Robeson Creek Watershed Restoration Plan

Robeson Creek
WATERSHED

Table of Contents

Table of Figures....iii
Table of Tables....iv
Acknowledgements....v

1 Introduction 1
1.1 Overview of Watershed Improvement Efforts....2
1.2 Watershed Characterization....4
1.3 Current and Former Projects within the Robeson Creek Watershed....8
1.3.1 TMDL Implementation Plan and Watershed Assessment (NCSU 2002-2004)....8
1.3.2 DWQ Benthic Reports (February and November 2001, and June 2009)....9
1.3.3 Robeson Creek NPS Restoration Watershed Project (NCSU 2003-2006)....11
1.3.4 Robeson Creek Visual Assessment (HRA 2004)....12
1.3.5 Robeson Creek Watershed Restoration Project (NCSU 2007-2011)....12
1.3.6 Town Lake Study and Restoration (NCSU 2007-2012)....14
1.3.7 Robeson Creek Water Quality Outreach Initiative (NCSU 2009-2012)....17
1.3.8 SWP and AP: Robeson Creek Status Report (Raleigh Regional Office 2008)....19
1.3.9 Southwest Shores of Jordan Lake (TLC and RCWC 2008)....20

2 Causes of Impairment and Pollutant Sources 22
2.1 Identification of Pollutant Sources for Total Phosphorus....23
2.2 Identification of Pollutant Sources for Biological Impairment....26

3 NPS Management Measures, Load Reduction Estimates and Critical Areas....28
3.1 Robeson Creek Total Phosphorus Reductions....28
3.2 Jordan Lake Nutrient Management Strategy....29
3.3 NPS management measures previously implemented....31
3.4 Recommended and Planned Nonpoint Source Management Measures....34
3.5 Critical Areas....38
3.5.1 Previously studied subwatersheds....38
3.5.2 Little Creek subwatershed and Town of Pittsboro....41
3.5.3 Camp Creek subwatershed....42
3.5.4 Turkey Creek subwatershed....44
3.5.5 Hill Creek subwatershed....45
3.5.6 Southwest Shores of Jordan Lake....45

4 Estimates of Amounts of Technical and Financial Assistance Needed 47
4.1 Technical Needs....47
4.2 Financial Needs and Potential Funding Sources....47
4.2.1 Federal Government....47
4.2.2 State Government....49
4.2.3 Local municipalities....50
4.2.4 Fee funded storm water utility....50
4.2.5 New development impact fees....50

5 Information and Education Component....51

5.1 Robeson Creek Watershed Council ... *51*
5.2 Stewards Program ... *51*
5.3 NC Cooperative Extension ... *51*
5.4 Soil and Water Conservation District ... *52*
5.5 Pittsboro Stage One Stormwater program ... *52*
5.6 Haw River Assembly ... *53*

6 Schedule for implementing the NPS Management Measures ... 54

7 Management Milestones ... 55
7.1 Robeson Creek TMDL ... *55*
7.2 Important Dates from the Jordan Lake Nutrient Strategy ... *55*
7.3 Aquatic Habitat ... *56*

8 loading reduction Achievment Criteria ... 57
8.1 Robeson Creek Watershed Plan Reduction Goal for Total Phosphorus ... *57*
8.2 Robeson Creek TMDL Target for Total Phosphorus Reduction ... *57*
8.3 Jordan Lake Reduction Goal for Nitrogen ... *57*

9 monitoring component ... 58
9.1 NCSU Stormwater Monitoring Network ... *58*
9.1.1 Monitoring Plan ... 58
9.1.2 Ambient Water Quality Monitor ... 60
9.1.3 Benthic Monitoring Sites ... 61
9.2 DWQ Monitoring Data ... *62*
9.2.1 Surface Water Monitoring ... 62
9.2.2 Benthic Monitoring Data ... 64

10 Next Steps ... 66

11 Literature Cited ... 67

Table of Figures

Figure 1. Robeson Creek watershed location. 5
Figure 2. Robeson Creek watershed land use map. 7
Figure 3. Robeson Creek watershed land use graph. 8
Figure 4. NCSU water quality monitoring sites. 9
Figure 5. Installation of BMPs. 12
Figure 6. BMPs installed in Robeson Creek watershed. 13
Figure 7. 2007 Stewards Award recipients. 13
Figure 8. Parrot Feather along Town Lake Shores. 14
Figure 9. Town Lake passive restoration conceptual drawing. 16
Figure 10. Assessment locations. 21
Figure 11. Aquatic life impairment sections of Robeson Creek shown in red. 23
Figure 12. Monitoring sites including NCSU Benthic Sites 27
Figure 13. Robeson Creek subwatersheds. 38
Figure 14. DWQ monitoring stations in Robeson Creek watershed. 63

Table of Tables

Table 1. Projects within Robeson Creek watershed. 4
Table 2. Land use distribution in Robeson Creek watershed. 6
Table 3. Biotic index score. 10
Table 4. Biotic index scores for Robeson Creek. 10
Table 5. Biotic index scores for Camp and Turkey Creeks. 10
Table 6. TP loads (kg) at Robeson Creek Cove. 29
Table 7. Total mass daily load NPS allocations of TP loads (kg). 29
Table 8. BMP data for Robeson Creek. 33
Table 9. Recommended management measures. 34
Table 10. Mean values for Robeson Creek monitoring data (DWQ 2/016/02). 64

Acknowledgements

This project was made possible by many individuals, organizations, and government agencies interested in protecting the Robeson Creek watershed, and by generous funding from the Environmental Protection Agency (EPA) Section 319 National Nonpoint Source Management Program. Any success in this watershed has been due to the strength of the partnerships and efforts that have been built over a decade to improve the water quality in Robeson Creek.

Many thanks to all the members of the Robeson Creek Watershed Council which is comprised of stakeholders including landowners, businesses and local, state, and federal government representatives and agencies that meet quarterly to discuss watershed issues and determine ways to address problems. Members of this council include North Carolina State University (NCSU), Haw River Assembly (HRA), Biocenosis, Town of Pittsboro, Chatham County, Natural Resources Conservation Service, Chatham Soil and Water Conservation District (SWCD), NC Cooperative Extension-Chatham County, North Carolina Division of Water Quality (DWQ), EPA, and numerous local businesses and landowners.

Special thanks to Karen Hall (North Carolina State University Water Quality Group) and Catherine Deininger (Biocenosis LLC) for working together as co-coordinators of this watershed effort for over 11 years. Karen oversees the watershed restoration projects, coordinates management measure design and implementation and provides monitoring and technical assistance. Catherine assists in coordinating management measure design and implementation, facilitates community involvement and provides outreach and education throughout the Robeson Creek watershed.

Many thanks to: Dan Line and Jamie Blackwell (NCSU) for creating BMP designs and making sure the stormwater monitoring samples get collected; Dave Penrose (NCSU) for coming down from Hotsprings annually to make sure we get a reliable benthic collection; Christy Perrin (NCSU) for leading the effort to prepare draft Town of Pittsboro Low Impact Development Ordinance; Kris Bass (NCSU) for his engineering restoration efforts on Town Lake and other stormwater wetlands; Paul Clark (formerly of NCDENR Division of Water Quality Planning Section Nonpoint Source Unit) for being a liaison to DWQ as well as his critical assistance with regulatory fact-finding; Tony Able (EPA Region 4) for creating a bridge between the Robeson Creek Watershed Council and the EPA; and Elaine Chiosso and Cynthia Crossen (HRA) for supporting our education efforts with the schools and town officials as well as providing a ongoing volunteer monitoring program in the watershed.

Representatives from Chatham County that warrant special appreciation include: Al Cooke and Glenn Woodard (North Carolina Cooperative Extension-Chatham County) and Brenda

Williams and Amanda Sands (Chatham County SWCD) who continue to provide invaluable support in implementation, education, and landowner contact; and Fred Royal (former Chatham County Environmental Director and resident of Pittsboro) who has been a great resource for all matters relating to stormwater.

The success that has been obtained in this watershed would not have been possible without the continued support of the Town of Pittsboro staff: Bill Terry, Town Manager; David Monroe, former Planning Director; Paul Horne, Parks Planner; Stuart Bass, Planning Director; and John Poteat, Public Works Utility Director.

Landowners and residents have been invaluable resources and supporters of this project. Jane Pyle, a resident of Pittsboro, has supported this effort from the very beginning days in 2001. Kathy Zaumsil of Rural Advancement Foundation International-USA (RAFI) and also a Pittsboro resident has been a longtime supporter of water quality improvements. Philip Culpepper (Chatham Park Investors, LLC) has provided insightful and useful advice in regards to development and water quality issues.

Portions of this document were copied directly from various resource management entities to incorporate information without misrepresenting their intent.

1 INTRODUCTION

The Robeson Creek Watershed Plan is made possible by the efforts of many people dedicated to improving water quality in the Pittsboro and Chatham County areas of North Carolina. Numerous citizens, nonprofit groups, local, state, and federal agencies, universities, businesses and landowners form the Robeson Creek Watershed Council and have contributed to the Best Management Practices (BMPs), educational campaigns and workshops, and overall outreach activities to bring about awareness to this impaired creek and its tributaries. This plan aims to document past work and provide direction for future water quality improvement endeavors in this watershed.

The purpose of the Robeson Creek Watershed Plan is to plan for and work toward healthy functioning streams and water bodies while providing sustainable recreational and economic opportunities for its users.

The organization of this plan was created using the EPA's *Handbook for Developing Watershed Plans to Restore and Protect Our Water,* (EPA 841-B-08-002, March 2008). The Robeson Creek Watershed Plan is divided into 11 sections. Section 1 documents the current condition of the watershed and all the past work that has gone into restoring the Robeson Creek watershed to a healthy ecosystem. Sections 2 thru 9 addresses the EPA's 9 Key Elements for a watershed restoration plan. Section 10 provides next steps to implement this restoration plan of Robeson Creek. Section 11 lists the references used in creating this plan.

EPA's 9 Key Elements addressed in Sections 2 thru 9

Section 2: An **identification of the causes and sources** or groups of similar sources that will need to be controlled to achieve the load reductions estimated in the watershed.

Section 3: An **estimate of the load reductions** expected for the management measures and a **description of the NPS management measures** that will need to be implemented to achieve load reductions as well as to achieve other watershed goals identified in the watershed based plan.

Section 4: An **estimate of the amount of technical and financial assistance needed** associated costs and or sources and authorities that will be relied upon, to implement the plan.

Section 5: An **information/education component** that will be used to enhance public understanding of the project.

Section 6: A **schedule for implementing the NPS management measures** identified in this plan that is reasonably expeditious.

Section 7: A description of interim, **measureable milestones for determining whether NPS management measures** or other control actions are being implemented.

Section 8: A set of **criteria that can be used to determine whether loading reductions are being achieved** overtime and substantial progress is being made towards attaining water quality standards.

Section 9: A **monitoring component** to evaluate the effectiveness of the implementation efforts over time measured against the criteria established under Section 9.

1.1 Overview of Watershed Improvement Efforts

Efforts to improve water quality in Robeson Creek began in 2001 with involvement by three groups: the Town of Pittsboro; the Haw River Assembly (HRA), a local nonprofit and River Keepers program; and the North Carolina State University (NCSU) Water Quality Group (WQG), which is part of NC Cooperative Extension.

In 2001, HRA formed the Stream Stewardship Program and the Robeson Creek Steering Committee. The same year, NCSU WQG began work to perform a watershed assessment for Robeson Creek and to write a total maximum daily load (TMDL) implementation plan to compliment the 2003 TMDL submitted to EPA to address the phosphorus inputs and resulting chlorophyll *a* impairment. To facilitate NCSU efforts, the Robeson Creek Technical Advisory Committee was formed. This group and the steering committee combined efforts in 2003 to form the now Robeson Creek Watershed Council (RCWC). In 2006, the Robeson Creek watershed was designated an EPA Targeted Watershed due primarily to the active watershed partnerships. As a result, EPA has directed additional resources to the RCWC in efforts improve the watershed. Officials from EPA and the North Carolina Division of Water Quality (DWQ) have been active participants in stakeholder meetings and information sharing.

Knowledge of Robeson Creek and its watershed has been gathered primarily through stream assessment efforts. NCSU performed an entire watershed assessment of Robeson Creek and its tributaries between 2002 and 2003. During that same time periods, NCSU completed a stream assessment along the length of Little Creek, the most urban tributary of Robeson Creek. The HRA conducted visual stream assessments with landowners from 2003 to 2005 throughout the watershed. In 2010 NCSU and HRA worked together to conduct a riparian assessment of 3 miles of the main stem of Robeson Creek. Data gathered from these assessments helped with identifying sites for BMPs.

With the support of other RCWC stakeholders, NCSU has implemented raingardens, stormwater wetlands, stream buffers and other stormwater BMPs throughout the Robeson Creek watershed. When possible, installation of stormwater BMPs was completed with the help of local citizens and the Town of Pittsboro. The RCWC has held workshops for landowners, business owners, developers, and local municipality officials to educate stakeholders on the importance of water quality and what they can do to help improve it. Annual newsletters are sent out to every landowner within the watershed. NCSU hosts a website dedicated to the information dissemination of activities happening within Robeson Creek. The site can be found at: (http://www.ncsu.edu/srp/robeson.html).

In 2004, HRA compiled a list of all businesses located the watershed and conducted a survey of willing businesses on their use of stormwater BMPs. Businesses that actively protect their

local creeks through sound BMPs were recognized with the Robeson Creek Stewardship Award. This award is given annually to citizens and businesses.

In 2004 NCSU performed a feasibility study of restoring water quality within Town Lake (http://www.ncsu.edu/srp/townlakestudy.pdf). Upon completing that study, NCSU recommended that the lake be converted to a wetland and that the invasive exotic plants plaguing the lake be controlled. The Town of Pittsboro Commissioners unanimously supported the recommendation. NCSU began work in 2009 to establish aquatic weed control in the lake. In 2011, work began to restore the lake to an emergent wetland system that would help restore water quality.

In 2001, the Town of Pittsboro completed a study identifying priority areas for sewer rehabilitation within their wastewater collection system. In 2003, the Town of Pittsboro completed a number of high priority manhole repairs in the Masonic Street basin using their own funds. In 2004 and 2010 the Town obtained funds from the North Carolina Rural Economic Development Center (Rural Center) to pay for 50% of the costs to evaluate and rehabilitate the sewer lines in the Credle Street basin.

In April 2010, Pittsboro completed their Minnesota Mining & Manufacturing Company (3M) Reclaimed Water System Project. An average of 600,000 gallons a day of reuse effluent from Pittsboro's Waste Water Treatment Plant (WWTP) can now be used by 3M in their evaporative cooling process reducing the discharge of effluent into Robeson Creek and reducing 3M's need for potable water. This project resulted in the installation of 26,100 feet of an 8-inch reclaimed water main running from the Pittsboro WWTP to the 3M facility and the installation of a 500,000 gallon water tank to hold reuse water. The funding for the project came from a Clean Water Management Trust Fund (CWMTF) grant, an EPA grant, Community Development Block (CDBG) Economic Development, NC Division of Water Quality's Construction Grants and Loans Section (CG&L) - Revolving Fund Loan, and a United States Department of Agriculture (USDA) Rural Economic Development Loan and Grant (REDLG).

During January of 2011, Pittsboro completed what they called their Wet Weather Flow Improvement Project for the wastewater treatment plant (WWTP). Improvements included an offline flow equalization basin, a return activated sludge pumping station, a new programmable logic controller panel and variable frequency drive for the existing influent pumps, an equalization pumping station, a flow metering vault, and a new ultraviolet disinfection system. These improvements increased the effectiveness of the plant, especially during wet weather when Robeson Creek was threatened by possible plant overflows. Pittsboro obtained funding for this project primarily through the NC Economic Recovery Funds that were disbursed thru the NC DWQ CG&L.

A compilation of the funding obtained to support the efforts in the Robeson Creek watershed to date is provided in Table 1 with the primary funding source listed. Over nine and half million dollars have been used in the Robeson Creek watershed on projects that will result

in direct improvements in surface water quality. A more detailed description of the project work completed thus far in the Robeson Creek watershed is summarized in Section 1.3.

Year	Primary Funding Source	Recipient	Funds	Work
2000	EPA 319 Program	HRA	$10,000	Established Stream Steward program in Robeson Creek watershed
2000	EPA 319 Program	NCSU	$210,000	Stream assessment and TMDL Implementation Plan
2002	EPA 319 Program	HRA	$36,982	Visual Stream Assessment
2003	EPA 319 Program	NCSU	$300,000	BMP implementation
2003	EPA 319 Program	HRA	$32,300	Business BMP survey and award program
2003	CWMTF	NCSU	$78,000	Feasibility study for restoring Town Lake
2004	NC Rural Center	Town of Pittsboro	$200,000	Evaluate and rehabilitate sewer lines in the Credle Street basin
2007	EPA 319 Program	NCSU	$470,000	BMP implementation and ordinance review
2008	EPA 319 Program	NCSU	$40,000	Aquatic weed control in Town Lake
2009	CWMTF	NCSU	$476,000	Restore Town Lake to a wetland
2009	USDA	NCSU	$239,000	Expansion of Stream Steward program, BMP implementation, environmental education of education
2010	EPA 319 Program	NCSU	$169,386	Benthic and ambient monitoring network
2010	NC Rural Center	Town of Pittsboro	$248,000	Rehabilitate remaining sewer lines in the Credle Street basin
2010	CWMTF & DWQ CG&L	Town of Pittsboro	$4,520,000	Installation of reuse water line and 500,000 gal water tank to 3M
2010	DWQ CG&L	Town of Pittsboro	$2,634,800	Added equalization basin to the existing WWTP and completed various other maintenance projects
		Total:	**$9,664,468**	

Table 1. Projects within Robeson Creek watershed.

1.2 Watershed Characterization

The Robeson Creek watershed, located within the lower Haw River watershed (Cape Fear Subbasin 030604; HUC 03030002060030), lies within Chatham County, North Carolina and encompasses 28.6 square miles (Figure 1). Located in the Piedmont physiographic region and mostly within the Town of Pittsboro Planning District, the Robeson Creek watershed is both rural and urban.

This watershed serves as a water supply source to Jordan Lake, a major water supplier to the Triangle Area of North Carolina. According to the Cape Fear River Basinwide Water Quality Plan (October 2005), the Robeson Creek watershed is classified as water supply IV (WS-IV),

Nutrient Sensitive Waters (NSW) and drains into the Haw River arm of Jordan Lake. Impaired ratings are listed for two bodies of water in the Haw River watershed: Robeson Creek and Pittsboro Lake. A TMDL for total phosphorus was developed for Robeson Creek in 2003 as a result of chlorophyll *a* violations in the Robeson Creek cove of Jordan Lake. The TMDL calls for a 71 % reduction from urban runoff as well as from the Pittsboro WWTP. The NCSU WQG assisted DWQ by writing a TMDL Implementation Plan for Robeson Creek that was submitted in draft form to the EPA in 2003. Currently, a total of 3.3 miles of segments of Robeson Creek ([16-38-(3)a] and [16-38-(3)c]) remain on the state's impaired waters or 303(d) list for impairment of aquatic life (NC 303(d) List, 2008 and draft 2010). Habitat degradation was cited in the basinwide plan as a result of urban runoff and nutrient enrichment from a poultry processing plant sprayfield. A TMDL for aquatic impairment is pending. Segment [16-38-(5)] is part of the Robeson Creek cove of Jordan Lake and is 303(d) listed for chlorophyll *a*.

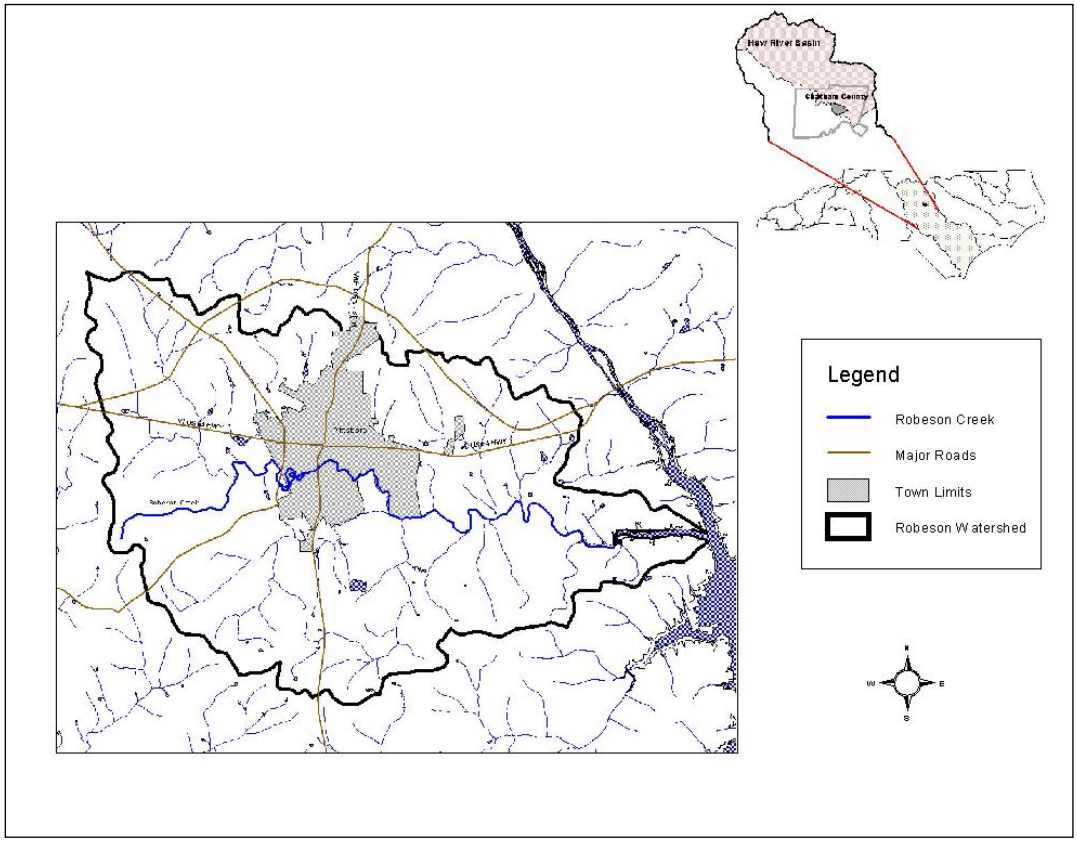

Figure 1. Robeson Creek watershed location.

During the fall and winter of 2002, NCSU performed a land use reconnaissance of the Robeson Creek watershed. Using 1997 orthophotos provided by Chatham County as base maps, NCSU personnel visually examined most of the land uses in the area either through a windshield survey or by walking into parcels. Areas that were not accessible by vehicle or foot were verified either by landowner contacts or conversations with Natural Resources Conservation Services (NRCS) and Cooperative Extension personnel. Land uses were

demarcated on the base maps and then translated into GIS format. From the GIS data, analysis was performed on various land uses throughout the watershed. These data are summarized in Table 2 and Figure 2, and shown in Figure 3.

Land Use Description	Square Miles	Percent
Unmanaged Forest	19.29	67.44
Managed Forest	1.69	5.90
Pasture	1.31	4.59
Hayfield	0.73	2.55
Row Crop	0.10	0.36
Open Space	0.22	0.77
Idle	0.22	0.78
Spray Field	0.29	1.02
High Density Residential	0.02	0.06
Medium Density Residential	0.60	2.11
Low Density Residential	2.92	10.22
Commercial	0.56	1.96
Two Lane Roads	0.30	1.05
Four Lane Roads	0.06	0.20
Water Bodies	0.28	0.99
Total Watershed	28.60	100.00

Table 2. Land use distribution in Robeson Creek watershed.

Figures 2 and 3 illustrate the breakdown of land use in the Robeson Creek watershed. Forested lands (managed and unmanaged) comprise a majority of the watershed at approximately 73%. Unmanaged forested areas are wood lots owned by individuals assumed to have no management plans. Managed forest areas are wood lots owned by timber industry or individual owners with known management plans.

Although the watershed is not considered agricultural in terms of animal and crop production, pasture and hayfields comprised a total of 8% of land use. Small farms containing few numbers of livestock, such as cattle, horses, and goats, are scattered throughout the area. Hayfields are also generally associated with these farms. No concentrated animal operations are located within the watershed. Only one small portion of the watershed contains row crops.

Townsend Foods, Inc. owns approximately 600 acres of land of which approximately 130 acres is used as spray irrigation fields. The company also manages a 16-acre lagoon that stores wastewater from its poultry processing plant and currently holds a DWQ nonpoint discharge permit (WQ0001755) that allows application of lagoon wastewater to the spray fields with no discharge to surface waters. In addition, the company manages a small herd of cattle on

pastures surrounding the spray fields. Hay is harvested from the sprayfields and used as food for livestock.

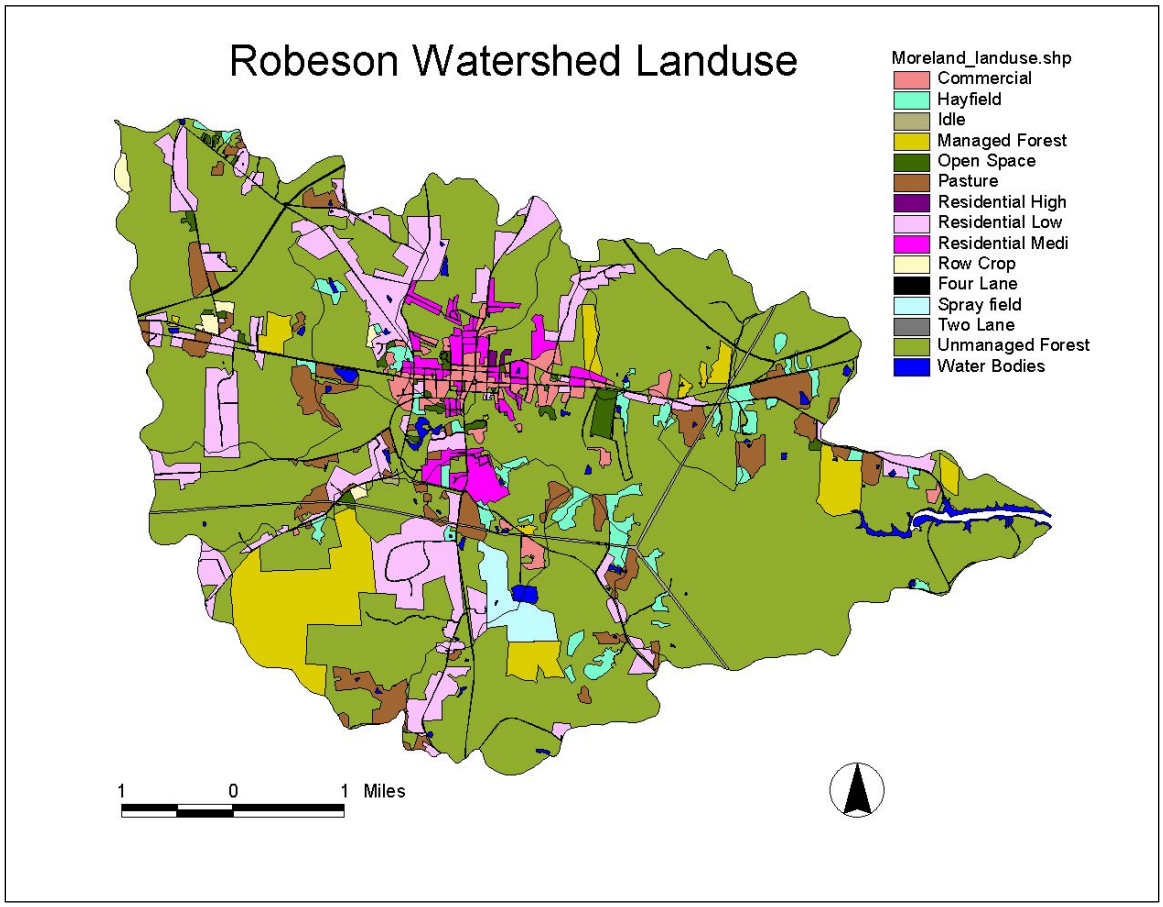

Figure 2. Robeson Creek watershed land use map.

Open and idle space comprises less than 2% of land use. Open space includes parks and recreational fields. Idle land comprises power line right-of-ways and abandoned agricultural fields.

The Town of Pittsboro lies completely within the Robeson Creek watershed. Residential and commercial land uses are predominately located in this urban center. The Pittsboro Waste Water Treatment Plant is also located within the town limits and directly discharges effluent into Robeson Creek (NPDES #NC0020354). This is the only point source discharge within the watershed.

Paved roads comprise about 1.25% of land use within the area. A new 4-lane bypass highway was completed in 2002 in the northern portion of the watershed.

Water bodies comprise 1% of the watershed. Stream miles within the watershed total 52, in addition to 130.28 acres of lake.

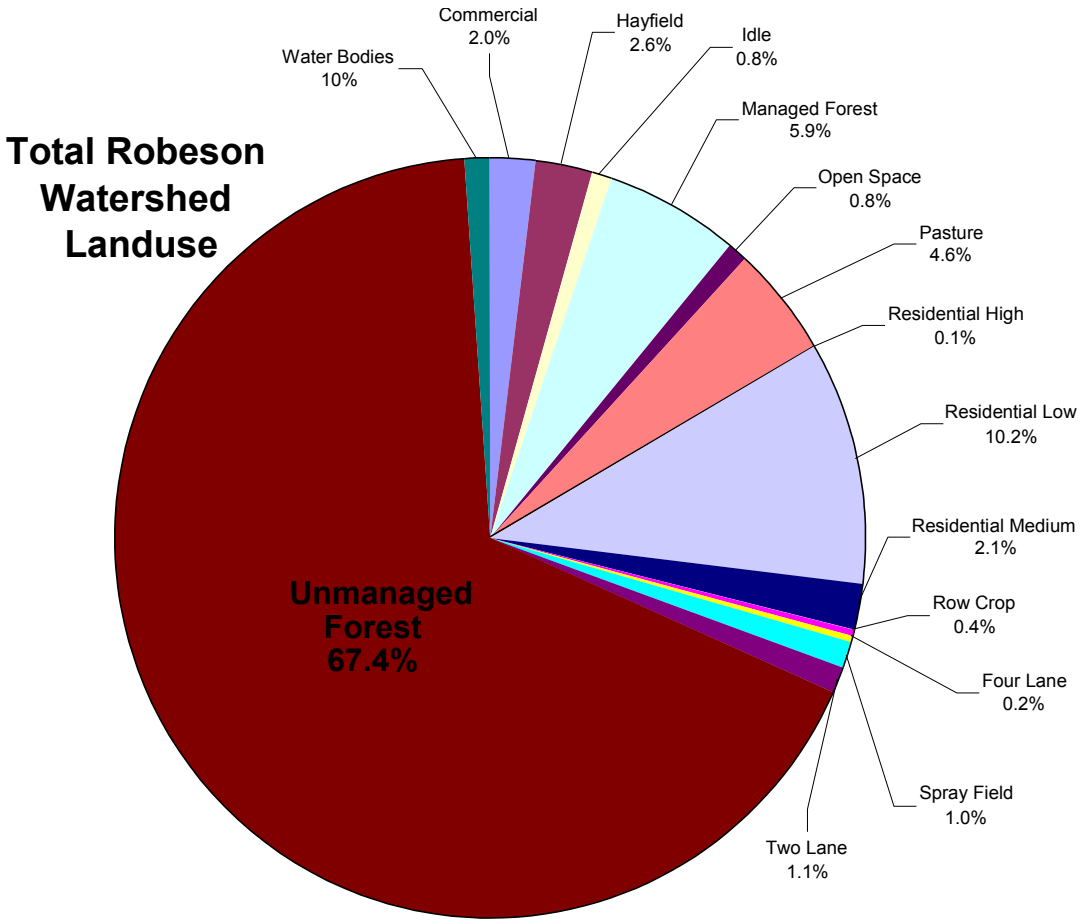

Figure 3. Robeson Creek watershed land use graph.

1.3 Current and Former Projects within the Robeson Creek Watershed

1.3.1 TMDL Implementation Plan and Watershed Assessment (NCSU 2002-2004)

The NC Department of Environment and Natural Resources, Division of Water Quality issued a draft TMDL for TP in Robeson Creek in June 2003 to address the chlorophyll *a* violations and restore designated uses to the creek. EPA approved the TMDL January 13, 2004 and the final report can be viewed online at http://portal.ncdenr.org/web/wq/ps/mtu/tmdl/tmdls. NCSU developed a TMDL Implementation Plan for Robeson Creek watershed to guide the restoration efforts for Robeson Creek in order to meet the TMDL for total phosphorus allocated to nonpoint pollutant sources. Critical areas of pollutant sources in subwatersheds of Robeson Creek were identified, and reduction strategies (BMPs) were suggested with recommendations given for their location. DWQ previously granted EPA Section 319 funding to the NCSU Water Quality Group to perform a watershed assessment for Robeson Creek and to develop a TMDL Implementation Plan to address meeting Nonpoint Source (NPS) load allocations for TP. These

documents can be viewed online at
http://www.bae.ncsu.edu/programs/extension/wqg/srp/robeson.html.

The watershed assessment helped to refine pollutant types and sources (beyond existing DWQ data) and to identify critical areas for implementation of BMPs at the subwatershed level. NCSU established water quality monitoring stations throughout the watershed (Figure 4). A detailed description of the ongoing monitoring efforts is described in detail in section 10. As part of the watershed assessment, a streambank and riparian area assessment was performed for two subwatersheds of Robeson Creek. Little Creek was chosen to represent an urban subwatershed and Camp Creek was selected as a rural subwatershed. The streambank assessment portion of the study included determination of the bank erodibility hazard index (BEHI) and Bank Height Ratio (BHR) to assess the impacts of streambank erosion on the watershed (Rosgen, 1996). Geographic Information System (GIS) was used to graphically depict the condition of the reaches. Eroding streambanks are a major contributor of sediment to waterbodies across the state and are responsible for instream habitat degradation.

Other components of this study included assessing the riparian condition of the stream reaches in terms of buffer density, width, composition, and maturity. The presence of instream habitat was also assessed, as well as any notable alterations that have occurred historically. The information gathered in this study was analyzed to highlight tributaries and reaches that are in need of restoration and/or stabilization.

The goal of this study was to more effectively target locations for future restoration, which will reduce sediment due to streambank erosion and improve habitat.

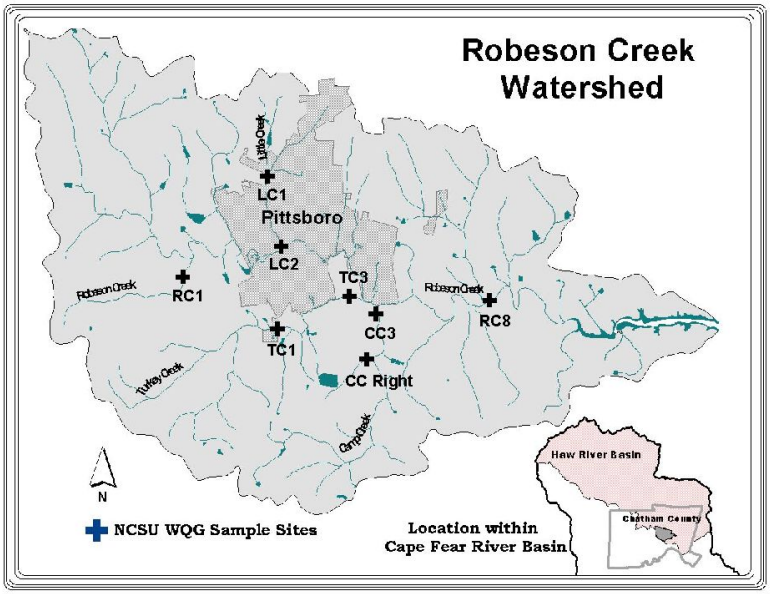

Figure 4. NCSU water quality monitoring sites.

1.3.2 DWQ Benthic Reports (February and November 2001, and June 2009)

The Division of Water Quality Biological Assessment Unit sampled sites on Robeson Creek in 1986 and 1990 resulting in a rating of Fair. In 1997 they sampled due to an oil spill on an unnamed tributary above the WWTP and again the site above the WWTP rated Fair. The last sampling on Robeson Creek by DWQ was conducted in 2001. They sampled in both January and September of 2001. Table 3 lists the North Carolina Biotic Index Scores and their ranges. The results of the DWQ sampling on Robeson Creek are given in Table 4.

North Caroline Biotic Index Score	
Excellent	<5.19
Good	5.19 to 5.78
Good/Fair	5.79 to 6.48
Fair	6.49 to 7.48
Poor	>7.48

Table 3. Biotic index score.

DWQ Benthic Macroinvertebrate NCBI scores for the Robeson Creek watershed

Robeson Creek						
Date	Above Pittsboro WWTP (RC1)	US 15/501 upstream of oil spill	Above WWTP Oil spill site	Below Pittsboro WWTP (RC2)	Above Turkey & Camp Creeks (RC3)	Most downstream site (RC5)
4/28/86				7.46*		
9/4/90	7.58			7.1		
3/6/97	6.64*	5.94	6.44			
1/19/01					6.41	5.93*
9/12/01						6.01
9/19/01	6.61			7.13		

Table 4. Biotic index scores for Robeson Creek.

In addition to sampling Robeson Creek in 2001, DWQ sampled sites along Camp and Turkey Creeks. They concluded that the input from the Townsend Foods facility was adversely affecting the macroinvertebrate community in both streams. Extremely high levels of ammonia and phosphorus were also reported from these tributaries. DWQ did note that Robeson Creek though showed some recovery at the site downstream of all these inputs as evidenced from the macroinvertebrate ratings of Fair and Good/Fair received in the January and September 2001 samples. The biotic index scores DWQ gave for Camp and Turkey Creeks are shown Table 5.

	Camp Creek		Turkey Creek		
Date	Upstream off SR 1012 (CC1)	UT Downstream Off SR 1012 (CC2)	Upstream US 15/501 (TC1)	Downstream SR 1012 (TC2)	Further downstream confluence (TC3)
1/19/01	6.27	7.57	6.45	7.56	6.16
5/5/09	4.78	5.47			
5/8/09			6.73	6.75	

Table 5. Biotic index scores for Camp and Turkey Creeks.

In 2009 DWQ again sampled Turkey and Camp Creeks. Scores they obtained for Camp Creek were greatly improved, but not for Turkey Creek. In 2004, Townsend Foods ceased the slaughtering of animals at their Pittsboro facility. They also began operating a wastewater recycling facility. Both of these actions resulted in a reduced volume of wastewater sprayed on the wastewater application fields that drain to Turkey and Camp Creeks, which in turn drains to Robeson Creek. These operational changes are likely partially responsible for the biological community improvement in Camp Creek.

1.3.3 Robeson Creek NPS Restoration Watershed Project (NCSU 2003-2006)

NCSU was awarded an EPA Section 319 grant to begin implementation of water quality projects and continue monitoring within the watershed. The objectives were to:

1) Implement BMPs in critical areas of the Robeson Creek watershed, targeted towards reducing nonpoint source TP loading to Robeson Creek and its tributaries to achieve the TMDL, as well as reducing other pollutants of concern identified in the watershed assessment. This work was guided by the Robeson Creek TMDL Implementation Plan.

2) Continue monitoring water quality of Robeson Creek and its tributaries in order to further refine critical areas for BMP implementation; evaluate progress made at achieving TMDL reductions for TP; and evaluate effectiveness of BMPs at reducing pollutant levels and improving water quality for all pollutants of concern.

3) Employ an educational campaign regarding water quality throughout the watershed for landowners, local businesses, public officials, agencies, and other interested parties. This will consist of workshops, tours, and literature distribution. Engage local stakeholders in discussions regarding selection and placement of BMPs.

Numerous BMPs were installed throughout the watershed (discussed in Section 3.3) with the primary focus being on the Little Creek subwatershed due to stormwater impacts as noted by the TMDL report. Water quality monitoring was continued from the previous watershed assessment project and is described in detail in section 9.0 of this report. Newsletters were distributed to watershed landowners informing them of issues in the watershed. Educational workshops and tours were given throughout the duration of this grant and RCWC meetings continued each quarter.

Figure 5. Installation of BMPs.

1.3.4 Robeson Creek Visual Assessment (HRA 2004)

HRA was awarded an EPA Section 319 grant that included funds to conduct a visual stream assessment within the Robeson Creek watershed using the NRCS Visual Stream Assessment Protocol (SVAP). These stream assessments provided us with the opportunity to educate landowners on stream stewardship and BMPs, stream restoration, and conservation. Thirty-four assessments were conducted and recommendations were written on how to address observed problems. Many of these recommendations included BMPs for controlling nonpoint source runoff including riparian buffers, fencing cattle out of the stream, rain gardens, and general BMPs such as cleaning up pet waste. These results from these assessments were shared with the NCSU WQG who implemented many of the recommendations with EPA Section 319 funds they received for BMPs.

1.3.5 Robeson Creek Watershed Restoration Project (NCSU 2007-2011)

NCSU was awarded an EPA Section 319 grant to continue implementation of water quality projects and continue monitoring within the watershed. The objectives were to:

1) Implement BMPs in critical areas of the Robeson Creek watershed, targeted towards reducing nonpoint source TP loading to Robeson Creek and its tributaries to achieve the TMDL. This work was guided by the Robeson Creek TMDL Implementation Plan.

2) Implement BMPs in identified impaired reaches of tributaries throughout the watershed to improve aquatic habitat.

3) Work with local government to develop stormwater and buffer ordinances.

4) Work with new developments to install proper BMPs for stormwater. Focus was on Low Impact Development (LID) practices.

5) Continue monitoring water quality of Robeson Creek and its tributaries to evaluate progress made at achieving TMDL reductions for TP as well as evaluate effectiveness of BMPs at reducing pollutant levels, improving aquatic habitat and improving water quality for all pollutants of concern.

BMPs were installed throughout the watershed and included stormwater wetlands, raingardens, and buffer plantings. Water quality monitoring as well as benthic habitat monitoring continued under this grant.

Figure 6. BMPs installed in Robeson Creek watershed.

Education campaigns and workshops were targeted at local officials, landowners, and developers to bring about more awareness of water quality issues in the watershed. Homeowners within a subdivision in the Turkey Creek subwatershed were targeted for education and implementation of BMPs based on LID practices. This work is ongoing. Permanent signs were installed at BMP locations to further educate the public about work in the watershed.

Figure 7. 2007 Stewards Award recipients.

The Robeson Creek Awards program was started in 2003 by the HRA. The RCWC has continued this program to recognize businesses and other landowners annually for good water quality practices and the implementation of stormwater BMPs. Robeson Creek Award recipients are recognized publically with the presentation of a Stewards Awards Certificate that is adorned with artwork by Emma Skurnick, a local well know botanical artist. Past recipients include residents that have planted riparian areas with native vegetation on their properties, local government agencies for assisting in raingarden plantings, a local church youth group for cleanup efforts in Robeson Creek, and local businesses that have installed stormwater BMPs such as raingardens, stormwater wetlands and cisterns.

Efforts to improve the town's stormwater and buffer ordinances resulted in the document "Town of Pittsboro Better Site Ordinance Review Design". A team of various stakeholders including the Town of Pittsboro, NCSU, HRA, local developers and citizens reviewed existing ordinances and made recommendations on ways to strengthen them using the Center for Watershed Protection's Better Site Design publication (1998). The town endorsed the team's recommendations and stricter stream buffer ordinances were enacted as a result. Stormwater ordinance review is continuing as part of the Jordan Lake Rules with help from NCSU under a separate grant.

A comprehensive watershed restoration plan was also written as part of this grant. Using the 2003 TMDL Implementation Plan as a guide, past and current water quality work in the watershed was documented. The restoration plan was written to address the EPA's 9-key elements for watershed restoration. A detailed description of this plan's format is discussed in Section 1.1.

1.3.6 Town Lake Study and Restoration (NCSU 2007-2012)

In 2007, a feasibility study was released summarizing options for restoring Town Lake in Pittsboro. NCSU obtained funding from CWMTF to determine the possibilities for restoring the lake, which is an impoundment of Robeson Creek, to a healthier aquatic system. This lake is classified by DWQ as "Impaired". Groups including the RCWC, HRA, Town of Pittsboro, and local citizens are concerned about water quality issues regarding the lake and have expressed avid interest in restoring it to a functioning water body and making the surrounding area more appealing for recreational use.

This former water supply lake impounds Robeson Creek and is located within the limits of the Town of Pittsboro. Town Lake is actually 2 lakes; one older "lower" lake and one newer "upper lake". Together, both water bodies comprise approximately 15 acres in surface area. DWQ has included the lake on the 303(d) list of impaired waters for aquatic macrophyte (plant) infestation. In the case of Town Lake, an aquatic weedy plant, parrot feather (*Myriophyllum aquaticum*), completely covered the lake shores and lake bottom (Figure 8). Parrot feather infestations are problematic because the plants form dense mats blocking water flow and creating unsuitable conditions for fish but providing excellent habitat for mosquitoes.

Figure 8. Parrot Feather along Town Lake Shores.

The lake was rated eutrophic in 2003. Chlorophyll *a* concentrations were elevated and algal blooms occurred throughout the summer (NCDENR, Division of Water Quality Basinwide Assessment Report-Cape Fear River Basin August 2004). The Basinwide Plan listed the lake as "Not Rated" for

aquatic life because all chlorophyll *a* samples exceeded the water quality criterion; however, only three samples were collected. A minimum of 10 samples are needed to assign a use support rating. The chlorophyll *a* levels were the highest recorded for the lake by DWQ (Cape Fear River Basinwide Water Quality Plan, 2005).

The Town Lake restoration feasibility study was conducted using a multi-prong approach in data collection. Citizens and town officials as well as historical documents and personal accounts were compiled to determine the historical time line of the lake. State agencies were utilized for technical data such as water quality and basinwide planning. Multiple engineering and surveying experts were contracted to collect data on sediment, water quality, dam and spillway repair, and lake restoration. All of this information was compiled to determine various restoration options for Town Lake. The primary objectives of this project were:

1. To collaborate with and support local initiatives for improving Town Lake and Robeson Creek watershed water quality.
2. To collect available historic land use, water use, and water quality data to help determine reasons for current water quality status.
3. To perform a technical study of the lake including water quality analysis, substrate analysis, and hydrogeomorphic survey of the lake.
4. To develop restoration alternatives to improve water within Town Lake.

The feasibility report outlined the various issues regarding Town Lake in Pittsboro, NC. Namely, the study stated that the lake is a degraded lake that is on the state's impaired waters list for aquatic weeds, is choked with sediment in its upper reaches, has a compromised dam and spillway, and is an impoundment of Robeson Creek which is a creek suffering from nutrient and biological impairments. The restoration feasibility study included collecting data on lake history, water quality, sedimentation, and the status of the dam and spillway and then analyzing the information to develop possible restoration alternatives for the lake. These alternatives included:

1. No restoration
2. Aquatic Weed Management
3. Dam and Spillway Repair
4. Upper Lake Dredging with Dam and Spillway Repair
5. Active Stream and Wetland Restoration
6. Passive Stream and Wetland Restoration

Aquatic weed management was recommended with most all alternatives. Dredging the upper lake and repairing the dam and spillway was determined to be the most expensive alternative. No restoration was the least expensive option; however, this was the only alternative not recommended. The preferred alternative recommended by the NCSU Water Quality Group was the passive stream and wetland restoration approach (Figure 9). This approach balances ecological and recreational goals of the restoration project, is not as

expensive as some of the other alternatives, involves less disturbance of the natural system, and has a higher probability of being funded than other alternatives.

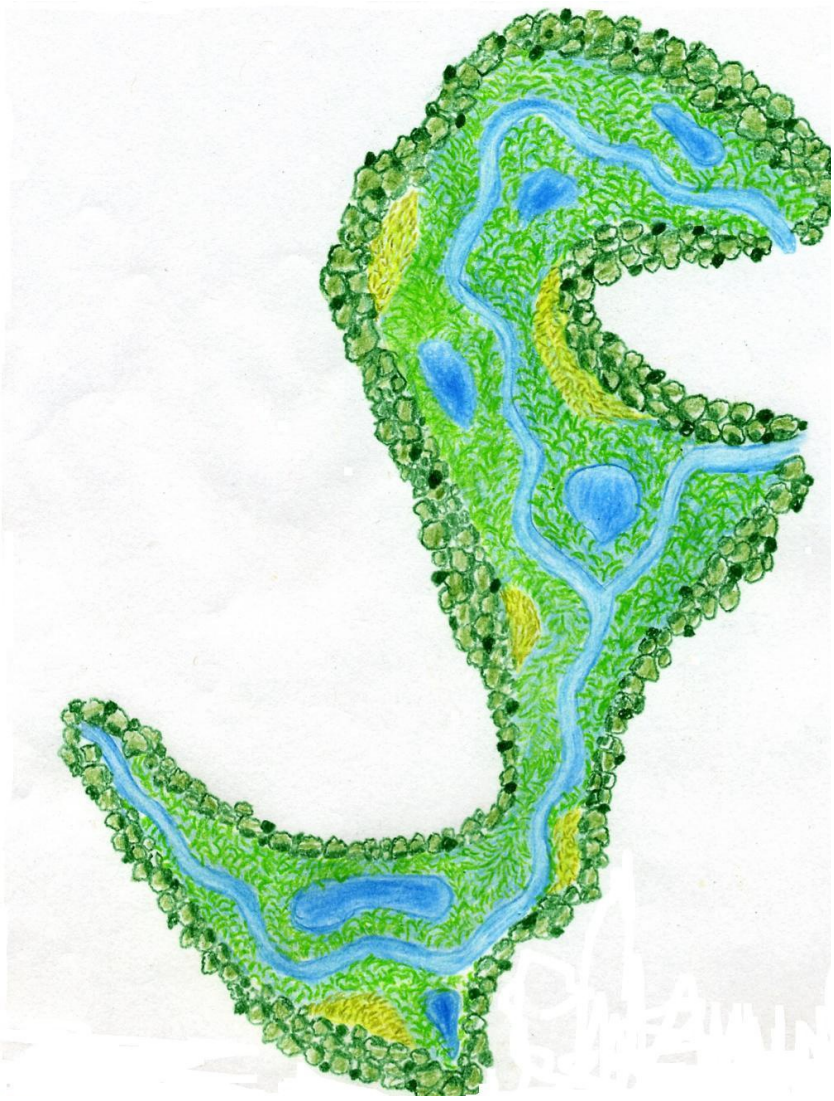

Figure 9. Town Lake passive restoration conceptual drawing.

Having presented all the alternatives to Town of Pittsboro elected officials, they unanimously voted to accept the preferred alternative recommended by NCSU. In 2008, NCSU was awarded a restoration grant by CWMTF to begin construction on the project. Due to various state budget constraints, the project did not get underway until 2011. At the time of this writing, the project is currently being built.

In addition to the restoration project, NCSU received a grant from EPA Section 319 in 2008 to treat and control invasive exotic aquatic weeds in the lake and terrestrial weeds around the lake's perimeter. The treatments were implemented for two years in preparation of the lake restoration.

Further, NCSU began collecting upstream and downstream water quality samples above and below Town Lake in 2010. This pre-construction data will be compared with post-construction data to determine water quality impacts created by the restoration.

1.3.7 Robeson Creek Water Quality Outreach Initiative (NCSU 2009-2012)

NCSU obtained a USDA National Institute of Food and Agriculture (NIFA) grant in 2009 to improve stakeholder awareness of water quality issues in the Robeson Creek watershed and help the community become self-sustainable in water quality improvements by meeting the following objectives:

1. *Strengthen the Town of Pittsboro's stormwater ordinances.*

   NCSU along with a review team are currently working with the Town of Pittsboro on rewriting the town's subdivision ordinance to encourage low impact development (LID). This work includes greatly strengthening the existing stream buffer rules and stormwater ordinances. This method has proven successful and has been well received by the town staff and officials.

   Anticipated results are more onsite stormwater controls, LID approaches to stormwater design and implementation, and improved water quality due to a reduction in stormwater runoff. One desired outcome is an improved community understanding and support of stormwater controls.

2. *Work with youth in local school system and other programs such as 4H, boy scouts and girl scouts to implement a rain garden and use it as an ongoing outdoor laboratory for educational programs on water quality.*

   The Chatham County School System has given NCSU permission to implement BMPs on several of its campuses. Two of these occur in the Robeson Creek watershed. The principals at both schools are highly in favor of water quality education and working with the schools' science teachers on this issue. Additionally, the 4-H program in Chatham County has summer camps at Jordan Lake and campers learn first-hand about the degradation of the lake's water supply. The Boy Scout and Girl Scout troops along with church youth groups and home school groups in Pittsboro are active in environmental projects such as stream sweeps and volunteer planting. This pool of youth and leadership within the watershed is an ideal group for using an outdoor learning laboratory such as a rain garden or BMP. The local Cooperative Extension and SWCD personnel work with youth and educators regularly, so this is an opportunity to engage area youth in understanding and promoting improved water quality. Programs will be advertised in the watershed newsletter, extension publications, and local newspaper. RCWC will also support and promote programs.

Anticipated results are an improved knowledge base of youth in the Robeson Creek watershed regarding the impact stormwater runoff has on water quality in our local streams. Youth leaders and educators will also have learned the skills and information to carry on environmental education sessions using the stormwater BMP as a tool. Thorough ongoing age-appropriate sessions, more area youth will become aware of the importance of their local water supply. Surveys of the youth will help extension personnel adapt programs and understand if students are being impacted.

3. *Work with businesses in the watershed to develop a water quality leadership challenge program.*

The Haw River Assembly is taking the lead on this facet of the outreach project. In 2003 the HRA began recognizing businesses and landowners as stream stewards that were implement pollution prevention measures at their businesses and on their properties. This program has been continued since 2003 by the RCWC with annual stream stewardship awards given in recognition for the implementation of stormwater BMPs.

Anticipated results will include a more water quality savvy and engaged business community. Also the evaluation tools developed for this program will give us another way to track the pollution prevention that we are obtaining through our work in this watershed. In addition by making this program include sequential challenge levels, we hope to keep businesses engaged and participating in improving the water quality in Robeson Creek beyond their initial recognition.

4. *Increase water quality awareness through educational signs and programs developed around existing water quality projects throughout the watershed.*

Education and outreach to stakeholders through educational signs, workshops, newsletters, and educational programs is one of the most important components of this project. NCSU and RCWC have continually performed outreach functions in the watershed since 2001. Public workshops have particularly been effective in reaching landowners interested in water quality issues. HRA has recruited several stream monitoring volunteers through these outreach campaigns. As the watershed population grows, we hope to reach out to more people and bring about awareness of water quality.

Anticipated results are increased knowledge of water quality issues in the Robeson Creek watershed and Jordan Lake among landowners and water users in the area. How many people are impacted by the outreach efforts will be measured by surveys (see #5). Also expected is increased participation in BMP implementation and volunteerism among stakeholders.

5. *Evaluate stakeholder attitudes about water quality through a series of surveys and questionnaires.*

Documenting effects of outreach activities on local watershed stakeholders will help determine success or failure of such efforts. Additionally, information from surveys and focus groups may provide new pathways of disseminating information to the public regarding water quality.

The expected results are capturing public opinion on existing efforts for water quality and understanding how coordinated educational campaigns can impact existing attitudes and increase knowledge of the watershed stakeholders.

1.3.8 SWP and AP: Robeson Creek Status Report (Raleigh Regional Office 2008)

The staff from the Surface Water and Aquifer Protection units of the Raleigh Regional Office worked together to prioritize known and potential pollution sources in the Robeson Creek watershed. They evaluated Pittsboro's wastewater treatment system, potential sources for stormwater runoff, and construction projects.

Findings

- Cursory review of flow data from Pittsboro's wastewater treatment plant suggested problems with inflow and infiltration, which could exacerbate the impaired conditions of the stream by allowing nutrients to flow out of the system and into the watershed.
- Sampling of Chandler Concrete waste stream found high concentrations of pH (11.31 su), conductivity (1952 umhos/cm2), carbonate (55 mg/l), total dissolved solids (843 mg/l), sulfate (240 mg/l), total kjeldahl nitrogen (17 mg/l), barium (350 ug/l), chromium, potassium (90 mg/l), and lithium (59 ug/l). The waste stream contains a low dissolved oxygen (DO) (4.8 mg/l))
- Sampling on five unnamed tributaries of Turkey Creek on Townsend property found higher concentrations of conductivity, total dissolved solids (TDS), total kjeldahl nitrogen (TKN), nitrite + nitrates (NO2 + NO3), total phosphorus (TP), barium, calcium, potassium, magnesium (0.69 mg/l), sodium (36 mg/l) and total nitrogen in comparison to a control stream off of site.
- Over 60% of the construction sites within the watershed did not comply with construction stormwater permit conditions or state water quality standards that resulted in notices of violations being issued.
- Nearly 58% of the inspected construction sites had construction stormwater condition violations, 29% had stream standard violations, and 13% had wetlands standard violation.
- Ten of the 17 sites inspected had violated their conditions for their DWQ 401 Water Quality Certifications.

In addition five sampling locations along Robeson Creek were sampled for various parameters. Most of the parameters were found to be within normal range.

Abnormal Data results

- Specific Conductance (conductivity @ 25°C) the conductivity levels ranged from 54 to 155 umhos. Specific Conductance is used as an indicator of the quality of water by estimating the dissolved solids/salts. Conductivity increased at each sampling location along Robeson Creek.
- Dissolved Oxygen (DO) levels ranged from 8.4 to 10.8 mg/l. The state limit is 5.0 mg/l daily average.
- Total Kjeldahl Nitrogen (TKN) (organic nitrogen and ammonia) levels ranged from <0.2 to 1.0 mg/l. TKN is the indicator of the amount of organic nitrogen from animal waste. DWQ generally expects TKN values below 0.5 mg/l.
- Nitrate + Nitrates (NO2 +NO3) levels ranged from 0.12 to 2.3 mg/l. DWQ generally expects to see values below 0.30 mg/l. Nitrates are indicators of aged nitrogen and often are the cause of algae problems.
- Total Phosphorus (TP) levels ranged from <0.02 to 0.26 mg/l. DWQ expects to see TP values below .05 mg/l in waters without waste impacts. Elevated levels can cause algae problems.

1.3.9 Southwest Shores of Jordan Lake (TLC and RCWC 2008)

The Preston Development Company has assembled nearly 6,500 acres of land with plans to create a large, mixed-use development which will be the largest such project in Chatham County's history. The majority of this land lies within Pittsboro's jurisdiction with a significant portion within the Robeson Creek watershed.

In early 2008, Preston Development Company approached Triangle Land Conservancy (TLC) to assess the land's conservation value and to make recommendations on which lands should be conserved, based on their natural, historic, cultural and environmental value. TLC assembled a team of experts from government agencies, nonprofit organizations, and interested citizens to carry out the assessment. The RCWC was asked to assess the riparian area along the main corridor of Robeson Creek that flowed through the project area.

The assessment of riparian corridors was limited to the main stem of Robeson Creek. Time and resource constraints prevented the work group from conducting an assessment of other creeks in the study area. Many of the findings and recommendations stemming from the assessment of Robeson Creek, however, might also apply to other creeks.

A total of 21 reaches were surveyed for riparian condition along approximately 16,000 linear feet of Robeson Creek that lies within the study area (Figure 10). Using maps and GPS, the majority of the stream channels bordering the Preston property was quantitatively and qualitatively assessed for riparian buffer quality. A semi-quantitative vegetation assessment guide (beta version) developed by NCSU was used in a series of reaches throughout the stream corridor.

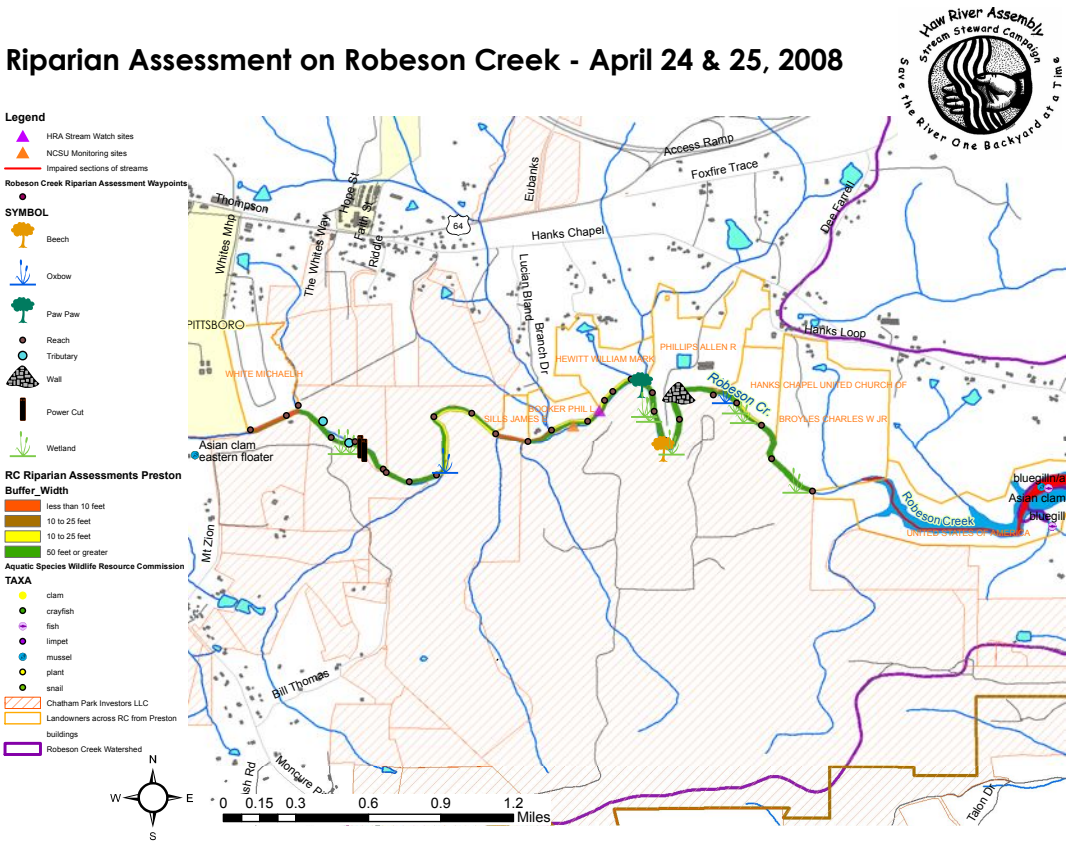

Figure 10. Assessment locations.

This three-mile section of Robeson Creek and its riparian area were found to be mostly intact with mature bottomland forests comprising the majority of the floodplain. The area provides excellent habitat, both aquatic and terrestrial. The creek is shaded by both buffer vegetation and upland vegetation. The floodplain is diverse with small tributaries, wetland areas, and numerous species of plants. The channel has suffered incision and widening most likely due to upstream inputs, but appears to be compensating well. Exotic invasive plants, especially silverberry, are pervasive throughout; the entire riparian area could benefit from a management plan for this problem vegetation. Additional planting of trees in areas where vegetation is sparse could also be part of an overall management plan to keep this section of Robeson Creek off of the impaired waters list and improve not only habitat, but also water quality.

2 CAUSES OF IMPAIRMENT AND POLLUTANT SOURCES

Robeson Creek was first placed on the 303(d) list in 1998 for chlorophyll *a* violations in 0.6 miles of the lower reach near its confluence with the Haw River, and for a biological impairment on the main stem of Robeson Creek from a point 0.7 miles downstream of SR 2159 to upstream of the mouth. The 303(d) process requires that a Total Maximum Daily Load (TMDL) be developed for each of the waters appearing on Part I of the 303(d) list. The objective of a TMDL is to estimate allowable pollutant loads and allocate to known sources so that actions may be taken to restore the water to its intended uses (USEPA, 1991).

DWQ issued a draft TMDL for TP in Robeson Creek in June 2003 to address the chlorophyll *a* violations and restore designated uses to the creek. EPA approved the TMDL January 13, 2004 and the final report can be viewed online at http://portal.ncdenr.org/web/wq/ps/mtu/tmdl/tmdls. This report focused on impairment related to chlorophyll *a* in the most downstream portion of Robeson Creek that flows into Jordan Lake, referred to hereafter as the Robeson Creek cove. The report determined sources and allowable loads of total phosphorus, which has been identified as the factor most limiting the growth of algae as measured by chlorophyll *a*.

Jordan Lake is a multi-use impoundment formed by the construction of a dam on the Haw River. The rreservoir consists of two distinct arms: the Haw River and New Hope Creek arms. Robeson Creek flows into the Haw River Arm of Jordan Lake. In 2002, the North Carolina Environmental Management Commission (EMC) determined that the Upper New Hope arm was impaired after it exceeded the state's chlorophyll *a* standard. The rest of the lake exceeded the standard in 2006. The Haw River arm exceeded the pH standard in 2006, and the New Hope arm exceeded the pH standard in 2008. In 2008, both arms were also listed for violation of the turbidity standard. EPA approved a Total Phosphorus and Total Nitrogen TMDL to address the chlorophyll *a* violations in 2007.

The 2008 NC State Impaired Waters List lists Robeson Creek from 0.9 miles upstream of Town Lake to an unnamed tributary downstream of Mount Zion Road (SR 1951) as impaired for aquatic life (3.3 miles segment). Figure 11 illustrates the impaired sections of the creek. According to DWQ the suspected cause of the impairment is high level of stormwater runoff. There is also an abundance of algae in Robeson Creek that indicates nutrient enrichment. According to the 2005 Cape Fear River Basinwide Report, the habitat and riparian area were stable downstream of the impaired segment to Jordan Lake. The Robeson Creek Arm of the Jordan Lake is listed as impaired for aquatic life due to high turbidity and high pH. This section is also impaired for fish consumption due to high levels of mercury (Draft 2008 303(d) List Integrated Report Category 5 http://h2o.enr.state.nc.us/tmdl/General_303d.htm).

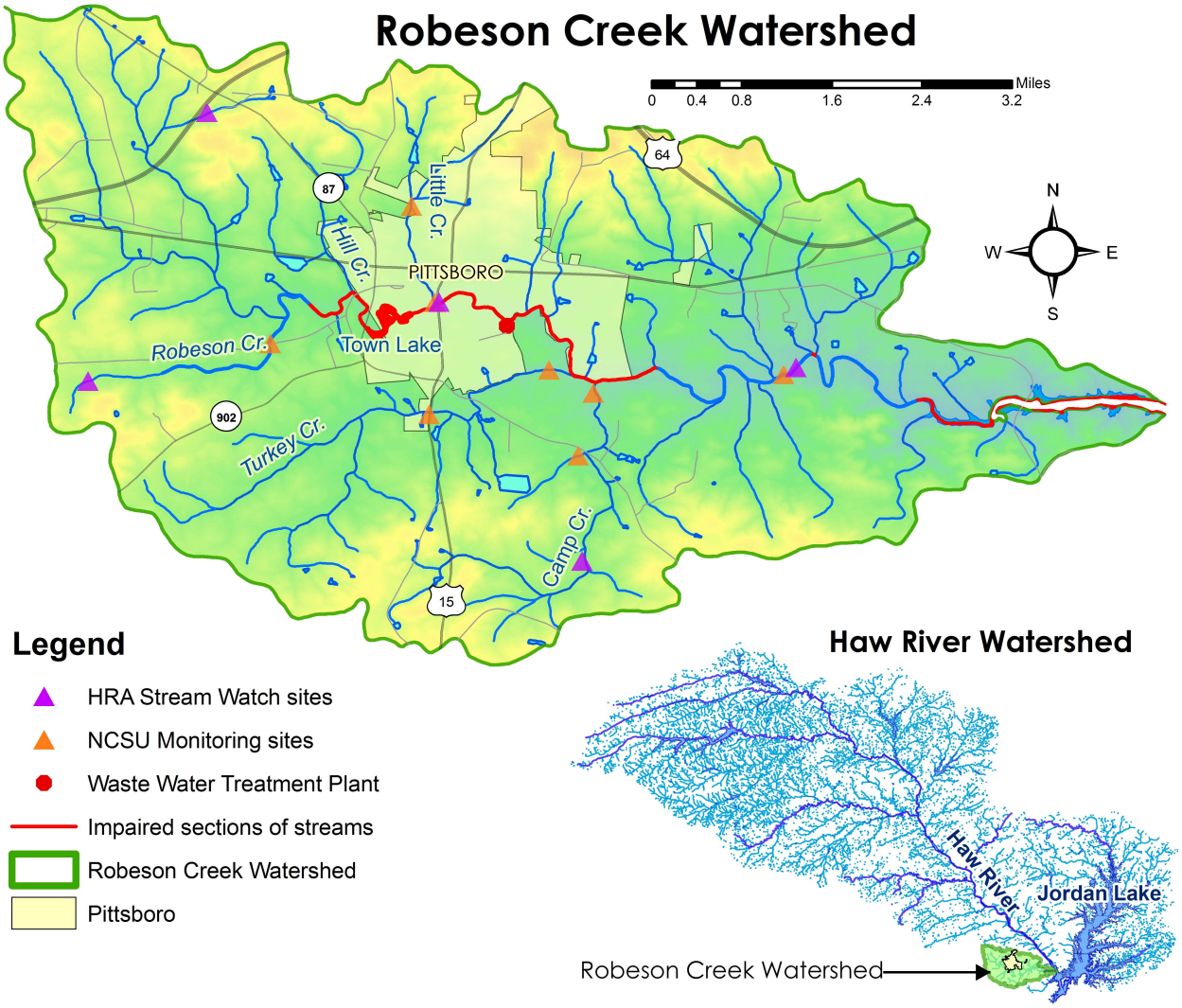

Figure 11. Aquatic life impairment sections of Robeson Creek shown in red.

2.1 Identification of Pollutant Sources for Total Phosphorus

Based on the Robeson Creek TMDL (2003), the primary ways nutrients are transported from the watershed into the surface waters are by stormwater runoff and direct point sources. Runoff from various land uses contributes nutrients to the impaired waterbody primarily during storm events. The other major source of nutrients is the Town of Pittsboro WWTP.

Point sources are typically those regulated under National Pollutant Discharge Elimination System (NPDES) programs. Permitted discharge facilities measure nutrient levels in their effluent at a frequency based on facility class and waste type. Currently, there is one NPDES permitted point source, the Pittsboro WWTP, in the Robeson Creek watershed. The plant discharges domestic waste in the watershed, five miles upstream from monitoring station RC8 (see Figure 4). The plant is permitted to discharge 0.75 MGD (monthly average) of effluent

water with TP concentration of 2.0 mg/liter (quarterly average). There are no regulated MS4 areas within the watershed.

While monitoring water quality in 2001, DWQ found that the annual average concentration of TP before reaching the WWTP site was 0.07 mg/l. TP measured at the site is the concentration of the effluent, not the concentration of the water of the creek. The average concentration peaked to 2.5 mg/l at the WWTP site, which was higher than the permitted concentration 2 mg/l. As the water routed to downstream, the concentration gradually reduced to 0.92 mg/l at a station downstream. The concentration of TP at the WWTP site ranged from 0.2 mg/l to 9.0 mg/l. Out of 16 samples collected in 2001, 8 samples indicated TP concentration below 1.9 mg/l and four indicated above 3.2 mg/l.

Nonpoint sources are diffuse sources that typically cannot be identified as entering a water body at a single location. Agriculture and urban lands were the two major nonpoint sources of TP in the watershed according to the TMDL report (2003). Agriculture land sources included cropland, pasture/hay land, and forested land. Urban land sources were streets, lawns, roofs, driveways, parking lots, and sewer.

Sources of TP in agriculture lands are chemical fertilizer, wastewater, and litter fall. In the watershed, a majority of farmers practiced animal grazing and hay cultivation during 2001. Townsend Foods, Inc. owns about 600 acres of land and manages a 16-acre lagoon. Most of the land is used to graze a modest herd of cattle except in the waste lagoon spray fields. The company has acquired a DWQ permit (WQ0001755) and is allowed to operate the spray fields (130 acres) with no discharge to surface waters.

The TMDL report states that Townsend Foods irrigated the spray fields three to four times a month during 2001. The amount of irrigation was estimated to be 2.6 mm per month. The concentration of TP in the irrigated lagoon wastewater was estimated to be 11 mg/l (3 kg/ha). Phosphorus from the irrigated wastewater, transported via surface and subsurface runoff, appears to have moved into Turkey Creek and Camp Creek. These results suggest that the spray fields owned by Townsend Foods Inc. may have delivered considerable amounts of P to Robeson Creek during storm events in 2001.

Some litter fall accumulation in forested lands also delivers organic P into Robeson Creek. This is described more in detail in the TMDL report.

Urban areas were determined to be a major source of TP to Robeson Creek as found in the TMDL report. Frequent dish and car washing soaps and detergents that contain P could be a source of TP to the creek, possibly via runoff and/or sewer leakage. The statewide phosphate detergent ban in 1988 may have minimized some (but not all) of these sources. Fertilizer applications to lawns are also a major source of TP in Robeson Creek. In 2001, fertilizers used for lawns were 18-24-10 (NPK) and 10-10-10. The fertilizers were applied four times in one year: two applications in March/April and remaining two in September/October. The fertilizers were applied to lawns at the rate of 50 pounds per 12,000 square feet.

The TMDL report cited that overall the combined effects of point sources and nonpoint sources were estimated to be 0.26 mg/l of TP in a year round average at the ambient station, RC8 (see Figure 4). The station is located about 1.8 miles upstream from the Robeson Creek cove.

DWQ employed the empirical eutrophication-modeling package, BATHTUB v. 5.4, to model the effect of nutrient loading on water quality in the Robeson Creek Cove. An estimation of tributary loadings for input into BATHTUB was determined using an associated model, FLUX v. 5.1. A physically-based watershed model, the Soil and Water Assessment Tool (SWAT), Version 2000, was used to assess the impact of point source and nonpoint source on TP in Robeson Creek watershed with varying land use and management conditions for 2001. Detailed information of this modeling effort can be found in the TMDL report.

The watershed model indicated that the discharge rate of water at the ambient station, RC8, was substantially higher during winter than summer. In total, winter TP load was 63% more than the summer TP load. Nonpoint sources were greater contributors of TP during the winter season. Urban areas contributed an estimated 814 kg (45%) of TP in 2001. Also, litter fall in the forested land contributed about 344 kg of TP (19%) and pasture/hay lands contributed about 253 kg (14%). Twenty-one percent (21%) of the pasture/hay lands contribution was derived from subwatersheds 2 and 4, where the wastewater spray fields were located. Contributions from forested lands and pasture lands were almost negligible during summer 2001. It could have been due to low flow, less litter fall, and high infiltration rates. During summer, infiltrability of lands remained high due to low soil moisture condition. The soluble P would most likely have leached down to ground water. Recharge of P from ground water the creek was assumed to be negligible in the TMDL report. Pittsboro WWTP and wet weather load from urban lands were the two major sources of TP during summer, with the WWTP being the largest source of TP (77%). The WWTP contributed about 503 kg and 398 kg of TP during summer and winter respectively. The plant contribution was about 26% more during summer. In a contrast, the urban contribution was about 80% less during summer. Urban sources may include stormwater runoff and leaking sewer lines.

Modeling results indicated that the reduction of Total Phosphorus required to meet the chlorophyll *a* standard at the Robeson Creek cove was 464 kg during the summer season (April – October). This translated into nonpoint and point source goals of 71% reduction of Total Phosphorous (Total Maximum Daily Load For Total Phosphorus for Robeson Creek). In 2004 with EPA Section 319 funding, the NCSU Water Quality Group wrote a TMDL Implementation Plan for the phosphorous TMDL. This document recommends specific actions within subwatersheds to help improve water quality and reduce pollutant loads.

For the Jordan Lake watershed, modeling results indicated that reduction in Total Phosphorus and Total Nitrogen would be needed to meet a chlorophyll *a* standard. The TMDL for Jordan Lake is based on meeting the criterion exceedance frequency of 10% during the

period from May through September. These reductions were allocated between the two arms of the lake with the New Hope Arm divided as the upper and lower sections:

- Upper New Hope Arm: 35% reduction in Total Nitrogen and 5% reduction in Total Phosphorus,
- Lower New Hope Arm: capped at the baseline, and
- Haw River Arm: 8% reduction in Total Nitrogen and 5 % reduction in Total Phosphorus.

The baseline year for the reduction is 2001 (B. Everett Jordan Reservoir, North Carolina Phase I Total Maximum Daily Load).

In addition to the TMDL, North Carolina adopted mandatory Jordan Lake Rules in 2009 to reduce the amount of nutrient pollution entering Jordan Lake. The full text of the rules can be found at www.jordanlake.org. The rules require:

- Reductions of nutrient loading from point source discharges,
- Reductions of nutrient runoff from agriculture, existing development, and new development, including from state and federal government-controlled lands,
- Protection of existing vegetated riparian buffers, and
- Sound fertilizer management.

2.2 Identification of Pollutant Sources for Biological Impairment

The Cape Fear Basinwide Report (2005) states that the degradation of habitat and a pollution tolerant benthic community of Robeson Creek [16-38-(3)a] (0.9 miles) from source to Town Lake could be caused by agriculture and impervious surfaces associated with Pittsboro.

Again the Basinwide Report states that Robeson Creek [16-38-(3)c] from Town Lake to a UT across from SR 1951 (2.4 miles) is impaired for aquatic life because of the Fair benthic community ratings at sites BB45, BB16 and BB12. There are indications of nutrient enrichment in Robeson Creek. Habitat and riparian areas were stable downstream in in segment 16-38-(3)d at several sites surveyed by DWQ (Figure 12). This lower segment (3.1 miles) is Supporting. The watershed which drains all of Pittsboro is experiencing rapid growth. The benthic communities are stressed by habitat degradation associated with runoff from urban areas and nutrients from Townsend Food spray fields. Townsend Foods reduced capacity in 2004 resulting in better waste management on spray fields. Townsend plans to permanently shut down their Pittsboro plant in 2011.

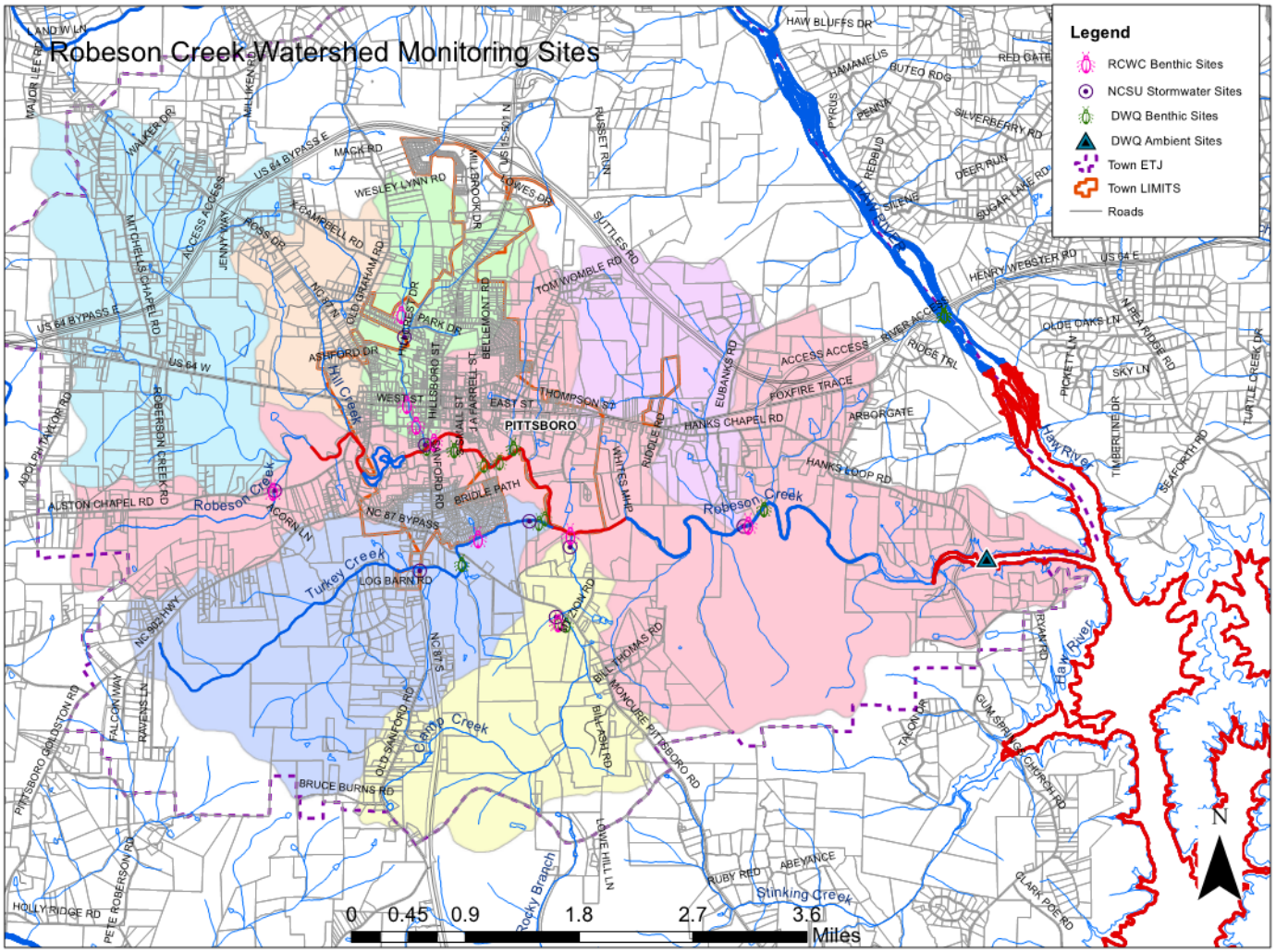

Figure 12. Monitoring sites including NCSU Benthic Sites

3 NPS MANAGEMENT MEASURES, LOAD REDUCTION ESTIMATES AND CRITICAL AREAS

Management measures within the Robeson Creek watershed aim to meet numerous goals. Reducing TP in the Robeson Creek cove through both point and nonpoint sources has been the main catalyst for BMPs and WWTP upgrades to date. The Jordan Lake TMDL must also be addressed in water quality improvement areas throughout this same watershed. Additionally, biological impairments are being targeted by watershed stakeholders as a major study and rehabilitation area of work. The following section discusses TMDL targets, management measures and critical areas in need of special attention.

3.1 Robeson Creek Total Phosphorus Reductions

The TMDL issued for the Robeson Creek Cove is the maximum amount of a pollutant (TP in this case) that a waterbody can receive and still meet water quality standards, allocated among point and nonpoint sources.

The TMDL for total phosphorus is as follows (NCDENR, 2003):

Loading allowed at critical condition*:	190 kg TP/summer (0.89 kg TP/day/summer)
Wasteload Allocation (WLA):	146 kg TP/summer (0.68 kg TP/day/summer)
Load Allocation (LA):	44 kg TP/summer (0.21 kg TP/day/summer)

* Critical condition: Hydrologically dry condition; summer algal growing season (April-October)

Chlorophyll *a* concentrations in the Robeson Creek Cove were highest during the summer growing season. Therefore, the TMDL focuses on loading and algal response during an extended growing season of April through October. Basing the TMDL on this warm weather period will also protect Robeson Creek during the cold weather period (November-March). Nevertheless, nutrient controls during winter are recommended because downstream waters (Jordan Lake) are affected by nutrients transported from this watershed. In addition, control of sediment sources during all times of the year will likely be needed to adequately address habitat degradation and biological impairment in Robeson Creek. The load allocation portion of the TMDL accounts for the loads associated with existing and future nonpoint sources, stormwater, and natural background.

Agriculture and urban lands were identified in the TMDL report (DENR, 2003) as the two major nonpoint sources of TP in the watershed. Agriculture land sources included cropland, pasture/hay land, and forested land. Urban land sources were identified as streets, lawns, roofs, driveways, parking lots and sewer.

Agricultural sources:

- Chemical fertilizer.
- Wastewater – Townsend Foods spray irrigation fields and 16acre lagoon.
- Litter fall – from forested lands during winter dormant season.

Urban sources:

- Dish and car washing with detergents containing phosphorous.
- Domestic sewage.
- Fertilizer application to lawns.

The Pittsboro Wastewater Treatment Plant and stormwater runoff from urban lands were identified as the two major sources of TP during the summer (Table 6).

Table 6. TP loads (kg) at Robeson Creek Cove.

Source Types	Summer	Winter	Total
Nonpoint Source			
Urban	150	814	964
Forest		344	344
*Pasture/hay land **		253	253
Total Nonpoint Source	150	1411	1561
Point Source			
WWTP	503	398	901

*21% derived from the subwatersheds where the wastewater spray fields are located

Table 7 presents the TMDL load allocations for *nonpoint sources*. As stated above, and as seen in Table 6, urban lands were the only nonpoint source that contributed TP during the summer season (150 kg). Reduction required from urban lands to meet the chlorophyll *a* standard in the cove was therefore 106 kg, to meet the 44 kg load allocation.

Table 7. Total mass daily load NPS allocations of TP loads (kg).

Source Types	TMDL for Summer
Urban	44
Forest	n/a
Pasture / hay lands	n/a

3.2 Jordan Lake Nutrient Management Strategy

The lower segment of Robeson Creek has also been identified as part of the Haw River arm of Jordan Lake. As a result the Jordan Lake TMDL will be applied to the Robeson Creek watershed. The Jordan Lake Nutrient Management Strategy (Jordan Rules) became effective August 2009. The Jordan Rules are divided into seven sections for implementation. A brief

summary of each section is given below. The timeline for implementing the Jordan Rules is given in Section 7.2.

Stormwater Rules – New Development

Local governments are required to develop stormwater programs that:

- Approve stormwater management plans for new development.
- Follow specific requirements of water supply watershed rules.
- Ensure maintenance of BMPs.
- Ensure enforcement and compliance.

Agriculture Rules

- Nutrient reduction goals for agricultural operations have been established. Reduction goals must be met at the subwatershed level.
- Watershed Oversight Committee has been established to implement and oversee the Agricultural Rules. If needed, local advisory committees may be established.

Stormwater Rules – Existing Development

Local governments must develop a Stage One program that includes:

- Public education program.
- Program to map MS4 system, outfalls, waters of U.S. and sanitary sewers.
- Program to identify and remove illegal discharges.
- Program to identify opportunities for retrofitting existing development.
- Program to ensure maintenance of BMPs.

DWQ is required to maintain a monitoring program in each arm of Jordan Lake. If monitoring results show impairment, local governments, state and federal entities must implement a Stage Two adaptive management program. The Stage One Stormwater program that Pittsboro developed with Chatham County is described in Section 5.5.

Fertilizer Management Rules

Fertilizer application for areas over 5 acres will be made by an applicator that has completed nutrient management training or pursuant to a nutrient management plan. This rule does not apply to use of fertilizer by homeowner on residential property.

Riparian Buffer Rule

- 50-foot wide riparian buffers are required on all surface waters, including intermittent and perennial streams, lakes, ponds and reservoirs.

- Local governments must develop and implement buffer programs except where DWQ has jurisdiction.
- Diffuse flow is required before stormwater runoff enters the buffer from any new ditch or manmade conveyance. It is required on all buffered streams, regardless of property size or type of land use.

Wastewater Discharge Rules

Applies to existing wastewater treatment facilities that receive nutrient-bearing wastewater and whose discharges are subject to individual NPDES permits.

- Distributes waste-load allocations of nitrogen and phosphorus among the dischargers within each subwatershed.
- Sets limits on nitrogen and phosphorus loads from larger dischargers (permitted flows at or above 0l1 MGD).
- Larger dischargers must optimize facilities to minimize nitrogen loads while process improvement are completed.

Provides for group compliance approach that allows dischargers to work collectively to meet their combined nutrient limits

3.3 NPS management measures previously implemented

Improvements at Townsend Foods (2004) – Townsend Foods - ceases slaughtering operations at Pittsboro facility and begins operating a wastewater recycling facility that greatly reduces the volume of wastewater sprayed on fields that drain to Turkey and Camp Creeks, tributaries to Robeson Creek.

Rain garden (2005) – Steve Carr (private business owner) property - captures stormwater runoff from parking lot and part of building roof prior to flowing to Little Creek (tributary to Robeson Creek). EPA Section 319 project

Buffer planting (2005) – Community volunteers plant shrubs and trees on Little Creek buffer on Steve Carr's property. EPA Section 319 project

Buffer planting (2006) – Community volunteers plant shrubs and trees on Little Creek and Tannery Branch buffer up and downstream of Steve Carr's property. This effort involves five different landowners. EPA Section 319 project

Stream restoration (2006) – Jane Pyle (private property owner) and Chatham Wellness Center properties - Restoration of Tannery Branch (tributary to Little Creek). EPA Section 319 project

Stormwater wetland (2006) – Rural Advancement Foundation International (RAFI) property - converts pond to stormwater wetland captures and treats stormwater runoff

from immediately surrounding area. This wetland is located less than 0.25 miles upstream of confluence of Little Creek with Robeson Creek. EPA Section 319 project

Rain garden (2007) – Located adjacent to (and captures runoff from) Town of Pittsboro basketball courts. EPA Section 319 project

Rain garden (2007) – Saint Bartholomew Episcopal Church property - captures runoff from Hanks Street. EPA Section 319 project

Rain garden (2007) – Pittsboro Community Center- captures runoff from businesses parking lots and two streets. EPA Section 319 project

Buffer planting (2007) – NCSU works with Walnut Grove apartments to clear invasive vegetation and plant native riparian plants. EPA Section 319 project

Stream restoration at confluence of Tannery Branch and Little Creek (2007) – Steve Carr (private business owner) and Margo High (private property owner) properties. EPA Section 319 project

Little Creek – buffer planting in vicinity of VFW (2008) – Stabilize stream bank and enhance wooded buffer. EPA Section 319 project

Habitat for Humanity rain garden and swales (2009) – Captures runoff from parking lot. EPA Section 319 project

Chatham Mills rain garden (2009) - Captures runoff from lawn and rooftop. EPA Section 319 project

Powell Place Park rain garden, green roof, and permeable pavers (2009-2010) - Captures runoff from playground and provides educational demonstration site. EPA Section 319 project

Piedmont Biofuels stormwater wetland (2010) - Captures runoff from parking lot and rooftops. EPA Section 319 project

Backyard Stream Repair, Buffer Planting, and Cistern Installation (2010) – Leigh Hall and Michael Smith (private land owners) – invasive plant removal, streambank repair, and riparian planting. USDA NIFA project

Law Enforcement Center rain garden (2011) – Captures runoff from expanded parking area and from rooftop. EPA Section 319 project

Town Lake restoration (2011) – Conversion of lake to wetland and stream ecosystem. CWMTF project

Southern Park erosion control demonstration (2011) – Captures runoff from expanded parking area using innovative erosion control techniques. EPA Section 319 project

Table 8 provides data on BMP measures currently installed in the Robeson Creek watershed. TN and TP reduction estimated for buffer plantings were based on the DWQ formula for calculation nutrient offset credits which established that restored buffers used for nutrient offset produce a total nitrogen reduction of 2,273.02 lbs per acre over 30 years and a total phosphorous reduction of 146.40 lbs per acre over 30 years. Stormwater BMP calculations were based on Wossink and Hunt (2003) median removal for stormwater wetlands in the Southeast being 33% for TP and 22% for TN.

Table 8. BMP data for Robeson Creek.

BMP	Acres	Year	Cost	Landowner	Description	TN lb/yr	TP lb/yr
Rain garden	0.008	2005	$1,200	Steve Carr	Captures runoff from 0.11 acre area (small parking lot and half of business building roof)	0.23*	0.04*
Buffer planting	0.138	2005	$300	Margo High	Planted at least five different species of trees and shrubs 20 feet from streambank.	10.4*	0.67*
Stormwater wetland	0.25	2006	$18,000	RAFI	Captures runoff from 30 acre area (parking lots building roofs, ball fields, and lawns	254.0*	30.00*
Buffer planting	0.046	2006	$100	Marilyn Beal	Planted at least five different species of trees and shrubs planted 10- 30 feet from streambank	3.48*	0.22*
Stream restoration & buffer planting	0.444	2006	$25,000	Jane Pyle & Chatham Wellness Center	Planted different species of plants 50 feet from streambank and restored upper section of Tannery Branch	33.6*	2.17*
Rain garden	0.005	2007	$2500	St Bartholomew Episcopal Church	Captures runoff from 0.02 acre area of Hanks Street and adjacent areas	0.1*	0.01 *
Rain garden	0.02	2007	$5,000	Town of Pittsboro	Captures runoff from 2 acre area (basketball and tennis courts and adjacent grassed area)	15.0*	1.10 *
Rain garden	0.04	2007	$3,500	Pittsboro Community Center	Captures runoff from 0.9 acre area (businesses parking lots and two streets)	7.0*	0.51*
Buffer planting	0.689	2007	$8,000	Walnut Grove apartments	Cleared invasives and planted native riparian plants on 30 foot buffer	52.2*	3.36*
Stream restoration & buffer planting	0.115	2007	$30,000	Carr and High	Planted different species of plants 20 feet from streambank and restored lower section of Tannery	8.7*	0.56*

					Branch		
Rain garden & 40 feet swale	0.023	2009	$7,000	Habitat for Humanity	Capture runoff from 3.2 acre area (parking lot)	240.0*	20.00*
Buffer planting	0.207	2009	$300	Little Creek in vicinity of VFW	Stabilized streambank with native plants 30 feet from top of bank	15.7*	1.01*
Rain garden	0.01	2010	$1,000	Chatham Mills	Captures runoff from 0.6 acre area (lawn and rooftop)	5.0*	0.30*
Backyard stream repair	0.275	2010	$20,000	Leigh Hall and Michael Smith	Invasive plant removal, streambank repair, and riparian planting to 20 feet on each side of stream	20.8*	1.34*
Town Lake restoration	12 sfc acres	2011	$500,000	Town of Pittsboro	Conversion from lake negatively impacted by aquatic weeds and phosphorous to stormwater wetland.	7,844*	709.89*
Rain garden	0.15	2011	$65,000	Law Enforcement Center	Permeable pavement, biorention area, native plantings to capture runoff from 2.33 acre area (expanded parking area and rooftop)	17.0*	1.30*

*** (estimated)**

3.4 Recommended and Planned Nonpoint Source Management Measures

The following table lists management measures needed over the next 10 years to achieve long-term water quality objectives.

Table 9. Recommended management measures.

Recommendations	Location	Time frame	Objectives	Output	Cost Estimate
BMP installation: Buffer planting	• Critical Areas along Little Creek, Hill Creek, urban tributaries, and Robeson Creek	5 to 10 yrs.	• Reduce peak stormwater flows by 15% • Reduce TSS by 30% • Reduce TP by 30% • Improve and maintain aquatic habitat • Increase recreational opportunities	100 acres planted in native trees and shrubs	**$500 per acre**
BMP installation: Raingardens	• Urban homes • Industrial sites • Parking lots • Downtown	10 yrs.	• Reduce peak stormwater flows by 15% • Reduce TSS by 30% • Reduce TP by 30% • Improve and maintain aquatic habitat	40 installed raingardens throughout watershed	**$10,000 per acre**

Recommendations	Location	Time frame	Objectives	Output	Cost Estimate
BMP installation: Stormwater wetlands	• Industrial sites • Parking lots • Developments	10 yrs.	• Reduce peak stormwater flows by 15% • Reduce TSS by 30% • Reduce TP by 30% • Improve and maintain aquatic habitat	20 installed stormwater wetlands throughout watershed	**$4,000 per acre**
BMP installation: Stream repair and restoration	• All degraded tributaries in watershed	10 yrs.	• Reduce peak stormwater flows by 15% • Reduce TSS by 30% • Reduce TP by 30% • Improve and maintain aquatic habitat • Increase recreational opportunities	40,000 linear feet of stream channel	**$264 per linear foot**
BMP installation: Wetland restoration	• All degraded wetlands in watershed	5 to 10 yrs.	• Reduce peak stormwater flows by 15% • Reduce TSS by 30% • Reduce TP by 30% • Improve and maintain aquatic habitat • Increase recreational opportunities	10 acres of restored wetland	**$36,000 per acre**
BMP installation: Livestock exclusion	• All tributaries in watershed where needed	5 yrs.	• Reduce TSS by 30% • Reduce TP by 30% • Improve and maintain aquatic habitat	3,000 linear feet of stream channel	**$2.72 per linear foot**
BMP installation: Cisterns	• Urban homes • Industrial sites • Downtown businesses	5 yrs.	• Reduce peak stormwater flows by 15% • Reduce TP by 30% • Improve and maintain aquatic habitat	30 installed cisterns throughout watershed	**$750 per 550 gallon cistern**
BMP installation: Nutrient Management	• Farms	10 yrs.	• Reduce TP by 30% • Improve and maintain aquatic habitat	5 management plants	**$500 per plan**

Recommendations	Location	Time frame	Objectives	Output	Cost Estimate
Strengthen local ordinances that protect water quality	• Town of Pittsboro • Chatham County	5 yrs.	• Reduce peak stormwater flows by 15% • Reduce TSS by 30% • Reduce TP by 30% • Improve and maintain aquatic habitat • Increase recreational opportunities	Better ordinances that protect stream buffers, require LID practices, reduce impervious surfaces	**Staff time**
Implement local stormwater program	• Town of Pittsboro	5 yrs.	• Reduce peak stormwater flows by 15% • Reduce TSS by 30% • Reduce TP by 30% • Improve and maintain aquatic habitat	Town runs its own stormwater program in order to better control stormwater inputs into watershed	**Staff time**
Implement local sediment and erosion control program	• Town of Pittsboro	5 yrs.	• Reduce peak stormwater flows by 15% • Reduce TSS by 30% • Reduce TP by 30% • Improve and maintain aquatic habitat	Town runs its own sediment and erosion control program in order to better control sediment inputs into watershed	**Staff time**
Watershed educational campaigns: Homeowner Workshops	• Homes throughout watershed	10 yrs.	• Increase awareness of water quality protection measures such as limited lawn fertilization • Encourage individual participation in watershed restoration	10 workshops including LID practices, stormwater issues, buffer maintenance, lawn maintenance	**$150 per workshop**
Watershed educational campaigns: Stream Stewardship Program	• Throughout watershed	10 yrs.	• Increase awareness of water quality protection measures • Encourage individual participation in watershed restoration	50 new businesses participating	**Staff time**

Recommendations	Location	Time frame	Objectives	Output	Cost Estimate
Watershed educational campaigns: Waterwise landscaping	Throughout watershed	10 yrs.	• Increase awareness of water quality protection measures • Encourage individual participation in watershed restoration through us of native plants to reduce irrigation and fertilization	5 workshops	**Staff time**
Watershed educational campaigns: Forestry BMPs	Throughout watershed	10 yrs.	• Increase awareness of water quality protection measures • Encourage individual participation in watershed restoration through us of forestry BMPs	5 workshops	**Staff time**

Much of the nonpoint source reductions will come from stormwater retrofits within existing developments. Examples of retrofits include grassy swales in place of curb and gutter, permeable pavement and pavers for sidewalks, driveways and parking lots, bioretention areas, stormwater wetlands, level spreaders and open space conservation. Education will be a key component as well; homeowners will learn ways to reduce watershed pollution through individual practices they can do on their own property. Within neighborhoods, homeowners can install cisterns and raingardens, reduce lawn fertilization, install native landscaping, plant and protect buffers along waterways and install and erosion control practices where needed.

Low impact development site design should be applied to new development construction. Phased grading during construction, narrower street widths, grass swales, and more open space are a few examples. Reuse water lines built into new homes and businesses would further assist water quality improvement efforts. More information on LID practices can be found at: http://www.ces.ncsu.edu/depts/agecon/WECO/lid/documents/NC_LID_Guidebook.pdf

Though no large scale farms exist within the watershed, small hobby farms and horse farms are located throughout the area. Livestock exclusion along streams, nutrient management planning, animal waste management, and buffer planting are types of measures that can be applied to reduce nutrient and sediment loading within the watershed.

The majority of the watershed is forested (see Figure 3). Education and outreach to landowners engaged in forestry management will be important in this watershed. Erosion control for logging roads, minimization of soil compaction during logging activities, and adherence to streamside management zone recommendations are management measures that

will help reduce pollution to surface waters. More information on forestry BMPs can be found at: http://dfr.nc.gov/water_quality/bmp_manual.htm

3.5 Critical Areas

Land use and water quality monitoring and modeling have indicated that the critical subwatersheds contributing nonpoint source phosphorus to Robeson Creek are Camp Creek, Little Creek and Turkey Creek. The majority of the watershed is impaired for aquatic habitat. This section discusses both specific and general best management practices for each subwatershed that can be implemented to reduce stormwater runoff volume and phosphorus load to Robeson Creek as well as address biological impairment with the surface waters of the Robeson Creek watershed.

3.5.1 Previously studied subwatersheds

The Robeson Creek Watershed Assessment project (see Section 1.3.1) identified six subwatersheds for further study (Figure 13) which are described below.

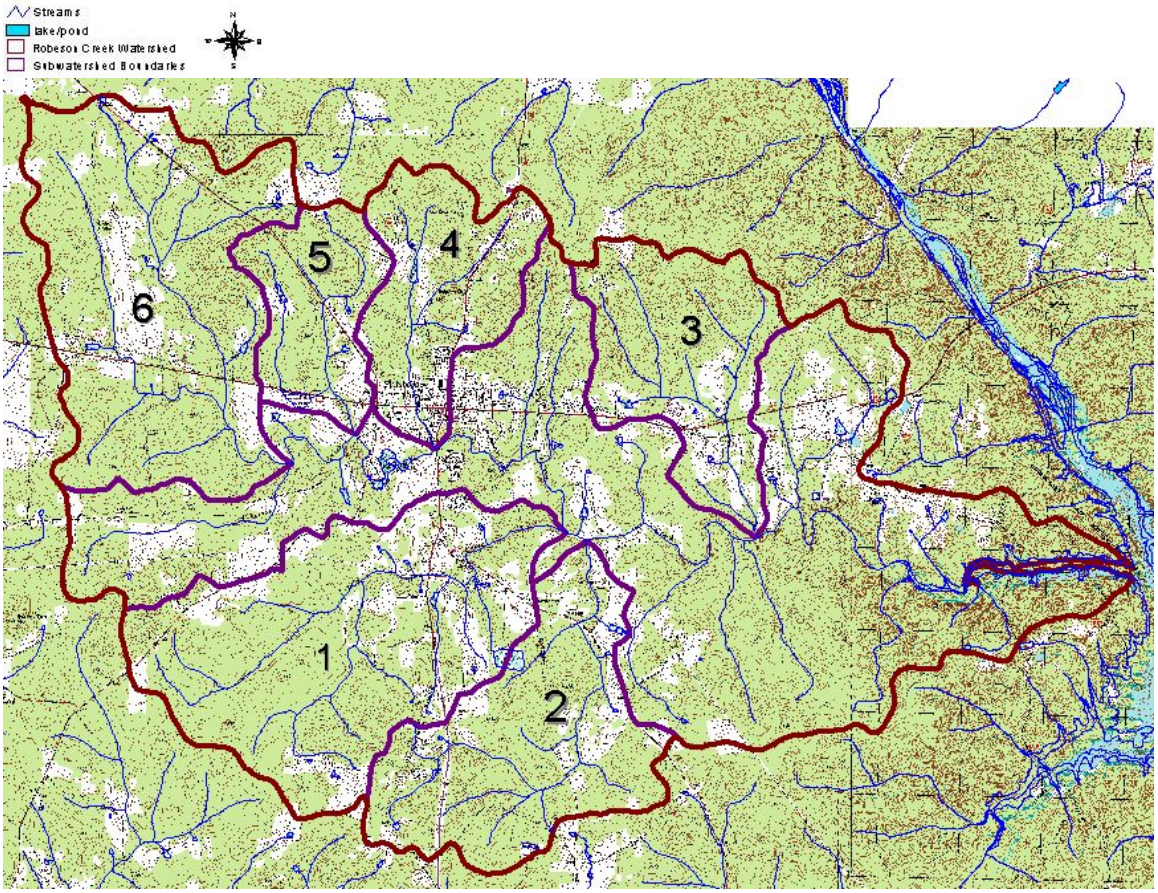

Figure 13. Robeson Creek subwatersheds.

Subwatershed 1

Referred to as *Turkey Creek subwatershed,* it includes all tributaries that drain into Turkey Creek, which in turn drains into Robeson Creek. This 4.6 square mile subwatershed is predominately rural, with approximately 66% of the land forested. Low to medium density residential development constitutes 18% of land use. Several established neighborhoods already exist, and new development is occurring in the northern most portion of the watershed, with several housing developments being built on and around the tributaries to Turkey Creek. Potterstone Village, a new housing development in the watershed, is nearly built out. Industry represents about 1% of land use and is limited to a sawmill operation, auto mechanic shops, and the Townsend Foods, Inc. poultry processing plant. A few small farms with minor cattle operations exist in the watershed. Pasture and hayfields represent approximately 8% of land use. A large 1000-acre tract of land located in the headwaters of Turkey Creek is owned by a private development group though no development as occurred to date. Formerly logged, this tract has potential for a large housing development or industrial complex.

The poultry processing plant maintains a sizable spray field and 16-acre wastewater lagoon that straddles Subwatersheds 1 and 2. For Turkey Creek subwatershed, approximately 3% of the total land use is constituted by the sprayfields. Runoff from these sprayfields into tributaries has resulted in past violations of Townsend Foods' permit requirements.

NCSU originally had two water quality monitoring stations in this subwatershed (see Figure 4). Station TC1 was located at a site above the poultry plant sprayfields and was discontinued due to persistent flooding at the site. Station TC 3 is located downstream of the plant. TC1 was also monitored by DWQ as part of the TMDL development process. TC3 was moved in 2009 to its present location due to landowner constraints.

Subwatershed 2

Also known as *Camp Creek subwatershed*, this 3.0 square mile subwatershed is also predominately rural, with approximately 76% of the land forested. Residential development represents only 8.5% of total land use within this subwatershed. About 8% of the land is used for pasture and hay with small farms scattered throughout the area. The poultry processing spray fields constitute almost 5% of the land use within Camp Creek subwatershed. The mining company 3M owns approximately 2,000 acres which straddles the Camp Creek subwatershed of Robeson Creek and the Stinking Creek watershed. The company manufactures shingle materials and works in conjunction with the onsite quarry Luck Stone. Luck Stone operates the quarry that supplies the andesite (greenstone) mineral that 3M uses in its roofing granule product. Luck Stone also processes the other quarried rock for the local construction market.

NCSU has two water quality monitoring sites located within this subwatershed (see Figure 4). Station CC2R is located at a site just below the poultry plant sprayfields and captures runoff from the fields. Station CC 3 is located near the confluence of Camp Creek and an unnamed tributary near Pittsboro-Moncure Road. These same stations were also monitored by DWQ

during the development of the TMDL. CC3 was moved in 2009 to its present location due to landowner constraints.

Subwatershed 3

This small subwatershed is approximately 2.2 square miles and is located in the northeastern portion of the Robeson Creek watershed. It is very hilly terrain and about 85% forested. Low density residential development represents approximately 4% of land use, although several large tracts of land could potentially be developed. Lands just to the west of this subwatershed are currently being developed with high density housing. According to the Town of Pittsboro, several landowners surrounding this subwatershed have requested rezoning permits to allow for housing development. Paved roads represent approximately 1.6% of land use and the new Highway 64 Bypass carves through the upper portion of the subwatershed. About 5% of the area is in pasture and hay production. Because a portion of the lower subwatershed is bounded by Highway 64 Business, 1.4% of the land is considered commercial.

NCSU has no monitoring stations located in Subwatershed 3, however, station RC8 is located just downstream of the subwatershed's confluence with Robeson Creek (see Figure 4).

Subwatershed 4

The *Little Creek subwatershed* is 1.7 square miles in size. It is the most urban subwatershed in the Robeson Creek watershed and is comprised of approximately half of the downtown Pittsboro area as well as a long segment of Highway 15-501 and part of Highway 64 Business. The majority of the watershed is forested, however, only at 59%. Low and medium density residential development make up 27% of total land use within the subwatershed. Commercial land use represents 8% and paved roads comprise 2.5% of land use within the area. Curb and gutter make up the majority of storm water flow ways within the commercial district. A few large tracts of land in the headwaters have recently been logged.

Development includes a 148-acre land parcel that lies partially in the northern portion of the watershed on the west side of Highway 15-501. It is a 1,010-unit high density housing development called Powell Place. Just on the east side of Highway 15-501 across from Powell Place is another large mixed-use development called Bellemont Station. Commercial businesses have been built on the north side of this property and housing construction is underway on the south side of the area. The area is approximately 150 acres. South of Bellemont Station is Chatham Forest, a 100-acre housing development that is nearly built out. Houses in this development are built on steep slopes in some cases and the northern most part of the development, which is also contains the steepest terrain, is currently under construction.

NCSU has two monitoring sites located within this subwatershed (see Figure 4). Station LC1 is located at a site above the Town's commercial center and serves as an upstream "background" monitoring site. Station LC2 is located at the confluence of Little Creek and Robeson Creek.

Subwatershed 5

Covering only 1.42 square miles in area, the *Hill Creek subwatershed* is the smallest of the six selected subwatersheds. Within its boundaries, about 51% of the land use is forested while 34% is in low density residential development. Approximately 6% of the subwatershed is in hay and pasture use due to one large beef cattle operation. The southern portion of the watershed is urban with about 3% commercial land use.

A high density housing development called Westmore is planned for approximately 200 acres within this subwatershed. To date, development has not commenced. Within this property lie wetlands associated with Hill Creek and an unnamed tributary. These wetlands are relatively intact based on the watershed assessment.

NCSU has no monitoring stations located in Subwatershed 5.

Subwatershed 6

This predominately rural subwatershed is one of the largest in Robeson Creek watershed, measuring 4.6 square miles in area. Almost 75% of land use is in forested tracts. Pasture makes up 6.5% of land use with scattered small cattle farms located throughout the area. Low density residential development constitutes approximately 13.5% of the subwatershed with several new low to medium density housing developments currently being built. The new Highway 64 bypass divides the subwatershed in half. Both two and four lane roads represent approximately 1.5% of overall land use in this area.

NCSU has no monitoring stations located in Subwatershed 6.

3.5.2 Little Creek subwatershed and Town of Pittsboro

According to previous assessments, the critical areas of nonpoint source phosphorus in the Little Creek subwatershed are associated with urbanization approximately one-half of the downtown Pittsboro area (including commercial and low to medium density residential), and segments of Hwy 15-501 and Hwy 64 Business. Several mixed used developments including Powell Place, Chatham Forest, and Bellemont Station have contributed significant nonpoint source pollutants into Little Creek. Construction on steep slopes and lack of sediment and erosion control has resulted in sedimentation to the creek over the past few years. Development is expected to continue for many years to come. In addition, several large tracts of land in the headwaters are actively managed forestlands and have recently been logged or are in the process of being logged.

Water quality monitoring stations are located along Little Creek (see Figure 4). Further, benthic monitoring along this creek has recently begun by NCSU. Monitoring data collected on this stream will be compared to data collected on an undeveloped segment of Camp Creek to determine baseline information and changes over time.

NCSU will be performing an updated watershed assessment of Little Creek in 2011. This assessment will compare data from the previous assessment to data collected during this assessment. Critical areas will be identified and restoration as well as BMP sites will be located.

All future development in the Little Creek subwatershed should aim for no net increase in nutrient loads based on the Robeson Creek TMDL. New development should implement LID principles and practices. Currently, curb and gutter and storm sewers are the dominant stormwater management practice for the Town. New development should implement grassy roadside swales in place of curb and gutter to the maximum extent possible.

The Town of Pittsboro should develop a Stormwater Management Plan, to include establishment of a watershed council, education program for homeowners and developers, implementation of BMPs, funding strategies, and a time line for implementation. Leaky sanitary sewer lines should be investigated. Pet waste pickup laws should be enacted. Further investigation needs to be performed in the Town of Pittsboro to identify areas or locations for stormwater BMPs, including evaluation of the existing stormwater conveyance system, soil types, and locations with sufficient space to install BMP practices.

Stormwater BMPs will continue to be vital in improving water quality in the Little Creek subwatershed and other tributaries with the Town of Pittsboro. Raingardens, stormwater wetlands, cisterns, permeable pavers, and buffer plantings will be the most beneficial. Landowner education will continue to be important, particularly in the areas of lawn care and buffer maintenance. Enforcement of sediment and erosion control laws need to be a high priority of local and state officials. Stream bank stabilization will be needed in actively eroding areas of the stream and tributaries.

3.5.3 Camp Creek subwatershed

The critical area of nonpoint source phosphorus in the Camp Creek subwatershed is the Townsend Foods spray field/pasture. In 2011, this facility will close completely. The future of the waste lagoon and spray fields is uncertain. However, because of the history of this site and known phosphorus loads into Camp and Turkey Creeks, it will still be considered a critical area. In addition, residential development and small farms are scattered throughout the subwatershed. The following is a general list of practices recommended for rural/agricultural areas. Below this list is a more detailed discussion of recommendations for the Townsend Foods spray field/pasture.

The 130 acres of spray field for the Townsend Foods chicken processing plant is located on sloping land. A cursory observation (during a brief tour of the operation) of the spray field revealed that the area is well vegetated with hay and pasture grasses, which contained a significant amount of fescue (it was winter at the time of the visit). Approximately 100 beef cows are pastured on the surrounding pasture. It is assumed that cattle operations by local farmers will continue despite the plant's closure. Specific soil information for the field and

pasture is not currently available. The fields are bordered by wooded areas that contain intermittent stream channels.

Given the conditions as outlined in the above paragraph, several BMPs would likely be effective at reducing phosphorus runoff. The presence of wooded riparian buffers around the perimeter of the fields likely helps reduce phosphorus levels in runoff by 3075% (i.e., Lowrance et al., 1984; Lowrance et al., 1995). However, ditches through riparian buffers zones often limit the effectiveness of the buffers. Level spreaders, which distribute stormwater runoff from the upland field across the riparian area, could be used to enhance the efficiency of the buffers. For example, monitoring of a wooded riparian zone in the Piedmont region of NC documented a 38% increase in the phosphorus filtering efficiency of the zone with, compared to without, the use of a level spreader (Franklin and Smolen, 1992). Level spreaders can be installed for little cost and usually do not require additional land to be removed from production. Areas where the riparian buffer width is minimal can be widened with tree and other vegetation planting. Grass buffers or field borders can also be installed or enhanced around the perimeter of the area.

A cursory observation indicated little erosion on the sprayfield; however, if there is erosion, a number of BMPs could be used to reduce it. The tendency of phosphorus to attach to, and thereby be transported with, sediment makes erosion control BMPs effective at phosphorus control as well. A more detailed evaluation of the sprayfields and pasture should be conducted to assess the potential for erosion control.

Another BMP option would be a constructed wetland or stormwater detention pond in or along the major drainage-ways from the fields. Constructed wetlands have been shown to reduce total phosphorus concentrations and loads in dairy wastewater effluent by anywhere from 12 to 74%. Reported reductions in phosphorus concentrations and loads of swine wastewater effluent ranged from 33 to 94%. Therefore, the potential for significant reductions in phosphorus runoff is possible using wetlands if the proper hydrologic conditions are present.

If the beef cows have unlimited access to streams in the pasture area, then livestock exclusion may be used to reduce both sediment and phosphorus loads and concentrations from the pasture area. In a 4.2-year monitoring study of a Piedmont NC dairy cow pasture, Line et al. (2000) documented a 58% reduction in total phosphorus loads as a result of livestock exclusion fencing and riparian vegetation establishment. The riparian corridor was 5070 ft on both sides of a 1200 ft reach of a small first order stream. In a similar study in Vermont, Meals (2001) documented a 49% decrease in total phosphorus export as the result of fencing dairy cows in several pastures out of a 28 m wide area along the stream. The two previously mentioned studies also reported significant reductions in sediment, nitrogen, and bacteria associated with cow exclusion. In a study involving beef cows, livestock exclusion fencing was shown to reduce long term (13 years) sediment export from a beef cow pasture in Ohio by 40% (Owens et al., 1996). This sizeable reduction in sediment export would likely also cause a significant reduction in phosphorus export.

A management practice to reduce soil phosphorus levels, if levels are very high, is to plant red clover on part of the spray fields or mixed with fescue. Red clover uses about twice as much phosphorus as fescue and makes a relatively high protein hay for cattle. However, red clover often uses little nitrogen, so this should be taken into consideration. Also, applying the effluent to parts of the pasture or possibly the surrounding woods could be a way to rest the spray field while still filtering the effluent.

Thus, these are several BMP options that could enhance the current treatment effect of the vegetation and soil system; however, the specific plan cannot be developed until additional information about the site is gathered and consultation with the landowners is conducted. Several of these practices are also applicable to other pastures in the watershed.

3.5.4 Turkey Creek subwatershed

As with Camp Creek, the critical areas of nonpoint source phosphorus in the Turkey Creek subwatershed are the Townsend Foods poultry processing plant and spray field/pasture, existing residential development, new construction of residential development, industry, and small farms. A 1000-acre tract of land in the headwaters formerly owned by Weyerhaeuser, Inc., and now owned by a development group was previously logged. Forestry BMPs were adhered to, though a very then row of trees were left as a buffer along the tributaries. The following are general lists of practices recommended for rural/agricultural areas, and for existing developed land and areas under construction. Below these lists is a more detailed discussion of recommendations for the Turkey Creek subwatershed.

With regard to the Townsend spray fields/pasture, see discussion above under Camp Creek subwatershed for suggested practices.

For existing and newly developed neighborhoods in the Turkey Creek subwatershed, homeowners should be educated on ways to reduce nonpoint source phosphorus generation and transport from their yards to receiving streams. This includes pet waste pickup and disposal, eliminating use of phosphate detergents, proper application (type, timing and amount) of lawn fertilizer, use of native plants in landscaping (require less water and nutrients), and regular maintenance of septic systems. In addition, homeowners should consider the use of cisterns for rooftop rainwater collection and reuse (which will reduce stormwater runoff volume and velocity), and also directing rooftop and driveway runoff to bioretention areas, or rain gardens.

For new development, ordinances should be enforced to ensure that existing riparian buffers be maintained and not destroyed. LID site design principles and practices should be employed to the maximum extent possible. The primary objective of LID is to mimic the predevelopment site hydrology by using site design techniques that store (i.e., cisterns, green roofs), infiltrate (i.e., bioretention, permeable pavement, grassy swales), evaporate, and detain runoff (i.e., reduced impervious surfaces). This in turn reduces stormwater runoff volume and velocities, and pollutant load, particularly nutrients and sediment, to adjacent waters. Erosion and sedimentation control practices should be implemented during construction of new

developments to the maximum extent possible. Such practices include sediment basins with skimmer and flocculant, phased grading, seeding of stockpiled soils, and level spreaders down-gradient of the outlet of the sediment basins. Implementation of LID and erosion control practices for new developments in Turkey Creek, particularly in the 1000-acre tract of land in the headwaters, will greatly reduce phosphorus and sediment nonpoint source pollutants from entering Robeson Creek. Future development should aim for no net increase in nutrient loads based on the current TMDL.

3.5.5 Hill Creek subwatershed

Though no monitoring has occurred in this subwatershed, the Westmore development will impact water resources within the area. Wetlands located along Hill Creek and an unnamed tributary within the development property should be protected to the maximum extent possible. Appropriate BMPs for development are described in the previous section.

3.5.6 Southwest Shores of Jordan Lake

Recommendations based on the riparian assessment described in Section 1.3.9 for the three-mile portion of Robeson Creek that flows through the 6,500 acres of land purchased by Preston Development Company follow:

1. Establish an approximately 300 feet conservation easement along the main stem of Robeson Creek. Triangle Land Conservancy or Haw River Assembly could potentially hold easement. The easement could potentially be used for a trail to connect historic Pittsboro and Preston development to Robeson Creek Boat Ramp on federal lands.

2. Maintain upland and riparian buffers to the maximum width possible. Riparian buffers no less than 100 feet on each side of Robeson Creek. Given that this is a major floodplain, wider buffers would accommodate more floodwater storage. Maintaining upland buffers would prevent erosion and runoff from entering the riparian buffer. Maintaining buffers is crucial to preventing this current segment of the creek from becoming listed for biological impairment.

3. Follow Chatham County Riparian Buffer Ordinance for protecting streams, wetlands, seeps and springs throughout the property. This would protect perennial streams with 100 feet buffers, intermittent streams and wetlands with 50 feet buffers, and ephemeral streams, seeps and springs with 30 feet buffers. Ephemeral and intermittent streams funnel the majority of water to larger order streams and should merit protection in addition to the perennial streams.

4. Protect and enhance wetlands and seeps. Robeson Creek has numerous floodplain wetlands and seeps. This not only diversifies terrestrial and aquatic habitat, but also filters water thereby improving water quality.

5. Planting more native vegetation in the buffer will enhance habitat and stabilize streambanks stability. Tree and shrub planting is recommended.

6. Invasive exotic vegetation is abundant in portions of the riparian area. A management plan to control and reduce these populations is recommended.

7. Investigate the potential historic significance of the manmade rock wall and ditch that borders the south side of Robeson Creek on Preston property across from Allen Phillips land.

4 ESTIMATES OF AMOUNTS OF TECHNICAL AND FINANCIAL ASSISTANCE NEEDED

4.1 Technical Needs

Through the efforts of the RCWC, coordination between local, state and federal agencies has been a key to successful implementation and coordination of water quality improvement efforts to date. Continued support from DWQ and EPA at the local levels will ensure streamlined responses to watershed issues as they arise. Local government involvement is also needed; planning departments and public utilities will continue to be crucial components in ordinance strengthening efforts and BMP implementation. Cooperative Extension and Soil and Water Conservation Districts serve as liaisons to the landowners and provide critical knowledge of the watershed. Local nonprofits and universities are important for continued studies as well as monitoring of the Robeson Creek watershed.

4.2 Financial Needs and Potential Funding Sources

Management measures will be ongoing as the population is expected to grow in the area. As a result, funding must come from a variety of sources. As the initial efforts of watershed restoration have gotten underway through grant funding, future efforts must move towards a self-sustaining funding mechanism. Grants should still play an important role in water quality improvement in the watershed; however, local stakeholders and elected officials need to have increasing ownership of clean water. The following lists potential funding sources.

4.2.1 Federal Government

EPA 319 National Nonpoint Source Management Program

Clean Water Act Section 319(h) funds are provided only to designated state and tribal agencies to implement their approved nonpoint source management programs. State and tribal nonpoint source programs include a variety of components, including technical assistance, financial assistance, education, training, technology transfer, demonstration projects, and regulatory programs. Each year, EPA awards Section 319(h) funds to states in accordance with a statebystate allocation formula that EPA has developed in consultation with the states.

USDA NIFA

The National Institute of Food and Agriculture or NIFA, which was formerly Cooperative State Research, Education, and Extension Service (CSREES) sponsors numerous grant-funded programs to advance knowledge for agriculture, the environment, human health and wellbeing, and communities.

USDA cost share programs under NRCS and FSA

EQIP

The Environmental Quality Incentives Program (EQIP) was reauthorized in the Farm Security and Rural Investment Act of 2002 (Farm Bill) to provide a voluntary conservation program for farmers and ranchers that promotes agricultural production

and environmental quality as compatible national goals. EQIP offers financial and technical help to assist eligible participants install or implement structural and management practices on eligible agricultural land.

CRP

The Conservation Reserve Program is a voluntary program for eligible agricultural landowners that provides technical and financial assistance to address soil, water, and related natural resource concerns. Through CRP, landowners can receive annual rental payments and cost share assistance to establish long-term, resource conserving covers on eligible farmland.

WHIP

The Wildlife Habitat Incentives Program (WHIP) is a voluntary program for people who want to develop and improve wildlife habitat on private lands. It provides both technical assistance and cost sharing to help establish and improve fish and wildlife habitat. Participants work with USDA's Natural Resources Conservation Service to prepare a wildlife habitat development plan in consultation with a local conservation district. The plan describes the landowner's goals for improving wildlife habitat, includes a list of practices and a schedule for installing them, and details the steps necessary to maintain the habitat for the life of the agreement.

WRP

The Wetland Reserve Program is a voluntary program and provides landowners with financial incentives to restore and protect wetlands in exchange for retiring marginal agricultural land. To participate in the program landowners may sell a conservation easement or enter into a cost share restoration agreement (landowners voluntarily limit future use of the land, but retain private ownership). Landowners and the NRCS jointly develop a plan for the restoration and maintenance of the wetland.

Urban and Community Forestry Challenge Cost Share Grants

The U.S. Forest Service's Urban and Community Forestry Challenge Cost Share Grant Program seeks to establish sustainable urban and community forests by encouraging communities to manage and protect their natural resources. In particular, the program supports an ecosystem approach to managing urban forests for their benefits to air quality, stormwater runoff, wildlife and fish habitat, and other related ecosystem concerns.

Clean Water State Revolving Fund Program

The CWSRF Program is available to fund a wide variety of water quality projects including all types of nonpoint source and estuary management projects, as well as more traditional municipal wastewater treatment projects. Loans are made to communities of all sizes, individuals, nonprofit organizations, and commercial enterprises.

4.2.2 State Government

NCDENR Division of Forest Resources

Forest Development Program

The Forest Development Program was established to provide financial assistance to landowners for reforestation purposes. These cost share funds are provided on a first come, first serve basis. The program covers approved practices for reforestation, including purchase of seedlings, tree planting and land preparations.

Forest Stewardship Program/Stewardship Incentive Program

The Forest Stewardship and Stewardship Incentive Programs were established to help landowners protect and enhance their forest lands and associated wetlands. The Forest Stewardship Program provides technical assistance to help landowners enhance and protect the timber, fish and wildlife habitat, water quality, wetlands, and recreational and aesthetic values of their property. The Stewardship Incentives Program provides cost share assistance to private landowners of implementing approved practices identified in the management plans developed under the Forest Stewardship Program.

NCDENR and Division of Soil and Water Conservation

Agriculture Cost Share Program

This program helps owner and renters of established agricultural operations improve their on-farm management by using BMPs. The BMPs include vegetative, structural or management systems that can improve the efficiency of farming operations. The results can make farmers more productive while reducing the potential for surface and ground water pollution.

CREP

The Conservation Reserve Enhancement Program (CREP) is a joint effort of the NC Division of Soil and Water Conservation, The Clean Water Management Trust Fund, the NC Ecosystem Enhancement Program, and the USDA to address water quality problems of the Neuse, Tar-Pamlico and Chowan river basins and the Jordan Lake watershed. CREP is a voluntary program that seeks to protect land along watercourses currently in agricultural productions. The aim is to reduce the impacts of sediment and nutrients within the targeted areas and improve wildlife habitat.

CCAP

The Community Conservation Assistance Program is a voluntary, incentive-based program designed to improve water quality through the installation of various best management practices on urban, suburban and rural lands, not directly involved in agricultural production. CCAP consists of educational, technical and financial assistance provided to landowners by local soil and water conservation districts.

DWQ

Clean Water Management Trust Fund
The Clean Water Management Trust Fund makes grants to local governments, state agencies and conservation nonprofits to help finance projects that specifically address water pollution problems. CWMTF will fund projects that enhance or restore degraded waters, protect unpolluted waters, and/or contribute toward a network of riparian buffers and greenways for environmental, educational, and recreational benefits.

Ecosystem Enhancement Program
The NC Ecosystem Enhancement Program (NCEEP) is a non-regulatory program that aims to protect and restore wetlands, streams and streamside areas throughout the state. The NCEEP offers many benefits to landowners interested in protecting and restoring wetlands, streams and riparian areas on their property. The NCEEP may pay up to 100% of the costs of restoration. The NCEEP can also acquire property by a fee simple purchase, by donation (for tax credits), or through purchase of a permanent conservation easement.

4.2.3 Local municipalities

The Town of Pittsboro and Chatham County may have funds available for various projects depending on needs and budget constraints. They have provided in-kind service on past BMP projects and have cost-shared projects such as raingardens.

4.2.4 Fee funded storm water utility

Local governments have funded stormwater pollution measures through charging inspection and permit fees, collecting dedicated contributions from land developers, taxing new development at an increased rate, forming regional stormwater management districts, and creating stormwater utilities. Stormwater utilities are a well-established, efficient, and feasible financing option that provides a dedicated revenue source for stormwater management.

4.2.5 New development impact fees

Development impact fees are one-time charges applied to offset the additional public service costs of new development. They are usually applied at the time a building permit is issued and are dedicated to provision of additional services, such as water and sewer systems, roads, schools, libraries, and parks and recreation facilities, made necessary by the presence of new residents in the area. They are essentially user fees levied in anticipation of use, expanding the capacity of existing services to handle additional demand.

5 INFORMATION AND EDUCATION COMPONENT

Public participation and education plays a crucial role in any watershed restoration effort, and will be a key feature in implementation of the restoration of the Robeson Creek watershed. The success of achieving clean water will be highly dependent on the level of interaction between state and government officials and local stakeholders, and the willingness of landowners to allow installation of BMPs on their property. In addition, it is crucial that a shared sense of responsibility be cultivated for reducing nutrient and sediment pollutants, for developing and maintaining partnerships, and for fostering voluntary implementation of BMPs. The Robeson Creek Watershed Council should coordinate and facilitate informational and educational efforts throughout the watershed. The following lists recommended programs to continue these efforts.

5.1 Robeson Creek Watershed Council

The RCWC has served as the clearinghouse for education and outreach programs. Through combined efforts of stakeholders serving in the council, multiple educational opportunities are offered each year throughout the watershed. The RCWC should continue its role as facilitator and coordinator of activities and programs to ensure streamlined successful educational endeavors.

5.2 Stewards Program

The goal of the Robeson Creek Stewards program is to promote community stewardship by encouraging businesses, local government agencies, schools, youth groups and home owner associations to voluntarily participate in reducing phosphorus and sediment runoff by implementing stormwater BMPs and to implement aquatic habitat protection and restoration. The Robeson Creek Stewards committee comprised of local business owners and government agencies that oversee the program. The Robeson Creek Stewards program works to obtain quantifiable data that can be used to evaluate the progress being made within the Robeson Creek watershed in reducing the amount of stormwater entering into the creek and in improving the aquatic habitat. A key component of the program is to establish a system for recordkeeping for tracking annually both the amount of phosphorus and sediment reduced as well as the area of aquatic habitat improved. Data will be gathered from participants using applications for recognition as Robeson Creek Stewards for pollution prevention and for aquatic habitat enhancement.

5.3 NC Cooperative Extension

NC Cooperative Extension has an extensive publication library on water quality issues. More information can be found at http://www.ces.ncsu.edu/. Local agents have been highly involved in Robeson Creek educational campaigns such as LID workshops and BMP workshops. They also serve as a key participant in the RCWC. Continued leadership of the local extension office would greatly benefit restoration efforts in the watershed.

5.4 Soil and Water Conservation District

The Chatham County Soil and Water Conservation District presents various educational programs throughout the year for both local schools and landowners. They interact one-on-one with landowners on various issues regarding soil and water throughout the county. They also help administer the Envirothon program for school age children. This program teaches students a wide array of material regarding all aspects of the environment.

5.5 Pittsboro Stage One Stormwater program

The Town of Pittsboro entered into an inter-local agreement with Chatham County to jointly meet the minimum requirement of the Jordan Lake Rules with respect to the Stage One Stormwater Rules. The inter-local agreement and the document *A Joint Stage One Adaptive Management Program for Existing Development in the Jordan Lake Watershed* is available on the Chatham County website at http://www.chathamnc.org/Index.aspx?page=1365.

Chatham County and Pittsboro's Stage One Program includes a public education program, a plan for identifying and removing illegal discharges, a BMP maintenance program, and a plan for identifying opportunities for retrofits and other projects to reduce nutrient loading. Neither Chatham County nor the Town of Pittsboro is an MS4 pursuant to the NPDES Phase 2 regulations and do not operate stormwater sewer systems so did not propose to do any mapping of outfalls under their Stage One Stormwater program. A brief description of Pittsboro's involvement in the Stage One Program is given below. This program was approved by DWQ.

Public Education

- Contributing partner in the Clean Water Education Partnership (CWEP), a regional water quality public education and participation program.
- Contributing partner in the Chatham Conservation Partnership (CCP), which includes water quality education outreach to the public. Details of the CCP program are available on the CCP wikispace at http://chathamconservation.wikispaces.com/.
- Participation in the RCWC activities performing research, retrofits, outreach and public education for water quality improvements in the Robeson Creek Watershed.
- Signage at town parks concerning water quality, riparian buffers and stormwater management.

Identify and Remove Illegal Discharges

Pittsboro will enact an Illicit Discharge ordinance in Year 2 (2011) of the program that will include the following BMPs for illicit discharge detection elimination:

- Establish and maintain appropriate legal authorities.
- Implement illicit discharge detection procedures.

- Employee training.
- Public education.
- Public reporting mechanism.

BMP Maintenance Program

The Town of Pittsboro will enact a storm water ordinance in Year 3 of the program (2012) that will include the following BMPs for a BMP Maintenance Program:

- Legal mechanism to require BMP's and long term operation and maintenance of structural BMPs.
- Legal mechanism to require annual inspections of structural BMPs.
- Training program for both employees and the general public.
- Mechanism to maintain an inventory of structural BMPs.
- Mechanism for annual review of the Operation and Maintenance (O&M) program.

Opportunities for Retrofits and Other Project to Reduce Nutrient Loading

The Town of Pittsboro currently has 7 retrofit BMP's designed and constructed in the Robeson Creek watershed. They plan to inspect and maintain these BMPs to ensure they are operating properly for full nutrient credits in the future, if necessary. Also Pittsboro will begin to add to Chatham County's BMP Retrofit Planning Map in Year 1 (2010) of the program and will continue to do so at a rate of at least two per year.

5.6 Haw River Assembly

The HRA continues to work to educate the Pittsboro community on stream stewardship. The Pittsboro community will be involved in the monitoring of the health of Robeson Creek Watershed through the HRA's volunteer Stream Watch program. Four-H, scout troops, and other community groups will be invited to participate in annual stream cleanups and in the planting of stream buffers and rain gardens. HRA also leads the Stewards Awards program that recognizes businesses and other landowners for good water quality practices and the implementation. HRA supports NCSU in their educational efforts through workshops, tours, education programs, and newsletters.

6 SCHEDULE FOR IMPLEMENTING THE NPS MANAGEMENT MEASURES

Table 9 describes the recommended management measures and time frame in which they will be implemented. The listed measures are part of a 10-year action plan to continue improving water quality in the watershed. Most measures will be installed on a 5 to 10 year basis depending on levels of funding and support. The RCWC will continue to spearhead these efforts.

7 MANAGEMENT MILESTONES

7.1 Robeson Creek TMDL

Water quality monitoring is continuing to determine if management measures are helping reduce TP loads based on the 2003 TMDL. Though the TMDL specifies a 71% reduction in nonpoint source TP during the summer months, the Robeson Creek Watershed Restoration Plan recommends actual reduction targets be based on a 10-year management plan based on annual measurements. The 10-year goal for TP reduction is 30% based on current 2011 loading rates. To help achieve this goal, additional reduction goals have been set including an annual 15% reduction in peak stormwater flow (based on 2010-2011 median peak flow rates) and an annual 30% reduction in TSS. The target year for these reductions is 2021. These loading targets are discussed in detail in section 3.0.

7.2 Important Dates from the Jordan Lake Nutrient Strategy

The dates listed here are the dates from the Jordan Lake Nutrient Strategy that are important with regards to Pittsboro and the Robeson Creek watershed. The Jordan Lake Rules were assumed effective August 11, 2009.

Stormwater Rules – New Development

- **February 2011**: DWQ submits model stormwater program, including model ordinance and accounting tool for nutrient loading.
- **September 2011**: Local governments submit stormwater programs for review

Stormwater Rules – Exisiting Development

- **December 31, 2009**: Local governments must submit their Stage One program.
- **March 1, 2017**: If monitoring report shows impairment of the Haw River, Stage Two program must be developed and implemented.

Fertilizer Management Rules

- **August 2012:** Fertilizer application shall be made by an applicator that has completed nutrient management training or pursuant to a nutrient management plan.

Riparian Buffer Rule

- **August 11, 2009**: DWQ begins implementing riparian buffer rules in its jurisdiction.
- **October 2009**: DWQ made model buffer ordinance available to local governments.
- **May 2010**: Local governments submitted local buffer programs for DWQ review.

Wastewater Discharge Rules

- **February 2010**: WWTP submitted optimization reports.
- **August 2010**: WWTP implemented optimization.
- **2010**: Compliance for phosphorus limits.
- **2016** compliance for nitrogen limits.

7.3 Aquatic Habitat

High nutrient loading, urban stormwater runoff, and sedimentation are several factors that contribute to impaired aquatic habitat in the Robeson Creek watershed. NCSU monitoring has documented high TP and N levels, high stormwater flows, and high TSS loads.

High nutrient loading leads to diversity and more abundance in more pollutant tolerant benthic macroinvertebrate species. High stormwater flows lead to scouring of benthic habitats leading to an overall decrease in benthic ratings. High loads of TSS create poor water quality and critically impair habitat due to a loss of rifle habitat.

A TMDL for aquatic habitat impairment is pending development. However, annual benthic macroinvertebrate monitoring performed by NCSU will assist in determining whether milestones are being met. Milestones based on the 10-year management plan (2011-2021) are as follows:

- Change biotic index rating from Poor and/or Fair to Good/Fair
- Increase richness values
- Reduce annual TP loads by 30% of current 2011 levels
- Reduce annual TSS loads by 30% of current 2011 levels
- Reduce annual peak stormwater flows by 15% of median 2010-2011 levels

8 LOADING REDUCTION ACHIEVMENT CRITERIA

8.1 Robeson Creek Watershed Plan Reduction Goal for Total Phosphorus

The phosphorus reduction goal based on realistic current and future efforts within the watershed is a 30% reduction in annual TP load to the downstream monitoring site RC8. This level of reduction is such that, even with the variability, if achieved it should be statistically significant and have an impact on the downstream Jordan Lake cove. To achieve this goal, a combination of education, BMP implementation, and land use planning efforts are being conducted.

8.2 Robeson Creek TMDL Target for Total Phosphorus Reduction

The phosphorus load reduction reported in the TMDL for the entire Robeson Creek watershed was 71% for both nonpoint and point source loads as measured during the summer months. Achieving this goal would require implementation of nonpoint and point source controls over the entire watershed at a cost of likely millions of dollars. Because this watershed projects implemented to date have not had these resources and have focused on the more urban areas of the watershed (which were identified in the TMDL as contributing most of the TP during the critical summer months), the goal for this current effort as well as future efforts is a 30% reduction in TP annual load to monitoring station RC8 (see Figure 4).

8.3 Jordan Lake Reduction Goal for Nitrogen

The nutrient reduction goal for the Haw River Arm of Jordan Lake is an annual 5% reduction for phosphorus and an 8% reduction for nitrogen. If the March 1, 2017, monitoring report or any subsequent monitoring report shows that nutrient-related water quality standards are not being achieved, a Stage Two stormwater program must be developed and implemented that shall include existing development.

9 MONITORING COMPONENT

9.1 NCSU Stormwater Monitoring Network

9.1.1 Monitoring Plan

NCSU began monitoring water quality in 2001 as part of the TP TMDL effort. The purpose of water quality monitoring associated with the TMDL implementation plan for Robeson Creek was basically to 1) determine if the TP TMDL was being met or on the way to being met and to 2) help guide the pollutant reduction effort required to meet the TP TMDL for Robeson Creek.

The ultimate measure of whether the TMDL was being met and the impairment reversed would be to initially monitor the cove at the confluence of Robeson Creek and Jordan Lake. However, because discharge could not be readily measured in the cove, the phosphorus load could not be determined. Additionally, in-lake or cove phosphorus concentrations may or may not respond as expected to reductions in phosphorus loading due to internal loading or other dynamics of the system. Hence, monitoring to determine if the 2003 TMDL for Robeson Creek is being met is occurring at station RC8 just upstream of where the impairment occurs (see Figure 4). The monitoring of the cove focuses on the summer months when the impairment is occurring. But for pollutants such as sediment and phosphorus, it is also important to determine loading during the winter months as these pollutants can remain in the system until the summer. For Robeson Creek, monitoring of the cove is continuing to be conducted by DWQ, while monitoring upstream throughout the watershed is being conducted by NCSU.

Additional monitoring is occurring throughout the Jordan Lake watershed to evaluate progress in reducing nutrient and nutrient related pollution in Jordan Lake as required by Section 3(c) of the Jordan Rules (S.L. 2009-216). N.C. Division of Water Quality has to conduct monitoring in Jordan Lake and to report results "until such time as the lake is no longer impaired by nutrient pollution." (see Jordan Lake Watershed Assessment Plan, http://portal.ncdenr.org/web/jordanlake/12). Nine monitoring stations are being sampled twice monthly during the growing season (May - September) and monthly during the non-growing season with in Jordan Lake. Three of these stations are in the Haw River Arm of Jordan Lake and are downstream of the confluence of Robeson Creek with the Haw River. Parameters that are being evaluated are chlorophyll *a,* nutrients (TP, TKN, NH_3, NO_2+NO_3), Turbidity, temperature, pH, dissolved oxygen, and conductivity.

Monitoring to help guide the pollutant reduction effort is more complicated and intensive. This monitoring is conducted to determine where most of the pollutant loading is originating and whether management/treatment efforts are being successful or whether they need to be redirected to other drainage areas. Ideally, monitoring every major tributary in the watershed for at least a year and then comparing the loads would be the best way to find out where the pollutants are coming from and prioritize reduction efforts; however, this is often time and cost prohibitive. Therefore, gathering land use, soils, topographic, land activity, and existing monitoring data for use in narrowing down pollutant sources and the tributaries of concern is needed. The result of this data gathering and assessment in Robeson Creek was that Turkey,

Little, and Camp Creeks were major contributors of NPS phosphorus and needed to be further evaluated. Hence, monitoring sites TC3 and TC1 on Turkey Creek, LC1 and LC2 on Little Creek, and CC3 and CC2R on Camp Creek were established. Unfortunately, site TC1 had to be abandoned after about a year of monitoring due to repeated flooding. Sites TC3 and CC3 had to be abandoned in April, 2009 due to the loss of landowner permission. These sites were moved upstream on each creek to new sites (TC2 and CC2). The upstream/downstream configuration of monitoring sites serves to isolate sections (i.e. upper, middle, and lower) of the drainage area to determine which of the sections is contributing disproportionate amounts of pollutants.

A background comparison site upstream of most pollutant sources is also valuable to establish the level of pollutant loading that should be possible in the absence of significant pollutant sources. In Robeson, this site was RC1, which is upstream of most known sources of phosphorus.

At each monitoring site, storm and non-storm event samples are collected. Numerous studies have shown that the majority of nonpoint source pollutant loading occurs during storm events; thus, storm event loads cannot be ignored. Flow proportional samples are collected by automated samplers during storm events when discharge is also monitored continuously. Because of the variability between events and seasonal activities, at least 50% of the storm events distributed over each season of the year, generating significant runoff during the period of monitoring, are being monitored and sampled. Regression relationships have been established from the monitored storms to estimate loads from the storms not monitored for most drainage areas. Even with these relationships, rainfall and runoff are being monitored continuously. A minimum of two years of monitoring is required to adequately establish loading rates; however, three to five years is needed to establish a water quality trend.

In addition to storm samples, monthly grab samples are collected from each site when there is sufficient discharge. Results from these samples along with continuous discharge data are used to compute the non-storm load for the month.

Storm and non-storm samples are analyzed for TP, while non-storm samples are also analyzed for dissolved phosphorus. Filtering and holding time limitations prevent storm-event samples from being used for dissolved phosphorus analysis. The dissolved or readily available phosphorus is often considered a more accurate measure of phosphorus available to algae and other plants that affect the cholorphyll *a* levels of the cove. The total phosphorus analysis includes phosphorus bound to sediment and to plant tissue, which are both generally unavailable to aquatic plants. Samples are analyzed for total suspended solids or suspended sediment as phosphorus is often bound to sediment. Analysis of samples for nitrogen forms can be conducted to provide additional information to help identify types of pollutant sources and whether certain types of nonpoint sources are being controlled. Samples collected in Robeson Creek are being analyzed for all these pollutants due to the mixture of point and nonpoint sources and the unknown nature of the nonpoint sources.

The duration of monitoring needed to adequately establish pollutant loads and water quality trends is the subject of considerable debate. A minimum of two years of monitoring storm and non-storm discharge should be conducted to establish loads from tributaries and the main stem for comparison. Seasonal and annual variability combine to require several years of monitoring. If pollution controls are being implemented, three to five years of monitoring is needed to establish a trend. Often stream systems require several years to flush pollutants out of the system depending on the complexity of the hydrology. For statistical robustness, the monitoring should be continuous from the time it begins prior to the implementation of pollutant controls to three to five years after most of the controls have been installed.

Explanatory parameters including discharge, rainfall, and land use should also be monitored. Discharge is being monitored continuously at each monitoring site in order to compute pollutant loads and understand the hydrology of the watershed. Rainfall is monitored to help explain nonpoint source pollutant loads and to provide data for development of rainfall-discharge relationships, which can help fill in gaps in discharge data when equipment fails. Land use data can help explain continued loading of phosphorus even when nonpoint sources have been controlled. For example, conversion of forest to homes can increase phosphorus loading even as sources of phosphorus from agricultural sources have been controlled. Also, monitoring or assessing stream bank stability and erosion may be a useful component as some sediment and possibly phosphorus may enter streams from streambank erosion, which could also cause continued or increased phosphorus loading even when upland sources have been controlled.

9.1.2 Ambient Water Quality Monitor

In September, 2002, the NCSU Water Quality Group began a monitoring program in Robeson Creek. This program included establishing 8 stream monitoring sites (see Figure 4) in the watershed. Two of the sites are on Robeson Creek itself and serve to document water quality conditions upstream (RC1) of most pollutant sources and then downstream (RC8) of most sources. Monitoring sites on 3 of the major tributaries were also established: upstream (TC1) and downstream (TC3) on Turkey Creek; upstream (LC1) and downstream (LC2) on Little Creek; near the outlet of Camp Creek (CC3) and on a tributary to Camp Creek (CC2R). TC1 was later discontinued and TC3 and CC3 had to be relocated in 2009. Two additional sites were added on a tributary to Little Creek in 2010. Two monitoring stations were installed upstream and downstream of Town Lake in 2010 to monitor water quality pre- and post-construction of the lake restoration project. Monthly grab sampling has been conducted at all sites since the start of monitoring. Samples were analyzed for total kjeldahl nitrogen (TKN), nitrate nitrogen (NO_3N), ammonia nitrogen (NH_3N), total phosphorus (TP), dissolved phosphorus (OP), and total suspended solids (TSS) using standard methods.

To date, continuous monitoring using automated samplers haves been established at 11 sites. Stage discharge rating tables have been established at each of the sites to allow for the computation of discharge from continuous monitoring of water depth. Flow-proportional samples have been collected during several storm events and analyzed for the same list of

analytes as the grab samples. A recording raingage which documents rainfall accumulation in 15-minute intervals was installed in the watershed.

9.1.3 Benthic Monitoring Sites

NCSU established nine benthic macroinvertebrate monitoring stations within the Robeson Creek watershed (see Figure 12). The nine stations selected include:

Robeson Creek:

- Robeson Creek at Alston Chapel Road. This is the most upstream monitoring location in the Robeson Creek catchment. The stream is very small at this point and may have stopped flowing during the drought of 2007.
- Robeson Creek upstream of NC 15/501 Bridge. This site is downstream of the confluence with Little Creek, which has BMPs planned for the catchment.
- Robeson Creek near Mark Hewitt's Farm near Hanks Chapel Road (SR 1943). This is the most downstream monitoring location in the catchment and coincides with benthic data collected by the NC Division of Water Quality.

Little Creek:

- Little Creek at Oakwood Drive. This is the most upstream location in this catchment. The stream is very small at this point and receives nonpoint source runoff from upstream activities.
- Little Creek north of US Highway 64 Business off of Rectory Street. This site was selected in a suburban reach of the catchment.
- Little Creek west of 15-501 off of West Chatham Street. This monitoring location is below the BMP planned to be implemented in the catchment.

Turkey Creek:

- Turkey Creek at Pittsboro/Moncure Road. This monitoring location was chosen to coincide with previous water quality investigations by the NC Division of Water Quality and NCSU. This location was moved slightly upstream during the 2009, 2010 and 2011 investigations.

Camp Creek:

- Camp Creek #1. This is the most upstream site in the catchment and is downstream of NC Hwy 87. The stream is very small at this point and may dry up during drought conditions.
- Camp Creek #2. This location was selected as a reference catchment and is located upstream of Moncure Pittsboro Road (SR 1012) at the site of DWQ's Camp Creek upstream site.

Collection Methods: The collection method was selected to mimic those used by the NC Division of Water Quality (NCDWQ 2006). These methods include collection of a kick net sample from the riffle habitat, a sweep net sample from a productive bank area, a leaf pack and conducting visual inspection of all habitat types for rare or cryptic organisms. All taxa (rather

than just EPT taxa) are "picked" in the field and preserved for identification. This method is termed the Qual 4 collection method in the DWQ protocol document. Organisms are then categorized as Abundant (10 or more specimens), Common (3 to 9 specimens) and Rare (less than 3 specimens). Field collection of the benthic macroinvertebrate samples was conducted cooperatively with researchers from the Haw River Assembly during both the 2008, 2009 and 2011 investigations with plans to continue monitoring through 2012 or longer depending on funding availability.

9.2 DWQ Monitoring Data

As part of the TMDL development process, DWQ monitored water quality of Robeson Creek and two of its tributaries, Turkey Creek and Camp Creek, from December 2000 to August 2002. DWQ granted Section 319 funding to the NCSU Water Quality Group to perform a watershed assessment for Robeson Creek and to develop a TMDL Implementation Plan to address meeting NPS load allocations for TP.

9.2.1 Surface Water Monitoring

The NC DENR Division of Water Quality conducted chemical and physical monitoring of waters in the Robeson Creek watershed from December 2000 to August 2002. Grab sampling and instantaneous discharge measurements were taken at least once per month at the following sites (see Figure 14):

RC4	Roberson Creek at the Hwy 15/501 bridge in Pittsboro
RC5ups	Roberson Creek WWTP upstream monitoring site
RC5eff	Roberson Creek WWTP effluent outfall site (#NC0020354)
RC5dns	Roberson Creek WWTP downstream monitoring site
TC1	Turkey Creek at Hwy 15/501 (upstream from Townsend Foods)
TC2	Turkey Creek at SR1012 (downstream from Townsend Foods)
TC3	Turkey Creek 100 feet upstream Roberson/Turkey confluence
CC2 left	Camp Creek upstream of tributary draining Townsend Foods
CC2 right	Unnamed tributary draining Townsend Foods property
CC2 bridge	Camp Creek at SR1012 (downstream from Townsend Foods property)
CC3	Camp Creek 100 feet upstream from Roberson/Camp confluence
RC8	Roberson Creek at flow rating site near Lucian Bland Rd.
RC10	Roberson Creek arm at boat ramp (ambient site #B2450000)
RC11	Roberson Creek arm at 0.5 mi downstream from RC10

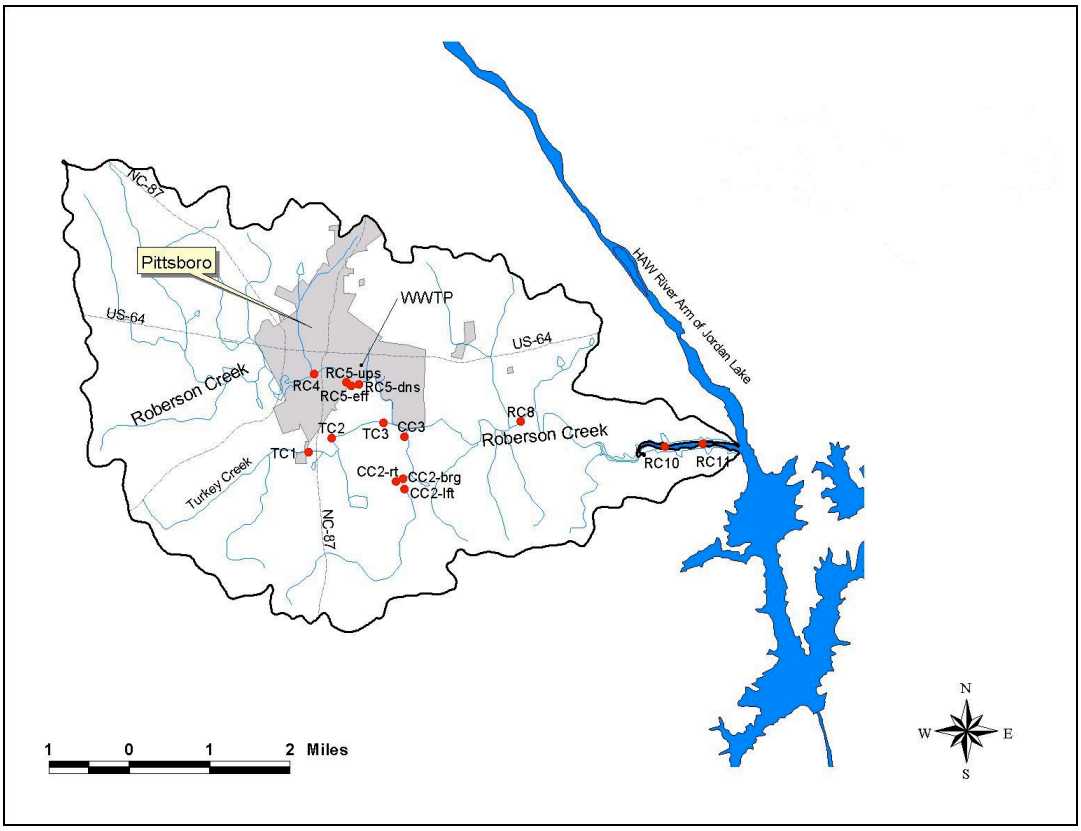

Figure 14. DWQ monitoring stations in Robeson Creek watershed.

Grab samples were analyzed for many parameters including total Kjeldahl nitrogen (TKN), nitrate + nitrite nitrogen (NO_X), ammonia nitrogen (NH_3N), total phosphorus (TP), and total nitrogen (TN). The average of all the samples are shown in Table 4. For concentrations less than the method detection limit (MDL), half of the MDL was used in computing the mean.

For sites on Robeson Creek itself, three sites focused around the Pittsboro WWTP. Comparing the upstream (RC5ups), effluent (RC5eff), and downstream (RC5dns) sites shows that there are considerable increases in nitrogen and phosphorus concentrations at Robeson Creek sites associated with the WWTP effluent. Because these sites (RC5ups and RC5dns) are close together, the probability that other sources of N and P, or changes in discharge, affected the concentration data is negligible. At the downstream most site (RC8), mean nitrogen and phosphorus concentrations had decreased considerably from the RC5 site, most likely due to dilution of concentrations from influent tributary waters. Mean pollutant concentrations at RC8 were greater than at the RC5ups site, indicating significant source(s) of pollutants between the sites.

Turkey Creek and Camp Creek enter Robeson Creek between sites RC5ups and RC8, which may account for some of the increased pollutant levels at RC8. The mean TP concentration at the outlet of Turkey Creek (TC3) was less than half the concentration at RC8, but still somewhat elevated. Given the increase in TP concentrations upstream to downstream in Turkey Creek, it

appears that much of the TP in the creek enters the stream around the Townsend Foods processing plant. The mean concentration of TP at the outlet of Camp Creek (CC3) was similar to RC8, more than twice as high as TC3. Using only this data, it appears that Camp Creek may be contributing more TP to RC8 than Turkey Creek. However, differences in discharge and other factors such as storm event loading need to be examined to confirm this assertion. NCSU is undergoing such monitoring, with preliminary results presented in the section below.

Table 10. Mean values for Robeson Creek monitoring data (DWQ 2/016/02).

Site	NH_3 mg/L	TKN mg/L	NOX mg/L	TP mg/L	TN mg/l	Flow cfs	Samples
Robeson Creek							
RC5ups	0.10	0.43	0.27	0.07	0.73	1.6	24
RC5eff	0.19	2.05	26.12	2.47	29.77	NA	22
RC5dns	0.17	0.90	10.08	0.91	10.71	2.2	26
RC8	0.18	0.74	2.81	0.26	3.61	44.2	44
Turkey Creek							
TC1	0.12	0.43	0.15	0.08	0.55	0.5	24
TC2	2.92	3.60	1.41	0.62	5.14	0.6	26
TC3	2.23	4.89	1.00	0.12	7.36	0.5	17
Camp Creek							
CC2L	0.09	0.43	0.30	0.21	0.85	0.4	21
CC2R	2.63	4.98	1.74	1.28	10.31	0.3	15
CC2B	1.58	2.78	1.86	0.72	8.00	0.5	9
CC3	0.08	0.45	0.21	0.22	0.73	0.4	18
Jordan Lake							
RC10	0.09	0.98	0.30	0.11	1.34	NA	22
RC11	0.03	1.07	0.20	0.09	1.32	NA	13

9.2.2 Benthic Monitoring Data

DWQ Biological Assessment Unit has sampled the following seven sites within the Robeson Creek watershed for benthic macroinvertebrates:

TC1 Turkey Creek at US 15/501 above Townsend Foods
TC2 Turkey Creek at SR 1012 below Townsend Foods
TC3 Turkey Creek 100ft upstream of Robeson Creek confluence (~ 1 mile downstream of TC2)

CC1 Camp Creek just above SR 1012 (does not receive runoff, Surface Water Monitoring (SWM) site CC2 left)
CC2 UT Camp Creek just above SR 1012 (receives runoff, SWM site CC2 right)

RC3 Robeson Creek 100ft upstream of Turkey Creek confluence
RC5 Robeson Creek at flow rating site near Lucian Bland Road (SWM site RC8)

A TMDL is pending for aquatic habitat impairments; however at this time sampling locations and methods for that effort are undetermined.

10 NEXT STEPS

Based on the 10-year management plan, many more BMPs will have to be installed to meet the target pollutant loading reductions. Recommended and planned measures are listed in Table 8. The Town of Pittsboro in conjunction with the RCWC should continue to move forward and build upon work completed in the watershed. Given the timeline for the Jordan Lake Rules as well as the Robeson Creek TMDL for TP, all stakeholders will need to be even more engaged in the water quality improvement effort. Funding sources need to be considered and obtained early in the management implementation phase.

Educational campaigns should remain a high priority. Working with schools, teachers, local businesses, landowners, homeowners, and officials, the RCWC can continue to build a network of ongoing participation and education that will build upon itself. The Stream Stewardship Program, water-wise landscaping, lawn maintenance workshops, and forestry BMP workshops can be of great benefit to the watershed. Cooperative Extension, SWCD, and HRA can lead these efforts.

Strengthening of local ordinances to protect water quality should continue. As the Town of Pittsboro grows, LID implementation of new developments has the potential to greatly reduce pollutants flowing to surface waters. Incorporation LID practices into local ordinances is recommended.

The Town of Pittsboro is encouraged to implement a local stormwater program and a sediment and erosion control program. As part of a stormwater program fee-based revenues will help the program pay for itself. A sediment and erosion control program will give the town more control over sedimentation violations; they can respond more quickly and deal with the issues directly. Considering the high inputs of stormwater as well as TSS into the watershed, this plan recommends the town make creating these two programs a top priority.

Critical areas specified in Section 3.5 should be a main focus of water quality protection and improvement efforts. Coordination with large landowners such as Preston Development Corporation and 3M is strongly encouraged to protect water quality resources within large areas of land. Additionally, other developers in the watershed should be engaged in the stakeholder process. RCWC can work with various developers to help them incorporate water quality preservation and protection measures into their plans.

11 LITERATURE CITED

Center for Watershed Protection (CWP). 1998. Better Site Design: A Handbook for Changing Development Rules in your Community. Ellicott City, MD: CWP. www.cwp.org/PublicationStore/bsd.htm

Chatham County and Town of Pittsboro, A joint Stage One Adaptive Management Program for Existing Development in the Jordan Lake Watershed, Submitted to NCDENR DWQ on December 15, 2009.

Decisions: The TMDL Process. Assessment and Watershed Protection Division, Washington, DC.

Franklin, E.C. and M.D. Smolen. 1992. Enhancement of the Effectiveness of Forested Filter Zones by Dispersion of Agricultural Runoff. UNCWRRI92270. UNC Water Resources Research Institute. Raleigh, NC.

Hydrostructures, P.A., Memorandum to Paul Clark on Pittsboro Sewer Rehabilitation History, September 20, 2010.

Hall, K., L. Lombardo, and D. Line. NCSU Water Quality Group, Robeson Creek Watershed Assessment, December 31, 2004.

Hall, K., L. Lombardo, D. Line, P.E., and D. Wise. NCSU Water Quality Group, Robeson Creek TMDL Implementation Plan, August 4, 2003.

Line, D.E., W.A. Harman, G.D. Jennings, E.J. Thompson, and D.L. Osmond. 2000. Nonpoint Source Pollutant Reductions Associated with Livestock Exclusion. J. Environmental Quality 29:1882-1890.

Line, D.E., W.A. Harman, G.D. Jennings. Comparing Sampling Schemes for Monitoring Pollutant Export From A Dairy Pasture. 1998. J. American Water Resources Association 34(6):1265-1273.

Lowrance, R., L.S. Altier, J.D. Newbold, R.R. Schnabel, P.M. Groffman, J.M. Denver, D.L. Correll, J.W. Gilliam, J.L. Robinson, R.B. Brinsfield, K.W. Staver, W. Lucas, and A.H. Todd. 1995. Water Quality Functions of Riparian Forest Buffer Systems in the Chesapeake Bay Watershed. U.S. Environmental Protection Agency, Washington, D.C. EPA 903R95004/CBP/TRS 134/95.

Lowrance, R.R., R.L. Todd, J. Fail, O. Hendrickson, R. Leonard, and L. Asmussen. 1984. Riparian Forest as Nutrient Filters in Agricultural Watersheds. Bioscience 34:374-377.

Meals, D.W. 2001. Lake Champlain Basin Agricultural Watersheds Section 319 National Monitoring Program Project: Final Report. Vermont Dept. Environmental Conservation, Water Quality Division. Waterbury, VT.

NC Division of Water Quality (DWQ). 2006. Standard Operating Procedures for Benthic Macroinvertebrates. NC Department of Environment and Natural Resources. Environmental Sciences Section, Biological Assessment Unit. Raleigh, NC.

NCDENR DWQ Biological Assessment Unit, Memorandum from Kathy Herring to Jimmie Overton on Macroinvertebrate Collections in Conjunction with Water Quality Surveys Conducted in Robeson Creek, Chatham County, Cape Fear River Subbasin 04, November 20, 2001.

NCDENR DWQ Water Quality Section, Total Maximum Daily Load (TMDL) for Total Phosphorus for Roberson Creek Subbasin 03-06-4 Cape Fear River Basin, North Carolina, Final Report August 2003, approved by EPA January 2004.

NCDENR DWQ, B. Everett Jordan Reservoir, North Carolina Phase I Total Maximum Daily Load, EPA approved September 20, 2007.

NCDENR EEP, Estimating/Calculating Riparian Buffer Credits, May 4, 2008.

NCSU Water Quality Group, Town Lake Restoration Study, May 2007.

NCSU Watershed Education for Communities and Officials on behalf of the Town of Pittsboro, Town of Pittsboro Better Site Design Ordinance Review, January 2010.

Owens, L.B., W.M. Edwards, and R.W. Van Keuren. 1996. Sediment Losses from a Pastured Watershed Before and After Stream Fencing. J. Soil and Water Conservation 51(1):90-94.

Raleigh Regional Office, Robeson Creek Restoration Project Raleigh Regional Office SWP and AP: Status Report, October 2008.

Rosgen, D. 1996. Applied River Morphology. Wildland Hydrology, Pagosa Springs, CO.

Town of Pittsboro, NC, Draft Environmental Impact Statement Proposed Wastewater Treatment Plant and Discharges into Robeson Creek and the Haw River, Submitted NCDENR DWQ Planning Branch September 30, 2009.

Town of Pittsboro, NC, Status of Capital Projects, Presented to Pittsboro Commissioners by William Terry on January 10, 2011.

Town of Pittsboro, NC, Status of Capital Projects, Presented to Pittsboro Commissioners by William Terry on March 22, 2010.

Triangle Land Conservancy and The Center for Sustainable Community Design, Institute for the Environment, University of North Carolina, Southwest Shore Conservation Assessment, Chatham County, NC, October 2008.

U.S. Environmental Protection Agency (USEPA). 1991. Guidance for Water Quality-Based . Guidance for Water Quality Based Decisions: The TMDL Process. Assessment and Watershed Protection Division, Washington, DC.

U.S. Environmental Protection Agency (USEPA). 2008. Handbook for Developing Watershed Plans to Restore and Protect Our Waters. Office of Water, Nonpoint Source Control Branch, Washington DC 20460. EPA 841B08002.

Wossink and Hunt (2003) The Economics of Structural Stormwater BMPs in North Carolina. WRRI Report #344.