

City of Chattanooga / Hamilton County

# Monitoring Strategy

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Hamilton County



Water Quality Program



WOOLPERT



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# City of Chattanooga/Hamilton County - Monitoring Strategy

## Background

The City of Chattanooga and Hamilton County have collected samples and macroinvertebrates to assess water quality within their respective communities for approximately 20 years. More recently, the partners have used multi-parameter sondes and automatic samplers to improve their ability to characterize water quality in local receiving waters. In addition to these efforts to evaluate water quality, the City has implemented stream gauge stations for flood alert notifications. The partners' historical water quality and quantity data collection has been wide-ranging and used to support a variety of temporary and long-term goals.

In August 2019, the City and County executed a Memorandum of Understanding (MOU) between the partners titled "Participation in a Joint Watershed Data Sharing Program". The MOU acknowledged the benefits of working in tandem with clearly identified goals and objectives for a long-term continuous monitoring program to enhance both data collection programs. The MOU served as the catalyst for the development of this monitoring strategy, which will help the partners prioritize implementation of a county-wide monitoring network and on-going sampling by watershed.

## 1.0 Program Objective/Drivers

The purpose of the MOU between the partners includes several objectives to be achieved with the joint monitoring program as follows:

- To comply with State and Federal Clean Water laws
- To enhance regional emergency management preparedness and response
- To ensure consistent water quality monitoring

As evidenced by these objectives and as stated in the MOU, the data will be used to monitor streamflow and water quality across jurisdictional boundaries. Although the MOU provides a foundation for the continuous monitoring program, it is important that the purpose and objectives also align with broader City of Chattanooga and Hamilton County council and departmental goals.

## 1.1 City of Chattanooga - Department of Public Works (DPW)

### 1.1.1 Mission Statement

Several of the City of Chattanooga's departments have developed vision and/or mission statements to summarize the primary directive/goal for its departments' services. The Mission Statement for the City DPW is included on the Public Works home page as follows:

*"Serve people with integrity and improve the infrastructure and environment through excellence."*

The City of Chattanooga has implemented and maintains many programs to improve the environment through water quality initiatives. Although the long-standing sampling program already helps the City of Chattanooga assess progress towards improved water quality, the proposed monitoring program will provide an uninterrupted and enhanced perspective of local conditions. The City of Chattanooga will obtain high-frequency data during dry and

wet conditions, day and night, weekdays, and weekends. The high-frequency data should serve as a springboard to identifying appropriate Best Management Practices (BMPs) to improve the environment.

### 1.1.2 Stormwater and Flood Management Policy

As part of the American Public Works accreditation process, the DPW has developed a Stormwater and Flood Management Policy (Policy) numbered DPW 27. The Policy defines the purpose of the document, target levels of service for public stormwater infrastructure, and those responsible for implementing City of Chattanooga services related to stormwater and flood management.

The proposed monitoring program will provide data to assist the City of Chattanooga with many of the 19 duties and goals listed in the Policy. The program will particularly assist with Section 27.4.e "Determining Effectiveness – Sampling and Monitoring" of its Water Quality Goals. The City of Chattanooga is likely to realize direct benefits from the monitoring program as it relates to the following sections of the Policy:

*Table 1: Monitoring Benefits Related to the Stormwater and Flood Management Policy*

Section	Practice	Benefit
27.3	Floodplain and Floodway Management	Post-storm recurrence interval calculation, flood map verification/improvement
27.4	Water Quality Goals	Pollutant assessment, determining effectiveness, assess impairments
27.5	System In-Flow of Polluted Runoff	Short- and long-term pollutant trends
27.6	Allowable Non-Stormwater Discharges into System	Illicit discharge detection
27.7	Watershed Stormwater Drainage Master Plan	Model calibration data
27.11	Stormwater System Improvement	General system capacity assessment, high watermarks
27.12	Sediment and Erosion Control	Monitoring real-time turbidity
27.13	Stormwater Flood Warning Systems	Flood alert notifications
27.19	Public Education	Provide public dashboard to real-time data and educational programs for schools

The monitoring program should help the City of Chattanooga meet and exceed the standards set in the City of Chattanooga’s Stormwater and Flood Management Policy.

## 1.2 Thrive Regional Partnership

The Thrive Regional Partnership (Thrive) is a visionary planning organization encompassing a 16-county region including northeast Alabama, northwest Georgia, and southeast Tennessee (see Figure 1). Both the City of Chattanooga and Hamilton County provide financial support to allow Thrive to function as an independent organization. The mission of the Thrive Regional Partnership is to address the complexities of regional growth and is stated on their website ([www.thriveregionalpartnership.org](http://www.thriveregionalpartnership.org)) as follows:

*"The Thrive Regional Partnership inspires responsible growth through conversation, connection, and collaboration in the tri-state Chattanooga region."*

Thrive has identified five (5) core values to guide the implementation of the program. Within the explanation of the core values are descriptions that can be easily be connected to the resourcefulness and benefits of the monitoring program ([www.thriveregionalpartnership.org/core-values](http://www.thriveregionalpartnership.org/core-values)).

The following are four (4) of the five (5) core values with excerpts that align with the monitoring program:

**Stewardship** – *"We are trusted stewards of... the region's natural and cultural resources."* – Continuous water quality data provides unrivaled environmental awareness and the ability for real-time oversight of critical natural resources.

**Relationship Building** – *"We recognize that progress moves at the speed of trust, and trust is built when collaborative solutions are designed around the voices of the people we serve."* – This strategy is based upon collaboration between the City of Chattanooga and Hamilton County. The intended integration of remote telemetry with continuous monitoring will provide the means to share real-time data with the public. Transparency builds trust.

**Results Oriented** – *"Our focus is on achieving measurable outcomes based on clear, strategic goals that align with our mission and purpose, rather than the appearance of results."* – The description of this core value could easily serve as the overarching objective of this joint monitoring program. Every aspect of this strategy development process and the resulting quantitative results (>200,000 data points/station/year) align with this core value.

**Quality** – *"The quality of our work reflects the quality of our organization and the region's aspirations."* – The monitoring approach selected by the partners uses cutting-edge sensor technology. With the planned development of SOPs and third-party QC, the quality of the dataset will be second to none. The data will allow public works staff to provide regional leaders with watershed assessments that can be relied upon.



Figure 1: Thrive 55 Regional Partners

The rollout of the Thrive program has been characterized and cleverly themed as a "Watershed Moment," a play on words regarding opportunity and the surrounding landscape which defines the tri-state region ([www.thriveregionalpartnership.org/projects/watershed-moment-vision](http://www.thriveregionalpartnership.org/projects/watershed-moment-vision)). The opening paragraph describing the Watershed Moment vision states the following:

*"The tri-state Chattanooga region is defined by a portion of the Tennessee River watershed and its tributaries. For thousands of years, these waters have been the lifeblood of the natural and human communities that inhabit this special and beautiful landscape of hills, hollows, towns, and farms."*

The Vision further includes references to Conservation, Protection, Restoration, Biodiversity, and Habitat within these tributaries that make up the watershed. The ability to measure the potential achievement of these goals is greatly facilitated by the data that will be generated by the joint monitoring program.

The proposed monitoring program appears vital and almost inseparable to achieving the realization of the Thrive Vision. With the footprint of the program in the most populated and central portion of the tri-state region, it is particularly more impactful than it might be elsewhere. If the City of Chattanooga and Hamilton County leadership truly aspire to support the goals within the Thrive initiative, it is clear that the joint monitoring program is unknowingly an essential component to the organization's success.

### 1.3 MS4 Permit Requirements

Most urban communities are subject to municipal separate storm sewer system (MS4) permit requirements, and the City of Chattanooga and Hamilton County are no exception. These permits typically require some degree of sampling or monitoring that is dependent upon the community's size (Phase 1 or Phase 2 MS4) and whether the community includes Total Maximum Daily Loads (TMDLs) within its political boundaries that include load allocations associated with stormwater runoff. The City of Chattanooga and Hamilton County are permitted MS4s through TDEC, although both are operating their MS4s under permits that have passed their expiration dates. Pending further progress and draft new permits from TDEC, the partners continue to adhere to these permits as listed below:

*Table 2: MS4 Permit Information*

Entity	MS4 Designation	Permit Number	Original Expiration Date
City of Chattanooga	Phase 1 – Individual Permit	TNS068063	Nov 30, 2015
Hamilton County	Phase 2 – General Permit	TNS000000	Sept 30, 2021

Both of these permits include requirements for sampling or monitoring, which has been the primary historical reason for the development of the on-going monitoring programs for each community.

#### 1.3.1 City of Chattanooga

The City of Chattanooga Phase 1 permit includes four sections that explain the sampling or monitoring requirements as follows:

##### **Section 2.2, Discharges into Waterbodies with EPA-Approved or Established TMDLs**

*"A monitoring component to assess the effectiveness of the BMPs in achieving the wasteload allocations must also be included in the plan. Monitoring can entail a number of activities, including but not limited to: outfall monitoring, in-stream monitoring or modeling. Monitoring requirements are further described in part 4 of this permit."*

### **Section 2.3, Discharges to Impaired Waterbodies without EPA-Approved TMDLs**

*"... the permittee... must demonstrate (through outfall monitoring, in-stream monitoring and/or modeling) that the discharge will not further the impairment. A monitoring component to assess the effectiveness of the BMPs in controlling the discharge of pollutants of concern must also be included in the plan. Monitoring can entail a number of activities, including but not limited to: outfall monitoring, in-stream monitoring or modeling. Monitoring requirements are further described in part 4 of this permit."*

In addition to these requirements, **Section 3.3, Stormwater Monitoring Program**, includes monitoring requirements that are unique to the City of Chattanooga. These wide-ranging requirements are particular regarding locations for data collection, parameters for collection, and frequency of the assessments. The City of Chattanooga is required to conduct the following:

- Wet weather monitoring for three (3) storms/year at five (5) select locations for over 30 different parameters
- Ambient annual monitoring at five (5) locations for the same parameters included for wet weather
- Biological monitoring at two (2) urban streams, twice/year
- Sampling for watershed characterization of Friar Branch for *E. coli* and TSS, twice/year
- Field sampling using the grid method to identify illicit discharges and track illicit discharges by landuse, twice/permit term
- Sampling at four (4) NPDES permitted industries and four (4) municipal waste management facilities once/year for a variety of parameters
- Collecting two (2) samples for PHFs during the summer once during the permit term
- Collection of samples from a sub-watershed without establishing MS4 maintenance procedures

**Section 4, Monitoring, Recordkeeping, and Reporting**, of the permit, provides two options for meeting the requirements under Section 2.2 and 2.3. The City of Chattanooga can conduct "Analytical" or "Non-analytical monitoring," and the permit provides details regarding compliance with each of these options.

### 1.3.2 Hamilton County

The TN NPDES general permit for discharges from small MS4s includes two sections in Section 3, Special Conditions, which require sampling or monitoring. Both sections include very similar language to that included in the City of Chattanooga individual permit. The following are excerpts from those sections of the permit:

#### **Section 3.1.1, Discharges into Waterbodies with EPA-Approved or Established TMDLs**

*"The SWMP must also contain a monitoring and/or evaluation component to assess the effectiveness of the BMPs in achieving the reductions, and overall compliance with the standard of the Maximum Extent Practicable (MEP). Monitoring can entail a number of activities, including but not limited to: outfall monitoring, instream monitoring or modeling. Monitoring requirements are further described in part 5 of this permit."*

#### **Section 3.1.2, Discharges into Waterbodies with Unavailable Parameters without TMDLs**

*"Compliance with this section shall be demonstrated through a monitoring component to assess the effectiveness of the BMPs in controlling the discharge of these pollutants. This component must also be included in the SWMP. Monitoring can entail a number of activities, including but not limited to: outfall monitoring, instream monitoring or modeling. Monitoring requirements are further described in part 5 of this permit."*

In **Section 5, Monitoring, Recordkeeping, and Reporting**, the permit provides two options for meeting the requirements under Section 3. Hamilton County must conduct “Analytical” and “Non-analytical monitoring,” and may follow the details provided in the permit or submit an alternative monitoring plan for approval by the State.

#### 1.4 TMDLs

As highlighted above, both the City of Chattanooga and Hamilton County MS4 permits require monitoring to be incorporated into the respective community's SWMP to evaluate the effectiveness of BMPs to meet TMDLs. The vast majority of Hamilton County drains within the Lower Tennessee River (HUC 06020001) watershed. Currently, there are nine (9) EPA-approved TMDLs for two (2) different watersheds that include portions of Hamilton County (Lower Tennessee River and Hiwassee). Of the nine (9) TMDLs, only six (6) are included within waterbodies in this monitoring strategy, all of which were developed for the Lower Tennessee River. The Lower Tennessee River watershed includes many of the watersheds that are characterized for potential monitoring throughout this strategy document. Table 3 below includes a list of the affected waterbodies and the respective TMDL parameter:

*Table 3: TMDL Pollutant Parameter by Listed Waterbody*

Listed Waterbody	TMDL Pollutant Parameter						
	pH	<i>E. coli</i>	Siltation, habitat alteration	pH, iron	Dioxins, PCBs	<i>E. coli</i>	PCBs, dioxin
Year	2005	2006	2006	2006	2009	2010	2010
North Market Street Branch	X	X				X	
Friar Branch	X					X	
Unnamed Trib to Citico Creek	X	X	X			X	
Spring Creek	X					X	
South Chickamauga Creek	X					X	
Lewis Branch	X					X	
Citico Creek	X	X	X				
Dobbs Branch	X	X	X				
Unnamed Trib to Chattanooga Creek	X	X	X				
McFarland Springs Branch	X	X				X	
Gillespie Springs Branch	X		X			X	
Chattanooga Creek	X	X	X		X	X	
Stringers Branch	X	X	X				
Lewis Branch		X	X				
Spring Creek		X					
Friar Branch		X	X				
South Chickamauga Creek		X	X				
South Suck Creek			X	X			
North Suck Creek				X			
Ninemile Branch			X				
N. Chickamauga Creek			X				
Unnamed Trib to Chattanooga Creek			X				
Mountain Creek			X			X	
Unnamed Trib to South Chickamauga Creek						X	
Macky Branch						X	
Wolfe Branch						X	

Listed Waterbody	TMDL Pollutant Parameter						
	pH	<i>E. coli</i>	Siltation, habitat alteration	pH, iron	Dioxins, PCBs	<i>E. coli</i>	PCBs, dioxin
Long Savannah Creek (incl. unnamed trib to Long Savannah Creek)						X	
Bivens Branch						X	
Shoal Creek						X	
Short Creek						X	
Stanley Branch						X	
Bee Branch						X	
Stringers Branch						X	
Rogers Branch						X	
Little Wolftever Creek						X	
Chestnut Creek						X	
Wilkerson Branch						X	
Unnamed Trib to Wolftever Creek						X	
Wolftever Creek						X	
Nickajack Reservoir							X

Although a comprehensive monitoring program is *recommended* to support the City of Chattanooga's mission statement, the City of Chattanooga's Storm Water and Flood Management Policy, and the Thrive Regional Partnership, the partners' MS4 permits *require* both entities to conduct monitoring for regulatory compliance.

## 2.0 Watershed Grouping

The partners provided 19 major watersheds of interest to consider for the monitoring strategy. In addition to and within the 19 major watersheds, the partners provided 49 subwatersheds that were delineated using ArcHydro software (note that these boundaries were not further edited/refined by Woolpert). After ultimately combining the major watersheds and subwatersheds to obtain an appropriate watershed scale for the evaluation, Woolpert and the partners identified a total of 31 subwatersheds for consideration, ranging from 1 to 26 square miles.

Collecting data from too large of a watershed would yield inconclusive information for BMP assessments or other targeted improvements. Conversely, equipment frequently becomes buried or unsubmerged when the upstream watershed is too small to produce consistent flow. In an effort to bring all subwatersheds to similar sizing, subwatersheds were merged, removed, and divided as follows:

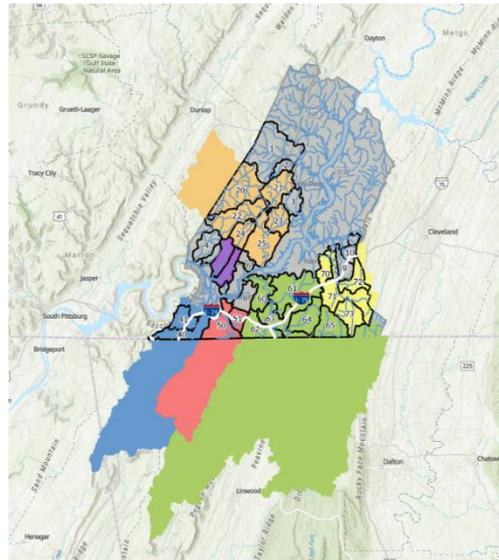


Figure 2: Watershed Grouping Inside Hamilton County

- Drainage outside of Hamilton County was noted in several subwatersheds before clipping each to the study area.
- Subwatersheds under 5 square miles were merged with one another where USGS streams and hydro coverage indicated merging was appropriate.

- Subwatersheds under 5 square miles with no notable characteristics pertaining to water quality and quantity monitoring and discharging directly to the Tennessee River or out of Hamilton County were removed from the analysis.
- Subwatersheds over 30 square miles were divided into upstream and downstream portions.

To better understand how different areas are related spatially and how they influence one another, subwatersheds were grouped by major watersheds in Hamilton County as follows: Chattanooga Creek, Lookout Creek, North Chickamauga Creek, South Chickamauga Creek, Stringers Branch, Wolftever Creek, and several individual watersheds discharging to the Tennessee River, Chickamauga Lake, or Harrison Bay.

### 3.0 Data Sources and Analysis

#### 3.1 Water Quality

Analysis of historical monitoring data was performed for 31 subwatersheds in order to characterize water quality parameters that might direct the partners’ future water quality data collection efforts. As previously mentioned, for analysis purposes, the grouping into six major watersheds, provides a macro level insight as a whole. The grouping of watersheds, titled “Other” in Appendix A, that drain directly to the Tennessee River should be considered individually and not as a group. Data were collected between 2009-2021 (herein referred to as historical data) from three different agencies for this effort: City of Chattanooga, Hamilton County, and TDEC. These data were combined within each subwatershed with minor adjustments where required to account for issues with units and other abnormalities. The sampling parameters that were reviewed for inter-watershed comparisons were total nitrogen (TN), total phosphorus (TP), total suspended solids (TSS), *E. coli*, dissolved oxygen (DO), and conductivity. Additional data for pH, lead, copper, and iron were sporadically available and included for reference in Appendix A.

Table 4: Summary of Sites Reviewed by Data Source and Watershed

Major Watershed	Reference Number	Subwatershed	Total Unique Sites	Total Number of Stations by Source		
				City of Chattanooga	Hamilton County	TDEC
Other	1	Soddy Creek	9		1	8
	2	Little Soddy Creek	2		1	1
	3	Daisy Dallas Tributary	1			1
	4	Middle Creek	8			8
	5	Shoal Creek	3		1	2
	7	North Market St Branch	12	12		1
	8	Citico Creek	18	17		4
	9	Rogers Branch	4		3	1
	11	Ison Springs Branch	1			1
North Chickamauga Creek	20	US North Chickamauga Creek	12			12
	21	Poe Branch	3		2	1
	22	Falling Water Creek	4		2	2
	23	Lick Branch	3		1	2
	24	Pitts Branch	8	2	3	5
	25	DS North Chickamauga Creek	13	10	1	3
Stringers Branch	30	Mountain Creek	11	7	3	4
	31	Stringers Branch	5	1	4	3
Lookout Creek	40	Lookout Creek	3	1		3
	41	Black Creek	6	1		6
Chattanooga Creek	50	Chattanooga Creek	28	20	1	10
	51	Dobbs Branch	10	10		1
South Chickamauga Creek	60	Downstream SDS South Chickamauga Creek	3	1		3
	61	Friar Branch	15	11		7
	62	Spring Creek	4	1	3	2

Major Watershed	Reference Number	Subwatershed	Total Unique Sites	Total Number of Stations by Source		
				City of Chattanooga	Hamilton County	TDEC
	63	Upstream SUS South Chickamauga Creek	8	1	3	6
	64	Mackey Branch	5	1	1	4
	65	Hurricane Creek	2			2
Wolftever Creek	70	Hunter Branch	1			1
	71	Wolftever Creek	7		4	5
	72	Little Wolftever Creek	4		3	2
	73	Chestnut Creek	5		2	4

As shown in Table 4, major watersheds considered in this effort were North Chickamauga Creek, Stringers Branch, Lookout Creek, Chattanooga Creek, South Chickamauga Creek, Wolftever Creek, and a category containing individual watersheds that were not grouped with any other subwatershed. The other category should be viewed as each watershed being separate and not considered as an overall watershed. Interpretation of the historical data is based on the assumption that samples were collected under both dry and wet weather conditions to provide an overall picture of average conditions in each watershed.

This section highlights key observations of the results of these analyses for the six major watershed groups as well as the individual subwatersheds in the "Other" category, organized by measured parameter. All tabular and graphical summaries of the historical data by each parameter are summarized and included in Appendix A. Subwatersheds with low sample counts for each parameter were included in these summaries for completeness, but the lack of data in certain locations should be cautiously considered when comparing these to other subwatersheds.

#### Total Nitrogen

Nitrogen is a key nutrient that stimulates the growth of aquatic plants and algae. Excess levels of nitrogen can lead to the overgrowth of these organisms, possibly resulting in oxygen depletion and unpleasing aesthetics. TDEC does not assign statewide numerical criteria to total nitrogen; therefore, the subwatersheds were compared only to one another. The average and median TN for the overall dataset are 0.86 mg/L and 0.61 mg/L, respectively. Ten of the considered subwatersheds (3, 7, 8, 23, 31, 40, 50, 51, 62, 70) have an average or median TN of over 1 mg/L. Three of these ten subwatersheds (3, 23, 70) have very limited datasets and should be interpreted with caution. Of particular note are the subwatersheds associated with the Chattanooga Creek major watershed. Chattanooga Creek (50) has a median of 0.6 mg/L and an average of 1.3 mg/L. This is due to a large number of outliers above the median, indicating possible local influences elevating total nitrogen at that location. Dobbs Branch (51) has the highest median and average TN of any considered subwatershed of 2.7 mg/L and 2.9 mg/L, respectively.

#### Total Phosphorus

Similarly to nitrogen, phosphorus is another key nutrient that can lead to the excess growth of aquatic plants and algae groups. Likewise, TDEC does not assign total phosphorus numeric criteria for surface waters; therefore, the inter-watershed comparisons will be used to note observations of interest. The overall average and median TP for the dataset are 0.05 mg/L and 0.02 mg/L, respectively. Eight of the observed subwatersheds (7, 8, 23, 30, 40, 50, 51, 63) have an average or median TP of over 0.05 mg/L. Lick Branch (23) has a limited dataset and should be interpreted with caution. Chattanooga Creek (50) has the highest average of all subwatersheds with a value of 0.12 mg/L; however, the median is 0.04 mg/L. This is again due to the large number of outliers at this location, eight of which are above 0.60 mg/L. Citico Creek (4) has the highest median of 0.09 mg/L and an average of 0.10 mg/L. Stringers Branch (30) is also of particular note, with six outliers greater than 0.60 mg/L.

#### Total Suspended Solids

Elevated TSS levels have a negative effect on macroinvertebrates/fish, stream aesthetics, water treatment costs (where applicable), and overall water quality. Excess TSS can also be an indicator of streak bank erosion or sediment

runoff from construction. TDEC again has not developed statewide numerical criteria, so comparisons will be made between subwatersheds and not a water quality standard. The overall dataset average and median are 14 mg/L and 5 mg/L, respectively. Of note, here are the seven subwatersheds (7, 8, 25, 30, 50, 51, 61) that have a large number of outliers greater than 50 mg/L. The periods of increased TSS during the time these samples were collected potentially indicates large amounts of sediment runoff or channel/stream bank erosion at these locations.

### ***E. coli***

The significant presence of *E. coli* in a waterway is a strong indicator of human or animal waste contamination. Potential sources are sanitary sewer overflows, leaks in septic or sanitary sewer systems, human waste from homeless communities, and runoff from domestic or wild animal waste. TDEC's single sample criteria for recreation is 487 CFU/100ml for exceptional waters and 941 CFU/100ml for other waters. The overall dataset average and median are 1,274 CFU/100mL and 270 CFU/100mL, respectively. Soddy Creek (1), Daisy Dallas Trib (3), Lick Branch (23), and Hurricane Creek (65) all have maximum sample concentrations less than the recreational bacteria standard for exceptional waters. Collectively, there were 167 samples out of the dataset that exceeded 5,000 CFU/100ml. North Market St Branch (7), Citico Creek (8), and Dobbs Branch (51) recorded 9%, 7.5%, and 10.5% of their total samples, respectively, at a value over 5,000 CFU/100mL. Dobb's Branch had the highest average out of the subwatersheds (3,559 CFU/100ml) followed by North Market St Branch (2,815 CFU/100ml), Citico Creek (2,495 CFU/100ml), Friar Branch (1,220 CFU/100ml) and DS North Chickamauga Creek (1,218 CFU/100ml).

### **Dissolved Oxygen**

Dissolved oxygen is a measure of how much oxygen in the water is available to living aquatic organisms, making it a very important component of stream health. Although dissolved oxygen in a waterway typically fluctuates in any given year due to seasonal temperature differences, the concentration can produce adverse impacts if it falls below the TDEC daily average standard of 5mg/L with a minimum DO level of 4 mg/L for a single measurement. Low DO can be the result of high levels of biological and/or chemical oxygen-depleting substances or stagnant water during dry periods. No subwatershed has an overall average less than 5 mg/L. Sixteen subwatersheds have had at least one measurement resulting in less than 4 mg/L of DO. Of particular note are North Market St Branch (7), Citico Creek (8), Downstream North Chickamauga Creek (25), Chattanooga Creek (50), and Dobbs Branch (51), which have had 10%, 7%, 8%, 8%, and 9% of their samples measure below 4 mg/L of DO, respectively.

### **pH**

High and low pH values can be an indicator of multiple factors contributing to anthropogenic effects on a stream. These conditions can also be exacerbated by acidic rainfall. TDEC standards state that pH should be between 6.0 – 9.0 for wadeable streams and 6.5 – 9.0 for larger waterbodies. North Chickamauga Creek (20) is the only subwatershed to have an average or median pH outside of these ranges with a value of 5.4 and 5.9, respectively. In total, eight subwatersheds have at least one measurement above a pH of 9, and fifteen subwatersheds have at least one measurement less than a pH of 6. Subwatersheds with a large number of outliers, indicating potential influencing factors, are Mountain Creek (30), Chattanooga Creek (50), and Friar Branch (61).

### **Conductivity**

Abrupt changes in concentrations and the fluctuation of conductivity within a watershed often indicates a discharge or source of pollution in the waterbody. A decrease in conductivity indicates dilution of the waterbody, which is usually the result of a storm event. Particular attention was given to outliers for this parameter to gain an understanding of how often a waterbody exceeds the normal range of conductivity values in that subwatershed. Nineteen subwatersheds show at least one outlier above the normal value. Citico Creek (8), Chattanooga Creek (50), Dobbs Branch (51), Downstream South Chickamauga Creek (61), and Friar Branch (62) show a large number of outliers, indicating potential discharge or runoff of pollutants into these waterbodies. Upstream North Chickamauga Creek (20) also displays a large range of conductivity values, potentially indicating regular water quality changes in that subwatershed.

### 3.2 Stage/Flow

The United States Geological Survey currently has 12 stream gauge stations within the major watersheds. Nine (9) stream gauge stations are within Hamilton County and seven (7) of these are within watersheds prioritized by this monitoring strategy (Table 5). The number of stream gauge stations or flood alert stations vary based on watershed.

*Table 5: Number of Active USGS Stations by Watershed within Hamilton County*

Watershed Name	Number of USGS Stations
South Chickamauga Creek	2
Chattanooga Creek Watershed	0
Wolftever Creek	1
Lookout Creek	1
Stingers Branch and Mountain Creek	2
North Chickamauga Creek	1
Citico Creek	0
Access Tributary to the Tennessee River	0

The City of Chattanooga and Hamilton County use stream stage, rainfall, and flow data from the USGS stations to calibrate local flood models. Additionally, data from some locations are used by the National Weather Service’s Advanced Hydrologic Prediction Service for the predictive National Water Model. Outside of water quantity, each USGS monitoring location includes a rain gauge that has been used to assist with the partners’ stormwater programs. With a large network of rain gauges, stage and flow already being collected in the major watersheds, the partners will leverage any current or historical data collection to avoid redundancy with any proposed monitoring stations.

## 4.0 Criticality Analysis

One approach for evaluating and prioritizing stations and data collection is through the coupled evaluation of water quality and quantity risks and consequences. The identification of possible threats to water quality and sources of flooding are important to consider in the protection of human and environmental health and safety. Although the management of several of these risks to water quality and quantity is not necessarily the partners' responsibility, these variables could be detrimental to water quality and quantity. They could also negate any incremental gains in water quality and quantity enhancement from BMPs implemented by the partners and should be monitored closely. The sections below list water quality and quantity risks and consequences considered while developing this monitoring strategy based upon available geospatial information (see Monitoring Strategy Matrix in Appendix B). Additional information is provided below regarding the source of the data and the date of the data source if known.

### 4.1 Water Quality and Quantity Risks

#### **Impervious Area**

A county-wide impervious area coverage was provided that included land coverage of airports, buildings, driveways, structures, parking, roads, sidewalks, and other miscellaneous impervious surfaces. While the Hamilton County land coverage dataset was created in 2012, information is routinely maintained and updated. Large areas of imperviousness and development correspond to high peak runoff rates and pollutant potential from non-point source runoff.

#### **Reported Sanitary Sewer Overflow (SSO)**

Reported SSOs account for all Hamilton County Waste and Wastewater Treatment Authority (WWTa) and City of Chattanooga Moccasin Bend Wastewater system five (5)-year totals (2016-2020) observed in each subwatershed. Total SSOs observed in 2020 alone were also quantified in each subwatershed. The five (5)-year total is indicative of the risk of future SSOs due to failing sanitary sewer infrastructure and the 2020 total of the current state of this infrastructure.

### **Remediation Sites**

Remediation Sites refers to sites that are or have been under the Tennessee Division of Remediation (DOR) supervision. Data were obtained from the DOR website in November 2021. The Division of Remediation identifies and investigates hazardous substance sites. Stormwater runoff from a remediation site poses threats to public and environmental health.

### **Permitted Industrial Facilities**

Tennessee's industrial stormwater discharge permit is known as the Tennessee Multi-Sector Permit (TMSP). TDEC provided county-wide TMSP coverage updated in 2021. The TMSP covers facilities with significant industrial materials exposed to rainfall and therefore maintains the potential for stormwater contamination.

### **Visual Stream Assessment Score**

Hamilton County and City of Chattanooga staff performed visual stream assessment at many stream segments throughout the study area. Hamilton County's stream assessment was conducted from 2010 to 2014, and the City of Chattanooga's stream assessment was performed from 2011 to 2015. Factors considered in the resulting score assigned to stream segments are canopy/vegetation, construction, alteration, blockage, outfalls/pipe crossings, and erosion. The total score was averaged in each subwatershed and designated to a category of low, medium, or high accordingly.

## 4.2 Water Quality and Quantity Consequences

### **Structures in the 500-Year Floodplain**

Hamilton County provided all existing structures within the 500-year FEMA floodplain in Hamilton County boundaries. These structures are susceptible to flooding.

### **Vulnerable Parks**

Vulnerable Parks refer to City of Chattanooga and Hamilton County parks and recreational facilities that fall within 100-ft of a stream. The City of Chattanooga and Hamilton County invite the public to enjoy these areas and should monitor them closely. Water quality and quantity issues in subwatersheds with vulnerable parks may pose a threat to public health and safety.

### **Managed Natural Areas**

Managed Natural Areas are state or federally managed properties within Hamilton County (2004). These areas are managed to protect Native American culture, wildlife habitat, or natural resources and include reservations, state parks, state forests, state wildlife refuges, habitat protection areas, wildlife sanctuaries, and other managed areas.

### **Impaired Waters and TMDLs**

While not depicted spatially, Impaired Waters from TDEC's 2020 303(d) list and TMDL Watersheds (October 2021) are included in the analysis. Subwatersheds with existing pollutants of concern that have resulted in the development of a TMDL or have the potential to become a TMDL are indicated with each pollutant of concern.

Each of the water quality and quantity risks and consequences included above have been identified on mapping by subwatershed and depicted in Figure 4 – Figure 8 and Appendix C. A tabular summary of each subwatershed is included in the Monitoring Strategy Matrix (Appendix B).

## 5.0 Watershed Priorities

The following section provides tiered watershed monitoring recommendations based on those factors highlighted earlier within this report. The recommendations range from the implementation of continuous water quality monitoring, to focused manual grab sampling during specific dry/storm conditions, to maintaining the sampling conducted by the partners. The following sub-sections define considerations used to categorize each subwatershed:

### High Priority

For those subwatersheds included within various TMDLs and subject to 303(d) impairments, demonstrated poor water quality trends (see Section 4.0) that maintain notable flood risk and considerable risks/consequences, high-frequency data collection using a combination of continuous monitoring and discrete sampling during dry and storm conditions is recommended. These subwatersheds were generally highly developed and located in the vicinity of the downtown Chattanooga area. They have been denoted as "High Priority," and detailed watershed summaries have been provided for each subwatershed.

### Priority

For subwatersheds with more moderate threats of adverse water quality, data trends that less frequently demonstrate concern, and fewer structures at risk of flooding, these subwatersheds have been grouped into a "Priority" subwatershed category. In some cases, these subwatersheds exhibited factors that indicated high priorities, but the watershed boundaries extended well beyond the City of Chattanooga or Hamilton County political boundaries. This implied potential reduced influence from the partners to make watershed-scale improvements and the need for multiple sample locations to assess influent to Hamilton County and effluent into the Tennessee River. These subwatersheds were prioritized lower for the onset of the continuous monitoring program. A two-tiered grab sampling approach is recommended for these watersheds.

### Long Term Priority

The remaining subwatersheds have been grouped into a category referred to as "Long Term Priorities," indicating reduced or lack of immediate threats to water quality and flooding relative to the other two categories. These subwatersheds were commonly located outside of city limits and were less developed. These subwatersheds may or may not currently include locations that are sampled by the partners but may include TDEC sample locations. It is recommended that current sampling in these watersheds is maintained.

A tabular summary of all of the factors considered for prioritizing subwatersheds is included in the Monitoring Strategy Matrix in Appendix B.

## 5.1 High Priority Subwatersheds

The summaries below provide an overarching review of conditions in each high priority subwatershed to help the partners identify watershed monitoring priorities. Area maps are included for each high-priority subwatershed. Figure 3 provides a legend for each area map to follow (Figure 4– Figure 8). It is recommended to reference the map in Appendix C to further clarify each subwatershed location relative to other subwatersheds. These subwatersheds below (listed in no particular order) should be considered immediately for continuous monitoring to improve watershed characterization capabilities and to manage risks from flooding:

Legend	
<u>Existing Stations</u>	<u>Consequences</u>
✚ USGS Gauges	• Structures in the 500 Year Floodplain
📍 Hamilton County Sampling Stations	🏠 Recreational Facilities
📍 Chattanooga Sampling Stations	🌿 Managed Natural Areas
📍 TNDEC Sampling Stations	
<u>Risks</u>	<u>Other</u>
🗑️ Active Landfills	🛣️ Interstates
🏭 Wastewater Treatment Facility	🚂 Railway Lines
🔵 Reported 2020 SSOs	🌊 Streams
🟢 Industrial Permits	🌊 Hydro Layer
🔹 Remediation Sites	📐 Hamilton County
Visual Stream Assessment Score	
🟢 Low	
🟡 Medium	
🔴 High	

Figure 3: Area Maps Legend

## Citico Creek (Subwatershed 8)

Located in the northeastern portion of downtown Chattanooga, the Citico Creek subwatershed is one of the subwatersheds that drains directly to the Tennessee River. Although draining only approximately six (6) square miles, the subwatershed is heavily regulated due to historical and well-documented water quality conditions. It includes 17 TDEC sample locations (the most of any subwatershed) and 16 City of Chattanooga sample locations that have been used for the identification/development of numerous existing impairments and TMDLs. As shown with the bullets below, the subwatershed is highly developed with many sources of concern related to water quality and flooding. With the extents of the subwatershed entirely contained within City of Chattanooga limits, continuous monitoring is recommended to further assess and characterize potential pollutant sources and BMPs to mitigate them.

- 100% within City of Chattanooga limits
- 34 existing sampling locations, tied for the subwatershed with most sample locations
- 61% impervious, 2<sup>nd</sup> most impervious subwatershed
- Moderate numbers of remediation sites and permitted industrial dischargers
- Includes 775 structures within the 500-year floodplain, 4<sup>th</sup> highest among all subwatersheds
- Includes six (6) impairment categories, most of all subwatersheds, and four (4) TMDL parameters
- Predominantly poor water quality over the last decade, highest median for TP among all subwatersheds, frequently elevated bacteria concentrations and low DO

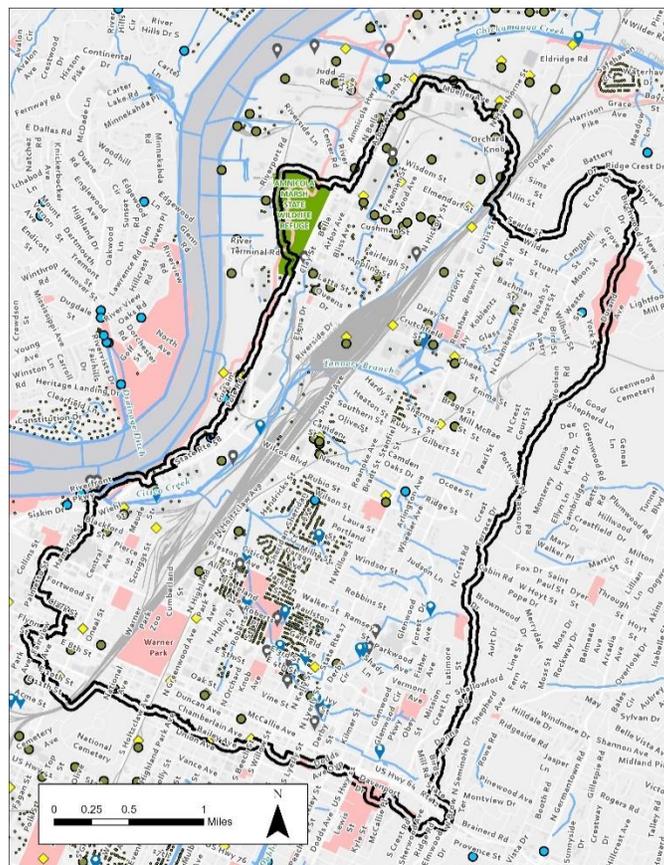


Figure 4. Citico Creek Area Map

## Downstream North Chickamauga (Subwatershed 25)

The Downstream North Chickamauga subwatershed (as named/delineated) includes 17 square miles, but unlike the Citico Creek subwatershed, this tributary conveys drainage from 5 other subwatersheds within unincorporated Hamilton County and neighboring Sequatchie County that make up the North Chickamauga subwatershed. Although draining a portion of Sequatchie County, it includes much less drainage area outside of Hamilton County than those subwatersheds located along the southern TN border such as Lookout Creek, Chattanooga Creek, and South Chickamauga Creek. The subwatershed does not include the highest numbers in any particular category yet has a broad range of notable concerns across virtually every category included in the Monitoring Strategy Matrix located in Appendix B. The bullets below include only those metrics from subwatershed 25, but efforts to improve water quality here would likely require similar improvements across other contributing subwatersheds.

- Located within the North Chickamauga subwatershed
- One of the more highly sampled subwatersheds
- Includes a moderate number of SSOs with 30 just in 2020
- Includes a moderate number of permitting industries and a medium visual stream assessment score
- Contains the 4<sup>th</sup> highest number of structures at risk of flooding, with 683
- Anticipate much higher flows in this subwatershed due to the contributing drainage area upstream and would require a robust monitoring station to withstand these conditions
- Graded poor for *E. coli* and DO over last decade with frequent outliers for conductivity, yet currently includes no 303d impairments and one TMDL

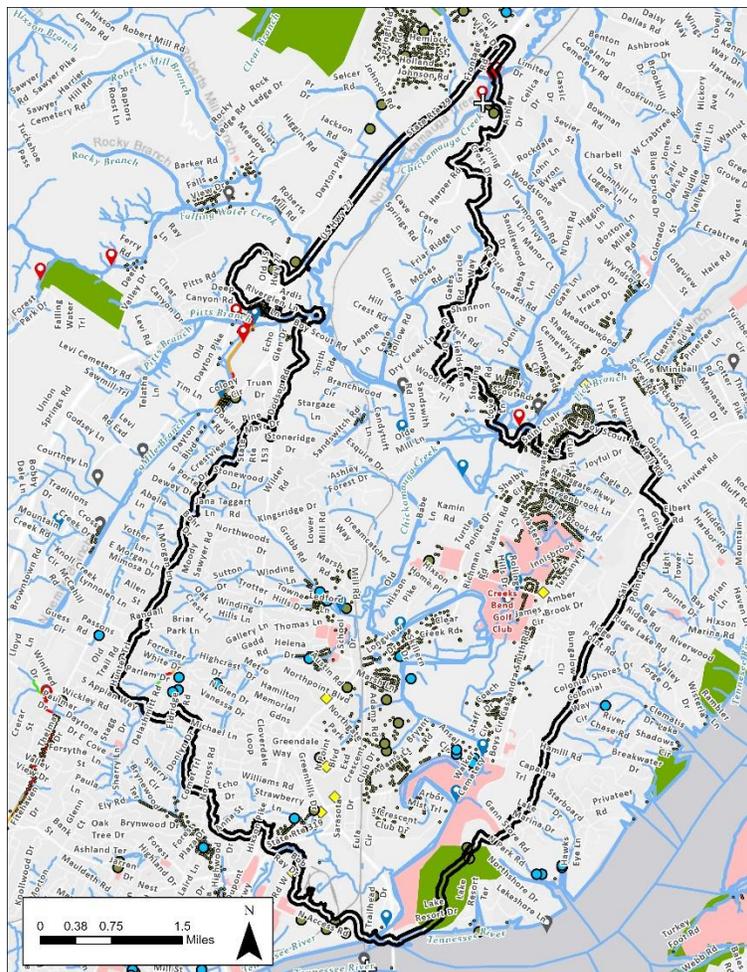


Figure 5. Downstream North Chickamauga Creek Area Map

## Stringers Branch (Subwatershed 31)

Stringers Branch subwatershed is located on the west side of the Tennessee River adjacent to the Mountain Creek subwatershed, both draining into Baylor Lake before discharging into the River. Most of the Stringers Branch subwatershed is contained within the City of Red Bank, with minor overlap from City of Chattanooga limits at the outlet of the subwatershed. The combination of only 12 structures at risk of flooding and one (1) USGS gauge station along the main stem of the creek indicate notable flood risk management efforts in the subwatershed. However, this subwatershed includes all of the evaluated water quality risks with a high visual stream assessment score and is under considerable regulatory scrutiny by TDEC via 303 impairments and TMDLs.

- Only 18% of the subwatershed is within City of Chattanooga limits
- Includes a moderate number of sampling stations with nine (9) and one (1) USGS gauge station
- One of only two (2) subwatersheds with a high average visual stream assessment score
- Contains the 4<sup>th</sup> highest number of SSOs since 2015 with 140 and 34 just in 2020
- Includes very few structures at risk of flooding and only one (1) vulnerable park/manage area
- Demonstrated fair water quality over the last ten (10) years with frequent TP outliers
- Heavily regulated for water quality four (4) 303(d) impairments and 4 TMDLs

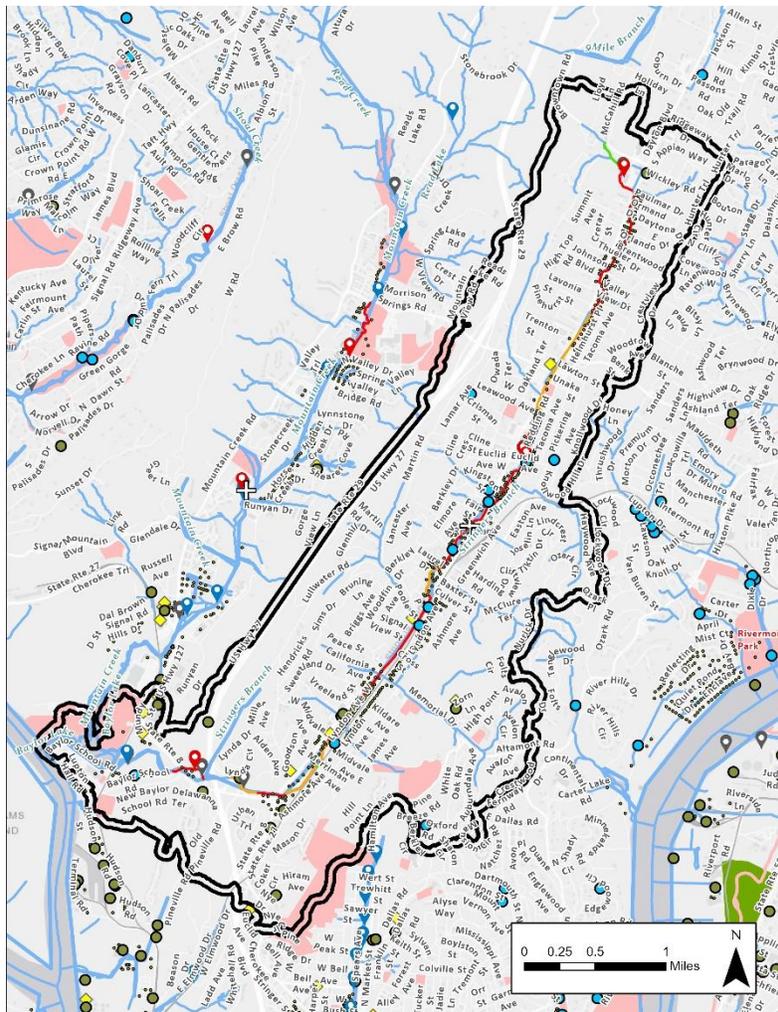


Figure 6. Stringers Branch Area Map

## Dobbs Branch (Subwatershed 51)

Dobbs Branch is a tributary to Chattanooga Creek in the southern portion of Hamilton County. These two subwatersheds are the most impervious subwatersheds within Hamilton County, with over 1000 structures at risk of flooding in each of the two (2) subwatersheds. Both subwatersheds exhibit poor water quality, evidenced by the analysis of the last decade of water quality data and the considerable number of 303(d) impairments and TMDLs. Dobbs Branch is recommended for continuous monitoring because the subwatershed is contained entirely within Hamilton County (and City of Chattanooga limits), in addition to being subject to water quality regulations for parameters that can be measured/approximated with commercially available sensors.

- Located within Chattanooga Creek subwatershed and 100% within City of Chattanooga limits
- Third highest number of City of Chattanooga sample locations with 12
- The subwatershed is 72% impervious, with 1377 structures at risk of flooding, both the highest of any other subwatersheds
- Third highest number of reported SSOs in 2020 with 43
- One (1) of only two (2) subwatersheds with a high average visual stream assessment score
- Third highest numbers of remediation sites and industrial permittees
- Includes four (4) vulnerable parks
- Poor to fair water quality data over the last decade, with highest average total nitrogen and *E. coli* among all subwatersheds, frequently low DO, and outliers for conductivity
- Tied with Chattanooga Creek for the most impairments with six (6) and four (4) TMDLs

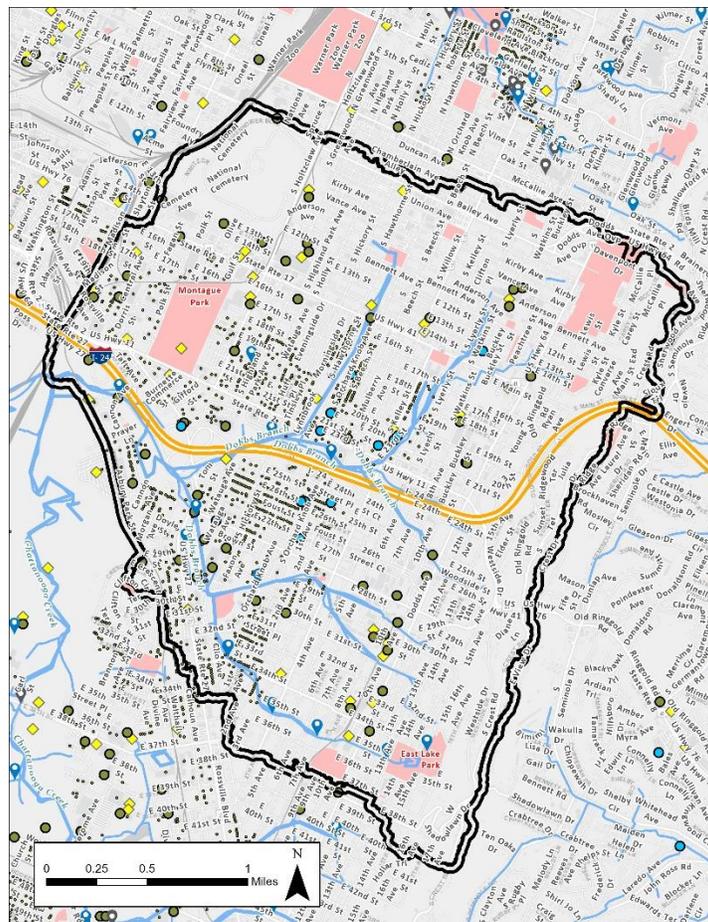


Figure 7. Dobbs Branch Area Map

## Friar Branch (Subwatershed 61)

The Friar Branch subwatershed is the largest of the subwatersheds within the overall South Chickamauga subwatershed at 23 square miles. The subwatershed includes high numbers of risk factors across all categories for water quality and quantity, but with the extents of the subwatershed contained entirely within the City of Chattanooga and Hamilton County, there is greater opportunity for possible improvements. There are many sampling and gauge stations across the subwatershed, but continuous monitoring can likely assist with source characterization of some of these issues.

- 72% within City of Chattanooga limits, the remainder of the subwatershed is within Hamilton County
- Second largest subwatershed at 23 square miles
- Heavily assessed with 11 TDEC, 11 City of Chattanooga sample stations, and one (1) USGS station
- Includes the 3<sup>rd</sup> highest imperviousness at 49% and 3<sup>rd</sup> highest number of structures at risk of 985
- Contains 2<sup>nd</sup> highest numbers of permitted industries and remediation sites
- Varied water quality results over the last decade, frequently low pH, and conductivity outliers
- Subject to four (4) 303(d) impairments and four (4) TMDLs

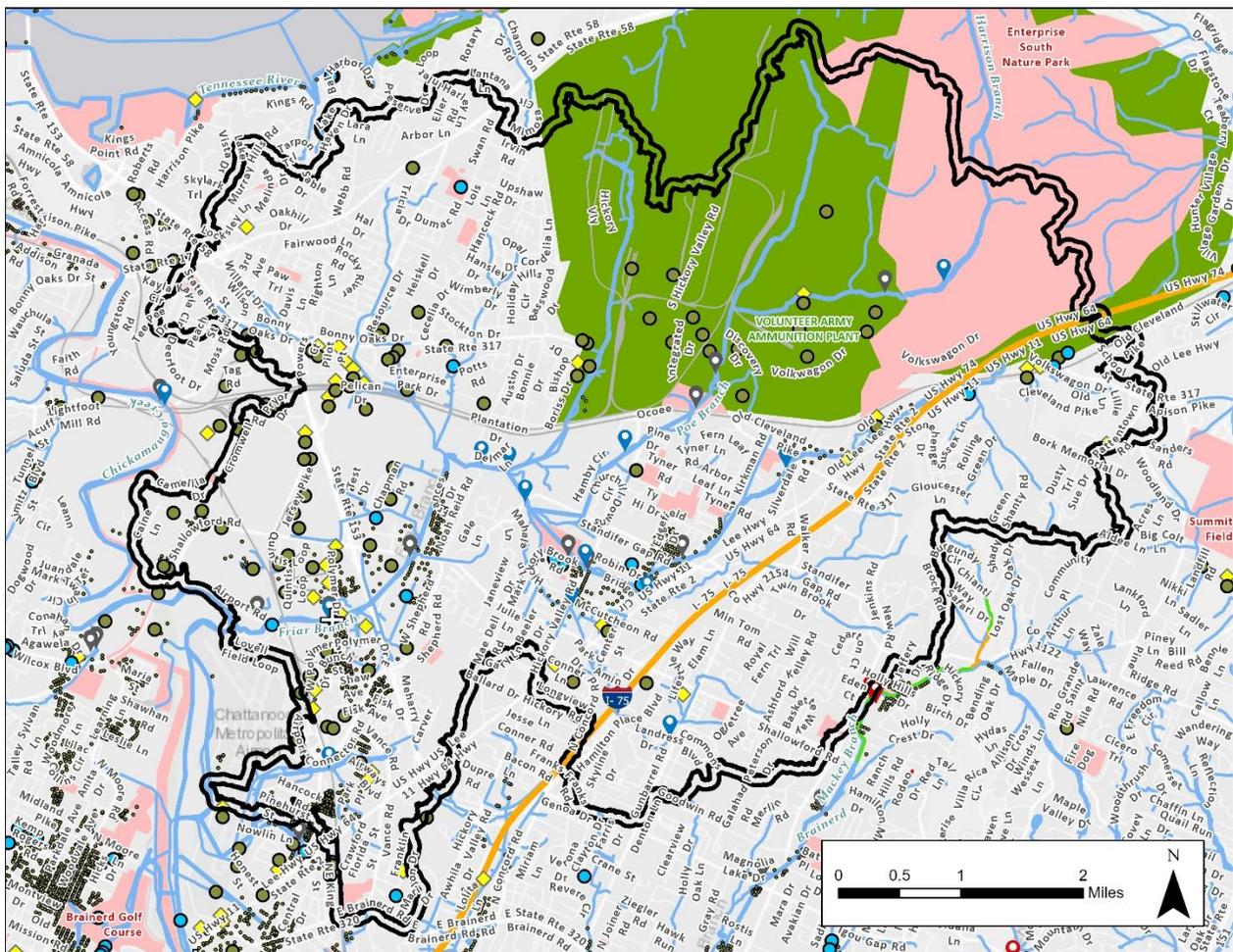


Figure 8: Friar Branch Area Map

## 5.2 Priority Subwatersheds

The Priority Subwatersheds are subject to a variety of water quality risks and consequences (see Monitoring Strategy Matrix in Appendix B), but do not presently contain consistent concerns across these categories (with one exception discussed further below). The Priority Subwatersheds should be regularly assessed through the partners' manual grab sampling programs and considered for continuous monitoring in the near future.

The Chattanooga Creek subwatershed includes substantial risks and consequences across each category that was included in this evaluation. The issues in the subwatershed are well-documented based upon the number of impairments and TMDLs. Along with Citico Creek, this subwatershed is tied for the most sampled subwatershed in Hamilton County and exhibited poor water quality for all six (6) parameters included in the historical data review. However, the distinction between this subwatershed and many of those listed in Section 5.1 is the considerable portion of the overall watershed located in northern Georgia (see Figure 2). Approximately 20% of the Chattanooga Creek overall watershed is located within Hamilton County, thereby limiting the degree of impact that the City of Chattanooga and Hamilton County could hope to achieve. In addition, continuous monitoring to assess the partners' contributions would require monitoring stations at the entry point of each creek/tributary into the subwatershed along the GA/TN border. For the start-up of the continuous monitoring program, the effort involved to assess this subwatershed is not commensurate with the benefits in water quality or flooding that the partners could hope to achieve. As referenced in Section 5.1, it is recommended that the Dobbs Branch tributary to Chattanooga Creek receive priority within the overall Chattanooga Creek subwatershed.

In addition to Chattanooga Creek, the following subwatersheds include some noteworthy risks and consequences to be aware of moving forward. Included with the list of subwatersheds (with subwatershed number in parentheses) below are some key items that stood out:

- Middle Creek (4) - SSOs
- Shoal Creek (5) - SSOs
- Access Road Tributary (6) – imperviousness, SSOs, flood risk
- North Market Street Branch (7) – imperviousness, impairments, poor water quality
- Rogers Branch (9)- SSOs
- North Chickamauga Creek (20) – flood risk, TMDLs
- Pitts Branch (24) – flood risk
- Mountain Creek (30) – vulnerable parks, impairments, TMDLs, poor/fair water quality
- Black Creek (41)– imperviousness, permitted industries
- Chattanooga Creek (50) – see paragraph above
- Downstream South Chickamauga Creek (63) – permitted industries, impairments, TMDLs
- Spring Creek (62) – imperviousness, SSOs
- Upstream South Chickamauga Creek (60) – imperviousness, SSOs, vulnerable parks, TMDLs
- Mackey Branch (64)– vulnerable parks, impairments
- Wolftever Creek (17)– vulnerable parks

## 5.3 Long-Term Priority Subwatersheds

The intent of the sub-sections in Section 5 of the report was to categorize priorities and to split up the subwatersheds somewhat evenly across each category. The Long-Term Priority subwatersheds rank lower in this evaluation relative to those subwatersheds discussed in Sections 5.1 and 5.2. However, some of these subwatersheds are subject to TMDLs (up to 1 TMDL if included in this section), so those respective requirements are still present.

Many of these subwatersheds are quite small or undeveloped but may be subject to development in the near future. The Long-Term Priorities include the following subwatersheds:

- Soddy Creek (1)
- Little Soddy Creek (2)
- Daisy Dallas Tributary (3)
- Varnell Creek (10)
- Ison Springs Branch (11)
- Poe Branch (21)

- Falling Water Creek (22)
- Lick Branch (23)
- Lookout Creek (40)
- Hurricane Creek (65)
- Hunter Branch (70)
- Little Wolftever (72)
- Chestnut Creek (73)

It should also be noted that there are other subwatersheds within Hamilton County, some of which include portions within City of Chattanooga limits, that were not included in this study due to highly undeveloped conditions or subwatershed size. Those subwatersheds would be categorized here as well.

## 6.0 Program Recommendations

The following sections highlight monitoring and sampling recommendations for each of the watershed categories in Section 5.0.

### 6.1 High Priority Watersheds

In order to manage monitoring program implementation costs and ensure that initial efforts are meeting the partners' stated goals, it is recommended that the partners take incremental steps towards continuous monitoring program implementation. Woolpert recommends selection of four (4) of the five (5) High Priority subwatersheds listed below for the initial installation of continuous monitoring stations:

- Citico Creek (8)
- Downstream North Chickamauga (25)
- Stringers Branch (31)
- Dobbs Branch (51)
- Friar Branch (61)

Woolpert recommends the partners continued use of YSI EXO multi-parameter sondes outfitted with water quality sensors to include, at a minimum, dissolved oxygen, turbidity, specific conductivity, pH, and temperature. With approval from the partners, Woolpert staff will perform field inspections of these subwatersheds above and identify physical locations within each subwatershed to potentially install permanent water quality stations. Areas near the outlet of each subwatershed on publicly accessible property will be the primary focus of the investigation.

In addition to the implementation of continuous monitoring in these watersheds, dry weather and storm event sampling is recommended to supplement the water quality sensor data. This is important due to the lack of sensor technology for several of the water quality parameters having adverse impacts on these watersheds (e.g., bacteria). Woolpert recommends the collection of single dry weather samples on two separate days each quarter. Storm event samples are also recommended twice/quarter, with a target of 3-4 samples/storm with a minimum of 10 minutes between samples. Dry and storm event samples should be collected adjacent to the monitoring station water quality sensors for the analysis at a minimum of sediment, nutrients, and bacteria. The collection of samples during varied streamflow conditions (dry and wet) will greatly improve the partners' ability to interpret the results and identify potential pollutant sources. Consistent sampling at each location within close proximity to the sensors will allow the partners to evaluate correlation over time between continuous and grab sample parameters. If a strong correlation is observed, some parameters typically measured via grab samples may be approximated at the same frequency as the continuous sensor data.

### 6.2 Priority Subwatersheds

For the Priority subwatersheds, it is recommended that the partners continue their water quality sampling programs with various changes to ensure consistency between the City of Chattanooga and Hamilton County programs. These changes will provide comparable results across the programs and enable further identification of County-wide priorities, pollutant sources, and watersheds that justify future continuous monitoring. In the absence of budget restrictions and limitations on staff resources, more frequent sampling across all watersheds would provide more

detailed watershed characterization capabilities. Since such factors are unavoidable, the following recommendations are based upon the overall Monitoring Strategy Matrix in Appendix B.

Table 6 below contains only the Priority Subwatersheds, with an aggregate risk and consequence rating based on the overall matrix. The Parameter of Concern category represents a combination of pollutant-specific needs based upon impairments/TMDLs and parameters that were identified as either “poor” or “fair” based upon the historical data review. Varied parameter analysis by watershed will require detailed coordination with the laboratory but can reduce analytical costs and maintain focus on those parameters that need further attention:

Table 6 Priority Subwatersheds and Sampling Recommendations

	Sub-Watershed Name	Reference Number	Risks	Consequences	Parameters of Concern						Grab Sampling Recommendations			
			Overall Rating	Overall Rating	TN	TP	TSS	<i>E. coli</i>	DO	pH	Twice/Quarter		Quarterly	
			H/M/L	H/M/L							Dry	Storm	Ambient	
Other	Middle Creek	4	Low	Low				x		x				o
	Shoal Creek	5	Medium	Low				x						o
	Access Rd Trib	6	High	Low							o	o		
	North Market St Branch	7	High	High	x	x	x	x	x	x	o	o		
	Rogers Branch	9	Medium	Low				x						o
North Chickamauga	Upstream North Chickamauga Creek	20	Low	High			x			x	o	o		
	Pitts Branch	24	Low	Medium						x				o
Stingers Branch	Mountain Creek	30	Low	High		x	x	x	x	x	o	o		
Lookout Creek	Black Creek	41	Medium	Medium					x					o
Chattanooga Creek	Chattanooga Creek	50	High	High	x	x	x	x	x	x	o	o		
South Chickamauga Creek	Downstream South Chickamauga Creek	60	High	High		x	x	x	x		o	o		
	Spring Creek	62	High	Medium	x		x	x	x		o	o		
	Upstream South Chickamauga Creek	63	High	High	x	x	x	x	x		o	o		
	Mackey Branch	64	Medium	Medium			x	x	x					o
Wolftever	Wolftever Creek	71	Medium	Low				x	x					o

Variable grab sampling approaches by subwatershed can be difficult to manage for field personnel, so two different sampling strategies are recommended, as noted above. For those subwatersheds with either a high risk or high consequence aggregate rating, dry weather and storm sampling are recommended, following the same protocol recommended for the High Priority watersheds in Section 6.1. This should greatly enhance the partners' abilities to characterize sample results. For the remaining subwatersheds, Woolpert recommends ambient quarterly sampling

at a minimum. However, the partners should always note the stream stage during the collection of these samples to help with data interpretation.

The collection of samples within all of these subwatersheds is recommended at the downstream end of the subwatershed to characterize the entire contributing drainage area. Although TDEC has historically collected ambient grab samples across many of these subwatersheds, samples have only been collected by the state in the Chattanooga Creek and Downstream South Chickamauga Creek subwatersheds over the last 18 months. The partners should not rely upon TDEC for sample data within the Priority subwatersheds.

### 6.3 Long Term Priority Subwatersheds

For Long-Term Priority subwatersheds, the City of Chattanooga, Hamilton County, and/or TDEC should continue to collect water quality samples as resources allow. One of these subwatersheds may also be considered in the future for more frequent sampling to better understand baseline conditions prior to development. It is recommended that the partners periodically obtain any available TDEC data to supplement and track general water quality trends in these subwatersheds. It is also Recommended that flood mapping in these subwatersheds be maintained prior to development, and appropriate ordinances are in place to prevent future development in areas of risk.

# Appendix A

## Historical Data Analysis

# Total Nitrogen (mg/L)

\*Whiskers equal the max/min value within 1.5x the interquartile range.

**Outliers above 10 mg/L**

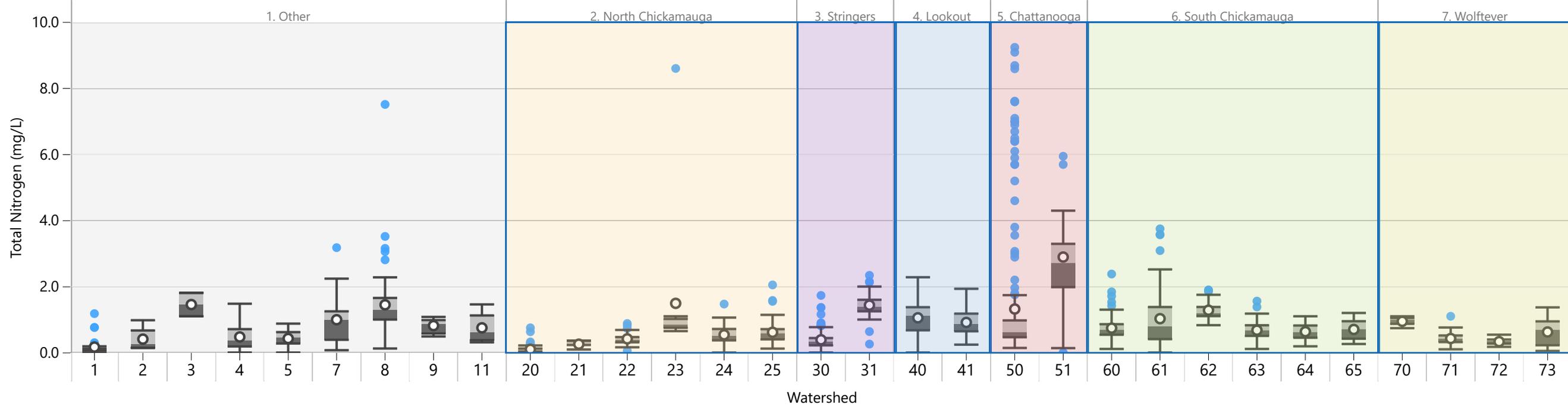
50: One (1)

51: One (1)

○ = Mean      ● = Outlier

Ref #	Watershed	Count	Avg	Med	Min	Max	Std Dev
1	Soddy Creek	35	0.2	0.1	0.0	1.2	0.2
2	Little Soddy Creek	4	0.4	0.3	0.1	1.0	0.3
3	Daisy Dallas Trib	2	1.5	1.5	1.1	1.8	0.4
4	Middle Creek	148	0.5	0.4	0.0	1.5	0.4
5	Shoal Creek	32	0.4	0.5	0.0	0.9	0.2
7	North Market St Branch	31	1.0	1.0	0.1	3.2	0.7
8	Citico Creek	71	1.4	1.3	0.1	7.5	1.0
9	Rogers Branch	16	0.8	0.9	0.5	1.1	0.2
11	Ison Springs Branch	4	0.8	0.6	0.3	1.5	0.4
20	US North Chickamauga Creek	68	0.1	0.1	0.0	0.8	0.1
21	Poe Branch	5	0.3	0.2	0.1	0.4	0.1
22	Falling Water Creek	41	0.4	0.4	0.1	0.9	0.2
23	Lick Branch	13	1.5	0.9	0.7	8.6	2.1
24	Pitts Branch	56	0.5	0.5	0.0	1.5	0.3
25	DS North Chickamauga Creek	74	0.6	0.6	0.1	2.1	0.3

Ref #	Watershed	Count	Avg	Med	Min	Max	Std Dev
30	Mountain Creek	108	0.4	0.3	0.0	1.7	0.3
31	Stringers Branch	43	1.4	1.4	0.3	2.3	0.4
40	Lookout Creek	27	1.1	1.1	0.0	2.3	0.5
41	Black Creek	36	0.9	0.9	0.2	1.9	0.4
50	Chattanooga Creek	236	1.3	0.6	0.1	10.2	2.0
51	Dobbs Branch	47	2.9	2.7	0.0	19.7	2.8
60	DS South Chickamauga Creek	101	0.7	0.7	0.1	2.4	0.3
61	Friar Branch	82	1.0	0.8	0.0	3.8	0.8
62	Spring Creek	35	1.3	1.2	0.8	1.9	0.3
63	US South Chickamauga Creek	79	0.7	0.7	0.1	1.6	0.3
64	Mackey Branch	57	0.6	0.6	0.2	1.1	0.2
65	Hurricane Creek	24	0.7	0.7	0.3	1.2	0.3
70	Hunter Branch	3	0.9	1.0	0.7	1.1	0.2
71	Wolftever Creek	20	0.4	0.4	0.1	1.1	0.2
72	Little Wolftever Creek	20	0.3	0.3	0.2	0.5	0.1
73	Chestnut Creek	28	0.6	0.7	0.0	1.4	0.4



\*Data were compiled between 2009-2021 from TDEC, City of Chattanooga, and Hamilton County

# Total Phosphorus (mg/L)

Ref #	Watershed	Count	Avg	Med	Min	Max	Std Dev
1	Soddy Creek	40	0.01	0.00	0.00	0.03	0.01
2	Little Soddy Creek	5	0.00	0.00	0.00	0.02	0.01
3	Daisy Dallas Trib	2	0.01	0.01	0.00	0.02	0.01
4	Middle Creek	153	0.01	0.01	0.00	0.05	0.01
5	Shoal Creek	38	0.01	0.01	0.00	0.07	0.01
7	North Market St Branch	40	0.10	0.06	0.02	0.40	0.09
8	Citico Creek	74	0.10	0.09	0.03	0.65	0.09
9	Rogers Branch	23	0.03	0.02	0.00	0.08	0.02
11	Ison Springs Branch	5	0.03	0.04	0.00	0.05	0.02
20	US North Chickamauga Creek	71	0.00	0.00	0.00	0.08	0.01
21	Poe Branch	5	0.02	0.02	0.02	0.04	0.01
22	Falling Water Creek	44	0.01	0.00	0.00	0.06	0.01
23	Lick Branch	15	0.10	0.03	0.01	0.88	0.22
24	Pitts Branch	57	0.02	0.02	0.00	0.05	0.01
25	DS North Chickamauga Creek	76	0.02	0.01	0.00	0.07	0.02

Ref #	Watershed	Count	Avg	Med	Min	Max	Std Dev
30	Mountain Creek	115	0.09	0.02	0.00	2.44	0.34
31	Stringers Branch	48	0.03	0.02	0.00	0.11	0.02
40	Lookout Creek	33	0.05	0.05	0.00	0.12	0.03
41	Black Creek	34	0.03	0.01	0.00	0.20	0.04
50	Chattanooga Creek	243	0.12	0.04	0.00	9.30	0.65
51	Dobbs Branch	46	0.10	0.04	0.00	1.54	0.27
60	DS South Chickamauga Creek	103	0.04	0.04	0.00	0.31	0.04
61	Friar Branch	86	0.01	0.01	0.00	0.07	0.01
62	Spring Creek	47	0.02	0.02	0.00	0.12	0.02
63	US South Chickamauga Creek	86	0.07	0.04	0.00	0.97	0.13
64	Mackey Branch	59	0.01	0.01	0.00	0.04	0.01
65	Hurricane Creek	22	0.02	0.02	0.00	0.05	0.01
70	Hunter Branch	3	0.01	0.00	0.00	0.02	0.01
71	Wolftever Creek	28	0.01	0.01	0.00	0.04	0.01
72	Little Wolftever Creek	26	0.01	0.01	0.00	0.03	0.01
73	Chestnut Creek	38	0.02	0.02	0.00	0.22	0.03

\*Whiskers equal the max/min value within 1.5x the interquartile range.

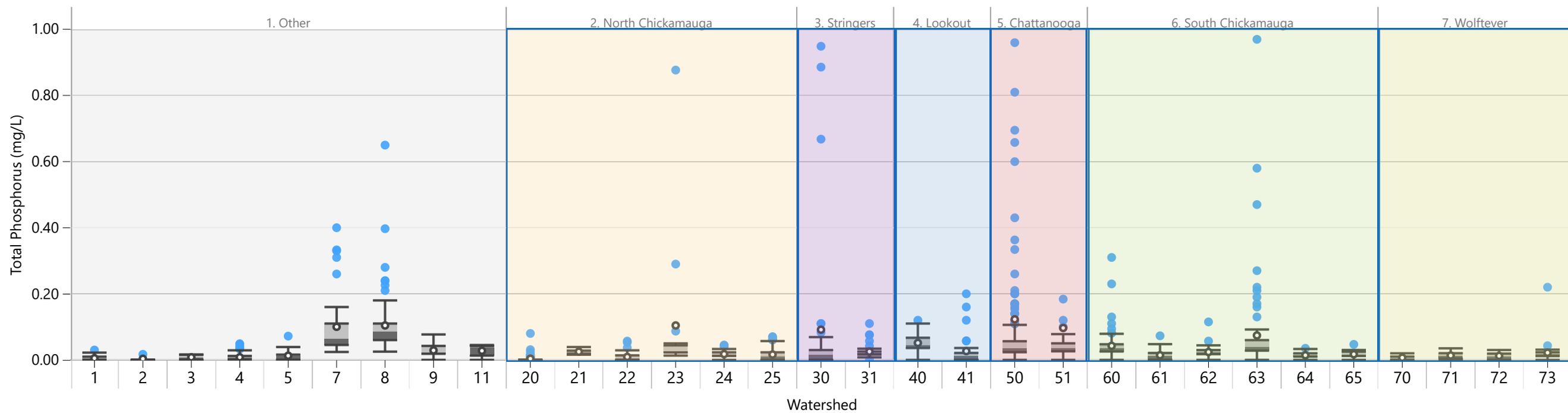
### Outliers above 1 mg/L

30: Three (3)

50: Three (3)

51: Two (2)

○ = Mean      ● = Outlier



\*Data were compiled between 2009-2021 from TDEC, City of Chattanooga, and Hamilton County

# Total Suspended Solids (mg/L)

\*Whiskers equal the max/min value within 1.5x the interquartile range.

## Outliers above 300 mg/L

**8:** Three (3)

**30:** Two (2)

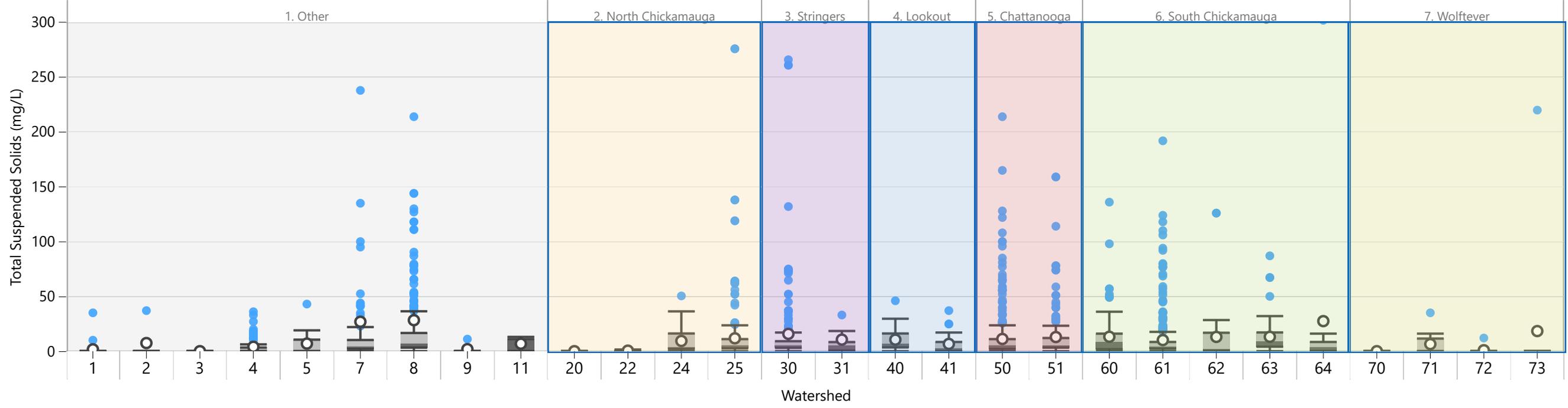
**64:** One (1)

○ = Mean

● = Outlier

Ref #	Watershed	Count	Avg	Med	Min	Max	Std Dev
1	Soddy Creek	27	2	0	0	35	7
2	Little Soddy Creek	5	7	0	0	37	15
3	Daisy Dallas Trib	1	0	0	0	0	0
4	Middle Creek	69	4	0	0	36	8
5	Shoal Creek	12	7	0	0	43	12
7	North Market St Branch	170	27	4	0	1,430	133
8	Citico Creek	388	28	7	0	1,100	108
9	Rogers Branch	6	2	0	0	11	4
11	Ison Springs Branch	5	7	10	0	13	6
20	US North Chickamauga Creek	43	0	0	0	0	0
22	Falling Water Creek	6	0	0	0	2	1
24	Pitts Branch	55	9	4	0	50	11
25	DS North Chickamauga Creek	294	12	6	0	276	28

Ref #	Watershed	Count	Avg	Med	Min	Max	Std Dev
30	Mountain Creek	258	16	6	0	319	42
31	Stringers Branch	65	11	5	0	345	42
40	Lookout Creek	28	11	7	0	46	11
41	Black Creek	30	7	3	0	37	9
50	Chattanooga Creek	472	11	6	0	214	21
51	Dobbs Branch	185	13	5	0	159	22
60	DS South Chickamauga Creek	133	13	9	0	136	18
61	Friar Branch	506	10	4	0	473	27
62	Spring Creek	34	13	2	0	126	30
63	US South Chickamauga Creek	84	13	9	0	87	15
64	Mackey Branch	49	27	4	0	414	90
70	Hunter Branch	3	0	0	0	0	0
71	Wolftever Creek	15	6	0	0	35	10
72	Little Wolftever Creek	14	1	0	0	12	3
73	Chestnut Creek	12	18	0	0	220	61



\*Data were compiled between 2009-2021 from TDEC, City of Chattanooga, and Hamilton County

# E. coli (MPN/100mL)

\*Whiskers equal the max/min value within 1.5x the interquartile range.

**Outliers above 5,000 cfu/100mL**

**7:** Twenty-one (21)    **8:** Thirty-seven (37)

**25:** Fourteen (14)    **50:** Forty (40)

**51:** Twenty-four (24)    **61:** Twenty-four (24)

**62:** One (1)    **63:** One (1)

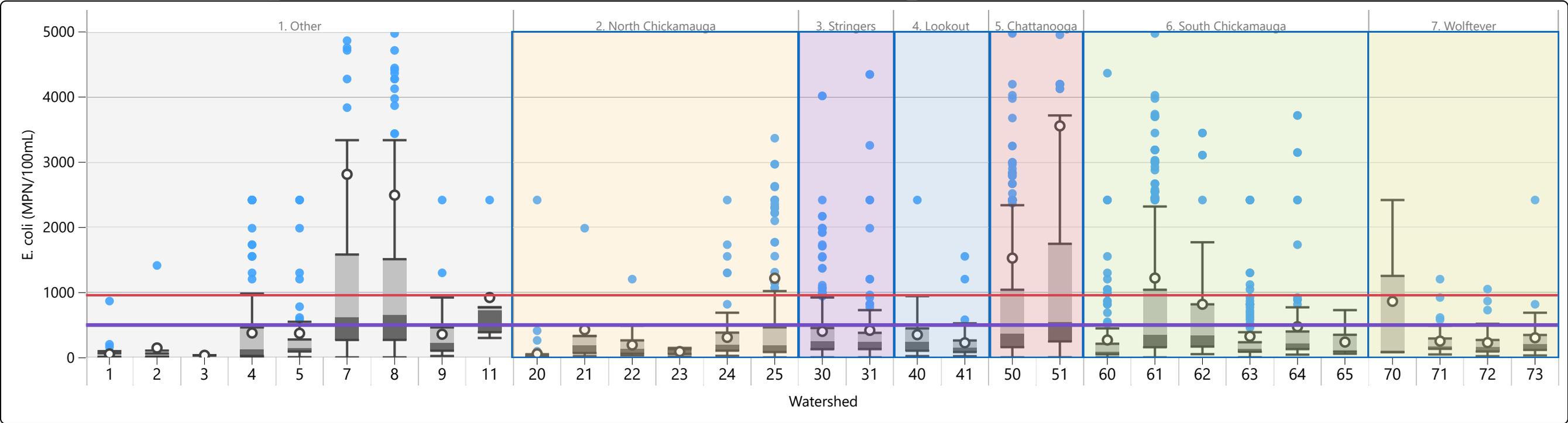
— = TDEC Std - Rec, Exceptional/ONRWs

— = TDEC Std - Rec, All Other Waters

○ = Mean    ● = Outlier

Ref #	Watershed	Count	Avg	Med	Min	Max	Std Dev
1	Soddy Creek	44	54	18	1	866	131
2	Little Soddy Creek	13	145	31	1	1,414	368
3	Daisy Dallas Trib	1	32	32	32	32	0
4	Middle Creek	161	375	126	1	2,420	581
5	Shoal Creek	57	371	148	3	2,420	591
7	North Market St Branch	224	2,815	618	0	48,400	7,851
8	Citico Creek	483	2,495	654	0	48,401	7,200
9	Rogers Branch	36	356	227	22	2,420	446
11	Ison Springs Branch	5	921	727	299	2,420	772
20	US North Chickamauga Creek	72	55	5	1	2,420	286
21	Poe Branch	7	426	185	20	1,986	648
22	Falling Water Creek	32	191	129	31	1,203	218
23	Lick Branch	7	90	112	11	146	50
24	Pitts Branch	111	308	196	24	2,420	352
25	DS North Chickamauga Creek	340	1,218	188	0	48,400	5,229

Ref #	Watershed	Count	Avg	Med	Min	Max	Std Dev
30	Mountain Creek	305	400	248	0	4,020	510
31	Stringers Branch	130	416	238	0	4,350	668
40	Lookout Creek	47	349	240	20	2,420	405
41	Black Creek	57	225	150	19	1,553	260
50	Chattanooga Creek	641	1,527	362	0	48,400	4,074
51	Dobbs Branch	227	3,559	544	1	48,400	10,066
60	DS South Chickamauga Creek	150	267	87	1	4,370	534
61	Friar Branch	521	1,220	346	0	48,401	3,359
62	Spring Creek	91	817	336	50	17,300	1,885
63	US South Chickamauga Creek	140	324	133	1	5,700	637
64	Mackey Branch	93	472	218	42	3,720	747
65	Hurricane Creek	11	236	96	56	727	224
70	Hunter Branch	3	862	86	80	2,420	1,101
71	Wolftever Creek	41	250	172	46	1,203	225
72	Little Wolftever Creek	43	227	166	19	1,050	219
73	Chestnut Creek	44	302	210	30	2,420	368



\*Data were compiled between 2009-2021 from TDEC, City of Chattanooga, and Hamilton County

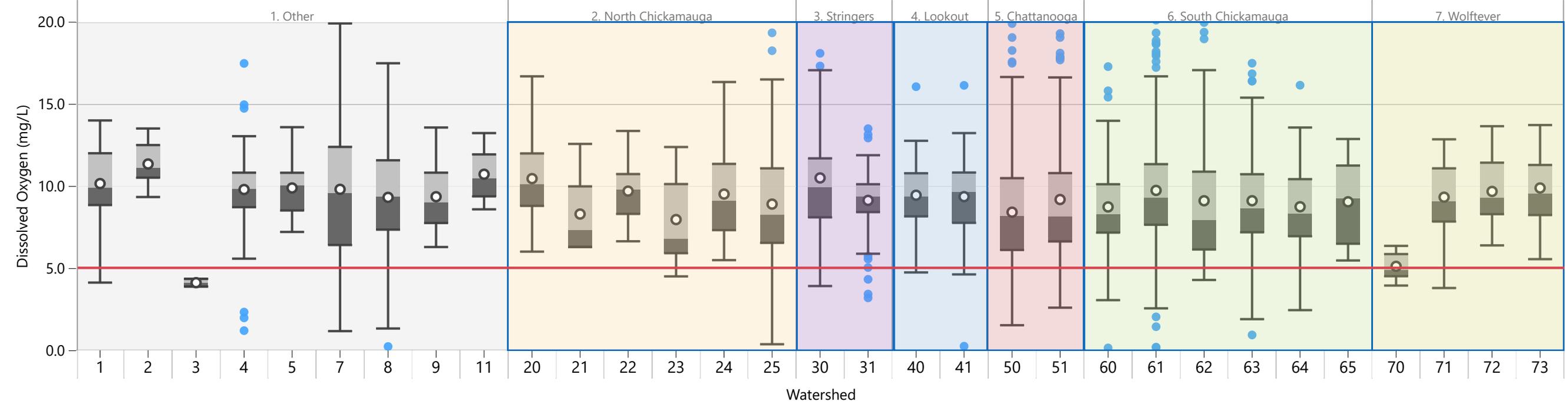
# Dissolved Oxygen (mg/L)

Ref #	Watershed	Count	Avg	Med	Min	Max	Std Dev
1	Soddy Creek	49	10.2	9.9	4.1	14.0	2.2
2	Little Soddy Creek	6	11.4	11.1	9.4	13.5	1.3
3	Daisy Dallas Trib	2	4.1	4.1	3.9	4.4	0.2
4	Middle Creek	152	9.8	9.9	1.2	17.5	2.1
5	Shoal Creek	33	9.9	10.1	7.2	13.6	1.7
7	North Market St Branch	151	9.8	9.6	1.2	19.9	4.5
8	Citico Creek	377	9.3	9.4	0.2	20.9	3.4
9	Rogers Branch	27	9.4	9.0	6.3	13.6	2.0
11	Ison Springs Branch	5	10.7	10.5	8.6	13.3	1.7
20	US North Chickamauga Creek	97	10.5	10.1	6.0	16.7	2.2
21	Poe Branch	6	8.3	7.3	6.3	12.6	2.3
22	Falling Water Creek	40	9.7	9.8	6.7	13.4	1.6
23	Lick Branch	11	8.0	6.8	4.5	12.4	2.7
24	Pitts Branch	82	9.5	9.1	5.5	16.4	2.6
25	DS North Chickamauga Creek	237	8.9	8.3	0.4	19.4	3.2

Ref #	Watershed	Count	Avg	Med	Min	Max	Std Dev
30	Mountain Creek	255	10.5	10.0	3.9	94.3	6.0
31	Stringers Branch	87	9.1	9.4	3.2	13.5	1.8
40	Lookout Creek	37	9.5	9.4	4.8	16.1	2.1
41	Black Creek	47	9.4	9.7	0.3	16.2	2.5
50	Chattanooga Creek	498	8.4	8.2	1.5	19.9	3.3
51	Dobbs Branch	197	9.2	8.2	2.6	23.8	3.9
60	DS South Chickamauga Creek	137	8.7	8.3	0.1	17.3	2.4
61	Friar Branch	580	9.8	9.3	0.2	47.5	3.6
62	Spring Creek	59	9.1	7.9	4.3	21.4	4.3
63	US South Chickamauga Creek	145	9.1	8.7	0.9	24.5	3.0
64	Mackey Branch	74	8.8	8.3	2.5	16.2	2.5
65	Hurricane Creek	26	9.1	9.3	5.5	12.9	2.2
70	Hunter Branch	5	5.1	4.9	4.0	6.4	0.9
71	Wolftever Creek	39	9.3	9.1	3.8	12.9	1.9
72	Little Wolftever Creek	35	9.7	9.3	6.4	13.7	1.9
73	Chestnut Creek	44	9.9	9.6	5.6	13.7	1.9

\*Whiskers equal the max/min value within 1.5x the interquartile range.

— = TDEC Standard  
 ○ = Mean  
 ● = Outlier



\*Data were compiled between 2009-2021 from TDEC, City of Chattanooga, and Hamilton County

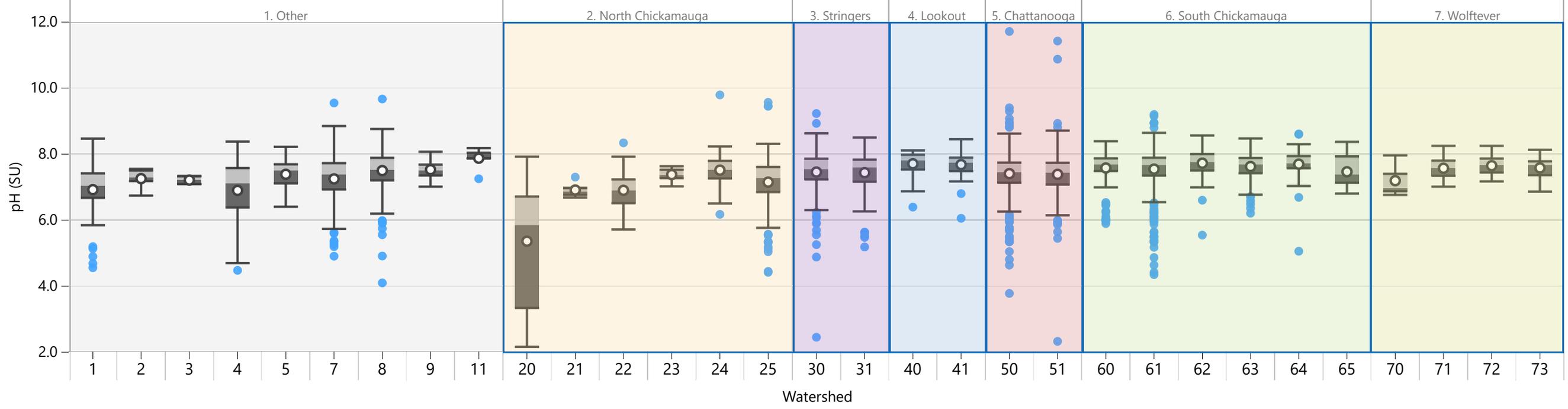
# pH

Ref #	Watershed	Count	Avg	Med	Min	Max	Std Dev
1	Soddy Creek	47	6.9	7.0	4.6	8.5	0.9
2	Little Soddy Creek	5	7.3	7.3	6.7	7.6	0.3
3	Daisy Dallas Trib	2	7.2	7.2	7.1	7.3	0.1
4	Middle Creek	152	6.9	7.1	4.5	8.4	0.9
5	Shoal Creek	33	7.4	7.5	6.4	8.2	0.4
7	North Market St Branch	148	7.2	7.4	4.9	9.6	0.8
8	Citico Creek	367	7.5	7.5	4.1	9.7	0.6
9	Rogers Branch	29	7.5	7.5	7.0	8.1	0.3
11	Ison Springs Branch	5	7.9	8.0	7.3	8.2	0.3
20	US North Chickamauga Creek	105	5.4	5.9	2.2	7.9	1.7
21	Poe Branch	6	6.9	6.9	6.7	7.3	0.2
22	Falling Water Creek	42	6.9	6.9	5.7	8.3	0.5
23	Lick Branch	11	7.4	7.4	7.0	7.6	0.2
24	Pitts Branch	87	7.5	7.5	6.2	9.8	0.5
25	DS North Chickamauga Creek	224	7.1	7.3	4.4	9.6	0.7

Ref #	Watershed	Count	Avg	Med	Min	Max	Std Dev
30	Mountain Creek	239	7.5	7.5	2.4	9.2	0.7
31	Stringers Branch	90	7.4	7.6	5.2	8.5	0.6
40	Lookout Creek	37	7.7	7.8	6.4	8.1	0.4
41	Black Creek	44	7.7	7.7	6.1	8.5	0.4
50	Chattanooga Creek	523	7.4	7.5	3.8	11.7	0.6
51	Dobbs Branch	183	7.4	7.4	2.3	11.4	0.8
60	DS South Chickamauga Creek	151	7.6	7.7	5.9	8.4	0.5
61	Friar Branch	527	7.5	7.7	4.3	9.2	0.6
62	Spring Creek	66	7.7	7.8	5.5	8.6	0.4
63	US South Chickamauga Creek	146	7.6	7.7	6.2	8.5	0.4
64	Mackey Branch	79	7.7	7.7	5.1	8.6	0.4
65	Hurricane Creek	26	7.5	7.4	6.8	8.4	0.5
70	Hunter Branch	5	7.2	7.0	6.8	8.0	0.4
71	Wolftever Creek	41	7.6	7.6	7.0	8.3	0.3
72	Little Wolftever Creek	39	7.6	7.7	7.2	8.3	0.3
73	Chestnut Creek	45	7.6	7.7	6.9	8.1	0.3

\*Whiskers equal the max/min value within 1.5x the interquartile range.

○ = Mean      ● = Outlier



\*Data were compiled between 2009-2021 from TDEC, City of Chattanooga, and Hamilton County

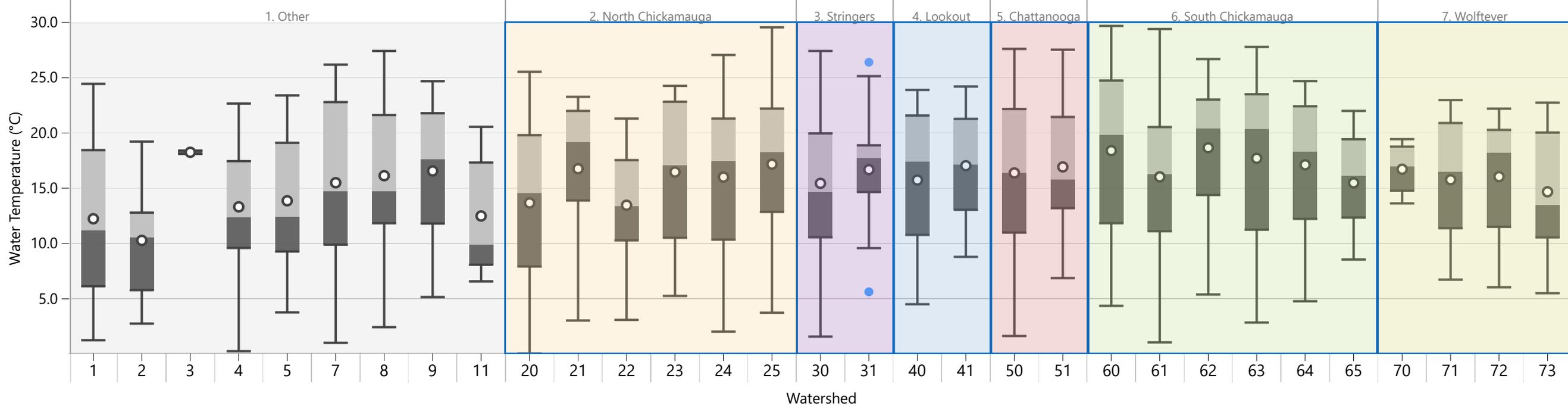
# Temperature (°C)

\*Whiskers equal the max/min value within 1.5x the interquartile range.

○ = Mean      ● = Outlier

Ref #	Watershed	Count	Avg	Med	Min	Max	Std Dev
1	Soddy Creek	49	12	11	1	24	7
2	Little Soddy Creek	6	10	11	3	19	5
3	Daisy Dallas Trib	2	18	18	18	18	0
4	Middle Creek	155	13	12	0	23	5
5	Shoal Creek	34	14	12	4	23	5
7	North Market St Branch	157	15	15	1	26	7
8	Citico Creek	403	16	15	2	27	6
9	Rogers Branch	30	17	18	5	25	6
11	Ison Springs Branch	5	12	10	7	21	5
20	US North Chickamauga Creek	100	14	15	0	26	7
21	Poe Branch	6	17	19	3	23	7
22	Falling Water Creek	42	13	13	3	21	4
23	Lick Branch	11	16	17	5	24	7
24	Pitts Branch	89	16	17	2	27	6
25	DS North Chickamauga Creek	236	17	18	4	30	7

Ref #	Watershed	Count	Avg	Med	Min	Max	Std Dev
30	Mountain Creek	257	15	15	2	27	6
31	Stringers Branch	89	17	18	6	26	4
40	Lookout Creek	37	16	17	4	24	6
41	Black Creek	46	17	17	9	24	4
50	Chattanooga Creek	511	16	16	2	28	6
51	Dobbs Branch	199	17	16	7	28	5
60	DS South Chickamauga Creek	141	18	20	4	30	7
61	Friar Branch	583	16	16	1	29	6
62	Spring Creek	64	19	20	5	27	5
63	US South Chickamauga Creek	148	18	20	3	28	7
64	Mackey Branch	79	17	18	5	25	6
65	Hurricane Creek	26	15	16	9	22	4
70	Hunter Branch	5	17	17	14	19	2
71	Wolftever Creek	42	16	16	7	23	5
72	Little Wolftever Creek	40	16	18	6	22	5
73	Chestnut Creek	45	15	13	5	23	5



\*Data were compiled between 2009-2021 from TDEC, City of Chattanooga, and Hamilton County

# Conductivity (mS/cm)

Ref #	Watershed	Count	Avg	Med	Min	Max	Std Dev
1	Soddy Creek	46	0.05	0.04	0.02	0.19	0.03
2	Little Soddy Creek	6	0.12	0.07	0.07	0.25	0.07
3	Daisy Dallas Trib	2	0.30	0.30	0.28	0.32	0.02
4	Middle Creek	155	0.17	0.16	0.02	0.58	0.09
5	Shoal Creek	34	0.19	0.18	0.09	0.49	0.08
7	North Market St Branch	158	0.32	0.30	0.00	0.83	0.12
8	Citico Creek	380	0.50	0.46	0.15	3.33	0.24
9	Rogers Branch	29	0.33	0.34	0.23	0.42	0.05
11	Ison Springs Branch	4	0.40	0.39	0.35	0.47	0.04
20	US North Chickamauga Creek	100	0.23	0.05	0.01	1.34	0.32
21	Poe Branch	6	0.13	0.13	0.10	0.17	0.03
22	Falling Water Creek	42	0.11	0.09	0.06	0.25	0.05
23	Lick Branch	11	0.30	0.31	0.24	0.33	0.03
24	Pitts Branch	89	0.30	0.29	0.15	0.60	0.08
25	DS North Chickamauga Creek	239	0.23	0.23	0.01	0.62	0.10

Ref #	Watershed	Count	Avg	Med	Min	Max	Std Dev
30	Mountain Creek	258	0.26	0.24	0.08	2.29	0.15
31	Stringers Branch	89	0.29	0.28	0.19	0.55	0.05
40	Lookout Creek	37	0.61	0.60	0.02	0.97	0.17
41	Black Creek	47	0.40	0.38	0.13	0.70	0.12
50	Chattanooga Creek	507	0.34	0.29	0.01	1.46	0.20
51	Dobbs Branch	198	0.43	0.43	0.12	0.98	0.13
60	DS South Chickamauga Creek	141	0.28	0.28	0.01	0.64	0.09
61	Friar Branch	584	0.39	0.38	0.00	1.73	0.17
62	Spring Creek	67	0.35	0.34	0.25	0.67	0.08
63	US South Chickamauga Creek	145	0.27	0.26	0.10	0.58	0.07
64	Mackey Branch	79	0.32	0.31	0.16	0.70	0.08
65	Hurricane Creek	26	0.28	0.25	0.13	0.42	0.09
70	Hunter Branch	4	0.24	0.24	0.23	0.27	0.02
71	Wolftever Creek	40	0.28	0.27	0.16	0.46	0.07
72	Little Wolftever Creek	37	0.17	0.17	0.09	0.27	0.04
73	Chestnut Creek	44	0.24	0.21	0.09	0.47	0.09

\*Whiskers equal the max/min value within 1.5x the interquartile range.

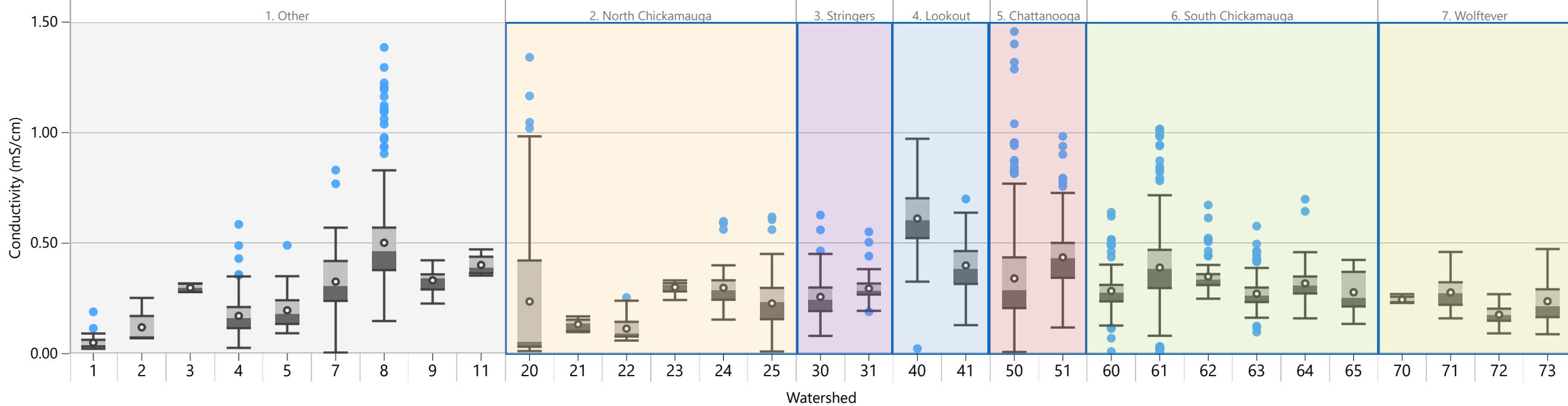
**Outliers above 1.5 mg/L**

**8:** One (1)

**30:** One (1)

**61:** One (1)

○ = Mean      ● = Outlier



\*Data were compiled between 2009-2021 from TDEC, City of Chattanooga, and Hamilton County

# Lead (ppb)

Ref #	Watershed	Count	Avg	Med	Min	Max	Std Dev
1	Soddy Creek	30	0.47	0.00	0.00	14.00	2.51
2	Little Soddy Creek	4	0.00	0.00	0.00	0.00	0.00
3	Daisy Dallas Trib	2	0.00	0.00	0.00	0.00	0.00
4	Middle Creek	9	0.16	0.16	0.00	0.44	0.14
11	Ison Springs Branch	5	0.26	0.00	0.00	0.66	0.32
20	US North Chickamauga Creek	14	0.85	0.43	0.00	2.24	0.74
22	Falling Water Creek	6	0.09	0.07	0.00	0.21	0.09

Ref #	Watershed	Count	Avg	Med	Min	Max	Std Dev
30	Mountain Creek	26	0.00	0.00	0.00	0.00	0.00
40	Lookout Creek	8	0.58	0.52	0.00	1.43	0.43
41	Black Creek	4	0.72	0.68	0.34	1.20	0.38
50	Chattanooga Creek	107	1.03	0.61	0.00	25.40	2.56
51	Dobbs Branch	11	7.87	0.00	0.00	56.60	16.48
60	DS South Chickamauga Creek	49	0.33	0.00	0.00	4.20	0.65
61	Friar Branch	18	0.00	0.00	0.00	0.00	0.00
70	Hunter Branch	3	0.00	0.00	0.00	0.00	0.00
71	Wolftever Creek	8	0.00	0.00	0.00	0.00	0.00
72	Little Wolftever Creek	4	0.45	0.00	0.00	1.80	0.78

\*Whiskers equal the max/min value within 1.5x the interquartile range.

### Outliers above 20 ppb

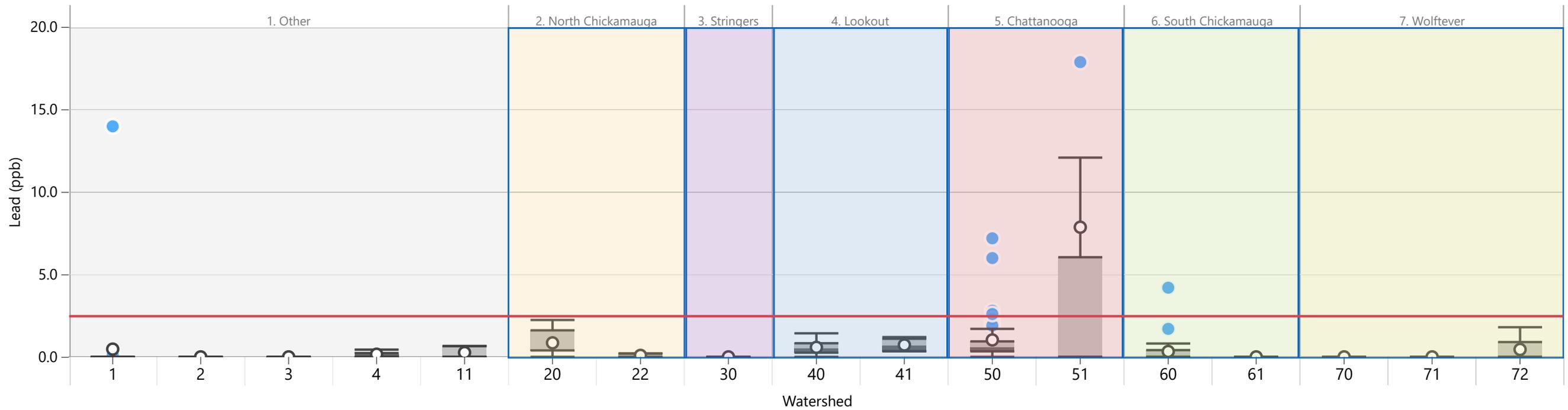
50: One (1)

51: One (1)

— = TDEC Standard

○ = Mean

● = Outlier



\*Data were compiled between 2009-2021 from TDEC, City of Chattanooga, and Hamilton County

# Copper (ppb)

Ref #	Watershed	Count	Avg	Med	Min	Max	Std Dev
4	Middle Creek	11	0.32	0.00	0.00	1.25	0.45
20	US North Chickamauga Creek	15	5.70	5.43	0.78	8.70	1.87
22	Falling Water Creek	6	0.00	0.00	0.00	0.00	0.00

Ref #	Watershed	Count	Avg	Med	Min	Max	Std Dev
30	Mountain Creek	26	0.00	0.00	0.00	0.00	0.00
40	Lookout Creek	8	0.85	1.00	0.00	1.41	0.55
41	Black Creek	4	1.35	1.40	0.79	1.80	0.42
50	Chattanooga Creek	96	1.90	1.10	0.00	31.30	4.31
51	Dobbs Branch	11	6.90	0.00	0.00	30.80	11.18
60	DS South Chickamauga Creek	50	0.86	0.76	0.00	3.60	0.69
61	Friar Branch	18	0.00	0.00	0.00	0.00	0.00

\*Whiskers equal the max/min value within 1.5x the interquartile range.

**Outliers above 10 ppb**

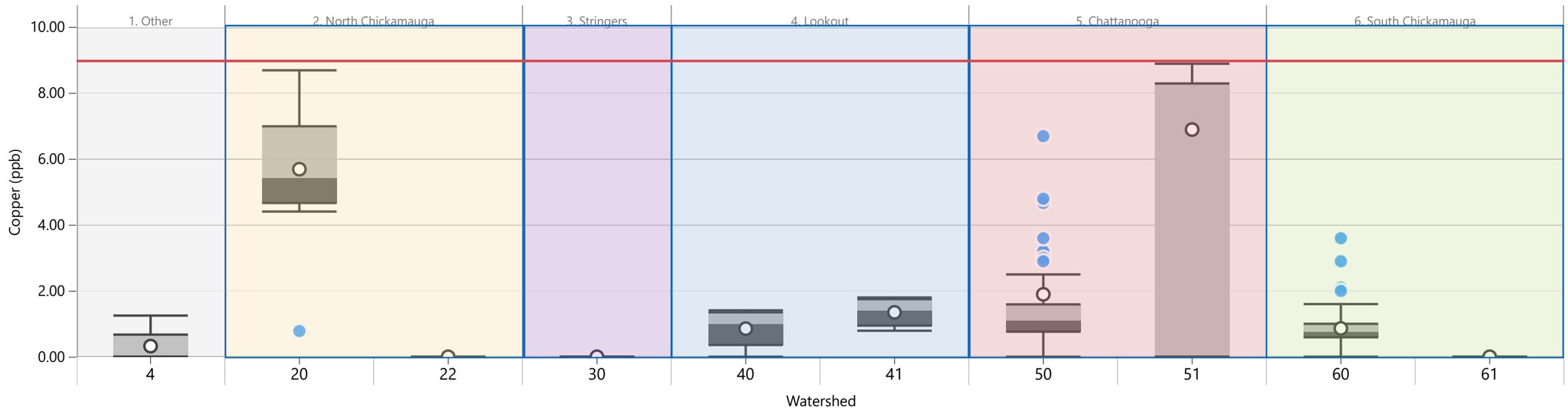
50: Two (2)

51: Two (2)

— = TDEC Standard

○ = Mean

● = Outlier



\*Data were compiled between 2009-2021 from TDEC, City of Chattanooga, and Hamilton County

# Iron (ppm)

Ref #	Watershed	Count	Avg	Med	Min	Max	Std Dev
1	Soddy Creek	27	0.12	0.07	0.01	0.52	0.13
2	Little Soddy Creek	5	0.04	0.03	0.01	0.07	0.02
3	Daisy Dallas Trib	2	0.03	0.03	0.02	0.03	0.00
4	Middle Creek	45	0.67	0.22	0.02	6.90	1.14
5	Shoal Creek	1	0.23	0.23	0.23	0.23	0.00
11	Ison Springs Branch	6	0.27	0.25	0.09	0.46	0.13
20	US North Chickamauga Creek	57	1.37	0.40	0.01	5.10	1.57
22	Falling Water Creek	6	0.12	0.10	0.08	0.23	0.05

Ref #	Watershed	Count	Avg	Med	Min	Max	Std Dev
30	Mountain Creek	23	0.58	0.34	0.15	2.97	0.62
40	Lookout Creek	8	0.38	0.36	0.11	0.76	0.19
41	Black Creek	4	0.39	0.36	0.24	0.60	0.13
50	Chattanooga Creek	105	0.55	0.40	0.16	2.24	0.42
51	Dobbs Branch	10	2.29	0.56	0.00	13.40	4.00
60	DS South Chickamauga Creek	49	0.38	0.24	0.06	3.20	0.50
61	Friar Branch	18	0.39	0.26	0.00	1.43	0.39
70	Hunter Branch	3	0.02	0.02	0.02	0.02	0.00
71	Wolftever Creek	8	0.25	0.26	0.03	0.48	0.15
72	Little Wolftever Creek	4	0.16	0.14	0.06	0.30	0.09
73	Chestnut Creek	2	1.42	1.42	0.54	2.30	0.88

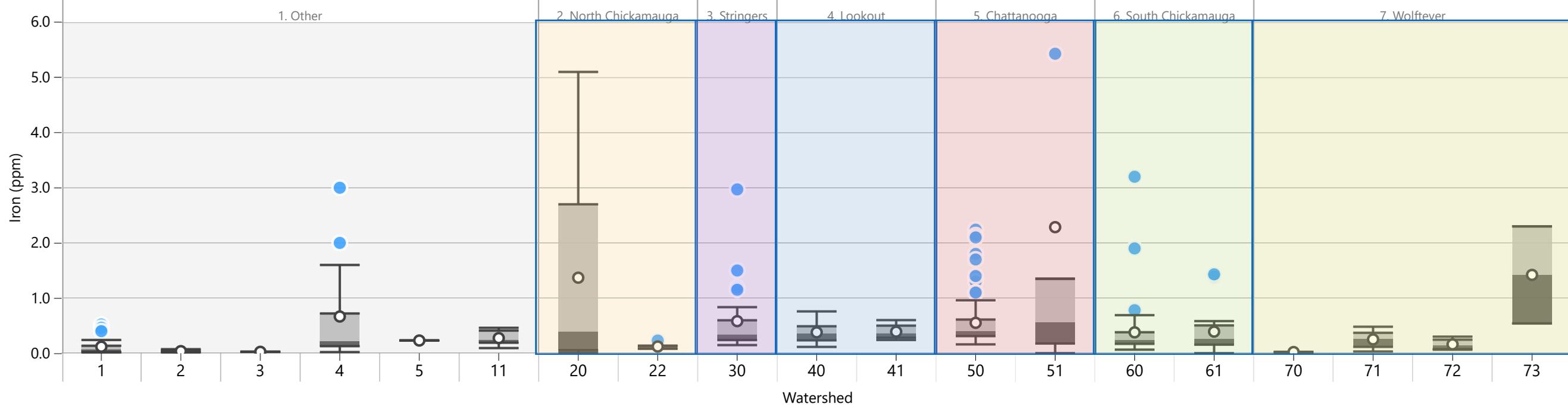
\*Whiskers equal the max/min value within 1.5x the interquartile range.

**Outliers above 6 ppm**

4: One (1)

51: One (1)

○ = Mean      ● = Outlier



\*Data were compiled between 2009-2021 from TDEC, City of Chattanooga, and Hamilton County

# Appendix B

## Monitoring Strategy Matrix

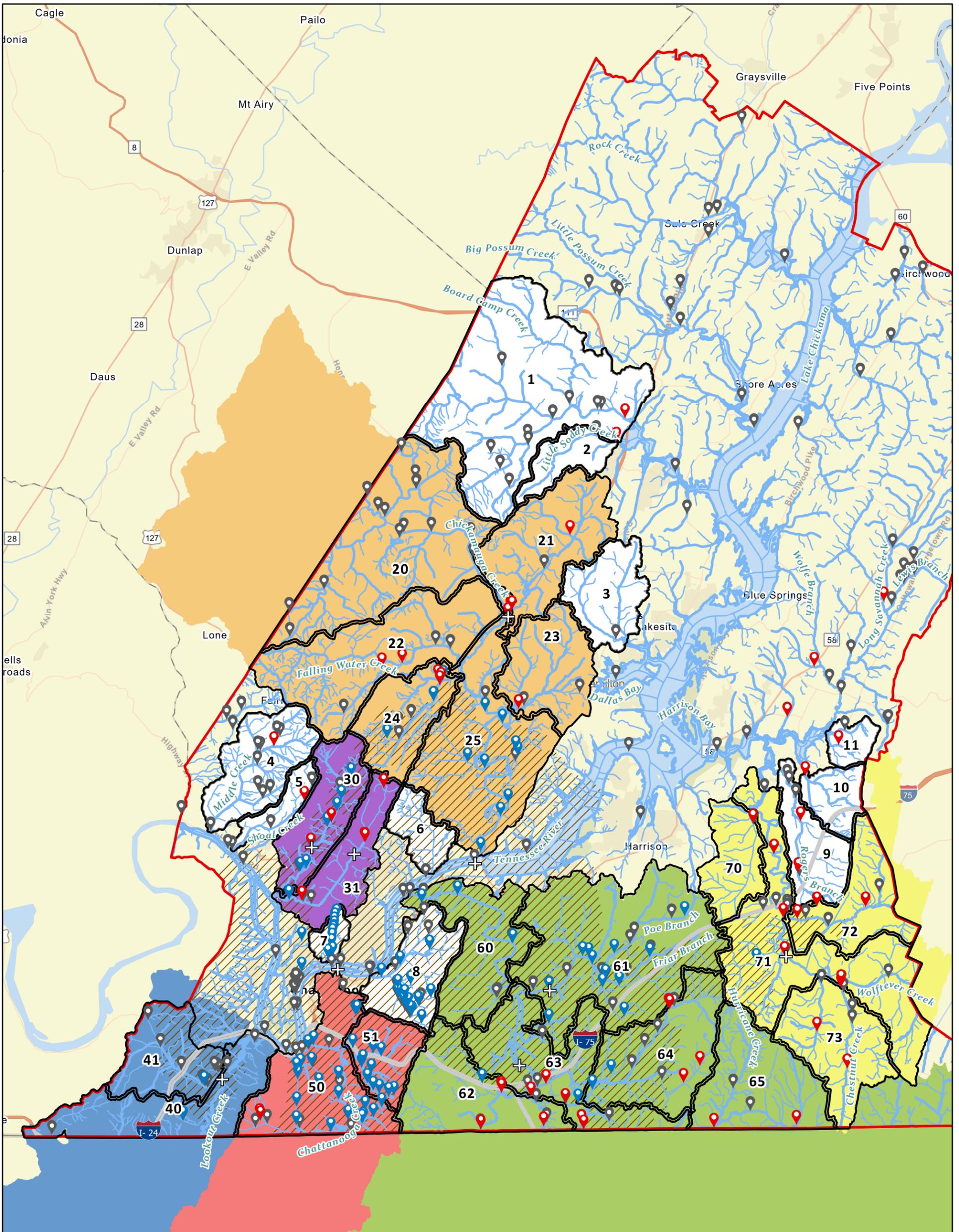
	Sub-Watershed Name	Reference Number	Basin Drainage Area sq.mi.	Basin Drainage Area Within City Limits Percentage	Watershed Extends Outside County Y/N	Existing Monitoring Stations					Risks						Consequences					Historical Data Review						Monitoring Priority Level					
						Total	City	County	TNDEC	USGS	Impervious Area	Reported SSOs		Remediation Sites	Permitted Industrial Facilities	Visual Stream Score	Structure Flood Risk	Vulnerable Parks	Managed Natural Areas	Impaired Waters		TMDLs	TN	TP	TSS	E. coli	DO		pH				
						Count	Count	Count	Count	Count	Percentage	2020	2016-2020	Count	Count	H/M/L	Count	Count	Type	Parameter	Parameter	2009-2021											
Other	Soddy Creek	1	26	0%	Yes	11		1	10		2%	1	2		1												Good	Good	Good	Good	Fair	Fair	Long-Term
	Little Soddy Creek	2	3	0%		3		1	2		5%			1	3																	Long-Term	
	Daisy Dallas Trib	3	6	0%		1			1		12%	2	4		1																	Long-Term	
	Middle Creek	4	7	0%		10		1	9		8%	11	50		1		3	State Forest				E. coli	Good	Good	Good	Good	Good	Good	Fair		Priority		
	Shoal Creek	5	2	1%		3		1	2		21%	16	60	1	1	Low		1				E. coli	E. coli	Good	Good		Good	Good	Good		Priority		
	Access Rd Trib	6	3	86%		1				1	36%	17	66	8	2	Medium	192															Priority	
	North Market St Branch	7	1	94%		13	12		1		49%		3	16	8	Medium	77	4				DO Habitat Alterations TP E. coli	E. coli	Fair	Poor	Fair	Poor	Poor	Fair		Priority		
	Citico Creek	8	6	100%		34	16		17	1	61%	4	17	23	55	Medium	775	1	State Wildlife Refuge				PCBs E. coli Other anthropogenic substrate alterations Nitrate/Nitrite TP DO	E. coli, Siltation, Habitat Alteration	Fair	Poor	Poor	Poor	Poor	Fair		High	
	Rogers Branch	9	5	0%		6		1	5		16%	21	84		4	Medium		2					E. coli	Good	Good	Good	Good	Good	Good		Priority		
	Varnell Creek	10	3	0%		1		1			8%	2	3																			Long-Term	
	Ison Springs Branch	11	2	0%		2		1	1		5%		1																			Long-Term	
North Chickamauga Creek	Upstream North Chickamauga Creek	20	21	0%	Yes	15			15		2%				1		442		Designated State Natural Area			Physical Substrate Habitat Alterations	pH, Siltation, Habitat Alteration	Good	Good	Good	Good	Good	Poor		Priority		
	Poe Branch	21	11	0%		4		2	2		10%	12	45	1	5			2				Physical Substrate Habitat Alterations	pH				Good				Long-Term		
	Falling Water Creek	22	16	0%	Yes	6		2	3	1	6%				9			1	Designated State Natural Areas				pH	Good	Good		Good	Good	Good		Long-Term		
	Lick Branch	23	8	0%		3		1	2		15%	1	1	1	1		10	1				E. coli	pH		Fair		Good				Long-Term		
	Pitts Branch	24	7	53%		12	2	2	7	1	12%	1	1		1	Medium	187		Designated State Natural Area			Alteration in stream-side or littoral vegetative covers	pH	Good	Good	Good	Good	Good	Good	Good		Priority	
	Downstream North Chickamauga Creek	25	17	73%		22	9	2	3	8	26%	30	103	6	16	Medium	683	3	Registered State Natural Area				pH	Good	Good	Fair	Poor	Poor	Fair		High		
Stringers Branch	Mountain Creek	30	7	59%		20	7	1	6	6	17%		1	4	5	Medium	106	5				E. coli Physical substrate habitat alterations	E. coli, Siltation, Habitat Alteration	Good	Poor	Poor	Fair	Fair	Fair		Priority		
	Stringers Branch	31	6	18%		14	1	3	5	5	25%	34	140	9	11	High	12	1				E. coli Nitrate/Nitrite Other anthropogenic substrate alterations	E. coli, Siltation, Habitat Alteration	Fair	Good	Fair	Fair	Fair	Fair		High		
Lookout Creek	Lookout Creek	40	10	19%	Yes	6	1		4	1	7%		4	2	7	Medium	6	2	Nature Center and National Military Park				E. coli		Fair	Fair	Good	Good	Fair	Good		Long-Term	
	Black Creek	41	7	56%		0					19%			5	24	Medium	91	1				E. coli Alteration in stream-side or littoral vegetative covers		Good	Good	Good	Good	Fair	Good		Priority		

	Sub-Watershed Name	Reference Number	Basin Drainage Area sq.mi.	Basin Drainage Area Within City Limits Percentage	Watershed Extends Outside County Y/N	Existing Monitoring Stations					Risks						Consequences					Historical Data Review						Monitoring Priority Level	
						Total	City	County	TNDEC	USGS	Impervious Area	Reported SSOs		Remediation Sites	Permitted Industrial Facilities	Visual Stream Score	Structure Flood Risk	Vulnerable Parks	Managed Natural Areas	Impaired Waters		TMDLs	TN	TP	TSS	E. coli	DO		pH
						Count	Count	County	Count	Count	Percentage	2020	2016-2020	Count	Count	H/M/L	Count	Count	Type	Parameter	Parameter	2009-2021							
Chattanooga Creek	Chattanooga Creek	50	11	81%	Yes	34	17	1	14	2	52%	46	173	149	106	Medium	1035	2	National Military Park	Dioxin (including 2,3,7,8-TCDD) PCBS E.coli Creosote DO Other anthropogenic substrate alterations	Dioxins, PCBS, E. coli, Siltation, Habitat Alteration	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Priority
	Dobbs Branch	51	5	100%		14	12		1	1	72%	43	133	33	62	High	1377	4		E.coli TP DO Ammonia Nitrate/Nitrite Other anthropogenic substrate alterations	E. coli, Siltation, Habitat Alteration	Poor	Fair	Poor	Poor	Poor	Fair	Fair	High
South Chickamauga Creek	Downstream South Chickamauga Creek	60	9	98%		10	1		5	4	27%	19	81	11	45	Medium	374	2		E. coli Physical Substrate Habitat alterations Sedimentation/siltation TP	E. coli, Siltation, Habitat Alteration	Good	Good	Fair	Fair	Fair	Good	Good	Priority
	Friar Branch	61	23	72%		27	11		11	5	49%	21	49	57	95	Medium	985	3		Nutrients Sedimentation Physical substrate habitat alteration	E. coli, Siltation, Habitat Alteration	Fair	Good	Poor	Poor	Fair	Fair	Fair	High
	Spring Creek	62	10	25%	Yes	10	1	4	5		35%	101	330	7	8	Medium	300	1	Wildlife Sanctuary	E. coli E. coli Sedimentation/siltation	E. coli	Fair	Good	Good	Fair	Fair	Good	Good	Priority
	Upstream South Chickamauga Creek	63	11	86%	Yes	10	1	2	6	1	48%	45	141	12	20	Medium	304	8	Wildlife Sanctuary	Nutrients E. coli	E. coli, Siltation, Habitat Alteration	Good	Poor	Good	Fair	Poor	Good	Good	Priority
	Mackey Branch	64	11	63%		15	2	3	7	3	25%	11	35	1	1	Medium	160	5	Wildlife Sanctuary	E. coli Physical Substrate Habitat alterations Sedimentation/siltation	E. coli	Good	Good	Good	Fair	Fair	Good	Good	Priority
	Hurricane Creek	65	11	1%	Yes	4		2	2		12%	1	3						1				Good	Good			Good	Good	Long-Term
Wolftever Creek	Hunter Branch	70	5	0%		2		1	1		10%		3			Low				Alteration in stream-side or Littoral vegetative covers									Long-Term
	Wolftever Creek	71	18	26%	Yes	14		3	10	1	12%	13	26	3	15	Medium		6		E. coli	E. coli	Good	Good	Good	Good	Fair	Good	Good	Priority
	Little Wolftever Creek	72	7	17%	Yes	7		2	5		8%			3	8	Medium				E. coli	E. coli	Good	Good		Good	Good	Good	Good	Long-Term
	Chestnut Creek	73	9	0%		8		3	5		8%	3	3	1	3			3			E. coli	E. coli	Good	Good		Good	Good	Good	Good

\*Historical data review categories are relative to one another  
\*Basin drainage within the City and Hamilton County only

# Appendix C

## Monitoring Prioritization Maps



**All Subwatersheds in Study Area**

**Other Information**

- Interstates
- Streams
- Hydro Layer
- ▭ Hamilton County
- ▭ Subwatersheds
- ▭ Chattanooga City Limits
- Major Watersheds
- ▭ Individual
- ▭ Chattanooga Creek
- ▭ Lookout Creek
- ▭ North Chickamauga Creek
- ▭ South Chickamauga Creek
- ▭ Stringers Branch
- ▭ Wolftever Creek

**Legend**

**Existing Stations**

- ⊕ USGS Gauges
- 📍 Hamilton County Sampling Stations
- 📍 Chattanooga Sampling Stations
- 📍 TNDEC Sampling Stations



\*All watershed boundaries were approximated by the City using Arc Hydro and have not been further refined

# Chattanooga Creek and Lookout Creek

## Legend

### Existing Stations

- USGS Gauges
- Hamilton County Sampling Stations
- Chattanooga Sampling Stations
- TNDEC Sampling Stations

### Other Information

- Interstates
- Streams
- Hydro Layer
- Hamilton County
- Subwatersheds
- Chattanooga City Limits
- Major Watersheds
- Individual
- Chattanooga Creek
- Lookout Creek
- North Chickamauga Creek
- South Chickamauga Creek
- Stringers Branch
- Wolftever Creek

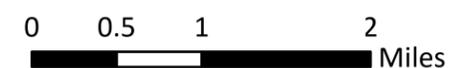
### Risks

- Active Landfills
- Wastewater Treatment Facility
- Reported 2020 SSOs
- Industrial Permits
- Remediation Sites
- Visual Stream Assessment Score
- Low
- Medium
- High

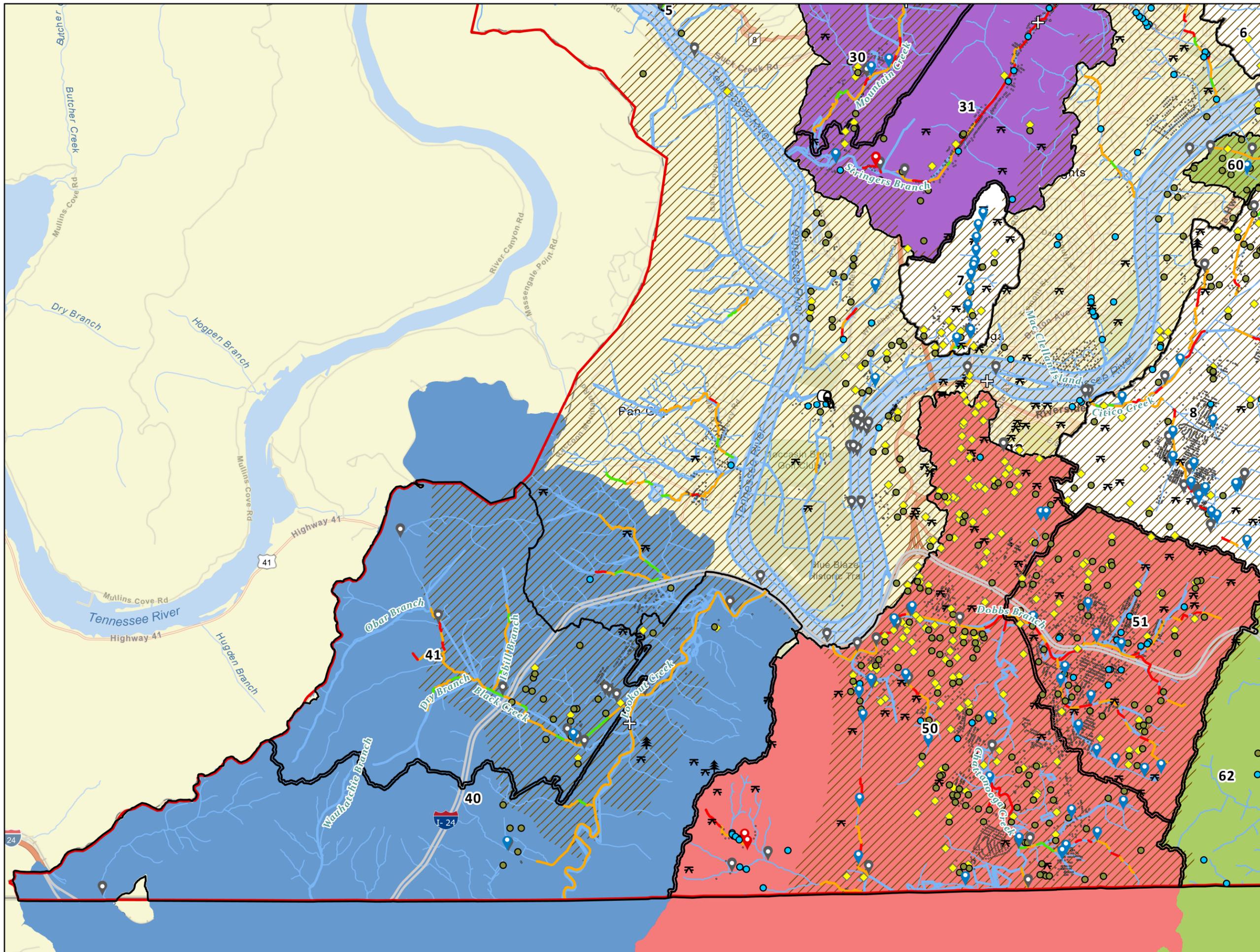
### Consequences

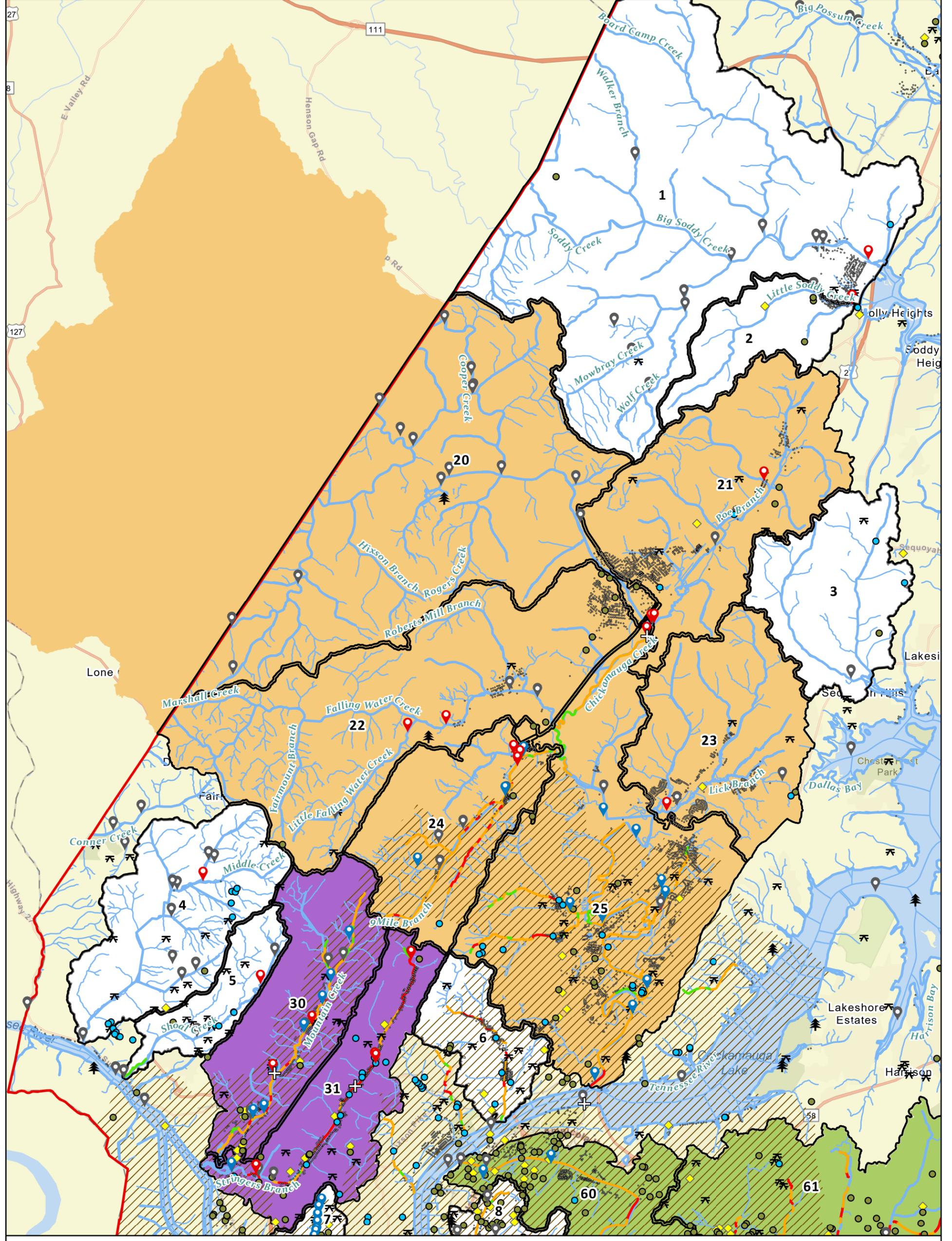
- Managed Natural Areas
- Recreational Facilities
- Structures in the 500 Year Floodplain

\*Impaired waters and TMDL watersheds are not depicted here, but are included in the accompanying summary matrix  
 \*Structures within the 500-year floodplain are those located within City limits only  
 \*All watershed boundaries were approximated by the City using Arc Hydro and have not been further refined



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**North Chickamauga Creek and Stringers Branch**

**Legend**

**Existing Stations**

- USGS Gauges
- Hamilton County Sampling Stations
- Chattanooga Sampling Stations
- TNDEC Sampling Stations

**Other Information**

- Interstates
- Streams
- Hydro Layer
- Hamilton County
- Subwatersheds
- Chattanooga City Limits
- Major Watersheds
- Individual
- Chattanooga Creek
- Lookout Creek
- North Chickamauga Creek
- South Chickamauga Creek
- Stringers Branch
- Wolfvever Creek

**Risks**

- Active Landfills
- Wastewater Treatment Facility
- Reported 2020 SSOs
- Industrial Permits
- Remediation Sites
- Visual Stream Assessment Score
- Low
- Medium
- High

**Consequences**

- Managed Natural Areas
- Recreational Facilities
- Structures in the 500 Year Floodplain

0 1 2 4 Miles

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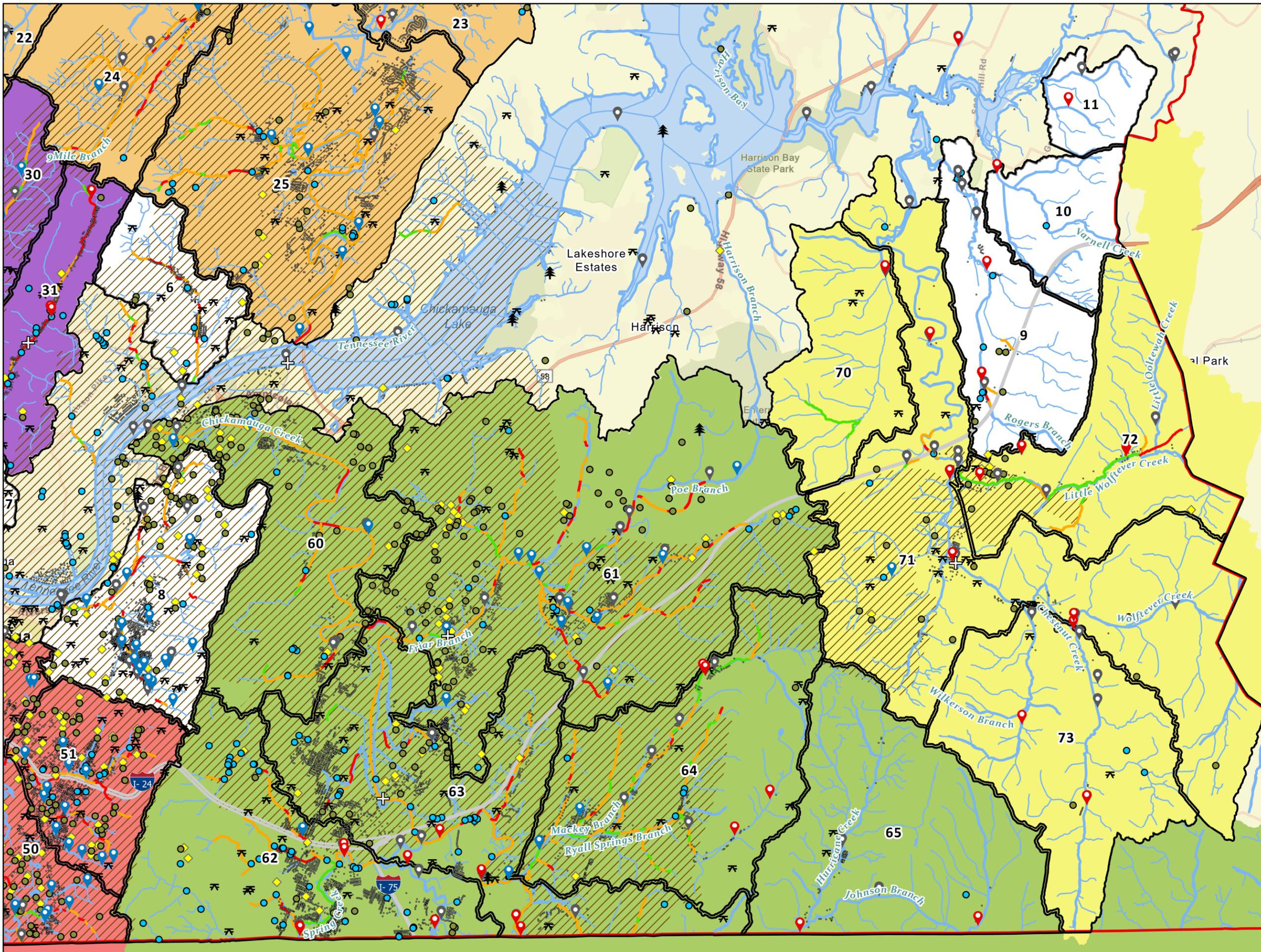
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# South Chickamauga Creek and Wolftever Creek



## Legend

Existing Stations	
	USGS Gauges
	Hamilton County Sampling Stations
	Chattanooga Sampling Stations
	TNDEC Sampling Stations
Other Information	
	Interstates
	Streams
	Hydro Layer
	Hamilton County
	Subwatersheds
	Chattanooga City Limits
	Major Watersheds
	Individual
	Chattanooga Creek
	Lookout Creek
	North Chickamauga Creek
	Stringers Branch
	Wolftever Creek
Risks	
	Active Landfills
	Wastewater Treatment Facility
	Reported 2020 SSOs
	Industrial Permits
	Remediation Sites
	Visual Stream Assessment Score
	Low
	Medium
	High
Consequences	
	Managed Natural Areas
	Recreational Facilities
	Structures in the 500 Year Floodplain

\*Impaired waters and TMDL watersheds are not depicted here, but are included in the accompanying summary matrix  
 \*Structures within the 500-year floodplain are those located within City limits only  
 \*All watershed boundaries were approximated by the City using Arc Hydro and have not been further refined

