LETTER OF TRANSMITTAL

October 10, 2011

JOB NO.

ATTENTION: Ms. Jill Bazinet

TO: Ms. Jill Bazinet P.E.
City of Alpharetta Engineering / Public Works
1790 Hembree Road
Alpharetta , Georgia 30009

RE: Final Draft Big Creek Watershed Study Update

WE ARE SENDING YOU ☐ ATTACHED ELECTRONICALLY ☐ UNDER SEPARATE COVER _____ THE FOLLOWING ITEMS:

☐ SHOP DRAWINGS ☐ PRINTS ☐ PLANS ☐ CERTIFICATION

☐ COPY OF LETTER ☐ PAYROLLS ☒ REPORT ☐ CD

COPIES	DATE	NO.	DESCRIPTION
1	10.10.2011		Final Draft Big Creek Watershed Study Update

THESE ARE TRANSMITTED AS CHECKED BELOW

☐ FOR APPROVAL ☐ NO EXCEPTION TAKEN ☐ SUBMIT _____ COPIES FOR DISTRIBUTION

☐ FOR YOUR USE/FILES ☐ MAKE CORRECTIONS NOTED ☐ RETURN _____ CORRECTED COPIES

☐ AS REQUESTED ☐ AMEND AND RESUBMIT ☐ RESUBMIT _____ COPIES FOR APPROVAL

☒ FOR REVIEW AND COMMENT ☐ REJECTED - (SEE REMARKS) ☐ RETURN _____ APPROVED COPIES

☐ _____

REMARKS:

COPY TO: File

SIGNED: Amanda Lester

IF ENCLOSURES ARE NOT AS NOTED, KINDLY NOTIFY US AT ONCE

580 W. Crossville Road
Suites 101-102
Roswell, Georgia 30075

October 10, 2011

Jill Bazinet P.E.
City of Alpharetta, Georgia
Engineering / Public Works
1790 Hembree Road
Alpharetta, GA 30009

Re: Final Big Creek Watershed Study Update

Dear Ms. Bazinet:

River To Tap (R2T) is pleased to provide the attached final draft of the Big Creek Watershed Study Update for the Cities of Alpharetta and Roswell. This update includes information and activities related to water supply watershed protection that have been implemented since the Big Creek Watershed Study was developed in 2000.

The final draft identifies updated land use percentages for the Department of Community Affairs Part 5 Criteria for Environmental Planning. John West of the DCA was contacted to confirm that the impervious percentages would not limit the Cities ability to comply with the Part 5 Criteria. Other updates in the final draft include best management practices identified specifically within Wills Park a City of Alpharetta owned property.

R2T, Inc. is committed to providing the municipalities with a quality Big Creek Watershed Study Update that will be used to comply with existing State and regional plans and regulations. Please call me at (770) 569-7038 ext. 103 if you have any questions on our qualifications, the scope of work, project schedule or cost.

Sincerely,
R2T, INC.

Amanda H Lester

Amanda Lester
Project Engineer

cc: Kimberly Ajy
Project File

580 W. Crossville Road
Suites 101-102
Roswell, Georgia 30075

Big Creek Watershed Study Update

ROSWELL
GEORGIA
SINCE 1854

Alpharetta
GEORGIA • USA

RIVER TO TAP, INC.

a reservoir of experience.

Executive Summary

This study presents an update to the Big Creek Watershed Study prepared by Camp Dresser & McKee in 2000 under the guidance of the Atlanta Regional Commission (ARC). The purpose of this document is to ensure that active participants, including the Cities of Alpharetta and Roswell, comply with the current federal, state, and local requirements.

The Big Creek basin is located in Cities of Alpharetta, Roswell, Milton, Johns Creek, Cumming, and Forsyth, Fulton and Cherokee Counties of Georgia. The watershed provides recreational and scenic value to the various jurisdictions and serves as a water supply source for the City of Roswell. The southern portion of the watershed is more developed than the northern portion as it lies within the Cities of Alpharetta and Roswell. Developed areas in the northern portion of the watershed are primarily within the City of Cumming. The watershed occupies an area of approximately 99 square miles at the Roswell water treatment plant intake.

The characteristics of the Big Creek watershed summarized in this study include location, soil type, topography and land use. Water quality data from the Cities of Alpharetta and Roswell are included to summarize the health of the streams within the Big Creek watershed. Potential pollution sources within the watershed have also been identified using GIS mapping and local resources.

Historically, ordinances and regulations regarding water quality varied between jurisdictions located in the watershed. However, each jurisdiction in the Big Creek watershed is now a member of the Metropolitan North Georgia Water Planning District (District). One of the District's goals is to provide consistency and regulatory compliance and accountability among jurisdictions in the greater Atlanta area to benefit water quality. The watershed management requirements of the District are identified in Section 3 of this report. The official code of Georgia and the Georgia Planning Act establishes requirements for small water supply watersheds. The requirements for these watersheds are identified in this study, as well as necessary measures the Big Creek jurisdictions can take to meet these requirements.

Future land use conditions that are managed by improved ordinances and include stormwater best management practices (BMPs) throughout the watershed provides the best opportunity to achieve water quantity, water quality and community goals. Recommendations for source and treatment controls to implement within the Big Creek watershed are identified in Section 6 and are presented by three categories in Table EX.1, including Public Awareness and Public Involvement, Non-structural Measures and Structural Measures.

TableEX.1
Big Creek Watershed Study
Recommended BMPs for Big Creek

Public Awareness and Public Involvement	Watershed Newsletter
	Public Awareness to Reduce FOGs
	School Education Activities
	Homeowner Education Workshops
Non-structural Measures	Septic Tank Elimination Program
	Increased Water Quality Monitoring
	Debris Removal from Structures
	Bacteria Source Tracking
	Neighborhood of Environmental Excellence
	Greenspace Acquisition and Management
Structural Measures	Stormwater Detention Basin – Wills Park
	Stormwater Detention Basin – Liberty Square
	Stormwater Detention Basin – Carriage Station
	Stormwater Detention Basin Retrofits
	Rain Gardens – Wills Park, Waller Parks
	Rain Barrels – Wills Park, Waller Parks
	Stream Bank Restoration (Various Locations)
	Disconnect Impervious Surfaces
	Reduce Impervious Surfaces
	Low Impact Development/Redevelopment and Green Infrastructure
	Alum Treatment of Regional Detention Ponds

Table of Contents

Section 1 Introduction 1
1.1 Overview 1
1.2 Purpose 1
1.3 Background 1
1.4 Goals and Objectives 4
Section 2 Watershed Characteristics 5
2.1 Description of the Watershed 5
2.2 Topography 7
2.3 Climate 7
2.4 Soils 9
2.5 Land Use 11
2.5.1 Existing Land Cover 11
2.5.2 Future Land Cover 11
2.6 Potential Pollution Sources 14
2.7 Sanitary Sewer Overflows and Septic Tanks 17
2.8 Water Quality Data 17
2.8.1 Water Quality Monitoring 19
Section 3 Regulatory Review 24
3.1 Introduction 24
3.2 Metropolitan North Georgia Water Planning District 25
3.3 Part 5 Environmental Criteria 26
3.3.1 Requirement - 1 Area within a Seven Mile Radius 26
3.3.2 Requirement – 2 Areas outside a Seven Mile Radius 27
3.3.3 Requirement 3 – Entire Watershed 28
Section 4 Estimating Current and Future Runoff and Flooding Impacts 31
4.1 Introduction 31
4.2 Floodplain Management/ Flood Damage Prevention Model Ordinance 31
4.3 District Plan Future-Conditions Floodplain Delineation 31
Section 5 Estimating Current and Future Water Quality Impacts 33
5.1 Introduction 33
5.2 Selection of Water Quality Parameters 33
5.3 Model Setup 33
5.4 Model Calibration 33
5.5 Model Results 34
5.6 Summary of Water Quality Model 39
Section 6 Recommended Watershed Management Plan 40
6.1 Introduction 40
6.2 Water Quality Control Measures 40
6.3 Watershed Management Scenarios 41
6.4 Source Controls 41
6.4.1 Ordinances 41
6.4.2 Pollution Prevention Programs 42
6.5 Treatment Controls 43
6.6 Public Awareness and Public Involvement 43
6.7 Non-Structural Measures 44
6.8 Structural Measures 47

6.8.1 Stormwater Detention Basins 47
6.8.2 BMP Demonstration Projects 50
6.8.3 Stream Bank Restoration 50
6.8.4 Disconnect Impervious Areas 51
6.8.5 Reduce Impervious Surfaces 53
6.8.6 Alum Treatment of Stormwater Runoff 56
Section 7 Water Conservation and Water Supply Protection 57
7.1 Introduction 57
7.2 Water Conservation 57
7.3 Water Supply Protection 58
7.3.1 Water Withdrawal Permits 58
7.3.2 Big Creek Source Water Assessment 58
7.3.3 Big Creek Park Wetlands Enhancement Project 59
7.3.4 Wetlands 59
7.3.5 Reuse Water 59
7.3.6 Outdoor Water Restrictions 59
References 60

Appendix A – EPA's Envirofacts List of Potential Pollution Facilities
Appendix B – SSO Details
Appendix C – Water Quality Data
Appendix D – Structural Measures Project Sheets
Appendix E – Streambank Restoration Guidelines
Appendix F – Big Creek Source Water Assessment

Table of Tables

TableEX.1 -Recommended BMPs for Big Creek ii
Table 2.1 - 303d Listed Streams in Big Creek Watershed 5
Table 2.2 - Monthly Average Temperature and Rainfall for Fulton County 7
Table 2.3 - Description of Soil Groups 9
Table 2.4 - City of Alpharetta Land Use 11
Table 2.5 - City of Roswell Land Use 12
Table 2.6 - Description of Water Dischargers within the Big Creek Watershed 14
Table 2.7 - Summary of SSO Events 17
Table 2.8 - Target Levels for Fecal Coliform 19
Table 2.9 - Summary of Events which Exceed State Standards from 2006 to February 2011 20
Table 2.10 - City of Roswell Bacteria Monitoring Results 21
Table 2.11 - Foe Killer Creek Water Quality Monitoring Results 22
Table 3.1 - District Watershed Management Measures 25
Table 5.1 - Estimated Annual Pollutant EMC 2001 and 2009 34
Table 5.2 - Estimated Annual Pollutant Load 2001 and 2009 35
Table 5.3 - Estimated Annual Pollutant EMC 2001, 2009 and 2017 37
Table 5.4 - Estimated Annual Pollutant Load 2001, 2009 and 2017 38
Table 6.1 - Sizing Criteria for Stormwater Features 40

Table 6.2 - Recommended BMPs for Big Creek 43
Table 6.3 - Recommended Stream Restoration Projects 51
Table 6.4 - Recommended Areas to Reduce Impervious Surfaces 54
Table 7.1 - Recommended Conservation Measures 57

Table of Figures

Figure 1-1 Location Map 3
Figure 2-1 303d Listed Streams 6
Figure 2-3 Soil Hydrologic Group 10
Figure 2-4 2009 Big Creek Land Use 13
Figure 2-5 Big Creek Potential Pollutant Sources 15
Figure 2-6 Big Creek Water Dischargers 16
Figure 2-7 Big Creek Water Quality Monitoring Location Map 23
Figure 3-1 Seven Mile Buffer Zone 27
Figure 3-2 Big Creek 7-Mile Buffer Zone Land Use 30
Figure 5-1 Graph of Estimated Annual Pollutant EMC for 2001 and 2009 35
Figure 5-2 Linear vs. Exponential Growth 36
Figure 5-3 Graph of Estimated Annual Pollutant Loads 2001, 2009 and 2017 38
Figure 6-1 Wills Park Stormwater Project Locations 49
Figure 6-3 Big Creek Reduced Impervious Surface Areas 55

Section 1 Introduction

1.1 Overview

This report presents the results of the Big Creek Watershed Study Update. The Big Creek Watershed Study was prepared in 2000 by Camp Dresser & McKee under guidance of the Atlanta Regional Commission (ARC). The Big Creek basin is located in the Cities of Alpharetta, Roswell, Milton, Johns Creek, Cumming, and Forsyth, Fulton and Cherokee Counties, Georgia. The active participants in this update are the Cities of Alpharetta and Roswell. The Big Creek Watershed Study Update includes the following sections:

- Section 1 presents the purpose of the update and a description of the study area.
- Section 2 presents the watershed characteristics including land use, climate, soils, potential pollutant sources and current water quality.
- Section 3 presents the local and regional watershed policies and regulations.
- Section 4 presents a summary of water quantity models developed by City of Alpharetta and City of Roswell.
- Section 5 presents a revised water quality model for the Big Creek watershed based on current and future land use.
- Section 6 presents the watershed management plan identifying projects the City of Alpharetta and City of Roswell can implement to improve watershed conditions.
- Section 7 presents water supply and conservation elements critical to maintaining the quality and quantity of water at the City of Roswell's drinking water intake to meet projected demands.

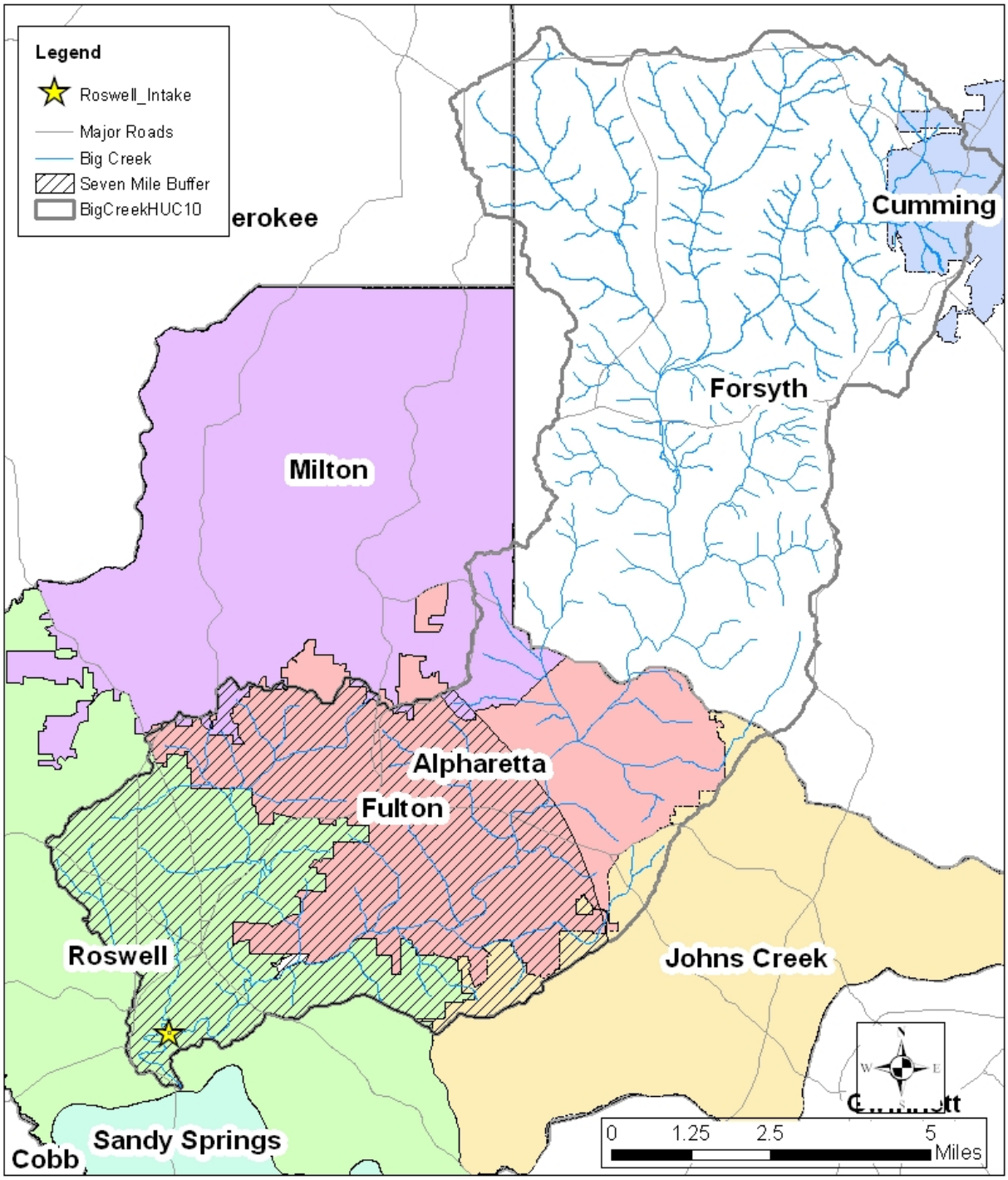
1.2 Purpose

The purpose of this update is to evaluate the existing Big Creek Watershed Study. The study was originally developed to provide a mutually agreeable protection plan for the Big Creek watershed among the various jurisdictions located within the Big Creek watershed. The update identifies the current local and regional watershed policies that have changed since the 2000 study was completed. In addition, all elements required in the State of Georgia Rules for Environmental Planning Criteria (Chapter 391-3-16) are detailed in Section 3 to ensure participating jurisdictions are meeting the requirements and are eligible for all state grants available from the Georgia Department of Community Affairs. The update presents water quantity data collected by study participants and results of water quality model completed as part of this study and presented in Section 5 of this report. The update also presents projects that could be implemented to improve the overall health of the watershed.

1.3 Background

Big Creek is located in urban and suburban portions of the Atlanta region and serves as a water supply for the City of Roswell. The watershed occupies an area of approximately 99 square miles at the Roswell water treatment plant intake. Figure 1-1 presents a location map of the Big Creek watershed. The Big Creek watershed is located primarily within the City of Alpharetta, City of Roswell and unincorporated Forsyth County. According to the 2010 US Census the City of Alpharetta has a population of 57,551 and

the City of Roswell has a population of 88,346. The Big Creek Watershed Study prepared in 2000 determined that the Big Creek watershed will urbanize nearly completely by the year 2020.



Big Creek 7-Mile Buffer Zone

Figure 1-1 Location Map

1.4 Goals and Objectives

The goal of this study is to develop a mutually agreeable protection plan for the Big Creek watershed. The Big Creek watershed has experienced the effects of urbanization and development such as stream bank erosion, increased flooding, water quality deterioration, and a decrease in habitat diversity. This update builds upon the existing watershed study and is designed to integrate opportunities for the implementation Best Management Practices (BMPs) for continued growth in the watershed. This study provides a forum for the City of Alpharetta and City of Roswell to integrate various ideas for watershed protection into a watershed wide plan. The goals of the study can be summarized to include:

- Updating the 2000 study to identify the current conditions of the Big Creek watershed.
- Updating the 2000 study to include requirements of the Georgia Planning Act Environmental Planning Criteria (Part 5 Criteria).
- Updating the 2000 study to include requirements of the Metro North Georgia Water Planning District (District) Watershed Management Plan and Water Supply and Conservation Plan.
- Updating the 2000 study to include BMPs and projects the City of Alpharetta and City of Roswell could implement to improve water quality and quantity within the Big Creek watershed.

Section 2 Watershed Characteristics

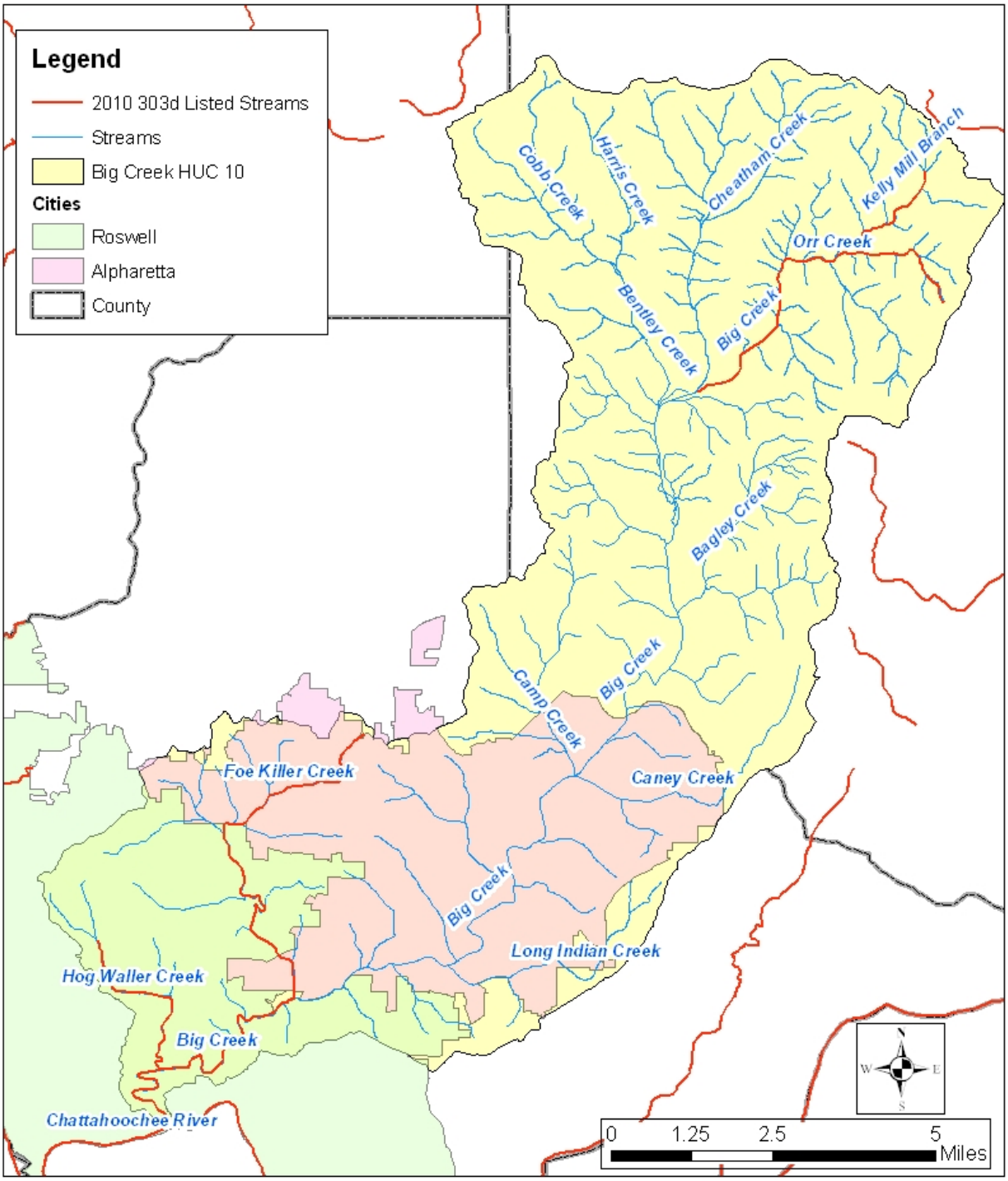
2.1 Description of the Watershed

The Big Creek basin is located in Cities of Alpharetta, Roswell, Milton, Johns Creek, Cumming, Forsyth, Fulton and Cherokee Counties. The southern portion of the watershed is more developed as it lies within the Cities of Alpharetta and Roswell. Developed areas in the northern portion of the watershed are primarily within the City of Cumming. The watershed provides recreational and scenic value to the various jurisdictions and serves as a water supply source for the City of Roswell where the watershed occupies an area of approximately 99 square miles at the Roswell water treatment plant intake.

The Big Creek Hydraulic Unit Code (HUC 10) is 0313000110. Several tributaries feed into Big Creek including Hog Waller Creek, Foe Killer Creek, Long Indian Creek, Caney Creek, Bagley Creek, Bentley Creek, Camp Creek, Cheatam Creek, Cobb Creek, Harris Creek, Kelly Mill Branch, Sawmill Branch and Orr Creek. Within the Big Creek watershed there are several rivers/streams listed on the Georgia Environmental Protection Division (EPD) 303(d) list for not supporting or for partially supporting their designated uses. Table 2.1 lists the streams on the state's 303(d) list. Figure 2-1 presents a location map of the 303d listed streams within the Big Creek watershed.

Table 2.1
Big Creek Watershed Study
303d Listed Streams in Big Creek Watershed

Stream	Extent Listed	Big Creek Jurisdiction	Water Use Classification	Criterion Violated	Potential Cause
Kelly Mill Branch	Headwaters to Orr Creek	City of Cumming Forsyth County	Fishing	FC	UR
Orr Creek	Upstream Castleberry Road (Tyson Foods) to Big Creek	City of Cumming Forsyth County	Fishing	FC	UR
Big Creek	Headwaters to Cheatham Creek (Forsyth County)	Forsyth County	Fishing	FC	UR
Big Creek	Highway 400 to Chattahoochee River	Roswell	Fishing /Drinking Water	FC	UR
Foe Killer Creek	Headwaters to Big Creek	Alpharetta/ Roswell	Fishing	FC	UR
Hog Waller Creek	Roswell	Roswell	Fishing	FC	UR



Big Creek 303d Stream Location Map

Figure 2-1 303d Listed Streams

Big Creek has an average discharge rate of 114 cubic feet per second at the USGS gauging station at Kimball Bridge Road i.e. represents 73 percent of the watershed. This equates to an annual runoff volume of 21.60 inches from the 72 square miles above the gauging station. The highest discharge recorded was a daily average of 4480 cfs with an instantaneous peak of 6100 cfs on February 3, 1982. The lowest record discharge was 1.7 cfs on July 22, 1986.

2.2 Topography

The main stem of Big Creek originates in Forsyth County and drains southward to the Chattahoochee River. The watershed topography is typical of the Piedmont area with the upland tributaries and the upstream reaches of the main stem having fairly steep slopes. Main stem slopes become much flatter in the lower reaches of the stream. The stream channel shows evidence of erosion, severe in some cases, as a result of increased discharges and velocities caused by development within the watershed. Figure 2-2 shows the USGS Digital Elevation Map of the Big Creek watershed.

2.3 Climate

The Big Creek area has a moderate climate where summers are warm and humid with average highs in the nineties and lows in the seventies degree Fahrenheit. Evening temperatures are cooler, but nights are often humid in the summer. Summer afternoon thunder showers are common. Winters in this area are mild with monthly average temperatures in January above freezing. Common winter highs are in the forties with lows in the thirties degree Fahrenheit. The monthly average temperature data for Fulton County are presented in Table 2.2.

The annual average rainfall for Fulton County is approximately 52 inches, which provides enough moisture to sustain water supply within the basin. In spite of abundant rainfall and fairly even distribution throughout the year, dry spells of varying lengths do occur. These are usually more frequent during late summer and autumn, when long periods of mild, sunny weather are common. Monthly average rainfall data for Fulton County is presented in Table 2.2.

Table 2.2
Big Creek Watershed Study
Monthly Average Temperature and Rainfall for Fulton County

Month	Average Monthly Temperature (°F)	Average Monthly Rainfall (inches)
January	39.1	5.17
February	42.8	4.69
March	50.3	5.79
April	57.9	3.94
May	65.4	4.88
June	73.0	3.59
July	76.7	4.32
August	75.8	4.56
September	70.1	3.96
October	59.0	3.59
November	50.3	3.72
December	42.7	4.40
	Average Temp 58.6	Total Rainfall 52.61

National Climate Data Center data from 1971-2000

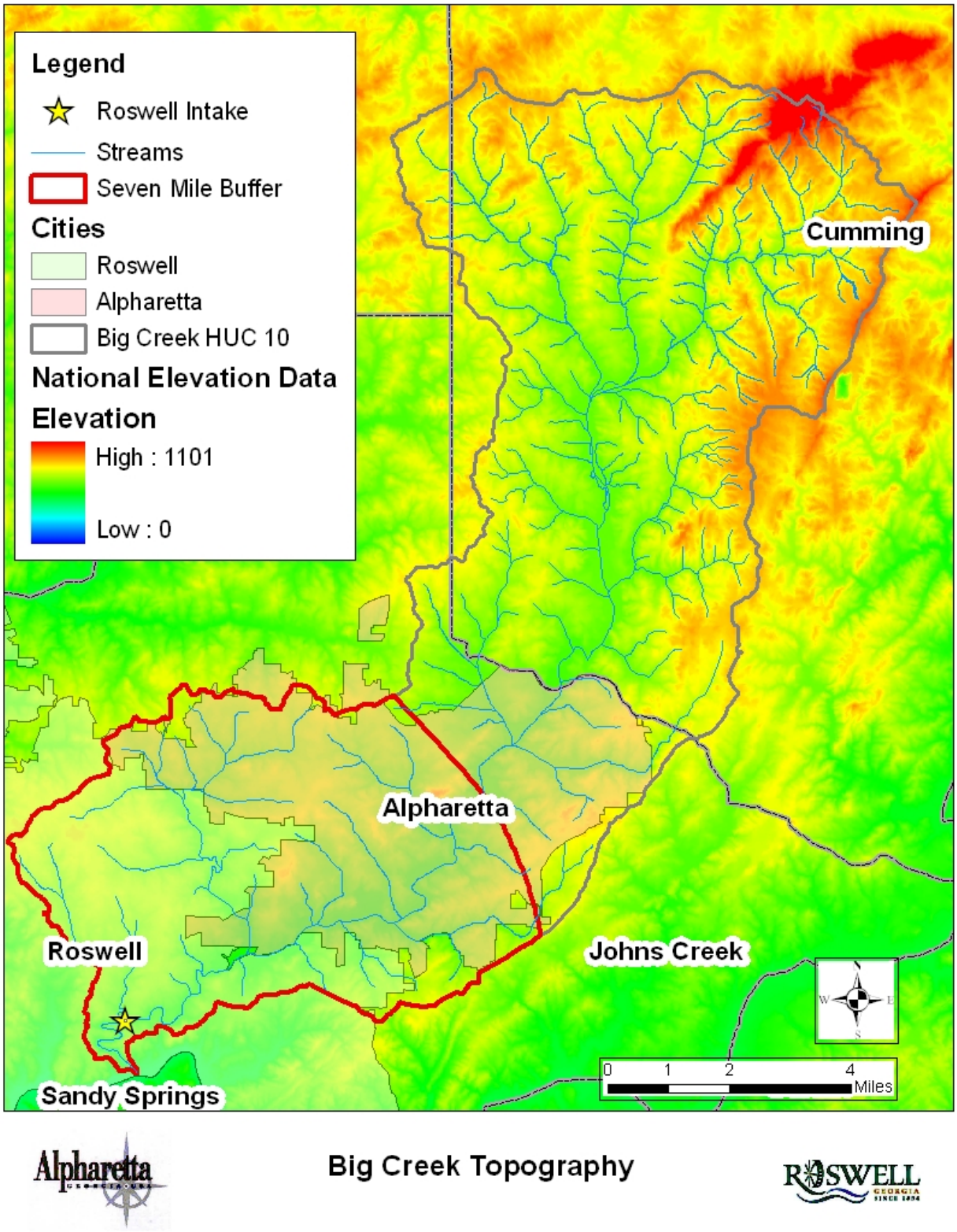


Figure 2-2 USGS Digital Elevation Map of Big Creek

2.4 Soil

The majority of the soil in the watershed is clay of the following categories: Cecil-Madison, Lloyd Cecil-Madison, and Cecil-Lloyd Appling (Figure 2-3). The soil types were determined based on the Natural Resource Conservation Service (NRCS) Soil Surveys for the counties as follows:

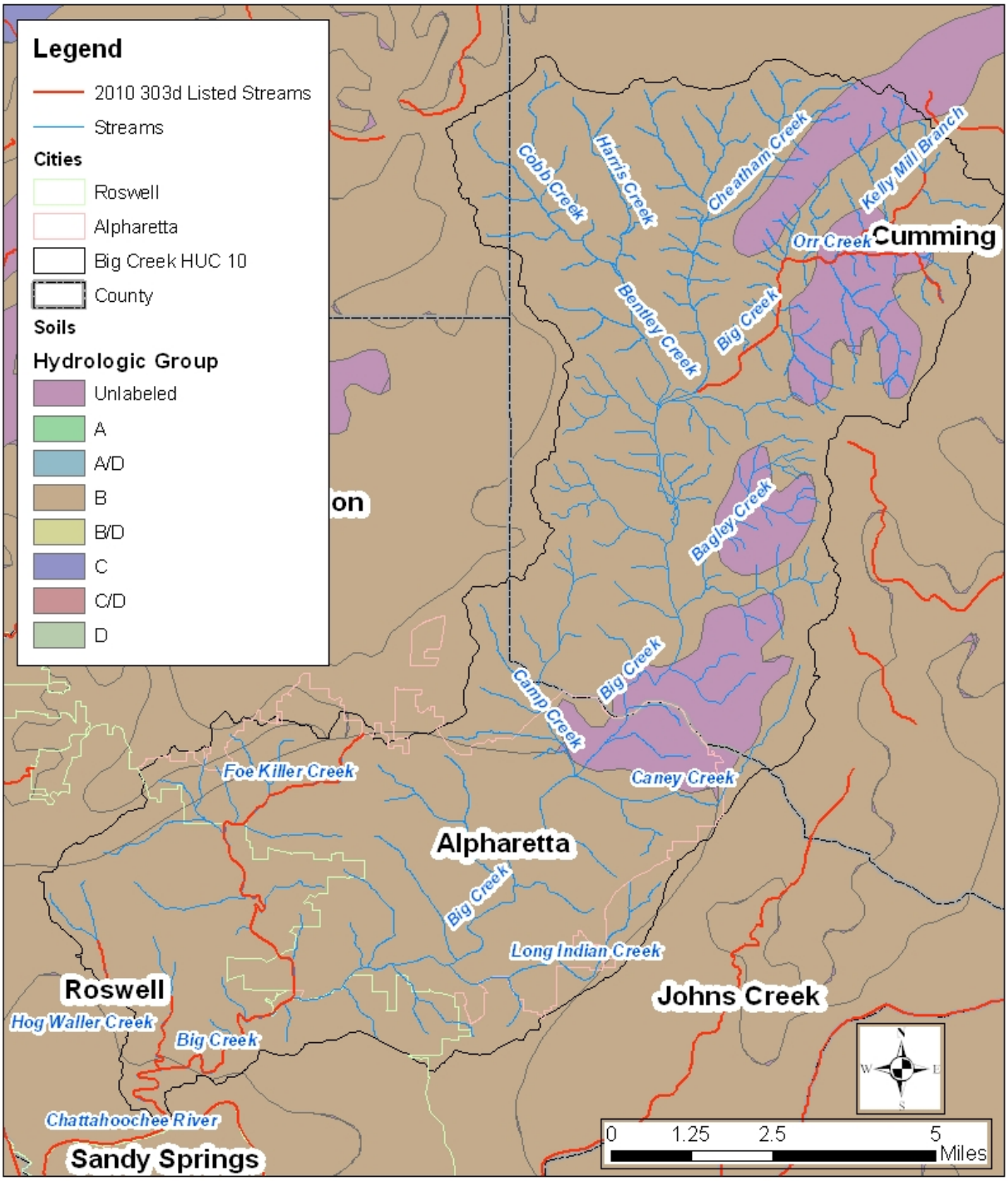
- Cecil soils generally have a high erosion hazard. They are typically deep with moderate moisture-holding capacity. The natural drainage is good to excessive. Cecil-Madison soil is generally well-drained, gently sloping upland.
- Lloyd soils also have a high erosion hazard. They are generally deep with moderate moisture-holding capacity. The natural drainage is also good.
- Madison soils have a moderate to high erosion hazard, are typically deep with a moderate moisture-holding capacity and are well to excessively drained.
- Appling soils have a moderate to high erosion hazard, are typically deep with a moderate moisture-holding capacity and drain well to excessive.
- Along the corridor of the stream, the soils tend to be Congaree-Chewacla-Wickham. The water table in these areas is high and the soils are sandier and pose relatively low erosion hazards.

A standard method of soil classification by Natural Resource Conservation Service (NRCS) is the hydrologic soils group. Soils are grouped into four hydrologic soil groups A through D. These groups are commonly used in hydrologic analyses to estimate infiltration rates and soil moisture capacities. A description of these soil groups is presented in Table 2.3

Table 2.3
Big Creek Watershed Study
Description of Soil Groups

Hydrologic Soil Group	Description
A (low runoff potential)	Soils that have high infiltration rates even when thoroughly wetted and a high rate of water transmission
B (moderately low runoff potential)	Soils that have moderate infiltration rates when thoroughly wetted and a moderate rate of water transmission
C (moderately high runoff potential)	Soils that have slow infiltration rates when thoroughly wetted and a slow rate of water transmission
D (high runoff potential)	Soils that have very slow infiltration rates when thoroughly wetted and a very slow rate of water transmission

The predominant soil type in the Big Creek watershed, according to the NRCS nomenclature, is hydrologic soil group B, with moderately-low runoff potential, moderate infiltration, and a moderate rate of water transmission. Alluvial deposits near the stream reaches is hydrologic soil group C, with slow infiltration rates when thoroughly wetted and a slow rate of water transmission.



Big Creek Soils Hydrologic Group Map

Figure 2-3 Soil Hydrologic Group

2.5 Land Use

The Big Creek watershed, located in northern Fulton County and southern Forsyth County, Georgia, has a drainage area of approximately 99 square miles (Figure 2-1). In the past this was one of the fastest growing areas in the Country. The watershed has undergone a transition from agriculture and wooded land to residential and commercial/industrial development, primarily along State Road 400.

2.5.1 Existing Land Cover

At present, land use in the Big Creek watershed is a mix of suburban and rural or undeveloped land. The majority of the developed areas are in the City of Roswell and the City of Alpharetta along State Road 400 and the more undeveloped and rural areas are in the upland areas in Forsyth County. The development across the watershed is residential with commercial and industrial areas located along the major transportation corridors. Existing land use figures were developed from the City of Alpharetta and City of Roswell Comprehensive Plans. Figure 2-4 shows the 2009 land use data prepared by the Atlanta Regional Commission for the Big Creek watershed.

2.5.2 Future Land Cover

The planning period for this project will correlate with the Comprehensive Plan future period of 2025. Local comprehensive plans indicated build-out conditions for City of Alpharetta and City of Roswell for 2025. Table 2.4 shows the current and future land use for City of Alpharetta. Table 2.5 shows the current and future land use for City of Roswell. The land use tables show future land use similar to existing land use.

Table 2.4
Big Creek Watershed Study
City of Alpharetta Land Use

City of Alpharetta	**2000 Land Use**	**2025 Land Use**	**2000 Land Use**	**2025 Land Use**
	Acres	**Acres**	**%**	**%**
Residential				
Single Family Detached Residential	8,035	8,252	53%	54%
Single Family Attached Residential	132	201	1%	1%
Multi-Family / Apartments	672	690	4%	5%
			0%	0%
Commercial/Office/Industrial			0%	0%
Retail Sales and Services /Hotels	761	961	5%	6%
Office	2,167	2,973	14%	19%
Manufacturing/Warehousing/Wholesale	288	313	2%	2%
			0%	0%
Other			0%	0%
Parks/Recreation/Conservation	1,182	1,212	8%	8%
Public/Institutional	603	603	4%	4%
Transportation/Communication/Utilities	58	58	0%	0%
Undeveloped	1,365	-	9%	0%
Total	**15,263**	**15,263**		

Table 2.5
Big Creek Watershed Study
City of Roswell Land Use

City of Roswell	**2004 Land Use**	**2025 Land Use**	**2004 Land Use**	**2025 Land Use**
	Acres	Acres	**%**	**%**
Estate Residential	nc	2,002		8%
Low-Density Residential	nc	6,397		25%
Suburban Residential	nc	4,090		16%
Medium-Density Residential	nc	2,085		8%
High-Density Residential	nc	1,431		6%
Single-Family Residential	13,131	-	52%	
Multi-Family Residential	1,739	-	7%	
Office Professional	689	473	3%	2%
Office Campus	nc	283		1%
Neighborhood Commercial	nc	73		0%
General Commercial	nc	1,397		5%
Commercial	1,137	-	4%	
Light Industrial	381	552	2%	2%
Public/Institutional	1,348	1,225	5%	5%
Park/Rec/Conservation	1,875	2,069	7%	8%
Trans/Comm/Utilities	119	136	0%	1%
Roads	2,645	3,006	10%	12%
Water	566	566	2%	2%
Vacant Land	1,648	6	7%	0%
Total	**25,277**	**25,789**		
Total Residential	**14,870**	**16,005**		

nc – new category

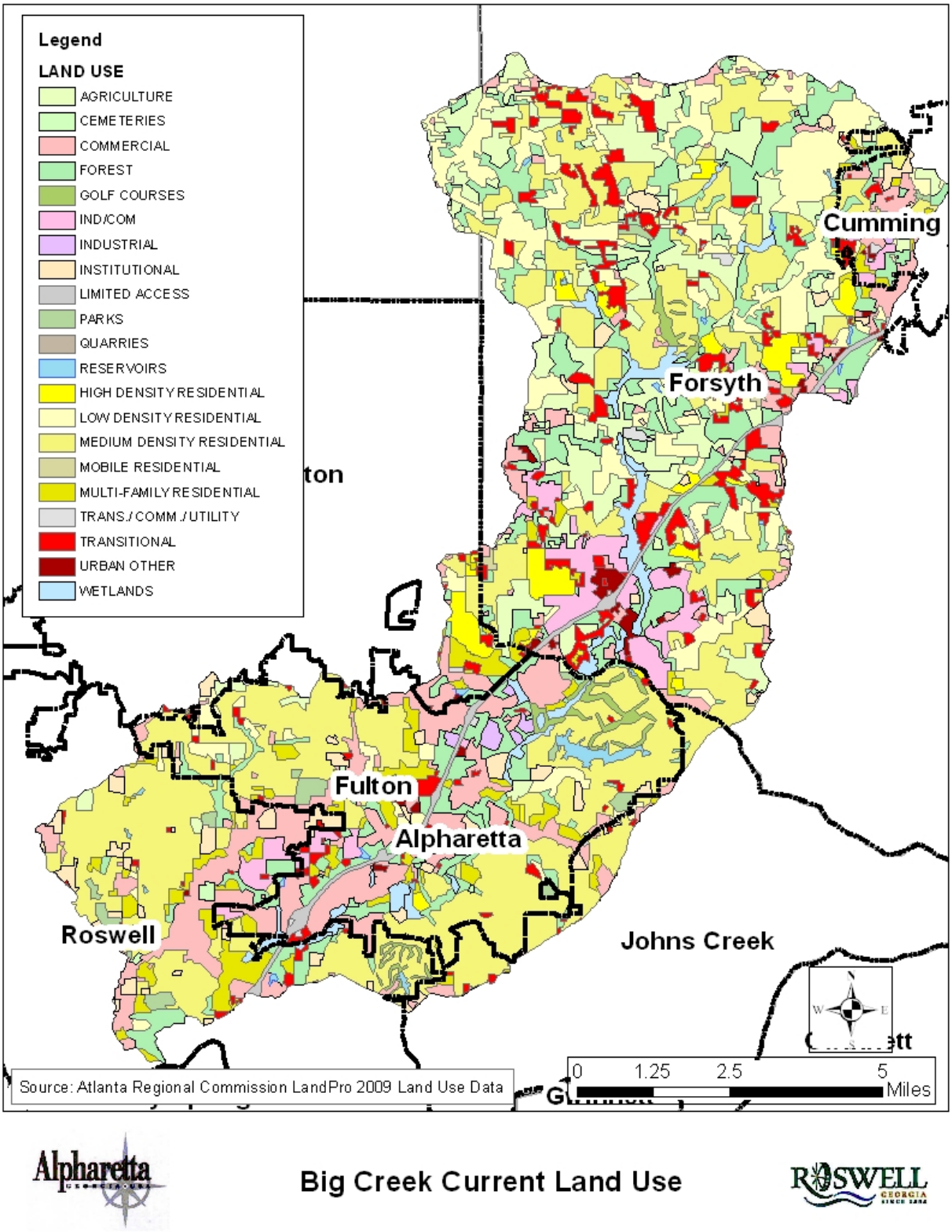


Figure 2-4 2009 Big Creek Land Use

2.6 Potential Pollution Sources

An environmental data review was conducted to identify potential sources of contamination. A search of the Georgia Department of Natural Resources (DNR) and Environmental Protection Agency (EPA) databases was conducted, including Comprehensive Environmental Response Compensation, and Liability Act (CERCLA) or Superfund Sites, Resource Conservation and Recovery Information System (RCRIS/RCRA), Toxic Release Inventory (TRI) and Hazardous Waste databases. Source information consisted of Geographic Information Systems (GIS) data from both the DNR and EPA (Figure 2-5). This information was then cross-referenced with the EPA's Envirofacts Multisystem website which allows users to search several environmental databases for facility information. This search was focused on CERCLA, RCRA, TRI, hazardous waste sites, and water dischargers located within the Big Creek watershed.

There were no CERCLA sites identified within the Big Creek watershed. A search for Resource Conservation and Recovery Act (RCRA) sites in the Big Creek watershed resulted in several facilities. The RCRA facilities include car dealers, auto repair shops, paint stores, dry cleaners, chemical laboratories, car care companies, energy corporations, food and beverage industries etc. None of the RCRA facilities were identified as Hazardous Wastes sites.

Several facilities were identified on the Toxic Inventory List (TRI); as well as, other facilities identified as water discharges or National Pollution Discharge Elimination System (NPDES) Industrial stormwater permits within the Big Creek sub-watershed. Appendix A lists the facilities identified by the EPA's Envirofacts website. Table 2.6 and Figure 2-6 detail the industrial and municipal water dischargers within the Big Creek watershed.

Table 2.6
Big Creek Watershed Study
Description of Water Dischargers within the Big Creek Watershed

Permit Holder	Permit Number	Address
LaFarge Building Materials	GA0047601	1163 Old Roswell Road Alpharetta, GA 30004
Colonial Pipeline	SCG670003	1185 Sanctuary Parkway Suite 100 Alpharetta, GA 30004
Plantation Pipeline	SCG670004	1435 Windward Concourse Alpharetta, GA 30005
Fowlers Water Reclamation	GAU020186	Atlanta Highway, Highway 8 Cumming, GA 30040
Commerce Boulevard	GAU030893	5705 Commerce Boulevard Alpharetta, GA 30004
Forsyth County Water and Sewer	GAU020195	110 E. Main Street Suite 150 Cumming GA 30040
Tyson Food Incorporated	GA0001074	340 West Maple Street Cumming, GA 30040

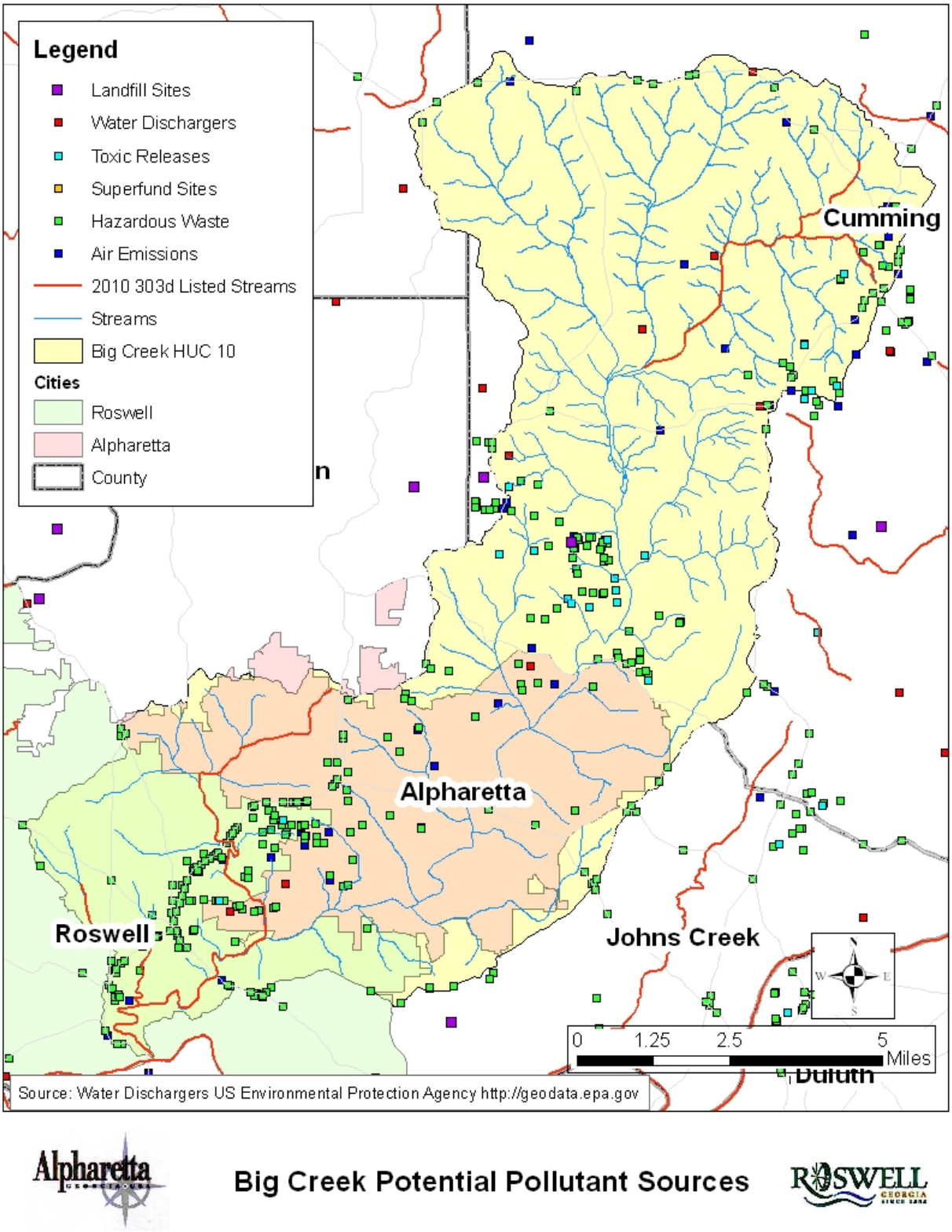
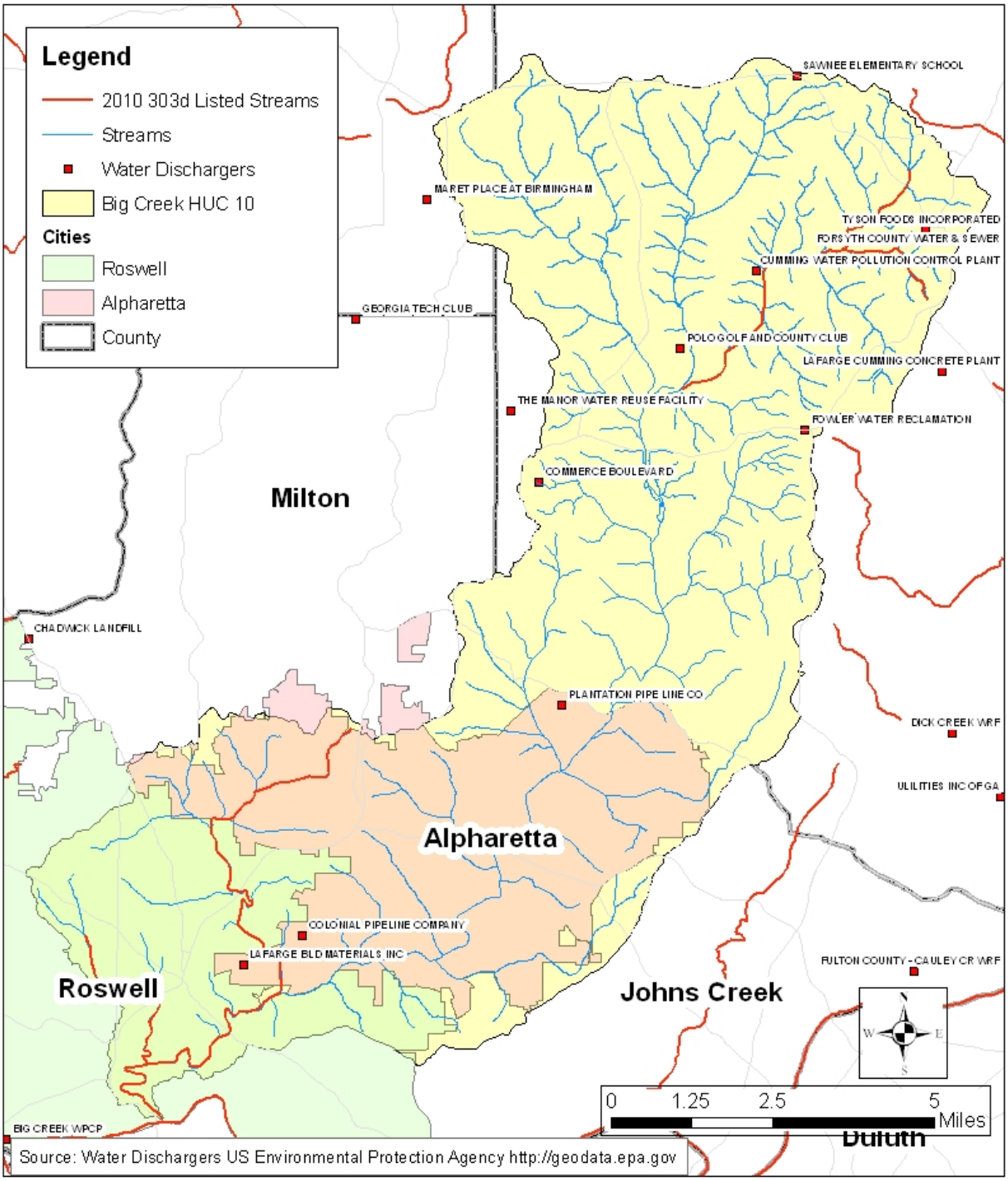


Figure 2-5 Big Creek Potential Pollutant Sources



Big Creek Water Discharges

Figure 2-6 Big Creek Water Dischargers

2.7 Sanitary Sewer Overflows and Septic Tanks

The Fulton County Department of Public Works responds to sanitary sewer overflow events. Table 2.7 lists the summary of Sanitary Sewer Overflow (SSO) events from 2001 to 2010 for the City of Alpharetta and for the City of Roswell. The two cities have similar trends for SSO events. The City of Alpharetta had the most SSOs in 2006 for this period while the City of Roswell had the most SSOs in 2009 for this period. The City of Alpharetta had less SSO events on average. This is likely a result of newer sewer lines and a smaller sewer area. A complete detailed list of SSO events between 2001 and 2010 is provided in Appendix B.

Table 2.7
Big Creek Watershed Study
Summary of SSO Events

Year	Alpharetta	Roswell
2001	4	8
2002	15	13
2003	7	11
2004	6	3
2005	14	14
2006	19	14
2007	7	18
2008	4	10
2009	7	22
2010	1	10
Average	8	12

2.8 Water Quality Data

The State of Georgia assesses its water bodies for compliance with water quality standards criteria. The Georgia EPD has developed a list of impaired stream segments by river basin within the state in accordance with Section 303(d) of the Clean Water Act (CWA). Assessed water bodies are placed into two categories with respect to designated uses: supporting, or not supporting.

The EPD has developed Total Maximum Daily Loads (TMDLs) in 2002 for impaired streams within the Big Creek watershed. The TMDLs established by EPD recommended the following percent reductions in fecal coliform:

- Big Creek Headwaters to Cheatham Creek – 82%
- Big Creek 400 to Chattahoochee River - 39%
- Foe Killer Creek – 5%
- Orr Creek – 91%
- Kelly Mill Branch – 3%
- Hog Waller Creek - 12%

The TMDL Implementation Plans developed in 2004 by EPD for the Big Creek, Foe Killer Creek, Orr Creek, Kelly Mill Branch and Hog Waller Creek, listed the following sources as the cause of stream impairment:

- Urban Runoff
- Sanitary Sewer Overflows (SSOs)
- Septic Tanks
- Animal Waste
- Illicit Connections

The 2004 TMDL Implementation Plan included City of Alpharetta and City of Roswell BMPs that were being implemented at the time of the plan. These BMPs included the following:

- Stormwater Management Ordinance
- Stormwater Design Manual
- Soil Erosion and Sedimentation Control Act
- Chattahoochee River Protection Ordinance
- Water Supply Watershed Protection
- Roadside Litter Removal
- Dry Weather Screening
- Stream Bank Protection Ordinance
- Structural Control Measures
- Steep Slope Ordinance
- Street Maintenance
- Illicit Discharge Detection and Elimination
- Keep Roswell Beautiful

The TMDL Implementation plan also included the following BMPs being implemented at the time of the plan by Fulton County:

- Emergency Sanitary Sewer Evaluation Study
- Interim Collection System Master Plan
- Survey of Sanitary Sewer
- Sanitary Sewer Modeling
- Flow Monitoring
- Improvements in Wastewater Treatment
- Database and Tracking of Unsewered Areas
- Permitting of Septic Systems

The TMDL Implementation Plans also included information related to public education and public involvement through the Clean Water Campaign. The Clean Water Campaign is the regional public education and public involvement organization. The Clean Water Campaign develops materials for municipalities to use and distribute to residences and businesses within its jurisdiction.

The TMDLs are developed for streams impaired as a result of elevated levels of fecal coliform bacteria. Bacteria found in surface water are caused by point source or non-point source pollution. Point sources can usually be directly identified, such as a discharge pipe from a sewage treatment plant, a leaking sewer crossing, or an illicit discharge. Non-point source pollution comes from many diffuse sources, making it difficult to determine the actual source(s) and even harder to control. Typically, non-point sources of bacteria result from rainfall or snowmelt moving over and through the ground. As runoff moves across surfaces, it picks up and carries bacteria, finally depositing them into lakes and rivers. The EPD sets target levels for fecal coliform in streams. Table 2.8 shows these target levels for both the wet and dry season established by the 30-day geometric mean.

Table 2.8
Big Creek Watershed Study
Target Levels for Fecal Coliform

Parameter	Designated Use	
	Drinking water and Fishing	**Recreation**
Fecal Coliform Bacteria (Geometric Mean)	200 col/100 ml (May-Oct)[1]	200 col/100 ml[1]
	1000 col/100 ml (Nov-April)[2]	
Dissolved Oxygen (Daily Average)	6.0 mg/L[3]	6.0 mg/L[3]
pH	6.0-8.5	6.0-8.5
Temperature	<90°F[4]	<90°F[4]

Notes:
1. Not to exceed value of 300 col/100mL for Lakes and Reservoirs and 500 col/100 mL for streams
2. Not to exceed value of 4,000 col/100mL
3. No sample may be less than 5.0 mg/L
4. Temperature increases may not exceed 5° for streams, 0°F for primary trout streams, 2°F for secondary trout streams

2.8.1 Water Quality Monitoring

The City of Alpharetta monitors water quality at seven locations along Big Creek and six tributaries to Big Creek. The water quality monitoring data was reviewed for the last five years (2006 to 2011). Results indicate water quality is improving during 2006 through 2011. The single sample values of bacteria only exceeded the state standards a few occurrences during the 2006-2011 time period. Results showed that dissolved oxygen levels were below the states limit several times during the drought period from 2007 to 2009 at most monitoring locations. Values of pH were rarely outside the state regulated limits. Table 2.9 shows the number of times the state standards were exceeded and the percent of the sample that was exceeded in the five year monitoring period for bacteria, dissolved oxygen, pH and temperature. The availability of data at each location monitored varied. The golf club site monitoring data showed elevated levels of bacteria several times between 2008 and 2011. The camp creek site monitoring data showed dissolved oxygen levels below the state standard several time between 2008 and 2011 during summer months. According to the Georgia EPD, "Water bodies may be determined as not supporting use designation if more than 10% of the single samples per year exceeded the EPA's recommended review criteria for bacteria of 400/100 mL during the months of May-October, and 4,000/100 mL during the months of November-April with the exception of waters classified as "Recreation" where the review criteria are 400/100 mL January - December. The complete water quality data set is included in Appendix C.

Table 2.9
Big Creek Watershed Study
Summary of Events which Exceed State Standards from 2006 to February 2011

	Fecal coliform	Water Temp.	pH	Dissolved Oxygen
Haynes Bridge Road				
Number Exceeds	0	0	1	1
% Exceeds	0%	0%	3%	3%
Kimball Bridge Road				
Number Exceeds	4	0	1	5
% Exceeds	8%	0%	2%	10%
Mansell Road				
Number Exceeds	2	0	0	7
% Exceeds	4%	0%	0%	15%
McGinnis Ferry Road				
Number Exceeds	3	0	1	8
% Exceeds	6%	0%	2%	16%
Old Milton Road				
Number Exceeds	3	0	0	7
% Exceeds	6%	0%	0%	15%
Webb Bridge Road				
Number Exceeds	2	0	0	5
% Exceeds	5%	0%	0%	11%
Windward Road				
Number Exceeds	2	0	0	5
% Exceeds	5%	0%	0%	12%
Camp Creek				
Number Exceeds	3	0	1	13
% Exceeds	9%	0%	3%	39%
Caney Creek				
Number Exceeds	4	0	6	10
% Exceeds	9%	0%	14%	23%
Golf Club				
Number Exceeds	10	0	3	12
% Exceeds	29%	0%	9%	35%
Lake Windward				
Number Exceeds	0	0	0	1
% Exceeds	0%	0%	0%	50%
Long Indian Creek				
Number Exceeds	1	0	5	5
% Exceeds	3%	0%	17%	17%
Tributary 8				
Number Exceeds	0	0	6	10
% Exceeds	0%	0%	16%	26%

The City of Roswell monitors for bacteria at one location on Big Creek between Georgia Highway 400 and the Chattahoochee River. Table 2.10 shows the geometric mean monitoring results from 2009 to 2011. Water quality shows some improvement at the Big Creek monitoring location and improved

changes in the summer season on Hog Waller Creek a tributary to Big Creek. The City of Roswell is committed to monitoring these streams for bacteria in 2011 and 2012. Values in bold exceed the states standard for bacteria as identified in Table 2.8 for the respected monitoring season.

Table 2.10
Big Creek Watershed Study
City of Roswell Bacteria Monitoring Results

Fecal Coliform Summary 2009-2010	**Big Creek**	**Hog Waller Creek**
May	**704**	**1073**
Aug	**658**	**2302**
Nov	598	329
Feb	427	151
Fecal Coliform Summary 2010-2011	**Big Creek**	**Hog Waller Creek**
May	**951**	**352**
Aug	**285**	**313**
Nov	238	481
Feb	206	225

Note: State standard 200 col/100 ml (May-Oct)

The City of Roswell and the City of Alpharetta monitor Foe Killer Creek, a tributary to Big Creek, in several locations. Figure 2 -7 shows the location of the shared monitoring sites. The City of Alpharetta leads the data collection effort for water quality monitoring. Water quality data was obtained from the City of Alpharetta for review and is included in Appendix C. Water quality data was collected from seven locations. The sampling locations include:

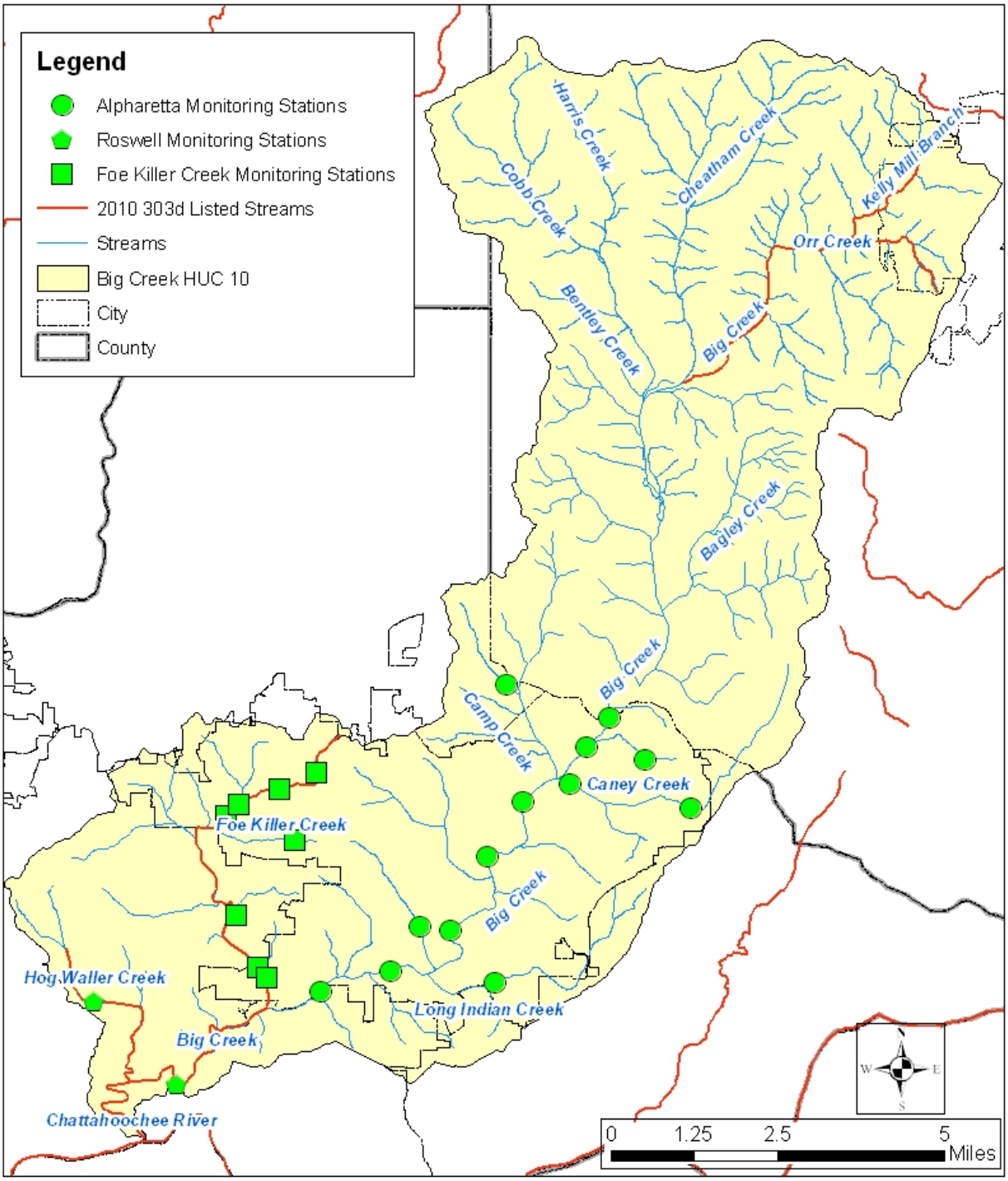
- Mayfield Manor near Mayfield Road in City of Alpharetta
- Mid-Broadwell Road in City of Alpharetta
- Fairfax Subdivision North of Rucker Road in City of Alpharetta
- Rucker Road in City of Alpharetta
- Tributary at Wills Park in City of Alpharetta
- Greenhouse Way in City of Roswell
- Rock Mill Way in City of Roswell
- Mansell Road in City of Roswell

The data was collected from 2004 to 2010. Grab sampling was conducted approximately once a month. This method differs from the preferred sampling schedule as identified in the Standard and Methodologies for Surface Water Monitoring (MNGWPD 2007). The Standard recommends colleting grab samples for bacteria (fecal coliform and *E. Coli*) analysis 16 times per year. Four samples are to be collected over a 30-day period (at intervals not less than 24 hours) during each of the following quarters: May-July, August-October, November-January, and February-April. Each set of four samples is used to calculate a geometric mean, per State guidelines. The data collected from Foe Killer Creek was used to construct a seasonal geometric mean to establish a base water quality for Foe Killer Creek. Tab le 2.11 shows the water quality results with the values in bold exceed the seasonal criteria.

Table 2.11
Big Creek Watershed Study
Foe Killer Creek Water Quality Monitoring Results

Date	Site 1 Mid- Broadwell Road	Site 2 Rucker Road	Site 3 Upper Hembree Road	Site 4 Greenhouse Drive	Site 5 Rock Mill Way	Site 6 Mansell Road
Jun-08	**760**	**646**	70	24	53	**350**
Sep-08	**8900**	**1343**	**425**	**361**	**276**	
Dec-08	94	153	49	19	**4451**	
Mar-09	122	222	14	19	**2200**	**1925**
Jun-09	**508**	**2314**	**641**	**251**		**1106**
Sep-09	**206**	**777**	**193**	**204**		**876**
Dec-09	83	182	50	50		**3944**

The water quality data shows Foe Killer Creek meets water quality standards during the Nov.-April season for the majority of the sampling sites between the years 2004 and 2010. However, Foe Killer Creek fails to meet the water quality standards during the May-Oct season for the majority of the sampling sites between the years 2004 and 2010. This result is typical among suburban streams listed for bacteria. The data trends show large quantities of bacteria during the wet years 2004-2006 representing a possible correlation between stormwater run-off and degraded water quality. This could be a result of bacteria attached to stream bed sediment that is disturbed during high volume and high velocity stormwater events that re-suspend these sediments in the sampling water column. This is confirmed by the correlation of high turbidity values with high bacteria values as seen in Appendix C.



Big Creek Water Quality Monitoring Location Map

Figure 2-7 Big Creek Water Quality Monitoring Location Map

Section 3 Regulatory Review

3.1 Introduction

Some parts of the Big Creek watershed are under the jurisdiction of the Cities of Alpharetta, Roswell, Milton, Johns Creek and Cumming, as well as Fulton, Forsyth, and Cherokee Counties. In addition, the entire watershed is subject to state and federal regulations concerning various aspects of stormwater management and water quality protection.

Historically, ordinances and regulations regarding water quality varied between jurisdictions located in the watershed. However, each jurisdiction in the Big Creek watershed is now a member of the Metropolitan North Georgia Water Planning District (District). One of the District's goals is to provide consistency and regulatory compliance and accountability among jurisdictions in the greater Atlanta area to benefit water quality.

The purpose of this section is to review the Georgia state and local regulations that are applicable to water supply watershed protection. Copies of various ordinances, regulations and policies were obtained from the governments having jurisdiction in the Big Creek watershed. Other regulations were obtained from the appropriate state and federal agencies. Existing federal, state and local policies and regulations affecting water quality in the Big Creek watershed are listed in this section.

The District Watershed Management Plan highlights the federal and state regulations jurisdictions must follow. Details of these regulations can be found in the District Watershed Management Plan document. These regulations include:

- Federal Clean Water Act
    - National Pollution Discharge Elimination System Program (NPDES) – Municipal Stormwater
    - Municipal Separate Storm Sewer Systems (MS4)
    - Stormwater Management Plan
    - National Pollution Discharge Elimination System Program (NPDES) – Industrial Discharge
    - National Pollution Discharge Elimination System Program (NPDES) – Wastewater Discharge
    - National Pollution Discharge Elimination System Program (NPDES) – Construction Runoff
    - Total Maximum Daily Load (TMDL) Program
    - Wetlands Protection (Section 404, Section 401 Permits)
- Federal Safe Drinking Water Act
    - Source Water Assessment Plans
- Federal Flood Protection Programs
    - National Flood Insurance Act
    - National Dam Safety Program
- Federal Endangered Species Act
- Georgia Water Quality Control Act
- Georgia Erosion and Sedimentation Control Act
- Metropolitan River Protection Act
- Georgia Planning Act

- Part 5 Environmental Criteria
- Water Supply Protection
- Critical area extent
- Include District elements in jurisdiction Comprehensive Plan

- Georgia State Water Plan

3.2 Metropolitan North Georgia Water Planning District

The Metropolitan North Georgia Water Planning District was developed by the Georgia General Assembly, Official Code of Georgia Chapter 5 Title 12 to establish policy, promote inter governmental coordination and protect water resources within the greater Atlanta region. The District created three guiding documents; the Watershed Management Plan, the Water Supply and Conservation Plan and the Wastewater Management Plan. The Plans were originally developed in 2003 and updated in 2009 and recommend water, wastewater and water resources planning scenarios and management measures for implementation by the jurisdictions in the District. Section 5 of the Watershed Management Plan summarizes the management measures which vary from adopting ordinances to developing floodplain maps and monitoring water resources. Table 3.1 presents the list of recommended management measures from Chapter 5 of the Watershed Management Plan.

Table 3.1
Big Creek Watershed Study
District Watershed Management Measures

Functional Category	Measure
Legal Authority	Post-Development Stormwater Management Ordinance
	Floodplain Management Ordinance
	Stream Buffer Protection Ordinance
	Illicit Discharge and Illegal Connection Ordinance
	Litter Control Ordinance
Watershed Planning	Comprehensive Land Use Planning
	Floodplain Delineation and Map Maintenance
	Sanitary Sewer and Septic System Coordination
Land Development	Integrated Development Review Process
	Stormwater Management Design Review Criteria and Standards
	Construction Erosion and Sedimentation Control
Asset Management	Stormwater Infrastructure Inventory
	Extent and Level of Service Policy
	Stormwater System Inspections
	Stormwater Maintenance Program
	Capital Improvement Plan
Pollution Prevention	Pollution Prevention/Good Housekeeping
	Illicit Discharge Detection and Elimination Program
Watershed Conditions Assessment	Long-term Ambient Trend Monitoring
	Habitat and Biological Monitoring
Education and Public Awareness	Local Education and Public Awareness Program
Resource-specific	Source Water Supply Watershed Protection
	TMDL Management
	Endangered Species Protection
	Watershed Improvement Projects

The District plan provides an umbrella plan that includes measures to comply with federal, state and local requirements. Several of the measures identified in the plan were already being implemented by some jurisdictions within the Big Creek watershed. The District plan provides a single source for tracking and managing compliance with watershed management programs.

Implementing the management measures identified in the Plan also allows jurisdictions to comply with the MS4 permit, and NPDES program requirements. Jurisdictions within the Big Creek watershed have been working to implement the District Plan measures. The floodplain mapping and stormwater inventory management measures have required significant effort and resources of each jurisdiction.

In order for a local government within the District to receive a permit for an increased water withdrawal, a new or increased discharge, or for an MS4 permit, that jurisdiction must be in compliance with the District plans. The Georgia EPD is responsible for auditing local governments to determine compliance with the plans. Georgia EPD has revised its audit checklist to reflect the Metro Water District Plan updates that were adopted in May 2009.

3.3 Part 5 Environmental Criteria

The official code of Georgia and the Georgia Planning Act establishes requirements for small water supply watersheds. The Big Creek water supply watershed is approximately 99 square miles above the City of Roswell drinking water intake. The watershed is subject to the minimum criteria for a small water supply watershed detailed below. These requirements include limiting impervious area, preserving buffer zones and limiting septic systems within a buffer. Buffer criteria are separated into two categories, within a seven mile radius upstream of the water intake and outside the seven mile radius of the water intake. The seven mile buffer is shown in Figure 3-1

3.3.1 Requirement - 1 Area within a Seven Mile Radius

The perennial stream corridors of a small water supply watershed within a seven (7) mile radius upstream of a governmentally owned public drinking water supply intake or water supply reservoir are protected by the following criteria:

- A buffer shall be maintained for a distance of 100 feet on both sides of the stream as measured from the stream banks.
- No impervious surface shall be constructed within a 150 foot setback on both sides of the stream as measured from the stream banks.
- Septic tanks and septic tank drainfields are prohibited in the setback area above.

Minimal development is identified within the buffers. This development is part of the Roswell Historic District and was likely constructed within the buffer prior to the Georgia Planning Act. The City of Roswell and City of Alpharetta currently prohibit new development within the buffer. This buffer is more restrictive than the stream buffer ordinance required by the District.

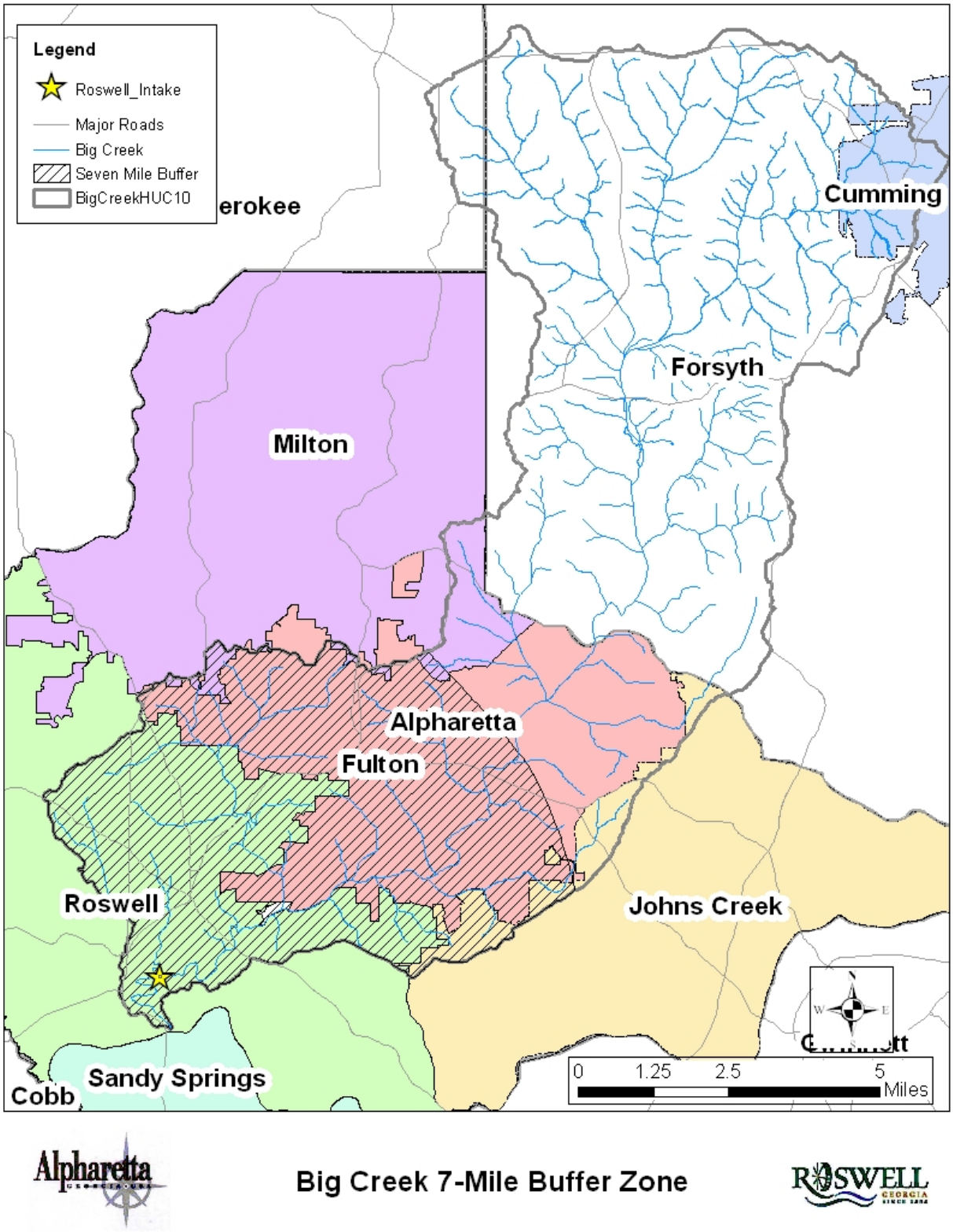


Figure 3-1 Seven Mile Buffer Zone

3.3.2 Requirement – 2 Areas outside a Seven Mile Radius

The perennial stream corridors within a small water supply watershed and outside a seven (7) mile radius upstream of a governmentally owned public drinking water supply intake or water supply reservoir are protected by the following criteria:

- A buffer shall be maintained for a distance of 50 feet on both sides of the stream as measured from the stream banks.
- No impervious surface shall be constructed within a 75 foot setback area on both sides of the stream as measured from the stream banks.
- Septic tanks and septic tanks drainfields are prohibited in the setback areas above.

Some historic development is identified within the buffers near Northpoint Parkway. The City of Roswell and City of Alpharetta currently prohibit new development within the buffer. This buffer requirement is similar to the required buffer from the District.

3.3.3 Requirement 3 – Entire Watershed

The following criteria apply to all locations in a small water supply watershed.

1. New sanitary landfills are allowed only if they have synthetic liners and leachate collection systems.

   No sanitary landfills were identified in the watershed according to EPA records reviewed in this study. No hazardous waste treatment or disposal facilities were identified within the watershed according to EPA records that were reviewed for this study. Facilities that handle hazardous materials should have a spill prevention control and countermeasures plan (SPCC).

2. New hazardous waste treatment or disposal facilities are prohibited.

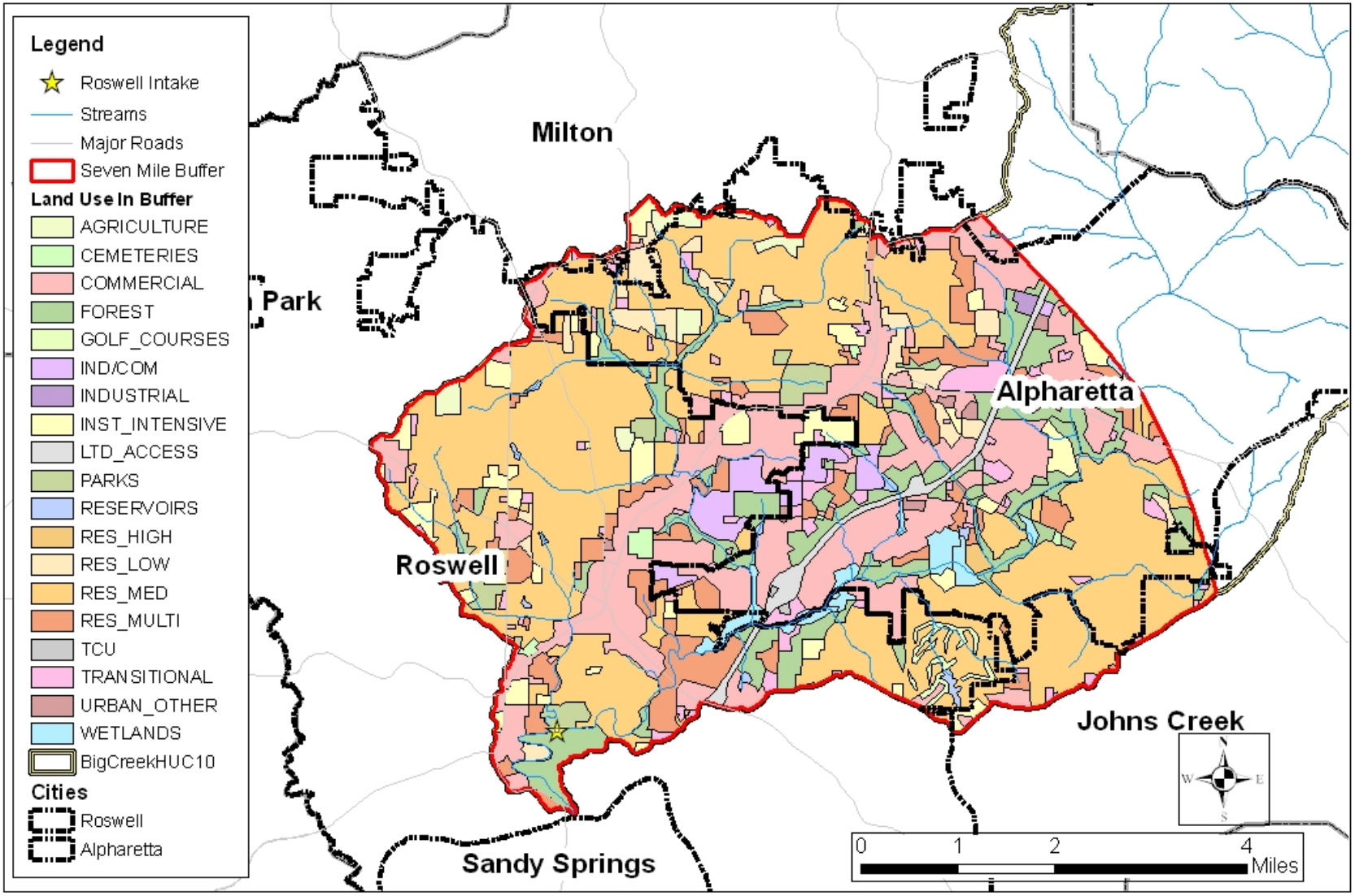
   No new hazardous waste treatment or disposal facilities are planned within the City of Alpharetta and the City of Roswell. These jurisdictions should work with other jurisdictions within the Big Creek Watershed to insure that hazardous waste treatment and disposal facilities are prohibited by the jurisdictions ordinances.

3. The impervious surface area, including all public and private structures, utilities, or facilities, of the entire water supply watershed shall be limited to twenty-five (25) percent, or existing use, whichever is greater.

   Land use and land cover data were used to identify the impervious surface area within the seven mile buffer. Atlanta Regional Commission Land Use data from 2009 was used to identify the percentage of impervious cover within the 7 mile buffer of Big Creek as seen in Figure 3-2. The City of Roswell and City of Alpharetta are addressing impacts from impervious surfaces by encouraging green infrastructure and low impact development within the watershed (See Section 6 of this report). All future development within the Cities must include stormwater management measures that detain runoff to pre-development conditions. This best management practice (BMP) and other improved development requirements will help reduce the impact impervious development has on the watershed.

4. New facilities which handle hazardous materials of the types and amounts determined by the Department of Natural Resources, shall perform their operations on impermeable surfaces having spill and leak collection systems as prescribed by the Department of Natural Resources.

   The jurisdictions within the Big Creek Watershed will ensure that any new facilities which handle hazardous materials will be monitored as part of the MS4 permit by performing commercial inspections on these highly visible pollutant sites (HVPS).



Big Creek 7-Mile Buffer Zone Land Use

Figure 3-2 Big Creek 7-Mile Buffer Zone Land Use

Section 4 Estimating Current and Future Runoff and Flooding Impacts

4.1 Introduction

The Big Creek Watershed Study developed in 2000 included a water quantity model. The EPA Storm Water Management Model (SWMM) was selected to assess the hydrology and hydraulics of the Big Creek Watershed. The model was run for several design storms (2,10,25, and 100-year) to determine peak discharge surface elevations and peak velocities under existing 1995 and future 2020 land use conditions. The modeling results showed an evaluation of flooding and stream erosion potential and to some degree the ability of groundwater to replenish streams at low flow.

4.2 Floodplain Management/ Flood Damage Prevention Model Ordinance

The District Plan requires jurisdictions to adopt the floodplain management/ flood damage prevention model ordinance. According to the District Plan, "The ordinance is intended to help jurisdictions integrate floodplain management with stormwater management during the land development process. The ordinance promotes a No Adverse Impact approach to floodplain encroachments, establishes planning requirements to map and regulate land development based on future-conditions hydrology, and promulgates higher freeboard and building standards than the FEMA minimums."

Local jurisdictions have adopted the floodplain model ordinance, or an equivalent ordinance or regulations, that:

- Regulates floodplains based on expected future land use conditions.
- Requires a floodplain management plan for land development activities within areas of special flood hazard.
- Includes a requirement that any land development within a floodplain be required to provide an engineering study to demonstrate that it will cause no adverse impact downstream or upstream.
- Specifies building requirements and provisions to minimize flood damages for both residential and non-residential structures within the floodplain.
- Provides appropriate variance and enforcement procedures.

4.3 District Plan Future-Conditions Floodplain Delineation

The District Plan also requires future-conditions floodplain delineation. Jurisdictions within the District are to map the 100-year future-conditions floodplain and update the maps as needed.

In 2003, FEMA embarked on a comprehensive, five-year initiative to update the nation's flood maps to reflect current flood risks, working with local governments, water management districts, and other partners. The new maps are digital, rather than paper-based. The process of Flood Map Modernization (or Map Mod) is currently ongoing. The process attempts to create view and use flood maps digitally and on-line.

The City of Alpharetta and the City of Roswell are partnering in this process to update their flood maps. The new digital flood maps will provide detailed, property-specific flood risk data to guide construction and flood insurance decisions. The planned release of these maps is in the summer of 2012. At that time, residents and business owners will have up-to-date, reliable, Internet-accessible data about the flood hazards they face.

The City of Alpharetta and City of Roswell have begun using the floodplain models to identify roadway structures which may need repair or replacement. These structures are added to the respective city's Capital Improvement Projects (CIP) list. The City of Alpharetta and City of Roswell have used the models and GIS data to understand which homes will have the greatest depth of water around the foundation during a flood. The models are also used to portray a more accurate understanding of risk of potential flooding both in and out of the floodplain. The City of Alpharetta and City of Roswell have used the models to evaluate the hydraulics of existing conditions to develop alternatives to reduce flooding impacts.

Any hydraulic revision which produces 0.01 foot of elevation difference in the base flood will be added to the model by the respective city. The process for this is a Conditional Letter of Map Revision (CLOMR) or Letter of Map Revision (LOMR). The cities will update the models and rerun the hydraulics (HEC-HMS) to capture additional development in the watershed. The City of Alpharetta and City of Roswell have a future conditions model as well that shows a built out condition based on current zoning.

Section 5 Estimating Current and Future Water Quality Impacts

5.1 Introduction

This section describes the development of the EPA Better Assessment Science Integrating point & Non-point Sources (BASINS) and the EPA Pollutant Load Estimation Model (PLOAD) for analyzing water quality impacts in the Big Creek watershed under existing and future conditions and presents the results of that analysis. The PLOAD representation of the Big Creek watershed was developed and calibrated to local NPDES stormwater data and ambient monitoring data.

Pollutant buildup and washoff algorithms within PLOAD were applied to simulate stormwater pollution loadings from individual land uses within the watershed. These algorithms assume that pollutant loads accumulate on the land surface during dry weather periods prior to a storm event and are washed off by stormwater runoff during each rainfall event. The model was driven by annual average rainfall data, which was considered representative of average annual conditions.

5.2 Selection of Water Quality Parameters

The water quality impacts analysis is limited to the following constituents or parameters:

- Sediment (TSS, TDS)
- Nutrients (total phosphorus, TKN, and Nitrate-Nitrite)
- Pathogens (fecal coliform)
- Heavy metals (lead, copper, zinc and cadmium)
- Oxygen demand (BOD, COD)

5.3 Model Setup

The model was developed using EPA Better Assessment Science Integrating point & Non-point Sources (BASINS) and the EPA Pollutant Load Estimation Model (PLOAD). Two land use data sets were used to construct the model, 2001 national land use data provided within the BASINS model and 2009 land use data provided by the Atlanta Regional Commission. These data sets were used to identify the trends for pollutant loads over time. Using these past data sets, future land use can be predicted using an extrapolation of the data.

The PLOAD Model uses land use and average rainfall to identify the pollutant Event Mean Concentrations (EMC's) and pollutant load. The model assigns percentages of imperviousness to each land use category to identify the contribution of stormwater runoff on pollutant loads. The model can then be calibrated to water quality monitoring data to ensure the model values are an accurate depiction of water quality trends.

5.4 Model Calibration

The values obtained from the model were compared to actual field data values from Water Quality Monitoring data for Big Creek. The values compared were limited to Pathogens, Copper and Phosphate EMC that were available from the water quality monitoring data. The model and field value for Pathogens EMC were within 19% for 2001 and 5% for 2009. The model results were also compared to

the 2000 Big Creek Watershed Study results. The model produced for this report showed pollutant values slightly less than those identified in the 2000 study. The District Plan provided model values for TSS and total phosphorus for existing and future conditions for the entire District area. The Districts values for TSS and total phosphorus were similar to the values calculated for this study. Under existing conditions, the estimated total phosphorus load to be 0.6 lbs/ac/yr and the estimated TSS to be 518 lbs/ac/yr as identified in the District Plan while the estimated total phosphorus load is 0.94 lbs/ac/yr and the estimated TSS load is 108 lbs/ac/yr as calculated in this study. Future conditions without treatment controls identified the estimated total phosphorus load to be 0.85 lbs/ac/yr and the estimated TSS is 518 lbs/ac/yr as identified in the District Plan while the estimated total phosphorus load is 3.97 lbs/ac/yr and the estimated TSS load is 400 lbs/ac/yr as calculated in this study.

5.5 Model Results

Tables 5.1 to 5.4 show the model results. The EMC change over the 8-year period (2001 to 2009) for each pollutant is presented in Table 5.1. The pollutant load change for each pollutant over the 8-year period is presented in Table 5.2. Figure 5-1 shows the different pollutants and their change from 2001 to 2009. All pollutant EMCs have increased except TSS and TDS.

Table 5.1
Big Creek Watershed Study
Estimated Annual Pollutant EMC 2001 and 2009

Pollutant (EMC)	Estimated Annual Pollutant EMC (mg/L) 2001	Estimated Annual Pollutant EMC (mg/L) 2009	% Change over 8-year period
Nickel	0.0075	0.0079	4.72
Mercury	0.0094	0.0099	4.37
Chromium	0.0075	0.0079	4.72
Cadmium	0.0047	0.0049	4.35
Lead	0.019	0.0197	3.71
Copper	0.0094	0.0099	4.35
Zinc	0.0944	0.0985	4.35
Phosphate	0.1893	0.1971	4.13
Organic Nitrogen	0.3786	0.3942	4.13
Ammonia	0.1893	0.1971	4.13
Total Kjeldahl Nitrogen	1.4144	1.4769	4.42
Nitrite	0.1893	0.1971	4.13
Nitrogen-Nitrate	0.9465	0.9855	4.13
Phosphorus	0.4679	0.4913	5.01
Total Nitrogen	1.893	1.9711	4.13
Total Dissolved Solids	54.0019	50.9044	-5.74
Total Suspended Solids	54.0019	50.9044	-5.74
Chemical Oxygen Demand	49.2921	49.7373	0.90
Biological Oxygen Demand	13.9082	14.7108	5.77
Pathogens[1]	1908.0974	1993.3367	4.47

1 - Pathogen EMC in Counts/100 ml

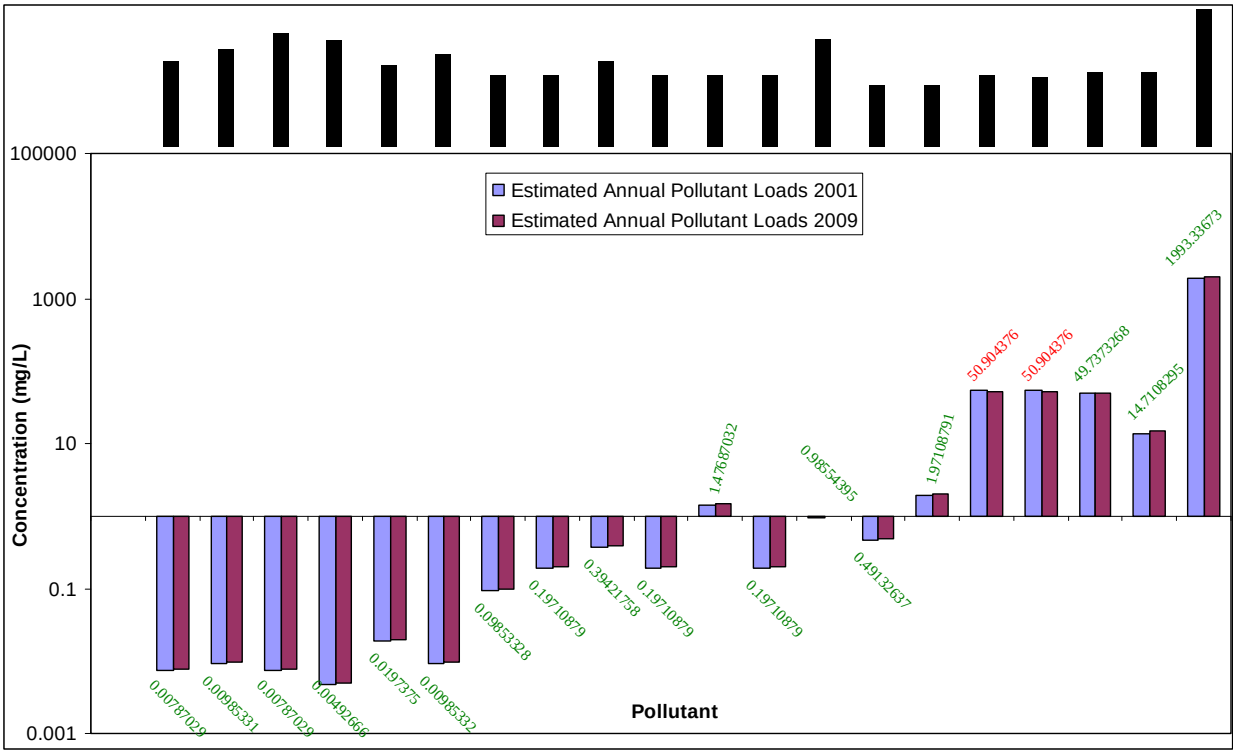


Figure 5-1 Graph of Estimated Annual Pollutant EMC for 2001 and 2009

Table 5.2
Big Creek Watershed Study
Estimated Annual Pollutant Load 2001 and 2009

Pollutant (Load)	Estimated Annual Pollutant Load in (lbs./acre) 2001	Estimated Annual Pollutant Load in (lbs./acre) 2009	% Change over 8-year period
Nickel	0.02	0.04	161%
Mercury	0.02	0.05	160%
Chromium	0.02	0.04	161%
Cadmium	0.01	0.02	160%
Lead	0.04	0.10	158%
Copper	0.02	0.05	160%
Zinc	0.19	0.49	160%
Phosphate	0.38	0.99	159%
Organic Nitrogen	0.76	1.97	159%
Ammonia	0.38	0.99	159%
Total Kjeldahl Nitrogen	2.84	7.39	160%
Nitrite	0.38	0.99	159%
Nitrogen-Nitrate	1.90	4.93	159%
Phosphorus	0.94	2.46	161%

Table 5.2
Big Creek Watershed Study
Estimated Annual Pollutant Load 2001 and 2009

Pollutant (Load)	Estimated Annual Pollutant Load in (lbs./acre) 2001	Estimated Annual Pollutant Load in (lbs./acre) 2009	% Change over 8-year period
Total Nitrogen	3.80	9.86	159%
Total Dissolved Solids	108.46	254.59	135%
Total Suspended Solids	108.46	254.59	135%
Chemical Oxygen Demand	99.00	248.75	151%
Biological Oxygen Demand	27.93	73.57	163%
Pathogens	3,832.36	9,969.34	160%

1 - Pathogen Load in Counts

The future pollutant values in 2017 were estimated, using the data from 2001 and 2009. The data was extrapolated using a linear and exponential graph. The results indicated that the linear plot is a better fit for the pollutant model. Assuming that the pollutants have a linear rate of increase, the data values could be extrapolated for future years. Figure 5-2 presents a graph showing the linear vs. exponential fit and how the growth varies after a period of time. Tables 5.3 and 5.4 show the Estimated Annual Pollutant EMC and Loads for 2017 compared to 2001 and 2009. Figure 5-3 presents a graph of the estimated future loads.

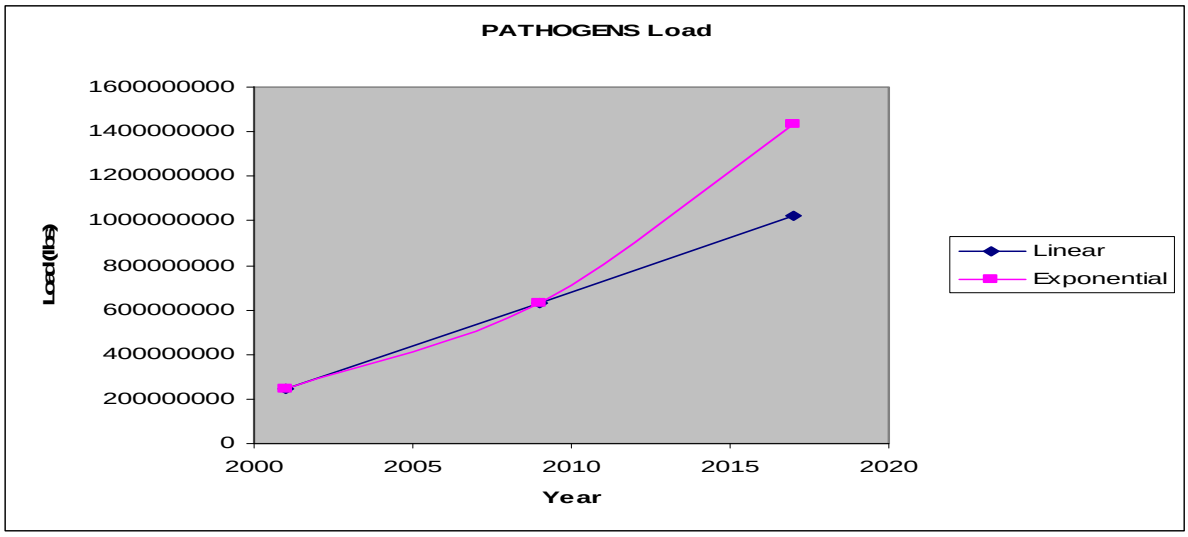


Figure 5-2 Linear vs. Exponential Growth

Table 5.3
Big Creek Watershed Study
Estimated Annual Pollutant EMC 2001, 2009 and 2017

Pollutant EMCs	Estimated Annual Pollutant EMCs (mg/L) 2001	Estimated Annual Pollutant EMCs (mg/L) 2009	Estimated Annual Pollutant EMCs (mg/L) 2017
Nickel	0.0075	0.0079	0.0080
Mercury	0.0094	0.0099	0.0103
Chromium	0.0075	0.0079	0.0082
Cadmium	0.0047	0.0049	0.0051
Lead	0.019	0.0197	0.0204
Copper	0.0094	0.0099	0.0103
Zinc	0.0944	0.0985	0.1026
Phosphate	0.1893	0.1971	0.2049
Organic Nitrogen	0.3786	0.3942	0.4098
Ammonia	0.1893	0.1971	0.2049
Total Kjeldahl Nitrogen	1.4144	1.4769	1.5393
Nitrite	0.1893	0.1971	0.2049
Nitrogen-Nitrate	0.9465	0.9855	1.0245
Phosphorus	0.4679	0.4913	0.5148
Total Nitrogen	1.893	1.971	2.0492
Total Dissolved Solids	54.0019	50.9044	47.8068
Total Suspended Solids	54.0019	50.9044	47.8068
Chemical Oxygen Demand	49.2921	49.7373	50.1826
Biological Oxygen Demand	13.9082	14.7108	15.5135
Pathogens	1,908.10	1,993.34	2,078.58

1 - Pathogen EMC in Counts/100 ml

Table 5.4
Big Creek Watershed Study
Estimated Annual Pollutant Load 2001, 2009 and 2017

Pollutant (Load)	Estimated Annual Pollutant Load in (lbs/acre) 2001	Estimated Annual Pollutant Load in (lbs/acre) 2009	Estimated Annual Pollutant Load in (lbs/acre) 2017
Mercury	0.02	0.05	0.08
Chromium	0.02	0.04	0.06
Cadmium	0.01	0.02	0.04
Lead	0.04	0.10	0.16
Copper	0.02	0.05	0.08
Zinc	0.19	0.49	0.80
Phosphate	0.38	0.99	1.59
Organic Nitrogen	0.76	1.97	3.18
Ammonia	0.38	0.99	1.59
Total Kjeldahl Nitrogen	2.84	7.39	11.93
Nitrite	0.38	0.99	1.59
Nitrogen-Nitrate	1.90	4.93	4.93
Phosphorus	0.94	2.46	3.97
Total Nitrogen	3.80	9.86	15.91
Total Dissolved Solids	108.46	254.59	400.72
Total Suspended Solids	108.46	254.59	400.72
Chemical Oxygen Demand	99.00	248.75	398.50
Biological Oxygen Demand	27.93	73.57	119.21
Pathogens	3,832.36	9,969.34	16,106.32

1 - Pathogen Load in Counts

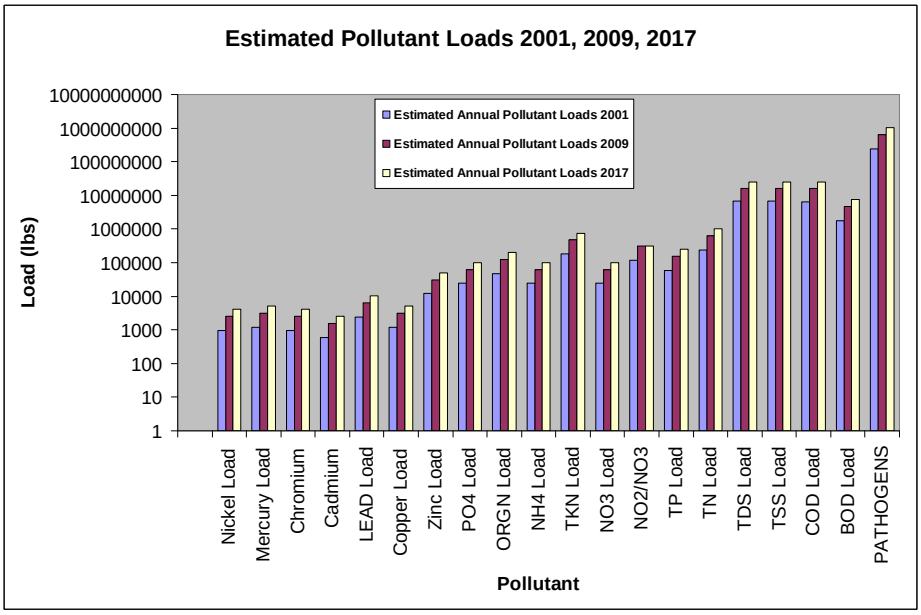


Figure 5-3 Graph of Estimated Annual Pollutant Loads 2001, 2009 and 2017

5.6 Summary of Water Quality Model

According to the 2001 Land Use data provided by EPA and the 2009 Land Use data provided by ARC, the EMC for 16 out of 16 Pollutants have increased slightly from 2001 to 2009. COD and BOD concentrations have increased along with TDS and TSS loads. The only decrease was in the EMC's of TDS and TSS. A site should aim to remove 80% of the average annual post-development TSS load. This may be achieved through the use of better site design practices or implementing structural stormwater controls. Runoff from impervious areas in the developed areas will increase the flow and contribute to erosion problems which in turn can be harmful to aquatic habitats.

Approximately 80% of land use in the Big Creek watershed is allocated to Medium Density Residential. This will greatly impact the water quality within the area. It is observed that the toxic metals have also increased. This is most likely related to runoff from parking lots and roads.

The pollutant with the most significant EMC increase is Total Phosphorus which increased by 5.01% over the eight year period. The most important concern is the Total Phosphorus load entering the stream or lake from an entire watershed. High STP (Soil Test Phosphorus) levels require long periods of time to be reduced to a normal recommended level. The increased phosphorus levels are partly a result of the use of household products by residents such as fertilizers and detergents. Automatic dishwasher detergent accounts for 10-12% of Phosphorus entering wastewater plants. Phosphorus is naturally occurring in soil and in water acts as a fertilizer for plants. Accelerated growth leads to dead plants which consume all the dissolved oxygen and deprive the other aquatic life of the oxygen they require.

Pathogen counts have also increased significantly and are possibly caused by sanitary sewer overflows, pet wastes and failing septic systems. Increasing residential development will result in a rise in the number of citizens in the area. Sanitary sewer overflows, natural fertilizers, failing septic tanks and pet wastes are usually likely sources for high levels of fecal coliform bacteria in urban run-off.

The aforementioned consequences have been a direct effect of increased land usage specifically medium density residential. It is evident that land development will have a negative impact on water quality. Proper preventative measures as described in Section 6 of this report should be taken to reduce these impacts of increasing nutrients and pathogens. The model will aid in efforts to predict future conditions and allow for guided community development.

Section 6 Recommended Watershed Management Plan

6.1 Introduction

The 2000 Big Creek Watershed Study included a section dedicated to the overview of water quality control measures for watershed protection (Section 6) and an analysis of watershed management scenarios (Section 7). In this study update, these sections have been eliminated and a brief summary of these sections have been included as part of the recommended watershed management plan.

6.2 Water Quality Control Measures

An overview of water quality control measures can be found in the Georgia Stormwater Management Manual (GSMM). The GSMM was drafted in 2001. Volume 2 of the GSMM includes design guidelines for designing stormwater management features including:

- Stormwater Ponds,
- Stormwater Wetlands,
- Bioretention Areas,
- Sand Filters,
- Infiltration Trenches,
- Enhanced Swales, and
- Other limited application structures.

The District Plan requires jurisdictions to adopt the use of the GSMM as the design standard for new stormwater management features. The GSMM includes stormwater sizing criteria in Table 1.3.1-1 and is reproduced here in Table 6.1. The stormwater management strategies recommended in this section should be designed using the GSMM and sized according to the criteria identified in Table 6.1.

Table 6.1
Big Creek Watershed Study
Sizing Criteria for Stormwater Features

Sizing Criteria	Description
Water Quality	Treat the runoff from 85% of the storms that occur in an average year. For Georgia, this equates to providing water quality treatment for the runoff resulting from a rainfall depth of 1.2 inches. Reduce average annual post-development total suspended solids loadings by 80%.
Channel Protection	Provide extended detention of the 1-year storm event released over a period of 24 hours to reduce bankfull flows and protect downstream channels from erosive velocities and unstable conditions.
Overbank Flood Protection	Provide peak discharge control of the 25-year storm event such that the post-development peak rate does not exceed the pre-development rate, to reduce overbank flooding.
Extreme Flood Protection	Evaluate the effects of the 100-year storm on the stormwater management system, adjacent properties, and downstream facilities and properties. Manage the impacts of the extreme storm event through detention controls and/or floodplain management.

6.3 Watershed Management Scenarios

Section 7 of the 2000 Big Creek Watershed Study included the following scenarios for watershed management:

Scenario 1: Status Quo – Future Land Use with Existing Controls

Scenario 2: Limit Impervious Area to Achieve Water Quality Goals

Scenario 3: Jurisdictions at 25% or Existing Impervious Area (whichever is greater)

Scenario 4: Watershed at 25% Impervious

Scenario 5: Future Land Use with Source Controls Only

Scenario 6: Future Land Use with Treatment Controls Only

Scenario 7: Future Land Use with Source and Treatment Controls

In the 2000 Big Creek Watershed Study modeling was conducted of all the possible scenarios. It was concluded that Scenario 7: Future Land Use with Source and Treatment Controls throughout the undeveloped portion of the watershed provides the best opportunity to achieve water quantity, water quality, and community goals. Besides allowing water quality targets to be met, the scenario also enhances and protects habitat and enhances social components such as recreation and overall environmental quality. While this scenario will require the application of Best Management Practices (BMPs) to new residential, commercial, and industrial development, that can be accomplished with minimal impact to economic growth in the watershed. Furthermore, the improvements to water management and environmental quality actually will accrue more benefits than the long-term cost.

Recognizing that water quality targets must be obtained, many of the scenarios became too costly in meeting that goal. For instance, the application of source controls only would seriously hinder the economic viability of the watershed.

6.4 Source Controls

Source controls are recommended for preventing pollution at the planning level. The existing source controls including ordinances and pollution prevention programs implemented by City of Alpharetta and City of Roswell are detailed below. Source controls can be implemented throughout the Big Creek watershed at minimal cost to the jurisdictions. Several existing source controls are already in place within the jurisdictions and continue to provide watershed protection.

6.4.1 Ordinances

The following ordinances have been adopted by the City of Alpharetta and City of Roswell as BMPs to provide watershed management support and improve water quality.

City of Alpharetta:

- Stormwater Management Ordinance – Unified Development Code Article 3 Section 3.3
    - Post Development Stormwater Management
    - Illicit Discharge and Illegal Connections
    - Stream Buffer Protection
    - Wetlands Protection
    - Water Supply Watershed Protection
    - Groundwater Recharge Area
    - Conservation Subdivision
- Erosion and Sedimentation Control Ordinance – Unified Development Code Article 3 Section 3.1
- Flood Damage Prevention Ordinance – Unified Development Code Article 3 Section 3.4
- Tree Protection – Unified Development Code Article 3 Section 3.2
- Litter Control – Municipal Code Chapter 10

City of Roswell:

- Post-Development Stormwater Management Ordinance – Chapter 7
- Erosion and Sedimentation Control Ordinance – Chapter 7
- Flood Damage Prevention Ordinance – Chapter 7
- Illicit Discharge and Illegal Connections Ordinance – Chapter 7
- Litter Control Ordinance – Chapter 7
- Stream Buffer Protection Ordinance – Article 21
- Groundwater Recharge Ordinance – Article 21
- Wetlands Ordinance – Article 21
- Conservation Subdivisions Ordinance – Article 28

6.4.2 Pollution Prevention Programs

The City of Alpharetta and City of Roswell implement the following programs as part of the Stormwater Management Plan (SWMP) required by the MS4 Phase I permit:

- Public Education and Public Involvement
- Street Sweeping
- Keep Alpharetta/Roswell Beautiful
- Illicit Discharge Detection and Elimination Program
- Litter Control
- Industrial Facility and Highly Visible Pollutant Source (HVPS) Inspections
- Alpharetta/Roswell Comprehensive Plans

Details for each pollution prevention program can be found in the City of Alpharetta SWMP and the City of Roswell SWMP. The Georgia Stormwater Management Manual is in the process of being updated to include stormwater pollution prevention measures. The Georgia Stormwater Management Manual should be referenced for additional pollution prevention measures.

6.5 Treatment Controls

Treatment Controls or BMPs can be implemented in an effort to reduce the elevated levels of bacteria in the Big Creek watershed. These BMPs range from public awareness and public involvement to treatment controls and structural measures implemented by the City of Alpharetta and City of Roswell. These BMPs primarily address reducing urban runoff volumes and velocities identified as the primary source of fecal coliform pollution. Table 6.2 shows the list of BMPs recommended for the Big Creek watershed.

Table 6.2
Big Creek Watershed Study
Recommended BMPs for Big Creek

Public Awareness and Public Involvement	Watershed Newsletter
	Public Awareness to Reduce FOGs
	School Education Activities
	Homeowner Education Workshops
Non-structural Measures	Septic Tank Elimination Program
	Increased Water Quality Monitoring
	Debris Removal from Structures
	Bacteria Source Tracking
	Neighborhood of Environmental Excellence
	Greenspace Acquisition and Management
Structural Measures	Stormwater Detention Basin – Wills Park
	Stormwater Detention Basin – Liberty Square
	Stormwater Detention Basin – Carriage Station
	Stormwater Detention Basin Retrofits
	Rain Gardens – Wills Park, Waller Parks
	Rain Barrels – Wills Park, Waller Parks
	Stream Bank Restoration (Various Locations)
	Disconnect Impervious Surfaces
	Reduce Impervious Surfaces
	Low Impact Development/Redevelopment and Green Infrastructure
	Alum Treatment of Regional Detention Ponds

6.6 Public Awareness and Public Involvement

Watershed Newsletter - The City of Alpharetta and City of Roswell should highlight Big Creek in a stormwater newsletter. The newsletter could be available on the City's website or included with the water and sewer bill as a billing insert or included as an ad in the recreation and parks course guide. The public awareness newsletter would include a map and photos of Big Creek along with protection measures homeowners can implement to reduce pollution into the streams such as, picking up pet waste, yard leaves, replacing grass stream banks with natural stream bank cover, and installing rain barrels and rain gardens to reduce stormwater runoff. Other topics could include reducing fats, oils, and grease (FOGs) to help prevent sanitary sewer overflows (SSOs).

Public Awareness to Reduce FOGs – Fulton County Sewer Use Ordinance limits Fats, Oils and Grease (FOGs) disposal from commercial facilities (Chapter 82 Article IV). However, spill reports indicate FOGs to be the leading cause of sewer overflows. The City of Alpharetta and City of Roswell should develop a web campaign and distribute brochures to reduce fats, oils, and grease from residents causing sanitary sewer overflows (SSOs). The brochures should be designed to inform homeowners of the consequences of grease build up in the sanitary sewer lines. Brochures should be designed for both English and Spanish readers. The City of Alpharetta and City of Roswell should develop grease disposal kits to distribute to homeowners as an alternate disposal for grease. The following resources could be used to assist in providing educational materials for the public:

- Georgia Department of Natural Resources Sustainability Division (FOG Posters)
- California Fats, Oils and Grease Workgroup – FOG Outreach
- Georgia F.O.G. Alliance

School Education Activities - The City of Alpharetta and City of Roswell should partner with local schools within the Big Creek watershed basin including Fulton Science Academy Middle School, Haynes Bridge Middle School, New Prospect Elementary School, Alpharetta High School, Creek View Elementary School, Northwoods Elementary School, and Ester Jackson Elementary School to reduce stormwater runoff from buildings and parking areas. Lesson plans about stormwater runoff could encourage class projects including painting rain barrels or building rain gardens. The following list includes references for school education activities.

- EPA Articles and Activities for Middle School Students – Streams in the City
- EPA Brochure - Build Your Own Rain Barrel
- Clean Water Campaign – Teachers Resources
- Clean Water Campaign – Rain Garden DIY Guide

The City of Alpharetta and the City of Roswell participate with schools within their districts in the EverGreen school program that promotes environmental stewardship.

Home Owners Education Workshops – The Big Creek jurisdictions should partner with home owners within the Big Creek watershed to reduce stormwater runoff and pollution prevention. Workshop topics to be covered include:

- Stream bank landscapes and encouraging the growth of natural stream bank cover.
- Pollution prevention near the stream; reducing yard waste, debris and pet waste.
- Septic tank maintenance and care. Opportunities to connect to sewer if available.

6.7 Non-Structural Measures

Septic Tank Elimination Program - A Septic Tank Elimination Program (STEP) should be developed to encourage home owners on septic systems to connect to available sewer. Elevated levels of fecal coliform in dry weather could be a result of failing septic systems or leaking sewers.
The STEP Program should include the following program elements.

- Review of current regulations.
- Prioritize areas to connect to sewer.
- Work with Fulton County to determine capacity analysis.
- Educate homeowners on process for connecting to existing sewers.
- Work with Fulton County to develop sewers in areas on septic only.
- Determine use and design of financial assistance program if any.

Increase Water Quality Monitoring - The jurisdictions of Big Creek should continue monitoring the stream for fecal coliform and *E. coli*. This sampling will provide the Cities with the data needed to evaluate streams and the current impact of stormwater on water quality. The monitoring should be conducted according to the City's approved Sampling Quality Assurance Plan (SQAP). The Standard recommends colleting grab samples for bacteria (fecal coliform and *E. Coli*) analysis 16 times per year. Four samples are to be collected over a 30-day period (at intervals not less than 24 hours) during each of the following quarters: May-July, August-October, November-January, and February-April. Each set of four samples is used to calculate a geometric mean, per State guidelines.

Remove Debris from Structures - The majority of the debris in Big Creek is a result of fallen trees from stream bank scour. In some areas these trees have floated downstream and become lodged against exposed sewer crossings. This can cause a decrease in the capacity of the stream and cause some areas to flood. Debris removal is recommended on sewer crossing locations. City crews should spot check known problem areas and sewer crossings after large rain events to remove potential debris.

Bacteria Source Tracking - Bacteria Source Tracking (BST) is a new methodology to determine the source of fecal coliform pathogen contamination in environmental samples. BST techniques appear to provide the best method to determine the origins of fecal contamination in water bodies. BST uses DNA sampling of the *E. Coli* bacteria found in the water sample and compares the samples to a DNA library to identify if the *E. Coli* source is human, dog, geese, deer or another wildlife source. Once the source of bacteria is identified specific target BMPs can be used to reduce the amount of fecal coliform contamination in the water body. The US EPA has developed a guidance document for Microbial Source Tracking. This document should be used to sample and test for specific pollution sources within the Big Creek watershed.

To determine a contaminate source, a qualified laboratory detects and quantifies the fecal *bacteroidetes* human gene biomarker for human fecal contamination. This is determined by quantitative polymerase chain reaction (qPCR) DNA analytical technology. PCR allows quantities of DNA to be amplified into large number of small copies of DNA sequences. This is accomplished with small pieces of DNA called primers that are complementary and specific to the genomes to be detected.

Through a heating process called thermal cycling, the double stranded DNA is denatured and inserted with complementary primers to create exact copies of the DNA fragment desired. This process is repeated rapidly many times ensuring an exponential progression in the number of copied DNA. If the primers are successful in finding a site on the DNA fragment that is specific to the genome to be studied,

then billions of copies of the DNA fragment will be available for detection by gel electrophoresis (Figure 6-1).

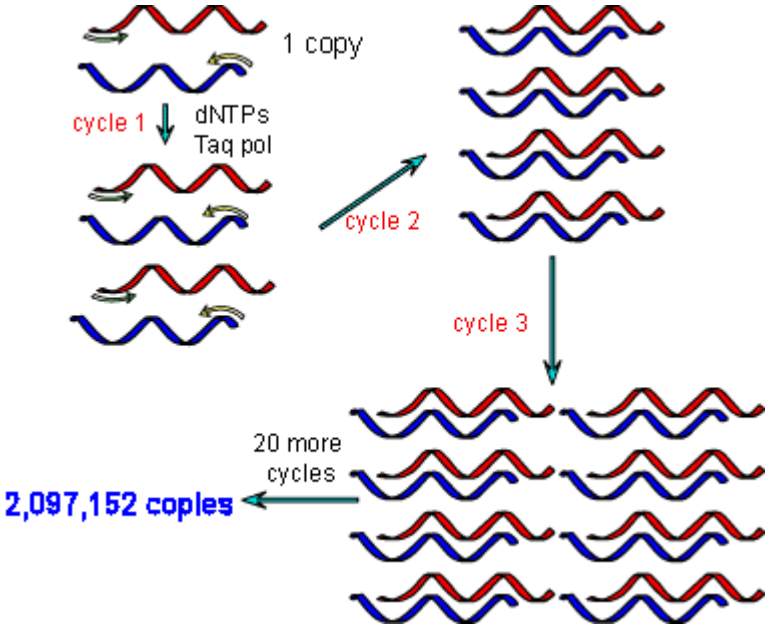


Figure 6-1 - Quantitative Polymerase Chain Reaction. Photo credit: Science Creative Quarterly 2009.

The gel electrophoresis apparatus uses an electrical field to distinguish different DNA fragments according to their molecular weights. Lighter DNA fragments will move farther along the gel than their heavier counterparts. At the end of the procedure different bands of accumulated DNA fragments will aggregate at different parts of the gel. It is this accumulation of DNA fragments that creates a band on the gel. Researchers use these bands to distinguish certain genomes such as the human gene biomarker from the *Bacteroides* and *Prevotella* genus.

The use of BST is limited because the tests are only applied to one certain genome at a time. The tests also only target one bacteria group. Generally, the target bacteria are found in low numbers making the tests difficult to depict accurately the levels of bacteria. The use of BST is expensive and a new technology. There are limited case studies to compare similar streams and BST results. More testing of this kind is needed to develop a better understanding of the technology and its usefulness for targeting TMDL pollutant sources.

Neighborhood of Environmental Excellence - The jurisdictions within the Big Creek watershed should consider partnering with Keep America Beautiful organizations and local homeowners associations to develop a program of neighborhoods of environmental excellence. The program could include several elements such as:

- Public education classes and workshops,
- Installing rain gardens,
- Installing rain barrels,

- Disposing of pet waste in trash receptacles,
- Disposing of grease and oil in trash receptacles,
- Reducing the amount of fertilizers and pesticides, and
- Installing pervious pavers for driveways and other impervious areas.

The Excellence program would encourage a percentage of homes in the neighborhood to adopt these environmentally friendly measures to qualify the neighborhood for the program. Program initiates could receive a sign for the neighborhood or a plaque for the clubhouse.

Greenspace Acquisition and Management - The Cities of Roswell and Alpharetta own several acres of greenspace along Big Creek. These properties are undeveloped stream buffers or areas used for passive parks and recreation. Greenspaces provide pervious surfaces to infiltrate stormwater runoff and protect streams banks from high velocity and volumes of water created by impervious surface runoff. The City of Alpharetta's Big Creek Greenway and the connecting Big Creek Park owned by City of Roswell provide stream buffers and wetlands protection along Big Creek. These properties are within the 100-year floodplain and provide flood protection and limit development within the floodplain. The Cities of Roswell and Alpharetta will continue to pursue greenspace acquisition within the Big Creek Watershed. Target areas for land acquisition for greenspace include properties within the floodplain of Big Creek or Foe Killer Creek.

6.8 Structural Measures

Big Creek is listed on the 2010 Federal Clean Water Act Section 303(d) list of impaired streams for exceeding permitted levels of fecal coliform bacteria. Structural measures are needed to reduce fecal coliform bacteria resulting from urban runoff velocity and volumes disturbing stream beds and suspending legacy sediments that contain bacteria. The following structural measures are suggested within the Big Creek watershed. Project sheets for the structural measures are included in Appendix D.

6.8.1 Stormwater Detention Basins

Several locations were identified for potential stormwater detention basins and other stormwater features within the Wills Park property. These areas are identified in Figure 6-1. The top locations for potential stormwater detention include two areas within Wills Park. Other locations include the Liberty Square subdivision and the Carriage Station subdivision.

Wills Park – The southeast corner of the Wills Park parcel is the low point for a drainage basin consisting of commercial properties located along South Main Street, Maxwell Road and Brady Place. Many of the structures and sites in the basin were likely constructed in the late 1960s to early 1970s, prior to development of ordinances that required stormwater detention. From a review of the area, some of the sites include detention structures that are poorly maintained and are overgrown with trees and other vegetation. The City of Alpharetta should work with property owners to encourage them to maintain the stormwater detention and water quality pond near the park, immediately west of Alpharetta Square Shopping Center. The City of Alpharetta could work with property owners to expand this pond to include detention for water quality. Construction of the ponds to capture runoff from the

predominantly commercial area, as well as Main Street, Maxwell Road, and Brady Place, would result in stormwater runoff volume reduction and water quality enhancement for the basin.

Wills Park – The north portion of Wills Park includes several ball fields, two parking areas, the pool and community building. This area drains to a tributary to Foe Killer Creek within Wills Park. The tributary in this area is severely damaged from high velocity and volume of stormwater runoff from the park and upstream commercial areas. This area is recommended for stormwater detention to improve park safety and provide improved water quality. Detailed project sheets are included in Appendix D of this report.

Liberty Square - Stream walks behind the Liberty Square neighborhood identified stream bank scour and reduced streambank vegetation resulting from high volume and velocity of stormwater runoff. The City of Roswell should consider constructing a stormwater detention basin near Liberty Square subdivision to capture and detain stormwater runoff from the nearby residential neighborhood. The Liberty Square neighborhood was constructed in the late 1970's prior to development ordinances that required stormwater detention.

Carriage Station - Stream walks near Riverwood Apartments and Carriage Station identified stream bank erosion and reduced streambank vegetation. Large trees have fallen in and around the stream as a result of stream bank scour. The City of Roswell should construct a Stormwater Detention Basin near Carriage Station to capture and detain stormwater runoff from nearby residential neighborhoods. A portion of the sewer easement could be used to construct a stormwater detention area to reduce the stormwater flows and reduce flooding.

The City's as-built drawings and other resources would be needed to develop a full model of detention along Big Creek. Evaluating existing detention ponds, especially in heavy industrial or commercially zone areas, such as the ones in Big Creek Park for clean-out or expansion to increase capacity could also reduce stormwater volume. The stormwater detention basins would be designed and sized according to the GSMM. Detention basins can decrease suspended solids by 60% to 90% and decrease bacteria by 50% to 90% according to the International Stormwater BMP Database literature (2009).

Stormwater Detention Basin Retrofits – Several existing stormwater detention basins are located within the City of Alpharetta and City of Roswell in the Big Creek Subwatershed. A stormwater pond survey could be implemented to identify the conditions of these existing facilities and the potential for these facilities to be retrofitted to include water quality detention.

The City of Alpharetta and City of Roswell will work with property owners to identify the potential to expand these ponds to include detention for water quality. Construction of the retrofits to capture runoff from the predominantly business parks and commercial areas would result in stormwater runoff volume reduction and water quality enhancement for the basin.

Big Creek
Wills Park Stormwater Improvement Projects

Figure 6-1 Wills Park Stormwater Project Locations

6.8.2 BMP Demonstration Projects

The City of Alpharetta Public Works Department should consider partnering with the City's Recreation and Parks Department to install rain gardens and rain barrels at Wills Park and Union Hill Park. The City of Roswell Public Works Department should consider partnering with the City's Department of Recreation and Parks to install rain gardens and rain barrels at Roswell Area Park, Hembree Park and Waller Park. Rain gardens and rain barrels are simple BMPs that can be duplicated by homeowners while providing stormwater detention to decrease volume and velocity of stormwater runoff. These rain gardens and rain barrels can be used as demonstration projects to educate home owners on how to build and install these features at their home.

6.8.3 Stream Bank Restoration

Streambanks have been reduced as a result of local scour. Local scour areas are a result of the high velocity and volume associate with stormwater runoff. The silt sand streambanks have eroded undercutting vegetation along the stream. The jurisdictions should increase the natural plantings along the streambank to restore streambanks. Preferred streambank restoration measures are described in detail in the Guidelines for Streambank Restoration by the Georgia Soil and Water Conservation Commission included in Appendix E. Table 6.3 identifies several areas for potential streambank restoration.

A planning assumption of $65 per linear foot was estimated for the streambank restoration projects based on literature reviewed from the US Department of Agriculture Forest Service. This estimate would provide a guide for planning for the recommended restoration projects. Sources or causes of streambank erosion should be identified and mitigated prior to streambank restoration to ensure long-term success of the restoration project. Careful planning will be needed to secure grant funding for these projects. Experts should be contacted to determine if streambank restoration can be conducted within the residential areas of the City of Alpharetta and the City of Roswell. Stream neighbors will need to be included as stakeholders in the streambank restoration process.

The Georgia EPD has developed a Streambank and Shoreline Stabilization Guidance document discussing preferred and acceptable methods of streambank stabilization. The preferred methods including live posts, live stakes, live fascines, brush layering, brush mattress, branch packing, toe protection, and vegetated geogrid. Permits must be obtained in advance of streambank restoration including US Army Corps of Engineers Nationwide permits and State of Georgia stream buffer variance permit. Detailed designs of streambank restoration projects would be needed to apply for grant funding. Section 319(h) grant funds, target watershed grants, and five star restoration grants may be helpful in funding streambank restoration projects. Figure 6-2 shows the potential locations for streambank restoration projects.

Table 6.3
Big Creek Watershed Study
Recommended Stream Restoration Projects

Location	Jurisdiction	Linear Feet Restored	Estimated Cost
Long Indian Creek			
States Bridge Road to Buice Road	Johns Creek	2,902	$ 189,000
Hog Waller Creek			
Fellowship School	Roswell	1,237	$ 81,000
Crosshaven Subdivision	Roswell	1,156	$ 76,000
Foe Killer Creek			
Squirrel Run to Rucker Road	Alpharetta	1,970	$ 129,000
Upper Hembree Road	Roswell	1,195	$ 78,000
Hembree Road	Roswell	1,133	$ 74,000
Warsaw and Mansell Road	Roswell	1,127	$ 74,000
Big Creek			
Camp Creek to Webb Bridge Road	Alpharetta	3,292	$ 214,000
Haynes Bridge Road	Alpharetta	3,063	$ 200,000
Oxbo Road	Roswell	1,323	$ 86,000
National Recreation Area	Roswell	1,816	$ 119,000

6.8.4 Disconnect Impervious Areas

Impervious areas directly connected to the storm drain system are a great contributor to non-point source pollution. Basic site planning principles for stormwater management is to minimize these directly connected impervious areas. This can be done by limiting overall impervious land coverage and disconnecting impervious areas by directing runoff from these impervious areas to pervious areas or small depressions. Locate impervious areas to drain to natural systems and when this is not possible, direct flows from impervious areas (roofs and paved surfaces) to bioretention areas, infiltration devices, drainage swales, retention areas, natural systems, or vegetated buffer. Disconnection can also reduce the calculated peak discharge rate by increasing the time of concentration. The City of Alpharetta and City of Roswell should evaluate City properties for the potential to disconnect areas of imperviousness. This can be accomplished by implementing some of the following measures:

- Direct roof downspouts to pervious areas
- Direct parking lot run-off to pervious areas
- Increase tree canopy cover over impervious areas
- Install green roofs
- Install pervious pavement

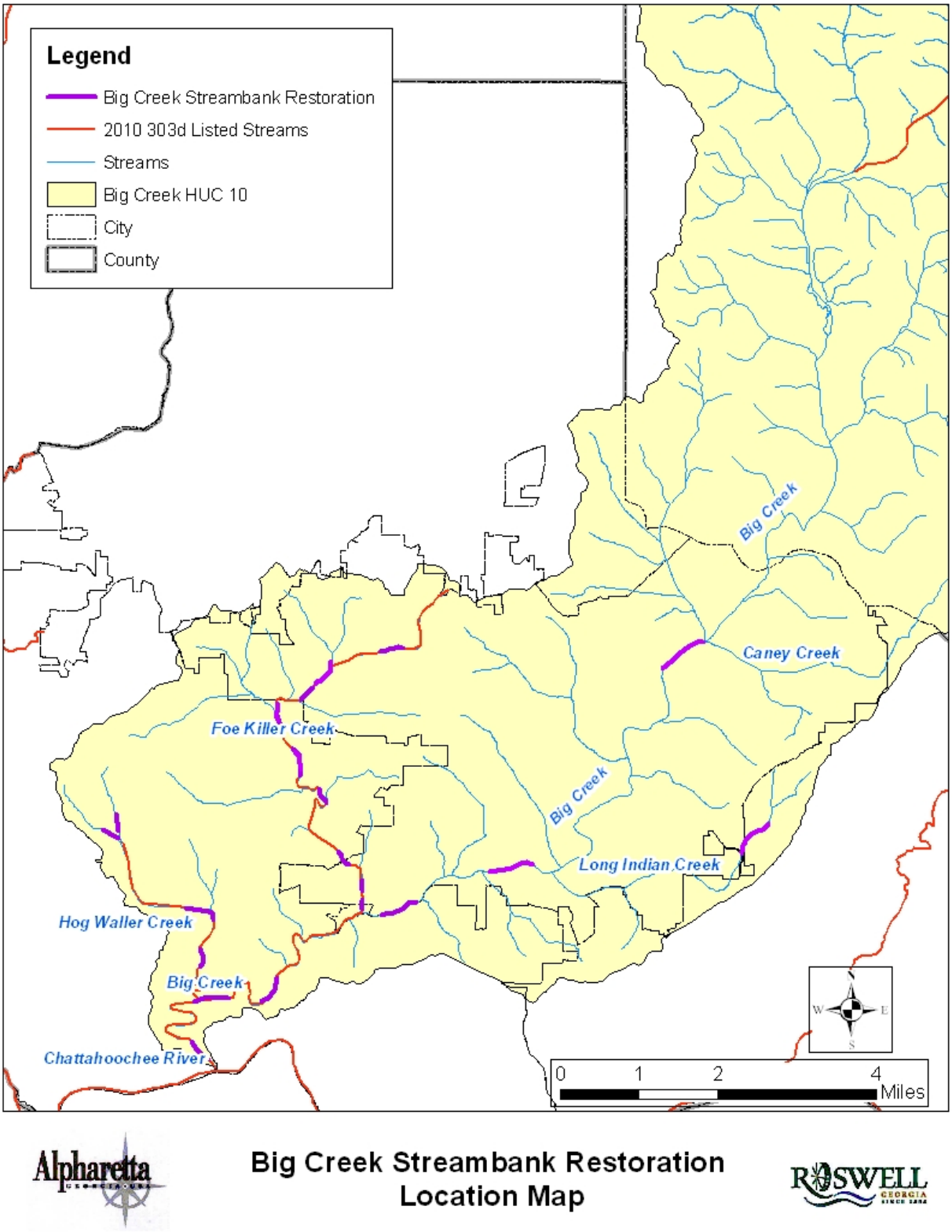


Figure 6-2 Big Creek Streambank Restoration Locations

6.8.5 Reduce Impervious Surfaces

Impervious areas repel rainwater and do not permit it to soak into the ground. Instead, water flows quickly into nearby streams, causing unnaturally large and sudden flows that contribute to stream erosion. As rainwater flows across impervious surfaces, it picks up pollutants such as oil and other engine fluids, and carries them into streams and marine areas, where they can harm aquatic plants and animals. The Cities of Alpharetta and Roswell will consider working with their respective development departments and commercial property owners to reduce impervious areas and increase streetscape plantings, parking islands, and replace impervious areas with pervious areas. Table 6.4 identifies areas for potential reduction in impervious surfaces. Reducing impervious surfaces will help to minimize water velocity and run-off. It will aid the reduction of pollutants and sediment deposits in waterways and reduce estuarial water temperatures. The Cities of Alpharetta and Roswell may consider adopting an ordinance or overlay district to reduce impervious surfaces in the Big Creek watershed. Figure 6-3 shows potential areas for reduced impervious surfaces.

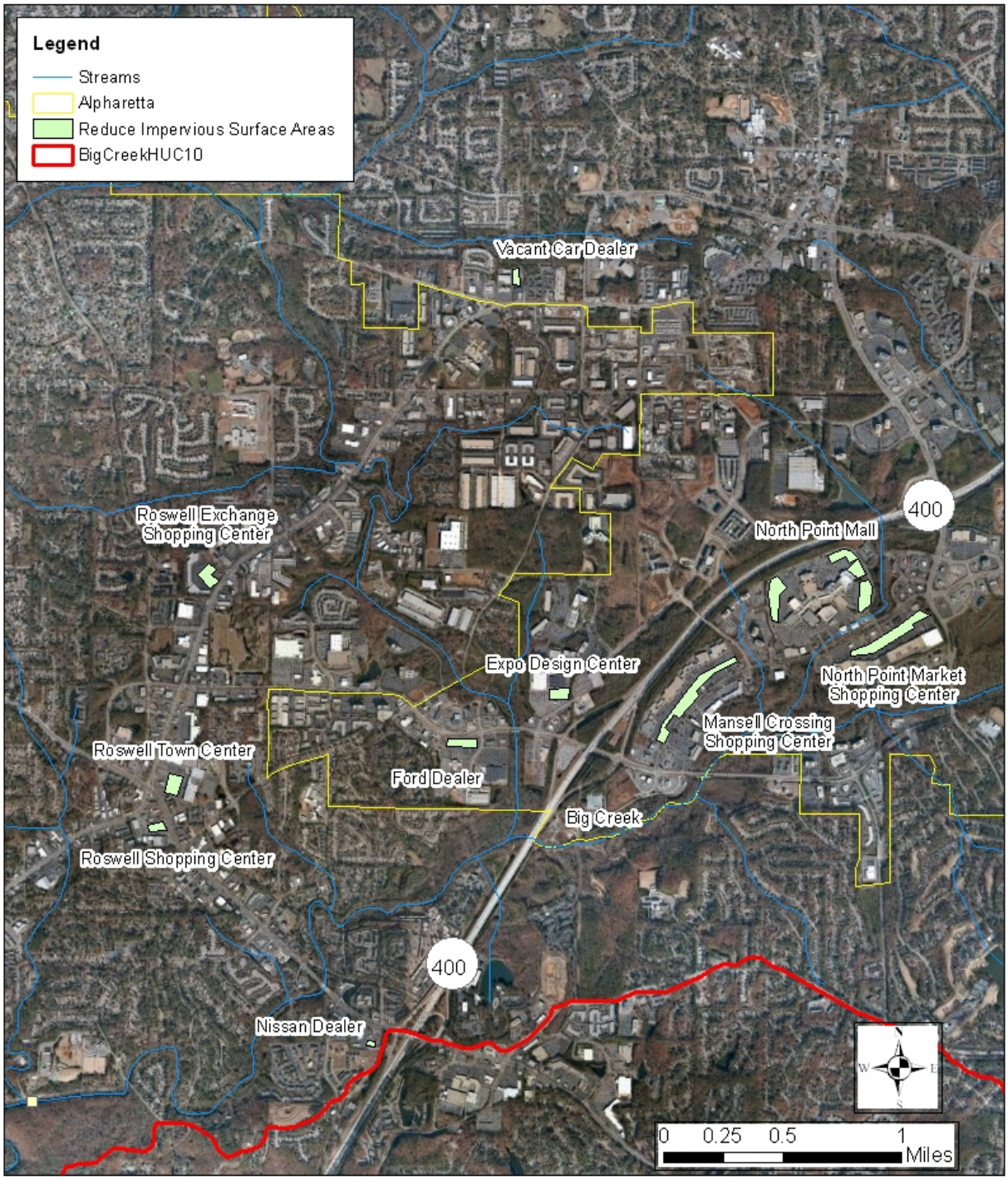
6.8.6 Low Impact Development/Redevelopment and Green Infrastructure

Low Impact Development is a collection of development practices to limit impacts of development on the environment.

- The City of Alpharetta and City of Roswell will review ordinances to ensure that they do not limit implementation of low impact development and redevelopment tools such as bioretention areas, green roofs, rain cisterns, pervious pavers, reduced parking areas, and other LID tools.
- The City of Alpharetta and City of Roswell will consider developing incentives to encourage LID and green infrastructure. These incentives could include: expedited plan review, reduced application fees, increased density, and reduced stormwater utility fee.
- The City of Alpharetta and City of Roswell will consider developing a Big Creek overlay district to incorporate the specific use of LID tools in the development and redevelopment of areas within the Big Creek Watershed. The overlay ordinance would also include incentives for using the LID and green infrastructure tools.

Table 6.4
Big Creek Watershed Study
Recommended Areas to Reduce Impervious Surfaces

Impervious Area	Basin	Jurisdiction	Parking lot Size (ac)	Estimated Parking Spaces	Proposed Impervious Surface Area Reduction (ac)	Vacant Parcels	Property Owner
Northpoint Market Shopping Center	Big Creek	Alpharetta	26.05	1,600	8.80	X	Cousins Properties
Mansell Crossing Shopping Center	Big Creek	Alpharetta	20.41	2,200	10.70	X	Centro
Home Depot Expo Design Center	Big Creek	Alpharetta	2.89	240	2.30	X	Corporate Property Dispositions
North Point Mall	Big Creek	Alpharetta	57.02	5,400	14.0	X	General Growth Properties
Vacant Car Dealerships	Foe Killer Creek	Alpharetta	2.63	390	1.40	X	CBRE
Roswell Exchange Shopping Center	Foe Killer Creek	Roswell	6.7	770	1.11	X	SRS
Roswell Town Center	Big Creek	Roswell	10.2	1,450	1.00	X	Mimms
Roswell Shopping Center	Hog Waller Creek	Roswell	4.0	500	0.44	X	The Shopping Center Group
Nissan Dealer	Big Creek	Roswell	7.0	540	1.75		Regal Nissan
Cherokee Ford Dealer	Foe Killer	Alpharetta	19.4	790	2.04		Cherokee Ford



Big Creek
Reduced Impervious Surface Areas

Figure 6-3 Big Creek Reduced Impervious Surface Areas

6.8.7 Alum Treatment of Stormwater Runoff

Alum treatment of stormwater runoff is the way to inject liquid alum into major storm sewer lines or water bodies. After being added to runoff, alum forms nontoxic precipitates of AI(OH)3 and AIPO4 which combine with suspended solids, phosphorus and heavy metals, causing them to be removed rapidly from the treated water. According to the GSMM, Alum treatment of stormwater runoff can consistently achieve a 90% reduction in total phosphorus, 50-70% reduction in total nitrogen, 50-90% reduction in heavy metals, and >99% reduction in fecal coliform. The removal efficiencies obtained with alum stormwater treatment are similar or exceed the removal efficiencies obtained using a dry retention or wet detention stormwater management facility. This treatment system is substantially less expensive than traditional treatment methods and often requires no additional land purchase.

Alum Treatment may be considered for existing regional detention ponds or new stormwater detention pond. Alum treatment may have a high operation and maintenance cost and requires extensive monitoring. Lake Windward or other regional detention facility may be considered for retrofit to add alum treatment for improved water quality.

Section 7 Water Conservation and Water Supply Protection

7.1 Introduction

The 2000 Big Creek Watershed Study did not include information on water conservation and water supply protection. Since that time the State of Georgia suffered one of the worst drought periods on record. In addition, the State of Georgia has been involved in legal proceedings regarding the amount of water municipalities within Georgia can withdrawal from the Chattahoochee River as it is a shared resource with the States of Alabama and Florida. Both the drought and the legal proceedings has provided awareness and growing concern for protecting existing water supplies.

Water conservation and water supply protection are important parts of the Big Creek Watershed Study. Big Creek provides a source of drinking water for the City of Roswell. This source can be compromised by drought, pollution, and over use. The U.S. District Court Judge Paul Magnuson ruled in 2009 that Lake Lanier would no longer be available as a water supply source for the metro Atlanta area. This ruling will require the U.S. Congress to authorize the lake for water withdrawal purposes. In 2011 the appeals court overruled Judge Magnuson's findings that the lake could not be used for water supply and gave the US Army Corps of Engineers one year to determine the amount of water withdrawal that could be removed from the lake. Water providers in the Atlanta Metro area have to consider using watershed management and water supply alternatives together to meet water supply demands. The jurisdictions within the Big Creek watershed should work together to form sustainable water supply solutions for Big Creek and maximize the amount of sustainable water withdrawal from Big Creek.

7.2 Water Conservation

The jurisdictions within Big Creek should continue to implement action items identified in the District's Water Supply and Conservation Plan to conserve water. Table 7.1 lists the conservation programs identified in Section 5 of the District's Water Supply and Conservation Plan that should be implemented within the Big Creek jurisdictions. The City of Alpharetta and City of Roswell have created several programs and outreach efforts to implement the recommended water conservation measures.

Table 7.1
Big Creek Watershed Study
Recommended Conservation Measures

5.1 Conservation Pricing
5.2 Replace Older, Inefficient Fixtures
5.3 Require Pre-rinse Spray Valve Retrofit Program
5.4 Rain Sensor Shut-off Switches on New Irrigation Systems
5.5 Require Sub-meter in New Multi-Family Buildings
5.6 Assess and Reduce Water System Leakage
5.7 Conduct Residential Water Audits
5.8 Distribute low-flow Retrofit Kits to Residential Users
5.9 Conduct Commercial Water Audits
5.10 Implement Education and Public Awareness Plan
5.11 Install High Efficiency Toilets and Urinals in Government Buildings
5.12 Require New Car Washes to Recycle Water

The City of Roswell is involved in several water conservation programs including the Metro District, Water First, a Georgia Department of Community Affairs program and Water Sense an EPA water conservation program. The City of Alpharetta has adopted water conservation requirements as part of the City's building codes.

7.3 Water Supply Protection

Big Creek supplies water for citizens of the City of Roswell. The City is allowed to withdrawal 1.2 MGD of water from Big Creek. This small water supply watershed is vulnerable to drought, pollution and over use. The jurisdictions within the watershed should work together to protect the water supply.

7.3.1 Water Withdrawal Permits

The City of Roswell is currently allowed a maximum 24 hour withdrawal of 1.2 MGD not to exceed a monthly average of 1.2 MGD. This permit includes the following special conditions:

- The flow below the intake on Big Creek should not be less than the 7Q10 of 8.4 cubic feet per day.
- The City must maintain interconnections to provide water supply during restricted periods.
- The City will monitor water quantity for Georgia EPD.
- The City will submit a water conservation plan program update every five years.

The Golf Club of Georgia is currently allowed to withdrawal a maximum 24 hour withdrawal of 2 MGD with a monthly average withdrawal of 1 MGD from either Lake Windward or Big Creek. The Golf Club of Georgia is restricted from water withdrawal when water levels at the Golf Club of Georgia intake are less than 7.3 cubic feet per second to protect the City of Roswell water intake.

The City of Roswell, Golf Club of Georgia and the Georgia EPD should consider reevaluating the water withdrawal permits from Big Creek. Priority water withdrawal should be given to municipalities for drinking water. The Golf Club of Georgia should work with local municipalities to provide reuse water for the golf course irrigation needs. Using reuse water for golf course irrigation is one part of a sustainable water supply solution for the Big Creek watershed.

7.3.2 Big Creek Source Water Assessment

The City of Roswell has developed a Source Water Assessment (2001) in partnership with the Atlanta Regional Commission. The source water assessment includes the entire Big Creek basin area (66,386 acres), an inventory of potential pollutant sources, and a susceptibility rating for the watershed. The Big Creek watershed has a susceptibility rating of medium-high. This rating was given based on the impervious surface percentage of 18.7% in the year 2001. The Source Water Assessment is included in Appendix F. The City should continue efforts to protect source water and improve water quality within the Big Creek watershed. Additional measures could be added to the source water assessment including, public education and involvement, a procedure for boil water advisories, purchase of

conservation easements, and other measures focused on reducing impervious surfaces within the source water basin.

7.3.3 Big Creek Park Wetlands Enhancement Project

The City of Roswell developed a regional stormwater detention pond near the Big Creek wetlands to capture urban stormwater runoff and to improve base flow conditions of Big Creek. The park includes two detention basins that collect stormwater. The stormwater ponds discharge to the Big Creek wetland area to supplement base flow conditions. The park was designed in 2002 and constructed in 2006. The City of Roswell Recreation and Parks department manages the park. The Big Creek jurisdictions should work together to protect wetlands near Big Creek.

7.3.4 Wetlands

The majority of stream corridor wetlands in the Big Creek watershed are palustrine forested or palustrine scrub-shrub. According to the U.S. Fish & Wildlife Service, which reports on the status and trends of wetlands and deepwater habitats in the U.S., this is the predominant wetland type in Georgia. The City of Roswell and City of Alpharetta have preserved areas surrounding the Big Creek wetlands as greenspace. These areas are used as parks and greenway paths for walking and biking. The Big Creek jurisdictions should continue to provide buffers for the Big Creek wetlands.

7.3.5 Reuse Water

The City of Roswell and City of Alpharetta should partner with local municipalities that provide reuse water. Connections should be made to reuse supplies for city irrigation uses including city buildings and park fields. The use of reuse water should replace potable water for all outdoor watering for City jurisdictions. Reuse water is one aspect of sustainable water resource management. The Cities should develop incentive programs for large outdoor water users, such as churches and office complexes, to use reuse water or stormwater for all outdoor watering to reduce the potable water demand.

7.3.6 Outdoor Water Restrictions

The Georgia Water Stewardship Act includes new guidelines for outdoor watering restrictions. Under the new guidelines citizens may take advantage of outdoor watering of lawns and landscapes seven days a week, regardless of the resident's streets address, between the hours of 4:00 PM and 10:00 AM. This includes use of irrigation systems and sprinklers. Between the hours of 10:00 AM and 4:00 PM no use of irrigation systems or sprinklers is permitted; however, hand watering with a shut-off nozzle is allowed anytime of the day and any day of the week.

For most other outdoor water uses, the odd / even address schedule remains in effect. Residents with odd numbered addresses are allowed outdoor water use on Tuesdays, Thursdays, and Sundays. Those with even numbered addresses are permitted outdoor water use on Mondays, Wednesdays, and Saturdays. The Big Creek jurisdictions will continue to follow the guidelines of the Georgia Water Stewardship Act. If drought conditions occur the City of Alpharetta and City of Roswell will follow the recommended water restrictions.

References

Bair, Brian. Stream Restoration Cost Estimates. USDA Forest Service http://www.st.nmfs.noaa.gov/st5/Salmon_Workshop/11_Bair.pdf

Big Creek Watershed Study. Camp Dresser & McKee. 2000.

Chapter 391-3-16 Rules for Environmental Planning Criteria. Georgia Department of Natural Resources Environmental Protection Division. http://www.dca.state.ga.us/development/planningqualitygrowth/programs/downloads/EPC.pdf May 2011.

Floodplain Information. City of Alpharetta Website. http://alpharetta.ga.us/index.php?p=477 May 2011.

Floodplain Information. City of Roswell Website. http://www.roswellgov.com/index.aspx?NID=1042 May 2011

Georgia Stormwater Management Manual Technical Handbook. Atlanta Regional Commission. August 2001.

National Climate Data Center data from 1971-2000. http://www.sercc.com/climateinfo/historical/historical_ga.html April 2011.

Soil Survey. Natural Resources Conservation Service. http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm. April 2011.

Stormwater Regulations Fact Sheet. http://www.phillyriverinfo.org/WICLibrary/SWFS4_April2008.pdf. June 2011.

TR-55 Urban Hydrology for Small Watersheds. Natural Resources Conservation Service. http://www.hydrocad.net/tr-55.htm. April 2011.

Unified Development Code. City of Alpharetta Website. http://www.alpharetta.ga.us/index.php?m=publications&id=17 May 2011.

Urban Stormwater BMP Performance Monitoring. International Stormwater BMP Database. Geosyntec Consultants and Wright Water Engineers, Inc. October 2009. http://www.bmpdatabase.org/Docs/2009%20Stormwater%20BMP%20Monitoring%20Manual.pdf June 2011.

U.S. Census Bureau, 2005-2009 American Community Survey. http://www.factfinder.census.gov/ April 2011.

U.S. Environmental Protection Agency. Envirofacts. http://www.epa.gov/enviro/index.html April 2011.

U.S. Environmental Protection Agency. Microbial Source Tracking Guide Document. June 2005.

http://www.epa.gov/nrmrl/pubs/600r05064/600r05064.pdf June 2011.

U.S. Environmental Protection Agency. Microbial Source Tracking Presentation. April 2005. http://www.water.rutgers.edu/Source_Tracking/MicrobialSourceTracking/MicrobialSourceTrackingEPA presentation.pdf June 2005.

U.S. Geological Survey. Digital Elevation Model. Georgia GIS Clearinghouse. 1979. http://gis.state.ga.us/

U.S. Geological Survey. National Weather Information System Real-time Water Quality Data. 02335700 BIG CREEK NEAR ALPHARETTA, GA. http://waterdata.usgs.gov/ga/nwis/current/?type=flow&group_key=basin_cd April 2011.

Water Quality in Georgia 2008- 2009. 2010 Integrated 305b/303d List. Georgia Department of Natural Resources Environmental Protection Division. 2010.

Water Supply and Conservation Plan. Metro North Georgia Water Planning District. May 2009.

Water Today. Water for the Future. March 2011. Georgia Department of Economic Development. http://www.georgia.org/SiteCollectionDocuments/WhyGeorgia/water_%20one_pager_032011.pdf June 2011.

Watershed Management Plan. Metro North Georgia Water Planning District. May 2009.

EPA Envirofacts Database
List of Potential Pollutant Facilities

TRI	JURISDICTION
HERMAN MILLER INC ROSWELL OPERATIONS	ROSWELL ALPHARETTA
MERIT INK & COATING	OTHER
DELEX CHEMICALS INC	OTHER
SCIENTIFIC GAMES INTERNATIONAL	OTHER
CHEMENCE INC	OTHER
INNOVATIVE CIRCUITS INC	OTHER
LAFARGE ALPHARETTA CONCRETE PLANT	ROSWELL
ADVANTIS TECHNOLOGIES	OTHER
METCAM	OTHER
HOPEWELL DESIGNS INC	OTHER
*CITY LOCATIONS ARE BASED ON EPA LOCATION	OTHER
*SOME LOCATIONS MAY HAVE CITY ADDRESSES	OTHER
REGAL CHEMICAL COMPANY	OTHER
COOKSON ELECTRONICS ASSEMBLY MATERIALS	OTHER
FAME PLASTICS INC	OTHER
HOOVER PRECISION PRODUCTS	OTHER
AMERICAN BOA	OTHER
TIMELESS ARCHITECTURAL REPRODUCTIONS	OTHER
NORTHSIDE FOODS CORPORATION	OTHER
TYSON FOODS INC	OTHER

*CITY LOCATIONS ARE BASED ON EPA LOCATION AND OR ADDRESS.
*SOME LOCATIONS MAY HAVE CITY ADDRESSES BUT ARE NOT LOCATED IN THE INCORPORATED AREA.

RCRA	JURISDICTION
CHRIS J KROGH INC	ALPHARETTA
TARGET STORE #0970	ALPHARETTA
WALMART SUPERCENTER #2941	ALPHARETTA
GA POWER CO NORTH FULTON OPER HQ	ALPHARETTA
WASHINGTON OIL ENVIRONMENTAL GROUP	ALPHARETTA
KIDDIE KANDIDS #00564	ALPHARETTA
ALPHARETTA CLEANERS	ALPHARETTA
JEFFS PAINT & BODY SHOP	ALPHARETTA
COSTCO WHOLESALE #743	ALPHARETTA
CSI LABORATORIES	ALPHARETTA
*CITY LOCATIONS ARE BASED ON EPA LOCATION AND OR ADD	ALPHARETTA
*SOME LOCATIONS MAY HAVE CITY ADDRESSES BUT ARE NOT	ALPHARETTA
PROFESSIONAL REPAIR	ALPHARETTA
ALPHARETTA AUTO SPECIALISTS	ALPHARETTA
AMERICAN HONDA MOTOR COMPANY INCORPORATED	ALPHARETTA
HEWLETT PACKARD COMPANY	ALPHARETTA
ANN TAYLOR 0302	ALPHARETTA
QUIKTRIP #765	ALPHARETTA
ALPHA CLEANERS	ALPHARETTA
GOODYEAR TIRE CENTER ALPHARETTA	ALPHARETTA
AT&T	ALPHARETTA
QUIKTRIP #782	ALPHARETTA
CIRCLE M FOOD SHOP #16	ALPHARETTA
BP OIL CO #70412	ALPHARETTA
HOME DEPOT #0149	ALPHARETTA
BAKO PATHOLOGY SERVICES LLC	ALPHARETTA
DIGITAL COMMUNICATIONS ASSOCIATION	ALPHARETTA
ORKIN EXTERMINATING CO	ALPHARETTA
SOLVAY EMPLOYEES HOUSEHOLD HW	ALPHARETTA
SOLVAY ADVANCED POLYMERS	ALPHARETTA
WASTE TRANSPORTERS INC	ALPHARETTA
IBM GLOBAL SERVICES	ALPHARETTA
TECHSONIC IND	ALPHARETTA
TECHNOLOGY RESOURCES INTL CORP	ALPHARETTA
ATHEROGENICS INC	ALPHARETTA
MOSS AUTOMOTIVE REPAIRS INC	ALPHARETTA
BST ALPRGASNA01 R00FQ	ALPHARETTA
BELAIR INDUSTRIES	ALPHARETTA
PERFORMANCE AUTO COLLISION INC	ALPHARETTA
ROSWELL RECYCLING CENTER	ALPHARETTA
PROTO SYSTEMS	ALPHARETTA
HAMES CONTRACTING INC	ALPHARETTA
ATLANTA CREATIVE GRAPHICS	ALPHARETTA
ALPHA CABINET SOLUTIONS	ALPHARETTA
KEEP ROSWELL BEAUTIFUL DAY	ALPHARETTA
HOME DEPOT HD0162	ALPHARETTA

RCRA	JURISDICTION
SAM'S CLUB #6646	ALPHARETTA
WAGNER CHEROKEE INC DIXIE CHEVRON	ALPHARETTA
CARSMETIC OF GEORGIA LLC	ALPHARETTA
PROFESSIONAL SWEDISH CAR REPAIR	ALPHARETTA
NTB STORE #859	ALPHARETTA
ACA AMOCO #313	ALPHARETTA
SERRA AL FORD	ALPHARETTA
WOODSTOCK QUALITY PAINT & BODY	ALPHARETTA
HENNESSY PORSCHE NORTH ATLANTA	ALPHARETTA
HERMAN MILLER INC ROSWELL OPERATIONS	ALPHARETTA
ATLANTA CREATIVE GRAPHICS	ALPHARETTA
BP FACILITY #70947	ALPHARETTA
EXXONMOBIL OIL CORPORATION 40528	ALPHARETTA
SULL GRAPHICS	ALPHARETTA
LAND ROVER NORTH POINT	ALPHARETTA
KLEEN SWEET CLEANERS	ALPHARETTA
WALMART SUPERCENTER #1578	ALPHARETTA
BP OIL CO #02283	ALPHARETTA
NAPA AUTO PARTS	ALPHARETTA
CHEQUERED FLAG IMPORT	ROSWELL
ROSWELL CLEANERS & COIN LAUNDRY	ROSWELL
DRYCLEANING DEPOT	ROSWELL
FEDERAL ENVIRONMENTAL SERVICES INC	ROSWELL
SHERWIN WILLIAMS CO	ROSWELL
TRONCALLI CHRYSLER-PLYMOUTH	ROSWELL
STROUDS SOUTHERN PRINTING	ROSWELL
HONDA CARLAND	ROSWELL
SPEEDY TRANSMISSION	ROSWELL
SOUTH CREEK DEVELOPMENT PARTNERS	ROSWELL
HOME DEPOT #0146	ROSWELL
BP OIL CO	ROSWELL
ROSWELL AUTO CENTER	ROSWELL
NATIONAL BULK TRANSPORT	ROSWELL
AUTO TREND COLLISION REPAIR	ROSWELL
NORTH ATLANTA COLLISION	ROSWELL
EAGLE CLEANERS	ROSWELL
SENTRY CLEANERS	ROSWELL
MORLEY J J ENTERPRISES INC	ROSWELL
AUDI OF ROSWELL INC	ROSWELL
BST RSWLGAME01 F5572	ROSWELL
ONE HOUR MARTINIZING	ROSWELL
AUTOBODY PLUS INC	ROSWELL
CITY OF ROSWELL BRIDGE INDUSTRIAL PAINTING SERVICES IN	ROSWELL
DELTA CHEVROLET	ROSWELL
MY FAVORITE CLEANERS INC	ROSWELL
CLASSIC CARE CLEANERS	ROSWELL

RCRA	JURISDICTION
STAR ENTERPRISES	ROSWELL
BARNES AUTOMOTIVE PARTS SERVICE	ROSWELL
NALLEY COLLISION CENTER	ROSWELL
MINIT LUBE #1162	ROSWELL
PROFESSIONAL CLEANERS	ROSWELL
ROSWELL AMC/JEEP/RENAULT INC	ROSWELL
GARYS PERFORMANCE	ROSWELL
GERBER COLLISION & GLASS	ROSWELL
NEWPORT VENTURES INC DBA PROFESSIONAL CLEANERS	ROSWELL
WALLER PARK EXTENSION MAINTENANCE SHOP	ROSWELL
PEACH STATE POOL SERVICE	ROSWELL
PERFECT PERFORMANCE INC	ROSWELL
CROWN FORD SALES INC	ROSWELL
ROSWELL ISUZU	ROSWELL
SHERWIN WILLIAMS #3621	ROSWELL
ASTECHNOLOGIES	ROSWELL
HOOVER ENT (FRMR ROSWELL FUN MACHINES)	ROSWELL
HICKS AUTOMOTIVE	ROSWELL
GLASSTECH PLASTICS INC	ROSWELL
RAINBOW EXPRESS	ROSWELL
GOODYEAR TIRE CENTER ROSWELL	ROSWELL
SAM'S CLUB #6646	ROSWELL
MAACO AUTO PAINTING AND BODY WORK	ROSWELL
EURO CRAFT INC	ROSWELL
RGC ENTERPRISES INC DBA LAUCK MOTORS	ROSWELL
CASTLEBERRY'S INTERIORS INC	ROSWELL
THE CLEANERS	ROSWELL
PENSKE AUTO CENTER	ROSWELL
RIGHT STUFF FOOD STORES AMOCO	ROSWELL
NICHOLS PAINT & BODY	ROSWELL
PHOTO CHEMICAL SYSTEMS INC	ROSWELL
ROSWELL TOYOTA ISUZU	ROSWELL
PEP BOYS #115	ROSWELL
SPENCER PEST CONTROL	ROSWELL
GENUINE PARTS CO	ROSWELL
IMPERIAL CLEANERS	ROSWELL
ALL PRO COLLISION	ROSWELL
MR TRANSMISSION	ROSWELL
BST RSWLGAHR F5564	ROSWELL
CLOTHING CARE V	ROSWELL
CURTIS 1000	ROSWELL
NTB STORE #648	ROSWELL
GATE CITY EQUIPMENT COMPANY INC	ROSWELL
1075 NORTHFIELD COURT	ROSWELL
ROKAN CORP	ROSWELL
RJ BODY SHOP	ROSWELL

RCRA	JURISDICTION
ROSWELL TOYOTA	ROSWELL
UNITED PARCEL SERVICE	ROSWELL
VARIAN ASSOCIATES	ROSWELL
JOHNSON CONTROLS INC	ROSWELL
REPRODUCTIVE INSTITUTE INC	ROSWELL
90S CLEANERS	ROSWELL
COMPUTONE CORPORATION	ROSWELL
IMC CORP	ROSWELL
HEMBREE CREST	ROSWELL
NORTH AMERICAN ENVIRONMENTAL CORP	ROSWELL
CIRCUITS ATLANTA INC	ROSWELL
CUSTOM SHUTTERS BY DESIGN INC	ROSWELL
STERLING AUTOBODY CENTERS	ROSWELL
VIRTUAL IMAGE	ROSWELL
NORTH FULTON REGIONAL HOSPITAL	ROSWELL
OLYMPUS AMERICA INC (OAI)	ROSWELL
SKYLINE DIGITAL IMAGES	ROSWELL
OPTIMEDICAL SYSTEMS INC	ROSWELL
KIMBERLY-CLARK CORPORATION	ROSWELL
ROYAL VALET	ROSWELL
KELLEY BUICK OF ROSWELL	ROSWELL
TRONCALLI JAGUAR	ROSWELL
ENTERGY SYSTEMS & SERVICES INCORPORATED	ROSWELL
CARE DYNAMIX DBA FLU BUSTERS	ROSWELL
ULTIMATE DISPLAY	ROSWELL
RBM OF ATLANTA NORTH	OTHER
ADVANTIS TECHNOLOGIES	OTHER
SOUTHERN AUTOMOTIVE SPECIALTY SHOPS	OTHER
PRECISION CONCRETE CONSTRUCTION	OTHER
DELEX CHEMICALS INC	OTHER
SCIENTIFIC GAMES INTERNATIONAL	OTHER
CHEMENCE INC	OTHER
AMERICAN ENVIRONMENTAL & CONSTRU SVC INC	OTHER
UNION HILL PROPERTY MGMT	OTHER
ARMECH CO INC	OTHER
TECHNICAL COATINGS COMPANY	OTHER
ATI-ACQUIRED TECHNOLOGY INC	OTHER
CI SUPPLY	OTHER
COOKSON ELECTRONICS ASSEMBLY MATERIALS	OTHER
E-Z GO DIVISION OF TEXTRON INC	OTHER
FLEX-PAC INC	OTHER
FLEET GARD ALPHARETTA MEADOWS	OTHER
PROTER PRECISION PRODUCTS CO	OTHER
RODENSTOCK NORTH AMERICA (FMR 2C OPTIC)	OTHER
HEPACO INC	OTHER
A & M INSTRUMENTS INC	OTHER

RCRA	JURISDICTION
SUPREMETAL INC	OTHER
PADGETT & ASSOCIATES	OTHER
M&H MANUFACTURING INC	OTHER
RIVES REALTY	OTHER
ALLIANCE GRAPHICS	OTHER
ACQUIRED TECHNOLOGY INC	OTHER
AP SPECIALTY METALS	OTHER
EPLANETEWASTE LLC	OTHER
PPG INDUSTRIES	OTHER
HDRO SOUTH INC	OTHER
SOUTHEAST TECHNICAL SALES & SVC	OTHER
MERIT INK & COATING	OTHER
L3 COMMUNICATIONS DISPLAY SYSTEMS	OTHER
IMPLUSE TECHNOLOGY LLC	OTHER
FASHION CLEANERS	OTHER
FRMR CIRREX OPS DUKE REALTY CORP OWNER	OTHER
HD SUOOKY PLUMBING / HVAC LTD HG5107	OTHER
ENVIRONMENTAL USA / RIVES REALTY CO	OTHER
SLEEVECO INCORPORATED	OTHER
CORRUGATED GEAR & SPROCKET INC	OTHER
ARCH CHEMICALS INC	OTHER
BP FACILITY #79658	OTHER
J & H EQUIPMENT	OTHER
SIEMENS INDUSTRY INC	OTHER
ENGINEERED CRANE SYSTEMS OF AMERICA	OTHER
EXIDE TECHNOLOGIES	OTHER
TARGET STORE #2431	OTHER
FRY'S ELECTRONICS	OTHER
BROOKS ECKERD PHARMACY #6748	OTHER
VISUAL PHYSICS LLC	OTHER
MILLENNIUM INFORMATION TECHNOLOGIES	OTHER
CLOUDBLUE TECHNOLOGIES	OTHER
PARATUS HEALTH SYSTEMS	OTHER
DIGISYS CORP	OTHER
HOUGHTON METAL FINISHING CO	OTHER
INNOVATIVE CIRCUITS INC	OTHER
ATLANTA RECYCLING SOLUTIONS LLC	OTHER
AIR PRODUCTS CO	OTHER
MAIN SOURCE GERMANY INC	OTHER
ANCHOR LITHKEMKO	OTHER
PANDUIT CORP OF GEORGIA	OTHER
BLAST CLEANING OF ATLANTA	OTHER
BP OIL CO	OTHER
BP FACILITY #77256	OTHER
CORPORATE PRINTERS INC	OTHER
HARBEN INCORPORATED	OTHER

RCRA	JURISDICTION
COUNTRY CUPBOARD #42	OTHER
HD SUPPLY CONSTRUCTION SUPPLY LTD	OTHER
FAME PLASTICS INCORPORATED	OTHER
BILLY HOWELL FORD LINCOLN MERCURY	OTHER
KARPATY LLC	OTHER
HOOVER PRECISION PRODUCTS INC	OTHER
COVENANT MANUFACTURING SERVICES INC	OTHER
BP FACILITY #77328	OTHER
CIRCLE M FOOD SHOP #18	OTHER
REGENCY CENTER LP	OTHER
ANDEAN MOTOR CO	OTHER
BILLY HOWELL COLLISION	OTHER
BILLY GERRELL GRADING	OTHER
TAM MFG INC	OTHER
TYSON FOODS INCORPORATED	OTHER
HOWELL BILLY FORD MERCURY INC	OTHER
HOLBROOK FOOD MARKET	OTHER
G & E COLLISION	OTHER
POWELL CLEANERS	OTHER
GROPHIC TOOLS INC	OTHER
TOWN AND COUNTRY CLEANERS	OTHER
OXFORD CLEANERS	OTHER
B & D ENTERPRISE INC	OTHER
EXXON RAS 40506	OTHER
TYSON FOODS VEHICLE MAINTENANCE FACILITES	OTHER
HOLBROOK FOOD STORE	OTHER
JIFFY LUBE STORE #1569	OTHER
GARRETTS DRY CLEANING CPD	OTHER
CIRCLE M FOOD SHOP #17	OTHER
GA COMPUTER INC	OTHER
INDUSTRIAL FLOOR COATING	OTHER
TYSON FOODS WASTEWATER FACILITY	OTHER
CHEVRON USA PRODUCTS CO 43249	OTHER
RITE AID #11696	OTHER
JEFFS BODY SHOP	OTHER
CUMMING DRY CLEANERS & LAUNDRY	OTHER
FORSYTH COUNTY SCHOOL BOARD	OTHER
MOUSE DESIGN STUDIO	OTHER

*CITY LOCATIONS ARE BASED ON EPA LOCATION AND OR ADDRESS.
*SOME LOCATIONS MAY HAVE CITY ADDRESSES BUT ARE NOT LOCATED IN THE INCORPORATED AREA.

LANDFILLS	JURISDICTIONS
KELLY MILL RD. NO 2	OTHER
TOMAHAWK RECYCLING	OTHER

*CITY LOCATIONS ARE BASED ON EPA LOCATION AND OR ADDRESS.
*SOME LOCATIONS MAY HAVE CITY ADDRESSES BUT ARE NOT LOCATED IN THE INCORPORATED AREA.

WASTEWATER DISCHARGER	JURISDICTION
LAFARGE BLD MATERIALS INC	ROSWELL
COLONIAL PIPELINE CO	ALPHARETTA
PLANTATION PIPE LINE CO	ALPHARETTA
COMMERCE BOULEVARD	ALPHARETTA
POLO GOLF AND COUNTRY CLUB	OTHER
FOWLER WATER RECLAMATION	OTHER
CUMMING WPCP	OTHER
TYSON FOODS INCORPORATED	OTHER
FORSYTH COUNTY WATER & SEWER	OTHER
SAWNEE ELEMENTARY SCHOOL	OTHER

*CITY LOCATIONS ARE BASED ON EPA LOCATION AND OR ADDRESS.
*SOME LOCATIONS MAY HAVE CITY ADDRESSES BUT ARE NOT LOCATED IN THE INCORPORATED AREA.

Appendix B
Big Creek Watershed Study Update
City of Roswell SSO Details

Date	Address	Cause	Receiving Waters
6/18/2001	14465 Morning Mtn Way	Grease	
6/25/2001	135 Fortuna Ct	Sewer Main not Connected	Tributary to Rocky Creek
7/19/2001	2035 Riverfall Drive	Debris	Tributary to Chattahoochee River
8/10/2001	1121 Alpharetta Street	Contractor Error	Big Creek
8/18/2001	1115 North Coleman Road	Sewer Stop Up	Tributary to Chattahoochee River
9/22/2001	Roswell Landing Lane	Debris	
10/22/2001	Roswell Mill on Vickery Creek	Debris	Big Creek
11/15/2001	190 Boxelder Road	Grease	Tributary to Chattahoochee River
1/10/2002	420 Roswell Hills Place	Grease	Tributary to Chattahoochee River
1/17/2002	80 West Crossville Road	Grease	Hog Waller Creek
1/19/2002	14200 Old Coarse Drive	Grease and Debris	Rocky Creek
1/19/2002	604 Roswell Green Lane	Grease	Hog Waller Creek
2/14/2002	420 Roswell Hills Place	Rock and Gravel	Tributary to Chattahoochee River
2/23/2002	Hidden Lake On Mill Pond Road	Grease	Hog Waller Creek
3/8/2002	125 Floss Flower Ct	Grease and Roots	Tributary to Chattahoochee River
3/21/2002	10575 Summer Creek Drive	Grease	Big Creek
3/22/2002	Azalea Drive	Concrete and Rocks	Chattahoochee River
5/13/2002	9135 Willeo road	Grease	Chattahoochee River
6/2/2002	240 North Smead Ct	Grease	Tributary to Chattahoochee River
11/18/2002	10320 Carleigh Lane	Roots	Big Creek
11/23/2002	9665 Loblolly Lane	Grease	Tributary to Chattahoochee River
1/18/2003	900 Wileo Road	Contractor Error	Tributary to Chattahoochee River
2/3/2003	39 Oxbo Road	Roots	Big Creek
3/1/2003	795 Aran Drive	Line Failure	Tributary to Chattahoochee River
4/23/2003	50 Maple Street	Grease	Big Creek
5/3/2003	65 Foal Drive	Grease and Roots	Tributary to Chattahoochee River
5/5/2003	10295 Kenross Road	Grease	Big Creek
6/13/2003	380 Wild Green Drive	Debris	Rocky Creek
6/21/2003	735 Oakham Drive	Excessive Rain	
7/27/2003	440 Barrington Drive East	Grease and Roots	Big Creek
9/13/2003	8230 Fairview Bluff	Grease and Debris	Tributary to Chattahoochee River
9/21/2003	10320 Carleigh Lane	Grease	Big Creek
11/16/2004	881 Tahoe Way	Grease and Debris	Big Creek
11/28/2004	River Mill and Vickery Creek	Debris	Big Creek
11/29/2004	310 Azalea Drive	Grease	Chattahoochee River
1/25/2005	Little River WWTP	Pump Failure	Little River
2/22/2005	Riverside Road Azalea Drive	Excessive Rain	Chattahoochee River
3/16/2005	Azalea Drive	Grease	Chattahoochee River
3/28/2005	Riverside Road Azalea Drive	Excessive Rain	Chattahoochee River
3/31/2005	Riverside Road Azalea Drive	Excessive Rain	Chattahoochee River
3/31/2005	Dogwood Road	Excessive Rain	Chattahoochee River
7/11/2005	Riverside Road Azalea Drive	Excessive Rain	Chattahoochee River
7/21/2005	1595 Oakfield Lane	Contractor Error	Hog Waller Creek
7/21/2005	839 Myrtle Street	Grease	Hog Waller Creek
10/12/2005	190 Worthington Hills Trace	Grease	Tributary to Big Creek
10/17/2005	765 North Wind Terrace	Grease	Rocky Creek
10/20/2005	1205 Worthington Hills Drive	Line Failure	Tributary to Big Creek
12/12/2005	9655 Loblolly Lane	Grease	Tributary to Chattahoochee River
12/24/2005	12065 Wexford Overlook	Grease	Rocky Creek
2/25/2006	140 Ridge Way	Grease	Tributary of Big Creek
3/4/2006	300 Merritt Drive	Grease	Tributary of Johns Creek
3/9/2006	100 Holcomb Ferry Road	Grease	Big Creek
3/13/2006	2950 Ascot Lane	Grease	Tributary of Big Creek
3/18/2006	350 Ridge Court	Roots	Tributary of Big Creek
4/7/2006	1355 Treebrook Court	Roots	Tributary of Little River
5/3/2006	6035 Heartford Circle	Debris	Tributary of Rocky Creek
5/22/2006	705 Springview Court	Service Line Failure	Tributary of Big Creek
6/12/2006	788 Old Roswell Road	Grease	Tributary of Big Creek

Appendix B

Big Creek Watershed Study Update

City of Roswell SSO Details

Date	Address	Cause	Receiving Waters
7/10/2006	235 Spearfield Trace	Manhole Failure	Tributary of Little River
8/21/2006	555 Mansell Road	Grease and Debris	Tributary of Big Creek
9/18/2006	190 Crossville Road	Roots and Grease	Tributary to Foe Killer Creek
11/16/2006	Azalea Drive Riverside	Excessive Rain	Chattahoochee River
12/30/2006	2865 Shurburne Drive	Debris	Tributary of Johns Creek
2/13/2007	725 Wood Valley Trace	Debris	Tributary of Big Creek
2/20/2007	90 Parkmont Drive	Grease and Debris	Tributary of Big Creek
2/22/2007	445 Creekside Court	Roots and Debris	Tributary of Big Creek
3/7/2007	146 Roswell Commons Way	Grease and Debris	Tributary of Big Creek
3/13/2007	880 Legacy Oaks Circle	Grease and Debris	Tributary of Big Creek
3/30/2007	1165 Hope Road	Grease and Debris	Tributary of Chattahoochee River
4/30/2007	875 Old Roswell Road	Grease and Debris	Tributary of Big Creek
5/1/2007	1000 Holcomb Bridge Road	Grease	Tributary of Big Creek
5/10/2007	9675 Loblolly Lane	Grease	Tributary of Big Creek
5/15/2007	1030 Marietta Highway	Pump Station Failure	Willeo Creek
7/13/2007	9120 Willeo Road	Grease	Tributary of Chattahoochee River
7/25/2007	205 Sloan Street	Plug Failure	Big Creek
8/17/2007	1470 Raintree CS	Roots and Grease	Tributary of Big Creek
9/27/2007	640 Granby Hill Place	Vandalism	Tributary of Johns Creek
10/1/2007	2475 Steeplechase Drive	Debris	Tributary of Johns Creek
10/24/2007	1300 Alpharetta Highway	Grease	Hog Waller Creek
11/4/2007	235 Spring Ridge Trace	Roots and Debris	Tributary of Big Creek
12/9/2007	290 Shallow Springs Court	Roots and Debris	Tributary of Little River
1/6/2008	160 River Run	Roots	Tributary to Chattahoochee River
2/10/2008	11895 Mountain Lake Road	Grease and Debris	
2/23/2008	11705 Highland Drive	Roots and Grease	Rocky Creek
4/15/2008	370 Wavetree Drive	Debris	Hog Waller Creek
6/5/2008	240 Stonebridge Trail	Line Failure	Hog Waller Creek
7/7/2008	8750 Nesbit Ferry Road	Grease and Debris	Tributary to Chattahoochee River
7/20/2008	350 Ridge Court	Debris	Tributary to Chattahoochee River
8/22/2008	10185 North Coleman	Roots and Debris	Tributary to Chattahoochee River
9/15/2008	1515 Wood Creek Trail	Grease	Big Creek
12/16/2008	456 Bellflower Court	Debris	Tributary to Chattahoochee River
1/6/2009	Azalea Drive Riverside	Excessive Rain	Chattahoochee River
2/27/2009	10 Regency Road	Grease and Debris	Tributary to Chattahoochee River
3/1/2009	Azalea Drive Riverside	Excessive Rain	Chattahoochee River
3/5/2009	113 Millbrook Circle	Pipe Failure in Creek	Hog Waller Creek
3/10/2009	310 Milesford Court	Debris	Tributary of Johns Creek
3/26/2009	1170 Oakhaven Drive	contractor error	Tributary of Little River
3/27/2009	Azalea Drive Riverside	Excessive Rain	Chattahoochee River
3/28/2009	Azalea Drive Riverside	Excessive Rain	Chattahoochee River
4/14/2009	140 Beech Lake Court	Line Failure due to storm damag	Tributary of Johns Creek
5/8/2009	883 Park Ridge Lane	Grease and Debris	Tributary of Big Creek
7/10/2009	1300 Worthington Hills Drive	Grease	Tributary of Big Creek
9/12/2009	370 Wavetree Drive	Roots	Hog Waller Creek
9/21/2009	Azalea Drive Riverside	Excessive Rain	Chattahoochee River
9/22/2009	Roswell Mill	Line Failure due to storm damag	Big Creek
9/23/2009	453 South Atlanta Street	Line Failure due to storm damag	Big Creek
10/12/2009	Azalea Drive Riverside	Excessive Rain	Chattahoochee River
10/22/2009	9350 North Lake Drive	Line Failure	Tributary to Chattahoochee River
11/11/2009	Azalea Drive Riverside	Excessive Rain	Chattahoochee River
11/13/2009	2830 Windrush Lane	Grease and Debris	Tributary of Big Creek
11/19/2009	381 East Crossville Road	Grease	Tributary of Big Creek
12/18/2009	Azalea Drive Riverside	Excessive Rain	Chattahoochee River
12/21/2009	1000 Holcomb Bridge Road	Grease and Debris	Big Creek
1/24/2010	Azalea Drive Riverside	Excessive Rain	Chattahoochee River
2/5/2010	Azalea Drive Riverside	Excessive Rain	Chattahoochee River
2/6/2010	Azalea Drive Riverside	Excessive Rain	Chattahoochee River

Appendix B

Big Creek Watershed Study Update

City of Roswell SSO Details

Date	Address	Cause	Receiving Waters
3/10/2010	Azalea Drive Riverside	Excessive Rain	Chattahoochee River
4/1/2010	726 Mimosa Blvd	Debris	Tributary to Chattahoochee River
4/17/2010	1300 Worthington Hills Drive	Grease	Tributary to Big Creek
5/27/2010	852 Zion Circle	Grease	Hog Waller Creek
7/2/2010	300 Barrington Drive East	Roots	Tributary to Big Creek
11/2/2010	3602 Timber Creek Circle	Grease	Tributary to Big Creek
12/20/2010	1145 Saratoga Road	Line Failure caused manhole to	Hog Waller Creek
1/16/2011	9010 Nesbit Ferry Road	Grease	Tributary to Johns Creek
2/8/2011	600 Old Holcomb Bridge Road	Grease	Tributary to Big Creek
3/9/2011	2415 Cox Road	Excessive Rain	Rocky Creek
3/10/2011	405 Fallen Leaf Lane	Excessive Rain	Tributary to Little River
3/13/2011	280 Elaine Drive	Debris	Tributary of Vickery Creek
4/16/2011	Azalea Drive Riverside	Excessive Rain	Chattahoochee River

Appendix B
Big Creek Watershed Study Update
City of Alpharetta SSO Details

Date	Address	Cause	Receiving Waters
7/6/2001	14515 Creek Club Drive	Debris	
10/21/2001	705 St. Regis Lane	Grease	Johns Creek
12/3/2001	640 Ashtree Path	Debris and Grease	Johns Creek
12/6/2001	1500 Rock Mill Road	Grease	Foe Killer Creek
1/17/2002	13301 Deerfield Parkway	Manhole overflow	
2/28/2002	4860 Hampton Square Drive	Grease	Tributary to Big Creek
3/8/2002	525 Park Bridge Parkway	Grease	Tributary to Big Creek
3/21/2002	10575 Summercreek Drive	Grease	Indian Creek to Big Creek
5/4/2002	2690 Roxburgh Drive	Grease	Tributary to Big Creek
5/29/2002	3600 Schooner Ridge Drive	Grease	Windward Lake to Big Creek
6/7/2002	2975 Roxburgh Drive	Grease	Tributary to Big Creek
6/13/2002	755 Grandbury Way	Grease	Tributary of Johns Creek
7/10/2002	153 Crocker Way	Grease and Debris	Tributary to Foe Killer Creek
7/18/2002	Lake Medlock Drive	Grease	Tributary to Johns Creek
8/18/2002	3301 Deerfield Parkway	Grease	Tributary to Big Creek
9/2/2002	3324 Chipping Wood Court	Grease and Debris	Chicken Creek
9/14/2002	14510 Morning Mountain Way	Pump Station Failure	Crooked Creek
9/21/2002	3324 Chipping Wood Court	Grease	Chicken Creek
11/9/2002	2765 Shurburne Drive	Grease	Tributary of Johns Creek
3/1/2003	1905 Evergreen Lane	Debris	Foe Killer Creek
5/3/2003	10475 Medlock Bridge Road	Grease	Johns Creek
5/9/2003	11201 State Bridge Road	Grease	Johns Creek
6/7/2003	185 Cobblestone Way	Grease	
8/13/2003	750 Culworth Manor	Grease	Tributary to Big Creek
9/18/2003	185 Cobblestone Way	Grease	
9/20/2003	1290 Taylor Oak Drive	Grease	Foe Killer Creek
11/27/2004	5235 Coacoochee Terrace	Pump Failure	Johns Creek
11/28/2004	740 Granbury Way	Grease and Debris	Tributary to Johns Creek
12/1/2004	181 Lantern Ridge Court	Grease	Tributary to Big Creek
12/12/2004	5725 Lake Manor Trace	Grease and Debris	Tributary to Johns Creek
12/23/2004	10935 Pinehigh Drive	Grease and Debris	Tributary to Big Creek
12/24/2004	810 Redlion Run	Roots	Tributary to Johns Creek
1/21/2005	565 Ashvale Overlook	Grease and Debris	Tributary to Johns Creek
2/1/2005	5235 Coacoochee Terrace	Pump Failure	Tributary to Johns Creek
2/7/2005	9010 Nesbit Ferry Road	Grease	Tributary to Johns Creek
3/25/2005	1420 Tamarack Way	Grease and Debris	Tributary to Big Creek
5/5/2005	2075 Willshire Glen	Debris	Tributary to Foe Killer Creek
5/20/2005	570 Clarinbridge Way	Grease	Tributary to Big Creek
7/9/2005	4860 Hampton Square Drive	Grease	Tributary to Big Creek
9/20/2005	333 North Point Center East	Grease and Debris	Tributary to Big Creek
10/3/2005	4625 Alexander Drive	Grease	Tributary to Big Creek
11/11/2005	340 Lake Manor Trail	Grease	Tributary to Johns Creek
11/25/2005	10160 Barston Court	Grease	Tributary to Johns Creek
12/14/2005	10155 Haynes Bridge Road	Grease	Tributary to Big Creek
12/15/2005	100 Birch Rill Drive	Grease	Tributary to Big Creek
12/29/2005	8495 Caney Creek Landing	Grease	Cane Creek
1/8/2006	315 Dewpoint Lane	Grease	Tributary of Johns Creek
1/12/2006	285 Leaf Court	Grease	Tributary of Johns Creek
1/14/2006	3630 New Heritage Drive	Grease	Tributary of Big Creek
2/8/2006	520 Niagara Circle	Contractor Error	Tributary of Big Creek
2/13/2006	1185 Marka Lane	Grease and Debris	Tributary of Foe Killer Creek
2/27/2006	5345 Cottage Farm Road	Broken Sewer Main	Tributary of Johns Creek
4/15/2006	710 Lake Medlock Drive	Grease	Tributary of Johns Creek
5/3/2006	5025 Jones Bridge Road	Debris and Grease	Tributary of Johns Creek
6/6/2006	13085 Morris Road Apt 5402	Grease	Tributary of Camp Creek
8/15/2006	4625 Alexander Drive	Grease	Tributary of Big Creek
9/30/2006	2525 Milford Lane	Grease	Tributary of Big Creek

Appendix B
Big Creek Watershed Study Update
City of Alpharetta SSO Details

Date	Address	Cause	Receiving Waters
10/1/2006	Haynes Bridge Road	Grease	Big Creek
10/2/2006	341 Pebble Trail	Grease and Debris	Foe Killer Creek
10/28/2006	2775 Shurburne Drive	Grease	Tributary of Johns Creek
11/11/2006	875 Melbourne Trail	Line Failure	Tributary of Big Creek
11/15/2006	875 Melbourne Trail	Pump Failure	Tributary of Big Creek
12/9/2006	13100 Deerfield Parkway	Grease	Tributary of Big Creek
12/19/2006	745 Crown Cove	Grease and Debris	Tributary of Little River
12/27/2006	Haynes Bridge Road	Grease	Big Creek
1/17/2007	350 Lake Manor Trace	Grease	Tributary of Johns Creek
2/12/2007	401 Huntington Drive	Grease	Tributary of Big Creek
2/24/2007	4860 Hampton Square Drive	Roots and Debris	Tributary to Chattahoochee River
4/16/2007	565 Ashvale Overlook	Grease	Tributary of Johns Creek
6/7/2007	230 Crabapple Chase Court	Debris	Tributary of Big Creek
7/23/2007	3530 Grey Abbey Drive	Grease and Debris	Tributary of Big Creek
12/22/2007	156 Crocker Way	Grease	Tributary of Foe Killer Creek
1/8/2008	250 Lantern Ridge Court	Grease	Tributary of Big Creek
5/16/2008	8802 Fairview Bluff	Debris, Roots	Tributary of Johns Creek
8/4/2008	3530 Grey Abbey Drive	Grease and Debris	Tributary of Big Creek
10/21/2008	415 Hepplewhite Drive	Debris, Roots	Tributary of Johns Creek
2/21/2009	5475 Royce Drive	Line Failure in Creek	Tributary to Johns Creek
3/10/2009	3655 Preston Ridge Road	Grease	Big Creek
5/29/2009	8202 Fairview Bluff	Debris	Tributary of Chattahoochee River
9/8/2009	180 Pruitt Drive	Grease	Foe Killer Creek
10/21/2009	10845 Haynes Bridge Road	Grease	Big Creek
11/3/2009	3275 Kimball Bridge Road	Grease and Debris	Big Creek
12/10/2009	8670 Barnwell Road	Grease	Tributary of Johns Creek
3/18/2010	10145 Haynes Bridge Road	Grease and Debris	Tributary to Big Creek
6/2/2011	1285 Hembree Road	Grease	Tributary to Big Creek

Geometric Mean Values for 2011-2012 Bacteria Sampling
City of Roswell - Public Works and Environmental Department

Fecal Coliform Summary 2011-2012	Q1 - May	Q2 - Aug	Q3 - Nov	Q4 - Feb
Rocky Creek	74	0	0	0
Hog Waller Creek	**277**	**0**	0	0
Willeo Creek	**608**	**0**	0	0
Big Creek	**766**	**0**	0	0

E. Coli Summary 2011-2012	Q1 - May	Q2 - Aug	Q3 - Nov	Q4 - Feb
Rocky Creek	62	0	0	0
Hog Waller Creek	**243**	**0**	0	0
Willeo Creek	**567**	0	0	0
Big Creek	**669**	**0**	0	0

Geometric Mean Values for 2010-2011 Bacteria Sampling
City of Roswell - Public Works and Environmental Department

Fecal Coliform Summary 2010-2011	Q1 - May	Q2 - Aug	Q3 - Nov	Q4 - Feb
Rocky Creek	118	56	46	30
Hog Waller Creek	**352**	**313**	481	225
Willeo Creek	166	**209**	265	281
Big Creek	**951**	**285**	238	206

E. Coli Summary 2010-2011	Q1 - May	Q2 - Aug	Q3 - Nov	Q4 - Feb
Rocky Creek	103	46	32	21
Hog Waller Creek	**352**	**278**	428	249
Willeo Creek	152	156	215	218
Big Creek	**790**	**241**	349	157

Geometric Mean Values for 2009-2010 Bacteria Sampling
City of Roswell - Public Works and Environmental Department

Fecal Coliform Summary 2009-2010	Q1 - May	Q2 - Aug	Q3 - Nov	Q4 - Feb
Rocky Creek	**230**	**299**	103	62
Hog Waller Creek	**1073**	**2302**	329	151
Willeo Creek	182	**711**	240	64
Big Creek	**704**	**658**	598	427

E. Coli Summary 2009-2010	Q1 - May	Q2 - Aug	Q3 - Nov	Q4 - Feb
Rocky Creek	168	414	70	43
Hog Waller Creek	956	1942	271	125
Willeo Creek	159	557	173	56
Big Creek	587	529	483	384

Water Quality Data
Big Creek Watershed Study
Tributary 8

SurveyDate	Turbidity	Fecalcoli	WaterTempF	pH	Dissoxy_meter	WeatherConditions
02/15/2011	1.87	0	50	6.71	8.25	fair
01/05/2011	1.33	10	49	6.76	9.52	Overcast
12/20/2010	0.79	0	47	6.75	9.41	Clear
11/04/2010	1.28	190	57	6.60	7.75	Overcast
10/12/2010	1.77	50	63	6.58	8.09	Partly Cloudy
08/18/2010	2.94	180	73	6.37	6.43	Partly Cloudy
08/04/2010	3.90	350	71	6.43	7.63	Clear
07/07/2010	1.10	40	67	6.30	7.13	Clear
05/25/2010	1.55	80	64	**5.63**	7.36	Partly Cloudy
04/21/2010	2.62	20	58	6.12	8.48	Overcast
04/07/2010	2.37	0	62	6.14	8.99	Partly Cloudy
02/19/2010	1.02	0	46	6.40	9.65	Clear
02/09/2010	1.79	15	49	**5.52**	8.55	Overcast
01/07/2010	1.17	0	45	**5.59**	10.80	Overcast
12/28/2009	1.68	0	48	**5.72**	9.83	Clear
11/18/2009	1.35	50	58	6.09	8.67	Overcast
10/21/2009	1.12	40	57	**5.65**	7.40	Clear
08/25/2009	1.34	37	68	6.30	**5.55**	Clear
07/28/2009	1.05	100	69	5.88	**5.53**	Clear
06/24/2009	1.40	20	68	6.35	**5.82**	Partly Cloudy
06/10/2009	1.80	0	72	6.49	6.31	Overcast
04/29/2009	1.40	250	61	6.56	7.77	Clear
04/16/2009	1.40	30	56	6.79	9.30	Clear
02/26/2009	1.20	10	55	6.72	8.84	Overcast
01/27/2009	1.10	20	53	6.78	8.75	Overcast
12/29/2008	0.90	10	54	6.63	8.20	Clear
11/12/2008	10.10	100	57	6.63	**5.17**	Cloudy
10/01/2008	0.70	330	64	6.27	**5.82**	Clear
09/17/2008	2.60	170	66	6.45	**5.67**	Overcast
08/20/2008	0.60	0	68	6.15	**4.54**	Cloudy
07/16/2008	1.00	30	68	6.40	**3.08**	Cloudy
06/11/2008	1.00	50	68	6.17	**3.34**	Cloudy
05/28/2008	1.80	70	64	7.07	**3.51**	
12/12/2007	0.50	70	61	**5.76**		Clear
11/28/2007	0.50	40	50	6.70	8.34	Clear
10/23/2007	1.90	280	66	6.52	6.15	Overcast
09/17/2007	0.50	30	64	6.67	6.52	Cloudy
08/21/2007	0.80	70	72	6.54	6.04	Clear
Number of Excedances		0	0	6	10	
% Excedance		0%	0%	16%	26%	

Water Quality Data
Big Creek Watershed Study
Long Indian Creek

SurveyDate	Turbidity	Fecalcoli	WaterTempF	pH	Dissoxy_meter	WeatherConditions
02/15/2011	3.48	60	44	7.16	11.28	Clear
01/05/2011	3.64	50	42	7.29	11.43	Overcast
12/20/2010	4.67	70	41	7.16	12.09	Clear
11/03/2010	3.88	320	54	7.08	9.28	Overcast
10/12/2010	4.42	200	63	7.06	8.02	Partly Cloudy
08/18/2010	7.43	440	78	6.90	6.38	Partly Cloudy
08/04/2010	6.64	70	78	7.01	6.49	Clear
07/07/2010	5.02	80	72	7.03	**5.89**	Clear
05/25/2010	5.14	50	67	**5.72**	6.21	Partly Cloudy
04/21/2010	6.18	20	58	6.38	8.24	Overcast
04/06/2010	3.68	0	63	6.44	9.17	Clear
02/19/2010	3.23	0	41	6.58	11.68	Clear
02/09/2010	5.32	30	46	**5.57**	9.63	Overcast
01/07/2010	3.78	0	37	**5.52**	12.91	Overcast
12/28/2009	5.62	60	44	**5.59**	11.36	Clear
11/18/2009	3.82	150	57	6.23	8.89	Overcast
10/21/2009	4.21	130	53	**5.80**	9.72	Clear
08/25/2009	3.36	110	70	6.80	6.08	Clear
07/28/2009	11.15	**2300**	73	6.15	6.19	Clear
06/24/2009	5.62	220	73	6.89	**5.50**	Partly Cloudy
06/10/2009	4.54	150	70	6.68	6.79	Overcast
04/29/2009	4.00	100	61	6.87	7.46	Clear
04/16/2009	4.10	57	56	6.80	9.54	Clear
02/26/2009	2.40	50	50	7.32	11.30	Overcast
01/21/2009	3.20	53	35	7.35	14.20	Clear
12/17/2008	3.40	10	55	7.04	8.90	Overcast
11/12/2008	2.20	20	50	7.15	7.00	Cloudy
10/01/2008	6.00	85	64	6.63	**3.73**	Clear
09/17/2008	6.00	130	68	6.98	**5.31**	Overcast
07/30/2008	8.00	230	75	7.01	**2.39**	Overcast
Number of Excedances		1	0	5	5	
% Excedance		3%	0%	17%	17%	

Water Quality Data
Big Creek Watershed Study
Lake Windward

SurveyDate	Turbidity	Fecalcoli	WaterTempF	pH	Dissoxy_meter	WeatherConditions
02/07/2006	5.30	0	46	7.10	**5.48**	Clear
01/10/2006	3.71	100	54	6.97	8.12	Clear
Number of Excedances		0	0	0	1	
% Excedance		0%	0%	0%	50%	

Water Quality Data
Big Creek Watershed Study
Golf Club

SurveyDate	Turbidity	Fecalcoli	WaterTempF	pH	Dissoxy_meter	WeatherConditions
02/15/2011	3.26	0	48	7.01	10.44	Clear
01/05/2011	3.22	10	45	6.92	10.55	Overcast
12/20/2010	3.13	40	43	7.01	9.88	Clear
11/04/2010	5.38	148	56	6.87	7.97	Overcast
10/12/2010	3.81	825	63	6.83	7.39	Partly Cloudy
08/31/2010	4.19	**3600**	70	6.87	6.81	Clear
08/25/2010	6.69	**12000**	72	6.91	6.15	Partly Cloudy
08/18/2010	24.80		76	6.63	6.05	Partly Cloudy
08/04/2010	7.28		75	6.73	**5.56**	Clear
07/07/2010	4.24	**4100**	72	6.76	**4.75**	Clear
05/25/2010	4.96	**16300**	67	6.05	**4.98**	Partly Cloudy
04/21/2010	6.82	0	57	6.24	6.72	Overcast
04/07/2010	4.57	0	63	6.18	7.12	Partly Cloudy
02/19/2010	2.71	0	45	6.56	10.76	Clear
02/09/2010	4.70	40	47	**5.90**	9.39	Overcast
01/07/2010	3.64	0	41	**5.85**	11.02	Overcast
12/28/2009	5.08	120	45	**5.89**	10.25	Partly Cloudy
11/18/2009	3.51	**4200**	58	6.05	7.67	Overcast
10/21/2009	3.22	450	56	6.06	8.58	Clear
08/25/2009	4.02	**4000**	70	6.46	**4.83**	Clear
07/28/2009	13.45	**13600**	74	6.31	**4.23**	Clear
06/24/2009	6.04	**4200**	72	6.48	**4.74**	Partly Cloudy
06/10/2009	6.44	**4700**	70	6.60	**5.61**	Overcast
04/29/2009	3.80	90	63	6.70	6.87	Clear
04/16/2009	3.20	90	54	6.90	9.65	Clear
02/26/2009	3.30	90	54	7.08	9.10	Overcast
01/27/2009	19.20	110	50	7.06	9.89	Overcast
12/29/2008	2.60	180	54	6.90	8.59	Clear
11/12/2008	2.60	50	54	6.77	6.19	Cloudy
09/17/2008	5.20	100	68	6.84	**5.52**	Overcast
08/20/2008	5.60	115	73	6.82	**4.90**	Cloudy
07/16/2008	5.40	167	72	6.71	**2.82**	Cloudy
06/25/2008	6.70	**510**	66	6.73	**3.05**	Clear
05/27/2008	6.30	150	70	7.03	**3.56**	
Number of Excedances		10	0	3	12	
% Excedance		29%	0%	9%	35%	

Water Quality Data
Big Creek Watershed Study
Caney Creek

SurveyDate	Turbidity	Fecalcoli	WaterTempF	pH	Dissoxy_meter	WeatherConditions
02/15/2011	4.68	50	46	6.90	7.66	Clear
01/05/2011	4.02	170	43	6.85	10.59	Overcast
12/20/2010	3.02	10	41	6.98	10.66	Clear
11/04/2010	4.48	1800	54	6.78	8.03	Overcast
10/12/2010	2.92	160	62	6.81	7.17	Partly Cloudy
08/18/2010	3.63	190	75	6.77	6.41	Partly Cloudy
08/04/2010	4.14	80	76	6.75	**5.85**	Clear
07/07/2010	3.26	190	71	6.78	6.31	Clear
05/25/2010	4.44	190	66	**5.81**	6.16	Partly Cloudy
04/21/2010	4.40	0	57	6.20	7.16	Overcast
04/07/2010	3.31	0	63	6.26	8.09	Partly Cloudy
02/19/2010	3.54	0	42	6.49	10.89	Clear
02/09/2010	6.58	0	46	**5.76**	9.57	Overcast
01/07/2010	4.33	0	39	**5.80**	11.83	Overcast
12/28/2009	8.20	20	44	**5.76**	10.77	Partly Cloudy
11/18/2009	3.70	100	57	**5.98**	7.99	Overcast
10/21/2009	3.76	140	54	**5.20**	8.90	Clear
08/25/2009	3.90	170	70	6.60	6.69	Clear
07/28/2009	9.90	**805**	71	6.02	6.41	Clear
06/24/2009	4.10	**640**	72	6.58	6.32	Partly Cloudy
06/10/2009	4.12	230	72	6.30	6.87	Partly Cloudy
04/29/2009	3.60	180	61	6.67	8.53	Clear
04/16/2009	5.00	90	53	6.76	10.12	Clear
02/26/2009	1.80	230	51	7.11	11.78	Overcast
01/27/2009	4.10	470	48	7.11	11.30	Overcast
12/29/2008	4.60	160	52	6.78	9.91	Clear
11/12/2008	3.00	50	50	6.80	6.35	Cloudy
10/01/2008	5.50	205	63	6.67	**5.35**	Clear
09/17/2008	4.30	0	66	6.75	**5.21**	Overcast
08/20/2008	5.00	405	72	6.77	**4.68**	Cloudy
07/16/2008	4.30	410	72	6.89	**3.12**	Cloudy
06/11/2008	5.30	10	73	6.55	**2.95**	Cloudy
05/28/2008	4.30	330	68	7.24	**3.10**	
12/18/2007	2.40	310	39	6.09		Clear
11/27/2007	4.70	100	50	7.03	9.04	Cloudy
10/23/2007	6.10	90	66	7.03	6.29	Overcast
09/17/2007	4.00	**570**	66	**60.00**	6.31	Cloudy
08/15/2007	5.00	200	77	6.94	**5.07**	Clear
07/12/2006		**2400**	79	7.12	7.06	Clear
04/25/2006	6.15	100	66	7.02	7.64	Clear
03/22/2006	11.00	400	48	7.06	**2.55**	Clear
02/13/2006	4.75		36	7.12	**4.40**	Clear
01/10/2006	6.18	300	55	6.94	7.03	Clear
Number of Excedances		4	0	6	10	
% Excedance		9%	0%	14%	23%	

Water Quality Data
Big Creek Watershed Study
Camp Creek

SurveyDate	Turbidity	Fecalcoli	WaterTempF	pH	Dissoxy_meter	WeatherConditions
02/15/2011	7.21	0	47	7.18	10.69	Clear
01/05/2011	15.80	60	42	7.01	11.45	Overcast
12/20/2010	8.10	0	39	7.38	11.63	Clear
11/04/2010	7.42	180	55	6.96	8.21	Overcast
10/12/2010	10.20	50	62	6.82	7.06	Partly Cloudy
08/18/2010	16.85	30	79	6.84	**4.56**	Clear
08/04/2010	14.30	140	80	6.81	**4.69**	Clear
07/07/2010	12.40	180	79	6.87	**4.89**	Clear
05/25/2010	14.95	60	73	6.19	**5.03**	Partly Cloudy
04/21/2010	11.50	0	60	6.40	6.86	Overcast
04/07/2010	8.86	0	70	6.40	**5.98**	Partly Cloudy
02/19/2010	7.85	0	43	6.70	11.48	Clear
02/09/2010	11.85	0	43	5.82	9.98	Overcast
01/07/2010	7.86	15	35	5.95	13.03	Overcast
12/28/2009	13.80	10	40	5.91	11.56	Partly Cloudy
11/18/2009	8.17	70	56	6.09	7.89	Overcast
10/21/2009	9.84	80	55	**5.79**	8.32	Clear
08/25/2009	11.90	**785**	75	6.36	**5.48**	Clear
07/28/2009	17.70	83	76	6.45	**4.22**	Clear
06/24/2009	27.80	120	80	6.80	**4.23**	Partly Cloudy
06/10/2009	24.10	**220**	75	6.65	**5.05**	Overcast
04/29/2009	13.00	80	70	6.76	6.00	Clear
04/16/2009	11.10	50	56	6.96	8.44	Clear
02/26/2009	7.00	30	54	7.11	9.69	Overcast
01/27/2009	6.80	50	48	7.09	10.60	Overcast
12/29/2008	6.90	50	52	6.83	8.76	Clear
11/12/2008	0.80	70	52	6.92	8.06	Cloudy
10/01/2008	14.30	610	66	6.83	6.21	Clear
09/17/2008	16.60	0	70	6.88	**5.34**	Overcast
08/20/2008	12.00	0	72	6.94	**5.03**	Cloudy
07/16/2008	14.60	**200**	73	6.62	**2.87**	Cloudy
05/27/2008	16.00	40	73	7.03	**3.28**	
01/10/2006	6.11	0	54	6.87	7.48	Clear
Number of Excedances		3	0	1	13	
% Excedance		9%	0%	3%	39%	

Water Quality Data
Big Creek Watershed Study
Windward Road

SurveyDate	Turbidity	Fecalcoli	WaterTempF	pH	Dissoxy_meter	WeatherConditions
02/23/2011	8.81	30	53	7.34	9.23	Clear
02/09/2011	11.70	15	41	7.19	11.91	Clear
02/01/2011	7.92	40	47	7.16	9.72	Overcast
01/05/2011	11.00	85	42	7.12	11.41	Overcast
12/09/2010	7.44	100	38	7.24	12.00	Clear
10/20/2010	8.30	90	59	7.27	8.49	Partly Cloudy
09/15/2010	9.34	130	69	7.20	7.69	Clear
08/18/2010	24.00	**500**	78	6.94	6.15	Clear
08/04/2010	11.45	**1000**	78	7.06	6.49	Clear
06/10/2010	18.10	250	72	6.28	6.68	Overcast
05/19/2010	16.60	0	67	6.24	7.11	Clear
04/15/2010	8.68	0	63	6.52	7.67	Overcast
03/30/2010	8.80	0	52	6.56	9.52	Clear
02/19/2010	8.42	9	42	6.75	11.44	Clear
01/28/2010	18.15	30	43	5.85	11.13	Partly Cloudy
01/14/2010	10.35	30	37	6.28	13.23	Clear
12/01/2009	9.86	80	49	6.16	10.14	Partly Cloudy
11/17/2009	11.75	50	55	6.07	9.10	Overcast
10/20/2009	10.75	120	52	5.56	9.54	Clear
08/20/2009	15.45	30	76	6.82	**5.44**	Overcast
07/22/2009	11.55	70	69	6.89	6.45	Partly Cloudy
06/29/2009	11.00	30	76	7.15	6.19	Clear
06/03/2009	16.20	160	71	6.87	6.85	Partly Cloudy
04/23/2009	17.20	20	57	6.92	8.98	Clear
03/24/2009	12.40	20	56	7.22	9.38	Overcast
02/24/2009	8.10	60	42	7.36	12.70	Clear
01/21/2009	9.90	30	36	7.46	13.40	Clear
12/16/2008	15.30	110	50	7.06	9.91	Overcast
12/03/2008	21.40	150	41	7.42	11.91	
10/21/2008	13.80	190	54	7.42	8.06	Cloudy
09/25/2008	6.90	170	63	7.37	7.17	Clear
08/20/2008	5.70	60	73	7.35	6.00	Cloudy
07/16/2008	15.50	210	73	7.16	**3.03**	Cloudy
06/25/2008	10.80	0	70	7.17	**3.27**	Clear
06/06/2008	5.50	130	55	7.53	8.78	Clear
05/27/2008	10.50	40	70	7.30	**3.56**	
12/18/2007	9.70	330	39	6.46	10.98	Cloudy
11/28/2007	6.10	80	50	7.19	9.68	Clear
10/29/2007	5.50	130	55	7.53	8.78	
09/26/2007	5.70	80	72	7.49	6.60	Clear
08/22/2007	8.00	30	77	7.48	6.08	Cloudy
05/03/2006	12.00	200	59	7.06	8.57	Cloudy
02/13/2006	4.75		36	7.07	**4.38**	Clear
Number of Excedances		2	0	0	5	
% Excedance		5%	0%	0%	12%	

Water Quality Data
Big Creek Watershed Study
Webb Road

SurveyDate	Turbidity	Fecalcoli	WaterTempF	pH	Dissoxy_meter	WeatherConditions
02/23/2011	6.26	0	54	7.24	8.81	Clear
02/09/2011	10.30	30	42	7.20	11.96	Clear
02/01/2011	8.90	20	47	7.20	10.50	Overcast
12/09/2010	7.84	40	38	7.26	12.31	Clear
10/20/2010	10.25	100	59	7.31	8.75	Partly Cloudy
09/15/2010	9.00	100	69	7.23	7.39	Clear
08/24/2010	11.35	195	78	6.98	6.68	Partly Cloudy
08/10/2010	11.90	45	77	7.10	6.91	Overcast
06/10/2010	17.05	140	73	6.41	6.61	Overcast
05/19/2010	13.45	0	68	6.37	6.89	Clear
04/15/2010	9.49	0	64	6.52	7.63	Partly Cloudy
03/30/2010	8.00	0	52	6.62	9.53	Clear
02/25/2010	10.50	0	42	6.65	11.18	Clear
01/28/2010	16.85	0	43	6.06	11.19	Partly Cloudy
01/14/2010	7.16	20	37	6.24	13.46	Clear
12/01/2009	8.98	80	49	6.22	8.95	Partly Cloudy
11/17/2009	10.60	50	55	6.16	8.57	Overcast
10/20/2009	11.05	160	53	5.53	9.41	Clear
08/20/2009	9.01	50	76	6.84	6.00	Overcast
07/28/2009	8.90	40	70	6.94	6.36	Partly Cloudy
06/29/2009	7.06	38	76	7.12	**5.45**	Clear
06/03/2009	12.25	110	71	6.87	6.00	Partly Cloudy
04/23/2009	15.30	90	58	6.92	8.94	Clear
03/24/2009	8.60	10	56	7.21	9.33	Overcast
02/24/2009	7.80	40	43	7.34	12.50	Clear
01/21/2009	9.00	50	36	7.34	13.10	Clear
12/16/2008	11.50	265	50	7.07	9.93	Overcast
12/03/2008	7.20	70	41	7.37	12.05	
10/21/2008	4.70	70	55	7.30	8.28	Clear
09/25/2008	6.40	210	63	7.35	7.20	Clear
09/03/2008	6.50	45	72	7.16	**5.54**	Clear
07/16/2008	1.20	20	75	6.98	**3.08**	Cloudy
06/25/2008	7.50	0	72	7.28	**3.26**	Clear
05/28/2008	10.20	10	70	7.32	**3.17**	
12/12/2007	5.10	120	57	6.60	9.52	Clear
11/27/2007	9.30	200	50	7.24	9.46	Cloudy
10/23/2007	9.10	510	66	7.59		Overcast
09/26/2007	6.00	100	54	7.54	6.58	Clear
08/08/2007	6.70	180	79	7.54	7.30	Clear
07/18/2006	11.10	**2600**	79	7.17	6.30	Clear
06/05/2006	5.50	**1800**	70	7.07	6.88	Clear
05/09/2006	12.80	100	62	7.05	8.25	Cloudy
03/08/2006	10.64	100	59	6.98	8.20	Clear
01/24/2006	55.80	2000	48	7.02	**4.46**	Overcast
Number of Excedances		2	0	0	5	
% Excedance		5%	0%	0%	11%	

Water Quality Data
Big Creek Watershed Study
Old Milton Road

SurveyDate	Turbidity	Fecalcoli	WaterTempF	pH	Dissoxy_meter	WeatherConditions
02/23/2011	6.96	40	53	7.29	9.27	Clear
02/09/2011	10.05	50	42	7.15	11.63	Clear
02/01/2011	8.23	50	47	7.21	10.35	Overcast
12/09/2010	7.81	120	38	7.27	12.27	Clear
10/20/2010	8.20	180	60	7.28	9.07	Partly Cloudy
09/15/2010	10.30	180	69	7.21	8.08	Clear
08/24/2010	11.90	190	77	6.93	6.85	Partly Cloudy
08/10/2010	11.25	60	77	7.05	6.91	Overcast
06/10/2010	13.90	140	72	6.35	6.52	Overcast
05/19/2010	14.80	0	68	6.39	6.81	Clear
04/15/2010	7.95	10	54	6.54	7.39	Partly Cloudy
03/30/2010	8.73	0	53	6.60	9.22	Clear
02/25/2010	10.60	0	43	6.70	10.84	Clear
01/28/2010	16.95	15	44	5.99	10.94	Partly Cloudy
01/14/2010	7.04	10	37	6.24	12.90	Clear
12/01/2009	9.30	60	50	6.21	9.62	Partly Cloudy
11/17/2009	8.70	70	56	6.17	8.79	Overcast
10/20/2009	10.04	100	53	5.16	9.51	Clear
08/20/2009	8.54	80	76	6.72	6.50	Overcast
07/22/2009	9.32	80	71	6.54	6.25	Partly Cloudy
06/29/2009	11.40	70	77	6.98	6.56	Clear
06/03/2009	13.50	130	71	6.86	7.03	Partly Cloudy
04/23/2009	14.60	50	58	6.91	8.72	Clear
03/24/2009	9.00	60	56	7.20	9.41	Overcast
02/24/2009	7.10	3500	43	7.29	12.60	Clear
01/21/2009	8.30	95	37	7.32	12.40	Clear
12/16/2008	10.80	130	50	7.08	10.13	Overcast
12/03/2008	5.90	70	41	7.30	12.23	
10/21/2008	4.40	70	55	7.43	8.32	Clear
09/03/2008	6.50	70	73	7.18	**5.40**	Clear
07/16/2008	10.50	80	73	7.17	**3.24**	Cloudy
06/25/2008	7.80	0	70	7.30	**3.48**	Clear
05/28/2008	10.10	40	70	7.43	**3.38**	
04/30/2008	8.60	40	59	6.90	**3.85**	
12/12/2007	4.60	80	57	6.61	9.64	Clear
11/27/2007	7.70	400	50	7.58	9.43	Cloudy
10/29/2007	5.20	200	57	7.61	8.90	Clear
09/17/2007	8.90	210	68	7.52	7.01	Clear
08/08/2007	17.50	110	77	7.69	6.25	Clear
07/18/2006	21.10	**2000**	80	7.14	7.01	Clear
06/20/2006	13.80	**2200**	78	7.09	7.99	Clear
05/09/2006	14.90	200	63	7.07	8.13	Cloudy
04/05/2006	8.41	200	59	7.09	7.90	Clear
03/22/2006	57.00	600	48	7.11	8.77	Clear
02/14/2006	5.44	0	43	7.11	**5.01**	Clear
01/26/2006		100				
01/24/2006	55.20	**4900**	50	7.06	**5.13**	Overcast
Number of Excedances		3	0	0	7	
% Excedance		6%	0%	0%	15%	

Water Quality Data
Big Creek Watershed Study
McGinnis Ferry Road

SurveyDate	Turbidity	Fecalcoli	WaterTempF	pH	Dissoxy_meter	WeatherConditions
02/23/2011	6.58	30	52	7.46	9.01	Clear
02/09/2011	10.70	20	41	7.23	11.96	Clear
02/01/2011	8.50	10	47	7.29	9.72	Overcast
12/09/2010	7.54	70	38	7.27	12.09	Clear
10/20/2010	8.74	110	59	7.26	8.95	Partly Cloudy
09/15/2010	10.80	170	69	7.16	7.64	Clear
08/24/2010	12.65	170	76	6.97	6.79	Partly Cloudy
08/10/2010	12.25	30	78	6.97	6.58	Partly Cloudy
06/10/2010	20.55	180	72	6.48	6.78	Overcast
05/19/2010	16.95	0	67	6.18	7.37	Clear
04/15/2010	8.44	0	63	6.44	7.81	Overcast
03/30/2010	8.94	0	52	6.54	9.56	Clear
02/25/2010	10.95	0	42	6.61	11.24	Clear
01/28/2010	20.75	30	43	**5.79**	11.06	Partly Cloudy
01/14/2010	7.54	20	37	6.44	13.50	Clear
12/01/2009	9.93	70	49	6.02	10.27	Partly Cloudy
11/17/2009	13.05	40	55	6.12	9.09	Overcast
10/20/2009	12.00	300	52	6.13	9.62	Clear
08/20/2009	14.60	180	76	6.62	**5.05**	Overcast
07/22/2009	16.00	140	70	6.92	**5.95**	Partly Cloudy
06/29/2009	13.00	140	76	7.10	6.11	Clear
06/03/2009	16.70	220	71	6.84	7.05	Partly Cloudy
04/23/2009	16.00	80	57	7.01	9.18	Clear
03/24/2009	9.80	10	55	7.25	9.56	Overcast
02/24/2009	7.40	20	42	7.57	12.80	Clear
01/21/2009	9.40	75	36	7.63	13.64	Clear
12/16/2008	12.60	80	50	7.12	10.12	Overcast
12/03/2008	11.00	140	41	7.59	12.47	
10/21/2008	5.30	85	54	7.42	8.90	Clear
09/25/2008	7.80	280	63	7.36	7.77	Clear
08/20/2008	7.60	270	73	7.31	6.78	Cloudy
07/16/2008	17.40	100	73	7.12	**3.05**	Cloudy
06/25/2008	19.40	50	70	7.06	**3.27**	Clear
05/27/2008	13.20	0	70	7.25	**3.60**	
04/30/2008	10.30	130	57	6.92	**3.14**	
12/18/2007	9.40	340	41	6.41	11.15	Cloudy
11/28/2007	6.10	80	48	7.26	9.89	Clear
10/29/2007	5.50	190	57	7.24	8.83	Clear
09/26/2007	6.40	120	72	7.49	6.65	Clear
08/22/2007	7.10	220	77	7.39	5.93	Clear
08/02/2006	7.70	**1900**	78	7.12	6.70	Clear
07/12/2006		**2500**	78	6.98	6.41	Clear
06/05/2006	6.10	**1500**	70	7.08	7.22	Clear
05/03/2006	27.90		79	6.79	**3.80**	Clear
05/03/2006	10.10	400	58	7.07	8.62	Clear
04/05/2006	8.02	400	59	7.02	7.80	Clear
03/08/2006	11.53	100	55	7.04	8.80	Clear
02/07/2006	78.50	200	48	7.07	**5.66**	Clear
01/26/2006						
01/24/2006	55.00	200	48	7.06	6.33	Overcast
Number of Excedances		3	0	1	8	
% Excedance		6%	0%	2%	16%	

Water Quality Data
Big Creek Watershed Study
Mansell Road

SurveyDate	Turbidity	Fecalcoli	WaterTempF	pH	Dissoxy_meter	WeatherConditions
02/23/2011	6.50	20	55	7.38	9.02	Clear
02/09/2011	10.80	20	42	7.17	11.74	Clear
02/01/2011	6.89	60	47	7.24	10.30	Overcast
12/09/2010	8.40	65	38	7.30	11.72	Clear
11/03/2010	7.28	260	55	7.23	8.73	Drizzle
10/05/2010	7.36	130	59	7.30	8.92	Clear
08/24/2010	10.70	50	78	7.01	6.46	Partly Cloudy
08/10/2010	8.86	120	79	7.17	6.01	Overcast
06/10/2010	13.55	200	72	6.64	6.56	Overcast
05/19/2010	11.70	215	68	6.35	7.02	Clear
04/15/2010	7.63	110	63	6.65	7.56	Clear
04/06/2010	6.12	0	65	6.54	7.92	Clear
02/25/2010	9.80	20	43	6.68	12.49	Clear
01/29/2010	14.70	50	45	6.12	8.59	Overcast
01/14/2010	5.95	1	37	6.28	13.07	Partly Cloudy
12/01/2009	8.42	30	50	6.24	10.37	Partly Cloudy
11/17/2009	9.41	55	56	6.33	9.03	Overcast
10/20/2009	10.65	195	53	5.79	9.80	Clear
08/20/2009	8.44	90	77	6.93	6.91	Overcast
07/22/2009	7.53	127	71	7.10	6.98	Partly Cloudy
06/30/2009	6.94	40	75	7.16	6.00	Clear
06/03/2009	12.15	100	72	6.97	6.56	Partly Cloudy
04/29/2009	10.30	20	65	7.24	8.11	Clear
03/24/2009	7.50	40	56	7.26	9.22	Overcast
02/26/2009	6.10	865	48	7.37	11.37	Overcast
01/27/2009	7.30	60	46	7.40	10.68	Overcast
12/17/2008	9.80	40	52	7.15	9.30	Overcast
12/10/2008	5.90	50	43	7.28	11.63	
10/29/2008	5.90	90	48	7.41	10.10	Clear
09/25/2008	7.40	190	64	7.32	7.59	Clear
09/03/2008	6.90	100	73	7.26	6.33	Clear
07/30/2008	7.80	100	75	7.34	**2.49**	Overcast
06/25/2008	9.20	40	73	7.30	**3.46**	Clear
05/28/2008						
05/28/2008	8.90	70	72	7.51	**3.50**	
04/30/2008	10.10	20	57	6.96	**3.47**	
12/11/2007	4.70	100	63	6.46	8.87	Clear
11/13/2007	4.80	180	52	7.56	9.98	Clear
10/09/2007	9.70	120	72	7.61	7.75	Cloudy
09/11/2007	9.40	270	73	7.60	7.14	Clear
08/15/2007	7.40	130	81	7.78		Clear
08/02/2006	8.10	**2000**	79	7.14	**5.77**	Clear
06/20/2006	8.00	**3400**	78	7.11	6.93	Clear
05/09/2006	14.60	380	63	7.05	7.74	Cloudy
04/12/2006	10.70	1000	59	7.01	8.70	Clear
03/22/2006	66.50	1100	50	7.04	8.60	Clear
02/14/2006	7.41	0	44	7.10	**5.54**	Clear
01/25/2006	23.50	300	50	6.88	**5.84**	Clear
Number of Excedances		2	0	0	7	
% Excedance		4%	0%	0%	15%	

Water Quality Data
Big Creek Watershed Study
Kimball Bridge Road

SurveyDate	Turbidity	Fecalcoli	WaterTempF	pH	Dissoxy_meter	WeatherConditions
02/23/2011	6.25	50	53	7.34	9.79	Clear
02/15/2011	7.07	10	45	7.35	11.00	Clear
02/01/2011	8.96	25	47	7.20	10.52	Overcast
12/09/2010	7.46	80	38	7.29	11.85	Clear
11/03/2010	6.81	130	56	7.25	9.32	Drizzle
10/05/2010	7.42	80	58	7.36	9.31	Clear
08/24/2010	11.20	300	77	7.01	6.16	Partly Cloudy
08/10/2010	9.04	30	78	7.09	7.27	Overcast
06/10/2010	14.05	**8200**	72	6.35	6.15	Overcast
05/19/2010	18.55	260	68	6.32	7.18	Clear
04/15/2010	7.95	50	64	6.57	7.85	Clear
04/06/2010	6.86	0	65	6.35	7.89	Clear
02/25/2010	10.65	0	43	6.66	11.98	Clear
01/29/2010	15.25	20	46	6.30	7.32	Overcast
01/14/2010	7.59	30	37	6.30	13.15	Partly Cloudy
12/01/2009	9.11	75	50	6.17	10.14	Partly Cloudy
11/17/2009	9.85	70	56	6.21	8.98	Overcast
10/20/2009	9.94	170	53	**5.07**	9.50	Clear
08/20/2009	7.70	90	76	6.91	**5.60**	Overcast
07/22/2009	10.70	100	71	7.04	6.25	Partly Cloudy
06/30/2009	9.41	10	74	7.21	6.08	Clear
06/03/2009	13.60	80	71	6.98	6.58	Partly Cloudy
04/23/2009	13.00	120	59	6.94	8.70	Clear
03/24/2009	7.50	50	56	7.22	9.06	Overcast
02/24/2009	8.10	1805	43	7.34	12.50	Clear
01/21/2009	7.80	70	36	7.36	13.90	Clear
12/16/2008	11.00	70	50	7.09	9.70	Overcast
12/03/2008	6.60	60	41	7.36	11.43	
10/29/2008	5.80	210	48	7.71	8.88	Clear
09/25/2008	9.20	220	64	7.36	6.80	Clear
09/03/2008	6.80	70	73	7.26	7.25	Clear
07/16/2008	10.80	100	75	7.16	**3.25**	Cloudy
06/25/2008	9.90	0	72	7.22	**3.36**	Clear
05/28/2008	9.80	80	70	7.39	**3.44**	
04/30/2008	9.40	95	57	6.97	**3.53**	
12/11/2007	5.40	220	63	6.54	8.82	Clear
11/13/2007	6.20	150	52	7.42	9.81	Clear
10/16/2007	6.60	100	63	7.43	7.63	Cloudy
09/11/2007	9.80	150	73	7.45	6.34	Clear
08/07/2007	6.90	70	79	7.62	6.45	Clear
07/18/2006	9.90	**1200**	80	7.13	6.22	Clear
06/20/2006	9.30	**3700**	79	7.12	6.66	Clear
05/09/2006	12.00	**500**	62	7.06	8.07	Cloudy
04/12/2006	8.56	700	61	6.93	8.60	
03/22/2006	57.70	800	48	7.04	8.70	Clear
02/14/2006	7.27	0	45	7.08	**5.19**	Clear
01/25/2006	22.80	600	50	6.87	6.09	Clear
Number of Excedances		4	0	1	5	
% Excedance		8%	0%	2%	10%	

SurveyDate	Turbidity	Fecalcoli	WaterTempF	pH	Dissoxy_meter	WeatherConditions
02/23/2011	5.65	30	54	7.36		Clear
02/09/2011	10.00	20	42	7.16	11.89	Clear
02/01/2011	7.76	10	47	7.25	10.50	Overcast
12/09/2010	8.11	90	38	7.27	12.49	Clear
11/03/2010	7.04	200	56	7.24	9.68	Drizzle
10/05/2010	7.13	85	58	7.31	9.82	Clear
08/24/2010	11.35	100	78	7.01	6.96	Partly Cloudy
08/10/2010	8.24	110	79	7.17	7.25	Overcast
06/10/2010	15.75	100	72	6.57	6.48	Overcast
05/19/2010	12.30	10	68	6.32	7.03	Clear
04/15/2010	8.58	80	63	6.60	7.89	Clear
04/06/2010	6.98	0	65	6.43	7.91	Clear
02/25/2010	10.00	5	43	6.64	12.35	Clear
01/29/2010	14.80	30	45	6.05	8.60	Overcast
01/14/2010	6.64	10	37	6.33	13.60	Partly Cloudy
12/01/2009	9.44	60	50	6.26	10.03	Partly Cloudy
11/17/2009	9.43	40	56	6.25	8.88	Overcast
10/20/2009	8.68	160	53	**5.44**	9.79	Clear
08/20/2009	8.28	120	76	6.89	**5.25**	Overcast
07/22/2009	7.62	190	71	6.97	6.86	Partly Cloudy
06/30/2009	7.10	20	75	7.16	5.31	Clear
06/03/2009	13.90	90	72	7.00	5.90	Partly Cloudy
04/23/2009	13.40	60	59	6.95	8.72	Clear
03/24/2009	8.40	50	55	7.25	9.22	Overcast
02/26/2009	7.20	1020	48	7.34	11.00	Overcast
01/27/2009	7.10	80	46	7.57	10.60	Overcast
12/17/2008	9.50	140	52	7.17	9.70	Overcast
12/03/2008	6.30	50	43	7.33	11.30	
10/29/2008	5.80	80	48	7.47	8.67	Clear
09/25/2008	7.40	150	64	7.37	6.76	Clear
09/03/2008	6.70	100	73	7.32	6.46	Clear
07/30/2008	6.30	0	77	7.35	2.29	Overcast
06/25/2008	7.70	200	73	7.33	3.35	Clear
05/28/2008	9.80	40	70	7.42	3.48	
12/04/2007	7.20	100	46	7.82	9.51	Clear
11/13/2007	4.50	440	52	7.68	9.90	Clear
10/16/2007	7.60	390	63	7.48	8.07	Cloudy
09/11/2007	8.00	250	73	7.60		Clear
08/07/2007	6.70	130	81	7.62	6.80	Clear
04/12/2006	6.58	900	61	6.84	8.80	Clear
Number of Excedances		0	0	1	1	
% Excedance		0%	0%	3%	3%	

Alpharetta - Water Quality Assurance

Engineering and Public Works

Summary Report - Details by Segment

51 **Foe Killer Ck. @ 1270 Mayfield Manor Dr.** **5 Surveys**

Survey Date	Turbidity (NTU)	P/A Bacteria	Fecal Coliforms Count (cfu/100ml)	Fecal Strep Count (cfu/100ml)	Fecal Strep Ratio	Water Temp (F)	Stream Depth (Inches)	Conductivity (uS/cm)	Dissolved Solids (ppm)	pH	Phosphate (ppm)	Nitrate-Nitrogen (ppm)	Flow Rate (ft/sec)	D.O. Meter (ppm)	D.O. Kit (ppm)	Chlorine (ppm)	Detergents (ppm)	Copper (ppb)	Alkalinity (ppm)	Phenols (ppb)	Hydro-carbons (ppm)	Total Index Value
10/23/2008	2.20		60		?	55	2.3	90.0	60	7.17	0.14		0.61	7.67				0.019				
10/02/2008	5.20		1160		?	59	2.8	80.0	60	7.28	0.21		0.01	6.33				0.000				
09/18/2008	6.30		2125		?	66	3.7	110.0	70	7.15	0.14		0.24	6.41				0.000				
09/11/2008	6.00		840		?	71	3.5	100.0	70	7.13	0.09		0.17	5.65			0.0	0.029				
6/11/2009	7.50		720		?	69	5.0	80.0	60	6.79	0.07		0.23	6.89				0.000				
Avg	5.44		981			64	3.4	92.0	64	7.10	0.13		0.25	6.59			0.0	0.010				
Min	2.20		60			71	2.3	80.0	60	6.79	0.07		0.01	5.65			0.0	0.000				
Max	7.50		2125			71	5.0	110.0	70	7.28	0.21		0.61	7.67			0.0	0.029				

Date 1/22/2010

Alpharetta - Water Quality Assurance

Engineering and Public Works

Summary Report - Details by Segment

44 **Foe Killer Creek northwest of Br in Saddle Creek Apts off Mid-Broadwell Rd** **22 Surveys**

Survey Date	Turbidity (NTU)	P/A Bacteria	Fecal Coliforms Count (cfu/100ml)	Fecal Strep Count (cfu/100ml)	Fecal Strep Ratio	Water Temp (F)	Stream Depth (Inches)	Conductivity (uS/cm)	Dissolved Solids (ppm)	pH	Phosphate (ppm)	Nitrate-Nitrogen (ppm)	Flow Rate (ft/sec)	D.O. Meter (ppm)	D.O. Kit (ppm)	Chlorine (ppm)	Detergents (ppm)	Copper (ppb)	Alkalinity (ppm)	Phenols (ppb)	Hydro-carbons (ppm)	Total Index Value
04/06/2009	5.70		120	2100	0.06	54	4.5	80.0	60	7.18	0.22		0.24	8.87				0.028				
03/11/2009	5.30		250	300	0.83	55	6.3	90.0	60	7.18	0.09		0.66	8.38				0.022				
02/11/2009	4.20		2500	1283	1.95	50	3.3	90.0	60	6.96	0.13		1.39	9.90				0.036				
01/14/2009	7.80		90	3700	0.02	41	6.0	110.0	80	6.80	0.28		0.74	11.91				0.010				
12/09/2008	3.70		30	80	0.38	43	3.3	80.0	60	7.40	0.10		1.18	10.40				0.023				
11/05/2008	3.40		720	160	4.50	52	3.0	90.0	60	7.17	0.14		0.18	6.40				0.026				
10/15/2008	4.90		410	385	1.06	63	2.3	80.0	60	7.78	0.11		0.59	5.62				0.020				
09/11/2008	7.00		270		?	72	1.0	100.0	70	7.05	0.19		1.60	5.42			0.0	0.029				
09/09/2008	11.30		8900	6800	1.31	70	1.3	80.0	50	6.78	0.14		0.83	5.35			0.0	0.052				
08/12/2008	14.50		225	80	2.81	68	0.0	110.0	70	6.49	0.06		0.00	1.16			0.0	0.029				
07/29/2008	9.60		460	845	0.54	73	1.0	100.0	70	6.80	0.14		0.27	1.76			0.0	0.028				
07/02/2008	8.30		410		?	64	1.5	90.0	60	6.85	0.17			3.14			0.0	0.045				
06/19/2008	10.50		760	995	0.76	64	1.5	90.0	60	7.28	0.51		1.10	3.11			0.0	0.092				
04/02/2008			745		?	59		90.0	60					8.83				0.000				
6/2/2009	7.70		750	4800	0.16	66	5.0	80.0	60	6.78	0.12		1.25	7.72				0.033				
6/23/2009	9.19		440	2300	0.19	73	3.5	90.0	60	6.88	0.06		0.80	6.28				0.005				
7/7/2009	7.64		70	570	0.12	72	3.0	90.0	60	6.72	0.08		0.51	5.38				0.006				2
8/4/2009	8.50		505	1430	0.35	72	4.5	80.0	50	6.20	0.15		0.51	5.97				0.007				
9/15/2009	10.50		140	1175	0.12	70	3.8	90.0	60	6.37	0.05		0.30	5.50				0.015				

Date 1/22/2010

Summary Report - Details by Segment

11/4/2009	5.00	580	270	2.15	53	22.5	90.0	60	5.03	0.05	0.33	8.39		0.008		
12/17/2009	6.25	80	30	2.67	45	20.5	80.0	60	5.79	0.06	0.38	9.80		0.012		
1/12/2010	4.34	120	10	12.00	39	18.5	70.0	50	5.67	0.11	0.47	11.28		0.011		
Avg	7.40	844	1438	1.68	60	5.5	88.6	61	6.72	0.14	0.67	6.84	0.0	0.024		2
Min	3.40	30	10	0.02	73	0.0	70.0	50	5.03	0.05	0.00	1.16	0.0	0.000		2
Max	14.50	8900	6800	12.00	73	22.5	110.0	80	7.78	0.51	1.60	11.91	0.0	0.092		2

Alpharetta - Water Quality Assurance

Engineering and Public Works

Summary Report - Details by Segment

40 **Foe Killer Creek in Fairfax Subdivision Recreational Area** **4 Surveys**

Survey Date	Turbidity (NTU)	P/A Bacteria	Fecal Coliforms Count (cfu/100ml)	Fecal Strep Count (cfu/100ml)	Fecal Strep Ratio	Water Temp (F)	Stream Depth (Inches)	Conductivity (uS/cm)	Dissolved Solids (ppm)	pH	Phosphate (ppm)	Nitrate-Nitrogen (ppm)	Flow Rate (ft/sec)	D.O. Meter (ppm)	D.O. Kit (ppm)	Chlorine (ppm)	Detergents (ppm)	Copper (ppb)	Alkalinity (ppm)	Phenols (ppb)	Hydro-carbons (ppm)	Total Index Value
09/09/2008	12.20		1900	1700	1.12	72	4.3	80.0	50	6.98	0.20		0.37	5.80			0.0	0.033				
08/12/2008	10.50		8200	990	8.28	68	0.0	110.0	70	6.68	0.15		0.00	1.62			0.0	0.049				
07/29/2008	7.80		50	435	0.11	79	2.3	90.0	60	7.03	0.26		0.15	1.88			0.0	0.065				
6/11/2009	10.55		600		?	70	7.5	80.0	60	6.76	0.15		0.38	6.35				0.000				
Avg	10.26		2688	1042	3.17	72	3.5	90.0	60	6.86	0.19		0.23	3.91			0.0	0.037				
Min	7.80		50	435	0.11	79	0.0	80.0	50	6.68	0.15		0.00	1.62			0.0	0.000				
Max	12.20		8200	1700	8.28	79	7.5	110.0	70	7.03	0.26		0.38	6.35			0.0	0.065				

Date 1/22/2010

Alpharetta - Water Quality Assurance

Engineering and Public Works

Summary Report - Details by Segment

03 **Foe Killer Creek at Rucker Rd past Spring Gate Subdivision** **65 Surveys**

Survey Date	Turbidity (NTU)	P/A Bacteria	Fecal Coliforms Count (cfu/100ml)	Fecal Strep Count (cfu/100ml)	Fecal Strep Ratio	Water Temp (F)	Stream Depth (Inches)	Conductivity (uS/cm)	Dissolved Solids (ppm)	pH	Phosphate (ppm)	Nitrate-Nitrogen (ppm)	Flow Rate (ft/sec)	D.O. Meter (ppm)	D.O. Kit (ppm)	Chlorine (ppm)	Detergents (ppm)	Copper (ppb)	Alkalinity (ppm)	Phenols (ppb)	Hydro-carbons (ppm)	Total Index Value
04/06/2009	9.10		200	525	0.38	55	6.0	80.0	60	7.02	0.00		0.67	8.92				0.027				
03/11/2009	7.70		580	220	2.64	56	6.0	80.0	60	7.11	0.16		0.59	9.09				0.048				
02/11/2009	5.60		80	380	0.21	50	5.5	80.0	60	7.08	0.08		0.32	9.16				0.026				
01/14/2009	8.30		190	705	0.27	41	7.5	90.0	60	6.77	0.14		0.50	11.55				0.018				
12/09/2008	5.50		140	120	1.17	44	17.7	80.0	50	6.99	0.14		0.01	7.92				0.000				
11/05/2008	9.40		500	420	1.19	54	6.0	70.0	50	7.23	0.24		0.08	5.10				0.003				
10/15/2008	5.60		720	448	1.61	64	2.8	70.0	50	7.82	0.18		0.48	4.60				0.014				
09/25/2008	7.30		775		?	59	7.0	80.0	50	7.05	0.13		0.18	5.37				0.013				
09/23/2008	7.90		1340		?	64	7.3	80.0	50	6.92	0.05		0.19	5.02				0.021				
09/18/2008	7.60		1700		?	68	3.2	80.0	50	6.99	0.07		0.63	5.38				0.019				
09/09/2008	15.40		2200	2800	0.79	72	3.0	80.0	60	6.78	0.20		0.37	4.95			0.0	0.015				
08/12/2008	11.60		260	370	0.70	68	2.7	80.0	50	6.94	0.05		0.00	4.40			0.0	0.036				
07/29/2008	12.40		605	655	0.92	73	2.7	80.0	50	6.91	0.17		0.00	1.98			0.0	0.057				
07/08/2008	9.80		1070		?	68	3.0	70.0	40	7.83	0.14			3.06			0.0	0.100				
06/17/2008	10.60		1180	480	2.46	73	3.5	80.0	50	7.03	0.10		0.36	3.18			0.0	0.005				
06/04/2008	11.00		1070	1900	0.56	70	6.0	90.0	60	6.97	0.20		0.40	2.83			0.0	0.020				
04/24/2008	6.10		50	260	0.19	63		90.0	60	6.51	0.26			6.89			0.0	0.000				
04/02/2008			1185		?	57		80.0	50					8.96				0.000				
12/11/2007	6.60		180	190	0.95	63	14.5	80.0	50	6.06	0.56			4.87				0.000				

Date 1/22/2010

11/27/2007	8.70	50	500	0.10	50	9.0	70.0	50	6.73	0.08	0.97	7.35			0.000					
10/16/2007	5.30	440	210	2.10	63	2.5	70.0	50	7.37	0.12	0.00	5.94			0.000					
09/11/2007	7.80	90	170	0.53	72	3.0	70.0	50	7.42	0.10	0.60	5.85			0.000					
08/21/2007	20.00	120	70	1.71	84	2.0	110.0	70	6.88	0.09	0.05	4.40			0.000					
04/14/2004	10.80	17200	140	122.86	54	11.0			6.42		0.67	8.30			0.000					10
05/12/2004	11.50	14900	2230	6.68					6.33	0.16					0.000					0
05/26/2004	11.00	13600	380	35.79	72	6.6	77.0		6.43	0.00	0.39	6.65			0.000					10
06/09/2004					70	6.0	66.0				0.48	6.85			0.000					
07/06/2004	14.90	80000	1070	74.77	75	7.0	75.0		6.58	0.10	0.47	6.51			0.102					
07/28/2004	28.50	15000	2060	7.28	79	10.0	59.0		6.88	0.06	0.95	7.10			0.093					
08/31/2004	46.10	27000	1120	24.11	75	8.0	61.0	40	6.99	0.06	0.44	6.96			0.082					
10/05/2004		7000	720	9.72	63	9.0	82.0	60			1.10	8.29			0.000					
10/27/2004	5.92	9400	380	24.74	66	9.0	80.0	50	6.81		0.50	7.26	0.00	0.0	0.101					
11/09/2004	11.60	9100	640	14.22		5.0	79.0	50		0.15	0.86				0.000					
11/30/2004	8.51	2700	180	15.00	52		77.0	50		0.14					0.189					
12/08/2004	15.20	2500	200	12.50	57	7.0	74.0	50	6.84	0.04	0.27	9.89			0.112					
01/11/2005	8.81	2200	200	11.00	55	5.0	72.0	50	6.23	0.08		10.59			0.000					12
01/26/2005		1700	210	8.10	54		67.0	40				6.67			0.000					13
02/02/2005	49.70	8700		?	55	6.0	55.0	40	6.67	0.20					0.000					
03/07/2005	6.92	700	60	11.67	59	9.0	62.0	40	6.66	0.20		6.90			0.115	0.00	0	0		
03/09/2005	13.30	520	100	5.20	46	18.0	70.0	50	6.61	0.13		10.90			0.000					0
04/25/2005	7.20	520	100	5.20	12	7.0	76.0	50		0.02					0.096					11

Summary Report - Details by Segment

06/09/2005	13.90	8500		?	61	16.0	0.0	0	6.50	0.00	0.00	0.00	0.00	8.5	0.00	0.0	0.000	0.00	0	0	9
06/29/2005	1.50				72	9.0	0.0	30	7.00	0.00	0.00	0.00	6.50	0.0	0.00	0.0	0.000	0.00	0	0	9
07/01/2005	23.70				73	10.0	68.0		6.79			1.50	7.75				0.089				
07/20/2005	10.80	3600	360	10.00	79	12.5	80.0	60	6.67	0.08		0.23	6.63		0.00	0.0	0.000	0.00	0	0	6
08/17/2005	55.90	7900	770	10.26	77	10.0	65.0	40	6.57	0.00			7.33				0.000				12
09/27/2005	12.60	680	480	1.42	22	6.0	80.0	60	7.32	0.03							0.000				11
09/28/2005	14.80	2200	600	3.67	72	6.0	74.0	50	7.98	0.04			4.50				0.059				28
10/05/2005	5.41				73	5.0	79.0	50	6.99	0.03		0.82	5.29				0.000				0
10/19/2005	7.33	4100	320	12.81	68	6.0	70.0	50	6.73	0.01		0.16	6.99				0.100				
11/09/2005		1400	410	3.41	63	8.4	82.0	50		0.24		0.31	6.75				0.000				
12/06/2005	12.30	400	260	1.54	43	9.6	76.0	50	7.24	0.19		0.24	9.93				0.100				
01/25/2006	10.90	100	200	0.50	48	22.8	71.0	50	6.95	0.05		0.44	6.50				0.110				
02/28/2006	6.81	400	2890	0.14	54	31.2	64.0	40	7.11	0.07		0.71	8.06				1.085				
04/25/2006	5.26	1000	720	1.39	64	13.2	78.0	60	6.96	0.06		0.33	7.87				0.114				
05/23/2006	9.00	1600	420	3.81	68	38.4	70.0	40	7.11	0.11		0.22	8.03				0.000				
06/28/2006	9.00	2000	350	5.71	79	21.6	73.0	50	7.07	0.06		0.22	7.37				0.000				
6/2/2009	11.40	8800	24600	0.36	66	5.3	80.0	60	6.57	0.06		0.81	7.07				0.058				
6/23/2009	11.70	280	1500	0.19	74	9.0	80.0	60	6.69	0.06		0.54	5.09				0.006				
7/7/2009	10.25	210	600	0.35	72	4.5	80.0	50	6.61	0.08		0.48	5.08				0.002				
8/4/2009	10.55	210	510	0.41	72	3.0	70.0	50	6.32	0.12		0.20	4.66				0.008				
9/15/2009	8.24	940	600	1.57	70	4.5	80.0	60	6.37	0.11		0.35	4.71				0.002				
11/4/2009	5.20	50	340	0.15	54	9.5	80.0	60	6.12	0.06		0.52	8.38				0.004				

Summary Report - Details by Segment

12/17/2009	8.03	150	40	3.75	44	17.5	80.0	60	5.91	0.11		0.14	10.70				0.011				
1/12/2010	5.47	30	30	1.00	38	15.5	80.0	50	5.72	0.07		0.76	12.46				0.004				
Avg	11.99	4459	1041	8.70	62	9.0	73.5	51	6.83	0.11	0.00	0.43	6.73	4.3	0.00	0.0	0.047	0.00	0	0	9.35714
Min	1.50	30	30	0.10	84	2.0	0.0	0	5.72	0.00	0.00	0.00	0.00	0.0	0.00	0.0	0.000	0.00	0	0	0
Max	55.90	80000	24600	122.86	84	38.4	110.0	70	7.98	0.56	0.00	1.50	12.46	8.5	0.00	0.0	1.085	0.00	0	0	28

Alpharetta - Water Quality Assurance

Engineering and Public Works

Summary Report - Details by Segment

11 **Foe Killer Creek trib in Wills Park off Old Milton Pkwy.** **46 Surveys**

Survey Date	Turbidity (NTU)	P/A Bacteria	Fecal Coliforms Count (cfu/100ml)	Fecal Strep Count (cfu/100ml)	Fecal Strep Ratio	Water Temp (F)	Stream Depth (Inches)	Conductivity (uS/cm)	Dissolved Solids (ppm)	pH	Phosphate (ppm)	Nitrate-Nitrogen (ppm)	Flow Rate (ft/sec)	D.O. Meter (ppm)	D.O. Kit (ppm)	Chlorine (ppm)	Detergents (ppm)	Copper (ppb)	Alkalinity (ppm)	Phenols (ppb)	Hydro-carbons (ppm)	Total Index Value
04/06/2009	10.30		450	175	2.57	54	14.5	120.0	80	6.62	0.06		1.05	7.26				0.020				
03/11/2009	9.70		130	320	0.41	57	9.3	110.0	80	6.67	0.11		0.57	6.10				0.040				
02/11/2009	5.70		975	340	2.87	54	14.0	120.0	80	6.63	0.04		0.22	6.84				0.007				
01/14/2009	6.30		80	60	1.33	48	13.3	140.0	100	6.47	0.16		0.25	8.61				0.041				
12/09/2008	6.40		0	70	0.00	50	11.0	130.0	90	6.56	0.16		0.01	3.19				0.013				
11/05/2008	6.40		410	845	0.49	57	6.3	130.0	90	6.51	0.16		0.00	1.72				0.000				
10/15/2008	11.40		1220	555	2.20	64	10.5	120.0	80	6.48	0.11		0.00	2.03				0.028				
09/23/2008	4.80		625		?	64	9.7	130.0	90	6.39	0.37		0.00	3.42				0.056				
09/18/2008	7.70		11000		?	66	7.8	140.0	90	6.49	0.21		0.00	2.05				0.002				
09/16/2008	10.30					66	7.7	160.0	100	6.45	0.09		0.00	1.55				0.000				
09/09/2008	19.10			4900	0.00	73	6.7	120.0	80	6.38	0.27		0.00	0.80			0.0	0.021				
08/12/2008	3.70		1265	510	2.48	68	7.3	140.0	90	6.52	0.13		0.00	3.60			0.0	0.039				
07/29/2008	5.40		1475	3800	0.39	73	8.0	140.0	90	6.44	0.14		0.00	1.84			0.0	0.030				
06/17/2008	8.20		200	380	0.53	72	11.0	140.0	90	6.67	0.22		0.00	2.41			0.0	0.029				
12/04/2007	5.60		70	140	0.50	46	6.0	140.0	90	6.50	0.22		0.00	4.20				0.000				
11/06/2007	2.90		450	830	0.54	54	4.0	140.0	90	6.70	0.15		0.00	3.88				0.000				
10/09/2007	8.70		490	330	1.48	70	5.0	130.0	90	6.67	0.13		0.00	1.61				0.000				
09/05/2007	4.40		1600	100	16.00	72	4.5	150.0	100	6.70	0.14		0.05	3.33				0.000				
08/14/2007	3.70		230	100	2.30	75	4.0	130.0	90	6.70	0.24		0.00	4.37				0.000				

Date 1/22/2010

04/05/2004	2.93	1500	40	37.50	61	2.0	123.0		7.01	0.13		1.16	10.67				0.000				11
05/12/2004	4.27	15300	360	42.50					6.52	0.08							0.000				3
05/26/2004	11.00	13600	380	35.79	75	6.5	77.0		6.43				6.65				0.000				
07/06/2004	6.06	37000	300	123.33	75	12.0	130.0		6.58	0.10		0.52	7.85				0.062				
10/05/2004		10000	320	31.25	64	6.0	128.0	90				0.40	7.87				0.000				
11/09/2004	4.43	12000	480	25.00	57	2.5	147.0	100		0.15			8.90				0.000				9
01/11/2005	8.18	2100	20	105.00		4.0	122.0	90	6.29	0.07			12.67				0.000				4
02/24/2005	53.40	3500		?	55	6.0	92.0	60	6.62	0.18			5.30				0.000				
03/09/2005	5.77	330	20	16.50	46	6.0	128.0	90	6.64	0.10			8.09				0.000				12
06/29/2005	30.70	600	280	2.14	73	3.0	95.0	70		0.37		0.09					0.000				7
08/17/2005	14.90	5000	610	8.20	77	8.0	117.0	80	6.48	0.00			7.05				0.000				8
09/27/2005	9.80	540	250	2.16	72	9.0	146.0	100	6.82	0.03							0.000				8
10/05/2005	37.20				73	6.0	142.0	100	7.19	0.12		0.28	3.70				0.000				8
11/09/2005		100	30	3.33	64	2.4	704.0	520	7.12	0.04	0.00		12.26	0.0	0.00	0.0	0.000	0.00	0	0	
12/06/2005	7.15	200	40	5.00	45	2.4	152.0	100	7.26	0.15		0.83	8.77				0.000				
02/28/2006	3.28	0	1610	0.00	52	2.4	131.0	90	7.07	0.05		0.45	8.18				0.000				
04/25/2006	4.77	900	110	8.18	66	2.4	136.0	90	7.06	0.12		0.91	8.07				0.000				
05/23/2006	3.00	1100	610	1.80	68	2.4	135.0	90	7.09	0.08		0.33	7.68				0.000				
06/28/2006	8.10	1600	280	5.71	78	2.4	81.0	50	7.14	0.85		0.40	5.90				0.000				
6/2/2009	8.00	260	1180	0.22	68	16.2	130.0	90	6.25	0.13		0.61	4.64				0.050				
6/23/2009	11.65	195	210	0.93	72	9.0	120.0	90	6.28	0.06		0.07	4.33				0.007				
7/7/2009	12.05	2300	1100	2.09	72	13.2	140.0	100	6.24	0.15		0.01	1.60				0.003				

Summary Report - Details by Segment

8/4/2009	8.10	505	370	1.36	72	11.5	140.0	100	5.77	0.10		0.01	1.66				0.004				
9/15/2009	85.10	2200	10400	0.21	75	16.0	130.0	90	6.44	1.09		0.06	4.39				0.066				
11/4/2009	7.80	50	60	0.83	61	19.0	110.0	80	5.99	0.05		0.01	6.12				0.003				
12/17/2009	4.68	10	0	?	53	20.0	110.0	80	5.92	0.04		0.42	8.12				0.016				
1/12/2010	4.00	10	0	?	49	17.5	120.0	90	5.66	0.07		0.27	8.66				0.012				
Avg	11.30	3060	793	12.64	64	8.2	140.4	98	6.57	0.17	0.00	0.24	5.53	0.0	0.00	0.0	0.012	0.00	0	0	7.77777
Min	2.90	0	0	0.00	78	2.0	77.0	50	5.66	0.00	0.00	0.00	0.80	0.0	0.00	0.0	0.000	0.00	0	0	3
Max	85.10	37000	10400	123.33	78	20.0	704.0	520	7.26	1.09	0.00	1.16	12.67	0.0	0.00	0.0	0.066	0.00	0	0	12

Summary Report - Details by Segment

11.e **21 Surveys**

Survey Date	Turbidity (NTU)	P/A Bacteria	Fecal Coliforms Count (cfu/100ml)	Fecal Strep Count (cfu/100ml)	Fecal Strep Ratio	Water Temp (F)	Stream Depth (Inches)	Conductivity (uS/cm)	Dissolved Solids (ppm)	pH	Phosphate (ppm)	Nitrate-Nitrogen (ppm)	Flow Rate (ft/sec)	D.O. Meter (ppm)	D.O. Kit (ppm)	Chlorine (ppm)	Detergents (ppm)	Copper (ppb)	Alkalinity (ppm)	Phenols (ppb)	Hydro-carbons (ppm)	Total Index Value
04/07/2009	6.10		48	167	0.29	47	7.5	120.0	90	7.01	0.08		1.27	10.33				0.011				
03/11/2009	7.00		160	70	2.29	61	7.0	120.0	90	7.07	0.16		0.86	8.51				0.034				
02/11/2009	4.60		470	100	4.70	54	7.5	130.0	100	7.04	0.19		0.41	9.11				0.006				
01/14/2009	7.20		160	367	0.44	41	7.0	150.0	100	6.80	0.12		0.30	11.90				0.028				
12/09/2008	6.30		80	170	0.47	46	4.8	150.0	110	7.05	0.19		0.56	8.14				0.000				
11/05/2008	3.10		0	40	0.00	55	2.8	190.0	130	7.05	0.12		0.75	6.30				0.000				
10/15/2008	5.90		240	180	1.33	68	2.3	180.0	130	6.95	0.11		0.50	5.89				0.015				
09/23/2008	3.40		50		?	66	0.5	200.0	140	7.02	0.12		0.50	6.21				0.006				
09/18/2008	8.20		130		?	72	3.2	210.0	140	7.20	0.08		0.40	7.76				0.004				
09/16/2008	5.70					70	1.0	220.0	150	6.92	0.10		1.00	6.25				0.013				
09/09/2008	8.60		2500	490	5.10	75	8.6	170.0	110	6.88	0.19		0.52	4.79			0.0	0.033				
08/12/2008	4.60		90	400	0.23	75	2.0	190.0	130	7.20	0.13		0.02	7.94			0.0	0.037				
07/29/2008	4.60		390	202	1.93	73	3.0	170.0	110	7.44	0.07		0.00	1.74			0.0	0.042				
06/17/2008	16.40		270	320	0.84	81	3.0	180.0	120	7.50	0.13		0.90	3.28			0.0	0.049				
06/04/2008	4.90		200	3150	0.06	75	3.0	160.0	100	7.41	0.12		0.59	3.18			0.0	0.036				
04/30/2008	4.30		210	110	1.91	68		130.0	90	6.98	0.18			3.98			0.0	0.019				
12/04/2007	40.90		180	130	1.38	41	8.5	140.0	90	7.26	0.20		0.00	8.82				0.000				
11/06/2007	2.70		120	110	1.09	55	7.0	190.0	120	7.36	0.09		0.00	7.27				0.000				
10/09/2007	3.30		100	100	1.00	73	2.5	180.0	120	7.17	0.22		0.02	5.90				0.000				

Summary Report - Details by Segment

09/05/2007	3.40	500	200	2.50	73	4.0	190.0	120	7.60	0.44	0.32				0.000
08/14/2007	14.20	1490	4400	0.34	95	2.5	190.0	130	7.07	0.20	0.00	7.93			0.000
Avg	7.88	369	595	1.44	65	4.4	169.5	115	7.14	0.15	0.45	6.76		0.0	0.016
Min	2.70	0	40	0.00	95	0.5	120.0	90	6.80	0.07	0.00	1.74		0.0	0.000
Max	40.90	2500	4400	5.10	95	8.6	220.0	150	7.60	0.44	1.27	11.90		0.0	0.049

11e **Foe Killer Creek trib 14 out of Wills Park at Wills Rd.** **7 Surveys**

Survey Date	Turbidity (NTU)	P/A Bacteria	Fecal Coliforms Count (cfu/100ml)	Fecal Strep Count (cfu/100ml)	Fecal Strep Ratio	Water Temp (F)	Stream Depth (Inches)	Conductivity (uS/cm)	Dissolved Solids (ppm)	pH	Phosphate (ppm)	Nitrate-Nitrogen (ppm)	Flow Rate (ft/sec)	D.O. Meter (ppm)	D.O. Kit (ppm)	Chlorine (ppm)	Detergents (ppm)	Copper (ppb)	Alkalinity (ppm)	Phenols (ppb)	Hydro-carbons (ppm)	Total Index Value
6/2/2009	4.42		600	1140	0.53	71	6.5	130.0	90	6.88	0.09		0.81	7.37				0.011				
6/23/2009	4.69		340	1130	0.30	75	8.5	150.0	110	7.00	0.08		0.60	6.98				0.011				
7/7/2009	4.46		310	900	0.34	76	4.2	190.0	130	6.92	0.09		0.16	6.70				0.006				
8/4/2009	5.46		1567	693	2.26	78	3.8	170.0	120	6.25	0.10		0.78	5.75				0.001				
9/15/2009	4.54		60	540	0.11	72	8.0	200.0	140	6.46	0.00		0.20	4.77				0.007				
11/4/2009	4.94		160	40	4.00	57	5.5	130.0	90	6.05	0.04		0.23	8.03				0.006				
12/17/2009	5.76		100	50	2.00	46	5.5	130.0	90	5.98	0.11		0.39	10.33				0.008				
Avg	4.90		448	642	1.36	68	6.0	157.1	110	6.51	0.07		0.45	7.13				0.007				
Min	4.42		60	40	0.11	78	3.8	130.0	90	5.98	0.00		0.16	4.77				0.001				
Max	5.76		1567	1140	4.00	78	8.5	200.0	140	7.00	0.11		0.81	10.33				0.011				

Alpharetta - Water Quality Assurance

Engineering and Public Works

Summary Report - Details by Segment

20 **Foe Killer Creek at Rock Mill Way, West of GA 400** **66** **Surveys**

Survey Date	Turbidity (NTU)	P/A Bacteria	Fecal Coliforms Count (cfu/100ml)	Fecal Strep Count (cfu/100ml)	Fecal Strep Ratio	Water Temp (F)	Stream Depth (Inches)	Conductivity (uS/cm)	Dissolved Solids (ppm)	pH	Phosphate (ppm)	Nitrate-Nitrogen (ppm)	Flow Rate (ft/sec)	D.O. Meter (ppm)	D.O. Kit (ppm)	Chlorine (ppm)	Detergents (ppm)	Copper (ppb)	Alkalinity (ppm)	Phenols (ppb)	Hydro-carbons (ppm)	Total Index Value
02/11/2009	4.90		2400	1230	1.95	52	12.0	80.0	60	7.62	0.04		0.85	12.00				0.015				
01/22/2009	4.30		320		?	39	11.8	80.0	60	7.62	0.16		0.90	13.30				0.020				
01/14/2009	7.00		11600	3700	3.14	43	14.0	90.0	60	7.22	0.08		1.43	13.20				0.011				
12/16/2008	5.40		2700		?	50	12.0	80.0	60	7.43			0.62	11.06				0.000				
12/09/2008	3.30		10400	7000	1.49	46	11.0	80.0	60	7.38	0.22		0.54	11.77				0.008				
11/05/2008	7.50		600	270	2.22	57	10.0	90.0	60	7.23	0.24		0.32	7.66				0.000				
10/15/2008	3.50		750	225	3.33	66	6.5	80.0	60	7.11	0.26		0.27	6.72				0.000				
09/23/2008	2.50		145		?	66	4.3	110.0	70	7.17	0.27		0.23	6.89				0.021				
09/18/2008	2.80		180		?	70	9.0	90.0	60	7.40	0.22		0.44	7.30				0.000				
09/16/2008	5.40		310		?	70	8.3	100.0	70	7.19	0.31		0.37	6.42				0.010				
09/09/2008	5.50		720	1135	0.63	73	8.7	90.0	60	7.39	0.11		0.52	7.12			0.0	0.001				
08/20/2008	2.90		80	170	0.47	72	6.5	110.0	70	6.85	0.39		0.01	4.62	0.2		0.0	0.035				
07/29/2008	3.00		10	160	0.06	77	8.0	90.0	60	7.25	0.25		0.34	2.58			0.0	0.033				
06/17/2008	4.30		20	200	0.10	75	7.0	90.0	60	7.49	0.15			3.52			0.0	0.040				
06/04/2008	5.20		180	230	0.78	72	10.0	100.0	60	7.38	0.22		0.82	2.95			0.0	0.031				
04/30/2008	4.80		300	1000	0.30	61		80.0	50	7.16	0.18			3.20			0.0	0.000				
04/02/2008			33500		?	59		80.0	50					9.59				0.000				
12/04/2007	5.70		3050	1050	2.90	43	6.0	80.0	50	6.96	0.16		1.89	10.45				0.000				
11/05/2007	2.10		3500	1300	2.69	54	4.0	110.0	70	7.14	0.25		2.20	7.12				0.000				

Date 1/22/2010

Summary Report - Details by Segment

10/09/2007	1.90	100	20	5.00	72	5.0	120.0	80	7.07	0.65	1.90	4.27	0.000		
09/05/2007	2.50	2020	210	9.62	72	5.0	100.0	60	7.33	0.33	10.42	6.55	0.000		
07/31/2007	3.00	1700	50	34.00	77	3.0	80.0	50	7.52	0.07	1.05	6.25	0.000		
04/05/2004	3.17	600	40	15.00	63		68.0		7.28	0.06	1.12	11.92	0.000		4
05/12/2004	5.70	830	240	3.46					7.01	0.03			0.000		3
05/26/2004	5.59	11900	180	66.11	73	4.0	77.0		7.02		1.35	8.40	0.000		13
06/09/2004						4.0	72.0		6.87		8.00		0.000		
07/01/2004	23.70				73	6.0			6.99		2.90	8.14	0.089		
07/06/2004	13.30	182000	880	206.82	77	12.0	64.0		7.05	0.05	1.38	7.85	0.000		
07/20/2004					75		66.0					8.15	0.000		
07/28/2004	27.20	180000	1640	109.76	75	6.0	55.0			0.04	2.58	7.91	0.021		
08/31/2004	14.70	13000	460	28.26	75	8.0	61.0	90	7.39	0.07	0.44	7.92	0.002		
10/05/2004		0	0	?									0.000		
10/05/2004		11000	480	22.92	64	8.0	71.0	50			1.01	9.45	0.000		0
10/27/2004	3.43	4100	230	17.83	64	10.0	152.0	100	7.22		0.64	7.39	0.000		14
11/09/2004	4.52	3500	420	8.33	57	9.0	79.0	50		0.14	0.75		0.000		10
11/30/2004	7.22	3700	120	30.83	52	6.0	76.0	50		0.25			0.000		6
12/08/2004	12.30	3000	460	6.52	59	6.0	72.0	40		0.12	1.92		0.000		
01/11/2005	6.62	2000	80	25.00		8.0	72.0	50	6.95	0.03		10.20	0.000		6
01/26/2005	5.92	800	20	40.00	54		67.0	40		0.10		7.78	0.100		0
02/24/2005	48.80	5400		?	57	9.0	53.0	30	6.70	0.00			0.000		
03/07/2005	4.22	700	40	17.50	59		70.0	40	6.99	0.07		8.78	0.266		8

Summary Report - Details by Segment

03/09/2005	12.30	930	120	7.75	46	13.0	68.0	50	6.78	0.08			8.87				0.000				20
03/30/2005	15.00	3600	30	120.00	59	9.0	61.0	40		0.20			6.82				0.185				18
04/25/2005	5.77	810	120	6.75	54	9.0	70.0	50	6.88	0.12					0.06		0.256				8
06/09/2005	46.60	7800	220	35.45			160.0		6.59	2.53		0.62	6.71				0.000				
06/29/2005	10.70	600	160	3.75	75	8.0	73.0	50		0.06		0.48					0.000				11
07/01/2005	23.90				73	18.0	93.0		6.42				6.53				0.600				3
07/20/2005	10.90	4000	650	6.15	79	10.0	69.0	50	6.87	0.08		0.93	8.58				0.587				
08/17/2005	30.80		1350	0.00	79	8.0	58.0	40	6.68	0.00			7.84				0.000				10
09/27/2005	13.10	370	130	2.85	72	6.0	84.0	60	6.92	0.01							0.000				10
09/28/2005	16.02	13900	960	14.48	72	7.8	64.0	50	6.65	0.07		0.44	5.70				0.015				
10/05/2005	6.75				75	6.0	88.0	60	6.78	0.07		1.25	7.67				0.000				9
10/19/2005	3.64	1600	80	20.00	70	9.6	85.0	50	7.01	0.25		0.19	8.09				0.000				
11/09/2005		100	110	0.91	64	8.0	85.0	60	7.17	0.16	0.00	0.83	8.53	0.0	0.00	0.0	0.000	0.00	0	0	
12/06/2005	13.00	500	280	1.79	41	19.2	75.0	50	7.22	0.13		0.42	10.91				0.100				
01/25/2006	11.70	0	370	0.00	48	20.4	75.0	50	6.96	0.03		0.79	6.63				0.120				
02/28/2006	6.82	200	1200	0.17	50	20.8	69.0	40	7.12	0.07		1.04	7.83				0.250				
04/25/2006	5.52	0	160	0.00	64	8.4	77.0	50	7.08	0.09		1.18	7.81				0.217				
05/23/2006	4.20	1900	1270	1.50	66	13.2	79.0	50	7.11	0.06		0.97	9.68				0.000				
06/20/2006	3.60	1800	410	4.39	77	6.0	85.0	50	7.11	2.37		1.01	7.60				0.000				
7/7/2009	3.20	280	290	0.97	75	9.8	90.0	70	6.90	0.16		0.34	6.09				0.007				2
8/4/2009	3.88	195	180	1.08	75	9.2	70.0	50	6.44	0.14		0.43	6.67				0.002				
9/15/2009	3.14	500	310	1.61	71	12.0	90.0	60	6.61	0.12		0.40	6.54				0.005				

Summary Report - Details by Segment

11/4/2009	4.14	2800	410	6.83	55	13.0	80.0	60	6.23	0.03		1.28	10.12				0.000				
12/17/2009	7.93	3700	1505	2.46	44	17.5	80.0	60	6.26	0.06		1.09	12.47				0.010				
1/12/2010	3.92	1000	600	1.67	38	14.0	80.0	60	6.23	0.06		1.57	13.43				0.014				
Avg	9.01	9062	633	17.12	63	9.4	82.4	56	7.03	0.22	0.00	1.27	8.03	0.1	0.03	0.0	0.047	0.00	0	0	8.15789
Min	1.90	0	0	0.00	79	3.0	53.0	30	6.23	0.00	0.00	0.01	2.58	0.0	0.00	0.0	0.000	0.00	0	0	0
Max	48.80	182000	7000	206.82	79	20.8	160.0	100	7.62	2.53	0.00	10.42	13.43	0.2	0.06	0.0	0.600	0.00	0	0	20

Alpharetta - Water Quality Assurance

Engineering and Public Works

Summary Report - Details by Segment

12 **Foe Killer Creek at Mansell Rd, West of GA 400** **21 Surveys**

Survey Date	Turbidity (NTU)	P/A Bacteria	Fecal Coliforms Count (cfu/100ml)	Fecal Strep Count (cfu/100ml)	Fecal Strep Ratio	Water Temp (F)	Stream Depth (Inches)	Conductivity (uS/cm)	Dissolved Solids (ppm)	pH	Phosphate (ppm)	Nitrate-Nitrogen (ppm)	Flow Rate (ft/sec)	D.O. Meter (ppm)	D.O. Kit (ppm)	Chlorine (ppm)	Detergents (ppm)	Copper (ppb)	Alkalinity (ppm)	Phenols (ppb)	Hydro-carbons (ppm)	Total Index Value
04/07/2009	5.30		2500	2700	0.93	49	12.7	80.0	60	7.31	0.07		1.12	10.89				0.023				
03/11/2009	5.30		1655	590	2.81	62	10.7	70.0	50	7.71	0.23		1.05	9.69				0.000				
06/19/2008	4.10		350	290	1.21	68	5.0	100.0	60	7.28	0.11		0.74	3.53			0.0	0.053				
04/05/2004	3.05		400	40	10.00	61	21.0	73.0		7.32	0.04		0.75	10.90				0.000				0
05/12/2004	5.32		480	200	2.40					6.79	0.03							0.000				
07/06/2004	12.20		92000	970	94.85	77	20.0	65.0		6.83	0.03		0.18	7.64				0.072				
10/05/2004			6000	360	16.67	63	15.0	74.0	50				0.29	8.49				0.000				10
01/11/2005	8.02		2100	50	42.00		13.0	73.0	50	6.81	0.05			9.27				0.000				5
02/24/2005	6.40		90	40	2.25	41	9.0	32.0	40	6.73	0.00		1.31	9.20				0.000				
03/09/2005	12.70		450	40	11.25	8	18.0	60.0	40	6.73	0.08			7.93				0.000				7
06/29/2005	10.90		6000	450	13.33	79	22.0	43.0	40	6.38	0.07		0.42	6.68		0.00	0.0	0.000	0.00	0	0	
11/09/2005			200	40	5.00	64	9.7	86.0	60	7.00	0.15	0.00	0.61	9.25		0.00	0.0	0.000	0.00	0	0	
12/06/2005	13.10		200	300	0.67	41	22.8	74.0	50	7.25	0.13		0.32	10.38				0.000				
6/2/2009	5.44		5400	1415	3.82	71	6.0	80.0	60	6.85	0.19		0.87	7.57				0.043				
6/23/2009	4.98		370	420	0.88	75	9.0	80.0	60	6.90	0.12		0.71	6.65				0.008				
7/7/2009	2.80		480	390	1.23	74	7.8	90.0	60	6.83	0.13		0.48	6.41				0.006				
8/4/2009	3.74		190	270	0.70	75	8.5	70.0	50	6.25	0.16		0.74	6.70				0.002				
10/21/2009	6.26		2600	500	5.20	53	25.0	70.0	50	6.80	1.04		0.35	9.97				0.021				
11/4/2009	4.44		1700	290	5.86	56	23.0	80.0	50	6.29	0.02		0.66	9.28				0.000				

Date 1/22/2010

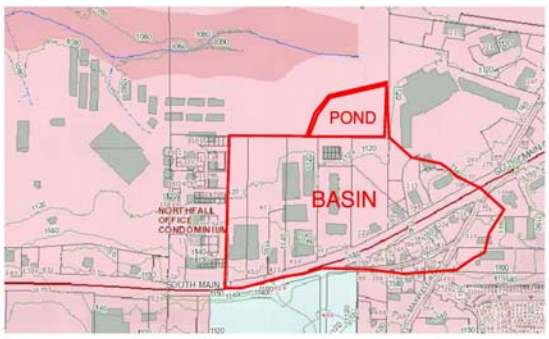
Summary Report - Details by Segment

12/17/2009	8.94	3750	815	4.60	45	18.0	80.0	50	6.32	0.10		0.94	12.07			0.016				
1/12/2010	4.00	1115	460	2.42	38	19.0	80.0	60	6.28	0.09		1.01	12.68			0.015				
Avg	6.68	6097	506	10.86	58	14.8	73.0	52	6.83	0.14	0.00	0.70	8.76	0.00	0.0	0.012	0.00	0	0	5.5
Min	2.80	90	40	0.67	79	5.0	32.0	40	6.25	0.00	0.00	0.18	3.53	0.00	0.0	0.000	0.00	0	0	0
Max	13.10	92000	2700	94.85	79	25.0	100.0	60	7.71	1.04	0.00	1.31	12.68	0.00	0.0	0.072	0.00	0	0	10

Wills Park - Detention Pond Project

The southeast corner of the Wills Park parcel is the low point for a drainage basin consisting of commercial properties located along South Main Street, Maxwell Road and Brady Place. Many of the structures and sites in the basin were apparently constructed in the late 1960s to early 1970s, prior to development of ordinances that required stormwater detention. Some of the commercial sites include detention structures, and others do not. The City of Alpharetta plans to construct a Stormwater Detention and Water Quality Pond in the park, immediately west of Alpharetta Square Shopping Center. Construction of the pond to capture runoff from the predominantly commercial area, as well as the impervious surfaces from Main Street, Maxwell Road, and Brady Place, would result in stormwater flowrate reduction and water quality enhancement for the basin.

The City of Alpharetta will task its design-build contractor to provide services necessary to design and construct the detention pond including the following:



Conceptual Design:

- Provide conceptual site, grading, details and design calculations for the detention ponds. Build up modeling for detention ponds routing and drainage study.
- submit to the City of Alpharetta for review. Develop accurate cost estimates for detention ponds construction.
- Review and select a final design with the City of Alpharetta Water Resources Department.

Detailed Design:

- Detailed design of the detention ponds option from the Conceptual Design Phase. Review submittal at 60% and 100% design will be provided.
- Review meetings with the City of Alpharetta Water Resources Department to discuss various design requirements of the project.
- Provide additional engineering such as relocating any utilities if necessary.
- Coordinate and complete all permitting activities.

Technical Review During Construction:

- Direct review and coordination of all technical reviews and submittals.
- Ensure compliance with contract documents, final design requirements and required permitting.
- Provide monitoring associated with the storm water pollution prevention plan.
- Four site visits by the design engineer will be provided as needed.
- Attend monthly project meeting.
- Prepare as-built drawings.
- Final project walk through.

Construction Management:

- Act as The City of Alpharetta owner representative for the construction activities.
- Ensure compliance with jurisdiction requirements and overall QA/QC.
- Overall cost and schedule monitoring and control for the City of Alpharetta.

Detention Pond Benefit Projection:

Wills Park	Flow Rate
Existing Total 100 yr Peakflow (cfs)	233
Post Pond Total 100 yr Peakflow (cfs)	108
Runoff Decrease (cfs)	125
Runoff Decrease Percentage	54%

City of Alpharetta Department of Environment / Public Works

Scope of Services:

Detailed Design
Construction Management
Field Inspection
Overall QA/QC
Technical Review

Client Contact:

Jill Bazinet
2 S Main Street
Alpharetta, Georgia 30009
Office: 678-297-6200

Projected Cost:

$165,000

Projected Project Duration:

5 months

Wills Park - Detention Pond Project

The southeast corner of the Wills Park parcel is the low point for a drainage basin consisting of commercial properties located along South Main Street, Maxwell Road and Brady Place. Many of the structures and sites in the basin were apparently constructed in the late 1960s to early 1970s, prior to development of ordinances that required stormwater detention. Some of the commercial sites include detention structures, and others do not. The City of Alpharetta plans to construct a Stormwater Detention and Water Quality Pond in the park, immediately west of Alpharetta Square Shopping Center. Construction of the pond to capture runoff from the predominantly commercial area, as well as the impervious surfaces from Main Street, Maxwell Road, and Brady Place, would result in stormwater flowrate reduction and water quality enhancement for the basin.

The City of Alpharetta will task its design-build contractor to provide services necessary to design and construct the detention pond including the following:

Conceptual Design:

- Provide conceptual site, grading, details and design calculations for the detention ponds. Build up modeling for detention ponds routing and drainage study.
- submit to the City of Alpharetta for review. Develop accurate cost estimates for detention ponds construction.
- Review and select a final design with the City of Alpharetta Water Resources Department.

Detailed Design:

- Detailed design of the detention ponds option from the Conceptual Design Phase. Review submittal at 60% and 100% design will be provided.
- Review meetings with the City of Alpharetta Water Resources Department to discuss various design requirements of the project.
- Provide additional engineering such as relocating any utilities if necessary.
- Coordinate and complete all permitting activities.

Technical Review During Construction:

- Direct review and coordination of all technical reviews and submittals.
- Ensure compliance with contract documents, final design requirements and required permitting.
- Provide monitoring associated with the storm water pollution prevention plan.
- Four site visits by the design engineer will be provided as needed.
- Attend monthly project meeting.
- Prepare as-built drawings.
- Final project walk through.

Construction Management:

- Act as The City of Alpharetta owner representative for the construction activities.
- Ensure compliance with jurisdiction requirements and overall QA/QC.
- Overall cost and schedule monitoring and control for the City of Alpharetta.

City of Alpharetta
Department of Environment / Public Works

Scope of Services:

Detailed Design
Construction Management
Field Inspection
Overall QA/QC
Technical Review

Client Contact:

Jill Bazinet
2 S Main Street
Alpharetta, Georgia 30009
Office: 678-297-6200

Projected Cost:

$165,000

Projected Project Duration:

1 Year

Wills Park - Bioretention Area Project

The City of Alpharetta will task its design build contractor with providing Design Engineering and Construction Management for the design and construction of two bioretention projects within the City of Alpharetta Wills Park. The design and construction of the bioretention areas are designed to disconnect impervious areas and detain first flush stormwater runoff velocity and volume to improve water quality.

Services provided to facilitate the design and construction of the pocket wetlands are as follows:

Conceptual Design:

- Provide conceptual site, elevation layouts, details and design calculations for the bioretention areas and submit to the City of Alpharetta for review.
- Develop cost estimates for three bioretention areas.
- Review and select a final layout with the City of Alpharetta Engineering / Public Works and Recreation & Parks Departments.

Detailed Design:

- Detailed design of the bioretention area option from the Conceptual Design Phase. Review submittal at 60% and 100% design will be provided.
- Review meetings with the City of Alpharetta Engineering / Public Works and Recreation & Parks Departments to discuss various design requirements of the project.
- Provide additional engineering to relocate any utilities if necessary.

Technical Review During Construction:

- Direct review and coordination of all technical reviews and submittals.
- Four site visits by the design engineer will be provided as needed.
- Attend monthly project meeting.
- Prepare as-built drawings.
- Final project walk through.

Public Education Signage:

- Provide education signage to demonstrate the processes to build rain gardens for home owners.
- Provide home owner education workshops to instruct home owners' construction of rain gardens at homes.

City of Alpharetta Engineering / Public Works

Scope of Services:

Detailed Design
Construction Management
Field Inspection
Overall QA/QC
Technical Review

Client Contact:

Jill Bazinet P.E.
1790 Hembree Road
Alpharetta, Georgia 30009
Office: 678.297.6200

Projected Cost:

$7 per cubic foot of water storage
Or $200,000

Projected Project Duration:

1 year

Wills Park - Stormwater Structure Retrofit Projects

The equestrian center at Wills Park and other locations within the park have several aging stormwater structures that could be retrofitted to include water quality detention. The equestrian center is a unique amenity the City of Alpharetta offers its citizens. The park features areas for training horses of every kind. The park also features an area to host horse shows and other equestrian competitions. Several horse stalls are also available for park quests attending events at the equestrian center. Park guests are strongly encouraged to clean up after their horses and prevent water pollution. The park could install several stormwater features to reduce the contribution of stromwater from the equestrian center and improve water quality.

Concrete control structures with weirs that allow for water quality detention could be installed near the horse stalls and near the athletic field parking area. Other stormwater structures in the horse stall area could be retrofitted with sand filters and infiltration trenches before the structure to infiltrate stormwater and improve water quality.

City of Alpharetta Engineering / Public Works

Scope of Services:

Detailed Design
Construction Management
Field Inspection
Overall QA/QC
Technical Review

Client Contact:

Jill Bazinet P.E.
1790 Hembree Road
Alpharetta, Georgia 30009
Office: 678.297.6200

Projected Cost:

Varies

Projected Project Duration:

Varies

Wills Park - Pervious Pavement Project

The City of Alpharetta will task its design build contractor with providing Design Engineering and Construction Management for the design and construction of pervious pavement parking areas at the existing parking lots within the City of Alpharetta Wills Park. The design and construction of the pervious pavement areas are designed to remove impervious surfaces and replace them with pervious pavement to reduce stormwater runoff and detain first flush stormwater runoff velocity and volume to improve water quality.
Services provided to facilitate the design and construction of the pervious pavement parking areas are as follows:

Conceptual Design:

- Provide conceptual site, elevation layouts, details and design calculations for the pervious pavement areas and submit to the City of Alpharetta for review.
- Develop cost estimates for pervious pavement options.
- Review and select a final layout with the City of Alpharetta Engineering / Public Works and Recreation & Parks Departments.

Detailed Design:

- Detailed design of the pervious pavement option from the Conceptual Design Phase. Review submittal at 60% and 100% design will be provided.
- Review meetings with the City of Alpharetta Engineering / Public Works and Recreation & Parks Departments to discuss various design requirements of the project.
- Provide additional engineering to relocate any utilities if necessary.

Technical Review During Construction:

- Direct review and coordination of all technical reviews and submittals.
- Four site visits by the design engineer will be provided as needed.
- Attend monthly project meeting.
- Prepare as-built drawings.
- Final project walk through.

Public Education Signage:

- Provide education signage to demonstrate the processes of pervious pavement and water quality benefits.
- Provide education workshops to showcase other water quality projects that can be completed by home owners.

City of Alpharetta Engineering / Public Works

Scope of Services:

Detailed Design
Construction Management
Field Inspection
Overall QA/QC
Technical Review

Client Contact:

Jill Bazinet P.E.
1790 Hembree Road
Alpharetta, Georgia 30009
Office: 678.297.6200

Projected Cost:

$3/sq foot
Approximately $150,000 per lot.

Projected Project Duration:

9 months

Rain Barrels

The City of Alpharetta would task with providing and installing rain barrels in community houses as demonstration projects to encourage home owners to install rain barrels at their homes to reduce flooding and provide irrigation water during droughts. This would reduce the first flush from building roofs that contain leaf and other organic debris and will reduce the volume and velocity of water returned to creeks.

Design:
The design of rain barrel is simple. Its basic components are consisted of:

- The barrels, normally made of plastic, and recommended to be at least 55 gallons. Most pre-manufactured barrels average about 60 gallons.
- A sealed top to resist child and to keep potential pests out, but still allow easy access for cleaning. Screens are often included to reduce particulate matters and the potential for mosquitoes at the barrel entrance.
- Connections to the downspout, runoff pipe, and spigot.

Set up:
Rain barrels usually arrive fully assembled for quick setup. Just cut the existing downspout about 46 inches from the ground, and add a 60 degree elbow to the end. Then just situate the rain barrels so water will land anywhere within the recessed top. Water will collect on the top surface and funnel into the barrel through the screened intake opening. The downspout does not need to be placed directly over the screens, or directly into the barrel.

Public Education Signage:
- Provide education signage to demonstrate the processes to set up rain barrels for home owners.
- Provide Home Owner Education Workshops to instruct home owners' to install rain barrels at homes.

City of Alpharetta Engineering / Public Works

Scope of Services:
Detailed Design
Construction Management
Field Inspection
Overall QA/QC
Technical Review

Client Contact:
Jill Bazinet P.E.
1790 Hembree Road
Alpharetta, Georgia 30009
Office: 678.297.6200

Projected Cost:
$100 per unit

Project Duration:
2 hours per unit

Bacteria Source Tracking

The City of Alpharetta will perform bacteria source tracking to determine the fecal coliform source in Big Creek and Foe Killer Creek.

Bacteria Source Tracking (BST) is a new methodology to determine the source of fecal pathogen contamination in environmental samples. BST techniques appear to provide the best method to determine the origins of fecal contamination in water bodies. BST uses DNA sampling of the *E. Coli* bacteria found in the water sample and compares the samples to a DNA library to identify if the *E. Coli* source is human, dog, bird, deer, horse or another wildlife source. Once the source of bacteria is identified specific target BMPs can be used to reduce the amount of fecal contamination in the water body.

Services provided to do Bacteria Source Tracking are as followings:

BST Sampling:
BST sampling is recommended for Big Creek and Foe Killer Creek. The goal of the BST sampling is to identify if the bacteria contamination is human source or animal source. Two samples will be collected from each stream and sent to an accredited laboratory.

Laboratory Analysis:
The laboratory will detect and quantify the fecal *bacteroidetes* human gene biomarker for human fecal contamination. This is determined by quantitative polymerase chain reaction (qPCR) DNA analytical technology. The laboratory results will indicate the Total Fecal *Bacteroidetes* Quantified, and the Human Fecal *Bacteroidetes* Quantified. This will allow the City to determine the percentage of fecal coliform bacteria that can be attributed to human activity.

If the laboratory tests reveal negative results for human fecal bacteria it can be assumed that the contamination source is from animals either wild or domestic such as dogs. Further testing can be performed to identify the source.

Best Management Practice Evaluation:
Based on the results of the BST, the City of Alpharetta can develop the appropriate Best Management Practices identified in the Big Creek Watershed Study to address the source of contamination.

City of Alpharetta Engineering / Public Works

Scope of Services:
Sampling
Analysis
Planning
Field Inspection
Overall QA/QC
Technical Review

Client Contact:
Jill Bazinet P.E.
1790 Hembree Road
Alpharetta, Georgia 30009
Office: 678.297.6200

Projected Cost:
$8,000

Project Duration:
4 weeks

Disconnect Impervious Surface

Impervious areas directly connected to the storm drain system are a great contributor to nonpoint source pollution. Disconnect Impervious Surfaces is a strategy involves managing runoff close to its source by intercepting, infiltrating, filtering, treating or reusing it as it moves from the impervious surface to the drainage system. Disconnection can also reduce the calculated peak discharge rate by increasing the time of concentration. These are natural methods offering greater environmental benefits, more visually attractive, and less expensive methods of stormwater control.

Two kinds of disconnection are:

(1) Simple disconnection, whereby rooftops and/or residential, commercial or industrial impervious surfaces are directed to natural pervious areas. Impervious disconnection spreads runoff from rooftops, parking lots, courtyards, driveways, sidewalks and other impervious surfaces into adjacent natural pervious areas where it is filtered or infiltrated.

(2) Disconnection leading to an alternative runoff reduction practices adjacent to the roof. When to drain to natural systems is not possible, direct flows from impervious areas to bioretention areas, infiltration devices, drainage swales, retention areas, or vegetated buffer.

Parking Lot Disconnection

Curb cuts or ribbon curb may be used to satisfy the impervious disconnection conditions. Parking grades shall be designed such that discharge is evenly distributed and concentrated flow is minimized.

Roadway Disconnection

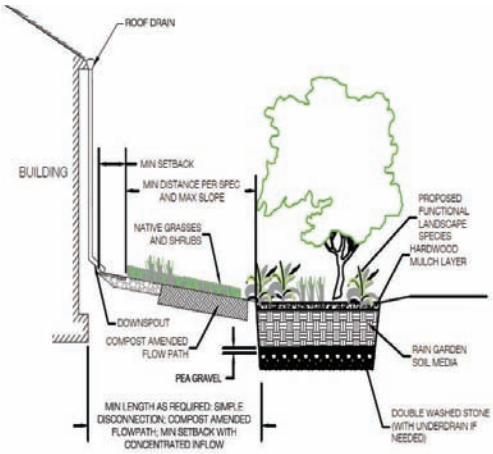
Modify urban sections that utilize swales and/ or rain gardens .

Residential Rooftop or Drive Way Disconnection

Direct runoff from the impervious surfaces to natural or alternative systems.

Commercial / Industrial Disconnection

Routing of rooftop runoff through swales and green spaces.



Services provided to facilitate the design and construction of impervious surface disconnection are as followings:

Conceptual Design:

- Provide conceptual site analysis, preliminary layouts, studies, details and design calculations for each watershed basin and submit to the City of Alpharetta for review.
- Develop cost estimates for each option.
- Review and select a final design for each plan with the City of Alpharetta .
- Coordinate and complete all permitting activities.

City of Alpharetta Engineering / Public Works

Scope of Services:

Detailed Design
Construction Management
Field Inspection
Overall QA/QC
Technical Review

Client Contact:

Jill Bazinet P.E.
1790 Hembree Road
Alpharetta, Georgia 30009
Office: 678.297.6200

Projected Cost:

Varies

Project Duration:

Varies

Detailed Design:

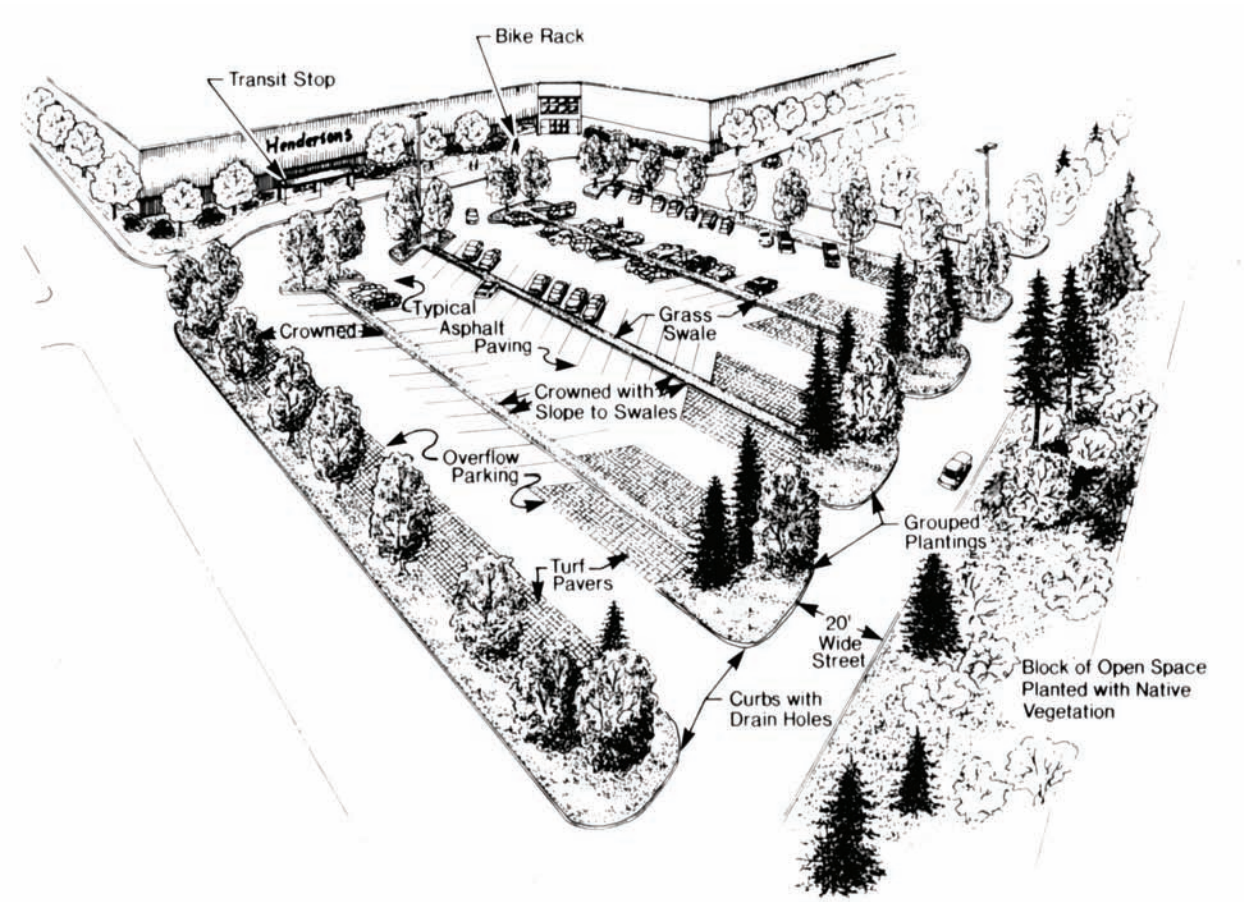
- Detailed design for each option from the Conceptual Design Phase. Review submittal at 60% and 100% design will be provided.
- Review meetings with the City of Alpharetta to discuss various design requirements of the project.
- Provide additional engineering services if necessary.

Technical Review During Construction:

- Direct review and coordination of all technical reviews and submittals.
- Site visits by the design engineer will be provided as needed.
- Attend monthly project meeting.
- Prepare as-built drawings.
- Final project walk through.

Construction Management:

- Act as The City of Alpharetta owner representative for the construction activities.
- Ensure compliance with design requirements and overall QA/QC.
- Overall cost and schedule monitoring and control for the City of Alpharetta. Review of payment requests.



Big Creek at Webb Bridge

The City of Alpharetta will task its design build contractor with providing Design Engineering and Construction Management for the design and construction of streambank restoration of Big Creek between Camp Creek and Webb Bridge Road within the City of Alpharetta. The design and construction of the restoration project is designed to restore streambanks and improve water quality and habitat within Big Creek.
Services provided to facilitate the design and construction of the streambank restoration are as follows:

Conceptual Design:

- Provide conceptual site, elevation layouts, details and design calculations for the restoration and submit to the City of Alpharetta for review.

- Develop cost estimates for the streambank restoration.
- Review and select a final layout with the City of Alpharetta Engineering / Public Works department.

Detailed Design:

- Detailed design of the streambank restoration option from the Conceptual Design Phase. Review submittal at 60% and 100% design will be provided.
- Review meetings with the City of Alpharetta Engineering / Public Works Departments to discuss various design requirements of the project.
- Provide additional engineering to relocate any utilities if necessary.

Technical Review During Construction:

- Direct review and coordination of all technical reviews and submittals.
- Four site visits by the design engineer will be provided as needed.
- Attend monthly project meeting.
- Prepare as-built drawings.
- Final project walk through.

Public Education Signage:

- Provide education signage to demonstrate the processes to improve habitat and water quality.

City of Alpharetta Engineering / Public Works

Scope of Services:

Detailed Design
Construction Management
Field Inspection
Overall QA/QC
Technical Review

Client Contact:

Jill Bazinet P.E.
1790 Hembree Road
Alpharetta, Georgia 30009
Office: 678.297.6200

Projected Cost:

$214,000

Project Duration:

9 months

Big Creek at Haynes Bridge

The City of Alpharetta will task its design build contractor with providing Design Engineering and Construction Management for the design and construction of streambank restoration of Big Creek near Haynes Bridge within the City of Alpharetta. The design and construction of the restoration project is designed to restore streambanks and improve water quality and habitat within Big Creek. Services provided to facilitate the design and construction of the streambank restoration are as follows:

Conceptual Design:

- Provide conceptual site, elevation layouts, details and design calculations for the restoration and submit to the City of Alpharetta for review.
- Develop cost estimates for the streambank restoration.
- Review and select a final layout with the City of Alpharetta Engineering / Public Works department.

Detailed Design:

- Detailed design of the streambank restoration option from the Conceptual Design Phase. Review submittal at 60% and 100% design will be provided.
- Review meetings with the City of Alpharetta Engineering / Public Works Department to discuss various design requirements of the project.
- Provide additional engineering to relocate any utilities if necessary.

Technical Review During Construction:

- Direct review and coordination of all technical reviews and submittals.
- Four site visits by the design engineer will be provided as needed.
- Attend monthly project meeting.
- Prepare as-built drawings.
- Final project walk through.

Public Education Signage:

- Provide education signage to demonstrate the processes to improve habitat and water quality.

City of Alpharetta Engineering / Public Works

Scope of Services:

Detailed Design
Construction Management
Field Inspection
Overall QA/QC
Technical Review

Client Contact:

Jill Bazinet P.E.
1790 Hembree Road
Alpharetta, Georgia 30009
Office: 678.297.6200

Projected Cost:

$200,000

Project Duration:

9 months

Foe Killer Creek - Squirrel Run to Rucker Road

The City of Alpharetta will task its design build contractor with providing Design Engineering and Construction Management for the design and construction of streambank restoration of Foe Killer Creek near Upper Hembree Road within the City of Alpharetta. The design and construction of the restoration project is designed to restore streambanks and improve water quality and habitat within Foe Killer Creek.

Services provided to facilitate the design and construction of the streambank restoration are as follows:

Conceptual Design:

- Provide conceptual site, elevation layouts, details and design calculations for the restoration and submit to the City of Alpharetta for review.
- Develop cost estimates for the streambank restoration.
- Review and select a final layout with the City of Alpharetta Engineering / Public Works department.

Detailed Design:

- Detailed design of the streambank restoration option from the Conceptual Design Phase. Review submittal at 60% and 100% design will be provided.
- Review meetings with the City of Alpharetta Engineering / Public Works Department to discuss various design requirements of the project.
- Provide additional engineering to relocate any utilities if necessary.

Technical Review During Construction:

- Direct review and coordination of all technical reviews and submittals.
- Four site visits by the design engineer will be provided as needed.
- Attend monthly project meeting.
- Prepare as-built drawings.
- Final project walk through.

Public Education Signage:

- Provide education signage to demonstrate the processes to improve habitat and water quality.

City of Alpharetta Engineering / Public Works

Scope of Services:

Detailed Design
Construction Management
Field Inspection
Overall QA/QC
Technical Review

Client Contact:

Jill Bazinet P.E.
1790 Hembree Road
Alpharetta, Georgia 30009
Office: 678.297.6200

Projected Cost:

$129,000

Project Duration:

9 months

Big Creek Overlay District

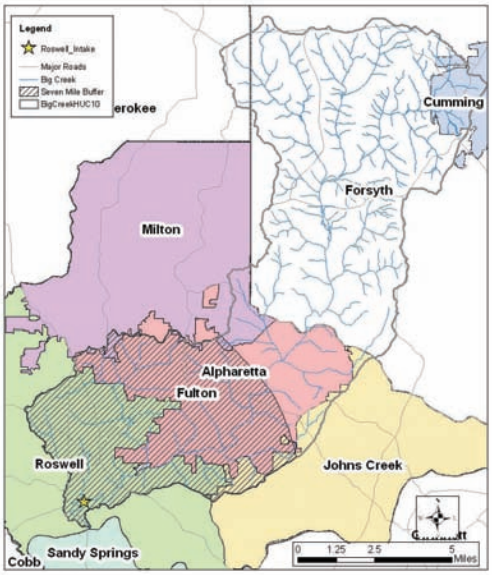
Impervious areas directly connected to the storm drain system are a great contributor to nonpoint source pollution. The Big Creek Overlay District provides regulatory support for incorporating low impact development and green infrastructure to commercial and business areas within the Big Creek Watershed. This strategy involves managing runoff close to its source by intercepting, infiltrating, filtering, treating or reusing it as it moves from the impervious surface to the drainage system. Removing and reducing impervious area can reduce the calculated peak discharge rate by increasing the time of concentration. These are natural methods offering greater environmental benefits, more visually attractive, and less expensive methods of stormwater control.

Purpose of the Overlay District:
The City of Alpharetta and City of Roswell will develop a Big Creek overlay district for the purpose of protecting the City of Roswell drinking water supply Big Creek and reducing the impervious surface area to 25% within the 7-mile radius of the drinking water intake.

Overlay District Area:
The Overlay District will be restricted within the Big Creek Watershed boundaries. This will include areas along tributaries to Big Creek including Foe Killer Creek and Hog Waller Creek.

Overlay District Requirements:
The Overlay District will provide developers guidelines for including low impact development features and green infrastructure within the development plans for new construction and redevelopment projects. These requirements might include the following elements:

- Reduce parking space requirements
- Direct roof downspouts to pervious areas
- Direct parking lot run-off to pervious areas
- Increase tree canopy cover over impervious areas
- Install green roofs
- Install pervious pavement
- Redevelop oversized parking incentives
- Create mini parks (Town Squares) within oversized parking areas



Big Creek 7-Mile Buffer Zone

City of Alpharetta Engineering / Public Works

Scope of Services:
Planning
Research Similar Ordinances
Support Public Meetings

Client Contact:
Jill Bazinet P.E.
1790 Hembree Road
Alpharetta, Georgia 30009
Office: 678.297.6200

Alice Champagne
305 Dobbs Drive
Roswell, Georgia 30075
Office: 770.641.3707

Projected Cost:
Varies

Project Duration:
24 Months

Green Infrastructure Incentives

Low Impact Development (LID) and green infrastructure can be used as a green approach to development and redevelopment. LID sites are designed to model natural systems, manage rainfall at the source using uniformly distributed smaller stormwater management features at the lot level. LID's goal is to mimic a site's predevelopment hydrology as closely as possible. Green infrastructure focuses on the capture, infiltration and reuse of stormwater to maintain or restore the natural hydrology. Providing incentives to implement LID and Green infrastructure could accelerate the use of these watershed management tools within the Cities of Alpharetta and Roswell

Proposed Incentives:

The following is a list of incentives to encourage the use of LID and Green infrastructure in development and redevelopment projects:

- Increased Densities
- Reduced Review Time / Expedited Review
- Property Tax Reduction
- Reduced Stormwater Utility Fee
- Reduced Application Fees
- Public Recognition
- Dedicated Review Team
- Adjustments in Required Parking
- Stormwater Facility Size Reduction
- Street Standard Flexibility
- Building Setback Reduction
- Minimum Lot Size Reduction

Techniques for Implementing LID:

The following is a list of incentives to encourage the use of LID and Green infrastructure in development and redevelopment projects:

- Bioretention Areas
- Tree Retention
- Flow Dispersion
- Stormwater Infiltration
- Alternative Surfacing Methods
- Protected Native Areas
- Reforestation
- Preserve Top Soil During Construction
- Limit Disturbed Areas
- Clustering Development
- Limit Total Imperviousness
- Alternative Conveyance Design
- Vegetated Roofs
- Rainwater Harvesting
- Minimal Excavation
- Shared Driveways
- Reduced Parking

Demonstration Projects:

The Cities should develop demonstration projects on City property to show the LID and green infrastructure techniques to developers and property owners.

City of Alpharetta Engineering / Public Works

Scope of Services:

Planning
Research Similar Ordinances
Support Public Meetings

Client Contact:

Jill Bazinet P.E.
1790 Hembree Road
Alpharetta, Georgia 30009
Office: 678.297.6200

Alice Champagne
305 Dobbs Drive
Roswell, Georgia 30075
Office: 770.641.3707

Projected Cost:

Varies

Project Duration:

24 Months

GUIDELINES FOR

STREAMBANK

RESTORATION

Revised March/2000

Developed by the Georgia Soil and Water Conservation Commission, in cooperation with Metro Atlanta Association of Conservation Districts, USDA Natural Resources Conservation Service and Georgia Environmental Protection Division. The preparation of this publication was financed through a grant from the U.S. Environmental Protection Agency under the provisions of Section 319 (h) of the Federal Pollution Control Act, as amended.

All programs and services of the federal, state and local agencies listed above are available on a nondiscriminatory basis without regard to race, color, national origin, religion, sex, age, marital status, handicap, or disability. If you need this document in an alternative format, please call 706-542-3065.

PREFACE

This booklet has been published by the Georgia Soil and Water Conservation Commission to help owners of streamside property understand how to prevent and, if necessary, correct simple streambank erosion problems. The booklet will describe the interactions of stream flows, streambanks, sediment, and streamside vegetation. An understanding of this information is intended to help a property owner appreciate the need for streambank protection and assist in selecting the most appropriate natural methods for correcting streambank erosion problems. Streambank stabilization techniques utilize live plant materials, structural measures, or a combination of both. The techniques described in this manual are intended for small stream systems with uncomplicated erosion problems.

Cover Photograph by Robbin B. Sotir & Associates.

ACKNOWLEDGEMENTS

The assistance, guidance, secretarial support, and technical consultations of Robbin B. Sotir & Associates and permission to use figures and photographs are gratefully acknowledged by the Soil and Water Conservation Commission. Gratitude is also extended to the following for their review and assistance in preparing this manual: Nelson R. Nunnally, Robbin B. Sotir & Associates, Mike Owsley, USDA Natural Resources Conservation Service; Jim Durrett, Trustee of the Georgia Conservancy; and John Gries, USDA Forest Service. Agency reviews were made by: The Atlanta Regional Commission, Georgia Cooperative Extension Service, Georgia Environmental Protection Division, Georgia Forestry Commission, and USDA Natural Resources Conservation Service.

Quotations and figures from the following publications are also acknowledged: 1) Pennsylvania Department of Environmental Resources Division of Scenic Rivers, "A Streambank Stabilization Manual" (1986); 2) North Carolina Sedimentation Control Commission, "Erosion and Sediment Control Planning and Design Manual" (undated); and 3) USDA Natural Resources Conservation Service, Engineering Field Handbook, Chapter 16, Streambank and Shoreline Protection and Chapter 18, "Soil Bioengineering for Upland Slope Protection and Erosion Reduction" (1992).

Elaine Nash and Ted Mikalsen were responsible for the overall organization and assembling of this manual.

Many people have contributed to the writing and review of this document. We would especially like to thank Donna Black, David Burgdorf, Donald H. Gray, Jim Helm, Sandie Hoover, Marian Hrubovcak, Devony Lehner, Esther Lev, Ed Moorhead, Ann Riley, Pat Stevens, and Virginia Tiernan for their contributions.

F. Graham Liles, Jr.
Executive Director
Georgia Soil and Water Conservation Commission

TABLE OF CONTENTS

BEFORE YOU BEGIN 1

PLANNING AND CARRYING OUT YOUR PROJECT 2

A FEW COMMENTS ABOUT STREAMS 5
- How Streams "Behave" (Stream Dynamics) 5
- Fish and Wildlife Habitat Values of Streams 6
- Stream Vegetation Zones 6

STREAMBANK EROSION PROCESSES AND TYPES 7
- Streambank Erosion Processes 7
- Some Common Types of Streambank and Streambank Erosion and Their Causes 8
  - General bank scour 8
  - Toe erosion and upper bank failure 8
  - Local streambank and streambed scour 8
  - Overbank runoff 10
- Evaluating Streambank Erosion Problems 10

MANAGING STREAMBANKS AGAINST EROSION 12

PROTECTING STREAMBANKS AGAINST EROSION 13
- Approaches to Streambank Protection 13
- Soil Bioengineering Erosion Control 13
  - Woody Vegetation 13
  - Nutrient testing 14
  - Soil samples 14
  - Bank preparation 14
  - Live stake 16
  - Joint planting 19
  - Live fascine 21
  - Brushmattress 27
  - Live cribwall 31
  - Branchpacking 35
  - Maintenance of vegetation protection 39
  - Other Structural Measures 39

GLOSSARY 41

APPENDIX 43

BEFORE YOU BEGIN

This document was created to inform landowners of streambank property how to use ready available native plant materials to restore and repair small streambank erosion problems. These techniques are also useful in the maintenance and enhancement of streambanks, as well as preventing streambank damage. The primary emphasis of this document is on woody vegetative treatments and as such does not cover most conventional structural techniques.

If you are considering a streambank stabilization project, please read this entire booklet before you begin and consider the following general advice. Because a number of technical disciplines are involved in stream work, you may encounter terms with which you are not familiar. These are defined in the glossary of this document.

First, it is important to realize that each stream and stream segment has its own unique qualities. Before you select a streambank stabilization technique, take the time to study and understand the cause of the problem you intend to address. The types and causes of streambank erosion are described in the Streambank Erosion section.

Second, ask for advice. Contract your local Soil and Water Conser-vation District, the Georgia Cooperative Extension Service in your county, or the Natural Resources Conservation Service for more infor-mation about streambank erosion problems, stabilization procedures, and the availability of plant and structure materials. Talk to your neighbors about the erosion conditions. Frequently, it is necessary to assess a long length of stream to fully understand the problem and to develop a lasting solution.

Third, there are many state and local ordinances in addition to federal laws that may apply to your streambank stabilization project. Be sure to check with all appropriate authorities before beginning any land-disturbing activities, particularly those adjacent to or in a stream. A listing of these agencies may be found in the appendix.

Finally, consider that any work you do on a stream may affect people upstream and downstream. Your property is only a small part of the overall steam and watershed system.

If you take the time to carefully plan your project, taking into account the factors that influence the behavior of your stream, you are more likely to be rewarded by a successful solution to your streambank erosion problem.

PLANNING AND CARRYING OUT YOUR PROJECT

Careful thought, planning and execution will be required to assure that your streambank stabilization project is done efficiently and correctly. Some steps in planning and carrying out your project area as follows:

1. Identify the Cause and Nature of the Problem – Identify upstream and watershed activities which may affect stream flow, observe upstream bank conditions, consult with up and downstream neighbors to determine if they too have a problem and if they would like to participate in a repair project. Contact your Natural Resources Conservation Service office and identify the type and severity of your bank erosion problems (see section on Streambank Erosion).

2. Contact Your Local Government – Local ordinances and State laws protect vegetative buffers along streambanks from land-disturbing activities. Before beginning any work, contact your local government regarding erosion and sedimentation to determine necessary procedures for the approval of the project and obtain guidance for protecting the stream during construction.

3. Contact the US Army Corps of Engineers – (1-800-448-2402) Savannah District, Regulatory Branch, P.O. Box 889, Attention SASOP-F, Savannah, Georgia 31402-0889, to determine whether a permit will be needed for your construction activity. In most cases, minor streambank restoration is already covered by a general permit.

4. Evaluate Alternatives and Select Appropriate Streambank Erosion Protection Measure(s) – Selected erosion protection measures which may be applied to specific erosion problems are listed in order of environmental benefits in Table 4. Table 4 also references the page where the measure is described. Table 5 describes the relative cost and complexity of each measure.

5. Determine When You Will Do the Project – Some practices must be installed during the dormant season.

6. Locate Underground Services Which Could be Affected by Construction Activities – Sewer lines, underground utilities, wells, septic tanks and drainfields, etc.

7. Plan or Design Erosion Protection Measures - Using the streambank protection measures (in the following section) that you have selected, design necessary structures, and define specific techniques on a sketch of your stream and streambanks. The sketch should be of sufficient scale and accuracy to allow you to estimate the amount of materials which will be needed for the project. Be sure to include erosion control items such as silt fence and hay bales.

8. List and Acquire Materials and Necessary Tools - Estimate and develop a list of the type and number of tools required (purchase or rental) and the amount of materials necessary to protect the stream and complete the project. Determine the source of tools and materials. In some cases, you may

have to locate and secure permission to harvest suitable plant materials or find a plant nursery which handles appropriate species.

9. Determine Access and Clean-up Cost – Be sure to consider access to the stream for machinery and vehicles onto your property and possibly your neighbors'. Typically, due to various site elements such as existing landscaping, irrigation systems, etc., urban sites have major access considerations. The costs for repairing construction damage also needs to be calculated.

10. Develop a Safety Plan – You may be working with power tools in wooded areas and adjacent to flowing and sometimes, deep water. Have appropriate safety devices such as goggles, leather work gloves and chaps for chain saw use. Consider insect and snake hazards, and avoid deep or stormwater flows.

11. Identify – Estimate the number of people that will be needed to complete the job, the time to complete the job, and assign responsibilities to individuals or teams.

But before you install your project, consider the following tips:

1. Be sure you have contacted the local unit of government for required permits (i.e. public works, engineering or planning and zoning offices). They can direct you to appropriate state and federal agencies if additional authorization is required.
2. Take steps to ensure that soil does not get pushed or washed into the stream during this project. Install and maintain sediment control devices where needed.
3. Start your work at the upstream end and work your way downstream.
4. Do not implement measures that restrict the size of the channel. Practices that restrict channel flow can cause flooding or increased erosion. Never plan to build out into the stream.
5. Do not use materials that may be poisonous to fish and aquatic life such as asphalt or wood treated with creosote.
6. Keep the stream channel and the banks as natural as possible to maintain habitats for fish, aquatic organisms, birds, and other animals.
7. Begin and end all streambank protection projects at stable points along the bank. This may be a point at which the main thrust of the flow is parallel to the bank, or at a stable structure such as a bridge or culvert. This may require cooperative efforts by several landowners.
8. Divert intensive sources of runoff such as gutter downspouts or street drainage away from the area to be treated and be sure to include appropriate drainage facilities for this flow.
9. Make sure you have protected the submerged part of the bank all the way to the channel bottom, and in some cases where undercutting has occurred, below the streambed. As a matter of course, it is better to start stabilization projects below the bed (bottom) of the stream; otherwise, the current may undermine the erosion control measures installed.

10. Be prepared to maintain your project. Inspect the project regularly, particularly after heavy rains and high flows, and make necessary repairs as soon as possible.

11. Reestablish streambank vegetation using native shrubs and trees.

A FEW COMMENTS ABOUT STREAMS

HOW STEAMS "BEHAVE" (Stream Dynamics)

River, stream, creek, brook, tributary, or branch — these words all mean different things to different people. Throughout this publication, the word "stream" means any continuous or intermittent flowing water — regardless of the channel size.

It is the nature of a stream to change its course, constantly shift, and meander. Erosion of streambanks is a natural part of this process by which the steam adjusts to changing conditions within the channel and its watershed. If you try to interfere with this process, you will be in a long-term battle against the natural tendency of the stream to move and change. However, because of man's development, especially in urban areas, this process may be accelerated.

The shape of the stream channel is a result of the flow of the water, the sediment carried, and the composition of the streambed and streambank materials. A stream channel must simultaneously accommodate the flow and carry its sediment load within the streambanks. The stream forms a continuous system of pools, riffles, bars, and curves to absorb the energy of the flow. See Figure 1. The adjustments a stream makes create a balance between the amount of water flowing in the channel, the amount of sediment it is transporting through the channel, and the changing slope and size of the channel. The erosion of channel bends along outside banks is usually offset by deposition along inside banks.

Streams are rarely perfectly straight. What appears to be a "straight" stream is in reality made up of small curves not easily recognized. Flowing water has a natural tendency to meander from one side to of a channel to the other, and soil, sand, and gravel are washed away from the areas where the current is fastest and deposited where the water moves more slowly.

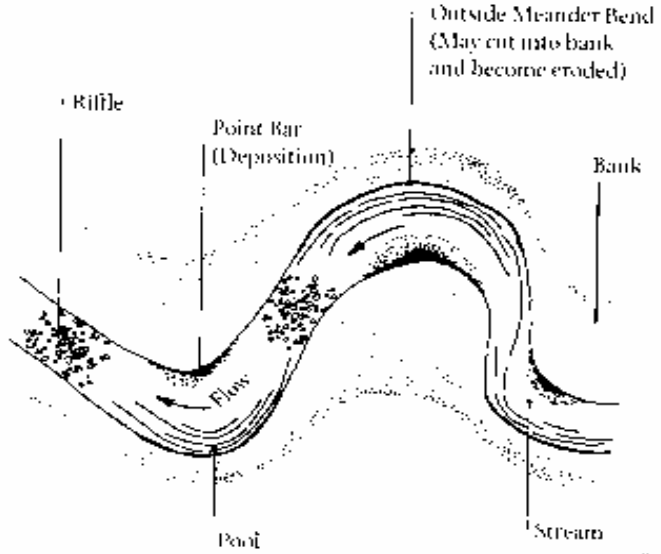


Figure 1 Illustration of streambank erosion and deposition.

Ralstin & Sotir & Associates

Changes in stream flow, sediment load, and erosion or deposition on the streambanks will cause the stream to seek a new balance. Increasing

paved areas or removing vegetative ground cover in the watershed will reduce the infiltration of rainfall and cause more runoff from the land. This leads to higher stream flows with an increased capacity to scour streambeds and undercut streambanks. Soil erosion from adjacent lands will cause increased sediment build up if the stream flow is insufficient to carry the load of soil (sediment) along the stream.

For those of you who live in urban or suburban areas, it is likely that your stream channel has or is in the process of adjusting to increased runoff by eroding deeper and/or wider. Many urban streams which have eroded their banks so that the channel can carry greater flows will have lost the streamside vegetation that helps control bank erosion.

Fish and Wildlife Habitat Values of Streams

A healthy aquatic population in a stream depends on maintaining a variety of suitable habitats, adequate food supply, and clean water. Fish and the aquatic organisms on which they feed require a mixture of habitats such as fast-flowing riffles, deep pools cool water, rocks, snags, and overhanging vegetation. Streamside vegetation is important to wildlife because it provides a food supply, shade to cool the water, and cover for roosting, resting, nesting, and protection.

Stream Vegetation Zones

Different natural vegetation zones adjacent to the stream should be considered when selecting an appropriate streambank stabilization technique. The typical natural zones of a stable streambank community are shown in Figure 2. These vegetation zones are distinguished by site conditions such as shape, steepness, soil make-up of the bank, variations in stream water depth, duration of flow, bank seepage, and flow rate.

Figure 2 Photograph of the vegetated zones in a healthy diverse riverine system.

STREAMBANK EROSION PROCESSES AND TYPES

This section describes streambank erosion processes, common types and causes of erosion and guidelines for evaluating streambank and streambed erosion problems.

Streambank Erosion Processes

Streambank erosion is a natural process that occurs when the forces of flowing water exceed the ability of the soil and vegetation to hold the banks in place. Natural rates of streambank erosion vary with stream size, the amount of vegetative cover, and the type of soil in the streambank. Under well-vegetated conditions, the smallest streams (those without any tributaries) may show little evidence of erosion over periods of several decades unless subjected to extreme flood events. Large streams, on the other hand, often show evidence of noticeable erosion, especially on outside bends. The forces that cause erosion increase during flood events, and most erosion occurs at these times. Human disturbances to watersheds that increase frequency and magnitude of runoff events also increase streambank erosion. Human disturbances include logging, mining, agriculture, and urbanization. Typical urban or suburban developments which may impact a stream include houses, garages, parking lots, and walkways, including areas cleared of forest and replaced by tailored lawns.

Loss of streambank and streamside vegetation reduces the resisting forces and makes streambanks more susceptible to erosion. This is often the single greatest contributing factor to harmful or accelerated erosion on small and medium-size streams. Streambank vegetation may be removed intentionally for various reasons, or its loss may be inadvertent due to trampling by animals or humans.

The erosive ability of a stream is a function of velocity, flow depth, and slope. Therefore, on small streams, erosion is largely a function of the size and frequency of storm flows. Small watersheds may have a tendency for very “flashy” flows that move stormwater quickly through the channel. Watershed changes that increase the size of floods and frequency of flooding, such as deforestation, agriculture and urbanization, are major contributors of streambank and streambed erosion. Woody bank vegetation helps reduce flow velocity in the vicinity of the bank. Thus, loss of woody vegetation increases the potential for streambank erosion. Channel modifications for flood control, drainage, or other purposes often increase stream energy enough to cause widespread erosion problems, especially if soils are easily erodible.

The resistance to erosion provided by soil depends on its cohesiveness and texture. Sandy soils have low cohesion, and particles are small enough to be moved by flows with velocities of one or two feet per second. Lenses or layers of erodible soil material are frequently susceptible to erosion problems. Fines are selectively removed from cohesionless soils that are heter-ogeneous mixtures of sand and gravel, leaving behind an armor of gravel that protects the streambed against further erosion. Deeply rooted bank vegetation, especially woody vegetation, develops a network, which increases resistance to erosion by adding strength to the bank materials.

If your stream has been straightened and widened (channelized), the stream channel will probably be making changes to recreate the shape and slope it used to have before it was changed (modified). It is not uncommon for the upper or middle reaches of these modified streams to erode because the straightened channel has increased the velocity of the stream flows. In the lower reaches of these modified streams it is common for the channel to fill up with sediment because the greater upstream flows and velocities are carrying more sediments downstream. If the channel is eroding, you can slow the stream velocities and rate of erosion by planting shrubs, trees, and other plants. If the channel is filling with sediments, one possibility for helping correct that is to make the channel narrower using plants and other means. Ask local experts for advice in this case.

Some common problems creating streambank erosion are logs, shopping carts, or debris jams which deflect flows off banks. One of the most useful activities a property owner can be involved in is organizing your up and downstream neighbors to remove these obstructions. This will reduce

potential bank erosion problems and increase the capacity of your stream channel to carry storm flows without over topping. Channel constrictions caused by rocks, old tires, cars, oil drums, etc. cause erosion up and downstream.

Some Common Types of Streambank and Streambed Erosion and Their Causes

Common types of streambank and streambed erosion problems and their causes are described below and summarized in Table 1. These are photographically illustrated in Figure 3.

General bank scour

General bank scour is widespread erosion of streambanks caused by excessive velocities. General scour of streambanks usually is confined to banks composed of easily eroded, unconsolidated material (such as sand) lacking adequate vegetative cover. Streambanks covered with a thick sod or with brushy vegetation seldom experience widespread scour, except during major flooding. Extensive reaches of exposed soils on sloping banks may be evidence of general scour.

Toe erosion and upper bank failure

Undercutting or removal of toe support usually leads to failure of the upper bank. Undercutting is the major cause of bank erosion or failure on the outside of meander bends. Bank failures attributable to loss of toe support are often identifiable by their characteristic nearly vertical slopes which lack vegetation. If the area is accessed soon after failure, you would notice the presence of failed masses of bank materials in the stream, and the location of the thalweg near the failed bank. The thalweg is the thread of deepest, fastest flowing water. Streambank degradation as described above can be responsible for erosion also.

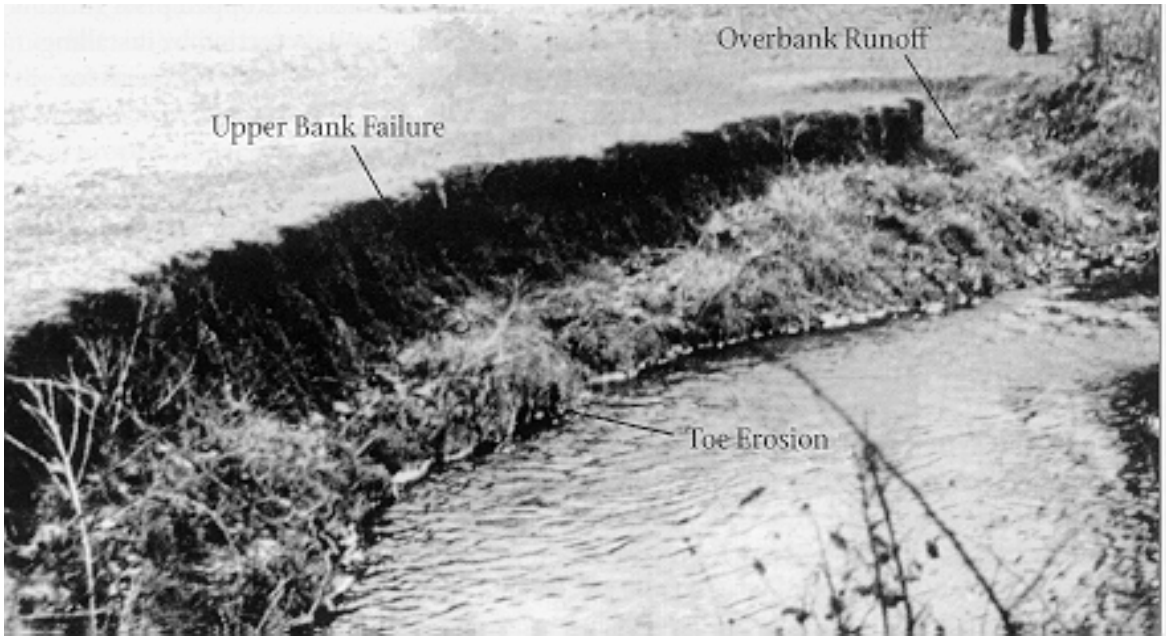
Local streambank and streambed scour

Localized scour is observed when isolated sections of eroding banks are found within otherwise stable reaches. Local bank scour may be associated with the presence of sand or other highly erodible material that is unable to maintain long term vegetative cover. Channel constrictions and flow obstructions may produce secondary currents that scour bed and banks.

TABLE 1
EROSION TYPES AND CAUSES

Type of Erosion	Causes
General bank scour	Increased discharge resulting from watershed changes; increased flow velocities caused by reduction in channel roughness or increased gradients; removal or loss of bank vegetation.
Toe erosion and upper bank failure	Removal of unconsolidated or loose lower bank materials, especially along outside bends. Widespread toe erosion may be associated with bed lowering
Local streambank and streambed scour	Scour of local lenses or deposits of unconsolidated material; erosion by secondary currents caused by flow obstructions and channel irregularities; loss of bank vegetation. Local bed scour may be caused by channel constrictions and flow obstructions. Some bed scour generally occurs below culverts.
Overbank runoff	Failure to provide adequate means of directing concentrated flows from overbank areas into the channel.

Adapted from Nelson R. Nunnally



Toe erosion, upper bank failure and overbank runoff.

Figure 3 Local streambed scour, note undercutting of the vegetation.

Photographs by Robbin B. Sotir & Associates

Bed scour is indicated by the presence of a hole (an area in the bed of a stream which has deepened due to a local increase in flow, increased flow velocity or the presence of secondary currents created by obstructions to flow).

Widespread erosion of the streambed that progressively lowers (deepens) the bed is referred to as bed degradation. This condition typically can not be handled by a single landowner since it most often results from watershed changes such as development which lessens water infiltration due to an increase in paved areas or open areas. Rainfall moves more rapidly to the stream channel increasing the size and frequency of runoff events. Streambed degradation also results from channel modifications that increase flow depths and/or slopes. To identify a degrading channel look for exposed foundations of bridge piers and drops of a foot or more at the downstream ends of culverts. A general absence of sediment in the creek bottom and lack of vegetation on the lower streambank may be evidence of general bed degradation. Bed degradation must be stopped prior to installation of streambank protection by installing structures in the bed. Again, ask local experts for advice in this case.

Overbank Runoff

Surface runoff coming from lawns, streets, parking lots, etc. can flow over the streambank and cause erosion problems. Overbank erosion is usually indicated by gully-like scars in the streambank.

Evaluating Streambank Erosion Problems

Whether an eroding bank needs to be repaired or protected from additional erosion depends on several factors, including type, extent, severity, and location of the erosion. Streambanks that appear to be well vegetated are usually stable. However, often banks that appear to be unstable and eroding are actually relatively stable. Differentiating between stable and eroding banks involves careful observation and evaluation of evidence about bank conditions. General conditions frequently associated with stable and eroding banks are summarized in Table 2.

TABLE 2
GENERAL CONDITIONS FREQUENTLY ASSOCIATED WITH STABLE AND ERODING BANKS

Characteristic	Stable Bank	Eroding Bank
Bank slope	**1H to 1V (Horizontal to Vertical) or** flatter; may be stepped or benched with vegetated berm at toe	often vertical or near vertical; may have mass of sod or other failed material at toe
Bank cover	may have variety of vegetation growing on slope, including ferns or moss	general absence of vegetation
Trees	often has trees growing on bank or on the bed at toe	standing live or dead trees inside the bank line, often leaning toward channel; fallen trees may obstruct flow
Bankline	relatively uniform or smoothly curving	irregular, sometimes with scalloped appearance
Sediment	sediment located in bars; bars may be partially stabilized by vegetation especially along bank toe	entire bed may be covered with sediment, bars not stabilized

Adapted from Nelson R. Nunnally

Evaluating the severity of streambank erosion is a somewhat subjective task that may involve the amount or the rate of erosion, relative location of the problem, and even the type of erosion involved. Erosion is a natural process, especially on sinuous or winding streams, and several feet of streambank erosion in a bend, or meander, might be no cause for concern. But, if erosion threatens structures such as bridges, roads, or homes; causes loss of valuable land; causes sedimentation that damages fish spawning grounds; or is in a highly visible location it might be considered severe. Table 3 provides some general guidance for establishing severity, but it should be used with considerable discretion.

TABLE 3
GENERAL GUIDANCE
FOR ESTABLISHING SEVERITY OF EROSION

Degree of Erosion	Characteristics
Stable to Mild	Little or no evidence of erosion; if eroding banks are present, they are small in extent (linear extent less than average bank height) and rates are modest (less than ½ foot per year); greater erosion may be tolerated at bends if it causes no associated problems.
Moderate	Extent of problem or rate of erosion exceeds criteria for stable class, but is less than severe.
Severe	Erosion covers large area of blank (linear extent greater than three times average bank height) and is occurring at a rate in excess of one foot per year or a rate that is unacceptable for safety, environmental, or economic reasons.

From Robbin B. Sotir & Associates

MANAGING STREAMBANK EROSION

Managing streambank erosion problems is less expensive than repairing damage from erosion. It is important to take steps to prevent streambank erosion problems from occurring. Preservation and protection of the native streamside vegetation community is an important key to streambank protection.

Since woody vegetation usually is the best streambank stabilizer, every effort should be made to maintain existing trees and shrubs. These plants will lessen the impact of rain directly on the soil, will trap sediment from adjacent land and will hold the soil in place with their root structures thereby, forming a root mat that stabilizes and reinforces the soil on the streambank. Plants also enhance the appearance of the stream and serve as wildlife habitat. Trees provide additional benefits by shading the stream to maintain the lower summertime water temperatures which are necessary for a healthy aquatic population. They prevent the stream channel from being choked by sun loving vegetation like rushes and reeds.

Here are some practical measures that can protect streambanks from erosion:

Maintain an Undisturbed Buffer Zone at least 25 Feet Wide (from the top of the bank back) on Both Sides of the Stream. This area needs the protection of a permanent vegetative cover. Where adjacent slopes are steep, a wider corridor of woody plant and shrubs is appropriate.

Restrict the Operation of Heavy Machinery, Construction, Animal Grazing, and Other Intensive Activities within the Buffer Zone. These activities compact the soil, decreasing infiltration, percolation, and soil aeration that leads to destruction of plants and plant habitat. Increased runoff and sedimentation are likely results.

Wise Management Practices for Agricultural and Forestry Activities. In agricultural areas, adopt practices such as con-servation tillage, contour cultivation, etc. to prevent erosion on cropland. Maintain an undisturbed riparian corridor of woody vegetation (filter strip) next to the stream. Keep livestock off the streambanks. Fencing can be used t o prevent livestock from damaging streambanks. Best management practices manuals are available from the Georgia Forestry Commission and the Georgia Soil and Water Conservation Commission.

Plant Vegetation. Where existing vegetation is sparse, planting site-specific native plants can be less expensive, offer higher survival rates, and give more protection than ornamental or non-native plants. Native self-maintaining perennial species can be selected and planted using the guidelines in this booklet.

Do Not Straighten Channels. This procedure, although it is quick and easy, is almost never effective in controlling erosion. Past experience has shown that channel straightening will simply change the location and nature of the erosion problem and will usually make the problem worse due to increased velocity and downstream impact.

PROTECTING STREAMBANKS AGAINST EROSION

This section discusses a number of approaches to protecting streambanks, list steps and considerations in planning and carrying out streambank stabilization projects, and describes some types of streambank erosion control measures.

Approaches to Streambank Protection

Streambank stabilization measures work either by reducing the force of flowing water, by increasing the resistance of the bank to erosion, or by some combination of both. Generally speaking, there are four (4) approaches to streambank protection: 1) the use of vegetation; 2) soil bioengineering; 3) the use of rock work in conjunction with plants; and 4) conventional bank armoring. Re-vegetation includes seeding and sodding of grasses, seeding in combination with erosion control fabrics, and the planting of woody vegetation (shrubs and trees). Soil bioengineering systems use woody vegetation installed in specific configurations that offer immediate erosion protection, reinforcement of the soils, and in time a woody vegetative surface cover and root network. The use of rock work in conjunction with plants is a technique which combines vegetation with rock work. Over time, the plants grow and the area appears and functions more naturally. Conventional armoring is a fourth technique which includes the use of rock, known as riprap, to protect eroding streambanks. This document emphasizes the use of woody vegetative techniques, therefore conventional armoring will not be covered here.

Revegetation measures may suffice if the stream is small, the bed is stable, and banks are not seriously eroded (see Table 2-3). These relatively low cost procedures can usually be accomplished by a homeowner.

A range of effective soil bioengineering re-vegetative measures may be used to solve common streambank erosion problems. These techniques are relatively inexpensive, can be implemented by landowners, provide environmental benefits such as habitat for fish and wildlife, and are aesthetically pleasing. When appropriately used and properly installed and maintained, vegetative systems usually provide the best and longest erosion protection. However, care must be taken to understand, design, and properly install these systems, some of which should be installed during the vegetation's dormant season (approximately November to March in Georgia).

Soil Bioengineering Erosion Control

This material is meant to be utilized as general information to better understand the merits of woody plant soil bioengineering systems. It is intended to better acquaint the reader with the "tools" of the technology and the terms. The systems described may be useful for small, simple problems where installed with appropriate guidance from knowledgeable professionals.

For soil bioengineering repairs, it will be necessary to locate and seek permission to cut native vegetation which roots easily from cuttings. A few examples of such vegetation are privet, willow, hawthorn, viburnum, and dogwood. Areas which frequently have such material are typically found in wetlands, sewer line easements, gravel pits, retention ponds, or along other stretches of stream. For the highest success rate, these need to be selectively harvested in the dormant season (November to March) and installed within a day or two. See Appendix I, Plant List for Unrooted Cuttings at the back of this document. These cuttings are typically combined with supplemental rooted plantings. A listing of these may also be found at the back of this document.

Woody vegetation

Shrub dogwoods, alders, and willows, (Banker's dwarf willow, Streamco purpleosier willow,

black willow, sandbar willow, meadow willow, heart-leaved willow, and Ward's willow), can be put into the soil either as cuttings or as nursery-grown seedlings. In dense shade, shrubs such as silky dogwood or evergreen ground covers such as Hall's honeysuckle are appropriate. Silky dogwood also does well in sunny and shady areas. See Appendix I for common and associated botanical names. It is important to remember that plant cuttings must be used during the dormant season (approximately November to March in Georgia), and seedlings should be planted in early spring or late fall. Planting willows harvested from a nearby area with soil and moisture conditions similar to the problem area will help increase their survival. Collect willows during the dormant season, and when storing or transporting the plans keep them cool and slightly moist. When purchasing rooted stock from a nursery, select native species to enhance survival, and decrease competition from other plants. Plant them as soon as possible. Alders should be nursery-grown seedlings one to two years old.

Nutrient testing

The streambank soils should be tested for nutrients. Fertilizer and limestone should be incorporated into the soil when necessary. When fertilizer is applied on the surface, it is best to apply about one-half at planting, one fourth when new growth is about two (2) inches tall, and one-fourth about six (6) weeks later. Split applications of fertilizers will reduce the potential for nutrient losses into the stream.

Soil samples

Take at least two (2) soil samples in two (2) different locations at approximately six (6) inches below the surface. In a long reach, a soil sample should be taken every one hundred (100) feet. Ask the laboratory to recommend rates to improve the soil conditions if fertilizers are needed to improve fertility for pioneer woody plants. Your local nursery will also be helpful. The Georgia Cooperative Extension Service, universities, and private laboratories do such tests. Be sure to check on time frames and costs.

Bank preparation

Typically, the eroded streambank will need to be graded back prior to the installation of the soil bioengineering systems. See Figure 4 for horizontal to vertical bank configurations.

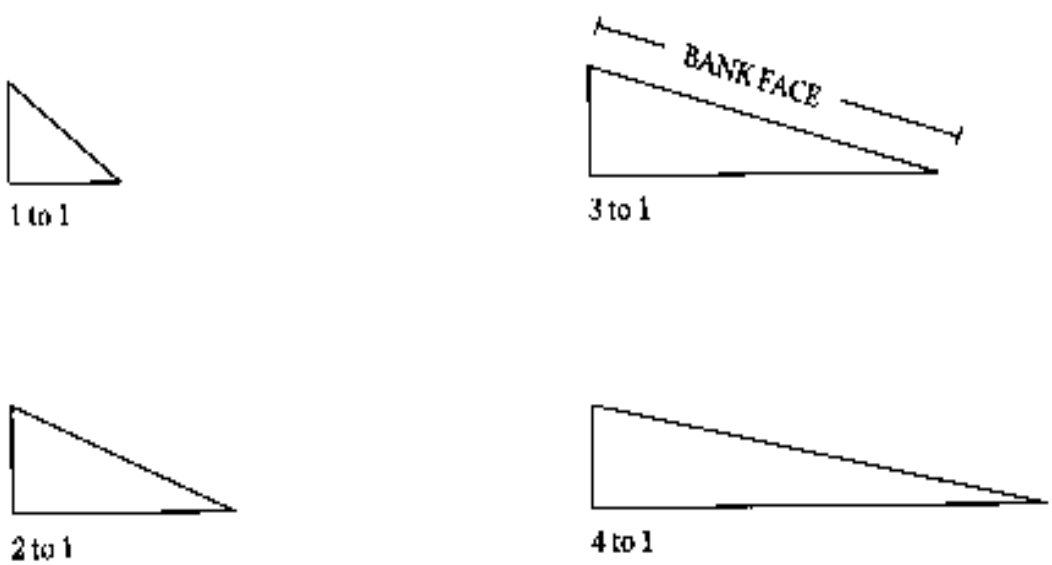


Figure 4 Illustrating different horizontal to vertical bank face configurations.

TABLE 4
SELECTED EROSION PROTECTION MEASURES FOR STREAMBANKS

Erosional Problems	Streambank Protection Measures Ranked by Environmental Benefits	Page No.
General bank scour	1. Brushmattress 2. Live fascine 3. Live staking 4. Joint planting	27 21 16 19
Toe erosion and upper bank failure	1. Live cribwall 2. Brushmattress with rock toe 3. Joint planting	31 27 19
Local streambank scour	1. Branchpacking 2. Live cribwall 3. Live fascine with erosion control fabric 4. Joint planting	35 31 21 19
Overbank runoff	Intercept and divert runoff and repair damage with : 1. Branchpacking 2. Live Fascine 3. Live staking with erosive control fabric	 35 21 16

Adapted from Robbin B. Sotir and Associates

TABLE 5
STREAMBANK EROSION PROTECTION MEASURES RELATIVE COSTS AND COMPLEXITY

Measure	Relative Cost	Relatively Complexity
Live stake	Low	Simple
Joint planting	Low*	Simple*
Live fascine	Moderate	Moderate
Brushmattress	Moderate	Moderate to Complex
Live cribwall	High	Complex
Branchpacking	Moderate	Moderate to Complex
Conventional vegetation	Low to Moderate	Simple to Moderate
Conventional bank armoring (riprap)	Moderate to High	Moderate to Complex

Assumes rock is in place.

From Robbin B. Sotir and Associates

Live Stake

Description

Live stakes are living, woody plant cuttings capable of rooting with relative ease. Willow species work best for this system. The cuttings are large enough and long enough to be tamped into the ground as stakes. They are intended to root and grow into mature shrubs that, over time, will serve to stabilize the soils and restore the riparian zone habitats. When first installed, they offer no immediate stabilization to the streambank. See Figures 5 through 8.

Advantages

- This is an effective stabilization and re-naturalization method for simple, or small problem sites.

- This technique is effective when construction time is limited and an inexpensive and simple method will handle the repair.

- Live staking is an effective system for securing natural geotextiles (erosion control fabrics) such as jute mesh, coir or other blanket surface treatments.

Live Materials

- The cuttings must be freshly cut and alive, with side branches removed, and with bark intact. They must be taken from species that root easily from cuttings, such as willow.

- The basal or butt ends (the end of the cutting closest to the ground) should be cut cleanly at an angle to facilitate easy insertion into the soil. The top should be cut square or blunt for tamping.

- Cuttings must be fresh and must be kept moist after they have been prepared into appropriate lengths.

- The live stake cuttings shall be prepared from 0.5 to 2-inch diameter stock. They work best when they are 2 to 3 feet in length.

Installation

- The cuttings should be tamped into the ground at right angles to the slope and angled downstream. They should be tamped into the ground carefully for approximately 4/5 of their length. A dead blow hammer works best to tamp the live stakes into the ground.

- Stakes should be spaced so that there are 2 to 4 cuttings per square yard. They should be placed in a random configuration to prevent gullies from forming and to produce a more natural effect in the re-vegetation area.

Tips for Success

- Care must be taken to ensure that the live stakes do not become stripped during the removal of the side branches and during actual installation. Cuts should be done with a saw rather than an ax.

- Install the live stakes the same day they are prepared.

- Start the installation at the water's edge and work up the bank.

- Cuttings that split or become "mushroomed" during tamping should be replaced.

- It is important to foot compact around each live stake after it has been installed.

- Install the cuttings right side up. Be sure that the buds are pointing upward.

- It is best when the slope has been graded back to at least 2H (Horizontal) to 1V (Vertical) or flatter when room is available.

- Erosion control fabrics can greatly enhance soil stabilization and in this case the live stakes can be used to secure down the fabric.

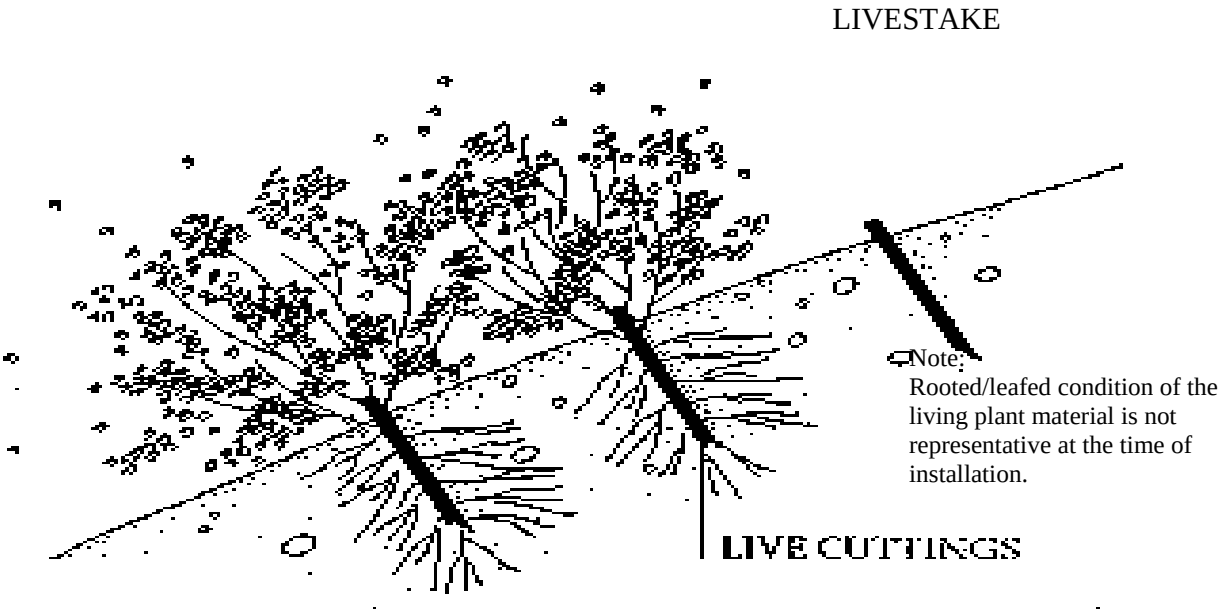


Figure 5 Illustration of a live stake. *Robbin B. Sotir & Associates*

Figure 6 A prepared livestake. *Photograph by Robbin B. Sotir & Associates*

Figure 7 Installation of a live stake.

Figure 8 Live stake after 2 years of growth. *Photographs by Robbin B. Sotir & Associates*

Joint Planting

Description

Joint planting is a system that installs live willow stakes (as previously described) between rock placed previously along the streambank. It is intended to increase the effectiveness of the rock system by forming a living root mat in the base upon which the rock has been placed and to improve the environmental function and aesthetics of the rocked bank. The rock needs to be loosely dumped or hand placed and no thicker than 2 feet. This is an excellent method to combine soil bioengineering with conventional systems. See Figures 9 through 11.

Advantages

- A joint planting system is typically used with a previously installed conventional riprap rock bank. It will enable a streambank to become naturalized.

- This system assists in dissipating energy and causes deposition to occur along the streambanks, thus developing a more natural look and function over time.

- Joint planting provides shade over water, thus reducing the temperature of the stream and making it more suitable for aquatic habitat.

Live Materials

- The cuttings must be freshly cut and alive, with side branches removed and with bark intact. They must be taken from a species that roots easily from cuttings.

- The basal ends should be cleanly cut at an angle, for easy insertion into the soil. The top should be cut square or blunt for tamping. Cuttings must be fresh and must be kept moist after they have been cut into appropriate lengths.

- The cuttings shall be 1 to 2 inches in diameter. They work best when they are 3 to 3.5 feet in length.

Installation

- At least two thirds of the length of t he live stake needs to be in the ground below the previously placed rock layer. A dead blow hammer works well to tamp the live stakes into the ground.

- The density of the installation generally ranges from 3 to 5 cuttings per square yard (slightly higher than for live stakes alone). The survival rate is usually a little lower in this system, due to the possibility for dryness and to the difficulty of getting the living unit installed deep enough.

- The stakes should be placed in a random configuration for a more natural effect, and better function.

Tips for Success

- The live stakes should be installed the same day they are prepared.

- The rock needs to be loosely dumped or hand placed and no thicker than 2 feet.

- Cuts should be done with a saw rather than an ax.

- Start the installation at the water's edge and work up the bank.

- It may be difficult to install live stakes in old riprap since the base will be very compacted. A pipe or rod can be used to make a pilot hole for the live stakes. After the rod has been driven in it must be carefully removed so as not to over enlarge the hole. You may want to add soil to the spaces around the rock.

- Replace any cuttings that split or lose their bark layer during tamping or that develop mushroom-like tops.

- Install the cuttings with the buds pointing upward.

JOINT PLANTING

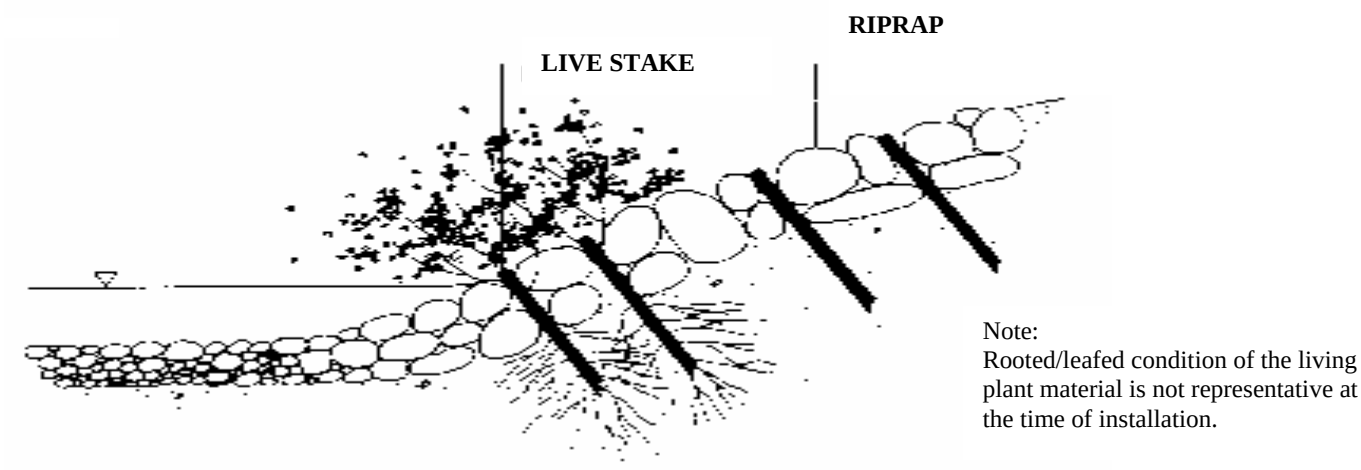


Figure 9 Illustration of joint planting *Robbin B. Sotir & Associates*

Figure 10 ***Installation of a live stake in joint planting*** **Photograph by Robbin B. Sotir & Associates**

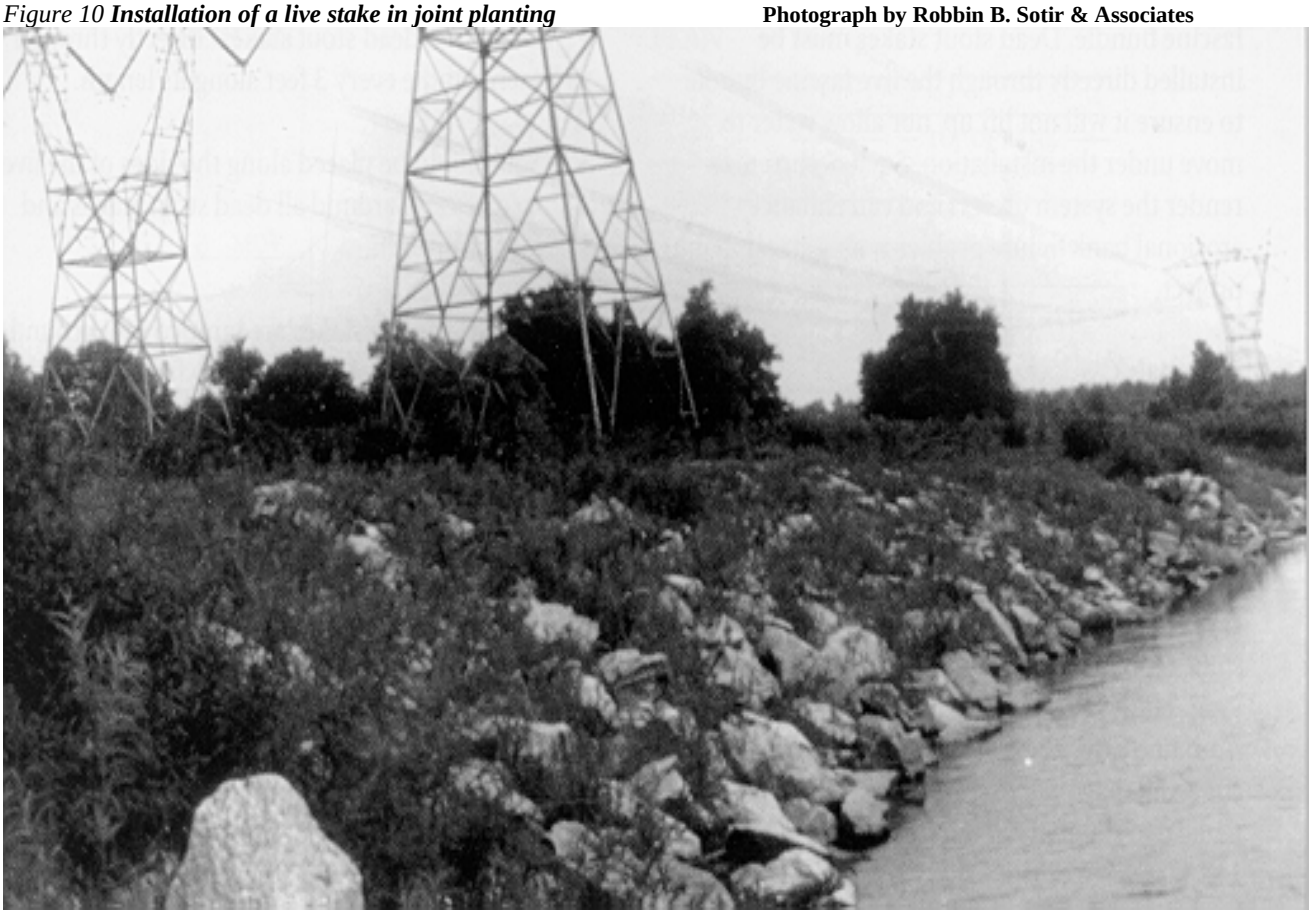


Figure 11 Joint planted bank after 2 years of growth. *Photograph by Robbin B. Sotir & Associates*

Live Fascine

Description

Live fascine structures are sausage-like bundles of live cut branches. Willow makes the best live fascines. They are placed into trenches along the streambank. Live fascine bundles are installed with live stakes and dead stout stakes. Successful use of live fascines requires careful assessment of site conditions, knowledge of installation procedures, and proper maintenance. See Figures 12 through 18.

Advantages

- This method offers reasonably inexpensive and immediate protection from erosion when properly used and installed.

- They are installed shallowly and create very little site disturbance as compared to other systems.

- The live fascines tend to break up the bank length into a series of shorter slopes separated by benches and serve to slow surface water flows and allow for more infiltration on droughty sites;

- Live fascines are capable of holding soil on the face of the streambank. They work especially well when they are combined with a surface cover such as jute mesh or coir fabrics.

- Live fascines provide surface stability and connecting support for the invasion of the surrounding aquatic, riparian, or upland slope vegetation.

Live Materials

- Live cuttings are placed in bundles and tied together. Live stakes are tamped in with a dead blow hammer on the downslope of the live fascine bundle.

Dead stout stakes must be installed directly through the live fascine bundle to ensure it will not lift up, nor allow water to move under the installation. Such occurrences render the system useless and can enhance erosional bank failure problems on a streambank project.

Dead Materials

- Natural, undyed baling twine is used to tie the live fascine bundles together.

- Dead stout stakes (see Figure 13) are used to secure the live fascines. They should be fabricated in the following manner. The dead stout stakes should be a minimum of 30 to 36 inches long. These are cut to the appropriate length from untreated 2x4 lumber. Each length shall be cut again diagonally across the 4 inch face, to make two stakes from each length (see Figure 14). The diagonal cut begins and ends 1/8 to ¼ inch from the edge of the piece so the finished stake will have a 1/8 to ¼ inch tip.

Installation

- The slope should be graded back to a 3H (Horizontal) to 1V (Vertical). See Figure 4 and Table 6.

- Live fascines are installed in shallow trenches that usually are a shovel deep and a shovel wide.

- Place live fascine bundles into the trenches.

- Drive the "dead stout stakes" directly through each bundle every 3 feet along its length.

- Soil should be placed along the sides of the live fascines and around all dead stout stakes and foot tamped in.

- Finally, the live stakes are tamped into the ground on the downslope sides of the live fascine bundles, halfway between each of the dead stout stakes.

Tips for Success

- These systems are installed shallowly and may dry out and become damaged over periods of drought. However, if they are well installed, they will act mechanically even if they do not grow.

- Be sure the bundles are well secured to the ground so that water cannot wash the soil out from under the live fascine bundles. This would preclude rooting and mechanical effectiveness as well.

- Use on banks with a face length of 15 feet or less.

- Be careful not to completely bury the live fascine. You should be able to see the top edge of the branches in the trench, given that the soil is adequately worked into and around the live fascine bundle.

TABLE 6

RECOMMENDED SPACING FOR LIVE FASCINES
(Measured Along the Bank Face)

Slope Steepness	Undisturbed Erosive Soils	Undisturbed Cohesive Soils	Fill Soils
3H to 1V or flatter	3' – 5'	5' – 7'	*3' – 5'
Steeper than 3H to 1V (up to 1H to 1V)	3'	3' – 5'	-0-

**not recommended along – use with erosion control fabrics*

From Robbin B. Sotir and Associates

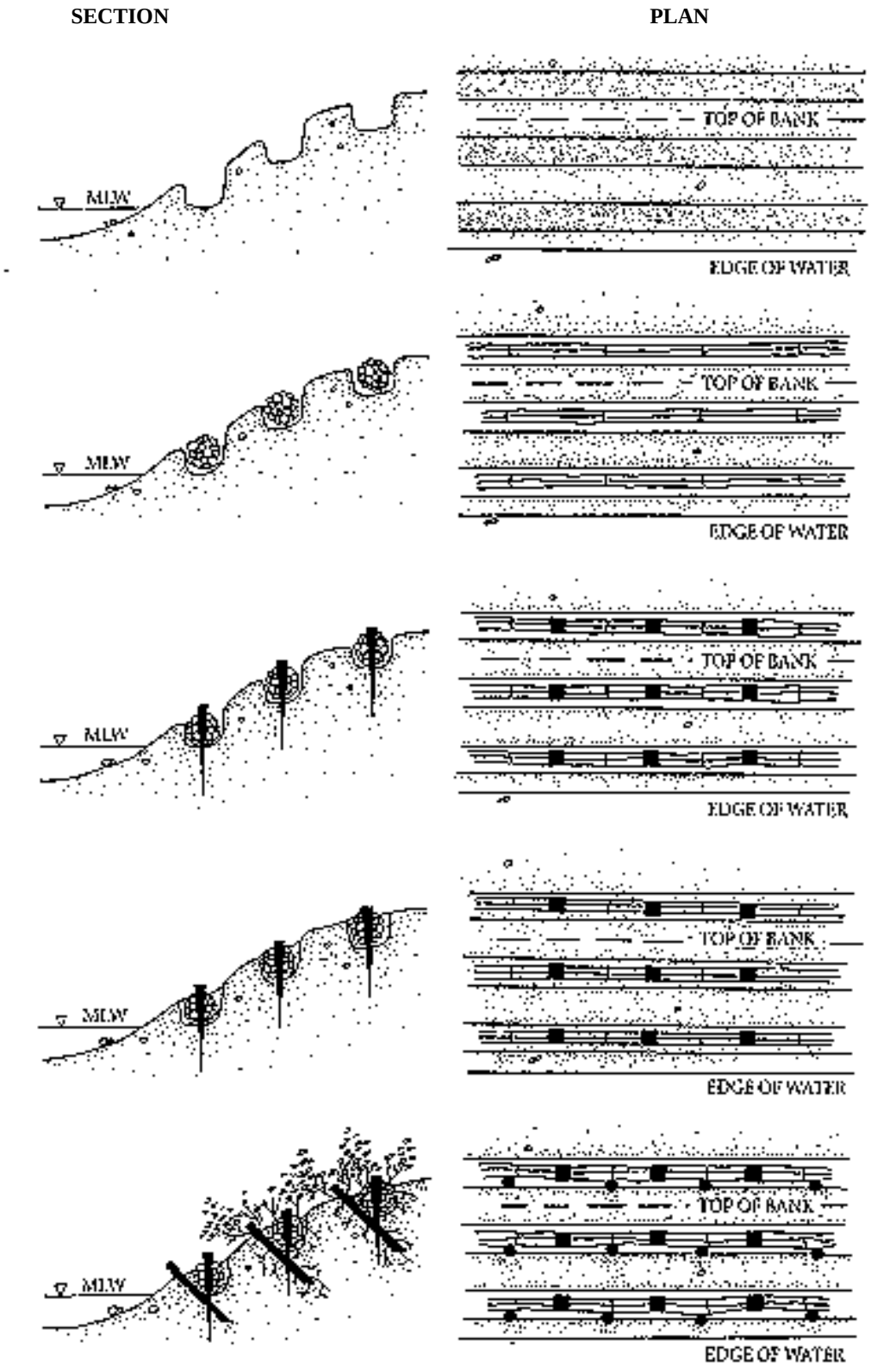
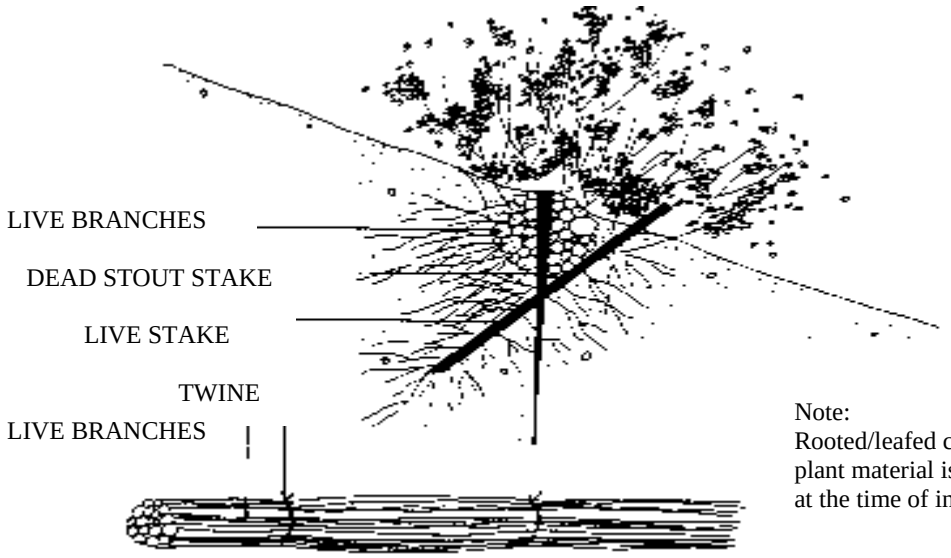


Figure 2 Live fascine installation procedures *Robbin B. Sotir & Associates*

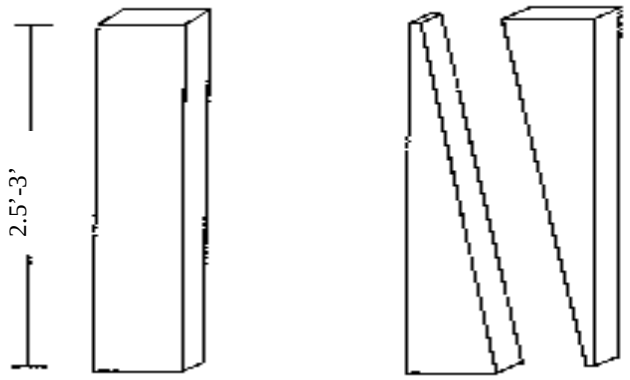
LIVE FASCINE



Note:
Rooted/leafed condition of the living plant material is not representative at the time of installation.

Figure 13 Illustration of a live fascine. *Robbin B. Sotir & Associates*

DEAD STOUT STAKE



Saw 2 x 4 timber diagonally to produce 2 Dead Stout Stakes.

Figure 14 Illustration of a dead stout stake ***Robbin B. Sotir & Associates***

Figure 15 Live fascine fabrication

Figure 16 Trenches being dug for live fascine installation, on a prepared bank.

Photographs by Robbin B. Sotir & Associates

Figure 17 Initial step in live fascine Installation

Figure 18 Live fascine in the second growing season.

Photographs by Robbin B. Sotir & Associates

Brushmattress

Description

The brushmattress is a combination of living units that forms an immediate, protective surface cover over the streambank. The living units used are as follows: live stakes, live fascines and a mattress branch cover. Brushmattress systems require a great deal of live material. They are all intended to root and grow to stabilize the bank soil. This is a more complicated and expensive system to evaluate, design, and install. See Figures 19 through 23.

Advantages

- This installation produces an immediate surface protection against floods.

- Brushmattress installations are able to capture sediment during flood conditions and assist in the rebuilding of the bank.

- They produce habitat rapidly and assist in enhancing the wildlife habitat value. They work well and quickly develop a healthy riparian zone.

Live Materials

- Cuttings must be taken from species that root rapidly and have long flexible branches.

- The branches are used in 3 ways:
  1. Live stakes – See Live Stake
  2. Live fascines – See Live Fascine
  3. Brushmattress – Long flexible branches placed against the bank surface.

- Live branches and live stakes for this installation should be .5 to 1 inch in diameter.

Dead Materials

- Undyed natural twine for bundling the live fascines.
- Wire to tie down and secure the branch mattress against the bank face.
- Dead stout stakes (see Figure 14) to secure the live fascines and branch mattress in place.

Installation

- The slope shall be machined back and carefully shaped to a 3H (Horizontal) to 1V (Vertical) or flatter. In very tight areas where space is limited and the soils are stiff (such as clays), it is possible that the bank can be steepened to a 2H (Horizontal) to a 1V (Vertical). See Figure 4.

- Beginning at the base of the slope, excavate the trench for the live fascine bundle installation, and place the live fascine directly into the excavated trench. Tamp live stakes and dead stakes over the slope face in a square pattern.

- Place the basal ends of the brushmattress at the base of the slope under the live fascine and the growing tips towards the top. The branches should lie smoothly against the bank.

- Drive dead stout stakes directly through the live fascine bundles.

- Wire down the mattress branches as close to the slope face as possible using the live and dead stout stakes and cover with soil.

Tips for Success

- Water must not drain over the bank through the installed brushmattress. This would cause gullies to form easily because the branches are placed up and down the slope.

- This system must be installed on a smoothly graded bank.

- It is important that the branches not be held under tension as this would raise the branches off the slope face.

- Be sure that after the brushmattress has been covered with soil, the branches are visible. Do not bury.

- Use on banks with a face length of 10 feet or less.

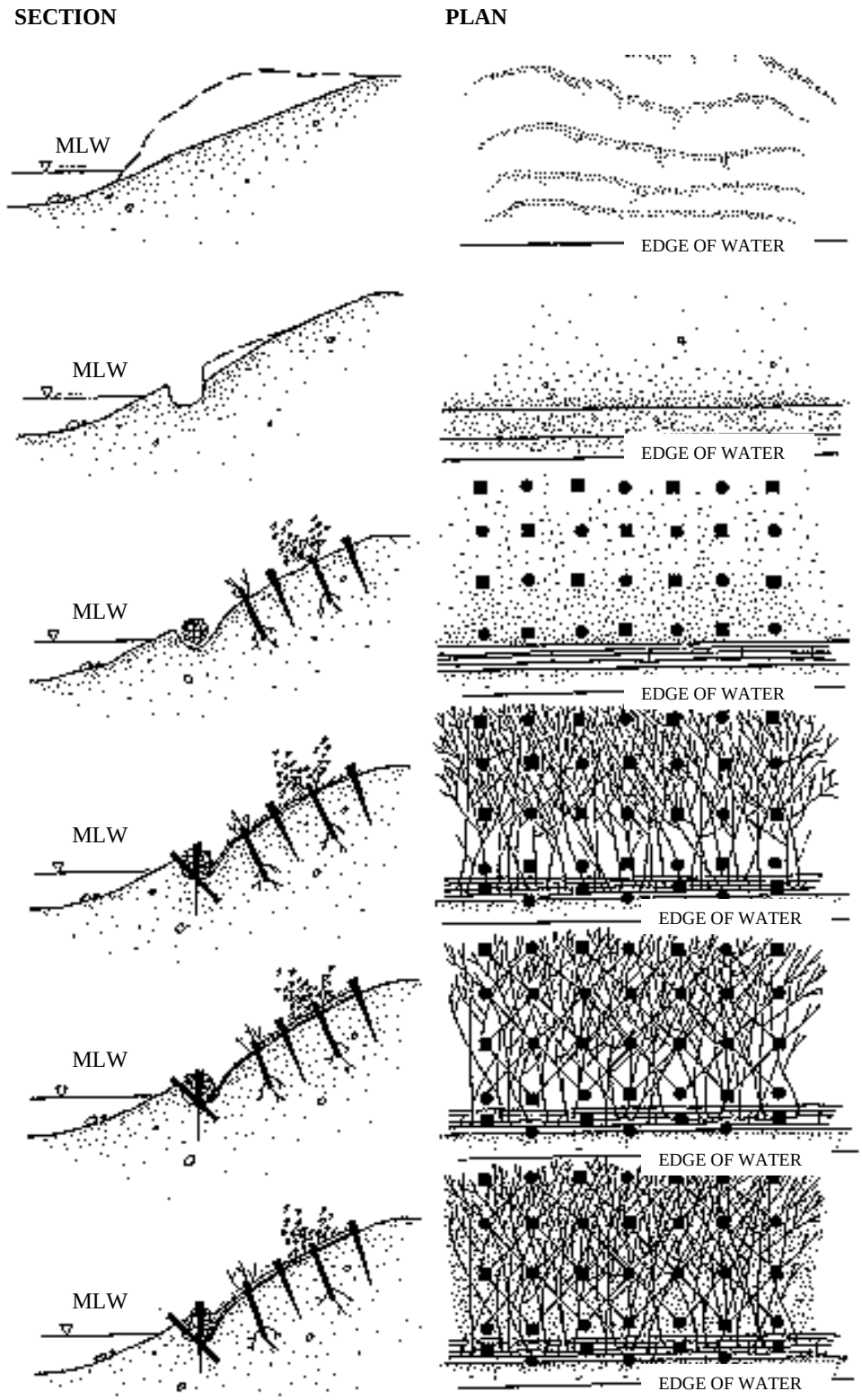


Figure 19 **Brush Mattress installation procedures.** ***Robbin B. Sotir & Associates***

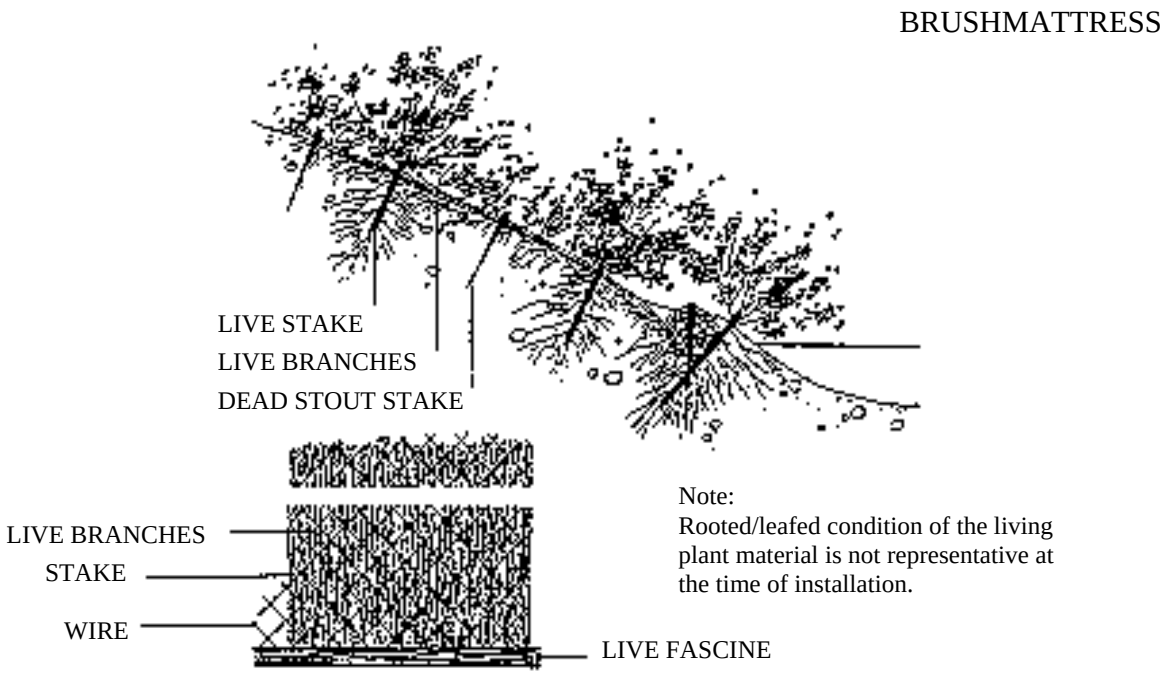


Figure 20 Ilustration of a brushmattress. *Robbin B. Sotir & Associates*

Figure 21 Brushmattress installation on a previously prepared 3H to 1V slope.

Photographs by Robbin B. Sotir & Associates

Figure 22 Brushmattress growth after 2 months.

Figure 23 Brushmattress growth after 2 years.

Photographs by Robbin B. Sotir & Associates

Live Cribwall

Description

A live cribwall installation is a rectangular framework of logs or timbers, rock, and woody cuttings that can protect an eroding streambank. These systems require a great deal of assessment and understanding of stream behavior. These can be complicated and expensive systems if you do not have a supply of wood and some volunteer help to install it. See Figures 24 through 28.

Advantages

- This system develops a natural streambank or upland slope appearance after it has begun to grow.
- These installations provide excellent habitat for a variety of fish, birds and animals.
- Live cribwalls are very useful where space is limited on small, narrow stream corridors.

Construction Guidelines

- The live cribwall system should be built during low to normal flow conditions.
- Construction is simplified by diverting flow from the construction site with berms or barriers.

Live Materials

- Live branches required for the installation should be .5 to 2 inches in diameter and 4 to 6 feet long.

Dead Materials

- 4 to 6 inch diameter or logs or timber in varying lengths are required.
- Fill material must drain well and must be capable of supporting plant growth.

Installation

- Excavation two (2) to three (3) feet below the surface of the streambed or bottom is necessary for live cribwall installation.
- First, place the long parallel and short right angle logs or timbers in the bottom of the excavation, all the way to the back of the bank.
- Secure the logs or timbers with nails or rebar at each crossing point. Fill with 2 to 4 inch rock and compact.
- Place the next layer of logs and stone fill. Continue until rock is above mean low water level (MLW). Above MLW fill with soil.
- Place the live brushy branches on the fill with the growing tips towards the stream and the basal ends oriented towards the slope. They should protrude from the front of the live cribwall construction.
- Continue with the logs or timbers, fill material, and brush placement to the top of the live cribwall and slope.
- The final layer should reach the top of the original bank. The wooden crib system should not protrude into the stream but rather be flush with the existing bank face on either side.

Tips for Success

- Live cribwall installations can fail if they are not placed on a competent foundation. These systems must be installed well into the bed to prevent washouts from occurring at the toe.
- The upstream and downstream ends are also prone to scour, and must be well keyed into the bank where they start and finish.
- Use in an area with a bank height of 4 feet or less.

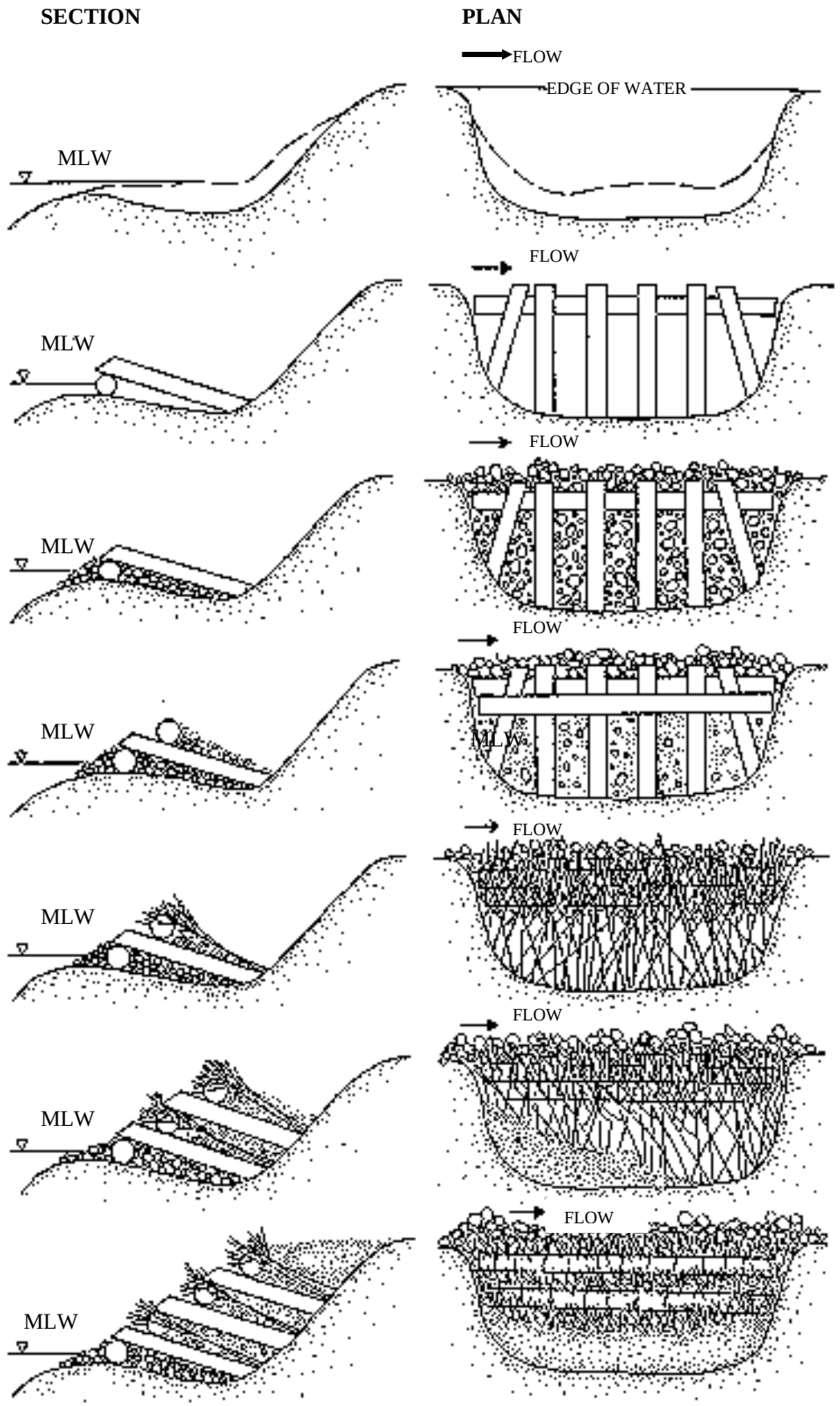


Figure 24 **Live cribwall installation procedures.** ***Robbin B. Sotir & Associates***

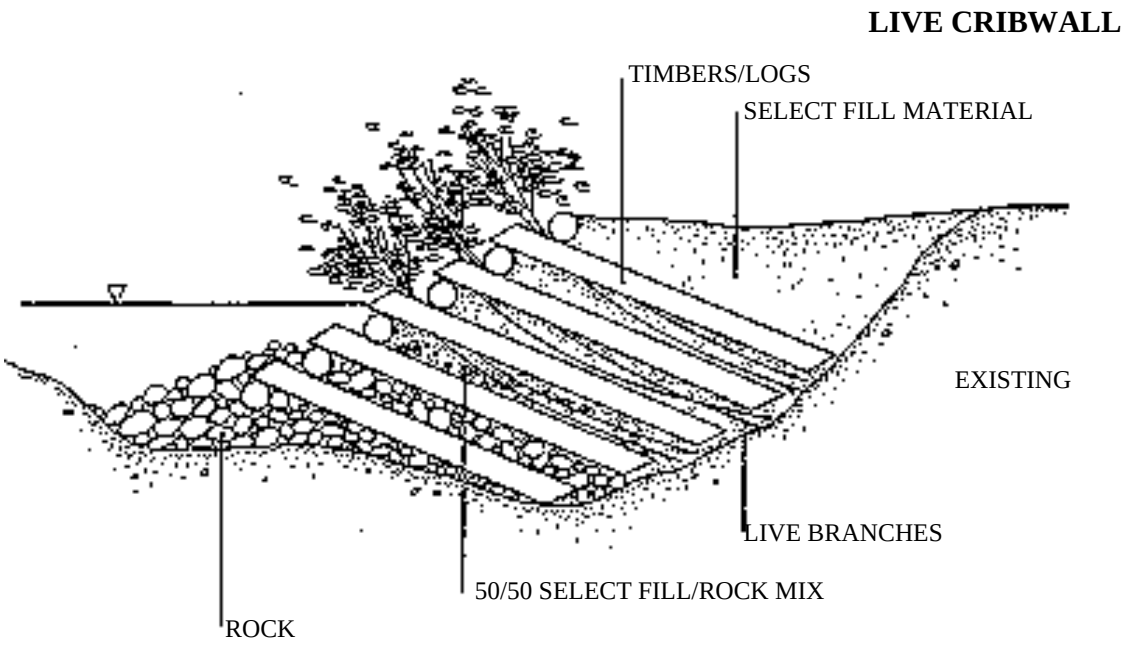


Figure 25 Illustration of a live cribwall. *Robbin B. Sotir & Associates*

Figure 26 Rock placement into the bottom of the structure.

Photograph by Robbin B. Sotir & Associates

Figure 27 Brush and wooden member placement.

Figure 28 Completed frontal view of the live cribwall.

Photographs by Robbin B. Sotir & Associates

Branchpacking

Description

Branchpacking is the process of alternating layers of live branches and soil, incorporated into a hole, gully or slumped out area in a slope or streambank. It has some similarities to a live cribwall in terms of branch orientation. The branches root to form a permanent reinforced installation, while the tips produce vegetative top growth that is intended to slow runoff and reduce erosion. This system offers a moderate to complex level of difficulty for construction. See Figures 29 through 34.

Advantages

- The branchpacking installation produces an immediate filter barrier, reducing scouring conditions, repairing gully erosion, and providing habitat cover and bank reinforcement.

- Branchpacking is one of the most effective and inexpensive methods for repairing holes in earthen embankments along small stream sites.

Live Materials

- Live cuttings, which root readily, are required.

- They should be .5 to 2 inches in diameter and 3 to 5 feet long.

Dead Materials

- Poles or timbers, such as 2 x 4 or 4 x 4, should be 5 to 8 feet long, depending on the specific site requirements.

- Backfill is used in between the layers of the brush.

Installation

- Starting at the lowest point, clean out the bottom and be sure it slopes towards the bank.

- Drive the poles or timbers vertically into the bottom of the washout approximately 4 feet deep and 1 foot apart.

- A thick layer of live branches is installed with the growing tips of the branches oriented toward the stream. The branches are placed in a fan-like and criss-cross fashion.

- The first layer of branches is followed by a mixed layer of rock and backfill.

- Each successive layer of branches should be followed by a layer of backfill. Compact the backfill thoroughly between each layer, until the top of the bank has been reached.

Tips for Success

- The system must be well compacted between each layer of branches and between the branches to prevent the soil from being washed out and to enhance the opportunity for rooting.

- The branches must be very brushy to be most effective.

- It is important to keep the branchpacking installation even with the existing bank and not allow it to protrude into the stream.

- Use on areas up to 4 feet high and 4 feet wide.

- The living branches must reach the back and sides of the repair site.

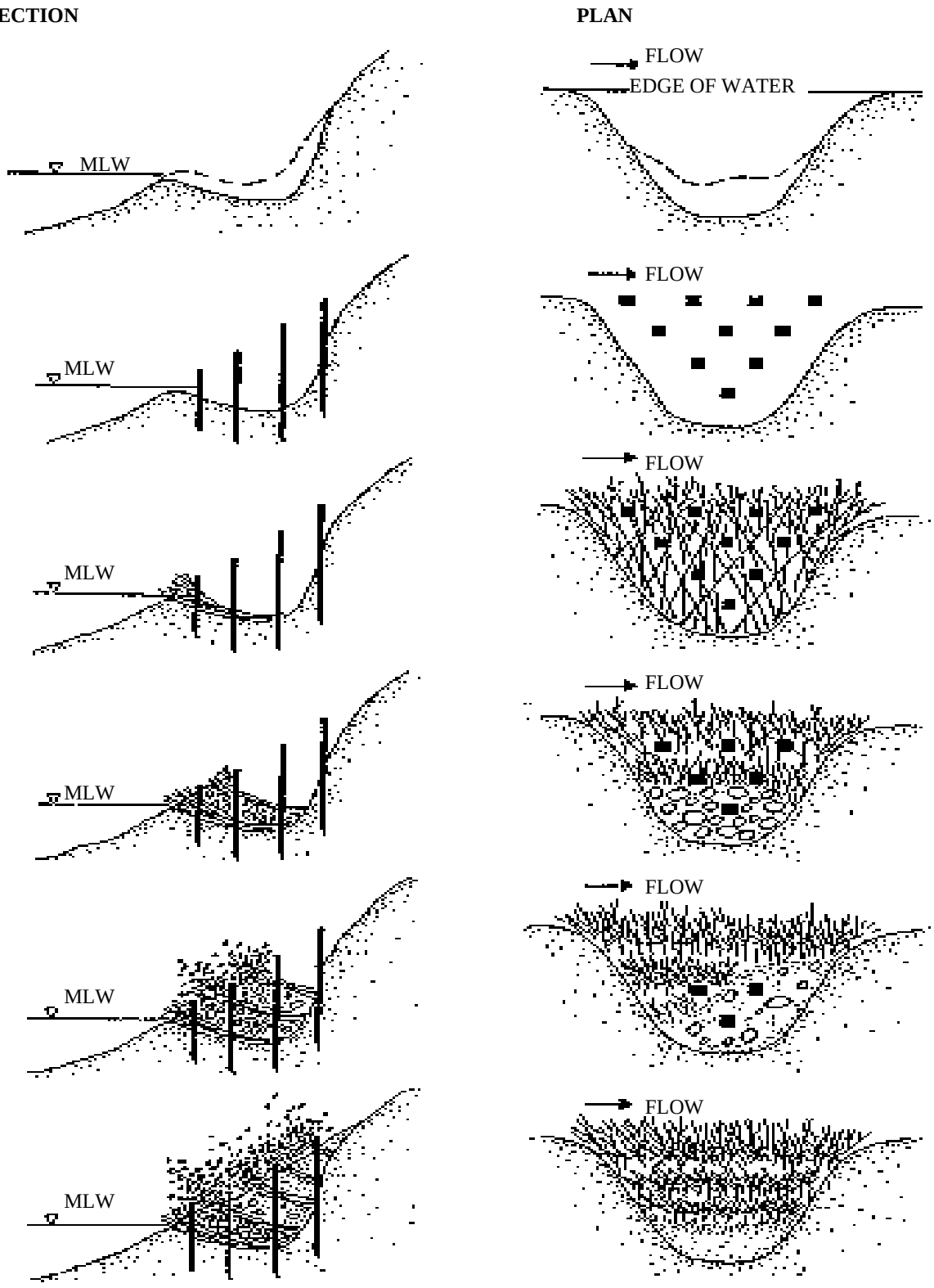


Figure 29 **Branchpacking installation procedures.** ***Robbin B. Sotir & Associates***

BRANCHPACKING

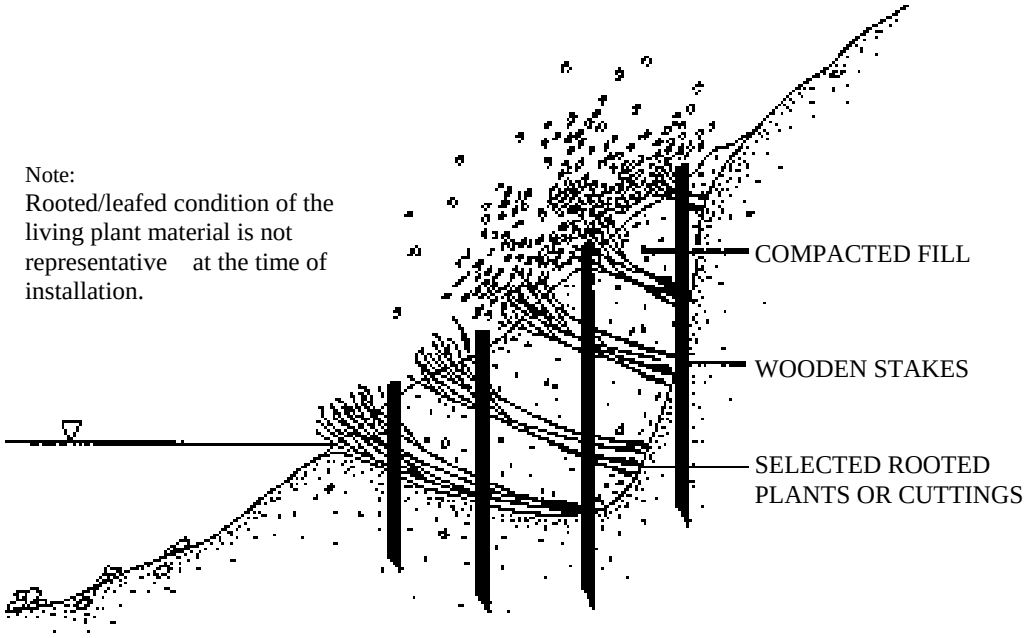


Figure 30 Illustration of branchpacking. *Robbin B. Sotir & Associates*

Figure 31 Excavating out the bottom in preparation for the installation.

Photograph by Robbin B. Sotir & Associates

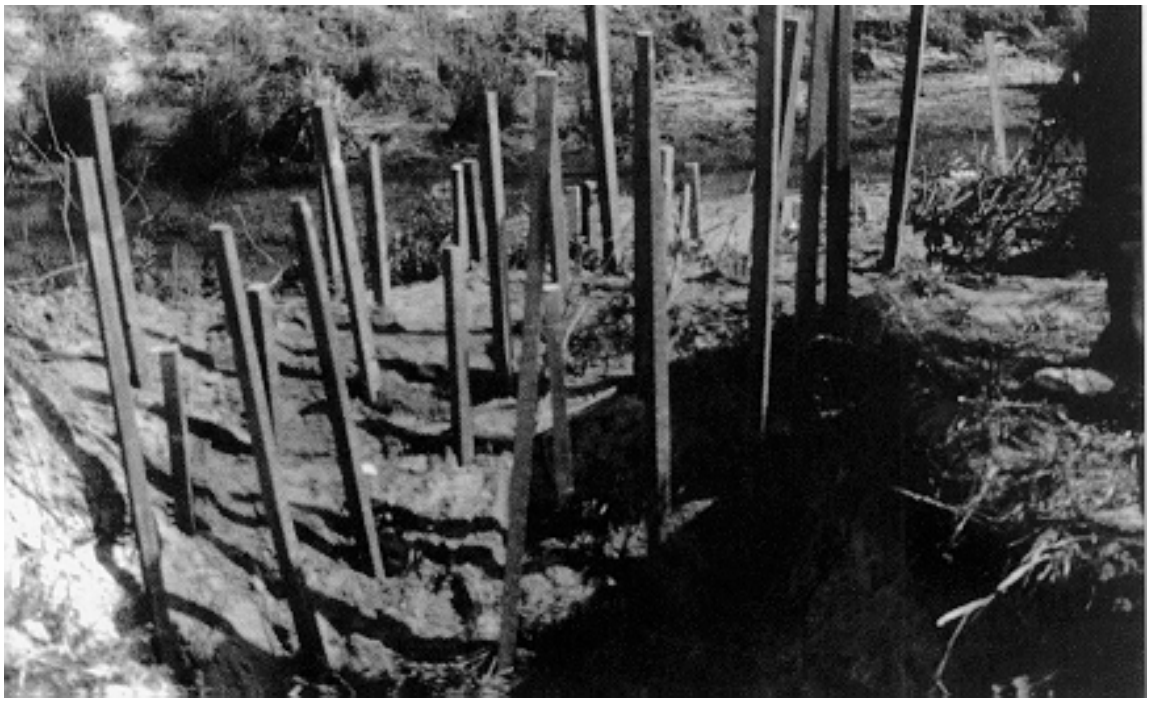


Figure 32 Illustrating the fill material and wooden placement.

Figure 33 Illustrating the branch fan-like criss-cross placement/configuration.

Photographs by Robbin B. Sotir & Associates

Figure 34 Example of a healthy 1 year old branchpacking structure

Photograph by Robbin B. Sotir & Associates

Maintenance of Vegetative Practices

Vegetated streambanks are always vulnerable to damage and repairs may be needed periodically. Check the banks after every high-water event, fixing gaps in the vegetative cover at once with structural materials or new plants, and mulching if necessary. Fresh cuttings from other plants on the bank may be used, or they can be taken from mother-stock plantings.

Other Structural Measures

There are many structural measures forstreambank protection that are not covered in this document for various reasons. Some, such as rock riprap, concrete bank paving, gabions, and drop structures used to control bed degradation, are intended for use where special problems or constraints exist. If you think your problem is larger or complex enough to need one of these alternatives, you are advised to contact your local Natural Resources Conservation Service office or Soil and Water Conservation District for advice prior to proceeding. These kinds of designs usually require detailed analysis by a professional and should be designed and installed by persons experienced in their use.

Many manufacturers produce a variety of materials intended for use in erosion control and streambank protection. Some of these products may be suitable for your needs and might provide cost effective alternatives where vegetative solutions are not preferred. It would be impractical to describe all of these materials, and any selective examples might be misinterpreted as an endorsement of those proprietary systems.

GLOSSARY

Alluvium – Sediment deposited by flowing water.

Bar – A bed form that is created by deposition of sediments and which extends above water at low flow.

Berm – A bench or terrace within a stream channel. Berms can be erosional or depositional features.

Dead Blow Hammer – A hammer filled with lead shot or sand.

Deposition – The accumulation of soil particles on the channel bed and banks.

Dormant Season – The time of year when plants are not growing and deciduous plants shed their leaves.

Duration of Flow – Length of time a stream floods.

Entrained – Picked up by flowing water.

Filter Strip – A strip of vegetation left undisturbed along a stream to prevent erosion and promote sediment deposition.

Flow Rate – Volume of flow per unit time. Usually expressed as cubic feet per second.

Meander – A broad, looping bend in a stream channel.

MLW – Mean Low Water.

Native Vegetation – Vegetation that is indigenous to our area and adapted to local conditions.

Non-cohesive – Friable, loose, or lacking internal strength.

Lenses – Non continuous layers of alluvium surrounded by alluvium of a different character.

Pool – A topographical low in the stream that is produced by scour and that generally contains fine-grained sediments.

Riffle – A topographical high area in a channel created by the accumulation of relatively coarse grained sediments.

Rill Erosion – Removal of the soil particles from a streambank slope by surface runoff moving through relatively small channels.

Riparian Buffer – An undisturbed, vegetated strip of land adjacent to a water course.

Riprap – Rock used to protect streambanks from erosion.

Riverine – The corridor or area along or near the banks of a river, stream, creek, etc., which have been produced by the waterway and is influenced by it.

Scour – The erosive action of flowing water that removes and carries away material from the streambed and banks.

Seepage – Groundwater emerging on the face of the streambank.

Secondary Currents – Currents that flow at an angle to the main downstream flow direction. Secondary currents are caused by channel restrictions and obstructions to flow.

Select Fill Material – Soil which is to be used for installation around the live cut plant materials. It should be natural and capable of supporting plant growth, and typically is mixed with fertilizer to improve its nutrient quality for the successful rooting of the live cuttings.

Sheet Erosion – The removal by surface runoff of a fairly uniform layer of soil from a bank slope.

Sinuous – Refers to a meandering or winding stream configuration.

Slump – The mass movement of soil, similar to a landslide. Bank failure is a type of slump.

Thalweg – A line connecting the deepest points along a channel.

Toe – The break in the slope at the foot of a bank where the bank meets the streambed.

Unconsolidated – Friable or loose material lacking internal cohesion.

Velocity – (Average Mean Velocity) Speed of the water typically measured in feet per second.

Watershed – The area that contributes runoff to a stream.

Wise Management Practice – Land treatments and land uses that enhance water quality most by reducing pollutant and sediment loads.

APPENDIX

PLANTS SUITABLE FOR USE AS UNROOTED (HARDWOOD) CUTTINGS

Species	Region	Tolerance To Flooding	Tolerance To Drought	Tolerance To Deposition	Tolerance To Shade
Acer negundo Boxelder	C,P,M	H	H	H	L
Baccharis halimifolia Groundsel bush	C,P (lower)	M	M	H	L
Cornus amomum Silky dogwood	P,M	L	M	L	M
Cornus sericia Ssp. stolonifera Red osier dogwood	P,M	L	M	H	M
Crataegus sp. Hawthon	C,P,M	M	H	L	L
Populus deltoids Eastern cottonwood	C,P,M	M	M	H	L
Salix sp. interior Sandbar willow	C,P,M	H	L	H	L
Salix nigra Black willow	C,P,M	H	H	H	L
Salix purpurea Streamco willow	C,P,M	H	M	H	L
Salix x cotteti Bankers willow	P,M	H	M	H	L
Sambucus canadensis American elderberry	P,M	H	M	M	M
Viburnum dentatum Arrowwood viburnum	C,P,M	M	M	M	M
Viburnum lentago Nannyberry viburnum	C,P,M	M	M	L	M
Robinia sp. Black locust	P,M	L	H	M	L

Adapted from the USDA/NRCS Engineering Field Handbook, Chapter 18

Legend:

Tolerance to Flooding, Drought, Deposition, and Shade
H = High
M = Medium
L = Low

Region
C = Coastal
P = Piedmont
M = Mountain

Rooting of all species will be improved if nearby vegetation is pruned to increase sunlight penetration.

Whenever possible, harvest hardwood cuttings as close to the repair site as possible.

Many of the above grow naturally along streams, in adjacent wetlands, along sewer and power line easements, and where streams enter lakes and along lake shores. Willows generally grow profusely in stormwater detention ponds in urban areas.

ALWAYS OBTAIN PERMISSION FROM THE PROPERTY OWNER BEFORE HARVESTING PLANTS!

NATIVE PLANT GUIDE FOR STREAMBANK PLANTING ROOTED STOCK

Species	Region	Stream Zone	Wildlife Value	Notes
Acer rubrum Red maple	M,P,C	Tree	High Seeds & browse	Rapid growth.
Alnus serrulata Smooth alder	M,P,C	Shrub	Moderate, Cover	Rapid growth. Stabilizes stream-banks. Sun.
Amorpha fruticosa False indigo	M,P,C	Shrub	Moderate	Sun.
Aronia arbutifolia Red chokeberry	M,P,C	Shrub	Moderate Cover & Food	Rhizomatous Colonial Shrub.
Asimina triloba Pawpaw	M,P,C	Tree	Important food for fox & possum	
Betula nigra River burch	M,P,C	Tree	Good for cavity nester	Full sun.
Carpinus caroliniana American hornbeam	M,P,C	Tree	Low	Partial shade.
Carya cordiformis Bitternut hickory	P,C	Tree	Moderate, food	Wet bottoms.
Catalpa bignonioides Catalpa tree	P,C	Tree	Unknown	
Celtis laevigata Sugarberry	P,C	Tree	High food cover	Partial shade.
Celtis occidentalis Hackberry	P,C	Tree	High	Partial shade.
Cephalantus occidentalis Buttonbush	M,P,C	Shrub	Moderate, ducks & Shorebirds are users. Nectar for humming-birds.	Sun.
Chionanthus virginicus Fringe tree	P,C	Tree	Moderate	Tolerant of shade.
Clethra alnifolia Sweet pepperbush	P,C	Shrub	Moderate	Partial shade. Good landscape value.
Cornus amomum Silky dogwood	M,P	Shrub	High, songbirds, Mammals	Shade tolerant. Good bank stabilizer.

Species	Region	Stream Zone	Wildlife Value	Notes
Cornus stricta Swamp dogwood	M,P	Shrub	High	Good bank stabilizer in shade.
Cornus florida Flowering dogwood	M,P,C	Tree	High, birds, food	Shade tolerant.
Cyrilla racemiflora Titi	C	Tree	Low	Light shade.
Diospyros virginia Persimmon	M,P,C	Tree	Extremely high Mammals	Not shade tolerant.
Fraxinus caroliniana Carolina ash	C	Tree	Moderate	Rapid growing. Streambank grower. Sun to partial shade.
Fraxinus pennsylvanica Green ash	M,P,C	Tree	Low	Rapid grower. Full sun.
Gleditsia aquatica Water locust	P,C	Tree	Low	Sun.
Gleditsia triacanthos Honey locust	P,C	Tree	Low	Full sun, thorns.
Hibiscus aculeatus Hibiscus Comfort root	C	Shrub	Unknown	Use on open level floodplain areas & Depressions in C.
Hibiscus militaris Hibiscus Halberd-leaved Marsh-mallow	C	Shrub	Unknown	Use on open level floodplain areas & Depressions in C.
Hibiscus lasiocarpus Hibiscus	C	Shrub	Unknown	Use on open level floodplain areas & Depressions in C.
Hibiscus moscheutos Hibiscus	C	Shrub	Unknown	Use on open level floodplain areas & Depressions in C.
Ilex coriacea Sweet Gallberry	C	Shrub	Unknown	
Ilex decidua Possumhaw	P,C	Shrub	High, food, nest sites	Sun or shade.
Ilex glabra Bitter gallberry or Inkberry	C	Shrub	High	Stoloniferous. Sun to some shade.

Species	Region	Stream Zone	Wildlife Value	Notes
Ilex opaca American holly	M,P, C	Tree	High, food, cover nests	prefers shade.
Ilex verticilata Winterberry	M,P	Shrub	High, cover & fruit for birds. Holds berries in winter.	Full sun to some shade. Seasonally flooded areas.
Ilex vomitoria Yaupon	C	Shrub	High, songbirds	Small tree, very adaptable, suckers.
Juglans nigra Black walnut	M,P	Tree	Good	Temporarily flooded wetlands along floodplains.
Juniperus virginiana Eastern red cedar	M,P,C	Tree	High, food	Tolerant to some shade in youth.
Leucothoe axillaris Leucothoe	C	Shrub	Low	Partial shade.
Lindera benzoin Common spicebush	M	Shrub	High, songbirds	Shade, acidic soils. Good understory.
Liriondendron tulipefera Tulip poplar	M,P	Tree	Low	Tolerant to partial Shade.
Liquidambar styraciflua Sweetgum	M,P,C	Tree	Low	Partial shade.
Lyonia lucida Lyonia or Fetterbush	C	Shrub	Low	Sun.
Magnolia virginia Sweetbay	P,C	Tree	Very low	Shade tolerant.
Myrica cerifera Southern wax myrtle	C	Shrub	Moderate	Light shade.
Nyssa ogeche Ogeechee lime	C	Tree	High, fruit, Cavity nesters	Wetland tree
Nyssa sylvatica Blackgum or sourgum	M,P,C	Tree	Moderate, seeds	Sun to partial shade.
Nyssa aquatica Swamp tupelo	C	Tree	High	Prefers shade.
Ostrya virginiana Hophornbeam	M,P,C	Tree	Moderate	Tolerant of all sun-light conditions.

Species	Region	Stream Zone	Wildlife Value	Notes
Persea borbonia Red bay	C	Tree	Good food, for quail and bluebirds.	Understory tree.
Pinus taeda Loblolly pine	P,C	Tree	Moderate	Poor sites.
Platanus occidentalis Sycamore	M,P,C	Tree	Low. Cavity Nesters	Transplants well. Rapid growth in full sun.
Populus deltoides Eastern cottonwood	M,P,C	Tree	High	Invasive roots. Rapid growth.
Quercus alba White oak	M,P,C	Tree	High, food	Prefers moist well drained soil.
Quercus laurifolia Swamp laurel oak	C	Tree	High	
Quercus lyrata Overcup oak	P,C	Tree	High	Sloughs & bottoms.
Quercus michauxii Swamp chestnut oak	M,P,C	Tree	High	Wetter sites than white oak.
Quercus nigra Water oak	M,P,C	Tree	High	
Quercus pagoda Cherrybark oak	M,P	Tree	High	
Quercus phellos Willow oak	M,P,C	Tree	High, mast	Full to partial sun.
Quercus shumardii Shumard oak	P,C	Tree	High	
Salix nigra Black willow	M,P,C	Shrub & Tree	Nesting	Rapid growth, full sun.
Rhododendron atlanticum Coast azelea	P,C	Shrub	Very low	Very fragrant, Suckers.
Rhododendron viscosum Swamp azelea	C	Shrub	Low	
Styrax american	C	Shrub	Unknown	

Species	Region	Stream Zone	Wildlife Value	Notes
Taxodium distichum Bald cypress	C	Tree	Good perching site	Full sun.
Tsuga canadensis Eastern hemlock	M	Tree	Moderate	Tolerates all light conditions.
Viburnum nudum Swamp haw	M,P,C	Shrub	High	Shade tolerant.

Legend:

Region

M = Mountains
P = Piedmont
C = Coastal Plain

Plant List Sources:

Brown, Claude L. & Kirkman, Katherine L. 1990. Trees of Georgia and Adjacent States.

Foote, Leonard E. & Jones, Samuel B., Jr. 1989. Native Shrubs and Woody Vines of the Southeast.

Georgia Cooperative Extension Service. Native Plants for Georgia Gardens.

Hightshoe, Gary L. 1988. Native Trees, Shrubs and Vines for Urban & Rural America.

USDA Natural Resources Conservation Service. 1973. Seacoast Plants of the Carolinas.

USDA Natural Resources Conservation Service, Engineering Field Handbook, Chapter 18, Soil Bioengineering for Upland Slope Protection and Erosion Reduction.

Suggested Hand Tools Typical Costs

Axe – regular size	@ $17.75 each
Chain saw	Rental
Chain saw chains	@ $25.00 each
Chain saw pants	@ $50.00 each
Dead blow hammers – 4 lbs.	@ $25.00 each
Eye protection goggles	@ $10.95 each
Files chain saw	@ $3.95 each
Files loppers	@ $9.95 each
Files – shovels & hand clippers	@ $5.25 each
Hammers – regular	@ $5.00 each
Hand pruning shears	@ $8.75 each
Leather work gloves	@ $9.95 each
Loppers	@ $24.90 each
Mattock Pick & Hoe	@ $21.50 each
Measuring Tapes – 100 feet	@ $20.95 each
Round point shovels	@ $23.95 each
Shovel handles	@ $8.60 each
Sledge hammer – regular size 8 lbs.	@ $33.70 each
Sledge hammer handle – 8 lbs.	@ $14.95 each
Sledge hammer hand size – 2 lbs..	@ $18.00 each
Sledge hammer handles – 2 lbs.	@ $ 8.60 each
Water pump & hoses	Rental
Wire cutters	@ $ 7.95 each

Suggested Materials List

Dead stout stakes

Fertilizer

Fill material

Filter cloth

Grass seed

Hay bales

Jute mesh fabric

Long straw for mulch

Nursery source for rooted stock

Rock

Silt fence

Source for branches (unrooted cuttings)

Twine (Baling)

Wire (20 gage electrical fencing)

Wooden stakes – 2.5 to 3.0 feet long

Wooden timber or logs

September 1994

Cost $28,000
Quantity 20,000

STATE SOIL & WATER CONSERVATION COMMISSION

SOIL-
OUR BASIC HERITAGE

1937

GEORGIA

Source Water Assessment Project

An Assessment of Potential for Pollution of Surface Drinking Water Supply Sources

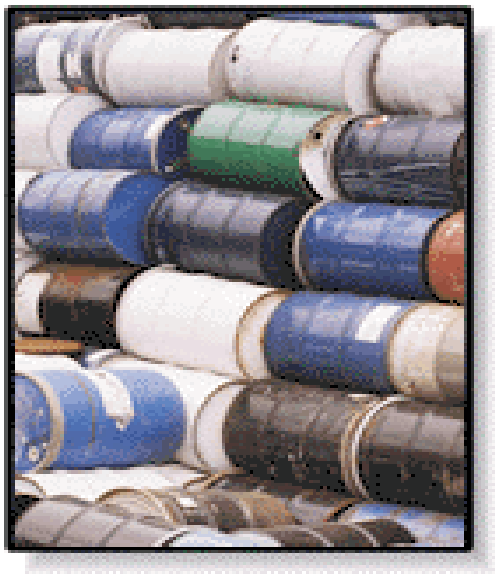
City of Roswell Department of Public Works
Drinking Water Supplied from the Big Creek Watershed

What is a Source Water Assessment?
A source water assessment is a study and report, unique to each water system that provides basic information about the source used to provide drinking water.

Who is involved in these Assessments?
The 1996 Amendments to the Federal Safe Drinking Water Act brought about new pollution prevention and protection measures that help ensure clean and safe drinking water. As a result, the U.S. Environmental Protection Agency (USEPA) has set a national goal that by 2005, the majority of the population is to receive its drinking water from systems with Source Water Protection Plans in place. As a first step, the USEPA requires all states to perform Source Water Assessments for each drinking water intake. The Georgia Environmental Protection Division (GAEPD) contracted with the Atlanta Regional Commission (ARC) to coordinate and facilitate the implementation of the State's Source Water Assessment Plan for 28 metro Atlanta public drinking water intakes.

What will the Assessments tell us?
The Source Water Assessments:

- identify the area of land that contributes the raw water used for drinking water,
- identify potential sources of contamination to drinking water supplies, and
- provide an understanding of the drinking water supply's susceptibility to contamination.



What is Water Pollution?
Water pollution is caused when substances such as chemicals, pathogens, sediment, and metals are released into the water. There are two types of water pollution, individual source and non-point source pollution.

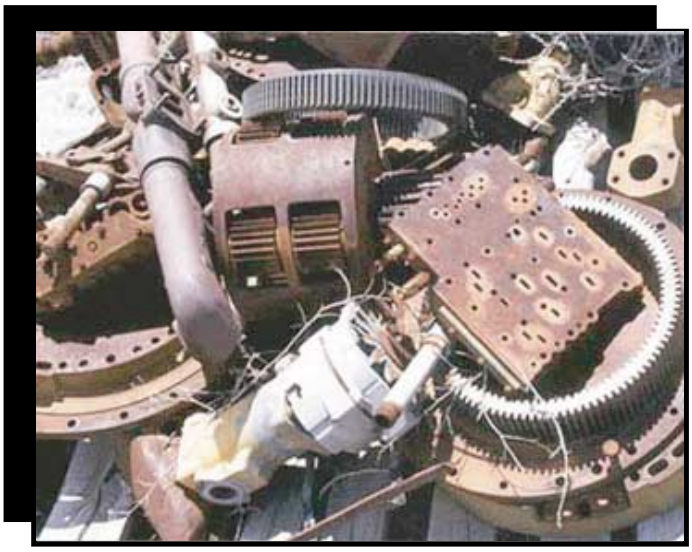
The City of Roswell Department of Public Works and the Atlanta Regional Commission have completed a source water assessment itemizing potential sources of surface water pollution to your drinking water supply. The results are summarized on the back side of this report.

ARC

Individual Source Pollution

Individual Source Pollution involves actual facilities, which have contaminants on site, which can pose a potential health risk if humans consume those contaminants.

Big Creek Water Supply Watershed	
Inventory of Potential Point Sources of Pollution	
Potential Pollutant Source Facilities	**Number of Facilities**
Agriculture	17
Airports	1
Asphalt Plants	1
Electric Substations	6
Fuel Facilities	92
Garbage Transfer Stations	3
Hazardous Waste Facilities	104
Junk/Scrap/Salvage Yards	6
Landfills	2
Large Industries which Utilize Hazardous Chemicals	25
Land Application Site (LAS) Permit Holders	1
Lift Stations	1
Mines	2
NPDES Permit Holders	3
Recycling Centers	4
Wastewater Treatment Facilities	1
Water Treatment Plants	1
Total	270



Non-Point Source Pollution

Non-point source pollution is caused by development and everyday activities that take place in residential, commercial and rural areas and is carried by rainfall to streams and lakes.

Each time it rains, the resulting runoff from rooftops, lawns, streets and parking lots pick up debris such as:

- Dust and Dirt
- Oil and other vehicle leaks
- Pet waste
- Lawn pesticides and fertilizers
- Leaves and grass clippings
- Paint and other household products

Big Creek Watershed
Non-point Source Considerations
18.7% Impervious Surface Area
4.4% Area of Watershed in Transition
233 Sewer Lines Crossing the streams near the intake
0 Railroads Crossing Streams near the intake
34 Identifiable Accidental Spill Sites

Leaky septic tanks and sewer lines, construction sites and bare ground areas are other sources of non-point source pollution.

These pollutants are deposited, untreated, into our streams, rivers, and lakes. Increased runoff from developed areas can also cause flooding and erosion of stream banks, which creates even more sediment that enters our waterways.

The amount of impervious cover from buildings, streets and parking lots is an indicator of potential pollutant loads from non-point source pollutants. The metro source water assessments watersheds with greater than 20 percent impervious surface ranked high for potential non-point pollution, between 10-20 percent ranked medium and less than 10 percent ranked low.

How were the watersheds ranked?

Individual source pollution and non-point source pollution considerations were combined to determine an overall susceptibility ranking for each watershed.

What does this mean?

This information can help communities understand the potential for contamination of their drinking water supplies and can be used to prioritize the need for protecting drinking water sources. For questions on this project contact Matthew Harper at mharper@atlantaregional.com

Watershed Susceptibility Ranking	
Drinking Water Supply Watershed	Overall Watershed Ranking
Big Creek	Medium-High

Environmental Planning Division
Atlanta Regional Commission
40 Courtland Street, NE
Atlanta, GA 30303