Nonpoint Source Pollution
of the
Bat Creek Watershed in Monroe County, TN

The Report of a Supplemental Environmental Project

by

Water Quality Improvement Committee
of the
Watershed Association of the Tellico Reservoir
tellicowater.org

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Acknowledgment

This report documents a project performed by the Water Quality Improvement Committee of the Watershed Association of the Tellico Reservoir. This work was performed as a Supplemental Environmental Project described in the Consent Decree of the litigation, Tennessee Clean Water Network, and the Watershed Association of the Tellico Reservoir, Plaintiffs, vs. City of Madisonville, Tennessee, Defendant, Case 3:14-cv-00555-TAV-HBG, entered 06/29/15 in the United States District Court for the Eastern District of Tennessee at Knoxville.

The City of Madisonville paid nearly $10,000 for laboratory analyses of water quality samples collected by volunteers to help target types, concentrations, and sources of nonpoint source pollution throughout the Bat Creek watershed to assist future environmental activities to reduce or eliminate pollution.

WATeR volunteers contributed about 3,500 hours planning and executing this project; and WATeR expended about $6,000 additional to purchase equipment, supplies and supplemental laboratory analyses in support of this project.

Although many volunteers participated in specific aspects, the activities described herein were primarily planned, performed, analyzed, and documented by these members of the WQIC:

Bill Agee	Tom Paul
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Lou Miller	Bill Waldrop, Chair

SUMMARY

Introduction

This report presents results of an 18-month water quality investigation project in Monroe County, Tennessee, conducted as a Supplemental Environmental Project (SEP) to satisfy commitments of a Federal Consent Decree (see preceding Acknowledgment page for details). The two-part objective of the investigation was to identify drainage areas contributing to nonpoint source pollution of Bat Creek, and to document the pollution types, concentrations, and source areas to support future remedial activities. The target audience of this report is a combination of agricultural and environmental specialists in and around Monroe County.

The activities contributing to this report (planning, field work, data analysis and report preparation) were performed by the Water Quality Improvement Committee (WQIC) of the Watershed Association of the Tellico Reservoir (WATeR). The approximate time frames for major segments of the investigation were: planning and orientation – fourth quarter 2015, field and laboratory analyses – 2016, and analysis and report preparation – first quarter 2017.

Within its 26 square mile watershed, Bat Creek flows from headwaters near Madisonville and meanders generally northeast about 14 miles before it enters a large embayment (bay or arm) of Tellico Lake. Outside of Madisonville, the watershed area is primarily rural and agricultural in character. Herds of grazing dairy and beef cattle are common, as are field crops.

The Tennessee Department of Environment and Conservation (TDEC) has classified Bat Creek as impaired by pollution. TDEC cited pollution parameters to be excess concentrations of E.Coli bacteria – a health issue to people, plus total Phosphorus and Nitrite + Nitrate (nitrogen) – both nutrients harmful to aquatic environments. Volunteers of WATeR collected monthly water samples over a seven-month period for analysis of these parameters by a certified commercial testing laboratory.

Seven locations were selected for sampling the main stem of Bat Creek, at stream crossings of public roads. In addition, 11 tributary stream locations were sampled at road crossings near the main stem of Bat Creek. About 47% of the total watershed area was sampled separately from the main stem via the tributary locations. The balance of the watershed drainage flowed directly to the main stem, where all flows were merged.

This program closely followed the methods, protocols and procedures that TDEC uses for their field sampling work and subsequent lab analyses. One unusual aspect was a commitment to attempt *in situ* flow measurements, with the intent of creating a system-wide “pseudo mass balance” for target pollutants. A true mass balance would identify the accumulation of a pollutant from feeder creeks throughout the watershed into a total at the discharge point of the creek, all data measured in mass per unit time (e.g., pounds per day). While that objective was not achievable to the extent or with the accuracy desired, the approach was successful enough to allow the team to prepare the insightful mass graphs used throughout this report. Those graphs are interpreted with some judgment, but proved to be of value by enabling the team to identify and prioritize various segments of the watershed for further action.

Field data and analytical test results collected during sampling activities in 2016 were condensed as average values for concentration and mass at each sample location to simplify interpretation of the database. Graphs provide visual perspective on relative relationships between locations and values of test results. Descriptive information about each sample location is presented as well as summary data tables for each sample location.

General Findings

This report identifies and ranks the types of pollutants in sampled tributaries and in segments of the Bat Creek main stem. The result is sufficient data for focused efforts to understand and reduce existing nonpoint source pollution in the identified sub-watersheds of Bat Creek.

Data presented isolate source areas of the various types of nonpoint source pollution throughout the Bat Creek watershed. This database will provide guidance to specific sources and appropriate measures for improvement.

There is much more to learn in identifying problem issues and areas due to the SEP team's limited access to major sectors of the watershed. Significant differences in parameters between main stem sections of Bat Creek should provide the rationale for continued efforts to assess land uses and identify areas of opportunity to reduce pollutant loadings.

Greater use of agriculture Best Management Practices (BMPs) throughout the watershed will certainly improve water quality.

Unusual drought conditions during 2016 did not necessarily represent typical concentrations or mass loading conditions which, with more normal rainfall, may be worse than those recorded here.

Pollutant-Specific Findings

<u>E.Coli bacteria</u> is the major pollutant of concern in the Bat Creek Watershed. Based on specialized laboratory gene speciation analyses, the apparent sources of E.Coli are not human but are animal. While results are not definitive, they do indicate that the focus of future efforts should be with BMPs for cattle, and perhaps goats and sheep, rather than problems from poorly functioning septic tank systems.

Levels of E.Coli exceeding the Tennessee water quality standard for recreation uses were recorded in all main stem and tributary sub-watersheds; and in many tributaries the levels exceeded the maximum detection limit of the lab test with varying frequencies. E.Coli "mass" tripled in the last few miles immediately before Bat Creek enters Tellico Lake. High levels of E.Coli in the lowest reach of Bat Creek are of concern since people use the embayment (Tellico Lake at "summer pool"), both above and below sample location B-1 (at Lakeside Road), for recreation and fishing.

Nitrate (nitrogen) at high levels is of concern throughout the Bat Creek Watershed. It is considered a major nutrient pollutant; and the mass loading increased substantially as the creek flows toward Tellico Lake. By far the greatest source of Nitrate in the watershed was the furthest downstream creek segment, where the Nitrate load more than doubled. Nitrate is present in relatively greater quantities than its companion nutrient Phosphorus.

Among tributaries, the most upstream tributaries of the watershed in more developed agricultural areas had the largest mass loadings of Nitrate, but at levels less than 10% of the total load at the downstream end of Bat Creek. The prominent sources of Nitrate are most likely agricultural operations, from fertilizer and animal waste, as well as decaying vegetative matter. The Madisonville wastewater treatment plant (WWTP) has been a significant source of Nitrogen, which should be reduced when the new WWTP is operational.

Phosphorus was present at nominal levels but decreased as Bat Creek flows toward Tellico Lake, probably due to vegetative uptake and from potential sequestering by sediments in the creek. The upper tributaries of Bat Creek had greater loadings of Phosphorous than the lower tributaries of the watershed, just the opposite of Nitrate. There was a spike in Phosphorus at a sample location downstream of Madisonville's WWTP, which currently appears to be the major source of Phosphorus in Bat Creek. The new Madisonville WWTP should substantially reduce Phosphorus levels in Bat Creek.

Turbidity (suspended material) was very high only in one sub-watershed. Turbidity generally increased along the main stem of Bat Creek toward Tellico Lake. Increased Turbidity levels are of concern due to potential negative effects on aquatic and benthic organisms in Bat Creek waters. The lowest reaches of Bat Creek had the highest Turbidity amounts during the sampling period. Elevated Turbidity levels after a rainfall event are expected; however, implementation of agriculture BMPs to reduce E.Coli should also reduce Turbidity.

Dissolved Oxygen average concentrations were above 7.0 ppm and are not of concern in spite of the nonpoint sources of pollution entering the creek. There appears to be effective natural re-aeration of the creek via small rapids along the length of the main stem of the creek as well as in many tributaries.

Prioritized Areas of Bat Creek Watershed

Tributaries – The focus for reducing nonpoint source pollution in the Bat Creek tributary watersheds should be directed above (upstream of) the sample locations cited for tributary sub-watersheds. Tributary sub-watersheds of greatest concern are summarized below in descending priority order. Tributary parameter ranking points identify the pollutants of highest concern in each of these individual watersheds.

Sub-watershed	Location
T-2	Tributary near Lakeside Road
T-13B	Craighead Creek at Brunner Road
T-6	Bulging Branch at Old Loudon Road
T-16	Old Highway 68 near Wilson Road

Main Stem – The focus for reducing nonpoint source pollution along the main stem of Bat Creek should be in the lower reaches (below sample location B-5) of the watershed. The main stem segments of greatest concern are summarized below in descending priority order.

Stem Segment	Description
B-2 to B-1	Far eastern part of the watershed between Farnsworth Road, Highway 72, and Summit Road
B-4 to B-2	Most northern part of the watershed; mainly north of Sweetwater Vonore Road (Highway 322)
B-5 to B-4	North central part of the watershed between the Bat Creek Knobs and Oak Grove Road

Recommendations

The following recommendations emphasize both (a) implementing BMPs in identified high priority areas and (b) conducting more sampling and analyses to further define additional sources of nonpoint source pollution in other sectors of the Bat Creek Watershed.

1. Identify a local sponsor (such as the Monroe County Soil Conservation District, the local NRCS office, UT Agriculture Extension Service, or other motivated organizations) to embrace the results of this study, assume a leadership role moving forward, seek external funding from available sources, and assist local farmers to implement BMPs more cost effectively.
2. The local sponsor can partner with other similar regional agencies (e.g., in Blount or McMinn Counties) to learn from their experiences about the financial benefits and incentives to the agriculture community of using BMPs that reduce nonpoint source pollution.
3. Implement agriculture BMPs within the Bat Creek Watershed at those priority areas identified.
4. Assess the nonpoint source pollution potential in areas of the watershed to which the SEP team had no access or limited data (e.g., T-14A and T-2); then factor that assessment into overall priorities for BMP initiatives.
5. Continue a nonpoint source water quality sampling program after the new Madisonville WWTP becomes operational to:
    (a) understand the characteristics of the Bat Creek Watershed in years of average rainfall and where access was not available,
    (b) provide additional data to local agencies in support of agriculture BMPs throughout the watershed, and
    (c) monitor water quality improvements in the watershed to confirm the effectiveness of operational BMPs.
6. Continue other educational and implementation support activities to abate nonpoint source pollution in the Bat Creek Watershed.
7. Enter the water quality data from this study into the TDEC Tellico Reservoir database to assist in future delisting of portions of the Bat Creek Watershed from the 303(d) list of impaired streams.
8. Conduct in-stream benthic observations to assess the impact of current Turbidity levels in the Bat Creek ecosystem.
9. Remove debris from road culverts, both ends and internally, to reduce the flooding that was commonplace upstream of culverts when significant rainfall events occurred.

BAT CREEK MAPS

Map 1 – Project Location – Tennessee map locating Monroe County, and Monroe County map locating the Bat Creek Watershed

Map 2 – Potential Sample Locations

Map 3 – Main Stem Sub-watersheds

Map 4 – Potential Tributary Sub-watershed Areas and Associated Main Stem Sub-watersheds

Map 5 – Sample Locations Used and Associated Sub-watershed Boundaries

Map 6 – Sampled Tributary Sub-watershed Areas and Associated Main Stem Sub-watersheds

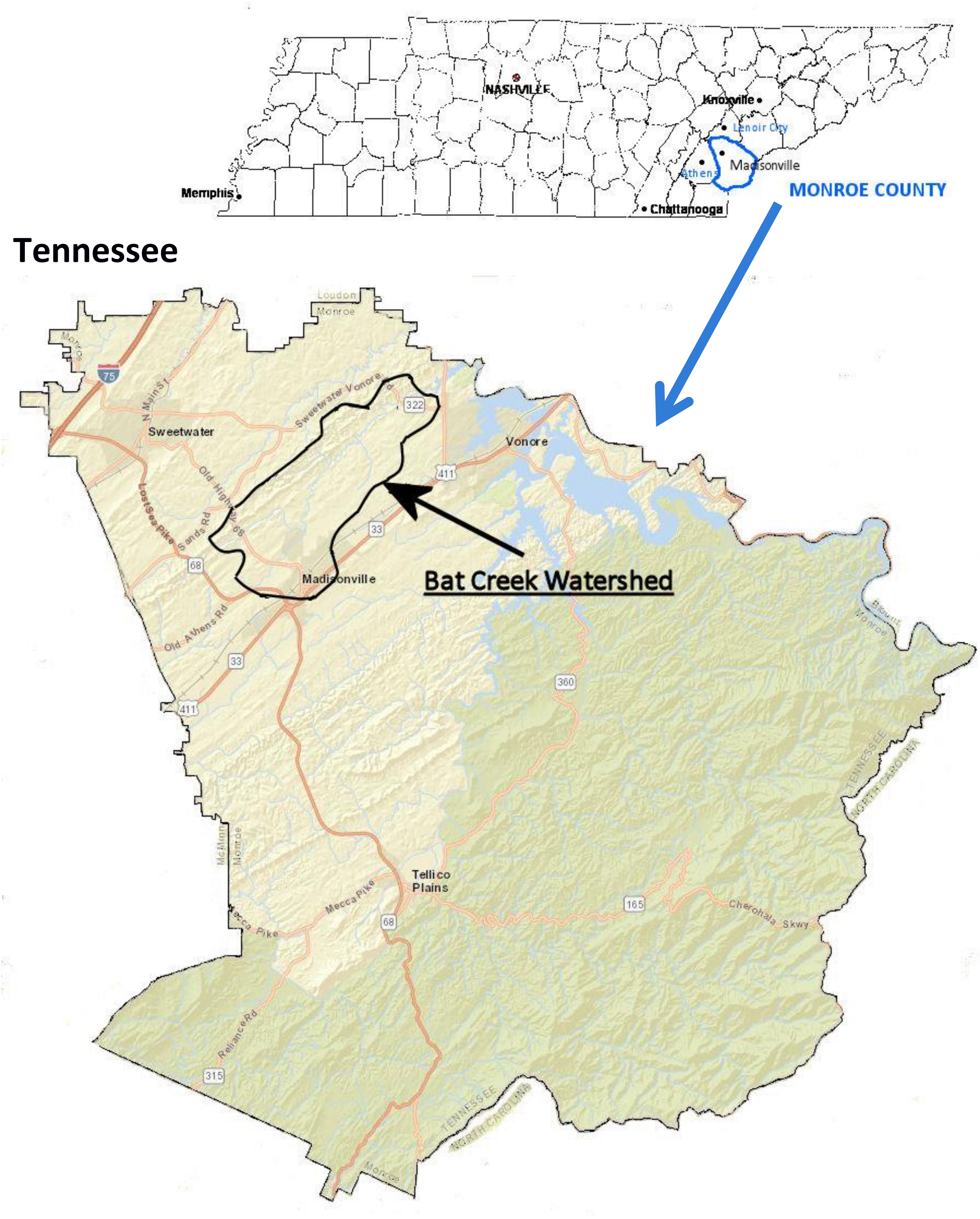
Map 7 – Priority Sub-watersheds

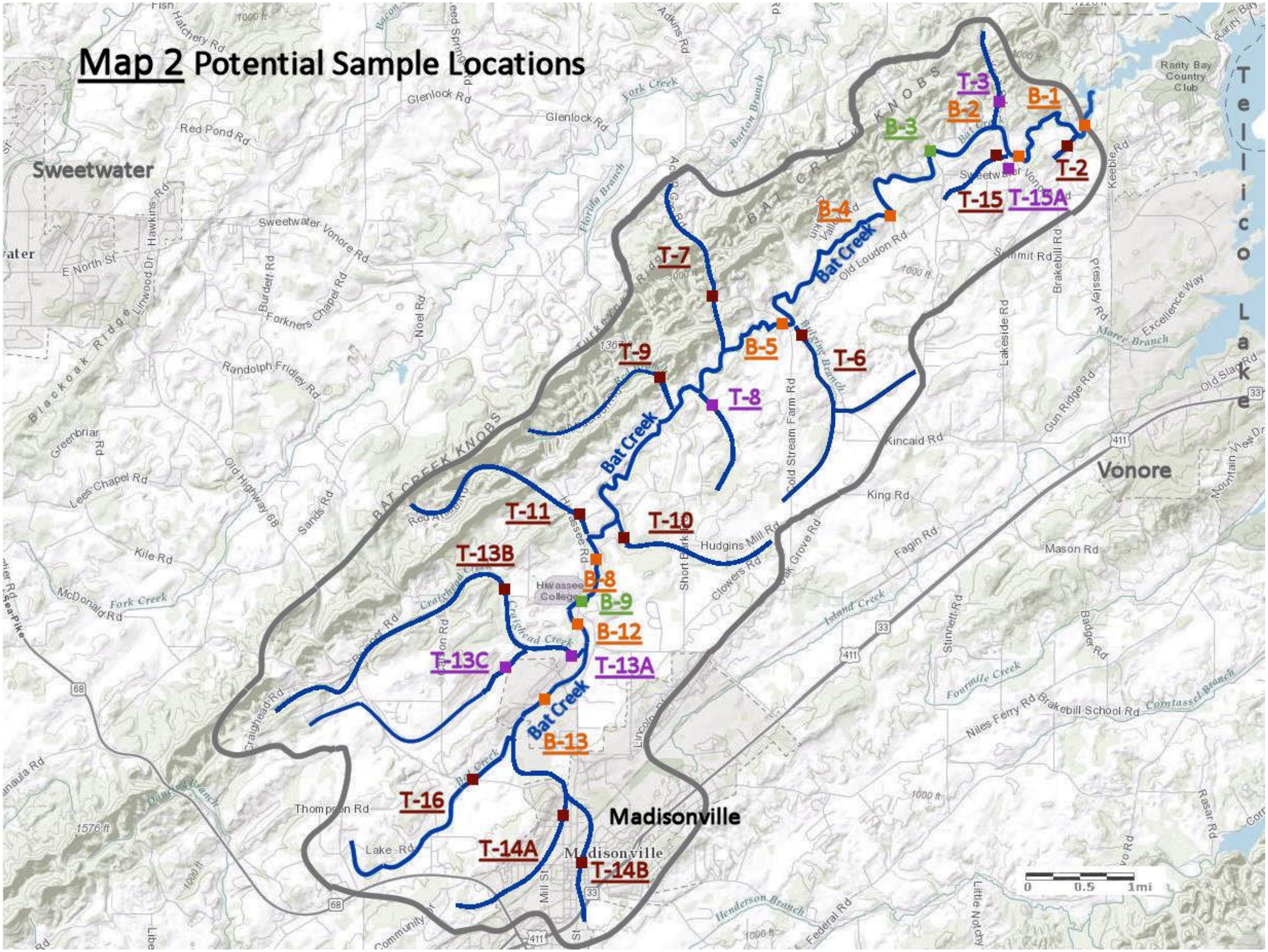
Map 8 – Watershed Sampling Map – A large, fold-out, version of Map 8 will be included with the full printed report.

Map Legend

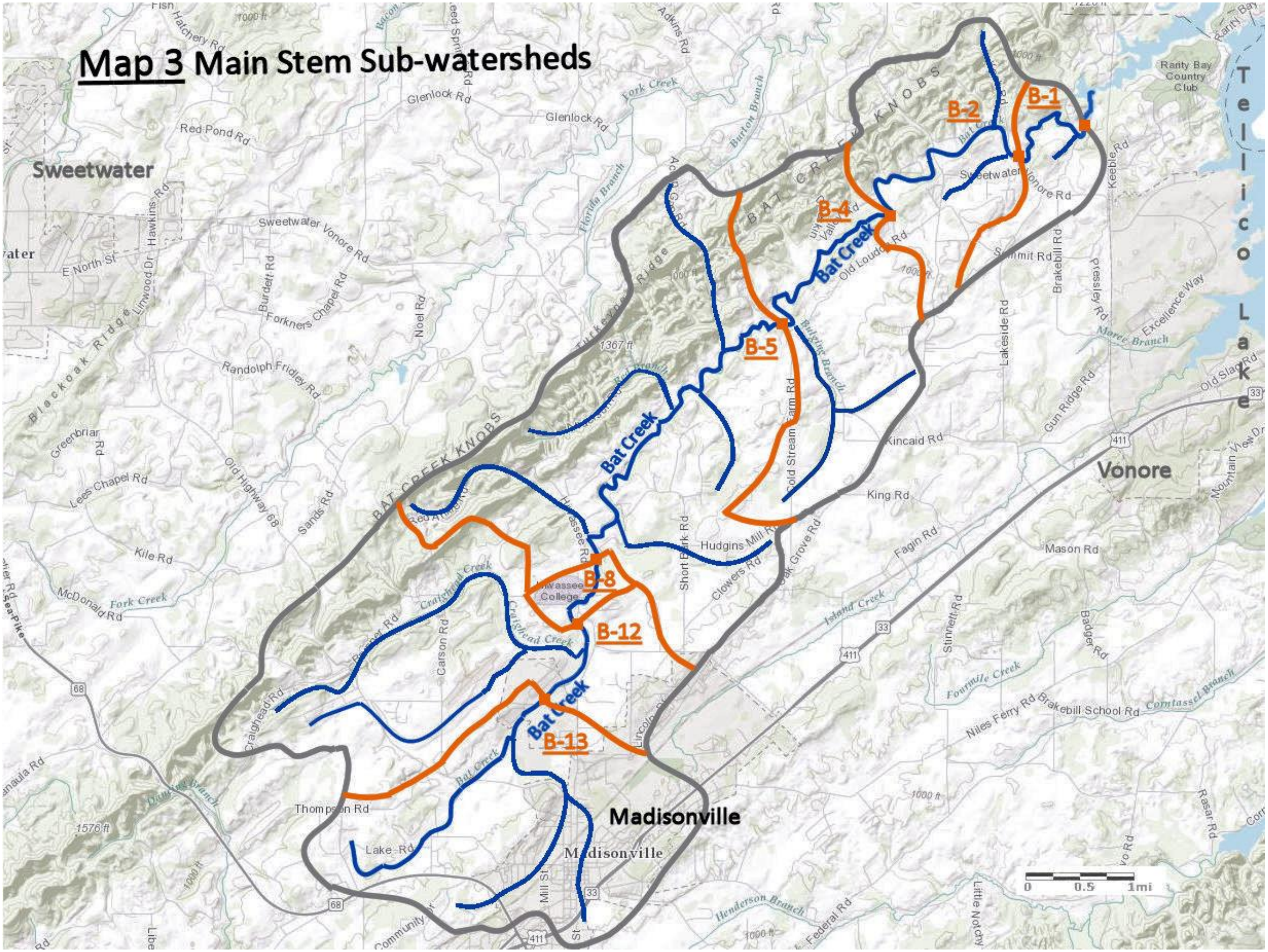
Symbol	Definition	Map
	Bat Creek Watershed Boundary	Maps 2, 3, 4, 5, 6, 7, 8
	Sampled Bat Creek Sub-watershed Boundary	Maps 3, 4, 5, 6, 7
B-5	Sampled Bat Creek Sub-watershed Site Label	Maps 2, 3, 4, 5, 6, 7, 8
	Sampled Bat Creek Sub-watershed Site	Maps 2, 3, 4, 5, 6, 7, 8
	Sampled Tributary Sub-watershed Boundary	Maps 4, 5, 6, 7
T-7	Sampled Tributary Sub-watershed Site Label	Maps 2, 4, 5, 6, 7, 8
	Sampled Tributary Sub-watershed Site	Maps 2, 4, 5, 6, 7, 8
	Sampled Tributary Sub-watershed Area	Maps 4, 6
B-9	Un-Sampled Bat Creek Sub-watershed Site Label	Map 2
	Un-Sampled Bat Creek Sub-watershed Site	Map 2
T-8	Un-Sampled Tributary Sub-watershed Site Label	Maps 2, 4
	Un-Sampled Tributary Sub-watershed Site	Maps 2, 4
	Un-Sampled Tributary Sub-watershed Area	Map 4
	Priority Sub-watershed Area	Map 7

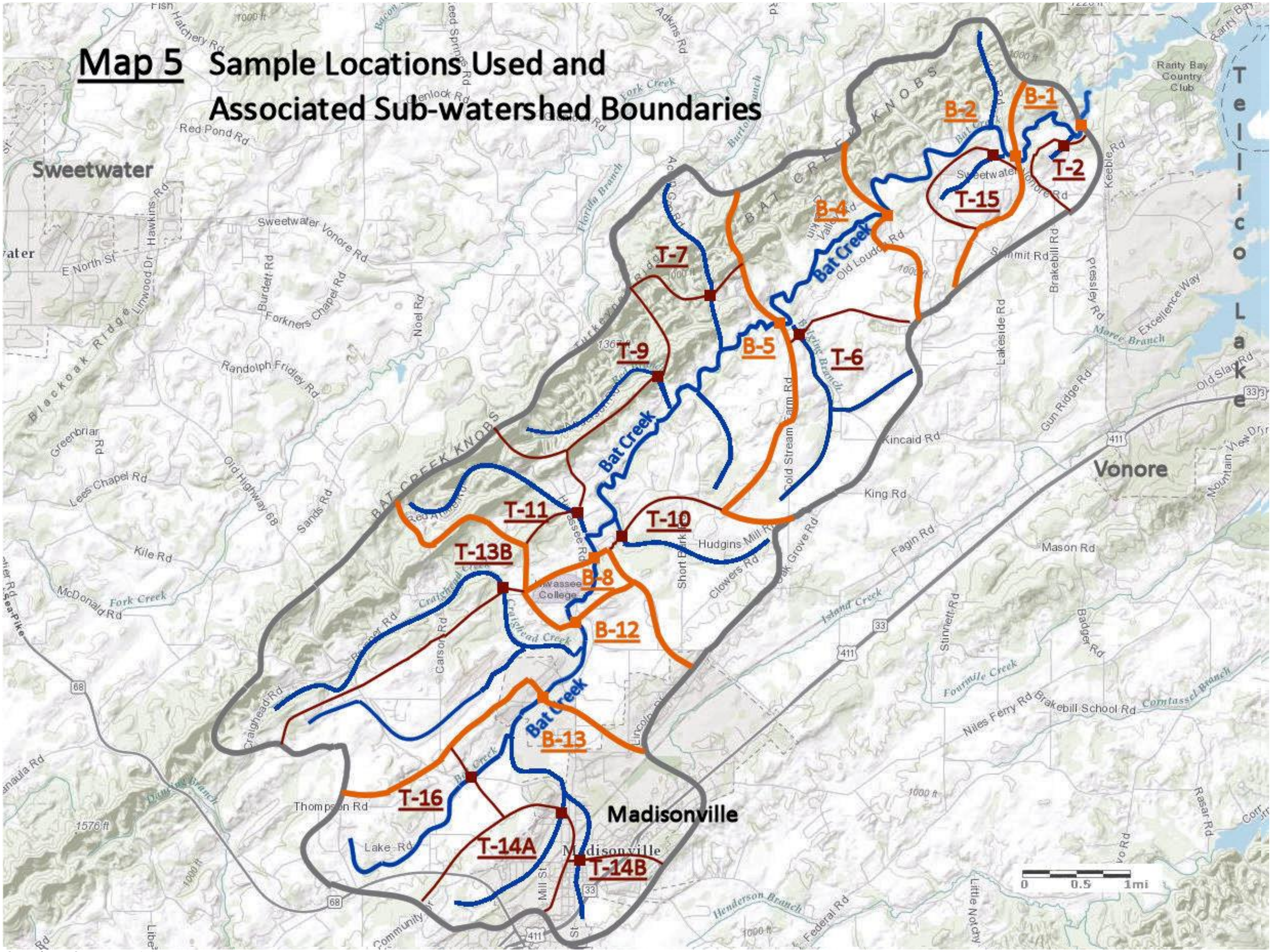
Map 1 – Project Location

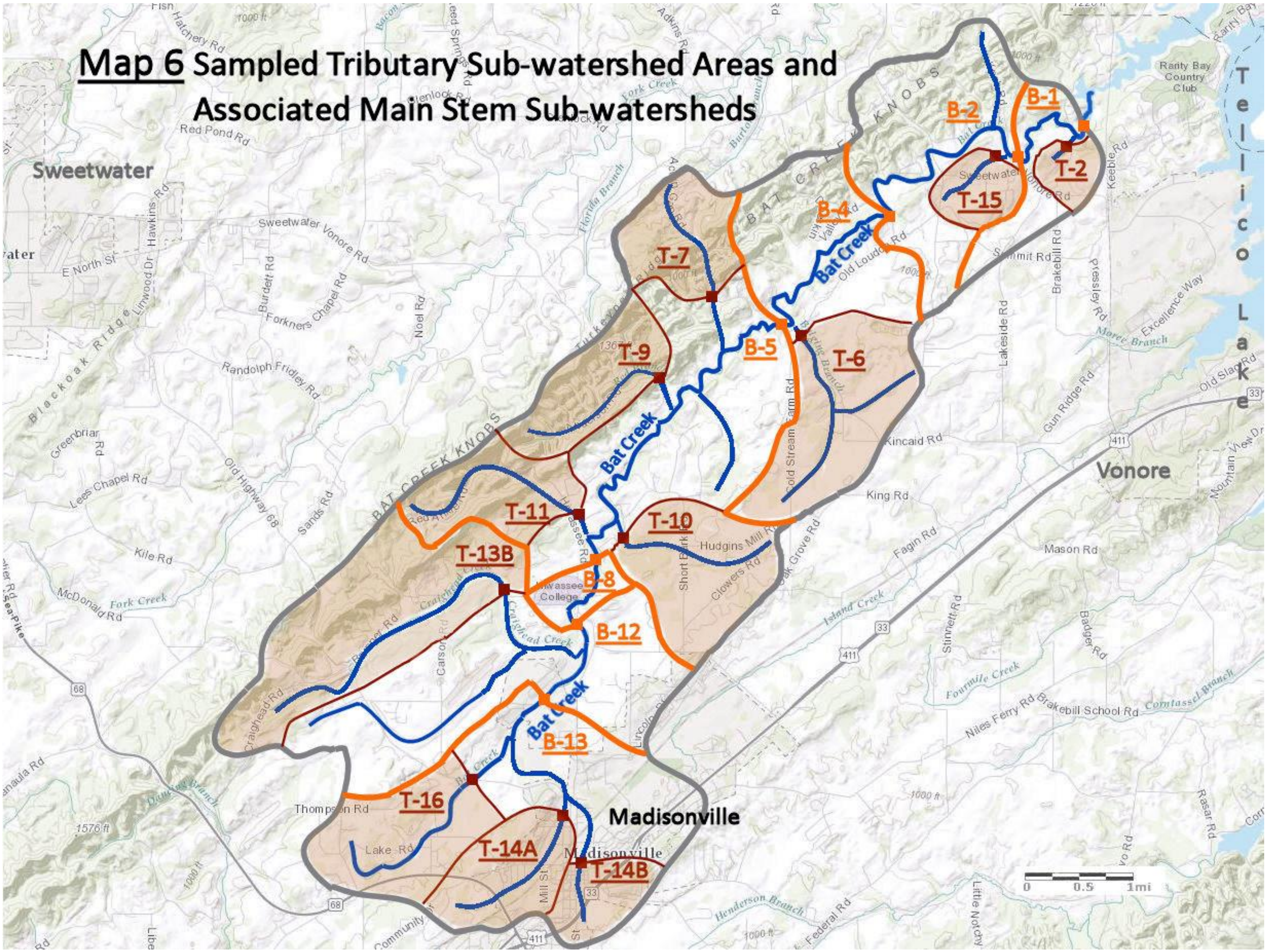


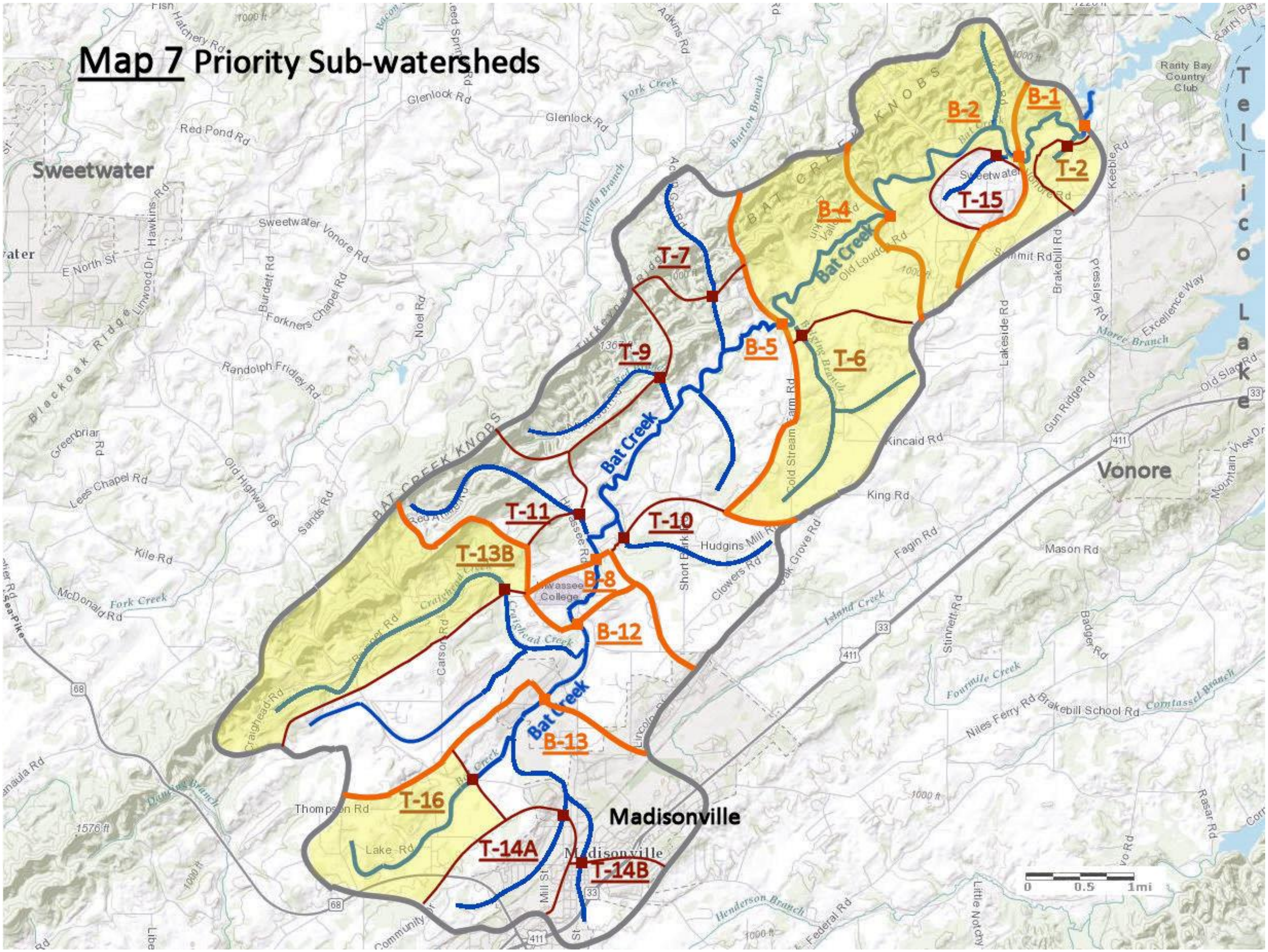

Map 2 Potential Sample Locations
Sweetwater
Vonore
Madisonville
Tellico Lake
Bat Creek
Bat Creek Knobs
Hiwassee College
T-2
T-3
T-6
T-7
T-8
T-9
T-10
T-11
T-13A
T-13B
T-13C
T-14A
T-14B
T-15
T-15A
T-16
B-1
B-2
B-3
B-4
B-5
B-8
B-9
B-12
B-13
Rarity Bay Country Club
Glenlock Rd
Red Pond Rd
Sweetwater Vonore Rd
E North St
Forkners Chapel Rd
Noel Rd
Randolph Fridley Rd
Greenbriar Rd
Lees Chapel Rd
Old Highway 68
Sands Rd
Kile Rd
McDonald Rd
Fork Creek
Hudgins Mill Rd
Clowers Rd
Oak Grove Rd
Old Stream Farm Rd
Kincaid Rd
King Rd
Fagin Rd
Mason Rd
Island Creek
Stinnett Rd
Badger Rd
Fourmile Creek
Niles Ferry Rd
Brakebill School Rd
Lakeside Rd
Brakebill Rd
Pressley Rd
Excellence Way
Gun Ridge Rd
Old Loudon Rd
Keeble Rd
Thompson Rd
Lake Rd
Mill St
Henderson Branch
Federal Rd
Little Notchy
Rasar Rd
Craighead Rd
Craighead Creek
Adkins Rd
0 0.5 1mi

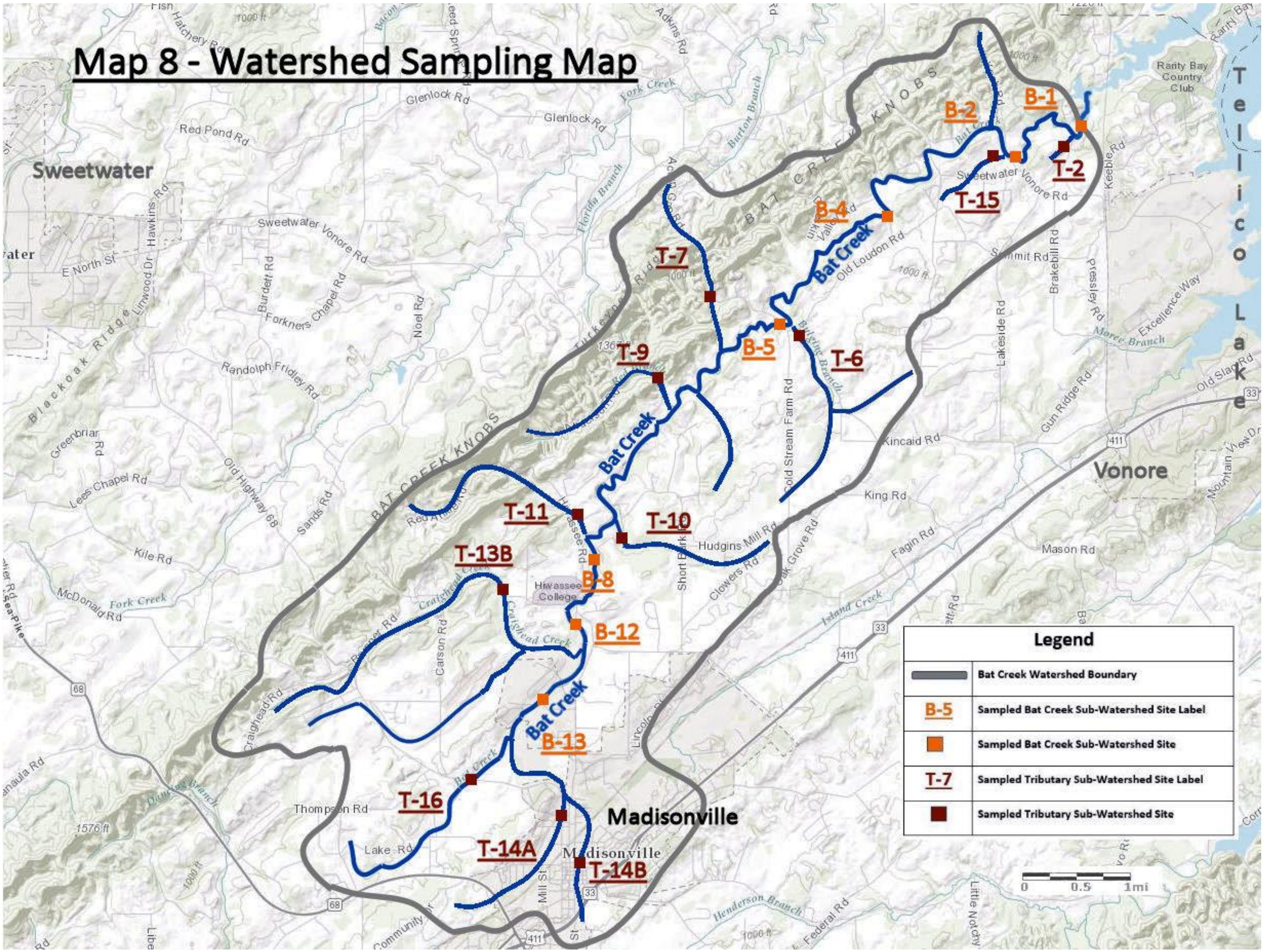
Map 3 Main Stem Sub-watersheds




Map 5 Sample Locations Used and
Associated Sub-watershed Boundaries
Sweetwater
Vonore
Madisonville
Tellico Lake
Bat Creek
B-1
B-2
B-4
B-5
B-8
B-12
B-13
T-2
T-6
T-7
T-9
T-10
T-11
T-13B
T-14A
T-14B
T-15
T-16
Hiwassee College
0 0.5 1mi


Map 6 Sampled Tributary Sub-watershed Areas and Associated Main Stem Sub-watersheds
Sweetwater
Vonore
Madisonville
Tellico Lake
Bat Creek
B-1
B-2
B-4
B-5
B-8
B-12
B-13
T-2
T-6
T-7
T-9
T-10
T-11
T-13B
T-14A
T-14B
T-15
T-16
Hiwassee College
Rarity Bay Country Club


Map 7 Priority Sub-watersheds
Sweetwater
Vonore
Madisonville
Tellico Lake
Bat Creek
B-1
B-2
B-4
B-5
B-8
B-12
B-13
T-2
T-6
T-7
T-9
T-10
T-11
T-13B
T-14A
T-14B
T-15
T-16
Rarity Bay Country Club
Bat Creek Knobs
0 0.5 1mi



Map 8 - Watershed Sampling Map
Sweetwater
Vonore
Madisonville
Tellico Lake
Bat Creek
Bat Creek Knobs
Hiwassee College
B-1
B-2
B-4
B-5
B-8
B-12
B-13
T-2
T-6
T-7
T-9
T-10
T-11
T-13B
T-14A
T-14B
T-15
T-16
Legend
Bat Creek Watershed Boundary
Sampled Bat Creek Sub-Watershed Site Label
Sampled Bat Creek Sub-Watershed Site
Sampled Tributary Sub-Watershed Site Label
Sampled Tributary Sub-Watershed Site
0
0.5
1mi

ABBREVIATIONS

Abbreviation	Definition
Ac	Acres
B or BC	Bat Creek main stem sample location designation
BMPs	Best Management Practices
cfs	Cubic feet per second
CFU	Colony Forming Unit
CWA	Clean Water Act (Federal)
DO	Dissolved Oxygen
E.Coli	Escherichia Coli (fecal bacterial public health hazard; waterborne or food)
EPA	U.S. Environmental Protection Agency
gpm	Gallons per minute
MGD	Million gallons per day
mg/l	Milligrams per liter
ml	Milliliter
N	Nitrogen
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NTU	Nephelometric Turbidity Unit
P	Phosphorus
PPD	Pounds per day
ppm	Parts per million
Q	Flow rate
SEP	Supplemental Environmental Project
T or Tr	Bat Creek tributary sample location designation
TCWN	Tennessee Clean Water Network
TDEC	Tennessee Department of Environment and Conservation
TKN	Total Kjeldahl Nitrogen
USGS	United States Geological Survey
WATeR	Watershed Association of the Tellico Reservoir
WQIC	Water Quality Improvement Committee (of WATeR)
WWTP	Wastewater treatment plant

NOMENCLATURE

Item	Definition	Comment
Ammonia	Nitrogen pollutant - formula NH3, measured and reported separately or as a component of TKN	Reported as Ammonia-nitrogen, reporting only the amount of N in NH3 measured; or reported with organic-N as TKN
Average	Sum of all values divided by the number of values	Used in calculating and graphing for Nitrite, Nitrate, Phosphorus, Dissolved Oxygen and Turbidity
cfs	Cubic feet/second	Flow rate – 1 cfs = 0.65 MGD
Geometric Mean	Normalized average value - the n*th* root of the product of n positive numbers	Used in calculating "average" values and graphing for E.Coli
High	High range value (vs. moderate and low) in group of data	Used for designating opportunity level for reducing pollution impact
Low	Low range value (vs. moderate and high) in group of data	Used for designating opportunity level for reducing pollution impact
Mass	Flow rate (cfs) multiplied by pollutant concentration (ppm)	Used in graphing for Nitrite, Nitrate, and Phosphorus (in PPD)
"Mass"	Flow rate (cfs) multiplied by pollutant concentration (colonies)	Used in graphing for E.Coli (in colonies)
MGD	Million gallons/day	Flow rate – 1 MGD = 694 gpm
Moderate	Mid-range value (vs. high or low) in group of data	Used for designating opportunity level for reducing pollution impact
Nitrate	Nitrogen pollutant - formula NO3 (nutrient)	Reported as Nitrate-nitrogen, reporting only the amount of N in NO3 measured
Nitrite	Nitrogen pollutant - formula NO2 (nutrient)	Reported as Nitrite-nitrogen, reporting only the amount of N in NO2 measured
Phosphorus	Pollutant measured as Phosphate - formula PO4 (nutrient)	Reported as Total Phosphorus, reporting only the amount of P in PO4 measured. Excludes organic-P (Total Ortho-Phosphorus).
ppm	Equals mg/l and may be used interchangeably	Measurement for low concentration, in "parts per million" parts
Q	Estimated flow rate based on limited reliable data	Used in graphing Flow and calculating Mass for: Nitrate, Phosphorus, and E.Coli
TKN	Total Kjeldahl Nitrogen, comprised of Ammonia-N and Organic-N	When added to Nitrite + Nitrate approximates Total Nitrogen

SECTION 1 – INTRODUCTION

Purpose

This report presents results of an 18-month water quality investigation project in Monroe County, Tennessee, conducted as a Supplemental Environmental Project (SEP) to satisfy commitments of a Federal Consent Decree (see preceding Acknowledgment page for details). The two-part objective of the investigation was to identify drainage areas contributing to nonpoint source pollution of Bat Creek, and to document the pollution types, concentrations, and associated source areas.

The target audience of this report is a combination of agricultural and environmental specialists in and around Monroe County. These results are intended to support a future application from a yet undetermined local government agency to obtain funding to implement projects that reduce these nonpoint sources of pollution, as necessary, to restore the water quality of Bat Creek. When such projects have successfully been implemented to restore the ecosystem of Bat Creek to acceptable levels per TDEC, WATeR intends to request TDEC to delist all or portions of Bat Creek as no longer being impaired.

Setting

Bat Creek is one of the major creeks flowing into Tellico Lake. The entire watershed of Bat Creek lies in Monroe County, Tennessee, except for the Bat Creek embayment of Tellico Lake, which lies at the creek mouth in Loudon County. See Maps 1 and 2 for orientation. The headwaters for this stream originate near Madisonville, and the creek meanders generally northeast about 14 creek miles before it discharges into the large embayment of Tellico Lake near Lakeside Road and Hwy 72.

The watershed is bounded on each side by ridges, creating a drainage basin ranging from two to four miles wide by ten miles long, providing a well delineated watershed of approximately 16,800 acres (about 26 square miles).

The drainage area north of Bat Creek is mostly forested, while the area south of Bat Creek is generally agricultural, pasture for cattle, with hay and row crops. The

City of Madisonville and the area immediately surrounding the City is developed urban and suburban.

About 32 tributaries of varying size contribute flow to Bat Creek, with significant overland flow directly into Bat Creek along its meandering length. For this study, Bat Creek is defined as beginning at the confluence of (a) “upper Bat Creek,” beginning in a pond off Lake Road and flowing east, and (b) the tributary that drains most of the City of Madisonville from the south. Several of the tributaries are classified as dry weather conveyances that contribute little flow and hence little pollution throughout the drier parts of the year. About 11 tributaries contribute significant flow to the main stem, including the originating Bat Creek “tributary.” See Map 2.

There are also two NPDES-permitted point source discharges into Bat Creek. The largest is from the City of Madisonville’s WWTP, described below. The other is from the much smaller Hiwassee College WWTP, located about two miles downstream, with a design flow of 80 gpm. Because the SEP scope was to investigate only nonpoint source pollution, no sampling was done of these two effluents. Their impacts are recorded after assimilation within the test results at the next main stem sample location downstream, as noted in Section 3. Each permitee reports discharge data directly to TDEC. These data remain on file for public access.

Regulatory Agency History

TDEC collects water quality samples from most streams throughout Tennessee on a five-year cycle. Results of this previous sampling led TDEC to include Bat Creek on a list of water quality limited streams impaired by pollution. The parameters listed as causes of pollution are: excess concentrations of E.Coli bacteria, total Phosphorus, and Nitrite + Nitrate.

E.Coli is a public health indicator of fecal pollution from humans or animals, occurring in food and water, with some strains causing severe abdominal pain and gastroenterological discomfort. Both Phosphorus and Nitrogen in various forms are nutrients that, in excessive quantities, can cause detrimental growth and buildup of algae and plants in waterways, resulting in reduced levels of Dissolved Oxygen (DO) and death of sensitive aquatic creatures.

The primary Bat Creek pollution sources identified by TDEC are pasture grazing and a municipal point source. Cattle grazing in pastures throughout several areas of the watershed, as well as cattle with unlimited access to streams, are likely sources of much of the nonpoint source pollution. Results of this investigation will assist those administrating future projects to identify likely source areas of nonpoint source pollution and to facilitate remediation.

The specified municipal point source of pollution refers to the Madisonville WWTP, with design capacity 0.8 MGD, located in the northeast portion of Madisonville (estimated population of 4,100). The outflow from this plant, including any bypass or overflow, discharges into an adjacent tributary of Bat Creek. This plant, initially built in 1961 with additions and modifications constructed in 1992 and 2000, is old and in need of major repair and upgrade. For several years, it has proved inadequate to properly process wastewater from Madisonville. These deficiencies have caused frequent violations of the TDEC-issued NPDES discharge permit as required by the Federal Clean Water Act (CWA).

Legal Intervention

In 2015, WATeR teamed with the Tennessee Clean Water Network (TCWN) to file suit in the Federal District Court for the Eastern District of Tennessee against the City of Madisonville for numerous violations of the Federal CWA from their WWTP. This litigation resulted in the entry of a Consent Decree. The solution was subsequently submitted to and accepted by the court as a resolution to the litigation. Terms of the Consent Decree require Madisonville to construct a new WWTP (also 0.8 MGD design capacity) adjacent to the existing plant and to continue discharging treated effluent into Bat Creek. Terms of the resolution are consistent with those imposed by TDEC in its proposed WWTP operating permit.

The Consent Decree of the Federal litigation also required Madisonville to fund a SEP, with the focus of the project to be nonpoint source pollution, in lieu of fines for numerous previous violations of the Federal CWA. WATeR and TCWN proposed, and Madisonville accepted, a provision for the City to pay up to $10,000 for laboratory analytical testing of water quality samples collected as described in this report.

Notable Qualification

The second half of 2015 was very wet, which was followed by a very wet February 2016. March through most of November 2016 saw limited rainfall, which resulted in drought conditions and low (or no) flow stream conditions with resulting little surface run-off into Bat Creek and its tributaries. This report should be viewed in consideration of these rainfall conditions, as documented herein at the end of Section 5.

Project Execution

The activities contributing to this report (planning, field work, data analysis, and report preparation) were performed by the WQIC of WATeR. The approximate time frames for major segments of the investigation were: planning and orientation – fourth quarter of 2015, field and laboratory analyses – 2016, and analysis and report preparation – first quarter of 2017.

Unpaid volunteers, who are retired professionals, collected samples and performed all other aspects of this investigation except for the laboratory analyses. The laboratory analyses were performed by a certificated laboratory, Microbac Laboratories in Maryville, Tennessee. Additional non-labor costs of field equipment, specialized lab analyses, and extraneous expenses required to conduct this investigation were provided by WATeR.

SECTION 2 – SAMPLE LOCATION SELECTION PROCESS

Initial Screening

The project goal was to gain safe access to the major tributaries of Bat Creek as well as direct access to Bat Creek itself to allow for a comprehensive sampling program identifying areas contributing nonpoint source pollution to Bat Creek along its length.

Initially, maps from the following sources were obtained: (a) Monroe County 911 maps, (b) USGS Quadrangle maps with contour or aerial photo base, (c) TDEC maps and information, and (d) Google Maps.

All the maps were studied in detail in order to identify the main stem of Bat Creek and the significant tributaries, as well as how to access potential sample locations. These maps were then combined into a "master" map that was used by project team members to drive throughout the watershed on public access roads on numerous occasions, taking notes identifying sample locations with easy access (public roads at culverts), desired locations on private land, and other desired locations, but which were difficult to access safely.

This field information was combined with the available maps to develop sample location descriptions and driving instructions so that they could easily be found on subsequent trips by additional staff.

The following list of potential sites was developed for additional field reconnaissance and assessment of access for safely collecting water samples and measuring stream flow.

There is no significance to the sequence of B and T location numbers used. Originally there were many "possible sample locations on the map" that were not appropriate or feasible to access; and the original non-sequential numbers remain. B numbers begin with B-1 at the mouth of Bat Creek and increase moving upstream.

Potential Bat Creek Sample Locations			
Tributary Site ID	Bat Creek Site ID	Location	Description
T-16	(B-15)	Tr -Old Highway 68	Old Highway 68 near Wilson Road
T-14A		Tr - Old Highway 68	Tributary on Old Highway 68 (at Y intersection with Hiwassee Road)
T-14B		Tr - Park Street	Tributary to Madisonville Branch tributary (at Park Street)
	B-13	BC -Legacy Drive	Legacy Drive
T-13B		Tr - Craighead Cr - Bruner Rd	Craighead Creek – (north arm at Brunner Road)
T-13C		Tr - Craighead Cr – South Trib	Tributary to Craighead Creek (south arm near airport)
T-13A		Tr - Craighead Cr - Century Farm	Craighead Creek at Century Farm
	B-12	BC - Century Farm	Century Farm Road
	B-9	BC - Hiwassee College	Hiwassee College bridge at Hiwassee Road
	B-8	BC - Short Bark Road	Short Bark Road (between T-10 and Hiwassee Road)
T-11		Tr - Red Ankle	Unnamed "Red Ankle" tributary (at Williams Road)
T-10		Tr - Short Bark Road	Tributary on Short Bark Road near Hiwassee Road
T-9		Tr - Red Branch	Red Branch tributary (at 450 Anderson Road)
T-8		Tr -Cold Stream Farm	Unnamed Tributary on west side of Cold Stream Farm Road
T-7		Tr - Acorn Gap Road	Unnamed Tributary on Acorn Gap Road
	B-5	BC - Acorn Gap Road	Acorn Gap Road (just north of Cold Stream Farm Road intersection)
T-6		Tr - Bulging Branch	Bulging Branch tributary (on Acorn Gap Road at intersection of Old Loudon Road)
	B-4	BC - Doeskin Valley	Doeskin Valley Road
T-3		Tr - Knob Road	Unnamed tributary that follows Knob Road
T-15		Tr - Hendrix Loop	Unnamed tributary that enters below bridge at Hendrix Loop
T-15A		Tr - Hendrix Spring	Spring at unnamed tributary that enters below bridge at Hendrix Loop
	B-3	BC - Rt 322	Rt 322
	B-2	BC - Hendrix Loop	Hendrix Loop Road (near bridge at Knob Road)
T-2		Tr - Lakeside Road	Unnamed tributary that enters near Lakeside Road.
	B1	BC - Lakeside Road	Lakeside Road at culvert (free-flowing only during winter)

Note to above table: T-16 was formerly noted as B-15. T-16 is used throughout this report.

Each site was visited at least two additional times to ensure that vehicles could be safely parked near the sample location, and the field sampling personnel could do field water quality measurements (*in situ*) directly in the stream. Samples were collected at some sites directly from the stream, or by attaching sample bottles to a pole, or by using a stainless steel bucket to withdraw water from the stream. The samples that were collected were then transferred to sample bottles.

Based on the above information the following seven sites were eliminated due to safety concerns, difficulty in obtaining access across private property, or a determination that no additional information of substantive value could be obtained.

Locations Eliminated for Sampling

Major desired tributaries T-3, T-8, T-13A, and T-13C were not sampled in that they required access across private property. A local sponsor to initiate contact with local property owners was unable to be secured by the project team. See Map 4 to locate these four sub-watersheds of interest, but without private property access.

The remaining potential sample locations (B-3 was replaced by B-4 in that B-3 could not be safely sampled) B-9 and T-15A were not sampled because they had access problems, were determined to be of secondary importance, or did not contribute additional substantive information about the watershed.

Sample Location Maps

Map 3 shows the <u>selected</u> locations along the main stem of Bat Creek, as well as the location of the sub-watershed boundary (broad orange lines) for each sample location. That boundary delineates the area draining into Bat Creek between that sample location and the next one upstream on the main stem.

Map 4 delineates all <u>potential</u> tributary sample points and the sub-watershed boundary (narrow dark red lines) for each, within a larger main stem sub-watershed.

Bat Creek Watershed and Sub-watershed Areas

The Bat Creek Watershed varies from two to four miles wide and is about 10 miles in length running in a northeasterly direction generally from Madisonville toward Tellico Lake. In that distance, Bat Creek meanders about 14 creek miles. The total watershed has an area of approximately 16,800 acres or 26 square miles.

The watershed was divided into sub-watersheds as indicated on Map 4 and in the following table. Those areas are shown as that drainage area above a sample location, as previously identified.

The tributary areas sampled from T-16 downstream through T-2 comprise a total area of approximately 7,860 acres or 47 % of the total Bat Creek Watershed. The major tributaries that were not able to be sampled (T-13A, T-13C, T-8 and T-3) have combined watershed areas totaling approximately 1,920 acres, which is 11% of the total Bat Creek Watershed. Had all tributaries been sampled that were desired, the total sampled tributary area would have been approximately 9,780acres or 58% of the total Bat Creek Watershed.

There is a major portion of the Bat Creek Watershed that flows “directly” into the stem of Bat Creek which comprises the following: unsampled tributary areas, small tributary areas and overland flow areas. Those in total comprise approximately 8,980 acres, 53% of the total Bat Creek Watershed. Flows from all those areas combine, grow and blend in the length of Bat Creek. Individual drainage segments cannot be isolated and directly sampled because the flow at all main stem sample locations includes the entire drainage area above that sample location.

Because of access limitations, the total “direct” flow area into the main stem of Bat Creek is larger than the total of sampled tributary areas noted above. See Map 4.

BAT CREEK WATERSHED AND SUB-WATERSHED AREAS								
Sample Location			**Sub-watershed Portion**		**Sub-watershed Total**		**Watershed Cumulative**	
			Acres		**Acres**	**Percent**	**Acres**	**Percent**
T-16 Tributary begin Bat Creek				908				
	T-16	(B-15)			908	5%	908	5%
B-13 main stem				1,306				
	T-14A			658				
	T-14B			302				
		B-13			2,266	13%	3,174	19%
B-12 main stem				733				
	T-13B		1,513					
	T-13C		897					
	T-13A		467					
	Craighead Creek			2,877				
		B-12			3,610	21%	6,784	40%
B-8 main stem				202				
		B-8			202	1%	6,986	41%
B-5 main stem				1,933				
	T-7			382				
	T-8			345				
	T-9			696				
	T-10			1,030				
	T-11			690				
		B-5			5,076	30%	12,062	72%
B-4 main stem				1,306				
	T-6			1,269				
		B-4			2,575	15%	14,637	87%
B-3 main stem				515				
		B-3			515	3%	15,152	90%
B-2 main stem				595				
	T-3			207				
	T-15			218				
		B-2			1,020	6%	16,172	96%
B-1 main stem				472				
	T-2			191				
		B-1			663	4%	16,835	100%
							26.3 sq. miles	

Note: This table includes (a) the four tributaries of interest that were not able to be sampled (T-13A, T-13C, T-8 and T-3), which have combined watershed areas totaling approximately 1,900 acres when areas between the identified sample locations and the main stem are included, and (b) main stem location B-3, which area is additive to the area of B-2 shown above.

SECTION 3 – SAMPLE LOCATION DESCRIPTIONS

General

The main stem of Bat Creek had seven locations selected for sampling, beginning at Sample Location B-13 and flowing northeast toward Tellico Lake for about 14 creek miles, terminating at Sample Location B-1. All of these sites were accessible from public roads with samples collected directly from Bat Creek.

Although there are estimated to be some 32 tributaries entering Bat Creek, from major to intermittent, only 11 tributary sample locations were selected that afforded direct access from public roads, with samples again collected directly from the creeks. See Map 6 for selected sample locations and their sub-watershed boundaries.

The Bat Creek Watershed is in Ecoregion 67, sub ecoregions 67f and 67i, as designated by EPA and TDEC. A range of hills, the Bat Creek Knobs, are present along the northern edge of the watershed. These heavily forested hills are sub ecoregion 67i. Most selected sample locations were in sub ecoregion 67f.

The land use descriptions by SEP team members are based on observations of the various sub-watersheds from public roads in the varying terrain of the area; hence the observations are limited by topography. Available aerial photography supplemented actual observations; however, the photography is generally out of date and was determined to be of limited value relative to present land use.

Sampling was not conducted directly below either Madisonville’s or Hiwassee College’s NPDES-permitted WWTP outfalls. The scope of this project was solely to study nonpoint pollution sources in the Bat Creek Watershed.

Selected Sample Locations			
Tributary Site ID	**Bat Creek Site ID**	**Location**	**Description**
T-16	(B-15)	Tr -Old Highway 68	Old Highway 68 near Wilson Road
T-14A		Tr - Old Highway 68	Tributary on Old Highway 68 (at Y intersection with Hiwassee Road)
T-14B		Tr - Park Street	Tributary to Madisonville Branch tributary (at Park Street)
	B-13	BC -Legacy Drive	Legacy Drive at Bat Creek
T-13B		Tr - Craighead Cr - Bruner Rd	Craighead Creek – (north arm at Brunner Road)
	B-12	BC - Century Farm	Century Farm Road
	B-8	BC - Short Bark Road	Short Bark Road (between T-10 and Hiwassee Road)
T-11		Tr - Red Ankle	Unnamed "Red Ankle" tributary (at Williams Road)
T-10		Tr - Short Bark Road	Tributary on Short Bark Road near Hiwassee Road
T-9		Tr - Red Branch	Red Branch tributary (at 450 Anderson Road)
T-7		Tr - Acorn Gap Road	Unnamed Tributary on Acorn Gap Road
	B-5	BC - Acorn Gap Road	Acorn Gap Road (just north of Cold Stream Farm Road intersection)
T-6		Tr - Bulging Branch	Bulging Branch tributary (on Acorn Gap Road at intersection of Old Loudon Road)
	B-4	BC - Doeskin Valley	Doeskin Valley Road
T-15		Tr - Hendrix Loop	Unnamed tributary that enters below bridge at Hendrix Loop
	B-2	BC - Hendrix Loop	Hendrix Loop Road (near bridge at Knob Road)
T-2		Tr - Lakeside Road	Unnamed tributary that enters near Lakeside Road
	B-1	BC - Lakeside Road	Lakeside Road at culvert (free-flowing only during winter)

Note to above table: T-16 was formerly noted as B-15. T-16 is used throughout this report.

DETAILED SAMPLE LOCATION DESCRIPTIONS

T-16 – Upper Bat Creek at Old Highway 68 (originally site B-15)

Sub-watershed	The Sub-watershed is in the vicinity of Old Highway 68 and is northwest of Madisonville.
Sub-watershed Area	Approximately 910 acres, 5 % of the entire Bat Creek Watershed.
Sample Location	The sample location for this Sub-watershed is at upper Bat Creek and Old Highway 68. The sample location is approximately 0.5 miles upstream from the confluence with the stem of Bat Creek.
Observations	Cattle where observed in this tributary upstream of this sampling location.
Primary Land Use	Pasture for cattle.

T-14A - Unnamed tributary that crosses Old Highway 68

Sub-watershed	The Sub-watershed is in the vicinity of the northern portion of Madisonville.
Sub-watershed Area	The Sub-watershed consists of approximately 660 acres, 4 % of the entire Bat Creek Watershed.
Sample Location	The sample location for this Sub-watershed is where the tributary crosses Old Highway 68. The sample location is approximately one mile upstream from the confluence with Bat Creek.
Observations	This sample location was impacted by a petroleum film on the water surface for a large part of the sampling period. Sampling was suspended during this time in that the impacts of petroleum were unknown, and certainly would not be representative of nonpoint pollution.
Primary Land Use	Developed Urban.

T-14B - Unnamed Tributary that crosses Park Street

Sub-watershed	The Sub-watershed is in the vicinity of downtown Madisonville.
Sub-watershed Area	Approximately 300 acres, 2 % of the entire Bat Creek Watershed.
Sample Location	The sample location for this Sub-watershed is where the tributary crosses Park Street. This site is used by TDEC for their sampling program. This site is located upstream of Madisonville’s WWTP. The sample location is approximately 1.5 miles upstream from the confluence with Bat Creek.
Primary Land Use	Developed Urban.

B-13 - Bat Creek at Legacy Drive

Sub-watershed	Generally west of Hiwassee Road, south of the Airport and northeast of downtown Madisonville along Bat Creek.
Sub-watershed Area	Approximately 1,310 acres, 8 % of the entire Bat Creek Watershed, drains directly into Bat Creek, in addition to the acreages of the sampled tributaries noted below.
Sample Location	Located at Legacy Drive off Hiwassee Road. The Upstream Sample Locations are Tributaries T-16, T-14A, T-14B. The City of Madisonville's WWTP discharges into a Bat Creek tributary about 0.3 miles downstream of T-14B and upstream of B-13. The Downstream Sample Location is B-12.
Observations	This is the beginning of Bat Creek as defined for this study, just below the first major confluence.
Primary Land Use	Pasture for cattle; suburban developed.
Total Upstream Bat Creek Watershed	Approximately 3,170 Acres, 19 % of the entire Bat Creek Watershed, are upstream of B-13.

T-13B - Craighead Creek at Brunner Road

Sub-watershed	The Sub-watershed is in the northwest part of the Bat Creek Watershed and is the northwest branch of Craighead Creek draining the Bat Creek Knobs.
Sub-watershed Area	Approximately 1,510 acres, 9 % of the entire Bat Creek Watershed.
Sample Location	Where the tributary crosses Brunner Road west of Hiwassee College. The sample location is approximately one mile upstream from the confluence with Bat Creek.
Observations	Cattle were observed in this tributary upstream of this sample location.
Primary Land Use	Forest and meadow.

B-12 - Bat Creek at Century Farm Road

Sub-watershed	The Sub-watershed is generally southwest and southeast of Hiwassee College.
Sub-watershed Area	The unsampled tributaries, and the area draining directly into Bat Creek total approximately 2,100 acres or 12% of the entire Bat Creek Watershed.
Sample Location	Located at Century Farm Road off Hiwassee Road. The only Upstream Sample Location between B-13 and B-12 is T-13B. The Downstream Sample Location is B-8.
Primary Land Use	Suburban and pasture for cattle.
Total Upstream Bat Creek Watershed	Approximately 6,800 Acres, 40 % of the entire Bat Creek Watershed, are upstream of B-12.

B-8 - Bat Creek at Short Bark Road

Sub-watershed	Generally, on both sides of Hiwassee Road in and adjacent to Hiwassee College.
Sub-watershed Area	Approximately 200 acres, 1 % of the entire Bat Creek Watershed. This Sub-watershed drains directly into Bat Creek. No tributaries enter between B-12 and B-8.
Sample Location	Located at Short Bark Road just east of Hiwassee Road. The Upstream Sample Location is B-12. The Downstream Sample Location is B-5.
Observations	This location is downstream of the permitted Hiwassee WWTP (permitted design flow of 80 gpm) outfall.
Primary Land Use	Institutional developed and mowed fields.
Total Upstream Bat Creek Watershed	Approximately 7,000 Acres, 41 % of the entire Bat Creek Watershed, are upstream of B-8.

T-11 - Red Ankle tributary that flows along Red Ankle Road.

Sub-watershed	Northwest of Hiwassee College, in the vicinity of the Bat Creek Knobs, and draining a portion of the Knobs.
Sub-watershed Area	Approximately 690 acres, 4 % of the entire Bat Creek Watershed.
Sample Location	Where the tributary crosses Williams Lane, near Hiwassee Road. Approximately 0.2 miles upstream from the confluence with Bat Creek.
Observations	Cattle were observed in this tributary upstream of this sample location.
Primary Land Use	Forest, meadow, and pasture for cattle.

T-10 - Unnamed tributary that crosses Short Bark Road.

Sub-watershed	In the vicinity of and northeast of Hiawassee College, draining land from the east.
Sub-watershed Area	Approximately 1,030 acres, 6 % of the entire Bat Creek watershed.
Sample Location	Approximately 0.2 miles upstream from the confluence with Bat Creek.
Primary Land Use	Pasture for cattle.

T-9 - Red Branch at Anderson Road

Sub-watershed	Along the mid-northern edge of the Bat Creek Watershed and drains a portion of the Bat Creek Knobs.
Sub-watershed Area	Approximately 700 acres, 4 % of the entire Bat Creek Watershed.
Sample Location	Where the tributary (Red Branch) crosses Anderson Road. Approximately 0.2 miles upstream from the confluence with Bat Creek.
Primary Land Use	Forest and meadow.

T-7 - Unnamed tributary that flows along and crosses Acorn Gap Road.

Sub-watershed	Along the mid-northern edge of the Bat Creek Watershed and drains a portion of the Bat Creek Knobs.
Sub-watershed Area	Approximately 380 acres, 2 % of the entire Bat Creek Watershed.
Sample Location	Located where the tributary crosses and flows along Acorn Gap Road. Approximately 0.5 miles upstream from the confluence with Bat Creek.
Primary Land Use	Forest and meadow.

B-5 - Bat Creek at Acorn Gap Road

Sub-watershed	Generally in the middle of the Bat Creek Watershed, between Anderson Road, Acorn Gap Road and Cold Stream Farm Road.
Sub-watershed Area	Approximately 2,280 acres, 13 % of the entire Bat Creek Watershed drains directly into Bat Creek or unsampled tributaries between B-8 and B-5, in addition to the acreages of the sampled tributaries noted below.
Sample Location	Located at Acorn Gap Road just north of Cold Stream Farm Road. The Upstream Sample Locations between B-8 and B-5 are T-7, T-9, T-10, and T-11. The Downstream Sample Location is B-4.
Primary Land Use	Pasture for cattle and row crops.
Total Upstream Bat Creek Watershed	Approximately 12,060 Acres, 72 % of the entire Bat Creek Watershed, are upstream of B-5.

T-6 - Bulging Branch at Acorn Gap Road

Sub-watershed	Generally in the middle of the Bat Creek Watershed, between Oak Grove Road and Cold Stream Farm Road, and drains an area from the south.
Sub-watershed Area	Approximately 1,270 acres, 8 % of the entire Bat Creek Watershed.
Sample Location	Located where the tributary (Bulging Branch) crosses Acorn Gap Road near Old Loudon Road. Approximately 0.1 miles upstream from the confluence with Bat Creek.
Observations	Cattle and goats were observed in this tributary upstream from the sample location.
Primary Land Use	Pasture for cattle and some goats.

B-4 - Bat Creek at Doeskin Valley Road.

Sub-watershed	Generally located between the opposing Bat Creek Watershed ridge lines, reaching from Bat Creek Knobs to Oak Grove Road in the eastern third of the watershed.
Sub-watershed Area	Approximately 1,310 acres, 8 % of the entire Bat Creek Watershed, drains directly into Bat Creek between B-5 and B-4, in addition to the acreage of the sampled tributary noted below.
Sample Location	Located at Doeskin Valley Road just north of Old Loudon Road. The only Upstream Sample Location between B-5 and B-4 is T-6. The Downstream Sample Location is B-2.
Observations	Cattle were observed in Bat Creek in the vicinity of this sampling location.
Primary Land Use	Forest and meadow north of Bat Creek, and farm pasture of cattle south of Bat Creek.
Total Upstream Bat Creek Watershed	Approximately 14,640 Acres, 87 % of the entire Bat Creek Watershed, are upstream of B-4.

T-15 - Unnamed tributary that enters Bat Creek at Hendrix Loop

Sub-watershed	The Sub-watershed is in the vicinity of Knob Road and Sweetwater Vonore Road near the eastern end of the Bat Creek Watershed.
Sub-watershed Area	Approximately 220 acres, 1 % of the entire Bat Creek Watershed.
Sample Location	Located where this tributary crosses Hendrix Loop Road near Knob Road, approximately 0.1 mile upstream from the confluence with Bat Creek.
Primary Land Use	Pasture for cattle.

B-2 - Bat Creek at Hendrix Loop

Sub-watershed	The Sub-watershed is generally very similar to the B-4 Sub-watershed and is just to the east. It covers an area from the Bat Creek Knobs nearly to Lakeside Road.
Sub-watershed Area	Approximately 1,320 acres, 8 % of the entire Bat Creek Watershed, drains directly into Bat Creek between B-4 and B-,(including B-3), in addition to the acreage of the sampled tributary noted below.
Sample Location	Located at Hendrix Loop Road near the bridge at Knob Road. This is the most downstream location (accessible by road) on Bat Creek that is not impacted by the level of the water in Tellico Lake. This site is used by TDEC for their sampling program. The only Upstream Sample Location between B-4 and B-2 is T-15. The Downstream Sample Location is B-1.
Observations	Cattle were observed in the creek upstream of this sample location. People were also observed fishing near this site.
Primary Land Use	Pasture for cattle, row crops and suburban development.
Total Upstream Bat Creek Watershed	Approximately 16,170 Acres, 96 % of the entire Bat Creek Watershed, are upstream of B-2.

T-2 - Unnamed tributary that flows along Lakeside Road

Sub-watershed	The Sub-watershed is in the vicinity of Lakeside Road and Bat Creek Shores Lane and appears to be spring fed. It is in the eastern-most part of the Bat Creek Watershed.
Sub-watershed Area	Approximately 190 acres, 1 % of the entire Bat Creek watershed.
Sample Location	Located within the pooled creek near Lakeside Road and Bat Creek Shores Lane. It can only be sampled when Tellico Lake is drawn down to “winter pool” level.
Observations	Cattle were observed in this tributary upstream of this sample location.
Primary Land Use	Pasture for cattle.

B-1 - Bat Creek at Lakeside Road

Sub-watershed	The Sub-watershed is located in the eastern-most part of the Bat Creek Watershed, generally located between Farnsworth Road, Highway 72 and Summit Road.
Sub-watershed Area	Approximately 470 acres, 3 % of the entire Bat Creek Watershed, drains directly into Bat Creek between B-2 and B-1, in addition to the acreage of tributary T-2.
Sample Location	Located at Lakeside Road and Bat Creek Shores Lane. When the lake is at normal "summer pool," Sample Location B-1 is impacted by the lake and flows in either direction or not at all. The only Upstream Sample Location between B-2 and B-1 is T-2.
Observations	Cattle were observed in feeder creeks a short distance above this location. At this point, Bat Creek enters Tellico Lake, which is the terminus of Bat Creek for purposes of this report. Distance via old Bat Creek channel to the former confluence with the Little Tennessee River is approximately 7 miles.
Primary Land Use	Pasture for cattle, and suburban development.
Total Upstream Bat Creek Watershed	Approximately 16,840 Acres, 100 % of the entire Bat Creek Watershed, are located upstream of B-1.

SECTION 4 – DATA COLLECTION

Approach

The SEP project was organized around a project manager, senior specialist advisors, and three task team leaders of the (1) field water quality measurement (*in situ* measurement) and sampling team, (2) flow measurement/estimation team, and (3) field land use observation team. Additionally, specific assignments were made for the development of field processes and procedures, safety plan, laboratory analysis interpretation, and financial management tasks.

The decision to attempt flow measurements, with the intent of creating a system-wide "pseudo mass balance" for targeted pollutants, was made after considerable discussion about the difficulty of being able to achieve that objective. In retrospect that was not achievable to the extent desired, but that approach was successful enough to allow the team to prepare the mass approximation graphs throughout this report. Those graphs are interpreted with some judgment, but proved to be of value by enabling the team to prioritize various segments of the watershed for further evaluation or corrective action.

A Procedures and Methods for Bat Creek Field Work manual (sampling methods, chain of custody protocols, quality assurance plan, and instrument calibration procedures) was developed, reviewed and implemented. This program closely followed the methods, protocols and procedures that TDEC uses for their field work and subsequent lab analyses. The draft procedures manual was submitted to the Knoxville TDEC office for comment and concurrence. A synopsis of implementation plans for the SEP program plus associated laboratory budget and analytical pricing were also sent to the City of Madisonville via their engineer of record, McGill & Associates, for comment prior to finalization. A Field Safety Plan was developed, reviewed and implemented.

The project has involved approximately 25 different volunteers engaged in field activities over the course of the study, all of whom went through a classroom training and orientation session, as well as field training of procedures and safety protocols that were implemented. The field teams were deployed on a monthly basis at least two days after a rainfall event (except in November, where a conscious decision was made to proceed sooner).

Constraints

The goal for the establishment of sample locations was to obtain direct access to all major tributaries as close as possible to the confluence of each with the main stem of Bat Creek. This was not possible due to the following constraints that the team encountered. Additionally, there were financial, schedule and human resource constraints that are common to all projects. Constraints were:

Limited public access to Bat Creek main stem and tributaries.

Access onto private land was not obtained.

Laboratory analysis: maximum limit of $10,000.

Safe parking and access to culverts and streams.

Backwater conditions at the outlet of Bat Creek when Tellico Lake is at “summer pool” level.

Very low flow conditions, summer and fall, with pooling of water and no measurable velocity at some tributary locations.

Culverts clogged with debris so flow measurements were not possible.

“Man made” barriers (fencing) at stream access points.

Dry weather sampling (minimum two days after a rain event per TDEC approach), except for November sampling right after a one inch rain event to observe pollutant concentration changes due to rain.

Phases 1 and 2 Sampling Program

The first phase of the field program was to conduct only *in situ* field water quality measurements. This phase was intended to familiarize the field personnel with actual field conditions and constraints. Additionally, this phase of the work was used to provide range-finding water quality data to reduce water quality laboratory analysis costs later in order to remain within the project budget.

Hach field water quality test kits were used to determine the water quality parameters of Nitrite, Nitrate, and Phosphorus. Dissolved Oxygen, Turbidity, water temperature, barometric pressure and pH were also measured using a variety of instruments owned by WATeR. The Phase 1 work allowed instrument operators to become proficient in calibration prior to every trip to the field, as well as to refine effective field operating and quality control procedures.

These Phase 1 activities began in November 2015 and melded into Phase 2, during which some selected water samples were collected for confirmatory laboratory analysis in April, 2016. The team determined that the *in situ* components of the overall program would continue through the duration of the targeted Phase 2 sampling and limited lab analysis program into Phase 3, depending on site access and availability of resources.

Phase 3 Sampling Program

The Phase 3 program was the heart of the SEP activity and efforts. It was comprised of collecting eight rounds of water samples April through November 2016, at about 15 sample locations each round, and then taking them to a certified laboratory for analysis. During hot weather months, field work was conducted only in cooler morning hours, so it took two days to complete a full round of samples. Typically, those dates were only a few days apart, weather permitting.

The selected sample locations and parameters for each sampling round were based on all data accumulated and reviewed about ten days prior to the next sampling round, plus consideration of the remaining budget.

As noted above, many of the *in situ* water quality measurements continued. The samples for laboratory analysis, including quality control duplicates and blanks, were collected, iced and driven directly to Microbac Laboratories in Maryville, TN, in accordance with the protocols established in the Procedures and Methods manual, and initiated during Phase 2, as well as the detailed laboratory requirements including quality control procedures.

The Microbac laboratory analyses consisted of: Nitrite, Nitrate, TKN, Phosphorus and E. Coli. A separate laboratory (Microbial Insights in West Knoxville, TN) was contracted to conduct limited E.Coli gene speciation analyses separately paid for by WATeR. Original laboratory reports are not included in this report, but are retained in project records. Because Microbac data was formatted in a more complex manner, the data was extracted and reformatted by parameter (sample location and date), then compiled at the end of this report as Supplemental Information. A quality control review was done to assure accurate data transfer.

The data presented in this report for Nitrite, Nitrate, TKN, Phosphorus and E.Coli are data received from laboratory analysis only for the months of April through October 2016.The data presented for Dissolved Oxygen, Turbidity, and pH are from field measurement activities during the same sampling period.

Micobac reports E. Coli using the MPN (Most Probable Number) Method of analysis. The actual units for E.Coli are Colony Forming Units (CFU), and CFU is used in this study for reporting E.Coli. The CFU Method, many times referred to as simply CFU, is a different analytical method for determining E.Coli units which was not used by Micobac or in this study.

Flow measurement activities began in January and continued through November 2016. These activities were generally conducted monthly and were coordinated within a few days of the water quality sampling team activities.

The field land use observation team started their activities in March 2016 with a comprehensive tour of the watershed using only public roads. They made periodic trips to the field to supplement observations that the sampling team or the flow measurement team had made and documented.

Field data, measurements, and observations presented in the text or as Supplemental Information were also extracted from field data sheets (which are retained in project records) and were checked for accurate transfer during preparation of this report.

SECTION 5 – WATER QUALITY DATA BY PARAMETER

General

This section graphically presents results of a water quality and quantity sampling program conducted for eight months between April 2016 and November 2016. A total of seven main stem Bat Creek locations and 11 Bat Creek tributaries were sampled on approximately a monthly basis. Samples were not always able to be collected or field measured due to access issues or low flow conditions. Flow was measured at only nine out of the 18 total sites, again usually on a monthly basis. Access for flow measurement was much more restrictive and difficult due to the requirement that depth of flow needed to be measured directly at the entrance or exit of a culvert on a consistent basis. Many culverts were blocked by tree branches and debris.

Results of the sampling program found that average Dissolved Oxygen concentrations at all sample locations were above 7.0 ppm. pH was well within normal ranges for a stream like Bat Creek that flows through topography with soils that are encountered within the watershed.

Nitrite values were always below the detection limit from April through October 2016, therefore there is no data presented for Nitrites in graphical form. Because of non-detect levels, it is assumed that the sum of Nitrite + Nitrate is clearly represented by Nitrate only.

The main focus of the sampling program was Nitrate, Phosphorus (measured as total P), E.Coli, and to a lesser extent TKN. Secondarily, Dissolved Oxygen and Turbidity were measured, using field instruments, directly in the creeks.

The data collected during the sampling program in 2016 are presented graphically as <u>average values for concentration and mass at each sample location</u>. For the interpretation in this section of the report, it is easier to visualize inter-relationships relative to other sample locations in the watershed with single values graphed for comparison.

In Sections 6 and 7, data summaries are presented at each sample location, showing for each parameter: number of samples, range (high and low) of concentration values, and average concentration, as well as average mass loading (based on concentration and flow).

The Supplemental Information sections appended at the rear of this report contain all the technical data reported by the analytical lab and key data collected *in situ* by the field team between April and November 2016.Because field conditions changed continually during the sampling period, data values changed at each location, some more than others. More in-depth review of tabular data in the Supplemental Information section may be of interest to some readers of this report. There is additional field data for Turbidity and Dissolved Oxygen that was collected from October 2015 through April 2016 that is not included in this report, but is retained in the project files.

TDEC uses the below-listed numerical values for Nitrate, Phosphorus and E.Coli as guidance in addition to their narrative criteria in making a determination as to whether a stream should be listed as impaired or not by each parameter.

Numerical Guidance Criteria:

Nitrate (as N) 1.22 ppm maximum

Phosphorus (total P) varies by location

Mile 8.1 (near T-2) 0.04 ppm maximum

Mile 19.3 and 20.0 (near T-14B) 0.09 ppm maximum

E.Coli 126 CFU/100 ml maximum

Microbac Laboratories reporting limits for various parameters are as listed below:

Lower reliable detection limit (RL) for Nitrate (as N) is 0.056 ppm

Lower reliable detection limit (RL) for Phosphorus (total P) is 0.075 ppm

Upper reliable detection limit (RL) for E.Coli is 2,400 CFU/100 ml

One half of the Lower RL was used as a surrogate for non-detect for Nitrate and Phosphorus and 2,400 CFU/100 ml was used when E.Coli was reported as greater than 2,400 CFU/100 ml when determining average or geometric mean values.

For most readers, the interpretations presented in the various sections of this report, leading to the Findings and Recommendations in Section 10, will be sufficient to provide insights into the current pollutant dynamics within the Bat Creek Watershed.

Flow

General Summary

Flow estimates were determined by measuring the diameter or height and width of the culverts and their respective lengths. Each time flow was calculated, the depth of flow and the travel time of a float (apple) through the culvert were measured. Based on this information the cross-sectional area of the flow and its velocity were determined; and hence the approximate volumetric flow rate of water could be first calculated and then adjusted using engineering judgment due to the method used for determining velocity through the culverts. It was common for the float to get caught in the culvert for an undetermined period of time, and many times the float had to be passed through the culvert multiple times.

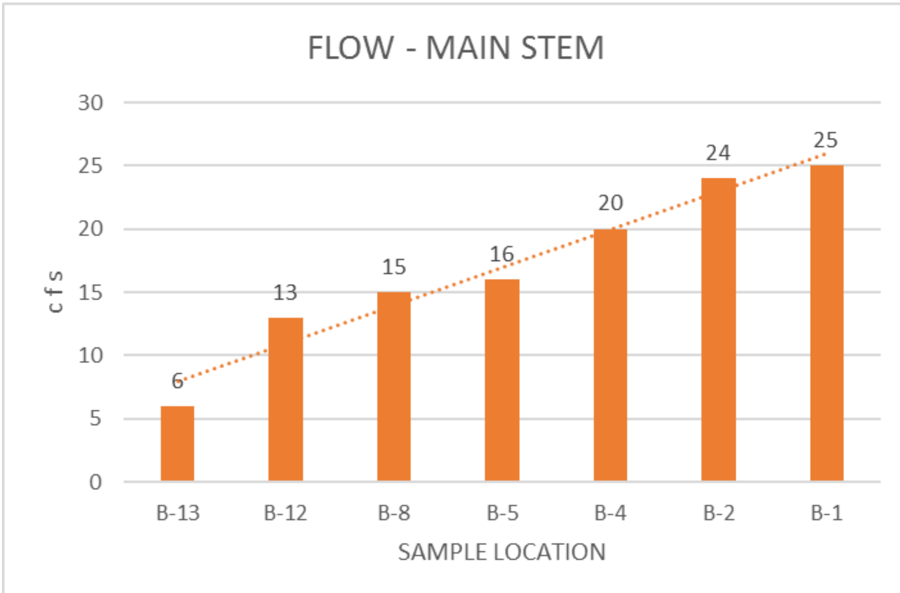
The following are sample locations where flow was estimated based on flow measurements: B-13, B-12, T-13B, B-8, T-11, T-9, T-6, B-4 and B-1.

See Supplement I, Flow, for additional detailed data.

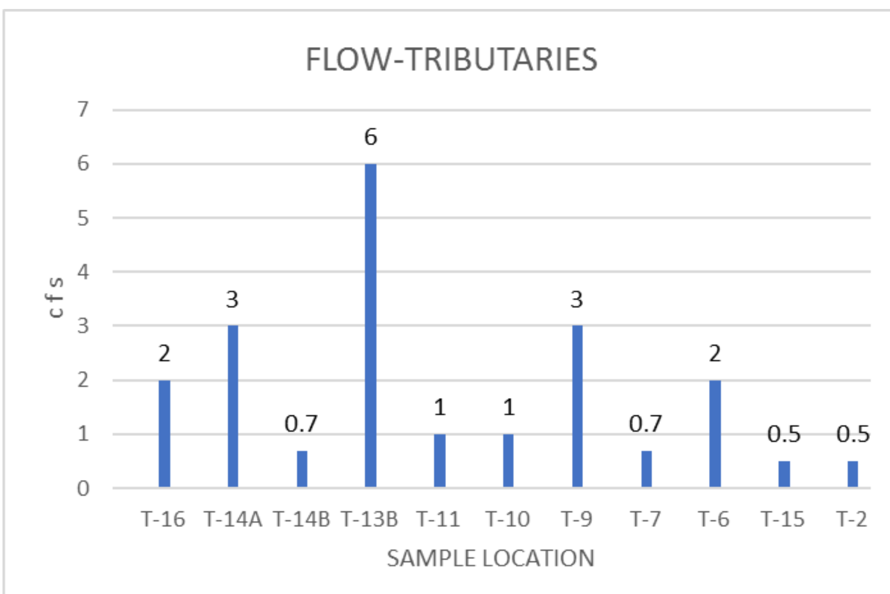
Sample locations where flow was estimated comparatively based on only engineering judgment, not based on flow measurements, are: T-16, T-14A, T-14B, T-10, T-7, B-5, T-15, B-2 and T-2.

Graphs of sample locations that follow, for the main stem of Bat Creek and the tributaries (as listed above), are presented as nominal average conditions during the sampling and flow measurement period. Placement of sample locations along the horizontal axis of graphs is always sequential from left to right, moving from the upper end of the watershed to the lower.

FLOW – MAIN STEM



FLOW – TRIBUTARIES



Nitrate

General Summary

Nitrate in this report is used to mean Nitrite + Nitrate in that Nitrite was always below the Detection Limit during the sampling period. Nitrate is found throughout the watershed and is considered a major nutrient pollutant. Nitrate is generally from agricultural operations including animal waste, fertilizer and likely also from decaying vegetative matter, especially in sub-watersheds that are part of the heavily wooded Bat Creek Knobs.

Nitrate concentrations (reported as nitrogen) at the tributary sample locations ranged from an average low of 0.43 ppm to a high of 4.33 ppm, a 10-fold difference. Concentrations at the main stem sample locations ranged from an average low of 0.86 ppm to a high of 1.85 ppm, generally increasing as Bat Creek flows toward Tellico Lake.

The mass of nitrate in the tributaries ranged from a low of 3 PPD at T-10 and T-7 to 20 PPD at T-13B.

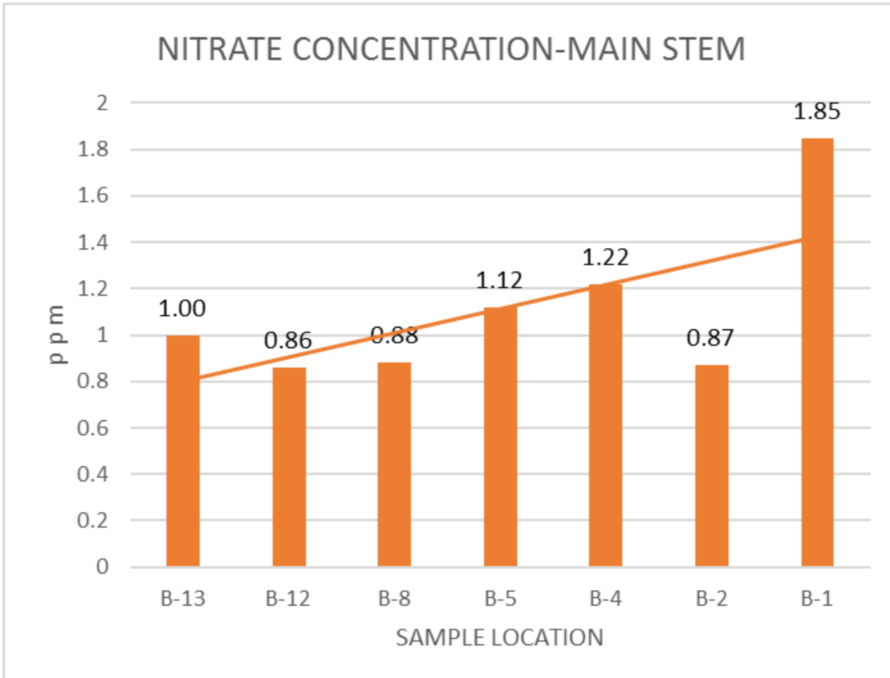
As the flow increased, the calculated mass of Nitrate increased from 32 PPD at B-13 to 249 PPD at B-1, an 8-fold increase. In the lowest segment of Bat Creek, from B-2 to B-1, the mass more than doubled, increasing from about 112 PPD to 249 PPD. The source of this huge increase warrants further detailed investigation.

It appears that vegetation within the creek does not uptake sufficient nitrogen to off-set the increased nitrogen loading.

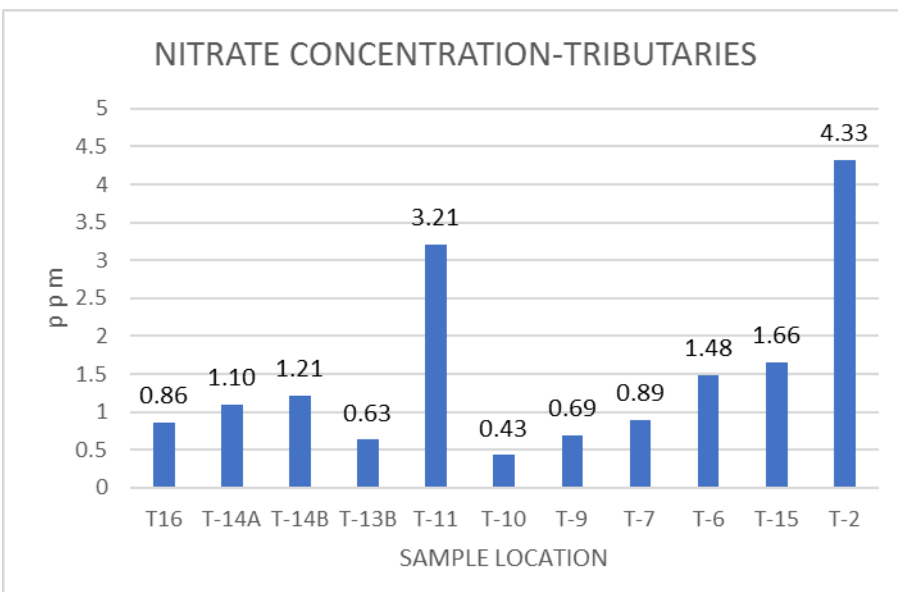
See Supplement A, Nitrite, for additional detailed data.

See Supplement B, Nitrate, for additional detailed data.

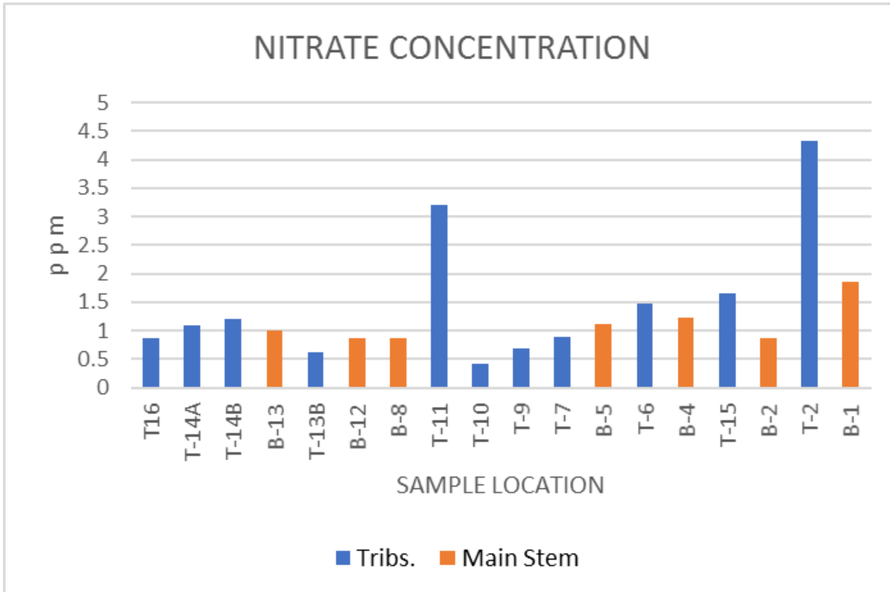
NITRATE CONCENTRATION – MAIN STEM



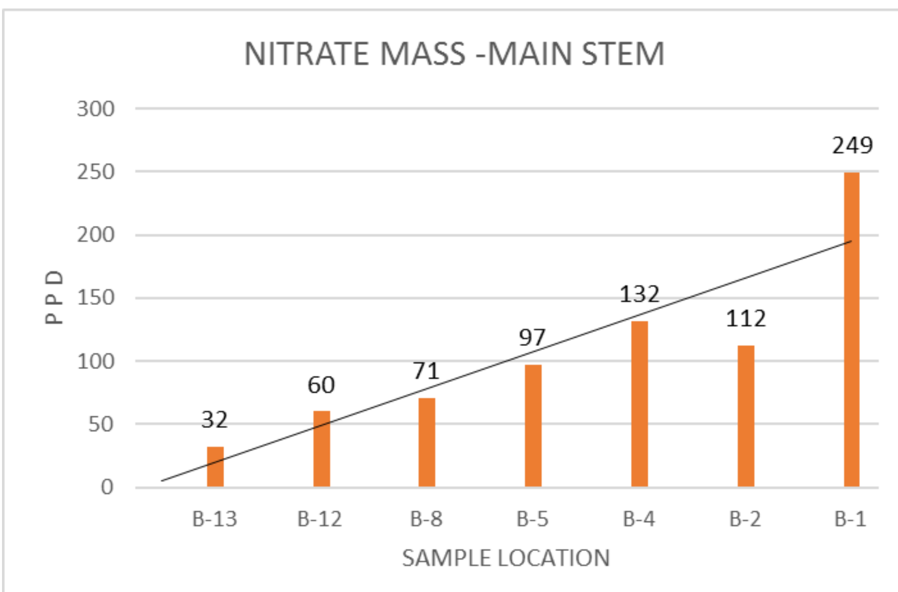
NITRATE CONCENTRATION – TRIBUTARIES



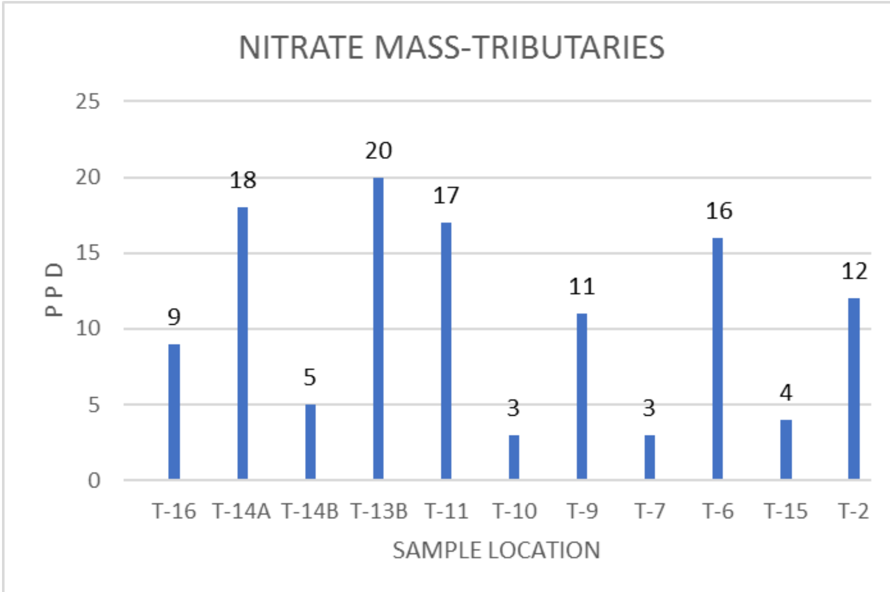
NITRATE CONCENTRATION – WATERSHED



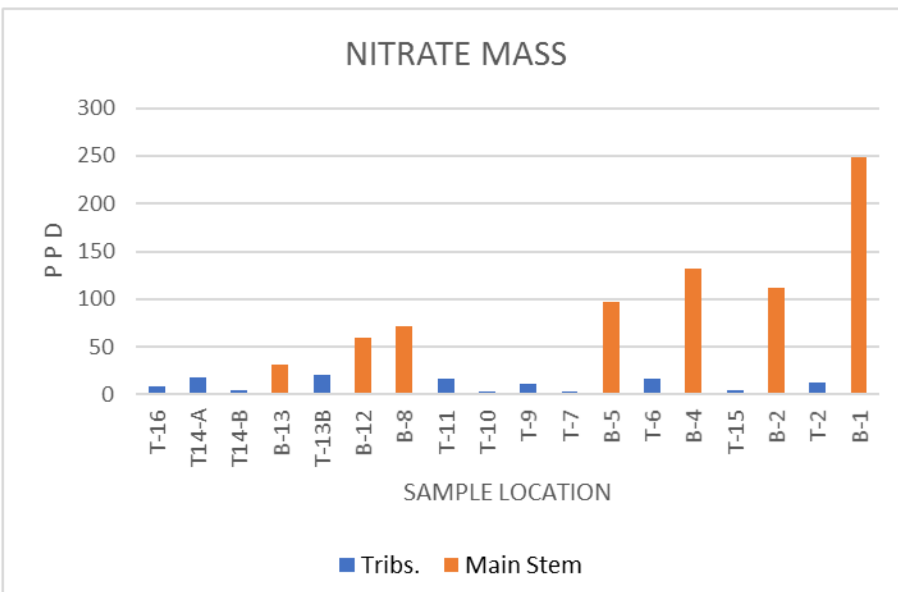
NITRATE MASS – MAIN STEM



NITRATE MASS – TRIBUTARIES



NITRATE MASS – WATERSHED



Phosphorus

General Summary

Phosphorus, although a major nutrient pollutant, is found throughout the watershed in relatively smaller quantities than its companion nutrient nitrogen. It certainly appears, based on the data collected, that the major source of Phosphorus into Bat Creek is from Madisonville's WWTP.

The concentration of Phosphorus at Sample Location B-13, downstream of the Madisonville WWTP, is 0.50 ppm which is the highest recorded, more than twice any other concentration measured anywhere in the watershed. The concentration decreases in Bat Creek as it flows toward Tellico Lake.

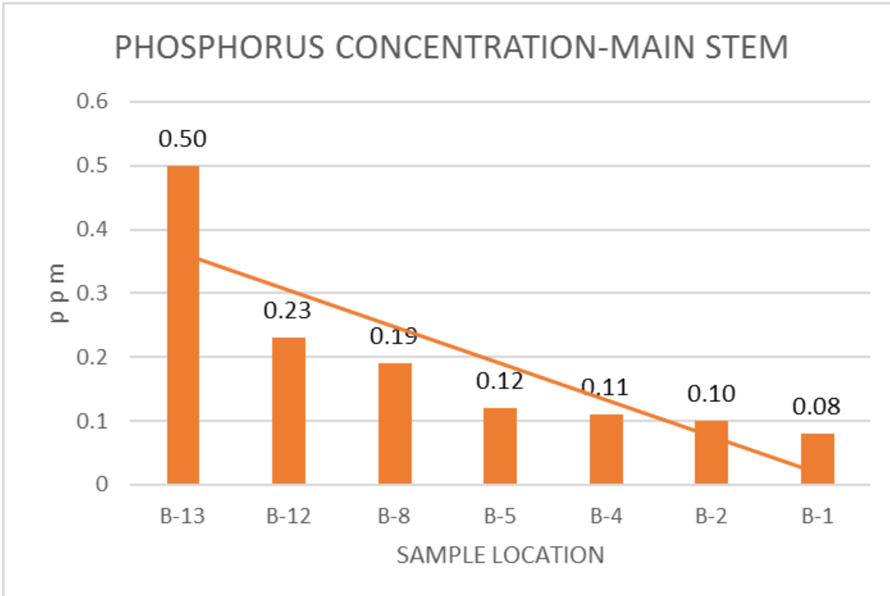
Phosphorus on a mass basis, pounds per day, at Sample Location B-13 is 16.2 PPD, where the upstream measured tributary sources added a sum of only 2.8 PPD into Bat Creek. Based on the effluent data submitted to TDEC by Madisonville during 2016, public information, the Madisonville WWTP discharged approximately 24 PPD of phosphorus, with the average daily contribution ranging between a high of 43.5 PPD and a low of 15.5 PPD. The total mass of Phosphorus, like the concentration amounts, decreased from B-13 at 16.2 PPD to 10.8 PPD at B-1 prior to Bat Creek entering Tellico Lake. This generally indicates that the uptake of Phosphorus by vegetation in the stream or sequestered in the stream sediments is greater than the phosphorus added from nonpoint sources along the creek.

There are certainly other sources of Phosphorus within the watershed, however there are two or less PPD from any of the individual tributary sources analyzed.

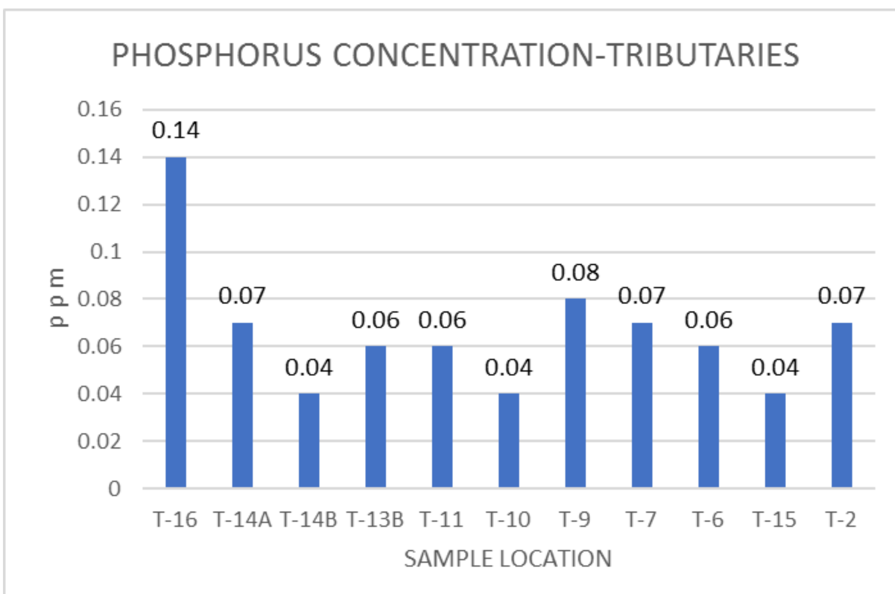
The new Madisonville WWTP that is currently under construction, to be operational July 2017, is expected to have a major positive impact on reducing Phosphorus in the Bat Creek Watershed.

See Supplement D, Phosphorus, for additional detailed information.

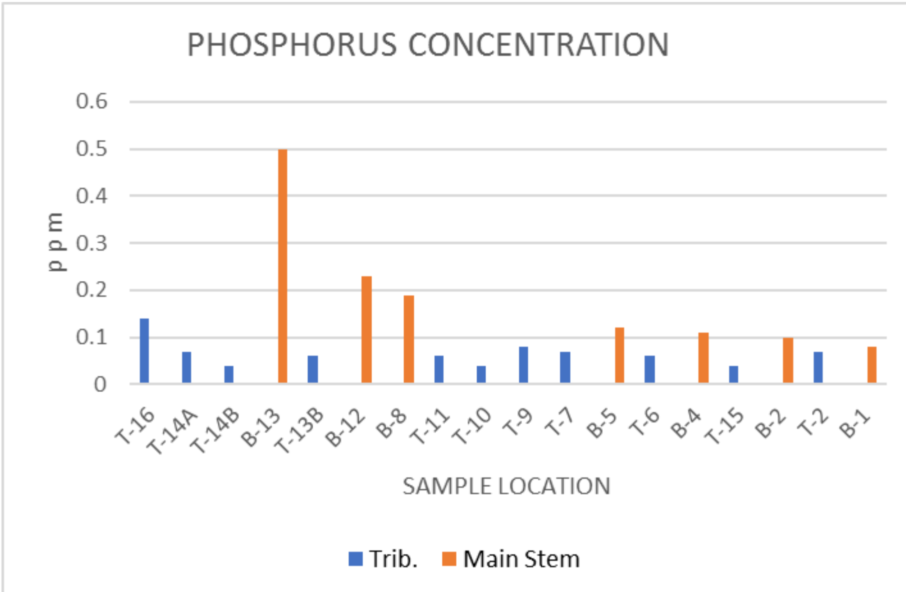
PHOSPHORUS CONCENTRATION – MAIN STEM



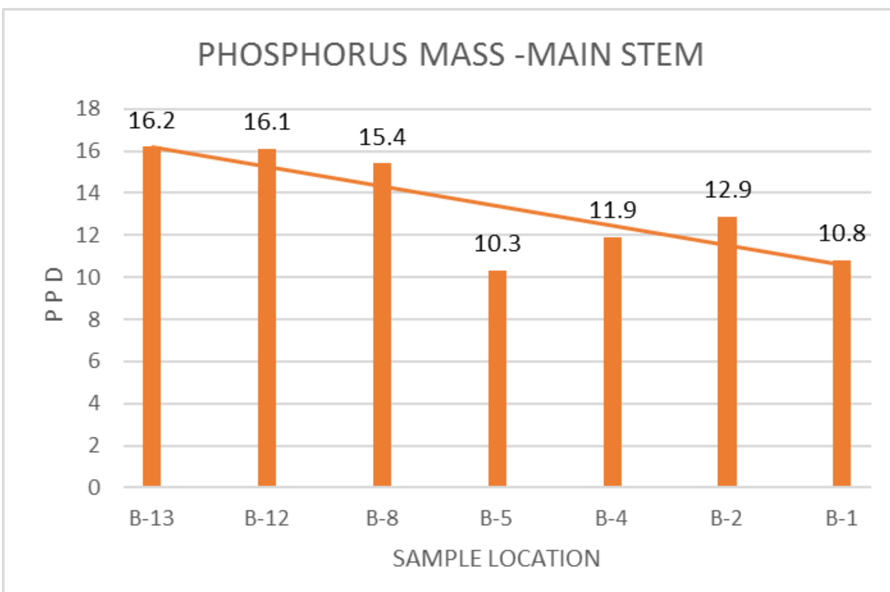
PHOSPHORUS CONCENTRATION – TRIBUTARIES



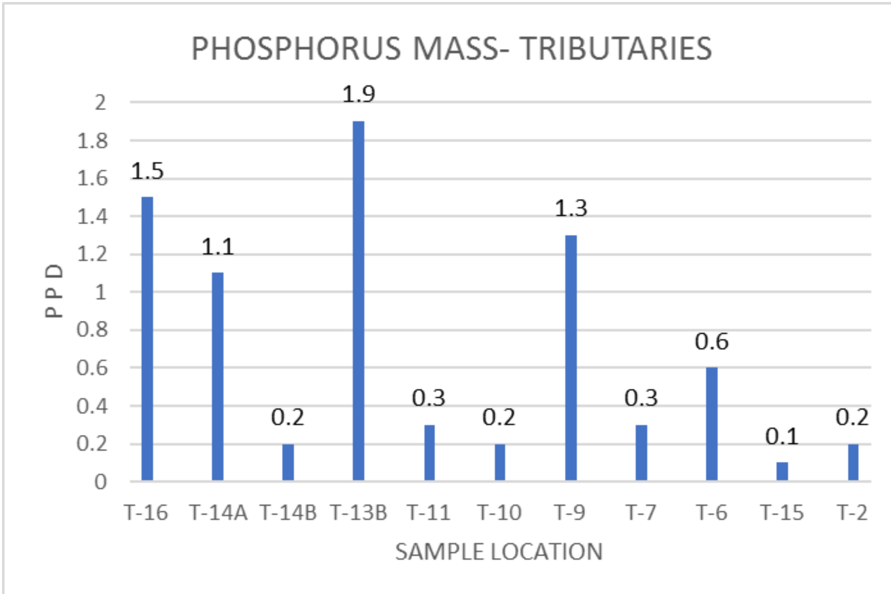
PHOSPHORUS CONCENTRATION – WATERSHED



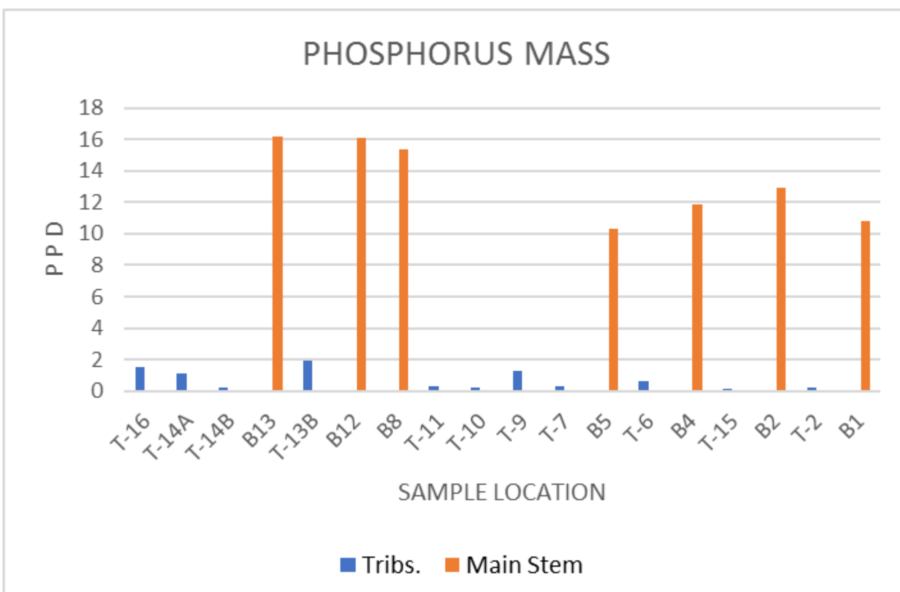
PHOSPHORUS MASS – MAIN STEM



PHOSPHORUS MASS – TRIBUTARIES



PHOSPHORUS MASS – WATERSHED



E.Coli

General Summary

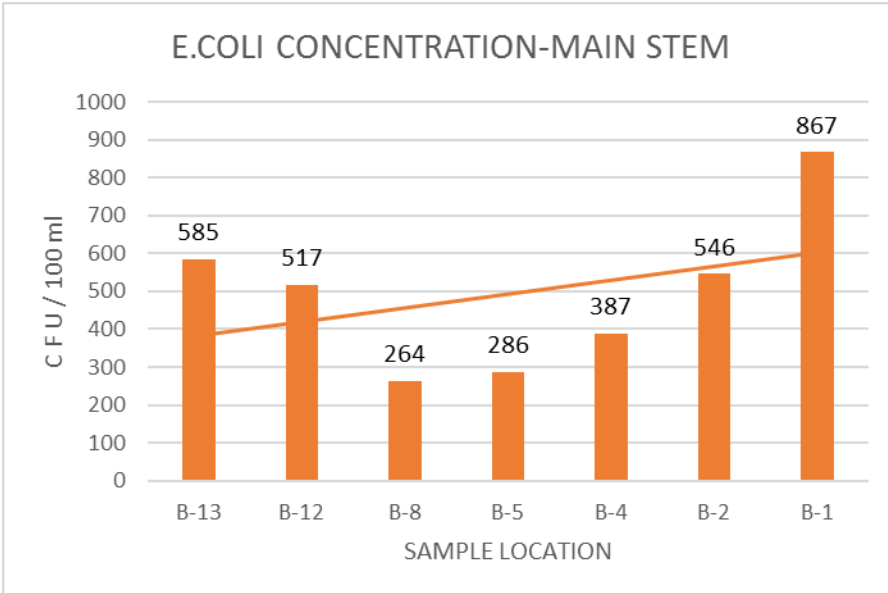
E.Coli levels are of major concern throughout the entire watershed. All of the sampled tributaries and the main stem of Bat Creek had E.Coli levels that exceeded the Tennessee standard (geometric mean of 126 CFU/100 ml), and thus prevent those waters from being classified as suitable for recreational uses. Five of the tributaries and one main stem sample location had E.Coli values that exceeded the Tennessee standard (geometric mean of 630 CFU/100 ml) to allow those waters to be classified for fish and wildlife use. Only in four samples, 4% of total samples, were E.Coli levels found to be less than 126 CFU/100 ml, the limit for recreational uses.

Fifteen samples, 15% of the total, had E.Coli levels equal to or greater than the upper detection limit of 2,400 CFU/100 ml. Among those 15, six tributary sample locations and four main stem sample locations had E.Coli concentrations that exceeded the upper detection limit on a least one occasion. Thus, it appears there are many locations in the watershed that experience very high E.Coli periodically.

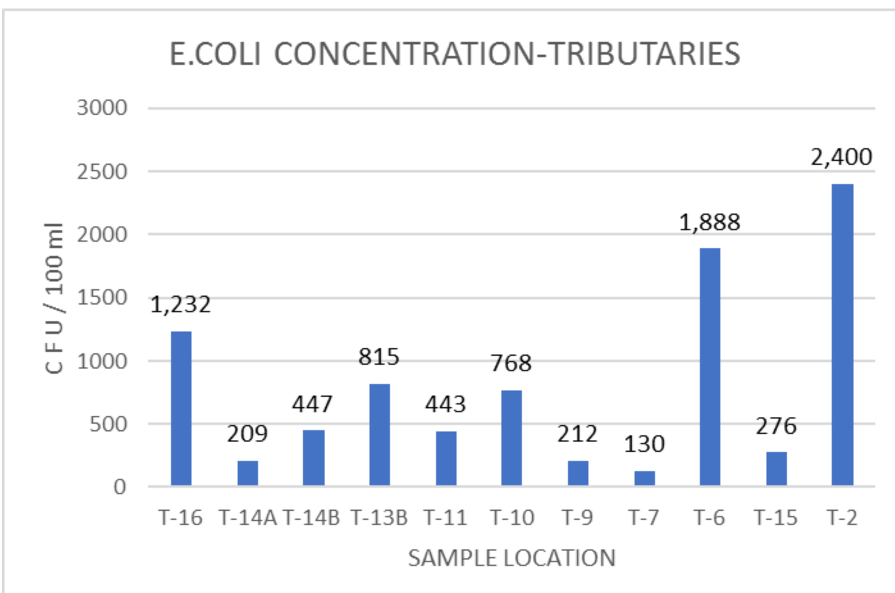
Gene speciation of E.Coli, totally funded by WATeR, found a very high probability that E.Coli was from animals not humans. Four samples were taken in August 2016, from Sample Locations T-13B, T-9, T-6 and B-2 (three major tributaries and the lower reach of Bat Creek). Results of all samples were very similar, with the three tributaries reporting below or barely above lower reporting limits (5-7 gene copies/ml) for both animal tests for ruminant species. In all cases the BacR test (for cows, sheep, goats and deer) slightly exceeded the results for the Rum2Bac test (for cows and sheep). At B-2, Hendrix Loop, the results were similar to the tributaries, with the HF183 test for human genes reported below the lower reporting limit for all four samples. While these results are not absolute, they do indicate that the focus of future efforts should be with BMPs for cattle and dairy cows rather than problems from poorly functioning septic systems.

For purposes of comparative analysis in this report, E.Coli “mass” is the product of multiplying flow rate (cfs) by colony count (CFU/100 ml), creating a “colonies” surrogate for true mass rate in PPD. See Supplement E, E.Coli, for additional detailed data.

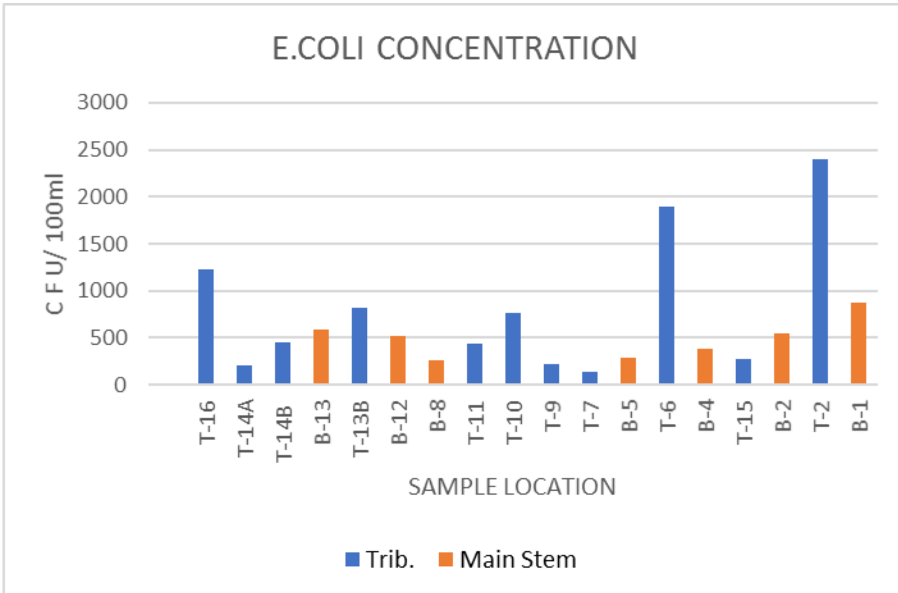
E.COLI CONCENTRATION – MAIN STEM



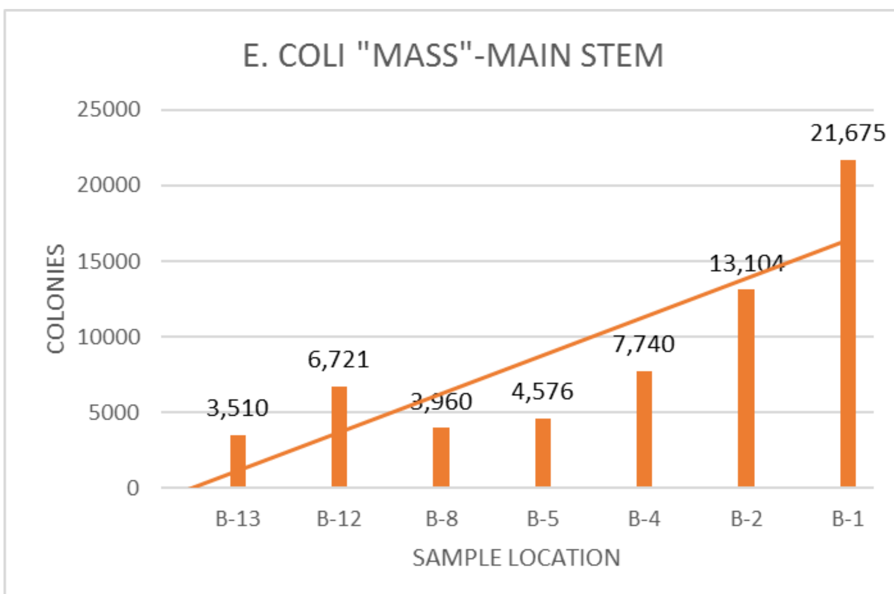
E.COLI CONCENTRATION – TRIBUTARIES



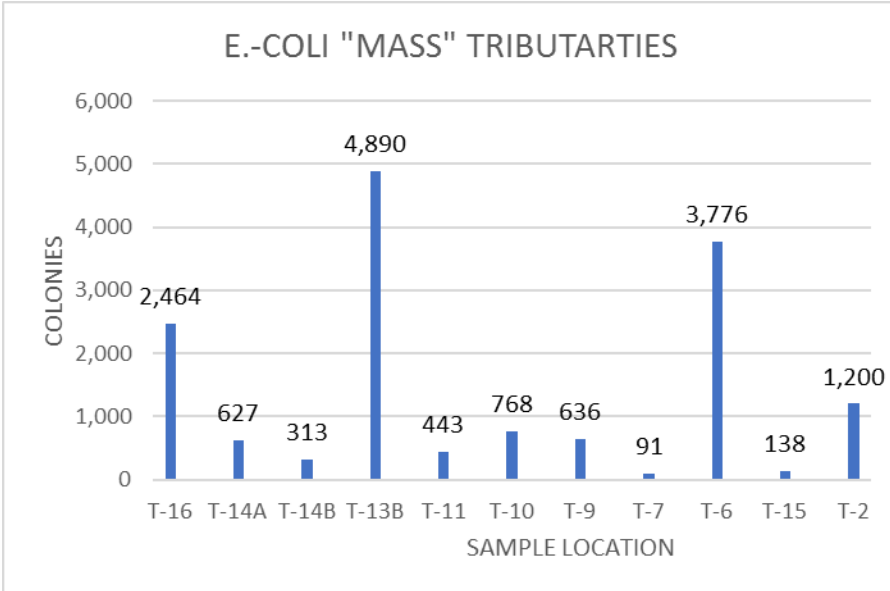
E.COLI CONCENTRATION – WATERSHED



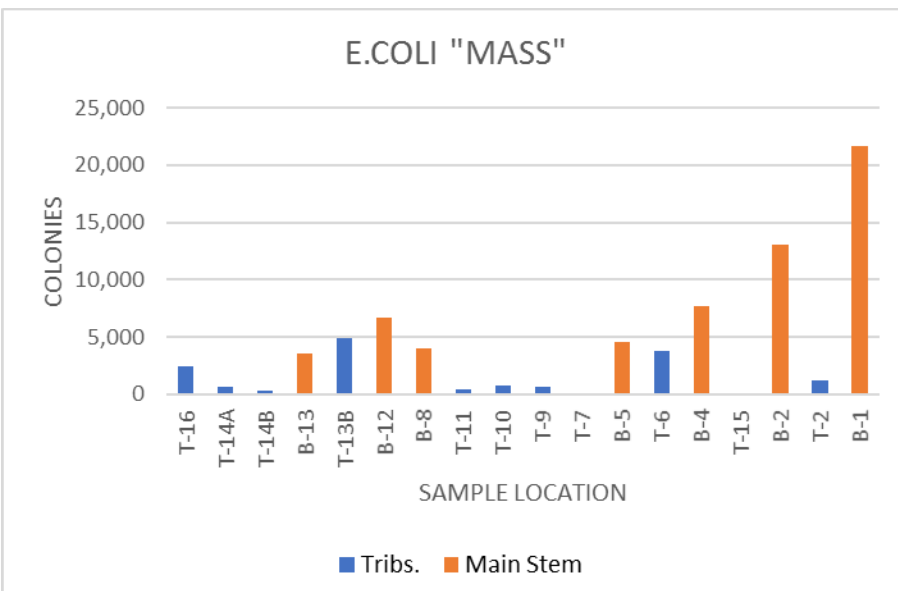
E.COLI "MASS" – MAIN STEM



E.COLI "MASS" – TRIBUTARIES



E.COLI "MASS" – WATERSHED



Dissolved Oxygen

General Summary

Dissolved Oxygen readings ranged from 5.80 ppm to 12.54 ppm. Oxygen saturation was between 68% and 160%. Both the mean and median oxygen saturation was 93%. There were only 9 out of 85 measurements where Dissolved Oxygen was less than 7.0 ppm.

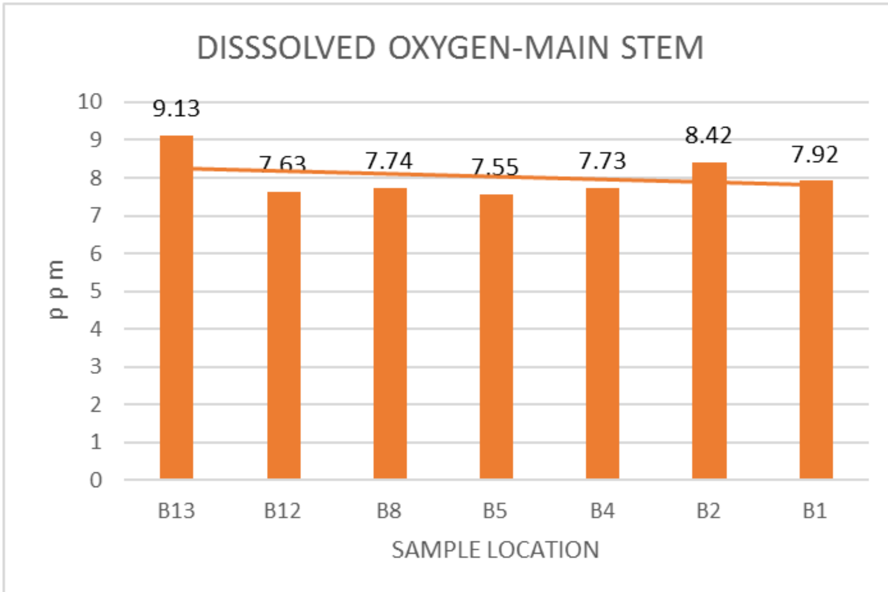
Lower oxygen saturation was generally associated with high Turbidity and high E.Coli levels. Other low saturation values were found in the stream that had the petroleum spill (T-14A), presumably due to increased oxygen demand. Tributary T-10, a stream with distinct water color and marginal flow, had low saturation values. Stream flow in Tributary T-10 ceased in July, precluding additional sampling.

Several incidences of oxygen saturation percentages in the 70%s and low 80%s, were recorded at B-13; however, oxygen saturation had recovered by the next sample site about one mile downstream.

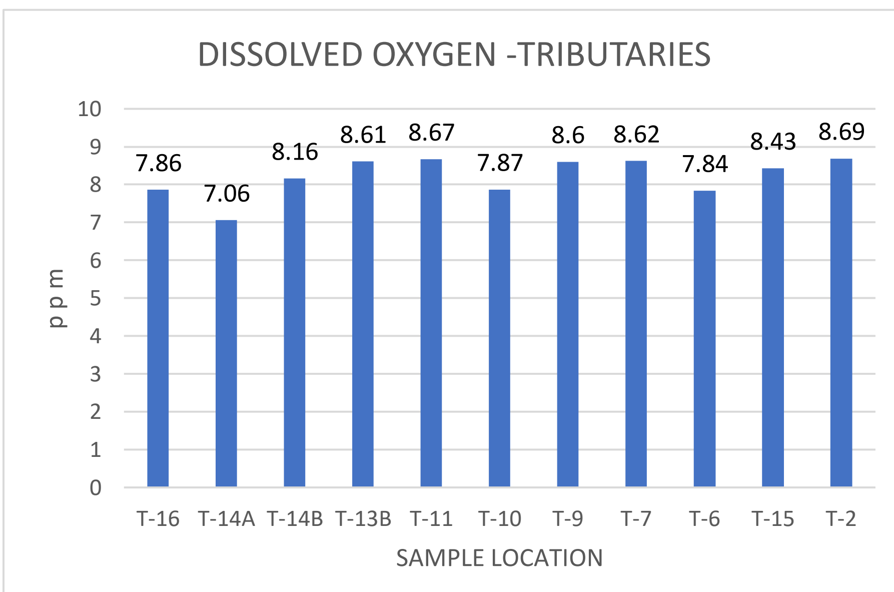
Submerged aquatic vegetation and many small rapids increased saturation values of dissolved oxygen to as high as 160% (supersaturated). A high rainfall event increased Turbidity which may have silted over the vegetation, and the vegetation began to disappear and oxygen supersaturation values were no longer found in subsequent samples. High nutrient values generally enhance vegetative growth which increases Dissolved Oxygen until the growth begins to die.

See Supplement F, Dissolved Oxygen, for additional detailed data.

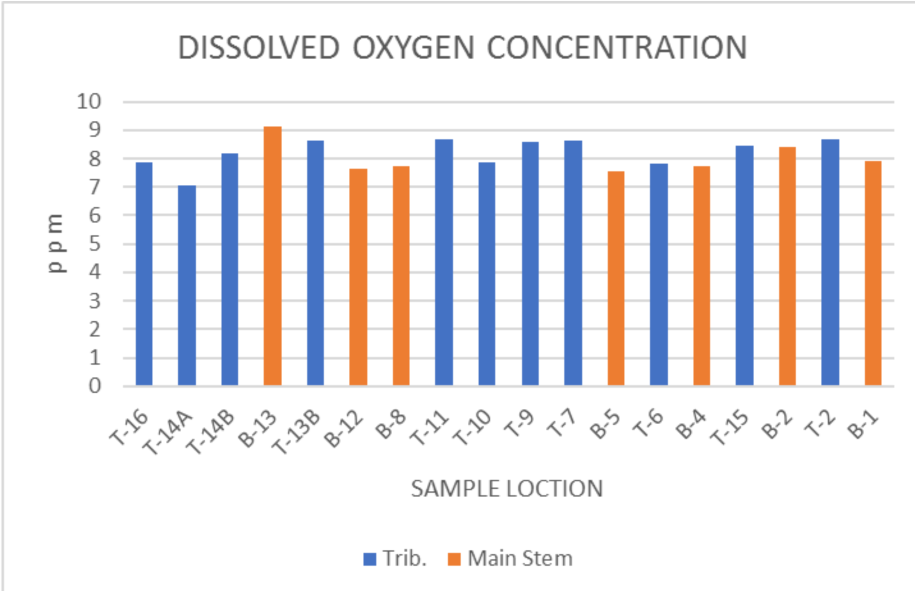
DISSOLVED OXYGEN CONCENTRATION – MAIN STEM



DISSOLVED OXYGEN CONCENTRATION – TRIBUTARIES



DISSOLVED OXYGEN CONCENTRATION – WATERSHED



Turbidity

General Summary

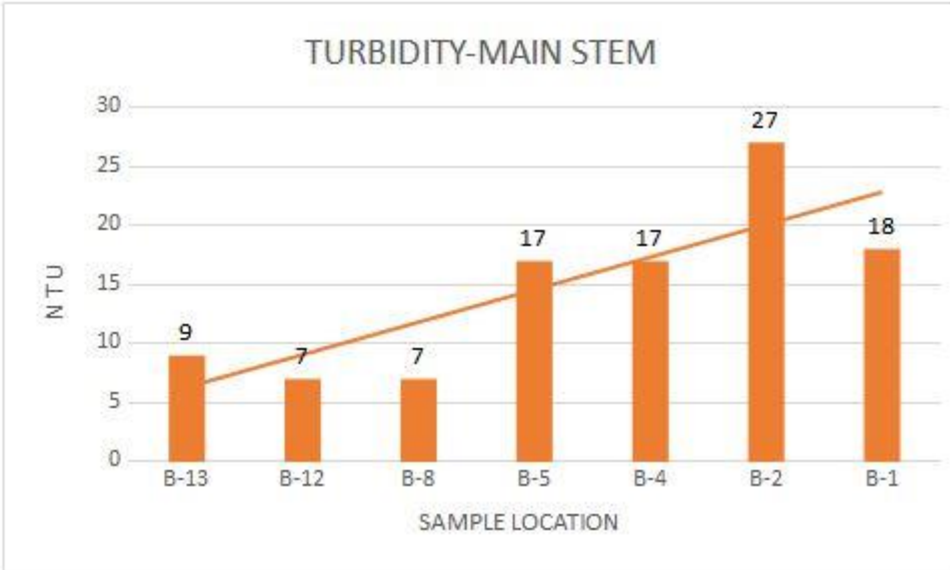
Turbidity was measured using a turbidity tube, and NTU (suspended sediment) values were determined by calculation. Turbidity values ranged 4-800 NTU for the entire watershed, and this range occurred at one sample location, T-16. The average measured Turbidity for most tributaries to Bat Creek was low, with nine of 10 tributaries averaging 5-10 NTU.

Most of the high Turbidity readings were measured in the lower section of Bat Creek, Sample Locations B-1 to B-5. This area of Bat Creek had substantial row crop agriculture in the sub-watersheds that drain into the main stem of the creek. The upper section of Bat Creek had an average of Turbidity reading of 7 NTU.

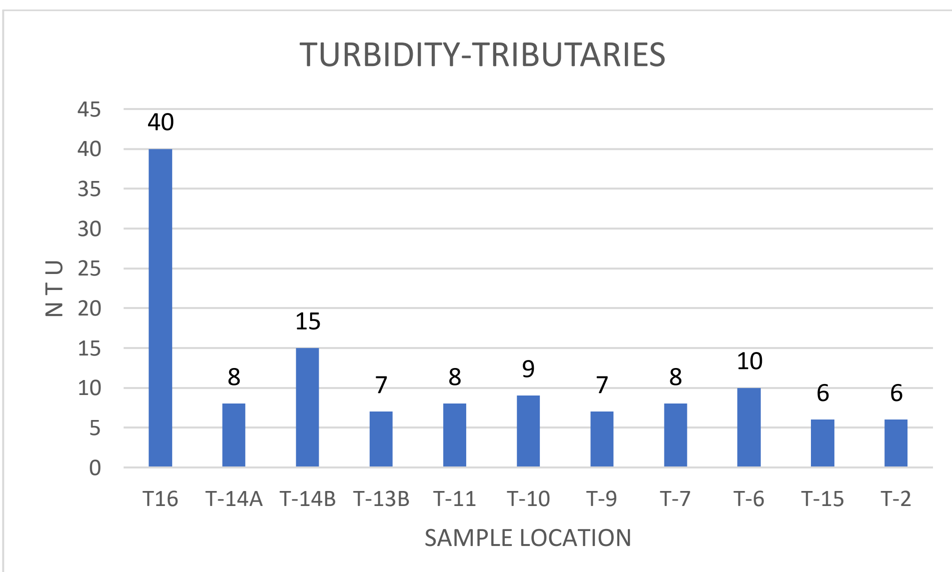
Large rainfall events substantively increased Turbidity in almost all cases. Even smaller rainfall events caused increased Turbidity in Bat Creek and most tributaries. Additionally, animal activity adjacent to and within Bat Creek and its tributaries can have a major impact on Turbidity in the watershed.

See Supplement G, Turbidity, for additional detailed data.

TURBIDITY – MAIN STEM

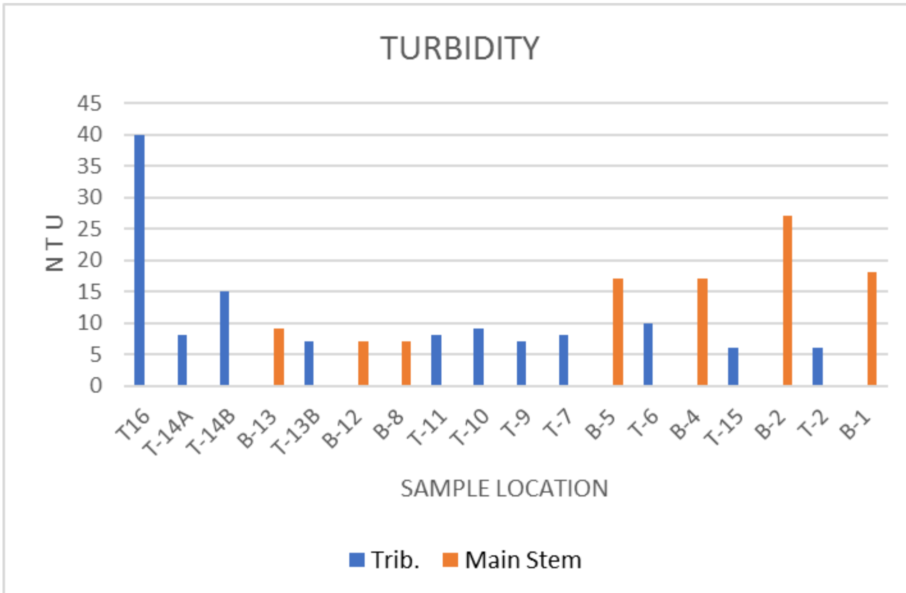


TURBIDITY – TRIBUTARIES



NOTE: T-16 actual average is 192 NTU. 40 NTU is only used as a surrogate for graphing purposes.

TURBIDITY – WATERSHED



pH

General Summary

The *in situ* pH readings ranged from 6.9 to 8.2. The vast majority (70%) of the readings were neutral to slightly basic; pH 7.0 to 7.6. Soils in this region are slightly acidic and it would be expected that water with a lot of soil in it would be acidic. The high pH readings were usually associated with sites with abundant aquatic vegetation that reduces the carbonic acid in the creek water.

See Supplement H, pH, for additional detailed data.

Total Kjeldahl Nitrogen (TKN)

General Summary

TKN was analyzed in the laboratory from water samples collected during the months of August, September, October and November 2016. There were four main stem sample locations (B-13, B-12, B-8 and B-5) and four tributary sample locations (T-11, T-9, T-7 and T-6). These sites were selected because higher than "average" Nitrate concentrations had been reported. TKN is a measure of the amount of organic nitrogen present including ammonia. Nitrite + Nitrate plus TKN (reported as nitrogen), is considered to be Total Nitrogen.

It appears that ammonia (reported as nitrogen) from the Madisonville WWTP (as currently performing) is entering Bat Creek above B-13. Ammonia is oxidized by a combination of differing natural conditions that exist along Bat Creek. This nitrogen (in the form of ammonia) is expected to decrease when the new WWTP becomes operational. See the following paragraph for interpretation.

TKN lab analyses are reported in the following tables. The two-part table presents the relationship between TKN and Nitrate-N at four locations in the stem of Bat Creek. At each of those locations, both TKN and Nitrate are reported on two or three dates; the TKN/Nitrate ratio is calculated for each pair, and then the ratios are averaged as a single value (in the lower right corners). The ratio is 1.0, with both concentration values averaging nearly the same, at B-13 just below the WWTP discharge. It is presumed that most of the TKN is ammonia that will readily oxidize *in situ* and convert to Nitrate as water flows downstream. When that happens, the ratio numerator becomes smaller and the denominator increases resulting in continued lowering of the ratio value. The sequentially decreasing ratio between Sample Locations B-13 and B-5 supports the assumption that ammonia is being converted naturally.

TKN CONCENTRATION DATA

TKN CONCENTRATION--ppm				
Sample Location	**August**	**September**	**October**	**November**
B-13	0.41	xxx	0.99	1.55
B-12	0.26	xxx	0.49	0.54
B-8	0.29	xxx	0.36	xxx
T-11	0.34	0.32	0.39	xxx
T-9	xxx	xxx	ND	xxx
T-7	xxx	xxx	ND	xxx
B-5	0.25	xxx	0.81	0.27
T-6	xxx	xxx	0.41	xxx
B-4	0.25	xxx	ND	xxx
B-2	0.32	xxx	ND	xxx

TKN/NITRATE-N RATIO

TKN/Nitrate-N Ratio based on ppm concentrations						
	B-13			B-12		
	TKN	NO3-N	Ratio	TKN	NO3-N	Ratio
August	0.41	0.78	0.52	0.26	0.68	0.38
September						
October	0.99	0.69	1.43	0.49	0.68	0.72
November	1.55	1.49	1.04			
Avg. Ratio			**1.00**			**0.55**

TKN/Nitrate-N Ratio based on ppm concentrations						
	B-8			B-5		
	TKN	NO3-N	Ratio	TKN	NO3-N	Ratio
August	0.29	0.61	0.48	0.25	0.8	0.32
September						
October	0.36	0.79	0.46	0.81	2.18	0.37
November				0.27	0.64	0.43
Avg. Ratio			**0.47**			**0.37**

Rainfall Information

General Summary

The local rainfall data (presented in graphic format on the next page) is an average of historical rainfall for Athens and Lenoir City, Tennessee, for 2015 and 2016, because there is not consistent rainfall data available for locations within Monroe County.

The last months of 2015, October through December, had much higher rainfall than normal which lead to recharging the ground water table prior to the beginning of 2016. This took place as the sampling program was beginning along Bat Creek. January 2016 rainfall was below 2015 and below the historical norms (2000 thru 2016). February precipitation was much higher than normal for 2016. Both of these events continued to recharge the ground water table, which in turn provided stream bank exfiltration into Bat Creek and kept the base flow near normal conditions.

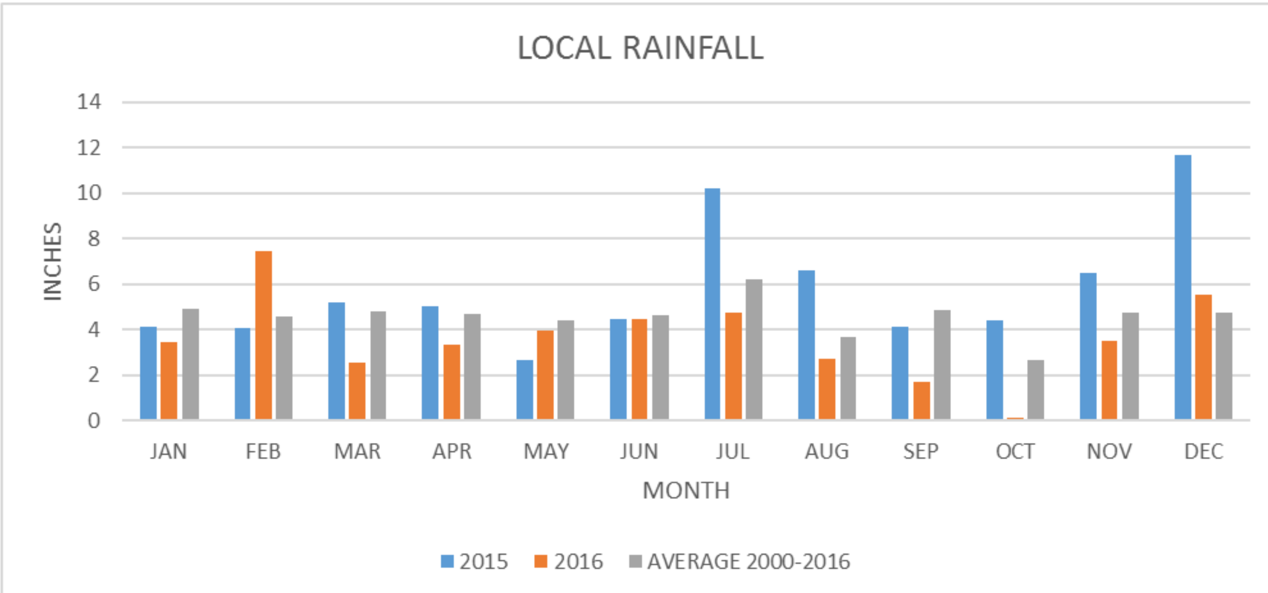
However, in March 2016 the entire area began a drought period that gradually worsened through the remainder of the year. The lowest precipitation occurred in October 2016, nearly setting a new record low since 1962. More normal rains returned to the area at the end of November and throughout December after the field sampling program was completed. The last set of data was collected on November 29 right after a one-inch rainfall event which began the “rainy” season.

The general lack of rainfall from March through November 2016 no doubt resulted in below low normal stream flows in the Bat Creek Watershed, and in some cases sampling was prohibited due to lack of flow or no flow. Stream flow measurement was even more severely limited with little or no velocity as well as clogged culverts. Little rainfall resulted in reduced surface runoff, the major component of nonpoint source pollution.

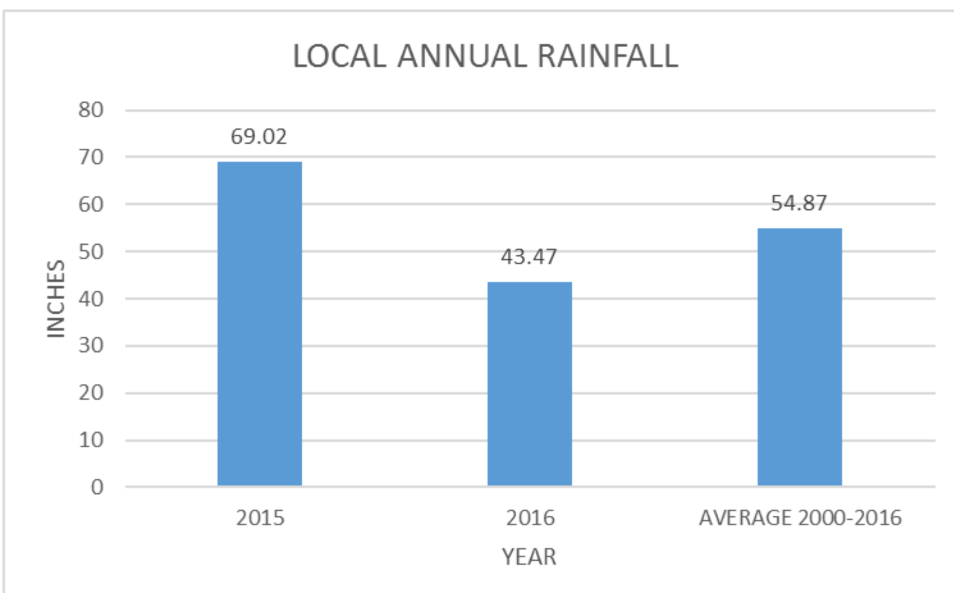
The 2016 sampling results as well as flow measurement generally do not reflect normal or average conditions, based on rainfall data for the past 17 years, in the Bat Creek Watershed. However, the analytical results are strong indicators of nonpoint sources of pollution.

See Supplement J, Rainfall, for additional detailed data.

AVERAGE MONTHLY RAINFALL



ANNUAL RAINFALL



SECTION 6 – TRIBUTARY WATER QUALITY DATA

General

Average concentration data and average mass data in Sections 6 and 7 are calculated averages of all samples analyzed at a location during the sampling period, April through November 2016.

Laboratory analysis data was used for Nitrate, Phosphorus, E.Coli and TKN, April through November 2016.

Field measurements were used for Turbidity and Dissolved Oxygen, April through November 2016.

Several sample locations were sampled only a few times due mainly to low flow conditions, unless otherwise noted.

See Map 6 to locate the sub-watershed areas of all of the sample locations discussed. The tributary data presented in Section 6 were evaluated comparatively by mathematical forced ranking as shown in Section 8, "Prioritization Analysis of Tributary Water Quality." Each tributary sample location represents a well-defined sub-watershed that can be analyzed, assessed and compared to the other defined sub-watersheds using a forced ranking approach. The descriptive notations for both concentration and mass for each Sub-watershed are relative one to the other. See Supplements A through K at the end of this report for additional detailed data.

Tributary T-16 (Old Highway 68)

The sample location is about one-half mile above the first confluence point of tributaries in upper Bat Creek, at Old Highway 68. This tributary is generally recognized as the beginning of Bat Creek, but it has characteristics of a tributary, particularly an isolated drainage area. This location was originally called B-15, and that designation was retained for backup data in the Supplemental Information Section.

This Sub-watershed had high concentrations of Phosphorus, E. Coli and Turbidity.

Concentration Data T-16			
Parameter	**Average Concentration**	**Range**	**Number of Samples**
Nitrate	0.86ppm	0.74-0.98 ppm	3
Phosphorus	0.14 ppm	0.04-0.23ppm	4
E. Coli	1,232 CFU/100ml	580->2,400 CFU/100ml	4
Turbidity	192 NTU	4-800 NTU	5
D O	7.86ppm	5.80-10.28 ppm	4

Estimated average annual flow (2016) was 2 cfs.

This Sub-watershed had high mass contributions of Phosphorus and E.Coli.

Mass Data T-16	
Parameter	**Average Mass**
Nitrate	9 PPD
Phosphorus	1.5 PPD
E.Coli	2,464 Colonies

Tributary T-14A (Old Highway 68)

The sample location is where the tributary crosses Old Highway 68.

The sample location is approximately one-half mile upstream from the confluence of this tributary with Bat Creek.

There is limited data from this location because there was a petroleum layer on the water surface during much of the sampling period and samples were not collected.

This Sub-watershed had a moderate concentration of Phosphorus.

Concentration Data T-14A			
Parameter	**Average Concentration**	**Range**	**Number of Samples**
Nitrate	1.10 ppm	1.06-1.16 ppm	3
Phosphorus	0.07 ppm	0.04-0.21 ppm	4
E. Coli	209 CFU/ 100ml	130-370 CFU/100ml	3
Turbidity	6 NTU	3-16 NTU	6
D O	7.06ppm	6.49-8.56 ppm	4

Estimated average annual flow (2016) was 3 cfs.

This Sub-watershed had high mass contributions of Nitrate and Phosphorus.

Mass Data T-14A	
Parameter	**Average Mass**
Nitrate	18 PPD
Phosphorus	1.1 PPD
E.Coli	627 Colonies

Tributary T-14B (Park Street)

The sample point for this Sub-watershed is where the tributary crosses Park street. This site is used by TDEC for their five-year sampling program. This site is located upstream of Madisonville's WWTP.

The sample location is approximately 1.5 miles upstream from the confluence of this tributary with Bat Creek.

This Sub-watershed had a high concentration spike of Turbidity.

Concentration Data T-14B			
Parameter	**Average Concentration**	**Range**	**Number of Samples**
Nitrate	1.21 ppm	0.97-1.41 ppm	5
Phosphorus	0.04 ppm	0.04-0.04 ppm	5
E. Coli	447 CFU/100ml	190-2,000 CFU/100ml	6
Turbidity	5 NTU	4-110 NTU	6
D O	8.16 ppm	7.6-8.82 ppm	5

Estimated average annual flow (2016) was 0.7 cfs.

This Sub-watershed had low mass contributions of all listed water quality parameters.

Mass Data T-14B	
Parameter	**Average Mass**
Nitrate	5 PPD
Phosphorus	0.2 PPD
E.Coli	313 Colonies

Tributary T-13B (Brunner Road)

The sample location is where the Craighead Creek tributary crosses Brunner Road west of Hiwassee College.

The sample location is approximately one mile upstream from the confluence of this tributary with Bat Creek.

This Sub-watershed had a high concentration of E.Coli.

Concentration Data T-13B			
Parameter	**Average Concentration**	**Range**	**Number of Samples**
Nitrate	0.63 ppm	0.48-0.98 ppm	6
Phosphorus	0.06 ppm	0.04-0.13 ppm	5
E. Coli	815 CFU/100ml	180->2,400 CFU/100ml	7
Turbidity	6 NTU	5-8 NTU	7
D O	8.61 ppm	8.20-9.64 ppm	6

Estimated average annual flow (2016) was 6 cfs, the highest of any tributary.

This Sub-watershed had the highest tributary mass contributions of Nitrate, Phosphorus and E.Coli.

Mass Data T-13B	
Parameter	**Average Mass**
Nitrate	20 PPD
Phosphorus	1.9 PPD
E.Coli	4,890 Colonies

Tributary T-11 (Red Ankle)

The sample location is where the Red Ankle tributary crosses Williams Lane, near Hiwassee Road.

The sample location is approximately 0.2 miles upstream from its confluence with Bat Creek.

This Sub-watershed had a high concentration of Nitrate.

Concentration Data T-11			
Parameter	**Average Concentration**	**Range**	**Number of Samples**
Nitrate	2.48 ppm	2.00-3.58 ppm	7
Phosphorus	0.06 ppm	0.04-0.12 ppm	5
E. Coli	443 CFU/100ml	140-1,400 CFU/100ml	7
Turbidity	6 NTU	4-9 NTU	7
D O	8.67 ppm	8.49-9.39 ppm	6

Estimated average annual flow (2016) was 1 cfs.

This Sub-watershed had a high mass contribution of Nitrate.

Mass Data T-11	
Parameter	**Average Mass**
Nitrate	17 PPD
Phosphorus	0.3 PPD
E.Coli	443 Colonies

Tributary T-10 (Short Bark)

The sample location is where the tributary crosses Short Bark Road just east of Hiwassee College.

The sample location is approximately 0.2 miles upstream from its confluence with Bat Creek.

This Sub-watershed had a moderate concentration of E. Coli.

Concentration Data T-10			
Parameter	**Average Concentration**	**Range**	**Number of Samples**
Nitrate	0.43 ppm	0.39-0.46 ppm	2
Phosphorus	0.04 ppm	0.04-0.04 ppm	4
E. Coli	768 CFU/100ml	290-2,400 CFU/100 ml	3
Turbidity	7 NTU	3-14 NTU	4
D O	7.87 ppm	6.56-9.42 ppm	3

Estimated average annual flow (2016) was 1 cfs.

This Sub-watershed had low mass contributions of all listed water quality parameters.

Mass Data T-10	
Parameter	**Average Mass**
Nitrate	3 PPD
Phosphorus	0.2 PPD
E.Coli	768 Colonies

Tributary T-9 (Red Branch)

The sample location is where the Red Branch tributary crosses Anderson Road.

The sample location is 0.2 miles upstream from its confluence with Bat Creek.

This Sub-watershed had a high concentration of Phosphorus.

Concentration Data T-9			
Parameter	**Average Concentration**	**Range**	**Number of Samples**
Nitrate	0.69 ppm	0.47-1.37 ppm	5
Phosphorus	0.08 ppm	0.04-0.14 ppm	5
E. Coli	212 CFU/100ml	130-580 CFU/100ml	5
Turbidity	4 NTU	3-8 NTU	6
D O	8.60 ppm	7.70-9.67 ppm	5

Estimated average annual flow (2016) was 3 cfs.

This Sub-watershed had a high mass contribution of Phosphorus.

Mass Data T-9	
Parameter	**Average Mass**
Nitrate	11 PPD
Phosphorus	1.3 PPD
E.Coli	768 Colonies

Tributary T-7 (Acorn Gap Road)

The sample location is where the tributary crosses and flows along Acorn Gap Road.

The sample location is 0.5 miles upstream from its confluence with Bat Creek.

This Sub-watershed had a moderate concentration of Phosphorus.

Concentration Data T-7			
Parameter	**Average Concentration**	**Range**	**Number of Samples**
Nitrate	0.89 ppm	0.68-1.16 ppm	5
Phosphorus	0.07 ppm	0.04-0.18 ppm	5
E. Coli	130 CFU/100ml	70-220 CFU/100ml	5
Turbidity	7 NTU	3-25 NTU	6
D O	8.62 ppm	7.68-10.31 ppm	5

Estimated average annual flow (2016) was 0.7 cfs.

This Sub-watershed had low mass contributions of all listed water quality parameters.

Mass Data T-7	
Parameter	**Average Mass**
Nitrate	3 PPD
Phosphorus	0.3 PPD
E.Coli	91 Colonies

Tributary T-6 (Bulging Branch)

The sample location is where the Bulging Branch tributary crosses Acorn Gap Road near Old Loudon Road.

The sample location is approximately 0.1 miles upstream from its confluence with Bat Creek.

This Sub-watershed had high concentrations of Nitrate and E.Coli.

Concentration Data T-6			
Parameter	**Average Concentration**	**Range**	**Number of Samples**
Nitrate	1.48 ppm	0.98-1.86 ppm	6
Phosphorus	0.06 ppm	0.04-0.13 ppm	5
E. Coli	1,888 CFU/100ml	1,300->2,400 CFU/100ml	7
Turbidity	9 NTU	6-19 NTU	7
D O	7.84 ppm	6.48-9.92 ppm	5

Estimated average annual flow (2016) was 2 cfs.

This Sub-watershed had high mass contributions of Nitrate and E.Coli.

Mass Data T-6	
Parameter	**Average Mass**
Nitrate	16 PPD
Phosphorus	0.6 PPD
E.Coli	3,776 Colonies

Tributary T-15 (Hendrix Loop Road)

The sample location is where this tributary crosses Hendrix Loop Road near Knob Road.

The sample location is approximately 0.1 miles upstream from its confluence with Bat Creek.

This Sub-watershed had a high concentration of Nitrate.

Concentration Data T-15			
Parameter	**Average Concentration**	**Range**	**Number of Samples**
Nitrate	1.66 ppm	1.51-1.88 ppm	4
Phosphorus	0.04 ppm	0.04-0.04 ppm	4
E. Coli	276 CFU/100ml	14->2,400 CFU/100ml	5
Turbidity	7 NTU	3-14 NTU	5
D O	8.43 ppm	8.20-9.08 ppm	6

Estimated average annual flow (2016) was 0.5 cfs.

This Sub-watershed had low mass contributions of all listed water quality parameters.

Mass Data T-15	
Parameter	**Average Mass**
Nitrate	4 PPD
Phosphorus	0.1 PPD
E.Coli	138 Colonies

Tributary T-2 (Lakeside Road)

The sample location is within the creek near Lakeside Road and Bat Creek Shores Lane. This location can only be sampled when Tellico Lake is drawn down to ”winter pool” level.

The sample location is approximately 0.1 miles upstream from its confluence with Bat Creek.

This Sub-watershed had high concentrations of Nitrate and E.Coli and a moderate concentration of Phosphorus.

Concentration Data T-2			
Parameter	**Average Concentration**	**Range**	**Number of Samples**
Nitrate	4.33 ppm	1.43-7.23 ppm	2
Phosphorus	0.07 ppm	0.04-0.09 ppm	2
E. Coli	>2,400 CFU/100ml	all >2,400 CFU/100ml	3
Turbidity	7 NTU	4-10 NTU	5
D O	8.69 ppm	8.69 ppm	1

Estimated average annual flow (2016) was 0.5 cfs.

This Sub-watershed had moderate mass contributions of Nitrate and E.Coli.

Mass Data T-2	
Parameter	**Average Mass**
Nitrate	12 PPD
Phosphorus	0.2 PPD
E.Coli	1,200 Colonies

SECTION 7 – MAIN STEM WATER QUALITY DATA

General

Average concentration data and average mass data in Sections 6 and 7 are calculated averages of all samples analyzed at a location during the sampling period, April through November 2016.

Laboratory analysis data was used for Nitrate, Phosphorus, E.Coli and TKN, April through November 2016.

Field measurements were used for Turbidity and Dissolved Oxygen, April through November2016.

Some sample locations were not sampled a few times for various reasons.

See Map 6 to locate the sub-watershed areas of all of the sample locations discussed. It was difficult to determine whether or not a Bat Creek stem sample represented pollution from the associated sub-watershed or from upstream sources. Therefore, comments on the following pages state only that a high concentration or mass of a pollutant existed at a sample location. The contribution of the sub-watershed segment, including tributaries immediately upstream and ending at a sample location, can only be estimated by comparing the differences between the selected sample location and the sampling location immediately upstream.

Interpretation of the data in Section 7 is presented in Section 9, "Prioritization Analysis of Main Stem Water Quality."

Main Stem B-13 (Legacy Drive)

The sample location is at Bat Creek and Legacy Drive.

This location is the most upstream sample location on the Bat Creek main stem, just below the confluence of tributaries from T-14A and T-16.

This sample location had high concentrations of Phosphorus and E.Coli.

Concentration Data B-13			
Parameter	**Avg. Concentration**	**Range**	**No. of Samples**
Nitrate	1.00 ppm	0.615-1.84 ppm	7
Phosphorus	0.50 ppm	0.28-0.59 ppm	5
E.Coli	585CFU/100ml	150->2,400 CFU/100ml	7
Turbidity	7 NTU	4-16 NTU	7
D O	9.13 ppm	7.50-12.54 ppm	6

Estimated average annual flow (2016) was 6 cfs.

This sample location had a high mass of Phosphorus.

Mass Data B-13	
Parameter	**Average Mass**
Nitrate	32 PPD
Phosphorus	16 PPD
E.Coli	3,510 colonies

Main Stem B-12 (Century Farm Road)

The sample location is at Bat Creek and Century Farm Road.

This sample location had high concentrations of Phosphorus and E.Coli.

Concentration Data B-12			
Parameter	**Avg. Concentration**	**Range**	**No. of Samples**
Nitrate	0.86 ppm	0.68-1.22 ppm	6
Phosphorus	0.23 ppm	0.14-0.42 ppm	5
E.Coli	517 CFU/100ml	250->2,400 CFU/100ml	7
Turbidity	8 NTU	4-13 NTU	7
D O	7.63 ppm	6.80-10.26 ppm	6

Estimated average annual flow (2016) was 13 cfs.

This sample location had high mass of Phosphorus and moderate mass of E.Coli.

Mass Data B-12	
Parameter	**Average Mass**
Nitrate	60 PPD
Phosphorus	16 PPD
E.Coli	6,721 colonies

Main Stem B-8 (Short Bark Road)

The sample location is at Bat Creek and Short Bark Road.

This sample location had a high concentration of Phosphorus.

Concentration Data B-8			
Parameter	**Avg. Concentration**	**Range**	**No. of Samples**
Nitrate	0.88 ppm	0.61-1.19 ppm	6
Phosphorus	0.19 ppm	0.12-0.30 ppm	5
E.Coli	264 CFU/100ml	150-340 CFU/100ml	6
Turbidity	8 NTU	4-16 NTU	7
D O	7.74 ppm	6.82-9.35 ppm	6

Estimated average annual flow (2016) was 15 cfs.

This sample location had a high mass of Phosphorus.

Mass Data B-8	
Parameter	**Average Mass**
Nitrate	71 PPD
Phosphorus	15 PPD
E.Coli	3,960 colonies

Main Stem B-5 (Acorn Gap Road)

The sample location is at Bat Creek and Acorn Gap Road.

This sample location had a high concentration of Nitrate.

Concentration Data B-5			
Parameter	**Avg. Concentration**	**Range**	**No. of Samples**
Nitrate	1.12 ppm	0.64-2.18 ppm	5
Phosphorus	0.12 ppm	0.04-0.11 ppm	5
E.Coli	286 CFU/100ml	160-440 CFU/100ml	4
Turbidity	20 NTU	10-38 NTU	4
D O	7.55 ppm	7.44-7.66 ppm	3

Estimated average annual flow (2016) was 16 cfs.

This sample location had high mass of Nitrate.

Mass Data B-5	
Parameter	**Average Mass**
Nitrate	97 PPD
Phosphorus	10 PPD
E.Coli	4,576 colonies

Main Stem B-4 (Doeskin Valley Road)

The sample location is at Bat Creek and Doeskin Valley Road.

This sample location had a high concentration of Nitrate.

Concentration Data B-4			
Parameter	**Avg. Concentration**	**Range**	**No. of Samples**
Nitrate	1.22 ppm	0.57-3.01 ppm	7
Phosphorus	0.11 ppm	0.09-0.13 ppm	5
E.Coli	387 CFU/100ml	100-2,400 CFU/100ml	7
Turbidity	21 NTU	6-38 NTU	6
D O	7.73 ppm	6.70-9.29 ppm	6

Estimated average annual flow (2016) was 20 cfs.

This sample location had high mass of all listed water quality parameters.

Mass Data B-4	
Parameter	**Average Mass**
Nitrate	132 PPD
Phosphorus	12 PPD
E.Coli	7,740 colonies

Main Stem B-2 (Hendrix Loop Road)

The sample location is at Bat Creek and Hendrix Loop Road.

This sample location had a high concentration of E.Coli.

Concentration Data B-2			
Parameter	**Avg. Concentration**	**Range**	**No. of Samples**
Nitrate	0.87 ppm	0.64-1.13 ppm	7
Phosphorus	0.10 ppm	0.10-0.11 ppm	5
E.Coli	546 CFU/100ml	390-895 CFU/100ml	6
Turbidity	41 NTU	9-75 NTU	7
D O	8.42 ppm	7.60-10.01 ppm	6

Estimated average annual flow (2016) was 24 cfs.

This sample location had high mass of all listed water quality parameters.

Mass Data B-2	
Parameter	**Average Mass**
Nitrate	112 PPD
Phosphorus	13 PPD
E.Coli	13,104 colonies

Main Stem B-1 (Lakeside Road)

The sample location is at Bat Creek and Lakeside Road.

Note: This sample location is in the backwater of Tellico Lake at the "summer pool" level, April through November. Flow is generally stagnant with little velocity in either direction.

This sample location had high concentrations of Nitrate and E.Coli.

Concentration Data B-1			
Parameter	**Avg. Concentration**	**Range**	**No. of Samples**
Nitrate	1.85 ppm	0.28-6.88 ppm	6
Phosphorus	0.08 ppm	0.04-0.15 ppm	5
E.Coli	867 CFU/100ml	250-2,400 CFU/100ml	9
Turbidity	25 NTU	10-47 NTU	7
D O	7.92 ppm	7.16-8.95 ppm	5

Estimated average annual flow (2016) was 25 cfs.

This sample location had high mass of Nitrate and E.Coli, and a moderate mass of Phosphorus.

Mass Data B-1	
Parameter	**Average Mass**
Nitrate	249 PPD
Phosphorus	11 PPD
E.Coli	21,675 colonies

SECTION 8 – PRIORITIZATION ANALYSIS OF TRIBUTARY WATER QUALITY

General

Both concentration and mass data from Section 6 are used herein to establish a location prioritization method.

For each sample location this ranking approach places the same relative "weight" on concentration and mass when the forced concentration points (10-0) are added to the forced mass points (10-0), which results in the tributary Forced Rank for Action (positions 1-11, with 1 highest) or prioritized order for action based on worst pollutant characteristics.

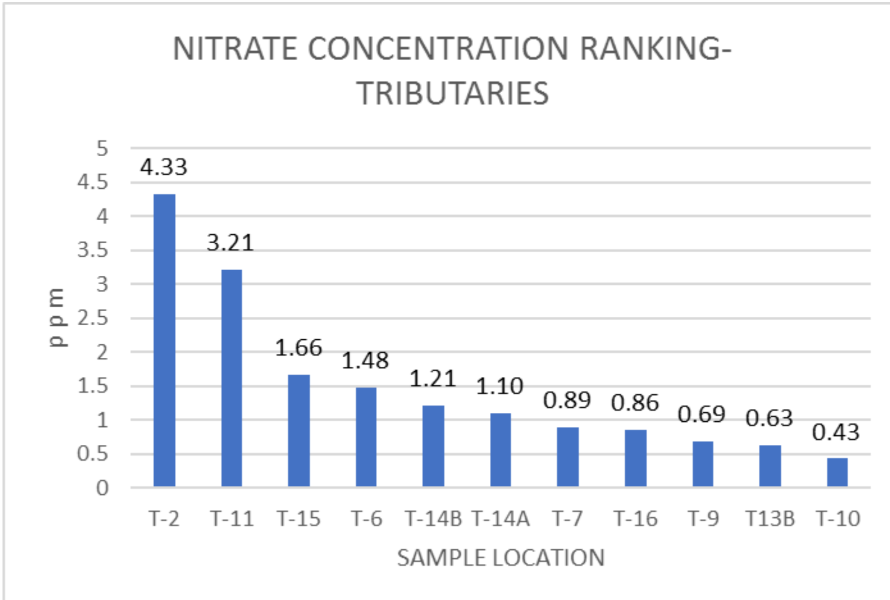
The only parameters considered in the forced ranking approach are Nitrate, Phosphorus and E.Coli, which are shown graphically. Each water quality parameter by itself was forced ranked first for average concentration and second for average mass of the same parameter, using average data from prior sections of this report.

The tributary sampled area is approximately 7,860 acres or 47% of the total Bat Creek Watershed (approximately 16,800 acres).

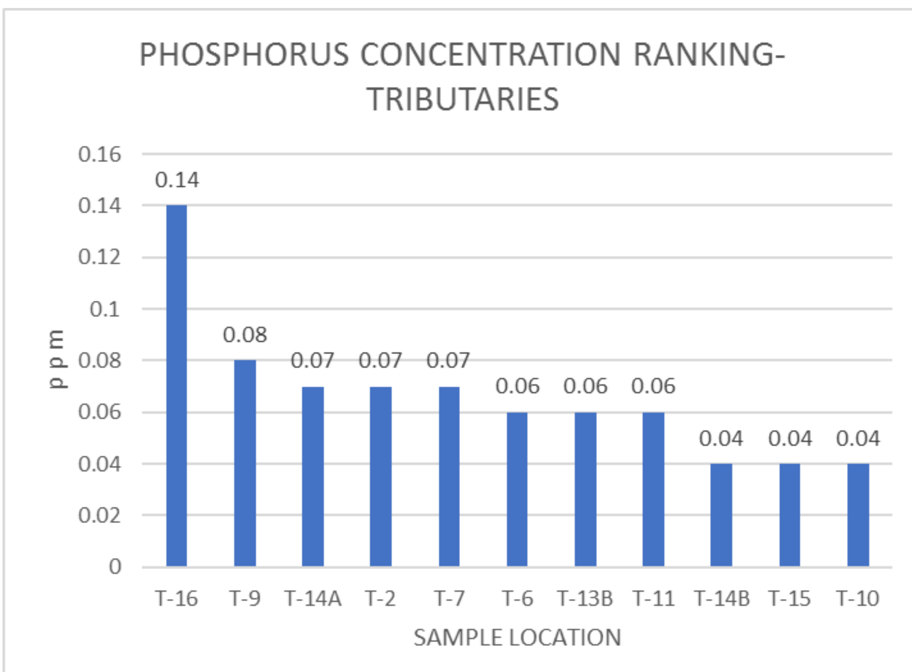
Tributary Concentration Forced Ranking

In addition to the three priority parameters, the concentration ranked graphs for Dissolved Oxygen and Turbidity are included for additional general information, but they were not directly used in the forced ranking approach.

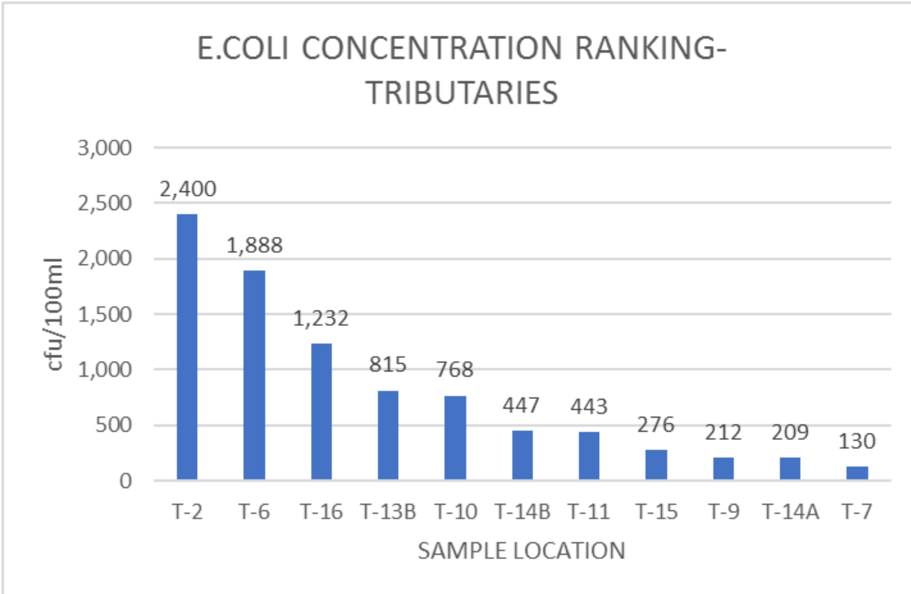
NITRATE CONCENTRATION FORCED RANKING – TRIBUTARIES



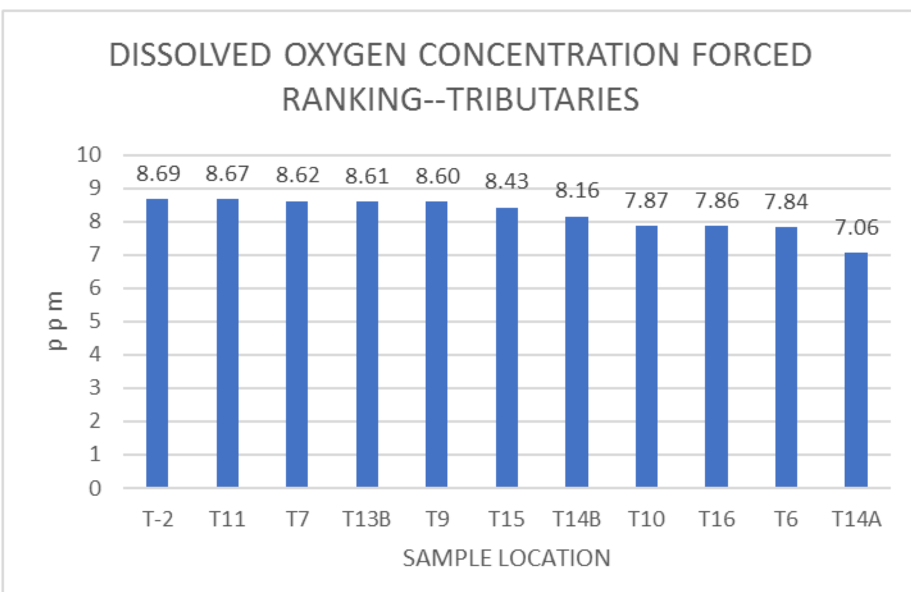
PHOSPHORUS CONCENTRATION FORCED RANKING – TRIBUTARIES



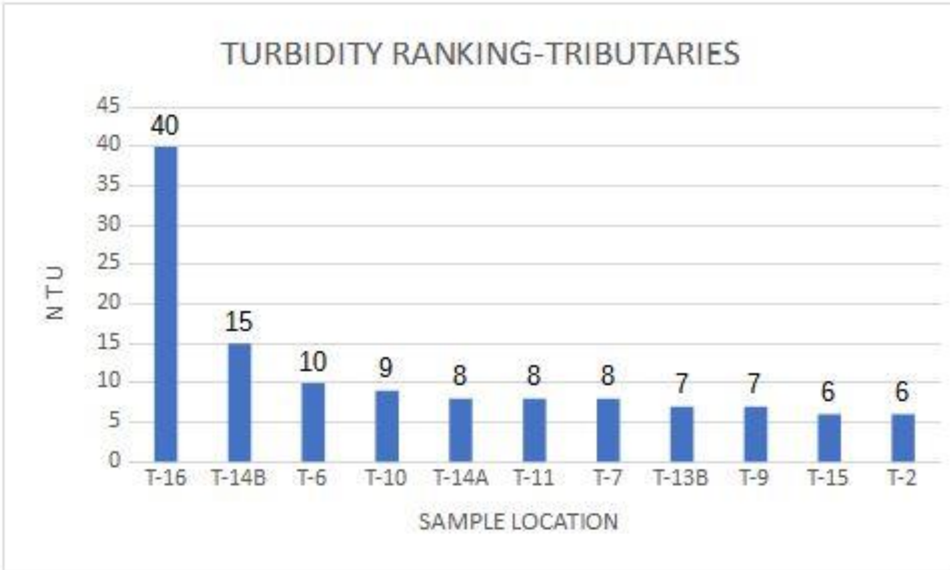
E.COLI CONCENTRATION FORCED RANKING – TRIBUTARIES



DISSOLVED OXYGEN CONCENTRATION FORCED RANKING – TRIBUTARIES



TURBIDITY FORCED RANKING – TRIBUTARIES



NOTE: T-16 actual average is 192 NTU. 40 NTU is only used as a surrogate for graphing purposes.

Tributary Concentration Parameter Ranking Summary

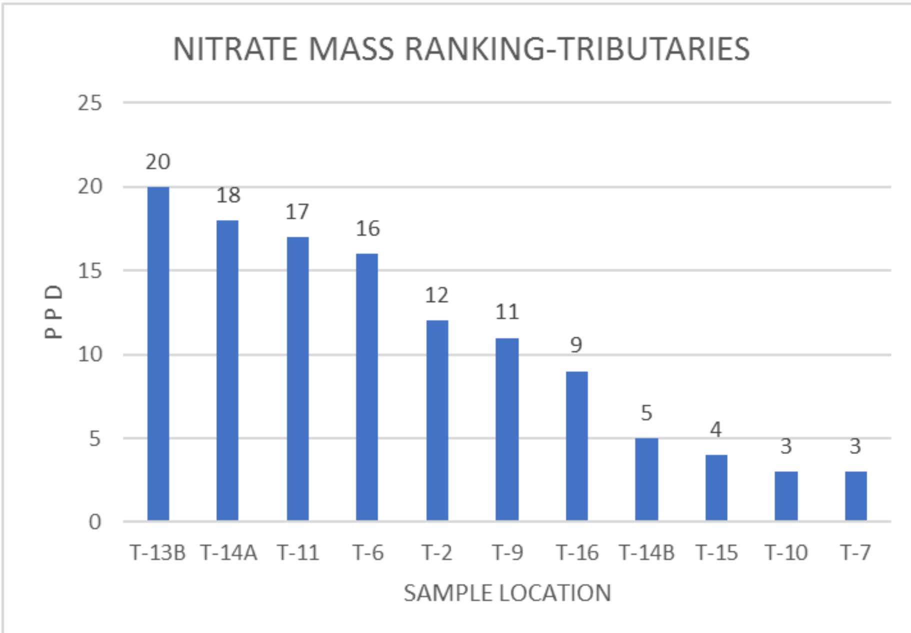
Addition of the concentration ranking points for each water quality parameter at each sample location results in forced ranking position of 1-11 for each sample location as shown on page 6 of this Section.

A higher ranking points number has a higher parameter concentration in the following table, resulting in overall Forced Rank (positions 1-11) at the left. This effectively reverses the numbering order in the Summed Ranking Points column, **so No. 1 Forced Rank is the top priority overall for tributary concentration follow-up and action.** The Parameter Ranking Points identify relative concentration priorities at each sample location. If the Summed Ranking Points resulted in the same value, the tributary with the higher E.Coli ranking points received the higher Forced Rank.

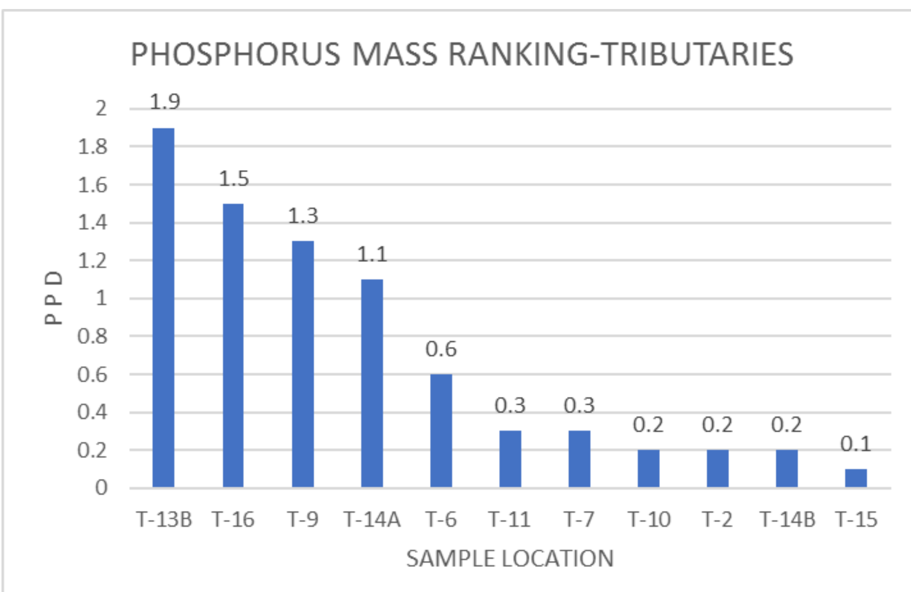
Tributary Concentration Ranking Summary					
Forced Rank	**Sample Location**	**Parameter Ranking Points**			**Summed Ranking Points**
		Nitrate	**Phosphorus**	**E.Coli**	
1	T-2	10	8	10	28
2	T-6	7	5	9	21
3	T-16	3	10	8	21
4	T-11	9	5	5	19
5	T-14A	5	8	2	15
6	T-13B	1	5	7	13
7	T-14B	6	2	5	13
8	T-15	8	2	3	13
9	T-9	2	9	2	13
10	T-7	4	8	0	12
11	T-10	0	2	6	8

Tributary Mass Forced Ranking

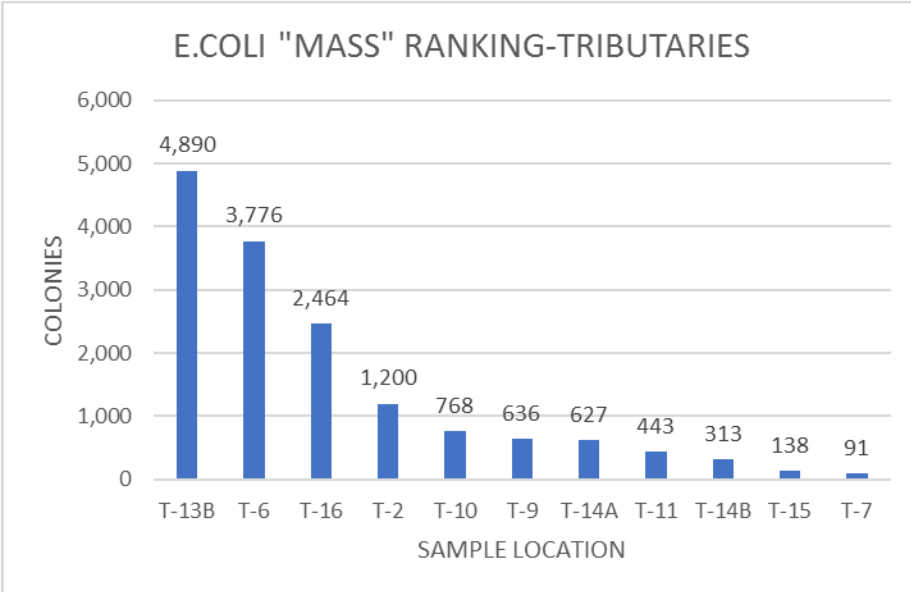
NITRATE MASS FORCED RANKING – TRIBUTARIES



PHOSPHORUS MASS FORCED RANKING – TRIBUTARIES



E.COLI "MASS" FORCED RANKING – TRIBUTARIES



Tributary Mass Parameter Ranking Summary

Addition of the mass ranking points for each water quality parameter at each sample location results in forced ranking of position 1-11 for each sample location as shown on page 10 of this Section.

A higher ranking points number has a higher parameter mass in the following table, resulting in overall Forced Rank (positions 1-11) at the left. This effectively reverses the numbering order in the Summed Ranking Points column, **so No. 1 Forced Rank is the top priority overall for tributary mass follow-up and action.** The Parameter Ranking Points identify relative mass priorities at each sample location. If the Summed Ranking Points resulted in the same value, the tributary with the higher E.Coli ranking points received the higher Forced Rank.

Tributary Mass Ranking Summary					
Forced Rank	**Sample Location**	**Parameter Ranking Points**			**Summed Ranking Points**
		Nitrate	**Phosphorus**	**E.Coli**	
1	T-13B	10	10	10	30
2	T-6	7	6	9	22
3	T-16	4	9	8	21
4	T-14A	9	7	5	21
5	T-9	5	8	5	18
6	T-2	6	3	7	16
7	T-11	8	5	3	16
8	T-10	1	3	6	10
9	T-14B	3	3	2	8
10	T-7	1	5	0	6
11	T-15	2	0	1	3

Tributary Overall Ranking – Concentration + Mass

The concentration Summed Ranking Points (from the Tributary Concentration Ranking Summary table, page 6 this Section) are added to the mass Summed Ranking Points (from the Tributary Mass Ranking Summary table, immediately preceding), which results in a summation of points as listed below. The Summed Ranking Points for each sample location provides combined and final forced ranking (positions 1-11) which are shown and noted in the Tributary Prioritized Sub-watersheds section (see following page).

Tributary Summation Ranking - Concentration + Mass			
Sample Location	**Concentration Ranking Points**	**Mass Ranking Points**	**Summed Ranking Points**
T-16	21	21	42
T-2	28	16	44
T-6	21	22	43
T-15	13	3	16
T-11	19	16	35
T-14A	15	21	36
T-13B	13	30	43
T-9	13	18	31
T-14B	13	8	21
T-10	8	10	18
T-7	12	6	18

Tributary Prioritized Sub-watersheds

The Bat Creek Tributary Sub-watersheds are shown in a forced ranked, prioritized order for further investigation and implementation of nonpoint source water quality improvement projects. See Map 6 for orientation. If the Summed Ranking Points resulted in the same value, the tributary with the higher Mass Ranking Points received the higher Forced Rank for Action and Prioritization.

Tributary Prioritized Sub-watersheds			
Forced Rank For Action	Sub-watershed	Description	Summed Ranking Points
1	T-2	Trib. near Lakeside Drive	44
2	T-13B	Craighead Creek at Brunner Rd	43
3	T-6	Bulging Branch at Old Loudon Rd	43
4	T-16	Old Highway 68 near Wilson Rd	42
5	T-14A	Old Highway 68 at Hiwassee Rd	36
6	T-11	Red Ankle at Williams Rd	35
7	T-9	Red Branch at Anderson Rd	31
8	T-14B	Trib. at Park Street	21
9	T-10	Short Bank Rd near Hiwassee Rd	18
10	T-7	Trib. along Acorn Gap Rd	18
11	T-15	Trib. at Hendrix Loop Rd	16

SECTION 9 – PRIORITIZATION ANALYSIS OF MAIN STEM WATER QUALITY

General

The three primary pollutants investigated in this water quality study are Nitrate (Nitrite + Nitrate), Phosphorus and E.Coli. Tributary water quality information is based on the nonpoint source pollution contributed by only the sampled tributary sub-watersheds, which total about 7,860 acres or 47% of the total Bat Creek Watershed.

The total of areas that were not sampled via tributary sample locations is about 8,980 acres or 53% of the total Bat Creek Watershed. The unsampled areas are: (1) areas that drain directly into the main stem (overland flow), (2) areas that are unsampled lower portions of tributaries, and (3) areas that drain via small tributaries into Bat Creek.

This second area of 8,980 acres (the focus of this Section 9) is larger than the total area of sampled tributaries, but water quality differences cannot be measured as easily or discretely. Parameters are addressed below, individually and in combination, over the full length of the main stem of Bat Creek to document how individual sub-watershed segments (between two stem sample locations) impact water quality prior to the combined flow entering Tellico Lake.

Mass loadings at the various sample locations along Bat Creek are more complex to comprehend than individual tributary sub-watersheds. The following interpretative analyses combined with empirical engineering judgment:

(1) describe how the tributaries and the main stem of Bat Creek interact from a broader perspective of the major pollutants in the Bat Creek Watershed and

(2) provide an assessment of relative significance (priority) of sub-watershed stem segments as targets of opportunity for potential corrective actions.

The following discussion focuses on changes in average mass loading between various sample locations along the stem of Bat Creek, considering intermediate contributions from tributaries. The accompanying mass graphs, integrating all stem and tributary sample locations, are the source of most observations and interpretations in this section.

Nitrate Mass

The average sum of Nitrate mass (measured as nitrogen) at T-16, T-14A and T14B was approximately equal to the amount measured at B-13 downstream of the Madisonville WWTP. TKN analysis (presented near the end of Section 5) shows that the amount of nitrogen discharged by the WWTP appears to be a contributing source to the watershed. Ammonia (measured as nitrogen) found in the WWTP effluent appeared to oxidize and convert to Nitrate as it traveled downstream. Thus, it was Nitrate which was sampled and analyzed. The operation of the new WWTP, which is under construction, is expected to further reduce the amount of Nitrate discharged into Bat Creek.

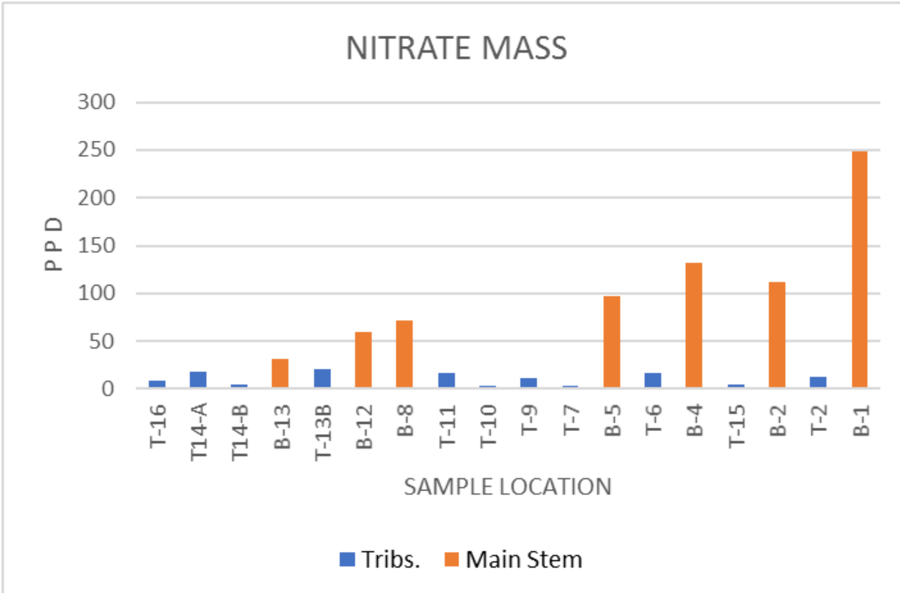
The mass doubled between Sample Locations B-13 and B-12, with the upper reaches of Craighead Creek and the large area of the B-12 watershed in agricultural use contributing to that amount.

In the five miles between B-8 and B-4 the Nitrate mass doubled again, with only half that amount attributable to the five tributaries that were sampled within that distance. The balance probably entered the main stem as direct runoff from adjacent crop land and cattle grazing activities. Ammonia, from whatever sources including animal waste, would naturally be converted to Nitrate as oxygen is introduced from vegetation or small rapids along the creek.

A 20% reduction in Nitrate mass occurred in the 2.5 mile section between B-4 and B-2, possibly attributable to vegetative uptake, flow measurement inaccuracies or other reasons.

In the short distance between B-2 and B-1, and from that small drainage area (only 4% of the Bat Creek watershed), the Nitrate nitrogen load increased from about 120 to 290 PPD (annually 53 tons of nitrogen entering Tellico Lake). That area of farming and much cattle grazing presents the opportunity for detailed follow-up investigation to understand the impacts of current agricultural practices.

NITRATE MASS – WATERSHED



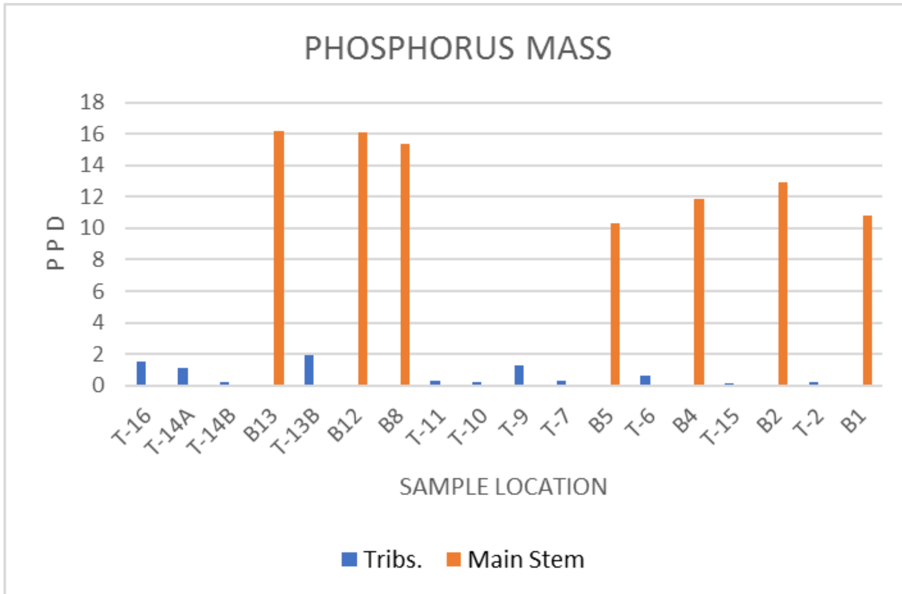
Phosphorus Mass

Sample Location B-13, downstream of the City of Madisonville's WWTP, recorded the highest mass of Phosphorus in the Bat Creek Watershed. Phosphorus is attributable to the built-up and occupied areas of the City in general, but most likely directly from the WWTP effluent discharge. See WWTP Phosphorus discussion in Section 5.

The Phosphorus load decreased about 30% over the length of the watershed, probably due to vegetative uptake, but also from potential sequestering by sediments in the creek. Phosphorus mass in the lower reaches of Bat Creek (six miles from B-5 to B-1) averaged 10-11 PPD.

It is expected that Phosphorus reductions in the effluent from Madisonville's new WWTP should further reduce the current loading, effecting a positive reduction in aquatic vegetative growth during the growing season in Bat Creek. The reduction of vegetative growth may reduce the very high dissolved oxygen concentrations which were encountered during the field sampling program.

PHOSPHORUS MASS – WATERSHED



E.Coli "Mass"

The primary areas contributing E.Coli within the Bat Creek Watershed were found to be the lower reaches below B-5 (nearly 75% of the load from 30% of the watershed area) and the upper reaches above B-12 (nearly 25% of the load from 40% of the watershed area). Therefore, there was little contribution from the middle 30% of the watershed area. The following discussion reviews the creek stem from upstream segment to downstream confluence with Tellico Lake.

For purposes of comparative analysis in this report, E.Coli "mass" is the product of multiplying flow rate (cfs) times colony count (CFU/100 ml) creating a "colonies" surrogate for true mass rate (normally expressed in PPD).

Apparent primary E.Coli contributions upstream of B-13 are:

(1) from suburban small recreational farms ("farmettes") and associated livestock activities upstream of T-16 (south of Old Hwy 68),

(2) similar land uses north of Old Hwy 68, and

(3) from Madisonville's WWTP operations that discharge into the creek.

At B-12 the measured average load was nearly double that at B-13; with a large amount of that coming from:

(1) above T-13B, the north branch of Craighead Creek,

(2) the south branch of Craighead Creek, and

(3) the area east of Hiwassee Road draining into the main stem of Bat Creek.

Observed land use above B-12 was a mix of suburban (farmettes) agriculture and livestock activities and larger scale farming and livestock operations.

Prior to the November 2016 sampling event, which followed a one-inch rainfall, only three times was the E.Coli concentration upper detection limit of 2400 CFU/100 ml exceeded at or above station B-12. That occurred once in May at T-13B and twice at T-16 in June and July. November concentration levels at or above 2000 CFU/100 ml were measured at T-14B, B-13, T-13B and B-12.

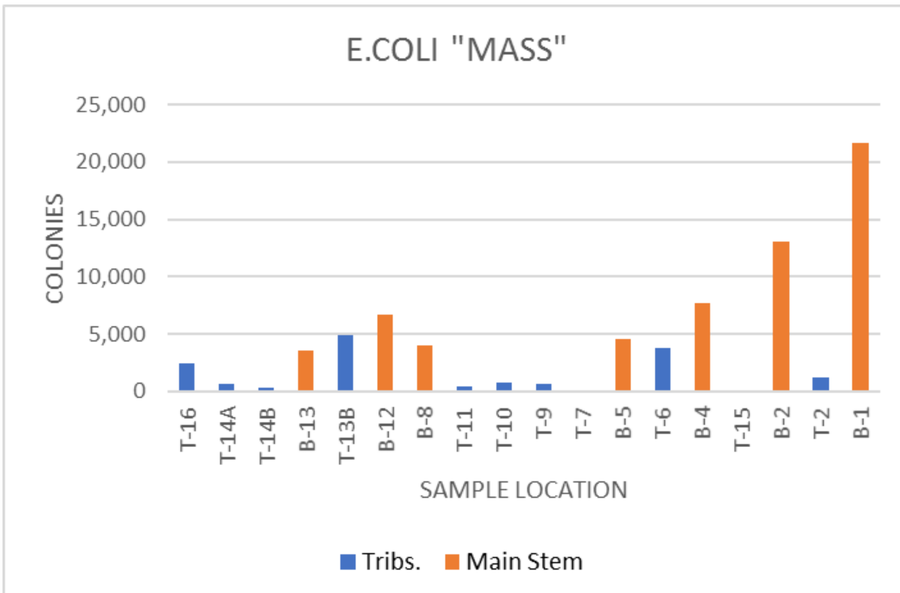
In the three mile middle reach of the creek between locations B-12 and B-5, none of the 12 samples from B-8 and B-5 exceeded 440 CFU/100 ml (although no samples were taken there in November). This section of the watershed appears to be of lower priority for corrective action.

The situation between Sample Locations B-5 and B-1 is entirely different. The three tributaries sampled in that six mile reach each had concentrations exceeding 2400 CFU/100 ml. At T-6, Bulging Branch, four of seven samples were at or above 2000 CFU/100 ml concentration. The average E.Coli "mass" loading of 3,776 colonies from the T-6 sub-watershed put that in a virtual tie for highest E.Coli tributary loading with tributaries T-16 and T-13B in the upper portion of the Bat Creek Watershed.

Review of the entire data set for E.Coli shows that there is a tremendous increase in E.Coli "mass" of about 6,000 colonies between B-4 and B-2, and again between B-2 and B-1. This indicates that most of that "mass" is entering Bat Creek by direct runoff from nearby cattle grazing or the presence of cattle in the creek (which was observed on a number of occasions at different locations in these lower reaches of Bat Creek below B-5).

The most downstream segment of Bat Creek and the Bat Creek embayment of Tellico Lake are routinely used for water contact recreation activities. The Tennessee standard for recreational water uses requires a geometric mean E.Coli concentration below 126 CFU/100 ml. (See Nomenclature table for definition of geometric mean.) This segment of Bat Creek as it flows into Tellico Lake has the highest E.Coli "mass" of all main stem segments, and the E.Coli concentration significantly exceeds the recreational use limit.

E.COLI "MASS" – WATERSHED



Summary

Nitrate mass is of major concern along the main stem of Bat Creek, beginning between Sample Locations B-13 and B-12 where it first doubles (~30 PPD increase). Then the Nitrate mass nearly doubles again between B-8 and B-4 (~60 PPD increase); and nearly doubles again between B-2 and B-1 (~120 PPD increase).

Phosphorus mass mainly enters Bat Creek from the Madisonville WWTP and decreases as the creek flows toward Tellico Lake. The other potential sources are minor by comparison.

E.Coli is the major pollutant within the Bat Creek Watershed, which includes direct non-tributary inputs along the main stem of Bat Creek. E.Coli "mass" is of some concern in the upper segment of the watershed above B-13; but it is of much more concern in the lower stem segments below B-5, where there were very low contributions from tributaries that were sampled. An obvious interpretation is that the problem could be surface runoff directly into the main stem or cattle in the creek, or both. E.Coli “mass” nearly tripled between locations B-4 and B-1, immediately before Bat Creek enters Tellico Lake near Hwy 72.

Overall, the focus for reducing nonpoint source pollution (from Nitrates and E.Coli) along the main stem of Bat Creek should be primarily in the lower reaches of the watershed (below B-5), and secondarily in the upper reaches (above and below B-13) for all three pollutants.

Prioritization of Main Stem Sub-watershed Segments

From mass loading information summarized above in this section of the report, the following is a prioritized list of Bat Creek main stem segments for further investigation and implementation of nonpoint source water quality improvement projects. Sub-watersheds of the high priority segments are shown in Map 7.

Priority Order	Stem Segment	Parameter Rationale
1	B-2 to B-1	High Nitrate and high E.Coli
2	B-4 to B-2	High E.Coli
3	B-5 to B-4	High Nitrate and moderate E.Coli
4	Above B-13	Moderate loadings of all three parameters
5	B-13 to B-12	Moderate Nitrate and E.Coli

SECTION 10 – FINDINGS AND RECOMMENDATIONS

General

This report identifies and ranks the types of pollutants in sampled tributaries and in segments of the Bat Creek main stem. There is now sufficient data available to define focused projects to further understand issues related to specific parameters and source areas, as well as to apply appropriate measures to reduce existing nonpoint source pollution in the identified sub-watersheds of Bat Creek.

The "pseudo mass balance" method utilized to move beyond "concentration only" perspectives did yield useful information to better assess the water quality situation throughout the Bat Creek Watershed. While the method was imprecise, results were directionally functional and helpful to produce the prioritization results herein.

There is much more to learn in identifying problem issues and areas due to the SEP team's limited access to major sectors of the watershed. Significant differences in parameters between main stem sections of Bat Creek should provide the rationale for continued efforts to assess land uses and identify areas of opportunity to reduce pollutant loadings.

This report, with data presented in tables, graphs, maps and lists, is structured to provide basis and direction for taking priority-based actions.

Unusual drought conditions during 2016 probably did not represent typical concentrations or mass loading conditions which, with more normal rainfall, may be worse than those recorded here.

There is limited evidence of agriculture BMPs in place throughout the watershed. Greater use of BMPs will certainly improve water quality.

Pollutant-Specific Findings

The information that follows is presented in priority order of importance based on the interpretive engineering judgment of the project team.

E.Coli

The major pollutant of concern in the Bat Creek Watershed is E.Coli. Based on specialized laboratory gene speciation analysis, the apparent sources of E.Coli are not human but are animal.

Four samples for speciation were taken on one occasion from three major tributaries with high E.Coli results and from main stem location B-2 (Hendrix Loop) in lower Bat Creek. Test results of all samples were very similar, with levels reported below or slightly above lower reporting limits for ruminant species and below the lower reporting limit for human markers. While these limited results are not definitive, they do indicate that the focus of future efforts should be with BMPs for cattle, and perhaps goats and sheep, rather than problems from poorly functioning septic tank systems.

Levels of E.Coli exceeding the Tennessee water quality standard of 126 CFU/100 ml for recreation uses were recorded in all main stem and tributary sub-watersheds; and in many tributaries the levels exceeded the maximum detection limit of 2,400 CFU/100 ml with varying frequencies. E.Coli “mass” tripled in the last few miles immediately before Bat Creek enters Tellico Lake. High levels of E.Coli in the lowest reach of Bat Creek, above location B-1, are of concern since people use the embayment (Tellico Lake at “summer pool”) both above and below this location for recreation and fishing.

Nitrate

Nitrate (nitrogen) at high levels is of concern throughout the Bat Creek Watershed. It is considered a major pollutant; and the mass loading increased substantially as the creek flows toward Tellico Lake, just the opposite of Phosphorus. By far the greatest source of Nitrate in the watershed was the B-2 to B-1 segment, where the Nitrate load more than doubled in this lowest reach of the creek. Nitrate is present in relatively greater quantities than its companion nutrient Phosphorus.

Among tributaries, the most upstream tributaries of the watershed in more developed agricultural areas had the largest mass loadings of Nitrate, but at levels less than 10% of the total load at B-1. The prominent sources of Nitrate are most likely agricultural operations, from fertilizer and animal waste, as well as decaying vegetative matter, especially in the heavily wooded Bat Creek Knobs areas north of Bat Creek. The Madisonville WWTP has been a significant source of Nitrogen, which should be reduced when the new WWTP is operational.

Phosphorus

Phosphorus was present at nominal levels but decreased as Bat Creek flows toward Tellico Lake, probably due to vegetative uptake, but also from potential sequestering by sediments in the creek. The upper tributaries of Bat Creek had greater loadings of Phosphorous than the lower tributaries of the watershed, just the opposite of Nitrate. There was a spike in Phosphorus at Sample Location B-13, which is downstream of Madisonville's WWTP, which currently appears to be the major source of Phosphorus in Bat Creek. The new Madisonville WWTP should substantially reduce Phosphorus levels in Bat Creek.

Turbidity

Turbidity (suspended material) was very high only in one sub-watershed (T-16). Turbidity generally increased along the main stem of Bat Creek toward Tellico Lake. The range of averaged Turbidity samples below B-8 was 7-38 NTU. The increased Turbidity levels are of concern due to potential negative effects on aquatic and benthic organisms in Bat Creek waters as well as in the nearby embayment. Sample Location B-2 had the highest Turbidity amounts during the sampling period. Elevated Turbidity levels after a rainfall event are expected; however, implementation of agriculture BMPs to reduce E.Coli should also reduce Turbidity.

Dissolved Oxygen

Dissolved Oxygen average concentrations were above 7.0 ppm and are not of concern in spite of the nonpoint sources of pollution entering the creek. There appears to be effective natural re-aeration of the creek via small rapids along the length of the main stem of the creek as well as in many tributaries.

pH

The physical characteristic pH was measured at all sampling points throughout the watershed. The pH values were well within the expected normal range given the geology and soils in the area.

Prioritized Areas of Bat Creek Watershed

Tributaries

The focus for reducing nonpoint source pollution in the Bat Creek tributary watersheds should be directed above (upstream of) the sample locations cited for tributary sub-watersheds, as detailed in Sections 6 and 8 of this report. The tributary sub-watersheds of greatest concern are summarized below in descending priority order. The high priority sub-watersheds are shown in Map 7. See Tributary Parameter Ranking Points (listed in the Tributary Mass Ranking Summary table near the end of Section 8) to identify the pollutants of highest concern in each of these individual watersheds.

Sub-watershed	Location
High Priority	
T-2	Tributary near Lakeside Road
T-13B	Craighead Creek at Brunner Road
T-6	Bulging Branch at Old Loudon Road
T-16	Old Highway 68 near Wilson Road
Moderate Priority	
T-14A	Old Highway 68 at Hiwassee Road
T-11	Red Ankle at Williams Road
T-9	Red Branch at Anderson Road

Main Stem

The focus for reducing nonpoint source pollution along the main stem of Bat Creek should be in the lower reaches (below B-5) of the watershed, and secondarily in the upper reaches (above and below B-13) as detailed in Sections 7 and 9 of this report. The main stem segments of greatest concern are summarized below in descending priority order. Sub-watersheds of the high priority segments are shown in Map 7. See the end of Section 9 for the pollutant parameter rationale for listing these main stem segments in this priority order.

Stem Segment	Description
High Priority	
B-2 to B-1	Far eastern part of the watershed between Farnsworth Road, Highway 72, and Summit Road
B-4 to B-2	Most northern part of the watershed; mainly north of Sweetwater Vonore Road (Highway 322)
B-5 to B-4	North central part of the watershed between the Bat Creek Knobs and Oak Grove Road
Moderate Priority	
Above B-13	West of Hiwassee Road; central and northeast Madisonville
B-13 to B-12	All of Craighead Creek; south of the airport; south of Hiawassee College

Recommendations

The following recommendations emphasize both (a) implementing BMPs in identified high priority areas and (b) conducting more sampling and analyses to further define additional sources of nonpoint source pollution in other sectors of the Bat Creek Watershed.

1. Identify a local sponsor (such as the Monroe County Soil Conservation District, the local NRCS office, UT Agriculture Extension Service, or other motivated organizations) to embrace the results of this study, assume a leadership role moving forward, seek external funding from available sources, and assist local farmers to implement BMPs more cost effectively.
2. The local sponsor can partner with other similar regional agencies (e.g., in Blount or McMinn Counties) to learn from their experiences about the financial benefits and incentives to the agriculture community of using BMPs that reduce nonpoint source pollution.
3. Implement agriculture BMPs within the Bat Creek Watershed at those areas identified in the Findings portion of this Section 10. This includes identified high priority segments of the main stem of Bat Creek and the high priority

tributary sub-watersheds. Opportunities exist to reduce levels of Nitrate, Phosphorus and E.Coli pollutants in areas documented herein.

4. Assess the nonpoint source pollution potential in areas of the watershed to which the SEP team had no access or limited data (e.g., T-14A and T-2); then factor that assessment into overall priorities for BMP initiatives.
5. Continue a nonpoint source water quality sampling program after the new Madisonville WWTP becomes operational to:

    (a) understand the characteristics of the Bat Creek Watershed in years of average rainfall and where access was not available,
    b) provide additional data to local agencies in support of agriculture BMPs throughout the watershed, and
    (c) monitor water quality improvements in the watershed to confirm the effectiveness of operational BMPs.
6. Continue other educational and implementation support activities to abate nonpoint source pollution in the Bat Creek Watershed.
7. Enter the water quality data from this study into the TDEC Tellico Reservoir database to assist in future delisting of portions of the Bat Creek Watershed from the 303(d) list of impaired streams.
8. Conduct in-stream benthic observations to assess the impact of current Turbidity levels in the Bat Creek ecosystem.
9. Remove debris from road culverts, both ends and internally, to reduce the flooding that was commonplace upstream of culverts when significant rainfall events occurred.

SUPPLEMENTAL INFORMATION

SUPPLEMENT A – NITRITE CONCENTRATION DATA (ppm as nitrogen (N))

SUPPLEMENT B – NITRATE CONCENTRATION DATA (ppm as nitrogen (N))

SUPPLEMENT C – TKN CONCENTRATION DATA (ppm)

SUPPLEMENT D – PHOSPHORUS CONCENTRATION DATA (ppm as total Phosphorus (P))

SUPPLEMENT E – E.COLI CONCENTRATION DATA (CFU/100ml)

SUPPLEMENT F – DISSOLVED OXYGEN CONCENTRATION DATA (ppm)

SUPPLEMENT G – TURBIDITY DATA (NTU)

SUPPLEMENT H – pH DATA

SUPPLEMENT I – FLOW DATA (cfs)

SUPPLEMENT J – RAINFALL DATA (inches)

SUPPLEMENT K – MADISONVILLE WWTP EFFLUENT DATA

GENERAL NOTES:

1-xxx indicates no sample was collected and analyzed

2-ND indicates that the analyzed sample was below the Reliable Detection Limit (RL)

SUPPLEMENT A- NITRITE CONCENTRATION DATA (ppm as Nitrogen)

	NITRITE mg/l (ppm)							
SITE	2016 APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
B-1	ND	ND	xxx	xxx	xxx	ND	xxx	xxx
T-2	ND	xxx	xxx	xxx	xxx	xxx	xxx	xxx
B-2	xxx	ND	xxx	xxx	xxx	ND	xxx	xxx
T-15	xxx	ND	xxx	xxx	xxx	xxx	xxx	xxx
B-4	xxx	ND	xxx	xxx	ND	ND	xxx	xxx
T-6	xxx	ND	xxx	xxx	xxx	ND	xxx	xxx
B-5	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
T-7	xxx	ND	xxx	xxx	xxx	xxx	xxx	xxx
T-9	xxx	ND	xxx	xxx	xxx	xxx	xxx	xxx
T-10	xxx	ND	xxx	xxx	xxx	xxx	xxx	xxx
T-11	xxx	ND	xxx	xxx	xxx	ND	xxx	xxx
B-8	xxx	ND	xxx	xxx	xxx	ND	xxx	xxx
T-13B	xxx	ND	xxx	xxx	xxx	ND	xxx	xxx
B-12	xxx	ND	xxx	xxx	xxx	ND	xxx	xxx
B-13	xxx	ND	xxx	xxx	xxx	ND	xxx	xxx
T-14A	xxx	ND	xxx	xxx	xxx	xxx	xxx	xxx
T-14B	xxx	ND	xxx	xxx	xxx	xxx	xxx	xxx
B-15	xxx	ND	xxx	xxx	xxx	xxx	xxx	xxx

NOTE: 1- Microbac Laboratories data

SUPPLEMENT B- NITRATE CONCENTRATION DATA (ppm as Nitrogen (N))

SITE	2016 APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	SUM	AVERAGE ppm	FLOW cfs	PPD	Site
B-1	1.08	1.15	1.05	6.88	xxx	0.28	xxx	0.68	11.12	1.85	25	249	**B-1**
T-2	1.43	xxx	xxx	xxx	xxx	xxx	xxx	7.23	8.66	4.33	0.5	12	**T-2**
B-2	xxx	1.11	1.13*	0.95	0.85	0.72	0.67*	0.64	6.07	0.87	24	112	**B-2**
T-15	xxx	1.62	1.88	1.64	1.51	xxx	xxx	xxx	6.65	1.66	0.5	4	**T-15**
B-4	xxx	1.17*	1.07	1.08	0.83	0.82	3.01	0.57	8.55	1.22	20	132	**B-4**
T-6	xxx	1.86	1.72	1.69	0.98	1.35	1.29	xxx	8.89	1.48	2	16	**T-6**
B-5	xxx	xxx	1.03	0.95	0.80	xxx	2.18	0.64	5.60	1.12	16	97	**B-5**
T-7	xxx	0.89	1.16	0.96	0.78	xxx	0.68	xxx	4.47	0.89	0.7	3	**T-7**
T-9	xxx	0.51	0.52	0.60	1.37	xxx	0.47	xxx	3.47	0.69	3	11	**T-9**
T-10	xxx	0.46	0.39	xxx	xxx	xxx	xxx	xxx	0.85	0.43	1	3	**T-10**
T-11	xxx	3.50	3.36	3.52	3.29	3.58	3.23	2.00	22.48	3.21	1	17	**T-11**
B-8	xxx	1.19	0.90	0.96	0.61	0.85	0.79	xxx	5.30	0.88	15	71	**B-8**
T13B	xxx	0.58	0.58	0.98	*0.48	0.65	0.50	xxx	3.77	0.63	6	20	**T13B**
B-12	xxx	1.22	0.92	0.83	0.68	0.82	0.68	xxx	5.15	0.86	13	60	**B-12**
B-13	xxx	1.84	0.84	0.62	0.78	0.77	0.69	1.49	7.03	1.00	6	32	**B-13**
T-14A	xxx	1.09	1.16	xxx	1.06	xxx	xxx	xxx	3.31	1.10	3	18	**T-14A**
T-14B	xxx	1.41	1.17	1.26	0.97	xxx	1.23	xxx	6.04	1.21	0.7	5	**T-14B**
T-16	xxx	0.85	0.98	0.74	xxx	xxx	xxx	xxx	2.57	0.86	2	9	**T-16**

NOTES:

1-* Average of two samples

RL is 0.56, 50% of RL used which is 0.28 ppm

2- Conversion factor (F) of 5.39 is used to calculate PPD in the formula (ppm) x (cfs) x factor (F) = PPD (mass)

3- Microbac Laboratories data

SUPPLEMENT C- TKN CONCENTRATION (ppm)

SITE	AUG ppm	SEP ppm	OCT ppm	NOV ppm
T13B	xxx	ND	ND	xxx
B-12	0.26	xxx	0.49	0.54
B-13	0.41	xxx	0.97	1.55
T-14A	xxx	xxx	xxx	xxx
T-14B	xxx	xxx	ND	xxx
B15	xxx	xxx	xxx	xxx
T-15A	xxx	xxx	xxx	xxx
B-2	0.32	xxx	0.30	xxx
B-8	0.29	xxx	0.36	xxx
B-4	0.25	xxx	xxx	xxx
B-5	0.25	xxx	0.81	0.27
T-11	xxx	0.32	0.39	xxx
T-6	xxx	xxx	0.41	xxx

NOTE: 1- Microbac Laboratories data

SUPPLEMENT D- PHOSPHORUS CONCENTRATION DATA (ppm as total Phosphorus (P))

SITE	2016 APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	AVERAGE ppm	FLOW cfs	MASS PPD	SITE
B-1	0.04	0.09	0.15	0.10	xxx	xxx	xxx	0.04	0.08	25	10.8	**B-1**
T-2	0.04	xxx	xxx	xxx	xxx	xxx	xxx	0.09	0.07	0.5	0.2	**T-2**
B-2	xxx	0.10	0.11	0.10	xxx	xxx	0.10	0.11	0.10	24	12.9	**B-2**
T-15	xxx	0.04	0.04	0.04	xxx	xxx	xxx	0.04	0.04	0.5	0.1	**T-15**
B-4	xxx	0.09	0.11	0.11	xxx	xxx	0.12	0.13	0.11	20	11.9	**B-4**
T-6	xxx	0.04	0.08	0.04	xxx	xxx	0.04	0.13	0.06	2	0.6	**T-6**
B-5	xxx	0.04	0.13	0.11	xxx	xxx	0.14	0.17	0.12	16	10.3	**B-5**
T-7	xxx	0.04	0.04	0.04	xxx	xxx	0.04	0.18	0.07	0.7	0.3	**T-7**
T-9	xxx	0.04	0.04	0.09	xxx	xxx	0.10	0.14	0.08	3	1.3	**T-9**
T-10	xxx	0.04	0.04	0.04	xxx	xxx	xxx	0.04	0.04	1	0.2	**T-10**
T-11	xxx	0.04	0.04	0.04	xxx	xxx	0.04	0.12	0.06	1	0.3	**T-11**
B-8	xxx	0.12	0.14	0.16	xxx	xxx	0.25	0.30	0.19	15	15.4	**B-8**
T-13B	xxx	0.04	0.04	0.04	xxx	xxx	0.04	0.13	0.06	6	1.9	**T-13B**
B-12	xxx	0.14	0.15	0.16	xxx	xxx	0.26	0.42	0.23	13	16.1	**B-12**
B-13	xxx	0.28	0.30	0.37	xxx	xxx	0.59	0.95	0.50	6	16.2	**B-13**
T-14A	xxx	0.04	0.04	0.04	xxx	xxx	xxx	0.21	0.07	3	1.1	**T-14A**
T-14B	xxx	0.04	0.04	0.04	xxx	xxx	0.04	0.04	0.04	0.7	0.2	**T-14B**
T-16	xxx	0.04	0.17	0.11	xxx	xxx	xxx	0.23	0.14	2	1.5	**T-16**

NOTES:

1- 0.04 ppm is used as a surrogate for not detectable (ND) which is 50% of the Reliable Detection (RL) for Microbac Laboratories

2- Conversion factor (F) of 5.39 is used to calculate PPD in the formula (ppm) x (cfs) x factor (F) = PPD (mass)

3- Microbac Laboratories data

SUPPLEMENT E- E.COLI CONCENTRATION DATA (CFU/100ml)

E.COLI

SITE	2016 APR 18	APR 26	MAY	JUN	JUL	AUG	SEP	OCT	NOV	GEO. MEAN CFU/100ml	FLOW c f s	"MASS" colonies
B-1	690	870	870	580	870	730	250	>2400	>2400	867	25	21,675
T-2	>2400	>2400	xxx	xxx	xxx	xxx	xxx	xxx	>2400	2,400	0.5	1,200
B-2	xxx	xxx	460	465*	460	770	390	895*	xxx	546	24	13,104
T-15	xxx	xxx	310	110	1400	>2400	xxx	xxx	14	276	0.5	138
B-4	xxx	xxx	370	520	240	180	650	100	2400	387	20	7,740
T-6	xxx	xxx	>2400	1700	1300	2000	>2400	1400	>2400	1,888	2	3,776
B-5	xxx	xxx	xxx	290	440	330	xxx	160	xxx	286	16	4,576
T-7	xxx	xxx	96	190	220	70	xxx	130	xxx	130	0.7	91
T-9	xxx	xxx	260	130	580	170	xxx	130	xxx	212	3	636
T-10	xxx	xxx	650	290	xxx	xxx	xxx	xxx	2400	768	1	768
T-11	xxx	xxx	310	520	140	170	520*	1200	1400	443	1	443
B-8	xxx	xxx	290	300	330	230	150	340	xxx	264	15	3,960
T-13B	xxx	xxx	>2400	1100	170	950*	1300	180	2400	815	6	4,890
B-12	xxx	xxx	460	330	340	390	250	820	>2400	517	13	6,721
B-13	xxx	xxx	1100	650	770	150	410	290	>2400	585	6	3,510
T-14A	xxx	xxx	190	130	xxx	370	xxx	xxx	xxx	209	3	627
T-14B	xxx	xxx	310	390	300	580	xxx	190	2000	447	0.7	313
T-16	xxx	xxx	580	>2400	>2400	xxx	xxx	xxx	690	1,232	2	2,464

NOTES
1- * Average of two samples
2- Used 2,400 in calculation when >2,400 was recorded
3-Microbac Laboratories data
4-Microbac Laboratories E. Coli data is reported as MPN, Most Probable Number, of Colony Forming Units (CFU).

SUPPLEMENT F-DISSOLVED OXYGEN CONCENTRATIONS

	2016			DO as ppm			
SITE	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**AVERAGE**
B-1	8.95	8.39	7.47	7.65	xxx	7.16	7.92
T-2	8.69	xxx	xxx	xxx	xxx	xxx	8.69
B-2	10.01	8.79	8.01	8.03	7.60	8.11	8.42
T-15	9.08	8.57	8.50	8.30	7.94	8.20	8.43
B-4	9.29	8.34	7.50	7.29	6.70	7.25	7.73
T-6	9.92	8.00	7.41	7.38	6.48	xxx	7.84
B-5	xxx	xxx	7.44	7.66	7.55	xxx	7.55
T-7	10.31	8.88	8.25	8.00	7.68	xxx	8.62
T-9	9.67	9.00	8.35	7.70	8.26	xxx	8.60
T-10	9.42	7.62	6.56	xxx	xxx	xxx	7.87
T-11	9.39	9.03	8.60	7.93	8.60	8.49	8.67
B-8	9.35	7.94	7.12	7.84	6.82	7.37	7.74
T13B	9.64	8.73	8.20	8.37	8.32	8.40	8.61
B-12	10.26	7.91	7.05	6.81	6.94	6.80	7.63
B-13	12.54	10.05	8.82	7.65	8.20	7.50	9.13
T-14A	8.56	6.50	6.49	xxx	6.70	xxx	7.06
T-14B	8.82	8.35	8.03	7.60	8.00	xxx	8.16
T-16	8.68	10.28	5.80	6.67	xxx	xxx	7.86

NOTE: Field Measurements

SUPPLEMENT G- TURBIDITY DATA (NTU)

SITE	2016 APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	AVERAGE
B-1	20	14	47	25	40	16	xxx	10	25
T-2	4	xxx	xxx	xxx	xxx	xxx	xxx	10	7
B-2	17	22	75	75	55	35	xxx	9	41
T-15	4	3	7	14	5	xxx	xxx	xxx	7
B-4	xxx	21	30	31	23	38	xxx	6	25
T-6	6	6	7	19	6	9	xxx	8	9
B-5	xxx	xxx	23	10	38	xxx	xxx	7	20
T-7	4	4	3	3	3	xxx	xxx	25	7
T-9	4	4	3	4	3	xxx	xxx	8	4
T-10	3	4	14	xxx	xxx	xxx	xxx	7	7
T-11	7	6	7	5	4	6	xxx	9	6
B-8	4	5	8	16	7	7	xxx	7	8
T-13B	7	7	8	5	6	8	xxx	8	7
B-12	8	4	13	6	6	6	xxx	13	8
B-13	4	4	4	16	5	5	xxx	10	7
T-14A	4	4	3	16	4	xxx	xxx	3	6
T-14B	5	3	4	5	4	xxx	xxx	15	5
T-16	4	4	800	150	xxx	xxx	xxx	8	192

NOTE: Calculated from field measured data

SUPPLEMENT H- pH DATA

SITE	pH median	range
B-1	7.7	7.5-7.9
B-2	7.7	7.7-7.9
B-4	7.7	7.3-7.9
B-8	7.5	7.0-7.6
B-12	7.5	7.4-7.7
B-13	7.8	7.4-8.2
T-16	7.1	6.9-7.2
T-2	7.5	7.3-7.5
T-15	7.6	7.5-7.9
T-6	7.5	7.1-7.7
T-7	7.8	7.5-8.0
T-9	7.6	7.3-7.7
T-10	7.2	7.1-7.4
T-11	7.5	7.3-7.8
T-13B	7.5	7.2-7.7
T-14A	7.1	7.0-7.2
T-14B	7.3	7.2-7.5

NOTE: Field measurements

SUPPLEMENT I--FLOW DATA (cfs)
Sheet 1/3

FIRST QUARTER 2016

SITE	#1 Trip Jan 11	#2 Trip Feb 19	#3 Trip Feb 29	#4 Trip Mar 18	#5 Trip Mar 30	1st Q AVERAGE
B-1	42	38	79*	36	34	38
B-4	xxx	xxx	212*	51	41	56
T-6	xxx	7	15*	1.3	1.6	3.2
T-9	xxx	xxx	2	3.3	1.4	2.2
T-11	xxx	2	2	2.5	2.2	2.2
B-8	xxx	33	62	57	29	45
B-12	xxx	56*	65*	25.7	20	23
T-13B	xxx	7	10	12	9.4	10
B-13	xxx	112*	33	16	13	21

SECOND QUARTER 2016

SITE	#6 Trip Apr 14	#7 Trip May 20	#8 Trip Jun 29	2nr Q AVERAGE
B-1	54	xxx	xxx	xxx
B-4	53	32	8	31
T-6	1.5	0.2	xxx	1
T-9	2	1	0.9	1
T-11	2	2	0.8	1
B-8	41	12	4	19
B-12	19	22	5	15
T-13B	7	3	4	5
B-13	19	11	1	7

NOTE: * NOT POSSIBLE --IGNORE

SUPPLEMENT I--FLOW DATA (cfs)

Sheet 2/3

	THIRD QUARTER 2016			
	#9 Trip	#10 Trip	#11 Trip	3rd Q
SITE	Jul 22	Aug 11	Sep 26	AVERAGE
B-1	xxx	xxx	xxx	xxx
B-4	7.2	11	11	9
T-6	xxx	xxx	0.4	xxx
T-9	0.6	16*	15	10
T-11	1.2	1	1	1
B-8	xxx	0.2	0.4	0.3
B-12	3.2	3	2.5	3
T-13B	9.5	9	8	9
B-13	8.8	4	xxx	6

	FOURTH QUARTER 2016
	#12 Trip
SITE	Nov 29
B-1	7
B-4	8
T-6	1
T-9	xxx
T-11	1
B-8	0.5
B-12	2.6
T-13B	7.2
B-13	29*

SUPPLEMENT I--FLOW DATA (cfs)

Sheet 3/3

QUARTERLY AVERAGE FLOW SUMMARY

SITE	1st Q AVERAGE	2nd Q AVERAGE	3rdQ AVERAGE	4th Q Nov 29	CALCULATED AVERAGE 2016	ESTIMATED AVERAGE ANNUAL FLOW**
B-1	38	xxx	xxx	7	22	25
B-4	56	31	9	8	25	20
T-6	3.2	1	xxx	1	2	2
T-9	2.2	1	10	xxx	4	3
T-11	2.2	1	1	1	1	1
B-8	45	19	0.3	0.5	16	15
B-12	23	15	3	2.6	11	13
T-13B	10	5	9	7.2	8	6
B-13	21	7	6	xxx	11	6

NOTE: **ESTIMATED ANNUAL FLOW IS BASED ON ENGINEERING JUDGEMENT

SUPPLEMENT J - RAINFALL DATA
(inches)

ATHENS,TN

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
2015	4.00	4.37	5.21	5.67	2.29	3.30	12.66	8.44	4.84	4.69	6.67	11.06	73.20
2016	3.40	7.34	2.73	4.01	4.25	3.96	4.35	2.00	2.28	0.09	4.11	4.46	42.98
Average	5.14	4.21	4.43	5.03	4.71	4.40	5.67	4.11	5.32	3.09	4.92	6.08	57.11

LENOIR CITY,TN

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
2015	4.25	3.74	5.23	4.41	3.00	5.60	7.74	4.76	3.40	4.10	6.27	12.34	64.84
2016	3.44	7.54	2.31	2.62	2.69	4.95	5.15	3.38	1.16	0.17	2.91	6.66	42.98
Average	4.67	4.80	4.14	4.30	4.15	3.83	6.74	3.68	4.34	2.27	3.61	5.63	52.16

AVERAGES

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
2015	4.12	4.06	5.22	5.04	2.64	4.45	10.20	6.60	4.12	4.39	6.47	11.70	69.01
2016	3.42	7.44	2.52	3.32	3.97	4.45	4.75	2.69	1.72	0.13	3.51	5.55	43.47
Average	4.91	4.55	4.78	4.66	4.43	4.62	6.20	3.69	4.83	2.68	4.76	4.76	54.87

ANNUAL TOTALS

2015	69.01
2016	43.47
Average	54.87

SUPPLEMENT K sheet 1/3

EFFLUENT MADISONVILLE WWTP

2015	FLOW(avg. month) MGD	P total PPD	ppm	N total PPD	ppm	E-coli CFU/100ml
JAN	0.806	57.8	8.5	12.1	1.8	126
FEB	0.833	65.2	9.4	9.1	1.3	189
MAR	0.809	9	1.3	5.9	0.9	1708
APR	0.753	9	1.4	14	2.2	76
MAY	0.331	7	2.5	xxx	xxx	95
JUN	0.263	20	9.1	1	0.5	29
JUL	0.941	21.5	2.7	1.5	0.2	57
AUG	0.458	22.7	5.9	0.4	1	16
SEP	0.369	24	8	2.9	0.9	15
OCT	0.458	32.6	8.5	10.4	2.7	14
NOV	0.682	21	3.7	3.8	0.7	54
DEC	1.001	20.4	2.4	4.4	0.5	36

NOTE: The above data set is only for comparison to 2016 data

SUPPLEMENT K sheet 2/3

EFFLUENT MADISONVILLE WWTP

2016	**FLOW (ave. month)**	**WWTP P total**		**WWTP N total**		**WWTP E-coli**
	MGD	**PPD**	**ppm**	**PPD**	**ppm**	**CFU/100 ml**
JAN	0.618	32.8	6.4	24.0	4.6	40
FEB	0.956	20	2.5	14.8	2.1	69
MAR	0.471	43.5	11.1	10.8	2.7	54
APR	0.37	24.2	7.8	9.2	3	68
MAY	0.269	29	12.9	11.5	5.1	64
JUN	0.237	23.2	11.7	6.5	3.3	37
JUL	0.184	24.8	16.2	4.9	3.2	43
AUG	0.17	15.3	10.8	8.2	5.8	30
SEP	0.16	18	13.5	9.4	7.0	4
OCT	0.18	22	14.7	10.1	6.7	41
NOV	0.26	20	9.2	8.7	4.0	126
DEC	0.57	15.5	3.3	17.3	3.4	55
AVERAGE	0.37	24	7.78	11.3	3.7	52.6 Geometric Mean

SUPPLEMENT K sheet 3/3

EFFLUENT MADISONVILLE WWTP

COMPARISON MADISONVILLE WWTP
WITH SAMPLE LOCATIONS B-1 AND B-13 , 2016
Averages
(B-13, First sample location downstream of WWTP)

	FLOW	NITRATE		PHOSPHORUS		E.COLI
	cfs	ppm	PPD	ppm	PPD	CFU/100 ml
WWTP	0.37	3.7	11.3	7.78	24	52.6
B-13	6	1.0	32	0.50	16.2	585
B-1	25	1.85	249	0.08	10.8	867
						Geo. Mean

APPENDICES

Appendix A – Excerpts from Consent Decree

IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF TENNESSEE
AT KNOXVILLE

TENNESSEE CLEAN WATER NETWORK, and the WATERSHED ASSOCIATION OF THE TELLICO RESERVOIR,	)	
Plaintiffs,	)	
v.	)	No. 3:14-cv-555 -TAV-CCS
CITY OF MADISONVILLE, TENNESSEE ,	)	
Defendant.	)	

CONSENT DECREE

WHEREAS, the parties to this Consent Decree are Plaintiffs Tennessee Clean Water Network and the Watershed Association of the Tellico Reservoir ("Plaintiffs"), and Defendant City of Madisonville ("Madisonville") (collectively the "Parties");

WHEREAS, Madisonville is a Tennessee municipality, and is the owner and operator of the Madisonville Wastewater Treatment Plant ("WWTP") and sewage collection system, which discharges pollutants to Bat Creek, a tributary of the Tellico Reservoir, pursuant to National Pollutant Elimination System ("NPDES") permit No. TN0025020 issued by the Tennessee Department of Environment and Conservation ("TDEC");

WHEREAS, Plaintiffs Tennessee Clean Water Network and the Watershed Association of the Tellico Reservoir are both Tennessee nonprofit corporations with members who live, work, and/or recreate on Bat Creek and/or the Tellico Reservoir downstream from the Madisonville WWTP;

Complaint, and in consideration of the mutual promises and covenants contained herein, with the consent of the Parties, IT IS HEREBY ADJUDCED, ORDERED, AND DECREED as follows:

I. JURISDICTION AND VENUE

1. For purposes of the entry of this Consent Decree, the Parties agree this Court has subject matter jurisdiction over this action, pursuant to 28 U.S.C. § 1331 and/or 33 U.S.C. § 1365(a). For purposes of the entry of this Consent Decree, the Parties agree that venue lies in this District pursuant to Section 505(c)(1) of the CWA, because it is the judicial district in which the alleged violations occurred.

II. COVERAGE

2. The provisions of this Consent Decree shall apply to, and be binding upon, the Parties and their respective officers, directors, successors, agents, and assigns.

3. Madisonville agrees not to challenge the terms of this Consent Decree in any bankruptcy proceeding.

III. SUPPLEMENTAL ENVIRONMENTAL PROJECT

4. Madisonville shall pay $10,000 for a Supplemental Environmental Project ("SEP") to address nitrogen and phosphorus impairment in Bat Creek described in Appendix A attached hereto, beginning within three months after entry of this Consent Decree. All SEP funds provided under this paragraph are to be expended within twenty-four months after entry of this Consent Decree. Madisonville shall execute any and all instruments necessary to ensure that the $10,000 payment is used as set forth in Appendix A for the intended purpose.

5. The Parties agree the SEP shall take the place of any civil penalties that might have been awarded for any violations of the CWA that might have been found had this matter progressed to trial.

Appendix A
Supplemental Environmental Project
Bat Creek Pollution Assessment

The Supplemental Environmental Project ("SEP") funds shall be utilized to conduct a surface water sampling program to better characterize key water quality parameters in Bat Creek and its tributaries, with the ultimate goal of developing corrective actions to address nonpoint source pollution in the sub-watershed.

Objective: The purpose of this SEP is to conduct a one to two year water sampling and analytical testing program to determine concentrations of E. coli, nitrites + nitrates, total nitrogen, total phosphorus, dissolved oxygen, and other key pollutant parameters in Bat Creek and its tributaries.

Rationale: The Tennessee Department of Environment and Conservation ("TDEC") lists Bat Creek pursuant to 303(d) of the CWA, 33 U.S.C. § 1313(d), as impaired for E. coli, nitrites + nitrates, and total phosphorus. However, there is limited water quality data to characterize the amounts and sources of these pollutants to Bat Creek from nonpoint sources. It is anticipated that data collected through this SEP would be used to identify, prioritize, and implement remediation projects to reduce nonpoint source loading of pollutants of concern to Bat Creek resulting from urban land use, agriculture practices, defective septic systems, and/or other causes. Any such remediation projects would be beyond the scope of this SEP.

Coordination: The Watershed Association of the Tellico Reservoir ("WATeR") will coordinate sampling and analysis activities, but will not receive SEP funds, which will be administered by Madisonville to pay sampling costs directly to a third party vendor(s). Neither Madisonville nor WATeR assumes liability to supplement the SEP funds or to conduct any monitoring beyond what the SEP funds cover. WATeR is a Tennessee nonprofit corporation with prior experience working successfully with TDEC on similar testing efforts in the Tellico Lake watershed, which added to knowledge of water quality conditions in that watershed.

Project Description: WATeR will develop and implement a sampling plan for Bat Creek and its tributaries, including a protocol consistent with TDEC's standard operating procedures. Expenses will consist laboratory analysis because sample collection will be performed by volunteers.

The work phases of this SEP would be: (1) program planning and design, (2) sample collection, (3) field and laboratory analysis and (4) data review and interpretation. Program planning will include developing work activities and sequencing, defining roles and responsibilities of involved parties for all phases, determining sampling locations and frequencies, specifying sampling methods consistent with TDEC standard operating procedures and field observation requirements, specifying lab analytical test procedures consistent with TDEC and EPA requirements, and selecting the format for reporting of results. Madisonville will provide input in the planning process for the sampling program.

Sampling locations will be prioritized based on information needs and the likelihood of high pollutant loading in specific locations, and will include locations both upstream and downstream from the wastewater treatment plant. Sampling locations shall not include any sites required to be sampled under any NPDES permit. Sampling along the mainstem of Bat Creek will receive primary emphasis initially, including sampling in the lower reaches of selected tributaries. When data indicate a likely source of upstream pollutant loading in a tributary, additional samples may be taken upstream for further characterization.

Sampling will then be conducted at prioritized locations throughout the Bat Creek sub-watershed. Trained volunteers will identify samples, maintain chains of custody, record field results, and ensure samples are properly transferred to accredited laboratories for analysis. Once laboratory results are received, WATeR will review and interpret results, and will prepare a final report identifying all results.

Timing: All sampling and analysis conducted with funds pursuant to Paragraph 4 of the Consent Decree shall be completed within 24 months after entry of this consent decree. At that time, WATeR will submit a written report of the sampling results to Tennessee Clean Water Network ("TCWN"), Madisonville, and TDEC. At the same time, Madisonville will separately present an accounting of all SEP funds expended to TCWN and WATeR. Supplemental sampling conducted utilizing funds pursuant to Paragraph 20 of the Consent Decree will be completed within 6 months of the payment of funds.

Appendix B –Cost Tracking Table for Microbac Invoices

Laboratory Expenditures for Bat Creek SEP -- 2016

Report Issue Date: 12/13/16 **FINAL COST REPORT; SAMPLING COMPLETE** Prepared by: Dick Sawinski of WATeR's WQIC

Microbac price: $105 for analysis of a set of samples (E.coli, NO2, NO3, Total P); $75 per set w/o NO2; TKN @ $40ea.
"Set" is the samples taken (for analysis of the parameters above) at one site (or blank/FB or dup/FD analysis) on a specific date and time.

Delivery Date of Samples to Lab	Sample Batch ID Code	No. Sites	No. FD & FB	Total Sets	Cost Estimate for Batch Delivered	Estimated Cum. Cost to Date	Invoiced Amount	Invoice Reference	Cum. Invoiced Cost
4/18/2016	1606087	2	0	2	210	210	210	RA6D00758	210
4/26/2016	1606548	2	0	E.c only	60	270	60	RA6D00951	270
5/18/2016	1607993	16	1	17	1785	2055	1785	RA6E00884	2055
6/13/2016	1609412	7	2	9	675	2730	675	RA6F00804	2730
6/17/2016	1609735	10	0	10	750	3480	750	RA6F00895	3480
7/13/2016	1610991	9	0	9	675	4155	675	RA6G00492	4155
7/14/2016	1611059	6	2	8	600	4755	600	RA6G00602	4755
8/18/2016	1613141	5	0	5 + 2 TKN	380	5135	380	RA6H01075	5135
8/22/2016	1613303	10	2	12+5TKN	950	6085	950	RA6H01247	6085
9/8/2016	1614336	9	2	11+2TKN	1070	7155	1070	RA6I00545	7155
10/18/2016	1616712	12	2	14wTKN	1640	8795	1640	RA6K00054	8795
11/29/2016	1618918	18	2	Various Partial	1110	9905	1110	RA6L00301	9905

Appendix C – Microbac Invoices Cited in Cost Tracking Table

MICROBAC

Microbac Laboratories, Inc.
Knoxville Division
505 East Broadway Avenue
Maryville, TN 37804-5744
865-977-1200
brian.richard@microbac.com

Invoice
Invoice Number: RA6D00758
Invoice Date: 04/22/2016
Client Code: RC029
Terms: 30 Days

Bill To:
City Of Madisonville
Valerie Watson
400 College Street N
Madisonville, TN 37354

Services Provided for:
Watershed Association of the Tellico Reservoir
106 Tigitsi Lane
Loudon, TN 37774

Project: Water Quality Improvement Committee

PO # 16-286

Received Date 04/18/2016

Work Order(s)	Quantity	Analysis/Description	Surcharge	Unit Cost	Extended Cost
1606087	2	Nitrate	0%	$30.00	$60.00
	2	Nitrite	0%	$30.00	$60.00
	2	Phosphorus, Total	0%	$15.00	$30.00
	2	E. coli	0%	$30.00	$60.00

Total Amount	**$210.00**
Prepaid Amount	**$0.00**
Balance Due	**$210.00**

Please detach invoice stub below and return with remittance

INVOICE #: RA6D00758
INVOICE Date: 04/22/2016
CUSTOMER #: RC029

Balance Due **$210.00**
Terms: 30 Days

Remittance To:

Microbac Laboratories, Inc
Attn: Locator RA
P.O Box 644733
Pittsburgh, PA 15264-4733

RARC029RA6D007582204201600021000

Microbac Laboratories, Inc.
Knoxville Division
505 East Broadway Avenue
Maryville, TN 37804-5744
865-977-1200
brian.richard@microbac.com

Invoice

Invoice Number: RA6D00951

Invoice Date: 04/28/2016
Client Code: RC029
Terms: 30 Days

Bill To:

City Of Madisonville
Valerie Watson
400 College Street N
Madisonville, TN 37354

Services Provided for:

Watershed Association of the Tellico Reservoir
106 Tigitsi Lane
Loudon, TN 37774

Project:	PO #	Received Date
Water Quality Improvement Committee	16-286	04/26/2016

Work Order(s)	Quantity	Analysis/Description	Surcharge	Unit Cost	Extended Cost
1606548	2	E. coli	0%	$30.00	$60.00

Total Amount	**$60.00**
Prepaid Amount	**$0.00**
Balance Due	**$60.00**

Please detach invoice stub below and return with remittance

INVOICE #: RA6D00951
INVOICE Date: 04/28/2016
CUSTOMER #: RC029

Balance Due **$60.00**
Terms: 30 Days

Remittance To:

Microbac Laboratories, Inc
Attn: Locator RA
P.O Box 644733
Pittsburgh, PA 15264-4733

RARC029RA6D00951280420160000600

MICROBAC®

Microbac Laboratories, Inc.
Knoxville Division
505 East Broadway Avenue
Maryville, TN 37804-5744
865-977-1200
brian.richard@microbac.com

Invoice

Invoice Number: RA6E00884

Invoice Date: 05/26/2016
Client Code: RC029
Terms: 30 Days

Bill To:
City Of Madisonville
Valerie Watson
400 College Street N
Madisonville, TN 37354

Services Provided for:
Watershed Association of the Tellico Reservoir
106 Tigitsi Lane
Loudon, TN 37774

Project:	PO #	Received Date
Water Quality Improvement Committee	16-286	05/18/2016

Work Order(s)	Quantity	Analysis/Description	Surcharge	Unit Cost	Extended Cost
1607993	17	Nitrate	0%	$30.00	$510.00
	17	Nitrite	0%	$30.00	$510.00
	17	Phosphorus, Total	0%	$15.00	$255.00
	17	E. coli	0%	$30.00	$510.00

Total Amount	**$1,785.00**
Prepaid Amount	**$0.00**
Balance Due	**$1,785.00**

Please detach invoice stub below and return with remittance

INVOICE #: RA6E00884
INVOICE Date: 05/26/2016
CUSTOMER #: RC029

Balance Due **$1,785.00**
Terms: 30 Days

Remittance To:

Microbac Laboratories, Inc
Attn: Locator RA
P.O Box 644733
Pittsburgh, PA 15264-4733

RARC029RA6E00884260520160017850O

MICROBAC®

Microbac Laboratories, Inc.
Knoxville Division
505 East Broadway Avenue
Maryville, TN 37804-5744
865-977-1200
brian.richard@microbac.com

Invoice

Invoice Number: RA6F00804
Invoice Date: 06/27/2016
Client Code: RC029
Terms: 30 Days

Bill To:
City Of Madisonville
Valerie Watson
400 College Street N
Madisonville, TN 37354

Services Provided for:
Watershed Association of the Tellico Reservoir
106 Tigitsi Lane
Loudon, TN 37774

Project: Water Quality Improvement Committee

PO # 16-286

Received Date 06/13/2016

Work Order(s)	Quantity	Analysis/Description	Surcharge	Unit Cost	Extended Cost
1609412	9	Nitrate	0%	$30.00	$270.00
	9	Phosphorus, Total	0%	$15.00	$135.00
	9	E. coli	0%	$30.00	$270.00

Total Amount	**$675.00**
Prepaid Amount	**$0.00**
Balance Due	**$675.00**

Please detach invoice stub below and return with remittance

INVOICE #: RA6F00804
INVOICE Date: 06/27/2016
CUSTOMER #: RC029

Balance Due **$675.00**
Terms: 30 Days

Remittance To:

Microbac Laboratories, Inc
Attn: Locator RA
P.O Box 644733
Pittsburgh, PA 15264-4733

RARC029RA6F00804270620160006750

MICROBAC

Microbac Laboratories, Inc.
Knoxville Division
505 East Broadway Avenue
Maryville, TN 37804-5744
865-977-1200
brian.richard@microbac.com

Invoice

Invoice Number: RA6F00895

Invoice Date: 06/28/2016
Client Code: RC029
Terms: 30 Days

Bill To:

City Of Madisonville
Valerie Watson
400 College Street N
Madisonville, TN 37354

Services Provided for:

Watershed Association of the Tellico Reservoir
106 Tigitsi Lane
Loudon, TN 37774

Project:	PO #	Received Date
Water Quality Improvement Committee	16-286	06/17/2016

Work Order(s)	Quantity	Analysis/Description	Surcharge	Unit Cost	Extended Cost
1609735	10	Nitrate	0%	$30.00	$300.00
	10	Phosphorus, Total	0%	$15.00	$150.00
	10	E. coli	0%	$30.00	$300.00

Total Amount	**$750.00**
Prepaid Amount	**$0.00**
Balance Due	**$750.00**

Please detach invoice stub below and return with remittance

INVOICE #: RA6F00895
INVOICE Date: 06/28/2016
CUSTOMER #: RC029

Balance Due **$750.00**
Terms: 30 Days

Remittance To:

Microbac Laboratories, Inc
Attn: Locator RA
P.O Box 644733
Pittsburgh, PA 15264-4733

RARC029RA6F00895280620160007500

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Microbac Laboratories, Inc.
Knoxville Division
505 East Broadway Avenue
Maryville, TN 37804-5744
865-977-1200
brian.richard@microbac.com

Invoice

Invoice Number: RA6G00492

Invoice Date: 07/20/2016
Client Code: RC029
Terms: 30 Days

Bill To:
City Of Madisonville
Valerie Watson
400 College Street N
Madisonville, TN 37354

Services Provided for:
Watershed Association of the Tellico Reservoir
106 Tigitsi Lane
Loudon, TN 37774

Project:	PO #	Received Date
Water Quality Improvement Committee	16-286	07/13/2016

Work Order(s)	Quantity	Analysis/Description	Surcharge	Unit Cost	Extended Cost
1610991	9	Nitrate	0%	$30.00	$270.00
	9	Phosphorus, Total	0%	$15.00	$135.00
	9	E. coli	0%	$30.00	$270.00

Total Amount	**$675.00**
Prepaid Amount	**$0.00**
Balance Due	**$675.00**

Please detach invoice stub below and return with remittance

INVOICE #: RA6G00492
INVOICE Date: 07/20/2016
CUSTOMER #: RC029

Balance Due **$675.00**
Terms: 30 Days

Remittance To:

Microbac Laboratories, Inc
Attn: Locator RA
P.O Box 644733
Pittsburgh, PA 15264-4733

RARC029RA6G004922007201600067500

Microbac Laboratories, Inc.
Knoxville Division
505 East Broadway Avenue
Maryville, TN 37804-5744
865-977-1200
brian.richard@microbac.com

Invoice

Invoice Number: RA6G00602
Invoice Date: 07/22/2016
Client Code: RC029
Terms: 30 Days

Bill To:
City Of Madisonville
Valerie Watson
400 College Street N
Madisonville, TN 37354

Services Provided for:
Watershed Association of the Tellico Reservoir
106 Tigitsi Lane
Loudon, TN 37774

Project: Water Quality Improvement Committee

PO # 16-286

Received Date 07/14/2016

Work Order(s)	Quantity	Analysis/Description	Surcharge	Unit Cost	Extended Cost
1611059	8	Nitrate	0%	$30.00	$240.00
	8	Phosphorus, Total	0%	$15.00	$120.00
	8	E. coli	0%	$30.00	$240.00

Total Amount	**$600.00**
Prepaid Amount	**$0.00**
Balance Due	**$600.00**

Please detach invoice stub below and return with remittance

INVOICE #: RA6G00602
INVOICE Date: 07/22/2016
CUSTOMER #: RC029

Balance Due **$600.00**
Terms: 30 Days

Remittance To:

Microbac Laboratories, Inc
Attn: Locator RA
P.O Box 644733
Pittsburgh, PA 15264-4733

RARC029RA6G00602220720160006000

MICROBAC

Microbac Laboratories, Inc.
Knoxville Division
505 East Broadway Avenue
Maryville, TN 37804-5744
865-977-1200
brian.richard@microbac.com

Invoice

Invoice Number: RA6H01075

Invoice Date: 08/30/2016
Client Code: RC029
Terms: 30 Days

Bill To:

City Of Madisonville
Valerie Watson
400 College Street N
Madisonville, TN 37354

Services Provided for:

Watershed Association of the Tellico Reservoir
106 Tigitsi Lane
Loudon, TN 37774

Project:	PO #	Received Date
Water Quality Improvement Committee	16-286	08/18/2016

Work Order(s)	Quantity	Analysis/Description	Surcharge	Unit Cost	Extended Cost
1613141	5	Nitrate	0%	$30.00	$150.00
	2	Total Kjeldahl Nitrogen	0%	$40.00	$80.00
	5	E. coli	0%	$30.00	$150.00

Total Amount	**$380.00**
Prepaid Amount	**$0.00**
Balance Due	**$380.00**

Please detach invoice stub below and return with remittance

INVOICE #: RA6H01075
INVOICE Date: 08/30/2016
CUSTOMER #: RC029

Balance Due **$380.00**
Terms: 30 Days

Remittance To:

Microbac Laboratories, Inc
Attn: Locator RA
P.O Box 644733
Pittsburgh, PA 15264-4733

RARC029RA6H0107530082016000380000

MICROBAC®

Microbac Laboratories, Inc.
Knoxville Division
505 East Broadway Avenue
Maryville, TN 37804-5744
865-977-1200
brian.richard@microbac.com

Invoice

Invoice Number: RA6H01247

Invoice Date: 08/31/2016
Client Code: RC029
Terms: 30 Days

Bill To:

City Of Madisonville
Valerie Watson
400 College Street N
Madisonville, TN 37354

Services Provided for:

Watershed Association of the Tellico Reservoir
106 Tigitsi Lane
Loudon, TN 37774

Project: Bat Creek

PO # 16-286

Received Date 08/22/2016

Work Order(s)	Quantity	Analysis/Description	Surcharge	Unit Cost	Extended Cost
1613303	11	Nitrate	0%	$30.00	$330.00
	2	Nitrite	0%	$30.00	$60.00
	5	Total Kjeldahl Nitrogen	0%	$40.00	$200.00
	12	E. coli	0%	$30.00	$360.00

Total Amount	**$950.00**
Prepaid Amount	**$0.00**
Balance Due	**$950.00**

Please detach invoice stub below and return with remittance

INVOICE #: RA6H01247
INVOICE Date: 08/31/2016
CUSTOMER #: RC029

Balance Due **$950.00**
Terms: 30 Days

Remittance To:

Microbac Laboratories, Inc
Attn: Locator RA
P.O Box 644733
Pittsburgh, PA 15264-4733

RARC029RA6H012473108201600095000

MICROBAC®

Microbac Laboratories, Inc.
Knoxville Division
505 East Broadway Avenue
Maryville, TN 37804-5744
865-977-1200
brian.richard@microbac.com

Invoice

Invoice Number: RA6I00545

Invoice Date: 09/16/2016
Client Code: RC029
Terms: 30 Days

Bill To:
City Of Madisonville
Valerie Watson
400 College Street N
Madisonville, TN 37354

Services Provided for:
Watershed Association of the Tellico Reservoir
106 Tigitsi Lane
Loudon, TN 37774

Project:	PO #	Received Date
Bat Creek SEP	16-286	09/08/2016

Work Order(s)	Quantity	Analysis/Description	Surcharge	Unit Cost	Extended Cost
1614336	11	Nitrate	0%	$30.00	$330.00
	11	Nitrite	0%	$30.00	$330.00
	2	Total Kjeldahl Nitrogen	0%	$40.00	$80.00
	11	E. coli	0%	$30.00	$330.00

Total Amount	**$1,070.00**
Prepaid Amount	**$0.00**
Balance Due	**$1,070.00**

Please detach invoice stub below and return with remittance

INVOICE #: RA6I00545
INVOICE Date: 09/16/2016
CUSTOMER #: RC029

Balance Due **$1,070.00**
Terms: 30 Days

Remittance To:

Microbac Laboratories, Inc
Attn: Locator RA
P.O Box 644733
Pittsburgh, PA 15264-4733

RARC029RA6I005451609201600107000

Microbac Laboratories, Inc.
Knoxville Division
505 East Broadway Avenue
Maryville, TN 37804-5744
865-977-1200
brian.richard@microbac.com

Invoice
Invoice Number: RA6K00054
Invoice Date: 11/02/2016
Client Code: RC029
Terms: 30 Days

Bill To:
City Of Madisonville
Valerie Watson
400 College Street N
Madisonville, TN 37354

Services Provided for:
Watershed Association of the Tellico Reservoir
106 Tigitsi Lane
Loudon, TN 37774

Project:	PO #	Received Date
Water Quality Improvement Committee	16-286	10/18/2016

Work Order(s)	Quantity	Analysis/Description	Surcharge	Unit Cost	Extended Cost
1616712	14	Nitrate	0%	$30.00	$420.00
	14	Total Kjeldahl Nitrogen	0%	$40.00	$560.00
	14	Phosphorus, Total	0%	$15.00	$210.00
	15	E. coli	0%	$30.00	$450.00

Total Amount	**$1,640.00**
Prepaid Amount	**$0.00**
Balance Due	**$1,640.00**

Please detach invoice stub below and return with remittance

INVOICE #: RA6K00054
INVOICE Date: 11/02/2016
CUSTOMER #: RC029

Balance Due **$1,640.00**
Terms: 30 Days

Remittance To:

Microbac Laboratories, Inc
Attn: Locator RA
P.O Box 644733
Pittsburgh, PA 15264-4733

RARC029RA6K000540211201600164000

MICROBAC

Microbac Laboratories, Inc.
Knoxville Division
505 East Broadway Avenue
Maryville, TN 37804-5744
865-977-1200
brian.richard@microbac.com

Invoice

Invoice Number: RA6L00301

Invoice Date: 12/09/2016
Client Code: RC029
Terms: 30 Days

Bill To:

City Of Madisonville
Valerie Watson
400 College Street N
Madisonville, TN 37354

Services Provided for:

Watershed Association of the Tellico Reservoir
106 Tigitsi Lane
Loudon, TN 37774

Project:	PO #	Received Date
Bat Creek	16-286	11/29/2016

Work Order(s)	Quantity	Analysis/Description	Surcharge	Unit Cost	Extended Cost
1618918	9	Nitrate	0%	$30.00	$270.00
	3	Total Kjeldahl Nitrogen	0%	$40.00	$120.00
	20	Phosphorus, Total	0%	$15.00	$300.00
	14	E. coli	0%	$30.00	$420.00

Total Amount	**$1,110.00**
Prepaid Amount	**$0.00**
Balance Due	**$1,110.00**

Please detach invoice stub below and return with remittance

INVOICE #: RA6L00301
INVOICE Date: 12/09/2016
CUSTOMER #: RC029

Balance Due **$1,110.00**
Terms: 30 Days

Remittance To:

Microbac Laboratories, Inc
Attn: Locator RA
P.O Box 644733
Pittsburgh, PA 15264-4733

RARC029RA6L003010912201600111000