Annual Report for Water Quality Monitoring Activities

City of Chattanooga and Hamilton County of Chattanooga, TN

July 2022 – June 2023

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1 Introduction

In June 2021, Woolpert was retained to help the City of Chattanooga and Hamilton County to enhance their current individual sampling efforts by developing a combined watershed monitoring program. Woolpert helped the City of Chattanooga and Hamilton County develop a comprehensive Monitoring Strategy (Strategy) to encompass needs across both communities related to water quality/quantity and to prioritize specific watersheds for more focused monitoring efforts. The Strategy included recommendations for continuous, real-time monitoring via permanently installed monitoring stations at key locations. In the Spring of 2022, the City of Chattanooga and Hamilton County began full implementation of the Strategy by collecting more targeted discrete samples during ambient/wet conditions in "Priority" watersheds and operating/maintaining four (4) permanent, continuous water quality monitoring stations in "High Priority" watersheds. Table 1 summarizes these stations, along with an accompanying overall map in Figure 1 and individual location maps for each station included in the Appendix.

Table 1. Continuous Water Quality Monitoring Stations

Station Name	Description	Waterbody	Jurisdiction
Dobbs Park City	Cannon Avenue – Park City Park	Dobbs Branch	City of Chattanooga
Friar Branch Polymer	Polymer Drive – adjacent to Mayfield Dairy Farms	Friar Branch	City of Chattanooga
N. Chick Greenway Farms	Walker Cemetery Road – Greenway Farms Parks	North Chickamauga Creek	City of Chattanooga
Stringers Signal Mountain	Signal Mountain Road – adjacent to Tire World & Auto Service	Stringers Branch	Hamilton County
*Mountain Creek Elem	North Runyan Drive – adjacent to Red Bank Elementary	Mountain Creek	City of Chattanooga

**In addition to the first four water quality monitoring stations listed above, the report also includes results from the temporary, City of Chattanooga-installed Mountain Creek North station.*

In order to align the monitoring results with the fiscal budget year for the City of Chattanooga and Hamilton County, the following report includes data collected from July 1, 2022 through June 30, 2023. The Methods section of the report includes information regarding the deployed monitoring equipment, calibration methods/frequencies, the data processing software and capabilities, and the volume of data included over the reporting term. The Results and Discussion section includes a general water quality analysis, in addition to seasonal trends and interpretation of results from the City of Chattanooga and Hamilton County's discrete sampling program.

Figure 1. Overall Monitoring Station Location Map

2 Methods

This section describes the methods used in the collection of water quality data and rainfall data, as well as the methods used to perform the analyses presented in this report.

2.1 Data Collection

2.1.1 Continuous Water Quality Data

The City of Chattanooga and Hamilton County maintain YSI EXO2 Series sondes at the five monitoring stations located on Dobbs Branch, Friar Branch, Mountain Creek, North Chickamauga Creek, and Stringers Branch. The sondes record water quality data in 15-minute time increments for stage, water temperature, specific conductivity, dissolved oxygen (DO), turbidity, and pH. The equipment deployed at the City of Chattanooga and Hamilton County's monitoring stations are maintained and calibrated according to manufacturer standards. The data collected at each monitoring station are recorded on-site by a CR1000x series datalogger and transmitted via a remote telemetry system to a server that hosts the data and displays it on the City of Chattanooga and Hamilton County's real-time monitoring website. This website allows for remote monitoring of the field equipment. Woolpert personnel routinely perform website

checks to alert the City of Chattanooga and Hamilton County to any anomalies and/or maintenance needs. City of Chattanooga and Hamilton County personnel perform site visits to conduct maintenance on the sondes as directed by website observations.

The City of Chattanooga and Hamilton County perform calibrations of the sondes at least bi-monthly, or as needed, followed by a quarterly correction of the collected water quality data, modeled after procedures outlined in USGS Techniques and Method 1-D3: Guidelines and Standard Procedures for Continuous Water-Quality Monitoring Station Operation, Record Computation, and Data Reporting. Additionally, the City of Chattanooga and Hamilton County will perform spot checks using a YSI ProDSS handheld multiparameter digital water quality meter to ensure the accuracy of the sonde.

2.1.2 Discrete Sample Water Quality Data

The City of Chattanooga and Hamilton County collect discrete samples at the five water quality monitoring stations mentioned throughout this report. Under this program, discrete samples for *E. coli*, total suspended solids (TSS), nitrate/nitrite, total Kjeldahl nitrogen (TKN), and total phosphorus (TP) are collected under ambient conditions and during storm events. Samples are then analyzed by a certified laboratory. Samples can only be collected when conditions are safe for field personnel and sufficient time is allowed for the samples to be delivered to the lab within the required maximum holding time for bacteria samples. Summary statistics are calculated in Section 3.3 to provide an indication of the concentration of these parameters generally observed at the monitoring stations.

2.1.3 Rainfall Data

The City of Chattanooga and Hamilton County maintain four (4) Hyquest Soltuions TB-4 tipping bucket rain gauges. Each water quality monitoring station, with the exception of the Mountain Creek station, has a designated rain gauge. These rain gauges provide an accurate rainfall dataset by recording 5-minute incremental rainfall measurements to the nearest hundredth of an inch. Rain gauges are cleaned as needed and field-validated bi-annually according to manufacturer instructions.

2.2 Data Processing

Prior to analysis of the continuous water quality data, the raw dataset was corrected using specialized software named Water Information Systems by KISTERS (WISKI), specifically designed for continuous water quality data preprocessing. Time series datasets are corrected so that erroneous data, which are not representative of true in-stream conditions, are not used in the data analysis process. This can be caused by sensor malfunction, entrapment of sediment or other debris in the stilling well or sonde guard, or other unpredictable equipment issues. These data are removed prior to analysis being performed to avoid introducing erroneous bias into the dataset. Approximating methods, such as linear interpolation and averaging techniques, are applied as needed to fill data gaps of less than four hours during predictable conditions (e.g. baseflow). Longer gaps are not filled due to decreased confidence in the predictably of the water quality parameters.

2.3 Data Analysis

The City of Chattanooga and Hamilton County maintain a robust data collection program that results in extensive and insightful water quality datasets. The City of Chattanooga and Hamilton County's discrete sample monitoring program collected 49 *E. coli*, 46 TSS, 48 nitrate/nitrite and TKN, and 48 TP samples across the five monitoring stations over the one-year term. The continuous water quality monitoring program recorded over 947,000 water quality values across the five monitored watersheds during this

monitoring period. By applying a set of statistical analyses, trends and observations are drawn from these datasets in Section 3 of this report.

In Section 3.1, basic summary statistics were calculated using the daily average values of the continuously monitored parameters. Daily averages were used as opposed to 15-minute continuous readings to better portray general water quality trends. This approach also mutes the impacts of individual data points that may be unreliable (i.e., organic debris temporarily blocking the optical sensor) but cannot be justifiably removed during the data correction process. These daily average datasets were used to generate a percent exceedance plot for each of the five continuously monitored water quality parameters. A percent exceedance plot is a graphical method for visualizing the detailed distribution of a dataset. In this analysis, each water quality value is plotted against the percentage of the monitoring period that the parameter was observed to be at or above that value. For example, for the coldest recorded temperature at a water quality station, the corresponding percent exceedance would be 100%, indicating that all recorded data were at or above this minimum temperature value during the monitoring period. The median value of the dataset is equivalent to the 50% exceedance value.

In Section 3.2, collected data were analyzed seasonally as defined by the corresponding solstices and equinoxes to address such trends in water quality across the monitoring year. For the purposes of this analysis, seasons were defined as follows:

- Fall: September 22 to December 20
- Winter: December 21 to March 19
- Spring: March 20 to June 20
- Summer: June 21 to September 21

In Section 3.3, discrete sampling results are summarized and compared to applicable TDEC water quality standards. Statistical summaries are provided for samples collected during ambient and storm conditions.

3 Results and Discussion

The City of Chattanooga and Hamilton County's continuous water quality monitoring program uses sondes at each of the five monitoring stations to collect information on five water quality parameters: temperature, turbidity, pH, specific conductivity, and DO. The continuous water quality data records in 15-minute increments. This dataset is supplemented with discrete sample data, which is analyzed in a laboratory to provide information on water quality parameters, such as *E. coli*, which can not be measured with an in-stream sensor. The continuous, in-stream dataset is summarized in Sections 3.1 and Section 3.2. Data collected under the discrete sampling program are summarized in Section 3.3 of this report. Both the continuous water quality and discrete sample data results are reported in the City of Chattanooga and Hamilton County's quarterly water quality monitoring reports. These reports are available on the City of Chattanooga and Hamilton County websites and provide a high-level summary of results but do not include data interpretation.

3.1 General Water Quality Analysis

The tables below contain summary statistics calculated from the water quality dataset collected by the continuous monitoring equipment at the five stations throughout the City of Chattanooga and Hamilton County. The datasets range from July 2022 through June 2023. In Table 2, summary statistics are calculated from a dataset of daily average values, providing a numeric representation of the water quality

during this monitoring period. Results are also presented in graphical form in Figure 2 through Figure 6, which display percent exceedance distributions for each water quality parameter.

Table 2. Annual Statistics from Daily Average Water Quality Data

Temperature (°C)						
	Mean	Std Deviation	Median	Minimum	Maximum	Range
Dobbs Branch	17.6	5.4	17.0	2.6	26.9	24.3
Friar Branch	16.7	5.3	16.4	3.5	26.5	23.0
Mountain Creek*	18.8	3.1	19.1	13.5	26.4	12.9
North Chick Creek	15.7	5.2	15.0	4.9	26.1	21.2
Stringers Branch	16.1	2.3	16.1	11.0	21.7	10.6
Dissolved Oxygen (mg/L)						
	Mean	Std Deviation	Median	Minimum	Maximum	Range
Dobbs Branch	6.0	2.3	5.7	0.2	10.5	10.3
Friar Branch#	8.4	1.3	8.3	5.6	11.6	6.0
Mountain Creek*	8.2	1.1	8.1	5.5	10.1	4.7
North Chick Creek	8.4	1.9	8.3	2.9	12.5	9.6
Stringers Branch	9.5	0.5	9.5	7.7	10.6	2.9
Specific Conductivity (µS/cm)						
	Mean	Std Deviation	Median	Minimum	Maximum	Range
Dobbs Branch	410	77	440	203	737	534
Friar Branch	322	84	341	78	513	435
Mountain Creek*	311	31	310	230	364	134
North Chick Creek	175	72	164	48	302	254
Stringers Branch	299	32	309	184	335	151
pH						
	Mean	Std Deviation	Median	Minimum	Maximum	Range
Dobbs Branch	7.6	0.1	7.7	7.2	7.9	0.7
Friar Branch#	7.9	0.1	7.9	7.5	8.2	0.7
Mountain Creek*	7.8	0.1	7.8	7.7	8.0	0.3
North Chick Creek	7.5	0.2	7.6	7.0	8.0	1.0
Stringers Branch**	7.8	0.3	7.7	7.4	9.4	2.0
Turbidity (FNU)						
	Mean	Std Deviation	Median	Minimum	Maximum	Range
Dobbs Branch	15.4	14.7	8.6	0.3	96.9	96.6
Friar Branch#	5.8	7.7	3.2	0.2	72.7	72.5
Mountain Creek*	6.5	7.6	4.0	2.2	56.1	53.9
North Chick Creek	7.3	6.6	5.5	2.1	54.5	52.4
Stringers Branch	6.2	7.7	3.8	1.0	53.0	51.9

*Data between 7/7/2022 – 3/31/2023 are not available due to equipment failures.
**Data between 9/1/2022 – 11/13/2022 are not available due to sensor failure.
#Data between 12/5/2022 – 1/9/2023 were removed due to the sonde being buried in sediment.

Figure 2 displays the percent exceedance plot for daily average water temperature values during the monitoring period at all five stations within the City of Chattanooga and Hamilton County's monitoring network. As indicated by no values falling within the red area of the figure, all daily average values were below the 30.5 °C TDEC maximum standard.

Overall, the temperature distributions are typical for a year-long dataset, with higher and lower temperatures due to seasonal influences. The Mountain Creek dataset shows higher temperatures throughout due to data only being collected at that site between July 1, 2022 – July 7, 2022 and April 4, 2023 – June 30, 2023. This biased the distribution high due to the sonde only recording during months with higher ambient temperatures. Stringers Branch shows a relatively flat distribution compared to the other three sites with a year-long dataset, which have larger temperature swings on each end of the distribution. This could be due to a combination of the sonde being mounted against a high concrete wall,

upstream conveyance through a large, concrete box culvert under the interstaten and tree canopy shading the stream. This could lead to the water being insulated in this location, leading to water temperatures that are less sensitive to changes in air temperature compared to the other monitoring locations.

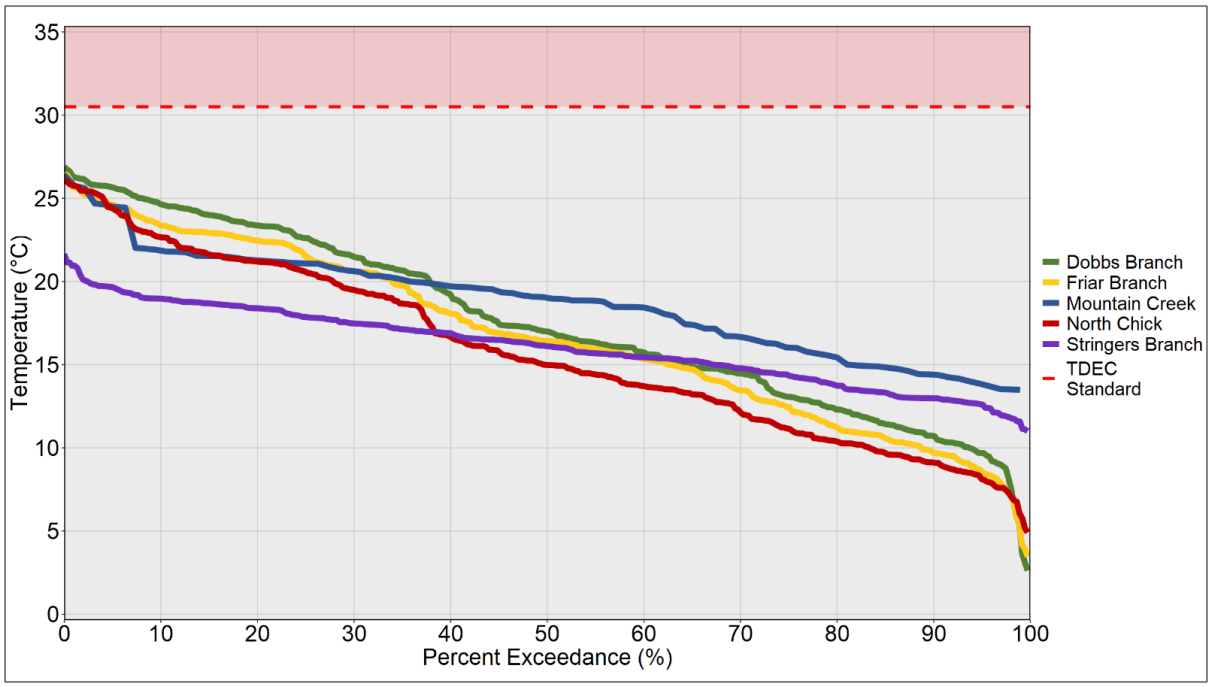

Figure 2. Percent Exceedance Distributions – Daily Average Data – Temperature

Figure 3 displays the percent exceedance distributions for daily DO values during the monitoring period at each of the five stations. As stated previously, Mountain Creek only displays data between July 1, 2022 – July 7, 2022, and April 4, 2023 – June 30, 2023 of the monitoring period. This likely biases the overall DO distribution lower due to excluding colder months when DO typically measures higher due to increased saturation.

Daily average DO fell below the 5.0 mg/L minimum daily average TDEC standard at the North Chick Creek station for 11 of the 357 monitored days within this monitoring period. This occurred between July 29-31, 2022, and November 2-10, 2022, excluding November 3rd. This could be due to long periods without significant rainfall, leading to stagnant conditions and increased DO consumption by algae and other aquatic life. This is indicated by the recovery of DO levels following a significant rain event during those times. The daily average DO at the Dobbs Branch station fell below the 5.0 mg/L minimum daily average TDEC standard for 121 of the 347 monitored days during this monitoring period. This is indicative of a highly impaired waterway with a multitude of possible causes, given the urban influence within this watershed. Chemical oxygen demand and biological oxygen demand could be due to a large number of SSOs or other illicit discharges within the Dobbs Branch watershed.

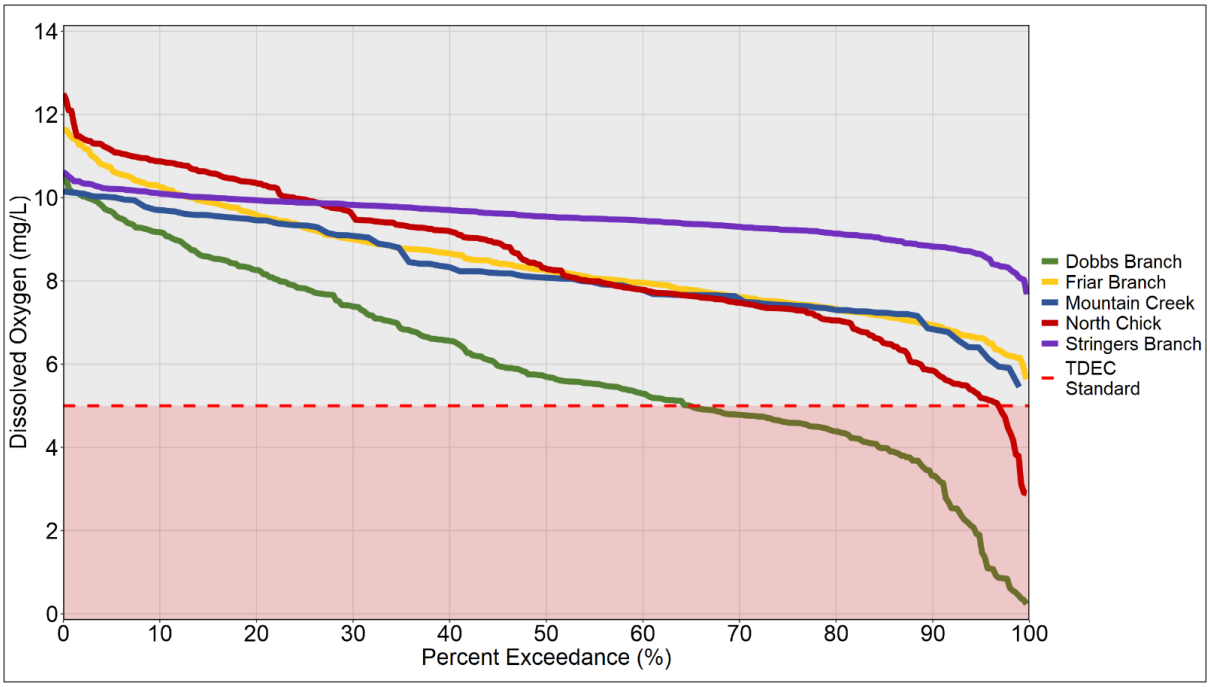

Figure 3. Percent Exceedance Distributions – Daily Average Data – Dissolved Oxygen

Figure 4 shows the percent exceedance distributions of daily average pH values at the five City of Chattanooga and Hamilton County monitoring stations during the monitoring period. The plot displays the most conservative lower and upper TDEC standard of 6.5 – 9 pH units, respectively. All stations, with the exception of Stringers Branch, fell within the acceptable range for this monitoring period. Stringers Branch exceeded the TDEC upper pH limit of 9.0 for 3 of the 292 days pH was monitored in this watershed. This occurred between July 21-23, 2022, with daily averages ranging between 9.2 – 9.4 pH units. Potential causes of this could be due to an SSO near the station due to the storm event beginning on July 20, 2022, or another illicit discharge occurring during this time period. This could also potentially be due to a faulty reading due to numerous pH sensor issues around this time.

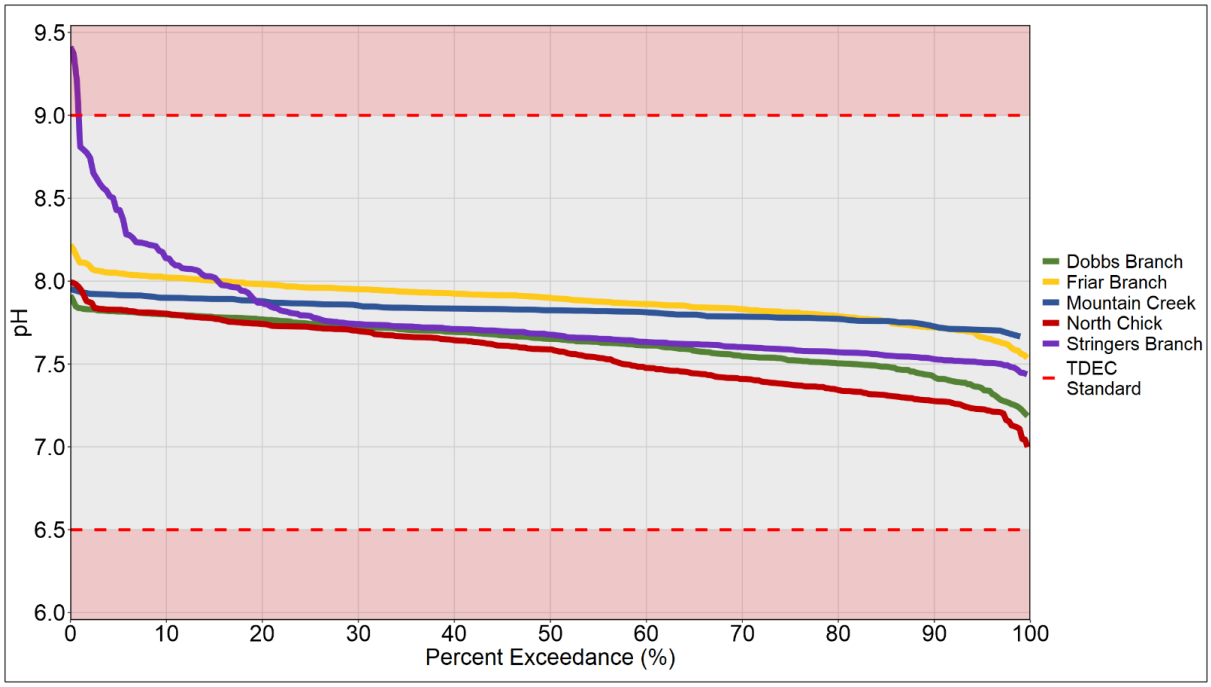

Figure 4. Percent Exceedance Distributions – Daily Average Data – pH

Figure 5 displays the percent exceedance distributions of daily average specific conductivity values at each of the five stations monitored by the City of Chattanooga and Hamilton County. There is no established TDEC standard for this parameter. Stringers Branch and Mountain Creek (limited monitoring period) displayed a very steady specific conductivity distribution throughout the monitoring period.

The tail on the upper end of the distribution at Friar Branch occurred between October 19-24, 2022. This increase does not coincide with a recorded storm event and is likely the result of an illicit discharge occurring during this time period. Dobbs Branch measured daily average specific conductivity much higher than any other watershed for the vast majority of the monitoring period. Similar to the reason for frequent low DO values at this site, this is likely caused by continuous discharges other than stormwater in the watershed. The tail on the upper end of the distribution at Dobbs Branch occurred between January 1-2, 2023. Given that this did not coincide with a recorded storm event, it is likely the result of an illicit discharge occurring during this time period. North Chick had consistently lower specific conductivity throughout the distribution. This could be due to a lower recurrence of SSOs in the watershed as well as lower baseflow total dissolved solids.

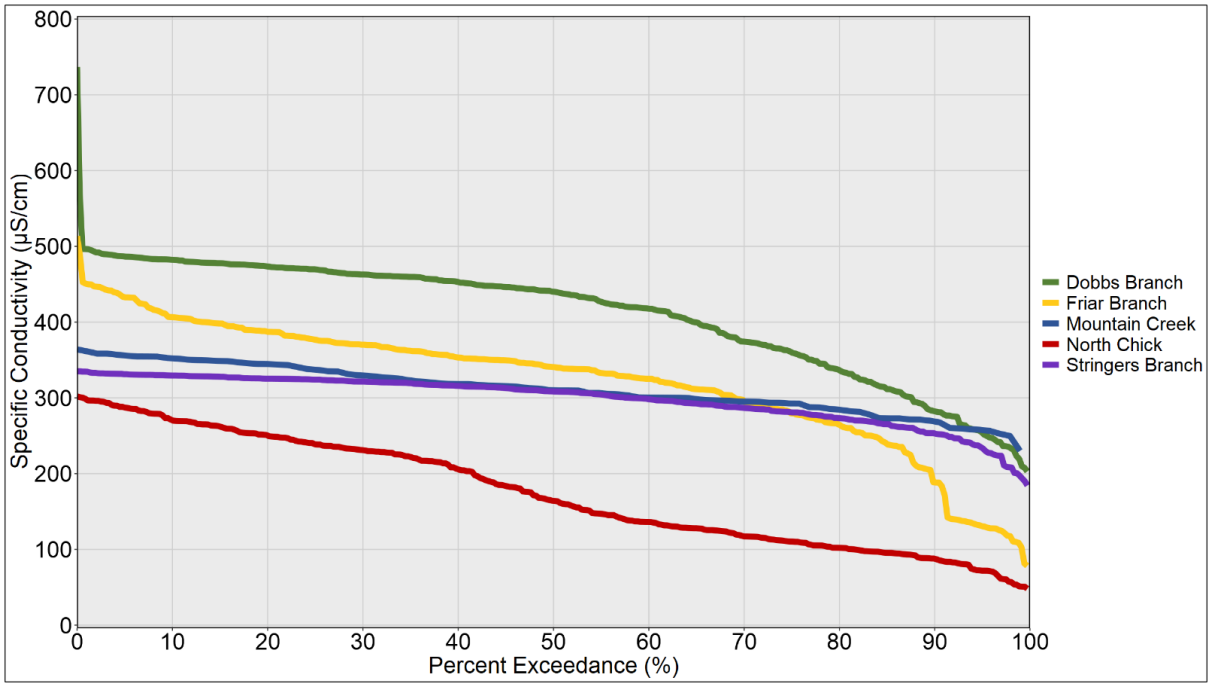

Figure 5. Percent Exceedance Distributions – Daily Average Data – Specific Conductivity

Figure 6 displays the percent exceedance distributions for daily average turbidity values. There is no explicit, numerical TDEC standard established for this parameter. All five stations exhibit values approaching 50 - 100 FNU on the upper end of the distributions. These elevated turbidity readings are in response to significant storm events that produce flashy runoff and high flow in the waterway. Turbidity is likely increased due to stream bank erosion and resuspension of prior sediment deposition in-stream. Dobbs Branch measured a higher daily average turbidity than any of the other four stations during approximately 67% of the monitoring period. This is likely the result of more exposed sediment due to erosion near this station.

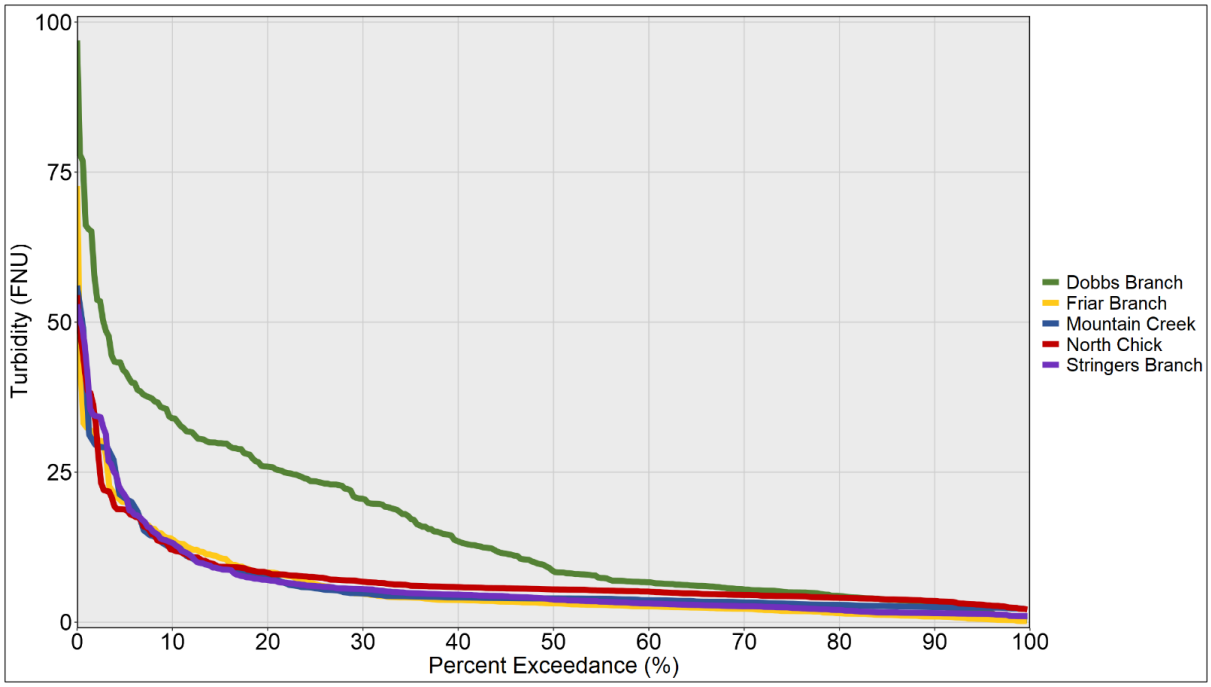

Figure 6. Percent Exceedance Distributions – Daily Average Data – Turbidity

3.2 Seasonal Trends

The datasets were divided into seasonal groups, as described in Section 2.3, to assess trends occurring in water quality seasonally across the monitoring year. For each seasonal group, a boxplots for each station summarizing the data are displayed in Figure 7 through Figure 11. Whiskers represent the minimum and maximum value recorded, while the black dot represents the mean of the data. Patterns were evident with some parameters, while other parameters showed very little seasonal variability.

Figure 7 below displays the seasonal mean values for water temperature at each of the five watersheds. As expected, the temperature varies seasonally at each station due to seasonal changes in ambient air temperature. Average water temperature is warmest during the summer seasons and coolest during the winter seasons.

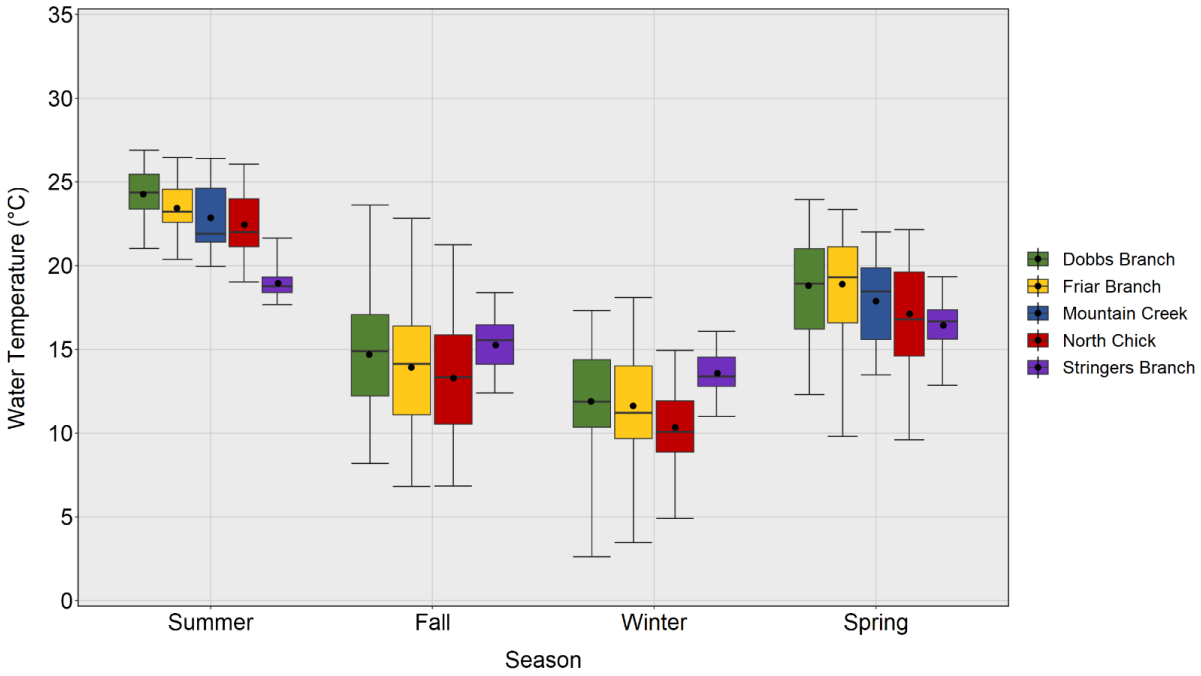

Figure 7. Seasonal Mean Water Temperature Values – Daily Average Data

Figure 8 displays the seasonal mean DO values at all monitored stations during the monitoring period. There is a clear seasonal trend in DO that mirrors the seasonal trend in water temperature. The lowest DO occurs in the summer season, while the highest DO occurs during the winter season. This relationship is expected because the DO levels in a body of water are dependent upon the water temperature, among several other factors. Water with a lower temperature has the capacity to hold more DO than water at a higher temperature. When water temperatures increase during the summer months, the streams cannot physically hold as much oxygen, so the DO levels decrease.

Algal and other phytoplanktonic organisms produce oxygen in streams during the process of photosynthesis, which also influences DO concentrations in streams. Populations of photosynthetic organisms increase in the summer and early fall months, which increases their rate of photosynthetic production. This seasonal process causes a slight increase in DO levels in the summer; however, as Figure 8 indicates, this increase is not enough to outweigh the impacts of high water temperatures in the summer, so there is still a large net decrease in DO levels in the summer months. The average seasonal DO was below the 5 mg/L TDEC standard for the summer season at Dobbs Branch, and it was lower than other stations during all seasons. This is evidence of a highly impaired waterway with a large amount of oxygen-demanding substances reducing the DO levels below the standard. This is exacerbated in the summer by higher water temperatures and stagnation due to periods of infrequent rainfall.

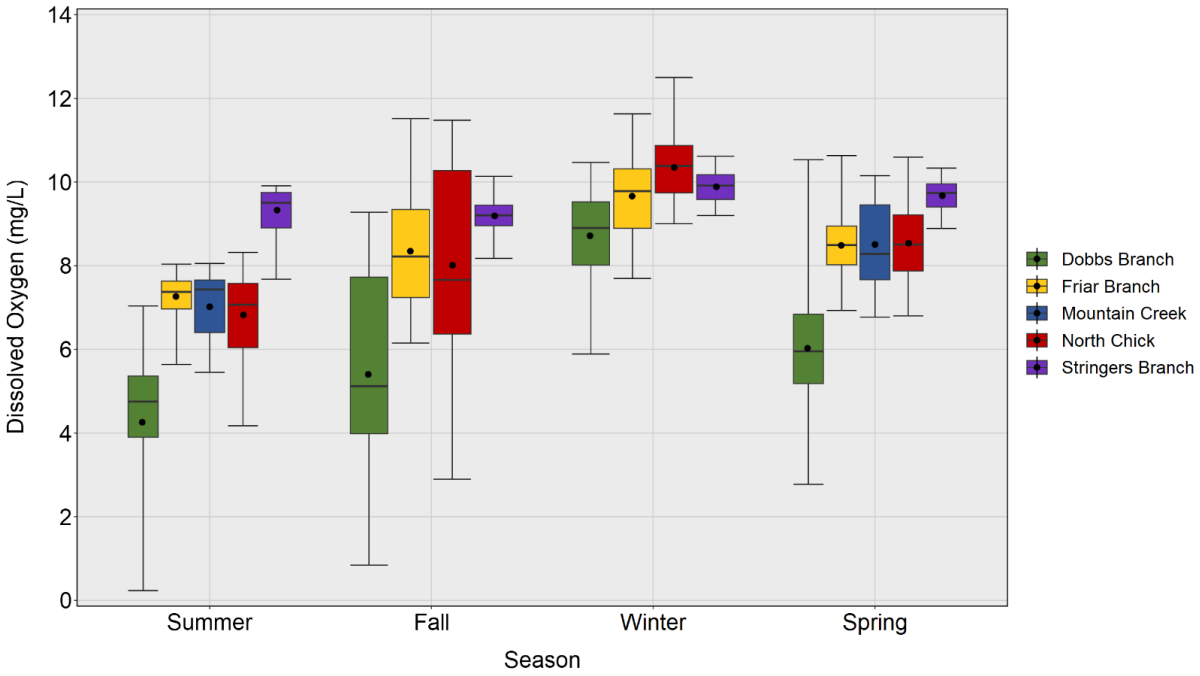

Figure 8. Seasonal Mean Dissolved Oxygen Values – Daily Average Data

Figure 9 and Figure 10 display the seasonal mean pH and specific conductivity levels at the City of Chattanooga and Hamilton County's five monitoring stations. As seen in the figures below, there is little to no evident seasonal impact on pH and specific conductivity for each individual station, with the exception of higher pH occurring during the summer at the Stringers Branch station. The photosynthetic process can often have a slight seasonal trend on pH at certain stations, causing elevated pH levels during the summer months. This may have had an impact along Stringers Branch, given that average pH was much higher at Stringers during the summer season. This could also potentially be due to SSOs or other illicit discharges occurring more frequently during the summer compared to the remainder of the year, although an increase in specific conductivity during the summer would also be expected were this to be the case. Specific conductivity at North Chick averaged notably lower during the winter and spring months than during the summer and fall months. This appears to be due to the winter and spring seasons recording much more frequent storm events than the other two seasons, leading to a consistent dilution of dissolved ions in the stream which tend to increase during dry periods.

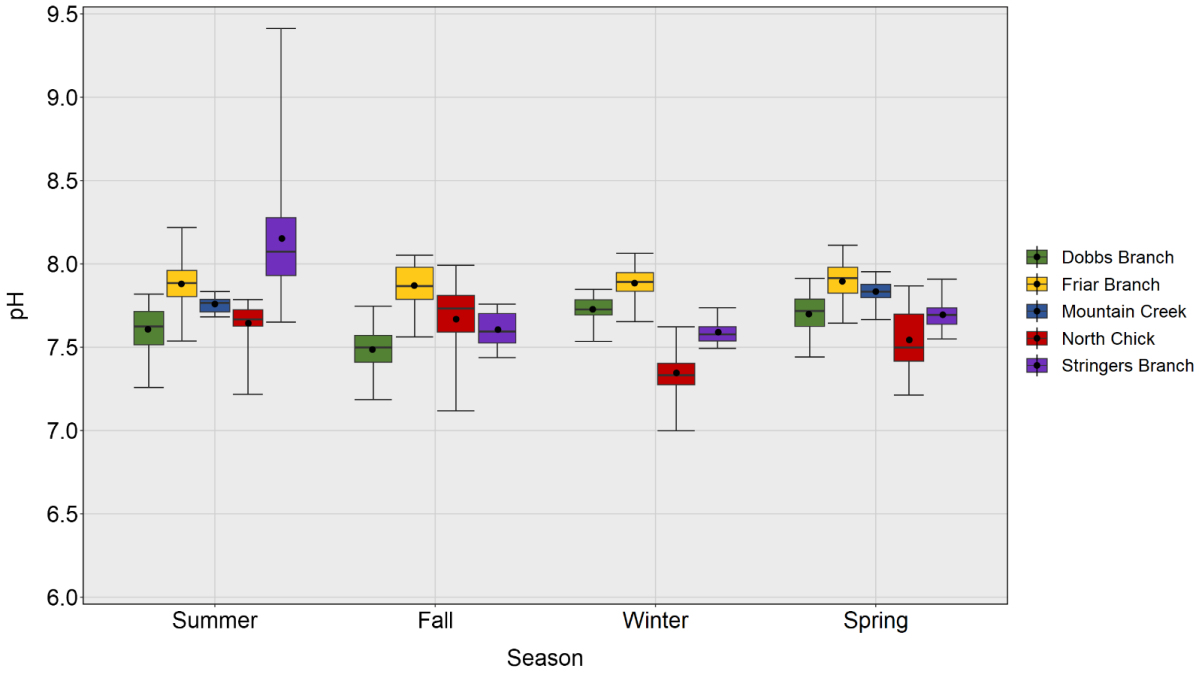

Figure 9. Seasonal Mean pH Values – Daily Average Data

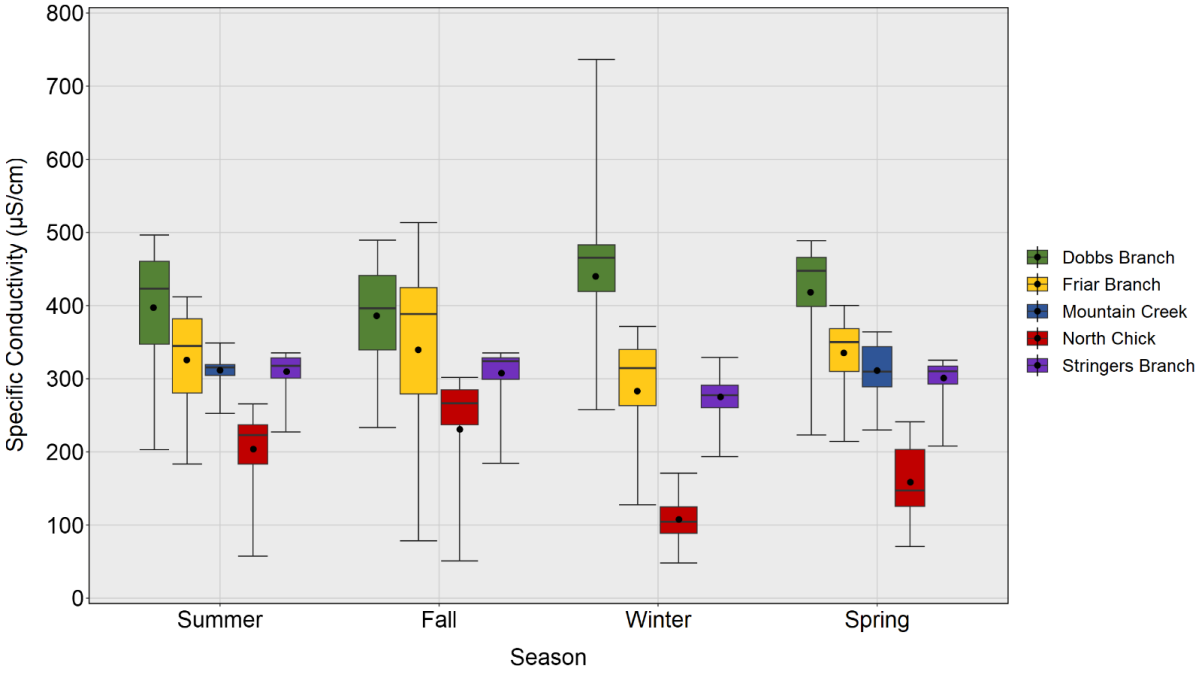

Figure 10. Seasonal Mean Specific Conductivity Values – Daily Average Data

Figure 11 displays the seasonal average turbidity levels recorded at each of the five stations. Table 3 shows the seasonal sum of precipitation across the watersheds. There is not a rain gauge located at the Mountain Creek station due to its proximity to the Stringers Branch station. Storm events drive turbidity levels in

water quality data, so turbidity can be found to have a seasonal pattern in a location with elevated seasonal rainfall and/or rainfall intensities, such as Dobbs Branch. Dobbs Branch precipitation amounts notably trend with the seasonal average turbidity, with spring having the lowest and summer having the highest for both measures. This trend is not displayed in other stations, perhaps due to lower erosion rates or lower rainfall intensities in those watersheds. Friar Branch and Stringers Branch measured notably higher average turbidity in the winter season. This is possibly due to there being more frequent, smaller storm events causing increased turbidity values for a larger portion of the winter season, as opposed to other seasons with less frequent, larger storm events.

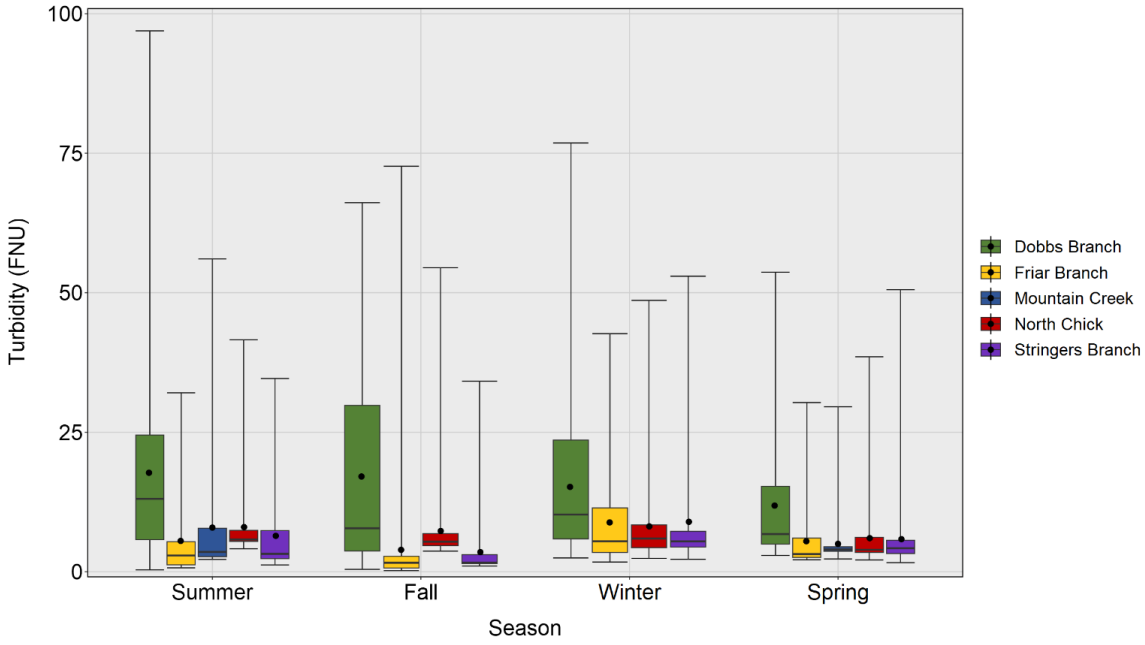

Figure 11. Seasonal Mean Turbidity Values – Daily Average Data

Table 3. Seasonal Precipitation Totals

Station	Summer	Fall	Winter	Spring	Total
Dobbs Branch	20.52	15.17	14.43	11.44	**61.56**
Friar Branch	16.57	14.4	14.25	11.22	**56.44**
North Chick	15.07	15.22	15.26	11.54	**57.09**
Stringers Branch	15.05	15.15	15.09	10.54	**55.83**

3.3 Discrete Sample Analysis

Discrete samples were collected periodically at the City of Chattanooga and Hamilton County's monitoring stations during the reporting period. Samples were collected during both ambient conditions and during storm events throughout the year. Summary statistics for each collected parameter are provided in the sections below.

3.3.1 *E. coli*

As part of their discrete sample collection program, the City of Chattanooga and Hamilton County collected a total of 46 *E. coli* samples throughout the monitored watersheds (Table 4). This includes 26 samples collected during storm conditions and 20 samples collected during ambient conditions. TDEC's single sample *E. coli* criteria for recreation is 487 CFU/100ml for exceptional waters and 941 CFU/100ml for other waters. As seen in Table 4 below, samples from Dobbs Branch, Friar Branch, and Stringers Branch exceeded both of these standards, while samples from Mountain Creek exceeded the 487 CFU/100ml standard. The three sites with the highest *E. coli* concentrations during the year were found to be Dobbs Branch, Friar Branch, and Stringers Branch, which all have an approved TMDL for *E. coli*. These three watersheds were identified in the City of Chattanooga / Hamilton County Monitoring Strategy as High Priority watersheds with several possible sources of high *E. coli* that may be investigated in an attempt to determine the primary sources within these watersheds. As expected, *E. coli* concentrations were measured to be higher at most stations during storm conditions due to runoff. The exception is the Mountain Creek station, which only had 1 *E. coli* sample collected during storm conditions during the monitoring year. This is not a large enough dataset to draw conclusions about the difference between ambient and storm conditions at this station.

Table 4. E. coli (MPN/100 mL) Sample Dataset Summary Statistics

E. coli (MPN/100mL) – Combined Storm/Ambient Samples							
	Mean	Std Deviation	Median	Minimum	Maximum	Range	Count
Dobbs Branch	11402	14410	4100	130	40000	39870	9
Friar Branch	754	662	410	120	2200	2080	9
Mountain Creek	278	185	240	110	550	440	5
North Chick	160	126	100	40	460	420	9
Stringers Branch	3035	4117	1100	60	11000	10940	17
E. coli (MPN/100mL) – Storm Samples							
	Mean	Std Deviation	Median	Minimum	Maximum	Range	Count
Dobbs Branch	19166	15610	24000	130	40000	39870	5
Friar Branch	696	460	390	340	1200	860	5
Mountain Creek*	120	-	-	-	-	-	1
North Chick	180	149	100	82	460	378	6
Stringers Branch	4562	4452	2200	80	11000	10920	11
E. coli (MPN/100mL) – Ambient Samples							
	Mean	Std Deviation	Median	Minimum	Maximum	Range	Count
Dobbs Branch	1698	1683	1160	370	4100	3730	4
Friar Branch	828	935	495	120	2200	2080	4
Mountain Creek	318	188	305	110	550	440	4
North Chick	120	70	150	40	170	130	3
Stringers Branch	235	236	160	60	700	640	6

*Due to a single sample being collected, the mean displayed here reflects the results of that sample.

3.3.2 Total Suspended Solids

As part of their discrete sample collection program, the City of Chattanooga and Hamilton County collected a total of 46 TSS samples throughout the monitored watersheds (Table 5). This includes 26 samples during storm conditions and 20 samples during ambient conditions. As expected, measured TSS concentrations tended to be higher during storm event samples. Notably, Dobbs Branch had a mean of 10.2 mg/l during ambient conditions and 151.9 mg/L during storm conditions. This is indicative of a significant amount of erosion and/or bed sediment re-suspension occurring upstream of this station.

Table 5. Total Suspended Solids (mg/L) Sample Dataset Summary Statistics

Total Suspended Solids (mg/L) – Combined Storm/Ambient Samples							
	Mean	Std Deviation	Median	Minimum	Maximum	Range	Count
Dobbs Branch	81.1	100.2	17.2	4.4	232.0	227.6	8
Friar Branch	6.7	3.9	5.8	2.4	13.6	11.2	8
Mountain Creek	4.6	3.1	4.0	2.4	10.0	7.6	5
North Chick	6.0	2.8	5.2	2.8	10.8	8.0	8
Stringers Branch	7.5	5.5	6.0	1.0	18.0	17.0	17
Total Suspended Solids (mg/L) – Storm Samples							
	Mean	Std Deviation	Median	Minimum	Maximum	Range	Count
Dobbs Branch	151.9	99.5	184.0	7.6	232.0	224.4	4
Friar Branch	9.3	3.8	9.2	5.2	13.6	8.4	4
Mountain Creek*	2.4	-	-	-	-	-	1
North Chick	6.0	2.8	5.2	3.6	10.8	7.2	5
Stringers Branch	9.6	5.3	7.0	2.0	18.0	16.0	12
Total Suspended Solids (mg/L) – Ambient Samples							
	Mean	Std Deviation	Median	Minimum	Maximum	Range	Count
Dobbs Branch	10.2	11.1	4.8	4.4	26.8	22.4	4
Friar Branch	4.1	1.9	3.8	2.4	6.4	4.0	4
Mountain Creek	5.1	3.4	4.0	2.4	10.0	7.6	4
North Chick	5.9	3.4	5.2	2.8	9.6	6.8	3
Stringers Branch	2.6	1.5	2.0	1.0	5.0	4.0	5

*Due to a single sample being collected, the mean displayed here reflects the results of that sample.

3.3.3 Nutrients

The City of Chattanooga and Hamilton County collected 48 nitrate/nitrite, TKN, and TP samples as part of their discrete sample collection program. This includes 28 samples of each collected during storm conditions and 20 samples of each collected during ambient conditions. Nitrate+nitrite results are shown separately for comparison to the *Development of Regionally-based Interpretations of Tennessee's Narrative Nutrient Criterion* document developed by TDEC (Table 6). Total Nitrogen (TN) in

Table 7 below is representative of the sum of nitrate+nitrite and TKN. TP results are summarized in Table 8. Undetectable concentrations were considered as zero (0) values for the purpose of the summary tables below.

According to the *Development of Regionally-based Interpretations of Tennessee's Narrative Nutrient Criterion* document developed by TDEC, Chattanooga falls within Level III ecoregion 67 of Nutrient Ecoregion XI. This corresponds to a TDEC recommended interpretation of the existing narrative criteria of 1.22 mg/L for nitrate+nitrite for this ecoregion. As seen in Table 6, all nitrate+nitrite samples collected are below this recommended interpretation criteria and, therefore, do not represent a concerning concentration of nitrate+nitrite. Although no recommend interpretation criteria is provided for TN or TKN, it is worth noting that TKN was only detected at the Dobbs Branch and Stringers Branch stations. This is likely due to the relatively high detection limits of 0.5 – 1 mg/L for parameters measured using the current lab method at all stations other than Stringers Branch. It would be beneficial to request the lab utilize a technique with a lower detection limit similar to Stringers Branch.

Table 6. Nitrate+Nitrite (mg/L) Sample Dataset Summary Statistics

Nitrate+Nitrite (mg/L) – Combined Storm/Ambient Samples							
	Mean	Std Deviation	Median	Minimum	Maximum	Range	Count
Dobbs Branch	0.78	0.16	0.73	0.61	1.02	0.41	9
Friar Branch	0.80	0.28	0.66	0.53	1.17	0.65	9
Mountain Creek	0.41	0.15	0.43	0.22	0.62	0.40	5
North Chick	0.46	0.13	0.45	0.29	0.73	0.44	9
Stringers Branch	0.03	0.01	0.03	0.02	0.06	0.04	16
Nitrate+Nitrite (mg/L) – Storm Samples							
	Mean	Std Deviation	Median	Minimum	Maximum	Range	Count
Dobbs Branch	0.75	0.14	0.73	0.64	0.99	0.35	5
Friar Branch	0.91	0.34	1.13	0.53	1.17	0.65	5
Mountain Creek*	0.62	-	-	-	-	-	1
North Chick	0.51	0.13	0.46	0.35	0.73	0.38	6
Stringers Branch	0.02	0.01	0.02	0.02	0.04	0.02	11
Nitrate + Nitrite (mg/L) – Ambient Samples							
	Mean	Std Deviation	Median	Minimum	Maximum	Range	Count
Dobbs Branch	0.81	0.19	0.81	0.61	1.02	0.41	4
Friar Branch	0.66	0.10	0.64	0.58	0.80	0.22	4
Mountain Creek	0.36	0.10	0.38	0.22	0.45	0.23	4
North Chick	0.37	0.08	0.38	0.29	0.45	0.17	3
Stringers Branch	0.05	0.01	0.04	0.04	0.06	0.02	5

*Due to a single sample being collected, the mean displayed here reflects the results of that sample.

Table 7. Total Nitrogen (mg/L) Sample Dataset Summary Statistics

Total Nitrogen (mg/L) – Combined Storm/Ambient Samples							
	Mean	Std Deviation	Median	Minimum	Maximum	Range	Count
Dobbs Branch	1.53	1.10	1.44	0.61	4.20	3.59	9
Friar Branch	0.80	0.28	0.66	0.53	1.17	0.65	9
Mountain Creek	0.41	0.15	0.43	0.22	0.62	0.40	5
North Chick	0.46	0.13	0.45	0.29	0.73	0.44	9
Stringers Branch	2.04	0.88	2.13	0.82	3.54	2.72	16
Total Nitrogen (mg/L) – Storm Samples							
	Mean	Std Deviation	Median	Minimum	Maximum	Range	Count
Dobbs Branch	1.96	1.31	1.62	0.74	4.20	3.46	5
Friar Branch	0.91	0.34	1.13	0.53	1.17	0.65	5
Mountain Creek*	0.62	-	-	-	-	-	1
North Chick	0.51	0.13	0.46	0.35	0.73	0.38	6
Stringers Branch	1.92	0.65	2.03	1.02	2.82	1.80	11
Total Nitrogen (mg/L) – Ambient Samples							
	Mean	Std Deviation	Median	Minimum	Maximum	Range	Count
Dobbs Branch	0.98	0.46	0.85	0.61	1.62	1.01	4
Friar Branch	0.66	0.10	0.64	0.58	0.80	0.22	4
Mountain Creek	0.36	0.10	0.38	0.22	0.45	0.23	4
North Chick	0.37	0.08	0.38	0.29	0.45	0.17	3
Stringers Branch	2.30	1.32	2.86	0.82	3.54	2.72	5

*Due to a single sample being collected, the mean displayed here reflects the results of that sample.

The recommended interpretation of the existing narrative criteria provided by TDEC is 0.04 mg/L for TP within this ecoregion. All samples collected at Stringers Branch measured above this recommended criteria. In conjunction with the high *E. coli* measurements at Stringers Branch, SSOs are a likely cause for the increased TP concentrations at this station. Other possible sources of TP are organic detritus and fertilizer use. The high detection limit of 0.5 mg/L at the other four stations leads to difficulty interpreting the results given that TP is generally found at much lower concentrations within streams. Similar to TKN, it is recommended that a lab method with a lower detection limit, similar to that used at Stringers Branch, be applied to measurements at these stations.

Table 8. Total Phosphorus (mg/L) Sample Dataset Summary Statistics

Total Phosphorus (mg/L) – Combined Storm/Ambient Samples							
	Mean	Std Deviation	Median	Minimum	Maximum	Range	Count
Dobbs Branch**	-	-	<0.500	<0.500	0.548	0.548	9
Friar Branch	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	9
Mountain Creek	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	5
North Chick	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	9
Stringers Branch	0.106	0.051	0.085	0.060	0.240	0.180	16
Total Phosphorus (mg/L) – Storm Samples							
	Mean	Std Deviation	Median	Minimum	Maximum	Range	Count
Dobbs Branch**	-	-	<0.500	<0.500	0.548	0.548	5
Friar Branch	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	5
Mountain Creek*	0.000	-	-	-	-	-	1
North Chick	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	6
Stringers Branch	0.116	0.059	0.110	0.060	0.240	0.180	11
Total Phosphorus (mg/L) – Ambient Samples							
	Mean	Std Deviation	Median	Minimum	Maximum	Range	Count
Dobbs Branch	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	4
Friar Branch	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	4
Mountain Creek	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	4
North Chick	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	3
Stringers Branch	0.082	0.013	0.080	0.070	0.100	0.030	5

*Due to a single sample being collected, the mean displayed here reflects the results of that sample.
**Mean and standard deviation are not displayed due to only a single sample being above the detection limit of 0.500 mg/L. The maximum value displayed here reflects the results of that sample.

Appendix

Monitoring Station Location Maps

City of Chattanooga/Hamilton County Monitoring Stations - Dobbs Branch at Park City Park

N

0 300 600 1,200 US Feet

Legend

- Monitoring Station
- Road
- Stream
- Waterbody

City of Chattanooga Water Quality Program

Hamilton County Water Quality Program

WOOLPERT

City of Chattanooga/Hamilton County Monitoring Stations - North Chickamauga Creek at Greenway Farms

N

0 300 600 1,200 US Feet

Legend

- Monitoring Station
- Road
- Stream
- Waterbody

City of Chattanooga Water Quality Program

Hamilton County Water Quality Program

WOOLPERT

City of Chattanooga/Hamilton County Monitoring Stations - Stringers Branch at Signal Mountain Road

N

0 300 600 1,200
US Feet

Legend

- Monitoring Station
- Road
- Stream
- Waterbody

City of Chattanooga Water Quality Program

Hamilton County Water Quality Program

WOOLPERT

City of Chattanooga/Hamilton County Monitoring Stations - Friar Branch at Polymer Drive

N

0 300 600 1,200 US Feet

Legend

- Monitoring Station
- Road
- Stream
- Waterbody

City of Chattanooga Water Quality Program

Hamilton County Water Quality Program

WOOLPERT