CITY OF GREENVILLE

SWIFT CREEK
WATERSHED MASTER PLAN

WKD # 20140067.00.RA

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Prepared for

City of Greenville
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Greenville, NC 27834

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EXECUTIVE SUMMARY

The City of Greenville retained WK Dickson to complete a Master Plan for the Swift Creek watershed. The goals of this master plan include: (1) evaluate the existing flooding, water quality and erosion problems, (2) recommend and prioritize capital improvements to control existing flooding by reducing the frequency and severity of flooding for property owners, and (3) identify stream stabilization projects to reduce the risk of property loss along streams and reduce sediment loads as a result of erosion. To assist in achieving the goals listed above, WK Dickson completed a stormwater drainage infrastructure inventory for drainage structures and features within the Swift Creek watershed. Over 700 drainage structures and approximately 19 miles of drainage pipe was located and incorporated into a GIS database as part of this effort.

The project included a broad range of stakeholders to collect as much data, information, and tacit knowledge of the watershed as feasible. The general public was solicited through questionnaires mailed to all property owners in the watershed and through an open house public meeting where residents and business owners were encouraged to provide feedback on stormwater issues in the watershed. Information collected from the questionnaires and public meeting can be found in Section 2.1 and Appendix D. City staff served as a critical stakeholder by providing valuable information regarding historical flooding and erosion problems in the watershed as well as providing feedback on potential capital improvements and their prioritization.

The project watershed is approximately 6.4 square miles and is located in the southwestern corner of Greenville. Approximately 33% of the watershed is contained in the City limits, and it is 55% developed as predominantly residential land use. WK Dickson conducted an Existing Conditions Analysis in order to evaluate the existing hydrologic and hydraulic characteristics of the Swift Creek watershed. Noted in this report as the Primary System are the following:

- Swift Creek Main Branch;
- Unnamed Tributary to Swift Creek (referred to as SCUT1); and
- Gum Swamp (Tributary to Swift Creek).

These Primary Systems were hydraulically studied in detail based on historical flooding of residential areas and roadways. Furthermore, high storm flows have eroded channel banks over time causing impacts to private yards, fences, and other property enhancements. In addition to the Primary Systems, a conveyance system (referred to as secondary system) in the Swift Creek watershed was analyzed to determine if it met the desired City design requirements outlined in Section 1.2. The secondary system was identified based on feedback from City residents and staff.

As a result of the Existing Conditions Analysis, multiple capital improvement and maintenance projects were identified to reduce the severity and frequency of flooding, stabilize stream banks,

and improve water quality through stormwater treatment practices. The proposed capital projects are as follows with the locations of each project shown on Figure ES-1.

Flood Control Projects

Swift Creek Main Branch Primary System

Alternative #1

Two alternatives are presented to improve flooding along Swift Creek Main Branch. Alternative #1 predominantly focuses on culvert improvements and floodplain benching to reduce the severity, frequency, and duration of flooding along Swift Creek. The proposed projects for Alternative #1 will require easements on private property in some instances, although entire property acquisition is not anticipated. The proposed projects for Alternative #1 are described below.

Thomas Langston Road – The existing 84" corrugated metal pipe (CMP) at this crossing is in fair condition and currently provides a 2-year level of service. In order to meet the desired 25-year level of service, the 84" CMP would need to be upsized.

Alternative #1 includes replacing the existing culvert with a 10' x 6' reinforced concrete box culvert (RCBC) and grading approximately 1,350 linear feet of floodplain benches in the left and right overbanks between Thomas Langston Road and Sterling Trace Drive. The floodplain benching will lower the tailwater for the culvert crossing reducing the proposed size of the new culverts. The proposed stream stabilization downstream of Thomas Langston Road could be incorporated into the floodplain benching. The maximum reduction in the 25-year WSEL upstream of Thomas Langston Road for this alternative is 1.94 feet. This alternative removes nine (9) properties from the 25-year floodplain and four (4) properties from the 100-year floodplain within the vicinity of Thomas Langston Road. Thomas Langston Road is maintained by NCDOT, therefore coordination with NCDOT would be required for any improvements within the right-of-way (ROW).

The majority of the proposed floodplain bench appears to be located within a Pitt County Drainage District easement based on the Pitt County OPIS website. Coordination with the Drainage District will be required to implement the proposed project.

Sterling Trace Drive – Currently, the twin 54" CMPs at this crossing provides a 2-year level of service. To meet the desired 25-year level of service, the CMPs will need to be replaced with twin 10' x 6' RCBCs. In addition to the culvert upgrade, Alternative #1 will include 1,690 linear feet of proposed floodplain benching downstream of Sterling Trace Drive in the left and right overbanks. The maximum reduction in the 25-year WSEL upstream of Sterling Trace Drive for this alternative is 1.51 feet for the 25-year event. Alternative #1 removes twelve (12) properties

from the 25-year floodplain, and nine (9) properties from the 100-year floodplain. Sterling Trace Drive is currently privately maintained. Many of the properties south of the crossing are located outside of the City limits.

The majority of the proposed floodplain bench appears to be located within a Pitt County Drainage District easement based on the Pitt County OPIS website. Coordination with the Drainage District will be required to implement the proposed project.

Alternative# 2

Alternative #2 evaluates the potential for creating upstream storage areas to detain runoff and lower peak flows, thereby reducing the size of downstream infrastructure improvements. Property acquisition will likely be required for the proposed detention area, although the extent of easements along Swift Creek will be less than those required for Alternative #1 as the limits of floodplain benching can be reduced as a result of the proposed detention area. The proposed projects for Alternative #2 are described below.

Megan Drive – The detention facility proposed near Megan Drive is located in the northwest corner of the Swift Creek Main Branch watershed. This thirty-two (32) acre wet detention pond is expected to reduce peak flows in the vicinity of Thomas Langston Road, and would subsequently eliminate the need for floodplain benching (as proposed for the Thomas Langston Road improvements, Alternative #1). The parcel is currently owned by Roberson Land Development and Blackwood Strickland LLC. Based on tax value the estimated land acquisition cost for this parcel would exceed $900,000. The large field at the east end of Megan Drive would be an ideal location for a 25-year facility because it has not been developed, and may be an aesthetic point of interest for future residents in addition to providing flood control. The regional detention facility will not impact the size of culverts along Swift Creek Main Branch but will reduce flows downstream to pre-project conditions.

Thomas Langston Road – The existing 84" CMP at this crossing is in fair condition and currently provides a 2-year level of service. In order to meet the desired 25-year level of service, the 84" CMP would need to be upsized.

Alternative #2 includes replacing the existing culvert with a 10' x 6' RCBC similar to Alternative #1, however floodplain benching will not be required as part of this alternative. The proposed stream stabilization downstream of Thomas Langston Road could be incorporated into the culvert improvements or completed separately. The maximum reduction in the 25-year WSEL upstream of Thomas Langston Road for this alternative is 1.92 feet. This alternative removes twelve (12) properties from the 25-year floodplain and one (1) property from the 100-year floodplain within the vicinity of Thomas Langston Road. Thomas Langston Road is maintained by NCDOT, therefore coordination with NCDOT would be required for any improvements within the right-of-way (ROW).

Sterling Trace Drive – Currently, the twin 54" CMPs at this crossing provides a 2-year level of service. To meet the desired 25-year level of service, the CMPs will need to be replaced with twin 10' x 6' RCBCs. In addition to the culvert upgrade, Alternative #2 will include 1,690 linear feet of proposed floodplain benching downstream of Sterling Trace Drive in the left and right overbanks, although the width of the proposed benching is less than that proposed in Alternative #1. The maximum reduction in the 25-year WSEL upstream of Sterling Trace Drive for this alternative is 1.47 feet for the 25-year event. Alternative #2 removes thirteen (13) properties from the 25-year floodplain, and ten (10) properties from the 100-year floodplain. Sterling Trace Drive is currently privately maintained. Many of the properties south of the crossing are located outside of the City limits.

The majority of the proposed floodplain bench appears to be located within a Pitt County Drainage District easement based on the Pitt County OPIS website. Coordination with the Drainage District will be required to implement the proposed project.

Swift Creek UT 1 (SCUT1) Primary System

Alternative #1

Two alternatives are presented to improve flooding along Swift Creek UT1. Alternative #1 predominantly focuses on culvert improvements and floodplain benching to reduce the severity, frequency, and duration of flooding along SCUT1. The proposed projects for Alternative #1 will require easements on private property in some instances, although entire property acquisition is not anticipated. The proposed projects for Alternative #1 are described below.

Thomas Langston Road – The existing 42" reinforced concrete pipe (RCP) at this crossing is undersized and only passes a 2-year storm event. The desired level of service at Thomas Langston Road is a 25-year storm.

Alternative #1 entails increasing the capacity of the culverts crossing by adding twin 42" floodplain culverts. The existing 42" RCP is in good condition and will remain in place. However, a field investigation revealed that the edge of the road and the edge of the culvert are eroding in this location, therefore the City should consider installing endwalls as part of the proposed improvements. In addition, 530 linear feet of floodplain benching is proposed downstream of Thomas Langston Road in the left and right overbanks. The maximum decrease in WSEL as a result of these improvements at Thomas Langston Road is 1.51 feet for the 25-year event. Additionally, eight (8) properties are removed from the 25-year floodplain and eleven (11) properties are removed from the 100-year floodplain. Thomas Langston Road is maintained by NCDOT, therefore coordination with NCDOT would be required for any improvements within the right-of-way (ROW).

The majority of the proposed floodplain bench appears to be located within a Pitt County Drainage District easement based on the Pitt County OPIS website. Coordination with the Drainage District will be required to implement the proposed project. Additionally, the floodplain benching could be coordinated with the proposed Swift Creek Greenway referenced in the 2004 Greenway Master Plan. Economy of savings could be provided if both projects are constructed at the same time.

Belfair Drive – Currently, the twin 48" RCPs at this crossing provides a 10-year level of service. To meet the desired 25-year level of service, the existing RCPs will need to be replaced with twin 6' x 4' RCBCs. The increased culvert capacity will provide the desired level of service. The maximum decrease in WSEL is 0.74 feet for the 25-year event just upstream of Belfair Drive as a result of the proposed improvements. There are no properties affected by the 25 or 100-year floodplains in the vicinity of Belfair Drive, therefore there were no properties removed as a result of these improvements.

Sterling Pointe Drive – The twin 42" RCPs at this crossing are undersized and only provide a 2-year level of service. The desired level of service at Sterling Pointe Drive is a 25-year storm.

Alternative #1 entails replacing the existing twin 42" RCPs with twin 11' x 4' RCBCs. In addition, 1,200 linear feet of floodplain benching is proposed downstream of Sterling Point Drive in the left and right overbanks. The maximum decrease in WSEL as a result of these improvements is 1.56 feet for the 25-year event. Three (3) properties are removed from the 25-year floodplain and twelve (12) properties are removed from the 100-year floodplain.

The majority of the proposed floodplain bench appears to be located within a Pitt County Drainage District easement based on the Pitt County OPIS website. Coordination with the Drainage District will be required to implement the proposed project. Additionally, the floodplain benching could be coordinated with the proposed Swift Creek Greenway referenced in the 2004 Greenway Master Plan. Economy of savings could be provided if both projects are constructed at the same time.

Alternative #2

Alternative #2 evaluates the potential for creating upstream storage areas to detain runoff and lower peak flows, thereby reducing the size of downstream infrastructure improvements. Property acquisition will likely be required for the proposed detention area, although the extent of easements along Swift Creek will be less than those required for Alternative #1 as the limits of floodplain benching can be reduced as a result of the proposed detention area. The proposed projects for Alternative #2 are described below.

Thomas Langston Road Detention – The Thomas Langston Road facility is proposed at the northern upstream section of the Swift Creek Tributary 1 watershed near Providence Place and is included in Alternative #2 for Swift Creek Tributary 1. The fifteen (15) acre wet detention

pond if implemented will require limited additional improvements at the Thomas Langston Road crossing. The parcel is currently owned by TMH Properties LLC and is slated for residential development. Based on tax value, the estimated land acquisition cost for this parcel would exceed $330,000. Passive recreational facilities could be added to the detention area to provide a community amenity.

Thomas Langston Road – The existing 42" RCP at this crossing is undersized and only passes a 2-year storm event. The desired level of service at Thomas Langston Road is a 25-year storm.

As a result of the proposed detention area upstream of Thomas Langston Road, the existing culvert crossing at Thomas Langston Road would convey the 25-year flow. A field investigation revealed that the edge of the road and the edge of the culvert are eroding in this location, therefore the City should consider installing endwalls on the existing culvert to stabilize the road. Floodplain benching is not required as part of Alternative #2. The maximum decrease in WSEL as a result of these improvements at Thomas Langston Road is 1.73 feet for the 25-year event. Additionally, eight (8) properties are removed from the 25-year floodplain and thirteen (13) properties are removed from the 100-year floodplain. Thomas Langston Road is maintained by NCDOT, therefore coordination with NCDOT would be required for any improvements within the right-of-way (ROW).

Belfair Drive – Currently, the twin 48" RCPs at this crossing provides a 10-year level of service. As a result of the proposed detention area upstream of Thomas Langston Road, the existing culvert crossing at Belfair Drive would convey the 25-year flow. The maximum decrease in WSEL is 2.38 feet for the 25-year event just upstream of Belfair Drive as a result of the proposed detention upstream of Thomas Langston Road. There are no properties affected by the 25-year or 100-year floodplains in the vicinity of Belfair Drive, therefore there were no properties removed as a result of these improvements.

Sterling Pointe Drive – The twin 42" RCPs at this crossing are undersized and only provide a 2-year level of service. The desired level of service at Sterling Pointe Drive is a 25-year storm.

Alternative #2 takes into account the implementation of the detention area proposed upstream of the Thomas Langston Road crossing. With the proposed detention area, the proposed culvert for Alternative #2 is twin 10' x 4' RCBCs which will provide the desired 25-year level of service. This alternative will not include the floodplain benching proposed as part of Alternative #1. The maximum decrease in WSEL during the 25-year storm as a result of these improvements is 1.42 feet for the 25-year event. Two (2) properties are removed from the 25-year floodplain and twelve (12) properties are removed from the 100-year floodplain.

Gum Swamp Primary System

Frog Level Road – The twin 78" CMPs at this crossing are currently operating at a 10-year level of service. In order to meet the desired 25-year level of service, the existing CMPs will need to

be replaced with twin 7' x 6' RCBCs. Additionally, 495 linear feet of floodplain benching along the left bank is required to lower the tailwater at the downstream end of Frog Level Road and allow the new culverts to convey the 25-year storm. The maximum decrease in WSEL as a result of these improvements is 0.83 feet for the 25-year event just upstream of the Frog Level Road crossing. Upstream of Frog Level Road, four (4) properties are removed from the 25-year floodplain and one (1) property is removed from the 100-year floodplain.

Frog Level Road is currently maintained by NCDOT and is located outside of the existing City limits. However, improvements to the culvert crossing will directly reduce water surface elevations for City residents located along Ashmoor Lane.

Gum Swamp Floodplain Benching - A total of 4,660 linear feet of floodplain benching is proposed in the left and right overbanks approximately 1,000 linear feet downstream of Frog Level Road. The floodplain benching lowers water surface elevations along the stream which will reduce the risk of flooding for properties along Sawgrass Drive as well as address the documented stream erosion problems along Gum Swamp. The maximum decrease in WSEL as a result of these improvements is 3.8 feet during the 25-year event. Along the studied reach of Gum Swamp, forty-three (43) properties are removed from the 25-year floodplain and seven (7) properties are removed from the 100-year floodplain.

The majority of the proposed floodplain bench appears to be located within a Pitt County Drainage District easement based on the Pitt County OPIS website. Coordination with the Drainage District will be required to implement the proposed project.

Secondary Systems

Davenport Farm Road – The downstream portion of this system is operating below the desired 10-year level of service due to the backwater from Gum Swamp. With the improvements proposed for the Frog Level Road crossing including the floodplain benching, the tailwater will be lowered and the Davenport Road system will operate at the desired level of service. Therefore, no capital improvements are proposed at this location.

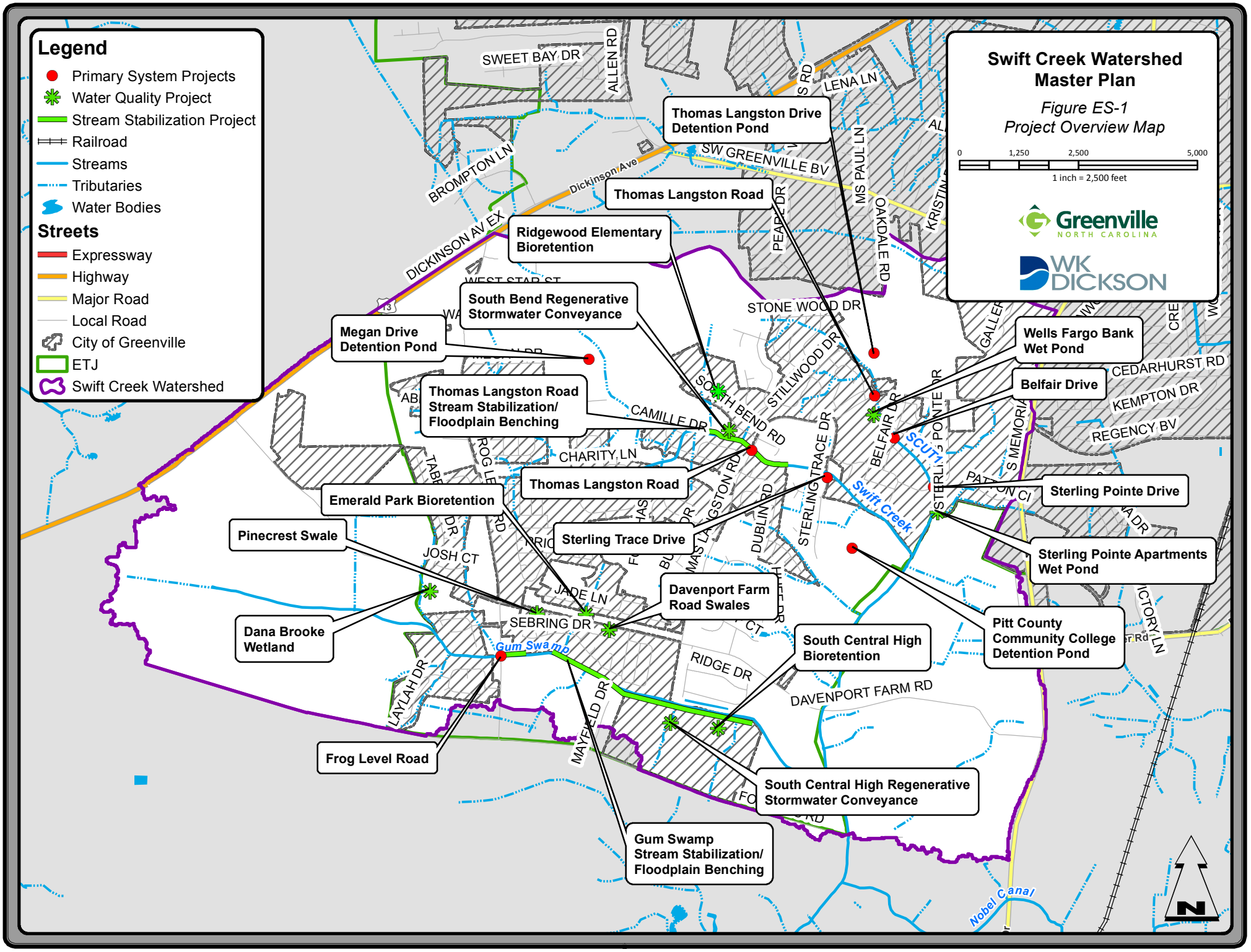
Regional Detention

If all of the proposed primary system improvements are completed as outlined in "Flood Control Projects" section, runoff will be conveyed more efficiently through the Swift Creek watershed, but will result in a 6% increase in the 25-year storm at the outlet of the watershed for Alternative #1 for future build out conditions when compared to existing conditions flows. To offset this increase in peak flow, a regional detention facility is proposed on a portion of the Pitt County Community College property east of Sterling Trace Drive near the confluence of Swift Creek and the unnamed tributary to Swift Creek. The 32-acre wet detention pond would reduce peak flows to below the pre-project conditions. For Alternative #2, the Pitt County

Community College Detention Pond would not be required due to the detention from the Megan Drive and Thomas Langston detention ponds.

If 25-year detention is required in the areas shown in Section 4.3, then the Pitt County Community College Detention Pond could be reduced to 20 acres in size for Alternative #1 resulting in no increase in peak flow at the outlet during the 25-year event during built out conditions.

For Alternative #2, 25-year detention for future development in the areas shown in Section 4.3 would allow the Megan Drive and Pitt County Community College Detention Pond to be eliminated. The Thomas Langston Pond would be required as proposed above for Alternative #2.


Legend
Primary System Projects
Water Quality Project
Stream Stabilization Project
Railroad
Streams
Tributaries
Water Bodies
Streets
Expressway
Highway
Major Road
Local Road
City of Greenville
ETJ
Swift Creek Watershed
Swift Creek Watershed Master Plan
Figure ES-1
Project Overview Map
0
1,250
2,500
5,000
1 inch = 2,500 feet
Greenville
NORTH CAROLINA
WK DICKSON
Thomas Langston Drive Detention Pond
Thomas Langston Road
Ridgewood Elementary Bioretention
South Bend Regenerative Stormwater Conveyance
Megan Drive Detention Pond
Thomas Langston Road Stream Stabilization/ Floodplain Benching
Emerald Park Bioretention
Thomas Langston Road
Pinecrest Swale
Sterling Trace Drive
Davenport Farm Road Swales
Dana Brooke Wetland
Frog Level Road
Gum Swamp Stream Stabilization/ Floodplain Benching
South Central High Regenerative Stormwater Conveyance
South Central High Bioretention
Pitt County Community College Detention Pond
Sterling Pointe Apartments Wet Pond
Sterling Pointe Drive
Belfair Drive
Wells Fargo Bank Wet Pond
SWEET BAY DR
ALLEN RD
LENA LN
BROMPTON LN
Dickinson Ave
SW GREENVILLE BV
MS PAUL LN
OAKDALE RD
DICKINSON AV EX
STONE WOOD DR
STILLWOOD DR
CEDARHURST RD
KEMPTON DR
REGENCY BV
SOUTH BEND RD
CAMILLE DR
CHARITY LN
BELFAIR DR
STERLING TRACE DR
DUBLIN RD
Swift Creek
JOSH CT
JADE LN
SEBRING DR
Gum Swamp
RIDGE DR
DAVENPORT FARM RD
LAYLAH DR
MAYFIELD DR
Nobel Canal
N

Flood Control Prioritization

To appropriately allocate City resources, the flood control projects listed above were prioritized based on the following categories as described in Appendix L:

- Public health and safety
- Severity of street flooding
- Cost effectiveness
- Effect of improvements
- Water quality – BMP
- Open channel – erosion control
- Implementation constraints
- Grant funding
- Constructability

Scores were assigned to each project for the factors listed above to determine the priority list. In some instances, project prioritization will be impacted by the required sequencing of projects to provide the highest possible flood reduction benefits and to reduce or negate any downstream impacts from the proposed projects. Table ES-1 shows the proposed prioritizations and conceptual cost estimates for the Flood Control Improvements. The City should re-visit the prioritization lists annually to determine if priorities should shift. The prioritization scoring for each project and a description of the aforementioned categories is included in Appendix L. The total cost for all of the recommended primary system improvements for Alternative #1 in the Swift Creek watershed is approximately $11,230,000. The total cost for all of the recommended primary and secondary system improvements for Alternative #2 in the Swift Creek watershed is approximately $30,910,000. The additional cost to construct the Pitt County Community College Detention Pond would be $18,280,000, which would only be required for Alternative #1.

Table ES-1: Flood Control Project Prioritization

Prioritization	Project	Cost
1	Thomas Langston Road (Swift Creek Main Branch) – Alt #1	$1,050,000
2	Alternative #2 – SCUT1	$8,050,000
3	Thomas Langston Road (SCUT1) – Alt #1	$370,000
4	Alternative #2 – Swift Creek Main Branch	$16,990,000
5	Frog Level Road (Gum Swamp)	$710,000
6	Gum Swamp Floodplain Benching	$5,160,000
7	Belfair Drive (SCUT1) – Alt #1	$380,000
8	Sterling Pointe Drive (SCUT1) – Alt #1	$1,190,000
9	Sterling Trace Drive (Swift Creek Main Branch) – Alt #1	$2,370,000

See Appendix L for prioritization details.

Stream Stabilization and Water Quality Projects

During the Existing Conditions Analysis, the majority of the streams were quantitatively assessed for stability. Based on this assessment, two (2) stream stabilization projects were identified as shown on Figure ES-1. Potential components of the stabilization project include, flattening the slope of the channel banks, installing erosion control matting and plantings, rock grade control structures, retaining walls, and rip-rap. Stream restoration projects typically include changing the pattern of the stream which can be difficult in urban areas due to the impacts on multiple property owners. Additionally, property boundaries are often defined by the stream centerline, further complicating urban stream restoration. The stabilization projects will protect residential yards, fences, and structures from further erosion, and substantially decrease the in-stream sediment loads to downstream receiving waters. Additionally, the floodplain benching along Gum Swamp could be combined with the stream stabilization proposed in the Upper Swift Creek and Fork Swamp Watershed Action Plan completed by Pitt County in 2012. The portion of Gum Swamp that was identified in the Action Plan for stabilization is outside the City limits, but in close proximity to the proposed floodplain benching. This project may be an opportunity for the City to partner with Pitt County.

The City should also work closely with the Pitt County Drainage District to determine the most effective ways to maintain streams in the watershed without impacting the stability of streambanks and habitat for macroinvertebrates. The maintenance activities that are keeping the streams clear from blockages have the unintended consequences of removing vegetation from the streambanks that can be vital to stabilizing the banks. As development continues to occur in this area, peak flows will increase and high flows will be longer in duration which could further erode the banks if they are not vegetated. Secondly, Swift Creek is currently listed as impaired for benthic macroinvertebrates. While the monitoring results summarized in Section 5.5 indicate it may be possible to delist Swift Creek from the Category 5 list, there is limited habitat within the streams for the macroinvertebrates to thrive. Some woody debris should remain in the stream to allow these organisms to thrive which will improve the water quality of the stream.

In addition to the stream stability projects, ten (10) water quality BMP retrofit projects were recommended. Potential project locations were initially identified using available GIS data by focusing on locations with contributing drainage areas that are highly impervious and preferably on publically-owned land. Impervious areas typically generate the highest concentration of pollutants, so treating the runoff from these areas would provide more pollutant material than treating water that carried fewer pollutants. Publically-owned land is ideal for BMP retrofits to reduce or eliminate potential land acquisition costs. See Section 5.2 for additional evaluation criteria for BMP retrofit sites. Potential locations that were identified using GIS were presented to the City. Following concurrence with the City, the final list of BMPs were field inspected to determine any project constraints present that may not be

discernible from GIS data, such as utility conflicts, limited access to the site, or private property conflicts.

The stream stabilization and water quality projects were prioritized using categories similar to those used to prioritize the flood control projects described above (See Appendix L). Cost effectiveness for the stream stabilization project was calculated based on a cost per linear foot of stabilized stream, while for water quality projects were calculated based on a cost per impervious acre treated. Tables ES-2 and ES-3 show the prioritization of the stream stabilization and water quality projects along with estimates of their preliminary cost.

Table ES-2: Stream Stabilization Project Prioritization

Prioritization	Project	Cost
1	Thomas Langston (Swift Creek Main Branch)	$810,000
2	Thomas Langston (SCUT1)	$70,000
	Total	$880,000

Table ES-3 Water Quality Project Prioritization

Prioritization	Project	Cost
1	Sterling Pointe Apartments Wet Pond Retrofit	$100,000
2	Ridgewood Elementary School Bioretention	$330,000
3	Emerald Park Bioretention	$240,000
4	South Bend RSC	$220,000
5	Pinecrest Water Quality Swale	$50,000
6	Wells Fargo Wet Pond Retrofit	$200,000
7	Davenport Farm Road Water Quality Swale	$100,000
8	South Central High School Bioretention	$1,300,000
9	Dana Brooke Wetland	$930,000
10	South Central High School RSC	$140,000
	Total	$3,610,000

See Appendix L for prioritization details.

25-Year Detention Analysis

As part of the Swift Creek Master Plan, an analysis was completed to determine if there are areas within the watershed that should be considered "well documented water quantity problems" requiring detention for the 25-year, 24-hour storm event. As noted in Section 3.1, documented flooding issues are located along Swift Creek Main Branch, Swift Creek Unnamed Tributary 1, and Gum Swamp in the vicinity of Thomas Langston Road and Frog Level Road. Large portions of the Swift Creek watershed remain undeveloped and could potentially cause increased flows greater than 10% higher than the current existing flows. These areas are outlined in Section 4.3.

If 25-year detention is required in the proposed areas, the need for infrastructure improvements will not be eliminated but the recommended improvements could be reduced in magnitude.

For Alternative #1, 25-year detention in the areas outlined in Section 4.3 will provide the following changes in the proposed improvements:

- Remove floodplain benching downstream of Thomas Langston Road ($650,000 reduction in cost);
- Reduce floodplain benching downstream of Sterling Trace Drive ($280,000 reduction in cost;
- Reduce size of Pitt County Community College Regional Detention to 20 acres ($6,850,000 reduction in cost); and
- Total potential cost savings in capital infrastructure - $7,780,000.

For Alternative #2, 25-year detention in the areas outlined in Section 4.3 will provide the following changes in the proposed improvements:

- Remove Megan Drive Detention Pond ($14,490,000 reduction in cost); and
- Total potential cost savings in capital infrastructure - $14,490,000

INTRODUCTION

1.1 PROJECT DESCRIPTION

The City of Greenville retained WK Dickson to complete a Watershed Master Plan for the Swift Creek watershed. As shown in Figure 1-1, the Swift Creek watershed is located in the southwestern corner of Greenville and generally drains north to south ultimately discharging to the Neuse River. As noted in the Executive Summary, the goals of the Master Plan include: (1) evaluate the existing flooding, water quality and erosion problems, (2) recommend and prioritize capital improvements to control existing flooding by reducing the frequency and severity of flooding for property owners, and (3) identify stream stabilization projects to reduce the risk of property loss along streams and reduce sediment loads as a result of erosion. To assist in achieving the goals listed above, WK Dickson completed a stormwater drainage infrastructure inventory for drainage structures and features within the Swift Creek watershed.

The Master Plan includes an evaluation of the segment of Swift Creek from approximately 2,400 feet upstream of Thomas Langston Road crossing at the upstream end to its confluence with an unnamed tributary to Swift Creek (referred to as SCUT1). The following tributaries were evaluated as part of this Master Plan:

- Swift Creek UT1 from approximately 650 feet upstream of Thomas Langston Road crossing at the upstream end to its confluence with Swift Creek at the downstream end; and
- Gum Swamp from to approximately 1,600 feet upstream of the Frog Level Road crossing at the upstream end to approximately 1,500 feet upstream of its confluence with Swift Creek at the downstream end.

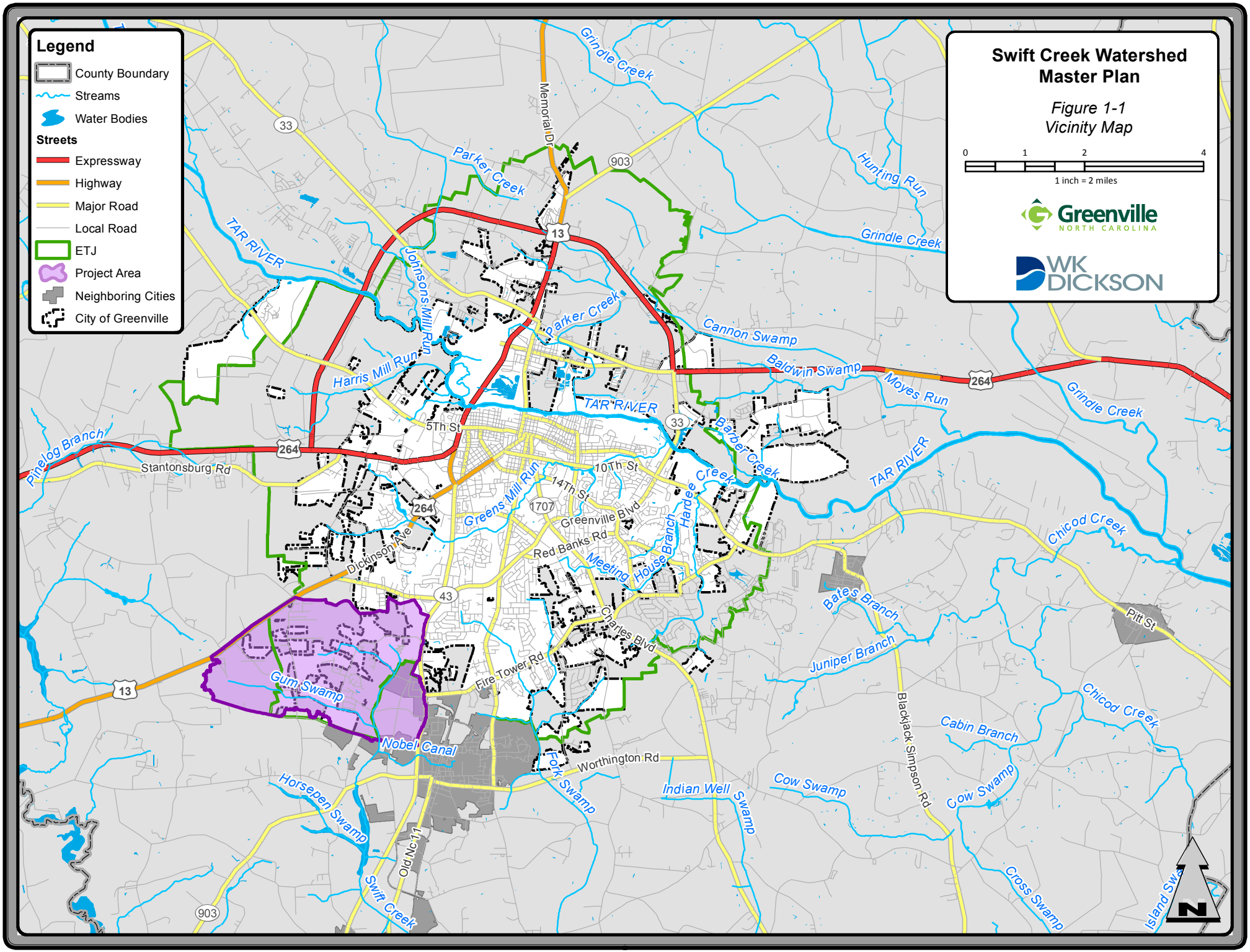
Additionally, a conveyance system that drains to Gum Swamp was evaluated. For the purposes of this report, Swift Creek, SCUT1, and Gum Swamp will be noted as primary systems and the conveyance system draining to Gum Swamp will be noted as the secondary system. A project area map showing the Swift Creek watershed and the conveyance system evaluated as part of this Master Plan is included as Figure 1-2. Detailed hydraulic analysis included the following:

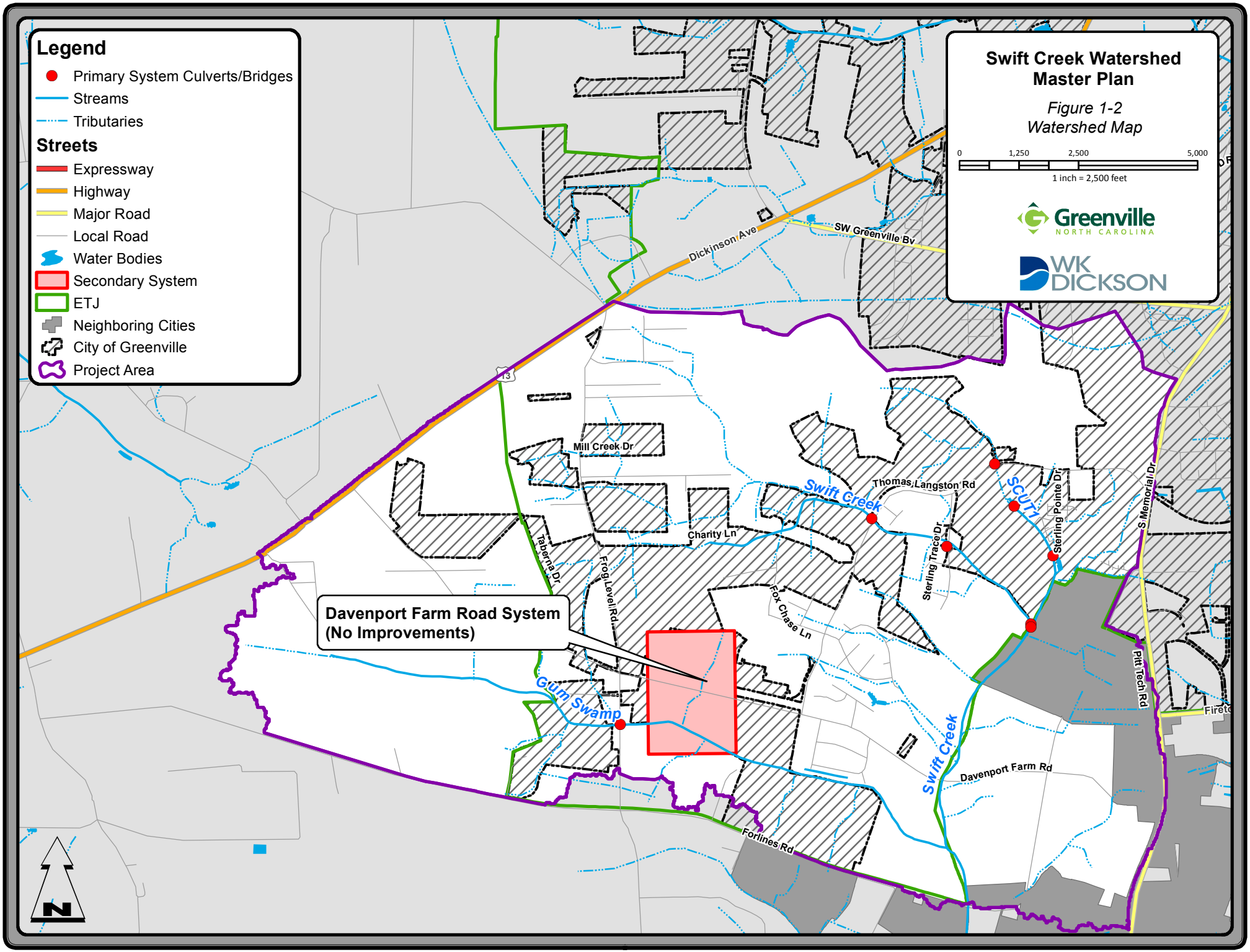
- Primary System – Swift Creek
    - Thomas Langston Road Culvert
    - Sterling Trace Drive Culvert

- Primary System – SCUT1
    - Thomas Langston Road Culvert
    - Belfair Drive Culvert
    - Sterling Pointe Drive Culvert

- Primary System – Gum Swamp
    - Frog Level Road Culvert

- Secondary Systems
    - Davenport Farm Road System


Legend
County Boundary
Streams
Water Bodies
Streets
Expressway
Highway
Major Road
Local Road
ETJ
Project Area
Neighboring Cities
City of Greenville
Swift Creek Watershed Master Plan
Figure 1-1
Vicinity Map
0 1 2 4
1 inch = 2 miles
Greenville NORTH CAROLINA
WK DICKSON
Grindle Creek
Memorial Dr
Parker Creek
Hunting Run
TAR RIVER
Johnsons Mill Run
Harris Mill Run
Cannon Swamp
Baldwin Swamp
Moyes Run
Pinelog Branch
Stantonsburg Rd
5Th St
10Th St
14Th St
Greens Mill Run
Barber Creek
Hardee Creek
Greenville Blvd
Red Banks Rd
Meeting House Branch
Dickinson Ave
Chicod Creek
Bates Branch
Pitt St
Juniper Branch
Charles Blvd
Fire Tower Rd
Gum Swamp
Nobel Canal
Worthington Rd
Fork Swamp
Horsepen Swamp
Old Nc 11
Swift Creek
Indian Well Swamp
Cow Swamp
Blackjack Simpson Rd
Cabin Branch
Cross Swamp
33
903
13
264
43
1707
N


Legend
Primary System Culverts/Bridges
Streams
Tributaries
Streets
Expressway
Highway
Major Road
Local Road
Water Bodies
Secondary System
ETJ
Neighboring Cities
City of Greenville
Project Area
Swift Creek Watershed Master Plan
Figure 1-2
Watershed Map
0
1,250
2,500
5,000
1 inch = 2,500 feet
Greenville
NORTH CAROLINA
WK DICKSON
Davenport Farm Road System (No Improvements)
Dickinson Ave
SW Greenville Bv
Mill Creek Dr
Swift Creek
Thomas Langston Rd
SCUT1
Sterling Pointe Dr
S Memorial Dr
Charity Ln
Taberna Dr
Frog Level Rd
Sterling Trace Dr
Fox Chase Ln
Gum Swamp
Pitt Tech Rd
Swift Creek
Davenport Farm Rd
Forlines Rd
N

1.2 DESIGN STANDARDS AND CRITERIA

The following design storms were used to evaluate the performance of the primary and secondary systems in this Master Plan:

- 10-year storm event – piped collection systems;
- 25-year storm event – minor thoroughfare roadway bridges and culverts;
- 50-year storm event – major thoroughfare roadway bridges and culverts;
- 100-year storm event – structural flooding of homes; and
- 100-year storm event – overtopping of railroad.

Table 1-1 shows the applicable storm for the project areas evaluated as part of this Master Plan. The corresponding rainfall depths for the design storms are included in Appendix A.

Table 1-1: Project Area Design Standards and Criteria

Drainage Type	Design Storm (years)	Project Area
Piped Collection Systems	10	• Davenport Farm Road Closed System
Minor Thoroughfare Roadway Crossings	25	• Thomas Langston Road Culvert (Swift Creek) • Sterling Trace Drive Culvert (Swift Creek) • Thomas Langston Road Culvert (SCUT1) • Belfair Drive Culvert (SCUT1) • Sterling Pointe Drive Culvert (SCUT1) • Frog Level Road Culvert (Gum Swamp)

EXISTING WATERSHED CONDITIONS

2.1 CITIZEN INPUT

The Master Plan included a citizen input component to solicit feedback and information regarding stormwater impacts and future stormwater management in the City. In August of 2014, the City began distribution of questionnaires related to stormwater management property owners in the Swift Creek watershed. Five (5) questionnaires were completed and returned to the City for consideration from Swift Creek watershed property owners. The questionnaire results were georeferenced according to the address of the questionnaire respondent (See Figure 2-1). Two (2) of the respondents indicated crawl space flooding at least once per year. Both of these respondents are located outside of the City's limits along Frog Level Road. One out of the five (5) respondents reported erosion threatening their yard. See Figure 2-2 for location of reported erosion. A sample questionnaire and the tabulated results are provided in Appendix D.

On November 4, 2014, the City provided another avenue for obtaining citizen input by holding a public meeting. An open house format allowed property owners to attend at their convenience and speak to City staff or representatives from WK Dickson. Four (4) residents from the watershed provided feedback at the meeting, however two (2) of these attendees live and have concerns outside the City limits. The other two (2) comments were related to maintenance issues. Minutes from this meeting are included as part of Appendix D.

The results and comments from the citizen's input contributed significantly to the identification and prioritization of problem areas, and validation of model results.

2.2 WATERSHED CHARACTERISTICS

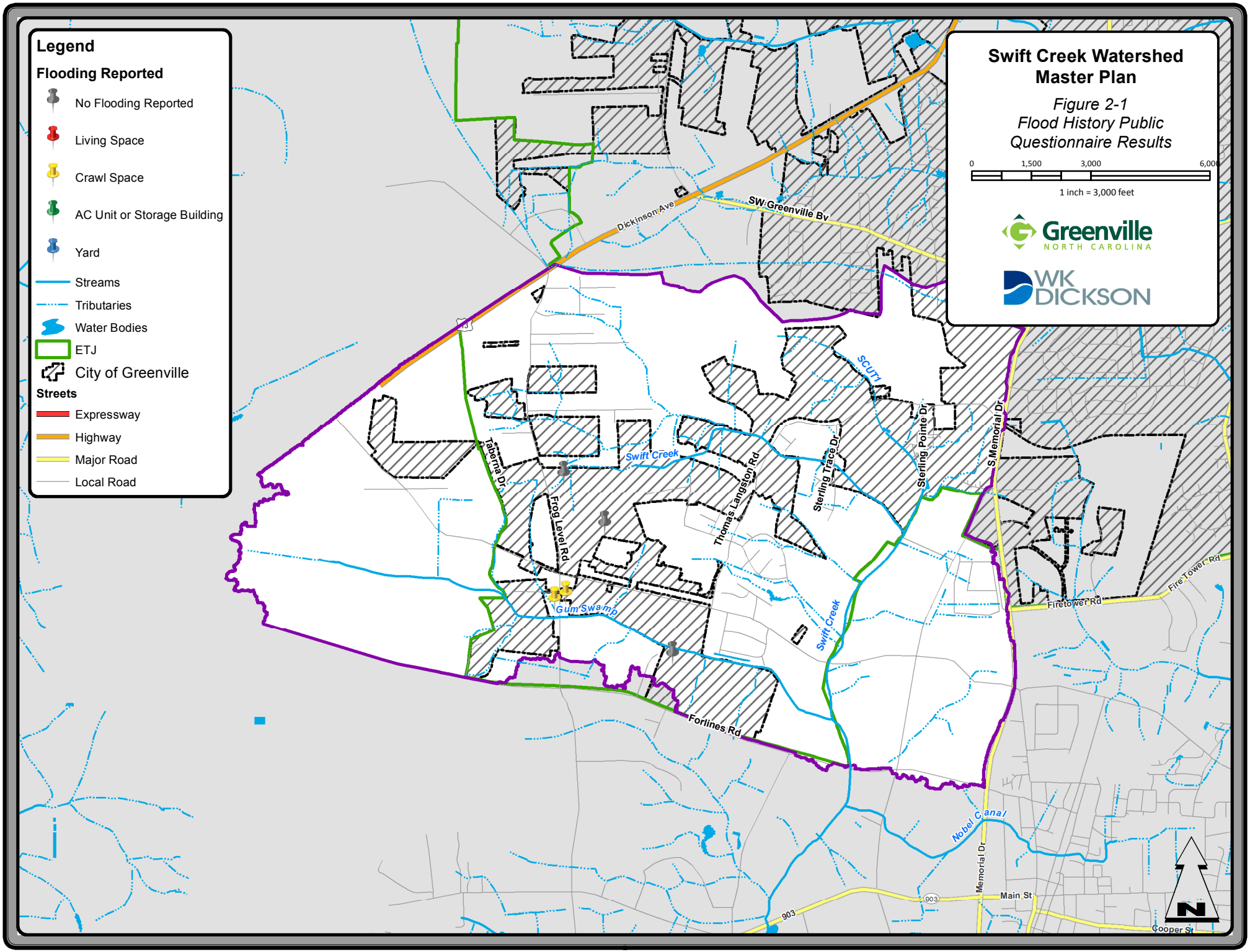
The Swift Creek watershed is approximately 4,100 acres (6.4 square miles) between its downstream boundary in the vicinity of Forlines Road and its upstream boundary along Dickinson Avenue. Approximately one-third (2 square miles) of the total watershed area is within the City limits. Land use in the watershed is approximately 55 percent built out as shown on the Existing Conditions Land Use Map included in Appendix C. The existing land use in the watershed is mostly residential and agricultural with a small percentage of commercial, office, and institutional (See Table 2-1a). The soils within the watershed are predominately NRCS hydrologic group C as shown on the Soils Map included in Appendix C. More detailed information about the land use and soils in the Swift Creek watershed is provided in Appendix A.

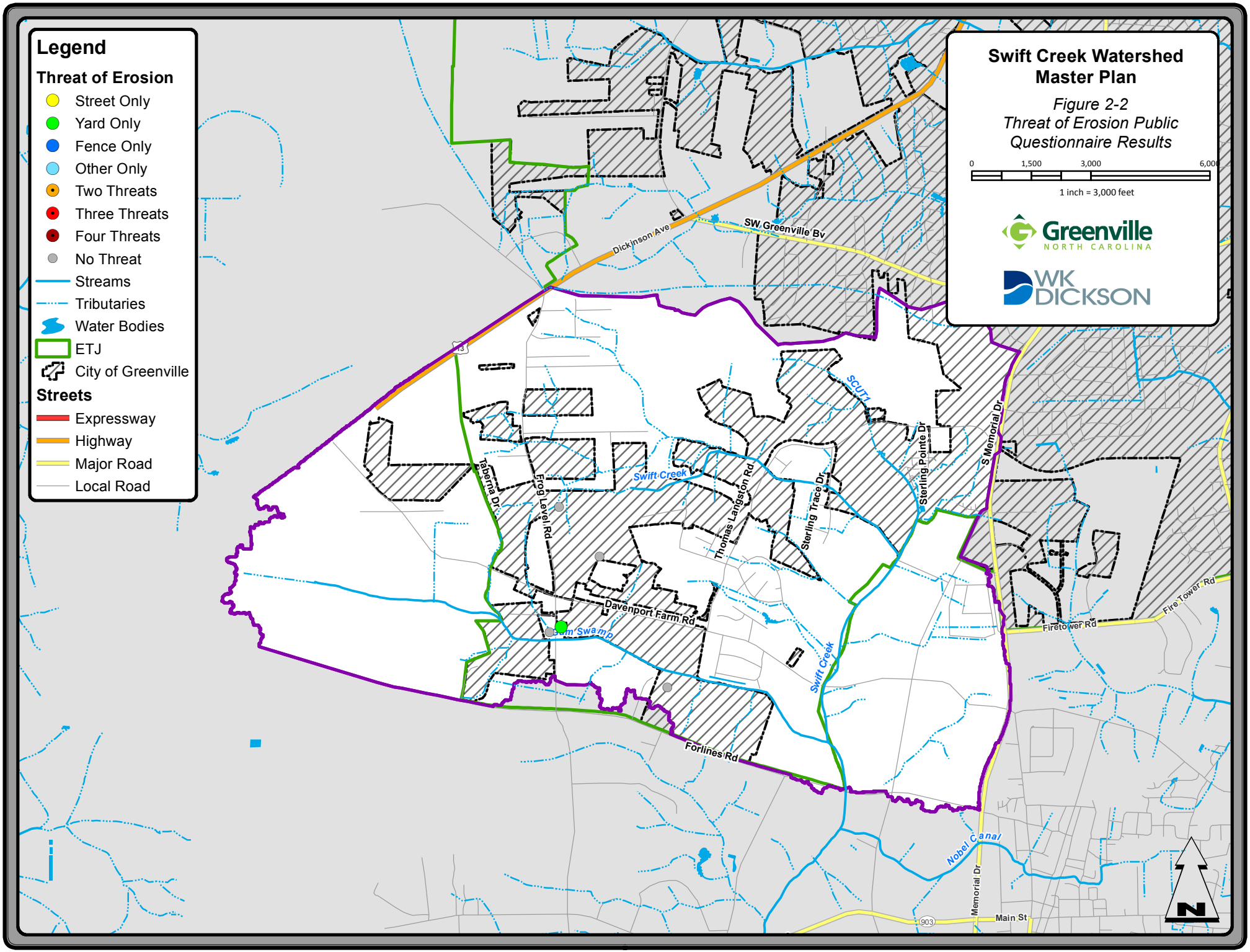
Table 2-1a: Swift Creek Watershed Existing Land Use

Land Use Category	Area (acres)
Commercial	151
Industrial	4
Mixed Use/Office/Institutional	425
Office/Institutional/Medical	22
Office/Institutional/Multi-Family	100
High Density Residential	142
Medium Density Residential	374
Low Density Residential	553
Very Low Density Residential	243
Conservation/Open Space	584
Right-of-Way	289
Agricultural/Cropland	1,207

Table 2-1b: Swift Creek Watershed Future Land Use

Land Use Category	Area (acres)
Commercial	303
Industrial	4
Mixed Use/Office/Institutional	411
Office/Institutional/Medical	20
Office/Institutional/Multi-Family	100
High Density Residential	252
Medium Density Residential	488
Low Density Residential	482
Very Low Density Residential	1,521
Conservation/Open Space	224
Right-of-Way	289


Legend
Flooding Reported
No Flooding Reported
Living Space
Crawl Space
AC Unit or Storage Building
Yard
Streams
Tributaries
Water Bodies
ETJ
City of Greenville
Streets
Expressway
Highway
Major Road
Local Road
Swift Creek Watershed Master Plan
Figure 2-1
Flood History Public Questionnaire Results
0
1,500
3,000
6,000
1 inch = 3,000 feet
Greenville
NORTH CAROLINA
WK DICKSON
Dickinson Ave
SW Greenville Bv
Taberna Dr
Frog Level Rd
Swift Creek
Thomas Langston Rd
Sterling Trace Dr
Sterling Pointe Dr
S Memorial Dr
Fire Tower Rd
Gum Swamp
Swift Creek
Forlines Rd
Nobel Canal
Memorial Dr
Main St
903
Cooper St


Legend
Threat of Erosion
Street Only
Yard Only
Fence Only
Other Only
Two Threats
Three Threats
Four Threats
No Threat
Streams
Tributaries
Water Bodies
ETJ
City of Greenville
Streets
Expressway
Highway
Major Road
Local Road
Swift Creek Watershed Master Plan
Figure 2-2
Threat of Erosion Public Questionnaire Results
0
1,500
3,000
6,000
1 inch = 3,000 feet
Greenville
NORTH CAROLINA
WK DICKSON
Dickinson Ave
SW Greenville Bv
SCUT
S Memorial Dr
Sterling Pointe Dr
Sterling Trace Dr
Thomas Langston Rd
Frog Level Rd
Taberna Dr
Swift Creek
Davenport Farm Rd
Bells Swamp
Forlines Rd
Firetower Rd
Fire Tower Rd
Nobel Canal
Memorial Dr
Main St
903
N

2.3 EXISTING CONDITIONS SURVEY AND FIELD DATA COLLECTION

For the Swift Creek Watershed Master Plan, stormwater utility infrastructure throughout the watershed in City limits was collected by WK Dickson and River & Associates personnel to compile a Geographic Information System (GIS) stormwater inventory database for the City. This was accomplished by using survey grade Global Positioning Systems (GPS) as the primary means of data capture to locate the x, y, and z coordinates of each visible stormwater system structure. Conventional surveying techniques were used to obtain attributes including but not limited to size, material, slope, and length. The data was collected using horizontal datum NAD 1983 and vertical datum NAVD 1988. A total of 719 closed system structures and 99,270 linear feet of pipe were collected as part of the inventory. Tables 2-2 and 2-3 summarize the inventory collected in the Swift Creek watershed.

Table 2-2: Inventory Summary – Closed System Structures

Structure Type	Number Surveyed
Yard Inlet	191
Drop Inlet	38
Junction Box	23
Pipe End	213
Pond Structure	9
Slab Top Inlet	15
Catch Basin	227
Underground Pipe Junction	3

Table 2-3: Inventory Summary – Pipes

Size	Length (Linear Feet)
15″ Diameter	19,157
18″ Diameter	18,464
24″ Diameter	18,489
30″ Diameter	12,588
36″ Diameter	12,396
42″ Diameter	6,671
48″ Diameter	6,543
54″ Diameter	1,634
60″ Diameter	1,197
66″ Diameter	40
72″ Diameter	394
'Other' Diameter*	1,697

*Includes mismatched pipe ends and diameters from underground pipe junctions.

Data was obtained for those open channels required to complete connectivity for modeling purposes. Attributes such as shape, lining type, bed type, flow, bottom width, top width, and bank height were collected for seventy-two (72) open channel sections totaling over ten (10) miles in length. For those sections of open channel where more detailed information was required for model input, cross sections were surveyed. Data including elevations for the top of the bank, bottom of bank, and channel centerline were obtained at forty-nine (49) cross sections throughout the Swift Creek watershed to supplement the existing FEMA cross section data. Refer to the City of Greenville's Storm Water System Inventory Standard Operating Procedures for additional information about the processes and details of the inventory database.

EXISTING WATERSHED ANALYSIS

3.1 PRIMARY SYSTEM HYDROLOGIC AND HYDRAULIC ANALYSES

3.1.1 HYDROLOGY

The purpose of the hydrologic analysis is to estimate the magnitude of selected frequency floods for the Swift Creek Watershed. The United States Army Corps of Engineers (USACE) HEC-HMS was selected to model the primary systems. HEC-HMS simulates the surface runoff response to precipitation for an interconnected system of surfaces, channels, and ponds. Input data for the HEC-HMS model was developed using topographic, land use, and soils maps in a GIS to delineate and calculate the basin areas and Natural Resources Conservation Service (NRCS) hydrologic parameters. Detailed descriptions of the model parameters can be found in Appendices A and B.

The HEC-HMS model offers a variety of methods for simulating the rainfall-runoff response, hydrograph development, channel and pond routing. The selection of methods for the analyses is based on the study objectives, data availability, and watershed characteristics. The precipitation data for the 24-hour duration, Type III storm was used to represent the synthetic rainfall event. The Type III storm was selected based on the location of the City of Greenville. The geographic boundaries for the different NRCS rainfall distributions are shown on Figure B-2 of NRCS document Urban Hydrology for Small Watersheds, dated June 1986 and commonly referred to as TR-55 (See Appendix A). As shown in TR-55 for the coastal regions of North Carolina including Greenville, a Type III storm is more characteristic. The NRCS curve number approach was selected to calculate runoff volumes from the precipitation data, and the sub-basin unit hydrographs for these flood volumes were developed using the NRCS lag times.

Peak flows for the primary systems were developed for the 2-, 10- , 25- , 50- and 100-year storm events. The existing conditions flows were developed assuming attenuation occurs at the following locations:

- Thomas Langston Road (Swift Creek)
- Sterling Trace Drive (Swift Creek)
- Thomas Langston Road (SCUT1)
- Belfair Drive (SCUT1)
- Sterling Pointe Drive (SCUT1)
- Frog Level Road (Gum Swamp)

Storage routing was modeled just upstream of the culverts listed above because of the large storage volume available behind the pipe's entrance. The culverts that have not been included provide little to no accessible storage volume in the area upstream of its respective crossing. The results of the hydrologic model used as input for HEC-RAS are summarized in Table 3-1.

A hard copy of the HEC-HMS output is included as Appendix H. The CD found in Appendix J contains this digital information.

Table 3-1: Existing Conditions Flows from HEC-HMS for Swift Creek Watershed

HEC-HMS Node	Road Name / Location	HEC-RAS Station	Storm Event				
			2-year (cfs)	10-year (cfs)	25-year (cfs)	50-year (cfs)	100-year (cfs)
SWIFT CREEK							
U/S Limit SC	Upstream Limit of Swift Creek	241994	122	249	342	426	520
Thomas Langston – SC	Thomas Langston Road	239601	173	358	496	620	754
Sterling Trace Drive	Sterling Trace Drive	237845	189	416	628	805	993
SWIFT CREEK UT1							
U/S Limit SCUT	Upstream Limit of SCUT1	4495	67	138	190	236	288
Thomas Langston – SCUT	Thomas Langston Road	3997	68	145	203	253	309
Belfair Drive	Belfair Drive	3015	84	163	220	283	351
Sterling Pointe Drive	Sterling Pointe Drive	1635	123	239	315	412	514
GUM SWAMP							
U/S Limit GS	Upstream Limit of Gum Swamp	9293	76	160	223	280	345
Frog Level Road	Frog Level Road	7759	172	368	513	660	825

3.1.2 HYDRAULICS

The purpose of the hydraulic analysis is to determine an existing level of flooding for the storm drainage network and to develop proposed solutions to mitigate flooding. The USACE HEC-RAS was selected to model the primary systems to remain consistent with the existing FEMA modeling. HEC-RAS calculates water surface profiles for steady, gradually varied flow in channels and floodplains. The standard backwater analysis for sub-critical flow was modeled for the Swift Creek Watershed. The model calculates the effect of obstructions, such as culverts, and building structures in the channel and floodplain on the water surface profile. The hydraulic computations are based on the solution of a one-dimensional energy equation with energy loss due to friction evaluated by Manning's equation. Input data for HEC-RAS include the following:

- Cross-section geometry of the channel and floodplain;
- Roughness coefficients to describe characteristics of the channel and floodplain;

- Size, shape, and characteristics of culverts and roadways along the stream reach; and
- Energy loss coefficients for flow in the channel and at roadway crossings.

Channel cross sections utilized in the HEC-RAS model were based on the existing FEMA cross sections and WK Dickson surveyed cross sections. The channel cross sections were merged with State LiDAR data to develop cross sections spanning the entire floodplain area.

There were three (3) separate HEC-RAS models developed to analyze the stream reaches located in the Swift Creek watershed. The starting water surface elevations for the HEC-RAS models were calculated using the slope-area method. They are as follows:

- 0.003 feet/feet for Swift Creek Main Branch
- 0.004 feet/feet for Swift Creek UT1
- 0.0026 for feet/feet for Gum Swamp

Hydraulic Performance

Six (6) roadway crossings were analyzed for flooding potential for the primary system. Two (2) were located along Swift Creek, one (1) along Gum Swamp and the remaining three (3) were located along SCUT1. Descriptions of the existing primary system crossings analyzed are summarized in Table 3-2. Pictures 3-1 through 3-6 of this report provide a visual image of the primary system crossings.

Table 3-2: Existing Condition of Primary System Crossings

Location	Size/Material	Condition
Thomas Langston Road (Main Branch)	84″ CMP	Poor
Sterling Trace Drive (Main Branch)	Twin 54″ CMPs	Fair
Thomas Langston Road (SCUT1)	42″ RCP	Fair
Belfair Drive (SCUT1)	Twin 48″ RCP	Good
Sterling Pointe Drive (SCUT1)	Twin 42″ RCP	Fair
Frog Level Road (Gum Swamp)	Twin 78″ CMP	Poor

Picture 3-1. Thomas Langston Road (Main Branch) – Downstream Face

Picture 3-2. Sterling Trace Drive –Upstream Face

Picture 3-3. Thomas Langston Road (SCUT1) – Upstream Face

Picture 3-4. Belfair Drive – Downstream Face

Picture 3-5. Sterling Pointe Drive – Upstream Face

Picture 3-6. Frog Level Road – Upstream Face

The 2-, 10-, 25-, 50- and 100-year existing conditions flood elevations for the primary system crossings are identified in Table 3-3. The minimum elevations at the top of the road for each crossing are also listed in Table 3-3. Along Swift Creek, neither of the two crossings is meeting the desired 25-year level of service. Thomas Langston Road and Sterling Trace Drive both overtop during a 10-year storm event.

Similarly, none of the three crossings along SCUT1 is operating at its desired 25-year level of service. Belfair Drive is meeting a 10-year level of service while Thomas Langston Road and Sterling Pointe Drive only meet a 2-year level of service. There is only one roadway crossing along Gum Swamp, Frog Level Road. It is located outside of the City's limit but within the ETJ. It currently is operating at a 10-year level of service. This is below the 25-year desired level of service.

Table 3-3: Hydraulic Performance for Existing Conditions Roadway Flooding

Location	Minimum Elevation at Top of Road (feet NAVD)	Desired Level of Service (Year)	Calculated Water Surface Elevations (feet NAVD)				
			2-year flood	10-year flood	25-year flood	50-year flood	100-year flood
SWIFT CREEK							
Thomas Langston Road (Culvert)	67.48	25-year	64.13	**67.61**	**68.16**	**68.43**	**68.65**
Sterling Trace Drive (Culvert)	62.53	25-year	62.28	**63.25**	**63.57**	**63.80**	**63.95**
SWIFT CREEK UT1							
Thomas Langston Road (Culvert)	66.81	25-year	65.97	**67.36**	**67.53**	**67.66**	**67.76**
Belfair Drive (Culvert)	64.81	25-year	62.59	64.50	**65.33**	**65.79**	**66.04**
Sterling Pointe Drive (Culvert)	60.71	25-year	60.47	**61.74**	**62.07**	**62.26**	**62.40**
GUM SWAMP							
Frog Level Road (Culvert)	65.11	25-year	62.70	64.96	**65.31**	**65.46**	**65.63**

*Bold text indicates the existing water surface has exceeded the crest or low point in the road thereby causing flooding.
** Green shade indicates crossing meets desired level of service. Red shade indicates crossing does not meet desired level of service.

In addition to evaluating the roadway crossings, an evaluation was performed to determine the residences along the primary system streams that are at risk of flooding during the 25- and 100-year storm event. The existing 25- and 100- year floodplains for these streams are shown in Figures 3-1 through 3-3. The mapped floodplains are based on model results obtained as part of the Master Plan and may differ from the published FEMA floodplains. For flood insurance purposes, the effective FEMA floodplain should be referenced. For structures outside of the 100-year effective FEMA floodplain, property owners must determine if purchasing flood insurance is necessary. The City is in no way responsible for determining if flood insurance is required or for notifying property owners of the potential risk of flooding.

Tables 3-4 through 3-6 list the lowest adjacent grade elevations along with the existing 25- and 100-year water surface elevation for those properties at risk of flooding. The lowest adjacent grade (LAG) elevations shown in the table are not surveyed and are estimated based on the State of North Carolina's LiDAR data. LAG flooding shown in the tables may not result in actual LAG or finished floor flooding, but it is indicative of structures being at risk of flooding.

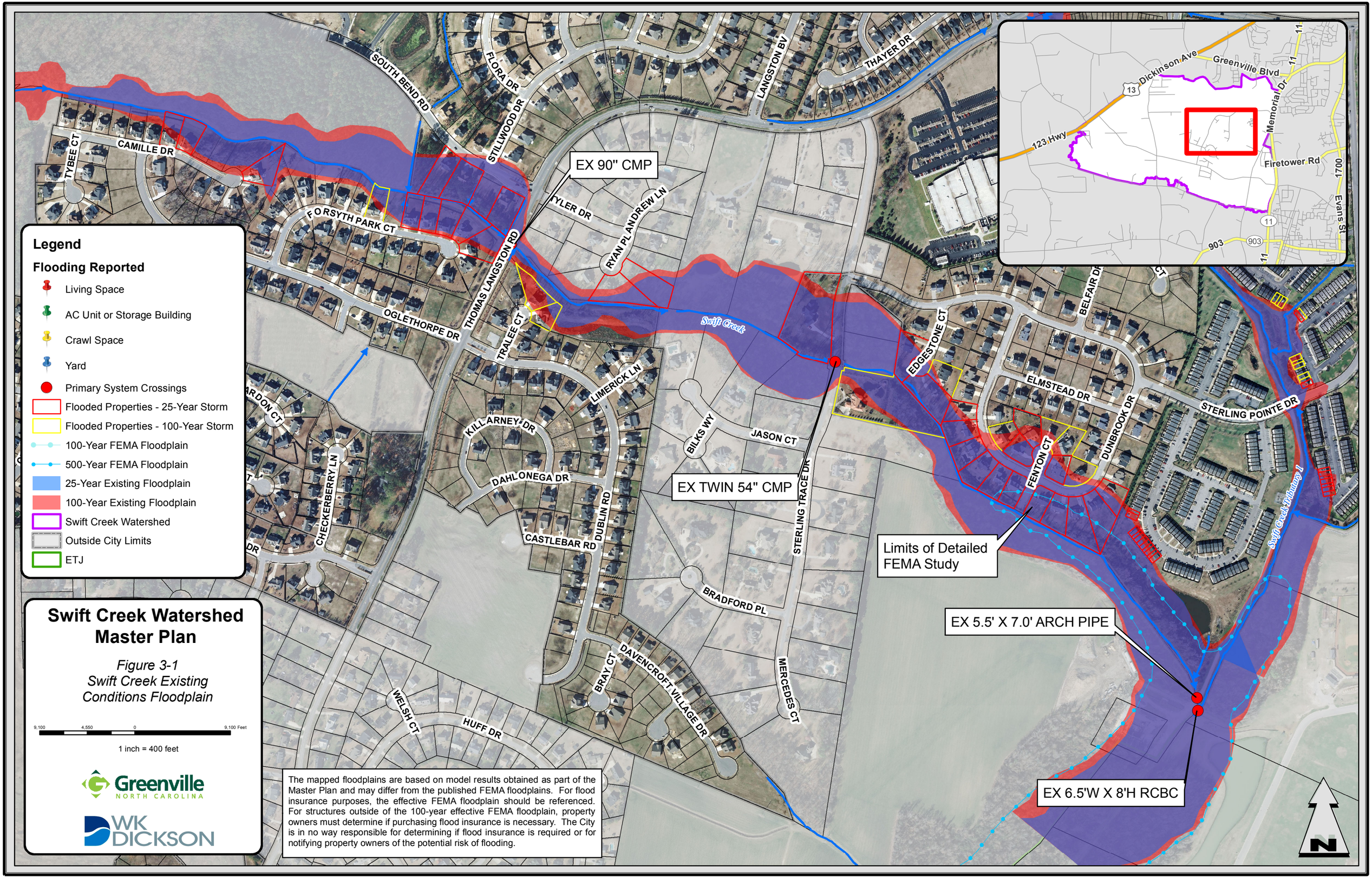
Table 3-4: Existing Conditions At-Risk Properties/Structures – Swift Creek

Address	LAG (feet NAVD)	Calculated Water Surface Elevations (feet NAVD)	
		25-year flood	100-year flood
3305 CAMILLE DR	69.04	**69.16**	**69.84**
3309 CAMILLE DR	69.00	**69.08**	**69.77**
3325 CAMILLE DR	68.27	**68.77**	**69.43**
908 DUNBROOK DR	60.22	**61.97**	**62.75**
912 DUNBROOK DR	61.48	**61.82**	**62.59**
916 DUNBROOK DR	61.48	**61.62**	**62.38**
917 DUNBROOK DR	61.58	61.35	**62.11**
920 DUNBROOK DR	60.00	**61.40**	**62.16**
924 DUNBROOK DR	60.03	**61.33**	**62.08**
925 DUNBROOK DR	61.00	**61.34**	**62.09**
928 DUNBROOK DR	60.03	**61.23**	**61.97**
1000 DUNBROOK DR	58.15	**61.08**	**61.81**
1004 DUNBROOK DR	58.15	**60.99**	**61.72**
1008 DUNBROOK DR	59.11	**60.82**	**61.53**
1012 DUNBROOK DR	59.80	**60.79**	**61.49**
1013 DUNBROOK DR	61.00	60.08	**61.74**
1016 DUNBROOK DR	59.80	**60.81**	**61.52**
3909 EDGESTONE CT	62.30	**62.56**	**63.34**
3912 EDGESTONE CT	62.80	62.26	**63.06**
3916 EDGESTONE CT	59.60	**62.28**	**63.06**
4100 FENTON CT	61.36	61.18	**61.92**
4104 FENTON CT	61.20	**61.26**	**62.00**
4105 FENTON CT	61.60	61.13	**61.88**
4109 FENTON CT	59.63	**61.12**	**61.86**
3832 FORSYTH PARK CT	68.61	68.31	**68.85**
3840 FORSYTH PARK CT	67.28	**68.25**	**68.78**
3844 FORSYTH PARK CT	66.59	**68.22**	**68.75**
3848 FORSYTH PARK CT	66.59	**68.20**	**68.71**
3852 FORSYTH PARK CT	67.30	**68.18**	**68.68**
3856 FORSYTH PARK CT	68.15	**68.18**	**68.68**
303 RYAN PL	64.00	**64.22**	**64.91**
304 RYAN PL	63.70	**64.16**	**64.82**
3608 SOUTH BEND RD	66.27	**68.25**	**68.78**
3612 SOUTH BEND RD	66.27	**68.22**	**68.74**
3704 SOUTH BEND RD	66.00	**68.18**	**68.67**

Address	LAG (feet NAVD)	Calculated Water Surface Elevations (feet NAVD)	
		25-year flood	100-year flood
3985 STERLING POINTE DR, UNIT EEE9	60.11	**60.60**	**61.28**
3985 STERLING POINTE DR, UNIT EEE8	60.11	**60.56**	**61.24**
3985 STERLING POINTE DR, UNIT EEE7	60.11	**60.56**	**61.24**
3985 STERLING POINTE DR, UNIT EEE6	60.11	**60.52**	**61.20**
3985 STERLING POINTE DR, UNIT EEE5	60.11	**60.48**	**61.16**
3985 STERLING POINTE DR, UNIT EEE4	60.11	**60.46**	**61.13**
3985 STERLING POINTE DR, UNIT EEE3	60.11	**60.45**	**61.11**
3985 STERLING POINTE DR, UNIT EEE2	60.11	**60.42**	**61.09**
3985 STERLING POINTE DR, UNIT EEE1	58.49	**60.41**	**61.07**
3989 STERLING POINTE DR, UNIT FFF2	60.60	**60.69**	**61.38**
3989 STERLING POINTE DR, UNIT FFF1	60.40	**60.66**	**61.36**
4000 STERLING TRACE DR	62.02	**63.61**	**64.02**
4005 STERLING TRACE DR	63.06	62.67	**63.42**
1901 TRALEE CT	64.71	64.49	**65.30**
1905 TRALEE CT	64.71	64.30	**65.03**

*Bold text indicates LAG flooding.

As shown in Table 3-4, forty-one (41) properties along Swift Creek were identified for being at risk of flooding in the 25-year storm event and an additional nine (9) properties were identified for the 100-year event. There were no reports of flooding received from residents along this stream reach.



Legend

Flooding Reported

- Living Space
- AC Unit or Storage Building
- Crawl Space
- Yard
- Primary System Crossings
- Flooded Properties - 25-Year Storm
- Flooded Properties - 100-Year Storm
- 100-Year FEMA Floodplain
- 500-Year FEMA Floodplain
- 25-Year Existing Floodplain
- 100-Year Existing Floodplain
- Swift Creek Watershed
- Outside City Limits
- ETJ

Swift Creek Watershed Master Plan

Figure 3-1
Swift Creek Existing Conditions Floodplain

9,100 4,550 0 9,100 Feet

1 inch = 400 feet

Greenville NORTH CAROLINA

WK DICKSON

The mapped floodplains are based on model results obtained as part of the Master Plan and may differ from the published FEMA floodplains. For flood insurance purposes, the effective FEMA floodplain should be referenced. For structures outside of the 100-year effective FEMA floodplain, property owners must determine if purchasing flood insurance is necessary. The City is in no way responsible for determining if flood insurance is required or for notifying property owners of the potential risk of flooding.

Table 3-5: Existing Conditions At-Risk Properties/Structures – SCUT1

Address	LAG (feet NAVD)	Calculated Water Surface Elevations (feet NAVD)	
		25-year flood	100-year flood
3605 PROVIDENCE PL	68.00	67.86	**68.22**
3609 PROVIDENCE PL	68.10	67.79	**68.15**
3613 PROVIDENCE PL	67.70	67.60	**67.87**
3900 STERLING POINTE DR, UNIT AA8	62.60	62.21	**62.66**
3900 STERLING POINTE DR, UNIT AA7	62.09	**62.20**	**62.63**
3900 STERLING POINTE DR, UNIT AA6	62.20	62.18	**62.60**
3900 STERLING POINTE DR, UNIT AA3	62.20	62.10	**62.49**
3900 STERLING POINTE DR, UNIT AA2	62.30	62.11	**62.49**
3900 STERLING POINTE DR, UNIT AA1	62.20	62.09	**62.46**
3906 STERLING POINTE DR, UNIT Z1	62.00	**62.31**	**62.80**
3906 STERLING POINTE DR, UNIT Z2	62.40	62.30	**62.80**
3917 STERLING POINTE DR, UNIT KK7	60.00	**60.36**	**61.01**
3917 STERLING POINTE DR, UNIT KK6	59.00	**60.34**	**61.00**
3917 STERLING POINTE DR, UNIT KK5	58.60	**60.33**	**60.98**
3917 STERLING POINTE DR, UNIT KK4	58.30	**60.30**	**60.95**
3917 STERLING POINTE DR, UNIT KK3	58.30	**60.28**	**60.94**
3917 STERLING POINTE DR, UNIT KK2	58.40	**60.27**	**60.93**
3917 STERLING POINTE DR, UNIT KK1	58.40	**60.25**	**60.91**
1300 THOMAS LANGSTON RD, UNIT 9	67.00	**67.56**	**67.81**

Address	LAG (feet NAVD)	Calculated Water Surface Elevations (feet NAVD)	
		25-year flood	100-year flood
1300 THOMAS LANGSTON RD, UNIT 8	67.10	**67.56**	**67.81**
1300 THOMAS LANGSTON RD, UNIT 7	67.20	**67.56**	**67.81**
1300 THOMAS LANGSTON RD, UNIT 6	67.30	**67.56**	**67.81**
1300 THOMAS LANGSTON RD, UNIT 5	67.83	67.56	**67.81**
1300 THOMAS LANGSTON RD, UNIT 4	67.58	67.56	**67.81**
1310 THOMAS LANGSTON RD, UNIT 7	67.42	**67.59**	**67.86**
1310 THOMAS LANGSTON RD, UNIT 6	67.42	**67.59**	**67.86**
1310 THOMAS LANGSTON RD, UNIT 5	67.42	**67.58**	**67.86**
1310 THOMAS LANGSTON RD, UNIT 4	67.60	67.50	**67.86**

*Bold text indicates LAG flooding.

As shown in Table 3-5, sixteen (16) properties along SCUT1 were identified for being at risk of flooding in the 25-year storm event and an additional twelve (12) properties were identified for the 100-year event. There were no reports of flooding received from residents along this stream reach. However, the City staff provided feedback regarding flooding in the area of the Legend Townhomes complex off of Thomas Langston Road.

Legend

- Primary System Crossings
- AC Unit or Storage Building
- Crawl Space

Flooding Reported

- Living Space
- Yard
- Flooded Properties - 25-Year Storm
- Flooded Properties - 100-Year Storm
- 100-Year FEMA Floodplain
- 500-Year FEMA Floodplain
- 25-Year Existing Floodplain
- 100-Year Existing Floodplain
- Swift Creek Watershed
- Outside City Limits
- ETJ

EX TWIN 42" RCP

EX TWIN 48" RCP

EX TWIN 42" RCP

Limits of Detailed FEMA Study

MONTERY DR
PROVIDENCE PL
PROVIDENCE PL
LANGSTON BV
THAYER DR
THOMAS LANGSTON RD
W VANCROFT CI
FREELAND LN
E VANCROFT CI
STERLING POINTE DR
WANETAS CT
BELFAIR DR
FELLOWES CT
EDGESTONE CT
ELMSTEAD DR
DUNBROOK DR
FENTON CT
TRALEE CT
LIMERICK LN
KILLARNEY DR
BILKS WY
JASON CT
STERLING TRACE DR
BRADFORD PL
PATTON CI
SOUTH SQUARE DR
REEDY BRANCH RD
S MEMORIAL DR
CHAPMAN RD
TICE RD
Swift Creek
Swift Creek Tributary 1

Dickinson Ave
Greenville Blvd
Memorial Dr
123 Hwy
Firetower Rd
Evans St
13
11
903
1700

Swift Creek Watershed Master Plan

Figure 3-2
Swift Creek Tributary 1
Existing Conditions Floodplain

9,100 4,550 0 9,100 Feet

1 inch = 400 feet

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The mapped floodplains are based on model results obtained as part of the Master Plan and may differ from the published FEMA floodplains. For flood insurance purposes, the effective FEMA floodplain should be referenced. For structures outside of the 100-year effective FEMA floodplain, property owners must determine if purchasing flood insurance is necessary. The City is in no way responsible for determining if flood insurance is required or for notifying property owners of the potential risk of flooding.

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Table 3-6: Existing Conditions At-Risk Properties/Structures – Gum Swamp

Address	LAG (feet NAVD)	Calculated Water Surface Elevations (feet NAVD)	
		25-year flood	100-year flood
1220 ASHMOOR LN	64.44	**65.52**	**65.94**
1224 ASHMOOR LN	64.44	**65.54**	**65.97**
1228 ASHMOOR LN	65.73	65.60	**66.07**
1232 ASHMOOR LN	64.98	**65.70**	**66.20**
1236 ASHMOOR LN	64.98	**65.76**	**66.27**
1300 ASHMOOR LN	64.98	**65.79**	**66.33**
1304 ASHMOOR LN	65.98	65.88	**66.39**
3904 FROG LEVEL RD	64.00	**65.37**	**65.73**
2404 SADDLEBACK DR, UNIT B	59.55	**61.75**	**62.73**
2404 SADDLEBACK DR, UNIT A	58.80	**61.71**	**62.69**
2408 SADDLEBACK DR, UNIT B	58.80	**61.65**	**62.61**
2408 SADDLEBACK DR, UNIT A	58.80	**61.65**	**62.61**
2412 SADDLEBACK DR, UNIT B	60.11	**61.54**	**62.49**
2412 SADDLEBACK DR, UNIT A	60.11	**61.49**	**62.43**
2416 SADDLEBACK DR, UNIT B	60.11	**61.45**	**62.39**
2416 SADDLEBACK DR, UNIT A	60.11	**61.42**	**62.35**
2500 SADDLEBACK DR, UNIT B	61.08	**61.33**	**62.25**
2500 SADDLEBACK DR, UNIT A	61.08	**61.30**	**62.21**
2504 SADDLEBACK DR, UNIT B	61.08	**61.26**	**62.17**
2504 SADDLEBACK DR, UNIT A	61.08	**61.21**	**62.11**
2508 SADDLEBACK DR, UNIT B	58.00	**61.14**	**62.02**
2508 SADDLEBACK DR, UNIT A	58.00	**61.09**	**61.97**
2512 SADDLEBACK DR, UNIT B	58.00	**60.91**	**61.79**
2512 SADDLEBACK DR, UNIT A	60.20	**60.91**	**61.79**
2400 SAWGRASS DR	62.80	**63.06**	**63.98**
2404 SAWGRASS DR	62.52	**63.02**	**63.95**
2408 SAWGRASS DR	62.52	**63.00**	**63.93**
2412 SAWGRASS DR	62.52	**62.94**	**63.89**
2416 SAWGRASS DR	62.30	**62.91**	**63.87**
2420 SAWGRASS DR	62.30	**62.88**	**63.85**
2424 SAWGRASS DR	62.30	**62.85**	**63.83**
2500 SAWGRASS DR	62.30	**62.79**	**63.77**
2504 SAWGRASS DR	62.00	**62.72**	**63.70**
2524 SAWGRASS DR	62.00	**62.37**	**63.37**
2608 A SAWGRASS DR	61.49	61.40	**62.78**

Address	LAG (feet NAVD)	Calculated Water Surface Elevations (feet NAVD)	
		25-year flood	100-year flood
2608 B SAWGRASS DR	61.49	61.40	**62.78**
805 SEBRING DR	63.00	**63.08**	**63.99**
809 SEBRING DR	61.96	**63.11**	**64.00**
901 SEBRING DR	62.00	**63.11**	**64.00**
905 SEBRING DR	62.00	**63.11**	**64.00**
909 SEBRING DR	62.00	**63.12**	**64.00**
913 SEBRING DR	62.00	**63.12**	**64.00**
917 SEBRING DR	62.00	**63.13**	**64.00**
921 SEBRING DR	62.38	**63.14**	**64.00**
1001 SEBRING DR	62.38	**63.14**	**64.00**
1005 SEBRING DR	62.38	**63.15**	**64.00**
1009 SEBRING DR	62.90	**63.16**	**64.00**
1013 SEBRING DR	62.60	**63.23**	**64.06**
1101 SEBRING DR	62.70	**63.34**	**64.16**
1105 SEBRING DR	62.60	**63.39**	**64.21**
1109 SEBRING DR	63.20	**63.50**	**64.30**
1113 SEBRING DR	64.08	63.59	**64.40**
1117 SEBRING DR	64.08	63.69	**64.50**
1125 SEBRING DR	64.05	63.95	**64.70**
2287 VALLEY DR	59.55	**59.60**	**60.44**
2279 WOODRIDGE DR	56.29	**58.36**	**59.18**
2289 WOODRIDGE DR	57.04	**58.60**	**59.43**
2299 WOODRIDGE DR	58.00	**58.81**	**59.64**
2311 WOODRIDGE DR	58.71	**58.95**	**59.77**
2321 WOODRIDGE DR	58.40	**59.08**	**59.91**
2333 WOODRIDGE DR	58.00	**59.34**	**60.17**
2341 WOODRIDGE DR	58.00	**59.42**	**60.25**

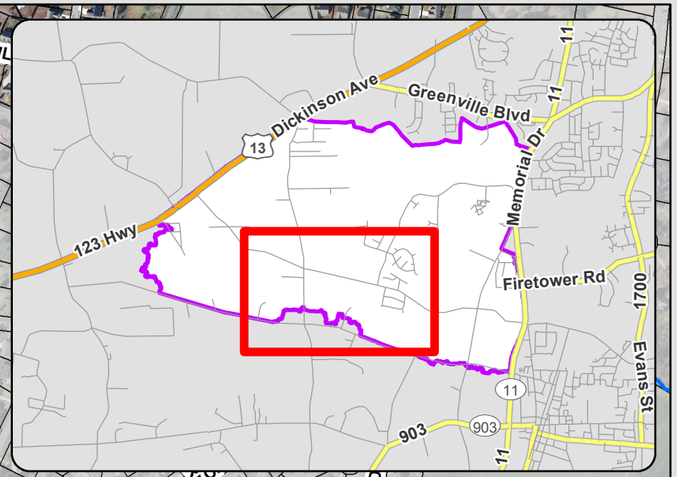
*Bold text indicates LAG flooding.

As shown in Table 3-6, fifty-four (54) properties along Gum Swamp were identified for being at risk of flooding in the 25-year storm event and an additional eight (8) properties were identified for the 100-year event. There were two (2) residents at the upstream end of the stream reach along Frog Level Road that provided feedback indicating they have experienced crawl space and building flooding.

Legend

Flooding Reported

- Living Space
- AC Unit or Storage Building
- Crawl Space
- Yard
- Primary System Crossings
- Flooded Properties - 25-Year Storm
- Flooded Properties - 100-Year Storm
- 100-Year FEMA Floodplain
- 500-Year FEMA Floodplain
- 25-Year Existing Floodplain
- 100-Year Existing Floodplain
- Swift Creek Watershed
- Outside City Limits
- ETJ



BERT CT
HAYLEY CT
ABERNA DR
JOSH CT
MASTERS LN
NICKLAUS DR
PRICE DR
PALMER DR
FOX CHASE LN
BUGLE DR
JADE LN
EMERALD PARK DR
RHINESTONE DR
GARNET WY
SELWOOD LN
DEARBORN CT
BRIGHTON DR
SEBRING DR
SENECA CT
Limits of Detailed FEMA Study
Gum Swamp
SAWGRASS DR
SADDLEBACK DR
SADLER DR
DAVENPORT FARM RD
CLIFF CT
VALE CT
CANYON DR
VALLEY DR
RIDGE DR
WOODRIDGE DR
HUFF D
EX TWIN 78" CMP
LANDRU CT
BRISTOL MOOR DR
LAYLAH DR
ASHMOOR LN
FROG LEVEL RD
FORLINES RD
MAYFIELD DR
VINEYARD DR

Swift Creek Watershed Master Plan

Figure 3-3
Gum Swamp Existing Conditions Floodplain

9,100 4,550 0 9,100 Feet

1 inch = 600 feet

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The mapped floodplains are based on model results obtained as part of the Master Plan and may differ from the published FEMA floodplains. For flood insurance purposes, the effective FEMA floodplain should be referenced. For structures outside of the 100-year effective FEMA floodplain, property owners must determine if purchasing flood insurance is necessary. The City is in no way responsible for determining if flood insurance is required or for notifying property owners of the potential risk of flooding.

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3.2 SECONDARY SYSTEM HYDROLOGIC AND HYDRAULIC ANALYSES

While Swift Creek and its tributaries are the primary source of flooding within the watershed, undersized systems can also lead to structural and roadway flooding. Based on the questionnaire responses, public meeting, and feedback from City staff, one (1) secondary system was identified for further evaluation, Davenport Farm Road System.

3.2.1 HYDROLOGY

The Environmental Protection Agency (EPA) Storm Water Management Model (SWMM) was selected as the hydrologic and hydraulic model for the Davenport Farm Road System. The system is a combination of closed pipe and open channel sections that can most accurately be modeled with SWMM. A detailed description about the hydrologic modeling methodology is included in Appendix A.

3.2.2 HYDRAULICS

Davenport Farm Road System

The Davenpart Farm Road System collects drainage from approximately 100 acres in the Pinecrest at Sawgrass Pointe, Emerald Place, and Fieldstream subdivisions. It discharges directly to Gum Swamp. The conveyance system is comprised of a 5′ x 7′ CMP arch that crosses Davenport Farm Road and twin 48″ RCPs that cross Sebring Drive and Jade Lane. Based on data collected during the inventory, the pipes are in good condition. These culverts are connected by open channels sections that have bank heights ranging from 4.8 to 6.5 feet with bottom widths that range from 2.5 to 5 feet. Flooding has been reported near the intersection of Davenport Farm Road and Garnet Way as noted from the City staff feedback.

Figure 3-4 shows that the level of service being provided by the existing system. The model results show that the lower portion of the existing system is operating at a 2-year level of service. This can be attributed to the high tailwater from the Gum Swamp primary system. The upper portion of the system is providing the desired level of service.

Legend

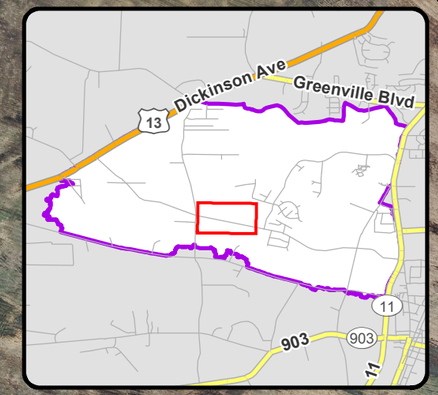
Flooding Reported

- Living Space
- AC Unit or Storage Building
- Crawl Space
- Yard

- Catch Basin
- Flared End Section
- Headwall
- Pipe End
- Difficult Access Structure
- Drop Inlet
- Junction Box
- Pond Structure
- Pond Dam
- Slab Top Inlet
- Underground Pipe Junction
- Yard Inlet
- Existing BMP
- Channels

Davenport Modeled Pipes

- < 2-year
- 2-year
- 10-year
- 25-year
- 50-year
- 100-year
- Non-Modeled Pipes



Trapezoidal Channel
Bottom Width: 5 ft
Top Width: 18 ft
Bank Height: 6.4 ft

EX Twin 48" RCPs

Trapezoidal Channel
Bottom Width: 2.5 ft
Top Width: 23 ft
Bank Height: 6 ft

The channel is able to pass the 100-year peak flow without ovetopping its banks.

The channel is able to pass the 100-year peak flow without ovetopping its banks.

EX 5' x 7' CMP Arch

EX Twin 48" RCPs

Trapezoidal Channel
Bottom Width: 5 ft
Top Width: 18 ft
Bank Height: 6.5 ft

Trapezoidal Channel
Bottom Width: 3 ft
Top Width: 18 ft
Bank Height: 4.8 ft

The channel is able to pass the100-year peak flow without ovetopping its banks.

The channel is able to pass the 2-year peak flow without ovetopping its banks.

Drainage Area to Outfall ~100 acres

JADE LN
TOPAZ DR
EMERALD PARK DR
RHINESTONE DR
SELWOOD LN
SEBRING DR
SHALLOWFORD CT
DAVENPORT FARM RD
SAWGRASS DR
SAYBROOK CT
SADDLEBACK DR
Gum Swamp

Swift Creek Watershed Master Plan

Figure 3-4
Davenport Farm Road
Existing Conditions

0 50 100 200

1 inch = 200 feet

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3.3 STREAM STABILITY FIELD ASSESSMENTS

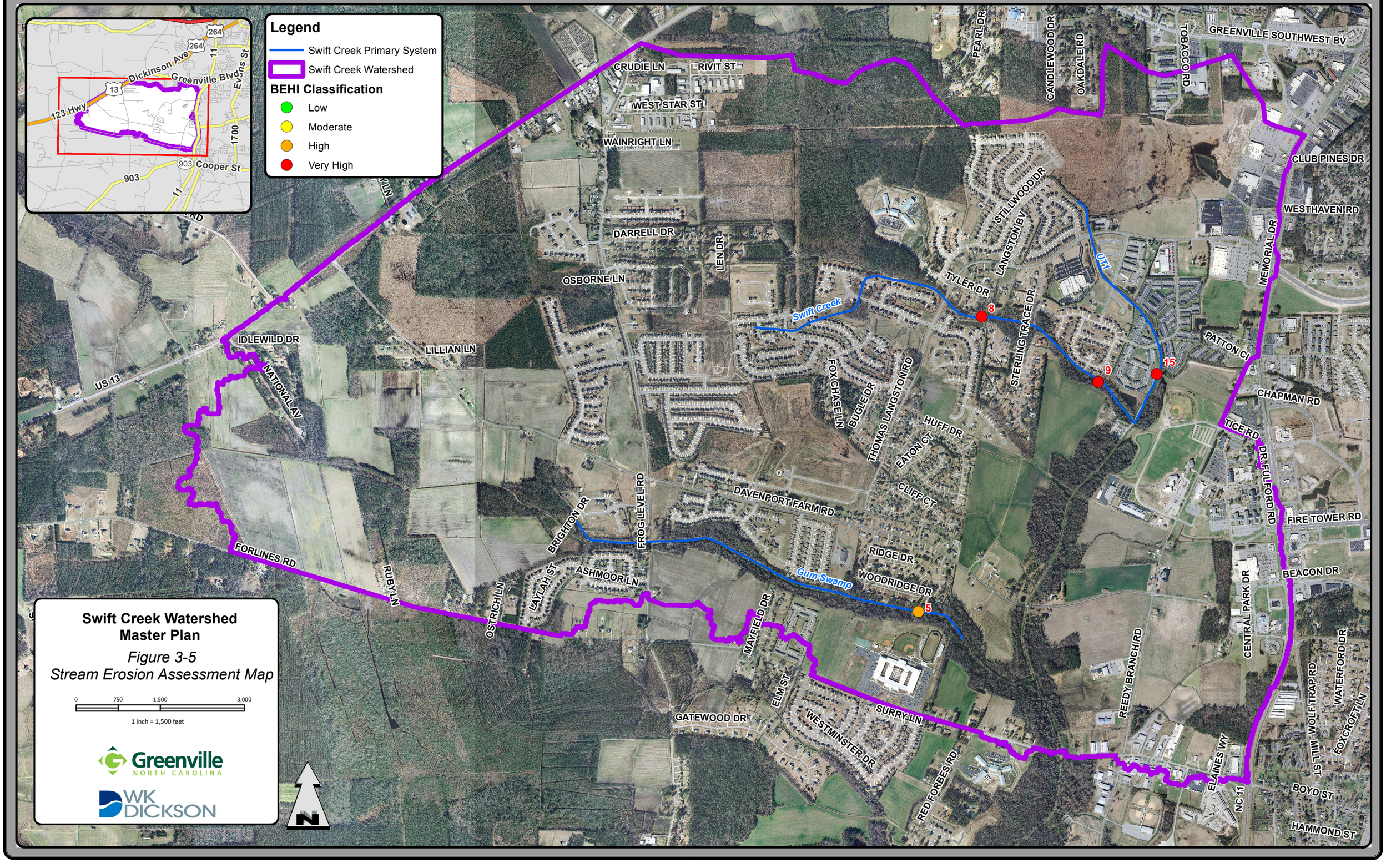
There are 7.2 miles of streams located in the Swift Creek Watershed. Within the watershed, all 2.8 miles of Swift Creek, and all 2.6 miles of Gum Swamp are classified for secondary recreation and aquatic wildlife survival and propagation (Class C) by NCDWR. Swift Creek and Gum Swamp are also classified as nutrient sensitive waters (NSW) by NCDWR, indicating it is subject to excessive growth of microscopic or macroscopic vegetation, or it may contribute to downstream nutrient loading (NCDWR 2011). All 2.8 miles of Swift Creek in the watershed are listed on the NC Water Quality Assessment and Impaired Waters List (also known as the Integrated 305(b) and 303(d) Report).

Field assessments measuring bank stability were conducted on all of the major stream channels within the Swift Creek Watershed. The Bank Erosion Hazard Index (BEHI) developed by Rosgen was used to evaluate the streams in the watershed. BEHI is an assessment tool that is used to quantify the erosion potential of a stream bank. Characteristics assessed as part of the BEHI rating include bank height ratio (stream bank height/maximum bankfull depth), ratio of rooting depth to bank height, root density, bank angle, and percent surface protection, and bank material composition. Each of these variables that affect the potential rate of stream bank erosion is assigned points based on specific evaluation criteria. BEHI scores range from five to fifty, with a score of fifty indicating the highest potential for erosion. A BEHI score of 5 to 19.5 indicates a very low or low potential for erosion; a score between 20 and 29.5 indicates a moderate potential for erosion; scores from 30 to 45 represent a high to very high potential for erosion; and scores between 46 and 50 indicate extreme erosion potential. The completed BEHI scores are provided in Appendix K.

In addition to BEHI ratings, a modified version of the channel stability assessment method (CSA) provided in "Assessing Stream Channel Stability at Bridges in Physiographic Regions" by Johnson (2006) was used to assess channel stability channels in the watershed. The CSA method was designed to evaluate stability indicators in the field. These parameters include: watershed characteristics, flow habit, channel pattern, entrenchment/channel confinement, bed material, bar development, presence of obstructions/debris jams, bank soil texture and coherence, average bank angle, bank vegetation/protection, bank cutting, and mass wasting/bank failure. The twelve indicators were scored in the field, and a rating of excellent, good, fair, or poor was assigned to each project reach based on the total score. The completed CSA scores and a field datasheet are provided in Appendix K.

There are three main drainage features, Swift Creek, Gum Swamp, and an unnamed tributary (UT1), in the Swift Creek Watershed (See Figure 3-5). Four BEHI assessments were performed within the Swift Creek Watershed. The two BEHI assessments, sampling points 8 and 9, performed on Swift Creek both scored in the Very High Range. Both of these sampling points had bank height/bankfull ratios in the very high range and root densities in the extreme range. Sampling point 15, the sample along UT1 also scored in the Very High Range. The reach had

bank height/bankfull ratios in the very high range and root densities in the extreme range. Sampling point 5, along Gum Swamp, scored in the High Range. The bank height/bankfull ratio is in the moderate range, but bank angle and root density scored in the high to extreme range along this reach. As highlighted in Section 5-1, Swift Creek is a sandbed channel that has multiple opportunities for bank stabilization. Stream projects 1 and 2 address stabilization and potential flooding issues.


Legend
Swift Creek Primary System
Swift Creek Watershed
BEHI Classification
Low
Moderate
High
Very High
Dickinson Ave
Greenville Blvd
Evans St
123 Hwy
Cooper St
264
13
903
11
1700
CRUDIE LN
RIVIT ST
WEST STAR ST
WAINRIGHT LN
DARRELL DR
LEN DR
OSBORNE LN
IDLEWILD DR
LILLIAN LN
US 13
NATIONAL AV
FORLINES RD
RUBY LN
OSTRICH LN
LAYLAH ST
BRIGHTON DR
FROG LEVEL RD
ASHMOOR LN
DAVENPORT FARM RD
CLIFF CT
EATON CT
HUFF DR
THOMAS LANGSTON RD
BUGLE DR
FOX CHASE LN
TYLER DR
STERLING TRACE DR
LANGSTON BV
STILLWOOD DR
PEARL DR
CANDLEWOOD DR
OAKDALE RD
TOBACCO RD
GREENVILLE SOUTHWEST BV
CLUB PINES DR
WESTHAVEN RD
MEMORIAL DR
PATTON CI
CHAPMAN RD
TICE RD
DR FULFORD RD
FIRE TOWER RD
BEACON DR
CENTRAL PARK DR
REEDY BRANCH RD
WATERFORD DR
FOXCROFT LN
WOLFTRAP MILL ST
BOYD ST
HAMMOND ST
NC 11
ELAINES WY
RED FORBES RD
WESTMINSTER DR
ELM ST
MAYFIELD DR
GATEWOOD DR
SURRY LN
RIDGE DR
WOODRIDGE DR
Gum Swamp
Swift Creek
UT1
5
8
9
15
Swift Creek Watershed
Master Plan
Figure 3-5
Stream Erosion Assessment Map
0
750
1,500
3,000
1 inch = 1,500 feet
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FLOOD MITIGATION ALTERNATIVES

4.1 PRIMARY SYSTEMS

Developing flood control alternative in an urban environment is a complex process based in limitations imposed by the constraints within the environment such as floodplain encroachments, increased peak flows due to impervious areas, public and private utilities, and private property. Improvements in this portion of the study were identified through an iterative process of infrastructure improvements, increasing floodplain storage, and evaluating detention options. Alternatives were finalized based on discussions with City staff. The top alternatives that achieve the goals of the project while minimizing impacts to residents and traffic are presented.

4.1.1 SWIFT CREEK

Thomas Langston Road – As determined by the existing conditions analysis, the existing 84" CMP at Thomas Langston Road is undersized and does not meet the desired 25-year level of service without overtopping. Currently, it provides a 2-year level of service. Since the City's design standards are not being met and the existing culvert is in fair condition, it is proposed that the existing system be replaced.

- Alternative #1 – As part of this alternative, the existing culvert will be replaced with a 10' x 6' RCBC. The culvert improvement will be coupled with floodplain benching downstream of the Thomas Langston Road crossing to lower the tailwater. The floodplain benching is proposed in the left and right overbanks for approximately 1,350 linear feet. The benching will range in width between 30 and 100 feet.

  With the proposed improvements, the crossing will provide the desired 25-year level of service with approximately one (1) foot of freeboard. The resulting upstream water surface elevations will be reduced by between 0.08 to 1.94 feet in the 25-year storm event. There are thirteen (13) properties located in the existing conditions 25-year floodplain and three (3) additional properties in the 100-year floodplain adjacent to Thomas Langston Road that are at risk for LAG flooding. The water surface elevations will be reduced for all of these properties. Nine (9) properties will be removed from the 25-year floodplain and four (4) from the 100-year floodplain with the implementation of this alternative. The remaining properties will continue to be exposed to LAG or structural flooding, although depth will be reduced. It should be noted that four (4) properties along Camille Drive not currently located in the existing 100-year floodplain will be added to future 100-year floodplain as a result of future upstream development.

Thomas Langston Road is maintained by NCDOT, therefore coordination with NCDOT would be required for any improvements within the right-of-way (ROW).

The majority of the proposed floodplain bench appears to be located within a Pitt County Drainage District easement based on the Pitt County OPIS website. Coordination with the Drainage District will be required to implement the proposed project.

Figure 4-1 summarizes the improvements proposed for Alternative #1. The total estimated cost for completing the culvert improvements and floodplain benching at Thomas Langston Road is $1,050,000.

- Alternative #2 – Alternative #2 includes upstream detention to reduce peak flows and therefore reduce the magnitude of the downstream improvements. There are several large parcels in the upstream portion of the watershed that are currently undeveloped. For the purposes of this study, a 32-acre detention pond is included in Alternative #2 east of Megan Drive as shown in Figure 4-1. The location and configuration of the proposed pond is conceptual and can be adjusted as necessary based on design constraints. Based on the detention provided by the Megan Drive Detention Pond, the floodplain benching downstream of Thomas Langston Road could be eliminated, however the proposed culvert size would remain a 10' x 6' RCBC.

  Similar to Alternative #1, the proposed improvements will bring the Thomas Langston Road up to the desired 25-year level of service with approximately one (1) foot of freeboard. The resulting upstream water surface elevations will be reduced by between 0.99 to 1.92 feet in the 25-year storm event. The water surface reductions achieved with this alternative are more significant and are seen further upstream that those from Alternative #1.

  As previously mentioned, there are thirteen (13) properties located in the 25- and 100-year floodplain adjacent to Thomas Langston Road that are at risk for LAG flooding. The water surface elevations will be reduced for all of these properties. Twelve (12) will be removed from the 25-year floodplain and one (1) from the 100-year floodplain with the implementation of this alternative. The remaining properties will continue to experience flooding but the severity and frequency will be reduced.

  Figure 4-1 summarizes the improvements proposed for Alternative #2. The total estimated cost for completing the culvert improvements at Thomas Langston Road is $410,000. The estimated cost for the Megan Drive Detention Pond is $14,490,000, which includes estimated land acquisition costs based on tax values available from Pitt County.

During a field inspection, there were several potential site restrictions and utility conflicts that were identified including overhead power lines located along Thomas Langston Road, which may need to be temporarily relocated. There also appears to be sanitary sewer, water, and gas lines that may need to be replaced or relocated during the culvert upgrades proposed as part of Alternatives #1 and #2. Impacts to traffic flow during construction were considered. Thomas Langston Road is a minor thoroughfare and it is anticipated that a road closure of flagged two-way one-lane operation will be required.

The installation of construction staging areas and entrances for the projects will require tree removal and temporary construction easements. The proposed floodplain benching and detention area are located on private property therefore permanent easements would be required to implement either Alternative #1 or #2. These easements would also be necessary for future maintenance of the floodplain benches or detention area. Alternative #1 which includes the proposed floodplain benching will require easements from up to a dozen property owners while Alternative #2 will require easements from two (2) property owners. Additionally, Alternative #2 will require land acquisition for the proposed wet detention pond.

Impacts from the construction of the floodplain benching will include tree removal and a section of 10" PVC sanitary sewer line located in the left overbank that may need to be replaced or relocated.

Sterling Trace Drive – The existing twin 54" CMPs at Sterling Trace Road are currently providing a 2-year level of service. Based on the existing conditions model results, the road overtops in the 10-year storm event and is not meeting the desired 25-year level of service. Since the City's design standards are not being met and the existing culvert is undersized, it is proposed that the existing system be replaced. Two alternatives were evaluated for this crossing.

Picture 4-1. Sterling Trace Drive – Existing CMPs

- Alternative #1 – As part of this alternative, the existing CMPs will be replaced with twin 10′ x 6′ RCBCs. This will be coupled with floodplain benching downstream of the Sterling Trace Drive crossing to offset the flow and water surface elevation increases from upsizing the upstream culvert. The floodplain benching is proposed in the left and right overbanks for 1,690 linear feet. The benching will range in width from 30 to 190 feet.

  With the proposed improvements, the crossing will provide the desired 25-year level of service with 0.36 feet of freeboard. The resulting upstream water surface elevations will

be reduced by 1.24 to 1.51 feet in the 25-year storm event while the downstream reductions will range from 0.29 to 1.86 feet.

There are twenty-eight (28) properties located in the existing conditions 25-year floodplain and six (6) additional properties in the 100-year floodplain downstream of Sterling Trace Drive that are at risk for LAG flooding. The water surface elevations will be reduced for all of these properties. Twelve (12) will be removed from the 25-year floodplain and nine (9) from the 100-year floodplain with the implementation of this alternative. The remaining properties will continue to be exposed to LAG or structural flooding, although depth will be reduced.

The majority of the proposed floodplain bench appears to be located within a Pitt County Drainage District easement based on the Pitt County OPIS website. Coordination with the Drainage District will be required to implement the proposed project.

Figure 4-1 summarizes the improvements proposed for Alternative #1. The total estimated cost for this alternative is $2,370,000.

- Alternative #2 – If the Megan Drive Detention Pond is constructed as proposed above, then the limits of the floodplain benching downstream of Sterling Trace Drive could be reduced but not eliminated. The culvert upgrades proposed as part of Alternative #1 will be the same for this alternative. The existing CMPs will be replaced with twin 10′ x 6′ RCBCs. As shown in Figure 4-1, the difference is a reduction in the width of the benching in the right overbank. This will reduce the amount of tree removal, excavation, and ultimately project costs associated with the proposed benching.

  As previously mentioned, there are thirty-four (34) properties located in the 25- and100-year floodplain downstream of Sterling Trace Drive that are at risk for LAG flooding. The water surface elevations will be reduced for all of these properties. Thirteen (13) will be removed from the 25-year floodplain and ten (10) from the 100-year floodplain with the implementation of this alternative. The remaining properties will continue to experience flooding but the severity and frequency will be reduced.

  Figure 4-1 summarizes the improvements proposed for Alternative #2. The total estimated cost for completing the proposed culvert improvements and reduced floodplain benching is $2,090,000.

During a field inspection, there were several potential site restrictions and utility conflicts that were identified. There appears to be water, gas, and electrical lines that may need to be replaced or relocated. Sterling Trace Drive is a two-lane residential roadway. It is anticipated that a road closure or a flagged two-way one-lane operation will be required. In order to gain

access and to install the proposed floodplain benching, tree removal would be required. It should be noted that the proposed floodplain benching is located on several private properties therefore easements will be required to complete this project and maintain the bench in the future. The installation of construction staging areas and entrances will require additional tree removal and temporary construction easements.

Megan Drive Proposed Detention Pond
(Alternative #2)

Thomas Langston Road
Existing: 84" CMP
Alternative #1: 10' x 6' RCBC with Floodplain Benching
Alternative #2: 10' x 6' RCBC

1350 LF of Floodplain Benching
and Stream Stabilization
(Alternative #1)

Sterling Trace Drive
Existing: Twin 54" CMP
Alternative #1: Twin 10' x 6' RCBCs with Floodplain Benching
Alternative #2: Twin 10' x 6' RCBCs with Reduced Floodplain Benching

1690 LF of Floodplain Benching
and Stream Stabilization
(Alternative #1)

1690 LF of Floodplain Benching
and Stream Stabilization
(Alternative #2)

Pitt County Community College
Proposed Detention Pond
(Alternative #2)

Legend

Flooding Reported

- Living Space
- AC Unit or Storage Building
- Crawl Space
- Yard

- Swift Creek Watershed
- Properties Removed - 25-Year Storm Alt 1
- Properties Removed - 100-Year Storm Alt 1
- Properties Removed - 25-Year Storm Alt 2
- Properties Removed - 100-Year Storm Alt 2
- Proposed Detention Pond
- Alternative #2 Floodplain Benching
- Alternative #1 Floodplain Benching
- Parcels

- Flared End Section
- Headwall
- Pipe End
- Catch Basin
- Difficult Access Structure
- Drop Inlet
- Junction Box
- Pond Structure
- Slab Top Inlet
- Underground Pipe Junction
- Yard Inlet
- Bridge
- Channels
- Pipes
- Existing BMP
- Outside City Limits
- ETJ

Swift Creek Watershed Master Plan

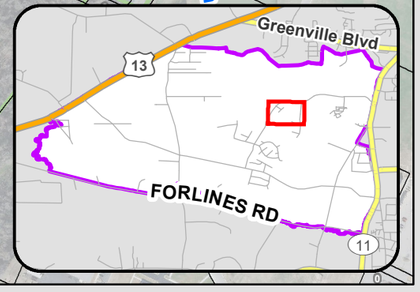
Figure 4-1
Swift Creek
Main Branch Alternatives

600 300 0 600 Feet

1 inch = 600 feet

Greenville
NORTH CAROLINA

WK DICKSON



A summary of the hydraulic performance for the improvements proposed for Alternatives #1 and #2 are included in Tables 4-1 and 4-3, and a summary of the improvements realized for reduction in WSEL and properties removed from floodplains is shown in Tables 4-2 and 4-4. The water surface elevations shown assume all proposed primary system improvements for Swift Creek are constructed. The level of improvement will be reduced if all projects are not implemented.

Table 4-1: Hydraulic Performance for Swift Creek – Alternative #1

Location	Minimum Elevation at Top of Road (feet NAVD)	Desired Level of Service	Calculated Water Surface Elevations (feet NAVD)				
			2-year flood	10-year flood	25-year flood	50-year flood	100-year flood
Thomas Langston Road (Proposed 10′ x 6′ RCBC with Floodplain Benching)	67.48	25-year	63.12	65.90	66.44	**67.78**	**68.19**
Sterling Trace Drive (Proposed Twin 10′ x 6′ RCBCs with Floodplain Benching)	62.53	25-year	60.09	61.30	62.17	**62.84**	**63.19**

*Bold text indicates the existing water surface has exceeded the crest or low point in the road thereby causing flooding.
** Green shade indicates crossing meets desired level of service. Red shade indicates crossing does not meet desired level of service.

Table 4-2: WSELs and Properties Removed from Floodplains – Alternative #1

Location	Decrease in WSEL (feet NAVD)		Properties Removed/Properties in Floodplain	
	25-Year	100-Year	25-Year	100-Year
Thomas Langston Road	1.94	0.57	9/13	4/16
Sterling Trace Drive	1.51	0.82	12/28	9/34

Table 4-3: Hydraulic Performance for Swift Creek – Alternative #2

Location	Minimum Elevation at Top of Road (feet NAVD)	Desired Level of Service	Calculated Water Surface Elevations (feet NAVD)				
			2-year flood	10-year flood	25-year flood	50-year flood	100-year flood
Thomas Langston Road (Proposed 10′ x 6′ RCBC with Detention Pond)	67.48	25-year	62.56	64.73	66.46	**67.76**	**68.17**
Sterling Trace Drive (Proposed Twin 10′ x 6′ RCBCs with Reduced Floodplain Benching and Detention Pond)	62.53	25-year	60.10	61.41	62.21	**62.90**	**63.24**

*Bold text indicates the existing water surface has exceeded the crest or low point in the road thereby causing flooding.
** Green shade indicates crossing meets desired level of service. Red shade indicates crossing does not meet desired level of service.

Table 4-4: WSELs and Properties Removed from Floodplains – Alternative #2

	Decrease in WSEL (feet NAVD)		Properties Removed/Properties in Floodplain	
Location	**25-Year**	**100-Year**	**25-Year**	**100-Year**
Thomas Langston Road	1.92	0.59	12/13	1/16
Sterling Trace Drive	1.47	0.77	13/28	10/34

4.1.2 SWIFT CREEK UT1

Thomas Langston Road – The existing 42" RCP at this crossing is currently providing a 2-year level of service. It overtops during the 10-year storm event and is not meeting the desired 25-year level of service. To meet the desired level of service, two (2) alternatives were evaluated for the Thomas Langston Road crossing.

- Alternative #1 – The goal of Alternative #1 is to increase the culvert capacity to obtain the desired level of service. It includes installing twin 42" floodplain culverts and endwalls along with 530 linear feet of floodplain benching downstream of the Thomas Langston Road crossing. The proposed benching will vary in width from 22 to 50 feet in the right and left overbanks. The location of the proposed floodplain benching is shown on Figure 4-2. The proposed improvements will bring the crossing up to the desired 25-year level of service with 0.78 feet of freeboard. The existing 42" RCP shown in Picture 4-2 is in good condition and will remain in place, although a headwall will need to be added to stabilize the road embankment.

Picture 4-2. Thomas Langston Drive – Existing RCP

There are eight (8) properties located in the existing conditions 25-year floodplain upstream of the Thomas Langston Drive crossing and five (5) additional properties in the existing conditions 100-year floodplain. The majority of these properties are located in Legends Townhomes complex. This is consistent with the reports from the WAP report and feedback obtained from City staff.

Implementing the improvements proposed as part of Alternative #1 will reduce the upstream water surface elevations from 0.15 to 1.51 feet in the 25-year storm. This will remove all eight (8) properties from the 25-year floodplain and eleven (11) from 100-year floodplain. While the water surface elevations will be lowered, several properties in the Legends Townhomes complex will remain in the 100-year floodplain. These properties will continue to experience flooding but the severity and frequency will be reduced.

Thomas Langston Road is maintained by NCDOT, therefore coordination with NCDOT would be required for any improvements within the right-of-way (ROW).

The majority of the proposed floodplain bench appears to be located within a Pitt County Drainage District easement based on the Pitt County OPIS website. Coordination with the Drainage District will be required to implement the proposed project. Additionally, the floodplain benching could be coordinated with the proposed Swift Creek Greenway referenced in the 2004 Greenway Master Plan. Economy of savings could be proposed if both projects are constructed at the same time.

Figure 4-2 summarizes the improvements proposed for Alternative #1. The total estimated cost for completing the culvert improvements and floodplain benching at Thomas Langston Road is $370,000.

- Alternative #2 – Alternative #2 includes upstream detention to reduce peak flows and therefore reduce the magnitude of the downstream improvements. There are several large parcels in the upstream portion of the watershed that are currently undeveloped. For the purposes of this study, a 15-acre detention pond is included in Alternative #2 north of Thomas Langston Road as shown in Figure 4-2. The location and configuration of the proposed pond is conceptual and can be adjusted as necessary based on design constraints. The detention pond will lower the downstream peak flows and consequently will not require any culvert upgrades at the Thomas Langston Road crossing, although a headwall would still be recommended. The existing 42" RCP will exceed the desired 25-year level of service with the implementation of proposed detention pond. However, erosion complaints require installation of endwalls at this crossing, which has been included in the cost estimate.

  Alternative #2 will reduce the upstream waster surface elevations from 1.73 to 2.11 feet in the 25-year storm and 0.67 to 1.3 feet in the 100-year storm. This will significantly lower the water surface elevations for the residents at the Legends Townhomes complex. All of the properties will be removed from the 25- and 100-year floodplains.

  Figure 4-2 summarizes the improvements proposed for Alternative #2. The total estimated cost for constructing the proposed detention area, including land acquisition costs based on Pitt County tax values is $7,630,000.

During a field inspection, there were several potential site restrictions and utility conflicts that were identified including overhead power lines located along Thomas Langston Road, which may need to be temporarily relocated. There appears to be sanitary sewer, water, gas, and electrical lines that may need to be replaced or relocated during the culvert upgrades proposed as part of Alternative #1. Impacts to the sanitary sewer lines in the right overbank were minimized to the extent possible, although manhole adjustments or other sanitary sewer

improvements may need to be completed based on the elevation of the sanitary sewer system and final design of the floodplain benching.

Impacts to traffic flow during construction were considered. Thomas Langston Road is a minor thoroughfare and it is anticipated that a road closure of flagged two-way one-lane operation will be required to complete Alternative #1. For Alternative #2, the proposed project is not located in the roadway therefore impacts to traffic are minimal.

The installation of construction staging areas and entrances for the either project will require tree removal and temporary construction easements. The proposed floodplain benching and detention area are located on private property therefore permanent easements would be required to implement Alternative #1 or #2. These easements would also be necessary for future maintenance of the floodplain benches or detention area.

Belfair Drive – As determined by the existing conditions analysis, the twin 48" RCPs at this crossing does not meet the desired 25-year level of service without overtopping. Currently, it provides between a 10- and 25-year level of service. There are two alternatives presented for the Belfair Drive crossing. They are as follows:

- Alternative #1 – As part of this alternative, the existing RCPs will be replaced with twin 6' x 4' RCBCs to increase the available culvert capacity to obtain the desired level of service. The upsized culvert will provide the desired 25-year level of service with 0.22 feet of freeboard. Figure 4-2 summarizes the improvements proposed at Belfair Drive.

  In addition to the improved level of service at Belfair Drive, upsizing the culvert provides upstream water surface reductions for the 25-year storm event ranging between 0.89 to 1.60 feet. There are no structures adjacent to this crossing located in the existing conditions 25- and 100-year floodplain. The total estimated cost for completing the culvert improvements at Belfair Drive is $380,000.

- Alternative #2 – The 15-acre detention pond proposed as part of Alternative #2 for the Thomas Langston Road crossing will lower the flows for Belfair Drive. Consequently, the existing twin 48" RCPs will exceed the desired 25-year level of service. Based on the condition of the existing culverts, this alternative does not include any improvements at this location. The existing RCPs will remain in place. It should be noted that the existing RCPs are obstructed. It is recommended as part of the maintenance projects that the 48" RCPs be cleaned out. (See Section 10 - Table 10-3)

  The water surface reductions achieved with Alternative #2 are higher than those in Alternative #1. This alternative will reduce the upstream waster surface elevations from 2.22 to 2.59 feet in the 25-year storm and 1.91 to 2.23 feet in the 100-year storm. This

does not impact any structures since there are none in the existing conditions 25- and 100-year floodplain.

During a field visit, there were several potential site restrictions and utility conflicts that were identified at this project location. There appears to be sanitary sewer, water, and electrical lines that may need to be replaced or relocated as part of Alternative #1. Impacts to traffic flow during construction were considered. Belfair Drive is a two-lane residential roadway. It is anticipated that a road closure or a flagged two-way one-lane operation will be required. The installation of construction staging areas will require tree removal and temporary construction easements.

Sterling Pointe Drive – The existing twin 42" RCPs shown in Picture 4-3 are currently operating at a 2-year level of service. In order to meet the desired 25-year level of service, it is proposed that the culverts at Sterling Pointe Drive be upsized. Two (2) alternatives were evaluated for this crossing. They are as follows:

Picture 4-3. Sterling Pointe Drive – Existing RCPs

- Alternative #1 – The goal of Alternative #1 is to provide the desired level of service by increasing the culvert capacity. It entails installing twin 11' x 4' RCBCs along with 1,200 linear feet of floodplain benching downstream of the Sterling Pointe Drive crossing. The location of the proposed floodplain benching is shown on Figure 4-2. The benching will vary in width from 15 to 200 feet. It is located mostly in the left overbank. The proposed improvements will bring the crossing up to the desired 25-year level of service with 0.17 feet of freeboard. The resulting upstream water surface elevations are reduced by 0.71 to 1.56 feet in the 25-year storm.

  There are nine (9) properties in the existing conditions 25-year floodplain adjacent to the Sterling Pointe Drive crossing. An additional nine (9) properties are in the existing conditions 100-year floodplain. All of these properties are located in the Sterling Pointe Townhomes complex. As a result of implementing Alternative #1, three (3) properties will be removed from the 25-year floodplain and twelve (12) from the 100-year floodplain. The remaining properties will continue to be exposed to potential LAG or structural flooding with reduced depths, frequency, and severity.

  The majority of the proposed floodplain bench appears to be located within a Pitt County Drainage District easement based on the Pitt County OPIS website. Coordination with the Drainage District will be required to implement the proposed

project. Additionally, the floodplain benching could be coordinated with the proposed Swift Creek Greenway referenced in the 2004 Greenway Master Plan. Economy of savings could be proposed if both projects are constructed at the same time.

The total estimated cost for completing the culvert improvements and floodplain benching at Sterling Pointe Drive is $1,190,000.

- Alternative # 2 – The Thomas Langston 15-acre detention pond described above will lower the flows for Sterling Pointe Drive. As a result, a smaller culvert upgrade will provide the desired 25-year level of service when compared to Alternative #1 and the floodplain benching could be eliminated. The culvert proposed as part of this alternative is twin 10' x 4' RCBCs (See Figure 4-2). It will pass the 25-year storm event with minimal freeboard.

  The resulting upstream water surface reductions will range from 1.42 to 1.59 feet in the 25-year storm event. Similar to Alternative #1, this alternative will remove two (2) properties from the 25-year floodplain and twelve (12) from the 100-year floodplain. The total estimated cost for completing the culvert improvements proposed for Alternative #2 at Sterling Pointe Drive is $420,000.

During a field visit, there were several potential site restrictions and utility conflicts that were identified at this project location. There appears to be sanitary sewer, water, and electrical lines that may need to be replaced or relocated as part of Alternatives #1 and #2. Impacts to traffic flow during construction were considered. Sterling Pointe Drive is a two-lane residential roadway. It is anticipated that a road closure or a flagged two-way one-lane operation will be required. The installation of construction staging areas will require tree removal and temporary construction easements.

Alternative #1 included additional impacts from the construction of the floodplain benching. There are two existing sanitary sewer lines (a gravity and force main) located in the left overbank for the entire length of the proposed benching. As part of this project, manhole adjustments or other sanitary sewer improvements may need to be completed based on the elevation of the sanitary sewer system and final design of the floodplain benching. There is also a maintenance road that runs parallel to the existing sanitary sewer lines that will need to be relocated and reconfigured within the proposed floodplain benching. The proposed floodplain benching is located on private property therefore permanent easements would be required to implement Alternative #1. These easements would also be necessary for future maintenance of the floodplain benches. A partial easement may already be in place for the existing maintenance road.

A summary of the hydraulic performance for the improvements proposed for Alternatives #1 and #2 along SCUT1 are included in Tables 4-5 and 4-7. The improvements realized for WSEL

reduction and properties removed from floodplains are shown in Tables 4-6 and 4-8. The water surface elevations shown assume all proposed primary system improvements for SCUT1 are constructed. The level of improvement will be reduced if all projects are not implemented.

Table 4-5: Hydraulic Performance for SCUT1 – Alternative #1

Location	Minimum Elevation at Top of Road (feet NAVD)	Desired Level of Service	Calculated Water Surface Elevations (feet NAVD)				
			2-year flood	10-year flood	25-year flood	50-year flood	100-year flood
Thomas Langston Road (Existing 42″ RCP with Proposed Twin 42″ Floodplain Culverts and Benching)	66.81	25-year	63.65	64.94	66.03	**67.08**	**67.36**
Belfair Drive (Proposed Twin 6′ x 4′ RCBCs)	64.81	25-year	62.41	63.69	64.59	**65.17**	**65.61**
Sterling Pointe Drive (Proposed Twin 11′ x 4′ RCBCs with Floodplain Benching)	60.71	25-year	58.85	59.90	60.54	**61.04**	**61.46**

*Bold text indicates the existing water surface has exceeded the crest or low point in the road thereby causing flooding.
** Green shade indicates crossing meets desired level of service. Red shade indicates crossing does not meet desired level of service.

Table 4-6: WSELs and Properties Removed from Floodplains – Alternative #1

Location	Decrease in WSEL (feet NAVD)		Properties Removed/Properties in Floodplain	
	25-Year	100-Year	25-Year	100-Year
Thomas Langston Road	1.51	0.36	8/8	11/13
Belfair Drive	0.89	0.49	0/0	0/0
Sterling Pointe Drive	1.56	0.94	3/9	12/18

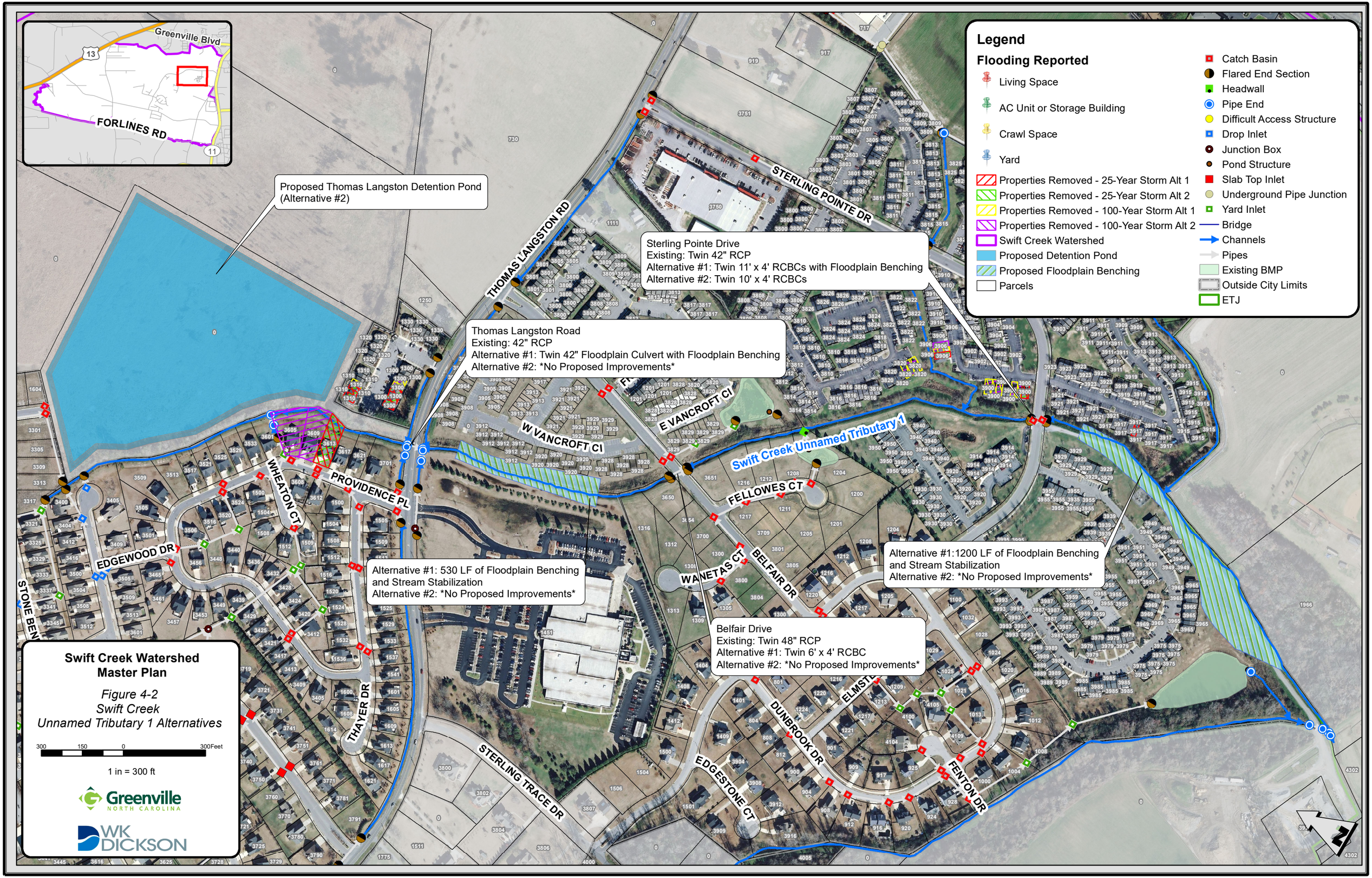
Table 4-7: Hydraulic Performance for SCUT1 – Alternative #2

Location	Minimum Elevation at Top of Road (feet NAVD)	Desired Level of Service	Calculated Water Surface Elevations (feet NAVD)				
			2-year flood	10-year flood	25-year flood	50-year flood	100-year flood
Thomas Langston Road (Existing 42″ RCP with Detention Pond)	66.81	25-year	64.24	65.20	65.81	66.44	**67.05**
Belfair Drive (Existing Twin 48″ RCPs with Detention Pond)	64.81	25-year	61.52	62.42	62.95	63.39	64.02
Sterling Pointe Drive (Proposed Twin 10′ x 4′ RCBCs with Detention Pond)	60.71	25-year	59.27	60.18	60.68	**61.02**	**61.35**

*Bold text indicates the existing water surface has exceeded the crest or low point in the road thereby causing flooding.
** Green shade indicates crossing meets desired level of service. Red shade indicates crossing does not meet desired level of service.

Table 4-8: WSELs and Properties Removed from Floodplains – Alternative #2

Location	Decrease in WSEL (feet NAVD)		Properties Removed/Properties in Floodplain	
	25-Year	100-Year	25-Year	100-Year
Thomas Langston Road	1.73	0.67	8/8	13/13
Belfair Drive	2.53	2.08	0/0	0/0
Sterling Pointe Drive	1.42	1.05	2/9	12/18


Greenville Blvd
13
FORLINES RD
11
Proposed Thomas Langston Detention Pond
(Alternative #2)
Sterling Pointe Drive
Existing: Twin 42" RCP
Alternative #1: Twin 11' x 4' RCBCs with Floodplain Benching
Alternative #2: Twin 10' x 4' RCBCs
Thomas Langston Road
Existing: 42" RCP
Alternative #1: Twin 42" Floodplain Culvert with Floodplain Benching
Alternative #2: *No Proposed Improvements*
Alternative #1: 530 LF of Floodplain Benching
and Stream Stabilization
Alternative #2: *No Proposed Improvements*
Alternative #1:1200 LF of Floodplain Benching
and Stream Stabilization
Alternative #2: *No Proposed Improvements*
Belfair Drive
Existing: Twin 48" RCP
Alternative #1: Twin 6' x 4' RCBC
Alternative #2: *No Proposed Improvements*
THOMAS LANGSTON RD
STERLING POINTE DR
E VANCROFT CI
W VANCROFT CI
Swift Creek Unnamed Tributary 1
FELLOWES CT
WANETAS CT
BELFAIR DR
PROVIDENCE PL
WHEATON CT
EDGEWOOD DR
STONE BEN
THAYER DR
STERLING TRACE DR
EDGESTONE CT
DUNBROOK DR
FENTON DR
ELMSTE
Legend
Flooding Reported
Living Space
AC Unit or Storage Building
Crawl Space
Yard
Properties Removed - 25-Year Storm Alt 1
Properties Removed - 25-Year Storm Alt 2
Properties Removed - 100-Year Storm Alt 1
Properties Removed - 100-Year Storm Alt 2
Swift Creek Watershed
Proposed Detention Pond
Proposed Floodplain Benching
Parcels
Catch Basin
Flared End Section
Headwall
Pipe End
Difficult Access Structure
Drop Inlet
Junction Box
Pond Structure
Slab Top Inlet
Underground Pipe Junction
Yard Inlet
Bridge
Channels
Pipes
Existing BMP
Outside City Limits
ETJ
Swift Creek Watershed
Master Plan
Figure 4-2
Swift Creek
Unnamed Tributary 1 Alternatives
300 150 0 300Feet
1 in = 300 ft
Greenville
NORTH CAROLINA
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4.1.3 GUM SWAMP

Frog Level Road – Based on the results obtained from the existing conditions analysis, the existing twin 78" CMPs at Frog Level Road are not passing the desired 25-year storm. Model results show the road overtops during the 10-year event. The proposed alternative entails replacing and upsizing the existing CMPs. The proposed culvert is a twin 7' x 6' RCBCs. The upsized culvert will provide the desired 25-year level of service with 0.55 feet of freeboard.

To lower the tailwater at Frog Level Road, 495 linear feet of floodplain benching has been proposed immediately downstream of Frog Level Road along the left and right overbanks (See Figure 4-3).

Picture 4-4. Frog Level Road – Existing CMPs

During a field inspection, there were several potential site restrictions and utility conflicts that were identified including overhead power lines located along Frog Level Road, which may need to be temporarily relocated. Impacts to traffic flow during construction were considered. Frog Level Road is a minor thoroughfare maintained by NCDOT. It is anticipated that a flagged two-way two-lane operation will be required. There are sanitary sewer and water lines that may also need to be replaced or relocated that are located in the overbanks.

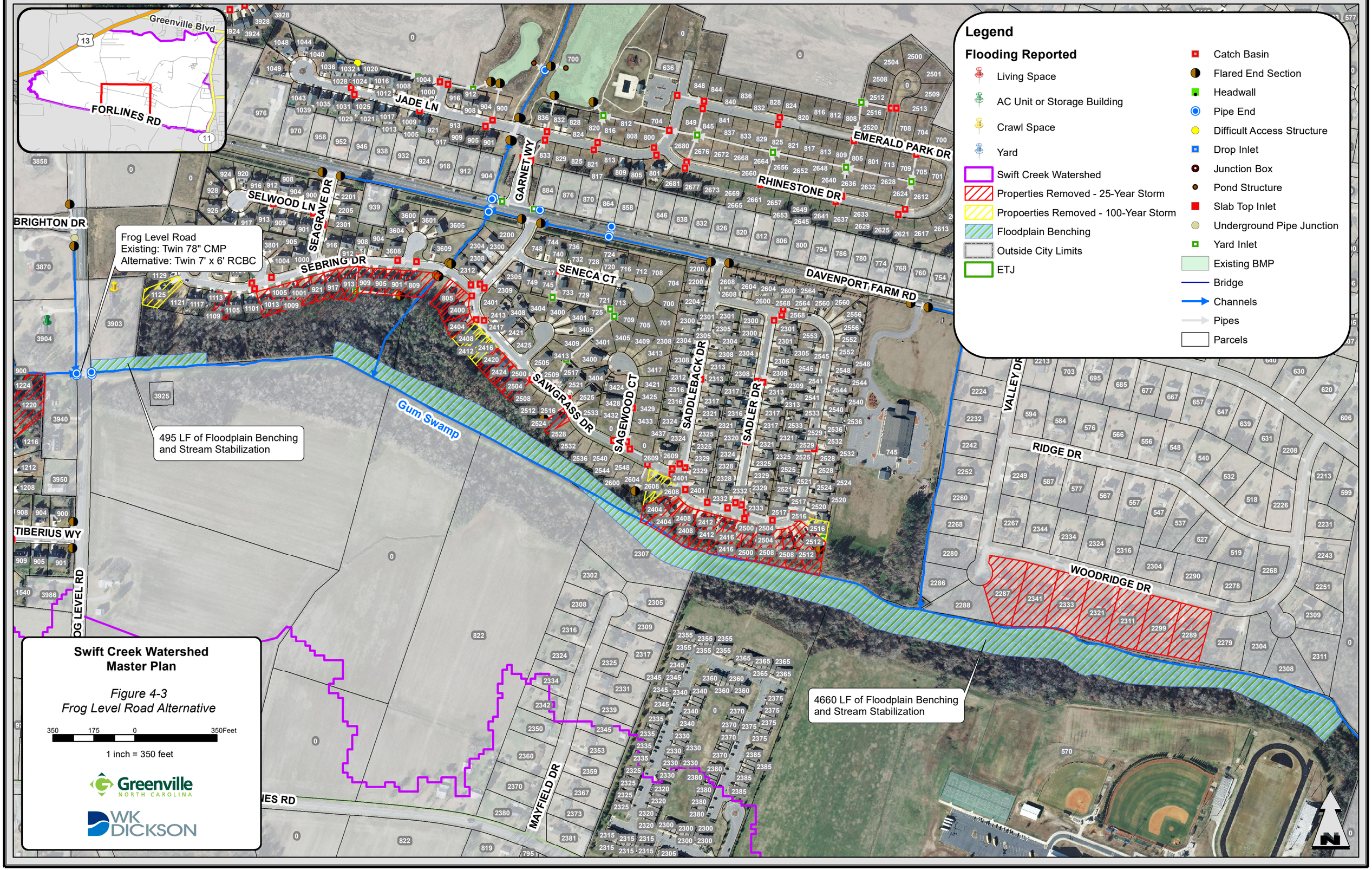
While the crossing is outside of the existing City limits, improvements to the culvert crossing will directly reduce water surface elevations for City residents located along Ashmoor Lane. The total estimated cost for this project is $710,000.

Gum Swamp Floodplain Benching – Approximately 500 feet downstream of Frog Level Road, an additional 4,660 linear feet of floodplain benching is proposed. This floodplain benching will help to significantly lower the water surface elevations along Gum Swamp, lower the tailwater for the Davenport Farm Road secondary system, and reduce the flood risk to properties along Sawgrass Drive. The floodplain benching could also be combined with the proposed stream restoration and stabilization downstream of the City limits as recommended in the Upper Swift Creek and Fork Swamp Watershed Action Plan. The proposed project could be an opportunity to partner with Pitt County since the Frog Level Road crossing is outside of the City limits although the new residential development along Frog Level Road is within City limits and dependent on the reliability of Frog Level Road.

Water surface reductions in the floodplain benching area could be as high as 3.8 feet during the 25-year storm event. Along the studied reach of Gum Swamp, forty-three (43) properties are removed from the 25-year floodplain and seven (7) properties are removed from the 100-year floodplain. The majority of the floodplain bench appears to be located within a Pitt County

Drainage District easement based on the Pitt County OPIS website. Coordination with the Drainage District will be required to implement the project. Tree removal will be a significant impact as a result of this project.

The total estimated cost for this project is $5,160,000.



Swift Creek Watershed Master Plan

Figure 4-3
Frog Level Road Alternative

350 175 0 350Feet

1 inch = 350 feet

Greenville NORTH CAROLINA

WK DICKSON

A summary of the hydraulic performance for the improvements proposed along Gum Swamp are included in Table 4-9. The realized benefits of the improvements as WSEL reduction and properties removed from floodplains are summarized in Table 4-10. The water surface elevations shown assume all proposed primary system improvements for Gum Swamp are constructed. The level of improvement will be reduced if all projects are not implemented.

Table 4-9: Hydraulic Performance for Gum Swamp

Location	Minimum Elevation at Top of Road (feet NAVD)	Desired Level of Service	Calculated Water Surface Elevations (feet NAVD)				
			2-year flood	10-year flood	25-year flood	50-year flood	100-year flood
Frog Level Road (Proposed Twin 7' x 6' RCBCs with 495 LF Floodplain Benching)	65.11	25-year	62.04	63.64	64.56	**65.18**	**65.41**
Gum Swamp Floodplain Benching	N/A	N/A	56.89	58.34	59.18	59.82	60.46

*Bold text indicates the existing water surface has exceeded the crest or low point in the road thereby causing flooding.
** Green shade indicates crossing meets desired level of service. Red shade indicates crossing does not meet desired level of service.

Table 4-10: WSELs and Properties Removed from Floodplains – Alternative #1

Location	Decrease in WSEL (feet NAVD)		Properties Removed/Properties in Floodplain	
	25-Year	100-Year	25-Year	100-Year
Frog Level Road (Twin Culverts and Floodplain Benching)	0.83	0.26	4/6	1/2
Gum Swamp Floodplain Benching	3.80	3.48	43/46	7/9

4.1.4 PITT COUNTY COMMUNITY COLLEGE REGIONAL DETENTION FACILITY

While developing the alternatives for the Swift Creek watershed, opportunities for potential regional detention facilities were explored within the watershed to offset potential increases in flows as a result of increasing the conveyance capacity of the system and as a result of future development. Most of the undeveloped areas within the watershed are currently outside of the City limits, but inside the ETJ. One such area is located on Pitt County Community College property near the confluence of Swift Creek Main Branch and Swift Creek Unnamed Tributary 1 (See Figure 4-1). This area was analyzed to determine the potential size of a regional facility to ensure the peak outflow at the downstream point of the watershed would be no higher for the 25-year storm when compared to existing conditions after the proposed improvements are constructed and the watershed is built out.

With respect to Alternative #1, the proposed regional facility would need to be approximately 32 acres in size to prevent an increase in the 25-year flow. This scenario assumes there would be no additional detention for the 25-year storm either as part of new development or as a result

of retrofits. The total estimated cost for this project is $18,280,000, which includes estimated land acquisition costs based on Pitt County tax records. Based on the development of a conceptual model, the proposed 32-acre detention pond would lower the flows in the 25-year storm by approximately 7 percent at the downstream limit of the watershed.

For Alternative #2, the two proposed detention ponds (Megan Drive and Thomas Langston) would reduce flows enough that the Pitt County Community College Regional Detention Facility would not be required to reduce flows to existing conditions.

The implementation of this facility will not impact any of the sizes of the culvert recommended as part of this Master Plan. However, it will reduce downstream flows and help to offset increases that will be created by upsizing upstream culverts.

During a field inspection, there were several potential site restrictions and utility conflicts that were identified. In order to gain access and to install the proposed regional detention facility, tree removal may be required, however in general the proposed limits of the facility are within an open agricultural field. It should be noted that the proposed regional detention facility is located on County property therefore some type of easement or acquisition arrangement would be required to complete this project and maintain the facility in the future. The installation of construction staging areas and entrances will require additional tree removal and temporary construction easements.

4.1.5 HYDROLOGY

The future land use was accounted for during the development of the proposed improvements. The hydrologic parameters including curve numbers were adjusted for the future conditions and alternatives models.

Peak flows for the primary systems were developed for the 2-, 10-, 25-, 50-, and 100-year storm events considering the future conditions and proposed alternatives. The future conditions peak flows are summarized in Table 4-3. In comparison to the existing conditions flows, the future conditions flows increases in the 25-year storm are as follows:

- Swift Creek – 12 to 19%
- SCUT1 – 2 to 8%
- Gum Swamp – 6 to 13%

Table 4-11: Future Conditions Flows from HEC-HMS for Swift Creek Watershed

HEC-HMS Node	Road Name / Location	HEC-RAS Station	Storm Event				
			2-year (cfs)	10-year (cfs)	25-year (cfs)	50-year (cfs)	100-year (cfs)
SWIFT CREEK							
U/S Limit SC	Upstream Limit of Swift Creek	241994	165	301	398	484	578
Thomas Langston – SC	Thomas Langston Road	239601	242	444	588	711	852
Sterling Trace Drive	Sterling Trace Drive	237845	256	494	703	877	1,067
SWIFT CREEK UT1							
U/S Limit SCUT	Upstream Limit of SCUT1	4495	70	142	194	241	293
Thomas Langston – SCUT	Thomas Langston Road	3997	78	158	217	268	325
Belfair Drive	Belfair Drive	3015	94	176	239	302	369
Sterling Pointe Drive	Sterling Pointe Drive	1635	130	247	327	431	531
GUM SWAMP							
U/S Limit GS	Upstream Limit of Gum Swamp	9293	86	173	237	295	361
Frog Level Road	Frog Level Road	7759	211	424	575	709	880

The alternative flows were developed from the future conditions taking into account attenuation for the proposed culvert sizes. They differed slightly from the future condition peak flows presented in Table 4-6. The peak flows used for the proposed alternatives are summarized in Tables 4-7 and 4-8. A hard copy of the HEC-HMS output is included as Appendix H. The CD found in Appendix J contains a digital copy of the HEC-HMS model for the Swift Creek watershed.

Table 4-12: Alternative #1 Flows from HEC-HMS for Swift Creek Watershed

HEC-HMS Node	Road Name / Location	HEC-RAS Station	Storm Event				
			2-year (cfs)	10-year (cfs)	25-year (cfs)	50-year (cfs)	100-year (cfs)
SWIFT CREEK							
U/S Limit SC	Upstream Limit of Swift Creek	241994	165	301	398	484	578
Thomas Langston – SC	Thomas Langston Road	239601	243	445	588	710	852
Sterling Trace Drive	Sterling Trace Drive	237845	260	509	705	872	1,062
SWIFT CREEK UT1							

U/S Limit SCUT	Upstream Limit of SCUT1	4495	70	142	194	241	293
Thomas Langston – SCUT	Thomas Langston Road	3997	80	160	216	267	325
Belfair Drive	Belfair Drive	3015	96	183	249	303	362
Sterling Pointe Drive	Sterling Pointe Drive	1635	136	267	358	440	522
GUM SWAMP							
U/S Limit GS	Upstream Limit of Gum Swamp	9293	86	173	237	295	361
Frog Level Road	Frog Level Road	7759	211	424	575	709	880

Table 4-13: Alternative #2 Flows from HEC-HMS for Swift Creek Watershed

HEC-HMS Node	Road Name / Location	HEC-RAS Station	Storm Event				
			2-year (cfs)	10-year (cfs)	25-year (cfs)	50-year (cfs)	100-year (cfs)
SWIFT CREEK							
U/S Limit SC	Upstream Limit of Swift Creek	241994	81	157	213	264	320
Thomas Langston – SC	Thomas Langston Road	239601	162	329	452	562	679
Sterling Trace Drive	Sterling Trace Drive	237845	225	459	629	802	972
SWIFT CREEK UT1							
Proposed Swift Det_17	Upstream Limit of SCUT1	4495	5	11	16	20	24
Thomas Langston – SCUT	Thomas Langston Road	3997	27	49	64	79	95
Belfair Drive	Belfair Drive	3015	44	79	103	123	148
Sterling Pointe Drive	Sterling Pointe Drive	1635	74	141	189	229	274
GUM SWAMP							
U/S Limit GS	Upstream Limit of Gum Swamp	9293	N/A	N/A	N/A	N/A	N/A
Frog Level Road	Frog Level Road	7759	N/A	N/A	N/A	N/A	N/A

4.1.6 HYDRAULICS

The hydraulic analysis for the proposed conditions was similar to the analysis completed for the existing conditions. The model was updated to reflect the proposed culvert improvements, as well as the floodplain benching locations.

4.2 SECONDARY SYSTEMS

Developing flood control alternatives for the secondary systems typically included increase in pipe capacity and/or rerouting flows where more space was available for improvements. In general, the proposed improvements for the secondary system are less complex from a permitting perspective since they typically do not require FEMA or 401/404 permits. However, the proposed improvements for secondary systems are oftentimes constrained by private property as space is typically limited between houses or other structures. Utility conflicts are another constraint that is typical for secondary system improvements. Secondary system improvements also considered feedback from City staff and residents as well as maintenance needs based on findings from the inventory and/or feedback from City staff.

Davenport Farm Road System

With the improvements proposed for the Frog Level Road crossing including the floodplain benching, the tailwater will be lowered along Gum Swamp and the Davenport Road system will operate at the desired level of service. Therefore, no capital improvements are proposed at this location. If improvements are not completed along Gum Swamp, there would be no infrastructure improvements in the Davenport Farm Road System that would improve the level of service due to the impacts of the tailwater on the system.

4.3 25-YEAR DETENTION ANALYSIS

In 2014, the City of Greenville enacted legislation requiring attenuation for new development and re-development for the one-year, five-year, and ten-year, 24-hour storm events. In addition, Section 9-9-10 of Ordinance No. 13-054 states the following:

"New development and redevelopment, as described in section 9-9-3, in areas at special risk with well documented water quantity problems as determined by the City Engineer, shall not result in a net increase in peak flow leaving the site from pre-development conditions for the 25-year, 24-hour storm event."

As part of the Swift Creek Master Plan, an analysis was completed to determine if there are areas within the watershed and the ETJ that should be considered "well documented water quantity problems" requiring detention for the 25-year, 24-hour storm event. Areas may be defined as well documented water quantity problems if either of the following is true:

- Structural flooding has been historically noted by property owners during storms considered smaller than the design event and this structural flooding has been corroborated by either high water marks, City staff input, or model results.
- Model results indicate structural flooding or roadway overtopping during storms smaller than the design storm and models results are corroborated by City staff input.

Portions of the watershed draining to the "well documented water quantity problems" may be considered for 25-year detention if any of the following are true:

- Future condition flows are 10% or greater than existing flows for a given subwatershed upstream of the water quantity problem.
- Proposed capital projects are not deemed to be feasible or cost effective for providing the required level of service for these water quantity problems based on future land use conditions.
- Cost differential between designing for existing conditions and future conditions is deemed to be significant and/or a significant number of structures would become floodprone during the 25-year design storm based on future conditions flows when compared to existing conditions flows.

It is assumed that for this analysis, systems with a 10-year level of service design would not be considered for the 25-year detention since the 10-year detention requirements would result in little to no increase in peak flows for the design event. Most secondary systems have a 10-year level of service, although secondary systems with significant documented water quantity problems that also include infrastructure requiring a level of service greater than a 10-year event may be evaluated for the 25-year detention requirement. There are no secondary systems for this evaluation of Swift Creek watershed that require more than 10-year level of service, therefore were not included in the 25-year detention requirement.

As noted in Section 3.1, documented flooding issues are located along Swift Creek Unnamed Tributary 1 and Gum Swamp in the vicinity of Thomas Langston Road and Frog Level Road. In addition to the documented flooding issues, model results show a number of homes and buildings at risk of flooding during the 25-year storm event. Large portions of the Swift Creek watershed remain undeveloped and could potentially cause increased flows greater than 10% higher than the current existing flows. These areas are shown in Figure 4-4.

For the purposes of evaluating if 25-year detention is appropriate, the Swift Creek watershed is divided into three (3) distinct areas based on the drainage feature that conveys runoff from that area. Then the entire Swift Creek watershed needs to be evaluated to limit increases in runoff from the south end of the City limits entering neighboring communities.

- Swift Creek Main Stem – While there were no documented reports of flooding along Swift Creek Main Stem, floodprone areas identified through modeling efforts are predominantly located upstream of Thomas Langston Drive and downstream of Sterling Trace Drive. As shown in Figure 4-4, there are extensive undeveloped areas that if developed, would significantly increase the 25-year flows. Project increases in flows during the 25-year storm could range from 10 to 20 percent in the Swift Creek Main Stem watershed. If 25-year detention was required for new development in the highlighted drainage basins, then the City could move forward with the proposed Alternative 2 options at Thomas Langston Road and Sterling Trace Drive without having to implement the Megan Drive detention pond. Assuming the City would have proceeded with Alternative #1, the projected savings by requiring the 25-year detention for the City would be approximately $930,000 in the Swift Creek Main Stem watershed.

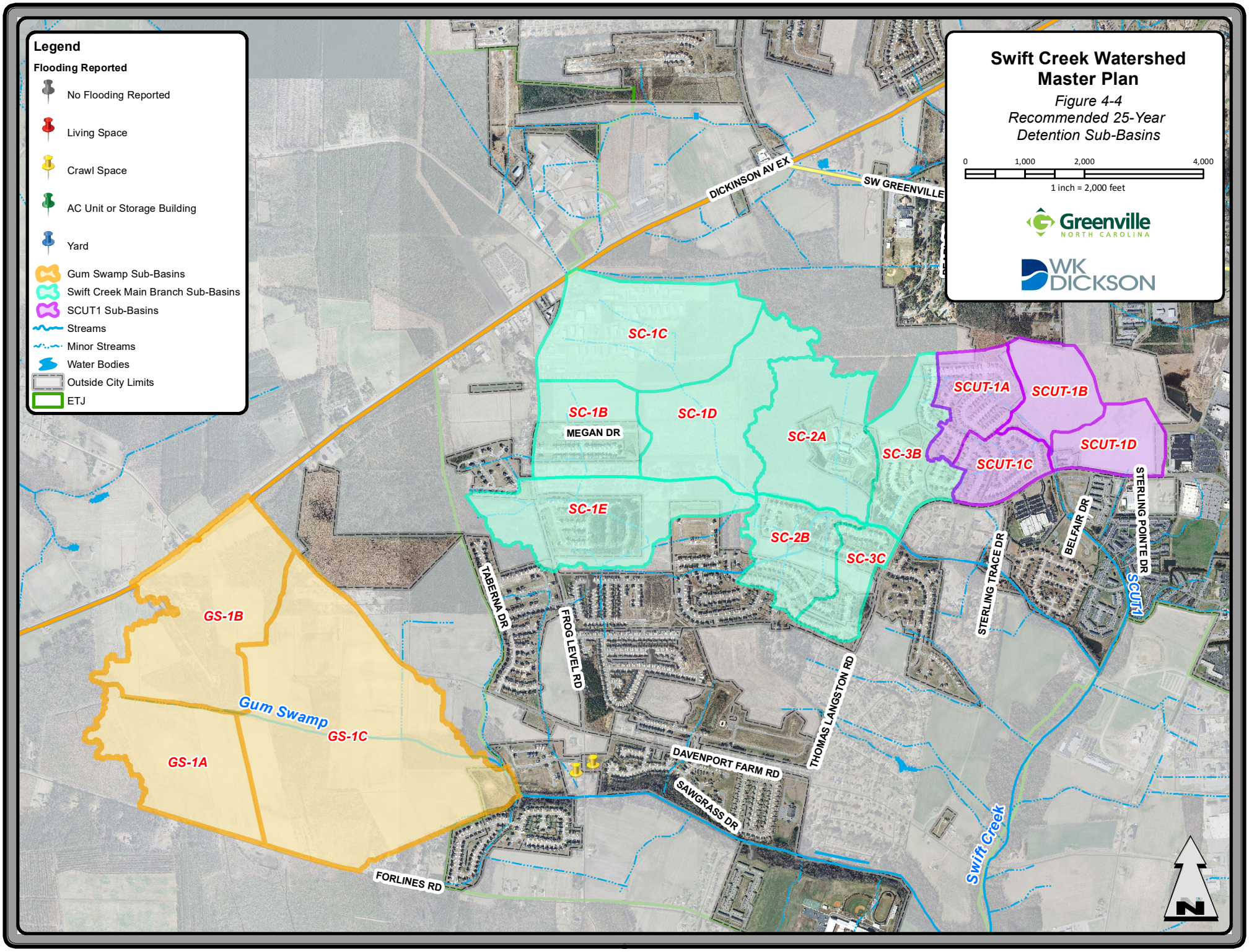
- Swift Creek Unnamed Tributary 1 – Documented reports of flooding along Swift Creek Main Unnamed Tributary 1 are predominantly located upstream of Thomas Langston Drive although modeling results also indicate floodprone areas in the vicinity of Belfair Drive and Sterling Pointe Drive. As shown in Figure 4-4, there are extensive undeveloped areas that if developed, would significantly increase the 25-year flows. Project increases in flows during the 25-year storm could range from 2 to 12 percent in the Swift Creek Unnamed Tributary 1 watershed. If 25-year detention was required for new development in the highlighted drainage basins then, the proposed culvert sizes at Sterling Pointe Drive and Belfair Drive could be slightly reduced, although the cost savings would not be significant.

- Gum Swamp – Documented reports of flooding along Gum Swamp are predominantly located upstream of Frog Level Road and along Sebring Drive and Sawgrass Drive downstream of Frog Level Road. As shown in Figure 4-4, there are extensive undeveloped areas that if developed, would significantly increase the 25-year flows. Project increases in flows during the 25-year storm could range from 6 to 11 percent in the Gum Swamp watershed. If 25-year detention was required for new development in the highlighted drainage basins then, the proposed culvert size at Frog Level Road and

extents of floodplain benching could be slightly reduced, although the cost savings would not be significant.

- Overall Swift Creek watershed – Changes in land use (future build-out conditions) and increasing culvert capacity will increase the 25-year flow at the outlet of the study area (City limits) by approximately 6%. Downstream communities including Ayden and Pitt County already experience flooding along Swift Creek in existing conditions, so any increase in flows could potentially increase the duration, severity, and frequency of flooding, although the limits of this study do not evaluate these potential impacts downstream of the City limits. If 25-year detention was required in the highlighted areas in Figure 4-14, the increase in the 25-year flow would be reduced to 1.2%. Therefore, the City could significantly reduce the size of the Pitt County Community College Regional Detention Area described in Section 4.1.4 to effectively ensure no net increase in the 25-year peak flow at the limits of the study for Alternative #1. The size of the detention area could be reduced to twenty acres which would result in a cost savings of $6,850,000.

Based on the analysis summarized above it is recommended that 25-year detention for the highlighted areas within the Swift Creek Main Branch Watershed be required and it is recommended that the City consider requiring 25-year detention for the highlighted areas in Swift Creek Unnamed Tributary 1 and Gum Swamp.


Legend
Flooding Reported
No Flooding Reported
Living Space
Crawl Space
AC Unit or Storage Building
Yard
Gum Swamp Sub-Basins
Swift Creek Main Branch Sub-Basins
SCUT1 Sub-Basins
Streams
Minor Streams
Water Bodies
Outside City Limits
ETJ
Swift Creek Watershed Master Plan
Figure 4-4
Recommended 25-Year Detention Sub-Basins
0
1,000
2,000
4,000
1 inch = 2,000 feet
Greenville
NORTH CAROLINA
WK DICKSON
DICKINSON AV EX
SW GREENVILLE
SC-1C
SC-1B
SC-1D
SC-2A
SC-3B
SC-1E
SC-2B
SC-3C
SCUT-1A
SCUT-1B
SCUT-1C
SCUT-1D
MEGAN DR
GS-1B
GS-1C
GS-1A
Gum Swamp
TABERNA DR
FROG LEVEL RD
THOMAS LANGSTON RD
STERLING TRACE DR
BELFAIR DR
STERLING POINTE DR
SCUT1
DAVENPORT FARM RD
SAWGRASS DR
FORLINES RD
Swift Creek
N

WATER QUALITY RECOMMENDATIONS

Traditional stormwater management has typically been designed to reduce flooding, but at times has neglected water quality by collecting runoff directly from impervious surfaces into a closed drainage system. Runoff from impervious areas collects high concentrations of pollutants and nutrients that if left untreated can cause negative impacts to water quality in the receiving waters. Negative impacts may include less biodiversity, hazards to the health of fish and wildlife, as well as human health hazards. Many communities in North Carolina now require some form of water quality treatment for new development; however existing developments typically have little or no water quality treatment. The City of Greenville developed a Stormwater Management Program (September, 2004) to outline its water quality requirements.

Stream stabilization projects can be constructed to reduce instream sediment loads and to protect private property from further erosion. Best management practices (BMPs) can be constructed to treat runoff prior to being discharged to the stormwater conveyance system and ultimately the receiving waters of the system. Retrofitting BMPs can be difficult due to limited space and other constraints. Several types of BMPs were evaluated: Bioretention Cells, Stormwater Wetlands, Wet Ponds, Regenerative Stormwater Conveyance (RSC), and Water Quality Swales. Projects identified in the Swift Creek watershed are described below.

5.1 STREAM STABILIZATION PROJECTS

Based on the basin-wide stream assessment completed as described in Section 3.3, two (2) stream stabilization projects were identified to help reduce instream erosion. Instream erosion can be a significant source of sediment that ultimately can impair the biodiversity of the downstream receiving waterbodies. The City should consider monitoring the stability of the primary streams throughout the Swift Creek watershed. As the watershed developments stream flows will become more intense for a longer period of time. While detention may mitigate peak flows, channel stability can be impacted by the period of time that high flows occur. The Pitt County Soil & Water Conservation District has historically maintained some of the streams in the Swift Creek watershed by removing debris and vegetation. While this maintenance can prevent blockages in the stream, the District's easement along the streambank has been cleared and maintained so that very little vegetation stabilizes the stream bank. As development occurs closer to the streambanks and impervious area lead to higher peak flows and intensities, the lack of vegetation on the streambanks may result in additional erosion of the streams in the watershed. The City should consider developing a maintenance plan in collaboration with the Drainage District that results in streams cleared of debris while at the same time promoting stable streambanks and habitat for macroinvertebrates.

In addition to the two projects described in this section, there is documented stream erosion along Gum Swamp downstream of South Central High School outside of the City limits. The stream erosion occurs downstream of the Gum Swamp floodplain benching project described in

Section 4. A more detailed description of the erosion problems and potential solutions can be found in the Upper Swift Creek and Fork Swamp Watershed Action Plan completed for Pitt County in 2012. Since this project is outside of the City limits, it has not been included in the recommended projects for this Master Plan, however the City may want to consider partnering with Pitt County on a comprehensive stream stabilization/restoration project for Gum Swamp.

The proposed stream stabilization projects will have impacts to property owners that will require temporary construction easements to complete the work and permanent easements for maintenance access. Proposed projects assume that the riparian buffers can be restored to existing conditions. During final design, the City will need to refer to the current buffer regulations to determine if more significant buffer restoration is required. The projects (not presented in order of importance) are described as follows:

Stream Stabilization Project #1: Thomas Langston Road

Stream Stabilization Project #1 is located in the residential neighborhood west of Thomas Langston Road behind the homes on Camille Drive and Forsyth Park Court. The project begins at a stormwater outfall on the right bank and extends approximately 1,250 feet to Thomas Langston Road. The project also incorporates 800 feet of stream stabilization, downstream of Thomas Langston Road, behind the homes along Ryan Place. Stream Stabilization Project #1 is a third order perennial stream section of Swift Creek. This project has a drainage area of approximately 1,050 acres.

Picture 5-1: Outfall at top of project

Land use surrounding Stream Stabilization Project #1 is mostly residential and includes drainage from an outfall at South Bend Road. This segment of Swift Creek flows east and has an average stream width of 8.5 feet. The average bank height along this reach is greater than 10 feet and bank angles are 80 degrees. The top channel width is greater than 15 feet. This area is surrounded by residential houses along the right bank and a partially wooded buffer along the left bank. The right bank appears to have some type of maintained easement, likely for the Drainage District. The bank has little to no vegetation in place to stabilize the streambank. As shown on Picture 5-1, a stormwater culvert from the neighborhood enters the stream at the upstream limits of the project and another stormwater culvert and drainage ditch enter the stream from the left bank further downstream (See Picture 5-2). Due to high flow events, sandy soils, and the lack of sufficient bank vegetation, the highly incised channel is eroding at an enhanced rate.

Picture 5-2: Ditch and outfall entering Swift Creek

Upstream of the crossing at Thomas Langston Road, shear stress and channel velocities are above the ideal conditions for a stable sand bed channel, with values reaching 0.41 lb/sq ft, and 3.49 ft/s, respectively. Downstream of Thomas Langston Road, several sections of the banks are unstable and have vertical bank angles (See Picture 5-3). The landowner at 304 Ryan Place verbally expressed major concerns to field staff about frequent flooding in her yard along the left bank.

Picture 5-3: Erosion downstream of Thomas Langston Road

Stream Stabilization Project #1 has opportunities for bank stabilization to prevent bank erosion along Swift Creek. Upstream of Thomas Langston Road, this project could be accessed from an open lot (Parcel # 070119) in the residential neighborhood along Forsyth Park Court. Bank erosion can be reduced by reinforcing the channel banks with rip-rap along bends and meanders to help prevent future bank failures. To prevent the right bank from eroding further onto adjacent residential property, a concrete or rock gabion wall may need to be constructed. The drainage outfall from South Bend Road is a good candidate for a Regenerative Stormwater Conveyance System (RSC), which would complement the stream stabilization efforts along Swift Creek. RSC systems are capable of conveying, storing, and treating runoff through infiltration, media filtration, and detention. RSCs are a linear system of riffles and step pools filled with a porous, carbon-rich bed material where pollutant removal processes may take place physically as well as biologically. The pools provide volume for runoff detention and infiltration, while the series of riffles are helpful in providing grade control for areas where steep slopes have caused instances of deep rill erosion or failed stream banks. RSCs can be very helpful in mitigating peak flows, as well as stabilizing channels and stream banks. Downstream of Thomas Langston Road, bank erosion can be reduced by grading channel banks back to a minimum 2 to 1 slope and placement of coir erosion control matting along banks and bare areas. Any debris jams in the channel should be removed to prevent channel widening. The entire area could be planted with a riparian seed mix to reinforce banks and prevent future erosion.

The estimated cost for the Thomas Langston Road project is $810,000. This stream stabilization project will run along the backside of several private properties, therefore there may be potential impacts to landscaping and fencing at the following properties:

- All of the houses along the north side of Forsyth Park Court;
- Three houses on south side of South Bend Road;
- 302 Ryan Place;
- 303 Ryan Place; and
- 304 Ryan Place.

Stream Stabilization Project #2: Thomas Langston Culvert

Stream Stabilization Project #2 is located at a culvert crossing at Thomas Langston Road near the residential homes on Providence Place. Stream Stabilization Project #2 would be a spot stabilization project that would span approximately 100 feet (the length of the crossing). Stream Stabilization Project #2 is a perennial stream section of SCUT1 and has a drainage area of 235 acres.

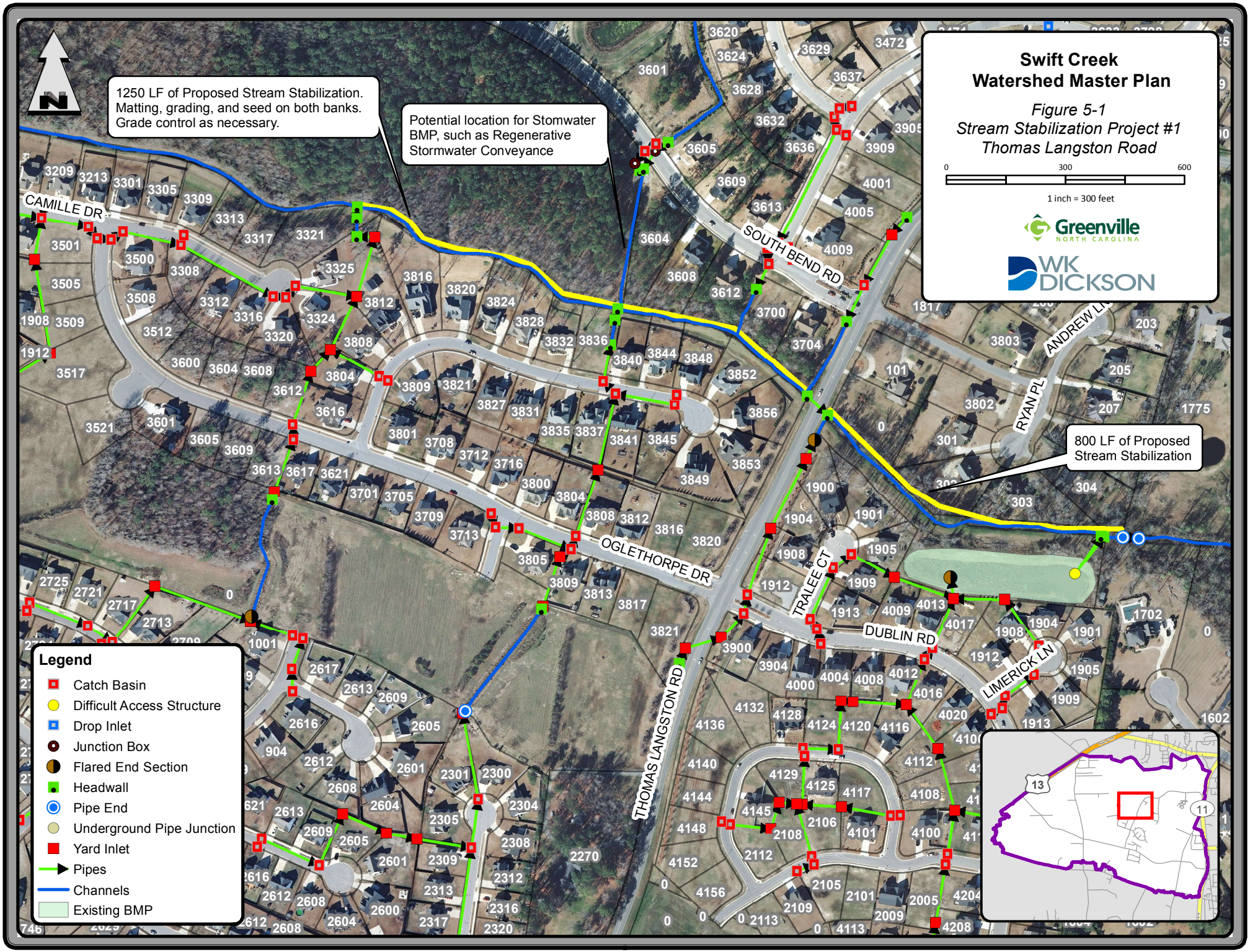
Picture 5-4: Perched culvert on north side of Thomas Langston Road

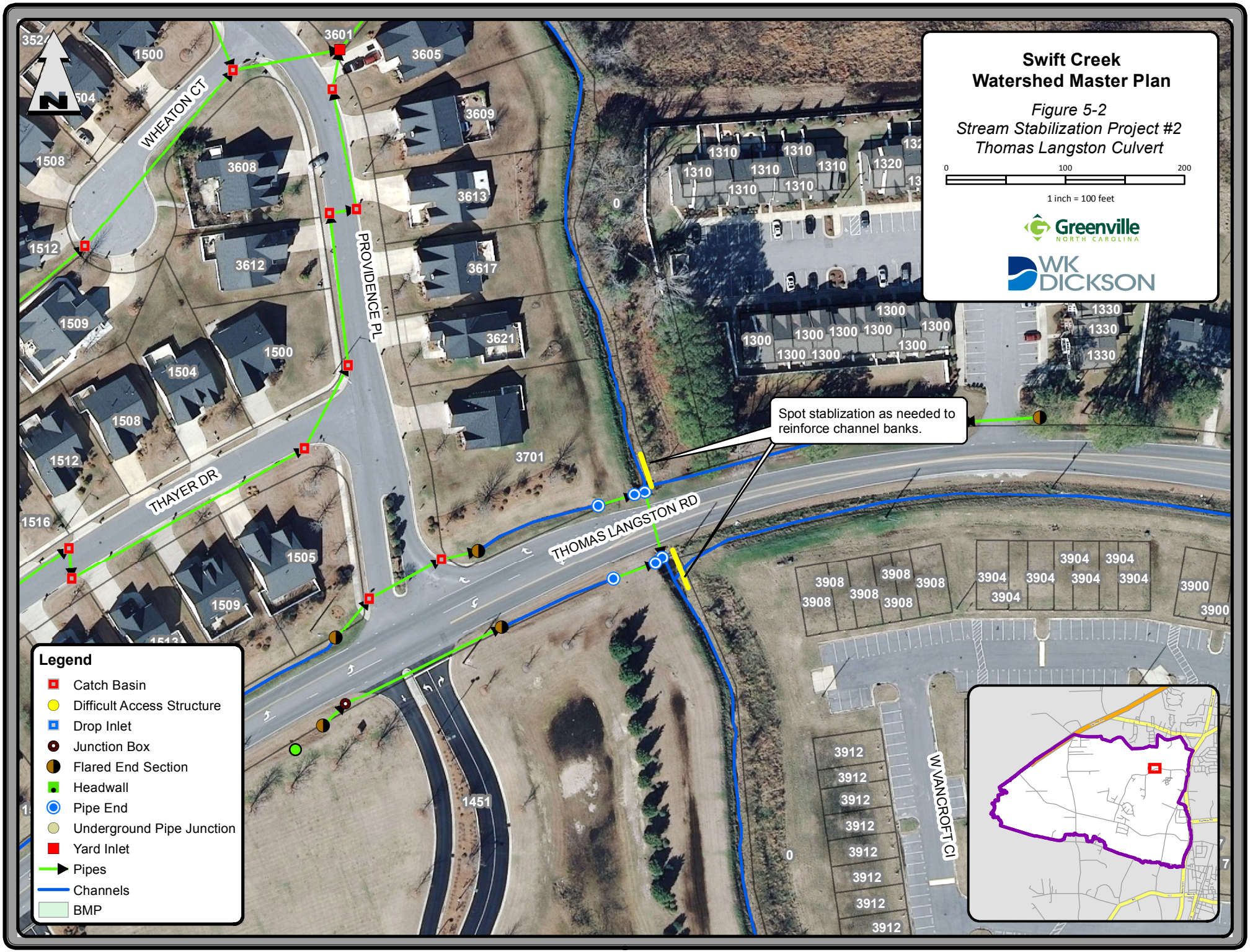
Land use immediately surrounding this project consists mainly of residential houses and undeveloped open space. The stream generally flows to the south within a steep eroded channel feature. The bottom width is approximately 6.5 feet wide. The right bank is 10 feet tall and the left bank is 9.5 feet tall with bank angles of 80 degrees. The average top channel width is 17 feet. The bank conditions along this stretch are slightly unstable due to a lack of sufficient bank vegetation along large portions of this reach. On the south side of Thomas Langston Road bank erosion has led to an exposed stormwater outfall pipe near the base of a utility pole.

Picture 5-5: Exposed pipe on south side of Thomas Langston Road

Stream Stabilization Project #2 has opportunities for bank stabilization to prevent the left bank from eroding further and exposing the stormwater pipes along Thomas Langston Road. This project could be accessed from Thomas Langston Road and from an existing sewer easement south of the project. Bank erosion can be reduced by reinforcing the channel banks with rip-rap to help prevent future bank failures. Bank erosion can be further reduced by placement of coir erosion control matting along banks and bare areas. Also, the entire project area could be planted with a riparian seed mix to reinforce banks.

This project could be completed simultaneously with the Thomas Langston culvert improvements, however if the culvert is not replaced the streambank erosion should still be addressed. The estimated cost for the Thomas Langston Culvert project is $70,000.


1250 LF of Proposed Stream Stabilization. Matting, grading, and seed on both banks. Grade control as necessary.
Potential location for Stomwater BMP, such as Regenerative Stormwater Conveyance
800 LF of Proposed Stream Stabilization
Swift Creek
Watershed Master Plan
Figure 5-1
Stream Stabilization Project #1
Thomas Langston Road
0
300
600
1 inch = 300 feet
Greenville
NORTH CAROLINA
WK DICKSON
CAMILLE DR
SOUTH BEND RD
OGLETHORPE DR
THOMAS LANGSTON RD
TRALEE CT
DUBLIN RD
LIMERICK LN
RYAN PL
ANDREW LN
Legend
Catch Basin
Difficult Access Structure
Drop Inlet
Junction Box
Flared End Section
Headwall
Pipe End
Underground Pipe Junction
Yard Inlet
Pipes
Channels
Existing BMP


Swift Creek
Watershed Master Plan
Figure 5-2
Stream Stabilization Project #2
Thomas Langston Culvert
0
100
200
1 inch = 100 feet
Greenville
NORTH CAROLINA
WK DICKSON
Spot stablization as needed to reinforce channel banks.
WHEATON CT
PROVIDENCE PL
THAYER DR
THOMAS LANGSTON RD
W VANCROFT CI
Legend
Catch Basin
Difficult Access Structure
Drop Inlet
Junction Box
Flared End Section
Headwall
Pipe End
Underground Pipe Junction
Yard Inlet
Pipes
Channels
BMP

5.2 BMP PROJECT IDENTIFICATION

BMPs were initially identified using various layers in GIS including the following: aerial photography, parcels, land use, storm water inventory, and topography. Sixteen (16) potential BMP locations were initially identified. These locations were field visited by WK Dickson staff in January 2016 to determine the feasibility of each site for a BMP. An overview map has been provided showing these sites (See Figure 5-3).

The proposed locations for the BMPs were evaluated based on the following criteria:

- Watershed Size/Drainage Area – Larger watershed sizes allow an opportunity for more treatment. A significant contributing drainage area would allow the use of a larger, more regional BMP such as a wet pond or extended detention wetland.
- Percentage of impervious area – Areas with high impervious percentages allow an opportunity for more treatment.
- Proximity to existing conveyance system – Runoff will need to be diverted into the BMP and then discharged back to the conveyance system. Locations in close proximity to the existing conveyance system will reduce the cost associated with constructing new drainage structures.
- Land Availability/Ownership – The proposed BMPs will require undeveloped land. Attempts were made to concentrate on publicly owned land because the high cost of private land can make a project unlikely.
- Topography – Sufficient vertical relief, up to 5 feet, is required to allow certain BMPs (i.e., bioretention and wet ponds) to function per NCDEQ design requirements.
- Hydrologic conditions – BMPs such as wet ponds or extended detention wetlands need the proper hydrologic conditions for plants to survive. The soils or existing water table must allow for the BMP facility to permanently hold stormwater runoff.

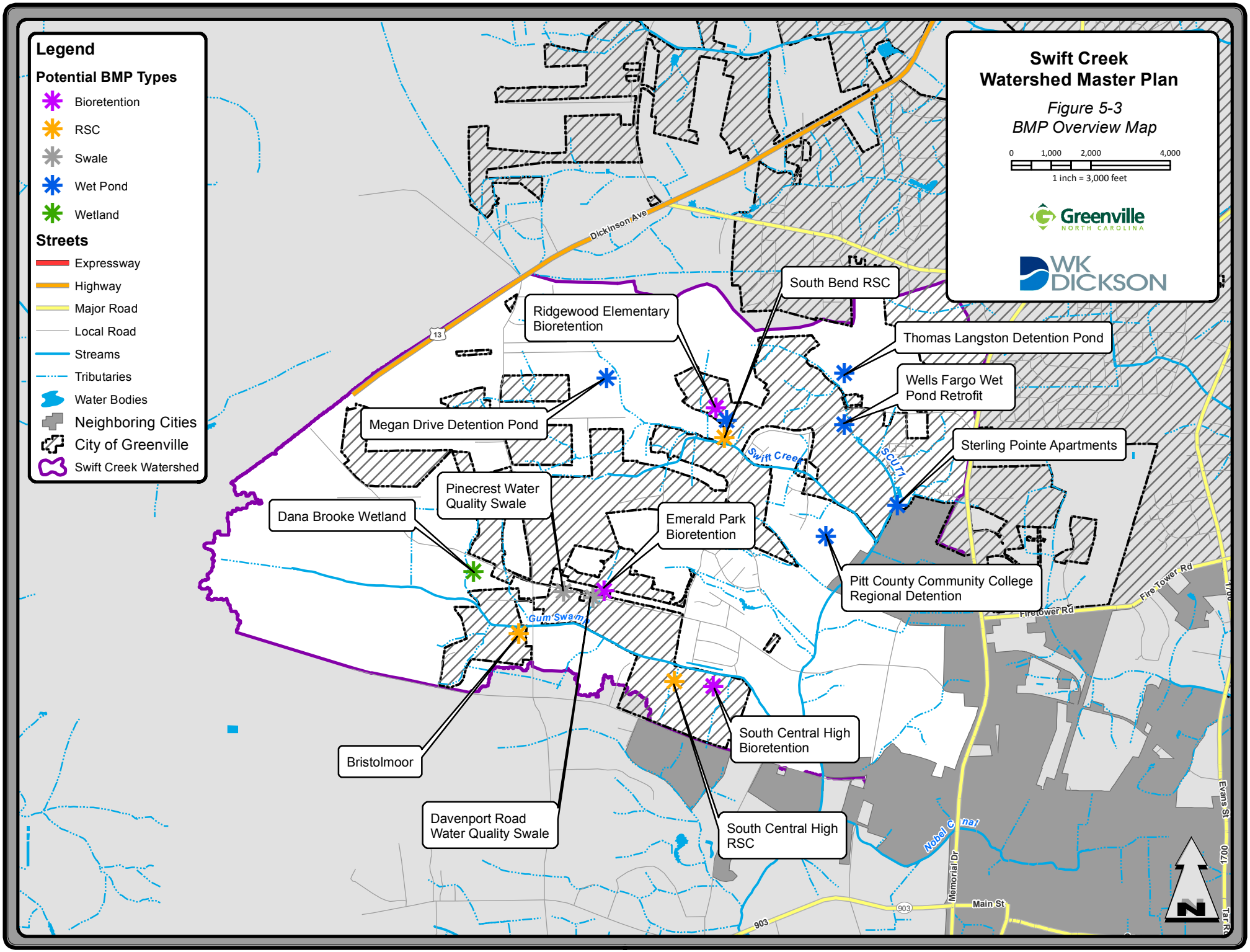
Public schools, parks, and churches were closely looked at due to the large impervious areas (e.g. parking lots) available for treatment and the educational benefits of installing a BMP on-site. Residents who provided feedback via online survey or by attending the public meeting held in November 2014 was taken into account. The feedback helped determine several locations where erosion, flooding, or water quality were of concern. Several of the sites identified met multiple criteria for a successful project and therefore were recommended in this Master Plan.

5.3 RECOMMENDED BMPS

Based on field visits and the above criteria, ten (10) sites were recommended for BMP retrofits in the Swift Creek Watershed. Factors that eliminated a site from consideration included the following: limited space, tree density, utility conflicts (e.g. high voltage transformers and other electrical distribution equipment), and insufficient topographic relief. Potential BMP sites show in Figure 5-3 that were removed from consideration after completing a site visit included

Christ's Church swale, Ridgewood Elementary Wet Pond retrofit, Brighton Place wetland, Bristolmoor RSC, and Emerald Park #1 Bioretention.

Preliminary conceptual design calculations completed for each of the recommended BMPs are included in Appendix I. The design calculations were based on methodologies found in the NCDEQ Stormwater BMP Manual. The size of the BMP is based on the contributing watershed area and the amount of impervious area within the watershed. Per NCDEQ requirements, the recommended BMPs were designed to treat runoff from the first one-inch of rainfall. The treatment volume is directly correlated to the amount of impervious area. Watersheds with larger amounts of impervious area convert more of the rainfall into runoff, thereby requiring a larger sized BMP.


Legend
Potential BMP Types
Bioretention
RSC
Swale
Wet Pond
Wetland
Streets
Expressway
Highway
Major Road
Local Road
Streams
Tributaries
Water Bodies
Neighboring Cities
City of Greenville
Swift Creek Watershed
Swift Creek Watershed Master Plan
Figure 5-3
BMP Overview Map
0 1,000 2,000 4,000
1 inch = 3,000 feet
Greenville
NORTH CAROLINA
WK DICKSON
South Bend RSC
Ridgewood Elementary Bioretention
Thomas Langston Detention Pond
Wells Fargo Wet Pond Retrofit
Megan Drive Detention Pond
Sterling Pointe Apartments
Pinecrest Water Quality Swale
Dana Brooke Wetland
Emerald Park Bioretention
Pitt County Community College Regional Detention
South Central High Bioretention
Bristolmoor
Davenport Road Water Quality Swale
South Central High RSC
Dickinson Ave
Swift Creek
SCUT1
Gum Swamp
Fire Tower Rd
Firetower Rd
Memorial Dr
Main St
Evans St
Tar Rd
903
13

Swift Creek Water Quality Project #1: Ridgewood Elementary Bioretention

A bioretention area is proposed in the open area downstream of the main parking lot for Ridgewood Elementary School (See Picture 5-6). This area drains the parking lot and some rooftop runoff from the school adjacent buildings. Some residential development is planned upstream of the drainage area and the City has noted erosion concerns in the channels draining downstream. A bioretention area close to the main parking lot of the school and front entrance also provide water quality educational opportunities. The bioretention area may be used in series with the existing wet pond downstream, which may require adding additional infrastructure to direct outflow from the bioretention area to the pond. The bioretention area will primarily provide water quality benefits by infiltrating and attenuating runoff prior to its discharge into Swift Creek.

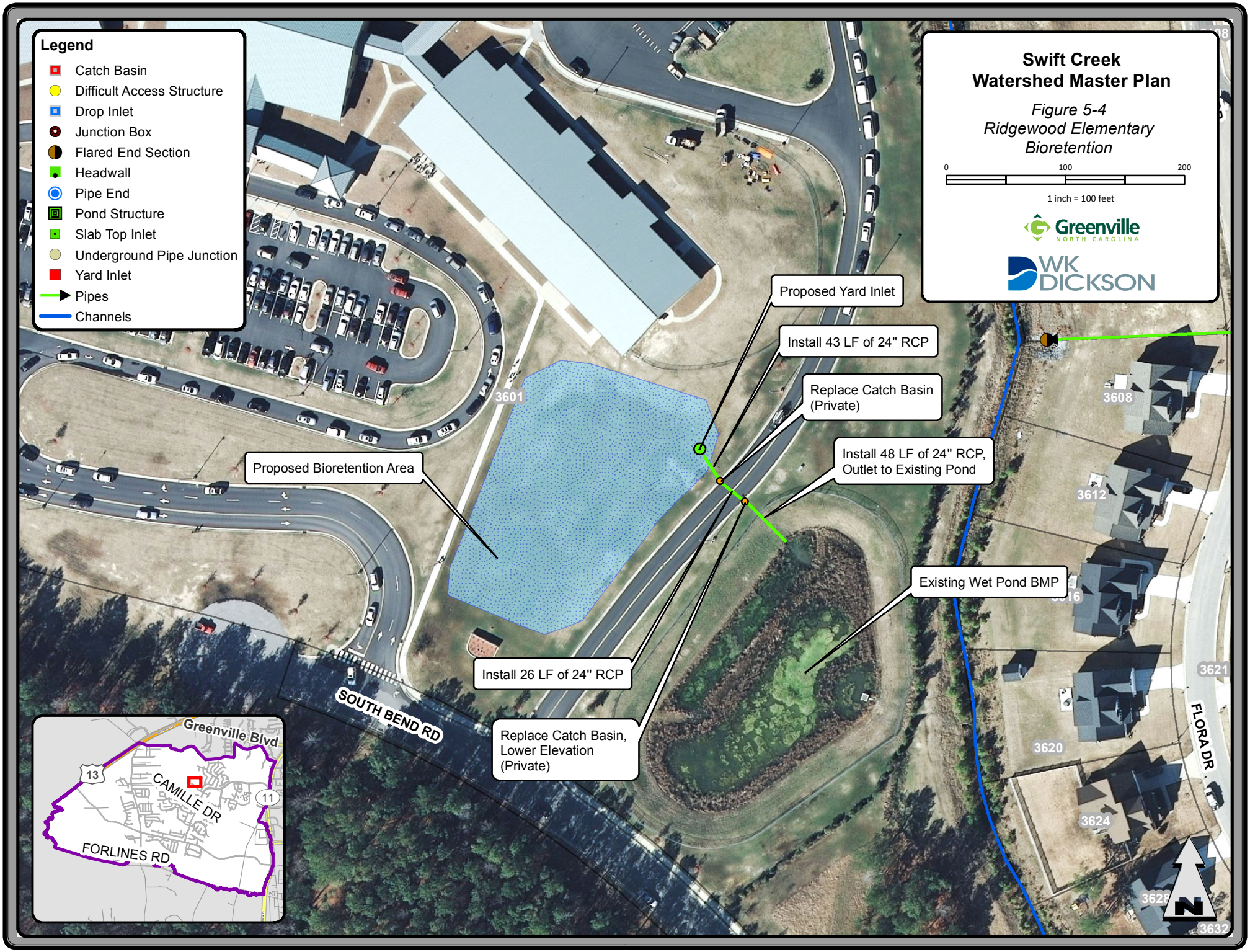
Picture 5-6. Proposed Location for Ridgewood Elementary Bioretention Area

The required surface area for the proposed bioretention is approximately 6,500 square feet (0.15 acres). A concept level plan of the proposed improvements is shown in Figure 5-4.

The proposed bioretention project consists of the following improvements:

- Install a bioretention pond designed to treat runoff from the adjacent parking lot and road. The proposed impervious areas draining to the proposed pond is approximately 2.6 acres.
- Install a yard inlet with a 24" outfall pipe directing flow into an existing conveyance system.

The proposed water quality project is located on county property. The estimated construction cost for the bioretention area at Ridgewood Elementary is $330,000.


Legend
Catch Basin
Difficult Access Structure
Drop Inlet
Junction Box
Flared End Section
Headwall
Pipe End
Pond Structure
Slab Top Inlet
Underground Pipe Junction
Yard Inlet
Pipes
Channels
Swift Creek
Watershed Master Plan
Figure 5-4
Ridgewood Elementary
Bioretention
0
100
200
1 inch = 100 feet
Greenville
NORTH CAROLINA
WK DICKSON
Proposed Yard Inlet
Install 43 LF of 24" RCP
Replace Catch Basin
(Private)
Install 48 LF of 24" RCP,
Outlet to Existing Pond
Proposed Bioretention Area
Existing Wet Pond BMP
Install 26 LF of 24" RCP
Replace Catch Basin,
Lower Elevation
(Private)
SOUTH BEND RD
FLORA DR
3601
3608
3612
3620
3621
3624
3628
3632
Greenville Blvd
13
11
CAMILLE DR
FORLINES RD
N

Swift Creek Water Quality Project #2: Pinecrest Water Quality Swale

A water quality swale is proposed in the Pinecrest neighborhood along Davenport Farm Road (See Picture 5-7). This area drains the road as well as runoff from the residential lots on Selwood Lane. From field observations, the existing drainage ditches are susceptible to trash and debris accumulation. This location would benefit from routine maintenance attention. The proposed project includes no plans to alter existing infrastructure. The swale will primarily provide water quality benefits by attenuating and slowing runoff prior to its discharge into Swift Creek.

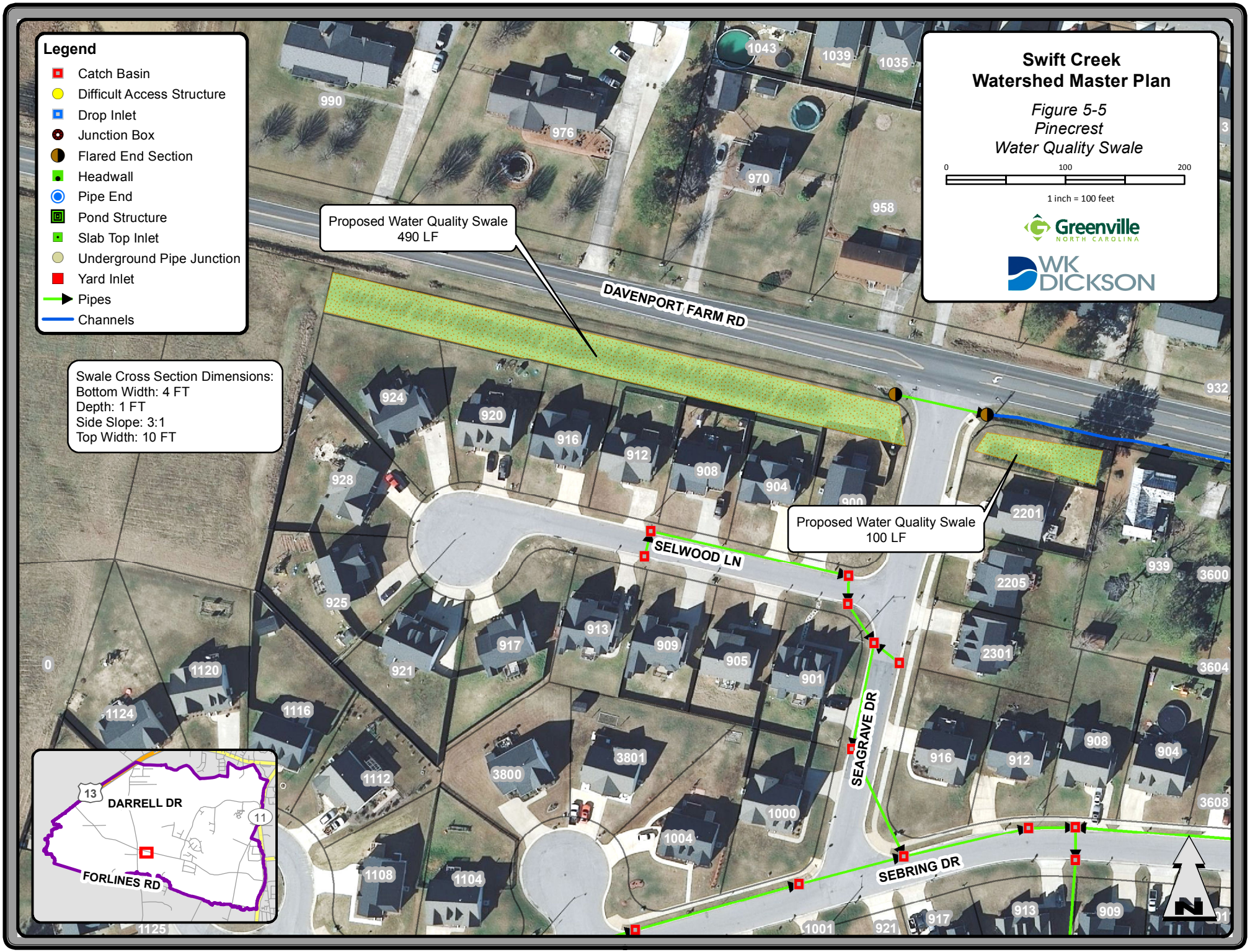
Picture 5-7. Proposed Location for Pinecrest Water Quality Swale

There are two proposed swales in this system and both with tie into existing stormwater runoff channels. The longest swale is 590 feet and the next swale downstream is 100 feet. Both swales have a top width of 10 feet, and depth of 1 foot with 3:1 side slopes. A concept level plan of the proposed improvements is shown in Figure 5-5.

The proposed water quality swale project consists of the following improvements:

- Install a swale designed to treat runoff from the adjacent lot and road. The proposed impervious areas draining to the proposed swale is approximately 2.1 acres.

The proposed water quality project is located on public property. The estimated construction cost for the water quality swale at Pinecrest is $50,000.


Legend
Catch Basin
Difficult Access Structure
Drop Inlet
Junction Box
Flared End Section
Headwall
Pipe End
Pond Structure
Slab Top Inlet
Underground Pipe Junction
Yard Inlet
Pipes
Channels
Swale Cross Section Dimensions:
Bottom Width: 4 FT
Depth: 1 FT
Side Slope: 3:1
Top Width: 10 FT
Proposed Water Quality Swale
490 LF
Proposed Water Quality Swale
100 LF
DAVENPORT FARM RD
SELWOOD LN
SEAGRAVE DR
SEBRING DR
DARRELL DR
FORLINES RD
Swift Creek
Watershed Master Plan
Figure 5-5
Pinecrest
Water Quality Swale
0
100
200
1 inch = 100 feet
Greenville
NORTH CAROLINA
WK DICKSON
N

Swift Creek Water Quality Project #3: Emerald Park Bioretention

A bioretention area is proposed in the open area next to Garnet Way in the Emerald Park subdivision (See Picture 5-9). This area drains residential lots and nearby streets. Stormwater runoff from the upstream neighborhood and street flows can be directed into the bioretention area. Some existing landscaping may be impacted, but the planting plan can include aesthetically pleasing vegetation for this highly visible area. There are no known utility conflicts in this area. The bioretention area will primarily provide water quality benefits by attenuating runoff prior to its discharge into Gum Swamp.

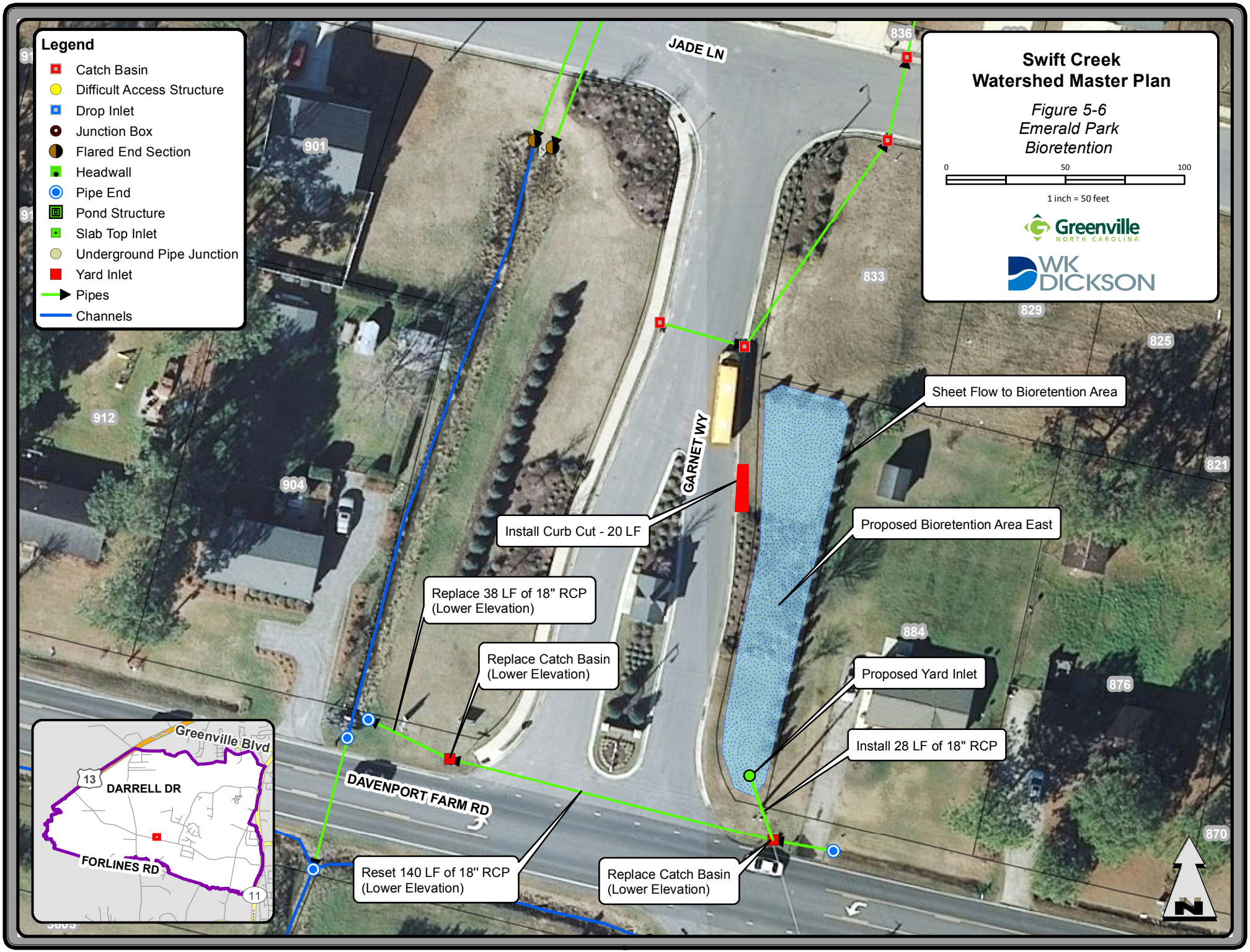
Picture 5-9. Proposed Location for Emerald Park Bioretention Area

The required surface area for the proposed bioretention is approximately 4,300 square feet (0.10 acres). A concept level plan of the proposed improvements is shown in Figure 5-6.

The proposed bioretention project consists of the following improvements:

- Install a bioretention pond designed to treat runoff from the adjacent lot and road. The proposed impervious areas draining to the proposed pond is approximately 1.1 acres.
- Install a yard inlet with an 18″ outfall pipe directing flow into an existing conveyance system.

The proposed water quality project is located on public property. The estimated construction cost for the bioretention area at Emerald Park is $240,000.


Legend
Catch Basin
Difficult Access Structure
Drop Inlet
Junction Box
Flared End Section
Headwall
Pipe End
Pond Structure
Slab Top Inlet
Underground Pipe Junction
Yard Inlet
Pipes
Channels
Swift Creek
Watershed Master Plan
Figure 5-6
Emerald Park
Bioretention
0
50
100
1 inch = 50 feet
Greenville
NORTH CAROLINA
WK DICKSON
JADE LN
GARNET WY
DAVENPORT FARM RD
DARRELL DR
FORLINES RD
Greenville Blvd
13
11
Sheet Flow to Bioretention Area
Install Curb Cut - 20 LF
Proposed Bioretention Area East
Replace 38 LF of 18" RCP
(Lower Elevation)
Replace Catch Basin
(Lower Elevation)
Proposed Yard Inlet
Install 28 LF of 18" RCP
Reset 140 LF of 18" RCP
(Lower Elevation)
Replace Catch Basin
(Lower Elevation)
836
901
833
829
825
912
904
821
884
876
870

Swift Creek Water Quality Project #4: Davenport Farm Road Water Quality Swales

A water quality swale is proposed along Davenport Farm Road (See Picture 5-10). This area drains the road as well as runoff from the residential lots on Seneca Court and Shallowford Court. The swales will tie in to the existing stormwater channels along Davenport Farm Road. There are no known utility conflicts and landscaping impacts will be minimal. The swale will primarily provide water quality benefits by attenuating and slowing runoff prior to its discharge into Gum Swamp.

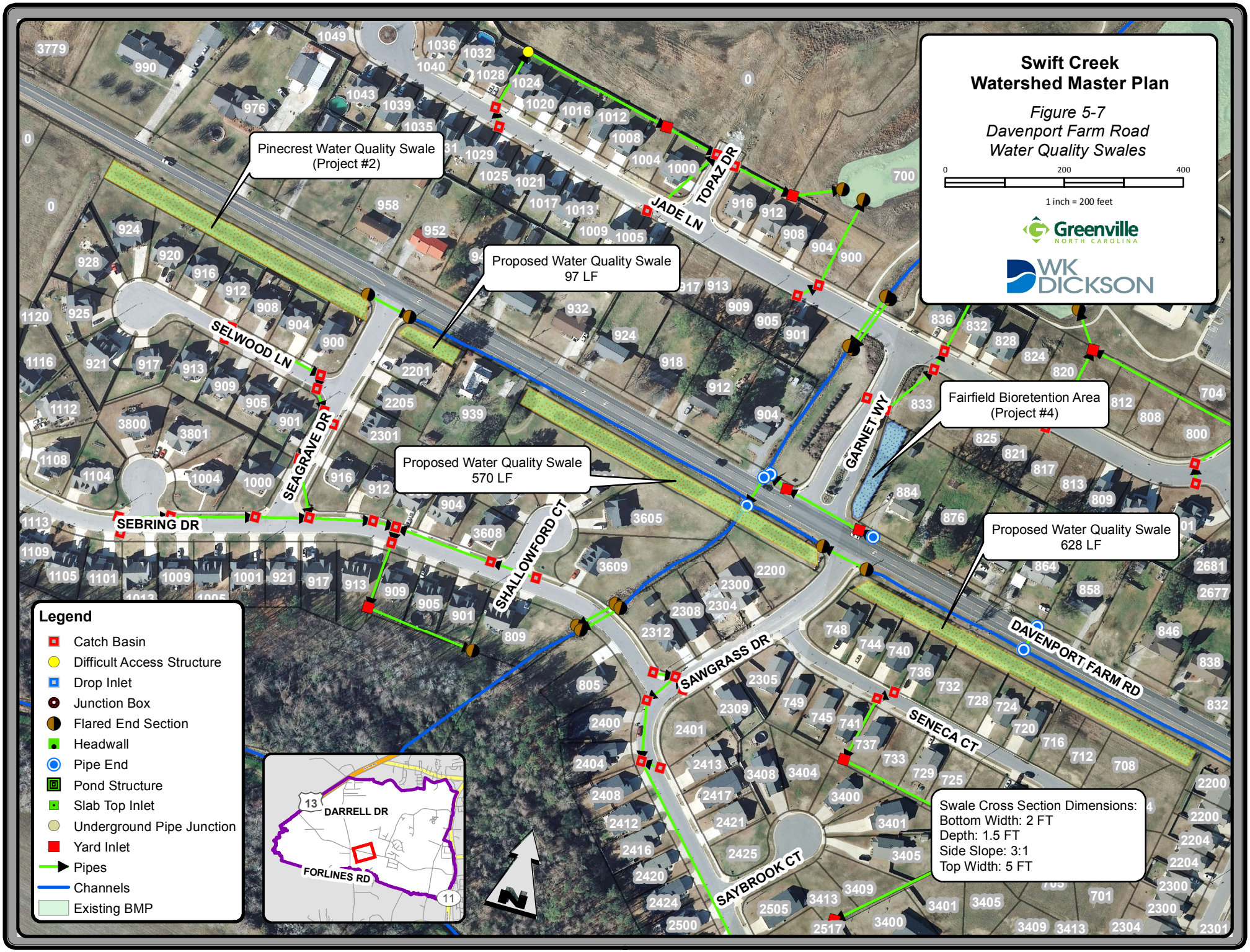
Picture 5-10. Proposed Location for Davenport Farm Road Water Quality Swales

The required length for the proposed swale is approximately 1,785 feet with a top width of 5 feet and depth of 1.5 feet. A concept level plan of the proposed improvements is shown in Figure 5-7.

The proposed water quality swale project consists of the following improvements:

- Install a swale designed to treat runoff from the adjacent lot and road. The proposed impervious areas draining to the proposed swale is approximately 0.95 acres.

The proposed water quality project is located within the DOT easement. The City may want to consider partnering with NCDOT on the swales as they would treat runoff from City areas and NCDOT right-of-way. The estimated construction cost for the water quality swale at Davenport Farm Road is $100,000.


Swift Creek
Watershed Master Plan
Figure 5-7
Davenport Farm Road
Water Quality Swales
0
200
400
1 inch = 200 feet
Greenville
NORTH CAROLINA
WK DICKSON
Pinecrest Water Quality Swale
(Project #2)
Proposed Water Quality Swale
97 LF
Proposed Water Quality Swale
570 LF
Fairfield Bioretention Area
(Project #4)
Proposed Water Quality Swale
628 LF
Swale Cross Section Dimensions:
Bottom Width: 2 FT
Depth: 1.5 FT
Side Slope: 3:1
Top Width: 5 FT
JADE LN
TOPAZ DR
SELWOOD LN
SEAGRAVE DR
SEBRING DR
SHALLOWFORD CT
GARNET WY
SAWGRASS DR
SENECA CT
SAYBROOK CT
DAVENPORT FARM RD
DARRELL DR
FORLINES RD
13
11
Legend
Catch Basin
Difficult Access Structure
Drop Inlet
Junction Box
Flared End Section
Headwall
Pipe End
Pond Structure
Slab Top Inlet
Underground Pipe Junction
Yard Inlet
Pipes
Channels
Existing BMP

Swift Creek Water Quality Project #5: South Bend Regenerative Stormwater Conveyance

A Regenerative Stormwater Conveyance (RSC) system is proposed downstream of a 60'' RCP outlet at the end of South Bend Drive (See Picture 5-11). This area drains residential lots and streets and is located close to the entrance of Ridgewood Elementary School. The proposed location is adjacent to a residential structure with a heavily armored channel susceptible to high flows. An RSC is an ideal project for this area as it will provide some water quality benefit as well as mitigate erosive forces on the existing channel prior to its discharge into Swift Creek.

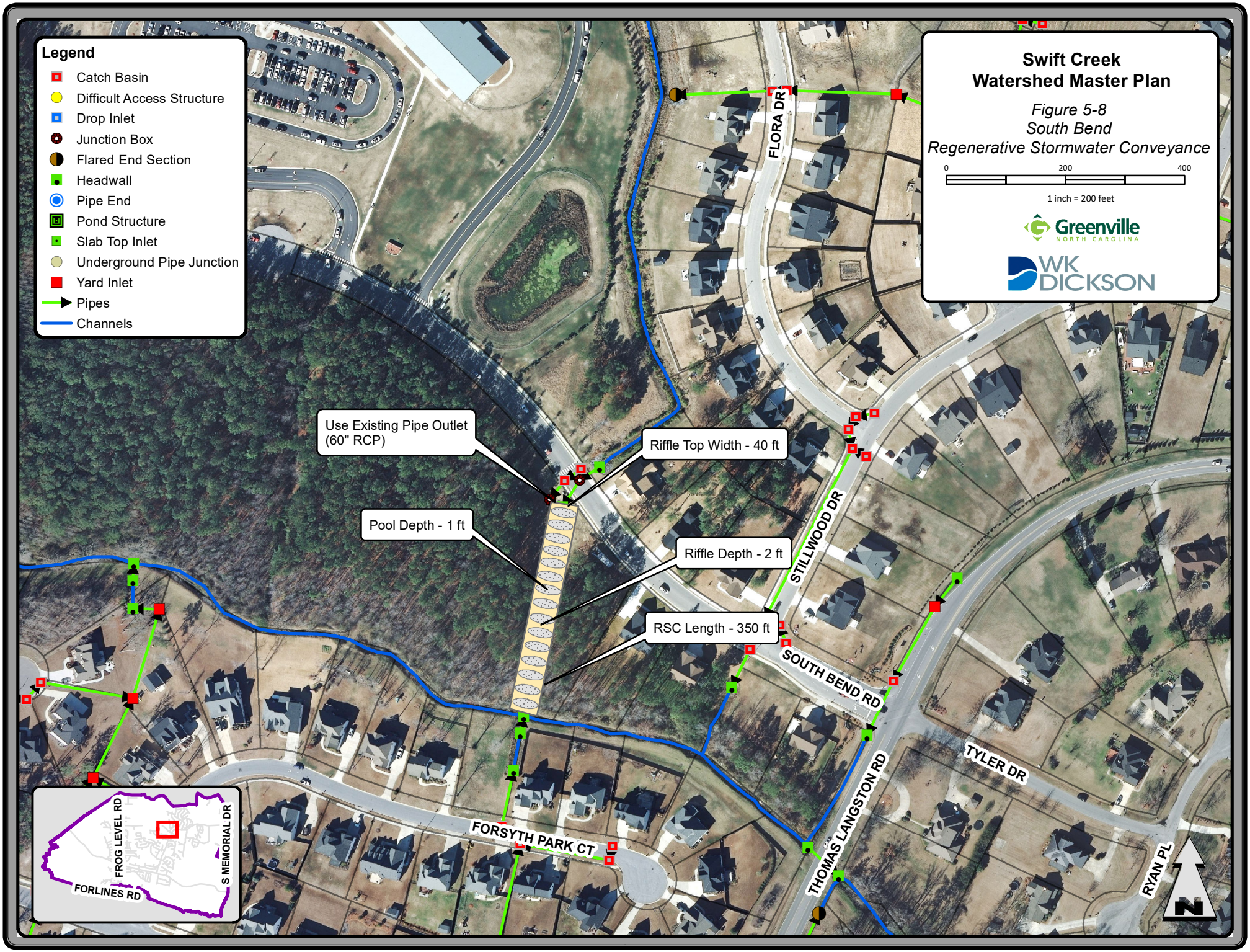
Picture 5-11. Proposed Location for South Bend Regenerative Stormwater Conveyance

The required surface area of the RSC is approximately 10,500 square feet. A concept level plan of the proposed improvements is shown in Figure 5-8.

The proposed RSC project consists of the following improvements:

- Install a RSC designed to treat runoff from the adjacent lot and road. The proposed impervious areas draining to the proposed pond is approximately 9.3 acres.
- Excavate step pools and install required boulders, cobbles, and infiltration media (quantities specified in Appendix I.)

The proposed water quality project is located on private property. In order to construct the RSC, an easement agreement would be required with the owners. The estimated construction cost for the RSC at South Bend Drive is $220,000.


Legend
Catch Basin
Difficult Access Structure
Drop Inlet
Junction Box
Flared End Section
Headwall
Pipe End
Pond Structure
Slab Top Inlet
Underground Pipe Junction
Yard Inlet
Pipes
Channels
Swift Creek
Watershed Master Plan
Figure 5-8
South Bend
Regenerative Stormwater Conveyance
0
200
400
1 inch = 200 feet
Greenville
NORTH CAROLINA
WK DICKSON
Use Existing Pipe Outlet (60" RCP)
Riffle Top Width - 40 ft
Pool Depth - 1 ft
Riffle Depth - 2 ft
RSC Length - 350 ft
FLORA DR
STILLWOOD DR
SOUTH BEND RD
TYLER DR
THOMAS LANGSTON RD
RYAN PL
FORSYTH PARK CT
FROG LEVEL RD
S MEMORIAL DR
FORLINES RD
N

Swift Creek Water Quality Project #6: Wells Fargo Bank Wet Pond Retrofit

A wet pond retrofit is proposed in the open area downstream of the main parking lot for Wells Fargo Bank along Thomas Langston Road (See Picture 5-12). This area drains the parking lot and some rooftop runoff from the adjacent buildings. There is room at the site for the pond to be expanded or dredging may be beneficial as the pond has evidence of sediment deposition indicated by excessive vegetation. A sanitary sewer line runs parallel to the storm channel that the pond eventually discharges to, and there is a gas line between the pond and the Wells Fargo parking lot that will need to be avoided or relocated. There are also parcels to the east of the existing wet pond that are slated for residential townhome development. The wet pond will primarily provide water quality benefits by attenuating runoff prior to its discharge into Swift Creek Tributary 1.

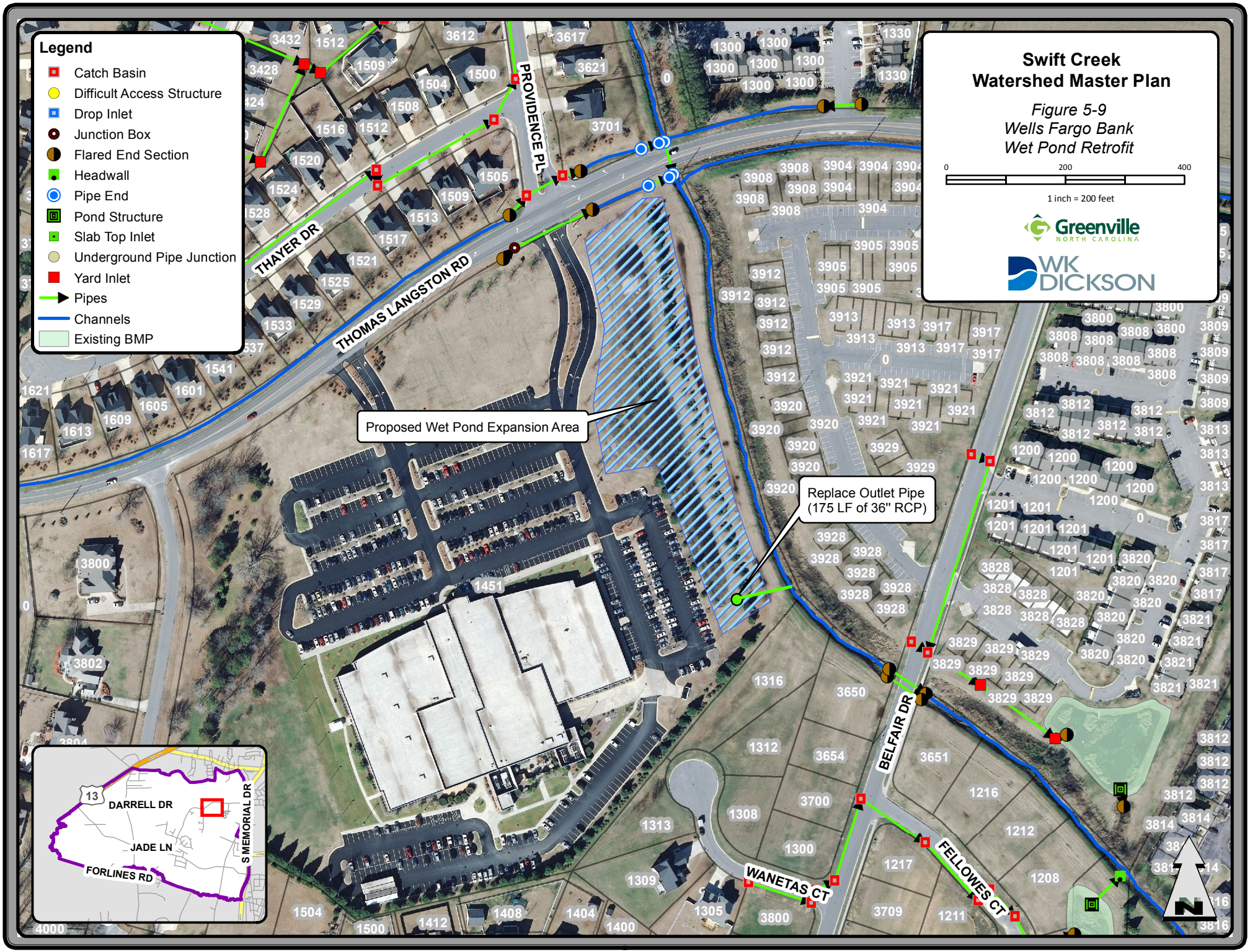
Picture 5-12. Proposed Location for Wells Fargo Bank Wet Pond Retrofit

The proposed surface area for the retrofit is approximately 14,000 square feet (0.32 acres). This project will involve retrofitting an existing wet pond. A concept level plan of the proposed improvements is shown in Figure 5-9.

The proposed wet pond retrofit project consists of the following improvements:

- Retrofit wet pond designed to treat runoff from the adjacent lot and road. The proposed impervious areas draining to the proposed pond is approximately 11.7 acres.
- Install a yard inlet with a 36" outfall pipe directing flow into an existing conveyance system.

The proposed water quality project is located on private property. In order to construct the pond, an easement agreement would be required with the owner. The estimated construction cost for the wet pond retrofit at Wells Fargo Bank is $200,000.


Legend
Catch Basin
Difficult Access Structure
Drop Inlet
Junction Box
Flared End Section
Headwall
Pipe End
Pond Structure
Slab Top Inlet
Underground Pipe Junction
Yard Inlet
Pipes
Channels
Existing BMP
Swift Creek
Watershed Master Plan
Figure 5-9
Wells Fargo Bank
Wet Pond Retrofit
0
200
400
1 inch = 200 feet
Greenville
NORTH CAROLINA
WK DICKSON
Proposed Wet Pond Expansion Area
Replace Outlet Pipe
(175 LF of 36" RCP)
THAYER DR
THOMAS LANGSTON RD
PROVIDENCE PL
BELFAIR DR
WANETAS CT
FELLOWES CT
DARRELL DR
JADE LN
FORLINES RD
S MEMORIAL DR
13
N

Swift Creek Water Quality Project #7: Sterling Pointe Apartments Wet Pond Retrofit

A wet pond retrofit is proposed for the open channel downstream of Sterling Pointe Apartments (See Picture 5-13). This area drains apartment buildings, parking lots, and agricultural area. Currently, stormwater is collected by a private system and treated in a wet pond downstream of the apartment parking lot. Field observations showed that this location is susceptible to trash deposition. Retrofitting the existing outlet structure for this pond may provide up to 5,000 cubic feet of additional storage. This location would likely require the removal of a beaver dam just downstream of the discharge point. The wet pond retrofit will primarily provide water quality benefits by detaining runoff prior to its discharge into Swift Creek Tributary 1.

Picture 5-13. Proposed Location for Sterling Pointe Apartments Wet Pond Retrofit

The required additional surface area is approximately 5,000 square feet. A concept level plan of the proposed improvements is shown in Figure 5-10.

The proposed wet pond retrofit project consists of the following improvements:

- Retrofit wet pond designed to treat runoff from the adjacent lot and road. The proposed impervious areas draining to the proposed pond is approximately 6.9 acres.
- Install a yard inlet with a 36" outfall pipe directing flow into an existing conveyance system.

The proposed water quality project is located on common area. The estimated construction cost for the wet pond retrofit at Sterling Pointe Apartments is $100,000.


Legend
Catch Basin
Difficult Access Structure
Drop Inlet
Junction Box
Flared End Section
Headwall
Pipe End
Pond Structure
Slab Top Inlet
Underground Pipe Junction
Yard Inlet
Pipes
Channels
Retrofit Existing BMP Outlet
Proposed Additional Storage Area - 5,000 sq ft
Install 53 LF of 36" RCP
Remove Beaver Dam/Debris
13
DARRELL DR
11
FORLINES RD
Swift Creek
Watershed Master Plan
Figure 5-10
Sterling Pointe Apartments
Wet Pond Retrofit
0
100
200
1 inch = 100 feet
Greenville
NORTH CAROLINA
WK DICKSON

Swift Creek Water Quality Project #8: South Central High School Regenerative Stormwater Conveyance

A Regenerative Stormwater Conveyance (RSC) system is proposed for the open channel formed on the athletic field downstream of South Central High School (See Picture 5-14). This area drains adjacent apartments, parking lots, and recreational area. Since this area is already channelized and possibly unstable, an RSC system is a potential BMP for this area. There is opportunity to use the system for water quality education since it is located on school property. A water main pipe is buried nearby but should not affect the proposed location. The RSC will primarily provide water quality benefits by slowing and infiltrating runoff prior to its discharge into Gum Swamp.

Picture 5-14. Proposed Location for South Central High Regenerative Stormwater Conveyance

The required surface area of the RSC is approximately 5,200 square feet. A concept level plan of the proposed improvements is shown in Figure 5-11.

The proposed RSC project consists of the following improvements:

- Install a RSC designed to treat runoff from the adjacent lot and road. The proposed impervious areas draining to the proposed pond is approximately 2.4 acres.
- Excavate step pools and install required boulders, cobbles, and infiltration media. The quantities are specified in Appendix I.

The proposed water quality project is located on county property. The estimated construction cost for the RSC at South Central High School is $140,000.

Swift Creek Water Quality Project #9: South Central High School Bioretention

A bioretention area is proposed in the open area next to South Central High School (See Picture 5-15). This area drains school buildings, parking lots, and athletic fields. The proposed location is currently functioning as an infiltration basin with a 24'' RCP outlet presumed to discharge to Gum Swamp. Retrofitting this area with a water quality bioretention design will provide additional storage in the internal water storage zone, as well as the water quality benefits the soil media infiltration provide. The existing infrastructure (private) will require additional modifications to tie-in properly with the BMP. The bioretention area will primarily provide water quality benefits by attenuating runoff prior to its discharge into Gum Swamp.

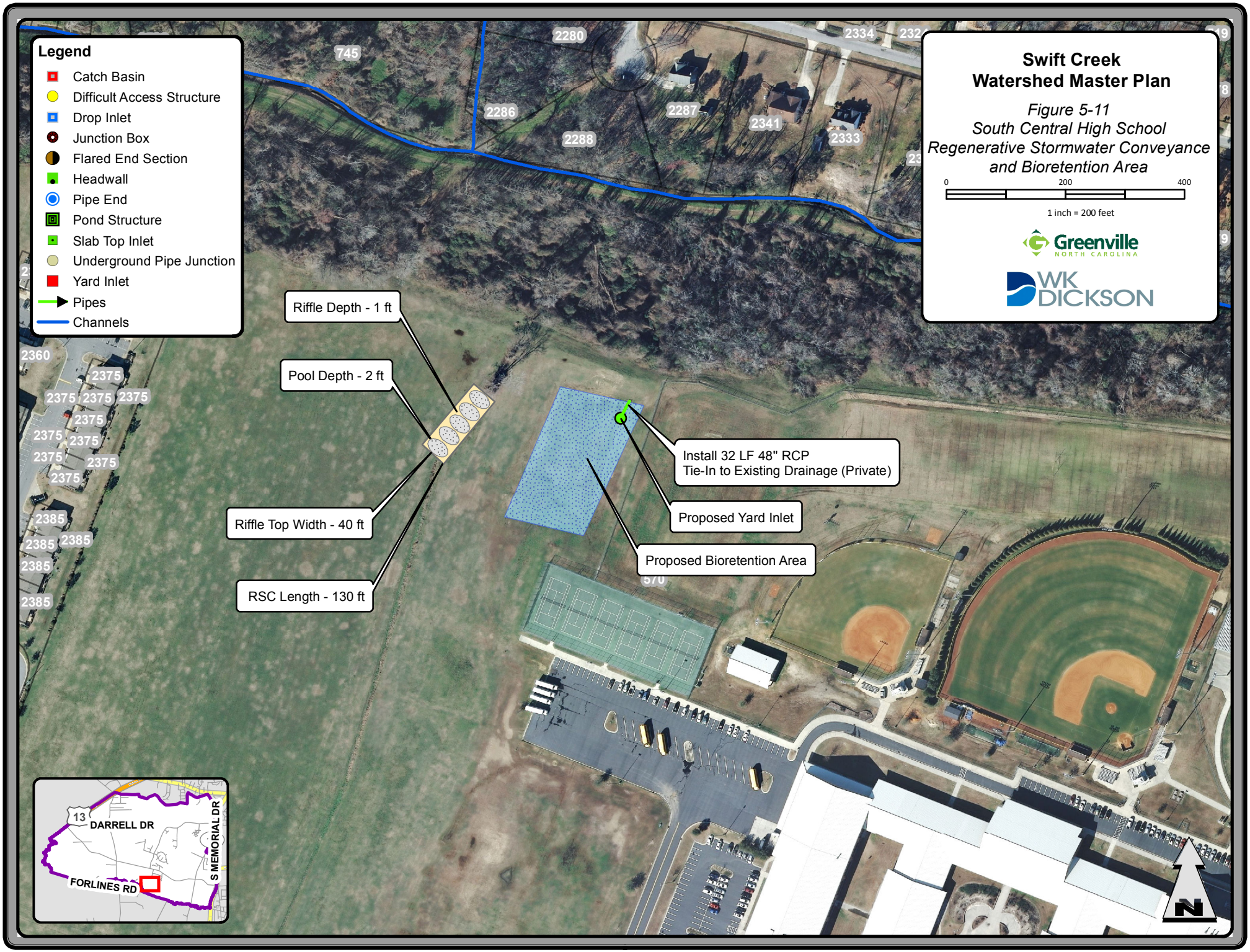
Picture 5-15. Proposed Location for South Central High School Bioretention Area

The required surface area for the proposed bioretention is approximately 27,000 square feet (0.62 acres), however 33,000 square feet (0.76 acres) are available to maximize the water quality benefit and decrease the possibility of ponded water on school grounds. The size of the bioretention area could also be reduced and still provide benefit if the land is needed for other uses, or the construction cost is too high. A concept level plan of the proposed improvements is shown in Figure 5-11.

The proposed bioretention project consists of the following improvements:

- Install a bioretention pond designed to treat runoff from the adjacent lot and road. The proposed impervious areas draining to the proposed pond is approximately 13.1 acres.
- Install a yard inlet with a 42" outfall pipe directing flow into an existing conveyance system.

The proposed water quality project is located on county property. The estimated construction cost for the bioretention area at South Central High School is $1,300,000.


Legend
Catch Basin
Difficult Access Structure
Drop Inlet
Junction Box
Flared End Section
Headwall
Pipe End
Pond Structure
Slab Top Inlet
Underground Pipe Junction
Yard Inlet
Pipes
Channels
Swift Creek
Watershed Master Plan
Figure 5-11
South Central High School
Regenerative Stormwater Conveyance
and Bioretention Area
0
200
400
1 inch = 200 feet
Greenville
NORTH CAROLINA
WK DICKSON
Riffle Depth - 1 ft
Pool Depth - 2 ft
Riffle Top Width - 40 ft
RSC Length - 130 ft
Install 32 LF 48" RCP
Tie-In to Existing Drainage (Private)
Proposed Yard Inlet
Proposed Bioretention Area
13
DARRELL DR
S MEMORIAL DR
FORLINES RD
N

Swift Creek Water Quality Project #10: Dana Brooke Wetland

A water quality wetland is proposed in the open area downstream of the Taberna subdivision south of Davenport Farm Road (See Picture 5-16). This area drains residential area and agricultural fields. The wetland will achieve maximum water quality benefit if the existing stream can be diverted to the wetland for treatment. There are minimal impacts from utilities; a gas line runs parallel with Davenport Farm Road that can be avoided during construction. Although this parcel is private property, the field visit confirmed the parcel is for sale. Therefore, there is an opportunity to work with the future developer to provide an 'enhanced' BMP treatment facility for the development. The wetland will primarily provide water quality benefits by attenuating runoff prior to its discharge into Gum Swamp.

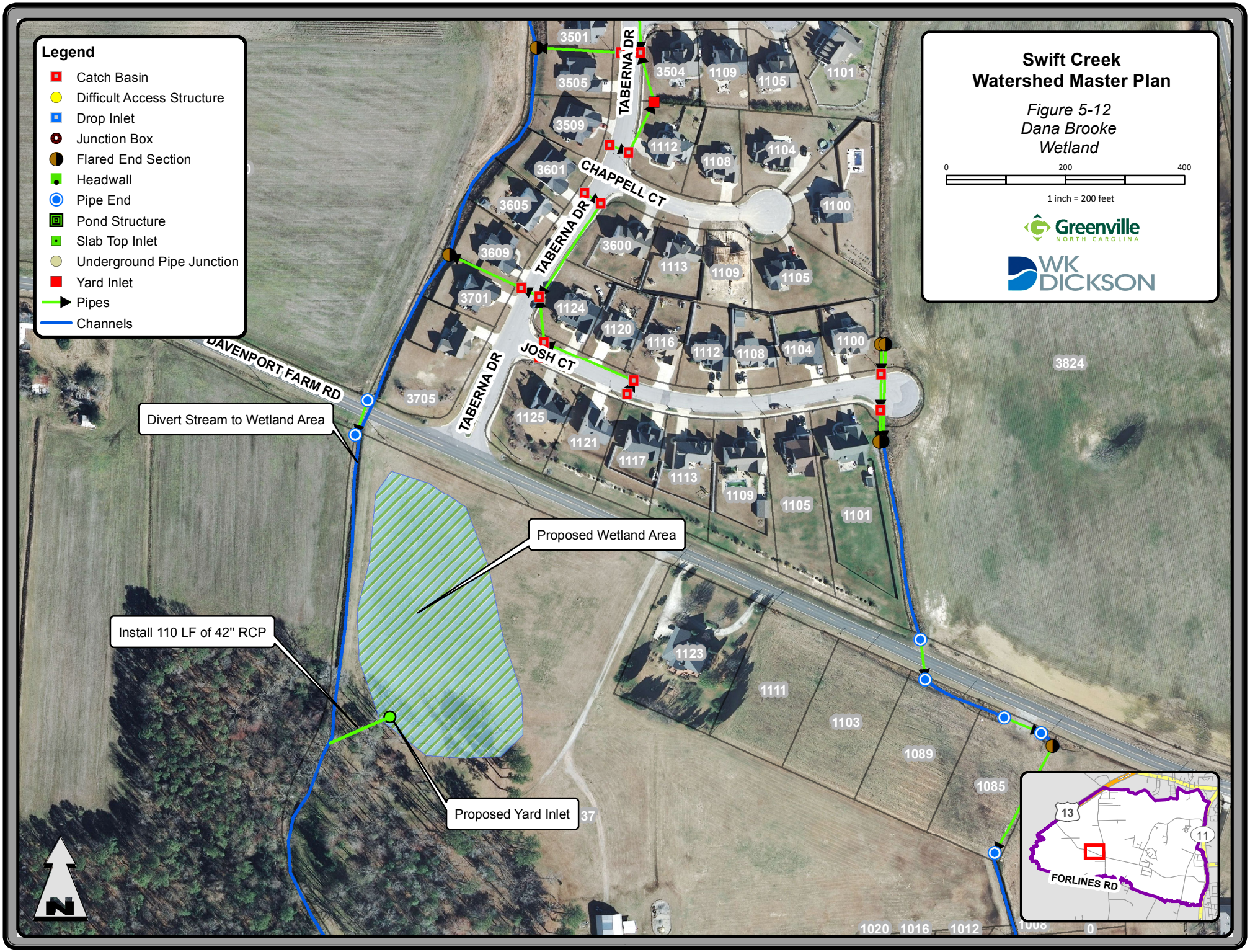
Picture 5-16. Proposed Location for Dana Brooke Wetland

The required surface area for the proposed wetland is approximately 94,000 square feet (2.2 acres). A concept level plan of the proposed improvements is shown in Figure 5-12.

The proposed wetland project consists of the following improvements:

- Install a wetland pond designed to treat runoff from the adjacent lots and road. The proposed impervious areas draining to the proposed pond is approximately 33 acres.
- Install a yard inlet with a 42" outfall pipe directing flow into an existing conveyance system.

The proposed water quality project is located on private property. In order to construct the wetland, an easement agreement would be required with the owner. The estimated construction cost for the wetland is $930,000.


Legend
Catch Basin
Difficult Access Structure
Drop Inlet
Junction Box
Flared End Section
Headwall
Pipe End
Pond Structure
Slab Top Inlet
Underground Pipe Junction
Yard Inlet
Pipes
Channels
Swift Creek
Watershed Master Plan
Figure 5-12
Dana Brooke
Wetland
0
200
400
1 inch = 200 feet
Greenville
NORTH CAROLINA
WK DICKSON
TABERNA DR
CHAPPELL CT
JOSH CT
DAVENPORT FARM RD
FORLINES RD
Divert Stream to Wetland Area
Proposed Wetland Area
Install 110 LF of 42" RCP
Proposed Yard Inlet
3501
3504
3505
3509
3601
3605
3609
3600
3701
3705
3824
1109
1105
1101
1112
1108
1104
1100
1113
1124
1120
1116
1125
1121
1117
1123
1111
1103
1089
1085
1020
1016
1012
13
11

5.4 NUTRIENT REMOVAL CAPACITIES

Along with determining the size and other design parameters for the proposed BMPs, nutrient removal efficiencies were calculated. Total Nitrogen (TN) and Total Phosphorous (TP) were computed based on the removal efficiencies provided in Jordan Lake Nutrient Loading Accounting Tool, version 2.0. While the Jordan Lake tool was developed specifically to address the Jordan Lake and Falls Lake Rules, the tool can apply throughout the State provided the appropriate physiographic location is used. For Greenville and Pitt County the Coastal Plain loading rates are recommended. Benefits of BMP retrofits should be revisited prior to implementation to utilize the most current research as these tools are frequently refined based on updated monitoring results and innovative technologies. The tool is available on NCDEQ website (http://portal.ncdenr.org/web/jordanlake/implementation-guidance-archive).

The tool provided the nutrient effluent concentrations and removal efficiencies for each BMP. It should be noted that the tool does not contain an entry for RSC systems, therefore the 'Sand Filter' option was used since RSCs function similarly to this BMP. The percent reduction has a direct effect on the concentration of nutrients in runoff. The calculated removal efficiencies are provided in the table below.

Table 5-1: Proposed BMP Pollutant Removal

Project	TN Removed (lb/ac/yr)	TP Removed (lb/ac/yr)
Project #1 – Ridgewood Elementary Bioretention	5.72	2.07
Project #2 – Pinecrest Water Quality Swale	1.21	0.93
Project #3 – Emerald Park Bioretention	3.57	1.18
Project #4 – Davenport Farm Road Water Quality Swales	1.19	0.69
Project #5 – South Bend RSC	1.83	0.91
Project #6 – Wells Fargo Bank Wet Pond Retrofit	3.87	2.87
Project #7 – Sterling Pointe Apartments Wet Pond Retrofit	3.13	2.14
Project #8 – South Central High School RSC	1.43	0.57
Project #9 – South Central High School Bioretention	6.77	2.53
Project #10 – Dana Brooke Wetland	2.18	1.20

5.5 IMPAIRED WATERS

Since 1998, Swift Creek has been classified as impaired for Benthos from NC 102 east of Ayden to the source. While a significant portion of the impaired reach is south of the City limits, approximately 3 miles of the impaired reach is either within City limits or within the City's ETJ. The impairment classification is based on one sampling event at NC 102 in 1995 that resulted in a Benthos rating of poor using the EPT sampling method. No specific stressors were identified by NCDEQ as the primary causes of the impaired status. Extensive water quality monitoring efforts were conducted in Swift Creek and its tributaries as well as sampling of the benthic macroinvertebrate community to better identify the existing conditions within the watershed and to determine if Swift Creek appears to be currently impaired with respect to Benthos

5.5.1 ASSESSMENT OF EXISTING WATER QUALITY CONDITIONS

East Carolina University (ECU) completed a water quality monitoring program in the Swift Creek watershed to determine whether nutrients, pathogens, sediments, or metals are impairing Swift Creek. Monitoring efforts included sampling stream flow during base and storm flow conditions a minimum of four times at seven different locations in Swift Creek. Monitoring locations are shown in Figure 5-13. A complete report of the water quality monitoring program is provided in Appendix M.

Sampling results were compared with water quality standards or surrogate standards to evaluate if parameters could potentially be contributing to stream degradation. The standards were more frequently exceeded during storm flow events rather than baseflow events.

Total Suspended Solids (TSS) concentrations exceeded NC standards for High Quality Waters during two storm events at most sampling locations in Swift Creek, while the turbidity standard was exceeded during the November 2014 storm event at five sites. Agricultural land use likely contributed to the exceedances in TSS and turbidity.

E. coli standards were only exceeded during one baseflow event, however all three storm events exceeded the standard primarily upstream of SC6, which would predominantly be located in or near Greenville City limits. Similar trends were found for chloride and organic nitrogen which could indicate a wastewater source of contamination within the watershed.

Nutrient concentrations did not exceed numeric standards, although Nitrate concentrations did increase downstream from the headwaters for both baseflow and stormflow events. The isotope analyses indicated that fertilizer or soil was likely the contributor of nitrate, however the isotope analysis at SC4 was more enriched which could indicate a wastewater source. Additional monitoring would be required, however if the source of wastewater could be isolated and repaired/treated, the water quality along the main stem could improve.

5.5.2 ASSESSMENT OF BENTHIC MACROINVERTEBRATE COMMUNITY

As part of the Master Plan, WK Dickson completed benthic macroinvertebrate sampling in 2014 and 2015 at multiple locations to clarify the extent of level of impairment in Swift Creek.

Benthic sampling was completed at seven locations in August 2014. Figure 5-13 shows the sampling locations throughout the Swift Creek Watershed. The most downstream sampling point is located at NC 102 where DENR completed the initial sampling that resulted in impairment. The August 2014 sampling results indicated that several of the upstream sampling sites had subwatersheds that were too small to collect data that would be comparable to the DENR compliance point. Therefore, benthic sampling efforts in February 2015 and August 2015 focused on the two most downstream sampling points shown as Points 6 and 7 in Figure 5-13. Sampling results for the three events are provided in Table 5-2.

Table 5-2: Swift Creek Benthic Monitoring Results

August 2015							
Site ID	1	2	3	4	5	6	7
EPT Taxa Richness	2	1	2	2	3	4	5
NC Biotic Index	7.6	7.5	7.1	7.3	7.2	6.5	6.6
Bioclassification[1]	F	F	F	F	F	G-F	G-F
Sampling Method	Standard Qualitative						
	February 2015			August 2015			
Site ID	6	7		6	7		
EPT Taxa Richness	2	4		9	13		
NC Biotic Index	7.6	6.4		6.8	6.6		
Bioclassification	F[1]	G-F[1]		G-F	G-F		
Sampling Method	Swamp			Standard Qualitative			

The Swift Creek benthic results demonstrate observable improvement between the 1995 and 2015 collections. The 2015 bioclassifications at sites 6 (NC 11) and 7 (NC 102) were Good-Fair as compared to Poor in 1995 at NC 102. In spite of the bioclassification ratings, the benthic habitat remains poor. Evidence of poor habitat is corroborated by the stream assessments as well as the ambient monitoring completed by ECU. The trend ambient monitoring results show high levels of total suspended solids and inorganic nitrogen at the sampling locations. The high levels of inorganic nitrogen could potentially be contributed to the channelization of the stream and a lack of woody debris that can limit the amount of denitrification. The higher TSS concentrations were found predominantly during wet weather events that can be indicative of in stream erosion and scour.

5.5.3 WATER QUALITY MANAGEMENT STRATEGIES

Based on the results summarized above, there is support for Swift Creek potentially to be delisted from the Category 5 list and not be considered impaired. The City should consider submitting the benthic monitoring results to the State for evaluation in delisting or reducing the length of impairment. Regardless of the State's determination of impairment, WK Dickson recommends the following strategies for improving water quality in the Swift Creek Watershed:

Establish riparian buffers: Due to a variety of factors including agricultural practices, residential development, and maintenance of the Pitt County Drainage District Easements, the majority of streams in the Swift Creek watershed have limited to no buffers. This allows pollutants to more easily runoff into the streams without being infiltrated and treated by a vegetated buffer. In addition, the lack of vegetation has caused increased stream erosion which provides a significant source of sediment to the stream.

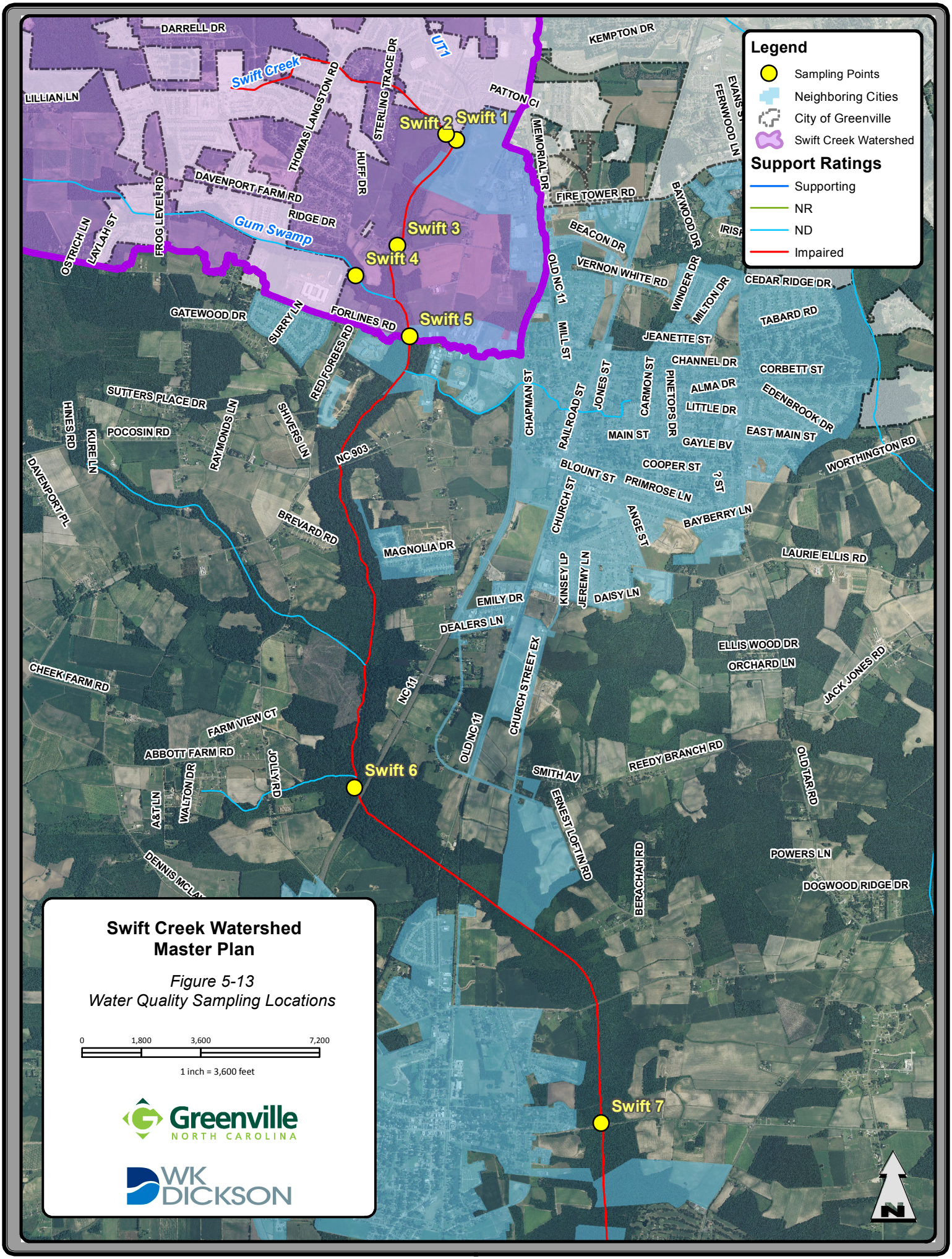
Stream stabilization: Complete stream stabilization projects recommended in this report to reduce instream sources of sediment.

Habitat enhancement: In part due to the maintenance activities of the Pitt County Drainage District, woody debris has been systematically removed from the stream to promote drainage and reduce the potential for blockages at crossings and within the stream. However, the benthic community depends on woody structures and debris for habitat a source of organic carbon. Habitat enhancement at key locations can improve the vitality and diversity of the benthic community.

Benthic relocation: Once habitat enhancement has been completed, a benthos community from a healthy ecosystem such as the reference reach in Hardee Creek can be relocated to Swift Creek to help accelerate the growth of the benthic community in Swift Creek.

Stormwater treatment: As development continues to occur in the watershed, stormwater treatment will be critical to improving the water quality. The health of the benthic community is typically tied to the amount of impervious surface in the watershed. The ten (10) BMP retrofit sites recommended as part of this Master Plan should be evaluated for implementation to help treat the existing stormwater runoff in the watershed.

Additional sampling in SC4: The City should consider additional sampling efforts in the tributary draining to SC4 to determine if there are sources of contamination related to wastewater and if so identify those sources to eliminate the intrusion of wastewater into the stream.


Legend
Sampling Points
Neighboring Cities
City of Greenville
Swift Creek Watershed
Support Ratings
Supporting
NR
ND
Impaired
Swift 1
Swift 2
Swift 3
Swift 4
Swift 5
Swift 6
Swift 7
Swift Creek
UT1
Gum Swamp
DARRELL DR
LILLIAN LN
THOMAS LANGSTON RD
STERLING TRACE DR
PATTON CI
KEMPTON DR
FERNWOOD LN
MEMORIAL DR
FIRE TOWER RD
BAYWOOD DR
DAVENPORT FARM RD
HUFF DR
RIDGE DR
FROG LEVEL RD
OSTRICH LN
LAYLAH ST
BEACON DR
VERNON WHITE RD
WINDER DR
MILTON DR
CEDAR RIDGE DR
TABARD RD
OLD NC 11
MILL ST
JEANETTE ST
GATEWOOD DR
SURRY LN
FORLINES RD
RED FORBES RD
CHANNEL DR
CORBETT ST
ALMA DR
EDENBROOK DR
LITTLE DR
EAST MAIN ST
SUTTERS PLACE DR
HINES RD
KURE LN
POCOSIN RD
RAYMONDS LN
SHIVERS LN
CHAPMAN ST
RAILROAD ST
JONES ST
CARMON ST
PINETOPS DR
MAIN ST
GAYLE BV
NC 903
BLOUNT ST
COOPER ST
PRIMROSE LN
WORTHINGTON RD
DAVENPORT PL
BREVARD RD
CHURCH ST
ANGE ST
BAYBERRY LN
MAGNOLIA DR
LAURIE ELLIS RD
KINSEY LP
JEREMY LN
DAISY LN
EMILY DR
DEALERS LN
ELLIS WOOD DR
ORCHARD LN
JACK JONES RD
CHEEK FARM RD
NC 11
CHURCH STREET EX
FARM VIEW CT
ABBOTT FARM RD
OLD NC 11
REEDY BRANCH RD
OLD TAR RD
JOLLY RD
WALTON DR
A&T LN
SMITH AV
ERNEST LOFTIN RD
BERACHAH RD
POWERS LN
DOGWOOD RIDGE DR
DENNIS MCLA
Swift Creek Watershed Master Plan
Figure 5-13
Water Quality Sampling Locations
0
1,800
3,600
7,200
1 inch = 3,600 feet
Greenville
NORTH CAROLINA
WK DICKSON
N

PUBLIC EDUCATION AND OUTREACH

Successful implementation of the Swift Creek Watershed Master Plan and stormwater as a whole requires extensive public education and outreach. The City has taken important steps in public outreach within the Swift Creek watershed through the use of direct mail questionnaires, web-based applications, and public meetings. Questionnaires were mailed to residents throughout the watershed in August of 2014 requesting feedback on flood-prone areas and any water quality concerns. Compiled results of the questionnaires can be found in Appendix D.

A public meeting was held on November 4, 2014, to introduce the project and facilitate further feedback from the public. The initial public feedback is critical to identifying flood-prone areas and validating model results. A follow-up was held on November 17, 2015 to share results of the Master Plan with the public. As selected projects proceed into design and construction continuous public outreach will be critical to the success of the projects. Additional public meeting and individual property owner meetings will help educate property owners on the benefits of the proposed projects as well as the temporary and permanent impacts from construction.

Aside from the public education and outreach completed for projects specific to the Swift Creek Watershed Master Plan, the City has several programs dedicated to educating the public about water quality and pollution. The City's website provides information about the Stormwater Program and the development of the Stormwater Utility and associated fees. Another outreach measure that could be considered would be to target those City residents that live adjacent to streams. For this select group, quarterly newsletter could be mailed presenting information regarding the importance of not illegally discharging item (e.g. yard waste, car batteries, and other miscellaneous debris) into the stream. The newsletter should encourage the residents to keep the stream clean and report any blockage.

A different approach could be coordinating with local schools to teach the students about age appropriate stormwater issues. There are many benefits to teaching children about stormwater issues including the students relaying the information to their parents. A presentation could be done in conjunction with an afternoon spent visiting and cleaning up a nearby stream. Adding an educational BMP near a school and park would be another outreach opportunity. The projects proposed at Ridgewood Elementary School would be an example. This along with the previously mentioned newsletter could be included in the Public Education section of the City's Action Report and Plan that must be completed annually to meet the requirements of the Neuse River Basin stormwater program.

ANTICIPATED PERMITTING

The proposed improvements described in Section 4 may require local, State, and/or Federal permits or approvals prior to the onset of construction. Based on the types of projects identified in the Swift Creek watershed, permits or approvals may be required for any of the following reasons:

- Stream and/or wetland impacts;
- FEMA floodway impacts;
- Land disturbance; and
- Potable water and sewer line adjustments.

The permitting matrix shown in Table 7-1 shows the different types of permits that are anticipated for each of the proposed flood control projects. The water quality retrofits may require erosion control permits if the area of disturbance is greater than 1.0 acres, but permits or agreements from DWQ, USACE, FEMA, and NCDOT are not anticipated for these projects.

The types of 404/401 permits are described below and may vary based on the length of stream impacts and/or acreage of wetland impacts. Wetlands will need to be delineated to determine the acreage of impacts. Permit requirements for a given project may change based on the final design and any changes to the existing regulations. The appropriate permitting agencies should be contacted during the design process to determine if permits will be required for the proposed project.

7.1 NORTH CAROLINA DIVISION OF WATER RESOURCES 401 WATER QUALITY CERTIFICATION AND US ARMY CORPS 404 PERMIT

Proposed improvements within the City of Greenville must adhere to the requirements set forth in Section 401 and 404 of the Clean Water Act. Required permitting can range from activities that are pre-authorized to those requiring pre-construction notification (PCN) for a Nationwide Permit (NWP) to those requiring an Individual Permit (IP). Individual permits may be required for projects with stream impacts greater than 300 feet and wetland impacts greater than 0.5 acres. It is anticipated that NWP #3 (Maintenance) and NWP #13 (Bank Stabilization) may be required to support the projects that include work within channels that are claimed jurisdictional by the US Army Corps of Engineers (USACE). Individual permits may be required for floodplain benches where significant wetland impacts may be encountered. More detailed explanations of the types of 404 permits are provided below.

NWP#3 – Maintenance

This permit authorizes the repair, replacement, or rehabilitation of any previously permitted or currently serviceable structure. A PCN is not required for minor deviations in the structure's configuration or filled area that occur as a result of changes in materials, construction techniques, or safety standards necessary to make repair or replacement, provided environmental impacts are minimal. A PCN to the USACE is required if a significant amount

of sediment is excavated/filled within the channel. NC Division of Water Quality (DWQ) does not typically require a PCN for NWP #3 but usually receives one as a courtesy.

Other provisions imposed by the State of North Carolina require that culvert inverts must be buried a minimum of 1-foot below the streambed for culverts greater than or equal to 48 inches in diameter to allow low flow passage of water and aquatic life. Culverts less than 48 inches in should be buried to a depth of 20 percent or greater of the culvert's diameter.

7.2 INDIVIDUAL PERMITS

Individual permits are required when stream or wetland impacts do not meet the conditions of a nationwide permit. Permit applications may be reviewed by multiple agencies including but not limited to USACE, DWQ, EPA, SHPO, NCWRC, and USFWS. The application is also made available for public review. There is no defined timeline for review of the application for an IP; therefore the permitting process for an IP is typically significantly longer that the review time for a NWP. Typically, 404 and 401 Individual Permits are applied for jointly and the review is concurrent.

7.3 FEDERAL EMERGENCY MANAGEMENT AGENCY (FEMA)

Streams with a drainage area greater than one square mile are typically modelled and mapped by FEMA for flood insurance purposes. The 100-year floodplain has been mapped for Gum Swamp from approximately 0.3 miles downstream of Frog Level Road to its confluence with the Swift Creek. The section of Swift Creek within the project limits does not have its 100-year floodway or floodplain mapped. Any proposed projects that will include grading within a FEMA defined floodway will require a Conditional Letter of Map Revision (CLOMR) submitted to FEMA for pre-approval purposes and a Letter of Map Revision (LOMR) upon completion of construction. Table 7-1 identifies projects where FEMA permitting is expected.

7.4 EROSION AND SEDIMENTATION CONTROL

North Carolina Department of Environmental Quality (NCDEQ) is another agency that requires notification before proposed activities are constructed. NCDEQ requires that an erosion and sedimentation control plan be submitted to the Land Quality Section for approval before the start of construction for any disturbance greater than one acres. Erosion and Sedimentation permits are anticipated for most of the proposed projects as shown in Table 7-1.

Table 7-1: Permitting Matrix for Proposed Projects

	FEMA	NCDEQ/ NPDES	404/401 (NWP)	404/401 (IP)	NCDOT	RAILROAD
PRIMARY SYSTEM PROJECTS						
Thomas Langston Road – Alternative #1 (Swift Creek)	X	X	X		X	
Thomas Langston Road – Alternative #2 (Swift Creek)	X	X	X		X	
Sterling Trace Drive – Alternative #1 (Swift Creek)	X	X	X			
Sterling Trace Drive – Alternative #2 (Swift Creek)	X	X	X			
Thomas Langston Road – Alternative #1 (SCUT1)		X	X		X	
Thomas Langston Road – Alternative #2 (SCUT1)					X	
Belfair Drive – Alternative #1 (SCUT1)		X	X			
Sterling Pointe Drive – Alternative #1 (SCUT1)		X	X			
Sterling Pointe Drive – Alternative #2 (SCUT1)		X	X			
Frog Level Road (Gum Swamp)		X	X		X	
Gum Swamp Floodplain Bench	X	X	X			
Megan Drive Detention Pond		X	X			
Thomas Langston Detention Pond		X	X			
Pitt Community College Detention Pond	X	X	X			
STREAM STABILIZATION PROJECTS						
Project #1 – Thomas Langston Road		X				
Project #2 – Thomas Langston Culvert		X				
WATER QUALITY PROJECTS						
Project #1 – Ridgewood Elementary Bioretention		X				
Project #2 – Pinecrest Water Quality Swale		X				
Project #3 – Emerald Park Bioretention		X				

	FEMA	NCDEQ/ NPDES	404/401 (NWP)	404/401 (IP)	NCDOT	RAILROAD
Project #4 – Davenport Farm Road Water Quality Swales		X			X	
Project #5 – South Bend RSC		X	X			
Project #6 – Wells Fargo Bank Wet Pond Retrofit		X				
Project #7 – Sterling Pointe Apartments Wet Pond Retrofit		X				
Project #8 – South Central High School RSC		X				
Project #9 – South Central High School Bioretention		X				
Project #10 – Dana Brooke Wetland		X				

FUNDING OPPORTUNITIES

8.1 WATER QUALITY IMPROVEMENT FUNDING

As the final designs of the proposed improvements are evaluated, the City is encouraged to investigate the potential funding mechanisms that are available for water quality projects. There are wide range of funding mechanisms that may be available to the City. Sources include the Clean Water Act Part 319 funds administered by the US EPA and North Carolina Cleanwater Management Trust Fund (CWMTF). CWMTF funding can include land acquisition costs, design fees, and construction costs to help finance projects that improve and protect water quality. In 2014, $24.8 million to fund projects throughout North Carolina (www.cwmtf.net).

The Clean Water State Revolving Fund (CWSRF) is another option. It offers low-interest loans that can be used to find stormwater projects with water quality components. It should be noted that typically, grants require some type of match funding. The matching requirements vary for each different type of grant. For example, the CWSRF requires a 20 percent match from the State based on the amount of Federal dollars awarded while the CWMTF does not have a specified match requirement.

The NCDEQ Division of Water Resources has a Water Resources Development Project Grant Program. The program provides cost-share grants and technical assistance. The grants are offered for the following purposes: general navigation, recreational navigation, water management, stream restoration, beach protection, land acquisition, and facility development for water-based recreation and aquatic weed control. Spring 2014, the program awarded grants ranging from $1,500 to $454,300. The total awarded across thirty-seven projects/recipients was $2,244,877 (www.ncwater.org).

8.2 FLOOD MITIGATION FUNDING

FEMA's Flood Mitigation Assistance (FMA) is a pre-disaster grant program designed to provide funding to Stated and communities in their efforts to reduce or eliminate the risk of repetitive flood damage to building and structures insured under the National Flood Insurance Program (NFIP). In order to be eligible, communities must have completed and approved Flood Mitigation Plans that assess the flood risk and identify actions to reduce that risk. Any State agency, participating NFIP community, or local agency is eligible to participate and should contact community officials.

Additional project grant eligibility criteria include a project that is:

- Cost effective;
- Cost beneficial to the National Flood Insurance Fund;
- Technically feasible; and

- Physically located in participating NFIP community or reduce future flood damages in an NFIP community.

A project must also comply with (1) the minimum standards of the NFIP Floodplain Management Regulations, (2) the applicant's Flood Mitigation Plan, and (3) all applicable laws and regulations. The State is the grantee and program administrator for FMA. FEMA distributes FMA funds to States that in turn provide funds to communities. FEMA may provide up to 75% of the total eligible costs. The remaining costs must be provided by a non-Federal source of which no more than half can be provided as in-kind contributions from third parties.

8.3 REVENUE AND GENERAL OBLIGATION BONDS

Municipalities in North Carolina have the authority to use binding for capital improvement projects under the State's General Statues. There are two types of bonds available for use – general obligation and revenue bonds. General obligation bonds are funds received after voter approval of bond referendum. A vote is required because general obligation bonds are secured using the City's taxing power. All revenues, including different taxes, can be used to pay off a general obligation debt. Revenue bonds, on the other hands, are backed by income generated by the City through fees collected (e.g., various utility fees including stormwater). Because their security is not as great as that of general obligation bonds, revenue bonds may carry a slightly higher interest rate.

8.4 UTILITY RATE STUDY

The City should consider completing a utility rate study to determine if the current rate is appropriate for funding the required operation of the Stormwater Division as well as capital projects. The enterprise fund was originally established in 2001 with collections beginning in 2003. In May 2013, City staff requested a fee increase of $0.50/ERU each year for the next five years to support capital projects and completion of the City-wide master plan. Currently as of July 1, 2015 the fee is $4.35 per ERU. Once planning is concluded the City should complete a detailed rate study based on the capital needs identified during the planning process.

COST ESTIMATES

The cost estimates provided as part of the Swift Creek Watershed Master Plan were prepared to assist City staff in making planning level decisions and prioritizing improvements. These cost estimates are not final design cost estimates. These costs were developed using recent bid tabulations from other communities and NCDOT projects within North Carolina. They include easement acquisitions, surveying, engineering, legal, and administrative costs. A detailed breakdown of the costs for the projects listed below in Table 9-1 is included in Appendix G. Projects are not listed based on priority. See Section 10 for a prioritization list. The cost estimates are approximate and are subject to change due to local costs, materials, delivery, construction, and other factors. BMP costs are based on the size of the BMP, the estimated excavation requires, and any associated structure of planting costs.

Table 9-1: Preliminary Project Cost Estimates

Projects	Preliminary Project Cost
PRIMARY SYSTEM PROJECTS	
Thomas Langston Road – Alternative #1 (Swift Creek)	$1,050,000
Sterling Trace Drive – Alternative #1 (Swift Creek)	$2,370,000
Alternative #2 – Swift Creek Main Branch	$16,990,000
Thomas Langston Road – Alternative #1 (SCUT1)	$370,000
Belfair Drive – Alternative #1 (SCUT1)	$380,000
Sterling Pointe Drive – Alternative #1 (SCUT1)	$1,190,000
Alternative #2 – SCUT1	$8,050,000
Frog Level Road (Gum Swamp)	$710,000
Gum Swamp Floodplain Bench	$5,160,000
Pitt County Community College Regional Detention	$18,280,000
STREAM STABILIZATION PROJECTS	
Project #1 – Thomas Langston Road	$810,000
Project #2 – Thomas Langston Culvert	$70,000
WATER QUALITY PROJECTS	
Project #1 – Ridgewood Elementary Bioretention	$330,000
Project #2 – Pinecrest Water Quality Swale	$50,000
Project #3 – Emerald Park Bioretention	$240,000
Project #4 – Davenport Farm Road Water Quality Swales	$100,000
Project #5 – South Bend RSC	$220,000
Project #6 – Wells Fargo Bank Wet Pond Retrofit	$200,000
Project #7 – Sterling Pointe Apartments Wet Pond Retrofit	$100,000
Project #8 – South Central High School RSC	$140,000
Project #9 – South Central High School Bioretention	$1,300,000
Project #10 – Dana Brooke Wetland	$930,000

PRIORITIZATION AND RECOMMENDATIONS

As previously noted, the primary goal of this study is to make improvement recommendations to reduce flooding within the Swift Creek Watershed. Currently, several conveyance systems do not meet the City hydraulic design requirements. WK Dickson has provided recommendations that help to reduce or eliminate the identified problems. Success criteria goals used to measure the proposed flood control project included the following:

- Providing improved level of service for roadways and structures;
- Economic feasibility;
- Minimizing stream and wetland impacts;
- Confirming physical feasibility using available GIS and survey data; and
- Minimizing easement acquisition.

Three different prioritization lists were developed for the proposed projects identified in Section 4 and 5; Flood Control Improvements, Stream Stabilization Improvements, and Water Quality Improvements. Projects were prioritized using the Prioritization Matric provided in Appendix L. The improvements were prioritized based on the following factors:

- Public health and safety;
- Severity of street flooding;
- Cost effectiveness;
- Effects of improvements;
- Water quality – BMP;
- Open channel –erosion control;
- Implementation constraints;
- Grant funding; and
- Constructability.

In some instances, project prioritization will be impacted by the required sequencing of projects to provide the highest possible flood reduction benefits and to reduce or negate any downstream impacts for the proposed projects. Downstream impacts are including in the scoring for Implementation Constraints, however upon completion of the scoring process, the prioritization list should be reviewed to ensure the projects are appropriately ranked based on sequencing. Table 10-1 shows the proposed prioritizations for the Flood Control Improvements. The City should re-visit the prioritization lists annually to determine if the priorities should change. If Alternative #1 has been completed for a specific project, then the Alternative #2 option should be removed from the CIP and vice versa. For Alternative #2 projects to meet the desired level of service, the Megan Drive and Thomas Langston Detention Ponds would need to be constructed.

Table 10-1: Flood Control Prioritization

Prioritization	Project
1	Thomas Langston Road (Swift Creek Main Branch) – Alt 1
2	Alternative #2 – SCUT1
3	Thomas Langston Road (SCUT1) – Alt 1
4	Alternative #2 – Swift Creek Main Branch
5	Frog Level Road (Gum Swamp)
6	Gum Swamp Floodplain Benching
7	Belfair Drive (SCUT1) – Alt 1
8	Sterling Pointe Drive (SCUT1) – Alt 1
9	Sterling Trace Drive (Swift Creek Main Branch) – Alt 1

Table 10-2: Stream Stabilization Prioritization

Prioritization	Project
1	Thomas Langston (Swift Creek Main Branch)
2	Thomas Langston (SCUT1)

Table 10-3: Water Quality Prioritization

Prioritization	Project
1	Sterling Pointe Apartments Wet Pond Retrofit
2	Ridgewood Elementary School Bioretention
3	Emerald Park Bioretention
4	South Bend RSC
5	Pinecrest Water Quality Swale
6	Wells Fargo Wet Pond Retrofit
7	Davenport Farm Road Water Quality Swale
8	South Central High School Bioretention
9	Dana Brooke Wetland
10	South Central High School RSC

Table 10-4 shows the recommended priorities for maintenance projects in the watershed. Maintenance locations were identified based on the condition assessment completed during the stormwater inventory. Structures receiving a condition of "poor" or "repair" are listed below for maintenance. More immediate maintenance needs may present themselves if portions of a conveyance system fail. Projects were prioritized based on the consequences of flooding. Projects requiring structural improvements (i.e. in danger of failing) were given priority over those driven by sediment/vegetation removal needs. Additionally, the impact of flooding and proximity to a citizen input response were also considered in project ranking. Maintenance costs assume that City staff will complete the construction. If maintenance projects are bid to a private contractor, the City should complete a more detailed cost estimate prior to bid.

Table 10-4: Maintenance Recommendations

Prioritization	Project	Estimated Cost
1	Replace 32 LF of 18" CMP - crushed bottom of pipe end near 3701 Providence Drive (SCUT010210)	$3,520
2	Replace 63 LF 18" RCP (sinkholes) near 912 Pencross Drive (pipe end SCMB010092)	$6,930
3	Replace 197 LF of 18" RCP (sinkholes) near 1900 Tralee Court (yard inlets SCMB010278 and SCMB01279)	$21,670
4	Replace 67 LF of 24" RCP - damaged pipe end near (1089 Davenport Farm Road (GSMB010196)	$10,050
5	Replace catch basin - sinkhole is collapsing fence in back of property 3338 Grove Point Drive (SCMB010386) and replace 163 LF of 24" RCP (sinkholes) at 3329 Langston Boulevard (catch basin SCMB010386 and yard inlet SCMB010385)	$28,820
6	Repair sinkhole for 190 LF of 36" RCP between GSMB010058 and GSMB010059 near 809 Sebring Drive	$45,600
7	Replace 39 LF of 36" CMP - damaged pipe end near 1312 Ashmoor Lane (GSMB010191)	$9,360
8	Replace 49 LF of 30" CMP - rusted bottom of pipe end near 3872 Frog Level Road (GSMB010344)	$8,820
9	Replace yard inlets (sinkhole) near 1217 Price Drive (GSMB010224), 1201 Price Drive (GSMB010226), and 1113 Price Drive (GSMB010228)	$18,000
10	Replace yard inlet (sinkhole) near SCUT010097 - rebar beginning to expose (SCUT010097)	$6,000
11	Replace yard inlets (sinkhole) near 3609 Flora Drive (SCMB010356) and 3459 Rounding Bend Road (SCMB010361)	$12,000
12	Replace yard inlet (sinkhole) near 3344 Stone Bend Drive (SCUT010195)	$6,000
13	Replace yard inlet (sinkhole) near 4105 Fenton Court (SCMB010425)	$6,000
14	Replace yard inlets (sinkhole) near 2301 Checkerberry Lane (SCMB010199) and 2604 Chardon Court (SCMB010202)	$12,000
15	Replace yard inlet as sinkhole is collapsing fence near 3629 Montery Drive (SCMB010366)	$6,000
16	Repair channel - major erosion of bank on eastside of pipe end near 3809 Oglethorpe Drive (SCMB010302) and replace yard inlet (sinkhole) near 3809 Oglethorpe Drive (SCMB010301)	$22,150
17	Replace yard inlet (sinkhole) near 2104 Charity Lane (SCMB010149)	$6,000
18	Replace yard inlets (sinkhole) near 3945 Palmer Drive - note there is a locked gate (GSMB010245 and GSMB010246)	$12,000

Prioritization	Project	Estimated Cost
19	Replace yard inlets (sinkhole) near 1916 Tybee Court (SCMB010393) and 1912 Tybee Court (SCMB010395)	$12,000
20	Replace yard inlet (sinkhole) near 3805 St Augustine Drive (SCMB010061)	$6,000
21	Replace yard inlet (sinkhole) near 1004 Jade Lane (GSMB010104)	$6,000
22	Replace yard inlet (sinkhole) near 3413 Saybrook Court (GSMB010040)	$6,000
23	Replace yard inlets (sinkhole) near 2660 Rhinestone Drive (GSMB010324) 2640 Rhinestone Drive (GSMB010329), 2516 Sapphire Court (GSMB010334), and 2624 Rhinestone Drive (GSMB010337)	$24,000
24	Sediment build-up in front of pipe end at 3750 Sterling Pointe Drive (SCUT010018)	$2,000
25	Dredge pipe ends at 3650 Belfair Drive - obstructed with sediment and debris (SCUT010052 and SCUT010053)*	$4,000
26	Dredge pipe end at 3820 Memorial Drive - obstructed with sediment (SCUT010024)	$2,000
27	Repair waterline discharging into pipe near 2108 Dahlonega Road (SCMB010258)	$10,000
28	Repair waterline discharging into pipe near 1604 Stone Wood Drive (SCUT010164)	$10,000
29	Repair waterline discharging into pipe near 1137 Davenport Farm Road (GSMB010253)	$10,000

*Required if Belfair Drive – Alternative #2 is selected for implementation

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

11. NC Department of Environmental Quality - Stormwater Rules

    http://portal.ncdenr.org/web/wq/ps/nps/tarpamstorm