Shoal Creek
Watershed Protection Plan

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1 Introduction

The City of Griffin, in Spalding County Georgia, has developed along the divide between the Upper Ocmulgee River system to the east and the Upper Flint River system to the west. A total of six watersheds within the City of Griffin are contained within these two river systems (see Figure 1-1). The Cabin Creek Watershed eventually drains to the Ocmulgee River. The Heads Creek, Shoal Creek, Wasp Creek, Honey Bee Creek, and the Potato Creek Watersheds eventually drain to the Flint River. The City of Griffin lies at the headwaters of all these watersheds.

The City of Griffin is seeking reissuance of its National Pollutant Discharge Elimination System (NPDES) permit for its municipal wastewater treatment plant in the Shoal Creek Service Area. The effluent from Shoal Creek Wastewater Treatment Plant (WWTP) is pumped to the Blanton Mill Spray Application Site and does not discharge directly to Shoal Creek at this time. As a part of issuance of NPDES point source permits, Georgia Environmental Protection Division (EPD) has adopted a watershed approach for evaluating point and nonpoint sources of pollution. Georgia EPD requires permit applicants to develop a watershed management plan that addresses ongoing land uses and discharges as well as impacts of future growth and increased discharges that may affect water quality. The May 6, 2004 Guidance for developing a watershed management plan includes the following three components: a Watershed Monitoring Plan, a Watershed Assessment, and a Watershed Protection Plan. The City of Griffin, in preparation for renewal of its wastewater treatment plant NPDES permit, developed watershed plan documents that meet the Georgia EPD requirements. A Watershed Monitoring Plan was prepared for Shoal Creek by Tetra Tech in May 2009 and has been approved by the EPD. A Watershed Assessment was prepared for Shoal Creek by Tetra Tech in November 2009 and has been approved by the EPD. This Protection Plan is provided as the final component of the Shoal Creek Watershed Management Plan.

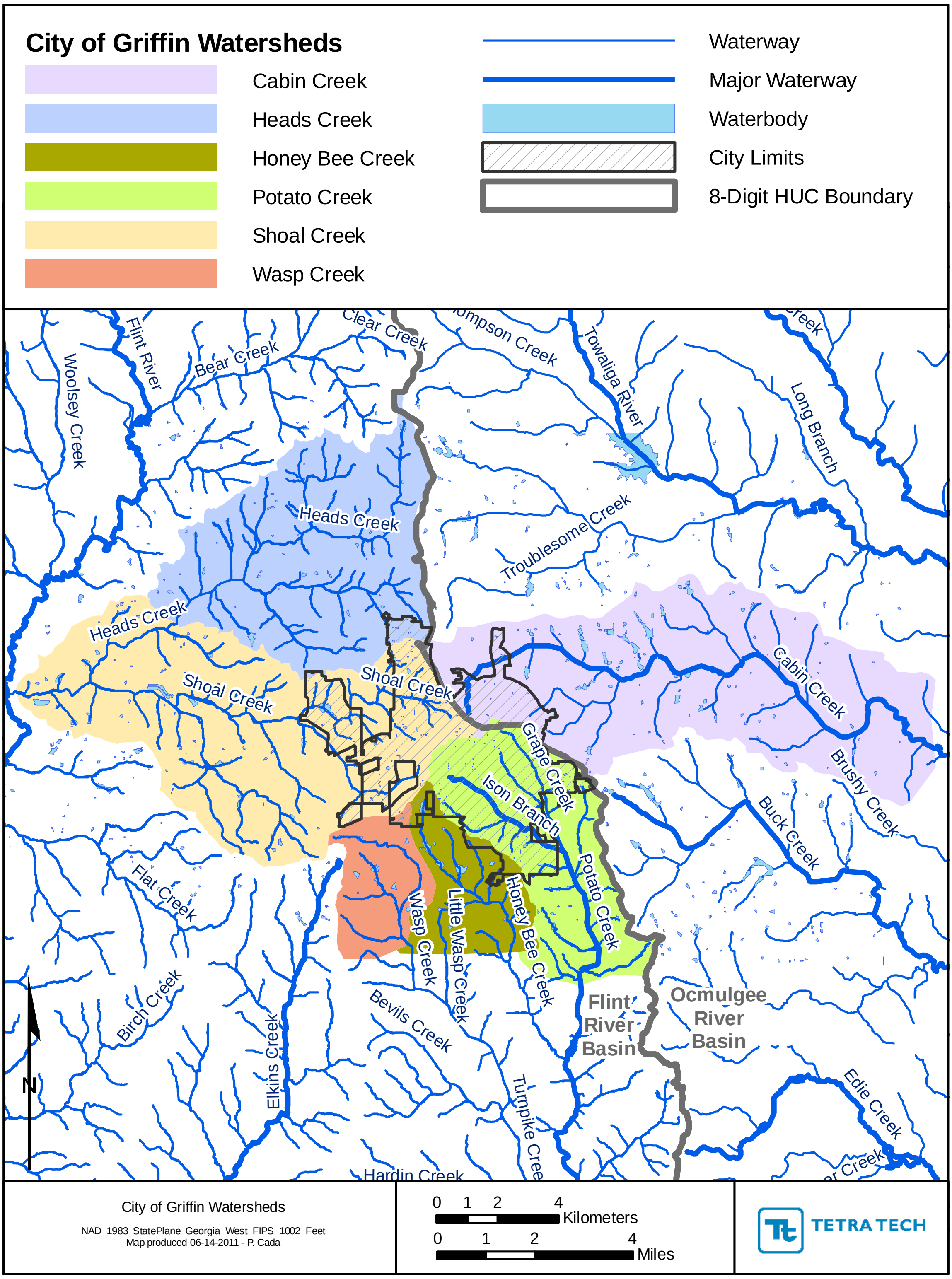

Figure 1-1 City of Griffin Watersheds

The Shoal Creek Protection Plan includes the following components:

1) Goals, objectives, indicators, and benchmarks
2) Existing conditions
3) Current watershed protection measures
4) Watershed projects and research
5) Long-term monitoring plan
6) Watershed management needs
7) Watershed management opportunities
8) Management recommendations

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2 Goals, Objectives, Indicators, and Benchmarks

2.1 GOALS, OBJECTIVES, AND INDICATORS

Watershed protection plans should be built on explicitly defined goals and objectives. In the context of watershed planning, a goal is a general statement about the desired condition or outcome of the watershed protection or restoration strategies, while objectives are specific statements that define what must be true for the goals to be achieved. Essentially, chosen objectives provide the foundation for watershed restoration and protection decisions. Because objectives are often difficult to measure directly, indicators can be used as measurable surrogates.

The recommended Shoal Creek Watershed goals, objectives, and indicators can be used in screening management options and crafting and selecting management strategies during future planning and implementation. It is also proposed that they be used to track progress and success in implementation of the plan. The City has adopted similar goals and objectives for the Potato Creek Protection Plan, and is adopting similar goals and objectives for the Cabin Creek Protection Plan in order to provide a standardized means of assessing watersheds and prioritizing projects city-wide.

In developing the draft goals and objectives, Tetra Tech drew upon the following key documents:

- City of Griffin Stormwater Utility Mission Statement
- Shoal Creek Watershed Assessment (Tetra Tech, 2009)
- Stream Channel Stability Assessment of the Shoal Creek Watershed (Tetra Tech, 2004)
- City of Griffin NPDES Stormwater Permit Notice of Intent (2007)

The Stormwater Utility Mission Statement provides clear guidance in developing goals and objectives,

> *To provide a comprehensive program for watershed management which includes: seeking out alternative funding mechanisms to enhance Griffin's stormwater management system; establish programs to address infrastructure problems; cost-effective design and construction of the necessary improvements; providing leadership through the implementation of Best Management Practices* [BMPs] *that will enhance water quality throughout the region; and improving the overall quality of life for our citizens.*

Through a comprehensive watershed management program, the Shoal Creek Watershed Management Plan addresses stormwater impacts from planned new development as well as impacts from uncontrolled runoff from existing development. It also addresses the City's desire to lead through example in implementing programs for construction, maintenance, and citizen engagement that reflect outstanding watershed stewardship. Watershed Goals and Objectives were developed based on the Stormwater Utility's existing program and existing conditions in the Shoal Creek watershed. The following are four overarching goals proposed for the protection plan:

1) Enhance water quality in the City and the region
2) Meet or exceed state and federal water quality requirements, including removal of the City of Griffin streams from the state's list of impaired waters
3) Implement innovative, cost-effective solutions
4) Improve the overall quality of life for citizens in the City of Griffin

Tetra Tech recommends eight objectives in support of these goals (see Table 2-1). All eight objectives support multiple goals; Table 2-1 shows these linkages.

Table 2-2 lists indicators in three categories—watershed impact, source, and programmatic. Watershed impact indicators are environmental measures such as benthic macroinvertebrate community, channel stability, and water quality. Source indicators are measures of potential stressors such as impervious area and deficient riparian area vegetation. Programmatic indicators refer to potential or actual management measures. As shown in Table 2-2, most of the indicators serve as measurable, meaningful surrogates for multiple protection objectives.

Finally, Table 2-3 describes each indicator as well as the proposed assessment tool for measurement. The assessment tools are comprehensive and include monitoring, stream surveys, watershed modeling, GIS (geographic information system) analysis, stormwater utility records, capital improvement project (CIP) program records, and program tracking.

Benchmarks have been developed for select indicators to assess status, help select among management options, and track progress in meeting objectives.

The goals, objectives, indicators, and benchmarks presented in this Plan essentially connect and enhance the tools already being used by the City in its comprehensive watershed management program. They also provide standardized means to assess watersheds and prioritize projects city-wide.

Table 2-1 Objectives Linked to Goals

Watershed Improvement Program Objectives		Goals			
		G1 **Enhance Water Quality**	**G2** **Meet Requirements**	**G3** **Be Cost-Effective & Innovative**	**G4** **Improve Quality of Life**
A.	Minimize impacts of stormwater runoff and erosion on stream *hydrology* to promote stable stream morphology, protect habitat, and support biota (city-wide)	■	■		■
B.	Minimize impacts to stream *water quality* from pollutants in stormwater runoff, particularly the following: • Impacted biota and habitat (watershed-wide) • Elevated concentrations of fecal coliform bacteria (watershed-wide) • Elevated nutrients (watershed-wide)	■			■
C.	Meet state and federal requirements such as Phase II stormwater and 303(d) listing of Shoal Creek for impaired biota	■	■		■
D.	Ensure BMPs are properly maintained and functioning	■	■		■
E.	Minimize impacts of large woody debris to promote stable stream morphology, protect habitat, and support biota (watershed-wide)	■			■
F.	Use low impact development (LID), green infrastructure, and innovative regional BMPs, to the extent practicable, to enhance water quality and quality of life in the community	■		■	■
G.	Actively engage the community in adopting measures to protect and restore streams	■	■	■	■
H.	Implement cost-effective City programs that provide leadership in watershed stewardship	■		■	■

Table 2-2 Watershed Impact, Source, and Programmatic Indicators Linked to Objectives

Watershed Impact Indicators	Objectives							
	A	B	C	D	E	F	G	H
Benthic communities	■	■	■	■	■	■	■	■
Aquatic habitat	■	■	■	■	■	■	■	■
Fish communities	■	■	■	■	■	■	■	■
Channel morphology	■		■	■	■	■	■	■
Channel stability	■		■	■	■	■	■	■
Instream sediment	■		■	■	■	■	■	■
Hydrology (frequency, magnitude, and duration of flows)	■	■	■	■	■	■	■	■
Drainage complaints	■				■		■	■
Percent riparian area deficient of vegetation	■	■				■	■	■
Percent connected natural area	■	■				■	■	■
Water quality (modeling of future conditions): relative nutrient, upland sediment, and metals loading.		■	■					■
Water quality (observed/measured): instream total phosphorus (TP), total nitrogen (TN), total suspended solids (TSS), fecal coliform (FC), metals, dissolved oxygen (DO), turbidity		■	■					■

Table 2-2 cont'd Watershed Impact, Source, and Programmatic Indicators Linked to Objectives

Source Indicators	Objectives							
	A	B	C	D	E	F	G	H
Impervious area	■	■	■	■		■	■	■
Stormwater outfalls	■	■						■
Property loss due to erosion	■	■	■	■	■	■	■	■
Percent of development with uncontrolled stormwater	■	■	■	■		■	■	■
Percent highways with uncontrolled stormwater	■	■	■			■		■
Sanitary sewer crossings and sewer spills		■						■
Deficient riparian area vegetation	■	■				■	■	■
TP, TN, TSS, metals loading (modeled)		■						

Table 2-2 cont'd Watershed Impact, Source, and Programmatic Indicators Linked to Objectives

PROGRAMMATIC INDICATORS	OBJECTIVES							
	A	B	C	D	E	F	G	H
# Cisterns installed	■	■				■	■	■
# Disconnected downspouts		■				■	■	■
# Retrofits of existing flood control structures for water quality/hydrology	■	■		■		■	■	■
Length stream restoration	■	■					■	■
Acres buffer restoration using native vegetation	■	■				■	■	■
Percent development using LID and green infrastructure (since 2009)	■	■		■		■	■	■
# BMPs providing neighborhood or community amenity (e.g., open space, garden, water features)	■	■				■	■	■
# Regional BMPs constructed	■	■		■		■	■	■
Percent development with stormwater BMPs functioning as designed	■	■	■	■		■	■	■
Percent City projects with LID or green infrastructure	■	■				■		■
Percent City projects with stormwater BMPs functioning as designed	■	■		■				■
Mitigation cost-effectiveness ($/load reduced)								■
Leveraged funding sources								■

Table 2-3 Description of Watershed Impact, Source, and Programmatic Indicators

Watershed Impact Indicators	Description	Assessment Tool
Benthic communities	Georgia DNR Standard Operating Procedures for Macroinvertebrate Biological Assessment	Monitoring
Aquatic habitat	Georgia DNR Standard Operating Procedures for Macroinvertebrate Biological Assessment	Stream survey
Fish communities	Standard Operation Procedure for Conducting Biomonitoring on Fish Communities in Wadeable Streams in Georgia (GA DNR, 2005)	Monitoring
Channel morphology	Visual based physical habitat assessment per Georgia DNR Standard Operating Procedures for Macroinvertebrate Biological Assessment; other options include the Incised Channel Evolution Model (ICEM) that defines the stages of channel evolution following land development, urbanization, and restoration	Stream survey
Channel stability	Visual based physical habitat assessment per Georgia DNR Standard Operating Procedures for Macroinvertebrate Biological Assessment; other options include a comparison of specific stream power and velocity to critical threshold values relevant to channel stability	Stream survey Watershed model
Instream sediment	Visual based physical habitat assessment per Georgia DNR Standard Operating Procedures for Macroinvertebrate Biological Assessment; other options include qualitative or quantitative estimate of sediment load generated by channel erosion (specify load if quantitative)	Qualitative assessment, literature review, or permanent cross section data
Hydrology (frequency, magnitude, and duration of flows)	A measure or index that uses storm event simulations to provide information on hydrologic alteration and potential impacts to stream morphology, habitat, and biota	Monitoring and storm event simulation
Drainage complaints	Records number of drainage complaints per square mile of developed area	Public works records
Percent riparian area deficient of vegetation	Percent of land within the riparian buffer lacking sufficient natural, vegetative cover. (If using the Multi-Resolution Land Characteristics Consortium [MRLC] Landscape Fire and Resource Management [LANDFIRE] 2001 data, <30 percent coverage within any vegetative layer could be used as an indicator of deficiency.)	Stream survey GIS analysis
Percent connected natural area	Percent of land within a subwatershed that supports natural areas with significant connectivity	GIS analysis
Water quality future conditions	Relative nutrient, metals, and upland sediment, loading	Watershed model
Water quality observed/measured	Instream TP, TN, TSS, FC, metals, DO, turbidity	Monitoring

Table 2-3 cont'd Description of Watershed Impact, Source, and Programmatic Indicators

Source Indicators	Description	Assessment Tool
Percent impervious area	Percent of land in subwatershed with impervious surface	GIS analysis of land use/ land cover data
Stormwater outfalls	Number and location of stormwater outfalls per mile of stream	Stream surveys and GIS analysis
Property loss due to erosion	Widening of stream channels resulting in property loss	Stream surveys; aerial photographs
Percent of development with uncontrolled stormwater	Areas of development prior to stormwater control requirements	Stormwater utility records
Percent highways with uncontrolled stormwater	Highways built prior to stormwater control requirements	Stormwater utility records
Sanitary sewer crossings and sewer spills	Number of locations where sanitary sewers cross streams per mile of stream; number of sanitary sewer spills or overflows per square mile of subwatershed	Stream surveys; record of spill notices
Percent riparian area deficient of vegetation	Percent of land within the riparian buffer lacking sufficient natural, vegetative cover	Stream surveys and GIS model
TP, TN, TSS, metals loading (modeled)	Estimated and predicted loading of nutrient, upland sediment, metals, and fecal coliform bacteria	Watershed model

Table 2-3 cont'd Description of Watershed Impact, Source, and Programmatic Indicators

Programmatic Indicators	Description	Assessment Tool
# Cisterns installed	Self explanatory	Program tracking
# Disconnected downspouts	Self explanatory	Program tracking
# Retrofits of existing flood control structures for water quality/hydrology	Self explanatory	CIP program records
Length stream restoration	Self explanatory	Program tracking
Acres buffer restoration	Self explanatory	Program tracking
Percent development using LID and green infrastructure (since 2009)	Self explanatory	Land development records
# Regional BMPs constructed	Self explanatory	CIP program records
Percent development with stormwater BMPs functioning as designed	Self explanatory	Inspections records
Percent City projects with LID or green infrastructure	Self explanatory	Program tracking
# BMPs providing neighborhood or community amenity (e.g., open space, garden, water features)	Rain gardens, constructed wetlands, greenways, ponds, tree planters, or BMPs that provide amenities in neighborhoods, parks, streetscapes, city courtyards/plazas, etc.	Program tracking
Percent City projects with stormwater BMPs functioning as designed	Self explanatory	Inspection records
Mitigation cost-effectiveness	Cost per ton of TSS reduced, cost per pound of nutrients and metals reduced, cost per detention volume, etc.	Program tracking; cost analysis
Leveraged funding sources	Grants received, cost-share dollars from other agencies, and in-kind contributions	Program tracking

2.2 BENCHMARKS

Tetra Tech has developed benchmarks as a means of tracking progress toward the recommended goals and objectives for City of Griffin watersheds. Benchmarks are indicator values that represent conditions at which a particular environmental objective has been achieved. The water quality benchmarks presented here are recommended for use in interpreting dry weather or long-term average concentration data. Benchmarks are also recommended for benthic communities, aquatic habitat, and impervious area. Tetra Tech recommends that the benchmarks be used to flag potential impacts during observed and simulated data review and evaluation. Note that these values are not recommended as standards for regulation or as absolute targets to denote unimpacted conditions.

Water Quality Benchmarks

The water quality benchmarks were developed primarily for use in evaluating baseflow, or dry weather, water quality monitoring data in streams. They are not directly applicable to measurements obtained from individual storms, which can often be much higher, but are applicable to interpreting long-term averages of concentration data obtained from a mix of dry weather and wet weather monitoring. The benchmarks would be appropriate to apply to the City of Griffin dry weather sample data that can be influenced by some wet weather events. The benchmarks should not be applied to data measured exclusively during wet weather events.

To develop the benchmarks, Tetra Tech reviewed the State of Georgia water quality regulations for any relevant standards (State of Georgia, 2010). For constituents that did not have numeric state standards, Tetra Tech reviewed literature values for reference conditions within the Georgia piedmont. The literature review focused on instream, baseflow measurements.

A benchmark range is recommended for each parameter for which targets are not directly established by a published state water quality criterion. If a parameter is observed above this range, this indicates that there is a potential for significant impacts, and that the stream reach should be investigated further. If the parameter is within the range, some moderate impacts due to water quality are likely but to a lesser extent. Reaches within the benchmark range would be considered a lower priority for investigation. Below the range, the parameter is not considered a concern for that stream reach and further investigation is likely unnecessary.

The City of Griffin dry weather monitoring data were used to develop the benchmarks. Tetra Tech used the data collected from January 1, 2005 through June 22, 2010 for the currently sampled Shoal Creek watershed stations: WQ-25, WQ-28, WQ-38, WQ-39, and WQ-42.

For the upper bounds of the TN and TP benchmark ranges, a regression equation from Dodds et al. (2002, 2006) was used to estimate the concentration at which benthic algal density would likely reach nuisance levels in the absence of other limiting factors, such as grazing or insufficient light. The coefficient of variation from the dry weather monitoring data was applied to the regression equation, and a Redfield ratio for TN:TP (molecular ratio of nutrients in phytoplankton) of 7.2 (by mass) was assumed, to develop unique TN and TP benchmarks. From these relationships, Tetra Tech calculated the upper 95 percent confidence intervals for TN and TP at which excessive algal growth would be expected. These values (1.1 mg/L TN and 0.19 mg/L TP) were used as the upper bounds of the benchmark ranges. When calculating the coefficient of variation, samples below the detection limit were included as half of the detection limit.

For the lower bounds of the TN and TP benchmark range, U.S. Environmental Protection Agency (EPA) nutrient criteria guidance for streams was used, and Tetra Tech consulted the specific guidance for Nutrient Subecoregion 45, which coincides with the City of Griffin. According to this guidance, if reference data are available, the 75^{th} percentile of reference data is recommended as a criterion. If reference data are not available, then the 25th percentile of the distribution of all observed concentrations is recommended as a reasonable approximation of reference conditions. The EPA guidance states that these recommended criteria should be used as guidance, but that states and other agencies should conduct further research to determine the most appropriate criteria for their location (USEPA, 2000). Consistent with the EPA guidance, the 75th percentile of concentrations from least-disturbed EPA Wadeable Stream Assessment reference-sites were used for the lower bounds of the TN and TP benchmark range (Herlihy and Sifneos, 2008).

For most of the remaining constituents, the upper and lower bounds were based on two types of reference values: (1) the highest reference values within the literature, and (2) the 25th percentile of dry weather water quality data (consistent with EPA guidance discussed above). The highest literature reference values were chosen because all information sources reflected relatively unimpacted conditions within the Georgia piedmont physiographic region, and the highest values among these sources should represent a potential threshold between natural (background) conditions and impacted conditions. When calculating the 25th percentile of the dry weather data, samples below the detection limit were included as half the detection limit. Collectively, these values provided a reasonable range below which a parameter is not considered a concern and represents achievement of objectives. For most constituents, the literature values represented the upper bound, and the 25th percentile of dry weather data represented the lower bound of the range. For NO_3-NO_2, the benchmarks were reversed because the literature value method produced a lower benchmark than the 25th percentile method. Because the Total Kjeldahl Nitrogen (TKN) literature reference value (2 mg/L) exceeded the TN upper bound (1.1 mg/L), so 1.1 mg/L was used as the TKN upper bound.

The benchmark for turbidity is especially uncertain, and this uncertainty should be accounted for when evaluating watershed conditions. Instead of using the maximum reference value, Tetra Tech is recommending 30 nephelometric turbidity units (NTU) as the upper bound benchmark, which represents the average reference conditions found in the literature search.

As noted above, the current set of benchmarks are established primarily for dry weather conditions and are not necessarily applicable during storm events, when runoff or channel erosion processes can cause elevated concentrations. For those constituents for which Georgia has adopted numeric water quality criteria, the differences between wet and dry weather concentrations are addressed through the use of two-number criteria. These criteria consist of an average or chronic value and an acute or instantaneous value. The acute (instantaneous) criterion is applicable to all individual observations, except as otherwise exempted, and is thus applicable to both wet and dry weather benchmarks. The more stringent average or chronic values provide benchmarks that are relevant to dry weather or average conditions, while the acute or instantaneous values provide benchmarks for all individual observations, including wet weather data.

For constituents for which numeric criteria have not been established in regulations, benchmarks for wet weather samples are more difficult to derive. As wet weather data are collected, the City of Griffin could consider wet weather benchmarks in addition to the dry weather benchmarks recommended in this report. Note that reference information on wet weather benchmarks was not readily available during this phase of the project. When reference data are available, wet weather benchmarks can vary considerably by local conditions. Benchmarks for TSS and turbidity, for example, are most relevant under dry weather conditions since these constituents can vary widely by channel condition under wet weather. Given these limitations, the best approach for assessing wet weather data for constituents without acute numeric criteria would be to evaluate the watershed data based on conditions within the watershed and not concentrations that are likely indicators of impacts. If load limits are developed in the future, these limits could be used to develop wet weather benchmarks to ensure that load limits are met.

The recommended benchmarks are summarized in Table 2-4 and Table 2-5. Table 2-4 lists the benchmarks based on water quality standards while Table 2-5 lists the benchmarks that were based on literature values and EPA criteria guidance. As noted above, the benchmarks were derived for use in evaluating average and baseflow (dry weather) water quality monitoring data in streams.

The benchmark ranges in Table 2-5 should be used to flag conditions in the watershed for further consideration and analysis. It is important to note that biological monitoring may indicate that impacts are occurring even when water quality data are within the ranges specified by the benchmarks. As additional water quality data are collected and compared to the benchmarks, further refinement may be warranted.

Table 2-4 Benchmarks Derived from Georgia Numeric Water Quality Criteria

Parameter	Benchmark[1]	Reference	Typical Nonpoint Sources
pH	Between 6.0 and 8.5	State of Georgia (2010) Standards	Decaying organic matter, groundwater
Dissolved copper (µg/L)[2]	7 µg/L at 50 mg/L CaCO3 (acute criterion, hardness dependent) 5 µg/L at 50 mg/L CaCO3 (chronic criterion, hardness dependent)	State of Georgia (2010) Standards	Road runoff (e.g., brakepads, automotive flaking); parking areas in urban and industrial sites (from vehicular traffic); roofing and storage building materials (e.g., copper gutters)
Dissolved zinc (µg/L)	65 µg/L at 50 mg/L hardness (acute and chronic criterion hardness dependent)	State of Georgia (2010) Standards	Road runoff (e.g., brakepads, automotive flaking); parking areas in urban and industrial sites (from vehicular traffic); corrugated metal roofing and siding; native soils
Dissolved Cadmium (µg/L)[2]	1.0 µg/L at 50 mg/L CaCO3 (acute criterion, hardness dependent) 0.15 µg/L at 50 mg/L CaCO3 (chronic criterion, hardness dependent)	State of Georgia (2010) Standards	Car exhaust
Dissolved Lead (µg/L) [2]	30 µg/L at 50 mg/L CaCO3 (acute criterion, hardness dependent) 1.2 µg/L at 50 mg/L CaCO3 (chronic criterion, hardness dependent)	State of Georgia (2010) Standards	Urban runoff, soil near roads containing legacy contamination from leaded gasoline, and soil near factories that use lead
Fecal coliform (# /100 mL)	May – October: 200 # /100mL 30-day geomean November – April: 4000 # /100mL instantaneous; 1000 # /100mL 30-day geomean	State of Georgia (2010) Standards	Wildlife, birds, pets, cattle, malfunctioning septic systems, sewer system leaks and spills, illicit connections

Table 2-4 cont'd Benchmarks Derived from Georgia Numeric Water Quality Criteria

Parameter	Benchmark[1]	Reference	Typical Nonpoint Sources
DO (mg/L)	>4 mg/L instantaneous; >5 mg/L daily average	State of Georgia (2010) Standards	Affected by biochemical oxygen demand (BOD)load, groundwater and activity of algae, and presence of heterotrophic bacteria and fungi

[1] Note: acute or instantaneous criteria are applicable benchmarks for both wet and dry weather conditions; chronic, average, or geomean criteria are applicable benchmarks for dry weather sampling.

[2]The copper, cadmium, and lead standards will need to be recalculated based on observed hardness and converted to total copper, total cadmium, and total lead to compare to monitoring data.

Table 2-5 Additional Water Quality Benchmarks for Dry Weather Monitoring Data

Parameter	Benchmark Range[1]	References for Lower Bound Benchmarks	References for Upper Bound Benchmarks	Typical Nonpoint Sources
TSS (mg/L)	2 to 13 mg/L	25th percentile of 2005–2010 dry weather observed data	Paul et al (2006) Roy et al (2003) Schoonover et al, (2005) Tetra Tech (2006)	Channel erosion, upland erosion, roads, agricultural tillage, construction/land disturbance
Turbidity (NTU)	5 to 30 NTU	25th percentile of 2005–2010 dry weather observed data	GA EPD (2007a) GA EPD (2007b) Tetra Tech (2006) Roy et al. (2003) Pitt (2000) USEPA (2000)	Primarily driven by TSS; color and dissolved organic matter from humus
BOD (mg/L)[2]	1 to 3 mg/L	25th percentile of 2005–2010 dry weather observed data	Fox and Absher (2002)	Manure, plant material, algal blooms, septic systems
TP (mg/L)	0.06 to 0.19 mg/L	Herlihy and Sifneos (2008)	Dodds et al. (2006) Dodds et al. (2002)	Agricultural and landscaping runoff (fertilizers and organic matter), regeneration from stream sediment
TN (mg/L)	0.7 to 1.1 mg/L	Herlihy and Sifneos (2008)	Dodds et al. (2006) Dodds et al. (2002)	Agricultural and landscaping runoff (fertilizers and organic matter), atmospheric deposition, septic systems
NO_3-NO_2 as N (mg/L)	0.4 to 0.8 mg/L	GA EPD (2007a) Gore et al. (2005) Roy et al. (2003) USEPA (2000)	25th percentile of 2005–2010 dry weather observed data	Same as TN
NH_3 as N (mg/L)[2]	0.03 to 1 mg/L	25th percentile of 2005–2010 dry weather observed data	GA EPD (2007a) Gore et al. (2005) Meyer et al. (2005) Roy et al. (2003) Schoonover et al. (2005)	Septic systems, agricultural groundwater, fertilizers, instream production from decaying organic matter, regeneration from stream sediment
TKN (mg/L)	0.7 to 1.1 mg/L	25th percentile of 2005–2010 dry weather observed data	TN upper bound	Same as TN
PO_4 as P(mg/L)[2]	0.01 to 1 mg/L	25th percentile of 2005–2010 dry weather observed data	Pitt (2000) Tetra Tech (2006)	Same as TP

[1] Sampling and analysis methods could not be verified for all references.
[2] Lower bound represents detection limit.

Other Benchmarks

Where information was available, Tetra Tech developed the following recommended benchmarks for indicators other than the water quality constituents. These benchmarks represent conditions at which the relevant goals and objectives may be met.

- Benthic Communities—Good or excellent rating.
- Aquatic Habitat—A score of 113 or higher (using the 2007 scoring methods), which indicates optimal or suboptimal habitat conditions.
- Impervious Area—Percent imperviousness of 25 or less is considered a desirable condition. Above this value, severe degradation is expected to occur and indicators of stream quality consistently shift to a poor condition (CWP, 2003). Most stream quality indicators begin to decline at 10 percent impervious, which could be used as a more conservative benchmark.

3 Existing Conditions

The Watershed Assessment, prepared by Tetra Tech in 2009, identified the primary pollutants and pollutant sources in the Shoal Creek Watershed. Much of the supporting information used in the Watershed Assessment originated from water quality and biological monitoring conducted in the watershed from 2001 to 2009, as well as from the Stream Channel Stability Assessment of the Shoal Creek Watershed that was completed in 2004.

Shoal Creek and its tributaries are experiencing ecological degradation that is typical of urban watersheds. The streams have been affected directly through channelization, and indirectly through changes in surrounding land use and the resulting changes in volume, velocity, and quality of stormwater runoff. These alterations to the land also lead to increased instream bank erosion. As noted in the Stream Channel Stability Assessment, there are several areas of severe erosion along the main reach of Shoal Creek and its tributaries, including a large headcut that could migrate upstream and eventually cause the upstream dam to fail (Site 43 on Map 3 of Stream Channel Stability Assessment).

The percent of impervious area in the service area watershed is approximately 17 percent. This high amount of impervious surface cover can be expected to result in hydrologic conditions and habitat conditions that will limit aquatic communities, as noticeable stream degradation can occur when impervious cover exceeds 10 percent. A benchmark of 25 percent impervious surface cover was developed for the Shoal Creek Watershed as severe degradation is expected to occur above this level. Subwatersheds SC2, SC3, SC4, SC6, SC7, SC8, SC10, HC1, and HC2 each have an impervious cover that exceeds this benchmark.

3.1 303(D) LISTED WATERBODIES

Because Shoal Creek and its tributaries have not been assessed by the State for water quality impairment, they are not listed for any impairment on the Georgia EPD 2008 or 2010 Clean Water Act 303(d) list of impaired streams that do not meet their designated uses. However, Wasp Creek, which is in the Shoal Creek Service Area, is listed for not supporting its designated use of fishing. The criterion violated is biota. The 303(d) listing attributes the impairments to nonpoint sources. A Total Maximum Daily Load (TMDL) for 5 miles of Wasp Creek was finalized in 2008. The listed area extends from the Wasp Creek headwaters to its confluence with Little Wasp Creek (some of which is within the Shoal Creek Service Area). A summary of the TMDL for Wasp Creek is provided in Table 3-1.

Table 3-1 TMDL for Wasp Creek

Parameter	Waste Load Allocation (WLA)	Load Allocation (LA) Non-Point	Margin of Safety (MOS)	TMDL	Percent Reduction
Biota (Sediment) 2008 TMDL report	0.3 tons/yr	37.1 tons/yr	implicit	5.5 tons/day	0%

The TMDL is the total amount of pollutant that can be assimilated by the receiving water body while achieving water quality standards. A TMDL is comprised of the sum of individual waste load allocations (WLAs) for point sources, and load allocations (LAs) for both non-point sources and natural background levels for a given watershed. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relation between pollutant loads and the quality of the receiving water body.

Conceptually, this definition is denoted by the equation:

$$TMDL = \Sigma \text{ WLAs} + \Sigma \text{ LAs} + MOS$$

3.1.1 Biota (sediment)

The Biota Impacted designation indicates that studies have shown a modification of the biological community; more specifically, fish. During 1998-2003, the Department of Natural Resources (DNR) Wildlife Resources Division (WRD) conducted studies of fish populations in the Flint River Basin. WRD used the Index of Biotic Integrity (IBI) and modified Index of Well-Being (IWB) to identify affected fish populations. The IBI and IWB values were used to classify the populations as Excellent, Good, Fair, Poor, or Very Poor. Stream segments with fish populations rated as Poor or Very Poor were listed as Biota Impacted, and were included in the partially supporting or not supporting list. The Wasp Creek stream segment was rated as Very Poor, and placed on the 303(d) list as partially supporting its designated use. The Biota Impacted designation indicates that studies have shown a significant modification of the biological community. The TMDL for Wasp Creek was completed in 2008.

The Flint River Basin and the Chattahoochee River Basin were the basins of focused monitoring in 2000 and 2010. One goal of the focused basin monitoring is to continue to monitor 303(d) listed waters. Therefore, additional monitoring of these streams will be initiated as appropriate during the next monitoring cycle to determine if there has been improvement in the biological communities.

INITIAL TMDL IMPLEMENTATION PLAN SEDIMENT (BIOTA IMPACTED) 2008

The 2008 Initial TMDL Implementation Plan includes a list of best management practices and provides for an initial implementation demonstration project to address one of the major sources of pollutants identified in this TMDL while State and/or local agencies work with local stakeholders to develop a revised TMDL implementation plan. It also includes a process whereby GA EPD and/or Regional Development Centers (RDCs) or other GA EPD contractors will develop expanded plans.

3.1.2 Downstream Impairment

Downstream of the service area, Wildcat Creek and Heads Creek are also listed for impairment on the EPD 2008 and 2010 303(d) lists. The entire length of Wildcat Creek is listed due to excessive levels of fecal coliform bacteria, while Heads Creek from the Heads Creek reservoir downstream to the confluence with Wildcat Creek is listed for impaired biota due to sediment for its designated use of fishing. Georgia EPD completed TMDLs in 2003 for both of these streams to address the water quality issues. Because Wildcat Creek receives flow from only two tributaries, Shoal and Heads Creek, water quality issues in the Shoal Creek Watershed can impact Wildcat Creek.

3.2 POLLUTANTS

The Shoal Creek Watershed Assessment evaluated data from the time that monitoring was initiated in 2001 through August of 2009. To better understand current conditions in the watershed, this Watershed Protection Plan provides a closer look at water quality data collected since 2005. Data from March 15, 2005 through June 22, 2010 is shown in the Water Quality Data table in Appendix A. Data for select parameters are summarized for sites SC0, SC2, SC5, SC10, and HC2 in the Data Summary table and in the box and whisker plots in Appendix A. This summary indicates the range of values and degree of dispersion in measurements for DO, TSS, fecal coliform, TP, and TN. A pollutant loading analysis was also conducted as part of this Protection Plan to identify which areas in the Shoal Creek Watershed are contributing the greatest annual sediment and nutrient loads. The analysis was done by hand-calculation using the City of Griffin's quarterly monitoring data from 2005 through 2009. Constituents examined include TSS, TP, ammonia, nitrate, nitrite, and TN. Subwatersheds are defined by the drainage area of each monitoring station and are referred to by the monitoring station site IDs. For example, the land that drains to station SC0 is named subwatershed SC0. Monitoring station SC0 is downstream of station SC10; therefore, subwatershed SC0 includes subwatershed SC10. For each constituent, there is a chart that depicts pollutant loading in lbs/yr, a chart that depicts pollutant loading in lbs/ac/yr, and a chart that depicts the 5-year mean and median pollutant loads by total subwatershed area and per acre. These charts are included in Appendix A. This analysis of recent data, in combination with the information presented in the Watershed Assessment, provides a comprehensive description of pollutants in the Shoal Creek Watershed.

Since 2005, water temperature measurements have all been below the state maximum standard of 90° F (32°C). All pH measurements have also been within state standards. State water quality standards have been violated based on biota, DO, and fecal coliform. The following discussion indicates occurrences, since 2005, when the standards were not met:

Biota—Impaired biota is indicated by a "Very Poor" IBI (Index of Biological Integrity) score for fish at site SC2 in 2005 and 2008.

DO— DO standards were violated as indicated by individual measurements less than 4.0 mg/L at two sample sites.

SC0: 8-21-06 (3.39 mg/L), 8-7-07 (2.61 mg/L), 8-21-08 (2.87 mg/L), 8-11-09 (1.8 mg/L), and 6-22-10 (3.81 mg/L);

HC2: 11-13-06 (3.82 mg/L), 6-13-07 (3.79 mg/L), and 7-6-09 (3.23 mg/L).

There is a strong inverse relationship between DO and water temperature, with low DO levels occurring during summer months—particularly in low-flow conditions (see the DO vs. Water Temperature graph and DO vs. Area-weighted Discharge graph in Appendix A).

Fecal Coliform—State standards for fecal coliform were violated based on individual measurements greater than 4,000 colonies/100 mL during winter months:

SC10: 12-10-08 (5,000/100mL);

SC2: 12-9-09 (4,200/100 mL).

Prior to 2010, fecal coliform was not sampled in such a way that the geometric mean could be calculated according to Georgia EPD methodology. Beginning in fiscal year 2010-2011, the City will be sampling fecal coliform between May and October in order to determine the geometric mean of fecal indicator bacteria in the watershed.

Neither Shoal Creek nor Heads Creek are on EPA's 303(d) list of impaired streams for those portions of the streams that are within or just downstream of the Shoal Creek Service Area. However, based on the findings of this assessment, both Shoal Creek and Heads Creek have, at certain points in time, qualified for impairment based on DO, and Shoal Creek has qualified for fecal coliform impairment and biota impairment for the designated use of fishing. Once hardness data is collected in this watershed, the dissolved fractions of copper and zinc can be calculated to determine whether or not State toxicity standards are being violated. Copper and zinc were noted as a potential concern in the Watershed Assessment as they were detected throughout the watershed.

Sediment is a concern in the Shoal Creek Watershed. Excessive sediment accumulation in the Griffin Country Club Lake was noted as a problem in the 2004 Stream Channel Stability Assessment. A Shoal Creek Sediment Evaluation (Appendix D of the Shoal Creek Watershed Assessment), conducted in 2005, attributed sediment loadings in Shoal Creek to sources both in the channel and in the adjacent uplands. Water quality data shows that TSS concentrations spike on occasion and is generally associated with heavy rain events. The TSS box and whisker plot indicates how much greater the maximum values are than the 75th percentiles. Median TSS loads for the 2005 to 2009 time period range from 2.77 lb/ac/yr (SC10 and SC2) to 9.44 lb/ac/yr (SC0). Subwatersheds SC0 and SC2 have the highest 5-year mean TSS loads. Average turbidity values exceed the upper bound benchmark at stations SC2 and SC5.

Fecal coliform bacteria are a concern throughout the Shoal Creek Watershed because of the generally high fecal coliform levels that tend to spike on occasion. Like TSS, high fecal coliform levels are also associated with rain events that wash the bacteria into the stream. Median fecal coliform counts range from 195 colonies/100 mL (SC0) to 610 colonies/100 mL (SC10). Some individual measurements are extremely high, as shown by the maximum values indicated on the Data Summary table and on the fecal coliform box and whisker plot in Appendix A.

Also of concern with regards to water quality are elevated levels of nutrients. The 2005 to 2010 Data Summary shows that median TP values range from 0.04 mg/L (SC2) to 0.06 mg/L (SC5). Average phosphorous concentrations are within the benchmark range (0.06–0.19 mg/L) for all stations. Median TN values range from 1.9 mg/L (SC5) to 2.5 mg/L (HC2). Average TN concentrations are greater than the upper bound benchmark (1.1 mg/L) at all monitoring stations.

Lastly, there is some concern about the detection of lead in the sediment at sample site SC8 in 2003. The measured lead concentration was above the EPA guidelines for threshold effect concentration (TEC) but below the probable effect concentrations (PEC).

3.3 Sources

Nonpoint source pollution is likely responsible for all of the water quality impairments in the Shoal Creek Watershed because none of the pollutants are originating from a single, identifiable source.

The primary source of sediment in the Shoal Creek Service Area is likely the areas of eroding soils along the banks of stream channels. Upland sediment is another potential source, particularly stormwater runoff from construction sites, farm land (such as the University of Georgia [UGA] Agricultural Experiment Station), and other areas where bare soil is exposed. Factors that might be contributing to the low DO at sites SC0 and HC2 include high water temperatures in summer months and poor mixing/aeration under low flow conditions. The Griffin Country Club Lake that is directly upstream of station SC0 could be affecting DO at this station. Fecal coliform bacteria appear to be a ubiquitous problem throughout the watershed. Given the high percent of residential land that drains into Shoal Creek and Heads Creek, pet waste is certainly contributing to this problem, and could potentially be the primary source of fecal coliform bacteria. Leaky sewer lines are another potential source of these bacteria. Zinc and copper are likely originating from roadways through the use of automobiles.

4 Current Watershed Protection Measures

4.1 Codes and Regulations

4.1.1 City of Griffin Ordinances

4.1.1.1 Stormwater Management Ordinance

The City of Griffin developed its first stormwater ordinance in January 1997 that established a dedicated funding source for the City to use to meet its future stormwater management program operational and capital investment needs. In other words, the utility would be used to effectively manage, protect, control, regulate, use, and enhance stormwater systems and facilities in Griffin in concert with the management of other water resources. The ordinance states that all property owners and developers of real property within the City shall provide, manage, maintain, and operate on-site stormwater systems sufficient to collect, convey, detain, and discharge stormwater in a safe manner consistent with all City of Griffin development regulations, and the laws of the State of Georgia and the United States. Any failure to meet this obligation shall constitute a nuisance and be subject to an abatement action filed by the City in the Municipal Court.

After the first stormwater ordinance was adopted, the City conducted a cost of services analysis and rate study to identify an equitable approach to funding stormwater management services and facilities. The resulting schedule of service charges was established in the second stormwater ordinance, which was issued in August 1997. That ordinance called for utility fees based on burden of stormwater quality control service requirements and costs posed by various properties throughout the City. Also identified in that ordinance was a provision for stormwater utility service charge credits (see next section), specification on how the stormwater service charge bills would be delivered and collected, and establishment of an effective date when the utility would go into effect.

A third stormwater management ordinance was issued in 1999. That ordinance was revised to meet new state regulations that required restating the legal structure and organization of the stormwater utility as a dedicated enterprise fund of the City. The 1999 ordinance authorized the formation of an organizational and accounting entity dedicated specifically to the management, maintenance, protection, control, regulation, use, and enhancement of stormwater systems in Griffin. The utility would operate under the direction of a Stormwater Utilities Director appointed by the City Manager. The ordinance also redefined the stormwater management problems, needs, goals, program priorities and funding opportunities of the City. The 1999 ordinance is structured so that credit is given to property owners that are reducing the impact of stormwater generated by their property. By reducing the peak discharge of stormwater from their property, the owners are helping the City protect properties downstream. All properties, other than single family residential properties, which have constructed stormwater retention or detention facilities and maintain them in accordance with City defined standards (see below), may be eligible for a percentage reduction, or credit, in that property's stormwater service fee. The credit shall only be applied to that portion of the property served by the detention basin. To receive any credit towards their stormwater service fee, the property owner must insure the following:

1) That such facility meets design, construction, and maintenance standards in effect at the time of construction (see City of Griffin Detention/Retention Facility Inspection Checklist);
2) A complete Credit Application Form sealed by a professional engineer licensed to practice in Georgia has been submitted; and
3) A signed Right-of-Entry has been provided to the City by the owner. Additional information on this program, including a Credit Application Form, can be found at www.cityofgriffin.com. If all

requirements and conditions are met, the credit will be available upon successful completion of an application process and successful completion of a City inspection. The credit shall remain in force as long as the facility is maintained in satisfactory condition.

The current stormwater management ordinance also includes post-development regulations, which were added to the ordinance in 2007. The ordinance requires developers to prepare a stormwater management plan and specifies stormwater management plan requirements. It also addresses post-development stormwater runoff quality and quantity impacts by requiring the use of BMPs (structural and non-structural) to achieve technical performance criteria. The ordinance itself establishes the major requirements, while the Stormwater Design Manual outlines the more detailed requirements, including design specifications. Note that while the City does not require that a developer use non-structural practices, a developer can reduce the required water quality treatment volume by using the following BMPs:

- Natural area conservation
- Stream buffers
- Vegetated channels
- Overland flow filtration/infiltration zones
- Environmentally sensitive large lot subdivisions

The above practices are defined in the City's Stormwater Design Manual. The City of Griffin encourages the use of LID practices and provides guidelines for the application of LID, including site analysis methods, hydrology considerations, and maintenance needs.

4.1.1.2 Development Ordinance

The City of Griffin adopted a development ordinance in January 2002 to regulate new development so that it meets the goals and requirements set forth in the City's Comprehensive Plan. The ordinance requires the review and approval of individual site plans by the City of Griffin Department of Development Services to ensure that the minimum requirements of the Zoning Ordinance, state laws, and other regulations are met, and that public improvements are constructed to the appropriate standards. In addition, adequate provision must be made for open space and recreation, landscaping, roads, drainage, water supply, and sewer capacity, as well as to ensure public health protection from fires or floods.

4.1.1.3 Tree Preservation Ordinance

The City of Griffin has a diversity and abundance of trees and shrubs on public and private lands and holds that these natural resources provide an economic and aesthetic value to the city. Trees increase property values, can positively affect an area economically, and beautify the landscape. Furthermore, certain city streets have historically constituted significant and attractive tree-lined corridors, which have contributed to a realization of increased property values and general improvement of corresponding neighborhoods.

Griffin has instituted a tree preservation ordinance, revised in March 2002, designed to protect the existing urban forest by regulating and controlling the planting, conservation, and replacement of trees and shrubbery on public lands within the City. The ordinance requires that any person planning to remove, destroy, cut, spray, prune, or plant any tree or shrub on public lands must obtain written permission from the Director of Public Works, or their designee, before commencing work. Failure to do so may result in significant penalties and/or restitution as ordered by the court. In addition, the ordinance created the position of City Arborist who is responsible for the proper planting, removal, care, and maintenance of trees and shrubs growing on city-owned property or city-controlled right-of-way in accordance with the City of Griffin Tree Ordinance and Administrative Guidelines. The City Arborist also serves as staff to the Tree Board comprised of senior representatives from various local departments. The Tree Board is tasked with a number of activities, including approving the removal and/or pruning of trees planted on public lands and the removal and/or pruning of trees on private property, to the extent such activities are regulated by the City ordinances and regulations.

4.1.1.4 Soil Erosion and Sediment Control Ordinance

The soil erosion and sediment control ordinance, updated in January 2010, regulates land-disturbing activities such as clearing, grading, excavating, or filling of land. The City of Griffin soil erosion and sediment control ordinance includes the following provisions:

- Approved plans for those land-disturbing activities that are not exempted shall be prepared before the land-disturbing activity takes place.
- The minimum requirements established by the ordinance and the state general permit shall be incorporated into the erosion, sedimentation, and pollution control plan.
- BMPs shall be required for all land-disturbing activities, including those for which a permit and/or approved plan is not required.
- A discharge of stormwater runoff from disturbed areas where BMPs have not been properly designed, installed, and maintained shall constitute a violation for each day on which such discharge results in the turbidity of receiving waters being increased by more than 25 NTU for waters supporting warm water fisheries or by more than 10 NTU for waters classified as trout streams.
- Every person shall be required, at a minimum, to follow protections at least as stringent as the state general permit and BMPs, including sound conservation and engineering practices to prevent and minimize erosion and resultant sedimentation, which are consistent with, and no less stringent than, those practices contained in the *Manual for Erosion and Sediment Control in Georgia*, as well as the additional minimum requirements specified in section 42-63 of the ordinance.
- Establishes a 25-foot buffer along the banks of all state waters. Land disturbing activity is prohibited within this buffer unless otherwise exempted under the ordinance.
- The following activities are exempt from the City of Griffin soil erosion and sediment control ordinance: surface mining, granite quarrying, minor-land disturbing activities, single-family residences, agricultural operations, forestry land management practices including harvesting, Natural Resource Conservation Service projects, projects less than one acre, public works projects, electrical system projects, and any public water system reservoirs.
- The local issuing authority shall require the posting of a performance bond, cash, irrevocable letter of credit, or any combination thereof up to, but not exceeding, $3,000 per acre or fraction thereof of the proposed land-disturbing activity.
- Penalties for violations include stop work orders, fines, and bond forfeitures.

NPDES General Permits No. GAR10001, No. GAR10002, and No. GAR10003 authorize storm water discharges to the waters of the State of Georgia from construction activities and regulate construction activities that disturb one or more acres.

4.1.1.5 Illicit Discharges and Connections Ordinance

The illicit discharges and connections ordinance regulates nonstormwater discharges to the municipal separate storm sewer system (MS4). The ordinance was updated in 2007 to give the City the authority and enforcement power to eliminate illicit discharges. As part of its illicit discharge detection and elimination program under the MS4 permit, the City is inspecting 20 percent of its storm sewer system outfalls per year for illicit discharges. The program also includes outreach to businesses, citizen reporting methods, volunteer curb marker placement, the inspection of road culvert pipes, and the inspection of wastewater treatment and industrial sites for compliance with stormwater pollution prevention plans (SWPPPs).

4.1.1.6 Floods

The City's floods ordinance was updated in December 2009. The purpose of this ordinance is to protect, maintain and enhance the public health, safety, environment, and general welfare, as well as to minimize public and private losses due to flood conditions in flood hazard areas. The ordinance also protects the beneficial uses of floodplain areas for water quality protection, streambank and stream corridor protection, wetlands preservation, and ecological and environmental protection through provisions designed to:

- Require that uses vulnerable to floods, including facilities that serve such uses, be protected against flood damage at the time of initial construction;
- Restrict or prohibit uses which are dangerous to life, health, and safety due to flooding or erosion hazards, or which increase flood heights, velocities, or erosion;
- Control filling, grading, dredging and other development activities that might increase flood damage or erosion;
- Prevent or regulate the construction of flood barriers that will unnaturally divert floodwaters or that might may increase flood hazards to other lands;
- Limit the alteration of natural floodplains, stream channels, and natural protective barriers that are involved in the accommodation of floodwaters; and
- Protect the stormwater management, water quality, streambank protection, stream corridor protection, wetland preservation, and ecological functions of natural floodplain areas.

The City has conducted surveys and modeling to develop floodplain delineations and base flood elevations (BFEs). New Federal Emergency Management Agency (FEMA) Digital Flood Insurance Rate Maps (DFIRMs) based on the City's floodplain mapping efforts were released in May 2010.

4.1.1.7 Litter Ordinance

The City's litter ordinance, last updated in 2002, provides for the public health, safety, and general welfare through the regulation and control of litter. The City's MS4 permit also contains a provision to control discarded building materials, concrete truck washout, chemicals, and other illegal dumping on both private and public property during construction site inspections. The City of Griffin also conducts annual volunteer stream cleanups citywide. The most recent clean-up in 2011 removed 7,480 pounds of litter and debris from city streams.

4.1.2 Spalding County Ordinances

4.1.2.1 Illicit Discharge and Connection Stormwater Ordinance

The Spalding County illicit discharge and connection stormwater ordinance provides for the health, safety, and general welfare of the citizens of Spalding County through the regulation of non-stormwater discharges to the storm drainage system. The objectives of this ordinance are to:

- Regulate the contribution of pollutants to the county separate storm sewer system (MS4) by stormwater discharges by any user;
- Prohibit illicit connections and discharges to the county MS4; and
- Establish legal authority to carry out all inspection, surveillance and monitoring procedures necessary to ensure compliance with the ordinance.

4.1.2.2 Soil Erosion and Sedimentation Control Ordinance

The Spalding County soil erosion and sedimentation control ordinance regulates land disturbing activities and includes the following provisions:

- The following activities are exempt from the Spalding County soil erosion and sediment control ordinance: surface mining, granite quarrying, minor-land disturbing activities, single-family residences, agricultural operations, forestry land management practices including harvesting, Natural Resource Conservation Service projects, projects less than one acre, public works projects, electrical system projects, and any public water system reservoirs.
- Requires that plans for those land-disturbing activities, which are not exempted by this ordinance, shall contain provisions for application of soil erosion and sedimentation control measures and practices. The provisions shall be incorporated into the erosion and sedimentation control plans.
- BMPs shall be required for all land-disturbing activities.
- A discharge of stormwater runoff from disturbed areas where BMPs have not been properly designed, installed, and maintained shall constitute a separate violation for each day on which such discharge results in the turbidity of receiving waters being increased by more than 25 NTU for waters supporting warm water fisheries or by more than 10 NTU for waters classified as trout waters.
- Every person shall be required, at a minimum, to follow protections at least as stringent as the state general permit and best management practices, including sound conservation and engineering practices to prevent and minimize erosion and resultant sedimentation, which are consistent with, and no less stringent than, those practices contained in the *Manual for Erosion and Sediment Control in Georgia*, as well as the additional minimum requirements specified in section 104 of the ordinance.
- Establishes a 25-foot buffer along the banks of all state waters. Land disturbing activity is prohibited within this buffer unless otherwise exempt under the ordinance.
- Establishes a 50-foot buffer along the banks of all state waters classified as trout streams. Land disturbing activity is prohibited within this buffer unless otherwise exempt under the ordinance.
- The local issuing authority may require the posting of a performance bond, cash, irrevocable letter of credit, or any combination thereof up to, but not exceeding, $3,000 per acre or fraction thereof of the proposed land-disturbing activity.
- Penalties for violations include stop work order, fines, and bond forfeitures.

4.2 BEST MANAGEMENT PRACTICES

The City of Griffin is proactive in its implementation and maintenance of stormwater BMPs. The City's Stormwater Division prides itself on going above and beyond what is expected, continually developing innovative programs and pushing forward with numerous measures aimed at protecting the City's waters from pollutants, and educating its citizens about stormwater issues. The Stormwater Division posts Annual Reports on its website:
http://www.cityofgriffin.com/Departments/PublicWorks/Stormwater/Education.aspx.

The City of Griffin's BMP commitments are described in detail in the City's MS4 permit Notice of Intent (NOI), included as Appendix B, and summarized in Table 4-2, below. This includes an ambitious list of structural and non-structural measures that the City is using to maintain and improve stormwater infrastructure, and water quality in the City's streams.

As an education and outreach measure, the City hosts an annual Erosion & Sedimentation and Stormwater Quality Workshop every October. This has grown into a very large event that includes presentations, vendors, and BMP demonstrations. The workshop is attended by representatives from federal, state, and local government, as well as private firms. With over 200 participants in 2010, the Workshop has become a significant forum for the discussion of stormwater issues and the demonstration of structural BMP measures that are available for use in the region.

The City of Griffin maintains records of pollutant reductions achieved through non-structural BMPs. Below are recent data on street sweeping and stream clean-up efforts:

- **Street sweeper data (June 2008 to October 2009):**

  The City removed an average of 66 tons of debris from 227 miles of streets per month for a yearly total of 792 tons removed from 2,725 miles of streets.

- **Steam clean-up data (2006 to 2011):**

  The data in Table 4-1 includes all efforts in the City of Griffin. Shoal Creek was included in the stream clean-up event in each of these years.

Table 4-1 Stream Clean-up Data

Year	Pounds Removed		
	Garbage	Recyclable Metals	Tires
2006	800	Not measured	440
2007	2,800	820	400
2008	2,180	200	1,000
2009	3,000	460	1,000
2010	4,100	380	400
2011	7,480	220	1,100

In addition to the BMP commitments described in the MS4 NOI, the City has implemented additional BMPs related to sewage management, flood control, and stormwater management, and public education and outreach. Table 4-2 summarizes the current watershed protection measures for the Shoal Creek Watershed. Measures are organized by codes and regulations, MS4 permit NOI commitments, and additional BMPs.

Table 4-2 Summary of Current Watershed Protection Measures

Best Management Practice (BMP)	Comments
CODES AND REGULATIONS	
City of Griffin Ordinances	
Stormwater management ordinance	Establishes a stormwater utility; requires developers to prepare a stormwater management plan and specifies stormwater management plan requirements; addresses post-development stormwater runoff quality and quantity impacts by requiring the use of BMPs
Development ordinance	Regulates new development
Tree preservation ordinance	Protects the existing urban forest by regulating and controlling the planting, conservation, and replacement of trees and shrubbery on public lands within the City
Soil erosion and sediment control ordinance	Regulates land-disturbing activities such as clearing, grading, excavating, or filling of land
Illicit discharges and connections ordinance	Regulates non-stormwater discharges to the municipal separate storm sewer system
Floods ordinance	Protects, maintains, and enhances public health, safety, environment, and general welfare; minimizes public and private losses due to flood conditions in flood hazard areas; protects the beneficial uses of floodplain areas for water quality protection, streambank and stream corridor protection, wetlands preservation and ecological and environmental protection
Litter ordinance	Provides for public health, safety, and general welfare through the regulation and control of litter
Spalding County ordinances	
Illicit discharge and connection ordinance	Regulates non-stormwater discharges to the county separate storm sewer system
Soil erosion and sedimentation control ordinance	Regulates land disturbing activities

Table 4-2 cont'd Summary of Current Watershed Protection Measures

Best Management Practice (BMP)	Comments
MS4 NOTICE OF INTENT (NOI) COMMITMENTS	
Public education and outreach on stormwater impacts	
1. Presentation of stormwater projects at commission meetings	Presented once a year
2A. Water Sourcebook Program	An ongoing WaterWise program
2B. Water education poster	Distributed annually to elementary schools
2C. Classroom education	Stormwater Division staff educates school and civic association children on stormwater, water quality, soil, erosion and sedimentation, and on fats, oils, and grease (FOG) issues
2D. Career day activities	Stomwater Division staff participate in at least one Career Day annually
3. Web site	Maintained regularly (www.cityofgriffin.com)
4. Flyers	Distributed in utility bills annually
5. Annual reports	Published on website and in local newspaper each year
6. Brochures and bookmarks	Distributed at public buildings, events, and festivals
7. Large display stand	Periodically updated with new material and moved to a new public location
8. Ecomasters CD	500 copies distributed annually to 3rd and 4th graders
9. BMP training site and annual training	The City of Griffin hosts an Erosion & Sedimentation Control and Stormwater Quality Workshop each October that includes speakers, vendors, and demonstrations
10. Annual stormwater workshop	A workshop is held each year on different stormwater issues. The workshop is open to the general public, commercial and industrial customers of the City.
Public participation and involvement	

Table 4-2 cont'd Summary of Current Watershed Protection Measures

Best Management Practice (BMP)	Comments
1. Curb marker program	500 markers are installed each year
2. Development of Watershed Advisory Council	Council meetings are held quarterly
3. Consumer satisfaction surveys	Mailed every other year.
4. Stream/lake clean-up event	City of Griffin Stormwater Division hosts an annual stream clean-up event
Illicit discharge detection and elimination	
1. Brochure mailings to restaurants and businesses	At least 100 brochures mailed each year
2. Citizen complaints/reporting of problems	Available through website and Environmental Hotline
3. Storm sewer outfall inspection	20% of City outfalls are inspected each year and the City attempts to identify and eliminate any free flowing illicit discharges.
4. Curb Marker Program	500 markers are installed each year
5. Inspection of road culvert pipes	Level 1&2 culverts inspected annually, level 3 semi-annually, and level 4 quarterly
6. SWPPP Site Inspections	Quarterly visual Inspections and annual site inspections at the five sites owned by the City
Construction site stormwater runoff control	
1. Enforcement of litter ordinance	During site inspections
2. Review of erosion control plans	Ongoing for development that disturbs over 1 acre of land
3. BMP Inspection at construction sites	Ongoing
4. Citizen complaints/reporting of problems	Available through website and Environmental Hotline
5. Pre-construction meetings	Prior to issuance of land disturbing permits for commercial projects
6. BMP training site and annual training	The City hosts an annual Erosion & Sedimentation Control and Stormwater Quality Workshop each October that includes multiple speakers, vendors, and demonstrations

Table 4-2 cont'd Summary of Current Watershed Protection Measures

Best Management Practice (BMP)	Comments
Post construction stormwater management in new development and redevelopment	
1. Inspection of ponds and stormwater facilities	Inspected annually, and deficiencies are corrected
2. Structural BMP evaluation	A structural BMP is evaluated annually
3. Loading Simulation Program C++ (LSPC) model distribution	Annual distribution to Planning Department.
Pollution prevention/good housekeeping for municipal operations	
1. Street Sweeping	The City sweeps a minimum of 700 miles of street every year
2. Vacuum and jet out storm drains	The City cleans a minimum of 2,500 storm drains and jets 10,000 feet of storm drain each year
3. Training program for city workers	Annual training for all Pubic Works departments
4. Review of flood control capital improvement projects	Every new project is evaluated for BMP opportunities
4A. Retrofit of existing structures	Review of one existing project each year
5. Use of City Pollution Prevention Plans	Quarterly visual Inspections and annual site inspections at the five sites owned by the City
6. Maintain a system of benchmarks	All 85 benchmarks are inspected and maintained annually; an inventory is maintained on the website
7. Paperless tracking of storm system operation and maintenance (O&M)	Storm system O&M activities are tracked using CityWorks
8. Tree inventory	Tree planting and removal is tracked through CityWorks
9. Basin assessment	One basin will be assessed each year for potential stormwater quality ponds

Table 4-2 cont'd Summary of Current Watershed Protection Measures

Best Management Practice (BMP)	Comments
ADDITIONAL BMPS	
Sewage management	
Sewage collection and treatment system	The City of Griffin maintains an extensive sewage collection and treatment system. The City has a preventative maintenance program for the collection system that includes the use of sewer jets and vacuum trucks and clearing of rights-of-way. Crews TV the lines on a regular basis to check for cracks or breaks. Responses to manhole overflows, broken sewer lines, and clogged lines include cleaning of the line and using hay and lime for absorption and odor control after a spill.
Flood control and stormwater management	
GIS mapping/inventory collection	The City of Griffin has compiled a GIS database inventory of all stormwater drainage structures/features (both natural and manmade attributes) within the City limits; this database continues to be updated/maintained
Stormwater Design Manual	The City Stormwater Design Manual addresses the need to control and minimize the impacts of urban development and stormwater runoff on the environment. It is available on the Stormwater Division website: http://www.cityofgriffin.com/Departments/PublicWorks/Stormwater.aspx
Floodplain mapping	The City of Griffin mapped the urbanized 100-Year floodplain within all its major streams. This floodplain has been incorporated as Zone A in FEMA FIRMs.
Impervious surface limitations	Impervious surface limitations have been incorporated into zoning regulations of the City's Municipal Code
Public education and outreach programs	
Road signage program	In 2000, the City posted signs at named tributary crossings identifying the name of the creek to promote public awareness and understanding of the need to protect the City's water resources
"Only Rain in the Drain" – illicit discharge video	Distributed at events and available on the Public Works and utilities website
Recycling program	The Solid Waste Division has a recycling program that includes curbside recycling pick up, and provides recycling containers to schools to encourage environmental stewardship

Table 4-2 cont'd Summary of Current Watershed Protection Measures

Best Management Practice (BMP)	Comments
Classroom education	Spalding County has established a learning trail and outdoor classroom. A Watershed Assistant has been provided for the Griffin/Spalding school system (funded jointly by the City, County, and UGA Extension Office). The Watershed Assistant presents watershed, water quality, water conservation and stormwater issues to the 4H Cloverleaf students, which includes all 5th grade students in the Griffin-Spalding County School System, private schools within the County, and home school groups. EnviroScape nonpoint source models are used by the City of Griffin to teach students how water can become polluted, as well as the effect their actions can have on water quality.

5 Watershed Projects and Research

5.1 Paragon Sub-basin Study

Paragon Consulting Group, Inc. has conducted a sub-basin study on the Shoal Creek Watershed to identify potential measures for improving water quality in the watershed. Within the limits of the City of Griffin, 55 basins in the Shoal Creek watershed were characterized based on information derived from field visits. The dominant land use was noted, current drainage features were described, and recommendations were made on what type of treatment measures, if any, could be implemented in each basin. The treatment options considered for this project include new stormwater detention ponds, retrofits to existing detention ponds, and proprietary BMP devices capable of treating 8 to 10 acres (such as the Stormceptor STC 11000). Existing outfall structures were identified in the study area and the drainage basins were divided into 351 sub-basins, sized approximately 8 to 10 acres such that each sub-basin could potentially be treated by 1 BMP device. Each sub-basin was assessed to identify if treatment was already included as part of the existing stormwater management system. In addition, each sub-basin was field assessed to identify if it was a candidate for structural BMP retrofit (available space for BMP). Sub-basins for which treatment was already in place and for which no space for BMP retrofit was available were removed from further consideration. The project identified 94 locations that may be suitable for proprietary BMPs, 18 locations where new ponds could be built, and 49 locations where existing ponds could be modified/retrofit.

5.2 2004 Stream Channel Stability Assessment

In 2004, the City performed a geomorphology study on the Shoal Creek Watershed above the Griffin Country Club Lake. At least 120 sites were assessed. Impacts from urban, upland, and natural activities were described for each site, as well as suspected sediment source hotspots and other potential influences on the stream channels. This assessment, conducted by Tetra Tech, included written characterizations of the stream, maps illustrating assessment results in terms of channel erosion activity, and photographs of assessment sites. The assessment was performed by a fluvial geomorphologist walking on the stream bed and conducting Rapid Geomorphic Assessments (RGAs). The 2004 Shoal Creek Geomorphic Assessment, titled *Stream Channel Stability Assessment of the Shoal Creek Watershed*, is included as Appendix C of the Shoal Creek Watershed Assessment.

The 2004 Geomorphic Assessment attributed sediment loadings in Shoal Creek to sources both in the channel and in the adjacent uplands. Several channel erosion hot spots were identified in the main stem and in some tributaries of Shoal Creek, where the most severe erosion was actively occurring. Also, based on land use data and known sediment delivery ratios typical for small watersheds, it was suggested that agricultural and construction site land uses are the dominant upland sediment sources for this watershed.

5.3 Hydrology and Water Quality Modeling

In March 2008, Tetra Tech updated the *Watershed Hydrology and Water Quality Report for the City of Griffin Watersheds*. The Watershed Hydrology Modeling Report presents the results for the model calibration and validation of the Cabin Creek (HUC8 No. 03070103, Upper Ocmulgee), Shoal Creek, Potato Creek, Heads Creek, and Honeybee Creek (HUC8 No. 03130005, Upper Flint) Watersheds. The Water Quality Report presents the results of the preliminary water quality calibration and validation of the same watersheds. The Loading Simulation Program C++ (LSPC) watershed model was used to represent the hydrological conditions. The model is capable of representing loading, both flow and water quality, from nonpoint and point sources. It was used to represent the variability of nonpoint source contributions through dynamic representation of hydrology and land practices. The model included all point and nonpoint source contributions.

In 2010, Tetra Tech amended the LSPC Watershed model to include data through the December 2009. This model is for the entire City of Griffin. The 2010 Watershed Hydrology and Water Quality Modeling Report is included in Appendix C.

Improvements in 2010 include the addition of monitored water quality data and U.S. Geologic Survey (USGS) flow records through December 2009. With this additional data, the model simulation time was extended, thereby improving the diversity of precipitation and response conditions for the modeled watersheds. In addition, the 2008 model represented water quality loading through accumulation and wash-off rates only. In this release, the water quality loading simulations were improved through the inclusion of biochemical processes.

Overall, the 2010 model hydrology calibration looks reasonable. However, in 2005 there was a large storm event in July followed by several smaller storms that caused a slightly elevated recession in the simulated results. The large storms in July and August followed by a period of dry weather in September and the first part of October 2005 appear to be causing a slight over prediction of the simulated flow. In 2006, there is good agreement between the simulated and observed flow. The only exception is for a few storm flows observed in the measured data in September that are not seen in the precipitation data, and are underestimated in the simulated flows. In 2007 there was a significant deficit in rainfall. As such, the simulations are reasonably good, but are slightly low for that year. In general, simulated flows during 2007 and a portion of 2008 follow the observed pattern and are within an acceptable margin of error given that much of the year flows were less than 5 cubic feet per second (cfs) and commonly drop to as low as 1 cfs. The 2009 simulations have good agreement.

At each of the calibration stations, the total volume error for the 6-year simulation was less than 10 percent. Similarly, the seasonal volumes for each of the gages were all less than 30 percent. The metric for both gages that was most difficult to calibrate was the error in 50 percent lowest flows. This problem is not uncommon when low flow conditions drop below 10 cfs. For the calibration stations, the flow is frequently less than 10 cfs and further exasperated by the drought conditions of 2006, 2007, and parts of 2008. During these extended dry periods, the observed flow could often drop to a range as low as 3 to 1 cfs, thereby causing large percentage variations detected in the low flow calibration metrics.

Like the hydrology calibration, the water quality calibration appears to be reasonable at the four water quality stations used for calibration (WQ-1 and WQ-28) and validation (WQ-15 and WQ-3). Water temperature simulation at each of the calibration and validation locations is very good. However, for isolated winter dates in 2007 and 2008, the temperature drops to 0°C. The reason for the simulated temperature drop in these isolated instances is because the simulated water depth is less than 2 inches. When the simulated water depth drops below 2 inches, the model applies the ambient air temperature as the water temperature. Overall, the water temperature simulation shows the seasonal trends well at all of the water quality stations.

DO is simulated well at three of the four water quality stations. The one exception is station WQ-15, which is at a location downstream of the point sources in the Cabin Creek Watershed. At WQ-15, the DO simulation is high from 2003 to 2008. Investigations into the high simulation suggest that one or both of the point source inputs are influencing the less than ideal DO response. Much like the temperature calibration, the dissolved oxygen simulation shows the seasonal trends well at all of the water quality stations.

BOD is simulated fairly well at each of the stations, but with notable caveats. At station WQ-15, the simulation misses several of the peak observed concentrations. This station is downstream of the point sources and the peak concentrations might be an artifact of the point source discharges. At water quality stations WQ-1 and WQ-3, the simulation appears to be slightly elevated. At these stations, the simulation is hovering around the detection limit data sets. At WQ-28, the simulated BOD concentrations are slightly less than the simulated concentrations at WQ-1 and WQ-3. At WQ-28, the simulated results are within a very agreeable range.

TN, ammonia, nitrate, and nitrite were generally simulated well at each of the stations. However, one anomaly was observed in the measured data set that not seen in the simulations. During 2005, there appears to be an increase in TN of about 2 mg/L at water quality stations WQ-1 and WQ-3, as well as an increase in the range of 1 to 2 mg/L at station WQ-28. WQ-15 does not reveal this trend as noticeably because both the simulated and measured results are heavily influenced by the upstream point sources.

TP was well simulated at each of the stations; however, at station WQ-3, the simulation appears to be slightly low. There is a golf course just upstream of WQ-3 that is the likely cause of the higher measured TP concentrations at this station. Unfortunately, the land use descriptions used in the model do not include golf courses, thereby making it difficult to improve the TP agreement at this station. orthophosphate was difficult to analyze at each of the stations. In several locations the measured orthophosphate concentrations are greater than the measured TP concentrations. Overall, the orthophosphate simulations follow an agreeable pattern and the concentrations are within an acceptable range.

5.4 North Griffin Regional Detention Pond Water Quality Monitoring

The City of Griffin completed construction of the North Griffin Detention Pond in 1998. It is within the 180-acre North Griffin Drainage Basin that is within the SC2 subwatershed. The pond provides detention for the upstream drainage, eliminating downstream flooding while using a natural wetland system to provide water quality enhancement for the sub-basin.

The second phase of the project, which was completed in 1999, involved construction of a bio-engineered wetland system within the pond. The constructed wetland was planted with vegetation that was specifically selected to promote the breakdown of contaminants present in the stormwater runoff. The vegetated pond holds stormwater draining from the basin and releases the water slowly into an established forested wetland downstream. The system has been shown effective in reducing some pollutants by 90 percent.

The Project was constructed, in part, using funds from a Clean Water Act Section 319 Grant. There are four water quality sample locations throughout the system. Sampling and analysis has been conducted since 1999 and includes the following constituents:

- TSS
- Total dissolved solids
- Turbidity
- Nitrate nitrogen
- Nitrite nitrogen
- Nitrate/nitrite nitrogen
- BOD
- TP
- TKN
- Chemical oxygen demand
- DO
- pH
- Specific conductance
- Oil & grease
- Total petroleum hydrocarbons
- Fecal coliform
- Total oopper
- Total lead
- Total zinc

The Final Report for this Watershed Project was completed in 2003 (Paragon, 2003) and is available on the City of Griffin's Stormwater Division website: http://www.cityofgriffin.com/Departments/PublicWorks/Stormwater/StormwaterProjects/tabid/375/Default.aspx.

5.5 Oakview Detention Pond Water Quality Monitoring

The Oakview Drainage Improvement Project consisted of retro-fitting an existing stormwater pond that provided detention for 55 acres of commercial and multi-family residential development. The previous detention pond was undersized and did not provide the desired level of flood control. The City of Griffin undertook the task of redesigning the existing pond and downstream drainage network to the appropriate engineering standards. At the same time, the City saw an opportunity to incorporate a water quality enhancement component into the redesigned pond that resulted in a comprehensive design that addressed both water quality protection and flood control concerns. The project was constructed in 2002. The Oakview Pond is just upstream of sample station HC1.

This project was also constructed, in part, using funds from a Clean Water Act Section 319 Grant. Note that water quality monitoring is no longer being conducted at the Oakview Pond.

6 Long-Term Monitoring Plan

Since 2001, the City of Griffin has implemented a monitoring program in coordination with the Georgia EPD for the Shoal Creek Watershed. The Shoal Creek monitoring stations are listed in Table 6-1 and depicted in Figure 6-1. Current monitoring stations include SC0, SC2, SC5, SC10, HC3, WC1, and one water quality reference site in Meriwether County (Figure 6-2).

Table 6-1 Shoal Creek Monitoring Stations

Site ID (Griffin ID)	Description	Sampling Start Date	Sampling End Date	Site Selection Rationale
SC0 – Shoal Creek (WQ-38)	Shoal Creek west of the Griffin Country Club	March 17, 2005	Present	Measures water quality leaving Shoal Creek Lake area and the Griffin jurisdiction
SC1 – Shoal Creek (WQ-24)	Shoal Creek west of the Griffin Country Club	July 31, 2001	September 22, 2004	Measures water quality leaving Griffin jurisdiction
SC2 – Shoal Creek (WQ-25)	Shoal Creek @ North Pine Hill Road	July 31, 2001	Present	Measures water quality re-entering Griffin from the Experiment Station Farms
SC3 – Shoal Creek (WQ-26)	Shoal Creek @ Highway 19/41 Bypass	July 31, 2001	September 22, 2004	Measures water quality leaving Griffin jurisdiction and entering Experiment Station Farms
SC4 – Shoal Creek (WQ-27)	Shoal Creek Main Stem Tributary @ Highway 19/41 Bypass	July 31, 2001	September 22, 2004	Measures water quality leaving Griffin jurisdiction and entering Experiment Station Farms
SC5 – Shoal Creek (WQ-28)	Southwest Tributary @ Southwest Corner of Griffin Country Club	July 31, 2001	Present	Measures water quality re-entering from Spalding County and leaving Griffin jurisdiction
SC6 – Shoal Creek (WQ-29)	Southwest Tributary @ South Pine Hill Road	July 31, 2001	September 22, 2004	Measures water quality leaving Griffin jurisdiction and entering Spalding County
SC7 – Shoal Creek (WQ-30)	Southwest Tributary @ Carver Road	July 31, 2001	September 22, 2004	Measures combined Griffin/Spalding County water quality from headwaters drainage
SC8 – Shoal Creek (WQ-31)	Shoal Creek @ Lyndon Road	July 31, 2001	September 22, 2004	Measures water quality from downtown headwaters area
SC10 – Shoal Creek (WQ-39)	Shoal Creek @ Highway 19/41	March 17, 2005	Present	Measures water quality from Shoal Creek headwaters originating in Griffin and entering Experiment Station Farms
HC1 – Heads	Heads Creek	July 31, 2001	September 22,	Measures water quality leaving

Table 6-1 cont'd Shoal Creek Monitoring Stations

Site ID (Griffin ID)	Description	Sampling Start Date	Sampling End Date	Site Selection Rationale
Creek (WQ-32)	Tributary @ Rosewood Road		2004	Griffin jurisdiction
HC2 – Heads Creek (WQ-33)	Heads Creek Tributary @ Lucky Street	July 31, 2001	July 6, 2009	Measures water quality leaving Griffin jurisdiction
HC3 – Heads Creek (WQ-41)	Heads Creek Tributary near service area boundary	August 11, 2009	Present	Measures water quality leaving service area
WC1 – Wasp (WQ-42)	Wasp Creek near service area boundary	August 26,2010	Present	Measures water quality leaving Shoal Creek service area
REF-1 (WQ-40)	Brittens Creek, Meriwether County	March 17, 2005	Present	Water quality reference site

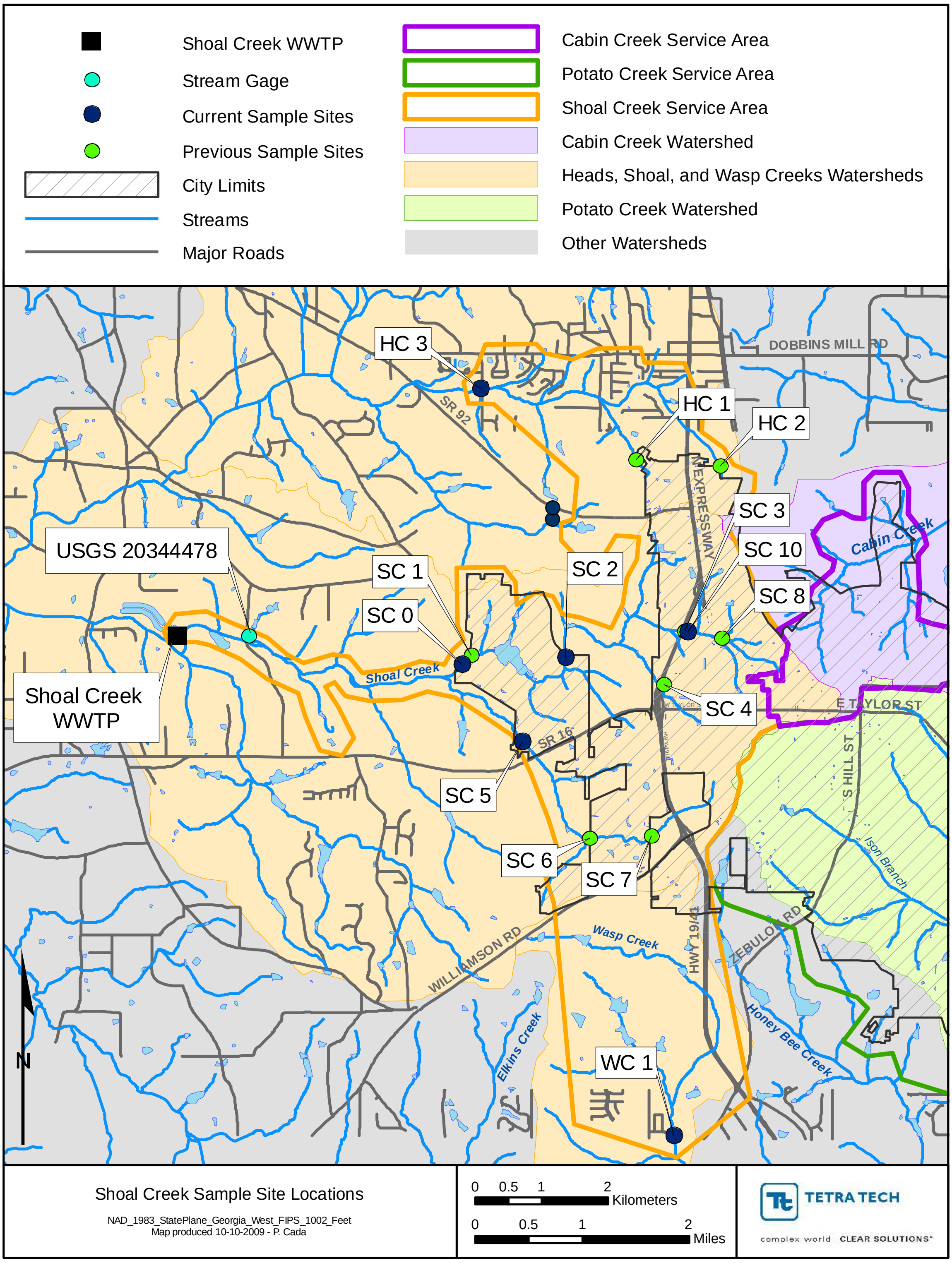

Figure 6-1 Shoal Creek Monitoring Stations

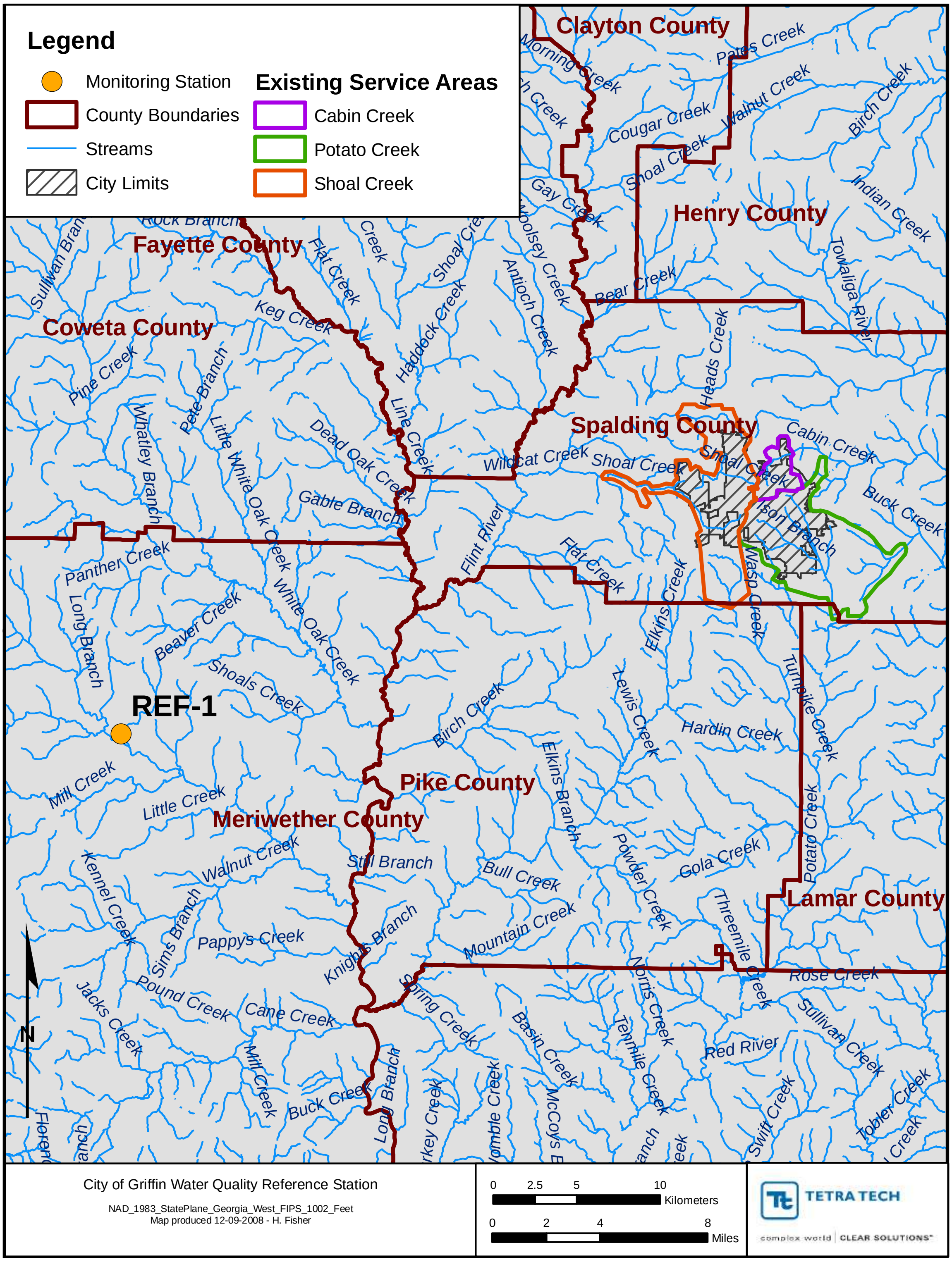

Figure 6-2 City of Griffin Water Quality Reference Monitoring Station

In the summer of 2001, a monitoring program was initiated that included 14 weeks of both in-situ and laboratory grab samples in the first year. Sampling continued thereafter, and this sampling has been used to establish current levels of water quality and detect any changes to water quality over time. When the monitoring program was initiated, there were a total of 10 sample sites in the service area that were used to obtain in-situ and grab samples (SC1 through SC 8, HC1, and HC2). Several of these stations have been revised to better reflect the needs of the monitoring program and the conditions of the watershed. Stations SC0 and SC10 were added in March 2005, and Stations HC1, SC1, SC3, SC4, SC6, SC7, and SC8 were decommissioned in the fall of 2004. The Georgia EPD recently recommended some changes to monitoring stations that are reflected in this long-term monitoring plan. On August 11, 2009, a new station, HC3, was added near the service area boundary on a Heads Creek tributary, replacing station HC2. Station WC1 on Wasp Creek was added in August 2010.

Since 2005, stations have been monitored quarterly for water quality. A USGS stream gage (station 02344478) is on Shoal Creek at Shoal Creek Road, near Griffin, which records gage height and discharge. Precipitation is measured at the Georgia Automated Environmental Monitoring Network (GAEMN) Georgia Experiment Station in Griffin.

The City of Griffin has also collected water quality reference data since March 2005, from station REF-1 at the location shown in Figure 6-2. This site is within the lower Piedmont eco-region.

The current monitoring stations—SC0, SC2, SC5, SC10, HC3, and WC1—are the sites that will continue to be monitored for the long-term monitoring plan. Flow in the Shoal Creek Watershed leaves and reenters Griffin jurisdiction in several areas. SC0, SC5 and SC10 all monitor water quality leaving the Griffin political boundaries. Because Wildcat Creek receives flow from Shoal Creek as well as Heads Creek, water quality issues in the Shoal Creek Service Area have some impact on downstream areas. SC0 and SC5 are the most downstream stations, which could be used to reflect input from Shoal Creek Watershed into Wildcat Creek. Any water quality impacts by future changes to land use or areas of new growth will be reflected in these most downstream stations as well. SC2 is in Shoal Creek at North Pine Hill Road on the west side of the City. This station best serves to monitor the water quality leaving the experimental farm area. Heads Creek water quality is monitored at HC3. This station is near the service area boundary along a Heads Creek tributary and measures the water quality that is leaving the City of Griffin. Wasp Creek water quality is monitored at WC1. This station is near the service area boundary along Wasp Creek and measures the water quality that is leaving the City of Griffin.

The drainage areas of the sample locations are representative of the major land uses and the 303(d)-listed (impaired) waterbodies in the service area. Because no future service area expansion is proposed, the monitoring station selection considered the existing service area only.

Water Quality Monitoring

The long-term monitoring plan for the Shoal Creek Watershed includes continued quarterly water quality monitoring, with two wet and two dry weather samples collected each year. Some parameters will be measured *in-situ* while others will be measured in a laboratory from samples collected at the sites (laboratory grab). The sampling schedule, as well as targets for wet and dry sample collection, is described in the City of Griffin QAPP (Appendix D). All water quality measurements will be taken using standard operating procedures approved or similar to those listed in 40 Code of Federal Regulations (CFR) part 136, excluding the fecal coliform method that uses a standard operating procedure published in *Standard Methods* but not listed in the CFR.

The City of Griffin's monitoring protocols for Shoal Creek are detailed in the Shoal Creek Monitoring Plan that was prepared by Tetra Tech in 2009. The monitoring protocol will continue as outlined in the monitoring plan, with the addition of a few new parameters. Beginning in fiscal year 2010-2011, composite samples will be taken that will cover the complete hydrograph during a wet weather event. The composite sample will rotate from year to year between stations SC2, WC1, and HC3. This is a revision from the Watershed Monitoring Plan, based on a recommendation from EPD. Beginning in fiscal year 2010-2011, the City will also begin sampling fecal coliform between May and October in order to determine the geometric mean of bacteria in the watershed. *Escherichia coli* (an important fecal coliform) will be sampled once per year beginning in fiscal year 2010-2011. The City will begin sampling water hardness, as calcium carbonate ($CaCO_3$), in fiscal year 2010-2011. This sampling will allow the City to calculate dissolved metals concentrations based on the total metal concentrations sampled for cadmium, copper, lead, and zinc. When possible, the City should measure or estimate stream flow during each sampling event at each monitoring site. If the stream is dry or there is no flow at a monitoring site, this will be noted in the field notes and the Annual Report. The City has conducted priority pollutant scans and sediment sampling in the past and may continue to do these analyses periodically at their discretion. Table 6-2 displays the parameters measured by the City, as well as the referenced standard operating procedure and accompanying detection limit.

Table 6-2 Water Quality Parameters Measured by the City of Griffin

Parameter	Sample Type	Method(s)	Detection Limit
Temperature			
Air	In-situ	Troll 9500	N/A
Water	In-situ	Troll 9500	N/A
Oxygen demand			
DO	In-situ	Troll 9500	N/A
Carbonaceous biochemical oxygen demand (5-day) (CBOD5)	Laboratory grab	SM 5210B	2.0 mg/L
Chemical oxygen demand (COD)	Laboratory grab	Hach Method 8000	2.0 mg/L
Sediment Load			
TSS	Laboratory grab	SM 2540D	1.0 mg/L
Turbidity	In-situ	Horiba U-10 Checker	N/A
Nutrients			
TP	Laboratory grab	Hach Method 8190	0.01 mg/L
Orthophosphate	Laboratory grab	SM 4500-P E	0.02 mg/L
Nitrates (NO_3)	Laboratory grab	Hach Method 8039	0.3 mg/L
Nitrites (NO_2)	Laboratory grab	Hach Method 8507	0.002 mg/L
Ammonia nitrogen	Laboratory grab	SM 4500-NH3 F	0.01 mg/L
TKN	Laboratory grab	SM 4500-Norg B/NH3 D	0.4 mg/L

Table 6-2 cont'd Water Quality Parameters Measured by the City of Griffin

Parameter	Sample Type	Method(s)	Detection Limit
Flow	In-situ	Visual estimate	N/A
Metals			
Specific conductivity (SpC)	In-situ	Troll 9500	N/A
pH	In-situ	Troll 9500	N/A
Total cadmium (Cd)	Laboratory grab	EPA 200.7	0.0005 mg/L
Total copper (Cu)	Laboratory grab	EPA 200.7	0.004 mg/L
Total lead (Pb)	Laboratory grab	EPA 200.7	0.005 mg/L
Total zinc (Zn)	Laboratory grab	EPA 200.7	0.004 mg/L
Dissolved Cd [1]	Calculated	Calculated	Calculated
Dissolved Cu [1]	Calculated	Calculated	Calculated
Dissolved Pb [1]	Calculated	Calculated	Calculated
Dissolved Zn [1]	Calculated	Calculated	Calculated
Hardness as $CaCO_3$[1]	Laboratory grab	Hach 8226	0.3 mg/L
Priority pollutants			
Priority pollutant scan	Laboratory grab	Multiple methods	Parameter dependent
Sediments			
Metals, pesticides, polychlorinated biphenyls (PCBs), polynuclear aromatic hydrocarbons (PAHs)	Laboratory grab	Multiple methods	Parameter dependent
Fecal Indicator Bacteria			
Fecal coliform	Laboratory grab	SM 9222 D	1 colony/100 mL
E. coli[1]	Laboratory grab	SM 9223 B	1 colony/100 mL

[1] Sampling required to measure these parameters will begin in fiscal year 2010-2011.

A regular assessment of water quality data will be conducted to compare measured data to established benchmarks and to characterize trends in each of the measured parameters. Annual progress reports to the Georgia EPD will relate pollutant concentrations to the water quality benchmarks established in this Watershed Protection Plan. These reports should include a statistical analysis of recent data, as well as figures such as time-series plots or box and whisker plots of pollutant concentrations and charts of pollutant loadings to observe trends over time for constituents of concern.

Biological Monitoring

The City of Griffin has conducted three Biological Assessments to date (2000, 2004/2005, and 2008/2009).

The City of Griffin will continue to conduct regular biological assessments as part of the long-term monitoring plan. In response to a request from Georgia EPD, monitoring was discontinued at station HC2, while a new station, HC3, was added in August 2009.

Macroinvertebrate and habitat sampling will be conducted twice every 5 years at sites SC0, SC2, SC5, SC10, and HC3. Fish community sampling will occur twice every 5 years at sites SC2 and SC5. Monitoring will be conducted using the most recent edition of the Georgia Department of Natural Resources' *Standard Operating Procedures for Macroinvertebrate Biological Assessment of Wadeable Streams in Georgia* and *Standard Operating Procedures for Conducting Biomonitoring on Fish Communities in Wadeable Streams in Georgia*. In-situ measurements and samples for alkalinity and nutrients (total phosphorous, orthophosphate, total Kjeldahl nitrogen, ammonia, nitrite/nitrate) will be taken immediately before habitat data and biological samples are collected. The nutrient data can also be used for one of the dry-weather water quality monitoring events. Sampling for the macroinvertebrate and fish assessments will be performed at least two weeks apart.

7 Watershed Management Needs

To address the impaired biota and water quality in the Shoal Creek Watershed, it is important that management measures are appropriately selected and implemented at strategic locations. Tetra Tech considered recent data and information and developed a framework to prioritize management needs based on spatial variation in the watershed. Information from the watershed assessment was used, in conjunction with further analysis of water quality data collected since 2005 and supporting studies in the watershed, such as the 2004 Stream Channel Stability Assessment and the 2005 Sediment Evaluation.

Through this review, management needs were identified on a subwatershed basis (defining subwatersheds as the land draining to each monitoring station). The watershed impact indicators were used to prioritize the subwatersheds for particular management needs relating to each indicator. Indicators considered for this evaluation were selected based on their relevance in the Shoal Creek Watershed and whether information or data were readily available. Watershed impact indicators were only used to prioritize subwatersheds for the portion of the service area within sub-basins SC0, SC2, SC5, SC10, and HC2. There is insufficient information for areas outside of these subwatersheds to prioritize those areas for management.

Where a subwatershed is identified as a priority for a particular indicator, management within that subwatershed is expected to provide water quality improvement within the subwatershed and at downstream locations. Therefore, some subwatersheds are selected as priorities for management because they can address a downstream management need. The strategies for identifying priority subwatersheds differed by indicator and are explained in more detail below.

Sediment, Channel Stability, and Channel Morphology

As discussed in Section 3, sediment is a concern in the Shoal Creek Watershed, as evidenced by areas of high channel erosion activity, documented problems with sediment accumulation in the Griffin Country Club Lake, instances of high concentrations of TSS at all of the monitoring stations, and the poor condition of biotic communities.

Sources of instream sediment include erosion from upland areas and erosion occurring along the banks of the stream channels. Although most of the sediment loading in the Shoal Creek Service Area is likely attributed to bank and channel erosion, upland sediment is another potential source—particularly stormwater runoff from construction sites, farm land, and other areas where bare soil is exposed. The highest 5-year mean TSS loads were seen in subwatersheds SC0 and SC2. The 2004 Stream Channel Stability Assessment characterized the geomorphic state of streams and identified erosion hot spots and areas of concern in the Shoal Creek Watershed, upstream of the Country Club Lake (Figure 7-1). The Assessment identified erosion hot spots in subwatersheds SC10 and SC2. Subwatershed SC10 is nested within subwatershed SC2, and SC2 is nested within SC0, so channel erosion in the SC10 and SC2 subwatersheds is likely a significant source of the TSS load in the SC2 and SC0 subwatersheds. The SC0, SC2, and SC10 subwatersheds are priority areas for managing sediment. Management measures that address upland sources and those that address stream channel sources should be considered. The SC10 and SC2 subwatersheds are priority areas for managing channel stability. Restoration of highly erosive reaches in these subwatersheds can serve to reduce the amount of sediment entering the stream. The 2004 Assessment noted channelization in a tributary of Shoal Creek that is within the SC2 subwatershed. Aerial photos show that there are also channelized stream reaches in the SC7 and SC10 subwatersheds that have been cleared of riparian vegetation. Subwatersheds SC2, SC5, and SC10 are priority areas for managing channel morphology.

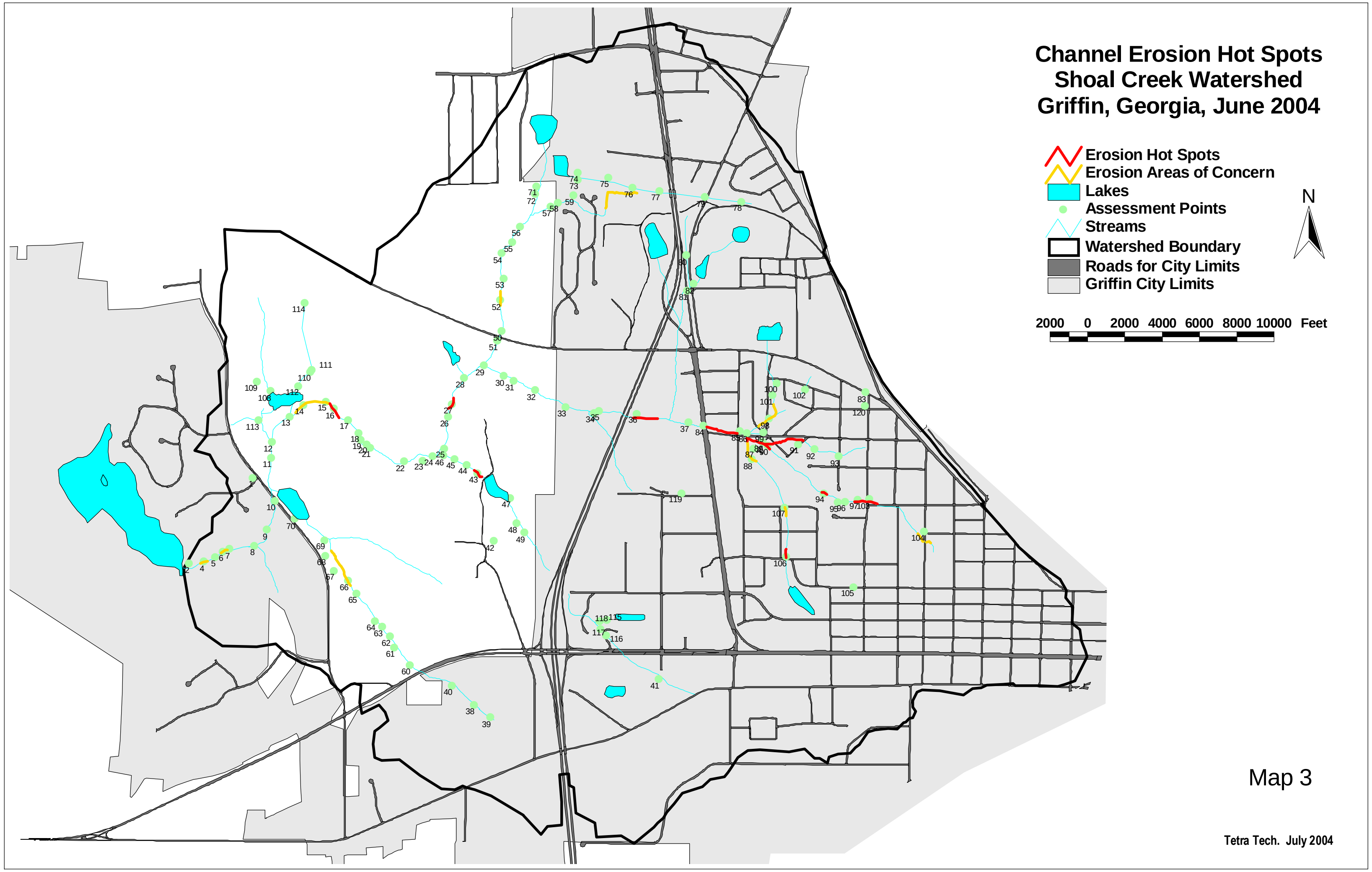

Figure 7-1 Channel Erosion Hot Spots from 2004 Stream Channel Stability Assessment

Hydrology

Disturbance and development in upland areas can alter the natural hydrology of a watershed and lead to lost watershed functions. These conditions can cause, among other impacts, erosion (both instream channels and in upland areas), increased flooding, and wetland conversion due to decreases in the water table. At the present time, hydrology modeling data have not been interpreted to provide estimates of where the greatest impacts of increased peak flow and volume from urban development might be occurring. Subwatersheds in the Shoal Creek service area range from 9 percent impervious cover (WC1) to 43 percent impervious cover (HC1). As an initial hypothesis, subwatersheds with an impervious surface cover greater than 20 percent are placing the greatest hydrologic stress on the stream system. Subwatersheds SC2 and SC10 should be prioritized for upland flow controls because these areas contain an extensive degree of urban development—greater than 20 percent impervious cover. These subwatersheds also exhibit areas of severe erosion and scour. BMPs implemented in subwatersheds SC2 and SC10 would provide flow control in heavily developed areas and reduce the rate of downstream erosion. Subwatershed HC1 is a concern due to its high percentage of impervious area, but it is not currently a priority because there is insufficient geomorphic or water quality data to characterize or confirm hydrologic impacts.

Metals

A management need for metals has not been identified for specific subwatersheds. Cooper and zinc have been detected throughout the watershed, but dissolved concentrations of metals have not been calculated. Therefore, metals management in the Shoal Creek Watershed should involve the calculation of the dissolved fraction of metals as part of the long-term monitoring plan before additional BMPs are identified and implemented.

Dissolved Oxygen

Low DO conditions exist in two locations within the watershed and might be impacting aquatic communities. The water quality data since 2005 indicates that DO standards were violated by individual measurements of less than 4.0 mg/L at monitoring stations SC0 and HC2. As noted in Section 3, there is a strong inverse relationship between DO and water temperature, with high water temperatures creating low DO levels during summer months, and particularly during low-flow conditions. Monitoring station SC0 represents, for the most part, flow from the Griffin Country Club Lake. The Lake is relatively large, covering approximately 35 acres. Under normal flow conditions, the lake discharges water from its lower depths and the water then continues downstream. Sediment deposition in the Lake may be negatively impacting DO. Stations upstream of the Lake did not exhibit problems with dissolved oxygen, which indicates the Lake is the likely cause of lowered DO downstream. Sample station HC2 is the smallest subwatershed in the Shoal Creek Assessment and would probably be the most affected by warm weather and low-flow drought conditions. Elevated nutrient concentrations could also be contributing to the low DO concentrations. To address low DO concerns in the priority subwatersheds SC0 (not including nested subwatersheds) and HC2, stream restoration opportunities should include the consideration of measures to improve DO. Such measures could include riparian zone enhancement to reduce water temperature and channel alteration to constrict flow and improve mixing at points along impacted reaches. BMP retrofits could be selected to reduce nutrient concentrations in runoff, reduce peak flows, increase base flow, and achieve a more natural hydrograph. Since the Griffin Country Club Lake is a potential cause of low DO at the monitoring station downstream, a lake management plan could be developed that aims to reduce organic load and increase aeration to increase DO levels leaving the lake.

Nutrients

Average TP concentrations from 2005 to 2010 are within the benchmark range at all stations, and occasionally exceed EPA recommendations for phosphorous concentrations in streams. Average TN concentrations exceed the upper bound benchmark at all stations. Nutrient reduction is a priority in all of the monitored subwatersheds, including SC0, SC2, SC5, SC10, and HC2. Management opportunities should include both upland (e.g., fertilizer management, BMP retrofits) and instream (e.g., stream restoration) strategies.

Bacteria (Fecal Coliform)

Fecal coliform counts provide an indicator of human health risk to pathogens that might be present in waterbodies. Current data indicate that fecal coliform levels are a concern in all monitored subwatersheds, with all stations included in the 2005 to 2010 summary having high median concentrations of fecal coliform bacteria. Thus, all of these areas, including subwatersheds SC0, SC2, SC5, SC10, and HC2, are priorities for managing bacteria. BMP types considered throughout the watershed should include those that are effective at removing fecal coliform bacteria from stormwater. Management needs related to fecal coliform pollution should be reassessed once geometric mean calculations are obtained and evaluated. It would also be advantageous for the City of Griffin to identify the source of fecal coliform bacteria in the Shoal Creek watershed, similar to the Bacterial Identification Study done for the City of Griffin's Potato Creek Watershed.

Physical Habitat and Biology

Aquatic communities provide indicators of overall ecosystem health. The 2008/2009 macroinvertebrate and fish monitoring data indicate that improvement of aquatic communities should be a watershed-wide effort. In 2008, the benthic macroinvertebrate community was rated poor at all five of the monitoring locations (SC0, SC2, SC5, SC10, and HC2). In 2009, the fish community was rated fair at station SC5 and very poor at station SC2. Given these findings, subwatersheds SC0, SC2, SC5, SC10, and HC2 were designated priority areas for overall improvement of biology.

Sedimentation, hydrology, and water quality all affect the viability of aquatic life in streams, and the subwatershed priorities for these stressors were addressed individually above. Although these stressors are indicators of habitat degradation, it is also useful to address the degradation of physical aquatic habitat directly. Habitat scores from the 2009 assessment indicate conditions that were marginal at SC0, SC5, and HC2, marginal/suboptimal at SC2, and suboptimal at SC10. These scores indicate that habitat degradation is prevalent throughout the watershed.

Where excessive sedimentation is occurring, habitat concerns are best addressed by implementing BMP measures aimed at sediment load reduction. Similarly, where low DO is limiting aquatic communities, BMP measures that increase DO concentrations should be considered. Once these and other sources of habitat degradation are addressed, then stream reaches can be evaluated for opportunities to improve physical aquatic habitat through restoration. Stream restoration activities should target the habitat parameters (e.g., vegetative protection, epifaunal substrate) that are in poor condition on a site-by-site basis. Habitat management is considered a priority in subwatersheds SC0, SC2, SC5, SC10, and HC2, but must be addressed through the management of stressors that have been identified at the subwatershed scale, as well as through restoration measures that directly improve physical habitat at individual sites. Restoration measures will provide an immediate improvement to habitat conditions, while the management of stressors will improve the long-term stability and health of the aquatic habitat and aquatic communities. Further degradation of aquatic communities can be minimized by preserving high quality, forested land in the watershed—particularly along stream corridors. Undeveloped land that is dominated by native vegetation provides food sources and habitat for macroinvertebrates and allows infiltration of stormwater. The preservation of land that is currently providing significant benefits to the watershed is a preventative measure that will ensure that these benefits are not lost.

Summary

Table 7-1 and Figure 7-2 summarize the management needs discussed above, noting which subwatersheds are priorities for each indicator. As management activities are implemented throughout the watershed, these priorities should be reviewed to assess progress in meeting watershed goals and objectives. Periodic adjustments to the priorities may be required based on the progress of watershed improvement projects, changes in watershed conditions, and information obtained from new monitoring stations.

Table 7-1 Management Priorities by Subwatershed

Watershed Impact Indicator	Considered in Evaluation	Priority Subwatersheds
Benthic communities	Yes	SC0, SC2, SC5, SC10, and HC2
Aquatic habitat	Yes	SC0, SC2, SC5, SC10, and HC2
Fish communities	Yes	SC0, SC2, SC5, SC10, and HC2
Channel morphology	Yes (2004 assessment)	SC2, SC5, and SC10
Channel stability	Yes (2004 assessment)	SC2 and SC10
Instream sediment	Yes (2004 assessment)	SC2 and SC10
Hydrology (frequency, magnitude, and duration of flows)	Best professional judgment through impervious data and geomorphic assessment	SC2 and SC10
Drainage complaints	No	N/A
Percent riparian area deficient of vegetation	No	N/A
Percent connected natural area	No	N/A
Water quality (modeling of future conditions): relative nutrient, upland sediment, and metals loading.	No	N/A
Water quality (observed/measured):		
Nutrients	Yes	SC0, SC2, SC5, SC10, and HC2
Instream sediment as TSS	Yes (2005–2009 loading analysis)	SC0 and SC2
Bacteria (fecal coliform)	Yes	SC0, SC2, SC5, SC10, and HC2
Metals	Yes	None
DO	Yes	SC0 (not including nested subwatersheds) and HC2

* Listed subwatersheds include upstream/nested subwatersheds unless otherwise noted.

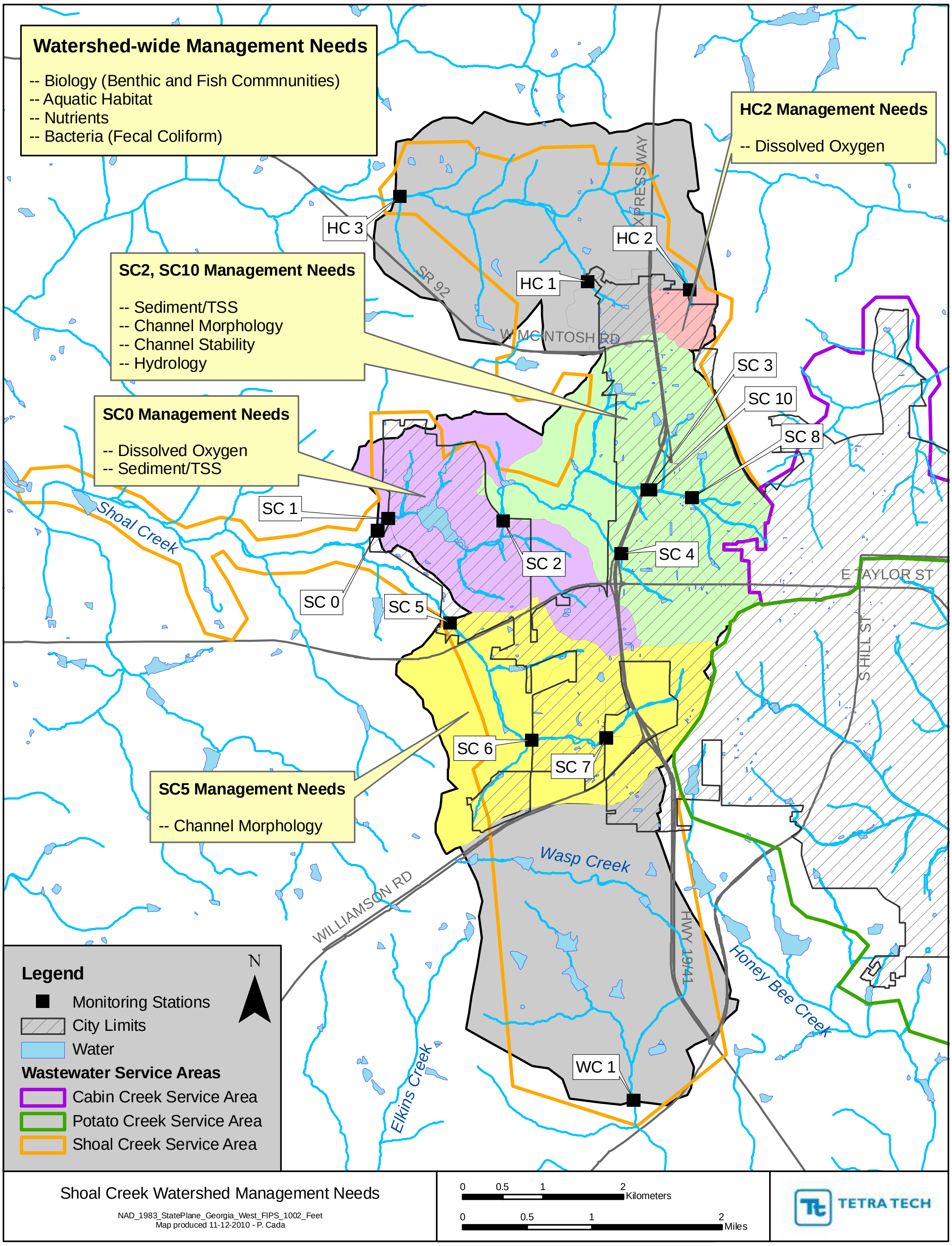

Figure 7-2 Shoal Creek Management Needs

8 Watershed Management Opportunities

Management opportunities have been identified that will best address the management needs of the Shoal Creek Watershed. The management needs identified in Section 7 are expressed in terms of watershed impact indicators. Because each watershed impact indicator addresses multiple objectives, management opportunities identified through these indicators will help achieve multiple objectives.

8.1 Identification of Potential Stream Restoration and BMP Sites

A desktop analysis was conducted to identify potential stream restoration and BMP sites in the Shoal Creek Service Area. Screening criteria, methodologies, and results are presented below.

Selection of Potential Stream Restoration Sites

The selection of stream restoration opportunities in the City of Griffin's Shoal Creek Service Area was based on the 2004 Stream Channel Stability Assessment. In that assessment, all stream reaches that were identified as erosion hot spots were selected for further evaluation. The nine selected reaches are identified in Figure 8-1.

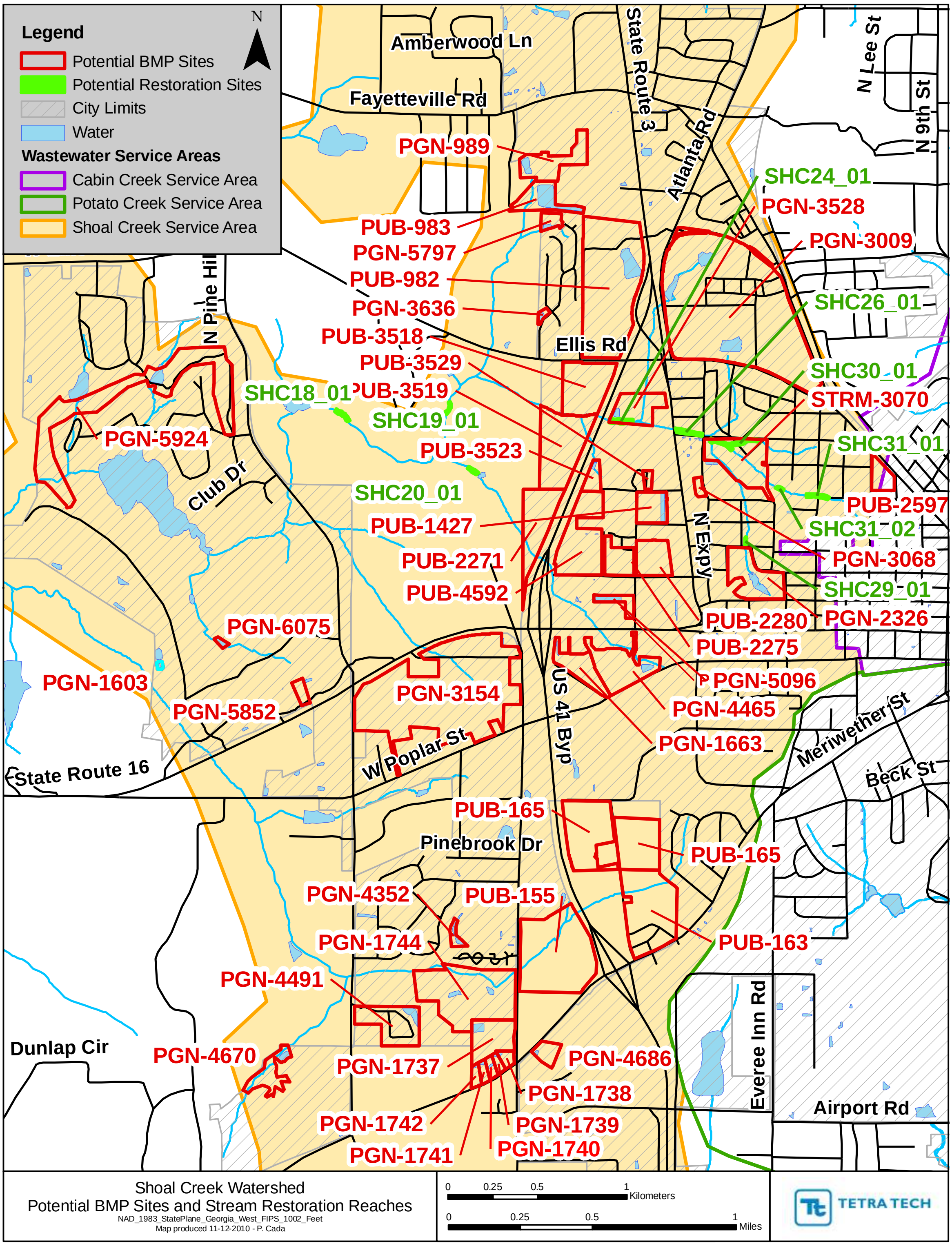

Figure 8-1 Potential BMP Sites and Stream Restoration Reaches

Selection of Potential BMP Sites

In preparation for the field investigation of potential new BMP opportunities in the City of Griffin's Shoal Creek Service Area, Tetra Tech conducted a desktop screening analysis using a variety of available data. GIS data included parcel information, aerial photography, sanitary and storm sewer locations, topographic and hydrographic data, wetland and hydric soil delineations, as well as a pond inventory and proposed BMP retrofits created by Paragon Consulting Group.

1) Initial BMP Site Selection

Selecting new BMP sites within a watershed typically requires reasonable assumptions to focus the search. The City of Griffin's parcel layer includes each individual parcel within the Shoal Creek Service Area. Similar to the Potato Creek BMP screening, Tetra Tech used the following three site selection criteria to identify potential sites for further screening: Paragon's modified and proposed BMP sites, public parcels, and riparian parcels adjacent to priority stream restoration reaches.

- <u>Paragon</u>—Paragon Consulting Group previously performed a field investigation for the City of Griffin that involved assessing existing stormwater ponds for water quality-based retrofits, as well as identifying new sites for water quality ponds and proprietary BMPs. Paragon's pond sites within the Cabin and Shoal Creek Service Areas were selected for further screening and prioritization.
- <u>Public</u>—Tetra Tech identified publicly owned parcels as opportunities because private land is potentially costly and complicated to acquire for BMP easements.
- <u>Stream</u>—Stream corridor BMP sites were identified in riparian areas along potential stream restoration reaches. Privately-owned parcels were included in the list of potential stream corridor sites because of the sites' high potential for immediate downstream improvement and typical unsuitability of riparian parcels for development by private interests.

The three site selection criteria and the number of potential sites associated with each criterion are provided in Table 8-1.

Table 8-1 Site Selection Criteria with Number of Potential Sites

Site Selection Criteria	Number of Sites—Shoal
Proposed Paragon sites (PGN)	New (33), modified (45)
Public parcels (PUB)	City (26), County (6)
Stream corridor BMP sites (STRM)	17
Total	**116***

*The total does not include duplicate counts for eleven sites that are included in more than one category.

2) Initial Constructability Analysis

Tetra Tech performed an initial constructability analysis for each site/parcel identified by the site selection criteria to remove infeasible sites from further BMP screening. The main criteria used to determine if a site is unfeasible for BMP construction include the following:

1. Insufficient upland (offsite) drainage;

2. Lack of available BMP area (non-forested); and
3. Stream/wetland impacts.

Unlike the Potato Creek BMP screening analysis, Tetra Tech removed all potential BMP sites if they were predominantly forested, unless the site exhibited excellent potential for effective stormwater treatment. Typically, BMP sites must receive considerable drainage from upland areas to be cost effective. The City's storm sewer network and topography data were used to assess a site's potential to collect and treat significant runoff volumes. For large public sites like schools, Tetra Tech used professional judgment to determine if treatment could be limited to onsite runoff due to the large impervious area associated with such locations.

Tetra Tech also assumed that a minimum of 0.5 acres of open land would be needed on each site to feasibly construct a stormwater BMP. This criterion was neglected for highly impervious sites in the downtown area where LID BMPs like permeable pavement and rainwater harvesting might be implemented using a 1:1 drainage to treatment area ratio.

Current federal and state regulatory interpretation of Section 404/401 compliance requirements limits the use of instream stormwater facilities, such as regional ponds or wetlands, where impacts to perennial and intermittent streams are necessary. The existence of perennial wetlands (according to National Wetlands Inventory) also limits the use of infiltrative-type BMPs and requires an extensive permitting process to meet U.S. Army Corps of Engineers (USACE) Section 404 compliance. As a result, Tetra Tech removed potential sites from further screening if they required an impact to natural wetlands or instream construction for implementation of a BMP.

3) BMP Screening Criteria

Following the initial BMP site selection and constructability analysis using the aforementioned criteria, a series of screening attributes were developed to score and prioritize the remaining potential sites. The attributes were devised to use "0" and "1" scoring, where "1" represents a positive attribute for BMP constructability and "0" represents a negative attribute.

Tetra Tech used a manual, GIS-based approach to screen the potential sites for all of attributes because automatic processes would not yield accurate results. All of the screening criteria are described below.

1. <u>Redundant Treatment</u>—The locations of potential BMP sites were evaluated relative to the City of Griffin's BMP geodatabase coverage to reduce redundant treatment. Existing BMPs included dry detention ponds and several proprietary BMPs. Sites without adjacent BMPs in their drainage area were scored a "1."
2. <u>Adjacent Streams</u>—Zero scoring was assigned to sites where BMP construction would impact a stream or wetland, which requires additional permitting to meet USACE Section 404 compliance. The data source for the stream layer is the National Hydrography Dataset.
3. <u>Utility Conflicts</u>—Sanitary sewers and water supply lines were the only utility layers available for the site screening. Conflicts were determined if the utility line intersected the site in the general vicinity of where a BMP could be located. Note that utility conflicts do not eliminate a BMP from being constructed within their easement, but could increase long-term maintenance cost (if sewer maintenance has to impact a BMP structure) and require additional permitting issues.
4. <u>Publicly-Owned Parcel</u>—Although this attribute was used as site selection criteria, publicly-owned parcels were also assigned a "1" score in the screening process due to their appeal for BMP retrofits.

5. High-Loading Land Use—Potential BMPs were credited with a “1” for this attribute if their drainage area included significant areas of land use with greater pollutant export rates. These types of land use include parking lots, industrial areas, high traffic roadways, golf courses, etc.
6. Downstream Condition—The erosion condition (based on 2008 Tetra Tech assessment) of the downstream channel was considered for each potential BMP site. BMPs were assigned the following scores depending on the channel condition immediately downstream.

Condition	Score
Not assessed	0
Low	0
Moderate	1
High	2

Sites were then scored for all six screening criteria and re-ranked accordingly by total score. Table 8-2 shows an example of the BMP attribute scoring for the second prioritization process.

Table 8-2 Example of BMP Site Scoring for Three BMP Sites

Site ID	Watershed	Adjacent BMPs	Utility Conflicts	Publicly-Owned	High-Loading Land Use	Stream/Wetland impact	Downstream Condition	Total Score
PGN-3528	Shoal	1	1	0	1	1	2	6
PUB-1427	Shoal	1	1	1	1	1	1	6
PUB-2597	Shoal	1	1	1	0	1	2	6

4) BMP Screening Process

After eliminating potential sites due to constructability limitations (e.g., no offsite drainage, insufficient area for BMP, heavily forested, stream/wetland impacts), the number of potential BMP sites was reduced from 116 sites to 49 sites. As part of the screening process, the 6 BMP screening criteria were applied to each of these 49 sites, which were subsequently ranked by their total screening score.

At this point the prioritization process deviated slightly from the Potato Creek methodology because the goal for the Shoal Creek Watershed was to include a proportionally large number of sites for field visits. During the screening criteria evaluation, seven sites were removed as potential BMP sites due to low screening scores and further professional judgment regarding difficult project constructability and effectiveness. The remaining 42 sites in the Shoal Creek Watershed were ranked by screening score.

5) BMP Screening Results

Following the screening process, Tetra Tech selected all 42 of the remaining screened sites for inclusion in the field investigation. Table 8-3 shows the final site list of sites, while Figure 8-1 shows the locations of the sites throughout the watershed.

Table 8-3 Final BMP Screening Site List

Rank #	BMP ID	Watershed	Parcel Owner	Total Score
1	PUB-2271	Shoal	Regents of UGA (Experiment Station)	6.5
2	PGN-3528	Shoal	Brentwood Investors, LLC	6
2	PUB-1427	Shoal	State of Georgia	6
2	PUB-2597	Shoal	City of Griffin	6
3	PUB-3529	Shoal	State of Georgia	5.5
4	PGN-3009	Shoal	Regents of UGA (Experiment Station)	5
4	PUB-163	Shoal	Spalding County	5
4	PUB-3518	Shoal	Regents of UGA (Experiment Station)	5
4	PUB-983	Shoal	City of Griffin	5
5	PGN-2326	Shoal	Spectra Properties, LLC	4.5
5	PUB-155	Shoal	Spalding County	4.5
5	PUB-3523	Shoal	State of Georgia	4.5
5	STRM-3070	Shoal	Griffin Old Mill, LLC	4.5
6	PGN-1603	Shoal	Wesminster Hills Homeowners Association	4
6	PGN-1738	Shoal	J V Properties Investment, Inc.	4
6	PGN-3154	Shoal	FAA Southern Federal Credit Union	4
6	PGN-5096	Shoal	LBA-GSA Griffin, LLC	4
6	PGN-5852	Shoal	G&M Properties, Inc.	4
6	PGN-989	Shoal	Griffin Crossroads, LLC	4
6	PUB-165	Shoal	Spalding County	4
6	PUB-2275	Shoal	Griffin-Spalding County Board of Education	4
6	PUB-2280	Shoal	City of Griffin	4
6	PUB-3519	Shoal	Regents of UGA (Experiment Station)	4
6	PUB-4592	Shoal	Unknown	4
7	PGN-1663	Shoal	CIT Small Business Lending Corp.	3.5
7	PGN-1739	Shoal	Sunshine Laundry, Inc.	3.5

Table 8-3 cont'd Final BMP Screening Site List

Rank #	BMP ID	Watershed	Parcel Owner	Total Score
7	PGN-1740	Shoal	Phyllis G. Justice	3.5
7	PGN-1741	Shoal	Bryan Wilmoth	3.5
7	PGN-1742	Shoal	James W. and Angelyn B. Woodall	3.5
7	PGN-3068	Shoal	Wandell J. and Van Dwight Coates	3.5
7	PGN-3636	Shoal	Ralph and Virginia Freeman	3.5
7	PGN-4352	Shoal	Unknown	3.5
7	PGN-4465	Shoal	Unknown	3.5
7	PGN-4491	Shoal	Unknown	3.5
7	PGN-4670	Shoal	Unknown	3.5
7	PGN-4686	Shoal	Unknown	3.5
7	PGN-5797	Shoal	Waterford on Ellis	3.5
7	PGN-6075	Shoal	Unknown	3.5
7	PUB-982	Shoal	Regents of UGA (Experiment Station)	3.5
8	PGN-1737	Shoal	Storage Villiage Griffin, LLC	3
8	PGN-1744	Shoal	Walden Pointe Apartments, LLC	3
8	PGN-5924	Shoal	Griffin Country Club	3

8.2 FIELD ASSESSMENT

A field crew consisting of three Tetra Tech employees and one City of Griffin staff member field located and assessed each of the 9 stream restoration sites and 42 BMP sites identified during the screening and site selection process for the Shoal Creek Watershed. The field crew identified and visited several additional sites during the field assessment that did not get included in the screening process based on additional recommendations from City staff, and based on additional opportunities identified in the field. During the field visit, the BMP team evaluated the potential site to determine if construction is feasible. For each site, the field crew created site sketches along with notes for potential stream restoration and BMP options and site constraints, and collected photographic documentation. For the feasible BMP sites, the field crew also assigned an engineering cost factor that reflects the extent that a site's constraints will influence the overall project cost (described further in Section 8.3)

Results of Stream Restoration Assessment

Three of the nine sites identified as potential restoration reaches were dropped prior to field evaluation due to property constraints. Three additional sites were dropped following the field evaluation, due to constructability issues, or because the site was not in poor enough condition to warrant restoration. The three remaining sites are listed in Table 8-4 and identified in Figure 8-2.

Table 8-4 Final Selected Stream Restoration Sites

Stream Restoration ID	Restoration Length (ft)	Parcel Owner
SHC30-01	1,060	Griffin Old Mill, LLC
SHC31-01	170	Marilyn M. Johnson
SHC31-02	150	Gleaves Rentals, LLC

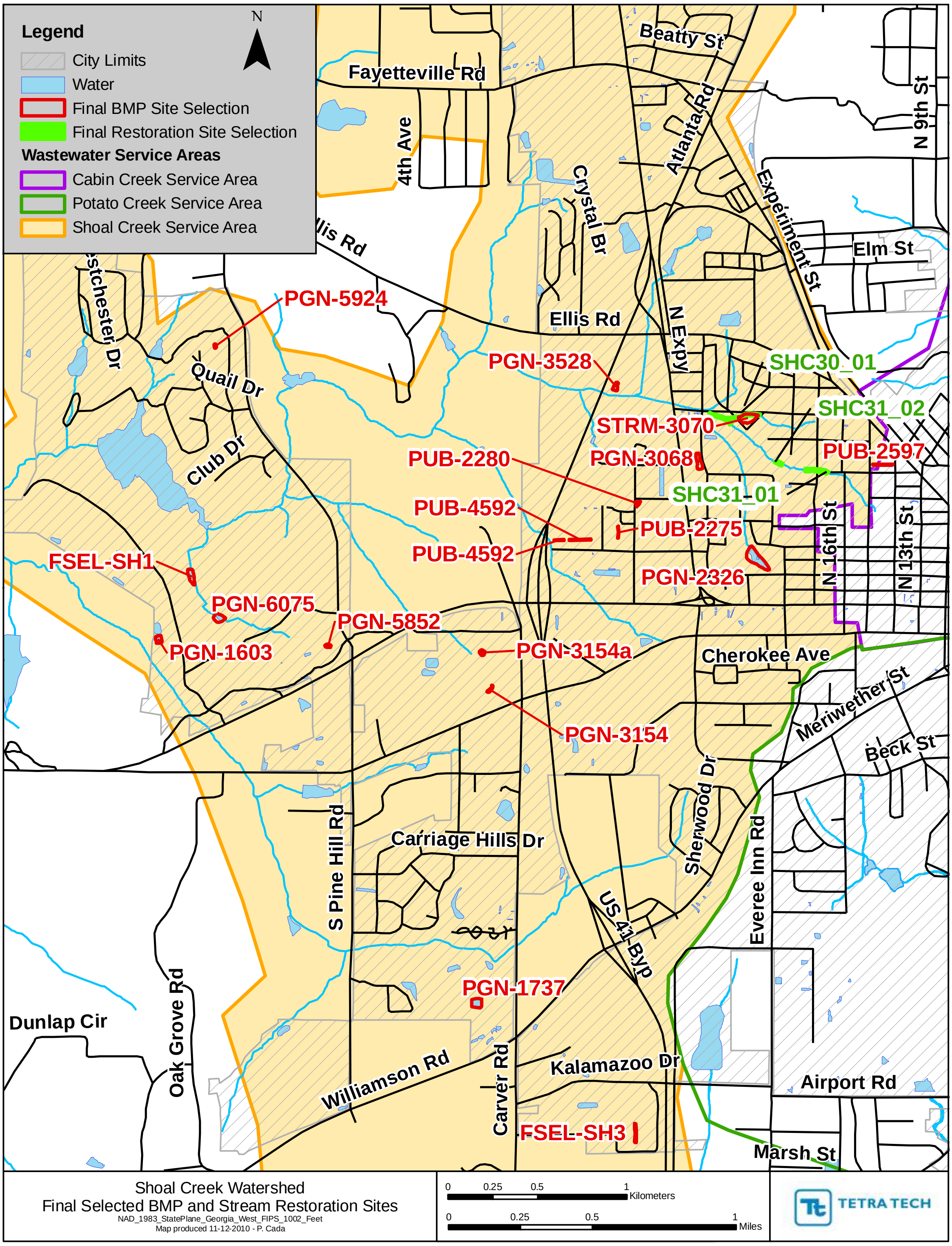

Figure 8-2 Selected BMP and Stream Restoration Sites

Results of BMP Assessment

Many of the BMP sites were deemed unfeasible as a retrofit opportunity upon the detailed field assessment due to various site constraints, which included utility conflicts, insufficient BMP area, steep slopes, and inadequate elevation grade between stormwater outfalls and BMP area. Out of the final 42 sites selected during the screening process, 15 sites in the Shoal Creek Watershed were recommended as potential retrofit sites and included in rating and prioritization evaluation (discussed below). Tetra Tech also identified two additional sites during the field assessment that are suitable for BMP construction and meet the BMP implementation goals. These sites were identified during the field activities as exhibiting high retrofit potential and field assessments were conducted on these sites. The resulting 17 recommended BMP sites are listed in Table 8-5 along with the parcel owner, parcel ID, and the proposed BMP type. The BMP types (wetland, wet pond, bioretention, and detention basin) are described in the City's Stormwater Design Manual. Figure 8-2 shows the site locations within the Shoal Creek Watershed. Project data sheets for each of these sites are included in Appendix E.

Table 8-5 Final Selected BMP Sites

BMP ID	Proposed BMP Type	Parcel Owner	Parcel ID
FSEL-SH1	Dry detention	Dixon-Alley Builders, Inc.	080A02030
FSEL-SH3	Wet pond or wetland	City of Griffin	049A02009
PGN-1603	Wetland	Searchlight Equity Co., LLC	080A02045
PGN-1737	Wetland	Storage Village Griffin, LLC	054E02004
PGN-2326	Wet pond	Spectra Properties, LLC	056 02001
PGN-3068	Dry detention/stream daylighting	Wandell J. & Vand Dwight Coates	059 01020
PGN-3154	Bioretention	Griffin-Spalding County Board of Education	055A01006
PGN-3154a	Dry detention	Griffin-Spalding County Board of Education	055A01006
PGN-3528	Wet pond	Brentwood Investors, LLC	060 01012
PGN-5852	Dry detention or Wetland	Ronnie et al. Perdue	080B01001
PGN-5924	Dry detention (WQ)	Griffin Country Club	080 03004
PGN-6075	Wet pond	Shoal Creek Development Co.	080A03008A
PUB-2275	Bioretention	Griffin-Spalding County Board of Education	055 01005
PUB-2280	Dry detention	City of Griffin	055 02005
PUB-2597	Dry detention	Griffin-Spalding County Board of Education	009 14001
PUB-4592	Bioretention + StormCeptor	Griffin-Spalding County Board of Education	055 01001A
STRM-3070	Wetland	Griffin Old Mill, LLC	059 02001

8.3 RATING SYSTEM AND RESULTS

Evaluation and Rating of Stream Restoration Reaches

The three final stream restoration sites remaining following field evaluation were characterized and evaluated based on information from the 2004 Stream Channel Stability Assessment, Spalding County parcel data, aerial photographs, and site visits. Six attributes were selected for the rating process that relate to constructability and public benefit. Higher scores were given to sites with public land ownership, good education potential, public amenity potential, good design potential and minimal earthwork needs, no utility conflicts, and a riparian zone that is less than 50 percent forested. An evaluation of the sites with respect to the rating criteria is presented in Table 8-6. The rating results are presented in Table 8-7. The highest possible score is 12. Site SHC30-01 scored 8. Sites SHC31-01 and SHC31-02 each scored 3.

All three sites are recommended for ongoing consideration, but site SHC30-01 is the most favorable option with respect to constructability and public benefit. It is recommended that a more detailed site evaluation be conducted on any reaches that are favorable to the City as potential restoration sites. A description of each site is presented below and the location of each is shown in Figure 8-2. Project data sheets for each of these sites are included in Appendix E.

Potential Stream Restoration Sites:

SHC30-01: This site is on a piece of property owned by Woody Heath (Griffin Old Mill, LLC) on the southeast corner of Lyndon Ave. and Melrose Ave. A textile mill once operated on the site, though the old mill building is currently being used as a classic car museum and family entertainment facility. Shoal Creek runs across the front of the property and two tributaries join the creek within the property. The proposed restoration reach is approximately 1,060 feet in length. The property is maintained with mowed grass to the top-of bank. The stream channel has weedy herbaceous vegetation on the banks and areas of moderate erosion. This stream reach is best suited for high level restoration. Activities would include laying back the bank slopes and contouring the channel to a stable profile. The design could incorporate meanders in the stream channel where space permits. The banks and riparian areas would be planted with native vegetation. The City of Griffin currently maintains the stream channels on this property.

SHC31-01: This is a stream segment near the intersection of N. 17th St. and Ray St. Restoration at this site would be limited to the reach that is west of 17th St. East of 17th St., the stream has been stabilized with rip-rap. The proposed restoration reach is approximately 170 feet in length. Restoration would involve spot stabilization, particularly along the right bank that is vertical and bare. The reach is in a residential area, and there is a house to the north and a house to the south which will limit the ability to lay back the banks. Although there are some trees and shrubs along the banks, the adjacent vegetation is primarily mowed lawn.

SHC31-02: The stream at this site runs between two apartment buildings. The proposed restoration reach is approximately 150 feet in length. The reach has steep, eroded banks, particularly the left bank. The stream is bordered by a narrow strip of shrubs and trees (approximately six feet on each bank, and then mowed grass beyond). Restoration would involve spot stabilization or laying back and stabilizing the banks.

Table 8-6 Stream Restoration Site Evaluation

	Restoration Reach		
Restoration Site Attribute	**SHC30-01**	**SHC31-01 (W. of 17th)**	**SHC31-02**
Ownership	Private: Griffin Old Mill, LLC	Private: Marilyn M. Johnson	Private: Gleaves Rentals, LLC
Education potential	Good—if City could purchase the land; large enough area for a park	Poor—small stream segment in a residential area	Poor—small stream segment between apartment buildings
Public amenity potential	Good—if City could purchase the land; large enough area for a park	Poor—small stream segment in a residential area	Poor—small stream segment between apartment buildings
Earthwork/design potential	Good design potential; minimal earthwork; no access constraints	Fair design potential; constrained by close proximity to houses; no access constraints	Fair design potential; moderate access constraints
Utility conflicts	Yes- GIS shows sewer line on right bank (not observed in the field)	Yes—sewer line on right bank	Yes—sewer line crossing
Forested/clear riparian zone	Clear riparian zone-mowed grass	Primarily grass; some trees, but >50% clear	Primarily grass; some trees, but >50% clear

Table 8-7 Stream Restoration Rating Results

Restoration Site Attribute	Rating	SHC30-01	SHC31-01	SHC31-02
Ownership				
Private	0	0	0	0
Public	2			
Education potential				
Poor	0		0	0
Good	2	2		
Public amenity potential				
No	0		0	0
Yes	2	2		
Earthwork/design potential (presume priority 2 restoration)				
Major alterations required/poor design potential	0			
Moderate alterations required/fair design potential	1		1	1
Minimal alterations required/good design potential	2	2		
Utility conflicts				
Yes	0	0	0	0
No	2			
Forested/Clear riparian zone				
Heavily forested	0			
>50% clear	2	2	2	2
Total		**8**	**3**	**3**

Evaluation and Rating of BMP Sites

Prioritization and evaluation of the 17 recommended BMP retrofit sites consisted of scoring and ranking the sites according to eight BMP attributes. Some of these attributes, like “education potential,” are qualitative and thus involve only a “yes” and “no”; attributes like runoff volume and pollutant reduction potential are quantitative and required additional hydrologic and BMP sizing calculations. Watershed size and characteristics were determined for each of the 17 recommended sites as well as determinations of target and available footprint and storage volume. Target water quality and stream protection volumes were calculated according the City of Griffin Stormwater Design Manual. Available site footprint was determined using GIS imagery and sketches made of each site during field assessment. Available water quality volume and stream protection volume were based on available site footprint and the field reviewers estimate of available storage depths of the proposed BMP.

Scoring BMP sites for the quantitative attributes also required threshold criteria (ranges of values) developed from all the site attribute values. Thresholds were selected to assign scores to ranges of attribute values, either based on the distribution of the attribute values or by using a ranking of the attribute values. BMP scoring was based on a total maximum score of 100 points with each attribute receiving a possible score between 0 and 10. Because there are only nine prioritization attributes and some attributes have more importance for BMP implementation than others, Tetra Tech applied weighting factors to each attribute to ensure that the maximum possible score equals 100. The weightings were based on the relative importance of the attribute to overall achievement of the goals and objectives. Each BMP prioritization attribute and its associated scoring criteria are described below. The weighting assumptions are discussed in the next section.

1. *Drainage Area Treated*—The amount of treated drainage area helps represent the combined water quality and quantity improvement attained from the BMP. The loading attributes described below differentiate how much load and flow are addressed depending on the type of BMP, whereas this attribute measures how much land in general is treated. The scoring criteria for the drainage area attribute are shown in Table 8-8. The treated drainage area represents the fraction of the total site drainage area that the BMP is capable of treating to equally score the undersized BMPs.

Table 8-8 Treated Drainage Area Scoring Criteria

Drainage Area Threshold	# of Sites	Score
< 3 acres	4	0
3–10 acres	7	2.5
10–30 acres	3	5
30+ acres	3	10

2. *Ownership*—Publicly owned parcels were given priority over privately owned parcels because easements and land acquisition will be easier and less expensive to acquire on public land. Thus, public parcels received a score of “10” while private parcels were scored “0.”
3. *Education Potential*—A benefit of retrofit sites on publicly exposed parcels is to provide opportunity for community education regarding stormwater management and watershed ecology. Examples of sites with good education potential include schools, high-trafficked public properties, churches, and parks. BMP sites that provide educational opportunities were scored a “10” while those that do not received a “0.”
4. *Maintenance Needs*—Regular BMP maintenance is required to ensure that a BMP performs as intended. Just as each type of BMP is different, so is the intensity and frequency of the necessary maintenance activities. BMP maintenance needs were considered either “frequent or intensive,” “moderate,” or “infrequent or minimal,” and assigned scores of “0,” “5,” and “10,” respectively. These levels of maintenance needs are based on the frequency of inspection, sediment cleanout, vegetation management, as well as the level of effort required for the various maintenance activities.
5. *Potential for Controlling Storm Flows*—This attribute categorizes the extent that a proposed BMP controls the stream protection runoff volume within its specific drainage area. Performance standards in the City of Griffin’s Stormwater Design Manual define the stream channel protection volume as the 1-year frequency storm event depth distributed over a 24-hour rainfall period. The scoring criterion for this attribute is the percentage of drainage area runoff from the 1-year, 24-hour storm event that can be stored within each BMP. This “storm control” volume includes both the water quality storage volume (i.e., 1.2” rainfall event) and any additional detention volume (when available) sized for the 1-year event. Runoff volumes were estimated using the “Simple Method” as defined in the City of Griffin’s Stormwater Design Manual (Paragon, 2007). Tetra Tech used NOAA’s Precipitation-Frequency Data Server (http://hdsc.nws.noaa.gov/hdsc/pfds) to determine a 1-year, 24-hour rainfall depth of 3.25 inches for the City of Griffin. Table 8-9 shows the scoring regime for the percent reduction in runoff volume provided by each potential BMP retrofit.

Table 8-9 Scoring Criteria for Storm Flow Reduction

Percent of Stream Protection Volume	Score
0–25%	0
25–50%	2.5
50–75%	5
75–90%	7.5
90–100%	10

6. *Potential for Reducing Pollutant Loads*—The existing LSPC model constructed by Tetra Tech for the Shoal Creek Watershed was used to estimate the annual pollutant loads of TSS, TP, and TN delivered to each BMP site from its contributing drainage area. Typical removal efficiencies for the three recommended BMP types were obtained from the Georgia and North Carolina BMP Manuals (see Table 8-10) and applied to the annual runoff loads. Many of the potential BMP measures will be undersized because the sites do not provide enough land area to treat the entire water quality volume. To estimate the relative load reduction for undersized BMPs, Tetra Tech scaled the removal efficiency by the fraction of the water quality volume that is available for treatment. The assumed scaling factors are shown in Table 8-11. Thus, the total annual pollutant load removed by each potential BMP site equals the annual runoff load estimated by the LSPC model multiplied by both the recommended BMP removal efficiency and the undersized scaling factor (if necessary). The calculated pollutant load reductions are reported in Table 8-12.

Table 8-10 BMP Removal Efficiencies

BMP Type	Source	TSS	TP	TN
Dry extended detention	NC BMP Manual (NCDENR, 2007)	50%	10%	10%
Wetland	GA BMP Manual (ARC, 2001)	80%	40%	30%
Bioretention	GA BMP Manual (ARC, 2001)	80%	60%	50%
Wet pond	GA BMP Manual (ARC, 2001)	80%	50%	30%

Table 8-11 Scaling Factors for Undersized BMPs

Percent of Water Quality Volume Treated	Percent of Full Removal Credit
25–49%	50%
50–74%	67%
75–99%	83%
100%	100%

Table 8-12 Pollutant Load Reductions

BMP ID	TSS Removal (lbs/yr)	TN Removal (lbs/yr)	TP Removal (lbs/yr)	Attribute Score
PGN-1603	7,094	20.2	1.1	7
PGN-6075	23,300	39.4	4.7	10
PGN-3154a	4,511	6.5	0.3	3
PGN-3154	2,465	10.7	0.6	4
PUB-2280	1,274	2.2	0.1	1
PUB-2275	1,363	6.0	0.3	2
PUB-4592	3,322	14.4	0.7	5
PGN-2326	69,155	202.1	13.2	10
PGN-3068	11,129	16.3	0.7	6
PGN-1737	8,777	23.9	1.3	8
PUB-2597	5,122	7.7	0.3	5
PGN-3528	9,883	25.8	1.8	6
STRM-3070	32,714	94.8	5.0	10
PGN-5924	1,059	2.4	0.1	1
PGN-5852	3,235	3.6	0.2	3
FSEL-SH1	14,295	29.2	1.0	9
FSEL-SH3	4,637	13.6	0.9	6

To assign attribute scores, the load reductions for each pollutant were ranked separately and averaged to determine a total average rank value for each BMP. The average rank was then used to develop percentiles for attribute scoring. Sites with a total average pollutant reduction rank in the 0-10th percentile range received a score of “1,” a site ranking in the 10th-20th percentile range received a score of “2,” and so on.

7. *LID, Green, and Innovative BMPs*—One objective of the watershed protection plan is to implement LID, green infrastructure, or regional innovative BMPs. Of the four types of BMPs recommended for the Shoal Creek Watershed, both bioretention and constructed wetlands fit this category and were scored a “10” while detention basins received a “0” score.

8. *Removal Efficiency Cost*—Cost estimates were developed for each BMP, comprising land acquisition, scaled construction, design and engineering, and operation and maintenance over a 20-year life-cycle. For private properties, land acquisition costs were based on the recent tax value (land portion only) for each parcel reported by the Spalding County Tax Assessor’s Office (http://qpublic3.qpublic.net/ga_search.php?county=ga_spalding) and prorated to the amount of area needed to construct the proposed BMP. It was assumed that an easement would be purchased from the landowner, and the acquisition costs was assumed to be 80 percent of the land value to account for the lesser cost of an easement. The acquisition cost for public properties was assumed to be zero.

   The construction costs were estimated from the unit cost equations reported in Schueler et al. (2007) and were adjusted from 2006 to 2010 dollars using an annual inflation rate of 3 percent. The construction cost assumptions are displayed in Table 8-13. Note that for construction cost of undersized bioretention cells, which is estimated based on the contributing drainage area (CDA), the CDA was adjusted to reflect the percentage of water quality volume that the specific BMP is capable of treating.

   To more accurately reflect each BMP’s construction costs given the site constraints, the general construction cost estimates were adjusted by a designer’s cost factor (1-10) that was assigned during the field assessment. Higher numbers reflect more site constraints that would require greater construction costs, such as significant earthwork and utility alterations. A designer’s cost factor of “5” represents the average construction cost estimated by the unit cost equations, so the construction cost was adjusted by 5 percent for each incremental deviation in the cost factor from “5.” For example, construction cost for projects with cost factors of “3” and “7” would be adjusted by (-)10 percent and 10 percent, respectively. Design and engineering costs were assumed to be 25 percent of the scaled construction cost.

Table 8-13 Construction Cost Assumptions, 2010 Dollars (Schueler et al., 2007)

BMP Type	Site Condition	Cost Assumption
Bioretention	Existing facility absent	\$10.50 per CF treatment volume (Scheueler et. al, 2007, Table E.4)
Dry detention	Existing BMP	$11.54*Vs^{0.780}$, Vs= Treatment Volume (Scheueler et. al, 2007, CC equation for new extended detention)
	Existing facility absent	\$5 per CF treatment volume (Scheueler et. al, 2007, Table E.4)
Wet pond	Unique site conditions	Site specific estimate for installation of riser barrel outlet and associated inlet features
	Existing facility absent	\$8350 per impervious acre treated (Scheueler et. al, 2007, Table E.2 median cost for new wet pond)
Wetland	Existing facility absent	\$9600 per impervious acre treated (Scheueler et. al, 2007, Table E.2 high range of new wetland unit cost)

Operation and maintenance (O&M) cost assumptions were based on information collected for a recent Tetra Tech publication on a green BMP O&M study (Tetra Tech, 2009). The study provided unit area annual O&M costs for multiple BMPs, including the four shown in Table 8-14.

Table 8-14 O&M Annual Cost Assumptions, 2010 Dollars (Tetra Tech, 2009)

BMP ID	Cost Equation
Constructed wetland	0.28*A
Dry detention basin	0.56*A
Bioretention	1.47*A
Wet pond	0.23*A

A = BMP surface area (sq. ft.)

The construction and O&M cost components were summed to calculate a total 20-year cost estimate. Final BMP Cost Estimates are shown in Table 8-15.

Table 8-15 Final BMP Cost Estimates

BMP ID	Raw Const. Cost Estimate	Const. Cost Adjusted to Cost Factor	Inflation Adjusted Const. Cost	Design and Eng.	20-Yr O&M	Property Acquisition	Total 20-Yr Cost
PGN-1603	$24,397	$24,397	$27,459	$6,865	$29,912	$10,186	$74,421
PGN-6075	$26,994	$34,073	$38,349	$9,587	$25,821	$1,996	$75,753
PGN-3154a	$73,382	$66,044	$74,333	$18,583	$43,456	$0	$136,372
PGN-3154	$34,460	$20,676	$23,271	$5,818	$85,558	$0	$114,648
PUB-2280	$26,287	$26,287	$29,586	$7,396	$36,441	$0	$73,423
PUB-2275	$23,017	$18,414	$20,725	$5,181	$40,237	$0	$66,143
PUB-4592	$118,879	$83,215	$93,659	$23,415	$172,855	$0	$289,929
PGN-2326	$200,000	$280,000	$315,142	$78,786	$222,221	$13,705	$629,855
PGN-3068	$232,612	$232,612	$261,807	$65,452	$161,235	$33,159	$521,652
PGN-1737	$46,661	$32,663	$36,762	$9,191	$35,100	$5,288	$86,340
PUB-2597	$67,636	$47,345	$53,287	$13,322	$46,882	$0	$113,491
PGN-3528	$21,459	$19,314	$21,738	$5,434	$30,154	$8,641	$65,967
STRM-3070	$91,805	$100,985	$113,660	$28,415	$146,660	$4,528	$293,262
PGN-5924	$23,475	$25,823	$29,064	$7,266	$16,272	$212	$52,813

Table 8-15 cont'd Final BMP Cost Estimates

BMP ID	Raw Const. Cost Estimate	Const. Cost Adjusted to Cost Factor	Inflation Adjusted Const. Cost	Design and Eng.	20-Yr O&M	Property Acquisition	Total 20-Yr Cost
PGN-5852	$39,135	$31,308	$35,237	$8,809	$36,168	$2,001	$82,216
FSEL-SH1	$51,896	$67,465	$75,933	$18,983	$167,124	$40,388	$302,428
FSEL-SH3	$20,217	$12,130	$13,653	$3,413	$32,332	$0	$49,398

The total 20-year cost for each BMP was divided by the 20-year load reductions provided by the BMP to obtain cost-effectiveness ratios for TSS, TN, and TP. The cost-effectiveness ratios for each BMP are shown in Table 8-16. Scoring of removal efficiency costs was performed similarly to the pollutant load reduction attribute where percentiles for the average ranking for each pollutant were used to score each site.

Table 8-16 Pollutant Removal Cost Estimates

BMP ID	TSS Removal Cost ($/lb/yr)	TN Removal Cost ($/lb/yr)	TP Removal Cost ($/lb/yr)	Attribute Score
PGN-1603	$0.52	$185	$3,464	8
PGN-6075	$0.16	$96	$798	10
PGN-3154a	$1.51	$1,051	$25,236	4
PGN-3154	$2.33	$535	$10,420	7
PUB-2280	$2.88	$1,666	$46,244	1
PUB-2275	$2.43	$551	$10,844	6
PUB-4592	$4.36	$1,005	$19,553	3
PGN-2326	$0.46	$156	$2,394	10
PGN-3068	$2.34	$1,596	$38,978	1
PGN-1737	$0.49	$180	$3,279	9
PUB-2597	$1.11	$735	$18,326	7
PGN-3528	$0.33	$128	$1,794	10
STRM-3070	$0.45	$155	$2,950	10
PGN-5924	$2.49	$1,100	$37,419	1
PGN-5852	$1.27	$1,137	$19,906	4
FSEL-SH1	$1.06	$518	$15,606	7
FSEL-SH3	$0.53	$181	$2,671	8

9. *Priority Subwatershed*—To better coordinate BMP implementation with the magnitude and extent of subwatershed issues, Tetra Tech developed a prioritization attribute that developed subwatershed management needs based on field-observed data. Management needs were assigned for instream sediment, channel stability, hydrology, nutrients, bacteria, biology, and DO. A BMP retrofit site was credited with a management need if it is in a subwatershed, or upstream of a subwatershed, with any of the above water quality/stream impairments. Tetra Tech summed the number of management needs allocated to each potential retrofit site and scored them accordingly based on the priority categories shown in Table 8-17.

Table 8-17 Subwatershed Priority Categories

# of Management Needs	Priority	Score
6	High	10
4-5	Medium	5
0-3	Low	0

Final BMP Scoring and Ranking

Following the evaluation and scoring of each recommended BMP site according to each prioritization attribute, all of the scores for each attribute were adjusted by a weighting factor. The selected BMP attributes cover a range of BMP selection criteria, including the magnitude and cost efficiency of pollutant load reduction, feasibility of land acquisition and construction, overall project costs, as well as several other indirect benefits. The weighting factors help emphasize BMP prioritization with respect to the project goals and balance the importance and skew that some attributes impose on the total prioritization score. For example, most of the quantitative attributes, like storm flow, pollutant load reduction, and cost-effectiveness, were considered the most importance factors for BMP prioritization because they directly target the watershed protection goals 1-3 specified in Section 2. Education potential and LID/green BMP classification (which have large scoring margins between the “yes” and “no” criteria) were weighted to have less influence on the total score. Although these qualities also address the goals and objectives, they are less critical to achieving the overall water quality and quantity goals. Table 8-18 shows the assigned weighting factor for each attribute, all the individual attribute scores for each BMP, and the final prioritization ranking based on the total BMP scores.

The high ranking opportunities provide multiple benefits, including major water quality and hydrology benefits. The three potential BMP retrofit sites with the highest prioritization for implementation include two existing dry detention basins in Wesminster Circle near the Griffin Country Club (PGN-6075 and FSEL-SH1) and an existing wet pond that is adjacent to a tributary of Shoal Creek and has an embankment that is in danger of failing (PGN-2326). All three of these sites treat large drainage areas, have good pollutant removal capabilities, and low removal efficiency costs. PGN-6075 and FSEL1-SH1 can each control over 90% of the stream protection runoff volume.

Table 8-18 BMP Attribute Scores and Final Ranking

BMP Ranking Attribute	*Weighting*	PGN-6075	FSEL-SH1	PGN-3154a	PGN-2326	PGN-1603	PUB-2597	PGN-1737	STRM-3070	PGN-3528	PGN-3068	PUB-2280	PUB-4592	PGN-3154	FSEL-SH3	PGN-5924	PGN-5852	PUB-2275
Drainage area treated	*1*	10	10	2.5	10	5	2.5	2.5	5	0	5	2.5	0	0	2.5	2.5	2.5	0
Ownership	*1*	0	0	10	0	0	10	0	0	0	0	10	10	10	10	0	0	10
Education potential	*0.5*	0	0	5	0	0	0	0	0	0	0	5	0	5	0	0	0	0
Maintenance needs	*1*	0	5	5	0	0	5	0	0	0	5	5	0	0	0	5	5	0
Storm flow control	*2*	20	20	20	5	20	5	20	0	5	15	5	5	5	0	10	0	0
Pollutant reduction	*2*	20	18	6	20	14	10	16	20	18	12	2	10	8	12	2	6	4
LID, green, or innovative BMP	*0.5*	0	0	0	0	0	0	0	0	0	0	0	5	5	0	0	0	5
Removal efficiency cost	*2*	20	14	8	20	16	14	18	20	20	2	2	6	14	16	2	8	12
Priority subwatershed	*1*	5	5	5	10	5	10	0	10	10	5	10	5	5	0	5	5	5
Total Score		**75**	**72**	**62**	**65**	**60**	**57**	**57**	**55**	**53**	**44**	**42**	**41**	**52**	**41**	**27**	**27**	**36**
Rank		1	2	4	3	5	6	6	8	9	11	12	13	10	14	16	16	15

8.4 BMP MODELING AND OPTIMIZATION

BMP optimization modeling was performed for the Shoal Creek Watershed. The Shoal Creek model was developed using BMPDSS Navigator spreadsheet-based decision support system. Inputs to the model include subwatershed delineation, land use distribution by subwatershed, BMP locations and design, BMP capital and O&M costs, and water quality goals at specific locations in the watershed.

The objective of this study was to recommend the most cost effective set of best management practices for achieving a set of water quality targets. Existing condition loads were calculated by taking yearly loads derived from the Hydrology and Water Quality model, calculating the 5-yr (2005-2009) average annual load for each of four Shoal Creek monitoring stations, then averaging those values to get a 5-yr watershed average. Water quality targets were developed for both TSS and nutrients in the Shoal Creek Watershed. For each nutrient parameter, as well as TSS, a watershed target was developed by calculating a 15 percent reduction in average load from existing conditions. Targets were developed in this manner in order to calculate reasonably attainable load reductions based on the recent water quality of this individual watershed.

The BMPDSS model optimizes BMP size and selection to achieve these water quality targets for annual average pollutant loading. Two assessment points were selected for the model to coincide with active monitoring locations at the outlet of subwatersheds SHC06 and SHC34. Locations of the assessment points and proposed BMPs, including ponds and proprietary devices, are shown in Figure 8-3. Assessment point SHC 06 corresponds to monitoring station SC 0, and assessment point SHC 34 corresponds to monitoring station SC 5. The original loading targets are in units of lbs per acre per year. Evaluation factors were calculated by multiplying the unit area loading targets by the total drainage area of each assessment point. The results of this calculation are presented below in Tables 8-19 and 8-20.

Table 8-19 Water Quality Loading Targets for Shoal Creek at SHC 06

Water Quality Parameter	Existing Unit Area Load (lbs / acre / year)	Existing Watershed Load (lbs / year)	Unit Area Loading Target (lbs / acre / year)	Watershed Evaluation Target Value (lbs / year)
TN	4.9	16,484	4.3	14,360
TP	0.081	272	0.074	247
TSS	392	1,310,431	390	1,302,398

Table 8-20 Water Quality Loading Targets for Shoal Creek at SHC 34

Water Quality Parameter	Existing Unit Area Load (lbs / acre / year)	Existing Watershed Load (lbs / year)	Unit Area Loading Target (lbs / acre / year)	Watershed Evaluation Target Value (lbs / year)
TN	4.6	8,240	4.3	7,636
TP	0.090	159	0.074	131
TSS	424	753,364	390	692,548

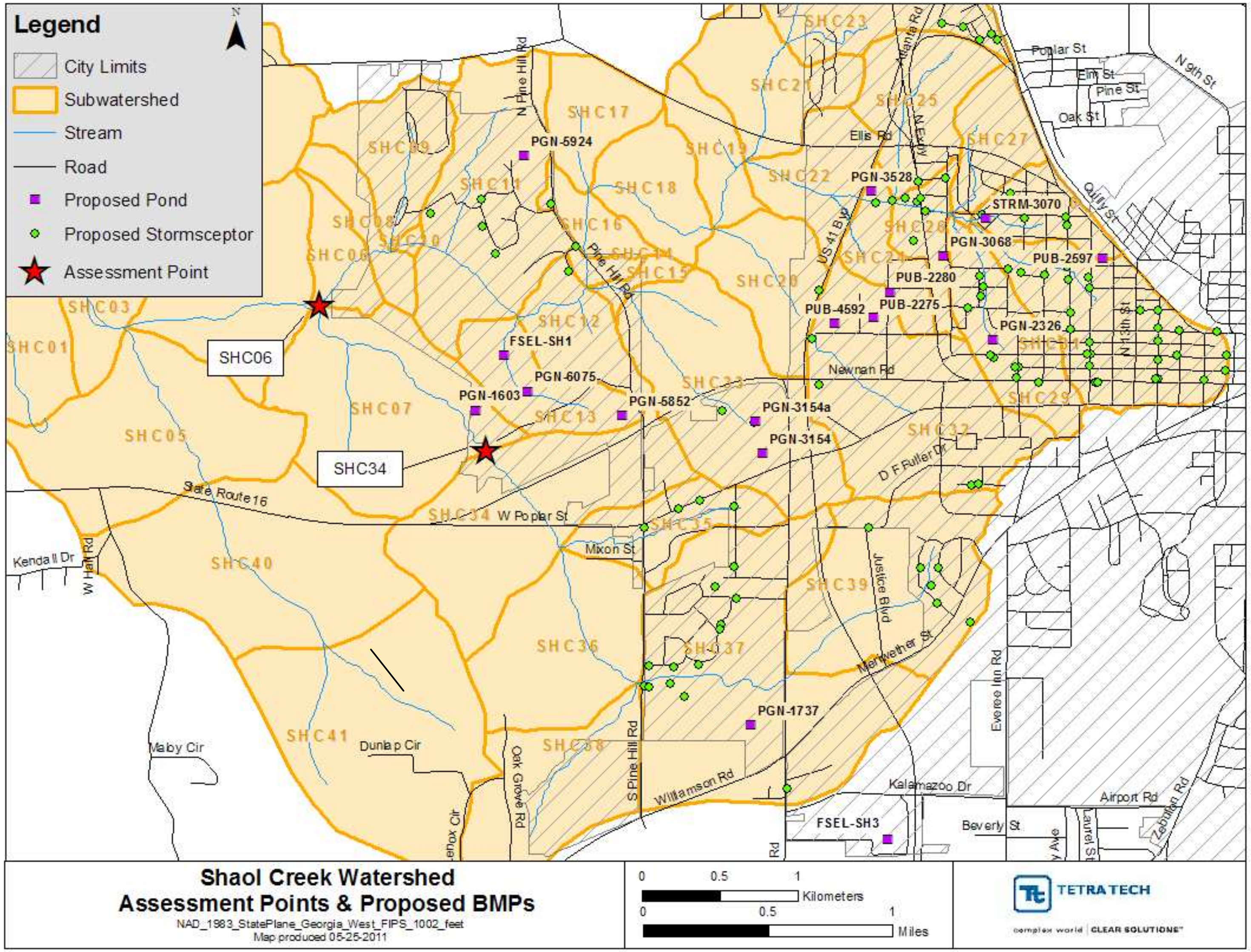

Figure 8-3 Shoal Creek Assessment Points and Proposed BMPs

Results

Seventeen proposed detention-style BMPs were evaluated for the Shoal Creek Watershed consisting of dry detention, bioretention, wet pond, wetland, and bioretention plus proprietary BMP device. Additionally, a series of proprietary hydrodynamic separators were evaluated. Each detention-style BMP was assigned a maximum surface area. Square geometry was assumed and BMP width was fixed. During the optimization, BMP length was allowed to vary between zero and the maximum length in steps of 10 percent. Optimization was performed using the nutrient and sediment loading criteria as objectives. Calendar years 2005-2009 were selected for the simulation to coincide with the calibration period of the Shoal Creek Hydrology and Water Quality model.

Table 8-21 below presents a summary of the near-optimal BMP sizing for proposed detention BMPs in the Shoal Creek Watershed. Optimization results are ranked descending by the removal efficiency cost attribute score as indicated in Table 8-16. This suggests that the proposed detention-style BMPs are the most cost-effective measures. While most cost-effective, they were only able to achieve the loading targets when selected in combination with hydrodynamic separators.

Table 8-21 Optimized BMP Sizing and Cost-effectiveness for Pollutant Removal

BMP ID	Width (ft)	Length (ft)	Percent Maximum Length	Removal Efficiency Cost Attribute Score	TSS Removal Cost ($/lb/yr)	TN Removal Cost ($/lb/yr)	TP Removal Cost ($/lb/yr)
STRM_3070	206	82	40%	10	$0.38	$30	$692
PGN_6075	106	53	50%	10	$0.28	$33	$750
PGN_3528	103	52	50%	10	$0.53	$67	$1,528
PGN_2326	281	224	80%	10	$1.66	$212	$4,825
PGN_1737	144	144	100%	9	$1.04	$134	$3,040
PGN_1603	117	58	50%	8	$0.07	$6	$126
FSEL_SH3	97	77	80%	8	$0.33	$20	$460
PUB_2597	82	25	30%	7	$2.76	$139	$3,160
FSEL_SH1	155	109	70%	7	$0.58	$48	$1,088
PGN_3154	57	34	60%	7	$7.51	$258	$5,866
PUB_2275	47	9	20%	6	$10.68	$103	$2,348
PGN_3154a	86	43	50%	4	$1.62	$109	$2,478
PGN_5852	72	43	60%	4	$2.98	$164	$3,729
PUB_4592	97	58	60%	3	$6.00	$435	$9,915
PGN_5924	48	39	80%	1	$5.26	$269	$6,106
PGN_3068	153	92	60%	1	$2.68	$238	$5,406
PUB_2280	73	44	60%	1	$1.95	$103	$2,328

The Stormsceptor inline hydrodynamic separator model STC 11000s was the proprietary BMP device proposed for implementation in the Shoal Creek Watershed. These units were modeled as generic, impermeable storage compartments using removal efficiencies of 80 percent for TSS and 50 percent for TN and TP. Removal efficiencies were applied to the outflow at each timestep. In practice, actual removal efficiencies will vary depending on the condition of the system and magnitude of individual storm sizes.

The cost of one Stormsceptor unit was calculated as the unit capital cost plus operation and maintenance over 20 years. Assuming capital costs of $50,250 per unit, $600.00 annual maintenance, and a 5 percent discount rate the present worth life cycle cost of one unit is $57,727.33. The capital cost per Stormsceptor unit was obtained on December 6, 2010 through conversation with a local manufacturer's sales representative.

Each subwatershed was assigned a maximum number of Stormsceptor units from GIS coverage of treatable basins developed by Paragon. The number of units in each subwatershed was set as a decision variable with bounds between zero and the maximum number of units increasing in steps of one unit. Table 8-22 presents a summary of the Stormsceptor optimization for the Shoal Creek Watershed. Cost-effectiveness values for pollutant removal in $/lb/year/unit were also calculated and are presented in Table 8-22. The 67 proprietary BMPs selected in Table 8-22 represent 71 percent of the 94 potential Stormsceptor devices identified during the Paragon study. The locations of all potential Stormsceptors are shown in Figure 8-3.

Pollutant removal cost was calculated as the pounds of pollutant removed divided by the cost per Stormsceptor unit. While all devices have the same cost and were modeled with the same removal efficiencies, unit pollutant removal costs will vary due to variations in land use distributions, pollutant loadings, and Stormsceptor drainage areas. Therefore, lower removal costs suggest more cost-effective opportunities for Stormsceptor implementation in a given subwatershed.

Table 8-22 Stormsceptor Optimization Results

BMP	Subwatershed	Number of Units Selected	Maximum # of Units	TSS Removal Cost ($/lb/yr/unit)	TN Removal Cost ($/lb/yr/unit)	TP Removal Cost ($/lb/yr/unit)
Stormsceptor11	SHC11	2	4	$0.08	$10	$236
Stormsceptor12	SHC12	1	1	$0.18	$26	$586
Stormsceptor14	SHC14	0	1	n/a	n/a	n/a
Stormsceptor16	SHC16	1	1	$2.45	$489	$10,710
Stormsceptor20	SHC20	1	1	$0.19	$27	$614
Stormsceptor23	SHC23	3	5	$0.17	$35	$784
Stormsceptor24	SHC24	1	2	$0.33	$64	$1,450
Stormsceptor25	SHC25	1	1	$0.14	$12	$280
Stormsceptor26	SHC26	6	6	$0.11	$22	$497
Stormsceptor29	SHC29	7	10	$0.56	$111	$2,507
Stormscaptor30	SHC30	0	5	n/a	n/a	n/a
Stormsceptor31	SHC31	17	28	$0.02	$5	$111
Stormsceptor32	SHC32	2	4	$0.15	$27	$620
Stormsceptor33	SHC33	2	2	$0.45	$91	$2,038
Stormsceptor35	SHC35	4	4	$0.46	$62	$1,408
Stormsceptor37	SHC37	13	13	$0.26	$35	$803
Stormsceptor39	SHC39	6	6	$0.46	$63	$1,427

Simulated Pollutant Loads and Flows

Tables 8-23 and 8-24 present the loading targets evaluated for the Shoal Creek Watershed, along with the simulated pollutant loads at both assessment points with the optimized BMPs from Tables 8-21 and 8-22, and without BMPs, highlighting the water quality benefit for each pollutant under the optimized scenario. Nutrient criteria for total nitrogen and total phosphorous and total suspended solids were used as objectives for the optimization.

Table 8-23 Simulated Pollutant Loads at SHC06 Assessment Point

Water Quality Parameter	Evaluation Target (lbs / yr)	Value at Watershed Outlet Without BMPs (lbs / yr)	Value at Watershed Outlet With BMPs (lbs / yr)
TN	14,360	16,484	13,636
TP	247	272	215
TSS	1,302,398	1,310,431	1,035,214

Table 8-24 Simulated Pollutant Loads at SHC34 Assessment Point

Water Quality Parameter	Evaluation Target (lbs / yr)	Value at Watershed Outlet Without BMPs (lbs / yr)	Value at Watershed Outlet With BMPs (lbs /yr)
TN	7,636	8,240	7,035
TP	131	159	133
TSS	692,548	753,364	556,873

For the simulation period, the BMP selection discussed previously was adequate to reduce TSS and TN loading to meet the targets at each assessment point. The evaluation target for TP was attained for the assessment point at subwatershed SHC06 but fell short of achieving the target at subwatershed SHC34 by 2 percent. The subwatersheds upstream of assessment point SHC34 had fewer proposed BMP opportunities and a shorter travel time decreasing the benefit of instream pollutant decay.

A peak flow target was also set for the main stem of Shoal Creek, although this target was not included as an evaluation factor for the optimization. The flow target was set at the estimated 2-year peak discharge based on Shoal Creek stream gage discharge data area weighted to monitoring station SC0 (assessment point SHC06). The objective is to not exceed this discharge limit more than one time per year. The peak flow target was not achievable under full implementation of all available BMPs. This objective was not used for optimization; however, the peak flow reduction benefit of the near-optimal solution is presented below in Table 8-25. The near-optimal solution results in a 32 percent reduction in peak flow at SHC06 as well as a 17 percent reduction in peak flow at SHC34.

Table 8-25 Simulated Peak Flows

Flow Parameter	Assessment Point	Evaluation Target (cfs)	Value Without BMPs (cfs)	Value With BMPs (cfs)
Peak Flow	SHC06	700	1,772	1,214
	SHC34	N//A	870	726

The cumulative cost of implementing all of these measures is $5.77 million which includes design, construction, and 20 years of O&M costs.

Discussion

The results presented in Table 8-21 represent the cost-effectiveness of pollutant removal for each of the proposed ponds and bioretention units under the optimized scenario. These measures of removal efficiency account for the optimized size of the features and are more refined than the removal efficiency costs presented in Table 8-16. Continuous simulation model with BMPDSS Navigator provides a robust framework of optimizing from among a suite of proposed BMPs in a watershed context that includes additional processes such as in-stream decay.

Optimization of Stormsceptor units was influenced by prior optimization of ponds and bioretention units, routing, and land use distribution which affects opportunity for pollutant removal. Selection of Stormsceptor units occurred most heavily in the urbanized, upstream headwaters where there was the most opportunity for sediment load reductions. Full implementation of Stormsceptors was selected upstream of assessment point SHC34 as only a single wet pond was proposed upstream of this point.

It is important to note that the simulation run that was done for this BMP optimization exercise used only two assessment points. Just because a target is met at an assessment point, does not mean it is met at all locations in the watershed. Additional simulations would need to be run using assessment points at different places in the watershed to see how individual subbasins respond to proposed BMPs.

For planning purposes, the results of this optimization modeling should be used in conjunction with the full set of recommendations presented in Section 8.5 to implement a comprehensive management plan. Optimization modeling is a valuable tool, but it is limited to the scope and constraints of the model. For example, the best management practices modeled in the Shoal Creek Watershed include only structural BMPs focused on controlling pollutants from urban stormwater sources. With cropland as the dominant land use in Shoal Creek Watershed, structural BMPs may not be the preferred solution in all situations. Many agricultural areas in the Shoal Creek Watershed were not evaluated as potential BMP sites because the land owner was not interested in collaborating with the City of Griffin on stormwater improvement projects. However, if stormwater improvement projects were to be considered in such agricultural areas, riparian buffer enhancement or fertilizer management measures may be more appropriate than detention ponds in those areas. In addition to the measures included in the optimization modeling, other complimentary measures can also support watershed improvements. A comprehensive management plan that includes the integration of BMPs, stream restoration, Low Impact Development (LID) measures, and programmatic measures will most fully address the problems in the Shoal Creek Watershed.

8.5 MANAGEMENT RECOMMENDATIONS

In this section, management actions are recommended that will help the City of Griffin meet its objectives for the Shoal Creek Watershed and achieve the overarching goals of this Protection Plan.

Structural BMPs

Significant protection can be provided to the Shoal Creek Watershed through the construction of structural BMPs that reduce storm flows and filter pollutants. These measures can include dry detention basins, wet ponds, bioretention areas, wetland creation areas, and proprietary BMP devices. In Section 8.3, 17 BMP sites are identified as opportunities for implementing projects that will achieve multiple objectives. Estimated costs for these structural BMP measures are detailed in Table 8-15. Additional benefit can be derived from installing proprietary BMP devices, such as Stormsceptors, in optimized locations, as determined from the BMP optimization modeling. Modeled pollutant reduction costs detailed in Section 8.4 can help prioritize these projects.

Stream Restoration

In Section 8.3, three stream restoration sites were identified that would improve water quality. Restoration projects that the City deems feasible should be incorporated into an Implementation Plan. If BMP projects are planned upstream of a selected restoration reach, the stream restoration project should not be initiated until upstream BMP projects are complete. This will give the restoration projects a better chance of success due to better management of storm flows. Stream restoration costs can vary widely depending on many situational factors. Estimated costs for stream restoration are presented in Table 8-26. Costs are broken out by the level of restoration involved. For the purposes of this Watershed Protection Plan, the high level of stream restoration would involve extensive excavation and construction activities that could include reconnecting a stream to its floodplain, creating a new channel, and restoring meanders and other features to a channel. The medium level of stream restoration would involve less extensive measures such as spot repairs for bank or channel erosion, levee removal, and instream grade control structures. The low level of stream restoration would include vegetation management, buffer restoration/enhancement, and preservation. The restoration sites identified in the Shoal Creek Watershed are candidates for high level (SHC30-01) and medium level (SHC31-01 and SHC31-02) restoration.

In addition to the three recommended restoration areas identified by Tetra Tech, numerous medium level restoration opportunities exist throughout the watershed. These are small, isolated areas of erosion along streambanks, around storm drain outfalls, or at headcuts (where there is an abrupt change instream gradient over an erodible surface). The cumulative contribution of TSS loads from these numerous erosional areas can be significant. Stormwater Division personnel should identify such “erosion hot spots” during their routine inspections, and spot repairs should be done using bank stabilization measures.

Low level restoration opportunities exist wherever stream banks are generally stable, but bank vegetation and riparian vegetation are lacking or are poor quality. Low level restoration can be facilitated through educational workshops discussed under non-structural BMPs, below.

Table 8-26 Stream Restoration Unit Cost Estimates

Restoration Level*	Unit	Approximate Unit Fee**
High—Complete channel reconstruction, bank stabilization, buffer restoration, instream structures, etc. They would all be riffle-pool channel design and have an average of 60 ft of riparian restoration on either side of the stream.	Linear foot	$150– $350
Medium—Spot repairs to stabilize streambanks, headcuts, and erosion around culverts.	Linear foot	$75– $200
Low—Minor bank shaping and vegetation enhancement, including a 2-meter strip of complete vegetation plantings on each bank.	Linear foot	$50–$100

* Restoration level categories were provided by Tetra Tech.

** Approximate Unit Fees are for preliminary planning purposes only and may change considerably based on the nature of a particular project characteristics and/or goals.

Note: Restoration costs can vary widely based on a number of factors including stream width, amount of earthwork required, size of the project (as the size of the project increases, the cost per unit will typically decline), etc. Restoration projects that include stormwater BMPs, wooded riparian zones, access and property constraints, flashy urban settings, or topographic/substrate issues can be expected to be associated with significant cost adjustments (for both design and construction). Design costs can be generally assumed to be approximately 30 percent for high level restoration, 15 percent for medium level restoration, and 10 percent for low level restoration of the costs provided. External cost considerations may include costs for formal bid document preparation, federal, state or local permitting (USACE, State Stream Buffer Variance, Land Disturbance Permitting, etc.), and extensive hydraulic/hydrologic modeling.

Source: Ecological Consultants, 2010, personal communication

Non-structural BMPs

The structural BMPs and restoration measures recommended above represent an important step toward addressing management needs in the Shoal Creek Watershed. However, stormwater BMP retrofits and stream restoration, in isolation, will not meet the Protection Plan goals and objectives. Some land with high impervious surface coverage or high contributing pollutant loads will remain untreated or continue to have uncontrolled runoff, either due to lack of landowner interest or a feasible structural BMP opportunity. Some pollutant sources, like fertilizers and pet waste, cannot be addressed by a limited number of structural BMPs; therefore, public policies, education, and outreach are necessary to encourage further pollutant load reduction. The City is currently operating a number of programs that address these management needs. As outlined in Section 4, ordinances have been updated or adopted to regulate how land is used and to minimize pollutant discharges. The City's MS4 stormwater program contains a diversity of strategies that target the multiple pollutant sources and stressors within the Shoal Creek watershed and citywide.

Because much has been accomplished to date, recommendations for future non-structural practices are limited to several key strategies that are likely to provide measurable improvements in water quality. As sediment and nutrient loading are important concerns in the watershed, strategies to preserve and restore riparian areas would fill a management gap not provided by currently programs or recommended structural projects. To accomplish this, a phased-approach could be used that begins with citizen education and transitions to requiring wider riparian buffer protection. The City could conduct citizen education workshops on maintaining and restoring native vegetation along streams. The efforts could involve riparian management events in which volunteers help to remove invasive species and restore riparian vegetation. As education events are implemented, the City could work on policies to increase undisturbed buffer requirements. For example, undisturbed buffer requirements could be increased from 25 to 50 feet from streams, with an additional 50 feet beyond this buffer where certain land uses are allowed but structures and other impervious surfaces are prohibited.

Fertilizer is another pollutant source for which non-structural practices can be successful in contributing to watershed improvement. Efforts could be directed towards encouraging or requiring the reduction of fertilizer use on private property. Educational landscaping workshops can be provided for the public on how to select the proper fertilizer and application rate. The workshops could also provide instruction on other landscaping techniques as an incentive for the public to participate. Educational efforts that provide direct and detailed instruction can be more effective than more indirect methods (mailings, public service announcements, etc.) because the attendees already have an interest and time investment in the techniques.

Fertilizer ordinances have been used in some local communities to reduce nutrient loading, and these ordinances can have multiple purposes. Some regulations prevent the application of fertilizer where it is not necessary (driveways, sidewalks, and other impervious surfaces) or where it has more significant impacts (near streams, wetlands, and other waterbodies). Fertilizer ordinances can also regulate application techniques, including how the timing and areal application rates are chosen for each property. These ordinances can be written to provide flexibility for individual landowners.

Installation of tree boxes was initially considered as a distributed BMP opportunity during the BMP field assessment but was removed from consideration due to the presence of mature trees along many of the city streets. Other program opportunities might become available to implement distributed BMPs in the future.

In summary, the non-structural techniques that appear to be most beneficial for future consideration are policies and programs that:

1) Promote riparian buffer preservation and restoration,
2) Encourage the reduction of fertilizer application, and
3) Plan future landscape and infrastructure improvement efforts to allow for implementation of distributed BMPs.

The extensive non-structural BMPs that the City is currently operating provide important benefits to the watershed. These additional non-structural BMPs are recommended for integration into the City's existing efforts to further address the Shoal Creek Watershed goals and objectives.

Implementation Schedule

The City of Griffin will implement new watershed management actions over the next few years, in addition to continuing their current management practices and stormwater programs. In an effort to meet the goals and objectives presented in this Protection Plan, the City will actively work to maintain and improve conditions in the Shoal Creek Watershed. Table 8-27 proposes a schedule for implementing new management actions over the next five fiscal years. Sources of funding will include the city's Stormwater Utility, Section 319 grants, and Water and Wastewater Division funds.

The City of Griffin will submit the following information to Georgia EPD by June 30th of each year:

a. Annual certification of Watershed Protection Plan implementation
b. Electronic submittal that includes:
    - Long-term trend water quality monitoring data using EPD's Excel template, available on GAEPD's website at:

http://www.gaepd.org/Documents/techguide wpb.html#wappg;

- Long-term habitat and biological monitoring data;
- Copies of all field data sheets, laboratory taxa lists, macroinvertebrate multimetric spreadsheets and fish IBI and Iwb metric calculations; and
- GIS coverages of the City's jurisdictional limits, service area and subwatershed delineations, unless already submitted.

c. Progress Report that includes:

- Discussion of the monitoring data and results;
- An evaluation of what the data shows in terms of water quality, the health of the biological communities, and any trends that are being shown by the data;
- Specific actions or BMPs that have been implemented; and,
- Summary of any changes and/or revisions to the Watershed Protection Plan, if necessary.

Table 8-27 Implementation Schedule

Fiscal Year (July 1 to June 30)	Management Action	Estimated Cost Range
2010–2011	Initiate coordination between City departments to allow for stormwater BMP planning as part of infrastructure improvement projects	
2011–2012	Identify areas in need of spot repairs (medium level restoration) through routine stormwater inspections; schedule priority repairs for the upcoming 1–2 years	
2012–2013	Conduct spot repairs on small, actively eroding areas identified through stomwater inspections	
	Select one BMP project based on BMP modeling results and City resources for implementation in fiscal year 2014–2015	
2013–2014	Continue with spot repairs on small, actively eroding areas identified through stormwater inspections	
2014-2015	Acquire property for the selected BMP project site	$0–$40,400
	Conduct design and engineering for the BMP measure	$3,400–$78,800
	Construct the BMP measure	$13,700–$315,000
	Select a stream restoration site (high level restoration) based on Protection Plan recommendations and begin detailed site investigation to determine scope of work and costs	
2017-2018	Design and construct the selected stream restoration project	$17,100–$393,800

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