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Upper Swift Creek and Fork Swamp Watershed Action Plan

Pitt County, North Carolina

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Contents

1. Introduction and Background 1
   1.1 Introduction 1
   1.2 Background 3
2. Subwatershed Characterization 5
   2.1 Subwatershed Delineation 5
   2.2 Subwatershed Descriptions 5
   2.2 Land Use Analysis 10
      2.2.1 Existing (Base Year) Land Use 10
      2.2.2 Future Land Use Conditions 12
   2.3 Regulations That Affect Water Resources 19
      2.3.1 Pitt County Regulations 20
      2.3.2 Town of Ayden Regulations 23
      2.3.3 City of Greenville Regulations 24
      2.3.4 Town of Winterville Regulations 28
   2.4 Impaired Waters – North Carolina CWA Section 303(d) List 30
3. Benthic Macroinvertebrate Monitoring 34
   3.1 Methodology 34
   3.2 Results 35
   3.3 General Observations and Recommendations for Improvement 40
   3.4 Identifying the Causes of the Benthic Impairments 40
4. Riparian Protection and Stream Enhancement 43
   4.1 Flooding in the Project Area 43
   4.2 Parcels Targeted for Riparian Protection 45
   4.3 Stream Enhancement 50
      4.3.1 Gum Swamp Stream Enhancement 50
5 Stormwater Control Measure Site Identification and Prioritization 56
   5.1 Site Identification 56
   5.2 SCM Database 59
   5.3 Ranking Procedure 65

5.4 Permitting for SCMs 70
5.4.1 Sites Where 401/404 Permitting is Not Required 71
5.4.2 Nationwide 43 Permit Application 71
5.4.3 Individual Permit Application 72
5.5 Stormwater SCM Inspection and Maintenance 73
5.5.1 Sediment Removal 73
5.5.2 Natural Debris and Trash Removal 74
5.5.3 Invasive Species Removal/Vegetation Maintenance 74
5.5.4 Mosquito and Pest Control 75
5.6 Low Impact Development 76
5.7 Non-Structural SCMs 77
6 Recommendations 79
6.1 Subwatershed Recommendations 79
6.1.1 Swift Creek Watershed 79
6.1.2 Fork Swamp Watershed 81
6.2 General Recommendations and Considerations 83
6.2.1 Coal-tar-based Pavement Sealcoat Ban 83
6.2.2 Flooding 84
6.2.3 Addressing the Cause of the Aquatic Life Impairment 85
6.2.4 Mitigation Requirements 86
6.2.5 Partnership with North Carolina Ecosystem Enhancement Program 86
6.2.6 Local Government Mitigation Bank 87
6.2.7 NCDOT Partnership 87
6.2.8 Stormwater Utility 87
6.2.9 Increasing Residential Stewardship Practices 89
6.2.10 Grant Funding Opportunities 90
Conclusion 93
Citations 95

Appendices

Appendix A – Historical Aerials

Appendix B – Benthic Macroinvertebrate Monitoring Results

Appendix C – Strategic Conservation Parcels

Appendix D – Gum Swamp Stream Enhancement

Appendix E – Stormwater Control Measures Database

Appendix E1 – Database Results

Appendix E2 – SCM Fact Sheets

Appendix E3 – SCM Cost Specifics

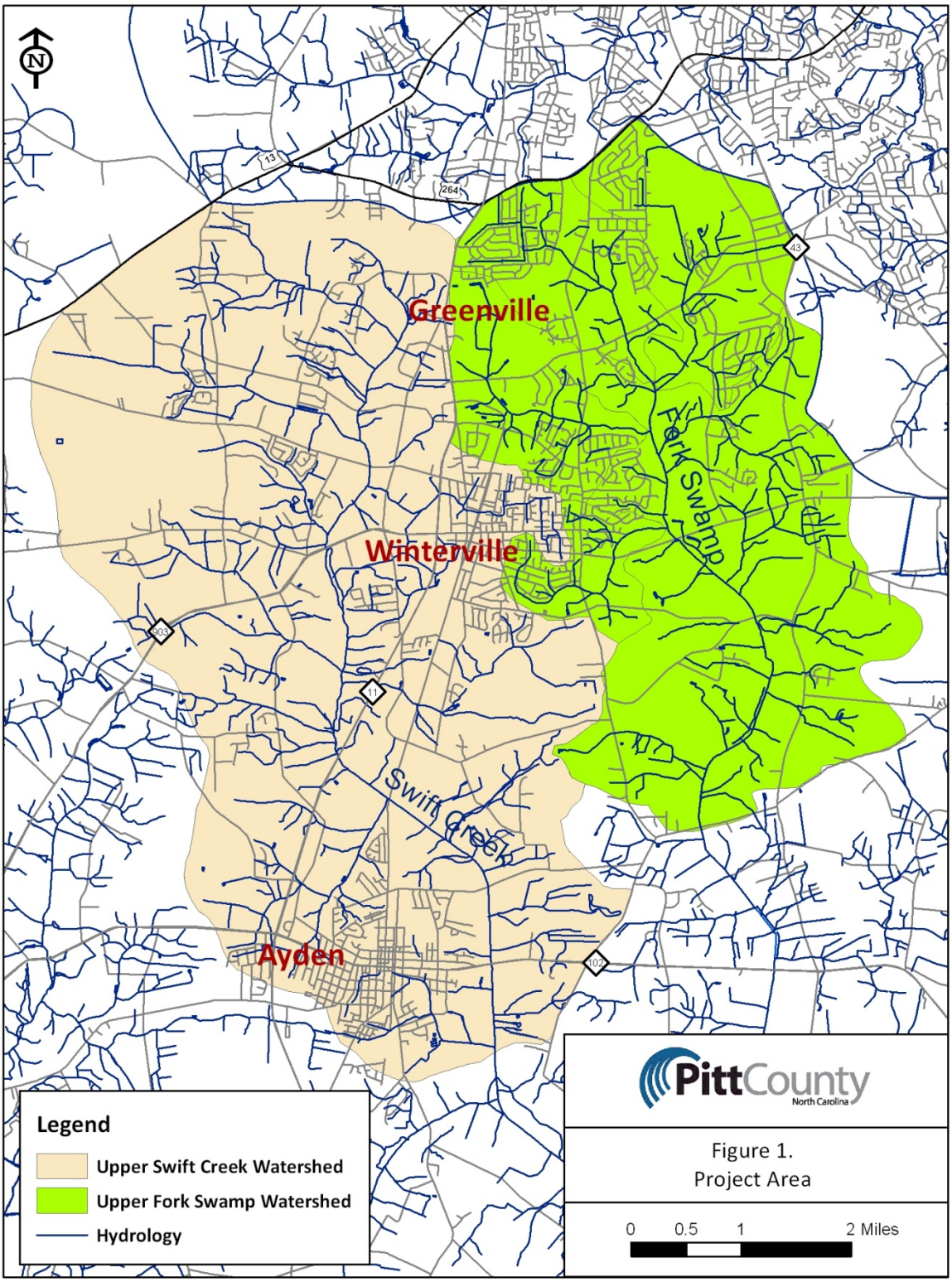
1. Introduction and Background

1.1 Introduction

The Pitt County Planning Department, in partnership with numerous local organizations, retained Michael Baker Engineering, Inc. (Baker), through a grant from the Clean Water Management Trust Fund (CWMTF), to develop a comprehensive watershed plan that focuses on managing stormwater and flood impacts. The project area includes the Upper Swift Creek and Fork Swamp watersheds upstream from approximately NC Highway 102. The Swift Creek project watershed extends downstream from NC 102 to include all of the Town of Ayden, and the Fork Swamp project watershed ends upstream from NC 102 at Ivy Road. The project area covers approximately 44.5 square miles (see Figure 1).

The **primary goals** of this watershed plan are to cost-effectively manage stormwater runoff from developed and developing areas, and manage floodplain impacts through strategic conservation easements and selective enhancement. The challenge is to improve water quality in watersheds with channelized stream networks. The project approach to develop the watershed plan is described below and includes six tasks.

1. Subwatershed characterization – divide the project area into subwatersheds and characterize them according to land use, stormwater conveyance, projected future growth, water quality, and floodprone areas. State and local regulations that affect water resources will be outlined.
2. Benthic macroinvertebrate monitoring – biologists conducted aquatic insect monitoring to establish baseline water quality and instream habitat conditions for the defined subwatersheds.
3. Riparian protection and stream enhancement – identify sites that provide flood storage and, as such, are targets for protection, as well as sites that would benefit from stream enhancement through the incorporation of floodplain benches and other natural channel design features.
4. Stormwater control measure (SCM) site identification and prioritization – identify sites that may be engineered to control stormwater runoff, estimate the cost to install those structural facilities, and rank them according to pollutant removal, cost, and approximate order for implementation.
5. Educational workshops – educate local officials and the public about the project and what they can do to help manage stormwater. These meetings seek to gain public input and support for project initiatives, such as the SCM, conservation, and enhancement sites.
6. Upper Swift Creek and Fork Swamp Watershed Action and Strategic Plan – culmination of the project to document the above tasks and recommend strategies for the county to address identified stormwater problems.


Greenville
Winterville
Ayden
Fork Swamp
Swift Creek
Legend
Upper Swift Creek Watershed
Upper Fork Swamp Watershed
Hydrology
PittCounty
North Carolina
Figure 1.
Project Area
0
0.5
1
2 Miles

An important aspect of this project has been stakeholder coordination to give and receive feedback on which project measures are likely to benefit water resources while also being acceptable from a more political standpoint. The stakeholder coordination has primarily been through quarterly meetings to discuss project progress, but also through communication between smaller groups.

The project area partners that attended the quarterly meetings and participated in the project discussions included the following:

- Pitt County Planning and Development
- Pitt County Drainage Districts 3 & 7
- Town of Winterville
- City of Greenville
- Town of Ayden
- Pitt Co. Soil & Water Conservation
- Natural Resources Conservation Service
- Pitt Community College
- NCDOT
- East Carolina University

1.2 Background

Numerous canals within the project area were originally dug in the 1920s through the 1940s when the land use was predominantly agricultural, in an effort to improve drainage from a swampy landscape. Over time, sediment filled in the canals and, as a result, flooding worsened.

The Soil Conservation Service cooperated with the Soil and Water Conservation Districts of Pitt, Craven and Beaufort counties, along with the Pitt County Commissioners and the state of North Carolina, to develop a Watershed Work Plan, which was agreed upon in early August of 1968. The implemented plan was to make significant improvements to flooding problems experienced by those farming in the watershed. The plan primarily called for the improvement of existing channels of Swift Creek. Only a small percentage of the proposed work would be new channelization. Federal funding was dedicated to provide financial assistance to implement the project. The plan was approved by the Committees of Congress on September 26, 1969, and approved for operation on December 19, 1969.

Legal disagreements delayed implementation of this project until 1979 when the main canals of Swift Creek and Fork Swamp were excavated to their original size and depth. In 1981, the Swift Creek and Fork Swamp lateral canals (i.e., tributaries) were also excavated to their original size and depth. The Pitt County Drainage Districts 3 and 7 were created to maintain the canals into the future.

The main channels were originally designed to carry the rainfall from a two-year storm and the laterals were designed to convey a five-year storm. The design dimensions were developed when the project area had mostly cropland and forest land cover. Since 1981, significant commercial and residential develop has taken place and changed the rainfall-runoff patterns such that flooding has again become an issue of concern. The upper portions of Swift Creek and Fork Swamp have now become developed with residential subdivisions and strip development with the businesses needed to provide services to a larger population. Appendix A includes three historical aerial photographs (one of southern Greenville, two of Winterville) and 2010 aerial images of the same areas.

Due to development, additional impervious cover, and an extensive stormwater conveyance system with pipes and ditches, runoff has increased in volume and the time needed to reach the channels has decreased. This results in larger volumes of runoff reaching the channels in a short period. As a result, flooding of land adjacent to the canals in many of the developed catchments occurs much more frequently than the two-year and five-year design storms.

According to the North Carolina Office of State Budget and Management, as of May 2012 population growth in Pitt County is projected to increase by 11.9 percent from 2010-2020 and by 10.5 percent from 2020-2030. This represents the 21st and 22nd highest projected growth rates out of the 100 North Carolina counties. This growth will bring additional development, along with the potential for additional stresses on water resources. This document aims to provide recommendations for managing existing development and growth such that it will have a reduced impact on water resources. Despite anticipated growth, it may also be possible to improve water resources in some locations. Efforts to meet these aims are detailed in this watershed plan.

2. Subwatershed Characterization

2.1 Subwatershed Delineation

To better organize the project area for documenting the findings of this study and for management purposes, the project area was divided into subwatersheds. The delineations followed drainage divides using several GIS shapefiles, including hydrography, hydrologic boundaries, roads, and two-foot contour intervals. The rationale for determining the subwatersheds was to select the major tributaries to Swift Creek and Fork Swamp. Table 1 and Figure 2 show the resulting 13 subwatersheds, which include eight in the Swift Creek watershed and five in the Fork Swamp watershed.

Table 1. Delineated Subwatershed Areas

Subwatershed	Watershed	Jurisdiction	Area (sq. mi.)
Upper Swift Creek	Swift Creek	Greenville, Winterville, County	3.94
Gum Swamp	Swift Creek	Greenville, County	2.80
Horsepen Swamp	Swift Creek	County	2.69
Nobel Canal	Swift Creek	Winterville, County	1.17
Reedy Branch	Swift Creek	Winterville, County	2.15
North Ayden	Swift Creek	Ayden, County	2.84
South Ayden	Swift Creek	Ayden, County	1.16
Lower Swift Creek	Swift Creek	Winterville, Ayden, County	10.69
Subtotal	**Swift Creek**	**Greenville, Winterville, Ayden, County**	**27.44**
Upper Fork Swamp	Fork Swamp	Greenville, County	2.06
NE Fork Swamp	Fork Swamp	Greenville, County	2.76
Western UT Fork	Fork Swamp	Greenville, Winterville, County	2.10
Eastern Winterville	Fork Swamp	Winterville, County	1.09
Lower Fork Swamp	Fork Swamp	Greenville, Winterville, County	9.02
Subtotal	**Fork Swamp**	**Greenville, Winterville, County**	**17.03**
Total	**Swift and Fork**		**44.47**

2.2 Subwatershed Descriptions

Brief descriptions of each subwatershed are provided below. Included in the descriptions are the 2006 and projected (for 2035) impervious cover; development of these will be explained in Section 2.2 (Land Use Analysis), but they are also listed here to characterize the existing and projected land development. Existing water quality will be reviewed in Section 3.1 through a discussion of benthic macroinvertebrate monitoring results.

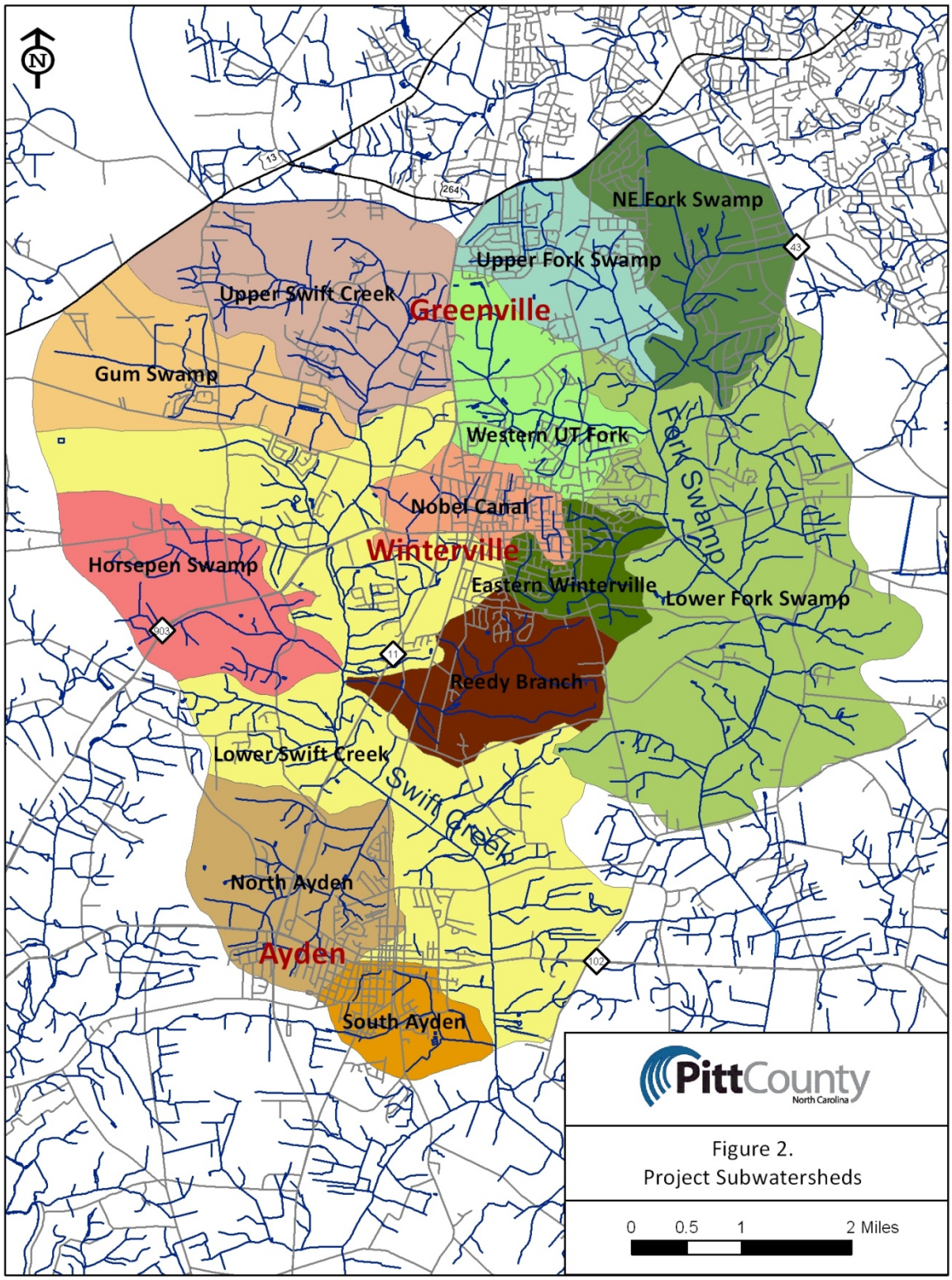


Figure 2.
Project Subwatersheds

Swift Creek Watershed

Upper Swift Creek – This subwatershed has significant recent and planned residential development, and includes Pitt Community College, part of the NC 11 commercial area, and the West Star light industrial area. Upper Swift Creek and the Swift Creek 46 (SC-46) lateral canal are maintained by the Pitt County Drainage Districts 3 and 7 within the subwatershed. Growth in this subwatershed is expected to be among the highest in the project area; the current impervious cover of 21 percent is projected to increase to 32 percent by 2035 (see Section 2.2). This will likely add water quality stressors and may increase flooding. More quantitative estimates of how water quality and flooding will change would require modeling studies, which are not part of this project. However, it is possible to address these concerns more generally with practical solutions, which are presented throughout this plan.

Gum Swamp – The subwatershed has residential development and includes the South Central High School on Forlines Road. Gum Swamp (also known as SC-40 by the Drainage Districts) and SC-40A are maintained drainage laterals in the subwatershed. Development in this subwatershed is currently not very dense, with just 12 percent impervious cover, and is projected to increase to 16 percent by 2035. However, the Gum Swamp channel is eroding on the downstream end near Swift Creek. This section of channel is targeted for stream enhancement, which is described in Section 4.3. Flooding occurs in the neighborhood upstream from the proposed stream enhancement project. The properties that experience flooding are located between the left bank of Gum Swamp and Woodridge and Sawgrass Drives. These properties extend into the mapped Federal Emergency Management Agency (FEMA) floodplain, which is a flood hazard area with base flood elevations established. Section 4 provides further discussion of floodplain areas and how they may be managed. The proposed stream enhancement project, if implemented, might reduce flooding along Woodridge and Sawgrass Roads because it would increase conveyance capacity via a larger channel that includes floodplain benches.

Development is projected to increase impervious cover to 16 percent by 2035. Gum Swamp is also known as SC-40 by the Drainage Districts. It and SC-40A are maintained drainage laterals in the subwatershed.

Horsepen Swamp – This is a largely undeveloped and agricultural subwatershed. Swift Creek 34 and 34B are maintained drainage canals within the Horsepen Swamp subwatershed. No flooding problems have been reported. The existing impervious cover is four percent and is projected to increase to five percent by 2035. However, water quality is not what would typically be expected for an undeveloped watershed. This is discussed in detail in in Section 3.

Nobel Canal – This is an urban subwatershed that includes much of downtown and western Winterville. It has a high percentage of impervious surface and few open spaces that might be used for structural stormwater control measures. The existing impervious cover is estimated to be 40 percent and is projected to increase to 47 percent by 2035. Additionally, there is evidence that the channel becomes dry (i.e., no water in the channel) during droughts and possibly even typical summer months. This is not unusual in an urban catchment, but it limits what improvements can be made. Nobel Canal is also known as the Swift Creek 39 drainage lateral.

Reedy Branch – This subwatershed includes southern Winterville and surrounding parts of the County. It currently has 8 percent impervious area and is projected to develop slightly to 11 percent by 2035. This type of subwatershed might be targeted for protection to maintain its rural character. Reedy Branch is also known as the Swift Creek 35 drainage lateral and is maintained by the Drainage District along with a tributary, Swift Creek 35A.

North Ayden – This subwatershed includes an unnamed tributary to Swift Creek that drains much of the Town of Ayden and surrounding agricultural areas within Pitt County. Ayden is somewhat densely developed, but there are good opportunities to install structural stormwater control measures to manage runoff. The subwatershed currently has 19 percent impervious area and is projected to increase to 25 percent by 2035. This tributary is also known as the Swift Creek 32 drainage lateral. The lower approximately 6,000 feet of it are maintained to its confluence with Swift Creek, which is very near where Swift Creek passes beneath Old NC 11.

South Ayden – This subwatershed, which includes the southeastern half of Ayden, is drained by an unnamed tributary to Swift Creek. It does not include as much rural area outside of the Town of Ayden as the North Ayden subwatershed; consequently, the percent impervious cover is currently 27 percent and is projected to increase to 34 percent by 2035. This is a fairly high impervious area where impacts to water quality are certain without adoption of stormwater control measures. The lower 4,000 feet of the tributary is maintained and is also known as the Swift Creek 26 drainage lateral.

Lower Swift Creek – This is a large subwatershed encompassing the mainstem of Swift Creek south of Davenport Farm Road, all of which is maintained. It includes many drainage laterals; however, the largest are included as separate subwatersheds in this study. The Lower Swift Creek subwatershed is largely rural and under the County's jurisdiction. It has 9 percent impervious area, which is projected to increase to 13 percent by 2035.

The NC Division of Water Quality (DWQ) has monitored the aquatic insects in this subwatershed (sampling at NC 102) since 1995 and found that the stream does not support its designated use for aquatic life. Consequently, Swift Creek has been on the North Carolina Clean Water Act

Section 303(d) list of impaired streams since 1998. To be removed from the list, the rating derived from the aquatic insect monitoring would need to improve to 'Good-Fair.' More discussion of this monitoring and project-specific results will be presented in Section 3.

Fork Swamp Watershed

Upper Fork Swamp – This subwatershed includes portions of southern Greenville. It has residential development in the south and the commercial areas along NC 11 and US 264 in the north. It is the most urban catchment in the project area, with currently 38 percent impervious cover. It is projected to increase to 44 percent by 2035. Despite this, reports of flooding are limited beyond the canal travel way. However, water quality problems are evident. The Drainage District maintains the main canal and Fork Swamp-32 from the railroad line, which is located approximately 1,000 upstream from Evans Road.

Northeast Fork Swamp – This is another urban subwatershed with 35 percent impervious cover that is estimated increase to 43 percent by 2035. It includes the commercial areas along NC 11, US 264, and Fire Tower Road to NC 43 (Charles Boulevard). It also includes one mile of Corey Road south of Fire Tower Road. There is a large flood control basin located off of Fire Tower Road west of Arlington/County Home Road. No part of this tributary to Fork Swamp is maintained by the Drainage Districts.

Western UT Fork Swamp –This subwatershed includes parts of southern Greenville and northeastern Winterville, including Fire Tower Road from NC 11 to Evans/Old Tar Road. It is projected to grow substantially with an increase in impervious cover from 28 to 39 percent by 2035. The unnamed tributary for this subwatershed is not maintained by the Drainage District. It occasionally floods in the vicinity of Old Tar Road in the Cedar Ridge and Preston Wood subdivisions.

Eastern Winterville –This subwatershed covers the southeastern portion of Winterville and it is projected to develop more than any other in the project area. The impervious cover is projected to increase from 21 to 33 percent by 2035. Flooding currently occurs in neighborhoods along Winterville's Main Street, including Ashley Meadows and Winterfield. The subwatershed includes tributaries to Fork Swamp that are also known as Fork Swamp 26 and 26A, both of which are maintained by the Drainage District.

Lower Fork Swamp – This is a large subwatershed encompassing the mainstem of Fork Swamp beginning approximately one-half mile downstream from Fire Tower Road. It is largely rural and under the County's jurisdiction, though it does include small parts of Greenville and Winterville. It has 7 percent impervious area, which is projected to increase to 11 percent by 2035. The main canal of Fork Swamp is maintained, as well as about a dozen lateral canals within the subwatershed.

2.2 Land Use Analysis

Baker conducted an exercise to forecast and analyze future land use conditions within the project area. This involved characterizing the existing land use and using the Greenville Urban Area Metropolitan Planning Organization (MPO) Transportation Analysis Zone (TAZ) forecasts, which utilize Census data to predict population, household, and employment growth for specific future years, to estimate how land use will change. TAZ forecasts are available for 2020 and 2035 for the project area; the project partners selected 2035 for the targeted year for projected future growth. Future land use forecasts are useful for planning the provision of services (e.g., sewer, water), as well as for modeling (water quality or quantity) to manage water resources.

The following sections describe the analysis process and include an evaluation of existing land use.

2.2.1 Existing (Base Year) Land Use

Step one in the process was to identify the existing land use of all tax parcels in the study area. This would provide a baseline to then determine the availability of land for new development in the future. It also establishes the land use scenario that contributes to the existing stormwater runoff, flood impacts, and water quality conditions. From this, one can get a sense of what future conditions might be like both with and without stormwater management.

Pitt County provided their parcel GIS dataset, which included an attribute noting the existing land use. This land use code was used to categorize the existing land use into eleven consolidated categories. The land use categories are used in water quality studies and include an assumed percentage of impervious cover based on literature values. Impervious land cover causes rainfall to runoff and includes such surfaces as rooftops and paved ground. The land use categories used are shown in Table 2 below.

Table 2. Consolidated Land Use Categories and Estimated Imperviousness

Land Use Name	CODE	Percent Impervious
Residential – Very Low Density (2+ acres per dwelling unit(d.u.))	RVL	8
Residential – Low Density (1.5-2 acres per d.u.)	RLL	14
Residential – Medium Low Density (1-1.5 acres per d.u.)	RML	18
Residential – Medium High Density (0.5-1 acres per d.u.)	RMH	23
Residential – High Density	RHH	29

(0.25-0.5 acres per d.u.)		
Residential – Multifamily/Very High Density (0.25 acres per d.u.)	RVH	50
Office/Institutional	OFF	70
Industrial	IND	70
Commercial	COM	85
Urban Green Space/Golf Course	UGR	0
Row Crop	ROW	0
Forest	FOR	0
Urban Road ROW	ROADU	100
Rural Road ROW	ROADR	75
Railroad ROW	RAIL	50

Residential categories were mapped from the land use codes and by using the actual size of the parcels to gauge the density level. Office and institutional uses, as well as schools, were categorized as Office/Institutional (OFF). Commercial uses were categorized as Commercial (COM) and industrial uses were categorized as Industrial (IND). Once the land use codes had been properly categorized, a manual review was completed to compare the categorized land use based on the parcel attributes to the use as indicated by aerial imagery. All rural residential home sites (RVL) parcels larger than 10 acres were manually switched to ROW or FOR as the vast majority of those parcels were farmland or forest. Other parcels were adjusted as necessary based on the visual inspection. Since uses are not always consistent across an entire parcel, the guiding principle of the categorization was to categorize each parcel by the use that constituted the majority of space within that parcel.

Next, undeveloped parcels were corrected as appropriate. Many parcels had a land use code from the parcel GIS layer indicating they were developed and in use but had no building on them. The parcel GIS layer also included fields for building tax value and for the number of buildings on the property. By selecting parcels with $0 in building tax value and with zero buildings on the property and visually checking against aerial imagery, undeveloped parcels were converted to urban green space (UGR).

Finally, roadway and railroad rights of way needed to be included because the County parcel data does not include transportation rights of way. All empty spaces between polygons were extracted as a polygon layer and divided into three parts: urban road right of way, rural road right of way, and railroad right of way. The distinction between urban and rural roadway right

of way was made using the Census Urbanized Area boundary layer. The steps outlined above produced an existing land use shape file for 2010, which can be seen in Figure 3.

To properly forecast land use from a base year to the future, the existing land use had to be adjusted (backward) to a 2006 base year to match the base year of the MPO socioeconomic forecasts. The "year built" attribute of the parcel data was used to reclassify any parcels with building completed between 2007 and the present as Urban Green Space (UGR). Figure 4 shows existing land use for base year 2006.

2.2.2 Future Land Use Conditions

Forecasting future land use was completed by estimating the area needed for development to meet the forecasted household and population growth indicated in the MPO socioeconomic forecasts for the study area. The Greenville Urban Area MPO provided the most recent socioeconomic forecasts for the region and the increase in households and employment were calculated for each Traffic Analysis Zone (TAZ) that intersected the study area. Table Table 3 shows the projected increase in population, households and employment for the TAZs wholly or partially within the study area. This provided the basis for determining the number of acres of new development within each TAZ. To determine the location of that development, the future land use plans for each jurisdiction were used. Pitt County and the Cities and Towns of Greenville, Ayden, and Winterville all provided GIS layers of their Future Land Use plans.

Table 3: Population, Households, and Employment Change 2006-2035

	Population	Households	Employment
TAZs Entirely within Study Area			
2006	31,415	12,914	11,581
2035	64,035	25,667	21,014
Change	32,620	12,753	9,433
TAZs Partially within Study Area			
2006	6,253	2,632	2,427
2035	14,318	5,689	3,453
Change	8,065	3,057	1,026
Total			
2006	37,668	15,546	14,008
2035	78,353	31,356	24,467
Change	40,685	15,810	10,459

To assign growth within each TAZ, the household and employment growth was analyzed for each TAZ and compared to the availability of developable land within each TAZ. For residential

growth, first any undeveloped but platted single-family or townhome developments were subtracted from the total additional households expected for that TAZ. Next, an evaluation of the developable area was conducted by comparing the planned land use within each TAZ to the total land available for development. Where sufficient land was available, one or more parcels within the TAZ that was also within an area planned for residential development was selected to change from UGR, FOR, or ROW to one of the residential development categories. The appropriate category was chosen based on the planned land use density for the area.

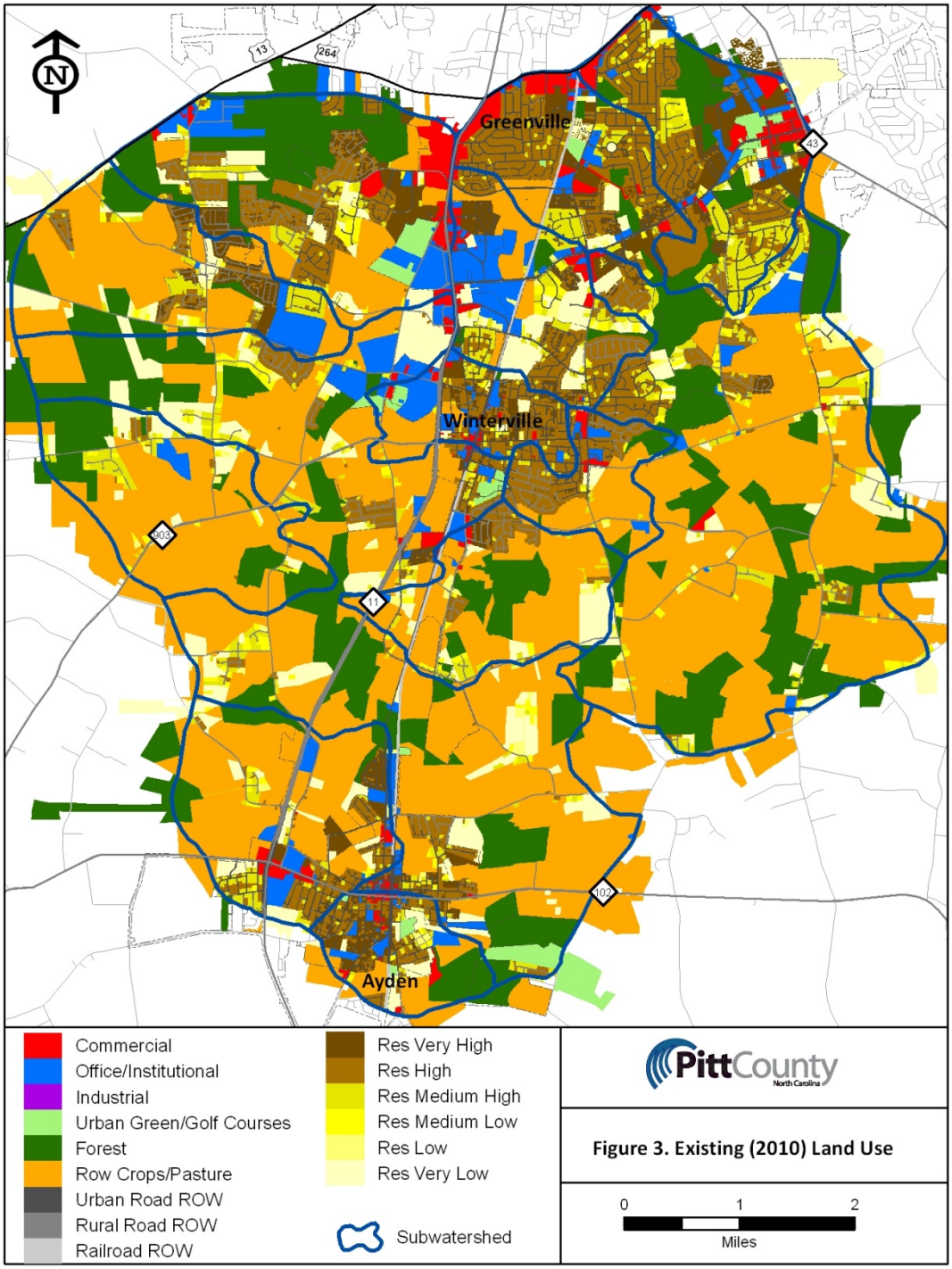


Figure 3. Existing (2010) Land Use

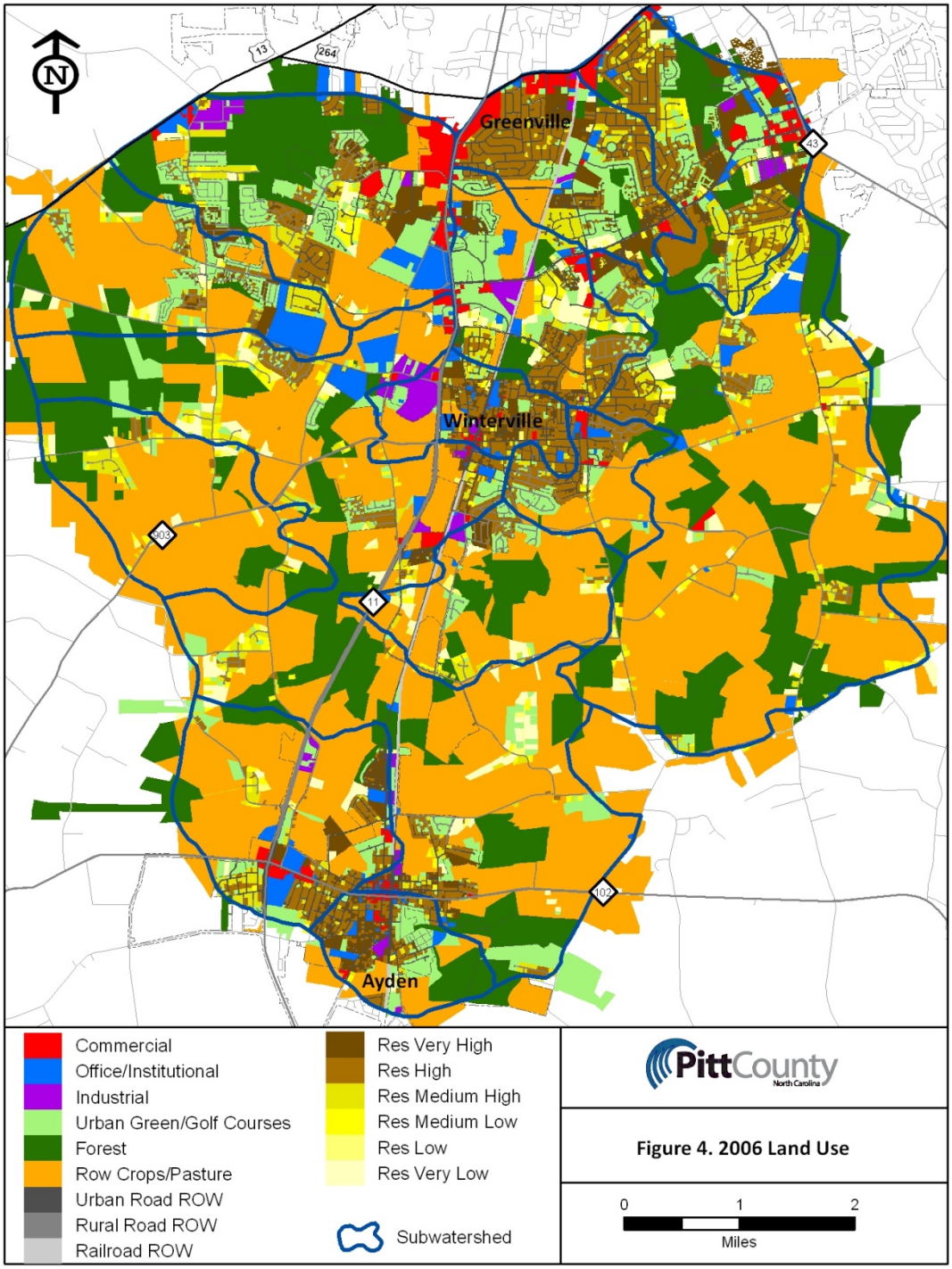


Figure 4. 2006 Land Use

In a number of TAZs, insufficient land was available to meet the expected household growth for that TAZ. In this case, household growth was shifted to nearby TAZs with sufficient planned residential developable land to ensure the overall study area met the projected household growth.

For commercial, office, and industrial growth, the employment forecasts were analyzed by type. For high end retail, retail, office, service, shopping, and hospital employment a ratio of 20 employees to one developed acre was assumed. For industrial and warehouse employment, a ratio of 9 employees to one developed acre was assumed.[1] These values were then summed for each TAZ to determine the number of acres of additional OFF, COM, or IND development necessary to meet the TAZ growth forecast. Similar to the approach for residential development, undeveloped but previously platted parcels were assumed to develop first. Next, undeveloped land categorized as ROW, UGR, or FOR was evaluated to see if it was planned for commercial or industrial development. Again, as with the residential development, in a number of TAZs insufficient land was available to meet the projected TAZ growth. Furthermore, in a few cases, commercial or industrial growth was forecasted within the TAZ, but the local jurisdiction had no areas within that TAZ planned for industrial or commercial growth. Employment growth was therefore assumed to shift to nearby TAZs that had an excess of planned commercial or industrial developable land, so that the overall study area maintained the overall projected level of commercial and industrial development.

The outcome of this forecasting is shown in Figure 5 and Table 4. Overall, approximately 4,600 acres shift from undeveloped or very low density rural categories (ROW, FOR, and UGR) to a higher density development category. This is about 16% of the overall study area. Most of this is necessary to accommodate the residential development, because there are about 4,000 acres of new RVH, RHH or RMH in 2035 versus 2006.

Table 4: Land Use Changes by Category

Land Use	Land Use Code	Existing Acres	Future Acres	Change in Acres
Residential – Very Low Density	RVL	722	718	-4
Residential – Low Density	RLL	213	226	12
Residential – Medium Low Density	RML	392	402	10
Residential – Medium High Density	RMH	1,201	2,160	960

[1] Typically, the Social Cost of Alternative Land Development Scenarios (SCALDS, FHWA, 1998) model assumptions would be used for these assumptions. The values from that model, however, would be relatively high for this study area. Therefore, values developed by Clark County, WA, for their Vacant Buildable Lands Model (http://gis.clark.wa.gov/gishome/reports/VacantLands/VacantLands.pdf) were used as the land use densities in Clark County are more similar than the assumptions used in the SCALDS model.

Residential – High Density	RHH	2,326	4,709	2,383
Residential – Multifamily/Very High Density	RVH	907	1,615	708
Office/Institutional	OFF	778	926	148
Industrial	IND	294	342	48
Commercial	COM	532	897	364
Urban Green Space/Golf Course	UGR	2,683	1,144	-1,539
Row Crop	ROW	13,125	10,702	-2,422
Forest	FOR	5,983	5,315	-668
Urban Road ROW	ROADU	1,038	1,038	0
Rural Road ROW	ROADR	902	902	0
Railroad ROW	RAIL	97	97	0
Grand Total		31,192	31,192	0

At the watershed level, using the impervious assumptions listed in Table 2, these land use changes lead to an overall increase in imperviousness of the project area from 16% to 21% impervious cover. However, this modest overall increase masks some substantial increases at the subwatershed level. In particular, the Eastern Winterville, Upper Swift Creek, and Western UT Fork Swamp subwatersheds are expected to experience the most substantial increase in imperviousness. Table **Error! Reference source not found.**5 summarizes the percent impervious cover for each watershed in the base (2006) and future land use conditions.

Table 5. Percent Impervious Cover by Subwatershed

Subwatershed	Watershed	Existing	Future	Change
Upper Swift Creek	Swift Creek	21%	32%	**11%**
Gum Swamp	Swift Creek	12%	16%	4%
Horsepen Swamp	Swift Creek	4%	5%	1%
Nobel Canal	Swift Creek	40%	47%	7%
Reedy Branch	Swift Creek	8%	11%	3%
North Ayden	Swift Creek	19%	25%	6%
South Ayden	Swift Creek	27%	34%	7%
Lower Swift Creek	Swift Creek	9%	13%	4%
Upper Fork Swamp	Fork Swamp	38%	44%	6%
NE Fork Swamp	Fork Swamp	35%	43%	8%
Western UT Fork	Fork Swamp	28%	39%	**11%**
Eastern Winterville	Fork Swamp	21%	33%	**12%**
Lower Fork Swamp	Fork Swamp	7%	11%	4%
Total	Swift and Fork	16%	21%	5%

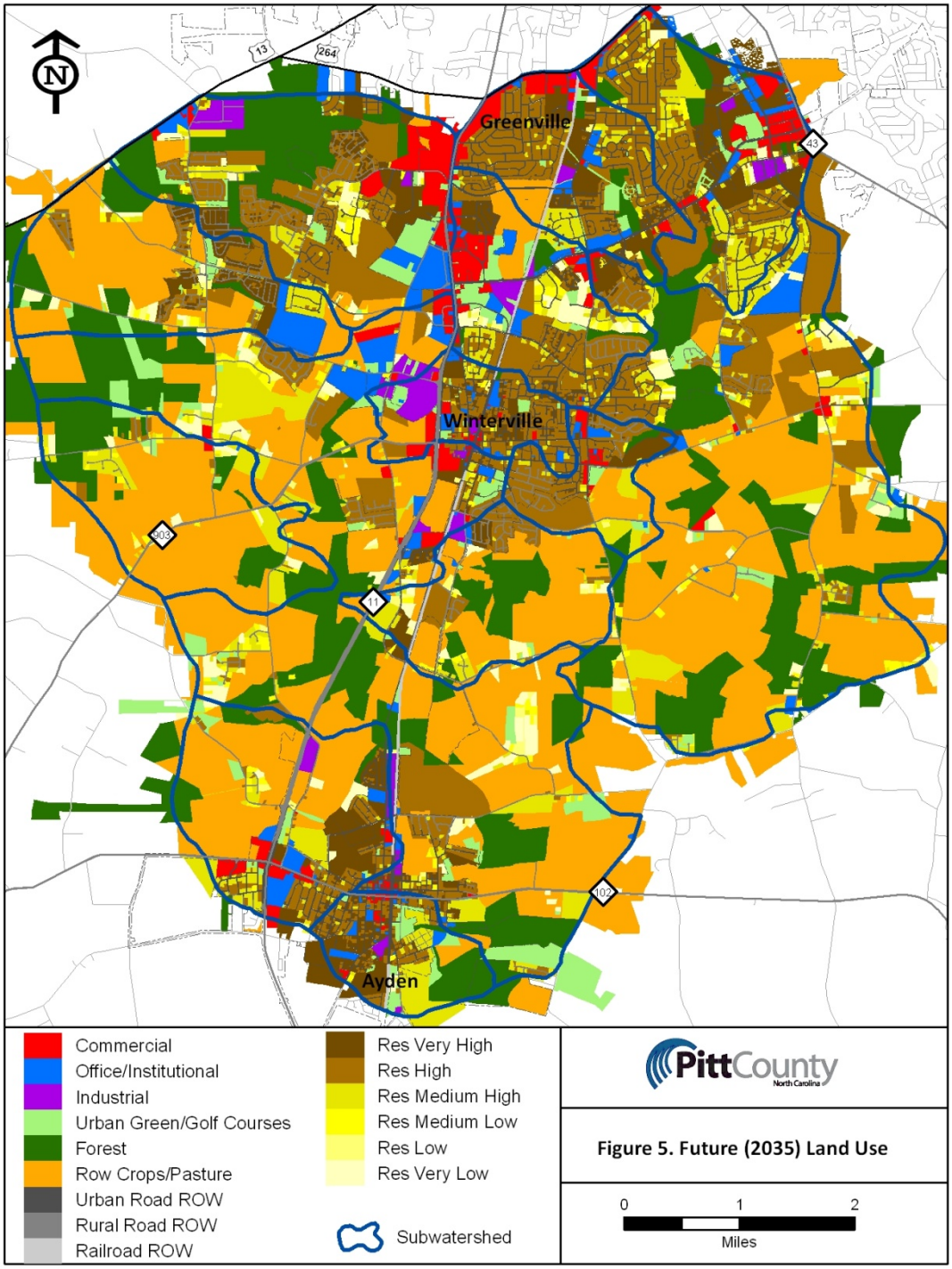


Figure 5. Future (2035) Land Use

2.3 Regulations That Affect Water Resources

The purpose of this discussion is to examine current regulations in the project area that address growth management, development, and stormwater management, and their potential impact on water quality. The discussion includes a review of Pitt County ordinances, as well as a review of regulations in Ayden, Greenville, and Winterville. State regulations pertaining to National Pollutant Discharge Elimination System (NPDES) Phase II Stormwater permitting and the state Neuse River Basin-Nutrient Sensitive Waters Management Strategy (known as the "Neuse Rules") are also covered. The state and local regulations reviewed in this section are summarized in Table 1.

Table 6. Pitt County Area Regulations that Influence Growth, Development, and Water Quality

Jurisdiction	Regulation	Effective Date
Pitt County	Pitt County Flood Damage Control Ordinance*	5/16/ 2008*
	Pitt County Soil Erosion and Sediment Control Ordinance	none listed
	Pitt County Riparian Buffer Protection Ordinance	8/1/2000
	Pitt County Stormwater Management Ordinance for Nutrient Control	10/12/2004
	Pitt County Subdivision Ordinance	7/1/1994
	Pitt County Water Supply Watershed Protection Ordinance	1/1/1994
	Zoning Ordinance of Pitt County, North Carolina	11/3/2003
Ayden	Town of Ayden, Buffer Strips and Landscaping	10/9/2006
	Town of Ayden, Subdivision Regulations	none listed
	Town of Ayden, Zoning Ordinance	4/9/2001
Greenville	City of Greenville Flood Damage Prevention Ordinance	6/8/1978
	City of Greenville Subdivisions Ordinance	1/12/1991
	City of Greenville Zoning Ordinance	6/13/1991
	City of Greenville Ordinance: Water Supply Watershed Overlay	6/10/1993

	City of Greenville Soil Erosion and Sedimentation Control Ordinance	1/8/1998
	City of Greenville Stormwater Utility	12/2002
	City of Greenville Stormwater Management and Control Ordinance[+]	9/9/2004[+]
	Horizons: Greenville's Community Plan, Comprehensive Plan Update	2/12/2004
	Horizons: Greenville's Community Plan 2009-2010 Update: Final Report	12/7/2010
Winterville	Manual of Standard Designs and Details	10/8/2007
	Subdivision Regulations of the Town of Winterville, North Carolina	2/14/2000
	Zoning Ordinance of the Town of Winterville, North Carolina	6/14/2010
State	NPDES Phase II Stormwater Permitting	Various
	Neuse River Basin-Nutrient Sensitive Waters Management Strategy (Neuse Rules)	1995

*Last updated FEMA map cited, no date on regulation

[+] This ordinance enacted the City of Greenville Stormwater Management Program to meet the requirements of the Tar-Pamlico Stormwater Rule.

2.3.1 Pitt County Regulations

The **Pitt County Flood Damage Control Ordinance** applies to all Special Flood Hazard Areas within Pitt County's jurisdiction, and within other jurisdictions that have reached agreement on the regulation. These areas have very limited development potential. The regulation allows "No encroachments, including fill, new construction, substantial improvements or new development within a distance of 20 feet each side from top of bank or five times the width of the stream, whichever is greater, unless certification without supporting documentation to establish the encroachment would not result in any increase in flood levels during the occurrence of the base flood discharge."

Environmental protections: Helpful to prevent specified (e.g., 100-year) flood levels from rising.

The **Pitt County Soil Erosion and Sediment Control Ordinance** is limited to the area within Pitt County's jurisdiction, and within other jurisdictions that have reached agreement on the regulation. The regulation does not apply to most agricultural practices. It also does not apply to silviculture practices if the practices comply with Forest Practice Guidelines Related to Water Quality. It requires an erosion control plan for development that disturbs more than one acre of land, and notes erosion control practices are required for activities disturbing less than an acre of land. It also requires that land disturbing activities near a lake or natural watercourse must have a buffer to confine visible siltation within 25 percent of the buffer zone nearest the land disturbing activity. The regulation limits the post construction velocity of the 10-year storm event to pre-development values or listed values within a provided appendix.

Environmental protections: The ordinance does not directly limit the development potential of jurisdictional parcels. It is helpful for preventing sediment deposition within the stream network.

The **Pitt County Riparian Buffer Protection Ordinance** establishes a 50-foot riparian buffer directly adjacent to surface waters within the county. The regulation applies to "lands used for agriculture, silviculture, forestry, or whenever land use changes take effect. Wetlands adjacent to surface waters shall be considered a part of the riparian buffer, but are regulated pursuant to 15A NCAC 2H .0506." Surface waters are present if the feature is approximately shown on either (a) the most recent version of the 1:24,000 scale USGS topographic map or (b) the most recent hard copy version of the soil survey map prepared by the Natural Resources Conservation Service. The required buffer is divided into two zones:

- Zone 1 – a 30-foot buffer from the appropriate edge of the watercourse (top of bank for streams, normal water level for lakes, ponds, and reservoirs) which will consist of essentially undisturbed vegetation
- Zone 2 – a 20-foot buffer extending from Zone 1 that is comprised of managed vegetation.

Exceptions are allowed for "airports, bridges, and nitrogen control ditches, drives for residential parcels greater than 25 linear feet of stream impacts, or greater than 2,500 square feet of riparian buffer; Subdivisions with less than 150 linear feet of stream impacts, or one-third acre of buffer impacts; Road crossings that impact greater than 40 linear feet of stream but less than or equal to 150 lf or less than one-third of an acre of riparian buffer; New stormwater management ponds; Stream restoration sites; Hiking trails, mining access, some utility crossings, periodic maintenance of modified natural streams such as canals, and other minor activities outside normal modeling protocols."

Environmental protections: This regulation increases environmental protections by limiting some types of development, as the buffer will, in some cases, extend beyond the Special Hazard

Flood Area or other area of controlled development. This could limit development of some parcels, where a buffer could be incompatible with certain types of development.

Riparian buffers are important to water quality because they protect streambanks, and filter runoff and groundwater inputs to the stream channel. They also slow and provide uptake of flood waters deposited beyond the streambank.

The **Pitt County Stormwater Management Ordinance for Nutrient Control** imposes nitrogen and phosphorus export limits for new development. Residential developments with a nitrogen export of 4.0 to less than 6.0 pounds per acre per year are given the following options:

- Install Best Management Practices (BMPs) to remove excess nitrogen
- Provide treatment for offsite developed areas that drain to the same stream to achieve the same nitrogen reduction
- Pay a one-time offset payment to the NC Ecosystem Enhancement Program (NCEEP) Riparian Buffer Restoration Fund using the applicable nitrogen and phosphorus offset payment calculations specified in the Nutrient Offset Payments Rule.

For new developments with a computed nitrogen export of 6.0 pounds or greater per acre per year, the applicant must use on-site BMPs to reduce the nitrogen export to below 6.0 pounds per acre per year, at which point the developer can use the options above to manage their net nitrogen export to 4 pounds or less per acre per year.

The regulation also places limits on non-residential development. For these developments with a net nitrogen export between 4.0 and 10.0 pounds per acre per year, the following options are offered:

- Install BMPs to remove excess nitrogen
- Provide treatment for offsite developed areas that drain to the same stream to achieve the same nitrogen reduction
- Pay a one-time offset payment to NCEEP's Riparian Buffer Restoration Fund using the applicable nitrogen and phosphorus offset payment calculations specified in the Nutrient Offset Payments Rule.

For new non-residential developments with a computed nitrogen export of 10.0 pounds per acre per year or more, the applicant must use on-site BMPs to reduce the nitrogen export to below 10.0 pounds per acre per year, at which point the developer can use the options above to manage their net nitrogen export to 4 pounds or less per acre per year.

Redevelopment projects that replace or expand existing structures or improvements and that result in a net increase in built-upon area shall achieve a 30 percent reduction in nitrogen

loading and no increase in phosphorus loading relative to the previous development. The developer may use on-site or off-site measures to achieve those loads.

The regulation also requires control of peak discharges for new development. New development is required to control peak discharge rate from the site for the 1-year, 24-hour storm to predevelopment levels to avoid contributing to erosion to the stream channel. Peak flow control is not required for developments that meet one or more of the following requirements:

1. The increase in peak flow between pre- and post-development conditions not over 10 percent
2. The proposed new development meets all of the following criteria: overall impervious surface is less than 15 percent and the remaining pervious portions of the site are utilized to convey and control the stormwater runoff.
3. Pitt County may exempt development in specific locations if such locations are prone to flooding and controlling peak flow will aggravate the flooding problems.

Environmental protections: The regulation should reduce nutrient exports associated with new development. However, developers often choose to pay the in lieu fee to NCEEP, which essentially transfers stormwater management out of the immediate project area. This will be further discussion in Section 6 – Recommendations.

The **Pitt County Zoning Ordinance** places limits on percent impervious cover for certain types of developments. In the Highway Corridor overlay zoning district, the maximum percent impervious for lots is 50 percent of the total area except when stormwater is retained or detained on-site. Any additional runoff caused by exceeding the 50 percent impervious over must be compensated for by on-site detention or retention measures. In areas zoned Shopping Center, at least 15 percent of the gross site must be landscaped open space. In areas zoned for Cluster Development, a minimum of 15 percent of the development must be public open space. A minimum 50-foot, vegetative buffer is required for development along all perennial waters. This is consistent with the Pitt County Riparian Buffer Protection Ordinance. A minimum 100-foot vegetative buffer is required for all new development activities that utilize the high density development option. For Planned Unit Development (PUD), 50 percent of the land area saved by reducing the individual lot sizes must be reserved for recreational or open space use. The location, extent, and purpose of land proposed for recreational or open space must be reviewed and approved by the Planning Director.

2.3.2 Town of Ayden Regulations

The **Ayden Buffer Strips and Landscaping Ordinance** requires the use of buffer strips whenever a manufacturing, processing, retail, wholesale trade, or warehousing use or public utility

installation is established that abuts or is across an easement or right-of-way from land zoned for residential use. The buffer strip consists of minimum of 10 feet in width, shall be composed of evergreen bushes, shrubs, and/or trees such that at least two rows of coverage are provided from the ground to a height of six feet within six years and foliage overlaps. A buffer strip may also be constructed of stone, block, brick, or other suitable building material, with a minimum height of five feet. The 10 feet required for the buffer strip shall be in addition to all normal front, rear, and side yard setback requirements.

The **Ayden Subdivision Regulations** does not establish open space or percent impervious requirements, but specifies that once plans have been accepted, open space and percent impervious cover should exist in perpetuity.

The **Ayden Zoning Ordinance** defines the various districts in the town, but does not establish percent impervious or open space requirements.

2.3.3 City of Greenville Regulations

The City of Greenville, North Carolina, **Flood Damage Prevention Ordinance** provides regulations to minimize public and private losses due to flood conditions within flood prone areas by provisions designed to:

1. Restrict or prohibit uses which are dangerous to health, safety and property due to water or erosion hazards, or which result in damaging increases in erosion or in flood heights or velocities;
2. Require that uses vulnerable to floods, including facilities, which serve such uses, be protected against flood damage at the time of initial construction;
3. Control the alteration of natural floodplains, stream channels, and natural protective barriers, which are involved in the accommodation of floodwaters;
4. Control filling, grading, dredging and all other development which may increase erosion or flood damage; and
5. Prevent or regulate the construction of flood barriers which will unnaturally divert flood waters or which may increase flood hazards to other lands.

The City of Greenville's **Subdivisions Ordinance** provides regulations to safeguard existing and potential development in appropriate locations and to preserve and promote a desirable ecological balance. Subdivisions shall be located, designed, and improved to preserve important natural water areas, related vegetation and wildlife habitats; to avoid creation of upstream impoundments or downstream runoff which would be harmful to such complexes or to existing or potential development in appropriate locations; and to maintain desirable groundwater levels.

For proposed subdivisions that are traversed by or includes in whole or in part a natural watercourse, marsh, pond, or lake of substantial significance in the ecology of the general area, the water body shall, to the maximum extent reasonably feasible, be maintained in its natural state, together with bordering lands and other suitable protective strip or buffer as required by the City Planning and Zoning Commission. The minimum width of any protective strip or other buffer required pursuant to this section shall not be less than 15 feet from the top of the bank as determined by the City Engineer.

The City Engineer may permit changes in the location or extent of significant natural waterways and water areas only after making findings that such changes will not adversely affect desirable ecological conditions, drainage or water retention, or result in undesirable location or amount of upstream impoundment or downstream discharge.

Adequate storm drainage shall be provided by means of storm drainage pipe and appurtenances thereto or by open or unenclosed drainage channels, all of which shall be installed in accordance with the Manual of Standard Designs and Details. The City Engineer shall determine what type of storm drainage shall be required and what improvements shall be installed. In the consideration of storm drain pipe size to be installed, the City Engineer shall take into consideration the existing drainage conditions, the effect upon those conditions by the proposed development and the future needs within the immediate area of the proposed development.

To protect development from flooding and other adverse water conditions, no subdivision shall be so located or improved to create impoundments of surface water on developable upstream land outside the subdivision, to increase surface drainage ways, to cause erosion onto neighboring property or into water areas, or to raise or lower groundwater levels in a manner which creates adverse effects within the subdivision or in surrounding areas. Where locations or improvements appear likely to have such effects, plats shall not be approved until suitable remedial measures have been provided.

To address floodprone or flood hazard areas, all subdivisions shall conform to the flood damage prevention regulations as set forth by the City Code. All subdivisions located in the area of special flood hazard as defined in section 9-6-2 shall be required to elevate all public streets located within the subdivision such that the lowest point on the street is no less than one foot below the 100-year flood elevation or no lower than the highest accessible point on the adjacent public street providing access to the site which shall be the point of entry between the development and the adjacent public street. All subdivisions located in the area of special flood hazard as defined in section 9-6-2 shall be required to elevate all private streets located within the subdivision upon property having a zoning classification allowing a residential use as a permitted use such that the lowest point on the street is no less than one foot below the 100-

year flood elevation or no lower than the highest accessible point on the adjacent public street providing access to the site which shall be the point of entry between the development and the public street. Notwithstanding the foregoing, additional points of access onto a public street may be allowed to be constructed at a lesser elevation provided that the access is no lower than the elevation of the point of access to the public street and provided that all elevations are no lower than the minimum necessary to provide safe access to the public street.

The City of Greenville's **Zoning Ordinance** provides regulations to provide for permanent open space and desirable buffers for environmentally sensitive areas and vegetation requirements to encourage the preservation of existing vegetation and stabilize the environment's ecological balance.

The City of Greenville's **Soil Erosion and Sedimentation Control Ordinance** regulates certain land-disturbing activities to control accelerated erosion and sedimentation in order to prevent the pollution of water and other damage to lakes, watercourses, and other public and private property by sedimentation within the city limits of the City of Greenville and the extraterritorial jurisdiction of the City.

The City of Greenville's **Stormwater Management and Control Ordinance** provides regulations to:

1. Protecting the public health, safety and welfare by controlling the discharge of pollutants into the stormwater conveyance system;
2. Promoting the public health, safety and general welfare and to minimize public and private losses due to flood conditions in specific areas by regulations designed to control the rate of release of stormwater runoff of certain developments where the rate of runoff has been significantly increased;
3. Promoting activities directed toward the maintenance and improvement of surface and ground water quality;
4. To protect the riparian buffer along all intermittent and perennial streams;
5. Limiting the nitrogen and phosphorus load from new development; and
6. Satisfying the requirements imposed upon the City of Greenville under the Tar-Pamlico Stormwater Rule (15A NCAC 2B .0258) and the National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) discharge permit issued by the state.

The **Horizons: Greenville's Community Plan, Comprehensive Plan Update**, cites the need to minimize impervious surfaces and to protect wetlands, floodways, and undisturbed floodways. It states that these areas should be preserved as open spaces. The plan recommends a

stormwater utility with rates based on percent impervious cover. The suggested rate was $2.85 per month per 2,000 square feet of impervious surface.

The plan notes the Tar-Pamlico and Neuse Buffer Rules, and notes that another regulatory approach would be to control the percent impervious cover allowed on newly developed sites. Other methods listed that could be used to manage stormwater included detention and retention basins, constructed wetlands green roofs, stream reconstruction, pervious pavement, bioretention areas, sand filters, and other Low Impact Development (LID) approaches. However, none of these approaches are mandated in the plan.

In December 2002, the Greenville City Council established a stormwater user fee that supports the NPDES and Tar-Pamlico Stormwater Rule permit requirements, stormwater management initiatives, and capital construction needs. The City also amended its land use plan in accordance with the Tar River Floodplain Redevelopment Plan. The changes made include:

- Increasing conservation/open space along the Tar River Corridor
- Relocating high density and medium density residential area outside the 100-year floodplain and the 500-year floodplain boundary
- Designating previously zoned areas of medium density residential housing as low density residential
- Designating areas previously zoned as high, medium, or low density development within the 100-year floodplain as very low density residential
- Expand the industrial employment/focus areas adjacent to industrial zoning and planned industrial park areas
- Designating previously low and very low residential areas in uplands (outside the 500-year floodplain boundary) as medium density residential
- Expanding the Airport Road/Highway 11, Stokes Highway, and Old Creek Road/US 264 commercial focus areas.

Environmental protections: The ordinance seeks to improve water quality by limiting development in protected areas, especially in or near floodplains. It balances these limits by increasing allowable density in upland areas, attempting to minimize the impact of the new limits on future development

The **Horizons: Greenville's Community Plan, Comprehensive Plan**, states that the City enforces a Water Supply Watershed Protection Ordinance, which restricts impervious area and specific used within the watershed protection zones up river of the intake for the water treatment plant. The plan adopts transition buffer requirements between incompatible uses (for example, industrial uses bordering residential uses). It is superseded by the comprehensive plan update discussed above

The **City of Greenville Ordinances** includes a Water Supply (WS) Watershed Overlay, which includes a Water Supply Critical Area (WS-C) and Water Supply Protected Area (WS-P).

Environmental protections: Limits some development activities in the listed areas, which should provide some water quality benefits. However, there are no water supply watersheds in the project area.

The **Greenville Stormwater Utility Program** builds on the recommendations of the Horizons: Greenville's Community Plan, Comprehensive Plan Update. The monthly fee is based on a tiered system tied to square feet (sf) of impervious area. The tiers are as follows

- Tier I, impervious area 200 to 2,000 sf
- Tier II, impervious area 2,001 to 4,000 sf
- Tier III impervious area 4,001 to 6,000 sf
- Tier IV, impervious area 6,001 sf and higher.

Environmental protections: The regulation provides a financial incentive to minimize percent impervious cover, which should increase infiltration and reduce stormwater outflows. The utility also funds other stormwater management activities, allowing additional improvements in water quality.

2.3.4 Town of Winterville Regulations

The **Town of Winterville, North Carolina, Manual of Standard Designs and Details** provides regulations on storm drainage and design, sedimentation and erosion control, and stormwater detention. All storm drainage pipes are designed for a 10-year storm, and catch basins are designed for a 2-year storm. The regulation also provides steps required to estimate runoff as well as runoff coefficients based on the lot size of the development.

Environmental protections: The regulation is designed to control stormwater runoff from initial designs through construction. This should provide controls for current and future development activities.

The **Chapter 154 Subdivision Ordinance of the Code of Ordinances of the Town of Winterville, North Carolina**, provides requirements for land dedicated for recreation, park, or open space development. This includes that such parcels are connected by a dedicated strip of land at least 30 feet in width, and that at least one-half of the total land dedicated shall be located outside the areas of special flood hazard, including the 100-year floodplain, and at least 75 percent of the total land dedicated must be outside of wetland areas.

Environmental protections: The regulation increases the amount of open space that is required beyond that protected by floodplain or wetland regulations, increasing the overall protected area within the development and increasing infiltration in new developments.

The **Chapter 155 Zoning Ordinance of the Code of Ordinances of the Town of Winterville, North Carolina** establishes that planned unit development (PUD) areas must protect environmentally sensitive areas, including floodway and floodway fringe areas, steep slopes and knolls, wetlands, water supply watersheds and recharge areas, rock outcrops, habitat for threatened and endangered species, areas of historic, archaeological, or architectural significance, and usable open space, as well as to protect trees and foliage, and control soil erosion and stormwater. The regulation also determines minimum buffer widths for incompatible uses, but these requirements can be minimized through the installation of fencing, minimizing the environmental component of these buffer requirements.

2.3.5 State Regulations

NPDES Phase II Stormwater Permitting is required by the US Environmental Protection Agency (USEPA) through DWQ for larger municipalities in North Carolina. The State of North Carolina assumed the entire NPDES program from the USEPA including the stormwater components, as allowed under the 1972 Clean Water Act (CWA). DWQ's web site summarizes the State's assumption of NPDES permitting: "In 1972, the National Pollutant Discharge Elimination System (NPDES) program was established under authority of the federal Clean Water Act and delegated to the Division of Water Quality for implementation in North Carolina. Phase I of the NPDES stormwater program was established in 1990. It focused on site and operations planning to reduce pollutant sources. Phase I covered industrial activities in 10 categories, construction activities that disturbed five or more acres, and municipalities with populations of 100,000 or more that owned or operated a municipal separate storm sewer system (MS4). Phase II of the program expanded permit requirements to construction disturbing an acre or more and smaller communities (< 100,000 population) and public entities that own or operate an MS4."

http://portal.ncdenr.org/web/wq/ws/su/npdessw (NCDWQ webpage)

The City of Greenville and the Towns of Winterville and Ayden are NPDES Permitted Phase II MS4s issued by DWQ and as such they must have stormwater management programs. The NPDES Phase II Rules define a stormwater management program for a small MS4 as a program composed of six elements that, when implemented together, are expected to reduce pollutants discharged into receiving water bodies to the maximum extent practicable (MEP). These six minimum control measures include:

- Public Education and Outreach Minimum Control Measure
- Public Participation/Involvement Minimum Control Measures

- Illicit Discharge Detection and Elimination Minimum Control Measure
- Construction Site Runoff Control Minimum Control Measure
- Post Construction Runoff Control Minimum Control Measure
- Pollution Prevention/Good Housekeeping Minimum Control Measure

The Neuse Rules where adopted pursuant to 1995 (Reg. Session, 1996) North Carolina Session Laws, C. 572, by the Environmental Management Commission with the goal of reducing nitrogen loading to the Neuse River estuary by 30 percent. The official name is the Neuse River Basin-Nutrient Sensitive Waters Management Strategy. It was established in North Carolina Administrative Code 15A NCAC 02B .0232-.0236, and includes the following rules:

- Protection of existing riparian areas (50 feet on both sides of intermittent and perennial streams)
- Reduction of wastewater discharge loading
- Basinwide stormwater requirements that essentially keep nitrogen loading from new development at 70 percent of loading from non-urban areas
- Reduction of loading from agricultural operations
- Nutrient management by commercial applicators of fertilizer

This project area is in the Neuse River Basin so all of the rules apply except the stormwater requirement, which did not include Pitt County or the three municipalities. However, the County essentially adopted this rule in County Stormwater Management Ordinance for Nutrient Control (see above).

2.4 Impaired Waters – North Carolina CWA Section 303(d) List

Every two years DWQ issues a list of waters in the state that do not meet water quality standards. Streams that do not meet standards are also considered to not meet their designated uses and are deemed to be impaired. This list is in accordance with Section 303(d) of the Clean Water Act and accordingly is known as the 303(d) list. Only one stream in the project area appears on the USEPA-approved 2012 303(d) list: Swift Creek from its source to NC Highway 102. This stream segment has been on the list since 1998 based on a benthic macroinvertebrate survey in 1995 that received a Poor rating.

To be removed from the 303(d) list, a stream would need to attain a Good-Fair rating from a benthic macroinvertebrate survey. Chapter 3 of this report presents benthic macroinvertebrate monitoring as part of this project. Based on an abbreviated survey, Swift Creek at NC 102

received a Fair rating. Thus, though the aquatic insect community has improved, it still is considered to be impaired.

When a stream segment has been assessed as impaired for aquatic life when a fish or benthic macroinvertebrate community sample received a bioclassification of Severe, Poor, or Fair and there were no other aquatic life standards violations, DWQ puts the segment in Category 5 of the 303(d) list, which requires a Total Maximum Daily Load (TMDL). A TMDL is the maximum amount of a pollutant that a stream can receive and still meet water quality standards. This is not a straightforward exercise for an impaired benthic macroinvertebrate community because a problem pollutant has not been identified, so one cannot put a limit on a pollutant.

DWQ has issued TMDLs for impervious cover in watersheds to address such impairments (e.g., Swift Creek in Wake County). USEPA approved this TMDL in 2009 but DWQ has, at least temporarily, discontinued issuing impervious cover TMDLs for impaired benthic communities. One issue with these TMDLs is that they are essentially not attainable because impervious cover effectively cannot be removed on a large scale. The stream must meet water quality standards to be removed from the 303(d) list, which is the case whether the TMDL was in effect or not. It puts the regulated entities in a state of non-compliance with a TMDL.

Another approach that DWQ will consider for impaired aquatic life is a Category 4b watershed plan. The following is taken from a guidance document provided by DWQ on 4b demonstration plans:

The USEPA regulations also acknowledge other pollution control requirements that may remove the need for a TMDL, including technology-based effluent limitations, more stringent effluent limitations, or other pollution control requirements (e.g. best management practices) that are stringent enough to achieve water quality standards within a reasonable period of time. These impaired waters where a TMDL is not required because they are expected to meet standards due to other pollution control requirements are commonly referred to as "Category 4b" waters, as described in USEPA Integrated Reporting (IR) guidance, http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/2008_ir_memorandum.cfm.

Process and timeline to request Category 4b

As the authorized implementer of the CWA in North Carolina, DWQ is responsible for assessing waters to learn if standards are being met. Participants may request that DWQ consider an impaired waterbody for Category 4b. Participants may be local governments, non-profit organizations, and other state agencies. The following is the process and timeline for these requests:

1. Requests can be submitted at any time to DWQ.

2. Participants must address the six elements set forth in USEPA/DWQ requirements (listed below).

3. DWQ must make the final decision on submitting a 4b demonstration to USEPA.

4. USEPA will evaluate on a case-specific basis a State´s decision to move an impaired waterbody from Category 5 to Category 4b and thereby not require a TMDL. Final designation of a waterbody for Category 4b is contingent upon approval of the 4b demonstration by USEPA. In the case where there is no EPA approval, the waterbody will remain in Category 5 and a TMDL is required.

5. After a 4b demonstration has been approved by USEPA, DWQ may request a progress report from the participant for tracking purposes.

USEPA and DWQ Requirements for 4b Demonstrations

The following information on what must be included in a 4b demonstration is largely based on EPA guidance. Because EPA's 4b guidance is intended for States, rather than third party "participants", DWQ has added information to further clarify expectations and the necessary information and review process. Participants are also encouraged to contact DWQ to discuss specific cases. Participants requesting the placement of an impaired waterbody into Category 4b are responsible for the development of the demonstration that a Category 4b designation is appropriate for the impaired waterbody. A Category 4b demonstration must provide the following information:

1. Identification of waterbody assessment unit number(s) and statement of the problem causing the impairment;

2. Description of pollution controls and how they will achieve water quality standards (WQS);

3. An estimate or projection of the time when WQS will be met;

4. Schedule for implementing pollution controls;

5. Monitoring plan to track effectiveness of pollution controls; and

6. Commitment to revise pollution controls, as necessary.

In cases where the impairment is based on non-attainment of a narrative (non-numeric) water quality criterion, the Category 4b demonstration should identify one or more appropriate numeric water quality target levels that will be used to evaluate attainment of the narrative water quality criteria. The Category 4b demonstration should also describe the basis for selecting the numeric target levels.

Further information on the six requirements is available through a link at the bottom of the following web page: http://portal.ncdenr.org/web/wq/ps/mtu/tmdl

3. Benthic Macroinvertebrate Monitoring

To characterize water quality and instream habitat in the project subwatersheds, benthic macroinvertebrate (i.e., benthos or aquatic insect) monitoring was conducted. This is useful because the insects are exposed to a suite of conditions over time and only those tolerant of the stream's conditions will be present. The more abundant a given species is in the sample, the more tolerant they are of the existing conditions. This monitoring provides a longer term characterization of water quality and habitat, as opposed to snap shots that would be obtained by collecting grab water samples and analyzing them for different constituents, such as nutrients, metals, pesticides, etc. It also is more feasible to collect the data because biologists visit the stream one time instead of on many occasions to collect enough grab samples to characterize the range of conditions observed at a site. The targeted time for benthic macroinvertebrate monitoring in areas of eastern North Carolina is late winter, when the chances of the streams experiencing very low flow (or no flow) conditions are smallest.

3.1 Methodology

Twelve stream sites in the project study area were sampled by Lenat Consulting Services for benthic macroinvertebrates on March 7-9, 2011.

All sites were sampled using the NC Division of Water Quality's Qual-4 method, which is an abbreviated 4-sample method developed for sampling streams less than 4 meters wide. Because of the limited habitat available at all sites, this method was used for all sites, regardless of width or drainage area. Details of the method can be found on the DWQ web site. http://portal.ncdenr.org/web/wq/ess/bau (follow Benthos SOP link on this webpage)

Sites are evaluated using EPT taxa richness, total taxa richness, and the NC Biotic Index. Better water quality produces higher taxa richness values, but a lower biotic index. Details of how these metrics are used also can be found on the DWQ web site. http://portal.ncdenr.org/web/wq/benthosdata (further information for interpreting this data is available on this webpage)

In addition to collecting benthos, USEPA's rapid bioassessment protocol was conducted to evaluate the habitat at each site. At the time benthic community sampling was carried out, stream habitat and riparian area conditions were evaluated for each reach using USEPA's rapid bioassessment protocol for low gradient streams (Barbour et al., 1999). This subjective protocol rates the aquatic habitat of the sampled reach by adding the scores of a suite of local (reach scale) habitat factors relevant to macroinvertebrates. Total scores range from zero

(worst) to 200 (best). On Form 3: Habitat Assessment Field Data Sheet for Low Gradient Streams ten individual factors to be rated include (each is worth 20 points, brief explanation provided):

1. Epifaunal Substrate/Available Cover – percent of substrate favorable as habitat;
2. Pool Substrate Characterization – based on composition of substrate materials;
3. Pool Variability –variety of pool size and depth;
4. Sediment Deposition –ability of stream to transport sediment;
5. Channel Flow Status – amount of channel or substrate that is covered by water;
6. Channel Alteration – degree of channelization or dredging;
7. Channel Sinuosity – actual stream length divided by straight line length from top to bottom;
8. Bank Stability – each bank evaluated separately (10 points each) for evidence of erosion;
9. Vegetative Protection – each bank evaluated separately (10 points each) for vegetative cover;
10. Riparian Vegetative Zone Width – each bank evaluated separately for width of riparian zone.

3.2 Results

None of the sites in the project area had good habitat. Habitat scores less than 100 are considered to be severely impaired. This does not mean that poor habitat is the primary cause of problems in the biological community, as many sites may have problems with toxicity, nutrient enrichment, and/or low dissolved oxygen. Simple habitat restoration, such as leaving woody debris that does not impede stream flow, may produce limited benefits.

Except where noted, all sites have been straightened (channelized) with an access road on one side and a vegetated bank on the opposite side. Maintenance activities often remove all woody debris from the channel. Water was generally clear at all sites, especially on the second and third day of collections (March 8 and 9, 2011). Although there had been about 0.5 inches of rain on March 6th, 2011, one day prior to the surveys, there were no problems with high water levels.

Recent droughts are likely to have had a negative effect on the aquatic fauna of these streams, especially the smaller streams. Lack of flow (or even lack of water) can seriously affect the biological integrity of these streams and make it difficult to assign a rating or bioclassification. The ratings produced here reflect both DWQ criteria and some best professional judgment.

Following are descriptive results of the monitoring by site. More detailed results may be found in Appendix B. Sites 1 through 8 are located in the Swift Creek Watershed and sites 9 through 14 are located in the Fork Swamp watershed. Sites 3, 11, and 13 were removed from the survey due to time constraints.

- #1 - Swift Creek at NC 102. Five meters wide with habitat score of 61. The lower Swift Creek site indicates some recovery from upstream problems, with higher EPT taxa richness (3), lower Biotic Index (7.1), and relatively high taxa richness (37). This was the only site with *Maccaffertium modestum* (Common) and *Acerpenna pygmaea* (Common). This pattern suggested **Fair** water quality at Site #1.

  This site has been sampled by DWQ 3 times, with a result of either a Fair or a Poor rating. EPT taxa richness was 8 in July 1991, 5 in August 1995, and 8 in March 2001. In comparison with the EPT taxa richness recorded in 2011 (3), this suggested a decline in water quality over the last decade. Repeated drought conditions, however, may have contributed to this decline in EPT taxa richness.

- #2 - Unnamed Tributary (UT) to Swift Cr. North of Ayden. This site at Old NC 11 is two meters wide with habitat score of 90. This site drains most of Ayden, except the southeastern portion. This site had only 1 EPT taxa, and a high Biotic Index (7.8), and relatively low total taxa richness (25). Furthermore, the abundance of the midge *Chironomus* suggested high organic loading. This pattern indicates **Poor** water quality.

- #4 - Reedy Branch (directly east of Horsepen Swamp). Two meters wide with a habitat score of 78. This site drains the southern part of Winterville. This site had 0 EPT taxa and low total taxa richness (22). This suggests **Poor** water quality.

- #5 - Horsepen Swamp. Two meters wide with a habitat score of 122. This subwatershed was less developed, but this was not reflected in the fauna. This site, however, had better habitat with well-developed pools and good bank areas. The fauna at this site suggested some low dissolved oxygen problems due to the abundance of the snail *Physa*. This may be due to animal waste. Combined with the elevated Biotic Index (7.7), this suggested **Poor** water quality.

- #6 - Nobel Canal. About 1 meter wide with a habitat score of 68. This site is located in Winterville immediately upstream from Reedy Branch Road and drains a heavily developed portion of Winterville. The very small size may limit the development of the aquatic fauna, especially if the stream normally stops flowing in summer months.
  The benthos community indicates **Very Poor** water quality. EPT taxa were absent, total taxa richness was very low (15) and the Biotic index was very high (8.2). Due to the small size of this stream, however, some problems may be due to extended periods with no flow (or no water).

- #7 - Gum Swamp. About two meters wide with a habitat score of 83. This is the best site in the study area, having lower biotic index (7.4), relatively higher EPT taxa richness (3), and high total taxa richness (45). This was the only site with the intolerant caddisfly *Triaenodes ignitus* (common) and the mayfly *Caenis* was abundant. This was also the only site having the snail *Helisoma anceps* (Abundant). Odonata richness was the

highest in this study (9). The overall assessment is a **Fair** rating. The better biological community may reflect a less developed watershed.

- #8 - Upper Swift Creek. This site at Davenport Farm Road is 2.5 meters wide with a habitat score of 80. This site had algal mats growing on the stream bottom, indicating high nutrient levels. Low EPT taxa richness, but without an extremely high biotic Index. The only highly tolerant abundant species was *Cricotopus bicinctus* (a midge). Odonate taxa richness was high (7). The overall assessment is a **Fair** rating.

- #9a - Upper Fork Swamp. This site, about 0.5 miles downstream from Fire Tower Road, was three meters wide and received a habitat score of 94. This sandy stream had poor instream habitat, no EPT taxa, low total taxa richness, and a community dominated by pollution-tolerant species (high biotic Index). This pattern suggested **Poor** water quality in Upper Fork Swamp.

- #9b - Northeast UT to Fork Swamp. Two meters wide with a habitat score of 118. This stream was not channelized and had a higher habitat score relative to other nearby streams. Site 9b has more leaves and snags than the channelized sites, and it is shaded by riparian vegetation. However, the benthic macroinvertebrate community was characterized by very high numbers of the worm *Lumbriculus variegatus*. This species is favored by organic loading, as long as dissolved oxygen levels remains high. This community suggests sporadic sewer leaks, possibly following high rainfall events. This site has **Poor** water quality.

- #10 - UT to Fork Swamp (Eastern Winterville subwatershed). This site just upstream of Worthington Road was on a very small (1.5 meters wide) stream and had a habitat score of 67. The site drains an eastern section of Winterville. It had very abundant algal growths, suggesting some upstream enrichment. Although EPT taxa richness was low (1), higher total taxa richness and lower Biotic Index suggested **Fair** water quality.

- #12 – Lower Fork Swamp east of Ayden. This site at Ayden Golf Club Road was five meters wide with a habitat score of 76. This site had good bank habitat (roots), but few snags and leafpacks. This site showed little improvement relative to the upstream site (9a) on Fork Swamp. The increase in total taxa richness (17 to 38) may be mainly due to an increase in stream size. EPT taxa richness remains low (1) and the biotic index remains high (7.7), indicating **Poor** water quality.

- #14 - Northwest UT Fork Swamp. This site was 2.5 meters wide with a habitat score of 104. This site was channelized at one time, but there has been no recent maintenance in the area sampled. The site is shaded by riparian vegetation and drains a heavily developed residential area in Winterville. EPT taxa were absent, but the lower biotic index indicated a less intolerant community. This pattern suggests **Poor-Fair** water quality.

Comparison Sites

Attempts to find a reference site (i.e., site in pristine or near-pristine condition) near Greenville were not successful, as all sites were either channelized or were non-flowing swamp streams. These non-flowing swamp streams do not represent a reasonable target for the management of the streams in the project area. Therefore, the following comparison sites are flowing swamp streams:

- Indian Swamp. This site at Stokestown Road was four meters wide and had a habitat score of 81. This site is a channelized canal that drains an agricultural area; very abundant filamentous algae suggested that high nutrient loading was a problem. These algal growths might be less prolific at other times of the year or at times with higher flow rates. The abundance of the snail *Physa* indicates problems with low dissolved oxygen, although there does not appear to be a problem with organic loading. The very abundant algal growths may cause dissolved levels to drop during the night, when respiration rates are high. Although the biotic index was high (7.6), this site had 2 EPT taxa and a relatively high total taxa richness (35). The mayfly *Caenis* was abundant, a pattern seen only in the least impacted Swift Creek tributary. These results suggest **Fair** water quality.

- Cow Swamp. This site at Galloway Crossroads was four meters wide with a habitat score of 118. Cow Swamp was channelized, but in a way that maintained some channel sinuosity. There may be some low-flow problems, however, as much of the channel was deep and slow-moving. Positive signs included both high total taxa richness and the abundance of intolerant freshwater mussels (*Elliptio*). This site is difficult to evaluate, but appears to have **Fair-Poor** water quality.

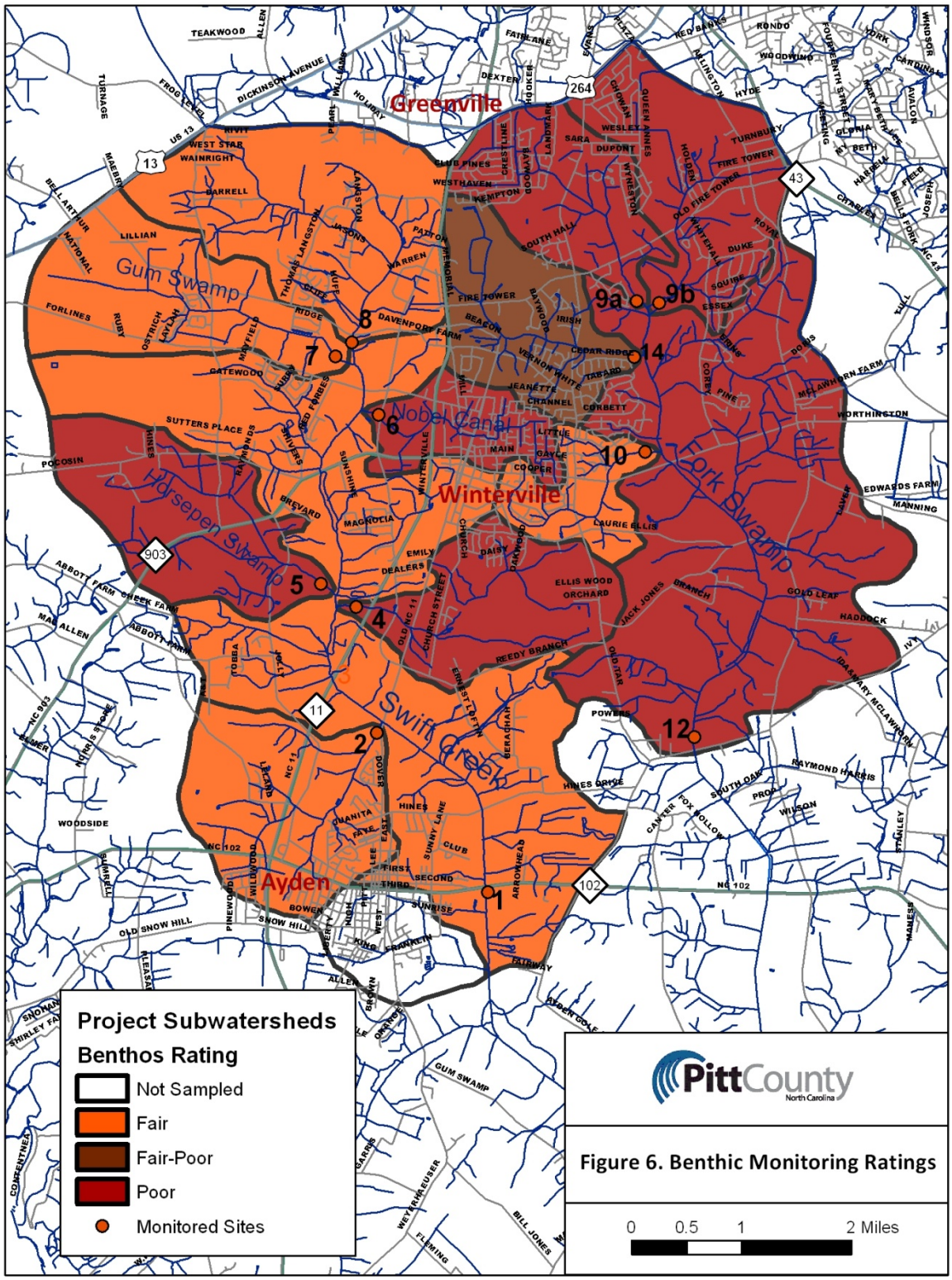


Figure 6. Benthic Monitoring Ratings

3.3 General Observations and Recommendations for Improvement

This section includes general comments from the biologist (Dave Lenat from Lenat Consulting Services) who conducted the benthic macroinvertebrate monitoring, and then concludes with recommendations for further monitoring to determine the causes of the benthic impairments.

Channelization (and continuing channel maintenance) has resulted in poor habitat for most of these streams. Maintenance crews appear to remove all of the wood in the stream. Different instructions (e.g., leave wood of a certain size that does not block flow), with feedback or rating *after* completing work, would improve stream habitat without affecting the Drainage District's mission of maintaining channel conveyance.

However, while there are obvious habitat problems in these streams, most sites had adequate habitat (e.g., small wood, bank areas, and leafpacks) to maintain a much more diverse community, with more pollution-intolerant species than those observed. Therefore, urban and agricultural runoff is likely a much greater contributor to the existing problems than poor habitat. Managing runoff through methods described in this plan will be necessary to reduce stormwater impacts and consequently improve instream water quality and the benthic macroinvertebrate communities.

All sites had Poor or Fair water quality, with the best sites being Gum Swamp and the downstream site on Swift Creek at NC 102. Low dissolved oxygen was indicated at two sites (Horsepen Swamp and Indian Swamp; the latter is a comparison site). Organic loading (possibly from sewage; i.e., sanitary sewer line overflows) was suggested at site 9B (Northeast Fork Swamp) and at site 2 (North Ayden - UT Swift Creek north of Ayden).

At many sites there were few abundant species, possibly due to both toxicity and scour from high streamflow velocity. Scour is less likely to be a problem under the low-flow conditions experienced by these streams in recent months. Very sparse fauna was observed at sites 4, 6, 9A, 10, and 14, based on both field notes and the number of abundant species.

Recovery in these streams is first observed by the addition of pollution-tolerant species, including Chironomidae (midges) and Odonata (dragonflies and damselflies). For this reason, total taxa richness is a useful tool in identifying areas of improving water quality/habitat quality.

3.4 Identifying the Causes of the Benthic Impairments

In terms of the causes of the benthic impairments, in addition to generally poor habitat, toxicity and nutrients from stormwater runoff are the likely causes. Given that algal mats are common throughout the channels of the study area and nutrients are common pollutants, it is apparent

that nutrient pollution is one of the primary stressors. Through photosynthesis, algal mats create dynamic dissolved oxygen conditions in the stream, whereby dissolved oxygen is high during daylight hours and low at night when the vegetation consumes oxygen through respiration. Toxicity, however, is more problematic to confirm and to identify the specific pollutants involved.

For confirmation of toxicity, the first steps to take are general tests that identify whether toxicity is present or not. Such tests include ambient toxicity tests (bioassays). Laboratory bioassays provide a method of assessing the presence of toxicity from multiple pollutants, and their cumulative effect on biota. Next, measured water column and sediment concentrations may be compared with a suite of published benchmarks to help evaluate whether observed concentrations might have an impact on aquatic life.

The first ambient toxicity test (bioassay) includes exposure of a water flea (*Ceriodaphnia dubia*) to water grab samples (i.e., container of stream water is analyzed) from the project streams. The acute toxicity test uses protocols defined in USEPA document EPA/600/4-90/027F (USEPA, 1993), which includes a 48-hour exposure and measures subject survival. The chronic toxicity test uses the North Carolina Ceriodaphnia Chronic Effluent Toxicity Procedure (NC Division of Water Quality, 1998), which measures subject survival and reproduction during a one-week exposure. DWQ favors the chronic test because, to some degree, it better represents field conditions that the local benthic macroinvertebrates experience.

Another useful bioassay is a forty-two day chronic toxicity sediment bioassay using *Hyallela azteca* as described in USEPA (2000). This measures longer-term exposure of organisms to a collection of pollutants that accumulated over time. This, of course, is more akin to actual field conditions.

In addition to bioassays, water column grab samples and sediment samples from the stream may be analyzed for specific toxic pollutants. These pollutants include:

- Metals
- Semi-volatile organics (USEPA Method 625)
- PAHs (polycyclic aromatic hydrocarbons; USEPA Method 610)
- Phenols (USEPA Method 604)
- MBAS (methyl blue active substances, an indicator of anionic surfactants)
- Chlorinated pesticides and PCBs
- Other pesticides

The results of the lab analyses are then compared with published benchmarks that have been shown to be toxic to aquatic life.

Much of the sampling for these parameters can be focused on sediment analyses, because sediment is a better long-term recorder of certain pollutants in the stream. Also, benthic macroinvertebrates are constantly exposed to sediment, in contrast to infrequent, potentially-toxic pulses of stormwater. Water benchmarks include the following:

- EPA's National Ambient Water Criteria (NAWQC) for freshwater (USEPA, 1999) and Tier II benchmarks (USEPA, 1995). Metals benchmarks were adjusted for hardness where possible (USEPA, 1999).
- DWQ's standards for protection of aquatic life – 15A NCAC 2B .0100 and .0200.

Sediment benchmarks are published in EPA's "A Guidance Manual to Support the Assessment of Contaminated Sediments in Freshwater Ecosystems" (USEPA, 2002). These benchmarks may be divided into categories for threshold effect concentrations, below which harmful effects are unlikely, and for probable effect concentrations, above which harmful effects are likely.

Two caveats for these sediment quality guidelines should be noted. First, they should be normalized for total organic carbon (TOC). Secondly, no total metals concentration benchmarks exist, which means cumulative metals effects cannot be accounted for.

Benchmarks are used as part of a larger screening process which is detailed in USEPA (2000) and NCDWQ (2003). All lines of evidence available, including toxicity bioassays, benthic macroinvertebrate surveys, and water quality/sediment chemistry, should be used to make a decision on the likelihood of pollutants to impact the benthos.

4. Riparian Protection and Stream Enhancement

This chapter presents floodplain conservation opportunities, as well as other riparian protection measures and a stream enhancement design.

4.1 Flooding in the Project Area

As discussed in Section 1.2, the canals in the project area were dug in the 1920s through the 1940s and were later designed in the 1960s for the main canals to convey the two-year storm and the lateral canals to convey the five-year storm. According to Charles Vandiford, the Maintenance Superintendent of the Southeast Drainage Commission, which includes Pitt County Drainage Districts 3 and 7, the main canals now convey much less than the two-year storm and some of the lateral canals convey less than the five-year storm. This indicates that flooding is a frequent occurrence. Typically, flooding is limited to the maintenance travel ways along the canals, particularly below Davenport Farm Road on Swift Creek and Fire Tower Road on Fork Swamp. When flooding is limited to the travel ways and swampy areas (not developed areas), this may be seen as a positive occurrence. This localized flooding decreases stream energy that may erode the canal channels and make them larger. It also decreases flooding downstream because it provides temporary storage and reduces the amount of discharge that is transported downstream.

However, in bigger storm events such as hurricanes, flooding extends beyond the travel ways. The only place where a paved road is regularly overtopped is Worthington Road by Fork Swamp. Additionally, discussions with local officials indicate that properties/buildings at the following locations are subject to flooding:

- Apartments along upper Swift Creek upstream of Thomas Langston Road.
- Subdivisions near Main Street in Winterville, including Ashley Meadows and Winterfield from the Fork Swamp 26 canal.
- Preston Trails and Cedar Ridge subdivisions near where an unmaintained Fork Swamp tributary crosses Old Tar Road.
- Houses within the floodplain of lower Swift Creek at NC 102.
- Homes on Woodridge and Sawgrass Drives along the left bank of Swift Creek 40 (Gum Swamp).
- Swift Creek in the vicinity of the Swift Creek 37 lateral canal (small tributary southwest of Winterville in the lower Swift Creek subwatershed) also floods several residences near Magnolia Drive.
- West Star area.
- 4415 Corey Road.

These locations are shown in Figure 7. With the exception of the first two locations near Thomas Langston Road and along Main Street in Winterville and the last two locations at West Star and Corey Road, the properties that experience flooding are located within mapped FEMA floodplain.

Flooding beyond the project area is also a problem in Pitt County. The bottom of the canal at NC 118 upstream from Vanceboro is at sea level, leaving water in the channel nowhere to go when flooding occurs. Consequently, flooding in this area is common and extensive. As development increases, it is likely that this will only worsen. The County is interested in taking steps now to alleviate future flooding.

Additional measures in the stream corridors may be helpful to manage flooding. These include:

- Use of berms to keep floodwaters in swamps for an extended period; berms are already present in many places, particularly on the travel way side
- Benching to provide better conveyance, where beneficial, as well as floodplain storage
- Wider floodplains to reduce flooding
- Debris removal following storms (this is already done well, but it must continue to be effectively managed after each storm)
- Model proposed conditions (benching, opening floodplain, stream enhancement for Gum Swamp, etc.) to see effect
- Seek to reduce peak events by detaining runoff in structural stormwater control measures
- Stricter County ordinance to limit floodplain development
- Consider installing culverts beneath travel ways to allow flood water to discharge into adjacent swamps and drain the swamps once flood water subsides
- Target large riparian (along stream channels) parcels for conservation.

These measures were discussed with the project partners, particularly Charles Vandiford from the Southeast Drainage Commission. Many may be feasible but would require expensive excavation (e.g., benching, widening floodplains) and would need to be modeled to determine the overall effect.

The measure to install culverts beneath the travel way would require closer field inspection managed by Mr. Vandiford. This may be done in places where the maintenance travel way is higher than the adjacent swamp and where the floodplain is wider, indicating more extensive flooding. Care must be taken with this approach not to flood other properties. GIS analysis was done to identify locations in the project area that meet this description. These include the following:

- Fork Swamp near Jack Jones Road. The left bank 3,000 feet upstream and 3,000 feet downstream from the road with some breaks where the travel way appears to be lower.
- Swift Creek downstream from old NC 11 and the railroad crossing. It appears that the travel way on the left bank is one foot higher than the forest beyond for approximately 4,700 feet to Hines Drive. After a gap it continues for another 3,000 feet to NC 102 and then continues for another 4,000 feet to the end of the project area.

In the following section, a method is described to identify large riparian parcels to target for conservation.

4.2 Parcels Targeted for Riparian Protection

This section describes the Geographic Information System (GIS) analysis used to identify large parcels that are adjacent to the stream channels that provide flood water storage and water quality benefits.

For this section, it is necessary to define different floodplain zones, as they are referred to by Federal Emergency Management Agency's (FEMA) floodplain mapping program.
Flood zones are geographic areas that FEMA has defined according to varying levels of flood risk. These zones are depicted on a community's Flood Insurance Rate Map (FIRM) or Flood Hazard Boundary Map. Each zone reflects the severity or type of flooding in the area.

Table 7. FEMA Floodzone Designations

Floodplain zone	Code definition
A*	Flood hazard area with no base flood elevations (BFE) established through modeling.
AE*	Flood hazard area with BFE established through modeling. Less than 1.0' rise from development permitted in AE zone.
AEFW*	Floodway with elevations established; more restrictive than AE, no development permitted within.
NEA*	Non-encroachment area. Floodway area established from limited detail study (points are not smoothed).
X (SHADED)	0.2 percent annual chance of flood

*defined as a high risk area with mandatory flood insurance purchase requirements.

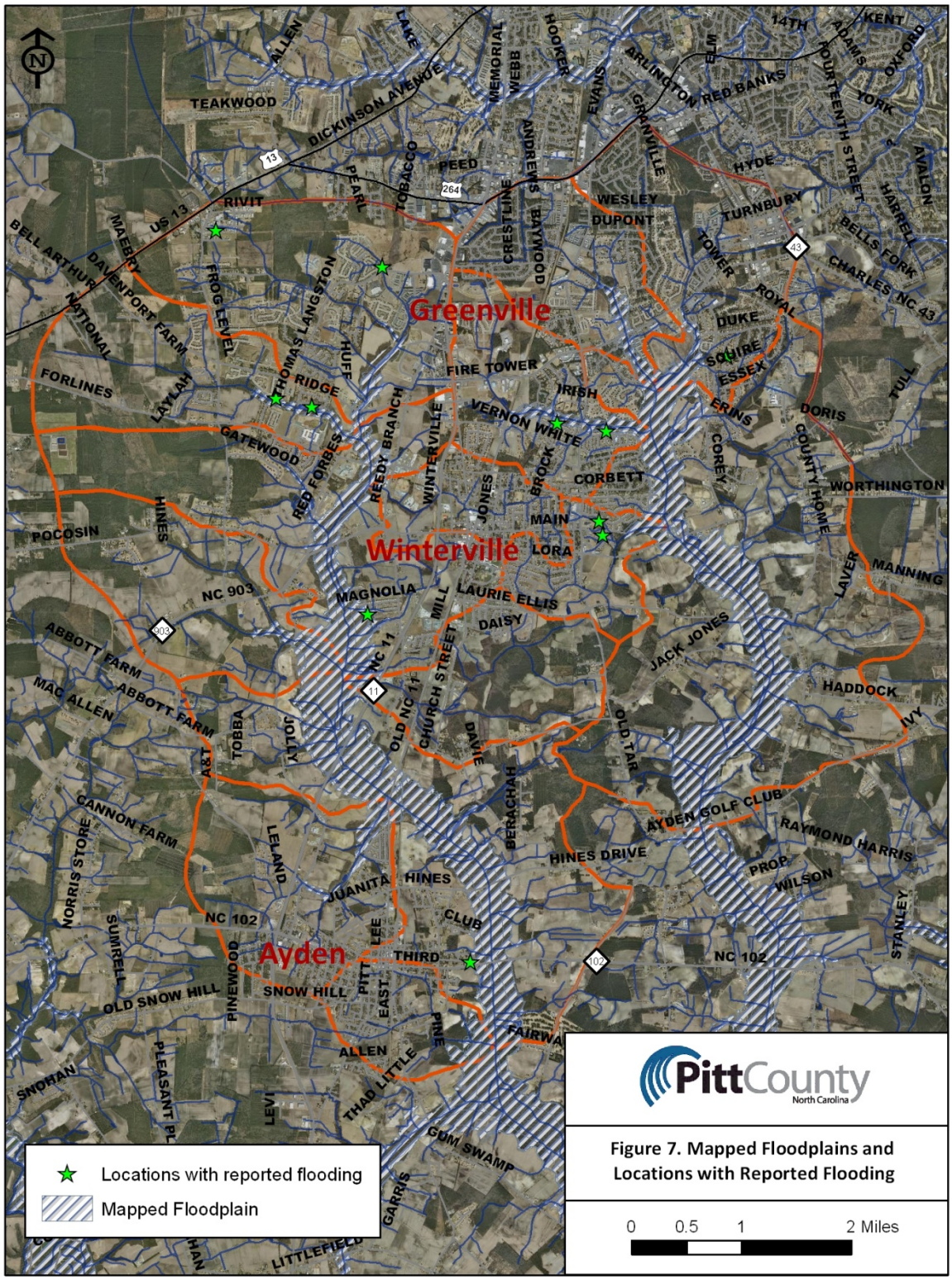


Figure 7. Mapped Floodplains and Locations with Reported Flooding

Working with the floodplains shape file provided by Pitt County Planning, Baker first removed the areas designated as AEFW, which represent the 100-year floodway with base flood elevations provided. AEFW is typically not developable except under extremely strict guidelines from FEMA, so it was assumed that these areas are essentially protected. The resulting mapped floodplains were used to select the county parcels that include the most floodplain area outside of AEFW. To reduce the area of the targeted parcels to only that within the floodplain, the County parcels were intersected with the floodplain layer (minus AEFW). The 56 largest parcels from the resulting selection each have at least 10 acres in the AE flood zone. Thirty six (36) of the largest overall parcels containing AE flood zones were selected for preservation. These are shown in Figure 8 and in the Strategic Conservation Parcels file (Parcels_fp_i_all_strategic.shp) and have a total area of 718 acres.

The only floodplain area that was considered for preservation was the AE zone (flood hazard area with base flood elevations (BFE) established). The non-encroachment area (NEA, floodway determined from limited detail study so the boundary is jagged and not smoothed) is treated like the AEFW zone so it was not considered. The X(SHADED) zone is the 0.2 percent chance flood area and development on it would not affect the flood levels except in very extreme events, so it was also omitted.

As an additional step, Baker obtained the recently digitized Drainage District easement areas to see how much of the targeted parcels were within the existing easements. Since these easements prevent development, it may be unnecessary to acquire the development rights from those areas of the flood parcels. The area of the selected parcels collectively has less than 26 acres within the Drainage District easements. This is probably because much of the easements are in areas mapped as AEFW and those were eliminated from the preservation search.

Appendix C contains the full information about the 36 strategic parcels, including the owner and their address, as well as current land value and landscape position. The current land value for the 36 parcels totals $15,756,812; however, this is for the total parcel area of 2,936 acres, which extends beyond the floodplain. The area within the floodplain is 718 acres. The total parcel value equals an average of $5,367 per acre, but one would expect that to be lower for acreage within the floodplain.

Additionally, it may be more appealing to landowners and less expensive to only purchase the development rights of the floodplain areas. This would entail putting the floodplain portions of a parcel in a conservation easement where development is not permitted in perpetuity. However, the current owner would maintain all other rights to the land, including who is permitted to enter it. Using $2,000 per acre as an example for the amount to put floodplain

acreage in a conservation easement, the strategic parcel areas within the floodplain (718 acres) would have an estimated value of $1,436,000.

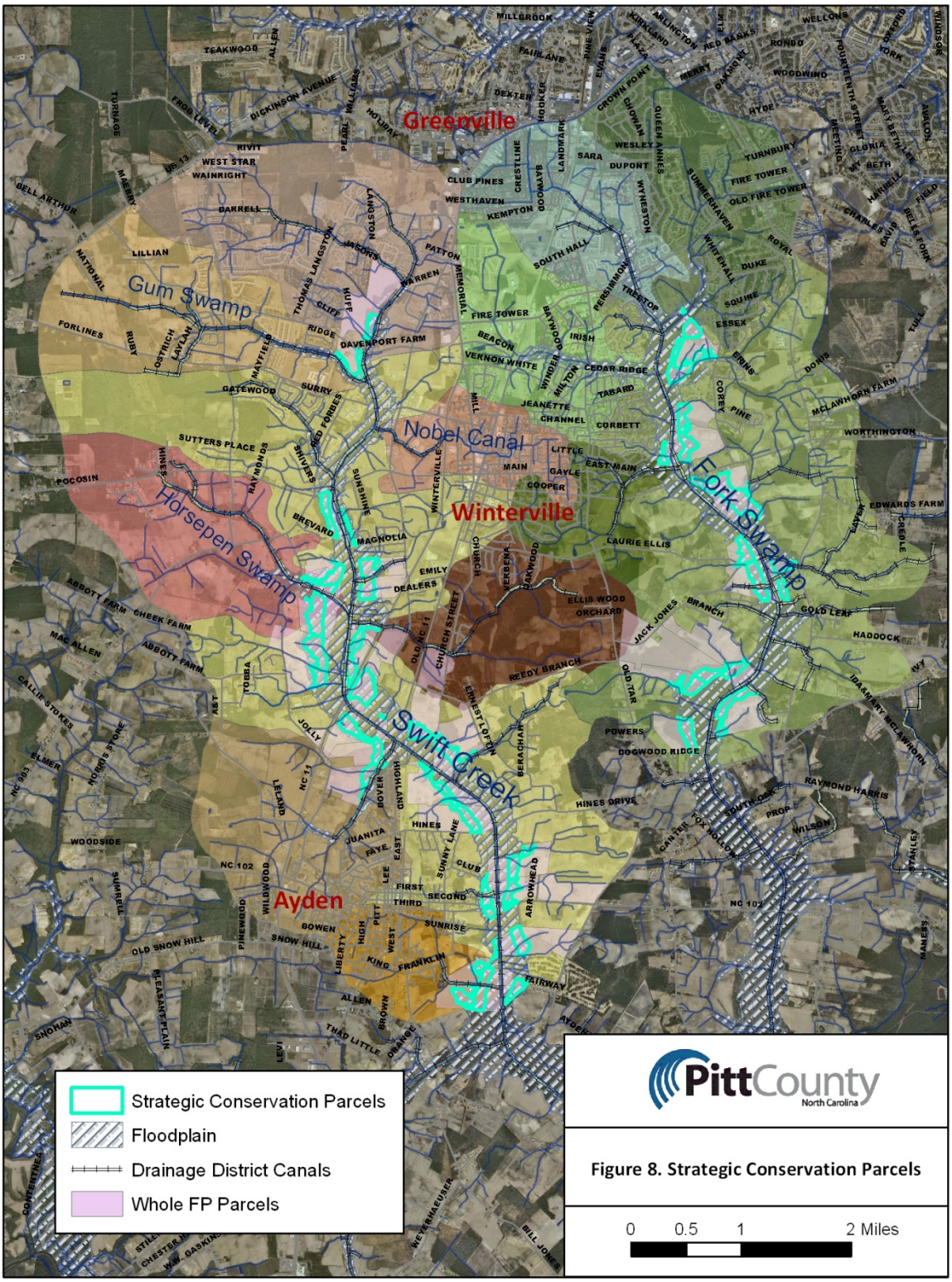


Figure 8. Strategic Conservation Parcels

4.3 Stream Enhancement

Originally, this project sought to identify 10 stream reaches that would benefit from stream restoration or enhancement. Stream restoration is the improvement of a channel's dimension (cross section), pattern (sinuosity), and profile (slope) so that the stream remains stable over time and provides improved stream functions. Stream enhancement involves lesser degrees of channel manipulation, with the same intent of improving channel stability and function. Typically, channel pattern is the most difficult channel parameter to manipulate because it involves greater land area and costs, and may not be compatible with adjacent land uses.

A common practice of stream restoration or enhancement is the incorporation of a floodplain bench that allows the stream to flood at approximately the 1.5-year discharge event. This is often referred to as the bankfull discharge, which, according to natural channel design theory, is the flow that moves the most sediment over time and maintains the channel form (Rosgen, 1996). Sediment is adequately transported at this discharge and energy from higher discharges is dissipated at and above the floodplain bench elevation. This does not mean that stream restoration will increase flooding because often a floodplain bench is excavated at an elevation lower than the natural floodplain within an incised stream. This is likely to be the design approach in the project area because raising the stream bed is generally not a good option; it would promote additional flooding in a floodprone area where development is often close to the stream channels.

After conducting field work in the project area to identify unstable reaches, it became apparent that relatively few reaches are unstable. This was an unexpected result and it is likely testament to the competent channel maintenance conducted by the Drainage Districts. Additionally, the main canals were designed to convey the 2-year discharge in the late 1960s and now convey much less than that, probably closer to a 1.5-year discharge or lower, which would put it close to the bankfull discharge that is optimal for channel stability.

Stream channel stability is related to a stream's ability to transport water and sediment load without eroding. Channel erosion is evident when the streambanks lack vegetation and are being actively washed away by streamflow and/or bank slumping. Sometimes riparian vegetation can prevent erosion of the stream channel even though a floodplain is not available near the bankfull discharge elevation.

4.3.1 Gum Swamp Stream Enhancement

One channel, Gum Swamp, is clearly unstable, has ample area to conduct stream enhancement, and has support for stabilization work from Pitt County Drainage Districts 3 and 7 and the Natural Resources Conservation Service (NRCS), which are the two entities responsible for maintaining channel conveyance in the area. Gum Swamp is a tributary to Swift Creek located

approximately 1,200 feet south of Davenport Farm Road in the northwest section of the study area. The lower 2,400 feet are unstable and subject to further erosion. According to Simon's Channel Evolution Theory, a stream that has incised (i.e., cut deeper) will then widen to create a floodplain at a lower elevation (Simon, 1989). The Gum Swamp streambed has dropped approximately two feet from its previous elevation after a culvert connecting it to Swift Creek was lowered. The channel has since been widening, as evidenced by the frequently steep and eroding right bank.

The project's stream enhancement component will focus on stabilizing this reach by recommending 20 cross sections that will improve channel dimension and incorporate floodplain benching. Additionally, Baker and Pitt County Planning consulted with the regulatory agencies, the U.S. Army Corps of Engineers (USACE) and DWQ, and other interested parties to develop a conceptual design to enhance Gum Swamp. The design will address the issues and concerns identified by the regulatory agencies, the Drainage Districts, and NRCS.

Baker conducted survey of Gum Swamp to form the basis for the design plans. Features surveyed include the stream channel, the maintenance travel way, the riparian buffer on the left bank, the sanitary sewer line, and wetlands interspersed along the sewer corridor. The maintenance travel way is located along the top of the right bank (looking downstream), which is typically near vertical and eroding. The left bank is more stable and has an approximately 30-foot wide riparian buffer, beyond which is a sanitary sewer line corridor and interspersed wetlands.

The design criteria are presented in Figure 9 and include the following:

- Avoid sanitary sewer line
- Minimize wetland impacts around sanitary sewer corridor
- Do not relocate existing channel; work above the ordinary high water mark
- Maintain travel way width of at least 18 feet
- No woody vegetation on right bank; minimal woody vegetation on left bank. This is to allow for maintenance access and to limit the potential for fallen trees to impede stream channel flow.

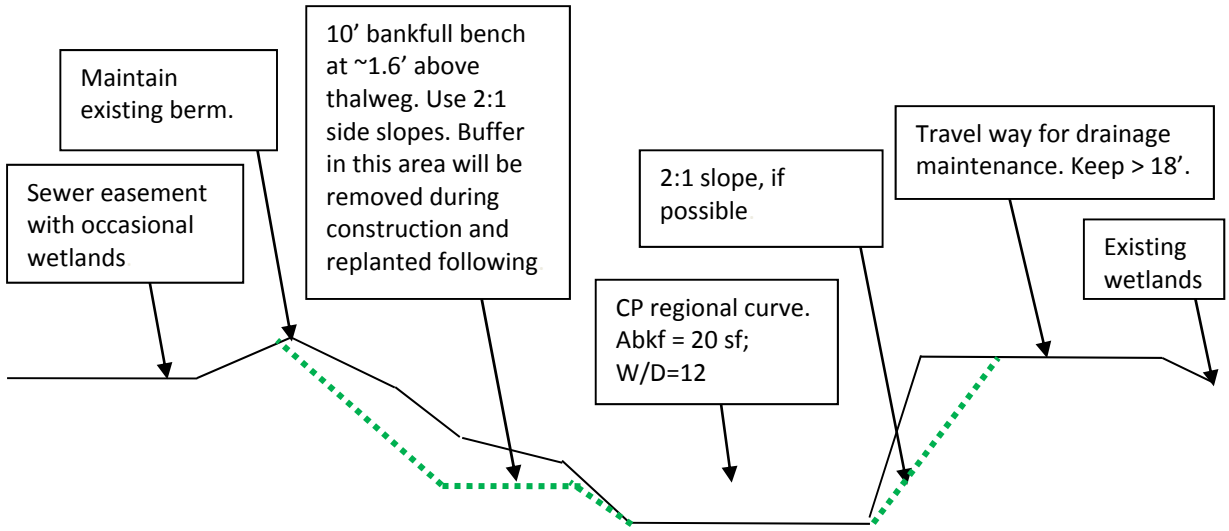


Figure 9. Conceptual design cross section for Gum Swamp (proposed is the dashed line)

The Coastal Plain regional curve was used to estimate the design bankfull dimensions. This regional curve was developed using bankfull measurements on 18 reference streams (Sweet and Geratz, 2003). The bankfull cross-sectional area for a Coastal Plain stream with a drainage area of 2.8 square miles (refer to Table 1 for Gum Swamp) is estimated to be 20 square feet (Figure 10). The design bankfull width-to-depth (W/D) ratio was derived from sand bed reference reaches and an analysis of sediment transport capacity. W/D ratios and slopes from reference sites were plotted and used to select the ratio for the project reach. This plot suggests a W/D ratio of 12 is appropriate given the approximate channel slope of 0.0016. A bankfull cross-sectional area of 20 square feet and a W/D ratio of 12 yield a bankfull width of 15.5 feet and a mean bankfull depth of 1.3 feet.

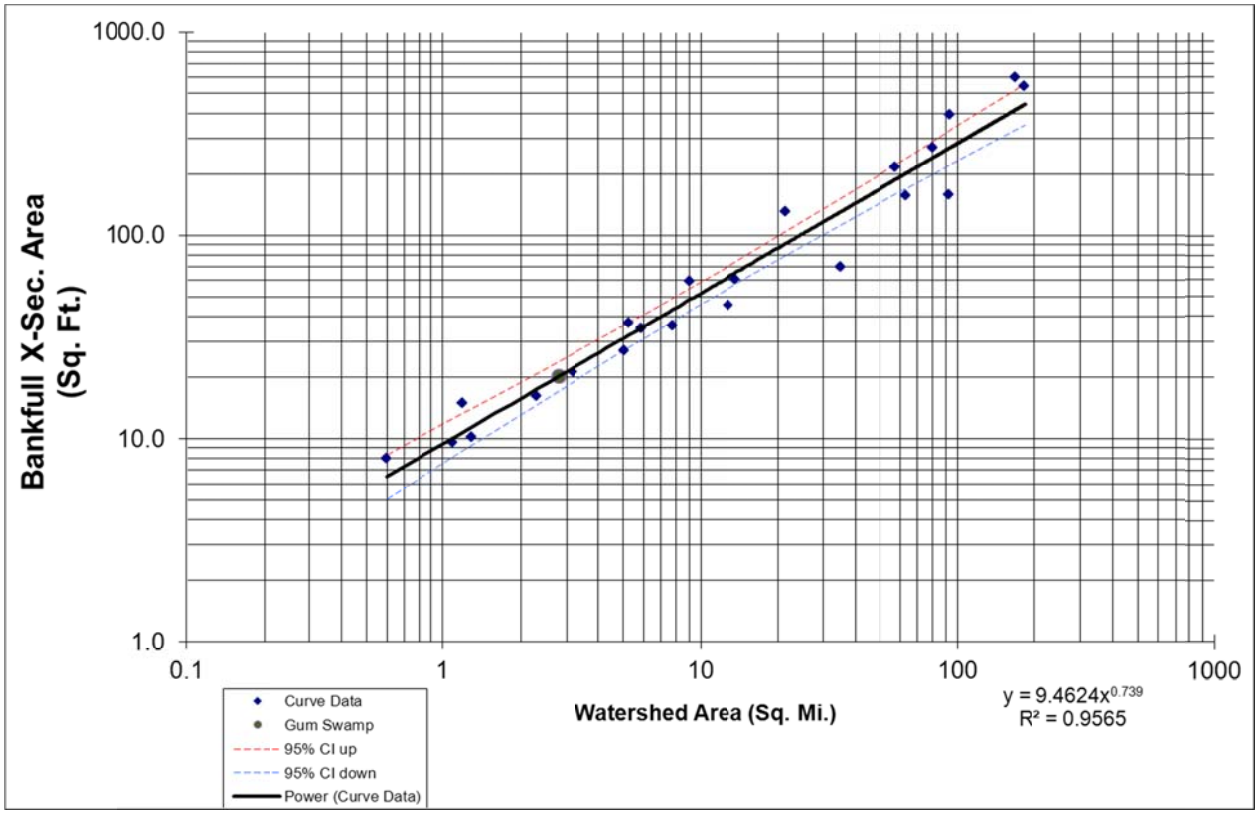


Figure 10. Coastal Plain Regional Curve including Gum Swamp Recommendation

The design plan sheets and 20 design cross sections are provided in Appendix D. A preliminary cost estimate based on quantities was developed to construct the project. The total estimated construction cost is $221,755, which equals $91 per linear foot.

Two meetings were held with the regulatory agencies; an on-site meeting and a scoping meeting. The on-site meeting was conducted with Ms. Emily Jernigan from the U.S. Army Corps of Engineers. Ms. Jernigan noted the wetland areas along the sewer easement, which were later surveyed, and gave her general impressions of the project. A scoping meeting regarding the Gum Swamp stream enhancement was held on February 8, 2012, in Washington, NC. The meeting was attended by representatives from the U.S. Army Corps of Engineers, U.S. Fish and Wildlife, and the North Carolina Department of Environment and Natural Resources (Divisions of Water Quality and Land Quality).

If the wetland impacts are less than 0.5 acres and less than 150 feet of stream channel are disturbed, it appears that a Nationwide 404 Permit may be granted by USACE. The regulations require mitigation if more than 150 feet of stream channel are disturbed and an individual permit if more than 300 feet are disturbed. The proposed work is not considered to disturb the channel unless it involves grading below the high water mark. The only locations where this is

proposed are where stream channel structures (e.g., grade control structures such as J-hook vanes) are installed. This totals less than 150 feet.

For the CWA 401 permit, DWQ stated that if no trees are planted on the left bank to replace those that are removed, mitigation would be required. However, minimal trees could be planted on the terrace slope to satisfy this requirement if shrubs and live stakes are planted on the streambank, floodplain bench, and terrace slope. Using only herbaceous vegetation will be acceptable on the right bank because no woody vegetation is currently present.

NRCS has requested that no woody vegetation be used on the right bank so that maintenance access remains feasible. It appears that DWQ's vegetation requirements for the left bank are acceptable to NRCS provided trees are limited to the terrace slope.

Additional notes from the scoping meeting include the following:

- Get landowner permission on notarized forms
- Do not plant invasive vegetation, including fescue
- Temporary impacts to wetlands are possible if topography is not changed; perhaps include wetland planting to compensate
- Include sewer easement within limits of disturbance if it is used for access
- All disturbed areas need to be stabilized within 7 days
- Stream impacts would be counted if changes are made to the channel below the ordinary high water mark.

The Pitt County Drainage Districts have requested information regarding what maintenance would be needed. With favorable weather and timely establishment of vegetation, the stabilization work on the project streambanks should require little or no maintenance. Limited erosion or sediment deposition may occur as part of the natural variation experienced in stream channels. This is expected and should not require maintenance. However, it is imperative that the slope and the cross section (i.e., bankfull width and depth) of the stabilized channel be maintained. Periodic inspections should identify any problems with slope and cross section before they become severe.

A maintenance plan specific to the project can be developed but in general the following measures are needed:

- An as-built survey to document the stream channel conditions after the project has been constructed
- Regular inspections annually and after large rainfall events
- The boulders and logs used to construct the grade control and flow diverting structures may shift or become dislodged during large storm events. These should be examined

closely to ensure they are serving the purpose intended by the design. It may be necessary to use heavy equipment to return the structure to its as-built condition.

- Structures should be reconstructed in accordance with the design plans and technical specifications.
- Repair work on the channel may include stabilization of eroded areas, removal of accumulated sediment, and/or resetting of boulders and logs in the in-stream structures, and replacing plantings that have experienced early or significant mortality.
- Should an erosion swale or rill develop on a streambank as a result of overland flow, it should be stabilized with seeding and erosion control matting per the technical specifications. Live stakes and/or bare root seedlings may also require replacement in such cases.
- For additional repairs to the stream channel not specified above, the as-built plans and technical specifications should be carefully reviewed.

In summary, the Gum Branch stream enhancement project is currently at the preliminary design phase and the issues to resolve before completing the project have been highlighted. The remaining tasks are to complete the profile, as well as permit application, specifications, and other construction documents. These remaining tasks will be completed at a future date once funding for such activities has been secured. It may be feasible to submit one grant application to complete this project through construction. Potential grant funding agencies are discussed in Section 6.1.10.

5 Stormwater Control Measure Site Identification and Prioritization

In addition to floodplain conservation, another method to mitigate flood damage is to manage stormwater runoff, which has increased significantly along with development in the project area.

One measure that has achieved consensus at the project meetings as a needed step to improve water resource management is the use of structural and non-structural measures for managing stormwater. This section will present the methods used to identify locations for structural stormwater control sites, size them, estimate costs, and rank them based on cost, pollutant removal, and other metrics. Ideas for non-structural stormwater management (i.e., ordinances, education, etc.) will also be discussed.

Structural stormwater control sites have been commonly called best management practices (BMPs). This term is not a good reflection of what the site does. An alternative name that is more accurate and is gaining favor is "stormwater control measure," or SCM. This report will use SCM to describe structural stormwater control sites.

Retrofitting structural SCMs to the landscape (i.e., installing them after development has occurred) serves multiple purposes in stormwater planning. SCMs collect water from an upstream catchment, provide treatment and detention, and control the release of the water to a stable downstream receiving conveyance (natural or otherwise). These devices are designed for safety and functionality, and often provide improved aesthetics. Other benefits may be incorporated where appropriate, such as enhancement of habitat or development of educational opportunities. In Pitt County, many of the proposed SCMs provide stormwater benefits in areas where no treatment presently exists. Newly developed and redeveloped areas may have some treatment mandated under state and local regulations.

In this study, SCM retrofit opportunities were developed to serve the following goals: (1) remove stormwater pollutants to improve water quality; and (2) detain runoff to reduce localized and downstream flooding and to address erosion problems where applicable. Every identified and developed SCM in this study addresses the water quality goal, while most address the water quantity (i.e., flooding) goal. The methods used to identify, conceptualize, prioritize, and provide cost estimates for SCMs are provided in the following sections.

5.1 Site Identification

To identify potential SCM sites, a GIS analysis was conducted. Datasets that were helpful in this exercise included aerial photography, hydrography (i.e., stream channels), 2-foot contour intervals, parcel data, and stormwater conveyance information. The goal was to identify

potentially-available space for an SCM in the path of stormwater runoff, whether via a pipe or a channel. Using GIS is an important step because it allows full view of the landscape which would often not be attainable on the ground (i.e., on site) due to obstructed views, private property constraints, and a very large area to cover.

The GIS analysis identified 116 potential sites that were further investigated in the field. These are shown in Figure 11. In some cases, a windshield survey (i.e., site viewed from a vehicle) was sufficient to determine if the site was not feasible for an SCM. In many cases, the site was walked to get a better understanding of how stormwater moved through the site and how a SCM might be incorporated.

Sites determined to be feasible in the field were further analyzed using GIS. The drainage area to a site was mapped using the 2-foot contours and preliminary calculations were made to determine the necessary approximate SCM area. The calculated SCM area was then drawn on the parcel to see if the needed space was available (pending landowner cooperation).

The SCM design volume was first based on detaining the first 1.0-inch rainfall event. If space was available to hold 1.5 inches of runoff then that volume was used. Either amount of rainfall is equivalent to “first flush” when the bulk of pollutants are washed off the land surface. In this sense, it is considered to be the water **quality** volume. The water **quantity** volume, which would have a greater effect on flooding, would hold a larger storm but would also require greater area, or would not detain the runoff for more than a brief period. In many cases that area might be available and a second, higher outlet for the SCM could be incorporated to hold and release a greater volume.

The stormwater SCMs assume build out conditions in the drainage area. If the parcels are not developed as expected then an SCM for a particular location may not be worth pursuing. One example of this is for the northwest parcel at the intersection of Davenport Farm Road and Frog Level Road. This parcel is not currently developed but Greenville’s future land use plan includes a mix of residential, office, and commercial development. The recommended SCM, and the corresponding prioritization data, assumes that the parcel will be developed according to the future land use plan.

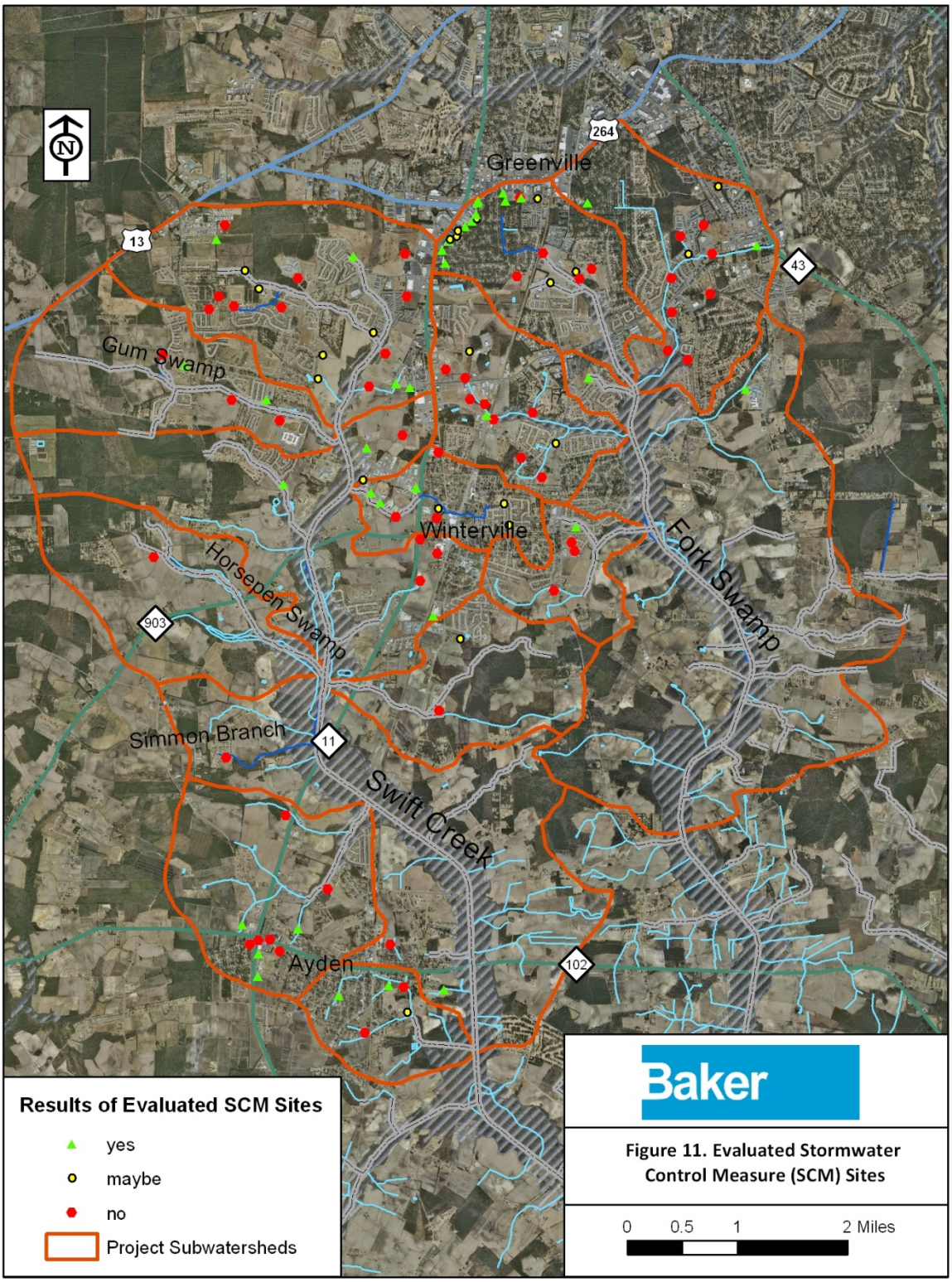


Figure 11. Evaluated Stormwater Control Measure (SCM) Sites

The sites proposed for further analysis were presented at the quarterly project meetings with area staff to see if there are plans for them to be developed. Several within the City of Greenville were eliminated for this reason.

5.2 SCM Database

After the preliminary review, 37 SCM sites were considered to be feasible and were subject to further analysis as part of the project's SCM database. The analyzed SCM sites and their drainage areas are shown in Figure 12. The database includes calculations for pollutant loading to and removal by the SCMs, as well as cost estimates based on a preliminary conceptual design. Next, a ranking procedure was developed to apply to the sites in order to prioritize them for implementation. These steps will be described in this section.

Pollutant loading was calculated using the Simple Method (Schueler, 1987). This method estimates runoff and pollutant loading for total suspended solids (TSS), total phosphorus (TP), and total nitrogen (TN) based on average annual rainfall, drainage area, impervious drainage area, and respective concentrations (TSS, TP, or TN) for a given catchment area based on land use. Event mean concentrations (EMCs) used in estimating pollutant loadings for these constituents were based on the North Carolina EMC data set prepared by CH2M Hill (NCDENR, 2000). Percent imperviousness was used as a surrogate for land use in determining EMCs for each SCM catchment since values of percent impervious closely correlate to specific land uses associated with each EMC value.

SCM types and footprint sizes proposed for each site were selected to match the existing conditions in terms of seasonal depth to water table, as well as the expected amount of runoff to detain. The design footprint sizing of all SCMs was determined by dividing the design volume by an average ponding depth for the particular SCM. Constructed stormwater wetlands used two feet (which includes deeper pools) and wet detention basins used three feet within the proposed footprint. One foot of ponding volume was used for bioretention areas, level spreaders with a vegetated filter strip, and other SCMs where existing conditions limited ponding depth.

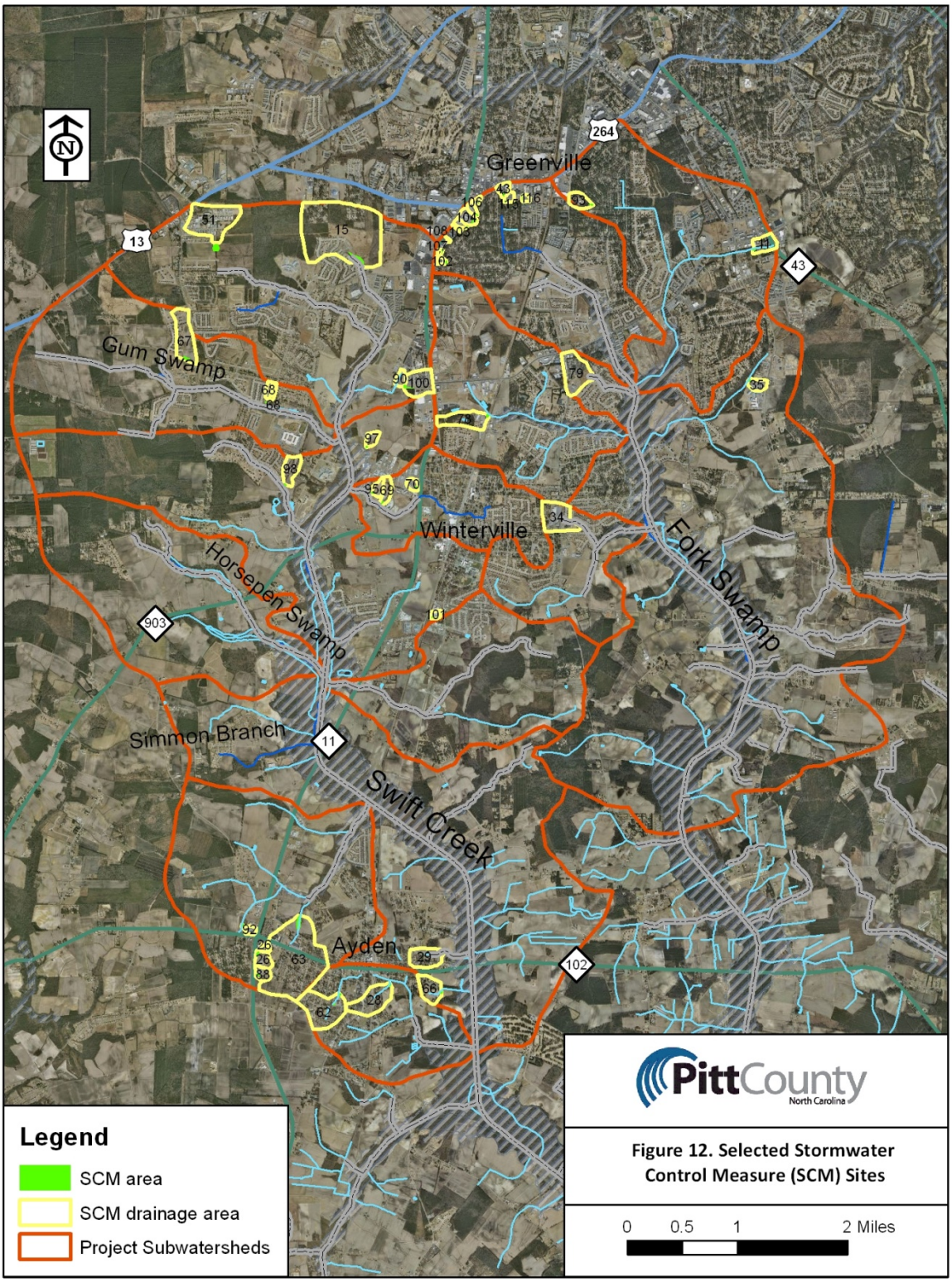


Figure 12. Selected Stormwater Control Measure (SCM) Sites

Brief descriptions follow for each of the types of SCMs considered in this study:

Stormwater wetland – Stormwater wetlands are constructed systems that mimic the functions of natural wetlands and use physical, chemical, and biological processes to treat stormwater pollution. Ideally, they should be located within one-half foot of the seasonal high water table.

Wet detention basin – A wet detention basin is a stormwater management facility that includes a permanent pool of water for removing pollutants and additional capacity above the permanent pool for detaining stormwater runoff. For the Swift Creek project, these are sited where the largest volumes of runoff are expected; in this sense, they are considered regional detention basins. Permitting for these can be difficult. This will be addressed in Section 5.4.

Level spreader and vegetated filter strip – A level spreader and vegetative filter strip (LS-VFS) consists of a concrete level spreader to convert concentrated runoff to sheet flow followed by a vegetative filter strip, which removes pollutants, promotes infiltration, and helps to prevent channelization.

Bioretention area - Bioretention is the use of plants and soils for removal of pollutants from stormwater runoff via adsorption, filtration, sedimentation, volatilization, ion exchange, and biological decomposition. In addition, bioretention provides landscaping and habitat enhancement benefits. Bioretention areas are also known as rain gardens when used on a small scale in residential or similar settings. Bioretention is not as well suited for the project area because they require two feet of separation between the bottom of the facility and the seasonal high water table. If this condition cannot be met, a rain garden could incorporate plants that tolerate wetter conditions and act more as a wetland.

Pollutant load reductions for TSS, TP, and TN and runoff reduction were generated for each SCM using the pollutant removal and runoff removal efficiencies cited in Table 4-1 of the NCDENR Stormwater BMP Manual (2007) and The Runoff Reduction Method Technical Memorandum (CWP, 2008), respectively. The reported removal efficiencies are shown in Table 7. Table 8 summarizes the estimated annual TSS removal rates in pounds for each of the 37 proposed SCMs. Removal rates for TSS, TP, and TN were used as parameters in ranking the water quality benefits for each proposed BMP. All pollutant loading and removal statistics for each proposed BMP site can be found in Appendix E.

Table 8. Reported removal efficiencies for each SCM Type (from DWQ BMP Manual)

SCM Type	TSS Removal	TP Removal	TN Removal	Runoff Reduction
Wetland	85%	35%	40%	25%
Detention Basin	85%	40%	25%	25%
Level Spreader/Vegetated Filter Strip	35%	35%	30%	15%
Bioretention Area	85%	45%	40%	25%

Table 9. Summary of estimated TSS loading and removal rates for each SCM

SCM Site ID	SCM Name	SCM Type	Drainage Area (acres)	Imper-vious Cover (%)*	Annual TSS Load (lbs)	Annual TSS Load Rate (lbs/ac)	Expected TSS Removal (lbs)
11	Car wash	wetland	17.9	50%	3,228	180.3	2,744
15	Thomas Langston	regional detention	231.5	40%	55,994	241.9	43,279
26	Ayden Middle - North	wetland	14.6	50%	2,633	180.3	2,238
28	Ayden cemetery	wetland	44.1	30%	3,941	89.4	3,349
29	Soybean field - Ayden	wetland	30.2	40%	3,930	130.1	3,340
34	Church - eastern Winterville	regional detention	43.9	60%	10,618	241.9	9,025
35	Wintergreen Elementary	wetland	9.9	40%	1,288	130.1	1,095

Table 9. Summary of estimated TSS loading and removal rates for each SCM

SCM Site ID	SCM Name	SCM Type	Drainage Area (acres)	Imper-vious Cover (%)*	Annual TSS Load (lbs)	Annual TSS Load Rate (lbs/ac)	Expected TSS Removal (lbs)
43	Convention Center	wetland	6.9	70%	2,186	316.8	1,858
51	West Star	regional detention	77	55%	16,137	209.6	13,717
62	Church - central Ayden	regional detention	64.9	70%	20,563	316.8	17,478
63	Ayden regional	regional detention	192	60%	46,440	241.9	39,474
66	Church - east Ayden	wetland	25.7	40%	3,344	130.1	2,842
67	Intersection - Frog Level	wetland	45	50%	8,116	180.3	6,898
68	Gum Swamp Church	LS/VFS	4.7	35%	511	108.7	179
69	Softball Complex east	wetland	11.7	15%	499	42.6	424
70	Roberts Company 1	LS/VFS or wetland	5.9	60%	1427	241.9	499
78	Winterville substation	wetland	34.6	30%	3,092	89.4	2,628
79	Old Tar Church	regional detention	46.6	60%	11,271	241.9	9,581
88	Ayden Middle - South	wetland	9.7	25%	699	72.0	594
90	PCC Child Development	wetland	7.3	70%	2,313	316.8	1,966
92	Ayden Food Lion	wetland	4.9	75%	1,765	360.1	1,500

Table 9. Summary of estimated TSS loading and removal rates for each SCM

SCM Site ID	SCM Name	SCM Type	Drainage Area (acres)	Imper-vious Cover (%)*	Annual TSS Load (lbs)	Annual TSS Load Rate (lbs/ac)	Expected TSS Removal (lbs)
93	TV Station	wetland	15.04	20%	850	56.5	722
95	Softball Complex entrance	LS/VFS	8.1	15%	345	42.6	121
97	Open Door Ministries	LS/VFS	8.1	40%	1,054	130.1	369
98	HS neighborhood	wetland	20	50%	3,607	180.3	3,066
100	PCC regional	regional detention	32.4	90%	16,771	517.6	14,255
101	Roberts Company 2	wetland	3.7	70%	1,172	316.8	996
102	Greenville Toyota South	wetland/bio-retention	3.05	90%	1,578	517.6	1,341
103	Greenville Motors	wetland	4.02	60%	972	241.9	826
104	Field Wetland	wetland	11.03	70%	3,495	316.8	2,970
106	East Carolina Chrysler SCM	wetland	4.67	80%	1,904	407.8	1,619
107	Greenville Toyota North	wetland	2.24	90%	1,159	517.6	985
108	Red Lobster SCM	bioretention	0.58	65%	161	277.5	58
111	Hibachi Grill	bioretention	1.57	90%	813	517.6	209
114	Kia Motors	wetland	2.12	80%	864	407.8	735
115	Convention Parking	wetland	4.33	80%	1,766	407.8	1,501

Table 9. Summary of estimated TSS loading and removal rates for each SCM

SCM Site ID	SCM Name	SCM Type	Drainage Area (acres)	Imper-vious Cover (%)*	Annual TSS Load (lbs)	Annual TSS Load Rate (lbs/ac)	Expected TSS Removal (lbs)
116	Convention Existing	bioretention	2.57	70%	814	316.8	599

*Percent Impervious cover estimated at build out conditions.

5.3 Ranking Procedure

A prioritization matrix was developed based on information gathered during the field assessment, the pollutant loading and removal analysis, cost estimates, and from acquired or developed GIS data. The purpose of prioritization is to develop a ranking system that identifies opportunities that address stormwater master planning goals at a high benefit-to-cost ratio and with minimal secondary impacts.

The ranking system scores SCM sites based on multiple parameters in the following categories and with the relative percent influence on total score in parentheses: Environmental Impact Factors (20 percent), Benefits (30 percent), and Cost and Constraints (50 percent). Cost was factored per unit of pollutant reduction and was given a higher weight because, though all are feasible, many SCMs are expensive and getting the most from limited funding is an important overall goal. Additionally, many other factors, such as land costs and construction feasibility, could be factored into the overall cost and that was considered to be more equitable than scores based on separate costs.

Each SCM was given a score of 1-3 (1 indicating lesser suitability, 3 indicating greatest suitability) for the parameters in the Environmental Impact Factors category and 1-4 for the parameters in the Benefits and Cost and Constraints categories. Each of the categories and parameters are listed below and described in further detail in Appendix E. Table 10 provides a summary of the scoring methodology.

- Environmental Impact Factors (20 percent)
    - Conflicts with Adjacent Land Uses – Consideration of existing and potential future land uses both on the property of interest and on adjacent properties
    - Impacts on Environmental Resources – Determines likelihood of impacts to regulatory streams and wetlands associated with the project
- Benefits (30 percent)
    - TN Pollutant Removal Quantity – Based on calculated reduction of total nitrogen

    - TP Pollutant Removal Quantity – Based on calculated reduction of total phosphorus
    - TSS Pollutant Removal Quantity – Based on calculated reduction of total suspended solids
    - Runoff Reduction Quantity – Based on calculated reduction of stormwater runoff
    - Public Education – Effectiveness score based on SCM location and visibility, as well as likelihood that it would be used as a teaching tool
- Costs and Constraints (50 percent)
    - Maintenance Access – Considers location and type of SCM and most probable access
    - Cost per unit Reduction Nitrogen – SCM cost divided by quantity of total nitrogen removed
    - Cost per unit Reduction Phosphorus – SCM cost divided by quantity of total phosphorus removed
    - Cost per unit Reduction Sediment – SCM cost divided by quantity of total suspended sediment removed
    - Cost per unit Runoff Reduction – SCM cost divided by quantity of total suspended sediment removed

Table 10. SCM Scoring Summary

Env Impact Factors (20%)		0.20				
Conflicts with Adjacent Land Uses	Impacts on Environmental Resources	Subscore				
1	*1*	*2*	*Lowest Score*			
3	*3*	*6*	*Highest Score*			

Benefits (30%)					0.30	
N Pollutant Removal Quantity	P Pollutant Removal Quantity	Sediment Pollutant Removal Quantity	Runoff Reduction Quantity	Public Education	Subscore	
1	*1*	*1*	*1*	*1*	*5*	*Lowest Score*
4	*4*	*4*	*4*	*4*	*20*	*Highest Score*

Cost and Constraints (50%)					0.50	
Maintenance Access	Cost per unit Reduction N	Cost per unit Reduction P	Cost per unit Reduction Sed	Cost per unit Reduction Runoff	Subscore	
1	*1*	*1*	*1*	*1*	*5*	*Lowest Score*
4	*4*	*4*	*4*	*4*	*20*	*Highest Score*

The pollutant removal quantities and costs per unit pollutant reduction for each SCM were calculated and then ranked from 1 to 37. The scores of 1-4 were applied approximately according to the quartile in which a given SCM was ranked. For example, an SCM ranked 25th would receive a score of 2 because it fell in the third quartile. Several adjustments were made if the quantitative results (i.e., calculations for quantity and cost per unit) placed an SCM closer to the quantitative results of another quartile than those of the quartile based on ranking alone.

The cost estimates provided in this report are preliminary estimates based on an abbreviated list of construction activities and materials with unit prices based on prior project experience. Further detail on the cost estimates are provided in Appendix E. The total estimated cost to construct the 37 selected SCMs is $5,042,000; this yields an average cost of approximately $136,000 per SCM though the costs vary widely, mostly depending on size.

With the individual scores for each parameter, percentages were then calculated for each SCM based on the total category score divided by the total possible score (6 for Environmental Impact Factors and 20 for Benefits and for Costs and Constraints). A total score for each SCM was then calculated by multiplying the percentage for each of the three categories by the aforementioned weights (20 percent for Environmental Impact Factors; 30 percent for Benefits; and 50 percent for Costs and Constraints). The rankings were then determined based on the total scores.

For the 37 selected SCMs, the summary ranking results are shown in Table 11.

Table 11. Ranking Results for Structural Stormwater Control Measures

SCM ID	SCM Name	Environmental Impact Factors (20% weight)	Benefits (30% weight)	Costs and Constraints (50% weight)	Total Score	Rank
26	Ayden Middle - North	83	80	85	83	1
67	Intersection - Frog Level	50	85	95	83	2
34	Church - eastern Winterville	50	90	90	82	3
63	Ayden regional	50	90	85	80	4
116	Convention Existing	100	45	90	79	5
100	PCC regional	33	100	80	77	6
15	Thomas Langston	33	90	85	76	7
66	Church - east Ayden	50	70	90	76	8
51	West Star	33	85	85	75	9
79	Old Tar Church	50	90	75	75	10
88	Ayden Middle - South	100	60	70	73	11
70	Roberts Company 1	100	40	80	72	12
35	Wintergreen Elementary	83	65	70	71	13
62	Church - central Ayden	33	90	75	71	13
104	Field Wetland/Bioretention	67	70	70	69	15
28	Ayden cemetery	50	70	75	69	16
98	HS neighborhood	67	65	70	68	17
101	Roberts Company 2	100	40	70	67	18
29	Soybean field - Ayden	50	65	70	65	19
97	Open Door Ministries	100	35	65	63	20

Table 11. Ranking Results for Structural Stormwater Control Measures

SCM ID	SCM Name	Environmental Impact Factors (20% weight)	Benefits (30% weight)	Costs and Constraints (50% weight)	Total Score	Rank
106	East Carolina Chrysler SCM	67	55	65	62	21
90	PCC Child Development	33	75	65	62	22
43	Convention Center	50	70	55	59	23
115	Convention Parking	83	55	50	58	24
78	Winterville substation	50	75	50	58	25
107	Greenville Toyota North	83	50	45	54	26
95	Softball Complex entrance	83	35	50	52	27
11	Car wash	50	65	45	52	28
102	Greenville Toyota South	83	50	40	52	29
69	Softball Complex east	83	40	45	51	30
68	Church - Gum Swamp	83	30	50	51	31
92	Ayden Food Lion	50	50	50	50	32
93	TV Station	67	55	35	47	33
103	Greenville Motors	67	50	35	46	34
108	Red Lobster SCM	83	30	40	46	35
111	Hibachi Grill	83	30	40	46	35
114	Kia Motors	67	45	30	42	37

The detailed scores that went into the scoring matrix can be found in Appendix E. Summary information and graphics for of each of the 37 individual stormwater SCMs are provided in SCM Fact Sheets (Appendix F).

With regards to the rankings, it should be noted that the emphasis on cost-to-benefit ratios favors bigger SCMs that have large drainage areas, as well as less expensive ones. One potential

problem with this is that USEPA, USACE, and DWQ have expressed favor for SCM sites that treat smaller areas and do not impound stream channels. They believe that the stream channels process pollutants and that providing treatment closer to the pollutant sources is a preferred approach (e.g., through Low Impact Development or smaller SCM sites). This is a good approach when development is planned and SCMs, such as rain gardens, bioretention swales, and reduced impervious cover, can be incorporated in the design and as the sites are constructed, but for retrofit situations it is often not feasible due to lack of available space in suitable locations. Also, compared to large sites, the cost for retrofitting small sites is typically high from a cost-benefit perspective.

An exception to these limitations for small sites is that localized retrofits could be done on the parcel scale (e.g., cisterns and rain gardens). These concepts were discussed at this study's educational workshop and further local efforts will be made to promote these types of projects. Also, more information on Low Impact Development (LID) is provided in Section 5.6. It would be beneficial to water resources if local developers added LID practices to their projects.

With regards to stream processing of pollutants, for the most part, the existing channels in the project area have been shown to be insufficient for providing suitable water quality for aquatic life (see Chapter 3). The streams in the project area have largely been dug from a swampy landscape and do not contain the dimensions and biota that would be naturally present in this geographic setting. The recommended SCMs tend to be wetlands or detention basins that would appear to be closer to the natural filtering mechanisms endemic to the project area.

5.4 Permitting for SCMs

As mentioned above, USACE and DWQ do not favor putting SCMs 'on line,' meaning in the path of existing stream channels. The regulations make this difficult, but typically possible, to achieve.

Generally USACE regulates the ordinary high water mark and below, and DWQ regulates the ordinary high water mark and above. One might consider USACE's domain to be the stream channel bottom and DWQ's to be the riparian buffer. This section includes a discussion of the permitting issues associated with constructing SCMs. Permitting is complicated and necessarily relevant to specific instances.

When a Section 404 permit is required by USACE, typically a Section 401 permit is required by DWQ. There are essentially two types of Section 404 permits: Nationwide Permits ("NWPs"), which are basically general permits that can be used for projects with impacts that will not exceed certain defined thresholds, and Individual Permits, which must be utilized for all projects with impacts that exceed such thresholds.

This section lays out three scenarios for permitting stormwater control measures, including:

- Sites where permitting is not required;
- Sites where an Army Corps of Engineers NWP 43 (or other NWP) application for a Section 404 permit;
- Sites where a USACE Individual Permit application for a 404 permit is required.

These three scenarios will be discussed in the following sections.

5.4.1 Sites Where 401/404 Permitting is Not Required

Permitting is not required when any aspect of an SCM site does not impact jurisdictional stream channel or wetlands, including discharging to them. Jurisdictional channels are considered to have an ordinary high water mark. Thus, perennial channels (i.e., channels that have continuous flow year round except during exceptionally dry period) are certainly jurisdictional. Intermittent streams (i.e., channels that flow for only part of the year) are probably also jurisdictional but a field determination must be made by USACE. Additionally, the USACE district engineer has the option of making a written determination that the discharge from an SCM will result in minimal adverse effects on an intermittent or ephemeral channel.

An example of a SCM site in the project area that would not require a permit is the proposed wetland site on the north side of Ayden Middle School. USACE visited this site in April 2012 and, after further review of historical data, determined that the drainage was constructed to drain the school property and is not a natural crenulation. Furthermore, the roadside ditch along NC 11 to which the school drainage discharges has been determined to be non-jurisdictional by USACE. Thus, the site does not impact nor discharge to any jurisdictional streams or wetlands and would not require a 404 permit.

DWQ would likely not have any buffer requirements since USACE does not consider the channel within the proposed SCM to be a stream, but this should be confirmed.

An erosion control permit would be needed from the County if more than one acre is disturbed (see Section 2.3.1).

5.4.2 Nationwide 43 Permit Application

USACE would require a Nationwide 43 permit application for SCM sites that impact less than 0.5 acres of non-tidal wetland or 300 linear feet of stream bed, unless for intermittent and ephemeral stream beds the district engineer waives the 300 linear foot limit by making a written determination concluding that the discharge will result in minimal adverse effects.

Additionally, discharges into wetlands and in perennial streams from stormwater management facilities are prohibited under this permit (i.e., an Individual permit would be required). All permanent and temporary crossings of waterbodies shall be suitably culverted, bridged, or otherwise designed and constructed to maintain low flows to sustain the movement of those aquatic species.

Mitigation would be required for loss of stream bed in excess of 150 feet. Generally, this means that another, nearby stream channel would need to be restored to compensate for impact by the SCM site. The permit applicant would be required to pay for this mitigation.

Examples of SCMs that would require a Nationwide 43 permit have not been confirmed by USACE but are expected to include the Convention Center wetland (SCM 43), east Ayden church (SCM 66), Toyota North (SCM 107), and the Field wetland (SCM 104).

Finally, the application must include a delineation of wetlands, other special aquatic sites, and other waters, such as lakes and ponds, and perennial, intermittent, and ephemeral streams, on the project site.

DWQ would require impacted stream buffer to be replaced. If this is not possible, buffer mitigation would be required.

Generally, DWQ does not permit any jurisdictional wetlands to be converted to or incorporated within SCMs.

5.4.3 Individual Permit Application

When SCM sites cause the loss of more than 0.5 acres of non-tidal wetlands or more than 300 linear feet of stream bed, USACE would require an Individual Permit. As above, exceptions may be made by the district engineer for intermittent or ephemeral streams. This is a more involved permit application and requires additional scrutiny by and meetings with other regulatory agencies, thus it is a more costly process. Again, mitigation would be required for loss of stream bed in excess of 150 feet.

An example of a proposed SCM site that would require an Individual application for a Section 404 permit is the regional detention site located off of Second Street in Ayden. This site would impact more than 700 linear feet of stream channel and would discharge to what would likely be considered perennial waters. A pond located beyond the right bank of the drainage canal does not appear to be directly connected to the canal. The SCM conceptual design is to incorporate this pond within the detention basin because it is not connected to the canal. Because it is not connected to the canal, the pond is not regulated by USACE.

Riparian buffer impacts would likely occur on the right bank, though DWQ may allow them to be replaced along the proposed SCM. Nevertheless, this is an example of an on-line SCM that would entail substantial permitting and mitigation requirements. Even though approximately $200,000 has been included in the cost of this site for mitigation and permitting, the site still ranks 4th out of 37 SCM sites. The pollutant removal quantities provided by this site essentially outweigh the high costs to obtain permits and construct it.

For mitigation, North Carolina Session Laws 2009-337 and 2011-343 require permit applicants to first look for private mitigation banks in the watershed. If mitigation bank credits are not available, NCEEP has an in lieu fee of $262/linear foot that would fulfill the mitigation requirement in the project area (700 linear feet times $262/linear foot is $183,400). This could be used to provide the necessary mitigation.

5.5 Stormwater SCM Inspection and Maintenance

For proper SCM function, and to maintain predicted water quality and quantity benefits, SCM inspection and maintenance recommendations should be implemented. This section of the watershed plan outlines the inspection and maintenance activities that should be performed to realize the long term goals for SCMs. An important question is who will maintain the SCMs. That is probably the responsibility to the lead agency that manages the development of the project. As part of the project's development, the lead agency may be able to secure a cost share arrangement whereby another entity assumes responsibility of long term maintenance.

The long term goals of maintenance include efficient stormwater detention, sediment and pollutant removal, aesthetic appeal, public safety, and mosquito/pest control. Stormwater SCM Operation and Maintenance (O&M) Plans can be used to ensure the function and integrity of structural SCMs. These O&M plans are generally intended for a specific period of time (typically 10 years) and go into effect after the SCMs have been constructed. The following maintenance activities should be performed to realize these long term goals and are described in this section:

- Sediment Removal
- Natural Debris and Trash Removal
- Invasive Species Removal/Vegetation Maintenance
- Mosquito and Pest Control

5.5.1 Sediment Removal

Maintaining the permanent pool volume is very important to the SCM's ability to remove pollutants from stormwater flow. Forebays and deep pool zones will fill with sediment over time and should be dredged with an excavator when the depth is reduced by one foot.

Elevations for deep pool zones and forebays should be documented in the plan sets. The depth of these zones should be checked at a specific time each year; a survey rod and a small boat may be needed in some cases. Equipment needed for dredging includes an excavator and at least one dump truck (with a recommended minimum capacity of eight cubic yards). Access should be made from designated areas. After the excess sediment has been excavated, it should be transported to a site where it can be spread to a depth of one inch and seeded. Seeding is necessary to stabilize the sediment and prevent further transport through the watershed. All excess sediment should be disposed of in a manner as to not cause pollution and should not be disposed of within 100 feet of streams or rivers. If this option is not feasible then the sediment should be taken to a landfill.

5.5.2 Natural Debris and Trash Removal

One of the most efficient mechanisms by which a SCM removes pollutants is from runoff detention, which allows pollutants to settle within the SCM. For constructed wetlands and wet detention ponds, detention of the design volume of stormwater is controlled by a water quality orifice in an SCM's primary outlet structure. If an orifice becomes clogged, stormwater is not allowed to drain between precipitation events, which will reduce the SCM's detention capacity volume for future storm events. In this scenario, stormwater runoff from the next storm will bypass through the top of the outlet structure without being detained and will thus go untreated. To prevent this unwanted scenario the orifice should be inspected and debris removed monthly or after each precipitation event exceeding one (1.0) inch. The trash rack on top of the outlet structure should be inspected and cleaned at the same time as the orifice.

In addition to removing natural debris and trash from the outlet structure, it should also be removed from the littoral shelf and pool zone for several reasons. Primarily, this trash may mobilize and clog the orifice and outlet structure in subsequent storms. Secondly, it is unattractive and will degrade the aesthetics of the SCM. Last, floating trash and litter can store small amounts of water and provide an environment for mosquito larvae to grow. Natural debris and trash should also be removed monthly or after every precipitation event exceeding one inch.

5.5.3 Invasive Species Removal/Vegetation Maintenance

Vegetation is very important to the pollutant removal capability of an SCM. The vegetation filters pollutants attached to sediment and also removes dissolved chemical pollutants. Pollutant removal and the stability of the vegetation are maximized with a diverse ecosystem of plants; therefore, plant diversity is targeted in the designs and invasive vegetation should be removed on a regular basis so it does not reduce diversity. For the first two years after construction, invasive vegetation should be removed in the spring and fall to ensure a healthy

and stable ecosystem of wetland vegetation. After the second year, invasive vegetation should be removed annually.

Cattails are the most common invasive vegetation found in wetlands. Some cattails are native to North Carolina; however, all species will eventually crowd out other wetland vegetation, which reduces pollutant removal capability, degrades aesthetics, and provides habitat for mosquito larvae. When cattails go dormant each fall, they shed fronds which eventually provide a protective layer for mosquitoes to breed. The roots form dense mats near the water surface that also provide mosquito breeding habitat. The selective removal of cattails and other invasive vegetation can be labor intensive. The most effective way to remove invasive vegetation is by manually applying an herbicide that is approved for aquatic environments with a cloth glove, such as glyphosate in the form of Rodeo©. A chemical-resistant glove should be worn underneath the cloth glove for protection. This method kills invasive vegetation at the roots, which may take on the order of two or more weeks. It is recommended that this technique be conducted by a certified landscape professional.

In addition to identifying and removing invasive vegetation, the planted SCM vegetation should also be inspected. If the planted vegetation has been damaged by wildlife or weakened by drought, it should be replanted between April 1st and September 30th. Once the vegetation has firmly established (approximately 2-3 years), it should be inspected for annual pruning in the dormant season by a certified landscape professional. Dead and diseased plants should be removed. Some species may cast too much shade and cause the herbaceous plants to no longer thrive so they should also be removed or pruned heavily. Lastly, any areas depicted in plan sets as the "No Mow Zone" should be inspected monthly to ensure they are not being mowed. These areas will be planted with riparian seed and will benefit water quality and prevent problems with geese if they are not mowed. Geese control is further discussed in the section below.

The bioretention areas or other SCMs that incorporate mulch will need to be re-mulched, perhaps annually, to maintain a mulch thickness of 3 inches. If unplanned development occurs within the watershed of a bioretention area resulting in large sediment runoff, the engineered bioretention soil media could become clogged with this sediment. This would prevent the stormwater from filtering through the media. If this happens, the media will need to be replaced.

5.5.4 Mosquito and Pest Control

Mosquito control is an important goal for the long term success of a wetland or wet detention pond. Mosquitoes are a nuisance and may transmit infectious diseases. Mosquitoes will most likely be controlled if the previous maintenance tasks, including natural debris, trash, and invasive species removal, are routinely performed. Also, aquatic environments with a diverse

plant community will attract insects that prey on mosquitoes, such as the dragonflies and damselflies. A backup measure is the introduction of the native mosquito fish (*Gambusia holbrooki*) to prey on larvae. This may reduce other insect populations, however, so it is not the preferred approach.

Rodents, such as muskrats and moles, can be harmful to the SCM by eating planted vegetation and burrowing/digging. The vegetation and SCM areas should be inspected twice a year for the presence of rodents. If rodents have infested the wetland site, a professional trapper should be contacted to remove them.

Geese are the most common pests in an urban setting. They degrade water quality by adding bacteria and nutrients through the digestive waste. Geese are also prone to eat freshly planted wetland vegetation. They can be discouraged from inhabiting a wetland if vegetation around the perimeter is allowed to grow, which creates a visual barrier to the geese. This will make the geese feel unsafe because they cannot see potential predators on the littoral shelf.

Several inspection and maintenance tasks should be performed by the appropriate local government throughout the calendar year for the SCMs to realize public safety, aesthetic, and water quality goals.

5.6 Low Impact Development

Low Impact Development (LID) is a holistic approach that incorporates site-specific ecosystem and watershed-based considerations for planning, design, and construction. The goal of LID is to mimic a site's predevelopment hydrology by using design techniques that infiltrate, filter, store, evaporate, and detain runoff close to the source. In other words, the overriding principle is to keep rainfall on site and prevent it from running off. This is a paradigm shift in stormwater management from efficient conveyance of stormwater runoff to the stream network.

LID seeks to control nonpoint source pollutants "nature's way" through the application of plant-soil-water mechanisms that maintain and protect the ecological and biological integrity of receiving waters and wetlands. LID stormwater practices were pioneered as a response to the need to solve a variety of water quality problems that were evident in increasingly urbanized and built environments. According to the Department of Defense (DOD) publication "Unified Facilities Criteria, Design: Low Impact Development Manual" (USDOD, 2010), the five key elements of LID are:

- Conservation – Preservation of native trees, vegetation, and soils and maintaining natural drainage patterns.
- Small-scale Controls – Mimic natural hydrology and processes

- Directing Runoff to Natural Areas – Encourages infiltration and recharge of streams, wetlands, and aquifers
- Customized Site Design – Ensures each site helps protect the entire watershed
- Maintenance, Pollution Prevention, and Education – Reduces pollutant loads and increases efficiency and longevity as well as educates and involves the public.

Research has shown that a decentralized LID approach to stormwater management offers superior alternatives compared to conventional stormwater management controls. The use of LID practices within Pitt County represents an environmentally sustainable approach to land and stormwater management. More information on LID in North Carolina can be found at:

http://www.ces.ncsu.edu/depts/agecon/WECO/lid/documents/NC_LID_Guidebook.pdf

5.7 Non-Structural SCMs

Non-structural SCMs are passive and are usually intended to be source control and pollution prevention measures. These measures can potentially reduce pollution carried by runoff by preventing or reducing the opportunity that stormwater is exposed to pollutants. When used properly, non-structural SCMs have the potential to be extremely effective in controlling pollutants and in reducing the need for more costly structural SCMs. In general, non-structural SCMs require administrative resources to ensure that they are implemented but they do not require engineering designs or maintenance. Non-structural SCMs are most effective when implemented on a widespread scale to restore natural hydrologic functions to the landscape. Some typical non-structural SCMs are:

- Public education and participation
- Land use planning and management (vegetative controls, reduced impervious areas, disconnected impervious areas)
- Material use controls (housekeeping practices, safer alternative products, pesticide and fertilizer use)
- Material exposure controls (material storage control, vehicle use reduction)
- Illegal dumping controls (illicit connection detection, removal, and prevention, leaking sanitary sewer control)
- Street and storm drain maintenance (roadway cleaning, catch basin cleaning, vegetation controls, storm drain flushing, roadway and bridge maintenance, and drainage channel maintenance)
- Construction site and post construction runoff control (policies that address all construction related runoff situations)

- Universal stormwater management ordinance to provide consistent stormwater management requirements for development across the regional area. The Universal Stormwater Model Ordinance for NC is a good source for this (Whisnant, 2007).

More information on non-structural SCMs can be found at the following websites:

http://h2o.enr.state.nc.us/su/documents/StormwaterManualALLCHAPTERS_000.pdf

http://www.stormwaterpa.org/non-structural-bmps.html

http://www.efc.unc.edu/publications/2007/UniversalStormwaterModelOrdinanceNC.pdf

6 Recommendations

Recommendations for improving water resource management in the project area are provided in this section. First, recommendations specific to the project subwatersheds are detailed. Second, general recommendations are listed and described.

6.1 Subwatershed Recommendations

This section lists each of the project subwatersheds and what can be done in them to improve water resource management.

6.1.1 Swift Creek Watershed

Upper Swift Creek – A number of SCMs introduced in Section 5, including SCMs 15, 51, 90, and 100 (see Chapter 5 and Appendix F), would improve water quality and mitigate high streamflows. The PCC campus could be a local education center for stormwater management. For example, PCC might introduce classes to teach SCM management. This is a growing field given that SCM are being implemented across the state.

The growth in this subwatershed is projected to be among the three highest in the project area. It will be important for the new development to include good stormwater management practices.

Gum Swamp – This subwatershed had the best water quality, so it may be worth efforts to preserve this status and perhaps improve upon it. This may be accomplished by installing SCMs (Frog Level if parcel is developed but prepare for that) and implementing the stream enhancement project. The flooding on Woodridge and Sawgrass Drives may be addressed through stream enhancement project. Relatively simple flood modeling could be performed to confirm this.

Horsepen Swamp – Due to its low level of urban development, it appears that this subwatershed could have good water quality. However, problems were noted relating to low dissolved oxygen and that this may be due to animal waste. Perhaps some local interaction with the farms in this subwatershed could help to improve agricultural runoff. Nutrient management of fertilizer and animal waste appear to be needed. If this could be accomplished, the water quality in Horsepen Swamp might readily improve because there is very limited urban development.

For maintaining diverse aquatic life, it is beneficial to maintain some undeveloped areas in an urbanizing watershed. Such channels can be a source of biological diversity and pollution-intolerant species that may drift downstream and populate sections of stream that would otherwise not harbor such biota. Horsepen Swamp could become such a source.

Nobel Canal – As previously discussed Nobel Canal has limited prospects for improving water quality. However, by managing stormwater, including installations of several SCMs, water quality in lower Swift Creek may benefit. The Roberts Company may be a willing partner to implement an SCM and the ball park complex on Reedy Branch Road offers two additional SCM sites.

Reedy Branch – This is another rural watershed with projections for minimal development. It may be treated similarly to Horsepen Swamp to preserve its rural character and serve as a source of pollution-intolerant species. One parcel at the outlet of this subwatershed is targeted for floodplain conservation.

Reedy Branch had worse habitat than Horsepen Swamp but less definitive water quality problems. Leaving smaller woody debris in the stream channel that does not impede streamflow, reducing sediment loading from the subwatershed, as well as replacing invasive riparian vegetation (e.g., Chinese privet) with native vegetation would provide habitat improvements.

North Ayden – There are four SCM sites in this subwatershed. The Ayden Middle school sites may be the best initial sites, particularly since permitting requirements appear to be minimal. The Ayden regional site off of Second St. could treat stormwater runoff from 192 acres. If the Food Lion site could be implemented, then runoff from this quadrant of Town would largely be treated. The challenge then is to make sure that future development includes stormwater controls.

South Ayden – This subwatershed was not monitored for water quality but it includes two SCM sites. Collectively, these two sites would treat runoff from 109 developed acres of Ayden.

The subwatershed has a fairly high impervious area, which is projected to increase to 34 percent so stormwater management controls will be necessary to prevent future impacts to water resources. These should include non-structural SCMs such as those discussed in Section 5.7.

Lower Swift Creek – This large subwatershed includes the monitoring site at NC 102 that puts Swift Creek on the 303(d) list of impaired streams for not meeting its designated use of supporting aquatic life. However, the monitoring from this project indicated some recovery from upstream problems. It rated Fair which is one level shy of a Good-Fair rating that would remove it from the impaired list. To ensure this, it would be beneficial to conduct the 4b demonstration discussed in Sections 2.4 and 6.2.3. Essentially, it would be helpful to reduce nutrient loading by implementing many of the SCMs proposed by this project. Nutrient loading can be addressed by treating runoff from impervious areas with structural SCMs (Section 5) and through implementation of non-structural SCMs (Section 5.7). Additionally, further testing can

determine if toxicity is a cause of impairment and potentially the specific pollutant(s) of concern. If those are identified, it would allow for determination of additional structural and non-structural SCMs that target them.

6.1.2 Fork Swamp Watershed

Northeast Fork Swamp – The benthic monitoring in this subwatershed points to a possible problem with sporadic sanitary sewer overflows following high rainfall events. A review of the sewer system should be conducted by the Greenville Utilities Commission, which operates the system in this area, and corrective measures should be taken.

This subwatershed is projected to develop such that the impervious cover may increase to 43 percent. This will require improved stormwater management to prevent local and downstream impacts to water resources. Two proposed structural SCM sites may be implemented, as well as non-structural SCMs. A large flood control basin located off of Fire Tower Road west of Arlington/County Home Road should be investigated to see if it could also provide water quality benefit (e.g., an additional smaller outlet to provide some detention of initial stormwater runoff).

Upper Fork Swamp – This site has poor water quality based on the monitoring from this study. However, 10 of the 37 proposed SCMs are located in this subwatershed (see Figure 13). They are concentrated along NC 11 and US 264, which makes this feasible from a permitting standpoint (i.e., close to headwaters) but potentially expensive if easements or property must be acquired. Non-structural SCMs would also be beneficial in terms of pollutant source control (i.e., coal-tar-based pavement sealant appears to be prevalent in this area).

Western UT Fork Swamp – This monitoring site had better habitat but unfavorable water quality. The impervious cover is projected to increase by 11 percent to 39 percent. One proposed SCM would provide some benefit but that leaves substantial unmanaged runoff. Non-structural SCMs would help to alleviate stress on water resources caused by increased development. Flooding in the vicinity of where the tributary crosses Old Tar Road depends on improved stormwater management.

Eastern Winterville – Nutrient runoff is apparent from the monitoring in this subwatershed. A structural SCM is proposed to treat runoff from 44 highly impervious acres. This would probably improve localized flooding though modeling is necessary for confirmation.

Additionally, impervious cover is projected to increase by 12 percent, most of all subwatersheds in the study. Consequently, non-structural SCMs are likely to be important to mitigate impacts to water resources.

Figure 13. Selected SCM Sites in Upper Fork Swamp Subwatershed

Lower Fork Swamp – Monitoring of this canal at Ayden Golf Club Road revealed good habitat but poor water quality. Toxicity should be assessed at this site, in addition to Swift Creek at NC 102. If toxicity is present, additional sampling would be helpful for identifying more specific sources (i.e., by individual pollutant and most likely locations). To improve habitat more small woody debris should be left, if possible.

A structural SCM site at Wintergreen Elementary should require minimal permitting (401 and 404 permits unlikely to be required) and would provide a very good educational opportunity. Additionally, a structural SCM site near the intersection of Old Tar Road and Fire Tower Road is estimated to treat runoff from 46 acres, 60 percent of which is estimated to be impervious. This site would be more difficult to permit because it may be situated on a jurisdictional stream channel.

6.2 General Recommendations and Considerations

6.2.1 Coal-tar-based Pavement Sealcoat Ban

One potential toxic stressor to the aquatic communities is polycyclic aromatic hydrocarbons (PAHs). This has been found to be present in the sediment of other urban North Carolina streams, including Burnt Mill Creek in Wilmington (NCDWQ, 2004).

Figure 14. Apparent Coal-Tar-Based Pavement Sealant in Project Area

PAHs come from the burning of fossil fuels and from coal-tar-based pavement sealcoat (Van Metre et al., 2000 and USGS, 2011). Given improvements in power generation and home heating technology over the past few decades, automobiles are the most likely fossil fuel source. Leading automobile sources of PAHs are car emissions and leaking crankcase oil, but also tire and roadway wear (Van Metre et al., 2000).

The most manageable and potentially largest source of PAHs is coal-tar-based pavement sealcoat (coal-tar sealant), which appears to have been used in a number of parking lots and driveways around the study area. Coal tar is a thick, black or brown liquid that is a byproduct of the carbonization of coal for the steel industry or the gasification of coal to make coal gas.

USGS published a paper 2011 that showed coal-tar sealant is a leading source of polycyclic aromatic hydrocarbons (PAHs), which are probable human carcinogens and are toxic to aquatic

life (benthos and fish). It is commonly used on driveways and parking lots east of the Continental Divide in the United States and around Pitt County, including the project area. The parking lots in commercial areas along NC 11 and US 264 appear to be "hot spots."

Coal-tar sealant can be tracked indoors on shoes, which increases health risks. Safe alternatives are available (asphalt-based sealant) at slightly higher cost. A five gallon container of asphalt-based sealant is generally averages $20 while the same container of coal-tar sealant averages $15. The same website mentions that Lowes and Home Deport generally do not sell coal-tar sealant. http://coaltarfreeamerica.blogspot.com/2011/03/cts-vs-asphalt-based-sealant-how-do.html

To determine if the product has a coal-tar base, look for the Chemical Abstracts Service (CAS) number 65996–93–2 on the product Material Safety Data Sheet (MSDS). The words "coal tar," "refined coal tar," "refined tar," "refined coal-tar pitch," or other similar terms may be listed on the MSDS or on the product container.

Several jurisdictions, including the City of Boone, North Carolina, the City of Austin, Texas, the City of Washington, D.C., Dane County, Wisconsin, and several suburbs of Minneapolis, Minnesota, have banned use of coal-tar-based sealcoat. Similar bans are under consideration in other jurisdictions. Pitt County may wish to consider banning coal-tar-based pavement sealcoat in an effort to improve water resources and protect human health.

6.2.2 Flooding

This study is been more focused on water quality than flooding because it has been funded by the North Carolina Clean Water Management Trust Fund, whose goal is to improve water quality in the state. However, several measures in the study address water quantity.

First, the selected SCM generally treat the first 1.0-inch of runoff but several could be designed to hold additional runoff. Also, capturing the first inch will reduce flooding in smaller areas and the smaller rainfall events, such as those less than the 10-year storm. The time of concentration for localized flooding (e.g., project subwatershed scale) is probably something on the order of 2 hours or less. The 10-year 2-hour storm for the project area is estimated to be 3.14 inches. Thus, if the most impervious portions of that subwatershed drained to an SCM that detained the first inch of runoff, there should be a noticeable difference in localized flood levels.

Additionally, the SCMs could be designed such that overflow spillways are incorporated at higher elevations to detain additional runoff. This would need to be developed in more detail as part of site specific designs.

The floodplain conservation effort to prevent development in 36 of the largest floodplain parcels would help to limit flooding from worsening in the future, as would local ordinances to limit runoff from new development.

The Pitt County Stormwater Management Ordinance, which follows the Neuse Rules, requires no net increase in peak flow leaving the development site from the predevelopment conditions for the 1-year, 24-hour storm. This should help to limit flooding due to new development.

Additionally, the City of Greenville also requires no net increase from the predevelopment conditions in peak flow leaving the development site for the 1-year, 24-hour storm.

The flood levels that occur along Gum Swamp (Swift Creek 40 lateral) may be reduced by the proposed stream enhancement project because it would increase capacity downstream of the floodprone area. Floodplain modeling would need to be conducted to confirm this potential.

Finally, the local jurisdictions could implement additional development regulations to address increased runoff through increased attenuation of larger storm events (i.e., 10-, 25-, and 100-year storm events).

6.2.3 Addressing the Cause of the Aquatic Life Impairment

It is possible that DWQ would use the NPDES Phase II stormwater permits for Greenville, Winterville, and Ayden to require SCM implementation to address the impaired water 303(d) listing for Swift Creek (see Section 2.4). This may come as part of the permit renewal process that is completed every five years. Whether a requirement stems from NPDES-permitting or not, should the local governments of Pitt County decide to address the Swift Creek water quality impairment (i.e., low rating for benthic macroinvertebrate community in Swift Creek at NC 102), a 4b demonstration, also known as a water quality recovery plan (WQRP), is probably the best option (see Section 2.4).

First, further study would be needed to determine more specific causes of the impairment (i.e., is toxicity a problem and if so, which pollutants are causing it) and an appropriate numeric water quality target for the pollutant of concern. Monitoring for that is discussed in Section 3.4. The SCMs recommended in Section 5 of this report would, for the most part, satisfy the second of the six 4b requirements. However, additional SCMs targeted to the identified pollutant of concern should be emphasized in a 4b plan. Such SCMs would be located near sources of the pollutant of concern. Also, it is possible that the sources of the pollutant of concern could be address through means other than a structural SCM (i.e., source reduction).

DWQ-administered CWA Section 319 funding would be available to complete a 4b demonstration and upon approval of that, 319 funding would be available for design and construction of SCMs.

Section 3.3 included recommendations from the biologist who conducted the benthic macroinvertebrate monitoring. Besides the general observation that stormwater runoff was a likely cause of impairment, the following recommendations were offered:

1. Leave some wood in the channel if it does not impede streamflow
2. Address low dissolved oxygen through nutrient management
3. Address organic loading by finding and fixing sanitary sewer overflows

6.2.4 Mitigation Requirements

In 2009 and 2011, the NC General Assembly passed Session Law 2009-337 and 2011-343, respectively, which promoted the use of private mitigation banks to fulfill compensatory mitigation requirements. A mitigation bank is a wetland, stream, or other aquatic resource area (e.g., riparian buffer) that has been restored, established, enhanced, or preserved for the purpose of providing compensation for unavoidable impacts to aquatic resources permitted under Section 404 or a similar state or local wetland regulation. Session Laws 2009-337 and 2011-343 require the purchase and procurement of credits through approved mitigation banks if such credits are available, even if EEP's price is lower.

The above Session Laws may prevent the possibility of the Pitt County local governments from either: 1) enacting a law to collect in lieu fees from local developers themselves; or 2) establishing a mitigation bank to sell credits to developers. Either way, the concept would be that local development mitigation fees would be used to fund local stormwater management projects, including SCMs and stream restoration. Should this be unallowable, the local governments probably could develop such projects and use those to offset their own development projects.

6.2.5 Partnership with North Carolina Ecosystem Enhancement Program

The Pitt County local governments may benefit by working with NCEEP to fund and design the construction of an SCM within the project limits as part of NCEEP's nutrient offset program. Typically, NCEEP uses funds generated from the nutrient offset program to restore riparian buffers, streams, or wetlands in rural areas, which often provides no benefit to water quality in urban areas. Thus, it is often the case the developers create impacts in urban areas and pay offset fees to NCEEP then the funds are used to improve water quality in rural areas. Effectively, this results in a net export of stormwater management from urban areas to rural ones. The Pitt County local governments could use this fact to request NCDENR to require EEP to establish water quality improvement projects in this project area. It may be worth noting that Swift Creek is on the 303(d) list for impaired aquatic life and indications are that stormwater runoff is the cause.

The local governments would benefit from this by not having to devote resources to implement stormwater projects. It would, however, have to spend staff time to lobby NCDENR and EEP to implement projects.

6.2.6 Local Government Mitigation Bank

Session Law 2011-343 requires permit applicants, including Pitt County local governments, make use of a private mitigation bank prior to using NCEEP if credits are available (see Section 6.2.4 above). This law also **may** prevent the local governments from establishing a bank with credits for sale to other entities. However, DWQ and the USACE may allow the local governments to establish mitigation credit for its own use per NCDENR's guidance dated July 2011, "Implementation of N.C. General Assembly Session Laws 2009-337 and 2011-343." The credit could be documented and pre-approved by the Corps and DWQ using a mitigation banking instrument set up such that only the local governments could use the credit.

The benefits to the Pitt County local governments may already have projects that could be used for mitigation credit, and establishing a mitigation bank would formally document such credit for the local government's use. This would prevent the possibility that mitigation credit that the local governments may be able to develop would be denied by the agencies at a later date. The main benefit is that mitigation can be very costly, and if the local governments are going to develop projects that could be used for mitigation, it could be cost effective to have those credits available rather than having to purchase them from a bank or the EEP.

6.2.7 NCDOT Partnership

Another source of alternative funding is through partnership with NCDOT. NCDOT has a BMP retrofit program that is administered by the Hydraulics Unit. The retrofit program seeks local partners to share the SCM costs and design and maintenance responsibilities. Typically, NCDOT would either own the SCM property or runoff from its ROW would be treated by the SCM.

It may also be possible for the local governments to receive mitigation credit for SCMs developed in collaboration with NCDOT.

6.2.8 Stormwater Utility

The local governments may wish to consider a public enterprise (stormwater utility) to help fund the costs of providing stormwater management. This funding mechanism can be used for all aspects of managing stormwater runoff, including operations and maintenance, capital improvements, management services, and growth. The City of Greenville has a stormwater utility and this may serve as an indication of its usefulness and public acceptance in the area.

The NC General Statutes (NCGS) authorize municipalities to create a public enterprise and establish a user fee for the services furnished [§160A-311-314]. A public enterprise includes "stormwater management programs designed to protect water quality by controlling the level

of pollutants in, and the quantity and flow of, stormwater and structural and natural stormwater drainage systems of all types" [§160A-311(10)].

The City of Washington, NC, is closer to Winterville and Ayden in terms of population (2009 population was 10,176). Washington has separate residential and non-residential rates. Residential rates are between $2 and $4 per month and do not include exemptions for small impervious areas. Non-residential rates begin at $10/month for less than 600 square feet of impervious area and go to $100/month for impervious areas greater than 100,000 sf. The most common charge appears to be $20/month for areas between 601 and 20,000 square feet. See http://www.washington-nc.com/client_resources/stormwater_resolution.htm for a further breakdown of the monthly service charges.

Benefits of a Stormwater Utility

Benefits from implementing a stormwater utility include:

- New Funding Source – Revenue generated by implementing a stormwater utility could be used as a new source of funds to supplement, or create the Town's stormwater management funding.
- Supplemental Funding Source – Revenues from a stormwater utility can be used to replace current general funds, from taxes, used for stormwater related project, which enables the tax based funding to be used for other community needs.
- Bondable Revenue Stream – Bonds for capital improvements can be issued to facilitate constructing stormwater management facilities because the revenue generated from a stormwater utility can be used to pay back bonds.
- Encouraging land stewardship – Land stewardship can be encouraged by rewarding property owners who reduce stormwater runoff from their property. Credits should be given for those who implement structural or non-structural SCMs that reduce stormwater runoff and/or improve water quality.

The stormwater utility requires a moderate effort to implement since it is a new funding mechanism that will require public hearings as well as the preparation of a billing mechanism. Impervious surface data must be collected and updated periodically, assuming it is the selected metric on which fees will be based. Operational costs are expected to be low, however, because the billing can be integrated with the local government's existing water, sewer, and solid waste bills. In terms of revenue capacity, the stormwater utility can fund the existing program as well as an expanded one because the payment of the fee is received from nearly every property owner, which constitutes a large base.

Disadvantages of a Stormwater Utility

Stormwater utilities can also bring a number of possible disadvantages. These disadvantages may be particularly important for an established community such as those in the project area, where residents have become accustomed to a particular way of life and cost of living. In many cases, stormwater utilities are unable to gain political traction without a major water quality concern. Other commonly cited disadvantages of stormwater utilities include:

- Increased bureaucracy – Stormwater utilities could be perceived as new and additional government. Government can present inefficiencies. Development and permit review times could potentially be increased and could add uncertainty to the land development process.
- New fees perceived as taxes – Stormwater utility fees are often viewed as new taxes even though a fee-for-service is not a tax. The implementation of a stormwater utility fee is not typically accompanied by a decrease in generally municipal tax rates and therefore represents an increase in the total cost of landownership.
- Basis for fees may be unclear – Stormwater utility fees are generally based the area of impervious surface on a parcel. But, the general public often has difficulty understanding the concept of impervious surface and grasping the link between impervious surface and stormwater management.
- Utilities are politically untenable – The perception of utilities as increasing bureaucracy and tax burden creates a natural opposition to them among voters. Overcoming this opposition may be politically infeasible in many communities. Therefore, getting support for stormwater utilities from elected officials can be very difficult.
- May require a significant public campaign to generate support – Because the concepts of stormwater management are often viewed by the general public as complex and unnecessary, and since fees associated with a stormwater utility are generally unpopular, establishing a stormwater utility could potentially require a public education campaign and significant patience on the part of stormwater utility proponents.
- Staffing commitments – A stormwater utility could require additional staffing for administration and enforcement. This could increase the operational cost to the Town.

6.2.9 Increasing Residential Stewardship Practices

Develop ways to reach out to home owners about watershed behaviors. Some potential outreach efforts include websites, giveaways, press releases and radio, community fairs, homeowner's meetings, work parties, library displays, BMP tours. Efforts should focus on creating motivation through the primary means of providing assistance (creating awareness, providing expertise & funding). Avenues to pursue may be grant funding, partnerships with local retailers to offer discounts for watershed-friendly project materials, engaging with volunteer groups (master gardeners, scouts, Lions Club, VFW, Rotary Club, etc.) to train them

on designing and installing projects, offering utility payment credits for desired behaviors, creating friendly competitions. Another technique is to piggy-back stormwater stewardship with other energy and water efficiency outreach.

Some activities that should be encouraged are:

- Rooftop/rain-gutter disconnection
- Rainwater harvesting
- Routing flow off of impervious surfaces (e.g. roof tops and driveways) into vegetated areas
- Reforestation
- Fertilizer reduction
- Controlling erosion
- Stream buffers
- Conservation landscaping (e.g., native plants that have low watering requirements)

These recommendations have been adapted from the following webcast:
http://mawaterquality.org/capacity_building/ResidentialStewardshipWebcast2011.htm

6.2.10 Grant Funding Opportunities

North Carolina Nonpoint Source CWA 319 Grant Program

By amendment to the federal Clean Water Act in 1987, the Section 319 Grant program was established to provide funding for efforts to reduce nonpoint source (NPS) pollution, commonly referred to as stormwater runoff pollution. The USEPA provides funds to state and tribal agencies. States and Tribes then allocate funds via a competitive process to public and non-profit organizations to address current or potential NPS concerns. Funds may be used to demonstrate innovative BMPs, support education and outreach programs, establish Total Maximum Daily Loads (TMDLs) for a watershed, restore impaired streams or other water resources, or conduct NPS assessment or applied research.

In North Carolina, the 319 Grant Program is administered by the NPS Unit within DWQ's Planning Branch. Each fiscal year North Carolina is awarded nearly $4.5 million for its 319 Grant program. Forty percent of the funding supports ongoing state nonpoint source programs. The remaining sixty percent is made available through a competitive grants process. In late winter each year, the NC 319 Program issues a request for proposals with an open response period of three months. Grants are divided into two categories: Base and Incremental. Base Projects

involve research, demonstration, or education efforts to support both protection and restoration related to NPS stressors. Incremental projects seek to restore streams or other waterbodies that are currently impaired and not meeting their intended uses. State and local governments, interstate and intrastate agencies, public and private nonprofit organizations, and educational institutions are eligible to apply for Section 319 monies. An interagency workgroup reviews the proposals and selects those of merit to be funded.

Swift Creek is a 303(d) listed stream. A 4b demonstration or TMDL could be funded through 319 Incremental funds and would be necessary before further 319 Incremental funds were made available for implementation.

A 67 percent match of the requested amount is required of the applicant. More information on the NC 319 Grant program can be found at:

http://portal.ncdenr.org/web/wq/ps/nps/319program

North Carolina Division of Water Resources Development Project Grant Program

The North Carolina Division of Water Resources program is designed to provide cost-share grants and technical assistance to local governments throughout the state. Applications for grants are accepted for seven purposes: General Navigation, Recreational Navigation, Water Management, Stream Restoration, Beach Protection, Land Acquisition and Facility Development for Water Based Recreation and Aquatic Weed Control. Stormwater projects for the area would be categorized under the Water Management purpose. There are two grant cycles per fiscal year and the application deadlines are July 1st and January 1st. The North Carolina General Assembly placed a 50 percent match requirement on Water Resources Development Project Grants during their 2011 session. This requirement will remain in place until rescinded by the North Carolina General Assembly. Additional information on NCDWR grants can be found at:

http://www.ncwater.org/Financial_Assistance/

North Carolina Clean Water Management Trust Fund

North Carolina's Clean Water Management Trust Fund (CWMTF) was established by the General Assembly in 1996. This project was funded by the CMMTF. CWMTF receives a direct appropriation from the General Assembly to issue 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. Since the emphasis of the CWMTF is primarily on water quality, funding from this source would be more applicable to BMP projects

rather than stormwater infrastructure projects. Other information on the CWMTF, such as grant cycles and applications can be found at:

http://www.cwmtf.net/#about.html

Clean Water State Revolving Fund (CWSRF)

The Federal Water Pollution Control Act (Clean Water Act or CWA), as amended in 1987, established the Clean Water State Revolving Fund (CWSRF) program. The CWSRF program offers low interest financing agreements for water quality projects, including stormwater BMPs and sewer projects for any city, town, district or other public body created under state law. The interest rate for the CWSRF is set on March 31st of each year at one half of the 20-year bond buyer's index with a financing term of 20 years. Applications and other supporting documents and guidance can be found at:

http://portal.ncdenr.org/web/wq/cgls/fap/apps

State and Tribal Assistance Grants (STAG)

The United States Congress identifies a number of special needs projects in the Appropriations Bill each year. The grants are awarded through the EPA. These grants are generally limited to 55 percent of the eligible project cost. CWSRF may be used as matching funds for water quality projects, including CWMTF grants. Federal grant requirements govern the STAG grants. There is no initial application for these grants. Communities should contact NCDENR to let a representative know about eligible projects within the town. There is no guarantee that the town would be included in the Appropriations Bill. Communities that are selected for inclusion in the Appropriations Bill will be contacted by NCDENR. Information regarding STAG grant procedures and eligible projects can be found at:

http://portal.ncdenr.org/web/wq/cgls/fap/stag

Community Development Block Grant Program (CDBG)

The Community Development Block Grant (CDBG) program is a very flexible program that provides communities with resources to address a wide range of unique community development needs. The program is funded by the US Department of Housing and Urban Development. The CDBG program provides annual grants on a formula basis to 1209 general units of local government and States. At least 70 percent of these funds must be used to benefit low and moderate income persons. These funds could be used to address community development including stormwater improvement project like BMPs and infrastructure in areas with predominately low-to moderate-income residents. Applications and other information regarding the CDBG Program can be found at:
http://portal.hud.gov/hudportal/HUD?src=/program_offices/comm_planning/communitydevelopment/programs

Conclusion

As stated in the introduction, the **primary goals** of this watershed plan are to cost-effectively manage stormwater runoff from developed and developing areas, and manage floodplain impacts through strategic conservation easements and selective enhancement. The plan assessed how these goals could be met in a six step process:

1. Subwatershed characterization – the project area was divided into 13 subwatersheds and a land use analysis was conducted to estimate the amount of development that may occur in each subwatershed by the year 2035.
2. Benthic macroinvertebrate monitoring – biological investigations identified stormwater runoff, possibly including toxicity, as a primary cause for impaired water quality throughout the project area. Specific results and recommendations are available for the subwatersheds.
3. Riparian protection and stream enhancement – this task focused on measures that may be taken to improve flooding in the project area and address associated impacts to stream channel stability and water quality. Numerous suggestions were offered to address flooding. Specific recommendations were made to identify the best floodplain parcels for protection, and preliminary plans were developed for a stream enhancement project at lower Gum Swamp.
4. Stormwater control measure (SCM) site identification and prioritization – 116 structural SCM sites were considered and 37 were assessed in detail. The assessment included pollutant loading and removal, cost estimates, and priority rankings for implementation. Additionally, insight was offered on how permitting would proceed for these sites and on how to maintain them.
5. Educational workshops – An educational workshop was held on July 26, 2012 that presented results from this project, as well as recommendations to homeowners on how to manage stormwater and other local efforts aimed at stormwater monitoring and management. Also, the project held quarterly meetings so that the project partners remained abreast of the work and had opportunities to offer input on how it should be conducted.
6. Upper Swift Creek and Fork Swamp Watershed Action Plan – this plan presented the results of the above tasks and went beyond those in a number of instances to offer additional insight and recommendations. This plan archives the project results and may serve as a foundation for the project partners to improve stormwater management.

Water quality improvements are expected with implementation of the non-structural and structural SCMs identified in this plan. With respect to the specific impairment to Swift Creek, a water quality recovery plan (e.g., 4b demonstration, see Sections 2.4 and 3.4) may be developed to assess toxicity and recommend more specific SCMs to address that or other identified causes of the impairment.

In terms of flooding, Section 4.1 provides several recommendations for how to address flooding from the stream channel network in the project area. The structural SCMs were conceptually

designed to treat the first flush of runoff, which is focused on improving water quality and not water quantity. However, the SCMs could be designed such that overflow spillways are incorporated at higher elevations to detain additional runoff. This would need to be developed in more detail as part of site specific designs. Last, flooding may be managed by following the non-structural SCMs detailed in Sections 5.6, 5.7, 6.2.2, and 6.2.9.

In terms of the cost to implement the recommended measures, the following were estimated for specific projects:

1. Floodplain protection – an estimated $1,436,000 is needed to purchase development rights for portions of 36 floodplain parcels totaling 718 acres.
2. Stream enhancement – an estimated $222,000 is needed to construct the Gum Swamp stream enhancement project. This does not include costs for final design, permitting, and construction documents so an estimated $45,000 should be added for that bring the total to $267,000.
3. Structural SCMs – An estimated $5,042,000 is needed to design, permit, and construct the 37 selected SCMs.

Thus, the total needed for recommended specific projects is $6,745,000. Funding assistance may be obtained from the grant opportunities listed in Section 6.2.10.

This watershed action plan has provided a foundation on which the project partners may build a stormwater management program using structural and non-structural means to address water quality and quantity problems. As projects are implemented, periodic monitoring should be conducted to track changes. For example, benthic macroinvertebrate monitoring of Swift Creek at NC 102 may be conducted by NCDWQ as part of their basinwide monitoring completed every five years. The County should request that NCDWQ include this site in their basinwide monitoring. Although flooding issues are typically evident without monitoring, a database could be maintained to document flood levels at specific locations and the precipitation amounts that preceded flooding. These steps will help the County gage if the implemented measures are making a difference or if additional steps should be taken.

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