CATEGORY 4B DEMONSTRATION PLAN TO ADDRESS BIOLOGICAL IMPAIRMENT IN LITTLE ALAMANCE CREEK, NC

Prepared by:
NC Department of Transportation
Hydraulics Unit
1590 Mail Service Center
Raleigh, NC 27699-1590
919.707.6700

City of Burlington
Water Resources Department
1103 S. Mebane St.
Burlington, NC 27215
336.222.5145

City of Graham
201 South Main Street
PO Drawer 357
Graham, NC 27253
336.570.6700

In Partnership with the:
NC Division of Water Resources
1601 Mail Service Center
Raleigh, NC 27699-1601

Commented [MBF1]: This is NCDENR's address. Need to update to DWR.

Draft
March 2014

This page is intentionally blank

Table of Contents

Commented [MBF2]: Delete since it is now published separately?

List of Tables

List of Figures

List of Acronyms

µg/L	micrograms per Liter
BEHI	Bank Erosion Hazard Index
BMP	best management practice
BSP	Bridge Stormwater Project
CFR	Code of Federal Regulations
cfs	cubic feet per second
CMY	county maintenance yard
DWQ	Division of Water Quality
DWR	Division of Water Resources
EMC	Environmental Management Commission
EOP	edge of pavement
ESD	extreme studentized deviate
ET	evapotranspiration
FHWA	Federal Highway Administration
GIS	geographic information system
IQR	interquartile range
IWS	internal water storage
JLSLAT	Jordan/Falls Lake Stormwater Load Accounting Tool
LATT	Little Alamance, Travis, and Tickle Creeks
LRL	laboratory reporting limit
LT-MDL	long-term method detection limit
LULC	land use / land cover
MDL	method detection limit
mg/L	milligrams per liter
MS4	municipal separate storm sewer systems
NBS	near bank stress
NC	North Carolina
NCAC	North Carolina Administrative Code
DEMLR	Division of Energy, Mineral and Land Resources
NCDENR	North Carolina Department of Environment and Natural Resources
NCDOT	North Carolina Department of Transportation
NCEEP	NC Ecosystem Enhancement Program
NCMIN	North Carolina Multimodal Infrastructure Network
NCSU	North Carolina State University
NO_2	nitrite
NO_3	nitrate
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NSW	Nutrient Sensitive Water
NWQL	National Water Quality Laboratory
$P_{0.25}$	25th percentile value
$P_{0.75}$	75th percentile value
PFC	permeable friction course
ROS	regression on order statistics
ROW	right-of-way
SMP	Stormwater Management Program

Commented [MBF3]: DOT comment:"Plan"?

MBF: Section 2.2 used "stormwater management plan". Section 5.1.1.1 uses "stormwater management program". Recommend retaining "program" here in the List of Acronyms if the word "program" is used in a program's title.

SPMD	semipermeable membrane device
SR	State Route
TKN	total Kjeldahl nitrogen
TMDL	total maximum daily load
TN	total nitrogen
TP	total phosphorus
UCFRBA	Upper Cape Fear River Basin Association
EPA	Environmental Protection Agency
USGS	United States Geological Survey

1.0 Introduction

Commented [BP4]: May need to consider an executive summary given current length.

The Little Alamance Creek watershed is located in Alamance County, North Carolina, within the upper Cape Fear River Basin (**Error! Reference source not found.**). The watershed is approximately 15.9 square m iles in size and is coincident with the United States Geological Survey (USGS) 12-digit hydrologic unit (HUC-12) 030300020309 boundary. The watershed is located within the Southern Outer Piedmont ecoregion (level IV), a subset of the larger Piedmont ecoregion (level III).

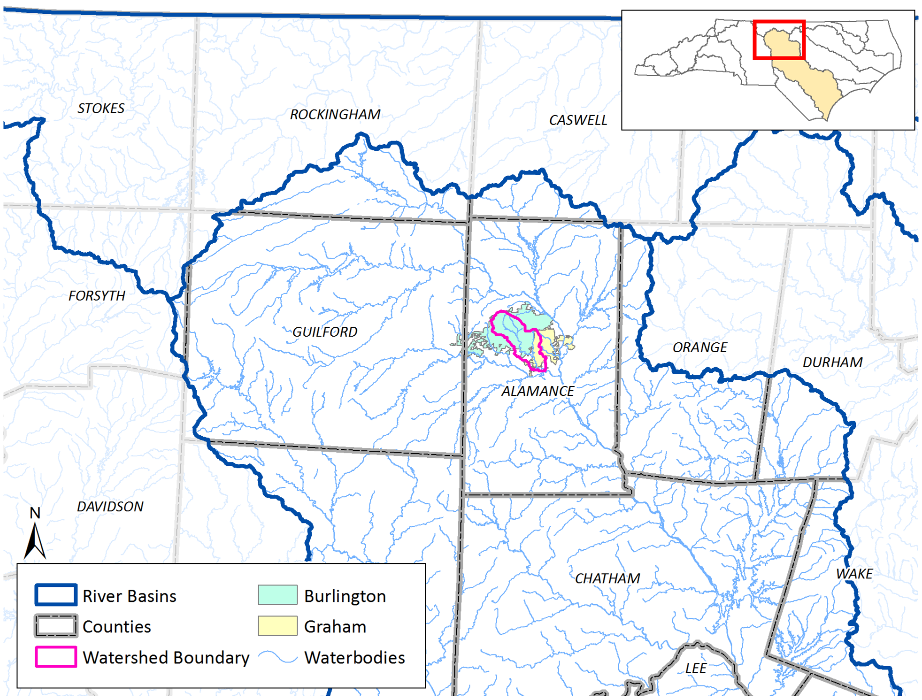

Figure 1-1. Little Alamance Creek watershed and surrounding region

The Little Alamance Creek watershed includes portions of the Cities of Burlington and Graham, and is drained by Little Alamance Creek and its tributaries; Cobble Branch, Brown Branch (also referred to as Willowbrook Creek), Dye Branch, and Bowden Branch. The creek flows southeast into Big Alamance Creek, approximately three miles upstream of its confluence with the Haw River. Little Alamance Creek and four tributaries have been assigned an assessment unit ID by the North Carolina Division of Water Resources (DWR) (Figure 1-2).

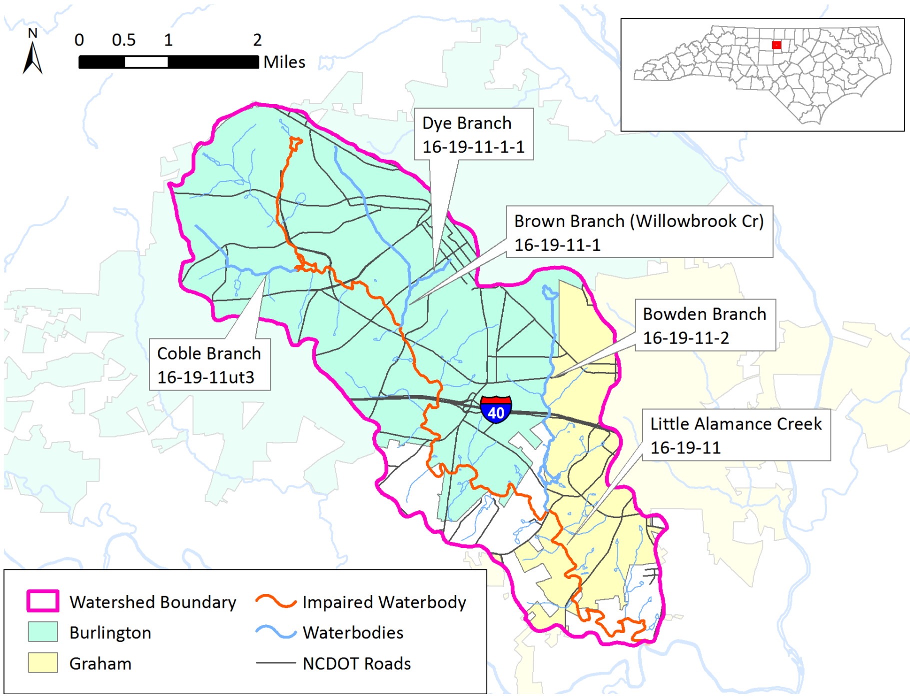

Figure 1-2. Little Alamance Creek, tributaries, and neighboring cities

DWR (formerly Division of Water Quality, DWQ) regularly assesses waters throughout the state to determine whether they are meeting the water quality standards specific for their designated surface water classification, as described in the North Carolina Administrative Code (NCAC) section 15A NCAC 02B. The results of these assessments are listed in the state's biennial Integrated Report (DWR, 2013) to the EPA, in fulfillment of the Clean Water Act (CWA). Each waterbody within the Integrated Report is assigned a Category based on its assessment results. Categories range from 1 to 5, with Categories 1 and 2 indicating no impairment, Category 3 indicating inconclusive data, and Categories 4 and 5 denoting impairment from one or more parameters.

Three tributaries of Little Alamance Creek have not yet been assessed by DWR (**Error! Reference source not found.**). Coble Branch was listed as a Category 3a due to inconclusive assessment results. In 2000, Little Alamance Creek was listed as impaired (Category 5) by DWR due to a Poor bioclassification rating of the benthic macroinvertebrate community (benthos). Little Alamance Creek was assigned a Good-Fair bioclassification for fish in 2013, but this does not negate the Category 5 rating due to a benthos bioclassification of Poor. Category 5 waterbodies not meeting defined standards, i.e., waterbodies that are biologically or otherwise impaired, are recorded in the state's 303(d) list of impaired waters, which is incorporated into the NC biennial Integrated Report.

Deleted: and therefore were listed as Category 3c

Commented [MBF6]: Confirm/adjust wording? Remove from text, and add as a footnote to Table 1?

Table 1-1. Summary of streams within the Little Alamance watershed (DWR, 2013)

Reach Name	Reach Description	Assessment Unit	Waterbody Classifi-cations*	2012 Integrated Report Category†	Rating	Length (miles)
Little Alamance Creek	From source to Big Alamance Creek	16-19-11	WS-V; NSW	5 1	Poor bioclassification (benthos, 2006)‡ Good-Fair bioclassificiation (fish, 2013)	12.6
UT to Little Alamance Creek (Coble Branch)	Source to Little Alamance Creek at Mays Lake	16-19-11ut3	--	3a	Not Rated	1.5
Brown Branch (Willowbrook Cr)	From source to Little Alamance Creek	16-19-11-1	WS-V; NSW	--	--	2.3
Dye Branch	From source to Brown Branch	16-19-11-1-1	WS-V; NSW	--	--	0.6
Bowden Branch (Boyd Creek)	From source to Little Alamance Creek	16-19-11-2	WS-V; NSW	--	--	3.8
Unnamed tributaries	--	--	--	--	--	>30.5

Notes:
* "WS-V" is Water Supply V. "NSW" is Nutrient Sensitive Waters.
† Categories range from 1 to 5, with letters used for subcategories. Categories 1 and 2 indicate no impairment; Category 3a indicates inconclusive data; Category 3c indicates no data; Categories 4 and 5 denote impairment.
‡ Assessment Unit 16-19-11 was first listed as impaired for poor bioclassification (benthos) on the 2000 303(d) List.

Commented [MBF7]: The 2012 Integrated Report seems to indicate that "5" is the "overall" category rating for this reach. (See clip below.) If this is correct, should we bold "5" or add a footnote stating that the "overall" category is 5?

2012 North Carolina Integrated Report

Cape Fear River Basin	10-digit Watershed	0303000203	Big Alamance Creek

> AU Number	Name	Description	Length or Area	Units	Classification	Category
> 16-19-11	**Little Alamance Creek (Gant Lake, Mays Lake)(Alamance County**	From source to Big Alamance Creek	12.6	FW Miles	WS-V;NSW	5

Category	Rating	Use	Reason for Rating	Parameter	Year
1	Supporting	Aquatic Life	Good Bioclassification	Ecological/biological Integrity FishCom	
5	Impaired	Aquatic Life	Poor Bioclassification	Ecological/biological Integrity Benthos	2000

> AU Number	Name	Description	Length or Area	Units	Classification	Category
> 16-19-11ut3	**UT to Little Alamance Creek (Coble Branch)**	Source to Little Alamance Creek at Mays Lake	1.5	FW Miles		3

Category	Rating	Use	Reason for Rating	Parameter	Year
3a	Not Rated	Aquatic Life	Not Rated Bioclassificati	Ecological/biological Integrity Benthos	

Commented [MBF8]: Temporary figure. Clip from 2012 Integrated Report, detailing how the data is represented. Skimming through the Integrated Report, I did not find any instances of there being two or more categories denoted in the far right column. It appears that the highest category number from the inset table was used for the far-right column. Also note that letters were dropped for the far right column. For example, if "3c" was printed in the inset table, "3" was printed on the far-right column.

Impairment for biological integrity is based on a narrative standard that pertains to the aquatic life use designation. Biological integrity has been defined as "the ability of an aquatic ecosystem to support and maintain a balanced and indigenous community of organisms having species composition, diversity, population densities and functional organization similar to that of reference conditions" (15A NCAC 02B .0202). In streams and rivers, biological integrity is often evaluated using quantitative and qualitative assessments of benthic macroinvertebrate and other aquatic community assemblages. The health of these aquatic communities is determined by water quality and habitat conditions as well as the interactions of complex chemical, physical, and biological processes that shape these stream conditions.

In contrast to most water quality impairments that indicate a specific pollutant of concern and cause of impairment, biological impairments simply indicate that an impaired condition exists. Biological assessments do not provide a cause of impairment nor do they necessarily indicate what management approaches are best suited to effectively address the impairment. Despite these limitations, the strength of biological evaluations is that they provide the best indication of overall aquatic health because they reflect both short and long term stream conditions and reflect any impacts of stressors and pollutants that may not be detected using episodic water quality chemistry measurements. In watersheds where no water quality standard violations have been identified, biological impairments may indicate the presence of infrequent stresses, pollutants, or activities for which current water quality standards or criteria do not exist or are inadequate in detecting.

1.1 Options for Addressing Biological Impairment Restoration Options

The goal of the Clean Water Act (CWA) is "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (33 U.S.C §1251(a)). Under Section 303(d) of the CWA, states are required to biennially prepare and submit to EPA a report that identifies waters that do not meet or are not expected to meet surface water quality standards after implementation of technology-based effluent limitations or other required controls. Impaired waterbodies, referred to as the "303(d) List" must be addressed through the preparation of total maximum daily loads (TMDLs), or other appropriate management action, including technology-based effluent limitations, more stringent effluent limitations, or other pollution control requirements (e.g., best management practices) that are stringent enough to achieve water quality standards (see 40 CFR 130.7(b)(1)) within a reasonable period of time.

As its name implies, a TMDL is intended to improve water quality by defining the maximum loading allowable for a given pollutant. When a waterbody is impaired for a known pollutant with identifiable pollutant sources, TMDLs provide an effective tool for defining the existing and allowable pollutant load and support activities that restore a waterbodies' intended uses. However, in watersheds where the pollutant or sources of impairment are unknown, existing and allowable loads cannot be calculated and other management approaches are needed to assess existing conditions, stressors or sources contributing to impairment, and potential implementation activities or approaches. In densely populated or urbanized watersheds, water quality and biological health may be compromised as a result of multiple physical, chemical, and biological stressors rather than a single pollutant or source.

In 2001-2003, NCDENR's Watershed Assessment and Restoration Program (WARP) performed intensive water quality and watershed studies in eleven biologically-impaired streams to identify the most likely causes of impairment, determine the major watershed activities and pollution sources contributing to those causes, and define watershed strategies for restoration activities and best management practices (BMPs) (NCDENR, 2003). In all eleven watersheds evaluated, the WARP reports concluded that biological impairment was caused by multiple stressors and sources and that restoration activities should include a wide range of management actions. Examples of management actions cited in the WARP studies included stream channel restoration in conjunction with stormwater retrofit BMPs, riparian vegetation and aquatic habitat restoration, actions to reduce organic debris and nutrient loading, mitigation of hydrological effects from existing development, addressing toxicological sources, improved sediment and erosion control practices, BMPs to prevent the delivery of pesticides to the stream, education programs, and collection of additional data. These recommendations, along with similar conclusions from other urban watershed studies, suggest that biological impairment is complex and that a broad range of management actions are generally needed to understand and correct these types of impairment.

1.2 Description of the 4b Demonstration Approach

The EPA encourages the use of alternative approaches—in addition to TMDLs—to achieve the water quality goals of the state (EPA, 2013). One listed alternative is known as the "Category 4b Demonstration" An impaired waterbody listed on Category 5 may be re-categorized as Category 4b when a management strategy that is expected to address the identified impairment(s) is approved by EPA.

Commented [MBF9]: DOT comment: Confirm that the EPA formally approves a 4b plan, or if instead there is implicit approval via EPA approving the waterbody's removal from the 303(d) list.

The objective of a 4b Demonstration is to "promote implementation activities designed to achieve water quality standards in a reasonable period of time" (NCDENR, 2011). To achieve this objective, the EPA has identified six elements that should be addressed within a 4b Demonstration (Table 1-2). These six elements are referenced in a Category 4b guidance document by DWR (DWQ, 2011 draft). Specifically, a 4b Demonstration should clearly **identify** the Category 5 waterbody and its impairment, describe the **water quality target** and the **pollution controls** to be implemented in order to reach said target, estimate the **time** upon which the specific water quality standard will be met, provide a **schedule** for implementation of various pollution controls, specify a **monitoring** plan, and provide a commitment to **revising** the 4b Demonstration, as necessary, toward meeting the stated water quality target. As presented in Table 1-2, each EPA element has been included in this 4b Demonstration for Little Alamance Creek.

Table 1-2. EPA-required elements for a Category 4b Demonstration (NCDENR, 2011)

Commented [MBF10]: DOT comment: "EPA/DWR"?

Category 4b Demonstration Six Required Elements[1]		Corresponding Report Sections
1	Identification of waterbody assessment unit number(s) and statement of the problem causing the impairment	Sections 1.0, 3.0, and 4.0
2	Description of pollution controls and how they will achieve water quality standards (WQS)	Section 5.0
3	An estimate or projection of the time when WQS will be met	Sections 6.0, 7.0, and 8.0
4	Schedule for implementing pollution controls	Section 6.2
5	Monitoring plan to track effectiveness of pollution controls	Section 7.0
6	Commitment to revise pollution controls, as necessary	Section 8.0

[1] Source: http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/2008_ir_memorandum.cfm and http://portal.ncdenr.org/web/wq/ps/mtu/alternatives

1.3 Project Partners

In 2011 and 2012, representatives from NCDENR, NCDOT, the Cities of Burlington and Graham, and other municipalities participated in meetings to discuss biologically impaired waterbodies and strategies for addressing impairment when the pollutant(s) causing impairment is unknown. During the course of these meetings, the Category 4b Demonstration, along with other options, was discussed as an alternative to a TMDL. After investigating these options, NCDOT, the Cities of Burlington and Graham (hereafter referred to as the "project partners") committed to supporting a Category 4b process to address impairment in Little Alamance Creek. As part of this commitment, the project partners have evaluated watershed data and information and jointly prepared a Category 4b report (this document) describing management actions that, when implemented, will contribute to the overall goal of restoring water quality and achieving a benthic macroinvertebrate community bioclassification of “Not Impaired”, “Good-Fair”, or better. Formal letters of those commitments along with DWR’s agreement to support a Category 4b process in the Little Alamance Creek watershed are presented in Appendix A of this document.

2.0 Historical Background

2.1 Historical Watershed Information

The original native inhabitants of present day Alamance County were referred to as the Shackory Indians by the German explorer Dr. John Lederer in 1670 (Euliss, 1984, 5). More commonly known as the Sissipahaw Indians they were Siouan and had settled between the Eno and Haw Rivers. Numerous village sites have been located along the Haw River and Alamance Creek which indicate that the Sissipahaw raised crops on fertile floodplains and hunted wild game.

Little else is known about the Sissipahaw. Native Americans left the area before the arrival of European settlers perhaps merging with the Catawba Indians, the largest Siouan tribe in the Piedmont. European settlement of the area began in the early 1700s; however, following the Tuscarora Indian Wars (1711-1713) and the English Crown's purchase of the Lords Proprietor's Colony (1729) many more settlers moved into the area (Vacca and Briggs Undated, under "Colonial History: European Settlement").

The Indian Trading Path linked Indians in east central Virginia with the Catawba Indians west of the Yadkin River in North Carolina. A segment of the Trading Path passed through Alamance County from northwest of Hillsborough toward Mebane crossing the Haw River at the Town of Haw River (Troxler 2000, under "East-west Pattern of the Trading Path Network in Alamance County"). Beyond the Haw River the Path split into a "western Trading Path" and a "lower Trading Path". The western Trading Path continued to Graham and beyond where it crossed both Little Alamance Creek and Great Alamance Creek.

The Trading Path became important for commerce between Virginia traders and the Catawba nation. In 1728 Colonel William Byrd of Virginia described the Trading Path as traversing "…the most fertile high land in this part of the world…" (Euliss 1984, 5). This and other similar descriptions of the area attracted settlers from the middle and northern colonies. Land in Piedmont North Carolina was relatively inexpensive when compared to Pennsylvania.

Quakers, Scots-Irish Presbyterians and German Lutherans and Reformed from Pennsylvania were among early immigrants who established numerous settlements in Alamance County (Vacca and Briggs Undated, under "Colonial History: Settlement Patterns").German Lutheran and Reformed settlers located along Alamance Creek and Stinking Quarters Creek. English, German and Welsh Quakers settled near Snow Camp along Cane Creek. Scots-Irish Presbyterians chose settlements in eastern Alamance County near Hawfields.

2.1.1 Land Uses and Population

Agriculture and silviculture were significant land uses in both the 18th and 19th centuries. Timber was harvested and sawmills were constructed to supply lumber to build settlements. The earliest farming was for subsistence and included growing fruits and vegetables and raising cattle and hogs. Corn, wheat, oats and rye, flax and tobacco were grown later in the 18^{th} century cotton as commercial crops. Numerous gristmills were built along the Haw River and its tributaries to produce corn meal and flour.

Many of these streams were ideal locations to construct dams and provided the channel slope and stream flow needed for mill races and water wheels. During the Industrial Revolution some early mill sites became the location for textile mills. Most provided water power for spinning machines and looms.

Commented [JSJ11]: This needs an introduction. An introduction would tie this into the overall document. Currently it is very confusing as to why anyone should care.

Commented [MRB12]: Potential subsections: Pre-colonial History or Native American Lands, then European Colonization or Agriculture and Textile Industry?

Commented [SCD13]: I agree. That would logically break the narrative into more easily read subsections.

Commented [PB14]: After now reading this entire section 2.1 and subsections. I think there may need to be an introduction and summary highlighting a theme for this history. That theme may be previous periods' reliance and hardship to creek through cultural and historical relations. In that sense, it seems some section nail this like the mills and sewer discharge but other sections, the connection is not as obvious.

The story for so many of these urban creeks is the evolution from pristine resource to agrarian utility to industrial engine to waste conveyance to urban eyesore to today were we attempt to restore them to the pristine resource we first found them. The tone should not suggest that full restoration can always be achieved but that a process must be endeavored much like the history of the impact in order to reverse the trend.

Possibly using this as a theme and path for the narrative may help to tie all these interesting facts together. Melissa's suggestion for section headings following historical periods may be valid for all of section 2.1. Then you can talk about all the issues and facts occurring at the same time together and not be constrained by the topical section headers.

Commented [SCD15]: When I drafted this Section I chose a default reference citation style. If there is a more appropriate style or the need to be consistent I will be glad to convert all of these reference citations.

Craig, Thanks for your level of documentation! Unfortunately, we do not have page numbers for all of the other citations, so I would suggest listing the page numbers in the Reference section only, and not the parenthetical citations. Thanks.

Commented [PB16]: There is good information in here and relevant to the objective of the document however I think it could be condensed to highlight some of the important points, such as duration of mill operation, density of mills, presence of dyes, etc.

Some were later converted to steam power. By the late 1830s there were 41 gristmills in Alamance County (Vacca and Briggs Undated, under "Textile Industry"). In 1879 there were 40 gristmills and 24 sawmills. Over half of these mills were built during the previous 20 years (Lounsbury 1980, 68). As late as 1928 there were still 30 mills, mill dams or mill sites located in the county.

A number of mills were located along Little Alamance Creek. A map of Alamance (Spoon, 1893) shows six hydro-powered mills located along Little Alamance Creek between its confluence with Great (Big) Alamance Creek and present-day Burlington (Figure 2-1).[Insert text if possible to identify what type mills these were, ex. Grist?]

Commented [SCD17]: I will make another attempt to contact Dr. William Murray Vincent at Elon University. He may have knowledge of this. Also, Josh was going to ask the Mayor of Graham.

Commented [JSJ18]: Could this be in bullets? This document may not always be printed in color and figures in black and white can be hard to read.

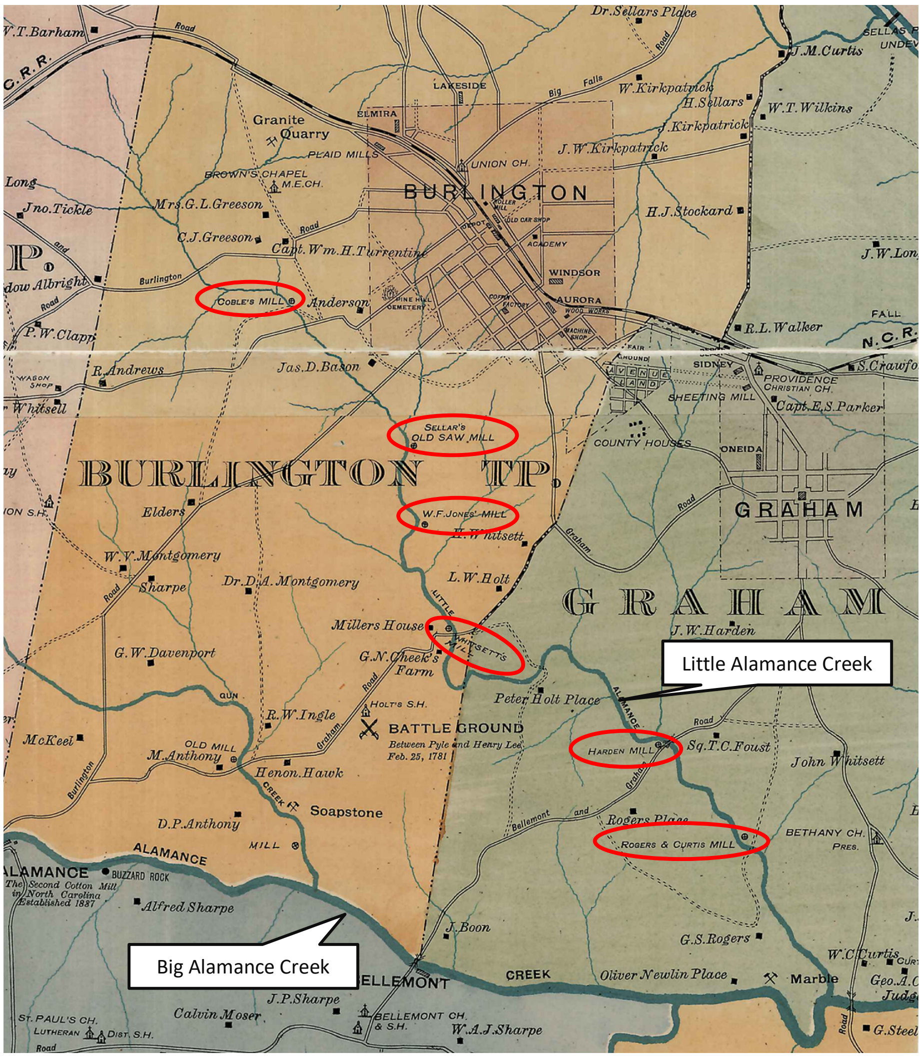

Figure 2-1. Historic map of Alamance County indicating six mills located within the Little Alamance Creek watershed (Spoon, 1893).

In 1832 John Trollinger built the first cotton mill in the county located on the Haw River north of Stony Creek. In 1837 Edwin M. Holt and his brother-in-law William Carrigan founded the Alamance Cotton Factory on Alamance Creek at Alamance.

Commented [JSJ19]: Can we shrink this and/or add the watershed to the image so that it's obvious what's within the watershed.

Josh, I previously attempted to georeference this image into ArcGIS, but was unsuccessful. I have re-worded the caption.

Carrigan later sold his interest to Holt who also acquired the Granite Cotton Factory at Haw River in 1845. In 1849 Edwin M. Holt built a yarn mill on the Haw River at Saxapahaw. He is considered the most important of the early mill owners in Alamance County. It was largely his vision that led to the growth of the textile industry in Alamance County and North Carolina.

Prior to that time most cotton grown in North Carolina was shipped to northern manufacturers to be converted into yarn. North Carolina mills were in turn paying higher prices for the yarns produced by the northern mills. Holt realized that building cotton mills in Alamance County would take advantage of already having the raw materials nearby, benefit from low freight rates to the mill, utilize established mill sites for water power and have abundant labor.

Commented [SCD20]: Agreed.

Commented [BAJ21]: Good information but if document length becomes an issue, this text could be shortened.

In 1879 there were six cotton mills in the county, and by 1890 there were 17. At least three late-19th century cotton mills were built near the headwaters of several Little Alamance Creek tributaries. These were the Plaid Mills (1883) in present-day Burlington and the Oneida Mill (1882) and the Sidney Mill (1885) both in present-day Graham (Dickenson 1987, various pages). Edwin M. Holt and his son Thomas M. Holt produced the first colored cotton goods in the South, installing looms in the Alamance Cotton Factory on Alamance Creek specifically for producing woven, dyed cotton cloth. This cloth became known as Alamance Plaids (Stockard 1900, 92).

Holt's mills produced hundreds of yards of cloth used to make Confederate uniforms during the Civil War. In 1883 he built the E.M. Holt Plaid Mills in present-day Burlington. Alamance Plaids were also manufactured at the Plaid Mills (Whitaker 1949, 103) and were very popular in both southern and northern markets. In 1900 the E. M. Holt Plaid Mills converted from the plaid fabric to gingham which it continued to produce until 1931 when it was converted again to manufacture yarn goods.

Commented [SCD22]: I would preserve this fact that Alamance Plaids were manufactured at the Plaid Mills in Burlington because the Mill is located in the headwaters of Little Alamance Creek.

Commented [BAJ23]: Good information but if document length becomes an issue, this text could be removed or shortened.

Color-fast indigo dye was used to produce the first Alamance Plaids (Vincent 2009, 76). Indican, a natural blue colorant is found in many plants world-wide. Indigofera plant varieties are generally considered to produce the largest amounts of Indican per plant and were highly desirable as sources for Indigo dye in the 19th century.

The production of Indigo dye followed essentially the same process world-wide between the 16th and the 19th centuries (Sweet Undated, 1-16). Indican is a water soluble glucoside which is easily extracted by steeping the plant leaves and stems in water. In the 19th century the production of Indigo dye required a series of large vats.

After steeping, the liquid created was allowed to ferment for 10 to 12 hours. During fermentation a natural enzyme known as Indimulsin was added to hydrolyze the Indican and eliminate glucose. The liquid would literally heave and swell and develop a foul odor.

The fermented liquid was then decanted into another vat exposing the Indican to air. The resultant oxidation process transformed the Indican into an insoluble form. Once in the second vat the fermented liquid was beaten or flailed with large paddles for several hours causing a precipitate called Indigotin to form in the bottom of the vat. The precipitate was dried and cut into small blocks of Indigo dye.

To be used as dye these blocks were ground into a powder and mixed in an alkaline (mordant) bath. Mordant agents were often metal oxides and included, at various times, tannic acid, alum, urine, chrome alum, sodium chloride, and certain salts of aluminum, chromium, copper, iron, iodine, potassium, sodium, and tin (Wikipedia 2014, under "Mordant").

They served to make the Indigo soluble again and enhanced the saturation of the yarn or cloth with the dye during the dying process. Once dyed the yarn or cloth was exposed to air to dry. The resultant oxidation process once again transformed the Indican into an insoluble form making the dye color-fast.

The production and use of indigo dye resulted in potential sources of surface water pollution. In addition to the reactants normally used in the production of the dye, caustic lye (sodium hydroxide) and slaked lime (calcium hydroxide) were sometimes added during the dyeing process to aid fermentation and to modify color intensity, respectively. Dye-related pollutants had the opportunity to enter the environment at three stages: during the manufacturing of the dye, during the application of the dye to the yarn or cloth, and during disposal.

In the late 19th century the first hosiery mills in the county began operation. In the 1920s, many cotton mills were converted to produce rayon and other fabrics. By 1934, Burlington Mills was the largest producer of rayon in the United States (Vacca and Briggs Undated, under "Textile Industry").

2.1.1.1 Railroad

In 1849 the North Carolina General Assembly enacted legislation creating the North Carolina Railroad Company. Various owners of textile mills in Alamance County were among the chief proponents of the railroad (Euliss 1984, 13). The route of the railroad greatly influenced area demographics and ensured that late 19th century mills and other manufacturing concerns would locate in towns near the railroad (Vincent 2009, 12). Seven late 19th century cotton mills were located adjacent to or in close proximity to the railroad in present-day Burlington and Graham. The railroad alignment followed the ridgeline that defines the upper watershed boundary of Little Alamance Creek.

A repair station was built midway along the route to service locomotive engines and rolling stock. Construction began in 1855 and was largely complete by 1859. The station was known as Company Shops and attracted engineers, mechanics and other skilled workers from 10 states and several foreign countries (Vincent 2009, 13).

The rapid population growth and diversity ultimately transformed the railroad town into a community of varied cultural backgrounds. The original railroad directors envisioned a company town characteristic of 19th century industrial development (Troxler 2006, under "Company Shops"). To control development they acquired 632 acres, although the railroad shops occupied less than 30 acres.

By 1859, Company Shops included 57 buildings that housed two machine shops, a blacksmith shop, a foundry, a carpentry shop, an engine shed, and car shed. In addition, a passenger and freight station, a two-story hotel, houses for workers and railway officials, and a company headquarters building were constructed.

Company Shops was incorporated in 1866. By 1893 the North Carolina Railroad had become part of the Southern Railway system. Southern Railway built new shops in Spencer, North Carolina. The acquisition of the railroad and the new shops in Spencer resulted in the transfer of many jobs. Resentment toward the railroad led citizens to seek a change in the town name. In February 1887, Company Shops formally became Burlington.

Commented [SCD24]: I agree this is a lengthy discussion. I suppose I was focused on the nature of the dye as a possible pollutant. I agree though that it can be removed or shortened if need be.

Commented [BAJ25]: Good information but if document length becomes an issue, this text could be removed or shortened.

Commented [MBF26]: Does/did rayon manufacturing have any water quality byproduct issues that we could or should to discuss here?

Commented [JSJ27]: How can we make this smack someone in the face about how it's related to the Little Alamance watershed? Perhaps a paragraph at the beginning or end about how potentially destructive all of this was to water quality.

Commented [PB28]: We need to highlight the importance of this topic on the creek and watershed. What makes this watershed stand out from other watersheds of the time?

Commented [SCD29]: Agreed.

Commented [BAJ30]: Good information but if document length becomes an issue, this text could be removed or shortened.

2.1.1.2 Sewage Discharge

In 1950, numerous complaints against the City of Burlington were filed with the North Carolina State Board of Health by citizens living along Little Alamance Creek. At that time Burlington was discharging sewage into Little Alamance Creek. As more complaints were being filed against the City of Burlington, the State Board of Health urged the city to construct a sewage disposal plant to avoid multiple law suits (The Burlington Daily Times-News, 6 December 1950).

In 1951, a claim in the amount of $20,000 was filed against City of Burlington by two residents of Graham for alleged damages arising from the city's discharge of sewage into Little Alamance Creek (The Burlington Daily Times-News, 27 April 1951). On January 10, 1962 the United States Community Facilities Administration approved a $38,235 loan for the preliminary planning of a major interceptor sewage line and waste treatment plant for the Little Alamance Creek drainage area (The Burlington Daily Times-News, 11 January 1962). The Burlington city council voted unanimously on January 16, 1962 to purchase a 58-acre tract for the construction of a waste treatment plant to be located near the confluence of Big Alamance Creek and the Haw River (The Burlington Daily Times-News, 17 January 1962).

The proximity of various mills and other industrial enterprises to Little Alamance Creek and its tributaries could have resulted in the discharge of potential pollutants dating to the Colonial period.

2.2 History of NC's Water Quality Permitting Programs

Eighteenth century interest in public water supply in antebellum North Carolina was mainly focused on fire protection (Howells 1989, 1). Well into the nineteenth century unsafe water supplies were frequently the cause of illness and death. Mortality figures from the Civil War reveal more deaths from disease than from battle with water-borne illnesses often cited.

In response to growing concern for hygiene and sanitation the North Carolina General Assembly created the North Carolina Board of Health in 1877. Early water quality analyses were limited by the incomplete understanding of the connection between water chemistry and disease and by the simplistic analytic technology of the time (Howells 1989, 5). Still, these efforts successfully made the connection in some instances between contaminated groundwater wells and illness.

Public concern for stream sanitation grew to include aquatic life and nuisance conditions. In 1883 the North Carolina General Assembly enacted An Act to Prevent Poisoning Streams of Water in this State. The Act made it illegal to use poisonous substances to catch, kill or drive fish in waters, creeks and rivers of the State (Howells 1990, 4).

In 1886 both the City of Durham and the City of Raleigh acted to provide community water systems. By 1888, the North Carolina Board of Health reported 12 communities with public water supply systems although the water quality for each varied. Turbidity was often reported. There was little to no use of the water provided by poorer classes, presumably because of the cost.

These early public water supplies generally received no treatment other than some degree of sedimentation. Whether deep wells or streams, the water sources themselves were not protected and were vulnerable to pollution. For this reason the City of Raleigh sought legislation in 1887 to protect the stream and watershed of Walnut Creek.

Commented [MRB31]: Consider a summary statement to the effect of: … many years of potentially impaired water quality.

Commented [SCD32]: In the absence of definitive history confirming industrial discharges from the mills or operations of Company Shops perhaps a statement could be made similar to, "The proximity of various mills and other industrial enterprises to Little Alamance Creek and its tributaries could have resulted in the discharge of potential pollutants dating to the Colonial period." This is just a suggestion so others please feel free to suggest alternatives.

Commented [SCD33]: I did not have a good sense of how much detail was needed here. It may suffice to indicate the history of the discharge in the 1950's and the response of the City to build the treatment plant. I would Michael to weigh in considering the historic information the City has.

Commented [BAJ34]: DOT comment on this section: Need to decide how best to make the case that textile mills and dyeing of fabrics and the development of Company Shops in the headwaters could have impacted water quality in Little Alamance Creek.

Commented [JSJ35]: We should mention the age Burlington and Graham's Collection System's as well as general info about them. i.e. both have sections of the collection system over 100 years old and alot of the system that is between 75 years and newer is clay pipe with 4' joints. Burlington should have some historical information about the LAC treatment plant as well.

Commented [PB36]: Land use, population, railroads, sewage discharge. These were hard topics to weave together so it seems like we need a central theme here that gets summarized at the end. My guess at this theme would be a reliance on the creek that we are not accustomed to today in order to show the hardship on the creek.

Commented [BAJ37]: I've included a few minor edits only. There is a lot of good info here so if we need to shorten, we can take a second look.

Commented [SCD38]: Same note as earlier regarding reference citation style. I can change it if needed.

Commented [MBF39]: DOT comment: Confirm the act's name.

Commented [MBF40]: DOT comment. "Record for clarity"

Thirty-five North Carolina Counties reported cases of Typhoid fever in 1888. In 1889 the North Carolina Board of Health issued several advisories that Cholera and Typhoid fever were commonly caused by polluted drinking water and recommended that drinking water be boiled. This time period also saw the general acceptance of the need to disinfect waste and treat sewage.

Beginning in 1889 the North Carolina General Assembly passed numerous legislative prohibitions against pollution by sawdust from lumber mills. Similar legislation was passed for various counties through 1921 (Howells 1990, 9).

In 1893, the North Carolina General Assembly authorized the North Carolina Board of Health to oversee all inland waters and determine their potential as domestic water supplies. This authority extended to the protection of watersheds. An early result in 1894 was the determination that the Little River water supply for the City of Goldsboro was contaminated by streams draining unsanitary areas of the City. The City was advised to abandon the river and obtain public water from deep wells.

In 1897 legislation was introduced in the North Carolina General Assembly that would have extended the police powers of cities and towns to their water supply watersheds and would have required periodic watershed inspections (Howells 1989, 22). Although the legislation was not enacted it prompted the North Carolina Board of Health to order all municipal water supplies inspected and tested chemically and bacteriologically. In 1899 the North Carolina General Assembly adopted legislation that required public water companies to undertake quarterly biological and chemical analyses.

By 1902 the number of North Carolina towns having public water supplies had grown to 27; however, the North Carolina Board of Health continued to express concern with the quality of the water furnished by some of the systems. The quarterly watershed inspections and water quality analyses were generally not being observed (Howells 1989, 35). Treatment was still commonly limited to mechanical filtration at times augmented by coagulation prior to filtration. Water quality analyses had improved to some degree but were often limited chemical analysis for chlorine, ammonia, nitrate and nitrite.

Prior to the 1950s there was no effective statewide law to control discharges to waters of the state (DeVane, Undated). In 1895 the North Carolina Board of Health reported that raw sewage was discharged to Walnut Creek, the water source for the City of Raleigh. Discharge of raw sewage directly to streams or their tributaries was common. In 1903, the North Carolina General Assembly adopted An Act to Protect Water Supplies. Under the law pollution of water sources was considered a misdemeanor offense subject to fines and imprisonment.

In 1905 the City of Durham sued Eno Cotton Mills under the Act alleging their wastewater discharge resulted in pollution of the City's Eno River water supply. The court ruled in favor of Durham, a decision that was subsequently sustained on appeal to the State Supreme Court (Howell 1989, 38).

By 1907 the North Carolina Board of Health had published water purification standards and advocated bacteriological analysis as the most appropriate test for acceptable drinking water. It was during this period that analyses for coliform indicator bacteria were first recommended.

In 1907 there were 48 communities with public water supplies but only 25 with sewer systems. Efforts to treat drinking water and protect public water supply watersheds continued. The North Carolina Board of Health first recommended disinfection with compounds of chlorine in 1911.

The same was not necessarily true for the discharge of sewage. While it was acknowledged by this time that studies of sewage treatment and industrial wastes were needed to determine the assimilative capacity of receiving streams there appears to have been some debate surrounding the legal rights of municipalities to discharge sewage. As late as 1926 a citizen petitioned the North Carolina Board of Health with concerns about the Town of Warsaw's raw sewage discharge. The Board declined to make specific finding or recommendations citing differences of opinion about the judicial right to discharge raw sewage to a stream.

Similarly the Town of Smithfield petitioned the North Carolina Board of Health over concerns about the City of Raleigh discharge of sewage. The Town alleged health hazards arising from contamination of their Neuse River water supply. Ultimately the Town of Smithfield sued the City of Raleigh in 1934 (DeVane, Undated). The Superior Court ruled in favor of the Town as did the State Supreme Court on appeal. The City of Raleigh was ordered to build a sewage disposal plant.

In 1911 the North Carolina General Assembly passed the first State legislation to prevent stream pollution from the disposal of tailings waste from mining activities (Howells 1990, 11). In 1915 the North Carolina General Assembly created a Fisheries Commission Board to oversee commercial fishing and authorized it to enforce discharges to State waters of deleterious materials and substances poisonous to fish life. Following this legislation the North Carolina General Assembly adopted An Act to Prevent Pollution of Fishing Stream and Trespass on State Fish Hatchery Property in 1927.

In 1927 a Stream Sanitation and Conservation Committee was formed representing the North Carolina Board of Health and the Conservation Commission. The committee was charged with investigation of stream pollution on the Neuse, Haw, Tar, Catawba and Roanoke Rivers (Howells 1989, 59).

Increasing concern for interstate waters pollution resulted in the North Carolina General Assembly enacting An Act Providing for Administration and Control of Interstate Waters in 1929.

In the 1930s the North Carolina Board of Health frequently cited stream pollution as one of the State's greatest problems. In 1945 the North Carolina General Assembly established the State Stream Sanitation and Conservation Committee.

At the federal level the first legislation to address water pollution was the 1899 Refuse Act. While its primary purpose was to prevent discharge of refuse into navigable waters, it was used successfully in the 1960s as an enforcement tool for the discharge of wastewater to navigable waters. The United States Congress enacted Public Law 845, the Federal Water Pollution Control Act in 1948. It was the beginning of federal-state cooperative water pollution control programs that continue today.

In 1951 the North Carolina General Assembly enacted the State Stream Sanitation Act which established the State Stream Sanitation Committee as an autonomous committee within the North Carolina Board of Health (Howells 1989, 60). The law authorized a comprehensive stream pollution control program determined by stream classification based upon present or contemplated best usage.

The State Stream Sanitation Committee adopted stream classifications and standards in 1953 (DeVane, Undated). The classifications were A-I: Protected Water Sources, A-II: Water Supply Sources Requiring Full Treatment, B: Body Contact Recreation, C: Fish Life Propagation, D: Agriculture, Fish Survival, Industrial Cooling and Processes and E: Navigation, Sewage and Industrial Waste and Disposal Short of Nuisance Conditions. For saline waters the classifications were SA: Shellfish Growing, SB: Body Contact Recreation, SC: Fish Propagation and SD: Navigation Short of Nuisance Conditions.

Commented [MBF41]: DOT comment: Is it possible to get a librarian to find out the early stream classification for Little Alamance Creek?

In 1955 the North Carolina General Assembly adopted acts to prohibit discharges of raw sewage, industrial waste and other noxious and deleterious substances into the Haw River and the Northeast Cape Fear River. Pollution of these waters was defined as conditions not meeting their best usage classification or violation of applicable water quality standards (Howells 1990, 79).

During the 1950s different committees within the North Carolina Board of Health administered the stream sanitation law and health code. The Division of Water Pollution Control was responsible for sources of pollution to classified waters. The Sanitary Engineering Division was responsible for sources of pollution to unclassified waters. In 1959 the Stream Sanitation Committee along with its Division of Water Pollution Control was transferred to a new Board of Water Resources.

The Federal Water Pollution Control Act was amended in 1956 by enactment of Public Law 660. The amendments authorized federal grants for construction of publicly owned wastewater treatment plants, increased technical assistance, broadened research and increased federal enforcement of wastewater discharges to interstate waters. The Act was amended again in 1961 and 1965. The 1965 requirements included standards for all streams in the United States, state-issued water quality standards for interstate waters and authorization for the Federal Water Pollution Control Administration to set standards where states failed to do so.

In North Carolina the Water and Air Resources Act was enacted in 1967 by the North Carolina General Assembly. The legislation called for pollution and water use surveys, preparation of comprehensive pollution abatement plans and development of surface water classifications based upon best use and associated water quality standards (Howells 1989, 61). The Board of Water Resources became the Board of Water and Air Resources. In 1968 the State’s lowest stream classification (E) was abolished.

Federal Water Pollution Control Administration regulations adopted in 1970 required cities receiving industrial wastes into their sewage systems to adopt sewer use ordinances. The ordinances provided for the collection of user charges sufficient to reimburse the cities the cost of treating industrial waste. On July 9, 1970 the Federal Water Pollution Control Administration was transferred to the newly created Environmental Protection Agency.

The North Carolina Pesticide Act of 1971 was enacted to address the fate of pesticides and their potential pollution of stream and lakes causing danger to aquatic life. The sale and use of pesticides were regulated and licensure was required for dealers and applicators (Howells 1990, 120).

In 1971 the North Carolina General Assembly authorized the first appropriations to aid the construction of local wastewater treatment plants. Also in that year the North Carolina General Assembly authorized a bond referendum to aid public water supply, strengthened enforcement provisions and pollution control monitoring requirements and established minimum standards for public water supplies.

In 1971, the North Carolina General Assembly transferred the Department of Water and Air Resources to a new Department of Natural and Economic Resources. The Board of Water and Air Resources became the North Carolina Environmental Management Commission (EMC) along with its Division of Environmental Management on July 1, 1974.

Also in 1971 the North Carolina General Assembly enacted the Mining Act. A major intent of the legislation was to condition the issuance of mining permits on pollution control measures. Permits could be denied if the mining operation would adversely affect freshwater, estuarine or marine fisheries or violate water quality standards.

The Federal Water Pollution Control Act was again amended in 1972. The amendments increased the maximum federal contribution for matching grants to construct publicly owned waste treatment plants. The Act also required that all new and existing industrial discharges be permitted under the National Pollution Discharge Elimination System (NPDES). Permitting was also required for sanitary waste discharges along with point source discharge technology-based standards. In 1975 the Environmental Protection Agency delegated responsibility to North Carolina for the administration of NPDES permits.

With the 1972 amendments to the Federal Water Pollution Control Act the original focus on protection of public water supplies was broadened to include protection of all water uses. Section 401 of the legislation authorized states including North Carolina to require water quality certifications for federally permitted or licensed activities that could result in a discharge of pollutants into waters of the United States. The certifications required that all state water quality standards, limitations and restrictions be met and were a condition for issuance of the federal permit or license. Section 401 was applicable to the Clean Water Act section 404 permits and authorizations, permits issued under Sections 9 and 10 of the Rivers and Harbors Act, licenses for hydroelectric power plants issued under the Federal Power Act and licenses issued by the Nuclear Regulatory Commission.

In 1973 the North Carolina General Assembly enacted the Sedimentation Pollution Control Act to regulate urban and highway construction land disturbing activities. The Sedimentation Control Commission and the Division of Land Resources were charged with policy-making and enforcement. Also in 1973 the North Carolina General Assembly adopted the Oil Pollution Control Act making it unlawful to discharge oil into any waters, tidal flats, beaches or lands or into any sewer or surface water drain without a permit.

In 1972 Congress passed the Federal Coastal Zone Management Act. To protect estuaries, marine ecosystems and other coastal resources the North Carolina General Assembly enacted the Coastal Area Management Act in 1974. The Act restricted development in environmentally sensitive areas and required local governments in coastal counties to adopt land-use plans that included policies and standards for public and private land and water use (Holm 2000, 22).

The Environmental Management Commission adopted federal effluent limitations in 1976. In 1977 Congress again amended the Federal Water Pollution Control Act. Emphasis was placed upon toxic pollutants and long-term funding for municipal sewage treatment construction grants. As a result, the Environmental Protection Agency listed sixty-five toxic pollutants in 1978 that would serve as the basis for developing effluent standards (Howells 1990, 135).

In 1978 the Division of Environmental Management proposed revisions to the State's water quality standards resulting from the triennial review required by Section 303 of the Federal Clean Water Act. This was the second time the standards were reviewed in their entirety since 1953. Proposed changes involved mixing zones, toxic chemicals and nutrient standards.

In response to concerns about nitrogen and phosphorus the Environmental Management Commission approved a supplemental Nutrient Sensitive Water Classification in 1979 for surface waters experiencing excessive algal or other aquatic plant growth. Subsequent supplemental classifications were approved for High Quality Waters (1989), Outstanding Resource Waters (1985) and Water Supply Waters (1985).

The North Carolina General Assembly enacted the North Carolina Safe Drinking Water Act in 1979 enabling the State to assume primary jurisdiction over drinking water standards authorized in the Federal Safe Drinking Water Act (Howells 1989, 62).

A comprehensive set of new NPDES regulations was adopted by the Environmental Protection Agency in 1979 and translated to permit regulations in 1980. They reflected best available technology (BAT) and best conventional technology (BCT) effluent limitations adopted by Congress in the 1977 Federal Clean Water Act amendments.

The Environmental Management Commission approved new water supply (WS) classifications in 1985. They were WS-I, WS-II, and WS-III, and were defined by the amount and types of point sources regulated by the state and local government land use efforts to control nonpoint pollution sources.

In 1987 the North Carolina General Assembly authorized a Clean Water Revolving Loan and Grant Fund in response to continued need for State aid for local government water and sewage facilities. Also in 1987 amendments to the Federal Water Pollution Control Act required states to designate at least 50% of federal funds in fiscal year 1989-90 for revolving loans. Following that period through fiscal year 1994 all federal funds were to be used for the revolving loan program (Howells 1990, 174).

The Division of Environmental Management proposed stormwater controls for development activities in the 20 coastal counties in 1987. They were designed to protect shellfish waters and coastal water quality. The Outstanding Resource Water classification, first adopted in 1985, played a significant role in this approach.

An Act to Establish Penalties for Failure to remove Prohibited Discharges and An Act to Establish Penalties for Prohibited Discharges were enacted in 1987. The former authorized civil penalties for the willful or negligent discharge of hazardous substances, the failure to report an illegal discharge or the failure to comply with compliance orders. The latter authorized civil penalties for the willful or negligent violation of classifications, standards, or limitations of prohibited discharges of radiological, chemical or biological warfare agents (Howells 1990, 216).

The North Carolina General Assembly adopted An Act to Establish a Septage Management Program in 1988. Septage could be disposed of only at public or community sewage systems designed and permitted to discharge effluent to surface waters.

In 1988 the Sedimentation Pollution Control Act was amended to strengthen compliance requirements and enforcement provisions. In 1989 the Environmental Management Commission adopted a turbidity standard to be imposed in cases of sedimentation violations.

The Division of Environmental Management reported on nonpoint source pollution assessment and management in 1989 in conformance with the 1987 amendments to the Federal Water Pollution Control Act. Thirty (30) percent of the State's streams were reported as degraded and nonpoint source pollution was cited as the primary source of degradation of freshwater rivers and streams in the State. Sources in order of importance were agriculture, urban runoff and construction with sediment identified as the most widespread cause of degradation (Howells 1990, 181).

About five percent of estuarine waters were degraded with nonpoint sources accounting for 72% of the degradation. Agriculture, septic tanks and urban runoff were the primary sources. Excess nutrients and fecal coliform bacteria were cited as the principal causes of degradation.

In response, the Division of Environmental Management nonpoint source management plan included agriculture and forestry cost-share programs to match funds for best management practices (BMP), a water supply watershed protection program, regulation under the Sedimentation Pollution Control Act and the Mining Act and coastal stormwater regulations. The North Carolina Nonpoint Program was approved by the Environmental Protection Agency in 1989.

State legislation and/or rules followed for mandatory nonpoint source pollution control in water supply watersheds, undisturbed buffer zones along trout waters, best management practices for silviculture, increased funding for agriculture, nonpoint source protection for High Quality Waters, expansion of nonpoint-related groundwater programs, watershed management programs, waste reduction and recycling and wetland protection.

In 1989, the North Carolina General Assembly enacted An Act to Authorize and Direct the Environmental Management Commission to Phase in Stormwater Runoff Rules and Programs. It required the Environmental Management Commission to begin a continuous planning process for the development and adoption of a state-wide stormwater management plan including rules and enforcement.

The North Carolina General Assembly also acted in 1989 to ratify the Water Supply Watershed Protection Act, requiring the Environmental Management Commission to adopt new water supply watershed classification rules. Appropriate classifications were required for all water supply watersheds in the state with associated minimum protective standards. Related legislation was passed to provide for a state water supply plan and local water supply plans.

In 1989, the North Carolina General Assembly created the North Carolina Department of Environment, Health and Natural Resources to consolidate all environmental, environmental health and natural resource programs into a single state agency (Howells 1990, 224).

Commented [JSJ42]: NPDES Phase I and NPDES Phase II should be discussed in general terms in this section and can even refer to present day watershed factors.

The Environmental Management Commission adopted a final set of Water Supply Watershed Protection rules in 1992. The rules restricted development densities, limited land uses, and required stream buffers to treat stormwater runoff and other nonpoint sources of pollution (North Carolina Cooperative Extension Service Undated, 1). Point sources of pollution including domestic and industrial wastewater discharges were also addressed. Local governments whose land-use jurisdictions included water supply watersheds were required to implement watershed protection plans and adopt ordinances meeting or exceeding state guidelines. WS-IV and WS-V waterbody classifications were also added.

Following an extensive fish kill in the Neuse River in 1995 the North Carolina General Assembly established a goal of reducing nitrogen in the Neuse River by 30% by 2001. To achieve this goal the Environmental Management Commission adopted the Neuse Buffer Rule in 1997 requiring a 50-foot vegetated riparian buffer along streams and rivers in the Neuse River Basin. Buffer rules were subsequently adopted in the Randleman Lake Water Supply Watershed in 1999, in the Tar-Pamlico River Basin in 2000, in the Catawba River Basin in 2004, in the Goose Creek Water Supply Watershed in 2009, and in the Jordan Lake Water Supply Watershed in 2009.

Commented [JSJ43]: The Jordan Lake Nutrient Strategy is very important for this watershed and should be discussed thoroughly.

Commented [MBF44]: DOT notes for this section:
“Phase I + II
Jordan Rules
Randleman Buffer”

Commented [JSJ45]: This is all interesting...but we need to tie it back to the watershed. Some of that can be done by saying that the earliest recorded treatment plant.... or the first regulated community water system...etc. But we do need to figure out how to tie it all back together I think.

MBF: Perhaps quickly noting that the Little Alamance Creek watershid is within the Jordan Lake Water Supply Watershed?

3.0 Present Day Little Alamance Creek and its Watershed

3.1 General Watershed Conditions

3.1.1 Topography

The Little Alamance Creek watershed is located in the Piedmont physiographic province of North Carolina. The 15.9 square mile watershed ranges in elevation from approximately 450 feet at the confluence with Big Alamance Creek to 700 feet in the headwaters. The Little Alamance Creek watershed is located entirely within one Level IV Ecoregion – the Southern Outer Piedmont. This ecoregion has lower elevations, less relief, and less precipitation than its neighboring ecoregions. The landform class is mostly dissected irregular with some rounded hills and ridges.

3.1.2 Geology and Soils

The Little Alamance Creek watershed lies in the Carolina Slate Belt. The watershed is composed mainly of three geological types: metamorphosed granitic rock in the northern headwaters of the watershed, and metamorphosed gabbro and diorite, and mafic metavolcanic rock in the middle and lower portions of the watershed. Gneiss, schist, and granite are typical rock types, and the rocks are more intensely deformed and metamorphosed than the geologic materials in neighboring ecoregions. The rocks are covered with deep saprolite and mostly red, clayey subsoils.

The predominant soil association in the Little Alamance Creek watershed is Mecklenburg-Enon-Cecil, comprising almost the entire watershed south of US-70. The Vance-Appling-Enon-Cecil association is found north of US-70 and encompasses the majority of the hydric soils found in the watershed. Hydric soils can be found throughout the watershed within the floodplain, but most predominantly along the Little Alamance Creek stream beds and surrounding area north of US-70.

3.1.3 Climate

Alamance County has a mild year-round climate with four seasonal changes. The annual Normal mean temperature is 59.2 °F, with the annual Normal minimum and maximum temperatures being 47.1 °F and 71.2 °F, respectively. The annual Normal rainfall is approximately 45 inches, while the average annual frozen precipitation is 4.0 inches (Weather station ID 311239; State Climate Office, 2013).

The Little Alamance Creek watershed has experience periods of moderate to exceptional drought in recent years. The NC Drought Management Advisory Council has recorded the weekly drought status for each 8-digit hydraulic unit code (HUC-8) since January 2000. Additional precipitation and drought information is presented in Section 4.1.2.

3.2 Surface Waters and Wetlands

3.2.1 Little Alamance Creek and Its Tributaries

The Little Alamance Creek watershed is located in the upper Cape Fear River Basin, within the Haw River subbasin. Little Alamance Creek flows into Big Alamance Creek approximately three miles upstream of its confluence with the Haw River. There are approximately 50 miles of perennial and intermittent streams in the watershed as determined by GIS of the USGS Quadmap. The Little Alamance Creek (Gants Lake, Mays Lake) (Alamance County) assessment unit is identified as 16-19-11. The assessment unit

Commented [SCD46]: Just checking. Is this Elon or Enon?

Commented [JSJ47]: It's Enon as far as I know.

Commented [JSJ48]: What % of the watershed is Type A, B, C, or D soils? From a practical perspective most people reading this won't know anything about Mecklenburg-Enon-Cecil. I can have this calculation done with the soils file on GIS. This should be followed with a brief description about A,B,C, & D Soils.

Commented [PB49]: I can get these estimates and I think that would be beneficial to regulators trying to understand the potential for runoff reduction measures.

Commented [BAJ52]: Suggest we replace this text with "Additional climate information is presented in Section 4.1.2." or move that information here.

Commented [MBF53]: Suggest noting the drought status at the time of specific sampling events, rather than the percent of time Alamance has been in a certain drought category. The former would provide context to the later discussion of any monitoring performed in the watershed. (Drought status at the last benthos sampling was D1-Moderate Drought.)

Suggest listing all of the possible drought categories (i.e., D0 – D4), so that he reader has context as to "how bad" a moderate drought is.

Deleted: 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 with November the driest month. All North Carolina's rivers and streams commonly have a maximum flow in late spring, with low flow in fall." Alamance County has been in "abnormally dry" or worse conditions 56 percent of the time according to NC DWR's Drought Monitor, which reports weekly drought conditions since 2000. Alamance County was in "moderate drought" or worse conditions 33 percent of the same period of record. Moderate drought is the . Moderate drought is the next worse condition above abnormally dry. ...

Deleted: . Moderate drought is the next worse condition above abnormally dry. ...

includes 12.6 freshwater miles from source to Big Alamance Creek. Little Alamance Creek is designated a Class C water, indicating that it is protected for secondary recreation, fish consumption, biological integrity, agriculture, and other uses suitable for Class C. Little Alamance Creek is also classified as a Water Supply V (WS-V) and Nutrient Sensitive Waters (NSW).

Key tributaries to the Little Alamance Creek include Bowden Branch also known as Boyd Creek (3.8 miles), Brown Branch also known as Willowbrook Creek (2.3 miles), and Dye Creek (0.6 miles). Bowden Branch originates as Snoffers Lake north of Providence Road and drains to the south to Little Alamance Creek immediately north of Monroe Holt Road in Graham. Bowden Branch divides Burlington and Graham north of I-85. The contributing watershed north of I-85 is primarily urban area as evidenced by a lack of delineated tributaries that have been piped for many decades. The watershed opens up to undeveloped and scattered developments south of I-85.

Brown Branch drains the older neighborhoods surrounding Burlington to the southwest of the watershed. The headwaters originate near West Webb Avenue and converge with Little Alamance Creek downstream of Pine Hill Cemetery. Much like Bowden Branch, there are very few delineated tributaries because the system is mostly piped and has been for a many decades.

Dye Creek is a tributary to Brown Branch. It originates near downtown Burlington and parallels Mebane Street before it joins Brown Branch downstream of Pine Hill Cemetery. The contributing watershed includes older neighborhoods southwest of downtown of Burlington and sporadic industrial/commercial developments.

3.2.2 Wetlands and Surface Waters

Wetland and surface waters can play an important role in balancing the hydrology of a watershed and providing instream water quality treatment. Approximately 15.2 acres of wetlands and 66.4 acres of ponds/lakes are within the Little Alamance Creek watershed (USFWS, 2013) This information needs to be confirmed at a local level as a number of wetlands and impoundments have been filled or drained in the past. Two significant surface impoundments on Little Alamance Creek include Gants Lake in the headwaters to the north and Mays Lake immediately upstream of US-70.

Table 3-1. Summary of wetland types within Little Alamance Creek watershed (USFWS, 2014)

Wetland Type	Count	Acreage
PEM - Freshwater Emergent Wetland	4	4.2
PFO - Freshwater Forested Wetland	3	5.6
PSS - Freshwater Shrub/Scrub Wetland	1	5.4
PUBH - Freshwater Pond	46	66.4
Total	54	81.6

3.3 Riparian Condition

The absence of riparian buffers exacerbates other stream habitat problems including bank failure, severe streambank erosion, burial of the bottom substrate, loss of riffle-pool sequences, and excessive light penetration which leads to declines in the respective metrics used to assess these habitat features. As part of the habitat assessments for the NCEEP Local Watershed Planning, riparian vegetative width was recognized as the second best indicator of low habitat scores. Both Brown Branch sites and the two

Deleted: The designated uses for this assessment unit are Class C andLittle Alamance Creek

Commented [MBF54]: Suggested rewording that more fully defines Class C waters.

Deleted: ;

Commented [BAJ55]: Or is this section more about wetlands and impoundments?

Commented [MBF56]: Values from the NCEEP (2007) study were 69.4 acres of wetlands, 362.4 acres of ponds/lakes. I recommend using the newer NWI numbers.

Commented [PB57]: I think this was supposed to be a comment to Michael and not intended as text for the document.

Commented [BAJ58]: All - Is this table helpful?

Commented [PB59]: I know one of the reason we might want to include this information is the availability of ponds that could be retrofitted for in-stream benefits. We don't need to say it here but later in the document we should draw on this information. Michael has also mentioned a number of drained wetlands he thought could be restored.

Commented [JSJ60]: Can we get rid of this table? Any type of national wetland index is suspect. I like the idea of referencing the general information but listing totals when it could be compared to previous documents is problematic.

most upstream Little Alamance Creek locations (Little Alamance Creek at Mebane Street and NC 54) scored below 5 on the scale of 1 to 10 for Riparian Vegetative Zone width. The three downstream sites had higher scores for this metric because they passed through lesser developed areas that still had riparian buffers intact.

3.4 Population and Land Use

3.4.1 Land Use

The Little Alamance Creek watershed overlays portions of the Cities of Burlington, the City of Graham, NCDOT right-of-way (ROW), and non-incorporated area. When combined, Burlington, Graham, and NCDOT make up 82.5% of the Little Alamance Creek watershed, leaving 17.5% of unincorporated area (Table 3-2). Roughly half of Burlington, one-third of Graham, and 63.4 miles of NCDOT roads are located within the watershed boundary.

Table 3-2. Summary of Burlington, Graham, and NCDOT areas within the Little Alamance Creek watershed

Name	Total Area (sq mi) *	Area within Watershed (sq mi)	Percent of Watershed Area
Burlington	21.3	10.2	64.4
Graham	7.2	2.1	13.3
NCDOT ROW†	--	0.8	4.8
Non-incorporated Areas	--	3.5	22.3
Little Alamance Creek Watershed	15.9	15.9	100.0

Note:
* Total area includes area outside of Little Alamance Creek watershed. NCDOT area outside of Little Alamance Creek watershed was not estimated for this table.
† Length of NCDOT roads within watershed is 63.4 miles.

Land use and land cover in the watershed play a substantial role in stream water quality and aquatic habitat. The Little Alamance Creek watershed is mostly urbanized with 89.4% of the area developed. Single family residential is the most predominant land use at 59.7% followed by industrial, which makes up 12.4% (Table 3-3). Both downtown Graham and Burlington are north of I-40/85 and the residential development radiates out from these urban cores. Industrial and commercial uses are clustered mainly around I-40/85 corridor and the major thoroughfares (US-70, NC87, NC-54, NC-49, and NC-100) between the urban cores and major thoroughfare intersection. NCDOT area is estimated to be approximately 4.8% of the watershed. Vacant and agricultural land may be mostly found south of I-85. There are some areas south of I-40/85 that are within the watershed and are outside of the jurisdiction of the City of Burlington, City of Graham, or NCDOT. These areas, 22.3% of the watershed, are under the jurisdiction of Alamance County. NCDENR completes a stormwater review of new projects in this area.

Commented [MBF61]: For this section, we need to choose between the NCEEP/PTCOG 2007 land use data and the NLCD land use data.

If NCEEP/PTCOG 2007, then we either need to produce a map, or only use Table 6.The reliance on municipal-specific zoning may be more useful.

If NLCD, then one sentence needs to be re-written.

Commented [PB62]: We could do that if the LATT data is separated for LAC and TT but I am thinking it is not.

Commented [BAJ63]: Maybe delete this column.

Commented [JSJ64]: Were these colors changed? They didn't print well when I printed the document.
I like the Total Square Area column.

Commented [JSJ65]: Does the 22.3% unincorporated include ETJ areas?

MBF: Josh, the values from Table 5 are based on the boundaries shown in Figure 2. Let me know if those boundaries look suspect.

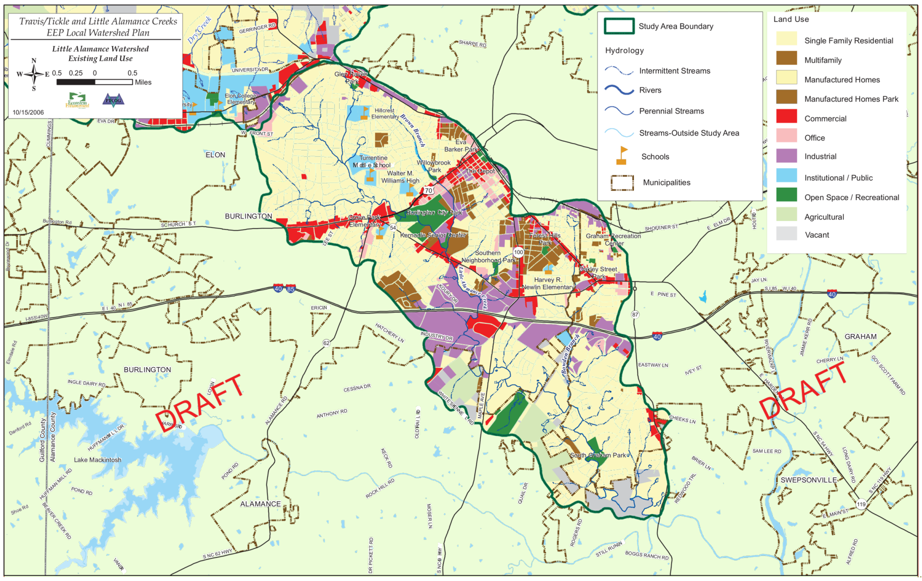

Table 3-3. Little Alamance Creek watershed land use (PTCOG, 2007)

Land Use	Acreage	Percentage of Watershed
Agriculture	318.0	3.6
Commercial	565.5	6.6
Industrial	1,082.1	12.4
Institutional	171.1	1.9
Mobile Homes	2.9	0.0
Multifamily	545.3	6.2
Office	226.6	2.6
Open Space/Recreational	256.9	2.9
Single Family	5,233.0	59.7
Vacant	360.4	4.1
Total Acreage in Parcels	8,761.8	100.0

Commented [JSJ66]: The City of Burlington's GIS department should be able to provide an updated document for this and the updated zoning or land use files.

MBF: If we wanted to re-make this map (and Table 6), I assume we would need both Burlington and Graham's parcel zoning GIS data. We would also have to reconcile/re-group zoning categories, if there isn't a 1:1 relationship between the two cities. Or, we could use the existing National Land Cover Database map (Figure 6).

Commented [MBF67]: Temporary figure. Here is the land use map from the reference 2007 LATT report (pg 79).

Commented [MBF68]: FYI, these values from the 2007 LATT report were compiled their land cover data from "tax parcel, zoning, and when available, land use GIS layers directly from several different municipalities as well as Alamance and Guilford Counties."

Commented [MBF69]: This equals 13.69 sq miles. Little Alamance watershed is 15.9 sq miles. Not sure why the 2007 LATT report is so low, when the same report lists the watershed at 16 sq miles.

Commented [JSJ70]: There is no county zoning, so anything that takes into acount zoning will not equal the total watershed.

MBF: Makes sense. Thanks!

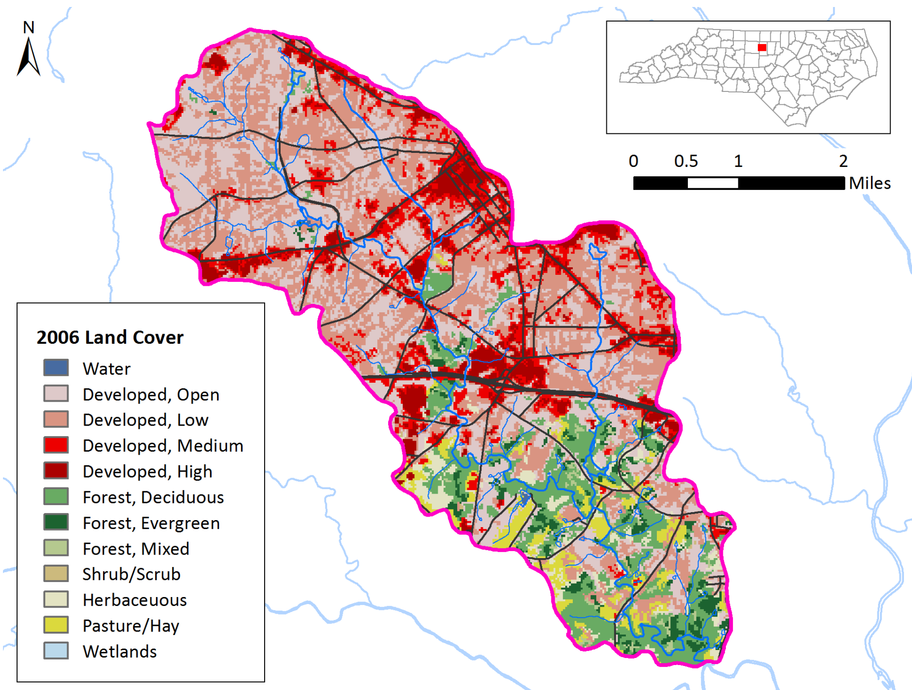

Figure 3-1. Land cover data (NLCD, 2006) for Little Alamance Creek watershed

Table 3-4. Summary of 2006 land cover values for Little Alamance Creek watershed (NLCD, 2006)

Land Use	Acreage	Percentage of Watershed
Water	6.0	0.1
Developed, Open	2,920.3	28.8
Developed, Low	3,311.2	32.6
Developed, Medium	1,153.8	11.4
Developed, High	687.0	6.8
Forest, Deciduous	1,085.5	10.7
Forest, Evergreen	258.6	2.5
Forest, Mixed	81.0	0.8
Shrub/Scrub	17.6	0.2
Herbaceous	262.9	2.6
Pasture/Hay	364.1	3.6
Wetlands, Woody	5.1	0.1
Total	10,153.0	100.0

3.4.2 Future Development Trends

Future development within the watershed north of I-40/85 is limited by existing development and topographical features. The primary areas of future development will be south of I-85/40 and appear to be predominately residential development with some limited industrial development to the south of Burlington and along the Burlington/Graham boundary. No firm redevelopment trends have been identified.

3.4.3 Current Population

Commented [MBF71]: Section content re-worded, as it was cut-n-pasted directly from another report.

An NCEEP report (2007) listed the Little Alamance Creek watershed population at 27,581, based on 2000 US Census data. The same report also provided a 2005 population estimate of 29,512 based on data from the Piedmont Triad Regional Council's Regional Data Center.

3.4.4 Future Population and Trends

Population in Little Alamance Creek has likely leveled off for the time being given the impacts of the recent recession on housing development. While there are small amounts of undeveloped land in the watershed, only a portion of these areas is likely to be developed as residential land use. Exact development types in the area south of I-40/85 have not been identified. Regional growth trends for the area indicate that multi-family development may be a major contributor to overall residential development.

4.0 Potential Stressors Causing Biological Impairment

The biological impairment listing for Little Alamance Creek is based on the results of benthic macroinvertebrate (benthos) sampling. Benthic macroinvertebrates have been surveyed 11 times by DWR – five times at one site and one time at six additional sites. The USGS also conducted one benthic survey at one site. Fish communities have been surveyed five times by DWR at one location. Locations of these and other previously monitored locations within the watershed are shown in Figure 4-1. Since different reports may refer to a single monitoring station using different names, Table 4-1 provides a cross-reference of station IDs for major online databases and reports.

Commented [MBF72]: Need to also mention fish surveys somewhere.

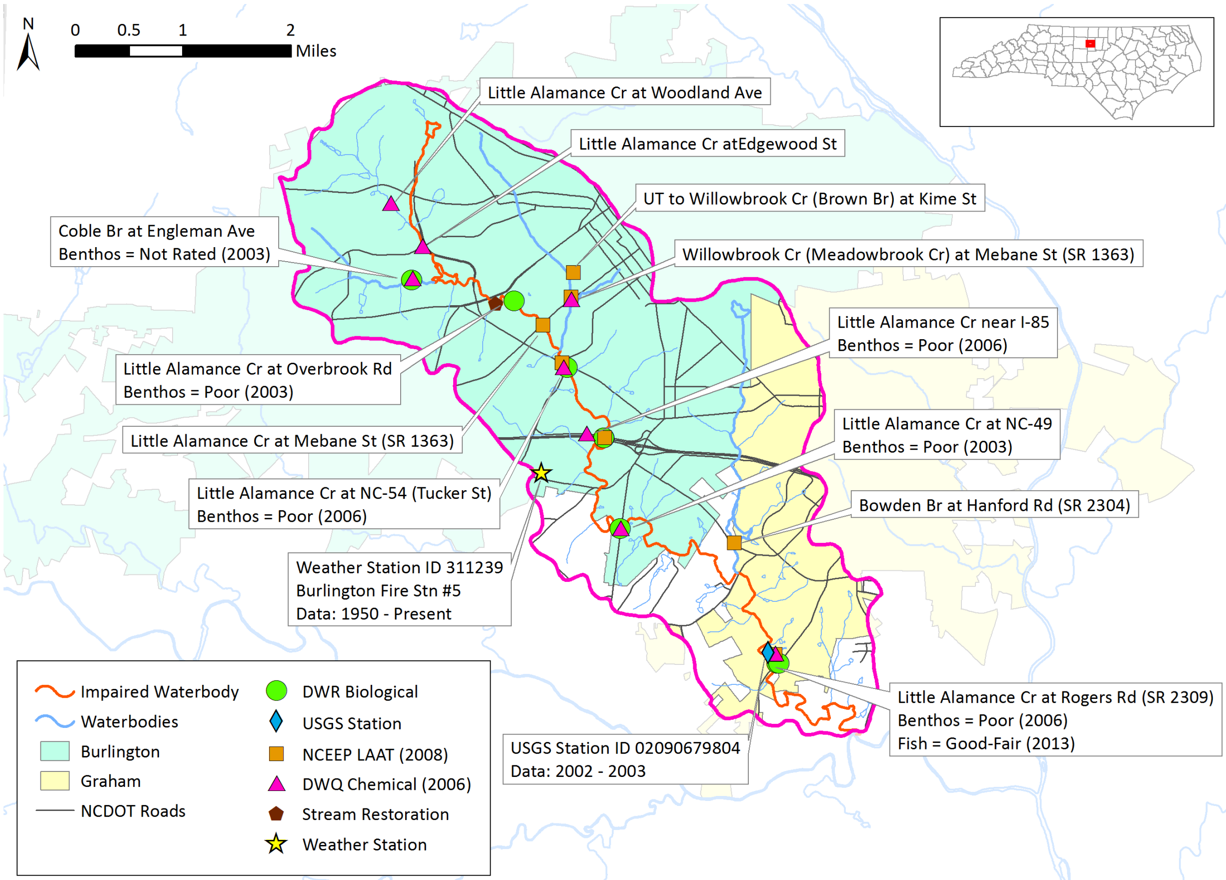

Figure 4-1. Previously monitored locations for biological, physicochemical, flow, and climate data within the Little Alamance Creek watershed. Most recent DWR bioclassification is noted at applicable sites.

Comm
green c
MBF: T

Table 4-1. Previously monitored sites, cross-referenced by reporting ID from select online databases and reports

Monitoring Location	DWQ Biological ID	USGS Station ID	NCEEP LATT (2008) ID	DWQ LATT (2006) ID
Little Alamance Cr at Rogers Rd (SR 2309)	BB388, B1920000, BF60	209679804	19	Little Alamance Cr at Rogers Rd
Coble Br at Engleman Ave	BB42	-	-	Coble Br at Engleman Ave
Little Alamance Cr at Edgewood St	-	-	-	Little Alamance Cr at Edgewood St
Little Alamance Cr at Woodland Ave	-	-	-	Little Alamance Cr at Woodland Ave
Bowden Br at Hanford Rd (SR 2304)	-	-	20	-
Little Alamance Cr at NC-49	BB131	-	-	Little Alamance Cr at NC-49
Little Alamance Cr near I-85	BB46, BB78	-	18	L Alamance Cr at Plantation Dr (I-85 Frontage)
Little Alamance Cr at NC-54	BB47	-	17	Little Alamance Cr at NC-54 (Tucker St)
Willowbrook Cr (Brown Br) at Mebane St (SR 1363)	-	-	15	Meadowbrook Cr at Mebane St
UT to Willowbrook (Brown Br) Cr at Kime St	-	-	14	-
Little Alamance Cr at Mebane St (SR 1363)	-	-	16	-
Little Alamance Cr at Overbrook Rd	BB193	-	-	-

The most downstream monitoring site in the watershed and the site with the most data, Little Alamance Creek at Rogers Road (SR 2309), has samples dating back to 1985. All benthos samples received a bioclassification rating of “Fair” or “Poor” each time. The site was Not Rated in 2008 due to low streamflow as a result of drought, but would have otherwise rated as “Fair.” Over the five sampling events at the site, a total of 11 taxa have been collected. All published DWR bioclassifications for Little Alamance Creek watershed monitoring locations are listed in Table 4-2.

Commented [MBF74]: Delete? The 2013 Fish rating may not have been published yet (though the rating is not considered draft). I believe a new 2013 benthos rating may come out soon, but is not currently available.

Table 4-2. DWR biological sampling results in the Little Alamance Creek watershed

Monitoring Location	STORET ID	Type	Sample Date	DWR Bioclassification
Little Alamance Cr at NC-49	BB131	6/23/2003	Benthos	Poor
Little Alamance Cr at Overbrook Rd	BB193	6/24/2003	Benthos	Poor
Little Alamance Cr at Rogers Rd (SR 2309)	BB388	7/14/2008	Benthos	Not Rated[1]
		9/12/2006	Benthos	Poor
		6/23/2003	Benthos	Fair
		7/10/1998	Benthos	Poor

Monitoring Location	STORET ID	Type	Sample Date	DWR Bioclassification
		7/29/1985	Benthos	Fair
Coble Br at Engleman Ave	BB42	6/24/2003	Benthos	Not Rated[2]
Little Alamance Cr near I-85 (Frontage Rd)	BB46	9/12/2006	Benthos	Poor
Little Alamance Cr at NC-54	BB47	9/12/2006	Benthos	Poor
Little Alamance Cr near I-85	BB78	6/23/2003	Benthos	Poor
Little Alamance Cr at Rogers Rd (SR 2309)	BF60	4/24/2013	Fish	Good-Fair
		4/16/2009	Fish	Good
		4/23/2003	Fish	Good
		4/8/1998	Fish	Fair
		11/4/1993	Fish	Good

[1] “Not Rated” due to low flow conditions.
[2] “Not Rated” due to a small catchment area.

4.1 Existing Water Quality Data and Previously Identified Stressors

A preliminary task in identifying potential stressors was to conduct a literature review and inventory of existing sources of data for the watershed. This task culminated in a document entitled *Little Alamance Creek 4b Demonstration Project Existing Data Inventory* (URS, 2014). The data inventory included a search of online databases, published documents, and personal communication with local officials. The overall conclusion of the inventory was that extensive data on water quality is lacking, and the results have been inconclusive in identifying specific stressors. The available water quality data have not been the result of continuous monitoring programs, but rather shorter-term targeted studies. The data are also not widespread throughout the watershed, and the majority of the sampling has occurred at one location (Little Alamance Creek at Rogers Road (SR 2309)). Table 4-3 summarizes the data sources containing water quality data, listed in chronological order by sample date.

Commented [MBF75]: DOT comment: This should be included in the executive summary.

Table 4-3. Summary of reports or online databases describing water quality data in the Little Alamance Creek watershed

Data Source	Date Range of Data Collection	Number of Sites Sampled
EPA STORET data download	1968-1975	1
Selected Physical, Chemical, and Biological Data for 30 Urbanizing Streams in the North Carolina Piedmont Ecoregion, 2002–2003. (USGS, 2007)	February 2003-July 2003	1
Draft TMDL to Address Impaired Biological Integrity in the Little Alamance Creek Watershed (DWQ, 2010)	June 2003	5
Draft Summary of Existing Water Quality Data (DWQ, 2006)	July 2006	8
Evaluation of Water Quality, Habitat and Stream Biology in the Little Alamance, Travis, and Tickle Creek Watersheds (DWQ, 2008)	December 2006-August 2007	6
Biological Assessments – Cape Fear River Basin (DWQ, 2009)	July 2008	1

4.1.1 Brief History of Water Quality Data Collection

The earliest known water quality sampling occurred from 1968 – 1975, at the SR 2309 location. A wide variety of parameters were analyzed, but the total number of samples was small. In addition, analytical techniques and quality assurance procedures have improved since that time period. The watershed is not known to be monitored again until 2003, when USGS conducted sampling on Little Alamance Creek

Commented [MBF76]: DOT comment: Were these samplings part of the NC Water and Air Resources Act described on p. 14?

MBF: I believe this sentence speaks to data found in STORET for site ID B1920000, which has physicochemical data for one location (B1920000, Rogers Rd at the bottom of the watershed), surveyed on-and-off from 1968 – 1975.

Commented [MBF77]: DOT comment: If these data are available on STORET please indicate so.

MBF: In addition to benthos and fish, STORET has some physicochemical data for one location (B1920000, Rogers Rd at the bottom of the watershed), surveyed on-and-off from 1968 – 1975. The complete list of analytes is relatively long.

at SR 2309 as part of a National Water Quality Assessment study. Continuous stream stage and stream temperature measurements were collected for one year and water chemistry samples were collected twice. Parameters analyzed included basic physiochemical parameters and nutrients as well as pesticides and herbicides. Also in 2003, DWQ conducted a TMDL stressor study that included five sample locations (CITE?). The study focused on benthic collections, but basic physiochemical data were collected concurrently. In July of 2006, DWQ personnel conducted a one-week study in an attempt to identify areas with water quality problems to assist with developing a plan for additional monitoring (CITE?). Single measurements of specific conductance were taken at eight bridge crossings across the watershed. All measurements were within normal range and did not indicate potential areas of concern. Additionally, an automated sampling device was installed at the SR 2309 location for one week, collecting hourly data on temperature, dissolved oxygen, pH, and specific conductance. Again, all measurements were within normal range. The largest water quality sampling effort occurred from December 2006 to August 2007, in support of the North Carolina Ecosystem Enhancement Program's (NCEEP) local watershed planning study (DWQ, 2008). The results of this study will be discussed below. The SR 2309 location had one additional measurement of physicochemical measurements associated with benthos sampling for the Cape Fear River Basin Biological Assessment in 2008. All measurements were within normal range.

Commented [MBF78]: DOT comment. Should this study be added to Table 9, if not already present?

Commented [MBF79]: Or should we add the word "major" to Table 9's caption?

Commented [MBF80]: DOT comment. Should this study be added to Table 9, if not already present?

Commented [MBF81]: Melissa, I believe I have referenced to this report elsewhere as "NCEEP, 2008". Before the document is final, I'll go through and correct those citations.

Commented [MBF82]: "metrics"?

Commented [MBF83]: DOT comment. Please define "normal range".

4.1.2 DWQ Sampling Data (2006-2007)

The most extensive water quality data reported was found in the Evaluation of Water Quality, Habitat, and Stream Biology in the Little Alamance, Travis and Tickle Creek Watersheds (DWQ, 2008). The data included sites in two neighboring rural watersheds in addition to the Little Alamance Creek watershed. Of the sources inventoried, this document contained the only dataset with multiple samples taken over a broad range of time and locations. DWQ conducted sampling at seven sites in the watershed over a period of seven months (December 2006 – August 2007). The sampling time period coincided with moderate to exceptional drought conditions across the state (), which may have influenced the results. The analysis included physicochemical parameters, nutrients, metals, and bacteria as well as benthic community samples and habitat assessments. The number of samples varied by site and parameter: physicochemical and nutrient parameters had between one and nine samples each, metals had between one and five samples each, and fecal coliform measurements had between two and five samples. Samples were taken approximately monthly during baseflow, and on three occasions during stormflow. Some key findings are summarized below.

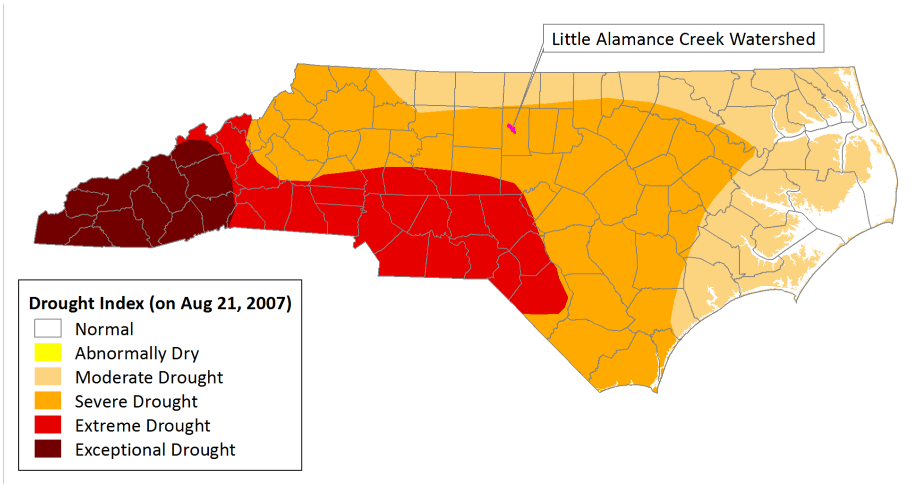

Figure 4-2. Statewide map of drought status on July 15, 2008 (NCDMAC, 2013)

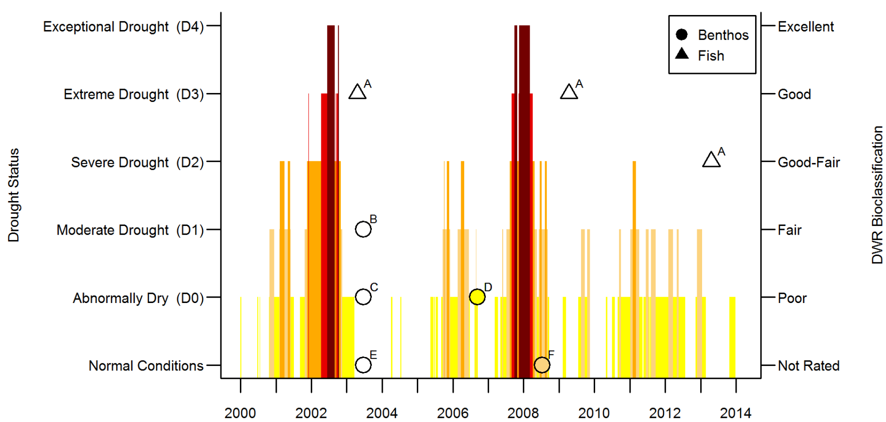

Figure 4-3. Weekly drought status history for Haw subbasin (HUC 03030002), which contains Little Alamance Creek watershed. DWR bioclassification ratings (right axis) for various monitoring sites within the Little Alamance Creek watershed. Color of symbol denotes the drought status of the watershed at the time of sampling. Upper-case letters denote sampled locations (STORET ID): A = BF60; B=BB388; C=BB131, BB78, BB193; D=BB46, BB47, BB388; E=BB42; F=BB388.

Physicochemical Parameters. The highest specific conductance measurements occurred in the headwater tributaries of Little Alamance Creek; values decreased at downstream monitoring locations.

Commented [JSJ84]: I like this map but it shouldn't be between these two sentences. It's too easy to lose your place.

Deleted:

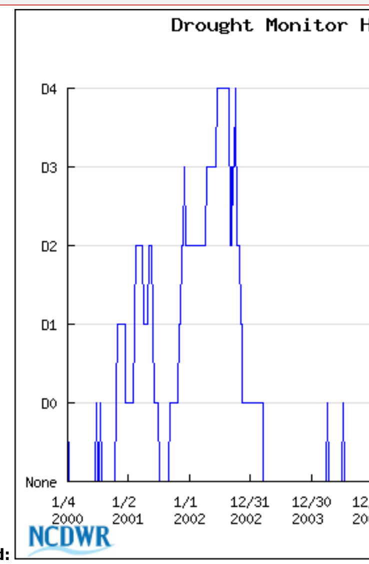

Figure 8. Drought status monitoring history for Haw subbasin, which contains Little Alamance Creek (NCDMAC, 2013)

Commented [JSJ85]: Can we do one with similar data that shows above and below average by month?
Currently it could be confusing as up means drought and nothing means rain. I think.

MBF: The "monitoring data figure" shows actual vs. normal precip data, averaged by month.

DWQ concluded that dissolved substances were originating from the urban area of downtown Burlington and were being diluted further downstream. Brown Branch (referred to as Willowbrook Creek in the DWQ report) samples showed several instances of supersaturated dissolved oxygen concentrations, which were attributed to dense algal blooms noted during sampling. Lower portions of the watershed were found to experience very low levels of dissolved oxygen, falling below the 4.0 mg/L water quality threshold on several occasions. The DWQ report attributed these occurrences to seasonal patterns associated with high air temperatures that were exacerbated by extreme drought conditions and very low flow. Water temperature and pH measurements were within normal ranges.

Nutrients. One site, Little Alamance Creek at Mebane Street, was found to have consistently high ammonia concentrations; the site also had the highest Total Kjeldahl Nitrogen (TKN) observed during the study. Willowbrook Creek and an unnamed tributary (UT) to Willowbrook Creek were found to have the highest phosphorus concentrations. The 2008 DWQ report indicated that elevated nutrient concentrations at Little Alamance Creek at Mebane Street and Willowbrook Creek and its UT could be linked to the potential presence of malfunctioning septic or sewage sources.

Metals. Copper, zinc, and lead were found at measureable concentrations within the watershed, predominantly in stormflow samples. Copper was detected in all but two stormflow samples, and most stormflow samples exceeded the 7 µg/L action level. In addition, one baseflow sample taken at Little Alamance Creek at SR 2309 was at the action level of 7 µg/L copper. Lead measurements exceeded the reporting limit only once, in a stormflow sample at Willowbrook Creek. The report stated that this pollutant may have originated from an old city vehicle maintenance facility or possibly from a landfill in the subwatershed. The Willowbrook Creek site also exceeded the action level for zinc (50 µg/L) in the same stormflow sample, which may also have originated from the same source as the lead. Zinc was measured in five out of seven stormflow samples, and detected in four baseflow samples.

Calcium and magnesium were noted as having somewhat elevated baseflow concentrations, possibly due to the abundance of pavement in the urban areas. Both were lower during stormflow samples, indicating dilution during rain events. Sodium concentrations were also elevated, particularly at Willowbrook Creek and Little Alamance Creek at Mebane Street, which is directly downstream of Willowbrook Creek. The report stated that the higher sodium could be an indicator of raw sewage contamination, but could also have originated from other sources.

Fecal Coliform Bacteria. Measurements of fecal coliform are used as an indicator of fecal contamination in water. Water contaminated with fecal material may carry Escherichia coli (E. coli) and other harmful pathogens which can cause food poisoning. Several baseflow samples exceeded the 400 cfu/100 ml reference level for fecal coliform bacteria: Willowbrook Creek, UT to Willowbrook Creek, and Little Alamance Creek at Mebane St. One stormflow sample at SR 2309 also exceeded the reference level. High fecal coliform values at these urban sites most likely indicate either sewer line leakage and/or the presence of considerable numbers of domestic pets and/or wildlife.

A display of recent monitoring data events compiled from multiple resources (including the DWQ 2008 report), actual and Normal monthly precipitation values, and weekly drought status for Little Alamance Creek watershed is provided in Figure 4-4.

Commented [JSJ86]: Jordan Lake should be mentioned here.

Deleted: the only toxic metals

Deleted: Among the non-toxic metals, c

Commented [MBF89]: Last sentence moved to the beginning of the paragraph and expanded.

Commented [MBF90]: I believe the fact that *baseflow* samples routinely exceeded the WQ standard is important, as it serves as evidence that (runoff from) impervious cover may not be the driving factor in LA not meeting FC standards. If stormflow samples rarely exceeded FC standards, then that would be further evidence.

Assuming we have enough data points, should we make more explicit the point that "Runoff from impervious cover does not appear to be contributing to the exceedances in FC. Instead, the high FC values at these urban…"

There is only one "qualified" stormflow sample, so we can only talk about the baseflow exceedances.

Commented [MBF91]: Since Little Alamance is not impaired for fecal coliform, it may not make sense to include the above comment in a summary section.

Commented [JSJ92]: Add MBF 125 comment to the summary section?

Deleted: Water with high fecal coliform can have substantial impacts to biological integrity. …

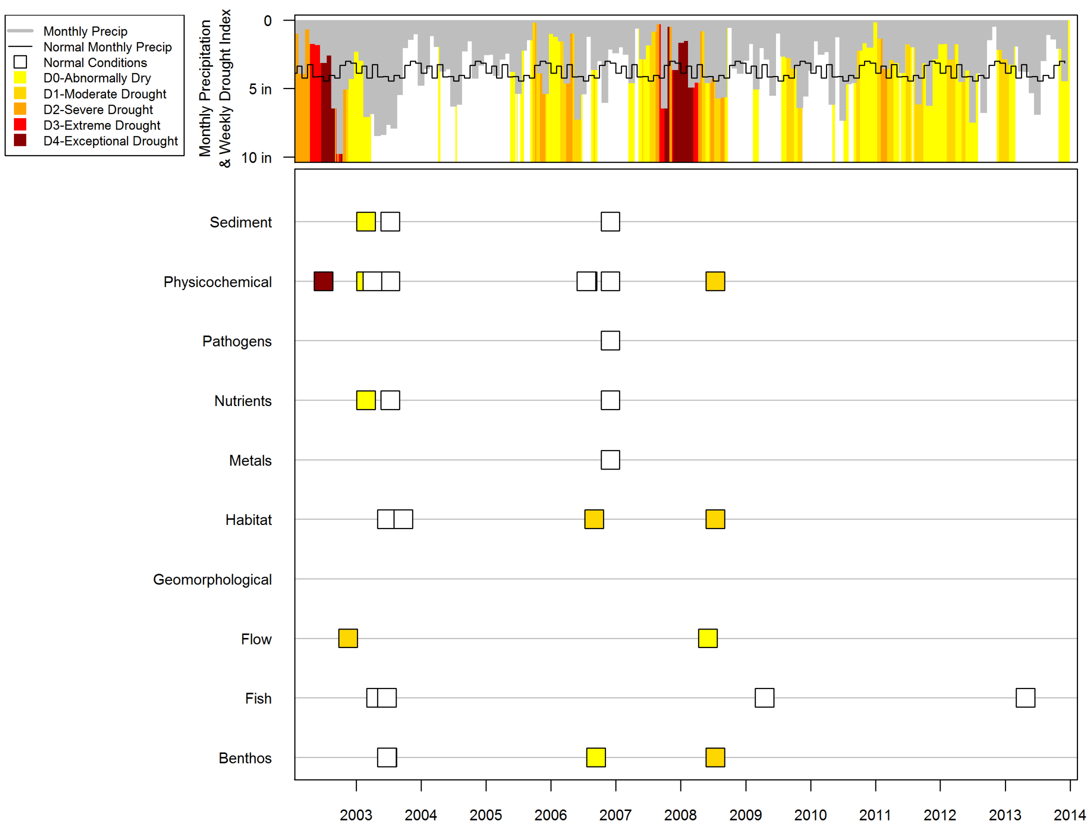

Figure 4-4. Summary of recent (since 2002) monitoring data for Little Alamance Creek watershed. Data compiled from multiple sources (URS, 2014). Top portion indicates monthly precipitation and Normal monthly precipitation from weather station ID 311239 (http://www.nc-climate.ncsu.edu/cronos). Color of square indicates the weekly drought status of Little Alamance Creek watershed at the time of sampling (http://www.ncdrought.org/archive/index.php).

Commented [MBF93]: DOT comment: Are above normal rainfall shown? Or is any condition not considered "drought" defaulting to normal?

MBF: Note that the NC drought council has two categories that are "not drought": "normal" and "abnormally dry"

Commented [MBF94]: DOT comment: Can the precip axis be flipped?

MBF: I defaulted to the inverted precip axis that is common in hyetographs.

Commented [JSJ95]: This graph is very confusing. Can we simplify this?

Josh, Figure updated. Caption updated.

DWQ Recommendations. Recommendations in the 2008 report included the following:

- Little Alamance Creek, particularly its tributary Willowbrook Creek, would likely benefit from stormwater controls to help moderate the flashy hydrology and to reduce sediment and chemical pollutant inputs.
- Restoration is recommended in the Willowbrook Creek subwatershed to improve conditions and to reduce downstream impacts on Little Alamance Creek.
- Particular attention needs to be directed to detecting and correcting the sources of high nutrients, heavy metals, and other pollutants in Willowbrook Creek and just downstream of its confluence with Little Alamance Creek.

Summary. The available water quality data are not sufficient to draw definitive conclusions about the source of the biological impairment in Little Alamance Creek watershed. The relatively intensive sampling done by DWQ in 2006-2007 did not identify a specific pollutant causing the impairment. Rather, it is likely that the impairment is due to a combination of many complex factors. The existing reports have attributed the impairment to the general conditions typical of an urban watershed, including the following sources:

- Hydro-modification
- Insufficient riparian buffer
- Streambank erosion
- Pollutants in stormwater runoff
- Degradation of in-stream habitat

4.2 Habitat, Riparian Condition, and Channel Geomorphology-related Stressors

Information on habitat, riparian condition, and channel geomorphology in the watershed is limited. Habitat assessments have been conducted at seven locations throughout the watershed, often concurrent with benthos sampling events. Five sites were evaluated by DWQ during the 2003 TMDL stressor study, and seven sites were evaluated by DWQ in 2006-2007. The habitat assessment scores throughout the watershed have ranged from 53 to 93, out of a maximum possible score of 100. The Little Alamance Creek at SR 2309 site has been assessed three times, with progressively lower scores each time; the scores were 73, 67, and 57 in 2003, 2006, and 2008 respectively. The lowest score was found at Little Alamance Creek at Mebane St. and the highest was at Bowden Branch at SR 2304. Willowbrook Creek at Mebane Street also had a poor habitat assessment score of 56. As previously noted in Section 4.1, this site had multiple water quality issues including elevated levels of phosphorous, lead, zinc, sodium, fecal coliform, and super-saturated dissolved oxygen due to an algal bloom. The reach had been channelized and has no woody riparian buffer. This site would have scored substantially lower if the bank erosion had been active, rather than partially stabilized by herbaceous vegetation and riprap along the bank slopes. Consequently, it is quite likely that bank erosion will become active again and that the habitat total score at this location will decline.

Of the individual metrics that compose the total score, insufficient riffle habitat was the primary contributing factor to low scores. Little Alamance Creek at four different locations (Mebane Street, NC 54, I-85 Frontage Road, and SR 2309) scored below 7 on a scale of 1 to 14 for this metric. The secondary factor contributing to low scores was lack of riparian buffer. The lack of good riparian buffer zones is a major issue in urban areas where land is at a premium. The absence of riparian buffer exacerbates other

Commented [MBF96]: This is directly from the report – unclear if "Stream restoration" is intended and, if so, if "subwatershed" be removed?

Commented [MBF97]: The below text was merged into the text in this section.

Habitat assessments were conducted as part of the Local Watershed Planning process for NCEEP in Little Alamance Creek watershed to evaluate the suitability of conditions within a stream to support aquatic life. The assessments were performed in 2006 in accordance with NCDENR's Benthic Macroinvertebrate Standard Operating Procedure (NCDENR DWQ, 2006). The procedure includes the assessment of several metrics which collectively evaluate the stream channel and riparian area for stability to support the propagation of aquatic invertebrates and fish.

Seven sites were assessed in Little Alamance Creek watershed. Four assessments were performed on Little Alamance Creek with individual assessments on Bowden Branch, Brown Branch, and an unnamed tributary to Brown Branch. Total scores ranged from 53 to 93 (100 total possible score). Little Alamance Creek at Mebane Street provided the lowest score while Bowden Branch at State Route 2304 scored the highest. The individual habitat metric most commonly contributing to reduced total scores in the watershed was Riffle Habitat. Little Alamance Creek at four different locations (Mebane Street, NC 54, I-85 Frontage Road, and SR 2309) scored below 7 on a scale of 1 to 14 for this metric.

Commented [MBF98]: I moved 1 paragraph to Section 5.1.3.1, since it discussed the benefits of the finished restoration. Map of restoration also moved there.

Commented [MBF99]: DOT comment: Consider providing a map with scores. Are the habitat sheets provided in an appendix?

MBF: The habitat total scores are listed in Figure 10 (pg 23) of the NCEEP 2008 LATT report. Those locations are shown on Figure 5, but no habitat scores are currently listed.

Commented [JSJ100]: Is this information available in a chart?

stream habitat problems including streambank erosion and subsequent burial of channel substrates, reduced shading, and reduced inputs of woody debris and leaf material.

Another potential stressor is the altered hydrology typical of an urban watershed. The 2008 DWQ study stated that scouring at high flows is a major issue throughout Little Alamance Creek and its tributaries. There are no long-term continuous data on flow, because there are no permanent gage stations in the watershed. However, stream flow data were collected as part of the USGS study on urbanizing piedmont streams in 2002 and 2003. Continuous stream stage data were collected hourly for one year, from November 16, 2002 to November 15, 2003. The overall mean discharge for the year was 14.9 cfs.

4.3 Stream Geomorphology

Commented [MBF101]: Either demote heading, remove heading, or rename Section 4.2.

There has been no comprehensive assessment of stream geomorphology performed in the Little Alamance Creek watershed for all streams. However, three reaches were evaluated for stream restoration. As part of the restoration projects, extensive geomorphological data was collected and documented in the restoration plans for Little Alamance Creek and Brown Branch. Both projects were proposed to be funded and constructed for NCEEP. Only one project consisting of the Little Alamance Creek and an unnamed tributary was constructed. Section 5.1.3.1 includes additional information on this restoration project. Table 4-4 summarizes key findings from the pre-restoration geomorphological data.

Commented [PB102]: Yes. Pre-construction. All reference reach data was from Greensboro.

Table 4-4. Geomorphological values for select reaches (Arcadis, 2008)

Data Source	Little Alamance Creek (City Park)	Unnamed Tributary to Little Alamance Creek (City Park)	Brown Branch (Willowbrook Park)
Drainage Area (sq mi)	4.2	0.1	0.8
Gradient (ft/ft)	0.0024	0.0095	0.0069
Channel to Depth Ratio	14.0	9.3	13.9
Sinuosity	1.2	1.1	1.01
D50 (mm)	2.4	3.4	8.4
Rosgen Classification	C5/1 and E5/1	E4/1	C4/1 and E4/1
NCDENR Stream Classification Score	47.5	33.0	35.5

Little Alamance Creek at Burlington's City Park in its pre-restoration condition was a pool-dominated system with approximately 65% of the stream length being comprised of pools. In the middle section of the project reach, the pools are separated by fairly short and steep bed-rock steps. The C5 stream type is a slightly entrenched, meandering, sand dominated, riffle/pool channel with a well-developed floodplain (Rosgen, 1996). The E5 stream type is characterized by low to moderate sinuosity, gentle to moderately steep gradients with very low channel width to depth ratios (Rosgen, 1996). The substrate of an E5/1 or C5/1 stream type is comprised mainly of sand, with the occurrence of bedrock. The hybrid classification given to Little Alamance Creek reflects the range of channel dimensions found throughout the site.

The upper reach of the unnamed tributary immediately downstream of Overbrook Road is steeper than the lower reach at the confluence with Little Alamance Creek. The lower reach is located in the relatively flat floodplain of Little Alamance Creek. The E4/1 stream type has gentle to moderately steep gradients with very low width to depth ratios. They are riffle/pool streams and exhibit gravel size bed material with areas of bedrock. Typically E4/1 channels are meandering streams.

Brown Branch exhibits the aforementioned characteristics of an E4/1 channel but a segment also exhibits C4/1 characteristics. The C4/1 stream type is a slightly entrenched, riffle/pool channel with a well-developed floodplain. The channel substrate is gravel-dominated with areas of bedrock. The C4/1 stream channels have gentle gradients of less than 2%, and display high width/depth ratios. Typically C4/1 channels are meandering but this channel is confined by the limits of Willowbrook Park.

4.4 Potential Point Source Stressors

There are generally two types of stressors that impact waterways: non-point source pollution and point source pollution. Point-source stressors originate from a readily identifiable source, such as a wastewater discharge pipe from an industrial process or a sewage treatment plant. EPA also classifies urban stormwater running off of impervious surfaces a point source pollutant, because it is collected and discharged directly to a stream or waterbody.

The NPDES Stormwater Program regulates stormwater discharges from municipal separate storm sewer systems (MS4s), construction activities, and industrial activities. There are three MS4 operators in the Little Alamance Creek watershed: City of Burlington, City of Graham, and NCDOT.

4.4.1 Critical Areas

There are a number of locations and land uses within Little Alamance Creek that may exhibit the potential to contribute to the degradation of water quality from contributing runoff, non-compliant operations, or past practices. These areas may no longer be contributing pollutants via runoff, spills, or groundwater to Little Alamance Creek or its tributaries but can be categorized as hot spots for future evaluation and monitoring. Typical facilities and land uses that fall into this category include landfills, NPDES discharges, dump sites, and industries no longer operating or now required to perform pretreatment of the wastewater. The City of Burlington has compiled a spatial dataset of these locations for reference in future planning efforts and plan implementation.

4.4.2 NPDES-permitted Stormwater Dischargers

The Cities of Burlington and Graham are both regulated MS4 Phase II NPDES communities (NCS000428 and NCS000408, respectively); they received NPDES permits July 1, 2005. NCDOT has an active NPDES permit (NCS000250) originally issued in 1998 and most recently renewed on September 10, 2010. A review of the NCDENR's Stormwater Permitting Program list (http://portal.ncdenr.org/web/lr/stormwater) indicates that there are 12 active NPDES general stormwater permit sites in or close to the Little Alamance Creek watershed, two No Exposure permits, and zero state stormwater permits within the watershed (Figure 4-5).

Commented [MBF103]: "if"?

Commented [JSJ104]: I'm not big on calling the MS4 a point source of pollution. I think that is problematic long term.

Commented [MBF105]: "critical areas" could also imply a pristine yet fragile/at risk habitat. However, I cannot think of a better sub-heading.

Commented [PB106]: This started out with the intention of identifying industrial land uses or facilities requiring pretreatment that may have a discrete impact on a particular branch or reach of LAC. The thought was that they might not have also been under this program but the program manager did not confirm this thought.

The outline I believe referenced permits in two sections. I am fine with moving it to section 4.3.

Commented [JSJ107]: Map? Should this be mentioned in implementation rather than in the critical areas section?

Commented [PB108]: It could be how far away from the watershed divide we used.

MBF: I used ~ 300 yards

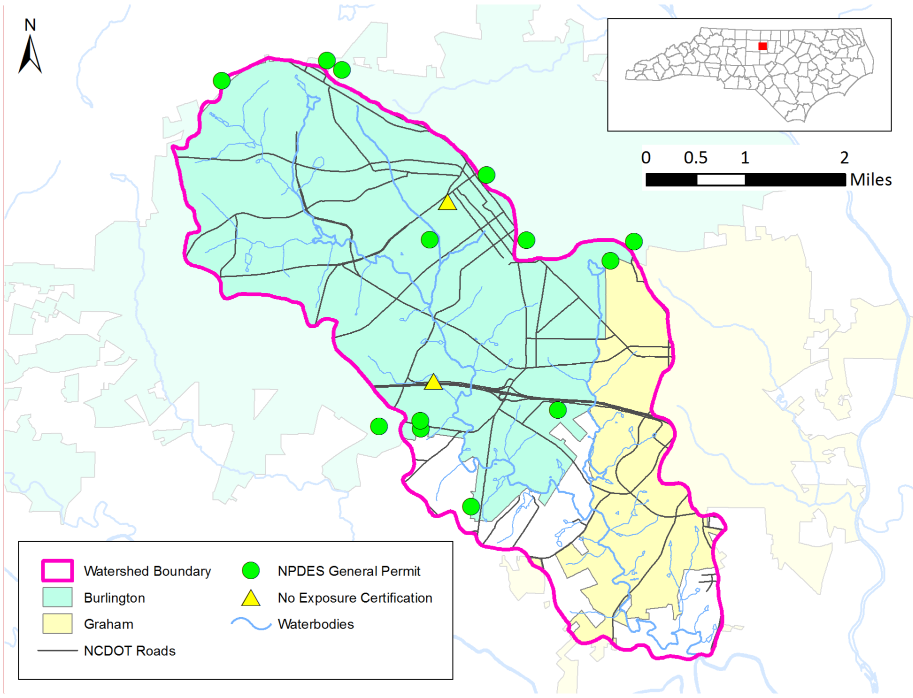

Figure 4-5. Active NPDES-permitted facilities within approximately 300 yards of Little Alamance Creek watershed

Commented [MBF109]: Add NCDOT road symbol to legend.

Commented [PB110]: Stormwater, may be fine if the figure stays within the subsection .

Patrick, see comment in Section 3.6.2. These green points were labeled NPDES General on the DEMLR site. DEMLR had a separate database for Stormwater sites, of which zero were located within/near the LAC watershed.

Commented [BAJ111]: If this figure is helpful, we may want to label the 12 permittees.

Commented [JSJ112]: Yes but the City's NPDES Phase II Permits aren't Point Sources.

Table 4-5. Permitted facilities in or near the Little Alamance Creek watershed (NCDEMLR, 2013)

Permit Class	Permit Number	Owner Name	Facility Name	Owner Type	Permit Type	Effective Date	Expiration Date	Permit Status
MS4	NCS000428	City of Burlington	Burlington city - Small MS4	Government - Municipal	Stormwater Discharge, Individual (MS4)	11/11/2011	11/10/2016	Active
MS4	NCS000408	City of Graham	Graham city - Small MS4	Government - Municipal	Stormwater Discharge, Individual (MS4)	11/11/2011	11/10/2016	Active
MS4	NCS000250	NCDOT - Hydraulics Unit	NC DOT Statewide Stormwater MS4	Government - State	Stormwater Discharge, Individual (MS4)	9/10/2010	9/9/2015	Active
General	NCG030188	Sapa Burlington LLC	SAPA Burlington, LLC	Non-Government	Metal Fabrication Stormwater Discharge COC	12/4/2012	10/31/2017	Active
General	NCG080315	Ernie Koury Jr	The Place	Non-Government	Transportation w/Vehicle Maintenance/Petroleum Bulk/Oil Water Separator Stormwater Discharge COC	11/1/2012	10/31/2017	Active
General	NCG080431	Carolina Tank Lines Inc	Carolina Tank Lines Incorporated	Non-Government	Transportation w/Vehicle Maintenance/Petroleum Bulk/Oil Water Separator Stormwater Discharge COC	11/1/2012	10/31/2017	Active
General	NCG080706	City of Burlington	Burlington Equipment Services	Government - Municipal	Transportation w/Vehicle Maintenance/Petroleum Bulk/Oil Water Separator Stormwater Discharge COC	11/1/2012	10/31/2017	Active
General	NCG170202	Burlington Industries LLC	Burlington Industries- BHP Plant	Non-Government	Textile Mill Products Stormwater Discharge COC	8/1/2009	7/31/2014	Active
General	NCG170228	Kayser-Roth Corporation	Kayser Roth Corp-Burlington Plant	Non-Government	Textile Mill Products Stormwater Discharge COC	8/1/2009	7/31/2014	Active
No Exposure	NCGNE0091	Homac Corporation	Lessona/Holt Distribution	Non-Government	Stormwater Discharge, No Exposure Certificate	5/1/2005	--	Active
No Exposure	NCGNE0831	Bd Diagnostics - Women's Health	BD Diagnostics - Women's Health	Non-Government	Stormwater Discharge, No Exposure Certificate	1/10/2012	--	Active
Within approximately 300 yards of Little Alamance Creek watershed:								
General	NCG080316	Lee Properties SC LLC	Tucker Street Industrial Park	Non-Government	Transportation w/Vehicle Maintenance/Petroleum Bulk/Oil Water Separator Stormwater Discharge COC	12/12/2012	10/31/2017	Active
General	NCG140089	Chandler Concrete Co., Inc.	Chandler Concrete Co - Burlington Plt #601	Non-Government	Ready Mix Concrete Stormwater/Wastewater Discharge COC	7/1/2011	6/30/2016	Active
General	NCG170213	Burlington Technologies	Burlington Manufacturing Services	Non-Government	Textile Mill Products Stormwater Discharge COC	8/1/2009	7/31/2014	Active
General	NCG170241	Glen Raven Inc	Glen Raven, Inc. Custom Fabrics	Non-Government	Textile Mill Products Stormwater Discharge COC	8/1/2009	7/31/2014	Active
General	NCG170242	Glen Raven Inc	Glen Raven Inc	Non-Government	Textile Mill Products Stormwater Discharge COC	8/1/2009	7/31/2014	Active
General	NCG200346	Commerical Metals Company	Commerical Metals Company	Non-Government	Wholesale Trade of Metal Waste and Scrap Stormwater Discharge COC	1/1/2010	12/31/2014	Active
General	NCG200483	--	OK Recycling	Individual	Wholesale Trade of Metal Waste and Scrap Stormwater Discharge COC	4/2/2012	12/31/2014	Active

Deleted: Industrial

Deleted: or within 300 feet of the watershed boundary

Commented [MBF113]: One additional NPDES site, NCG170250, was 77 yds away based on Burlington's data, and 1,200 yards away based on DEMLR's data. I'm not sure which data on that facility is correct.

There are 16 industrial facilities in or within approximately 300 yards of Little Alamance Creek watershed that are required by the City to perform some level of pretreatment of their wastewater (Table 4-5). Most of these facilities are operating within the textile industry while many of the others are operating in the food packing industry. Given the nature of these facilities and current compliance with the City's pretreatment program they are likely no longer a significant concern to water quality from a discharge perspective.

Commented [PB114]: This is GIS information provided to me by Michael. http://burlingtonnc.gov/index.aspx?NID=770
These are wastewater permittees not to be confused with storwmater.

Commented [JSJ115]: Will get City of Graham info.

There are eight entities that hold coverage under a NCDENR Stormwater Permit. These permittees are typically required to either manage stormwater discharges from industrial activities or reduce non-point source contributions for pollutants of particular concern. Compliance with their permit is reviewed by NCDENR Division of Energy, Mineral, and Land Resources (DEMLR). The permittees include:

- The City of Burlington, which holds individual permit NCS000428 for Phase II municipal separate storm sewer systems (MS4) discharges
- The City of Graham, which holds individual permit NCS000408 for Phase II MS4 discharges
- NCDOT, which holds individual permit NCS000250 for municipal separate storm sewer systems (MS4) discharges
- Kayser Roth Corp – Burlington Plan, which holds coverage under NCG170228 for Textile Mills
- The Place, which holds coverage under NCG080315 for Transit and Transportation
- Tucker Street Industrial Park, which holds coverage under NCG080316 for Transit and Transportation
- SAPA Burlington, LLC, which holds coverage under NCG030188 for Metal Fabrication
- Burlington Equipment Services, Inc, which holds coverage under NCG080706 for Transit and Transportation
- Burlington Industries-BHP Plant, which holds coverage under NCG170202 for Textile Mills

Commented [BAJ116]: Add DOT?

4.4.3 NPDES-permitted Wastewater Dischargers

There are no active NPDES wastewater discharge permits in the Little Alamance Creek watershed. Previously, the City of Burlington wastewater treatment plant was located at present-day Graham City Park, but the facility was closed in _____.

Commented [MBF117]: Earlier text referred to the "South Graham Municipal Park." Just wanted to confirm that this is a different park. I searched here (http://www.cityofgraham.com/departments/recreation-and-parks/facilities/parks/) and didn't see Graham City Park.

4.4.4 Non-permitted Point Sources

The sources reviewed for the data inventory did not identify any specific point sources of pollution, though the area around Willowbrook Creek was recommended for further investigation due to several samples with higher fecal, nutrient, and heavy metal concentrations. Some potential point sources to be investigated in this area include leaking sewer lines or septic systems, and a vehicle maintenance facility. There is also an unlined abandoned landfill adjacent to Little Alamance Creek; unlined landfills have the potential to convey contaminants into the stream via the groundwater movement. See Section x.x for more information on non-permitted point sources.

Commented [MBF118]: I'm not clear as to which section this should be. If no such section, then delete sentence.

4.5 Potential Nonpoint Source Stressors

There are a multitude of potential nonpoint source stressors in the watershed. Stormwater runoff may contain a complex mixture of contaminants that are accumulated as precipitation flows across the surface. Some pollutants commonly found in urban stormwater runoff include: pesticides and nutrients from lawns, gardens, and golf courses, oil and other fluids from motor vehicles, heavy metals from roof shingles, gutters, and motor vehicles, road salts, virus, bacteria and nutrients from pet/wildlife waste and failing septic systems or leaking sewer lines, and sediment from eroding stream banks and construction sites. Thermal pollution can also be an issue, as water temperatures are increased as they flow across dark impervious surfaces such as streets and rooftops. While these pollutants are common in most urban stormwater, none of these specific stressors have been identified as the main source of impairment for the Little Alamance Creek watershed.

Approximately 30% of the Little Alamance Creek watershed is comprised of impervious surfaces (Elon University, 2010). Growth of impervious surface appears to have leveled off, as percentages for the watershed were 26.0% and 26.2% based on 2001 and 2006 National Land Cover Database (NLCD) GIS data, respectively. There are also private stormwater conveyance systems that are not part of the MS4s. The areas outside of the MS4 stormwater conveyance systems primarily include the riparian areas adjacent to streams and lakes, as well as a small unincorporated area between Burlington and Graham in the central southern portion of the watershed.

4.6 Potential Legacy Stressors

There are three identified historic wastewater discharge or landfill sites within Little Alamance Creek. There is a historic landfill site located under the Pine Hill Cemetery and the Burlington Public Works facility on Mebane Street between Little Alamance Creek and Brown Branch. The 95-acre landfill was closed in XXXX and is likely unlined per current standards. At the confluence of Brown Branch and Little Alamance Creek on the other side of Mebane Street is a historic wastewater sludge application site. A second wastewater sludge application site is located where the South Graham Municipal Park is located. These sites are no longer active but could have lasting impacts to the water quality within the watershed.

[ENTER A SHORT SUMMARY FROM SECTION 2 HERE?]

Commented [MBF119]: ncgolf.com lists 2 sites w/in LA watershed:

Shamrock Golf Club
1722 Shamrock Dr
Burlington NC 27215
336-227-8566

Alamance Country Club
2402 Pineway Dr
Burlington NC 27215
336-584-1326

Commented [MBF120]: DOT comment: Change “identified in” to “identified to be in excessive concentrations in”

MBF: I think the original intent of this sentence was that none of these “stressor groups” were identified as the main cause of Little Alamance Creek’s impairment. Melissa, please confirm my tracked changes if appropriate.

Deleted: in

5.0 Pollution Controls

Restored biological integrity and aquatic life use in Little Alamance Creek will depend on the implementation of pollution controls, management practices and other strategies and activities designed to mitigate the stressors discussed in Section 4.0. Collectively referred to as best management practices (BMPs), these activities function to reduce or avoid pollutant inputs to receiving waters in order to achieve water quality protection goals and restore and maintain the chemical, biological, and hydrologic integrity of the receiving waterbodies. BMPs provide this function through the reduction of pollutant loads that are delivered to a waterbody, control of discharges that could alter natural hydrology, or mitigation of other stressors that might contribute to impairment.

Deleted: and impacts of stormwater often associated with development and other land disturbing activities.

Commented [MBF121]: "loadings"?

Commented [MBF122]: Move/merge with Section 5.2?

5.1 Existing Controls in the Watershed

The project partners engage in a number of programs that serve to reduce non-point source loadings, improve stormwater management, and protect natural resources throughout Little Alamance Creek watershed. These programs are either regulatory based or focused on providing a level of service to the communities the project partners represent. The programs and their overarching objectives are discussed below.

5.1.1 Non-Structural Practices and Programs

BMPs can be broadly categorized as "structural" or "non-structural". Non-structural BMPs often include land use, development, and management strategies aimed at minimizing or preventing pollutants from entering stormwater. These strategies may include education and public involvement programs to influence behaviors and changes in activities that contribute to pollution as well as improved management of potential sources of pollutants (such as training on fertilizer application and storage). Non-structural BMPs may be geared toward stormwater professionals, the general public, or government agencies. Industry-related workshops serve to inform stormwater professionals on current regulations and BMPs applicable to their daily activities. Public outreach through advertising campaigns and signage can be helpful in educating and involve neighboring communities. Collecting stormwater-related data and creating an inventory of stormwater outfalls and existing BMPs can help agencies better allocate resources for current maintenance or future expansion.

Commented [MBF123]: Moved this paragraph f/ Section 5.0.

Commented [JSJ124]: I think this would be a good place for a small sample map.

Nonstructural control measures are processes, policies, or practices implemented to influence behaviors, decisions, or actions that reduce the amount of pollution entering surface waters. Some examples of nonstructural control measures applicable to the highway environment include street sweeping, public outreach and education, litter control, and management of fertilizer application within the right-of-way. Nonstructural control measures can also be decision-making practices that guide staff to engage in alternative activities or use alternative designs.

Commented [MBF125]: Need to merge this paragraph with the first paragraph.

Commented [MBF126]: DOT comment: "pesticide"?

5.1.1.1 Municipal NPDES Phase II Programs

The Cities of Burlington and Graham maintain permits to discharge stormwater from their MS4s under the NPDES program administered by NCDENR. They were most recently reissued permit coverage for the current five year cycle in November 2011. This current cycle is only the second cycle of permit coverage for both communities, so the program is new to the communities after starting in 2005. The MS4 permit requires communities to implement a program focusing on the six minimum measures as well as reduce non-point source loading in accordance with the wasteload allocation of an EPA approved

TMDL. The permittees are required to develop and implement BMPs for the following six minimum measures to the maximum extent practicable.

1. Public Education and Outreach
2. Public Participation and Involvement
3. Illicit Discharge Detection and Elimination
4. Construction Site Runoff Management
5. Post Construction Runoff Management
6. Good Housekeeping/Pollution Prevention

Each of these measures consists of required Best Management Practices (BMPs), measurable goals for each BMP and an implementation schedule for the 5 year permit cycle. Additionally, the City of Graham has a Comprehensive Stormwater Management Program and completes annual reporting about the NPDES Phase II Program. Because the NPDES Program concentrates on water quality it has limited provisions concerning water quantity and flooding controls.

Commented [PB127]: Both permittees do this so why are we singling out Graham here.

Commented [MBF128]: This sentence feels out of place. It may be better served as an introductory sentence that goes on to describe existing/potential flood control-related BMPs. Move/merge to Section 5.1.1.6 "Post Construction Runoff Program"?

Commented [MBF129]: Perhaps delete this paragraph, move subsection 5.1.1.2 "HSP", and jump into Public Education?

Commented [MBF130]: The previous paragraph lists the 6 EPA elements, then the DOT HSP program is discussed, then we return to the 6 EPA elements. To address this disconnect, should this subsection be moved to after "Pollution Prevention and Good Housekeeping"?

5.1.1.2 Highway Stormwater Program

The Highway Stormwater Program (HSP), established in 1998, is an NCDOT-wide initiative to protect and improve water quality while fulfilling NCDOT's mission of providing and supporting a safe and integrated transportation system that enhances the state. NCDOT received their first Phase I permit in 1998; it includes all of the Phase II requirements as well as an additional requirement including the implementation of BMP retrofits. NCDOT performs numerous activities through various programs as a means to comply with their permit. These programs include an illicit discharge detection and elimination program, storm sewer system inventory and prioritization program, development of a BMP Toolbox for post-construction highway runoff, BMP inspection and maintenance program, vegetation management program, encroachment program for assuring all system tie-ins are NCDENR permitted dischargers, construction program, industrial activities program, education and involvement program, and research program.

5.1.1.3 Public Education and Outreach and Public Involvement Programs

All of the project partners currently have Public Education, Outreach and Public Involvement Programs that they use to educate the public about the need for better water quality in stormwater. The Cities of Burlington and Graham operate very similar Public Education Plans as part of their NPDES Phase II and Jordan Lake Stage 1 Programs (included later in this section). The Cities Public Education Plans are described first, followed by NCDOT's External Education Program.

The Cities programs have general objectives to distribute education materials to the community and/or to conduct equivalent outreach activities about the impacts of storm water discharges on surface waters and the steps the public can take to reduce pollutants in stormwater runoff. These objectives have been further refined to target residents, school children, local businesses (specifically gas station owners and landscaping companies), and industry because these groups have the most impact on stormwater pollution prevention.

The education program targets total suspended solids (TSS), sediment, and nutrient loadings because turbidity, sedimentation, and nutrients are the pollutants of concern in downstream waters.

The Cities have partnered with Stormwater Smart, an education and outreach organization, hosted by the Piedmont Triad Regional Council (PTRC). Stormwater Smart is a cooperative group that is funded by several Piedmont municipalities. It was created in 2005 to provide education and outreach for the new MS4 Permittees (like Graham and Burlington) and concentrates on direct education of school children and residents. The Stormwater Smart Outreach and Education Coordinator is Elizabeth Jernigan and a copy of the Stormwater Smart's Annual Report is available at http://www.stormwatersmart.org/pdf/Annual%20Reports/2012-2013_Annual_Report_Web.pdf and provides a comprehensive outlook for the Fiscal Year 2012-2013 period.

The Cities have previously worked with the PTRC and Stormwater Smart on a grant funded watershed specific public education program that was labeled the "Little Alamance Restoration Alliance" or LARA. LARA was intended to concentrate efforts within the watershed to:

- Increasing the stormwater awareness of property owners (residential and business) and their access to techniques for reducing runoff pollution
- Establishing partnerships and working with community leaders to foster institutional environmental stewardship in watershed communities
- Increasing public stewardship and understanding of water quality principles through direct monitoring upon Little Alamance Creek
- Promoting diverse and self-sustaining native riparian and upland vegetation
- Working with local media providers to publicize project objectives

The project had some success but not enough to continue its momentum when grant funding expired.

The Cities of Burlington and Graham have also worked together to do stream cleanups along Bowden Branch, known locally as Boyd Creek, that establishes the border between Burlington and Graham (Figure 5-1). The stream cleanups have been building in momentum and attracted a large group of citizens in 2013.

Figure 5-1. Volunteers shown cleaning up Bowden Branch (known locally as Boyd Creek).

The City of Burlington is also a member of the Piedmont Triad Water Quality Partnership and the PTWQP complements Stormwater Smart through Mass Media. More Info from COB.

NCDOT provides training to educate employees and the general public about how to avoid or minimize their impact on water quality. Rest areas, for example, offer a unique venue and opportunity to influence the behavior, decisions, and actions of our citizens and visitors. Various types of media from course curriculum to signage and posters are used to convey the message of environmental stewardship. Several NCDOT business units have education or training efforts related to the implementation of environmental programs or activities.

5.1.1.4 Illicit Discharge Detection and Elimination

All of the project partners have Illicit Discharge Detection and Elimination (IDDE) Programs. The IDDE Programs are intended to reduce discharges to the stormwater system that are not entirely composed of stormwater. There are a few permitted discharges and firefighting related discharges that are allowed.

An illicit discharge is typically dirt, soap, pet waste, litter, oil, fertilizer, pesticides, or raw sewage and often times comes from "generating sites." Generating sites are points of pollution that continue over a period and are recurring at regular or irregular intervals.

The Cities of Burlington and Graham have IDDE ordinances and NCDOT's permit provide a backbone to the IDDE program. The IDDE ordinances permits specific discharges into the MS4 as legal, provides legal authority to restrict illegal discharges, prohibits illicit connections, provides conditions for cleaning up and preventing polluted spills, provides for right-of-entry into property to investigate prohibited activities, and provides options for enforcement. The IDDE program also includes dry weather testing of outfalls into the stream system. Dry weather testing and streamwalks are used to identify potential illicit discharges. The IDDE ordinances are based on the DWQ's Model Ordinance.

The second basis for the municipal IDDE programs are the Cities' MS4 maps. The mapping programs were completed in the first permit cycle by GPS mapping and are now usable in a GIS format. The map includes the entire MS4 system and provides for easy access to aid in the investigation of illicit discharges. An investigator with the map could find an illicit discharge and then follow the flow of the discharge upstream until finding a source of the discharge.

Commented [PB131]: I think this is not worth mentioning at all. It's a detail that has little bearing on the impairment.

Commented [JSJ132]: Pollutants don't originate at a generating site.

Commented [PB133]: Josh, I thought you wrote or pulled this section in from somewhere.

Commented [MBF134]: Need to confirm that NCDOT IDDEP operations match what is written in this paragraph. Else add a sentence to the end of the paragraph along the lines of "NCDOT manages its own IDDE program, which includes …"

Commented [MBF135]: "permits" implies legality, so is "as legal" needed? Or am I misreading this sentence?

Commented [PB136]: I would do away with this first part. While it permits some non-stormwater discharges (springs, de-chlorinated pool discharges, etc) its primary purpose is provide the legal authority to restrict and prohibit.

Commented [MBF137]: Cite?

Commented [PB138]: This is kind of an awkward opening line for this section. I wouldn't necessarily say the mapping is the basis of the IDDE, it was more or less an effort to understand the terminus and connection of the MS4 to WOTS. No doubt it serves a lot of uses but mapping was not the impetus.

Commented [JSJ139]: The maps are completed. And this is an item that has been done at significant cost. The entities should get credit for work completed.

Commented [MBF140]: Language in this paragraph, such as "entire", "easy", and "completed" may say more than what is intended. Consider deleting where appropriate.

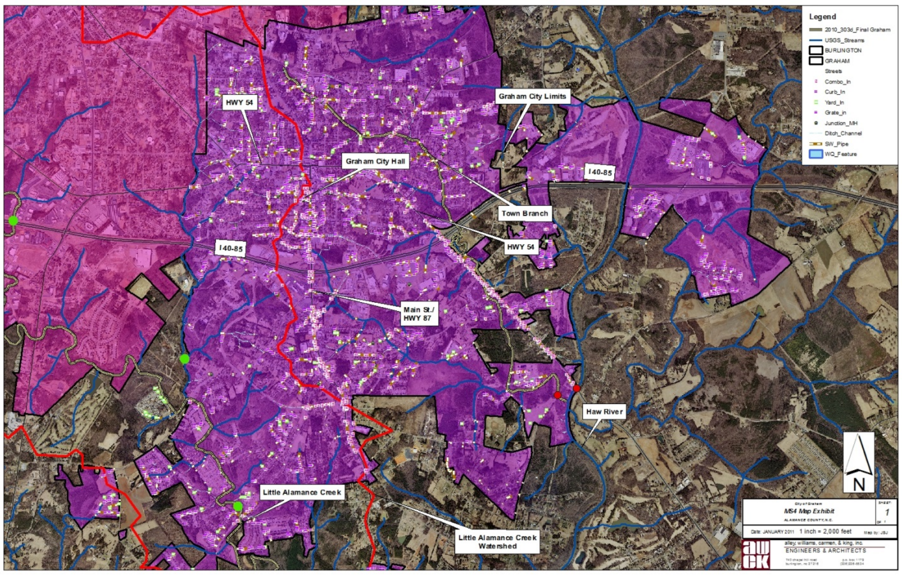

Figure 5-2. City of Graham MS4

Commented [MBF141]: Josh, the darker-purple area (Graham) boundary does not match the GIS boundary I have for Graham. Is the boundary pictured the most recent boundary? If so, can you email this specific Graham boundary to me so that I can update the other maps? I have a “Graham MS4.mxd”, with a “graham_limits” layer but I do not have this shapefile. Thanks.

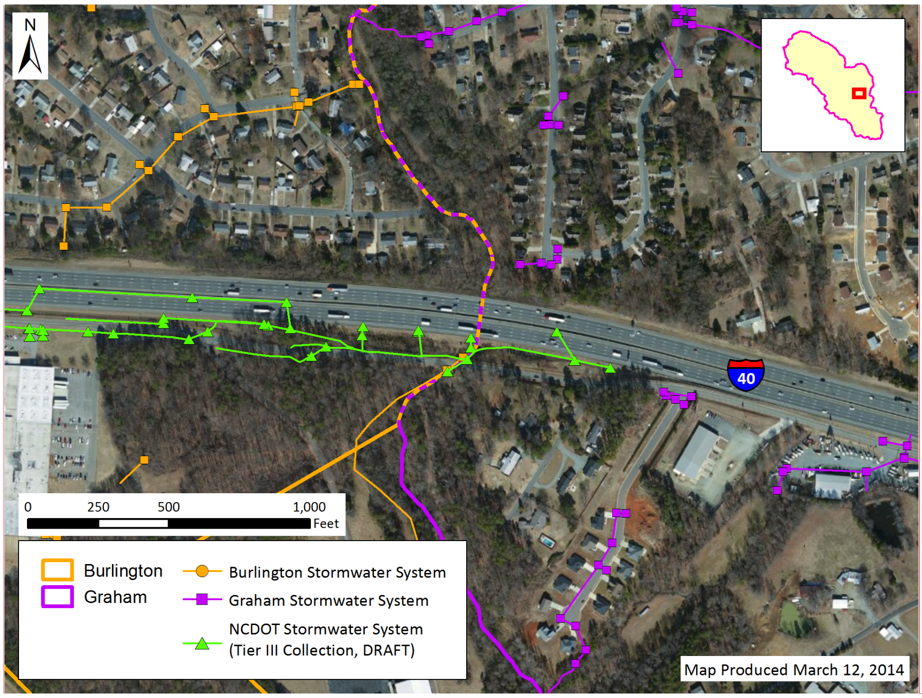

Figure 5-3. Stormwater infrastructure system inventory identified through the individual inventory programs of the City of Burlington, the City of Graham, and NCDOT. NCDOT data was collected in May, 2013.

Commented [MBF142]: DOT comment: Adjust symbology to be consistent with others (i.e., inlet locations)

MBF: I may have turned on a point layer that should be left off.

This comment (may have wrong data layers turned on) may apply to all of the partners. Burlington/Graham/DOT, feel free to email me a list of which point layers (or attribute categories if you use one master point layer) are appropriate to display on this map.

Commented [MBF143]: This figure uses outfall data from all 3 partners. Let me know the team's thoughts. Thanks.

Municipal and NCDOT staff are trained regularly to identify illicit discharges and the reporting process for these discharges. This training is combined with the Pollution Prevention and Good Housekeeping training of public works, utilities, recreation, planning, and administrative staff as well as some fire and police personnel.

NCDOT's IDDE Program collects information and provides training to NCDOT staff who have the potential to locate and report illicit discharges in the field. NCDOT staff coordinate with NCDENR, who then handle enforcement of the regulations. Drainage into the existing DOT stormwater drainage system, known as encroachment, is also monitored through NCDOT's program for driveway permits. These permits require the landowner connecting to NCDOT's ROW to determine whether any drainage entering the ROW is adequately permitted and will not generate an illicit discharge or otherwise impact NCDOT's drainage.

Commented [MBF144]: DOT comment: Need to check the NPDES forms.

5.1.1.5 Erosion and Sediment Control Program

The City of Burlington Engineering Department administers an erosion control program within the city limits and extraterritorial jurisdictional area. This program operates under the direction of the Land Quality Section of NCDENR which enforces the requirements of the Sedimentation Pollution Control Act of 1973 on a statewide basis. The Sedimentation Pollution Control Act of 1973 is a performanceoriented law that allows flexibility in determining the most economical and effective methods for controlling erosion and sediment. The North Carolina Sedimentation Control Commission sponsored the development of the North Carolina Erosion and Sedimentation Control Planning and Design Manual (NCDENR, 2013), a basic reference used during plan preparation, review, implementation, and enforcement to minimize and control the effects of erosion and sedimentation on surrounding land, water bodies and ecosystems. Plans are required to be prepared by, or under the direction of, a Professional Engineer, Professional Land Surveyor, Registered Architect, or Registered Landscape Architect.

Commented [JSJ145]: PE, PLS, AIA, or ASLA are specific titles.

Erosion Control within the City of Graham is held to similar standards but jurisdiction is delegated back to the NCDENR, DEMLR Land Quality Section.

Commented [SCD146]: Did Graham ever have a local erosion and sedimentation control ordinance? If not, it may better to say that jurisdiction lies with DEMLR Land Quality Section. Otherwise this sentence might be interpreted that Graham gave up local control and the State resumed jurisdiction.

Commented [JSJ147]: Technically the Phase II Permit includes a section on "Construction Site Runoff Controls" that the City has to write in that this is being delegated back to DENR.

In 1991, NCDENR's Sedimentation Control Commission reauthorized the 1974 NCDOT delegation agreement granting authority to administer its own Sediment and Erosion Control Program. NCDOT must ensure that land-disturbing activities conducted by the Department are in compliance with the Sedimentation and Pollution Control Act of 1973. The Division of Land Quality reviews NCDOT's Sediment and Erosion Control Program on an annual basis for compliance and reauthorization.

NCDOT has partnered with the Biological and Agricultural Engineering and Soil Science Departments at NCSU to create an Erosion and Sediment Control Stormwater Certification Program. Certification through this program promotes compliance with erosion and sediment control/stormwater provisions on NCDOT projects and provides comprehensive training to inspectors, project managers, installers, and designers employed by NCDOT and by contractors. Any site manager responsible for a contracted project that has an erosion control plan or any supervisor of crews who install erosion and sediment controls on construction sites are now required to have this certification. Three (3) levels of certification are being implemented, including Level I for those who directly supervise crews who install erosion and sediment controls on construction sites, Level II for those who supervise or direct grading work, culvert replacement work, and bridge construction work over rivers and streams, and Level III for employees and contractors who are involved with the design of erosion and sediment control and elements to be included in the plans.

With the implementation of the certification program, major construction projects are subject to multiple layers of review for compliance with the Sedimentation and Pollution Control Act, including installation, maintenance and effectiveness of the erosion control measures, and plan implementation. The multiple layers of review include:

- Implementation of an Erosion and Sediment Controls/Stormwater Pollution Prevention Plan that has been prepared or reviewed by a Level III-certified designer
- Daily observation and review by on-site staff or contractors who have completed the certification through Level II
- Installation and activities overseen by on-site staff or contractors who have completed the certification through Level I
- Monthly review by NCDOT's Roadside Environmental Field Operations Engineer or Technician

5.1.1.6 Post Construction Runoff Program

The Cities of Burlington and Graham have typical NPDES Phase II Post Construction Programs to reduce impacts from stormwater runoff. These programs include a Post Construction Ordinance, administrative forms that support it, and a review process. The Post Construction Programs apply to projects that exceed 1 acre of disturbance or have a common plan of development that will cumulatively exceed 1.0 acre of disturbance. Projects that exceed 24% built-upon area are considered high density projects, projects that are less than 24% BUA are low density projects. High Density Projects are then required to meet the following requirements:

- Treat runoff from the first 1" of rain (the first flush)
- Treated Runoff is to be for 85% TSS removal
- Discharge treated water at a rate less than or equal to the Predevelopment rate for the 1 year 24 hour storm
- Discharge treated water between 48-120 hours
- Stormwater Control Measures must be in easements and must have a recorded operation and maintenance agreement
- Compliance with the Jordan Lake Riparian Buffer Protection Ordinance

BMPs, as well as runoff calculations, are prepared based upon the NC DWQ BMP Manual (NCDENR, 2007) and then reviewed by licensed local reviewers.

Low Density Projects are required to comply with the Jordan Lake Buffer Protection Ordinance that went into effect in fall 2011. Both Low and High Density Projects are required to comply with the City's Storm Sewer Design Manual which governs storm drainage design as well as peak runoff rates and provides for evaluation of the 10 and 100-year design storms.

In addition, the City of Graham currently evaluates projects that exceed the 1 acre disturbance threshold to provide calculations to evaluate the projects 10-year and 100-year peak discharges to limit downstream property from flooding or erosion. Projects that are greater than 10% of the drainage area can be required to match the pre-development runoff rate for the 10-year or the 100-year storm if city staff is concerned about downstream flooding or erosion.

Through their Post-Construction Stormwater Program (PCSP), NCDOT regulates stormwater from new NCDOT development and redevelopment for new built upon area by requiring structural and non-structural practices to protect water quality, reduce pollutant loading, and minimize post-construction impacts to water quality. As part of the PCSP, NCDOT implements post-construction BMPs for discharges, controls runoff from new development and redevelopment, and implements the approved NCDOT Best Management Practices Toolbox as well as defining Toolbox implementation and training.

The NCDOT PCSP also outlines minimum stormwater control measures (minimum measures) that are implemented on all projects where appropriate. Minimum measures are applied during both planning and design phases, that protect water quality, minimize pollutant loading, and minimize post-construction impacts to water quality. Many of the minimum measures embody the low impact development (LID) and green infrastructure (GI) concepts of conservation and use of on-site natural features to retain or treat runoff close to the source.

Examples of minimum measures considered for roadway projects during the planning phase (such as during the Merger Process) include:

- Maximizing shoulder section
- Minimizing roadway side slopes

Commented [JSJ148]: Change seems confusing to me.

Commented [PB149]: Could open with Low Density projects, those under 24% BUA, are required to manage and convey stormwater by vegetated means (whatever is in the permit) and then transition with new sentence on High Density and their requirements.

Commented [MBF150]: Assumed preference of "BMP" over "SCM" in this document. Change globally, if needed.

Commented [JSJ151]: Removing capitalization looks sloppy in my opinion.
The 1" storm produce x amount of runoff. Some of the first 1" is not runoff.
Preferred to use SCM to be consistent with permit and since BMP is used consistently in the permit for practices rather than structures.

Commented [JSJ152]: NC DWQ BMP Manual is the proper name included in the permit and ordinance.

Deleted: Stormwater Control Measures

Commented [JSJ153]: By rule for both.

Commented [MBF154]: Are there 2 storm sewer design manuals (1 for Burlington and 1 for Graham) or 1?

Commented [PB155]: Did I mess something on the Merger Process elsewhere.

- Minimizing the impacts of runoff to environmentally-sensitive areas
- Promoting sensitive intersection of streams

During the design phase (such as while the project drawings are being prepared) for roadway projects, the following minimum measures are considered:

- Providing adequate ground cover
- Stabilizing slopes
- Providing adequate energy dissipation
- Utilizing natural features and drainage pathways
- Maximizing vegetative conveyance
- Encouraging diffuse flow
- Minimizing direct discharge from bridges

For non-roadway projects, which follow a different workflow than roadway projects, the following minimum measures are considered:

- Maximizing vegetative and natural conveyance
- Minimize impervious surfaces (also known as built-upon area or BUA)
- Minimize land disturbance and soil compaction
- Disconnection practices

These measures are an important part of program compliance and highlight the wide-ranging practices NCDOT employs to protect surface waters.

5.1.1.7 Pollution Prevention and Good Housekeeping

Pollution Prevention is an overall goal of all three of the stormwater programs and Good Housekeeping is a key to that goal. Municipalities, in general, conduct many activities that can pose a threat to water quality. Municipal facilities are the primary potential source of contamination but with good housekeeping habits this potential can be reduced or eliminated. The Cities of Burlington and Graham attempt to minimize stormwater pollution from municipal operations by complying with best management plans for each municipal facility. BMPs listed within each City Facilities O&M Plans that are intended to reduce or eliminate stormwater exposure of oil, grease, pesticides, herbicides, fertilizers, sediment, and other materials used by the City. Each of the City facilities is inspected annually and any issues are noted, written into the Facility O&M Plan, and discussed with the facility supervisor.

Commented [JSJ156]: Pollution Prevention and Good Housekeeping is a proper noun.

Municipal staff with the greatest exposure to stormwater are trained on Pollution Prevention and Good Housekeeping (PPGH) on a regular basis. The training is typically combined with illicit discharge detection and elimination training. The PPGH portion of the training concentrates on good housekeeping functions. This often includes identification of bad habits that can take place and how to fix the situation to reduce the risk of pollution to stormwater.

The Cities of Burlington and Graham both conduct street sweeping operations on a regular basis of curb and gutter streets. City of Burlington also performs quarterly catch basin and inlet grate cleaning throughout the City. This includes City and NCDOT streets within the Cities jurisdictions.

5.1.1.8 Collection System Improvements

The Cities of Burlington and Graham both have aging Collection Systems that have experienced several Sanitary Sewer Overflows in the Little Alamance Watershed within recent memory. While considerable effort is made to maintain the Collection Systems, aging collection systems of brick manholes and vitrified clay pipe has significant infiltration and inflow issues. Additionally, if water can get into the collection system (I/I) then it can get out of the collection system via exfiltration.

Commented [MBF157]: "the past few years"?

Both municipalities have worked to rehabilitate portions of the Collection System recently. The City of Graham sliplined x' within the watershed in 2009-2010 as part of a larger ARRA/Stimulus funded project that rehabilitated x' through sliplining throughout the City. During the ARRA project the City tried to concentrate on outfall lines and did not rehabilitate any manholes within the project. Immediately after the project, the City saw an increase in flows due to a reduction in exfiltration.

Commented [JSJ158]: Sewer outfall lines run along streams.

The City of Burlington has an annual contract with Insituform, Inc. and has sliplined x' within the last x years. The City has seen x benefit. MORE FROM COB.

Commented [MBF159]: If there isn't much more to add to this paragraph, consider merging with the previous paragraph.

5.1.2 Jordan Lake Rules

The Little Alamance Creek watershed is within the Jordan Lake Watershed and all of the project partners are subject to the Jordan Lake Nutrient Strategy. The Jordan Lake Nutrient Strategy is composed of a set of regulatory rules enacted in 2009 that have since been augmented or replaced by a series of NC General Assembly Session Laws. The Jordan Lake Nutrient Strategy is often referred to as the Jordan Lake Rules.

Jordan Lake has had water quality issues from its creation, with the North Carolina Environmental Management Commission declaring it as nutrient-sensitive waters (NSW) the same year it was impounded. Since that time, the lake has consistently rated as eutrophic or hyper-eutrophic, with excessive levels of nutrients present. "Eutrophic" is an over-abundance of nutrients in the lake, primarily nitrogen and phosphorus, which can result in algal blooms and poor water quality. Nutrients make their way to the lake from sources such as wastewater discharges, rainfall runoff from agriculture and stormwater runoff from new and existing developed lands throughout the watershed. Excessive nutrient inputs can drive excessive growth of microscopic algae, which imparts a greenish, murky appearance to the water, causes taste and odor problems in potable water, and consumes dissolved oxygen. Insufficient oxygen levels can then stress or kill fish and other aquatic life. Excess nutrients also favor the growth of undesirable algae that does not support the food chain and can release toxins into the water. While not necessarily making the lake unfit for fishing, swimming, or drinking uses, excessive nutrients can impact these uses and produce undesirable algae in the lake.

The Jordan Lake Rules are designed to protect and improve water quality in the lake. The rules were developed over several years through a process that involved extensive meetings, public hearings, and negotiations between residents, environmental groups, local and state government agencies, and other stakeholders in the watershed. Specific issues addressed by the rules include reducing pollution from wastewater discharges, stormwater runoff from new and existing development, agriculture, and fertilizer application.

The primary rules that affect local governments (like the Cities of Burlington and Graham) are the Stormwater Management for New Development, Stormwater Management for Existing Development, Protection of Existing Riparian Buffers, Wastewater Discharge Requirements, Options for Offsetting

Nutrients Loads, Session Law 2009-216, Session Law 2009-484, Session Law 2011-394, and to a lesser extent the Fertilizer Management Rule. Some of these rules as well as the rule regulating the State and Federal Entities also applies to NCDOT.

The Protection of Existing Riparian Buffer Rules was implemented in 2011 after the Stage 1 Existing Development Programs were adopted in 2009 and Waste Water Treatment Plant compliance with Total Phosphorous limitations by January 1, 2010.

The New Development Programs, Stage 2 Existing Development Program, and Wastewater Treatment Plant Compliance with Total Nitrogen Limitations were all delayed for three years. This establishes the following compliance timeframes for these rules:

- New Development Programs – August 2017
- Stage 2 Existing Development Programs – 2017 for the Upper New Hope Creek Watershed (Durham), 2020 for the Haw River Watershed
- Wastewater Treatment Total Nitrogen Limits – 2019 (unless enacted with 2016 Permit Renewals)

Additionally, Session Bill 2013-395 created a study to determine if "mechanical circulation" within Jordan Lake could reduce algal growth within the lake. This study will be completed by NDENR and Medora Corporation for $1.44 million and will include the leasing of 36 Solar Bee Circulators. The Solar Bee's, similar to the ones in the Graham-Mebane Lake, are a relatively new technology and the outcome of the study is unknown at this point.

Commented [BAJ160]: Good info but may not be directly relevant to the 4b.

Commented [JSJ161]: Probably true and could confuse the issue.

The Jordan Lake nutrient management Rule for state and federal entities (15A NCAC 02B .0271) requires NCDOT to develop and implement Programs for new development and existing development activities. NCDOT's new development program for compliance with the Jordan Lake nutrient management rules was approved by the North Carolina Environmental Management Commission (EMC) on November 8, 2012 (NCDOT, 2012). Implementation of the program, referred to as the Jordan Lake Guided Reduction of Excess Environmental Nutrients (or GREEN) Program began in January 2013. The GREEN program was initiated by NCDOT to integrate and enhance NCDOT's stormwater and nutrient management practices and to support compliance with the Jordan Lake Rules. NCDOT's timeline for compliance with the State and Federal Entities' rule is as follows:

- Riparian buffer protection – August 2009
- Fertilizer application training – August 2012
- New road and non-road development program – January 2013
- Existing road and non-road development program – March 2017

5.1.2.1 Stream Buffers

All of the project partners have Riparian Buffer Protection Programs that were implemented as part of the Jordan Lake Rules. For the Cities, the enforcement mechanism for the Buffer Protection Program is the Jordan Riparian Buffer Protection Ordinance that was approved in late 2010. The Buffer Programs establish a protected buffer along surface waters (primarily perennial and intermittent streams but also ponds and other surface waters) shown on the USGS Quadmaps or the NRCS Soil Survey Maps. The buffer has two different zones: Zone 1 is the closest 30' from the top of bank in all directions; Zone 2 is from 30' to 50' from the top of bank in all directions (Figure 5-4). Zone 1 is to remain undisturbed while

Zone 2 is to remain vegetated. The Cities includes Riparian Buffer Protection Program training with their employee training.

Commented [MBF162]: Should we specify which department/division receives this training?

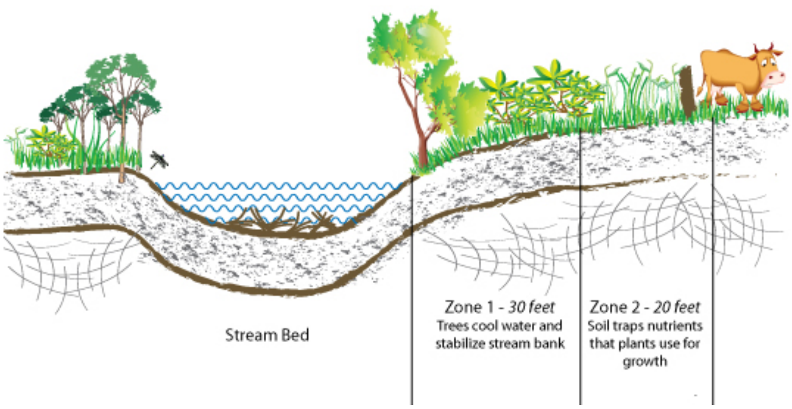

Figure 5-4. Illustration of the Buffer Protection Program zones (CITE IMAGE)

5.1.2.2 Stage 1 Existing Development Programs

The Jordan Lake Rules require all local governments within the watershed to establish programs similar to the NPDES Phase II programs and to conduct retrofit opportunity studies. Since the Cities of Burlington and Graham were already NPDES Phase II communities they only had to complete the retrofit opportunity studies. These retrofit programs are intended to provide a framework for identifying retrofit opportunities to reduce nutrient loading within the Jordan Lake Watershed. The program is intended to identify both structural and non-structural retrofits that seek to reduce pollution and nutrients from being carried downstream by stormwater runoff. By either controlling stormwater runoff or reducing the pollution in the runoff, stormwater retrofits reduce downstream pollution in streams, rivers, and lakes. Both Burlington and Graham have set up their programs to favor potential projects within the Little Alamance Creek watershed. These specific projects will be discussed during the implementation section.

5.1.2.3 State and Federal Entities Rule

Commented [BAJ163]: Move text from 5.1.2 here? Or, maybe delete this subsection.

5.1.3 Structural Practices

5.1.3.1 Stream Restoration

Stream restoration of Little Alamance Creek and unnamed tributary located in Burlington's City Park was completed in April 2012. Prior to restoration activities, the majority of the site was experiencing severe bank erosion. Bank erosion caused the stream to become overly wide in some sections and mid-channel bars had developed because the stream did not have the capacity to transport sediment through these reaches. The channel was exhibiting high bank heights, shallow rooting depths, and low rooting densities (a function of the lack of woody vegetation). An estimated 694 tons of sediment per year were being contributed by this segment of Little Alamance Creek, with the unnamed tributary contributing an additional 55 tons of sediment per year.

The 2,633 feet of Stream Enhancement I (NCEEP project ID 92372) was designed by ARCADIS G&M of North Carolina, Inc and provides improvement to water quality, flood attenuation, and aquatic habitat (Figure 5-5). In addition, the project qualifies for compensatory mitigation credit for unavoidable impacts to streams and riparian buffers in Cape Fear River Basin. The project is currently in a five-year monitoring phase. Specific project improvements as reported in NCEEP's Project Summary include:

Commented [PB164]: It was mostly enhancement. There was less than 200 feet of restoration.

- Reducing non-point sources of pollution associated with historic lawn maintenance in the park area by providing a vegetative buffer adjacent to Little Alamance Creek and its unnamed tributary and the installation of stormwater best management practices (BMPs) to treat surface runoff (the riparian buffer will remain in a state-owned conservation easement in perpetuity)
- Reducing sedimentation on-site and in downstream receiving waters through a reduction of bank erosion associated with current vegetation maintenance practices and through providing afforested vegetative buffer adjacent to Little Alamance Creek and its tributary
- Reestablishing stream stability and the capacity to transport watershed flows and sediment loads by restoring stable dimension, pattern, and profile
- Promoting floodwater attenuation through increased flood storage capacity by construction of bankfull benches along Little Alamance Creek and its tributary
- Improving aquatic habitat by enhancing streambed variability

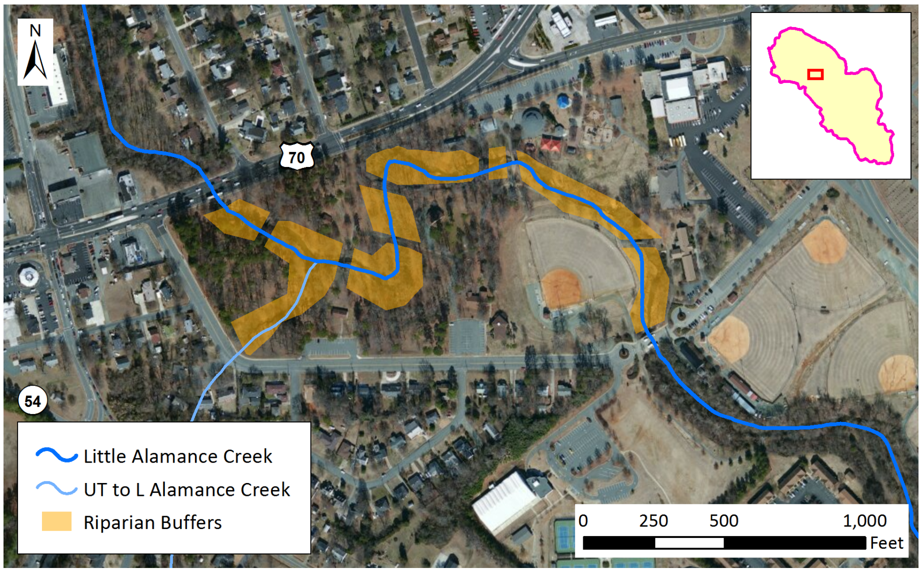

Figure 5-5. NCEEP stream restoration project in Burlington, NC

This project opportunity was identified through NCEEP's Local Watershed Plan (LWP) for Travis, Tickle and Little Alamance Creek. There remain a handful of similar stream restoration/enhancement and stormwater BMP retrofit opportunities identified in the LWP. This project serves as a model for future implementation of similar projects.

5.1.3.2 Retrofits

The City of Burlington approved the design and construction of bioretention area at the Burlington Aquatic Center located at David L. Maynard, Sr. Aquatic Center in 2012. The bioretention area collects and treats 2.2 acres of runoff from a multi-recreational use facility that was previously being conveyed along an eroding ditch. The bioretention area is also located downstream of the Kernodle Center cistern thereby increasing its in-series BMP efficiency. The project was funded by stormwater utility fees.

Commented [MBF165]: Delete address?

A bioretention retrofit was identified by Alley, Williams, Carmen & King, Inc as part of their Retrofit BMP Selection Study for the City of Burlington. The study was principally performed to identify BMP retrofit opportunities for impaired watersheds and to support compliance with the Jordan Lake Nutrient Management Strategy. The study identified and prioritized another 18 locations. The bioretention area at the Aquatic Center serves as model for other potential retrofit opportunities.

Commented [MBF166]: Does this paragraph belong in Section 5.2.2?

5.2 Potential Pollution Controls

5.2.1 Non-Structural Practices

Table 5-1 lists various non-structural BMPs that correspond with the EPA's six minimum required elements for Category 4b demonstrations.

Table 5-1. Potential non-structural BMPs and their corresponding EPA-required element

EPA-required Element	Potential Non-structural BMPs
1. Public Education and Outreach	• Ongoing NCDOT's Swat-a-Litterbug program • Relevant stormwater-related presentations to members of the stormwater and ecological industry
2. Public Involvement and Participation	• Annual stream cleanup events • Ongoing Adopt-a-Highway program participation • Ongoing NCDOT Litter Sweep program • Annual Tarp Day program • New/updated stormwater-related city/NCDOT websites to mention? • Ongoing stormwater research with NC State University and other universities
3. Illicit Discharge Detection and Elimination (IDDE)	• Annual/regular updates to IDDE databases, as needed • Increased upkeep of municipal drainage structures • Ongoing efforts toward NCDOT's encroachment program
4. Construction Site Runoff Controls	• Ongoing employee training/certification of applicable sediment and erosion control regulations? • Ongoing/improved tracking of sediment and erosion violations?
5. Post-construction Site Runoff Controls	• Explore cost sharing options with various stakeholders for future structural BMPs • Ongoing inspection and maintenance program of existing structural BMPs • See Section 5.2.2 for additional structural BMP information
6. Pollution Prevention and Good Housekeeping for Municipal Operations	• Ongoing nutrient management programs for employees and sub-contractors • Ongoing efforts of facility-specific Stormwater Pollution Prevention Plan (SPPP)

Commented [MBF167]: Burlington/Graham/NCDOT: Please add/delete/edit/confirm items in this table, as needed. I entered some items from NCDOT's annual report with the assumption that various events would continue in the future. If any event was a 1-time thing, please delete.

Commented [MBF168]: Confirm that there are AAH segments in the watershed.

Commented [MBF169]: This program may be labeled differently for Burlington and Graham?

5.2.1.1 Fertilizer Management

All commercial fertilizer applicators in the Jordan Lake Watershed are required to be certified in nutrient application, but the local municipalities are not involved in promoting or regulating applicators. The Cities of Burlington and Graham could begin promoting that applicators need to do be certified and recording which applicators are certified. NCDOT staff and contractors who apply fertilizers on highway rights of way receive training on fertilizer management and nutrient application decisions through

NCSU's "Nutrient Management Training: Jordan Lake Watershed"[1] online course. In addition to this training, NCDOT partners with the North Carolina Department of Agriculture and Consumer Services (NCDA&CS) to analyze soil samples and provide recommendations on fertilizer composition and application rates.

5.2.1.2 Increased Upkeep of Drainage Structures

The MS4 within the Little Alamance Creek watershed is aging just as the collection system is aging. While the aging collection system is a larger issue, an aging MS4 can be a source of pollution through erosion, sedimentation, and leaves or debris that would not normally reach streams. Repairing issues within the MS4 could reduce erosion and other sources of pollution within the watershed.

5.2.1.3 Cost Sharing of Potential Improvements

The Cities of Burlington and Graham, as are most communities, have been approached by citizens wanting to solve minor flooding or storm drainage issues. These issues are generally on private property but with some connection to public property. The City has investigated these issues in the past and if an amenable solution was present then the City may have been involved in the solution. In the future, the Cities could include prioritization and perhaps additional funding for projects that promote green infrastructure or provide non-point source pollution reduction as part of the overall improvement. This could be through additional matching funds from a City to incentivize projects or through prioritization of projects.

5.2.1.4 Gross Solids Removal Research Project

Awaiting information from NCSU

5.2.1.5 Nutrient Management Education

5.2.2 Structural Practices

Structural BMPs are used to control and treat stormwater runoff. These controls often include stormwater retention, detention, and treatment devices that mitigate altered hydrologic and pollutant loadings that are typically associated with land disturbance and development. Structural BMPs can provide hydrologic and hydraulic benefits by reducing runoff volume, increasing ground water recharge, reducing the peak flow and duration of high stream flows, and reducing stream velocities. While many of these hydrologic benefits will directly benefit water quality, many structural BMPs provide additional water quality benefits through additional treatment and pollutant removal mechanisms (Table 5-2). For most structural BMPs, the removal mechanism involves sequestering the pollutant within the BMP (typically bound to the soil or within vegetation) or completely removing it from the aquatic environment. For example, sediment-bound phosphorus may be trapped within a forebay BMP and prevented from entering the receiving waterbody, whereas water-soluble nitrate (NO_3) may be transformed into nitrogen gas (N_2) and enter the atmosphere.

Certain pollutants are more efficiently removed using different removal mechanisms. Suspended solids can be removed through sedimentation or filtration. Nitrogen loadings may be reduced through plant

[1] Online at http://go.ncsu.edu/JordanLakeTraining

Commented [MBF170]: Should there be additional language here about continuing the efforts of the past ARRA sliplining project to capture more feet of pipe and to focus on aging manholes that were not prioritized during the ARRA project discussed in Section 5.1.1.8?

Commented [JSJ171]: MS4 is a Municipal Separate Storm Sewer System. It is the entire system. Drainage Structures are a part of the system.

MBF: Good point. I had gotten used to using "MS4" as shorthand (in another project) when referring to the MS4 permittee (i.e., jurisdiction), and not the system itself.

Commented [MBF172]: May be helpful to clarify who's initial funds the city is proposing to match?

Commented [MBF173]: I do not know if there is enough meaningful text to be inserted under every BMP sub-heading in Section 5.2.2.

Deleted: ¶

Commented [MBF174]: Paragraphs and table moved from Section 5.0.

uptake or be transformed into nitrogen gas (N_2) via denitrification. Metals including copper, lead, and zinc are efficiently removed through sorption onto organic matter such as mulch (Davis et al., 2001) or peat (Chen et al., 1990). Hydrocarbons such as oil and grease are efficiently sorbed onto mulch and subsequently biodegraded (i.e., removed from the environment) by microbes (Hong et al., 2006). A reduction in thermal pollution has been documented in filtration BMPs (Jones and Hunt, 2009; DiGennario, 2008). Variable success has been shown in reducing pathogen loadings with structural BMPs (Sullivan et al., 2006; Hathaway et al., 2009). Because of the variable removal rate, a combination of treatment and source-reduction measures for pathogens is typically recommended.

Commented [JSJ175]: This paragraph is very technical. Can it be simplified?

Structural BMPs may be incorporated into new development or retrofitted into an existing development. Selecting the appropriate BMP type depends largely on site-specific criteria such as drainage area, topography, soil characteristics, water table elevation, and pollutant(s) of concern. After the type of BMP has been selected, the previously mentioned location-specific criteria are used to customize the control measure for the given site. Often, a structural BMP is actually an assembly of multiple BMPs working in sequence to maximize pollutant reduction. For example, a level spreader may include a forebay, a vegetated buffer, a forested buffer, and a bypass swale, in addition to the actual level spreader component.

Table 5-2. Select structural BMPs and their pollutant removal mechanism (adapted from NCDOT, 2013)

Sructural BMP	Description	Infiltration	Filtration	Detention	Sedimentation	Sorption	Microbial-mediated transformation	Biological uptake	Pollution Prevention	Energy dissipation
Bioretention Basin	A type of media filter with a shallow basin, engineered media, an underdrain system, and landscaped vegetation.		X			X	X	X		
Dry Detention Basin	A shallow, dry basin with an outlet pipe or orifice near the invert of the basin.			X	X	X				
Filter Strip	A linear section of land, either grassed or forested, that physically filters and infiltrates stormwater.	X	X			X		X		
Filtration Basin	A type of media filter with a shallow basin, engineered media, and an underdrain system.		X			X	X	X		
Forebay	A small basin located upstream of another BMP.			X	X					
Hazardous Spill Basin	A shallow basin with an outlet control structure that can trap all flow that enters the basin.								X	
Infiltration Basin	A shallow basin in permeable soils that detains and infiltrates stormwater runoff.	X				X				
Level Spreader	A trough and level lip used to redistribute concentrated stormwater as diffuse flow. Typically combined in a system with a filter strip.	X								X
Riparian Buffers	A defined width of protected or restored land—wooded or not—adjacent to both sides of a streambank.		X				X	X		X
Preformed Scour Hole	A riprap-lined basin formed at the outlet of a pipe with a diameter less than or equal to 18 inches.	X								X
Stormwater Wetland	An engineered marsh or swamp with dense wetland vegetation.			X	X	X	X	X		
Stream Restoration	The re-establishment of the self-sustaining functions of a stream through channel modification and re-alignment.				X		X			X
Swale	A broad and shallow channel with dense vegetation.	X	X		X		X			
Wet Detention Basin	A shallow basin that maintains a permanent pool of water by using an elevated outlet control structure.			X	X		X	X		

Commented [JSJ176]: Is this the simplest explanation? If so it needs a definition.

Table 5-3 lists various structural BMPs and the impairment(s) they have the potential to address.

Table 5-3. Select structural BMPs and the type of stressors they may address†

	Hydro modification	Insufficient Riparian Buffer	Streambank Erosion	Pollutants in Stormwater Runoff	Degradation of Instream Habitat
Bioretention Basin	•				
Dry Detention Basin	•				
Filter Strip	•	•			
Filtration Basin	•				
Forebay					
Hazardous Spill Basin	•				
Infiltration Basin	•				
Level Spreader	•				
Preformed Scour Hole					
Stormwater Wetland	•				
Swale	•				
Wet Detention Basin	•				
Riparian Buffer Restoration		•			•
Stream Restoration			•		•
Elimination of Illicit Discharges and Dumps				•	
Pond Retrofits	•		•		

● = High ◒ = Medium ○ = Low "-" = None

† Benefits of any structural BMPs depend upon site-specific criteria such as location relative to the receiving waterbody, topography, soil characteristics, water table elevation, and influent pollutants. [EDIT DISCLAMER? subject to change?, not all inclusive?]

5.2.2.1 Stream Stabilization and Restoration

Stream walks were conducted in targeted subwatersheds throughout Little Alamance Creek watershed as part of the NCEEP LATT report (NCEEP, 2007). Over 18 miles or roughly 77% of Little Alamance Creek and its tributaries were assessed. During the stream walks, 156 Best Management Practice project opportunities were identified of which there were 24 instances for riparian buffer enhancement or restoration. This was the second-most recommended strategy throughout the watershed as a result of these stream walks and another reinforcing indicator of the impact to riparian condition within the watershed.

5.2.2.2 Dry Detention Basins

Stuff.

5.2.2.3 Backyard Rain Gardens

Stuff.

Commented [MBF177]: Non-structural

Commented [JSJ178]: Shouldn't all of these items reduce pollutants in stormwater runoff? Shouldn't anything that potentially reduce flow help streambank erosion and degradation of instream habitat.

Commented [MBF179]: Table to be updated with new symbology.

Commented [MBF180]: Paragraphed was moved from Section 3.5. Please adjust/delete text as needed, now that it is located in the "Potential Pollution Controls" Section.

Commented [BAJ181]: Any potential concern that the recommendation biases streams?

Commented [JSJ182]: I think this entire paragraph should be cited as the EEP study's results.

Commented [PB183]: I am not sure I follow your question Brian but we could possibly do without this section here and move it to the pollution controls section as a possible management strategy.

Commented [MBF184]: I do not know if there is enough meaningful text to be inserted under every BMP sub-heading in Section 5.2.2. Also, after 60 pages, the reader has likely stopped reading and is now skimming.

Therefore, we could delete these items and add them into the above table, if not already accounted for.

Items where there is something meaningful to say (like numbers from the LATT report on stream stabilization) can still be added here.

Commented [MBF185]: Delete?

5.2.2.4 Bio-Retention Basins

Stuff.

5.2.2.5 Enhanced Buffers on City Properties

Stuff.

5.2.2.6 Buffer Enhancement/Restoration (Buffer Buyback)

Stuff.

5.2.2.7 In Stream Structures

Stuff.

5.2.2.8 Stormwater Wetlands

Stuff.

5.2.2.9 Existing Pond and Lake Controls Retrofits

Stuff.

Commented [MBF186]: Delete?

Commented [MBF187]: Non-structural. Add to Table 13?

Commented [MBF188]: Non-structural. Add to Table 13?

Commented [MBF189]: Delete?

Commented [MBF190]: Delete?

Commented [MBF191]: "Existing" discussion belongs in Section 5.1.

Commented [MBF192]: Delete?

6.0 Implementation

[List/discuss specific objectives (preferably in terms of a quantifiable metric) for this 4b project, relating them back to overall stream health?]

Table 6-1 connects potential structural and non-structural BMPs to measurable outcome-based objectives for the Little Alamance Creek 4b project.

Table 6-1. Select BMPs and the specified objective they help meet†

BMP	Stream Aesthetics	Riparian Buffer	Secondary Recreation	Stream-bank Stability	Physico-chemical Parameters	Biological Parameters
Bioretention Basin						
Dry Detention Basin						
Filter Strip						
Filtration Basin						
Forebay						
Hazardous Spill Basin						
Infiltration Basin						
Level Spreader						
Preformed Scour Hole						
Stormwater Wetland						
Swale						
Wet Detention Basin						
Riparian Buffer Restoration		●				
Stream Restoration				●		
Elimination of Illicit Discharges and Dumps	●					
Pond Retrofits						

● = High ◒ = Medium ○ = Low "-" = None

† Benefits of any structural BMPs depend upon site-specific criteria [match disclaimer to previous table's disclaimer]

6.1 Phased Approach/Target Area

6.2 Schedule

Commented [MBF193]: Thoughts on the usefulness of this table? Any BMP listed here should be an actual option, since this is Section 6.

Commented [MBF194]: "goal"? "outcome-based objective"?

Commented [BAJ195]: could be useful for annual reporting

Commented [MBF200]: Need to define a specific list of parameters, e.g., DO, Cu, TSS, etc.

Commented [MBF196]: Gross solids (i.e., trash). Metrics could be miles of adopt-a-highway, number of stream cleanup events, bags of trash filled, or tons of trash collected.

Other items besides gross solids?

Commented [MBF197]: Could be a relative metric where Jan 2014 is the baseline, and we only track "buffers added/expanded".

Could measure the feet of cow fencing added, if this is a concern in the watershed.

Commented [MBF198]: Fecal coliform. Other metrics?

Commented [MBF199]: BEHI? Tons/yr of sediment erosion? BEHI requires field visits; tons/yr value could be calculated via field visits (http://water.epa.gov/scitech/datait/tools/warsss/upload/2005_08_31_watershed_tools_warsss_pla_9st01tabV15.pdf) or from models.

Does NCDENR have a BEHI or Near Bank Stress worksheet? If not, EPA/WARSSS has multiple pdf worksheets (http://water.epa.gov/scitech/datait/tools/warsss/figures.cfm#work).

Commented [MBF201]: Table to be updated with new symbology.

7.0 Monitoring Plan to Track Effectiveness of Pollution Controls

8.0 Future Revisions Based on Monitoring Outcomes

9.0 Summary and Conclusions

10.0 Acknowledgements

FINAL edits: search for consistent use on:

- Little Alamance Creek, watershed or Watershed
- nonpoint and non-point
- instream or in-stream
- point-source and point source
- site and Site
- two periods or one period between sentences
-

References

DeVane, Boyd. Undated. History of Wastewater Permitting in North Carolina. PowerPoint presentation by Boyd DeVane. Raleigh, NC: North Carolina Department of Environment and Natural Resources.

Dickinson, Patricia S. 1987. Bellemont Mill Village Historic District, Alamance County, N.C. Washington, D.C.: National Park Service, National Register of Historic Places nomination document.

Euliss, Elinor Samons, ed. 1984. Alamance County: The Legacy of Its People and Places. Greensboro, N.C.: Legacy Publications.

Holm, Hannah. 2000. The Evolution of State Initiatives in North Carolina. Popular Government. Fall, 21.

Howells, David H. 1989. Historical Account of Public Water Supplies in North Carolina. Raleigh: The Water Resources Research Institute of the University of North Carolina.

Howells, David H. 1990. Quest for Clean Streams in North Carolina: An Historical Account of Stream Pollution Control in in North Carolina. Raleigh: The Water Resources Research Institute of the University of North Carolina.

Lounsbury, Carl. 1980. Alamance County Architectural Heritage. Graham, N.C.: Alamance County Historical Properties Commission.

NCDENR, 2007. Surface Water and Wetlands Standards. 15A NCAC 02B. Raleigh, NC: North Carolina Office of Administrative Hearings. [online at: http://h2o.enr.state.nc.us/admin/rules/codes_statutes.htm]

NCDENR, 2014. Watershed Assessment and Restoration Program (WARP) Project File Archive. [Accessed January 16, 2014 online at: http://portal.ncdenr.org/web/wq/swp/ws/pdu/wat/warp]

North Carolina Cooperative Extension Service. Undated. Economic Impacts of the Water Supply Watershed Protection Act. Raleigh: North Carolina Cooperative Extension Service.

Spoon, William L. 1893. Map of Alamance County, North Carolina. Cleveland, Ohio: H.B. Stranahan & Co., Engravers.

Stockard, Sallie Walker. 1900. The History of Alamance. Raleigh. N.C.: Capitol Printing Company.

Sweet, David G. Undated. Indigo in World History: Production, Distribution & Consumption: 1-16.

The Burlington Daily Times-News. 1950. 6 December.

The Burlington Daily Times-News. 1951. 27 April.

The Burlington Daily Times-News. 1962. 11 January.

The Burlington Daily Times-News. 1962.17 January.

Troxler, Carole Watterson. 2000. East-west Pattern of the Trading Path Network in Alamance County. Alamance County Historical Association. http://facstaff.elon.edu/troxlerc/alacotp.htm (accessed December 16, 2013).

Troxler, George W. 2006. Company Shops. NCPEDIA.http://ncpedia.org/company-shops (accessed December 20, 2013).

EPA, 2013. A long-term vision for assessment, restoration, and protection under the Clean Water Act Section 303(d) program. [Accessed January 16, 2014 online at: http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/upload/vision_303d_program_dec_2013.pdf]

Vacca, Michele, and Benjamin Briggs. Undated. History of Alamance County 1670-1945.Alamance County Architectural Survey Update.http://www.hpo.ncdcr.gov/surveyreports/AlamanceCountySurveyUpdate(Historic%20Contexts)-2002.pdf (accessed December 16, 2013).

Vincent, William Murray. 2009. Historic Alamance County: A Biographical History. San Antonio, Texas: Historical Publishing Network.

Whitaker, Walter. 1949. Centennial History of Alamance County, 1849-1949. Durham: The Seeman Printery, Inc.

Wikipedia. 2013. Mordant. Wikipedia Foundation, Inc., http://en.wikipedia.org/wiki/Mordant (accessed January 3, 2014).

NCDWR, 2013. 2012 North Carolina Integrated Report. North Carolina Department of Environment.

Arcadis G&M of North Carolina, Inc., 2008. Little Alamance Creek Stream Restoration, Alamance County, State Construction Office Project Number: D07050S, Final Restoration Plan, for NCDENR, Ecosystem Enhancement Program, January 2008.

Elon University, 2010. Little Alamance Restoration Alliance Meeting - Slide Presentation and Land Cover Summary Statistics, Elon University Department of Environmental Studies, June 2010.

EPA STORET Database, [Accessed June 6, 2013 online at: http://www.epa.gov/storet/].

Giddings, E.M., *et al*., 2007. Selected Physical, Chemical, and Biological Data for 30 Urbanizing Streams in the North Carolina Piedmont Ecoregion, 2002–2003: U.S. Geological Survey Data Series 279, [online at: http://pubs.water.usgs.gov/ds279]

NCDENR DWQ, 1996. Cape Fear River Basinwide Water Quality Plan, October 1996.

NCDENR DWQ, 2000. Cape Fear River Basinwide Water Quality Plan, July 2000.

NCDENR DWQ, 2005. Cape Fear River Basinwide Water Quality Plan, October 2005.

NCDENR DWQ, 2006. Draft Summary of Existing Water Quality Data for Little Alamance, Travis, and Tickle Creek, September 2006.

NCDENR DWQ, 2007. Evaluation of Water Quality, Habitat, and Stream Biology in the Little Alamance, Tickle, and Travis Creek Watersheds, Draft Final Report, February 2008.

NCDENR DWQ, 2009. Cape Fear River Basin – 2009 Biological Assessments [online at: http://portal.ncdenr.org/web/wq/ess/reports]

NCDENR DWQ, 2010. Total Maximum Daily Load to Address Impaired Biological Integrity in the Little Alamance Creek Watershed, Alamance County, Cape Fear River Basin, Draft, December 2010.

NCDENR DWQ, 2011. North Carolina's Division of Water Quality Category 4b Demonstration Guidance. Draft. December 2011. [online at: http://portal.ncdenr.org/web/wq/ps/mtu/alternatives]

NCDENR DWQ, 2012. 2012 North Carolina Integrated Report. Approved by the United States Environmental Protection Agency on August 10, 2012. [online at : http://portal.ncdenr.org/c/document_library/get_file?uuid=9d45b3b4-d066-4619-82e6-ea8ea0e01930&groupId=38364, http://portal.ncdenr.org/web/wq/ps/mtu/assessment]

NC Natural Heritage Program, [Accessed July 9, 2013 online at: http://www.ncnhp.org/]

PTCOG, 2007. Little Alamance, Travis, and Tickle Creek Watershed Characterization Phase I, Final Report for NCDENR NCEEP, March 2007.

PTCOG, 2008. Little Alamance, Travis, and Tickle Creek Watersheds Assessment: An Ecosystem Enhancement Program Funded Local Watershed Plan Phase II, for NCDENR NCEEP June 2008.

PTCOG, 2008. Little Alamance, Travis, and Tickle Creek Watersheds Report and Project Atlas: An Ecosystem Enhancement Program Funded Local Watershed Plan Phase III, for NCDENR NCEEP, November2008.

State Climate Office of North Carolina, [Accessed June 8, 2013 online at: http://www.nc-climate.ncsu.edu/]

US Fish and Wildlife Service, [Accessed July 9, 2013 online at: http://www.fws.gov/wetlands/Data/State-Downloads.html]

NCDMAC (North Carolina Drought Management Advisory Council). 2013
http://www.ncdrought.org/archive/index.php.

NCDENR. 2013. Erosion and Sediment Control Planning and Design Manual.
http://portal.ncdenr.org/web/lr/publications.

NCDENR. 2007. North Carolina Division of Water Quality Stormwater Best Management Practices Manual.

Appendix A:
Letters of Commitment to Category 4b Demonstration in Little Alamance Creek

This page intentionally left blank

Appendix B:

Commented [MBF202]: This was originally intended to be the Data Inventory document. However, NCDENR has already published it online (http://portal.ncdenr.org/c/document_library/get_file?uuid=797c97ab-cba5-4d94-b153-416b7f5c6f23&groupId=38364), so perhaps we should delete this appendix?

This page intentionally left blank