Watershed Plan and Preliminary Characterization Report for Friar Branch

City of Chattanooga

Water Quality Program

Department of Public Works – Engineering

March 4, 2014

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Watershed Plan and Preliminary Characterization Report

FOR

FRIAR BRANCH

WATERSHED

City of Chattanooga
Water Quality Management
Department of Public Works – Engineering
Prepared by Jessica Thompson

March 4, 2014

	Revision	Date

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APPROVALS AND CONCURRENCES

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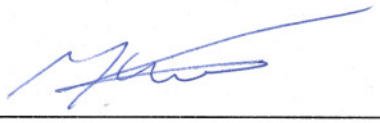

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Signature

Date

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Water Quality Manager

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Abbreviations, Acronyms, and Terminology

BMP	Best Management Practices
CITY	City of Chattanooga
CSO	Combined Sewer Overflow
CWA	Clean Water Act
DO	Dissolved Oxygen
EPA	Environmental Protection Agency (United States)
EMC	Event Mean Concentration
FEMA	Federal Emergency Management Agency
GIS	Geographic Information Systems
HUC	Hydrologic Unit Code
I & I	Inflow and Infiltration
ICM	Impervious Cover Model
IDP	Illicit Discharge Potential
LID	Low Impact Development
NPDES	National Pollutant Discharge Elimination System
PHF	Pesticides, Herbicides and Fertilizers
Report	Friar Branch Watershed Plan and Preliminary Characterization Report
SPL	Seasonal Pollutant Load
SSO	Sanitary Sewer Overflow
TDEC	Tennessee Department of Environment and Conservation
TMDL	Total Maximum Daily Load
TSMP	Tennessee Stream Mitigation Program
TSS	Total Suspended Solids
TVA	Tennessee Valley Authority
USGS	United States Geologic Survey
Watershed	Friar Branch Watershed

Definitions

303(d) list – The section of the federal Clean Water Act that requires a listing by states, territories, and authorized tribes of impaired waters, which do not meet the water quality standards that states, territories, and authorized tribes have set for them, even after point sources of pollution have installed the minimum required levels of pollution control technology. (TDEC)

305(b) report – The section of the federal Clean Water Act that requires EPA to assemble and submit a report to Congress on the condition of all water bodies across the Country as determined by a biennial collection of data and other information by States and Tribes. (TDEC)

Benthic – Bottom dwelling. (TDEC)

Best Management Practices (BMP) – Schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to implement the prohibitions listed in Section 31-53(b) of [City of Chattanooga's] ordinance. BMP's include treatment requirements, operating procedures, and practices to control plant site runoff, spillage or leaks, sludge waste disposal, or drainage from raw materials storage. BMP's also include alternative means (i.e., management plans) of complying with, or in place of, certain established categorical pretreatment standards and effluent limits. (*NPDES Permit No. TNS068063)*

Brownfield – Real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant (*NPDES Permit No. TNS068063)*

Buffer (buffer zone) – A strip of dense undisturbed perennial native vegetation, either original or reestablished, that borders streams and rivers, ponds and lakes, wetlands, and seeps. Buffer zones are established for the purposes of slowing water runoff, enhancing water infiltration, and minimizing the risk of any potential nutrients or pollutants from leaving the upland area and reaching surface waters. (*Rainwater Management Guide*)

Canopy – Branches of trees and leaves that cast shade over the stream.

Combined Sewer Overflow (CSO) – During rainfall events, the volume of stormwater entering a combined sewer system often is far greater than the capacity of the interceptor (large collector pipe) and sewage treatment plant and, as a result, the untreated sewage and stormwater mixture empties directly into receiving waters through designated overflow points. (Natural Resource Defense Council)

Combined Sewer System (CSS) – A wastewater collection and treatment system in which domestic and industrial wastewater is combined with storm runoff. (*Rainwater Management Guide*)

Dissolved Oxygen (DO) – The amount of oxygen present in a water body and available for fish and other aquatic animals to use.

E. coli – A type of fecal coliform bacteria commonly found in the intestines of animals and humans. *E. coli* is short for *Escherichia coli*. The presence of *E. coli* in water is a strong indication of recent sewage or animal waste contamination. Sewage may contain many types of disease-causing organisms. (EPA)

Eutrophication – Nutrient enrichment (nitrogen, phosphorus, and carbon) from sewage effluent, runoff, or atmospheric deposition to surface waters. This process can increase the growth potential for algae and aquatic plants. Excessive eutrophication can leave waterbodies devoid of most life, impede navigation, and result in aesthetic nuisances. (Natural Resources Defense Council)

Event Mean Concentration (EMC) – A method for characterizing pollutant concentrations in a receiving water from a runoff event often chosen for its practicality. The value is determined by composing (in proportion to flow rate) a set of samples, taken at various points in time during a runoff event, into a single sample for analysis. (Natural Resources Defense Council)

Exceptional Tennessee Waters – Surface waters of the State of Tennessee that satisfy the characteristics as listed in Rule 1200-4-3.06 of the official compilations – rules and regulations of the State of Tennessee. Characteristics include waters within state or national parks, wildlife refuges, wilderness or natural areas; State or Federal Scenic Rivers; Federally-designated critical habitat; waters within an area designated as Lands Unsuitable for Mining; waters with naturally reproducing trout; waters with exceptional biological diversity or; other waters with outstanding ecological or recreational value as determined by the department. (*NPDES Permit No. TNS068063*)

Green Infrastructure – Green Infrastructure is a strategically planned and delivered network comprising the broadest range of high quality green spaces and other environmental features. It should be designed and managed as a multifunctional resource capable of delivering those ecological services and quality of life benefits required by the communities it serves and needed to underpin sustainability. Its design and management should also respect and enhance the character and distinctiveness of an area with regard to habitats and landscape types. Green Infrastructure includes established green spaces and new sites and should thread through and surround the built environment and connect the urban area to its wider rural hinterland. Consequently it needs to be delivered at all spatial scales from sub-regional to local neighborhood levels, accommodating both accessible natural green spaces within local communities and often much larger sites in the urban fringe and wider countryside. (Natural England, http://www.urbanspaces.eu/files/Green_Infrastructure_Guidance.pdf) taken from the (*Rainwater Management Guide*)

Habitat – The part of the physical environment where plants and animals live.

Headwater – The source and upper part of a stream.

Hot Area – An area where land use or activities generate highly contaminated runoff, with concentrations of pollutants in excess of those typically found in stormwater.

Illicit Discharge – Refers to any discharge to a municipal separate storm sewer that is not entirely composed of stormwater, except discharges authorized under an NPDES permit (other than the NPDES permit for discharges from the MS4) and discharges resulting from fire fighting activities. (*NPDES Permit No. TNS068063*)

Illicit Discharge Potential (IDP) – A numerical ranking system, which incorporates a series of quantifiable indices having a direct impact on water quality.

Impaired Waters – Any segment of surface water that has been identified as failing to support classified uses. The division periodically compiles a list of such waters known as the 303(d) list. (*NPDES Permit No. TNS068063*)

Impervious – Not allowing the passage of water through the surface of the ground or ground covering or a substantial reduction in the capacity for water to pass through the surface of the ground or ground covering. (*Rainwater Management Guide*)

Infiltration – a complex process of allowing runoff to penetrate the ground surface and flow through the upper soil surface. (*Rainwater Management Guide*)

Inflow and Infiltration (I & I) – Excess water that flows into sewer pipes from groundwater and stormwater. Groundwater *infiltrates* into sewer pipes through holes, cracks, joint failures, and faulty connections. Stormwater *inflows* into sewers through downspouts, foundation drains, storm drain cross-connections, and holes in manhole covers.

Low Impact Development (LID) – LID is a stormwater management and design strategy that is integrated into design of the development project to conserve natural resources that provide valuable natural functions associated with controlling and filtering stormwater; minimize & disconnect impervious surfaces; direct runoff to natural and landscaped areas conducive to infiltration; use distributed small-scale controls or integrated stormwater management practices to mimic the site's pre-project hydrology. (LID Handbook, County of San Diego, CA) taken from *Rainwater Management Guide*

Municipal Separate Storm Sewer (MS4) – A conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains):

- Owned or operated by a State, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to State law) having jurisdiction over disposal of sewage, industrial wastes, stormwater, or other wastes, including special districts under State law such as a sewer district, flood control district or drainage district, or similar entity, or a designated and approved management agency under section 208 of the CWA that discharges to waters of the state;
- Designated or used for collecting or conveying stormwater;
- Which is not a combined sewer; and
- Which is not part of a Publicly Owned Treatment Works (POTW).
(*NPDES Permit No. TNS068063*)

National Pollutant Discharge Elimination System (NPDES) – A provision of the Clean Water Act that prohibits discharge of pollutants into waters of the United States unless a special permit is issued by the EPA, a state, or (where delegated) a tribal government or an Indian reservation. (Natural Resources Defense Council)

Pollutant – Any substance that, when present in a hydrologic system at sufficient concentration, degrades water quality in ways that could become harmful to human and/or ecological health or that may impair the use of water for recreation, agriculture, industry, commerce or domestic purposes.

Sanitary Sewer Overflow (SSO) – Wastewater entering sanitary sewers is so great, because of blockages, a lack of capacity, inflow and infiltration, or other reasons, that the collection system or sewage treatment plant cannot handle the increased flow. As a result untreated sewage empties directly into receiving waters, often from manholes or up through sewer connections. (Natural Resources Defense Council)

Stormwater – Stormwater runoff, snowmelt runoff, and surface runoff and drainage. (*NPDES Permit No. TNS068063*)

Stream – Surface water that is not a wet weather conveyance. (*NPDES Permit No. TNS068063*)

Stream Channelization – Any activity that moves, straightens, shortens, cuts off, diverts, or fills a stream channel, whether natural or previously altered. Such activities include the widening, narrowing, straightening, or lining of a stream channel that alter the amount and speed of the water flowing through the channel. Examples of channelization are lining channels with concrete; pushing gravel from the stream bed and placing it along the banks; and placing streams into culverts. (EPA)

Sub-Basin – Smaller areas that make up a watershed.

Total Maximum Daily Load (TMDL) – A study that quantifies the amount of a pollutant that can be assimilated in a water body, identifies the sources of the pollutant, and recommends regulatory or other actions to be taken to achieve compliance with applicable water quality standards based on the relationship between pollution sources and in-stream water quality conditions. A TMDL can be expressed as the sum of all point source loads (Waste Load Allocations), non-point source loads (Load Allocations), and an appropriate margin of safety (MOS), which takes into account any uncertainty concerning the relationship between effluent limitations and water quality. TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measure. (*NPDES Permit No. TNS068063*)

Watershed Basin – Also called drainage basin, it is the area of land where all surface water converges to a single point, usually to a river.

Watershed – A geographic area which drains to a common outlet, such as a point on a larger stream, lake, underlying aquifer, estuary, wetland, or ocean. (TDEC)

Watershed Sub-Basin – An even smaller area within a watershed. It drains a more specific, smaller, area either to an outfall or straight to a creek or stream.

Wetlands – Ecosystems whose soil is saturated for long periods seasonally or continuously, including marshes, swamps and ephemeral ponds.

Executive Summary

The Friar Branch Watershed Plan and Preliminary Characterization Report (Report) identifies key issues within the watershed and singles out priority sub-basins. This document will serve as a strategic planning tool for the City of Chattanooga Water Quality Program to develop a watershed management plan that will guide full-blown watershed characterization. Included in this document are critical elements necessary for watershed characterization:

- Watershed description and background
- Current land use
- Water quantity and quality data
- Regulatory status
- Future tasks and goals

The City has defined sub-basins as smaller drainage areas within a larger watershed. Friar Branch's sub-basins range in size from 0.6 to 1.9 square miles. This Report analyzes characteristics and conditions of the watershed, including history, land use, demographic data, drainage service requests, stream designated uses, watershed characterization sampling data, and illicit discharge potential (IDP) score. The IDP score is a ranking system used to identify the priority sub-basins according to their likelihood of allowing pollutants to enter its streams. The priority sub-basins determined by the IDP score are EF 29, EF 30, and EF 36, shown in Figure 1 on the following page.

The ultimate goal of watershed planning and management is to restore impaired streams to the original unimpaired conditions. The 303(d) list identifies 18.94 miles of stream in Friar Branch as not meeting the water quality standards specified by the State of Tennessee. Meeting percent reduction goals and total maximum daily loading (TMDL) requirements will aid in the restoration of these streams. Causes of impairments for Friar Branch include loss of biological integrity due to siltation, excessive nutrient loadings, physical substrate habitat loss, and *E. coli.* Structural and non-structural stormwater BMPs will help achieve TMDLs for tributaries of the watershed. Following this Watershed Plan and Preliminary Characterization Report, retrofit evaluation will identify potential project sites within the priority sub-basins. The City will complete a cost-benefit analysis and implementation plan following the selection of project sites.

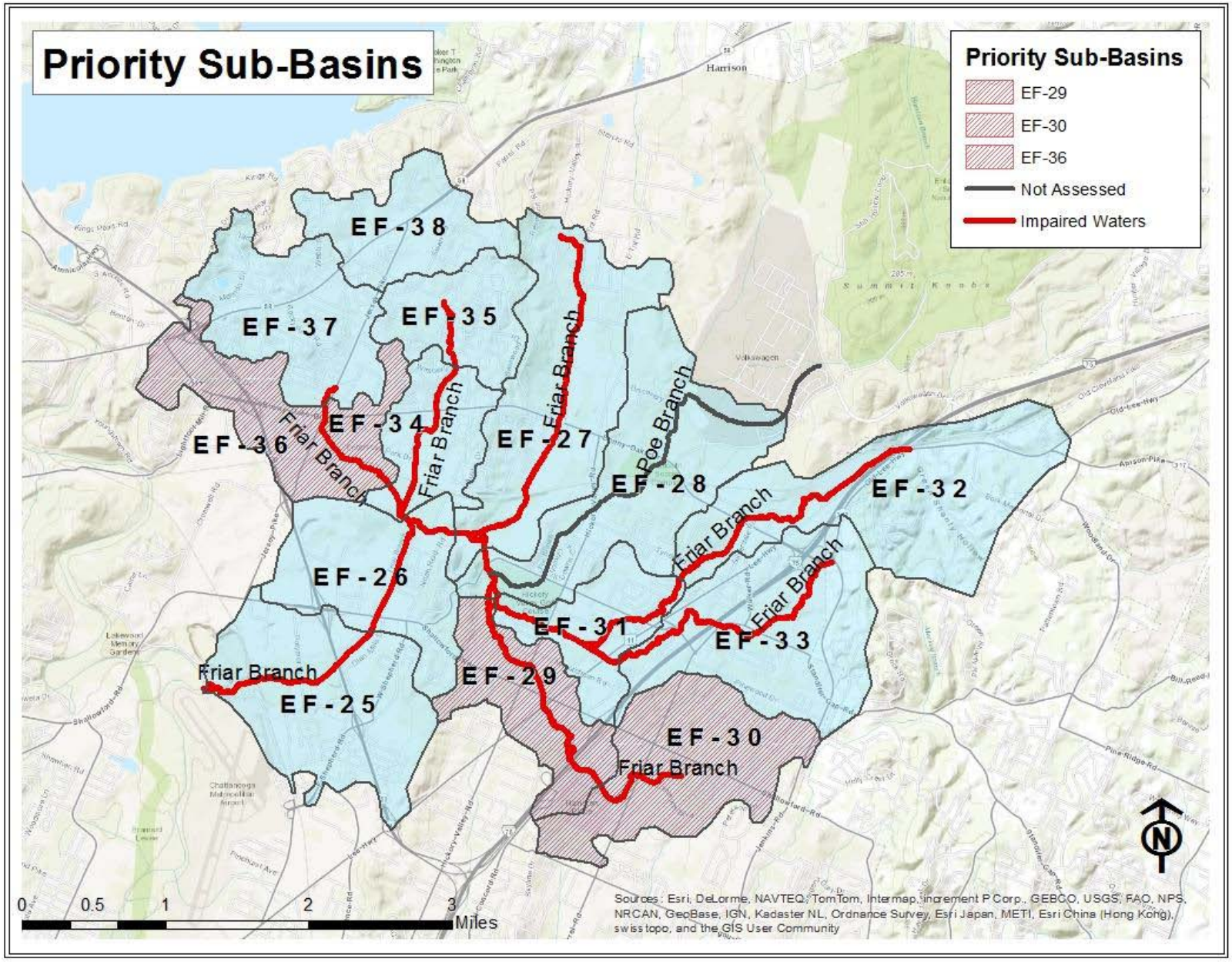

Figure 1. Priority Sub-Basins.

I. Introduction

The Tennessee Department of Environment and Conservation (TDEC), Division of Water Resources issued the City of Chattanooga a National Pollutant Discharge Elimination System (NPDES) permit for the discharge of stormwater from the municipal separate storm sewer system (MS4) effective January 1, 2011. Section 3.3.5 of this permit, states,

> The city will conduct watershed characterization for Friar Branch no later than two years following the effective date of the permit. Sampling for *E. coli* and total suspended solids will be conducted twice each year to determine both pollutant loading and source identification. Results of watershed characterization shall be submitted with each Annual Report.[1]

The Friar Branch Watershed Plan and Preliminary Characterization Report (Report) is the first step in completing the watershed characterization required by the NPDES permit. The Report presents data available from extensive sampling and monitoring in order to formulate conclusions regarding the overall quality of the watershed. The Report identifies: land uses within the Friar Branch Watershed (watershed); the conditions of the watershed, including water quantity and quality issues; the potential for illicit discharges to occur; the monitoring program in which the City follows; and lastly education and community outreach opportunities and goals. Following the Report, the City will identify potential projects sites for stormwater retrofits that will serve to both effectively improve water quality and educate community members of the importance of stormwater management. Figure 2 depicts the twelve watersheds in Chattanooga.

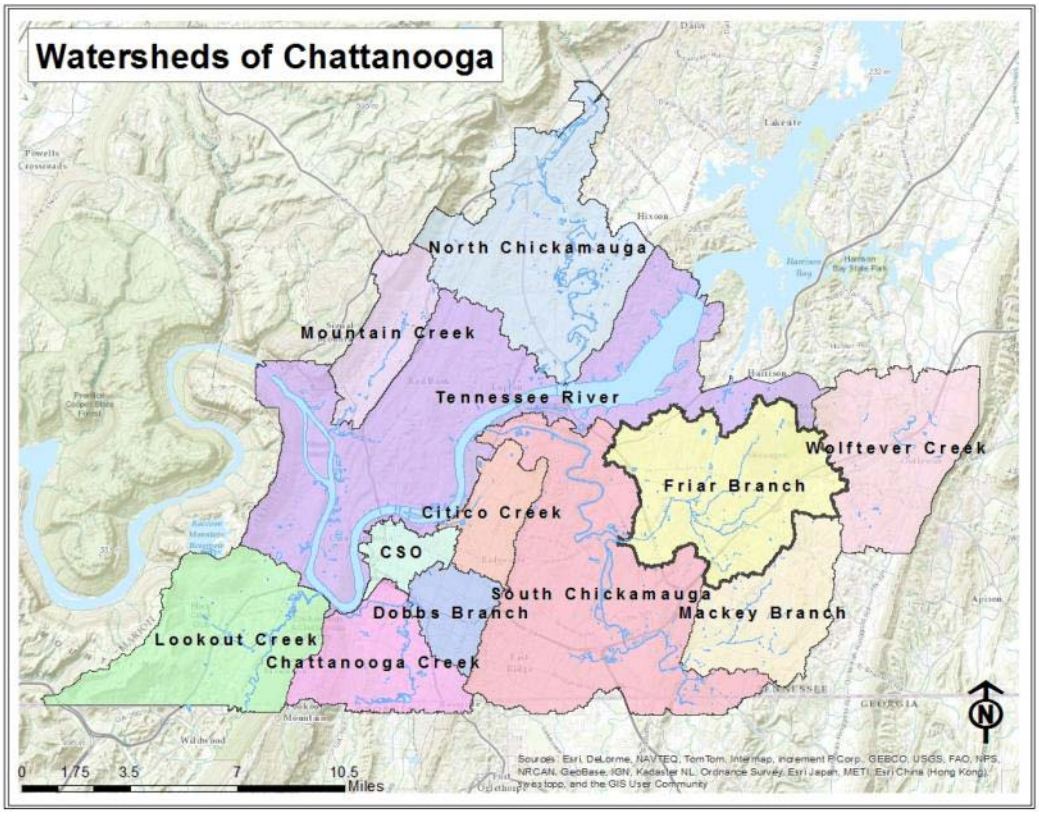

Figure 2. Watersheds of Chattanooga.

Mission:

It is the City's vision to restore the waterways within the Friar Branch Watershed as close to their natural state as possible, promote a healthy and sustainable ecosystem, protect the watershed from future degradation, and most importantly improve the quality of life within this watershed.

Strategies:

- Develop and implement a Comprehensive Watershed Plan and Characterization Report in accordance with the NPDES permit.
- Identify sub-basins of greatest concern through analysis of monitoring and sampling data and illicit discharge potential scores.
- Select project sites that are capable of having the greatest improvements in water quantity and quality while simultaneously educating the community members.
- Implement green infrastructure and low impact development strategies at these project sites to better manage stormwater runoff from highly impervious areas within the watershed.
- Remove Friar Branch from TDEC's 303(d) list by meeting the reductions goals for *E. coli* and siltation/habitat alteration and by permanently keeping pollutant loadings below the defined TMDL for Friar Branch.

II. Watershed Description

The Friar Branch Watershed is a part of the Middle Tennessee-Chickamauga Watershed (Hydrologic Unit: 06020001), within the Upper Tennessee River Basin. The waterbody ID for Friar Branch is 06020001007_0100. The City has defined sub-basins as smaller drainage areas that make up a larger watershed. The Friar Branch Watershed consists of fourteen sub-basins, ranging in size from 0.6 to 1.9 square miles, and drains a total area of approximately 17 square miles. Figure 3 below identifies the sub-basins of Friar Branch. Poe Branch and Friar Branch are the predominant tributaries within the Friar Branch Watershed, totaling 22.7 miles of stream. Poe Branch consists of 3.65 miles of stream and Friar Branch consists of 18.94 miles of stream. Poe Branch lies within sub-basin EF 28 and EPA has not assessed the stream. EPA has determined the remaining 18.94 miles of Friar Branch to be impaired.[2] Friar Branch is comprised of a largely commercial and suburban residential region, which includes Hamilton Place Mall and the other retail establishments along the Gunbarrel/Shallowford Corridor.

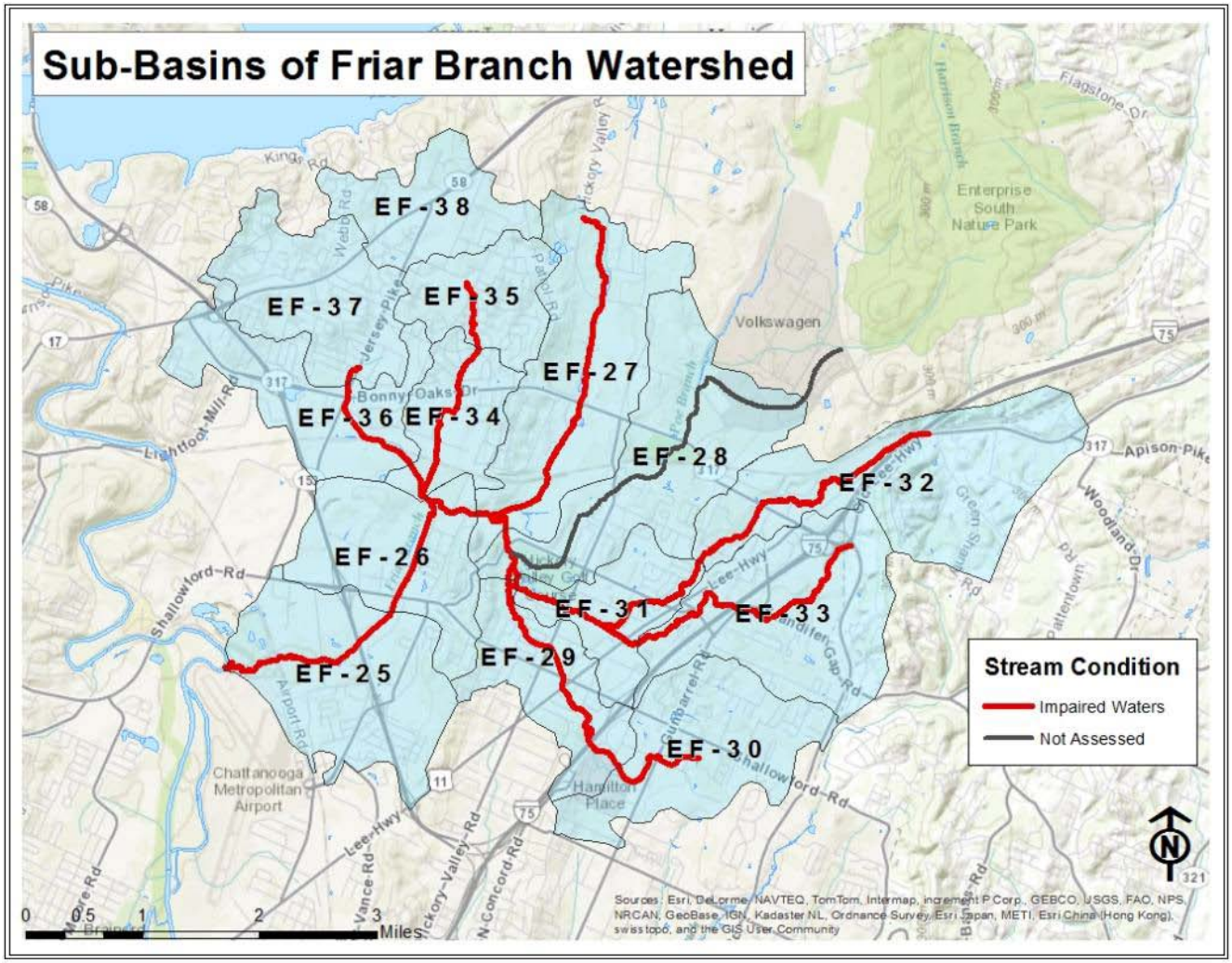

Figure 3. Sub-Basins of Friar Branch Watershed.

Table 1. Area of sub-basins in Friar Branch.

Sub-Basin	Acres	Sub-Basin	Acres
EF 32	1,203.1	**EF 37**	730.0
EF 27	1,164.9	**EF 36**	696.4
EF 28	1,092.9	**EF 29**	551.0
EF 33	1,043.8	**EF 38**	511.5
EF 25	1,002.7	**EF 31**	445.1
EF 30	841.3	**EF 35**	437.1
EF 26	737.1	**EF 34**	420.1
TOTAL		**10,877 acres**	

Friar Branch is as an Exceptional Tennessee Water because of the state threatened Chickamauga Crayfish.[3] According to the Tennessee Department of Environment and Conservation (TDEC), Exceptional Tennessee Waters are waters in which "degradation cannot be authorized unless (1) there is no reasonable alternative to the proposed activity that would render it non-degrading and (2) the activity is in the economic or social interest of the public."[4] Exceptional Tennessee Waters require more stringent water quality criteria. For instance, the maximum allowable limit for *E. coli* in exceptional waters for the use of recreation is 487 colony-forming units per 100 ml (for an individual sample); whereas, the maximum allowable limit for *E. coli* in any other waters is 941 colony-forming units per 100 ml.

Friar Branch is located in a Ridge and Valley, 67f, Level IV, ecoregion. The 67f ecoregion is Southern Limestone/Dolomite Valleys and Low Rolling Hills. TDEC describes this region as,

> A heterogeneous region composed predominately of limestone and cherty dolomite. Landforms are mostly low rolling ridges and valleys, and the soils vary in their productivity. Land cover includes intensive agriculture, urban and industrial uses, as well as areas of thick forest. White oak forest, bottomland oak forest, and sycamore-ash-elm riparian forests are the common forest types. Grassland Barrens intermixed with cedar-pine glades also occur here.[5]

Friar Branch is on TDEC's 303(d) list as "not supporting" of its designated uses, thereby making it a priority for water quality improvement. The 303(d) list is a list of impaired and threatened waters submitted to Congress as part of the 305(b) report every two years.[6] Friar Branch is impaired for *E. coli* and loss of biological integrity due to siltation, nutrients, and habitat loss. The sources of pollution are from construction activities and discharges of municipal separate storm sewer systems (MS4) as a result of urban runoff and sanitary sewer overflows. [7]

The land use within Friar Branch is largely commercial and residential. Upon the completion of Hamilton Place Mall came the establishment of other retail centers in the surrounding area. Development leads to increased amounts of imperviousness. Highly impervious areas produce large volumes of stormwater runoff causing stream bank erosion and water quality degradation from increased pollutant loadings. As

more residential properties are developed, sewer lines become strained from the added sanitary sewer volume, increasing the frequency potential for SSOs to occur.

The City's Water Quality Program has identified "hot areas" throughout Chattanooga. These are areas where land use or activities generate highly contaminated runoff, with concentrations of pollutants in excess of those typically found in stormwater. The City's *Water Quality Program Hot Areas Action Plan* defines hot areas based on the density of illicit discharges from facilities such as concrete or asphalt producing facilities, auto repair and supply shops, large commercial parking lots, and restaurants.[8] Figure 4 identifies the two hot areas found within Friar Branch.

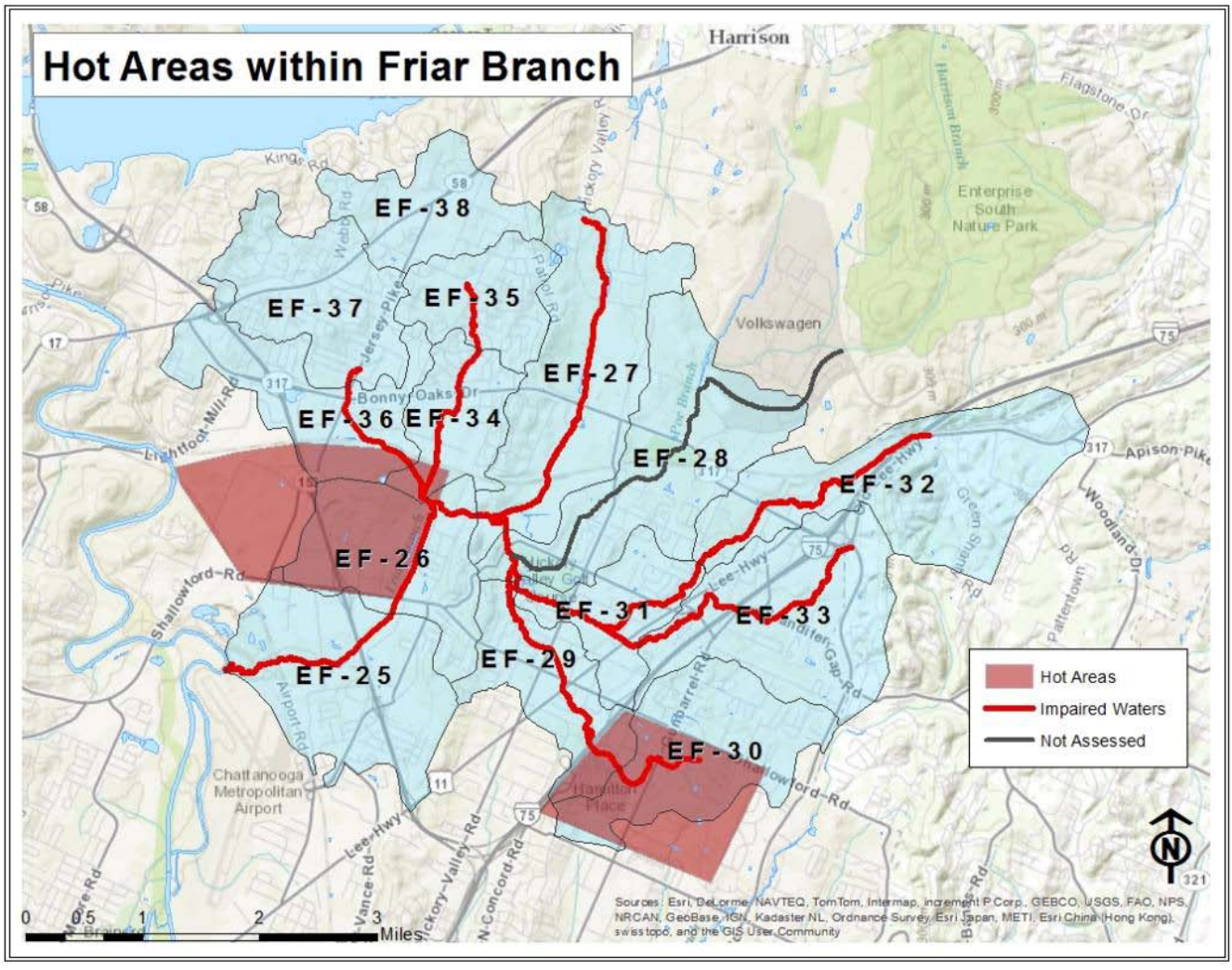

Figure 4. Hot Areas within Friar Branch.

III. Watershed Background

A. History

Prior to the development of Hamilton Place Mall, Friar Branch predominately consisted of undeveloped land. Since the completion of the mall in 1987, seven other retail centers have been added to the surrounding area, totaling 2,817,390 square feet, or approximately 65 acres, of retail space.[9] The rise in commercial development has resulted in an increase in imperviousness. The image below illustrates the concentration of imperviousness surrounding Hamilton Place Mall, specifically in sub-basins EF 29 and EF 30.

Friar Branch has recently become home to the Amazon Fulfillment Center, additionally a portion of the Volkswagen Assembly Plant lies within the watershed borders. Both facilities are located in the northeastern section of the watershed. Friar Branch consists of the neighborhoods of Bonny Oaks, Lake Hills, Tyner, Airport, Concord, and small portions of Summit and Murray Hills. These regions were determined by the voting precincts defined by the City.

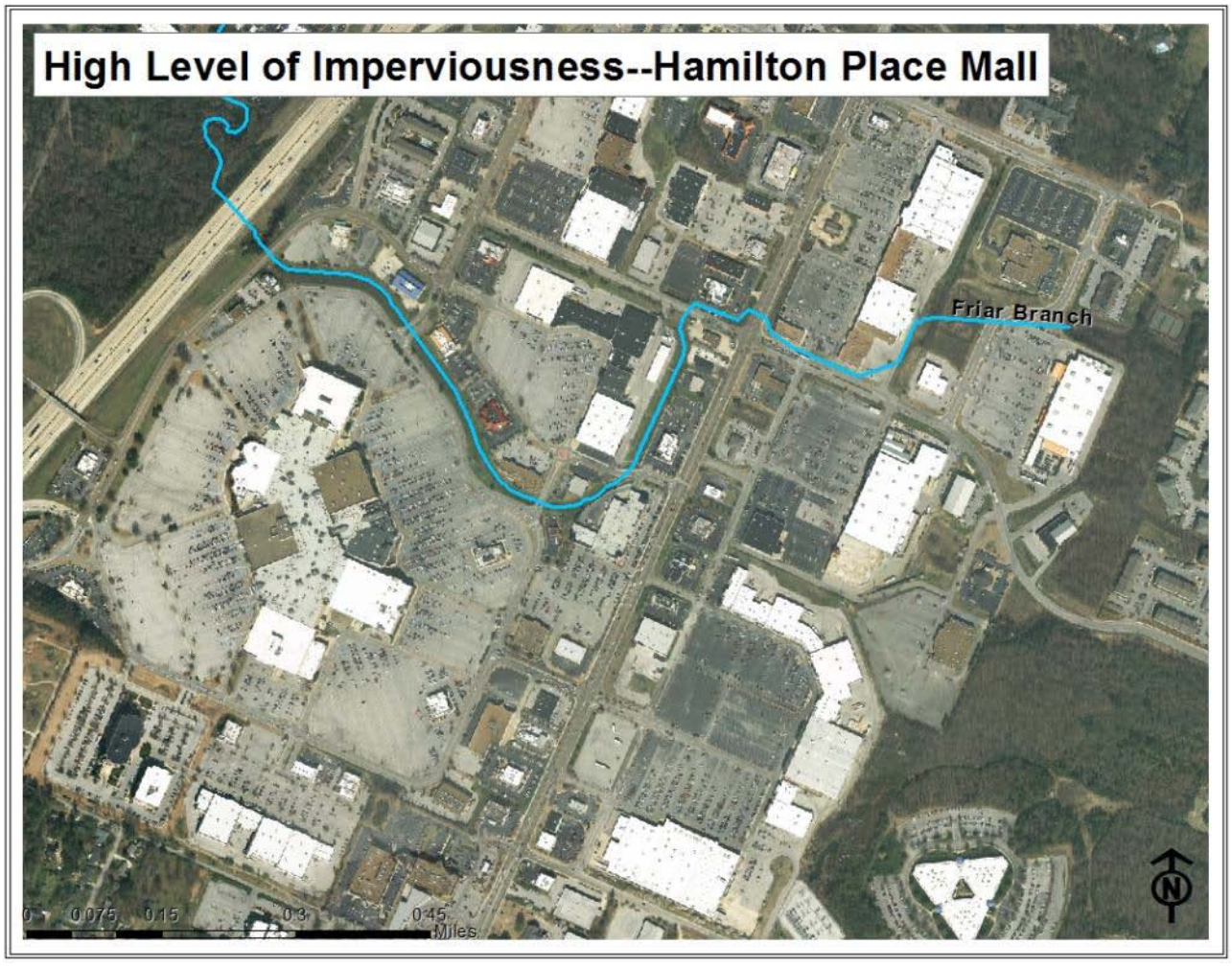

Figure 5. High Level of Imperviousness—Hamilton Place Mall.

B. Demographics

The demographic information in this report is from the Census Bureau's *2007-2011 American Community Survey 5-Year Estimates*. The report divides data by census tracts and compares to values for Chattanooga (City), Tennessee (State) and the United States (Nation). Figure 6 below depicts residential land use with census tract boundaries in order to analyze the residential areas of the tracts that lie within the watershed borders. Census Tract 9802 lies within the Friar Branch border; however, was not included in analysis because the portion within Friar Branch does not contain residential properties. In general, both household and family income rates are high, as well as, high school graduation rates. Additionally, poverty rates and unemployment rates remain low when compared to statistics for city, state and national rates. Table 2 on the following page illustrates the demographic data for each of the census tracts within Friar Branch.

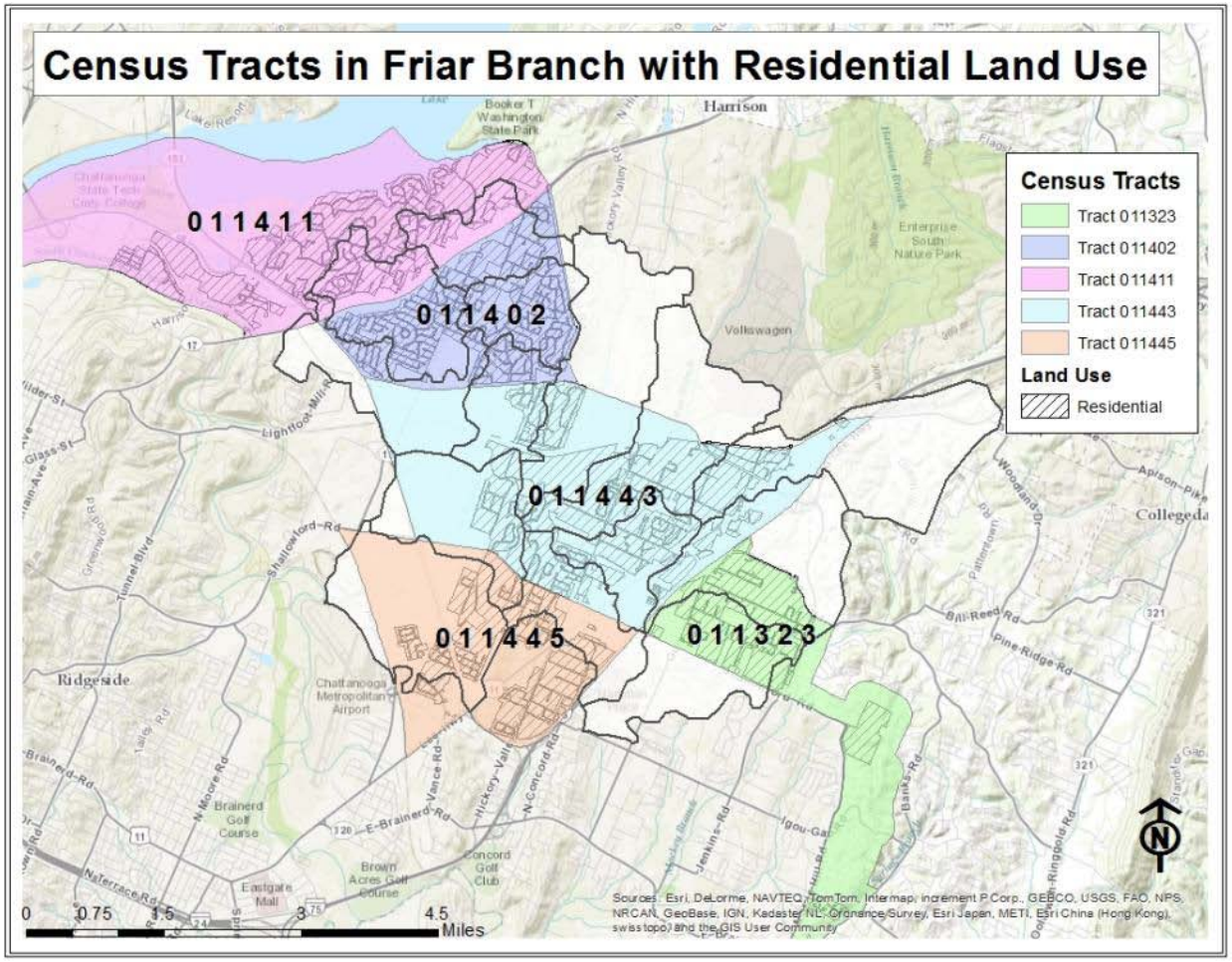

Figure 6. Census Tracts in Friar Branch with Residential Land Use.

Table 2. Demographic Information.

	Tract 113.23 (011323)	Tract 114.02 (011402)	Tract 114.11 (011411)	Tract 114.43 (011443)	Tract 114.45 (011445)	City, Chattanooga, TN	State, Tennessee	Nation, United States
Population	5,380	6,354	3,621	5,365	3,740	166,298	6,297,991	306,603,772
Median Age	46.2	35.0	45.2	42.6	36.6	36.4	38.3	37.3
% 65 and older	19.8%	12.9%	17.9%	20.1%	18.9%	15.0%	13.7%	13.3%
Median household income (dollars)	$78,984	$40,034	$42,528	$36,306	$33,688	$22,800	$25,243	$30,500
Median family income (dollars)	$93,443	$49,303	$51,111	$47,500	$52,568	$46,069	$52,273	$61,455
All families below poverty in past 12 months	3.4%	8.2%	10.0%	9.9%	18.2%	22.1%	13.7%	11.7%
Percent high school graduate or higher	90.0%	84.1%	87.3%	85.6%	86.9%	84.1%	84.2%	85.9%
Percent Unemployed	3.0%	8.3%	18.7%	12.3%	6.5%	15.4%	10.6%	10.3%

Source: 2007-2011 American Community Survey 5-Year Estimates

IV. Land Use

The nine categories of land use include residential, vacant, industrial, recreation, commercial, institutional, transportation, utilities, and agriculture. In Friar Branch, the leading land use types are residential (34%), vacant properties (17%) and industrial properties (14%). Figure 7 below shows all land use categories within the watershed. Each category is then further broken down into sub-categories, shown in Figure 8. Figures 9-14 and Tables 3-8 on the following pages show specific data regarding the land uses of Friar Branch.

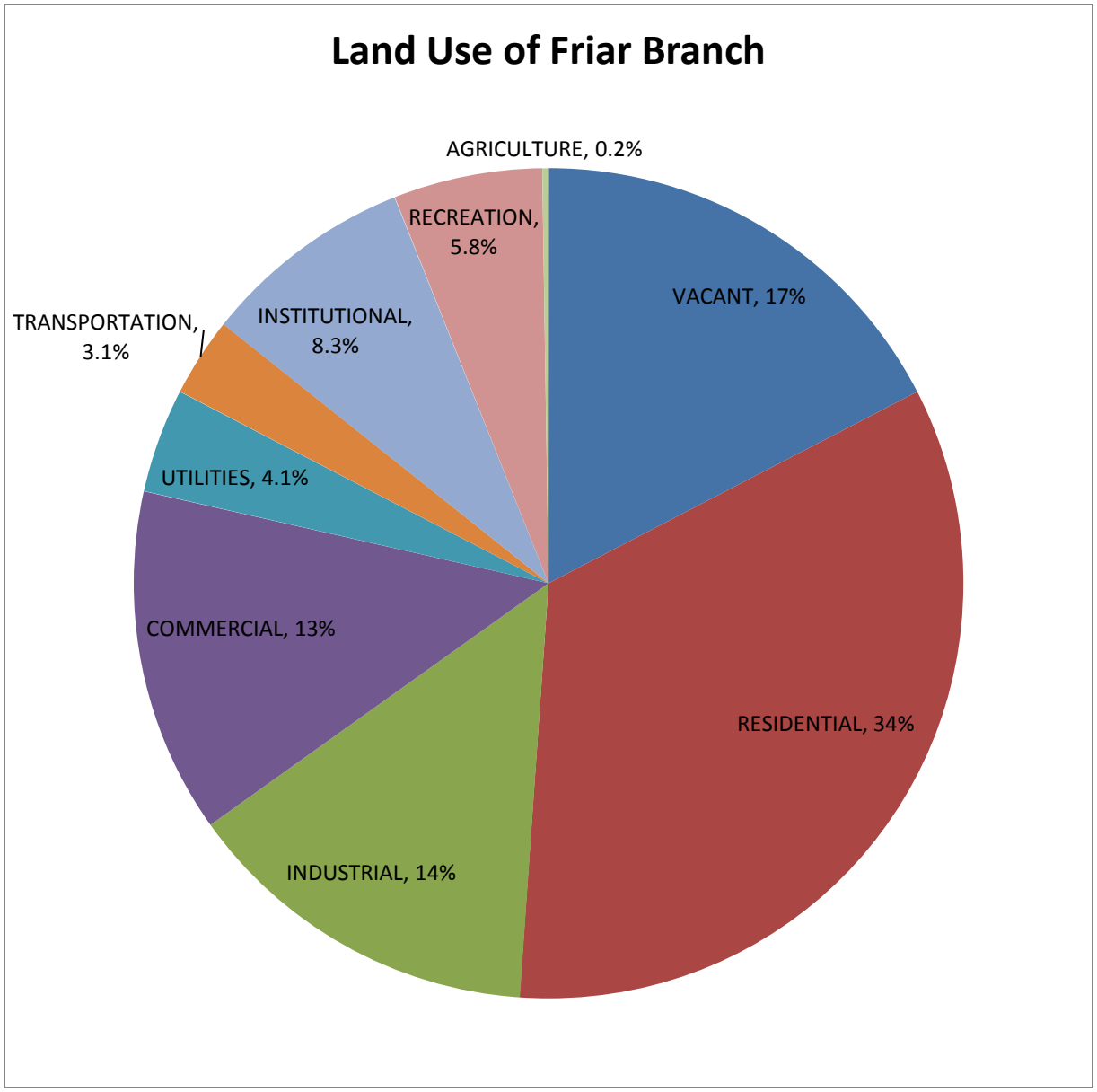

Figure 7. Land Use of Friar Branch.

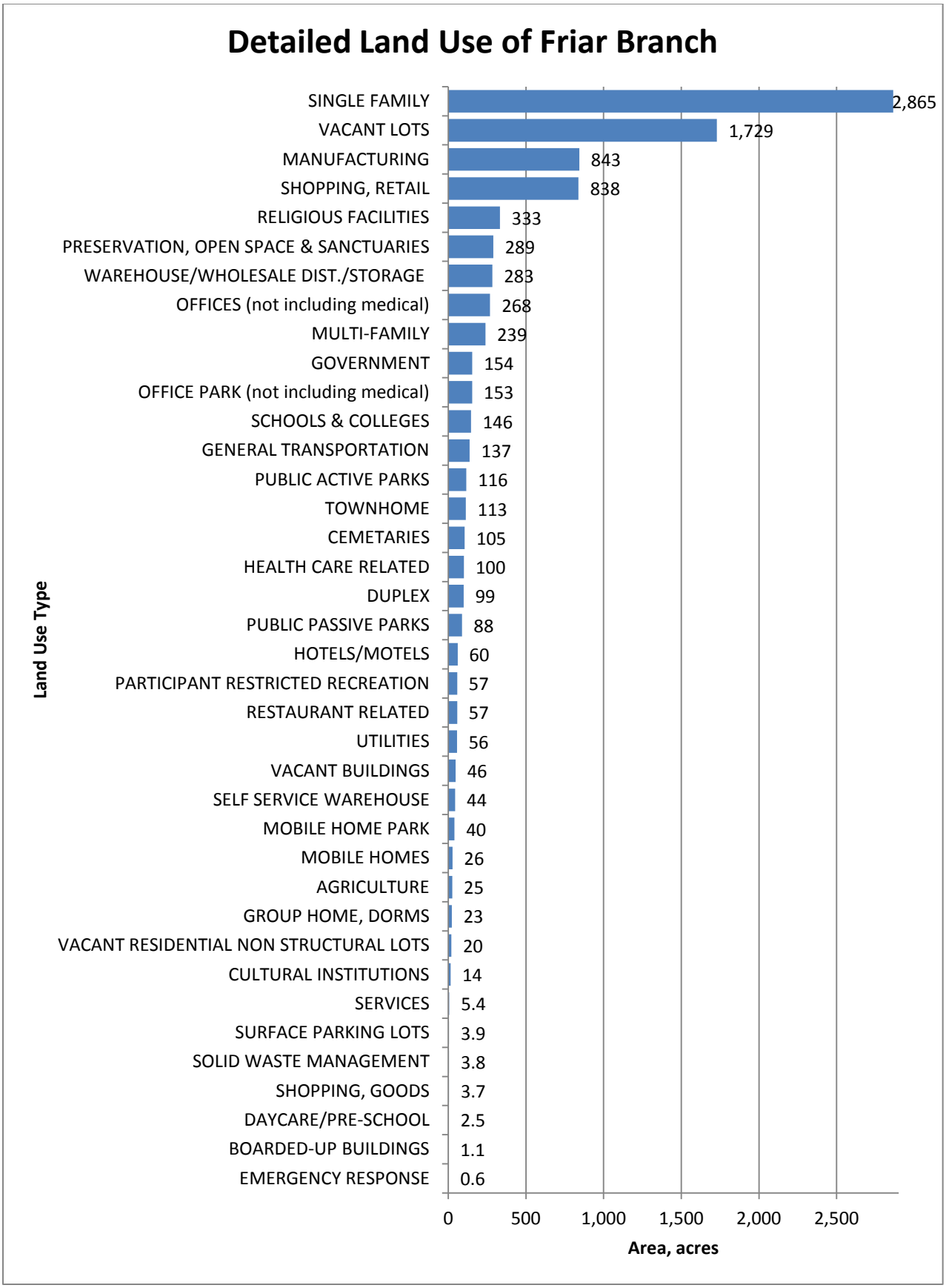

Figure 8. Detailed Land Use of Friar Branch.

A. Residential

The primary land use in the Friar Branch Watershed is residential. Residential properties are defined as single-family houses, duplexes, multi-family houses (three or more units), group homes (dormitories, retirement homes, etc.), mobile homes, attached townhomes, and mobile home parks. Sub-basin EF 32 has the greatest area of residential properties but EF 35 has the largest percentage of residential properties within its sub-basin.

Table 3. Residential Area.

Residential		
Sub-Basin	Acres	Percent of Sub-Basin
EF 35	280.8	64%
EF 37	401.4	55%
EF 31	218.1	49%
EF 38	249.7	49%
EF 32	498.5	41%
EF 29	205.1	37%
EF 33	356.4	34%
EF 34	142.9	34%
EF 30	281.3	33%
EF 26	182.9	25%
EF 28	266.0	24%
EF 36	126.8	18%
EF 25	134.3	13%
EF 27	140.2	12%
Total	3484.5	

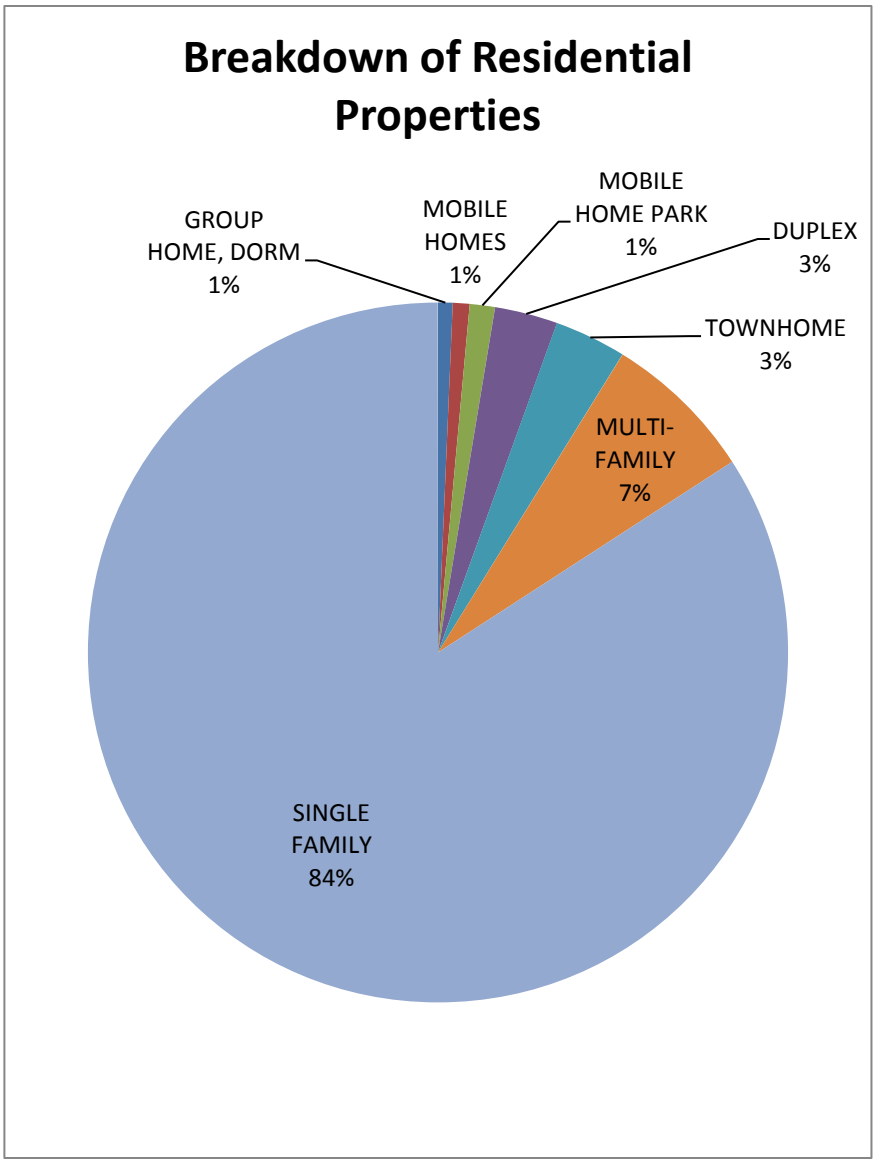

Figure 9. Breakdown of Residential Properties.

B. Vacant

The next leader in land use is vacant properties. This category consists of vacant lots, vacant buildings, residential non-structural lots, and boarded-up buildings. Only 1.1 acres are comprised of boarded-up buildings and 46 acres are vacant buildings, totaling only 2.6% of all the vacant properties in the watershed; low when compared to other parts of Chattanooga. Many of the vacant lots in the area are adjoined to single-family residences.

Table 4. Vacant Area.

Vacant		
Sub-Basin	Acres	Percent of Sub-Basin
EF 27	550.3	47%
EF 32	306.3	25%
EF 28	175.1	16%
EF 25	148.8	15%
EF 33	148.0	14%
EF 30	119.0	14%
EF 38	59.6	12%
EF 26	72.0	10%
EF 36	60.5	9%
EF 37	62.8	9%
EF 29	35.0	6%
EF 31	23.0	5%
EF 35	20.4	5%
EF 34	15.4	4%
Total	1796.3	

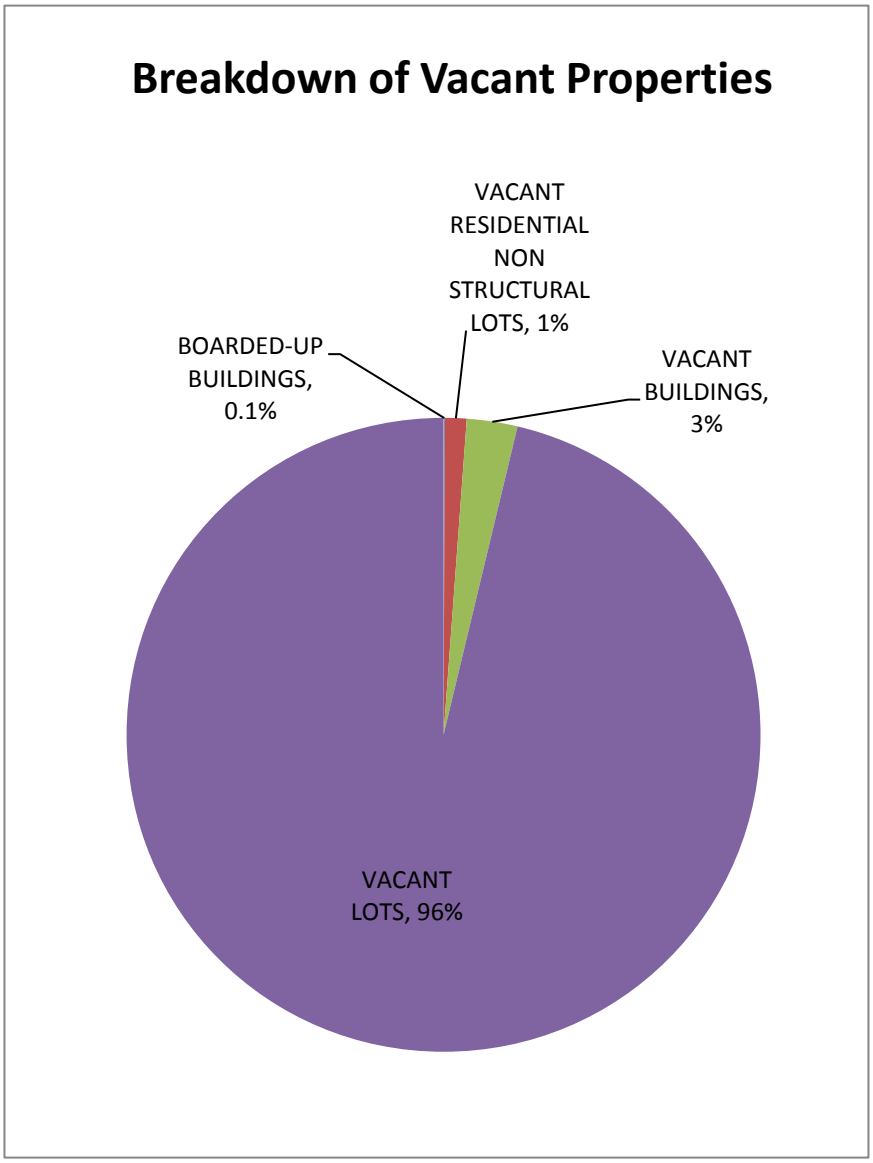

Figure 10. Breakdown of Vacant Properties.

C. Industrial

Industrial properties consist of solid waste management facilities, self-service warehouses and mini-storage facilities, warehouses and wholesale distributors, and lastly manufacturing facilities. The Amazon Distribution Center and a portion of the Volkswagen Manufacturing Plant lie within Friar Branch; however, the majority of Volkswagen is located in Poe Branch Watershed. Friar Branch Watershed is home to 23 other industrial facilities, two of which are "high-risk" – Lectrus Corporation and Benton Oil Services, Inc.

Table 5. Industrial Area.

Industrial		
Sub-Basin	Acres	Percent of Sub-Basin
EF 34	150.6	36%
EF 28	318.3	29%
EF 27	310.7	27%
EF 36	167.6	24%
EF 25	235.4	23%
EF 26	151.6	21%
EF 32	58.1	5%
EF 37	22.8	3%
EF 33	23.9	2%
EF 38	10.3	2%
EF 29	-	-
EF 30	-	-
EF 31	-	-
EF 35	-	-
Total	1449.4	

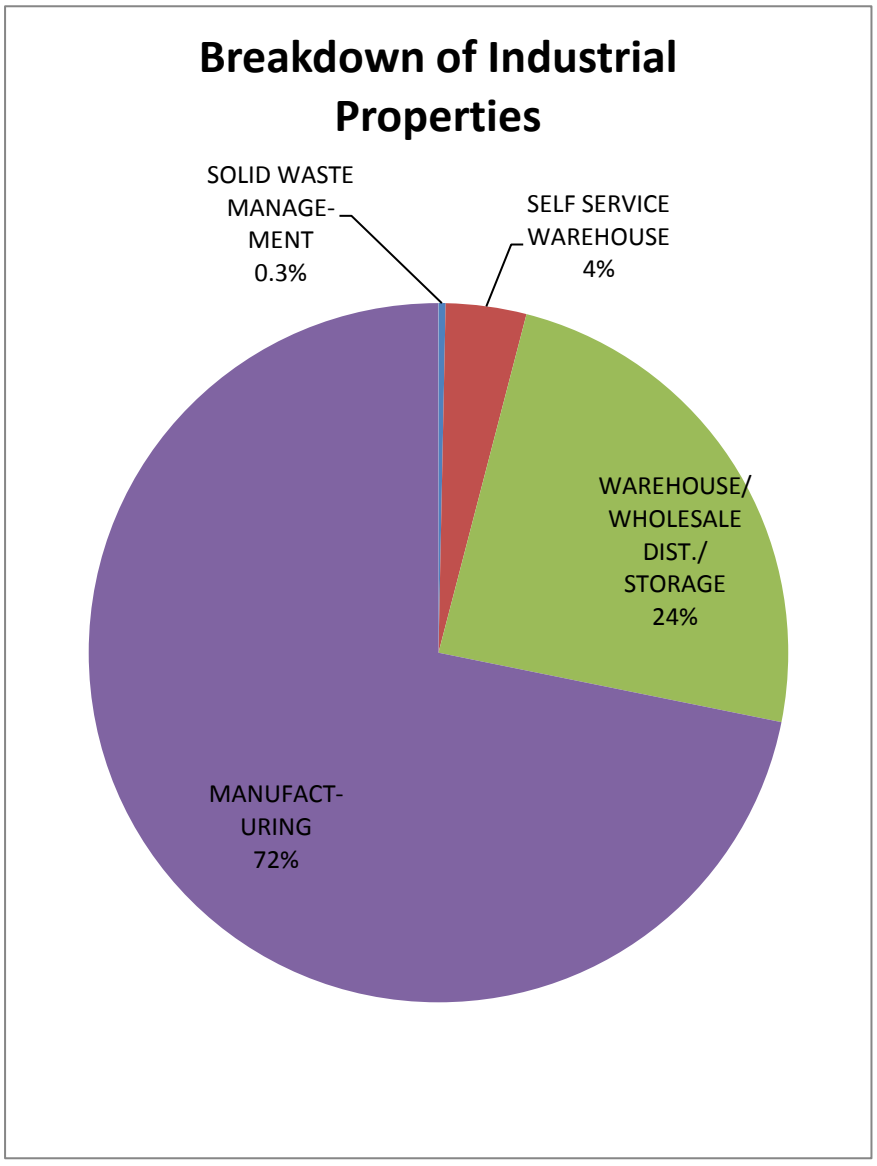

Figure 11. Breakdown of Industrial Properties.

D. Commercial

Friar Branch is a largely commercial area. This watershed is home to Hamilton Place Mall, the second largest mall in Tennessee. The mall's footprint is 210 acres.[10] The presence of Hamilton Place Mall has attracted many other retail businesses and restaurants to Gunbarrel and Shallowford Roads. With the presence of commercial properties also comes an increased amount of impervious area. Hamilton Place and the surrounding properties have the highest concentration of imperviousness in the entire watershed.

Table 6. Commercial Area.

Commercial		
Sub-Basin	Acres	Percent of Sub-Basin
EF 29	204.5	37%
EF 30	295.7	35%
EF 26	232.0	31%
EF 31	79.2	18%
EF 36	112.6	16%
EF 38	79.0	15%
EF 25	136.4	14%
EF 37	90.9	12%
EF 33	88.1	8%
EF 34	10.8	3%
EF 32	28.9	2%
EF 28	15.6	1%
EF 27	14.2	1%
EF 35	-	-
Total	1388.0	

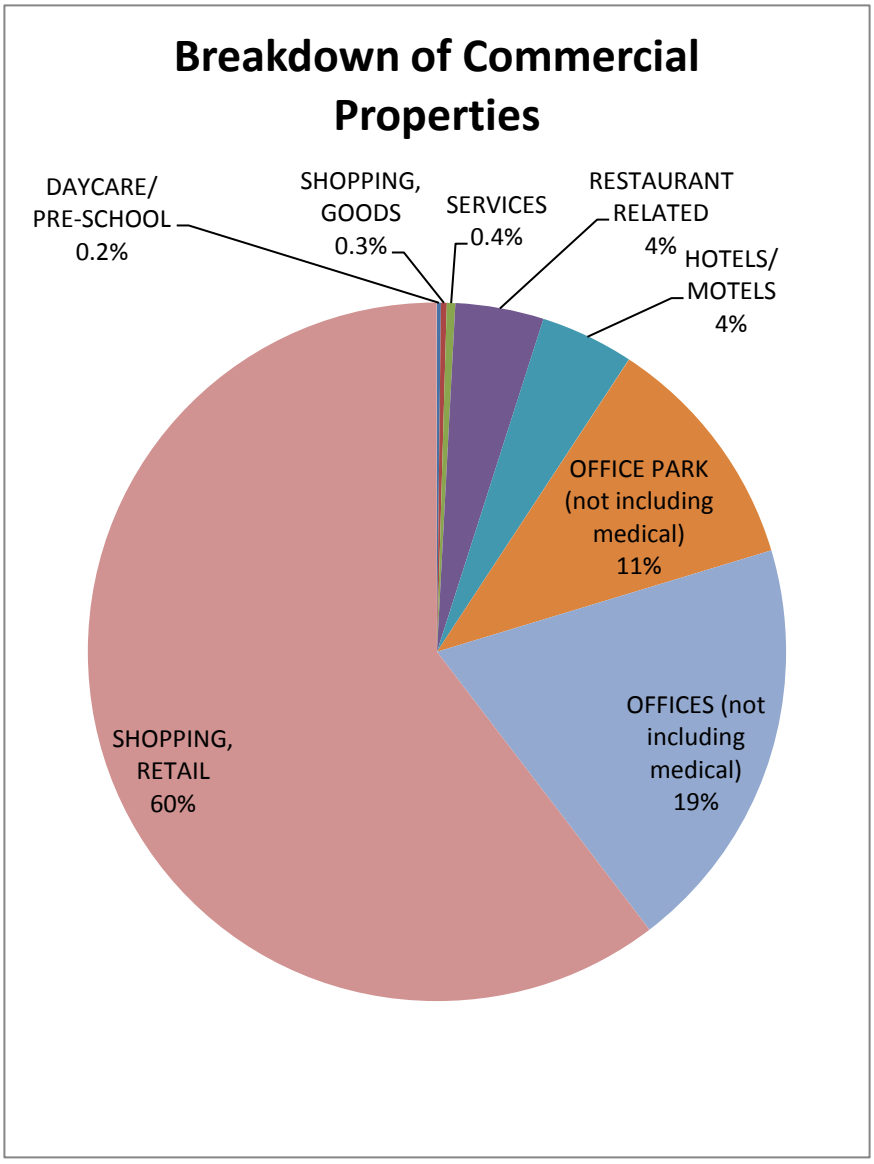

Figure 12. Breakdown of Commercial Properties.

E. Institutional

Institutional properties consist of emergency response, cultural institutions, health care related, cemeteries, schools and colleges, government facilities, and religious facilities. Approximately eight percent of land use in Friar Branch is Institutional properties. Sub-basin EF-33 has the most properties, totaling 158.4 acres.

Table 7. Institutional Area.

Institutional		
Sub-Basin	Acres	Percent of Sub-Basin
EF 33	158.4	15%
EF 25	108.0	11%
EF 27	125.1	11%
EF 28	112.3	10%
EF 30	86.1	10%
EF 35	38.3	9%
EF 31	36.8	8%
EF 38	31.4	6%
EF 36	42.3	6%
EF 26	28.5	4%
EF 32	37.7	3%
EF 37	21.7	3%
EF 29	15.8	3%
EF 34	10.2	2%
Total	853	

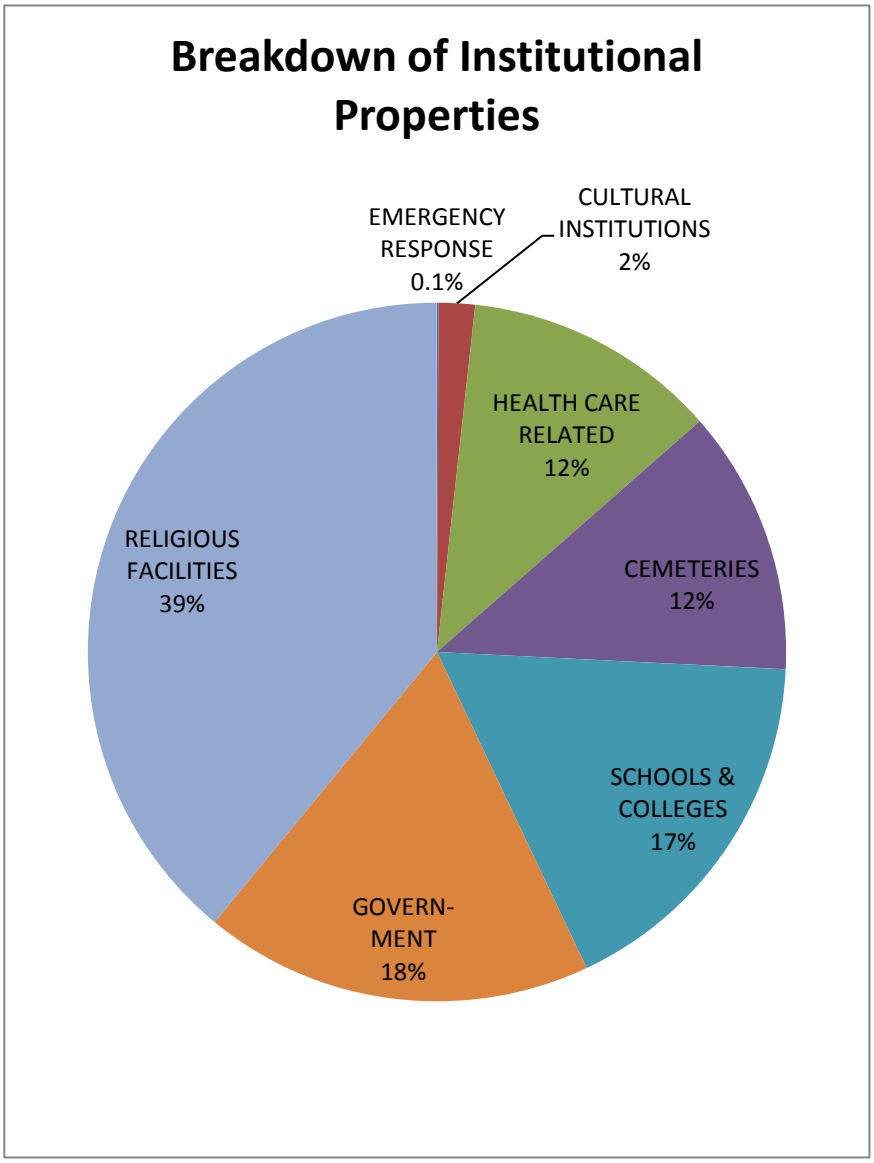

Figure 13. Breakdown of Institutional Properties.

F. Recreation

Recreational properties are broken down as public passive parks; public active parks, such as baseball fields and playgrounds; participant restricted recreation, such as YMCA, private golf courses, and private recreation facilities; and lastly preservations, open spaces, and sanctuaries. Many of the subdivisions have community lots and parks that contribute to the public passive and active parks.

Table 8. Recreational Area.

Recreation		
Sub-Basin	Acres	Percent of Sub-Basin
EF 27	221.0	19%
EF 31	44.7	10%
EF 28	105.3	10%
EF 35	33.7	8%
EF 32	73.0	6%
EF 38	25.8	5%
EF 33	37.3	4%
EF 37	15.5	2%
EF 29	9.3	2%
EF 36	11.1	2%
EF 30	12.1	1%
EF 25	9.4	1%
EF 34	0.9	0.2%
EF 26	-	-
Total	599.3	

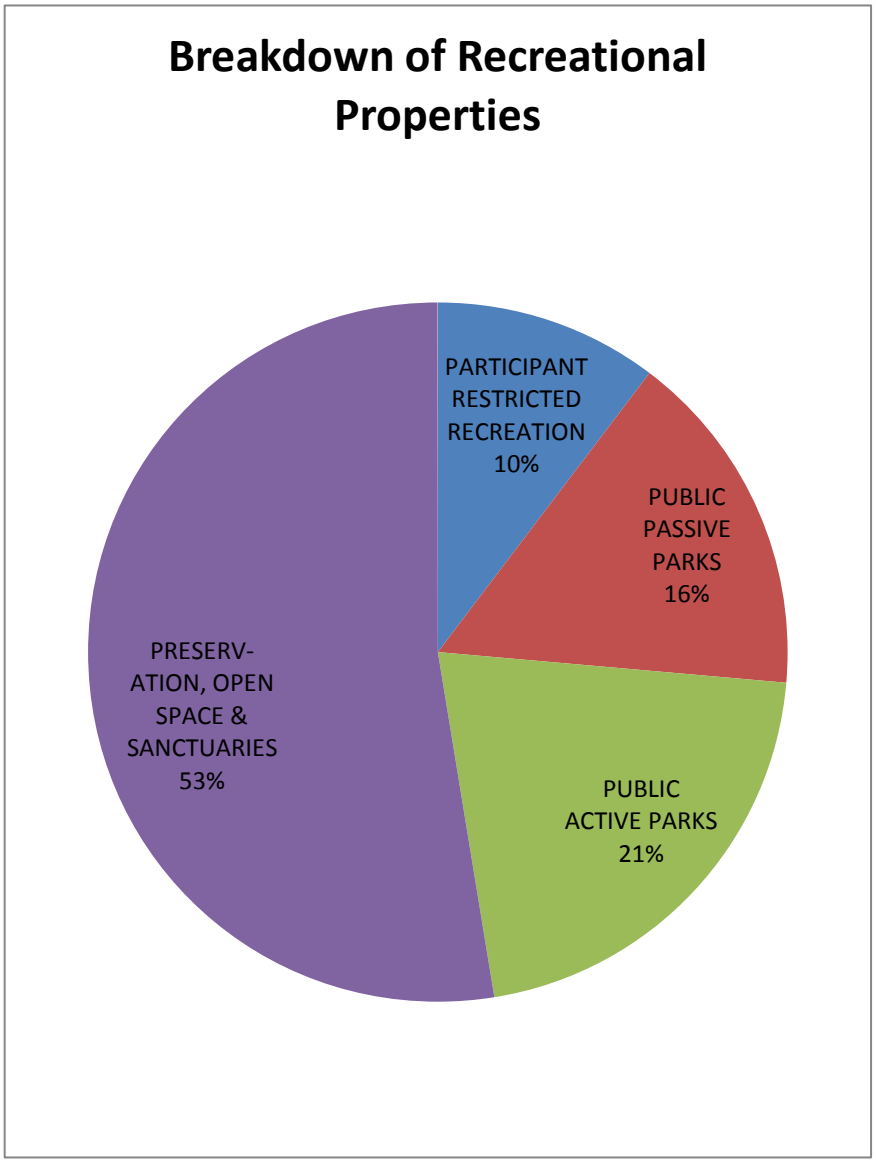

Figure 14. Breakdown of Recreational Properties.

V. Watershed Conditions

A. Water Quantity

In the City, should a drainage issue arise, residents may file a service request through Chattanooga's 311 call service. Over the past five years (August 11, 2008-August 7, 2013), 682 service requests were filed within the Friar Branch Watershed – approximately 13% of all drainage service requests received for the entire city during the same time period. Table 9 details the service requests by sub-basin and Figure 15 locates the service requests. Sub-basin EF 37 had a total of 151 service requests as well as the most reoccurring requests at the same area. Additionally, EF 37 had the most drainage issues per acre for the entire watershed.

Table 9. Drainage Service Requests.

Sub-Basin	Square Miles	Total Drainage Service Requests	Service Requests per Square Mile
EF 37	1.1	151	132.38
EF 35	0.7	69	101.04
EF 34	0.7	50	76.18
EF 38	0.8	59	73.83
EF 29	0.9	44	51.11
EF 31	0.7	29	41.69
EF 25	1.6	54	34.47
EF 30	1.3	42	31.95
EF 26	1.2	36	31.26
EF 36	1.1	26	23.90
EF 28	1.7	38	22.25
EF 33	1.6	30	18.39
EF 32	1.9	17	9.04
EF 27	1.8	11	6.04

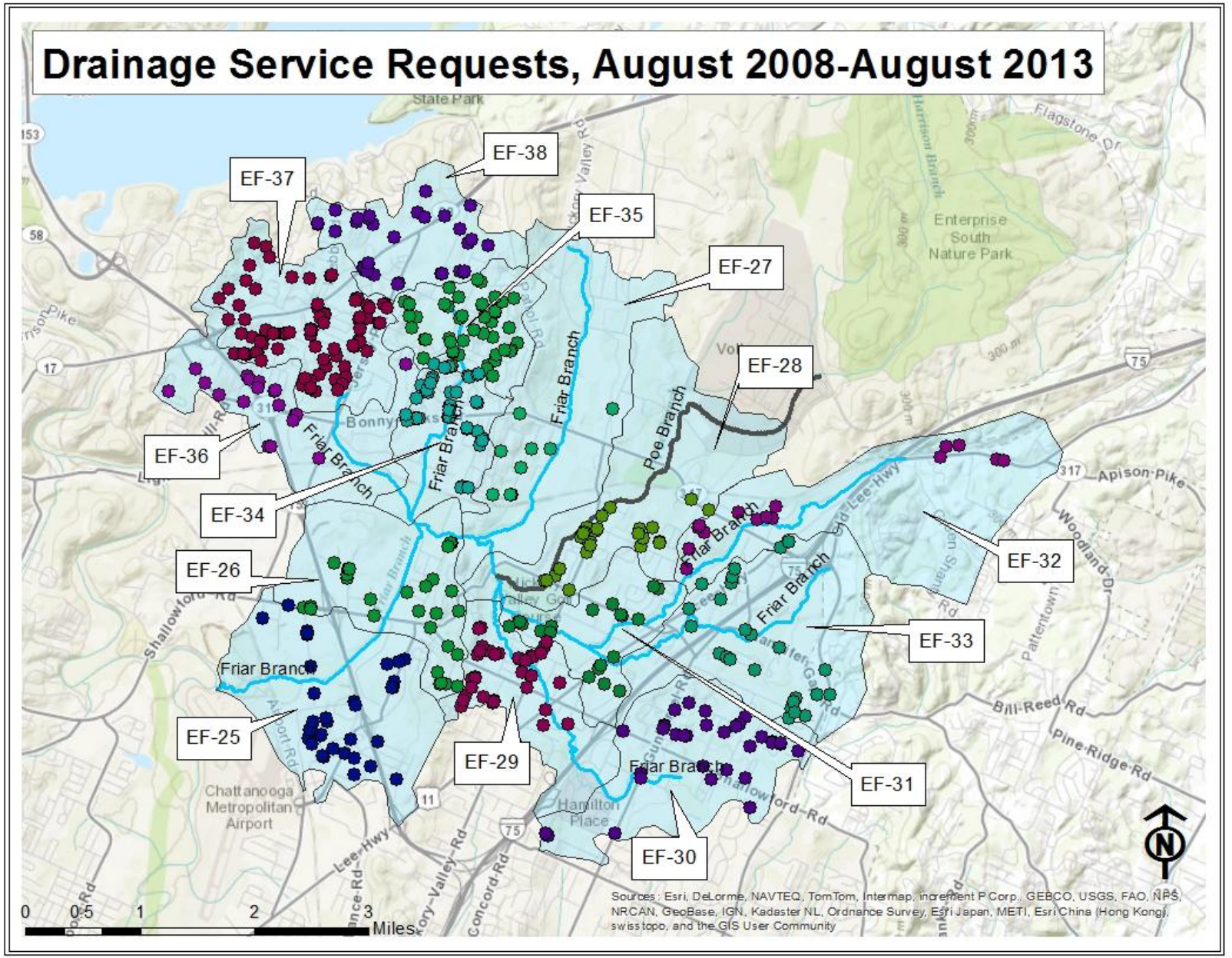

Figure 15. Drainage Service Requests, August 2008-August 2013.

B. Water Quality

A stream's water quality is representative of its surrounding land use. Highly commercial areas typically have large amounts of impervious surface, causing large volumes of stormwater to quickly run off parking lots, streets, sidewalks, and roofs. Runoff from these areas carries oils, grease, heavy metals, and trash. Industrial facilities discharge stormwater runoff or industrial wastewater to streams as permitted by their NPDES permit. These discharges may carry chemicals or toxic substances as a result of the particular industrial processes.

Many times, sewer lines develop cracks or root penetration, causing inflow and infiltration (I & I). During heavy rain events, stormwater will flow into the sewer lines, causing them to reach capacity. Upon reaching capacity, overflows occur causing elevated levels of *E. coli*.

It is important to monitor the volume and quality of stormwater runoff and how it affects the receiving waters. As water quality decreases, it will eventually reach a point where it no longer meets one or more of its designated uses. In this occurrence, EPA will assign a total maximum daily load (TMDL) for the stream and the City will develop strategies to return the impaired water to its previous unimpaired state.

1. Designated Uses

A stream's designated use is defined by EPA as, "uses specified in Water Quality Standards for each waterbody or segment whether or not they are being attained." Uses include public water supplies, protection and propagation of fish, shellfish and wildlife, recreation, agriculture, industry, navigation, coral reef preservation, marinas, groundwater recharge, aquifer protection, and hydroelectric power.[11] Friar Branch's designated uses are fish and aquatic life, recreation, livestock watering, and irrigation. Designated uses affected by impaired waters in Friar Branch are fish and aquatic life and recreation.[12] Table 10 details the designated uses for all Chattanooga Streams and Table 11, on the following page, shows Friar Branch's cause of impairment and the impacted designated use.

Table 10. Streams in Chattanooga and their Designated Uses.

Stream	Description	Use Classifications
Lookout Creek	Mile 0.0 to GA/TN state line	*Fish and aquatic life, Industrial Water Supply, Recreation, Livestock Watering, Irrigation*
Black Creek	Mile 0.0 to origin	*Fish and aquatic life, Recreation, Livestock Watering, Irrigation*
Chattanooga Creek	Mile 0.0 to GA/TN state line	*Fish and aquatic life, Industrial Water Supply, Recreation, Livestock Watering, Irrigation*
Citico Creek	Mile 0.0 to origin	*Fish and aquatic life, Recreation, Livestock Watering, Irrigation*
S. Chickamauga Creek	Mile 0.0 to GA/TN state line	*Fish and aquatic life, Industrial Water Supply, Recreation, Livestock Watering, Irrigation*
Friar Branch	**Mile 0.0 to origin**	***Fish and aquatic life, Recreation, Livestock Watering, Irrigation***
Mackey Branch	Mile 0.0 to origin	*Fish and aquatic life, Recreation, Livestock Watering, Irrigation*
North Chickamauga Creek	Mile 0.0 to 13.2	*Fish and aquatic life, Recreation, Livestock Watering, Irrigation*
Wolftever Creek	Mile 0.0 to origin	*Fish and aquatic life, Recreation, Livestock Watering, Irrigation*

Table 11. Impairment Status of Friar Branch.

Waterbody ID	Impacted Waterbody	Miles	Cause	Impacted Use	TMDL Priority*	TMDL Status	Pollutant Source
TN06020001007-0100	Friar Branch	18.94	Loss of biological integrity due to siltation	Fish and Aquatic Life	NA	Completed	Site Clearance
			--	--	--	--	Discharges from MS4
			--	--	--	--	--
			Nutrients	Fish and Aquatic Life	L	Needed	Discharges from MS4
			Physical substrate habitat loss	Fish and Aquatic Life	NA	Completed	Discharges from MS4
			--	--	--	--	
			E. coli	Recreation	NA	Completed	Discharges from MS4
							SSOs (collection system failure)

Source: Year 2010, 303(d) List available online at: http://www.tn.gov/environment/water/docs/wpc/2010_303d_final.pdf

***TMDL Priorities**

Medium (M): Tools are available to produce the TMDL, but the stream is not in a watershed being studied in the next two years. TMDL will be produced in the next five years

Low (L): Tools are not currently available to produce the TMDL and the stream is not in the watershed being studied in the next two years. TMDL will be produced in the next twelve years

Not Applicable (NA):

4a-A TMDL has already been completed, submitted to EPA, and approved by EPA

4b-A TMDL is not needed because a different type of control strategy is in place which will bring about compliance with the criterion in a reasonable amount of time

4c-The impact to the stream is not being caused by a pollutant

2. Water Quality Sampling

The City performs sampling and monitoring for temperature, pH, dissolved oxygen (DO), conductivity, total suspended solids (TSS), and *E. coli* as part of the watershed characterization sampling required for Friar Branch. Results from these parameters are representative of a stream's water quality. Watershed characterization sampling began July 2012 in accordance with the NPDES Permit and monthly sampling continues at ten locations within the Friar Branch watershed. Additionally, the Water Quality Program collected five samples within a 30-day period from October 16-November 7, 2013 in order to determine a geometric mean for Friar Branch. Figure 16 shows the ten locations for watershed characterization sampling and Figures 17-22 present the results of the watershed characterization sampling. Sample Location 1 is dry for parts of the year; therefore, sampling data is unavailable during those months. The City performs additional monitoring programs as part of (and in addition to) the NPDES permit requirements. Further discussion of these monitoring programs is in the "Monitoring Program" section of this report.

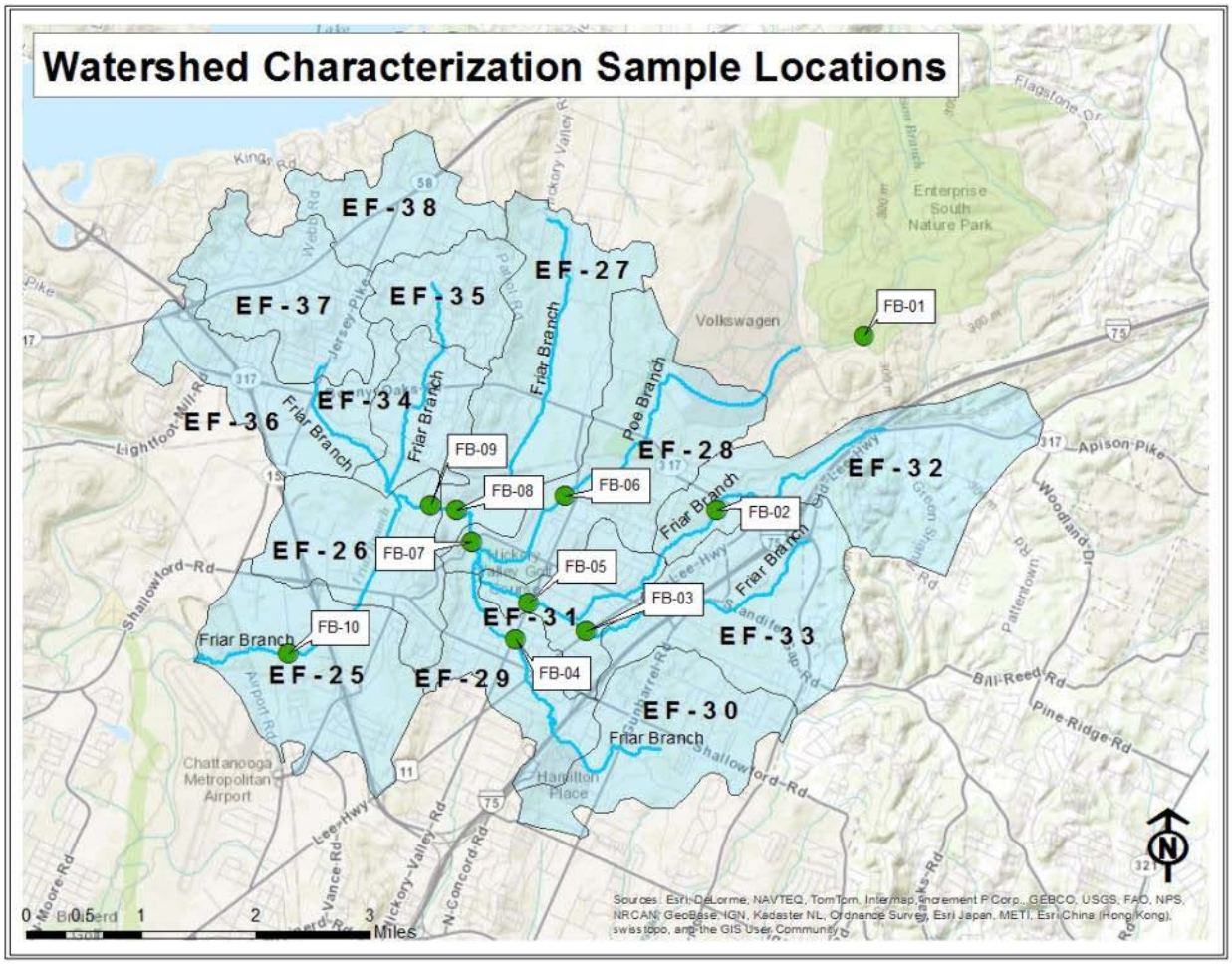

Figure 16. Watershed Characterization Sampling Locations.

a) *Temperature*

According to TDEC, the maximum allowable temperature for all designated uses is 30.5°C.[13] Aquatic life is dependent on certain temperature ranges for optimal health, especially during growth and reproductive stages. Temperature affects oxygen content, the rate of photosynthesis by aquatic plants, the metabolic rate by aquatic organisms, and the sensitivity of organisms to toxic wastes, parasites and diseases.[14] Temperature sampled at Location 4 on July 18, 2012 was above the maximum allowable limit, with a temperature of 33.5°C. All other samples were within the acceptable range. The red dotted line on Figure 17 below represents the maximum allowable temperature of 30.5°C and labels outlying values.

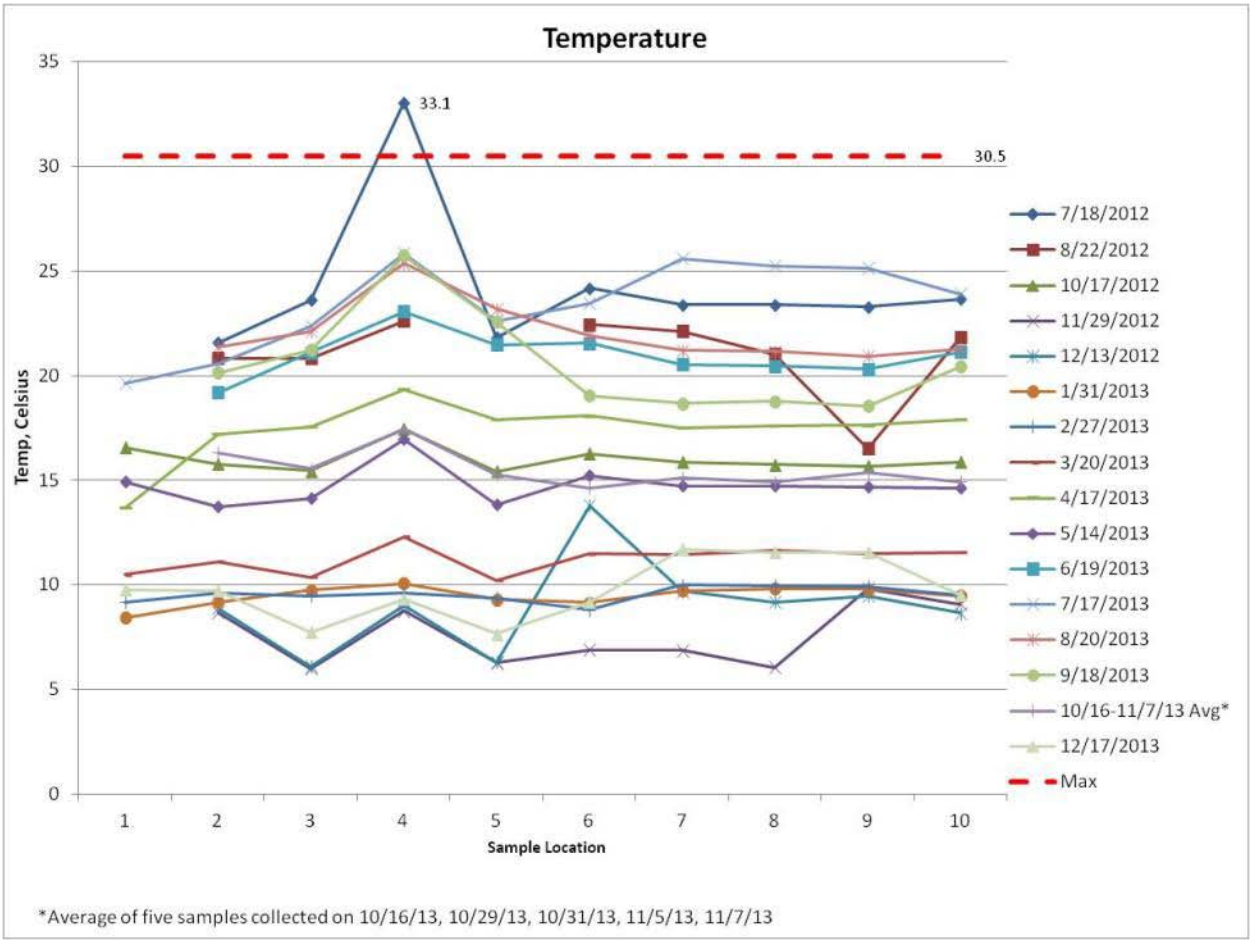

Figure 17. Temperature.

b) *pH*

The acceptable pH range for wadeable streams is 6.0-9.0 for all designated uses.[15] pH levels can affect both chemical and biological processes. If pH levels are outside the acceptable limits, stream diversity is reduced, as it adds stress to the physiological systems of organisms and reduces reproduction. Additionally, at low pH levels, toxic elements and compounds become more mobile and more readily consumed by aquatic plants and animals. Acid rain, surrounding geological formations and wastewater discharges can all cause changes in pH.[16] Three samples collected at location 1 had a pH below the acceptable limit. Figure 18 depicts the results of the watershed characterization sampling for pH and labels the values lying outside of the allowable limits.

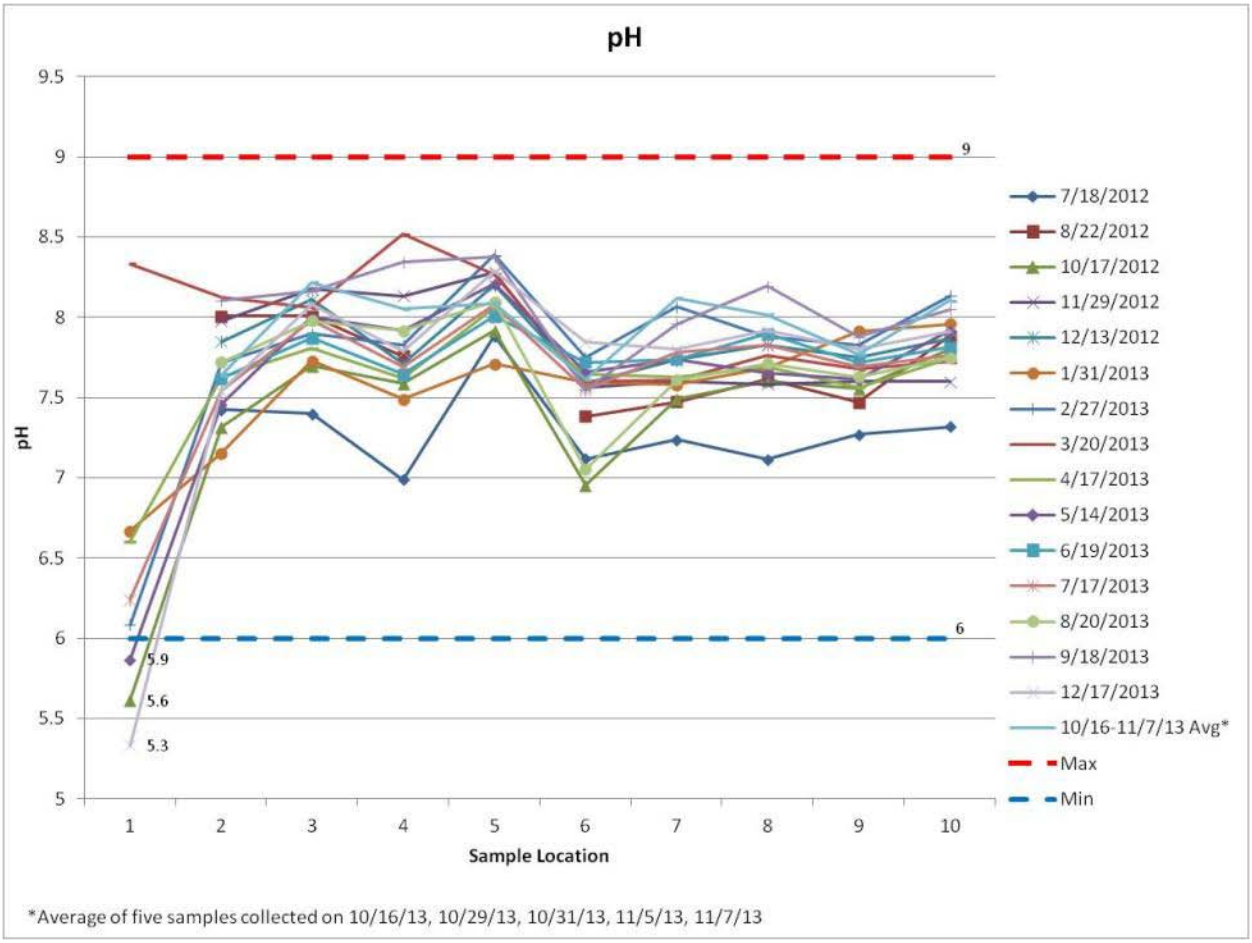

Figure 18. pH.

c) *Conductivity*

There is no defined quantitative criterion for conductivity; however, EPA states that conductivity of rivers in the United States typically ranges from 50 to 1500 µS/cm.[17] Conductivity is the ability of water to pass an electrical current. Inorganic dissolved solids can increase conductivity; whereas, organic compounds inhibit an electrical current, meaning a lower conductivity. As temperature increases, so does conductivity. A high conductivity could indicate a potentially failing sewer system and a low conductivity could indicate a potential oil spill.[18] All data collected for conductivity at Sample Location 1 resulted in very low conductivity. This could mean there is a consistently high level of inorganic material present. Furthermore, on July 18, 2012, Sample Location 8 had a conductivity of 1,726 µS/cm, much higher than other values sampled. Figure 19 details the remaining data for conductivity at the ten locations from July 2012- November 2013.

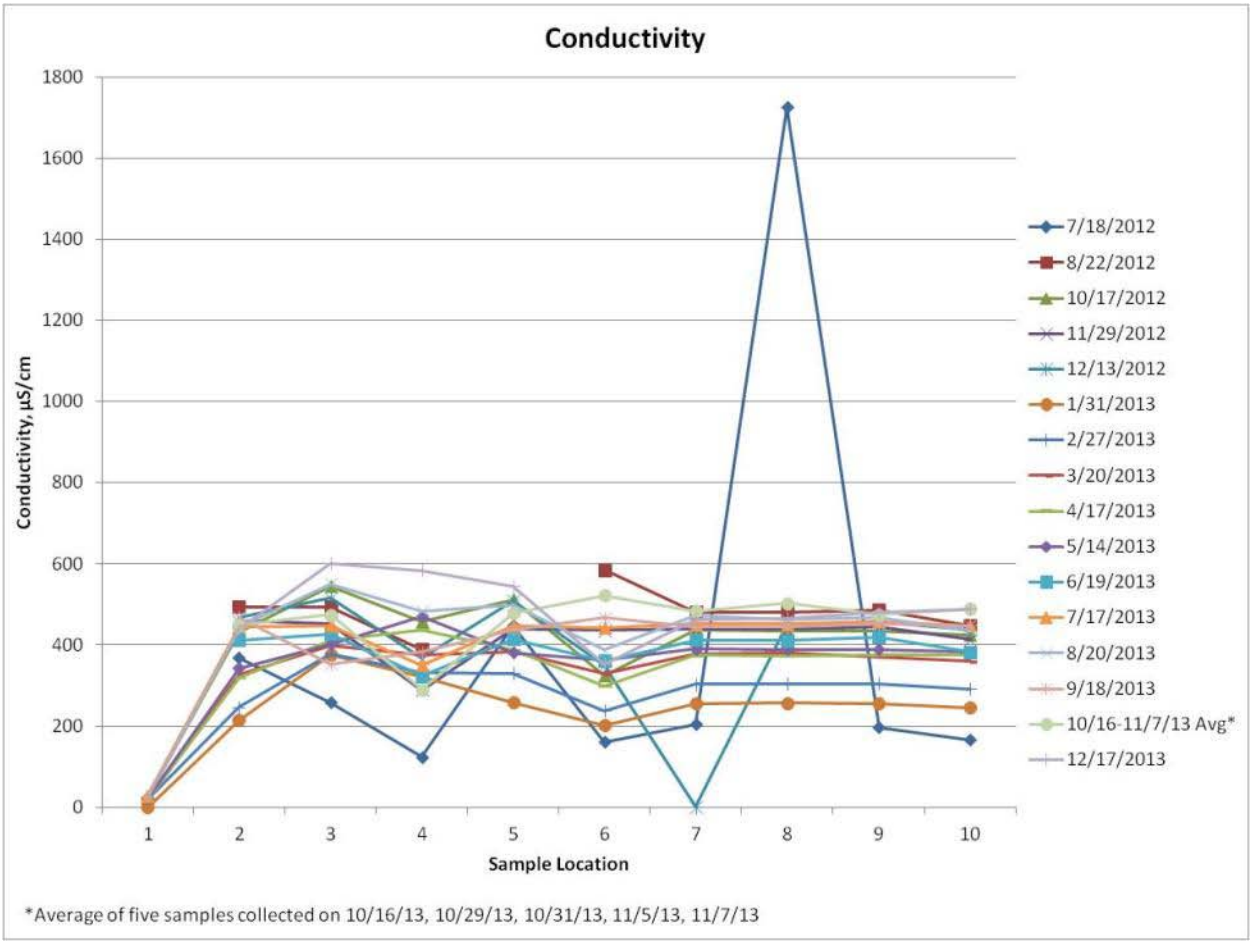

Figure 19. Conductivity.

d) *Dissolved Oxygen*

For the designated use of fish and aquatic life, TDEC states that dissolved oxygen must be greater than 5.0 mg/l. All other uses should have enough dissolved oxygen present to prevent odors of decomposition and other offensive conditions.[19] Microorganisms consume oxygen, breaking down organic material often found in wastewater from sewage treatment plants. When microorganisms consume more oxygen than produced, low dissolved oxygen results. Low dissolved oxygen levels affect certain animals, causing them to move away, weaken, or die when the amount of oxygen in a stream becomes too low. Warmer water temperatures have lower levels of dissolved oxygen than cooler waters.[20] All sample locations had dissolved oxygen levels greater than 5.0 mg/l as seen in Figure 20 below.

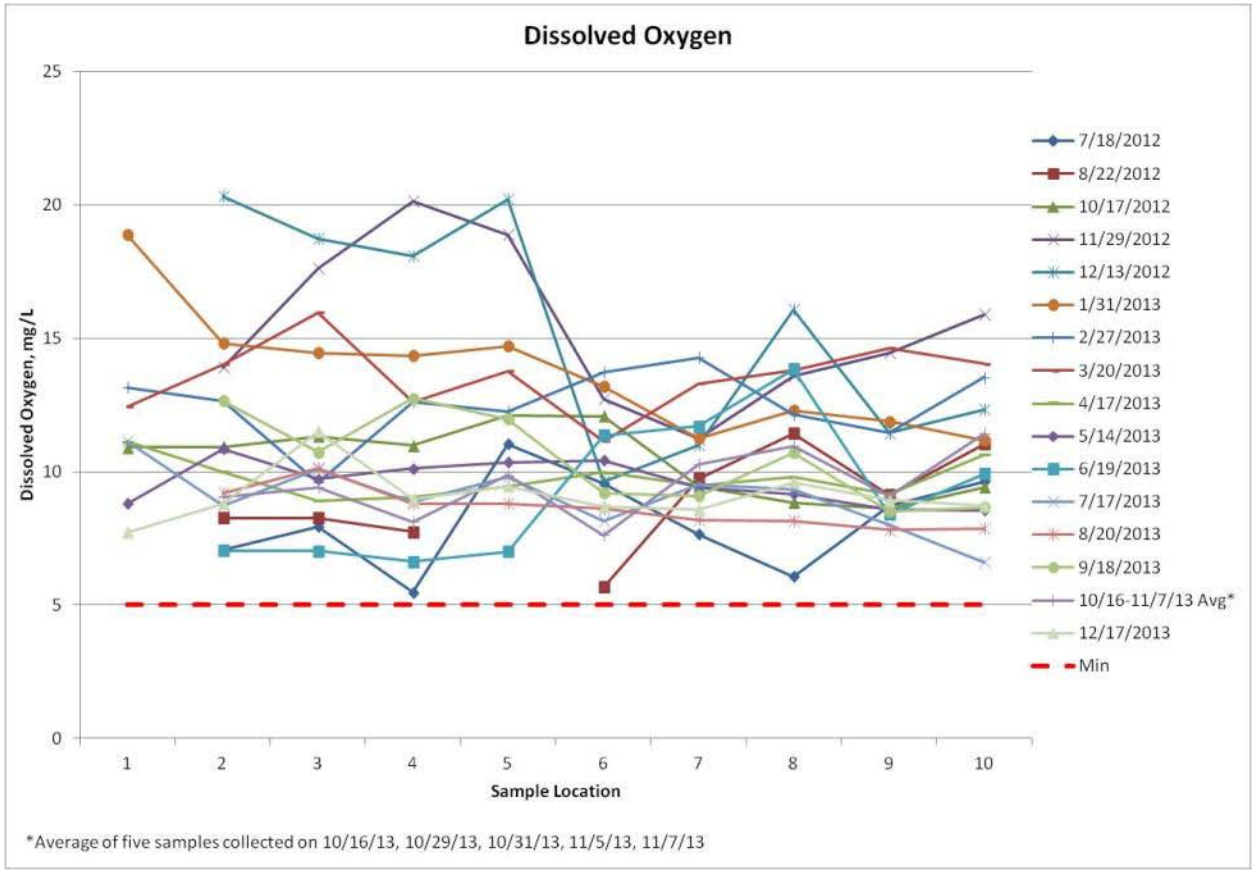

Figure 20. Dissolved Oxygen.

e) *Escherichia coli*

EPA recommends *E. coli* as the indicator of health risk resulting from water contact in waters intended for recreational use. *E. coli* levels for fish and aquatic life shall not exceed 2,880 units/100ml for any individual sample. Friar Branch is an Exceptional Tennessee Water; therefore, the maximum criterion for *E. coli* is more stringent for the designated use of recreation. *E. coli* levels for recreation in Friar Branch shall not exceed 487 units/100ml, where it is normally 941 units/100ml for any other non-exceptional waterbody.[21] The presence of *E. coli* indicates a possible leak or discharge from a sewer system or septic system. Additional sources of contamination include runoff carrying animal manure and stormwater runoff.[22] Sample Locations 3, 5, and 7 had consistently high levels of *E. coli* for all dates sampled. Three samples were above the limit for fish and aquatic life; however, several more samples were above the allowable limit for recreation. Figure 21 shows all values collected for *E. coli* beginning July 2012. The dotted red lines indicate the allowable limits for recreation and aquatic life.

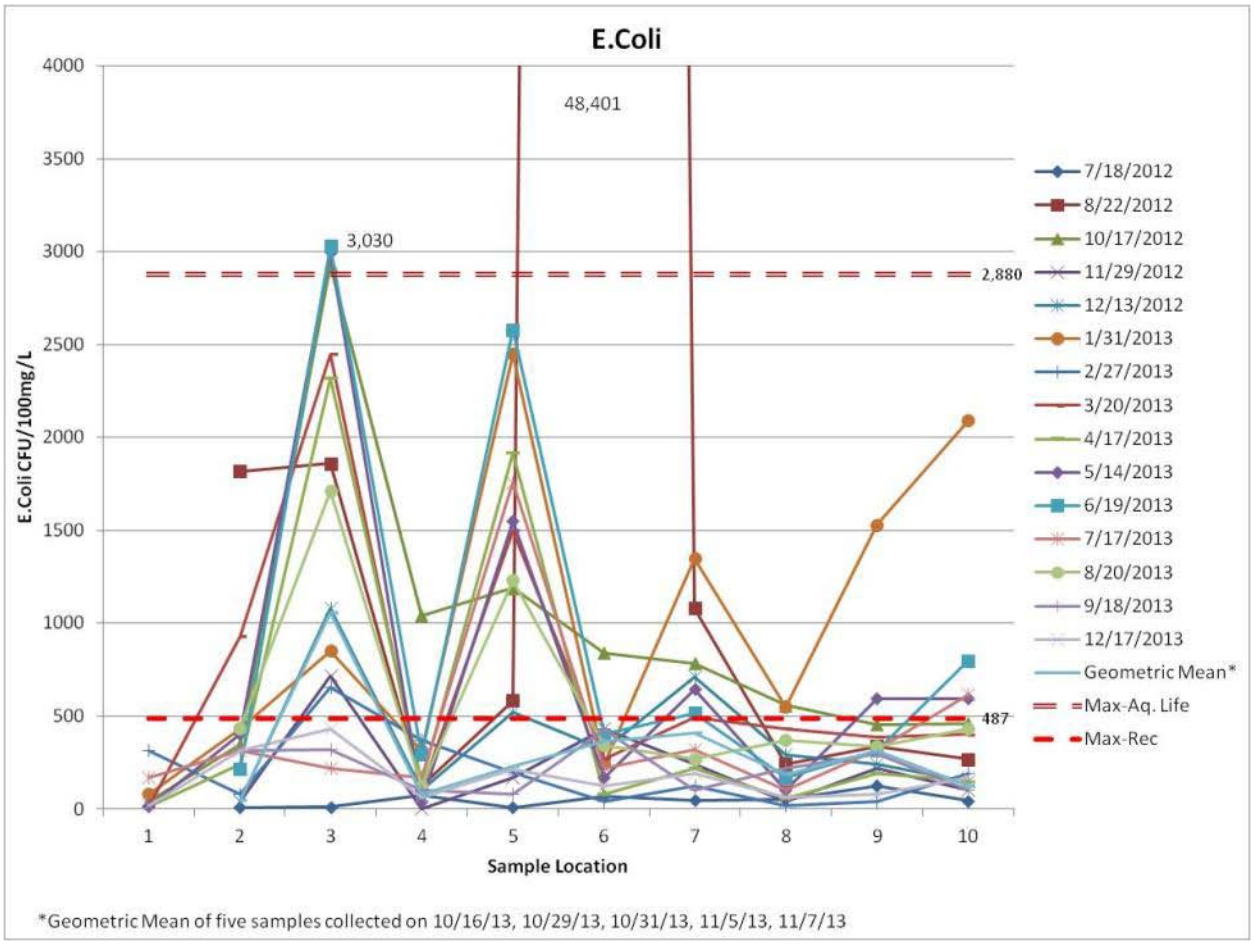

Figure 21. *E. coli*.

f) *Total Suspended Solids*

Suspended solids are particles that will not pass through a 2-micron filter, including silt and clay particles, plankton, algae, fine organic debris, and other particulate matter. Toxic materials can cling to suspended solids, making them become carriers for the toxic particles. In streams with a high amount of suspended solids, pesticide concentrations can increase to amounts greater than the original application. There is no quantitative maximum for total suspended solids; however, it serves as an indicator of the effects of stormwater runoff from the surrounding properties. Higher levels of solids typically result after rain events, especially in highly developed areas. [23] During the week of July 11-July 17, 2012, 4.17 inches of rain fell, (above the historical average of 1.04 inches for the week). The high levels of rain could be the cause of the high TSS levels collected July 18, 2012. Figure 22 shows the results of sampling for TSS.

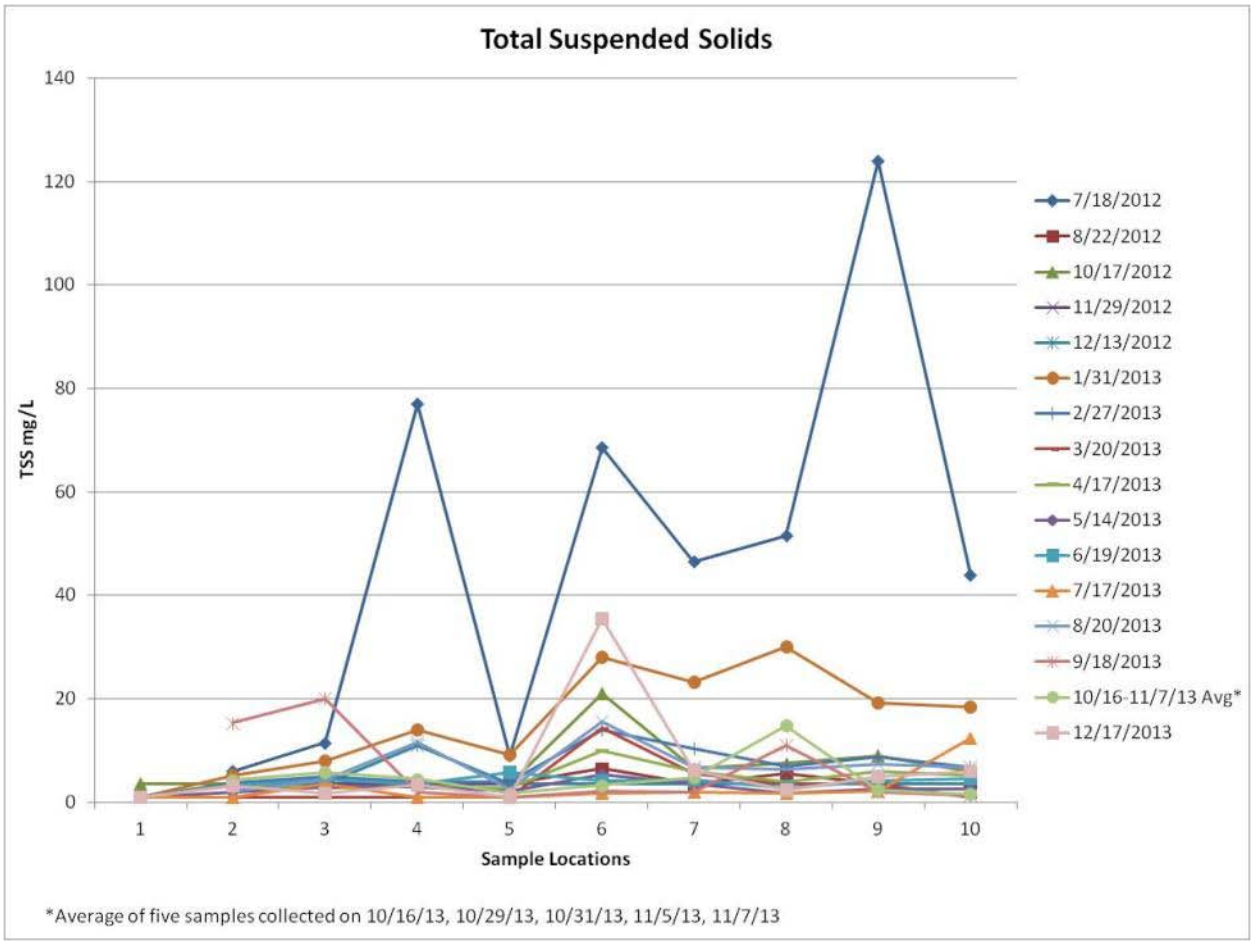

Figure 22. Total Suspended Solids.

C. Illicit Discharge Potential (IDP)

Illicit discharge potential (IDP) quantifies the likelihood an illicit discharge will occur and used to identify priority sub-basins. The criteria for determining the IDP score includes discharge complaints, age of sanitary sewer infrastructure, impervious cover, outfalls per mile of stream, NPDES permitted industrial dischargers, amount of clay pipe present, stream corridor assessment, drainage complaints, SSOs, area of industrial property, area of commercial property, and presence of hot areas, all shown on Table 12. Table 13 indicates individual scores, 1-3, for each sub-basin, and total raw score for all categories. Figure 23 on page 37 depicts the IDP scores for each sub-basin.

Table 12. Categories for Determining IDP Score.

Criteria for Determining Score	1	2	3
Discharge Complaints*	< 5	≥ 5 but < 10	≥ 10
Age of Infrastructure	< 25 years	25-50 years	> 50 years
Percent Impervious	< 25%	≥ 25% but < 60%	≥ 60%
Outfalls Density	< 10	≥ 10 but < 20	≥ 20
Industrial Permitees*	< 2	≥ 2 but < 5	≥5
Clay Pipe	< 2,500 ft	≥ 2,500 ft but < 5,000 ft	≥ 5,000 ft
SCORE (≥ 17)	< 1,000 ft	≥ 1,000 ft but < 2,500 ft	≥ 2500 ft
Drainage Service Requests*	< 25	≥ 25 but < 75	≥ 75
SSOs*	< 5	≥ 5 but < 10	≥ 10
Area Industrial	< 10%	≥ 10% but < 20%	≥ 20%
Area Commercial	< 10%	≥ 10% but < 20%	≥ 20%
Hot Area Present		yes	
***per square mile**			

Table 13. IDP Score for Sub-Basins.

Sub-Basin	Discharge Complaints	Age of Infrastructure	Percent Impervious	Outfall Density	Industrial Permitees	Clay Pipe	SCORE (≥17)	Drainage Service Requests	SSOs	Area Industrial	Area Commercial	Hot Area	Total
	qty/mi^2	year	%	#/mile	qty/mi^2	ft	ft	qty/mi^2	qty/mi^2	%	%	yes/no	
EF 29	3	2	2	3	-	1	3	2	2	3	3	2	26
EF 30	3	2	2	3	-	-	3	2	1	3	2	2	23
EF 36	2	2	2	3	3	-	2	1	1	3	2	2	23
EF 34	1	2	2	2	2	-	1	3	1	3	3	2	22
EF 31	1	2	2	2	-	1	2	2	3	3	3	-	21
EF 25	1	2	2	2	2	3	-	2	1	3	2	-	20
EF 26	2	2	2	2	-	2	1	2	1	3	2	-	19
EF 33	1	2	2	3	1	-	3	1	1	3	2	-	19
EF 35	1	2	1	3	-	-	2	3	1	3	3	-	19
EF 27	1	2	1	1	1	2	2	1	1	3	2	-	17
EF 37	1	2	2	3	-	-	-	3	1	3	2	-	17
EF 38	2	2	2	-	-	-	-	2	2	3	3	-	16
EF 32	1	2	1	2	-	-	3	1	1	2	2	-	15
EF 28	1	2	1	2	-	-	-	1	1	3	2	-	13

"-" indicates IDP score is not applicable for the particular location and category

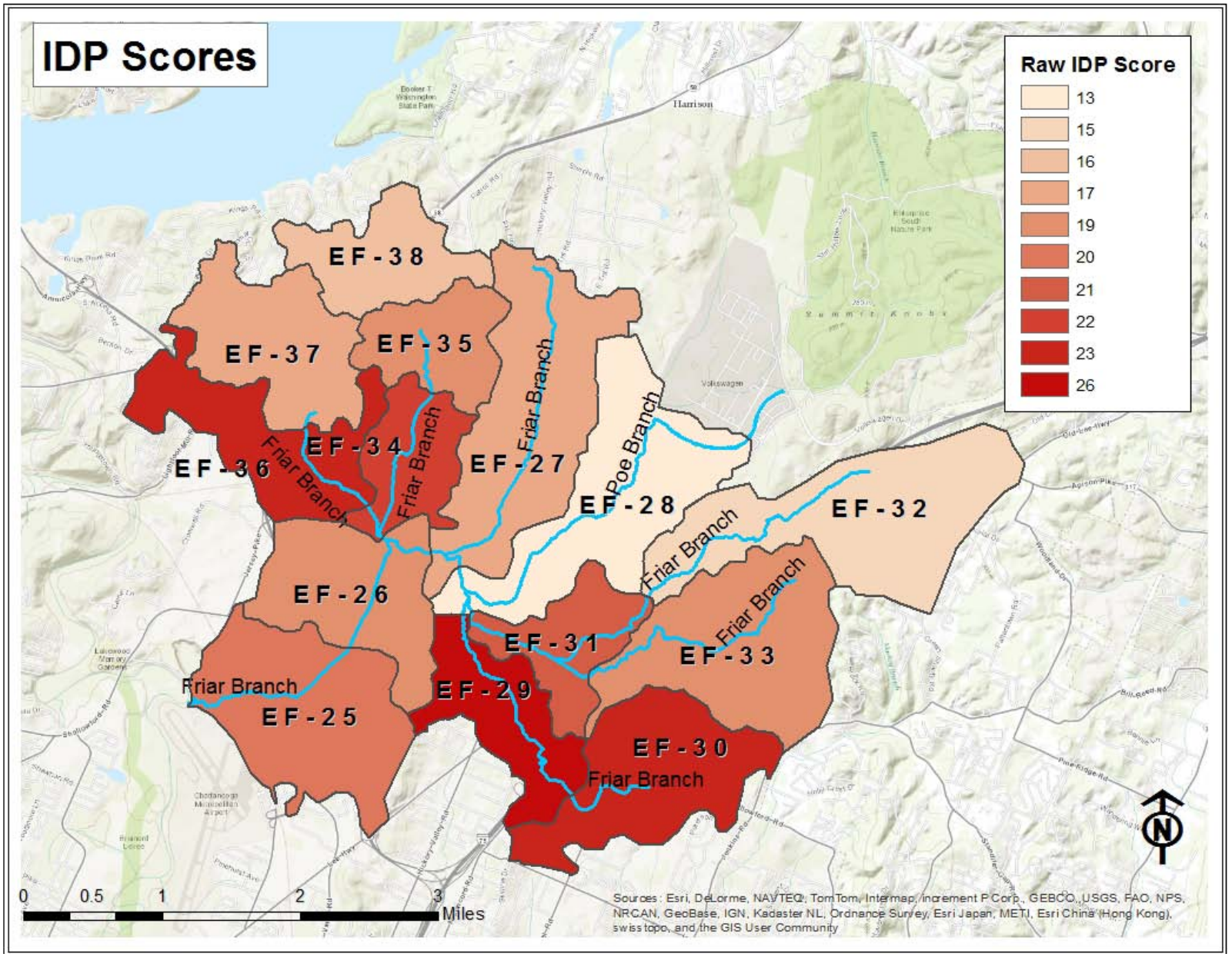

Figure 23. IDP score.

1. Discharge Complaints

For this report, past discharge complaints include illicit discharges and emergency spill responses for a five-year period (July 2008-July 2013). IDP scores are given based on the number of illicit discharges per square mile. Table 14 shows the total number of complaints per square mile for each sub-basin and the corresponding IDP score.

Table 14. Discharge Complaints.

Sub-Basin	Square Miles	Discharge Complaints	Complaints per Square Mile	IDP Score
EF 29	0.9	10	11.62	3
EF 30	1.3	14	10.65	3
EF 36	1.1	6	5.51	2
EF 26	1.2	6	5.21	2
EF 38	0.8	4	5.01	2
EF 31	0.7	3	4.31	1
EF 33	1.6	6	3.68	1
EF 34	0.7	2	3.05	1
EF 25	1.6	4	2.55	1
EF 32	1.9	4	2.13	1
EF 37	1.1	2	1.75	1
EF 35	0.7	1	1.46	1
EF 28	1.7	2	1.17	1
EF 27	1.8	1	0.55	1

2. Age of Infrastructure

The sanitary sewer system in Friar Branch is relatively new, with the oldest line dating 1969 and the majority of the lines built in the mid-70s. In the 1950's to 1970's, the most commonly used materials for sewer lines were cast iron, asbestos cement and clay pipes. PVC pipes became popular in the 1980's and remain the most commonly used pipe today. Cast iron pipes are extremely durable but rust and corrosion eventually cause holes to form. Asbestos cement is also a durable material; however, the use of asbestos in building materials is now banned. Clay pipes have a tendency to leak at the joints. As sewage leaks, tree roots attract to the area and over time, penetrate the clay sewer line.[24] Any crack or hole in a sewer line causes inflow and infiltration (I & I). As I & I occurs, rainwater and groundwater enters the sewer line and raw sewage seeps into the ground, adding to *E. coli* contamination. During periods of heavy rain, the volume of water leaking into the sewer lines can cause the lines to reach capacity, resulting in SSOs. As sewer lines age, these problems only worsen. Replacement of damaged lines will reduce the amount of raw sewage leaking into the ground and nearby streams through I & I. Table 15 shows the age of infrastructure for each sub-basin.

Table 15. Age of Infrastructure.

Sub-Basin	Age of Infrastructure	IDP Score
EF 25	1969	2
EF 26	1977	2
EF 27	1977	2
EF 28	1975	2
EF 29	1977	2
EF 30	1977	2
EF 31	1977	2
EF 32	1979	2
EF 33	1979	2
EF 34	1981	2
EF 35	1975	2
EF 36	1975	2
EF 37	1977	2
EF 38	1977	2

3. Clay Pipe

There are five sub-basins in Friar Branch with clay pipes present, totaling just over 12,000 linear feet. Because clay pipes leak from their joints and often have problems with root penetration, they are a common source of raw sewage discharge. Table 16 shows the sub-basins that contain clay sewer lines and how many linear feet are present in each.

Table 16. Clay Pipe.

Sub-Basin	Clay Pipe, ft	IDP Score
EF 25	5,798	3
EF 26	2,693	2
EF 27	2,517	2
EF 29	625	1
EF 31	450	1

4. Impervious Cover

The amount of impervious cover contributes to the volume of runoff produced for a given area. Any surface that does not allow infiltration is considered impervious - buildings, parking lots, sidewalks, and roadways to name a few. As imperviousness increases, infiltration decreases. Large volumes of runoff can result in stream bank erosion and increased flood potential. Additionally, as stormwater travels across an impervious surface, it picks up pollutants such as oil, grease, heavy metals, trash, and debris.[25]

The Impervious Cover Model (ICM) relates the percentage of impervious cover to the water quality of a stream. Depending on the percent of imperviousness, streams are classified as sensitive, impacted, non-supporting, or urban drainage. The model can aid in making predictions regarding the future quality of a stream based on its current imperviousness. There has been controversy regarding the accuracy of the ICM; however, a study in 2008 showed that 72% of the streams analyzed either confirmed or reinforced the ICM.[26] Table 17 shows the percent imperviousness and the ICM in Figure 24 on the following page shows all streams in Friar Branch as either "impacted" or "non-supporting" with impervious cover ranging from 11-56%.

Table 17. Percent Impervious Cover.

Sub-Basin	Percent Impervious	IDP Score
EF-29	46%	3
EF-36	41%	3
EF-25	40%	3
EF-26	40%	3
EF-30	39%	3
EF-37	31%	3
EF-33	31%	3
EF-31	29%	3
EF-34	28%	3
EF-38	27%	3
EF-32	14%	2
EF-28	14%	2
EF-35	14%	2
EF-27	12%	2

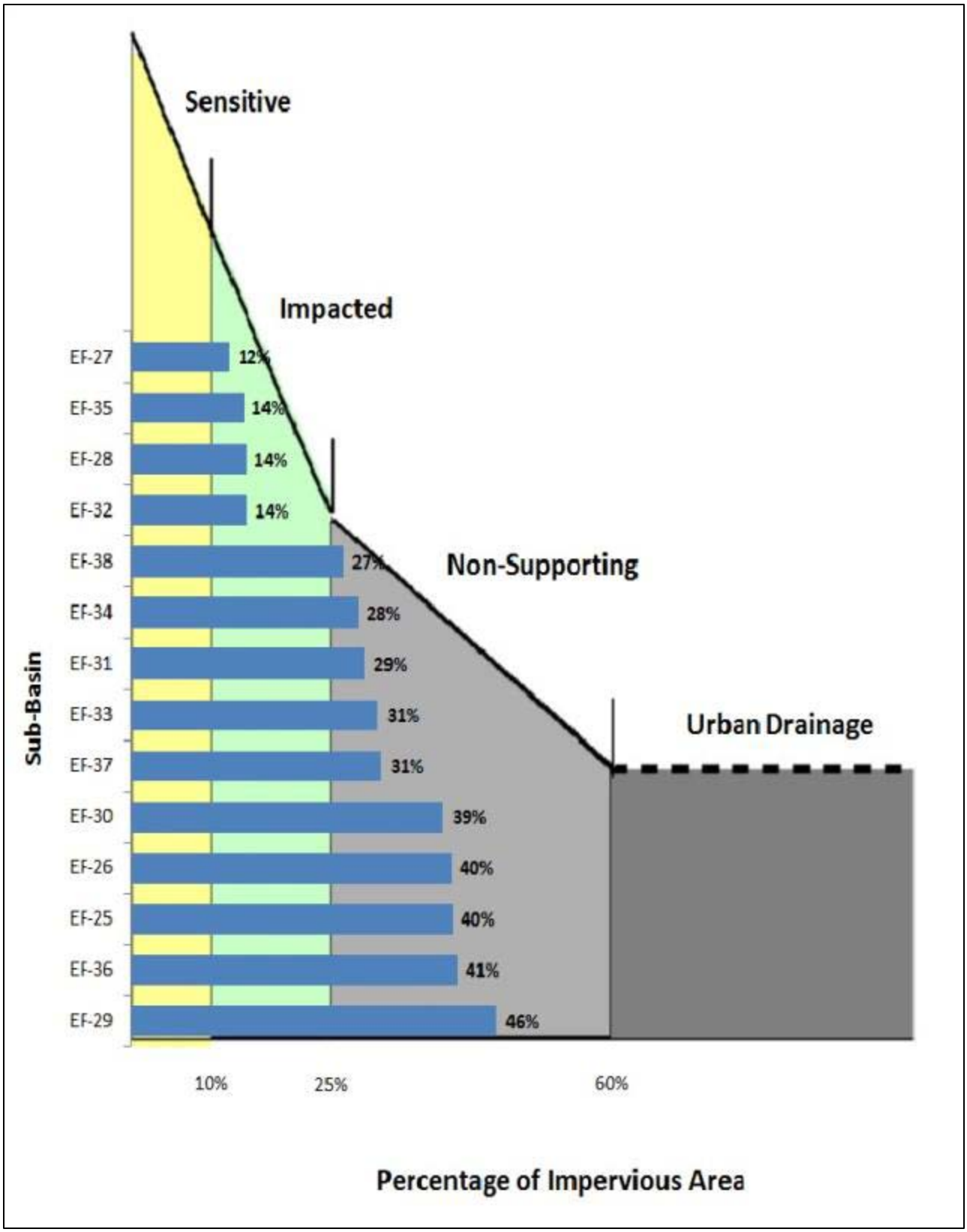

Figure 24. Impervious Cover Model with Percent Imperviousness.

5. Outfall Density

The number of outfalls per mile of stream in each sub-basin determines the outfall density. As outfall density increases, so does the potential for illicit discharges from MS4s. Sub-basin EF 37 had the greatest outfall density of the watershed. The outfall density for all sub-basins is detail in Table 18.

Table 18. Outfall Density.

Sub-Basin	Miles of Stream	Number of Outfalls	Outfall Density (outfalls/mile)	IDP Score
EF 37	0.16	11	70	3
EF 35	0.53	18	34	3
EF 30	0.79	22	28	3
EF 33	2.10	56	27	3
EF 29	1.87	48	26	3
EF 36	0.83	18	22	3
EF 31	2.01	36	18	2
EF 34	1.49	26	17	2
EF 26	1.27	19	15	2
EF 32	2.16	30	14	2
EF 25	1.46	17	12	2
EF 28	3.67	42	11	2
EF 27	2.92	28	10	2

6. NPDES Permitted Industrial Dischargers

Any facility discharging pollutants from a point source to waters of the state must have a NPDES discharge permit. Types of discharges include industrial and commercial wastewater, industrial stormwater, and municipal wastewater discharges.[27] The majority of NPDES permit holders in Friar Branch discharge stormwater from industrial facilities. This is important to monitor because stormwater can come in contact with potentially harmful contaminants from the parking lots and other impervious areas of the industrial facility. Two of the permit types in Friar Branch are for the discharge of treated groundwater used to clean underground storage tanks that previously held gasoline. Before discharging the groundwater, it must be treated to separate the oil and water. Two additional sites have hydrostatic permits for the discharge of wastewater resulting from testing new and/or used vessels to ensure there are no leaks. Lastly, Citgo Petroleum Corporation has an individual NPDES permit, authorizing the discharge of stormwater runoff, loading rack wash water and hydrostatic tank test water.[28] More

industrial dischargers in an area increase the possibility of having more polluted stormwater runoff and contaminants entering the waterways. Tables 19 and 20 below show the number of industrial dischargers per square mile and the industries holding NPDES permits and their permit type.

Table 19. Density of NPDES Permitted Dischargers.

Sub-Basin	Square Miles	NPDES Dischargers	Dischargers per Square Mile	IDP Score
EF 36	1.1	10	9.19	3
EF 34	0.7	2	3.05	2
EF 25	1.6	4	2.55	2
EF 33	1.6	1	0.61	1
EF 27	1.8	1	0.55	1

Table 20. NPDES Permit Holders and Permit Type.

NPDES Permit Holder	Permit Type**	Sub-Basin
AAA Cooper Transportation - Chattanooga	TMSP	EF 25
Kenco Transportation Services	TMSP	EF 25
Highway Transport Chemical LLC - Chattanooga	TMSP	EF 25
BASF Corporation	TMSP	EF 25
ADM - Enterprise South	TMSP	EF 27
Former Jabo's Party Shop	UST	EF 33
Chattanooga DC	TMSP	EF 34
Former Majik Market	UST	EF 34
Ready Mix USA - Jersey Pike Plant & Hiwassee Paving, LLC	TMSP	EF 36
Kinder Morgan Southeast Terminals, LLC. Chattanooga Terminal	TMSP	EF 36
Benton Oil Service, Inc. - Bulk Storage Facility	TMSP	EF 36
United Parcel Service - Chattanooga	TMSP	EF 36
Magellan Terminals Holdings, LP	TMSP	EF 36
Magellan Terminals Holdings, LP	TMSP	EF 36
Ready Mix USA - Jersey Pike Plant	TMSP	EF 36
Magellan's Chattanooga II Terminal	Hydrostatic	EF 36
Magellan Terminals Holdings, L.P. - Chattanooga Terminal	Hydrostatic	EF 36
Citgo Petroleum Corporation	Individual	EF 36
**Permit Type Description:		
TMSP: Tennessee Storm Water Multi-Sector General NPDES Permit for Industrial Activities		
Hydrostatic: General NPDES Permit for Discharges of Hydrostatic Test Water		
UST: General NPDES Permit for Discharges of Treated Groundwater Associated with Underground Storage Tank Remediation		

7. Stream Corridor Evaluation

SCORE, or Stream Corridor Evaluation, is the City of Chattanooga's method for visually inspecting all streams in Chattanooga in accordance with the NPDES permit requirements. SCORE analyzes streams and gives them a score of 1-5 for each of the following categories: in or near stream construction, channel alteration, barriers and blockages, outfalls, current erosion, canopy, and buffer. Thirty-five is the greatest possible score for the stream corridor evaluation. In order to determine the IDP score for each sub-basin, the total linear feet with a score of 17 or greater was determined. The channels in the poorest condition are in sub-basins EF 29, EF 30 and EF 33, respectively. Table 21 displays the linear feet of stream with a resulting SCORE of 17 or greater and the IDP score for each sub-basin.

Table 21. Linear feet of stream segment with SCORE of 17 or greater.

Sub-Basin	Segments with SCORE of 17 or greater (ft)	IDP Score
EF 29	3439	3
EF 33	2976	3
EF 30	2544	3
EF 32	2500	3
EF 27	2000	2
EF 35	1826	2
EF 36	1008	2
EF 31	1005	2
EF 26	500	1
EF 34	500	1
EF 25	0	-
EF 28	0	-
EF 37	0	-
EF 38	0	-

8. Drainage Service Requests

The number of drainage service requests is an important indicator when using the IDP score. Many times, flooding issues can also result in sanitary sewer overflows. Additionally, severe erosion can occur at the outfall when a conveyance system is discharging large volumes of water at high velocities, resulting in degradation of streams. The Watershed Conditions – Water Quantity section above quantifies drainage service requests for Friar Branch. Table 22 below shows the number of drainage service requests for each sub-basin, the service requests per square mile for each sub-basin, and its resulting IDP score.

Table 22. Drainage Service Requests.

Sub-Basin	Square Miles	Total Drainage Service Requests	Service Requests per Square Mile	IDP Score
EF 37	1.1	151	132.38	3
EF 35	0.7	69	101.04	3
EF 34	0.7	50	76.18	3
EF 38	0.8	59	73.83	2
EF 29	0.9	44	51.11	2
EF 31	0.7	29	41.69	2
EF 25	1.6	54	34.47	2
EF 30	1.3	42	31.95	2
EF 26	1.2	36	31.26	2
EF 36	1.1	26	23.90	1
EF 28	1.7	38	22.25	1
EF 33	1.6	30	18.39	1
EF 32	1.9	17	9.04	1
EF 27	1.8	11	6.04	1

9. Sanitary Sewer Overflows

EPA defines sanitary sewer overflows (SSOs) as "occasional unintended discharges of raw sewage from municipal sanitary sewers." SSOs occur as a result of blockages, breaks in the sewer line, lines reaching capacity from I & I, inadequate sewer maintenance and operation, power failure, poor system design, and vandalism.[29] This report analyzes SSOs from July 2008-July 2013. All recorded SSOs in Friar Branch occurred as a result of heavy rain events and blockages (grease, candy residue, gravel, roots, trash, and concrete). During the five-year period, 47 SSOs occurred in Friar Branch – approximately 8.7% of all SSOs that occurred in the City during the same time period. EF 31 had 20 reported SSOs, more than any other sub-basin, with more than half occurring at the same address as a result of heavy rain events.

Table 23. Sanitary Sewer Overflows.

Sub-Basin	Square Miles	SSOs	SSOs per Sq. Mile	IDP Score
EF 31	0.7	20	28.76	3
EF 38	0.8	5	6.26	2
EF 29	0.9	5	5.81	2
EF 35	0.7	3	4.39	1
EF 36	1.1	3	2.76	1
EF 37	1.1	3	2.63	1
EF 25	1.6	3	1.91	1
EF 34	0.7	1	1.52	1
EF 33	1.6	2	1.23	1
EF 30	1.3	1	0.76	1
EF 32	1.9	1	0.53	1
EF 26	1.2	0	0	-
EF 27	1.8	0	0	-
EF 28	1.7	0	0	-

10. Industrial and Commercial

Industrial and commercial properties have a tendency to produce more contaminated runoff resulting from increased amounts of impervious area, production of toxic substances, or increased traffic and heavy equipment use. Sub-basins were given an IDP score based on the percentage of industrial and commercial properties. All sub-basins scored greater than two in each category, meaning they all have at least 10% industrial and 10% commercial properties.

Table 24. Percentage of Industrial Properties.

Sub-Basin	Area Industrial	IDP Score
EF 34	56%	3
EF 35	54%	3
EF 31	53%	3
EF 38	46%	3
EF 29	43%	3
EF 36	34%	3
EF 37	32%	3
EF 26	32%	3
EF 30	28%	3
EF 25	23%	3
EF 33	23%	3
EF 28	22%	3
EF 27	20%	3
EF 32	20%	2

Table 25. Percentage of Commercial Properties.

Sub-Basin	Area Commercial	IDP Score
EF 34	32%	3
EF 35	31%	3
EF 31	31%	3
EF 38	27%	3
EF 29	25%	3
EF 36	20%	2
EF 37	19%	2
EF 26	19%	2
EF 30	16%	2
EF 25	14%	2
EF 33	13%	2
EF 28	12%	2
EF 27	12%	2
EF 32	11%	2

VI. Monitoring Program

The City adheres to a Stormwater Monitoring Program as defined by the NPDES permit in order to meet the water quality requirements of the Clean Water Act. This monitoring program requires wet weather monitoring, ambient monitoring, biological monitoring, watershed characterization, field screening, industrial monitoring, pesticide, herbicide and fertilizer sampling, and visual stream survey. TDEC will use this information to assist in determining if the stream is meeting its designated uses. If it is found that a stream is not meeting a designated use, it is listed on the 303(d) list, which is then included in a report to Congress. From the 303(d) list, EPA will define a total maximum daily loading (TMDL) for each cause of impairment. It is then the City's job to develop strategies to meet the required percent reductions as defined as part of the TMDL. TMDLs are defined for *E. coli* and Siltation and Habitat Alteration for the Lower Tennessee River Watershed, including Friar Branch. Friar Branch's percent load reduction goal (PLRG) to achieve the TMDL for *E. coli* is 82.9% and 61.2% for siltation and habitat alteration.[30] Figure B1 of Appendix B identifies locations of wet weather monitoring, in-stream ambient monitoring, biological sampling, watershed characterization sampling, field screening, and industrial monitoring.

A. Wet Weather Monitoring

The City performs concentrated commercial wet weather monitoring in Friar Branch three times per year. City of Chattanooga's NPDES Permit No. TNS068063 specifies the parameters for wet weather monitoring. Table A2 of Appendix A lists theses monitoring parameters. For all parameters listed in the permit, with the exception of pH, a seasonal pollutant load (SPL) and event mean concentration (EMC) must be calculated.[31]

B. Ambient Monitoring

The City maintains in-stream ambient monitoring annually at five defined locations within Chattanooga, two of which is in Friar Branch. Ambient monitoring includes the same parameters as wet weather (Table A2 of Appendix A).[32]

C. Biological Sampling

The City conducts biological sampling twice per year (1st and 3rd quarter of each permit year) in Friar Branch and Dobbs Branch.[33] The Friar Branch location is upstream of Noah Reid Road crossing at Station "Friar002.5". Biological sampling is important because it provides information that cannot be determined from other types of sampling and monitoring. Macroinvertebrates show the cumulative effect that environmental factors play on water quality and watershed health, while taking into account

specific ecological conditions. Biological monitoring is also an indicator of progress made in meeting water quality improvement objectives.[34]

D. Watershed Characterization

The NPDES permit requires the City conduct watershed characterization for Friar Branch. The permit requires sampling for *E. coli* and TSS twice per year to determine pollutant loading and source identification.[35] The City's Water Quality Program has decided to perform sampling on a monthly basis. The City will sample five times in a 30-day period with at least 24 hours in between each sample in order to develop a geometric mean for *E. coli*. Watershed characterization sampling results are shown on Figures 17-22 above.

E. Field Screening

The NPDES permit requires one field screening sample location in every quarter-mile grid for industrial and heavy commercial land uses and one per half-mile grid for all other land uses. The City must inspect each sample location twice per five-year permit term.[36] Field screening identifies land use, type of infrastructure present (pipe, open channel or culvert), flow rate, chemical characteristics, physical characteristics, outfall characterization, and non-illicit discharge concerns. Sampling parameters include temperature, pH, conductivity, DO, turbidity, phosphate, chlorine, detergents, phenol, copper, ammonia, and hydrogen sulfide. If any analysis exceeds the allowable levels, the field inspector must continue sampling upstream to locate the possible source of discharge. If a discharge is discovered, an illicit discharge inspection report must be completed. For the current permit term, there are 81 field screening sample locations in Friar Branch.

F. Industrial Monitoring

Each year of the permit term, the City is required to sample an industrial discharger that holds its own individual NPDES permit. Industrial monitoring includes visual inspection of stormwater discharge for color, odor, clarity, oil/grease sheen, and foam. The City performs analysis of the stormwater and tests for parameters defined in the NPDES permit. Citgo Petroleum Corporation is the industrial sampling site located in Friar Branch. Other locations outside of Friar Branch are AKZO Nobel Surface Chemistry, Hunter Oil Co. Inc., and Chattem Chemicals. Additionally, the City monitors municipal waste management facilities annually including stormwater samples from the City Wide Services, Summit Landfill, Moccasin Bend Landfill, and 36th Street Landfill.[37]

G. Pesticide, Herbicide and Fertilizer Program

Once during the permit term, the City will collect a minimum of two grab samples between April and September to test for pesticides, herbicides, and fertilizers (PHF). These samples will come from an area likely to use pesticide, such as a golf course or residential community.[38] The location of the PHF sample sites will vary for each permit term.

H. Stream Corridor Evaluation (SCORE) Program

The NPDES permit requires the City to visually inspect all *impaired* stream segments once per five-year permit term; however, the City goes beyond this and inspects *all* stream segments within the city limits. The minimum requirements in the permit state that evaluation must be performed immediately upstream and downstream of each MS4 outfall that discharges to an impaired stream segment.[39] The City has elected to use the Stream CORridor Evaluation, SCORE, as the means of visual inspection. SCORE identifies and evaluates channel stability, sediment loading and in-stream habitat through visual inspections and stream walks.[40] Chattanooga's Water Quality Program website lists more information regarding the SCORE program. Figure B7 of Appendix B identifies the results of SCORE for the Friar Branch Watershed.

VII. Stormwater Pollutant Reduction Strategies

A. Stream Restoration Project

The City's Water Quality Program completed a stream restoration project in Friar Branch through a partnership with the Tennessee Stream Mitigation Program (TSMP). The project spanned approximately 8,000 linear feet of stream, converting the concrete channels as closely back to a natural meandering stream as possible. The stream was relocated away from residential properties, allowing the creation of 35 acres of riparian conservation easement. Additional benefits of the stream restoration project include the creation of a wildlife refuge, removal of invasive non-native vegetation and planting of native trees and shrubs, improvement of the abundance and diversity of biota, and providing an educational learning opportunity for community members.[41] Just over one third of streams in Friar Branch (approximately seven miles) have been converted from their natural state. Ideally, all streams should remain in their original state or be converted as closely back to their previous, natural state as possible. Potential project sites for future stream restoration projects will be analyzed and selected following this watershed characterization report. Figure 25 depicts an aerial footprint of the Friar Branch Stream Restoration and Figures 26 and 27 show pre and post restoration pictures.

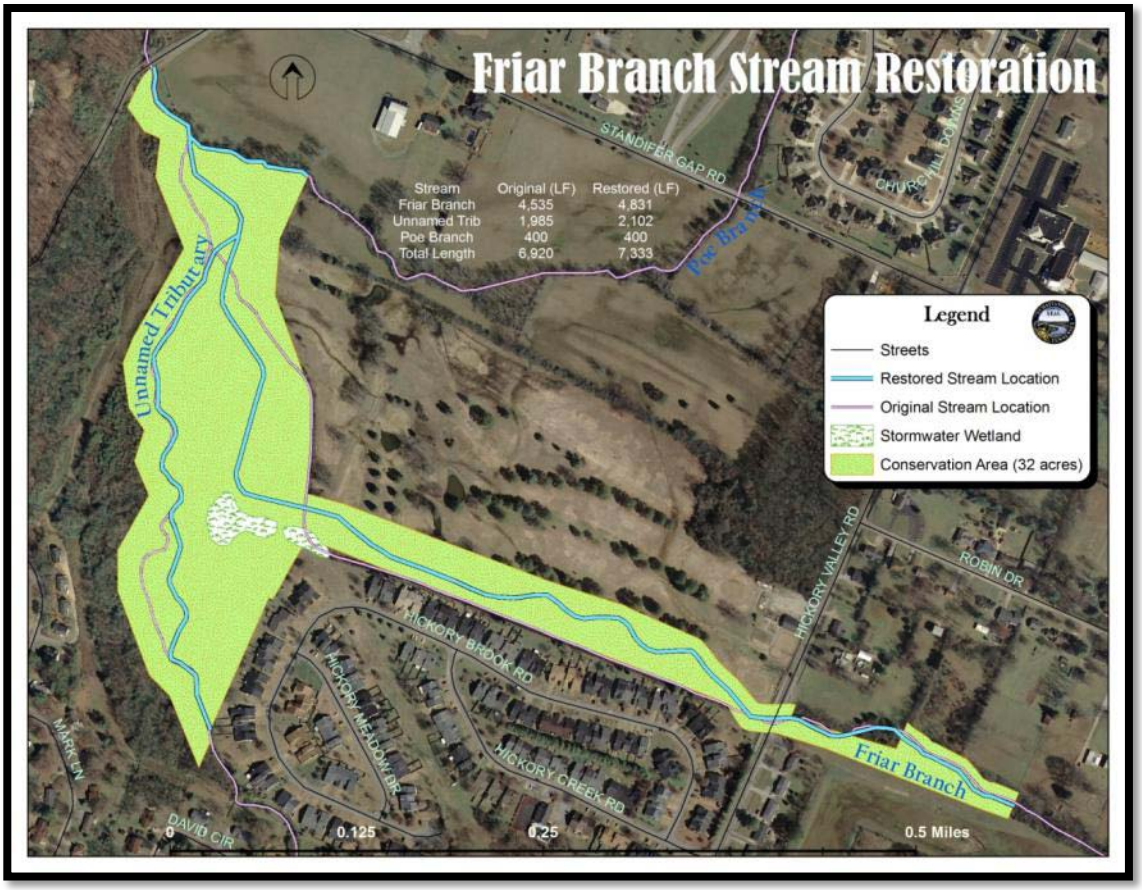

Figure 25. Friar Branch Stream Restoration.

Figure 26. Channelized Stream Before Restoration.

Figure 27. Friar Branch Restoration After Completion.

B. Low Impact Development and Green Infrastructure

In Friar Branch, vacant properties are the second leading land use, just behind residential. There is a total of 1,724 acres of vacant lots. This means there is room for growth, whether it is residential, commercial or industrial. It is important to ensure all future projects, whether new or redevelopment, utilize low impact development practices and green infrastructure devices for stormwater control and pollution reduction. The City is in the process of developing new policies, ordinances and codes regarding rainwater management and water quality that will be effective Fall 2014. The *Rainwater Management Guide* will aid developers and design professionals in effectively meeting the new rainwater runoff requirements through green infrastructure and low impact development. The *Rainwater Management Guide* states,

> Compliance with the current NPDES MS4 Permit requires the City to establish a comprehensive stormwater management program to develop, implement, and enforce controls to reduce the discharge of pollutants from areas of new development and redevelopment. The program includes volume management, water quality, and flow rate standards for onsite stormwater management facilities and focuses on low-impact development and green infrastructure best management practices.[42]

The new requirements in the *Rainwater Management Guide* require the first inch of rainfall to stay *on site*, whereas previously, the rainfall was detained and piped off site. Friar Branch (and all other exceptional/impaired watersheds) requires the first 1.6 inches to be managed on site because it is an Exceptional Tennessee Water due to the state threatened Chickamauga Crayfish. For new and redevelopments that use green infrastructure and low impact development, stormwater fee credits and other incentives will be available. Incentives include public-private partnership opportunities for redevelopment and retrofits, a grant program for green infrastructure retrofits and a Low Impact Development Excellence Award.[43]

Examples of green infrastructure include rain gardens, pervious pavements, green roofs, and runoff capture and reuse, just to name a few. These techniques promote infiltration back into the ground rather than routing the stormwater to the nearest drain. Many of the green infrastructure devices also improve aesthetics of the area.



Figure 28, 29, and 30. Left: Infiltration Planter ; Middle: Green Roof, The Crash Pad, Chattanooga, TN; Right: Permeable Parking Lot, Jefferson St. Apartment Complex, Chattanooga, TN

C. Pathogen Reduction

The TMDL defined for Friar Branch requires an 82.9% load reduction for *E. coli.* In order to achieve this goal, the City must aim to eliminate as many illicit discharges as possible, specifically those from sanitary sewer lines and septic systems. Current strategies for detecting and eliminating illicit discharges include infrared investigation and receiving discharge complaints through the City's 311 call service, in addition to the regular monitoring programs.

Infrared investigations identify locations where a change in temperature is present. The Water Quality Program must inspect each identified location and determine if an illicit discharge is present. If an illicit discharge is detected and believed to be a sanitary sewer leak, a sample must be collected and sent to the lab for *E. coli* analysis.

Calls regarding illicit discharges are received at the City's 311 call center. Upon receiving a service request regarding a sanitary sewer discharge, the Water Quality Program has three days to inspect the request. If the Water Quality Program confirms an illicit discharge, the property owner is issued a Notice of Violation and has seven days to come into compliance. Chattanooga City Code 31-4 states it is the responsibility of the property owner or user of the sewer to repair and maintain sanitary sewer service lines.[44] If the property owner does not come into compliance, a court order will be issued. Lastly, if the court order is not met, the property will be turned into Neighborhood Services to be condemned.

Based on the types of development within the Friar Branch Watershed, septic systems are common in the area – many of which that have not been properly documented. Septic systems can be a major contributor towards E. *coli* contamination. In order to identify contamination sources and effectively meet the required load reductions, efforts to locate and inspect all septic systems should be made.

Implementing effective stormwater management practices will reduce sanitary sewer overflows. Most SSO events occur as a result of heavy rainfall. During periods of heavy rain, sewer lines can reach capacity either through I & I in sanitary sewer lines or excessive volume in combined sewer systems. The implementation of the new stormwater management requirements will reduce the volume of water leaving all new and redevelopments. A reduction in water volume will result in less stormwater runoff entering sanitary sewer lines and reduce the likelihood of an overflow to occur. To prevent future SSOs, the City should identify properties with chronic SSOs and implement solutions that address the cause of overflow.

D. Education and Community Outreach

Members of the Friar Branch community should be well educated on the importance of watershed stewardship. Community education and media campaigns will be the primary means of informing residents on watershed stewardship. One of the best approaches to educate the community is teaching by example. The stormwater BMP projects will serve as first-hand educational opportunities for Friar Branch's community members.

Residents must be mindful of what activities around their homes will result in harmful substances entering the storm drains. For example, many people do not realize the resulting pollutants from activities such as washing cars. Soap, chemicals, oils, grease, and heavy metals can all end up in car wash water. The Water Quality Program has brochures regarding Best Management Practices for activities such as car maintenance and outside and inside home maintenance. These brochures are available by request from the Public Works Department – Water Quality Program.

The City's Water Quality Program has recently developed an educational video explaining the importance of stormwater management. This video highlights the stormwater management pilot project at the Chattanooga Metropolitan Airport. It is a part of an educational media campaign and will be available on the City's website, YouTube and other media outlets.

The Tennessee Environmental Council organized a tree planting day in partnership with Hamilton County, the City of Chattanooga and South Chickamauga Creek Greenway Alliance. The tree planting day in Chattanooga was a part of a larger event, "10k Tree Day", which was an effort to plant 10,000 trees throughout Tennessee on March 8-9, 2013. The Chattanooga location was the First Tee of Chattanooga Player Development Complex in order to re-establish the tree canopy near the Friar Branch Stream Restoration Project. The City will continue to organize additional community engagement days similar to the 10k Tree Day.

Figures 31 and 32. 10K Tree Day. Volunteers planting trees along the Friar Branch Stream Restoration Project in March 2013.

VIII. Regulatory Status

As of the Reporting Year 2010 for the 303(d) list, the overall status of Friar Branch is impaired. The 303(d) lists 18.94 miles of stream in Friar Branch as impaired, resulting in the required development and establishment of a TMDL by EPA. The designated uses of fish and aquatic life and recreation are both impaired. EPA has completed TMDLs for *E. coli*, habitat alteration, and sedimentation and siltation. A TMDL is still needed for Nutrient and Eutrophication Biological Indicators. A stream must attain water quality standards for Tennessee in order for the removal from the 303(d) list.

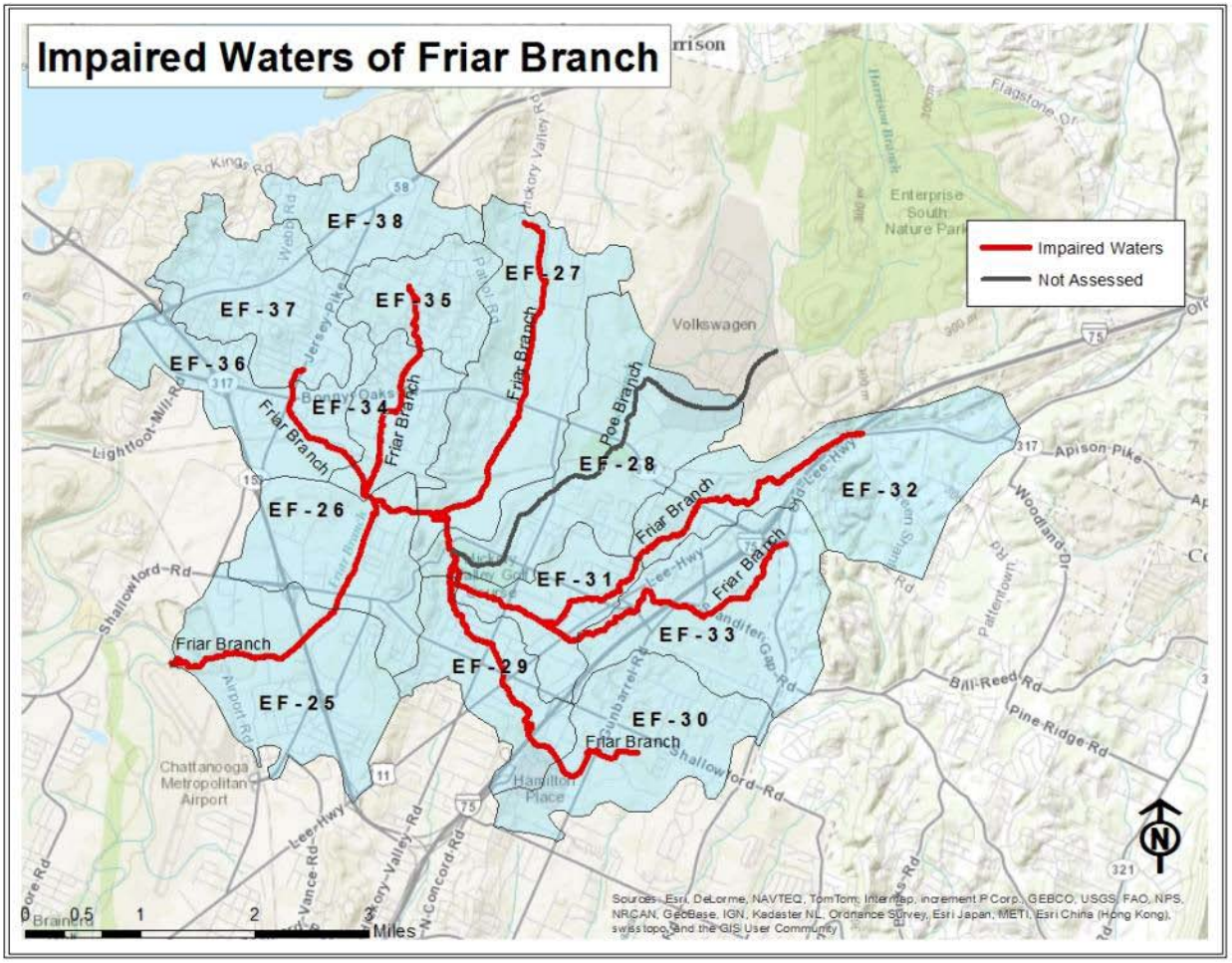

Figure 30. Impaired Waters of Friar Branch.

IX. Conclusions

The Friar Branch Watershed, within the Middle Tennessee-Chickamauga Watershed, drains an area of approximately 17 square miles. There are 14 smaller sub-basins within the watershed, each draining an area of 0.6 to 1.9 square miles. The watershed is comprised of two tributaries of the Tennessee River, Friar Branch (18.94 miles) and Poe Branch (3.65 miles), totaling 22.7 miles of stream. EPA has listed Friar Branch on the 303(d) list of impaired waters, but has not assessed Poe Branch. In order for EPA to remove Friar Brach from the list, the stream must meet water quality standards for the State of Tennessee.

Leading land uses in Friar Branch are residential, industrial, vacant, and commercial. Industrial and commercial properties tend to have highly impervious areas as well as a higher potential for illicit discharges to occur. Residential areas can add strain to the sewer infrastructure, increasing the potential for an SSO to occur. Vacant properties are beneficial in that they are undeveloped and allow more infiltration to occur. Additionally, more vacant properties provide more opportunities for the development of stormwater BMP projects.

The Report identifies sub-basin EF 37 as having the highest frequency of drainage issues. When a resident has a drainage issue, they call the City's 311 call service to fill a drainage service request. In Friar Branch, the 311 call center received 682 drainage service requests from a five year period (August 11, 2008-August 7, 2013)—approximately 13% of all drainage requests within the City during the same time period.

The City's Water Quality Program performs watershed characterization sampling on a monthly basis in accordance with the NPDES Permit No. TNS068063. Sampling parameters include temperature, pH, dissolved oxygen, conductivity, total suspended solids, and *E. coli.* The data is compared to water quality criteria (*General Water Quality Criteria*) for maximum and minimum values set by TDEC. The City also performs additional monitoring and sampling in order to meet requirements set in the NPDES permit.

This Report utilizes an IDP score to determine the potential for an illicit discharge to occur. Twelve factors determine the IDP score – discharge complaints, age of sanitary sewer infrastructure, impervious cover, outfalls per mile of stream, NPDES permitted industrial dischargers, amount of clay pipe present, stream corridor assessment, drainage complaints, SSOs, area of industrial property, area of commercial property, and presence of hot areas. Raw scores for sub-basins within Friar Branch range from 14-29 (with a score of 12 being the lowest and 36 being the highest). The City identified priority sub-basins based on the top three sub-basins with the highest IDP score.

As part of the requirements of the NPDES permit, the City is required to complete a watershed characterization of Friar Branch. This Watershed Plan and Preliminary Characterization Report is the first step in the process. Following this Report, retrofit evaluation will identify potential project sites within the priority sub-basins – EF 29, EF 36, and EF 30. Retrofit evaluations will select sites according to

common locations identified in the Center for Watershed Protection's (CWP) *Manual 3: Urban Stormwater Retrofit Practices.* This manual identifies thirteen common locations to look for retrofits and evaluations will begin in the priority sub-basins then move to any feasible location within the watershed. Upon completion of the retrofit evaluation, the City will complete a cost-benefit analysis and implementation plan for the most feasible sites identified.

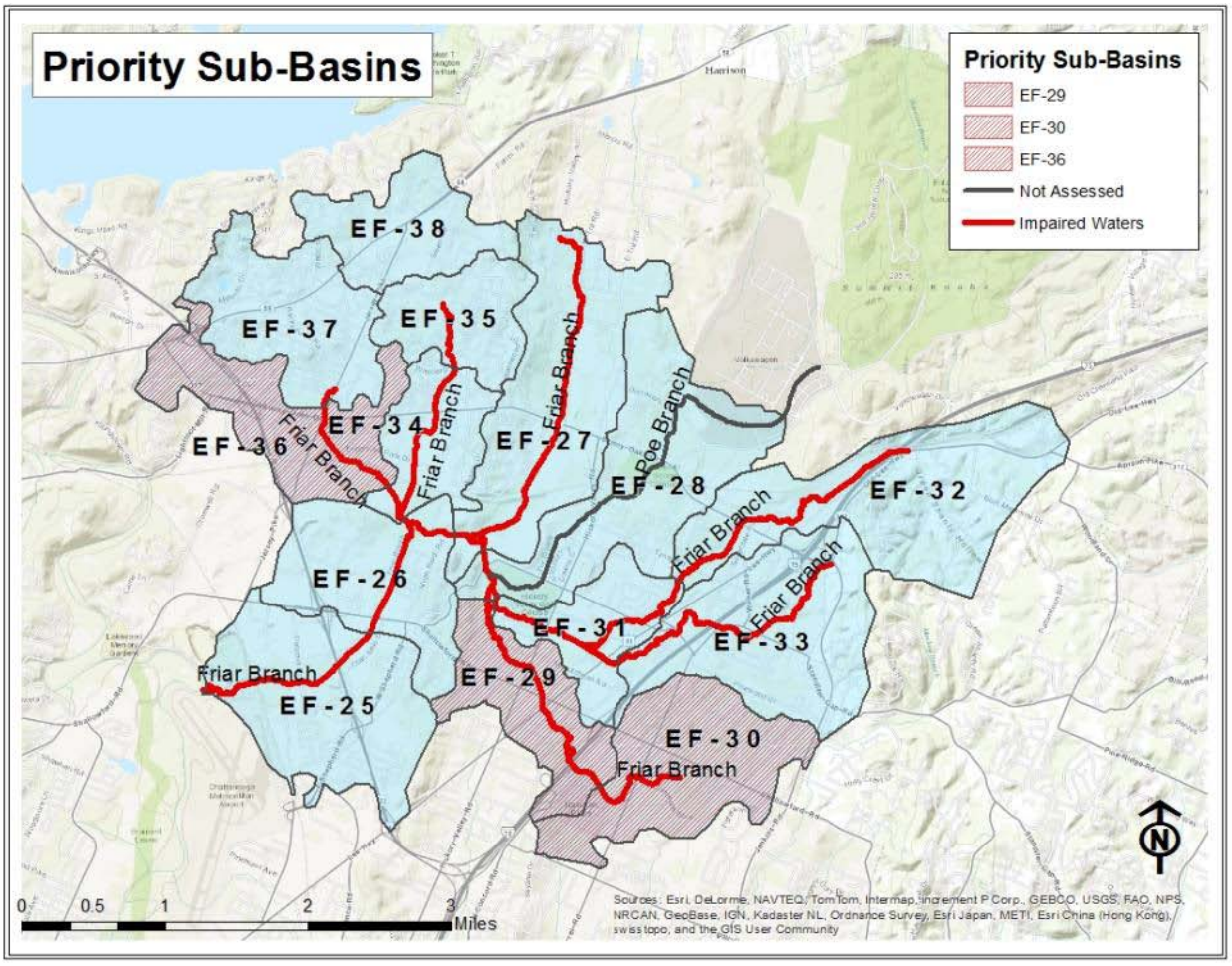

Figure 31. Priority Sub-Basins

Appendix A

Monitoring Plan and Monitoring Parameters

Table A1. Monitoring Plan for Friar Branch.
Table A2. Parameters for Wet Weather and Ambient Monitoring.

Table A1. Monitoring Plan for Friar Branch.

Monitoring Plan			
Station ID	**Location**	**Frequency**	**Monitoring Parameters**
Wet Weather			
Concentrated Commercial	Gunbarrel Road and Landress Drive	3x per year	See Table A1
Ambient Monitoring			
Derby Downs	2765 Derby Downs Drive	Annually	See Table A1
Polymer Dr	2121 Polymer Drive		
Biological Monitoring			
FRIAR002.5HM	East of Noah Reid Rd. and stream intersection	Twice per year -- 1st & 3rd Quarter	Benthic Macroinvertebraes
Watershed Characterization Sampling			
FB-01	Enterprise South Nature Park-Poe Run Rd.	Monthly	pH, dissolved oxygen, conductivity, temperature, *E.coli*, TSS
FB-02	7236 Bonny Oaks		
FB-03	Intersection of Friar Branch and Lee Hwy (7151)		
FB-04	2330 Hickory Valley Rd.		
FB-05	6749 Hickory Brook Rd.		
FB-06	2765 Deby Downs Dr.		
FB-07	Intersection of Poe Branch and Standifer Gap Rd.		
FB-08	7350 Noah Reid Rd		
FB-09	North of 7325 Noah Reid Rd.		
FB-10	2121 Polymer Dr.		
TMDL Sampling			
FRIAR002.7HM	6749 Hickory Brook Rd.	Monthly	pH, dissolved oxygen, conductivity, temperature, E.coli, TSS
FRIAR000.8HM	2121 Polymer Dr.		
Hot Areas			
Hot Area 8	East of RR to creek, South of RR to Shallowford	Annually	pH, dissolved oxygen, conductivity, temperature, E.coli, TSS
Hot Area 10	East of I-75 to Galahad, South of Shallowford to		
Field Screening			
82 Locations	One per quarter-mile or half-mile grid, depending on land use	Twice per Permit Term	When flowing: pH, dissolved oxygen, conductivity, temperature, chlorine, ammonia, detergents, phenols, copper, phosphate, and hydrogen sulfide
SCORE			
All stream segments	Throughout Friar Branch Watershed	Once per Permit Term	Non-analytical: landuse, buffer, canopy, flow conditions, channel alterations, channel dimensions

Table A2. Parameters for Wet Weather and Ambient Monitoring.

Parameters for Wet Weather and Ambient Monitoring	
pH	biochemical oxygen demand (BOD5)
total suspended solids (TSS)	chemical oxygen demand (COD)
total dissolved solids (TDS)	dissolved phosphorus
total ammonia nitrogen (as N)	total phosphorus
total ammonia plus organic nitrogen	total Kjeldahl nitrogen
nitrate plus nitrite nitrogen (as N)	trichloroethylene
total nitrogen	bis (2 ethly-hexyl) phthalate
oil and grease	total recoverable chromium
methylene chloride	total recoverable beryllium
vinyl chloride	total recoverable lead
fluoranthene	total recoverable zinc
Cyanide, Total	
Phenols, Total	
total recoverable copper	
total recoverable nickel	
total recoverable arsenic	
total recoverable cadmium	
Special Analyses	
E. coli (1 storm/year)	

Appendix B

Supplemental Maps

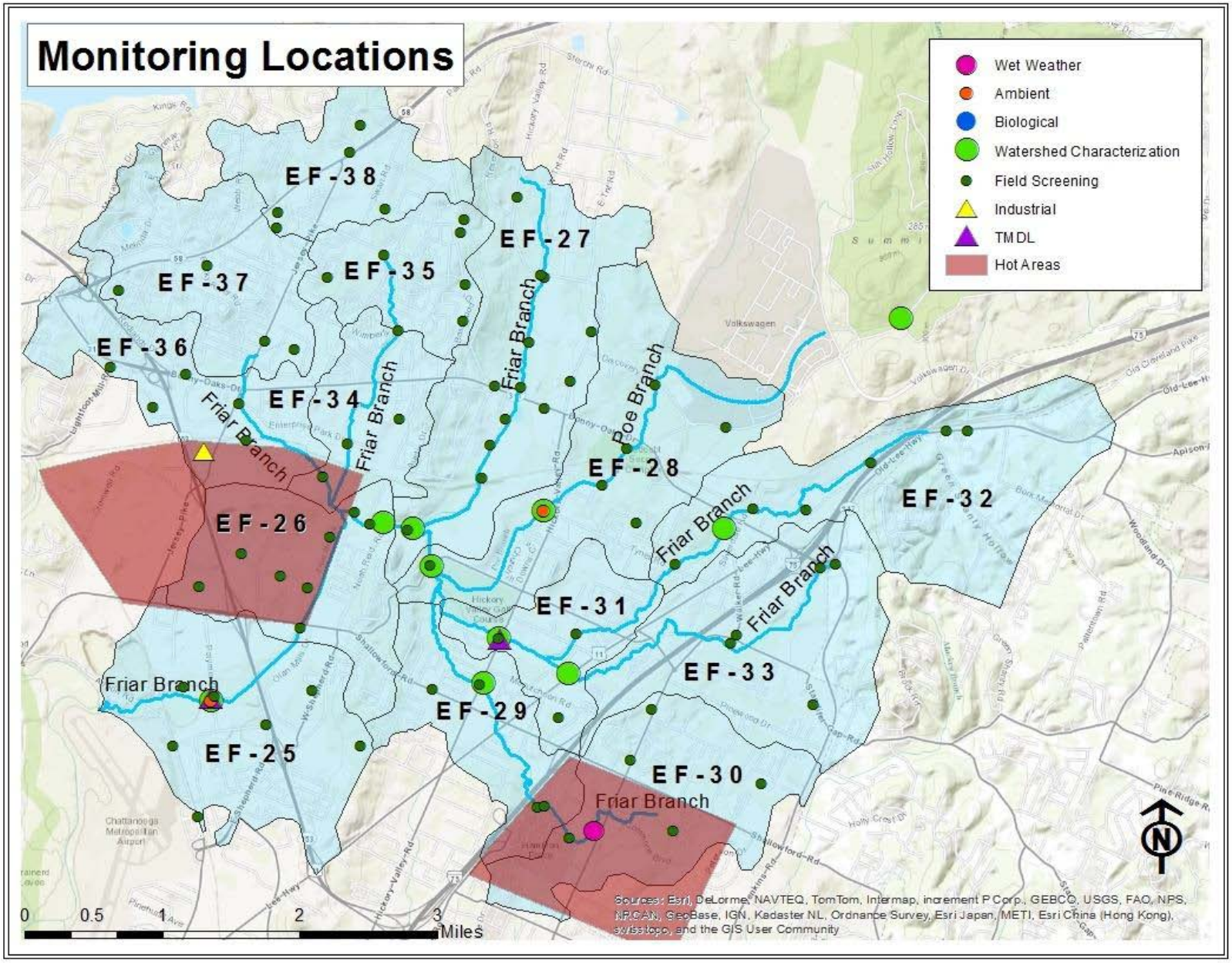

Figure B1. Monitoring Locations.

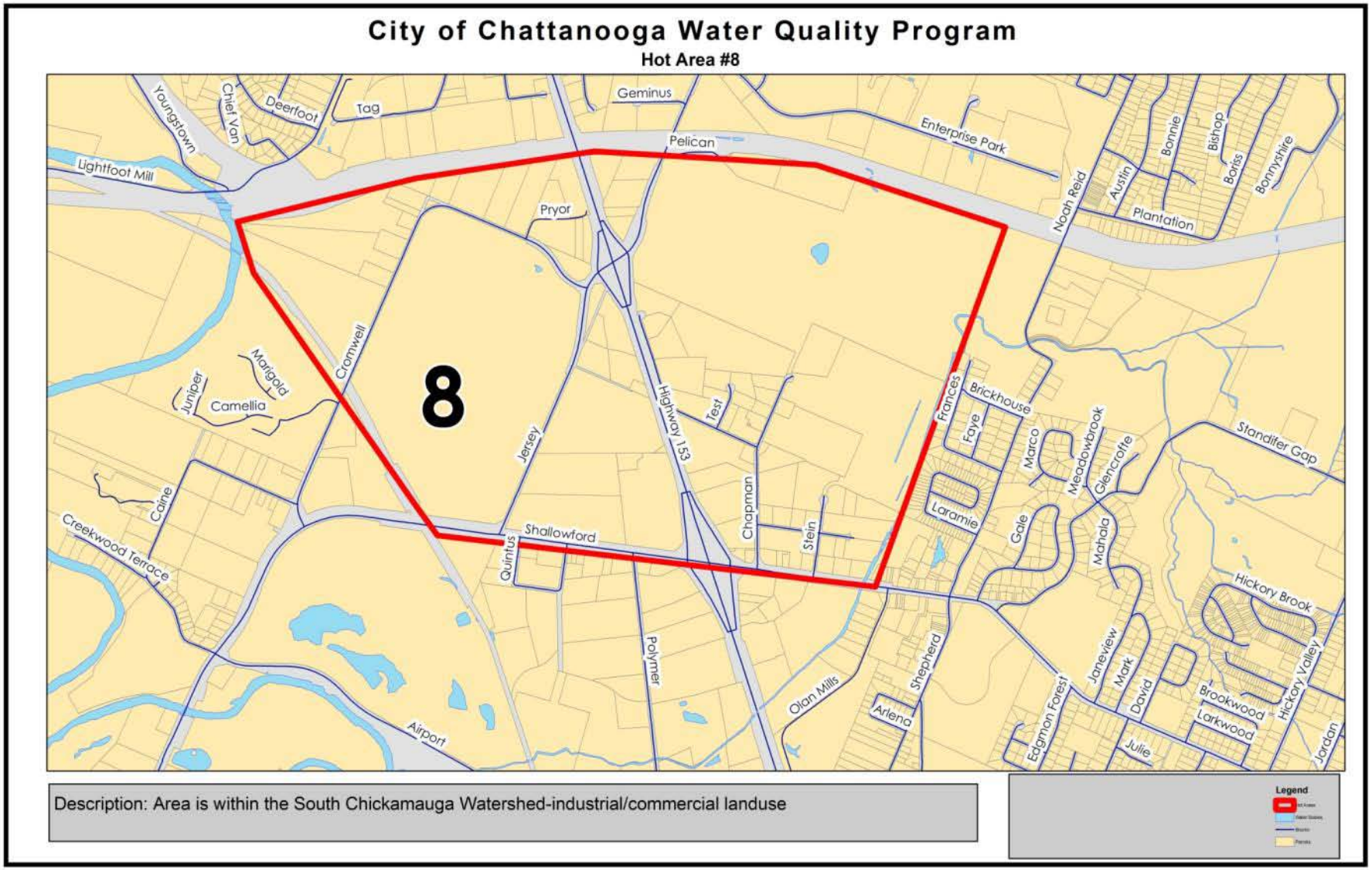

Figure B2. Hot Area #8.

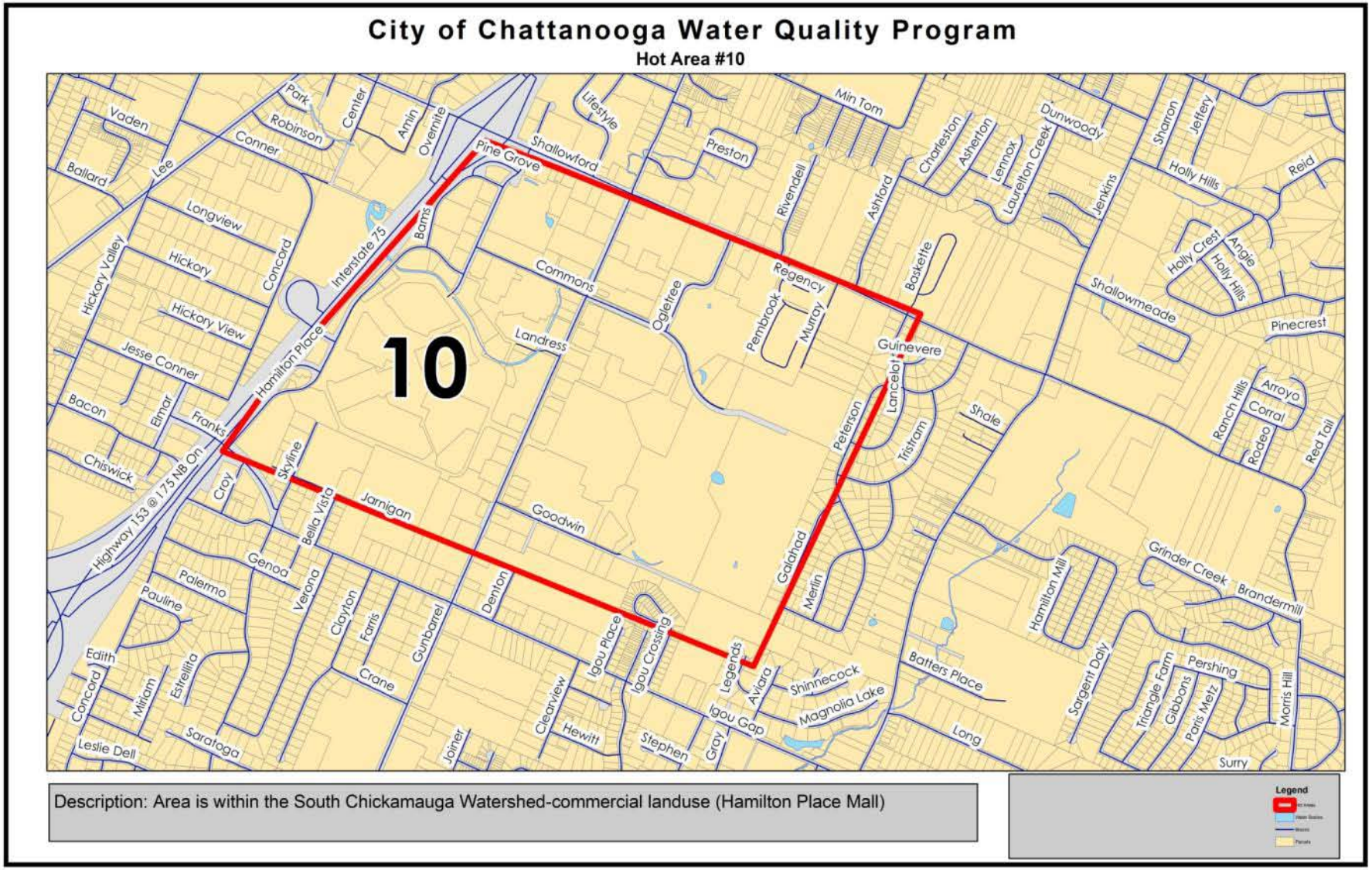

Figure B3. Hot Area #10.

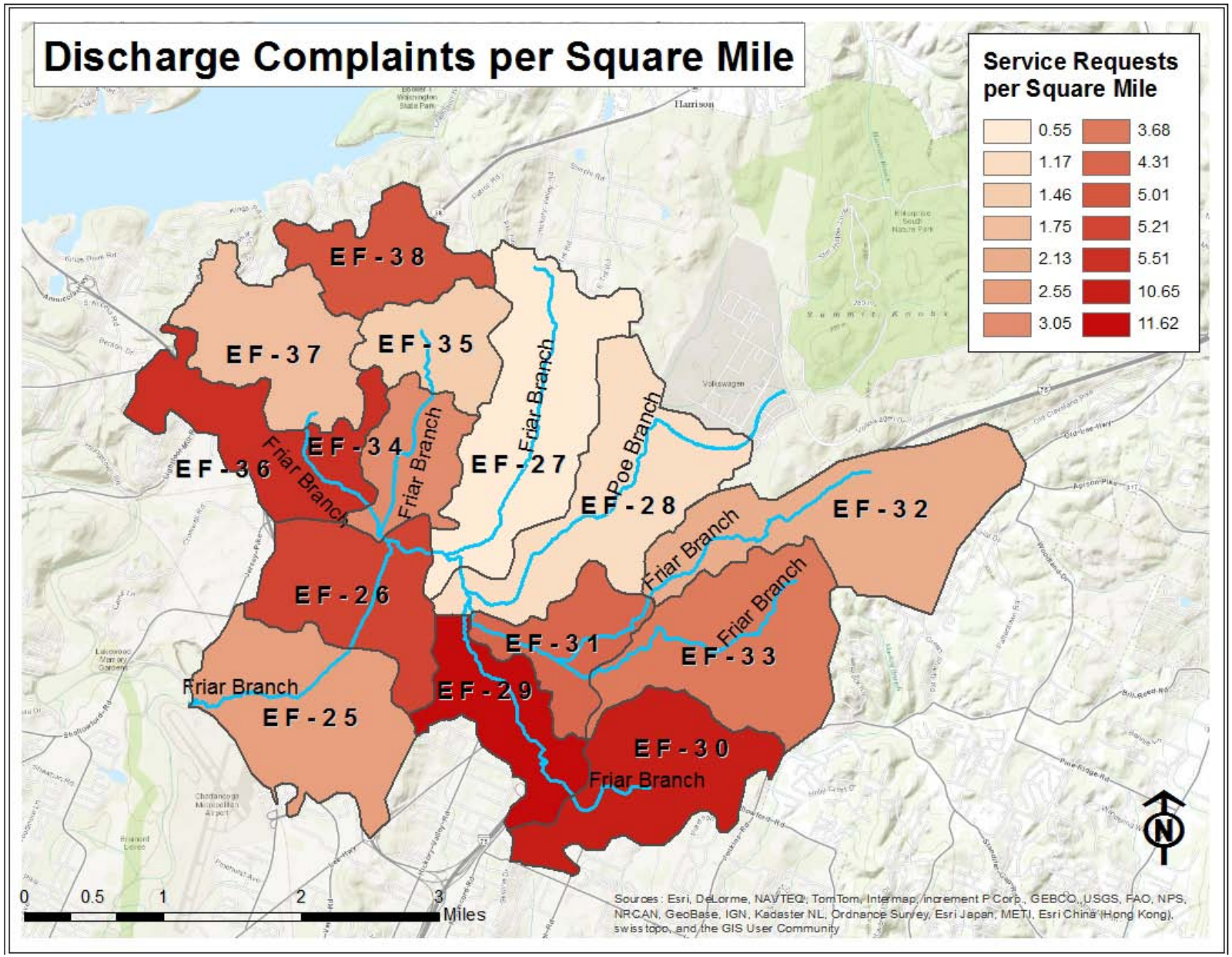

Figure B4. Discharge Complaints per Square Mile.

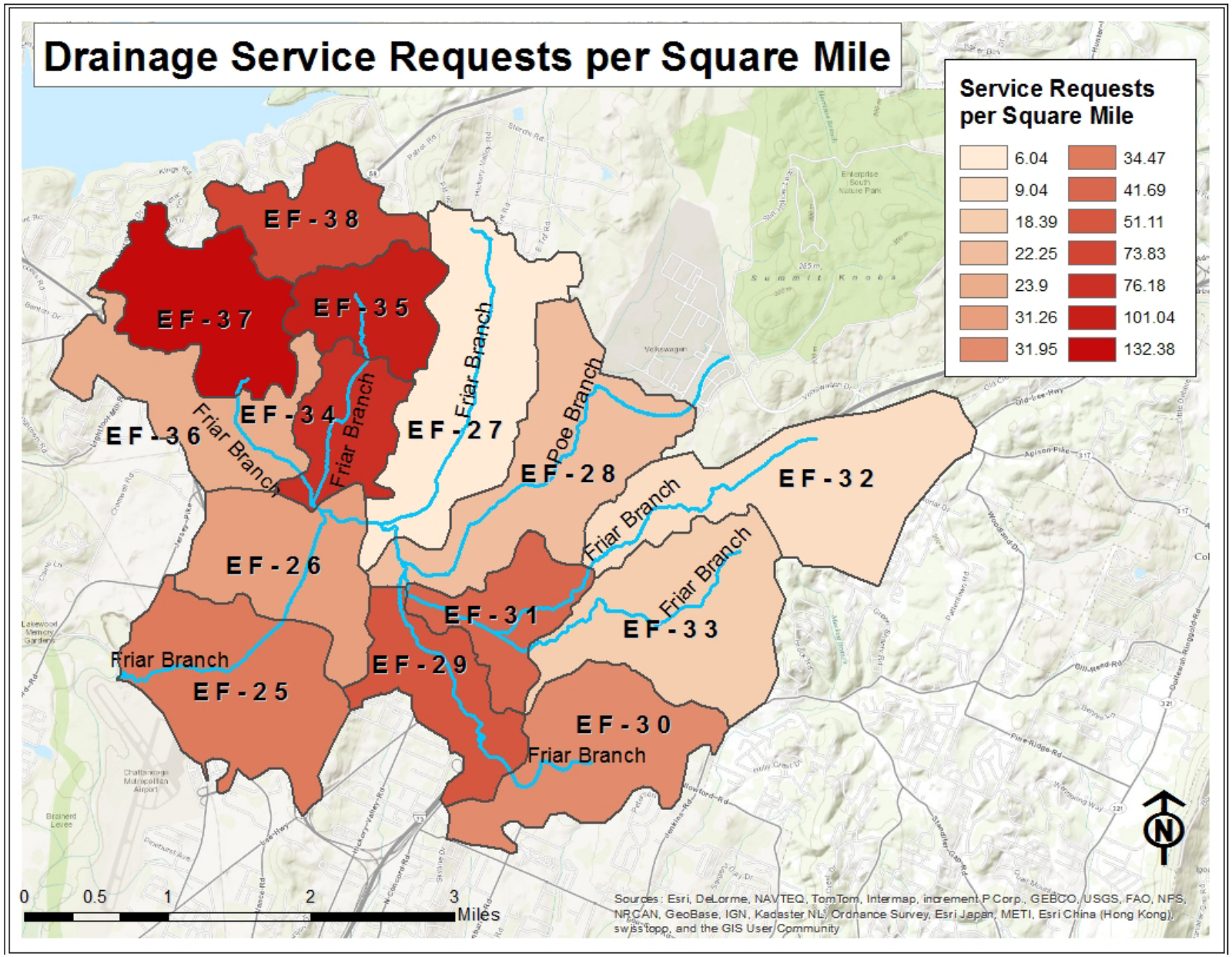

Figure B5. Drainage Complaints per Square Mile.

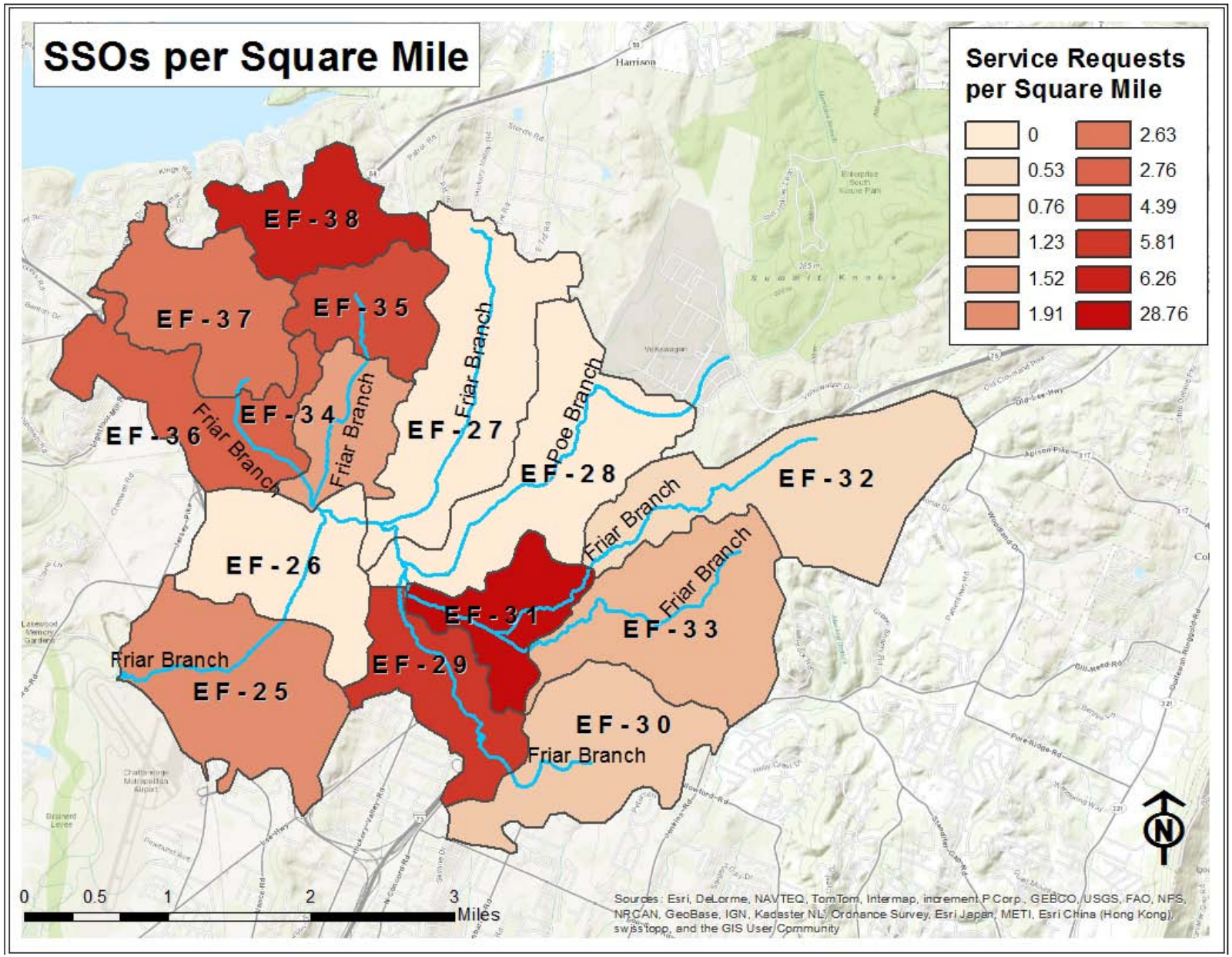

Figure B6. Sanitary Sewer Overflows per Square Mile.

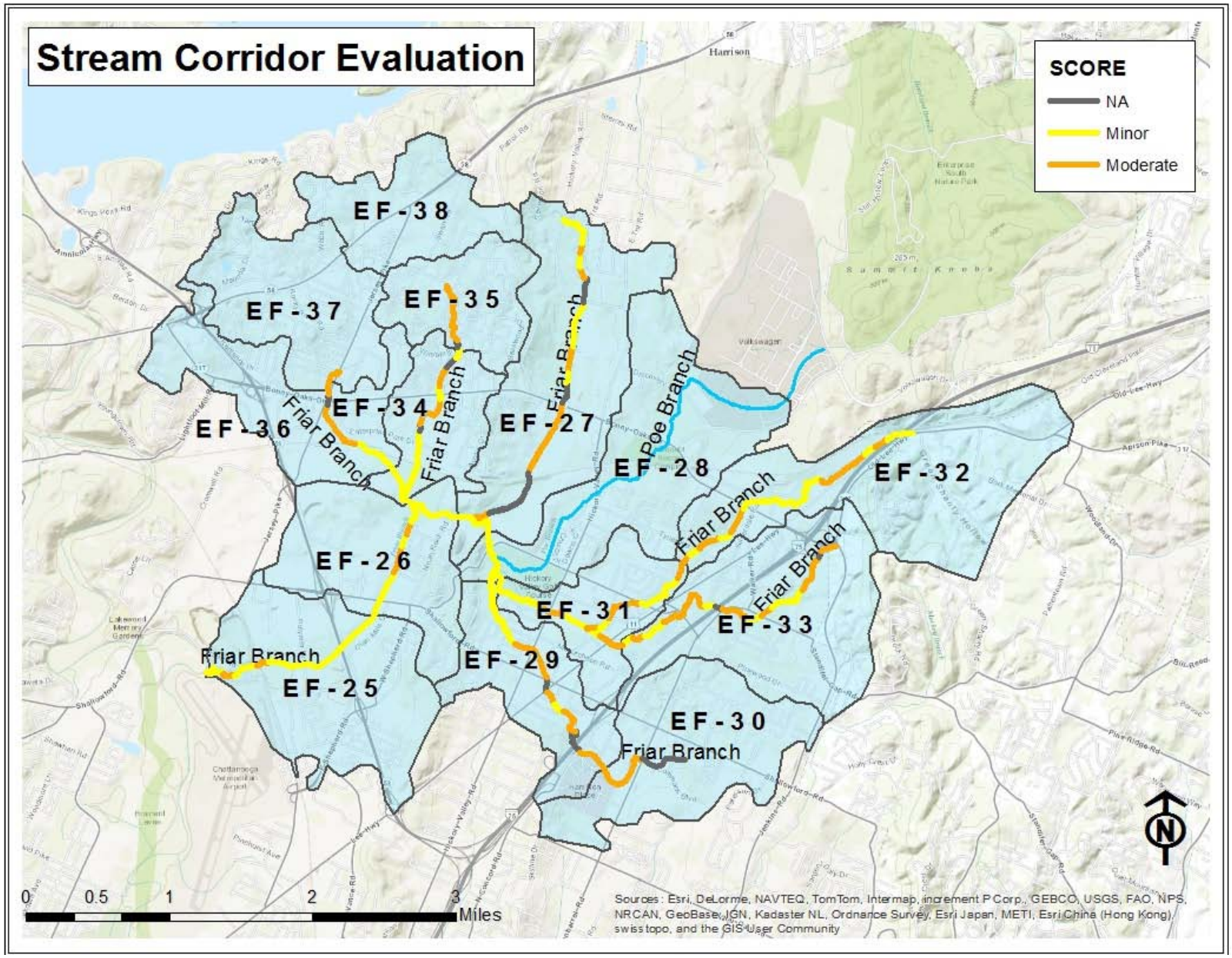

Figure B7. Stream Corridor Evaluation.

Notes

[1] Tennessee Department of Environment and Conservation, Division of Water Pollution Control, *NPDES Permit No. TNS068063* (Nashville: January 2011), 26.

[2] EPA, "2010 Waterbody Report for Friar Branch," *Watershed Assessment, Tracking & Environmental Results,* http://iaspub.epa.gov/tmdl_waters10/attains_waterbody.control?p_list_id=TN06020001007_0100&p_cycle=2010&p_report_type=, (Accessed 5 November 2013).

[3] Tennessee Department of Environment and Conservation, "The Known Exceptional Tennessee Waters and Outstanding National Resource Waters," *Introduction to Exceptional Waters and ORNQ in Tennessee,* http://environment-online.state.tn.us:8080/pls/enf_reports/f?p=9034:34304:221641303500701:::::.

[4] "The Known Exceptional Tennessee Waters and Outstanding National Resource Waters"

[5] USDA and NRCS, *Lower Clinch River Rapid Watershed Assessment* (September 2009), 8, http://www.lowerclinchwatershed.org/m/LowerClinchRWA.pdf,

[6] EPA, "National Water Quality Inventory Report to Congress," *Water: Water Quality Reporting (305b),* http://water.epa.gov/lawsregs/guidance/cwa/305b/index.cfm.

[7] Tennessee Department of Environment and Conservation, Division of Water Pollution Control, *Year 2010 303(d) List* (Nashville: August 2010), 92, http://www.tn.gov/environment/water/docs/wpc/2010_303d_final.pdf.

[8] City of Chattanooga, "'Hot Areas' Action Plan," *NPDES Permit TN0068063* (June 2011), 3.

[9] Mike Pare, "Hamilton Place – What a history: CBL flagship, celebrates 25 years a regional centerpiece," *Times Free Press (5* August 2012), http://www.timesfreepress.com/news/2012/aug/05/hamilton-place-what-a-history-cbl-flagship-celebr/

[10] CBL & associates Properties, Inc., "Hamilton Place," *CBL* (2013), http://www.cblproperties.com/pag.nsf/PropertiesforJQueryMap/A334BD2C68888EC98525757F007733E0?OpenDocument.

[11] EPA, "Water Quality Standards Handbook – Chapter 2: Designation of Uses (40 CFR 131.10)," *Water: Handbook,* http://water.epa.gov/scitech/swguidance/standards/handbook/chapter02.cfm.

[12] "2010 Waterbody Report for Friar Branch".

[13] Tennessee Department of Environment and Conservation, Division of Water Resources, *General Water Quality Criteria*, Chapter 1200-04-03, 3-16, http://www.tn.gov/sos/rules_all/2013/1200-04-03.20130702.pdf.

[14] EPA, "Temperature," *Water: Monitoring and Assessment,* http://water.epa.gov/type/rsl/monitoring/vms53.cfm.

[15] *General Water Quality Criteria*, 3-16.

[16] EPA, "pH," *Water: Monitoring and Assessment,* http://water.epa.gov/type/rsl/monitoring/vms54.cfm

[17] *General Water Quality Criteria*, 3-16.

[18] EPA, "Conductivity," *Water: Monitoring and Assessment,* http://water.epa.gov/type/rsl/monitoring/vms59.cfm

[19] *General Water Quality Criteria*, 5.

[20] EPA, "Dissolved Oxygen and Biochemical Oxygen Demand," *Water: Monitoring and Assessment,* http://water.epa.gov/type/rsl/monitoring/vms52.cfm

[21] *General Water Quality Criteria*, 3-16.

[22] EPA, "Fecal Bacteria," *Water: Monitoring and Assessment,* http://water.epa.gov/type/rsl/monitoring/vms511.cfm.

[23] EPA, "Total Solids," *Water: Monitoring and Assessment,* http://water.epa.gov/type/rsl/monitoring/vms58.cfm.

[24] Greg R. Wayman, "Sewer Lines: Problems, Signs & Solutions," *Foundation-2-Rooftop, Inc,* http://www.omaha-home-inspection.com/hometips-sewerlines-12-3-07.pdf.

[25] Department of Public Works, *Resource Rain: Rainwater Management Guide,* City of Chattanooga, 1-1, http://www.chattanooga.gov/public-works/city-engineering-a-water-quality-program/water-quality-program/44-public-works/989-resource-rain.

[26] Schueler, Tom, Lisa Fraley-McNeal, "The Impervious Cover Model Revisited: review of recent ICM research" (presented at the Symposium on Urbanization and Stream Ecology, 23-24 May 2008), http://chesapeakestormwater.net/wp-content/uploads/downloads/2012/01/ICM20Research20and20Planning20Implications1.pdf.

[27] TDEC, "National Pollutant Discharge Elimination System (NPDES) Permit," http://www.tn.gov/environment/permits/npdes.shtml.

[28] EPA, "Performance and Trends: Tennessee Water Activity Dashboard," *Enforcement & Compliance History Online (ECHO) (*Accessed October 29, 2013), http://www.epa-echo.gov/echo/stateperformance/dashboard.php?media=water&state=TN&view=activity.

[29] EPA, "Sanitary Sewer Overflows and Peak Flows," *Watershed Assessment, Tracking & Environmental Results,* 2012, http://cfpub.epa.gov/npdes/home.cfm?program_id=4

[30] Tennessee Department of Environment and Conservation, Division of Water Pollution Control, *TMDL for E. coli in the Lower Tennessee River Watershed* (September 15, 2010), E-78; TMDL *for Siltation and habitat Alteration in the Lower Tennessee River Watershed* (25 September 2006), 27.

[31] *NPDES Permit No. TNS068063,* 24.

[32] *NPDES Permit No. TNS068063*, 25.

[33] *NPDES Permit No. TNS068063*, 26.

[34] City of Portland, *Fanno-Tryon Macroinvertebrate Monitoring Plan (*9 February 2007), http://www.portlandoregon.gov/bes/article/264454.

[35] *NPDES Permit No. TNS068063*, 26.

[36] *NPDES Permit No. TNS068063*, 26.

[37] *NPDES Permit No. TNS068063*, 27.

[38] *NPDES Permit No. TNS068063*, 28.

[39] *NPDES Permit No. TNS068063*, 33.

[40] Chattanooga Water Quality Program, "Stream Corridor Evaluation (SCORE)," *Public Works,* http://www.chattanooga.gov/public-works/city-engineering-a-water-quality-program/water-quality-program/44-public-works/718-stream-corridor-evaluation-score.

[41] Chattanooga Water Quality Program, "Friar Branch Restoration Project," (presented at public meeting, November 20, 2008), slides 6-8.

[42] Department of Public Works, 1-2.

[43] City of Chattanooga, "resource: Rain," http://www.chattanooga.gov/images/citymedia/publicworks/WQ/ResourceRain/RRS.P1.Base-RPA.2013-smaller_file_size.pdf.

[44] City of Chattanooga, "Sewers, Mains and Drainage," *Chattanooga City Code* Chapter 31-4, http://www.chattanooga.gov/city-council-files/CityCode/31%20-%20Sewers,%20Mains%20and%20Drainage.pdf.

Image Sources:

Figure 27: City of Chattanooga Water Quality Program
Figure 28: Public Meeting Presentation, 15 April 2010, City of Chattanooga Water Quality Program
Figure 29: Public Meeting Presentation, 15 April 2010, City of Chattanooga Water Quality Program
Figure 30: http://www.studiolimage.com/planning_site/guidelines/03340guide-site-storm.html
Figure 31: http://www.crisangsteninteriors.com/blog/2012/08/repurposed-fun-at-the-crash-pad-in-chattanooga/