Final

Big Creek Watershed Improvement Plan

Prepared for

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Executive Summary

In 2003, the Big Creek Watershed was identified by the Metropolitan North Georgia Water Planning District (District) as substantially impacted. As a result, the County selected the Big Creek Watershed for development of its first Watershed Improvement Plan (WIP). This WIP was designed to comply with regulatory requirements and identify the most beneficial and cost-effective projects for water quality improvement in the Big Creek Watershed. According to the District, it is recommended that the County work to implement watershed improvement projects beginning in 2008 until water quality objectives are met, as evidenced through the County's Environmental Monitoring Program. This WIP is designed to help the County achieve several purposes:

- Comply with District guidelines as required by the GAEPD for the County's water supply, wastewater, and stormwater permits.
- Implement the recommendation included in the County's Watershed Protection Plan (WPP) to develop and implement watershed improvement projects.
- Address nonpoint source impacts to 303(d) listed streams.
- Identify causes of degradation within subwatersheds.
- Specify the retrofits or restoration needed to meet water quality goals and/or return these areas to desired condition.
- Evaluate the benefits and costs of potential projects.
- Identify priority areas where projects could have the greatest impact.
- Plan budgets for watershed improvement project implementation.

Watershed improvement projects were identified through field studies, infrastructure inventories, Geographic Information Systems (GIS) analysis, and previous documentation of watershed management activities and recommendations. These potential projects were categorized as (1) stormwater Best Management Practice (BMP) retrofit—projects aimed at improving structures to retain and treat stormwater or (2) stream channel restoration—projects that stabilize stream banks and restore aquatic habitats, riparian corridors, and small lakes and reservoirs to improve water quality, promote ecological integrity, and reduce erosion and sedimentation. For both types of projects, benefits were evaluated using several criteria, including water quality, flood/channel protection, habitat/biological integrity, implementation constraints, and accessibility. Preliminary project costs were estimated based upon historical project costs in the area. These costs are provided as a range to assist with future planning efforts and budget considerations.

According to the District, it is recommended that the County work to implement watershed improvement projects beginning in 2008 until water quality objectives are met, as evidenced through the County's Environmental Monitoring Program. A capital improvement plan (CIP) was developed as a planning-level overview for watershed improvement activities in each subwatershed based on impervious cover. For the CIP, projects with budgets across a wide spectrum have been identified as priorities in subwatersheds with high impervious cover. Subwatersheds identified as non-priority in this WIP are areas where future study must be conducted to better assess the watershed conditions to determine if watershed improvement projects are necessary. Recommended projects should allow the County some flexibility in future planning efforts when considering available annual budgets. It should be noted that recommended projects can be phased to occur over multiple years for budgeting purposes. However, each phase should provide an independently achievable level of watershed improvement. This WIP is presented as a planning guide for the County and should be re-evaluated according to budgetary requirements, regulatory requirements, and dynamic conditions in the watershed, which may change project priorities. Guidance from the District is scheduled for updates in 2008, which may affect WIP requirements.

This WIP was designed to provide specific projects for implementation, as well as costs and construction techniques that can be applied to future needs and critical areas that are identified at a later date. In either case, watershed improvement projects will provide both short- and long-term solutions to remedy problems in the Big Creek Watershed. Although watershed improvement projects will address critical areas needing improvement, future degradation can be prevented through the County's other watershed management and protection strategies, including a routine maintenance program, proactive environmental policies, and preventative watershed monitoring activities. Continued monitoring in portions of the watershed with the potential for high future growth will also assist in preventing future stream quality issues.

1.0 Introduction

Throughout Forsyth County, increased development from the Atlanta area is intensifying land use changes. These changes are especially concentrated in the southern portion of the County, around the Big Creek Watershed. As a result, Forsyth County has established several County-wide watershed protection strategies to prevent stream degradation due to the existing and future development. These protection strategies are based on District guidance and GAEPD requirements. Strategies include establishment of protective ordinances, procedures for development review, stormwater collection requirements, illicit discharge monitoring, and stream monitoring. These County-wide programs are in place to identify and prevent further degradation; however, the County must also address existing problems that were caused by previous alterations and disturbances.

Problems will not improve with time unless specific improvement efforts are made to control stormwater runoff and restore stream channel conditions. To address these problems, Forsyth County will target specific impacted watersheds for improvements, as recommended by the District. In 2003, the Big Creek Watershed was identified by the District as substantially impacted based on high levels of impervious cover. Compliance with District guidelines is required by the GAEPD as part of the County's permits for water supply, wastewater, and stormwater. As a result, the County selected the Big Creek Watershed for development of its first Watershed Improvement Plan (WIP). This WIP was designed to comply with regulatory requirements and identify the most beneficial and cost-effective projects for water quality improvement in the Big Creek Watershed.

1.1 Watershed Management Compliance

To comply with GAEPD requirements and District guidance, the County developed several reports to plan watershed management compliance activities. Initially, the County developed the Community Watershed Assessment and Management Plan (WAMP), which was completed in 2000, to comply with permit requirements and provide a roadmap for all the County's proposed watershed management activities, including development of WIPs. Since WAMP approval, the County has submitted annual reports to document implementation progress based on activities proposed in the WAMP. More recently, regulatory requirements have been updated, resulting in development of the County's Watershed Protection Plan (WPP). The WPP was submitted to GAEPD in 2006 to provide an update to the WAMP by revising implementation schedules for watershed management activities. In the WPP, a WIP for the Big Creek Watershed was scheduled for implementation in 2007.

The County has also developed other programs that are tied to watershed management activities, and are referenced in the WAMP and WPP, including the Big Creek Watershed Study Master Plan (2000), Environmental Monitoring Plan (2003 to present), and the Stormwater Management Plan (SWMP) (2005). The Big Creek Watershed Study Master Plan provided a comprehensive plan across multiple jurisdictions. It also provides data which contribute to the foundation of the WIP. The Environmental Monitoring Plan presents data which contributed to calculating the benefit scores for the projects listed in the WIP. The Environmental Monitoring Plan was first established through the WAMP. Three of the stations that were initially monitored in 1999 for the WAMP are located on Big Creek. Since May 2003, these three stations have been monitored for water quality. The SWMP is a guide to preventing nonpoint source pollution and is required by the County's National Pollutant Discharge Elimination System (NPDES) permit. It also describes procedures and BMPs which will be used for future projects.

1.2 Purpose and Overall Approach

This WIP is designed to help the County achieve several purposes:

- Comply with District guidelines.
- Implement the recommendation included in the County's WPP to develop and implement watershed improvement projects.
- Identify causes of degradation within subwatersheds.
- Specify the retrofits or restoration needed to meet water quality goals and/or return these areas to desired condition.
- Evaluate the benefits and costs of potential projects.
- Identify priority areas where projects could have the greatest impact.

For this document, watershed improvement projects were identified through field studies, infrastructure inventories, Geographic Information Systems (GIS) analysis, and previous documentation of watershed management activities and recommendations. These potential projects were categorized as (1) stormwater BMP retrofit—projects aimed at improving structures to retain and treat stormwater or (2) stream channel restoration—projects that stabilize stream banks and restore aquatic habitats, riparian corridors, and small lakes and reservoirs to improve water quality, promote ecological integrity, and reduce erosion and sedimentation. The following paragraphs provide an outline of the technical approach for the remaining sections of this WIP.

In Section 2.0, watershed conditions and specific problems are characterized using existing information including land use, impervious cover, water quality, and population densities. Subwatersheds are then prioritized based on the level of degradation.

Once priority subwatersheds were identified, potential projects were developed, as described in Section 3.0, by using GIS analysis, field reconnaissance, and water quality data to assess the condition of stream reaches and existing BMPs. Once a potential project was identified, a decision was made to identify the most applicable and effective project activity based on the problems at that particular project site. The various types of retrofit and restoration project activities that were considered are described in Section 3.0. Recommended types of projects were matched to the problems in each subwatershed. A basic planning-level cost estimate was developed for these projects based on a range of past costs.

Following project selection, projects were ranked using calculated cost-benefit ratios for projects, as described in Section 4.0. Multiple benefit criteria were scored and then summed for each project. Criteria included water quality, property protection, habitat and biological integrity, implementation constraints, and accessibility. Preliminary project cost estimates were developed based upon past project costs in the area. These costs were provided as a range to assist with future planning efforts and budget considerations. In some circumstances, BMP retrofit projects were combined with stream restoration projects if the projects were geographically close to each other and would provide a compounded benefit when combined.

From this list of ranked projects, a capital improvement plan for future projects (Section 5.1) was developed with the assumption that the County would work to implement the most highly prioritized projects (if feasible) according to District guidance. The projects vary in range of cost and potential construction time. This plan was created to allow the County some flexibility in their implementation and to address the most heavily impacted areas in the watershed first. Subwatersheds identified as non-priority in this WIP are areas where future study must be conducted to better assess the watershed conditions before further projects can be recommended.

2.0 Watershed Condition

Forsyth County streams drain into one of two major river basins: the Chattahoochee River basin to the southeast and the Coosa River basin to the northwest. The Big Creek Watershed is part of the Chattahoochee River basin, which flows south toward the Gulf of Mexico and also drains portions of Alabama and Florida. Sixty percent of the Big Creek Watershed is located in Forsyth County. The entire Big Creek Watershed encompasses over 99 square miles from its headwaters in the City of Cumming within Forsyth County to its confluence with the Chattahoochee River downstream of Forsyth County (Figure 1). In addition to Forsyth County, the Big Creek Watershed is located in several other jurisdictions including Cherokee and Fulton Counties, as well as the Cities of Milton, Alpharetta, Cumming, Roswell, and Johns Creek. Due to the large number of municipalities that occur in the Big Creek Watershed, communication and coordination between jurisdictions is essential to address watershed problems holistically.

Recently, the Cities of Roswell and Alpharetta have developed projects for watershed improvement. In Roswell, the Big Creek Wetlands Enhancement Project and Trail was completed in 2006 through a grant from the United States Environmental Protection Agency (USEPA). This watershed improvement project occurred in a City-owned park along Big Creek with elements including a boardwalk walking trail, open space for recreation, preservation of existing wetlands and construction of new wetlands, a forebay, and a detention pond for stormwater treatment. The City of Alpharetta has implemented a watershed improvement project known as the Big Creek Greenway, which provides protection to portions of the Big Creek riparian zone. This greenway includes a multi-use trail that follows Big Creek through the City of Alpharetta. The City of Roswell is planning to connect to the trail at the border of the two cities. Forsyth County has also begun to develop a design plan to extend the trail from McGinnis Ferry Road to Bethelview Road in Forsyth County. Issues related to prior property access logistics, rights-of-way, and land preservation must be addressed before implementation. The County could potentially leverage efforts and support for the trail project to also include watershed improvement elements such as stream restoration or stormwater BMP construction.

In addition to reviewing other projects in the Big Creek Watershed, it is also critical to study current watershed conditions for the portion of the Big Creek Watershed that is located in the County's jurisdiction. Prior to any decisions regarding watershed improvement project implementation, the County should identify problem areas in order to determine if (and where) watershed improvement projects are necessary.

2.1 Urban Impacts on Watershed Conditions

The Big Creek Watershed is located in the southern portion of the County. Forsyth County has been undergoing extremely rapid growth, and over the last 5 years the County has been one of the 5 fastest growing counties in the United States. In general, this type of growth has decreased the amount of forested and agricultural land and increased the amounts of low- and medium-density residential and commercial land use.

Along with more intense land uses, impervious cover also increases. As impervious cover increases in a watershed, hydrologic conditions in stream channels are altered, leading to increased stormwater pulses, sediment transport, and bank erosion. While "total impervious cover" measures all impervious areas associated with a type of land use, "effective impervious cover" is used by the District as a measure of land areas where stormwater runoff drains directly into streams and is not detained or treated in structural BMPs. Effective impervious cover is, in general, more correlated with detrimental impacts to biological and water quality.

In addition to impacts caused by impervious cover, construction activities associated with development can also negatively impact streams. Without proper stormwater controls, construction activities can lead to increased water quality impacts due to sedimentation and nonpoint source runoff.

Since the WAMP was completed in 2000, the County has implemented activities to prevent stream degradation, including stream monitoring, stormwater collection system and outfall inspections, adoption of appropriate design specifications for BMPs, substantial revisions to their stormwater and floodplain ordinances, enforcement of these ordinances, and public education. These activities can prevent further stream degradation and provide stormwater controls in recently developed areas. However, there are also existing problems that are likely caused by outdated stormwater controls and past stream alterations. Thus, the County can implement watershed improvement projects to address existing problem areas in the watershed.

2.2 Streams Listed in the Georgia 305(b) Report

Section 305(b) of the Clean Water Act requires that states develop and institute a biannual monitoring and reporting program that describes water quality conditions of state waters. This report, known as the 305(b) report, provides an assessment of surface-water quality as supporting, partially supporting, or not supporting a designated use. Table 1 provides a summary of the 305(b) report stream status for the Big Creek Watershed within Forsyth County and the City of Cumming. Orr Creek is listed for fecal coliform and copper violations and is located in the City of Cumming. Big Creek is listed as partially supporting its designated use due to fecal coliform and copper violations. Copper violations were likely caused by point source discharges that are being addressed. The County is currently compiling monitoring data to support a request that Big Creek be delisted for the copper violations. The potential origins of the fecal coliform pollution include urban runoff and nonpoint sources.

TABLE 1
Big Creek Watershed Streams Listed in Georgia 305(b) Report [a]
Big Creek Watershed Improvement Plan

Watershed/Stream	Water Use Classification	Criterion Violated [b]	Evaluation	Evaluated Causes [c]	Stream Miles	303(d) Status [d]
Big Creek (headwaters to Cheatham Creek)	Fishing	FC, Cu	Partially Supporting	UR, I2	3	3,3
Kelly Mill Branch (headwaters to Orr Creek)	Fishing	FC	Partially Supporting	UR	2	3
Orr Creek (Upstream of Castleberry Rd (Tyson Foods) to Big Creek)	Fishing	FC, Cu	Not Supporting	NP	3	3,3

Source: GAEPD, January 2006a.

[a] Note that, as acknowledged in the Georgia 305(b) report, the data used to develop these lists are not rigorously screened and/or subjected to standard quality control protocol for use in this manner.

[b] FC = fecal coliform bacteria; Cu = copper

[c] UR = urban runoff/urban effects; I2 = residual from industrial source; NP = nonpoint sources/unknown sources

[d] ”3” Indicates area where a Total Maximum Daily Load (TMDL) has been developed

2.3 Existing Subwatershed Conditions

The headwaters of Big Creek originate within the City limits of Cumming, which is a rapidly urbanizing region. Along its length in Forsyth County, Big Creek is crossed by numerous roadways including Highway 400, McGinnis Ferry Road, Majors Road, McFarland Road, Atlanta Highway (Highway 9), and Bethelview Road. In Forsyth County, major tributaries to Big Creek include (from upstream to downstream): Kelly Mill Branch, Cheatham Creek, Bentley Creek, and Bagley Creek.

In order to assess differences in land use patterns, the Big Creek Watershed was divided into 19 subwatersheds (Table 2, Figure 2). Each subwatershed represents drainages associated with tributaries of Big Creek. Subwatersheds were characterized using GIS-based data from Forsyth County and publicly available land use coverages and geographic information (Figures 3 to 5). The GIS-based procedure was used to identify areas with high population density and intensive land uses. In addition, water quality monitoring results were used to highlight current or emerging trends in water quality impairment and aid in the identification of impacted reaches. GIS data, land use from 2003, and population density from 2005, were tabulated for each subwatershed as shown in Table 2 and Figures 2 and 3. Table 2 lists effective impervious cover for each subwatershed, as calculated using the 2003 land use data from the County and average impervious cover for each land use type from the Atlanta Regional Commission.

TABLE 2
Subwatersheds in the Big Creek Watershed
Big Creek Watershed Improvement Plan

Subwatershed Code	Receiving Waters	Effective Impervious Cover	Pop. Density Range (persons per square mile)	Dominant Land Use	Wetlands and/or Extensive Floodplains
Substantially Impacted Subwatersheds (Impervious Cover > 10%)					
BC05	Big Creek	18%	850 to 950	Industrial	Yes-Floodplains
KM02	Kelly Mill Creek	16%	850 to 950	Institutional/Residential	No
BC01	Big Creek	15%	750 to 850	Industrial/Residential	Yes-Floodplains
CN01	Caney Creek	12%	950 to 1250	Residential/Agriculture	No
SB01	Sawmill Branch	11%	750 to 850	Residential/Forest	Yes-Floodplains
BT03	Big Creek Tributary	11%	500 to 650	Residential/Industrial	No
BG01	Bagley Creek	11%	500 to 650	Agriculture/Residential	No
Other Subwatersheds (Impervious Cover ≤10%)					
BT01	Big Creek Tributary	10%	500 to 650	Residential/Agriculture Industrial	Yes-Floodplain
KM01	Kelly Mill Creek	10%	950 to 1250	Residential/Institutional	No
BN01	Bentley Creek	10%	750 to 850	Residential/Forest	Yes-Wetlands and Floodplain
BT02	Big Creek Tributary	9%	500 to 650	Residential/Forest	No
CH03	Cheatham Creek	8%	750 to 850	Agriculture/Residential	Yes-Floodplains
CH02	Cheatham Creek	8%	500 to 650	Residential/Forest	Yes-Floodplains
CB01	Cobb Creek	8%	500 to 650	Residential/Agriculture	Yes-Floodplains
BC03	Big Creek	8%	750 to 850	Residential/Forest	Yes-Floodplains/Wetlands
BC02	Big Creek	8%	850 to 950	Residential/Forest	Yes-Floodplains
BC04	Big Creek	7%	650 to 750	Residential/Agriculture	Yes-Floodplains
CH01	Cheatham Creek	7%	500 to 650	Agriculture/Residential	No
HR01	Harris Creek	6%	500 to 650	Agriculture/Residential	No

13 Figure 4

Population Density

Figure 5

Effective Impervious Cover

2.3.1 Priority Subwatersheds

Within the Big Creek Watershed, subwatersheds BG01, BT03, SB01, CN01, BC01, KM02, and BC05 have an effective impervious cover greater than 10 percent, which is defined by the District as being a substantial impact (Table 2). These subwatersheds will be classified as priority where projects could have the greatest potential benefit. However, KM02 and BC01 will not be included as priority areas due to their location within the City of Cumming. Because these subwatersheds are already developed, land use and impervious cover are not as likely to dramatically change over the next 10 to 20 years. Thus, these subwatersheds are most appropriate for implementation of stream restoration projects in conjunction with BMP retrofits. Though other subwatersheds have effective impervious cover of 10 percent or less, some of these subwatersheds, for example HR01 and CB01, are experiencing urban growth and will likely become priority areas in the near future. Specific information about each priority subwatershed is listed below.

2.3.1.1 Big Creek (BC05)

This subwatershed has the highest effective impervious cover (18 percent) of any subwatershed in the Big Creek Watershed. Land uses are intensive and include mainly industrial areas with many roadways. Population densities are relatively high with approximately 750 to 850 persons per square mile. Watershed improvement activities in this subwatershed would be most effective if they reduced additional storm inputs to the system through BMP retrofitting and improvements. Riparian buffer and connectivity improvement to existing wetland corridors in the system would help dissipate large storm events and provide an opportunity for sediment to settle out of the system. Bank and channel improvements may be best executed on a reach-by-reach basis. Efforts at improving these elements may be unsuccessful if not conducted in concert with reductions in upstream storm flows and sediment inputs due to the high-flow events seen in this portion of the Big Creek Watershed.

2.3.1.2 Caney Creek (CN01)

Caney Creek flows into Big Creek downstream of the southern County boundary. However, the majority of the subwatershed (CN01) occurs within the County. This subwatershed has substantial (12 percent) effective impervious cover. This is also the most densely populated area in the Big Creek Watershed (950 to 1250 persons per square mile). BMP retrofitting and general reductions in impervious cover within the subwatershed would reduce further degradation of in-channel habitats and would decrease storm flow impacts. Bank and channel stabilization and riparian improvements could be successful in this subwatershed if combined with successful stormwater management.

2.3.1.3 Sawmill Branch (SB01)

The developed portion of Sawmill Branch (SB01) is primarily residential, though a large section of the subwatershed is currently undeveloped. The effective impervious cover is substantial (11 percent) in the subwatershed. Population densities are relatively high with approximately 750 to 850 persons per square mile. An extensive floodplain is associated with the mainstem of Sawmill Branch, providing opportunities for riparian and in-stream improvements, including bank and channel stabilization. BMP retrofits of facilities associated with subdivisions and institutional facilities should be completed to reduce channelization impacts and erosional forces associated with storm flows.

2.3.1.4 Big Creek Tributary (BT03)

The portion of the Big Creek watershed in BT03 is characterized by residential and industrial development, and substantial effective impervious cover (11 percent). The population density of this subwatershed remains low with approximately 500 to 650 persons per square mile. Stormwater management in the subwatershed is primarily in the form of detention and retention ponds less than 10 to 15 years old. This subwatershed has a limited floodplain and would be best served by riparian restoration where possible, BMP retrofitting to decrease storm flow intensity, and in-stream habitat improvements.

2.3.1.5 Bagley Creek (BG01)

Bagley Creek, comprising both BG01 and BT02, enters Big Creek in the southeastern portion of the County and drains primarily residential and agricultural lands adjacent to the Highway 400 corridor. The effective impervious cover for BG01 is substantial (11 percent), due to the inclusion of Highway 400. Due to the residential and agricultural nature of the land uses, population densities remain low with approximately 500 to 650 persons per square mile. Opportunities for improvement of the subwatershed include buffer enhancement and stream restoration/habitat improvement. BMP retrofits in subdivisions and animal waste and facility management on agricultural lands would also serve to improve water quality and storm flow impacts.

2.3.2 Other Subwatersheds

The effective impervious cover for subwatersheds KM01 and KM02 is moderate to substantial for Big Creek at 10 to 16 percent, and this area is one of the most densely populated in the Big Creek Watershed. Orr Creek is 303(d)-listed for fecal coliform and dissolved copper violations. Kelly Mill Creek is also 303(d)-listed for fecal coliform violations.

The majority of subwatersheds BC01 and BC02 are located in the sewer service area of the City of Cumming, and urbanization has played a large role in water quality issues and stream changes. The effective impervious cover is moderate to substantial, ranging from 8 to 15 percent. This upper reach of Big Creek is 303(d)-listed for dissolved copper and fecal coliform bacteria, and analysis of collected data has shown water quality has been impacted by point and nonpoint source pollutants.

The effective impervious cover for Bentley Creek (BN01) is moderate (10 percent) for the Big Creek Watershed. Land use types are predominantly residential, with some agricultural, public/institutional, and forested lands. Population densities are moderate, at approximately 750 to 850 persons per square mile.

The effective impervious cover in the CH01, CH02, and CH03 subwatersheds is also relatively low (7 to 8 percent). Similar to Harris and Cobb Creeks, the Cheatham Creek subwatersheds (especially in the headwaters) are not as developed as other parts of the Big

Creek Watershed have become in the last 5 to 10 years; however, they are expected to sustain a higher proportion of new development in the coming years.

Land use within the portion of the Big Creek Watershed in BC03 and BC04 is primarily low- to medium-density residential with a relatively low effective impervious cover of 7 to 8 percent. Based on environmental monitoring data since 1999, the habitat, fish community, and benthic macroinvertebrate community are degraded, with the primary impacts from high stormwater velocities resulting in increased erosive forces, sedimentation, and probable increases in chemical inputs. Previous modeling of nutrient transport (included in the WAMP) has shown that this reach of Big Creek receives fewer nutrients than the upstream reach. This is likely attributable in part to the smaller size of the subwatershed, but also to the shift in land use from urban in the upstream segment to low-density residential development that is predominant in this segment.

Harris and Cobb Creeks (HR01 and CB01) are not as developed as other parts of the Big Creek Watershed, but they are expected to sustain a higher proportion of new development in the coming years. As a result, effective impervious cover in these areas is relatively low for the Big Creek Watershed (6 to 8 percent), but has increased since 2005 due to new developments that have mixed uses with residential and commercial components.

3.0 Potential Projects

As described in Section 2.0, the Big Creek Watershed was divided into 19 subwatersheds with drainage areas ranging from 0.73 to 5.38 square miles (Figure 2). Subwatersheds were delineated to provide a more manageable size for selecting, organizing, presenting, prioritizing, and implementing projects recommended in this WIP. Priority subwatersheds were also identified where the effective impervious cover was greater than 10 percent.

Recommended projects improve water quality in two different ways. These project types include: (1) BMP retrofitting, where projects are focused on infrastructure improvements to increase stormwater capacity and treatment and (2) stream restoration, where projects involve natural channel design techniques to improve the current condition of the physical stream channel in order to provide appropriate habitat for aquatic organisms, decrease sedimentation, and increase stormwater filtration in riparian areas. Each of the two project types is critical to overall watershed improvement.

Projects were identified based on a desktop analysis using GIS databases from the County. After projects were identified, field teams were sent out to verify field conditions at the identified project locations and to recommend project techniques to be used for each project. Based on the two project types, this section discusses specific information about project identification and selection and recommended project techniques, and potential projects that will be evaluated for costs and benefits in Section 4.0.

3.1 BMP Retrofit Projects

As described in the County's SWMP, procedures are in place to require appropriate structural BMPs for new development. Thus, this WIP addresses existing problems where existing structures are either not functioning properly or must be retrofitted to improve storage and/or treatment capacity. Specifically, this WIP identifies opportunities to increase stormwater detention/treatment and minimize erosion and sedimentation due to ineffective stormwater control structures.

Slowing and treating runoff flow is the primary objective of a typical BMP. Retrofitting or removing outdated BMP infrastructure helps to maintain adequate treatment capacity and prevent undesirable erosion around ineffective structures. Detention ponds and associated structures (such as inlets and outfalls) are the primary types of BMP that can be retrofitted to improve functioning. In many instances, older detention ponds cannot contain the proper volume of stormwater within their basins. This may be due to increased impervious cover in the basin, sedimentation in the ponds or other structures, and/or disrepair or maintenance issues.

3.1.1 BMP Retrofit Project Identification and Selection

The County maintains a BMP inventory that is linked to a GIS database. From this database, 39 of over 300 detention ponds in the Big Creek Watershed were selected for further investigations to potentially improve stormwater retention/detention and treatment (using retrofitting techniques). Ponds were selected based on whether the outlet pipe size was greater than 36 inches and whether they met at least one of the following criteria:

- Built prior to the year 2000 (resulted in ponds built between 1989 and 1999)
- Located in areas of mainly residential land use
- Drain directly to Big Creek
- Availability of County staff input and knowledge

Of the original 39 detention ponds, 29 were selected for field verification if: (1) adequate information could not be determined from the GIS database or (2) the ratio of stormwater drainage area to detention pond capacity was high compared to the other recommended ponds because a high ratio indicates that the BMP may not be properly sized for the drainage area.

The field reconnaissance identified BMPs that were functioning properly, as well as BMPs with potential problems in functioning and design. Of the 39 initial potential BMP retrofit projects, 21 projects were identified as requiring retrofits and selected for evaluation in the cost and benefit analysis in Section 4.0. Just over half of the 21 projects were located in BC05 and CN01, which are the two priority subwatersheds with the highest impervious cover. In many instances, BMP structures were providing inadequate stormwater capacity and were (1) designed for use during construction and then abandoned after serving their build-out purpose (Photo 1), (2) in-stream features actively contributing to degraded channel conditions (Photo 2), or (3) improperly built or maintained to serve a useful purpose (Photo 3). Recommendations for these projects are summarized in Table 3. Recommended project techniques are discussed in the following section. Project locations are shown in Figure 6.

Photo 1

Photo 2

Photo 3

TABLE 3
BMP Retrofit Projects for Evaluation
Big Creek Watershed Improvement Plan

Subwatershed	ID	Location	Structure Type	Input Pipe Resizing	Structure Removal	Pond Redesign	Outfall Retrofitting	Downstream Channel Stabilization
Priority Subwatersheds (Impervious Cover > 10%)								
Big Creek (BC05)	BMP07	Windward Chase-1235 Old Alpharetta Rd.	OCS/detention pond	Yes				
	BMP08	Windward Chase-1220 Old Alpharetta Rd.	OCS/detention pond				Yes	
	BMP10	Chatsworth Subdivision-3215 Munsey Ct.	OCS		Yes	Yes	Yes	
	BMP11	Windrose Subdivision-2340 Rosewalk	OCS/small detention area			Yes		
	BMP12	Windward Business Center-1015 Windward Ridge	OCS/detention pond			Yes	Yes	
	BMP13	Windward Business Center-1030 Windward Ridge	OCS/manmade channel		Yes	Yes	Yes	
	BMP14	Chatsworth Subdivision-Bristol Ln. cul-de-sac.	OCS/detention pond	Yes		Yes	Yes	
	BMP19	1200 Bluegrass Lakes	In-line wet detention pond receiving stream waters and numerous stormdrain outfalls					Yes
	BMP20	1455/1465 Bluegrass Lakes	Dry detention pond with presumed sand filter					Yes
	BMP24	955 McFarland-400	48” corrugated metal pipe (CMP) OCS at detention pond	Yes		Yes	Yes	Yes
Caney Creek (CN01)	BMP09	Springmonte-2640 Springmonte Pl	Perennial wet pond				Yes	

TABLE 3
BMP Retrofit Projects for Evaluation
Big Creek Watershed Improvement Plan

Subwatershed	ID	Location	Structure Type	Input Pipe Resizing	Structure Removal	Pond Redesign	Outfall Retrofitting	Downstream Channel Stabilization
Other Subwatersheds (Impervious Cover ≤10%)								
Big Creek (BT01)	BMP28	Highland Ridge Office Park	OCS 60" CMP at detention pond			Yes	Yes	
Big Creek (BT02)	BMP02	Shiloh Farms	In-line OCS tower and berm near Shiloh Farms amenities			Yes	Yes	
	BMP03	Shiloh Farms	In-line OCS tower and berm adjacent to Shiloh Rd. E.			Yes	Yes	
Big Creek (CH02)	BMP15	Sawnee View Farms	Inline wet detention pond with siphon drainage to stream				Yes	
Big Creek (BC02)	BMP17	Bethelview Downs	Three in-line wet detention ponds. Two ponds drain to third pond.				Yes	Yes
	BMP26	Bethel Limited	OCS 66" reinforced concrete pipe (RCP) at detention pond			Yes	Yes	
Bentley Creek (BC04)	BMP05	Dressage	In-line OCS and berm with shallow retention area.			Yes	Yes	
	BMP01	Oakmont Subdivision-4695 Oakmont Bend	OCS Tower with V-Notch		Yes			
	BMP16	Dressage	Wet detention pond in a small intermittent stream drainage, includes aerator and outfall is a shallow concrete sluice.			Yes	Yes	
	BMP21	Publix-Midway Shopping Center	Baffled wet detention pond with 48" outfall and 24" input orifice				Yes	Yes

Figure 6

BMP Retrofit Project Locations

3.1.2 BMP Retrofit Project Techniques

Based on the GIS and field analysis, the following BMP retrofitting techniques were identified as potential approaches for watershed improvement projects: input pipe resizing, structure removal, outfall retrofitting and downstream channel stabilization, and detention pond redesign. Each technique is described in the following subsections.

Input Pipe Resizing

When development in a drainage area increases, changes to the hydrologic conditions can influence storm flows to a BMP. As a result, some detention pond inputs are undersized which decreases the effectiveness of the pond during heavy rain events. After further study, input pipes may be replaced to allow for greater stormwater capacity in the pond, which can increase efficiency.

Structure Removal

Some stormwater control structures are no longer functioning to control stormwater as originally intended due to changes in the drainage area. In addition, these structures may actually contribute to degraded stream conditions by increasing localized erosion and sedimentation. Removal of these ineffective structures can prevent further degradation in the drainage area. For example, a common scenario is an in-stream structure along a perennial stream. In this scenario, it is often appropriate to remove the outdated in-line structure and redesign another BMP to be located outside of the stream buffer. However, studies must be completed to fully understand the consequences of structure removal for downstream reaches. Successful structure removal may also require localized stream restoration, in addition to BMP relocation.

Outfall Retrofitting and Downstream Channel Stabilization

Outfall retrofitting is a useful and potentially cost-effective tool for increasing stormwater capacity and treatment effectiveness of existing stormwater BMPs. Retrofitting of outfalls can include adding debris screens, adding riprap and gravel at inlets, decreasing inlet size or installing v-notch inlets, and/or increasing outlet height. Outfall retrofitting can also include improving outflow pipe location, angle, and design to reduce erosive forces and flashiness of flows. However, retrofitting the outfall is limited by the size of the pond it serves and may require a retrofit combining several elements. In some cases, proper stabilization such as riprap can be used at the outfall to prevent excessive erosion. This downstream channel stabilization can often be paired with outfall retrofitting to improve BMP functioning.

Detention Pond Redesign/Reconstruction

Existing detention ponds can be redesigned and reconstructed to increase detention capacity, provide increased stormwater treatment, and provide other benefits such as wildlife habitat and aesthetic appeal. This type of retrofit can be accomplished by increasing bank heights, deepening ponds, removing old sediments, and installing baffles. These retrofits are generally more expensive solutions than retrofitting an outfall. Also, expanding the footprint of the pond is not always possible due to adjacent properties. Often this retrofit can be avoided if a BMP is properly maintained.

3.2 Stream Restoration Projects

According to the District, the ultimate goal of a WIP is to restore streams to meet their designated uses by improving water quality, ecology, and the condition of the stream channel. Natural channel design and bioengineering techniques are recommended to restore streams to an equilibrium that supports a diverse and healthy aquatic community.

3.2.1 Stream Restoration Project Identification and Selection

Stream restoration reaches were identified based on subwatersheds that had moderate to substantial levels of impervious cover, as defined in Section 2.0. To maximize project feasibility, reaches were selected in areas that had a mostly undeveloped corridor extending at least 100 feet on either side of the stream channel. Most reaches were identified in priority subwatersheds. A total of 10 stream reaches were initially identified for further study of the potential for stream restoration and/or riparian enhancement. Following the identification of potential stream restoration projects, a field crew verified the condition and location of these reaches at all road crossings in or near the project reaches.

The field reconnaissance identified some stream reaches that appeared to be stable, but most showed signs of degradation. Of the 10 initial potential stream restoration projects, 8 projects were identified for potential restoration and selected for evaluation in the cost and benefit analysis in Section 4.0. Seven of these projects were identified in priority subwatersheds. Sedimentation and erosion were problems found at many reaches (Photos 4, 5, 6). In addition, reaches often had inadequate vegetative buffers (Photo 7). All of these problems decrease channel stability and available habitat to support robust aquatic communities. Recommendations for these projects are summarized in Table 4. Recommended project techniques are discussed in the following section. Project locations are shown in Figure 7.

Photo 4

Photo 5

Photo 6

Photo 7

TABLE 4
Stream Restoration Projects for Evaluation
Big Creek Watershed Improvement Plan

Subwatershed	ID	Reach Length (feet)	Channel Restoration	Channel Enhancement Structures	Wetland Restoration	Other Buffer Enhancement	Riparian Preservation	Possible Park Inclusion
Priority Subwatersheds (Impervious Cover > 10%)								
Big Creek (BC05)	SRP04	2730	Yes	Yes			Yes	Yes
	SRP03	3296		Yes			Yes	Yes
Caney Creek (CN01)	SRP07	6244		Yes			Yes	
Sawmill Branch (SB01)	SRP08	7482		Yes	Yes	Yes	Yes	
Big Creek Tributary (BT03)	SRP02	5675	Yes	Yes			Yes	
	SRP01	5154	Yes	Yes			Yes	
Bagley Creek (BG01)	SRP06	13165	Yes					
Other Subwatersheds (Impervious Cover ≤10%)								
Big Creek Tributary (BT01)	SRP05	3212	Yes				Yes	Yes

Figure 7

Stream Restoration Project Locations

3.2.2 Stream Restoration Project Techniques

The following techniques were evaluated for each of the potential stream restoration reaches: structures for stream bank/channel stabilization, stream channel restoration and preservation, and wetland restoration and riparian buffer enhancement. These techniques can be used in combination or individually to enhance stream habitat and improve water quality. Each technique is discussed further in the following subsections. See Appendix A for more information about stream channel restoration.

Structures for Stream Bank/Channel Stabilization

A common factor along most degrading streams is the erosion of stream banks and the introduction of sediment to stream habitat from this erosion. Bank stabilization is an approach that typically reduces the bank slope so that it is less susceptible to the erosive force of storm events. In addition to slope reduction, bank stabilization often involves the placement of vegetation, geotextiles, and/or rock to help protect the bank from direct impacts from flowing water.

Channel incision or channel cutting are additional types of impacts common to degraded streams. Channel stabilization is employed to counteract these impacts. Installing grade control structures, in the form of an upstream-facing V or a W, is the primary method for improving bank stability by diverting strong flows to the middle of the channel and away from banks.

Degraded streams are often characterized by having monotypic, uniform habitat that provides little cover or structure for organisms. Directly adding structure, in the form of boulders, j-hooks, and cross vanes helps create riffle and pool diversity and provides direct cover. Improving or increasing riparian vegetation also helps to provide habitat and cover for aquatic organisms.

Stream Channel Restoration and Preservation

In many cases, streams have been impacted to an extent where bank and channel stabilization techniques alone may not be effective. One of five levels of stream improvement can be used. Some of these levels incorporate the structures described in the previous subsection. Level 1 requires the highest amount of work and Level 5 the lowest. See Appendix A for a schematic representation of each restoration level. The improvement levels and corresponding descriptions are as follows:

- Level 1: Re-establish channel on previous floodplain using relic channel or construction of a new bankfull discharge channel. Design new channel for dimension, pattern, and profile characteristic of stable form. Fill in existing incised channel to the new floodplain elevation.
- Level 2: Construct a new bankfull discharge channel in the existing channel, at a higher elevation. Stabilize and vegetate banks.
- Level 3: Construct a new bankfull discharge channel in the existing channel, at the existing bed elevation. Stabilize and vegetate banks.

- Level 4: Perform spot repair, including erosion control measures over shorter stream segments.
- Level 5: Preserve existing relatively stable channel and riparian area.

Wetland Restoration and Riparian Buffer Enhancement

Wetlands present in the stream buffer can act as filters to prevent pollutants and pulses of stormwater from entering the stream. In the same manner, undisturbed vegetated riparian buffers that are at least 75 feet wide help protect streams from peak runoff flows and help reduce chemical inputs to streams through infiltration. Wetlands and other stream buffers can be enhanced with the introduction of native vegetation and the removal of exotic and invasive species. Buffer areas disturbed during other enhancement and alteration activities associated with restoration can be replanted with native vegetation.

Possible Park Inclusion

By incorporating walking trails and other passive recreational opportunities into a stream restoration project, public support and support from multiple County departments can contribute to project momentum. Parks can provide an additional beneficial use for large riparian areas, while allowing them to remain in a natural, vegetated state to act as a buffer for stream impacts. Thus, parks should be considered as a design element when planning stream restoration projects.

4.0 Cost and Benefit Analysis

Watershed improvement projects should be prioritized to provide the greatest benefit to the stream ecosystem and water quality. However, a project must also fit within the County's budget to be feasible and successful. When projects are being prioritized, costs and benefits should be compared to identify those that provide the most benefit for a given cost. This section provides an overview of the methods used to estimate project costs and to quantify project benefits. A summary of findings is also provided to show the cost to benefit ratio of projects in priority subwatersheds.

4.1 Approach to Determine Estimated Project Costs

In order to identify projects that would provide the greatest benefit compared to cost, planning-level cost estimates were developed for both BMP and stream restoration projects. Estimates of land value were included only for stream restoration projects; no acquisition was included for BMP retrofits.

Using costs from other projects in the Atlanta area, a general range of costs for each project was developed. Due to the number of unknowns involved in the potential scope of these projects, a more defined cost for each of these projects can be achieved if the project is selected for implementation during detailed design. At the planning level used in this WIP, a cost range will provide the County with a tool to manage future budgets and projects.

4.1.1 BMP Retrofit Project Cost Estimating

Planning level cost ranges were developed for each project based upon the various types of implementation activities associated with BMP retrofit projects (Table 5). These cost ranges were further categorized according to the size of the BMP, as a larger BMP will require a greater level of effort. Engineering design, services during construction, and permitting were included in the estimated cost for each project. However, some construction elements were not applicable to all projects, depending on the recommended construction techniques. Construction elements were separated into general categories of work associated with each type of BMP retrofit activity. The majority of the retrofit activities were categorized under pipe installation/rehabilitation, earthwork (grading, dredging, excavation, etc.), or installation/modification of the outlet control structure (OCS). Mobilization and other incidental construction costs were also accounted for in all construction costs. Design and services during construction were calculated as 45 percent of the total construction cost. Permitting was a fixed cost that increased with the size of the BMP. A 20 percent contingency factor was added to the total cost of each project including construction and design. Based on costs from previous projects, the contingency factor was included to account for escalating construction and materials costs, as well as unforeseen elements of the project.

These cost estimates provide a basis for planning level project budgets, but further investigation will be necessary to more accurately determine the scope of the project.

TABLE 5
Basis for BMP Retrofit Project Cost Estimates
Big Creek Watershed Improvement Plan

Implementation Activity	Small BMP (less than 1 acre)		Medium BMP (1 to 3 acres)		Large BMP (greater than 3 acres)	
	Min	Max	Min	Max	Min	Max
Piping*	$5,000	$10,000	$10,000	$25,000	$25,000	$50,000
Earthwork*	$50,000	$75,000	$75,000	$150,000	$150,000	$300,000
Control structure installation*	$15,000	$30,000	$30,000	$45,000	$45,000	$60,000
Mobilization/Incidental Construction Costs	$100,000	$150,000	$150,000	$250,000	$250,000	$350,000
Engineering design & procurement (25%)**	$55,000	$78,750	$85,000	$136,250	$142,500	$215,000
Services during construction (20%)**	$44,000	$63,000	$68,000	$109,000	$114,000	$172,000
Permitting	$50,000	$50,000	$75,000	$75,000	$100,000	$100,000
Contingency (20%)†	$63,800	$91,350	$98,600	$158,050	$165,300	$249,400

*Cost estimates were developed based on the project-specific techniques, which may not necessarily include all the construction elements listed above.

**Percentages are applied to the total of the construction costs of each project.

†This percentage was applied to the sum of all aspects of the project including construction, engineering, services during construction, and permitting.

Stream Restoration Project Cost Estimating

A planning level cost estimate was developed for each stream restoration project based on historic project costs from the metropolitan Atlanta area. The project costs were based on restoration level (ranging from 1 to 5), the stream order, and the length of the project (Table 6).

The stream buffer and project length were used to calculate a project area. A stream buffer was assumed based upon the stream order, so that as the stream order increased, the buffer would also increase from the minimum buffer width of 75 feet. Using the project area, a cost for the land necessary to acquire the project was calculated. The majority of the areas adjacent to the identified stream restoration projects are on private property so land acquisition was an important factor in the project costs. A range for each project is provided due to the planning-level basis of these projects. Generally, as the length of the project increases, the cost per foot of the project decreases due to the economies of scale associated with these types of projects. On the other hand (and more obviously), the cost per foot of the stream restoration projects increases as the level of effort associated with the project increases. Similar to the BMP retrofit projects, the estimated costs of these projects include engineering, procurement, and permitting. The engineering, surveying, and permitting costs were based upon the level of effort and historical costs.

TABLE 6
Basis for Stream Restoration Project Cost Estimates
Big Creek Watershed Improvement Plan

	Restoration Levels 1 to 3 (channel redesign)		**Restoration Level 4** (structure installation)		**Restoration Level 5** (preservation and buffer enhancement)	
Implementation Activity	**Project Length 3,000 ft**	**Project Length 15,000 ft**	**Project Length 2,500 ft**	**Project Length 7,500 ft**	**Project Length 2,500 ft**	**Project Length 7,500 ft**
Survey	$3,000	$20,000	$3,000	$15,000	$3,000	$12,000
Design & Construction (per foot of project length)	$400 $380 $360*	$400 $380 $360*	$320	$320	$240	$240
Prelim Engineering & Permitting	$30,000	$30,000	$15,000	$15,000	$15,000	$15,000
Hydraulic & Hydrologic Modeling	$10,000	$50,000	$0	$0	$0	$0
Real Estate Acquisition (per acre of project area)	$20,000	$20,000	$20,000	$20,000	$20,000	$20,000

*Different costs are listed for each Restoration Level (Level 1 = $400, Level 2 = $380, Level 3 = $360)

4.2 Approach to Determine Estimated Project Benefits

This section outlines the process implemented to evaluate the benefit of each potential project by assigning a score based on 5 evaluation criteria, including water quality, property protection, habitat/biological integrity, implementation constraints, and accessibility. Table 7 lists the 5 evaluation criteria. BMP retrofit projects are scored for water quality, but not for habitat and biological integrity. Stream restoration projects are scored for habitat and benefit criteria, but not for water quality. Although water quality and habitat/biological integrity are both positively impacted by both BMP retrofit and stream restoration projects, the benefit scoring criteria were designed to focus on the primary functions of each project type. Each criterion has a score range from 0 to 5, with 0 being no benefit and higher scores showing increasing benefits. For water quality, property protection, and habitat/biological integrity, BMP retrofitting projects and stream restoration projects are ranked on different sub-criteria to better characterize the benefits of each project type, as shown in Table 6. The summed score for the 5 criteria is then used in conjunction with cost to compare and evaluate projects.

TABLE 7
Benefit Evaluation Criteria
Big Creek Watershed Improvement Plan

Benefit Evaluation Criteria	BMP Retrofit	Stream Restoration
Water Quality	X	
Property Protection	X	X
Habitat and Biological Integrity		X
Implementation Constraints	X	X
Accessibility	X	X

4.2.1 Water Quality

A primary goal of this WIP is to improve water quality in the Big Creek Watershed. Nonpoint source pollutants are known to be a primary source of water quality degradation in Forsyth County. County streams are most often included on the State's 303(d) list for fecal coliform violations due to nonpoint sources of pollution. In addition, bank erosion due to intense pulses of stormwater also lead to problems with sedimentation. Thus, BMP retrofit projects were assessed for water quality benefits on the basis of potential reduction in nonpoint pollutant loadings, which can be represented by sediment and fecal coliform concentrations. Sediment and fecal coliform were used as the water quality criteria for BMP retrofit projects due to the nature of these projects to detain stormwater. The drainage area to pond area ratio was used to score BMP retrofit projects because it provides a dimensionless value to represent how effectively the BMP can detain stormwater and provide water quality treatment. The score is based upon percent reduction in fecal coliform and TSS loading. No reduction earns a score of 0, and if the project has the highest possible percent reduction, the score is 5. The following ranges were used for the water quality benefit scores.

Sediment and fecal coliform reduction score for BMP retrofit projects:

- Drainage area to detention capacity area ratio less than 100 = 5
- Drainage area to detention capacity area ratio between 100 to 300 = 3
- Drainage area to detention capacity area ratio greater than 300 = 1

4.2.2 Property Protection

For BMP retrofit projects, property protection scores were calculated based on the ability of the proposed project to reduce downstream flooding. A BMP retrofit project can decrease stream flow volumes in a proportion that is directly related to how efficiently the BMP detains stormwater for a given drainage area. Thus, the ratio of drainage area to detention capacity area was used to score BMP projects for property protection. For stream restoration projects, scoring of this criterion was based on flood protection, or how well a project could reduce the immediate threat of erosion to structures located in the floodplain. The following ranges were used for property protection scoring:

Downstream channel flood protection score for BMP retrofit projects:

- Drainage area to detention capacity area ratio less than 100 = 5
- Drainage area to detention capacity area ratio between 100 to 300 = 3
- Drainage area to detention capacity area ratio greater than 300 = 1

Flood protection score for stream restoration projects:

- No risk to structures in floodplain = 5
- Mild risk to structures in floodplain = 3
- High risk to structures in floodplain = 1

4.2.3 Habitat and Biological Integrity

Habitat and biological integrity scores were based on how well a project could improve aquatic habitats. As seen in many urbanized watersheds such as Big Creek, the combination of historical channel alterations and more current land development lead to increased flows during storms, destroying aquatic habitat and stream integrity. Scores were calculated based on the ability of the proposed project to improve overall aquatic habitat conditions. A longer stream restoration reach is assumed to provide a greater amount of stream stability and valuable habitat to support a healthy biotic community. The following ranges were used for habitat and biological integrity scoring:

Habitat and biological integrity score for stream restoration projects:

- Linear feet of stream greater than 6,000 = 5
- Linear feet of stream between 4,001 and 6,000 = 4
- Linear feet of stream between 2,501 and 4,000 = 3
- Linear feet of stream between 1,001 and 2,500 = 2
- Linear feet of stream less than 1,000 = 1

4.2.4 Implementation Constraints

The implementation issues score focuses on circumstances that can affect project implementation schedules and budgets. The two components used for scoring are parcel ownership and environmental permitting. Each of the two components was given a score from 1 to 5, with an average then calculated to give an overall site constraint score.

If the project site consists of multiple parcels, then it was assumed that it would be more difficult to implement than a project consisting of fewer parcels. However, if the property is owned by the County, then property ownership was not considered a constraint.

The environmental impact of the project has a direct relationship on the ability to implement the project. A project with significant environmental impact may require extensive permitting, which may increase the cost and extend the time for a project. Existing BMPs that can be retrofitted are assumed to have no or minimal adverse environmental impacts. If the proposed BMP retrofit is located on a headwater stream segment, it may be covered by a US Army Corps of Engineers (USACE) Nationwide Permit (NWP), most likely NWP 43 for Stormwater Management Facilities. However, according to General Condition 26 in the NWP guidance, a project must obtain an individual permit if it requires an above-grade fill within a 100-year Federal Emergency Management Agency (FEMA) floodplain. Unless a project is a BMP retrofit without stream impacts, a stream buffer variance through the County and through GAEPD will also be required. Also, the National Wetlands Inventory (NWI) mapping of wetlands compiled by the federal government was compared with project locations. It is assumed that any project located within an NWI wetland will have significant environmental impact and is therefore assigned a score of zero.

Projects were assigned an implementation score based on the following ranges:

Parcel ownership and number for BMP retrofit and stream restoration projects:

- County parcel = 5
- 1 parcel = 3
- 2 or more parcels = 1

Potential USACE and GAEPD permitting for BMP retrofit and stream restoration projects:

- Upland BMP not located on stream = 5
- BMP located in stream or stream restoration that may be permitted using an NWP and stream buffer variance = 3
- BMP located in stream or stream restoration that may be permitted with a stream buffer variance, but does not qualify under an NWP = 1
- BMP or stream restoration that would impact an NWI wetland = 0

4.2.5 Accessibility

The accessibility score reflects the feasibility of staging construction near the project site. If the project is difficult to reach with a vehicle, then construction staging becomes more involved and may require temporary road construction in undeveloped areas. The accessibility of the site to a road or parking lot was scored as follows:

- Project site is easily accessible by both foot and vehicle = 5
- Project site is easily accessible by foot, but not by vehicle = 3
- Project site is not easily accessible for foot or by vehicle = 1

4.3 Benefit and Cost Analysis

Using the evaluation criteria scores described in Section 5.2 and the minimum estimated project cost described in Section 5.1, each project was scored based on a ratio of the cost to benefit. See Appendix B for a complete list of evaluated projects and benefit scores for each evaluation criterion. When calculating the cost/benefit ratio for the BMP retrofit and stream restoration projects, an average cost was derived from the calculated range of costs. This average cost was used to develop the ratios in order to allow for easier ranking of the projects by priority. The prioritization of the projects was developed as a guidance tool for planning future watershed improvement activities. As a result, the cost range is taken into consideration after prioritizing the projects and sorting them into a capital improvement plan.

All evaluated projects are summarized in Table 8. Projects are also summarized in Appendix B. These projects were evaluated based on their cost to benefit ratio to determine which projects could provide the watershed with the most benefit for a given cost. BMP retrofit projects had benefit scores ranging from 10 to 17 and average costs ranging from $287,200 to $1,152,750. Stream restoration projects had benefit scores ranging from 9 to 13 and average costs ranging from $571,025 to $3,780,844. Benefit scoring for stream restoration projects were generally lower due to criteria for implementation constraints and accessibility. Cost estimates for stream restoration projects were generally higher than for BMP retrofit projects. This outcome was expected due to the less developed, more environmentally sensitive location of stream restoration projects compared to the already developed locations of BMP retrofit projects. However, both stream restoration and BMP retrofit projects are critical to improving watershed conditions and should both be considered for implementation. Stream restoration project scores should be compared to other stream restoration projects to determine the best projects.

Up to this point in the document, projects have been evaluated based on (1) location in a priority subwatershed and (2) a relatively low cost to benefit ratio. In the next section, projects will also be evaluated to determine if they can be grouped with other BMP retrofit projects and stream restoration projects in the same drainage area. This will increase the likelihood of project success for stream restoration projects.

TABLE 8
Cost and Benefit Analysis
Big Creek Watershed Improvement Plan

Subwatershed	ID	Project Type	Benefit Score	Average Estimated Cost	Cost:Benefit Ratio
Priority Subwatersheds (Impervious Cover > 10%)					
Big Creek (BC05)	BMP07	BMP retrofit	11	$287,200	26,109
	BMP10	BMP retrofit	13	$343,650	26,435
	BMP12	BMP retrofit	17	$452,400	26,612
	BMP14	BMP retrofit	16	$452,400	28,275
	BMP13	BMP retrofit	15	$443,700	29,580
	BMP08	BMP retrofit	11	$356,700	32,427
	BMP11	BMP retrofit	11	$413,250	37,568
	BMP24	BMP retrofit	11	$465,450	42,314
	BMP19	BMP retrofit	12	$674,250	56,188
	SRP04	Stream restoration	9	$571,025	63,447
	BMP20	BMP retrofit	17	$1,087,500	63,971
	SRP03	Stream restoration	9	$702,800	78,089
Caney Creek (CN01)	BMP09	BMP retrofit	15	$787,350	52,490
	SRP07	Stream restoration	11	$786,258	71,478
Sawmill Branch (SB01)	SRP08	Stream restoration	13	$1,759,196	135,323
Big Creek Tributary (BT03)	SRP02	Stream restoration	12	$2,377,441	198,120
	SRP01	Stream restoration	10	$2,549,846	254,985
Bagley Creek (BG01)	SRP06	Stream restoration	13	$3,780,844	290,834

TABLE 8
Cost and Benefit Analysis
Big Creek Watershed Improvement Plan

Subwatershed	ID	Project Type	Benefit Score	Average Estimated Cost	Cost:Benefit Ratio
Other Subwatersheds (Impervious Cover ≤10%)					
Big Creek Tributary (BT01)	BMP28	BMP retrofit	16	$1,244,100	77,756
	SRP05	Stream restoration	11	$1,240,881	112,807
Big Creek Tributary (BT02)	BMP03	BMP retrofit	14	$769,950	54,996
	BMP02	BMP retrofit	13	$1,244,100	95,700
Caney Creek (CH02)	BMP15	BMP retrofit	14	$739,500	52,821
Big Creek (BC02)	BMP26	BMP retrofit	17	$1,244,100	73,182
	BMP17	BMP retrofit	11	$1,152,750	104,795
Big Creek (BC04)	BMP05	BMP retrofit	15	$1,244,100	82,940
	BMP01	BMP retrofit	10	$356,700	35,670
	BMP16	BMP retrofit	17	$1,174,500	69,088
	BMP21	BMP retrofit	16	$1,178,850	73,678

*Average estimated cost is the average of the minimum and maximum cost

5.0 Recommendations

Each subwatershed was evaluated to determine if watershed improvement projects would be effective for improving stream conditions and preventing degradation. A summary of recommendations for each subwatershed is provided in Table 9 based on effective impervious cover as a representation for disturbance in the subwatershed. Two-page fact sheets summarizing project locations, field assessments, and preliminary recommended project types are provided for each project in Appendix C.

Five priority subwatersheds that occur in the County (but not in the City of Cumming) were identified in Section 2.0. Within these five priority subwatersheds, there are two subwatersheds with 16 and 18 percent effective impervious cover (that is, BC05 and CN01). These two subwatersheds have the greatest concentration of impervious cover which is evenly spread throughout the subwatershed (see land uses in Figure 3). Based on observations in the field during this WIP, watershed improvement projects could improve stream conditions in these two subwatersheds. In the other three priority subwatersheds with 11 percent effective impervious cover, high impervious cover is more limited to local areas within the subwatershed as shown in the current land use (Figure 3). Patterns of disturbance are more localized problem areas and may not warrant large scale restoration efforts. Because this WIP provides a study of conditions at a larger, subwatershed scale, more detailed studies are necessary to determine if WIP projects are warranted in these areas. Further field studies should document conditions in these localized areas of intense land uses.

TABLE 9
WIP Recommendations
Big Creek Watershed Improvement Plan

Subwatershed Status	Subwatershed	Effective Impervious Cover	WIP Recommendation
Priority	Big Creek (BC05)	18%	See WIP projects in Table 10 and Figure 8.
	Caney Creek (CN01)	16%	
Priority	Sawmill Branch (SB01)	11%	Further study recommended to characterize existing conditions and determine if watershed improvement projects are necessary.
	Big Creek Tributary (BT03)	11%	
	Bagley Creek (BG01)	11%	
City of Cumming	Kelly Mill Creek (KM02)	16%	Coordinate with the City of Cumming.
	Big Creek (BC01)	15%	

TABLE 9
WIP Recommendations
Big Creek Watershed Improvement Plan

Subwatershed Status	Subwatershed	Effective Impervious Cover	WIP Recommendation
Other	Big Creek Tributary (BT01)	10%	Continue to monitor conditions through the Environmental Monitoring Program, routine inspections and stream walks; address problems as needed.
	Kelly Mill Creek (KM01)	10%	
	Bentley Creek (BN01)	10%	
	Big Creek Tributary (BT02)	9%	
	Cheatham Creek (CH03)	8%	
	Cheatham Creek (CH02)	8%	
	Cobb Creek (CB01)	8%	
	Big Creek (BC03)	8%	
	Big Creek (BC02)	8%	
	Big Creek (BC04)	7%	
	Cheatham Creek (CH01)	7%	
	Harris Creek (HR01)	6%	

Projects recommended for the Big Creek WIP are those that are cost-effective, feasible, and that can provide achievable improvements to the watershed. In addition, projects were also recommended when they may be combined with other projects in the same drainage area as part of a larger alternative. By combining projects in an alternative, water quality and stream condition improvement can be maximized. By combining different project types in one alternative, water quality goals may be more successfully met with a decrease in land acquisition costs and construction costs due to consolidated labor and equipment needs.

Table 10 provides a list of stream restoration projects, BMP retrofit/construction projects, and various combinations that are recommended based on their location in the top 2 priority subwatersheds, benefit related to cost, and ability to be grouped in the same drainage area with other projects. Alternatives are prioritized for implementation based on the lowest cost to benefit ratio. Locations for all recommended projects are shown in Figure 8.

TABLE 10
Recommended Projects and Alternatives
Big Creek Watershed Improvement Plan

Alternative ID and Priority for WIP	Subwatershed	Project	Project Type(s)	Cost to Benefit Ratio*	Estimated Cost Range
1	Big Creek (BC05)	BMP14	BMP retrofit	28,275	$374,100 to $530,700
		BMP13	BMP retrofit	29,580	$365,400 to $522,000
		BMP08	BMP retrofit	32,427	$295,800 to $417,600
		BMP11	BMP retrofit	37,568	$348,000 to $478,500
				SUBTOTAL:	**$713,400 to $1,000,500**
2	Big Creek (BC05)	BMP24	BMP retrofit	42,314	$382,800 to $548,100
				SUBTOTAL:	**$382,800 to $548,100**
3	Big Creek (BC05)	SRP04	Stream restoration	63,447	$364,000 to $778,100
				SUBTOTAL:	**$364,000 to $778,100**
4	Big Creek (BC05)	BMP19	BMP retrofit	56,188	$522,000 to $826,500
		BMP20	BMP retrofit	63,971	$870,000 to $1,305,000
		SRP03	Stream restoration	78,089	$448,000 to $957,600
				SUBTOTAL:	**$1,840,000 to $3,089,100**
5	Caney Creek (CN01)	BMP09	BMP retrofit	52,490	$687,300 to $887,400
		SRP07	Stream restoration	71,478	$501,200 to $1,071,315
				SUBTOTAL:	**$1,188,500 to $1,845,000**

*Cost to benefit ratio was calculated using the average of the minimum and maximum value in the estimated cost range.

Figure 8

Project Alternatives

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Though all of these project alternatives provide benefits to water quality and hydrologic conditions in the watershed, the alternatives combining several smaller projects offer more benefit from a cost perspective. A cost savings can be expected from these projects due to the sharing of common costs which are typical of each construction project. In addition, alternatives can be divided for implementation in several phases, where each phase can provide sustainable benefits. Alternative 3 also offers a benefit due to its proximity to the Big Creek Greenway project, which may be extended into Forsyth County. A project in this location could potentially be used to leverage priorities for multiple County departments.

Due to the limited project scope and affected area for the BMP projects compared to the stream restoration projects, stream restoration projects are generally more beneficial from a watershed perspective. These projects provide beneficial results for a larger portion of the watershed. However, cost/benefit ratios are higher for stream restoration projects due to the higher costs associated with design and construction and greater implementation constraints and accessibility due to the size and location in environmentally sensitive areas; thus, some BMP projects are prioritized above stream restoration projects.

5.1 Planning Implications

This WIP is presented as a planning-level tool to plan budgets and prioritize the County's future watershed improvement efforts, while also following GAEPD requirements and District guidance. According to the District, it is recommended that the County work to implement watershed improvement projects beginning in 2008 until water quality objectives are met, as evidenced through the County's Environmental Monitoring Program. It should be noted that recommended projects can be phased to occur over multiple years for budgeting purposes. However, each phase should provide an independently achievable level of watershed improvement. In addition, the County can leverage watershed improvement efforts through County maintenance activities as discussed in Appendix D.

Projects with budgets across a wide spectrum have been identified as priorities. This will allow the County some flexibility in future planning efforts when considering available annual budgets. Once funds have been allocated to a project, there will be additional costs to bring the project to the construction stage (i.e. further surveying, permitting, and engineering design) which should be taken into account during planning. The capital improvement plan (CIP) is summarized in Table 11 as a as a planning-level overview for watershed improvement activities in each subwatershed based on impervious cover. This plan is presented as a planning guide for the County and should be re-evaluated according to budgetary requirements and dynamic conditions in the watershed, which may change project priorities.

TABLE 11
Capital Improvement Plan Summary
Big Creek Watershed Improvement Plan

Phase	Description
Phase I	Implement stream restoration and BMP retrofit projects based on cost and benefits, as well as feasibility in top 2 priority subwatersheds (BC05 and CN01).
Phase II	Perform stream walks and BMP infrastructure inventories in highly developed portions of the *other* 3 priority subwatersheds (SB01, BT03, BG01) to determine if and where watershed improvement projects should occur.
Phase III	Continue to monitor conditions in all subwatersheds through the Environmental Monitoring Program and routine inspections and stream walks; address problems as needed.

This WIP was designed to provide specific projects for implementation, as well as costs and construction techniques that can be applied to future needs and critical areas that are identified at a later date. In either case, watershed improvement projects will provide both short- and long-term solutions to remedy problems in the Big Creek Watershed. Although watershed improvement projects will address critical areas needing improvement, future degradation can be prevented through the County's other watershed management and protection strategies, including a routine maintenance program, proactive environmental policies, and preventative watershed monitoring activities. Continued monitoring in portions of the watershed with the potential for high future growth will also assist in preventing future stream quality issues.

Appendix A
Natural Channel Design Techniques

Appendix B
Cost and Benefit Evaluation Summary

Appendix C
Project Fact Sheets

Appendix D
Potential Improvements Associated with County Maintenance Activities

Several types of watershed improvement projects can be addressed in conjunction with County maintenance activities throughout the Big Creek Watershed and potentially throughout the County. These potential improvements are not identified as projects in this document, but may be performed by the County as maintenance issues arise. The following maintenance activities may include a watershed improvement component: road crossings, utility crossings (perpendicular), utility easements (parallel), impoundment outfalls, and riparian buffer clearing.

The traditional engineering design associated with these infrastructure projects typically involves piles of rock (riprap) to stabilize stream banks impacted by the roads, utility crossings, outfalls, and/or cutting or eradicating woody riparian vegetation. These practices may serve the immediate needs of maintaining access to and "stabilizing" the infrastructure, but the long-term effects to the stream can be negative. The removal of riparian vegetation, for example, destabilizes the channel banks by preventing plants with sturdy root structures from establishing, and encouraging the proliferation of invasive species that eventually dominate native species. Bank erosion tends to occur on these unvegetated banks. The County may consider some basic maintenance changes that group similar impacts to streams together so that these impacts are addressed consistently County-wide. These changes are described below and are summarized in Table D-1.

TABLE D-1
County-wide Maintenance Issues that May Include a Watershed Improvement Component
Big Creek Watershed Improvement Plan

Application	Common Problems	Current Practice	Recommended Changes
Underground utility	Scour often occurs upstream and downstream of crossing. It occurs upstream due to inadequate or partially blocked pipes/culverts. Downstream scour is often due to head-cutting back towards the crossing or side-cutting influenced by the angle of the flow from under the road.	Mowed turf grass in right-of-way (ROW) along riparian corridor to the tops of banks and placement of riprap on some exposed pipes in streams.	Plant a native grass mix on full banks and riparian zones. Avoid species with deep roots. Raise grade near exposed pipes. Use rock structures to direct flow to middle of channel.
Overhead utility	Loss of riparian buffer and deeply rooted bank vegetation, particularly near the stream bank and within the 25-foot buffer leads to increased runoff from surrounding land and causes reduced bank stability. Reduced shade also causes warmer average water temperatures.	Mowed old field or turf grass in ROW along riparian corridor to the tops of banks.	Plant a native mix of grasses and shrubs on full banks and riparian zones. Avoid trees and tall species of shrubs. Select species with deep roots for banks. Install grade controls in streams that have down-cut along ROW.
Impoundment outfalls	High energy flow from outfalls creates scour pools or bank erosion below the outfall pipe.	Outfall pipes draining into small pools or directly into streams.	Install energy dissipaters below the outfall and plant a mix of native grasses, shrubs, and trees along the banks and riparian.

TABLE D-1
County-wide Maintenance Issues that May Include a Watershed Improvement Component
Big Creek Watershed Improvement Plan

Application	Common Problems	Current Practice	Recommended Changes
Scoured banks	Loss of riparian buffer allows for more rapid runoff of rainfall into the stream. Resulting scour can erode stream banks and stream beds. Remaining riparian vegetation is less effective at removing suspended sediments from runoff.	Placement of concrete, riprap, or other hard fill along banks.	Identify source of the problem. Establish stable slope and plant banks and riparian with a mix of native grasses, shrubs, and trees.
Stream crossings	Removal and loss of bank vegetation often leads to bank erosion at and near the crossing. Exposed underground crossings in down-cut streams act as possible barriers to fish migration and are at greater risk of rupture.	Banks cut to allow passage. Riprap or no cover placed on stream bed.	Install W- or V-weir (to direct flow). Install riprap and shrub joint plantings. Plant riparian with suitable native grasses. Install materials in crossing to allow for vehicle passage.
Road Crossings - clogged or blocked culverts	Scour often occurs upstream and downstream of crossing. It occurs upstream due to inadequate or partially blocked pipes/culverts. Downstream scour is often due to head-cutting back towards the crossing or side-cutting influenced by the angle of the flow from under the road.	Clearing of sediment and debris as part of regular maintenance or following citizen complaints.	Install a W- or V-weir (to direct flow) in the channel. Plants banks and riparian with a mix of native grasses, shrubs and trees. With new culverts add low-flow and high-flow culverts to prevent sediment buildup.
Dry detention ponds	Trees and shrubs are allowed to grow in some, limiting volume.	Trees and shrubs are allowed to grow in some, limiting volume.	Plant native grass mix. Avoid growth of trees and shrubs and clear out vegetation on a regular basis.
Homeowners associations	Planted vegetation is often not drought-resistant or deep-rooted to prevent erosion.	Mix of ornamental vegetation and turf grass.	Plant with a mix of native grasses, shrubs, and trees within constraints of existing deed restrictions and long-term maintenance contracts.
Public open space	Planted vegetation is often not drought-resistant or deep-rooted to prevent erosion.	Varies	Plant with a mix of native grasses, shrubs and trees, especially near drainage swales and near stream banks. Do not mow within 25 feet of top of channel bank.

Utility Easements

In many locations, underground utilities provide grade control of the channel bed. However, the banks are typically maintained such that no vegetation can establish. Both bank stability and habitat are enhanced if the banks are allowed to have tall, well rooted, native grasses. If riprap or other rock is necessary for bank stabilization, tall grasses or low growing shrubs planted in soil between the rocks can provide some shade for the stream.

Parallel overhead utility lines also frequently have severely impaired stream channels. Channels are often incised, with no woody vegetation to stabilize the banks. If the banks are allowed to have tall, well rooted, native grasses and low growing shrubs, both bank stability and habitat are enhanced. Grade control structures in these reaches also help prevent channel incision. Typically, the impact of bank instability at the crossing extends upstream and downstream of the actual crossing. Utility crossing designs and construction (regardless of whether they include just riprap or added vegetation) should include transitional bank protection that includes (at a minimum) herbaceous and woody vegetation for 50 feet upstream and downstream of the crossing.

Impoundment Outfalls

The stream channels immediately downstream of the outfall pipe from an impoundment are typically severely degrading and eroding. The erosive forces of the flows that pass through these pipes should be dissipated and the channel banks protected with vegetation.

Scoured Banks

Several isolated segments of stream bank erosion occur near infrastructure or other valuable property. Property owners or others often try to stop the erosion with riprap without determining the sources of the problem. Often the problem is caused or exacerbated by stream flow that is oriented directly at a poorly vegetated bank. A mixture of redirecting this erosive flow and establishing a stable bank with a gradual slope and well rooted vegetation can prevent further bank scour.

Road Crossings

Traditional roadway culvert design involves determining the design flow capacity necessary for the culverts to convey stormwater under the road crossing and selecting an appropriately sized barrel (multiple barrels if necessary). Field observation of many of these culverts reveals that often one barrel acts as the "low-flow" channel and the others fill up with sediment and debris. As these barrels continue to fill over time, the total capacity of the multiple barrel system is reduced. High-flow events can no longer pass through the culverts, causing scour and undermining of the culvert barrels and the road crossing embankment.

An alternative to this traditional design is to provide the same capacity for the design flow, but to change the configuration of the culvert barrels to accommodate the natural hydraulics of the channel. This altered configuration involves the design and construction of a smaller low-flow culvert, and higher flow barrels (relief barrels) at the bankfull bench elevation. The purpose of the low-flow channel is to convey the bankfull flow (approximately the 1.5-year storm). This smaller channel should be designed to have the appropriate bankfull width for the location (which is kept clear by flushing of small flow events), while maintaining sufficient water depth to support fish passage. The higher flow barrels should be designed with inverts at the bankfull elevation and be of sufficient size to convey the design flow in excess of the capacity of the low-flow barrel. While it is critical that the low-flow channel width be set at the bankfull width, the top of the low-flow barrel may be as high as the top of the relief barrels. Multiple low-flow barrels may be used if needed to attain the bankfull width.

New construction of road crossings typically involves concrete or CMP, or concrete box culverts. Another component to designing more habitat-friendly and stable road crossings is to install the barrels such that the low-flow barrel invert is established below the design grade of the channel. The grade is raised inside the culvert to the design grade by the addition of native rock material or rock material that will not be transported in a certain design storm. The low-flow barrel should be sized such that when the rock material is added to the bottom of the low-flow barrel, the barrel still has sufficient capacity to convey the bankfull flow. This rocky substrate provides a consistent benthic environment through the road crossing, better habitat for aquatic macroinvertebrates, and does not impede fish passage.

The stability of the road crossing can be enhanced by the addition of a grade control and flow-directing structure such as a cross vane or W-weir structure. The installation of a cross vane (or W-weir for larger channels) upstream of a road crossing directs the low flow into the center of the channel (low-flow barrel) and protects the banks during high-flow events. The cross vane should be located such that the upstream end of the low-flow barrel is located at the end of the glide feature. This allows the pool feature immediately downstream of the cross vane to dissipate energy before reaching the road crossing.

Dry Detention Ponds

Detention ponds are often neglected after construction, and trees and shrubs often grow within the basin. The growth of these shrubs and trees (unchecked) reduces the design treatment capacity of the BMP and may threaten the integrity of the earthen embankments.

Homeowners Associations

Private property owners and homeowner associations often want the "neat" appearance of closely mowed turf grass lawns up to the top of the stream bank. However, this control over native grasses, shrubs, and trees greatly reduces the ability of the channel to protect itself from bank erosion. Education of citizens regarding the regulations the County must comply with; the benefits of protecting stream banks from property loss; and that native grasses, trees, and shrubs can be attractive as part of a protective (and state-regulated) riparian buffer will help communicate the need for private property owners' help with protecting the County's streams, as well as their own ability to prevent erosion in their yard.

Public Open Space

Public open spaces offer ideal opportunities for setting an example for good riparian corridor management for the public to observe. County maintenance staff are directed not to mow within 25 feet of the top of bank. As indicated through public education signage, native grasses, trees, and shrubs can be attractive as part of a protective (and State-regulated) riparian buffer.