Project: Reduction of Nonpoint Source Pollution in Bat Creek Watershed

Lead Organization: University of Tennessee Extension (in collaboration from Watershed Association of the Tellico Reservoir or "WATeR")

Watershed: Bat Creek, Monroe Co., TN
Little Tennessee River Watershed HUC 06010204
Bat Creek Subwatershed HUC 060102040504

Causes and Sources of Nonpoint Source Pollution in the Watershed:

The Bat Creek Watershed discharges into the Tellico Reservoir of the Little Tennessee River. Tellico Reservoir is the newest reservoir in the TVA system. The adjacent land surrounding this reservoir is strictly managed consistent with a TVA Reservoir Land Management Plan administered by the Tellico Reservoir Development Agency (TRDA). This reservoir is the driving force for expanding the economy in much of the three counties joining the reservoir. Several communities adjacent to the reservoir, founded since closure of Tellico Dam in 1979, account for well over 10,000 new residents to the area. The industries located within the TRDA Tellico West Industrial Park provide employment to more than 2,000 residents of the surrounding counties where unemployment rates have been historically higher than average. Tellico Reservoir is a very popular recreational destination for boating, fishing, camping, etc. It has the reputation of being a clean reservoir. It is essential that this reputation not be tarnished by inflow of streams polluted by either point source or nonpoint source pollution.

Bat Creek Watershed covers 19,925 acres (31 sq. miles) of Monroe County located in Figure 1 in the Valley and Ridge physiographic region of Tennessee. The headwaters of Bat Creek originate in or near Madisonville, the county seat, with a reported population of 4,770 in 2016. Several tributaries of various size feed into the creek as it flows generally northeast about 19 miles through rural areas before discharging into Tellico Reservoir of the Little Tennessee River (Figure 2). With the closure of Tellico Dam in 1979, Tellico Reservoir flooded about seven miles of Bat Creek, thereby leaving all free-flowing portions of Bat Creek and that portion of the Watershed exclusively in Monroe Co.

The Bat Creek Watershed is bounded on the northern side by a ridge known as the Bat Creek Knobs. The satellite photograph (Figure 2) of the watershed reveals that this area is primarily forested and relatively steep, with little agriculture. This section of the watershed is described as a heterogeneous region composed predominantly of limestone and cherty dolomite (Ref. 1). The hydrologic soil group consists chiefly of soils with moderately fine to fine texture with low infiltration rates when wet and having a layer that impedes downward movement of water.

The southern side of the watershed consists of lowlands, rolling valleys, slopes and hilly areas dominated by shale and limestone soils. These soils have textures that are moderately coarse to coarse with moderate infiltration rates when wet. They are moderately deep to deep soils, and moderately to well drained. Sinkholes and depressions are relatively common. Small farms, pastures, and rural residences subdivide the land. Most of the agriculture in the watershed is in this section. These soil types are summarized in Table 1 extracted from the State Soil Geographic Database Soil Map Unit in Subwatershed 060102040504 from Ref. 2:

Table 1: Soil Characteristics of Bat Creek Watershed

Unit	% Hydric	Permeability (in./hr.)	Soil pH	Soil Texture	Soil Erodibility
Northern	0.00	1.17	4.95	Silty Loam	0.33
Southern	0.00	1.68	5.11	Loam	0.27

Land use distribution (land cover) in the Bat Creek Watershed is summarized in Table 2 (from Ref. 3) below:

Table 2: Distribution of Land Cover of the Bat Creek Watershed (% of total)

	Forest	Pasture/Hay	Row Crops	Residential	Comm./Ind.	Other
Percentage:	55.1	30.9	8.1	1.8	1.0	3.1

The inventory of livestock reported in Ref. 3 compiled in 2006, is shown in Table 3.

Table 3: Inventory of Livestock throughout the Bat Creek Watershed

Beef Cow	Milk Cow	Poultry	Hogs	Sheep	Horse
725	225	100	20	65	380

The number and type of livestock shown in Table 3 suggest that agriculture in the Bat Creek Watershed is a significant contributor to nonpoint source pollution. Although a recent oversupply of milk in this area has led to a reduction in the number of milk cows, it is reasonable to assume that farmers will continue to utilize their pastures by converting to beef cattle, but some pastures may be converted to growing row crops. Therefore, this inventory seems reasonable to support and guide improvements of agricultural practices to reduce nonpoint source pollution in the Bat Creek Watershed.

Approximately 3% of the Bat Creek Watershed is comprised of developed land, with a majority in low density residential landcover. There exists an opportunity to work with private land owners to implement small-scale, infiltration-based practices to minimize the amount of runoff and pollutants coming from the developed landscape and into Bat Creek. Over 70% of soils in the basin are classified in the hydrologic soil group B, which is ideal for infiltration in rain gardens and bioswales.

There are two NPDES permitted discharges in the Bat Creek Watershed. Madisonville operates a wastewater treatment plant with an outfall permitted to discharge 0.8 mgd (million gallons per day) at Bat Creek Mile 19.3 (TN0025020). Hiwassee College also is permitted (TN0054909) to discharge 0.06 mgd of treated effluent at Mile 16.4. In addition to these permitted wastewater discharges, Ref. 3 reports a rural population of 1,772 residents using septic systems throughout the watershed.

The water supply for Madisonville and vicinity is pumped from a water treatment plant in Vonore, TN located on Tellico Reservoir six miles upstream from the mouth of Bat Creek. Wastewater from throughout Madisonville is pumped to their treatment plant located on the north side of Madisonville. The treated effluent from this plant is discharged into a tributary of Bat Creek. Because the ultimate source of the water comes from Tellico Reservoir, this assures that Bat Creek maintains a perennial flow during a drought. The 7Q10 flow of Bat Creek is listed in Ref. 2 as 5.81 cubic feet per second. The stream is subject to periodic flooding from heavy rainfall. The average annual rainfall total in Madisonville is 52 inches.

Essentially all major tributaries throughout the Bat Creek Watershed were included on TDEC's 303(d) list of impaired waterbodies, in four separate reports (Ref. 4). The four listings covered 19.15 miles of Bat Creek and its tributaries. The listing for the upstream portion, consisting of 5.2 miles of Bat Creek and an unnamed tributary, identified the Municipal Point Source as the cause of impairment. The specific parameters exceeding limits were Nitrate & Nitrite, Total Phosphorus, Escherichia coli (E. coli), and Low Dissolved Oxygen. In two listings for downstream segments of the Watershed totaling 13.95 miles, E. coli, Nitrate & Nitrite, and Total Phosphorus were noted as pollutants. Pollution was attributed to Pasture Grazing, the Municipal Point Source, and Collection System Failure. The total maximum daily load (TMDL) specifies a >91.7 % load reduction for E. coli.

The Madisonville Wastewater Treatment Plant, as noted above, has been identified as one of the primary sources of pollution, most notably of E. coli. This plant was replaced when a new treatment plant began operation in late June 2017. The old plant was retired and dismantled. The new plant discharges effluent into the same tributary at the same location as the older plant, with a maximum permitted discharge rate of 0.8 mgd.

In addition to meeting water quality standards, for a stream to be removed from the 303(d) listing, the relative health of the biological community must also attain a healthy rating. To evaluate the biological health of Bat Creek, TDEC conducted macroinvertebrate surveys at three locations in 2013 and two locations in 2014. These habitat surveys were performed near the three regular TDEC water quality sampling locations. One site was in a park within the city of Madisonville shortly upstream of the wastewater treatment plant, and a second site was shortly downstream of the effluent of the plant. Although the most upstream site in the park did show improvement the second year of macroinvertebrate testing, results from the surveys at both sites revealed a stressed benthic community both years (Ref. 5). The single macroinvertebrate survey performed in 2013 about 10 miles downstream from the treatment plant did attain a passing score. The advent of the new treatment plant in 2017 will improve the water quality at both downstream survey sites. Implementing additional agricultural BMPs will not only improve water quality, but also reduce sediment in the streambed. These improvements should produce promising improvements of the biotic community.

Staff of the Monroe Co. NRCS and Soil Conservation District working with local farmers have successfully implemented eleven BMP projects throughout the Bat Creek Watershed (Ref. 3). Although these projects undoubtedly improved the water quality of Bat Creek and its tributaries, subsequent results of water quality sampling revealed that additional improvements will be required before Bat Creek can be removed from the list of 303(d) impaired waterbodies.

To facilitate the next phase of improvement of the Bat Creek Watershed, the Watershed Association of the Tellico Reservoir (WATeR) developed and implemented a two-year project to identify regions throughout the Bat Creek Watershed contributing to nonpoint sources of pollution. Water quality samples were collected monthly for seven months in 2016 at 18 locations along the creek and major tributaries (Figure 3). Each sample site provided localized data from a delineated subwatershed of the Bat Creek Watershed upstream of the sample site. Flow rate measurements accompanied water sampling at each site with the intent of creating a system-wide “pseudo mass balance” for target pollutants. The sampling and analysis program closely followed the methods, protocols, and procedures that TDEC uses for their sampling work and subsequent lab analyses.

Results from laboratory analyses were prioritized according to mass flow rates of E. coli, phosphorus, and total nitrogen to help identify the primary regions producing each pollutant listed by TDEC. The results were documented in Ref. 6. Figure 4 presents an example of results of this ranking of sources of the various pollutants of primary concern throughout the watershed. This information will allow the UT Agricultural Extension staff to efficiently target their future efforts in working with farmers to implement BMPs designed to eliminate specific sources and types of pollution. Implementing BMPs in these critical sub-watersheds, combined with previously discussed water quality projects, should produce significant environmental improvements throughout Bat Creek. These improvements will provide a major step toward the goal of allowing TDEC to remove Bat Creek from the 303(d) list of impaired streams.

Estimate of Load Reductions

BMP List, Educational Activities and Budget

Rural BMPs that will be implemented include streambank stabilization, livestock exclusion fencing, sediment trapping devices, and NPDES monitoring, among others and are spearheaded by an extensive outreach campaign.

Estimate costs for BMPs suggested in the restoration plan and reductions in soil loss and pathogens are summarized in Table 4. For the more expensive BMPs, the project will encourage land-owners to apply for federal and state cost-share programs managed by the NRCS and the Tennessee Department of Agriculture (TDA).

Table 4. Estimated costs for BMPs suggested in the restoration plan

BMP Name	Quantity	Cost/Unit	Budget Estimate
Livestock fencing	5,703 feet	$3.50 per foot	$19.961
Cool season pasture renovation	211 acres	$150 per acre	$31,650
Alternative watering systems	6	$1,300 ea.	$7,800
Stream crossing	3	$1,200 ea.	$3,600
Native warm season pasture establishment	150	$200 per acre	$30,000
Fenceline hay feeder systems	3	$3,000 ea.	$9,000
Urban rain gardens / bioswales	3	$2,000 ea.	$2,000
Estimate total			$108.011

Estimated reductions of nitrogen, phosphorus and sediment were made using the Tennessee NPS Program Pollutant Load Reduction Estimation Tool in Table 5. We used the nitrogen, phosphorus and sediment reduction factors for fencing, watering systems, stream crossings and rain gardens directly from the tool. For cool season pasture renovation and native warm season grass plantings we used the estimates for "forage and biomass plantings" and for the feedline hay feeders we used the "heavy use area" estimates. It should be noted that these are very rough estimates. Other tools such as the wikiwatershed online tool (https://wikiwatershed.org/) estimate that load reductions from the raingardens for example, could be much more at 240 lbs N and 3 lbs P.

Table 5. Estimated **Nitrogen, Phosphorus and Sediment Loss Reductions for Proposed** BMPs **using the Tennessee NPS Program Pollutant Load Reduction Estimation Tool**

BMP Name	N Reduction (lbs N)	P Reduction (lbs P)	Sediment Reduction (tons)
Livestock fencing	1425.8	114.1	34.2
Forage and Biomass Planting (includes cool season pasture renovation and native warm season pasture establishment)	2447.6	238.3	63.2
Alternative watering systems	421.4	35.3	0.0
Stream crossing	150.9	22.5	8.4
Heavy Use Areas (includes fenceline hay feeder systems)	0.3	0.0	0.0
Urban rain gardens / bioswales	94.8	36.0	3.6
Estimated Reduction	**4541 lbs N**	**446 lbs P**	**109.4 tons**

Our strategy is to reach as many landowners as possible by focusing on implementing relatively inexpensive agricultural BMPs. For example, improvements to pasture management can be achieved through encouraging land-owners to take regular soil tests ($15 per soil sample) and follow soil test recommendations from the University of Tennessee. Improvements in the quality of pasture will be achieved through re-seeding of over-grazed or degraded pastures and control of unpalatable weeds through the adoption of an appropriate herbicide program and by rotational grazing. Soil erosion from areas that receive excessive hoof traffic can be reduced by constructing animal traffic lanes and the provision of alternative sources of water. The budget also includes requests for cattle stream-crossings, alternative watering systems, fencing to exclude cattle from the creek and to provide cattle travel lanes.

This approach has been successful in the nearby Pond Creek and Oostanaula watershed projects where we have demonstrated that improvements in pasture management can be a "win-win" situation. Improvements in the quantity and quality of grass will not only improve a farmer's animal production, but can significantly reduce soil erosion and thus protect water quality.

We believe that the Bat Creek Watershed partnership is in an ideal position to make a meaningful impact on water quality by focus on implementing agricultural BMPs in the upper reaches of the watershed and an outreach program targeting stakeholders in the urban parts of the watershed – primarily within the City of Madisonville.

In the urbanized parts of the watershed including the City of Madisonville, rain gardens and bioswales are landscape practices that will help maintain or restore a natural drainage system in place of conventional hardened channels and pipes that carry runoff to nearest streams as fast as possible. These "green infrastructure" practices use the runoff as an amenity by capturing it in slight depressions of amended soils and adapted plants. The result is a landscape that mimics the natural flow of water through the landscape instead of sending erosive pulses of stormwater runoff downstream, which can cause costly damage to public and private infrastructure over time. The benefits of green infrastructure for the private land owner include less mowing maintenance, more diverse plant options, and attraction of interesting and beneficial wildlife to the property.

Residential rain gardens and bioswales will be sited, designed, and built in strategically-selected locations in the watershed where maximum benefit of runoff reduction and pollutant removal may be achieved. These practices will be designed to capture approximately an inch of runoff from contributing impervious surfaces. It is expected that a spectrum of rain garden applications will be used throughout the basin, ranging from small "micro rain gardens" that manage runoff from a single roof downspout, to large common space practices that have internal topographic features to help spread and soak in runoff. In general, these practices will be native soil rain gardens, where organic material is incorporated into the existing soil and storage is created through shallow temporary ponding. As needed, underdrains and additional aggregates will be added depending on specific site conditions. Areas with relatively high risk of nutrient export from residential fertilizer applications will be prioritized. Rain garden plants will be selected from a list of species proven to successfully establish in rain garden conditions. Planting plans will be created in consultation with private property owners to communicate expectations and ensure satisfaction. Educational materials and resources developed by UT Extension faculty will be used to teach new rain garden owners how to care for and maintain a healthy rain garden for years to come.

Timeline, Tasks, and Assessment of Progress

Depending on the level of funding, we anticipate that it will take a minimum of 3 to 5 years to implement a number of BMPs. We will focus on relatively simple BMPs that benefit farmer's production systems as well as those that have a water quality benefit. This will be achieved by demonstrating some of the technologies that most producers may not be very familiar with – for example native warm season grasses as summer pastures (that also "rest" the cool season pastures over the summer months) and fenceline hay feeder systems (to improve winter access to hay feeding sites, as well as reduce hay losses over the winter months). For more established practices such as cool season pasture renovation, installation of alternative cattle and horse watering systems, and stream crossings some cost-share funds may be needed to assist producers to implement. In Madisonville we recommend establishing some high visibility BMPs that intercept stormwater – for example, rain gardens and bioswales. All these BMP demonstrations and cost-share BMPs will be included as part of a watershed-wide education and education outreach with partners from the agricultural community, as well as those from the urban areas.

Progress will initially be assessed by the number of BMPs installed, educational events conducted and the implementation of other practices across the watershed.

Criteria to Assess Achievement of Load Reduction Goals

Achievement of non-point source load reduction goals is difficult to predict due to variations in weather and individual farmers choices. The assessment tools (RUSLE 2, WEP, nutrient management plans, whole farm conservation plans etc.) that agencies such as NRCS use on a daily basis when working with producers enrolled in their programs will be used where possible. On a field-by-field basis farmers and landowners should be encouraged to use conservation agriculture practices. For example, practices such as no-till and the use of winter cover crops on row crop fields to reduce soil erosion losses, and rotational grazing, forage diversification and other recommended grazing management practices for livestock systems.

There is often a significant time lag of months or even years, between the implementation of BMPs and having them function as designed. BMPs should be selected based on their cost effectiveness and ability to reduce nutrient, soil and stream bank erosion losses into the nearby receiving streams.

Monitoring and Documentation Success

Sampling of Water Quality in Bat Creek Watershed

Water sampling in the Bat Creek Watershed has been performed routinely by TDEC, and more recently by WATeR, using QA procedures that are consistent with those used by TDEC. To address the effectiveness of efforts to reduce nonpoint source pollution in the watershed in the event that this application is funded, water sampling by both TDEC and WATeR will be needed. The results of analysis of TDEC water quality sampling will determine when water quality and biological conditions have recovered adequately for Bat Creek to be removed from the 303(d) list of impaired streams. The results of WATeR's sampling will be used to provide adequate resolution (by time and location) to judge the effectiveness of individual BMPs that will be implemented throughout the grant period.

Bat Creek is sampled by TDEC as part of their five-year sampling plan program. The sampling consists of water quality parameters and the macrobenthic Index of Biotic Integrity (IBI). There are three TDEC sampling sites in Bat Creek: one each above and below the Madisonville Wastewater Treatment plant, and one at Mile 8 of Bat Creek approximately a mile upstream of the Bat Creek embayment in Tellico Reservoir. The next scheduled surveys are to be conducted in 2018 and 2023.

Because the five-year surveys performed by TDEC at their three sampling sites are neither frequent nor numerous enough to provide adequate resolution to evaluate the effectiveness of individual BMPs implemented through this grant, volunteers of the Water Quality Improvement Committee (WQIC) of WATeR will sample in the Bat Creek Watershed at appropriate times and locations shortly after the implementation of each BMP. Where practical, water samples will be collected immediately downstream of the BMP project site, and analyzed to evaluate the local effect of the BMP on water quality. Samples will also be collected at the subwatershed site in which the BMP was performed (for subwatershed sites, see Fig. 5).

The water sampling team is comprised of retired professionals experienced in water quality sampling. In 2013, WQIC volunteers collected water quality samples from ten streams throughout the watershed of the Tellico Reservoir to assist the Knoxville TDEC office with their routine five-year sampling. They also performed monthly sampling at 18 sites throughout the Bat Creek Watershed in 2016 (Fig. 3) to identify types and sources of nonpoint source pollution (Ref. 6).

Water temperature, dissolved oxygen, and pH will be measured using a meter. Water clarity will be measured by turbidity tube. Water samples will be collected for analysis of nitrogen, phosphorus, and E. coli. These analyses will be performed by Microbac Laboratories, Inc., a certified commercial testing laboratory located in Maryville, TN. WATeR will pay the expenses for laboratory analyses of their collected samples, as a community contribution in support of this water quality improvement project.

It should be noted that monitoring will be performed by qualified <u>volunteers</u>, and no 319 funds will be used for this activity. WATeR – the Watershed Association of the Tellico Reservoir will pay the expenses for laboratory analyses of their collected samples, as a community contribution in support of this water quality improvement project.

References

1 Custom Soil Resource Report for Loudon County, TN and Monroe County, Tennessee, US Dept. of Agriculture, NRCS Natural Resources Conservation Service, April 2018.

2 Little Tennessee River Watershed (06010204) of the Tennessee River Basin, Watershed Water Quality Management Plan, TN Dept. of Environment and Conservation, Division of Water Pollution Control, Water Management Section, Revised 2005.

3 Total Maximum Daily Load (TMDL) for E. Coli in the Little Tennessee River Watershed (HUC 06010204) Blount, Loudon, & Monroe Counties, Tennessee, TN Dept. of Environment and Conservation, Div. of Water Pollution Control, April 2006.

4 Proposed Final 2018 List of Impaired and Threatened Waters in Tennessee, Greg Denton, TN Dept. of Environment and Conservation, Div. of Water Pollution Control, April 2018.

5 Personal Communication, Larry Everett, Knoxville Field Office, TN Dept. of Environment and Conservation, Division of Water Pollution Control, June 2018.

6 Nonpoint Source Pollution of the Bat Creek Watershed in Monroe County, TN, The Report of a Supplement Environment Project, Water Quality Improvement Committee, Watershed Association of the Tellico Reservoir, May 2017.

Figures

Figure 1 – Location Map of Monroe Co. and Bat Creek Watershed

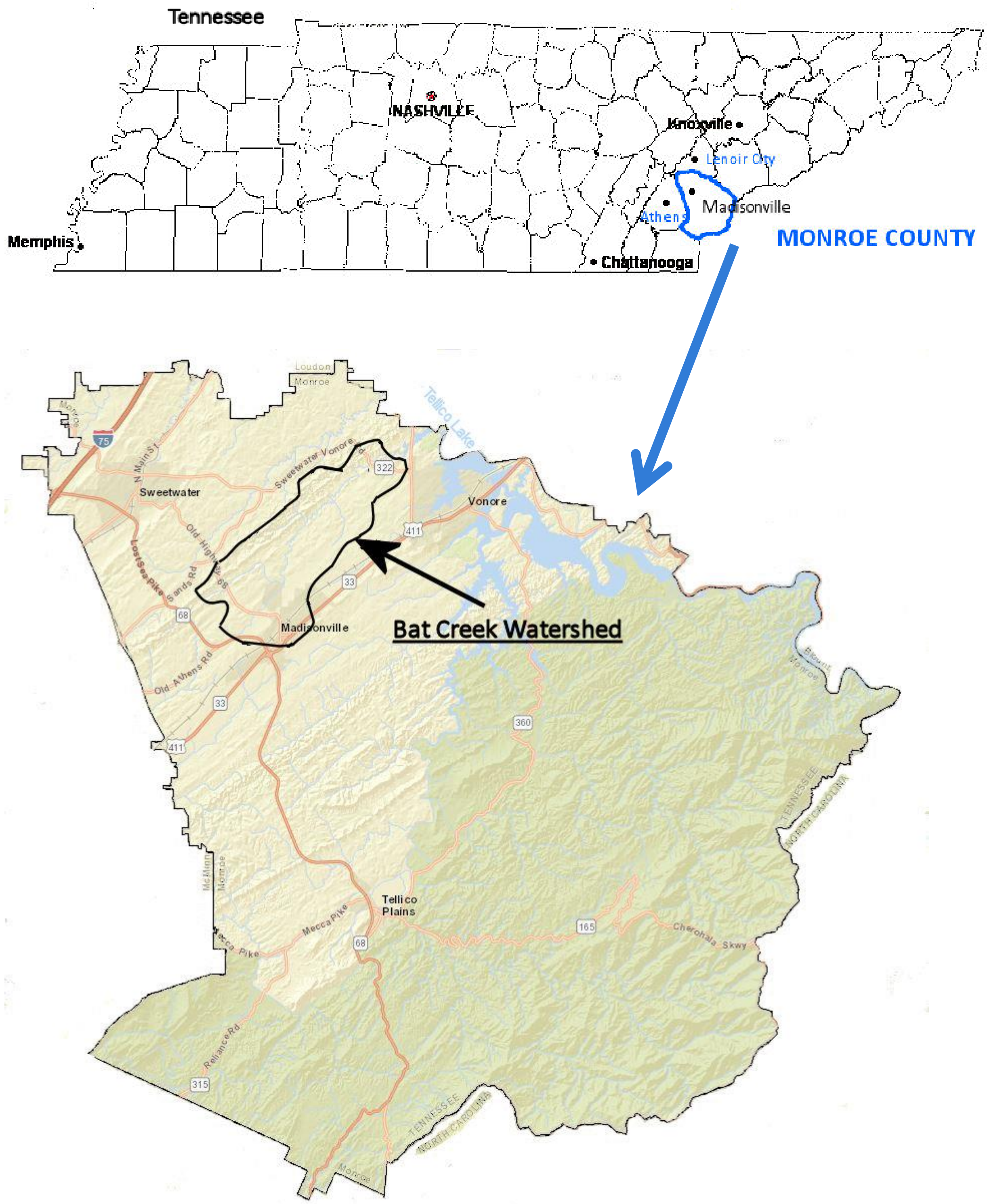
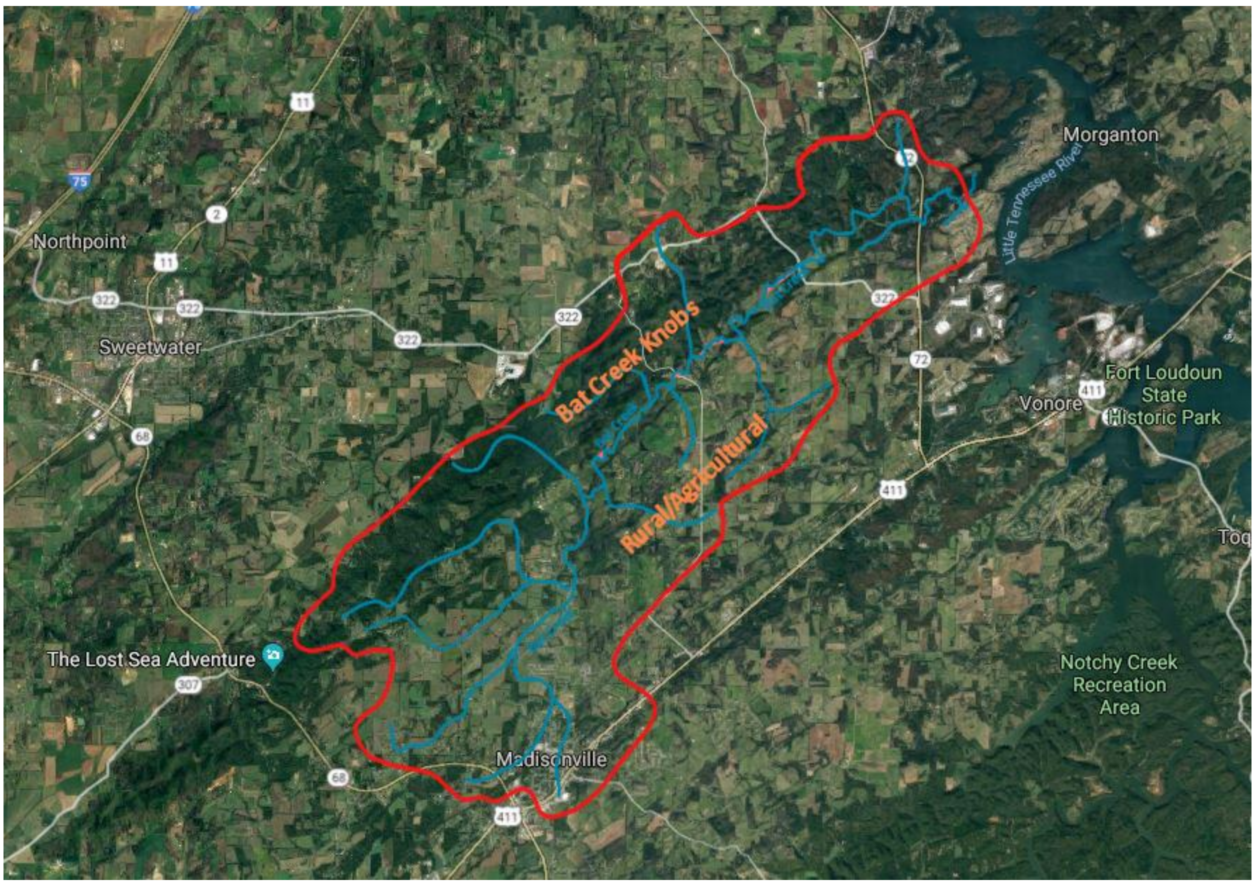


Figure 2 – Satellite Photo of Watershed Boundary with Creek and Tributaries



The red line is the Bat Creek Watershed boundary.

The blue lines are Bat Creek and Tributaries

Figure 3 – Watershed Sampling Map

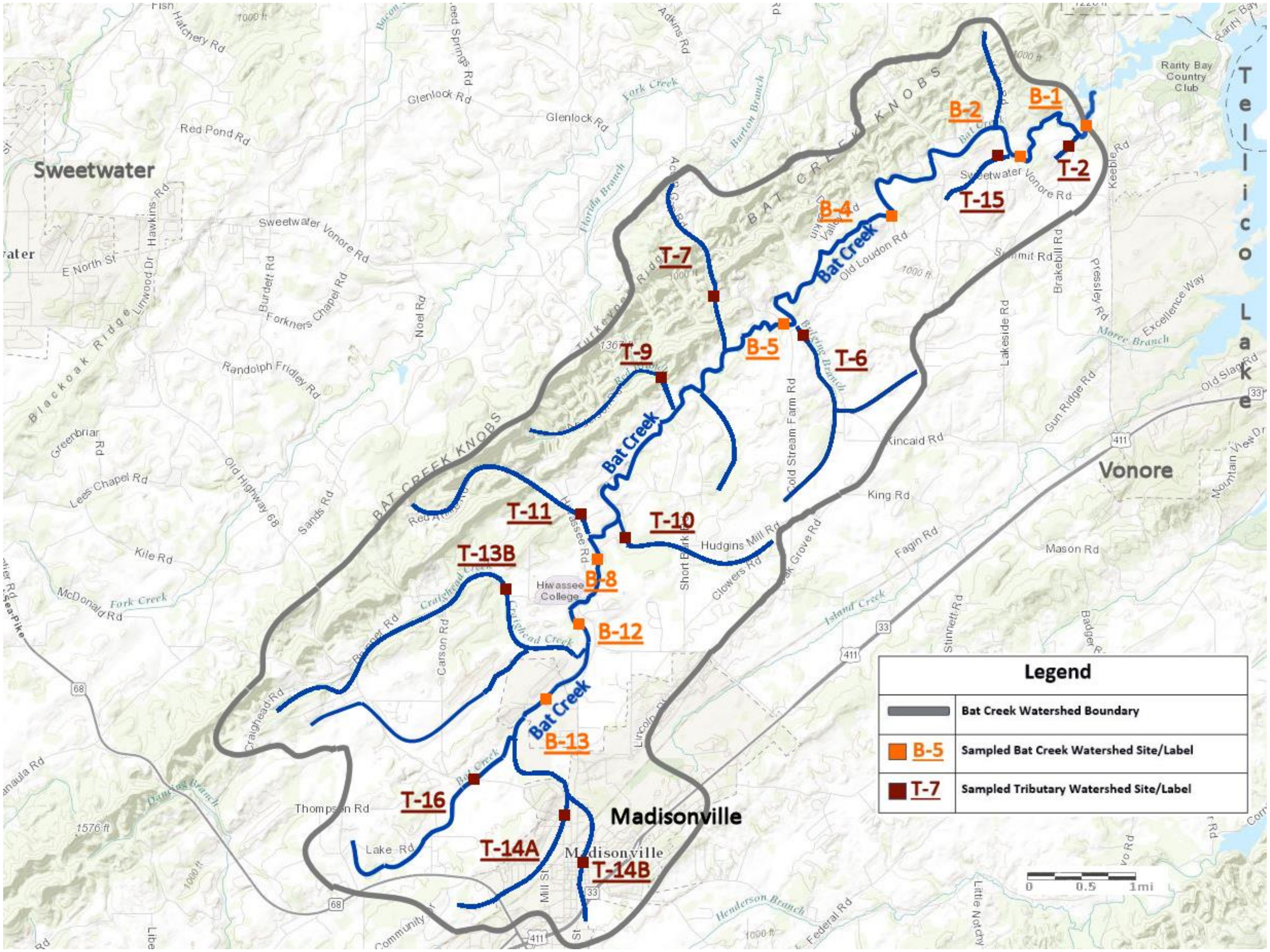
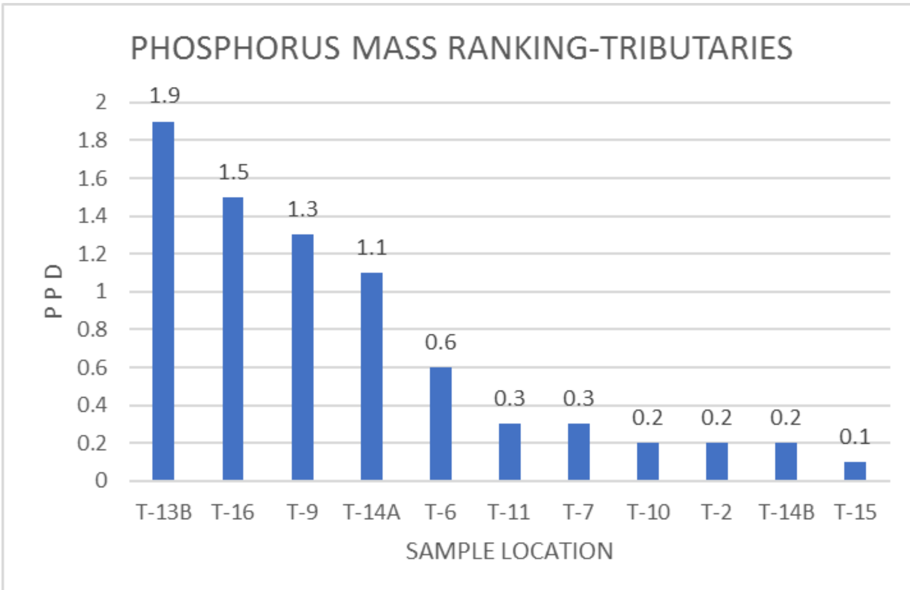


Figure 4 – Examples of Ranked Pollutant Mass Flow Rates from WATeR Sampling Project

PHOSPHORUS MASS FORCED RANKING – TRIBUTARIES



E.COLI "MASS" – WATERSHED

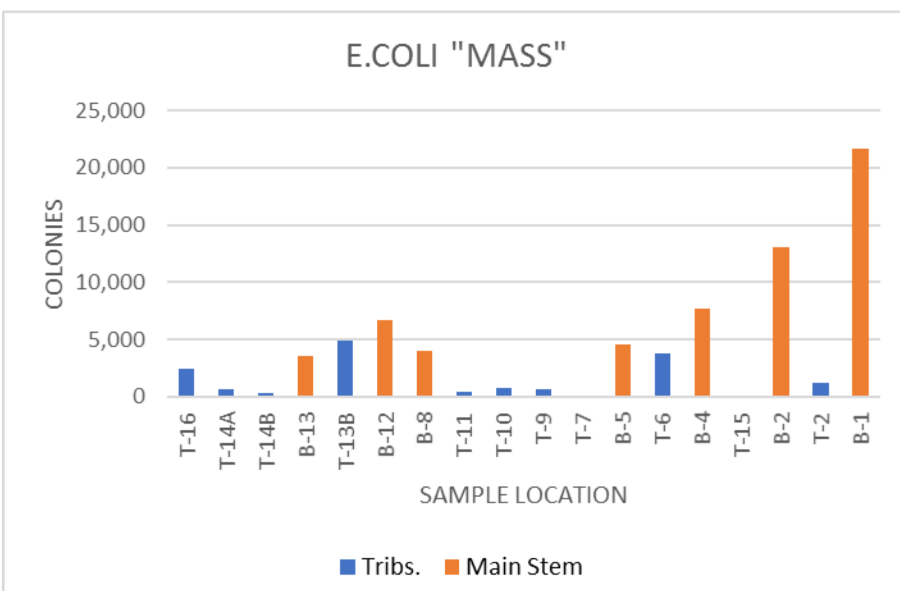


Figure 5 – Water Quality Sample Sites and Associated Upstream Sub-Watershed Boundaries