COMPREHENSIVE STORMWATER

PILOT MASTER PLAN

FOR

NORTH CHICKAMAUGA CREEK WATERSHED

City of Chattanooga
Stormwater Management
Department of Public Works - Engineering

March 30, 2005

Authorized By:	Revision	Date
Mounir Y. Minkara, Ph.D., P.E.	1	3/30/05

Mounir Y. Minkara, Ph.D., P.E.
Water Quality Manager
&
William C. Payne, P.E.
Assistant City Engineer

Stormwater Management
City of Chattanooga-Engineering
Department of Public Works

1250 Market Street, Suite 2100
Development Resource Center
Chattanooga, TN 37402-2713

Phone (423) 668-2530
Fax (423) 757-2482
SWM@mail.chattanooga.gov

PURPOSE

The purpose of this document is to develop a comprehensive pilot stormwater watershed-based master plan for North Chickamauga Creek, which can be used as a model for other watersheds in the City of Chattanooga. This document is part of the City of Chattanooga's National Pollutant Discharge Elimination System (NPDES) Permit requirements (Part II Section C.2.h). The Stormwater Management encourages watershed based development that balances development needs and the protection of the watershed. This plan is intended for a 5-year period and it is to be updated annually.

Table of Content

DEFINITIONS

Watershed – is an entire area that drains into a single water body system (creek, stream, lake, or wetland). This area contributes to the hydrology and pollution of the water body.

BMPs – Best Management Practices are controls used to reduce the impact on receiving water body of activities in the watershed. BMPs can be structural or non-structural. Structural BMPs are physical controls such detention ponds. Non-Structural BMPs are non- physical entities such as enforcement, education, etc.

TMDL – Total Maximum Daily Load, the allowable loadings or other quantifiable parameters for a water body to meet water quality standards. The TMDL process provides a flexible assessment and planning framework for identifying load reductions or other actions needed to attain water quality standards. The U.S. EPA's TMDL program is authorized under Section 303(d) of the Clean Water Act and is a guide to establish state standards unique to individual water bodies and watersheds.

GIS – Geographic Information System GIS is a system of hardware and software used for storage, retrieval, mapping, and analysis of geographic data. Spatial features are stored in a coordinate system (latitude/longitude, state plane, UTM, etc.), which references a particular place on the earth. Descriptive attributes in tabular form are associated with spatial features. Spatial data and associated attributes in the same coordinate system can then be layered together for mapping and analysis. GIS can be used for scientific investigations, resource management, and development planning.

Urban Growth – Development that makes intensive use of land for the location of structures such as buildings, roads and other impermeable surfaces.

SECTION I: INTRODUCTION

Stormwater master planning is an important tool in the assessment and prioritization of both existing and future stormwater problems, as well as a methodology to consider alternative stormwater management solutions. A stormwater master plan is prepared to consider what stormwater management practices and measures would best meet the needs for an urban drainage area or watershed.

Typical stormwater master plans are most often used to address specific single functions such as water quality control, drainage provision, flood mitigation, cost/benefit analysis, or risk assessment, and to prescribe specific management alternatives and practices. Multi-objective stormwater master planning broadens this traditional definition to potentially include land use planning and zoning, water quality and quantity, habitat, recreation, and aesthetic considerations. The broadest type of stormwater master plan is the comprehensive watershed plan. Comprehensive watershed management is not a new program but it is a process to align, coordinate, and build upon existing programs.

For any stormwater master plan, it is important to: (1) clearly identify and quantify the objectives and the issues the plan will address; (2) recognize the constraints (technical, political, legal, financial, social, physical) that limit the possible solutions; and (3) develop a clear technical approach that will address the key issues and needs while staying within the constraints to potential solutions. The goal of the City of Chattanooga's comprehensive watershed plan is to provide an implementation guideline to prevent or reduce long term impacts at the watershed scale. As a continuation of this broad plan, more specific plans or studies will be followed to effectively focus on tangible outcomes. One example will be to study the effect of current and future land uses at the sub-watershed level on stream quality. Another example could be the study of the level of enforcement needed to reduce the water quality impact of anthropogenic activities and meet state water quality standards.

SECTION II: NORTH CHICKAMAUGA CREEK - WATERSHED DESCRIPTION

North Chickamauga Creek is located in the Middle Tennessee-Chickamauga watershed, Hydrologic Unit (06020001). North Chickamauga Creek begins near the crest of Walden Ridge in Hamilton County, Tennessee, approximately fifteen (15) miles from downtown Chattanooga. The creek itself is formed by the convergence of two small streams, Standifer and Brimer Creeks and flows eastward to the Tennessee River. North Chickamauga Creek is approximately thirty-two (32) miles long and drains close to one-hundred twenty (120) square miles of upland and valley land (EPA Region 4 NPS Program TN 96 Project).

Numerous tributaries (Falling Water, Nine Mile Creek, Poe Branch, and Lick Branch) merge into North Chickamauga Creek as it travels from Walden Ridge through Soddy Daisy, Middle Valley and Hixson prior to emptying into the Tennessee River just below the Chickamauga Dam. Two springs, Cave Springs and Rogers Springs, also contribute to North Chickamauga Creek.

The headwaters of North Chickamauga Creek navigate through portions of the Cumberland Plateau and Cumberland Escarpment, leaving in its wake a gorge that is approximately ten (10) miles long with steep slopes, sandstone bluffs and rich coves. The gorge area is filled with a diverse mixture of plants and animals, including federally threatened large flowered skullcap (Scutellaria Montana) and the federally endangered Virginia spiraea (Spiraea virginiana) (TDEC, Division of Water Pollution Control).

The underlying geology of the watershed is predominantly Karst Paleozoic carbonate rocks, residual clay-rich regolith and coarse alluvium (Pavlicek, 1996). Siliciclastic rocks of the Pennsylvanian age are predominant on the Cumberlain Pateau while carbonate rock predominate in the valley and ridge area of the watershed (Pavlicek, 1996). The watershed is characterized by the presence of numerous caves and springs. For example, Cave Springs, one of the most productive spring systems in Tennessee, is the primary source of water for Hixson Utility and produces approximately five (5) million gallons of water per day for domestic and municipal uses (Pavlicek, 1996).

As a result of the karst hydrogeology of the watershed, portions of North Chickamauga Creek disappear and resurface in a delicate balance of aquifer recharge and subsurface flow. The underlying geology also impacts the water chemistry of North Chickamauga Creek. Water samples collected from Lick Branch and Poe Branch contain high calcium bicarbonate indicating base flow came from a carbonate aquifer and samples collected from North Chickamauga Creek contain high calcium magnesium sulfide indicating that the primary contributors to flow are a mixture of the carbonate aquifer, the Pennsylvanian formations, and acid-mine drainage (Pavlicek, 1996).

SECTION III: NORTH CHICKAMAUGA CREEK - WATERSHED BACKGROUND

The upper eighteen (18) miles of North Chickamauga Creek have been heavily impacted by acid mine drainage. Numerous small-scale coal mines along Standifer Creek and Hogskin Branch have produced significant impacts on the watershed. Low pH, high sulfate and elevated concentrations of iron, manganese and aluminum are characteristic of the upper reaches of North Chickamauga Creek and have significantly reduced the benthic and fish population (EPA Region 4 NPS Program TN 96 Project).

In an attempt to thwart further degradation of the watershed, the Environmental Protection Agency (EPA) initiated an assessment of acid producing mine sites in the upper North Chickamauga Creek watershed. The assessment resulted in a major reclamation project where the EPA identified five (5) sites for corrective action. Numerous restoration techniques have been deployed, including passive treatment systems, road upgrades and construction, backfilling four (4) deep mine openings, constructing limestone channels from the mine openings to constructed wetlands, placing dam embankments, installing wetland drain systems and revegetation of all affected areas (EPA Region 4 NPS Program TN 96 Project).

Additional contributors to the water quality issues of North Chickamauga Creek include the underlying geology of the watershed. North Chickamauga Creek originates on the Cumberland Plateau (which is comprised mostly of Pennsylvanian silicicliastics shales and coal seams) and meanders through the Cumberland Escarpment (which is composed of limestone and dolomite). Pyrite within the Pennsylvanian shales and coals can also produce significant amounts of sulfate naturally (Pavlicek, 1996).

Compounding the impacts of acid mine drainage and natural background sources are anthropogenic activities associated with development. The lower sections of North Chickamauga Creek travel through one of the most rapidly growing areas in Hamilton County. Water quality problems in the lower stream section include sedimentation and elevated fecal coliform counts (EPA Region 4 NPS Program TN 96 Project).

Numerous programs have been initiated in an attempt to protect and restore the water quality in North Chickamauga Creek. Joint public/private partnerships including: U.S. Environment Protection Agency (EPA), Tennessee Valley Authority, Office of Surface Mine Reclamation, Army Corps of Engineers, University of Tennessee at Chattanooga, City of Chattanooga, Bowater, State of Tennessee Department of Environment and Conservation (TDEC) Division of Water Pollution Control (WPC), Tennessee Aquarium, North Chickamauga Greenway Alliance, Trust for Public Land and private citizenry; have been developed. Cooperative projects include land acquisitions for watershed preservation, stream bank stabilization, water monitoring programs, and development of greenway trails and paths.

Within the City of Chattanooga boundaries land use in the North Chickamauga Creek watershed is as follows:

Category	**MAPSQFT**	**ACRES**	**% AREA**
commercial	30,792,445	945.7	6.59
farm	20,579,571	632.1	4.41
heavy industrial	8,784,545	269.8	1.88
heavy residential	9,810,150	301.3	2.10
institutional	33,125,316	1,017.4	7.09
light industrial	2,730,290	83.9	0.58
light residential	167,844,915	5,154.9	35.93
play	11,984,794	368.1	2.57
transportation	5,178	0.2	0.00
utility	7,881,745	242.1	1.69
vacant	102,795,389	3,157.1	22.00
ROW	70,827,472	2,175.3	15.16
Total area of Lower North Chickamauga Watershed within City Limits	467,161,809	14,347.7	100.00

SECTION IV: STORMWATER MASTER PLAN OBJECTIVES

The primary objective of this stormwater master plan is to provide a guide to integrated stormwater watershed management, which includes floodplain management, water quality control and site-specific management. Additionally, this plan is designed to provide guidance for planners, developers, policy makers, and the general public based on principals of effective urban stormwater management. The critical issues facing Chattanooga are managing urban growth, protecting the watershed resources and reducing the impact of urban growth on the public and the environment. The two major issues that this watershed plan is addressing are the impact of urban development on surface water quality and flood management. More specifically, the goal of this plan is to provide guidance to:

1. Reduce flood damage from current levels.
2. Reduce pollutant loads from the current level.
3. Maintain or enhance the overall aquatic diversity in the watershed.
4. Maintain or improve the current channel integrity in the watershed.
5. Control or avoid development in the floodplain.
7. Create or maintain a connected buffer system throughout the watershed.
8. Accommodate economic development and encourage low impact development in the watershed.
9. Promote public awareness and involvement.

As a follow up or update to this plan, Stormwater Management will develop specific actions plans and sub-watershed plans with implementation guidelines and timelines for each of the pertinent goals.

SECTION V: STORMWATER MASTER PLAN ELEMENTS

A. *Identification of Stormwater Master Plan Elements*

This plan is comprised of two primary elements: water quality and water quantity. The water quality elements are addressed based on the known existing conditions of the local streams. Water quality management addresses the impact of land use, such as development, on biological, chemical and physical qualities of the streams. Floodplain management is the other major element in stormwater master planning. Floodplain management addresses the impact of land use on flooding around major streams. Watershed management also addresses the BMPs that are used or need to be adopted to implement plan.

B. *Water Quality Management*

1. Water Quality Impact

One goal of this watershed plan is to provide a guidance document detailing strategies to meet water quality criteria and to assist in setting pollutant reduction goals in the target watershed, N. Chickamauga Creek and its tributaries. Surface water quality is impacted by pollutant runoff resulting from urban activities exposed to stormwater. Urban development directly impacts stream water quality. Urban runoff contains different pollutants (sediments, pathogens, pesticides, oils, detergents, etc.) that end up in streams, creeks, wetlands and other water bodies if not properly controlled.

Poorly managed land disturbing activities result in the runoff of sediment (during construction) into the stormwater drainage system that discharges into the surface water bodies. Elevated sediment loads in surface water causes a variety of impacts on the water quality by affecting water flow, lowering oxygen levels, decreasing biodiversity, and by the impairment of the receiving water body to support designated uses (i.e. drinking, recreation, etc.). In addition to sediment, aging domestic sanitary sewer lines leak sewage into surface water causing nutrient built-up and pathogens to be present in stormwater. Also, many human activities introduce pollutants (oil, pesticides, pathogens, nutrients) into stormwater that eventually discharge into surface water bodies through storm water conveyances if not controlled by BMPs.

Surface water bodies that are not supporting their designated uses are considered impaired and limited to certain uses. A list of streams and lakes that are “water quality limited” is compiled by TDEC-WPC and it is called the 303(d) List. The 303(d) List names streams and lakes “waters of the state” which exceed or are expected to exceed water quality standards in the next two years and need additional pollution controls. Water quality limited streams are those that have one or more properties that violate water quality standards. They are considered impaired by pollution and not fully meeting designated uses. Once a stream has been placed on the 303(d) List, it is considered a priority for water quality improvement efforts. These efforts include traditional regulatory approaches such as permit issuance, but also include efforts to control pollution sources that have historically been exempted from regulations, such as certain agricultural and forestry activities. If a stream is on the 303(d) List, TDEC-WPC cannot authorize additional loadings of the same pollutant(s). In extreme cases, it may mean that dischargers of certain pollutants will not be allowed to expand or locate on 303(d) listed streams until the sources of pollution have been controlled. The following table provides the streams that were identified on the 303(d) List by TDEC-WPC in the City of Chattanooga:

Water Body	State ID	Miles Impaired	Cause of Impairment	TMDL Priority	Pollutant Source	Comments
N. Market St. Branch	001 T-0200	2.5	Pathogens	Medium	Collection system failure.	One or more uses impaired.

Water Body	**State ID**	**Miles Impaired**	**Cause of Impairment**	**TMDL Priority**	**Pollutant Source**	**Comments**
Friar Branch	007-0100	26.9	Siltation Organic enrich. / Low DO Alterations of stream side Pathogens	Low Medium Low Medium	Land development. Discharges from MS4 area.	One or more uses impaired.
Unnamed tributary to N. Chick. Creek	067-0100	4.3	Siltation Alterations of stream side	Low Low	Land development. Hydro Modification.	Near Grubb Rd. One or more uses impaired.
Ninemile Branch	067-0210	4.0	Low DO Physical substrate habitat alterations	Medium Low	Pasture Grazing Channelization	One or more uses impaired.
Rogers Branch	067-1100	1.9	Pesticides Low DO Flow alterations	Low Medium Low	Discharges from MS4 area. Upstream impoundment. Spills.	Fish kill in this stream. Pesticide spill. One or more uses impaired.
Unnamed Tributary to Citico Creek	1240-0100	1.2	Phosphorus Thermal modifications Pathogens Alterations of stream-side	Medium Low Medium Low	Collection system failure. Discharges from MS4 area. Hydro Modification.	Water contact advisory. Orchard Grove area. One or more uses impaired.
Citico Creek	1240-1000	6.1	Nutrients Low DO Pathogens Alterations of stream-side	Medium Medium Medium Low	Collection system failure. Hydro Modification.	One or more uses impaired.

Water Body	**State ID**	**Miles Impaired**	**Cause of Impairment**	**TMDL Priority**	**Pollutant Source**	**Comments**
Dobbs Branch	1244 - 0100	5.3	Organic enrich. / Low DO Pathogens Alterations of stream-side	Medium Medium Low	Collection system failure. Hydro Modification.	One or more uses impaired.
Unnamed tributary to Chattanooga Creek	1244 - 0200	1.4	Pathogens Alterations of stream-side	Medium Low	Combined sewer overflow. Hydro Modification.	Near Cedar Hill School. One or more uses impaired.
Chattanooga Creek	1244 - 1000	8.4	PCBs Dioxins Organic enrich. / Low DO Pathogens Alterations of stream-side Oil and Grease	Low Low Medium Medium Low Low	Combined sewer overflow. Discharges from MS4 area. Non-industrial permitted. Hydro Modification. Spills. Contaminated sediment.	Water contact and fishing advisories in this section. Some contaminated sediment removed by Superfund. One or more uses impaired.
Chattanooga Creek	1244 - 2000	3.5	Pathogens	Medium	Source in other state.	Water contact advisory. One or more uses impaired.
Stringers Branch	426-0100	5.8	Pathogens Alterations of stream-side	Medium Low	Collection system failure. Discharges from MS4. Hydro Modification.	Water contact advisory. Stream heavily culverted/altered One or more uses impaired.
Mountain Creek	426-1000	3.2	Alterations of stream-side	Low	Land development. Discharges from MS4.	Impacted by development. One or more uses impaired.

The identification of water bodies that are not meeting their designated use and the development of total maximum daily loads (TMDLs) for those water bodies are required by Section 303(d) of the Clean Water Act and EPA Water Quality Planning and Management Regulations (40 CFR part 130). The TMDL process is designed to restore and maintain the quality of those impaired water bodies through the establishment of pollutant specific allowable loads.

For each stream on the 303(d) List, TMDLs are being established. TDEC-WPC provides a written TMDL plan and analysis that is reviewed and approved by EPA. This plan is to make sure that a water body will reach and maintain water quality standards. The TMDL plan takes into consideration existing pollutant loads and reasonably foreseeable increases in pollutant loads. The goal of a TMDL plan is to allocate pollutant loads and define a set of actions to be undertaken by local authorities so that water quality standards can be achieved. TMDLs are currently being developed for Chattanooga area streams and parameters (pathogens, siltation, etc.) will be assigned by TDEC-WPC to the City in the next year or two.

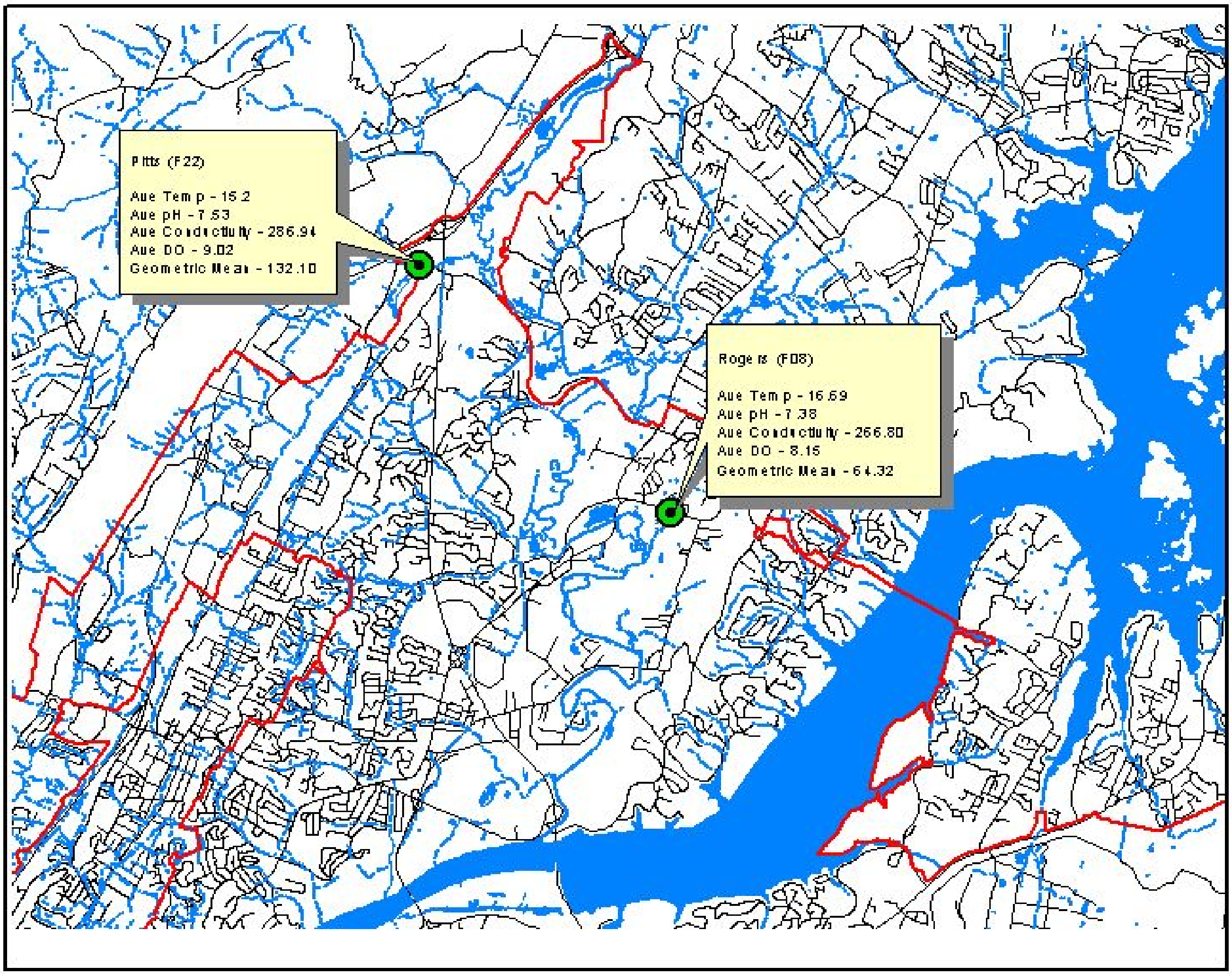
In July 2001, the Department of Biological and Environmental Sciences at the University of Tennessee at Chattanooga (UTC) concluded an assessment study of water quality, habitat features and biotic assemblages in ridge and valley streams in Chattanooga. The study covered 66 streams in the Chattanooga area including seven (7) locations in the N. Chickamauga Creek watershed. These seven locations and their watershed characteristics are listed in the following table:

Site No.	**Stream**	**Stream Order**	**Watershed Area (acre)**	**% Urbananized**
SW-26	Roger’s Branch	1	1,114	67.9
SW-27	Unamed Trib. To Roger’s Branch	1	124	20.2
SW-29	Pitts Branch	4	4,158	12.0
SW-30	Nine Mile Branch	1	198	9.5
SW-31	Pitts Branch	3	1,114	6.6

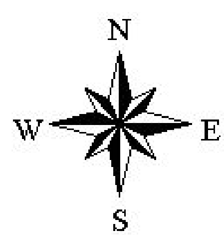
The study concluded that sedimentation, nutrient enrichment, other nonpoint source runoff, and loss of buffering riparian zones are the greatest threat to the streams in this area.

Additional data collected during the City's wet-weather surveillance program is depicted by the graphs below. Stream surveillance was conducted at Pitts Branch and Rogers Branch, which are two tributaries draining into N. Chickamauga Creek. Figure 1 below shows the location of wet-weather stream surveillance sites in N. Chickamauga watershed.

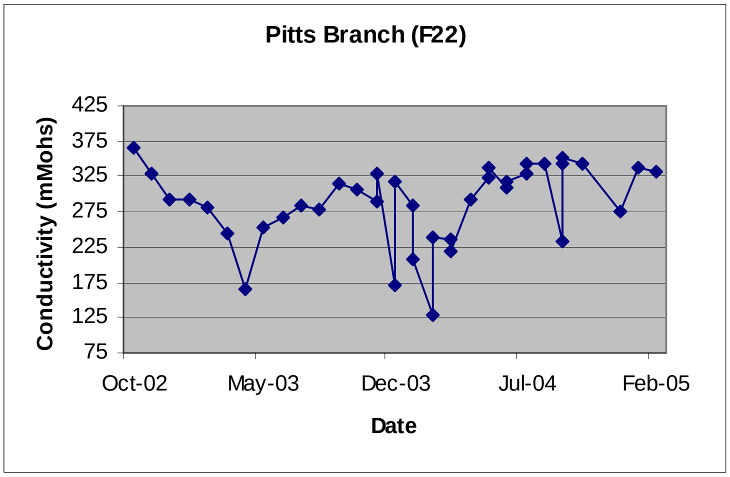
Figure # 1

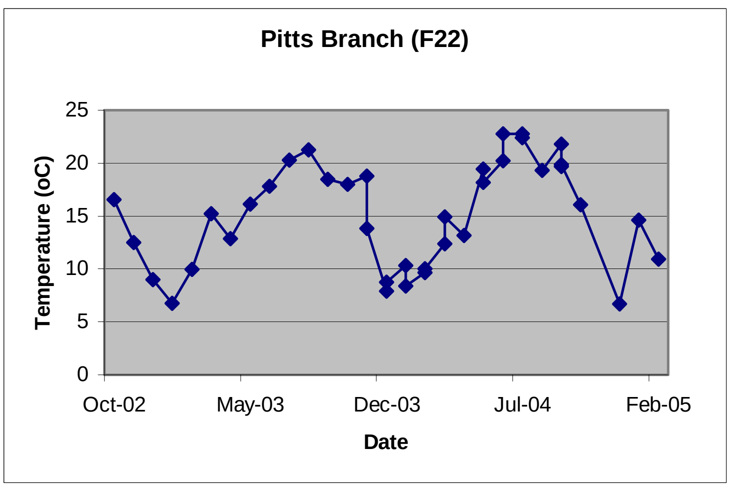


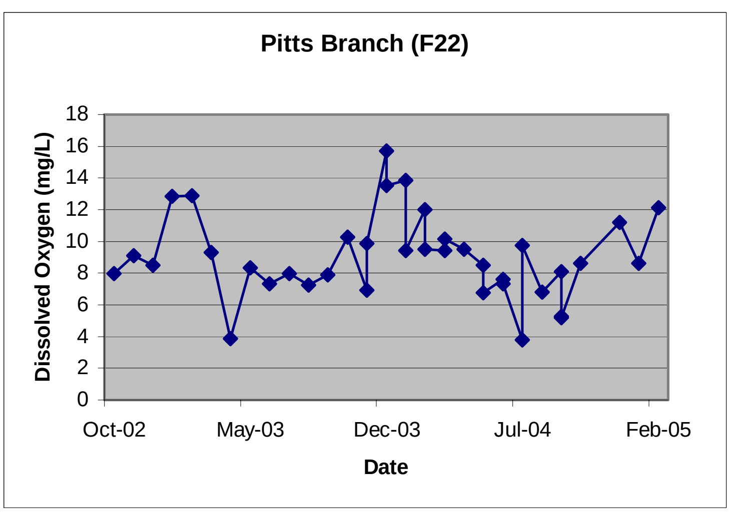
Location of wet-weather surveillance sites in the N. Chickamauga Creek watershed.

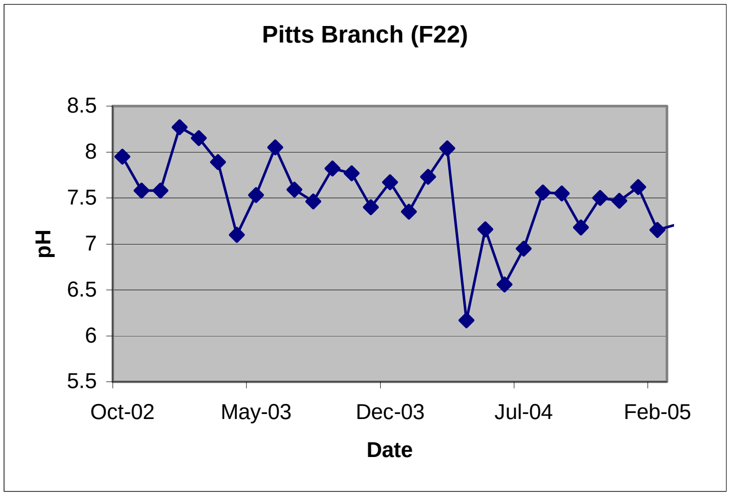


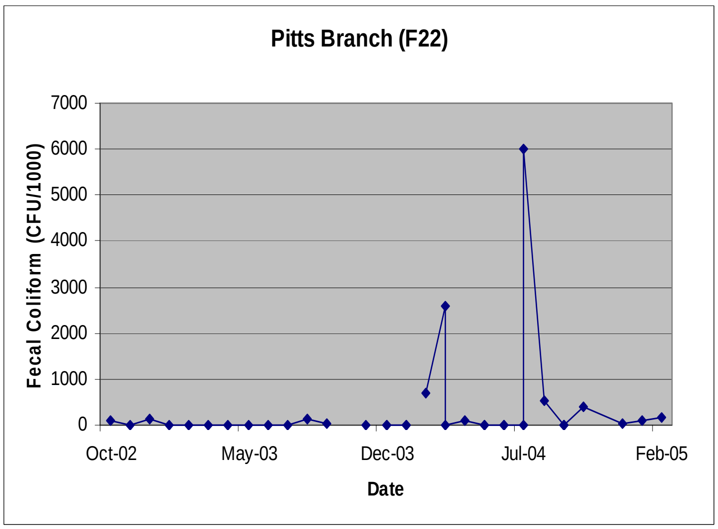
The following figures depict the average temperature, dissolved oxygen, conductivity, pH, and geometric mean of fecal coliform colonies. Historical data included in the statistics began in 2002.

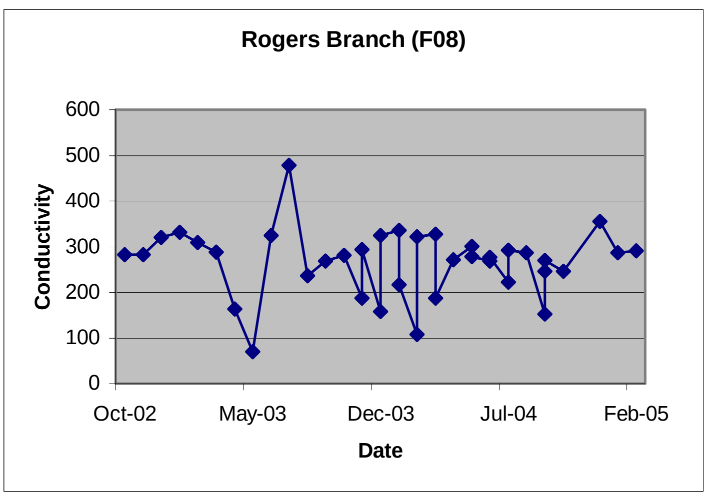


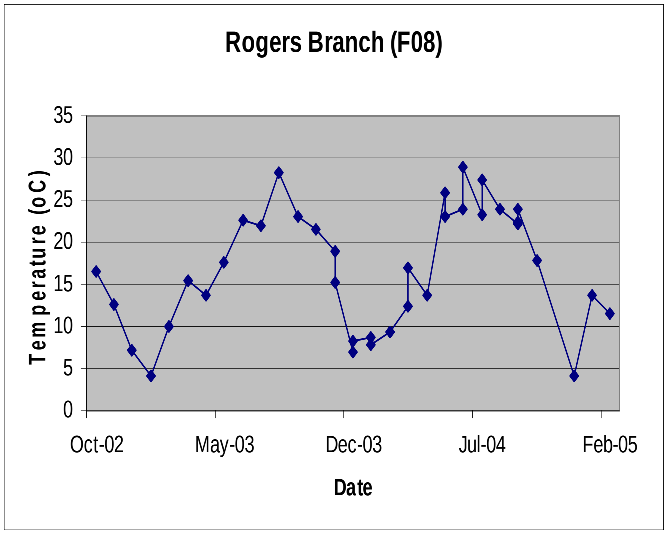


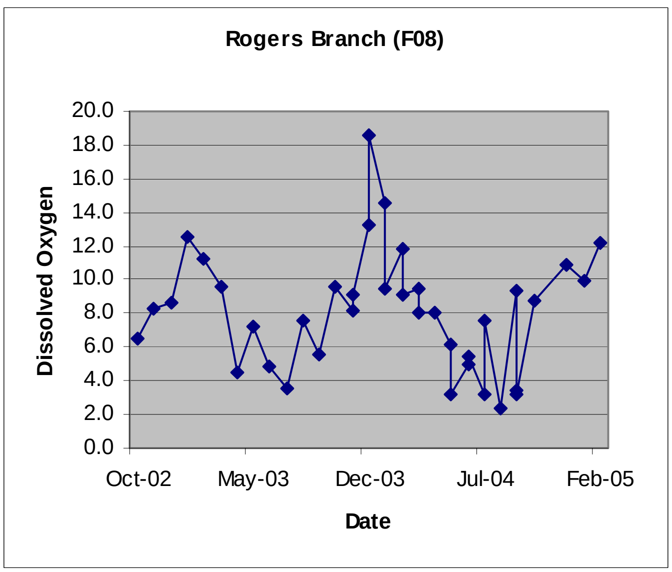


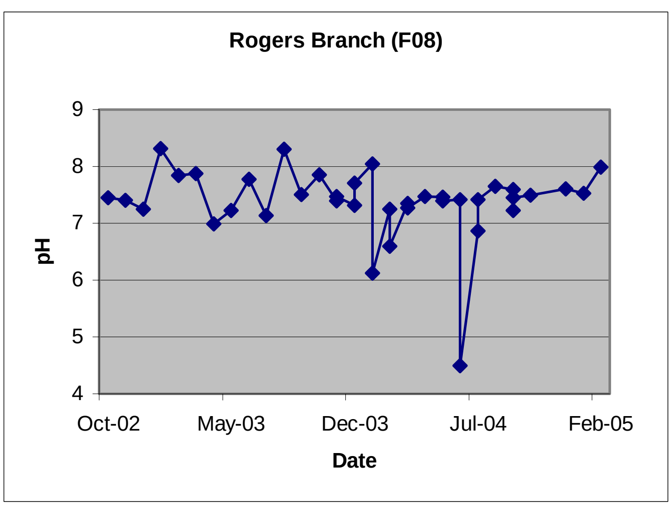

Pitts Branch (F22)
pH
8.5
8
7.5
7
6.5
6
5.5
Oct-02
May-03
Dec-03
Jul-04
Feb-05
Date

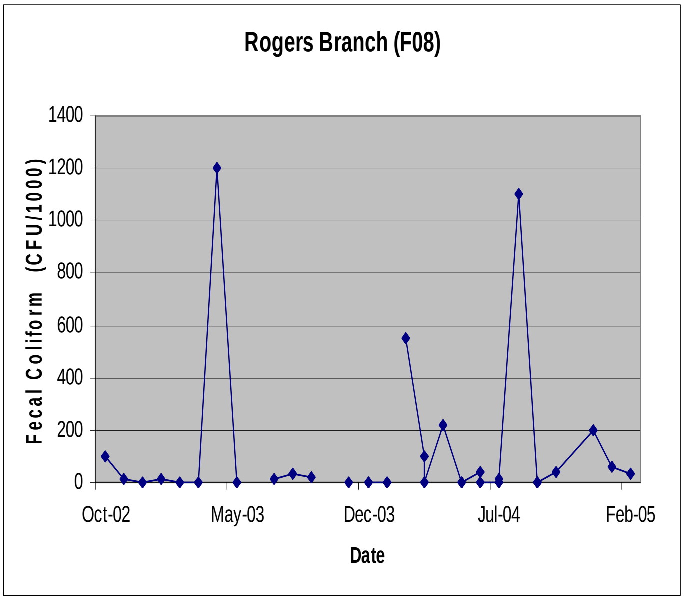

Pitts Branch (F22)
Fecal Coliform (CFU/1000)
7000
6000
5000
4000
3000
2000
1000
0
Oct-02
May-03
Dec-03
Jul-04
Feb-05
Date


Rogers Branch (F08)
Conductivity
600
500
400
300
200
100
0
Oct-02
May-03
Dec-03
Jul-04
Feb-05
Date


Rogers Branch (F08)
Temperature (oC)
35
30
25
20
15
10
5
0
Oct-02
May-03
Dec-03
Jul-04
Feb-05
Date


Rogers Branch (F08)
Dissolved Oxygen
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Oct-02
May-03
Dec-03
Jul-04
Feb-05
Date


Rogers Branch (F08)
pH
9
8
7
6
5
4
Oct-02
May-03
Dec-03
Jul-04
Feb-05
Date



2. Biological/Habitat Impact

In the same study by UTC, four sites in N. Chickamauga watershed on Nine Mile Branch (stream order 3) were studied for biotic assemblages. These sites have the following watershed characteristics:

Site No.	Watershed Area (ac)	% Urban	% Agriculture	% Forestry
NB-1	1,535	9.2	24.5	66.3
NB-2	1,634	8.7	26.2	65.1
NB-3	2,748	13.8	26.9	59.3
NB-4	3,020	14.0	27.4	58.6

The study found evidence of loss of overall and EPT taxa richness at the lower reach sites (NB-3 and NB-4). These two sites correspond to higher % Urban and had the lowest rating. The EPT taxa richness indicates the presence of different families in three insect orders (mayflies, stoneflies and caddisflies) that are considered pollution intolerant.

Benthic data collected at Nine Mile/Pitts Branch for years 2002, 2003 and 2004 listed the stream as being moderately and slightly impaired, respectively. Data collected for Rogers Branch for years 2003 and 2004 characterized the stream as being moderately impaired.

Year	Stream	Taxa Richness	EPT Richness	%EPT	%OC	NCBI	%Dominant	%Clingers	Score
2002	Pitts (F22)	17	2	8.8	67.7	6.21	17.65	23.53	16
2003		20	2	22.06	33.8	4.36	24.88	29.58	22
2004		17	1	45.1	35.78	6.41	45.1	53.43	24
2003	Rogers (F08)	19	2	31.28	42.29	6.72	27.31	35.68	20
2004		10	1	30.88	54.38	5.97	30.88	30.85	20

3. Watershed-Wide Monitoring Program

a. Monitoring Program Objective

The primary objective of the City's monitoring plan is to identify pollutant sources and pollutant reduction needs and to meet the NPDES permit requirements. The Stormwater Management staff is reviewing the existing monitoring program and re-developing a monitoring program that better addresses the program objectives. A key part of the future monitoring program assessment is to evaluate BMPs. Areas where BMPs are currently in use will be compared with areas where BMPs are not extensively employed to evaluate BMP effectiveness and studies will be conducted to gauge the benefits of future BMPs. The purposes of this monitoring program are multifaceted and involve not only identifying water quality impairment/improvement but also monitoring the effectiveness of the management plans and recommended BMPs. The long-term chemical, biological, and hydrological monitoring data will provide valuable information on the increasing or decreasing health of the watershed. Based on the monitoring data collected and the experience gained in implementing the plan, and other factors, refinements will be made in future watershed plans.

b. Existing and Revised Comprehensive Monitoring Program

According to the NPDES permit, the City is required to develop a monitoring program and conduct continuous monitoring. The monitoring program consists of two primary program elements: Illicit discharge detection and elimination; and Monitoring.

i. Illicit Discharge Detection and Elimination

The illicit discharge program is multi-faceted, and designed to locate non-storm water discharges into the MS4 system. Elimination of non-storm water discharges is conducted through inspections and ordinance enforcement. The City's program consists of a number of mechanisms by which illicit discharges are identified including inspection and complaint investigation.

Inspection is the primary avenue for non-storm water detection. The inspection program consists of industrial inspections, emergency response, residential, commercial and municipal discharge inspections and construction site inspections. Additionally, stormwater management staff conduct field-screening, wet-weather surveillance and stream inspections.

The industrial aspect of this program consists of two distinct approaches, industrial inspection and industrial monitoring. The industrial monitoring program will be discussed later under the monitoring section. *Industrial inspections* are conducted at about 12 "high-risk" industrial facilities per year. City Yards and the 36^{th} street landfill are inspected twice a year. Industrial inspections are also conducted when accidental releases of non-storm water material (product, process water, fuel, etc.) have occurred at the facility in the past year. The City is in the process of identifying all industrial outfalls (both state defined industrial outfalls and those points at which stormwater physically exits the property). Accurate outfall locations will improve the accuracy of our industrial monitoring program.

Emergency response actions are conducted in response to calls from the local fire department, local industries, or state/federal agencies. Spill response is initiated by the accidental discharge of non-storm water into the MS4 system. Stormwater personnel provide technical assistance and advise to first responders about drainage and proper clean up methods in order to contain and/or mitigate releases.

Residential, commercial and municipal discharge inspections are most commonly conducted in response to citizen complaints or field observations. In an effort to locate possible sources of sanitary discharge, Stormwater Management conducts smoke testing in cooperation with other agencies, such as Moccasin Bend Waste Water Treatment Plant, in priority areas to identify leaks in the domestic sewer. Once possible discharges are discovered, individual agencies work towards a resolution. Moccasin Bend follows up through sealing cracks and/or replacing/fixing structures and Stormwater Management through enforcing city ordinances to correct service lines.

Construction site inspections are conducted routinely at active construction, demolition, excavation, alteration, and fill sites for which land disturbing permits have been issued. Construction inspections include pre-construction meetings, weekly and final inspections. Stormwater infrastructure is inspected to insure compliance with volume and pre-treatment requirements.

The *field screening program* is conducted annually during the summer season. This program has been established to monitor all outfalls within the MS4 system. Every outfall must be monitored once every two years. Field screening is conducted at approximately 150 locations yearly, which have been selected based on the following criteria:

1. Field screening sites that have historically detected contamination.
2. Known outfalls which have not been field screened.
3. Newly documented outfalls.
4. Low priority outfalls.

Field screening inspections must be conducted twice within 24 hours per site with monitored parameters including water temperature, pH, dissolved oxygen (DO), conductivity, chlorine, detergents, phenol, copper, and flow measurements. Each sample point is located using a GPS system and photos are taken.

Also included under the field-screening segment of the program is the *wet weather surveillance* program. Wet-weather surveillance is conducted following 0.5 inch rainfall or greater at least once a month. This screening provides visual data regarding possible improper disposal during wet flush conditions along priority streams. Currently Stormwater Management monitors ten (10) locations within the city (Figure 2).

Figure # 2

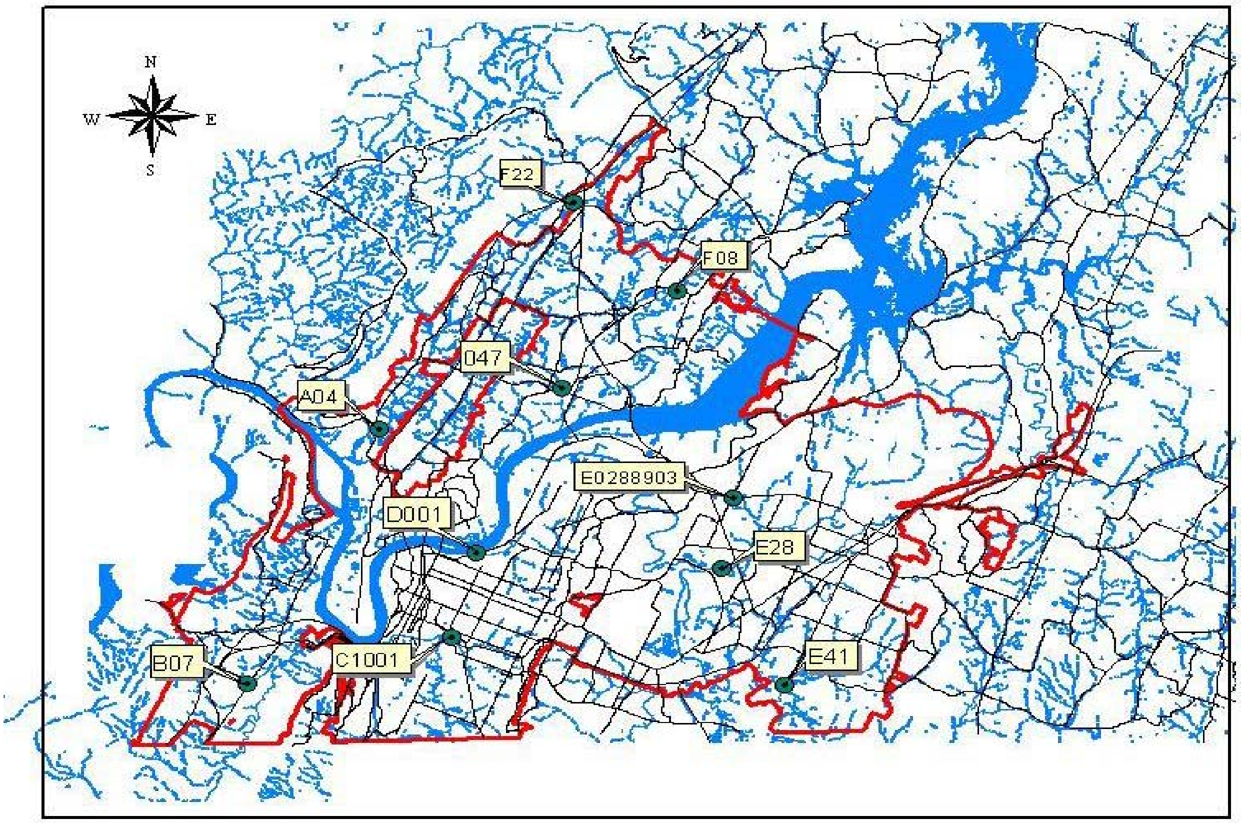


Figure depicts locations of current wet-weather surveillance sites within the City limits.

Monitored locations are: Mountain Creek (A04), Black Creek (B07), Dobbs Branch (C1001), Citico Creek (D001), Friar Branch (E28), Mackey Branch (E41), South Chickamauga Creek Tributary (E0288903), Rogers Branch (F08), Pitts Branch (F22) and Tennessee River Tributary (047). Parameters evaluated include DO, pH, temperature, conductivity and turbidity. Grab samples for fecal coliform analysis are collected as well.

The City will reinitiate detailed stream inspections or "*stream walks*". The goal is to walk or boat about 75 % of major streams every year. The purpose of the inspection involves identification of direct discharges into "waters of the state" as well as quantification of stream corridor health. Parameters measured during the stream inspection include information about the water quality and physical characteristics of the stream banks, such as erosion, scour potential, vegetative cover, etc.

All identified illicit discharges are documented using a computerized database and mitigation and/or enforcement is tracked. All data collected during the illicit discharge phase of the program will be used to adapt the monitoring program to specific watershed needs, as well direct watershed-specific education efforts.

ii. Monitoring

The monitoring aspect of the program includes: wet weather monitoring, ambient monitoring, industrial monitoring, automated stream sampling, biological monitoring, and pesticide, herbicide and fertilizer (PHF) monitoring. Pilot studies, such as use of infrared aerial photography, optical brightener analysis and genetic tracing, will be implemented as special needs are identified within the watershed.

Wet-Weather Monitoring Program

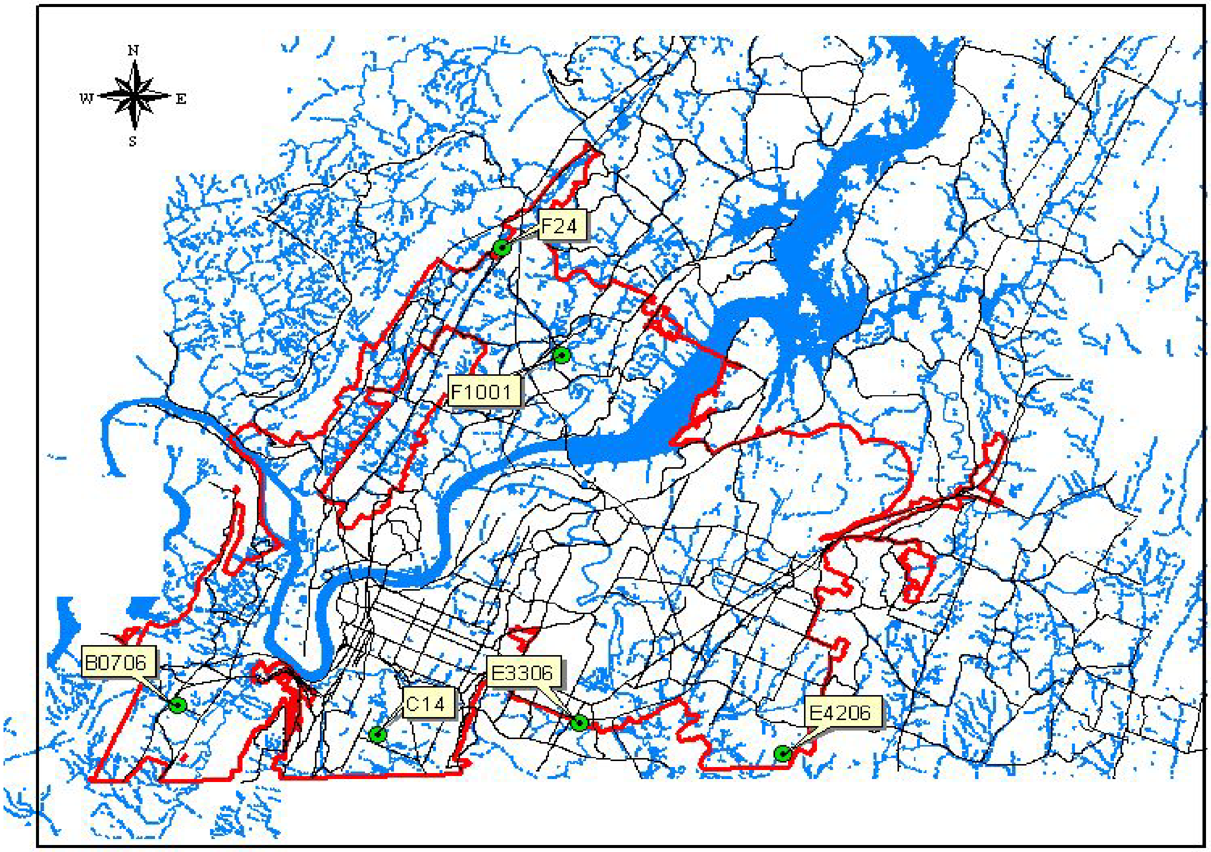
The wet-weather program is designed to provide data necessary to calculate seasonal loadings (four times a year) and event mean concentrations within the evaluated watersheds. Wet-weather points have been specifically identified to meet the criterion specified in the NPDES permit (i.e. defined major outfalls). A series of portable automatic samplers will be used to grab samples within the first thirty (30) minutes of a one-half (0.5) inch rain event and flow weighted composites will be collected within the first three (3) hours. Parameters to be sampled include:

Parameters for Wet-Weather Monitoring	
Total Suspended Solids (TSS)	Biochemical Oxygen Demand (BOD)
Total Dissolved Solids (TDS)	Chemical Oxygen Demand (COD)
Oil and Grease	Fecal Coliform
Total Ammonia plus Organic Nitrogen	Total Recoverable Chromium
Nitrate plus Nitrite Nitrogen (as N)	Total Recoverable Copper
Total Nitrogen	Total Recoverable Lead
Total Phosphorus	Total Recoverable Nickel
Dissolved Phosphorus	Total Recoverable Zinc
Methylene Chloride	Total Recoverable Arsenic
Trichloroethylene	Total Recoverable Beryllium
Vinyl- Chloride	Total Recoverable Cadmium
Bis (2-ethyl-hexyl)phthalate	Total Cyanide
Fluoranthena	

The initial wet-weather sampling points have been selected based on homogeneous land use. Six sites have been selected within the city limits covering four different watersheds (Figure 3). Following is a listing of the selected sites:

Location	**Land Use**	**Outfall Description**	**Basin ID (Creek)**
Adams Road	Commercial	Channel	F1001 (N. Chickamauga)
Labeling Way	New Industrial	Pipe	B0706 (Lookout)
Workman Road	Old Industrial	Channel	C14 (Chattanooga)
S. Moore @ N. Terrace	Old Residential	Channel	E3306 (S. Chickamauga)
Corridor J	Undeveloped	Channel	F24 (N. Chickamauga)
Iris Road	New Development	Channel	E4206 (S. Chickamauga)

Figure # 3



Proposed locations of wet-weather sample points. Wet-weather points are located at state defined outfalls.

As the wet-weather program evolves, the City proposes to broaden the scope of sample points to evaluate stormwater runoff pollutant loads at the sub-watershed level throughout the city. The initial program is specifically designed to meet the requirements outlined in the NPDES permit, but will be expanded to target priority pollutants as TMDLs are developed for each of the city's eight (8) watersheds.

Ambient Monitoring Program

The ambient monitoring program will utilize fixed station samplers/flow meters and will be located in streams for continuous flow measurements. Ambient monitoring stations are shown in Figure 4 and listed as follows:

Figure # 4

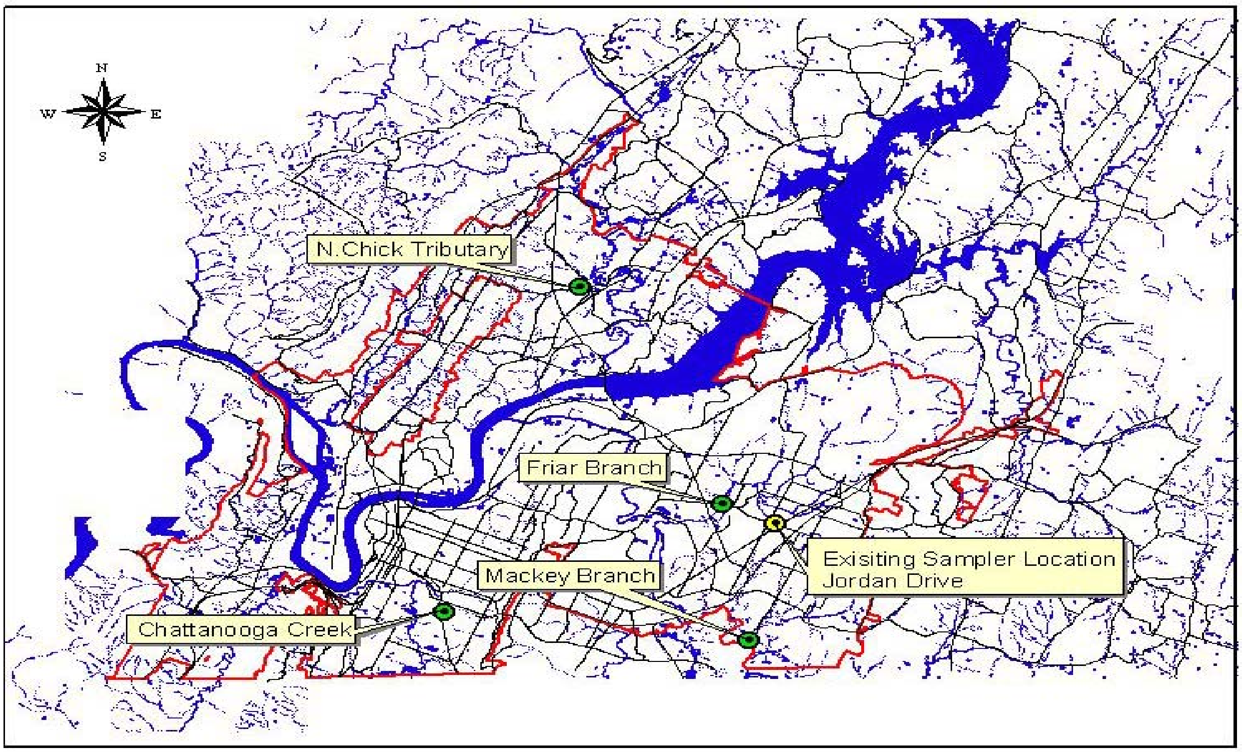


Figure depicts proposed location of automatic samplers for ambient monitoring program.
Currenlty one station is operational at Jordan Drive.
Existing station is highlighted.

Location	**Receiving Stream**	**Basin ID**
Mackey Branch	S. Chickamauga Creek	E41
Friar Branch @ Shallowford Rd.	S. Chickamauga Creek	E2806
Chattanooga Crk. @ Cannon Ave	Chattanooga Creek	C1002
Trib. to N. Chick. @ School Dr.	N. Chickamauga Creek	F12
Trib. to Friar Branch @ Jordan Dr.	S. Chickamauga Creek	(no I.D.)

Both grab and composite samples will be collected on a seasonal basis and analyzed for the above list of parameters. By utilizing the optimum placement of fixed station units, it is proposed to collect direct (real time) data (i.e. rainfall and runoff values), which may be used to calculate pollutant loadings elsewhere in the watershed as the scope of the monitoring program, evolves.

Biological Monitoring Program

Biological monitoring will include benthic macroinvertebrate sampling and will be conducted on two urban stream sites twice per year (Spring and Fall). Target streams are those previously listed as being on the 303(d) List, not meeting classified uses. The two initial sites for benthic sampling will be Rogers Branch (F08) and Citico Creek at Carver Recreation Facility. The Tennessee Biological Standard Operating Procedure protocol will be followed.

Industrial Monitoring Program

Industrial monitoring will be conducted at a minimum of ten (10) industrial outfalls per year throughout the city. Samples will consist of grab samples collected during the first thirty (30) minutes of a rain event and will include the above list of parameters specified in the wet-weather portion. Industrial sites will be selected based on the industry's history of releases, watershed characteristics and a result of industry's self-monitoring. Sampling of the City's municipal City-Wide Services facilities will be included, but on a semiannual basis. Outfall data will be compiled into GIS along with monitoring data that are reported to the state by the facilities and used to develop management strategies such as containing releases and estimating industrial-point source pollutants entering into "waters of the state".

Pesticide, Herbicide and Fertilizer (PHF) Program

PHF sampling will also be performed to monitor the presence and concentration of pesticides, herbicides, and fertilizers in streams. The samples will be analyzed for the following six (6) parameters: pesticides, herbicides, phosphate, TKN (Total Kjeldahl Nitrogen), nitrate/nitrite, and ammonia. The proposed PHF monitoring site for the North Chickamauga Creek watershed is located at Creeks Bend Golf Course (5900 Hixson Pike), which drains directly into Rogers Branch. Additional sample points throughout the City include: Coolidge Park which drains into TN River, Fontaine Woods Apartment Complex which drains into Mountain Creek, Belleau Woods Subdivision which drains into a tributary to Ryall Springs Branch, Brown Acre Golf Course (Brainerd Rd.) which drain into S. Chickamauga Creek, and Single View Condominiums which drains into Mountain Creek. The PHF sampling will be conducted twice per year in spring and fall at each proposed site.

iii. Monitoring Program Evaluation

Data collected during the illicit discharge investigation and monitoring phases of the program will be used for watershed characterization. Synthesized data will be used to prioritize sites requiring either additional attention or protection. Strategic plans will be developed and implemented to address the specific needs identified during sampling. The total watershed management plan will be a dynamic project in which key elements will be monitored and the program altered to meet the specific project goals.

The primary goal of master planning is to design proactive watershed management strategies specific to the individual needs of each watershed. For example, the North Chickamauga Creek watershed has a dynamic not seen in other watersheds within the city limits. Because of the underlying geology and mining activities at the upper reaches of the watershed, North Chickamauga Creek faces unique challenges. By collecting data and evaluating all activities within the watershed (such as urban sprawl, acid mine drainage, natural background pyrite effects, fluctuations in stream flow due to the effects of the Chickamauga dam, stream bank scour, etc.), it is possible to develop a watershed management plan tailored to the individual needs of each watershed.

4. Structural Best Management Practices

Structural Best Management Practices (BMPs) are used to physically protect streams by the installation of various stormwater structures to control runoff before entering streams. Structural BMPs can be of various scale designed and installed for specific pollutant removal. Stormwater structural BMPs can be installed for a specific site such as a construction or residential site and commercial or industrial facility. Multiple structural BMPs can be used at various locations for effective pollutant control. Structural BMPs are also used to control runoff from large drainage areas or subwatersheds. These are called regional BMPs. Regional BMPs can be used by municipalities to reduce the impact of stormwater pollution on receiving streams. The ultimate goal of the BMPs is the improvement of stormwater quality entering our streams.

The following are structural BMPs that are commonly used to control stormwater runoff:

BMP	Function
Silt Fence	Trap sediment from construction activity. Used downstream around pile of exposed soil.
Check Dam	Control sediment from construction activity. Slows down runoff and trap sediment. Used in a defined stormwater channel.
Constructed Wetland	Sediment and nutrient removal. Aestatic value as well.
Sediment Basin	Sediment deposition.
Oil Separator	Remove oil and grease.
Retention Basin	Sediment and nutrient Removal.
Rip-Rap	Slow down runoff and stabilize soil. Used to stabilize slopes.
Inlet Protection	Protect storm drain inlet from pollutants (mainly sediment).
Outlet Protection	Energy dissipater at the outlet structure.
Geosynthetics	Rolled mats used to cover exposed slopes.
Gabion Basket	Wire basket filled with rocks. Mainly used to stabilize stream banks.
Grass/seed Cover	Seeding is used to re-establish vegetative cover. Permanent or temporary cover. Commonly used with mulch.
Mulch	Used for temporary cover of exposed soil.
Turf Blanket	Used for permanent cover of exposed soil.

BMP	Function
Topsoil; Compost	Can be used to provide nutrient and surface cover when seeding.
Hay Bales	Can be used for inlet protection and as check dams.
Sand/Media Filter	Provide nutrient, sediment, floatable, some O&G removal. Can be used to retrofit detention pond.
Organic Filter	Special media can be used to target certain pollutants.
Sand Bags	Used to filter out sediment when pumping sediment laden water.
Flocculants/Coagulants	Chemical products (powder/granular) added to sediment laden water to settle solids/sediments.
Enhanced Swales	Vegetated open channel. Can be used to remove nutrients and infiltrate runoff.
Infiltration Trenches	Excavated trench filled with rocks to infiltrate runoff water from the sides and bottom of trench.
Vegetative Strips	Strip of vegetation adjacent to impervious surface that allow runoff water to filter through the vegetative cover before entering detention pond, storm drains, catch basin, and/or the community waters.
Porous Paving	Porous material used to infiltrate part of the stormwater runoff.
Proprietary Structures	Commercial units designed to remove certain pollutants from stormwater runoff. The units are installed to capture runoff from developed site.
Dry Pond	Surface storage basin to capture and slowly release runoff. No permanent water pool.
Wet Pond	Surface storage basin to capture and slowly release runoff. Contain permanent water pool.
Underground Basin	Series of UG pipes or vaults used to store surface runoff and slowly releasing it.

Stormwater Management is planning to revise the 2001 BMP Manual. The revised manual will also contain a plan to maintain the long-term performance of the City's BMP system. This plan will include BMP accessibility, sediment/debris removal and disposal techniques, inspection methodology, and maintenance techniques for specific BMPs.

5. Non-Structural Best Management Practices

In addition to structural BMPs, the city also utilizes many non-structural practices and programs that enhance stormwater management.

There are a variety of non-structural BMPs that the City has implemented and is implementing to address water quality within its jurisdiction. These non-structural BMPs include:

• Detecting sewage collection system failure (smoke test, maintenance/repair, illicit discharge enforcement)

• Conducting GIS Mapping / Inventory/ As-Found project

• Stormwater BMP Manual

• Continuing stormwater infrastructure maintenance and re-initiating private facility inspection

• Passing stormwater and timber harvesting ordinances and planning to propose new ordinances

• Inspection and enforcement (hiring additional staff, implementing new enforcement protocol, issuance of Notice of Violations, Compliance Orders, Cease and Desist Order, and Civil Penalties).

• Public education and outreach programs (newsletter, presentations, training, stenciling, radio shows, watershed activities)

• Spill response program (24 hr/d-7d/week response with the Fire Department to all spills)

The following is a list of projects that will be conducted in our target watershed, N. Chickamauga Creek:

- Send out letters to neighborhood associations within this watershed informing them of availability to speak on water quality management issues
- Aggressively seek stormdrain stenciling opportunities
- Host a “Watershed Appreciation Day” during spring/summer months
- Speak at area Hamilton County Schools on the function and importance of stormdrain infrastructures

6. Water Quality Modeling

Modeling is one of many assessment tools used in watershed planning and management. The goal in water quality modeling is to adequately simulate the various processes and interactions of stormwater pollution. Water quality models can be used to predict loadings of various types of stormwater pollutants. These models share the various features of hydrologic and hydraulic models in that it is the runoff flow that carries the pollutants.

Water quality models can reflect pollution from both point and nonpoint sources. Water quality models tend to have applications that are targeted toward specific pollutants, source types or receiving waters. Some models involve biological processes as well as physical and chemical processes. Often great simplifications or gross assumptions are necessary to be able to model pollutant accumulations, transformations, and eventual impacts. Detailed short time increment predictions are seldom needed for the assessment of receiving water quality. Hence, the total storm event loads or mean concentrations are normally adequate. Simple spreadsheet-based loading models involve an estimate of the runoff volume which, when multiplied by an event mean concentration, provide an estimate of pollution loading. Such simple models tend to be more accurate the longer the time period over which the pollution load is averaged.

There are a variety of model capabilities that address the specific concerns within a watershed at an appropriate level of detail. Models can be used not only to evaluate alternative management approaches, but also to assess current and potential future problems in the watershed. The utilization of the model may have various purposes. Screening models are preliminary desktop procedures to provide an initial estimate of stream flows and pollutant loads. Planning models are used for overall watershed assessments as well as for initial estimates of the effectiveness and costs of various management strategies. Design models are oriented toward the detailed simulation of individual storm events and are effective tools for determining a least-cost control strategy for watershed quality problems. Operational models are used in producing actual management decisions during storm events. The City's Stormwater Management Section is seeking to use water quality modeling for the following applications:

- Estimation of annual pollutant (e.g. sediment, nutrient, pathogens, and chemicals) loading into major streams in this watershed under existing land use and existing management practices.
- Estimation of annual pollutant (e.g. sediment, nutrient, pathogens, and chemicals) loading into major streams in this watershed under the projected land use (including population growth and new development) and existing management practices.
- Estimation of annual pollutant (e.g. sediment, nutrient, pathogens, and chemicals) loading into major streams in this watershed under the projected land use and proposed scenarios of management practices.
- Determining the contribution of point source (industrial point sources) on pollutant loading.

The ability of models to predict future conditions is very useful for projecting the outcome(s) of various (or combination of) possible management and regulatory measures and strategies. Modeling is thus a tool to aid in selecting management options that will provide the desired outcome(s).

Among the new management and regulatory strategies that could be identified in modeling are:

- Land use planning
- BMPs selection (buffer zones, stream restoration, enforcement, education, etc.)
- New or amended ordinances

7. Steep Slope Management

Certain terrain features such as steep slope can increased non-point source stormwater run-off and erosion. Slopes, when improperly developed can significantly increase the amount and velocity of stormwater. This run-off can cause unexpected flooding, septic tank intrusion, severe erosion, and stream channel alteration. Such increases in speed and volume also carry soil down the slopes into streams causing sedimentation and damage to aquatic life and habitat.

Since the 1970s, staff to the Chattanooga-Hamilton County Regional Planning Commission has remained consistent in recommending minimal development and encouraging recreation, wildlife, and forestry uses on slopes of 25% or greater. These 25% grades are referenced as "steep" and "unbuildable", "unsuitable for development", or "recommended for recreation and/or conservation" in many past and current plans. Although slope concerns have been cited repeatedly over the last few decades, the City continues to wrestle with ways to minimize and responsibly manage development on steep slopes as growth pressures rise.

In 1999, the Regional Planning Agency (RPA) facilitated a workgroup referred to as the Resource Management Task Force. This group was charged to describe, define, and prioritize areas most suitable for development and highlight sensitive areas in need of careful consideration and review prior to any development proposal. Of the sensitive areas, slopes with grades of 25% or greater, were defined as "steep" and described as "areas [that] pose severe limitations to development". The report also detailed that "development in these areas could be detrimental to public welfare, health, and safety and development in these areas could negatively impact the scenic identity of the County". This characterization was supported by the recently adopted countywide 2004 Hamilton County *Natural Hazards Mitigation Plan* which acknowledged 25% or greater slopes as steep and vulnerable to landslide as well as being contributors to flash flooding. Additional documents such as the 2004 Tree Protection Resource Management Advisory Committee *Final Report* also supported concerns for steep slopes by indicating that "special attention should be given to steep slopes" and that "erosion and aesthetic problems increase when irresponsible site clearing and land disturbance is combined with slope and hillside issues."

In an attempt to better manage and protect steep slopes, RPA began researching policies for steep slope protection and steep slope development options. Following a regional peer city review, the Knoxville-Knox County Metropolitan Planning Organization's *Design Guidelines for Stream Bank Development and Water Quality Protection* was found to be a simplified culmination of the differing

BMPs across the southeast. Their BMPs recommend the following for steep slope protection:

- Minimize cut and fill for new development on steep slopes. Limit the steepness of cut and fill slopes to a maximum of 3:1 (33%).
- Limit development of slopes exceeding 25% grades to residential
- uses with a maximum density of one dwelling unit per two acres. Residential development on slopes between 16% and 25% is recommended at a maximum density of 1-3 dwelling units per acre (Figure 6).

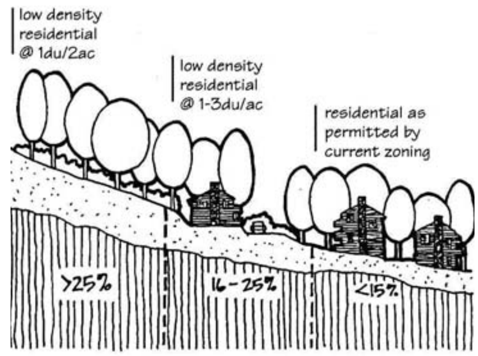


Figure 6.

- Revegetate slopes as part of the development process.
- Respect natural contours so that new development follows natural contours and avoids swales or natural drainage areas as these areas are likely to be flooded and cause runoff to be displaced to other sites downstream (Figure 7).

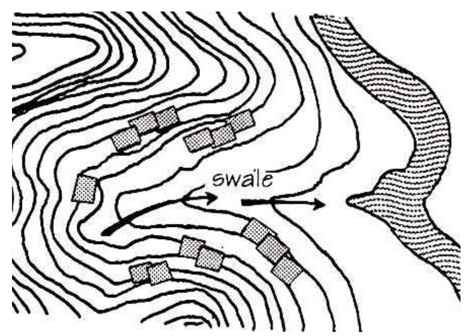


Figure 7.

- Locate roads in new development parallel to the contour of the land to minimize erosion and to reduce the runoff rate more effectively (Figure 8).

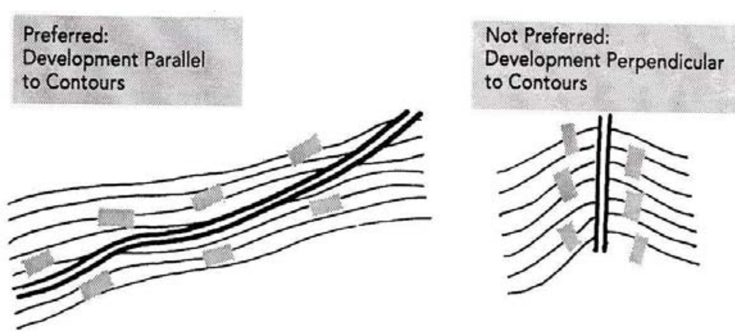


Figure 8.

The RPA has chosen this set of guidelines as a point from which discussion may be initiated. The RPA intends to recommend a steep slope evaluation within its upcoming *CompPlan 2030*. This review would be part of a larger Sensitive Areas Study slated for creation during 2005-2006 Work Program. Such a study is expected to engage appropriate stakeholders and agency representatives regarding reasonable development policies and principals. Staff of the RPA would develop an inventory of developed and undeveloped sensitive slope areas. In addition, the study's partners would assist in the creation of maps to identify focus areas for priority attention.

C. Water Quantity/Floodplain Management

1. Flood Assessment

A flood management plan is where only the essential components, alignment, and functions of a drainage system are analyzed. The focuses of these types of studies are on water quantity control and flood prevention or protection. Flood studies might be performed to assess the nature of, and determine solutions for, out-of-bank flow events that adversely impact public and private lands. Frequently, a flood assessment study typically analyzes both existing conditions and projected future "build-out" discharges for selected return frequency runoff events. The hydrology and hydraulics of the system are analyzed to determine surface water profiles and elevations. This provides information as to where impacts are expected to occur. Examples of a flood assessment are examining the effects of detention on flooding and providing improved flood protection (e.g., flood proofing structures, levies, acquisition of flood prone properties, etc.).

Not all flood prone areas have been identified in Chattanooga. Current mapping included major creeks only. Approximately 100 miles of streams have already been analyzed in Chattanooga. Data from GIS indicates that there are about 200 miles of unmapped streams. These are primarily small urban streams subject to flash flooding. It is estimated that at least half of these (about 100 miles) should have analyses performed to establish floodplains. This analysis should be based on future built-out conditions.

2. Floodplain Modeling

Hydrologic and hydraulic (H & H) models such as HEC-HMS and HEC-RAS can be used to determine flood elevations, velocities, distribution and pressures using flow rates and boundary characteristics as inputs.

Hydrologic models are used to determine flow rates at various points throughout a watershed or pipe network given the typical inputs of rainfall, basin characteristics and basin structure. Survey information, such as cross-sectional information and ponding elevations are used to create models using HEC-RAS. Zoning maps will be utilized to determine the future curve numbers of a specific basin.

Detailed H & H modeling is time consuming and expensive. Approximate floodplain modeling is fast and relatively inexpensive, although less accurate. By establishing approximate floodplains sooner, unmapped areas receive the protection they deserve until more accurate detailed study can be completed. Hydrology models for approximate studies can be used in the water quality modeling discussed earlier in this document.

3. Flood Mitigation Analysis

The City's stormwater drainage system evaluation will consist of evaluating drainage facilities within the City limits. Deterioration of drainage facilities will be noted during the evaluation. During heavy rain events, flooding conditions will be observed noting specifically any roadway flooding and structural flooding as well as non-structural flooding. The existing drainage system will be evaluated under existing and future land use scenarios and any problem areas identified (hot spots) for both scenarios. Possible improvements will be identified and preliminary cost estimates and benefit levels will be determined. Feasible solutions will be selected for implementation. The City of Chattanooga will be performing hydrologic and hydraulic modeling for each basin within the city including N. Chickamauga watershed.

4. Flood Benefit/Cost Analysis

Potential alternatives must be analyzed to identify feasible alternatives prior to performing detailed design work. The feasibility analysis includes calculation of a Benefit/Cost Ratio (BCR) and the practicality of the solution. Any project with a BCR equal to or greater than 1.0 is feasible and should be considered further. As BCR goes higher than 1.0, the return on investment for the project increases.

Traditional cost analysis always includes life cycle costs for operation, maintenance and replacement. BCR calculation for any project should include projections of future losses prevented during this same life cycle time frame. Inclusion of these future savings in the project benefits indicates the true life cycle benefits against the traditional life cycle costs.

5. Conservation of Floodplain Areas

Riparian areas are critical components of floodplain management systems. Riparian zones serve important roles as buffers and habitat for wildlife and aquatic species, and function as natural flood storage areas when preserved in their natural, undeveloped state. Conservation of riparian areas is the key to good floodplain management. Acquisition of riparian areas by municipalities, other governmental entities or non-profit organizations with a declared intent of protecting these natural buffers is the key to protecting the integrity of watershed.

When considering the Benefit/Cost Ratio of riparian acquisition projects the benefits should include the savings realized by preventing development in the floodplain. Current regulations allow development in the floodplain up to the floodway provided the structures are elevated at or above the Base Flood Elevation. While this will protect the structure for some period of time after initial construction, future build out within the watershed will increase flood elevations over time, possibly endangering the structure. Future flood plains based on full build-out of the watershed will identify the maximum extent of flooding and identify undeveloped areas that should be protected.

D. *Better Site Design/Low Impact Development (LID) Practices*

Conservation of natural features is integral to better site design. The first step in better site design is to identify and preserve the natural features and resources that can be used in the protection of water resources by reducing stormwater runoff, providing runoff storage, reducing flooding, preventing soil erosion, promoting infiltration, and removing storm water pollutants. Some of the natural features that should be taken into account include:

- Areas of undisturbed vegetation
- Floodplains and riparian areas
- Ridgetops and steep slopes
- Natural drainage pathways
- Intermittent and perennial streams
- Wetlands
- Aquifers and recharge areas
- Shallow bedrock or high water table
- Other natural features or critical areas

Low Impact Development (LID) practices are effective alternatives and supplements to conventional stormwater management to remedy the adverse impacts that development has had on stormwater. LID is also recognized as having economic and community development benefits, such as beautifying the environment and enhancing the livability of public spaces, assisting with reducing the urban heat island effect, and creating locally-based "green collar" job opportunities.

Planning and implementation of LID stormwater controls in redevelopment areas and urban retrofits is quite complex and more iterative than standard end-of-pipe processes. The LID process requires evaluating and calculating water quantity and quality benefits against the goals and the opportunities. Suburban environments, or greenfields, typically have less constraints and variables in terms of space, surfaces, infrastructure, socioeconomic characteristic, and consistency of land use, and potentially present the opportunity for more predictable outcomes. Urbanized areas, however, have a wide range of community and economic goals, complex environmental and design regulations, distinctive community characteristics, and a broad mix of land uses.

Competing interests can change the land uses within a short period of time. Additionally, the physical factors in the urban environment such as highly-connected impervious surfaces, compacted soils, limited pervious areas, the effectiveness of existing infrastructure, site topography, proximity of pervious areas to impervious surfaces, and available open space impact the predictability of streamlining the planning process. Other variables impact the decision to use LID in urban areas, such as the overall acceptance of LID and the roles of various stakeholders.

The LID Center (Beltsville, Maryland) conducted stormwater modeling to demonstrate the effectiveness of LID strategies. The modeling was done to evaluate and demonstrate the effectiveness of LID for meeting pollution reduction goals and determining the water quality benefits of using LID. The results of this study will be evaluated by Chattanooga (as part of the revised BMP Manual) to determine the advantages and disadvantages of the LID stormwater controls and determine the most appropriate technologies that achieve the water quality and quantity goals as well as the economic, environmental, and community development goals.

The success of LID stormwater controls depends on the perceptions of all stakeholders that are affected by their use, and educating residents on the visual aesthetics, potential impacts on neighborhood property values, and maintenance requirements.

SECTION VI: MASTER PLAN IMPLEMENTATION & RECOMENDATIONS

This document is intended to provide a background of stormwater elements, provide an account of on-going activities and set goals for the City's stormwater program. This document details specific actions and directives for the implementation of a comprehensive watershed master plan. Each watershed has unique characteristics and problems that must be addressed by the master plan. Social, economic, topographic, and physical variables must be evaluated to derive a "workable" watershed management plan tailored to meet the specific needs of the watershed.

By developing this comprehensive watershed master plan, the City has outlined a "plan of action" by which it will implement coordinated tasks. The strategic plan includes the following items:

- Implement a long-term monitoring program and enforcement program to provide management feedback and to assess whether the management strategies are achieving the stream quality goals and in-coming TMDLs set for each watershed. Continuous watershed monitoring provides a baseline to gauge the effectiveness of implementation. The monitoring plan provides data to perform specific recommended actions. The purposes of a long-term monitoring program are multifaceted and involve not only identifying water quality impairment/improvement but also monitoring the effectiveness of the management plans and recommended BMPs. The long-term chemical, biological, and hydrological data will provide valuable information on the increasing or decreasing health of the Watersheds. Based on the monitoring data collected, experience gained in implementing the Watershed Management Plans, and other factors, refinements will be made in the future to the Watershed Management Plans.
- Monitor the performance of the structural and non-structural BMPs. Such a program can include inspection of private and public structural BMPs. The water quality assessments can

yield additional BMP options that are recommended for implementation in the watersheds. The BMPs are based on enhancing existing conditions conducive to good stream quality and implementing development controls, both structural and non-structural, for controlling pollutant runoff.

- An update of the existing BMP Manual. The last update of the BMP Manual was in 2001. The updated manual will be geared toward each watershed taking into consideration watershed-based issues.
- Review existing stormwater ordinance. Propose amendments and new ordinances as tools to implement plan strategies that will address water quality and flood plain management.
- Perform a study to evaluate the effectiveness of a sub-watershed inspection regime to address specific streams quality issues.
- Conduct a study to determine the specific impact of certain activities/conditions such as development, impervious cover, etc. on stream quality at the sub-watershed level and project future impervious cover on stream quality and floodplains. This information can be very useful for zoning strategies.
- Develop a water quality-modeling program to address pollutant loadings and alternative management strategies. Identify any need for capital or other projects (stream restoration, bank stabilization, regional BMPs, etc.) to improve stormwater within the City.
- Establish a riparian buffer system to mitigate flood impacts and protect water quality and stream banks.
- Develop a guidance document for engineers and developers for Better Site Design / Low Impact Development Techniques.