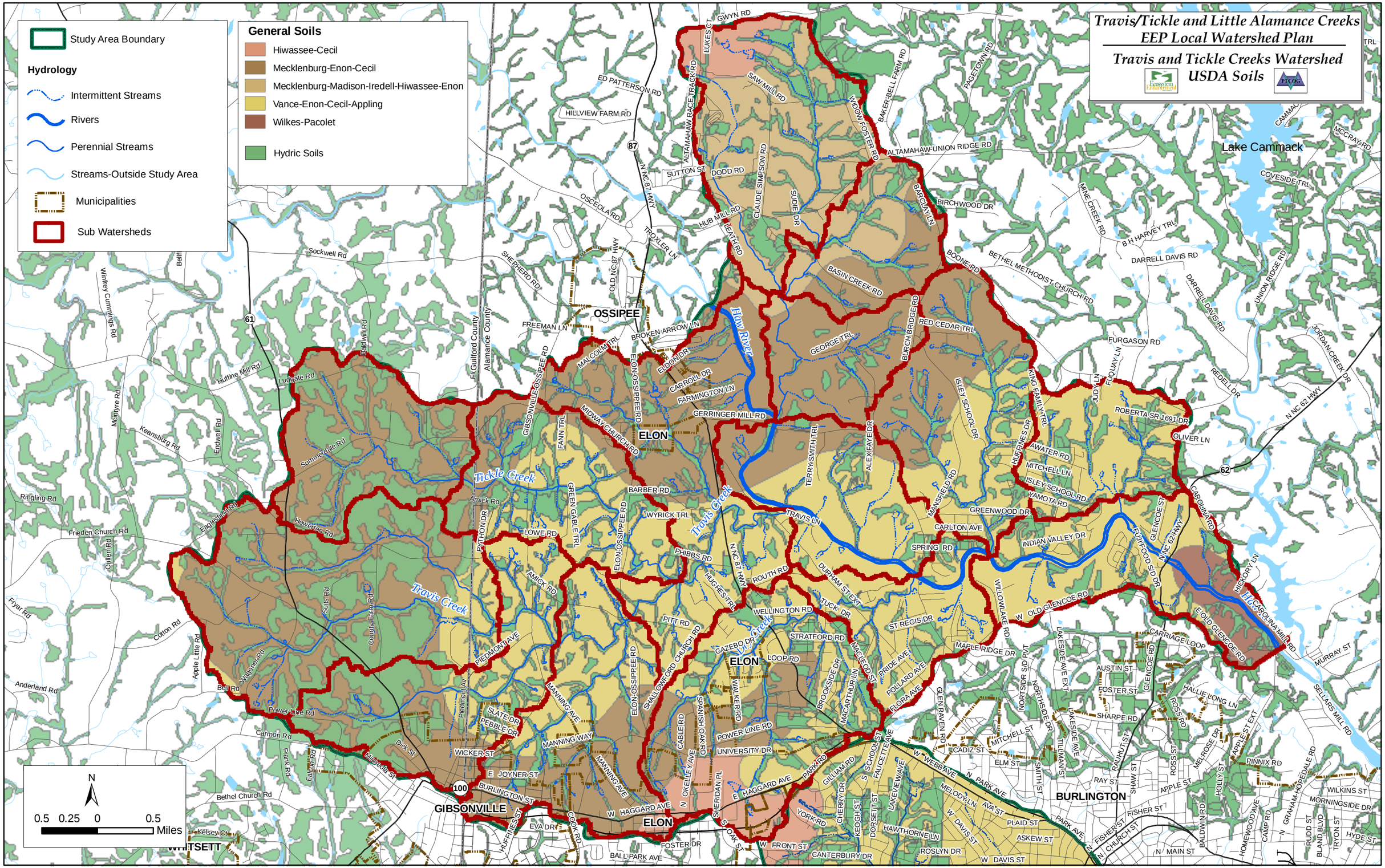
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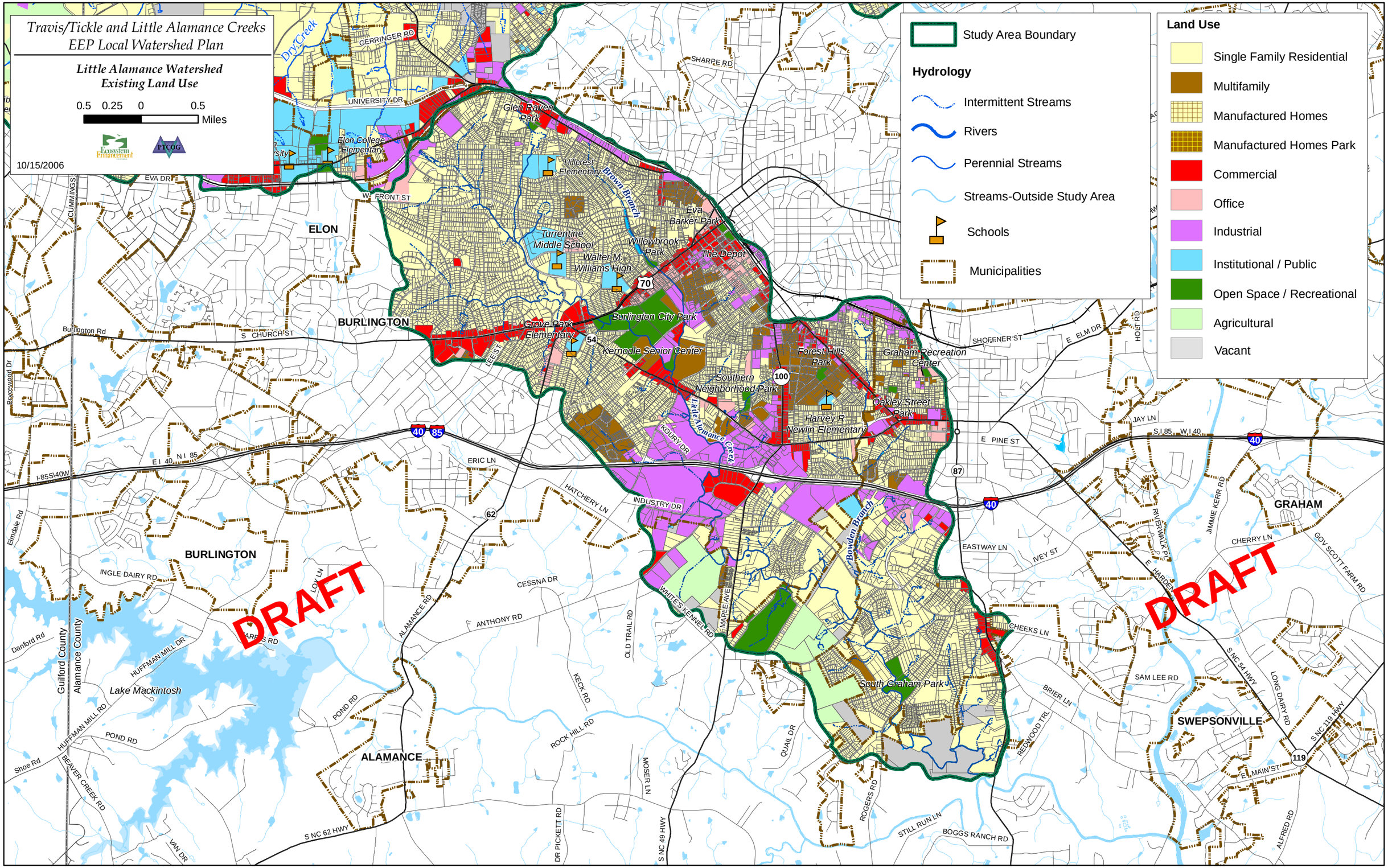
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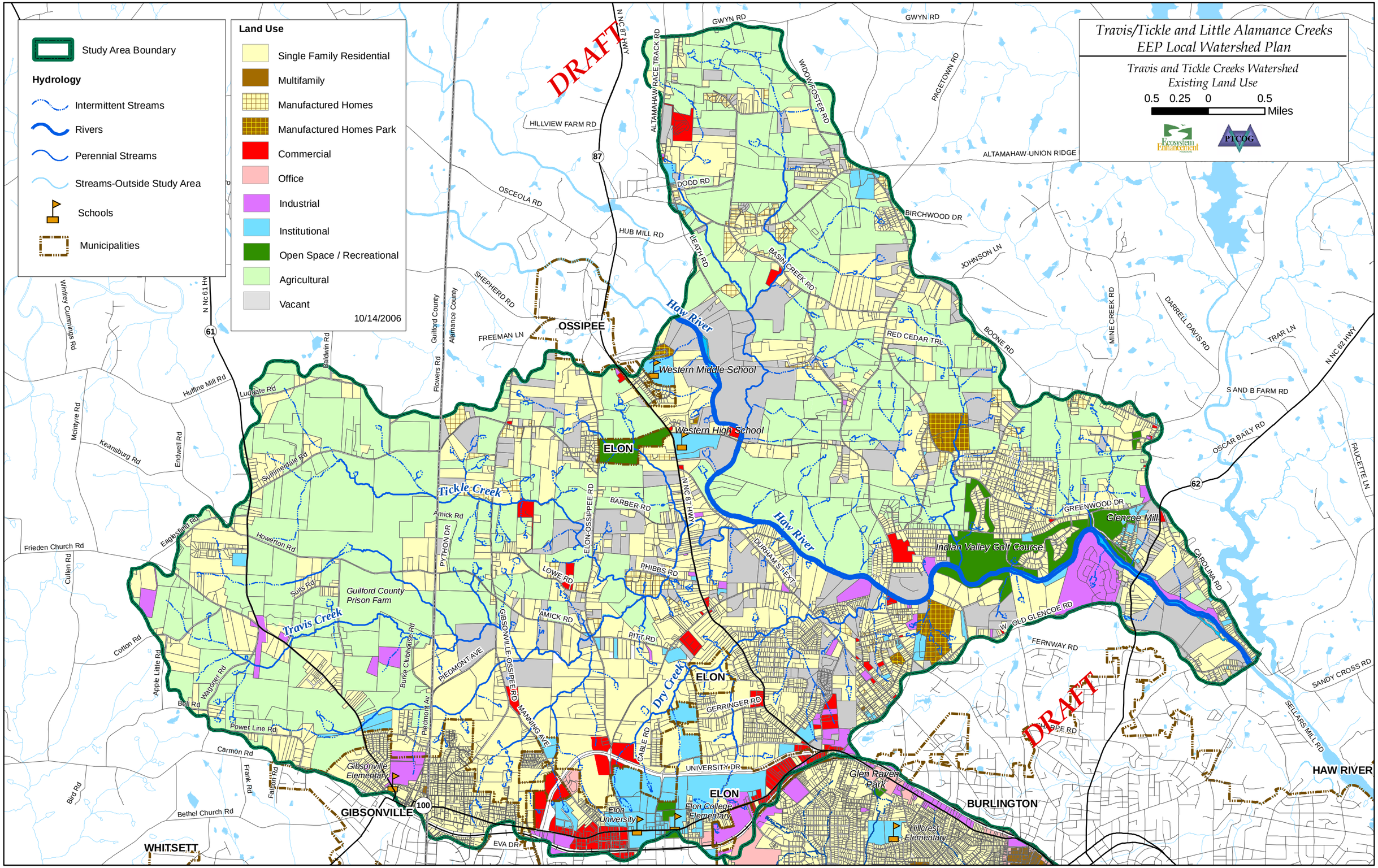
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